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A THERMAL TRANSPORT MODEL FOR THE UPPER AQUIFER OF THE LITTLE MIAMI AQUIFER SYSTEM, CINCINNATI, OHIO

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Abstract

Industrialization and urbanization threaten the water quality of highly conductive glacial outwash aquifers, such as the Little Miami Aquifer System in Cincinnati, Ohio. This two-layer aquifer system directly underlies a municipal golf course and airport, and also provides drinking water to the Village of Indian Hill. In the event of contamination, the efficacy of remediation techniques would depend on an accurate assessment of transport parameters. This study describes the interaction between the upper aquifer of the LMAS and the Little Miami and Ohio Rivers, proposes a conceptual model for transport, and uses a computer model to test the conceptual model.

The conceptual model describes the lower reaches of the LMAS, where the northern and eastern boundaries are the Little Miami River, the southern boundary is the Ohio River, and the western boundary is limestone and shale bedrock. As modeled, surface water and underflow provide all groundwater sources and sinks. These sources and sinks, modeled as fluxes into and out of the modeled area, are calculated by MODULAR, a USGS finite-difference numerical model which outputs groundwater fluxes based on changes in Ohio River stage.

The computer model, Saturated-Unsaturated Transport (a USGS finite-element numerical model, "SUTRA"), allows the modeling of either energy or solute transport. Both types of transport undergo advection, diffusion, and dispersion. Both transport balance equations track a particular quantity per unit volume of solid matrix

plus fluid. In both cases, values for longitudinal and transverse dispersivity determine to what extent energy or solute sources will mix with groundwater in the aquifer, and how far these sources will spread. Dispersivity values determined by calibration of an energy transport model can then be used in a solute transport model, in conjunction with solute properties, to predict the extent of possible contamination.

Failure to calibrate the computer model indicates one or more faulty assumptions in the conceptual model. The conceptual model assumes that sources to the system include only surface water and underflow contributions. Because these sources are not producing a groundwater temperature drop as observed in the field, another mechanism is probably providing a source of water. It is likely that vertical infiltration into the upper aquifer would provide enough cold water to produce the April, 1994 groundwater temperature change.

The probability of vertical infiltration puts the upper aquifer at risk not only from surface water contamination, but also from seepage contamination through the overlying soil. Further modeling of the area, which includes vertical infiltration as a source, will more fully characterize transport processes and contamination potential of the LMAS. Pollutants at the golf course and airport, as well as soil pollutants upgradient from the study area, should be considered as potential sources of contamination to the upper aquifer when considering pollution prevention and remediation.

Acknowledgments

I would like to thank my advisor, Dr. David Nash, for having enough confidence in me to suggest a project involving technology about which I knew so little. "Datalogger," "Wylbur," and "Flux2nod" are words I am sure never to forget. I am also grateful to Dr. Nash for his patience and persistence when solving computer problems at short notice. I thank Dr. Maynard for his help regarding clay analysis and solute transport, as well as for offering lab work to provide financial support. I thank Dr. Pryor for illustrating the importance of depositional models and for his careful examination of figures. I am grateful to Piper Copeland, as well as Kym Anderson, Jennifer Tegan, Matt Duty, Clint Dameron, Amanda Dameron, and Alex Dannin, for helping me collect field data. I am especially indebted to Dr. Lowell for providing help in the field, offering map work to provide financial support, and the generous use of his computers.

I could not have conducted this project without the assistance of Andy Otterbein and the rest of the Reeves Golf Course Maintenance Crew. The golf cart was greatly appreciated, and the scenery was beautiful!

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I. Introduction

Intrinsic to the understanding of groundwater remediation is an understanding of groundwater transport. Using computer models to describe groundwater transport greatly enhances the efficacy of remediation techniques. Calibration of a primary solute transport model is not always possible, because the field area is not contaminated, or because of the expense of solute data collection. A viable option is to calibrate a thermal energy transport model, using water temperature as a proxy for solute concentration. Both quantities are transported by advection, dispersion, and diffusion. A calibrated transport model will accurately describe the way transport mechanisms function in a geologic system, transporting either energy or solutes.

The water quality of glacial outwash aquifers is at risk from urbanization and industrialization (Evans, 1977). These aquifers occupy laterally continuous buried valleys throughout the state of Ohio (Figure 1), and are the major source of drinking water for those communities who rely on groundwater. Major streams associated with these aquifers increase their groundwater yield, and also their chance for contamination. For those communities relying solely on groundwater for their drinking water needs, the threat of contamination poses a critical problem.

The Little Miami Aquifer System (LMAS) in eastern Cincinnati, Ohio, is a glacial outwash aquifer associated with two major streams. The Reeves Golf Course Wellfield provides an opportunity to study transport in the LMAS and its interaction with the Little Miami and

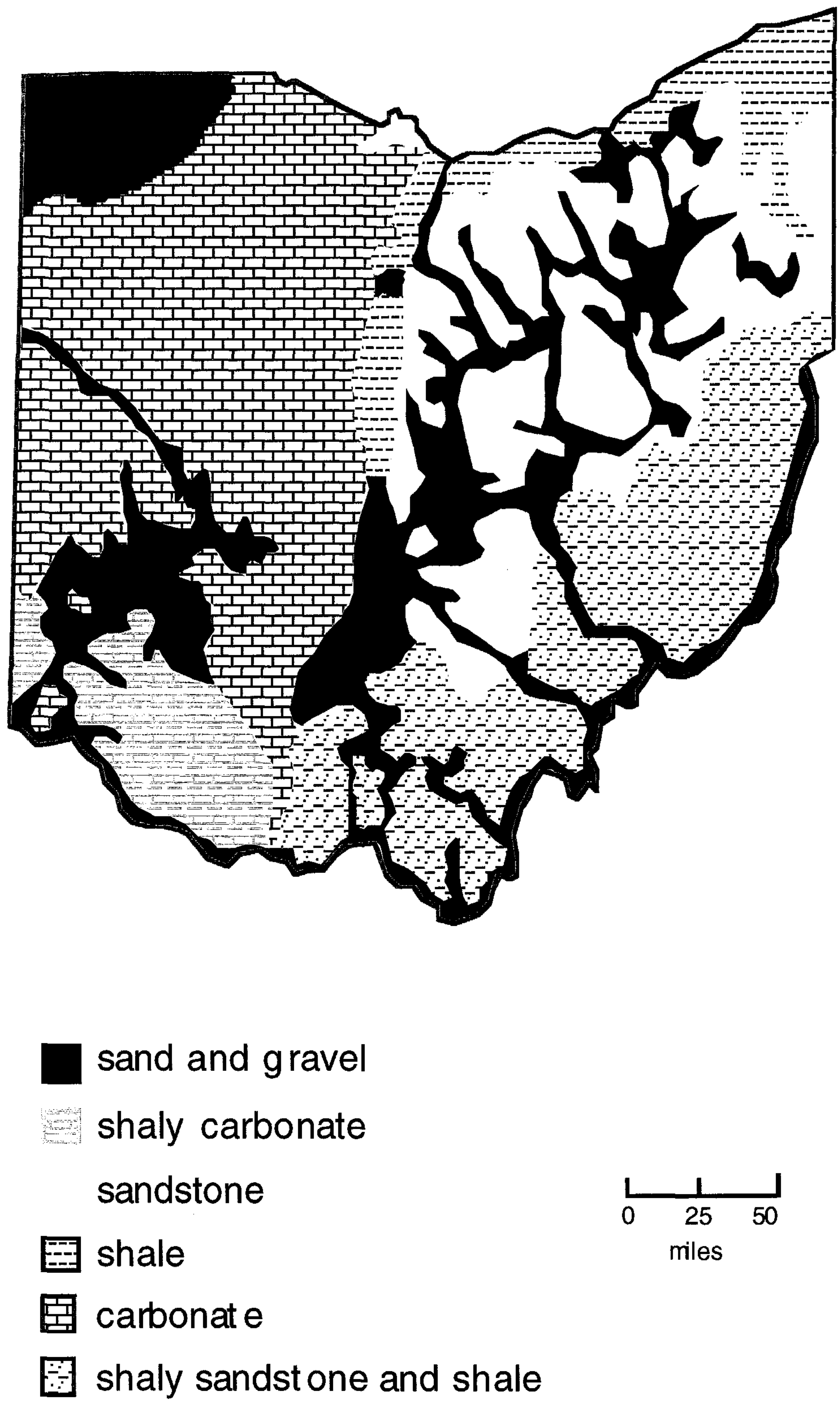


Figure 1 Aquifers of Ohio
(after Swisshelm, Lane, and Stein, 1987).

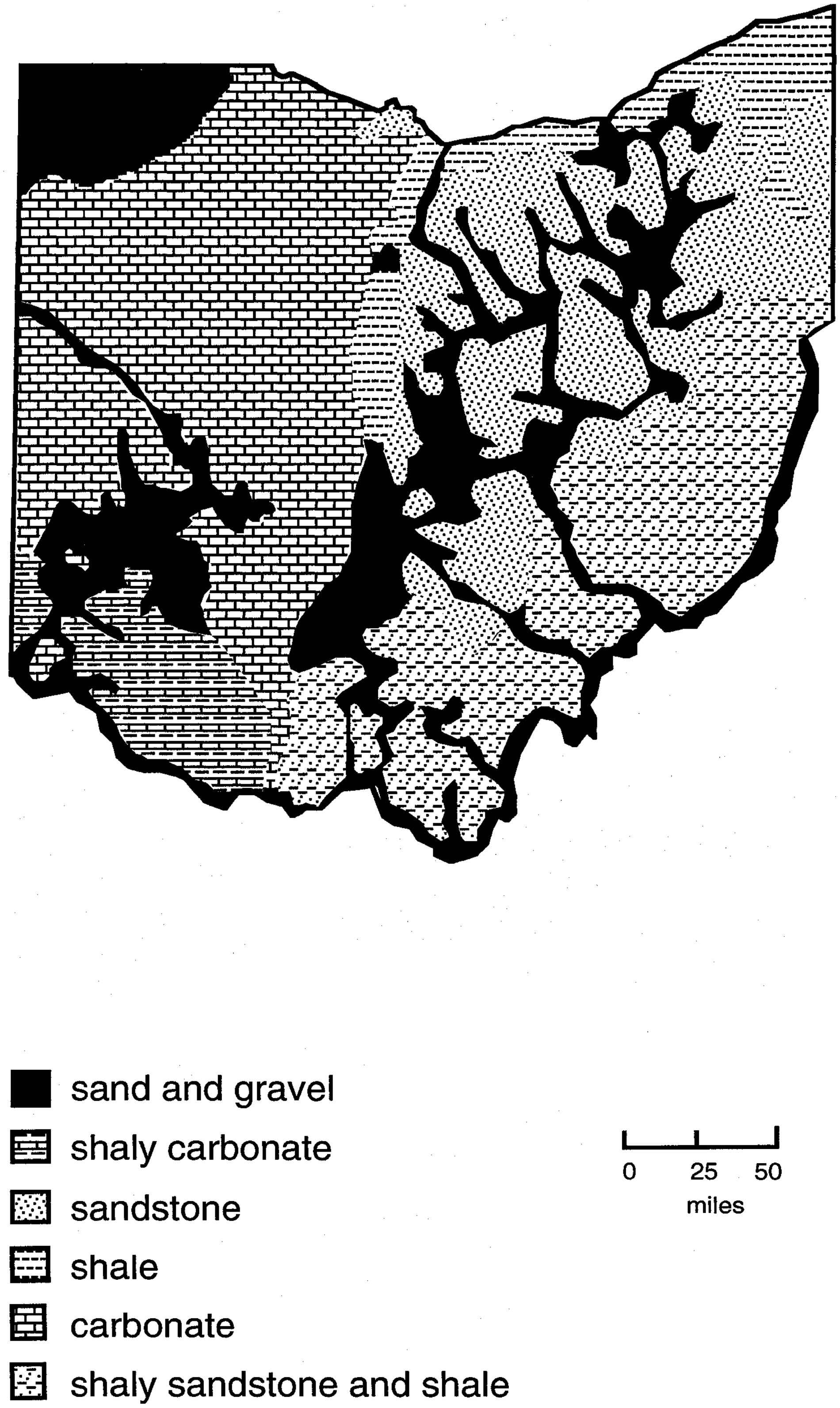


Figure 1 Aquifers of Ohio
(after Swisshelm, Lane, and Stein, 1987).

Ohio Rivers. Field observations at Reeves Wellfield allow the development of a conceptual transport model that can be tested and refined with SUTRA (Saturated-Unsaturated Transport), a USGS FORTRAN computer program (Voss, 1984). The study described here is part of a larger investigation that consists of a groundwater flow model developed by Copeland (1996) and an energy transport model, described here. The flow model describes aquifer recharge and discharge and the magnitude and direction of groundwater flow. The transport model develops, calibrates, and tests an energy transport model for the same area of the LMAS. The model can then be used to describe solute transport for the LMAS and probably many other sand and gravel outwash aquifers.

Purpose of Study

This study employs a thermal energy transport model to determine transport parameters and characterize transport processes of the upper aquifer of the LMAS and assess the sensitivity of the aquifer to contamination. The model is calibrated by matching modeled results to groundwater temperature data collected in the field. A calibrated computer model will not only describe thermal energy transport, but also solute (contaminant) transport, because both processes are governed by advection, diffusion, and dispersion. Transport parameters determined in the model can then be used to model past, present, or future contaminant transport scenarios.

Location of the Study Area

The portion of the LMAS studied here is located in Cincinnati, Ohio, within Hamilton County (Figure 2). Reeves Golf Course Wellfield is contained within the Lunken Airport Playfield, located at the intersection of Beechmont and Wilmer Avenues. The Wellfield encompasses approximately 0.5 square miles. The northern and southern boundaries of the study area are roughly 39°07'00" and 39°06'15" north latitude, respectively. The eastern and western boundaries are roughly 84°23'45" and 84°26'15" west longitude, respectively. Limestone and shale bedrock form the western boundary, Duck Creek constitutes the northern boundary, and the Little Miami River is the eastern boundary. The modeled area extends south to the Ohio River (approximately 0.5 miles), although groundwater data was only available for the area of Reeves Golf Course.

Previous Investigations

Study of local geology began when Fenneman (1916) described the bedrock and glacial geology of Cincinnati and vicinity, and discussed water-bearing formations in the area. Durrell, *et al.* (1961), Teller (1970), and Goldthwait, *et al.* (1981) described the history of Southwestern Ohio at the southernmost limit of pre-Illinoian, Illinoian, and late Wisconsin age glaciations. Goldthwait, *et al.* (1961) mapped the glacial deposits of Ohio, and Brockman (1989) mapped these deposits in Hamilton County. Gooding (1963, 1975)

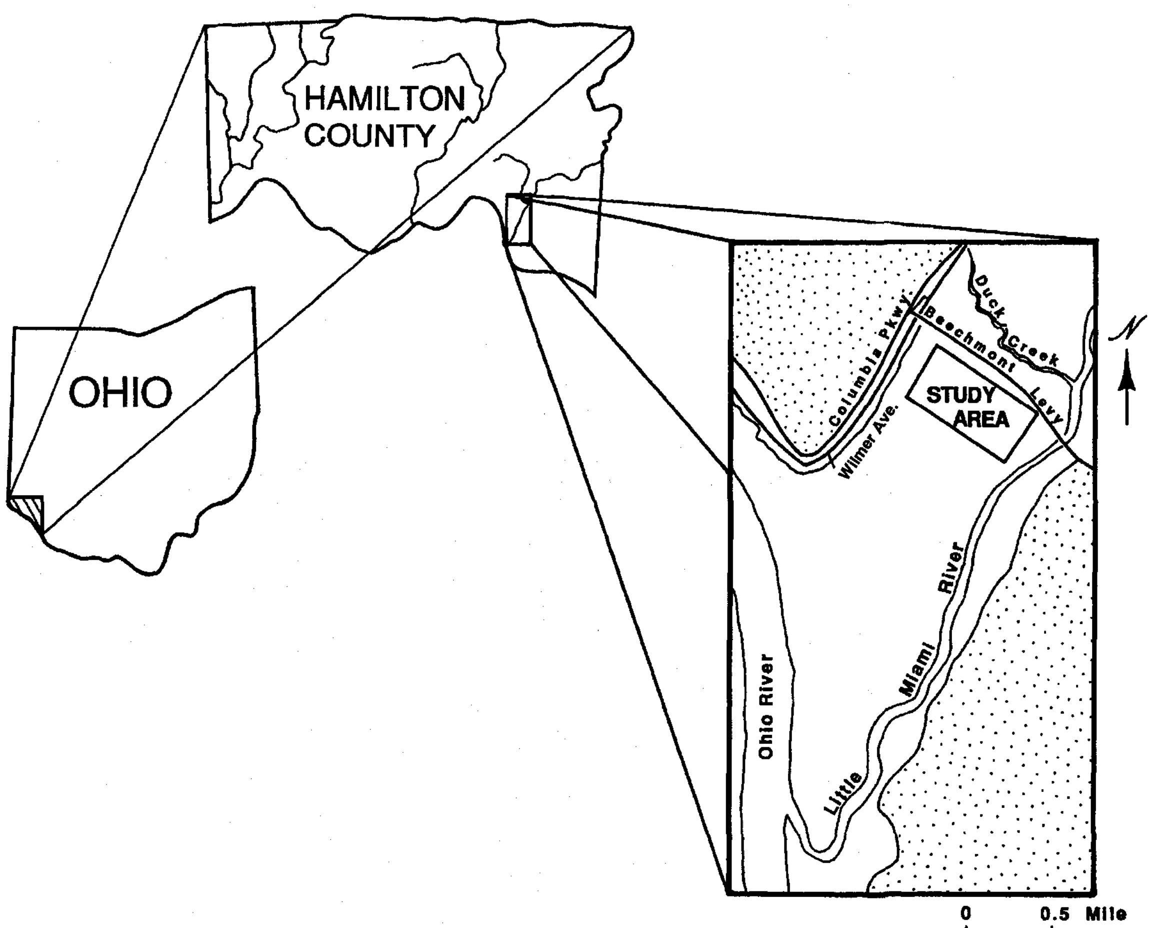


Figure 2 Location of Reeves Colf Course Wellfield.

developed a glacial stratigraphic classification for southeastern Indiana and southwestern Ohio. Durrell (1982) described drainage changes from pre-Kansan to post-Wisconsin time which deposited the LMAS and other glacial outwash aquifers. Chapter III describes these drainage changes.

Several authors have described groundwater resources in the area (Bernhagen and Schaefer, 1947; Christie, 1986; Evans, 1977; Klaer and Thompson, 1947; Norris and Spieker, 1966; Spieker, 1968; Stout, VerSteeg, and Lamb, 1943; Swisshelm, Lane, and Stein, 1987). Norris and Spieker (1966) estimate that nearly one-quarter of all groundwater pumped in the State of Ohio is provided by the Miami Valley aquifer system. One reach of this system provides drinking water to 1.5 million people in the City of Dayton and the surrounding area. The Little Miami Aquifer System currently provides drinking water for 15,000 people in the Village of Indian Hill.

Development of groundwater resources is greatly enhanced by groundwater modeling, and several authors have used computer models to predict and describe groundwater flow in Midwest glacial outwash environments. In areas where municipalities use, or propose to use, groundwater as a water supply, models have predicted induced infiltration and water-level decline (Fidler, 1975; Razem, 1983; Spieker, 1968; Starn, 1988; Weiss and Razem, 1980). Shaver and Ripley (1989) determined recharge and evapo-transpiration parameters for use in allocating groundwater for irrigation. Baily and Imbrigiotta (1982) modeled groundwater flow in outwash along Indiana's White River Valley in order to characterize water resources in an 88-square mile area.

A few authors have used transport models to describe and predict energy or solute transport in glacial outwash aquifers. Weinreb (1987) used SUTRA to investigate thermal contamination at Purdue University's wellfield. He used a homemade thermocouple probe attached to a digital thermometer to monitor groundwater as it was pumped from a production well, and to construct groundwater temperature profiles in wells by measuring groundwater temperature at 10-foot intervals. Schaefer, Galya, and Moore (1989) used a computer model to accurately represent groundwater flow in unconsolidated glacial deposits at an unnamed site in the Midwest, yet were unable to accurately calibrate the transport portion of the model. Plomb and Arnett (1992) combined groundwater flow modeling, particle transport, and Geographic Information System techniques to promote effective wellhead protection in the Great Miami River Valley. Mercer and others (1989) developed a flow and transport model to assist in the remediation of hazardous waste at the Chem-Dyne site in Hamilton, Ohio.

Research of the LMAS began when a Research Challenge Grant from the Ohio Board of Regents funded the installation of the Reeves Wellfield in 1987-1989. Nash and Savage (1990) conducted a year-long groundwater level monitoring program of the site. They determined the direction of groundwater flow in the Upper Aquifer to be generally southeasterly toward the Little Miami and the direction of groundwater flow in the Lower Aquifer to be southerly toward the Ohio River, with reversal of direction during flooding. Nash and Savage (1990) suggest that (1) a confining layer between the two aquifers effectively isolates groundwater flow between them, (2) the Upper Aquifer communicates well with the Little Miami but the Lower aquifer does not, and (3) the channel of the Little Miami does not penetrate the clay confining layer, minimizing its effect on the Lower Aquifer. Preliminary modeling of the river-groundwater interaction (Nash and Savage, 1990) generated a hydraulic conductivity value of 65 m/day and a storage coefficient of 0.1. However, the model did not consider leakage of precipitation through the silty clay layer above the Upper Aquifer. This layer was presumed to be sufficiently fine-grained enough to prevent infiltration (Figure 3).

Geologic Setting

Greater Cincinnati lies within the till plain portion of the Central Lowland physiographic province (Fenneman, 1938) and contains gently rolling ground moraine with bands of terminal moraine and outwash filled valleys. Surficial deposits include Kansan ground moraine and undifferentiated Illinoian material (Figure 4). Reeves Wellfield lies in the Little Miami Valley, a pre-glacial valley incised by the late Tertiary ("Teays Age") Licking River into Ordovician limestone and shale bedrock (Durrell, 1982; Norris and Spieker, 1966). Prior to glaciation, this river flowed to the north (Figure 5a).

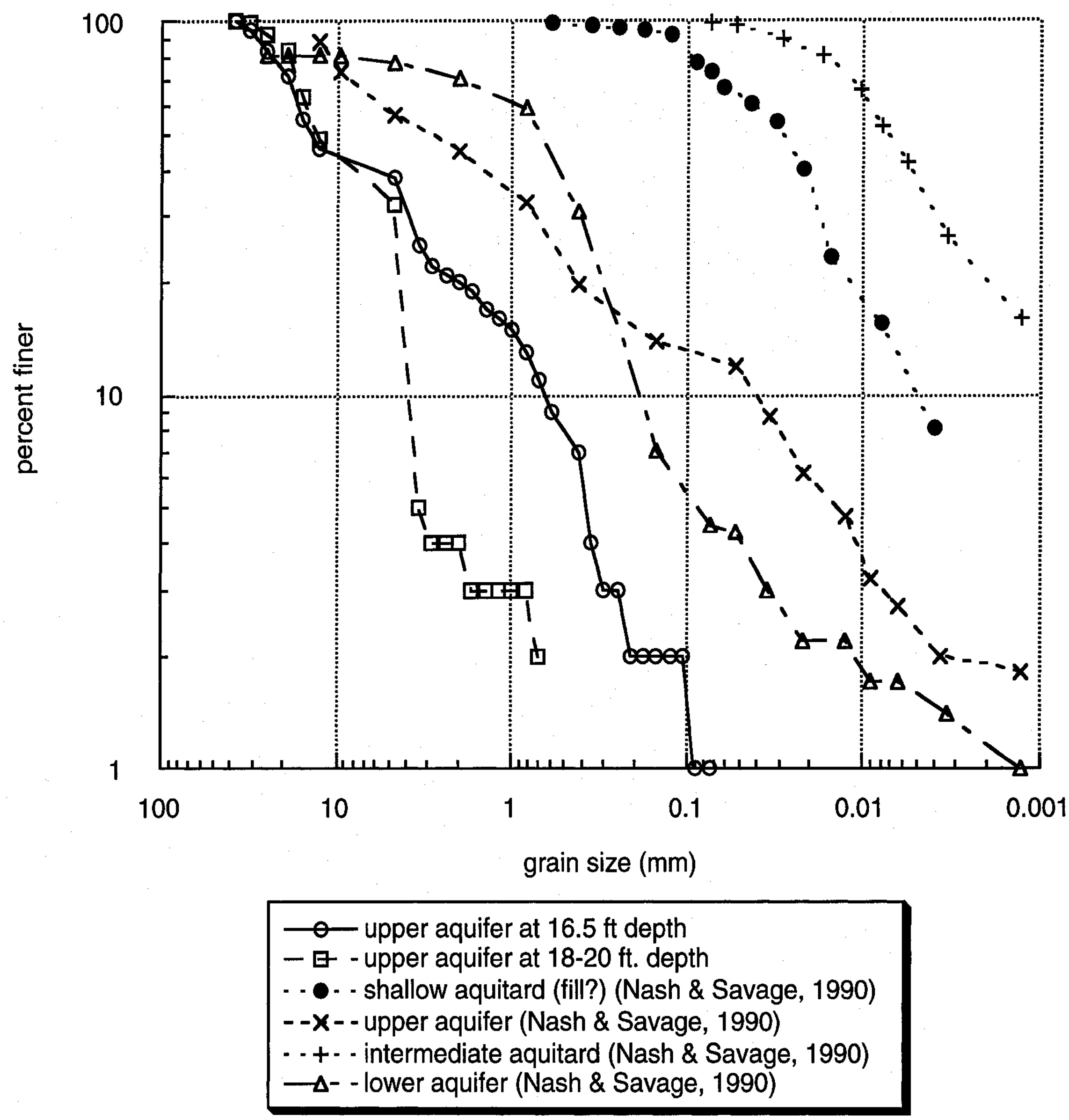


Figure 3 Granulometry at Reeves Golf Course Wellfield.

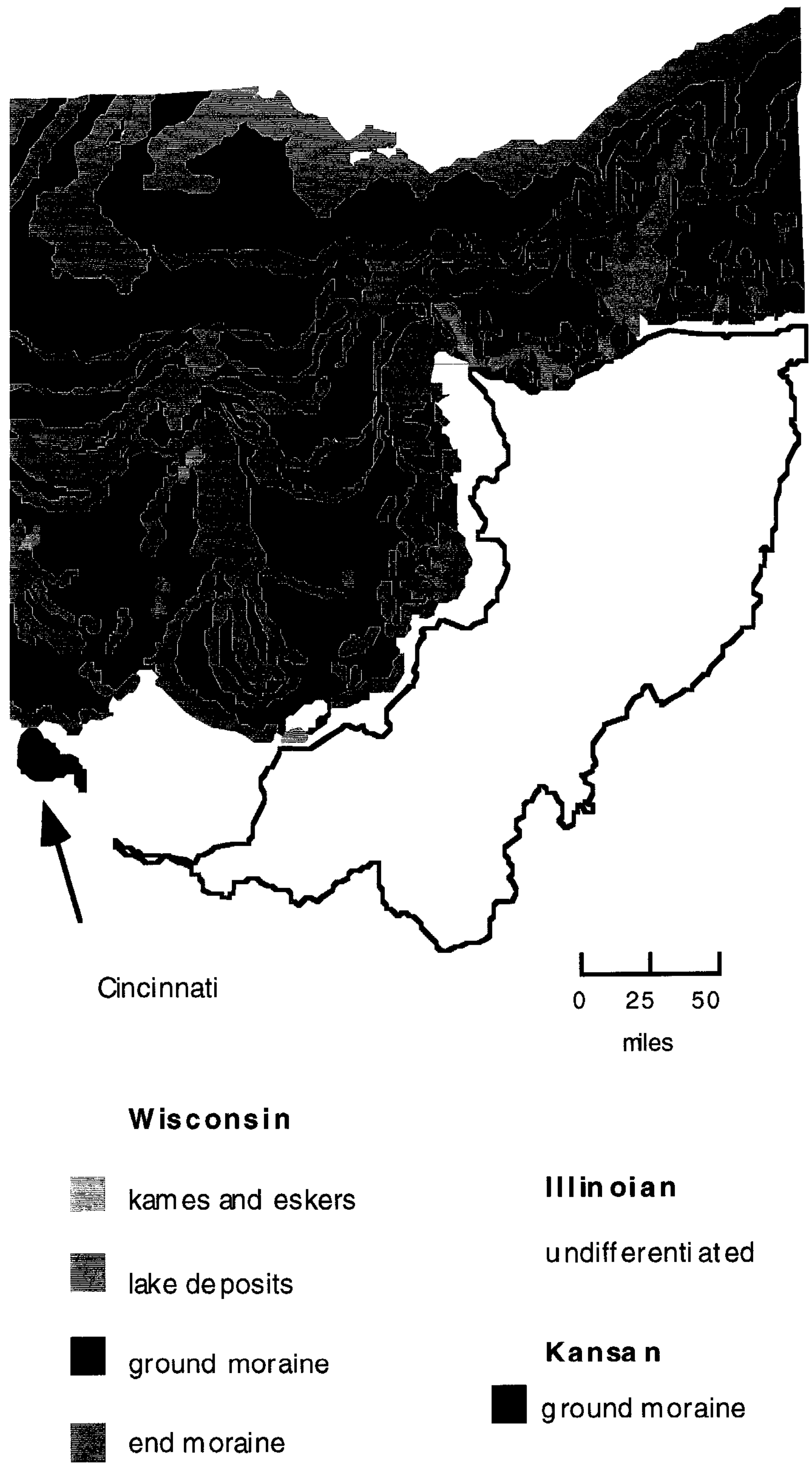


Figure 4 Glacial deposits of Ohio (after Goldthwait, *et al.* , 1961).

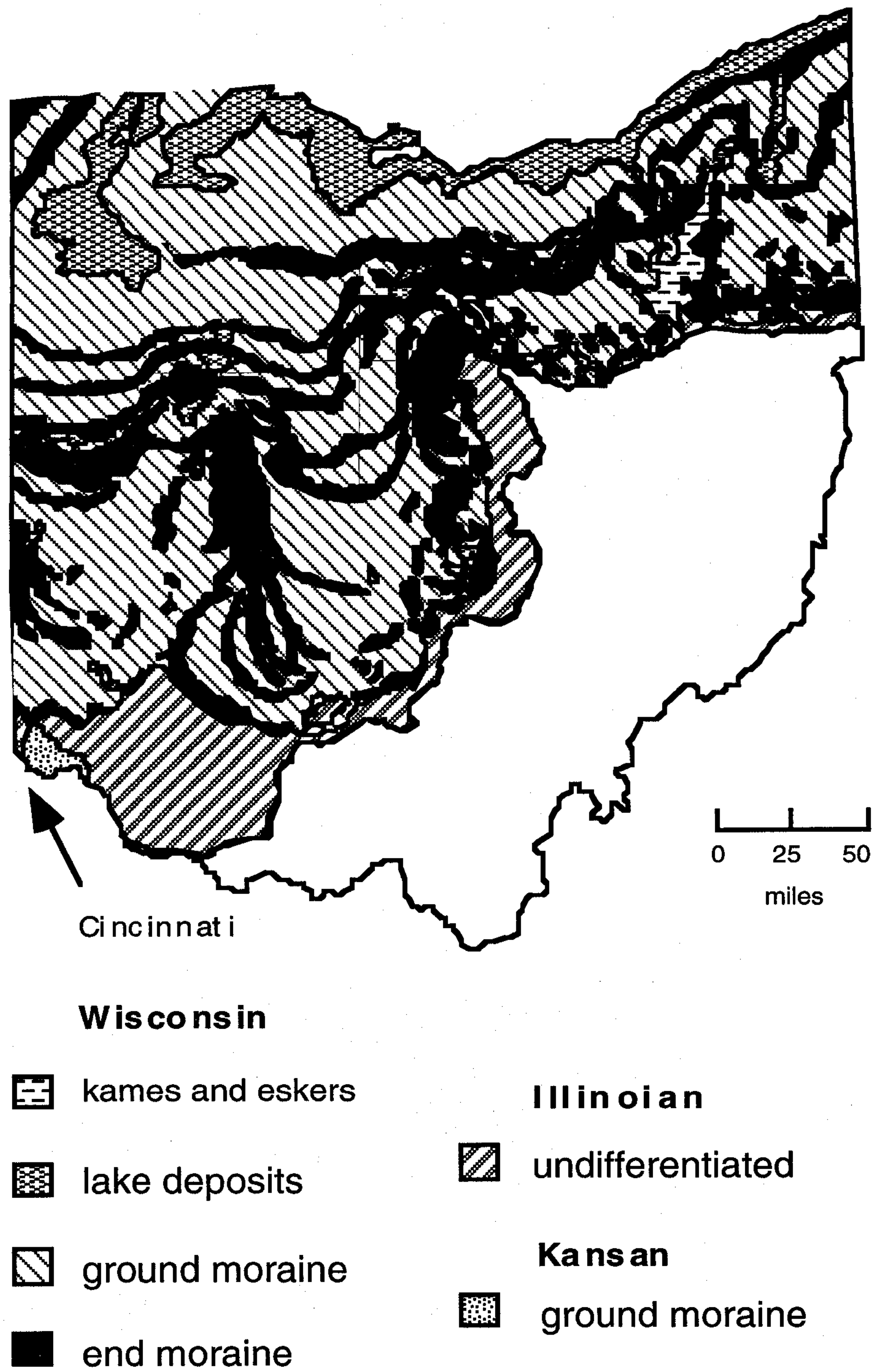


Figure 4 Glacial deposits of Ohio (after Goldthwait, *et al.*, 1961).

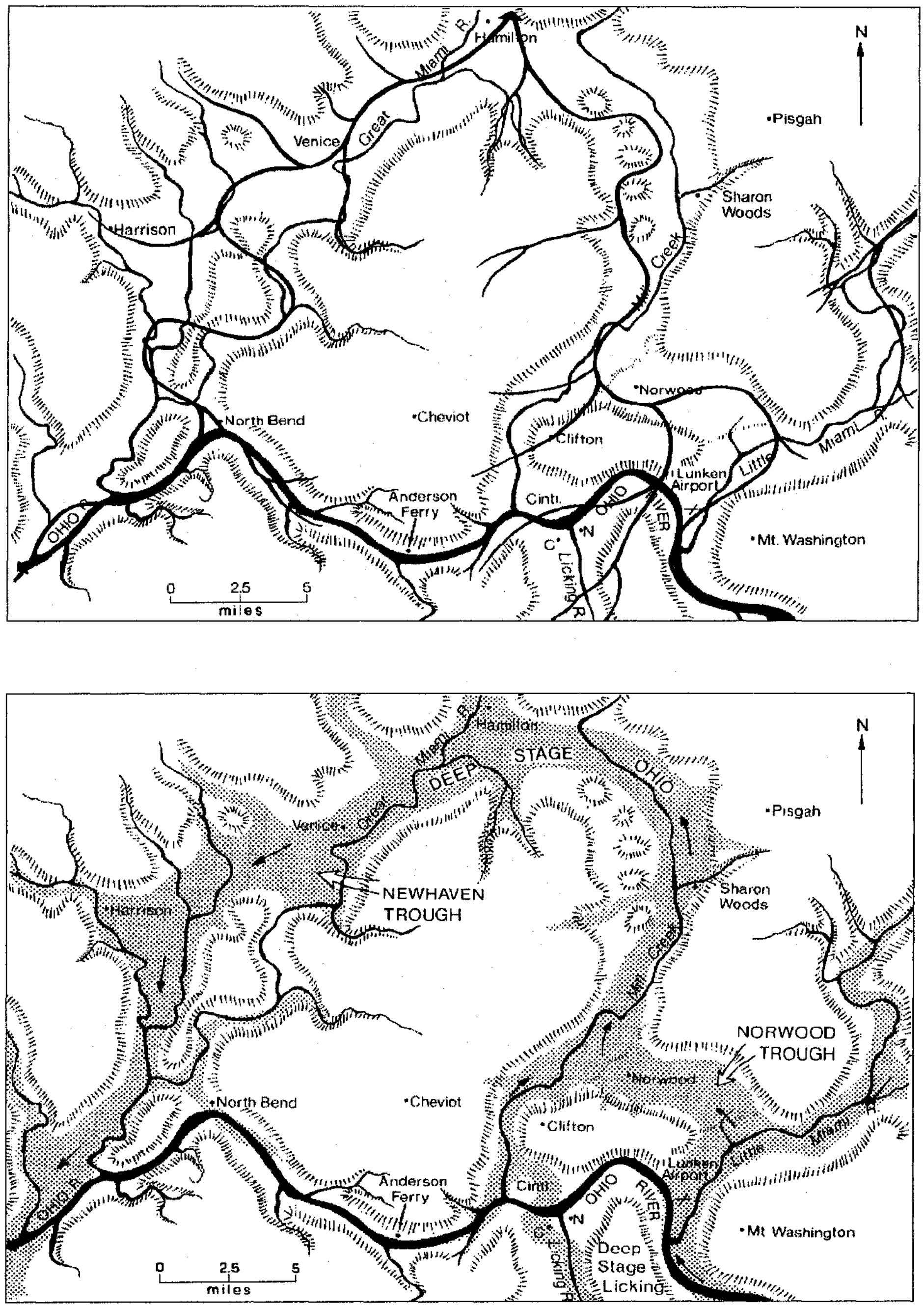


Figure 5 a. The Licking River in Teays Time.
b. The Deep Stage River.
(after Durrell, 1982)

Glacial History

The LMAS is a product of the retreat of glaciers in the Pleistocene Epoch. The advance of the Kansan ice sheet in the Early to Middle Pleistocene dammed the Teays Age Licking River and formed a pro-glacial lake. As the ice sheet melted, high velocity meltwater incised the valley 100 feet deeper than the modern Ohio, Little Miami, and Great Miami River Valleys, and formed the Deep Stage Drainage System (Durrell, 1982, Figure 5b). A second pro-glacial lake formed when the Illinoian ice sheet advanced and dammed the Deep Stage River, leaving deposits of lake clay. In some areas, the Illinoian till overlies the lake clay, marking a re-advance of the ice sheet. The last of the Pleistocene glaciers, the Wisconsin, advanced twice into southwestern Ohio, approximately 70,000 and 19-18,000 BP (Figure 6a). The melting ice deposited large quantities of sand and gravel outwash. Modern streams occupy the same Deep Stage valleys and incise into the outwash deposits (Figure 6b).

