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Quality of Ground Water in Pleistocene and Holocene Subunits of the Mississippi River Valley Alluvial Aquifer, 1998

Water-Resources Investigations Report 03-4202

U.S. Department of the Interior
U.S. Geological Survey

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QUALITY OF GROUND WATER IN PLEISTOCENE AND HOLOCENE SUBUNITS OF THE MISSISSIPPI RIVER VALLEY ALLUVIAL AQUIFER, 1998

by Gerard J. Gonthier

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 03-4202

National Water-Quality Assessment Program

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FOREWORD

The U.S. Geological Survey (USGS) is committed to serve the Nation with accurate and timely scientific information that helps enhance and protect the overall quality of life, and facilitates effective management of water, biological, energy, and mineral resources. Information on the quality of the Nation's water resources is of critical interest to the USGS because it is so integrally linked to the long-term availability of water that is clean and safe for drinking and recreation and that is suitable for industry, irrigation, and habitat for fish and wildlife. Escalating population growth and increasing demands for the multiple water uses make water availability, now measured in terms of quantity *and* quality, even more critical to the long-term sustainability of our communities and ecosystems.

The USGS implemented the National Water-Quality Assessment (NAWQA) Program to support national, regional, and local information needs and decisions related to water-quality management and policy. Shaped by and coordinated with ongoing efforts of other Federal, State, and local agencies, the NAWQA Program is designed to answer: What is the condition of our Nation's streams and ground water? How are the conditions changing over time? How do natural features and human activities affect the quality of streams and ground water, and where are those effects most pronounced? By combining information on water chemistry, physical characteristics, stream habitat, and aquatic life, the NAWQA Program aims to provide science-based insights for current and emerging water issues. NAWQA results can contribute to informed decisions that result in practical and effective water-resource management and strategies that protect and restore water quality.

Since 1991, the NAWQA Program has implemented interdisciplinary assessments in more than 50 of the Nation's most important river basins and aquifers, referred to as Study Units. Collectively, these Study Units account for more than 60 percent of the overall water use and population served by public water supply, and are representative of the Nation's major hydrologic landscapes, priority ecological resources, and agricultural, urban, and natural sources of contamination.

Each assessment is guided by a nationally consistent study design and methods of sampling and analysis. The assessments thereby build local knowledge about water-quality issues and trends in a particular stream or aquifer while providing an understanding of how and why water quality varies regionally and nationally. The consistent, multi-scale approach helps to determine if certain types of water-quality issues are isolated or pervasive, and allows direct comparisons of how human activities and natural processes affect water quality and ecological health in the Nation's diverse geographic and environmental settings. Comprehensive assessments on pesticides, nutrients, volatile organic compounds, trace metals, and aquatic ecology are developed at the national scale through comparative analysis of the Study-Unit findings.

The USGS places high value on the communication and dissemination of credible, timely, and relevant science so that the most recent and available knowledge about water resources can be applied in management and policy decisions. We hope this NAWQA publication will provide you the needed insights and information to meet your needs, and thereby foster increased awareness and involvement in the protection and restoration of our Nation's waters.

The NAWQA Program recognizes that a national assessment by a single program cannot address all water-resource issues of interest. External coordination at all levels is critical for a fully integrated understanding of watersheds and for cost-effective management, regulation, and conservation of our Nation's water resources. The Program, therefore, depends extensively on the advice, cooperation, and information from other Federal, State, interstate, Tribal, and local agencies, non-government organizations, industry, academia, and other stakeholder groups. The assistance and suggestions of all are greatly appreciated.

Robert M. Hirsch
Associate Director for Water

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
Length		
inch (in.)	2.54	centimeter
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
Area		
square foot per day (ft^2/d))	0.09290	square meter per day
square mile (mi^2)	2.590	square kilometer
Volume		
gallon (gal)	3.785	liter
gallon (gal)	0.003785	cubic meter
gallon (gal)	3.785	cubic decimeter
Flow rate		
foot per second (ft/s)	0.3048	meter per second
foot per day (ft/d)	0.3048	meter per day
foot per year (ft/yr)	0.3048	meter per year
million gallons per day (Mgal/d)	0.04381	cubic meter per second
inch per year (in/yr)	25.4	millimeter per year
Mass		
pound, avoirdupois (lb)	0.4536	kilogram
Radioactivity		
picocurie per liter (pCi/L)	0.037	becquerel per liter
tritium unit (TU)	0.118	becquerel per liter
tritium unit (TU)	3.2	picocurie per liter
Hydraulic conductivity		
foot per day (ft/d)	0.3048	meter per day
Hydraulic gradient		
foot per mile (ft/mi)	0.1894	meter per kilometer
Application rate		
pound per acre (lb/acre)	1.121	kilograms per hectare

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F = (1.8 \times °C) + 32$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C = (°F - 32) / 1.8$$

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD83).

Altitude, as used in this report, refers to distance above or below sea level.

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L), micrograms per liter (µg/L), or picograms per kilogram of water (pg/kg).

1 Liter of water by volume is approximately 1 kilogram by mass.

1000 grams (g) = 1 kilogram (kg)

1000 milligrams (mg) = 1 gram

1000 micrograms (µg) = 1 milligram

ACRONYMS AND ABBREVIATIONS USED IN THIS REPORT:

BP-before present
DOC-Dissolved Organic Carbon
GIRAS-Geographic Information Retrieval and Analysis System
GIS-Geographic Information System
GPS-global positioning system
LOWESS-LOcally WEighted Scatterplot Smoothing
MCL-Maximum Contaminant Level
NAWQA-NAtional Water-Quality Assessment Program
NTU-nephelometric turbidity units
NWQL-National Water-Quality Laboratory
SMCL-Secondary Maximum Contaminant Level
SPE-solid-phase extraction
TU-Tritium Unit
USEPA- U.S. Enviornmental Protection Agency
USGS-U.S. Geological Survey
VOC-volatile organic compounds

QUALITY OF GROUND WATER IN PLEISTOCENE AND HOLOCENE SUBUNITS OF THE MISSISSIPPI RIVER VALLEY ALLUVIAL AQUIFER, 1998

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ABSTRACT

Twenty-five wells screened in the Holocene alluvium and 29 wells screened in the Pleistocene valley trains were sampled during 1998 as part of a study of the quality of ground water in the Mississippi River Valley alluvial aquifer. The study area is the extent of the Holocene alluvium (16,400 square miles) and Pleistocene valley train deposits (12,100 square miles) within the Mississippi Alluvial Plain.

Of the comprehensive suite of constituents analyzed, only one detection of one element (arsenic) exceeded the U.S. Environmental Protection Agency's maximum contaminant level for drinking water. Manganese, iron, and dissolved-solids concentrations of water from some wells exceeded secondary maximum contaminant levels. At least one pesticide was detected in water from 19 of the 54 wells. The most frequently detected pesticide was bentazon. Other detected pesticide compounds were molinate, fluometuron, 2,4-D, fenuron, atrazine, deethylatrazine, metolachlor, propanil, and p,p'DDE. At least one volatile organic compound (VOC) was detected above the reporting limit in water from 4 of 54 wells. Detected VOCs included dichlorodifluoromethane, MTBE, and diisopropyl ether. The occurrences or concentrations of suspected surface contaminants of nitrate, pesticides, and VOCs are not significantly different between the two subunits.

Ground-water geochemistry is significantly different between the Holocene alluvium and the Pleistocene valley trains. Barium, potassium, dissolved organic carbon, radium-226, chromium, iron, magnesium, calcium, bicarbonate, dissolved solids, ammonia, phosphorus, and fluoride were present in greater concentrations in water from the Holocene alluvium than in water from the Pleistocene valley trains. Tritium, sulfate, radon-222, pH, and, chloride had greater concentrations or values in water from the Pleistocene valley trains than in water from the Holocene alluvium. Data indicate that water in the Holocene alluvium is older and is under more reducing conditions than water in the Pleistocene valley trains.

INTRODUCTION

In 1991, the U. S. Geological Survey (USGS) began implementation of the National Water-Quality Assessment (NAWQA) Program to provide a consistent description of the Nation's ground- and surface-water resources. The NAWQA Program consists of river basins or aquifer systems, referred to as study units, throughout the Nation. The objectives of the NAWQA Program are to (1) determine the general ground- and surface-water quality of the Nation's water resources, (2) determine the natural and anthropogenic factors affecting the water quality, and (3) determine any changes in water quality through time. Implementation of the study units is on a rotational basis (Leahy and others, 1990). Between 14 and 20 study units were implemented in 1991, 1994, and 1997. The Mississippi Embayment Study Unit (fig. 1) is one of 17 study units that began in 1994.

The quality of ground water in the Mississippi River Valley alluvial aquifer (hereafter referred to as the alluvial aquifer) was studied in order to provide scientific information to help manage the water resources of the alluvial aquifer. Water use from the alluvial aquifer is enormous; annual average pumpage from the aquifer is about 7 Bgal/d (Mesko and others, 1990). This amount of water pumped from the alluvial aquifer is equivalent to about 4 inches of rain on the land overlying the alluvial aquifer per year. Most of the water is pumped during the growing season and is used to irrigate crops or maintain aquaculture. However, some of the water is used for public supply and industry. The chemical analysis of water in the alluvial aquifer provides an opportunity to monitor the infiltration of potential contaminants into a vast ground-water system that not only affects drinking water supplies but also affects soil in farmland as a result of irrigation.

The hydrogeology of the alluvial aquifer has been investigated as a single Quaternary unit (Grubb, 1986; Ackerman, 1989). A large source of information about the alluvial aquifer comes from the Regional Aquifer-System Analysis Program. Quaternary geologists have recently delineated the areal extent of several significantly different geologic units that constitute the alluvial aquifer based on age and depositional setting (Saucier and Snead, 1989, Saucier, 1994a, b; Autin and others, 1991). Almost all of these geologic units can be grouped into three major hydrogeologic subunits within the alluvial aquifer--the Holocene alluvium, the Pleistocene valley train deposits, and the Prairie complex.

