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Distribution and occurrence of perchloroethylene in Missoula Valley Aquifer

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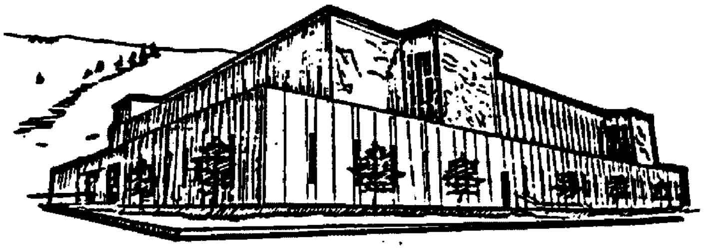

THE DISTRIBUTION AND OCCURRENCE OF PERCHLOROETHYLENE IN THE MISSOULA VALLEY AQUIFER

by

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In June of 1988 routine sampling of Mountain Water Company (MWC) wells in Missoula, Montana indicated the presence of several volatile organic compounds (VOCs). By March of 1989, ten MWC wells were known to contain detectable concentrations of VOCs, including three wells with levels of perchloroethylene above 0.005 mg/l, the EPA's proposed Maximum Contaminant Level (MCL). Perchloroethylene is a widely used solvent; possible sources of the contaminants include drycleaners, carwashes, and automotive repair facilities.

The goal of this study is to document the sources, occurrence and migration pathways of perchloroethylene in the Missoula Valley Aquifer (MVA). A 41 well monitoring network was established to characterize groundwater flow in the study area. The lithostratigraphy of the study area was characterized by evaluating existing well log data for use in detailed geologic cross-sections of the aquifer. Groundwater sampling for VOC analysis was conducted to define the vertical and lateral extent of contamination in the aquifer. Computer modeling techniques were incorporated to analyze the three dimensional flow dynamics around a large production well in several generic stratigraphic settings common to the Missoula Valley Aquifer.

Results of the investigation indicate that the lateral extent, thickness, and composition of Unit Two of the Missoula Valley Aquifer is highly variable. In some areas of the aquifer, the finer-grained Unit Two is totally absent. Information from the existing well logs indicate that in most areas of the aquifer Unit Two is too coarse-grained to act as a significant barrier to the advance of a contaminant from the surface. Water sampling indicates that perchloroethylene contamination is widespread throughout the study area at levels below the EPA's proposed MCL. Low level PCE contamination will likely persist for many years due to the fact that perchloroethylene is extremely stable in well-oxygenated groundwater environments such as the MVA. Analysis of the available VOC data indicates that perchloroethylene most likely reaches the aquifer in dissolved form, or dissolves in the upper portion of the aquifer rather than sinking to the aquifer base. Three dimensional computer modeling of generic stratigraphic settings within the MVA indicate that large production wells are capable of drawing water from the water table in the most common stratigraphic settings, with capture zones varying from 75 to 250 feet in width.

ACKNOWLEDGEMENTS

Many people deserve thanks for the successful completion of this project. At the risk of leaving a few of them out I will attempt to thank them here. Special thanks go to my committee members Drs. Nancy Hinman, Vicki Watson, and Bill Woessner. The Montana Water Quality Bureau and Mountain Water Company also deserve a great deal of thanks for supplying the funding that made this project possible. Mountain Water Company and the Missoula City-County Health Department were very helpful and allowed me free access to their knowledge of, and data on the aquifer. Thanks to all of my friends in the Geology and Environmental Studies departments for their help, especially Bob Anderson, Alan English, and John Nugent.

Most of all I would like to thank my friends in Missoula, especially the Dinner Club and my other friends in the Environmental Studies department for keeping me well-fed and well-balanced. It is important to remember what we are really working for. I would also like to thank my family for their support and encouragement through the years. Finally, I would like to thank Glenda Skillen for all of her help.

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INTRODUCTION

Statement of the Problem

During the past 40 years, more than 40,000 types of synthetic chemicals have been manufactured, and with the demands of society the number and volume of these compounds continues to increase (Wilson et al., 1981). These chemicals are constantly being released into the air, water, and soil environments through manufacture, transport, use, and disposal activities. These releases increase human exposure to toxins, causing adverse health effects. Because of its toxic effects on humans, the Environmental Protection Agency (EPA) has included the solvent perchloroethylene (PCE) on the list of priority pollutants.

In recent years the behavior of volatile organic compounds (VOCs) in vadose and saturated systems has been studied in both natural and laboratory settings (Schwille, 1988; Estes et al., 1988; Parsons and Barrio-Lage, 1985; Mendoza and McAlary, 1990; Roberts et al., 1986). The transport of dense non-aqueous phase liquids (DNAPLs) in groundwater can be affected by advection, dispersion, sorption, and biological or chemical transformations (Curtis et al., 1986). Under specific environmental conditions some VOCs have been shown to persist for more than 30 years in an aquifer (Barber et al., 1988). In other lab and natural settings PCE has been shown to undergo reductive transformation to lower molecular weight compounds (Parsons et al., 1984).

Solvents (including PCE) are commonly referred to as dense non-aqueous phase liquids (DNAPLs) because of their density, which is greater than water, and their relative immiscibility with water. Dense non-aqueous phase liquids such as PCE can produce a complex distribution of contaminants in groundwater that is extremely difficult to investigate and remediate (WCGR, 1989).

Perchloroethylene is one of the most frequently found volatile organic compounds in groundwater supplies (Vogel and McCarty, 1985). The increasing occurrence of groundwater contamination by VOCs is directly related to the rapid growth in production and use of these chemicals. A recent groundwater supply survey (Westerick, 1984) indicates that 21% of all water systems had one or more VOCs present. PCE was the most frequently found contaminant at 7.3%.

In June of 1988, Mountain Water Company (MWC) of Missoula, Montana began quarterly sampling of its production wells for VOCs. The June sampling indicated the presence of VOCs in all five of MWC's composite samples (samples from up to five wells were mixed together before analysis). December 1988 samples from individual wells revealed a perchloroethylene concentration of 5.4 parts per billion (ppb) in MWC well #8 at Schilling and South Avenue, precipitating the shutdown of that well. By March 1989, ten MWC wells were known to contain detectable concentrations of VOCs. By far the most ubiquitous compound found in the samples was perchloroethylene.

Goals of the Project

The goal of this study is to document the sources, occurrence and migration pathways of PCE in the Missoula Valley Aquifer. My work will rely heavily upon my interpretation of aquifer lithostratigraphy and the behavior of PCE in such coarse-grained material. To accomplish these goals the following objectives have been emphasized:

1. Conduct a literature review of the chemical and physical behavior of PCE in vadose zones and groundwater systems.

2. Characterize the stratigraphy of the study area by examining existing well logs.

3. Establish a monitoring well network based in part upon the stratigraphy.

4. Characterize the groundwater flow system by developing potentiometric maps and estimating the hydraulic properties of the aquifer.

5. Characterize the lateral and vertical extent of PCE contamination in the study area through water sampling.

6. Evaluate the 3-D capture zone associated with possible PCE contamination of a single well representing several generic stratigraphic settings within the Missoula Valley Aquifer.

Study Area Setting

The Missoula Valley, approximately 35 square miles in size, is located in a fault-bounded basin in west-central Montana. The Missoula Valley is the eastern portion of a long intermontane depression trending N 55° W, which narrows to the northwest. The valley is bounded on the north by the Rattlesnake Hills; on the south by the Bitterroot Range; on the east by the Sapphire Range; and on the west by the Ninemile Divide (Geldon, 1979). The topography of the valley floor is relatively flat, sloping gradually towards the confluence of the Bitterroot and Clark Fork Rivers which drain the Missoula Valley.

The Missoula Valley climate is semiarid. Winter is dominated by Pacific maritime air, which is occasionally displaced by cold continental air. Annual precipitation averages 13.29 inches. Peak precipitation months are May and June. February and March are the driest months.

The study area (Figure 1) covers most of the developed area of Missoula. The formal study area consists of sections 16, 21, 28, 29, 31, and 32 of Township 13 North, Range 19 West.

Hydrogeology

The Missoula Valley Aquifer has been designated as a Sole Source Aquifer by the US EPA (MCCHD, 1987) and has been extensively studied in recent years. Projects have been conducted primarily by the University of Montana and private consulting firms; recent studies have examined the hydraulic properties of the aquifer and specific contamination episodes.

The Missoula Valley Aquifer is stratigraphically complex. The aquifer is composed of three units throughout most areas

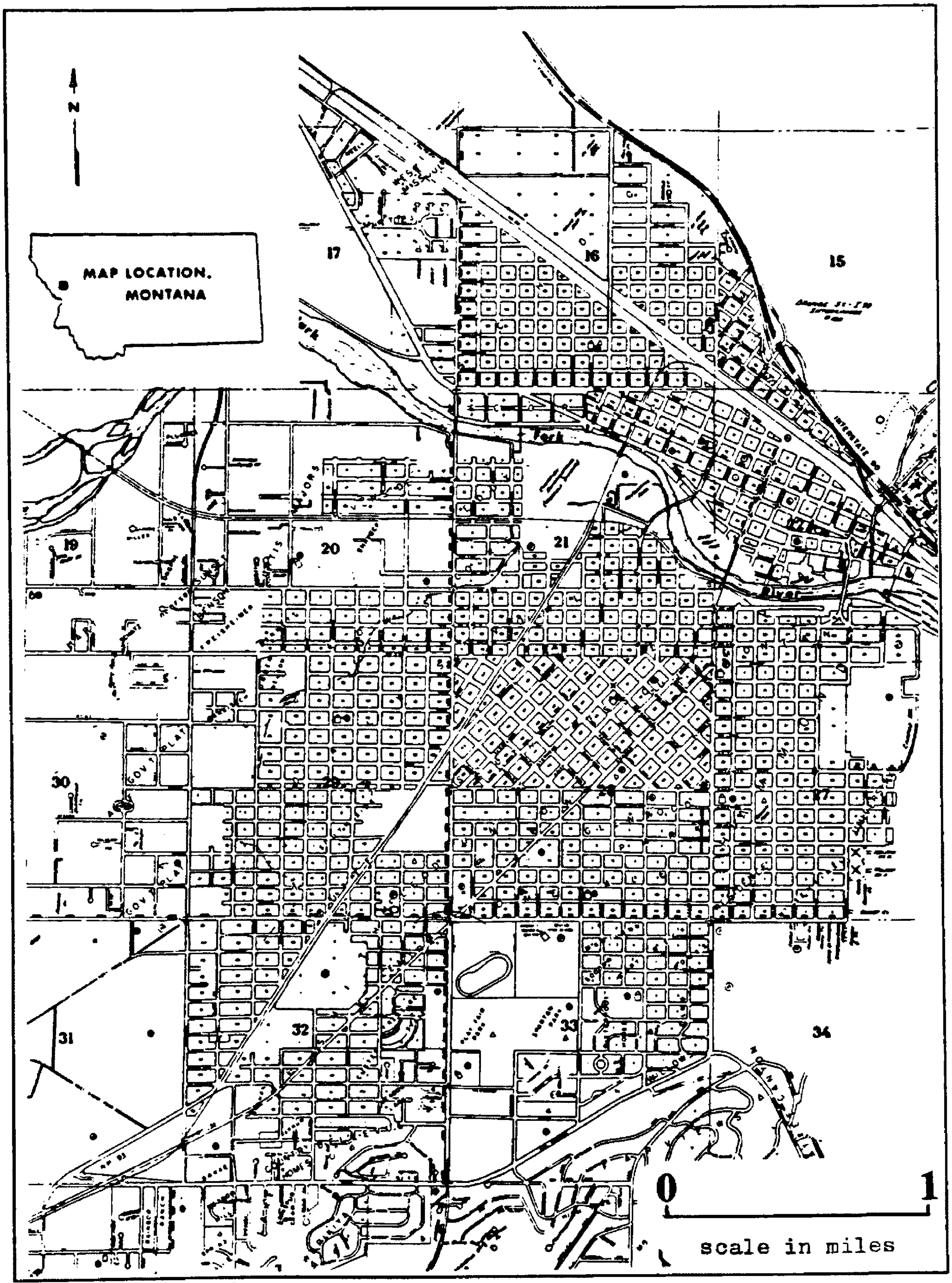


Figure 1 Study Area.

of the aquifer (Morgan, 1986; Woessner, 1988). Woessner (1988) describes the top unit, Unit One, as 10 to 30 feet thick, and generally lying above the saturated zone of the aquifer. The surficial unit consists of interbedded boulders, cobbles, gravels, sands, and minor amounts of silt and clay. Unit One is thought to have been deposited by large aggrading river systems fed by glacial melt waters during the late stages of the Pleistocene.

The middle zone, Unit Two, is approximately 40 feet thick and appears to have a reduced ability to transmit water due to its relatively fine-grained nature. Unit Two generally consists of a yellow, silty, sandy clay with interbedded gravel and sand lenses. Unit Two is likely related to the deposition of Pleistocene glacial Lake Missoula sediments which are exposed in the northwestern part of the valley. Unit Two is laterally discontinuous, being replaced by coarser fluvial deposits in some areas.

Unit Three, the basal unit, ranges from 50 to 100 feet thick and is dominated by very coarse-grained sediments, coarsening downward. Unit Three yields large quantities of water to the many wells developed in it. Minor amounts of tan, fine-grained sediments are interlayered with the coarse sands and gravels. Unit Three probably is the product of channel lag, point bar, and floodplain deposits from a large fluvial system developed during the Pleistocene or late Tertiary. Morphologically similar deposits are present in today's Clark Fork River channel and floodplain.

Contamination Studies

Studies conducted by earlier workers have illustrated the vulnerability of the Missoula Valley Aquifer to contamination. Previous studies of various contaminants have identified several potential contamination routes including infiltration through the vadose zone (Unit One) from spills and leaks (Peery, 1988; Pottinger, 1988), storm water injection wells (Wogsland, 1988), and septic systems (Ver Hey, 1987). The lack of any laterally continuous protective layer makes the unconfined Missoula Valley Aquifer particularly susceptible to contamination from the surface.

Thesis Organization

This thesis is made up of six chapters. In Chapter One the nature of the problem and the goals and objectives of the study are described; the study area setting is also described in Chapter One. Chapter Two discusses the properties and behavior of PCE in the environment; Chapter Three explains the methodology used in this investigation. Chapter Four is a discussion of the results of this investigation. The fifth chapter discusses the computer model and its results. The final chapter includes the conclusions and recommendations of this study.

CHAPTER 2

PERCHLOROETHYLENE IN THE ENVIRONMENT

Perchloroethylene

Perchloroethylene, C_2Cl_4, went into commercial production as a dry cleaning agent before World War I in the United Kingdom and Germany, then in the United States in 1925. Since 1960, industrial demands have produced a tremendous growth in production rates, roughly seven percent a year (Barbash and Roberts, 1986). Table 1 summarizes world production capacity and demand for PCE.

Table 1 PCE Production and Demand (X1000 metric tons).

Area	Capacity	Demand
USA	474	331
Europe	517	431
Japan	83	57
Canada	26	15
Latin America	1	11
TOTALS	1101	845

(Keil, 1978)

The major use of PCE is as a drycleaning fluid. Other applications are vapor degreasing, cold cleaning of metals, textile processing, and as a chemical intermediate in the manufacture of fluorocarbons (Kiel, 1978) (Table 2). In the past PCE was also used as a component in the manufacture of anesthetic drugs and other consumer products (Sittig, 1985). However, with the toxicity data currently available these uses have been eliminated.

PCE is a non-flammable liquid and is the most stable of

Table 2 PCE Usage.

Activity	Percent Usage
drycleaning	66%
textile processing	13%
metal degreasing	13%
fluorocarbons manufacture	3%
miscellaneous	5%

(Keil, 1978)

the chlorinated ethanes and ethylenes, requiring only a small amount of stabilizers (Keil, 1978). Perchloroethylene's important physical properties are listed in Table 3, and other significant information can be found in Table 4.

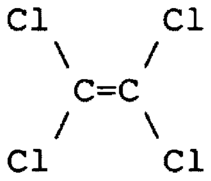
Table 3 Physical Properties of Perchloroethylene.

Property	Conditions	Value	Source
Boiling Point	@101 kPa	121.2 C	Keil, 1978
Melting Point		-22.7 C	Keil, 1978
Vapor Pressure	@15 C	0.932 mPa	Keil, 1978
	@25	0.839 mPa	Keil, 1978
	@50	0.657 mPa	Keil, 1978
Vapor Density	@b.p.	5.8 kg/m^3	Keil, 1978
Specific Gravity	@10	1.63120 g/cm^3	Keil, 1978
	@20	1.62260 g/cm^3	Keil, 1978
Octanol/Water Partition Coef	@20	364 mg/l	Schwille, 1988
Solubility	@20	200 mg/l	Schwille, 1988
Interfacial Tension	@20	47.5 dyne/cm	Anderson, 1989

PCE Solubility and Water Quality

Perchloroethylene has a solubility of 200 parts per million (ppm), a saturation concentration 40,000 times the EPA's Maximum Contaminant Level (MCL). PCE will rapidly reach concentrations near saturation if sufficient free product is available. For PCE occurrences in groundwater EPA has set a recommended MCL of zero (Federal Register, 1985). However,

Table 4 Other PCE Information.

Parameter	Value
Common Names	tetrachloroethylene perchloroethylene carbon dichloride ethylene tetrachloride perclene tetrachloroethene perchloroethene
CAS Registry Number	CAS 127-18-4
Department of Transportation	UN 1897
Empirical Formula	C_2Cl_4
Structural Formula	
Molecular Weight	165.83
Maximum Contaminant Level (MCL)	0.005 mg/l

once groundwater supplies become contaminated, a zero concentration is extremely difficult to reach due to the sorption of the compound onto the aquifer material. The sorbed material then becomes a persistent source of contamination.

PCE Mobility

The transport of PCE in the environment is a complex process, depending upon such factors as solubility, vapor density, air-water partition coefficient, chemical and biological reactivity, and sorption by soil particles. The soil environment consists of solid, liquid, and gas phases, which combine to form various physical, biological, and chemical environments. When an organic chemical, such as PCE, is spilled on soil the chemical's transport becomes a multiphase phenomenon affected by many processes. These processes include volatilization from soil and water, adsorption and degradation, both chemical and biological (Pye et al., 1983).

PCE Mobility in the Unsaturated Zone

Dense non-aqueous phase liquid (DNAPL) contaminants enter the ground as free phase liquids due to chemical spills, waste burials, and leaking storage tanks. As these liquids migrate through the unsaturated zone a certain amount of liquid will be retained in the soil by capillary forces. When the amount of a DNAPL spill is less than the capacity of the unsaturated zone, the fluid will spread itself out under the influence of gravity until it reaches the state of residual saturation (S_r) (S_r = vol. residual NAPL/Vol. pore space). Residual saturation is expressed as a percentage of the available pore space. This trapped fraction may occupy 2-20% of the available pore spaces (Falta, et al., 1989). A spill can be completely immobilized before it reaches the water table, depending upon the size of the spill, the depth to groundwater and the soil's retention capacity (R) (liters/m^3), where $R = S_r * n * 1000$ (n = porosity of the aquifer material). When the DNAPL (ex. PCE) is present in sufficient volume it will accumulate to levels which are higher than residual saturation on top of layers with lower permeabilities (10^{-4}m/sec) (Schwille, 1988). Although the DNAPL is immobile at this stage, chemical transport in the gaseous or aqueous phase may result in groundwater contamination. Barring the presence of a low hydraulic conductivity layer, a PCE plume in the unsaturated zone would likely be narrow, almost cigar shaped (Schwille, 1988).

Vapor Phase Transport

In environments with a deep water table and low infiltration rates, gas phase transport may be the dominant process by which the groundwater becomes contaminated in the absence of direct infiltration (Falta et al., 1989; Mendoza and McAlary, 1990). For example, at the Idaho National Engineering Laboratory, the water table lies 177m below land surface, and it is postulated that the groundwater contamination by carbon tetrachloride is caused by gas phase transport (Hull, 1988).

Gas phase transport is accomplished by advection and diffusion, which are influenced by phase partitioning into the water and soil phases (Falta et al., 1989). Gas phase advection may result from gas pressure or gas density gradients (Mendoza and McAlary, 1990). Schwille (1988) suggests that vapors from solvents may spread laterally by diffusion and density-driven advection in the unsaturated zone and lead to groundwater contamination (Figure 2).

As the liquid VOCs with high vapor pressures and molecular weights evaporate, the density of the surrounding gas changes with respect to the ambient soil gas. This

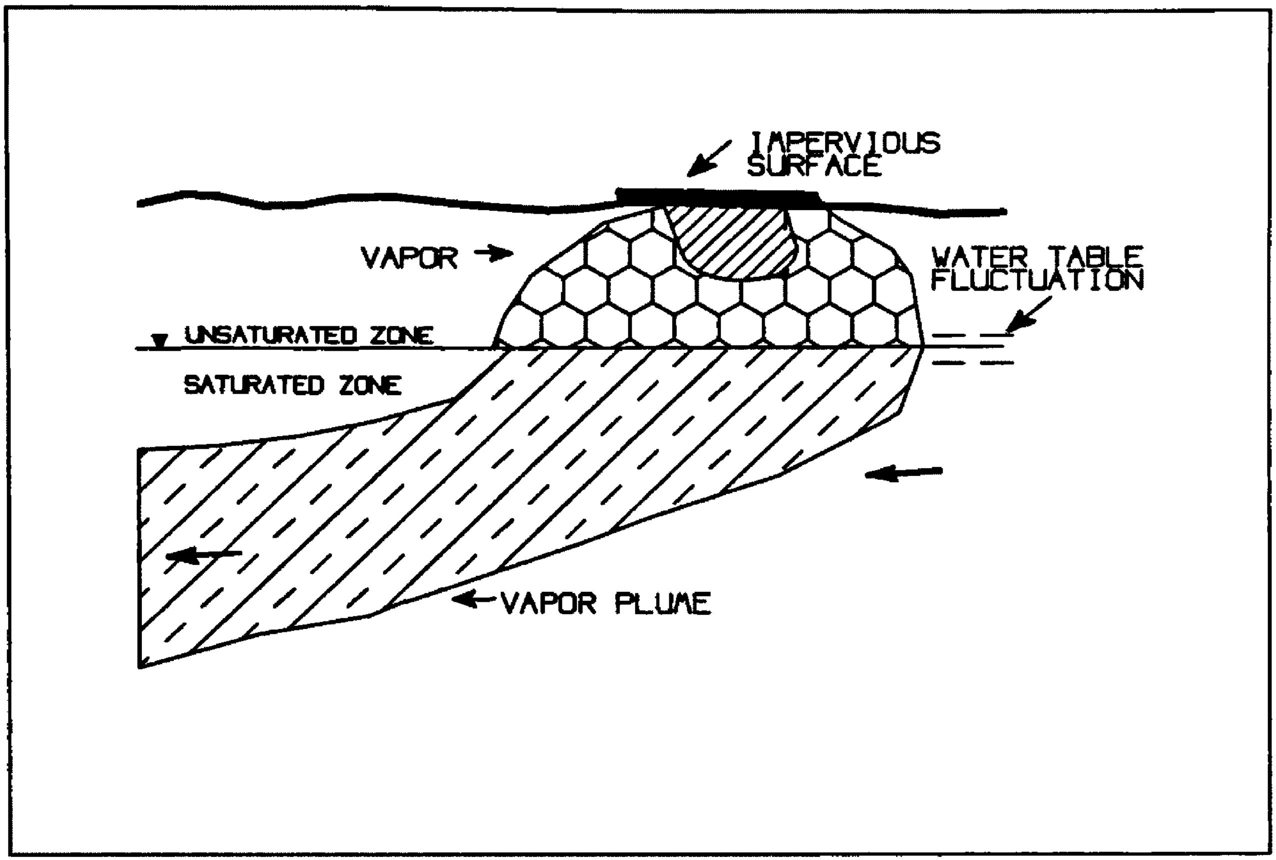


Figure 2 Contamination of groundwater by infiltration of dense vapor through vadose zone.

density contrast results in advective flow. The significance of this advective flow is dependent upon the properties of both the evaporating chemical, and the porous medium. Under some conditions gas flow may dominate the transport of contaminants. DNAPLs with high vapor pressures and Henry's constants are most suitable for vapor phase transport in the unsaturated zone (Mendoza and McAlary, 1990). Highly permeable materials in areas of little infiltration are the most suitable medium for vapor phase transport.

Sorption Processes

Sorption processes can significantly affect the mobility of VOCs in some materials. The term sorption includes both adsorption onto a surface as well as absorption into the aquifer material. In various soil environments both of these processes contribute to the persistence of VOCs in the groundwater system.

Absorption, generally a reversible process, refers to the diffusion of a solute into the matrix of the soil/aquifer material. This diffusion process is extremely slow but may become significant depending upon the concentration of the contaminant, the physical properties of the contaminant and the solid, and the length of contact time. Long periods of contact time, with high concentration and a porous material will increase the significance of absorption. The contaminant can then de-absorb (leach) by diffusion when the concentration gradient is reversed.

VOCs adsorb to both mineral surfaces and organic matter (OM). VOCs can be significantly attenuated by adsorption onto soil particles that are high in OM (Schwille, 1988; Chiou et al., 1983). Soils with low OM content are less effective at slowing the advance of an infiltrating DNAPL. Soils that contain nearly pure minerals with little OM sorb hydrocarbons only minimally. Estes et al. (1988) showed that montmorillonite clay will adsorb VOCs at the parts-per-billion range. Adsorption rates varied little over the 2-10 pH range studied. The small amount of VOC adsorbed by the montmorillonite, however, was adsorbed irreversibly.

Halocarbons adsorb primarily on the OM of the soil. The upper soil horizons contain the bulk of the OM in a soil profile. Most high-yield, coarse-grained aquifers are nearly free of OM. When dissolved VOCs reach the coarser layers they will be largely unretained (Schwille, 1988).

Critical Height

If the volume of a DNAPL spill exceeds the retention capacity of the unsaturated zone, the contaminant will percolate to the capillary fringe. To enter the saturated zone of the aquifer, the DNAPL must build up sufficient pressure to displace the water from the pores. Due to high densities, VOCs have the ability to penetrate the water table and move to the bottom of the aquifer. The penetration of the water table depends upon whether or not the pressure head of the DNAPL exceeds the capillary pressure barrier between the water and the DNAPL. The critical height (z_c) necessary to overcome the capillary pressure and penetrate the water table can be calculated using Hobson's equation (Villaume, 1985),

$$z_c = \frac{2\gamma \cos\theta \, (1/r_t - 1/r_p)}{(\rho_w - \rho_h) \, g}$$

where γ is the water-CHC interfacial tension, θ is the contact angle between the fluid boundary and the solid surface, r_t and r_p are the radii of the throat and pore respectively, ρ_w and ρ_h are the densities of the pore water and the hydrocarbon respectively, and g is the acceleration due to gravity.

Based upon rhombohedral packing of spherical grains, the pore radius will be 0.207D and the throat radius will be

0.077D where D is the grain diameter (Villaume et al., 1985). The Hobson equation yields critical height estimates in Table 5 for PCE in saturated porous media. As the numbers indicate, given the effects of capillary pressure, saturated silts and clays can present an effective barrier to the further penetration of a free phase DNAPL. Coarse sands and gravels, however, will easily be penetrated by these fluids.

Table 5 Critical Height necessary for a column of PCE to penetrate porous media saturated with water.

Porous Media	Grain Diameter (mm)	z_c (cm)
coarse sand	1.0	13
fine sand	0.1	130
silt	0.01	1300
clay	0.001	13000

(Anderson et al.) (Values of z_c were calculated using $\Delta\rho=0.62 g/cm^3$, $\gamma=47.5$ dyne/cm, and $\cos\theta=1$ (perfect wetting).)

Mobility in the Saturated Zone

The concentration of dissolved organic matter in groundwater affects the solubility of PCE and other DNAPLs. Because DNAPLs are nonpolar they interact more strongly with other organic matter than they do with water (which is polar). Studies indicate that the presence of dissolved OM can increase the solubility of DNAPLs in water (Chiou et al., 1984, 1986).

In oxygenated aquifers with low OM content, PCE has been shown to be very mobile and persistent (Barber et al., 1988; Curtis et al., 1986; Roberts et al., 1986). Studies indicate that PCE and other halogenated solvents will travel at or near the average linear groundwater velocity. Barber and coworkers (1988) reported a retardation rate of 1.0 (i.e. no retardation) for PCE in the sand and gravel aquifer they studied (K = $1.3X10^{-3}$m/s, n=0.35, f_{oc}=0.001). Roberts and coworkers (1986) report a retardation factor of 2.7 to 3.9 for PCE in their field study at the Borden, Ontario site (an unconfined sand aquifer, K = $7X10^{-5}$m/s, n=0.33, f_{oc}=.0.0002) (Mackay et al., 1986). Curtis and coworkers (1986) conducted laboratory experiments with the Borden aquifer materials. Batch experiments indicated a retardation rate of 3.6 ±0.3 for PCE in these materials. The Borden, Ontario studies indicate that organic solute retardation increases with the solutes relative hydrophobicities (Roberts et al., 1986). These two field studies indicate that the total mass of PCE is conserved; PCE behaves similarly to conservative elements such as boron, and has been shown to persist for more than thirty years in the groundwater environment (Barber et al., 1988).

Should a sufficient quantity of DNAPL be spilled to penetrate the water table the potential exists for the DNAPL to sink into the aquifer as a free phase. In such a case the DNAPL will sink into the aquifer until it is dissolved by groundwater flow (Figure 3) or encounters a fine-grained layer (Figure 4). In extreme cases the DNAPL may reach the bottom of the aquifer and form free-phase pools (Figure 5). As long as the DNAPL remains in the free phase its flow direction is dictated by gravity rather than groundwater flow direction (Schwille, 1988).

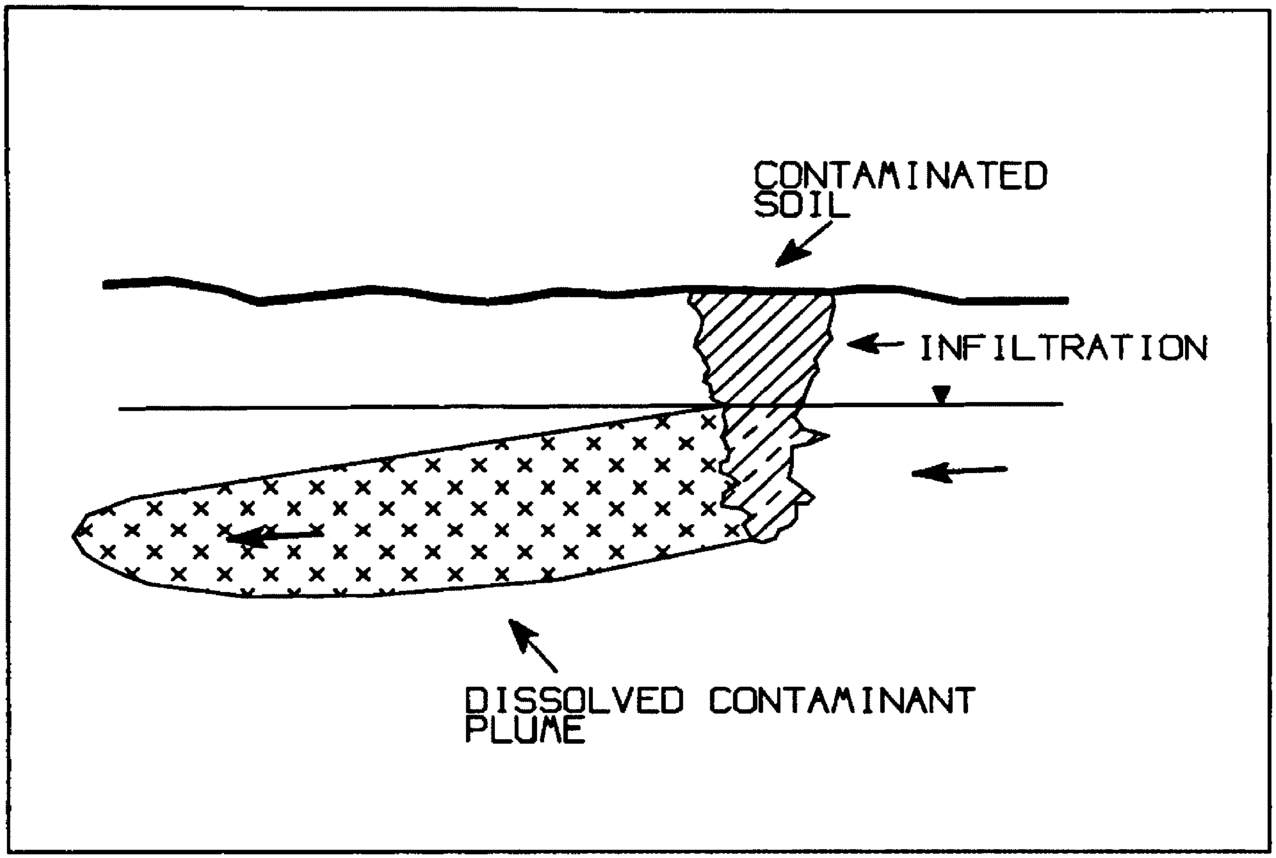


Figure 3 Contamination of groundwater by partial penetration of dense non-aqueous phase liquid into saturated zone.

Transformations

The potential exists for halogenated aliphatic compounds such as PCE to transform to lower molecular weight chloroethenes under reducing environmental conditions (Vogel et al., 1987). Both chemical (abiotic) and biological transformations may occur (Parsons et al., 1984). Most chemical transformations tend to be slow, but they may be significant at the time scales involved in some groundwater systems. Biotic transformations tend to be much more rapid, providing sufficient substrate, nutrients, and biota are present to

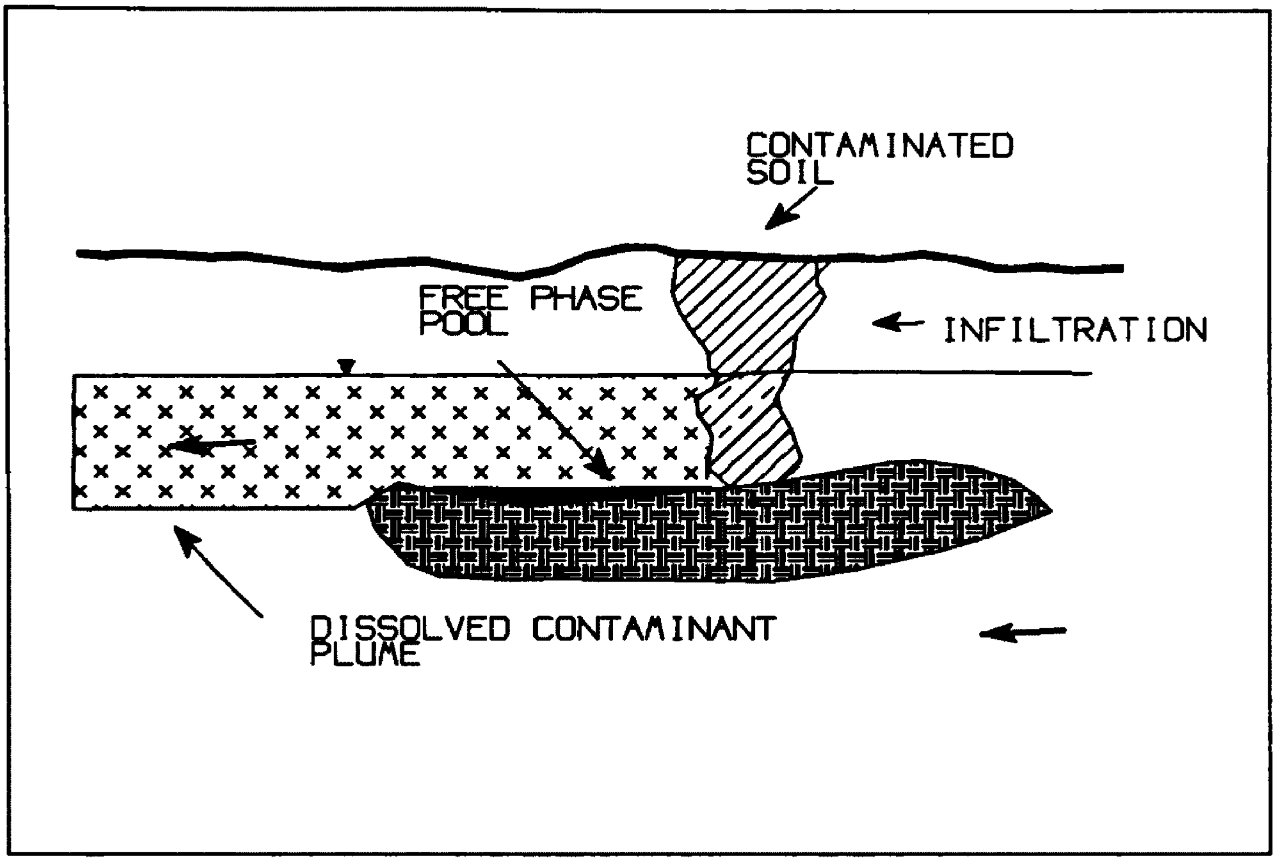


Figure 4 Contamination of groundwater by partial penetration of dense non-aqueous phase liquid to an impermeable lens in the saturated zone.

mediate such transformations (Vogel et al., 1987). Reductive dehalogenation is the likely mechanism of transformation, but chlorinated alkenes such as PCE are less reactive to this and other biotransformation mechanisms than are other halogenated organics (Parsons and Barrio-Lage, 1985). Chlorinated ethenes have been shown to transform very slowly under ambient environmental conditions (Barrio-Lage et al., 1986).

