USE OF GEOGRAPHIC INFORMATION SYSTEMS FOR ASSESSING GROUNDWATER POLLUTION POTENTIAL BY PESTICIDES IN CENTRAL THAILAND

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This study employed geographic information systems (GIS) technology to evaluate the vulnerability of groundwater to pesticide pollution. The study area included three provinces (namely, Kanchana Buri, Ratcha Buri, and Suphan Buri) located in the western part of central Thailand. Factors used for this purpose were soil texture, percent slope, primary land use, well depth, and monthly variance of rainfall. These factors were reclassified to a common scale showing potential to cause groundwater contamination by pesticides. This scale ranged from 5 to 1 which means high to low pollution potential. Also, each factor was assigned a weight indicating its influence on the movement of pesticides to groundwater. Well depth, the most important factor in this study, had the highest weight of 0.60 while each of the remaining factors had an equal weight of 0.10. These factors were superimposed by a method called "arithmetic overlay" to yield a composite vulnerability map of the study area.

Maps showing relative vulnerability of groundwater to contamination by pesticides were produced. Each of them represented the degree of susceptibility of groundwater to be polluted by the following pesticides: 2,4-D, atrazine, carbofuran, dicofol, endosulfan, dieldrin & aldrin, endrin, heptachlor & heptachlor epoxide, total BHC, and total DDT. These maps were compared to groundwater quality data derived

from actual observations. However, only the vulnerability maps of atrazine, endosulfan, total BHC, and heptachlor & heptachlor epoxide showed the best approximation to actual data. It was found that about 7 to 8%, 83 to 88% and 4.9 to 8.7% of the study area were highly, moderately, and lowly susceptible to pesticide pollution in groundwater, respectively.

In this study a vulnerability model was developed, which is expressed as follow: $V = 0.60C_W + 0.10C_S + 0.10C_R + 0.10C_L + 0.10C_{SL}$. Its function is to calculate a vulnerability score for a certain area. The factor "V" in the model represents the vulnerability score of a certain area, whereas C_W, C_S, C_R, C_L, and C_{SL} represent the values or classes assigned to well depth, soil texture, monthly variance of rainfall, primary land use, and percent slope in that area.

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CHAPTER 1

INTRODUCTION

Background Information

Groundwater is an important resource worldwide. In the United States, for instance, more than 90% of the public water supply originates from groundwater (Villeneuve et al., 1990). In Thailand groundwater has been used for drinking water over the past five decades (Ramnarong, 1985). Other groundwater uses include municipal, industrial, and agricultural supplies. Gupta (1997) estimated that the percentages of the total water supply contributed by groundwater in Thailand were: 50% for drinking water, 10% for municipal supply, 20% for industrial supply, 15% for agricultural practices, and 5% for other activities.

Groundwater can be contaminated easily in a multitude of ways, including applications of agricultural pesticides and fertilizers. In recent years much attention has been focused on groundwater contamination by agricultural practices. There is a vast body of literature concerning groundwater contamination events in many parts of the world. For example, it was reported that pesticides are a common source of groundwater contamination in rural Canada, where groundwater is extracted locally from wells (Crowe and Milburn, 1995). In the United States, 17 different pesticides (e.g., atrazine and alachlor) were detected in groundwater in 23 states (Cohen et al., 1986). Another study conducted by the U.S. Environmental Protection Agency indicated that 46 pesticides were found in groundwater in 26 states as a result of normal agricultural applications (Trautmann et al., 1998).

Not only pesticides, but also nitrate originating from fertilizers was reported to be a primary source of groundwater contamination in parts of the western, mid-western, and northeastern United States (Nolan et al., 1997). For example, 62 samples of groundwater taken from the Seymour water-bearing formation in north central Texas were polluted with nitrate concentrations ranging from 21 to 183 mg/L, and 39 samples exceeding the recommended United States Department of Health limit of 45 mg/L (Wendt et al., 1976). The U.S. Environmental Protection Agency (1992) also reported that about 2.4% of rural wells in the country had nitrate concentrations above the national drinking water standard of 45 mg/L.

In Thailand, a number of pesticides such as carbofuran, endosulfan, dicofol, atrazine, and 2,4-D were detected in domestic wells of seven provinces in the central part of the country. In a study conducted by the Pollution Control Department (PCD, 1995), the maximum concentration levels of these pesticides found in groundwater samples taken from 210 wells in this area were: 0.620 ppb for carbofuran, 1.692 ppb for endosulfan, 0.306 ppb for dicofol, 1.890 ppb for atrazine, and 0.210 ppb for 2,4-D. Additionally, Asnachinda (1996) reported that high concentrations of nitrate, up to 290 mg/L NO_3, were found in groundwater samples collected from agricultural areas of the Chiang Mai province in northern Thailand.

Statement of the Problem

Current pesticide concerns include their widespread usage, high toxicity, and environmental persistence. In Thailand, pesticide applications have increased rapidly over the past decade. Imported pesticides increased from 20,537 metric tons in 1987 to 45,701 metric tons in 1996, or approximately double within ten years. More than 90% of the pesticides imported each year were herbicides, insecticides, and fungicides (DOA, 1996).

Usage of pesticides has greatly increased agricultural production. However, there has also been an increased potential for groundwater contamination. The more the pesticides are used, the higher the potential of groundwater contamination. This is due to the fact that pesticides applied to farmland can move downward with deep percolation from the root zone to underlying groundwater. The problem of groundwater quality deterioration in Thailand caused by pesticide contamination is, therefore, taken into consideration in this study.

Objectives of the Study

As pesticide applications increase in Thailand, the need to protect groundwater becomes greater. Monitoring groundwater for pesticides is the first step toward protecting groundwater resources. However, it is impractical to monitor groundwater beneath all areas because of time and budget constraints. Therefore, a technique for assessing groundwater vulnerability to contamination by pesticides needs to be established. This technique would help identify areas where pesticides are likely to impact groundwater. Once the areas are identified, groundwater monitoring programs can be focused in such areas. Information derived from the monitoring programs would be helpful for protecting groundwater resources.

Several methods have been used to assess vulnerability of groundwater to contamination by organic contaminants. These include the DRASTIC model (Aller et al., 1987), pesticide root zone model (PRZM) (Carsel et al., 1985), vulnerability to pesticides model (VULPEST) (Villeneuve et al., 1990), leaching potential index (LPI) (Meeks and Dean, 1990), attenuation factor (AF) (Rao et al., 1985), and pesticide analytical model (PESTAN) (Enfield et al., 1982). However, this study proposes to use geographic information systems (GIS) technology to assess groundwater pollution potential by pesticides in central Thailand. Specifically, the objectives of this research are:

(1) To produce maps of the study area showing relative vulnerability of groundwater to pesticide pollution

(2) To compare groundwater quality data derived from actual observations with the vulnerability maps

(3) To develop a model for predicting the degree of susceptibility of groundwater to contamination by pesticides

(4) To make recommendations for further studies involving the assessment of groundwater pollution potential by pesticides

CHAPTER 2

LITERATURE REVIEW

Groundwater Vulnerability Assessment

Various attempts to evaluate degree of vulnerability of groundwater to organic contaminants have been made over the past two decades. According to Barbash and Resek (1996), predicting pesticide contamination in groundwater can be accomplished by: (1) generating mathematical simulations of pesticide movement and fate in groundwater, (2) using other solutes, such as nitrate and tritium, as pesticide indicators, and (3) large-scale assessments of the groundwater vulnerability to pesticide contamination. Villeneuve et al. (1990) described three methods for determining groundwater vulnerability to contamination: (1) site-specific evaluation by a specialist in hydrogeology, (2) index methods or rating systems, and (3) pesticide fate and transport models.

1. Index methods

There are many index methods for assessing groundwater vulnerability to contamination. Among these, the DRASTIC rating system seems to be most popular. DRASTIC was developed in 1987 by the U. S. Environmental Protection Agency as a tool for assessing relative groundwater pollution potential (Aller et al., 1987). It has been used to design a sampling strategy for the National Pesticide Survey. Its name is an acronym for seven factors used to determine relative rankings: Depth to water (D), net

Recharge (R), Aquifer media (A), Soil media (S), Topography (T), Impact of the vadose zone media (I), and hydraulic Conductivity of the aquifer (C).

Although DRASTIC has been widely used, it has several shortcomings as a tool for identifying areas vulnerable to pesticides. Meeks and Dean (1990) stated that the first shortcoming of DRASTIC is the use of subjective scoring. Secondly, it does not consider the interaction between the chemical of concern and the physical environment when scoring vulnerability. As management decisions need to be chemical-specific, the use of DRASTIC seems inadequate. Holden and others (1992) also concluded that the utility of DRASTIC is unclear, because the complex weighting and rating procedures used in this system are self-defeating. However, some studies showed positive results after modifying the DRASTIC system. For example, Klingler (1993) showed that adding land cover data to DRASTIC may result in a better predictor of groundwater pollution potential.

The leaching potential index (LPI) is an alternative index method. Its purpose is to evaluate the relative susceptibility of groundwater to contamination by pesticides. There are four factors used in this method, including soil-water velocity, retardation factor, chemical decay rate, and groundwater depth. These factors are used to calculate a leaching potential index (LPI), which is an indicator of pollution susceptibility. Basically, higher values of LPI indicate a greater susceptibility of groundwater to contamination. This index is physically based and uses chemical and environmental properties in the susceptibility evaluation (Meeks and Dean, 1990).

Another index method used to assess groundwater vulnerability is the attenuation factor (AF). This is an index of the relative likelihood of groundwater contamination computed on the basis of applied chemical leaching beyond the surface soil layers. Key factors used to calculate an AF value include solute velocity, solute degradation in the vadose zone, and thickness of the vadose zone. AF values range from 0 to 1; a value of zero implies that none of the applied chemicals is likely to contaminate groundwater, whereas a value of 1 indicates that all of the chemicals may leach into groundwater (Rao et al., 1985).

2. Simulation models

An example of a simulation model used as an evaluation tool for groundwater contamination by pesticides is VULPEST (vulnerability to pesticides). The model simulates transport of organic compounds through the unsaturated zone. It permits evaluation of groundwater vulnerability to pesticides in terms of contamination risk (Villeneuve et al., 1990).

Among all of the simulation models, the pesticide root zone model (PRZM) seems to be most common. Carsel and others (1985) developed this model in order to evaluate pesticide leaching potential under field crop conditions. There are many factors contributing to pesticide leaching, e.g., chemical solubility in water, pesticide formulation, soil properties, climate conditions, crop types, water management methods, and cropping practices (Enfield et al., 1982; Selim et al., 1977; Davidson et al., 1975). Therefore, PRZM needs input data corresponding to the characteristics of the soil, climate, pesticides, crop, and agricultural management practices.

In addition to VULPEST and PRZM, other models have also been applied for simulating the fate and transport of pesticides in soil and groundwater. Examples include

Chemical, Runoff, and Erosion from Agricultural Management Systems (CREAMS) (Knisel, 1980), Groundwater Loading Effects of Agricultural Management Systems (GLEAMS) (Leonard et al., 1990), Leaching Model for Pesticides (LEACHMP) (Wagenet and Hutson, 1986), and Pesticide Analytical Model (PESTAN) (Enfield et al., 1982). However, these models are most useful only at local scales; required data elements generally are not available at regional scales.

Geographic Information Systems (GIS) as a Tool for Assessing Groundwater Vulnerability

Geographic Information Systems (GIS) have been widely used for many purposes over the past decade. They are "a powerful set of tools for storing and retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes" (Clarke, 1997). Cowen (1988) defined GIS as a decision support system involving the integration of spatially referenced data in a problem solving environment. This system provides the technical basis for studying problems that are spatial, multidisciplinary, and holistic in nature, allowing an integrated approach previously unattainable.

Following are a number of studies that employed GIS technology to assess groundwater vulnerability:

- Schmidt (1987) developed a GIS weighting model based on five factors: type of bedrock, depth to bedrock, depth to water table, soil characteristics, and surficial deposit characteristics. As a result, a groundwater susceptibility map of Wisconsin was produced.

- Nebert and Anderson (1987) used a GIS to prepare a database for evaluating the potential for groundwater contamination by pesticides in Oregon. Factors used in this study included precipitation, soils, land cover, geology, and shallow aquifers.

- Khan and Liang (1989) applied an attenuation factor (AF) to evaluate the groundwater contamination potential of eleven pesticides for the Island of Oahu, Hawaii. A GIS was used to produce maps of the relative likelihood of groundwater contamination by these chemicals.

- Petersen and others (1991) applied a GIS to evaluate agricultural non-point source pollution potential in Pennsylvania. The data layers used for this study included land cover, farm animal density, topography, soils, precipitation, and a rainfall-runoff factor.

- Halliday and Wolfe (1992) applied a GIS and DRASTIC model with information on cropping, fertilizer application rates, aquifers, and aquifer recharge areas. The result was a nitrogen fertilizer pollution potential map of Texas.

- Atkinson and others (1992) used the DRASTIC model and a GIS to assess groundwater pollution potential of Texas. In this study, the GIS included each of the seven parameters in DRASTIC, which could be updated as required.

- Hudak and others (1993) integrated the capabilities of a GIS for analyzing spatially referenced data. The results concluded that GIS is capable of enhancing the field-applicability of established methodologies for groundwater quality monitoring network design.

- Messier and others (1994) used vulnerability (DRASTIC) and leaching potential (GUS, Groundwater Ubiquity Score) variables modeled with GIS to identify areas where groundwater was susceptible to corn pesticide contamination.
- Searing and Shirmohammadi (1994) used a GIS and GLEAMS to model environmentally at-risk areas. Several variables such as land cover, farming practices, animal density, topography, soils, and seasonal precipitation amounts were used in this study.

It is evident that geographic information systems (GIS) play an important role in evaluating and predicting the pollution potential for groundwater on a regional scale. There is a growing need among policy makers, administrators, and bureaucrats to use GIS technology for this purpose.

Factors Affecting Groundwater Contamination by Pesticides

Many factors govern groundwater contamination by pesticides. According to Banton and Villeneuve (1989), factors affecting the migration of pesticides, and thus the vulnerability of groundwater systems, can be classified into four categories: (1) geological factors of the saturated and unsaturated zones, (2) hydrodynamic, hydrogeochemical and biological factors, (3) bio-physio chemical characteristics of the contaminant, and (4) impact factors related to water use. Barbash and Resek (1996) also pointed out that data on the physical and chemical characteristics of the subsurface environment, as well as on the physical and chemical properties of the solutes themselves, are indispensable for accurately assessing groundwater vulnerability to pesticide contamination. Examples of the factors mentioned above are discussed in the following list.

1. Depth to water table

Depth to water table determines the depth to which a contaminant must travel before reaching the aquifer. It is an important factor affecting vulnerability to contamination from the surface since agricultural chemicals most often affect the near surface or uppermost aquifers (Leonard and Knisel, 1988). Koterba and others (1993) found that pesticide residues mainly occupied the shallow parts of surficial aquifers, with about 90% of the detection occurring in samples collected within 10 meters of the water table. Only a few pesticides were detected in samples collected from deeper wells.

2. Soil

Soil is commonly considered as the upper weathered zone of the earth with averages 6 feet or less in depth. It has a significant impact on the amount of recharge which can infiltrate into the ground and, hence, on the ability of a contaminant to move vertically into the vadose zone (Aller et al., 1987). Generally, soil texture plays an important role in affecting transportation of pesticides. Di Muccio and others (1990) studied the effect of soil texture on atrazine transportation in northern Italy. Atrazine was found in loamy soil at a depth of 10 to 30 centimeters during the second month of application. In a loamy-sandy soil, a significant amount of atrazine was found below a depth of 10 centimeters after only the first month. The researchers concluded that the quicker arrival of atrazine at greater depths in the loamy-sandy soil than in the loamy soil was a result of increased percolation due to a higher permeability. Soil texture also greatly affects the adsorption of pesticides. It was reported that aldrin and lindane were adsorbed least in sand, and by increasing amounts in silty clay loam, light sandy clay loam, coarse silt, silty clay, sandy loam, clay loam and muck (Edwards, 1973).

Soil organic matter can affect transportation of pesticide as well. It influences how much water is retained in the soil and how well pesticides are adsorbed. Increasing the soil organic matter will enhance the soil's ability to hold both water and dissolved pesticides in the root zone. The higher the organic content in the soil, the higher water retention and the greater adsorption of pesticides (Waldron, 1992).

3. Aquifer material

An aquifer is defined as a body of saturated rock or sediment that is capable of transmitting useful quantities of water to wells or springs. Common aquifer materials include consolidated and unconsolidated sand and gravel, sandstone, limestone, and fractured rocks (Hudak, 1999). In general, the larger the grain size and the more fractures or openings within the aquifer, the higher the permeability and consequently the greater the potential for pollution to migrate through the aquifer (Aller et al., 1987).

4. Topography

This factor refers to the slope and slope variability of the land surface. Basically, topography helps control the likelihood that a contaminant will run off or remain on the surface in one area long enough to infiltrate (Aller et al., 1987). As the slope increases, the chance of infiltration decreases and the contaminant is more readily carried away. On the other hand, the contaminant will infiltrate into the ground rather than run off when the slope is flat.

5. Land use/land cover

This is another important factor relating to groundwater vulnerability of pesticide contamination. In general, groundwater beneath agricultural areas has larger concentrations of pesticides in comparison to undeveloped area. Cain and others (1989) reported that water underlying agricultural areas from the High Plains aquifer in Nebraska, the recharge zone of the Potomac-Raritan-Magothy aquifer system of New Jersey, and the upper glacial aquifer on Long Island in New York had an increased frequency of detection of pesticides in comparison to less developed areas.

It has been suggested that land use/land cover data should be included in a comprehensive groundwater protection study (Dee and Mlay, 1990). Koterba and others (1993) emphasized that the accuracy in predicting groundwater contamination by pesticides is increased significantly when land use/land cover is taken into account. Moreover, Klingler (1993) also indicated that adding land cover data to the DRASTIC model may result in a product that is a better predictor of groundwater pollution potential by pesticides.

6. Irrigation and rainfall

Pesticides moving into groundwater can be affected by the amount of water used in irrigation and also the amount of rainfall in a particular area. The more the water used in irrigation and the more the water derived from rainfall, the greater the opportunity for groundwater contamination by pesticides. Therefore, areas with high rates of rainfall and irrigation are most susceptible to leaching of pesticides, especially if the soils are highly permeable. For a shallow and unconfined aquifer, if high rainfall or heavy irrigation occurs during or shortly after the application of agricultural chemicals, the chemicals will be quickly leached from the root zone and then percolate downward to groundwater within a few days (Trautmann and others, 1998). Cain and others (1989) reported that the frequency of detection of triazine herbicides was greater in groundwater from intensively irrigated areas of the High Plains aquifer of Nebraska than in areas with less intensive irrigation.

7. Pesticide properties

The properties of pesticides such as solubility, adsorption, and degradation also affect leaching potential. Pesticides that dissolve readily in water are highly soluble and generally carried with the water flow. Such pesticides have greater potential of being moved downward through the soil, and possibly leaching to groundwater. However, many pesticides do not leach because they are adsorbed on the soil particles. Pesticides strongly adsorbed onto soil are not likely to leach, regardless of their solubility. Pesticides that are weakly adsorbed, on the other hand, will leach in varying degrees depending on their solubility. Degradation is another property that affects the potential for a pesticide to reach groundwater. Its persistence influences the ability for contamination. The longer the pesticide lasts before it is broken down, the longer it is subject to the forces of leaching. However, many highly persistent pesticides may not reach groundwater because of their low solubility and strong adsorption to soil particles. On the other hand, some soluble pesticides of low persistence may be able to contaminate groundwater (Waldron, 1992).

8. Management practices

The way in which a pesticide is applied also determines leaching potential. Injecting or incorporating a pesticide into soil makes it readily available for leaching. Most of the pesticides contaminating groundwater are incorporated into the soil rather than sprayed onto crops. In addition, the rate and timing of a pesticide's application are critical in determining whether it will leach to groundwater. The larger the amount used and the closer the time of application to a heavy rainfall or irrigation, the more likely pesticides will leach to groundwater (Waldron, 1992).

CHAPTER 3

DESCRIPTION OF THE STUDY AREA

Location and Scope

The study area is located in the western part of central Thailand. It occupies three provinces, namely, Kanchana Buri, Ratcha Buri, and Suphan Buri (Figure 1). Geographically, Kanchana Buri and Ratcha Buri provinces are located in the Mae Klong River Basin, whereas Suphan Buri province is a part of the Tha Chin River Basin (Figure 2). These three provinces have a total area of 3,003,762 hectares. Kanchana Buri, which is divided into thirteen districts, is the largest province and occupies an area of 1,948,315 hectares. The other two provinces are each divided into ten districts covering areas of 519,646 hectares for Ratcha Buri and 535,801 hectares for Suphan Buri (DLA, 2002). Indeed, the study area is approximately 6% of the whole country, which is about 51.4 million hectares.

Population

It is reported that total population of the study area in 2001 was approximately 2.46 million. This consists of 786,001, 821,603 and 858,201 persons in Kanchana Buri, Ratcha Buri, and Suphan Buri provinces, respectively (DLA, 2002). Among these, Kanchana Buri province has the lowest population density, which is approximately 40 persons per square kilometer. The other two provinces, Ratcha Buri and Suphan

Buri, have population densities of 158 and 160 persons per square kilometer, respectively. The most populated areas are in the lowland east and southeast of the study area.

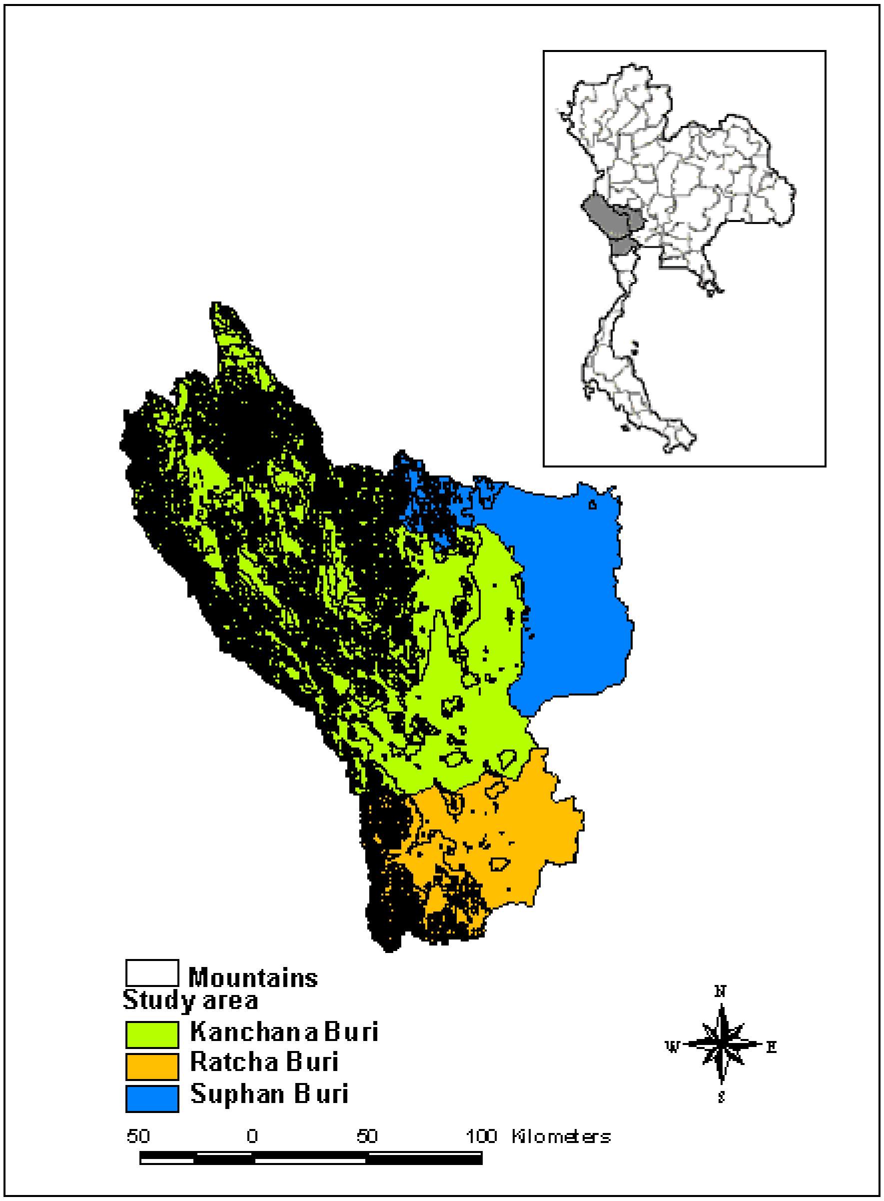


Figure 1 Map of the study area

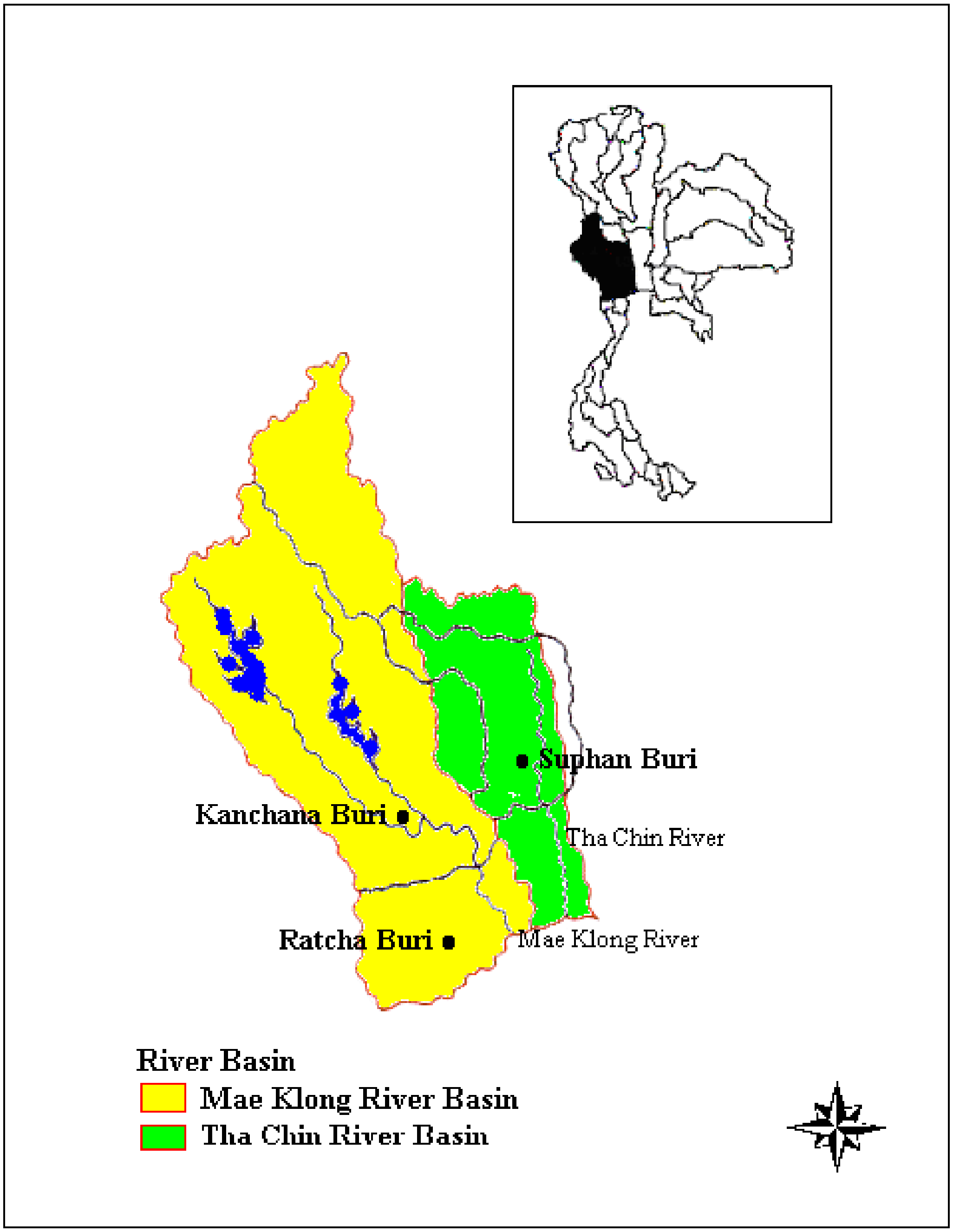


Figure 2 Map showing watershed boundaries of the study area

Topography

As mentioned earlier, the study area is mostly located in the Mae Klong River Basin and partly in the Tha Chin River Basin. The topography is mainly flood plain in the east, transitioning to foothills and mountainous areas in the west (see Figure 1). The flood plain in the eastern and southeastern parts of the study area has a very flat slope ranging from 0-5%, which is generally covered by agricultural land. The terrain in the western and northwestern parts, however, slopes up to more than 35% and is mainly occupied by tropical evergreen, deciduous and mixed deciduous forests.

Meteorology

The climate of the study area as a whole is dominated by tropical southwest and northeast monsoons. It is actually divided into three seasons. The hot season generally starts from the middle of February and ends at the middle of May. The rainy season, or southwest monsoon season, begins in the middle of May until the end of October. The cold season, or northeast monsoon, usually ranges from the end of October to the middle of February.

The southwest monsoon contributes substantially to annual rainfall in the study area, which varies from one year to another. Based on observations from 50 weather stations, the average annual rainfall of the study area during 1990 to 1999 was about 1,182 millimeters. Kanchana Buri had a greater amount of rainfall than the other two provinces. Its average annual rainfall was 1,359.5 millimeters, while annual rainfall in Ratcha Buri and Suphan Buri averaged 1,000.1 and 980.7 millimeters, respectively (MD, 2000a).

Soil

Soil types in the study area vary from very fine to medium and coarse textures. The very fine and moderately fine textures include clay, gravelly clay, clay loam and sandy clay loam. The medium texture includes loam and silt loam. And lastly, the moderately coarse and coarse textures range from sandy loam to sand, gravelly and stony. Soils with fine and medium textures occur in the lowland in the east and southeast, whereas the highland west and northwest of the study area is mainly occupied by coarse textured soil.

Groundwater Resources

Ramnarong (1993) described the study area as hydrogeologically divided into highland and lowland areas, in which groundwater occurs in consolidated and unconsolidated aquifers, respectively. In the highland area, aquifers are classified as carbonate aquifer, Khorat aquifer, Mae Sot aquifer, gneissic aquifer, metasediment aquifer, metamorphic aquifer and granitic aquifer (Piancharoen, 1982). Details of each of these aquifers are briefly described as follows:

- The carbonate aquifer includes Permain and Ordovician limestone. It occupies the northern, western, and also southern parts of the Mae Klong Basin (Figure 3). Groundwater in this aquifer occurs mainly in solution cavities and bedding planes in the limestone, at the contact zone between limestone and inter-bedded shale, and occasionally in fault zones. Water well yields average 5 to 20 m^3/hr, but some yield up to 50 m^3/hr.

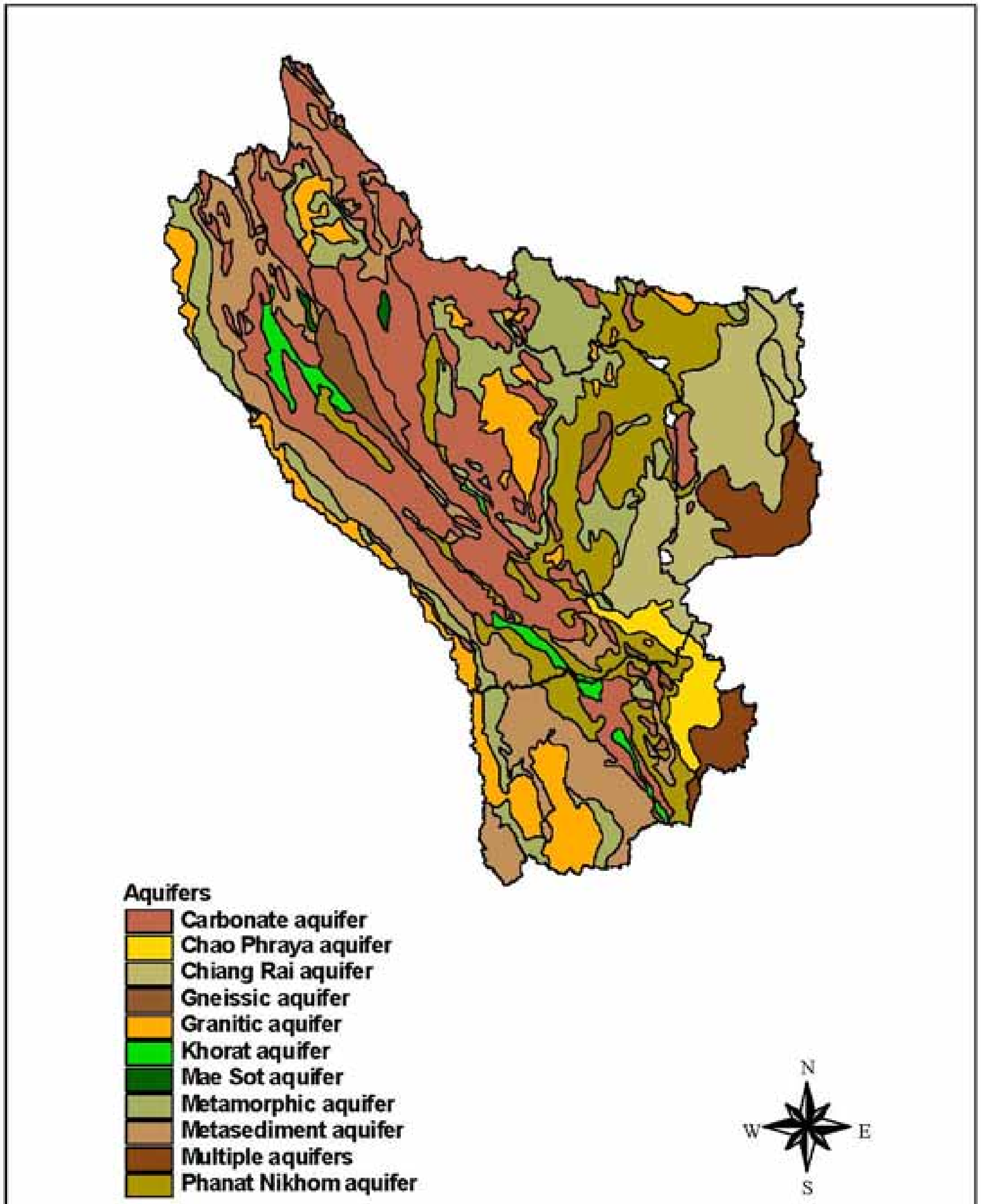


Figure 3 Map of aquifers in the study area

- The Khorat aquifer exists in small areas in the western and southern parts of the Mae Klong Basin (Figure 3). Rocks forming the aquifer consist of dark brown to grayish brown variegated shale, soft slabby micaceous sandstones, sequences of friable siltstones, resistant bedded sandstones and some conglomerates. Groundwater occurs in complex fracture zones of indurated shale and slabby sandstones at a depth less than 50 meters. Yields of individual wells range from 3 to 10 m^3/hr, but yields of 20 m^3/hr or more can be expected from wells penetrating contact zones with limestone.

- The Mae Sot aquifer exists as narrow strips at the area north of the Mae Klong Basin (Figure 3). Rocks forming the aquifer consist of semi-consolidated lacustrine and fluviatile sediments at the upper part, limestone marls, carbonaceous to oil shale, mudstones, lignite and sandstones at the lower part. The aquifer is generally not productive due to semi-consolidated properties and a poorly developed fissure system. Wells in this aquifer usually yield less than 3 m^3/hr, but can yield up to 6 m^3/hr with surficial recharge.

- The gneissic aquifer exists in a small area north of the Mae Klong River Basin (Figure 3). Rocks forming the aquifer consist of granite, granodiorite, diorite, and gneisses. Yields of wells generally do not exceed 3 m^3/hr.

- The metasediment aquifer occupies narrow strips extending from the western to southern, and northwestern to northeastern parts of the Mae Klong Basin (Figure 3). Rocks forming the aquifer consist of clastic sediments of quartzitic sandstones and feldspathic sandstones. Inter-bedded tuffs and agglomerates occur in places. Groundwater occurs only in joints and fractures that are generally complex, and not well interconnected. Average yield of water wells is 3 to 5 m^3/hr, but up to 10 m^3/hr at some locations.

- The metamorphic aquifer occupies many areas in every part of the Mae Klong Basin except the area southeast of the basin (Figure 3). This aquifer consists of metamorphic rocks ranging in ages from Cambrian to Devonian. Slates, phyllites, quarzites, and shcists are dominant. Groundwater is devoid in many places. Wells yield less than 3 m^3/hr.

- The granitic aquifer is exposed as ridges in the central, northern, western, and southwestern parts of the Mae Klong River Basin (Figure 3). The aquifer is a combination of granite, granodiorite, diorite and associated intrusive rocks and gneiss. Groundwater comes mainly from joint systems or decomposed zones, at a rate of less than 3 m^3/hr.

In the lowland area, rocks forming the aquifers are unconsolidated deposits of gravel, sand, and clay of deltaic plains, recent alluvial plains and rolling terraces. Types of aquifers in this area can be classified as follows:

- The Phanat Nikhom aquifer exists as large areas north and west of the Tha Chin River Basin, and also some areas in the central and southern parts of the Mae Klong Basin (Figure 3). The aquifer consists mainly of clay and sandy clay. Average yield of individual wells in this aquifer is approximately 1 to 2 m^3/hr.

- The Chiang Rai aquifer occupies a large area extending from the eastern to western part of the Tha Chin Basin, and a small area southeast of the Mae Klong Basin (Figure 3). This aquifer consists of thick sequences of clay beds, unassorted sand, and gravel in clay. Water well yields average 1 to 2 m^3/hr in some locations, but some yield up to 20 m^3/hr.

- The Chao Phraya aquifer exists as a narrow strip southeast of the Mae Klong River Basin (Figure 3). This aquifer is a combination of sand and gravel, with intercalated clay or silt. Average yield of individual wells in this aquifer is approximately 7 to 8 m^3/hr.

- The multiple aquifer occupies a large area in the eastern part of the Tha Chin River Basin and southeastern part of the Mae Klong River Basin (Figure 3). This aquifer is mainly a combination of sand and gravel, which forms extensive multiple confined aquifers of high productivity. Yields up to 45 m^3/hr can be obtained from individual wells.

Land Use and Land Cover

Based on a database from the Department of Local Administration (2002), the total area of Kanchana Buri, Ratcha Buri and Suphan Buri provinces is approximately 3,003,700 hectares. Of this, 42% is occupied by forest, 35% by agricultural land, and 23% by other land cover such as urban areas and water bodies (see Figure 6). Most of the forest, or about 85%, occupies half of Kanchana Buri province in the northern and northwestern parts of the study area. Only about 10% exists in the southern and southwestern parts. Types of forest range from tropical evergreen to deciduous and mixed deciduous forests.

Agricultural land occupies a large area of flood plain extending from the eastern to the central, and from the northeastern to the southeastern parts of the study area. The two major field crops are rice and sugarcane, which occupy about half of the agricultural area in the three provinces. In 1998, the Office of Agricultural Economics reported that the planted areas of rice and sugarcane were 284,800 and 271,900 hectares, respectively (OAE, 1999). Almost 50% of rice fields are in Suphan Buri province, whereas 55% of sugarcane exists in Kanchana Buri province. Other field crops grown in the study area include cassava, corn, cotton, soybean, mung bean, and pineapple.

CHAPTER 4

DATA COLLECTION AND DESCRIPTION

Types and Sources of Data

A variety of data are needed for assessing groundwater pollution potential by pesticides. In previous studies, researchers used many types of data for this purpose. These included *(1) depth to water table* (Aller et al., 1987; Schmidt, 1987; Meeks and Dean, 1990; Atkinson et al., 1992), *(2) soil* (Carsel et al., 1985; Aller et al., 1987; Schmidt, 1987; Nebert and Anderson, 1987; Petersen et al., 1991; Atkinson et al., 1992; Searing and Shirmohammadi, 1994; Messier et al., 1994), *(3) aquifer* (Aller et al., 1987; Nebert and Anderson, 1987; Halliday and Wolfe, 1992; Atkinson et al., 1992; and Messier et al., 1994), *(4) topography* (Aller et al., 1987; Petersen et al., 1991; Atkinson et al., 1992; Messier et al., 1994; Searing and Shirmohammadi, 1994), *(5) land use and land cover* (Nebert and Anderson, 1987; Petersen et al., 1991; Klingler, 1993; Searing and Shirmohammadi, 1994), *(6) rainfall* (Nebert and Anderson, 1987; Petersen et al., 1991; Searing and Shirmohammadi, 1994) and *(7) irrigation* (Cain et al., 1989). In this research, some of the data mentioned above were applied in order to achieve the study's goals. It is important to note that collecting the data for this study was mainly based on their availability in relevant agencies of the royal Thai government. Following are the list of such data and their sources:

1. Soil data

This data was derived from the Department of Land Development (DLD, 1992). It is GIS data in vector format, which contains series number, name, soil unit, soil texture, drainage, and effective depth of the soils in the study area. Among these, soil texture was used as the first variable for assessing groundwater vulnerability to contamination by pesticides.

2. Topography data

Topography data was derived from the Pollution Control Department (PCD, 1997). This is GIS data in vector format. It provides many kinds of information such as contour, elevation, and slope classes, expressed as ranges of percent slope, of the three provinces in the study area. The percent slope was assigned as the second variable used for this study.

3. Land use and land cover data

Land use and land cover are also GIS data in vector format. The source of this data was the Department of Environmental Quality Promotion (DEQP, 1995 and 1998). It provides information such as major land use (e.g., A = Agricultural land, F = Forest, U = Urban and built up land, and W = Water bodies), group land use (e.g., A01 = Paddy field, A02 = Field crops, and A03 = Perennial crops), and primary land use (e.g., A0202 = Corn, A0203 = Sugarcane, and A0204 = Cassava). In this study, primary land use was assigned as the third variable for evaluating the potential for pesticides to contaminate groundwater.

4. Well data

Well data was also collected for this study. It was derived from the Department of Mineral Resources (DMR, 1996a and 1996b). The data includes geographic locations, diameters, depths, static water levels, and yields of wells located in the study area. Among these, well depth was chosen as the fourth variable. It was used instead of depth to water for two reasons. First, depth to water varies from time to time depending on seasons in a year. Second, depth to water could give misleading information for a well in a confined aquifer (i.e., the potentiometric surface could be near ground level, but the aquifer might be far below ground level).

5. Meteorology data

This data was derived from the Meteorological Department (MD, 2000a and 2000b). It contains geographic locations and the amount of monthly rainfall during 1990 to 1999 of fifty weather stations located in the study area. From this data, the average annual rainfall and monthly variance of rainfall at each weather station were calculated. Either one or both of them could be used as the last variable for assessing groundwater pollution potential by pesticides.

In summary, the study focused on five variables affecting the migration of pesticides to groundwater. These comprised two geological variables of the saturated and unsaturated zones (soil texture and well depth), one physical variable (percent slope) and one anthropogenic variable (primary land use) of the surface environment, and lastly one meteorological variable (rainfall). Based on these variables, maps of the study area showing relative vulnerability of groundwater to pesticide pollution can be produced.

Maps were created for each data layer, and composite maps of all variables were also constructed.

6. Groundwater quality data

Groundwater quality data were derived from the Pollution Control Department (PCD, 1995). It provides information about pesticide residues found in groundwater of the study area. Ninety samples of groundwater were collected and analyzed for a number of pesticides. Those included 10 different insecticides and herbicides, namely endosulfan, dicofol, total BHC, total DDT, heptachlor & heptachlor epoxide, dieldrin & aldrin, endrin, carbofuran, atrazine, and 2,4-D. Concentrations in groundwater of each pesticide were compared with the vulnerability maps.

Description of Data

The data used for assessing groundwater pollution potential by pesticides in central Thailand can be described as follow:

1. Soil texture

Types of soil in the study area vary from very fine and moderately fine to moderately coarse and coarse textures, and can be defined into eleven groups (Table 1). These consist of clay, gravelly clay, clay loam, sandy clay loam, loam, silt loam, very fine sandy loam, sandy loam, sand, gravelly and stony. Figure 4 shows the distribution of soil texture in the study area. In fact, soil textures in each group are either the texture of topsoil alone or a combination between the textures of topsoil and subsoil. For example, “clay” represents the texture of topsoil while “clay/clay loam” refers to the textures of topsoil and subsoil. Generally, this combination is on the basis of 60% for topsoil and 40% for subsoil (DLD, 2000).

Table 1 Soil texture in the study area

Group	Soil texture	Topsoil/subsoil
1	Clay	Clay, Clay/clay, Clay/clay loam, Clay/gravelly, Clay/gravelly clay, Clay/sand, Clay/sandy clay loam, Clay/sandy loam, Clay/silt loam, Clay/very fine sand loam.
2	Gravelly clay	Gravelly clay, Gravelly clay/gravelly, Gravelly clay/ gravelly clay, Gravelly clay/clay, Gravelly clay/clay loam, Gravelly clay/sandy loam.
3	Clay loam	Clay loam, Clay loam/clay, Clay loam/clay loam, Clay loam/gravelly, Clay loam/gravelly clay, Clay loam/sandy loam.
4	Sandy clay loam	Sandy clay loam, Sandy clay loam/clay, Sandy clay loam/clay loam, Sandy clay loam/gravelly, Sandy clay loam/sand, Sandy clay loam/sandy clay loam, Sandy clay loam/sandy loam, Sandy clay loam/very fine sandy loam.
5	Loam	Loam, Loam/silt loam.
6	Silt loam	Silt loam, Silt loam/clay, Silt loam/clay loam, Silt loam/gravelly clay, Silt loam/sandy clay loam, Silt loam/sandy loam, Silt loam/silt loam, Silt loam/very fine sandy loam.
7	Very fine sandy loam	Very fine sandy loam.
8	Sandy loam	Sandy loam, Sandy loam/gravelly, Sandy loam/clay, Sandy loam/clay loam, Sandy loam/sand, Sandy loam/sandy clay loam, Sandy loam/sandy loam.
9	Sand	Sand, Sand/gravelly, Sand/sand, Sand/sandy loam.
10	Gravelly	Gravelly, Gravelly/gravelly, Gravelly/sandy loam.
11	Stony	Stony, Stony/stony.

Source: DLD, 1992.

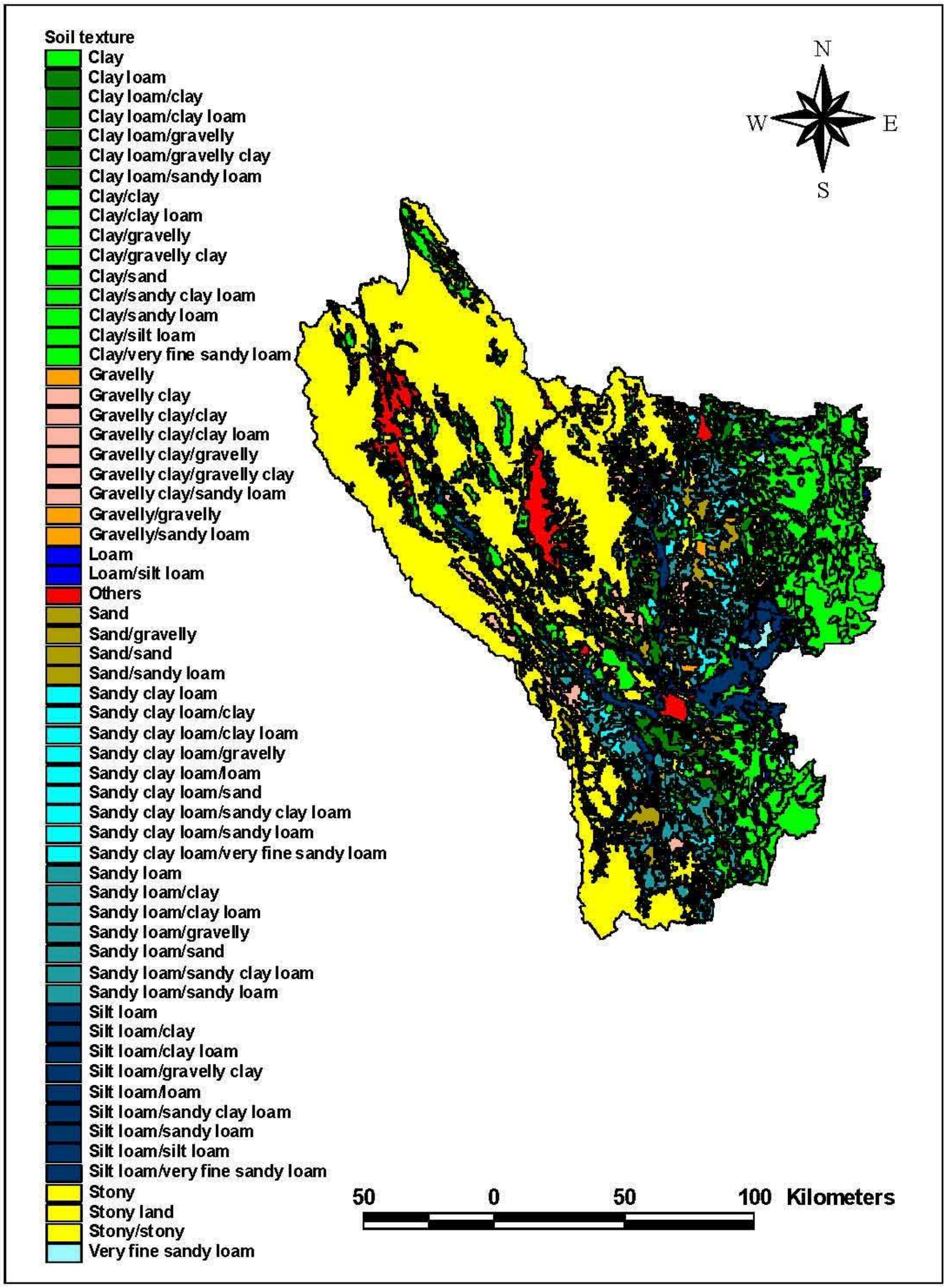


Figure 4 Map of soil texture in the study area

2. Percent slope

Slope of the study area can be divided into eight classes varying from very flat to very steep. Each class is expressed in terms of the percentage of slope, which includes 0-5%, 5-10%, 10-15%, 15-20%, 20-25%, 25-30%, 30-35%, and greater than 35% (Table 2). The pattern of all slope classes in the entire study area is illustrated in Figure 5.

Table 2 Percent slope of the terrain in the study area

Slope class	Class range (% slope)
1	0- 5%
2	5-10%
3	10-15%
4	15-20%
5	20-25%
6	25-30%
7	30-35%
8	>35%

Source: PCD, 1997.

3. Primary land use

Land use and land cover in the study area are classified into five major groups as shown in Figure 6. These consist of urban and built-up land (U), agricultural land (A), forest (F), water bodies (W), and miscellaneous (M). Also, each major group is classified into subgroups called “group land use”. And each group land use is again divided into a number of primary land uses. There are 56 types of primary land uses in the entire study area (Table 3). Of these, 27 land use types are agricultural land. Table 4 shows some of primary land uses in each major group.

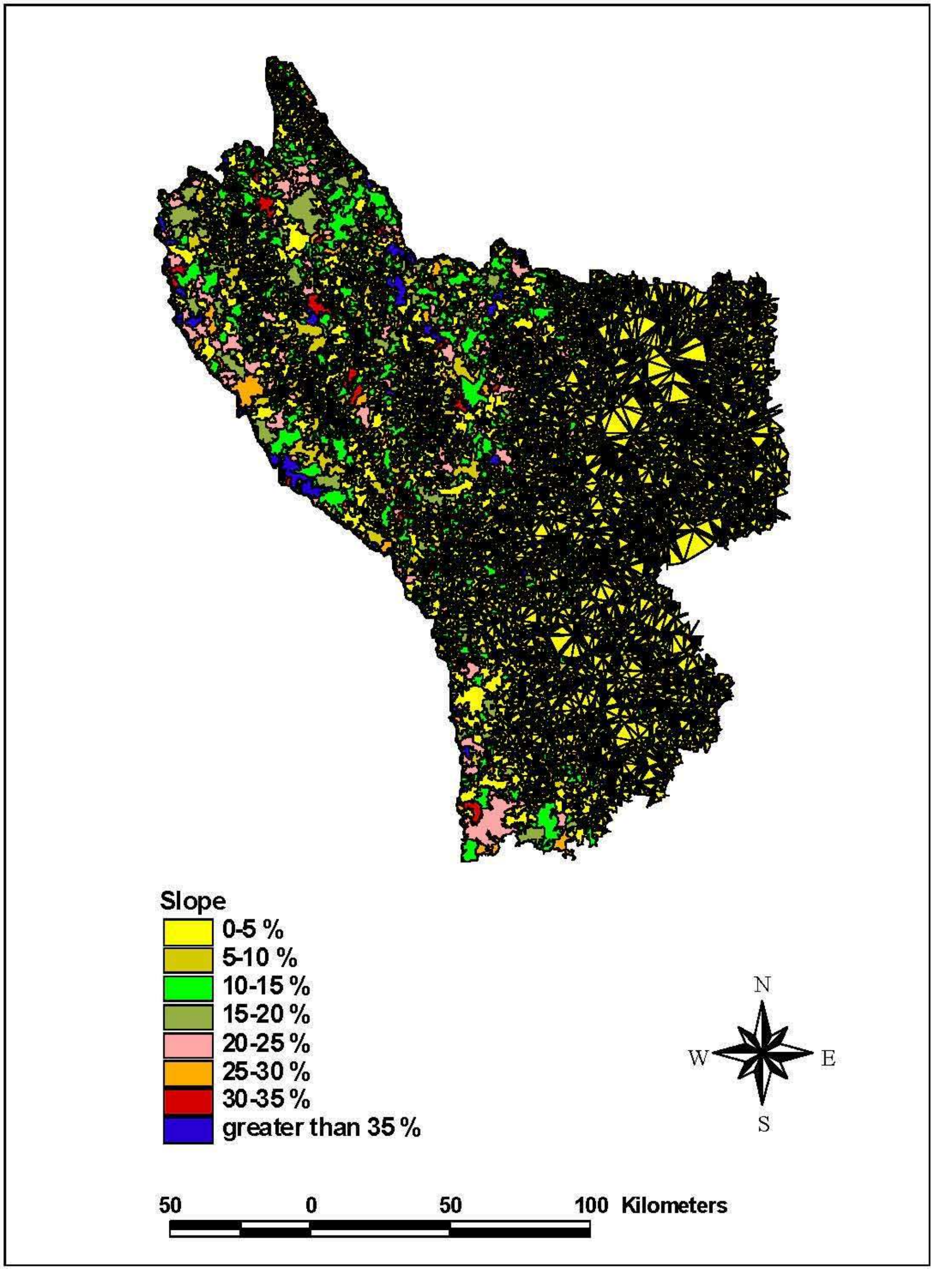


Figure 5 Map of percent slope in the study area

Table 4 Primary land uses in the study area

Major land use	Primary land use
Urban and built-up land (U)	City, town, commercial and services, Villages, Industries, Institutional area, Recreation area.
Agricultural land (A)	Rice, Corn, Sugarcane, Cassava, Pineapple, Cotton, Mung bean, Soybean, Sweet potato, Perennial, Orchards, Coconut, Horticultures, Vegetables, Pasture and farmhouse, Aqua-cultural area.
Forest (F)	Evergreen forest, Deciduous forest, Mixed deciduous forest, Dipterocarp forest, Forest plantation.
Water bodies (W)	Rivers and canals, Lakes, Reservoirs, farm ponds.
Miscellaneous (M)	Rangeland, Wetland, Mines, Sand pits, soil pits, Garbage dumps.

Source: DEQP, 1995.

4. Well depth

There are more than 2,000 wells distributed in the study area; however, only 1,665 wells were used for this study (Table 5). Of these, 820 wells are located in Kanchana Buri, 553 in Ratcha Buri and 292 in Suphan Buri. There is a wide range of well depth, which varies from 5 to 273 meters. However, it is apparent that more than 1,300 wells, or approximately 80%, have depths ranging between 20 to 100 meters. Only 13% of the wells have depths greater than 100 meters, and another 7% have depths less than 20 meters (Table 6). The distribution of all wells is shown in Figure 7. Wells are very densely located in the lowland of the study area when compared to the highland. This is because areas in the lowland are mainly occupied by agricultural land along with residential area. On the other hand, the highland is sparsely populated and mostly covered by forest.

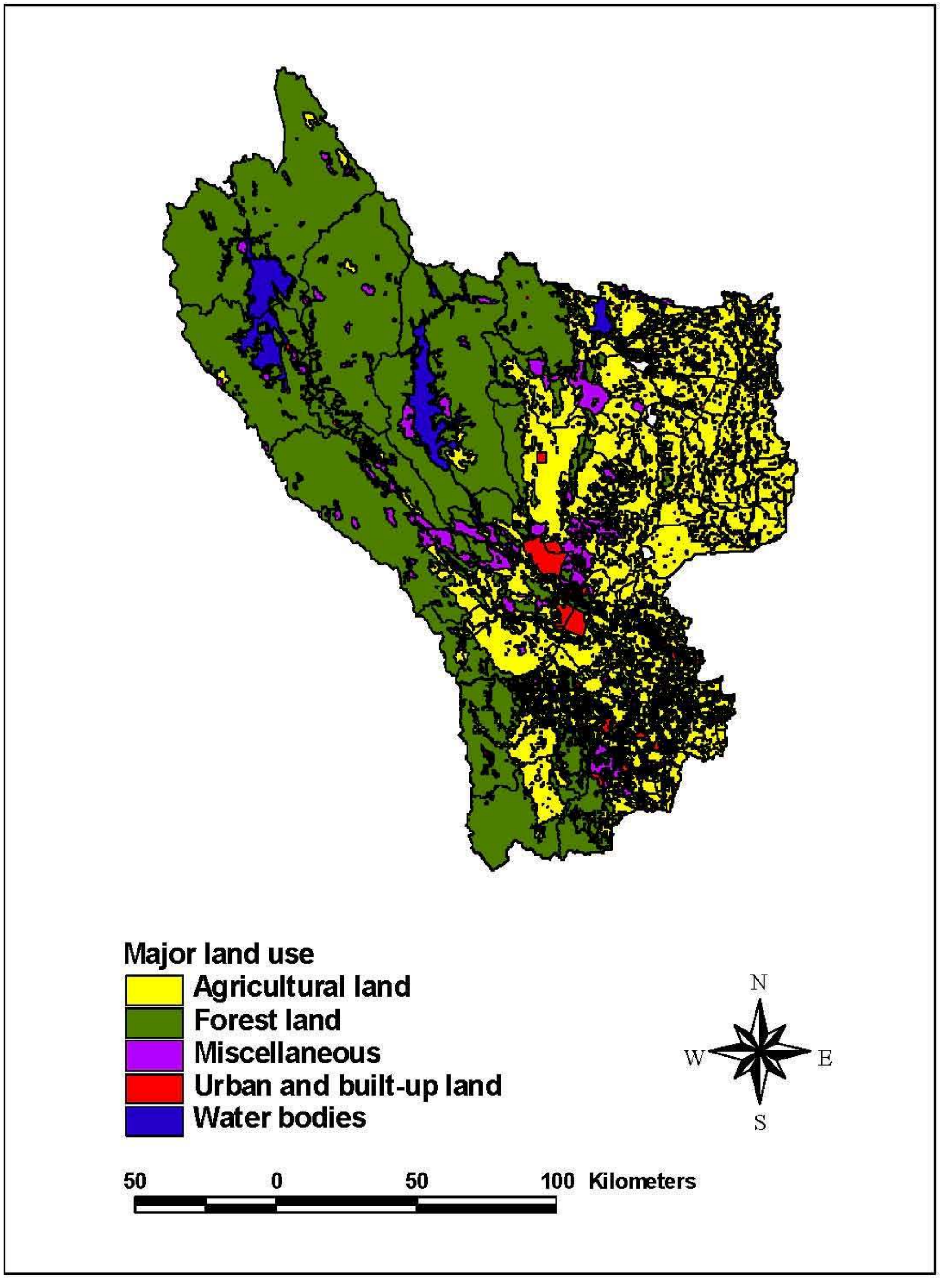


Figure 6 Map of major land use in the study area

Table 6 Depth of wells in the study area

Well depth	Numbers of wells	Percent
0- 20.0 meters	118	7.08
20.1- 50.0 meters	1,024	61.50
50.1-100.0 meters	310	18.62
100.1-150.0 meters	142	8.52
150.1-200.0 meters	61	3.66
200.1-250.0 meters	7	0.42
>250.0 meters	3	0.20
Total	1,665	100.00

Source: DMR, 1996a and 1996b.

5. Rainfall

As shown in Figure 8, there are 50 weather stations located in the entire study area. Of these, 26 stations are in Kanchana Buri and each of 12 stations are in Ratcha Buri and Suphan Buri provinces (Table 7). Rainfall data from these stations include the amount and average of monthly rainfall during 1990-1999. From this data, the average annual rainfall could be obtained by summing up the average rainfall of each month in that period (Table 8). Table 9 lists the average annual rainfall of each station, which ranges between 569.6 and 2,539.5 millimeters. The minimum value of 569.6 millimeters occurred at a station just southeast of the study area, whereas the maximum value of 2,539.5 millimeters occurred in the northern part of the study area.

Also, monthly variance of rainfall at each station is illustrated in Table 9. This variance was calculated by using monthly rainfall data in each station during the same period (see an example in Table 10). It was found that monthly variance of rainfall varied widely, from 3,432 to 59,710 for the entire study area. The lowest and highest monthly variances occurred at the southeast and northern edge of the study area, respectively. This reflects more variable rainfall in the mountainous terrain to the north.