Purpose and Scope

This report describes the results of a study to determine the occurrence and distribution of inorganic and organic chemical constituents in shallow ground water from the Holocene alluvium and the Pleistocene valley train deposits of the alluvial aquifer, but does not include the quality of water in the Pleistocene Prairie complex, the third of the three major hydrogeologic units within the alluvial aquifer. Assessing aquifer properties and determining factors affecting the water quality of the alluvial aquifer are beyond the scope of this study. Scope of the work included collection of water samples from 25 wells screened in the Holocene alluvium ("HA" wells) and 29 wells screened in the Pleistocene valley train deposits ("VT" wells) during summer 1998. All water samples were analyzed for turbidity, water temperature, pH, specific conductance, dissolved oxygen concentration, alkalinity, ferrous iron, and sulfide (hereafter referred to as field parameters), major ions, nutrients, trace elements, pesticides, volatile organic compounds (VOCs), radioisotopes, and stable isotopes. Land use was assessed within 164 and 1,641 ft of each well. Information including well depth, well use, estimated water level, casing material, location, and discharge was also collected for each of the 54 wells that were sampled.

Location

The alluvial aquifer is located in the Mississippi Alluvial Plain of the Lower Mississippi River Valley. The Mississippi Alluvial Plain within the south-central United States is about 30,600 mi^2 (fig. 1). The study area is the extent of the Holocene alluvium (16,400 mi^2) and Pleistocene valley train deposits (12,100 mi^2) shown in figure 1, within the Mississippi Alluvial Plain. Both hydrogeologic subunits of the alluvial aquifer are present in eastern Arkansas, western Kentucky, northeastern Louisiana, northwestern Mississippi, southeastern Missouri, and western Tennessee.

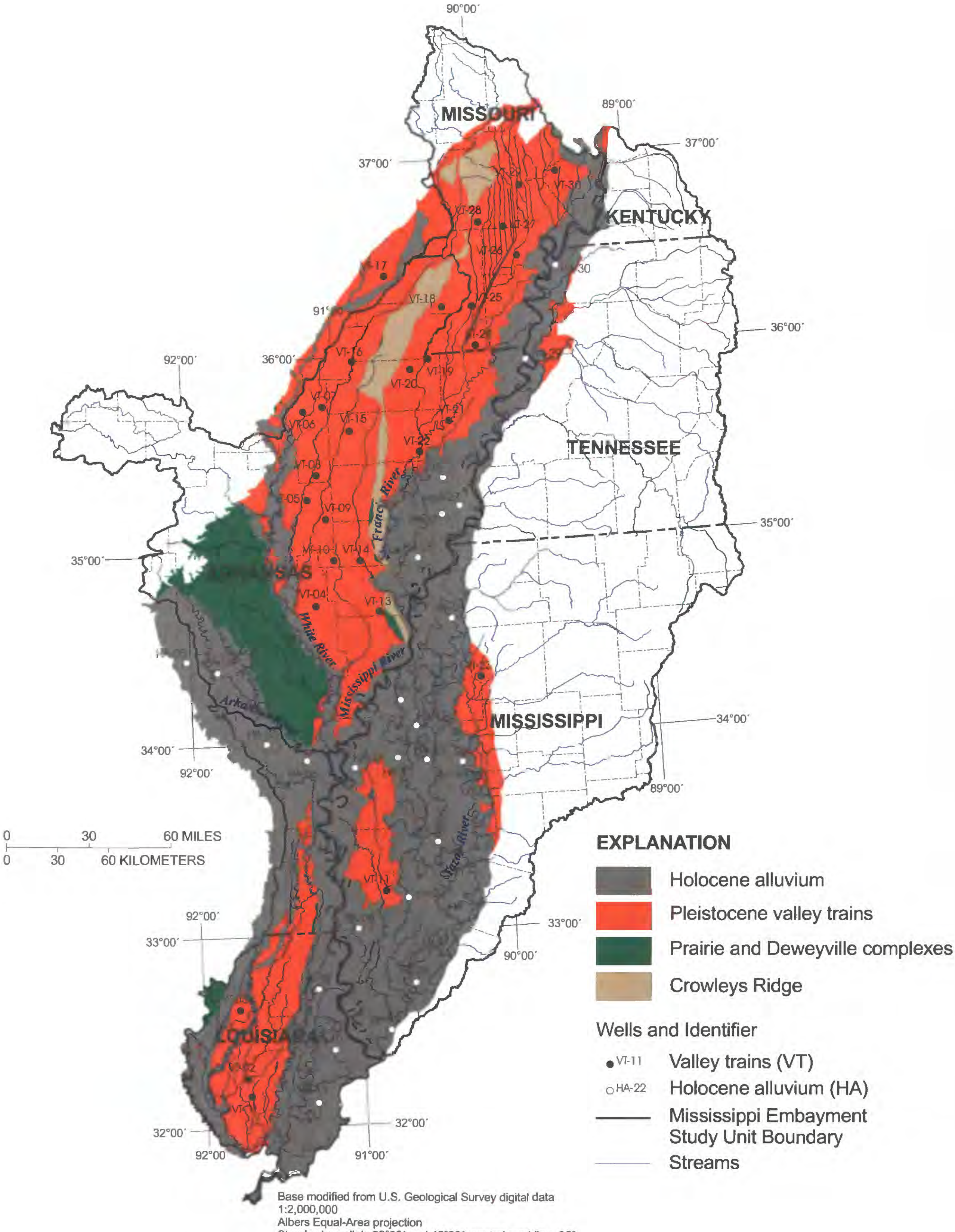

Figure 1. Location of wells screened in the Holocene alluvium and Pleistocene valley trains of the Mississippi River Valley alluvial aquifer, 1998.

Acknowledgments

The author extends appreciation to well owners for allowing their wells to be sampled. Well owners included crop farmers, municipalities, fish farmers, home owners, commercial crop dusting operations, a church, and a steel mill. Jan Jones of the U.S. Geological Survey played a crucial role in coordinating sampling efforts.

ENVIRONMENTAL SETTING

Climate

Climate in the Mississippi Alluvial Plain is humid-temperate. Mean annual air temperature ranges from 57 ^oF in the northern part of the alluvial plain (southeastern Missouri) to 65 ^oF in the southern part (northern Louisiana). Mean annual precipitation ranges from about 48 in/yr in the northern part of the Mississippi Alluvial Plain to 56 in/yr in the southern part. Precipitation generally is greatest in April and least in October, but is fairly evenly distributed throughout the year. Minor drought conditions occur frequently during the summer months in the central and northern part of the Mississippi Alluvial Plain (north of Louisiana) when evapotranspiration is high (U.S. National Climatic Data Center, 1999a, b).

Physiography

The Mississippi Alluvial Plain is a major physiographic region of the Coastal Plain Province described by Fenneman (1938). The alluvial aquifer coincides with the Mississippi Alluvial Plain (Ackerman, 1989). Within the Mississippi Alluvial Plain is Crowleys Ridge, about 800 mi^2 of a long, narrow, elevated erosional remnant of the Gulf Coastal Plain that extends from southeastern Missouri into eastern Arkansas (Boswell and others, 1968; Fenneman, 1938). The Mississippi Alluvial Plain consists of mostly flat terrain with meandering streams; relief within a 1-mi^2 area ranges from less than 5 to 25 ft. The Holocene alluvium and the youngest deposits of the Pleistocene valley trains (of late Wisconsin age) are very flat, with relief typically less than 5 ft. Older deposits of the Pleistocene valley trains (of early Wisconsin age) have higher relief, ranging from 5 to 25 ft. Land-surface altitude in the Mississippi Alluvial Plain increases from south to north, ranging from 65 to 325 ft above sea level.

Geology

The Mississippi Alluvial Plain is situated in the western part of the Mississippi Embayment which is a geologic structural trough (Boswell and others, 1968). The Mississippi Embayment extends 600 mi from its apex at the southern tip of Illinois to the Louisiana coast. This area of subsidence since the Mesozoic has been filled with thick deposits of sediments, mostly sands and clays, of Jurassic to Holocene age. Within the Mississippi Embayment region, river courses, the largest being the Mississippi, Arkansas, and Ohio, have carved a large erosional feature that defines the current extent of the Mississippi Alluvial Plain. During the Quaternary, up to 300 ft of alluvial sediments filled the Mississippi Alluvial Plain. These sediments are referred to as the Quaternary alluvium in Arkansas by Ackerman (1989). The Quaternary alluvium overlies and is laterally adjacent to older Tertiary formations of sand and clay, and Paleozoic formations of limestone, dolostone, sandstone, and shale at the northwestern edge of the Mississippi Alluvial Plain. Crowleys Ridge, an erosional remnant, is an area where the Quaternary alluvium is absent. Sediment deposition of Quaternary alluvium occurred under different environmental settings, including braided streams, natural levees, fluvial point bars, and backswamps (Saucier, 1994a, b; Autin and others, 1991). Despite different depositional settings, the Quaternary alluvium has two distinct but gradational lithologies, fine grain material (clays and silts) that typically overlies coarse grain material (sands and gravels) (Boswell and others, 1968).

The Quaternary alluvium has been separated into more than 30 geologic units based on environmental setting of deposition and age (Saucier, 1994b). Almost all of these separate geologic units can be grouped into three major units: Pleistocene Prairie complex, Pleistocene valley trains, and the Holocene alluvium (table 1) (Autin and others, 1991; Saucier, 1994a). The Prairie complex, which is older than the Pleistocene valley trains and the Holocene alluvium, was deposited in a number of different environmental settings including braided streams and abandoned meanders. Saucier (1994a) suggested that the Prairie complex was deposited between about 120,000 years before present (B.P.) and the last glacial maximum about 18,000 years B.P. The Pleistocene valley trains were mostly deposited during two main time periods, between about 60,000 and 25,000 years B.P. (referred to as the valley trains of early Wisconsin glaciation) and during the waning phase of the latest glacial period between 18,000 and 10,000 years B.P. (referred to as the valley trains of late Wisconsin glaciation). Glacial outwash flowing from north to south provided enough energy to cause sediment to be deposited by braided streams in the Lower Mississippi River Valley. Sediment deposited by braided streams forms the valley trains throughout the alluvial plain. By about 9,000 years B.P., the rate of glacial outwash into the Lower Mississippi River Valley declined and valley train deposition ceased. After Pleistocene valley train deposition ceased, a lower energy deposition continued near meandering major rivers such as the Mississippi and the Arkansas. Autin and others (1991) reported that the depositional transition from Pleistocene valley trains (braided streams) to Holocene alluvium (meander-stream) started near Baton Rouge, Louisiana around 12,000 years B.P., and migrated northward to near Cairo, Illinois by 9,000 years B.P. Where the Pleistocene valley train deposits and Holocene alluvium are geographically situated next to each other, the Holocene alluvium overlies the Pleistocene valley trains (fig. 2). Scattered throughout the extent of the Holocene alluvium, remnants of the Pleistocene valley trains and Prairie complexes also exist at the base of the alluvium (Autin and others, 1991).