Distribution of Aquifers in Ohio

While 58% of Ohioans, including Cincinnatians, depend on surface water for domestic, industrial, and agricultural use (Shindel and Eberle, 1986), 42% use groundwater (Swisshelm and Lane, 1988). Ohio's principal aquifers are composed of sand and gravel, shaly sandstone and shale, sandstone, shale, carbonate, and shaly carbonate. Although most of Cincinnati's public water supply comes

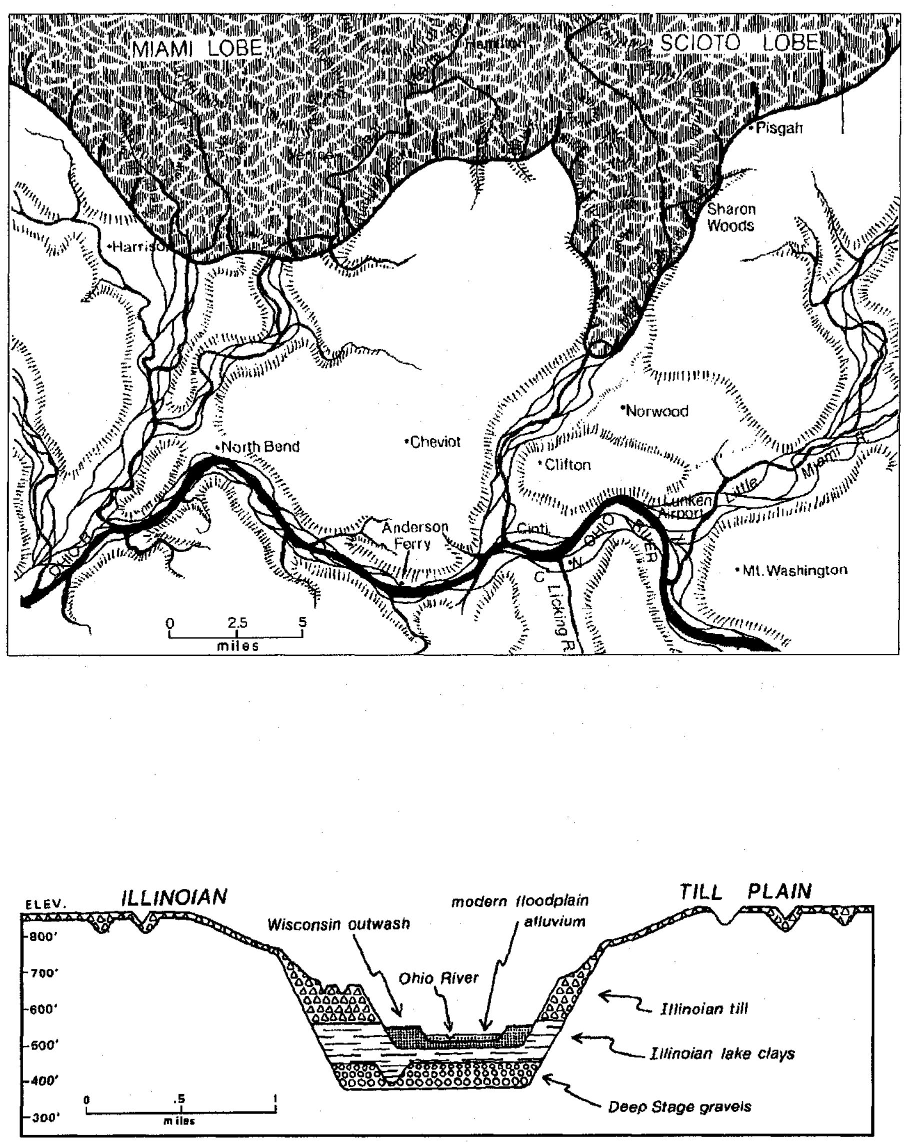


Figure 6 a. Wisconsinan glaciation.
b. Glacial stratigraphy of the Cincinnati Area.
(after Durrell, 1982)

from the Ohio River, most of Montgomery, Butler, and Hamilton Counties obtain their water from sand and gravel aquifers (Swisshelm and Lane, 1988).

General Description of Groundwater Transport

Groundwater transports energy and solutes by advection, diffusion, dispersion, and convection. Advection is the transport of energy and solutes at the same velocity as groundwater. Diffusion is the transfer of kinetic energy from atoms vibrating at a higher velocity to atoms vibrating at a lower velocity when the two atoms collide. In energy transport, energy diffuses throughout the solid matrix and the groundwater itself. In solute transport, molecules and ions diffuse within the fluid.

Dispersion refers to mixing and spreading caused by molecular diffusion and by variations in velocity within the porous medium, mainly caused by heterogeneities. Small scale dispersion, which is on the order of centimeters, becomes negligible when compared to aquifer heterogeneities, where dispersion occurs as energy and solutes move selectively around less permeable units (Figure 7). Large-scale dispersion is on the order of meters. In addition, temperature and density differences cause groundwater flow by convection, where groundwater and its heat content move from one region to another (Bear, 1972). Because the thermal model described in this study is a map view model and not a cross-sectional model, convection is not considered.

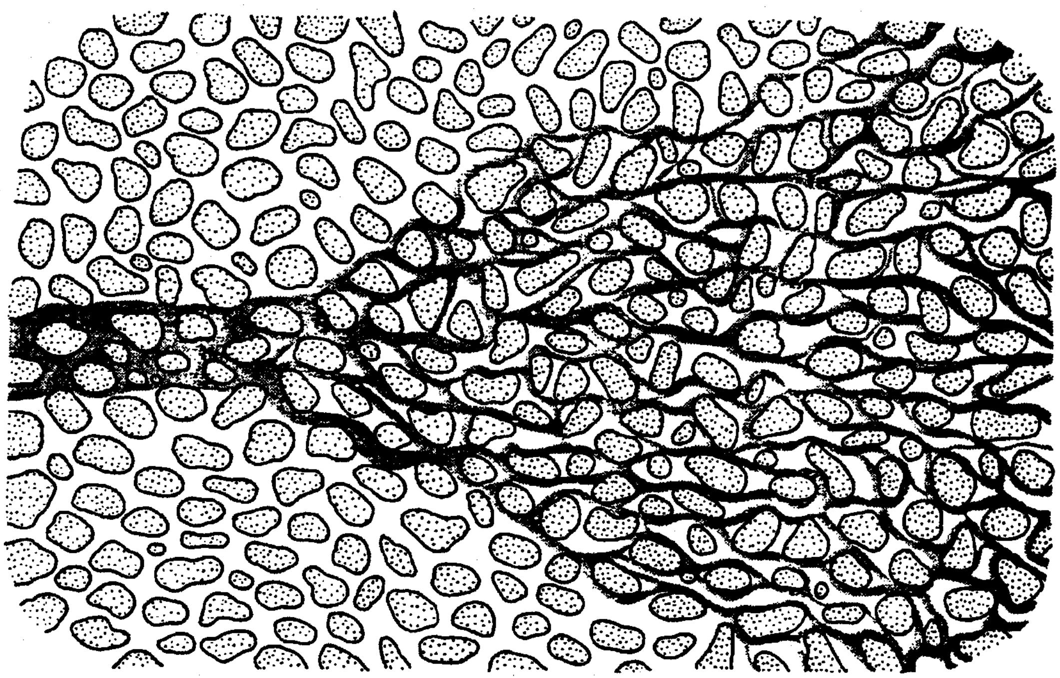


Figure 7 Statistical distribution of flow paths around local heterogeneities leads to dispersion. (Freeze and Cherry, 1979)

Copeland (1996)'s MODULAR (McDonald and Harbough, 1988) model describes groundwater flow, and hence advective transport, in the Upper Aquifer of the LMAS. MODULAR does not describe convection, dispersion, or convection.

Energy and solutes disperse in the direction of groundwater flow (longitudinally), and transverse to the direction of groundwater flow (Figure 8). Dispersion will transform a tracer slug, injected instantaneously as an initial point, into an ellipse at some point down-gradient. Because longitudinal dispersion exceeds transverse dispersion, the major axis of the ellipse becomes oriented parallel to the flow direction.

A classical experiment illustrates dispersion (Wang and Anderson, 1982). A tracer is continuously introduced at the up-gradient end of a laboratory sand column through which water is flowing under steady state conditions. C/C_0 is relative tracer concentration. C is the concentration of the tracer at the outlet and C_0 is the initial concentration of the inflow. If no dispersion occurs, the breakthrough curve showing the change in relative concentration over time will be a step function (Figure 9). If dispersion does occur, the initially steep concentration front will smear, as individual tracer particles travel along different flow paths at different velocities.

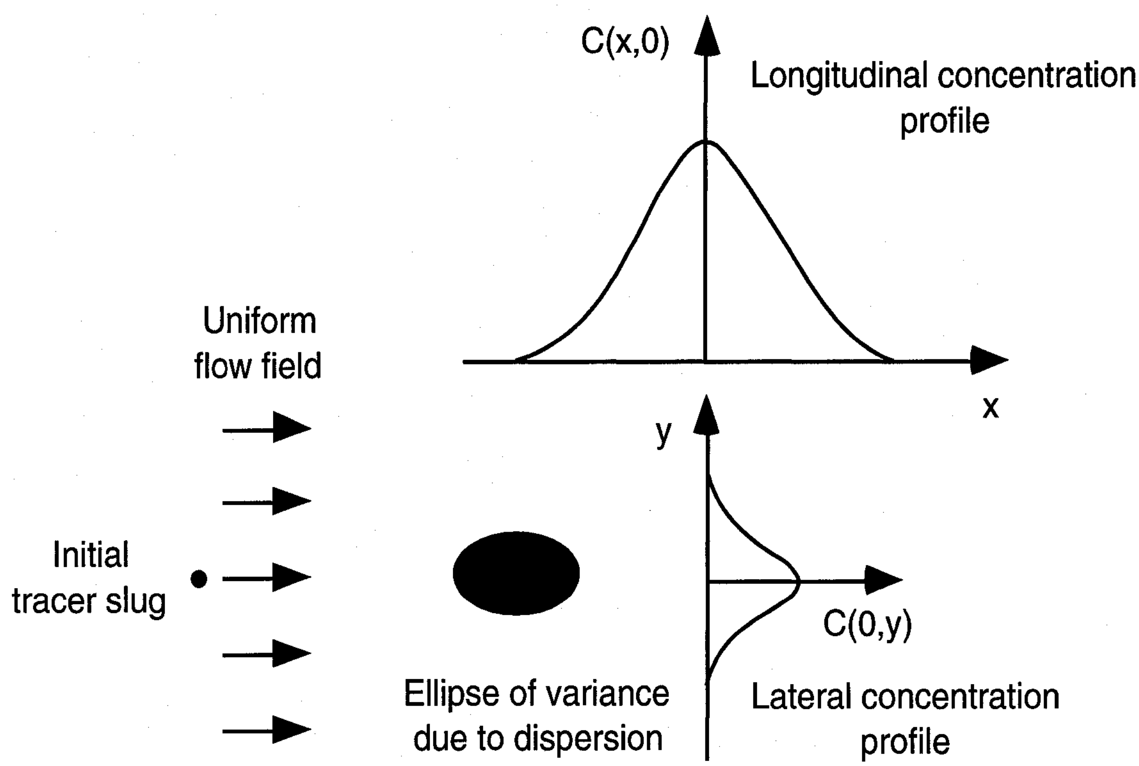


Figure 8 Dispersion of an instantaneous point source in a uniform flow field. The graphs show the longitudinal and lateral distributions of concentration in the ellipse. (from Wang and Anderson, 1982)

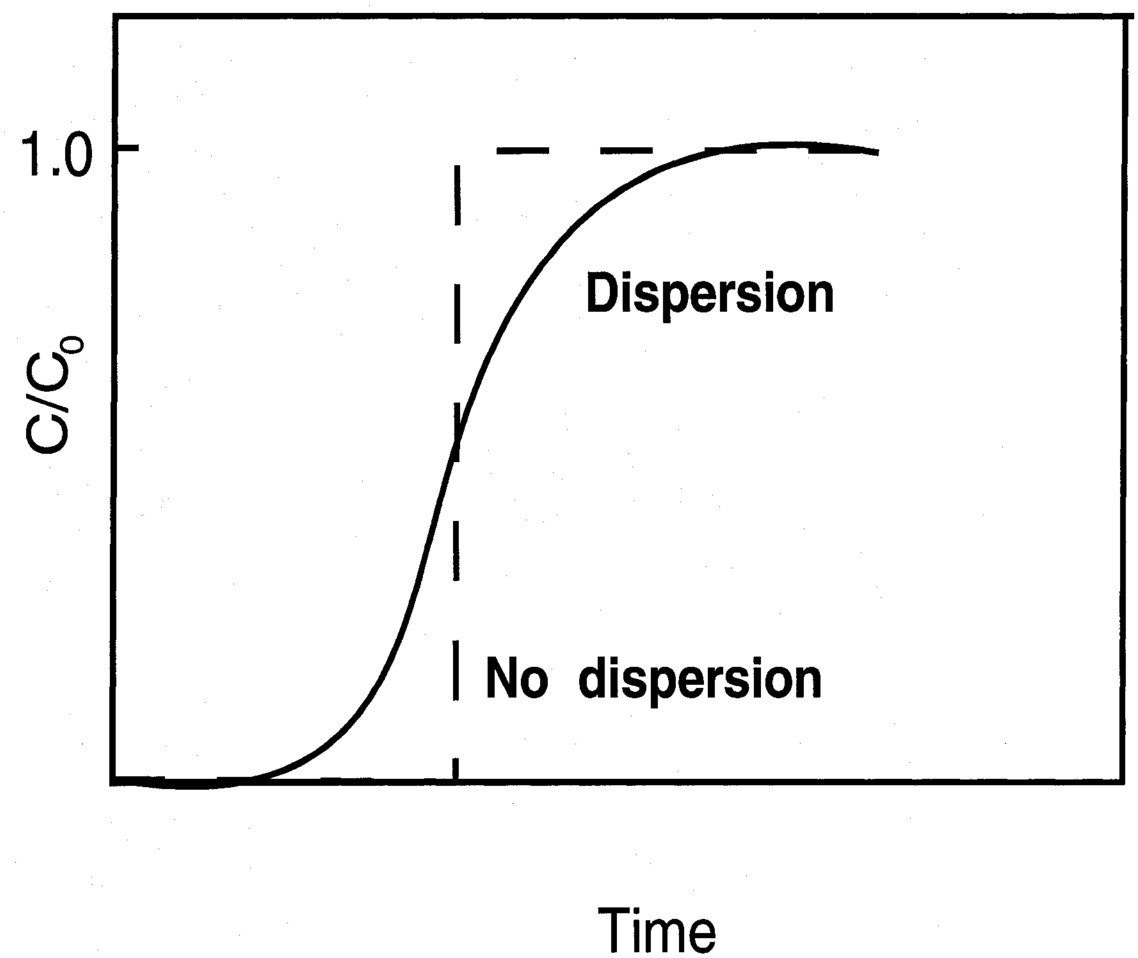


Figure 9 Breakthrough curves when dispersion is present and when it is not. (Wang and Anderson, 1982)

II. Methodology

To calibrate a groundwater transport model, modeled results must be matched to observed field data. In this study, groundwater levels and temperatures were collected from nine monitoring wells at Reeves Wellfield (Figure 10), and at the Little Miami River. Both long-term and short-term observations were made.

Over the long-term, groundwater temperatures were measured approximately bi-monthly, from July, 1993 to July, 1994. A Keck submersible sampling pump (Figure 11) was used to empty the well of two well volumes before measuring temperature. This was done to ensure accurate measurement of groundwater temperature outside the casing, not the temperature of standing water in the well. A Yellow Springs Instruments (YSI) water quality monitoring system (model 3500) measured temperature to the nearest 0.1 °C as the groundwater passed a flow-through chamber (Figure 12).

Over the short-term, groundwater temperatures were measured at 30-minute intervals over several week-long periods. YSI thermistors were lowered to a few feet above the bottom of the well and connected to Campbell 21x dataloggers (Figure 13). Temperatures were recorded at 30-minute intervals. The general accuracy of the thermistors is 0.01 °C; the worst case accuracy is 0.1 °C. Because the thermistors were placed at the bottom of the well, they measured standing well-water temperature, which will not necessarily be the aquifer temperature, particularly when groundwater flow is low.

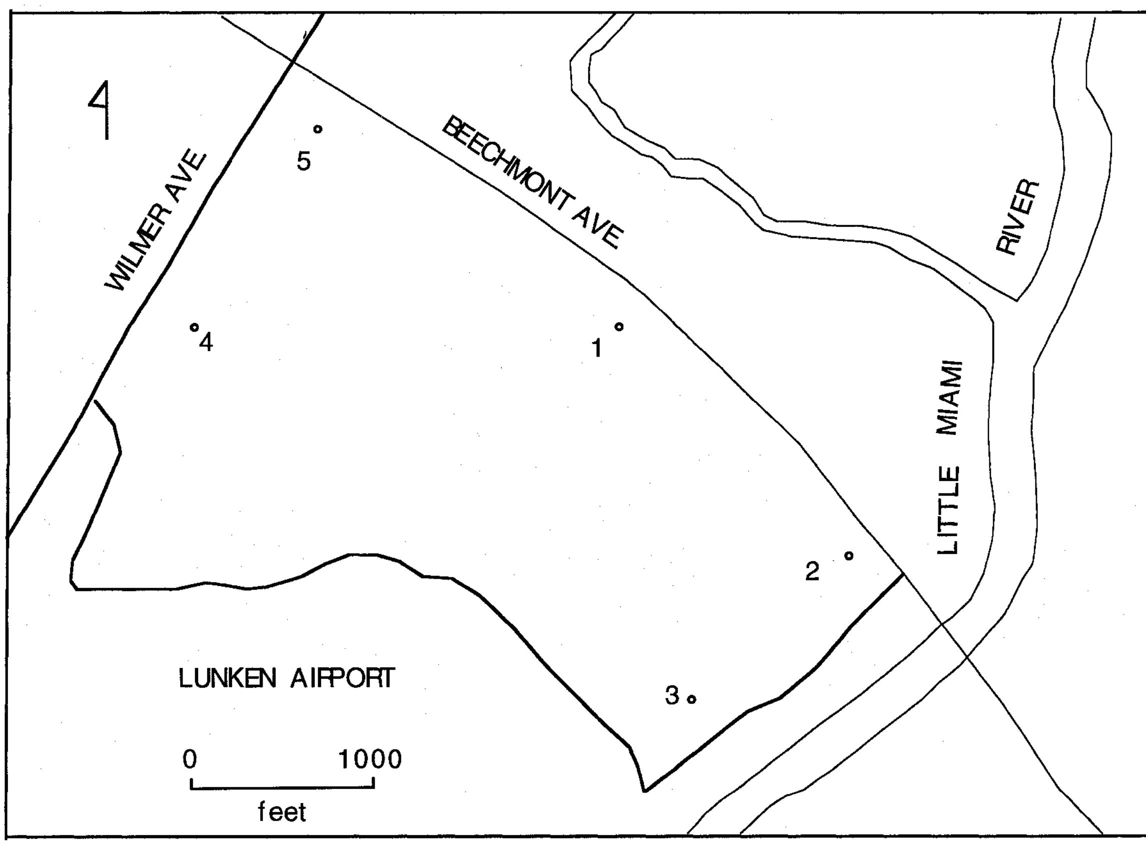


Figure 10 Diagram of Reeves Wellfield

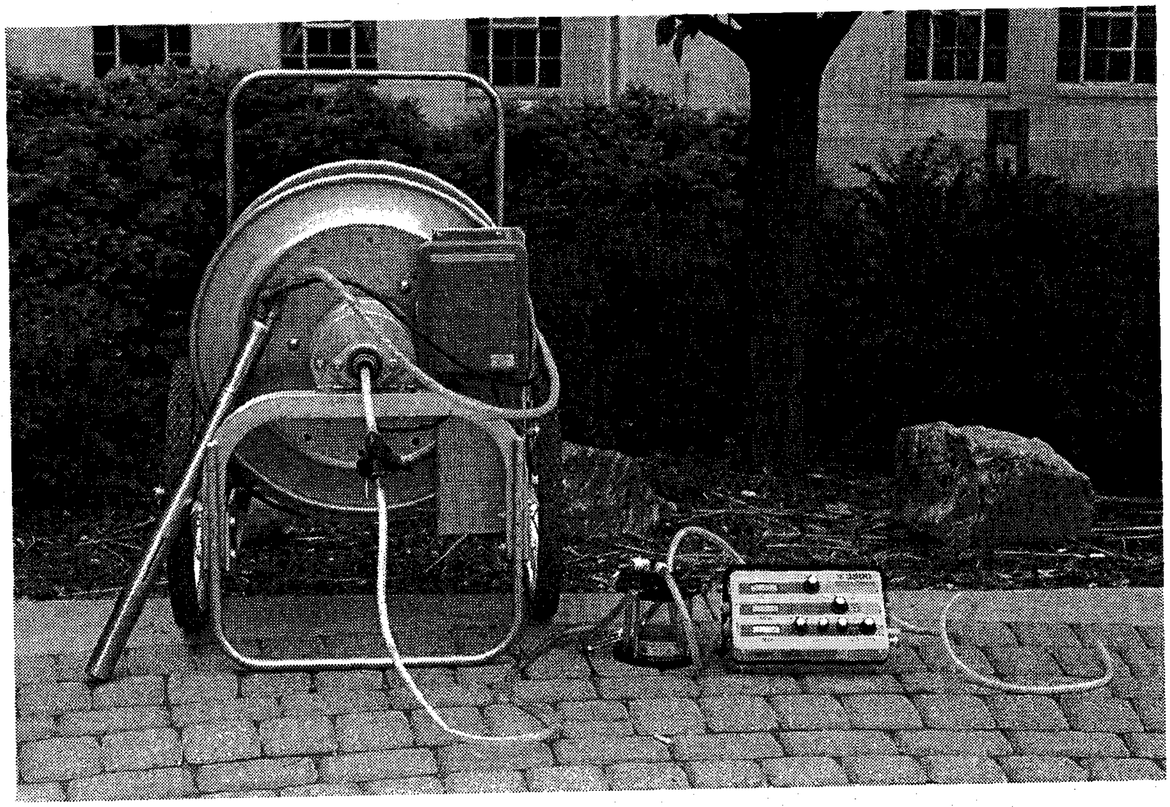


Figure 11 Keck submersible sampling pump.

Figure 12 YSI water quality monitoring system.

Figure 13 Campbell 21x datalogger.

To calibrate a transport model, observed field data must match the solute concentration or temperature changes in response to hydrologic stresses on the system.

The temperature of the Little Miami River was monitored at the Bass Island Canoe Launch, at the intersection of Wooster Pike and Newtown Road. This site is approximately 3.6 miles northeast of the wellfield, however, this was the nearest site with easy access to the river. Temperatures were measured manually with a hand-held thermometer at locations in the river where water was actively flowing. As verified on two occasions, the river's temperature at the wellfield is within 1 °C of the river's temperature at Bass Island.

III. Geology

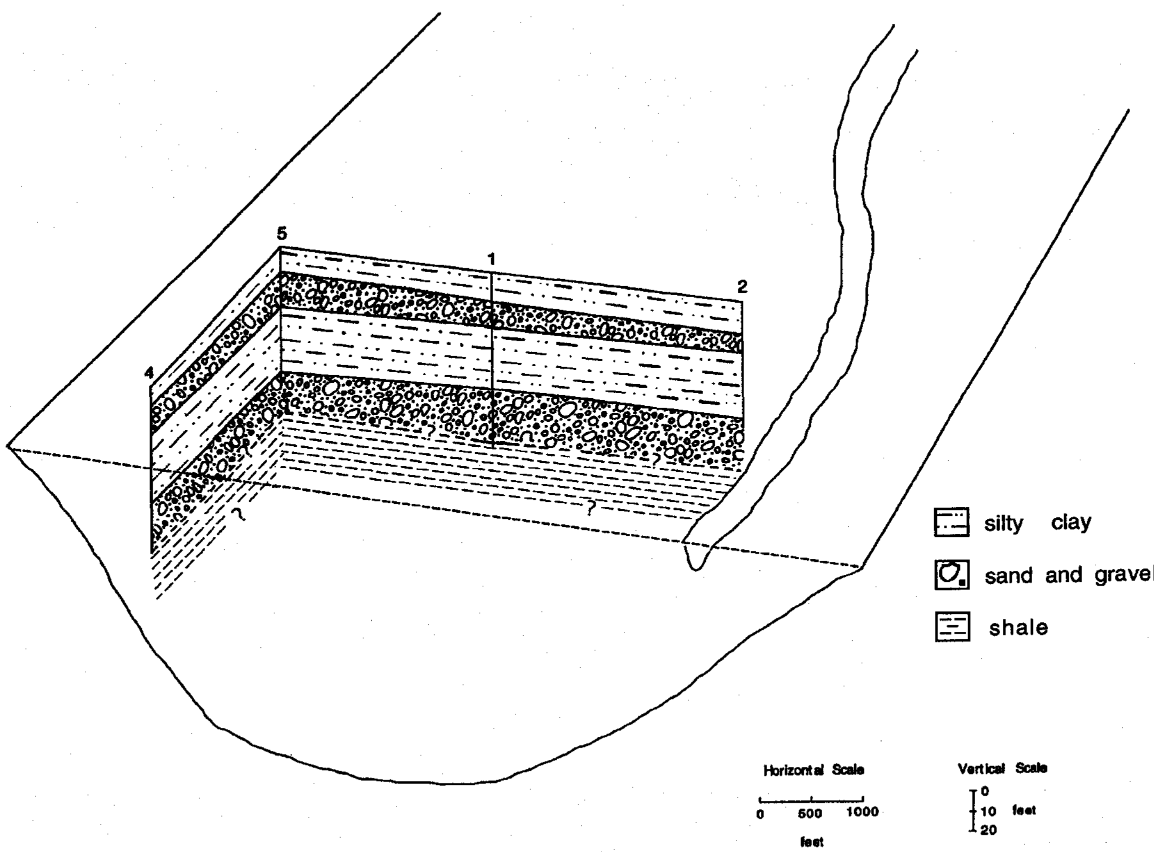
Construction of a valid computer model depends on the development of an accurate conceptual model based on a thorough understanding of local geology. Well logs, sample collection, and x-ray diffraction contributed to an understanding of the geology of the LMAS.

Subsurface Geology

The valley train deposits at Reeves Wellfield consist of the lower aquifer, a confining silty clay layer which acts as an aquitard, an upper aquifer, and an upper aquitard (Figure 14).

Samples were collected for grain-size analysis during well installation. The width of the auger only permitted collection of grains less than two inches in diameter, therefore, grains larger than seven inches were not collected, and grain-size analysis was biased toward smaller grain sizes.

The upper silty clay layer is non-expandable and consists of modern alluvium and fill from construction of Lunken Airport, Reeves Golf Course, and Beechmont Levee. Presumably, the Little Miami River deposited this silty clay as overbank deposits during flood events. Slow-moving flood waters would have deposited suspended silt and clay, forming extensive, widespread, thin vertical accretionary deposits. The fine-grained size (Figure 3) of this layer suggests it acts as an aquitard for the Upper Aquifer. Prior to construction of the airport, the Little Miami River meandered to the



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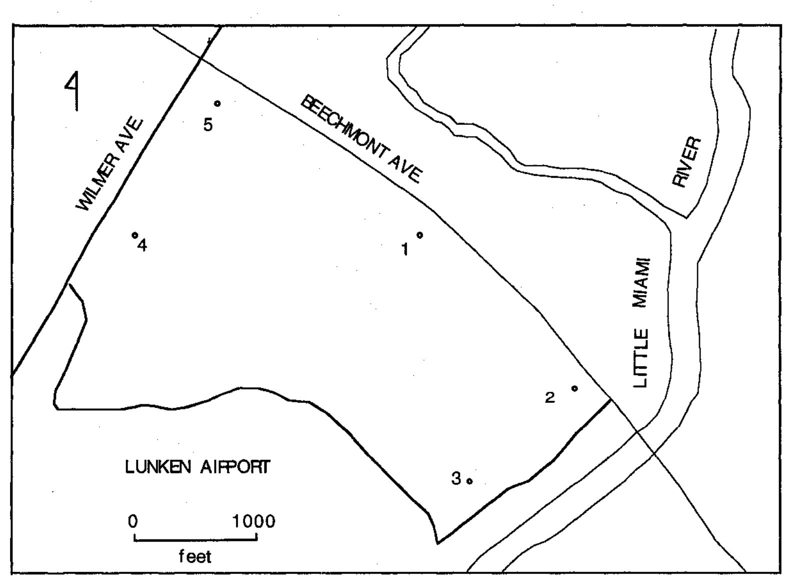


Figure 14 Fence diagram of Little Miami Aquifer System at Reeves Wellfield.

west. To prevent flooding of the airport, the river was pushed to the east and leveed.

Rounded to well-rounded sand and gravel composes the upper aquifer. The grains are poorly to very poorly sorted according to Folk's Inclusive Graphic Standard Deviation method (Folk and Ward, 1957).

Underlying the upper aquifer is a silty clay, as described by Durrell (1982), Nash and Savage (1990), and Teller (1973). X-ray diffraction of this clay shows it to be non-expandable and to contain primarily illite, kaolinite, chlorite, and quartz (Figure 15), minerals commonly found in local rocks and soils.

Very poorly sorted sand and gravel compose the lower aquifer (Figure 3). Several authors offer conflicting possible ages for the lower sand and gravel deposits in local valleys. Arguments for a pre-glacial age include Durrell (1982) and Teller (1973). Durrell (1982) gives a pre-Illinoian age to the lower aquifer and Teller (1973) describes pre-glacial alluvium in the Little Miami Valley as buried under several feet of clay. Others describe Deep Stage time as a period of valley entrenchment, and Deep Stage streams as still incising their valleys when the cycle ended (Spieker, 1966; Norris and Spieker, 1968). Klaer and Thompson (1948) state that the only valley deposits in the area in pre-Illinoian time were ordinary stream deposits of sand and gravel, which in most places did not exceed 10 feet in thickness. Arguments for an Illinoian age include Fenneman (1938) and Teller (1973). Fenneman (1938) argues that some of the Illinoian outwash may still remain beneath present streams, and Teller (1973) describes Illinoian outwash overlying

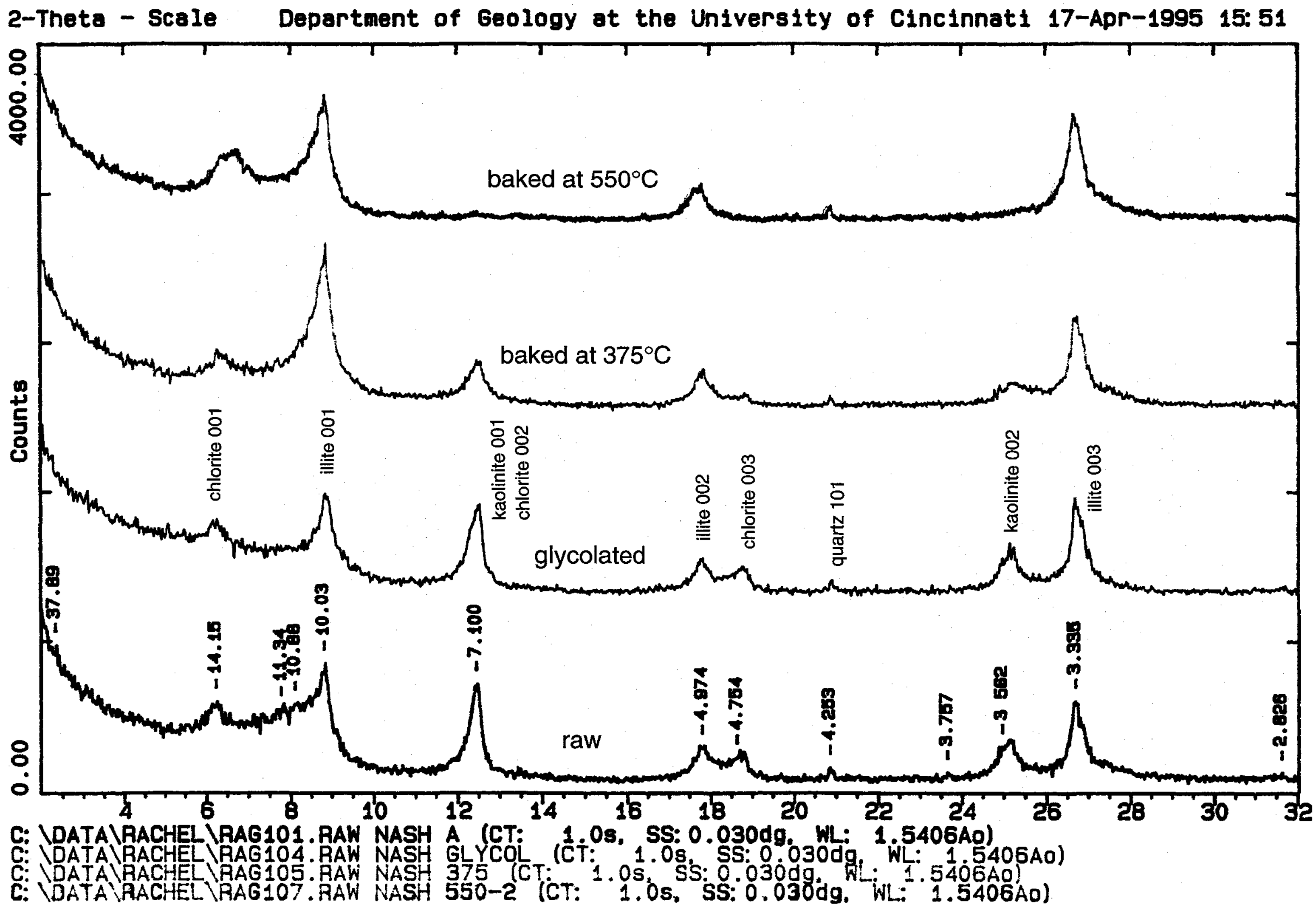


Figure 15 X-ray diffraction plot of intermediate silty clay unit.

pre-glacial alluvium and bedrock. Conversely, Fenneman (1938) also argues that the strong current of the river may have carried away most of the Illinoian deposits in the Little Miami Valley and Norris and Spieker (1966) agree. Norris and Spieker (1966) describe a Wisconsinan two-layer aquifer system in the Dayton area, however, here a till layer acts as the intervening layer (Figure 16).

It is unlikely that both the lower and upper aquifers at Reeves Wellfield are Wisconsinan, because a clay layer intervenes, and no mention of a Wisconsinan lake exists in the literature. The erosive nature of the Deep Stage drainage probably precludes it as a source for the lower aquifer. Field research would provide insight to the relative age of the Lower Aquifer and the other glacial sediments in the Little Miami Valley.