Substitution reactions involve the replacement of the halogen atom (ex. chlorine) with a nucleophile (attacking group) (Vogel et al., 1987). The most important substitution reaction is hydrolysis, which occurs when the nucleophile is hydroxide. If the nucleophile is another base, then the

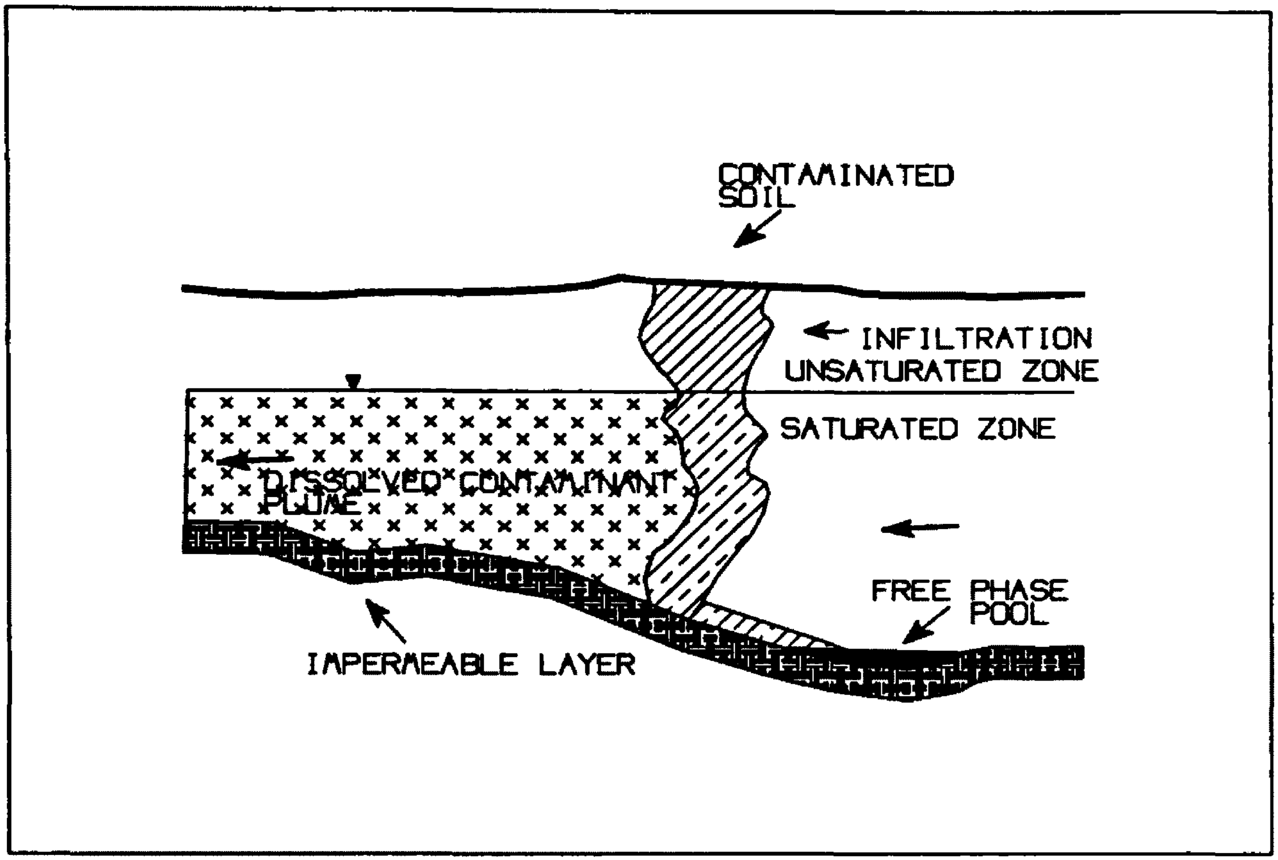


Figure 5 Full penetration of aquifer with formation of dense non-aqueous phase liquid pool.

reaction is termed nucleophilic substitution. Half-lives of these reactions range from days to centuries (Vogel et al., 1987). Because the reaction involves the exchange of two bases, pH is an important factor in determining rates; high pH values will promote the abiotic reactions for ethenes (Hinman et al., 1990). Reducing conditions are required for some nucleophiles (ex. hydrogen sulfide) to be an important factor in substitution reactions.

Some generalizations can be drawn from the work of Vogel et al. (1987). Chlorine is not a good "leaving group" in comparison with other halogens; other halogens are lost more readily from the hydrocarbon. Therefore, chlorinated hydrocarbons are more stable to abiotic substitution reactions than are other types of halogenated hydrocarbons. Increased halogenation leads to slower substitution reactions and longer half-lives. Abiotic substitution reactions might also be enhanced by catalysts such as clays.

The loss of a halogen and a hydrogen from an alkane to form an alkene is termed dehydrohalogenation (Vogel et al., 1987). This reaction proceeds most rapidly at extremely high or neutral pH values. Chlorinated compounds are less reactive than those with other halogens. This reaction is unlikely to occur unless halogenated alkanes are formed during reduction of PCE or other contaminants (Hinman et al., 1990).

PCE is highly oxidized compared to other alkenes and is therefore more stable in oxidizing environments. If the groundwater system is oxygenated, halogenated hydrocarbons are extremely stable; if the system is reduced, halogenated hydrocarbons are not stable and are likely to undergo reduction (Vogel and McCarty, 1985, 1987; Vogel et al., 1987). Because extreme conditions are required for the oxidation of these types of compounds due to their oxidized nature, these reactions will not be discussed. Transition metals act as catalysts for reduction reactions of halogenated hydrocarbons in both abiotic and biotic systems (Vogel et al., 1987). In the presence of transition metals under reducing conditions, halogenated alkenes undergo substitution of hydrogen for halogen via reduction, leading to the production of ethene, ethane, or vinyl chloride (VC), which may then be metabolized to CO_2. Figure 6 shows potential pathways for the reduction of PCE. With increased halogenation, reduction becomes more likely than does oxidation. For PCE the rate of oxidation is extremely slow, while the reduction rate is significant. The actual rate of the reaction is dependent upon the reductant and specific concentration conditions.

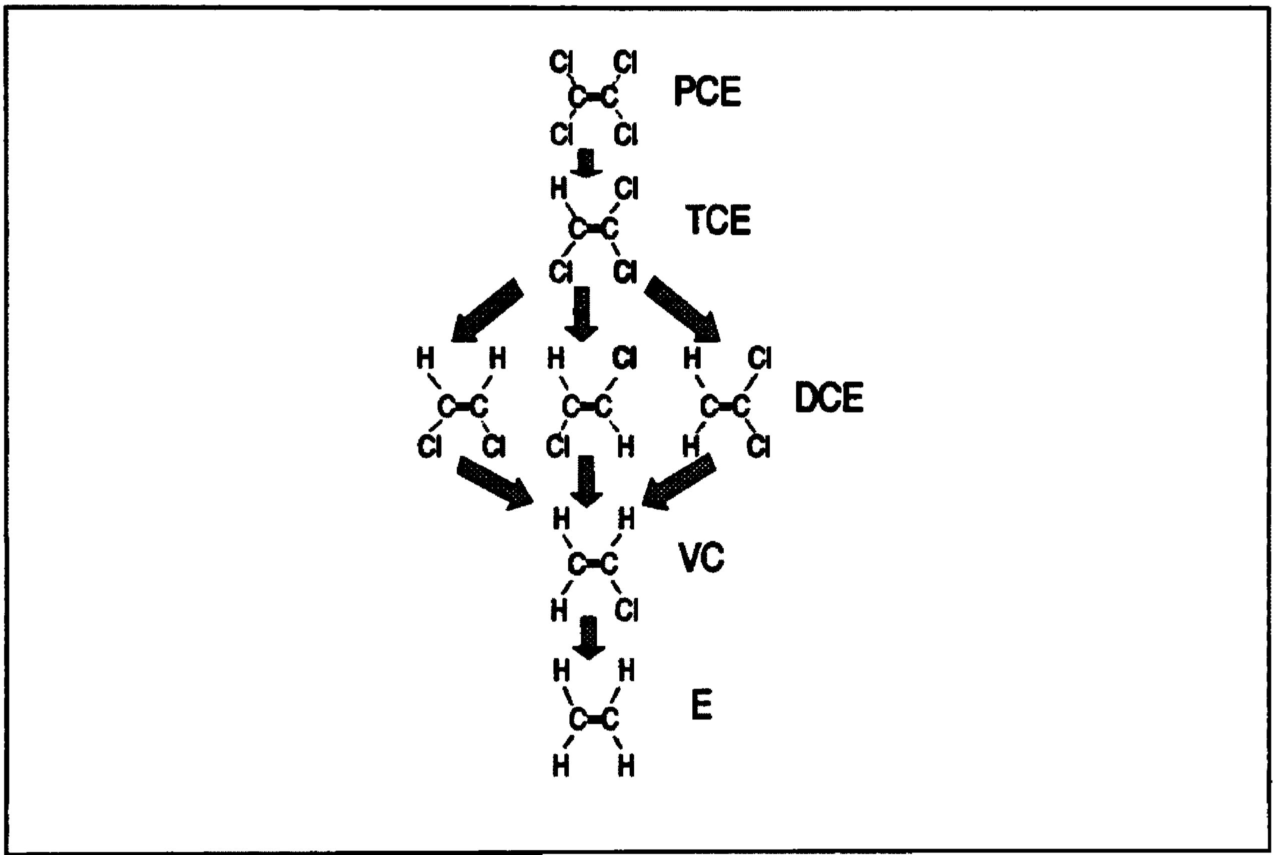


Figure 6 Reaction pathway for reduction of PCE to ethene.

CHAPTER THREE

METHODS

This chapter will describe the methods of study used to yield the results discussed in chapter four.

Defining Aquifer Stratigraphy

A primary objective of the study was to accurately characterize the lithostratigraphy of the study area by identifying lenses or zones of lower hydraulic conductivity (i.e. those zones with high silt or clay content). This was accomplished by gathering and interpreting all available well logs from the Montana Department of Natural Resources and Conservation (DNRC) and the Montana Bureau of Mines and Geology (MBMG). I recorded information concerning owner, depth, and diameter of the well casing, then plotted the locations on section maps. The well logs were organized and categorized as to their reliability. My interpretation of the aquifer lithostratigraphy relied heavily upon the well logs which I deemed to be the most reliable. The most reliable well logs were those in which the driller reported the water yielding characteristics of the strata, and gave a detailed lithologic description.

Based upon this information I drew cross-sections detailing the stratigraphy throughout the study area. To further characterize the aquifer, I produced surface contour maps of the bottom of the aquifer (the top of the Tertiary sediments) and the top of Unit Two. These two maps are based solely upon my interpretation of existing well logs.

I then reevaluated my interpretation of the aquifer lithostratigraphy based upon previous (Geldon, 1979; Allen, 1983; Morgan, 1986; Peery, 1988) and concurrent (Miller, 1990) research. I also employed geophysical methods to gain insight into the aquifer's lithostratigraphy. I used the Department of Geology's Bison 1570A seismic instrument at the Playfair Park area. Despite the Bison's signal enhancement capability, I was unsuccessful due to buildings, traffic, and other cultural interferences and a lack of contrast between units. Additionally, electrical resistivity techniques were used in July of 1990 in conjunction with Earthworks, Inc at the Playfair/Fairgrounds area. The electrical resistivity method, using a Geonics EM16R, met with limited success.

Characterizing the Flow System

I selected existing wells for use in the monitoring well network based upon their location, completion depth, reliability of well log information, and availability. The monitoring well network was designed to show head distribution throughout the study area. Those wells brought into the network were used for water level measurements on a biweekly to monthly basis. Three continuous water level recorders were installed for this study. One Stephens Type-F chart recorder was installed at MV-42 (South/Bancroft). Two pressure transducers were installed, one at MV-31 (Montana Power, Russell Street) and one at McCormick Park (MV-35).

Water level measurements were made from surveyed well heads with a steel tape graduated to a hundredth of a foot. I surveyed the elevations of all wells that were not previously used as part of a University of Montana study. Missoula County Surveyor bench marks were used as a reference. Static water level elevations were then used to produce a series of potentiometric maps; groundwater flow direction was interpreted by plotting flow lines and equipotential lines.

Hydraulic properties of the aquifer were estimated using information from pumping tests and a review of the literature. Work done by Clark (1986) and Miller (1990) provide the most reliable estimates of aquifer properties.

Predicting PCE Behavior in the Missoula Valley Aquifer

The literature review of the behavior of PCE in groundwater systems identified several parameters which control its migration and potential transformations. To determine the properties (especially the organic content) of the soils in the Missoula Valley, I consulted the local Soil Conservation Service office and conducted a review of the literature on the Missoula Valley soils.

I determined the dissolved oxygen content of the groundwater at several locations throughout the valley. I used a YSI Model 54 Oxygen Meter to measure oxygen concentrations at discrete levels within the wells. Measurements were taken in late September of 1990 and early June of 1991. I measured the oxygen levels at two different times of the year to determine if there was any seasonal variation.

Defining Extent of Contamination

I also developed the monitoring well network to help delineate the vertical and lateral extent of PCE contamination. MWC wells, which were extensively sampled, usually draw water from the deeper portions of the aquifer. To compliment this, I sampled the shallower domestic wells in order to define the vertical extent of contamination. I also used University of Montana monitoring wells and domestic wells to define the lateral extent of contamination in areas without MWC wells.

VOC samples were collected following Montana Department of Health and Environmental Sciences (DHES) protocol. At a minimum, I purged all wells of at least three well volumes of water. After the three well volumes were removed, I continued to purge the wells until temperature, pH, and specific conductance all stabilized. By following this procedure, I insured that my VOC samples were representative of the water in the aquifer at that location.

All of the samples I collected from domestic wells were collected as close as possible to the well head. In all cases, the samples were taken at a spigot before the water entered a holding or pressure tank. The samples I collected from the University of Montana monitoring wells were taken by bailer. I followed the same procedure for purging all wells.

When purging and sampling the well with a bailer, I was careful not to allow the bailer to splash into the water, preventing turbidity and volatilization of any contaminant.

Two 40-ml vials were collected at each sampled well. Energy Labs supplied the clear glass sample vials with teflon-silica septa lined screw caps. No bubbles or air spaces were allowed in the samples. Immediately upon collection the samples were put in a cooler with blue ice. At the beginning of each sampling day I took a "blind trip blank" of DI (de-ionized) water at the University of Montana Botany Building, filling two sample vials. The DI water on campus is known to be free of organic contamination (Keller, personal communication). After completing each round of sampling the samples were shipped to Energy Labs in Billings via Greyhound bus. Before shipping, the blue ice was replaced with freshly frozen blue ice. No sample was held for more than 24 hours before shipping.

Energy Labs in Billings analyzed the samples using EPA Method 502.2. EPA Method 502.2 is an analytical technique that analyzes for regulated and unregulated volatile organic compounds (VOCs). A list of the constituents in EPA Method 502.2 is given in Appendix A. Upon completing the analysis the results and completed chain of custody forms were returned to John Arrigo at the Montana DHES Water Quality Bureau in Helena. Results were then returned to me at the University of Montana Geology Department.

These results and the results of the most recent MWC analysis were used in determining which wells would be sampled or resampled in the next round.

Identifying Potential Sources

Early in the project, I reviewed aerial photographs of the study area to identify potential sources. I investigated photos dating from 1947 to 1989, at various sources including the U.S. Forest Service, Soil Conservation Service, Montana Highway Department in Helena, and the Missoula City-County Health Department. This allowed the identification of historical as well as current potential sources.

I also reviewed and compiled reports from the Montana Department of Health and Environmental Sciences (DHES) and the Missoula City-County Health Department (MCCHD) to locate other potential sources. I obtained the Halogenated Solvent Users registration list from the DHES (DHES, 1991a). State law in Montana requires all businesses that use more than 20 gallons of halogenated solvents to register with the DHES. I also obtained the Montana Toxic Air Pollutant Emissions Inventory from the Montana Air Quality Bureau (DHES, 1991b). This list includes information on the type of facility, and the type and volume of pollutants emitted. As part of the Well Head Protection Program the MCCHD conducted on-site inspections of businesses in the Missoula Valley that are likely to use chlorinated solvents. Over 149 businesses were identified as probable past or present sources of chlorinated solvents.

Many of these businesses were not hooked to the city sewer, but disposed of their wastes via Class V injection wells. During the course of this study the EPA, in conjunction with MCCHD, began strict regulation of these types of disposal systems.

CHAPTER FOUR

RESULTS

PCE Behavior in the Missoula Valley Aquifer

I believe that it is unlikely that free phase PCE has reached the bottom of the MVA. This statement is based on the fact that PCE rapidly reaches saturation in water after contact; no VOC sample from the MVA has contained more than 13 ppb, which is one-fifteenth the saturation concentration of 200 ppb in water. Also, MCCHD inspections have uncovered no evidence of a PCE spill large enough to penetrate into the saturated zone. Nonetheless, the possibility remains that a free phase pool has formed on the bottom of the aquifer. Due to the sparse sampling network and extremely rapid flow rates (6-20 feet/day) (Peery, 1988), PCE could dissolve into the groundwater at levels well below saturation and be diluted by the time it reaches a sampling point.

Groundwater in the MVA has an extremely low dissolved organic matter (OM) content (Peery, 1988); therefore, solubility enhancement should be negligible. The OM content of the soils in the Missoula Valley are also very low. The Moiese and Grantsdale Loam are the two most common soil types in the study area, and they have OM ranging from 2-5% (Blaine, personal communication). Soils with such low OM content are not effective at absorbing an infiltrating DNAPL. Below the upper eight inches of soil these OM levels fall off drastically.

As stated earlier, PCE is extremely stable in an oxidizing groundwater environment. I conducted in situ measurements of oxygen levels at several monitoring wells throughout the study area (Table 6).

Table 6 Dissolved Oxygen Levels (ppm)

Well	May 1987*	Sept 1990	June 1991
MV-31		8.8 (0-10 ft below SWL)	8.1 (0-10)
		8.3 (>10)	8.6 (>10)
MV-35		8.4 (0-10)	8.5 (0-10)
MV-36		x	7.1 (0-10)
MV-37		7.9 (0-10)	8.3 (0-10)
MV-41		8.0 (0-10)	9.5 (0-10)
		8.6 (>10)	8.5 (>10)
MV-42		7.2 (0-10)	8.8 (0-10)
		9.0 (>10)	9.9 (>10)
3001-S	2.5		
3002-S	2.0		
3002-D	6.0		
3003-S	3.8		
3003-D	5.8		
3004-S	2.0		
3004-D	7.3		
1022-S	2.2		

*(Peery, 1988)

I calibrated the YSI oxygen meter in the field. In all cases the oxygen levels were above 7 ppm. I did not bail the wells before taking the readings because I felt that would introduce oxygen into the system. Measuring dissolved oxygen after bailing is generally unacceptable because it can alter the natural oxygen levels (Rose and Long, 1988). Because the wells are perforated through the water table I also felt that the water in the casing would be fairly representative of the water in the aquifer, at least to the extent necessary to determine oxygen levels at a qualitative level rather than quantitative. During the bailing of MV-41 and MV-42 for VOC analysis, I monitored pH, specific conductance, and temperature until the three parameters stabilized. The maximum change at either well was 0.15 pH unit, 5 umhos/cm, and 1°C. Such a small change in these other chemical parameters (after the removal of at least three well volumes) indicates that the water in the well is in communication with the aquifer to the extent necessary to allow qualitative analysis of the dissolved oxygen levels.

This evidence indicates that the groundwater in the MVA is well-oxygenated. The prospects of transformation of PCE in aerobic water such as this are poor (Wilson and McNabb, 1983). It is unlikely PCE will breakdown under the prevailing conditions in the MVA; however, locally reducing conditions, such as near a petroleum spill, could lead to degradation of PCE. Peery's (1988) data shows that in an area of petroleum contamination the dissolved oxygen levels in the MVA drop significantly, yet remain oxygenated.

Geophysics

In an effort to further define the stratigraphy of the aquifer, I used the Bison Signal Enhancement Seismograph Model 1570A with a single geophone. The Bison is capable of enhancing the signal-to-noise ratio by stacking shots at each geophone location. Despite this capability, the results of my refraction study were inconsistent and inaccurate, producing unusable data. I attribute this difficulty to two factors primarily. The first is a low signal-to-noise ratio due to the cultural interferences at the Fairground/Playfair Park site. The second factor leading to the poor results is difficulties in determining first arrival times.

In July of 1990 I assisted Earthworks, Inc in conducting a VLF resistivity study at the Missoula County Fairgrounds. The abundance of cultural features such as pipes and power lines seriously limited the ability to collect useable data. The overall data density is too low to resolve details, and the 1-D inversion model used did not permit the resolution of thin beds. However, the study did yield some general conclusions about this area of the aquifer. In the upper 50 feet resistivity values were consistent with those expected of sandy to silty gravel. In the 50-150 foot depth range, a SE trending resistivity low was identified in the Carnival area. This resistivity low could be due to either locally conductive groundwater or to a higher clay content within this part of the alluvium. Assuming that the total dissolved solids in the groundwater are consistent in the 200-300 ppm range (McMurtrey et al, 1965; Woessner, 1988) a clayey to silty sand would be predicted in this area (Van der Poel, personal communication, 1991).

Aquifer Lithostratigraphy

The geologic cross-sections that I developed are based entirely on the well logs obtained during the course of the study. The lithostratigraphy of the study area has been interpreted based upon Morgan's (1986) and Woessner's (1988) three stratigraphic zones of the MVA. A narrower definition of Woessner's Unit Two has been applied, making it more meaningful in terms of contaminant transport. Specifically, greater emphasis has been placed on the driller's reports of the ability of the strata to yield water, and the relative amounts of fine versus coarse material. Additionally, coarser layers within Unit Two have been identified, as well as fine-grained zones within Unit Three. The location of the geological cross-sections is shown in Figure 7. The resulting cross-sections are shown in Figure 10 through Figure 18.

Based on the well logs, Unit Two is an inconsistent unit in terms of thickness, composition, and lateral extent. North of the Clark Fork River Unit Two appears to be a much more consistent layer, both in terms of thickness and lateral extent. It does, however, remain variable in relation to the relative composition of fine versus coarse-grained material. In all of the logs examined from the north side of the river, at least one zone of fine-grained material was noted.

South of the Clark Fork River, Unit Two is much less consistent. Six logs from wells along South Avenue West made no indication of a fine-grained zone at a level consistent with the presence of Unit Two. In many other logs, Unit Two was reported as only occurring below the static water level (SWL), thereby seriously reducing its effectiveness as a

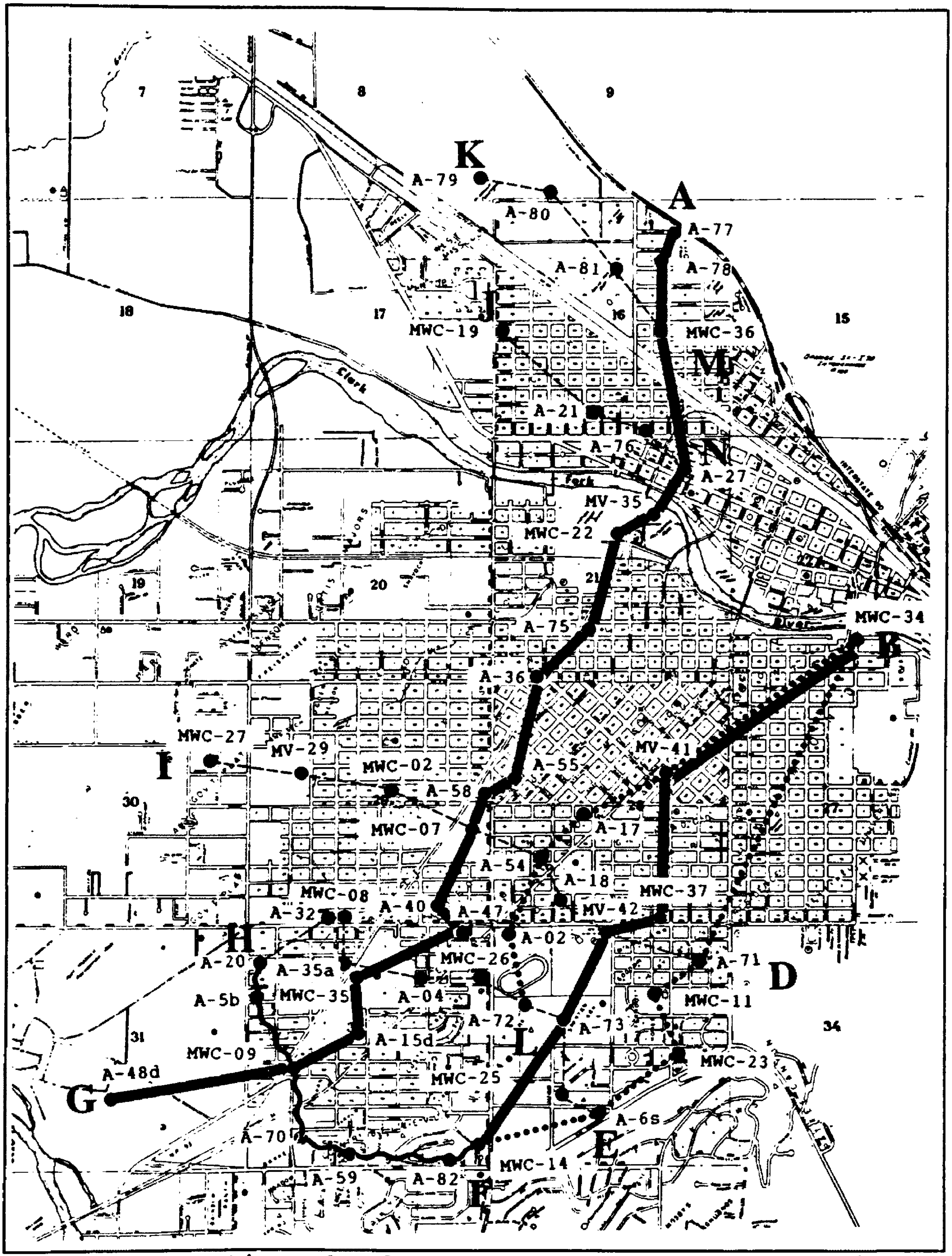


Figure 7 Location of wells used to develop cross-sections.

protective layer. In other well logs, Unit Two was restricted to a thin clay seam or a thick package of clay with significant amounts of coarse material mixed in. All of these scenarios are less than effective at protecting a groundwater resource from surface contamination.

In map view a pattern exists for the presence of Unit Two. Figure 8 shows the surface contours of Unit Two. Generally, the surface slopes towards the confluence of the Bitterroot and Clark Fork Rivers. In a zone along South Ave. West, however, Unit Two seems to be totally absent. Figure 9 shows the contact between the Tertiary sediments and Unit Three of the MVA.

Based upon the information available from existing well logs, Unit Two seems to be thickest and finest-grained in the SE portion of the study area. Miller's (1990) pump tests and the electrical resistivity work done as part of this study corroborate this, both indicating that this area of the aquifer is relatively less transmissive. The lowest fine-grained layer identified in the cross sections from the SE portion of the study area (Figure 13 and Figure 15) seems to correlate with Geldon's (1979) bench gravels. Geldon identified this stratigraphic zone as being of Pliocene to Pleistocene in age.

Interpreting the lithostratigraphy of an aquifer such as the MVA is a difficult process. Even the best well logs are often sketchy, and only a handful have been carefully logged

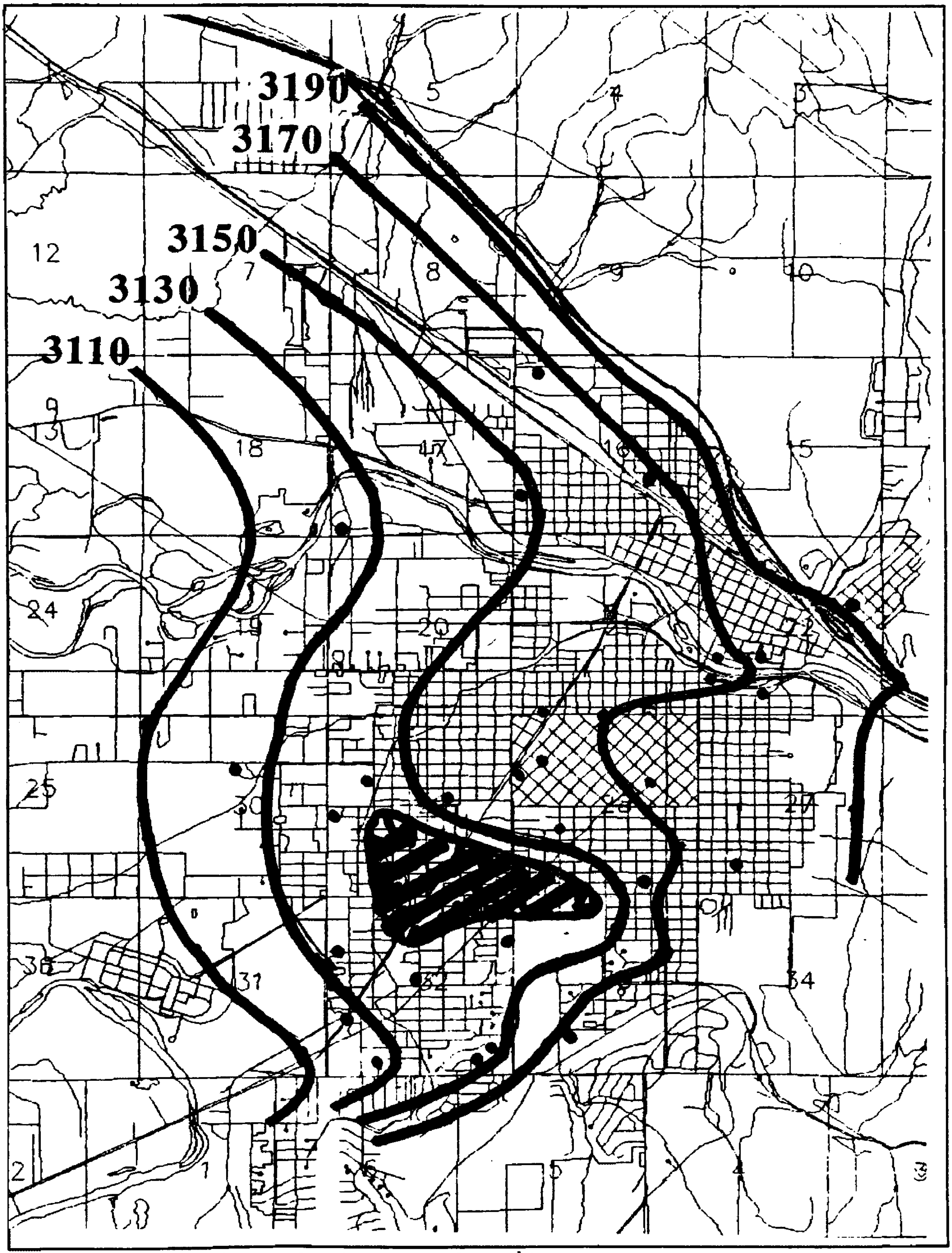


Figure 8 Surface Contours of Unit Two.

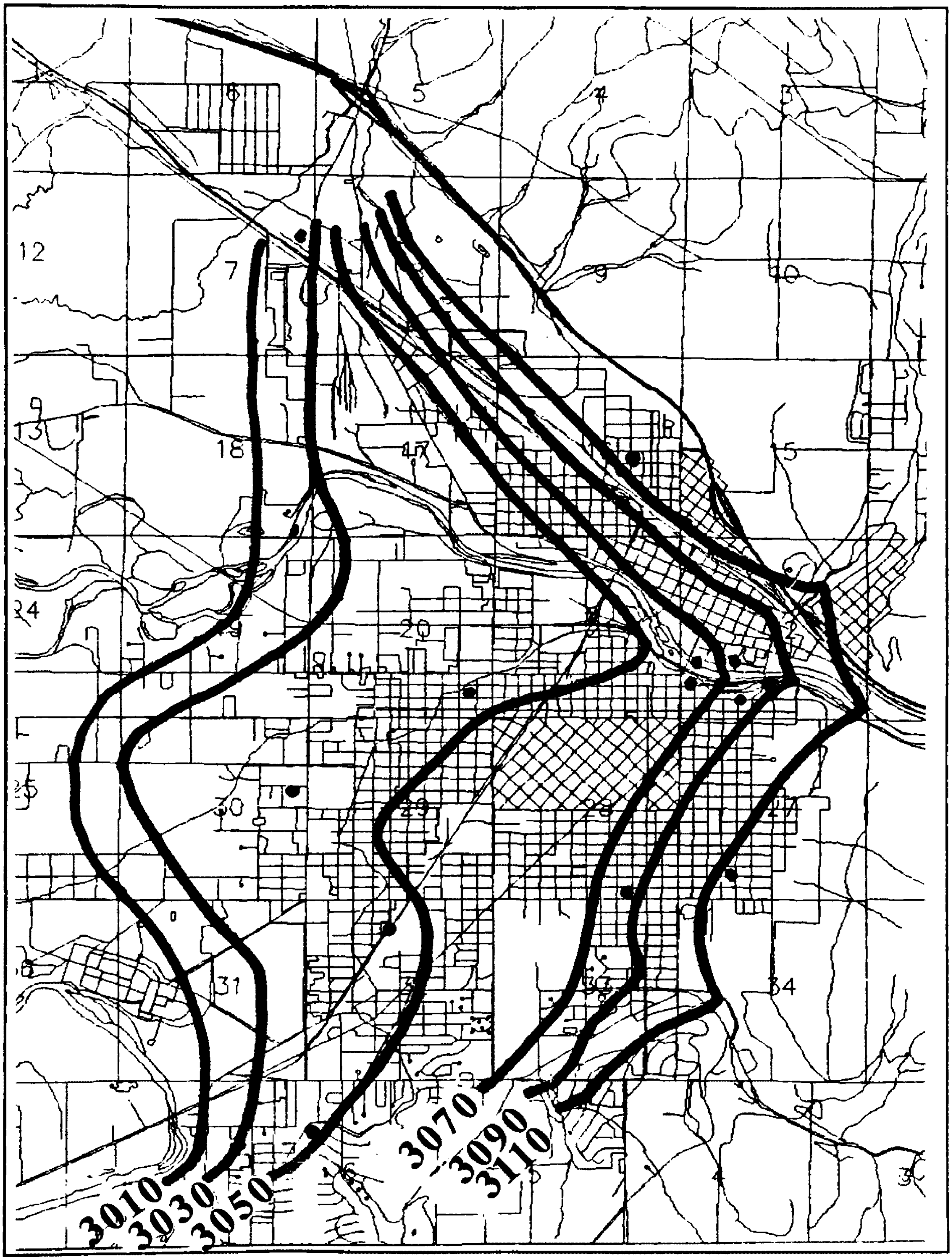


Figure 9 Surface contours of the Tertiary sediments.

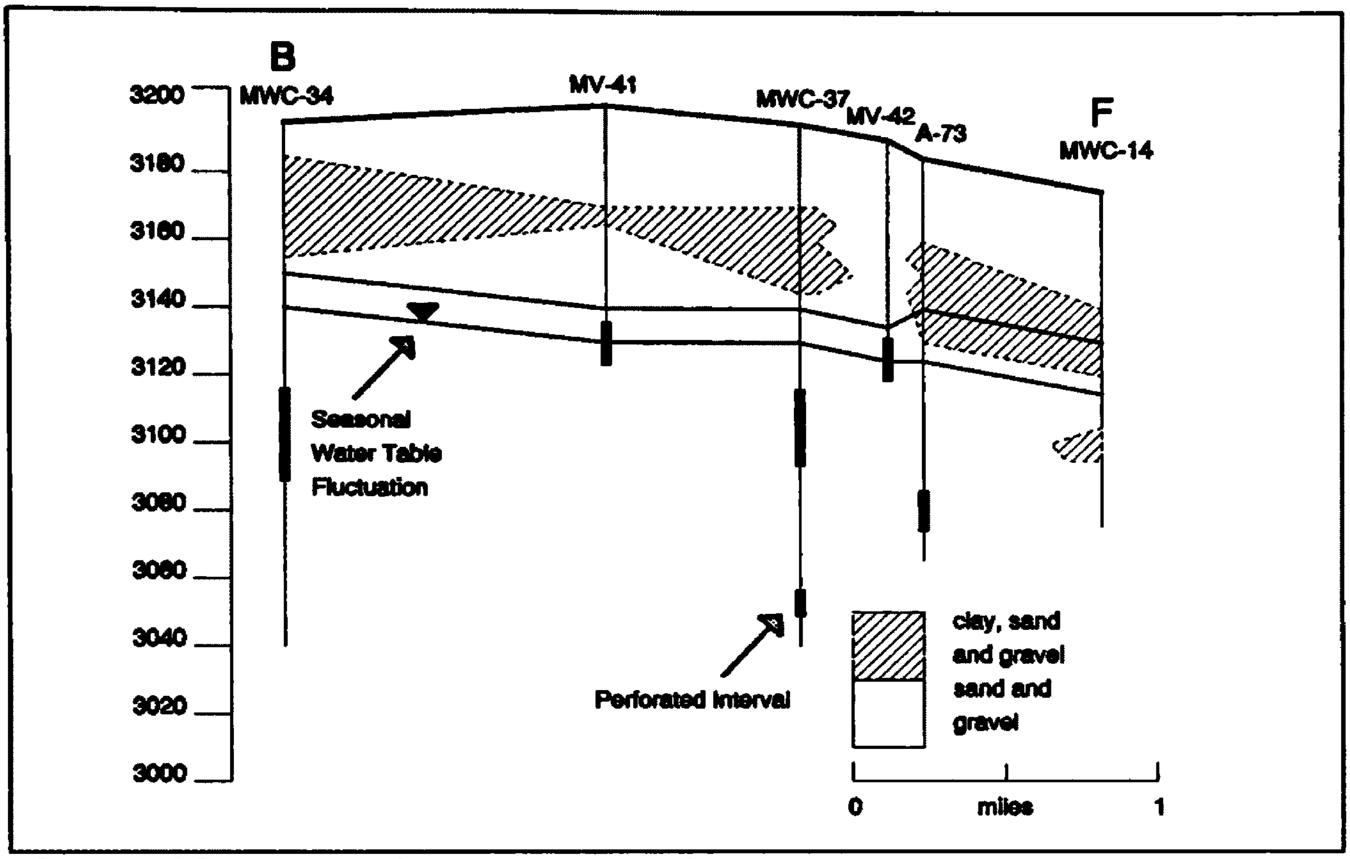


Figure 10 Geologic cross-section B-F.

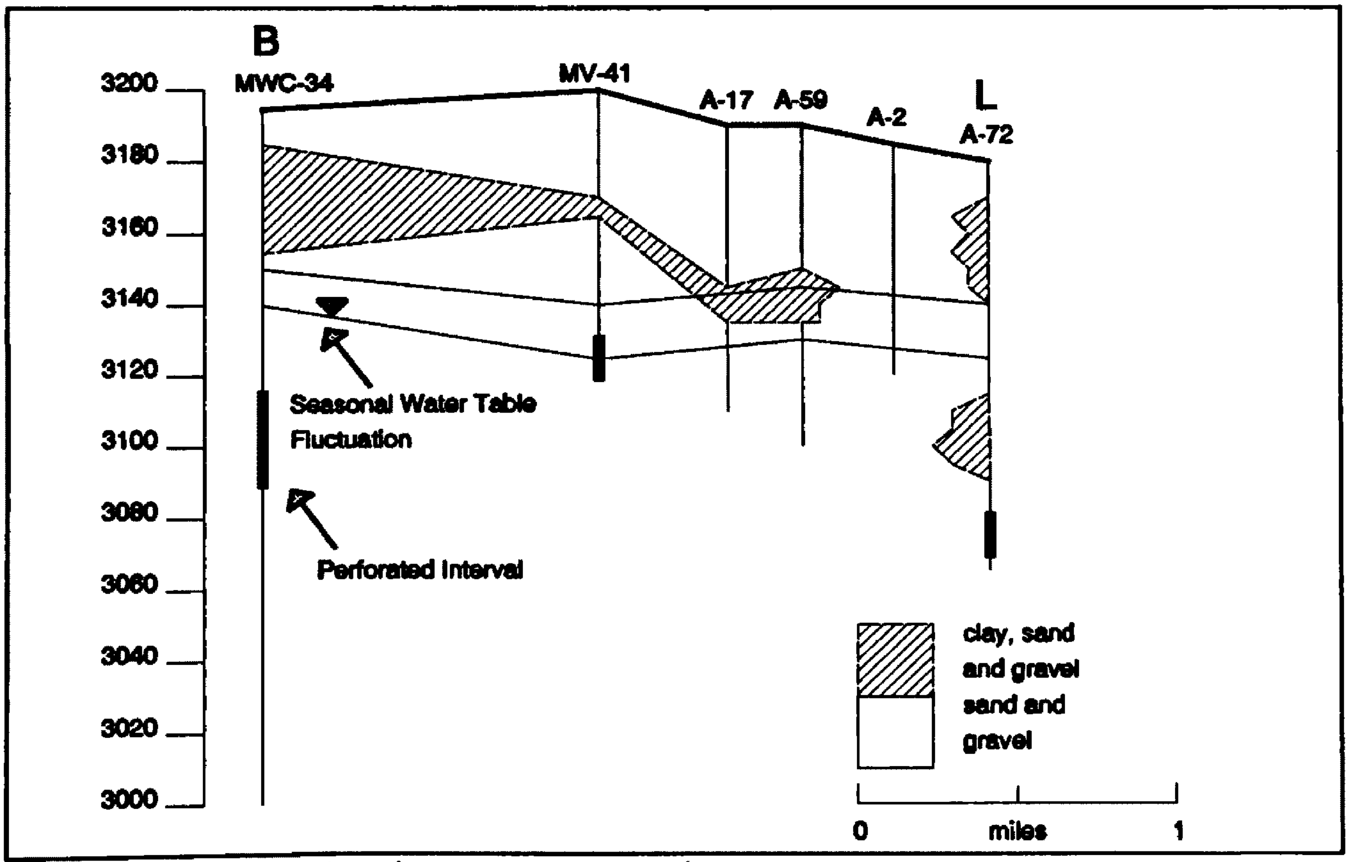


Figure 11 Geologic cross-section B-L.