Table 1. Relation of geologic units within the Mississippi Alluvial Plain of the Lower Mississippi River Valley to hydrogeologic units

[Modified from Saucier (1994a) and Ackerman (1989)]

<table>
<tr><th colspan="6">Geology</th><th rowspan="3">Hydrogeology</th></tr>
<tr><th colspan="3">Geologic age</th><th rowspan="2">Geologic units</th><th rowspan="2">Geologic subunits</th><th rowspan="2">Lithology</th></tr>
<tr><th>Period</th><th>Epoch</th><th>Stage</th></tr>
<tr><td rowspan="5">Quaternary</td><td>Holocene</td><td></td><td rowspan="5">Quaternary alluvium</td><td>Alluvium</td><td>Unconsolidated clays, silts, and sands deposited in fluvial, deltaic, lacustrine, and marine environments</td><td rowspan="5">Mississippi River Valley alluvial aquifer</td></tr>
<tr><td rowspan="4">Pleistocene</td><td>late Wisconsin</td><td rowspan="3">Valley trains</td><td rowspan="3">Two sequences (early and late Wisconsin) of braided stream deposits consisting of massive sands and gravel</td></tr>
<tr><td>middle Wisconsin</td></tr>
<tr><td>early Wisconsin</td></tr>
<tr><td>Sangamon</td><td>Prairie complex</td><td>Diverse time-transgressive depositional sequence representing fluvial to marine environments</td></tr>
</table>

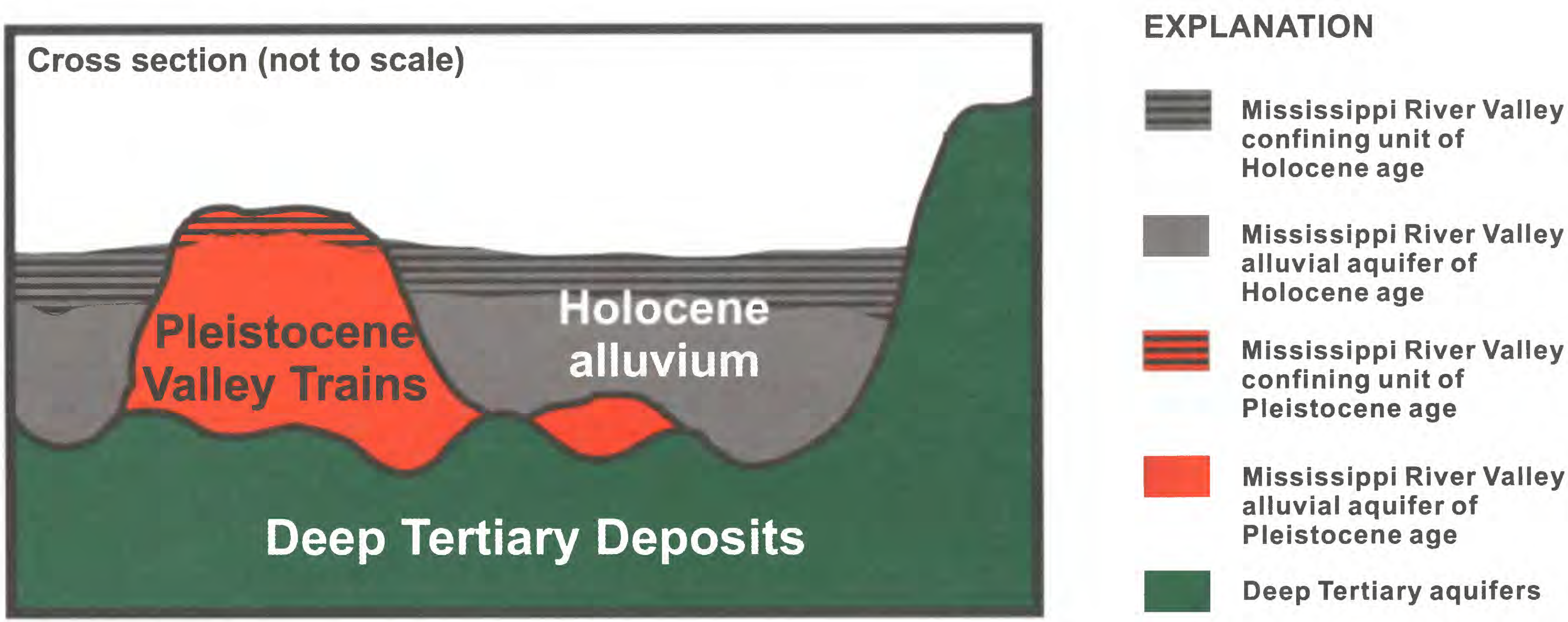

Figure 2. Schematic cross section of the Holocene alluvium and Pleistocene valley trains of the Mississippi River Valley alluvial aquifer.

The different depositional settings have led to different lithologic characteristics between all three major units. Differences between the Pleistocene valley trains and the Holocene alluvium are emphasized in the following discussion. The Pleistocene valley train deposits have generally coarser grain size than the Holocene alluvium. Drillers' logs from Arkansas and Missouri indicate that the clay and silt surficial unit is thicker in the Holocene alluvium than it is in the Pleistocene valley train deposits. Drillers' logs also indicate that the sand and gravel layer is thicker in the Pleistocene valley train deposits than in the Holocene alluvium (Gonthier, 1998).

Hydrogeology

The upper silt and clay of the Quaternary alluvium comprise the Mississippi River Valley confining unit (Gonthier and Mahon, 1994) (hereafter referred to as the confining unit), whereas the lower sand and gravel of the Quaternary alluvium comprise the alluvial aquifer (Ackerman, 1989; Boswell and others, 1968). Confining unit thickness generally ranges from 10 to 50 ft and generally increases from north to south. Vertical hydraulic conductivity of the confining unit ranges from 0.0004 to 0.5 ft/d (Ackerman, 1989). Alluvial aquifer thickness generally ranges from 60 to 140 ft and generally increases from north to south. Extremes in alluvial aquifer thickness occur where the confining unit is locally absent or very thick. Horizontal hydraulic conductivity in the alluvial aquifer is about 205 ft/d (Ackerman, 1989). Wells screened in the alluvial aquifer typically yield between 1,000 and 2,000 gal/min (Whitfield, 1975; Boswell and others, 1968). Hydraulic conductivity of the alluvial aquifer is greater than the hydraulic conductivity of the adjacent and underlying Tertiary or Paleozoic aquifers. Predevelopment regional flow is believed to be generally from the older adjacent and underlying aquifers towards the alluvial aquifer (Williamson and others, 1990).

Well pumpage, stream stages, and precipitation are major factors affecting the water budget of the alluvial aquifer. Major rivers incise the confining unit and attribute the largest component of flow into or out of the alluvial aquifer. During spring floods, rivers recharge the alluvial aquifer; however, during low stage, streams receive water from the alluvial aquifer. Well pumpage lowers water levels in the alluvial aquifer and increases the amount of long-term recharge that streams contribute to the alluvial aquifer (Ackerman, 1989; Sumner and Wasson, 1984; Broom and Lyford, 1981; Reed and Broom, 1979; Broom and Reed, 1973; Whitfield, 1975). Further discussion about the hydrology of the alluvial aquifer is in Ackerman (1989), Sumner and Wasson (1984), Whitfield (1975), and Boswell and others (1968).

Because hydraulic conductivity generally is greater with larger grain size (Freeze and Cherry, 1979), hydraulic conductivity may be greater in the Pleistocene valley trains than in the Holocene alluvium. The different environmental settings during which the Pleistocene valley trains and the Holocene alluvium were deposited probably contributed to different hydrogeologic characteristics between these two deposits. Specific depositional features such as point bars in the Holocene alluvium may locally provide higher hydraulic conductivities and yields than the Pleistocene valley trains. In contrast, "clay-plugs" in the Holocene alluvium--abandoned meanders filled with fine sediment--(Saucier, 1994a, b; Saucier and Snead, 1989; Fisk, 1944; Gonthier and Mahon, 1994) impede horizontal ground-water flow within the alluvial aquifer (Bryant and Dowty, 1998).

Land Use

Land use in the Mississippi Alluvial Plain is mostly agriculture (80 percent) with some forest (16 percent), surface water (3 percent), and urban (1 percent) (fig. 3). The most significant land-use changes occurred during the 1940's and 1950's when forest land was cleared for agriculture. Agriculture in the Mississippi Alluvial Plain is predominantly row crops. The most common crops