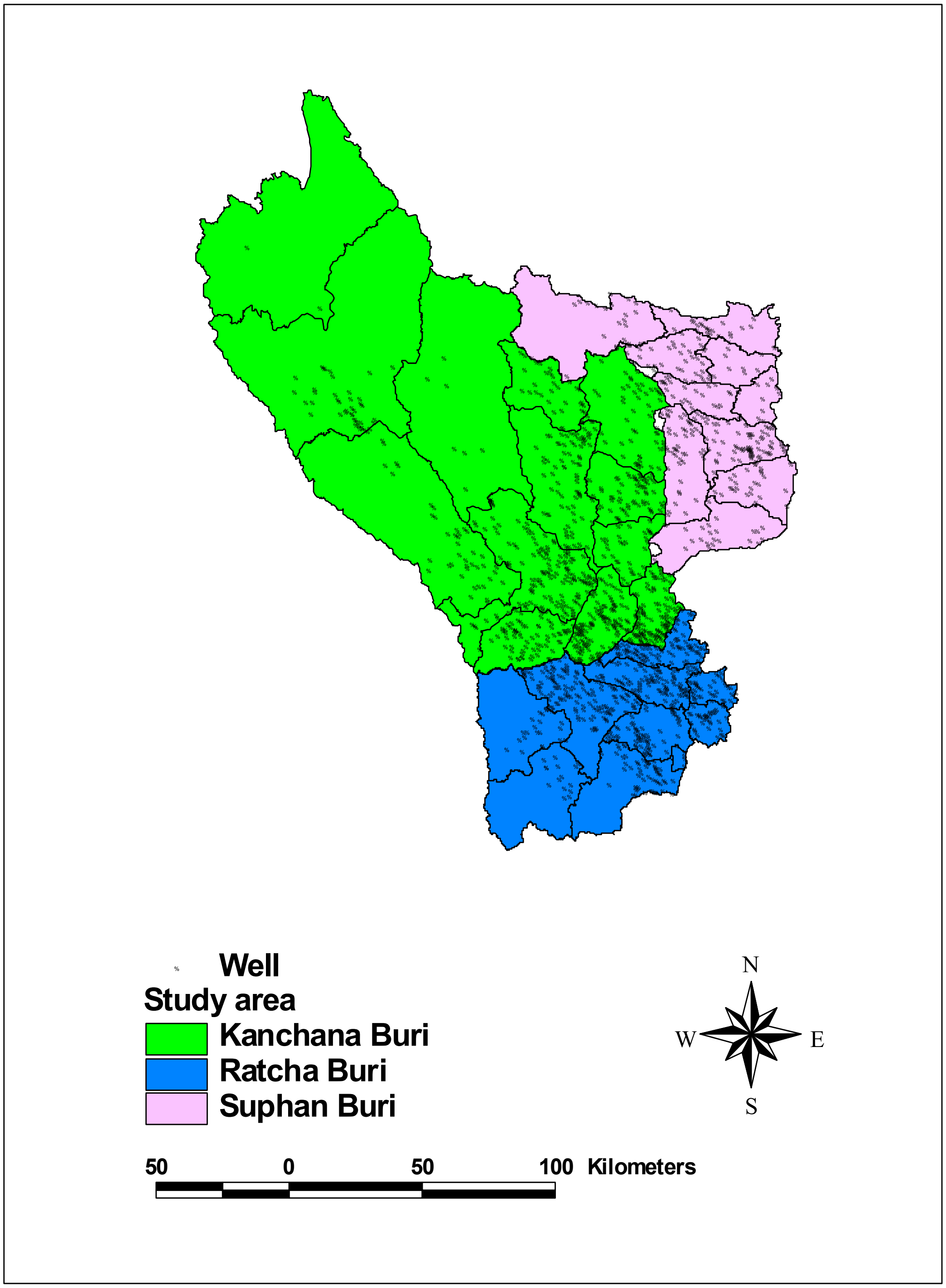


Figure 7 Map showing locations of wells in the study area

Table 9 Rainfall data from fifty weather stations in the study area

No.	Station name	AAR[1/]	MVR[2/]
1	Sai Yok	1,206.2	12,571
2	Sangkhla Buri	2,539.5	59,710
3	Tha Muang	930.2	11,053
4	Tha Maka	988.2	9,418
5	Si Sawat	866.8	6,856
6	Lao Khwan	798.4	10,412
7	Bo Phloi	1,252.6	24,421
8	Phanom Thuan	866.6	8,230
9	Ban Rai School	1,874.4	31,511
10	Wat Hin Dat School	1,515.1	19,410
11	Ban Lin Thin School	1,562.8	22,545
12	Wiset Kun Schol	1,581.0	24,147
13	Ban Wia Khadi School	2,380.1	54,288
14	Wachiralongkhon Dam	978.3	8,366
15	T. Nong Pru, A. Bo Phloi	978.1	9,182
16	Hin Lup Plantation	1,245.4	20,258
17	Erawan National Park	970.2	7,245
18	Sai Yok National Park	1,635.1	24,761
19	Soldier Animal Breeding	1,037.6	9,472
20	Ban Khao Lek	1,262.1	14,679
21	Ban Phu Toei Kaeng Lawa	1,484.4	14,854
22	Huay Malai	2,271.0	51,292
23	Ban Na Suan	1,049.0	8,784
24	K.A. Dan Makam Tia	1,227.1	14,238
25	Kanchana Buri	1,042.9	10,121
26	Thong Pha Phum	1,804.8	25,964
27	Ratcha Buri	1,057.1	9,519
28	Photharam	901.0	7,520
29	Damnoen Saduak	1,111.6	12,760
30	Pak Tho	1,070.6	9,504
31	Ban Pong	715.8	6,158
32	Chom Bung	733.6	5,523
33	Wat Phleng	729.6	7,348
34	Suan Phung	1,223.2	13,288
35	Bang Phae	1,075.2	11,224
36	Tham Chom Pon Royal Garden	875.6	6,895
37	Maenam Pachi Wildlife Conservation Center	1,276.6	11,555
38	Ratchaburi Rice Research Station	1,231.9	11,347
39	Song Phi Nong	999.7	10,264
40	Doembang Nangbuat	1,063.2	23,753
41	U thong	881.0	8,133
42	Sam Chuk	995.2	8,768
43	Si Prachan	569.6	3,432
44	Don chedi	968.6	9,573
45	Dan Chang	1,075.1	11,094
46	K.A. Nong Ya Sai	917.6	7,946
47	Suphanburi Rice Research Station	974.0	8,973
48	Kraseo Self-Help Settlement	1,356.4	15,679
49	Suphan Buri	1,011.3	9,233
50	U thong Agromet	956.9	9,387

Source: MD, 2000a

Note: [1/] Average Annual Rainfall (AAR) [2/] Monthly Variance of Rainfall (MVR)

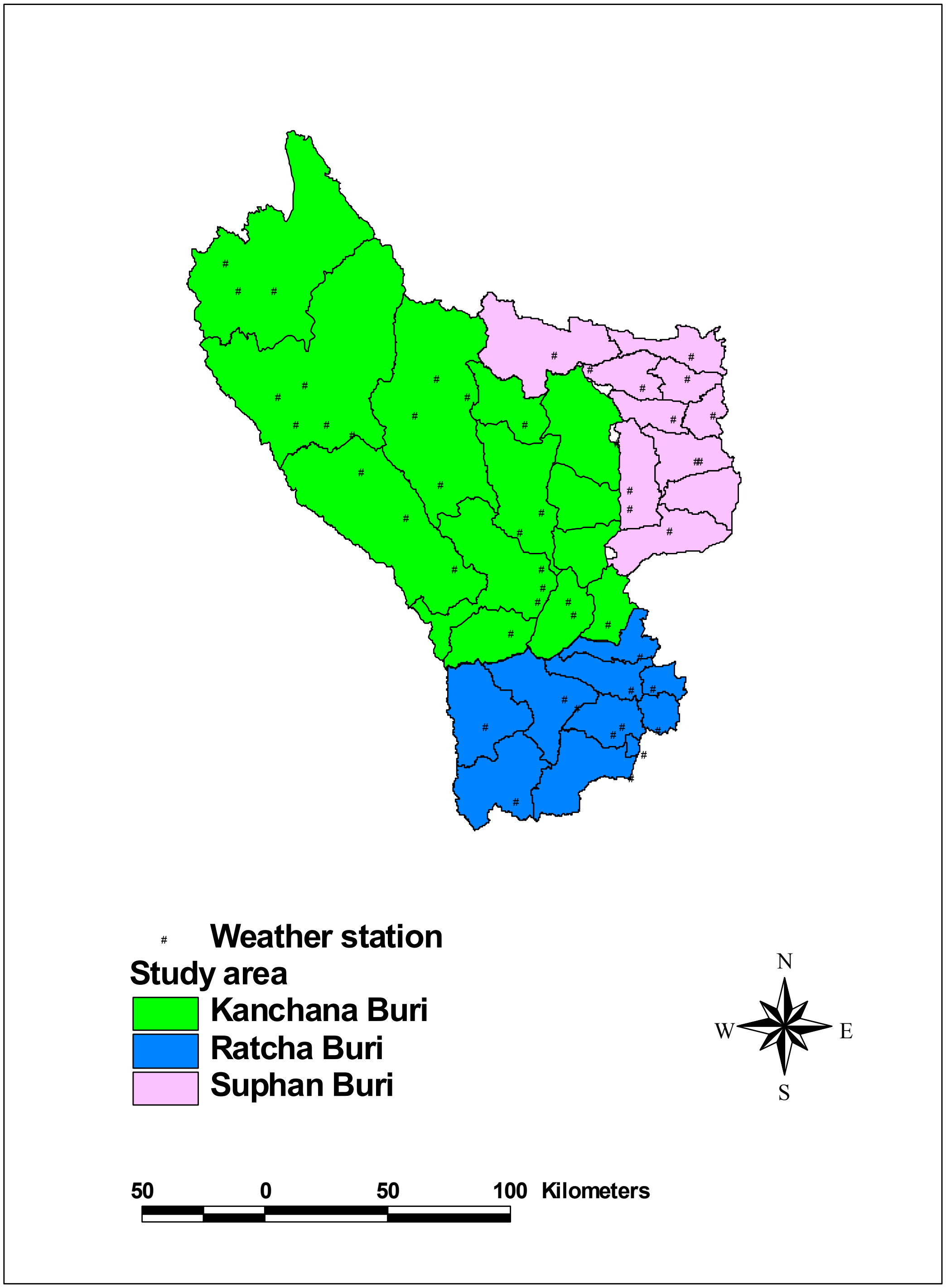


Figure 8 Map showing locations of weather stations in the study area

6. Pesticide residues in groundwater

In recent years pesticide concentrations were detected in groundwater of the study area. According to the Pollution Control Department (1995), 90 samples of groundwater were analyzed for insecticides and herbicides. These were samples collected from domestic wells located mostly at the east and southeast parts of the study area (Figure 9 and Table 11). Water samples from each well were analyzed for the following chemicals: 2,4-D, atrazine, carbofuran, dicofol, dieldrin & aldrin, endosulfan, endrin, heptachlor & heptachlor epoxide, total BHC, and total DDT (Table 12).

Maximum concentrations of pesticides in groundwater varied from 0.111 ppb for endrin to 9.681 ppb for total DDT (Table 13). Total DDT had the greatest concentration level among all chemicals, which exceeds the national groundwater quality standard of 2.0 ppb. Dieldrin & aldrin, and heptachlor & heptachlor epoxide had maximum concentrations of 3.440 and 1.369 ppb. The concentrations of these two pesticides also exceed the Thailand's groundwater quality standard of 0.03 ppb for dieldrin and 0.40 ppb for heptachlor.

It is important to note that some of the chemicals found in groundwater samples have been banned for two decades. These consist of total BHC, endrin, total DDT, dieldrin & aldrin, and heptachlor & heptachlor epoxide (Table 14). The reason behind banning these pesticides is mainly due to their long persistence in the environment such as soil and water. The remaining pesticides (i.e., 2,4-D, atrazine, carbofuran, dicofol, and endosulfan) are still used for agricultural purposes in Thailand. The amount of 2,4-D and atrazine imported to the country each year is apparently higher than those of carbofuran, dicofol, and endosulfan.

Table 13 Concentrations of pesticides found in groundwater of the study area

Pesticide name	Maximum concentration (ppb)[1/]	Average concentration (ppb)[1/]	Thai standard (ppb)[2/]	USEPA standard (ppb)[3/]
2,4-D	0.210	0.011	30.00	70.00
atrazine	1.890	0.110	3.00	3.00
carbofuran	0.620	0.064	-	40.00
dicofol	0.270	0.022	-	-
dieldrin & aldrin*	3.440	0.053	0.03	-
endosulfan	0.298	0.026	-	-
endrin*	0.111	0.002	-	2.00
heptachlor &	1.369	0.122	0.40	0.40
heptachlor epoxide*			0.20	0.20
total BHC*	0.575	0.075	-	-
total DDT*	9.681	0.185	2.00	-

Sources: [1/] PCD, 1995.
[2/] PCD, 2000.
[3/] USEPA, 1994.
Note: * Banned pesticides

Table 14 List of banned pesticides and their effective dates

No.	Pesticide name	Effective date
1	BHC	6 March 1980
2	endrin	23 July 1981
3	DDT	4 March 1983
4	dieldrin	16 May 1988
5	aldrin	23 September 1988
6	heptachlor & heptachlor epoxide	23 September 1988

Source: PCD, 1994.

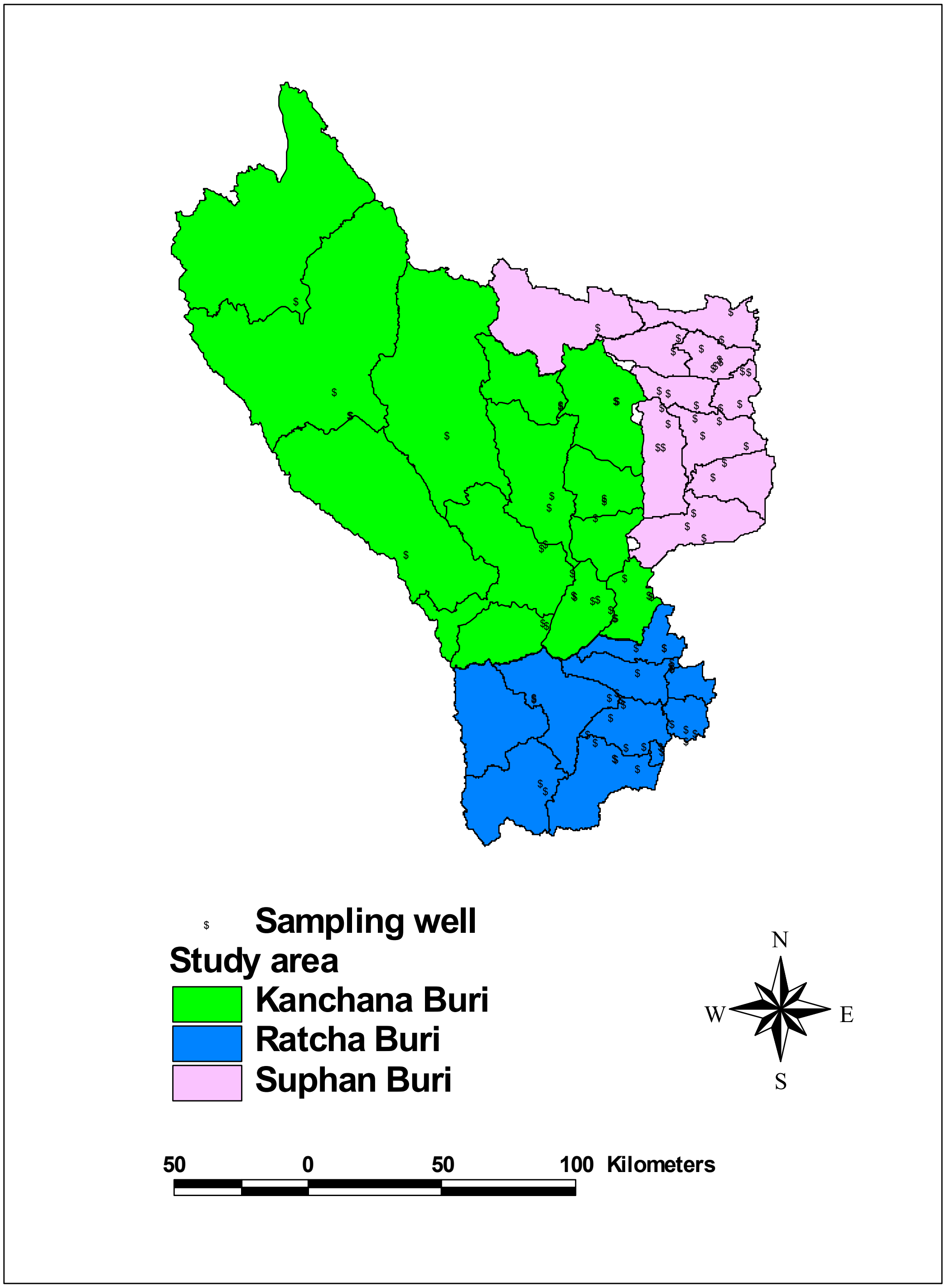


Figure 9 Map showing locations of sampling wells

CHAPTER 5

METHODOLOGY

Application of GIS Methods

The purpose of this study is to use geographic information systems (GIS) technology for assessing groundwater pollution potential by pesticides in central Thailand. This technology can help produce maps of the study area showing relative vulnerability of groundwater to pesticide pollution. The application of GIS methods for this study is described below:

1. Identification of data layers

As mentioned in the previous chapter, this study focused on five variables affecting migration of pesticides to groundwater. Therefore, all of these variables including (1) soil texture, (2) percent slope, (3) primary land use, (4) well depth, and (5) rainfall were used for the GIS approach. In the case of rainfall, however, either average annual rainfall or monthly variance of rainfall, or both of them, could be involved. It was also noted earlier that the first three variables are GIS data in vector format, whereas the last two variables are not. Thus, both well depth and rainfall need to be converted into GIS format as well. In addition, each of soil texture and primary land use, which was originally derived as individual data for Kanchana Buri, Ratcha Buri, and Suphan Buri provinces, need to be combined into one area. Following are the GIS methods used for these purposes.

1.1 Add event theme

Conversion of well depth and rainfall data into GIS format can be accomplished by the method called "Add event theme". This method is used to add a new theme to a view of any GIS project using an event table. An event table contains geographic locations such as an address, latitude and longitude coordinates, or a route location (Hohl and Mayo, 1997). In this research, however, the geographic locations of wells and weather stations that provide well depth data and rainfall data are both in the Universal Transverse Mercator (UTM) coordinate system. The event table of wells is shown in Table 5 and the event table of weather stations is shown in Table 7.

As a result of "Add event theme", well depth was converted into GIS data in the form of a point feature theme. This theme contained 1,665 points representing depths of all wells used for this study (see Figure 7). In the same manner, rainfall was also converted into two different point feature themes. Each theme contained 50 points representing average annual rainfall (AAR) and monthly variance of rainfall (MVR) of all weather stations in the study area (see Figure 8). Conversion of both well depth and rainfall data into vector format was performed by ArcView version 3.2.

1.2 Merging features

The GIS method used to combine soil texture and primary land use data of each individual province into one area is called "Merging features". By this method, a new theme is created from two or more adjacent themes that contain the same geometric type. Soil themes of Kanchana Buri, Ratcha Buri, and Suphan Buri provinces that have soil texture as a common geometric type were merged together. As a result, a new soil theme of the entire study area was created (see Figure 4). It was a polygon feature theme containing soil texture as one field in its attribute table. Also, a new land use theme of the study area was created by the same method from three themes covering the three provinces separately (see Figure 6). It was another polygon feature theme that has primary land use as one field in its attribute table. Merging soil texture and primary land use data into single layers was done using the GeoProcessing wizard in ArcView vesion 3.2.

The data collection and preprocessing step resulted in five data layers or themes to be used in this study. All of these GIS layers are in vector format. Table 15 illustrates that soil, slope, land use and land cover data layers are polygon feature themes while well and rainfall data layers are in the form of point feature theme. The variable in each data layer played a key role for evaluating groundwater susceptibility to contamination by pesticides for the following reasons:

- Soil texture is capable of affecting transportation of pesticides to groundwater. The coarser textured the soil, the greater the chance of pesticides reaching groundwater. For example, sand is loose and permeable; therefore, it is easy for pesticides to pass through and reach groundwater. On the other hand, clay particles are very small, sticky when wet and form compact lumps when dry. Clay deposits have low permeability and high surface area for adsorption. These properties help protect pesticides against contamination in groundwater.

- Percent slope contributes to the likelihood that pesticides will run off or remain on the land surface long enough to infiltrate to groundwater. The lesser the percent slope, the greater the chance of infiltration and the greater the amount of pesticides contaminating groundwater.

- Primary land use relates directly to the amount of pesticides available in an area. It can be concluded that groundwater beneath agricultural land with heavy use of pesticides has a greater opportunity to be polluted by the chemicals than that of other land uses.

- Well depth indicates the depth to aquifer, which relates to the risk of pollution potential by pesticides. The shallower the depth of a well, the higher the susceptibility of groundwater contamination by pesticides.

- Amount of rainfall affects the movement of pesticides into groundwater. In general, the higher the average annual rainfall, the greater the amount of pesticides reaching groundwater. Rainfall distributed evenly over a year would facilitate percolation and groundwater recharge. Evenly distributed rainfall would be reflected by a low monthly variance. The lower the monthly variance of rainfall, the greater the opportunity of pesticides percolating toward groundwater. In contrast, sporadic rainfall would lead to runoff.

<u>Table 15</u> List of data layers involved in this study

Data layer	Feature	Variable
1. Soil	Polygon	Soil texture
2. Slope	Polygon	Percent slope
3. Land use and land cover	Polygon	Primary land use
4. Well	Point	Well depth
5. Rainfall	Point	Average annual rainfall (AAR)
		and/or
	Point	Monthly variance rainfall (MVR)

2. Manipulation of data layers

All data layers or themes used to evaluate groundwater susceptibility to contamination by pesticides need to be manipulated by the following methods. First, it is necessary to convert polygon feature themes from vector to raster data. The reason behind this conversion is that many functions, especially those involving surfaces and overlay operations, are simpler to perform with raster than vector data structure. Moreover, raster data structures are relatively easy to conceptualize as a method of representing space (DeMers, 2000). Second, point feature themes need to be interpolated into continuous grid cells, which means that they are converted from vector to raster data as well. Third, each data layer needs to be reclassified into a certain group. This is to produce a consistent scheme among all layers or themes and to limit the number of classes to the level of detail in individual data layer.

2.1 Converting polygon feature themes

The process of converting a polygon feature theme from vector to raster data structure is so called “Vector conversion” or “Rasterization” (Bernhardsen, 1999). Polygons are converted to cells, and each cell falling within a polygon is assigned a value equal to the polygon attribute value. The cells are usually in rectangular or, more often, square shape called “grid cells”. All grid cells are the same size, and each occupies the same amount of geographic space as any other. Common cell size varies from 10 x 10 m, 100 x 100 m, 1 x 1 km, and 10 x 10 km (Bernhardsen, 1999). The smaller the cell size and the greater the numbers of cells that represent an area, the more accurate the representation of that area. In this study, each cell had a square size of 100 x 100 m or 1 hectare. The size was chosen on the basis of spatial resolution of available data and computational considerations. Vector conversion of soil, slope, and land use/land cover themes were performed using ArcView spatial analyst.

2.2 Interpolating point feature themes

This process, called "Interpolation", is a function used to generate a continuous surface from sampled point values. Interpolation predicts values for cells in a raster from a limited number of sample data points. It can be used to predict unknown values of any geographic point data such as elevation, rainfall, chemical concentrations, noise levels, and so on. The assumption that makes interpolation a useful technique is that spatially distributed objects are spatially correlated; in other words, things that are close together tend to have similar characteristics. By this assumption, the values of points close to sampled points are more likely to be similar than those that are further apart (McCoy and Johnston, 2001).

There are three common methods of point interpolation, namely (1) Inverse Distance Weighted (IDW), (2) Spline, and (3) Kriging. No matter which method is selected, the more sample points and the greater their areal coverage, the more reliable the results (McCoy and Johnston, 2001). However, it is important to say that having more sample points does not always improve the accuracy or quality of the output. Indeed, it quite often increases the computation time and the data volume. In some cases, too much data tends to produce unusual results because clusters of points in areas where the data are easy to collect are likely to yield a surface representation that is unevenly generalized and therefore unevenly accurate (DeMers, 2000). Following are descriptions of each interpolation method:

- Inverse Distance Weighted (IDW) interpolation estimates the value for each grid cell in an output grid theme by averaging a set of sample points in a point feature theme. An average value is calculated based upon sample point values and their distance from the grid cell. Therefore, sample point values closer to the cell have a greater influence on the cell's estimated value than those that are farther away. The IDW interpolation method provides two options to select the sample points, a fixed number of nearest points to the grid cell and a fixed radius around a grid cell. With the first option, a number of nearest sample points to be used for estimating each grid cell will be specified. In contrast, the second option assigns a radius to define which sample points are used. It means that all samples falling within this radius will be used to calculate the average for the cell. Generally, the IDW method is particularly well suited to deal with abruptly changing data because it can incorporate barriers into its estimation process (ESRI, 2001).

- Spline interpolation estimates the value of geographic features in an area by using a set of sample points. This method divides the theme into regions, and uses the sample points found in each region to predict individual cell values for that region. Basically, the number of regions in a theme is based upon the number of points selected for estimating the cell values. If the number of points selected decreases, the number of regions will increase. As a result, the area of each region is smaller and the estimated cell values are closer to local sample point values (ESRI, 2001). There are two options in this method, which are Regularized and Tension interpolation. The Regularized option creates a smooth, gradually changing surface with values that may lie outside the sample data range. On the other hand, the Tension creates a less smooth surface with values more closely constrained by the sample data range (McCoy and Johnston, 2001). It is noted that Spline interpolation is better for showing a gradually changing surface while the IDW method is better for showing extremes in the data. Spline interpolation would also be the better choice for irregularly spaced data; in other words, it will create the better result when dealing with unevenness in the distribution of sample points (ESRI, 2001). This method is best for gently varying surfaces such as elevation, water table heights, or pollution concentrations (McCoy and Johnston, 2001).

- Kriging interpolation is a statistical method that quantifies the correlation of the measured points through variography or spatial modeling. When making a prediction for an unknown location, Kriging weights the nearby measured points by their configuration around the prediction location and uses the fitted model from variography to determine a value. The fitted model, called "Semivariogram model", consists of different types including Circular, Spherical, Exponential, Gaussian, and Linear. The choice of which model to use is based on the statistical relationship among the measured points. However, the spherical model seems to be one of the most commonly used models. There are two options in Kriging interpolation. The first option is Ordinary Kriging, which is the most general and widely used of Kriging methods. Universal Kriging is the second option, which should only be used when there is a trend in the data, using scientific judgment to describe it. In addition to the option, it is also important to specify what type of search neighborhood, fixed or variable search radius, to be used in Kriging interpolation. A fixed search radius requires a certain distance so that all the measured points falling within that distance will be used in the calculation of each interpolated cell. With a variable search radius, the number of measured points used in calculating the value of each interpolated cell is specified. This makes the radius distance vary for each interpolated cell, depending on the density of the measured points near the interpolated cell (McCoy and Johnston, 2001).

IDW and Spline interpolation methods are available in ArcView spatial analyst, whereas Kriging can be performed using ArcGIS spatial analyst. In this study, all three of these methods were applied for interpolating well and rainfall feature themes. The purpose is to compare predicted values of cells derived from each interpolation method with actual values of well depth and rainfall. The method that yields the most accurate result would be finally used for point interpolation in this study.

2.3 Reclassifying data layers

Reclassifying simply means replacing input cell values with new output cell values. There are many reasons why data need to be reclassified; for example, it is needed to replace values based on new information, to group certain values together, and to reclassify values to a common scale (McCoy and Johnston, 2001). In this study, each data layer needs to be reclassified to a common scale showing its potential to cause contamination of groundwater by pesticides. This scale consists of five classes for each data layer with a value from 5 to 1, meaning high to low pollution potential. The reclassifications of all data layers were conducted by using ArcView spatial analyst 2.0 (ModelBuilder).

- The soil data layer was reclassified by its texture, which is the most permanent of all soil characteristics. According to Olson (1981), soil texture can be categorized into five groups, including coarse textured (sand, loamy sand), moderately coarse textured (sandy loam), medium textured (very fine sandy loam, loam, silt loam, silt), moderately fine textured (clay loam, sandy clay loam, silty clay loam), and fine textured (sandy clay, silty clay, clay). The soil data layer was reclassified in accordance with the categories mentioned above. Table 16 shows the reclassification of soil texture into five classes. Because of this, each cell in this layer was assigned a value varying from 5 (coarse textured) to 1 (fine textured).

Table 16 Reclassification of the soil data layer

Soil texture	Value	Reclassification
Stony Gravelly Sand (coarse, medium, fine, very fine) Loamy sand (coarse, medium, very fine)	5	Coarse textured
Sandy loam (coarse, medium, fine)	4	Moderately coarse textured
Very fine sandy loam Loam Silt loam Silt	3	Medium textured
Clay loam Sandy clay loam Silty clay loam	2	Moderately fine textured
Gravelly clay Sandy clay Silty clay Clay	1	Fine textured

As described in the previous chapter, however, soil textures in the study area are either the texture of topsoil alone or a combination between the texture of topsoil and subsoil. In the latter case, the textures of both topsoil and subsoil should be taken into account for identifying a new value of that combination. Table 17 illustrates how a value of each combination between the texture of topsoil and subsoil are identified.

- The slope data layer was reclassified by percent slope of land surface. Reclassification of slope consisted of the following classes: very flat slope, flat slope, medium slope, steep slope, and very steep slope. Table 18 shows the range of percent slope in each class and its value. It is noted that each cell in this layer had a value varying from 5 (very flat slope) to 1 (very steep slope).

- The land use and land cover data layer was reclassified by primary land use, which relates directly to the amount of pesticides available in an area. This means that pesticide application is different from one type of primary land use to another. Primary land use such as rice or corn has a heavy use of pesticides when compared to the use in cities, towns, or villages. Besides, there is no evidence of pesticide usage in some primary land uses such as natural forest, rangeland, and water bodies. Reclassifying land use and land cover data layer was based on the degree of pesticide usage in each type of primary land use. The higher the degree of pesticide used, the greater the value was assigned. Because of this, the value of 5 was assigned for primary land uses with very high usage of pesticides, whereas the value of 1 was assigned for those with very low usage. And primary land uses without pesticide application were assigned the value of zero (0).

Table 17 Identifying values for the textures of topsoil/subsoil in the soil data layer

Soil texture (Top soil/subsoil)	Identification method	Value
Clay/clay	(0.6)(1) + (0.4)(1) = 1.0	1
Clay/clay loam	(0.6)(1) + (0.4)(2) = 1.4	1
Clay/gravelly	(0.6)(1) + (0.4)(5) = 2.6	3
Clay/gravelly clay	(0.6)(1) + (0.4)(1) = 1.0	1
Clay/sand	(0.6)(1) + (0.4)(5) = 2.6	3
Clay/sandy clay loam	(0.6)(1) + (0.4)(2) = 1.4	1
Clay/sandy loam	(0.6)(1) + (0.4)(4) = 2.2	2
Clay/silt loam	(0.6)(1) + (0.4)(3) = 1.8	2
Clay/very fine sandy loam	(0.6)(1) + (0.4)(3) = 1.8	2
Clay loam/clay	(0.6)(2) + (0.4)(1) = 1.6	2
Clay loam/clay loam	(0.6)(2) + (0.4)(2) = 2.0	2
Clay loam/gravelly	(0.6)(2) + (0.4)(5) = 3.2	3
Clay loam/gravelly clay	(0.6)(2) + (0.4)(1) = 1.6	2
Clay loam/sandy loam	(0.6)(2) + (0.4)(4) = 2.8	3
Gravelly/gravelly	(0.6)(5) + (0.4)(5) = 5.0	5
Gravelly/sandy loam	(0.6)(5) + (0.4)(4) = 4.6	5
Gravelly clay/gravelly	(0.6)(1) + (0.4)(5) = 2.6	3
Gravelly clay/gravelly clay	(0.6)(1) + (0.4)(1) = 1.0	1
Gravelly clay/clay	(0.6)(1) + (0.4)(1) = 1.0	1
Gravelly clay/clay loam	(0.6)(1) + (0.4)(2) = 1.4	1
Gravelly clay/sandy loam	(0.6)(1) + (0.4)(4) = 2.2	2
Loam/silt loam	(0.6)(3) + (0.4)(3) = 3.0	3
Sand/gravelly	(0.6)(5) + (0.4)(5) = 5.0	5
Sand/sand	(0.6)(5) + (0.4)(5) = 5.0	5
Sand/sandy loam	(0.6)(5) + (0.4)(4) = 4.6	5
Sandy clay loam/clay	(0.6)(2) + (0.4)(1) = 1.6	2
Sandy clay loam/clay loam	(0.6)(2) + (0.4)(2) = 2.0	2
Sandy clay loam/gravelly	(0.6)(2) + (0.4)(5) = 3.2	3
Sandy clay loam/sand	(0.6)(2) + (0.4)(5) = 3.2	3
Sandy clay loam/sandy clay loam	(0.6)(2) + (0.4)(2) = 2.0	2
Sandy clay loam/sandy loam	(0.6)(2) + (0.4)(4) = 2.8	3
Sandy clay loam/very fine sandy loam	(0.6)(2) + (0.4)(3) = 2.4	2
Sandy loam/gravelly	(0.6)(4) + (0.4)(5) = 4.4	4
Sandy loam/clay	(0.6)(4) + (0.4)(1) = 2.8	3
Sandy loam/clay loam	(0.6)(4) + (0.4)(2) = 3.2	3
Sandy loam/sand	(0.6)(4) + (0.4)(5) = 4.4	4
Sandy loam/sandy clay loam	(0.6)(4) + (0.4)(2) = 3.2	3
Sandy loam/sandy loam	(0.6)(4) + (0.4)(4) = 4.0	4
Silt loam/clay	(0.6)(3) + (0.4)(1) = 2.2	2
Silt loam/clay loam	(0.6)(3) + (0.4)(2) = 2.6	3
Silt loam/gravelly clay	(0.6)(3) + (0.4)(1) = 2.2	2
Silt loam/sandy clay loam	(0.6)(3) + (0.4)(2) = 2.6	3
Silt loam/sandy loam	(0.6)(3) + (0.4)(4) = 3.4	3
Silt loam/silt loam	(0.6)(3) + (0.4)(3) = 3.0	3
Silt loam/very fine sandy loam	(0.6)(3) + (0.4)(3) = 3.0	3
Stony/stony	(0.6)(5) + (0.4)(5) = 5.0	5

Table 18 Reclassification of the slope data layer

Percent slope	Value	Reclassification
0- 5 %	5	Very flat slope
6-10 %	4	Flat slope
11-15 %	3	Medium slope
16-20 %	2	Steep slope
> 20 %	1	Very steep slope

It is also important to note that land use and land cover data layer was reclassified separately for each type of pesticides involved in this study. This is because the use patterns of pesticides are relatively different in any kind of crop. For example, atrazine is usually applied at a very high degree in corn, but dicofol is not. Another example is the difference between using 2,4-D and endosulfan in cassava. In this case, the use of 2,4-D is considerably high in comparison to endosulfan. By this reason, six reclassification schemes as shown in Table 19 were established for the following pesticides: 2,4-D, atrazine, carbofuran, dicofol, endosulfan, and a group of banned chemicals (i.e., dieldrin & aldrin, endrin, heptachlor & heptachlor epoxide, total BHC, and total DDT).

- The well data layer was reclassified by depth of well, which was used instead of depth to water table. Depth to water or depth to aquifer could have been used here, but depth to water would be largely irrelevant for confined aquifers, and depth to aquifer data were too coarse and lacked spatial resolution. This layer was reclassified into five classes including very shallow well, shallow well, medium well, deep well, and very deep well. Table 21 shows the range of well depth in each class and its value indicating the potential to cause contamination of groundwater by pesticides. Each cell in this data layer was assigned a value varying from 5 (very shallow well) to 1 (very deep well).

Table 19 Reclassification of the land use/land cover data layer

Chemical	Primary land use	Value	Reclassification*
2,4-D	Rice, Corn, Cassava	5	Very high usage
	Cotton, Soybean, Mung bean, Peanut, Pineapple, Sugarcane, Sweet potato	4	High usage
	Vegetables, Horticultures [1/], Coconut, Orchards [2/]	3	Medium usage
	Perennial [3/], Pasture and farmhouse, Forest plantation	2	Low usage
	City & town, Commercial and Services, Villages, Industries, Institutional area, Recreation area	1	Very low usage
atrazine	Cotton, Corn, Cassava	5	Very high usage
	Rice, Soybean, Mung bean, Peanut, Pineapple, Sugarcane, Sweet potato	4	High usage
	Vegetables, Horticultures [1/], Coconut, Orchards [2/]	3	Medium usage
	Perennial [3/], Pasture and farmhouse, Forest plantation	2	Low usage
	City & town, Commercial and Services, Villages, Industries, Institutional area, Recreation area	1	Very low usage
carbofuran	Rice, Vegetables	5	Very high usage
	Corn, Soybean, Mung bean, Peanut, Horticultures [1/]	4	High usage
	Cotton, Cassava, Sugarcane, Sweet potato, Coconut	3	Medium usage

Table 19 (continued)

Chemical	Primary land use	Value	Reclassification*
	Pineapple, Orchards [2/]	2	Low usage
	Pasture and farmhouse, Forest plantation, Perennial [3/], City & town, Commercial and Services, Villages, Industries, Institutional area, Recreation area	1	Very low usage
dicofol	Vegetables	5	Very high usage
	Rice, Horticultures [1/]	4	High usage
	Cotton, Soybean, Mung bean, Peanut	3	Medium usage
	Corn, Cassava, Sugarcane, Sweet potato, Coconut, Pineapple, Orchards [2/]	2	Low usage
	Pasture and farmhouse, Forest plantation, Perennial [3/], City & town, Commercial and Services, Villages, Industries, Institutional area, Recreation area	1	Very low usage
endosulfan	Rice, Cotton, Vegetables	5	Very high usage
	Corn, Soybean, Mung bean, Peanut, Horticultures [1/]	4	High usage
	Sugarcane, Sweet potato	3	Medium usage
	Cassava, Coconut, Pineapple, Orchards [2/]	2	Low usage
	Pasture and farmhouse, Forest plantation, Perennial [3/], City & town, Commercial and Services, Villages, Industries, Institutional area, Recreation area	1	Very low usage

Table 19 (continued)

Chemical	Primary land use	Value	Reclassification*
Banned Pesticides[4/]	Cotton, Vegetables	5	Very high usage
	Rice, Corn, Soybean, Mung bean, Peanut, Horticultures [1/], Sweet potato	4	High usage
	Sugarcane, Cassava, Coconut, Pineapple, Orchards [2/]	3	Medium usage
	Pasture and farmhouse, Forest plantation	2	Low usage
	Perennial [3/], City & town, Commercial and services, Villages, Industries, Institutional area, Recreation area	1	Very low usage

Note: [1/] Flowers, vineyard, pepper, strawberry, passion fruit, raspberry.

[2/] Orange, mango, tamarind, jack fruit, rose apple, lime, banana, etc.

[3/] Eucalyptus, casuarinas, acacia, bamboo, etc.

[4/] dieldrin & aldrin, endrin, heptachlor & heptachlor epoxide, total BHC, total DDT.

* Reclassification of pesticide usage is reliable on the data shown in Table 20

Table 21 Reclassification of the well data layer

Depth of well	Value	Reclassification
< 10.0 meters	5	Very shallow well
10.1- 20.0 meters	4	Shallow well
20.1- 50.0 meters	3	Medium well
50.1-100.0 meters	2	Deep well
> 100.0 meters	1	Very deep well

- The rainfall data layer was reclassified by average annual rainfall (AAR) and monthly variance of rainfall (MVR). Like the first four data layers, reclassifying both forms of rainfall were performed under a five-class scheme. That is, average annual rainfall was reclassified into very high, high, medium, low, and very low amount with the value varying from 5 to 1 (Table 22). On the other hand, monthly variance of rainfall was reclassified into very low, low, medium, high, and very high variance with the value varying from 5 to 1 (Table 23).

Both average annual rainfall and monthly variance of rainfall were reclassified by the "equal interval" method, which means that the range in each class is the same. As a result, average annual rainfall was grouped into the following classes: less than 508, 508.1-1,016; 1,016.1-1,524; 1,524.1-2,032; and 2,032.1-2,540 millimeters (Table 22). And monthly variance of rainfall was grouped into five classes including less than 11,942; 11,943-23,885; 23,886-35,828; 35,829-47,771; and 47,772-59,710 (Table 23).

Table 22 Reclassification of the rainfall data layer by average annual rainfall

Average annual rainfall (AAR)	Value	Reclassification
2,032.1-2,540.0 mm	5	Very high AAR
1,524.1-2,032.0 mm	4	High AAR
1,016.1-1,524.0 mm	3	Medium AAR
508.1-1,016.0 mm	2	Low AAR
< 508.0 mm	1	Very low AAR

Table 23 Reclassification of the rainfall data layer by monthly variance of rainfall

Monthly variance of rainfall (MVR)	Value	Reclassification
<11,942	5	Very low MVR
11,943-23,885	4	Low MVR
23,886-35,828	3	Medium MVR
35,829-47,771	2	High MVR
47,772-59,710	1	Very high MVR

3. Analysis of data layers

The final step of GIS application in this study is to analyze all data layers through the process called "Overlay". Overlay is a spatial operation in which a thematic layer is superimposed onto another to form a new layer. In fact, this operation can be performed both in vector and raster data; however, raster overlay is often more efficient than vector overlay. This is because attribute values in raster data are not listed in tables as in vector data, but are represented by grid cells in thematic layers. Therefore, arithmetic operations and some other statistical operations can be performed directly during the overlay process. That is, two or more thematic layers may be combined, subtracted, multiplied, etc., to create a new layer with new value for each grid cell (Bernhardsen, 1999).

There are a number of different rules associated with the overlay process. These consist of dominance rule, contributory rule, and interaction rule. Dominance rule determines the result of combination by selecting a single value that dominates all the others. Contributory rule uses each layer's attribute value to create a composite result, often using a mathematical operation like addition. The third rule, interaction rule, goes beyond independent contribution to exploit the interaction between values. The result depends on the specific combination of attribute values for some layers taken together (Chrisman, 1996).

In this study overlay process was performed under the contributory rule, using arithmetic operation as a key function. This kind of overlay is so called "Arithmetic overlay", which means that values assigned to two or more input themes are combined arithmetically (+, -, *, /) to produce an output grid (ESRI, 2000). In the case of addition operation, those values are first multiplied by influence factors and then added together to produce an output grid. This kind of arithmetic overlay is, therefore, named “Additive overlay” (Ormsby and Alvi, 1999). The arithmetic or additive overlay can be conducted by using ArcView spatial analyst 2.0 (ModelBuilder).

During the process of additive overlay, all data layers used in this study were superimposed to yield a composite vulnerability map. In so doing, values assigned to all cells in each layer were multiplied by their weight or influence factor. This is because each data layer differs with respect to its influence on groundwater contamination by pesticides. Then, those values of one layer that place at the same location with values of the others were added together. The result was an output layer with a new value for each cell. The example in Figure 10 illustrates the multiplication of each value, and also the addition of all multiplied values. That is, a multiplied value of 1.0 (5 x 0.2, coarse textured) is added to the following multiplied values of 2.5 (5 x 0.5, very shallow well), 0.5 (5 x 0.1, very flat slope), 0.5 (5 x 0.1, very high usage of pesticides in land use), and 0.5 (5 x 0.1, very high rainfall) to yield a final value of 5.0, which is the highest possible value. This value represents the vulnerability score of a cell showing the degree of groundwater susceptibility to contamination by pesticides in a certain area.

It is important to emphasize that weighting of each data layer depends upon its influence to cause contamination of groundwater by pesticides. The more the influence of a layer, the greater the weight is assigned. The weights of all layers must be summed to 1. It is necessary that weighting scheme should be figured out before conducting arithmetic overlay. As shown in Figure 11, the values of X_1 to X_5 and/or X_6 represent the weight of soil texture, percent slope, primary land use, well depth, average annual rainfall and/or monthly variance rainfall grid, respectively. In this study, a number of weighting schemes were designed for conducting overlay operations. And these operations were performed separately for each of the following pesticides: 2,4-D, atrazine, carbofuran, dicofol, endosulfan, and the group of banned pesticides.

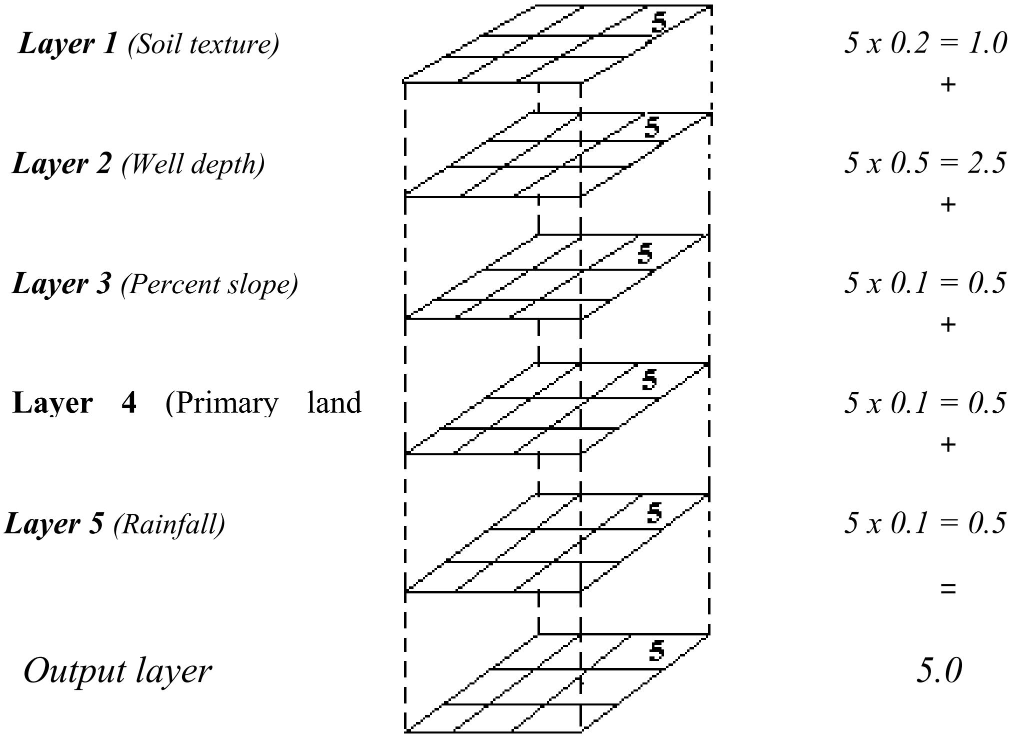


Figure 10 Schematic diagram showing raster overlay process for this study

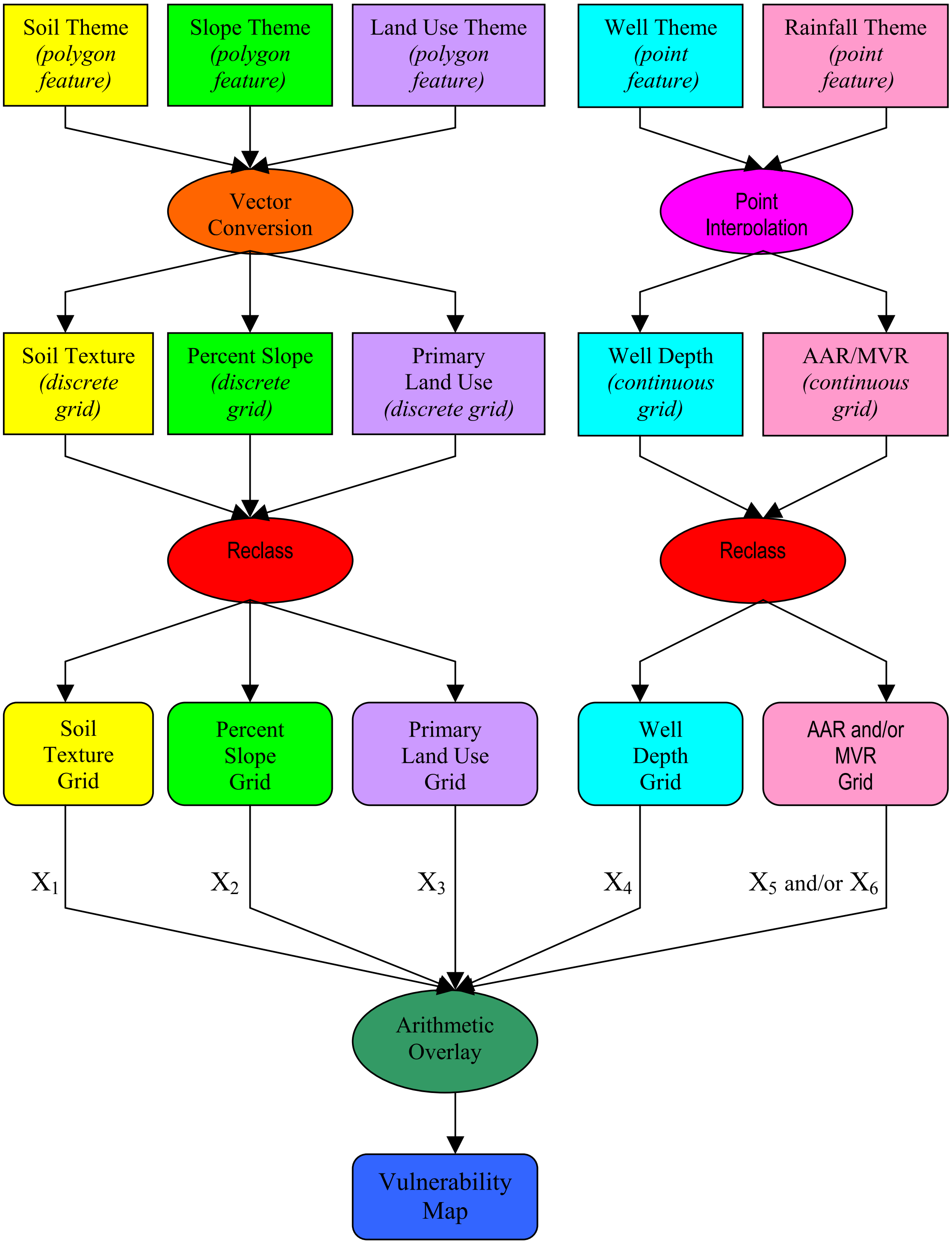


Figure 11 Flow chart of GIS methods used in this study

Application of Statistical Method

Correlation was chosen as the statistical method in this study by two reasons. First, it helped identify weighting schemes for overlay analysis. By means of correlation, the relationship between each data layer and concentrations of pesticides in groundwater could be found. And correlation coefficients, both Pearson product-moment (r) and Spearman rank (r_s), derived from this method were used as the criteria to determine the weight of each data layer. Second, correlation was used to compare the vulnerability scores derived from each map with groundwater quality data derived from actual observations. This is to test the relationship between a produced vulnerability map and the actual data. If correlation coefficient is close to 1, it means that the vulnerability map produced from a GIS is highly significantly correlated to the actual groundwater quality data, and vice versa.

1. Correlation for identifying weighting schemes

As said earlier, weighting schemes for overlay analysis can be identified by means of correlation. That is, it is helpful to figure out the relationship between each data layer (soil texture, percent slope, primary land use, well depth, AAR and MVR) and concentrations of pesticides found in groundwater. The correlation coefficient derived from this method plays a key role in determining the weight of each layer. The higher the value of correlation coefficient, the greater the weight is assigned to a layer. If the correlation coefficient is close to 1, it means that a layer is highly correlated to the concentrations of pesticides found in groundwater. Therefore, that layer should have high influence to cause contamination of groundwater by pesticides. However, if there is no correlation between the data layer and pesticide concentrations, that layer would have less influence on groundwater pollution by pesticides.

Two sets of data were involved in conducting correlation in this step. These consisted of (1) concentrations of each pesticide found in groundwater from 90 wells in the study area, and (2) values or classes assigned to the cells of each data layer placed at the same location with those wells. From these data, a number of correlations were conducted in which each of them identified the relationship between concentrations of each pesticide and each data layer. The results, in terms of Pearson product-moment and Spearman rank correlation coefficients, were finally taken into consideration so that a number of options for weighting schemes could be established.

2. Correlation for comparing vulnerability scores with actual data

Correlation also compared vulnerability scores with groundwater quality data derived from actual observations. This was conducted after overlay analysis had been performed and a vulnerability map had been produced. The correlation coefficient indicates the relationship between a produced vulnerability map and the actual data. If the correlation coefficient is close to 1, the vulnerability map is highly correlated to the actual groundwater quality data, and vice versa.

There were two sets of data used for conducting correlation in this step: (1) concentrations of each pesticide found in groundwater from 90 wells in the study area, and (2) vulnerability scores of the cells or mapping units where those wells are located. Correlation conducted in this step depended upon a number of weighting schemes designed from the previous step. The results derived from a weighting scheme were compared to the results derived from the others. This was done to figure out the best weighting scheme, which produced a vulnerability map the best-approximated actual data. The best weighting scheme would also be used to develop a model for calculating vulnerability scores, which indicate the degree of groundwater susceptibility to contamination by pesticides in any area.

In this study, correlation was conducted using a statistical software package called "Statistical Analysis System (SAS)". In fact, Pearson product-moment correlation is a parametric statistic, which is more powerful than Spearman rank (nonparametric) correlation. However, Pearson parametric correlation has stringent assumptions underlying its use, e.g., normal distribution of data and homogeneity of variances (Beitinger, 1999). Because of these requirements, many researches including this study are likely to use Spearman rank (nonparametric) correlation. It is noted that if data do not meet parametric assumptions, Spearman rank correlation can be more powerful than Pearson product-moment correlation.

CHAPTER 6

RESULTS AND DISCUSSION

Vector Conversion

Three polygon feature themes (i.e., soil, slope, and land use/land cover) were converted from vector to raster data structure. The results derived from this process were three discrete grids representing soil texture, percent slope, and primary land use of the study area. Each of them contained a number of cells with the size of 100 x 100 m or 1 hectare. Figure 12 shows the map of soil texture grid, which is categorized into the following groups: clay, gravelly clay, clay loam, sandy clay loam, loam, silt loam, very fine sandy loam, sandy loam, sand, gravelly, stony, and others. The last group represents areas occupied by any categories rather than soil such as water bodies and rock land. It is evident that the lowland east and southeast of the study area is mainly occupied by clay together with other soil textures including loam, silt loam, sandy loam, sandy clay loam, and very fine sandy loam. Highland area in the west and southwest, on the other hand, are occupied mostly by stony with some clay and sand.

Figure 13 is the map of percent slope grid that is divided into eight classes as follow: 0-5%, 5-10%, 10-15%, 15-20%, 20-25%, 25-30%, 30-35%, and greater than 35%. It shows that the flood plain lying from the eastern to southeastern parts has a slope ranging from 0-5%. And slope between 10% to greater than 35% can be found in the mountainous area especially in the northwest, west, and southwest of the study area.

However, there are small valleys with 0-5 % slope located in between high mountains of this area. Figure 14 represents the primary land use grid, which is shown as the subgroups of major land use called “group land use”. The group land use in this grid consists of paddy field, field crops, orchards, horticultures, evergreen and deciduous forests, natural water bodies, etc. Rice, which is a major crop of the study area, occupies most part of flood plain in the east, whereas other main crops such as sugarcane, corn, and cassava occupy the area in between paddy field in the eastern part and forest in the western and southwestern parts of the study area.

Point Interpolation

This process generates a continuous grid from sampled point values in vector data. The continuous grid contains a number of predicted values in which each of them represents an attribute value for a cell. Three methods (i.e., IDW, Spline, and Kriging) were applied for interpolating well and rainfall feature themes in this study. However, Spline interpolation was chosen for further operations for the following reasons. First, Spline is generally the better choice when dealing with unevenness in the distribution of sample points like well and rainfall data. Second, spline controls how tightly the surface conforms to the sample points and the smoothness or stiffness of the resulting surface. And third, it was found that Spline created more accurate results than the other two methods. This can be seen in Table 24 that compares the predicted values derived from each method with the actual values of well depth. It is apparent that all methods generated some of the predicted values that are not equal to the actual values. Among these, Spline interpolation generated more closely approximated observed data.

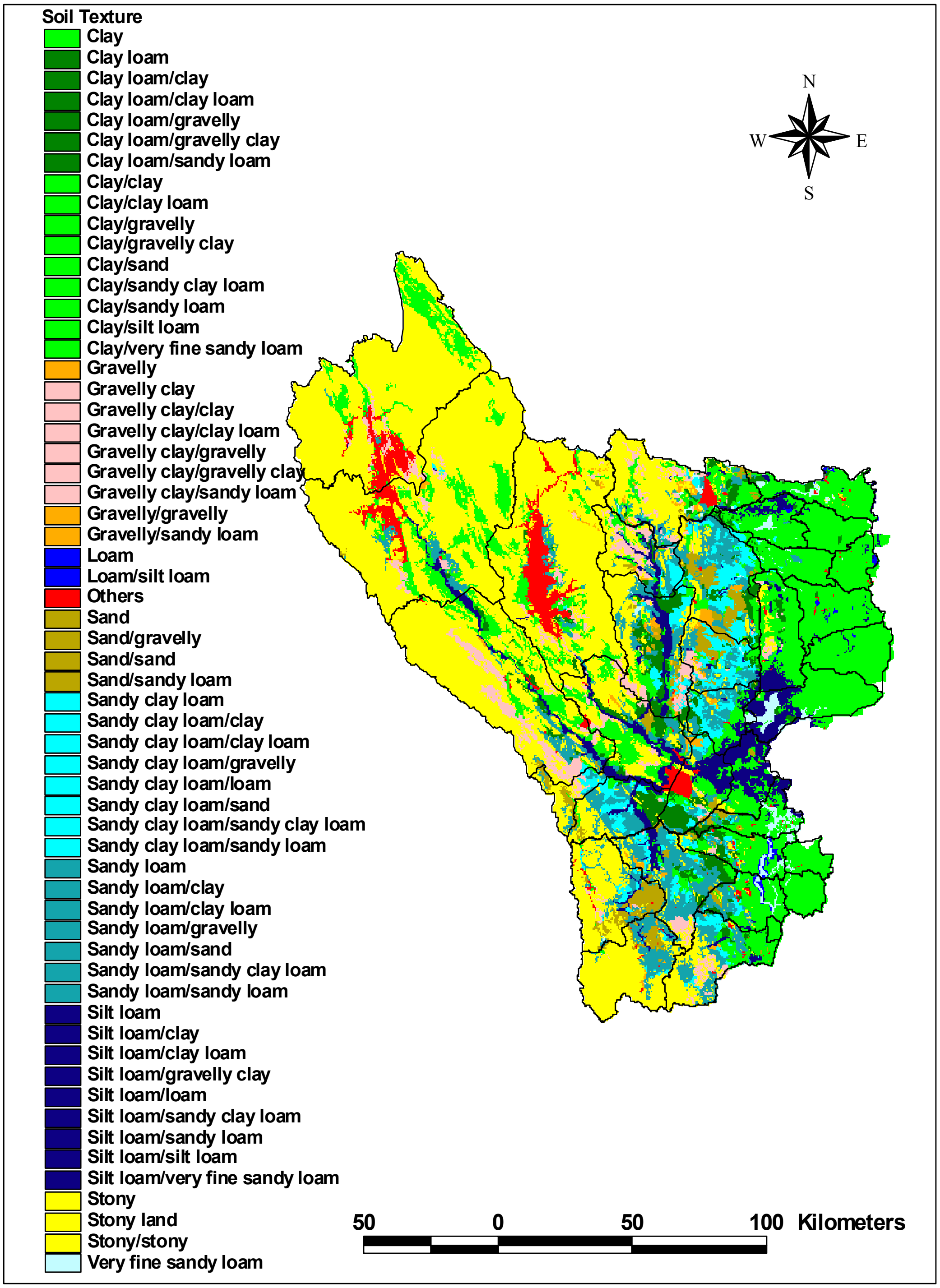


Figure 12 Map of the soil texture grid generated by vector conversion method

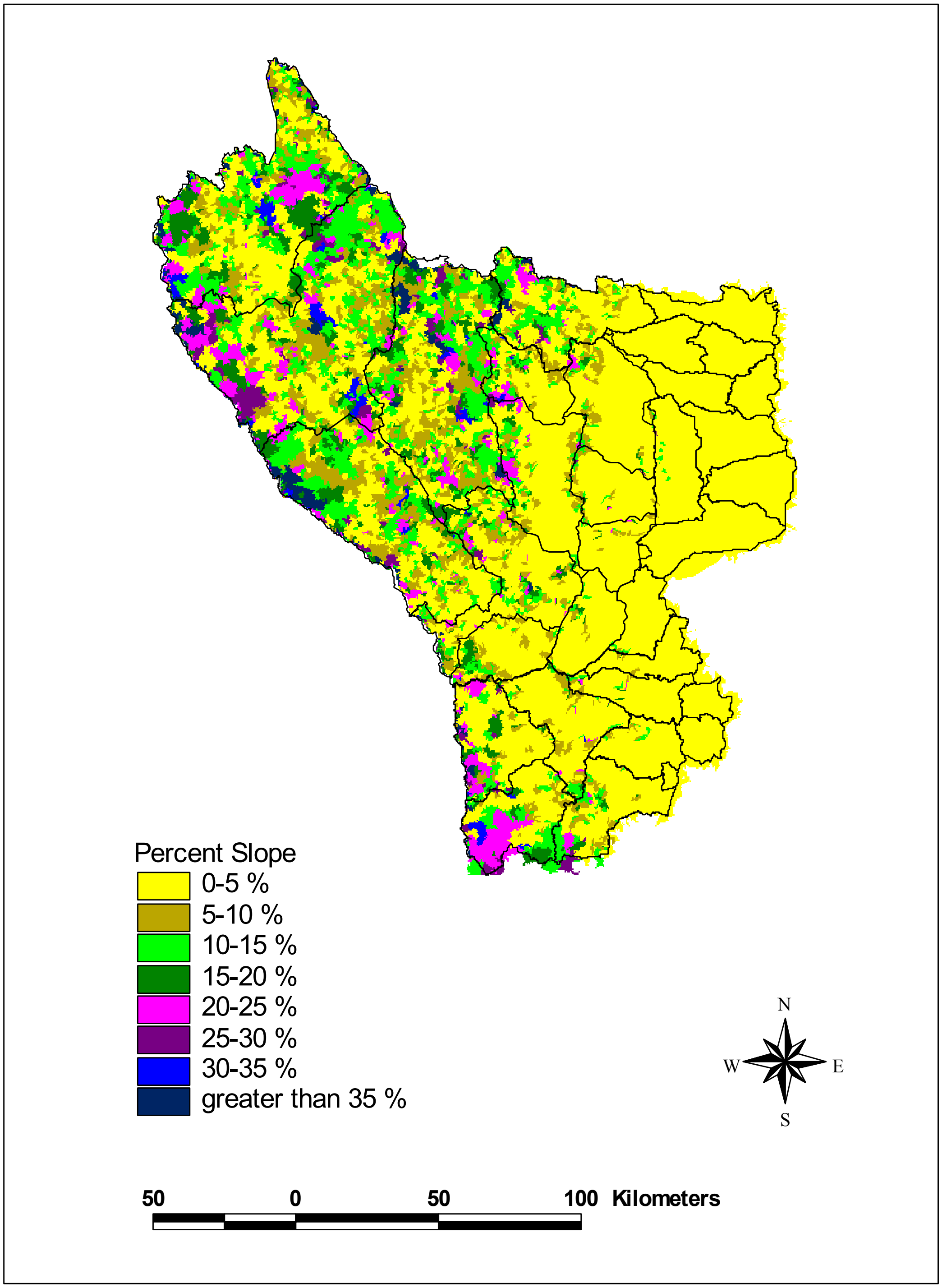


Figure 13 Map of the percent slope grid generated by vector conversion method

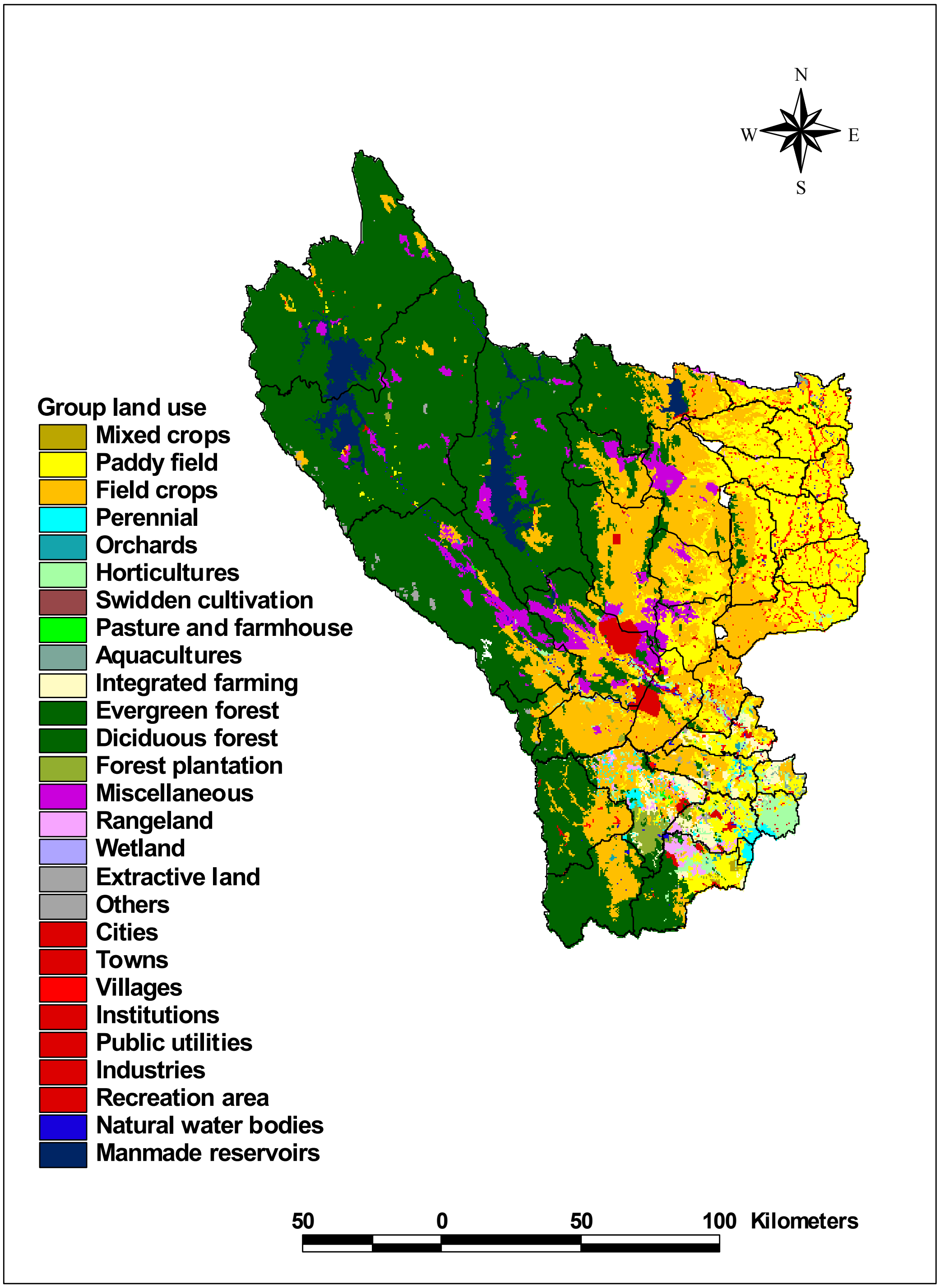


Figure 14 Map of the primary land use grid generated by vector conversion method

Spline interpolation converted two point feature themes (i.e., well and rainfall) to continuous grids. That is, the well feature theme was converted to a continuous grid of well depth ranging from 0.9 to 295 meters. The rainfall feature theme was converted to two grids: (1) a continuous grid of average annual rainfall (AAR) ranging from 525 to 2,806 millimeters, and (2) a continuous grid of monthly variance rainfall (MVR) ranging between 3,428 and 67,492. Each of these continuous grids contained a number of cells having the same size as the first three grids.

In Figure 15, the well depth grid is categorized into the following groups: less than 20, 20.1-50, 50.1-100, 100.1-150, 150.1-200, and greater than 200 meters. It was found that well depths in the lowlands east and southeast of the study area range from 50 up to greater than 200 meters, which are deeper when compared to well depths in the highlands of the western and northwestern parts. Depths of aquifers in the lowlands are much deeper than those in the highlands. However, aquifers in the lowlands are unconsolidated deposits of gravel and sand and therefore generate higher yields of water than consolidated aquifers in the highlands. For example, water wells in the eastern part, which is occupied by the Chiang Rai aquifer, may yield up to 20 m^3/hr. And yields of 45 m^3/hr can also be obtained from individual wells in the southeastern part, which is occupied by the multiple aquifer. Because of higher yielding formations in the lowlands, deeper wells have been widely used in this area.

For the average annual rainfall (AAR) and monthly variance rainfall (MVR) grids, each of them is divided by the "equal interval" method into five classes. The range of each class for both grids is illustrated in Figures 16 and 17, respectively. According to

Figure 16, average annual rainfall between 1,400 and 2,800 millimeters occurs in the mountainous area in the western and northwestern parts. This is due to the influence of southwest monsoon that contributes substantial amount of rainfall especially from May to October of each year. However, the amount of rainfall is quite low for the rest of a year. For the lowland area in the eastern and southeastern parts, average annual rainfall ranges approximately from 500 to 1,400 millimeters. Its low amount of rainfall comes from a rain shadow effect caused by the mountainous area in the west and northwest of the study area.

In Figure 17, high monthly variance of rainfall appears specifically in the western and northwestern parts. This is because rainfall in these areas do not distribute evenly over a year. Heavy rain usually comes only during the southwest monsoon season, whereas the cold and hot seasons do not have a large amount of rain. In contrast, rainfall distribution in other parts especially in the east and southeast of the study area does not differ from one month to another. Therefore, low monthly variance of rainfall can be expected in these parts. In this situation, rainfall is more likely to infiltrate into groundwater rather than running off through land surface.