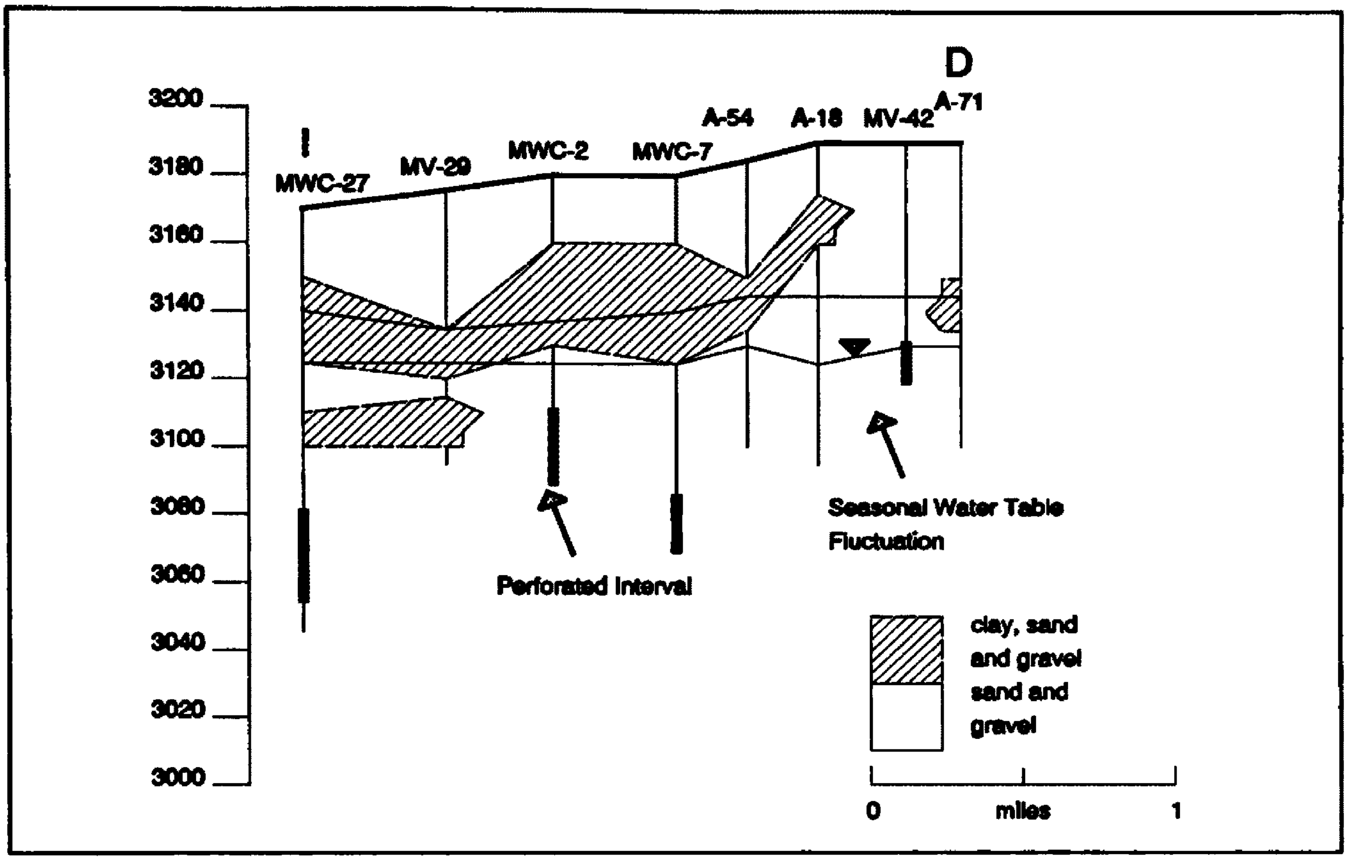


Figure 12 Geologic cross-section I-D.

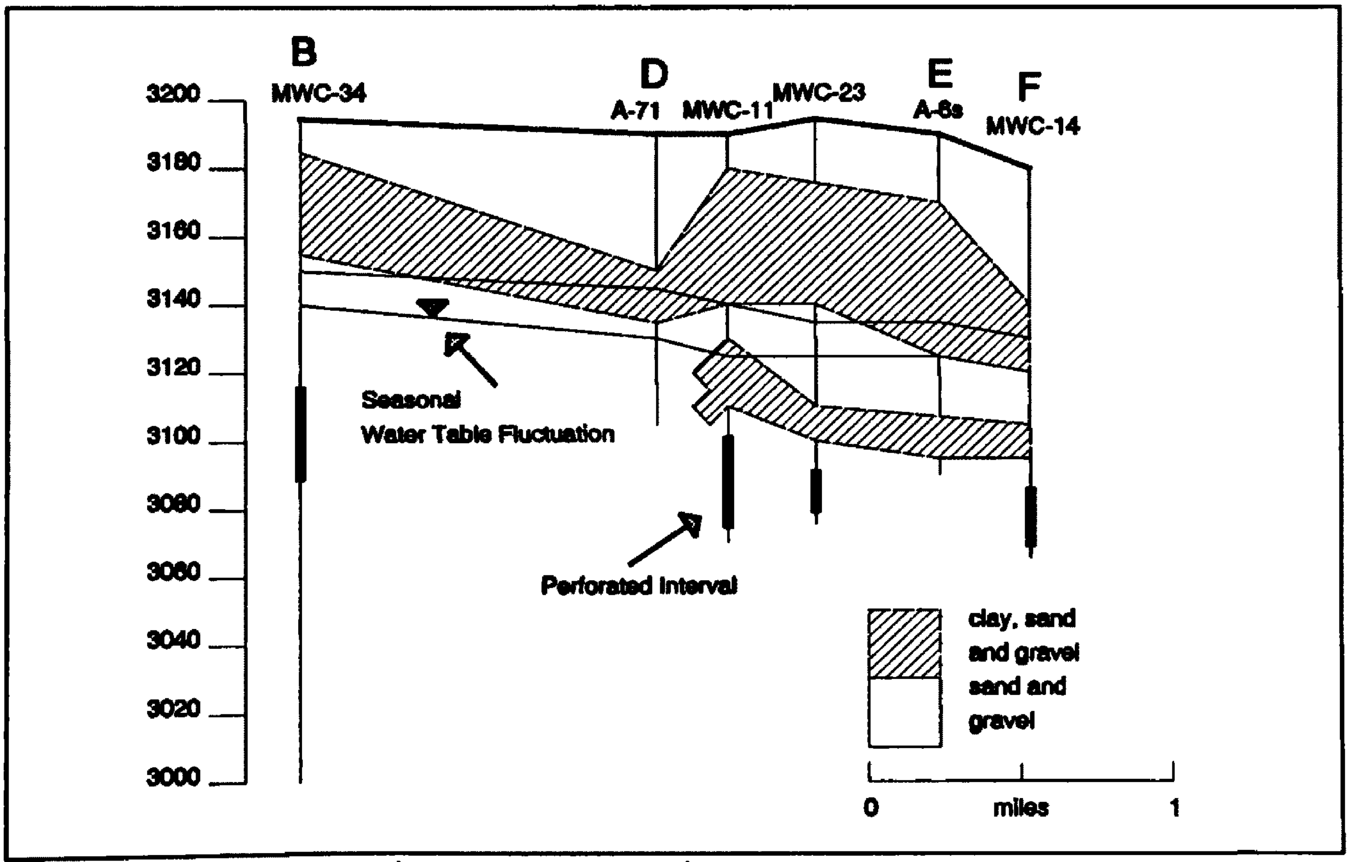


Figure 13 Geologic cross-section B-D-E-F.

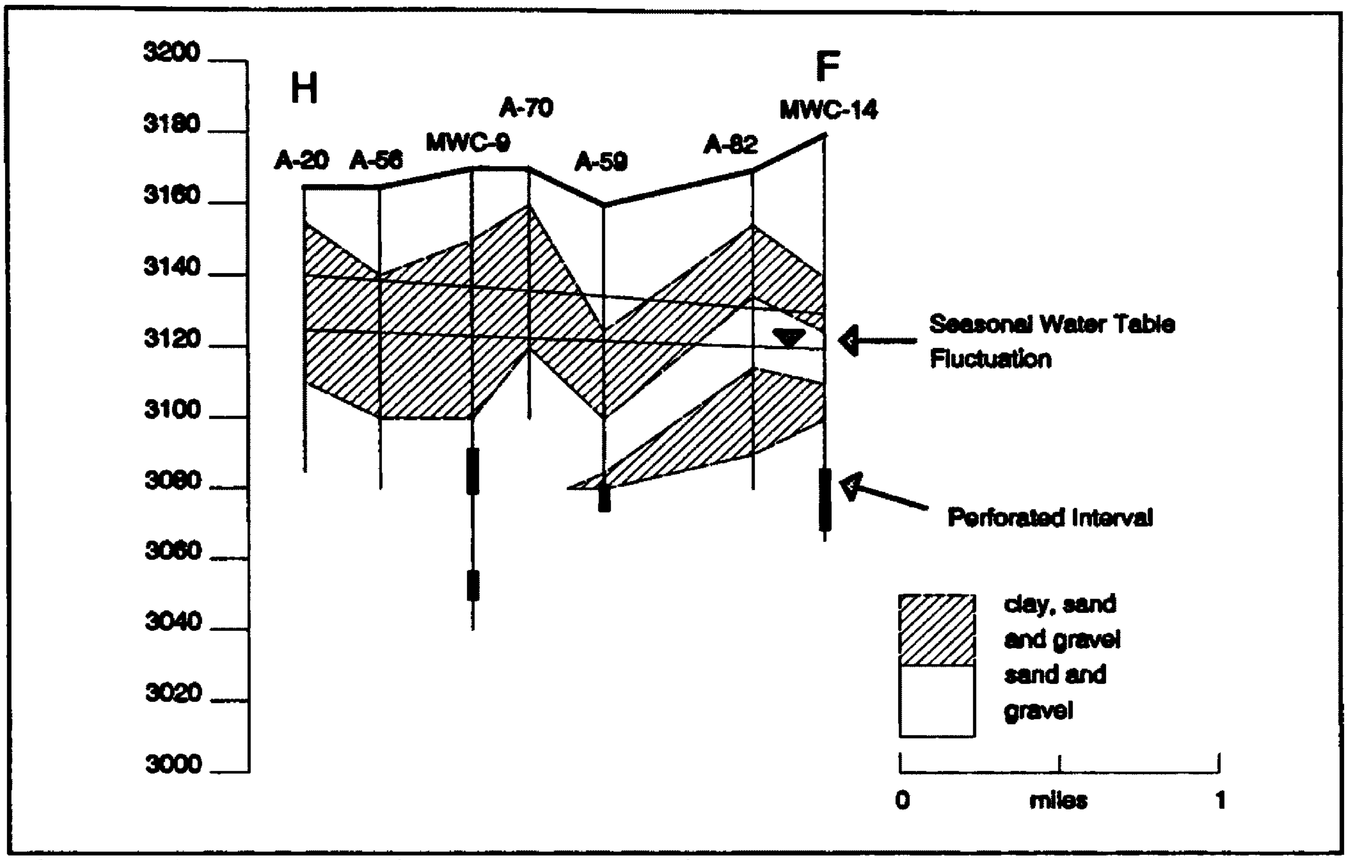


Figure 14 Geologic cross-section H-F.

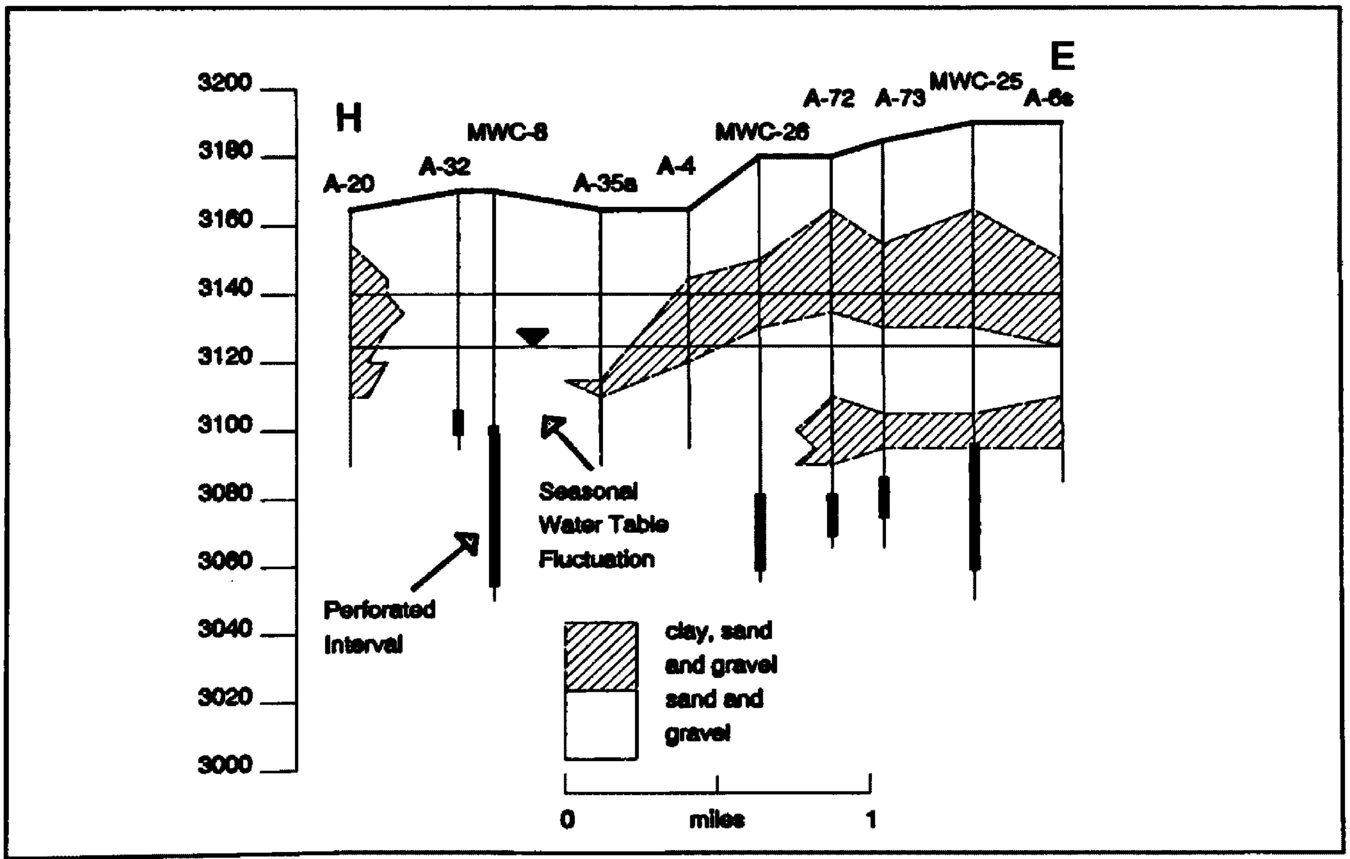


Figure 15 Geologic cross-section H-E.

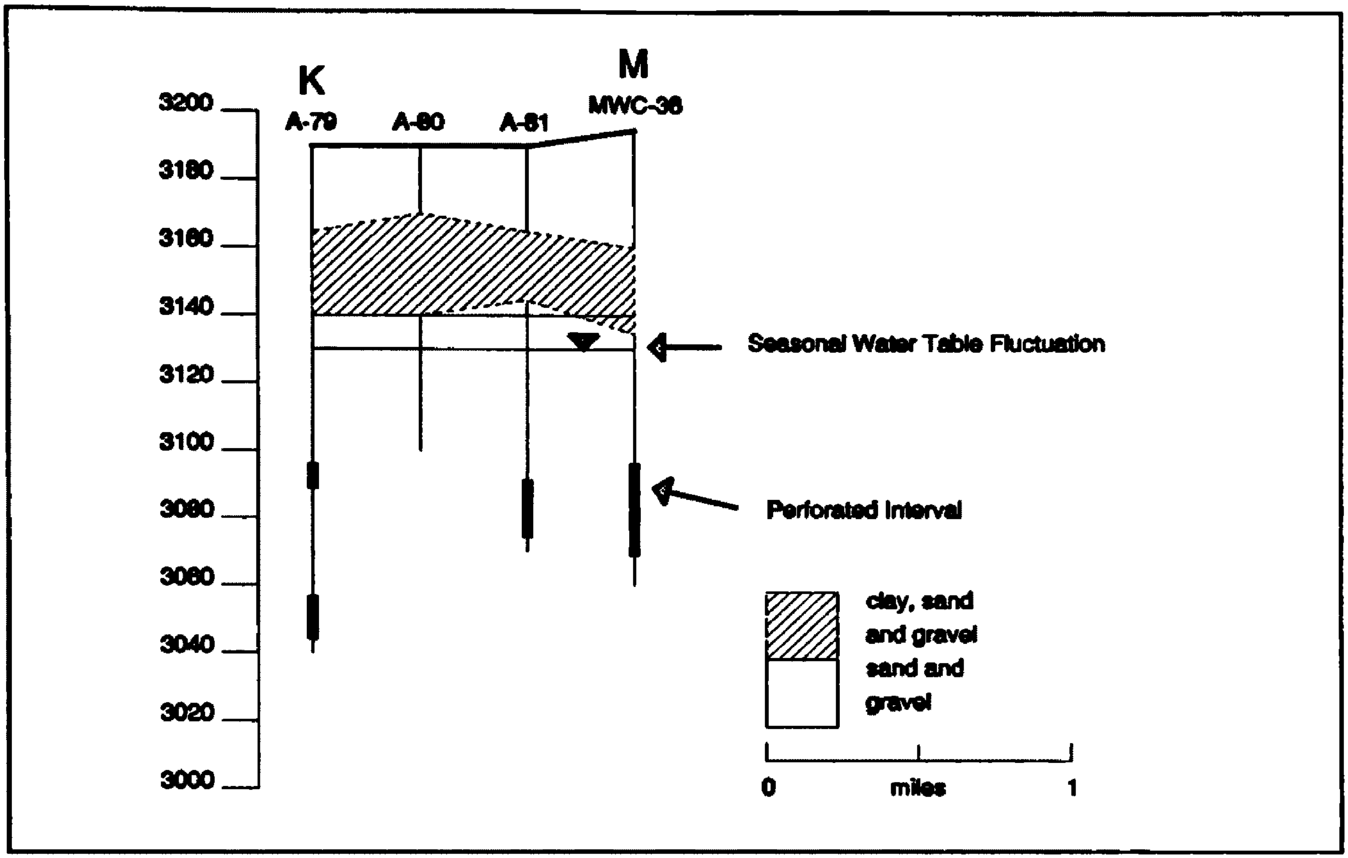


Figure 16 Geologic cross-section K-M.

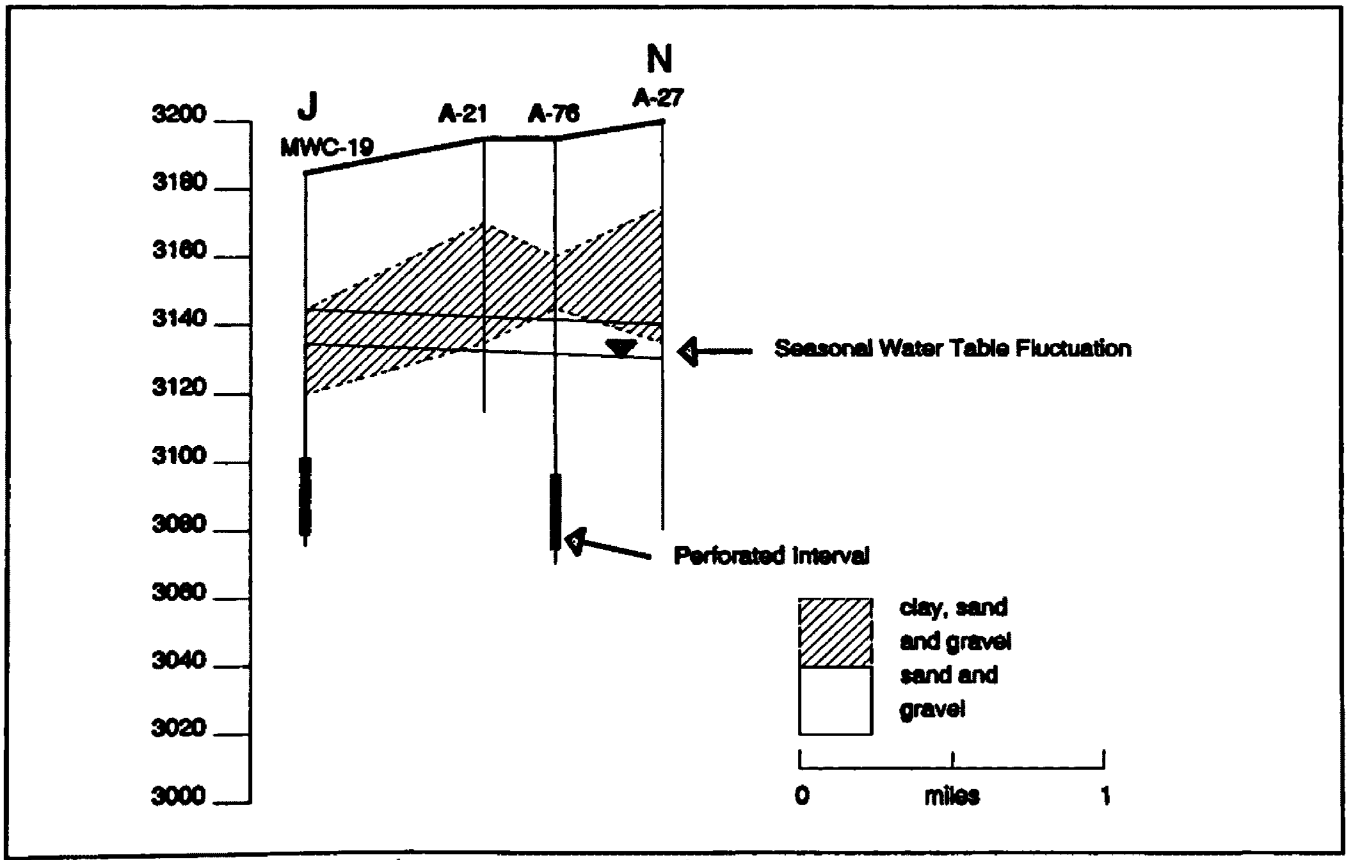


Figure 17 Geologic cross-section J-N.

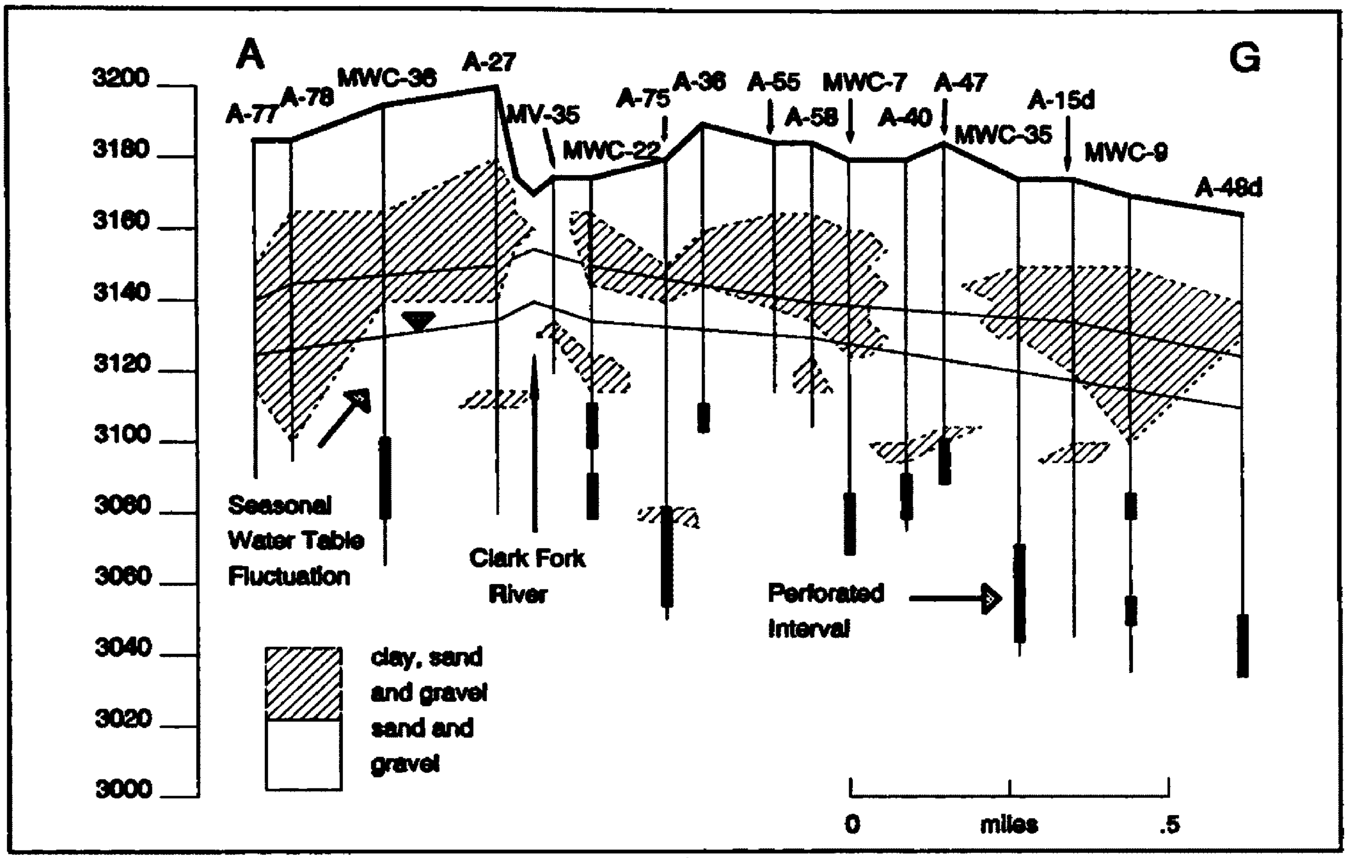


Figure 18 Geologic cross-section A-G.

by geologists. The accuracy of any map or cross-section produced to characterize the stratigraphy is a direct function of the lithological descriptions and the number and location of well logs available. For this reason, the relationship between the presence of Unit Two and the location of a probable source does not eliminate the possibility that that source is contaminating the aquifer.

Flow System

The monitoring well network developed for static water level measurement for this study consisted of 41 wells, three of which were equipped with continuous water level recorders. Criteria for selection of these wells included availability, location, and quality of well log data. Wells were monitored from November of 1989 to September of 1990, on a monthly to bi-monthly basis. Figure 19 shows the locations of wells in the SWL monitoring network, while the SWL data can be found in Appendix B.

I produced potentiometric maps (Figure 20, Figure 21, and Figure 22) which show the direction of groundwater flow. Groundwater flow direction is relatively constant, with a few seasonal variations. The highest water levels were recorded in June of 1990, while the lowest water table elevations occurred in March of 1990.

North of the Clark Fork River, groundwater moves parallel to the river towards its ultimate discharge point north of the Clark Fork's confluence with the Bitterroot River. The Clark Fork is a losing stream, recharging the aquifer from Hellgate Canyon to the vicinity of the Reserve Street Bridge. Groundwater flow on the south side of the Clark Fork is away from the river towards the confluence of the two rivers. Along the southern margin of the valley, groundwater flow parallels the base of the South Hills.

I attempted to define the significance of vertical flow gradients within the study area, but I was only able to locate one pair of wells in the interior of the valley that were sufficiently close to attempt to quantify vertical flow. I used water level measurements taken by myself and Wogsland (1988) to determine the significance of vertical flow in this

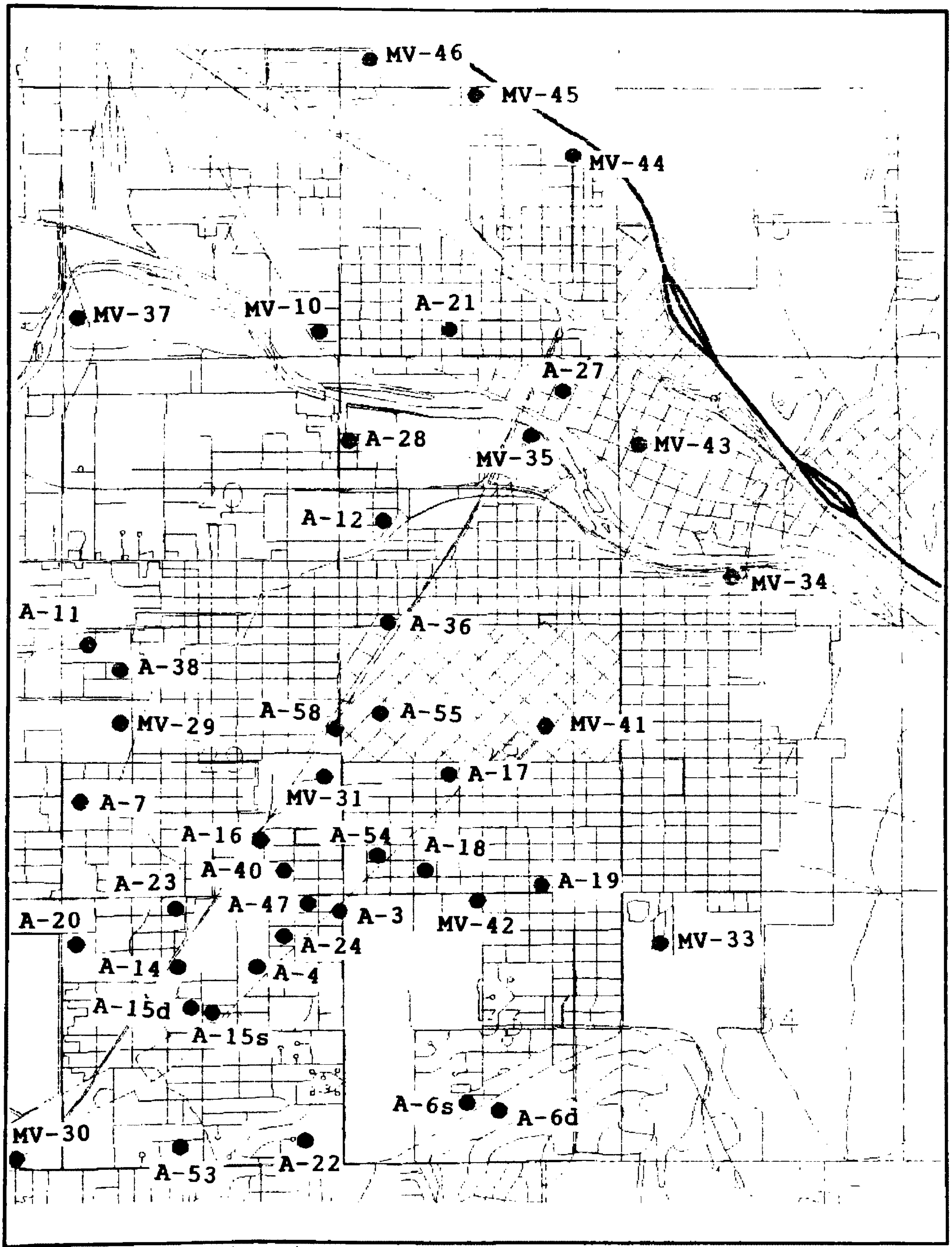


Figure 19 Monitoring well network.

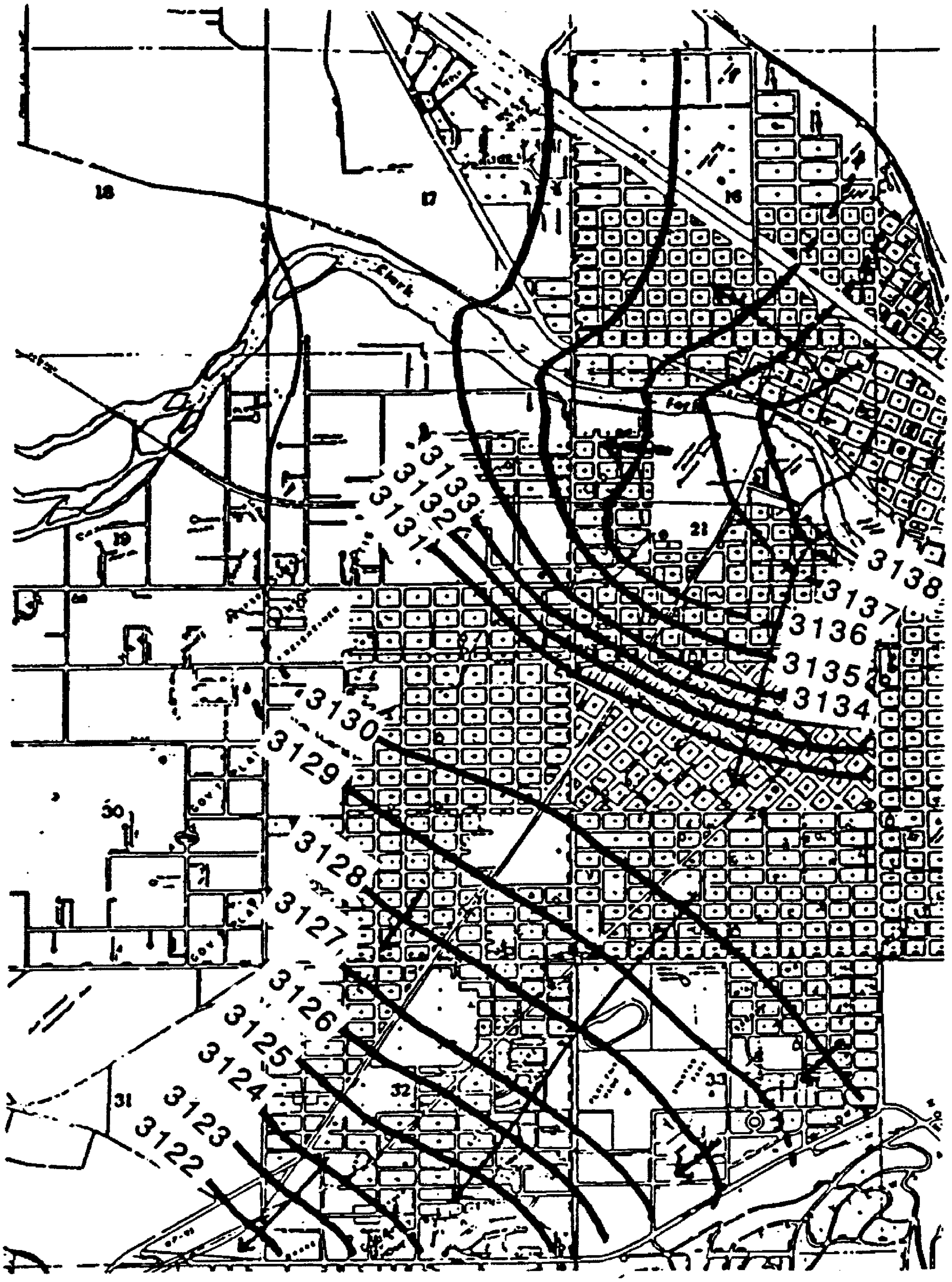


Figure 20 Potentiometric surface for March 1990.

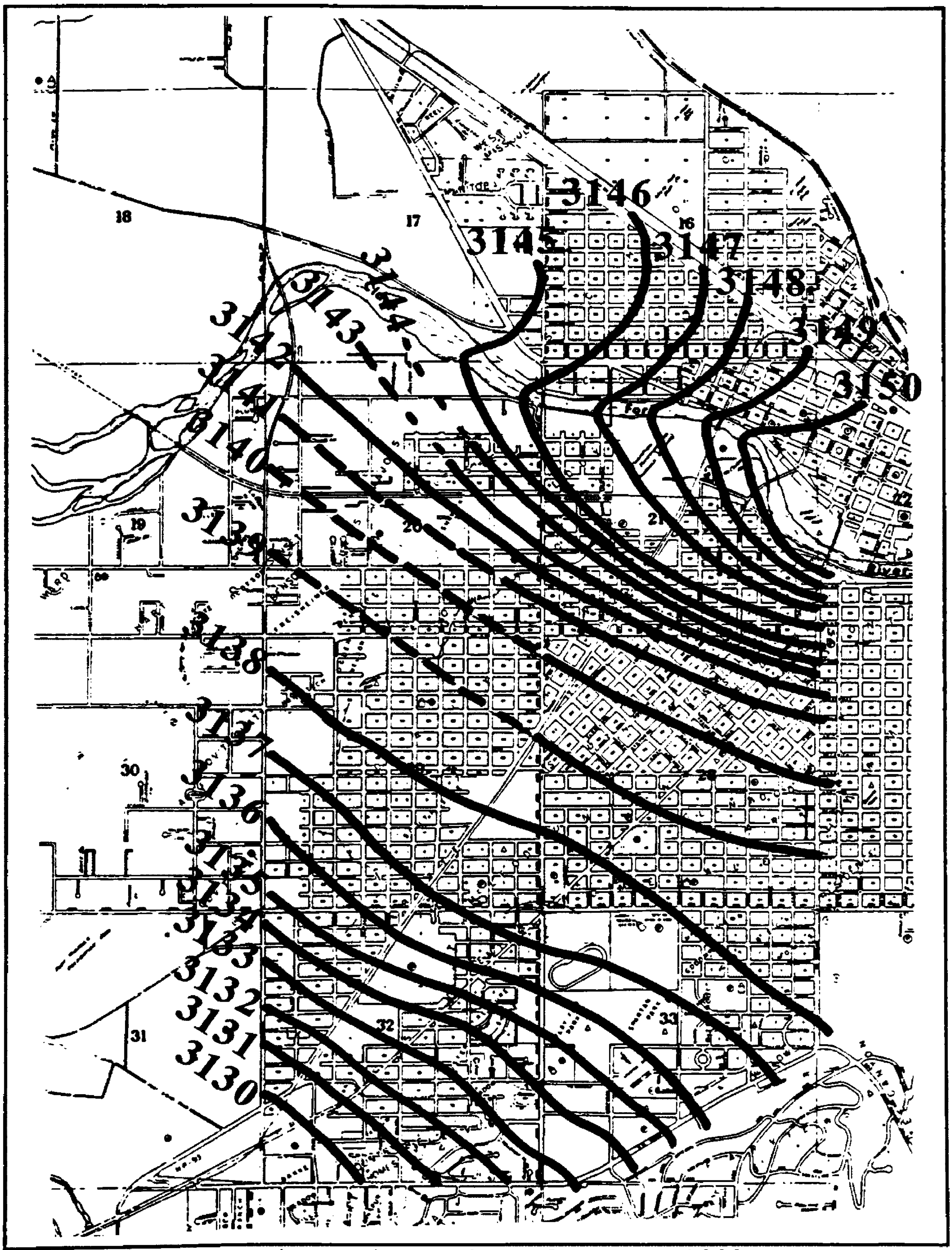


Figure 21 Potentiometric surface for June 1990.