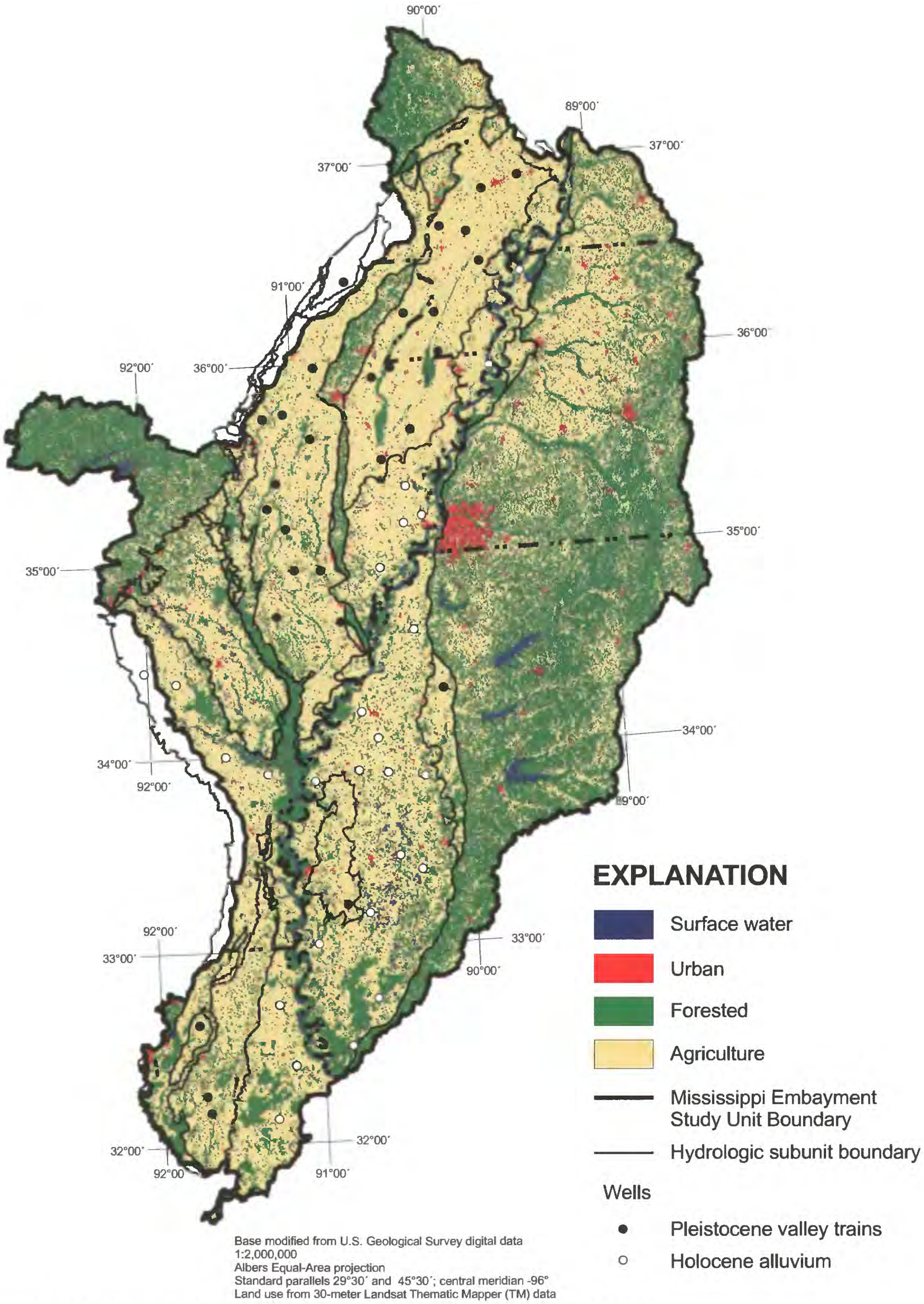

Figure 3. Land use in the Mississippi Embayment Study Unit, 1990's.

include rice, cotton, soybeans, corn, and sorghum. During the mid 1990's, cotton acreage decreased as much as 50 percent in some places and has been converted to other crops, mostly corn acreage (U.S. Department of Agriculture, 1997). Aquaculture, mostly catfish, is also a significant agricultural activity in the Mississippi Alluvial Plain that has increased over the last several years. Pecan-tree orchards constitute some of the agriculture in the southern part of the study area. Most of the forest land in the Mississippi Alluvial Plain occurs as isolated areas of hardwoods in publicly owned refuges and forests. Small areas were reforested within the Mississippi Alluvial Plain from the 1970's to the 1990's. Urban areas in the Mississippi Alluvial Plain consist of the local and interstate highway systems and small, rural communities. Surface water in the Mississippi Alluvial Plain includes the Mississippi, Arkansas, White, St. Francis, and Yazoo Rivers, oxbow lakes of these rivers, and other smaller rivers.

Pesticide Application

Pesticides in water supplies have been of concern since before 1972 when the manufacture and usage of DDT was banned in the United States. Many different pesticides are used today for controlling the plants, insects, and fungi that inhibit the growth of crops, obscure rights-of-way, create a nuisance, and threaten human health. Pesticides have widely varying chemical and physical properties and have a tendency to reside in the soil zone (Hem, 1985). Herbicides generally are more soluble than other pesticides, and are more likely to infiltrate into ground water (R.H. Coupe, U.S. Geological Survey, oral commun., 1999).

Annual pesticide application rate on agricultural land within the Mississippi Alluvial Plain was estimated to be 33 million pounds or about an average of 2.3 lb/acre during the index years from 1987 to 1991 (Gianessi and Puffer, 1990, 1992a, b). Most of the pesticides applied were herbicides. Herbicide application rate on agricultural land within the Mississippi Alluvial Plain during the index years was estimated to be 25 million pounds or about an average of 1.7 lb/acre. The herbicide most heavily used was propanil. The average application rate of propanil was 0.32 lb/acre. Other herbicides commonly used on agricultural land within the Mississippi Alluvial Plain included MSMA, trifluralin, metolachlor, molinate, pendimethalin, fluometuron, alachlor, and atrazine. Average application rates for these herbicides were between 0.07 and 0.19 lb/acre. Bentazon and 2,4-D were also used on agricultural land within the Mississippi Alluvial Plain both at an average of 0.03 lb/acre (Gianessi and Puffer, 1990, 1992a, b).

The insecticide application rate on agricultural land within the Mississippi Alluvial Plain during the index years was estimated to be 6.8 million pounds or about an average of 0.47 lb/acre. The insecticide most heavily used was methyl parathion, which was applied at an average rate of 0.11 lb/acre. Other insecticides commonly used included thiodicarb, profenofos, acephate, sulprofos, and dicrotophos. Average application rates for these insecticides were between 0.02 and 0.05 lb/acre (Gianessi and Puffer, 1990, 1992a, b).

The fungicide application rate on agricultural land within the Mississippi Alluvial Plain during the index years was estimated to be 1.3 million pounds or about an average of 0.09 lb/acre. The fungicide most heavily used was benomyl, which was applied at an average rate of 0.03 lb/acre. Other fungicides commonly used included PCNB, sulfur, and mancozeb. Average application rates for these fungicides were between 0.01 and 0.02 lb/acre.

The pesticide application rates reported here are for agricultural land use only. Therefore, actual pesticide usage in the Mississippi Embayment Study Unit is likely greater. Data from Gianessi and Puffer (1990, 1992a, b) do not include pesticide usage in urban settings. Barbash and Resek (1996) note that pesticide usage in urban settings is substantial.

STUDY DESIGN, DATA COLLECTION, AND DATA ANALYSIS

The design and data-collection methods used for this study were similar to those used in other NAWQA study units. Lapham and others (1995) described site selection and well documentation, and Koterba and others (1995) describe ground-water sample-collection methods for the NAWQA Program. The alluvial aquifer study comprises two "study-unit surveys," the Holocene alluvium and the Pleistocene valley trains. A study-unit survey is one of three NAWQA ground-water study components. The objective of a study-unit survey is to determine the occurrence and distribution of ground-water quality within a hydrogeologic setting. The selection of wells for a study-unit survey is not targeted to any specific land use.

Ground-Water Sampling Network

A sampling network was designed to obtain an unbiased evaluation of the ground-water resources in the Holocene alluvium and Pleistocene valley trains of the Mississippi River Valley alluvial aquifer. A geographical information system (GIS) based computer program (Scott, 1990) was used to randomly locate sites to find nearby wells screened in the alluvial aquifer. A 3-mi buffer was placed between the Holocene alluvium and the Pleistocene valley trains to prevent the selection of sites near hydrogeologic contacts. The GIS program uses an equal-area method to select sampling locations that are scattered throughout the study area. Stringent criteria were used to select the best available wells. Wells selected for sampling in the alluvial aquifer were to have a driller's report and to have a spigot near the well head prior to any treatment or holding tank. Public- and domestic-supply wells were preferred for sampling. Twenty-five of the selected wells were screened in the Holocene alluvium; 29 wells were screened in the Pleistocene valley trains (table 2).

Collection of Site Information

Site characteristic information, including location, land-surface altitude, land use, well depth, well use, casing type, and pump type, was collected at all sites. Well plumbing and sample set up methods were also documented. Most water-level values were estimated. Measured water-levels at four wells were less than 7 ft different from estimated water levels. Latitude and longitude were determined for each well by using global positioning system (GPS) equipment. Latitude and longitude determinations are relative to the North American Reference Datum 1983 (NAD83) and are accurate to within one second.

Well-head condition and land use within 164 and 1,640 ft of each well were documented during summer 1998. The area immediately surrounding a well was inspected for possible contamination hazards including the presence of oil spills, dead vegetation, bore holes, construction projects, gas stations, oil production wells, swimming pools, and pesticide mixing operations. Land-use categories include row crop, aquaculture, pasture, residential, commercial-community, light industrial, low development parks (such as playgrounds and ball fields), vacant land, transportation, utilities, rangeland (young perennial vegetation), forest, wetland, and surface water. Land use within 164 ft of each well was mapped on site by direct observation. Land use within 1,640 ft of each well was delineated by using aerial photographs from the early to mid 1990's, 7-1/2 minute topographic maps, and by direct observation while driving within the 0.3-mi^2 radius. Land-use percentages within 1,640 ft of each well were determined by using a NAWQA standardized GIS technique (Harvey and others, 1996). Land-use percentages are listed in Appendix 1 tables 1-13a through 1-14b.

Table 2. Selected information for sampled wells screened in the Holocene alluvium and Pleistocene valley trains of the Mississippi River Valley alluvial aquifer, 1998

[D M S, Degrees, minutes, seconds; ft, feet; bls, below land surface; --, no data available; PVC, polyvinyl chloride; QA, quality assurance samples that were collected; -, no quality assurance sample; S, pesticide and volatile organic compound QA samples were spiked in the field; R, replicate QA samples for most constituents were collected; B, field-equipment blank QA samples were collected; gal, gallons]