Depositional Model

It is likely that the LMAS consists of deposits left by a sandy braided stream (Figure 17, Walker, 1984). Evidence to support the braided depositional model includes rapid discharge fluctuations, a heavy load of coarse sediment, and easily erodible banks. The lack of exposed section makes a close comparison with the model difficult. However, the genesis of the sediments and observation of modern glacial outwash environments supports the assumption of a sandy braided stream as a depositional model. Glacial ice, melting as climate changed seasonally over hundreds of years, produces rapid discharge fluctuations. Glaciers contain an immense amount of coarse sediment. Channels in modern glacial outwash

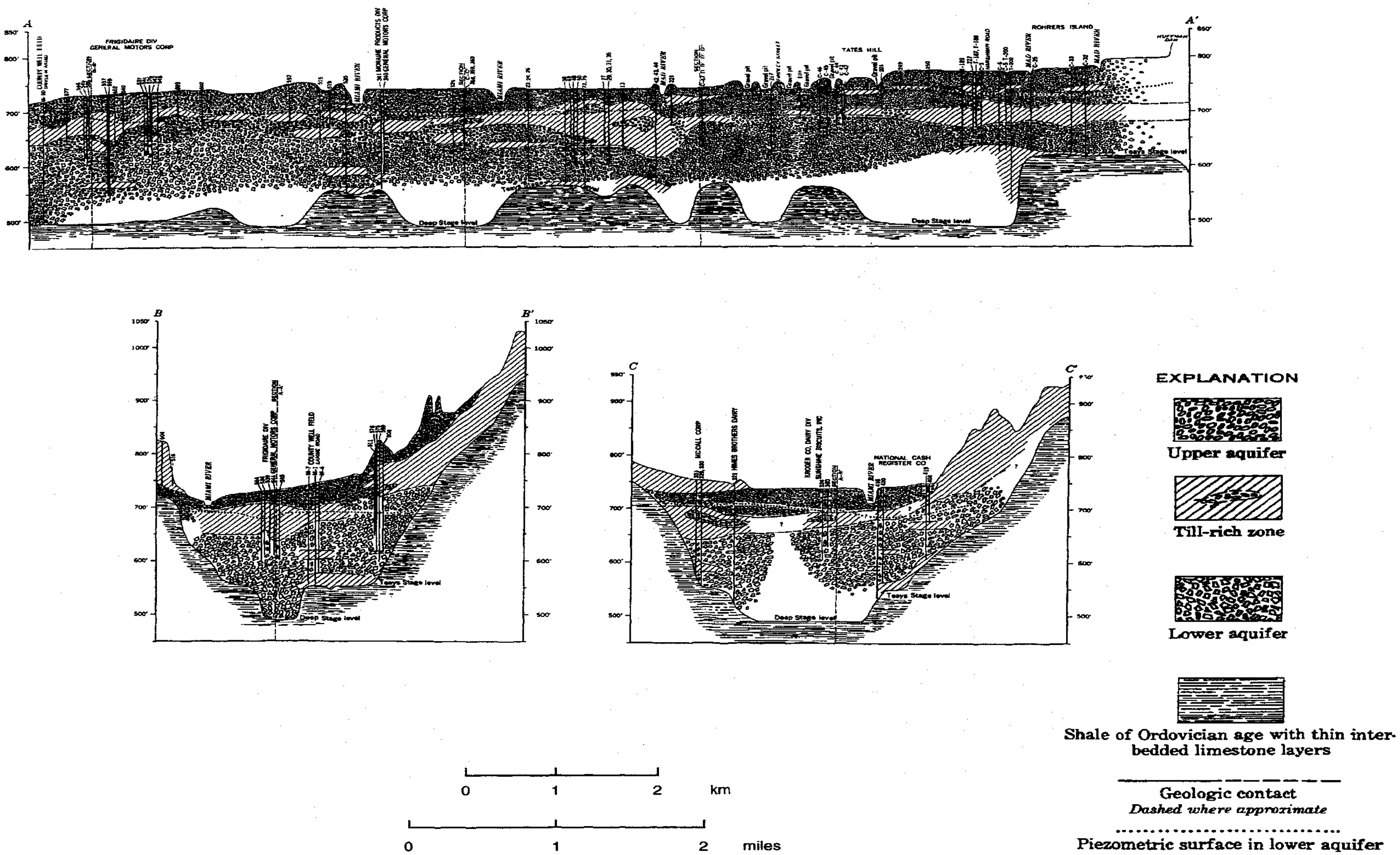


Figure 16 Glacial Stratigraphy at Dayton,Ohio.

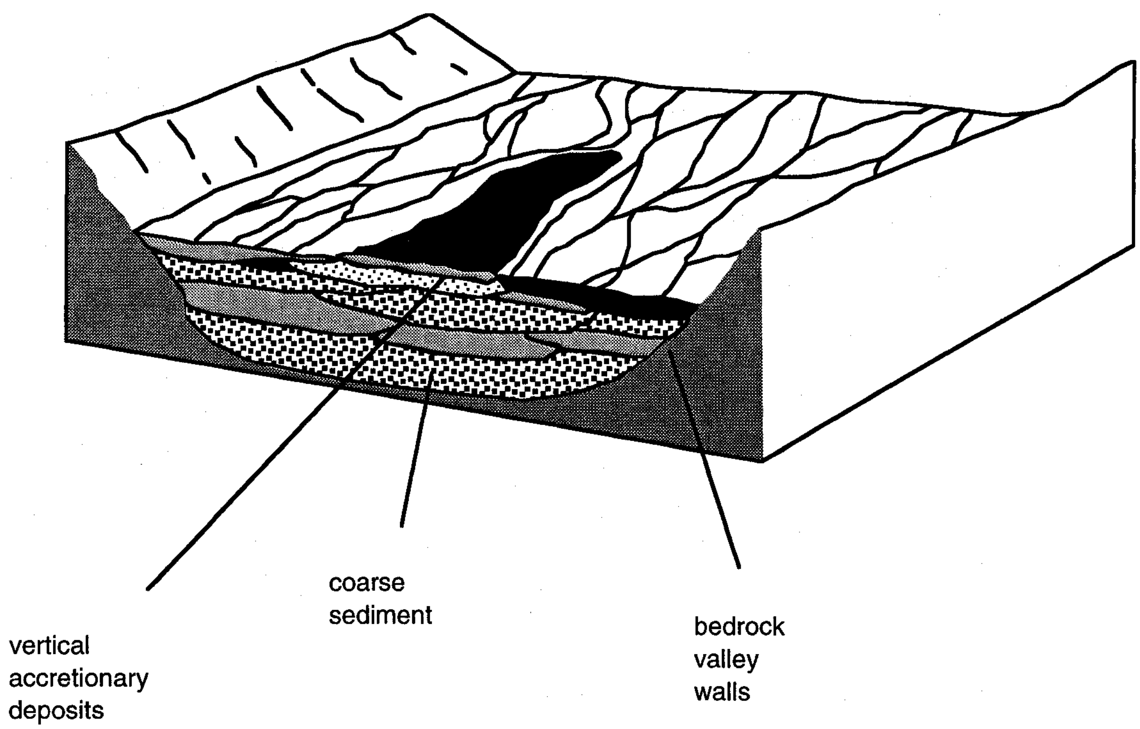


Figure 17 Depositional model for Little Miami Valley Aquifer System (after Walker, 1984).

often change course, dissecting previously deposited material to form new channel banks. The depositional model also shows the braided stream existing within bedrock valley walls, and the sediments as valley train deposits. The Little Miami Aquifer System exemplifies this model, because the Teays Age Licking River eroded limestone and shale bedrock to form what is now the Little Miami Valley, and melting glaciers filled the valley with outwash deposits.

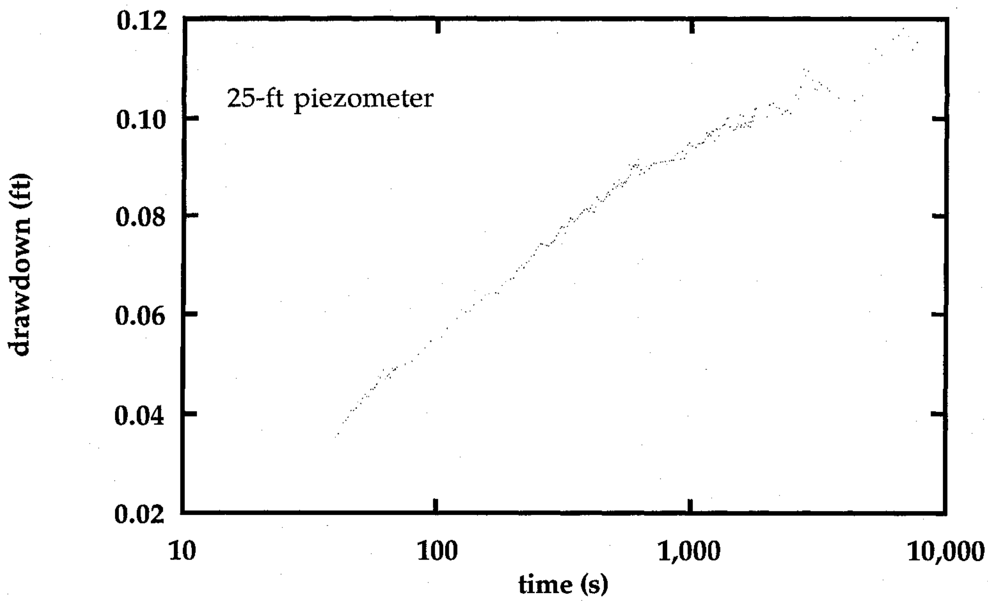
IV. Hydrogeology

For a model to accurately reflect how groundwater and energy are transported through a geologic system, parameters which determine groundwater movement must be determined.

Hydraulic Properties

Sorting and rounding in the glacial melt-out environment produces highly permeable sand and gravel aquifers. The complex glacial melt-out environment also allows for a high degree of heterogeneity. Modelers have attempted to use statistics to characterize lithological uncertainty and heterogeneity (Ferris, 1995; Fogg, 1989; Phillips, Wilson and Davis, 1989; Ritzi and others, 1994) where field data is limited. Rafalko and Hawley (1992) evaluated the precision with which solute transport can be predicted from different levels of information regarding hydraulic conductivity. Others have used empirical approaches in conjunction with grain-size distribution (Milne-Home and Schwartz, 1989) and borehole geophysics and well log analysis (Paillet, 1989; Taylor, 1989; Javandel, 1989) to determine hydrogeologic properties.

Hydraulic tests are preferable to modeled results, but these tests are costly. The results of a pump test performed in conjunction with the City of Cincinnati are presented in Figure 18. Appendices A and A.1 present analysis of the pump test. Using the time-drawdown method (Domenico and Schwartz, 1990), the average hydraulic conductivity was determined to be 1.0E-02 m/s and the



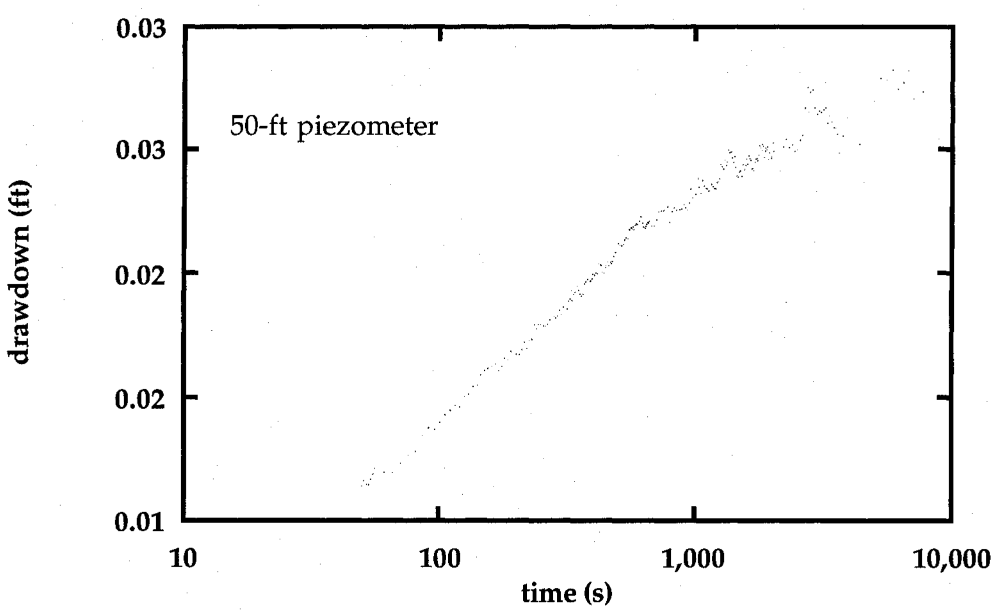


Figure 18 Pump test data at 25- and 50-ft piezomters.

average coefficient of storage was determined to be 0.004. The distance-drawdown method (Domenico and Schwartz, 1990) produced similar results. These values fall within the range of reported values in the area (Table 1).

Location	Hydraulic Conductivity (m/s)	Coefficient of Storage	Reference
Great Miami River Valley, Venice, Ohio	1.41E-03		Dove, 1961
Great Miami River Valley, Dayton, Ohio	9.42E-04		Norris and Spieker, 1966
Great Miami River Valley, Dayton, Ohio	3.5E-4 m/s (water table) 5.9E-4 m/s (confined)	0.20 (unconfined) 0.0001 (confined)	Fidler, 1975
Great Miami River Valley, Fairfield, Ohio	1.16E-03		Spieker, 1968b
Mad River Valley, Champaign Co., Ohio	1.20E-02	0.16	Feulner, 1961
The Plains, Athens County, Ohio	1.34E-03		Starn, 1988
Scioto River Valley, Franklin County, Ohio	1.41E-03	0.1 (unconfined)	Razem, 1983
White River Valley, Johnson and Morgan Counties, Indiana	1.20E-03		Bailey and Imbrigiotta, 1982

Table 1 Hydraulic parameter values for sand and gravel aquifers in southern Ohio and Indiana.

Local Groundwater Recharge and Discharge

Groundwater which enters the modeled area is termed underflow. Copeland (1996) determined a calibrated value of 2000 m^3 for underflow into the study area. During periods of high river stage, the Ohio and Little Miami Rivers also recharge the aquifer.

Copeland (1996) observed that when the Ohio River stage was above 25 feet, the mouth of the Little Miami at Reeves Wellfield was in the pool of the Ohio. She used the Ohio River stage data to determine recharge and discharge from the Little Miami and Ohio Rivers. SUTRA uses these volumetric fluxes as input.

The study area receives an average annual precipitation of approximately 42 inches (Nichols, 1990). On the average, the State of Ohio receives an average of 39 inches per year, of which 11 inches runs off immediately, 22 inches is lost by evapo-transpiration, and 6 inches reaches the water table. Of these 6 inches, 2 inches eventually discharges to streams, and the rest is lost by evapo-transpiration and consumptive use (Shindel and Eberle, 1986). Large-scale precipitation events cause river stage to rise (Figure 19) and hence increase the groundwater level, thereby increasing fluxes from the rivers to the aquifer.

The Upper Aquifer discharges to the Little Miami and Ohio Rivers. No pumping occurs anywhere in the study area. Nash and Savage (1990) determined a low-flow southeasterly direction of groundwater flow. During floods flow is northerly and away from the Little Miami and Ohio Rivers. The Lower Aquifer flows more

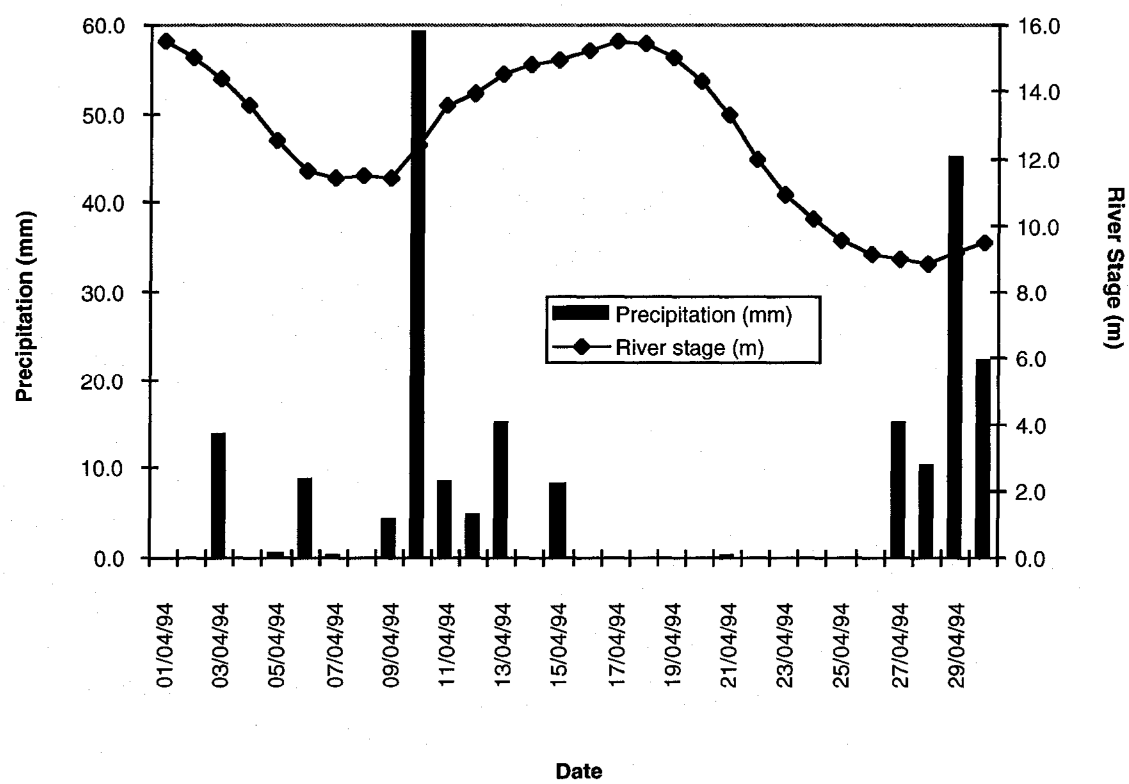


Figure 19 Precipitation and Ohio River stage data for the April, 1994 rainfall event.

southerly during non-peak discharge. Because of the difference in groundwater flow between the two aquifers, Nash and Savage (1990) suggested that the Lower Aquifer does not communicate well with the Little Miami.

V. Groundwater Temperatures

Temperature data were collected from April, 1993 to May, 1995. Monitoring programs of both long-term and short-term duration promoted insight into general groundwater trends and particular groundwater responses.

Long-term Data

The long-term data (Figure 20) show groundwater to be colder than the Little Miami River from October to May and warmer than the river from May to October. Groundwater temperatures varied throughout the period of record from 12 to 21 °C. The data shows no temperature gradient between the wells closest to the river (2a, 3, and 3a), and those farther from the river (1, 1a, 4, 4a, 5, and 5a). No large-scale difference in temperature exists between the upper and lower aquifers.

Short-term Data

Well water temperatures were monitored electronically for several periods (Figures 21 - 23 and Appendix B). It was assumed that wells closer to the Little Miami River have greater responses to river stage changes. Increases in river stage recharge the aquifer, and raise groundwater levels. This recharge is assumed to travel as a pulse across the wellfield, from northeast to southwest. The pulse

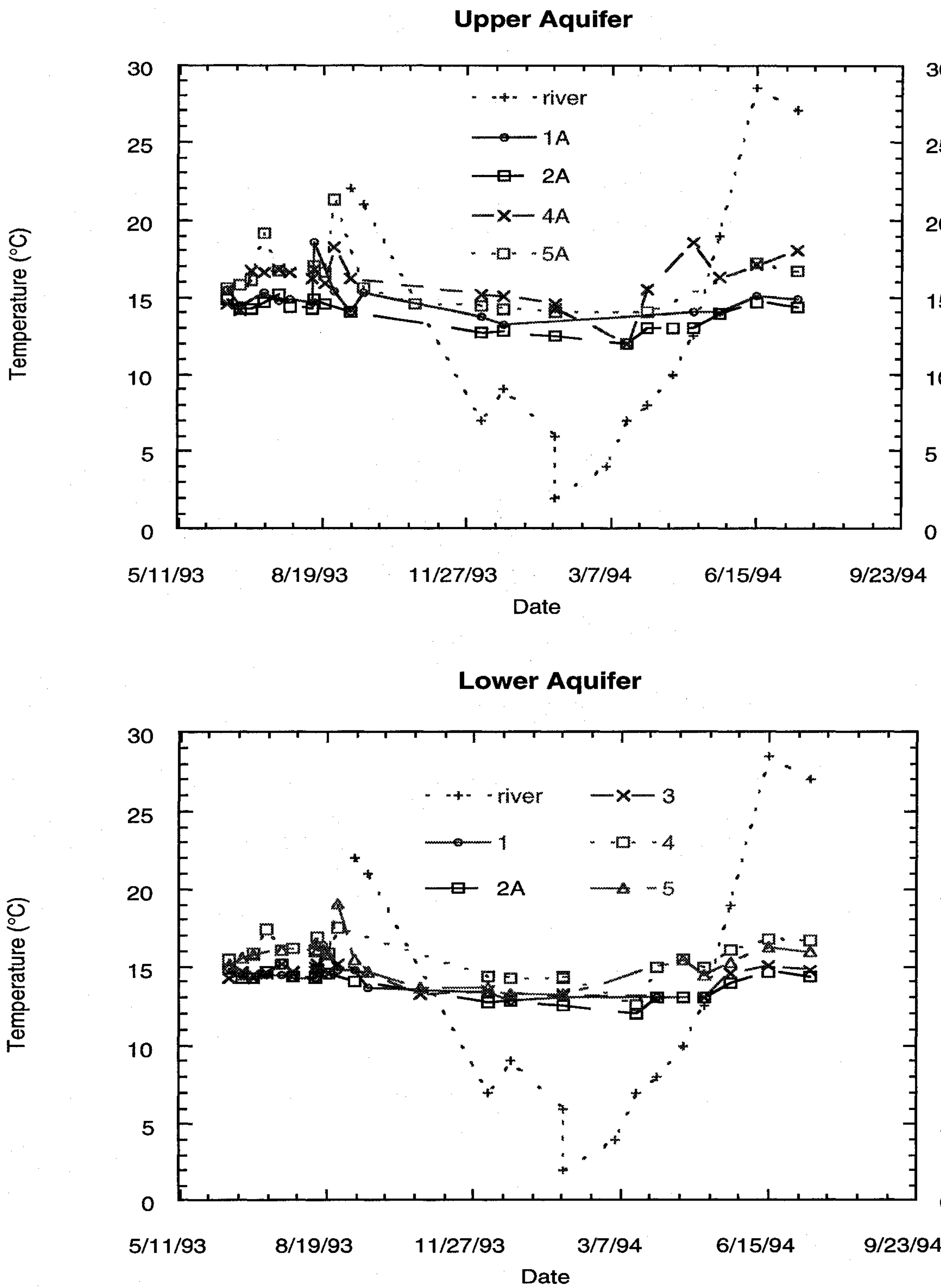


Figure 20 Long-term temperature data for upper and lower aquifers.

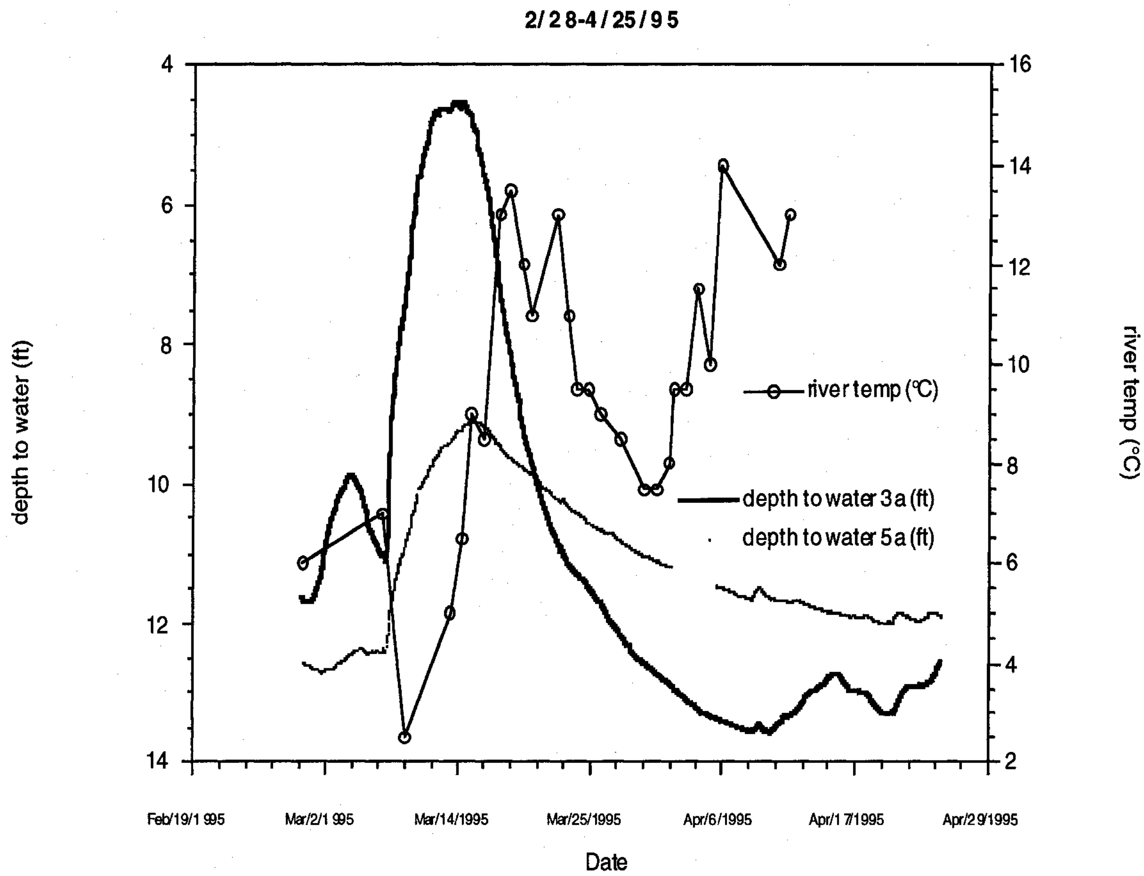


Figure 21 Depth to groundwater and river temperature data for wells 3a and 5a, 2/28-4/25/95, showing attenuation at well 5a.

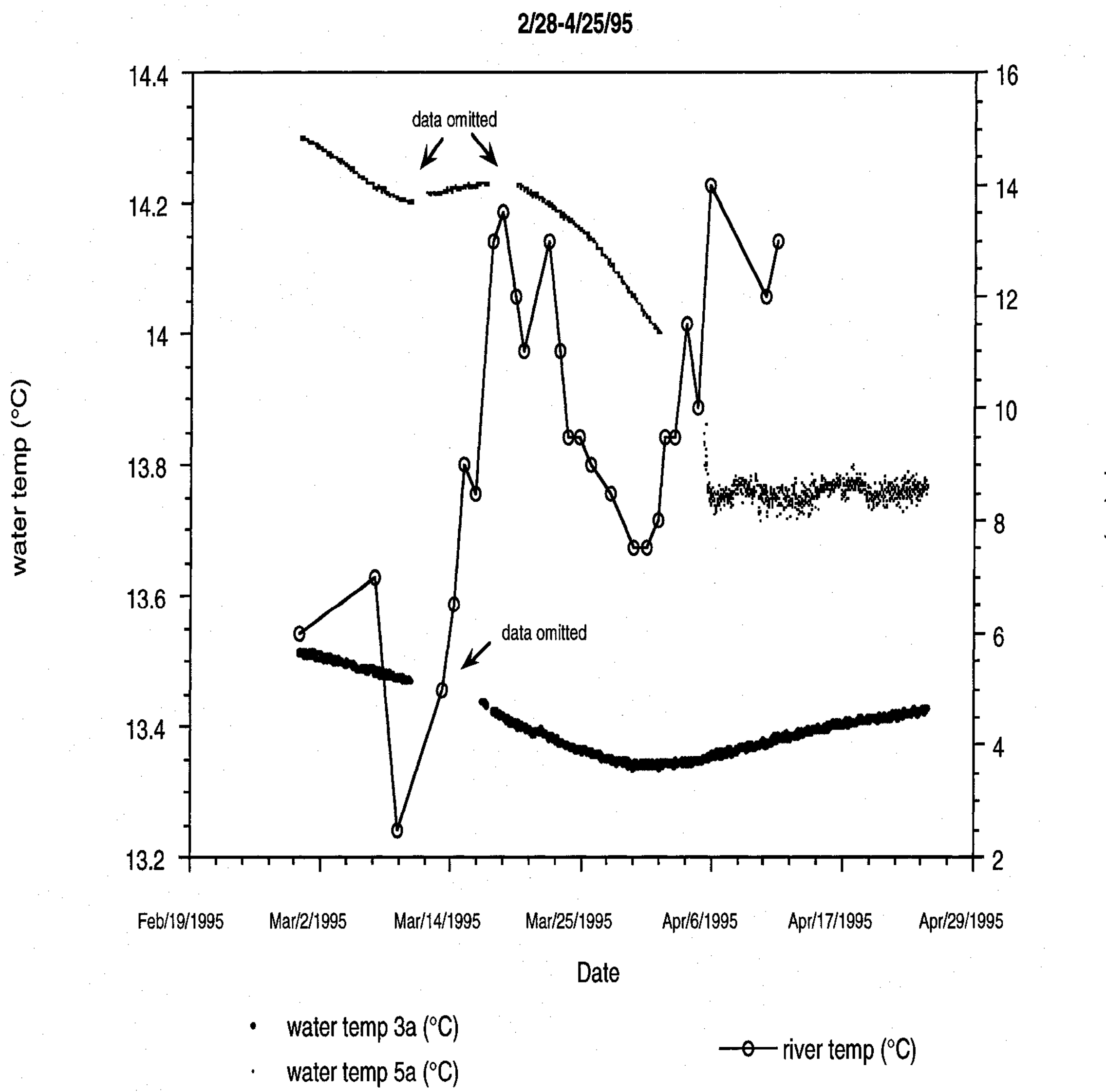


Figure 22 Temperature data for wells 3a and 5a, 2/28-4/25/95. Data were omitted because readjustment of pressure transducer mixed water in the well, altering the established thermal gradient. The mixing caused a temporary warming of well water which did not reflect temperature of water in the aquifer.

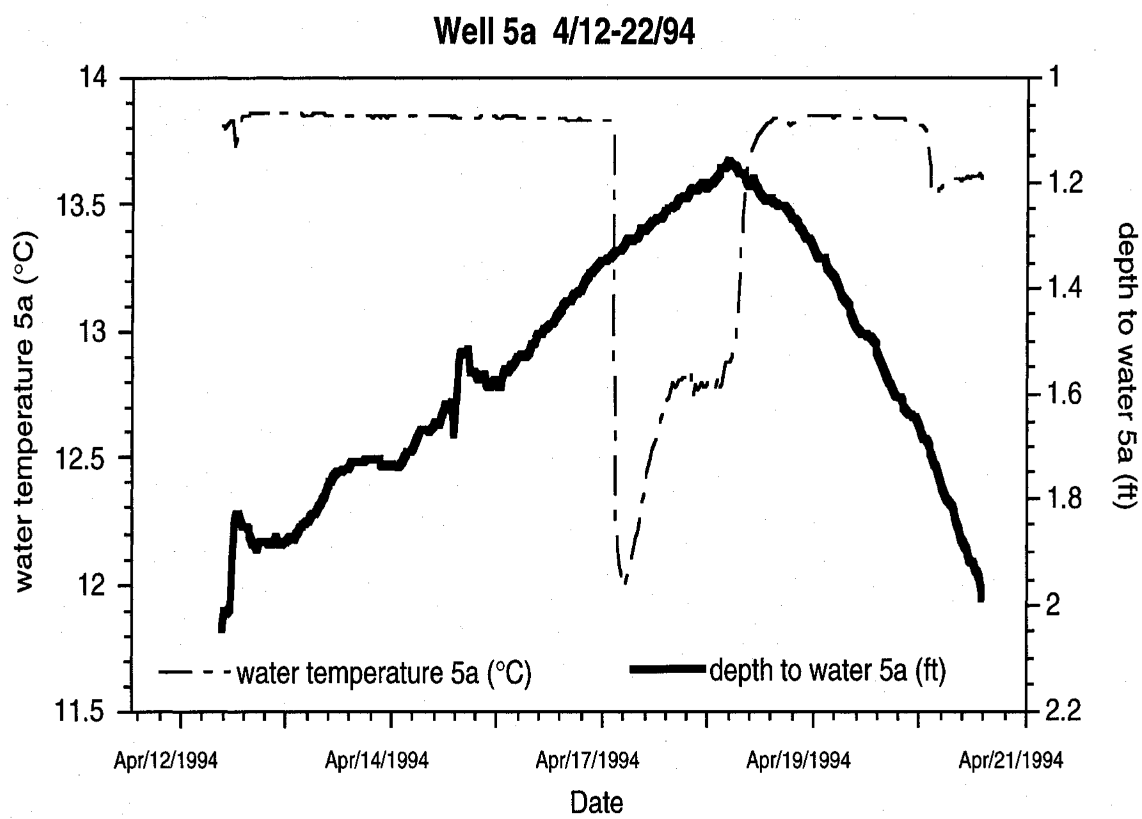


Figure 23 Groundwater depth and temperature data for well 5a, 4/12-22/94.

is strongest near the river, and weakens as it travels to the west. The responses of the well closest to the river (well 3a) and a well farthest from the river (well 5a) evidence this weakening pulse. The water level response to the pulse at well 5a is attenuated when compared to the water level response to the pulse at well 3a (Figure 21). Increases in groundwater levels at both wells correspond to a decrease in river temperature, therefore, the recharge pulse is colder then the ambient groundwater (Figure 22). Larger pulses cause groundwater temperature to decrease sharply (Figure 23).

VI. Conceptual Model

The development of a computer model begins with a conception of how the system to be modeled works. The geography, geology, and hydrogeology of the Reeves Wellfield promote a fairly well-constrained conceptual model (Figure 24).

Western Boundary

Limestone and shale bedrock valley walls constitute the western side of the Little Miami Valley and the western edge of the modeled area. Limestone and shale have hydraulic conductivities on the order of 1.0e-3 m/day. For the modeled area, the western boundary is approximately 7300 meters long, and the aquifer thickness is approximately 4 meters. Hydraulic gradient is assumed to be negligible because the water table is sufficiently deep that it will not parallel topography and will be relatively flat. According to Darcy's Law, the groundwater source from the western boundary will be approximately:

$$Q = K \cdot A \cdot dh/dl$$
$$= 1.0e\text{-}3 \text{ m/day} \cdot (7300\text{m} \cdot 4\text{m})$$
$$= 30 \text{ m}^3/\text{day}$$

This contribution is deemed negligible, and the boundary is considered no-flow.

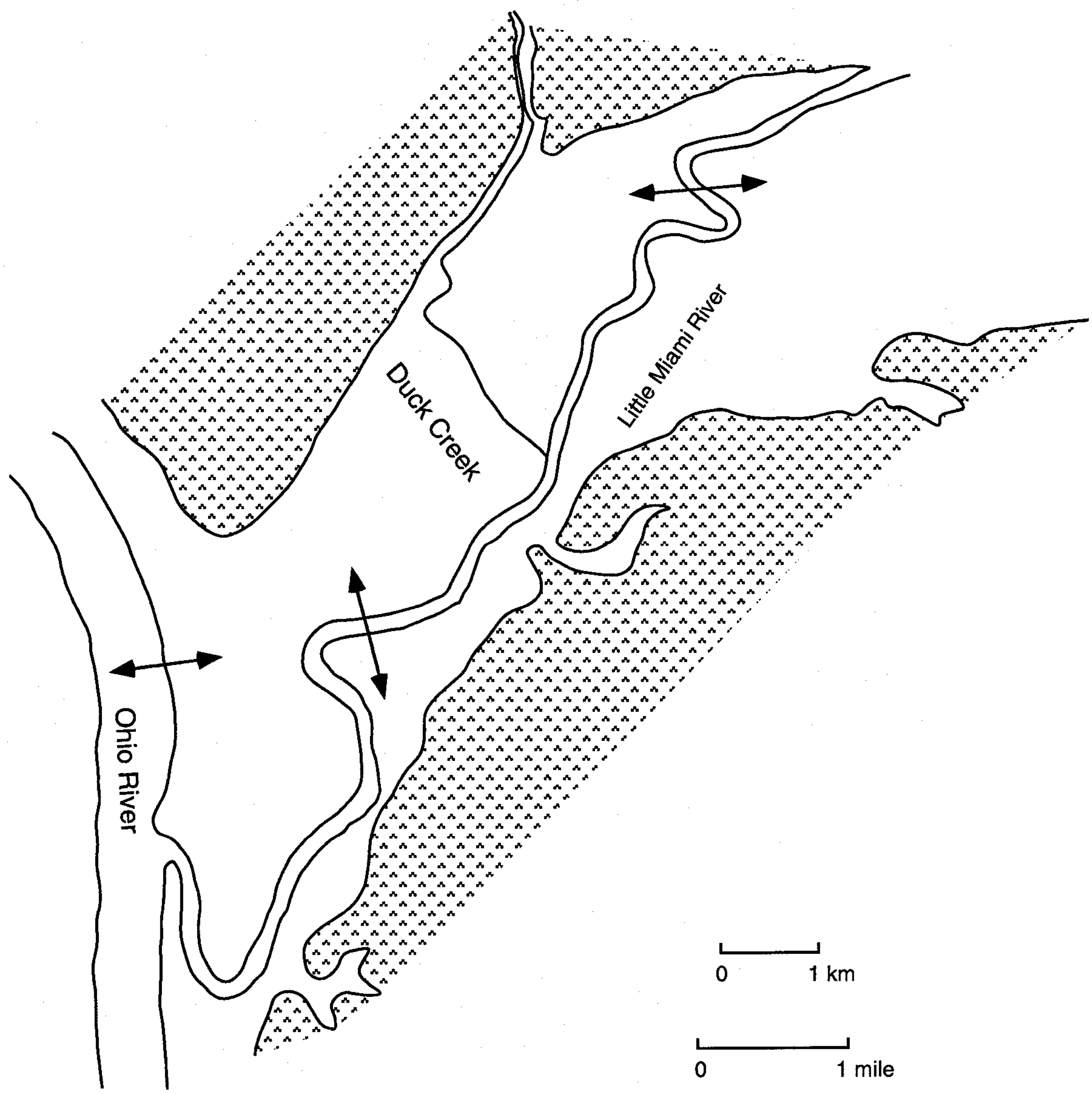


Figure 24 Conceptual model.

Duck Creek

Field examination of suggests that the banks of Duck Creek are composed of overbank deposits, presumably the upper silty clay, and that the Creek does not penetrate the Upper Aquifer. However, Gates (1994) modeled the Creek as penetrating. Copeland (1995) modeled the Creek as non-penetrating, as did this study. No fluid or energy sources are sinks are modeled at Duck Creek.

Eastern and Northern Boundaries

The Little Miami River represents the eastern boundary of the model. This is also a variable flux boundary, and may represent either recharge or discharge. Water may move either from the river into the aquifer, or vice versa, based on the river's stage. These fluxes also vary with time.

Southern Boundary

The Ohio River is the model's southern boundary. The River represents a recharge and discharge zone, and groundwater fluxes move from the aquifer into the river and vice versa.