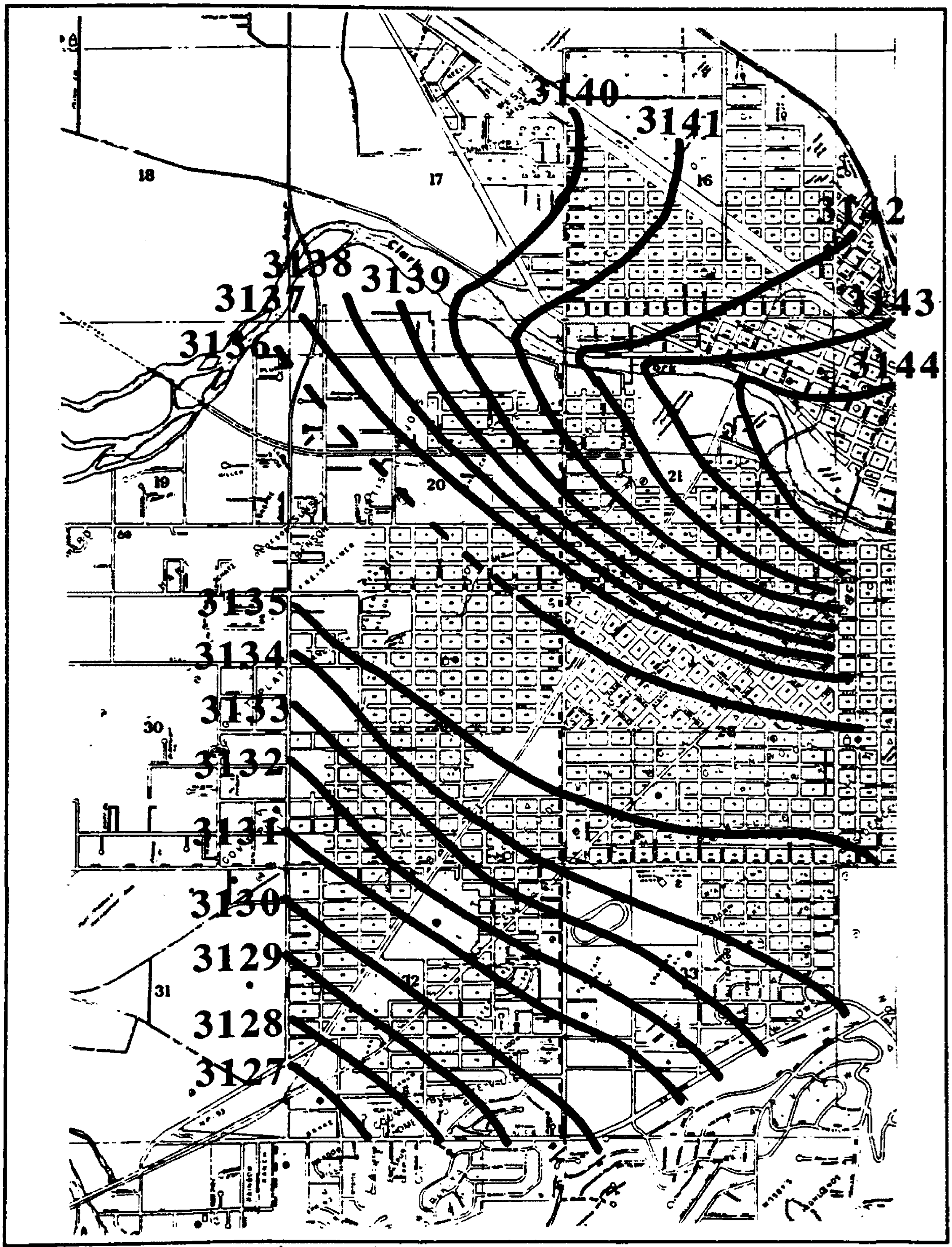


Figure 22 Potentiometric surface for September 1990.

portion of the aquifer.

I used wells A-15s and A-15d near Southgate Mall to determine vertical flow gradients. The wells are approximately 40 feet apart, which is less than ideal, but the best available for this purpose. Both wells draw water only from their open end; A-15s is finished at 79 feet, and A-15d is finished at 126 feet. Measurements taken over the course of the two studies indicate that there is a measurable upward flow gradient at this location a majority of the time. The average difference is 0.06824 feet. This yields an upward flow gradient of 0.0014519 which is somewhat greater than the horizontal gradient established in earlier studies (Clark, 1986; Peery, 1988).

Near the Clark Fork River, Peery (1988) documented a downward component of flow. A downward flow gradient of 0.004 to 0.01 was found near the river, which is one to two orders of magnitude greater than the horizontal (0.0007) component of flow in that area.

It is difficult, if not impossible, to make conclusions based upon this evidence. Some rough generalizations can, however, be made. Along the losing reaches of the Clark Fork, the vertical component of flow is strongly downward, up to two orders of magnitude greater than the horizontal component. In the interior of the valley, flow is likely to be horizontal, with local heterogeneities in the aquifer material producing slight variations in flow from the horizontal. As the groundwater approaches the gaining reaches of the Clark Fork and Bitterroot Rivers the upward flow component increases.

Extent of Contamination

There are two primary factors that could control the extent of contamination in the Missoula Valley Aquifer. Those factors are: well depth and distance from the source. Figure 23 indicates that there is a relationship between PCE concentration and the square root of distance from potential sources. This relationship is probably stronger than is indicated by an R-squared value of 0.48 (correlation = 0.694). Factors such as relative contaminant loading by the individual sources, relative position in the flow path from the source, the presence or absence of Unit Two, and seasonal water table fluctuations would affect this relationship. Additionally, some sources of PCE may not yet be identified, while other potential sources may not actually be sources.

I also evaluated the relationship of the following three variables on PCE concentration: 1) the depth to the water table, 2) well depth, and 3) well intake depth below the water table. None of these three variables had any effect on PCE concentration in the wells sampled. Figure 24 shows that there is no relationship between well depth and PCE concentration (R^2=0.09) (correlation = 0.294). This serves as further support for the idea that free phase PCE has not reached the bottom of the MVA. If free phase PCE were at the bottom of the saturated zone, the deeper wells would have much higher concentrations than have been found.

Some wells display seasonal trends that closely follow the static water level (SWL) elevation (Figure 25 to Figure 29). The Mountain Water Company wells with the highest concentration levels show the strongest relationship. MWC-36 (Figure 30) on the north side shows virtually no relationship between PCE concentration and SWL. The PCE concentrations at MWC-36 are only slightly above the detection limit (0.5 ppb), this could account for the lack of a relationship between the two variables at MWC-36. A contaminated lense may be in the vadose zone during the autumn and winter. In the spring and early summer when the water table rises, the lense would be submerged, allowing contaminants to dissolve. A second possible explanation for this trend is that seasonal infiltration from the surface passes through a zone of residual PCE contamination in the vadose zone. This would bring dissolved PCE to the water table, causing increased PCE levels in the nearby wells. Infiltration from the surface is increased in highly developed areas, such as where most potential sources of PCE contamination are located.

Potential Sources

After reviewing the aerial photographs, DHES, and MCCHD records I located these potential sources on a map (Figure 31). The sources shown on the map are only those that are known to currently use, or have in the past used

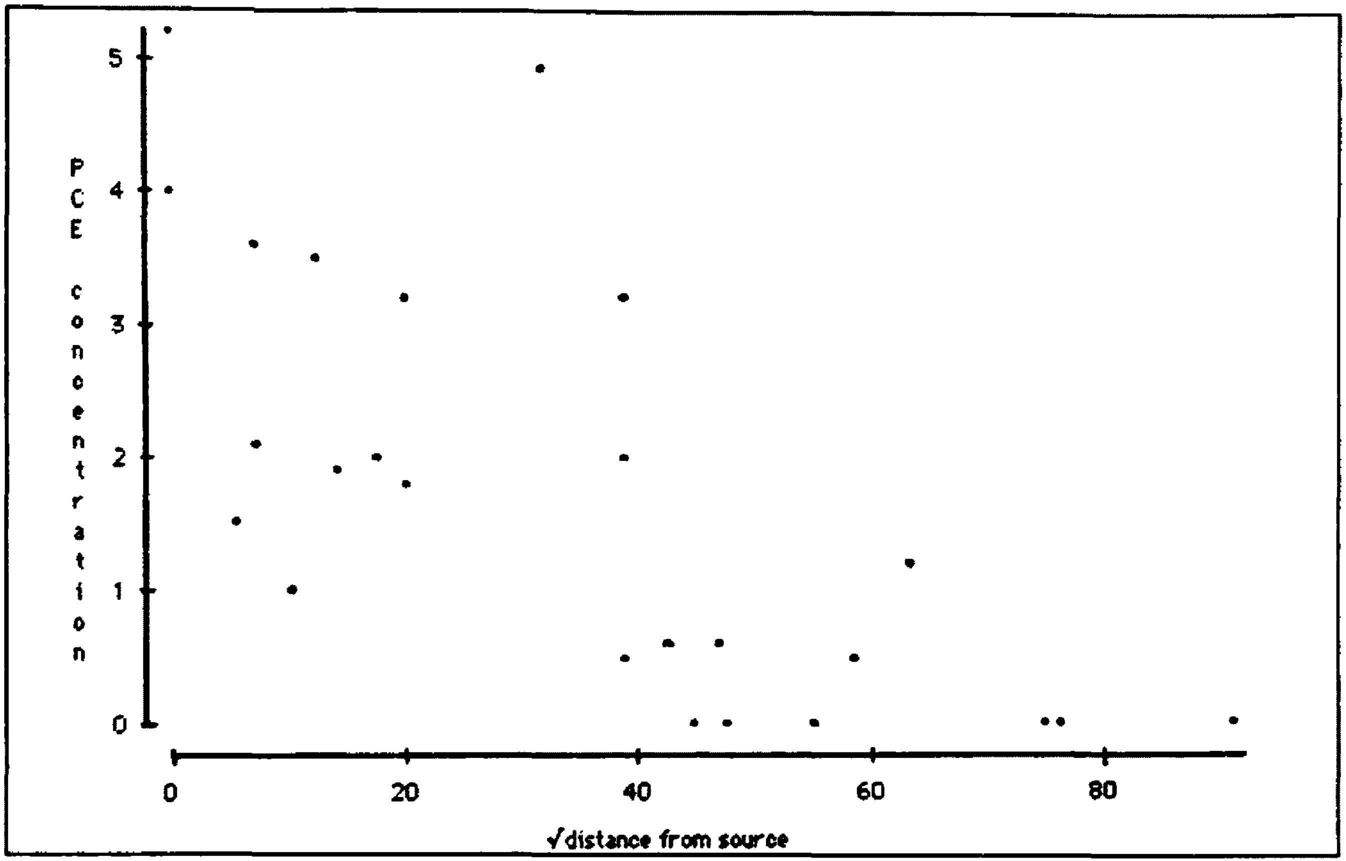


Figure 23 PCE concentration vs. square root of distance from probable source.

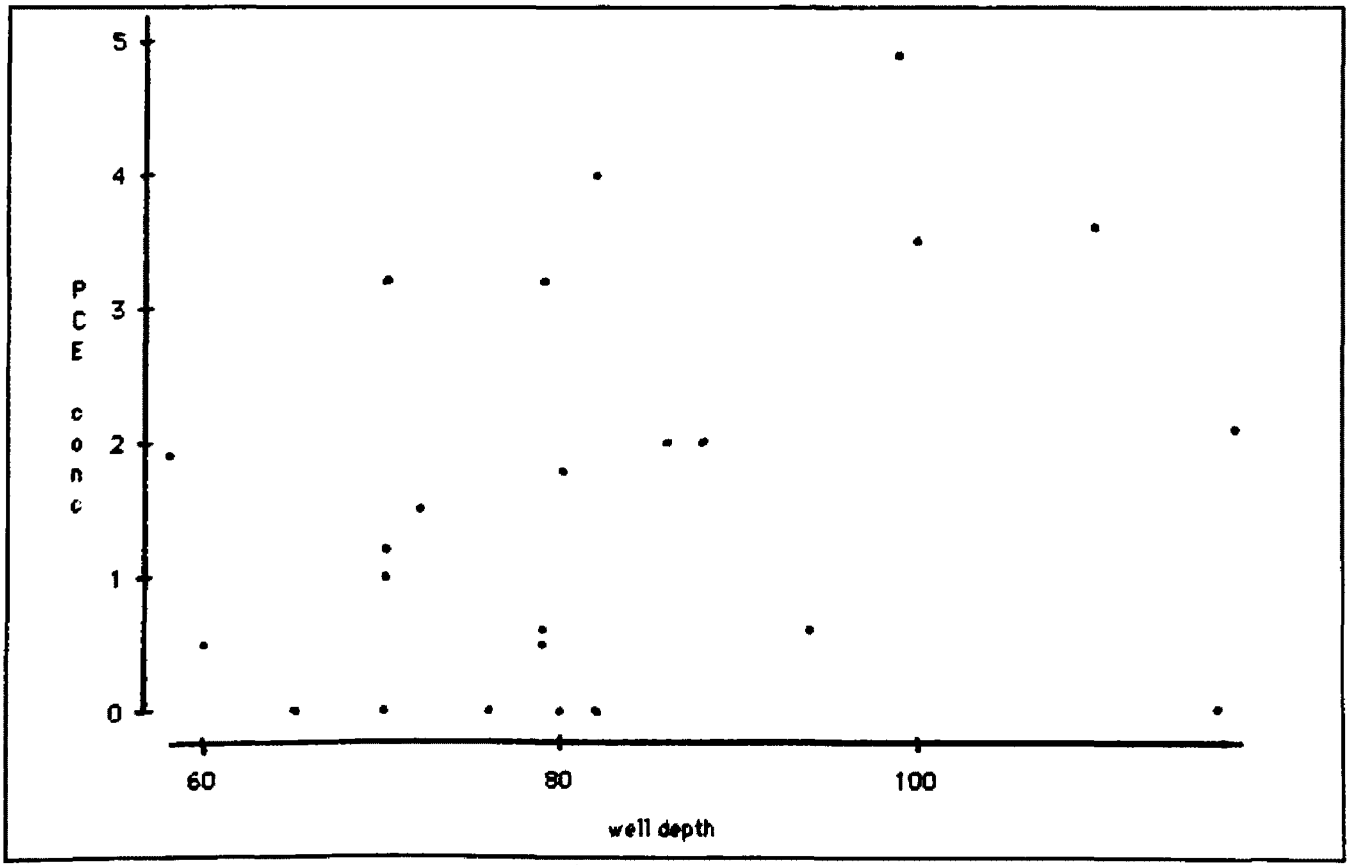


Figure 24 PCE concentration vs. well depth.

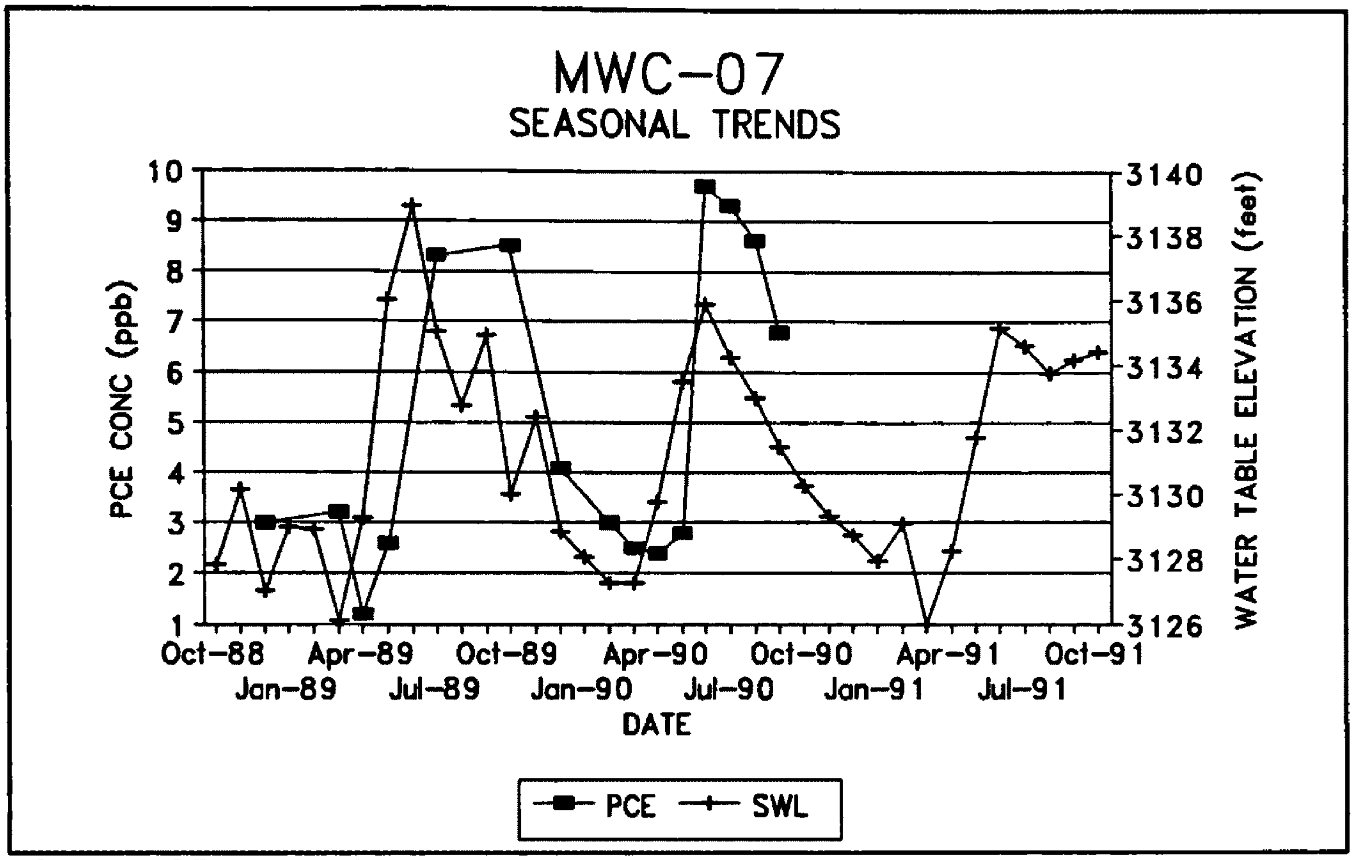


Figure 25 MWC-07, seasonal trends.

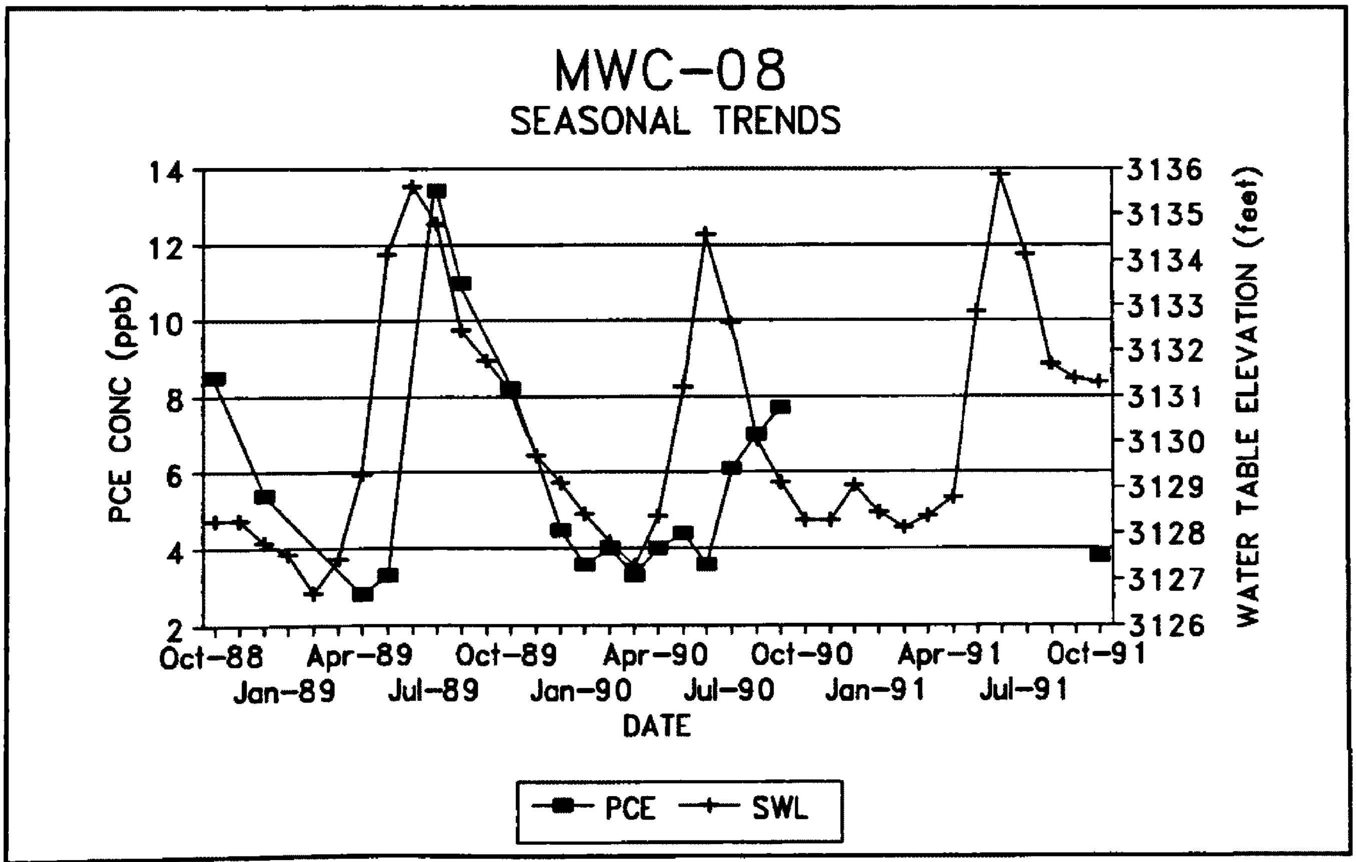


Figure 26 MWC-08, seasonal trends.

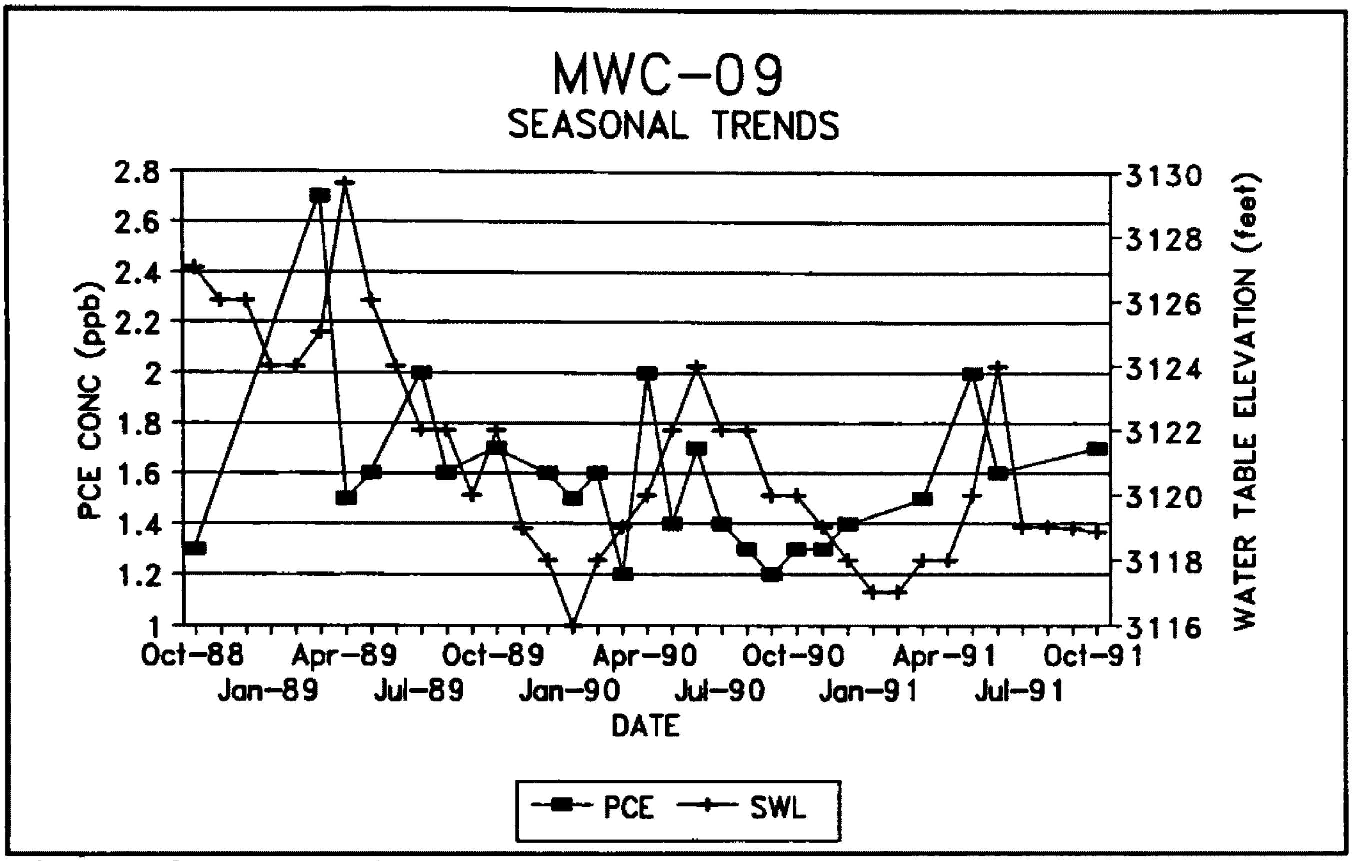


Figure 27 MWC-09, seasonal trends.

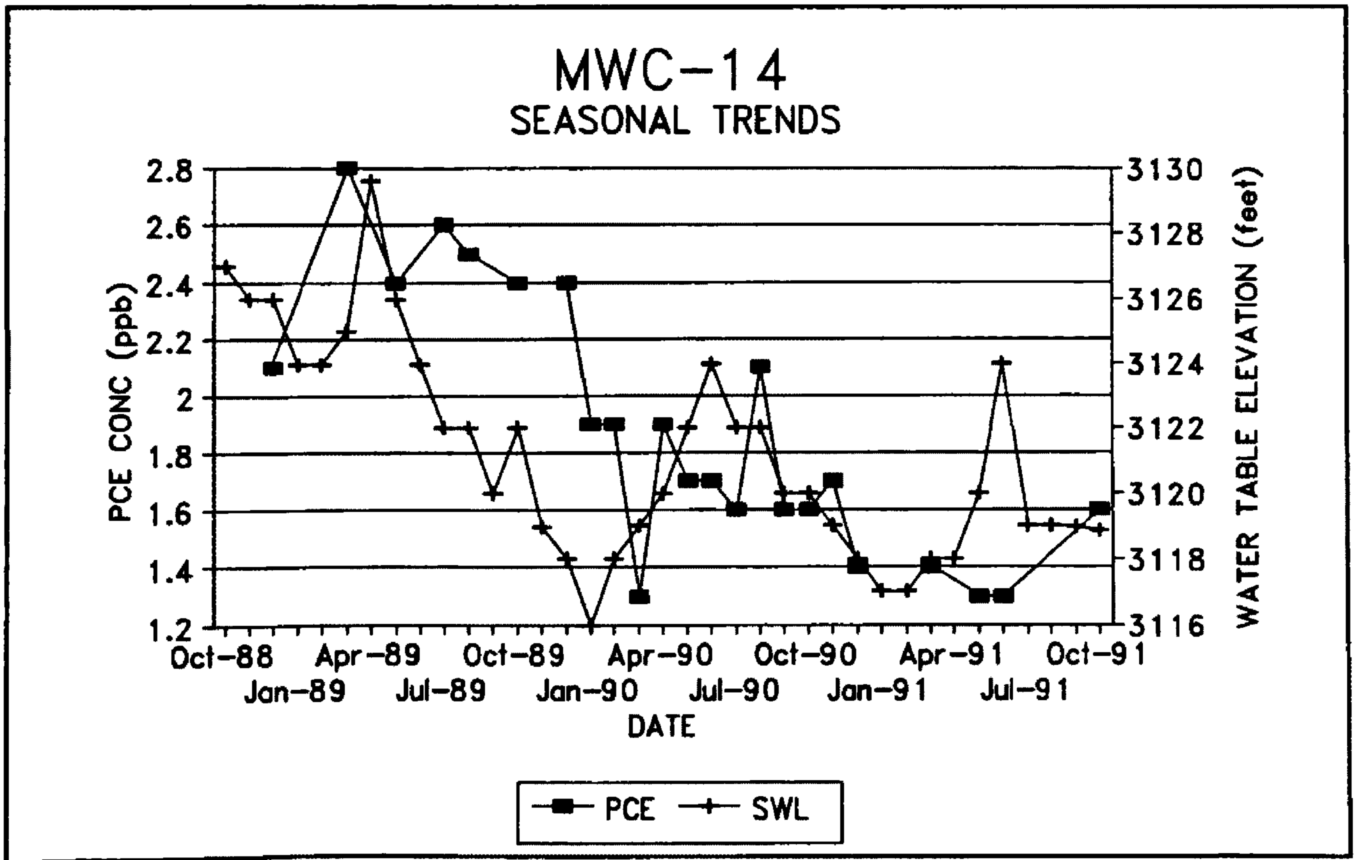


Figure 28 MWC-14, seasonal trends.

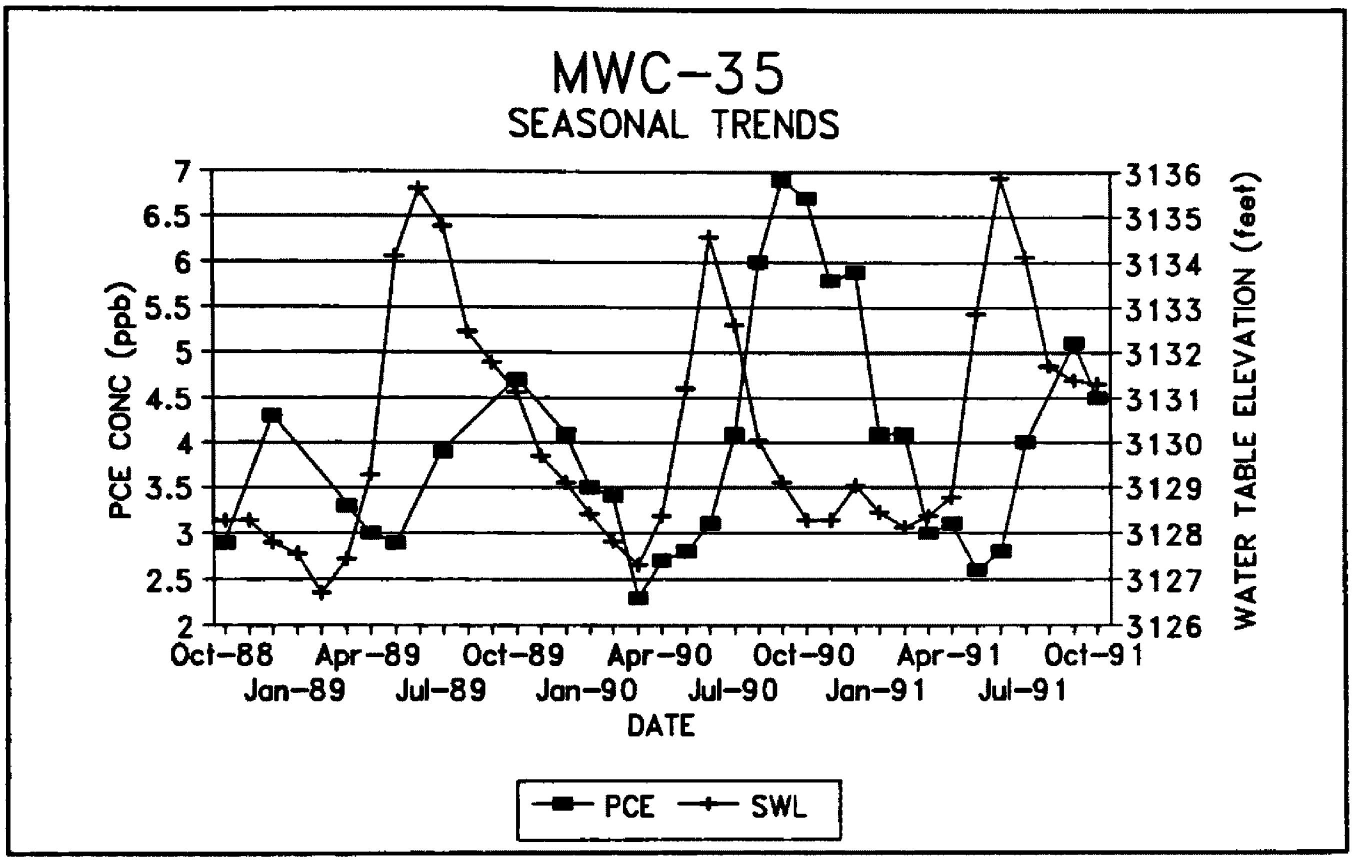


Figure 29 MWC-35, seasonal trends.

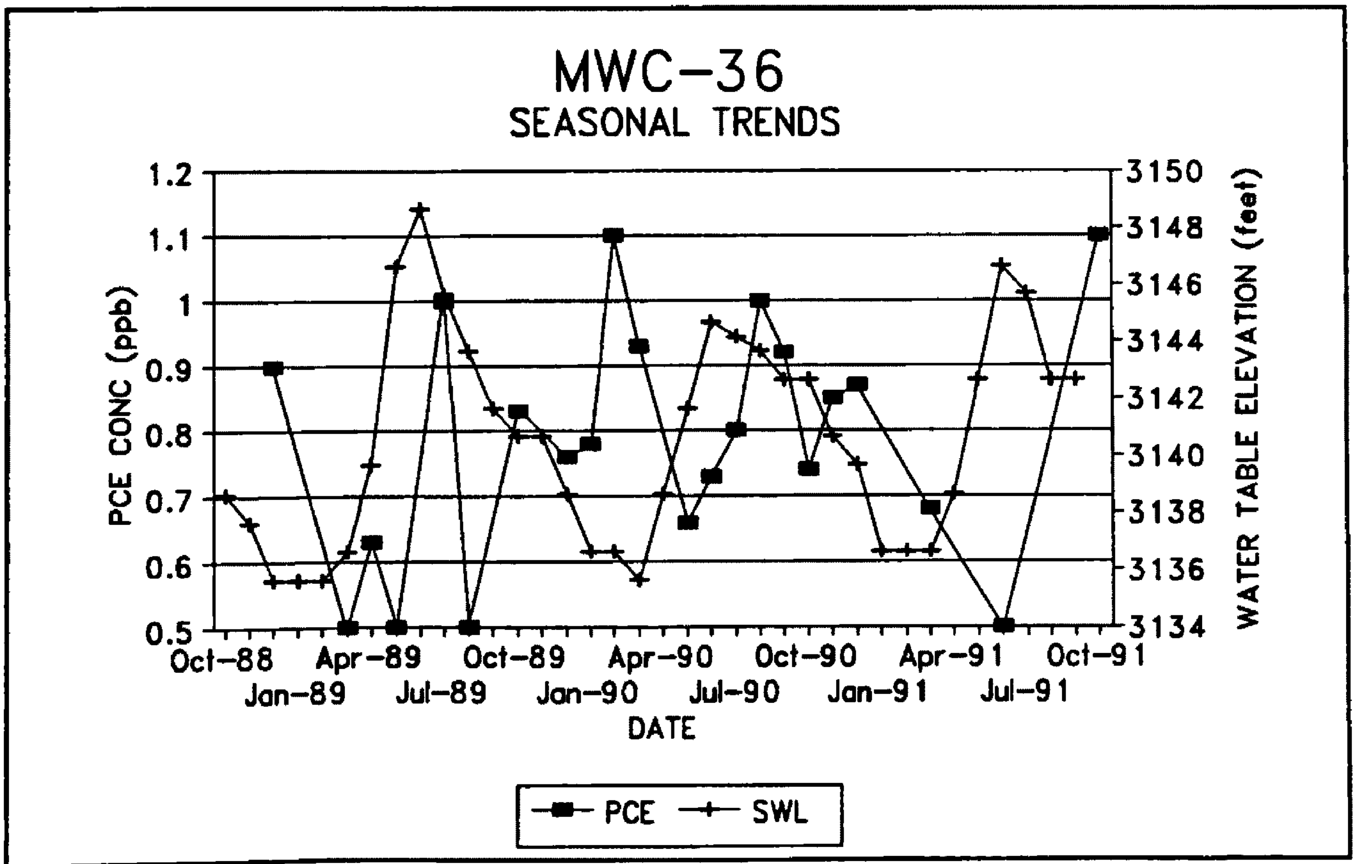


Figure 30 MWC-36, seasonal trends.

perchloroethylene. Many additional potential sources of VOC contamination have been identified, but there is no evidence of the use of PCE. On this potential source map is overlaid the capture zone of the MWC wells in the study area (Hydrometrics, 1991).

The location of a source directly upgradient of a well results in contamination of that well regardless of well depth or pumping rate. The most severe contamination is along the railroad tracks and in the Southgate Mall area. These areas have the unfortunate combination of a missing Unit Two, and high density of potential sources.