Station number (refers to fig. 1)	Location information: North latitude (D M S)	Location information: West longitude (D M S)	Location information: Land-surface altitude (ft)	Sample information: Well depth (ft)	Sample information: Sample date (1998)	Sample information: Depth to water (ft bls)	Sample information: Well use	Sample information: Casing material	Sample information: Sampler type	Sample information: Remarks	Sample information: QA data
Wells screened in the Holocene alluvium											
HA-3	34 00 21	91 32 05	166	100	July 28	31	Irrigation	PVC	Spigot		-
HA-4	34 23 08	91 49 58	205	110	July 27	38	Irrigation	PVC	Irrigation cross		-
HA-5	34 26 56	92 01 39	221	100	July 16	23	Irrigation	Steel	Irrigation cross		S
HA-6	33 54 42	91 16 42	154	105	July 30	33	Irrigation	Steel	Alfalfa valve		-
HA-7	33 51 53	90 58 34	146	116	June 25	25	Agriculture	--	Special fitting		-
HA-8	33 01 42	91 00 08	110	110	June 24	12	Commercial	PVC	Spigot	Tank, 100 gal	-
HA-9	32 43 09	91 16 29	90	96	May 14	10	Irrigation	PVC	Irrigation cross	Air entrained	-
HA-10	32 23 59	91 11 07	80	128	May 11	7	Public supply	Steel	Spigot		-
HA-11	32 07 31	91 18 16	76	77	May 18	8	Domestic	PVC	Spigot	Tank, 10 gal	-
HA-12	32 29 35	90 49 00	95	200	May 20	13	Domestic	PVC	Spigot	Tank, 15 gal	-
HA-15	33 54 20	90 41 50	147	150	June 04	40	Church	PVC	Spigot	Tank line	-
HA-16	34 12 33	90 39 36	164	60	June 24	21	Domestic	PVC	Spigot	Tank, 10 gal	-
HA-17	35 09 45	90 19 40	209	110	July 13	29	Irrigation	Steel	Spigot		-
HA-18	34 56 28	90 29 57	201	100	July 14	18	Irrigation	Iron	Irrigation cross		-
HA-19	34 04 14	90 34 05	160	80	June 25	39	Irrigation	PVC	Irrigation cross		R
HA-20	33 53 18	90 30 30	141	112	June 23	33	Irrigation	Steel	Alfalfa valve		-
HA-21	33 10 37	90 40 45	106	110	June 02	30	Aquaculture	Steel	Alfalfa valve		-
HA-22	32 43 55	90 39 18	96	100	June 11	14	Irrigation	PVC	Irrigation cross		R
HA-25	33 52 08	90 16 55	148	100	June 23	13	Commercial	PVC	Irrigation cross		-
HA-26	34 37 04	90 18 09	187	112	June 10	25	Aquaculture	Steel	Special fitting		-
HA-27	35 12 04	90 12 40	216	125	July 13	23	Irrigation	PVC	Irrigation cross		B
HA-28	35 21 04	90 18 23	220	60	July 14	28	Irrigation	Iron	Alfalfa valve		-
HA-29	35 56 39	89 43 02	256	85	July 20	10	Dewater	PVC	Irrigation cross		-
HA-30	36 25 01	89 29 00	305	100	July 23	22	Irrigation	Steel	Spigot		-
HA-31	33 27 30	90 28 05	119	100	July 29	47	Aquaculture	Steel	Alfalfa valve	Open to sky	B, S

Table 2. Selected information for sampled wells screened in the Holocene alluvium and Pleistocene valley trains of the Mississippi River Valley alluvial aquifer, 1998--Continued

Station number (refers to fig. 1)	Location information			Sample information							
	North latitude (D M S)	West longitude (D M S)	Land-surface altitude (ft)	Well depth (ft)	Sample date (1998)	Depth to water (ft bls)	Well use	Casing material	Sampler type	Remarks	QA data
Wells screened in aquifers beneath the Holocene alluvium											
HA-01	32 46 10	91 43 49	97	255	May 19	63	Public supply	Steel	Spigot		R
HA-23	33 04 13	90 19 25	108	--	June 03	--	Commercial	Steel	Spigot		B, S
Wells screened in the Pleistocene valley trains											
VT-01	32 10 13	91 43 16	67	79	May 13	12	Public supply	Steel	Spigot		-
VT-02	32 15 47	91 44 33	73	40	May 13	13	Domestic	PVC	Spigot	Tank, 5 gal	B
VT-03	32 37 26	91 46 22	90	110	May 12	17	Public supply	Steel	Spigot		S
VT-04	34 42 42	91 10 32	182	110	June 09	30	Irrigation	PVC	Irrigation cross		S
VT-05	35 15 50	91 12 01	204	127	June 15	15	Public supply	Iron	Spigot		-
VT-06	35 43 41	91 12 08	240	102	June 17	14	Public supply	Steel	Spigot		-
VT-07	35 44 56	91 04 18	243	100	June 17	40	Irrigation	PVC	Irrigation cross		B
VT-08	35 23 38	91 08 05	220	60	June 16	35	Irrigation	PVC	Irrigation cross		-
VT-09	35 09 45	91 05 13	217	150	June 18	61	Irrigation	PVC	Irrigation cross	Hole nearby	-
VT-10	34 56 49	91 02 47	208	130	July 06	64	Irrigation	PVC	Irrigation cross		-
VT-11	33 12 58	90 48 48	106	131	June 24	22	Aquaculture	Steel	Alfalfa valve		S
VT-13	34 40 25	90 46 04	210	120	July 15	20	Irrigation	PVC	Irrigation cross		R
VT-14	34 56 26	90 52 29	214	120	July 09	47	Irrigation	PVC	Irrigation cross		-
VT-15	35 36 58	90 54 08	248	180	June 16	95	Public supply	Iron	Spigot		-
VT-16	35 58 39	90 51 50	261	120	July 01	46	Public supply	Iron	Spigot		-
VT-17	36 24 45	90 37 29	292	104	June 29	20	Aquaculture	Steel	Spigot	Tank, 100 gal	-
VT-18	36 14 12	90 15 03	260	100	June 30	12	Domestic	--	Spigot	Tank, 200 gal	-
VT-19	35 58 13	90 21 38	238	100	July 07	11	Irrigation	Steel	Special fitting		-
VT-20	35 55 17	90 28 57	237	110	June 30	17	Irrigation	PVC	Irrigation cross		B
VT-21	35 38 42	90 14 58	228	110	July 08	20	Irrigation	Steel	Alfalfa valve		-
VT-22	35 29 38	90 26 56	216	120	July 08	25	Irrigation	Steel	Irrigation cross		-
VT-23	34 18 27	90 08 05	170	110	June 10	16	Aquaculture	Steel	Special fitting		-
VT-24	36 01 48	90 02 38	240	95	July 07	6	Irrigation	Steel	Irrigation cross		-
VT-25	36 13 59	90 03 10	266	145	July 23	6	Public supply	Steel	Spigot		-
VT-26	36 28 58	89 44 09	272	25	July 22	7	Aquaculture	PVC	Irrigation cross		-
VT-27	36 38 07	89 48 50	282	100	July 22	6	Irrigation	Steel	Irrigation cross		R
VT-28	36 39 56	89 58 42	299	109	July 21	10	Public supply	Steel	Spigot		-
VT-29	36 50 47	89 41 30	299	186	July 21	--	Public supply	Steel	Spigot		R
VT-30	36 54 34	89 26 44	321	100	July 20	15	Public supply	Steel	Spigot		-

Ground-Water Sample Collection and Analysis

Analyses of water samples from the 54 wells screened in the alluvial aquifer include major ions (calcium, magnesium, sodium, iron, potassium, manganese, bicarbonate, sulfate, chloride, fluoride, and bromide), nutrients (nitrite, nitrite-plus-nitrate, ammonia, ammonia-plus-organic nitrogen, phosphorus, and orthophosphate), dissolved organic carbon (DOC), 18 trace elements including iron, 83 pesticides, 85 VOCs, radon, tritium, and stable oxygen and hydrogen isotopes. Water samples from 27 wells were analyzed for 30 additional pesticides or degradation products. Water samples from 22 wells were analyzed for radium-226. Field parameters (turbidity, water temperature, pH, specific conductance, dissolved oxygen, alkalinity, turbidity, ferrous iron, and sulfide) were measured at all sites. Methods used to perform the analyses are listed in table 3. Ground-water quality data are presented in Appendix 1.

Water samples were collected from 27 irrigation wells, 11 public-supply wells, 7 aquaculture wells, 5 domestic wells, 2 commercial wells, a church well, and a dewatering well near a subsurface structure. Water samples were collected from 22 wells through a spigot, from 21 wells through a high-yield open-pipe discharge using an "irrigation cross," from 7 wells with "alfalfa valves" through a specially designed alfalfa-valve cover, and from 4 wells through custom designed fittings. All sampling procedures were designed to capture ground water into a fluoropolymer tube with stainless steel fittings prior to the water reaching atmosphere. Each well was sampled once.

Quality-Assurance Data Collection

Quality-assurance samples were collected at 16 locations and included field-equipment blanks, source-solution blanks, replicate samples, and field spiked samples (Appendix 1). Six field-equipment blanks were collected for major ions, trace elements, and pesticides. Six field-equipment blanks and source-solution blanks were collected for nutrients, DOC, and VOCs. Replicate samples of major ions, nutrients, DOC, trace elements, radon, and stable isotopes were collected at five wells. Manganese was analyzed from both major ion and trace element samples (Appendix 1 tables 1-2a and 1-2b and 1-6a and 1-6b) so that replicate analyses of manganese were performed for all wells. Triplicate samples were spiked in the field with pesticides at six wells. Duplicate samples were spiked in the field with VOCs at six wells.

Data were statistically analyzed for quality assurance. Water from all wells had cation-anion equivalent differences of less than 10 percent. Data from blanks indicated that contamination from field equipment did not significantly contribute to the concentrations of constituents found in water from wells with the possible exceptions of aluminum and zinc. Minor contamination of aluminum and zinc in blanks required that the reporting limits used in the data summary for these two constituents were raised from the laboratory reporting limit of 1 μg/L to 5 μg/L. Tebuthiuron was the only pesticide detected in a field-equipment blank, but it was not detected in any of the water samples. No VOCs were detected in field-equipment blanks that were not also detected in the accompanying source solution blank. Data from replicates indicated that most sampling results were reproducible with values of variability that were usually similar to field-equipment blank concentrations. Exceptions were bromide, phosphorus, and orthophosphate, which had replicate values that differed by 50 percent.

Field-spike data indicated that most pesticides had recoveries that generally were between 60 and 140 percent. But most pesticides also had some recoveries less than 60 percent. *p,p'*DDE, disulfoton, deethylatrazine, terbufos, acifluorfen, aldicarb sulfoxide, carbaryl (using liquid chromatography with UV detection), chloramben, dichlobenil, MCPB, oxamyl, and propham frequently had recoveries less than 60 percent. Aldicarb, aldicarb sulfone, chlorothalonil, clopyralid, and cis-permethrin consistently had recoveries less than 60 percent. Linuron had some recoveries greater

Table 3. Laboratory analysis methods for measured water-quality constituents, Mississippi River Valley alluvial aquifer, 1998

[VOCs, volatile organic compounds; DOC, dissolved organic carbon]

Constituent or constituent group	Analysis method	Reference
Turbidity, whole water	Nephelometric turbidity units, spectrophotometry, Method EPA 180.1	HACH (1997)
Ferrous iron, whole water	1, 10 Phenanthroline Method, spectrophotometry	HACH (1997)
Sulfide, whole water	Methylene Blue Method, spectrophotometry, Method EPA 376.2	HACH (1997)
Major ions, water	Atomic absorption spectrometry	Fishman and Friedman (1989)
Nutrients, water	Colorimetry	Fishman and Friedman (1989)
DOC, water	UV-promoted persulfate oxidation and infrared spectrometry	Brenton and Arnett (1993)
Trace elements, water	Atomic absorption spectrometry	Fishman and Friedman (1989)
Pesticides, water	Gas chromatography/mass spectrometry	Zaugg and others (1995)
Pesticides, water	Liquid chromatography with UV detection	Werner and others (1996)
Pesticides and degradation products, water	Gas chromatography/mass spectrometry	Zimmerman and Thurman (1999)
VOCs, water	Purge and trap capillary gas chromatography/mass spectrometry	Rose and Schroeder (1995)
Radon-222, water	Liquid scintillation, 100-minute counting time	American Society for Testing and Materials (1995)
Radium-226, water	Radon emanation technique, Method EPA 903.1	U.S. Environmental Protection Agency (1980)
Tritium, water	Electrolytic enrichment with gas counting	Ostlund and Dorsey (1975)
Oxygen-18, water	For oxygen-18: Equilibration with gaseous CO_2 and mass spectrometry	Epstein and Mayeda (1953)
Deuterium-2, water	For deuterium-2: Equilibration with hydrogen and mass spectrometry	Coplen and others (1991)

than 140 percent and some recoveries less than 60 percent. Methyl azinphos, carbaryl (using gas chromatography/mass spectrometry), and carbofuran consistently had recoveries greater than 140 percent.