VII. Computer Simulation of Groundwater Flow and Thermal Energy Transport

Description of the Model

SUTRA (Saturated-Unsaturated Transport), a USGS FORTRAN computer program, simulates groundwater flow and energy transport in a subsurface environment (Voss, 1984). The model employs a two-dimensional hybrid finite-element and integrated finite difference method to approximate the governing equations that describe groundwater flow and thermal energy transport. Groundwater fluxes calculated by Copeland's (1996) MODULAR model allowed for development and calibration of the SUTRA model.

Groundwater Flow

SUTRA simulates groundwater flow through numerical solution of a fluid mass balance equation. This is a calculation of how the amount of fluid mass contained within the void spaces of the solid matrix changes with time. The equation describing the fluid mass balance is expressed as the sum of pure water and pure solute mass balances:

$$\frac{\delta(\varepsilon S_W \rho)}{\delta t} = -\underline{\nabla} \cdot (\varepsilon S_W \rho \underline{v}) + Qp + T \qquad (7.1)$$

where

$\frac{\delta(\varepsilon S_W \rho)}{\delta t}$: total change in fluid mass contained in the void space with time

$\varepsilon(x,y,t)$: porosity; volume of voids per total volume of voids plus matrix [dimensionless]

$S_w(x,y,t)$: water saturation; volume of water per volume of voids [dimensionless]

$\rho(x,y,t)$: fluid density $[M/L_f^3]$

$\underline{\nabla} \cdot (\varepsilon S_w \rho \underline{v})$: changes in fluid mass because of advective flow

$\underline{v}(x,y,t)$: average fluid velocity [L/s] where, for constant density, saturated flow:

$\underline{v} = -K/\varepsilon \cdot \underline{\nabla} h$

$K(x,y,t)$ = hydraulic conductivity [L/s]

$h(x,y,t)$ = hydraulic head [L]

$Q_p(x,y,t)$: fluid mass source (including pure water mass plus solute mass dissolved in source water) $[M/(L3 \cdot s)]$

$T(x,y,t)$: solute mass source (e.g. dissolution of solid matrix or desorption)

SUTRA calculates fluid pressures, as they vary with time, everywhere in the simulated subsurface system. These pressures may be converted to heads by the following equation

$$h = \frac{p}{\rho g} \qquad (7.2)$$

where

$h\ (x,y,t)$ = hydraulic head (L)

$p\ (x,y,t)$ = fluid pressure ($M/L \cdot s^2$)

g = gravitational acceleration (L/s^2)

Thermal Energy Transport

Thermal energy is transported in an aquifer by advection, dispersion, and thermal conduction. Advection is transport at the average fluid velocity of groundwater, $\underline{v}$, calculated from Darcy's Law. Energy is also transported by diffusion, from higher to lower temperatures through the fluid and solid aquifer matrix. Because actual groundwater flow velocities may vary from point to point from the average fluid velocity, SUTRA employs an additional transport mechanism to approximate the effects of mixing of different temperature groundwaters moving both faster and slower than average fluid velocity. This mechanism, dispersion, adds to the thermal conductivity of the fluid-solid medium in particular directions dependent upon the direction of fluid flow. Dispersion is conceptualized in two dimensions as a diffusion-like process with anisotropic diffusivities.

SUTRA simulates thermal energy transport by calculating the time rate of change of the amount of energy stored in the solid matrix and fluid. In any particular volume of solid matrix plus fluid, the amount of energy contained is:

$$[\varepsilon S_W \rho e_W + (1-\varepsilon)\rho_S e_S] \cdot VOL \qquad (7.3)$$

where

e_w	:	energy per unit mass water [E/M]
	=	c_wT
e_s	:	energy per unit mass solid matrix [E/M_G]
	=	c_sT
		where
		c_s : solid grain specific heat
ρ_s	:	density of solid grain in solid matrix [M_G/L_G^3]

and where [E] units are energy units [$M{\cdot}L^2/s^2$].

The stored energy in a volume may change with time because of in-flowing of ambient water of a different temperature, injection of well water of a different temperature, changes in the total fluid mass of water in the volume, thermal conduction (energy diffusion) into or out of the volume, and energy dispersion in or out of the volume (Voss, 1984).

The balance of changes in stored energy with various energy fluxes is expressed as:

$$\frac{\delta[\varepsilon S_w \rho e_w + (1-\varepsilon)\rho_s e_s]}{\delta t} = -\underline{\nabla}\cdot(\varepsilon S_w \rho e_w \underline{v}) + \underline{\nabla}\cdot[\lambda \underline{I}\cdot\underline{\nabla}T] + \underline{\nabla}\cdot[\varepsilon S_w \rho c_w \underline{D}\cdot\underline{\nabla}T] + Q_p c_w T^* + \varepsilon S_w \rho \gamma_o^w + (1-\varepsilon)\rho_s \gamma_o^s \qquad (7.4)$$

where

$\frac{\delta[\varepsilon S_w \rho e_w + (1-\varepsilon)\rho_s e_s]}{\delta t}$: the total change in energy stored in both the fluid and solid matrix

$\underline{\nabla} \cdot (\varepsilon S_w \rho e_w \underline{v})$	:	average advection of energy into or out of the volume
$\underline{\nabla} \cdot [\lambda \underline{I} \cdot \underline{\nabla} T]$	:	heat conduction contributions to locally stored energy

where

$\lambda(x,y,t)$	:	bulk thermal conductivity of solid matrix plus fluid [E/(s·L·°C)] : $\lambda = \varepsilon S_w \lambda_w + (1-\varepsilon)\lambda_s$ λ_w : fluid thermal conductivity λ_s : solid thermal conductivity
$\underline{I}$	:	identity tensor (ones on diagonal, zeroes elsewhere) (2x2) [1]
$T(x,y,t)$	:	fluid temperature [°C]

$\underline{\nabla} \cdot [\varepsilon S_w \rho c_w \underline{D} \cdot \underline{\nabla} T]$	:	dispersive energy contributions not accounted for by average energy advection

where

c_w	:	specific heat of water [E/(M·°C)]
$\underline{D}(x,y,t)$	:	dispersion tensor (2x2) [L^2/s]
$Q\rho c_w T^*$	:	energy added by a fluid source with temperature T^*
$\varepsilon S_w \rho \gamma_o{}^w + (1-\varepsilon)\rho_s \gamma_o{}^s$	:	energy production (endothermic reactions) in the fluid and solid, respectively

where

$\gamma_o^w(x,y,t)$: energy source in fluid [E/M·s]

$\gamma_o^s(x,y,t)$: energy source in solid grains [E/M·s]

SUTRA calculates fluid temperatures, as they vary with time, everywhere in the simulated subsurface system.

Comparison of Energy and Solute Transport

The saturated-unsaturated energy balance (7.3) accounts for energy fluxes, sources and sinks, describing how the energy per unit volume of solid matrix plus fluid, $[eS_w re_w + (1-e)r_s e_s]$, changes with time at each point in space. Similarly, the solute plus adsorbate mass (the species mass) per unit volume of solid matrix plus fluid, $(eS_w rC) + d[(1-e)]r_s C_s)$, changes with time at each point in space because of solute and adsorbate fluxes, sources and sinks according to the following equation

$$\frac{\delta(\varepsilon S_w \rho C)}{\delta t} + \frac{\delta[(1-\varepsilon)]\rho_s C_s)}{\delta t} = -\underline{\nabla} \cdot (\varepsilon S_w \rho \underline{v} C) + \underline{\nabla} \cdot [\varepsilon S_w \rho (D_m \underline{I} + \underline{D}) \cdot \underline{\nabla} C] + \varepsilon S_w \rho \Gamma_w + (1-\varepsilon)\rho_s \Gamma_s + Q_p C^* \tag{7.5}$$

where

$\frac{\delta(\varepsilon S_w \rho C)}{\delta t}$: the total changes in solute mass with time in a unit volume

where

$C(x,y,t)$	:	fluid solute mass fraction (or solute concentration) (mass solute per mass total fluid) $M_S/M_G]$
$\frac{\delta[(1-\varepsilon)]\rho_S C_S)}{\delta t}$	:	change in total adsorbate mass

where

C_S	:	specific concentration of adsorbate on solid grains (mass adsorbate/(mass solid grains plus adsorbate))
$\underline{\nabla} \cdot (\varepsilon S_W \rho \underline{v} C)$	:	average advection of solute mass into or out of the volume
$\underline{\nabla} \cdot [\varepsilon S_W \rho (D_m \underline{I} + \underline{D}) \cdot \underline{\nabla} C]$	:	the contribution of solute diffusion and dispersion to the local changes in solute mass

where

D_m	:	apparent molecular diffusivity of solute in solution in a porous medium including tortuosity effects $[L^2/s]$
$\varepsilon S_W \rho \Gamma_W$	:	the contribution to dissolved species mass of chemical, biological or radioactive reactions in the fluid
Γ_W	:	solute mass source in fluid (per unit fluid mass) produced by chemical and biological reactions

$(1-\varepsilon)\rho_S\Gamma_S$: the contribution to adsorbed species mass of chemical, biological, or radioactive reactions in the solid

where

Γ_S (x,y,t) : adsorbate mass source (per unit solid matrix mass) produced by chemical, biological, or radioactive reactions within the adsorbed material itself $[M_S/M_G \cdot s]$

Q_pC^* : dissolved species mass added by a fluid source

where

C^* : solute concentration of fluid sources (mass fraction)

Both balances, therefore, track a particular quantity per unit volume of solid matrix plus fluid.

As described in the introduction, both energy and solute mass undergo advection, dispersion, and diffusion. Fluid sources and sinks produce similar sources and sinks of energy and solute mass. Zero-order processes, wherein energy may be produced by an endothermic reaction and solute may be produced by a biological process, for example, both produce energy and species mass. Energy production was not considered in this study because the matrix was assumed to be inert. Also, the linear adsorption process in solute transport is similar to the storage of energy in aquifer material. Only the non-linear sorption processes and first-order production of solute and adsorbate, such as linear biological oxygen demand (BOD), have no readily apparent analogy in terms of energy.

The balances of energy per unit volume, (7.3), and total species mass per unit volume (7.5), may be expressed in a single unified balance in terms of a variable, U(x,y,t), which may either represent T(x,y,t) or C(x,y,t):

$$\frac{\delta(\varepsilon S_w \rho c_w U)}{\delta t} + \frac{\delta[(1-\varepsilon)]\rho_s U_s)}{\delta t} + \underline{\nabla} \cdot (\varepsilon S_w \rho c_w \underline{v} U) - \underline{\nabla} \cdot \{\rho c_w [\varepsilon S_w (\sigma_w \underline{I} + \underline{D})$$

$$+ (1-\varepsilon)\sigma_s \underline{I}] \cdot \underline{\nabla} U\} = Q \rho c_w U^* + \varepsilon S_w \rho \Gamma_w + (1-\varepsilon)\rho_s \Gamma_s \qquad (7.6)$$

where

for energy transport

$U = T$

$U_s = c_s T$

$U^* = T^*$

$\sigma_w = \frac{\lambda_w}{\rho c_w}$

$\sigma_s = \frac{\lambda_s}{\rho c_w}$

$\Gamma_w = \lambda_o{}^w$

$\Gamma_s = \lambda_o{}^s$

for solute transport

$U = C$

$U_s = C_s$

$U^* = C^*$

$\sigma_w = D_m$

$\sigma_s = 0$

$c_w = 1$

Model Assumptions

The following assumptions were made to simplify the model:

1. The aquifer is confined, isotropic, homogeneous, saturated, and of constant thickness (3.81 m = 12.5 ft).
2. Groundwater flow is two-dimensional in map view.
3. Advection, diffusion, and hydrodynamic dispersion transport heat throughout the system.
4. Thermal equilibrium between the solid and liquid phase is achieved instantaneously.
5. Initial temperatures everywhere in the modeled system are steady-state (13.85 °C).
6. The west boundary is a no-flow bedrock boundary.
7. Heat capacities, thermal conductivities, compressibilities, and solid grain densities are treated as constants, both temporally and spatially.
8. Fluid density and viscosity vary with temperature, and are internally calculated by SUTRA using temperature-based empirical formulas.
9. Energy production by the solid matrix is negligible because the matrix was assumed to be inert.

Model Construction

This model is a map-view model of a confined, saturated, two-dimensional, transient flow system and transient transport of thermal energy in the groundwater and solid aquifer matrix.

Finite-element grid (Figure 25)

A transparent grid of 1 cm square elements laid on the Newport, KY-OH 7.5 minute topographic map provided the means to create finite-elements as required by SUTRA. Each element is 90 m by 90 m, and the total grid is 47 columns by 81 rows. Based on the topography of the valley, the total modeled area is 3330 meters in the east-west direction and 8100 meters in the north-south direction. Squares which fell out of the modeled area received "0" values, squares which fell inside the modeled area received "1" values. Squares which fell on the bedrock boundary received "B" values. Squares which fell on the Duck Creek, Little Miami River, and Ohio River boundaries received D, M, and R values, respectively. This matrix of symbols was translated into a node map for use in SUTRA.

Model Input

Voss (1984) suggests values for several constant properties of fluid and solid matrix, and for flow and transport parameters. SUTRA internally calculates a bulk thermal conductivity value based on fluid and solid thermal conductivity according to the equation:

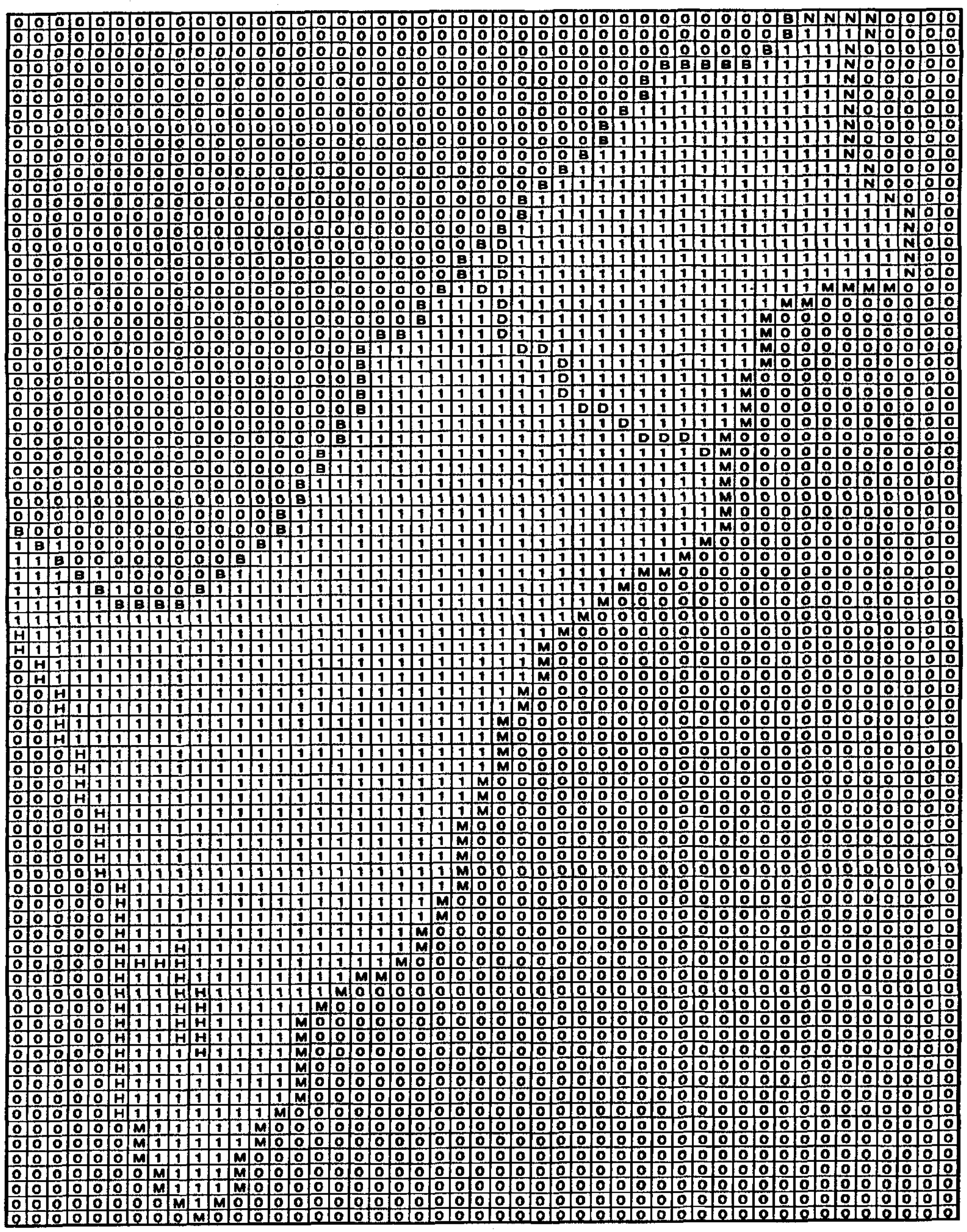


Figure 25 Symbol matrix used to generate finite element grid for use in the SUTRA computer model. Squares which fell outside the modeled area received "0" values, squares which fell inside the modeled area received "1" values. Squares which fell on the bedrock boundary received "B" values. Squares which fell on the Duck Creek, Little Miami River, and Ohio River boundaries received D, M, and R values, respectively.

$$\lambda = \varepsilon S_w \lambda_w + (1-\varepsilon)\lambda_s$$

where

λ	:	bulk thermal conductivity [E/(s•L•°C)]		
λ_w	:	fluid thermal conductivity [E/(s•L•°C)]		
λ_s	:	solid thermal conductivity [E/(s•L•°C)]		
ε	:	porosity	=	0.15
S_w	:	saturation	=	1

Thermal conductivity (l_s) values vary from 0.25 J/m•s•°C for loose, dry pumice to 5.0 J/m•s•°C for dolomite (Janza, 1975). Voss (1984) suggests a value of 0.6 J/m•s•°C for λ_w and a value of 3.5 J/m•s•° C for λ_s. Mitchell and Tsung (1978) used the thermal needle technique to calculate bulk thermal conductivity values for saturated porous sediments. The calculated value for l, 3.065 J/m•s•°C, falls within their expected range (0.872 - 3.487 J/m•s•°C). This value also closely corresponds to a bulk thermal conductivity value of 2.775 J/m•s•°C, calculated by Weinreb (1987) for sand and gravel outwash in Illinois.

For solid grain specific heat capacity, SUTRA suggests a value of 840 J/(kg•°C) for sandstone at 20°C. This value falls within the range of values for common dry rock materials (795-920°C) as given by Bear (1972). The model uses the standard value for the specific heat of water, c_w, at 20°C, 4182 J/(kg•°C).

Dispersion describes the mixing of fluids which actually travel through the solid matrix at velocities different from the average velocity in two space dimensions, $\underline{v}$, calculated from Darcy's law

(Voss, 1984). The dispersion tensor, D, is a function of advective flow and dispersivity, according to the equations

$$d_L = \alpha_L \cdot v$$

$$d_T = \alpha_T \cdot v$$

where

d_L	:	longitudinal dispersion coefficient $[L^2/s]$
d_T	:	transverse dispersion coefficient $[L^2/s]$
α_L	:	longitudinal dispersivity of solid matrix [L]
α_T	:	transverse dispersivity of solid matrix [L]
v	:	magnitude of velocity $\underline{v}$ [L/s]

Dispersion complicates transport modeling because of the impossibility of knowing, or even estimating, groundwater velocities throughout a modeled area. Anderson and Woessner (1992) note that dispersivity values are correction factors to account for this process. Movement along preferential flow paths (Anderson, 1991) and transient effects (Goode and Konikow, 1990b) further complicate the quantification of dispersion. Because of discrepancies between lab and field measurements of dispersivity, field-scale dispersivities must be determined by tracer tests or other field techniques. Gelhar, Welty, and Rehfeldt (1992) reviewed dispersivity observations from 59 different field sites, and determined that longitudinal dispersivity increases with observation scale. In addition, at a given scale, longitudinal dispersivity values range over 2-3 orders of magnitude and higher reliability data fall in the lower portion of the range. Figure 26 presents their findings and Table 2 presents dispersivity

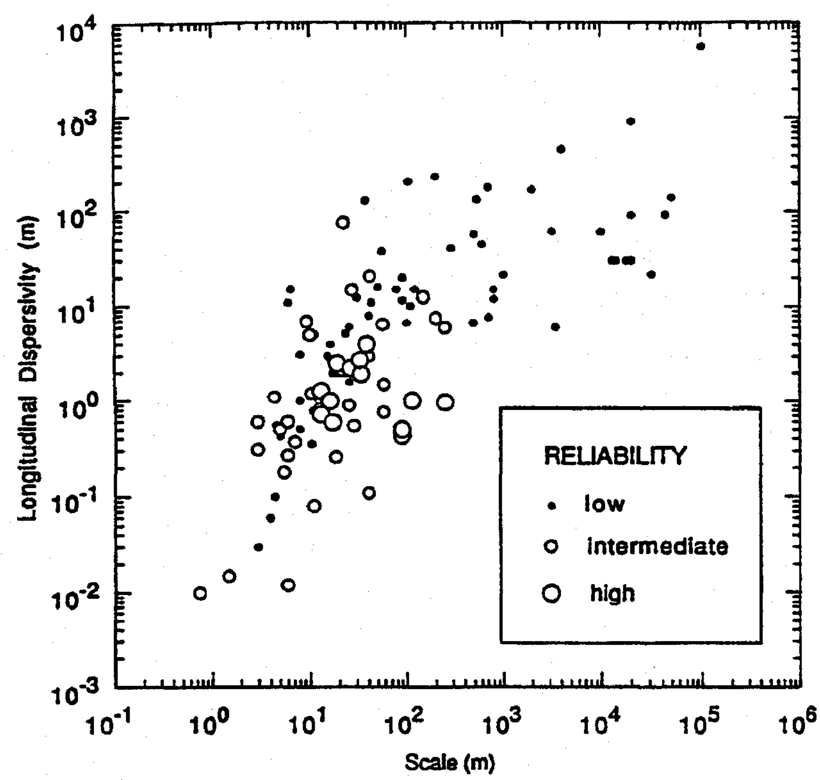


Figure 26 Longitudinal dispersivity versus scale with data classified by reliability (Gelhar, Welty, and Rehfieldt, 1992).

Site Name	Rock Type	Average Aquifer Thickness, m	K (m/s) or T (m^2/s)	Effective Porosity, %	Velocity, m / d	Scale of Test, m	Dispersivity, D_l, D_t, D_v
Hanford, WA	glacio-fluviatile sands and gravels	64	5.7e-4 to 3.0e-2 m/s	18	0.3	20,000	30.5/18.3
Handford, WA	glacio-fluviatile sands and gravels	64	1.7e-1 m^2/s	10	26 31	3,500, 4,000	6 460
Borden	glacio-fluvial sand	7-27	1e-4 to 1e-6 m / s	38	0.01-0.04	600	30-60
Borden	glacio-fluvial sand	9	7.2e-5 m/s	33 (total)	0.09	90	0.43/0.039
Dormach, Germany	fluvial-glacial gravels	14			20	10	5, 1.9
Long Island	glacial outwash	43	7.5e-4 m/s	35	0.43	1,000	21.3/4.2
Borden	glacio-fluvial sand	9	7.2e-5 m/s	33 (total)	0.09	90	0.50/0.05/0.0022
Borden	glacio-fluvial sand	7-27	4.8e-5 to 7.6e-5	38	0.07-0.25	11 0.75	0.08/0.03 0.01/0.005
Spokane Aquifer, WA and ID	glacio-fluvial sand and gravel	152	9e-5 m^2/s to 6.5 m^2/s	7-40	0.003-2.8	43,400	91.4/27.4

Table 2 Dispersivity values for glacio-fluvial sand and gravel aquifers.

values for glacial sands and gravels. Gelhar, Welty, and Rehfeldt (1992) also cite the popularity of using a transverse dispersivity which is about one third of the longitudinal dispersivity, but note that no simulation systematically demonstrates the appropriateness of using this value for horizontal transverse dispersivity. Voss (1984) states that transverse dispersivities are typically between one tenth and one third of longitudinal dispersivity.

The model describes the aquifer as isotropic and homogeneous. Copeland (1996) determined the hydraulic conductivity value to be 262.5 m/s. Because hydraulic conductivity, through viscosity, depends on temperature and density, SUTRA requires input in the form of permeability, and thus allows density-dependent flow and transport. Permeability is derived from hydraulic conductivity according to the equation

$$k = \frac{\mu K}{\rho |g|}$$

where

k	=	intrinsic permeability $[L^2]$
m	=	fluid viscosity $[M/L \cdot s]$
K	=	hydraulic conductivity $[L/s]$
ρ	=	fluid density $[M/L_f^3]$
g	=	gravitational acceleration $[L/s^2]$ ($9.81\ m/s^2$)

Table 3 presents a summary of input parameters.

Mesh and coordinate data	
number of elements in mesh	1405
number of nodes in mesh	1538
element size, x direction	90 m
element size, y direction	90 m
x-component of gravity vector	0 m/s^2
y-component of gravity vector	0 m/s^2
Flow parameters	
fluid compressibility	1.8e-5 $[kg/m{\cdot}s2]^{-1}$
solid matrix compressibility	0 $[kg/m{\cdot}s2]^{-1}$
porosity	0.15
intrinsic permeability (isotropic)	3.10e-10 m^2
fluid density	internally calculated
fluid base density	998 kg/m^3
base temperature for fluid density calculation (background temperature)	20 °C
fluid viscosity	internally calculated
Transport parameters	
longitudinal dispersivity	500 m
transverse dispersivity	167 m
fluid thermal conductivity	0.6 J/m·s·°C
solid grain thermal conductivity	3.5 J/m·s·°C
fluid specific heat capacity	4182 J/kg·°C
solid grain specific heat capacity	840 J/kg·°C
density of a solid grain	2650 kg/m^3
Initial and boundary conditions	
constant head at northern boundary	varies with time
constant head at southern boundary	varies with time
constant head at eastern boundary	varies with time
western boundary	no flow and thermally insulated
time step	3600 s

Table 3 Input parameters.

Model Calibration and Results

Calibrating a computer model is an educated trial and error process. Modeled results which do not match observed field conditions provide clues into the inaccuracies of the conceptual model. Using output from one modeling program (MODULAR) as input into another modeling program (SUTRA) further complicates the calibration process. To this end, intermediate JCL (Job Control Language) programs were written to transfer data from MODULAR to SUTRA. When using intermediate programs, the modeler must use extreme care to ensure that the two modeling programs are really "speaking" to one another.

As a first effort, a finite-element grid of ten elements wide by ten elements long (the "Ten By Ten" model) was employed to ensure that results in MODULAR could be reproduced by SUTRA. The Ten By Ten grid consisted of fluid sources at the northern boundary and fluid sinks at the southern boundary, a construction similar to the Little Miami model. Here the initial "bugs" of the intermediate programs were identified.

Firstly, fluid fluxes which MODULAR output in terms of m^3/day had to be converted into mass fluxes in terms of kg/s. Secondly, for steady-state simulations, MODULAR had to output one value of specified pressure in its flux output. This value was set equal to the Ohio River stage for the node at the lower-left corner of the model. Thirdly, it became evident that MODULAR and SUTRA results cannot exactly match, because SUTRA allows fluid viscosity to change with temperature; MODULAR does not.

Running MODULAR and SUTRA based on the Little Miami model of field conditions produced several changes to the conceptual model. Firstly, an initial nodal spacing of 60 m became too cumbersome. Considering the distance between the data collection points (much greater than 60 m), the nodal spacing was changed to 90 m. This change promoted greater modeling efficiency. Secondly, an initial conceptual model with Duck Creek as the northern boundary proved unfeasible. The temperature change produced by a cold water influx at Duck Creek dissipated before reaching the location of well 5a. Consequently, the northern boundary of the modeled area was extended to the Little Miami River. These changes did not produce a model run which replicated the observed field conditions for the April, 1994 event.

The Ten By Ten model provided a more efficient means to test the range of possible outcomes based on the known data. Thirteen runs of the Ten By Ten model varied in terms of permeability, porosity, thermal conductivity, specific heat and dispersivity (Table 4). Observation of the model results at a point 540 meters from the fluid source revealed that the existing Little Miami model could not replicate the observed field conditions, and hence could not be calibrated. The 540 meter observation point was chosen because the first five rows downgradient from the fluid source do not always provide accurate observations (Voss, 1984). The true corollary of well 5a in the Ten By Ten model would have been in the fourth row, or 360 meters from the fluid sources. Ten By Ten model run number 11 (Figure 27) produced a maximum temperature drop of 0.55 °C, however, the observed temperature drop was 1.9 °C (Figure 23).

Variable → Run ↓	permeability (m^2)	porosity	solid grain thermal conductivity (J/m•s•°C)	solid grain specific heat capacity (J/m•s•°C)	dispersivity (longitudinal/ transverse, m)
1	1.0204e-9	0.15	3.5	840	500/167
2	1.0204e-9	0.15	3.5	840	5000/1670
3	1.0204e-9	0.15	3.5	840	50/16.7
4	1.0204e-9	0.15	3.5	840	5/1.67
5	1.0204e-8	0.15	3.5	840	500/167
6	1.0204e-10	0.15	3.5	840	500/167
7	1.0204e-9	0.05	3.5	840	500/167
8	1.0204e-9	0.25	3.5	840	500/167
9	1.0204e-9	0.15	0.35	840	500/167
10	1.0204e-9	0.25	35.0	840	500/167
11	1.0204e-9	0.15	3.5	84.0	500/167
12	1.0204e-9	0.15	3.5	8400	500/167

Table 4 Ten By Ten model run parameters.

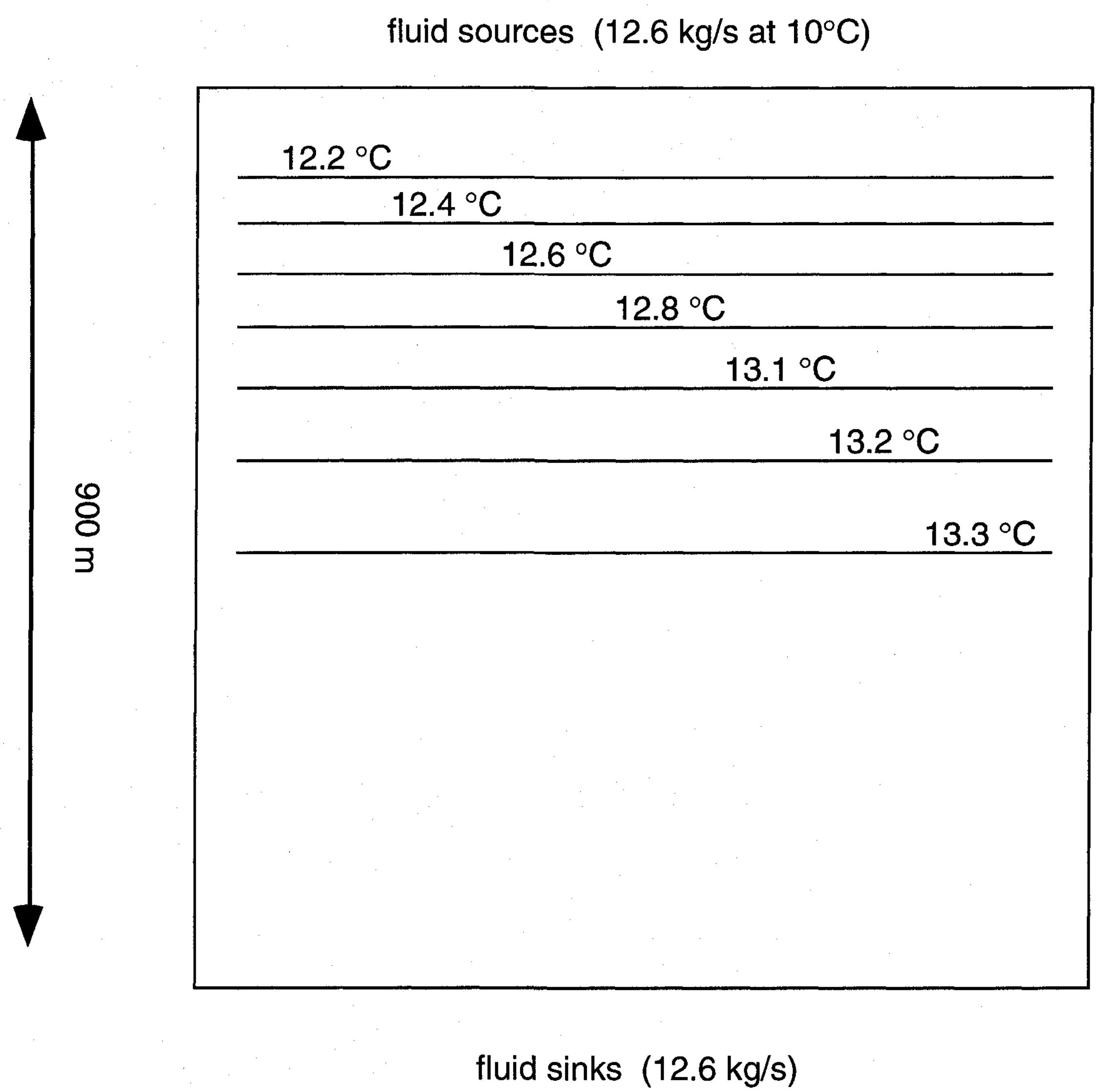


Figure 27 SUTRA results for the Ten By Ten model.

A sensitivity analysis of the Little Miami model showed that even at extreme input parameter values, the conceptual model could not replicate the observed field conditions (Table 5 and Figure 28). The observation point for the sensitivity analysis was 540 m downgradient from the Little Miami River, chosen in the same manner as the observation point in the Ten By Ten model. Thus, with a high degree of certainty, the numerical model can not be calibrated within the plausible range of input parameters. At the values shown in Table 3, the SUTRA model produced no temperature change at the location of well 5a (Figure 29).

Variable → Run ↓	permeability (m^2)	porosity	solid grain thermal conductivity (J/m•s•° C)	solid grain specific heat capacity (J/m•s•° C)	dispersivity (longitudinal/ transverse, m)
1	3.10e-10	0.15	3.5	840	500/167
2	3.10e-10	0.15	3.5	840	50/16.7
3	3.10e-10	0.15	3.5	840	5000/1670
4	3.10e-10	0.15	3.5	84	500/167
5	3.10e-10	0.15	3.5	8400	500/167
6	3.10e-10	0.15	0.35	840	500/167
7	3.10e-10	0.05	35.0	840	500/167

Table 5 Little Miami Upper Aquifer sensitivity analysis parameters.

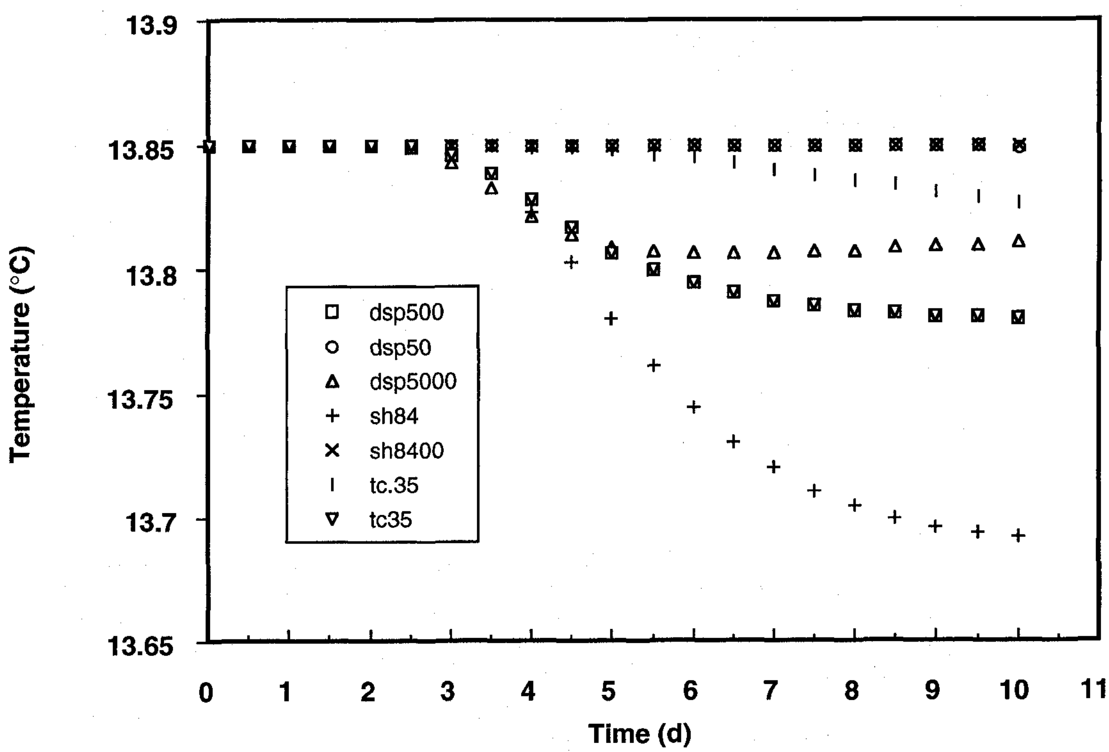


Figure 28 Sensitivity analysis for SUTRA model of the Little Miami Upper Aquifer.