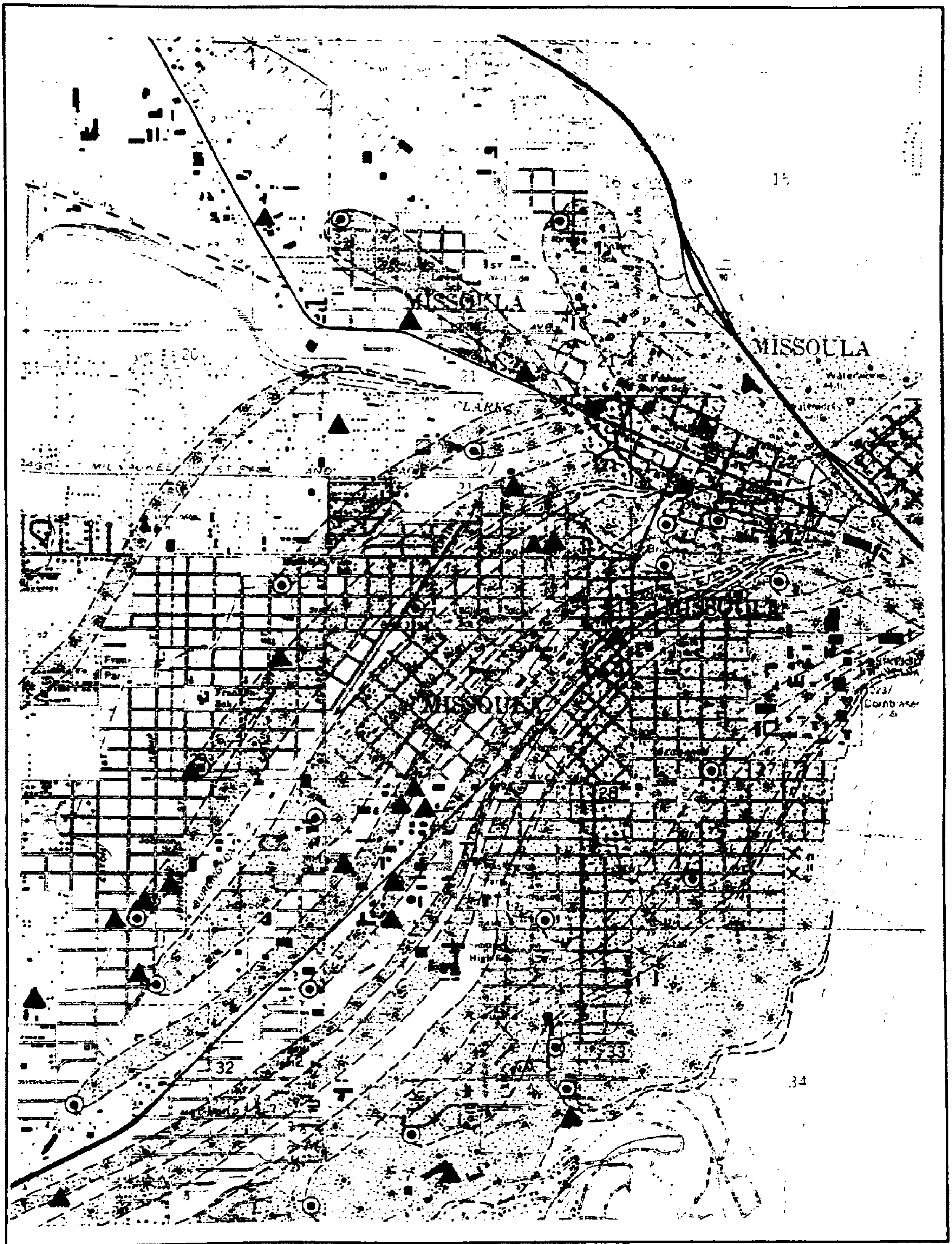


Figure 31 Potential Sources (triangles) and MWC capture zones.

CHAPTER FIVE

COMPUTER MODELING

In order to better understand the 3-D flow system around wells in the Missoula Valley Aquifer, I used MODFLOW (McDonald and Harbaugh, 1988) to generate steady state flow fields for four generic stratigraphic settings common to the MVA. I then used PATH3D (Zheng, 1990), a particle tracking program which utilizes MODFLOW output, to calculate path lines to a well in three dimensions.

Conceptual Model

On a regional scale, it is valid to conceptualize the Missoula Valley Aquifer as a two-dimensional, unconfined aquifer. Aquifer tests by Miller (1990) indicate that layers within the aquifer are well connected, and my review of well logs from the valley indicates that Unit Two is discontinuous, as well as highly variable in terms of composition and thickness.

However, on a local scale, Unit Two has the potential to control the flow dynamics around a pumping well. I conceptualize the perchloroethylene (PCE) contamination in the MVA to be the result of infiltrating PCE which reaches the water table in the dissolved phase, or dissolves within the upper portion of the aquifer. PCE is then drawn to pumping wells by advection rather than sinking to the bottom of the aquifer as a result of its high specific gravity. This conceptual model is supported by data which shows no relationship between well depth and PCE concentration.

Model Selection

I selected MODFLOW, the USGS three-dimensional groundwater flow model because of its availability, excellent documentation, and the past success of other workers in applying it to three-dimensional groundwater flow systems (McDonald and Harbaugh, 1984). The version of MODFLOW I used was MODFLOW-EM (available from International Ground Water Modeling Center). MODFLOW-EM is compiled for use on a computer with extended memory, this allows for the use of large model grids.

PATH3D is a particle tracking program for calculating groundwater paths in three-dimensional flow fields. PATH3D is a well documented and carefully verified three-dimensional particle tracking program that has been successful in solving a wide range of field problems (Zheng, 1990). In order to take advantage of the available extended memory I recompiled version 2.5 of PATH3D (available from Papadopulos and Associates) using the Lahey FORTRAN compiler. To allow for the use of a larger model grid, it was necessary for me to modify the LENY array in the main program of PATH3D before recompiling the source codes.

MODFLOW Input

I created a variable grid system which modeled an area of 2000 feet by 965 feet. In all cases, the 2000 feet long Y axis was oriented parallel to groundwater flow and modeled as a no-flow boundary. The upper and lower boundaries of the 965 feet long X axis were modeled as constant head cells to create a pre-pumping gradient of 0.0009. The variable grid consists of 82 rows, 41 columns (Figure 32), and 9 layers. A single well is modeled at column 21, row 60. The well pumps at 945 GPM; withdrawal is split evenly between layers 6 and 7. The variable grid system was used in order to provide a higher degree of resolution around the pumping well. The largest cell dimension is 30 feet by 30 feet; the cells around the well are the smallest at 15 feet by 15 feet. The parameters described above remain constant for each of the four stratigraphic settings that were modeled. Table 7 summarizes the parameters that vary between models; schematic representations of the four stratigraphic settings that were modeled are shown (Figure 33 through Figure 36).

Although these models are somewhat generic, they are intended to be representative of actual conditions found in the Missoula Valley Aquifer. The pumping well in the model is based upon MWC-07. MWC-07 has an average pumping rate of 945 GPM, and is finished about 20 feet above the bottom of the aquifer, with 14 feet of perforated interval. The hydraulic conductivity value that I used for the coarse-grained layer (Unit Three) is 9000 ft/d, which is based upon the results of Miller's (1990) aquifer test at MWC-07. Miller also

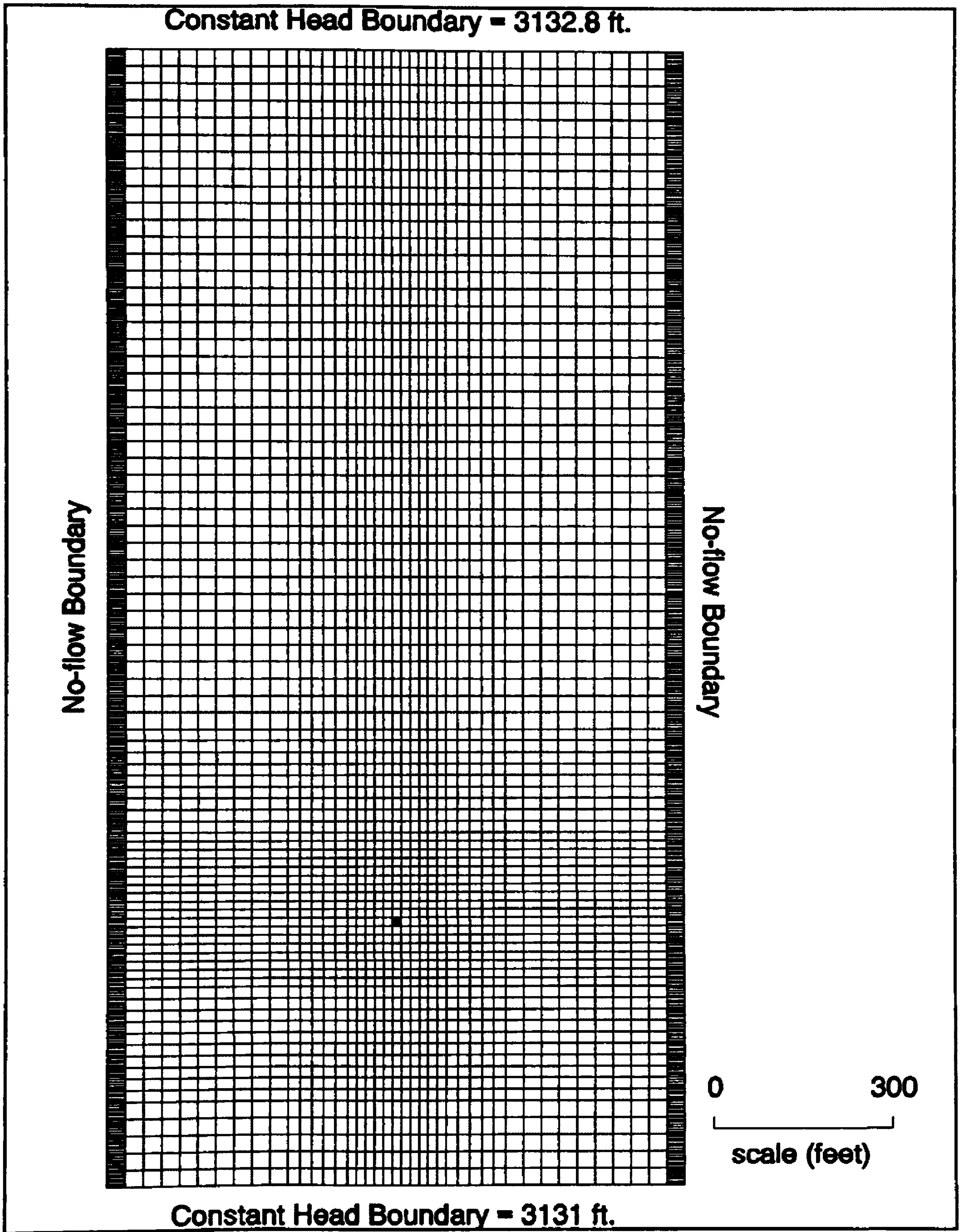


Figure 32 Model grid. Well location indicated by black square.

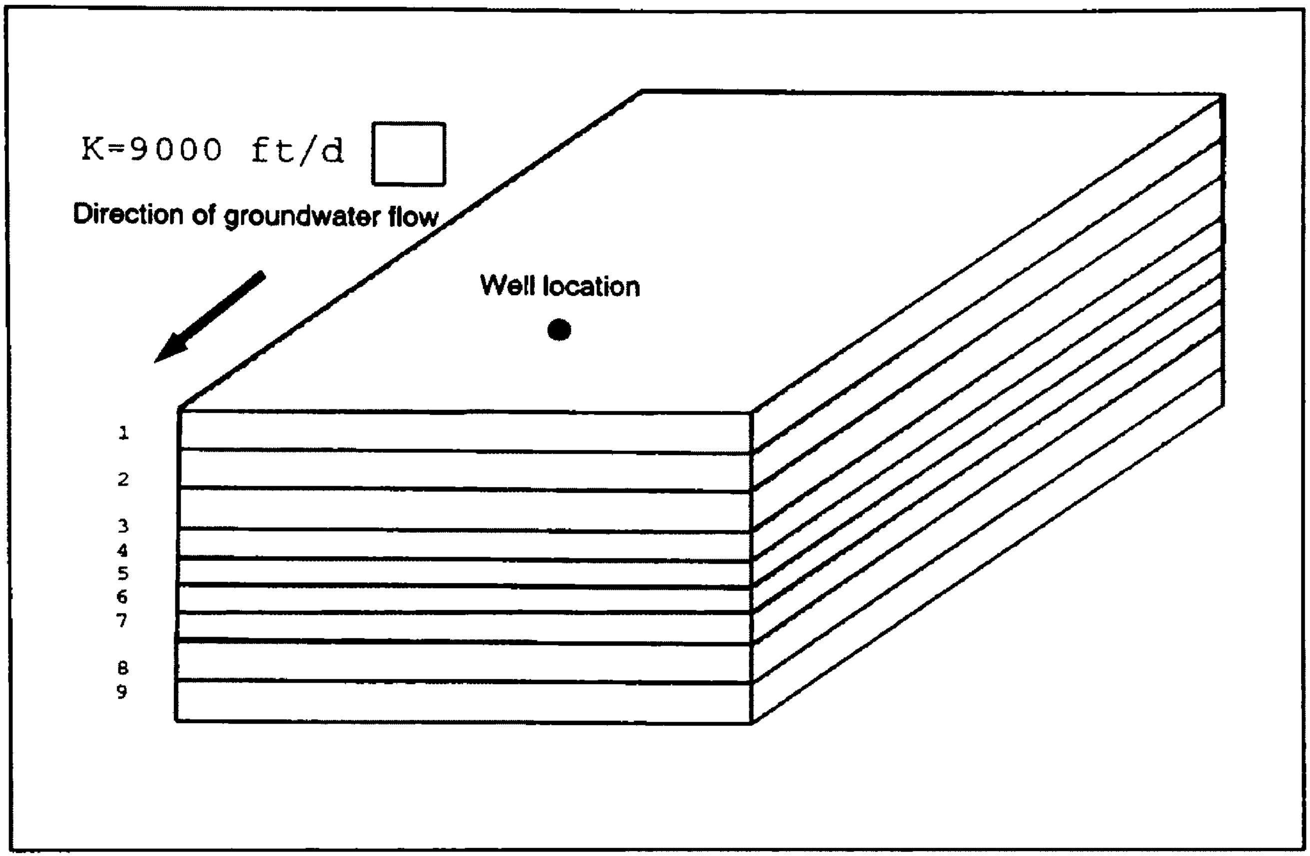


Figure 33 Stratigraphic setting A.

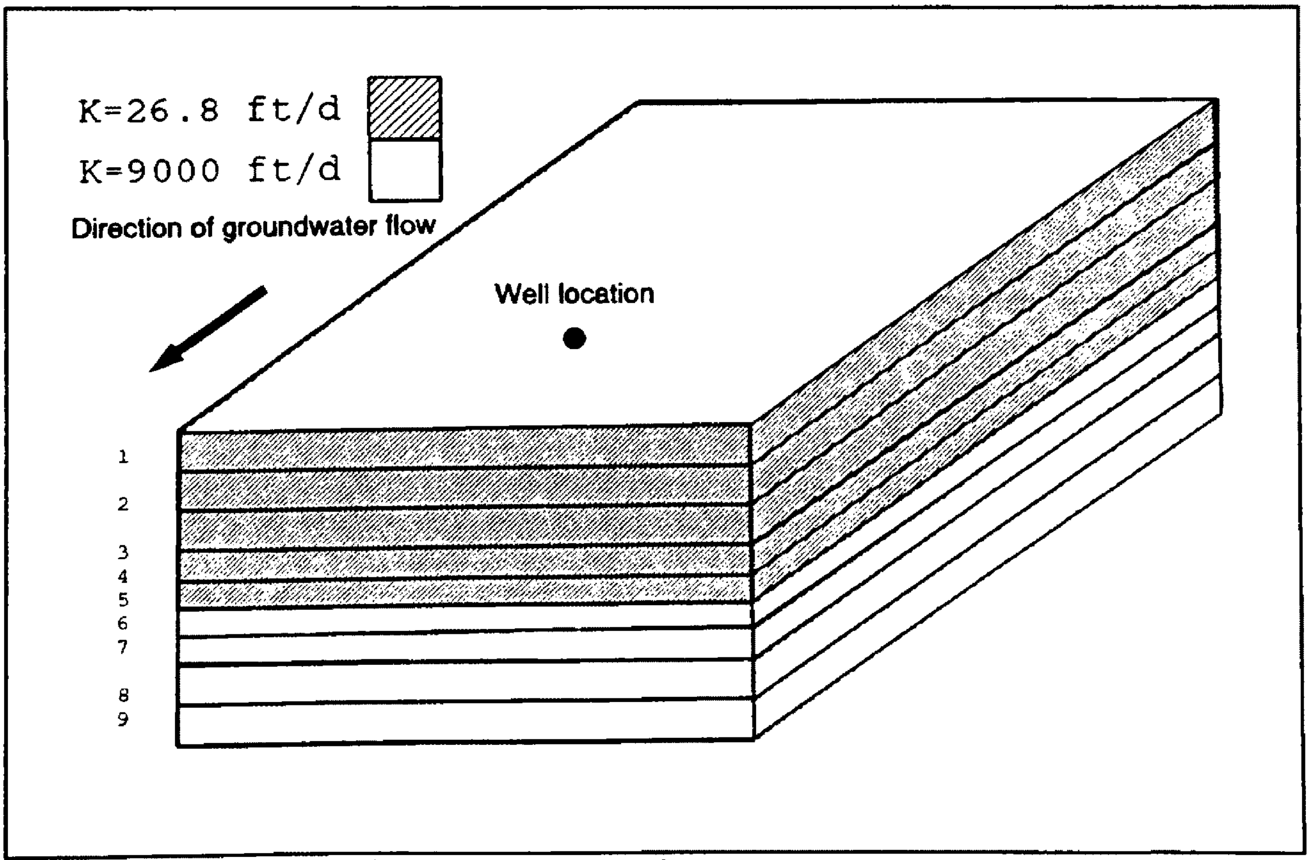


Figure 34 Stratigraphic setting B.

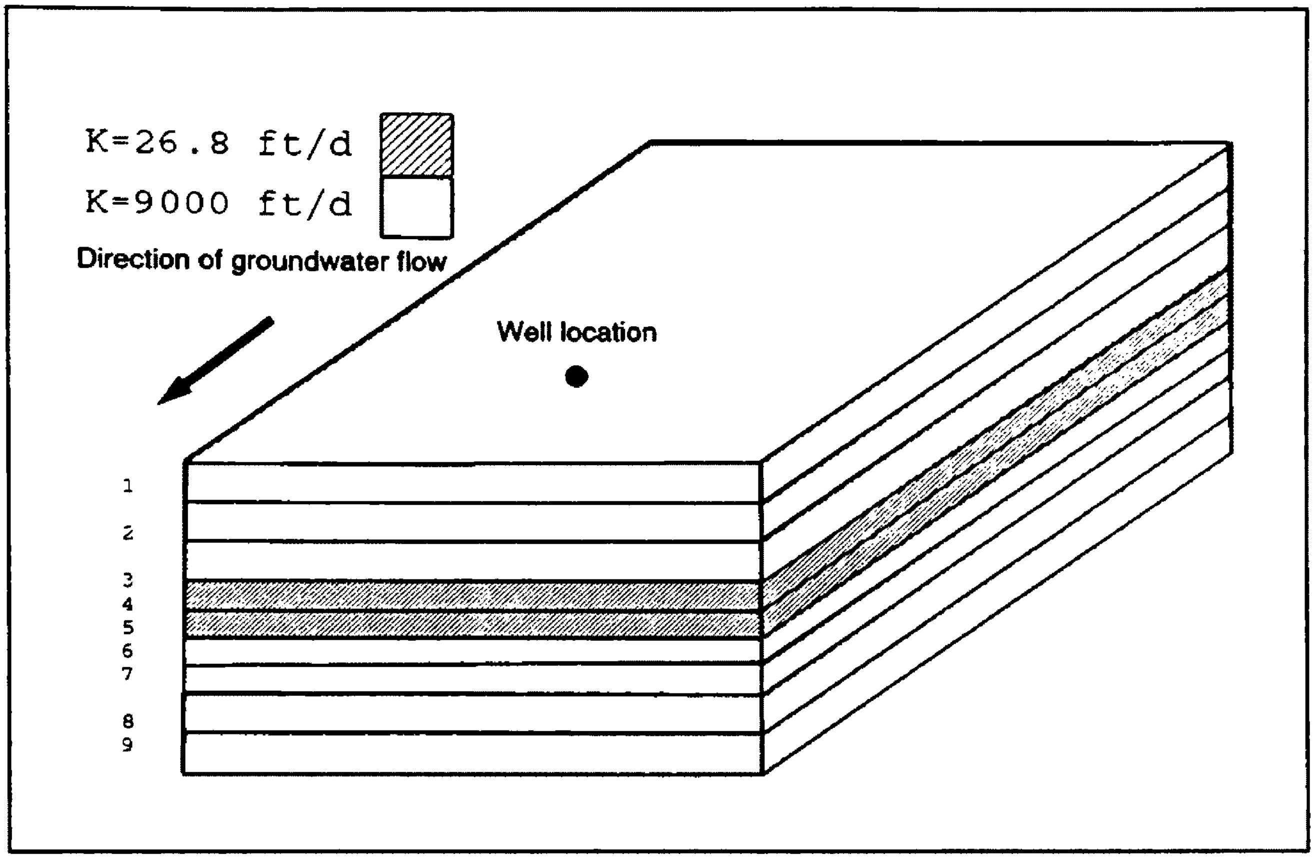


Figure 35 Stratigraphic setting C.

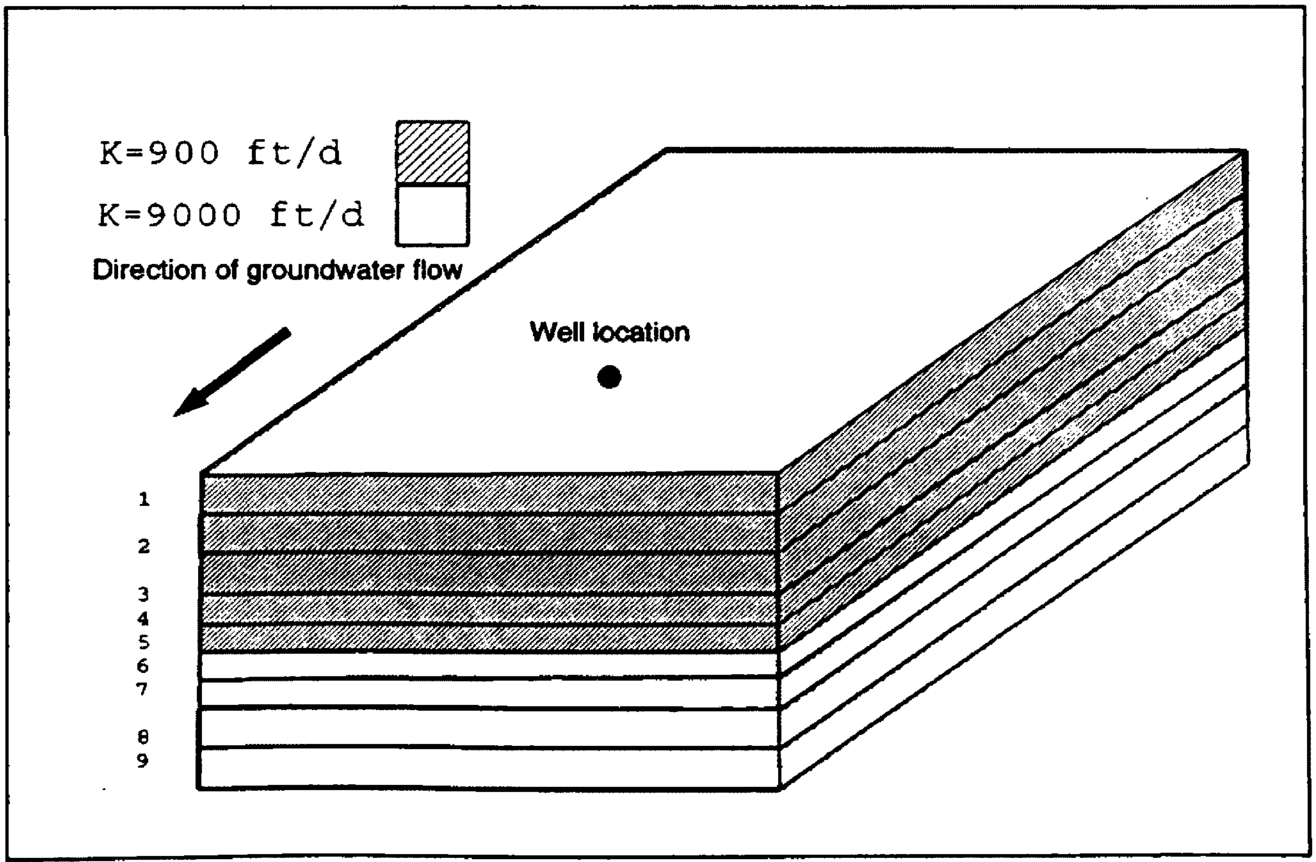


Figure 36 Stratigraphic setting D.

Table 7 Model parameters.

Layer	Thick.	Parameter	Setting A	Setting B	Setting C	Setting D
1	10 ft	K_x (ft/s)	0.104167	0.0003102	0.104167	0.0104167
		Bottom (ft)	3122	3122	3122	3122
		VCONT(ft/s)	0.003125	0.3102E-05	0.003125	0.10417E-03
2	10 ft	T (ft^2/s)	1.04167	0.003102	1.04167	0.104167
		VCONT (ft/s)	0.003125	0.3102E-05	0.003125	0.10417E-03
3	10 ft	T (ft^2/s)	1.04167	0.003102	1.04167	0.104167
		VCONT(ft/s)	0.003125	0.3600E-05	0.89E-05	0.12255E-03
4	7 ft	T (ft^2/s)	0.729169	0.0021714	0.0021714	0.0729167
		VCONT(ft/s)	0.004463	0.4400E-05	0.440E-05	0.14880E-03
5	7 ft	T (ft^2/s)	0.729169	0.0021714	0.0021714	0.0729167
		VCONT(ft/s)	0.0044643	0.8900E-05	0.890E-05	0.28800E-03
6	7 ft	T (ft^2/s)	0.729169	0.729169	0.729169	0.729169
		VCONT(ft/s)	0.446E-02	0.446E-02	0.446E-02	0.446E-02
7	7 ft	T (ft^2/s)	0.729169	0.729169	0.729169	0.729169
		VCONT(ft/s)	0.3906E-02	0.3906E-02	0.3906E-02	0.3906E-02
8	9 ft	T (ft^2/s)	0.937503	0.937503	0.937503	0.937503
		VCONT(ft/s)	0.0032895	0.0032895	0.0032895	0.0032895
9	10 ft	T (ft^2/s)	1.04167	1.04167	1.04167	1.04167

calculated a vertical hydraulic conductivity of 2700 ft/d at this location. I modeled the aquifer base at 77 feet below the static water level based upon my interpretation of the depth to the Tertiary sediments at this location (Figure 9). Hydraulic conductivity (K) values for the fine-grained layers in model settings B and C are taken from Woessner's (1988) estimate for Unit Two (26.8 ft/d). Based upon my review of well logs, I consider this value to be much too low for the central portion of the valley. In model setting D, I increased the K of the fine-grained layer to 900 ft/d. A hydraulic conductivity of 900 ft/d is a reasonable value for a silty, sandy, gravel (Freeze and Cherry, 1979; Fetter, 1988). The input files for the final MODFLOW simulations are in Appendix C.

PATH3D Input

PATH3D is designed as a post processor for MODFLOW; hence, little modification is required of the MODFLOW data files. PATH3D requires several variables to be added to the Block Centered Flow (BCF) package of MODFLOW. The PATH3D input files are also found in Appendix C. The porosity values for the coarse-grained layers is set at 20% (Woessner, 1988). In model settings B and C, I set the porosity for the fine-grained layers at 35%; in model setting D, the porosity was set at 30%. Both of these values are representative of porosity for such unconsolidated sediments (Davis and DeWiest, 1966; Freeze and Cherry, 1979).

In addition to the modification of the BCF file, PATH3D requires a particle tracking input file with additional information. The particle tracking input file contains information about the number of particles to be inserted and their location.

Model Results

For each of the four stratigraphic settings (A, B, C, D) that I modeled, I inserted particles at the water table and on the aquifer bottom. By inserting particles at both the top and bottom of the saturated zone I was able to compare the zone of contribution at both levels.

In an attempt to display the three-dimensional flow systems in two dimensions, I have drawn schematic representations of the data generated by PATH3D. The following information is necessary to fully understand the schematic drawings. The general direction of groundwater flow is from left to right. Solid flow lines indicate horizontal movement, dashed lines indicate vertical movement of a particle.

For particles inserted at the water table the following is true: the upper block in the schematic represents model layers 1, 2 and 3. The middle block represents layers 4 and 5; the bottom block represents layer 6 and 7 of the model. Layers 8 and 9 are not represented in these drawings because the particles never enter these layers.

For particles inserted at the aquifer bottom, the top block represents model layers 4 and 5. The middle block represents layers 6 and 7; the bottom block represents model layers 8 and 9. Layers 1, 2 and 3 are not represented in these schematics because the particles never enter these layers.

In all four of the stratigraphic settings modeled, the flow fields remained unaffected by the pumping well until the particles were within 200 feet of the well. Further, in all cases, the particles remained in the same model layer until they were within about 75 feet of the well.

Stratigraphic setting A (constant K of 9000 ft/d) is analogous to the two-dimensional regional model used by Hydrometrics (1991) to develop wellhead protection zones for Mountain Water Company wells. The coarser grid necessary to run the regional model does not supply the same degree of resolution as this local model does. Therefore, it is difficult to compare the capture zones between the Hydrometrics model and my stratigraphic setting A. Results of this model indicate that the high K produces a narrow capture zone in the order of about 75 feet wide (Figure 37 and Figure 38). Stratigraphic setting A is representative of the central part of the valley in areas where Unit Two is absent, or lies above the water table.

In stratigraphic setting B, the capture zone for the pumping well is the largest for any of the settings modeled. This generic model represents a situation in which an unusually fine-grained (K=26.8 ft/d) Unit Two lies above the extremely coarse-grained (K=9000 ft/d) Unit Three. Situations such as this may be found in localized areas of the aquifer where Unit Two is composed of a clay layer. It should be noted that the low K in the upper layers resulted in slight boundary effects along the no-flow boundaries; on one side the furthest particle was pulled one column towards the pumping well. This generic model resulted in the greatest effect on the flow field (Figure 39 and Figure 40) of any situation modeled.

Stratigraphic setting C models a relatively rare situation in the Missoula Valley Aquifer, one in which all three hydrostratigraphic units are saturated. This situation might be found near the Clark Fork River where the water table is shallow. In this generic model, I used Woessner's (1988) estimate for hydraulic conductivity for Unit Two (26.8 ft/d), and applied Miller's (1990) aquifer test data to Units One and Three (K=9000 ft/d). In the first particle tracking simulation for this stratigraphic setting, I inserted the particles at the water table. Every particle passed through the system virtually unaffected by the pumping well (Figure 41) (i.e. it passed through the system without changing columns or layers). To further evaluate the effect of Unit Two in this situation, I inserted particles at 25 feet below the water table (5 feet above the top of Unit Two in

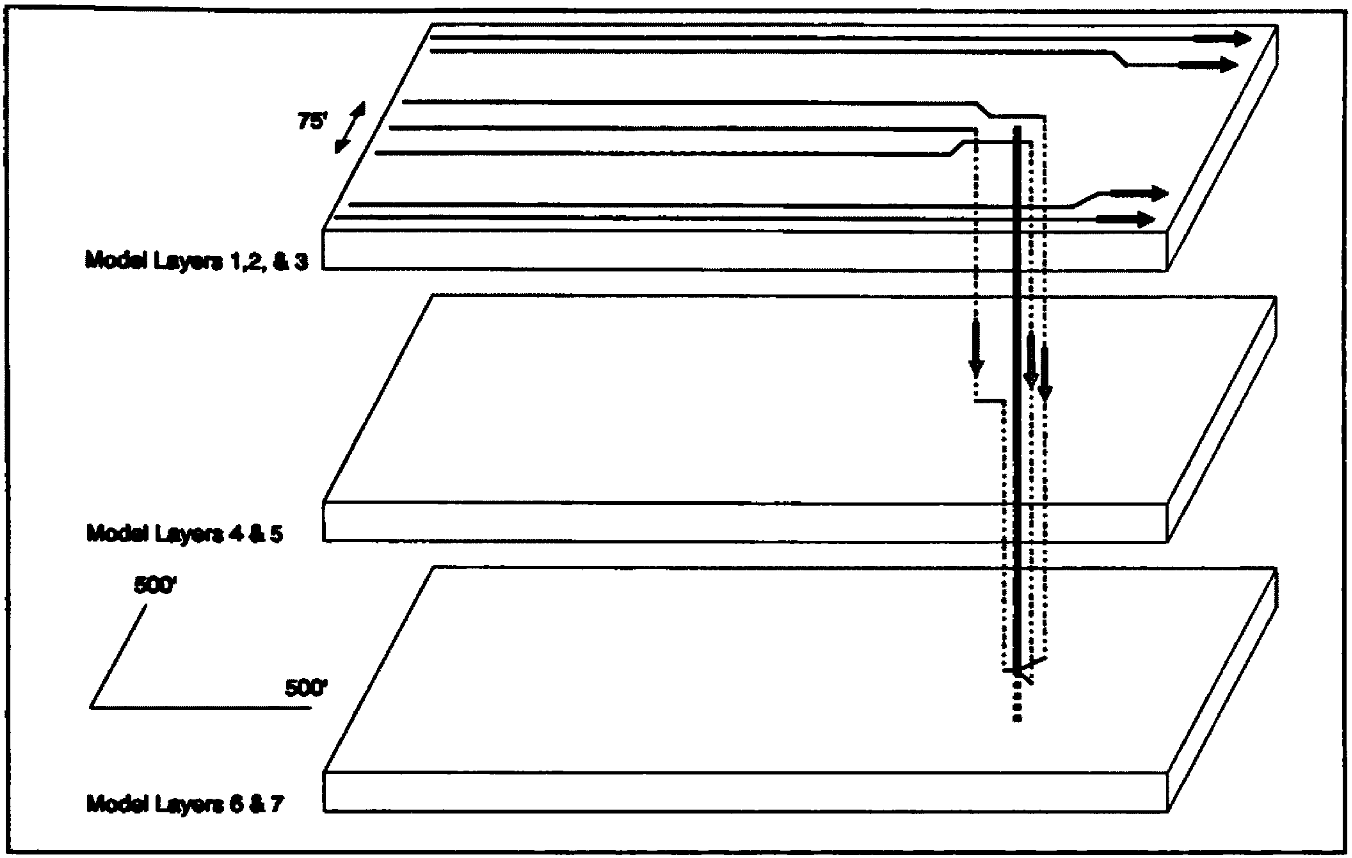


Figure 37 Scenario A. Particles inserted at the water table.

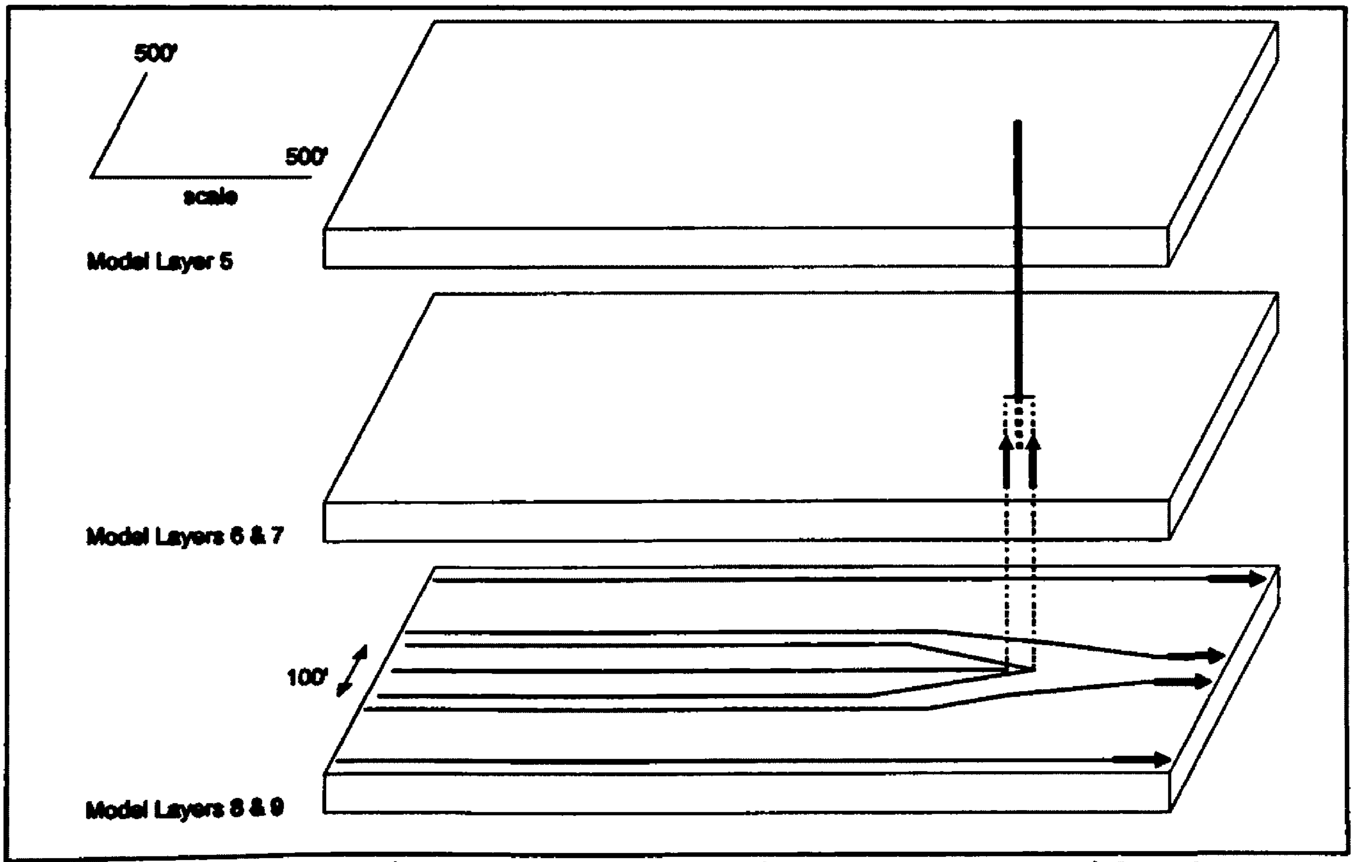


Figure 38 Scenario A. Particles inserted at aquifer bottom.