Spike recoveries for all VOCs averaged about 64 percent. Twenty-seven VOCs had recoveries consistently less than 60 percent. Carbon disulfide and iodomethane had the lowest recoveries of all VOCs, less than 50 percent. Acetone had the greatest recovery, about 107 percent. Variance in VOC recoveries were greater between spikes than within duplicate spikes.

Statistical Methods for Data Analysis

Data were statistically analyzed by using methods presented by Helsel and Hirsch (1992). Box plots, and scatter plots were used to graphically present the data. LOcally WEighted Scatterplot Smoothing (LOWESS) was used to summarize trends on scatter plots (Cleveland, 1979). The nonparametric Wilcoxon rank-sum test was used to indicate the difference between groups of water samples collected in wells in either the Holocene alluvium or the Pleistocene valley trains. Sample sizes of groups of data ranged from 12 to 29. Statistical techniques accounted for the effects of small sample size. The medians of the groups were assumed to be significantly different from one another if the probability that the observed difference occurs by chance (p-value) was less than 5 percent (<0.05). Kendall's tau was used to indicate the strength of monotonic correlation between concentrations of constituents in samples. In this study, one constituent or property was considered correlated to another if the p-value associated with the Kendall's tau test was less than 0.05. Some statistically "nonsignificant" differences or correlations are indicated in the text when the p-values were close to, but greater than, 0.05.

Holding tanks on wells possibly affected the concentrations of some trace elements, VOCs, and radium-226. The results of these constituents in water from these wells were included in Appendix 1, the summary tables, and interpretation in this report. The wells that had holding tanks prior to the sample collection point are listed in table 2. Water temperature, which was affected by sunlight, was included in Appendix 1 and summary tables.

GROUND-WATER QUALITY

Results of measurements of field parameters and analyses of major ions, nutrients, trace elements, pesticides, VOCs, radon, radium, tritium, and stable isotopes are summarized in this section of the report. The water-quality data set is provided in tables in Appendix 1.

Field Parameters

Field parameters measured during sampling included: depth to water, turbidity, water temperature, pH, specific conductance, dissolved oxygen, alkalinity, ferrous iron, and sulfide. A summary of field-parameter measurements is listed in table 4. Turbidity was less than 30 NTU (nephelometric turbidity units) indicating that most water was clear. Some turbidity was from the oxidation of ferrous iron into ferric iron oxide particles suspended in the water sample after the water sample was exposed to the atmosphere. Samples were collected during hot summer days. Based on measurements taken at nine wells, water temperature increased by between 0.4 and 2.2 °C as water flowed from the well head to the sample chamber. The water temperature was not used for interpretation in this report. Actual water temperatures were less than or equal to the values summarized in table 4 and in Appendix 1 tables 1-1a and 1-1b. Water from 22 wells had detectable concentrations of oxygen. Water from seven wells simultaneously had ferrous iron (greater than 100 µg/L) and dissolved oxygen (greater than 0.2 mg/L), indicating the possibility that air was entraining into the water prior to reaching the sampling point.

Some field-parameter values were significantly different in water from wells screened in the Holocene alluvium compared to water from wells screened in the Pleistocene valley trains. Values

Table 4. Summary of field-parameter data for water from 25 wells screened in the Holocene alluvium and for water from 29 wells screened in the Pleistocene valley trains of the Mississippi River Valley alluvial aquifer, 1998

[Data are in Appendix 1, table 1-1a and 1-1b; NTU, nephelometric turbidity units; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter]

Field parameter	Units	Minimum	Median	Maximum
Mississippi River Valley alluvial aquifer (54 wells) including the 25 wells screened in the Holocene alluvium and the 29 wells screened in the Pleistocene valley trains				
Water level below land surface	Feet	0	20	95
Turbidity	NTU	0.07	0.4	26.4
Water temperature[1]	°C	15	18.3	23.5
pH	pH units	6.3	7.1	7.9
Specific conductance	µS/cm at 25°C	256	593	1,340
Dissolved oxygen concentration	mg/L	<0.1	<0.1	5.9
Alkalinity	mg/L as $CaCO_3$	92	277	473
Ferrous iron	µg/L	<1	3,000	15,900
Sulfide	mg/L	<0.001	0.009	0.038
Wells screened in the Holocene alluvium of the Mississippi River Valley alluvial aquifer (25 wells)				
Water level below land surface	Feet	7	23	47
Turbidity	NTU	0.07	0.67	26.4
Water temperature[1]	°C	16.5	18.5	23.5
pH	pH units	6.6	7.0	7.2
Specific conductance	µS/cm at 25°C	376	619	1,240
Dissolved oxygen concentration	mg/L	<0.1	<0.1	0.7
Alkalinity	mg/L as $CaCO_3$	190	299	473
Ferrous iron	µg/L	600	5,300	15,900
Sulfide	mg/L	<0.001	0.012	0.038
Wells screened in the Pleistocene valley trains of the Mississippi River Valley alluvial aquifer (29 wells)				
Water level below land surface	Feet	0	16.9	95
Turbidity	NTU	0.07	0.3	2.
Water temperature[1]	°C	15	17.5	22
pH	pH units	6.3	7.1	7.9
Specific conductance	µS/cm at 25°C	256	525	1,340
Dissolved oxygen concentration	mg/L	<0.1	<0.1	5.9
Alkalinity	mg/L as $CaCO_3$	92	237	427
Ferrous iron	µg/L	<1	2,210	7,200
Sulfide	mg/L	<0.001	0.009	0.029

[1] Water temperature was affected by sunlight.

of pH are greater in the Pleistocene valley trains than in the Holocene alluvium (p-value = 0.0015). Median values of specific conductance and alkalinity are greater in the Holocene alluvium than in the Pleistocene valley trains (p-values were 0.025 and 0.0025, respectively).

Major Ions

Major ions usually determine some basic chemical characteristics of water such as taste and hardness. Calcium and magnesium contribute to hardness of water which is an indicator of water's ability to form insoluble residues with soaps and to form scale in plumbing features associated with heating water (Hem, 1985). Dissolved solids can affect the suitability of water for drinking purposes. Iron and manganese can cause staining to plumbing and laundry. Low concentrations of fluoride can help prevent tooth decay. Major ions analyzed in sample water were calcium, magnesium, sodium, iron, potassium, manganese, silica, bicarbonate, sulfate, chloride, fluoride, and bromide. Dissolved solids concentrations were also determined.

Calcium was the dominant cation averaging 56 percent of the cation equivalents (table 5). Magnesium and sodium averaged 26 and 13 percent of the cation equivalents, respectively. Iron was also a major cation, averaging 3.7 percent of the cation equivalents. Bicarbonate was the dominant anion, averaging 84 percent of the anion equivalents. Sulfate and chloride averaged 8.1 and 7.8 percent of the anion equivalents, respectively. Fifty-three wells had a calcium bicarbonate type water; one well in the southern part of the study area (VT-01) had a mixed to sodium chloride type water. The water from most wells was hard.

Table 5. Summary of major-ion concentrations in water from 25 wells screened in the Holocene alluvium and in water from 29 wells screened in the Pleistocene valley trains of the Mississippi River Valley alluvial aquifer, 1998

[Data are in Appendix 1, tables 1-2a through 1-3b. Concentrations are in milligrams per liter. Iron is assumed to have a valence of 2 in calculating equivalent percentage; 0.4 percent of the cation equivalents is assumed to be from ammonia; --, not applicable]

Major constituents	Equivalents of cations and anions (percent)	Minimum	Median	Maximum
Mississippi River Valley alluvial aquifer (54 wells) including the 25 wells screened in the Halocene alluvium and the 29 wells screened in the Pleistocene valley trains				
Cations				
Calcium	56.1	28	72	130
Magnesium	25.5	6.5	22	45
Sodium	13.1	4.2	13.5	125
Iron	3.7	<0.01	6.2	19.4
Potassium	0.9	0.7	2.3	4.4
Manganese	0.3	<0.004	0.579	1.93
Anions				
Bicarbonate, as HCO_3	83.9	112	338	577
Sulfate	8.1	<0.1	19.5	120
Chloride	7.8	2.1	7.2	230
Fluoride	<0.2	<0.1	0.22	0.37
Bromide (42 wells)	<0.05	0.013	0.092	0.84
Other				
Silica, as SiO_2	--	21	32	45
Dissolved solids	--	167	343	730

Table 5. Summary of major-ion concentrations in water from 25 wells screened in the Holocene alluvium and in water from 29 wells screened in the Pleistocene valley trains of the Mississippi River Valley alluvial aquifer, 1998--Continued

Major constituents	Equivalents of cations and anions (percent)	Minimum	Median	Maximum
Wells screened in the Holocene alluvium of the Mississippi River Valley alluvial aquifer (25 wells)				
Cations				
Calcium	55.8	49	77	130
Magnesium	26.3	12	24	33
Sodium	11.6	4.5	13	77
Iron	5.1	4.8	9.7	19.4
Potassium	0.9	1.5	2.6	4.4
Manganese	0.3	0.157	0.583	1.370
Silica, as SiO_2		22	33	45
Anions				
Bicarbonate, as HCO_3	87.1	232	365	577
Sulfate	6.0	<0.1	5.4	120
Chloride	6.7	2.1	6.4	140
Fluoride	<0.2	0.12	0.26	0.36
Bromide (16 wells)	<0.05	0.046	0.098	0.48
Other				
Dissolved solids	--	224	355	728
Wells screened in the Pleistocene valley trains of the Mississippi River Valley alluvial aquifer (29 wells)				
Cations				
Calcium	56.9	28	67	120
Magnesium	24.9	6.5	15	45
Sodium	14.7	4.2	14	125
Iron	2.3	<0.01	3.8	10.7
Potassium	0.8	0.7	1.9	4
Manganese	0.4	<0.004	0.563	1.93
Anions				
Bicarbonate, as HCO_3	77.8	112	289	521
Sulfate	11.8	4.1	24	75
Chloride	10.1	2.6	8.9	230
Fluoride	<0.2	<0.1	0.16	0.37
Bromide (26 wells)	<0.05	0.013	0.088	0.84
Other				
Silica, as SiO_2	--	21	32	42
Dissolved solids	--	167	313	730

Manganese concentrations exceeded the USEPA secondary maximum contaminant level (SMCL) of 50 µg/L in 52 wells; iron concentrations exceeded the SMCL of 300 µg/L in 49 wells; dissolved solids exceeded the SMCL of 500 mg/L in 10 wells.