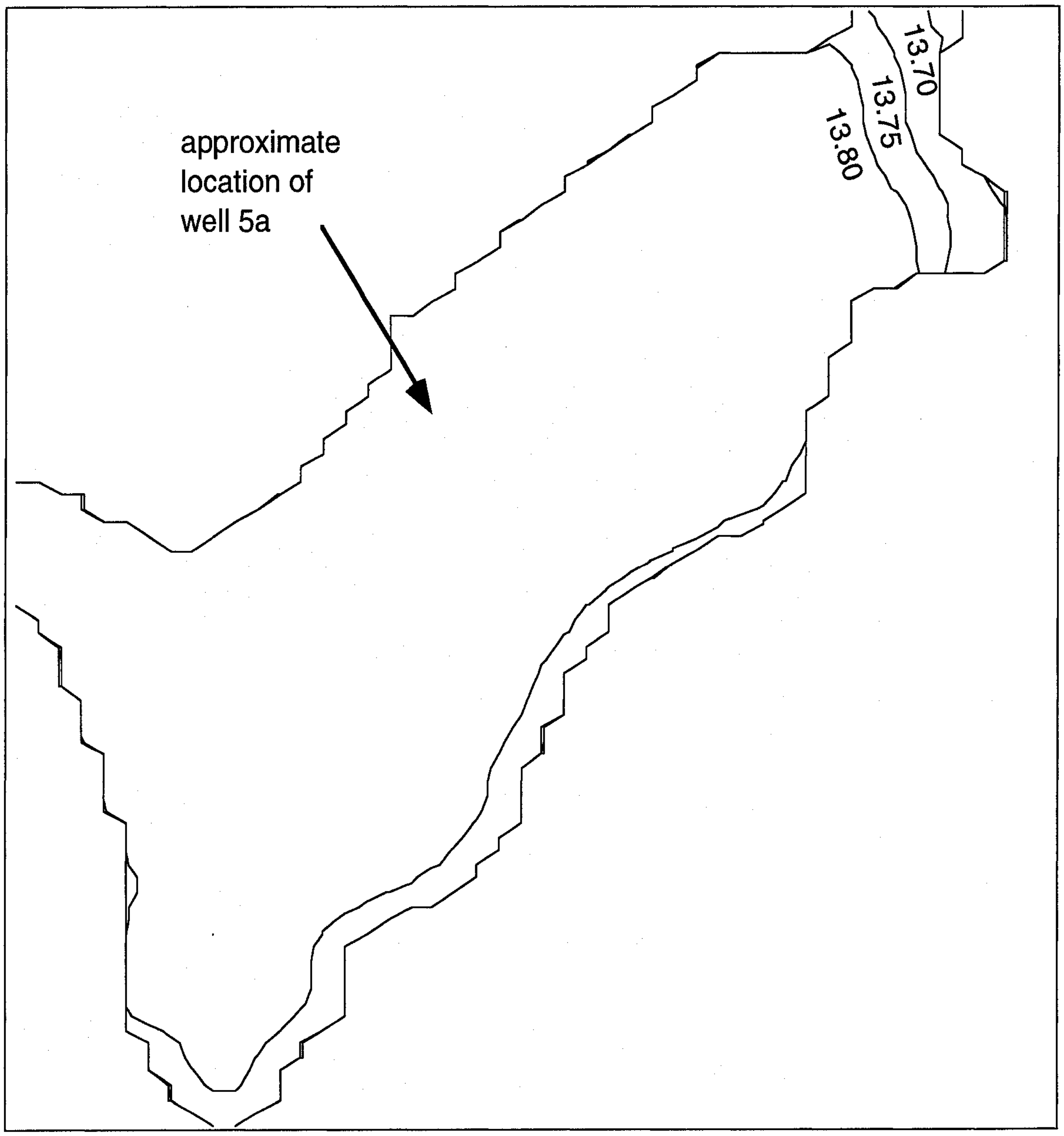


Figure 29 SUTRA results for the Little Miami Upper Aquifer. Isotherms are in degrees Celsius.

VIII. Summary and Conclusions

The efficacy of a numerical model hinges on the conceptual model which defines it. A numerical model may or may not accurately reproduce field conditions if the modeler has conceived the model incorrectly. If reasonable adjustments of input values fail to calibrate the model, the modeler must ask if the concept and its assumptions are valid.

The Little Miami model assumes all groundwater sources come from surface water contributions and underflow. The model results show that a cold water pulse dissipates before reaching well 5a, and does not produce the temperature drop that was observed in the field. Therefore, the upper silty clay layer above the upper aquifer must be more permeable than previously thought. Infiltration through the upper silty clay would provide an additional water source, possibly large enough to cause the cold water pulse observed at well 5a.

The results of this thesis suggest that vertical infiltration be included as a source of recharge to the Upper Aquifer of the LMAS. Hydraulic conductivity values on the order of 1.0e-02 m/s to 1.0e-03 m/s should be employed to determine groundwater resources and groundwater pollution potential. The LMAS should be considered a highly conductive groundwater unit, with a high potential for groundwater supply and groundwater contamination. Vertical infiltration through the upper silty clay will transport contaminants to the upper aquifer. Urbanization in the form of a municipal golf course and industrialization in the form of a municipal airport have put the lower reaches of the Little Miami Aquifer System at risk for pollution. Evaluators of groundwater contamination should consider pesticides, herbicides, Underground Storage Tanks, and waste disposal facilities as likely sources.

Although the City of Cincinnati currently does not use groundwater as a major source of drinking water, the resources of the Little Miami Aquifer System and the Miami Valley Aquifer System, which have a parallel geologic history, should be protected and conserved. The Village of Indian Hill currently pumps 4.7 million gallons per day from the upper aquifer of the LMAS to provide drinking water for 15,000 people. The LMAS may one day be a water resource for other people when surface water demand increases or supply decreases.

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Appendix A.1 Pumptest Data

r (ft) =	25		r (ft) =	50	
time (s)	drawdown (m)	log time	time (s)	drawdown (m)	log time
40	0.10850	1.60206	50	0.11430	1.69897
41	0.11060	1.61278	51	0.11640	1.70757
42	0.11490	1.62325	52	0.11490	1.71600
43	0.11710	1.63347	53	0.11490	1.72428
44	0.11810	1.64345	54	0.11700	1.73239
45	0.12030	1.65321	55	0.11910	1.74036
46	0.12460	1.66276	56	0.12150	1.74819
47	0.12450	1.67210	61	0.11980	1.78533
48	0.12560	1.68124	66	0.11950	1.81954
49	0.12990	1.69020	71	0.12360	1.85126
50	0.12880	1.69897	76	0.12650	1.88081
51	0.13180	1.70757	81	0.12840	1.90849
52	0.13410	1.71600	86	0.13490	1.93450
53	0.13290	1.72428	91	0.13800	1.95904
54	0.13300	1.73239	96	0.13730	1.98227
55	0.13720	1.74036	101	0.14030	2.00432
56	0.13710	1.74819	106	0.14320	2.02531
57	0.13830	1.75587	111	0.14510	2.04532
58	0.14040	1.76343	116	0.14700	2.06446
59	0.14460	1.77085	121	0.14630	2.08279
60	0.14460	1.77815	126	0.15070	2.10037
61	0.14460	1.78533	131	0.15150	2.11727
62	0.14880	1.79239	136	0.15450	2.13354
63	0.14340	1.79934	141	0.15530	2.14922
64	0.14540	1.80618	146	0.15930	2.16435
65	0.14650	1.81291	151	0.16110	2.17898
66	0.14430	1.81954	156	0.16200	2.19312
67	0.14960	1.82607	161	0.16280	2.20683
68	0.14860	1.83251	166	0.16360	2.22011
69	0.14950	1.83885	171	0.16080	2.23300
70	0.15050	1.84510	176	0.16260	2.24551
75	0.15250	1.87506	181	0.16590	2.25768
80	0.15430	1.90309	186	0.16530	2.26951
85	0.15840	1.92942	191	0.16860	2.28103
90	0.16250	1.95424	196	0.16790	2.29226
95	0.16660	1.97772	201	0.16770	2.30320
100	0.16640	2.00000	206	0.16740	2.31387
105	0.16940	2.02119	211	0.16930	2.32428
110	0.17450	2.04139	216	0.17250	2.33445
115	0.17430	2.06070	221	0.16970	2.34439
120	0.18040	2.07918	226	0.17300	2.35411
125	0.18570	2.09691	231	0.17350	2.36361
130	0.18440	2.11394	236	0.17930	2.37291
135	0.18520	2.13033	241	0.17760	2.38202

140	0.18930	2.14613	246	0.17940	2.39094
145	0.19230	2.16137	251	0.17910	2.39967
150	0.19200	2.17609	256	0.17890	2.40824
155	0.19500	2.19033	261	0.17860	2.41664
160	0.19580	2.20412	266	0.17940	2.42488
165	0.19330	2.21748	271	0.18120	2.43297
170	0.19620	2.23045	276	0.17950	2.44091
175	0.19600	2.24304	281	0.18280	2.44871
180	0.20110	2.25527	286	0.18220	2.45637
185	0.20310	2.26717	291	0.18300	2.46389
190	0.20500	2.27875	296	0.18520	2.47129
195	0.20470	2.29003	301	0.18350	2.47857
200	0.20550	2.30103	306	0.18640	2.48572
205	0.20960	2.31175	311	0.18610	2.49276
210	0.21150	2.32222	316	0.18580	2.49969
215	0.21340	2.33244	321	0.18910	2.50651
220	0.21200	2.34242	326	0.18990	2.51322
225	0.21500	2.35218	331	0.18930	2.51983
230	0.21580	2.36173	336	0.19150	2.52634
235	0.21880	2.37107	341	0.19230	2.53275
240	0.21960	2.38021	346	0.19520	2.53908
245	0.22260	2.38917	351	0.19310	2.54531
250	0.22450	2.39794	356	0.19140	2.55145
255	0.22640	2.40654	361	0.19080	2.55751
260	0.22610	2.41497	366	0.19160	2.56348
265	0.22580	2.42325	371	0.19590	2.56937
270	0.22550	2.43136	376	0.19670	2.57519
275	0.22520	2.43933	381	0.19750	2.58092
280	0.22710	2.44716	386	0.19720	2.58659
285	0.22790	2.45484	391	0.19690	2.59218
290	0.22870	2.46240	396	0.19770	2.59770
295	0.23170	2.46982	401	0.19960	2.60314
300	0.23360	2.47712	406	0.19930	2.60853
305	0.23660	2.48430	411	0.20010	2.61384
310	0.23740	2.49136	416	0.19980	2.61909
315	0.23710	2.49831	421	0.20380	2.62428
320	0.23320	2.50515	426	0.20350	2.62941
325	0.23760	2.51188	431	0.20320	2.63448
330	0.24060	2.51851	436	0.20040	2.63949
335	0.24250	2.52504	441	0.20020	2.64444
340	0.24220	2.53148	446	0.20240	2.64933
345	0.24050	2.53782	451	0.20320	2.65418
350	0.24160	2.54407	456	0.20500	2.65896
355	0.24240	2.55023	461	0.20330	2.66370
360	0.24320	2.55630	466	0.20440	2.66839
365	0.24510	2.56229	471	0.20410	2.67302
370	0.24600	2.56820	476	0.20490	2.67761
375	0.24780	2.57403	481	0.20680	2.68215
380	0.24750	2.57978	486	0.20870	2.68664

385	0.24830	2.58546	491	0.20840	2.69108
390	0.24800	2.59106	496	0.21030	2.69548
395	0.24670	2.59660	501	0.21220	2.69984
400	0.24850	2.60206	506	0.20940	2.70415
405	0.25080	2.60746	511	0.21160	2.70842
410	0.24650	2.61278	516	0.21130	2.71265
415	0.24620	2.61805	521	0.21100	2.71684
420	0.24940	2.62325	526	0.21170	2.72099
425	0.25590	2.62839	531	0.21360	2.72509
430	0.25450	2.63347	536	0.21440	2.72916
435	0.25380	2.63849	541	0.21410	2.73320
440	0.25350	2.64345	546	0.21380	2.73719
445	0.25610	2.64836	551	0.21790	2.74115
450	0.25310	2.65321	556	0.21760	2.74507
455	0.25490	2.65801	561	0.21830	2.74896
460	0.25610	2.66276	566	0.21800	2.75282
465	0.25800	2.66745	571	0.21890	2.75664
470	0.25870	2.67210	576	0.21750	2.76042
475	0.25740	2.67669	581	0.21930	2.76418
480	0.25710	2.68124	586	0.22020	2.76790
485	0.25780	2.68574	591	0.21990	2.77159
490	0.26070	2.69020	596	0.21960	2.77525
495	0.26370	2.69461	601	0.22240	2.77887
500	0.26210	2.69897	606	0.22110	2.78247
505	0.26110	2.70329	611	0.22300	2.78604
510	0.26260	2.70757	616	0.22270	2.78958
515	0.26380	2.71181	621	0.22020	2.79309
520	0.26670	2.71600	626	0.21890	2.79657
525	0.26290	2.72016	631	0.21860	2.80003
530	0.26480	2.72428	636	0.21830	2.80346
535	0.26230	2.72835	641	0.21900	2.80686
540	0.26420	2.73239	646	0.21990	2.81023
545	0.26490	2.73640	651	0.22060	2.81358
550	0.26460	2.74036	656	0.22030	2.81690
555	0.26550	2.74429	661	0.22110	2.82020
560	0.26740	2.74819	676	0.21910	2.82995
565	0.26820	2.75205	691	0.21930	2.83948
570	0.27610	2.75587	706	0.22170	2.84880
575	0.26970	2.75967	721	0.22500	2.85794
580	0.27310	2.76343	736	0.22530	2.86688
585	0.27500	2.76716	751	0.22550	2.87564
590	0.27540	2.77085	766	0.22570	2.88423
595	0.27510	2.77452	781	0.22690	2.89265
600	0.27630	2.77815	796	0.22070	2.90091
605	0.27590	2.78176	811	0.22510	2.90902
610	0.27420	2.78533	826	0.22650	2.91698
615	0.27970	2.78888	841	0.22560	2.92480
620	0.27610	2.79239	856	0.22580	2.93247
625	0.27010	2.79588	871	0.22590	2.94002

630	0.27310	2.79934	886	0.22610	2.94743
635	0.27300	2.80277	901	0.22770	2.95472
650	0.27110	2.81291	916	0.22650	2.96190
665	0.27560	2.82282	931	0.22570	2.96895
680	0.27360	2.83251	946	0.22840	2.97589
695	0.27600	2.84198	961	0.23430	2.98272
710	0.27740	2.85126	976	0.23060	2.98945
725	0.27760	2.86034	991	0.23220	2.99607
740	0.27890	2.86923	1006	0.23240	3.00260
755	0.27800	2.87795	1021	0.23830	3.00903
770	0.27820	2.88649	1036	0.23490	3.01536
785	0.27840	2.89487	1051	0.23240	3.02160
800	0.27640	2.90309	1066	0.23770	3.02776
815	0.27880	2.91116	1081	0.23530	3.03383
830	0.27910	2.91908	1096	0.23450	3.03981
845	0.27910	2.92686	1111	0.23430	3.04571
860	0.28170	2.93450	1126	0.23340	3.05154
875	0.28310	2.94201	1141	0.23360	3.05729
890	0.28190	2.94939	1156	0.23600	3.06296
905	0.27990	2.95665	1171	0.23510	3.06856
920	0.28470	2.96379	1186	0.23420	3.07408
935	0.28020	2.97081	1201	0.23430	3.07954
950	0.28310	2.97772	1216	0.23680	3.08493
965	0.28850	2.98453	1231	0.23690	3.09026
980	0.29010	2.99123	1246	0.23850	3.09552
995	0.28790	2.99782	1261	0.24400	3.10072
1010	0.28810	3.00432	1276	0.24310	3.10585
1025	0.29160	3.01072	1291	0.24230	3.11093
1040	0.28700	3.01703	1306	0.24570	3.11594
1055	0.28970	3.02325	1321	0.24380	3.12090
1070	0.28960	3.02938	1336	0.24490	3.12581
1085	0.28970	3.03543	1351	0.24990	3.13066
1100	0.29000	3.04139	1366	0.24890	3.13545
1115	0.29010	3.04727	1381	0.24910	3.14019
1130	0.29230	3.05308	1396	0.24670	3.14489
1145	0.29620	3.05881	1411	0.24480	3.14953
1160	0.29420	3.06446	1426	0.24740	3.15412
1175	0.29540	3.07004	1441	0.24300	3.15866
1190	0.29450	3.07555	1456	0.23950	3.16316
1205	0.29710	3.08099	1471	0.23900	3.16761
1220	0.29700	3.08636	1486	0.24120	3.17202
1235	0.29120	3.09167	1501	0.24150	3.17638
1250	0.29850	3.09691	1516	0.23940	3.18070
1265	0.29830	3.10209	1531	0.24390	3.18498
1280	0.29430	3.10721	1546	0.24190	3.18921
1295	0.29870	3.11227	1561	0.24210	3.19340
1310	0.29680	3.11727	1576	0.24370	3.19756
1325	0.30120	3.12222	1591	0.24610	3.20167
1340	0.30140	3.12710	1606	0.24410	3.20575

1355	0.30160	3.13194	1621	0.24750	3.20978
1370	0.30520	3.13672	1636	0.24630	3.21378
1385	0.30540	3.14145	1651	0.24580	3.21775
1400	0.30590	3.14613	1666	0.24240	3.22167
1415	0.30010	3.15076	1681	0.24250	3.22557
1430	0.30020	3.15534	1696	0.24160	3.22943
1445	0.30370	3.15987	1711	0.24500	3.23325
1460	0.29820	3.16435	1726	0.24620	3.23704
1475	0.29840	3.16879	1741	0.24640	3.24080
1490	0.29860	3.17319	1756	0.24550	3.24452
1505	0.30000	3.17754	1771	0.24780	3.24822
1520	0.30250	3.18184	1786	0.25150	3.25188
1535	0.30130	3.18611	1801	0.25040	3.25551
1550	0.30740	3.19033	1816	0.25200	3.25912
1565	0.29980	3.19451	1831	0.24970	3.26269
1580	0.30100	3.19866	1846	0.25120	3.26623
1595	0.30670	3.20276	1861	0.24680	3.26975
1610	0.29990	3.20683	1876	0.24950	3.27323
1625	0.30220	3.21085	1891	0.25070	3.27669
1640	0.30130	3.21484	1906	0.24990	3.28012
1655	0.30040	3.21880	1921	0.25120	3.28353
1670	0.30060	3.22272	1936	0.24590	3.28691
1685	0.30290	3.22660	1951	0.24850	3.29026
1700	0.29980	3.23045	1966	0.24520	3.29358
1715	0.30330	3.23426	1981	0.24650	3.29688
1730	0.30600	3.23805	1996	0.24740	3.30016
1745	0.30370	3.24180	2011	0.25270	3.30341
1760	0.30660	3.24551	2026	0.24950	3.30664
1775	0.31110	3.24920	2086	0.24780	3.31931
1790	0.31130	3.25285	2146	0.24150	3.33163
1850	0.30840	3.26717	2206	0.25100	3.34361
1910	0.30450	3.28103	2266	0.25440	3.35526
1970	0.30630	3.29447	2326	0.25090	3.36661
2030	0.31390	3.30750	2386	0.25210	3.37767
2090	0.31470	3.32015	2446	0.24950	3.38846
2150	0.31220	3.33244	2506	0.24990	3.39898
2210	0.31180	3.34439	2566	0.25390	3.40926
2270	0.30780	3.35603	2626	0.25580	3.41929
2330	0.30990	3.36736	2686	0.26670	3.42911
2390	0.31060	3.37840	2746	0.27510	3.43870
2450	0.30820	3.38917	2806	0.27330	3.44809
2510	0.31540	3.39967	2866	0.27420	3.45728
2570	0.32050	3.40993	2926	0.26670	3.46627
2630	0.31760	3.41996	2986	0.26460	3.47509
2690	0.32530	3.42975	3046	0.26570	3.48373
2750	0.33580	3.43933	3106	0.26510	3.49220
2810	0.33200	3.44871	3166	0.26620	3.50051
2870	0.33510	3.45788	3226	0.26700	3.50866
2930	0.33240	3.46687	3286	0.26100	3.51667
2990	0.32900	3.47567	3346	0.26390	3.52453

3050	0.32430	3.48430	3406	0.26150	3.53224
3110	0.32390	3.49276	3466	0.25900	3.53983
3170	0.32800	3.50106	3526	0.25870	3.54728
3230	0.32650	3.50920	3586	0.25630	3.55461
3290	0.32620	3.51720	3646	0.24870	3.56182
3350	0.32710	3.52504	3706	0.25050	3.56891
3410	0.32460	3.53275	3766	0.25550	3.57588
3470	0.32320	3.54033	4366	0.25230	3.64008
3770	0.31820	3.57634	4666	0.25400	3.66894
4370	0.31630	3.64048	4966	0.26990	3.69601
4670	0.32020	3.66932	5266	0.27930	3.72148
4970	0.33950	3.69636	5566	0.27850	3.74554
5270	0.34800	3.72181	5866	0.28250	3.76834
5570	0.34430	3.74586	6166	0.27460	3.79000
5870	0.34850	3.76864	6466	0.27740	3.81064
6170	0.35380	3.79029	6766	0.28240	3.83033
6470	0.35650	3.81090	7066	0.27080	3.84917
6770	0.36040	3.83059	7366	0.26750	3.86723
7070	0.35560	3.84942	7666	0.27360	3.88457
7370	0.34770	3.86747			
7670	0.35190	3.88480			

Constants

Q =	0.003786 m3/s
B=	3.809814081 m

Equations

slope = s, drawdown over one log cycle
int = do, zero drawdown
T = 2.3*Q/4pi*s
K = T/B
storage = 2.25*T*10^(-do/log t)

Analysis at 25-ft piezometer

for time = 67-630 s

slope (s, log t)	int. (s, log t)
0.013351284	-0.009830522
x	y
67	0.014549921
630	0.027544268
T =	0.051900977 m2/s
K	0.013622968 m/s
storage:	0.010959441

for time = 845-3410 s

slope (s, log t)	int. (s, log t)
0.007846640	0.005223037
x	y
845	0.028189029
3410	0.032943290
T	0.088311007 m2/s
K	0.023179873 m/s
storage:	0.000739077

Analysis at 50-ft piezometer

for time = 50-601 s

slope (s, log t)	int. (s, log t)
0.009811190	-0.005585177
x	y
50	0.011083741
601	0.021678890
T =	0.070627991 m2/s
K	0.018538435 m/s
storage:	0.002538036

for time = 961-3166 s

slope (s, log t)	int. (s, log t)
0.006330717	0.004262970
x	y
961	0.023145748
3166	0.026423715
T	0.109457536 m2/s
K	0.028730414 m/s
storage:	0.000224968

Average T: 0.080074378
Average K: 0.021017922
Average storage:0.003615380

Appendix B Short-term Groundwater Depth and Temperature Data

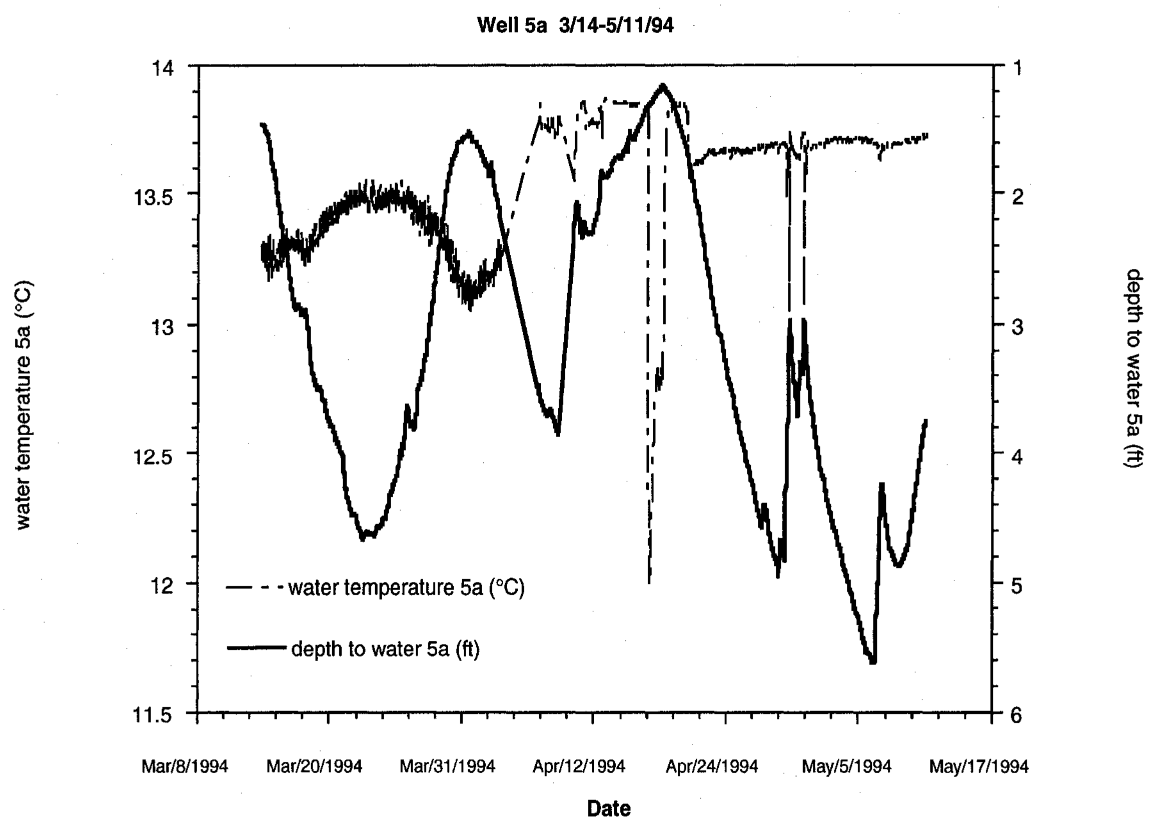

Figure 30 Temperature and depth to water data for well 5a, 3/14-5/11/94.

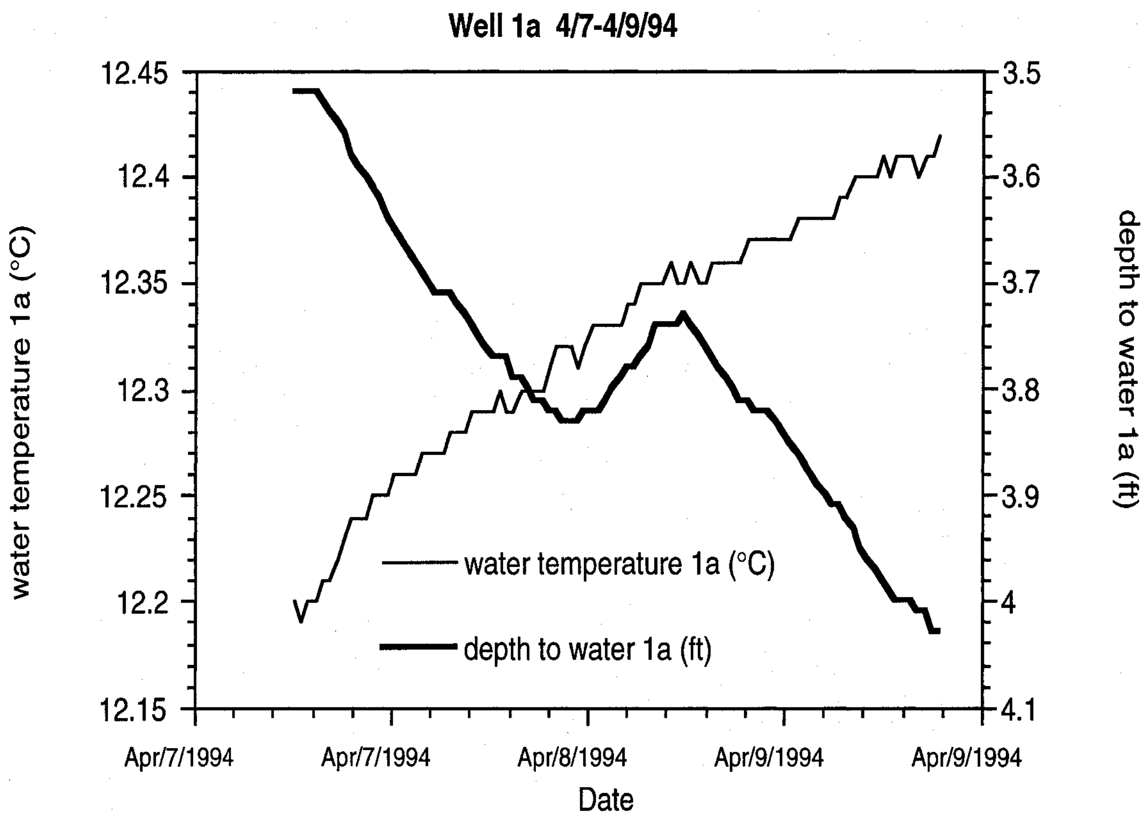

Figure 31 Temperature and depth to water data for well 1a, 4/7-9/94.

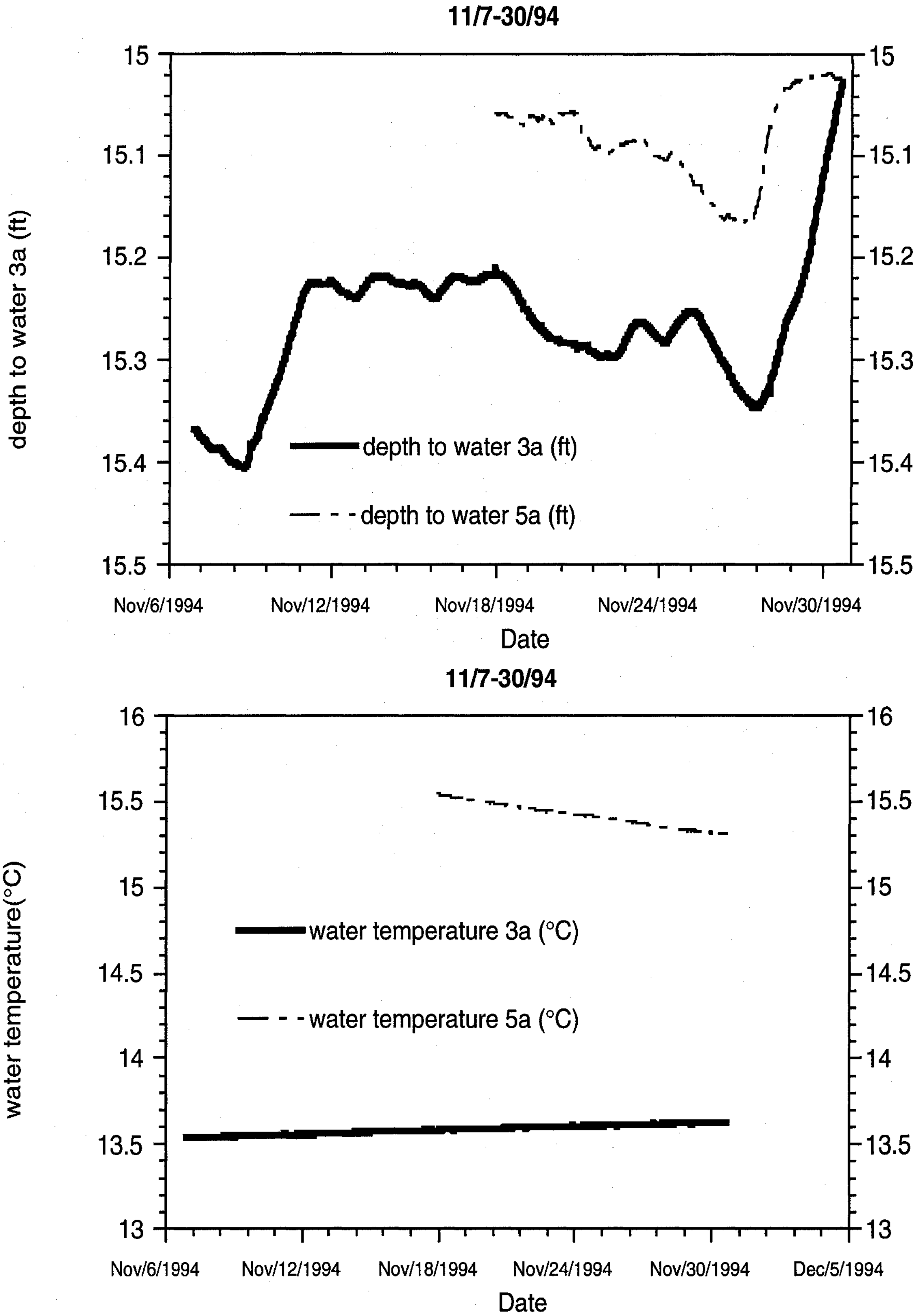

Figure 32 Temperature and depth to water and temperature data for wells 3a and 5a, 11/7-30/94.