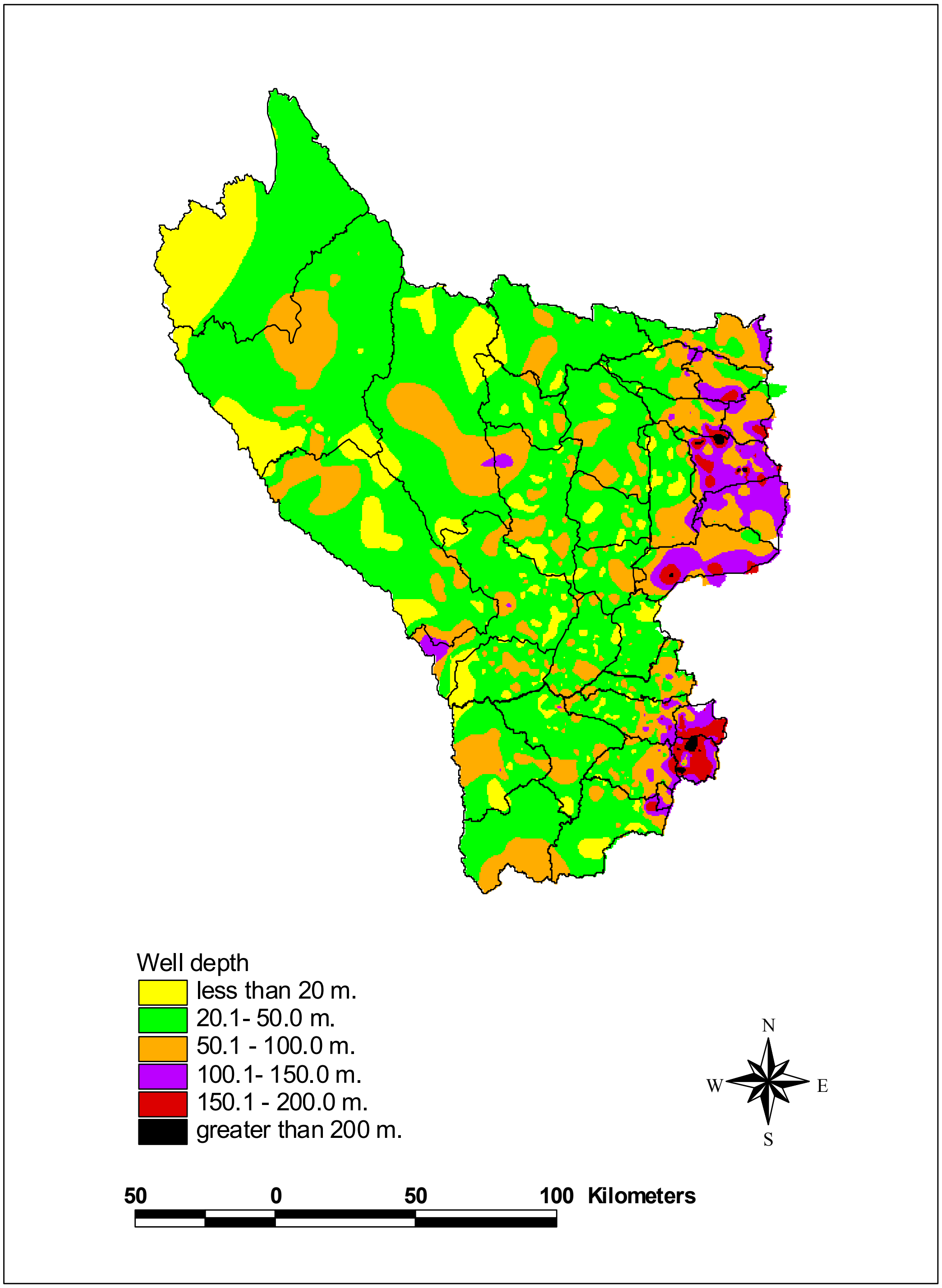


Figure 15 Map of the well depth grid generated by point interpolation method

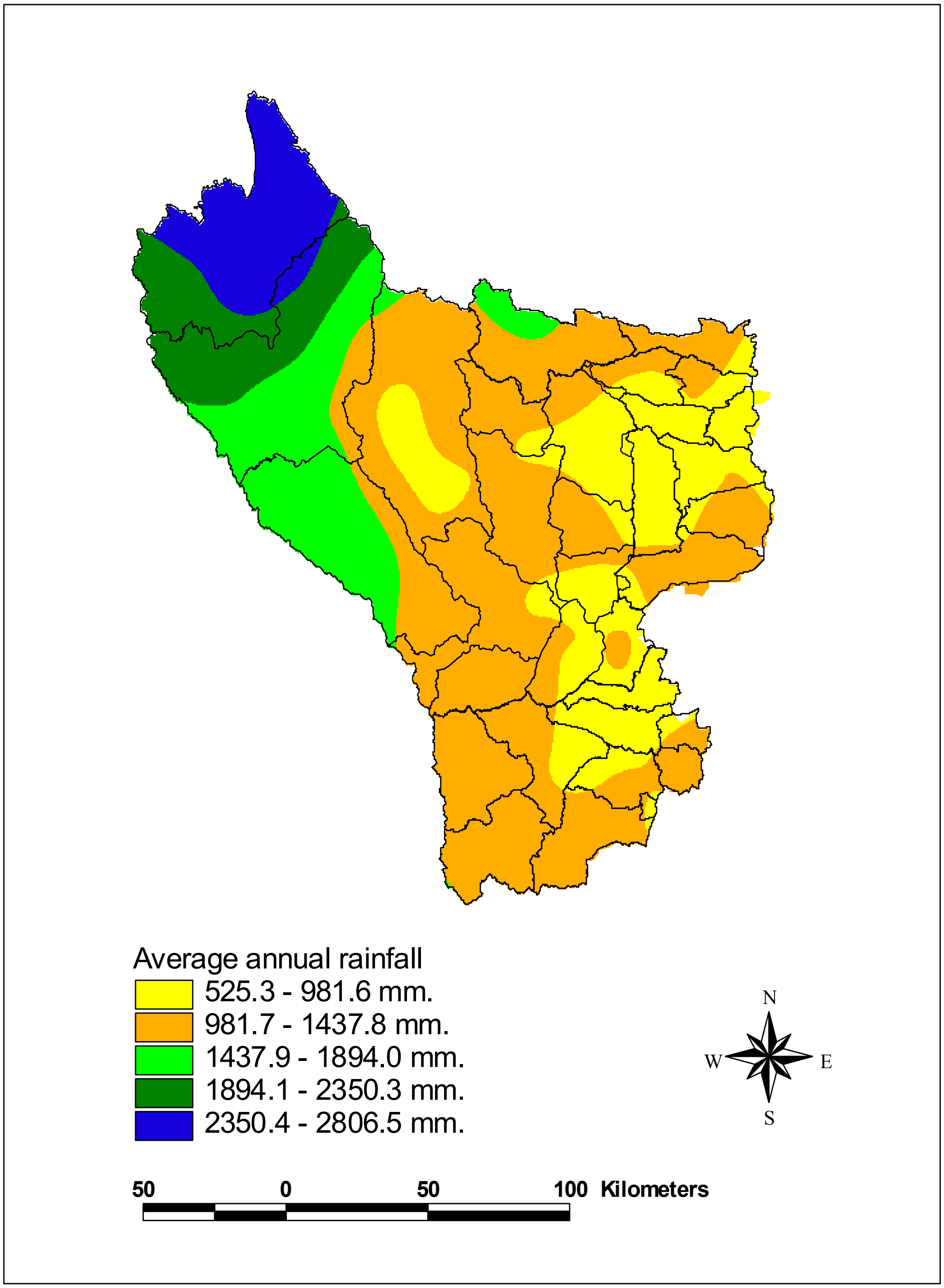


Figure 16 Map of the average annual rainfall grid generated by point interpolation method

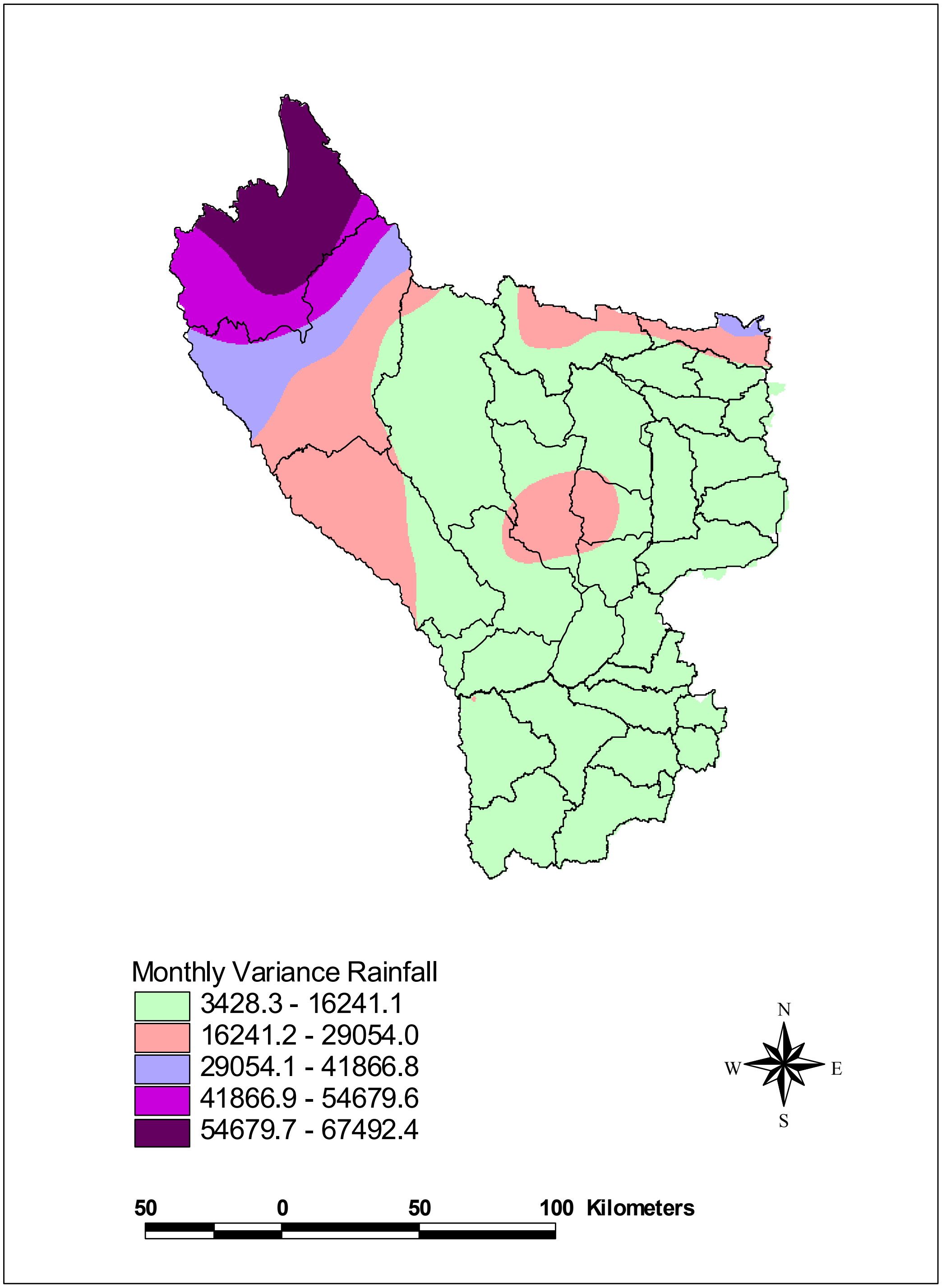


Figure 17 Map of the monthly variance rainfall grid generated by point interpolation method

Reclassification

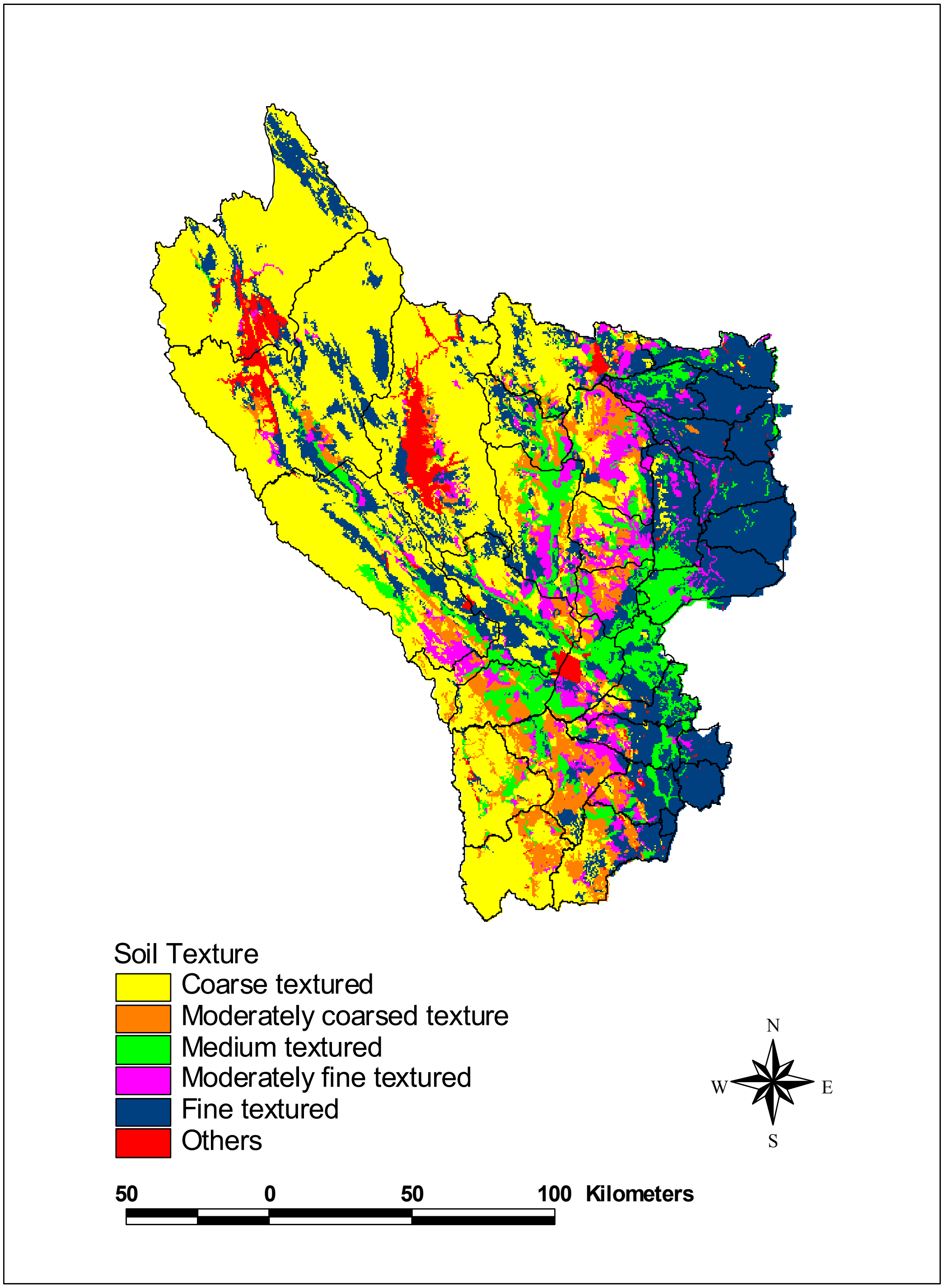
In this step, all grids created by vector conversion and point interpolation were reclassified. It means that attribute values of all cells in each grid were reclassified to a common scale showing the potential to cause contamination of groundwater by pesticides. As described in chapter 5, this scale consists of five classes in which each class has a value varying from 5 (high pollution potential) to 1 (low pollution potential). The results derived from reclassification of each grid theme are shown below:

1. Reclassification of soil texture grid

The soil texture grid was reclassified into coarse, moderately coarse, medium, moderately fine, and fine textured with a value from 5 to 1. Types of soil texture falling within each class can be seen in Tables 16 and 17. It is noted that areas that are not occupied by soil (i.e., water bodies and rock land), which is a group called “others” in soil texture grid, were assigned a value of zero. In some cases, however, surface water and fractured rock can affect groundwater quality if they are contaminated by pesticides. Figure 18 is soil texture grid that was reclassified and used as the first layer in overlay analysis.

2. Reclassification of percent slope grid

The percent slope grid was reclassified into very flat slope, flat slope, medium slope, steep slope, and very steep slope with a value from 5 to 1. The range of percent slope in each class can be seen in Table 18. Figure 19 is the percent slope grid after reclassifying into five classes mentioned above. This reclassified grid was used as the second layer in overlay analysis.



<u>Figure 18</u> Map of the soil texture grid generated by reclassification method

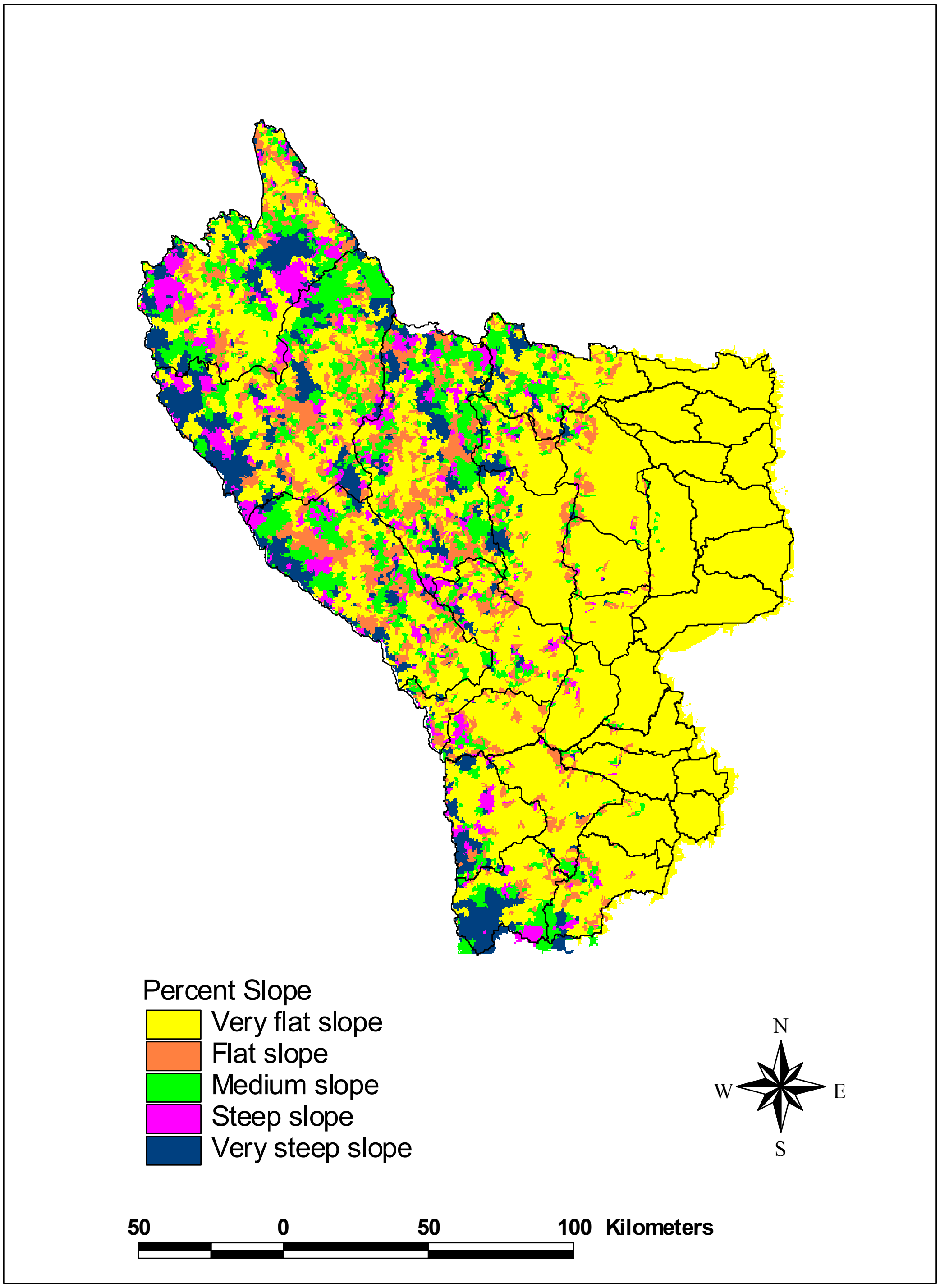


Figure 19 Map of the percent slope grid generated by reclassification method

3. Reclassification of primary land use grid

The primary land use grid was reclassified into five classes depending on the degree of pesticide usage in each type of land use. These consist of very high usage, high usage, medium usage, low usage, and very low usage of pesticides. Each class has a value varying from 5 to 1 (see Table 19). However, a group of primary land uses that has no evidence of pesticide usage (i.e., natural forest, rangeland, and water bodies) was reclassified as "none" and given a value of zero. This is because land use type without pesticide application should not have potential to cause contamination in groundwater.

Reclassification of primary land use was done separately for each type of pesticides. Because of this, six primary land use grids were generated to represent the reclassifications of 2,4-D, atrazine, carbofuran, endosulfan, dicofol, and a group of banned chemicals (dieldrin & aldrin, endrin, heptachlor & heptachlor epoxide, total BHC, and total DDT). Figures 20 to 25 show the primary land use grids of such pesticides, and each of them was used as the third layer in overlay analysis.

According to the maps shown in Figures 20 to 25, it is evident that mountainous area located from the northwestern to southwestern parts of the study area was reclassified as "none" because the area is mainly occupied by forest. On the other hand, the remaining areas were reclassified differently from one map to another depending on the degree of pesticide usages in land use and land cover types of each map. In Figure 20, which is the primary land use map for 2,4-D, the eastern and southeastern parts of the study area were dominantly reclassified as "very high usage", and the area located in between the west and the east was dominantly reclassified as "high usage". Only a few areas in this map were reclassified as “medium usage”, “low usage”, and “very low usage”.

In the primary land use map for atrazine, it is found that most of the lowland area was reclassified as “high usage” (see Figure 21). This map is therefore dominated by two classes, which included “none” in the west and “high usage” in the east of the study area. The primary land use maps for carbofuran and endosulfan are shown in Figures 22 and 23. It is noted that both maps look similarly; that is, the eastern and southeastern parts were dominantly reclassified as “very high usage”, whereas the area located in between the west and the east of the study area was mainly reclassified as “medium usage”. This is because the use patterns of the two pesticides do not quite differ from each other. Figure 24 shows the primary land use map for dicofol. In this map, the lowland area was dominantly reclassified as two classes, “high usage” in the eastern and southeastern parts and “low usage” in the area between east and west.

The final map of primary land use grids is for a group of banned pesticides (shown in Figure 25). This map contains three main classes including “none”, “medium usage”, and “high usage”. As said earlier, the highland area from the northwestern to southwestern parts is occupied by forest and therefore was reclassified as “none”. The other two classes appear in the lowland area in which “high usage” was found in the east and southeast and “medium usage” was found in the area between east and west of the study area.

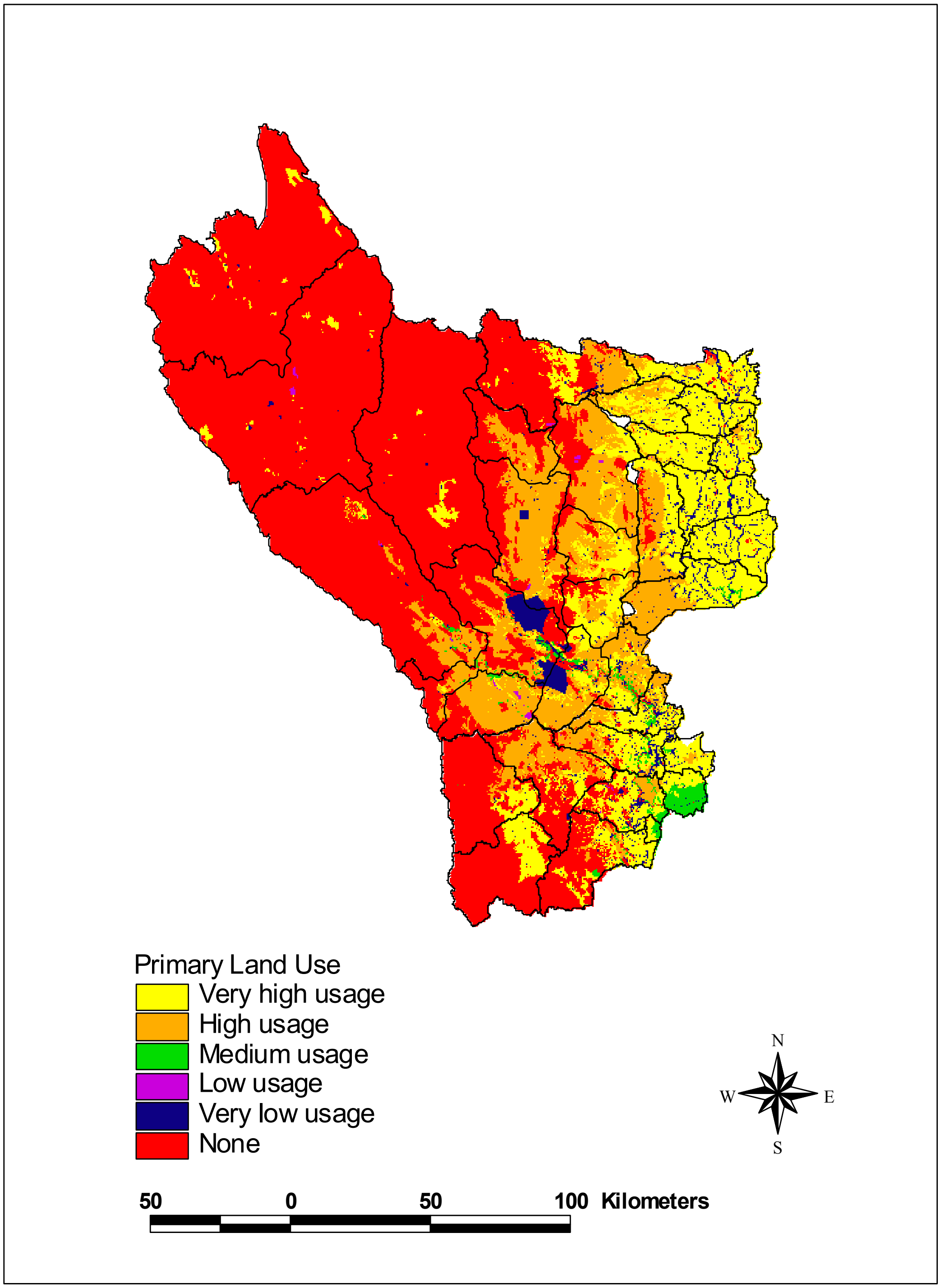


Figure 20 Map of the primary land use grid generated for 2,4-D by reclassification method

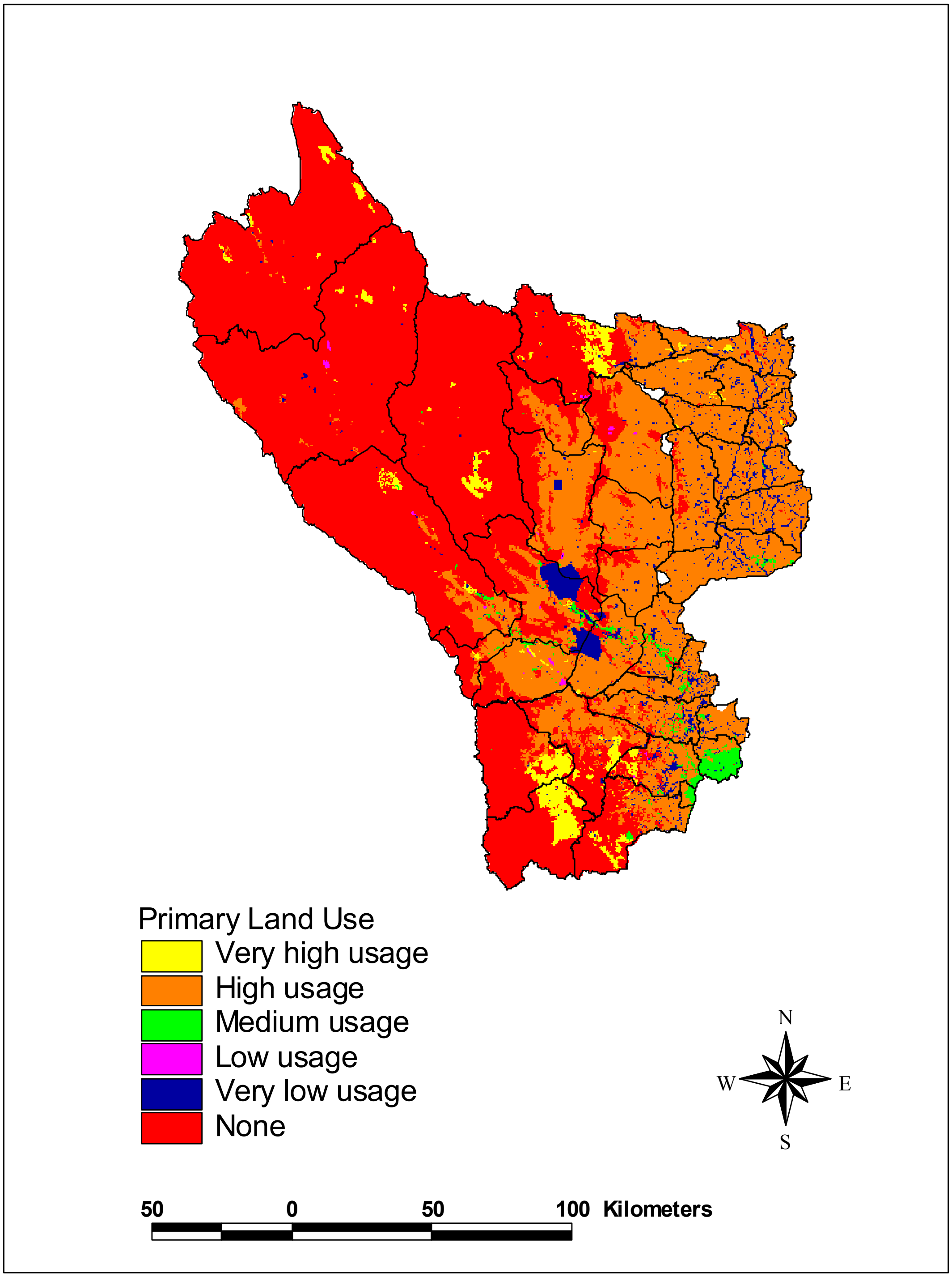


Figure 21 Map of the primary land use grid generated for atrazine by reclassification method

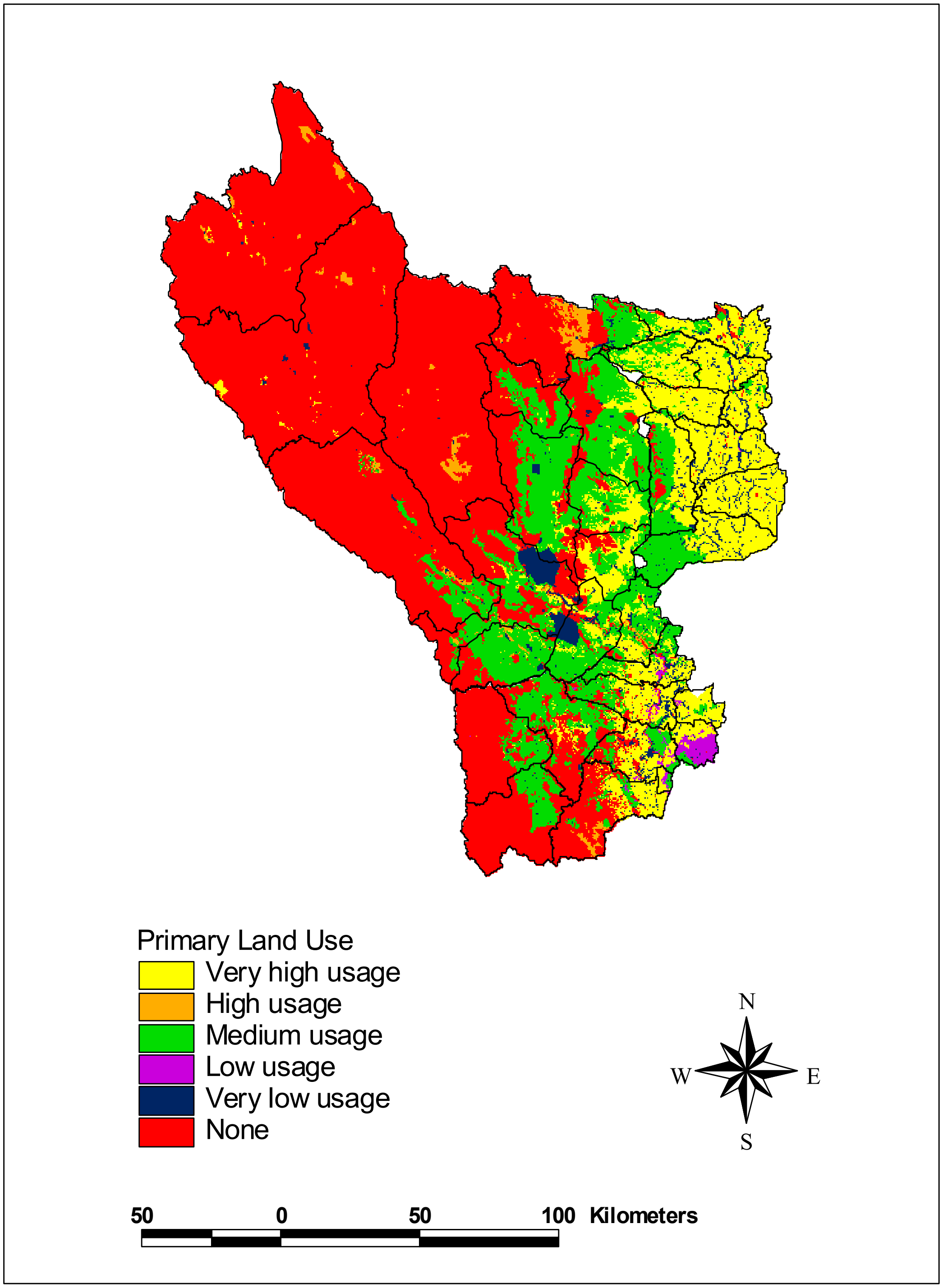


Figure 22 Map of the primary land use grid generated for carbofuran by reclassification Method

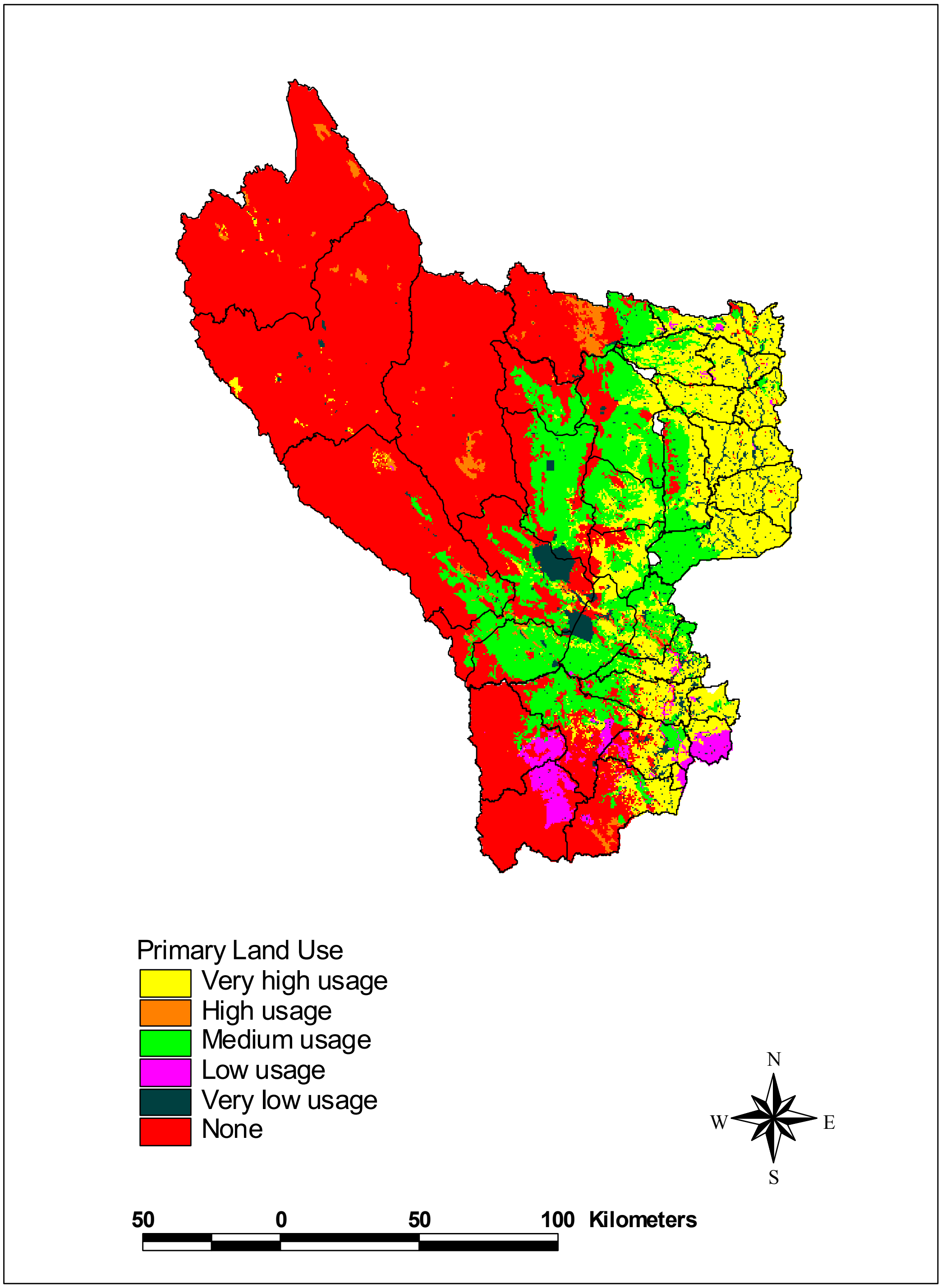


Figure 23 Map of the primary land use grid generated for endosulfan by reclassification method

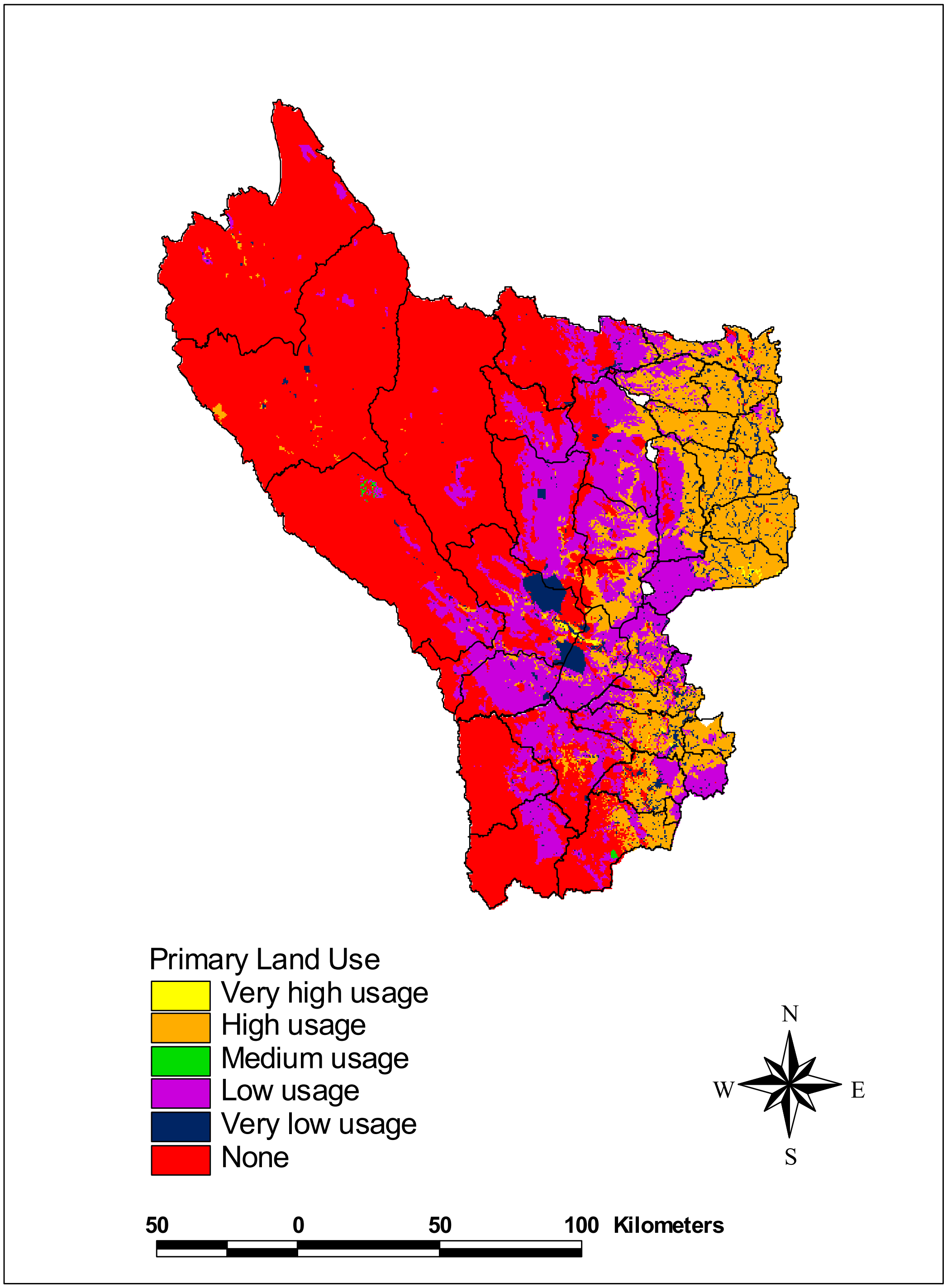


Figure 24 Map of the primary land use grid generated for dicofol by reclassification method

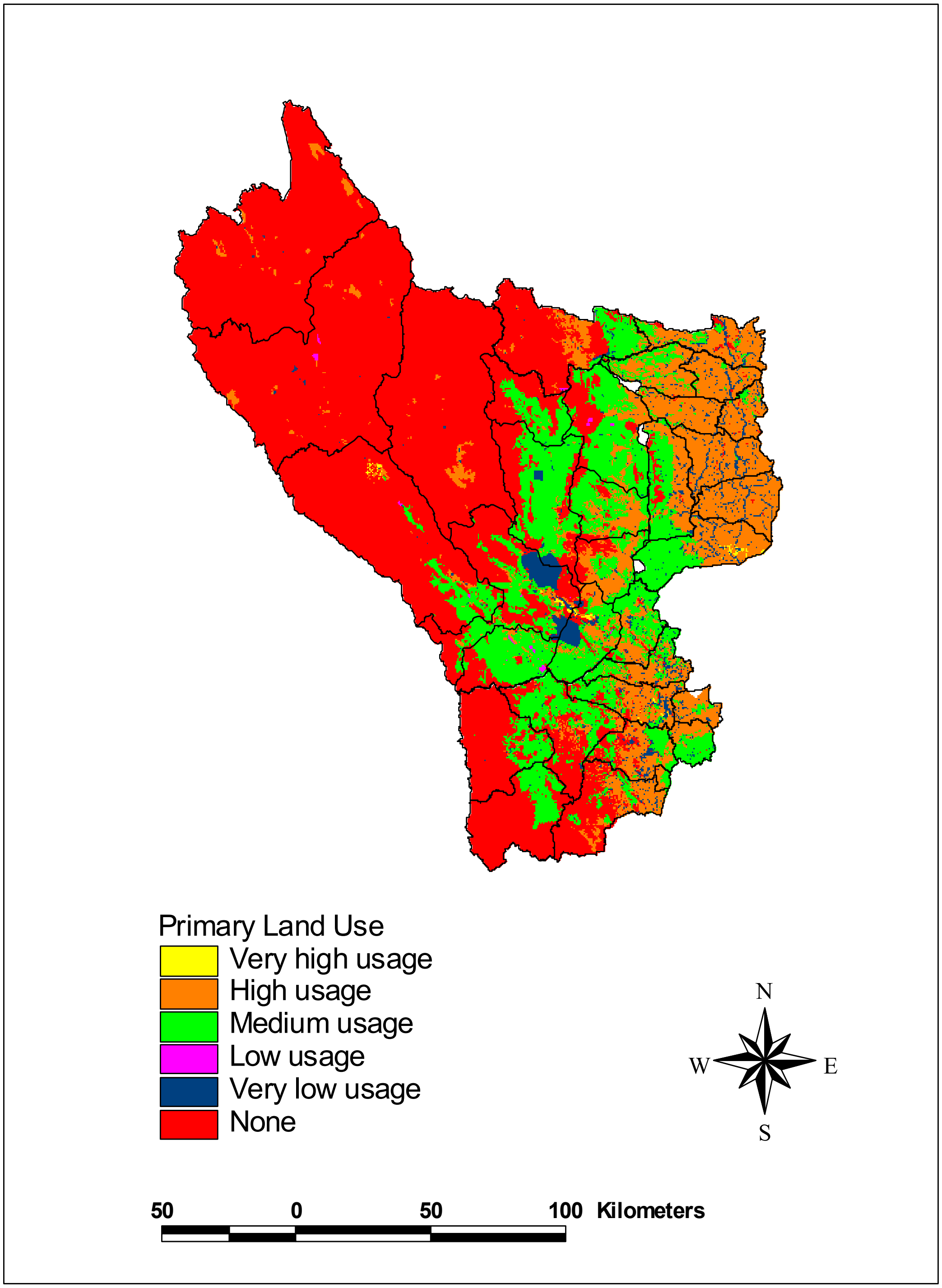


Figure 25 Map of the primary land use grid generated for a group of banned pesticides by reclassification method

4. Reclassification of well depth grid

The well depth grid was reclassified into very shallow well, shallow well, medium well, deep well, and very deep well with a value from 5 to 1. The depth of well in each class ranges between less than 10 meters for very shallow well; 10.1-20 meters for shallow well; 20.1-50 meters for medium well; 50.1-100 meters for deep well; and greater than 100 meters for very deep well (Table 21). The map of well depth grid is shown in Figure 26. This figure illustrates that the study area is dominated by “medium well” except for areas in the eastern and southeastern parts, which are dominated by “deep and very deep well”. The well depth grid was the fourth layer in overlay analysis.

5. Reclassification of AAR and MVR grids

The average annual rainfall (AAR) grid was reclassified into five classes including very high AAR, high AAR, medium AAR, low AAR, and very low AAR. Each class has an equal interval with a value varying from 5 to 1 (see Table 22). In the same manner, the monthly variance rainfall (MVR) grid was also reclassified into five classes with an equal interval in each class. Values of 5 to 1 were assigned to very low MVR, low MVR, medium MVR, high MVR, and very high MVR, respectively (see Table 23). Maps of both rainfall grids are illustrated in Figures 27 and 28. Figure 27 shows that the highland area is mostly occupied by “high and very high AAR”, whereas the lowland area is occupied by “low and medium AAR”. In Figure 28, the highland area especially in the northwestern part is occupied by “high and very high MVR”, and the remaining area is dominated by “low and very low MVR”. Either one or both of these grids could be used for overlay analysis.

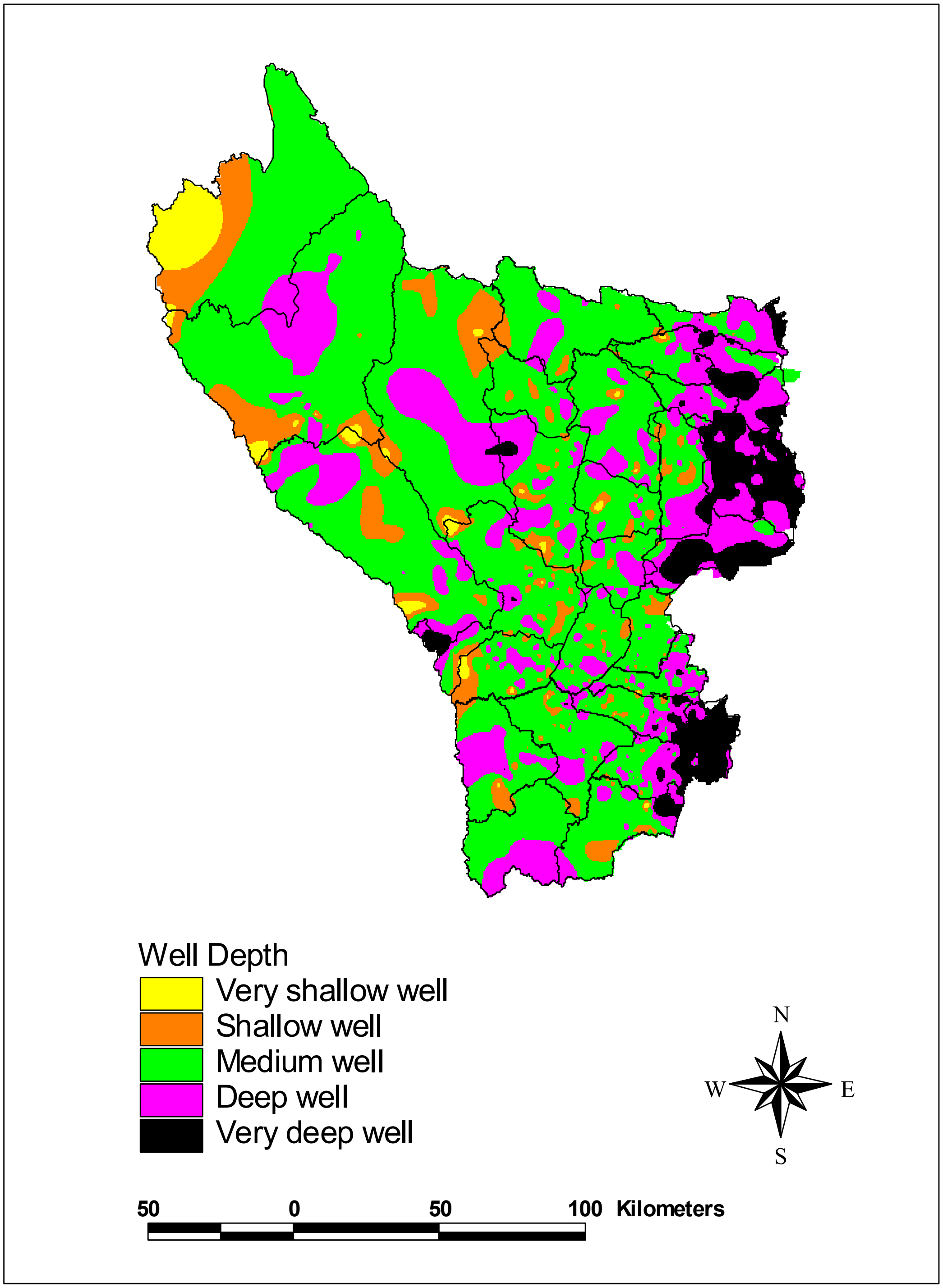


Figure 26 Map of the well depth grid generated by reclassification method

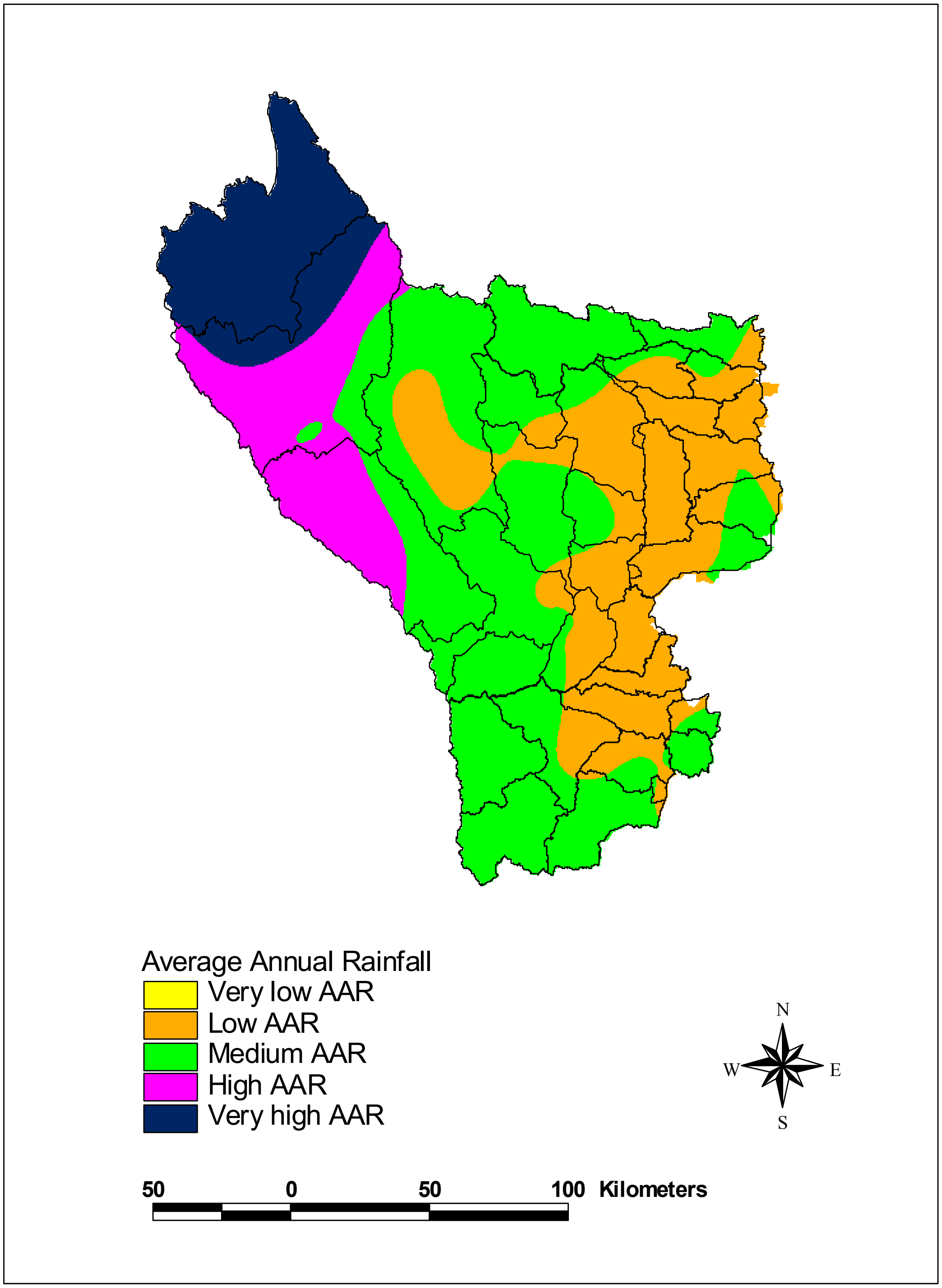


Figure 27 Map of the average annual rainfall grid generated by reclassification method

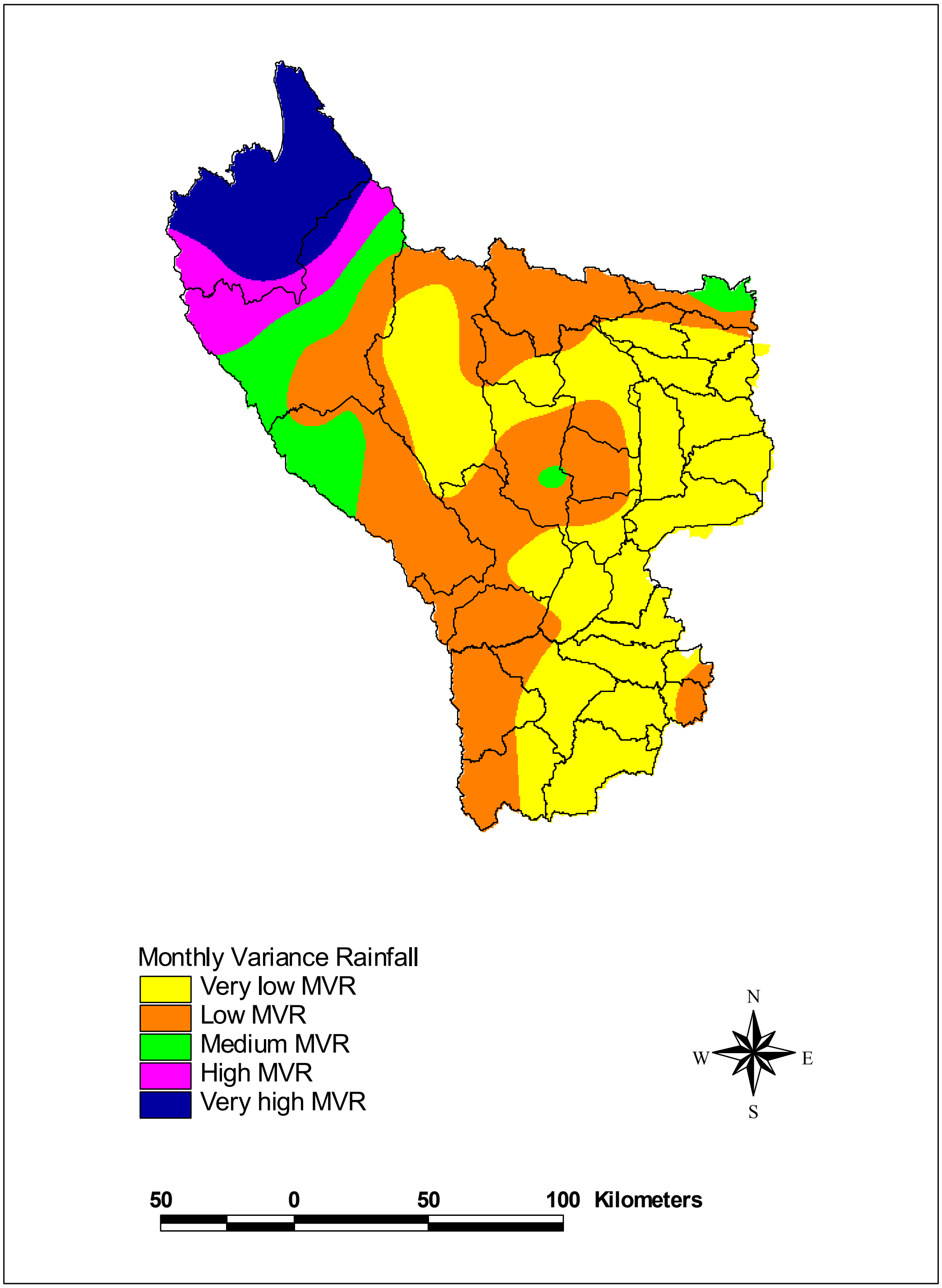


Figure 28 Map of the monthly variance rainfall grid generated by reclassification method

Arithmetic Overlay

1. Weighting schemes

Weighting schemes were obtained by conducting correlations between two data sets. These data consisted of (1) pesticide concentrations found in groundwater from 90 wells in the study area, and (2) values or classes assigned to the cells of each data layer placed at the same location with those wells (Table 25). From these data, a number of correlations were conducted in which each of them identified the relationship between concentrations of each pesticide and each data layer (see an example in Table 26). The results, in terms of Pearson product-moment and Spearman rank correlation coefficients (r and r_s), are illustrated in Table 27. Only the correlation coefficients whose probabilities are less than or equal to 0.05 (Pr and/or $Pr_s \leq 0.05$) were taken into consideration for determining the weighting schemes.

According to Table 27, it was found that there were relationships between concentrations in groundwater of some pesticides and some data layers. That is, concentrations of endosulfan, atrazine, and heptachlor & heptachlor epoxide were significantly correlated to well depth (Pr and/or $Pr_s \leq 0.05$). Concentrations of total BHC were significantly correlated to well depth, soil texture, and primary land use (Pr and/or $Pr_s \leq 0.05$). And concentrations of dicofol were significantly correlated to percent slope and monthly variance rainfall ($Pr_s \leq 0.05$). In the meantime, concentrations of all pesticides were not significantly correlated to average annual rainfall (Pr and/or $Pr_s \geq 0.05$). As a result, average annual rainfall was eliminated from further operations in this study because it was considered as the least influence factor to cause groundwater pollution by pesticides when compared to the others. Because of this, the five remaining layers including soil texture, well depth, percent slope, primary land use, and monthly variance rainfall were eventually used for overlay analysis.

It was found that all five layers had values of correlation coefficients ranging from 0.204 to 0.351 with probabilities $\leq$ 0.05 (Table 27). Statistical speaking, these correlations seem to be low since the coefficients were not close to 1. The reason why the correlation coefficients were low probably comes from low contamination of each pesticide in groundwater. It was found that average concentrations in groundwater of all pesticides ranged between 0.002 to 0.185 ppb (see Table 13). These low concentrations may lead to low coefficients when conducting correlation tests. Besides, a high number of non-detectable samples in water analysis may be another reason to cause low correlation coefficient. For example, about 60 of 90 samples or 67% were non-detectable in water analysis for dicofol, and 78 of 90 samples or 87% were non-detectable in the case of water analysis for atrazine.

By means of correlation coefficient, well depth was placed at the first rank because it had the highest correlation coefficient, 0.351. Soil texture was placed at the second rank because of having a correlation coefficient of 0.269. Monthly variance rainfall was placed at the third rank due to its correlation coefficient of 0.211. And the other two layers, primary land use and percent slope, were placed at the last rank because they had the lowest values of correlation coefficients, 0.204. By this ranking, the greater weight was given to well depth while the smaller weight was given to primary land use and percent slope. Table 28 shows four options of weighting schemes that were designed

Table 27 Correlation coefficients showing relationships between pesticide concentrations and data layers

Data Layer / Pesticide		Soil Texture		Well Depth		Percent Slope		Primary land use		AAR [1/]		MVR [2/]	
carbofuran	r, r_s	-0.131	-0.174	-0.278	-0.256	-0.002	0.065	0.046	0.034	-0.190	-0.184	0.115	0.094
	Pr, Pr_s	*0.224*	*0.105*	*0.007*	*0.014*	*0.982*	*0.542*	*0.662*	*0.746*	*0.072*	*0.061*	*0.278*	*0.374*
endosulfan	r, r_s	0.022	-0.058	**0.332**	**0.351**	-0.080	-0.144	-0.185	-0.164	0.034	0.063	0.015	-0.122
	Pr, Pr_s	*0.833*	*0.589*	***0.001***	***0.001***	*0.452*	*0.174*	*0.079*	*0.121*	*0.747*	*0.555*	*0.887*	*0.248*
dicofol	r, r_s	-0.005	-0.181	0.016	-0.167	0.121	**0.204**	0.018	0.151	-0.155	-0.148	0.128	**0.211**
	Pr, Pr_s	*0.958*	*0.092*	*0.876*	*0.114*	*0.255*	***0.053***	*0.865*	*0.153*	*0.143*	*0.162*	*0.226*	***0.045***
atrazine	r, r_s	0.037	0.112	**0.283**	**0.271**	-0.240	-0.151	-0.046	0.019	0.073	0.004	-0.054	-0.018
	Pr, Pr_s	*0.729*	*0.299*	***0.006***	***0.009***	*0.022*	*0.154*	*0.660*	*0.854*	*0.490*	*0.967*	*0.606*	*0.863*
2,4-D	r, r_s	0.028	0.059	-0.102	-0.057	0.026	-0.026	-0.135	-0.095	-0.029	0.024	-0.103	-0.146
	Pr, Pr_s	*0.792*	*0.584*	*0.336*	*0.587*	*0.806*	*0.805*	*0.201*	*0.368*	*0.786*	*0.819*	*0.332*	*0.167*
total BHC	r, r_s	**0.229**	**0.269**	0.106	**0.262**	0.104	0.097	**0.204**	0.108	-0.146	0.001	0.195	0.117
	Pr, Pr_s	***0.032***	***0.011***	*0.316*	***0.012***	*0.327*	*0.360*	***0.052***	*0.310*	*0.169*	*0.987*	*0.064*	*0.268*
total DDT	r, r_s	-0.011	-0.053	0.087	0.050	0.042	0.087	0.116	0.137	-0.088	0.084	0.068	-0.041
	Pr, Pr_s	*0.914*	*0.620*	*0.414*	*0.638*	*0.693*	*0.411*	*0.273*	*0.196*	*0.409*	*0.427*	*0.519*	*0.696*
heptachlor & hept. epoxide	r, r_s	0.037	0.069	0.150	**0.253**	-0.042	-0.013	-0.009	-0.011	0.081	-0.016	-0.163	-0.164
	Pr, Pr_s	*0.727*	*0.519*	*0.157*	***0.016***	*0.690*	*0.902*	*0.931*	*0.914*	*0.446*	*0.878*	*0.123*	*0.121*
dieldrin & aldrin	r, r_s	0.025	0.069	0.076	-0.022	0.023	-0.102	0.042	-0.130	-0.061	-0.063	0.043	0.071
	Pr, Pr_s	*0.812*	*0.523*	*0.472*	*0.832*	*0.829*	*0.336*	*0.693*	*0.219*	*0.564*	*0.554*	*0.686*	*0.500*
endrin	r, r_s	-0.133	-0.172	-0.021	-0.127	0.040	0.053	0.141	0.110	-0.041	-0.007	0.012	-0.038
	Pr, Pr_s	*0.217*	*0.110*	*0.838*	*0.232*	*0.706*	*0.614*	*0.183*	*0.300*	*0.698*	*0.946*	*0.909*	*0.716*

Note: [1/] Average Annual Rainfall r = Pearson correlation coefficient Pr = Probability of pearson correlation coefficient
[2/] Monthly Variance Rainfall r_s = Spearman correlation coefficient Pr_s = Probability of spearman correlation coefficient

for overlay operation. The purpose of having more than one option is to compare the results derived from conducting arithmetic overlay. The option that yields the most accurate result will be chosen for producing a final vulnerability map of the study area.

Table 28 Weighting schemes for overlay operation

Data layer	Weighting schemes			
	Option 1	Option 2	Option 3	Option 4
1. Well depth	0.60	0.50	0.40	0.35
2. Soil texture	0.10	0.20	0.15	0.20
3. Monthly variance rainfall	0.10	0.10	0.15	0.15
4. Primary land use	0.10	0.10	0.15	0.15
5. Percent slope	0.10	0.10	0.15	0.15
Total weight	1.00	1.00	1.00	1.00

When comparing these weighting schemes to other models such as DRASTIC, it is found that ranking of parameters used to evaluate groundwater contamination by pesticides is different. In DRASTIC model, seven parameters are involved in the process. Among these, depth to water and soil are both placed in the first rank because of having the highest weights of 5. Topography, in terms of percent slope, is in the third rank due to its weight of 3 (see Table 29). The other four parameters (i.e., net recharge, aquifer media, impact of vadose zone, and hydraulic conductivity) have weights varying from 2 to 4. In this study, however, only five parameters were involved in the evaluation process. Depth of well, which is similar to depth to water in DRASTIC, was in the first rank having a weight varying from 0.60 to 0.35 among the four options. It was the parameter most strongly related to groundwater pollution potential by pesticides. Soil and percent slope were in the second and fifth rank, respectively. The weight of soil varied between 0.10 and 0.20, which is much lower than that of well depth. And the weight of percent slope varied only between 0.10 and 0.15. Both soil and percent slope were weighted more heavily in DRASTIC. Aquifer media and hydraulic conductivity were not considered in this study because it focused on potential for contaminants to reach aquifers as opposed to movement of contaminants within an aquifer.