Median concentrations of major ions in water from the Holocene alluvium were different from those of water from the Pleistocene valley trains. Median concentrations of dissolved solids, calcium, magnesium, potassium, bicarbonate, and fluoride were greater in water from the Holocene alluvium than in water from the Pleistocene valley trains (fig. 4). Median concentrations of sulfate and chloride were greater in water from wells screened in the Pleistocene valley trains than in water from wells screened in the Holocene alluvium (fig. 4).

Magnesium concentrations increased with increasing calcium concentration in water from the alluvial aquifer (Kendall's tau = +0.64, p-value <0.00005; fig. 5). Also, magnesium concentrations increased with calcium concentration in water from both the Holocene alluvium and the Pleistocene valley trains (Kendall's tau values = +0.65 and +0.67, respectively; p-values are <0.00005). Still, the relation between magnesium and calcium in water from the Holocene alluvium was different from the relation between magnesium and calcium in water from the Pleistocene valley trains (fig. 5). The rate of the increase of magnesium concentrations decreased with increasing calcium concentration in water from the Holocene alluvium. In contrast, the rate of the increase of magnesium concentrations increased with increasing calcium concentration in water from the Pleistocene valley trains. The resulting LOWESS smoothing curves on graphs in figure 5 are different between the two hydrogeologic subunits. The relation between calcium and magnesium concentration in water from wells in the Holocene alluvium is illustrated by a convex, LOWESS smoothing curve. In contrast, the relation between calcium and magnesium concentration in water from wells in the Pleistocene valley trains is illustrated by a concave, LOWESS smoothing curve.

Concentrations of major ions measured during this study (summarized in table 5) are similar to concentrations measured in previous studies of the alluvial aquifer (Pettijohn and others, 1992). The ratios of magnesium to calcium in water from the 54 wells sampled during this study (from 0.27 to 0.77) were also similar to the ratios reported by Pettijohn and others (1992). Some of the water-quality variation that was reported by Pettijohn and others (1992) was not detected in water from the 54 wells sampled during this study. For example, rare places in the alluvial aquifer occur where the water type is sodium bicarbonate, magnesium bicarbonate, or sodium chloride. A small area in southeastern Arkansas has concentrations of dissolved solids and chloride greater than 1,000 and 500 mg/L, respectively. This area of elevated dissolved solids concentrations in southeastern Arkansas comprises a sodium chloride type water. Fitzpatrick (1985) delineated this area in detail. Pettijohn and others (1992) also report elevated concentrations of dissolved solids and chloride in the extreme southern part of the study area where well VT-01 had mixed to sodium chloride type water.

Nutrients and Dissolved Organic Carbon

Nutrients can affect human health and can be associated with other surface derived contaminants. Nutrients discussed in this report consist of the chemical species of nitrogen and phosphorus. Nitrate in water can promote the growth of pathogens that may cause gastrointestinal related illness. Elevated concentrations of nitrate nitrogen in drinking water (exceeding the MCL of 10 mg/L) have been associated with methemoglobinemia or "blue-baby" syndrome and with increased rates of stomach cancer (Dorsch and others, 1984; Forman and others, 1985; Fan and others, 1987; National Research Council, 1985). Organic carbon can promote decreased dissolved oxygen concentrations, which in turn can affect the nutrient species and other constituents present in water.

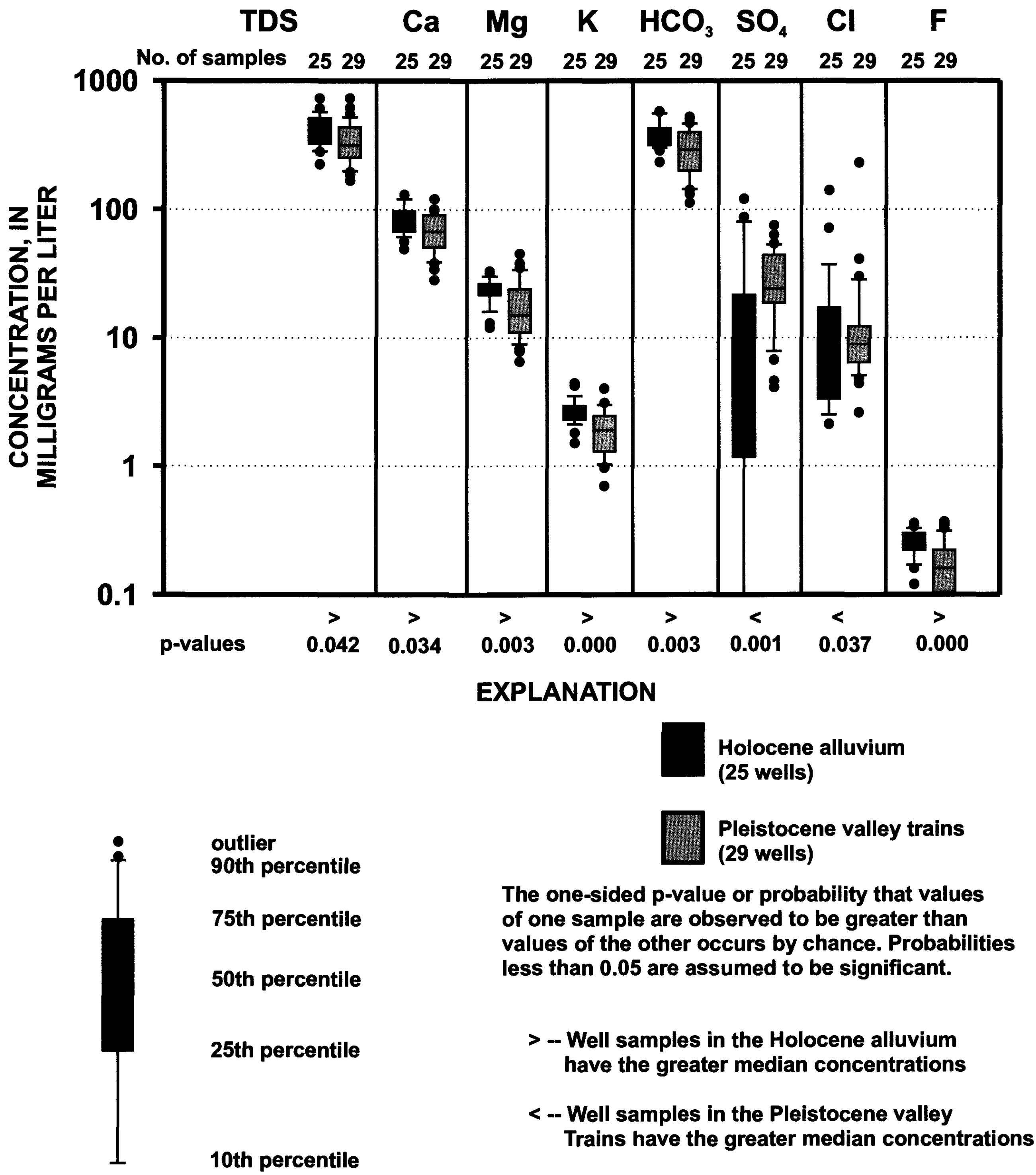

Figure 4. Dissolved solids, calcium, magnesium, potassium, bicarbonate, sulfate, chloride, and fluoride concentrations in water from wells screened in the Mississippi River Valley alluvial aquifer by hydrogeologic subunit, 1998.