Appendix C

SUTRA output
for the
Little Miami Upper Aquifer model

J E S 2   J O B   L O G — S Y S T E M   S 4 7 0 — N O D E   U C C C M V S

```
14.56.47 JOB 2671  IEF196I $HASP906 CPU=  180:00  REG= 5120K  TAPE=00  CLASS=Z  STEPS=003
14.56.47 JOB 2671  $HASP906 PGELLADC CPU=  180:00  REG= 5120K  TAPE=00  CLASS=Z  STEPS=003
23.04.56 JOB 2671  $HASP373 PGELLADC STARTED - INIT 16 - CLASS Z - SYS S470
23.04.56 JOB 2671  ACF9CCCD USERID PGELLAD  IS ASSIGNED TO THIS JOB
06.27.50 JOB 2671  F ZWYL,TO PGELLAD PGELLADC JOB 2671 RUNSUTRA HAS COMPLETED ON S470
06.27.50 JOB 2671  $HASP395 PGELLADC ENDED
------ JES2 JOB STATISTICS ------
    23 MAY 96 JOB EXECUTION DATE
           34 CARDS READ
       89,855 SYSOUT PRINT RECORDS
            0 SYSOUT PUNCH RECORDS
        6,567 SYSOUT SPOOL KBYTES
       442.91 MINUTES EXECUTION TIME
        1 //PGELLADC JOB (E312XY,,,,,,,,),'RUNSUTRA',                             JOB 2671
          //         MSGCLASS=D,MSGLEVEL=(2,0),REGION=5120K,
          //         TIME=(180,0)
          *** $ACFJ219 ACF2 ACTIVE UCCCMVS                                            ACF2
          ***JOBFROM $ACFJ201 ACF2 CONTROL CARD SUCCESSFULLY SCANNED
          ***ROUTE PRINT RMT41                                                      3.
          ***JOBPARM L=900                                                          4.
          ***                                                                       5.
          ***        * * * LINK-EDIT AND GO WITH SUTRA OBJECT CODE * * *            6.
          ***                                                                       7.
        2 //LINKNGO     EXEC FORTVLG                                                8.
        5 //LKED.SYSPRINT DD DUMMY                                                  9.
       14 //LKED.SYSLIN DD DSN=PGEL.GHYDRO.LIB(SUTOBJ),DISP=SHR                    10.
          ***GO.FT06F001 DD DSN=PGELLAD.SUTRA.OUTPUT,SPACE=(TRK,(500,10),RLSE),    11.
          ***            DCB=(RECFM=FB,LRECL=133,BLKSIZE=6118),UNIT=SYSDA,         12.
          ***            DISP=(NEW,CATLG),VOL=SER=WRK471                            13.
          ***GO.FT06F001 DD UNIT=3480,DISP=(NEW,PASS),VOL=SER=C18310,              14.
          ***            DCB=(RECFM=FB,LRECL=133,BLKSIZE=6118),                     15.
          ***            DSN=SUTRA.OUTPUT,LABEL=(47,SL),SPACE=(TRK,(500,500),RLSE) 16.
       20 //GO.FT01F001 DD DSN=PGELLAD.FLUX2NOD,DISP=SHR                           17.
       21 //GO.FT02F001 DD DSN=PGELLAD.FLUX.OUTPUT,SPACE=(TRK,(50,10),RLSE),       18.
          //            DCB=(RECFM=FB,LRECL=80,BLKSIZE=6160),UNIT=SYSDA,           19.
          //            DISP=(NEW,CATLG),VOL=SER=WRK471                            20.
       22 //GO.FT55F001 DD DSN=PGELLAD.LIB.LISA(UNIT55),DISP=SHR                   21.
       23 //GO.FT06F002 DD SYSOUT=*                                                 22.
          ***GO.FT66F001 DD DSN=PGELLAD.UNIT66,DISP=SHR                             23.
       24 //GO.FT66F001 DD DSN=PGELLAD.UNIT66,SPACE=(TRK,(50,10),RLSE),            24.
          //            DCB=(RECFM=FB,LRECL=80,BLKSIZE=6160),UNIT=SYSDA,           25.
```

```
     //           DISP=(NEW,CATLG),VOL=SER=WRK471                               26.
  25 //GO.SYSIN    DD DSN=PGELLAD.LIB.LISA(UNIT5T),DISP=SHR                     27.
     ***LIST EXEC PGM=TAPEMNGL                                                  28.
     ***SYSPRINT DD SYSOUT=A                                                    29.
     ***SYSUT1   DD UNIT=3480,DISP=(OLD,KEEP),VOL=SER='C18310'                  30.
  26 //FINISHED    EXEC WNOTIFY                                                 31.
IEF142I PGELLADC LKED LINKNGO - STEP WAS EXECUTED - COND CODE 0000
IEF373I STEP /LKED    / START 96144.2304
IEF374I STEP /LKED    / STOP  96144.2305 CPU    0MIN 00.46SEC SRB    0MIN 00.10SEC VIRT   432K SYS   296K EXT       4K SYS    8896K
IEF142I PGELLADC GO LINKNGO - STEP WAS EXECUTED - COND CODE 0000
IEF373I STEP /GO      / START 96144.2305
IEF374I STEP /GO      / STOP  96145.0627 CPU   97MIN 13.01SEC SRB   20MIN 00.33SEC VIRT   116K SYS   392K EXT    3472K SYS    8900K
IEF142I PGELLADC NOTIFY FINISHED - STEP WAS EXECUTED - COND CODE 0000
IEF373I STEP /NOTIFY  / START 96145.0627
IEF374I STEP /NOTIFY  / STOP  96145.0627 CPU    0MIN 00.02SEC SRB    0MIN 00.00SEC VIRT    16K SYS   292K EXT       8K SYS    8872K

$$$$$$$$$$$$$$$$$$$$$$$$$                    KOMAND  ONLINE  COSTING           LEVEL=V331      $$$$$$$$$$$$$$$$$$$$$$$$$$

                         QUANTITY    RESOURCE                             DOLLAR         ESTIMATED
                         MEASURED    DESCRIPTION                           RATE            COST

                               34    JCL / DATA READ INTERNAL             .30/1000           .01
                           89,818    SYSOUT PRINT RECORDS-LOCAL          1.15/1000         103.29
                        1.9539608    PROCESSOR HOURS                   675.00/HOUR       1,318.92
                         228.8793    KCORE HOURS VIRTUAL                .032/KHOUR          7.32
                                     MULTIPLICATION FACTOR               1.00   *        1,429.54 = JOB COST     $1,429.54
                                     TABLE USED:   OCTS4701

          FILE BALANCE     $6,508.33           TOTAL CHARGES      $3,709.26            ACCOUNT BALANCE     $2,799.07
IEF375I  JOB /PGELLADC/ START 96144.2304
IEF376I  JOB /PGELLADC/ STOP  96145.0627 CPU   97MIN 13.49SEC SRB   20MIN 00.43SEC
*********************************************************************************************************************

                                          SSSS   UU  UU  TTTTTT  RRRRR     AA
                                         SS   S  UU  UU  T TT T  RR  RR   AAAA
                                         SSSS    UU  UU    TT    RRRRR   AA  AA
                                            SS   UU  UU    TT    RR R    AAAAAA
                                         SS  SS  UU  UU    TT    RR RR   AA  AA
                                          SSSS    UUUU     TT    RR  RR  AA  AA
```

U N I T E D   S T A T E S   G E O L O G I C A L   S U R V E Y

SUBSURFACE FLOW AND TRANSPORT SIMULATION MODEL

-VERSION 1284-2D-

* SATURATED-UNSATURATED FLOW AND SOLUTE OR ENERGY TRANSPORT *

****

* * * * *   S U T R A   E N E R G Y   T R A N S P O R T   S I M U L A T I O N   * * * * *

****

Energy Transport Model for Little Miami Aquifer System

S I M U L A T I O N   M O D E   O P T I O N S

- ASSUME SATURATED FLOW ONLY
- ALLOW TIME-DEPENDENT FLOW FIELD
- ALLOW TIME-DEPENDENT TRANSPORT
- COLD START - BEGIN NEW SIMULATION
- STORE RESULTS AFTER EACH TIME STEP ON UNIT-66 AS BACK-UP AND FOR USE IN A SIMULATION RE-START

S I M U L A T I O N   C O N T R O L   N U M B E R S

1538   NUMBER OF NODES IN FINITE-ELEMENT MESH
1405   NUMBER OF ELEMENTS IN MESH
67   ESTIMATED MAXIMUM FULL BAND WIDTH FOR MESH

0   EXACT NUMBER OF PINCH NODES IN MESH

0   EXACT NUMBER OF NODES IN MESH AT WHICH PRESSURE IS A SPECIFIED CONSTANT OR FUNCTION OF TIME
0   EXACT NUMBER OF NODES IN MESH AT WHICH TEMPERATURE IS A SPECIFIED CONSTANT OR FUNCTION OF TIME

1538   EXACT NUMBER OF NODES AT WHICH FLUID INFLOW OR OUTFLOW IS A SPECIFIED CONSTANT OR FUNCTION OF TIME

0   EXACT NUMBER OF NODES AT WHICH A SOURCE OR SINK OF ENERGY IS A SPECIFIED CONSTANT OR FUNCTION OF TIME

0   EXACT NUMBER OF NODES AT WHICH PRESSURE AND TEMPERATURE WILL BE OBSERVED
0   MAXIMUM NUMBER OF TIME STEPS ON WHICH OBSERVATIONS WILL BE MADE

N U M E R I C A L   C O N T R O L   D A T A

0.00000	"UPSTREAM WEIGHTING" FACTOR
1.0000D-02	SPECIFIED PRESSURE BOUNDARY CONDITION FACTOR

T E M P O R A L   C O N T R O L   A N D   S O L U T I O N   C Y C L I N G   D A T A

240	MAXIMUM ALLOWED NUMBER OF TIME STEPS
3.6000D+03	INITIAL TIME STEP (IN SECONDS)
8.6400D+05	MAXIMUM ALLOWED SIMULATION TIME (IN SECONDS)
1	TIME STEP MULTIPLIER CYCLE (IN TIME STEPS)
1.00000	MULTIPLICATION FACTOR FOR TIME STEP CHANGE
3.6000D+03	MAXIMUM ALLOWED TIME STEP (IN SECONDS)
1	FLOW SOLUTION CYCLE (IN TIME STEPS)
1	TRANSPORT SOLUTION CYCLE (IN TIME STEPS)

O U T P U T   C O N T R O L S   A N D   O P T I O N S

12   PRINTED OUTPUT CYCLE (IN TIME STEPS)

- CANCEL PRINT OF NODE COORDINATES, THICKNESSES AND POROSITIES
- CANCEL PRINT OF ELEMENT PERMEABILITIES AND DISPERSIVITIES
- CANCEL PRINT OF NODE AND PINCH NODE INCIDENCES IN EACH ELEMENT

- CANCEL PLOT OF PRESSURES
- CANCEL PLOT OF TEMPERATURES

- CALCULATE AND PRINT VELOCITIES AT ELEMENT CENTROIDS ON EACH TIME STEP WITH OUTPUT

- CALCULATE AND PRINT FLUID AND ENERGY BUDGETS ON EACH TIME STEP WITH OUTPUT

I T E R A T I O N   C O N T R O L   D A T A

NON-ITERATIVE SOLUTION

C O N S T A N T   P R O P E R T I E S   O F   F L U I D   A N D   S O L I D   M A T R I X

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     1.7800D-05      COMPRESSIBILITY OF FLUID
     0.0000D+00      COMPRESSIBILITY OF POROUS MATRIX

     4.1800D+03      SPECIFIC HEAT CAPACITY OF FLUID
     8.4000D+02      SPECIFIC HEAT CAPACITY OF SOLID GRAIN

  FLUID VISCOSITY IS CALCULATED BY SUTRA AS A FUNCTION OF TEMPERATURE IN UNITS OF [KG/(M*S)]

     1.0000D+00      VISCO, CONVERSION FACTOR FOR VISCOSITY UNITS,  [DESIRED UNITS] = VISCO*[KG/(M*S)]

     2.6500D+03      DENSITY OF A SOLID GRAIN

  FLUID DENSITY, RHOW
  CALCULATED BY SUTRA IN TERMS OF TEMPERATURE, U, AS:
  RHOW = RHOW0 + DRWDU*(U-URHOW0)

     9.9800D+02      FLUID BASE DENSITY, RHOW0
     0.0000D+00      COEFFICIENT OF DENSITY CHANGE WITH TEMPERATURE, DRWDU
     2.0000D+01      TEMPERATURE, URHOW0, AT WHICH FLUID DENSITY IS AT BASE VALUE, RHOW0

     6.0000D-01      THERMAL CONDUCTIVITY OF FLUID
     3.5000D+00      THERMAL CONDUCTIVITY OF SOLID GRAIN

P R O D U C T I O N   A N D   L O S S   O F   E N E R G Y

  PRODUCTION RATE (+)
  LOSS RATE (-)

     0.0000D+00      ZERO-ORDER RATE OF ENERGY PRODUCTION/LOSS IN FLUID
     0.0000D+00      ZERO-ORDER RATE OF ENERGY PRODUCTION/LOSS IN SOLID GRAINS

C O O R D I N A T E   O R I E N T A T I O N   T O   G R A V I T Y

  COMPONENT OF GRAVITY VECTOR
  IN +X DIRECTION, GRAVX
     0.0000D+00      GRAVX = -GRAV * D(ELEVATION)/DX

  COMPONENT OF GRAVITY VECTOR
  IN +Y DIRECTION, GRAVY
     0.0000D+00      GRAVY = -GRAV * D(ELEVATION)/DY
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N O D E   I N F O R M A T I O N

PRINTOUT OF NODE COORDINATES, THICKNESSES AND POROSITIES CANCELLED.

SCALE FACTORS :

1.0000D+00	X-SCALE
1.0000D+00	Y-SCALE
1.0000D+00	THICKNESS FACTOR
1.5000D-01	POROSITY FACTOR

E L E M E N T   I N F O R M A T I O N

PRINTOUT OF ELEMENT PERMEABILITIES AND DISPERSIVITIES CANCELLED.

SCALE FACTORS :

3.1000D-10	MAXIMUM PERMEABILITY FACTOR
3.1000D-10	MINIMUM PERMEABILITY FACTOR
1.0000D+00	ANGLE FROM +X TO MAXIMUM DIRECTION FACTOR
5.0000D+02	MAXIMUM LONGITUDINAL DISPERSIVITY FACTOR
5.0000D+02	MINIMUM LONGITUDINAL DISPERSIVITY FACTOR
1.6700D+02	TRANSVERSE DISPERSIVITY FACTOR

F L U I D   S O U R C E   D A T A

**** NODES AT WHICH FLUID INFLOWS OR OUTFLOWS ARE SPECIFIED ****

NODE NUMBER (MINUS INDICATES TIME-VARYING FLOW OR TEMPERATURE)	FLUID INFLOW(+)/OUTFLOW(-) (FLUID MASS/SECOND)	TEMPERATURE [DEGREES CELCIUS] OF INFLOWING FLUID
-1		
-2		
-3		
.		
.		
.		
-1536		
-1537		
-1538		

THE SPECIFIED TIME VARIATIONS ARE USER-PROGRAMMED IN SUBROUTINE B C T I M E .

M E S H   C O N N E C T I O N   D A T A

PRINTOUT OF NODAL INCIDENCES AND PINCH NODE CONNECTIONS CANCELLED.

**** MESH ANALYSIS ****

ACTUAL MAXIMUM BANDWIDTH, 67, WAS CALCULATED IN ELEMENT 682
-------INPUT BANDWIDTH IS 67

E N D   O F   I N P U T   F R O M   U N I T - 5

I N I T I A L   C O N D I T I O N S

TIME INCREMENT 3.6000D+03 SECONDS

ELAPSED TIME : 0.0000D+00 SECONDS
0.0000D+00 MINUTES
0.0000D+00 HOURS
0.0000D+00 DAYS
0.0000D+00 WEEKS
0.0000D+00 MONTHS
0.0000D+00 YEARS

P R E S S U R E

NODE		NODE		NODE		NODE		NODE		NODE	
1	1.40839770D+06	2	1.40851941D+06	3	1.40859501D+06	4	1.40856391D+06	5	1.40855409D+06	6	1.40859017D+06
7	1.40862861D+06	8	1.40861243D+06	9	1.40860185D+06	10	1.40860032D+06	11	1.40860794D+06	12	1.40862416D+06
13	1.40863525D+06	14	1.40863338D+06	15	1.40862839D+06	16	1.40862729D+06	17	1.40862988D+06	18	1.40863090D+06
19	1.40866943D+06	20	1.40865906D+06	21	1.40865235D+06	22	1.40865007D+06	23	1.40864945D+06	24	1.40865037D+06
25	1.40865059D+06	26	1.40867403D+06	27	1.40867331D+06	28	1.40867092D+06	29	1.40866939D+06	30	1.40866941D+06
31	1.40867083D+06	32	1.40867761D+06	33	1.40868916D+06	34	1.40868779D+06	35	1.40868812D+06	36	1.40868772D+06
37	1.40868735D+06	38	1.40868787D+06	39	1.40868992D+06	40	1.40869336D+06	41	1.40869427D+06	42	1.40871744D+06
43	1.40870877D+06	44	1.40870428D+06	45	1.40870409D+06	46	1.40870428D+06	47	1.40870510D+06	48	1.40870666D+06
49	1.40870855D+06	50	1.40871386D+06	51	1.40872200D+06	52	1.40872139D+06	53	1.40872129D+06	54	1.40872034D+06
55	1.40872008D+06	56	1.40872059D+06	57	1.40872147D+06	58	1.40872264D+06	59	1.40872433D+06	60	1.40872634D+06

61	1.40872939D+06	62	1.40873439D+06	63	1.40873294D+06	64	1.40873367D+06	65	1.40873485D+06	66	1.40873565D+06
67	1.40873653D+06	68	1.40873753D+06	69	1.40873845D+06	70	1.40873904D+06	71	1.40873911D+06	72	1.40873835D+06
73	1.40873740D+06	74	1.40874604D+06	75	1.40874732D+06	76	1.40874948D+06	77	1.40875100D+06	78	1.40875232D+06
79	1.40875363D+06	80	1.40875456D+06	81	1.40875440D+06	82	1.40875251D+06	83	1.40874855D+06	84	1.40874605D+06
85	1.40876028D+06	86	1.40876198D+06	87	1.40876477D+06	88	1.40876661D+06	89	1.40876780D+06	90	1.40876985D+06
91	1.40877199D+06	92	1.40877157D+06	93	1.40876796D+06	94	1.40876107D+06	95	1.40875683D+06	96	1.40877582D+06
97	1.40877793D+06	98	1.40878122D+06	99	1.40878258D+06	100	1.40878368D+06	101	1.40878776D+06	102	1.40879209D+06
103	1.40879208D+06	104	1.40878700D+06	105	1.40877652D+06	106	1.40876996D+06	107	1.40879295D+06	108	1.40879564D+06
109	1.40879968D+06	110	1.40880060D+06	111	1.40880236D+06	112	1.40880939D+06	113	1.40881640D+06	114	1.40881763D+06
115	1.40881202D+06	116	1.40879711D+06	117	1.40878689D+06	118	1.40881216D+06	119	1.40881572D+06	120	1.40882111D+06
121	1.40882262D+06	122	1.40882557D+06	123	1.40883594D+06	124	1.40884656D+06	125	1.40884979D+06	126	1.40884509D+06
127	1.40883098D+06	128	1.40882081D+06	129	1.40882052D+06	130	1.40883406D+06	131	1.40883882D+06	132	1.40884635D+06
133	1.40884946D+06	134	1.40885463D+06	135	1.40886943D+06	136	1.40888424D+06	137	1.40888966D+06	138	1.40888668D+06
139	1.40887687D+06	140	1.40885794D+06	141	1.40884231D+06	142	1.40883743D+06	143	1.40885941D+06	144	1.40886551D+06
145	1.40887580D+06	146	1.40888179D+06	147	1.40889345D+06	148	1.40891406D+06	149	1.40893067D+06	150	1.40893785D+06
151	1.40893642D+06	152	1.40892678D+06	153	1.40891030D+06	154	1.40888342D+06	155	1.40886123D+06	156	1.40884758D+06
157	1.40884540D+06	158	1.40889069D+06	159	1.40889645D+06	160	1.40890801D+06	161	1.40891999D+06	162	1.40894208D+06
163	1.40896895D+06	164	1.40898641D+06	165	1.40899473D+06	166	1.40899399D+06	167	1.40898477D+06	168	1.40896727D+06
169	1.40894305D+06	170	1.40890816D+06	171	1.40887849D+06	172	1.40886409D+06	173	1.40885412D+06	174	1.40893014D+06
175	1.40893945D+06	176	1.40895770D+06	177	1.40897367D+06	178	1.40900059D+06	179	1.40903267D+06	180	1.40905170D+06
181	1.40906063D+06	182	1.40906014D+06	183	1.40905062D+06	184	1.40903264D+06	185	1.40900655D+06	186	1.40897481D+06
187	1.40894041D+06	188	1.40889996D+06	189	1.40887117D+06	190	1.40885796D+06	191	1.40897836D+06	192	1.40899514D+06
193	1.40902574D+06	194	1.40904947D+06	195	1.40907735D+06	196	1.40910751D+06	197	1.40912678D+06	198	1.40913595D+06
199	1.40913532D+06	200	1.40912513D+06	201	1.40910575D+06	202	1.40907794D+06	203	1.40904282D+06	204	1.40900105D+06
205	1.40895393D+06	206	1.40889578D+06	207	1.40886405D+06	208	1.40903448D+06	209	1.40905708D+06	210	1.40909872D+06
211	1.40913469D+06	212	1.40916630D+06	213	1.40919285D+06	214	1.40921186D+06	215	1.40922108D+06	216	1.40922010D+06
217	1.40920887D+06	218	1.40918757D+06	219	1.40915667D+06	220	1.40911673D+06	221	1.40906837D+06	222	1.40901139D+06
223	1.40894326D+06	224	1.40889511D+06	225	1.40887342D+06	226	1.40909805D+06	227	1.40912643D+06	228	1.40917867D+06
229	1.40922251D+06	230	1.40925877D+06	231	1.40928728D+06	232	1.40930692D+06	233	1.40931651D+06	234	1.40931522D+06
235	1.40930276D+06	236	1.40927908D+06	237	1.40924439D+06	238	1.40919907D+06	239	1.40914357D+06	240	1.40907841D+06
241	1.40900678D+06	242	1.40892369D+06	243	1.40887977D+06	244	1.40917196D+06	245	1.40920567D+06	246	1.40926696D+06
247	1.40931730D+06	248	1.40935862D+06	249	1.40939058D+06	250	1.40941232D+06	251	1.40942291D+06	252	1.40942162D+06
253	1.40940794D+06	254	1.40938166D+06	255	1.40934279D+06	256	1.40929155D+06	257	1.40922845D+06	258	1.40915455D+06
259	1.40907089D+06	260	1.40897697D+06	261	1.40891347D+06	262	1.40888613D+06	263	1.40926143D+06	264	1.40926435D+06
265	1.40929994D+06	266	1.40936442D+06	267	1.40942077D+06	268	1.40946771D+06	269	1.40950409D+06	270	1.40952893D+06
271	1.40954132D+06	272	1.40954048D+06	273	1.40952581D+06	274	1.40949691D+06	275	1.40945362D+06	276	1.40939602D+06
277	1.40932451D+06	278	1.40923992D+06	279	1.40914387D+06	280	1.40904292D+06	281	1.40894018D+06	282	1.40888914D+06
283	1.40928366D+06	284	1.40932480D+06	285	1.40940094D+06	286	1.40947001D+06	287	1.40953380D+06	288	1.40958736D+06
289	1.40962915D+06	290	1.40965803D+06	291	1.40967302D+06	292	1.40967324D+06	293	1.40965797D+06	294	1.40962663D+06
295	1.40957887D+06	296	1.40951455D+06	297	1.40943383D+06	298	1.40933722D+06	299	1.40922606D+06	300	1.40910241D+06
301	1.40896950D+06	302	1.40890117D+06	303	1.40934872D+06	304	1.40940114D+06	305	1.40949897D+06	306	1.40958390D+06
307	1.40965734D+06	308	1.40971886D+06	309	1.40976714D+06	310	1.40980106D+06	311	1.40981954D+06	312	1.40982157D+06
313	1.40980626D+06	314	1.40977285D+06	315	1.40972076D+06	316	1.40964960D+06	317	1.40955920D+06	318	1.40944960D+06

319	1.40932075D+06	320	1.40917181D+06	321	1.40900416D+06	322	1.40891586D+06	323	1.40943198D+06	324	1.40949380D+06
325	1.40960893D+06	326	1.40970822D+06	327	1.40979296D+06	328	1.40986362D+06	329	1.40991952D+06	330	1.40995955D+06
331	1.40998253D+06	332	1.40998728D+06	333	1.40997270D+06	334	1.40993781D+06	335	1.40988179D+06	336	1.40980396D+06
337	1.40970385D+06	338	1.40958104D+06	339	1.40943482D+06	340	1.40926307D+06	341	1.40905373D+06	342	1.40894061D+06
343	1.40953400D+06	344	1.40960408D+06	345	1.40973505D+06	346	1.40984631D+06	347	1.40994231D+06	348	1.41002308D+06
349	1.41008775D+06	350	1.41013511D+06	351	1.41016377D+06	352	1.41017236D+06	353	1.41015951D+06	354	1.41012398D+06
355	1.41006467D+06	356	1.40998065D+06	357	1.40987116D+06	358	1.40973559D+06	359	1.40957332D+06	360	1.40938337D+06
361	1.40916261D+06	362	1.40900872D+06	363	1.40893849D+06	364	1.40963235D+06	365	1.40965901D+06	366	1.40974265D+06
367	1.40987726D+06	368	1.40999910D+06	369	1.41010668D+06	370	1.41019853D+06	371	1.41027327D+06	372	1.41032935D+06
373	1.41036512D+06	374	1.41037890D+06	375	1.41036904D+06	376	1.41033400D+06	377	1.41027234D+06	378	1.41018286D+06
379	1.41006456D+06	380	1.40991676D+06	381	1.40973921D+06	382	1.40953268D+06	383	1.40930752D+06	384	1.40906730D+06
385	1.40894494D+06	386	1.40966411D+06	387	1.40974271D+06	388	1.40989237D+06	389	1.41003221D+06	390	1.41016632D+06
391	1.41028670D+06	392	1.41039104D+06	393	1.41047741D+06	394	1.41054389D+06	395	1.41058846D+06	396	1.41060911D+06
397	1.41060382D+06	398	1.41057068D+06	399	1.41050792D+06	400	1.41041398D+06	401	1.41028759D+06	402	1.41012791D+06
403	1.40993474D+06	404	1.40970934D+06	405	1.40945135D+06	406	1.40914478D+06	407	1.40898059D+06	408	1.40975683D+06
409	1.40985279D+06	410	1.41003422D+06	411	1.41019813D+06	412	1.41034762D+06	413	1.41048283D+06	414	1.41060149D+06
415	1.41070142D+06	416	1.41078031D+06	417	1.41083574D+06	418	1.41086529D+06	419	1.41086650D+06	420	1.41083706D+06
421	1.41077476D+06	422	1.41067766D+06	423	1.41054411D+06	424	1.41037288D+06	425	1.41016342D+06	426	1.40991573D+06
427	1.40963005D+06	428	1.40930336D+06	429	1.40907748D+06	430	1.40897439D+06	431	1.40987877D+06	432	1.40998666D+06
433	1.41019296D+06	434	1.41037595D+06	435	1.41054337D+06	436	1.41069548D+06	437	1.41083064D+06	438	1.41094643D+06
439	1.41104016D+06	440	1.41110893D+06	441	1.41114982D+06	442	1.41115990D+06	443	1.41113635D+06	444	1.41107651D+06
445	1.41097795D+06	446	1.41083850D+06	447	1.41065640D+06	448	1.41043038D+06	449	1.41015995D+06	450	1.40984660D+06
451	1.40950932D+06	452	1.40915765D+06	453	1.40898154D+06	454	1.40996697D+06	455	1.41002244D+06	456	1.41015848D+06
457	1.41036930D+06	458	1.41056814D+06	459	1.41075388D+06	460	1.41092492D+06	461	1.41107905D+06	462	1.41121347D+06
463	1.41132493D+06	464	1.41141001D+06	465	1.41146519D+06	466	1.41148698D+06	467	1.41147201D+06	468	1.41141709D+06
469	1.41131924D+06	470	1.41117571D+06	471	1.41098405D+06	472	1.41074217D+06	473	1.41044845D+06	474	1.41010283D+06
475	1.40970309D+06	476	1.40925347D+06	477	1.40901637D+06	478	1.41000352D+06	479	1.41011809D+06	480	1.41034142D+06
481	1.41055748D+06	482	1.41077333D+06	483	1.41097882D+06	484	1.41117105D+06	485	1.41134706D+06	486	1.41150338D+06
487	1.41163608D+06	488	1.41174101D+06	489	1.41181398D+06	490	1.41185086D+06	491	1.41184769D+06	492	1.41180069D+06
493	1.41170629D+06	494	1.41156115D+06	495	1.41136208D+06	496	1.41110604D+06	497	1.41078999D+06	498	1.41040964D+06
499	1.40995561D+06	500	1.40938958D+06	501	1.40908111D+06	502	1.41010963D+06	503	1.41024561D+06	504	1.41050699D+06
505	1.41075299D+06	506	1.41098918D+06	507	1.41121685D+06	508	1.41143318D+06	509	1.41163462D+06	510	1.41181683D+06
511	1.41197498D+06	512	1.41210401D+06	513	1.41219893D+06	514	1.41225488D+06	515	1.41226727D+06	516	1.41223174D+06
517	1.41214416D+06	518	1.41200056D+06	519	1.41179708D+06	520	1.41152985D+06	521	1.41119468D+06	522	1.41078624D+06
523	1.41029626D+06	524	1.40970378D+06	525	1.40927503D+06	526	1.40906663D+06	527	1.41024944D+06	528	1.41039826D+06
529	1.41068744D+06	530	1.41095465D+06	531	1.41121344D+06	532	1.41146589D+06	533	1.41170993D+06	534	1.41194124D+06
535	1.41215429D+06	536	1.41234301D+06	537	1.41250121D+06	538	1.41262291D+06	539	1.41270254D+06	540	1.41273484D+06
541	1.41271491D+06	542	1.41263809D+06	543	1.41249986D+06	544	1.41229578D+06	545	1.41202133D+06	546	1.41167184D+06
547	1.41124250D+06	548	1.41072942D+06	549	1.41015330D+06	550	1.40947094D+06	551	1.40910991D+06	552	1.41033118D+06
553	1.41041214D+06	554	1.41059673D+06	555	1.41088184D+06	556	1.41116249D+06	557	1.41144278D+06	558	1.41172271D+06
559	1.41199902D+06	560	1.41226593D+06	561	1.41251609D+06	562	1.41274166D+06	563	1.41293502D+06	564	1.41308912D+06
565	1.41319762D+06	566	1.41325472D+06	567	1.41325504D+06	568	1.41319346D+06	569	1.41306501D+06	570	1.41286476D+06
571	1.41258775D+06	572	1.41222891D+06	573	1.41178346D+06	574	1.41124915D+06	575	1.41062069D+06	576	1.40988111D+06

577	1.40935557D+06	578	1.40910810D+06	579	1.41038309D+06	580	1.41052606D+06	581	1.41080676D+06	582	1.41107891D+06
583	1.41136951D+06	584	1.41167132D+06	585	1.41198227D+06	586	1.41229703D+06	587	1.41260721D+06	588	1.41290259D+06
589	1.41317278D+06	590	1.41340832D+06	591	1.41360112D+06	592	1.41374423D+06	593	1.41383147D+06	594	1.41385711D+06
595	1.41381570D+06	596	1.41370192D+06	597	1.41351047D+06	598	1.41323598D+06	599	1.41287290D+06	600	1.41241555D+06
601	1.41185744D+06	602	1.41119084D+06	603	1.41043336D+06	604	1.40958267D+06	605	1.40913794D+06	606	1.41045316D+06
607	1.41053063D+06	608	1.41070903D+06	609	1.41098468D+06	610	1.41126471D+06	611	1.41156457D+06	612	1.41188943D+06
613	1.41223683D+06	614	1.41259899D+06	615	1.41296330D+06	616	1.41331471D+06	617	1.41363905D+06	618	1.41392477D+06
619	1.41416306D+06	620	1.41434685D+06	621	1.41446989D+06	622	1.41452628D+06	623	1.41451033D+06	624	1.41441647D+06
625	1.41423916D+06	626	1.41397274D+06	627	1.41361117D+06	628	1.41314765D+06	629	1.41257367D+06	630	1.41187847D+06
631	1.41103284D+06	632	1.40992468D+06	633	1.40930599D+06	634	1.41052384D+06	635	1.41065978D+06	636	1.41091212D+06
637	1.41115357D+06	638	1.41142626D+06	639	1.41173345D+06	640	1.41208294D+06	641	1.41247458D+06	642	1.41289804D+06
643	1.41333269D+06	644	1.41375511D+06	645	1.41414493D+06	646	1.41448920D+06	647	1.41477968D+06	648	1.41501031D+06
649	1.41517503D+06	650	1.41526784D+06	651	1.41528288D+06	652	1.41521443D+06	653	1.41505686D+06	654	1.41480442D+06
655	1.41445092D+06	656	1.41398923D+06	657	1.41341035D+06	658	1.41269983D+06	659	1.41182946D+06	660	1.41072343D+06
661	1.40985508D+06	662	1.40942087D+06	663	1.41078094D+06	664	1.41087974D+06	665	1.41108062D+06	666	1.41129889D+06
667	1.41155224D+06	668	1.41185794D+06	669	1.41222954D+06	670	1.41267717D+06	671	1.41318373D+06	672	1.41371707D+06
673	1.41423059D+06	674	1.41469854D+06	675	1.41510747D+06	676	1.41545611D+06	677	1.41573968D+06	678	1.41595216D+06
679	1.41608726D+06	680	1.41613893D+06	681	1.41610147D+06	682	1.41596932D+06	683	1.41573690D+06	684	1.41539829D+06
685	1.41494693D+06	686	1.41437488D+06	687	1.41367213D+06	688	1.41282682D+06	689	1.41187750D+06	690	1.41073336D+06
691	1.40985111D+06	692	1.40940555D+06	693	1.41105833D+06	694	1.41110434D+06	695	1.41122914D+06	696	1.41140738D+06
697	1.41162981D+06	698	1.41191064D+06	699	1.41229867D+06	700	1.41280091D+06	701	1.41344891D+06	702	1.41412049D+06
703	1.41476699D+06	704	1.41530888D+06	705	1.41578515D+06	706	1.41619724D+06	707	1.41654014D+06	708	1.41680679D+06
709	1.41699022D+06	710	1.41708420D+06	711	1.41708317D+06	712	1.41698195D+06	713	1.41677535D+06	714	1.41645806D+06
715	1.41602454D+06	716	1.41546913D+06	717	1.41478691D+06	718	1.41397970D+06	719	1.41304558D+06	720	1.41202662D+06
721	1.41081140D+06	722	1.40987510D+06	723	1.40940321D+06	724	1.41121873D+06	725	1.41124939D+06	726	1.41133779D+06
727	1.41147497D+06	728	1.41165556D+06	729	1.41188085D+06	730	1.41218050D+06	731	1.41285180D+06	732	1.41353695D+06
733	1.41470315D+06	734	1.41537652D+06	735	1.41598065D+06	736	1.41652517D+06	737	1.41700716D+06	738	1.41741701D+06
739	1.41774498D+06	740	1.41798288D+06	741	1.41812456D+06	742	1.41816508D+06	743	1.41809989D+06	744	1.41792440D+06
745	1.41763398D+06	746	1.41722411D+06	747	1.41669096D+06	748	1.41603255D+06	749	1.41524908D+06	750	1.41434705D+06
751	1.41332450D+06	752	1.41222244D+06	753	1.41091593D+06	754	1.40991160D+06	755	1.40940752D+06	756	1.41131403D+06
757	1.41133504D+06	758	1.41139771D+06	759	1.41150437D+06	760	1.41163801D+06	761	1.41179846D+06	762	1.41193517D+06
763	1.41537639D+06	764	1.41604935D+06	765	1.41670629D+06	766	1.41732682D+06	767	1.41788915D+06	768	1.41837664D+06
769	1.41877400D+06	770	1.41907215D+06	771	1.41926615D+06	772	1.41935263D+06	773	1.41932809D+06	774	1.41918843D+06
775	1.41892949D+06	776	1.41854744D+06	777	1.41803932D+06	778	1.41740370D+06	779	1.41664157D+06	780	1.41575560D+06
781	1.41475373D+06	782	1.41363357D+06	783	1.41243868D+06	784	1.41103431D+06	785	1.40995626D+06	786	1.40915558D+06
787	1.40900920D+06	788	1.41136604D+06	789	1.41137932D+06	790	1.41141728D+06	791	1.41148351D+06	792	1.41163017D+06
793	1.41167616D+06	794	1.41673405D+06	795	1.41747428D+06	796	1.41818350D+06	797	1.41884832D+06	798	1.41942860D+06
799	1.41990384D+06	800	1.42026592D+06	801	1.42051487D+06	802	1.42065108D+06	803	1.42067136D+06	804	1.42057182D+06
805	1.42034839D+06	806	1.41999736D+06	807	1.41951588D+06	808	1.41890254D+06	809	1.41815773D+06	810	1.41728433D+06
811	1.41628681D+06	812	1.41517551D+06	813	1.41395094D+06	814	1.41266516D+06	815	1.41118157D+06	816	1.41002119D+06
817	1.40944404D+06	818	1.40905192D+06	819	1.41139021D+06	820	1.41139768D+06	821	1.41141657D+06	822	1.41142404D+06
823	1.41823421D+06	824	1.41909557D+06	825	1.41989336D+06	826	1.42059296D+06	827	1.42115054D+06	828	1.42156994D+06
829	1.42187588D+06	830	1.42206522D+06	831	1.42213441D+06	832	1.42207923D+06	833	1.42189518D+06	834	1.42157819D+06

835	1.42112497D+06	836	1.42053353D+06	837	1.41980358D+06	838	1.41893700D+06	839	1.41793865D+06	840	1.41681611D+06
841	1.41558559D+06	842	1.41425859D+06	843	1.41291537D+06	844	1.41165075D+06	845	1.41036397D+06	846	1.40945391D+06
847	1.40900031D+06	848	1.41139856D+06	849	1.41140153D+06	850	1.41141192D+06	851	1.41141727D+06	852	1.41998648D+06
853	1.42106362D+06	854	1.42194779D+06	855	1.42250760D+06	856	1.42298765D+06	857	1.42335320D+06	858	1.42359913D+06
859	1.42372182D+06	860	1.42371563D+06	861	1.42357520D+06	862	1.42329566D+06	863	1.42287286D+06	864	1.42230377D+06
865	1.42158689D+06	866	1.42072286D+06	867	1.41971512D+06	868	1.41857145D+06	869	1.41730485D+06	870	1.41594208D+06
871	1.41452313D+06	872	1.41308050D+06	873	1.41167626D+06	874	1.41024227D+06	875	1.40929704D+06	876	1.40886566D+06
877	1.41140034D+06	878	1.41139975D+06	879	1.42308583D+06	880	1.42331591D+06	881	1.42397253D+06	882	1.42452346D+06
883	1.42494803D+06	884	1.42525632D+06	885	1.42543819D+06	886	1.42548640D+06	887	1.42539458D+06	888	1.42515674D+06
889	1.42476753D+06	890	1.42422247D+06	891	1.42351831D+06	892	1.42265363D+06	893	1.42162970D+06	894	1.42045155D+06
895	1.41913005D+06	896	1.41768334D+06	897	1.41613572D+06	898	1.41451873D+06	899	1.41286007D+06	900	1.41123986D+06
901	1.40966391D+06	902	1.40889505D+06	903	1.42361455D+06	904	1.42474054D+06	905	1.42559481D+06	906	1.42616251D+06
907	1.42666136D+06	908	1.42704061D+06	909	1.42728824D+06	910	1.42739739D+06	911	1.42736018D+06	912	1.42716945D+06
913	1.42681846D+06	914	1.42630086D+06	915	1.42561109D+06	916	1.42474490D+06	917	1.42370017D+06	918	1.42247789D+06
919	1.42108319D+06	920	1.41952605D+06	921	1.41782167D+06	922	1.41599021D+06	923	1.41406227D+06	924	1.41207042D+06
925	1.41004665D+06	926	1.40902904D+06	927	1.42694425D+06	928	1.42719477D+06	929	1.42790448D+06	930	1.42850062D+06
931	1.42895486D+06	932	1.42927722D+06	933	1.42945495D+06	934	1.42947936D+06	935	1.42934254D+06	936	1.42903621D+06
937	1.42855185D+06	938	1.42788098D+06	939	1.42701573D+06	940	1.42594962D+06	941	1.42467836D+06	942	1.42320046D+06
943	1.42151785D+06	944	1.41963611D+06	945	1.41756536D+06	946	1.41532179D+06	947	1.41293173D+06	948	1.41043712D+06
949	1.40917018D+06	950	1.42754465D+06	951	1.42884481D+06	952	1.42982215D+06	953	1.43045483D+06	954	1.43100414D+06
955	1.43141182D+06	956	1.43166574D+06	957	1.43175968D+06	958	1.43168499D+06	959	1.43143198D+06	960	1.43098956D+06
961	1.43034569D+06	962	1.42948813D+06	963	1.42840522D+06	964	1.42708660D+06	965	1.42552369D+06	966	1.42371007D+06
967	1.42164158D+06	968	1.41931606D+06	969	1.41673321D+06	970	1.41390504D+06	971	1.41087735D+06	972	1.40932291D+06
973	1.43142821D+06	974	1.43171677D+06	975	1.43253266D+06	976	1.43320297D+06	977	1.43369818D+06	978	1.43403652D+06
979	1.43420815D+06	980	1.43420518D+06	981	1.43401681D+06	982	1.43362867D+06	983	1.43302431D+06	984	1.43218630D+06
985	1.43109716D+06	986	1.42973987D+06	987	1.42809840D+06	988	1.42615789D+06	989	1.42390458D+06	990	1.42132474D+06
991	1.41840106D+06	992	1.41509992D+06	993	1.41143811D+06	994	1.40951966D+06	995	1.43213629D+06	996	1.43368339D+06
997	1.43483185D+06	998	1.43554518D+06	999	1.43614511D+06	1000	1.43657394D+06	1001	1.43682953D+06	1002	1.43690961D+06
1003	1.43680074D+06	1004	1.43648374D+06	1005	1.43593656D+06	1006	1.43513581D+06	1007	1.43405756D+06	1008	1.43267777D+06
1009	1.43097259D+06	1010	1.42891872D+06	1011	1.42649347D+06	1012	1.42367414D+06	1013	1.42043381D+06	1014	1.41672159D+06
1015	1.41228920D+06	1016	1.40991326D+06	1017	1.43679560D+06	1018	1.43712490D+06	1019	1.43805334D+06	1020	1.43877243D+06
1021	1.43927836D+06	1022	1.43962322D+06	1023	1.43980127D+06	1024	1.43979198D+06	1025	1.43956863D+06	1026	1.43910222D+06
1027	1.43836278D+06	1028	1.43731958D+06	1029	1.43594121D+06	1030	1.43419575D+06	1031	1.43205114D+06	1032	1.42947595D+06
1033	1.42644062D+06	1034	1.42291884D+06	1035	1.41888960D+06	1036	1.41430218D+06	1037	1.41113105D+06	1038	1.40967598D+06
1039	1.43765096D+06	1040	1.43955847D+06	1041	1.44088040D+06	1042	1.44156836D+06	1043	1.44213477D+06	1044	1.44257951D+06
1045	1.44287878D+06	1046	1.44299677D+06	1047	1.44289631D+06	1048	1.44254070D+06	1049	1.44189327D+06	1050	1.44091655D+06
1051	1.43957167D+06	1052	1.43781823D+06	1053	1.43561469D+06	1054	1.43291970D+06	1055	1.42969515D+06	1056	1.42591391D+06
1057	1.42158189D+06	1058	1.41695539D+06	1059	1.41216070D+06	1060	1.40976744D+06	1061	1.44364061D+06	1062	1.44385077D+06
1063	1.44447431D+06	1064	1.44510249D+06	1065	1.44567949D+06	1066	1.44613767D+06	1067	1.44642034D+06	1068	1.44647916D+06
1069	1.44627069D+06	1070	1.44575254D+06	1071	1.44488110D+06	1072	1.44361024D+06	1073	1.44189072D+06	1074	1.43967042D+06
1075	1.43689557D+06	1076	1.43351402D+06	1077	1.42948257D+06	1078	1.42478861D+06	1079	1.41940404D+06	1080	1.41338501D+06
1081	1.41021899D+06	1082	1.44655172D+06	1083	1.44677619D+06	1084	1.44735612D+06	1085	1.44812535D+06	1086	1.44890201D+06
1087	1.44957533D+06	1088	1.45006916D+06	1089	1.45032953D+06	1090	1.45030982D+06	1091	1.44996417D+06	1092	1.44924400D+06