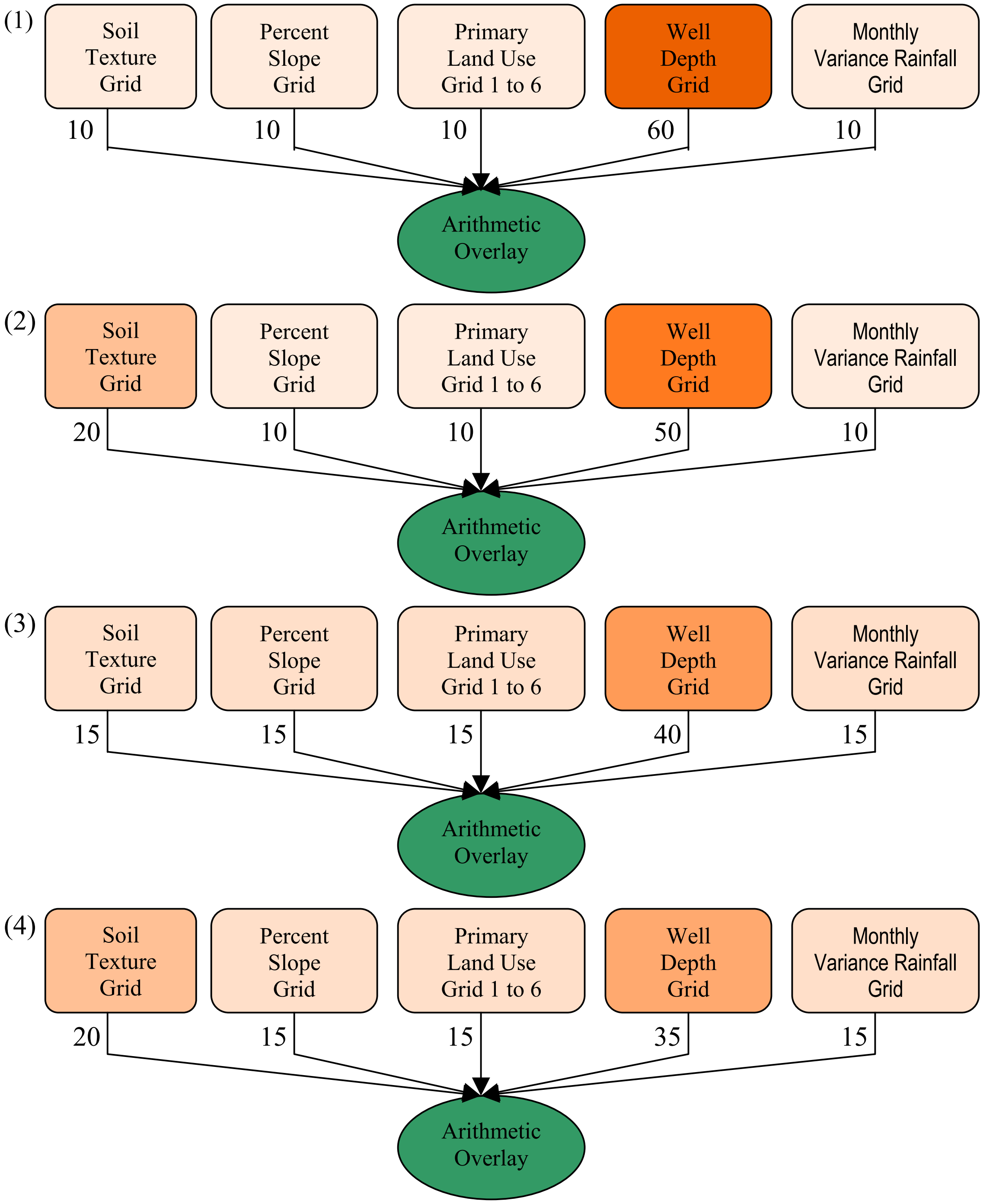
Table 29 Pesticide DRASTIC parameter weights

DRASTIC Parameter	Weight
Depth to water (D)	5
Net recharge (R)	4
Aquifer media (A)	3
Soil media (S)	5
Topography (T)	3
Impact of vadose zone (I)	4
Hydraulic conductivity (C)	2

Source: Aller and others (1987)

2. Overlay operation

As shown in Table 28, arithmetic overlay was conducted on five data layers. Well depth played the most important role because of its highest weight, whereas the other four layers were less important since they had lower weights than well depth. However, four options of weighting scheme were designed by which the weight of well depth in each option varied from one to another. This made the weights of the other four layers change because the total weight of five layers must be summed to 1. Figure 29 shows the operations of arithmetic overlay by four options of weighting scheme. These operations were performed separately for each pesticide (i.e., 2,4-D, atrazine, carbofuran, dicofol, endosulfan, and the group of banned pesticides). The result derived from each operation was a map showing relative vulnerability of groundwater to contamination by each pesticide.



Note: Primary land use grid 1 to 6 represents reclassified grid for 2,4-D, atrazine, carbofuran, dicofol, endosulfan, and a group of banned chemicals (dieldrin & aldrin, endrin, heptachlor & heptachlor epoxide, total BHC, and total DDT), respectively.

Figure 29 Flow chart of arithmetic overlays conducted by four weighting schemes

Vulnerability Map

A vulnerability map contains a number of grid cells in which each cell is assigned a value showing relative vulnerability of groundwater to pesticide pollution. This value, so called “vulnerability score”, is calculated during the operation of arithmetic overlay. It represents the degree of susceptibility of groundwater to contamination by pesticides. The higher the value or vulnerability score, the higher the degree of groundwater susceptibility. Therefore, areas with high vulnerability scores are prone to be polluted by pesticides from any sources.

It is noted that the possibility of vulnerability scores ranges between 0.65 and 5. The lowest score, 0.65, is the result derived from overlay operation using the fourth option as weighting scheme (Table 30). In this case, three data layers including well depth, monthly variance rainfall, and percent slope have values of 1, the lowest scale in their reclassification schemes. The other two layers, soil and primary land use, have values of zero (0) since a cell in each of both layers is fallen in the group of “others” in soil texture grid and “none” in primary land use grid. In the same manner, the highest score of 5.0 is derived from overlay operation that all data layers have values of 5, which is the highest scale in their reclassification schemes. Table 30 also illustrates the possibility of vulnerability scores derived from conducting arithmetic overlay by the other three options. It is found that vulnerability scores of the maps produced by the first to third weighting schemes range from 0.80 to 5.00, 0.70 to 5.00, and 0.70 to 5.00, respectively.

Table 30 Possibility of vulnerability scores

Data layer	Weight	Vulnerability score	
		Lowest score	Highest score
Option 1			
Well depth	0.60	0.60 x 1 = 0.60	0.60 x 5 = 3.00
Soil texture	0.10	0.10 x 0 = -	0.10 x 5 = 0.50
Monthly variance rainfall	0.10	0.10 x 1 = 0.10	0.10 x 5 = 0.50
Primary land use	0.10	0.10 x 0 = -	0.10 x 5 = 0.50
Percent slope	0.10	0.10 x 1 = 0.10	0.10 x 5 = 0.50
Total score		0.80	5.00
Option 2			
Well depth	0.50	0.50 x 1 = 0.50	0.50 x 5 = 2.50
Soil texture	0.20	0.20 x 0 = -	0.20 x 5 = 1.00
Monthly variance rainfall	0.10	0.10 x 1 = 0.10	0.10 x 5 = 0.50
Primary land use	0.10	0.10 x 0 = -	0.10 x 5 = 0.50
Percent slope	0.10	0.10 x 1 = 0.10	0.10 x 5 = 0.50
Total score		0.70	5.00
Option 3			
Well depth	0.40	0.40 x 1 = 0.40	0.40 x 5 = 2.00
Soil texture	0.15	0.15 x 0 = -	0.15 x 5 = 0.75
Monthly variance rainfall	0.15	0.15 x 1 = 0.15	0.15 x 5 = 0.75
Primary land use	0.15	0.15 x 0 = -	0.15 x 5 = 0.75
Percent slope	0.15	0.15 x 1 = 0.15	0.15 x 5 = 0.75
Total score		0.70	5.00
Option 4			
Well depth	0.35	0.35 x 1 = 0.35	0.35 x 5 = 1.75
Soil texture	0.20	0.20 x 0 = -	0.20 x 5 = 1.00
Monthly variance rainfall	0.15	0.15 x 1 = 0.15	0.15 x 5 = 0.75
Primary land use	0.15	0.15 x 0 = -	0.15 x 5 = 0.75
Percent slope	0.15	0.15 x 1 = 0.15	0.15 x 5 = 0.75
Total score		0.65	5.00

Vulnerability scores in each map were divided by the “equal interval” method into three classes. These consisted of low susceptibility, medium susceptibility, and high susceptibility to contamination by pesticides. The vulnerability scores falling within each class is shown in Table 31. Groundwater beneath areas with high susceptibility needs to be monitored continuously so that protective measures can be established. Monitoring program is also necessary in the areas with medium susceptibility because groundwater resource in such areas is likely to be polluted by pesticides as well.

Table 31 Classification of vulnerability scores

Vulnerability score	Degree of susceptibility
Option 1 (0.80 – 5.00)	
0.8 – 2.2	Low susceptibility
2.3 – 3.6	Medium susceptibility
3.7 – 5.0	High susceptibility
Option 2 and 3 (0.70 – 5.00)	
0.70 – 2.13	Low susceptibility
2.14 – 3.56	Medium susceptibility
3.57 – 5.00	High susceptibility
Option 4 (0.65 – 5.00)	
0.65 – 2.10	Low susceptibility
2.11 – 3.55	Medium susceptibility
3.56 – 5.00	High susceptibility

There were 24 vulnerability maps produced by overlay operation. These maps were categorized into 4 groups in which each group was derived from conducting arithmetic overlay by each weighting scheme (see Figure 29). Each group consisted of 6 maps and one of them represented a vulnerability map for 2,4-D, atrazine, carbofuran, dicofol, endosulfan, and the group of banned pesticides (i.e., total BHC, total DDT, heptachlor & heptachlor epoxide, dieldrin & aldrin, and endrin), respectively. From these maps, vulnerability scores showing the degree of groundwater susceptibility to pesticide pollution in the entire study area were obtained. These vulnerability scores were compared to groundwater quality data. And only maps with the best approximated actual groundwater quality data were chosen as the final vulnerability maps of the study area.

Comparison of Vulnerability Map and Groundwater Quality Data

The purpose of comparing a vulnerability map and groundwater quality data is to test the relationship between vulnerability scores derived from a produced map and pesticide concentrations in groundwater derived from actual observations. Two data sets used for this purpose are shown in Table 32, which consisted of (1) concentrations of each pesticide found in groundwater from 90 wells in the study area and (2) vulnerability scores of the cells or mapping units where those wells are located. From these data, a number of correlations were conducted in which each of them identified the relationship between concentrations of each pesticide and vulnerability scores of each map (see an example in Table 33). The results, in terms of Pearson product-moment and Spearman rank correlation coefficients (r and r_s), are illustrated in Table 34. It is noted that only the correlation coefficients whose probabilities are less than or equal to 0.05 (Pr and/or $Pr_s \leq 0.05$) were taken into consideration for comparing the vulnerability maps with the actual groundwater quality data.

According to Table 34, it was found that concentrations in groundwater of four pesticides were significantly correlated to vulnerability maps (Pr and/or $Pr_s \leq 0.05$). These pesticides included endosulfan, atrazine, total BHC, and heptachlor & heptachlor epoxide. The relationship between concentrations in groundwater of pesticides mentioned above and the vulnerability maps produced by different weighting schemes can be described below:

Table 34 Correlation coefficients showing relationships between pesticide concentrations and vulnerability maps

Weighting scheme Pesticide		Option 1 60:10:10:10:10		Option 2 50:20:10:10:10		Option 3 40:15:15:15:15		Option 4 35:20:15:15:15	
carbofuran	r, r_s	-0.273	-0.288	-0.271	-0.314	-0.216	-0.266	-0.211	-0.270
	Pr,Pr_s	*0.009*	*0.006*	*0.010*	*0.002*	*0.042*	*0.012*	*0.048*	*0.010*
endosulfan	r, r_s	**0.261**	**0.250**	**0.225**	**0.221**	0.150	0.145	0.132	0.116
	Pr,Pr_s	***0.013***	***0.018***	***0.034***	***0.038***	*0.162*	*0.176*	*0.218*	*0.280*
dicofol	r, r_s	0.048	-0.124	0.052	-0.125	0.076	-0.044	0.092	-0.039
	Pr,Pr_s	*0.654*	*0.247*	*0.627*	*0.244*	*0.476*	*0.678*	*0.393*	*0.714*
atrazine	r, r_s	**0.230**	**0.229**	0.193	**0.213**	0.147	0.183	0.113	0.163
	Pr,Pr_s	***0.031***	***0.031***	*0.071*	***0.046***	*0.169*	*0.087*	*0.290*	*0.127*
2,4-D	r, r_s	-0.158	-0.108	-0.142	-0.094	-0.168	-0.106	-0.149	-0.104
	Pr,Pr_s	*0.141*	*0.313*	*0.184*	*0.380*	*0.116*	*0.323*	*0.165*	*0.331*
total BHC	r, r_s	**0.320**	**0.360**	**0.309**	**0.367**	**0.258**	**0.358**	**0.216**	**0.314**
	Pr,Pr_s	***0.002***	***0.0006***	***0.003***	***0.0004***	***0.014***	***0.0006***	***0.042***	***0.002***
total DDT	r, r_s	0.126	0.120	0.119	0.117	0.137	0.164	0.138	0.151
	Pr,Pr_s	*0.238*	*0.262*	*0.266*	*0.277*	*0.200*	*0.125*	*0.197*	*0.159*
heptachlor & hept.epoxide	r, r_s	0.136	**0.214**	0.120	**0.207**	0.100	0.185	0.086	0.168
	Pr,Pr_s	*0.204*	***0.044***	*0.263*	***0.052***	*0.353*	*0.084*	*0.424*	*0.117*
dieldrin & aldrin	r, r_s	0.102	-0.055	0.101	-0.008	0.105	-0.032	0.111	-0.015
	Pr,Pr_s	*0.341*	*0.604*	*0.344*	*0.935*	*0.326*	*0.764*	*0.300*	*0.886*
endrin	r, r_s	0.003	-0.110	-0.015	-0.127	0.020	-0.091	0.008	-0.103
	Pr,Pr_s	*0.974*	*0.306*	*0.886*	*0.235*	*0.850*	*0.394*	*0.940*	*0.337*

Note: r = Pearson correlation coefficient Pr = Probability of pearson correlation coefficient
r_s = Spearman correlation coefficient Pr_s = Probability of spearman correlation coefficient

Concentrations in groundwater of endosulfan, atrazine, and heptachlor & heptachlor epoxide were significantly correlated to the vulnerability maps produced by the first two options of weighting schemes (Pr and/or $Pr_s \leq 0.05$), but were not significantly correlated to the maps produced by the third and fourth options (Pr and/or

$Pr_s \geq 0.05$). This means that the relationships were found only between groundwater quality data and the vulnerability maps produced by the first and second options. When comparing between these two options, however, the first option (60:10:10:10:10) seemed to be the better weighting scheme than the other one for producing the vulnerability maps of these three pesticides. The reason is that correlation coefficients of the first option were greater than those of the second option (see Table 34).

Concentrations in groundwater of total BHC were highly significantly correlated to the vulnerability maps produced by the first two options of weighting schemes (Pr and/or $Pr_s \leq 0.001$), and were significantly correlated to the vulnerability maps produced by the third and fourth options (Pr and/or $Pr_s \leq 0.05$). This means that the relationships between groundwater quality data and the vulnerability maps, especially those produced by the first two options of weighting schemes, could be found. However, it was apparent that correlation coefficients of the first option were greater than those of the others (see Table 34). By this reason, it can be concluded that the first option of weighting schemes (60:10:10:10:10) would be the better choice to produce a vulnerability map for total BHC than the other options.

The result described above indicates that producing a map showing relative vulnerability of groundwater to contamination by pesticides in the study area can be the most reliable on arithmetic overlay having 60:10:10:10:10 as the weighting scheme. There were only four of ten pesticides whose concentrations found in groundwater were correlated to the vulnerability maps, but these correlations occurred in the same direction. That is, the values of correlation coefficient tended to decrease from the first to the fourth option of weighting schemes (see Table 34). In other words, the first weighting scheme had the potential to produce a vulnerability map with higher correlation to actual groundwater quality data than the others. Thus, the first weighting scheme was used for arithmetic overlay to produce vulnerability maps for any kind of pesticides in the study area. Intuitively, this is logical because well depth should exert a major control on contamination potential. Often pesticides reach groundwater by traveling along the edges of a well boring, in which case soil properties would exert even less control on aquifer contamination.

The vulnerability maps of four pesticides (endosulfan, atrazine, total BHC, and heptachlor & heptachlor epoxide) are shown in Figures 30 to 32. These maps can be used as a tool for policy makers or administrators of government agencies to prioritize areas vulnerable to pesticide pollution. Once the areas are prioritized, groundwater monitoring programs and protective measures can be focused particularly on the areas with high susceptibility to contamination by pesticides. This helps the government save the budget in monitoring groundwater resources because the programs are needed only in the highest susceptible areas. However, monitoring groundwater beneath areas with medium susceptibility is also recommended, but it is not necessary to do as often as needed in the areas with high susceptibility. In addition, groundwater monitoring programs and protective measures could be done specifically in the areas with high population density.

According to the maps shown in Figures 30 to 32, areas with high, medium, and low susceptibility to contamination by each pesticide were identified. It was found that there was about 88% of the study area whose groundwater was moderately susceptible to contamination by endosulfan, 83% by atrazine, and 84% by total BHC and heptachlor & heptachlor epoxide. Approximately 7 to 8% of the area was highly susceptible to be polluted by these pesticides. And the area with low susceptibility varied between 4.9 and 8.7 % among these four pesticides (Table 35).

Table 35 Areas with different degrees of groundwater susceptibility to contamination by pesticides

Degree of susceptibility	Area (hectare)	Percent
(1) endosulfan		
High susceptibility	202,899	7.3
Medium susceptibility	2,420,444	87.8
Low susceptibility	134,367	4.9
(2) atrazine		
High susceptibility	233,444	8.2
Medium susceptibility	2,389,021	83.2
Low susceptibility	247,550	8.6
(3) total BHC and heptachlor & heptachlor epoxide		
High susceptibility	195,223	6.8
Medium susceptibility	2,425,902	84.5
Low susceptibility	247,899	8.7

It can be seen that the entire study area both in the lowland and highland is dominated by medium susceptibility. However, the area on focus of this study is the lowland especially in the eastern and southeastern parts. This is because these two parts are important in terms of high population density. The maps show that the lowland in the east of the study area, which is located in Suphan Buri province, is dominated by low and medium susceptibility. This results from deeper wells in this area and to a lesser extent, more finely textured soil. The lowland in between the eastern and western parts, which is located in Kanchana Buri province, is mainly occupied by medium susceptibility together with many scattering areas highly susceptible to pesticide pollution. And the lowland in the southeastern part, which is located in Ratcha Buri province, is dominated by medium susceptibility except for the area in the east of this part that is occupied by low susceptibility. However, some small areas with high susceptibility are also found in Ratcha Buri province. It is therefore concluded that groundwater resources in Suphan Buri and Ratcha Buri provinces have lower susceptibility to be polluted by pesticides than that in Kanchana Buri province. In other words, Kanchana Buri is the area that groundwater contamination possibly occurs easier than the other two provinces. When taking the population densities of these three provinces into consideration, it is found that the degree of high and medium susceptibility mostly occur in the lowest populated area of Kanchana Buri (40 persons/square kilometer) rather than the highest populated areas of Ratcha Buri and Suphan Buri (158 to 160 persons/square kilometer).

It is obvious in this study that depth of well is the most important factor indicating how serious the degree of groundwater susceptibility in any area could be. An area with deeper well depth can be considered as an area with low susceptibility of groundwater to pesticide pollution, and vice versa. This can be seen by comparing the map of well depth grid in Figure 26 to the vulnerability maps in Figures 30 to 32. Figure 26 shows that the entire study area is dominated by “medium well”. This is the reason why the entire study area in each vulnerability map (Figure 30, 31, and 32) is dominated by medium susceptibility. In the same manner, areas with “deep and very deep well” in the eastern and southeastern parts of the well depth map are dominated by low susceptibility in the vulnerability maps. Also, areas with “shallow and very shallow well” scattering in between east and west of the well depth map are occupied by high susceptibility in all of vulnerability maps.

A preponderance of medium susceptibility areas rather than distinct regions of high and low susceptibility also reflects that there are few areas where all of the vulnerability factors are high. In the lowland, for example, application rates of pesticides are high but soil textures are finer and wells are deeper. In the highland, there are areas of shallow well depth and coarse soil, but application rates of pesticides are low and topography is steep. Thus, these factors cancel each other over large parts of the study area.

It is important to emphasize that users of the vulnerability maps shown in Figures 30 to 32 should pay more attention in the lowland east and southeast of the study area than the highland in the western and northwestern parts. The reason behind this suggestion is that areas in the lowland are mainly occupied by agricultural land along with residential area and have a high population density. On the other hand, the highland is sparsely populated and mostly covered by forested area. Therefore, actions must be taken immediately in the lowlands with high vulnerability of groundwater to pesticide pollution. In the meantime, some areas with a high degree of vulnerability in the highland, especially in the northwestern part of the study area, might warrant only modest attention.

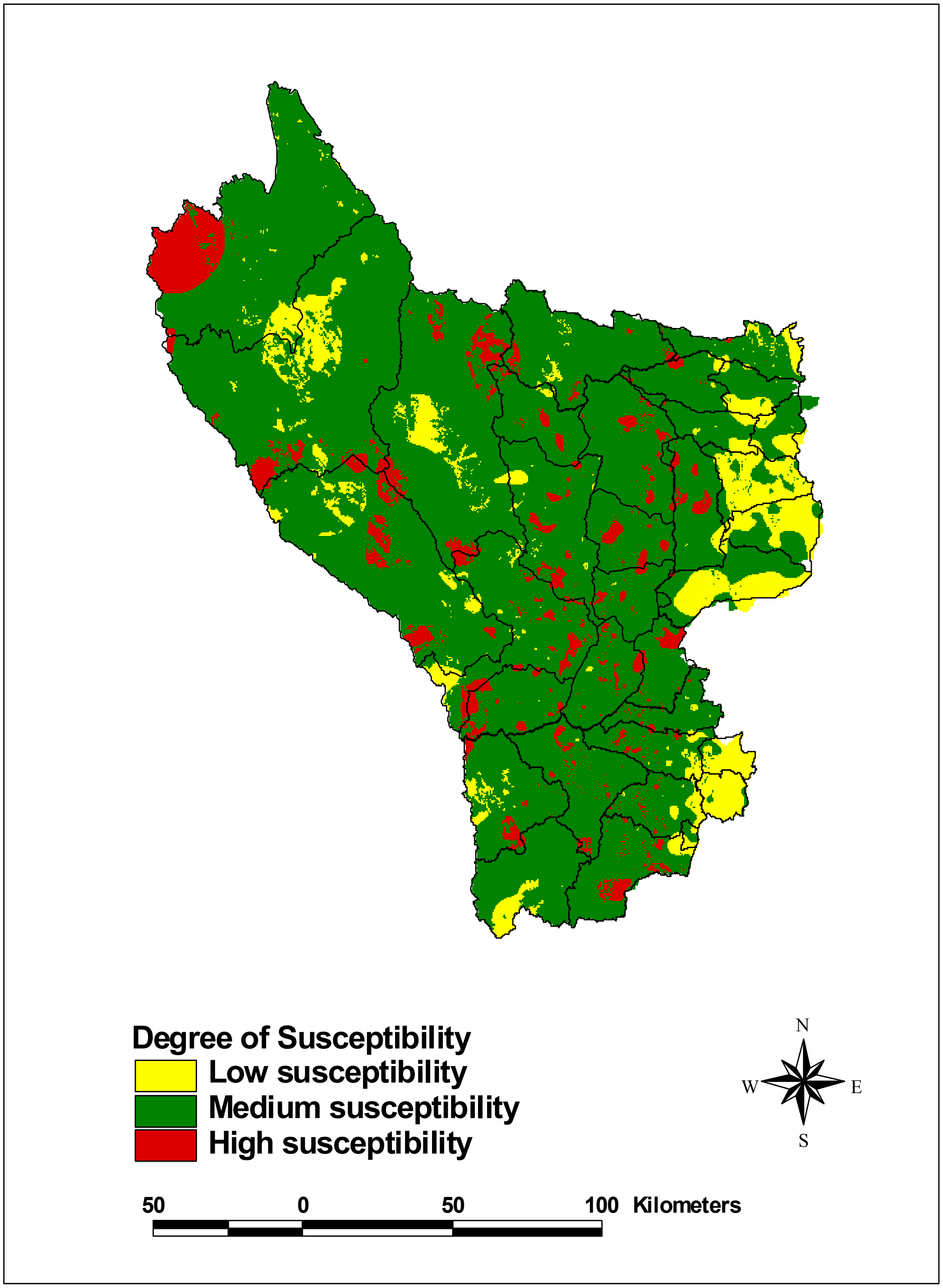


Figure 30 Map showing susceptibility of groundwater to contamination by endosulfan

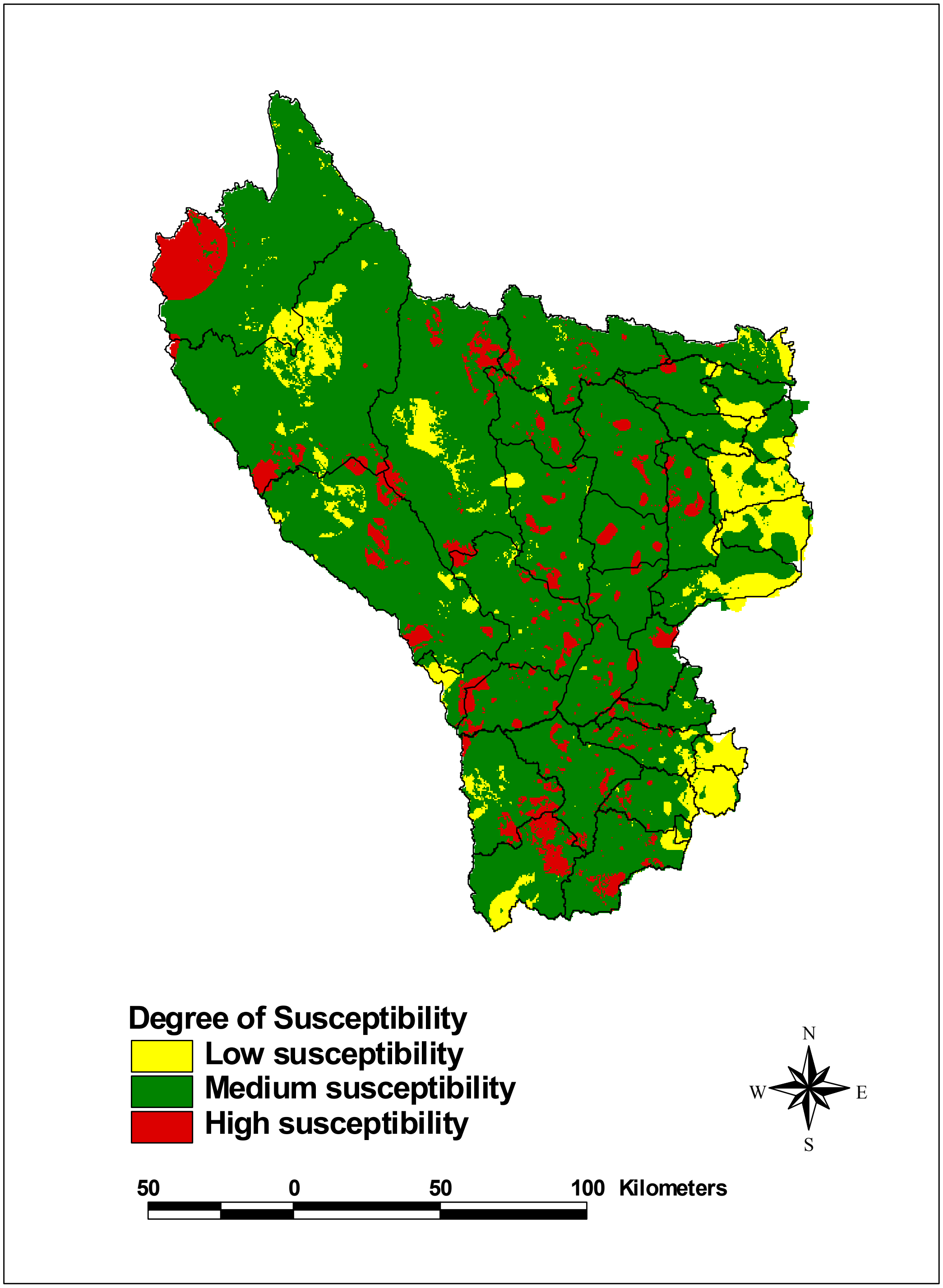


Figure 31 Map showing susceptibility of groundwater to contamination by atrazine

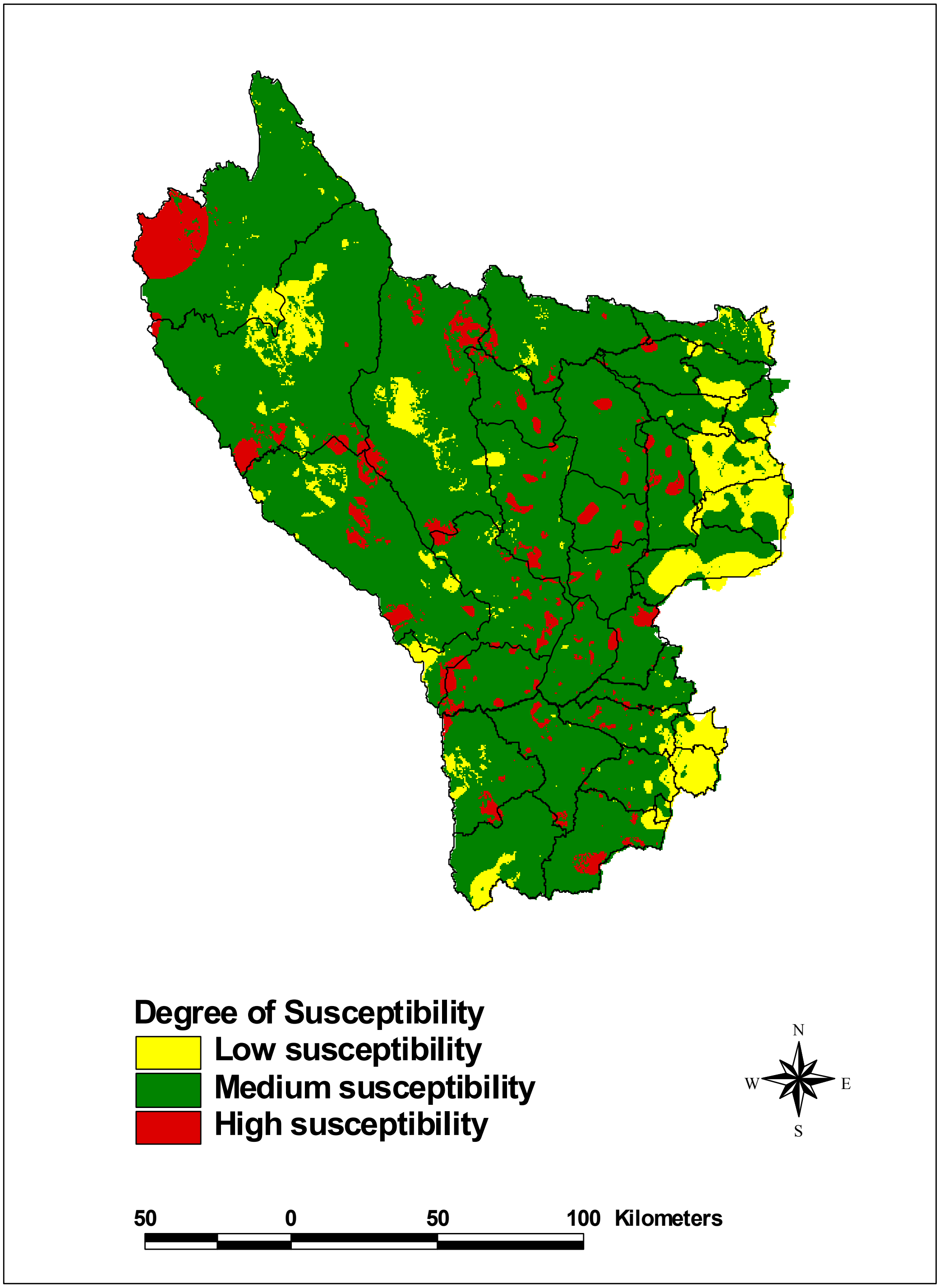


Figure 32 Map showing susceptibility of groundwater to contamination by total BHC and heptachlor & heptachlor epoxide

Vulnerability Model

In general terms, a model is a representation of reality. It helps describe or predict how things work in the real world. According to McCoy and Johnston (2001), models can be divided into two main types: (1) representation models that represent the objects in the landscape, and (2) process models that attempt to simulate processes in the landscape. The process models are used to describe processes and also to predict what will happen if some action occurs. There are many types of process models to solve a wide variety of problems, i.e., suitability model, distance model, hydrologic model, and surface model. The surface model is relevant to this study because it can be used to predict the pollution level for various locations in a certain area.

In this study a surface model was developed for predicting the degree of susceptibility of groundwater to contamination by pesticides. It was named as "vulnerability model" in accordance with its function; that is, the model can be used to calculate a vulnerability score for a certain area. As a result of this score, the possibility to cause contamination of groundwater by pesticides in that area can be figured out. In other words, the model helps identify areas where pesticides are likely to impact groundwater. This is very helpful to conduct a monitoring program for protecting groundwater resources in such areas.

The vulnerability model was developed by overlaying well depth, soil texture, monthly variance rainfall, primary land use, and percent slope; taking into account their influence factors or weights. As described in the previous chapter, the overlay process can be accomplished by two consecutive steps; (1) multiplying a value or class assigned to a cell in each data layer by its weight, and (2) adding the multiplied values or classes of all layers together to produce a vulnerability score (see Figure 10). This process can help develop the vulnerability model, which is expressed as the following equation:

$$V = \sum_{n=1}^{5} (W_n * C_n) \qquad (1)$$

where : V = Vulnerability score of a cell or mapping unit

W = Weight or influence factor for data layer n

C = Value or class assigned to a cell or mapping unit in data layer n

The vulnerability model can also be expressed as the second equation shown below, which is equivalent to the first equation shown above:

$$V = W_W * C_W + W_S * C_S + W_R * C_R + W_L * C_L + W_{SL} * C_{SL} \qquad (2)$$

where :

V = Vulnerability score of a cell or mapping unit

W_W = Weight or influence factor for well depth (W)

C_W = Value or class assigned to a cell or mapping unit in well depth

W_S = Weight or influence factor for soil texture (S)

C_S = Value or class assigned to a cell or mapping unit in soil texture

W_R = Weight or influence factor for monthly variance rainfall (R)

C_R = Value or class assigned to a cell or mapping unit in monthly variance rainfall

W_L = Weight or influence factor for primary land use (L)

C_L = Value or class assigned to a cell or mapping unit in primary land use

W_{SL} = Weight or influence factor for percent slope (SL)

C_{SL} = Value or class assigned to a cell or mapping unit in percent slope

In the second equation, however, the value or class assigned to a cell or mapping unit in each data layer can be substituted by the weighting scheme used in the overlay process. And the result derived from the previous step concludes that the best of weighting schemes considered for this study is 60:10:10:10:10. This scheme means that the weights or influence factors for well depth (W_W), soil texture (W_S), monthly variance rainfall (W_R), primary land use (W_L), and percent slope (W_{SL}) are 0.60, 0.10, 0.10, 0.10, and 0.10, respectively. By replacing these weights into the second equation, it will produce the vulnerability model that can be expressed as the third equation below:

$$V = 0.60\,C_W + 0.10\,C_S + 0.10\,C_R + 0.10\,C_L + 0.10\,C_{SL} \qquad (3)$$

where :

V = Vulnerability score of a certain area

C_W = Value or class assigned to well depth in a certain area

C_S = Value or class assigned to soil texture in a certain area

C_R = Value or class assigned to monthly variance of rainfall in a certain area

C_L = Value or class assigned to primary land use in a certain area

C_{SL} = Value or class assigned to percent slope in a certain area

The vulnerability model is another tool used for identifying areas vulnerable to pesticide contamination in groundwater. It is helpful in the case that a vulnerability map of the study area is not available. By means of this model, areas can be prioritized on the basis of vulnerability scores. Areas with high vulnerability scores are likely to be polluted by pesticides in groundwater than those of low scores. Therefore, policy makers or administrators of government agencies are able to focus on specific locations so that groundwater monitoring programs and protective measures can be implemented. In addition, researchers or private sectors can use this model to determine the degree of susceptibility of groundwater to contamination by pesticides beneath the area or location of their interests.

In fact, the vulnerability model shown in equation (3) is well suited to predict the degree of susceptibility of groundwater to contamination by pesticides in this study area. However, the model would be modified if it were used in any other area in a local scale. It is important that well depth, soil texture, monthly variance of rainfall, primary land use, and percent slope of that area must be available for calculating vulnerability scores. The value or class assigned to each of these factors can be obtained from reclassification schemes shown in chapter 5. However, it is needed to reconsider the reclassification of primary land use because of two reasons. Firstly, the degree of pesticide usage in each crop may be different from one area to another. Secondly, there may be other types of primary land use rather than those shown in the reclassification scheme of this study. Reclassification of monthly variance of rainfall is also necessary to be modified. This is due to the fact that an amount of monthly rainfall usually varies from one geographic location to another. For example, the amount of rainfall in southern Thailand is much higher than other regions of the country throughout a year. More importantly, the weighting scheme used in the model also needs to be reestablished depending upon pesticide concentrations found in groundwater of that area. This is because the level of pesticide concentrations found in groundwater of one area may differ from those in the others. Because of this data, weights or influence factors assigned to all parameters used in the model may be changed. It is recommended that a wide variety of pesticides should be used for identifying a weighting scheme. The more the pesticides are used for this purpose, the more reliable the results.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This study focused on using geographic information systems (GIS) technology to assess groundwater pollution potential by pesticides in central Thailand. Specifically, the main objectives of the study were: (1) to produce maps of the study area showing relative vulnerability of groundwater to pesticide pollution, (2) to compare actual groundwater quality data with the vulnerability maps, and (3) to develop a model for predicting the degree of susceptibility of groundwater to contamination by pesticides. To achieve this goal, a variety of data were collected from many relevant agencies of the royal Thai government. These included soil texture, percent slope, primary land use, well depth, rainfall, and groundwater quality data of the study area.

A number of GIS methods were used to manipulate the data mentioned above. Soil texture, percent slope, and primary land use were converted from polygon features to discrete grids by “vector conversion”. At the same time, well depth and rainfall were converted from point features to continuous grids by “point interpolation”. These five data layers, which affect migration of pesticides to groundwater, were then reclassified to a common scale showing the potential to cause contamination of groundwater by pesticides. This scale consisted of five classes for each data layer with a value from 5 to 1, meaning high to low pollution potential. Finally, all of the reclassified data layers were superimposed by the process called “Arithmetic overlay” to yield a composite vulnerability map. This was the map showing relative vulnerability of groundwater to contamination by pesticides in the study area.

It is noted that four weighting schemes (i.e., 60:10:10:10:10, 50:20:10:10:10, 40:15:15:15:15, and 35:20:15:15:15) were applied during the overlay operation. These schemes were designed by conducting correlations between two data sets as follows: (1) pesticide concentrations found in groundwater from 90 wells in the study area, and (2) values or classes assigned to the cells of each data layer placed at the same location with those wells. The schemes represented the weights or influence factors for well depth, soil texture, monthly variance of rainfall, primary land use, and percent slope, respectively. Well depth played the most important role and was assigned the highest weight. There were a number of arithmetic overlays operated by these four weighting schemes. And these operations were performed separately for each pesticide (i.e., 2,4-D, atrazine, carbofuran, dicofol, endosulfan, and the group of banned pesticides). The results derived from all operations were maps showing relative vulnerability of groundwater to contamination by these pesticides in the study area.

Vulnerability maps produced from the GIS technique were compared to groundwater quality data of the study area. This is to test the relationships between those maps and available data derived from actual observations. The comparisons were conducted by correlations between the following data sets: (1) concentrations of each pesticide found in groundwater from 90 wells in the study area, and (2) vulnerability scores of the cells or mapping units where those wells are located. As a result, it was found that there were four pesticides (i.e., endosulfan, atrazine, total BHC, and heptachlor & heptachlor epoxide) whose concentrations in groundwater were correlated to the vulnerability maps. That is, concentrations in groundwater of endosulfan, atrazine, and heptachlor & heptachlor epoxide were significantly correlated to the vulnerability maps produced by the first two weighting schemes (Pr and/or $Pr_s \leq 0.05$), but were not significantly correlated to the maps produced by the third and fourth schemes (Pr and/or $Pr_s \geq 0.05$). In the case of total BHC, its concentrations in groundwater were highly significantly correlated to the vulnerability maps produced by the first two weighting schemes (Pr and/or $Pr_s \leq 0.001$), and also were significantly correlated to the vulnerability maps produced by the third and fourth schemes (Pr and/or $Pr_s \leq 0.05$).

When taking correlation coefficients into consideration, it was apparent that correlation coefficients of the first weighting scheme (60:10:10:10:10) were greater than those of the others. This means that this scheme generated a stronger relationship between the vulnerability maps and actual groundwater quality data than the others. In other words, it had the potential to produce a vulnerability map with higher correlation to actual groundwater quality data than the other schemes. By this reason, it is concluded that the first weighting scheme would be the better choice than the others for producing a vulnerability map of the study area.

Three final maps of the study area were produced using the first option of weighting schemes. Each of them represents the degree of susceptibility of groundwater to contamination by endosulfan, atrazine, and total BHC and heptachlor & heptachlor epoxide. The maps show that about 83 to 88% of the entire study area is occupied by medium susceptibility, 7 to 8% by high susceptibility, and 4.9 to 8.7% by low susceptibility. Among these, the lowland especially in the eastern and southeastern parts tends to have lower susceptibility of groundwater contamination than other parts in the study area. These maps are therefore helpful for policy makers or administrators of government agencies to prioritize areas vulnerable to pesticide pollution. Once the areas are prioritized, groundwater monitoring programs and protective measures can be focused particularly on the areas with high susceptibility to contamination by pesticides. This helps the government save the budget because it is not necessary to monitor ground water resources beneath all of the entire study area.

In addition to vulnerability maps produced from the GIS technique, a vulnerability model was also developed for predicting the degree of susceptibility of groundwater to contamination by pesticides. The function of this model is to calculate a vulnerability score for a certain area. By this function, the vulnerability model can be expressed as the following equation:

$$V = 0.60\ C_W + 0.10\ C_S + 0.10\ C_R + 0.10\ C_L + 0.10\ C_{SL}$$

In this equation the factor "V" represents the vulnerability score of a certain area, whereas the other factors (C_W, C_S, C_R, C_L, and C_{SL}) represent the values or classes assigned to well depth, soil texture, monthly variance of rainfall, primary land use, and percent slope in that area. By this score, the possibility to cause contamination of groundwater by pesticides can be figured out. That is, groundwater resources beneath areas with high vulnerability scores are more susceptible to pesticide pollution than groundwater in the areas with low scores.

The vulnerability model is considered as another tool for identifying areas vulnerable to pesticide contamination if a vulnerability map is not available. By means of the model, policy makers or administrators of government agencies are able to prioritize areas so that groundwater monitoring programs and protective measures can be implemented on a specific area. In addition, researchers or private sectors can use this model to determine the degree of susceptibility of groundwater contamination beneath the area or location of their interests.

It is noted that the vulnerability model shown in the equation above is well suited to predict the degree of groundwater susceptibility in this study area. However, it can be applied in any other area in a local scale if all data used in the model (i.e., well depth, soil texture, monthly variance of rainfall, primary land use, and percent slope) is available. Besides, reclassification of primary land use and monthly variance of rainfall needs to be modified from the reclassification schemes used in this study. This is because of the following reasons: (1) the degree of pesticide usage in each crop may be different from one area to another, and there may be other types of primary land use rather than those shown in the reclassification scheme of this study, and (2) an amount of monthly rainfall usually varies from one geographic location to another. Moreover, weights or influence factors assigned to all parameters in this model need to be modified as well. This is due to the level of pesticide concentrations found in groundwater of one area may differ from those in the others.

Recommendations

Following are a list of recommendations for further studies involving the assessment of vulnerability of groundwater to contamination by pesticides:

(1) In this study, well depth was chosen as one of the data layers used to evaluate the vulnerability of groundwater to pesticide pollution. This type of data indicates how far a pesticide will be carried through soil media from land surface to groundwater level. However, well depth does not represent the actual distance between land and groundwater level. This is because wells are drilled below first encountered groundwater levels. The greater the depth of a well below groundwater, the more protection it has against contamination. To avoid this problem, it is recommended to use depth of aquifer as another alternative. This type of data is better than well depth because it represents the actual distance between land surface and an aquifer.

There is another reason why depth of aquifer should be used instead of well depth. That is, well depth is a kind of irregularly distributed data. A cluster of wells is usually found in some areas like domestic or agricultural land, whereas only a few of them can be found in forested areas. Because of this, the result of interpolating well feature theme may not be accurate in areas having a few sample points.

(2) Primary land use was the only anthropogenic factor involved in the study. It is therefore recommended that not only primary land use but also other anthropogenic factors should be taken into account. The amount of water used in irrigation is an example of another anthropogenic factor. This type of data can be used in the assessment because it affects the movement of pesticides into groundwater. The more the water used

in irrigation, the greater the opportunity of pesticides reaching groundwater. It is anticipated that taking anthropogenic factors into the assessment process may yield more accurate results.

(3) Physical properties of pesticides are important in assessing groundwater vulnerability because they are associated with leaching and persistence. Therefore, it is recommended for future studies to take this factor into consideration. Solubility in water is an example of those physical properties. Basically, pesticides with high solubility in water have greater opportunity to leach to groundwater than those with low solubility. Atrazine, for example, is highly soluble in water when compared to DDT and dieldrin. Because of this, it tends to contaminate groundwater more than the other two chlorinated hydrocarbon insecticides. Another example of physical properties of pesticides is Octanol-water partition coefficient (Kow). It is the ratio of a pesticide's concentration in the octanol phase to its concentration in the aqueous phase. This property is generally indicative of a pesticide's ability to accumulate in fatty tissues rather than remain in water. The higher the value of Kow, the greater the tendency of a pesticide to adsorb to soil containing organic carbon or to accumulate in biota. Therefore, pesticides with high Kow (e.g., DDT and dieldrin) have lesser opportunity to leach to groundwater than those with low Kow such as atrazine.

Table 36 compiles a list of ten pesticides used in this study with their physical properties relating to potential for groundwater contamination. In addition, the scores showing physical property hazard of these pesticides have been proposed. In fact, this is only a guideline to develop a physical property hazard scheme for future studies. In this

Table, the physical property hazard score for solubility in water as well as Kow is proposed into 3 to 1, meaning high to low potential to cause contamination in groundwater by pesticides.

Table 36 Physical properties of pesticides relating to potential for groundwater contamination

Pesticide	Physical property *	Score
1. 2,4-D	Solubility in water : 500 mg/L at 20 °C	3
	Kow (Log Kow) : 2.81	3
2. atrazine	Solubility in water : 30 mg/L at 20 °C	2
	Kow (Log Kow) : 2.75	3
3. carbofuran	Solubility in water : 700 mg/L at 25 °C	3
	Kow (Log Kow) : 2.32	3
4. dicofol	Solubility in water : 0.8 mg/L at 20 °C	2
	Kow (Log Kow) : 4.27	2
5. endosulfan	Solubility in water : 0.32 mg/L at 22 °C	2
	Kow (Log Kow) : 2.23	3
6. dieldrin	Solubility in water : 0.186 mg/L at 25 °C	2
	Kow (Log Kow) : 6.2	1
7. endrin	Solubility in water : 0.23 mg/L at 25 °C	2
	Kow (Log Kow) : 5.34	1
8. heptachlor	Solubility in water : 0.03 mg/L at 25 °C	1
	Kow (Log Kow) : 5.44	1
9. BHC	Solubility in water : 0.005 mg/L at 25 °C	1
	Kow (Log Kow) : 5.5-6.2	1
10. DDT	Solubility in water : 0.001-0.04 mg/L at 20-25 °C	1
	Kow (Log Kow) : 6.38	1

* Source: USEPA

Note that pesticide properties are not spatial data; therefore, they do not vary spatially from one geographic location to another. Because of this, the properties of pesticides cannot be overlaid onto other GIS layers such as soil texture and well depth. However, they could be used to refine a vulnerability map produced for each pesticide. For example, if solubility in water of atrazine were used in the study, the vulnerability map of atrazine (Figure 31) could be refined by multiplying it by a hazard score similar to the concept in Table 36. This will make the map of atrazine differ from those of total BHC and Heptachlor & heptachlor epoxide (Figure 32) because vulnerability scores of the latter maps would be multiplied by a lower hazard score. After refining the vulnerability scores, there would be less similarity in Figures 31 and 32. Note that Table 36 is only an example of a physical property hazard scheme. In fact, deriving actual hazard scores would require a more detailed investigation of the effects of water solubility, Kow, and other pesticide properties on groundwater vulnerability.

(4) Soil texture is the most permanent of all soil characteristics, and was chosen as one factor for assessing groundwater pollution potential by pesticides in this study. However, soil organic content can also be used for this purpose. The reason is that it indicates how much water is retained and how well pesticides are adsorbed in the soil. Soil containing high organic content has greater ability to stop the movement of pesticides to groundwater; in other words, it is able to hold both water and dissolved pesticides in the vadose zone. Therefore, it is recommended to use soil organic content as another alternative to evaluate the susceptibility of groundwater to contamination by pesticides.

(5) Assigning weights or influence factors to data layers used in the assessment of groundwater vulnerability is a very important issue. According to this study, the weighting schemes were obtained by conducting correlations between two sets of data. These consisted of pesticide concentrations found in groundwater of the study area and values or classes assigned to the cells of each data layer. The result showed that there were five of ten pesticides whose concentrations in groundwater were significantly correlated to data layers. This helped identify the weights or influence factors of all data layers used in the study. However, the result mentioned above may be changed if more pesticides are used in the process of identifying weighting schemes. It is expected that the more the pesticides are used, the more reliable the results. By this reason, it is recommended to collect groundwater samples and analyze for a wide variety of pesticides. This data will be useful to improve weighting schemes.

Other approaches to assigning weights should also be considered for future studies. A computationally intensive, Monte Carlo approach would consider all possible combinations of values for a given set of factors. The best combination could be identified by comparing vulnerability scores with actual pesticide concentrations in groundwater. Multiplicative rather than additive overlays could also be investigated. Additionally, different combinations of weights could be used for different pesticides. For example, if soil organic content were one of the factors, this factor would warrant more weight for pesticides with a high Kow.

(6) This study employed a GIS method called "arithmetic or additive overlay" to produce vulnerability maps of the study area. This approach reclassifies the cell values of

two or more input themes to a common scale, then multiplies the reclassified values by influence factors and adds the values to produce an output grid. However, a special value called “restricted” can be used for areas where no data is available (e.g., no data of pesticide usages is available in forested areas) or where there is a body of water (ESRI, 2000). These areas will not be included in the assessment process of groundwater pollution potential by pesticides. The “restricted” option was not used in this study.

(7) As mentioned in chapter 5, reclassifying the land use and land cover data layers relied on the degree of pesticide usage. This kind of data was obtained by interviewing farmers from many provinces in the central and eastern parts of the country. From this data, the amount of pesticide (e.g., carbofuran, endosulfan, dicofol, atrazine, and 2,4-D) used per unit area was identified for each crop such as rice, corn, cassava, cotton, peanut, mung bean, etc. However, it is found that there was no data available for the group of banned pesticides, which include dieldrin & aldrin, endrin, heptachlor & heptachlor epoxide, total BHC, and total DDT. This is because all of banned pesticides listed above have not been used in agriculture for about a decade or so. Farmers were therefore unable to recognize the amount of banned pesticides used in the past. Thus, it is recommended for further investigations to choose only currently used pesticides so that more accurate data about the application rate per unit area of pesticides can be obtained from the farmers.

(8) In this study pesticide concentrations in groundwater was the data used to identify weighting schemes for overlay operations and for the model, and to compare with vulnerability maps produced from the GIS. If this type of data is not available,

however, both purposes can be accomplished using data derived from actual observations of pesticide concentrations in the vadose zone. It is obvious that pesticides in the vadose zone have a chance of moving downward to groundwater if they are highly soluble in water and not adsorbed by soil particles or soil organic matters. Therefore, the higher the pesticide concentrations in this zone, the higher the chance of groundwater to be polluted. It is recommended that more observations of pesticide concentrations in the vadose zone should be designed in order to obtain more accurate results when using this data to achieve the purposes mentioned above.

APPENDIX

Table 3 Land use and land cover in the study area (Source: DEQP, 1995 and 1998)

No.	Mlu_code	Glu_code	Plu_code	Primary land use
				Agricultural land
1	A	A00	A0000	Mixed crops
	A	A01	A0100	Paddy field
2			A0101	Transplanting rice
3			A0103	Rice
4			A0104	Rice
	A	A02	A0200	Field crops
5			A0202	Corn
6			A0203	Sugarcane
7			A0204	Cassava
8			A0205	Pineapple
9			A0207	Cotton
10			A0208	Mung bean
11			A0209	Soybean
12			A0216	Upland rice
13			A0219	Sweet potato
	A	A03	A0300	Perennial
14			A0304	Eucalyptus
15			A0307	Casuarina
	A	A04	A0400	Orchards
16			A0401	Mixed orchards
17			A0402	Orange
18			A0405	Coconut
19			A0413	Longan
	A	A05	A0500	Horticultures
20			A0501	Mixed horticultures
21			A0502	Vegetables
22			A0504	Vineyard
23	A	A06	A0600	Swidden cultivation
	A	A07	A0700	Pasture and farmhouse
24			A0704	Swine farmhouse
	A	A09	A0900	Aquacultures
25			A0901	Mixed aquacultures
26			A0903	Shrimp farm
27	A	A10	A1000	Integrated farming
				Forest land
28	F	F01	F0100	Evergreen forest
	F	F02	F0200	Deciduous forest
29			F0201	Mixed deciduous forest
30			F0202	Deciduous dipterocarp forest
	F	F03	F0300	Forest plantation
31			F0302	Pine
32			F0303	Dipterocarpus
33			F0304	Eucalyptus
				Miscellaneous
34	M	M00	M0000	Miscellaneous land
	M	M01	M0100	Rangeland
35			M0101	Grass
36			M0102	Scrub
37			M0104	

Table 3 (continued)

No.	Mlu_code	Glu_code	Plu_code	Primary land use
38	M	M02	M0200	Wetland
	M	M03	M0300	Extractive land
39			M0301	Mines
40			M0302	Soil pits
41			M0303	Sand pits
	M	M04	M0400	Others
42			M0403	Bare exposed rock
				Urban and built-up land
	U	U01	U0100	Cities, Towns, Commercial and Services
43			U0101	Cities
44			U0102	Towns
45			U0103	Commercial and services
46	U	U02	U0200	Villages
47	U	U03	U0300	Institutions
	U	U04	U0400	Public utilities
48			U0401	Airports
49			U0402	Railway stations
50			U0403	Bus terminals
	U	U05	U0500	Industries
51			U0502	Factories
	U	U06	U0600	Others
52			U0601	Recreation area
53			U0603	Cemeteries
				Water bodies
	W	W01	W0100	Natural water bodies
54			W0101	Rivers and canals
55			W0102	Lakes
	W	W02	W0200	Manmade reservoirs
56			W0201	Reservoirs

Note: Mlu = Major land use
Glu = Group land use
Plu = Primary land use

Table 5 Well data of the study area (Source: DMR, 1996a and 1996b)

NO.	Well ID	UTM Easting	UTM Northing	Depth (m)	NO.	Well ID	UTM Easting	UTM Northing	Depth (m)
1	KB 25143	554120	1538925	33.5	51	MS 0077	559111	1553179	38.1
2	Q 0808	554490	1538669	33.5	52	A-36	562572	1551661	35.1
3	MS 0065	554444	1539646	30.5	53	PKCB 70	561151	1551117	70.0
4	Q 0933	551722	1542786	15.2	54	Q 0876	560585	1553860	42.3
5	Q 0920	553859	1541416	21.3	55	Q 0978	560324	1553236	27.0
6	MD 0356	554166	1540607	27.4	56	KB 25120	560903	1550106	39.7
7	-	557240	1542771	25.9	57	Q 0830	558643	1551037	24.3
8	Q 0893	560502	1539637	61.0	58	Q 0855	558704	1551790	38.1
9	Q 0892	554657	1544297	15.2	59	Q 0857	556531	1552710	30.4
10	1828	555622	1546154	19.5	60	L-10	562572	1551661	44.0
11	Q 0934	556151	1546665	21.3	61	Q 0194	562635	1552645	73.2
12	MD 0358	556095	1545875	21.3	62	2690	542432	1563094	11.5
13	L-20	561801	1538199	24.4	63	MS 0214	545013	1560071	33.5
14	Q 0193	555655	1544142	24.3	64	-	557713	1551808	36.6
15	MD 0367	551851	1553639	42.6	65	MS 0272	543318	1560544	50.3
16	-	552552	1556373	22.0	66	TP-3	543664	1568529	37.5
17	MS 0022	551908	1556345	35.0	67	MD 0228	551550	1559014	30.4
18	-	551971	1555826	40.0	68	MD 0366	544392	1562224	31.5
19	Q 0954	553284	1558710	33.0	69	MD 0367	544327	1561663	61.5
20	Q 0968	554455	1560067	36.0	70	9596	547256	1566313	32.0
21	-	553673	1559710	36.0	71	Q 0785	547306	1566801	21.3
22	Q 0891	556753	1563566	18.2	72	9600	545043	1557780	20.0
23	MD 0415	558341	1560928	22.9	73	-	542758	1563672	18.0
24	Q 0820	551314	1562353	21.3	74	Q 0935	544517	1563409	19.5
25	KB 25099	552406	1561850	21.3	75	Q 0952	541500	1562532	30.0
26	Q 0966	551301	1560913	18.0	76	MD 0431	541931	1561687	27.4
27	MD 0277	552610	1562852	15.2	77	Q 0877	544523	1564355	24.3
28	Q 0897	551341	1552418	27.4	78	PKCB 59	540554	1552188	54.0
29	Q 0919	550632	1551092	48.7	79	PKCB 67	539041	1552176	96.0
30	P 16/231	552878	1554401	30.5	80	Q 0863	538934	1550304	42.6
31	L-23	526289	1572296	39.6	81	KB 201	549536	1561001	36.4
32	Q 0937	523827	1580119	19.5	82	A-44	551146	1558458	65.6
33	-	524166	1579530	18.3	83	Q 0986	539536	1561126	29.0
34	Q 0821	523598	1580631	24.3	84	1940	530306	1565686	21.2
35	MD 0432	525110	1571457	24.3	85	KB 25219	536030	1571434	33.0
36	Q 0822	525768	1569489	33.5	86	9599	533769	1573596	56.6
37	Q 0823	521321	1570899	33.5	87	Q 0969	540531	1565819	21.0
38	-	517160	1573152	24.0	88	Q 0803	539341	1567648	30.4
39	MD 0392	517694	1572593	48.7	89	Q 0804	532400	1565192	30.4
40	26915	554844	1552336	18.3	90	Q 0873	533065	1564324	24.3
41	1732	553733	1552521	19.0	91	KB 25162	535245	1558395	45.1
42	Q 0858	553537	1551363	15.2	92	KB 25074	536876	1572719	21.3
43	PKCB 39	554340	1553908	37.0	93	741	537710	1569366	37.4
44	9597	554536	1552669	20.0	94	A16/271	537602	1570702	27.4
45	Q 0918	559875	5549109	15.2	95	9598	538821	1569366	20.0
46	MS 0213	559403	1548098	24.3	96	L-34	545049	1541023	30.5
47	13789	561938	1548537	43.0	97	L-1	542784	1541967	24.4
48	Q 0829	560160	1551312	42.6	98	KB 25077	542166	1541492	21.3
49	1380	559799	1550662	31.0	99	MD 0481	543925	1540777	18.2
50	MD 0360	558069	1554658	18.2	100	MS 0210	538350	1543903	32.0

Table 5 (continued)

NO.	Well ID	UTM Easting	UTM Northing	Depth (m)	NO.	Well ID	UTM Easting	UTM Northing	Depth (m)
101	MS 0263	540219	1542341	32.0	151	21563	533731	1523573	24.2
102	KB 25076	537142	1543535	21.3	152	MD 0394	535025	1523800	27.4
103	-	536745	1542167	18.0	153	KB 25086	542228	1528255	27.4
104	L-2	536264	1542918	24.4	154	MD 0348	543989	1528204	42.7
105	9496	546922	1553867	38.0	155	MS 0337	544582	1530092	49.5
106	MD 0500	545876	1553367	39.6	156	MS 0067	540672	1524960	68.6
107	Q 0824	544855	1555080	36.5	157	KB 25025	541089	1526526	48.7
108	18831	545185	1554513	37.5	158	MD 0349	538885	1524136	54.9
109	L-36	545584	1555836	42.0	159	KB 25153	538303	1523353	14.6
110	Q 0953	542638	1555301	18.0	160	A-1	540625	1531852	60.0
111	-	543341	1555149	18.0	161	MD 0350	536561	1527467	48.8
112	Q 0825	543108	1554437	30.4	162	21921	535556	1526194	36.3
113	MD 0368	548754	1557502	18.2	163	KB 25194	539385	1526788	33.0
114	Q 0951	548972	1558850	15.0	164	Q 0928	546363	1534875	24.4
115	-	542764	1550342	22.0	165	Q 0973	552750	1533834	31.5
116	Q 0982	539667	1550188	36.0	166	MS 0334	552372	1533446	30.0
117	Q 0889	541835	1552068	28.9	167	17477	551249	1532961	73.4
118	3118	541727	1551183	25.0	168	17478	551206	1533335	71.2
119	Q 0949	548053	1554649	22.5	169	17479	550736	1533223	42.7
120	KB 25165	549930	1546195	20.7	170	Q 0925	549278	1529641	27.4
121	MD 0480	551828	1539770	30.4	171	MD 0351	548855	1529794	59.4
122	MD 0479	550283	1544445	30.4	172	Q 0878	542193	1538552	18.3
123	-	548576	1543886	30.0	173	MD 0261	547270	1531800	30.5
124	L-37	549976	1541913	28.0	174	Q 0922	546016	1536150	57.9
125	A-16/272	550514	1538967	18.3	175	KB 25147	541459	1535168	39.0
126	S 0043	548250	1542767	54.9	176	Q 0921	545300	1537200	51.8
127	MD 0472	545971	1544316	61.0	177	MD 0353	541090	1535231	39.6
128	Q 0963	545817	1546132	27.0	178	Q 0926	549250	1532254	27.4
129	MS 0211	543776	1545990	73.2	179	Q 0810	549154	1532731	30.5
130	1456	551133	1540454	16.0	180	MS 0166	542079	1540209	18.3
131	1797	550399	1542904	19.5	181	Q 0819	535665	1535339	48.8
132	Q 0979	534335	1543330	22.5	182	7388	536474	1535503	61.0
133	MD 0484	518017	1534894	21.3	183	Q 0818	533728	1537386	60.9
134	-	516350	1536032	80.0	184	18015	534525	1536948	42.4
135	-	517087	1535488	24.0	185	MS 0219	532787	1533964	36.6
136	KB 25174	539049	1547875	33.0	186	MS 0218	532665	1533619	54.9
137	Q 0947	538810	1548937	36.0	187	Q 0879	534020	1532735	27.4
138	MS 0087	538242	1548372	38.1	188	Q 0981	532814	1541293	24.0
139	DB 0045	525298	1539089	30.4	189	MS 0340	534778	1531626	60.0
140	KB 25026	525875	1538398	20.7	190	MD 0434	528911	1533900	42.7
141	MS 0212	530474	1540364	30.4	191	MS 0343	530586	1534915	37.5
142	KB 25154	521676	1537133	20.7	192	MS 0339	526188	1531494	42.0
143	-	529726	1543704	24.0	193	Q 0881	529401	1531074	18.3
144	Q 0868	519105	1526535	12.1	194	MS 0156	545264	1523373	24.4
145	-	528099	1534206	24.0	195	MD 0427	545671	1523406	30.5
146	MS0336 (1)	544466	1531587	63.0	196	MS 0215	546761	1526378	18.3
147	MD 0424	554952	1531100	73.2	197	MD 0421	563435	1543901	18.3
148	TP 76	540800	1528805	62.5	198	MD 0173	563038	1541735	30.5
149	MS 0071	538979	1531098	73.1	199	32069	564632	1541944	24.4
150	2404	536938	1529770	19.0	200	MS 0106	565911	1538096	36.6

Table 5 (continued)

NO.	Well ID	UTM Easting	UTM Northing	Depth (m)	NO.	Well ID	UTM Easting	UTM Northing	Depth (m)
201	34274	565964	1538509	41.4	251	KB 25088	565754	1537498	15.2
202	MS 0148	563341	1540228	42.7	252	-	566506	1542677	25.0
203	MS 0152	564761	1540946	48.8	253	MD 0136	557382	1533075	24.4
204	MS 0330	564713	1539636	36.6	254	MS 0259	557618	1533291	42.7
205	14025	564172	1540898	36.8	255	MD 0137	555328	1535210	24.4
206	MS 0150	564594	1539015	30.5	256	MS 0258	555736	1534638	48.8
207	MS 0181	565411	1538530	36.6	257	16035	554336	1535525	36.3
208	DB 42	574904	1537054	30.5	258	-	559057	1533331	30.0
209	-	574621	1537169	28.0	259	MS 0142	559525	1530405	42.7
210	MS 0164	569642	1543217	30.5	260	9605	557824	1530214	60.0
211	MS 0167	569404	1543807	30.5	261	MS 0147	553361	1530085	54.9
212	P 10/306	568518	1544915	23.8	262	16040	555239	1528319	33.3
213	KB 25190	560800	1547382	27.0	263	1787	555910	1535301	40.0
214	1685	561398	1546293	23.0	264	16036	557067	1535778	24.2
215	KB 25192	562585	1547241	33.0	265	MS 0145	557848	1535630	42.7
216	MS 0171	569225	1541510	24.4	266	16034	557145	1534164	27.8
217	27566	569587	1542528	15.3	267	28462	558506	1535933	25.0
218	1097	571842	1537617	25.5	268	KB 25049	558818	1531335	38.0
219	MS 0306	567587	1537803	27.4	269	28464	557667	1534761	18.0
220	30781	566931	1536345	48.8	270	35776	557365	1534255	37.0
221	15907	568193	1536309	30.0	271	32068	555991	1529574	42.7
222	30782	570323	1537184	24.4	272	30398	556010	1528272	36.6
223	27943	570091	1537046	21.4	273	26783	554799	1527816	42.7
224	27925	560207	1528981	30.8	274	9606	557854	1532331	46.0
225	MD 0391	560826	1530039	48.8	275	7079	555963	1532345	21.0
226	MS 0305	567365	1534468	36.6	276	9607	555417	1532388	46.5
227	31811	569857	1541083	24.4	277	7078	555997	1533854	31.5
228	MX 0026	572206	1548517	51.8	278	MS 0174	561559	1535803	42.7
229	MD 0253	570363	1549168	30.5	279	MS 0296	560821	1536478	36.6
230	27548	568257	1545706	21.4	280	MS 0301	560315	1534853	36.6
231	MD 0423	570347	1535968	42.7	281	27550	560795	1535878	31.5
232	MD 0422	569488	1535415	21.3	282	27551	561524	1536413	32.6
233	34778	569710	1535182	42.7	283	8986	570350	1543167	30.0
234	MS 0168	571547	1535762	33.5	284	MD 0419	572398	1543167	30.5
235	MS 0169	572773	1535069	36.7	285	MD 0418	572370	1545907	30.5
236	MS 0170	572000	1535712	24.4	286	27567	574262	1542049	21.4
237	18292	569802	1534716	37.2	287	MD 0268	568174	1553455	54.9
238	20569	570830	1533893	63.6	288	MS 0179	565492	1552222	35.6
239	MS 0044	565169	1527460	60.9	289	MS 0180	564561	1552883	30.6
240	26780	568324	1527413	36.6	290	MS 0177	566389	1547922	42.7
241	MS 0078	575445	1534155	33.5	291	13627	566663	1550709	43.0
242	MS 0172	574316	1533287	30.5	292	31803	561078	1523493	45.7
243	31809	574616	1534120	33.5	293	34585	561817	1523399	42.7
244	MS 0229	570956	1532984	27.4	294	MD 0228	564284	1523468	71.8
245	MS 0227	570550	1531825	32.0	295	MD 0522	564112	1524081	60.9
246	MD 0267	569656	1529277	76.2	296	31218	564972	1525317	30.5
247	14955	568672	1541271	20.0	297	30776	563739	1522970	42.7
248	27549	565657	1542432	21.4	298	MS 0063	556836	1522589	73.2
249	MS 0328	567413	1538492	24.4	299	36636	556682	1522218	60.0
250	3290	566397	1538798	32.5	300	32460	554826	1523207	67.2