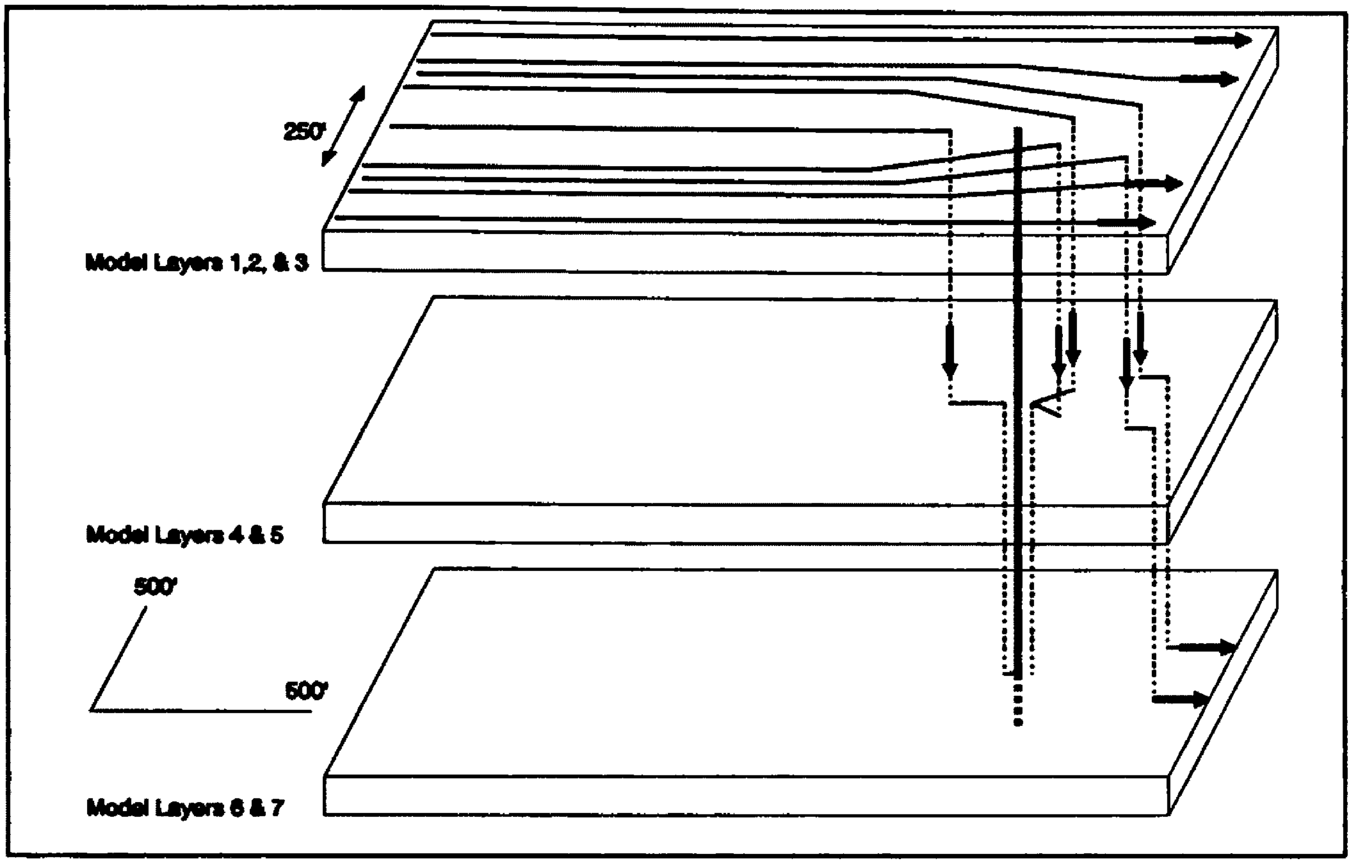


Figure 39 Scenario B. Particles inserted at the water table.

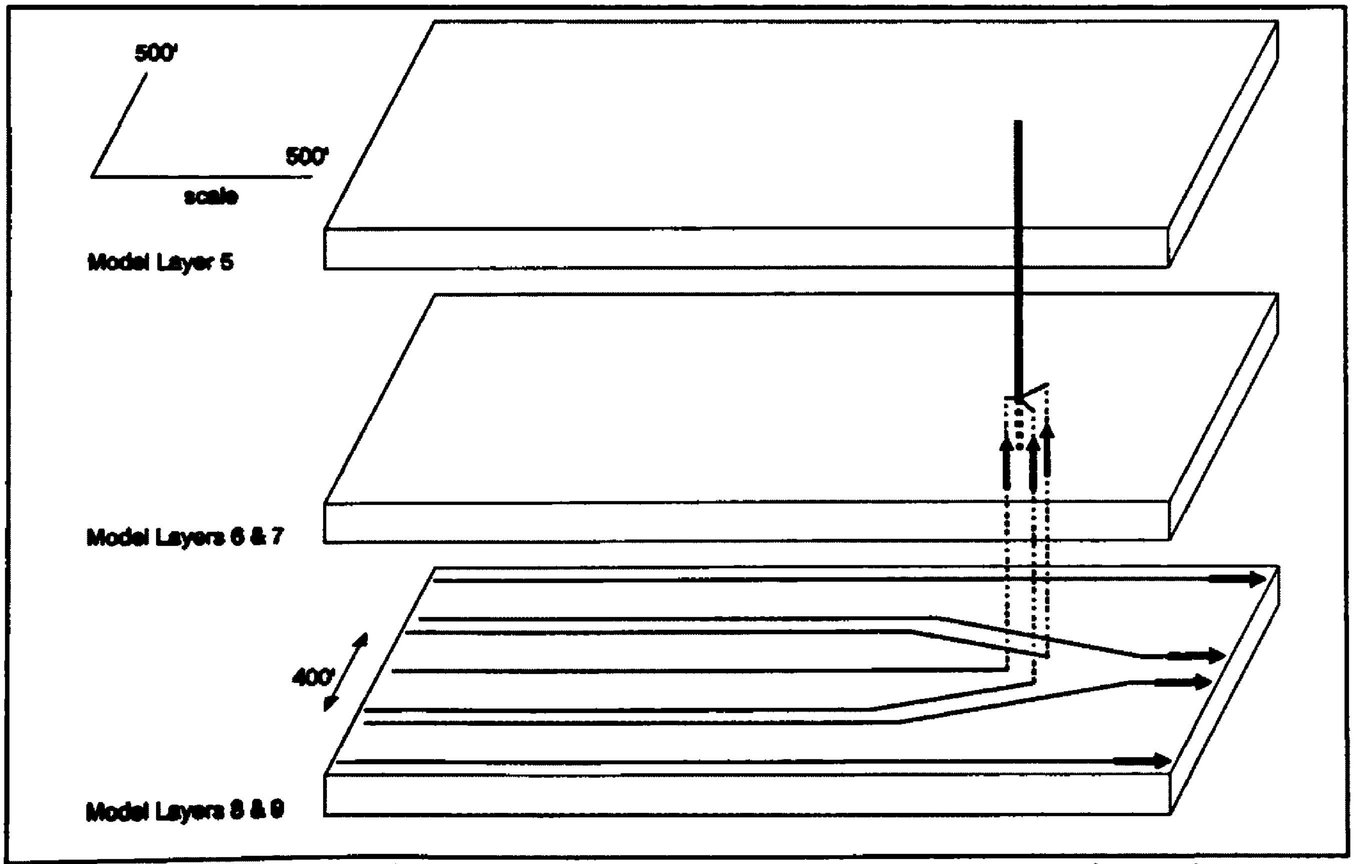


Figure 40 Scenario B. Particles inserted at aquifer bottom.

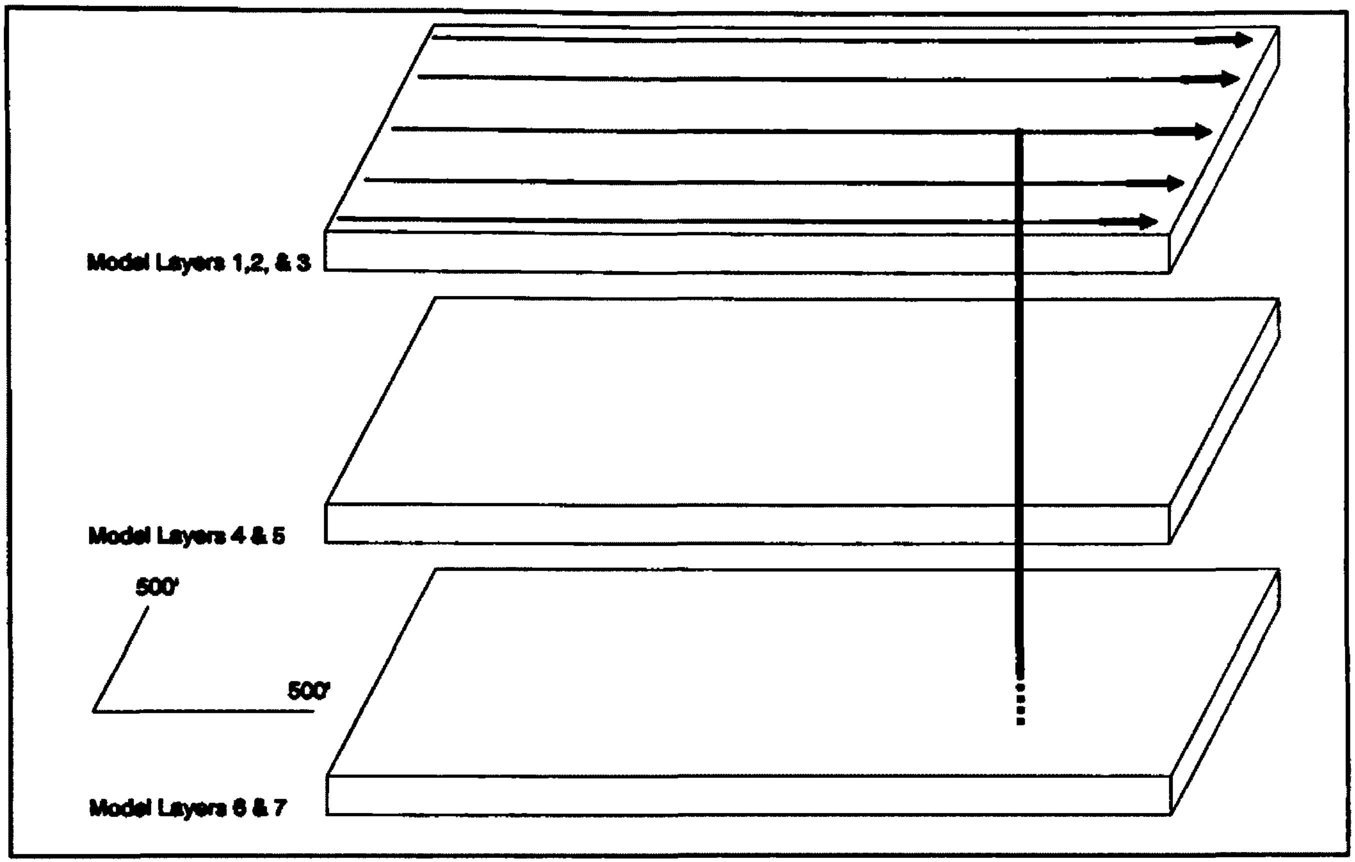


Figure 41 Scenario C. Particles inserted at the water table.

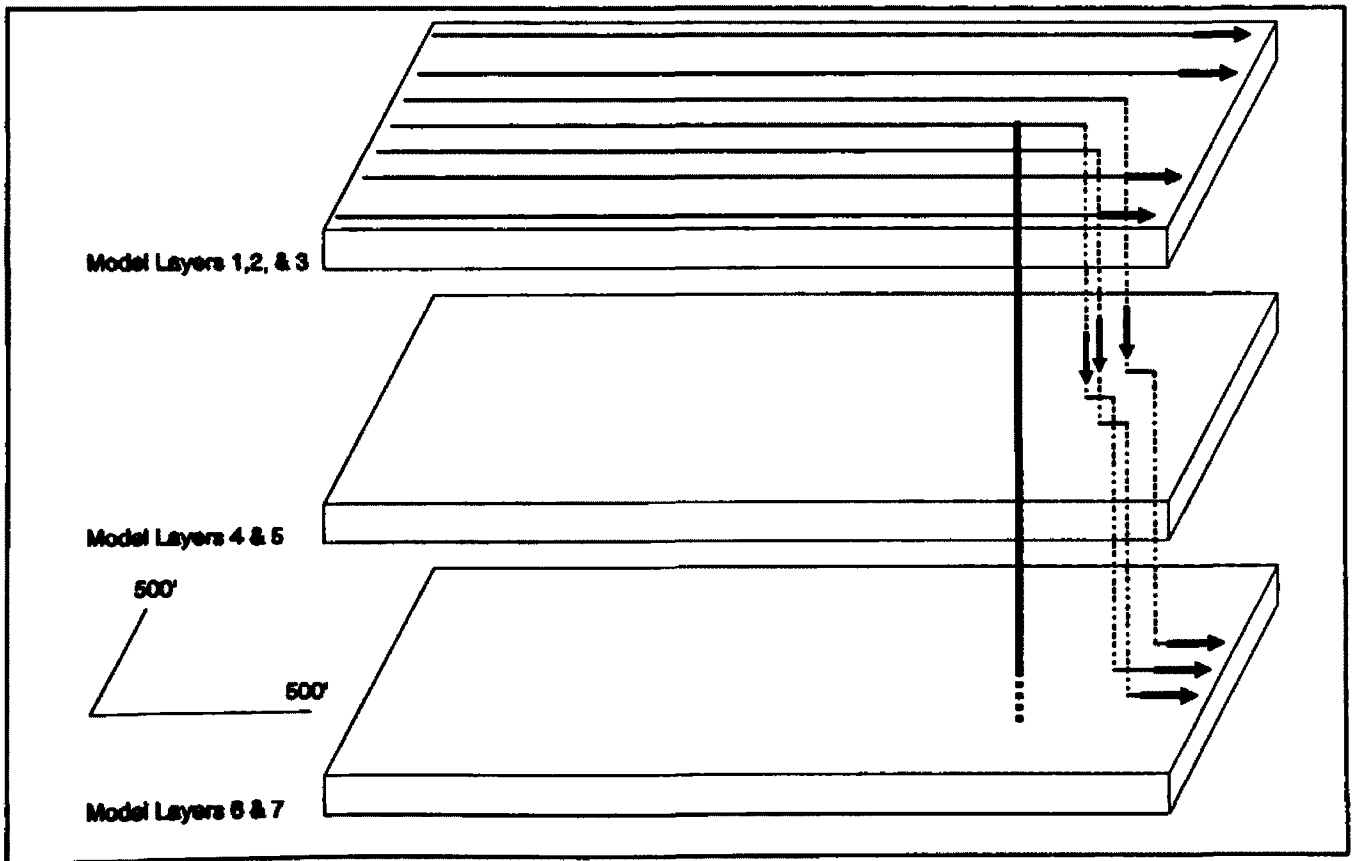


Figure 42 Scenario C. Particles inserted 25 feet below the water table.

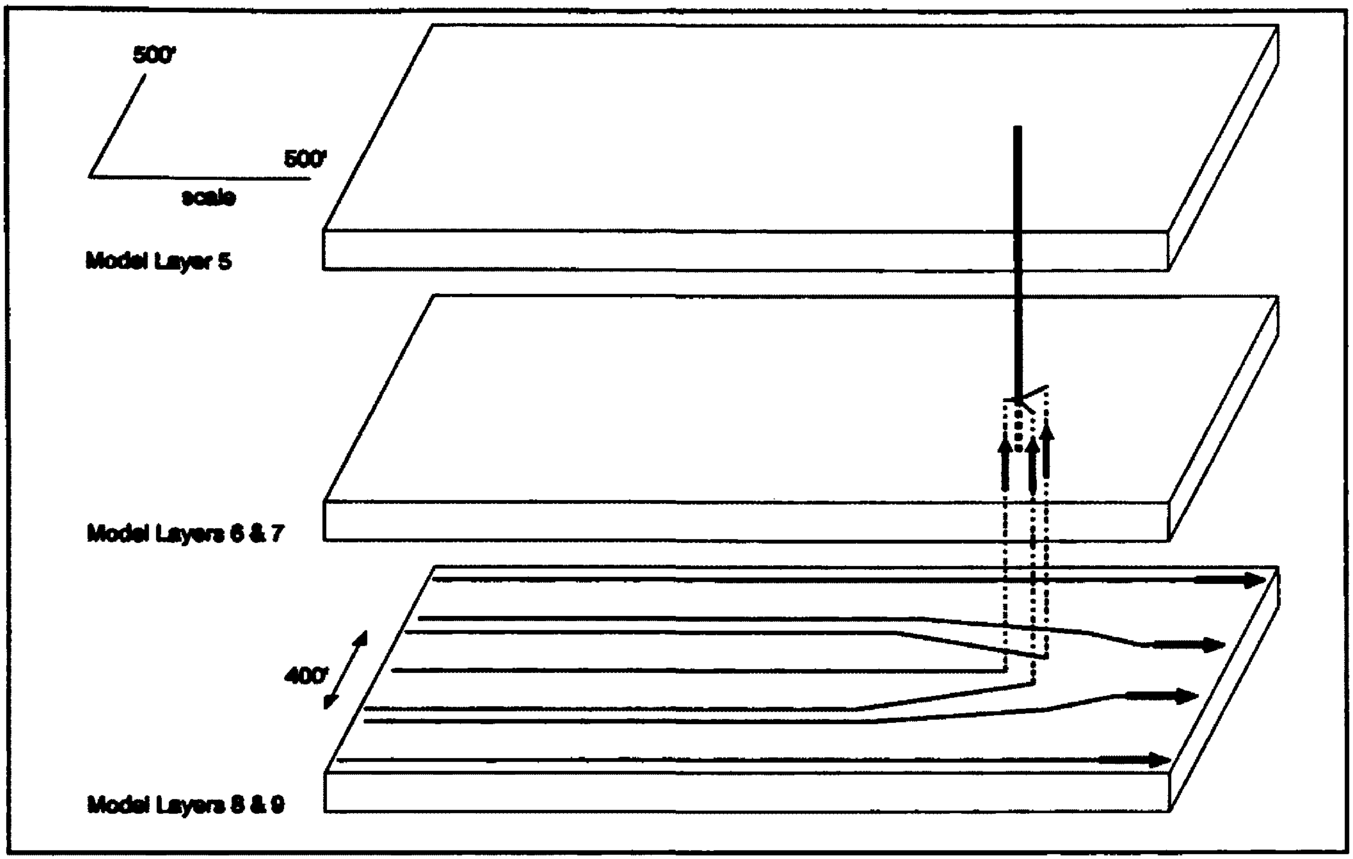


Figure 43 Scenario C. Particles inserted at aquifer bottom.

this model). In this situation, the particles were unaffected by the pumping well until they passed by the well. Particles within 30 feet of the well were drawn down into layer 6 after passing by the well but continued to flow downgradient to the model boundary (Figure 42). None of the particles inserted above Unit Two in this model were captured by the well. The capture zone for particles inserted at the aquifer bottom (Figure 43) is very similar for stratigraphic settings B and C.

Stratigraphic setting D represents a situation which is relatively common in the Missoula Valley Aquifer; Unit Two is

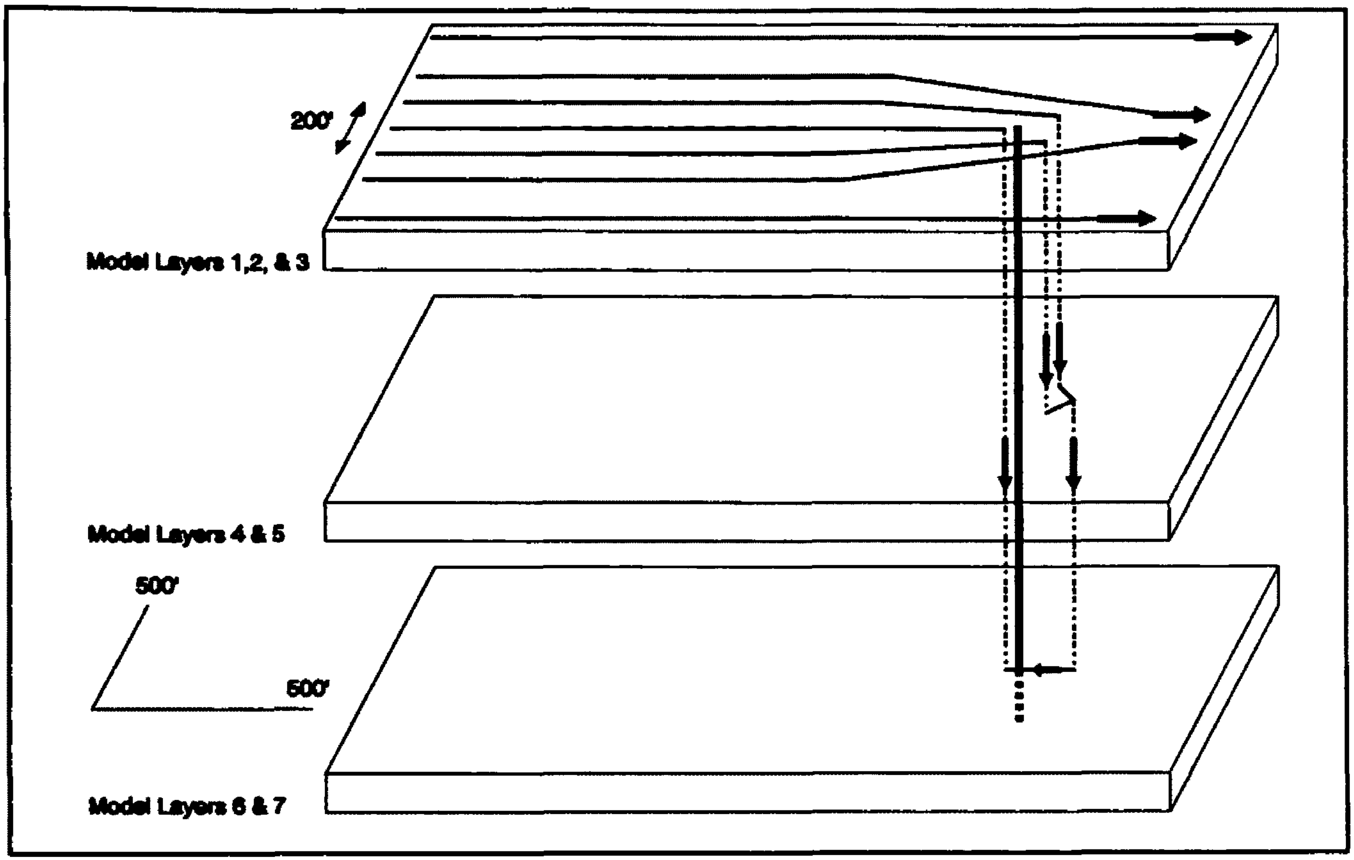


Figure 44 Scenario D. Particles inserted at the water table.

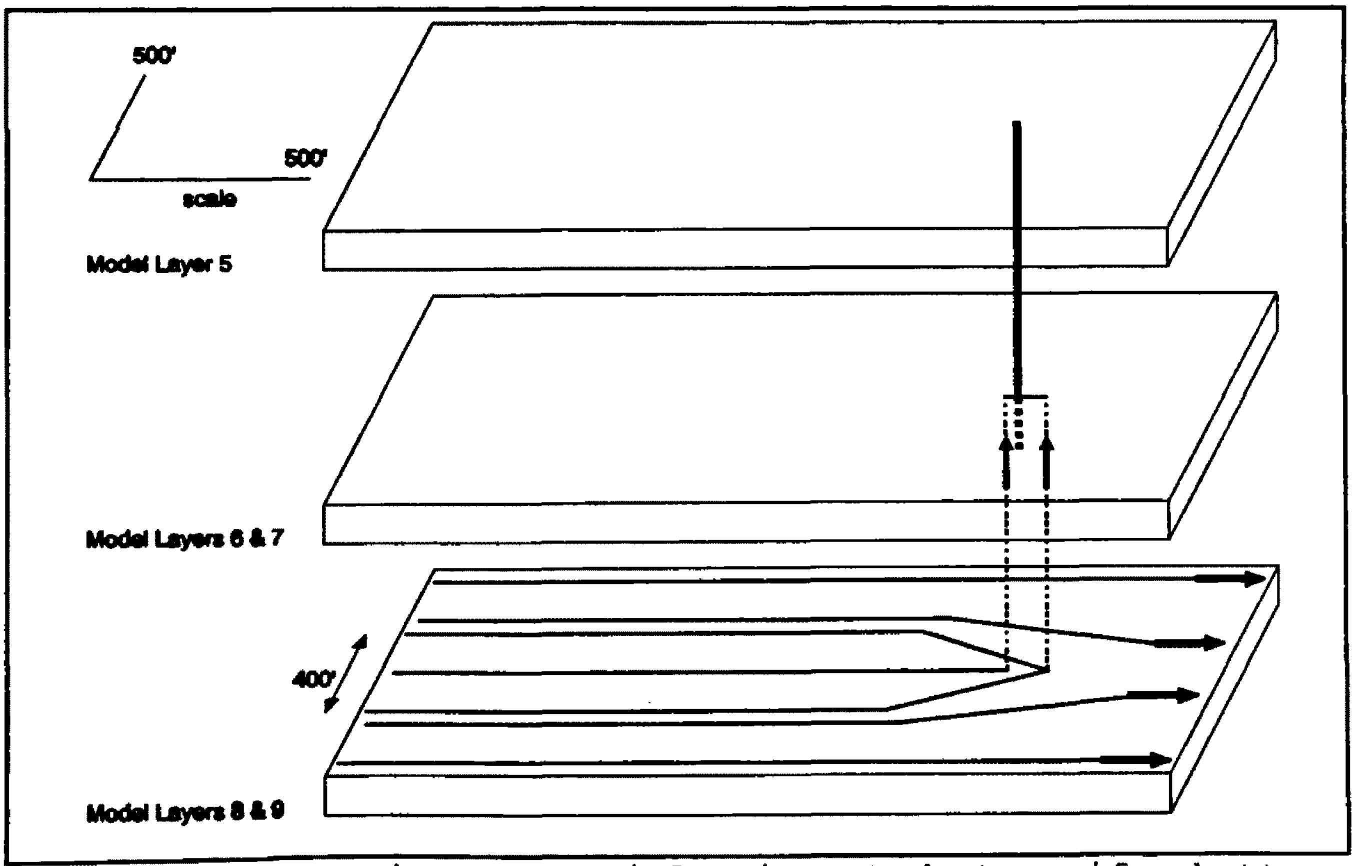


Figure 45 Scenario D. Particles inserted at aquifer bottom.

present as a silty, sandy, gravel layer (K=900 ft/d), and Unit Three is an extremely coarse-grained layer (K=9000 ft/d). This situation is representative of many areas in the central portion of the study area. As would be expected, the size of the capture zone for this model falls between that of stratigraphic setting A and B. Once again, the flow field is unaffected until the particle is within about 200 feet of the pumping well, and all vertical flow occurs within 75 feet of the well (Figure 44 and Figure 45).

Model Summary

The four generic models discussed above are based upon representative stratigraphic settings within the Missoula Valley Aquifer. These four generic models allow some generalizations to be made about the three-dimensional flow dynamics around large production wells in the Missoula Valley Aquifer. The capture zone widths for each of the stratigraphic settings are shown in Table 8. The capture zone widths vary with the hydraulic conductivities of the aquifer material. In stratigraphic setting A, where there are no fine-grained layers, the capture zones are very narrow. The other stratigraphic settings (B, C, and D) have much wider capture zones. This may be caused by the pumping well drawing the majority of its water from a much smaller portion of the aquifer.

These generic models also indicate that deep wells with high pumping rates are capable of drawing contaminants directly from the water table under the most common stratigraphic settings. This means that even the deepest wells in the MVA may be vulnerable to contaminants that are present in the upper portion of the aquifer.

Table 8 Capture zone widths (feet).

Particle Location	Setting A[1]	Setting B[2]	Setting C[3]	Setting D[4]
Inserted at SWL	75	250	0[*]	200
Inserted at 25′ below SWL	NA	NA	0[*]	NA
Inserted at bottom	100	400	400	400

[1] Unit Two not present.

[2] Unit Two in model layers 1,2,3,4, and 5. (K = 26.8 ft/d).

[3] Unit Two in model layers 4 and 5. (K = 26.8 ft/d).

[4] Unit Two in model layers 1,2,3,4, and 5. (K = 900 ft/d).

[*] No particles captured by pumping well.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The level of perchloroethylene contamination in the MVA has been relatively constant since its discovery in June of 1988. Because of the oxygenated, low organic content nature of the aquifer, the contamination will likely persist at declining levels for years, even after the sources are controlled or eliminated.

Dissolved perchloroethylene is continually detected at some wells, but in the late summer concentrations increase. This peak comes about one month after the seasonal water table high. Most likely, as the water table rises, it comes into contact with PCE-contaminated lenses or residual and creates higher levels of dissolved product in the aquifer. Another possible explanation for the seasonal fluctuation in the PCE concentration is infiltration from the surface which passes through a zone of residual saturation in the vadose zone. I assume the travel time to the well accounts for the lag between the concentration peak and the water table high.

Near Southgate Mall, in the central part of the valley, Unit Two appears to be absent, leaving the aquifer without a fine-grained layer in this area. However, Unit Two most likely does offer some marginal protection in that where it is present, it would act to spread the contamination over time (due to its greater retention capacity as compared to Units

One and Three) and space, thus reducing a small, isolated waste stream to a more diffuse source. This is in contrast to the margins of the valley, near Pattee Creek and Rattlesnake Creek, where there are clay layers that appear to be sufficiently fine-grained to offer significant protection against the infiltration of contaminants from the surface.

Multiple sources of perchloroethylene contamination have been identified. Undoubtedly, some of these sources account for the widespread contamination of the aquifer. My analysis of the available data indicates that there has been no single spill which was capable of forming a free phase pool at the bottom of the aquifer. Instead, I hypothesize that the perchloroethylene is dissolved in the upper portion of the aquifer.

Three dimensional groundwater modeling indicates that large production wells have a narrow capture zone in the Missoula Valley Aquifer (as little as 75 feet wide). Generally, contaminants at the water table will be drawn into the well rather than flowing by. This indicates that dissolved PCE in the upper portion of the aquifer will likely be captured by the deep, large production wells. The exception to this is the situation in which a saturated Unit One lies above a modeled low hydraulic conductivity Unit Two.

Recommendations

To further define the stratigraphy of the Missoula Valley Aquifer, it will be necessary to drill additional monitoring wells with geologists on hand to properly log the wells. The flow system of the Missoula Valley Aquifer is well understood, with the exception of the vertical component of flow. Nested monitoring wells at selected locations would answer many of the remaining questions about both the stratigraphy and the flow system.

Protection of Missoula's vulnerable Sole Source Aquifer requires that contamination be prevented rather than remediated. Banning the retail sale and use of perchloroethylene and other halogenated solvents in Missoula County would prevent the major problem of unregulated users. Currently, dry cleaners are the largest single users of perchloroethylene in Missoula; continued use of halogenated products at these facilities will be necessary until economically viable alternatives are available. Until that time, dry cleaners should be thoroughly investigated to insure proper storage, handling and disposal of their wastes. The use of a municipal sewer system for perchloroethylene disposal has been documented as the source of groundwater contamination in Bozeman, Montana (Bugosh, 1990). This points to the need for testing the sewer lines outside of these facilities for VOCs and also for insuring the integrity of the service line and connection. Vadose zone sampling directly below the service connection should also be done.

Automotive service stations and carwashes are also documented sources of PCE in Missoula. Economical and effective alternatives are available for use in these facilities. The elimination of 5X28 injection wells combined with a ban on the retail sale of halogenated solvents would largely eliminate these facilities as sources.

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APPENDICES

APPENDIX A

SUMMARY OF VOC DATA

Regulated and Unregulated Volatile Organic Compoounds (VOCs)
EPA Methods 502.2 & 524.2
Sampling: 2-40 ml glass/teflon vials completely full with no air bubbles.
Store at 4 degrees C. Add 10 mg sodium thiosulfate to chlorinated samples.
Preserve with two drops hydrochloric acid per vial.

Holding Time: 14 days.

Compound	MDL (ug/l)	Compound	MDL (ug/l)
Benzene	0.50	1,2-Dichloropropane	1.00
Bromobenzene	1.00	1,3-Dichloropropane	1.00
Bromochloromethane	1.00	2,2-Dichloropropane	1.00
Bromodichloromethane	1.00	1,1-Dichloropropene	1.00
Bromoform	1.00	cis-1,3-Dichloropropene	1.00
Bromomethane	1.00	trans-1,2-Dichloropropene	1.00
n-Butylbenzene	1.00	Ethylbenzene	1.00
sec-Butylbenzene	1.00	Hexachlorobutadiene	1.00
tert-Butylbenzene	1.00	Isopropylbenzene	1.00
Carbon tetrachloride	0.50	p-Isopropyltoluene	1.00
Chlorobenzene	1.00	Methylene Chloride	1.00
Chloroethane	1.00	Naphthalene	1.00
Chloroform	1.00	n-Propylbenzene	1.00
Chloromethane	1.00	Styrene	1.00
2-chlorotoluene	1.00	1,1,1,2-Tetrachloroethane	1.00
4-chlorotoluene	1.00	1,1,2,2-Tetrachloroethane	1.00
1,2-Dibromo-3-chloropropane	1.00	Tetrachloroethene	0.50
Dibromochloromethane	1.00	Toluene	1.00
1,2-Dibromoethane	1.00	1,2,3-Trichlorobenzene	1.00
Dibromomethane	1.00	1,2,4-Trichlorobenzene	1.00
1,2-Dichlorobenzene	1.00	1,1,1-Trichloroethane	0.50
1,3-Dichlorobenzene	1.00	1,1,2-Trichloroethane	1.00
1,4-Dichlorobenzene	0.50	Trichloroethene	0.50
Dichlorodifluoromethane	1.00	Trichlorofluoromethane	1.00
1,1-Dichloroethane	1.00	1,2,3-Trichloropropane	1.00
1,2-Dichloroethane	0.50	1,2,4-Trimethylbenzene	1.00
1,1-Dichloroethene	0.50	1,3,5-Trimethylbenzene	1.00
cis-1,2-Dichloroethene	1.00	Vinyl chloride	0.50
trans-1,2-Dichloroethene	1.00	Xylenes	1.00

MDL = Minimum Method Detection Limit

DATE	WELL	PCE	TCE	DCE	VC	TCA	BDCM	DBCM	DCFM	CTET	DCEA	NAP	CFRM	COMMENT
4/26/89	MWC-01	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SIXTH STREET WELL
10/3/89	MWC-01	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SIXTH STREET WELL
5/23/90	MWC-01	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SIXTH STREET WELL
6/19/90	MWC-01	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SIXTH STREET WELL
6/20/90	MWC-01	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SIXTH STREET WELL
8/27/90	MWC-01	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SIXTH STREET WELL
9/25/90	MWC-01	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SIXTH STREET WELL
6/27/91	MWC-01	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SIXTH STREET WELL
9/30/91	MWC-01	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SIXTH STREET WELL
4/26/89	MWC-02	0.60	0.0	0.0	0.00	3.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	FOURTEENTH STREET WELL
5/23/89	MWC-02	<0.50	0.0	0.0	0.00	4.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	FOURTEENTH STREET WELL
7/12/89	MWC-02	0.70	0.0	0.0	0.00	2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	FOURTEENTH STREET WELL
8/25/89	MWC-02	<0.50	0.0	0.0	0.00	1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	FOURTEENTH STREET WELL
10/3/89	MWC-02	0.50	0.0	0.0	0.00	0.65	0.0	0.0	0.0	0.0	0.0	0.0	0.0	FOURTEENTH STREET WELL
5/23/90	MWC-02	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	FOURTEENTH STREET WELL
6/19/90	MWC-02	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	FOURTEENTH STREET WELL
7/30/90	MWC-02	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	FOURTEENTH STREET WELL
8/27/90	MWC-02	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	FOURTEENTH STREET WELL
9/25/90	MWC-02	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	FOURTEENTH STREET WELL
6/25/91	MWC-02	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	FOURTEENTH STREET WELL
12/15/88	MWC-07	3.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
3/22/89	MWC-07	3.20	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
4/6/89	MWC-07	1.10	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
4/26/89	MWC-07	1.20	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
5/23/89	MWC-07	2.60	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
7/12/89	MWC-07	8.30	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
7/31/89	MWC-07	8.10	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
8/25/89	MWC-07	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
10/3/89	MWC-07	8.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
12/12/89	MWC-07	4.10	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
1/3/90	MWC-07	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
2/21/90	MWC-07	3.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL

DATE	WELL	PCE	TCE	DCE	VC	TCA	BDCM	DBCM	DCFM	CTET	DCEA	NAP	CFRM	COMMENT
3/21/90	MWC-07	2.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
4/23/90	MWC-07	2.40	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
5/7/90	MWC-07	2.30	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
5/23/90	MWC-07	2.80	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
6/7/90	MWC-07	4.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
6/25/90	MWC-07	9.70	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
6/27/90	MWC-07	4.30	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
7/2/90	MWC-07	8.70	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
7/11/90	MWC-07	9.30	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
7/19/90	MWC-07	6.70	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
7/30/90	MWC-07	7.40	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
7/31/90	MWC-07	7.20	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
8/7/90	MWC-07	8.60	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
8/27/90	MWC-07	8.30	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
9/25/90	MWC-07	6.80	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MPC WELL
10/5/88	MWC-08	3.80	0.0	0.0	0.00	0.00	0.0	0.0	17.0	0.0	0.0	0.0	0.0	SCHILLING STREET WELL
10/18/88	MWC-08	8.50	0.0	0.0	0.00	0.00	0.0	0.0	3.3	0.0	0.1	0.0	0.0	SCHILLING STREET WELL
12/15/88	MWC-08	5.40	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SCHILLING STREET WELL
4/26/89	MWC-08	2.80	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SCHILLING STREET WELL
5/23/89	MWC-08	3.30	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SCHILLING STREET WELL
7/12/89	MWC-08	11.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SCHILLING STREET WELL
7/31/89	MWC-08	13.40	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SCHILLING STREET WELL
7/31/89	MWC-08	11.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SCHILLING STREET WELL
8/25/89	MWC-08	11.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SCHILLING STREET WELL
10/3/89	MWC-08	8.20	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SCHILLING STREET WELL
12/11/89	MWC-08	4.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SCHILLING STREET WELL
1/3/90	MWC-08	3.60	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SCHILLING STREET WELL
2/21/90	MWC-08	4.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SCHILLING STREET WELL
3/21/90	MWC-08	3.30	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SCHILLING STREET WELL
4/23/90	MWC-08	4.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SCHILLING STREET WELL
5/7/90	MWC-08	4.40	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SCHILLING STREET WELL
5/23/90	MWC-08	2.60	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SCHILLING STREET WELL

DATE	WELL	PCE	TCE	DCE	VC	TCA	BDCM	DBCM	DCFM	CTET	DCEA	NAP	CFRM	COMMENT
6/7/90	MWC-08	2.80	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SCHILLING STREET WELL
6/25/90	MWC-08	3.60	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SCHILLING STREET WELL
7/11/90	MWC-08	5.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SCHILLING STREET WELL
7/30/90	MWC-08	6.10	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SCHILLING STREET WELL
8/7/90	MWC-08	7.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SCHILLING STREET WELL
8/27/90	MWC-08	6.60	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SCHILLING STREET WELL
9/25/90	MWC-08	7.70	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SCHILLING STREET WELL
10/3/91	MWC-08	3.80	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	1.0	SCHILLING STREET WELL
10/5/88	MWC-09	1.30	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
3/13/89	MWC-09	1.10	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
3/22/89	MWC-09	2.70	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
3/22/89	MWC-09	2.40	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
4/26/89	MWC-09	1.40	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
4/26/89	MWC-09	1.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
5/23/89	MWC-09	1.60	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
7/12/89	MWC-09	2.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
8/25/89	MWC-09	1.60	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
10/3/89	MWC-09	1.70	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
12/11/89	MWC-09	1.60	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
1/3/90	MWC-09	1.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
2/21/90	MWC-09	1.60	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
3/21/90	MWC-09	1.20	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
4/23/90	MWC-09	2.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
4/23/90	MWC-09	1.80	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
5/23/90	MWC-09	1.40	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
6/19/90	MWC-09	1.70	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
7/30/90	MWC-09	1.40	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
8/27/90	MWC-09	1.30	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
9/25/90	MWC-09	1.20	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
10/23/90	MWC-09	1.30	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
11/9/90	MWC-09	1.30	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
12/19/90	MWC-09	1.40	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL

DATE	WELL	PCE	TCE	DCE	VC	TCA	BDCM	DBCM	DCFM	CTET	DCEA	NAP	CFRM	COMMENT
3/27/91	MWC-09	1.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
5/27/91	MWC-09	2.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
6/28/91	MWC-09	1.60	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
9/30/91	MWC-09	1.70	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DIXON AVENUE WELL
10/5/88	MWC-10	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	HILDA AVENUE WELL
9/11/90	MWC-10	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	HILDA AVENUE WELL
10/5/88	MWC-11	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	AGNES AVENUE WELL
9/30/91	MWC-11	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	AGNES AVENUE WELL
12/15/88	MWC-14	2.10	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL
3/13/89	MWC-14	1.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL
3/13/89	MWC-14	2.70	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL
3/22/89	MWC-14	2.60	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL
3/22/89	MWC-14	2.80	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL
5/23/89	MWC-14	2.40	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL
7/12/89	MWC-14	2.60	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL
8/25/89	MWC-14	2.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL
10/3/89	MWC-14	2.40	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL
12/11/89	MWC-14	2.40	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL
1/3/90	MWC-14	1.90	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL
2/21/90	MWC-14	1.90	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL
3/21/90	MWC-14	1.30	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL
4/23/90	MWC-14	1.90	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL
5/23/90	MWC-14	1.70	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL
6/19/90	MWC-14	1.70	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL
7/30/90	MWC-14	1.60	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL
8/27/90	MWC-14	2.10	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL
9/25/90	MWC-14	1.60	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL
10/23/90	MWC-14	1.60	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL
11/9/90	MWC-14	1.70	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL
12/19/90	MWC-14	1.40	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL
3/27/91	MWC-14	1.40	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL
5/27/91	MWC-14	1.30	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL

DATE	WELL	PCE	TCE	DCE	VC	TCA	BDCM	DBCM	DCFM	CTET	DCEA	NAP	CFRM	COMMENT
6/28/91	MWC-14	1.30	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL
9/30/91	MWC-14	1.60	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTH RUSSELL WELL
12/15/88	MWC-16	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24th STREET WELL
3/13/89	MWC-16	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24th STREET WELL
4/26/89	MWC-16	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24th STREET WELL
5/23/89	MWC-16	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24th STREET WELL
7/12/89	MWC-16	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24th STREET WELL
8/25/89	MWC-16	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24th STREET WELL
10/3/89	MWC-16	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24th STREET WELL
12/11/89	MWC-16	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24th STREET WELL
12/11/89	MWC-16	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24th STREET WELL
2/21/90	MWC-16	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24th STREET WELL
4/23/90	MWC-16	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24th STREET WELL
6/19/90	MWC-16	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24th STREET WELL
7/30/90	MWC-16	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24th STREET WELL
8/27/90	MWC-16	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24th STREET WELL
9/25/90	MWC-16	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24th STREET WELL
10/23/90	MWC-16	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24th STREET WELL
11/19/90	MWC-16	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24th STREET WELL
12/19/90	MWC-16	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24th STREET WELL
12/19/90	MWC-16	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24th STREET WELL
3/28/91	MWC-16	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24th STREET WELL
3/28/91	MWC-16	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24th STREET WELL
5/27/91	MWC-16	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24th STREET WELL
6/28/91	MWC-16	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24th STREET WELL
12/15/88	MWC-18	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GHARRETT STREET WELL
4/26/89	MWC-18	0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GHARRETT STREET WELL
5/23/89	MWC-18	0.58	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GHARRETT STREET WELL
7/12/89	MWC-18	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GHARRETT STREET WELL
8/25/89	MWC-18	0.74	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GHARRETT STREET WELL
10/3/89	MWC-18	0.58	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GHARRETT STREET WELL
12/11/89	MWC-18	0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GHARRETT STREET WELL

DATE	WELL	PCE	TCE	DCE	VC	TCA	BDCM	DBCM	DCFM	CTET	DCEA	NAP	CFRM	COMMENT
12/11/89	MWC-18	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GHARRETT STREET WELL
1/3/90	MWC-18	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GHARRETT STREET WELL
2/21/90	MWC-18	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GHARRETT STREET WELL
3/21/90	MWC-18	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GHARRETT STREET WELL
4/23/90	MWC-18	0.78	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GHARRETT STREET WELL
5/23/90	MWC-18	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GHARRETT STREET WELL
6/19/90	MWC-18	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GHARRETT STREET WELL
7/31/90	MWC-18	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GHARRETT STREET WELL
8/27/90	MWC-18	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GHARRETT STREET WELL
9/25/90	MWC-18	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GHARRETT STREET WELL
6/26/91	MWC-18	1.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GHARRETT STREET WELL
12/15/88	MWC-19	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NORTH RUSSELL WELL
12/11/89	MWC-19	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NORTH RUSSELL WELL
1/4/90	MWC-19	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NORTH RUSSELL WELL
2/21/90	MWC-19	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NORTH RUSSELL WELL
3/21/90	MWC-19	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NORTH RUSSELL WELL
4/23/90	MWC-19	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NORTH RUSSELL WELL
5/22/90	MWC-19	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NORTH RUSSELL WELL
6/19/90	MWC-19	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NORTH RUSSELL WELL
7/30/90	MWC-19	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NORTH RUSSELL WELL
8/27/90	MWC-19	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NORTH RUSSELL WELL
9/25/90	MWC-19	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NORTH RUSSELL WELL
10/23/90	MWC-19	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NORTH RUSSELL WELL
11/9/90	MWC-19	0.00	0.0	0.0	0.00	0.00	1.0	1.0	0.0	0.0	0.0	0.0	0.0	NORTH RUSSELL WELL
12/19/90	MWC-19	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	1.2	NORTH RUSSELL WELL
1/30/91	MWC-19	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	1.3	NORTH RUSSELL WELL
6/27/91	MWC-19	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	1.0	NORTH RUSSELL WELL
12/15/88	MWC-20	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CATLIN STREET WELL
10/3/89	MWC-20	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CATLIN STREET WELL
12/11/89	MWC-20	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CATLIN STREET WELL
1/3/90	MWC-20	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CATLIN STREET WELL
2/21/90	MWC-20	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CATLIN STREET WELL

DATE	WELL	PCE	TCE	DCE	VC	TCA	BDCM	DBCM	DCFM	CTET	DCEA	NAP	CFRM	COMMENT
3/21/90	MWC-20	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CATLIN STREET WELL
4/23/90	MWC-20	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CATLIN STREET WELL
5/23/90	MWC-20	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CATLIN STREET WELL
6/19/90	MWC-20	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CATLIN STREET WELL
7/30/90	MWC-20	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CATLIN STREET WELL
8/27/90	MWC-20	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CATLIN STREET WELL
9/25/90	MWC-20	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CATLIN STREET WELL
10/23/90	MWC-20	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CATLIN STREET WELL
11/19/90	MWC-20	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CATLIN STREET WELL
12/27/90	MWC-20	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CATLIN STREET WELL
1/8/91	MWC-20	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CATLIN STREET WELL
3/27/91	MWC-20	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	1.0	CATLIN STREET WELL
5/27/91	MWC-20	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CATLIN STREET WELL
6/28/91	MWC-20	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CATLIN STREET WELL
9/30/91	MWC-20	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CATLIN STREET WELL
12/15/88	MWC-22	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	INTERMOUNTAIN WELL
3/13/89	MWC-22	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	INTERMOUNTAIN WELL
4/26/89	MWC-22	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	INTERMOUNTAIN WELL
5/23/89	MWC-22	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	INTERMOUNTAIN WELL
7/12/89	MWC-22	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	INTERMOUNTAIN WELL
8/25/89	MWC-22	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	INTERMOUNTAIN WELL
10/3/89	MWC-22	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	INTERMOUNTAIN WELL
12/11/89	MWC-22	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	INTERMOUNTAIN WELL
1/3/90	MWC-22	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	INTERMOUNTAIN WELL
2/21/90	MWC-22	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	INTERMOUNTAIN WELL
3/21/90	MWC-22	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	INTERMOUNTAIN WELL
4/23/90	MWC-22	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	INTERMOUNTAIN WELL
5/22/90	MWC-22	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	INTERMOUNTAIN WELL
6/19/90	MWC-22	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	INTERMOUNTAIN WELL
7/30/90	MWC-22	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	INTERMOUNTAIN WELL
8/27/90	MWC-22	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	INTERMOUNTAIN WELL
9/25/90	MWC-22	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	INTERMOUNTAIN WELL

DATE	WELL	PCE	TCE	DCE	VC	TCA	BDCM	DBCM	DCFM	CTET	DCEA	NAP	CFRM	COMMENT
10/23/90	MWC-22	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	INTERMOUNTAIN WELL
11/9/90	MWC-22	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	INTERMOUNTAIN WELL
12/27/90	MWC-22	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	INTERMOUNTAIN WELL
6/25/91	MWC-22	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	INTERMOUNTAIN WELL
12/15/88	MWC-23	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	PATTEE CREEK 25 HORSE
10/3/88	MWC-24	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	PATTEE CREEK 50 HORSE
5/23/90	MWC-24	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	PATTEE CREEK 50 HORSE
12/15/88	MWC-25	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	STEPHENS AVENUE WELL
8/25/89	MWC-25	4.20	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	STEPHENS AVENUE WELL
10/3/89	MWC-25	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	STEPHENS AVENUE WELL
12/11/89	MWC-25	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	STEPHENS AVENUE WELL
1/3/90	MWC-25	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	STEPHENS AVENUE WELL
2/21/90	MWC-25	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	STEPHENS AVENUE WELL
3/21/90	MWC-25	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	STEPHENS AVENUE WELL
4/23/90	MWC-25	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	STEPHENS AVENUE WELL
5/23/90	MWC-25	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	STEPHENS AVENUE WELL
6/19/90	MWC-25	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	STEPHENS AVENUE WELL
7/31/90	MWC-25	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	STEPHENS AVENUE WELL
8/27/90	MWC-25	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	STEPHENS AVENUE WELL
9/25/90	MWC-25	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	STEPHENS AVENUE WELL
10/23/90	MWC-25	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	STEPHENS AVENUE WELL
11/19/90	MWC-25	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	STEPHENS AVENUE WELL
12/19/90	MWC-25	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.5	0.0	0.0	0.0	STEPHENS AVENUE WELL
6/25/91	MWC-25	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	STEPHENS AVENUE WELL
9/30/91	MWC-25	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	STEPHENS AVENUE WELL
10/5/88	MWC-26	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BENTON AVENUE WELL
12/15/88	MWC-26	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BENTON AVENUE WELL
3/13/89	MWC-26	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BENTON AVENUE WELL
4/26/89	MWC-26	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BENTON AVENUE WELL
5/23/89	MWC-26	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BENTON AVENUE WELL
7/12/89	MWC-26	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BENTON AVENUE WELL
8/25/89	MWC-26	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BENTON AVENUE WELL

DATE	WELL	PCE	TCE	DCE	VC	TCA	BDCM	DBCM	DCFM	CTET	DCEA	NAP	CFRM	COMMENT
10/3/89	MWC-26	0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BENTON AVENUE WELL
10/3/89	MWC-26	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BENTON AVENUE WELL
12/11/89	MWC-26	0.64	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BENTON AVENUE WELL
1/3/90	MWC-26	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BENTON AVENUE WELL
2/21/90	MWC-26	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BENTON AVENUE WELL
3/21/90	MWC-26	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BENTON AVENUE WELL
4/23/90	MWC-26	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BENTON AVENUE WELL
5/23/90	MWC-26	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BENTON AVENUE WELL
6/19/90	MWC-26	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BENTON AVENUE WELL
7/31/90	MWC-26	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BENTON AVENUE WELL
8/27/90	MWC-26	0.52	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BENTON AVENUE WELL
9/25/90	MWC-26	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BENTON AVENUE WELL
10/23/90	MWC-26	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BENTON AVENUE WELL
11/9/90	MWC-26	0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BENTON AVENUE WELL
12/19/90	MWC-26	0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BENTON AVENUE WELL
6/25/91	MWC-26	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BENTON AVENUE WELL
9/30/91	MWC-26	0.80	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	1.0	BENTON AVENUE WELL
10/5/88	MWC-27	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26th STREET WELL
9/11/90	MWC-27	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26th STREET WELL
10/5/88	MWC-28	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DESMET WELL
10/5/88	MWC-29	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ORCHARD AVENUE WELL
12/11/89	MWC-29	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ORCHARD AVENUE WELL
1/3/90	MWC-29	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ORCHARD AVENUE WELL
10/3/88	MWC-31	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	KIWANIS STREET WELL
10/3/88	MWC-32	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ARTHUR AVENUE WELL
10/3/88	MWC-33	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4th & GERALD WELL
10/3/88	MWC-34	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MAURICE AVENUE WELL
10/5/88	MWC-35	2.90	0.0	0.0	0.00	0.00	0.0	0.0	2.6	0.0	0.0	0.0	0.0	SOUTHGATE WELL
12/15/88	MWC-35	4.30	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
3/13/89	MWC-35	3.10	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
3/13/89	MWC-35	3.30	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
4/26/89	MWC-35	3.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL

DATE	WELL	PCE	TCE	DCE	VC	TCA	BDCM	DBCM	DCFM	CTET	DCEA	NAP	CFRM	COMMENT
5/7/89	MWC-35	2.20	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
5/23/89	MWC-35	2.90	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
7/12/89	MWC-35	3.90	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
10/3/89	MWC-35	4.70	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
12/11/89	MWC-35	4.10	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
1/3/90	MWC-35	3.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
2/21/90	MWC-35	3.40	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
3/21/90	MWC-35	2.30	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
4/23/90	MWC-35	2.70	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
5/23/90	MWC-35	2.80	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
6/7/90	MWC-35	2.10	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
6/19/90	MWC-35	3.10	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
7/11/90	MWC-35	3.70	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
7/31/90	MWC-35	4.10	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
8/7/90	MWC-35	4.90	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
8/27/90	MWC-35	6.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
9/11/90	MWC-35	6.90	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
9/25/90	MWC-35	6.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
10/9/90	MWC-35	6.70	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
10/9/90	MWC-35	6.70	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
10/23/90	MWC-35	5.30	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
11/8/90	MWC-35	5.80	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
11/9/90	MWC-35	4.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
12/10/90	MWC-35	5.90	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
12/19/90	MWC-35	4.30	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
1/30/91	MWC-35	4.10	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
2/26/91	MWC-35	4.10	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
3/27/91	MWC-35	3.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
4/29/91	MWC-35	3.10	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
5/27/91	MWC-35	2.60	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
6/25/91	MWC-35	2.80	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	1.0	SOUTHGATE WELL
7/31/91	MWC-35	4.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	1.0	SOUTHGATE WELL

DATE	WELL	PCE	TCE	DCE	VC	TCA	BDCM	DBCM	DCFM	CTET	DCEA	NAP	CFRM	COMMENT
9/30/91	MWC-35	5.10	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	1.0	SOUTHGATE WELL
11/5/91	MWC-35	4.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE WELL
12/15/88	MWC-36	0.90	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DICKENS WELL
3/13/89	MWC-36	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DICKENS WELL
4/26/89	MWC-36	0.63	0.0	0.0	0.00	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DICKENS WELL
5/23/89	MWC-36	0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DICKENS WELL
7/12/89	MWC-36	1.00	0.5	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DICKENS WELL
8/25/89	MWC-36	0.50	0.5	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DICKENS WELL
10/3/89	MWC-36	0.83	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DICKENS WELL
12/11/89	MWC-36	0.76	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DICKENS WELL
1/3/90	MWC-36	0.78	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DICKENS WELL
2/21/90	MWC-36	1.10	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DICKENS WELL
3/21/90	MWC-36	0.93	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DICKENS WELL
5/22/90	MWC-36	0.66	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DICKENS WELL
6/19/90	MWC-36	0.73	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DICKENS WELL
7/30/90	MWC-36	0.80	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DICKENS WELL
8/27/90	MWC-36	1.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DICKENS WELL
9/25/90	MWC-36	0.92	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DICKENS WELL
10/23/90	MWC-36	0.74	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DICKENS WELL
11/9/90	MWC-36	0.85	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DICKENS WELL
12/27/90	MWC-36	0.87	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DICKENS WELL
3/27/91	MWC-36	0.68	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DICKENS WELL
6/28/91	MWC-36	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DICKENS WELL
9/30/91	MWC-36	1.10	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DICKENS WELL
4/6/89	PW	0.60	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MISSION PAINT (A-47)
4/6/89	PW	4.40	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	PHIL YATES (A-23)
4/6/89	PW	1.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	SOUTHGATE OFFICES (A-24)
4/6/89	PW	3.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	PHIL YATES (A-23)
4/6/89	PW	4.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	AMERICAN DENTAL (A-5b)
4/6/89	PW	0.60	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CHECKER AUTO PARTS (A-15s)
4/6/89	PW	1.80	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	L & R TIRE
5/3/89	PW	4.80	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ROCKY MTN COMM

DATE	WELL	PCE	TCE	DCE	VC	TCA	BDCM	DBCM	DCFM	CTET	DCEA	NAP	CFRM	COMMENT
5/3/89	PW	1.40	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	INDUSTRIAL SUPPLY MSLA
7/7/89	PW	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	TRI-STATE EQUIPMENT
7/7/89	PW	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GOMER'S DIESEL
7/7/89	PW	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CLIFF PHILLIPS - OLD WELL
7/7/89	PW	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CLIFF PHILLIPS - NEW WELL
11/27/89	PW	1.20	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BILLIE GARDNER (A-22)
11/28/89	PW	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BUD VACURA (A-16)
11/28/89	PW	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	DOROTHY LANGE (A-11)
12/7/89	PW	1.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	S & S CARWASH (A-32)
2/26/90	PW	4.90	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	LEWIS & CLARK BLDG (A-6s)
2/26/90	PW	5.20	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	AMERICAN DENTAL (A-5b)
2/26/90	PW	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	C MARTINEZ (A-21)
2/26/90	PW	2.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	AUTOGLASS SPECIALIST (A-54)
2/27/90	PW	2.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	E CHILCOATE (A-41b)
5/2/90	PW	1.20	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	3.4	35.1	0.0	ROCKY MTN COMM
5/3/90	PW	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	4.3	0.0	FRONTIER GAS
4/27/89	PWS	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	HAWTHORNE SCHOOL (WELL 1)
5/3/89	PWS	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N DAVIS DUPLEXES
5/3/89	PWS	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	EL MAR ESTATES WELL 6
5/3/89	PWS	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	EL MAR ESTATES WELL 5
5/3/89	PWS	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	EL MAR ESTATES WELL 2
5/3/89	PWS	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	EL MAR ESTATES WELL 1
5/9/89	PWS	0.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MOBILE CITY TRAILER COURT
11/28/89	PWS	3.20	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BEACH TRANSPORT. (A-17)
5/10/89	PWS1859	0.00	1.8	15.8	0.00	0.00	0.0	0.0	0.0	0.0	2.6	0.0	0.0	WP & SASH - FACTORY WELL
5/10/89	PWS1859	2.20	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	WP & SASH - BOILER WELL
2/7/90	PWS1859	1.60	0.5	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	WP & SASH - FACTORY WELL
2/7/90	PWS1859	2.80	0.5	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	WP & SASH - BOILER WELL
5/30/90	PWS1859	3.60	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	WP & SASH - BOILER WELL
6/4/90	PWS1859	1.40	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	WP & SASH - FACTORY WELL
9/21/90	PWS1859	3.30	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	WP & SASH - BOILER WELL
9/21/90	PWS1859	2.10	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	WP & SASH - FACTORY WELL

DATE	WELL	PCE	TCE	DCE	VC	TCA	BDCM	DBCM	DCFM	CTET	DCEA	NAP	CFRM	COMMENT
1/3/91	PWS1859	1.80	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	WP & SASH - FACTORY WELL
1/8/91	PWS1859	1.90	0.5	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	WP & SASH - BOILER WELL
4/22/91	PWS1859	1.20	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	WP & SASH - FACTORY WELL
4/22/91	PWS1859	2.70	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	WP & SASH - BOILER WELL
2/26/90	PWS2490	1.90	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	MSLA COUNTRY CLUB (A-48)
2/26/90	PWS2698	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	GREYHOUND BUS (A-7)
7/12/89	PWS293	<0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	CLARK FORK WATER CO.
4/27/89	PWS3159	2.00	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	FORT MISSOULA (well 2)
9/7/88	PWS3237	0.50	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	VFW TRAILER COURT
5/4/89	PWS3237	0.90	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	VFW TRAILER COURT
8/8/89	PWS829	0.00	0.0	0.0	0.00	3.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	L TWITE DUPLEX
5/10/89	PWS837	1.80	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	LOUISIANA PACIFIC
TOTAL	ALL	641.6	4.3	15.8	0.0	15.8	1.0	1.0	22.9	0.5	6.1	39.4	9.5	

NOTES: all units are ug/l

< indicates that the compound is present, but below the practical quantitation limit

a value of zero indicates the compound is below detection limits (BDL)

MWC = Mountain Water Company

PWS = Public Water Supply (MT ID#)

PW = Private Well

PCE = Perchloroethene

TCE = Trichloroethene

DCE = Dichloroethene

VC = Vinyl Chloride

TCA = Trichloroethane

BDCM = Bromodichloromethane

DBCM = Dibromochloromethane

DCFM = Dichlorodifluoromethane

CTET = Carbon Tetrachloride

DCEA = Dichloroethane

NAP = Naphthalene

CFRM = Chloroform

APPENDIX B

WELL INVENTORY
AND
STATIC WATER LEVEL DATA

(all measurements in feet above mean sea level)

WELL	OWNER	DEPTH	ELEV	T	R	S	LOCATION	OTHER
A-02	FAIRGROUNDS	65.0	?	13	19	33	SOUTH/RUSSELL	
A-03	PRUYN VET	100.0	3187.22	13	19	32	2501 RUSSELL	
A-04	1ST BANK SOUTHSIDE	81.0	3176.88	13	19	32	2801 BROOKS	
A-05B	AMERICAN DENTAL	82.0	3166.16	13	19	32	2800 RESERVE	
A-06D	TERRACE WEST	140.0	3196.64	13	19	33	619 SW HIGGINS	
A-06S	LEWIS & CLARK DENTAL	99.0	3188.37	13	19	33	690 SW HIGGINS	
A-07	GLAD TIDINGS ASSEMBLY	68.0	3168.48	13	19	29	1714 RESERVE	
A-10	GREYHOUND	60.0	3165.09	13	19	16	1660 W BROADWAY	MV-10
A-11	LANGE, DOROTHY	80.0	3175.59	13	19	29	2385 S 8 W	
A-12	MCDONALD, JOSEPH	?	3167.11	13	19	21	1270 S 1 W	
A-12B	TRIP BLANK	0.0	0.00	13	19	-	-	
A-13	TRIP BLANK	0.0	0.00	13	19	-	-	
A-14	GRIZZLY MINI GOLF	106.0	3171.11	13	19	32	SOUTHGATE MALL	
A-15D	FOWLER, BRUCE	126.0	3173.36	13	19	32	2005 ERNEST	
A-15S	CHECKER AUTO	79.0	3173.22	13	19	32	3121 BROOKS	
A-16	VACURA, TOM	70.0	3179.93	13	19	29	2003 GARFIELD	
A-17	BEACH TRANSPORT	79.0	3190.79	13	19	28	825 MOUNT	
A-18	SHERWOOD, LAURA	90.0	3191.49	13	19	28	2200 STEPHENS	
A-19	HOLLIBAUGH, E.L.	72.5	3193.62	13	19	28	444 SOUTH AVE W	
A-20	BIG SKY VET	79.0	3166.64	13	19	32	2411 DEARBORN	
A-21	MARTINEZ, CAYETANA	79.5	3195.89	13	19	16	1337 SHERWOOD	
A-22	GARDENER, BILLIE	70.0	3171.20	13	19	32	1626 PITTMAN	
A-23	YATES, PHIL	100.0	3165.53	13	19	32	2141 SOUTH AVE W	
A-24	INTERMOUNTAIN ADMIN.	70.0	3178.54	13	19	32	1719 DEARBORN	
A-25	TRIP BLANK	0.0	0.00	13	19	-	-	
A-26	TIDYMANS	100.0	3181.71	13	19	32	2501 BROOKS	
A-27	GARDEN CITY MEDICAL	118.3	3203.87	13	19	21	601 SPRUCE	
A-28D	BOSCHERT, KAREN	100.0	3170.72	13	19	21	1400 MONTANA	
A-28S	BOSCHERT, KAREN	0.0	3163.98	13	19	21	1400 MONTANA	
A-29	JOSEPH, FRED	79.0	3174.42	13	19	29	1405 EATON	MV-29
A-30	SERVPRO	48.0	3159.15	13	19	31	3912 BROOKS	MV-30
A-31	UNIV OF MONTANA	110.0	3175.99	13	19	29	1903 RUSSELL	MV-31
A-32	WOHL, GLEN	72.0	?	13	19	29	SOUTH/SCHILLING	
A-35	UNIV OF MONTANA	58.5	3176.78	13	19	21	MCCORMICK PARK	MV-35
A-35A	ENGINE REBUILDERS	78.5	?	13	19	32	2601 KEMP	
A-36	THOMPSON DENTAL	88.5	3192.09	13	19	21	1201 S 6 W	
A-37	KGVO PLAZA	99.0	3176.86	13	19	32	2501 CATLIN	
A-38	MINTZ, WILLIAM	59.0	3175.30	13	19	29	1013 EATON	
A-39	SILVER, F.M.	84.0	?	13	19	28	621 STEPHENS	
A-40	JEFFERSON SCHOOL	104.6	3180.55	13	19	29	1700 SOUTH AVE W	
A-41	UNIV OF MONTANA	76.3	3199.97	13	19	28	BLAINE/CROSBY	MV-41
A-41B	CHILCOTE, ELAINE	88.0	?	13	19	28	650 BROOKS	
A-42	UNIV OF MONTANA	70.3	3190.32	13	19	33	SOUTH/BANCROFT	MV-42
A-43	COUNTY COURTHOUSE	?	3188.33	13	19	21	200 W BROADWAY	MV-43
A-44	ST MARY'S CEMETERY	?	3197.52	13	19	16	EAST	MV-44
A-45	ST MARY'S CEMETERY	?	3188.06	13	19	16	WEST ANNEX	MV-45
A-46	CITY OF MISSOULA	105.0	3189.19	13	19	16	CITY CEMETERY	MV-46
A-47	MISSION PAINT	94.0	3182.25	13	19	32	1605 SOUTH AVE W	
A-48	MISSOULA COUNTRY CLUB	58.4	?	13	19	31	SHOP WELL	
A-53	BIG BEAR RESOURCES	84.0	3160.58	13	19	32	2115 38 ST	
A-54	AUTOGLASS SPECIALISTS	86.0	3188.36	13	19	28	1023 KENSINGTON	
A-55	NORDIC APT.	73.0	3187.96	13	19	28	1130 LONGSTAFF	
A-58	MARTIN DEVELOP CO.	79.0	3186.22	13	19	29	1525 RUSSELL	
A-71	DON MISEVIC	89.0	?	13	19	33	215 FAIRVIEW	
A-72	MISSOULA PARKS & REC	116.0	?	13	19	33	PLAYFAIR PARK	
A-73	MISSOULA PARKS & REC	117.0	?	13	19	33	HOCKEY RINK	
A-75	SELF SERV. FURNITURE	127.0	?	13	19	21	1001 S 3 W	
A-76	MONTANA POWER COMPANY	122.0	?	13	19	16	1100 TOOLE	
A-77	JEMN, INC	92.0	?	13	19	16	SCOTT ST	
A-78	F.A. CLARK	90.0	?	13	19	16	1005 CHARLO	
A-79	MISSOULA CITY CEM.	152.0	?	13	19	8	CITY CEMETERY	
A-80	HUNTON PRECAST	90.0	?	13	19	16	1700 RODGERS	
A-81	WHITE PINE AND SASH	118.0	?	13	19	16	1301 SCOTT	
A-82	VERN OCHSNER	84.0	?	13	19	32	1616 39TH	

Well A-3
Pruyn Vet
2501 Russell
elev. 3187.22

DATE	TAPE HOLD	DEPTH	SWL
14-NOV-89	60.20 - 3.33	56.87	3130.35
24-NOV-89	59.00 - 3.64	55.31	3131.91
09-DEC-89	59.00 - 3.25	55.75	3131.47
11-JAN-90	58.50 - 2.02	56.48	3130.74
27-JAN-90	59.00 - 2.25	56.75	3130.47
24-FEB-90	59.00 - 1.57	57.43	3129.79
26-MAR-90	60.00 - 2.25	57.75	3129.47
12-APR-90	60.00 - 2.72	57.28	3129.94
28-APR-90	57.00 - 2.30	54.70	3132.52
11-MAY-90	55.00 - 1.08	53.92	3133.30
14-JUN-90	50.00 - 0.50	49.50	3137.72
14-JUL-90	52.00 - 1.35	50.65	3136.57
07-SEP-90	54.00 - 0.96	53.04	3134.18

Well A-4
First Bank Southside
2801 Brooks
elev. 3176.88

DATE	TAPE HOLD	DEPTH	SWL
14-NOV-89	49.00 - 2.20	46.80	3130.08
24-NOV-89	49.00 - 2.08	46.92	3129.96
09-DEC-89	49.00 - 1.68	47.32	3129.56
11-JAN-90	49.50 - 1.50	48.00	3128.88
27-JAN-90	50.00 - 1.76	48.24	3128.64
24-FEB-90	50.00 - 1.10	48.90	3127.98
26-MAR-90	50.00 - 0.82	49.18	3127.70
12-APR-90	50.00 - 1.23	48.77	3128.11
28-APR-90	47.00 - 0.57	46.43	3130.45
11-MAY-90	47.00 - 1.34	45.66	3131.22
14-JUN-90	42.00 - 0.66	41.34	3135.54
07-SEP-90	45.00 - 0.26	44.74	3132.14

Well A-6d
Terrace West
619 SW Higgins
elev. 3196.84

DATE	TAPE HOLD	DEPTH	SWL
24-FEB-90	70.00 - 2.09	67.91	3128.93
24-MAR-90	70.00 - 1.69	68.31	3128.53
26-MAR-90	70.00 - 1.54	68.46	3128.38
12-APR-90	70.00 - 1.53	68.47	3182.37
28-APR-90	68.00 - 1.07	66.93	3129.91
11-MAY-90	67.00 - 1.05	65.95	3130.89
14-JUN-90	63.00 - 1.27	61.73	3135.11

Well A-6s
Lewis & Clark Bldg.
690 SW Higgins
elev. 3188.37

DATE	TAPE HOLD	DEPTH	SWL
24-FEB-90	70.00 - 9.48	60.52	3127.85
24-MAR-90	63.00 - 2.02	60.98	3127.39
26-MAR-90	63.00 - 1.89	61.11	3127.26
12-APR-90	63.00 - 1.53	61.47	3126.90
28-APR-90	61.00 - 0.65	60.35	3128.02
11-MAY-90	61.00 - 2.76	58.24	3130.13
14-JUN-90	57.00 - 2.95	54.05	3134.32
14-JUL-90	57.00 - 1.64	55.36	3133.01
07-SEP-90	60.00 - 2.73	57.27	3131.10

A-7
Church
1714 Reserve
elev. 3168.48

DATE	TAPE HOLD	DEPTH	SWL
07-NOV-89	42.00 - 3.43	38.57	3129.91
24-NOV-89	40.00 - 1.12	38.88	3129.60
09-DEC-89	40.00 - 0.77	39.23	3129.25
11-JAN-90	41.00 - 1.04	39.46	3128.52
27-JAN-90	42.00 - 1.86	40.14	3128.34
24-FEB-90	44.00 - 3.18	40.82	3127.66
26-MAR-90	44.00 - 3.16	40.84	3127.64
12-APR-90	44.00 - 4.06	39.94	3128.54
28-APR-90	41.00 - 3.49	37.51	3130.97
11-MAY-90	40.50 - 3.74	36.76	3131.72
14-JUN-90	36.00 - 3.52	32.48	3136.00
14-JUL-90	37.50 - 4.45	33.05	3135.43
07-SEP-90	38.00 - 1.37	36.63	3131.85

MV-10
Greyhound
1660 W Broadway
elev. 3165.09

DATE	TAPE HOLD	DEPTH	SWL
27-JAN-90	45.00 - 14.96	30.04	3135.05
24-FEB-90	35.00 - 4.08	30.92	3134.17
26-MAR-90	34.00 - 3.27	30.73	3134.36
12-APR-90	32.20 - 3.51	28.69	3136.40
28-APR-90	27.00 - 2.73	24.27	3140.82
11-MAY-90	26.00 - 1.73	24.27	3140.82
14-JUN-90	21.00 - 1.27	19.73	3145.36
07-SEP-90	27.50 - 2.63	24.87	3140.22

A-11
Dorothy Lange
2385 S 8 W
elev. 3175.59

DATE	TAPE HOLD	DEPTH	SWL
07-NOV-89	45.00 - 2.30	42.70	3132.89
24-NOV-89	45.00 - 1.97	43.03	3132.56
28-NOV-89	46.00 - 2.80	43.20	3132.39
09-DEC-89	45.00 - 1.05	43.95	3131.64
11-JAN-90	46.00 - 1.99	44.01	3131.58

A-12
John McDonald
1270 S 1 W
elev. 3167.11

DATE	TAPE HOLD	DEPTH	SWL
24-NOV-89	29.00 - 0.56	28.44	3138.67
11-JAN-90	30.00 - 0.54	29.46	3137.65
27-JAN-90	31.00 - 1.11	29.89	3137.22
24-FEB-90	32.00 - 1.23	30.77	3136.34
26-MAR-90	32.00 - 1.60	30.40	3136.71
12-APR-90	40.00 - 2.47	37.53	3129.58
28-APR-90	28.00 - 3.71	24.29	3142.82
11-MAY-90	25.00 - 0.57	24.43	3142.68
07-SEP-90	26.00 - 1.22	24.78	3124.33

A-14
Grizzly Mini Golf
S.G. Mall
elev. 3171.15

DATE	TAPE HOLD	DEPTH	SWL
11-JAN-90	50.00 - 5.96	44.04	3127.11
27-JAN-90	OIL ON WATER		
24-FEB-90	OIL ON WATER		
26-MAR-90	OIL ON WATER		
12-APR-90	OIL ON WATER		
28-APR-90	50.00 - 7.40	42.60	3128.55
14-JUL-90	47.00 - 8.17	38.83	3132.32

A-15s
Checker Auto Parts
3121 Brooks
elev. 3173.22

DATE	TAPE HOLD	DEPTH	SWL
11-JAN-90	50.00 - 3.50	46.50	3126.72
27-JAN-90	50.00 - 3.28	46.72	3126.50
24-FEB-90	51.00 - 3.69	47.31	3125.91
24-MAR-90	50.00 - 2.45	47.55	3125.67
26-MAR-90	50.00 - 2.42	47.58	3125.64
12-APR-90	49.00 - 1.71	47.29	3125.93
11-MAY-90	45.00 - 0.45	44.55	3128.67
14-JUN-90	42.00 - 1.67	40.33	3132.89
14-JUL-90	43.00 - 1.59	41.41	3131.81
07-SEP-90	45.00 - 1.51	43.49	3129.73

A-15d
Bruce Fowler
2005 Ernest
elev. 3173.36

DATE	TAPE HOLD	DEPTH	SWL
21-NOV-89	47.00 - 1.56	45.44	3127.92
24-NOV-89	48.00 - 2.40	45.60	3127.76
11-JAN-90	50.50 - 3.93	46.57	3126.79
27-JAN-90	50.00 - 3.22	46.78	3126.58
24-FEB-90	51.00 - 3.62	47.38	3125.98
24-MAR-90	50.00 - 2.39	47.61	3125.75
26-MAR-90	50.00 - 2.37	47.63	3125.73
12-APR-90	49.00 - 1.37	47.63	3125.73
11-MAY-90	46.00 - 1.40	44.60	3128.76
14-JUN-90	42.10 - 1.73	40.37	3132.99
14-JUL-90	43.00 - 1.32	41.68	3131.68
07-SEP-90	45.00 - 1.45	43.55	3129.81

A-16
Bud Vacura
2003 Garfield
elev. 3179.93

DATE	TAPE HOLD	DEPTH	SWL
09-NOV-89	50.00 - 1.10	48.90	3131.03
24-NOV-89	51.00 - 2.36	48.64	3131.29
09-DEC-89	51.00 - 1.91	49.09	3130.84
11-JAN-90	52.00 - 2.22	49.78	3130.15
27-JAN-90	53.00 - 2.93	50.07	3129.86
24-FEB-90	51.00 - 0.22	50.78	3129.15
26-MAR-90	52.00 - 1.05	50.95	3128.98
12-APR-90	52.00 - 1.74	50.26	3129.67
28-APR-90	50.00 - 2.16	47.84	3132.09
11-MAY-90	49.00 - 2.16	46.84	3133.09

A-17
Beach Transport
825 Mount
approx elev. 3190.79

DATE	TAPE HOLD	DEPTH	SWL
14-NOV-89	59.00 - 1.34	57.66	3133.13
24-NOV-89	60.00 - 2.14	58.86	3131.93
09-DEC-89	60.00 - 1.62	58.38	3132.41
11-JAN-90	61.00 - 1.87	59.13	3131.66
27-JAN-90	62.00 - 2.58	59.42	3131.37
24-FEB-90	61.00 - 0.82	60.18	3130.61
26-MAR-90	62.00 - 1.61	60.39	3130.40
12-APR-90	63.00 - 2.36	60.64	3130.15
28-APR-90	60.00 - 3.37	56.63	3134.16
11-MAY-90	57.00 - 1.02	55.98	3134.81
14-JUN-90	53.00 - 1.75	51.25	3139.54
14-JUL-90	57.00 - 4.56	52.44	3138.35
07-SEP-90	58.00 - 2.93	55.07	3135.72

A-18
Laura Sherwood
2200 Stephens
approx elev. 3191.49

DATE	TAPE HOLD	DEPTH	SWL
14-NOV-89	64.00 - 4.24	59.76	3131.73
24-NOV-89	62.00 - 2.05	59.95	3131.54
09-DEC-89	62.00 - 1.58	60.42	3131.07
11-JAN-90	63.00 - 1.82	61.18	3130.31
27-JAN-90	63.70 - 2.23	61.47	3130.02
24-FEB-90	63.00 - 0.80	62.20	3129.29
26-MAR-90	64.00 - 1.43	62.57	3128.92
12-APR-90	63.00 - 0.96	62.04	3129.45
28-APR-90	61.50 - 1.86	59.64	3131.85
11-MAY-90	59.00 - 0.50	58.50	3132.99
14-JUN-90	55.00 - 1.04	53.96	3137.53
14-JUL-90	56.00 - 0.96	55.04	3136.45
07-SEP-90	59.00 - 1.46	57.54	3133.95