1093	1.44809639D+06	1094	1.44646324D+06	1095	1.44428087D+06	1096	1.44148038D+06	1097	1.43798936D+06	1098	1.43373552D+06
1099	1.42864208D+06	1100	1.42259350D+06	1101	1.41512510D+06	1102	1.41106706D+06	1103	1.44897132D+06	1104	1.44927397D+06
1105	1.45009068D+06	1106	1.45115519D+06	1107	1.45224255D+06	1108	1.45319802D+06	1109	1.45395342D+06	1110	1.45445983D+06
1111	1.45467379D+06	1112	1.45454884D+06	1113	1.45403257D+06	1114	1.45306614D+06	1115	1.45158309D+06	1116	1.44950803D+06
1117	1.44675551D+06	1118	1.44322929D+06	1119	1.43882201D+06	1120	1.43341625D+06	1121	1.42689413D+06	1122	1.41909279D+06
1123	1.41357887D+06	1124	1.41104451D+06	1125	1.45063736D+06	1126	1.45124060D+06	1127	1.45256773D+06	1128	1.45423032D+06
1129	1.45572673D+06	1130	1.45702744D+06	1131	1.45808748D+06	1132	1.45888058D+06	1133	1.45937486D+06	1134	1.45952271D+06
1135	1.45926878D+06	1136	1.45854955D+06	1137	1.45729155D+06	1138	1.45540896D+06	1139	1.45280064D+06	1140	1.44934655D+06
1141	1.44490434D+06	1142	1.43931268D+06	1143	1.43242569D+06	1144	1.42454497D+06	1145	1.41583101D+06	1146	1.41134599D+06
1147	1.45125951D+06	1148	1.45191946D+06	1149	1.45520478D+06	1150	1.45742685D+06	1151	1.45942807D+06	1152	1.46110542D+06
1153	1.46247783D+06	1154	1.46359729D+06	1155	1.46442011D+06	1156	1.46489576D+06	1157	1.46496699D+06	1158	1.46456766D+06
1159	1.46361959D+06	1160	1.46202937D+06	1161	1.45968387D+06	1162	1.45644353D+06	1163	1.45213320D+06	1164	1.44653125D+06
1165	1.43937457D+06	1166	1.43023891D+06	1167	1.41892380D+06	1168	1.41270033D+06	1169	1.45774709D+06	1170	1.46092988D+06
1171	1.46358021D+06	1172	1.46539771D+06	1173	1.46711793D+06	1174	1.46860880D+06	1175	1.46981073D+06	1176	1.47067012D+06
1177	1.47113175D+06	1178	1.47112961D+06	1179	1.47058345D+06	1180	1.46939657D+06	1181	1.46745035D+06	1182	1.46459500D+06
1183	1.46063428D+06	1184	1.45529797D+06	1185	1.44816723D+06	1186	1.43847788D+06	1187	1.42416612D+06	1188	1.41575567D+06
1189	1.46687177D+06	1190	1.46762995D+06	1191	1.46985200D+06	1192	1.47199025D+06	1193	1.47391410D+06	1194	1.47554218D+06
1195	1.47683749D+06	1196	1.47775595D+06	1197	1.47823044D+06	1198	1.47818107D+06	1199	1.47751326D+06	1200	1.47611158D+06
1201	1.47382965D+06	1202	1.47047355D+06	1203	1.46577007D+06	1204	1.45929959D+06	1205	1.45034761D+06	1206	1.43730520D+06
1207	1.42660422D+06	1208	1.41932498D+06	1209	1.41815293D+06	1210	1.46843192D+06	1211	1.47159600D+06	1212	1.47438014D+06
1213	1.47712383D+06	1214	1.47952750D+06	1215	1.48159160D+06	1216	1.48337711D+06	1217	1.48482048D+06	1218	1.48585062D+06
1219	1.48639056D+06	1220	1.48635408D+06	1221	1.48563843D+06	1222	1.48411528D+06	1223	1.48161875D+06	1224	1.47792742D+06
1225	1.47274178D+06	1226	1.46566674D+06	1227	1.45695635D+06	1228	1.44443902D+06	1229	1.43427965D+06	1230	1.42985657D+06
1231	1.42668414D+06	1232	1.42998620D+06	1233	1.43926696D+06	1234	1.44097005D+06	1235	1.47488499D+06	1236	1.47918370D+06
1237	1.48278037D+06	1238	1.48536261D+06	1239	1.48791506D+06	1240	1.49025673D+06	1241	1.49229735D+06	1242	1.49395812D+06
1243	1.49517101D+06	1244	1.49586585D+06	1245	1.49596092D+06	1246	1.49535682D+06	1247	1.49393254D+06	1248	1.49154465D+06
1249	1.48803847D+06	1250	1.48333966D+06	1251	1.47730524D+06	1252	1.47064308D+06	1253	1.46418274D+06	1254	1.45468753D+06
1255	1.44948183D+06	1256	1.45428630D+06	1257	1.46505226D+06	1258	1.49575749D+06	1259	1.54286395D+06	1260	1.48715154D+06
1261	1.48820357D+06	1262	1.49131009D+06	1263	1.49444882D+06	1264	1.49744606D+06	1265	1.50015737D+06	1266	1.50251235D+06
1267	1.50446519D+06	1268	1.50597129D+06	1269	1.50697532D+06	1270	1.50741026D+06	1271	1.50720308D+06	1272	1.50628405D+06
1273	1.50461113D+06	1274	1.50219232D+06	1275	1.49920529D+06	1276	1.49599947D+06	1277	1.49277691D+06	1278	1.49077969D+06
1279	1.49212999D+06	1280	1.49908468D+06	1281	1.51445551D+06	1282	1.54011722D+06	1283	1.55325691D+06	1284	1.48924201D+06
1285	1.49340936D+06	1286	1.49718888D+06	1287	1.50117206D+06	1288	1.50493905D+06	1289	1.50838205D+06	1290	1.51146728D+06
1291	1.51420044D+06	1292	1.51657518D+06	1293	1.51855646D+06	1294	1.52010575D+06	1295	1.52119121D+06	1296	1.52179934D+06
1297	1.52195195D+06	1298	1.52173863D+06	1299	1.52134816D+06	1300	1.52107579D+06	1301	1.52145853D+06	1302	1.52338844D+06
1303	1.52813159D+06	1304	1.53719985D+06	1305	1.55194009D+06	1306	1.57220615D+06	1307	1.58378110D+06	1308	1.49772626D+06
1309	1.50311792D+06	1310	1.50812298D+06	1311	1.51280263D+06	1312	1.51698046D+06	1313	1.52075115D+06	1314	1.52428921D+06
1315	1.52757186D+06	1316	1.53057168D+06	1317	1.53327031D+06	1318	1.53566772D+06	1319	1.53778913D+06	1320	1.53969648D+06
1321	1.54150451D+06	1322	1.54339920D+06	1323	1.54567005D+06	1324	1.54874873D+06	1325	1.55322916D+06	1326	1.55985288D+06
1327	1.56938802D+06	1328	1.58261608D+06	1329	1.60045324D+06	1330	1.61061948D+06	1331	1.50873667D+06	1332	1.51558280D+06
1333	1.52144384D+06	1334	1.52579782D+06	1335	1.53025989D+06	1336	1.53463209D+06	1337	1.53885576D+06	1338	1.54289408D+06
1339	1.54674402D+06	1340	1.55043155D+06	1341	1.55401044D+06	1342	1.55756440D+06	1343	1.56121341D+06	1344	1.56512385D+06
1345	1.56951919D+06	1346	1.57468696D+06	1347	1.58096175D+06	1348	1.58860441D+06	1349	1.59791982D+06	1350	1.60883946D+06

1351	1.62298199D+06	1352	1.63139108D+06	1353	1.52797576D+06	1354	1.52965318D+06	1355	1.53463511D+06	1356	1.53985628D+06
1357	1.54513696D+06	1358	1.55033563D+06	1359	1.55541455D+06	1360	1.56038886D+06	1361	1.56531342D+06	1362	1.57026849D+06
1363	1.57535234D+06	1364	1.58068036D+06	1365	1.58638616D+06	1366	1.59261790D+06	1367	1.59952067D+06	1368	1.60722823D+06
1369	1.61582294D+06	1370	1.62443248D+06	1371	1.63380231D+06	1372	1.63912173D+06	1373	1.63862974D+06	1374	1.53117705D+06
1375	1.53742607D+06	1376	1.54318701D+06	1377	1.54945681D+06	1378	1.55574454D+06	1379	1.56195468D+06	1380	1.56805240D+06
1381	1.57409097D+06	1382	1.58016987D+06	1383	1.58640314D+06	1384	1.59290280D+06	1385	1.59977572D+06	1386	1.60712416D+06
1387	1.61503473D+06	1388	1.62354745D+06	1389	1.63256913D+06	1390	1.64211256D+06	1391	1.65275511D+06	1392	1.65560324D+06
1393	1.64997647D+06	1394	1.54384821D+06	1395	1.55159276D+06	1396	1.55902766D+06	1397	1.56647414D+06	1398	1.57371417D+06
1399	1.58076504D+06	1400	1.58775532D+06	1401	1.59486831D+06	1402	1.60227044D+06	1403	1.61007942D+06	1404	1.61839247D+06
1405	1.62728807D+06	1406	1.63681789D+06	1407	1.64697555D+06	1408	1.65761551D+06	1409	1.66773012D+06	1410	1.67874700D+06
1411	1.68561158D+06	1412	1.55959621D+06	1413	1.56873678D+06	1414	1.57743301D+06	1415	1.58572545D+06	1416	1.59356409D+06
1417	1.60126324D+06	1418	1.60926865D+06	1419	1.61772487D+06	1420	1.62674646D+06	1421	1.63641945D+06	1422	1.64680371D+06
1423	1.65793639D+06	1424	1.66983304D+06	1425	1.68245025D+06	1426	1.69570597D+06	1427	1.69988540D+06	1428	1.69462961D+06
1429	1.57815507D+06	1430	1.58901748D+06	1431	1.59861335D+06	1432	1.60622234D+06	1433	1.61445380D+06	1434	1.62320835D+06
1435	1.63260486D+06	1436	1.64275250D+06	1437	1.65372769D+06	1438	1.66556526D+06	1439	1.67828249D+06	1440	1.69192509D+06
1441	1.70666117D+06	1442	1.72315555D+06	1443	1.73223819D+06	1444	1.60791136D+06	1445	1.61056304D+06	1446	1.61847005D+06
1447	1.62712569D+06	1448	1.63650801D+06	1449	1.64671767D+06	1450	1.65791233D+06	1451	1.67016668D+06	1452	1.68345513D+06
1453	1.69773058D+06	1454	1.71301069D+06	1455	1.72949616D+06	1456	1.74771257D+06	1457	1.75731755D+06	1458	1.61266617D+06
1459	1.62162723D+06	1460	1.62997637D+06	1461	1.63917858D+06	1462	1.64898804D+06	1463	1.65978706D+06	1464	1.67198018D+06
1465	1.68556203D+06	1466	1.70037828D+06	1467	1.71622800D+06	1468	1.73299970D+06	1469	1.75076233D+06	1470	1.76974214D+06
1471	1.77957331D+06	1472	1.63068654D+06	1473	1.64116620D+06	1474	1.65099361D+06	1475	1.66020066D+06	1476	1.67139302D+06
1477	1.68459660D+06	1478	1.69970607D+06	1479	1.71630100D+06	1480	1.73387677D+06	1481	1.75207187D+06	1482	1.77082121D+06
1483	1.79024432D+06	1484	1.80014843D+06	1485	1.65802884D+06	1486	1.66086373D+06	1487	1.66954644D+06	1488	1.68085482D+06
1489	1.69519037D+06	1490	1.71229927D+06	1491	1.73134078D+06	1492	1.75101681D+06	1493	1.77067773D+06	1494	1.79019238D+06
1495	1.80987920D+06	1496	1.81978830D+06	1497	1.66209583D+06	1498	1.66862702D+06	1499	1.67625125D+06	1500	1.68718741D+06
1501	1.70247278D+06	1502	1.72301302D+06	1503	1.74577353D+06	1504	1.76873975D+06	1505	1.78935302D+06	1506	1.80935004D+06
1507	1.82914168D+06	1508	1.83906693D+06	1509	1.67492299D+06	1510	1.67856244D+06	1511	1.68944516D+06	1512	1.70517598D+06
1513	1.72661624D+06	1514	1.76523524D+06	1515	1.78792712D+06	1516	1.80859378D+06	1517	1.82832654D+06	1518	1.84863598D+06
1519	1.85835481D+06	1520	1.78749765D+06	1521	1.80890110D+06	1522	1.82932289D+06	1523	1.84682977D+06	1524	1.86538516D+06
1525	1.88381989D+06	1526	1.90181488D+06	1527	1.84089613D+06	1528	1.84813070D+06	1529	1.86497796D+06	1530	1.88126515D+06
1531	1.89664481D+06	1532	1.90320401D+06	1533	1.84863065D+06	1534	1.85736507D+06	1535	1.87396378D+06	1536	1.88952485D+06
1537	1.90149069D+06	1538	1.90618894D+06								

T E M P E R A T U R E

NODE		NODE		NODE		NODE		NODE		NODE	
1	13.850000000	2	13.850000000	3	13.850000000	4	13.850000000	5	13.850000000	6	13.850000000
.											
.											
.											
1531	13.850000000	1532	13.850000000	1533	13.850000000	1534	13.850000000	1535	13.850000000	1536	13.850000000
1537	13.850000000	1538	13.850000000								

LISA: 0.0417 DAYS 0.0400 DAYS 0.39999999E-01

NASH 1 0.41667E-01 0.40000E-01

RESULTS FOR TIME STEP 240

TIME INCREMENT 3.6000D+03 SECONDS

ELAPSED TIME : 8.6400D+05 SECONDS
1.4400D+04 MINUTES
2.4000D+02 HOURS
1.0000D+01 DAYS
1.4286D+00 WEEKS
3.2854D-01 MONTHS
2.7379D-02 YEARS

P R E S S U R E

NODE		NODE		NODE		NODE		NODE		NODE	
1	1.35799494D+06	2	1.35798783D+06	3	1.35923516D+06	4	1.36036236D+06	5	1.36039536D+06	6	1.35932399D+06
7	1.35949753D+06	8	1.36185040D+06	9	1.36510180D+06	10	1.36508576D+06	11	1.36185738D+06	12	1.35963938D+06
13	1.35959146D+06	14	1.36475158D+06	15	1.37147886D+06	16	1.37098686D+06	17	1.36435516D+06	18	1.35953930D+06
19	1.35942994D+06	20	1.36328670D+06	21	1.37043063D+06	22	1.37704248D+06	23	1.37598005D+06	24	1.36661773D+06
25	1.35996284D+06	26	1.35939905D+06	27	1.36622912D+06	28	1.37735537D+06	29	1.38261619D+06	30	1.38134103D+06
31	1.37243949D+06	32	1.36364880D+06	33	1.35888168D+06	34	1.36048723D+06	35	1.36949164D+06	36	1.38266931D+06
37	1.38804020D+06	38	1.38698178D+06	39	1.38032598D+06	40	1.36708944D+06	41	1.35898296D+06	42	1.37503288D+06
43	1.37239214D+06	44	1.37792001D+06	45	1.38837160D+06	46	1.39288187D+06	47	1.39215923D+06	48	1.38622411D+06
49	1.37440740D+06	50	1.36391417D+06	51	1.35843155D+06	52	1.37604711D+06	53	1.38049410D+06	54	1.38794110D+06
55	1.39361504D+06	56	1.39679319D+06	57	1.39612300D+06	58	1.39140138D+06	59	1.38322871D+06	60	1.37109914D+06
61	1.36198724D+06	62	1.35791400D+06	63	1.37943792D+06	64	1.38426839D+06	65	1.39219150D+06	66	1.39695425D+06
67	1.39905315D+06	68	1.39848445D+06	69	1.39496526D+06	70	1.38806448D+06	71	1.37814165D+06	72	1.36507389D+06
73	1.35780324D+06	74	1.38110340D+06	75	1.38595766D+06	76	1.39357242D+06	77	1.39746074D+06	78	1.39886473D+06
79	1.39855737D+06	80	1.39620281D+06	81	1.39067727D+06	82	1.38086683D+06	83	1.36653419D+06	84	1.35822616D+06
85	1.38157955D+06	86	1.38621147D+06	87	1.39298699D+06	88	1.39552154D+06	89	1.39468683D+06	90	1.39499302D+06
91	1.39573674D+06	92	1.39158189D+06	93	1.38205327D+06	94	1.36707382D+06	95	1.35825816D+06	96	1.38140775D+06
97	1.38569241D+06	98	1.39130088D+06	99	1.39095475D+06	100	1.38812467D+06	101	1.39071243D+06	102	1.39467687D+06
103	1.39202023D+06	104	1.38290790D+06	105	1.36736965D+06	106	1.35802721D+06	107	1.38096195D+06	108	1.38491311D+06
109	1.38949105D+06	110	1.38677504D+06	111	1.38387563D+06	112	1.38872269D+06	113	1.39416383D+06	114	1.39295502D+06
115	1.38488566D+06	116	1.36837059D+06	117	1.35802724D+06	118	1.38040334D+06	119	1.38414291D+06	120	1.38820473D+06
121	1.38526951D+06	122	1.38264221D+06	123	1.38820892D+06	124	1.39475152D+06	125	1.39486321D+06	126	1.38867542D+06
127	1.37540429D+06	128	1.36334106D+06	129	1.35700336D+06	130	1.37969038D+06	131	1.38333667D+06	132	1.38738855D+06
133	1.38492695D+06	134	1.38297933D+06	135	1.38924595D+06	136	1.39646823D+06	137	1.39759420D+06	138	1.39365774D+06

139	1.38577706D+06	140	1.37309329D+06	141	1.36240377D+06	142	1.35691376D+06	143	1.37870789D+06	144	1.38218931D+06
145	1.38631621D+06	146	1.38488249D+06	147	1.38574566D+06	148	1.39293452D+06	149	1.39898474D+06	150	1.40059640D+06
151	1.39852737D+06	152	1.39311004D+06	153	1.38506832D+06	154	1.37295823D+06	155	1.36288382D+06	156	1.35670188D+06
157	1.35654298D+06	158	1.37813359D+06	159	1.38031356D+06	160	1.38336111D+06	161	1.38426381D+06	162	1.38929975D+06
163	1.39722923D+06	164	1.40168836D+06	165	1.40333757D+06	166	1.40234631D+06	167	1.39901972D+06	168	1.39331592D+06
169	1.38564310D+06	170	1.37434207D+06	171	1.36534379D+06	172	1.36084610D+06	173	1.35670973D+06	174	1.37852364D+06
175	1.38104102D+06	176	1.38496362D+06	177	1.38665939D+06	178	1.39225757D+06	179	1.40019809D+06	180	1.40405771D+06
181	1.40552495D+06	182	1.40517343D+06	183	1.40318672D+06	184	1.39960420D+06	185	1.39421474D+06	186	1.38746101D+06
187	1.37975326D+06	188	1.36919181D+06	189	1.36097198D+06	190	1.35693815D+06	191	1.37984341D+06	192	1.38430728D+06
193	1.39101058D+06	194	1.39365758D+06	195	1.39756426D+06	196	1.40301888D+06	197	1.40592437D+06	198	1.40713421D+06
199	1.40710063D+06	200	1.40599768D+06	201	1.40379370D+06	202	1.40037955D+06	203	1.39554711D+06	204	1.38873033D+06
205	1.37947785D+06	206	1.36541868D+06	207	1.35708129D+06	208	1.38149912D+06	209	1.38665275D+06	210	1.39474142D+06
211	1.39958940D+06	212	1.40291687D+06	213	1.40553319D+06	214	1.40738230D+06	215	1.40824635D+06	216	1.40833694D+06
217	1.40775170D+06	218	1.40644256D+06	219	1.40420619D+06	220	1.40062915D+06	221	1.39505231D+06	222	1.38639389D+06
223	1.37294518D+06	224	1.36236616D+06	225	1.35756194D+06	226	1.38288463D+06	227	1.38842747D+06	228	1.39726973D+06
229	1.40247478D+06	230	1.40548767D+06	231	1.40731635D+06	232	1.40841853D+06	233	1.40897793D+06	234	1.40908602D+06
235	1.40878479D+06	236	1.40799977D+06	237	1.40649989D+06	238	1.40384604D+06	239	1.39933201D+06	240	1.39201579D+06
241	1.38165566D+06	242	1.36647259D+06	243	1.35764280D+06	244	1.38453581D+06	245	1.39015914D+06	246	1.39920458D+06
247	1.40416758D+06	248	1.40687022D+06	249	1.40831450D+06	250	1.40907265D+06	251	1.40943317D+06	252	1.40952375D+06
253	1.40936816D+06	254	1.40888654D+06	255	1.40785901D+06	256	1.40587359D+06	257	1.40228789D+06	258	1.39631583D+06
259	1.38699259D+06	260	1.37308386D+06	261	1.36251665D+06	262	1.35797495D+06	263	1.38206017D+06	264	1.38658943D+06
265	1.39353461D+06	266	1.40101311D+06	267	1.40535800D+06	268	1.40770218D+06	269	1.40888939D+06	270	1.40945938D+06
271	1.40971105D+06	272	1.40978210D+06	273	1.40970055D+06	274	1.40939554D+06	275	1.40867229D+06	276	1.40716384D+06
277	1.40428800D+06	278	1.39923456D+06	279	1.39109558D+06	280	1.37998348D+06	281	1.36569760D+06	282	1.35780106D+06
283	1.38228042D+06	284	1.38771879D+06	285	1.39680869D+06	286	1.40259952D+06	287	1.40627973D+06	288	1.40827302D+06
289	1.40925822D+06	290	1.40970764D+06	291	1.40989532D+06	292	1.40995234D+06	293	1.40990938D+06	294	1.40970836D+06
295	1.40918104D+06	296	1.40800035D+06	297	1.40561855D+06	298	1.40123484D+06	299	1.39392128D+06	300	1.38274291D+06
301	1.36710651D+06	302	1.35811898D+06	303	1.38296933D+06	304	1.38873211D+06	305	1.39807277D+06	306	1.40375817D+06
307	1.40699073D+06	308	1.40870637D+06	309	1.40953352D+06	310	1.40989787D+06	311	1.41004442D+06	312	1.41009148D+06
313	1.41006932D+06	314	1.40993078D+06	315	1.40953069D+06	316	1.40857479D+06	317	1.40654669D+06	318	1.40264171D+06
319	1.39573165D+06	320	1.38442520D+06	321	1.36779113D+06	322	1.35806814D+06	323	1.38377951D+06	324	1.38964121D+06
325	1.39903894D+06	326	1.40456488D+06	327	1.40755324D+06	328	1.40906387D+06	329	1.40977044D+06	330	1.41007265D+06
331	1.41019128D+06	332	1.41023138D+06	333	1.41022109D+06	334	1.41012186D+06	335	1.40980856D+06	336	1.40901828D+06
337	1.40727115D+06	338	1.40377710D+06	339	1.39736745D+06	340	1.38649908D+06	341	1.36878681D+06	342	1.35809450D+06
343	1.38515475D+06	344	1.39093832D+06	345	1.40024843D+06	346	1.40534916D+06	347	1.40805311D+06	348	1.40938840D+06
349	1.40999751D+06	350	1.41025277D+06	351	1.41035213D+06	352	1.41038794D+06	353	1.41038547D+06	354	1.41031330D+06
355	1.41006508D+06	356	1.40941119D+06	357	1.40792148D+06	358	1.40487384D+06	359	1.39919421D+06	360	1.38951646D+06
361	1.37432286D+06	362	1.36262862D+06	363	1.35758948D+06	364	1.38260069D+06	365	1.38716826D+06	366	1.39420454D+06
367	1.40179764D+06	368	1.40620031D+06	369	1.40855142D+06	370	1.40970720D+06	371	1.41022993D+06	372	1.41044796D+06
373	1.41053428D+06	374	1.41056841D+06	375	1.41057245D+06	376	1.41052122D+06	377	1.41032649D+06	378	1.40979405D+06
379	1.40855470D+06	380	1.40598433D+06	381	1.40116519D+06	382	1.39300474D+06	383	1.38139606D+06	384	1.36603396D+06
385	1.35745573D+06	386	1.38290670D+06	387	1.38840184D+06	388	1.39756781D+06	389	1.40337850D+06	390	1.40706080D+06
391	1.40904960D+06	392	1.41002979D+06	393	1.41047432D+06	394	1.41066254D+06	395	1.41074090D+06	396	1.41077606D+06

397	1.41078677D+06	398	1.41075328D+06	399	1.41060438D+06	400	1.41018065D+06	401	1.40917470D+06	402	1.40706077D+06
403	1.40305326D+06	404	1.39620687D+06	405	1.38533086D+06	406	1.36831520D+06	407	1.35814144D+06	408	1.38389635D+06
409	1.38971845D+06	410	1.39907539D+06	411	1.40468955D+06	412	1.40784382D+06	413	1.40952739D+06	414	1.41035395D+06
415	1.41073227D+06	416	1.41089823D+06	417	1.41097355D+06	418	1.41101272D+06	419	1.41103106D+06	420	1.41101337D+06
421	1.41090341D+06	422	1.41057287D+06	423	1.40976904D+06	424	1.40804801D+06	425	1.40471857D+06	426	1.39880726D+06
427	1.38911203D+06	428	1.37423954D+06	429	1.36290188D+06	430	1.35806010D+06	431	1.38545967D+06	432	1.39123745D+06
433	1.40056300D+06	434	1.40572723D+06	435	1.40853077D+06	436	1.40997349D+06	437	1.41067657D+06	438	1.41100377D+06
439	1.41115595D+06	440	1.41123346D+06	441	1.41127996D+06	442	1.41130747D+06	443	1.41130432D+06	444	1.41122666D+06
445	1.41097208D+06	446	1.41033299D+06	447	1.40893156D+06	448	1.40614818D+06	449	1.40109114D+06	450	1.39272747D+06
451	1.38113868D+06	452	1.36616704D+06	453	1.35789612D+06	454	1.38300650D+06	455	1.38757464D+06	456	1.39462527D+06
457	1.40225732D+06	458	1.40672092D+06	459	1.40915055D+06	460	1.41039238D+06	461	1.41099817D+06	462	1.41128944D+06
463	1.41143670D+06	464	1.41152199D+06	465	1.41157960D+06	466	1.41161843D+06	467	1.41162935D+06	468	1.41157830D+06
469	1.41138382D+06	470	1.41087526D+06	471	1.40973027D+06	472	1.40740118D+06	473	1.40306810D+06	474	1.39574108D+06
475	1.38423853D+06	476	1.36779310D+06	477	1.35825361D+06	478	1.38332012D+06	479	1.38884412D+06	480	1.39806267D+06
481	1.40392428D+06	482	1.40766769D+06	483	1.40973007D+06	484	1.41079257D+06	485	1.41132175D+06	486	1.41159081D+06
487	1.41174188D+06	488	1.41184086D+06	489	1.41191384D+06	490	1.41196684D+06	491	1.41199238D+06	492	1.41196404D+06
493	1.41181729D+06	494	1.41141258D+06	495	1.41047719D+06	496	1.40852931D+06	497	1.40480514D+06	498	1.39819053D+06
499	1.38717656D+06	500	1.36930079D+06	501	1.35852203D+06	502	1.38435675D+06	503	1.39022207D+06	504	1.39964706D+06
505	1.40530748D+06	506	1.40851456D+06	507	1.41026787D+06	508	1.41117916D+06	509	1.41165027D+06	510	1.41190970D+06
511	1.41207317D+06	512	1.41219208D+06	513	1.41228526D+06	514	1.41235601D+06	515	1.41239792D+06	516	1.41239047D+06
517	1.41228308D+06	518	1.41196328D+06	519	1.41120427D+06	520	1.40959101D+06	521	1.40643207D+06	522	1.40068733D+06
523	1.39097457D+06	524	1.37552259D+06	525	1.36342361D+06	526	1.35799889D+06	527	1.38608555D+06	528	1.39191288D+06
529	1.40127548D+06	530	1.40643879D+06	531	1.40926315D+06	532	1.41076381D+06	533	1.41155428D+06	534	1.41198571D+06
535	1.41224780D+06	536	1.41243240D+06	537	1.41257790D+06	538	1.41269671D+06	539	1.41278961D+06	540	1.41285076D+06
541	1.41286429D+06	542	1.41279128D+06	543	1.41254323D+06	544	1.41193704D+06	545	1.41062907D+06	546	1.40803798D+06
547	1.40329842D+06	548	1.39534553D+06	549	1.38401854D+06	550	1.36758329D+06	551	1.35808599D+06	552	1.38446228D+06
553	1.38883916D+06	554	1.39573893D+06	555	1.40324501D+06	556	1.40757060D+06	557	1.40995077D+06	558	1.41122591D+06
559	1.41191997D+06	560	1.41232936D+06	561	1.41260657D+06	562	1.41282151D+06	563	1.41300090D+06	564	1.41315140D+06
565	1.41327157D+06	566	1.41335585D+06	567	1.41339198D+06	568	1.41335077D+06	569	1.41316476D+06	570	1.41269142D+06
571	1.41165856D+06	572	1.40960067D+06	573	1.40581960D+06	574	1.39948118D+06	575	1.38954792D+06	576	1.37467432D+06
577	1.36333621D+06	578	1.35843768D+06	579	1.38562096D+06	580	1.39111149D+06	581	1.40011048D+06	582	1.40534210D+06
583	1.40869414D+06	584	1.41059788D+06	585	1.41165870D+06	586	1.41227714D+06	587	1.41268189D+06	588	1.41298743D+06
589	1.41324282D+06	590	1.41346409D+06	591	1.41365296D+06	592	1.41380613D+06	593	1.41391819D+06	594	1.41397970D+06
595	1.41396934D+06	596	1.41383740D+06	597	1.41347672D+06	598	1.41267834D+06	599	1.41107544D+06	600	1.40809469D+06
601	1.40291809D+06	602	1.39453380D+06	603	1.38273046D+06	604	1.36705932D+06	605	1.35827367D+06	606	1.38534502D+06
607	1.38924523D+06	608	1.39574812D+06	609	1.40296343D+06	610	1.40721276D+06	611	1.40970873D+06	612	1.41118076D+06
613	1.41205649D+06	614	1.41262358D+06	615	1.41304330D+06	616	1.41339225D+06	617	1.41369943D+06	618	1.41397125D+06
619	1.41420556D+06	620	1.41439783D+06	621	1.41454292D+06	622	1.41463347D+06	623	1.41465422D+06	624	1.41456968D+06
625	1.41430154D+06	626	1.41369251D+06	627	1.41245558D+06	628	1.41011161D+06	629	1.40593460D+06	630	1.39898565D+06
631	1.38789799D+06	632	1.36991599D+06	633	1.35906495D+06	634	1.38730511D+06	635	1.39265645D+06	636	1.40093271D+06
637	1.40559897D+06	638	1.40868894D+06	639	1.41054092D+06	640	1.41166691D+06	641	1.41240536D+06	642	1.41295393D+06
643	1.41341350D+06	644	1.41382445D+06	645	1.41419607D+06	646	1.41452729D+06	647	1.41481394D+06	648	1.41505158D+06
649	1.41523534D+06	650	1.41535930D+06	651	1.41541259D+06	652	1.41537049D+06	653	1.41517724D+06	654	1.41471705D+06

655	1.41376987D+06	656	1.41195258D+06	657	1.40865694D+06	658	1.40296797D+06	659	1.39357477D+06	660	1.37840141D+06
661	1.36546535D+06	662	1.35896463D+06	663	1.39585449D+06	664	1.39917783D+06	665	1.40452115D+06	666	1.40781093D+06
667	1.40985892D+06	668	1.41116439D+06	669	1.41202996D+06	670	1.41268700D+06	671	1.41325908D+06	672	1.41379510D+06
673	1.41429117D+06	674	1.41474091D+06	675	1.41513804D+06	676	1.41548319D+06	677	1.41577244D+06	678	1.41600092D+06
679	1.41616333D+06	680	1.41625172D+06	681	1.41624926D+06	682	1.41611749D+06	683	1.41577411D+06	684	1.41505795D+06
685	1.41368072D+06	686	1.41116969D+06	687	1.40682816D+06	688	1.39978432D+06	689	1.39009560D+06	690	1.37613319D+06
691	1.36468637D+06	692	1.35894016D+06	693	1.40484672D+06	694	1.40567952D+06	695	1.40758947D+06	696	1.40943075D+06
697	1.41070592D+06	698	1.41157118D+06	699	1.41224472D+06	700	1.41285972D+06	701	1.41353294D+06	702	1.41419262D+06
703	1.41481772D+06	704	1.41534283D+06	705	1.41580903D+06	706	1.41621815D+06	707	1.41656559D+06	708	1.41684533D+06
709	1.41705184D+06	710	1.41717895D+06	711	1.41721546D+06	712	1.41713604D+06	713	1.41688521D+06	714	1.41635199D+06
715	1.41533513D+06	716	1.41350709D+06	717	1.41040419D+06	718	1.40555146D+06	719	1.39837597D+06	720	1.38904256D+06
721	1.37573301D+06	722	1.36473140D+06	723	1.35916912D+06	724	1.40867061D+06	725	1.40896873D+06	726	1.40970052D+06
727	1.41053629D+06	728	1.41123952D+06	729	1.41176668D+06	730	1.41219033D+06	731	1.41292686D+06	732	1.41362390D+06
733	1.41476164D+06	734	1.41541602D+06	735	1.41600660D+06	736	1.41654315D+06	737	1.41702288D+06	738	1.41743632D+06
739	1.41777471D+06	740	1.41803146D+06	741	1.41820157D+06	742	1.41827804D+06	743	1.41824535D+06	744	1.41806851D+06
745	1.41767641D+06	746	1.41693965D+06	747	1.41564895D+06	748	1.41351209D+06	749	1.41015436D+06	750	1.40520475D+06
751	1.39813166D+06	752	1.38902736D+06	753	1.37596398D+06	754	1.36512333D+06	755	1.35963808D+06	756	1.41038814D+06
757	1.41050113D+06	758	1.41079156D+06	759	1.41116304D+06	760	1.41151092D+06	761	1.41177973D+06	762	1.41195816D+06
763	1.41541619D+06	764	1.41607821D+06	765	1.41672486D+06	766	1.41733984D+06	767	1.41790061D+06	768	1.41839092D+06
769	1.41879637D+06	770	1.41910940D+06	771	1.41932674D+06	772	1.41944514D+06	773	1.41945619D+06	774	1.41933941D+06
775	1.41905245D+06	776	1.41851761D+06	777	1.41760767D+06	778	1.41613315D+06	779	1.41384004D+06	780	1.41039548D+06
781	1.40545195D+06	782	1.39847684D+06	783	1.38954804D+06	784	1.37669318D+06	785	1.36608937D+06	786	1.35960328D+06
787	1.35942102D+06	788	1.41112126D+06	789	1.41116485D+06	790	1.41127610D+06	791	1.41138940D+06	792	1.41159334D+06
793	1.41168486D+06	794	1.41675177D+06	795	1.41748735D+06	796	1.41819254D+06	797	1.41885650D+06	798	1.41943893D+06
799	1.41992025D+06	800	1.42029369D+06	801	1.42056104D+06	802	1.42072393D+06	803	1.42077794D+06	804	1.42071174D+06
805	1.42050157D+06	806	1.42010313D+06	807	1.41944131D+06	808	1.41839898D+06	809	1.41680438D+06	810	1.41442541D+06
811	1.41095216D+06	812	1.40606408D+06	813	1.39926968D+06	814	1.39072870D+06	815	1.37855914D+06	816	1.36898317D+06
817	1.36423702D+06	818	1.35995063D+06	819	1.41140587D+06	820	1.41142184D+06	821	1.41145856D+06	822	1.41147453D+06
823	1.41824223D+06	824	1.41910213D+06	825	1.41989912D+06	826	1.42060031D+06	827	1.42116227D+06	828	1.42159006D+06
829	1.42190996D+06	830	1.42212047D+06	831	1.42221873D+06	832	1.42219824D+06	833	1.42204582D+06	834	1.42173698D+06
835	1.42122910D+06	836	1.42045234D+06	837	1.41929932D+06	838	1.41761316D+06	839	1.41518407D+06	840	1.41173828D+06
841	1.40701973D+06	842	1.40066216D+06	843	1.39311504D+06	844	1.38488585D+06	845	1.37399719D+06	846	1.36511316D+06
847	1.36048447D+06	848	1.41150102D+06	849	1.41149881D+06	850	1.41150213D+06	851	1.41151092D+06	852	1.41999110D+06
853	1.42106805D+06	854	1.42195296D+06	855	1.42251581D+06	856	1.42300183D+06	857	1.42337758D+06	858	1.42363954D+06
859	1.42378555D+06	860	1.42381030D+06	861	1.42370573D+06	862	1.42345818D+06	863	1.42304406D+06	864	1.42242371D+06
865	1.42153342D+06	866	1.42027653D+06	867	1.41851412D+06	868	1.41606595D+06	869	1.41270651D+06	870	1.40825772D+06
871	1.40255618D+06	872	1.39519010D+06	873	1.38609615D+06	874	1.37377540D+06	875	1.36469986D+06	876	1.36083355D+06
877	1.41152112D+06	878	1.41152099D+06	879	1.42308893D+06	880	1.42331959D+06	881	1.42397820D+06	882	1.42453320D+06
883	1.42496494D+06	884	1.42528486D+06	885	1.42548441D+06	886	1.42555772D+06	887	1.42549866D+06	888	1.42529875D+06
889	1.42494468D+06	890	1.42441451D+06	891	1.42367230D+06	892	1.42266092D+06	893	1.42129386D+06	894	1.41944471D+06
895	1.41694187D+06	896	1.41354701D+06	897	1.40889720D+06	898	1.40250773D+06	899	1.39369668D+06	900	1.38253285D+06
901	1.36854843D+06	902	1.36083970D+06	903	1.42361724D+06	904	1.42474345D+06	905	1.42559871D+06	906	1.42616905D+06
907	1.42667276D+06	908	1.42706012D+06	909	1.42732054D+06	910	1.42744877D+06	911	1.42743841D+06	912	1.42728289D+06