Table 5 (continued)

NO.	Well ID	UTM Easting	UTM Northing	Depth (m)	NO.	Well ID	UTM Easting	UTM Northing	Depth (m)
301	TP-10	557428	1527254	30.0	351	MS 0310	579509	1536537	27.4
302	32065	553529	1524192	61.0	352	-	578790	1535502	24.0
303	32066	559960	1526695	21.4	353	33824	577648	1535698	18.3
304	S 0039	561528	1524113	45.7	354	2389	577362	1535047	30.5
305	26913	556940	1523464	60.9	355	7304	579861	1541655	42.0
306	32064	556588	1526776	24.4	356	14555	579662	1540237	36.0
307	26781	556188	1525817	24.4	357	1981	578822	1536241	28.0
308	14525	558524	1527936	19.0	358	MS 0085	578862	1538382	30.5
309	31798	563795	1525273	27.5	359	17876	578701	1539032	27.4
310	34799	563460	1524719	79.3	360	MS 0188	589322	1534026	39.6
311	31799	556522	1523502	42.7	361	27564	590323	1533687	21.4
312	TP 12	557091	1525505	18.0	362	27563	589615	1534488	18.3
313	-	555378	1522473	55.0	363	KB 25204	590817	1536394	33.0
314	-	557510	1526407	28.0	364	MS 0189	550501	1536104	42.7
315	-	578324	1532019	30.0	365	MS 0190	589765	1535733	42.7
316	26778	577295	1531918	42.7	366	27565	589582	1535490	33.5
317	TP-9	578672	1531932	36.0	367	27560	589306	1545227	36.5
318	14258	578039	1531709	43.0	368	KB 25082	577496	1547144	21.3
319	MS 0220	581633	1533504	27.4	369	-	578255	1547045	20.0
320	MS 0298	580787	1532360	27.4	370	KB 25016	583833	1537808	39.6
321	KB 25009	580681	1532728	30.5	371	27573	587537	1538874	26.5
322	14256	580335	1532143	36.8	372	16868	587761	1535370	24.3
323	MS 0297	579846	1533171	32.0	373	33818	587784	1536410	33.6
324	14253	580729	1533953	60.0	374	17878	580720	1543160	33.4
325	31810	580830	1535811	27.7	375	MS 0081	588793	1532057	48.8
326	MS 0381	578620	1534554	27.0	376	-	587927	1532053	44.0
327	14254	579693	1532574	55.0	377	-	587202	1529929	44.0
328	KB 25195	576940	1532842	27.0	378	7401	586326	1531457	48.5
329	30780	575523	1530324	28.0	379	27545	586825	1531187	42.7
330	14406	575707	1530648	24.6	380	MD 0304	586227	1531980	39.6
331	34586	585440	1529869	30.5	381	14410	585221	1531169	40.0
332	KB 25008	584897	1528626	29.0	382	-	585319	1531563	42.0
333	MS 0037	583507	1530058	19.8	383	MS 0030	587664	1532795	36.6
334	MS 0038	587278	1527522	41.2	384	DB 43	586915	1533374	36.6
335	MS 0039	582608	1529270	30.5	385	16693	586150	1534098	30.3
336	MS 0300	582327	1528888	24.4	386	32072	585995	1533421	39.6
337	Q 0190	579935	1529947	18.3	387	KB 25127	584402	1532165	21.3
338	15911	579887	1529522	30.5	388	MS 0031	583304	1533070	30.5
339	27543	581148	1531116	30.5	389	MS 0221	583271	1531968	30.5
340	736	581665	1530778	28.3	390	27562	583762	1532811	24.4
341	1056	579725	1530227	16.8	391	-	584460	1548914	14.0
342	-	579421	1531327	24.0	392	-	584705	1549200	15.0
343	DB 41	581444	1538544	30.5	393	KB 25104	583376	1548519	21.3
344	MS 0028	580523	1540065	30.5	394	-	582299	1549323	30.0
345	-	580936	1539784	54.0	395	14954	588911	1535266	36.2
346	-	580716	1540799	24.0	396	-	589440	1536084	36.0
347	-	579907	1542125	24.0	397	-	589331	1539638	33.0
348	MS 0100	578040	1538960	30.5	398	497	591334	1538262	53.4
349	14554	577707	1539019	27.0	399	MS 0327	589943	1541337	36.6
350	14553	578344	1540873	24.4	400	MS 0083	590992	1542234	42.7

Table 5 (continued)

NO.	Well ID	UTM Easting	UTM Northing	Depth (m)	NO.	Well ID	UTM Easting	UTM Northing	Depth (m)
401	MS 0311	592788	1540842	30.5	451	MS 0001	565740	1560616	30.5
402	-	592906	1541751	24.0	452	Q 0782	568996	1561032	24.4
403	-	594264	1541954	28.0	453	Q 0801	565108	1567122	41.2
404	MS 0275	592182	1544110	36.0	454	-	580865	1580808	91.5
405	-	591451	1545358	36.0	455	MD 0185	580815	1580098	54.9
406	33826	588034	1552083	18.3	456	MD 0466	577293	1580883	30.5
407	-	590823	1551362	14.0	457	Q 0886	578941	1579371	18.3
408	MS 0222	590507	1553950	18.3	458	17135	576886	1580666	36.6
409	14691	588930	1548926	12.0	459	17143	588853	1580375	24.4
410	27561	588951	1552851	27.0	460	MS 0321	583500	1577679	35.1
411	MS 0223	587397	1554267	36.6	461	P 16/142	583452	1577332	42.7
412	-	586184	1553026	15.0	462	Q 0201	574606	1576367	30.5
413	-	586981	1556728	50.0	463	MD 0183	574881	1578847	36.6
414	7297	587374	1555278	41.0	464	17144	587800	1578986	30.4
415	1071	583606	1555156	42.2	465	17142	587389	1579973	24.3
416	-	584775	1553918	18.0	466	17692	582896	1578202	54.4
417	Q 0214	579288	1553914	42.8	467	20296	573633	1577515	43.0
418	Q 0205	580706	1556902	48.8	468	Q 0832	572701	1578011	48.8
419	MS 0332	574774	1550908	30.0	469	Q 0781	578142	1584284	51.8
420	MD 0470	573111	1552695	27.4	470	17139	582213	1580510	36.6
421	KB 25013	576040	1556244	53.4	471	MS 0019	572436	1587335	24.4
422	Q 0213	576521	1554378	61.1	472	Q 0797	579822	1586131	36.6
423	DB 44	576734	1554364	54.9	473	A 16/329	580514	1586530	21.3
424	17704	572539	1550955	39.5	474	AR 2/87	581064	1586521	48.8
425	MD 0179	571125	1555981	51.8	475	KB 25019	581667	1583726	27.4
426	MD 0469	575597	1558482	42.7	476	MS 0254	581683	1584397	42.7
427	-	571314	1571959	45.0	477	MD 0311	584743	1584368	30.5
428	P15/82	572230	1573035	61.0	478	P 15/110	584564	1588404	24.4
429	Q 0861	572083	1566288	21.3	479	Q 0780	583037	1589739	36.6
430	Q 0786	574115	1566002	79.3	480	Q 0888	584059	1590778	61.0
431	Q 0800	571503	1568003	24.4	481	Q 0887	580834	1589563	30.5
432	Q 0860	573009	1565712	29.0	482	P 15/112	582312	1587953	30.5
433	MS 0025	575536	1571916	21.3	483	Q 0834	581880	1589061	36.6
434	Q 0197	581332	1563548	67.1	484	MD 0508	579765	1590552	35.1
435	Q 0885	581828	1567731	18.3	485	Q 0799	577482	1589116	30.5
436	17703	583491	1569533	48.7	486	MD 0509	577954	1589085	36.6
437	17700	582283	1566189	42.6	487	Q 0932	577269	1589990	36.6
438	MD 0140	583299	1569248	48.8	488	Q 0779	581158	1588175	24.4
439	P 16/308	582924	1573886	27.4	489	Q 0835	579984	1589233	30.5
440	MS 0011	581030	1569292	36.6	490	Q 0798	579164	1590412	24.4
441	MS 0024	586799	1577563	36.6	491	P 16/305	578512	1586812	33.5
442	MS 0088	582988	1569845	54.9	492	Q 0833	579052	1587218	24.4
443	MD 0383	571106	1558708	42.7	493	MD 0513	568904	1582432	24.4
444	TP-37	596539	1576579	49.5	494	22993	569070	1582277	36.2
445	AR 2/89	582718	1570408	43.9	495	P 16/312	571366	1584236	27.4
446	Q 0862	568692	1550154	24.4	496	MS 0060	571145	1574838	24.4
447	MS 0023	567180	1563807	35.1	497	20295	570758	1574545	33.4
448	MS 0007	566617	1565604	24.4	498	Q 0200	571399	1574394	24.4
449	MS 0009	566873	1567288	79.3	499	13135	564683	1586008	35.0
450	21557	570733	1559121	36.4	500	MS 0013	571682	1581061	36.6

Table 5 (continued)

NO.	Well ID	UTM Easting	UTM Northing	Depth (m)	NO.	Well ID	UTM Easting	UTM Northing	Depth (m)
501	MS 0318	572234	1581755	42.7	551	2994	552098	1568851	31.0
502	MS 0026	564717	1585081	24.4	552	Q 0871	554029	1569586	27.4
503	MS 0061	563805	1578688	30.5	553	-	554113	1576824	24.0
504	P 16/152	564846	1579024	36.6	554	MS 0269	549641	1564288	18.3
505	22994	568494	1581491	30.6	555	Q 0865	551894	1568123	21.3
506	TP-42	568347	1577421	54.9	556	Q 0869	554698	1564854	27.4
507	MS 0237	556081	1584138	48.8	557	-	552627	1564088	19.0
508	MS 0238	556883	1583131	42.7	558	-	556479	1564962	41.0
509	Q 0709	556624	1583727	30.5	559	Q 0784	552205	1563702	13.7
510	Q 0964	556537	1583300	24.0	560	-	551297	1564528	24.0
511	Q 0206	555432	1582313	24.4	561	2979	553829	1567922	46.0
512	28924	555612	1584428	43.1	562	TP-16	544587	1575970	21.0
513	28960	554494	1578960	28.4	563	A 16/0223	543113	1576655	70.1
514	-	550019	1583050	62.0	564	9290	545342	1576053	36.5
515	MD 0247	548528	1584486	42.7	565	Q 0872	552158	1571696	18.3
516	-	550198	15790071	60.0	566	-	561301	1573306	30.0
517	23959	552132	578608	18.2	567	Q 0870	559460	1564129	24.4
518	Q 0837	561597	1581511	30.5	568	Q 0867	551642	1570650	21.3
519	Q 0991	561030	1582604	30.0	569	-	544639	1604963	54.0
520	-	562210	1583020	30.0	570	MD 0141	545630	1604990	42.7
521	-	560467	1588817	28.0	571	MS 0323	551840	1605056	36.6
522	-	559033	1588468	20.0	572	4838	550057	1605502	22.0
523	Q 0992	546362	1585522	15.2	573	-	553300	1606039	28.0
524	Q 0993	555865	1588189	36.6	574	24950	540485	1600818	89.5
525	Q 0838	555676	1590457	30.6	575	MD 0375	554966	1601818	42.7
526	MN 0021	550905	1593703	56.4	576	MS 0076	553589	1602474	18.3
527	-	551158	1593528	54.0	577	S 0037	554094	1595532	24.4
528	9309	546604	1591218	85.0	578	KB 25215	556200	1604141	39.0
529	Q 0839	543400	1597053	22.9	579	8448	556771	1594638	35.0
530	-	544640	1595780	30.0	580	9308	556224	1594638	30.8
531	9189	543259	1590537	25.0	581	24137	556467	1596900	49.3
532	-	548404	1587946	20.0	582	-	556917	1597511	48.0
533	MS 0240	547739	1593339	36.6	583	MD 0202	550725	1601613	30.5
534	MS 0241	543286	1595227	33.5	584	MD 0374	549006	1601946	30.5
535	8447	555863	1589814	42.0	585	7865	548313	1602380	25.0
536	-	554684	1605576	30.0	586	MS 0316	551137	1598727	36.6
537	A 16/0135	555660	1605887	15.2	587	MS 0242	552731	1598443	18.3
538	7576	558513	1607419	24.0	588	-	550098	1595844	17.0
539	MS 0114	558131	1604717	36.6	589	MS 0324	557979	1602283	54.9
540	MD 0376	557521	1604288	45.7	590	-	557230	1601324	44.0
541	-	558337	1603338	18.0	591	-	560489	1601596	54.0
542	-	558467	1603678	40.0	592	MD 0468	576643	1614083	30.5
543	-	560058	1605506	44.0	593	MD 0289	574515	1610866	30.5
544	-	560373	1605918	40.0	594	MS 0286	584529	1613523	48.8
545	MD 0318	562679	1607410	30.5	595	MD 0494	583306	1612156	48.8
546	MD 0246	560844	1610331	36.6	596	-	585919	1605827	30.0
547	-	561548	1610162	76.0	597	-	585665	1606038	42.0
548	MS 0266	559879	1604571	61.0	598	7573	588577	1601888	34.5
549	MS 0239	557428	1574679	79.3	599	AR2/126	588503	1602692	33.5
550	S 0035	554813	1573934	91.5	600	MS 0285	582599	1616227	30.5

Table 5 (continued)

NO.	Well ID	UTM Easting	UTM Northing	Depth (m)	NO.	Well ID	UTM Easting	UTM Northing	Depth (m)
601	P16/258	585888	1608017	27.4	651	24138	559400	1612305	30.3
602	P16/336	588470	1600130	27.4	652	MD 0317	557515	1610362	36.6
603	A-54	586960	1600106	61.0	653	MS 0295	550123	1614007	12.2
604	A-53	585745	1602411	48.8	654	5911	550538	1607788	30.0
605	R 8/221	589306	1600648	33.5	655	MD 0175	550147	1607486	36.6
606	Q 0794	577915	1606377	42.7	656	MD 0412	547205	1624449	30.5
607	P 10/192	576868	1607088	45.7	657	MS 0075	551410	1617044	24.4
608	Q 0842	566155	1602800	24.4	658	MD 0411	540283	1621050	36.6
609	MD 0478	564784	1606042	36.6	659	MD 0315	544963	1617697	30.5
610	MD 0320	572698	1602328	54.9	660	Q 0796	542512	1619828	30.5
611	-	576053	1602914	30.0	661	MS 0267	548386	1622946	42.7
612	MD 0292	579578	1594203	24.4	662	MS 0322	547092	1613624	42.8
613	MS 0290	579452	1597433	22.9	663	MD 0464	546723	1626437	42.7
614	MS 0090	580346	1623814	36.6	664	-	545783	1629428	50.0
615	A 16/61	564852	1632234	39.6	665	MD 0416	539932	1623781	30.5
616	MS 0283	574204	1628066	54.9	666	TP-46	552652	1624923	42.8
617	Q 0846	582208	1626740	30.5	667	MS 0274	552113	1626640	24.4
618	A 16/68	584780	1629077	18.3	668	16913	544101	1628085	24.2
619	Q 0847	576830	1631296	24.4	669	MD 0296	545922	1621242	13.7
620	MS 0284	576053	1625891	67.1	670	-	501173	1579483	40.0
621	MD 0323	576106	1626350	36.6	671	Q 0912	483031	1602184	42.7
622	MS 0364	578408	1628739	36.6	672	Q 0911	482768	1602963	24.4
623	Q 0843	574764	1623285	21.3	673	MS 0058	518426	1557098	26.4
624	MS 0353	573155	1622265	12.5	674	-	507848	1557250	26.0
625	MS 0358	562617	1621600	31.5	675	Q 0899	508674	1557831	24.4
626	-	563676	1619737	26.0	676	MS 0059	513921	1559617	73.2
627	Q 0845	578832	1618960	30.5	677	Q 0898	518774	1549804	24.4
628	A16/286	581624	1620213	21.3	678	Q 0957	516074	1546094	27.0
629	MS 0192	586840	1618074	51.8	679	MD 0486	520803	1549866	36.7
630	Q 0848	578537	1623633	24.4	680	-	525112	1555251	24.0
631	-	577384	1620779	30.0	681	Q 0961	530397	1557334	36.0
632	-	579080	1621849	36.0	682	MS 0207	529289	1557875	32.0
633	R 10/1411	573096	1617629	51.9	683	L-45	530695	1546825	20.0
634	MD 0293	583381	1621792	30.5	684	5945	459966	1630032	43.0
635	MS 0281	586593	1620690	27.4	685	36631	577679	1627994	30.5
636	18879	586927	1620602	36.3	686	Q 0908	473325	1609815	24.4
637	MD 0187	585423	1621725	36.6	687	Q 0916	474160	1607579	27.4
638	P 10/290	573162	1619201	18.3	688	Q 0910	477163	1606584	30.5
639	MS 0205	541965	1631259	48.8	689	Q 0913	477900	1607615	15.2
640	MS 0293	536033	1629245	30.5	690	P10/172	479339	1609918	12.2
641	21927	534423	1635524	18.2	691	-	480034	1610762	15.0
642	MS 0292	539040	1633321	22.9	692	Q 0906	474691	1609662	24.4
643	MD 0417	556651	1621990	24.4	693	Q 0905	473687	1608767	30.5
644	A 16/237	555707	1622224	36.6	694	Q 0907	474882	1607993	36.7
645	MS 0243	557506	1614078	54.9	695	13629	456455	1617231	30.7
646	MS 0244	558257	1615965	48.8	696	16911	473826	1618446	30.5
647	MD 0463	558538	1613503	42.7	697	-	470875	1618364	38.0
648	MS 0245	557724	1617214	61.0	698	16912	459264	1651487	60.0
649	MS 0246	557283	1616395	67.1	699	-	431862	1673730	5.0
650	MS 0247	557824	1609629	30.5	700	Q 0944	535005	1621145	21.0

Table 5 (continued)

NO.	Well ID	UTM Easting	UTM Northing	Depth (m)	NO.	Well ID	UTM Easting	UTM Northing	Depth (m)
701	-	513488	1598970	30.0	751	MT 0090	593790	1629400	33.0
702	-	537943	1620909	18.0	752	MT 0064	596400	1632590	45.0
703	KB 25044	486656	1629972	21.3	753	MN 0375	597790	1635960	63.0
704	KB 25042	463782	1626835	39.6	754	MN 0379	587290	1631150	45.0
705	AR2/179	465146	1619793	44.2	755	MN 0276	603340	1636150	51.0
706	KB 25070	465984	1618147	21.3	756	MN 0277	595200	1642400	75.0
707	KB 25039	472812	1610770	39.6	757	MN 0291	582840	1630500	33.0
708	Q 0904	475937	1606868	24.4	758	MN 0275	602700	1628690	79.5
709	P 10/173	472753	1609109	48.8	759	MN 0217	595700	1638000	49.5
710	KB 25071	449648	1620729	27.4	760	MN 0218	592290	1637650	66.0
711	KB 25090	471078	1612556	33.5	761	MN 0172	585150	1630500	45.0
712	KB 25041	466984	1612959	27.4	762	MN 0173	579340	1633750	33.0
713	Q 0915	472326	1614022	18.3	763	MN 0027	590250	1637400	39.0
714	2549	471377	1615257	19.5	764	MT 0023	627000	1608500	120.0
715	13629	474485	1616361	45.9	765	MT 0024	625500	1606500	117.0
716	24952	514625	1570001	66.7	766	MN 0201	619900	1599940	262.5
717	MS 0122	510204	1568441	27.4	767	MT 0059	620790	1599690	100.5
718	KB 25223	501946	1578522	39.0	768	MT 0079	620500	1599190	99.0
719	KB 25161	510731	1570382	51.2	769	MN 0365	620700	1600190	105.0
720	KB 25037	486700	1590881	24.4	770	MN 0134	621090	1599940	273.0
721	KB 25056	487933	1595097	27.4	771	MN 0239	621290	1600690	117.0
722	KB 25159	499887	1555345	20.7	772	MN 0032	620250	1599750	267.0
723	KB 25156	500433	1559211	45.1	773	MT 0047	617790	1599800	114.0
724	KB 25157	516510	1558070	32.9	774	MT 0077	618400	1600190	111.0
725	KB 25158	512536	1553615	32.9	775	MN 0303	617400	1600090	120.0
726	MX 0031	520765	1557473	30.5	776	MN 0254	620290	1600840	120.0
727	KB 25093	523005	1552557	27.4	777	MN 0114	621150	1599250	123.0
728	MD 0502	517204	1549513	30.5	778	MN 0184	620840	1597900	93.0
729	MS 0209	527796	1551020	19.8	779	MN 0265	619250	1600340	123.0
730	KB 25097	525494	1556781	45.7	780	MN 0143	620900	1596900	135.0
731	MN 0310	579090	1636800	30.0	781	MN 0360	621450	1598250	96.0
732	MN 0311	574500	1635300	21.0	782	MN 0316	621450	1597690	145.5
733	MN 0312	598790	1633840	24.0	783	MN 0266	624040	1596750	123.0
734	MN 0273	591590	1639150	21.0	784	MN 0299	624400	1597500	114.0
735	MN 0171	583400	1636840	27.0	785	MN 0156	607150	1603090	165.0
736	MT 0087	600400	1627400	66.0	786	MN 0205	621200	1597250	111.0
737	MT 0088	595290	1629090	60.0	787	MN 0051	622840	1595650	150.0
738	MT 0089	603290	1625090	60.0	788	MN 0072	624040	1600440	121.5
739	MT 0066	605290	1625590	87.0	789	MN 0183	626090	1599150	99.0
740	MT 0067	602200	1626800	66.0	790	MT 0098	628200	1598800	111.0
741	MT 0062	596400	1625300	51.0	791	MN 0136	627750	1598440	153.0
742	MT 0063	506890	1623400	63.0	792	MN 0052	633450	1600190	174.0
743	MN 0376	602650	1631250	93.0	793	MN 0135	633450	1599440	147.0
744	MN 0313	605540	1626500	105.0	794	DF 0212	627499	1598987	100.5
745	MN 0216	599450	1624500	70.5	795	MN 0229	632400	1602090	118.5
746	MN 0351	601150	1640650	93.0	796	MN 0241	632400	1601050	105.0
747	MN 0307	603700	1637400	109.5	797	MN 0340	628000	1608000	120.0
748	MN 0308	602340	1638050	105.0	798	MN 0122	628650	1602690	138.0
749	MN 0309	600700	1633590	105.0	799	MN 0182	628950	1600550	129.0
750	MT 0065	594700	1635400	42.0	800	MN 0199	614250	1596500	132.0

Table 5 (continued)

NO.	Well ID	UTM Easting	UTM Northing	Depth (m)	NO.	Well ID	UTM Easting	UTM Northing	Depth (m)
801	MN 0067	628150	1601090	123.0	851	MT 0069	592700	1600190	30.0
802	MT 0084	629590	1608500	117.0	852	MN 0282	590500	1606190	33.0
803	MT 0085	607900	1606590	66.0	853	MN 0306	602150	1605840	45.0
804	MN 0141	628840	1608090	90.0	854	MN 0178	590340	1607440	21.0
805	MN 0137	629450	1608800	127.5	855	MN 0179	592290	1600190	30.0
806	MN 0140	627150	1605590	117.0	856	MN 0008	598750	1606900	93.0
807	MT 0022	620200	1605400	114.0	857	MT 0073	596700	1605190	21.0
808	MN 0342	620590	1604590	114.0	858	MT 0074	595400	1595190	21.0
809	MN 0287	621700	1605590	117.0	859	MT 0075	595400	1607500	21.0
810	MN 0233	620900	1605690	118.5	860	MN 0284	589900	1593050	22.5
811	MT 0078	615500	1601000	111.0	861	MT 0037	596500	1606800	18.0
812	MN 0357	615900	1600900	123.0	862	MN 0252	594250	1594840	24.0
813	MN 0231	616540	1595750	124.5	863	MT 0048	603400	1599690	36.0
814	MN 0232	614900	1599050	109.5	864	MT 0032	602200	1598590	30.0
815	S 0064	610590	1602500	153.0	865	MT 0007	603290	1596800	33.0
816	MN 0157	604450	1604250	159.0	866	MN 0367	594790	1596400	33.0
817	MT 0038	601090	1613400	63.0	867	MT 0006	595700	1598090	63.0
818	MT 0009	604790	1611190	70.5	868	MN 0253	591700	1598590	28.5
819	MN 0358	602750	1611650	63.0	869	MN 0180	592750	1598000	21.0
820	MN 0181	612590	1610050	249.0	870	MN 0213	590040	1599900	18.0
821	MN 0237	604340	1610000	181.5	871	MN 0214	596450	1598500	39.0
822	MN 0040	607250	1609590	201.0	872	Q 0202	590450	1577400	36.0
823	MN 0238	609150	1598150	150.0	873	S 0066	594090	1583750	85.5
824	MN 0294	605400	1600400	123.0	874	MN 0106	592540	1580050	85.5
825	MT 0041	606900	1591800	99.0	875	MN 0057	594000	1584340	81.0
826	S 0065	607950	1595750	153.0	876	DMR 002	594540	1588190	35.4
827	MN 0335	608200	1595400	159.0	877	MD 0060	590040	1576440	87.0
828	MT 0025	623290	1602500	105.0	878	MN 0297	600650	1581340	99.0
829	MN 0142	625200	1604400	147.0	879	MN 0055	612750	1639000	141.0
830	MN 0200	625000	1604190	118.5	880	MN 0317	612200	1636800	30.0
831	S 0022	620650	1605690	165.0	881	MN 0350	623290	1629090	33.0
832	MN 0349	608500	1609190	112.5	882	S 0025	618450	1628150	141.0
833	MT 0016	619290	1608690	99.0	883	MN 0363	618290	1629400	87.0
834	MT 0049	616500	1606000	75.0	884	MN 0371	612790	1629300	81.0
835	MT 0042	600000	1611500	39.0	885	MN 0372	611250	1634400	66.0
836	MN 0292	594450	1611550	60.0	886	MN 0268	607000	1626650	109.5
837	MT 0004	597340	1610500	24.0	887	MN 0030	585250	1559340	69.0
838	MN 0109	590900	1614150	51.0	888	MN 0100	596590	1563590	201.0
839	MN 0011	598150	1609940	33.0	889	MN 0322	607290	1567090	111.0
840	MN 0029	589700	1612150	30.0	890	MN 0336	606590	1565000	90.0
841	MN 0108	589650	1612750	43.5	891	MN 0369	622250	1569750	141.0
842	MD 0459	587650	1613090	30.0	892	MT 0034	625400	1571190	87.0
843	MT 0031	589500	1614500	43.5	893	MN 0318	623900	1565500	165.0
844	MT 0029	596290	1612800	33.0	894	MN 0321	623250	1569750	142.5
845	MT 0030	598400	1609500	30.0	895	MN 0368	625290	1566900	159.0
846	MT 0115	600590	1607590	90.0	896	MT 0070	620590	1566690	114.0
847	MT 0072	593790	1601400	30.0	897	MN 0104	605290	1581090	108.0
848	MT 0083	599000	1605300	72.0	898	MN 0319	607900	1570190	57.0
849	MT 0002	592900	1605500	31.5	899	MN 0325	605650	1569690	123.0
850	MT 0068	593400	1599900	39.0	900	MN 0323	608090	1574690	93.0

Table 5 (continued)

NO.	Well ID	UTM Easting	UTM Northing	Depth (m)	NO.	Well ID	UTM Easting	UTM Northing	Depth (m)
901	MN 0324	605290	1572590	87.0	951	MN 0344	615090	1587500	105.0
902	MC 0485	602900	1571250	117.0	952	MT 0027	613700	1585590	72.0
903	MN 0101	609250	1566400	165.0	953	MT 0028	607400	1584300	96.0
904	MN 0097	602540	1567300	135.0	954	MN 0327	613340	1585900	99.0
905	MN 0099	598900	1566500	136.5	955	MT 0026	614700	1585000	78.0
906	MN 0058	605040	1564050	57.0	956	MN 0295	636000	1594550	99.0
907	MN 0096	604650	1565800	111.0	957	MN 0296	609790	1583550	57.0
908	MN 0095	596750	1571050	120.0	958	MN 0326	615700	1585800	66.0
909	MN 0093	588650	1572250	22.2	959	MT 0019	622400	1594590	96.0
910	MN 0130	590590	1624650	42.0	960	MT 0033	619500	1592500	102.0
911	MN 0127	590090	1626800	48.0	961	MT 0008	624790	1592000	111.0
912	MN 0013	600250	1621500	69.0	962	S 0023	626090	1590090	123.0
913	MN 0099	612900	1620690	123.0	963	MT 0021	622790	1580400	117.0
914	MN 0012	605340	1623050	33.0	964	MT 0001	624400	1582300	90.0
915	MT 0039	607290	1616300	75.0	965	MN 0314	619500	1583400	94.5
916	MN 0261	609340	1616090	63.0	966	MN 0361	622700	1579690	72.0
917	MN 0262	607500	1611690	123.0	967	MT 0043	634300	1579000	111.0
918	MN 0023	598790	1615190	54.0	968	MT 0018	634200	1585090	108.0
919	MN 0329	597790	1616900	61.5	969	MT 0017	622700	1594590	111.0
920	MN 0211	595950	1622900	34.5	970	MT 0044	624790	1591690	108.0
921	MN 0175	592000	1619300	39.0	971	MN 0206	624900	1593000	106.5
922	MN 0210	596450	1617800	112.5	972	MD 0455	556590	1653900	33.0
923	MN 0126	595150	1617750	105.0	973	MD 0453	559500	1653590	21.0
924	MN 0174	589400	1621750	33.0	974	MD 0454	562700	1652500	57.0
925	MT 0092	587700	1624690	25.5	975	MC 0484	577950	1653440	34.5
926	MT 0093	588790	1624400	27.0	976	MC 0479	573840	1649000	22.5
927	MN 0177	588590	1624800	39.0	977	MD 0451	575150	1654840	30.0
928	MN 0129	587400	1624940	27.0	978	MD 0449	568540	1653300	30.0
929	S 0024	616750	1611400	123.0	979	MD 0450	568400	1656690	24.0
930	MT 0102	602790	1620090	100.5	980	MN 0378	573840	1645590	45.0
931	MN 0236	608400	1615440	150.0	981	MN 0302	573650	1640150	36.0
932	S 0063	589250	1626150	42.0	982	MN 0263	575150	1638190	37.5
933	MT 0100	613400	1620500	105.0	983	MN 0073	573340	1647500	42.0
934	MT 0101	607400	1623800	105.0	984	MN 0028	570500	1637800	27.0
935	MT 0071	616090	1620800	117.0	985	MD 0444	579900	1638550	30.0
936	MN 0250	623750	1611440	91.5	986	MD 0445	565900	1641500	24.0
937	MN 0374	625900	1610250	102.0	987	MD 0446	578000	1650400	37.5
938	MN 0069	625250	1614250	165.0	988	MC 0478	571540	1646400	36.0
939	MT 0113	623400	1623590	93.0	989	Q 0362	554790	1652900	46.5
940	MN 0026	628650	1625500	55.5	990	MN 0163	599340	1647400	48.0
941	MN 0068	627500	1623800	87.0	991	MN 0159	606590	1643690	60.0
942	MN 0070	631790	1620440	63.0	992	MN 0160	602700	1645190	63.0
943	MN 0071	625400	1618440	57.0	993	MN 0015	602250	1645690	99.0
944	MN 0025	630590	1622300	51.0	994	MN 0269	590900	1651150	36.0
945	MT 0118	621000	1585800	102.0	995	MN 0169	598750	1646900	36.0
946	MN 0234	622540	1587840	126.0	996	MN 0170	592040	1644050	45.0
947	MN 0235	621040	1583840	100.5	997	MN 0044	605900	1642340	111.0
948	MN 0267	624090	1587050	114.0	998	MN 0289	604750	1642550	93.0
949	MN 0345	614700	1590400	96.0	999	MN 0045	600750	1643500	105.0
950	MN 0343	613400	1589090	111.0	1000	MN 0271	624790	1634900	66.0

Table 5 (continued)

NO.	Well ID	UTM Easting	UTM Northing	Depth (m)	NO.	Well ID	UTM Easting	UTM Northing	Depth (m)
1001	MN 0053	629750	1637150	105.0	1051	N 0054	564700	1505400	30.0
1002	MN 0042	622040	1647590	87.0	1052	N 0047	564000	1505700	33.0
1003	MT 0011	608900	1641500	45.0	1053	MS 0043	561900	1505600	36.0
1004	MN 0290	613590	1642690	58.5	1054	25076	567500	1503600	22.5
1005	MN 0281	610500	1646340	42.0	1055	N 0055	566300	1503800	45.0
1006	MN 0043	613400	1641400	12.0	1056	7602	567900	1503800	29.5
1007	MN 0168	605400	1643750	63.0	1057	R4/28	567200	1505000	28.5
1008	MN 0164	603590	1647550	39.0	1058	R 1134	563000	1504500	36.0
1009	MN 0166	604150	1644340	57.0	1059	N 0052	569000	1505300	45.0
1010	MN 0167	604900	1644150	57.0	1060	18242	568800	1504400	65.0
1011	MN 0161	601000	1645550	75.0	1061	MD 0342	568400	1503100	69.1
1012	MN 0362	617590	1644190	36.0	1062	15414	566900	1501400	30.5
1013	MN 0279	621150	1645090	69.0	1063	5694	566600	1500600	16.7
1014	18725	546800	1519200	25.1	1064	MS 0047	565700	1501600	28.5
1015	MD 0327	546500	1520400	30.0	1065	25075	564300	1504200	22.5
1016	25087	545600	1522400	30.0	1066	15444	562600	1508200	37.4
1017	18270	545100	1518400	36.9	1067	MD 0305	547500	1512700	36.0
1018	18271	544300	1519600	36.9	1068	25059	549100	1512900	30.0
1019	25084	543500	1521100	31.5	1069	16791	551300	1509700	31.5
1020	C 0720	547000	1519800	33.0	1070	15939	551000	1508500	39.4
1021	18281	548900	1517300	19.2	1071	Q 0315	549600	1508600	42.0
1022	13425	550300	1516600	17.7	1072	N 0059	549500	1509100	30.0
1023	18923	552100	1521000	19.7	1073	MD 0154	553200	1509500	30.0
1024	18914	552000	1518200	31.0	1074	R 0734	552500	1509600	30.0
1025	18121	552000	1519900	42.8	1075	R 0733	552200	1510500	18.0
1026	R 0634	551700	1519100	30.0	1076	18261	548400	1506900	22.6
1027	Q 0314	550800	1519200	40.5	1077	18245	548200	1506800	13.9
1028	17862	548900	1522900	31.0	1078	R 0233	546700	1505600	24.0
1029	18269	547700	1514900	31.0	1079	Q 0316	546300	1505700	24.0
1030	18239	547200	1515200	36.9	1080	25089	546200	1504300	36.0
1031	18238	546700	1515500	36.9	1081	C 0734	545000	1505100	24.0
1032	18237	546600	1516700	42.8	1082	16456	542100	1514600	43.3
1033	18233	546400	1517500	36.9	1083	MD 0306	541900	1513300	30.0
1034	18236	546000	1516000	42.8	1084	R 0534	541400	1513100	24.0
1035	18235	544500	1516700	42.8	1085	18267	538900	1516200	25.6
1036	18234	542800	1518500	37.2	1086	18024	542100	1511100	39.4
1037	R 0532	553100	1512300	29.1	1087	18266	541200	1512100	36.4
1038	16786	550800	1524200	31.0	1088	C 0640	546500	1510900	30.0
1039	15411	555700	1518100	121.6	1089	25049	545800	1509900	28.5
1040	13392	555700	1518600	65.0	1090	18023	545100	1508500	44.3
1041	R 0834	555200	1516800	30.0	1091	18265	544000	1509300	25.6
1042	18283	538300	1518100	25.1	1092	18268	548700	1513900	44.3
1043	18282	537100	1518800	36.9	1093	MS 0046	551600	1513400	21.0
1044	18280	536000	1517000	31.0	1094	C 0721	551200	1512000	22.5
1045	18279	536000	1517600	25.1	1095	17269	548200	1512600	47.3
1046	MD 341	535600	1518000	33.0	1096	18913	556900	1509600	51.2
1047	R 1034	535400	1518500	30.0	1097	25079	555900	1509700	22.5
1048	MD 0339	550400	1519600	16.5	1098	R 0432	557700	1514000	29.1
1049	MD 0071	565900	1505900	28.5	1099	15395	557200	1514700	18.7
1050	N 0060	566900	1506100	33.0	1100	MD 0430	555400	1514800	42.0

Table 5 (continued)

NO.	Well ID	UTM Easting	UTM Northing	Depth (m)	NO.	Well ID	UTM Easting	UTM Northing	Depth (m)
1101	C 0717	560500	1507000	25.5	1151	16123	603300	1501300	144.8
1102	C 0638	561500	1511700	42.0	1152	MD 0287	604100	1501300	171.2
1103	15415	560700	1510300	42.3	1153	19038	604200	1502400	161.5
1104	C 0639	559500	1511000	36.0	1154	MD 0273	605200	1502100	177.2
1105	25008	558300	1512100	51.0	1155	MD 0225	607500	1504200	183.2
1106	R 0832	554200	1513000	24.0	1156	18104	606900	1503800	182.2
1107	25060	574500	1503700	31.5	1157	691	605800	1503600	182.2
1108	C 0739	574000	1503500	39.0	1158	MD 0338	605900	1503000	210.2
1109	MD 0070	577500	1505500	21.0	1159	8983	606700	1503700	177.3
1110	C 0648	576800	1505700	30.0	1160	418	608000	1504400	121.1
1111	C 0647	576800	1506400	36.0	1161	19580	610400	1495500	128.0
1112	5693	573100	1508800	38.4	1162	17667	609600	1497500	178.3
1113	C 0644	572500	1509600	42.0	1163	2338	608900	1500500	144.1
1114	N 0064	574800	1509900	36.0	1164	2061	605100	1497900	167.4
1115	R5/28	574600	1510200	28.5	1165	9198	611900	1501600	85.2
1116	C 0632	565100	1513900	27.0	1166	498	610700	1506500	117.1
1117	R3/28	565000	1512100	28.5	1167	2643	610500	1506200	155.6
1118	25029	570200	1512200	30.0	1168	MD 0198	597900	1503200	201.2
1119	17475	572900	1512200	30.0	1169	9291	598300	1503400	206.8
1120	7391	569000	1512200	47.3	1170	403	599500	1506100	129.0
1121	17474	569900	1512900	30.0	1171	MN 0061	598500	1499600	186.2
1122	C 0633	567800	1513900	36.0	1172	16120	598300	1499800	177.9
1123	25077	578700	1507200	46.5	1173	8913	600000	1497100	203.4
1124	MD 0072	578000	1508100	31.5	1174	MN 0195	600000	1497300	121.0
1125	17473	570400	1507300	25.5	1175	2394	601800	1502400	146.8
1126	C 0635	570000	1509500	30.0	1176	14034	601900	1502500	181.7
1127	C 0634	569600	1509300	36.0	1177	1068	601000	1502500	148.2
1128	C 0645	574500	1507800	36.0	1178	19130	609800	1495700	165.5
1129	25030	563000	1515000	75.1	1179	MN 0196	599000	1494100	141.1
1130	C 0643	556300	1502400	42.0	1180	MD 0199	601000	1495500	192.2
1131	MD 0073	561800	1502200	57.0	1181	18493	611600	1513800	147.7
1132	25074	555200	1504100	34.5	1182	18296	608200	1511500	143.8
1133	MD 0241	562300	1497700	36.0	1183	10469	612600	1512700	189.1
1134	Q 0163	561600	1497600	75.1	1184	1439	615200	1511100	156.6
1135	25043	562900	1497900	45.0	1185	6996	613600	1513000	172.4
1136	N0063	558300	1504400	45.0	1186	4948	613800	1510600	162.5
1137	18922	556400	1501300	42.8	1187	5721	610700	1515500	140.8
1138	25080	555800	1507700	48.0	1188	13218	607000	1515300	142.3
1139	18877	555400	1505100	42.8	1189	7569	608000	1517700	148.2
1140	25086	562600	1497200	36.0	1190	5194	609000	1517000	141.3
1141	C 0718	558200	1506300	30.0	1191	14440	610100	1518200	118.7
1142	R 0932	558000	1501400	24.6	1192	183	600600	1514400	113.1
1143	C 0722	560800	1501500	30.0	1193	5291	600300	1514700	145.3
1144	MD 0288	608500	1494400	180.0	1194	1715	600300	1513900	147.1
1145	MN 0060	602800	1500000	180.0	1195	460	600800	1513400	123.1
1146	21048	605700	1500000	159.6	1196	442	601300	1512800	111.1
1147	25035	605700	1500200	162.0	1197	5771	605700	1513300	116.2
1148	18038	604400	1502500	163.0	1198	1073	602500	1512100	117.1
1149	13404	604000	1502100	167.9	1199	1683	610600	1508100	152.3
1150	8984	604000	1502400	191.1	1200	7084	611500	1506000	156.6

Table 5 (continued)

NO.	Well ID	UTM Easting	UTM Northing	Depth (m)	NO.	Well ID	UTM Easting	UTM Northing	Depth (m)
1201	8595	611200	1508100	160.1	1251	MS 0160	576400	1526000	18.0
1202	7083	614600	1509200	161.5	1252	17471	575800	1524000	37.4
1203	4949	613600	1508000	161.5	1253	7371	574400	1525000	26.6
1204	424	597800	1514800	74.8	1254	17273	577900	1525400	48.7
1205	1193	598900	1514500	156.2	1255	12253	575000	1528400	24.1
1206	1108	601400	1517900	104.4	1256	12254	571100	1527400	37.4
1207	MD 0436	600000	1517400	57.0	1257	15736	570800	1527800	36.4
1208	X 0067	599300	1510900	168.2	1258	MD 0395	570700	1528700	36.0
1209	17666	599700	1512000	177.8	1259	MS 0158	570000	1527400	49.5
1210	4983	598600	1511500	148.7	1260	1710	591700	1524800	53.7
1211	5007	599500	1509300	150.7	1261	7406	590300	1525700	38.1
1212	13637	601300	1509200	150.7	1262	18494	587600	1526100	39.4
1213	MS 0064	599800	1508800	190.7	1263	652	601400	1522200	53.7
1214	1107	599900	1508000	180.2	1264	700	596200	1522000	53.2
1215	9836	602300	1509200	177.3	1265	15729	595500	1527100	76.8
1216	10000	606100	1508000	183.7	1266	1020	593800	1530400	68.4
1217	7570	606800	1509800	160.1	1267	C 0495	593400	1530700	72.0
1218	9999	605700	1510800	152.7	1268	378	595500	1532200	83.7
1219	MD 0272	607700	1509900	183.2	1269	C 0496	593400	1538400	60.0
1220	15805	594600	1541000	48.1	1270	367	592500	1534100	68.9
1221	710	593100	1536400	26.8	1271	17877	592200	1534300	63.0
1222	25082	592900	1537800	28.5	1272	MD 0439	594400	1527400	81.1
1223	MD 0498	593600	1537900	30.0	1273	12687	591400	1522100	42.8
1224	778	596300	1536400	30.0	1274	MS 0136	586600	1523000	36.0
1225	7405	599000	1539500	77.8	1275	1936	592700	1530200	87.1
1226	1547	598000	1539500	38.8	1276	1926	591500	1528900	43.6
1227	14404	595200	1541400	48.1	1277	364	592000	1527600	83.7
1228	MD 0097	580400	1527300	36.0	1278	2633	596600	1529800	58.1
1229	MD 0075	579900	1523200	39.0	1279	362	597300	1527900	83.7
1230	13397	580700	1525000	42.3	1280	7370	598300	1528200	48.3
1231	Q 0159	580000	1524700	51.0	1281	112	593900	1527900	75.3
1232	Q 0161	582100	1523300	54.0	1282	X 0064	594300	1527800	135.1
1233	MD 0040	581600	1524100	69.1	1283	1947	588800	1531800	62.1
1234	N 0075	581300	1522800	18.0	1284	14817	602900	1527000	64.0
1235	Q 0160	578600	1524200	30.0	1285	7301	601700	1527400	42.3
1236	N 0071	577100	1523200	19.0	1286	14818	601400	1526000	59.6
1237	14945	578500	1526200	72.3	1287	14557	600500	1526000	65.0
1238	12252	577800	1526900	36.4	1288	MS 0036	600900	1526000	70.6
1239	14947	576900	1529100	56.1	1289	18490	598600	1526700	78.8
1240	N 0070	577600	1525500	31.5	1290	18491	600300	1528400	59.1
1241	25040	574300	1526900	28.5	1291	7302	604300	1528700	27.6
1242	13396	575000	1526400	48.7	1292	25034	586600	1524700	33.0
1243	15731	574500	1526100	30.5	1293	R2/29	585600	1524500	46.5
1244	Q 0162	571900	1525200	42.0	1294	13612	583500	1525400	27.1
1245	1492	571200	1525200	23.6	1295	13610	581100	1528600	30.0
1246	MD 0396	571100	1524700	30.0	1296	1961	585400	1527400	33.0
1247	MS 0159	573600	1526200	18.0	1297	13611	581500	1527400	31.5
1248	16503	568500	1522500	90.6	1298	13613	583000	1527100	29.5
1249	MS 0156	572800	1528600	34.5	1299	15737	584200	1521400	34.5
1250	N 0076	571500	1528100	30.0	1300	MS 0135	584200	1251500	34.5

Table 5 (continued)

NO.	Well ID	UTM Easting	UTM Northing	Depth (m)	NO.	Well ID	UTM Easting	UTM Northing	Depth (m)
1301	644	597000	1525300	60.0	1351	9748	577600	1473400	55.1
1302	638	598000	1527700	51.2	1352	MD 0407	567800	1477200	30.0
1303	1070	596900	1522500	59.1	1353	7579	577700	1475400	41.4
1304	1790	602500	1524500	79.3	1354	MD 0406	577900	1476500	48.0
1305	1054	604300	1526100	93.6	1355	MD 0158	573900	1487900	45.0
1306	373	599000	1527300	68.9	1356	13608	570800	1489000	72.4
1307	1513	588600	1478600	48.0	1357	9750/1	573000	1487400	32.5
1308	25011	589000	1478200	57.0	1358	MD 0201	573500	1491500	24.0
1309	MD 0059	584300	1479100	30.0	1359	MD 0157	571500	1490800	22.5
1310	MD 0052	586000	1478300	30.0	1360	25069	570900	1491500	28.5
1311	20783	585600	1478700	23.6	1361	13607	564800	1488700	31.5
1312	25014	586800	1477800	27.0	1362	20577	571800	1521700	23.6
1313	MD 0082	573400	1491800	24.0	1363	MS 0134	579400	1512600	24.0
1314	MD 0172	582700	1485200	24.0	1364	5557	576000	1514500	16.4
1315	MD 0047	582500	1485400	30.0	1365	MD 0400	579500	1513800	30.0
1316	MS 0095	579000	1484800	38.0	1366	4404	579400	1514500	24.6
1317	25078	578500	1485200	46.5	1367	8484	580300	1515700	36.4
1318	7581	575700	1483700	23.6	1368	6414	581500	1516400	30.5
1319	MD 0224	584400	1486000	24.0	1369	MD 0092	577900	1519400	30.0
1320	MD 0329	579800	1481700	48.0	1370	15386	574400	1521500	31.5
1321	25020	579400	1483200	45.0	1371	5558	574900	1514400	18.4
1322	25068	578900	1480400	34.5	1372	25025	574800	1515800	30.0
1323	MD 0159	582000	1485600	30.0	1373	12250	573600	1516500	22.6
1324	25058	580800	1486400	37.5	1374	MS 0056	571600	1515400	42.0
1325	25057	582000	1484700	33.0	1375	C 0494	589500	1510400	54.0
1326	C 0462	581900	1483900	24.0	1376	C 0493	589000	1511800	54.0
1327	MD 0345	574200	1485100	27.0	1377	15412	589600	1513000	52.2
1328	25067	573300	1483000	24.0	1378	4402	589300	1512500	52.2
1329	146	591700	1478800	68.0	1379	4825	589200	1512200	56.8
1330	20780	591200	1473900	41.4	1380	C 0570	588800	1511000	54.0
1331	20779	588000	1474900	22.6	1381	12251	592200	1516100	59.6
1332	20778	585700	1474500	24.6	1382	7402	592200	1516500	53.2
1333	9794	585000	1474600	32.5	1383	MD 0046	591700	1519100	42.0
1334	25036	584300	1474700	45.0	1384	15397	591200	1510300	52.2
1335	C 0465	583800	1475000	24.0	1385	1447	588900	1508100	51.7
1336	MD 0171	577000	1473400	36.0	1386	5720	586800	1518500	42.3
1337	MD 0405	586900	1481100	93.1	1387	15389	586500	1519400	41.4
1338	C 0637	561800	1510400	39.0	1388	Q 0184	586300	1518800	42.0
1339	C 0464	586300	1481400	75.1	1389	MD 0409	599100	1520300	48.0
1340	20781	586200	1481600	53.2	1390	188	597100	1521100	54.1
1341	25023	585400	1482700	48.0	1391	18866	593400	1507900	140.8
1342	MD 0404	585300	1483100	60.0	1392	MD 0283	592000	1506400	100.6
1343	MD 0063	585100	1483500	48.0	1393	632	591500	1506300	56.6
1344	MD 0048	585000	1483800	22.5	1394	MD 0336	592400	1507700	120.0
1345	MD 0066	586900	1482800	150.1	1395	Q 0183	587200	1516300	42.0
1346	MD 0058	582500	1480300	42.0	1396	8483	586200	1515400	104.9
1347	C 0726	580800	1479000	30.0	1397	8482	586000	1516400	65.5
1348	MD 0160	581300	1474200	30.0	1398	11989	585400	1517500	80.8
1349	MD 0050	579000	1476200	24.0	1399	15734	585000	1519300	66.5
1350	MD 0161	578400	1475700	24.0	1400	15730	584400	1520700	54.2

Table 5 (continued)

NO.	Well ID	UTM Easting	UTM Northing	Depth (m)	NO.	Well ID	UTM Easting	UTM Northing	Depth (m)
1401	12537	583700	1517200	60.6	1451	15416	565400	1517300	30.2
1402	12536	580700	1522200	5.9	1452	18916	565500	1516200	36.9
1403	20571	579700	1520900	20.7	1453	25026	563300	1516700	21.0
1404	MD 0193	579100	1521000	30.0	1454	18919	564700	1517300	42.8
1405	15387	581000	1518900	27.0	1455	MS 0139	563500	1521600	54.0
1406	8485	589400	1515100	63.5	1456	MD 0098	564200	1521700	33.0
1407	MD 0042	588300	1513600	54.0	1457	MS 0138	570500	1521400	25.5
1408	MS 0161	578200	1511900	31.5	1458	MD 0227	599500	1518500	105.1
1409	MD 0164	577100	1510900	30.0	1459	MD 0252	600200	1519900	45.0
1410	MS 0132	576800	1511800	36.0	1460	MD 0196	600800	1518900	90.0
1411	Q 0185	579400	1511900	30.0	1461	Q 0165	585100	1506600	54.0
1412	MS 0162	573000	1514200	18.0	1462	510	581900	1504700	42.3
1413	8915	572600	1514600	6.4	1463	9835	581500	1505900	97.5
1414	13635	582200	1509300	41.9	1464	1438	593500	1494800	84.1
1415	20576	579300	1509100	46.3	1465	115	589300	1489300	86.7
1416	13636	578800	1509400	52.7	1466	624	586900	1497000	93.8
1417	7383	578500	1509200	33.4	1467	1113	588400	1493200	111.1
1418	MS 0163	578600	1509800	67.6	1468	25019	584500	1491700	45.0
1419	15628	582700	1515100	24.1	1469	8746	583200	1490000	48.7
1420	5691	582300	1515300	28.6	1470	14949	582800	1491400	71.4
1421	11988	584200	1516100	39.4	1471	MD 0222	582300	1492700	33.0
1422	6386	583600	1515500	29.9	1472	8745	582300	1493100	55.6
1423	7384	584600	1515300	42.1	1473	MD 0401	582100	1490500	54.0
1424	6168	584200	1515100	28.1	1474	25081	581400	1488500	22.5
1425	11991	582600	1513600	18.7	1475	MS 0119	581100	1488600	52.5
1426	20427	586900	1511800	52.2	1476	R 0933	581900	1489600	21.0
1427	MD 0069	586300	1511900	82.0	1477	5555	583100	1488400	22.6
1428	7385	587500	1511000	106.4	1478	MS 0120	583000	1488100	24.0
1429	15413	594800	1512900	147.7	1479	25048	582800	1488800	30.0
1430	MD 0438	594400	1513300	147.1	1480	25085	567800	1496700	28.5
1431	471	594500	1512500	113.2	1481	9746	568500	1493900	21.4
1432	16707	596500	1511600	137.9	1482	MS 0130	567200	1494300	34.5
1433	13740	596200	1511900	124.1	1483	MS 0128	571100	1494800	37.5
1434	13741	596600	1510800	124.1	1484	MD 0067	570600	1494500	15.0
1435	190	597100	1512100	57.3	1485	C 0740	569400	1495000	24.0
1436	467	594500	1514400	76.5	1486	MD 0240	567200	1495300	18.0
1437	488	597700	1518000	51.2	1487	20574	568200	1497100	29.5
1438	556	596900	1515600	68.9	1488	MD 0343	571100	1497800	33.0
1439	469	597700	1509400	147.7	1489	20573	570600	1498200	53.2
1440	18185	597600	1519400	147.7	1490	MD 0493	594300	1499500	126.1
1441	25005	597200	1509400	123.1	1491	R 0232	593600	1500600	48.0
1442	15739	595200	1511300	157.6	1492	C 0492	594200	1501300	54.0
1443	15392	596300	1510400	118.7	1493	MD 0491	593500	1502200	51.0
1444	MD 0435	594900	1510000	153.1	1494	MD 0197	591700	1503400	102.1
1445	1758	594400	1509700	99.0	1495	C 0489	592400	1504200	60.0
1446	MS 0131	593400	1518900	157.6	1496	MD 0490	592000	1504300	63.1
1447	MN 0066	592200	1514200	153.1	1497	MS 0125	591500	1504900	88.6
1448	1376	591900	1515300	62.5	1498	C 0491	592900	1502800	66.1
1449	R 5001	591700	1517400	63.1	1499	MD 0286	591500	1504500	52.5
1450	Q 0157	570400	1515900	24.0	1500	8747	577600	1491700	38.4

Table 5 (continued)

NO.	Well ID	UTM Easting	UTM Northing	Depth (m)	NO.	Well ID	UTM Easting	UTM Northing	Depth (m)
1501	MD 0061	577600	1491000	45.0	1551	Q 0317	544300	1505300	24.0
1502	8744	582600	1494300	59.6	1552	9364	544000	1504500	31.5
1503	MS 0124	581500	1493700	36.0	1553	25091	541900	1503800	30.0
1504	MD 0080	580100	1493600	24.0	1554	Q 0187	550100	1499900	48.0
1505	616	578700	1493600	21.7	1555	18874	549700	1498100	60.0
1506	MD 0235	577600	1493300	54.0	1556	9492	539700	1498400	25.6
1507	MD 0402	579300	1493600	60.0	1557	25088	542700	1503200	18.0
1508	MS 0127	579600	1491400	48.0	1558	9365	535600	1496400	94.5
1509	MD 0237	579700	1494400	30.0	1559	Q 0164	537100	1496500	30.0
1510	R 1033	580900	1495300	42.0	1560	MD 0218	538700	1501200	36.0
1511	MD 0236	580600	1494900	42.0	1561	R 0433	556300	1485100	18.0
1512	MD 0496	578700	1494600	30.0	1562	25071	555200	1484000	22.5
1413	9453	578700	1495100	55.6	1563	MD 0167	549300	1493800	24.0
1514	R 0535	580400	1498100	30.0	1564	10001	548700	1484200	42.3
1515	MD 0330	582100	1495600	54.0	1565	R 1032	547700	1487500	42.0
1516	C 0741	578900	1496300	33.0	1566	Q 0218	509500	1600000	30.5
1517	MD 0234	577700	1496100	39.0	1567	Q 0883	519982	1599900	71.6
1518	R 0635	574900	1498100	48.0	1568	PKCB-29	460837	4629179	40.0
1519	MD 0163	578100	1497600	27.0	1569	PKCB-33	462946	1628737	60.0
1520	25083	578000	1498000	28.5	1570	-	460665	1629576	36.0
1521	MD 0497	577800	1497300	24.0	1571	A-10	461315	1629473	30.0
1522	X 0065	576900	1499700	48.0	1572	5943	466451	1617542	53.5
1523	25045	576200	1499400	34.5	1573	-	470175	1621073	40.0
1524	25046	576600	1502000	46.5	1574	36034	472170	1610882	60.0
1525	1478	593400	1491500	44.3	1575	P16/224	474935	1607990	39.6
1526	MD 0165	595900	1489200	148.6	1576	13632	454099	1617097	24.1
1527	7586	596200	1483800	123.6	1577	-	455997	1612589	18.3
1528	20593	596100	1487600	116.2	1578	A-7	449850	1625946	24.4
1529	7587	596200	1486700	71.9	1579	P16/163	499400	1625799	61.0
1530	R 0134	534900	1489200	13.5	1580	13786	457445	1621664	50.0
1531	R 0435	529100	1490100	30.0	1581	A-69	457327	1620770	80.0
1532	15365	536000	1494700	90.6	1582	20294	471301	1612911	21.0
1533	9236	534100	1493500	29.5	1583	36033	468932	1613509	60.0
1534	9493	551200	1493700	42.8	1584	5944	469452	1614118	19.5
1535	C 0723	540700	1496700	30.0	1585	P10/174	474840	1616053	48.8
1536	25070	541900	1496700	30.0	1586	-	511214	1565437	40.0
1537	C 0725	544100	1483300	30.0	1587	-	513326	1570905	66.0
1538	4475	542900	1491200	23.6	1588	KB 25163	513956	1585275	26.8
1539	R 0335	542900	1491200	24.0	1589	Q 0902	511550	1568847	45.7
1540	R 0533	549900	1480300	39.0	1590	P16/1164	510991	1568201	24.4
1541	R 0334	549200	1479200	28.5	1591	36632	483621	1593995	70.0
1542	R 0135	543400	1486500	30.0	1592	Q 0917	488340	1594100	33.5
1543	MD 0166	544400	1483600	31.5	1593	MD 0487	520118	1560722	76.2
1544	MS 0049	553300	1474900	24.0	1594	Q 0900	511526	1561129	62.5
1545	MD 0200	552700	1473100	36.0	1595	MS 0069	514210	1556726	76.2
1546	R 1132	550900	1475900	24.0	1596	-	514419	1557298	60.0
1547	MS 0050	553300	1477400	31.5	1597	MS 0057	516799	1562248	29.0
1548	R 0235	545300	1477100	36.0	1598	-	507113	1568783	40.0
1549	15399	550700	1472400	49.2	1599	3052	501313	1575928	24.0
1550	9363	541700	1500200	82.6	1600	P10/158	502169	1575460	30.5

Table 5 (continued)

NO.	Well ID	UTM Easting	UTM Northing	Depth (m)	NO.	Well ID	UTM Easting	UTM Northing	Depth (m)
1601	DB 0046	522103	1545006	76.2	1651	Q 0836	583627	1593506	61.0
1602	-	522163	1544133	88.0	1652	-	579345	1596145	15.0
1603	-	525351	1558426	36.0	1653	A-56	579264	1597243	30.5
1604	MS 0208	527070	1560160	35.1	1654	A 16/218	572910	1597438	91.5
1605	PKCB83	529138	1558545	45.0	1655	A 16/136	523831	1574889	27.4
1606	PKCB 85	530161	1558198	45.0	1656	-	523681	1581453	24.0
1607	21563	533731	1523573	24.2	1657	KB 25110	523734	1530128	15.2
1608	KB 25063	534938	1525356	24.5	1658	MD 0135	505850	1633300	39.6
1609	2922	535025	1523800	34.0	1659	MD 0457	566250	1651650	28.5
1610	MS 0154	531146	1526110	48.8	1660	21923	536127	1634521	24.3
1611	KB 25206	530668	1523710	33.0	1661	18017	540298	1631759	42.5
1612	MD 0263	532665	1533619	35.1	1662	MD 0413	545426	1628308	32.0
1613	-	534737	1539975	22.0	1663	MN 0301	575590	1638400	33.0
1614	MD 0362	532665	1533619	36.5	1664	MN 0264	575250	1638690	30.0
1615	20568	528988	1527591	27.4	1665	MN 0272	570840	1637250	22.5
1616	MS 0109	528828	1532740	44.2					
1617	MS 0342	532170	1532941	60.0					
1618	KB 25067	531968	1531720	45.7					
1619	MS 0110	529935	1535972	61.0					
1620	3228	531192	1536375	29.0					
1621	KB 25224	531252	1527902	45.0					
1622	KB 25034	527980	1533369	26.8					
1623	MS 0308	559239	1528017	36.6					
1624	28461	558768	1528189	20.0					
1625	31807	559577	1528572	24.4					
1626	MS 0104	556813	1532485	30.5					
1627	KB 25064	556786	1532179	27.4					
1628	MS 0302	557987	1529434	30.5					
1629	-	585381	1543764	50.0					
1630	27569	586691	1543361	33.5					
1631	490	588715	1543101	43.4					
1632	33823	586289	1540920	24.4					
1633	-	588463	1538841	42.0					
1634	7566	589962	1536864	39.3					
1635	MS 0326	589553	1537316	42.7					
1636	33821	589274	1538582	24.4					
1637	1374	582357	1550608	19.0					
1638	-	584700	1552918	28.0					
1639	-	585100	1552951	22.0					
1640	KB 25185	574752	1579702	27.0					
1641	P 10/285	575455	1590258	36.6					
1642	R 8/212	574739	1591222	21.3					
1643	R 8/209	570441	1589292	27.4					
1644	R 8/210	571035	1589465	36.6					
1645	A 16/81	578466	1588836	45.7					
1646	MD 0213	577981	1594287	30.5					
1647	MD 0291	578778	1594375	30.5					
1648	A-55	578703	1593528	61.0					
1649	KB 25029	578100	1594768	29.9					
1650	P16/272	586622	1593131	21.3					

Table 7 List of weather stations in the study area

No.	Station code	Station name	UTM Easting	UTM Northing
		Kanchana Buri		
1	450001	Sai Yok	521587	1556828
2	450002	Sangkhla Buri	448065	1667467
3	450003	Tha Muang	570211	1538483
4	450004	Tha Maka	584626	1534840
5	450005	Si Sawat	505384	1617643
6	450006	Lao Khwan	587976	1606741
7	450007	Bo Phloi	557517	1579002
8	450008	Phanom Thuan	557356	1556936
9	450009	Ban Rai School	449767	1625067
10	450010	Wat Hin Dat School	469488	1613975
11	450011	Ban Lin Thin School	480254	1610278
12	450012	Wiset Kun Schol	456924	1613994
13	450013	Ban Wia Khadi School	428398	1678578
14	450016	Wachiralongkhon Dam	568396	1544008
15	450017	T. Nong Pru, A. Bo Phloi	550256	1614008
16	450018	Hin Lup Plantation	548544	1571610
17	450019	Erawan National Park	516169	1590000
18	450020	Sai Yok National Park	483384	1595530
19	450021	Soldier Animal Breeding	555796	1543977
20	450023	Ban Khao Lek	526910	1625030
21	450024	Ban Phu Toei Kaeng Lawa	501797	1577093
22	450026	Huay Malai	433737	1667502
23	450027	Ban Na Suan	514348	1632392
24	450029	K.A. Dan Makam Tia	545019	1531054
25	450201	Kanchana Buri	557584	1549510
26	450401	Thong Pha Phum	460868	1629716
		Ratcha Buri		
27	424001	Ratcha Buri	590168	1494307
28	424002	Photharam	593722	1509066
29	424003	Damnoen Saduak	604603	1492517
30	424004	Pak Tho	593846	1474044
31	424005	Ban Pong	597279	1521982
32	424006	Chom Bung	572113	1501624
33	424007	Wat Phleng	599226	1483280
34	424008	Suan Phung	534263	1494176
35	424009	Bang Phae	602735	1509099
36	424011	Tham Chom Pon Royal Garden	566695	1505297
37	424013	Maenam Pachi Wildlife Conservation Center	546938	1464707
38	424301	Ratchaburi Rice Research Station	586301	1491038
		Suphan Buri		
39	425002	Song Phi Nong	609677	1571802
40	425003	Doembang Nangbuat	618364	1641189
41	425004	U thong	593432	1588327
42	425005	Sam Chuk	616582	1632669
43	425006	Si Prachan	627422	1617975
44	425007	Don chedi	611276	1616052
45	425008	Dan Chang	577109	1636198
46	425009	K.A. Nong Ya Sai	598660	1628902
47	425010	Suphanburi Rice Research Station	620333	1599504
48	425011	Kraseo Self-Help Settlement	562748	1641686
49	425201	Suphan Buri	622129	1599512
50	425301	U thong Agromet	593460	1580954

Source: MD, 2000b

<u>Table 8</u> Monthly rainfall of fifty weather stations during 1990-1999 (Source: MD, 2000a)

(1) STATION : 450001 Sai Yok PROVINCE : Kanchana Buri

YEAR		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990	Amt.	.0	1.1	24.0	71.2	112.8	59.3	47.6	66.1	171.0	251.5	60.8	.0	
1991	Amt.	T	6.5	37.5	40.6	217.7	116.0	76.0	156.1	129.5	357.4	10.4	21.0	
1992	Amt.	T	22.8	T	.3	98.9	71.5	165.2	92.1	80.3	407.8	.3	.1	
1993	Amt.	.0	.2	69.1	152.3	143.4	71.5	125.2	88.1	224.7	100.6	T	9.0	
1994	Amt.	T	12.3	84.3	56.3	200.5	87.3	185.6	181.4	112.5	39.5	3.7	6.4	
1995	Amt.	.0	.3	5.6	123.8	133.7	174.3	101.9	236.3	283.7	209.0	7.3	.0	
1996	Amt.	5.6	19.5	32.2	160.6	112.0	121.9	249.1	170.0	660.0	184.2	100.1	.0	
1997	Amt.	1.1	.5	70.7	95.8	67.5	25.5	144.8	174.0	244.1	212.7	65.9	9.1	
1998	Amt.	.0	17.9	2.5	49.0	122.4	72.9	113.2	158.3	308.9	433.0	71.3	.3	
1999	Amt.	.0	12.4	19.1	497.6	171.0	118.1	78.0	120.2	108.5	302.0	139.7	13.5	
MEAN	Amt.	.7	9.4	34.5	124.8	138.0	91.8	128.7	144.3	232.3	249.8	46.0	5.9	(1206.2)