A-19
E.L. Hollibaugh
444 South Ave W
elev. 3193.62

DATE	TAPE HOLD	DEPTH	SWL
14-NOV-89	62.00 - 1.00	61.00	3132.62
24-NOV-89	63.00 - 1.77	61.23	3132.39
09-DEC-89	63.50 - 1.80	61.70	3131.92
11-JAN-90	65.00 - 2.49	62.51	3131.11
27-JAN-90	63.00 - 0.20	62.80	3130.82
24-FEB-90	65.00 - 1.50	63.50	3130.12
26-MAR-90	66.00 - 0.90	65.10	3128.52
12-APR-90	66.00 - 1.17	64.83	3128.79
28-APR-90	66.00 - 1.95	64.05	3129.57
11-MAY-90	65.00 - 3.62	61.38	3132.24
14-JUN-90	61.00 - 4.16	56.84	3136.78
14-JUL-90	59.00 - 0.99	58.01	3135.61
07-SEP-90	64.00 - 3.94	60.06	3133.56

A-20
Big Sky Vet
2411 Dearborn
elev. 3166.64

DATE	TAPE HOLD	DEPTH	SWL
07-NOV-89	38.00 - 0.25	37.75	3128.89
24-NOV-89	39.70 - 0.70	39.00	3127.64
09-DEC-89	40.00 - 0.65	39.35	3127.29
11-JAN-90	41.00 - 1.06	39.94	3126.70
27-JAN-90	42.00 - 2.23	40.77	3125.87
26-MAR-90	43.00 - 2.10	40.90	3125.74
12-APR-90	43.00 - 2.63	40.37	3126.27
28-APR-90	40.00 - 1.56	38.44	3128.20
11-MAY-90	39.00 - 1.42	37.58	3129.06
14-JUN-90	35.00 - 1.63	33.37	3133.27
14-JUL-90	36.00 - 1.60	34.40	3131.24
07-SEP-90	38.00 - 1.37	36.63	3130.01

A-21

Cayetana Martinez
1337 Sherwood
elev. 3195.89

DATE	TAPE HOLD	DEPTH	SWL
21-NOV-89	59.00 - 1.13	57.87	3138.02
11-JAN-90	60.00 - 0.78	59.22	3136.67
27-JAN-90	61.00 - 1.40	59.60	3136.29
24-FEB-90	62.00 - 1.44	60.56	3135.33
26-MAR-90	62.00 - 1.64	60.36	3135.53
12-APR-90	61.00 - 2.51	58.49	3137.40
11-MAY-90	56.00 - 2.04	53.96	3141.93
14-JUN-90	51.00 - 1.78	49.22	3146.67
14-JUL-90	52.00 - 1.09	50.91	3144.98
07-SEP-90	55.00 - 0.60	54.40	3141.49

A-22

Billie Gardner
1626 Pittman
elev. 3171.20

DATE	TAPE HOLD	DEPTH	SWL
21-NOV-89	46.00 - 2.58	43.42	3127.78
24-NOV-89	46.00 - 2.56	43.44	3127.76
28-NOV-89	46.00 - 2.55	43.45	3127.75
09-DEC-89	46.00 - 2.22	43.78	3127.42
11-JAN-90	46.00 - 1.59	44.41	3126.79
27-JAN-90	46.00 - 1.38	44.62	3126.58
24-FEB-90	49.00 - 3.81	45.19	3126.01
26-MAR-90	49.00 - 2.69	46.31	3124.89
12-APR-90	49.50 - 4.07	45.43	3125.77
28-APR-90	47.00 - 3.05	43.95	3221.25
11-MAY-90	45.50 - 2.71	42.79	3128.41
14-JUN-90	42.00 - 3.40	38.60	3132.60
14-JUL-90	42.00 - 2.28	39.72	3131.48
07-SEP-90	44.00 - 2.33	41.67	3129.53

A-23
Phil Yates
2141 South Ave W
elev. 3165.53

DATE	TAPE HOLD	DEPTH	SWL
21-NOV-89	38.00 - 2.06	35.94	3129.59
24-NOV-89	38.00 - 2.02	35.98	3129.55
09-DEC-89	38.00 - 1.61	36.39	3129.14
11-JAN-90	39.00 - 1.98	37.02	3128.51
27-JAN-90	39.00 - 1.72	37.28	3128.25
24-FEB-90	39.00 - 1.06	37.94	3127.59
26-MAR-90	40.00 - 1.88	38.12	3127.41
12-APR-90	40.00 - 2.47	37.53	3128.00
28-APR-90	37.00 - 1.59	35.41	3130.12
11-MAY-90	36.00 - 1.59	34.41	3131.12
14-JUN-90	32.00 - 3.42	28.58	3136.95
07-SEP-90	37.00 - 3.55	33.45	3132.08

A-24
Intermountain Admin.
1719 Dearborn
elev. 3178.34

DATE	TAPE HOLD	DEPTH	SWL
24-NOV-89	50.50 - 2.53	47.97	3130.37
09-DEC-89	50.00 - 1.60	48.40	3129.94
11-JAN-90	50.00 - 0.91	49.09	3129.25
27-JAN-90	50.10 - 0.76	49.34	3129.00
24-FEB-90	51.00 - 0.99	50.01	3128.33
26-MAR-90	52.00 - 1.63	50.37	3127.97
12-APR-90	51.00 - 1.16	49.84	3128.50
28-APR-90	48.50 - 1.12	47.38	3130.96
11-MAY-90	48.00 - 1.38	46.62	3131.72
14-JUN-90	44.00 - 1.82	42.18	3136.16
14-JUL-90	45.00 - 1.55	43.45	3134.89
07-SEP-90	47.00 - 1.25	45.75	3132.59

A-27

Garden City Medical
601 Spruce
elev. 3203.87

DATE	TAPE HOLD	DEPTH	SWL
11-JAN-90	67.00 - 2.05	64.95	3138.92
27-JAN-90	67.00 - 1.69	65.31	3138.56
24-FEB-90	67.00 - 0.69	66.31	3137.56
26-MAR-90	68.00 - 2.03	65.97	3137.90
12-APR-90	67.00 - 2.92	64.08	3139.79
28-APR-90	61.50 - 1.63	59.87	3144.00
11-MAY-90	61.00 - 1.30	59.70	3144.17
14-JUN-90	56.00 - 1.20	54.80	3149.07
14-JUL-90	57.00 - 0.22	56.78	3147.09
07-SEP-90	61.00 - 0.89	60.11	3143.76

A-28d

Karen Boschert
1400 Montana
elev. 3170.72

DATE	TAPE HOLD	DEPTH	SWL
24-FEB-90	39.00 - 2.23	36.77	3133.95
26-MAR-90	40.00 - 4.58	35.42	3135.30
12-APR-90	34.00 - 0.60	33.40	3137.32
28-APR-90	33.50 - 4.39	29.11	3141.61
11-MAY-90	30.00 - 0.77	29.23	3141.49
14-JUN-90	27.80 - 3.16	24.64	3146.08
14-JUL-90	29.00 - 2.54	26.46	3144.26
07-SEP-90	32.00 - 2.33	29.67	3141.05

A-28s

Karen Boschert
1400 Montana
elev. 3163.98

DATE	TAPE HOLD	DEPTH	SWL
24-FEB-90	33.00 - 4.31	28.69	3135.29
26-MAR-90	31.00 - 2.64	28.36	3135.62
12-APR-90	28.00 - 1.64	26.36	3137.62
28-APR-90	26.00 - 3.95	22.05	3141.93
11-MAY-90	24.00 - 1.82	22.18	3141.80
14-JUN-90	20.00 - 2.46	17.54	3146.44
14-JUL-90	21.00 - 1.63	19.37	3144.61
07-SEP-90	24.00 - 1.39	22.61	3141.37

MV-29
Fred Joseph
1405 Eaton
elev. 3174.42

DATE	**TAPE HOLD**	**DEPTH**	**SWL**
07-NOV-89	44.00 - 0.70	43.00	3131.12
24-NOV-89	45.00 - 1.41	43.59	3130.83
09-DEC-89	45.00 - 1.03	43.97	3130.45
11-JAN-90	46.00 - 1.38	44.62	3129.80
27-JAN-90	48.50 - 3.57	44.93	3129.49
24-FEB-90	47.00 - 1.36	45.64	3128.78
26-MAR-90	47.00 - 1.36	45.64	3128.78
12-APR-90	46.00 - 1.42	44.58	3129.84
28-APR-90	43.00 - 1.14	41.86	3132.56
11-MAY-90	43.00 - 1.77	41.23	3133.19
14-JUL-90	39.00 - 1.41	37.59	3136.83
07-SEP-90	41.00 - 0.49	40.51	3133.91

MV-30
Fireplace Center
3912 Brooks
elev. 3159.15

DATE	**TAPE HOLD**	**DEPTH**	**SWL**
09-DEC-89	41.00 - 3.69	37.31	3121.84
11-JAN-90	38.00 - 0.75	37.25	3121.90
27-JAN-90	38.00 - 0.54	37.46	3121.69
24-FEB-90	39.50 - 1.64	37.86	3121.29
26-MAR-90	40.00 - 2.10	37.90	3121.25
12-APR-90	39.00 - 1.57	37.43	3121.72
28-APR-90	37.00 - 1.03	35.97	3123.18
11-MAY-90	37.00 - 1.30	35.70	3123.45
14-JUN-90	33.50 - 1.35	32.15	3127.00
14-JUL-90	35.50 - 2.01	33.49	3125.66
07-SEP-90	37.00 - 1.84	35.16	3123.99

MV-31
MPC
1903 Russell
elev. 3175.99

DATE	**TAPE HOLD**	**DEPTH**	**SWL**
01-DEC-89	45.00 - 1.25	43.75	3132.24
11-JAN-90	52.00 - 7.29	44.71	3131.28
27-JAN-90	47.00 - 1.99	45.01	3130.98
24-FEB-90	48.00 - 2.24	45.76	3130.23
26-MAR-90	50.00 - 4.06	45.94	3130.05
29-MAR-90	54.00 - 8.03	45.97	3130.02
12-APR-90	47.00 - 1.80	45.20	3130.79
28-APR-90	44.00 - 1.36	42.64	3133.35
11-MAY-90	44.00 - 2.33	41.67	3134.32
14-JUN-90	40.30 - 3.02	37.28	3138.71
14-JUL-90	40.00 - 1.87	38.13	3137.86
07-SEP-90	44.00 - 3.27	40.73	3135.26
09-AUG-90	43.00 - 3.01	39.99	3136.00

MV-33
Dornblaser Field
elev. 3205.16

DATE	**TAPE HOLD**	**DEPTH**	**SWL**
28-APR-90	75.00 - 2.75	72.25	3129.91
11-MAY-90	74.00 - 3.53	70.47	3134.69
14-JUN-90	68.50 - 2.22	66.28	3138.88
14-JUL-90	67.00 - 0.26	66.74	3138.42
07-SEP-90	72.00 - 0.90	71.10	3134.06

MV-34
Madison Street Bridge
elev. 3188.13

DATE	**TAPE HOLD**	**DEPTH**	**SWL**
01-DEC-89	41.00 - 1.55	39.45	3148.68
12-APR-90	40.00 - 1.31	38.69	3149.44
28-APR-90	35.00 - 1.00	34.00	3154.13
11-MAY-90	35.00 - 1.90	33.10	3155.03
14-JUN-90	30.00 - 1.74	28.26	3159.87
14-JUL-90	32.00 - 0.64	31.36	3156.77
07-SEP-90	35.00 - 0.37	34.63	3153.50

MV-35
University of Montana
McCormick Park
elev. 3175.78

DATE	**TAPE HOLD**	**DEPTH**	**SWL**
01-DEC-89	36.00 - 1.10	34.90	3140.88
11-JAN-90	40.00 - 4.05	35.95	3139.83
27-JAN-90	39.00 - 2.63	36.37	3139.41
24-FEB-90	39.00 - 1.66	37.34	3138.44
26-MAR-90	39.00 - 2.06	36.94	3138.84
12-APR-90	37.50 - 2.84	34.66	3141.12
28-APR-90	33.00 - 2.73	30.27	3145.51
11-MAY-90	31.00 - 0.60	30.40	3145.38
12-JUN-90	29.00 - 3.57	25.43	3150.35
14-JUN-90	26.00 - 0.54	25.46	3150.32
14-JUL-90	28.00 - 0.14	27.86	3147.92
09-AUG-90	32.00 - 1.40	30.60	3145.18
07-SEP-90	35.00 - 3.99	31.01	3144.77

A-36
Thompson Dental
1201 S 6 W
elev. 3192.09

DATE	**TAPE HOLD**	**DEPTH**	**SWL**
09-DEC-89	58.00 - 2.06	55.94	3136.15
11-JAN-90	58.00 - 0.95	57.05	3135.04
27-JAN-90	59.00 - 1.67	57.33	3134.76
24-FEB-90	60.00 - 2.39	57.61	3134.48
26-MAR-90	72.00 - 14.59	57.41	3134.68
12-APR-90	59.00 - 3.22	55.78	3136.31
28-APR-90	55.00 - 2.97	52.03	3140.06
11-MAY-90	53.00 - 1.10	51.90	3140.19
14-JUN-90	49.00 - 1.90	47.10	3144.99
14-JUL-90	50.00 - 1.00	49.00	3143.09
07-SEP-90	53.00 - 1.23	51.77	3140.32

MV-37
Reserve Street
elev. 3154.59

DATE	**TAPE HOLD**	**DEPTH**	**SWL**
28-APR-90	21.00 - 5.56	15.44	3139.15
30-APR-90	16.00 - 0.22	15.78	3138.81
11-MAY-90	17.00 - 1.02	15.98	3138.61
28-MAY-90	16.00 - 1.98	14.02	3140.57
14-JUN-90	16.00 - 3.63	12.37	3142.22
14-JUL-90	16.00 - 2.01	13.99	3140.60
07-SEP-90	18.00 - 1.21	16.79	3137.80

A-38
William Mintz
1013 Eaton
elev. 3175.30

DATE	**TAPE HOLD**	**DEPTH**	**SWL**
07-NOV-89	44.00 - 1.75	42.25	3133.05
24-NOV-89	44.00 - 1.40	42.60	3132.70
09-DEC-89	44.00 - 1.05	42.95	3132.35
11-JAN-90	46.00 - 2.38	43.62	3131.68
27-JAN-90	45.00 - 1.02	43.98	3131.32
24-FEB-90	45.00 - 0.30	44.70	3130.65
26-MAR-90	46.00 - 1.41	44.59	3130.71
28-APR-90	45.00 - 4.52	40.48	3134.82
11-MAY-90	42.00 - 2.04	39.96	3135.34
14-JUN-90	38.00 - 3.05	34.95	3140.35
14-JUL-90	38.00 - 1.50	36.50	3138.80
07-SEP-90	40.00 - 0.66	39.34	3135.96

A-40
Jefferson School
1700 South Ave W
elev. 3180.55

DATE	**TAPE HOLD**	**DEPTH**	**SWL**
24-NOV-89	50.00 - 1.14	48.86	3131.69
09-DEC-89	50.00 - 0.70	49.30	3131.25
11-JAN-90	50.05 - 0.51	49.99	3130.56
27-JAN-90	52.00 - 1.73	50.27	3130.28
26-MAR-90	52.00 - 0.80	51.20	3129.35
12-APR-90	53.50 - 2.89	50.61	3129.94
28-APR-90	51.00 - 2.70	48.30	3132.25
11-MAY-90	49.00 - 1.77	47.23	3133.32
14-JUN-90	45.00 - 2.26	42.74	3137.81
14-JUL-90	45.00 - 1.03	43.97	3136.58
07-SEP-90	49.00 - 2.70	46.30	3134.25

MV-41

University of Montana
Blaine/Crosby
elev. 3199.97

DATE	**TAPE HOLD**	**DEPTH**	**SWL**
30-NOV-89	70.00 - 3.07	66.93	3133.04
09-DEC-89	70.00 - 3.18	66.82	3133.15
11-JAN-90	69.00 - 1.08	67.92	3132.05
27-JAN-90	70.00 - 1.79	68.21	3131.76
24-FEB-90	70.00 - 1.04	68.96	3131.01
26-MAR-90	71.00 - 1.88	69.12	3130.85
12-APR-90	71.00 - 2.61	68.39	3131.58
28-APR-90	69.00 - 3.80	65.20	3134.77
11-MAY-90	67.00 - 2.43	64.57	3135.40
14-JUN-90	62.00 - 2.21	59.79	3140.18
14-JUL-90	62.00 - 1.03	60.97	3139.00
09-AUG-90	64.00 - 0.75	63.25	3136.72
07-SEP-90	66.00 - 2.29	63.71	3136.26

MV-42

University of Montana
South/Bancroft
elev. 3190.32

DATE	**TAPE HOLD**	**DEPTH**	**SWL**
30-NOV-89	65.00 - 7.14	57.86	3132.46
09-DEC-89	60.30 - 2.27	58.03	3132.29
09-JAN-90	66.00 - 7.24	58.76	3131.56
11-JAN-90	60.00 - 1.21	58.79	3131.53
27-JAN-90	60.00 - 0.92	59.08	3131.24
11-FEB-90	61.00 - 1.55	59.45	3130.87
24-FEB-90	60.00 - 0.23	59.77	3130.55
26-MAR-90	63.00 - 2.63	60.37	3129.75
12-APR-90	63.00 - 2.75	60.25	3130.07
28-APR-90	59.00 - 1.95	57.05	3133.27
11-MAY-90	57.50 - 0.74	56.76	3133.56
12-JUN-90	55.00 - 2.72	52.28	3138.04
14-JUN-90	55.00 - 2.78	52.22	3138.10
14-JUL-90	55.00 - 1.66	53.34	3136.98
09-AUG-90	57.00 - 1.70	55.30	3135.02
07-SEP-90	59.00 - 3.39	55.61	3134.71

MV-43
County Courthouse
200 W Broadway
elev. 3188.33

DATE	**TAPE HOLD**	**DEPTH**	**SWL**
01-DEC-89	50.00 - 1.28	48.72	3139.61
26-MAR-90	57.00 - 6.40	50.60	3137.73
12-APR-90	53.00 - 4.48	48.52	3139.81
11-MAY-90	49.00 - 2.06	46.94	3141.39
14-JUN-90	44.00 - 2.82	41.18	3147.15

MV-44
St. Mary's Cemetery
(East well)
elev. 3197.52

DATE	**TAPE HOLD**	**DEPTH**	**SWL**
24-FEB-90	OIL ON WATER		
12-APR-90	OIL ON WATER		
14-JUN-90	OIL ON WATER		

MV-45
St. Mary's Cemetery
(West Annex well)
elev. 3188.06

DATE	**TAPE HOLD**	**DEPTH**	**SWL**
01-DEC-89	52.00 - 1.83	50.17	3137.89
24-FEB-90	56.00 - 3.46	52.54	3135.52
26-MAR-90	55.00 - 2.42	52.58	3135.48
12-APR-90	55.00 - 1.83	53.17	3134.89
28-APR-90	50.00 - 1.82	48.18	3139.88
11-MAY-90	49.00 - 2.27	46.73	3141.33
14-JUN-90	45.00 - 1.37	43.63	3144.43
14-JUL-90	45.00 - 2.05	42.95	3145.11
07-SEP-90	47.00 - 0.48	46.52	3141.54

MV-46
City Cemetery
Missoula
elev. 3189.19

DATE	**TAPE HOLD**	**DEPTH**	**SWL**
01-DEC-89	54.00 - 1.76	52.24	3136.95
11-JAN-90	59.00 - 5.01	53.99	3135.20
27-JAN-90	57.00 - 3.41	53.59	3135.60
24-FEB-90	57.00 - 2.43	54.57	3134.62
26-MAR-90	57.00 - 2.46	54.59	3134.65
12-APR-90	56.00 - 2.65	53.35	3135.84
28-APR-90	51.00 - 2.19	48.81	3140.38
11-MAY-90	50.00 - 1.31	48.69	3140.50
14-JUN-90	49.50 - 5.92	43.58	3145.61
14-JUL-90	47.00 - 2.23	44.77	3144.42
07-SEP-90	50.00 - 1.08	48.92	3140.27

A-47
Mission Paint
1605 South Ave W
elev. 3182.25

DATE	**TAPE HOLD**	**DEPTH**	**SWL**
30-NOV-89	55.00 - 3.71	51.29	3130.96
11-JAN-90	53.00 - 2.57	50.43	3131.82
27-JAN-90	52.60 - 0.90	51.70	3130.55
24-FEB-90	53.00 - 0.58	52.42	3129.83
26-MAR-90	54.00 - 1.30	52.70	3129.55
12-APR-90	54.00 - 1.84	52.16	3130.09
28-APR-90	51.00 - 1.57	49.43	3132.82
11-MAY-90	50.00 - 1.21	48.79	3133.46
14-JUN-90	46.00 - 1.65	44.35	3137.90
14-JUL-90	47.00 - 1.53	45.47	3136.78
07-SEP-90	49.00 - 1.11	47.89	3134.36

A-53
Big Bear Resources
2115 S 38 St.
elev. 3160.48

DATE	TAPE HOLD	DEPTH	SWL
21-NOV-89	37.00 - 2.38	34.62	3125.86
24-NOV-89	37.00 - 2.23	34.77	3125.71
09-DEC-89	38.00 - 2.98	35.02	3125.46
11-JAN-90	37.00 - 1.39	35.61	3124.87
27-JAN-90	37.00 - 1.21	35.79	3124.69
24-FEB-90	37.00 - 0.69	36.31	3124.17
26-MAR-90	38.00 - 1.47	36.53	3123.95
12-APR-90	43.00 - 6.69	36.31	3124.17
28-APR-90	35.00 - 0.33	34.67	3125.81
11-MAY-90	35.00 - 1.00	34.00	3126.48
14-JUN-90	31.00 - 1.12	29.88	3130.60
14-JUL-90	32.00 - 1.01	30.99	3129.49
07-SEP-90	34.00 - 1.12	32.88	3127.60

A-54
Autoglass Specialists
1023 Kensington
approx elev. 3188.36

DATE	TAPE HOLD	DEPTH	SWL
11-JAN-90	59.00 - 1.60	57.40	3130.96
27-JAN-90	59.00 - 1.32	57.68	3130.69
24-FEB-90	59.00 - 0.57	58.43	3129.93
26-MAR-90	61.00 - 2.35	58.65	3129.71
12-APR-90	59.00 - 1.05	57.95	3130.41
28-APR-90	56.00 - 0.66	55.34	3133.02
11-MAY-90	55.00 - 0.65	54.35	3134.01
14-JUN-90	51.00 - 1.26	49.74	3138.62
14-JUL-90	52.00 - 1.18	50.82	3137.54
07-SEP-90	54.00 - 0.57	53.43	3134.93

A-55
Nordic Apartments
1130 Longstaff
elev 3187.96

DATE	TAPE HOLD	DEPTH	SWL
11-JAN-90	59.00 - 2.33	56.67	3131.29
27-JAN-90	59.00 - 1.32	57.68	3130.28
24-FEB-90	63.00 - 5.26	57.74	3130.22
26-MAR-90	60.00 - 2.12	57.88	3130.08
12-APR-90	60.50 - 3.47	57.03	3130.93
28-APR-90	57.00 - 2.68	54.32	3133.64
11-MAY-90	55.00 - 1.57	53.43	3134.53
14-JUN-90	50.00 - 1.22	48.78	3139.18
14-JUL-90	51.00 - 1.13	49.87	3138.09
07-SEP-90	53.00 - 0.46	52.54	3135.42

A-58
Martin Development Co.
1525 Russell
elev. 3186.22

DATE	**TAPE HOLD**	**DEPTH**	**SWL**
14-NOV-89	57.00 - 3.24	53.76	3132.46
24-NOV-89	56.00 - 2.05	53.95	3132.27
09-DEC-89	56.00 - 1.58	54.42	3131.80
24-FEB-90	58.00 - 1.80	56.20	3130.02
26-MAR-90	58.00 - 1.67	56.33	3129.89
28-APR-90	53.00 - 0.18	52.82	3133.40

APPENDIX C

COMPUTER MODEL INPUT FILES

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****BASIC PACKAGE - WELLS OFF**** 3-D MODEL AROUND A SINGLE WELL IN THE MVA WITH
VARIABLE GRID SPACING
IBOUND ARRAY AND HEADS REMAIN CONSTANT FOR ALL NINE MODEL LAYERS
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         1         1(40I2)           -2
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          1          0          1          1


****OUTPUT CONTROL PACKAGE - WELLS ON****
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****WELL PACKAGE - WELLS OFF****
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          2
          6         60         210.0000
          7         60         210.0000


****WELL PACKAGE - WELLS ON****
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          2
          6         60         21-1.054
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****STRONGLY IMPLICIT SOLVER PACKAGE INPUT****
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1.0000     .10000E-03          1.00000               1
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WELLS PUMPING AT 945 GPM - IBOUND ARRAY REMAINS CONSTANT FOR ALL NINE MODEL LAYERS
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 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
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 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
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 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
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 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
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 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
 0-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1 0
999.00
       -50 0.100E+01                            -1
       -50 0.100E+01                            -1
       -50 0.100E+01                            -1
       -50 0.100E+01                            -1
       -50 0.100E+01                            -1
       -50 0.100E+01                            -1
       -50 0.100E+01                            -1
       -50 0.100E+01                            -1
       -50 0.100E+01                            -1
86400              11.5000
```

```
****BLOCK CENTERED FLOW PACKAGE INPUT - STRATIGRAPHIC SETTING A****
        1         0                                      *ISS, IBCFCB
  1 0 0 0 0 0 0 0 0                                      *LAYCON
        0 0.100E+01                                      *TRPY
       11 0.100E+01(7G11.4)                            12*DELR
   30.00      30.00      30.00      30.00      30.00      30.00      30.00
   30.00      30.00      30.00      20.00      20.00      20.00      20.00
   20.00      15.00      15.00      15.00      15.00      15.00      15.00
   15.00      15.00      15.00      15.00      15.00      20.00      20.00
   20.00      20.00      20.00      30.00      30.00      30.00      30.00
   30.00      30.00      30.00      30.00      30.00      30.00
       11 0.100E+01(7G11.4)                            12*DELC
   30.00      30.00      30.00      30.00      30.00      30.00      30.00
   30.00      30.00      30.00      30.00      30.00      30.00      30.00
   30.00      30.00      30.00      30.00      30.00      30.00      30.00
   30.00      30.00      30.00      30.00      30.00      30.00      30.00
   30.00      30.00      30.00      30.00      30.00      30.00      30.00
   30.00      30.00      30.00      30.00      30.00      20.00      20.00
   20.00      20.00      20.00      20.00      20.00      20.00      20.00
   15.00      15.00      15.00      15.00      15.00      15.00      15.00
   15.00      15.00      15.00      15.00      15.00      15.00      15.00
   15.00      15.00      15.00      15.00      20.00      20.00      20.00
   20.00      20.00      20.00      20.00      20.00      20.00      20.00
   30.00      30.00      30.00      30.00      30.00
        0 0.104E+00                                      *K-1
        0 0.122E+03                                      *BOT-1
        0 0.313E-02                                      *VCONT-1
        0 0.104E+01                                      *T-2
        0 0.313E-02                                      *VCONT-2
        0 0.104E+01                                      *T-3
        0 0.368E-02                                      *VCONT-3
        0 0.729E+00                                      *T-4
        0 0.446E-02                                      *VCONT-4
        0 0.729E+00                                      *T-5
        0 0.446E-02                                      *VCONT-5
        0 0.729E+00                                      *T-6
        0 0.446E-02                                      *VCONT-6
        0 0.729E+00                                      *T-7
        0 0.391E-02                                      *VCONT-7
        0 0.938E+00                                      *T-8
        0 0.329E-02                                      *VCONT-8
        0 0.104E+01                                      *T-9
```

```
****BLOCK CENTERED FLOW PACKAGE INPUT - STRATIGRAPHIC SETTING B****
        1        -1                                      *ISS, IBCFCB
  1 0 0 0 0 0 0 0 0                                      *LAYCON
        0 0.100E+01                                      *TRPY
       11 0.100E+01(7G11.4)                            12*DELR
   30.00      30.00      30.00      30.00      30.00      30.00      30.00
   30.00      30.00      30.00      20.00      20.00      20.00      20.00
   20.00      15.00      15.00      15.00      15.00      15.00      15.00
   15.00      15.00      15.00      15.00      15.00      20.00      20.00
   20.00      20.00      20.00      30.00      30.00      30.00      30.00
   30.00      30.00      30.00      30.00      30.00      30.00
       11 0.100E+01(7G11.4)                            12*DELC
   30.00      30.00      30.00      30.00      30.00      30.00      30.00
   30.00      30.00      30.00      30.00      30.00      30.00      30.00
   30.00      30.00      30.00      30.00      30.00      30.00      30.00
   30.00      30.00      30.00      30.00      30.00      30.00      30.00
   30.00      30.00      30.00      30.00      30.00      30.00      30.00
   30.00      30.00      30.00      30.00      30.00      20.00      20.00
   20.00      20.00      20.00      20.00      20.00      20.00      20.00
   15.00      15.00      15.00      15.00      15.00      15.00      15.00
   15.00      15.00      15.00      15.00      15.00      15.00      15.00
   15.00      15.00      15.00      15.00      20.00      20.00      20.00
   20.00      20.00      20.00      20.00      20.00      20.00      20.00
   30.00      30.00      30.00      30.00      30.00
        0 0.310E-03                                      *K-1
        0 0.122E+03                                      *BOT-1
        0 0.310E-05                                      *VCONT-1
        0 0.310E-02                                      *T-2
        0 0.310E-05                                      *VCONT-2
        0 0.310E-02                                      *T-3
        0 0.360E-05                                      *VCONT-3
        0 0.217E-02                                      *T-4
        0 0.440E-05                                      *VCONT-4
        0 0.217E-02                                      *T-5
        0 0.890E-05                                      *VCONT-5
        0 0.729E+00                                      *T-6
        0 0.446E-02                                      *VCONT-6
        0 0.729E+00                                      *T-7
        0 0.391E-02                                      *VCONT-7
        0 0.938E+00                                      *T-8
        0 0.329E-02                                      *VCONT-8
        0 0.104E+01                                      *T-9
```

```
****BLOCK CENTERED FLOW PACKAGE INPUT - STRATIGRAPHIC SETTING C****
         1        -1                                       *ISS, IBCFCB
 1 0 0 0 0 0 0 0 0                                         *LAYCON
          0 0.100E+01                                      *TRPY
         11 0.100E+01(7G11.4)                           12*DELR
  30.00      30.00      30.00      30.00      30.00      30.00      30.00
  30.00      30.00      30.00      20.00      20.00      20.00      20.00
  20.00      15.00      15.00      15.00      15.00      15.00      15.00
  15.00      15.00      15.00      15.00      15.00      20.00      20.00
  20.00      20.00      20.00      30.00      30.00      30.00      30.00
  30.00      30.00      30.00      30.00      30.00      30.00
         11 0.100E+01(7G11.4)                           12*DELC
  30.00      30.00      30.00      30.00      30.00      30.00      30.00
  30.00      30.00      30.00      30.00      30.00      30.00      30.00
  30.00      30.00      30.00      30.00      30.00      30.00      30.00
  30.00      30.00      30.00      30.00      30.00      30.00      30.00
  30.00      30.00      30.00      30.00      30.00      30.00      30.00
  30.00      30.00      30.00      30.00      30.00      20.00      20.00
  20.00      20.00      20.00      20.00      20.00      20.00      20.00
  15.00      15.00      15.00      15.00      15.00      15.00      15.00
  15.00      15.00      15.00      15.00      15.00      15.00      15.00
  15.00      15.00      15.00      15.00      20.00      20.00      20.00
  20.00      20.00      20.00      20.00      20.00      20.00      20.00
  30.00      30.00      30.00      30.00      30.00
          0 0.104E+00                                      *K-1
          0 0.122E+03                                      *BOT-1
          0 0.313E-02                                      *VCONT-1
          0 0.104E+01                                      *T-2
          0 0.313E-02                                      *VCONT-2
          0 0.104E+01                                      *T-3
          0 0.890E-05                                      *VCONT-3
          0 0.217E-02                                      *T-4
          0 0.440E-05                                      *VCONT-4
          0 0.217E-02                                      *T-5
          0 0.890E-05                                      *VCONT-5
          0 0.729E+00                                      *T-6
          0 0.446E-02                                      *VCONT-6
          0 0.729E+00                                      *T-7
          0 0.391E-02                                      *VCONT-7
          0 0.938E+00                                      *T-8
          0 0.329E-02                                      *VCONT-8
          0 0.104E+01                                      *T-9


****BLOCK CENTERED FLOW PACKAGE INPUT - STRATIGRAPHIC SETTING D****
         1        -1                                       *ISS, IBCFCB
 1 0 0 0 0 0 0 0 0                                         *LAYCON
          0 0.100E+01                                      *TRPY
         11 0.100E+01(7G11.4)                           12*DELR
  30.00      30.00      30.00      30.00      30.00      30.00      30.00
  30.00      30.00      30.00      20.00      20.00      20.00      20.00
  20.00      15.00      15.00      15.00      15.00      15.00      15.00
  15.00      15.00      15.00      15.00      15.00      20.00      20.00
  20.00      20.00      20.00      30.00      30.00      30.00      30.00
  30.00      30.00      30.00      30.00      30.00      30.00
         11 0.100E+01(7G11.4)                           12*DELC
  30.00      30.00      30.00      30.00      30.00      30.00      30.00
  30.00      30.00      30.00      30.00      30.00      30.00      30.00
  30.00      30.00      30.00      30.00      30.00      30.00      30.00
  30.00      30.00      30.00      30.00      30.00      30.00      30.00
  30.00      30.00      30.00      30.00      30.00      30.00      30.00
  30.00      30.00      30.00      30.00      30.00      20.00      20.00
  20.00      20.00      20.00      20.00      20.00      20.00      20.00
  15.00      15.00      15.00      15.00      15.00      15.00      15.00
  15.00      15.00      15.00      15.00      15.00      15.00      15.00
  15.00      15.00      15.00      15.00      20.00      20.00      20.00
  20.00      20.00      20.00      20.00      20.00      20.00      20.00
  30.00      30.00      30.00      30.00      30.00
          0 0.104E-01                                      *K-1
          0 0.122E+03                                      *BOT-1
          0 0.104E-03                                      *VCONT-1
          0 0.104E+00                                      *T-2
          0 0.104E-03                                      *VCONT-2
          0 0.104E+00                                      *T-3
          0 0.123E-03                                      *VCONT-3
          0 0.729E-01                                      *T-4
          0 0.149E-03                                      *VCONT-4
          0 0.729E-01                                      *T-5
          0 0.288E-03                                      *VCONT-5
          0 0.729E+00                                      *T-6
          0 0.446E-02                                      *VCONT-6
          0 0.729E+00                                      *T-7
          0 0.391E-02                                      *VCONT-7
          0 0.938E+00                                      *T-8
          0 0.329E-02                                      *VCONT-8
          0 0.104E+01                                      *T-9
```

```
****PATH3D INPUT - STRATIGRAPHIC SETTING A - APPENDED TO BCF FILE***
         0 0.132E+03                                       *HTOP
         0 0.100E+02                                       *DZ-1
         0 0.100E+02                                       *DZ-2
         0 0.100E+02                                       *DZ-3
         0 0.700E+01                                       *DZ-4
         0 0.700E+01                                       *DZ-5
         0 0.700E+01                                       *DZ-6
         0 0.700E+01                                       *DZ-7
         0 0.900E+01                                       *DZ-8
         0 0.100E+02                                       *DZ-9
         0      0.20                                       *POROSITY-1
         0      0.20                                       *POROSITY-2
         0      0.20                                       *POROSITY-3
         0      0.20                                       *POROSITY-4
         0      0.20                                       *POROSITY-5
         0      0.20                                       *POROSITY-6
         0      0.20                                       *POROSITY-7
         0      0.20                                       *POROSITY-8
         0      0.20                                       *POROSITY-9
```

```
****PATH3D INPUT - STRATIGRAPHIC SETTING B - APPENDED TO BCF FILE***
         0 0.132E+03                                       *HTOP
         0 0.100E+02                                       *DZ-1
         0 0.100E+02                                       *DZ-2
         0 0.100E+02                                       *DZ-3
         0 0.700E+01                                       *DZ-4
         0 0.700E+01                                       *DZ-5
         0 0.700E+01                                       *DZ-6
         0 0.700E+01                                       *DZ-7
         0 0.900E+01                                       *DZ-8
         0 0.100E+02                                       *DZ-9
         0      0.35                                       *POROSITY-1
         0      0.35                                       *POROSITY-2
         0      0.35                                       *POROSITY-3
         0      0.35                                       *POROSITY-4
         0      0.35                                       *POROSITY-5
         0      0.20                                       *POROSITY-6
         0      0.20                                       *POROSITY-7
         0      0.20                                       *POROSITY-8
         0      0.20                                       *POROSITY-9
```

```
****PATH3D INPUT - STRATIGRAPHIC SETTING C - APPENDED TO BCF FILE***
         0 0.132E+03                                       *HTOP
         0 0.100E+02                                       *DZ-1
         0 0.100E+02                                       *DZ-2
         0 0.100E+02                                       *DZ-3
         0 0.700E+01                                       *DZ-4
         0 0.700E+01                                       *DZ-5
         0 0.700E+01                                       *DZ-6
         0 0.700E+01                                       *DZ-7
         0 0.900E+01                                       *DZ-8
         0 0.100E+02                                       *DZ-9
         0      0.20                                       *POROSITY-1
         0      0.20                                       *POROSITY-2
         0      0.20                                       *POROSITY-3
         0      0.35                                       *POROSITY-4
         0      0.35                                       *POROSITY-5
         0      0.20                                       *POROSITY-6
         0      0.20                                       *POROSITY-7
         0      0.20                                       *POROSITY-8
         0      0.20                                       *POROSITY-9
```

******PATH3D INPUT - STRATIGRAPHIC SETTING D - APPENDED TO BCF FILE*****

```
 0 0.132E+03                                   *HTOP
 0 0.100E+02                                   *DZ-1
 0 0.100E+02                                   *DZ-2
 0 0.100E+02                                   *DZ-3
 0 0.700E+01                                   *DZ-4
 0 0.700E+01                                   *DZ-5
 0 0.700E+01                                   *DZ-6
 0 0.700E+01                                   *DZ-7
 0 0.900E+01                                   *DZ-8
 0 0.100E+02                                   *DZ-9
 0      0.30                                   *POROSITY-1
 0      0.30                                   *POROSITY-2
 0      0.30                                   *POROSITY-3
 0      0.30                                   *POROSITY-4
 0      0.30                                   *POROSITY-5
 0      0.20                                   *POROSITY-6
 0      0.20                                   *POROSITY-7
 0      0.20                                   *POROSITY-8
 0      0.20                                   *POROSITY-9
```

******PATH3D INPUT - PARTICLES INSERTED ON AQUIFER BOTTOM******

```
18         1         0         2         1
 0     1.e10   1.E-04       1.0       100         1         3
 2         1         9        -1
 5         1         9        -1
 7         1         9        -1
10         1         9        -1
14         1         9        -1
19         1         9        -1
21         1         9        -1
23         1         9        -1
28         1         9        -1
32         1         9        -1
35         1         9        -1
37         1         9        -1
40         1         9        -1
```

******PATH3D INPUT - PARTICLES INSERTED AT WATER TABLE******

```
18         1         0         2         1
 0     1.e10   1.E-04       1.0       100         1         3
 2         1         1        -1
 5         1         1        -1
 7         1         1        -1
10         1         1        -1
14         1         1        -1
19         1         1        -1
21         1         1        -1
23         1         1        -1
28         1         1        -1
32         1         1        -1
35         1         1        -1
37         1         1        -1
40         1         1        -1
```