913	1.42697376D+06	914	1.42649835D+06	915	1.42583629D+06	916	1.42495398D+06	917	1.42379548D+06	918	1.42226784D+06
919	1.42021472D+06	920	1.41737095D+06	921	1.41330593D+06	922	1.40737373D+06	923	1.39881278D+06	924	1.38680593D+06
925	1.37077181D+06	926	1.36168600D+06	927	1.42694650D+06	928	1.42719751D+06	929	1.42790883D+06	930	1.42850812D+06
931	1.42896783D+06	932	1.42929910D+06	933	1.42949069D+06	934	1.42953574D+06	935	1.42942825D+06	936	1.42916138D+06
937	1.42872629D+06	938	1.42810986D+06	939	1.42729022D+06	940	1.42622735D+06	941	1.42484447D+06	942	1.42299344D+06
943	1.42039897D+06	944	1.41658470D+06	945	1.41081560D+06	946	1.40210735D+06	947	1.38941966D+06	948	1.37210192D+06
949	1.36224614D+06	950	1.42754662D+06	951	1.42884695D+06	952	1.42982503D+06	953	1.43045968D+06	954	1.43101257D+06
955	1.43142629D+06	956	1.43168998D+06	957	1.43179923D+06	958	1.43174771D+06	959	1.43152856D+06	960	1.43113338D+06
961	1.43055094D+06	962	1.42976360D+06	963	1.42873800D+06	964	1.42740513D+06	965	1.42562249D+06	966	1.42311179D+06
967	1.41937421D+06	968	1.41360649D+06	969	1.40468929D+06	970	1.39142507D+06	971	1.37312292D+06	972	1.36268151D+06
973	1.43142983D+06	974	1.43171873D+06	975	1.43253578D+06	976	1.43320837D+06	977	1.43370761D+06	978	1.43405277D+06
979	1.43423559D+06	980	1.43425057D+06	981	1.43409019D+06	982	1.43374417D+06	983	1.43319968D+06	984	1.43243874D+06
985	1.43142966D+06	986	1.43010722D+06	987	1.42833450D+06	988	1.42583864D+06	989	1.42211993D+06	990	1.41635406D+06
991	1.40734738D+06	992	1.39363082D+06	993	1.37431274D+06	994	1.36319646D+06	995	1.43213768D+06	996	1.43368489D+06
997	1.43483388D+06	998	1.43554864D+06	999	1.43615126D+06	1000	1.43658486D+06	1001	1.43684870D+06	1002	1.43694273D+06
1003	1.43685689D+06	1004	1.43657664D+06	1005	1.43608500D+06	1006	1.43536101D+06	1007	1.43437197D+06	1008	1.43305493D+06
1009	1.43128024D+06	1010	1.42878955D+06	1011	1.42510660D+06	1012	1.41943757D+06	1013	1.41060839D+06	1014	1.39708541D+06
1015	1.37644185D+06	1016	1.36420754D+06	1017	1.43679672D+06	1018	1.43712628D+06	1019	1.43805559D+06	1020	1.43877650D+06
1021	1.43928585D+06	1022	1.43963693D+06	1023	1.43982606D+06	1024	1.43983600D+06	1025	1.43964482D+06	1026	1.43922942D+06
1027	1.43856429D+06	1028	1.43761446D+06	1029	1.43631878D+06	1030	1.43455675D+06	1031	1.43209198D+06	1032	1.42849071D+06
1033	1.42303246D+06	1034	1.41466538D+06	1035	1.40210758D+06	1036	1.38397176D+06	1037	1.37078548D+06	1038	1.36569547D+06
1039	1.43765193D+06	1040	1.43955954D+06	1041	1.44088193D+06	1042	1.44157115D+06	1043	1.44214010D+06	1044	1.44258970D+06
1045	1.44289804D+06	1046	1.44303243D+06	1047	1.44296054D+06	1048	1.44265199D+06	1049	1.44207617D+06	1050	1.44119544D+06
1051	1.43995022D+06	1052	1.43822995D+06	1053	1.43582344D+06	1054	1.43234733D+06	1055	1.42716955D+06	1056	1.41938892D+06
1057	1.40800952D+06	1058	1.39339710D+06	1059	1.37561559D+06	1060	1.36600208D+06	1061	1.44364144D+06	1062	1.44385186D+06
1063	1.44447631D+06	1064	1.44510646D+06	1065	1.44568741D+06	1066	1.44615323D+06	1067	1.44645021D+06	1068	1.44653475D+06
1069	1.44637000D+06	1070	1.44592093D+06	1071	1.44514737D+06	1072	1.44399104D+06	1073	1.44235066D+06	1074	1.44003896D+06
1075	1.43671951D+06	1076	1.43183609D+06	1077	1.42457954D+06	1078	1.41402530D+06	1079	1.39909344D+06	1080	1.37914666D+06
1081	1.36786132D+06	1082	1.44655233D+06	1083	1.44677700D+06	1084	1.44735763D+06	1085	1.44812846D+06	1086	1.44890842D+06
1087	1.44958834D+06	1088	1.45009485D+06	1089	1.45037857D+06	1090	1.45039964D+06	1091	1.45012051D+06	1092	1.44949914D+06
1093	1.44847815D+06	1094	1.44696392D+06	1095	1.44478924D+06	1096	1.44165579D+06	1097	1.43706194D+06	1098	1.43024178D+06
1099	1.42011618D+06	1100	1.40526394D+06	1101	1.38320145D+06	1102	1.37020559D+06	1103	1.44897180D+06	1104	1.44927461D+06
1105	1.45009190D+06	1106	1.45115773D+06	1107	1.45224792D+06	1108	1.45320914D+06	1109	1.45397586D+06	1110	1.45450354D+06
1111	1.45475546D+06	1112	1.45469414D+06	1113	1.45427618D+06	1114	1.45344475D+06	1115	1.45211221D+06	1116	1.45012743D+06
1117	1.44722261D+06	1118	1.44294000D+06	1119	1.43655011D+06	1120	1.42700453D+06	1121	1.41302208D+06	1122	1.39316797D+06
1123	1.37912490D+06	1124	1.37420812D+06	1125	1.45063777D+06	1126	1.45124116D+06	1127	1.45256879D+06	1128	1.45423252D+06
1129	1.45573134D+06	1130	1.45703709D+06	1131	1.45810722D+06	1132	1.45891960D+06	1133	1.45944895D+06	1134	1.45965695D+06
1135	1.45949904D+06	1136	1.45891887D+06	1137	1.45783373D+06	1138	1.45610609D+06	1139	1.45349513D+06	1140	1.44958587D+06
1141	1.44370880D+06	1142	1.43490781D+06	1143	1.42210339D+06	1144	1.40569820D+06	1145	1.38580845D+06	1146	1.37504827D+06
1147	1.45125990D+06	1148	1.45192000D+06	1149	1.45520595D+06	1150	1.45742887D+06	1151	1.45943213D+06	1152	1.46111385D+06
1153	1.46249517D+06	1154	1.46363194D+06	1155	1.46448674D+06	1156	1.46501835D+06	1157	1.46518135D+06	1158	1.46492052D+06
1159	1.46415802D+06	1160	1.46276919D+06	1161	1.46053979D+06	1162	1.45710047D+06	1163	1.45184661D+06	1164	1.44388019D+06
1165	1.43210309D+06	1166	1.41507348D+06	1167	1.39188978D+06	1168	1.37869095D+06	1169	1.45774853D+06	1170	1.46093205D+06

1171	1.46358390D+06	1172	1.46540509D+06	1173	1.46713307D+06	1174	1.46863924D+06	1175	1.46986984D+06	1176	1.47078024D+06
1177	1.47132740D+06	1178	1.47145864D+06	1179	1.47110119D+06	1180	1.47014385D+06	1181	1.46840063D+06	1182	1.46555182D+06
1183	1.46106250D+06	1184	1.45408975D+06	1185	1.44333996D+06	1186	1.42680287D+06	1187	1.40027466D+06	1188	1.38410193D+06
1189	1.46687442D+06	1190	1.46763344D+06	1191	1.46985855D+06	1192	1.47200339D+06	1193	1.47394047D+06	1194	1.47559368D+06
1195	1.47693437D+06	1196	1.47793034D+06	1197	1.47852885D+06	1198	1.47866229D+06	1199	1.47823434D+06	1200	1.47709021D+06
1201	1.47496662D+06	1202	1.47141824D+06	1203	1.46571740D+06	1204	1.45672745D+06	1205	1.44274499D+06	1206	1.42071463D+06
1207	1.40396159D+06	1208	1.39802476D+06	1209	1.39897135D+06	1210	1.46843457D+06	1211	1.47159980D+06	1212	1.47438614D+06
1213	1.47713522D+06	1214	1.47954998D+06	1215	1.48163553D+06	1216	1.48346029D+06	1217	1.48497169D+06	1218	1.48611296D+06
1219	1.48682183D+06	1220	1.48701918D+06	1221	1.48658460D+06	1222	1.48531803D+06	1223	1.48288534D+06	1224	1.47875453D+06
1225	1.47215900D+06	1226	1.46217199D+06	1227	1.44942997D+06	1228	1.43133377D+06	1229	1.41841936D+06	1230	1.41426859D+06
1231	1.41238757D+06	1232	1.41847410D+06	1233	1.42807658D+06	1234	1.42995345D+06	1235	1.47488941D+06	1236	1.47918992D+06
1237	1.48279038D+06	1238	1.48538151D+06	1239	1.48795169D+06	1240	1.49032620D+06	1241	1.49242446D+06	1242	1.49418086D+06
1243	1.49554258D+06	1244	1.49645148D+06	1245	1.49682340D+06	1246	1.49652247D+06	1247	1.49533043D+06	1248	1.49292308D+06
1249	1.48889298D+06	1250	1.48298260D+06	1251	1.47494664D+06	1252	1.46601882D+06	1253	1.45748279D+06	1254	1.44509674D+06
1255	1.43886926D+06	1256	1.44449985D+06	1257	1.45423005D+06	1258	1.48071273D+06	1259	1.52153175D+06	1260	1.48715862D+06
1261	1.48821259D+06	1262	1.49132596D+06	1263	1.49447870D+06	1264	1.49750237D+06	1265	1.50026058D+06	1266	1.50269432D+06
1267	1.50477183D+06	1268	1.50646216D+06	1269	1.50771628D+06	1270	1.50845430D+06	1271	1.50855580D+06	1272	1.50785876D+06
1273	1.50619717D+06	1274	1.50345280D+06	1275	1.49976548D+06	1276	1.49551870D+06	1277	1.49087002D+06	1278	1.48728052D+06
1279	1.48700062D+06	1280	1.49191717D+06	1281	1.50373191D+06	1282	1.52247389D+06	1283	1.53136485D+06	1284	1.48924897D+06
1285	1.49341861D+06	1286	1.49720258D+06	1287	1.50119620D+06	1288	1.50498335D+06	1289	1.50846272D+06	1290	1.51160968D+06
1291	1.51444165D+06	1292	1.51696493D+06	1293	1.51915392D+06	1294	1.52096934D+06	1295	1.52235949D+06	1296	1.52326545D+06
1297	1.52363795D+06	1298	1.52348334D+06	1299	1.52290649D+06	1300	1.52211310D+06	1301	1.52156882D+06	1302	1.52208951D+06
1303	1.52478218D+06	1304	1.53074600D+06	1305	1.54055533D+06	1306	1.55313161D+06	1307	1.56002992D+06	1308	1.49773655D+06
1309	1.50313137D+06	1310	1.50814276D+06	1311	1.51283662D+06	1312	1.51704093D+06	1313	1.52085722D+06	1314	1.52446872D+06
1315	1.52786256D+06	1316	1.53101972D+06	1317	1.53392440D+06	1318	1.53656718D+06	1319	1.53894589D+06	1320	1.54107289D+06
1321	1.54298952D+06	1322	1.54478362D+06	1323	1.54662434D+06	1324	1.54880142D+06	1325	1.55173802D+06	1326	1.55593609D+06
1327	1.56181849D+06	1328	1.56960331D+06	1329	1.57943564D+06	1330	1.58484191D+06	1331	1.50875140D+06	1332	1.51560059D+06
1333	1.52146940D+06	1334	1.52584105D+06	1335	1.53033430D+06	1336	1.53475678D+06	1337	1.53905609D+06	1338	1.54320046D+06
1339	1.54718722D+06	1340	1.55103333D+06	1341	1.55476820D+06	1342	1.55842967D+06	1343	1.56206448D+06	1344	1.56573410D+06
1345	1.56952351D+06	1346	1.57354732D+06	1347	1.57793344D+06	1348	1.58272680D+06	1349	1.58793897D+06	1350	1.59337734D+06
1351	1.59976385D+06	1352	1.60367672D+06	1353	1.52799166D+06	1354	1.52967223D+06	1355	1.53466440D+06	1356	1.53990440D+06
1357	1.54521536D+06	1358	1.55045833D+06	1359	1.55559620D+06	1360	1.56063987D+06	1361	1.56563072D+06	1362	1.57062059D+06
1363	1.57565759D+06	1364	1.58077812D+06	1365	1.58600189D+06	1366	1.59132441D+06	1367	1.59670051D+06	1368	1.60203335D+06
1369	1.60715170D+06	1370	1.61122738D+06	1371	1.61437175D+06	1372	1.61427611D+06	1373	1.61016658D+06	1374	1.53119150D+06
1375	1.53744123D+06	1376	1.54320562D+06	1377	1.54948393D+06	1378	1.55578539D+06	1379	1.56201372D+06	1380	1.56813034D+06
1381	1.57417894D+06	1382	1.58023946D+06	1383	1.58639069D+06	1384	1.59268672D+06	1385	1.59914592D+06	1386	1.60574362D+06
1387	1.61239527D+06	1388	1.61892545D+06	1389	1.62500402D+06	1390	1.63029861D+06	1391	1.63486536D+06	1392	1.63262028D+06
1393	1.62432957D+06	1394	1.54386160D+06	1395	1.55160380D+06	1396	1.55903824D+06	1397	1.56648496D+06	1398	1.57372235D+06
1399	1.58075986D+06	1400	1.58771141D+06	1401	1.59473453D+06	1402	1.60195302D+06	1403	1.60941778D+06	1404	1.61712602D+06
1405	1.62501286D+06	1406	1.63293264D+06	1407	1.64062073D+06	1408	1.64762318D+06	1409	1.65283722D+06	1410	1.65655528D+06
1411	1.65919379D+06	1412	1.55960236D+06	1413	1.56873315D+06	1414	1.57741889D+06	1415	1.58569227D+06	1416	1.59349273D+06
1417	1.60111484D+06	1418	1.60897267D+06	1419	1.61716142D+06	1420	1.62572021D+06	1421	1.63462358D+06	1422	1.64377069D+06
1423	1.65297163D+06	1424	1.66192664D+06	1425	1.67016431D+06	1426	1.67702714D+06	1427	1.67568467D+06	1428	1.66691732D+06

1429	1.57813980D+06	1430	1.58897760D+06	1431	1.59854265D+06	1432	1.60609661D+06	1433	1.61422136D+06	1434	1.62278248D+06
1435	1.63184342D+06	1436	1.64143056D+06	1437	1.65149922D+06	1438	1.66190927D+06	1439	1.67242634D+06	1440	1.68273356D+06
1441	1.69246763D+06	1442	1.70131591D+06	1443	1.70592335D+06	1444	1.60782572D+06	1445	1.61045732D+06	1446	1.61829484D+06
1447	1.62682135D+06	1448	1.63597345D+06	1449	1.64579109D+06	1450	1.65634303D+06	1451	1.66757683D+06	1452	1.67928450D+06
1453	1.69115565D+06	1454	1.70282755D+06	1455	1.71395037D+06	1456	1.72439155D+06	1457	1.72940603D+06	1458	1.61256925D+06
1459	1.62147562D+06	1460	1.62974946D+06	1461	1.63880488D+06	1462	1.64835529D+06	1463	1.65871275D+06	1464	1.67018734D+06
1465	1.68264540D+06	1466	1.69575208D+06	1467	1.70904769D+06	1468	1.72204960D+06	1469	1.73432654D+06	1470	1.74549361D+06
1471	1.75075682D+06	1472	1.63048816D+06	1473	1.64086462D+06	1474	1.65054287D+06	1475	1.65947441D+06	1476	1.67017699D+06
1477	1.68258014D+06	1478	1.69645087D+06	1479	1.71120390D+06	1480	1.72609806D+06	1481	1.74042785D+06	1482	1.75365086D+06
1483	1.76530179D+06	1484	1.77068030D+06	1485	1.65758770D+06	1486	1.66033682D+06	1487	1.66872997D+06	1488	1.67950626D+06
1489	1.69293647D+06	1490	1.70864347D+06	1491	1.72564857D+06	1492	1.74249033D+06	1493	1.75820435D+06	1494	1.77219788D+06
1495	1.78418839D+06	1496	1.78962931D+06	1497	1.66162549D+06	1498	1.66799972D+06	1499	1.67535686D+06	1500	1.68573738D+06
1501	1.70002356D+06	1502	1.71883486D+06	1503	1.73921618D+06	1504	1.75904672D+06	1505	1.77567618D+06	1506	1.79018322D+06
1507	1.80239143D+06	1508	1.80790621D+06	1509	1.67417446D+06	1510	1.67763958D+06	1511	1.68795658D+06	1512	1.70264135D+06
1513	1.72227228D+06	1514	1.75676491D+06	1515	1.77637542D+06	1516	1.79299228D+06	1517	1.80740890D+06	1518	1.82017535D+06
1519	1.82565239D+06	1520	1.77665176D+06	1521	1.79426055D+06	1522	1.81053701D+06	1523	1.82306487D+06	1524	1.83515901D+06
1525	1.84736292D+06	1526	1.86007850D+06	1527	1.82056497D+06	1528	1.82498958D+06	1529	1.83606454D+06	1530	1.84703624D+06
1531	1.85703500D+06	1532	1.86102714D+06	1533	1.82675748D+06	1534	1.83164462D+06	1535	1.84171349D+06	1536	1.85212105D+06
1537	1.86015314D+06	1538	1.86329938D+06								

T E M P E R A T U R E

NODE		NODE		NODE		NODE		NODE		NODE	
1	13.763343944	2	13.763400497	3	13.771193544	4	13.779752752	5	13.780087092	6	13.771695255
7	13.761801475	8	13.781597242	9	13.794087175	10	13.794306784	11	13.782059586	12	13.763624447
13	13.772841825	14	13.790280790	15	13.807025854	16	13.805408962	17	13.787887342	18	13.767609114
19	13.759273217	20	13.781312451	21	13.798587626	22	13.818728247	23	13.810523277	24	13.792903911
25	13.775814580	26	13.764641493	27	13.785493431	28	13.804984146	29	13.829242640	30	13.818177656
31	13.799163611	32	13.781666714	33	13.758310972	34	13.780262226	35	13.793560767	36	13.810132562
37	13.836547321	38	13.829466608	39	13.806503980	40	13.789514112	41	13.773418934	42	13.796056780
43	13.791502025	44	13.804235955	45	13.819681745	46	13.841295057	47	13.839042304	48	13.817638155
49	13.799811651	50	13.786634823	51	13.772178674	52	13.796425976	53	13.809461388	54	13.819599115
55	13.833423229	56	13.845752171	57	13.844651315	58	13.830585952	59	13.811489717	60	13.794782822
61	13.778586120	62	13.757680989	63	13.801064994	64	13.818901291	65	13.835054517	66	13.845101238
67	13.848766128	68	13.848189673	69	13.841755865	70	13.826467851	71	13.804984381	72	13.785763735
73	13.765062649	74	13.801109458	75	13.819672042	76	13.836951992	77	13.846937873	78	13.845889313
79	13.846283834	80	13.845956721	81	13.833622211	82	13.809517587	83	13.789129104	84	13.769230705
85	13.800722614	86	13.819260843	87	13.837128494	88	13.841271627	89	13.829810056	90	13.831295822
91	13.844644756	92	13.834047400	93	13.809279720	94	13.789041506	95	13.769172977	96	13.800128909
97	13.818503044	98	13.836679753	99	13.827117232	100	13.813031029	101	13.821732178	102	13.841333601
103	13.834134586	104	13.808450178	105	13.788463660	106	13.768567652	107	13.799531348	108	13.817643437
109	13.835608581	110	13.817406785	111	13.801286105	112	13.819964580	113	13.838985581	114	13.836160327

115	13.809902732	116	13.792372021	117	13.776177110	118	13.799089213	119	13.817071379	120	13.835046929
121	13.816877033	122	13.799999097	123	13.819676222	124	13.838067854	125	13.840639562	126	13.817474580
127	13.799179566	128	13.785659489	129	13.771983939	130	13.798739618	131	13.816714627	132	13.834910246
133	13.816854352	134	13.801202996	135	13.820555562	136	13.839004130	137	13.845202970	138	13.830249325
139	13.810261148	140	13.794456357	141	13.783012899	142	13.772142135	143	13.797421891	144	13.815678031
145	13.832190225	146	13.816251339	147	13.811216938	148	13.827272486	149	13.842409932	150	13.848125376
151	13.842171779	152	13.827821824	153	13.809037722	154	13.794749620	155	13.785520018	156	13.771027542
157	13.754025671	158	13.793602082	159	13.805711842	160	13.815315730	161	13.804632010	162	13.821842190
163	13.836572277	164	13.846444300	165	13.849445801	166	13.847770880	167	13.841591910	168	13.828015134
169	13.810833805	170	13.798598483	171	13.787343203	172	13.776140215	173	13.767702529	174	13.794105839
175	13.807016366	176	13.818051036	177	13.811315811	178	13.823704527	179	13.840299954	180	13.848668363
181	13.849862496	182	13.849607617	183	13.847731589	184	13.842138000	185	13.830457370	186	13.817029719
187	13.804136198	188	13.791542279	189	13.776675382	190	13.755058866	191	13.798525650	192	13.817046438
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1087	13.850000000	1088	13.850000000	1089	13.850000000	1090	13.850000000	1091	13.850000000	1092	13.850000000
1093	13.849999995	1094	13.849999838	1095	13.849996737	1096	13.849959767	1097	13.849708878	1098	13.848659152
1099	13.845956315	1100	13.842917242	1101	13.841820238	1102	13.842182339	1103	13.850000000	1104	13.850000000
1105	13.850000000	1106	13.850000000	1107	13.850000000	1108	13.850000000	1109	13.850000000	1110	13.850000000
1111	13.850000000	1112	13.850000000	1113	13.850000000	1114	13.849999996	1115	13.849999889	1116	13.849998107
1117	13.849979359	1118	13.849847460	1119	13.849194291	1120	13.847642498	1121	13.846137555	1122	13.845728221
1123	13.846392772	1124	13.847197381	1125	13.850000000	1126	13.850000000	1127	13.850000000	1128	13.850000000
1129	13.850000000	1130	13.850000000	1131	13.850000000	1132	13.850000000	1133	13.850000000	1134	13.850000000
1135	13.850000000	1136	13.849999997	1137	13.849999932	1138	13.849998981	1139	13.849989506	1140	13.849911429
1141	13.849551396	1142	13.848813739	1143	13.848199894	1144	13.848180376	1145	13.848552076	1146	13.849002350

1147	13.850000000	1148	13.850000000	1149	13.850000000	1150	13.850000000	1151	13.850000000	1152	13.850000000
1153	13.850000000	1154	13.850000000	1155	13.850000000	1156	13.850000000	1157	13.850000000	1158	13.849999998
1159	13.849999959	1160	13.849999479	1161	13.849993973	1162	13.849951460	1163	13.849785508	1164	13.849509030
1165	13.849384687	1166	13.849480919	1167	13.849589109	1168	13.849705330	1169	13.850000000	1170	13.850000000
1171	13.850000000	1172	13.850000000	1173	13.850000000	1174	13.850000000	1175	13.850000000	1176	13.850000000
1177	13.850000000	1178	13.849999999	1179	13.849999978	1180	13.849999700	1181	13.849996657	1182	13.849976941
1183	13.849914832	1184	13.849839820	1185	13.849829540	1186	13.849848732	1187	13.849843707	1188	13.849771114
1189	13.850000000	1190	13.850000000	1191	13.850000000	1192	13.850000000	1193	13.850000000	1194	13.850000000
1195	13.850000000	1196	13.850000000	1197	13.849999999	1198	13.849999987	1199	13.849999830	1200	13.849998375
1201	13.849990833	1202	13.849972255	1203	13.849954282	1204	13.849945255	1205	13.849905419	1206	13.849752277
1207	13.849103018	1208	13.845772785	1209	13.842034849	1210	13.850000000	1211	13.850000000	1212	13.850000000
1213	13.850000000	1214	13.850000000	1215	13.850000000	1216	13.850000000	1217	13.850000000	1218	13.849999999
1219	13.849999992	1220	13.849999913	1221	13.849999323	1222	13.849996896	1223	13.849991618	1224	13.849984019
1225	13.849962614	1226	13.849866823	1227	13.849477204	1228	13.848096118	1229	13.844507909	1230	13.834571317
1231	13.801865416	1232	13.758209756	1233	13.725242110	1234	13.717071766	1235	13.850000000	1236	13.850000000
1237	13.850000000	1238	13.850000000	1239	13.850000000	1240	13.850000000	1241	13.850000000	1242	13.850000000
1243	13.849999995	1244	13.849999954	1245	13.849999714	1246	13.849998770	1247	13.849995863	1248	13.849985745
1249	13.849942619	1250	13.849764256	1251	13.849091039	1252	13.847149871	1253	13.841888202	1254	13.827982593
1255	13.800874289	1256	13.764145627	1257	13.730318683	1258	13.717675122	1259	13.718936877	1260	13.850000000
1261	13.850000000	1262	13.850000000	1263	13.850000000	1264	13.850000000	1265	13.850000000	1266	13.849999999
1267	13.849999994	1268	13.849999958	1269	13.849999753	1270	13.849998739	1271	13.849994070	1272	13.849973479
1273	13.849889580	1274	13.849579500	1275	13.848597210	1276	13.845887112	1277	13.838736754	1278	13.823761979
1279	13.798883322	1280	13.765025324	1281	13.733353115	1282	13.719418406	1283	13.716054908	1284	13.850000000
1285	13.850000000	1286	13.850000000	1287	13.850000000	1288	13.850000000	1289	13.850000000	1290	13.849999998
1291	13.849999988	1292	13.849999922	1293	13.849999547	1294	13.849997563	1295	13.849988024	1296	13.849946940
1297	13.849790839	1298	13.849276081	1299	13.847814125	1300	13.844110089	1301	13.835922899	1302	13.820711767
1303	13.796776510	1304	13.765084765	1305	13.733586682	1306	13.716705934	1307	13.712459598	1308	13.850000000
1309	13.850000000	1310	13.850000000	1311	13.850000000	1312	13.849999999	1313	13.849999995	1314	13.849999972
1315	13.849999835	1316	13.849999075	1317	13.849995163	1318	13.849976948	1319	13.849901720	1320	13.849631515
1321	13.848800928	1322	13.846624553	1323	13.841726927	1324	13.832202287	1325	13.816236390	1326	13.793055333
1327	13.763584706	1328	13.731936044	1329	13.712205999	1330	13.706136149	1331	13.850000000	1332	13.850000000
1333	13.850000000	1334	13.849999998	1335	13.849999989	1336	13.849999939	1337	13.849999665	1338	13.849998223
1339	13.849991122	1340	13.849959367	1341	13.849833396	1342	13.849399619	1343	13.848127000	1344	13.844983886
1345	13.838468561	1346	13.826966733	1347	13.809398112	1348	13.786178774	1349	13.759124539	1350	13.730546900
1351	13.708618489	1352	13.698197348	1353	13.850000000	1354	13.849999999	1355	13.849999995	1356	13.849999974
1357	13.849999870	1358	13.849999351	1359	13.849996796	1360	13.849984869	1361	13.849933818	1362	13.849739094
1363	13.849092551	1364	13.847261546	1365	13.842912558	1366	13.834336146	1367	13.820258007	1368	13.800434626
1369	13.776395227	1370	13.751593708	1371	13.729713168	1372	13.710438815	1373	13.683710323	1374	13.850000000
1375	13.849999996	1376	13.849999987	1377	13.849999942	1378	13.849999731	1379	13.849998775	1380	13.849994462
1381	13.849975598	1382	13.849898801	1383	13.849617810	1384	13.848717633	1385	13.846245515	1386	13.840535329
1387	13.829615796	1388	13.812506127	1389	13.790372629	1390	13.765534607	1391	13.744174069	1392	13.727798610
1393	13.713634022	1394	13.849999995	1395	13.849999960	1396	13.849999872	1397	13.849999463	1398	13.849997729
1399	13.849990596	1400	13.849961825	1401	13.849851789	1402	13.849468351	1403	13.848287322	1404	13.845144394

1405	13.838058244	1406	13.824791864	1407	13.804570231	1408	13.780066887	1409	13.756194243	1410	13.737789898
1411	13.729533019	1412	13.849999954	1413	13.849999683	1414	13.849998990	1415	13.849995955	1416	13.849984104
1417	13.849940380	1418	13.849786635	1419	13.849283776	1420	13.847807671	1421	13.844020999	1422	13.835706593
1423	13.820413257	1424	13.797527664	1425	13.770807229	1426	13.749071465	1427	13.735108676	1428	13.719262647
1429	13.849999631	1430	13.849998049	1431	13.849993441	1432	13.849973357	1433	13.849905352	1434	13.849689154
1435	13.849040761	1436	13.847257018	1437	13.842894174	1438	13.833627003	1439	13.816924009	1440	13.792212064
1441	13.764082258	1442	13.743516531	1443	13.735064781	1444	13.849996686	1445	13.849989487	1446	13.849957597
1447	13.849849169	1448	13.849533463	1449	13.848683763	1450	13.846552350	1451	13.841680338	1452	13.831790916
1453	13.814424850	1454	13.789008873	1455	13.760159867	1456	13.739764253	1457	13.731332310	1458	13.849996838
1459	13.849981711	1460	13.849938457	1461	13.849772722	1462	13.849288600	1463	13.848113254	1464	13.845507600
1465	13.840120355	1466	13.829890004	1467	13.812563543	1468	13.787487101	1469	13.758762615	1470	13.737495154
1471	13.727505145	1472	13.849979201	1473	13.849914402	1474	13.849701320	1475	13.848955256	1476	13.847210721
1477	13.843824111	1478	13.837712445	1479	13.827255310	1480	13.810467885	1481	13.786527248	1482	13.758680978
1483	13.736871303	1484	13.725198079	1485	13.849902285	1486	13.849636647	1487	13.848613255	1488	13.846047201
1489	13.841179212	1490	13.833803345	1491	13.822883487	1492	13.806880464	1493	13.784459472	1494	13.758069745
1495	13.736617548	1496	13.724027847	1497	13.849920263	1498	13.849580182	1499	13.848395767	1500	13.845008152
1501	13.838277576	1502	13.827845566	1503	13.816020298	1504	13.800734352	1505	13.779733109	1506	13.754743989
1507	13.734327408	1508	13.721957878	1509	13.849667282	1510	13.848312572	1511	13.844596818	1512	13.836899162
1513	13.824005763	1514	13.807082977	1515	13.791883973	1516	13.772152261	1517	13.748042442	1518	13.727485890
1519	13.715679950	1520	13.796574755	1521	13.780955446	1522	13.763434379	1523	13.739827627	1524	13.717621740
1525	13.701873575	1526	13.685877533	1527	13.767890263	1528	13.754665589	1529	13.734932737	1530	13.711961579
1531	13.693681540	1532	13.678349572	1533	13.767090910	1534	13.746928675	1535	13.733142012	1536	13.712131420
1537	13.689626574	1538	13.668954961								

F L U I D M A S S B U D G E T AFTER TIME STEP 240, IN (MASS/SECOND)

-2.7419712D+03	RATE OF CHANGE IN TOTAL STORED FLUID DUE TO PRESSURE CHANGE, INCREASE(+)/DECREASE(-)
0.0000000D+00	RATE OF CHANGE IN TOTAL STORED FLUID DUE TO TEMPERATURE CHANGE, INCREASE(+)/DECREASE(-)
-2.7419712D+03	TOTAL OF FLUID SOURCES AND SINKS, NET INFLOW(+)/NET OUTFLOW(-)
0.0000000D+00	TOTAL OF FLUID FLOWS AT POINTS OF SPECIFIED PRESSURE, NET INFLOW(+)/NET OUTFLOW(-)

TIME-DEPENDENT FLUID SOURCES OR SINKS

NODE	INFLOW(+)/OUTFLOW(-) (MASS/SECOND)
1	-2.4850702D+00
2	-2.4850702D+00
3	-3.8981409D+00
.	.
.	.
.	.
1536	3.5254145D+00

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              1537          3.4455080D+00
              1538          1.7047443D+00

ENERGY BUDGET       AFTER TIME STEP   240,    IN (ENERGY/SECOND)

 5.9041832D+04     NET RATE OF INCREASE(+)/DECREASE(-) OF ENERGY IN FLUID
 1.7852779D+05     NET RATE OF INCREASE(+)/DECREASE(-) OF ENERGY IN SOLID GRAINS
 0.0000000D+00     NET ZERO-ORDER PRODUCTION(+)/LOSS(-) OF ENERGY IN FLUID
 0.0000000D+00     NET ZERO-ORDER PRODUCTION(+)/LOSS(-) OF ENERGY IN SOLID GRAINS
-1.5812446D+08     NET GAIN(+)/LOSS(-) OF ENERGY THROUGH FLUID SOURCES AND SINKS
 0.0000000D+00     NET GAIN(+)/LOSS(-) OF ENERGY THROUGH INFLOWS OR OUTFLOWS AT POINTS OF SPECIFIED PRESSURE
 0.0000000D+00     NET GAIN(+)/LOSS(-) OF ENERGY THROUGH ENERGY SOURCES AND SINKS

           ENERGY SOURCES OR SINKS AT FLUID SOURCES AND SINKS

              NODE        SOURCE(+)/SINK(-)
                            (ENERGY/SECOND)

                 1         -1.4296802D+05
                 2         -1.4296861D+05
                 3         -2.2439098D+05
                 .               .
                 .               .
                 .               .
              1536          2.0409682D+05
              1537          1.9947079D+05
              1538          9.8692762D+04


*** LAST SOLUTION HAS BEEN STORED ON UNIT 66 ***

SUTRA SIMULATION TERMINATED AT COMPLETION OF TIME PERIOD
***** ********** ********** ** ********** ** **** ******
MESSAGE SUMMARY: MESSAGE NUMBER - COUNT
                     208      511  OR OVER
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