(2) STATION : 450002 Sangkhla Buri PROVINCE : Kanchana Buri

YEAR		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990	Amt.	.0	.0	49.4	85.2	395.1	396.8	418.6	435.0	336.9	239.4	23.0	.0	
1991	Amt.	1.1	.0	7.2	91.0	161.2	686.7	536.8	738.0	274.5	100.7	.0	12.6	
1992	Amt.	10.4	.4	.0	59.9	74.7	351.6	388.5	570.9	312.5	408.1	.3	.1	
1993	Amt.	-	-	-	-	-	-	-	663.6	413.1	24.1	.0	T	
1994	Amt.	1.4	.0	37.4	45.5	515.5	491.3	899.9	732.4	305.3	158.3	1.6	.0	
1995	Amt.	28.7	.0	34.3	74.7	391.1	536.1	320.0	446.2	446.8	157.2	8.3	.0	
1996	Amt.	.0	81.4	120.0	133.3	245.6	397.9	695.3	414.5	505.7	109.5	87.7	.0	
1997	Amt.	.0	4.0	52.4	10.1	378.9	252.0	1101.1	907.0	206.3	-	37.5	.0	
1998	Amt.	.0	.0	.0	12.0	297.3	258.6	208.9	231.2	351.7	179.8	.0	31.9	
1999	Amt.	-	-	87.4	156.4	252.8	375.0	572.7	585.1	307.1	207.8	25.6	.0	
MEAN	Amt.	5.2	10.7	43.1	74.2	301.4	416.2	571.3	572.4	346.0	176.1	18.4	4.5	(2539.5)

(3) STATION : 450003 Tha Muang PROVINCE : Kanchana Buri

YEAR		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990	Amt.	.0	.0	13.1	45.7	154.9	42.8	32.8	132.0	75.9	314.3	23.7	.0	
1991	Amt.	.0	10.1	.0	59.7	83.0	54.7	64.8	80.0	145.2	139.2	.0	73.3	
1992	Amt.	.0	.0	.0	.0	50.5	106.9	168.0	34.6	129.2	287.2	.0	.0	
1993	Amt.	.0	.0	40.1	37.8	81.8	82.1	19.3	125.8	272.0	206.7	.0	9.2	
1994	Amt.	.0	.0	.0	47.0	396.3	304.0	68.4	112.3	170.8	44.8	.0	.0	
1995	Amt.	.0	.0	6.8	50.2	201.2	77.4	80.9	376.7	146.4	21.7	.0	.0	
1996	Amt.	.0	.0	.0	55.0	39.4	193.9	110.6	60.6	158.5	5.6	22.9	-	
1997	Amt.	-	-	-	27.4	-	-	-	-	-	-	-	-	-
1998	Amt.	.0	.0	.0	2.0	.3	106.3	285.0	153.0	206.0	348.0	-	-	
1999	Amt.	-	-	-	495.1	-	-	-	-	-	-	-	-	-
MEAN	Amt.	.0	1.3	7.5	82.0	125.9	121.0	103.7	134.4	163.0	170.9	6.7	13.8	(930.2)

(4) STATION : 450004 Tha Maka PROVINCE : Kanchana Buri

YEAR		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990	Amt.	.0	.0	9.2	9.8	152.0	67.3	37.1	76.9	94.1	242.8	52.1	.0	
1991	Amt.	.0	7.2	T	28.3	65.3	64.0	38.2	204.9	156.4	197.6	.7	79.7	
1992	Amt.	2.1	7.4	.0	.0	34.4	125.6	172.8	92.8	313.8	222.5	T	8.7	
1993	Amt.	.0	.0	23.8	51.5	66.3	59.4	72.6	70.2	290.8	224.8	T	.0	
1994	Amt.	.0	.0	30.7	23.4	177.7	238.4	61.6	158.7	230.5	81.6	.0	.0	
1995	Amt.	2.4	1.8	21.6	1.9	82.3	72.2	258.8	317.0	286.1	158.6	30.3	.3	
1996	Amt.	-	.0	.0	9.1	31.1	-	122.8	110.0	344.9	122.1	33.2	.2	
1997	Amt.	.0	T	15.0	44.3	-	55.5	41.9	103.6	-	-	-	.0	
1998	Amt.	.0	.0	23.7	14.4	120.1	117.0	-	77.2	210.3	313.4	100.3	2.4	
1999	Amt.	.0	53.9	18.3	287.3	-	92.3	114.3	96.0	172.3	444.7	58.6	2.3	
MEAN	Amt.	.5	7.0	14.2	47.0	91.2	99.1	102.2	130.7	233.2	223.1	30.6	9.4	(988.2)

Table 8 (continued)

(5) STATION : 450005 Si Sawat PROVINCE : Kanchana Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	-	-	-	-	-	-	-	-	-	-	-	-	
1991 Amt.	-	-	-	-	-	-	-	-	-	-	-	-	
1992 Amt.	-	-	-	-	-	-	-	137.9	48.5	149.0	-	1.9	
1993 Amt.	.0	.0	21.8	21.8	76.7	53.3	-	-	-	-	-	-	
1994 Amt.	.0	2.3	43.3	13.3	141.1	93.7	224.5	122.7	169.5	84.9	2.1	2.6	
1995 Amt.	.4	9.2	9.2	15.5	119.1	41.2	74.0	275.1	227.5	-	4.0	.0	
1996 Amt.	.0	7.4	.0	5.5	99.9	85.4	163.4	-	-	-	-	-	
1997 Amt.	-	-	.0	-	-	-	-	189.9	172.3	-	-	-	
1998 Amt.	-	-	-	-	-	-	-	-	-	-	-	-	
1999 Amt.	-	-	-	-	-	-	41.4	82.1	42.5	337.8	127.0	.0	
MEAN Amt.	.1	4.7	14.9	14.0	109.2	68.4	125.8	161.5	132.1	190.6	44.4	1.1	(866.8)

(6) STATION : 450006 Lao Khwan PROVINCE : Kanchana Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	5.5	5.3	52.8	T	171.1	13.0	32.5	47.9	-	405.7	36.1	.0	
1991 Amt.	.0	T	14.8	10.2	78.7	30.9	47.4	39.1	277.7	171.0	T	.0	
1992 Amt.	.0	.0	.0	.0	57.7	190.5	122.0	106.5	105.5	449.2	.0	T	
1993 Amt.	.0	T	27.3	62.7	175.3	31.6	16.4	54.3	230.1	61.8	.0	.0	
1994 Amt.	.0	.0	.0	15.3	85.8	71.2	35.5	69.4	179.8	101.4	.0	.0	
1995 Amt.	-	-	-	-	-	-	-	-	-	-	-	-	
1996 Amt.	-	-	-	-	-	-	-	-	-	-	-	-	
1997 Amt.	-	-	-	-	-	-	-	52.4	391.5	138.6	11.3	-	
1998 Amt.	-	-	-	-	-	-	-	-	-	-	-	-	
1999 Amt.	-	-	-	-	-	-	-	-	-	-	-	-	
MEAN Amt.	1.1	1.1	19.0	17.6	113.7	67.4	50.8	61.6	236.9	221.3	7.9	.0	(798.4)

(7) STATION : 450007 Bo Phloi PROVINCE : Kanchana Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	T	T	62.5	113.8	262.1	39.4	50.9	9.8	77.6	397.8	94.5	.0	
1991 Amt.	.0	7.0	26.1	114.6	165.6	9.8	25.5	165.5	122.5	315.8	.0	.0	
1992 Amt.	14.6	8.2	.0	2.1	47.0	124.6	95.3	44.8	47.2	350.2	.0	.0	
1993 Amt.	.0	.0	42.0	46.3	115.8	96.1	19.1	117.3	294.4	-	-	-	
1994 Amt.	.0	.0	171.0	49.8	219.4	121.1	111.4	80.0	337.6	192.2	-	-	
1995 Amt.	-	-	-	-	-	-	-	-	-	-	-	-	-
1996 Amt.	-	-	-	-	-	329.2	1091.6	513.5	398.6	158.6	131.1	.0	
1997 Amt.	.0	.0	49.0	36.0	8.9	7.4	47.9	81.7	222.9	-	93.1	-	
1998 Amt.	-	-	1.1	16.1	-	55.8	108.9	142.3	153.5	178.0	94.5	.0	
1999 Amt.	16.2	24.7	17.2	233.9	178.2	18.0	47.5	52.4	36.1	527.8	188.5	.1	
MEAN Amt.	4.4	5.7	46.1	76.6	142.4	89.0	177.6	134.1	187.8	302.9	86.0	.0	(1252.6)

(8) STATION : 450008 Phanom Thuan PROVINCE : Kanchana Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	.0	.0	10.6	11.7	156.5	10.3	40.9	81.4	130.9	339.4	29.3	.0	
1991 Amt.	.0	31.1	61.5	40.8	85.1	15.1	46.2	132.8	236.0	274.9	.6	72.6	
1992 Amt.	1.8	3.3	.0	.0	44.5	183.5	96.9	89.1	43.2	312.0	.0	14.8	
1993 Amt.	.3	.0	51.6	9.3	120.9	134.2	45.4	72.4	261.9	333.9	.6	17.1	
1994 Amt.	.0	.0	94.7	33.6	133.9	80.7	103.1	59.3	209.4	143.5	.0	T	
1995 Amt.	.0	.0	.0	37.7	64.6	97.0	49.1	216.9	325.2	101.3	10.8	.0	
1996 Amt.	.0	6.8	5.7	68.8	103.1	60.6	116.3	131.6	380.4	118.1	70.8	.6	
1997 Amt.	.0	.8	13.1	21.5	59.2	2.3	21.7	68.0	188.0	101.4	35.9	T	
1998 Amt.	-	.0	.0	6.6	93.8	113.4	70.6	31.6	116.5	237.1	-	.0	
1999 Amt.	.0	19.1	25.9	167.8	108.6	38.9	23.4	26.1	85.5	406.0	81.1	8.0	
MEAN Amt.	.2	6.1	26.3	39.8	97.0	73.6	61.4	90.9	197.7	236.8	25.5	11.3	(866.6)

Table 8 (continued)

(9) STATION : 450009 Ban Rai School PROVINCE : Kanchana Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	T	2.0	22.8	47.7	236.8	335.7	245.1	275.8	272.8	223.0	63.0	.0	
1991 Amt.	T	T	18.3	66.6	294.4	675.9	370.0	626.4	215.0	111.1	.0	8.1	
1992 Amt.	T	T	.0	24.2	188.0	210.5	325.6	435.3	192.9	192.7	.0	T	
1993 Amt.	T	.0	13.0	81.9	151.3	190.1	256.5	308.2	296.7	117.0	.0	T	
1994 Amt.	.0	44.8	56.5	95.4	169.0	268.5	814.1	493.1	197.7	243.9	4.2	T	
1995 Amt.	14.3	.0	43.5	70.8	203.8	380.7	241.1	519.0	323.0	170.6	.8	.9	
1996 Amt.	.0	.4	80.7	122.8	137.4	238.6	595.5	350.0	408.2	137.4	35.1	.0	
1997 Amt.	.0	T	16.2	32.0	138.0	166.3	762.9	555.3	259.7	45.7	10.0	.0	
1998 Amt.	1.3	.0	33.4	8.0	210.0	133.8	185.2	149.9	235.5	97.9	18.0	T	
1999 Amt.	17.7	3.1	57.6	329.3	-	258.3	244.5	349.4	281.5	280.5	113.6	1.3	
MEAN Amt.	3.3	5.0	34.2	87.9	192.1	285.8	404.1	406.2	268.3	162.0	24.5	1.0	(1874.4)

(10) STATION : 450010 Wat Hin Dat School PROVINCE : Kanchana Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	.0	.0	125.6	58.4	96.7	120.1	298.5	163.7	242.6	147.8	46.4	T	
1991 Amt.	.0	1.7	.0	68.7	270.8	245.9	179.9	527.6	88.4	13.1	.0	10.6	
1992 Amt.	1.4	.0	.0	47.1	99.1	155.6	331.1	248.7	214.0	128.9	.0	1.6	
1993 Amt.	.0	.0	15.7	35.7	100.8	62.5	192.6	311.8	214.2	39.8	T	.0	
1994 Amt.	.0	5.0	42.7	T	191.6	288.2	439.1	354.3	225.0	69.2	32.2	5.0	
1995 Amt.	3.7	.0	81.1	151.5	246.8	242.8	181.8	414.6	445.5	53.5	.0	.0	
1996 Amt.	.0	47.8	16.2	124.5	148.8	207.5	500.0	318.8	413.1	145.8	135.4	.0	
1997 Amt.	.0	.0	5.3	T	159.7	127.6	556.0	418.0	278.6	22.9	80.8	.0	
1998 Amt.	7.5	.0	.0	44.8	345.0	160.9	146.2	211.6	185.6	170.2	.0	.0	
1999 Amt.	100.5	.0	33.9	235.6	164.2	75.3	217.5	284.3	127.8	470.5	81.6	T	
MEAN Amt.	11.3	5.5	32.1	76.6	182.4	168.6	304.3	325.3	243.5	126.2	37.6	1.7	(1515.1)

(11) STATION : 450011 Ban Lin Thin School PROVINCE : Kanchana Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	T	.0	54.2	133.4	74.8	172.5	192.3	103.6	88.3	136.8	97.9	.0	
1991 Amt.	19.2	8.6	.0	63.8	90.6	404.0	246.9	435.4	241.1	139.1	.0	16.6	
1992 Amt.	1.6	T	T	29.4	163.5	189.0	263.7	188.1	179.8	179.1	.0	2.5	
1993 Amt.	7.2	.0	46.9	113.5	165.5	89.9	310.6	305.6	95.8	32.2	.0	.0	
1994 Amt.	.0	.0	20.0	45.8	243.1	280.7	528.7	512.2	311.2	73.2	28.5	7.9	
1995 Amt.	.0	.0	6.6	25.3	190.9	312.0	165.6	352.6	537.6	-	-	-	
1996 Amt.	-	-	-	-	-	-	-	-	-	-	-	-	
1997 Amt.	.0	T	55.9	78.9	81.4	335.1	708.3	408.2	270.7	85.5	-	-	
1998 Amt.	.0	.0	6.1	-	-	121.3	181.3	105.1	378.4	191.4	-	19.5	
1999 Amt.	25.3	2.5	36.9	228.3	116.3	88.5	257.8	205.2	277.4	424.6	117.1	-	
MEAN Amt.	5.9	1.2	25.2	89.8	140.8	221.4	317.2	290.7	264.5	157.7	40.6	7.8	(1562.8)

(12) STATION : 450012 Wiset Kun School PROVINCE : Kanchana Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	1.2	.0	4.4	76.5	139.7	238.4	198.9	77.2	84.2	105.3	24.9	.0	
1991 Amt.	.0	.0	.0	31.1	210.1	403.2	359.2	517.5	198.1	96.9	.0	3.5	
1992 Amt.	.0	9.2	.0	26.6	150.8	173.7	299.6	304.7	98.0	255.1	6.1	7.9	
1993 Amt.	.0	.0	107.4	58.5	177.9	163.3	304.3	240.0	215.4	27.5	.0	.0	
1994 Amt.	.0	.0	113.8	24.5	122.8	263.0	435.8	508.8	174.1	18.1	.0	44.4	
1995 Amt.	5.2	.0	132.4	27.5	204.3	316.7	319.0	473.8	468.7	97.2	.0	.0	
1996 Amt.	.0	51.5	61.8	21.6	92.8	163.1	556.4	214.4	423.3	132.4	104.5	.0	
1997 Amt.	.0	.0	1.8	13.0	142.2	179.5	579.8	782.8	252.6	88.1	18.5	-	
1998 Amt.	.0	.0	-	.0	-	170.7	148.1	86.8	170.9	150.0	16.9	.0	
1999 Amt.	83.7	2.3	40.4	245.4	165.4	174.5	187.3	358.4	183.1	283.0	104.5	.0	
MEAN Amt.	9.0	6.3	51.3	52.5	156.2	224.6	338.8	356.4	226.8	125.4	27.5	6.2	(1581.0)

Table 8 (continued)

(13) STATION : 450013 Ban Wia Khadi School PROVINCE : Kanchana Buri

YEAR		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990	Amt.	.0	.0	.0	119.4	313.8	472.8	361.5	326.1	257.1	221.9	46.4	.0	
1991	Amt.	.0	9.5	15.8	126.1	165.9	847.5	540.4	779.2	199.4	123.7	.0	18.8	
1992	Amt.	19.6	9.5	.0	130.2	115.8	392.8	409.6	651.0	175.7	161.8	.0	8.4	
1993	Amt.	.0	.0	21.4	91.7	240.4	287.6	439.6	653.7	285.5	57.2	.0	.0	
1994	Amt.	.0	.0	89.5	71.9	433.5	293.5	671.4	548.8	168.7	121.4	12.5	.0	
1995	Amt.	52.4	.0	117.0	133.2	380.9	495.1	269.5	442.2	430.7	144.8	.0	.0	
1996	Amt.	.0	126.0	42.2	158.7	199.1	337.8	577.1	502.5	441.7	202.9	104.8	.0	
1997	Amt.	.0	.0	22.6	44.7	309.8	252.5	1188.5	975.7	283.6	56.4	33.5	.0	
1998	Amt.	-	.0	.0	.0	354.7	184.4	161.2	105.8	-	122.0	5.0	31.0	
1999	Amt.	23.6	7.5	23.6	169.9	392.4	342.6	498.6	560.4	442.9	186.6	44.4	.8	
MEAN	Amt.	10.6	15.3	33.2	104.6	290.6	390.7	511.7	554.5	298.4	139.9	24.7	5.9	(2380.1)

(14) STATION : 450016 Wachiralongkhon Dam PROVINCE : Kanchana Buri

YEAR		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990	Amt.	2.1	2.9	17.7	41.3	171.5	38.5	68.3	123.6	88.8	243.6	34.4	.0	
1991	Amt.	-	-	.0	54.4	51.1	50.5	51.1	91.7	196.0	151.0	.0	97.6	
1992	Amt.	7.6	T	.0	.0	27.6	75.6	211.3	33.0	124.6	-	-	-	
1993	Amt.	.0	.0	50.2	55.0	93.0	71.9	54.8	95.4	251.2	180.6	.0	63.0	
1994	Amt.	.0	.0	57.6	13.3	299.8	120.8	109.8	114.3	186.2	116.2	.7	.0	
1995	Amt.	.0	.0	24.4	-	142.2	74.2	165.6	340.5	284.8	-	12.2	.0	
1996	Amt.	.0	.0	5.2	63.3	142.5	162.8	159.2	81.2	408.6	160.2	38.5	.0	
1997	Amt.	.0	.0	94.5	38.9	8.7	9.0	86.8	92.3	190.1	149.0	79.1	1.0	
1998	Amt.	.0	14.2	.0	.0	107.1	93.9	123.8	153.8	216.9	348.3	88.8	.0	
1999	Amt.	.0	28.3	5.0	241.1	129.2	28.5	59.8	37.6	157.3	365.1	-	5.0	
MEAN	Amt.	1.1	5.0	25.5	56.4	117.3	72.6	109.1	116.3	210.5	214.3	31.7	18.5	(978.3)

(15) STATION : 450017 T.Nong Pru A.Bo Phloi PROVINCE : Kanchana Buri

YEAR		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990	Amt.	-	-	-	-	-	-	-	-	-	-	-	-	
1991	Amt.	-	-	-	-	-	-	-	-	-	-	-	-	
1992	Amt.	-	-	-	-	-	-	-	24.1	73.7	355.6	.0	30.1	
1993	Amt.	.0	.0	3.7	19.6	106.2	106.5	47.8	86.3	317.2	129.2	8.8	14.0	
1994	Amt.	.0	.0	136.6	5.4	149.7	108.4	131.9	65.8	288.7	151.3	6.2	.0	
1995	Amt.	.0	.0	.5	79.0	76.1	37.2	69.9	220.3	307.5	117.3	40.4	.0	
1996	Amt.	.0	61.0	20.1	142.1	264.2	95.1	101.3	42.3	381.6	240.4	156.8	.0	
1997	Amt.	.0	.0	.0	T	38.4	T	63.4	87.2	216.5	135.5	19.2	.0	
1998	Amt.	-	3.8	31.8	19.4	127.2	43.9	109.2	142.4	211.0	277.1	13.6	.0	
1999	Amt.	21.2	.0	12.5	251.1	202.5	45.5	26.0	107.7	122.3	215.5	-	27.6	
MEAN	Amt.	3.5	9.3	29.3	73.8	137.8	62.4	78.5	97.0	239.8	202.7	35.0	9.0	(978.1)

(16) STATION : 450018 Hin Lup Plantation PROVINCE : Kanchana Buri

YEAR		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990	Amt.	-	-	-	-	-	-	-	-	-	-	-	-	
1991	Amt.	-	-	-	-	-	-	-	-	-	-	-	-	
1992	Amt.	-	-	-	-	-	-	-	-	-	-	-	-	
1993	Amt.	.0	.0	70.6	54.3	-	-	-	-	-	-	-	-	
1994	Amt.	.0	.0	147.4	36.8	399.9	288.4	275.3	275.0	623.4	299.4	29.0	.0	
1995	Amt.	15.8	-	17.2	31.4	298.0	201.4	-	557.1	-	247.8	-	-	
1996	Amt.	.0	.0	9.1	222.1	155.1	65.5	168.4	109.8	-	-	-	-	
1997	Amt.	-	-	1.3	4.8	.5	3.3	43.0	41.5	61.6	37.4	16.5	-	
1998	Amt.	.0	35.1	.0	76.5	23.2	5.2	22.4	14.3	187.3	367.3	143.3	.0	
1999	Amt.	.1	25.3	33.0	411.0	143.0	25.5	-	70.1	74.1	51.0	52.0	1.0	
MEAN	Amt.	2.7	12.1	39.8	119.6	170.0	98.2	127.3	178.0	236.6	200.6	60.2	.3	(1245.4)

Table 8 (continued)

(17) STATION : 450019 Erawan National Parks PROVINCE : Kanchana Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	.0	29.8	31.2	55.8	146.7	72.7	57.6	42.3	112.7	155.8	57.8	.0	
1991 Amt.	.0	.0	16.0	68.5	218.4	122.4	46.0	111.3	20.6	191.8	.0	63.3	
1992 Amt.	.0	11.7	T	39.6	26.6	114.4	206.4	84.3	52.5	281.0	.1	4.5	
1993 Amt.	.0	.0	66.2	76.1	97.1	98.4	50.2	68.9	180.2	92.6	.0	T	
1994 Amt.	T	8.0	219.1	73.0	167.6	79.5	173.0	142.6	138.2	185.6	3.8	11.3	
1995 Amt.	4.7	.0	28.9	48.5	141.4	52.5	172.2	205.9	209.3	101.2	T	.0	
1996 Amt.	.0	58.6	1.2	85.5	94.7	116.5	210.3	118.1	416.9	124.9	.0	.0	
1997 Amt.	.0	.0	51.8	100.6	96.5	16.0	246.7	368.0	208.9	-	62.4	.0	
1998 Amt.	.0	T	17.4	.0	115.5	131.5	164.9	57.5	-	88.6	17.1	.0	
1999 Amt.	12.1	.0	89.8	168.2	197.2	15.0	25.9	83.6	96.1	334.4	37.5	T	
MEAN Amt.	1.7	10.8	52.2	71.6	130.2	81.9	135.3	128.3	159.5	172.9	17.9	7.9	((970.2)

(18) STATION : 450020 Sai Yok National Parks PROVINCE : Kanchana Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	.0	.0	9.3	80.2	176.1	179.4	124.2	159.2	204.2	43.3	83.6	.0	
1991 Amt.	.0	5.2	.0	32.4	95.8	348.2	289.3	525.4	255.0	165.7	.0	15.2	
1992 Amt.	.0	.0	.0	14.6	215.4	175.6	254.7	182.9	168.2	142.7	.0	3.4	
1993 Amt.	.0	.0	58.3	117.4	136.0	81.8	267.5	189.4	221.3	101.7	.1	.0	
1994 Amt.	.0	.0	59.4	82.7	195.8	176.0	584.6	478.3	128.9	47.2	61.0	10.7	
1995 Amt.	75.7	.0	39.2	39.4	196.3	132.5	321.6	463.5	324.0	50.9	.0	.0	
1996 Amt.	.0	36.5	62.0	213.6	146.7	295.4	773.6	437.9	567.1	524.4	47.1	.0	
1997 Amt.	.0	.0	37.1	102.4	133.8	106.9	539.3	175.2	146.5	-	-	-	
1998 Amt.	.0	.0	.0	73.1	154.9	114.3	163.7	189.7	429.3	360.3	49.3	17.5	
1999 Amt.	12.1	10.0	14.3	240.3	116.8	131.2	191.0	404.4	188.1	261.3	61.0	2.3	
MEAN Amt.	8.8	5.2	28.0	99.6	156.8	174.1	351.0	320.6	263.3	188.6	33.6	5.5	(1635.1)

(19) STATION : 450021 Solder Animal Breeding PROVINCE : Kanchana Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	.0	.0	19.0	64.0	199.5	50.0	24.0	50.5	123.5	246.5	94.0	.0	
1991 Amt.	.0	50.0	5.0	71.0	63.2	45.5	50.2	99.0	131.5	336.5	2.0	61.0	
1992 Amt.	34.0	15.0	.0	T	30.0	103.5	224.8	97.5	66.9	369.0	T	3.5	
1993 Amt.	.0	.0	60.0	24.0	123.9	68.5	43.2	95.2	350.3	209.6	.0	14.8	
1994 Amt.	.0	9.5	133.7	80.5	161.3	121.9	129.9	88.7	217.0	102.0	6.2	.0	
1995 Amt.	.0	.0	36.5	8.0	140.5	128.4	66.2	222.0	281.2	136.9	24.0	.0	
1996 Amt.	.0	.0	26.1	76.5	103.6	94.4	204.3	171.4	453.3	178.4	42.0	.0	
1997 Amt.	.0	.0	126.4	37.5	25.0	-	45.7	132.2	268.5	143.4	121.9	.0	
1998 Amt.	.0	5.6	.0	25.5	163.4	93.7	122.7	102.6	160.9	434.9	132.7	.0	
1999 Amt.	T	20.3	.0	249.8	171.2	23.7	19.3	38.3	159.0	247.8	59.5	.0	
MEAN Amt.	3.4	10.0	40.7	63.7	118.2	81.1	93.0	109.7	221.2	240.5	48.2	7.9	(1037.6)

(20) STATION : 450023 Ban Khao Lek PROVINCE : Kanchana Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	6.0	8.7	75.2	29.8	264.3	75.9	60.1	46.7	78.7	329.8	85.8	.0	
1991 Amt.	.0	6.4	66.3	82.4	130.8	74.6	44.1	76.1	179.0	407.0	.0	5.2	
1992 Amt.	.0	.0	5.0	49.7	118.6	51.3	246.0	109.4	49.1	439.1	.0	20.8	
1993 Amt.	.0	.0	64.4	59.4	114.0	79.8	63.7	46.9	377.8	306.2	3.0	14.2	
1994 Amt.	.0	14.0	118.8	36.7	295.5	86.5	87.0	73.8	281.9	167.6	6.7	5.1	
1995 Amt.	T	.0	45.4	129.5	100.4	27.7	70.0	252.7	235.6	176.8	112.5	.0	
1996 Amt.	.0	49.2	15.5	163.4	166.5	76.5	169.2	155.3	512.5	285.0	92.6	.0	
1997 Amt.	-	15.0	102.6	14.3	7.7	39.3	88.3	77.7	184.6	-	115.1	-	
1998 Amt.	.0	.0	66.9	455.0	85.6	107.3	67.2	108.5	435.1	144.4	92.3	5.8	
1999 Amt.	67.2	14.9	-	346.1	176.8	23.2	42.9	63.6	178.0	561.7	155.2	25.9	
MEAN Amt.	8.1	10.8	62.2	136.6	146.0	64.2	93.9	101.1	251.2	313.1	66.3	8.6	(1262.1)

Table 8 (continued)

(21) STATION : 450024 Ban Phu Toei Kaeng Lawa PROVINCE : Kanchana Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	T	.7	57.9	95.3	122.1	89.0	142.4	132.7	73.8	180.7	30.1	.0	
1991 Amt.	6.4	7.3	66.1	61.2	176.5	146.5	118.7	247.7	192.8	273.9	.5	1.5	
1992 Amt.	.0	T	5.0	65.5	240.6	227.3	189.5	151.9	117.4	293.3	.5	4.9	
1993 Amt.	-	.0	143.7	-	68.8	95.5	-	-	-	-	-	-	
1994 Amt.	-	-	-	-	-	-	-	-	-	-	-	-	
1995 Amt.	.0	.8	21.8	32.1	217.2	162.7	169.5	385.5	293.1	285.9	6.0	.0	
1996 Amt.	.2	102.7	83.7	220.6	114.6	196.9	374.2	168.2	470.6	216.2	92.4	.0	
1997 Amt.	-	.0	-	-	-	-	241.9	173.1	230.9	-	48.7	.0	
1998 Amt.	-	-	-	-	-	115.7	125.7	103.5	419.7	259.9	63.4	.0	
1999 Amt.	4.4	-	33.2	470.0	177.6	69.4	77.5	188.5	197.6	496.0	94.8	-	
MEAN Amt.	1.8	15.9	58.8	157.5	159.6	137.9	179.9	193.9	249.5	286.6	42.1	.9	(1484.4)

(22) STATION : 450026 Huay Malai PROVINCE : Kanchana Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	.0	.0	.0	16.6	151.0	425.9	251.9	215.2	328.4	118.6	19.9	.0	
1991 Amt.	.0	3.1	.0	76.4	203.4	703.9	464.3	476.4	138.4	121.3	.0	15.3	
1992 Amt.	26.3	T	.0	36.0	77.7	299.2	296.8	572.2	284.8	137.5	.0	33.9	
1993 Amt.	T	.0	39.2	45.9	253.7	145.4	398.9	652.1	307.0	43.9	.0	.0	
1994 Amt.	.0	.0	76.6	60.8	367.5	412.8	763.4	775.6	298.5	126.4	.6	.0	
1995 Amt.	47.7	.0	74.4	107.7	265.0	656.5	274.2	522.5	280.6	229.2	17.0	.0	
1996 Amt.	-	102.4	17.6	80.8	252.6	331.9	669.6	461.4	466.3	173.9	86.5	.0	
1997 Amt.	-	.0	16.5	34.9	272.4	343.1	1160.6	897.3	272.1	85.9	20.4	.0	
1998 Amt.	T	.0	.0	6.0	322.3	175.7	105.7	222.5	309.6	251.7	.0	33.2	
1999 Amt.	30.5	40.2	49.0	283.3	295.1	334.7	581.8	433.1	386.7	237.3	102.8	.0	
MEAN Amt.	13.1	14.6	27.3	74.8	246.1	382.9	496.7	522.8	307.2	152.6	24.7	8.2	(2271.0)

(23) STATION : 450027 Ban Na Suan PROVINCE : Kanchana Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	T	.0	25.3	67.9	94.9	77.5	87.2	62.3	97.5	317.6	59.2	.0	
1991 Amt.	T	1.4	.0	76.4	94.8	151.7	84.1	168.5	133.9	241.8	.0	4.2	
1992 Amt.	.0	.4	2.2	12.1	120.8	39.6	149.7	131.5	48.9	258.6	.0	11.4	
1993 Amt.	.0	.0	19.9	55.6	154.4	45.3	103.3	142.1	289.1	-	-	-	
1994 Amt.	-	-	-	-	-	-	-	-	-	-	-	-	
1995 Amt.	-	-	-	-	-	-	-	-	-	-	-	-	
1996 Amt.	.0	7.8	7.9	121.8	202.6	121.1	198.2	141.4	417.0	156.3	75.4	T	
1997 Amt.	.0	.0	.0	25.8	68.3	49.2	172.8	149.3	-	144.7	51.0	.0	
1998 Amt.	.0	-	-	-	-	-	-	-	-	-	-	-	
1999 Amt.	-	-	31.6	209.5	109.9	59.4	45.2	280.8	161.5	357.5	59.5	3.2	
MEAN Amt.	.0	1.6	12.4	81.3	120.8	77.7	120.1	153.7	191.3	246.1	40.9	3.1	(1049.0)

(24) STATION : 450029 K.A.Dan Makam Tia PROVINCE : Kanchana Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 no data													
1991 Amt.	-	-	-	-	-	-	-	-	-	-	-	-	
1992 Amt.	-	-	-	-	-	-	-	-	-	-	-	-	
1993 Amt.	.0	.0	67.5	54.0	89.9	42.4	63.8	96.5	282.7	232.6	13.1	10.5	
1994 Amt.	.0	.0	26.3	49.2	192.9	95.7	120.8	163.3	146.7	159.9	.0	2.5	
1995 Amt.	.0	.0	59.9	76.7	197.6	131.6	129.0	283.9	389.1	204.0	5.4	.0	
1996 Amt.	.0	.0	56.9	143.0	67.3	84.6	267.0	182.8	615.7	221.7	23.4	.0	
1997 Amt.	.0	.0	125.7	65.9	29.8	40.8	61.3	95.2	312.2	-	-	-	
1998 Amt.	-	-	-	11.3	137.8	114.1	110.6	146.2	317.7	324.5	-	-	
1999 Amt.	-	18.8	21.2	372.5	199.2	26.8	59.4	74.4	70.4	348.1	83.2	4.7	
MEAN Amt.	.0	3.1	59.6	110.4	130.6	76.6	116.0	148.9	304.9	248.5	25.0	3.5	(1227.1)

Table 8 (continued)

(25) STATION : 450201 Kanchanaburi PROVINCE : Kanchana Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	.0	.5	25.6	81.2	224.4	54.2	68.3	47.5	115.3	299.8	50.6	.0	
1991 Amt.	.0	25.5	14.8	52.3	196.2	78.5	51.2	79.4	165.3	271.4	17.8	44.3	
1992 Amt.	21.6	9.9	.0	T	15.6	64.0	197.2	140.9	75.4	319.3	T	15.8	
1993 Amt.	T	.0	30.1	21.6	124.5	55.5	59.7	74.0	383.0	189.4	.2	17.0	
1994 Amt.	.0	T	45.1	51.3	195.4	99.5	169.8	105.8	276.3	190.9	2.6	T	
1995 Amt.	.0	.3	25.2	64.1	102.6	68.8	95.3	186.8	298.4	96.9	27.2	.0	
1996 Amt.	.0	T	18.1	64.9	143.3	169.0	209.5	181.5	469.7	192.3	47.4	.5	
1997 Amt.	.0	T	6.3	22.9	24.7	3.2	60.5	135.6	252.8	85.9	78.1	.0	
1998 Amt.	.0	10.7	.0	2.2	96.0	130.9	123.3	119.6	125.2	455.8	139.6	.0	
1999 Amt.	.5	23.3	1.1	271.7	190.0	39.5	69.2	93.8	99.1	305.7	80.9	4.7	
MEAN Amt.	2.2	7.0	16.6	63.2	131.3	76.3	110.4	116.5	226.1	240.7	44.4	8.2	(1042.9)

(26) STATION : 450401 Thong Pha Phum PROVINCE : Kanchana Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	.0	T	110.2	126.4	292.1	257.1	232.8	198.9	237.4	273.2	.0	.0	
1991 Amt.	3.4	T	4.1	114.9	174.4	566.9	369.7	599.3	127.5	137.5	T	6.1	
1992 Amt.	2.8	1.8	.0	62.9	82.8	244.7	382.0	351.3	175.4	151.8	.0	31.9	
1993 Amt.	.0	.0	91.6	102.5	186.2	175.5	279.1	279.4	262.0	83.4	T	T	
1994 Amt.	.0	24.6	38.0	21.2	286.3	227.0	649.1	430.2	197.4	119.3	11.3	1.0	
1995 Amt.	7.7	.0	50.0	47.4	257.0	259.6	229.8	454.7	277.4	200.9	T	4.8	
1996 Amt.	.0	4.9	16.2	156.8	154.6	253.5	629.1	314.8	346.8	205.9	46.6	.0	
1997 Amt.	.0	.0	42.7	55.9	166.3	203.6	695.2	541.6	245.9	93.0	13.8	.0	
1998 Amt.	.0	.0	3.9	23.3	293.4	175.8	123.4	103.5	231.4	174.2	20.6	5.5	
1999 Amt.	29.4	7.6	102.1	267.9	220.6	258.9	243.7	359.6	215.3	348.4	76.8	.3	
MEAN Amt.	4.3	3.9	45.9	97.9	211.4	262.3	383.4	363.3	231.7	178.8	16.9	5.0	(1804.8)

(27) STATION : 424001 Ratchaburi PROVINCE : Ratcha Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	-	-	-	-	-	-	-	-	-	-	-	-	
1991 Amt.	-	-	-	-	-	-	-	-	-	-	-	-	
1992 Amt.	1.2	.0	.0	.0	65.5	151.4	110.6	202.5	111.9	314.4	T	.0	
1993 Amt.	.0	.0	42.7	16.1	188.3	163.0	130.4	101.2	278.3	252.4	8.2	22.0	
1994 Amt.	.0	.0	73.7	.0	203.8	114.8	90.4	70.4	190.2	63.1	.0	5.9	
1995 Amt.	.0	.0	46.3	.0	58.7	128.6	271.7	186.3	351.5	270.7	21.9	.0	
1996 Amt.	.0	8.3	9.0	132.2	224.8	160.4	163.7	135.2	369.3	220.0	50.5	12.5	
1997 Amt.	4.5	.0	T	25.9	19.2	18.6	21.1	49.7	141.3	239.1	163.2	.0	
1998 Amt.	.0	T	.0	20.0	122.2	129.2	219.3	31.2	-	-	-	-	
1999 Amt.	T	T	5.6	43.2	-	T	-	-	-	-	-	-	
MEAN Amt.	.7	1.0	22.2	29.7	126.1	108.3	143.9	110.9	240.4	226.6	40.6	6.7	(1057.1)

(28) STATION : 424002 Photharam PROVINCE : Ratcha Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	3.9	.0	2.5	39.9	152.6	49.6	148.1	60.6	108.0	303.2	37.3	.0	
1991 Amt.	.0	35.7	.0	34.8	85.5	37.5	55.4	91.3	181.8	234.6	4.7	56.4	
1992 Amt.	.0	5.7	.0	.0	52.4	132.5	169.8	130.3	165.2	390.1	.0	4.7	
1993 Amt.	.0	4.2	93.0	27.5	83.9	122.6	35.7	110.1	174.1	237.0	.0	.0	
1994 Amt.	.0	.0	61.0	.0	195.7	120.8	86.1	89.8	324.2	82.4	.0	4.4	
1995 Amt.	.0	73.4	6.7	4.4	62.8	112.3	85.4	172.9	339.2	178.1	8.6	.0	
1996 Amt.	.0	34.2	4.8	4.9	112.3	91.4	87.0	193.3	262.5	127.5	80.5	.0	
1997 Amt.	.0	.0	T	11.0	41.0	18.8	69.3	44.5	209.1	209.0	31.0	.0	
1998 Amt.	.0	.0	.0	.0	45.1	145.0	162.1	69.1	87.2	127.6	-	-	
1999 Amt.	.0	.0	.0	213.1	104.5	60.3	79.4	66.9	279.5	-	-	-	
MEAN Amt.	.4	15.3	16.8	33.6	93.6	89.1	97.8	102.9	213.1	209.9	20.3	8.2	(901.0)

Table 8 (continued)

(29) STATION : 424003 Damnoen Saduak PROVINCE : Ratcha Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	.0	.0	51.2	26.7	144.3	148.6	134.4	62.1	299.4	261.8	16.7	.0	
1991 Amt.	.0	28.7	37.8	30.8	67.5	107.1	114.7	210.6	146.3	178.1	.0	21.1	
1992 Amt.	1.6	.0	.0	.0	59.4	186.3	159.2	66.0	162.1	327.0	.0	4.7	
1993 Amt.	.0	.0	47.9	4.7	26.5	45.6	16.4	58.2	30.6	162.4	.0	4.3	
1994 Amt.	.0	.0	150.6	.0	293.4	109.6	28.6	35.9	52.4	49.8	.0	.0	
1995 Amt.	.0	.0	.0	.0	55.1	115.4	404.1	181.2	530.4	121.1	44.7	4.2	
1996 Amt.	.0	18.7	10.3	95.4	315.0	130.9	261.7	59.5	448.6	203.8	200.2	10.8	
1997 Amt.	.0	.0	.0	.8	150.5	53.0	96.1	18.8	387.4	298.5	210.4	.0	
1998 Amt.	.0	.0	-	-	-	194.6	138.8	136.3	-	225.7	-	-	
1999 Amt.	2.5	8.5	6.5	105.2	257.0	106.7	46.7	120.0	-	324.5	50.8	.0	
MEAN Amt.	.4	5.6	33.8	29.3	152.1	119.8	140.1	94.9	257.2	215.3	58.1	5.0	(1111.6)

(30) STATION : 424004 Pak Tho PROVINCE : Ratcha Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	.0	.0	48.1	82.1	116.3	80.9	67.7	69.0	165.1	219.6	117.6	.0	
1991 Amt.	.0	20.4	.0	43.2	19.9	103.7	92.1	155.9	162.9	340.4	.0	-	
1992 Amt.	.0	.0	.0	.0	101.3	164.4	155.7	49.1	97.8	338.5	2.8	.0	
1993 Amt.	.0	.0	47.1	31.3	57.9	96.0	80.9	186.6	201.9	317.9	4.0	.0	
1994 Amt.	.0	.0	57.8	.0	239.0	47.4	54.3	55.2	277.0	100.8	.0	20.2	
1995 Amt.	.0	.0	10.0	.0	194.6	310.5	290.1	172.4	275.3	138.9	10.0	.0	
1996 Amt.	.0	.0	43.0	68.6	185.1	145.0	153.6	142.8	320.7	267.9	97.3	10.8	
1997 Amt.	.0	.0	.0	81.2	34.4	61.4	83.8	48.7	251.6	159.2	273.6	.0	
1998 Amt.	-	.0	.0	.0	32.1	202.0	176.1	92.5	223.4	229.7	95.2	.0	
1999 Amt.	-	6.8	.0	157.7	237.2	35.6	11.8	164.6	203.6	229.7	84.2	.0	
MEAN Amt.	.0	2.7	20.6	46.4	121.8	124.7	116.6	113.7	217.9	234.3	68.5	3.4	(1070.6)

(31) STATION : 424005 Ban Pong PROVINCE : Ratcha Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	.0	.0	.0	6.8	99.8	25.4	51.3	9.5	134.0	335.8	15.0	.0	
1991 Amt.	.0	24.7	48.7	11.1	28.7	32.1	50.6	122.4	81.6	163.8	2.2	63.7	
1992 Amt.	14.1	18.6	.0	.0	25.2	77.2	140.9	45.3	74.2	257.5	.0	.0	
1993 Amt.	.0	.0	42.5	.0	55.4	65.0	32.1	111.7	185.9	226.3	.0	.0	
1994 Amt.	.0	.0	27.7	.0	62.4	101.2	51.6	35.5	230.2	39.9	.0	.0	
1995 Amt.	.0	.0	.0	20.5	70.7	24.2	117.6	227.7	368.1	55.4	.0	.0	
1996 Amt.	.0	-	.0	21.5	28.3	106.4	36.6	42.6	198.5	61.2	18.4	.0	
1997 Amt.	.0	.0	.0	.0	41.0	93.5	66.5	8.2	63.7	83.6	134.1	.0	
1998 Amt.	-	.0	.0	-	-	-	-	-	-	-	-	-	
1999 Amt.	.0	4.2	20.9	204.4	115.4	68.2	160.3	222.4	280.4	-	111.1	.0	
MEAN Amt.	1.6	5.3	14.0	29.4	58.5	65.9	78.6	91.7	179.6	152.9	31.2	7.1	(715.8)

(32) STATION : 424006 Chom Bung PROVINCE : Ratcha Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	.0	.0	17.7	8.5	81.0	46.1	38.6	41.7	115.3	185.6	66.1	.0	
1991 Amt.	.0	T	5.3	36.0	50.7	26.8	-	42.3	101.4	-	15.7	.0	
1992 Amt.	T	25.8	T	.0	51.0	44.6	56.9	33.9	67.2	342.9	T	.0	
1993 Amt.	T	.0	56.3	15.2	113.4	71.1	77.7	61.7	194.4	286.4	T	T	
1994 Amt.	.0	.0	25.6	T	194.6	66.5	122.9	56.1	206.1	54.0	T	.0	
1995 Amt.	.0	.0	20.2	25.3	73.4	111.8	143.8	273.9	257.5	95.7	.0	.0	
1996 Amt.	.0	.0	.0	112.8	207.4	13.4	132.1	13.4	177.9	70.8	18.2	.0	
1997 Amt.	.0	.0	12.7	17.5	23.0	17.0	43.6	56.4	104.9	105.2	147.3	.0	
1998 Amt.	.0	.0	15.7	.0	22.7	109.4	-	86.7	239.0	113.0	69.3	1.5	
1999 Amt.	.0	10.5	10.0	171.1	125.9	78.2	25.7	89.3	154.8	233.6	75.1	.0	
MEAN Amt.	.0	3.6	16.4	38.6	94.3	58.5	80.2	75.5	161.9	165.2	39.2	.2	(733.6)

Table 8 (continued)

(33) STATION : 424007 Wat Phleng PROVINCE : Ratcha Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	.0	.0	1.9	2.1	40.9	12.5	69.3	63.3	62.1	71.1	1.2	.0	
1991 Amt.	.0	3.0	3.8	2.1	3.7	9.2	34.0	15.0	40.4	55.6	63.7	1.3	
1992 Amt.	1.2	.0	.0	.0	81.6	130.5	181.0	166.3	48.3	122.4	.0	T	
1993 Amt.	3.2	.0	37.5	21.4	37.4	149.7	65.6	153.5	139.5	298.6	5.1	3.8	
1994 Amt.	.0	T	52.9	1.2	221.6	50.5	47.1	44.6	224.9	154.7	3.1	35.9	
1995 Amt.	.0	.0	105.5	.0	65.3	14.0	208.7	101.6	366.9	79.9	11.9	T	
1996 Amt.	.0	4.2	.0	5.3	299.4	109.9	129.1	57.8	338.4	147.9	17.9	.0	
1997 Amt.	.0	.0	.0	5.8	.0	4.8	121.6	19.7	217.4	183.0	221.1	.0	
1998 Amt.	.0	.0	T	.0	22.3	153.4	59.3	53.5	74.9	122.2	T	32.4	
1999 Amt.	1.0	1.0	-	54.9	291.2	49.2	42.7	26.7	60.8	348.3	3.7	.0	
MEAN Amt.	.5	.8	22.4	9.3	106.3	68.4	95.8	70.2	157.4	158.4	32.8	7.3	(729.6)

(34) STATION : 424008 Suan Phung PROVINCE : Ratcha Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	.0	.0	82.1	44.2	159.8	32.1	38.1	93.7	179.2	327.5	65.0	.0	
1991 Amt.	.0	4.3	70.9	136.6	150.3	70.6	125.2	109.8	115.9	272.7	9.8	47.5	
1992 Amt.	.0	38.0	.0	31.3	114.6	101.5	198.4	50.3	140.8	361.5	2.6	.0	
1993 Amt.	.0	.0	87.5	96.7	189.3	43.2	86.7	98.3	259.5	475.8	.0	.0	
1994 Amt.	.0	.0	134.3	15.9	290.1	102.4	178.6	154.3	116.2	119.6	.0	.0	
1995 Amt.	.0	4.5	.0	105.6	158.1	146.3	125.2	284.8	300.5	502.9	6.3	.0	
1996 Amt.	.0	18.4	46.3	136.3	259.6	54.2	228.4	192.5	497.1	351.4	112.6	13.7	
1997 Amt.	.0	.0	28.8	73.9	61.7	27.8	76.7	133.6	180.0	97.8	233.6	.0	
1998 Amt.	.0	.0	.0	26.0	43.9	62.5	111.0	74.0	246.5	238.6	39.4	21.8	
1999 Amt.	-	14.3	32.2	149.4	155.2	39.4	52.3	151.8	105.7	507.3	78.3	.0	
MEAN Amt.	.0	8.0	48.2	81.6	158.3	68.0	122.1	134.3	214.1	325.5	54.8	8.3	(1223.2)

(35) STATION : 424009 Bang Phae PROVINCE : Ratcha Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	.0	.0	.0	44.3	139.0	76.4	90.5	87.4	153.2	304.2	32.5	-	
1991 Amt.	.0	30.8	39.8	78.9	67.9	49.0	50.8	154.2	144.7	207.9	7.5	73.6	
1992 Amt.	.0	8.6	.0	.0	41.7	209.2	213.8	113.7	192.7	231.3	20.0	.0	
1993 Amt.	.0	.0	60.3	18.9	202.4	115.4	154.0	167.9	162.7	270.6	-	-	
1994 Amt.	.0	.0	14.8	.0	94.8	94.2	89.3	133.4	368.7	68.9	.0	6.2	
1995 Amt.	.0	.0	.0	4.0	108.1	113.0	137.3	215.7	637.0	128.1	11.5	.0	
1996 Amt.	.0	.0	2.0	49.8	161.9	135.1	240.0	-	-	-	-	-	
1997 Amt.	-	-	-	-	-	-	-	-	-	-	-	-	
1998 Amt.	-	-	-	-	-	-	-	-	-	-	-	-	
1999 Amt.	-	9.9	-	120.4	150.0	92.1	59.6	81.0	133.0	339.8	38.7	-	
MEAN Amt.	.0	6.2	16.7	39.5	120.7	110.6	129.4	136.2	256.0	221.5	18.4	20.0	(1075.2)

(36) STATION : 424011 Tham Chom Pon Royal Garden PROVINCE : Ratcha Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	7.1	.0	21.3	11.8	148.3	52.7	46.3	57.1	223.9	264.0	93.0	.0	
1991 Amt.	.0	.8	3.2	54.4	121.4	33.5	59.8	123.5	161.8	161.1	1.2	94.2	
1992 Amt.	.0	34.9	.0	T	30.6	84.5	99.5	49.0	98.1	302.2	T	T	
1993 Amt.	2.3	.0	63.3	29.1	134.1	62.6	47.5	72.7	179.2	226.4	2.5	6.2	
1994 Amt.	.0	.0	59.0	4.7	156.9	31.9	86.6	34.4	197.3	48.8	.0	8.8	
1995 Amt.	4.0	2.8	35.8	11.8	148.9	128.0	177.5	200.9	306.7	197.6	14.3	.0	
1996 Amt.	.0	3.3	.0	119.6	182.3	76.4	249.4	149.3	350.3	147.9	21.8	11.6	
1997 Amt.	.0	2.9	3.2	44.6	15.0	19.9	26.1	59.2	154.5	107.4	214.2	.0	
1998 Amt.	.0	.0	40.0	.0	48.9	73.8	126.3	45.8	176.4	82.3	51.9	.0	
1999 Amt.	6.5	16.5	2.5	227.1	62.0	23.5	53.9	96.2	145.2	319.4	78.0	.0	
MEAN Amt.	2.0	6.1	22.8	50.3	104.8	58.7	97.3	88.8	199.3	185.7	47.7	12.1	(87506)

Table 8 (continued)

(37) STATION : 424013 Maenam Pachi Wildlife Conservation Center PROVINCE : Ratcha Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 no data													
1991 Amt.	-	-	-	-	-	-	-	-	-	396.1	7.1	90.3	-
1992 Amt.	.0	61.0	.5	160.1	236.7	-	-	13.8	36.4	400.2	97.8	.0	
1993 Amt.	.0	.0	65.7	99.6	158.0	112.2	40.4	61.9	273.4	283.4	28.2	4.5	
1994 Amt.	.0	17.6	88.8	41.5	174.7	74.2	120.0	69.2	145.0	171.6	6.0	33.0	
1995 Amt.	5.0	7.5	40.2	76.3	144.4	143.5	95.8	315.7	261.5	336.8	38.3	T	
1996 Amt.	T	10.0	69.2	128.2	164.9	142.5	286.5	-	-	-	-	-	
1997 Amt.	-	-	-	-	-	-	-	-	-	-	-	-	-
1998 Amt.	-	-	-	-	-	-	-	-	-	-	-	-	-
1999 Amt.	-	-	-	-	-	-	-	-	-	-	-	-	-
MEAN Amt.	1.0	19.2	52.9	101.1	175.7	118.1	135.7	115.2	179.1	317.6	35.5	25.6	(1276.7)

(38) STATION : 424301 Ratchaburi Rice Research Station PROVINCE : Ratcha Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 no data													
1991 Amt.	-	-	-	-	-	-	-	-	-	-	-	-	-
1992 Amt.	-	-	-	-	-	-	-	-	-	-	-	-	-
1993 Amt.	8.0	.0	53.2	11.4	122.1	111.9	59.5	141.8	203.2	243.5	23.6	24.5	
1994 Amt.	.0	.0	70.3	T	243.1	136.9	84.4	81.2	247.5	80.3	T	9.8	
1995 Amt.	T	.0	55.9	T	-	-	-	-	-	-	-	-	-
1996 Amt.	.0	12.0	17.9	139.5	185.0	187.6	174.5	110.5	375.4	249.9	65.1	4.1	
1997 Amt.	T	T	2.0	41.0	21.7	62.9	47.8	86.4	336.1	341.7	348.7	T	
1998 Amt.	.0	7.8	1.9	1.7	135.3	255.9	298.7	168.5	252.7	165.5	57.4	9.0	
1999 Amt.	1.6	8.8	7.0	157.8	297.9	121.2	73.7	119.5	174.4	280.3	56.3	1.4	
MEAN Amt.	1.4	4.1	29.7	50.2	167.5	146.1	123.1	118.0	264.9	226.9	91.9	8.1	(1231.9)

(39) STATION : 425002 Song Phi Nong PROVINCE : Suphan Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	.0	.0	93.3	T	55.0	22.4	79.6	96.3	321.4	408.9	88.8	.0	
1991 Amt.	.0	56.8	69.2	55.4	28.2	34.0	74.6	75.0	231.9	150.3	2.7	15.3	
1992 Amt.	.0	5.9	.0	.0	36.0	191.4	97.0	353.3	114.9	315.4	.0	6.5	
1993 Amt.	T	.0	24.2	72.8	42.0	76.8	56.9	46.0	281.8	219.8	.0	6.9	
1994 Amt.	.0	.0	96.4	25.9	105.8	122.5	126.2	71.8	180.9	118.5	.0	.0	
1995 Amt.	T	.0	8.3	.9	132.7	198.0	121.8	132.6	542.4	115.9	.0	.0	
1996 Amt.	.0	.0	T	51.6	165.6	100.1	50.3	32.5	299.7	70.4	50.2	.0	
1997 Amt.	.0	.0	6.5	15.4	27.2	92.3	67.8	71.9	166.0	124.7	38.0	.0	
1998 Amt.	.0	.0	.0	50.9	165.2	33.9	217.2	122.0	262.6	222.7	39.4	T	
1999 Amt.	T	19.3	83.4	161.6	308.2	33.1	122.6	81.8	231.1	273.8	129.7	.0	
MEAN Amt.	.0	8.2	38.1	43.5	106.6	90.5	101.4	108.3	263.3	202.0	34.9	2.9	(999.7)

(40) STATION : 425003 Doembang Nangbuat PROVINCE : Suphan Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	.0	.0	49.5	.0	158.6	83.5	43.2	232.9	157.8	214.7	13.4	.0	
1991 Amt.	.0	.0	27.7	23.7	26.9	91.1	51.3	163.4	564.4	1409.8	.0	.0	
1992 Amt.	17.4	T	.0	.0	100.9	56.7	288.6	107.1	224.4	234.4	.0	7.7	
1993 Amt.	.0	.0	7.2	114.7	191.1	182.0	19.7	32.6	181.0	63.2	.0	.0	
1994 Amt.	.0	.0	179.8	.0	76.7	166.3	16.0	61.3	192.5	181.7	.0	.0	
1995 Amt.	.0	.0	18.5	34.6	72.7	139.6	174.0	158.8	350.6	148.8	16.0	.0	
1996 Amt.	.0	.0	14.7	56.4	63.9	159.6	39.1	124.9	228.7	119.6	36.3	.0	
1997 Amt.	.0	.0	.0	37.6	68.3	54.1	61.4	52.0	255.0	103.1	.0	.0	
1998 Amt.	.0	.0	.0	21.8	118.3	125.4	98.8	98.5	144.2	94.2	34.3	13.7	
1999 Amt.	.0	27.6	7.0	268.9	271.5	50.5	82.8	143.6	129.2	273.9	24.5	.0	
MEAN Amt.	1.7	2.8	30.4	55.8	114.9	110.9	87.5	117.5	242.8	284.3	12.5	2.1	(1063.2)

Table 8 (continued)

(41) STATION : 425004 U Thong PROVINCE : Suphan Buri

YEAR		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990	Amt.	.0	.0	24.7	T	185.0	28.2	77.9	155.5	157.0	500.9	58.5	.0	
1991	Amt.	.0	43.2	28.2	.0	99.6	18.2	26.6	114.5	216.7	158.3	.0	62.5	
1992	Amt.	.0	.0	.0	.0	91.7	188.1	174.8	124.0	85.4	242.3	.0	.0	
1993	Amt.	.0	.0	25.7	43.1	49.6	89.1	35.3	87.0	183.6	87.3	.0	7.1	
1994	Amt.	.0	.0	72.2	13.6	69.3	78.9	4.9	36.6	226.5	93.0	.0	.0	
1995	Amt.	.0	.0	.0	.0	22.8	48.9	106.9	107.6	278.7	163.5	13.4	.0	
1996	Amt.	.0	.0	31.4	76.3	139.7	203.2	52.5	40.3	328.4	122.3	91.6	.0	
1997	Amt.	.0	T	T	29.5	71.8	47.2	12.6	71.8	237.8	112.5	13.7	.0	
1998	Amt.	.0	23.2	.0	34.6	162.7	67.6	170.6	74.0	142.7	145.3	54.7	31.3	
1999	Amt.	.0	2.6	53.7	212.7	187.2	53.1	120.1	36.8	147.5	436.7	164.0	.0	
MEAN	Amt.	.0	6.9	23.6	41.0	107.9	82.3	78.2	84.8	200.4	206.2	39.6	10.1	(881.0)

(42) STATION : 425005 Sam Chuk PROVINCE : Suphan Buri

YEAR		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990	Amt.	3.4	.0	49.9	1.4	186.7	64.2	25.8	161.5	178.8	-	-	-	
1991	Amt.	.0	.0	36.0	7.2	73.6	67.8	63.1	153.8	230.0	194.8	.0	16.7	
1992	Amt.	1.1	8.5	.0	.0	66.5	129.8	191.9	88.6	178.1	358.7	.0	2.1	
1993	Amt.	T	.0	7.8	64.1	152.5	86.0	38.7	91.2	117.0	89.8	T	5.3	
1994	Amt.	18.3	.0	179.4	T	85.3	130.2	43.6	84.6	159.3	149.7	.0	.0	
1995	Amt.	.0	-	40.0	62.3	61.5	105.7	129.8	231.2	407.9	157.0	14.0	.0	
1996	Amt.	.0	.0	2.5	59.5	139.3	123.6	82.6	65.7	406.8	177.4	48.0	.0	
1997	Amt.	.0	.0	T	34.5	107.9	30.8	77.0	96.9	226.9	210.5	1.7	.0	
1998	Amt.	.0	.0	T	66.7	113.8	83.1	143.2	127.0	142.2	265.6	43.4	7.9	
1999	Amt.	T	10.3	43.5	324.1	300.5	104.7	170.1	89.9	248.7	263.6	24.2	5.8	
MEAN	Amt.	2.3	2.1	35.9	62.0	128.8	92.6	96.6	119.0	229.6	207.5	14.6	4.2	(995.2)

(43) STATION : 425006 Si Prachan PROVINCE : Suphan Buri

YEAR		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990	Amt.	.0	.0	7.8	.0	35.0	18.8	53.9	53.2	119.5	216.9	.0	.0	
1991	Amt.	.0	3.2	5.8	40.7	75.6	16.8	59.9	130.4	130.9	148.8	.0	25.4	
1992	Amt.	.0	1.5	.0	.0	24.1	158.3	64.1	64.3	35.9	225.0	.0	.0	
1993	Amt.	.0	.0	7.4	70.8	147.1	70.0	15.7	60.8	193.3	33.1	.0	.0	
1994	Amt.	5.3	.0	98.1	.0	94.0	80.2	27.5	61.2	123.8	71.3	.0	.0	
1995	Amt.	.0	.0	.0	34.7	78.4	59.0	43.3	82.3	188.5	-	-	-	
1996	Amt.	.0	.0	.0	97.3	125.0	70.8	36.2	29.5	160.3	-	-	-	
1997	Amt.	.0	.0	.0	9.8	-	-	-	-	-	25.3	-	-	
1998	Amt.	.0	.0	.0	.0	26.7	40.7	165.5	-	86.3	156.2	-	-	
1999	Amt.	-	-	-	-	-	-	-	-	-	-	-	-	
MEAN	Amt.	.6	.5	13.2	28.1	75.7	64.3	58.3	68.8	129.8	125.2	.0	5.1	(569.6)

(44) STATION : 425007 Don Chedi PROVINCE : Suphan Buri

YEAR		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990	Amt.	4.7	.0	33.4	.0	124.8	23.7	13.1	91.7	188.0	408.3	2.1	.0	
1991	Amt.	.0	.0	T	76.0	107.2	8.1	32.8	138.5	201.7	184.8	T	4.1	
1992	Amt.	3.2	.0	.0	.0	113.0	162.1	139.0	130.6	171.1	298.6	.0	T	
1993	Amt.	.0	.0	8.1	177.1	160.6	76.4	41.6	131.6	140.5	82.9	T	T	
1994	Amt.	.0	.0	149.8	177.1	30.5	89.4	30.5	87.1	245.7	167.8	.0	.0	
1995	Amt.	.0	.0	7.4	125.9	43.5	60.5	149.2	101.6	339.6	111.8	1.5	.0	
1996	Amt.	.0	5.3	.0	99.6	154.0	214.8	127.6	61.0	268.5	221.8	70.7	.0	
1997	Amt.	.0	.0	.0	18.7	124.4	50.0	79.5	56.2	300.9	144.6	.0	.0	
1998	Amt.	.0	21.0	.0	20.4	103.9	86.2	41.3	24.6	88.0	119.2	9.6	23.7	
1999	Amt.	.0	41.3	85.6	256.1	408.4	65.9	66.4	75.8	401.4	331.0	19.8	.0	
MEAN	Amt.	.8	6.8	28.4	95.1	137.0	83.7	72.1	89.9	234.5	207.1	10.4	2.8	(968.6)

Table 8 (continued)

(45) STATION : 425008 Dan Chang PROVINCE : Suphan Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	21.7	.0	70.3	17.0	178.9	17.8	33.0	135.2	90.8	381.8	97.2	.0	
1991 Amt.	.0	.0	82.8	15.4	-	-	-	-	-	-	-	-	
1992 Amt.	.0	.0	.0	.0	78.2	180.7	124.9	61.4	176.0	385.5	.0	.0	
1993 Amt.	-	-	-	-	-	-	-	-	-	-	-	-	-
1994 Amt.	.0	.0	246.8	36.0	135.1	162.5	50.5	40.2	316.6	132.4	.0	.0	
1995 Amt.	.0	.0	.4	44.9	60.3	63.0	70.6	263.1	503.0	93.2	70.3	.0	
1996 Amt.	.0	.0	104.6	106.0	98.8	129.5	87.7	170.4	298.7	173.0	56.0	.0	
1997 Amt.	.0	.0	19.0	108.0	70.0	17.0	44.1	42.5	197.6	88.0	10.0	.0	
1998 Amt.	.0	2.6	.0	41.7	105.0	235.6	136.9	145.9	115.2	130.2	158.8	-	
1999 Amt.	-	.0	-	288.8	232.5	43.0	59.0	98.8	165.4	400.7	-	-	
MEAN Amt.	2.7	.3	65.5	73.1	119.9	106.1	75.8	119.7	232.9	223.1	56.0	.0	(1075.1)

(46) STATION : 425009 K.A.Nong Ya Sai PROVINCE : Suphan Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	27.8	.0	35.9	.0	151.1	40.9	45.2	98.6	129.7	278.7	.0	.0	
1991 Amt.	.0	.0	65.6	39.0	77.3	14.3	3.6	153.1	204.0	148.0	.0	15.3	
1992 Amt.	.0	.0	.0	.0	142.1	145.1	211.9	86.2	118.9	171.9	.0	.0	
1993 Amt.	.0	.0	5.8	127.5	98.4	94.1	71.5	150.9	211.4	121.2	.0	.0	
1994 Amt.	.0	.0	126.0	.8	132.4	52.5	23.9	112.3	368.6	66.9	.0	.0	
1995 Amt.	.0	.0	5.2	26.1	128.0	152.3	237.1	125.6	311.6	100.1	T	.0	
1996 Amt.	.0	.0	19.5	68.3	63.9	132.8	98.2	186.3	437.6	168.6	35.7	.0	
1997 Amt.	.0	.0	5.8	.0	60.3	34.2	89.1	87.0	267.1	143.0	5.5	.0	
1998 Amt.	.0	4.8	.0	56.1	-	189.0	91.7	129.9	-	-	-	-	
1999 Amt.	T	73.9	16.0	164.4	T	31.7	81.3	109.9	247.7	265.3	31.7	-	
MEAN Amt.	2.8	7.9	28.0	48.2	94.8	88.7	95.4	124.0	255.2	162.6	8.1	1.9	(917.6)

(47) STATION : 425010 Suphan Buri Rice Research Station PROVINCE : Suphan Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	12.5	.0	10.5	15.5	128.9	25.0	34.5	132.7	110.9	459.9	38.7	.0	
1991 Amt.	.0	5.7	43.7	9.8	94.1	18.9	36.5	168.7	153.9	217.6	.0	44.8	
1992 Amt.	T	3.9	.0	.0	33.2	115.4	135.7	143.9	115.5	417.9	.0	.0	
1993 Amt.	2.5	.0	10.4	99.5	195.6	99.6	14.8	59.7	135.6	82.4	T	5.1	
1994 Amt.	17.3	T	62.0	19.3	170.2	177.1	64.5	45.2	236.6	123.1	T	.2	
1995 Amt.	.0	.0	1.2	9.6	104.6	70.4	90.7	138.2	411.7	91.9	12.7	.0	
1996 Amt.	.0	1.8	1.4	77.4	98.0	91.6	125.0	120.9	343.6	180.1	108.7	.0	
1997 Amt.	.0	.7	.0	55.6	120.2	25.2	37.1	78.0	291.2	144.7	13.8	.0	
1998 Amt.	.0	.0	.0	32.8	98.5	121.8	212.4	144.2	215.1	267.9	95.4	.9	
1999 Amt.	17.9	70.2	127.3	154.1	239.2	-	182.8	59.9	137.6	208.5	73.9	.7	
MEAN Amt.	5.0	8.2	25.7	47.4	128.3	82.8	93.4	109.1	215.2	219.4	34.3	5.2	(974.0)

(48) STATION : 425011 Kraseo Self-Help Settlement PROVINCE : Suphan Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 no data													
1991 Amt.	-	-	-	-	-	-	-	-	-	-	-	-	-
1992 Amt.	-	-	-	-	-	-	-	-	188.3	486.2	.0	.7	-
1993 Amt.	.0	.0	199.9	17.1	145.5	137.0	73.2	88.8	230.7	122.9	T	T	
1994 Amt.	T	12.0	354.3	11.4	160.5	184.6	50.1	35.7	282.8	126.5	T	.0	
1995 Amt.	.0	.0	31.9	78.3	163.3	91.1	203.2	346.9	507.1	223.0	97.1	.0	
1996 Amt.	.0	3.2	59.1	117.6	155.7	197.2	111.2	132.2	465.3	274.5	64.4	T	
1997 Amt.	.0	T	108.4	101.4	44.9	35.0	41.4	115.0	157.0	126.3	29.2	.0	
1998 Amt.	.0	T	1.6	43.3	116.2	161.3	107.9	296.5	125.2	286.3	142.6	.0	
1999 Amt.	12.4	12.7	104.4	337.2	254.7	35.1	88.7	101.1	335.1	457.2	76.5	11.0	
MEAN Amt.	1.8	4.0	122.8	100.9	148.7	120.2	96.5	159.5	286.4	262.9	51.2	1.5	(1356.4)

Table 8 (continued)

(49) STATION : 425201 Suphan Buri PROVINCE : Suphan Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	10.2	.0	10.1	7.3	135.7	26.0	37.2	128.0	110.0	453.1	42.9	.0	
1991 Amt.	.0	6.0	40.9	11.2	108.5	21.9	52.0	176.1	146.2	215.4	.0	41.7	
1992 Amt.	1.6	3.6	.0	.9	30.6	131.5	133.1	168.9	117.9	445.9	.0	.3	
1993 Amt.	3.3	.0	12.4	95.6	194.4	114.8	13.5	69.1	136.7	88.9	.4	5.1	
1994 Amt.	14.7	T	75.2	23.3	167.2	192.7	65.0	46.3	252.6	108.4	T	T	
1995 Amt.	.0	.0	.7	14.3	94.9	79.4	100.6	156.0	424.0	86.5	11.9	.0	
1996 Amt.	.0	1.5	.5	87.4	110.4	107.8	132.7	128.6	331.0	176.8	124.0	.6	
1997 Amt.	.0	1.0	T	55.9	135.7	25.0	40.9	81.2	292.1	151.3	18.4	.0	
1998 Amt.	.0	31.9	.2	69.6	89.8	116.1	229.5	147.6	254.9	277.3	87.9	.6	
1999 Amt.	14.9	64.1	112.6	144.4	220.9	120.1	171.8	64.3	146.7	209.3	72.9	.8	
MEAN Amt.	4.5	10.8	25.3	51.0	128.8	93.5	97.6	116.6	221.2	221.3	35.8	4.9	(1011.3)

(50) STATION : 425301 U Thong Agromet PROVINCE : Suphan Buri

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1990 Amt.	7.9	.0	8.8	6.6	147.4	29.5	38.7	76.7	304.1	489.0	86.2	.0	
1991 Amt.	.0	62.1	39.3	16.5	129.8	22.7	16.8	109.3	233.4	186.4	.5	74.7	
1992 Amt.	T	3.4	.0	.2	68.2	115.3	129.9	130.6	80.4	297.4	T	T	
1993 Amt.	6.4	T	21.0	37.3	55.2	90.0	61.0	99.0	141.1	132.4	.0	24.4	
1994 Amt.	T	T	132.4	10.7	54.8	129.3	45.8	54.7	165.9	40.7	1.1	T	
1995 Amt.	.0	.0	2.8	6.2	-	-	-	-	-	-	-	-	
1996 Amt.	.0	3.3	1.5	131.3	102.6	160.5	64.4	82.3	297.1	174.9	67.0	.6	
1997 Amt.	.0	7.5	7.6	62.7	22.5	36.2	19.2	116.6	164.6	221.7	19.6	2.1	
1998 Amt.	.0	16.6	1.9	50.4	163.4	121.9	93.2	47.7	245.3	281.2	105.3	.7	
1999 Amt.	.2	62.5	27.2	265.3	144.5	81.3	126.5	31.3	148.8	526.1	169.7	11.2	
MEAN Amt.	1.5	15.5	24.3	58.7	98.7	87.4	66.2	83.1	197.9	261.1	49.9	12.6	(956.9)

Table 10 An example of calculating the variance of monthly rainfall data

```
DATA MONTHLY RAINFALL;
INPUT RAINFALL @@;
LIST;
* STA NO. 450001 (SAI YOK);
* KANCHANA BURI;
CARDS;
 .0    1.1   24.0   71.2  112.8   59.3   47.6   66.1  171.0  251.5   60.8     .0
 .0    6.5   37.5   40.6  217.7  116.0   76.0  156.1  129.5  357.4   10.4   21.0
 .0   22.8     .0     .3   98.9   71.5  165.2   92.1   80.3  407.8     .3     .1
 .0     .2   69.1  152.3  143.4   71.5  125.2   88.1  224.7  100.6     .0    9.0
 .0   12.3   84.3   56.3  200.5   87.3  185.6  181.4  112.5   39.5    3.7    6.4
 .0     .3    5.6  123.8  133.7  174.3  101.9  236.3  283.7  209.0    7.3     .0
5.6   19.5   32.2  160.6  112.0  121.9  249.1  170.0  660.0  184.2  100.1     .0
1.1     .5   70.7   95.8   67.5   25.5  144.8  174.0  244.1  212.7   65.9    9.1
 .0   17.9    2.5   49.0  122.4   72.9  113.2  158.3  308.9  433.0   71.3     .3
 .0   12.4   19.1  497.6  171.0  118.1   78.0  120.2  108.5  302.0  139.7   13.5
PROC MEANS;
VAR RAINFALL;
PROC UNIVARIATE PLOT NORMAL;
VAR RAINFALL;
RUN;
```

```
                              The MEANS Procedure

                          Analysis Variable : RAINFALL

              N           Mean        Std Dev        Minimum        Maximum
            ---------------------------------------------------------------
            120    100.4991667    112.1192519              0    660.0000000
            ---------------------------------------------------------------

                           The UNIVARIATE Procedure
                              Variable:  RAINFALL

                                   Moments

              N                         120    Sum Weights                120
              Mean               100.499167    Sum Observations       12059.9
              Std Deviation      112.119252    Variance            12570.7266
              Skewness           2.00304286    Kurtosis            5.84463013
              Uncorrected SS     2707926.37    Corrected SS        1495916.47
              Coeff Variation     111.56237    Std Error Mean      10.2350406


                          Basic Statistical Measures

                  Location                    Variability

              Mean     100.4992     Std Deviation           112.11925
              Median    72.2000     Variance                    12571
              Mode       0.0000     Range                   660.00000
                                    Interquartile Range     139.50000
```

Table 11 List of sampling wells (Source: PCD, 1995)

Well no.	Well ID	UTM Easting	UTM Northing	Depth (m)	Responsible Agency
KB1	Q0194	562635	1552645	73.2	DMR
KB2	4707	551102	1561841	42.0	PWD
KB3	MD0277	552610	1562852	15.2	DMR
KB4	S0034	554255	1576615	85.4	"
KB5	S0036	554855	1580580	79.3	"
KB6	MD0463	558538	1613503	42.7	"
KB7	5913	558237	1613565	49.0	PWD
KB8	7574	579383	1615418	36.8	"
KB9	A16/70	578836	1615166	24.4	DOH
KB10	MD0183	574881	1578847	36.6	DMR
KB11	KB25185	574752	1579702	27.0	DARD
KB12	MD0182	571295	1572799	53.4	DMR
KB13	-	515959	1602948	50.0	"
KB14	16912	459264	1651487	60.0	PWD
KB15	16911	473826	1618466	30.5	"
KB16	16910	479766	1610030	30.4	"
KB17	P10/172	479339	1609918	12.2	DOH
KB18	18014	553154	1533628	42.4	PWD
KB19	KB25144	551520	1534357	26.8	DARD
KB20	KB25156	500433	1559211	45.1	"
KB21	MD0421	563435	1543901	18.3	DMR
KB22	1164	562944	1544309	16.7	PWD
KB23	MD0419	572398	1543167	30.5	DMR
KB24	MS0032	570515	1542269	51.8	"
KB25	1374	582357	1550608	19.4	PWD
KB26	MD0139	576971	1539229	24.4	DMR
KB27	1981	578822	1536241	28.0	PWD
KB28	KB25102	578714	1536281	21.3	DARD
KB29	1692	592182	1544092	45.0	PWD
KB30	KB25129	591456	1544289	30.5	DARD
RB1	X0065	576900	1499700	48.0	DMR
RB2	18261	548400	1506900	22.6	PWD
RB3	18245	548200	1506800	13.9	DMR
RB4	R1132	550900	1475900	24.0	PWD
RB5	MD0200	552700	1473100	36.0	DMR
RB6	20576	579300	1509100	46.3	DOH
RB7	Q0183	587200	1516300	42.0	DMR
RB8	MD0227	599500	1518500	105.1	"
RB9	MD0252	600200	1519900	45.0	"
RB10	1723	600100	1517400	50.9	"
RB11	MD0436	600000	1517400	57.0	-
RB12	MD0489	597000	1525400	57.0	DMR
RB13	644	597000	1525300	60.0	"
RB14	MS0136	586600	1523000	36.0	"
RB15	MD0165	595900	1489200	148.6	PWD
RB16	20593	596100	1487600	116.2	-
RB17	2458	605200	1495500	167.4	DMR
RB18	MD0288	608500	1494400	180.0	"
RB19	3154	605200	1491300	67.0	"
RB20	MN0195	600000	1497300	121.0	"
RB21	9746	568500	1493900	21.4	PWD

Table 11 (continued)

Well no.	Well ID	UTM Easting	UTM Northing	Depth (m)	Responsible Agency
RB22	MD0157	571500	1490800	22.5	DMR
RB23	25002	578600	1485300	50.1	״
RB24	MS0095	579000	1484800	38.1	״
RB25	MD0057	586900	1481200	24.0	״
RB26	115	589300	1489300	86.7	-
RB27	MD0102	582700	1488900	52.0	PWD
RB28	510	581900	1504700	42.3	״
RB29	9835	581500	1505900	97.5	-
RB30	C648	576800	1505700	30.0	PWD
SB1	MN0042	622040	1647590	88.4	DMR
SB2	-	618800	1637800	-	״
SB3	MN0372	611250	1634400	66.0	״
SB4	MN0309	600700	1633590	105.0	״
SB5	MN0308	602340	1638050	105.0	״
SB6	-	572200	1641900	-	״
SB7	-	617900	1630400	-	״
SB8	MN0363	618290	1629400	87.0	״
SB9	MN0240	615250	1627150	117.0	DOH
SB10	-	609100	1613900	-	DMR
SB11	MT0029	596290	1612800	33.0	״
SB12	MT0040	598590	1618190	60.0	DOH
SB13	-	595170	1619000	-	DMR
SB14	MT0091	598590	1606900	24.0	״
SB15	-	594600	1598500	-	״
SB16	MN0214	596450	1598500	39.0	״
SB17	MT0033	619500	1592500	102.0	״
SB18	MN0344	615090	1587500	105.0	״
SB19	-	611800	1565300	-	-
SB20	MN0069	625250	1614250	165.0	DMR
SB21	-	618400	1612800	-	PWD
SB22	MN0026	628650	1625500	55.5	DMR
SB23	-	626300	1626400	-	״
SB24	MT0114	616400	1628300	114.0	״
SB25	MN0349	608500	1609190	112.5	״
SB26	-	617500	1607800	-	-
SB27	-	611500	1602900	-	PWD
SB28	MT0020	627602	1598854	129.0	DMR
SB29	MN0325	605650	1569690	123.0	״
SB30	MN0323	608090	1574690	93.0	״

Note: DMR = Department of Mineral Resources

DARD = Department of Accelerated Rural Development

DOH = Department of Health

PWD = Public Works Department

Table 12 Pesticide residues in groundwater samples of the study area (Source: PCD, 1995)

unit : ppb

NO.	TOTAL BHC	TOTAL DDT	HEPT. & H. EPOX	ENDO SULFAN	DIELDRIN &ALDRIN	ENDRIN	DICOFOL	CARBO FURAN	ATRAZINE	2,4-D
KB1	0.028	ND	0.070	ND	0.078	ND	ND	ND	ND	ND
KB2	0.011	ND	0.330	ND	0.003	ND	ND	ND	0.868	ND
KB3	0.005	0.063	0.460	0.022	ND	ND	ND	ND	ND	ND
KB4	0.030	0.137	0.586	0.018	0.045	ND	ND	ND	ND	ND
KB5	0.037	0.052	ND	0.015	ND	ND	ND	ND	ND	ND
KB6	0.132	0.364	0.730	0.038	0.018	ND	ND	ND	0.843	ND
KB7	0.068	0.065	ND	0.030	ND	ND	ND	ND	ND	ND
KB8	0.032	ND	ND	0.028	tr	ND	ND	ND	ND	ND
KB9	0.302	9.681	0.010	ND	3.440	ND	ND	ND	ND	ND
KB10	0.036	0.029	ND	0.029	ND	ND	ND	ND	ND	ND
KB11	0.050	0.047	0.040	0.034	ND	ND	ND	ND	ND	ND
KB12	0.020	ND	0.800	0.018	tr	ND	ND	ND	1.140	ND
KB13	ND	ND	ND	0.077	0.008	ND	ND	ND	ND	ND
KB14	0.002	ND	0.400	ND	0.104	ND	ND	ND	ND	ND
KB15	0.022	ND	0.340	0.023	ND	ND	ND	ND	ND	ND
KB16	ND	ND	ND	0.057	ND	ND	ND	ND	ND	ND
KB17	tr	0.050	ND	0.279	ND	ND	ND	ND	1.739	ND
KB18	0.007	ND	0.003	ND	ND	ND	ND	ND	ND	ND
KB19	0.072	0.028	0.393	0.031	0.019	ND	ND	ND	ND	0.090
KB20	0.020	0.033	0.700	0.033	ND	ND	ND	ND	ND	ND
KB21	0.015	ND	0.305	ND	0.036	ND	ND	0.260	1.221	ND
KB22	0.031	ND	0.206	ND	0.028	ND	ND	ND	ND	ND
KB23	0.104	0.005	0.035	ND	ND	ND	ND	ND	ND	ND
KB24	0.041	ND	0.212	0.198	ND	ND	0.270	ND	ND	ND
KB25	0.446	0.059	0.016	0.138	0.080	ND	0.053	ND	ND	ND
KB26	0.157	0.016	0.236	0.298	0.071	ND	0.235	ND	ND	0.120
KB27	0.007	ND	0.009	0.076	0.012	ND	0.126	ND	ND	ND
KB28	0.159	0.028	0.337	0.201	tr	ND	0.084	ND	ND	ND
KB29	0.243	tr	ND	ND	ND	ND	ND	0.120	0.070	ND
KB30	0.124	ND	0.008	0.136	0.003	ND	0.060	ND	ND	0.080

Table 12 (continued)

unit : ppb

NO.	TOTAL BHC	TOTAL DDT	HEPT. & H. EPOX	ENDO SULFAN	DIELDRIN &ALDRIN	ENDRIN	DICOFOL	CARBO FURAN	ATRAZINE	2,4-D
RB1	0.151	ND	0.571	ND	0.006	ND	ND	ND	1.890	ND
RB2	0.163	ND	ND	ND	ND	ND	ND	ND	ND	ND
RB3	0.244	ND	0.030	ND	0.005	ND	ND	ND	0.580	ND
RB4	0.046	0.176	ND	ND	0.037	ND	ND	ND	ND	ND
RB5	0.117	0.024	ND	ND	tr	ND	ND	ND	ND	ND
RB6	0.086	0.068	0.030	0.034	0.075	ND	ND	0.050	ND	ND
RB7	0.309	0.120	0.668	0.100	0.060	ND	0.077	0.040	ND	ND
RB8	0.575	0.221	ND	ND	0.042	ND	0.008	ND	ND	ND
RB9	0.069	0.187	ND	ND	ND	ND	0.008	ND	ND	0.087
RB10	0.328	0.014	ND	ND	0.057	ND	ND	ND	ND	ND
RB11	0.184	0.009	ND	ND	ND	ND	ND	ND	1.296	ND
RB12	0.265	0.004	ND	ND	0.028	ND	ND	ND	ND	ND
RB13	0.115	0.038	ND	ND	0.012	ND	ND	0.100	ND	0.070
RB14	0.086	0.116	0.539	0.043	0.003	ND	ND	ND	ND	ND
RB15	0.099	0.009	1.369	0.042	0.019	0.026	0.035	ND	ND	ND
RB16	ND	0.008	ND	ND	0.042	ND	ND	ND	ND	ND
RB17	ND	0.008	ND	ND	0.026	ND	ND	ND	ND	ND
RB18	0.175	0.009	ND	ND	0.043	ND	0.013	ND	ND	0.060
RB19	0.195	0.353	0.043	0.035	0.051	0.042	0.087	ND	ND	ND
RB20	0.064	0.008	0.026	ND	0.007	ND	0.014	ND	ND	ND
RB21	0.040	0.186	ND	0.013	0.007	ND	ND	ND	ND	ND
RB22	ND	0.003	ND	ND	0.008	ND	ND	ND	0.180	ND
RB23	0.198	0.004	0.215	ND	ND	ND	ND	ND	ND	ND
RB24	0.074	0.008	ND	0.026	0.030	ND	0.081	ND	ND	ND
RB25	0.105	0.031	ND	0.051	0.002	ND	0.029	0.200	ND	ND
RB26	0.035	0.170	ND	ND	ND	ND	ND	ND	ND	ND
RB27	0.022	0.025	ND	0.031	0.036	ND	0.037	ND	ND	ND
RB28	0.170	0.041	ND	ND	0.018	ND	ND	ND	ND	ND
RB29	0.035	0.006	ND	ND	0.006	ND	ND	ND	0.047	ND
RB30	0.118	3.217	0.071	0.064	0.074	0.111	0.080	0.070	ND	0.070

Table 12 (continued)

unit : ppb

NO.	TOTAL BHC	TOTAL DDT	HEPT. & H. EPOX	ENDO SULFAN	DIELDRIN &ALDRIN	ENDRIN	DICOFOL	CARBO FURAN	ATRAZINE	2,4-D
SB1	ND	0.022	0.06	ND	0.015	ND	0.073	0.140	ND	0.100
SB2	0.008	0.041	ND	ND	0.010	ND	ND	0.180	ND	ND
SB3	ND	0.007	ND	ND	ND	ND	0.065	ND	ND	ND
SB4	ND	0.009	0.050	0.005	ND	ND	0.044	ND	ND	ND
SB5	0.075	ND	ND	ND	ND	ND	ND	0.191	ND	0.100
SB6	0.024	ND	ND	ND	ND	ND	ND	0.120	ND	ND
SB7	ND	0.003	0.15	ND	ND	ND	0.078	0.130	ND	ND
SB8	0.040	ND	ND	ND	0.011	ND	ND	ND	ND	ND
SB9	0.045	0.019	ND	0.012	ND	ND	0.011	ND	ND	ND
SB10	0.013	0.014	ND	ND	ND	ND	ND	ND	ND	ND
SB11	ND	ND	ND	ND	ND	ND	0.046	ND	ND	ND
SB12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SB13	0.036	0.025	0.206	0.067	ND	ND	0.069	0.510	ND	ND
SB14	ND	ND	ND	ND	ND	ND	0.012	0.049	ND	ND
SB15	ND	ND	ND	ND	ND	ND	ND	0.410	0.010	ND
SB16	ND	ND	0.043	ND	0.013	ND	ND	0.140	ND	ND
SB17	ND	ND	0.128	ND	0.006	ND	ND	0.620	ND	ND
SB18	ND	0.153	ND	0.031	0.003	ND	tr	0.511	ND	0.210
SB19	ND	0.119	0.219	0.011	ND	ND	0.038	0.036	ND	ND
SB20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SB21	ND	0.105	ND	ND	ND	ND	ND	ND	ND	ND
SB22	ND	ND	ND	ND	0.005	ND	tr	ND	ND	ND
SB23	ND	ND	ND	ND	0.009	ND	0.018	ND	ND	ND
SB24	0.203	ND	0.018	ND	tr	ND	0.119	0.176	ND	ND
SB25	ND	ND	ND	ND	0.001	ND	0.004	ND	ND	ND
SB26	ND	ND	0.005	ND	0.006	ND	0.025	0.470	ND	ND
SB27	ND	ND	ND	ND	0.010	ND	ND	ND	ND	ND
SB28	0.001	0.381	0.184	ND	0.014	ND	tr	0.460	ND	ND
SB29	ND	ND	ND	ND	0.006	ND	0.057	0.200	tr	ND
SB30	tr	ND	0.130	ND	tr	ND	ND	0.560	ND	ND

Table 20 Degree of pesticide usages in the central and eastern parts of Thailand (Source: PCD, 1998 and 1999)

(1) carbofuran

Crop	Location (Province)	Area treated by pesticide (rai) 1/	Amount of pesticide used (kg) 2/	Ratio (kg/rai)	Average ratio (kg/rai)
Rice	Chachoengsao	26,470	9,660	0.365	0.317
	Nakhon Nayok	6,298	2,391	0.380	
	Samut Prakan	4,509	925	0.205	
Corn	Chachoengsao	447	71	0.159	0.159
Peanut	Chachoengsao	343	14	0.041	0.123
	Prachin Buri	1,600	129	0.081	
	Rayong	2,443	779	0.319	
	Sa Kaeo	76	4	0.053	
Soybean	Sa Kaeo	677	78	0.115	0.115
Cotton	Chachoengsao	1,977	178	0.090	0.057
	Prachin Buri	2,140	54	0.025	
Coconut	Chon Buri	15,258	1,350	0.088	0.049
	Rayong	5,128	51	0.010	

(2) dicofol

Crop	Location (Province)	Area treated by pesticide (rai) 1/	Amount of pesticide used (kg) 2/	Ratio (kg/rai)	Average ratio (kg/rai)
Rice	Prachin Buri	3,856	417	0.108	0.108
Cotton	Lop Buri	180	11	0.061	0.061
Soybean	Kanchana Buri	3,860	200	0.051	0.051
Peanut	Chainat	700	25	0.036	0.036

Table 20 (continued)

(3) endosulfan

Crop	Location (Province)	Area treated by pesticide (rai) [1/]	Amount of pesticide used (kg) [2/]	Ratio (kg/rai)	Average ratio (kg/rai)
Rice	Chachoengsao	86,049	16,481	0.191	0.278
	Samut Prakan	24,278	3,252	0.134	
	Chainat	20,640	6,064	0.293	
	Samut Songkham	333	142	0.426	
	Suphan Buri	17,331	6,016	0.347	
Cotton	Prachin Buri	6,665	1,025	0.154	0.250
	Kanchana Buri	12,472	4,697	0.376	
	Lop Buri	547	107	0.195	
	Sara Buri	921	254	0.275	
Peanut	Sara Buri	3,614	1,154	0.319	0.168
	Sing Buri	354	61	0.172	
	Chachoengsao	3,382	119	0.035	
	Kanchana Buri	170	25	0.147	
Corn	Chon Buri	89	12	0.134	0.162
	Chachoengsao	86,049	16,481	0.191	
Soybean	Prachin Buri	1,409	193	0.136	0.126
	Lop Buri	6,095	713	0.117	
Mung bean	Chantha Buri	1,452	138	0.095	0.117
	Lop Buri	143	15	0.105	
	Ayuthaya	889	82	0.092	
	Sara Buri	124	22	0.177	

Table 20 (continued)

(4) 2,4-D

Crop	Location (Province)	Area treated by pesticide (rai) [1/]	Amount of pesticide used (kg) [2/]	Ratio (kg/rai)	Average ratio (kg/rai)
Rice	Chantha Buri	15,454	1,740	0.113	0.494
	Chachoengsao	324,987	54,479	0.168	
	Nakhon Nayok	181,693	79,137	0.435	
	Prachin Buri	331,696	38,233	0.115	
	Rayong	17,090	4,854	0.284	
	Samut Prakan	15,731	10,403	0.661	
	Kanchana Buri	6,958	860	0.124	
	Pathumthani	6,187	6,361	1.028	
	Samut Songkham	584	270	0.462	
	Suphan Buri	3,592	975	0.271	
	Bangkok	5,901	6,777	1.148	
	Samut Sakhon	792	285	0.360	
	Ayuthaya	9,685	12,189	1.258	
Cassava	Chantha Buri	8,233	1,764	0.214	0.454
	Chon Buri	5,981	2,481	0.415	
	Rayong	3,263	2,394	0.734	
Corn	Suphan Buri	28,155	14,170	0.503	0.451
	Chainat	250	100	0.400	
Pineapple	Chantha Buri	1,325	454	0.343	0.343
Cotton	Kanchana Buri	320	84	0.262	0.262
Coconut	Chon Buri	5,725	412	0.072	0.072

Table 20 (continued)

(5) atrazine

Crop	Location (Province)	Area treated by pesticide (rai) [1/]	Amount of pesticide used (kg) [2/]	Ratio (kg/rai)	Average ratio (kg/rai)
Cotton	Phetcha Buri	306	199	0.652	0.526
	Kanchana Buri	1,545	619	0.401	
Corn	Chachoengsao	404	206	0.510	0.389
	Kanchana Buri	10,060	3,236	0.322	
	Lop Buri	289,007	115,823	0.401	
	Sara Buri	98,917	30,732	0.311	
	Chainat	478	181	0.379	
	Ratcha Buri	5,548	2,278	0.411	
Cassava	Sa Kaeo	2,936	1,175	0.400	0.385
	Kanchana Buri	1,427	528	0.370	
Mung bean	Sara Buri	715	169	0.236	0.236
Pineapple	Ratcha Buri	74	17	0.230	0.230
Rice	Chainat	42,486	3,304	0.078	0.201
	Lop Buri	1,383	243	0.176	
	Nakhon Pathom	13,819	993	0.072	
	Ratcha Buri	138	66	0.478	

Note: 1 rai = 0.16 hectare (or 1 hectare = 6.25 rai)

[1/] and [2/] are the data derived from interviewing farmers in the central and eastern parts of Thailand

Table 24 Comparison of actual values of well depth and predicted values generated by different interpolation methods

Well No.	Well Depth		Spline Method			IDW Method			Kriging Method		
	meter	Value[1/]	Value[2/]	Value[3/]	Value[4/]	Value[5/]	Value[6/]	Value[7/]	Value[8/]	Value[9/]	Value[10/]
KB1	73.2	2	2	2	2	2	2	2	2	2	(3)
KB2	42.0	3	3	3	3	3	3	3	3	3	3
KB3	15.2	4	4	4	4	4	4	4	4	4	4
KB4	85.4	2	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
KB5	79.3	2	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
KB6	42.7	3	3	3	3	3	3	3	3	3	3
KB7	49.0	3	3	3	3	3	3	3	3	3	3
KB8	36.8	3	3	3	3	3	3	3	3	3	3
KB9	24.4	3	3	3	3	3	3	3	3	3	3
KB10	36.6	3	3	3	3	3	3	3	3	3	3
KB11	27.0	3	3	3	3	3	3	3	3	3	3
KB12	53.4	2	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
KB13	50.0	3	(2)	(2)	(2)	3	3	3	3	3	3
KB14	60.0	2	2	2	2	2	2	2	2	2	2
KB15	30.5	3	3	3	3	3	3	3	3	3	3
KB16	30.4	3	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)
KB17	12.2	4	4	4	4	4	4	4	4	4	4
KB18	42.4	3	3	3	3	3	3	3	3	3	3
KB19	26.8	3	3	3	3	3	(2)	3	3	3	3
KB20	45.1	3	3	3	3	3	3	3	3	3	3
KB21	18.3	4	4	4	4	4	4	4	(3)	(3)	(3)
KB22	16.7	4	4	4	4	(3)	4	(3)	(3)	(3)	(3)
KB23	30.5	3	3	3	3	3	3	3	3	3	3
KB24	51.8	2	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
KB25	19.4	4	4	4	4	4	4	4	(3)	(3)	(3)
KB26	24.4	3	3	3	3	3	3	3	3	3	3
KB27	28.0	3	3	3	3	3	3	3	3	3	3
KB28	21.3	3	3	3	3	3	3	3	3	3	3
KB29	45.0	3	3	3	3	3	3	3	3	3	3
KB30	30.5	3	3	3	3	3	3	3	3	3	3
RB1	48.0	3	3	3	3	3	3	3	3	3	3
RB2	22.6	3	3	3	3	(4)	(4)	(4)	3	3	3

Table 24 (continued)

Well No.	Well Depth		Spline Method			IDW Method			Kriging Method		
	meter	Value[1/]	Value[2/]	Value[3/]	Value[4/]	Value[5/]	Value[6/]	Value[7/]	Value[8/]	Value[9/]	Value[10/]
RB3	13.9	4	4	4	4	4	4	4	(3)	(3)	(3)
RB4	24.0	3	3	3	3	3	3	3	3	3	3
RB5	36.0	3	3	3	3	3	3	3	3	3	3
RB6	46.3	3	3	3	3	3	3	3	3	3	3
RB7	42.0	3	3	3	3	3	3	3	(2)	(2)	(2)
RB8	105.1	1	1	1	1	1	1	1	(2)	(2)	(2)
RB9	45.0	3	3	3	3	3	3	3	(2)	(2)	(2)
RB10	50.9	2	2	2	2	2	2	2	2	2	2
RB11	57.0	2	2	2	2	2	2	2	2	2	2
RB12	57.0	2	2	2	2	2	2	2	2	2	2
RB13	60.0	2	2	2	2	2	2	2	2	2	2
RB14	36.0	3	3	3	3	3	3	3	3	3	3
RB15	148.6	1	1	1	1	1	1	1	1	1	1
RB16	116.2	1	1	1	1	1	1	1	1	1	1
RB17	167.4	1	1	1	1	1	1	1	1	1	1
RB18	180.0	1	1	1	1	1	1	1	1	1	1
RB19	67.0	2	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
RB20	121.0	1	1	1	1	1	1	1	1	1	1
RB21	21.4	3	3	3	3	(4)	(4)	(4)	3	3	3
RB22	22.5	3	3	3	3	3	3	3	3	3	3
RB23	50.1	2	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
RB24	38.1	3	3	3	3	3	3	3	3	3	3
RB25	24.0	3	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
RB26	86.7	2	2	2	2	2	2	2	2	2	2
RB27	52.0	2	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
RB28	42.3	3	3	3	3	3	3	3	(2)	(2)	(2)
RB29	97.5	2	2	2	2	(1)	(1)	(1)	2	2	2
RB30	30.0	3	3	3	3	3	3	3	3	3	3
SB1	88.4	2	2	2	2	2	2	2	2	2	2
SB2	-	-	-	-	-	-	-	-	-	-	-
SB3	66.0	2	2	2	2	2	2	2	2	2	2
SB4	105.0	1	1	1	1	1	1	1	(2)	(2)	(2)

Table 24 (continued)

Well No.	Well Depth		Spline Method			IDW Method			Kriging Method		
	meter	Value[1/]	Value[2/]	Value[3/]	Value[4/]	Value[5/]	Value[6/]	Value[7/]	Value[8/]	Value[9/]	Value[10/]
SB5	105.0	1	1	1	1	1	1	1	(2)	(2)	(2)
SB6	-	-	-	-	-	-	-	-	-	-	-
SB7	-	-	-	-	-	-	-	-	-	-	-
SB8	87.0	2	2	2	2	2	2	2	2	2	2
SB9	117.0	1	1	1	1	1	1	1	1	1	1
SB10	-	-	-	-	-	-	-	-	-	-	-
SB11	33.0	3	3	3	3	3	3	3	3	3	3
SB12	60.0	2	2	2	2	2	2	2	2	2	2
SB13	-	-	-	-	-	-	-	-	-	-	-
SB14	24.0	3	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
SB15	-	-	-	-	-	-	-	-	-	-	-
SB16	39.0	3	3	3	3	3	3	3	3	3	3
SB17	102.0	1	1	1	1	1	1	1	1	1	(2)
SB18	105.0	1	1	1	1	1	1	1	(2)	(2)	(2)
SB19	-	-	-	-	-	-	-	-	-	-	-
SB20	165.0	1	1	1	1	1	1	1	1	1	1
SB21	-	-	-	-	-	-	-	-	-	-	-
SB22	55.5	2	2	2	2	2	2	2	2	2	2
SB23	-	-	-	-	-	-	-	-	-	-	-
SB24	114.0	1	1	1	1	1	1	1	1	(2)	(2)
SB25	112.5	1	1	1	1	1	1	1	1	1	1
SB26	-	-	-	-	-	-	-	-	-	-	-
SB27	-	-	-	-	-	-	-	-	-	-	-
SB28	129.0	1	1	1	1	1	1	1	1	1	1
SB29	123.0	1	1	1	1	1	1	1	1	(2)	1
SB30	93.0	2	2	2	2	2	2	2	2	2	2

Note 1:
[1/] Actual value of well depth
[2/] Predicted value from Tension Spline (4, 2.0)
[3/] Predicted value from Tension Spline (8, 2.0)
[4/] Predicted value from Tension Spline (12, 2.0)
[5/] Predicted value from a fixed points of IDW (8,2)
[6/] Predicted value from a fixed points of IDW (8,5)
[7/] Predicted value from a fixed points of IDW (12,2)
[8/] Predicted value from a fixed radius of Kriging (8)
[9/] Predicted value from a variable radius of Kriging (4)
[10/] Predicted value from a variable radius of Kriging (8)

Note 2: Values in the parentheses mean the predicted values that are not the same as their actual values

Table 25 Data used in correlation tests for identifying weighting schemes

Well No.	carbofuran (ppb)	Value or class of each data layer					
		Soil texture	Well depth	Percent slope	Primary land use	AAR	MVR
KB1	-	4	2	5	0	2	5
KB2	-	2	3	5	1	2	4
KB3	-	4	4	5	1	2	4
KB4	-	3	3	5	1	3	4
KB5	-	1	3	5	1	3	3
KB6	-	2	3	5	3	2	5
KB7	-	2	3	5	3	2	5
KB8	-	1	3	5	3	2	5
KB9	-	2	3	5	3	2	5
KB10	-	2	3	5	5	3	4
KB11	-	2	3	5	5	3	4
KB12	-	2	3	5	5	3	4
KB13	-	2	2	3	0	2	5
KB14	-	1	2	5	0	5	2
KB15	-	2	3	5	0	4	4
KB16	-	1	4	4	0	4	4
KB17	-	1	4	4	0	4	4
KB18	-	-	3	5	1	3	4
KB19	-	1	3	4	3	3	4
KB20	-	3	3	5	0	4	4
KB21	0.260	-	4	2	1	2	5
KB22	-	3	4	2	0	2	5
KB23	-	3	3	5	3	2	5
KB24	-	3	3	5	1	2	5
KB25	-	3	4	5	3	2	5
KB26	-	3	3	5	1	2	5
KB27	-	1	3	5	3	2	5
KB28	-	1	3	5	3	2	5
KB29	0.120	3	3	5	3	2	5
KB30	-	3	3	5	1	2	5
RB1	-	2	3	5	5	2	5
RB2	-	2	3	5	3	3	5
RB3	-	2	4	5	3	3	5
RB4	-	5	3	5	3	3	5
RB5	-	4	3	5	3	3	5
RB6	0.050	1	3	5	0	2	5
RB7	0.040	1	3	5	1	2	5
RB8	-	3	1	5	5	2	5
RB9	-	3	3	5	5	2	5
RB10	-	3	2	5	5	2	5
RB11	-	3	2	5	1	2	5
RB12	-	3	2	5	1	2	5
RB13	0.100	3	2	5	1	2	5
RB14	-	1	3	5	5	2	5
RB15	-	1	1	5	2	2	5

Table 25 (continued)

Well No.	carbofuran (ppb)	Value or class of each data layer					
		Soil texture	Well depth	Percent slope	Primary land use	AAR	MVR
RB16	-	1	1	5	3	2	5
RB17	-	1	1	5	1	3	4
RB18	-	1	1	5	2	3	4
RB19	-	1	1	5	3	3	4
RB20	-	1	1	5	2	3	5
RB21	-	2	3	5	0	2	5
RB22	-	3	3	5	0	3	5
RB23	-	1	3	5	5	3	5
RB24	-	4	3	5	1	3	5
RB25	0.200	1	2	5	1	3	5
RB26	-	1	2	5	1	3	5
RB27	-	2	3	5	1	3	5
RB28	-	1	3	4	5	2	5
RB29	-	1	2	5	5	2	5
RB30	0.070	1	3	5	5	2	5
SB1	0.140	1	2	5	0	3	3
SB2	0.180	1	2	5	5	3	4
SB3	-	1	2	5	1	3	5
SB4	-	1	1	5	5	2	5
SB5	0.191	3	1	5	1	3	4
SB6	0.120	-	3	5	0	3	4
SB7	0.130	1	2	5	5	2	5
SB8	-	1	2	5	1	2	5
SB9	-	1	1	5	1	2	5
SB10	-	1	1	5	5	2	5
SB11	-	2	3	5	5	2	5
SB12	-	1	2	5	5	2	5
SB13	0.510	1	2	5	5	2	5
SB14	0.049	3	2	5	1	2	5
SB15	0.410	1	2	5	3	2	5
SB16	0.140	2	3	5	3	2	5
SB17	0.620	3	1	5	1	2	5
SB18	0.511	1	1	5	1	2	5
SB19	0.036	1	1	5	5	2	5
SB20	-	1	1	5	5	2	5
SB21	-	1	2	5	5	2	5
SB22	-	3	2	5	1	2	5
SB23	-	1	2	5	5	2	5
SB24	0.176	1	1	5	5	2	5
SB25	-	1	1	5	1	2	5
SB26	0.470	1	2	5	5	2	5
SB27	-	1	1	5	5	2	5
SB28	0.460	1	1	5	5	2	5
SB29	0.200	1	1	5	5	2	5
SB30	0.560	2	2	5	1	2	5

Table 25 (continued)

Well No.	endosulfan (ppb)	Value or class of each data layer					
		Soil texture	Well depth	Percent slope	Primary land use	AAR	MVR
KB1	-	4	2	5	0	2	5
KB2	-	2	3	5	1	2	4
KB3	0.022	4	4	5	1	2	4
KB4	0.018	3	3	5	1	3	4
KB5	0.015	1	3	5	1	3	3
KB6	0.038	2	3	5	3	2	5
KB7	0.030	2	3	5	3	2	5
KB8	0.028	1	3	5	3	2	5
KB9	-	2	3	5	3	2	5
KB10	0.029	2	3	5	5	3	4
KB11	0.034	2	3	5	5	3	4
KB12	0.018	2	3	5	5	3	4
KB13	0.077	2	2	3	0	2	5
KB14	-	1	2	5	0	5	2
KB15	0.023	2	3	5	0	4	4
KB16	0.057	1	4	4	0	4	4
KB17	0.279	1	4	4	0	4	4
KB18	-	-	3	5	1	3	4
KB19	0.031	1	3	4	3	3	4
KB20	0.033	3	3	5	0	4	4
KB21	-	-	4	2	1	2	5
KB22	-	3	4	2	0	2	5
KB23	-	3	3	5	3	2	5
KB24	0.198	3	3	5	1	2	5
KB25	0.138	3	4	5	3	2	5
KB26	0.298	3	3	5	1	2	5
KB27	0.076	1	3	5	3	2	5
KB28	0.201	1	3	5	3	2	5
KB29	-	3	3	5	3	2	5
KB30	0.136	3	3	5	1	2	5
RB1	-	2	3	5	5	2	5
RB2	-	2	3	5	3	3	5
RB3	-	2	4	5	3	3	5
RB4	-	5	3	5	2	3	5
RB5	-	4	3	5	2	3	5
RB6	0.034	1	3	5	0	2	5
RB7	0.100	1	3	5	1	2	5
RB8	-	3	1	5	5	2	5
RB9	-	3	3	5	5	2	5
RB10	-	3	2	5	5	2	5
RB11	-	3	2	5	1	2	5
RB12	-	3	2	5	1	2	5
RB13	-	3	2	5	1	2	5
RB14	0.043	1	3	5	5	2	5
RB15	0.042	1	1	5	2	2	5

Table 25 (continued)

Well No.	endosulfan (ppb)	Value or class of each data layer					
		Soil texture	Well depth	Percent slope	Primary land use	AAR	MVR
RB16	-	1	1	5	2	2	5
RB17	-	1	1	5	1	3	4
RB18	-	1	1	5	2	3	4
RB19	0.035	1	1	5	2	3	4
RB20	-	1	1	5	2	3	5
RB21	0.013	2	3	5	0	2	5
RB22	-	3	3	5	0	3	5
RB23	-	1	3	5	5	3	5
RB24	0.026	4	3	5	1	3	5
RB25	0.051	1	2	5	1	3	5
RB26	-	1	2	5	1	3	5
RB27	0.031	2	3	5	1	3	5
RB28	-	1	3	4	5	2	5
RB29	-	1	2	5	5	2	5
RB30	0.064	1	3	5	5	2	5
SB1	-	1	2	5	0	3	3
SB2	-	1	2	5	5	3	4
SB3	-	1	2	5	1	3	5
SB4	0.005	1	1	5	5	2	5
SB5	-	3	1	5	1	3	4
SB6	-	-	3	5	0	3	4
SB7	-	1	2	5	5	2	5
SB8	-	1	2	5	1	2	5
SB9	0.012	1	1	5	1	2	5
SB10	-	1	1	5	5	2	5
SB11	-	2	3	5	5	2	5
SB12	-	1	2	5	5	2	5
SB13	0.067	1	2	5	5	2	5
SB14	-	3	2	5	1	2	5
SB15	-	1	2	5	3	2	5
SB16	-	2	3	5	3	2	5
SB17	-	3	1	5	1	2	5
SB18	0.031	1	1	5	1	2	5
SB19	0.011	1	1	5	5	2	5
SB20	-	1	1	5	5	2	5
SB21	-	1	2	5	5	2	5
SB22	-	3	2	5	1	2	5
SB23	-	1	2	5	5	2	5
SB24	-	1	1	5	5	2	5
SB25	-	1	1	5	1	2	5
SB26	-	1	2	5	5	2	5
SB27	-	1	1	5	5	2	5
SB28	-	1	1	5	5	2	5
SB29	-	1	1	5	5	2	5
SB30	-	2	2	5	1	2	5

Table 25 (continued)

Well No.	dicofol (ppb)	Value or class of each data layer					
		Soil texture	Well depth	Percent slope	Primary land use	AAR	MVR
KB1	-	4	2	5	0	2	5
KB2	-	2	3	5	1	2	4
KB3	-	4	4	5	1	2	4
KB4	-	3	3	5	1	3	4
KB5	-	1	3	5	1	3	3
KB6	-	2	3	5	2	2	5
KB7	-	2	3	5	2	2	5
KB8	-	1	3	5	2	2	5
KB9	-	2	3	5	2	2	5
KB10	-	2	3	5	4	3	4
KB11	-	2	3	5	4	3	4
KB12	-	2	3	5	4	3	4
KB13	-	2	2	3	0	2	5
KB14	-	1	2	5	0	5	2
KB15	-	2	3	5	0	4	4
KB16	-	1	4	4	0	4	4
KB17	-	1	4	4	0	4	4
KB18	-	-	3	5	1	3	4
KB19	-	1	3	4	2	3	4
KB20	-	3	3	5	0	4	4
KB21	-	-	4	2	1	2	5
KB22	-	3	4	2	0	2	5
KB23	-	3	3	5	2	2	5
KB24	0.270	3	3	5	1	2	5
KB25	0.053	3	4	5	2	2	5
KB26	0.235	3	3	5	1	2	5
KB27	0.126	1	3	5	2	2	5
KB28	0.084	1	3	5	2	2	5
KB29	-	3	3	5	2	2	5
KB30	0.060	3	3	5	1	2	5
RB1	-	2	3	5	4	2	5
RB2	-	2	3	5	2	3	5
RB3	-	2	4	5	2	3	5
RB4	-	5	3	5	2	3	5
RB5	-	4	3	5	2	3	5
RB6	-	1	3	5	0	2	5
RB7	0.077	1	3	5	1	2	5
RB8	0.008	3	1	5	4	2	5
RB9	0.008	3	3	5	4	2	5
RB10	-	3	2	5	4	2	5
RB11	-	3	2	5	1	2	5
RB12	-	3	2	5	1	2	5
RB13	-	3	2	5	1	2	5
RB14	-	1	3	5	4	2	5
RB15	0.035	1	1	5	2	2	5

Table 25 (continued)

Well No.	dicofol (ppb)	Value or class of each data layer					
		Soil texture	Well depth	Percent slope	Primary land use	AAR	MVR
RB16	-	1	1	5	2	2	5
RB17	-	1	1	5	1	3	4
RB18	0.013	1	1	5	2	3	4
RB19	0.087	1	1	5	2	3	4
RB20	0.014	1	1	5	2	3	5
RB21	-	2	3	5	0	2	5
RB22	-	3	3	5	0	3	5
RB23	-	1	3	5	4	3	5
RB24	0.081	4	3	5	1	3	5
RB25	0.029	1	2	5	1	3	5
RB26	-	1	2	5	1	3	5
RB27	0.037	2	3	5	1	3	5
RB28	-	1	3	4	4	2	5
RB29	-	1	2	5	4	2	5
RB30	0.080	1	3	5	4	2	5
SB1	0.073	1	2	5	0	3	3
SB2	-	1	2	5	4	3	4
SB3	0.065	1	2	5	1	3	5
SB4	0.044	1	1	5	4	2	5
SB5	-	3	1	5	1	3	4
SB6	-	-	3	5	0	3	4
SB7	0.078	1	2	5	4	2	5
SB8	-	1	2	5	1	2	5
SB9	0.011	1	1	5	1	2	5
SB10	-	1	1	5	4	2	5
SB11	0.046	2	3	5	4	2	5
SB12	-	1	2	5	4	2	5
SB13	0.069	1	2	5	4	2	5
SB14	0.012	3	2	5	1	2	5
SB15	-	1	2	5	2	2	5
SB16	-	2	3	5	2	2	5
SB17	-	3	1	5	1	2	5
SB18	tr	1	1	5	1	2	5
SB19	0.038	1	1	5	4	2	5
SB20	-	1	1	5	4	2	5
SB21	-	1	2	5	4	2	5
SB22	tr	3	2	5	1	2	5
SB23	0.018	1	2	5	4	2	5
SB24	0.119	1	1	5	4	2	5
SB25	0.004	1	1	5	1	2	5
SB26	0.025	1	2	5	4	2	5
SB27	-	1	1	5	4	2	5
SB28	tr	1	1	5	4	2	5
SB29	0.057	1	1	5	4	2	5
SB30	-	2	2	5	1	2	5

<u>Table 25</u> (continued)

Well No.	atrazine (ppb)	Value or class of each data layer					
		Soil texture	Well depth	Percent slope	Primary land use	AAR	MVR
KB1	-	4	2	5	0	2	5
KB2	0.868	2	3	5	1	2	4
KB3	-	4	4	5	1	2	4
KB4	-	3	3	5	1	3	4
KB5	-	1	3	5	1	3	3
KB6	0.843	2	3	5	4	2	5
KB7	-	2	3	5	4	2	5
KB8	-	1	3	5	4	2	5
KB9	-	2	3	5	4	2	5
KB10	-	2	3	5	4	3	4
KB11	-	2	3	5	4	3	4
KB12	1.140	2	3	5	4	3	4
KB13	-	2	2	3	0	2	5
KB14	-	1	2	5	0	5	2
KB15	-	2	3	5	0	4	4
KB16	-	1	4	4	0	4	4
KB17	1.739	1	4	4	0	4	4
KB18	-	-	3	5	1	3	4
KB19	-	1	3	4	4	3	4
KB20	-	3	3	5	0	4	4
KB21	1.221	-	4	2	1	2	5
KB22	-	3	4	2	0	2	5
KB23	-	3	3	5	4	2	5
KB24	-	3	3	5	1	2	5
KB25	-	3	4	5	4	2	5
KB26	-	3	3	5	1	2	5
KB27	-	1	3	5	4	2	5
KB28	-	1	3	5	4	2	5
KB29	0.070	3	3	5	4	2	5
KB30	-	3	3	5	1	2	5
RB1	1.890	2	3	5	4	2	5
RB2	-	2	3	5	4	3	5
RB3	0.580	2	4	5	4	3	5
RB4	-	5	3	5	5	3	5
RB5	-	4	3	5	5	3	5
RB6	-	1	3	5	0	2	5
RB7	-	1	3	5	1	2	5
RB8	-	3	1	5	4	2	5
RB9	-	3	3	5	4	2	5
RB10	-	3	2	5	4	2	5
RB11	1.296	3	2	5	1	2	5
RB12	-	3	2	5	1	2	5
RB13	-	3	2	5	1	2	5
RB14	-	1	3	5	4	2	5
RB15	-	1	1	5	3	2	5

Table 25 (continued)

Well No.	atrazine (ppb)	Value or class of each data layer					
		Soil texture	Well depth	Percent slope	Primary land use	AAR	MVR
RB16	-	1	1	5	3	2	5
RB17	-	1	1	5	1	3	4
RB18	-	1	1	5	3	3	4
RB19	-	1	1	5	3	3	4
RB20	-	1	1	5	3	3	5
RB21	-	2	3	5	0	2	5
RB22	0.180	3	3	5	0	3	5
RB23	-	1	3	5	4	3	5
RB24	-	4	3	5	1	3	5
RB25	-	1	2	5	1	3	5
RB26	-	1	2	5	1	3	5
RB27	-	2	3	5	1	3	5
RB28	-	1	3	4	4	2	5
RB29	0.047	1	2	5	4	2	5
RB30	-	1	3	5	4	2	5
SB1	-	1	2	5	0	3	3
SB2	-	1	2	5	4	3	4
SB3	-	1	2	5	1	3	5
SB4	-	1	1	5	4	2	5
SB5	-	3	1	5	1	3	4
SB6	-	-	3	5	0	3	4
SB7	-	1	2	5	4	2	5
SB8	-	1	2	5	1	2	5
SB9	-	1	1	5	1	2	5
SB10	-	1	1	5	4	2	5
SB11	-	2	3	5	4	2	5
SB12	-	1	2	5	4	2	5
SB13	-	1	2	5	4	2	5
SB14	-	3	2	5	1	2	5
SB15	0.010	1	2	5	4	2	5
SB16	-	2	3	5	4	2	5
SB17	-	3	1	5	1	2	5
SB18	-	1	1	5	1	2	5
SB19	-	1	1	5	4	2	5
SB20	-	1	1	5	4	2	5
SB21	-	1	2	5	4	2	5
SB22	-	3	2	5	1	2	5
SB23	-	1	2	5	4	2	5
SB24	-	1	1	5	4	2	5
SB25	-	1	1	5	1	2	5
SB26	-	1	2	5	4	2	5
SB27	-	1	1	5	4	2	5
SB28	-	1	1	5	4	2	5
SB29	tr	1	1	5	4	2	5
SB30	-	2	2	5	1	2	5

Table 25 (continued)

Well No.	2,4-D (ppb)	Value or class of each data layer					
		Soil texture	Well depth	Percent slope	Primary land use	AAR	MVR
KB1	-	4	2	5	0	2	5
KB2	-	2	3	5	1	2	4
KB3	-	4	4	5	1	2	4
KB4	-	3	3	5	1	3	4
KB5	-	1	3	5	1	3	3
KB6	-	2	3	5	4	2	5
KB7	-	2	3	5	4	2	5
KB8	-	1	3	5	4	2	5
KB9	-	2	3	5	4	2	5
KB10	-	2	3	5	5	3	4
KB11	-	2	3	5	5	3	4
KB12	-	2	3	5	5	3	4
KB13	-	2	2	3	0	2	5
KB14	-	1	2	5	0	5	2
KB15	-	2	3	5	0	4	4
KB16	-	1	4	4	0	4	4
KB17	-	1	4	4	0	4	4
KB18	-	-	3	5	1	3	4
KB19	0.090	1	3	4	4	3	4
KB20	-	3	3	5	0	4	4
KB21	-	-	4	2	1	2	5
KB22	-	3	4	2	0	2	5
KB23	-	3	3	5	4	2	5
KB24	-	3	3	5	1	2	5
KB25	-	3	4	5	4	2	5
KB26	0.120	3	3	5	1	2	5
KB27	-	1	3	5	4	2	5
KB28	-	1	3	5	4	2	5
KB29	-	3	3	5	4	2	5
KB30	0.080	3	3	5	1	2	5
RB1	-	2	3	5	5	2	5
RB2	-	2	3	5	4	3	5
RB3	-	2	4	5	4	3	5
RB4	-	5	3	5	5	3	5
RB5	-	4	3	5	5	3	5
RB6	-	1	3	5	0	2	5
RB7	-	1	3	5	1	2	5
RB8	-	3	1	5	5	2	5
RB9	0.087	3	3	5	5	2	5
RB10	-	3	2	5	5	2	5
RB11	-	3	2	5	1	2	5
RB12	-	3	2	5	1	2	5
RB13	0.070	3	2	5	1	2	5
RB14	-	1	3	5	5	2	5
RB15	-	1	1	5	3	2	5

Table 25 (continued)

Well No.	2,4-D (ppb)	Value or class of each data layer					
		Soil texture	Well depth	Percent slope	Primary land use	AAR	MVR
RB16	-	1	1	5	3	2	5
RB17	-	1	1	5	1	3	4
RB18	0.060	1	1	5	3	3	4
RB19	-	1	1	5	3	3	4
RB20	-	1	1	5	3	3	5
RB21	-	2	3	5	0	2	5
RB22	-	3	3	5	0	3	5
RB23	-	1	3	5	5	3	5
RB24	-	4	3	5	1	3	5
RB25	-	1	2	5	1	3	5
RB26	-	1	2	5	1	3	5
RB27	-	2	3	5	1	3	5
RB28	-	1	3	4	5	2	5
RB29	-	1	2	5	5	2	5
RB30	0.070	1	3	5	5	2	5
SB1	0.100	1	2	5	0	3	3
SB2	-	1	2	5	5	3	4
SB3	-	1	2	5	1	3	5
SB4	-	1	1	5	5	2	5
SB5	0.100	3	1	5	1	3	4
SB6	-	-	3	5	0	3	4
SB7	-	1	2	5	5	2	5
SB8	-	1	2	5	1	2	5
SB9	-	1	1	5	1	2	5
SB10	-	1	1	5	5	2	5
SB11	-	2	3	5	5	2	5
SB12	-	1	2	5	5	2	5
SB13	-	1	2	5	5	2	5
SB14	-	3	2	5	1	2	5
SB15	-	1	2	5	4	2	5
SB16	-	2	3	5	4	2	5
SB17	-	3	1	5	1	2	5
SB18	0.210	1	1	5	1	2	5
SB19	-	1	1	5	5	2	5
SB20	-	1	1	5	5	2	5
SB21	-	1	2	5	5	2	5
SB22	-	3	2	5	1	2	5
SB23	-	1	2	5	5	2	5
SB24	-	1	1	5	5	2	5
SB25	-	1	1	5	1	2	5
SB26	-	1	2	5	5	2	5
SB27	-	1	1	5	5	2	5
SB28	-	1	1	5	5	2	5
SB29	-	1	1	5	5	2	5
SB30	-	2	2	5	1	2	5

Table 25 (continued)

Well No.	total BHC (ppb)	Value or class of each data layer					
		Soil texture	Well depth	Percent slope	Primary land use	AAR	MVR
KB1	0.028	4	2	5	0	2	5
KB2	0.011	2	3	5	1	2	4
KB3	0.005	4	4	5	1	2	4
KB4	0.030	3	3	5	1	3	4
KB5	0.037	1	3	5	1	3	3
KB6	0.132	2	3	5	3	2	5
KB7	0.068	2	3	5	3	2	5
KB8	0.032	1	3	5	3	2	5
KB9	0.302	2	3	5	3	2	5
KB10	0.036	2	3	5	4	3	4
KB11	0.050	2	3	5	4	3	4
KB12	0.020	2	3	5	4	3	4
KB13	-	2	2	3	0	2	5
KB14	0.002	1	2	5	0	5	2
KB15	0.022	2	3	5	0	4	4
KB16	-	1	4	4	0	4	4
KB17	tr	1	4	4	0	4	4
KB18	0.007	-	3	5	1	3	4
KB19	0.072	1	3	4	3	3	4
KB20	0.020	3	3	5	0	4	4
KB21	0.015	-	4	2	1	2	5
KB22	0.031	3	4	2	0	2	5
KB23	0.104	3	3	5	3	2	5
KB24	0.041	3	3	5	1	2	5
KB25	0.446	3	4	5	3	2	5
KB26	0.157	3	3	5	1	2	5
KB27	0.007	1	3	5	3	2	5
KB28	0.159	1	3	5	3	2	5
KB29	0.243	3	3	5	3	2	5
KB30	0.124	3	3	5	1	2	5
RB1	0.151	2	3	5	4	2	5
RB2	0.163	2	3	5	3	3	5
RB3	0.244	2	4	5	3	3	5
RB4	0.046	5	3	5	3	3	5
RB5	0.117	4	3	5	3	3	5
RB6	0.086	1	3	5	0	2	5
RB7	0.309	1	3	5	1	2	5
RB8	0.575	3	1	5	4	2	5
RB9	0.069	3	3	5	4	2	5
RB10	0.328	3	2	5	4	2	5
RB11	0.184	3	2	5	1	2	5
RB12	0.265	3	2	5	1	2	5
RB13	0.115	3	2	5	1	2	5
RB14	0.086	1	3	5	4	2	5
RB15	0.099	1	1	5	3	2	5

Table 25 (continued)

Well No.	total BHC (ppb)	Value or class of each data layer					
		Soil texture	Well depth	Percent slope	Primary land use	AAR	MVR
RB16	-	1	1	5	3	2	5
RB17	-	1	1	5	1	3	4
RB18	0.175	1	1	5	3	3	4
RB19	0.195	1	1	5	3	3	4
RB20	0.064	1	1	5	3	3	5
RB21	0.040	2	3	5	0	2	5
RB22	-	3	3	5	0	3	5
RB23	0.198	1	3	5	4	3	5
RB24	0.074	4	3	5	1	3	5
RB25	0.105	1	2	5	1	3	5
RB26	0.035	1	2	5	1	3	5
RB27	0.022	2	3	5	1	3	5
RB28	0.170	1	3	4	4	2	5
RB29	0.035	1	2	5	4	2	5
RB30	0.118	1	3	5	4	2	5
SB1	-	1	2	5	0	3	3
SB2	0.008	1	2	5	4	3	4
SB3	-	1	2	5	1	3	5
SB4	-	1	1	5	4	2	5
SB5	0.075	3	1	5	1	3	4
SB6	0.024	-	3	5	0	3	4
SB7	-	1	2	5	4	2	5
SB8	0.040	1	2	5	1	2	5
SB9	0.045	1	1	5	1	2	5
SB10	0.013	1	1	5	4	2	5
SB11	-	2	3	5	4	2	5
SB12	-	1	2	5	4	2	5
SB13	0.036	1	2	5	4	2	5
SB14	-	3	2	5	1	2	5
SB15	-	1	2	5	3	2	5
SB16	-	2	3	5	3	2	5
SB17	-	3	1	5	1	2	5
SB18	-	1	1	5	1	2	5
SB19	-	1	1	5	4	2	5
SB20	-	1	1	5	4	2	5
SB21	-	1	2	5	4	2	5
SB22	-	3	2	5	1	2	5
SB23	-	1	2	5	4	2	5
SB24	0.203	1	1	5	4	2	5
SB25	-	1	1	5	1	2	5
SB26	-	1	2	5	4	2	5
SB27	-	1	1	5	4	2	5
SB28	0.001	1	1	5	4	2	5
SB29	-	1	1	5	4	2	5
SB30	tr	2	2	5	1	2	5

Table 25 (continued)

Well No.	total DDT (ppb)	Value or class of each data layer					
		Soil texture	Well depth	Percent slope	Primary land use	AAR	MVR
KB1	-	4	2	5	0	2	5
KB2	-	2	3	5	1	2	4
KB3	0.063	4	4	5	1	2	4
KB4	0.137	3	3	5	1	3	4
KB5	0.052	1	3	5	1	3	3
KB6	0.364	2	3	5	3	2	5
KB7	0.065	2	3	5	3	2	5
KB8	-	1	3	5	3	2	5
KB9	9.681	2	3	5	3	2	5
KB10	0.029	2	3	5	4	3	4
KB11	0.047	2	3	5	4	3	4
KB12	-	2	3	5	4	3	4
KB13	-	2	2	3	0	2	5
KB14	-	1	2	5	0	5	2
KB15	-	2	3	5	0	4	4
KB16	-	1	4	4	0	4	4
KB17	0.050	1	4	4	0	4	4
KB18	-	-	3	5	1	3	4
KB19	0.028	1	3	4	3	3	4
KB20	0.033	3	3	5	0	4	4
KB21	-	-	4	2	1	2	5
KB22	-	3	4	2	0	2	5
KB23	0.005	3	3	5	3	2	5
KB24	-	3	3	5	1	2	5
KB25	0.059	3	4	5	3	2	5
KB26	0.016	3	3	5	1	2	5
KB27	-	1	3	5	3	2	5
KB28	0.028	1	3	5	3	2	5
KB29	tr	3	3	5	3	2	5
KB30	-	3	3	5	1	2	5
RB1	-	2	3	5	4	2	5
RB2	-	2	3	5	3	3	5
RB3	-	2	4	5	3	3	5
RB4	0.176	5	3	5	3	3	5
RB5	0.024	4	3	5	3	3	5
RB6	0.068	1	3	5	0	2	5
RB7	0.120	1	3	5	1	2	5
RB8	0.221	3	1	5	4	2	5
RB9	0.187	3	3	5	4	2	5
RB10	0.014	3	2	5	4	2	5
RB11	0.009	3	2	5	1	2	5
RB12	0.004	3	2	5	1	2	5
RB13	0.038	3	2	5	1	2	5
RB14	0.116	1	3	5	4	2	5
RB15	0.009	1	1	5	3	2	5

Table 25 (continued)

Well No.	total DDT (ppb)	Value or class of each data layer					
		Soil texture	Well depth	Percent slope	Primary land use	AAR	MVR
RB16	0.008	1	1	5	3	2	5
RB17	0.008	1	1	5	1	3	4
RB18	0.009	1	1	5	3	3	4
RB19	0.353	1	1	5	3	3	4
RB20	0.008	1	1	5	3	3	5
RB21	0.186	2	3	5	0	2	5
RB22	0.003	3	3	5	0	3	5
RB23	0.004	1	3	5	4	3	5
RB24	0.008	4	3	5	1	3	5
RB25	0.031	1	2	5	1	3	5
RB26	0.170	1	2	5	1	3	5
RB27	0.025	2	3	5	1	3	5
RB28	0.041	1	3	4	4	2	5
RB29	0.006	1	2	5	4	2	5
RB30	3.217	1	3	5	4	2	5
SB1	0.022	1	2	5	0	3	3
SB2	0.041	1	2	5	4	3	4
SB3	0.007	1	2	5	1	3	5
SB4	0.009	1	1	5	4	2	5
SB5	-	3	1	5	1	3	4
SB6	-	-	3	5	0	3	4
SB7	0.003	1	2	5	4	2	5
SB8	-	1	2	5	1	2	5
SB9	0.019	1	1	5	1	2	5
SB10	0.014	1	1	5	4	2	5
SB11	-	2	3	5	4	2	5
SB12	-	1	2	5	4	2	5
SB13	0.025	1	2	5	4	2	5
SB14	-	3	2	5	1	2	5
SB15	-	1	2	5	3	2	5
SB16	-	2	3	5	3	2	5
SB17	-	3	1	5	1	2	5
SB18	0.153	1	1	5	1	2	5
SB19	0.119	1	1	5	4	2	5
SB20	-	1	1	5	4	2	5
SB21	0.105	1	2	5	4	2	5
SB22	-	3	2	5	1	2	5
SB23	-	1	2	5	4	2	5
SB24	-	1	1	5	4	2	5
SB25	-	1	1	5	1	2	5
SB26	-	1	2	5	4	2	5
SB27	-	1	1	5	4	2	5
SB28	0.381	1	1	5	4	2	5
SB29	-	1	1	5	4	2	5
SB30	-	2	2	5	1	2	5

Table 25 (continued)

Well No.	heptachlor& hept.epoxide (ppb)	Value or class of each data layer					
		Soil texture	Well depth	Percent slope	Primary land use	AAR	MVR
KB1	0.070	4	2	5	0	2	5
KB2	0.330	2	3	5	1	2	4
KB3	0.460	4	4	5	1	2	4
KB4	0.586	3	3	5	1	3	4
KB5	-	1	3	5	1	3	3
KB6	0.730	2	3	5	3	2	5
KB7	-	2	3	5	3	2	5
KB8	-	1	3	5	3	2	5
KB9	0.010	2	3	5	3	2	5
KB10	-	2	3	5	4	3	4
KB11	0.040	2	3	5	4	3	4
KB12	0.800	2	3	5	4	3	4
KB13	-	2	2	3	0	2	5
KB14	0.400	1	2	5	0	5	2
KB15	0.340	2	3	5	0	4	4
KB16	-	1	4	4	0	4	4
KB17	-	1	4	4	0	4	4
KB18	0.003	-	3	5	1	3	4
KB19	0.393	1	3	4	3	3	4
KB20	0.700	3	3	5	0	4	4
KB21	0.305	-	4	2	1	2	5
KB22	0.206	3	4	2	0	2	5
KB23	0.035	3	3	5	3	2	5
KB24	0.212	3	3	5	1	2	5
KB25	0.016	3	4	5	3	2	5
KB26	0.236	3	3	5	1	2	5
KB27	0.009	1	3	5	3	2	5
KB28	0.337	1	3	5	3	2	5
KB29	-	3	3	5	3	2	5
KB30	0.008	3	3	5	1	2	5
RB1	0.571	2	3	5	4	2	5
RB2	-	2	3	5	3	3	5
RB3	0.030	2	4	5	3	3	5
RB4	-	5	3	5	3	3	5
RB5	-	4	3	5	3	3	5
RB6	0.030	1	3	5	0	2	5
RB7	0.668	1	3	5	1	2	5
RB8	-	3	1	5	4	2	5
RB9	-	3	3	5	4	2	5
RB10	-	3	2	5	4	2	5
RB11	-	3	2	5	1	2	5
RB12	-	3	2	5	1	2	5
RB13	-	3	2	5	1	2	5
RB14	0.539	1	3	5	4	2	5
RB15	1.369	1	1	5	3	2	5

Table 25 (continued)

Well No.	heptachlor& hept.epoxide (ppb)	Value or class of each data layer					
		Soil texture	Well depth	Percent slope	Primary land use	AAR	MVR
RB16	-	1	1	5	3	2	5
RB17	-	1	1	5	1	3	4
RB18	-	1	1	5	3	3	4
RB19	0.043	1	1	5	3	3	4
RB20	0.026	1	1	5	3	3	5
RB21	-	2	3	5	0	2	5
RB22	-	3	3	5	0	3	5
RB23	0.215	1	3	5	4	3	5
RB24	-	4	3	5	1	3	5
RB25	-	1	2	5	1	3	5
RB26	-	1	2	5	1	3	5
RB27	-	2	3	5	1	3	5
RB28	-	1	3	4	4	2	5
RB29	-	1	2	5	4	2	5
RB30	0.071	1	3	5	4	2	5
SB1	0.036	1	2	5	0	3	3
SB2	-	1	2	5	4	3	4
SB3	-	1	2	5	1	3	5
SB4	0.050	1	1	5	4	2	5
SB5	-	3	1	5	1	3	4
SB6	-	-	3	5	0	3	4
SB7	0.125	1	2	5	4	2	5
SB8	-	1	2	5	1	2	5
SB9	-	1	1	5	1	2	5
SB10	-	1	1	5	4	2	5
SB11	-	2	3	5	4	2	5
SB12	-	1	2	5	4	2	5
SB13	0.206	1	2	5	4	2	5
SB14	-	3	2	5	1	2	5
SB15	-	1	2	5	3	2	5
SB16	0.043	2	3	5	3	2	5
SB17	0.128	3	1	5	1	2	5
SB18	-	1	1	5	1	2	5
SB19	0.219	1	1	5	4	2	5
SB20	-	1	1	5	4	2	5
SB21	-	1	2	5	4	2	5
SB22	-	3	2	5	1	2	5
SB23	-	1	2	5	4	2	5
SB24	0.018	1	1	5	4	2	5
SB25	-	1	1	5	1	2	5
SB26	0.005	1	2	5	4	2	5
SB27	-	1	1	5	4	2	5
SB28	0.184	1	1	5	4	2	5
SB29	-	1	1	5	4	2	5
SB30	0.130	2	2	5	1	2	5

Table 25 (continued)

Well No.	dieldrin & aldrin (ppb)	Value or class of each data layer					
		Soil texture	Well depth	Percent slope	Primary land use	AAR	MVR
KB1	0.078	4	2	5	0	2	5
KB2	0.003	2	3	5	1	2	4
KB3	-	4	4	5	1	2	4
KB4	0.045	3	3	5	1	3	4
KB5	-	1	3	5	1	3	3
KB6	0.018	2	3	5	3	2	5
KB7	-	2	3	5	3	2	5
KB8	tr	1	3	5	3	2	5
KB9	3.440	2	3	5	3	2	5
KB10	-	2	3	5	4	3	4
KB11	-	2	3	5	4	3	4
KB12	tr	2	3	5	4	3	4
KB13	0.008	2	2	3	0	2	5
KB14	0.104	1	2	5	0	5	2
KB15	-	2	3	5	0	4	4
KB16	-	1	4	4	0	4	4
KB17	-	1	4	4	0	4	4
KB18	-	-	3	5	1	3	4
KB19	0.019	1	3	4	3	3	4
KB20	-	3	3	5	0	4	4
KB21	0.036	-	4	2	1	2	5
KB22	0.028	3	4	2	0	2	5
KB23	-	3	3	5	3	2	5
KB24	-	3	3	5	1	2	5
KB25	0.080	3	4	5	3	2	5
KB26	0.071	3	3	5	1	2	5
KB27	0.012	1	3	5	3	2	5
KB28	tr	1	3	5	3	2	5
KB29	-	3	3	5	3	2	5
KB30	0.003	3	3	5	1	2	5
RB1	0.006	2	3	5	4	2	5
RB2	-	2	3	5	3	3	5
RB3	0.005	2	4	5	3	3	5
RB4	0.037	5	3	5	3	3	5
RB5	tr	4	3	5	3	3	5
RB6	0.075	1	3	5	0	2	5
RB7	0.060	1	3	5	1	2	5
RB8	0.042	3	1	5	4	2	5
RB9	-	3	3	5	4	2	5
RB10	0.057	3	2	5	4	2	5
RB11	-	3	2	5	1	2	5
RB12	0.028	3	2	5	1	2	5
RB13	0.012	3	2	5	1	2	5
RB14	0.003	1	3	5	4	2	5
RB15	0.019	1	1	5	3	2	5

Table 25 (continued)

Well No.	dieldrin& aldrin (ppb)	Value or class of each data layer					
		Soil texture	Well depth	Percent slope	Primary land use	AAR	MVR
RB16	0.042	1	1	5	3	2	5
RB17	0.026	1	1	5	1	3	4
RB18	0.043	1	1	5	3	3	4
RB19	0.051	1	1	5	3	3	4
RB20	0.007	1	1	5	3	3	5
RB21	0.007	2	3	5	0	2	5
RB22	0.008	3	3	5	0	3	5
RB23	-	1	3	5	4	3	5
RB24	0.030	4	3	5	1	3	5
RB25	0.002	1	2	5	1	3	5
RB26	-	1	2	5	1	3	5
RB27	0.036	2	3	5	1	3	5
RB28	0.018	1	3	4	4	2	5
RB29	0.006	1	2	5	4	2	5
RB30	0.074	1	3	5	4	2	5
SB1	0.015	1	2	5	0	3	3
SB2	0.010	1	2	5	4	3	4
SB3	-	1	2	5	1	3	5
SB4	-	1	1	5	4	2	5
SB5	-	3	1	5	1	3	4
SB6	-	-	3	5	0	3	4
SB7	-	1	2	5	4	2	5
SB8	0.011	1	2	5	1	2	5
SB9	-	1	1	5	1	2	5
SB10	-	1	1	5	4	2	5
SB11	-	2	3	5	4	2	5
SB12	-	1	2	5	4	2	5
SB13	-	1	2	5	4	2	5
SB14	-	3	2	5	1	2	5
SB15	-	1	2	5	3	2	5
SB16	0.013	2	3	5	3	2	5
SB17	0.006	3	1	5	1	2	5
SB18	0.003	1	1	5	1	2	5
SB19	-	1	1	5	4	2	5
SB20	-	1	1	5	4	2	5
SB21	-	1	2	5	4	2	5
SB22	0.005	3	2	5	1	2	5
SB23	0.009	1	2	5	4	2	5
SB24	tr	1	1	5	4	2	5
SB25	0.001	1	1	5	1	2	5
SB26	0.006	1	2	5	4	2	5
SB27	0.010	1	1	5	4	2	5
SB28	0.014	1	1	5	4	2	5
SB29	0.006	1	1	5	4	2	5
SB30	tr	2	2	5	1	2	5

Table 25 (continued)

Well No.	endrin (ppb)	Value or class of each data layer					
		Soil texture	Well depth	Percent slope	Primary land use	AAR	MVR
KB1	-	4	2	5	0	2	5
KB2	-	2	3	5	1	2	4
KB3	-	4	4	5	1	2	4
KB4	-	3	3	5	1	3	4
KB5	-	1	3	5	1	3	3
KB6	-	2	3	5	3	2	5
KB7	-	2	3	5	3	2	5
KB8	-	1	3	5	3	2	5
KB9	-	2	3	5	3	2	5
KB10	-	2	3	5	4	3	4
KB11	-	2	3	5	4	3	4
KB12	-	2	3	5	4	3	4
KB13	-	2	2	3	0	2	5
KB14	-	1	2	5	0	5	2
KB15	-	2	3	5	0	4	4
KB16	-	1	4	4	0	4	4
KB17	-	1	4	4	0	4	4
KB18	-	-	3	5	1	3	4
KB19	-	1	3	4	3	3	4
KB20	-	3	3	5	0	4	4
KB21	-	-	4	2	1	2	5
KB22	-	3	4	2	0	2	5
KB23	-	3	3	5	3	2	5
KB24	-	3	3	5	1	2	5
KB25	-	3	4	5	3	2	5
KB26	-	3	3	5	1	2	5
KB27	-	1	3	5	3	2	5
KB28	-	1	3	5	3	2	5
KB29	-	3	3	5	3	2	5
KB30	-	3	3	5	1	2	5
RB1	-	2	3	5	4	2	5
RB2	-	2	3	5	3	3	5
RB3	-	2	4	5	3	3	5
RB4	-	5	3	5	3	3	5
RB5	-	4	3	5	3	3	5
RB6	-	1	3	5	0	2	5
RB7	-	1	3	5	1	2	5
RB8	-	3	1	5	4	2	5
RB9	-	3	3	5	4	2	5
RB10	-	3	2	5	4	2	5
RB11	-	3	2	5	1	2	5
RB12	-	3	2	5	1	2	5
RB13	-	3	2	5	1	2	5
RB14	-	1	3	5	4	2	5
RB15	0.026	1	1	5	3	2	5

Table 25 (continued)

Well No.	endrin (ppb)	Value or class of each data layer					
		Soil texture	Well depth	Percent slope	Primary land use	AAR	MVR
RB16	-	1	1	5	3	2	5
RB17	-	1	1	5	1	3	4
RB18	-	1	1	5	3	3	4
RB19	0.042	1	1	5	3	3	4
RB20	-	1	1	5	3	3	5
RB21	-	2	3	5	0	2	5
RB22	-	3	3	5	0	3	5
RB23	-	1	3	5	4	3	5
RB24	-	4	3	5	1	3	5
RB25	-	1	2	5	1	3	5
RB26	-	1	2	5	1	3	5
RB27	-	2	3	5	1	3	5
RB28	-	1	3	4	4	2	5
RB29	-	1	2	5	4	2	5
RB30	0.111	1	3	5	4	2	5
SB1	-	1	2	5	0	3	3
SB2	-	1	2	5	4	3	4
SB3	-	1	2	5	1	3	5
SB4	-	1	1	5	4	2	5
SB5	-	3	1	5	1	3	4
SB6	-	-	3	5	0	3	4
SB7	-	1	2	5	4	2	5
SB8	-	1	2	5	1	2	5
SB9	-	1	1	5	1	2	5
SB10	-	1	1	5	4	2	5
SB11	-	2	3	5	4	2	5
SB12	-	1	2	5	4	2	5
SB13	-	1	2	5	4	2	5
SB14	-	3	2	5	1	2	5
SB15	-	1	2	5	3	2	5
SB16	-	2	3	5	3	2	5
SB17	-	3	1	5	1	2	5
SB18	-	1	1	5	1	2	5
SB19	-	1	1	5	4	2	5
SB20	-	1	1	5	4	2	5
SB21	-	1	2	5	4	2	5
SB22	-	3	2	5	1	2	5
SB23	-	1	2	5	4	2	5
SB24	-	1	1	5	4	2	5
SB25	-	1	1	5	1	2	5
SB26	-	1	2	5	4	2	5
SB27	-	1	1	5	4	2	5
SB28	-	1	1	5	4	2	5
SB29	-	1	1	5	4	2	5
SB30	-	2	2	5	1	2	5

Table 26 An example of correlation test for identifying weighting schemes

```
DATA CARBOFURAN;
INPUT X Y @@;
LABEL X = 'CARBOFURAN CONC.';
LABEL Y = 'SOIL CLASS.';
CARDS;
0     4 0     2 0     4 0     3 0     1 0     2 0     2 0     1 0     2
0     2 0     2 0     2 0     2 0     1 0     2 0     1 0     1 0     *
0     1 0     3 0.260 * 0     3 0     3 0     3 0     3 0     3 0     1
0     1 0.120 3 0     3 0     2 0     2 0     2 0     5 0     4 0.050 1
0.040 1 0     3 0     3 0     3 0     3 0     3 0.100 3 0     1 0     1
0     1 0     1 0     1 0     1 0     1 0     2 0     3 0     1 0     4
0.200 1 0     1 0     2 0     1 0     1 0.070 1 0.140 1 0.180 1 0     1
0     1 0.191 3 0.120 * 0.130 1 0     1 0     1 0     1 0     2 0     1
0.510 1 0.049 3 0.410 1 0.140 2 0.620 3 0.511 1 0.036 1 0     1 0     1
0     3 0     1 0.176 1 0     1 0.460 1 0     1 0.460 1 0.200 1 0.560 2
PROC PRINT LABEL;
PROC CORR PEARSON SPEARMAN;
VAR X Y;
RUN;
```

```
                                       The CORR Procedure
                                2  Variables:    X        Y


                                       Simple Statistics

Variable       N       Mean    Std Dev     Median    Minimum    Maximum  Label
X             90    0.06370    0.14223          0          0    0.62000  CARBOFURAN CONC.
Y             87    1.83908    1.01011    1.00000    1.00000    5.00000  SOIL CLASS.


                               Pearson Correlation Coefficients
                                  Prob > |r| under H0: Rho=0
                                     Number of Observations

                                                        X             Y
                          X                       1.00000      -0.13151
                          CARBOFURAN CONC.                       0.2247
                                                       90            87
                          Y                      -0.13151       1.00000
                          SOIL CLASS.              0.2247
                                                       87            87


                               Spearman Correlation Coefficients
                                  Prob > |r| under H0: Rho=0
                                     Number of Observations

                                                        X             Y
                          X                       1.00000      -0.17489
                          CARBOFURAN CONC.                       0.1052
                                                       90            87

                          Y                      -0.17489       1.00000
                          SOIL CLASS.              0.1052
                                                       87            87
```

Table 32 Data used in correlation tests for comparing vulnerability scores and actual groundwater quality

Well No.	carbofuran (ppb)	Vulnerability score			
		Option 1	Option 2	Option 3	Option 4
KB1	-	2.6	2.8	2.9	3.0
KB2	-	3.0	2.9	3.0	2.9
KB3	-	3.8	3.8	3.7	3.7
KB4	-	3.1	3.1	3.1	3.1
KB5	-	2.8	2.6	2.7	2.6
KB6	-	3.3	3.2	3.4	3.4
KB7	-	3.3	3.2	3.4	3.4
KB8	-	3.2	3.0	3.3	3.2
KB9	-	3.3	3.2	3.4	3.4
KB10	-	3.4	3.3	3.6	3.5
KB11	-	3.4	3.3	3.6	3.5
KB12	-	3.4	3.3	3.6	3.5
KB13	-	2.2	2.2	2.3	2.3
KB14	-	2.0	1.9	2.0	1.9
KB15	-	2.9	2.8	2.8	2.8
KB16	-	3.3	3.0	2.9	2.8
KB17	-	3.3	3.0	2.9	2.8
KB18	-	2.8	2.5	2.7	2.5
KB19	-	3.0	2.8	3.0	2.9
KB20	-	3.0	3.0	3.0	3.0
KB21	0.260	3.2	2.8	2.8	2.6
KB22	-	3.4	3.3	3.1	3.0
KB23	-	3.4	3.4	3.6	3.6
KB24	-	3.2	3.2	3.3	3.3
KB25	-	4.0	3.9	4.0	3.9
KB26	-	3.2	3.2	3.3	3.3
KB27	-	3.2	3.0	3.3	3.2
KB28	-	3.2	3.0	3.3	3.2
KB29	0.120	*	*	*	*
KB30	-	*	*	*	*
RB1	-	3.5	3.4	3.7	3.7
RB2	-	3.3	3.2	3.4	3.4
RB3	-	3.9	3.7	3.8	3.7
RB4	-	3.6	3.8	3.9	4.0
RB5	-	3.5	3.6	3.7	3.8
RB6	0.050	2.9	2.7	2.8	2.7
RB7	0.040	3.0	2.8	3.0	2.9
RB8	-	2.4	2.6	3.1	3.2
RB9	-	3.6	3.6	3.9	3.9
RB10	-	3.0	3.1	3.5	3.5
RB11	-	2.6	2.7	2.9	2.9
RB12	-	2.6	2.7	2.9	2.9
RB13	0.100	2.6	2.7	2.9	2.9
RB14	-	3.4	3.2	3.6	3.5
RB15	-	1.9	1.9	2.3	2.3

Table 32 (continued)

Well No.	carbofuran (ppb)	Vulnerability score			
		Option 1	Option 2	Option 3	Option 4
RB16	-	2.0	2.0	2.5	2.5
RB17	-	1.7	1.7	2.0	2.0
RB18	-	1.8	1.8	2.2	2.2
RB19	-	1.9	1.9	2.3	2.3
RB20	-	1.9	1.9	2.3	2.3
RB21	-	3.0	2.9	3.0	2.9
RB22	-	3.1	3.1	3.1	3.1
RB23	-	3.4	3.2	3.6	3.5
RB24	-	3.3	3.4	3.4	3.5
RB25	0.200	2.4	2.3	2.6	2.5
RB26	-	2.4	2.3	2.6	2.5
RB27	-	3.1	3.0	3.1	3.1
RB28	-	3.3	3.1	3.4	3.3
RB29	-	2.8	2.7	3.2	3.1
RB30	0.070	3.4	3.2	3.6	3.5
SB1	0.140	2.1	2.0	2.1	2.1
SB2	0.180	2.7	2.6	3.0	3.0
SB3	-	2.4	2.3	2.6	2.5
SB4	-	2.2	2.2	2.8	2.8
SB5	0.191	1.9	2.1	2.3	2.4
SB6	0.120	2.7	2.4	2.5	2.4
SB7	0.130	2.8	2.7	3.2	3.1
SB8	-	2.4	2.3	2.6	2.5
SB9	-	1.8	1.8	2.2	2.2
SB10	-	2.2	2.2	2.8	2.8
SB11	-	3.5	3.4	3.7	3.7
SB12	-	2.8	2.7	3.2	3.1
SB13	0.510	2.8	2.7	3.2	3.1
SB14	0.049	2.6	2.7	2.9	2.9
SB15	0.410	2.6	2.5	2.9	2.8
SB16	0.140	3.3	3.2	3.4	3.4
SB17	0.620	2.0	2.2	2.5	2.6
SB18	0.511	1.8	1.8	2.2	2.2
SB19	0.036	2.2	2.2	2.8	2.8
SB20	-	2.2	2.2	2.8	2.8
SB21	-	2.8	2.7	3.2	3.1
SB22	-	2.6	2.7	2.9	2.9
SB23	-	2.8	2.7	3.2	3.1
SB24	0.176	2.2	2.2	2.8	2.8
SB25	-	1.8	1.8	2.2	2.2
SB26	0.470	2.8	2.7	3.2	3.1
SB27	-	2.2	2.2	2.8	2.8
SB28	0.460	2.2	2.2	2.8	2.8
SB29	0.200	2.2	2.2	2.8	2.8
SB30	0.560	2.5	2.5	2.7	2.7

Table 32 (continued)

Well No.	endosulfan (ppb)	Vulnerability score			
		Option 1	Option 2	Option 3	Option 4
KB1	-	2.6	2.8	2.9	3.0
KB2	-	3.0	2.9	3.0	2.9
KB3	0.022	3.8	3.8	3.7	3.7
KB4	0.018	3.1	3.1	3.1	3.1
KB5	0.015	2.8	2.6	2.7	2.6
KB6	0.038	3.3	3.2	3.4	3.4
KB7	0.030	3.3	3.2	3.4	3.4
KB8	0.028	3.2	3.0	3.3	3.2
KB9	-	3.3	3.2	3.4	3.4
KB10	0.029	3.4	3.3	3.6	3.5
KB11	0.034	3.4	3.3	3.6	3.5
KB12	0.018	3.4	3.3	3.6	3.5
KB13	0.077	2.2	2.2	2.3	2.3
KB14	-	2.0	1.9	2.0	1.9
KB15	0.023	2.9	2.8	2.8	2.8
KB16	0.057	3.3	3.0	2.9	2.8
KB17	0.279	3.3	3.0	2.9	2.8
KB18	-	2.8	2.5	2.7	2.5
KB19	0.031	3.0	2.8	3.0	2.9
KB20	0.033	3.0	3.0	3.0	3.0
KB21	-	3.2	2.8	2.8	2.6
KB22	-	3.4	3.3	3.1	3.0
KB23	-	3.4	3.4	3.6	3.6
KB24	0.198	3.2	3.2	3.3	3.3
KB25	0.138	4.0	3.9	4.0	3.9
KB26	0.298	3.2	3.2	3.3	3.3
KB27	0.076	3.2	3.0	3.3	3.2
KB28	0.201	3.2	3.0	3.3	3.2
KB29	-	*	*	*	*
KB30	0.136	*	*	*	*
RB1	-	3.5	3.4	3.7	3.7
RB2	-	3.3	3.2	3.4	3.4
RB3	-	3.9	3.7	3.8	3.7
RB4	-	3.5	3.7	3.7	3.8
RB5	-	3.4	3.5	3.6	3.6
RB6	0.034	2.9	2.7	2.8	2.7
RB7	0.100	3.0	2.8	3.0	2.9
RB8	-	2.4	2.6	3.1	3.2
RB9	-	3.6	3.6	3.9	3.9
RB10	-	3.0	3.1	3.5	3.5
RB11	-	2.6	2.7	2.9	2.9
RB12	-	2.6	2.7	2.9	2.9
RB13	-	2.6	2.7	2.9	2.9
RB14	0.043	3.4	3.2	3.6	3.5
RB15	0.042	1.9	1.9	2.3	2.3

Table 32 (continued)

Well No.	endosulfan (ppb)	Vulnerability score			
		Option 1	Option 2	Option 3	Option 4
RB16	-	1.9	1.9	2.3	2.3
RB17	-	1.7	1.7	2.0	2.0
RB18	-	1.8	1.8	2.2	2.2
RB19	0.035	1.8	1.8	2.2	2.2
RB20	-	1.9	1.9	2.3	2.3
RB21	0.013	3.0	2.9	3.0	2.9
RB22	-	3.1	3.1	3.1	3.1
RB23	-	3.4	3.2	3.6	3.5
RB24	0.026	3.3	3.4	3.4	3.5
RB25	0.051	2.4	2.3	2.6	2.5
RB26	-	2.4	2.3	2.6	2.5
RB27	0.031	3.1	3.0	3.1	3.1
RB28	-	3.3	3.1	3.4	3.3
RB29	-	2.8	2.7	3.2	3.1
RB30	0.064	3.4	3.2	3.6	3.5
SB1	-	2.1	2.0	2.1	2.1
SB2	-	2.7	2.6	3.0	3.0
SB3	-	2.4	2.3	2.6	2.5
SB4	0.005	2.2	2.2	2.8	2.8
SB5	-	1.9	2.1	2.3	2.4
SB6	-	2.7	2.4	2.5	2.4
SB7	-	2.8	2.7	3.2	3.1
SB8	-	2.4	2.3	2.6	2.5
SB9	0.012	1.8	1.8	2.2	2.2
SB10	-	2.2	2.2	2.8	2.8
SB11	-	3.4	3.4	3.7	3.7
SB12	-	2.8	2.7	3.2	3.1
SB13	0.067	2.8	2.7	3.2	3.1
SB14	-	2.6	2.7	2.9	2.9
SB15	-	2.6	2.5	2.9	2.8
SB16	-	3.3	3.2	3.4	3.4
SB17	-	2.0	2.2	2.5	2.6
SB18	0.031	1.8	1.8	2.2	2.2
SB19	0.011	2.2	2.2	2.8	2.8
SB20	-	2.2	2.2	2.8	2.8
SB21	-	2.8	2.7	3.2	3.1
SB22	-	2.6	2.7	2.9	2.9
SB23	-	2.8	2.7	3.2	3.1
SB24	-	2.2	2.2	2.8	2.8
SB25	-	1.8	1.8	2.2	2.2
SB26	-	2.8	2.7	3.2	3.1
SB27	-	2.2	2.2	2.8	2.8
SB28	-	2.2	2.2	2.8	2.8
SB29	-	2.2	2.2	2.8	2.8
SB30	-	2.5	2.5	2.7	2.7

Table 32 (continued)

Well No.	dicofol (ppb)	Vulnerability score			
		Option 1	Option 2	Option 3	Option 4
KB1	-	2.6	2.8	2.9	3.0
KB2	-	3.0	2.9	3.0	2.9
KB3	-	3.8	3.8	3.7	3.7
KB4	-	3.1	3.1	3.1	3.1
KB5	-	2.8	2.6	2.7	2.6
KB6	-	3.2	3.1	3.3	3.2
KB7	-	3.2	3.1	3.3	3.2
KB8	-	3.1	2.9	3.1	3.0
KB9	-	3.2	3.1	3.3	3.2
KB10	-	3.3	3.2	3.4	3.4
KB11	-	3.3	3.2	3.4	3.4
KB12	-	3.3	3.2	3.4	3.4
KB13	-	2.2	2.2	2.3	2.3
KB14	-	2.0	1.9	2.0	1.9
KB15	-	2.9	2.8	2.8	2.8
KB16	-	3.3	3.0	2.9	2.8
KB17	-	3.3	3.0	2.9	2.8
KB18	-	2.8	2.5	2.7	2.5
KB19	-	2.9	2.7	2.8	2.7
KB20	-	3.0	3.0	3.0	3.0
KB21	-	3.2	2.8	2.8	2.6
KB22	-	3.4	3.3	3.1	3.0
KB23	-	3.3	3.3	3.4	3.4
KB24	0.270	3.2	3.2	3.3	3.3
KB25	0.053	3.9	3.8	3.8	3.8
KB26	0.235	3.2	3.2	3.3	3.3
KB27	0.126	3.1	2.9	3.1	3.0
KB28	0.084	3.1	2.9	3.1	3.0
KB29	-	*	*	*	*
KB30	0.060	*	*	*	*
RB1	-	3.4	3.3	3.6	3.5
RB2	-	3.2	3.1	3.3	3.2
RB3	-	3.8	3.6	3.7	3.6
RB4	-	3.5	3.7	3.7	3.8
RB5	-	3.4	3.5	3.6	3.6
RB6	-	2.9	2.7	2.8	2.7
RB7	0.077	3.0	2.8	3.0	2.9
RB8	0.008	2.3	2.5	2.9	3.0
RB9	0.008	3.5	3.5	3.7	3.3
RB10	-	2.9	3.0	3.3	3.4
RB11	-	2.6	2.7	2.9	2.9
RB12	-	2.6	2.7	2.9	2.9
RB13	-	2.6	2.7	2.9	2.9
RB14	-	3.3	3.1	3.4	3.3
RB15	0.035	1.9	1.9	2.3	2.3

Table 32 (continued)

Well No.	dicofol (ppb)	Vulnerability score			
		Option 1	Option 2	Option 3	Option 4
RB16	-	1.9	1.9	2.3	2.3
RB17	-	1.7	1.7	2.0	2.0
RB18	0.013	1.8	1.8	2.2	2.2
RB19	0.087	1.8	1.8	2.2	2.2
RB20	0.014	1.9	1.9	2.3	2.3
RB21	-	3.0	2.9	3.0	2.9
RB22	-	3.1	3.1	3.1	3.1
RB23	-	3.3	3.1	3.4	3.3
RB24	0.081	3.3	3.4	3.4	3.5
RB25	0.029	2.4	2.3	2.6	2.5
RB26	-	2.4	2.3	2.6	2.5
RB27	0.037	3.1	3.0	3.1	3.1
RB28	-	3.2	3.0	3.3	3.2
RB29	-	2.7	2.6	3.0	3.0
RB30	0.080	3.3	3.1	3.4	3.3
SB1	0.073	2.1	2.0	2.1	2.1
SB2	-	2.6	2.5	2.9	2.8
SB3	0.065	2.4	2.3	2.6	2.5
SB4	0.044	2.1	2.1	2.6	2.6
SB5	-	1.9	2.1	2.3	2.4
SB6	-	2.7	2.4	2.5	2.4
SB7	0.078	2.7	2.6	3.0	3.0
SB8	-	2.4	2.3	2.6	2.5
SB9	0.011	1.8	1.8	2.2	2.2
SB10	-	2.1	2.1	2.6	2.6
SB11	0.046	3.4	3.3	3.6	3.5
SB12	-	2.7	2.6	3.0	3.0
SB13	0.069	2.7	2.6	3.0	3.0
SB14	0.012	2.6	2.7	2.9	2.9
SB15	-	2.5	2.4	2.7	2.7
SB16	-	3.2	3.1	3.3	3.2
SB17	-	2.0	2.2	2.5	2.6
SB18	tr	1.8	1.8	2.2	2.2
SB19	0.038	2.1	2.1	2.6	2.6
SB20	-	2.1	2.1	2.6	2.6
SB21	-	2.7	2.6	3.0	3.0
SB22	tr	2.6	2.7	2.9	2.9
SB23	0.018	2.7	2.6	3.0	3.0
SB24	0.119	2.1	2.1	2.6	2.6
SB25	0.004	1.8	1.8	2.2	2.2
SB26	0.025	2.7	2.6	3.0	3.0
SB27	-	2.1	2.1	2.6	2.6
SB28	tr	2.1	2.1	2.6	2.6
SB29	0.057	2.1	2.1	2.6	2.6
SB30	-	2.5	2.5	2.7	2.7

Table 32 (continued)

Well No.	atrazine (ppb)	Vulnerability score			
		Option 1	Option 2	Option 3	Option 4
KB1	-	2.6	2.8	2.9	3.0
KB2	0.868	3.0	2.9	3.0	2.9
KB3	-	3.8	3.8	3.7	3.7
KB4	-	3.1	3.1	3.1	3.1
KB5	-	2.8	2.6	2.7	2.6
KB6	0.843	3.4	3.3	3.6	3.5
KB7	-	3.4	3.3	3.6	3.5
KB8	-	3.3	3.1	3.4	3.3
KB9	-	3.4	3.3	3.6	3.5
KB10	-	3.3	3.2	3.4	3.4
KB11	-	3.3	3.2	3.4	3.4
KB12	1.140	3.3	3.2	3.4	3.4
KB13	-	2.2	2.2	2.3	2.3
KB14	-	2.0	1.9	2.0	1.9
KB15	-	2.9	2.8	2.8	2.8
KB16	-	3.3	3.0	2.9	2.8
KB17	1.739	3.3	3.0	2.9	2.8
KB18	-	2.8	2.5	2.7	2.5
KB19	-	3.1	2.9	3.1	3.0
KB20	-	3.0	3.0	3.0	3.0
KB21	1.221	3.2	2.8	2.8	2.6
KB22	-	3.4	3.3	3.1	3.0
KB23	-	3.5	3.5	3.7	3.7
KB24	-	3.2	3.2	3.3	3.3
KB25	-	4.1	4.0	4.1	4.1
KB26	-	3.2	3.2	3.3	3.3
KB27	-	3.3	3.1	3.4	3.3
KB28	-	3.3	3.1	3.4	3.3
KB29	0.070	*	*	*	*
KB30	-	*	*	*	*
RB1	1.890	3.4	3.3	3.6	3.5
RB2	-	3.4	3.3	3.6	3.5
RB3	0.580	4.0	3.8	4.0	3.9
RB4	-	3.8	4.0	4.2	4.3
RB5	-	3.7	3.8	4.0	4.1
RB6	-	2.9	2.7	2.8	2.7
RB7	-	3.0	2.8	3.0	2.9
RB8	-	2.3	2.5	2.9	3.0
RB9	-	3.5	3.5	3.7	3.7
RB10	-	2.9	3.0	3.3	3.4
RB11	1.296	2.6	2.7	2.9	2.9
RB12	-	2.6	2.7	2.9	2.9
RB13	-	2.6	2.7	2.9	2.9
RB14	-	3.3	3.1	3.4	3.3
RB15	-	2.0	2.0	2.5	2.5

Table 32 (continued)

Well No.	atrazine (ppb)	Vulnerability score			
		Option 1	Option 2	Option 3	Option 4
RB16	-	2.0	2.0	2.5	2.5
RB17	-	1.7	1.7	2.0	2.0
RB18	-	1.9	1.9	2.3	2.3
RB19	-	1.9	1.9	2.3	2.3
RB20	-	2.0	2.0	2.5	2.5
RB21	-	3.0	2.9	3.0	2.9
RB22	0.180	3.1	3.1	3.1	3.1
RB23	-	3.3	3.1	3.4	3.3
RB24	-	3.3	3.4	3.4	3.5
RB25	-	2.4	2.3	2.6	2.5
RB26	-	2.4	2.3	2.6	2.5
RB27	-	3.1	3.0	3.1	3.1
RB28	-	3.2	3.0	3.3	3.2
RB29	0.047	2.7	2.6	3.0	3.0
RB30	-	3.3	3.1	3.4	3.3
SB1	-	2.1	2.0	2.1	2.1
SB2	-	2.6	2.5	2.9	2.8
SB3	-	2.4	2.3	2.6	2.5
SB4	-	2.1	2.1	2.6	2.6
SB5	-	1.9	2.1	2.3	2.4
SB6	-	2.7	2.4	2.5	2.4
SB7	-	2.7	2.6	3.0	3.0
SB8	-	2.4	2.3	2.6	2.5
SB9	-	1.8	1.8	2.2	2.2
SB10	-	2.1	2.1	2.6	2.6
SB11	-	3.4	3.3	3.6	3.5
SB12	-	2.7	2.6	3.0	3.0
SB13	-	2.7	2.6	3.0	3.0
SB14	-	2.6	2.7	2.9	2.9
SB15	0.010	2.7	2.6	3.0	3.0
SB16	-	3.4	3.3	3.6	3.5
SB17	-	2.0	2.2	2.5	2.6
SB18	-	1.8	1.8	2.2	2.2
SB19	-	2.1	2.1	2.6	2.6
SB20	-	2.1	2.1	2.6	2.6
SB21	-	2.7	2.6	3.0	3.0
SB22	-	2.6	2.7	2.9	2.9
SB23	-	2.7	2.6	3.0	3.0
SB24	-	2.1	2.1	2.6	2.6
SB25	-	1.8	1.8	2.2	2.2
SB26	-	2.7	2.6	3.0	3.0
SB27	-	2.1	2.1	2.6	2.6
SB28	-	2.1	2.1	2.6	2.6
SB29	tr	2.1	2.1	2.6	2.6
SB30	-	2.5	2.5	2.7	2.7

Table 32 (continued)

Well No.	2,4-D (ppb)	Vulnerability score			
		Option 1	Option 2	Option 3	Option 4
KB1	-	2.6	2.8	2.9	3.0
KB2	-	3.0	2.9	3.0	2.9
KB3	-	3.8	3.8	3.7	3.7
KB4	-	3.1	3.1	3.1	3.1
KB5	-	2.8	2.6	2.7	2.6
KB6	-	3.4	3.3	3.6	3.5
KB7	-	3.4	3.3	3.6	3.5
KB8	-	3.3	3.1	3.4	3.3
KB9	-	3.4	3.3	3.6	3.5
KB10	-	3.4	3.3	3.6	3.5
KB11	-	3.4	3.3	3.6	3.5
KB12	-	3.4	3.3	3.6	3.5
KB13	-	2.2	2.2	2.3	2.3
KB14	-	2.0	1.9	2.0	1.9
KB15	-	2.9	2.8	2.8	2.8
KB16	-	3.3	3.0	2.9	2.8
KB17	-	3.3	3.0	2.9	2.8
KB18	-	2.8	2.5	2.7	2.5
KB19	0.090	3.1	2.9	3.1	3.0
KB20	-	3.0	3.0	3.0	3.0
KB21	-	3.2	2.8	2.8	2.6
KB22	-	3.4	3.3	3.1	3.0
KB23	-	3.5	3.5	3.7	3.7
KB24	-	3.2	3.2	3.3	3.3
KB25	-	4.1	4.0	4.1	4.1
KB26	0.120	3.2	3.2	3.3	3.3
KB27	-	3.3	3.1	3.4	3.3
KB28	-	3.3	3.1	3.4	3.3
KB29	-	*	*	*	*
KB30	0.080	*	*	*	*
RB1	-	3.5	3.4	3.7	3.7
RB2	-	3.4	3.3	3.6	3.5
RB3	-	4.0	3.8	4.0	3.9
RB4	-	3.8	4.0	4.2	4.3
RB5	-	3.7	3.8	4.0	4.1
RB6	-	2.9	2.7	2.8	2.7
RB7	-	3.0	2.8	3.0	2.9
RB8	-	2.4	2.6	3.1	3.2
RB9	0.087	3.6	3.6	3.9	3.9
RB10	-	3.0	3.1	3.5	3.5
RB11	-	2.6	2.7	2.9	2.9
RB12	-	2.6	2.7	2.9	2.9
RB13	0.070	2.6	2.7	2.9	2.9
RB14	-	3.4	3.2	3.6	3.5
RB15	-	2.0	2.0	2.5	2.5

Table 32 (continued)

Well No.	2,4-D (ppb)	Vulnerability score			
		Option 1	Option 2	Option 3	Option 4
RB16	-	2.0	2.0	2.5	2.5
RB17	-	1.7	1.7	2.0	2.0
RB18	0.060	1.9	1.9	2.3	2.3
RB19	-	1.9	1.9	2.3	2.3
RB20	-	2.0	2.0	2.5	2.5
RB21	-	3.0	2.9	3.0	2.9
RB22	-	3.1	3.1	3.1	3.1
RB23	-	3.4	3.2	3.6	3.5
RB24	-	3.3	3.4	3.4	3.5
RB25	-	2.4	2.3	2.6	2.5
RB26	-	2.4	2.3	2.6	2.5
RB27	-	3.1	3.0	3.1	3.1
RB28	-	3.3	3.1	3.4	3.3
RB29	-	2.8	2.7	3.2	3.1
RB30	0.070	3.4	3.2	3.6	3.5
SB1	0.100	2.1	2.0	2.1	2.1
SB2	-	2.7	2.6	3.0	3.0
SB3	-	2.4	2.3	2.6	2.5
SB4	-	2.2	2.2	2.8	2.8
SB5	0.100	1.9	2.1	2.3	2.4
SB6	-	2.7	2.4	2.5	2.4
SB7	-	2.8	2.7	3.2	3.1
SB8	-	2.4	2.3	2.6	2.5
SB9	-	1.8	1.8	2.2	2.2
SB10	-	2.2	2.2	2.8	2.8
SB11	-	3.5	3.4	3.7	3.7
SB12	-	2.8	2.7	3.2	3.1
SB13	-	2.8	2.7	3.2	3.1
SB14	-	2.6	2.7	2.9	2.9
SB15	-	2.7	2.6	3.0	3.0
SB16	-	3.4	3.3	3.6	3.5
SB17	-	2.0	2.2	2.5	2.6
SB18	0.210	1.8	1.8	2.2	2.2
SB19	-	2.2	2.2	2.8	2.8
SB20	-	2.2	2.2	2.8	2.8
SB21	-	2.8	2.7	3.2	3.1
SB22	-	2.6	2.7	2.9	2.9
SB23	-	2.8	2.7	3.2	3.1
SB24	-	2.2	2.2	2.8	2.8
SB25	-	1.8	1.8	2.2	2.2
SB26	-	2.8	2.7	3.2	3.1
SB27	-	2.2	2.2	2.8	2.8
SB28	-	2.2	2.2	2.8	2.8
SB29	-	2.2	2.2	2.8	2.8
SB30	-	2.5	2.5	2.7	2.7

Table 32 (continued)

Well No.	total BHC (ppb)	Vulnerability score			
		Option 1	Option 2	Option 3	Option 4
KB1	0.028	2.6	2.8	2.9	3.0
KB2	0.011	3.0	2.9	3.0	2.9
KB3	0.005	3.8	3.8	3.7	3.7
KB4	0.030	3.1	3.1	3.1	3.1
KB5	0.037	2.8	2.6	2.7	2.6
KB6	0.132	3.3	3.2	3.4	3.4
KB7	0.068	3.3	3.2	3.4	3.4
KB8	0.032	3.2	3.0	3.3	3.2
KB9	0.302	3.3	3.2	3.4	3.4
KB10	0.036	3.3	3.2	3.4	3.4
KB11	0.050	3.3	3.2	3.4	3.4
KB12	0.020	3.3	3.2	3.4	3.4
KB13	-	2.2	2.2	2.3	2.3
KB14	0.002	2.0	1.9	2.0	1.9
KB15	0.022	2.9	2.8	2.8	2.8
KB16	-	3.3	3.0	2.9	2.8
KB17	tr	3.3	3.0	2.9	2.8
KB18	0.007	2.8	2.5	2.7	2.5
KB19	0.072	3.0	2.8	3.0	2.9
KB20	0.020	3.0	3.0	3.0	3.0
KB21	0.015	3.2	2.8	2.8	2.6
KB22	0.031	3.4	3.3	3.1	3.0
KB23	0.104	3.4	3.4	3.6	3.6
KB24	0.041	3.2	3.2	3.3	3.3
KB25	0.446	4.0	3.9	4.0	3.9
KB26	0.157	3.2	3.2	3.3	3.3
KB27	0.007	3.2	3.0	3.3	3.2
KB28	0.159	3.2	3.0	3.3	3.2
KB29	0.243	*	*	*	*
KB30	0.124	*	*	*	*
RB1	0.151	3.4	3.3	3.6	3.5
RB2	0.163	3.3	3.2	3.4	3.4
RB3	0.244	3.9	3.7	3.8	3.7
RB4	0.046	3.6	3.8	3.9	4.0
RB5	0.117	3.5	3.6	3.7	3.8
RB6	0.086	2.9	2.7	2.8	2.7
RB7	0.309	3.0	2.8	3.0	2.9
RB8	0.575	2.3	2.5	2.9	3.0
RB9	0.069	3.5	3.5	3.7	3.7
RB10	0.328	2.9	3.0	3.3	3.4
RB11	0.184	2.6	2.7	2.9	2.9
RB12	0.265	2.6	2.7	2.9	2.9
RB13	0.115	2.6	2.7	2.9	2.9
RB14	0.086	3.3	3.1	3.4	3.3
RB15	0.099	2.0	2.0	2.5	2.5

Table 32 (continued)

Well No.	total BHC (ppb)	Vulnerability score			
		Option 1	Option 2	Option 3	Option 4
RB16	-	2.0	2.0	2.5	2.5
RB17	-	1.7	1.7	2.0	2.0
RB18	0.175	1.9	1.9	2.3	2.3
RB19	0.195	1.9	1.9	2.3	2.3
RB20	0.064	2.0	2.0	2.5	2.5
RB21	0.040	3.0	2.9	3.0	2.9
RB22	-	3.1	3.1	3.1	3.1
RB23	0.198	3.3	3.1	3.4	3.3
RB24	0.074	3.3	3.4	3.4	3.5
RB25	0.105	2.4	2.3	2.6	2.5
RB26	0.035	2.4	2.3	2.6	2.5
RB27	0.022	3.1	3.0	3.1	3.1
RB28	0.170	3.2	3.0	3.3	3.2
RB29	0.035	2.7	2.6	3.0	3.0
RB30	0.118	3.3	3.1	3.4	3.3
SB1	-	2.1	2.0	2.1	2.1
SB2	0.008	2.6	2.5	2.9	2.8
SB3	-	2.4	2.3	2.6	2.5
SB4	-	2.1	2.1	2.6	2.6
SB5	0.075	1.9	2.1	2.3	2.4
SB6	0.024	2.7	2.4	2.5	2.4
SB7	-	2.7	2.6	3.0	3.0
SB8	0.040	2.4	2.3	2.6	2.5
SB9	0.045	1.8	1.8	2.2	2.2
SB10	0.013	2.1	2.1	2.6	2.6
SB11	-	3.4	3.3	3.6	3.5
SB12	-	2.7	2.6	3.0	3.0
SB13	0.036	2.7	2.6	3.0	3.0
SB14	-	2.6	2.7	2.9	2.9
SB15	-	2.6	2.5	2.9	2.8
SB16	-	3.3	3.2	3.4	3.4
SB17	-	2.0	2.2	2.5	2.6
SB18	-	1.8	1.8	2.2	2.2
SB19	-	2.1	2.1	2.6	2.6
SB20	-	2.1	2.1	2.6	2.6
SB21	-	2.7	2.6	3.0	3.0
SB22	-	2.6	2.7	2.9	2.9
SB23	-	2.7	2.6	3.0	3.0
SB24	0.203	2.1	2.1	2.6	2.6
SB25	-	1.8	1.8	2.2	2.2
SB26	-	2.7	2.6	3.0	3.0
SB27	-	2.1	2.1	2.6	2.6
SB28	0.001	2.1	2.1	2.6	2.6
SB29	-	2.1	2.1	2.6	2.6
SB30	tr	2.5	2.5	2.7	2.7

Table 32 (continued)

Well No.	total DDT (ppb)	Vulnerability score			
		Option 1	Option 2	Option 3	Option 4
KB1	-	2.6	2.8	2.9	3.0
KB2	-	3.0	2.9	3.0	2.9
KB3	0.063	3.8	3.8	3.7	3.7
KB4	0.137	3.1	3.1	3.1	3.1
KB5	0.052	2.8	2.6	2.7	2.6
KB6	0.364	3.3	3.2	3.4	3.4
KB7	0.065	3.3	3.2	3.4	3.4
KB8	-	3.2	3.0	3.3	3.2
KB9	9.681	3.3	3.2	3.4	3.4
KB10	0.029	3.3	3.2	3.4	3.4
KB11	0.047	3.3	3.2	3.4	3.4
KB12	-	3.3	3.2	3.4	3.4
KB13	-	2.2	2.2	2.3	2.3
KB14	-	2.0	1.9	2.0	1.9
KB15	-	2.9	2.8	2.8	2.8
KB16	-	3.3	3.0	2.9	2.8
KB17	0.050	3.3	3.0	2.9	2.8
KB18	-	2.8	2.5	2.7	2.5
KB19	0.028	3.0	2.8	3.0	2.9
KB20	0.033	3.0	3.0	3.0	3.0
KB21	-	3.2	2.8	2.8	2.6
KB22	-	3.4	3.3	3.1	3.0
KB23	0.005	3.4	3.4	3.6	3.6
KB24	-	3.2	3.2	3.3	3.3
KB25	0.059	4.0	3.9	4.0	3.9
KB26	0.016	3.2	3.2	3.3	3.3
KB27	-	3.2	3.0	3.3	3.2
KB28	0.028	3.2	3.0	3.3	3.2
KB29	tr	*	*	*	*
KB30	-	*	*	*	*
RB1	-	3.4	3.3	3.6	3.5
RB2	-	3.3	3.2	3.4	3.4
RB3	-	3.9	3.7	3.8	3.7
RB4	0.176	3.6	3.8	3.9	4.0
RB5	0.024	3.5	3.6	3.7	3.8
RB6	0.068	2.9	2.7	2.8	2.7
RB7	0.120	3.0	2.8	3.0	2.9
RB8	0.221	2.3	2.5	2.9	3.0
RB9	0.187	3.5	3.5	3.7	3.7
RB10	0.014	2.9	3.0	3.3	3.4
RB11	0.009	2.6	2.7	2.9	2.9
RB12	0.004	2.6	2.7	2.9	2.9
RB13	0.038	2.6	2.7	2.9	2.9
RB14	0.116	3.3	3.1	3.4	3.3
RB15	0.009	2.0	2.0	2.5	2.5

Table 32 (continued)

Well No.	total DDT (ppb)	Vulnerability score			
		Option 1	Option 2	Option 3	Option 4
RB16	0.008	2.0	2.0	2.5	2.5
RB17	0.008	1.7	1.7	2.0	2.0
RB18	0.009	1.9	1.9	2.3	2.3
RB19	0.353	1.9	1.9	2.3	2.3
RB20	0.008	2.0	2.0	2.5	2.5
RB21	0.186	3.0	2.9	3.0	2.9
RB22	0.003	3.1	3.1	3.1	3.1
RB23	0.004	3.3	3.1	3.4	3.3
RB24	0.008	3.3	3.4	3.4	3.5
RB25	0.031	2.4	2.3	2.6	2.5
RB26	0.170	2.4	2.3	2.6	2.5
RB27	0.025	3.1	3.0	3.1	3.1
RB28	0.041	3.2	3.0	3.3	3.2
RB29	0.006	2.7	2.6	3.0	3.0
RB30	3.217	3.3	3.1	3.4	3.3
SB1	0.022	2.1	2.0	2.1	2.1
SB2	0.041	2.6	2.5	2.9	2.8
SB3	0.007	2.4	2.3	2.6	2.5
SB4	0.009	2.1	2.1	2.6	2.6
SB5	-	1.9	2.1	2.3	2.4
SB6	-	2.7	2.4	2.5	2.4
SB7	0.003	2.7	2.6	3.0	3.0
SB8	-	2.4	2.3	2.6	2.5
SB9	0.019	1.8	1.8	2.2	2.2
SB10	0.014	2.1	2.1	2.6	2.6
SB11	-	3.4	3.3	3.6	3.5
SB12	-	2.7	2.6	3.0	3.0
SB13	0.025	2.7	2.6	3.0	3.0
SB14	-	2.6	2.7	2.9	2.9
SB15	-	2.6	2.5	2.9	2.8
SB16	-	3.3	3.2	3.4	3.4
SB17	-	2.0	2.2	2.5	2.6
SB18	0.153	1.8	1.8	2.2	2.2
SB19	0.119	2.1	2.1	2.6	2.6
SB20	-	2.1	2.1	2.6	2.6
SB21	0.105	2.7	2.6	3.0	3.0
SB22	-	2.6	2.7	2.9	2.9
SB23	-	2.7	2.6	3.0	3.0
SB24	-	2.1	2.1	2.6	2.6
SB25	-	1.8	1.8	2.2	2.2
SB26	-	2.7	2.6	3.0	3.0
SB27	-	2.1	2.1	2.6	2.6
SB28	0.381	2.1	2.1	2.6	2.6
SB29	-	2.1	2.1	2.6	2.6
SB30	-	2.5	2.5	2.7	2.7

Table 32 (continued)

Well No.	heptachlor& hept.epoxide (ppb)	Vulnerability score			
		Option 1	Option 2	Option 3	Option 4
KB1	0.070	2.6	2.8	2.9	3.0
KB2	0.330	3.0	2.9	3.0	2.9
KB3	0.460	3.8	3.8	3.7	3.7
KB4	0.586	3.1	3.1	3.1	3.1
KB5	-	2.8	2.6	2.7	2.6
KB6	0.730	3.3	3.2	3.4	3.4
KB7	-	3.3	3.2	3.4	3.4
KB8	-	3.2	3.0	3.3	3.2
KB9	0.010	3.3	3.2	3.4	3.4
KB10	-	3.3	3.2	3.4	3.4
KB11	0.040	3.3	3.2	3.4	3.4
KB12	0.800	3.3	3.2	3.4	3.4
KB13	-	2.2	2.2	2.3	2.3
KB14	0.400	2.0	1.9	2.0	1.9
KB15	0.340	2.9	2.8	2.8	2.8
KB16	-	3.3	3.0	2.9	2.8
KB17	-	3.3	3.0	2.9	2.8
KB18	0.003	2.8	2.5	2.7	2.5
KB19	0.393	3.0	2.8	3.0	2.9
KB20	0.700	3.0	3.0	3.0	3.0
KB21	0.305	3.2	2.8	2.8	2.6
KB22	0.206	3.4	3.3	3.1	3.0
KB23	0.035	3.4	3.4	3.6	3.6
KB24	0.212	3.2	3.2	3.3	3.3
KB25	0.016	4.0	3.9	4.0	3.9
KB26	0.236	3.2	3.2	3.3	3.3
KB27	0.009	3.2	3.0	3.3	3.2
KB28	0.337	3.2	3.0	3.3	3.2
KB29	-	*	*	*	*
KB30	0.008	*	*	*	*
RB1	0.571	3.4	3.3	3.6	3.5
RB2	-	3.3	3.2	3.4	3.4
RB3	0.030	3.9	3.7	3.8	3.7
RB4	-	3.6	3.8	3.9	4.0
RB5	-	3.5	3.6	3.7	3.8
RB6	0.030	2.9	2.7	2.8	2.7
RB7	0.668	3.0	2.8	3.0	2.9
RB8	-	2.3	2.5	2.9	3.0
RB9	-	3.5	3.5	3.7	3.7
RB10	-	2.9	3.0	3.3	3.4
RB11	-	2.6	2.7	2.9	2.9
RB12	-	2.6	2.7	2.9	2.9
RB13	-	2.6	2.7	2.9	2.9
RB14	0.539	3.3	3.1	3.4	3.3
RB15	1.369	2.0	2.0	2.5	2.5

Table 32 (continued)

Well No.	heptachlor& hept. epoxide (ppb)	Vulnerability score			
		Option 1	Option 2	Option 3	Option 4
RB16	-	2.0	2.0	2.5	2.5
RB17	-	1.7	1.7	2.0	2.0
RB18	-	1.9	1.9	2.3	2.3
RB19	0.043	1.9	1.9	2.3	2.3
RB20	0.026	2.0	2.0	2.5	2.5
RB21	-	3.0	2.9	3.0	2.9
RB22	-	3.1	3.1	3.1	3.1
RB23	0.215	3.3	3.1	3.4	3.3
RB24	-	3.3	3.4	3.4	3.5
RB25	-	2.4	2.3	2.6	2.5
RB26	-	2.4	2.3	2.6	2.5
RB27	-	3.1	3.0	3.1	3.1
RB28	-	3.2	3.0	3.3	3.2
RB29	-	2.7	2.6	3.0	3.0
RB30	0.071	3.3	3.1	3.4	3.3
SB1	0.036	2.1	2.0	2.1	2.1
SB2	-	2.6	2.5	2.9	2.8
SB3	-	2.4	2.3	2.6	2.5
SB4	0.050	2.1	2.1	2.6	2.6
SB5	-	1.9	2.1	2.3	2.4
SB6	-	2.7	2.4	2.5	2.4
SB7	0.125	2.7	2.6	3.0	3.0
SB8	-	2.4	2.3	2.6	2.5
SB9	-	1.8	1.8	2.2	2.2
SB10	-	2.1	2.1	2.6	2.6
SB11	-	3.4	3.3	3.6	3.5
SB12	-	2.7	2.6	3.0	3.0
SB13	0.206	2.7	2.6	3.0	3.0
SB14	-	2.6	2.7	2.9	2.9
SB15	-	2.6	2.5	2.9	2.8
SB16	0.043	3.3	3.2	3.4	3.4
SB17	0.128	2.0	2.2	2.5	2.6
SB18	-	1.8	1.8	2.2	2.2
SB19	0.219	2.1	2.1	2.6	2.6
SB20	-	2.1	2.1	2.6	2.6
SB21	-	2.7	2.6	3.0	3.0
SB22	-	2.6	2.7	2.9	2.9
SB23	-	2.7	2.6	3.0	3.0
SB24	0.018	2.1	2.1	2.6	2.6
SB25	-	1.8	1.8	2.2	2.2
SB26	0.005	2.7	2.6	3.0	3.0
SB27	-	2.1	2.1	2.6	2.6
SB28	0.184	2.1	2.1	2.6	2.6
SB29	-	2.1	2.1	2.6	2.6
SB30	0.130	2.5	2.5	2.7	2.7

Table 32 (continued)

Well No.	dieldrin& aldrin (ppb)	Vulnerability score			
		Option 1	Option 2	Option 3	Option 4
KB1	0.078	2.6	2.8	2.9	3.0
KB2	0.003	3.0	2.9	3.0	2.9
KB3	-	3.8	3.8	3.7	3.7
KB4	0.045	3.1	3.1	3.1	3.1
KB5	-	2.8	2.6	2.7	2.6
KB6	0.018	3.3	3.2	3.4	3.4
KB7	-	3.3	3.2	3.4	3.4
KB8	tr	3.2	3.0	3.3	3.2
KB9	3.440	3.3	3.2	3.4	3.4
KB10	-	3.3	3.2	3.4	3.4
KB11	-	3.3	3.2	3.4	3.4
KB12	tr	3.3	3.2	3.4	3.4
KB13	0.008	2.2	2.2	2.3	2.3
KB14	0.104	2.0	1.9	2.0	1.9
KB15	-	2.9	2.8	2.8	2.8
KB16	-	3.3	3.0	2.9	2.8
KB17	-	3.3	3.0	2.9	2.8
KB18	-	2.8	2.5	2.7	2.5
KB19	0.019	3.0	2.8	3.0	2.9
KB20	-	3.0	3.0	3.0	3.0
KB21	0.036	3.2	2.8	2.8	2.6
KB22	0.028	3.4	3.3	3.1	3.0
KB23	-	3.4	3.4	3.6	3.6
KB24	-	3.2	3.2	3.3	3.3
KB25	0.080	4.0	3.9	4.0	3.9
KB26	0.071	3.2	3.2	3.3	3.3
KB27	0.012	3.2	3.0	3.3	3.2
KB28	tr	3.2	3.0	3.3	3.2
KB29	-	*	*	*	*
KB30	0.003	*	*	*	*
RB1	0.006	3.4	3.3	3.6	3.5
RB2	-	3.3	3.2	3.4	3.4
RB3	0.005	3.9	3.7	3.8	3.7
RB4	0.037	3.6	3.8	3.9	4.0
RB5	tr	3.5	3.6	3.7	3.8
RB6	0.075	2.9	2.7	2.8	2.7
RB7	0.060	3.0	2.8	3.0	2.9
RB8	0.042	2.3	2.5	2.9	3.0
RB9	-	3.5	3.5	3.7	3.7
RB10	0.057	2.9	3.0	3.3	3.4
RB11	-	2.6	2.7	2.9	2.9
RB12	0.028	2.6	2.7	2.9	2.9
RB13	0.012	2.6	2.7	2.9	2.9
RB14	0.003	3.3	3.1	3.4	3.3
RB15	0.019	2.0	2.0	2.5	2.5

Table 32 (continued)

Well No.	dieldrin& aldrin (ppb)	Vulnerability score			
		Option 1	Option 2	Option 3	Option 4
RB16	0.042	2.0	2.0	2.5	2.5
RB17	0.026	1.7	1.7	2.0	2.0
RB18	0.043	1.9	1.9	2.3	2.3
RB19	0.051	1.9	1.9	2.3	2.3
RB20	0.007	2.0	2.0	2.5	2.5
RB21	0.007	3.0	2.9	3.0	2.9
RB22	0.008	3.1	3.1	3.1	3.1
RB23	-	3.3	3.1	3.4	3.3
RB24	0.030	3.3	3.4	3.4	3.5
RB25	0.002	2.4	2.3	2.6	2.5
RB26	-	2.4	2.3	2.6	2.5
RB27	0.036	3.1	3.0	3.1	3.1
RB28	0.018	3.2	3.0	3.3	3.2
RB29	0.006	2.7	2.6	3.0	3.0
RB30	0.074	3.3	3.1	3.4	3.3
SB1	0.015	2.1	2.0	2.1	2.1
SB2	0.010	2.6	2.5	2.9	2.8
SB3	-	2.4	2.3	2.6	2.5
SB4	-	2.1	2.1	2.6	2.6
SB5	-	1.9	2.1	2.3	2.4
SB6	-	2.7	2.4	2.5	2.4
SB7	-	2.7	2.6	3.0	3.0
SB8	0.011	2.4	2.3	2.6	2.5
SB9	-	1.8	1.8	2.2	2.2
SB10	-	2.1	2.1	2.6	2.6
SB11	-	3.4	3.3	3.6	3.5
SB12	-	2.7	2.6	3.0	3.0
SB13	-	2.7	2.6	3.0	3.0
SB14	-	2.6	2.7	2.9	2.9
SB15	-	2.6	2.5	2.9	2.8
SB16	0.013	3.3	3.2	3.4	3.4
SB17	0.006	2.0	2.2	2.5	2.6
SB18	0.003	1.8	1.8	2.2	2.2
SB19	-	2.1	2.1	2.6	2.6
SB20	-	2.1	2.1	2.6	2.6
SB21	-	2.7	2.6	3.0	3.0
SB22	0.005	2.6	2.7	2.9	2.9
SB23	0.009	2.7	2.6	3.0	3.0
SB24	tr	2.1	2.1	2.6	2.6
SB25	0.001	1.8	1.8	2.2	2.2
SB26	0.006	2.7	2.6	3.0	3.0
SB27	0.010	2.1	2.1	2.6	2.6
SB28	0.014	2.1	2.1	2.6	2.6
SB29	0.006	2.1	2.1	2.6	2.6
SB30	tr	2.5	2.5	2.7	2.7

Table 32 (continued)

Well No.	endrin (ppb)	Vulnerability score			
		Option 1	Option 2	Option 3	Option 4
KB1	-	2.6	2.8	2.9	3.0
KB2	-	3.0	2.9	3.0	2.9
KB3	-	3.8	3.8	3.7	3.7
KB4	-	3.1	3.1	3.1	3.1
KB5	-	2.8	2.6	2.7	2.6
KB6	-	3.3	3.2	3.4	3.4
KB7	-	3.3	3.2	3.4	3.4
KB8	-	3.2	3.0	3.3	3.2
KB9	-	3.3	3.2	3.4	3.4
KB10	-	3.3	3.2	3.4	3.4
KB11	-	3.3	3.2	3.4	3.4
KB12	-	3.3	3.2	3.4	3.4
KB13	-	2.2	2.2	2.3	2.3
KB14	-	2.0	1.9	2.0	1.9
KB15	-	2.9	2.8	2.8	2.8
KB16	-	3.3	3.0	2.9	2.8
KB17	-	3.3	3.0	2.9	2.8
KB18	-	2.8	2.5	2.7	2.5
KB19	-	3.0	2.8	3.0	2.9
KB20	-	3.0	3.0	3.0	3.0
KB21	-	3.2	2.8	2.8	2.6
KB22	-	3.4	3.3	3.1	3.0
KB23	-	3.4	3.4	3.6	3.6
KB24	-	3.2	3.2	3.3	3.3
KB25	-	4.0	3.9	4.0	3.9
KB26	-	3.2	3.2	3.3	3.3
KB27	-	3.2	3.0	3.3	3.2
KB28	-	3.2	3.0	3.3	3.2
KB29	-	*	*	*	*
KB30	-	*	*	*	*
RB1	-	3.4	3.3	3.6	3.5
RB2	-	3.3	3.2	3.4	3.4
RB3	-	3.9	3.7	3.8	3.7
RB4	-	3.6	3.8	3.9	4.0
RB5	-	3.5	3.6	3.7	3.8
RB6	-	2.9	2.7	2.8	2.7
RB7	-	3.0	2.8	3.0	2.9
RB8	-	2.3	2.5	2.9	3.0
RB9	-	3.5	3.5	3.7	3.7
RB10	-	2.9	3.0	3.3	3.4
RB11	-	2.6	2.7	2.9	2.9
RB12	-	2.6	2.7	2.9	2.9
RB13	-	2.6	2.7	2.9	2.9
RB14	-	3.3	3.1	3.4	3.3
RB15	0.026	2.0	2.0	2.5	2.5

Table 32 (continued)

Well No.	endrin (ppb)	Vulnerability score			
		Option 1	Option 2	Option 3	Option 4
RB16	-	2.0	2.0	2.5	2.5
RB17	-	1.7	1.7	2.0	2.0
RB18	-	1.9	1.9	2.3	2.3
RB19	0.042	1.9	1.9	2.3	2.3
RB20	-	2.0	2.0	2.5	2.5
RB21	-	3.0	2.9	3.0	2.9
RB22	-	3.1	3.1	3.1	3.1
RB23	-	3.3	3.1	3.4	3.3
RB24	-	3.3	3.4	3.4	3.5
RB25	-	2.4	2.3	2.6	2.5
RB26	-	2.4	2.3	2.6	2.5
RB27	-	3.1	3.0	3.1	3.1
RB28	-	3.2	3.0	3.3	3.2
RB29	-	2.7	2.6	3.0	3.0
RB30	0.111	3.3	3.1	3.4	3.3
SB1	-	2.1	2.0	2.1	2.1
SB2	-	2.6	2.5	2.9	2.8
SB3	-	2.4	2.3	2.6	2.5
SB4	-	2.1	2.1	2.6	2.6
SB5	-	1.9	2.1	2.3	2.4
SB6	-	2.7	2.4	2.5	2.4
SB7	-	2.7	2.6	3.0	3.0
SB8	-	2.4	2.3	2.6	2.5
SB9	-	1.8	1.8	2.2	2.2
SB10	-	2.1	2.1	2.6	2.6
SB11	-	3.4	3.3	3.6	3.5
SB12	-	2.7	2.6	3.0	3.0
SB13	-	2.7	2.6	3.0	3.0
SB14	-	2.6	2.7	2.9	2.9
SB15	-	2.6	2.5	2.9	2.8
SB16	-	3.3	3.2	3.4	3.4
SB17	-	2.0	2.2	2.5	2.6
SB18	-	1.8	1.8	2.2	2.2
SB19	-	2.1	2.1	2.6	2.6
SB20	-	2.1	2.1	2.6	2.6
SB21	-	2.7	2.6	3.0	3.0
SB22	-	2.6	2.7	2.9	2.9
SB23	-	2.7	2.6	3.0	3.0
SB24	-	2.1	2.1	2.6	2.6
SB25	-	1.8	1.8	2.2	2.2
SB26	-	2.7	2.6	3.0	3.0
SB27	-	2.1	2.1	2.6	2.6
SB28	-	2.1	2.1	2.6	2.6
SB29	-	2.1	2.1	2.6	2.6
SB30	-	2.5	2.5	2.7	2.7

Table 33 An example of correlation test for comparing groundwater quality data and vulnerability maps

```
DATA CARBOFURAN;
INPUT X Y @@;
LABEL X = 'CARBOFURAN CONC.';
LABEL Y = 'VULNERABILITY SCORE';
CARDS;
0     2.6 0     3.0 0     3.8 0     3.1 0     2.8 0     3.3 0     3.3 0     3.2 0     3.3
0     3.4 0     3.4 0     3.4 0     2.2 0     2.0 0     2.9 0     3.3 0     3.3 0     2.8
0     3.0 0     3.0 0.260 3.2 0     3.4 0     3.4 0     3.2 0     4.0 0     3.2 0     3.2
0     3.2 0.120 *   0     *   0     3.5 0     3.3 0     3.9 0     3.6 0     3.5 0.050 2.9
0.040 3.0 0     2.4 0     3.6 0     3.0 0     2.6 0     2.6 0.100 2.6 0     3.4 0     1.9
0     2.0 0     1.7 0     1.8 0     1.9 0     1.9 0     3.0 0     3.1 0     3.4 0     3.3
0.200 2.4 0     2.4 0     3.1 0     3.3 0     2.8 0.070 3.4 0.140 2.1 0.180 2.7 0     2.4
0     2.2 0.191 1.9 0.120 2.7 0.130 2.8 0     2.4 0     1.8 0     2.2 0     3.5 0     2.8
0.510 2.8 0.049 2.6 0.410 2.6 0.140 3.3 0.620 2.0 0.511 1.8 0.036 2.2 0     2.2 0     2.8
0     2.6 0     2.8 0.176 2.2 0     1.8 0.470 2.8 0     2.2 0.460 2.2 0.200 2.2 0.560 2.5
PROC PRINT LABEL;
PROC CORR PEARSON SPEARMAN;
VAR X Y;
RUN;
```

```
                                 The CORR Procedure
                           2  Variables:    X         Y


                                 Simple Statistics
  Variable            N         Mean      Std Dev       Median      Minimum      Maximum
  X                  90      0.06381      0.14255            0            0      0.62000
  Y                  88      2.79886      0.57044      2.80000      1.70000      4.00000
                          Variable    Label
                          X           CARBOFURAN CONC.
                          Y           VULNERABILITY SCORE


                            Pearson Correlation Coefficients
                               Prob > |r| under H0: Rho=0
                                 Number of Observations


                                                   X              Y
                        X                    1.00000       -0.27371
                        CARBOFURAN CONC.                     0.0099
                                                  90             88
                        Y                   -0.27371        1.00000
                        VULNERABILITY SCORE   0.0099
                                                  88             88


                           Spearman Correlation Coefficients
                               Prob > |r| under H0: Rho=0
                                 Number of Observations


                                                   X              Y
                        X                    1.00000       -0.28866
                        CARBOFURAN CONC.                     0.0064
                                                  90             88
                        Y                   -0.28866        1.00000
                        VULNERABILITY SCORE   0.0064
                                                  88             88
```

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