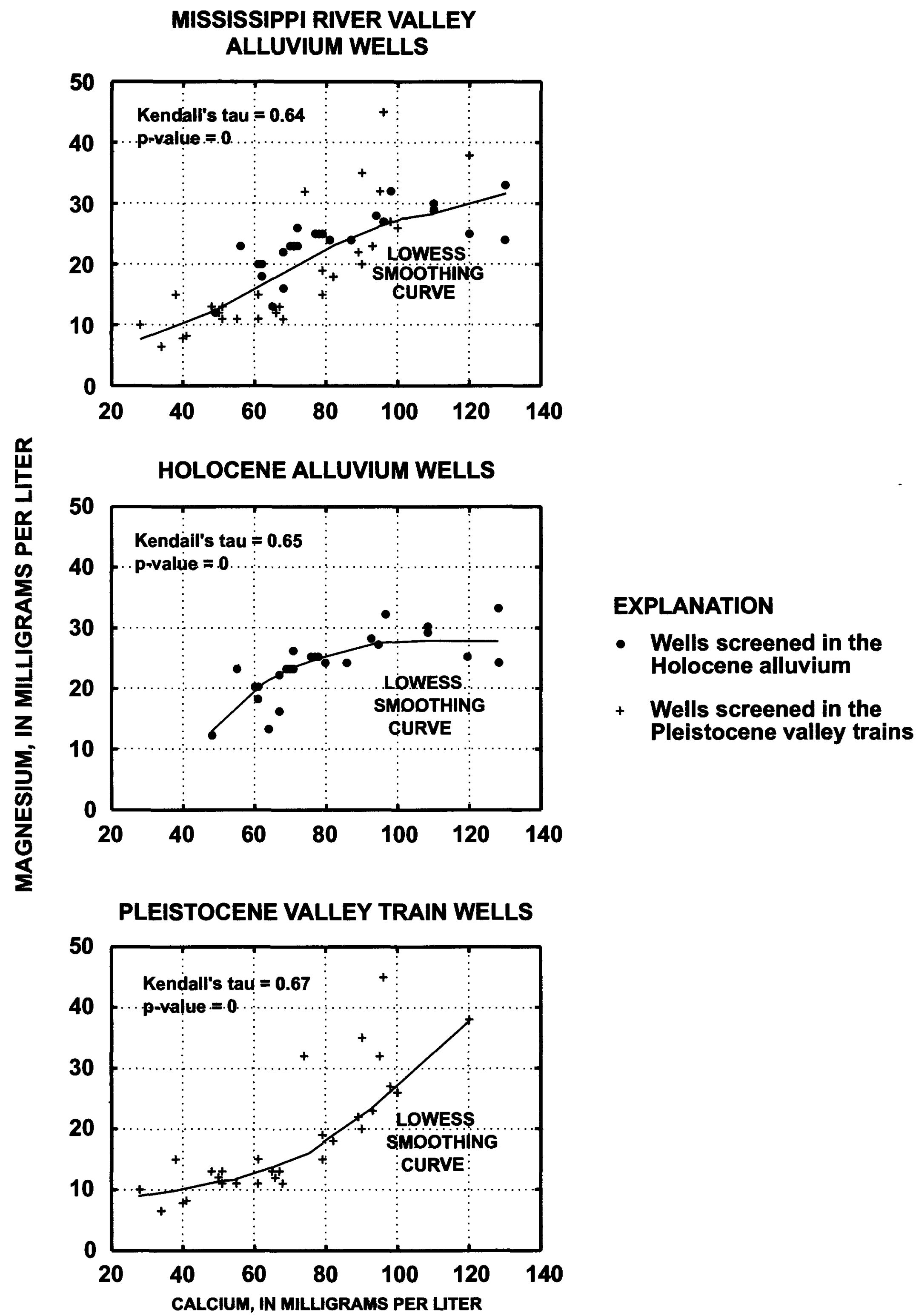

Figure 5. Relation of magnesium concentration with calcium concentration in water from 25 wells screened in the Holocene alluvium and in water from 29 wells screened in the Pleistocene valley trains of the Mississippi River Valley alluvial aquifer, 1998.

Ground-water samples were analyzed for nitrite, nitrite plus nitrate, ammonia, ammonia plus organic nitrogen, phosphorus, orthophosphate, and DOC. Nutrients were present in low concentrations in water from the alluvial aquifer (table 6). No nutrient concentrations exceeded MCLs. The most frequently detected nutrient was ammonia, which was detected in water from all 54 wells. Ammonia was the nutrient with the greatest concentration (2.64 mg/L), which was detected in a well screened in the Holocene alluvium (HA-06). The maximum concentration for nitrite plus nitrate nitrogen was 2.61 mg/L (VT-02). Nitrite was detected in water from 19 of 54 wells and had a maximum concentration of 0.059 mg/L (VT-19). The maximum concentration of DOC was 5.1 mg/L (HA-06). Median concentrations of ammonia, ammonia plus organic nitrogen, phosphorus, and DOC were greater in water from wells screened in the Holocene alluvium than in water from wells screened in the Pleistocene valley trains (fig. 6).

Table 6. Summary of nutrient and dissolved organic carbon concentrations in water from 25 wells screened in the Holocene alluvium and in water from 29 wells screened in the Pleistocene valley trains of the Mississippi River Valley alluvial aquifer, 1998

[Data are in Appendix 1,tables 1-4a and 1-4b; Concentrations are in milligrams per liter; --, the U.S. Environmental Protection Agency did not have a maximum contaminant level set for this constituent during the writing of this report. Maximum contaminant levels are from U.S. Environmental Protection Agency (1999)]

Constituent	Reporting limit	Number of detections	Median	Maximum concentration	Maximum contaminant levels
Mississippi River Valley alluvial aquifer (54) including the 25 wells screened in the Holocene alluvium and the 29 wells screened in the Pleistocene valley trains					
Nitrite as N	0.01	19	<0.01	0.059	1
Nitrite plus nitrate as N	0.05	16	<0.05	2.61	10
Ammonia as N	0.03	54	0.33	2.64	--
Ammonia plus organic nitrogen as N	0.1	41	0.33	3.1	--
Phosphorus[1]	0.01	47	0.22	1.32	--
Orthophosphate as P	0.02	46	0.066	1.0	--
Dissolved organic carbon	0.2	53	1.3	5.1	--
Wells screened in the Holocene alluvium of the Mississippi River Valley alluvial aquifer (25 wells)					
Nitrite as N	0.01	11	<0.01	0.038	1
Nitrite plus nitrate as N	0.05	7	<0.05	0.346	10
Ammonia as N	0.03	25	0.58	2.64	--
Ammonia plus organic nitrogen as N	0.1	24	0.64	3.1	--
Phosphorus[2]	0.01	21	0.745	1.32	--
Orthophosphate as P	0.02	22	0.085	0.885	--
Dissolved organic carbon	0.2	25	1.7	5.1	--
					--
Wells screened in the Pleistocene valley trains of the Mississippi River Valley alluvial aquifer (29 wells)					
Nitrite as N	0.01	8	<0.01	0.059	1
Nitrite plus nitrate as N	0.05	9	<0.05	2.61	10
Ammonia as N	0.03	29	0.14	1.5	--
Ammonia plus organic nitrogen as N	0.1	17	0.17	1.7	--
Phosphorus	0.01	26	0.112	1.03	--
Orthophosphate as P	0.02	24	0.049	1.0	--
Dissolved organic carbon	0.2	28	1.0	1.9	--

[1] Analyzed for in 51 wells.
[2] Analyzed for in 22 wells.

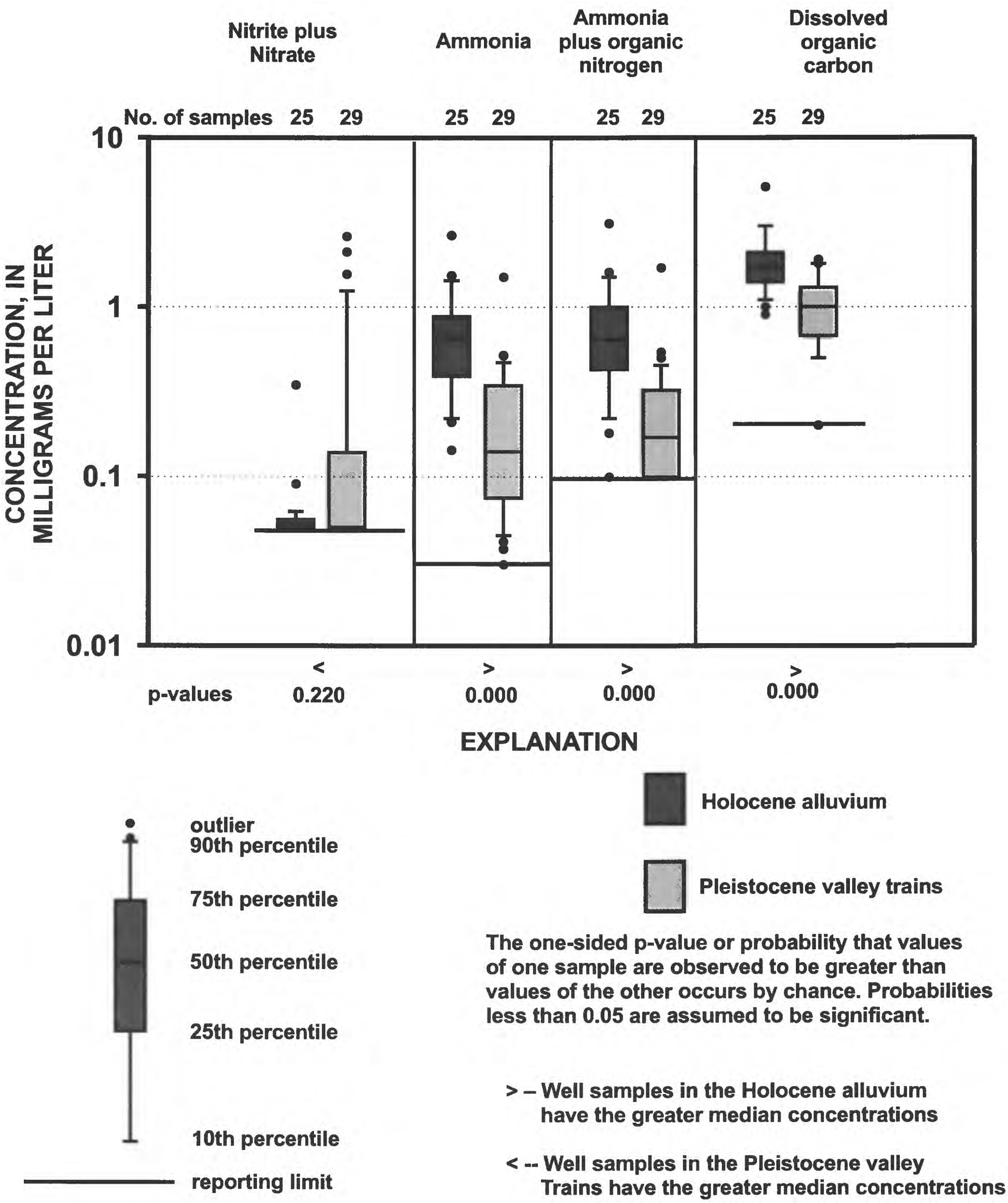

Figure 6. Nutrients and dissolved organic carbon concentrations in water from wells screened in the Mississippi River Valley alluvial aquifer by hydrogeologic subunit, 1998.

Reported nitrate concentrations of previous studies of wells in Missouri and Louisiana were compared to nitrate concentrations found in this study. Mesko and Carlson (1988) reported nitrate concentrations in water from wells in southeastern Missouri--often exceeding 5 mg/L, greater than nitrate concentrations in water from seven wells in southeastern Missouri in this study which were all less than 1 mg/L. Wells in the study reported by Mesko and Carlson (1988) were mostly shallow domestic wells (less then 50 ft deep). Whitfield (1975) reported nitrate concentrations in wells in northeastern Louisiana, ranging from 0 to about 6 mg/L, compared to nitrate concentrations in water from six wells in this study, ranging from <0.05 to about 2.5 mg/L.

Trace elements

Trace elements analyzed in water from the alluvial aquifer included: arsenic, aluminum, antimony, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, molybdenum, nickel, selenium, silver, uranium, and zinc (table 7). This diverse group of constituents is generally categorized as metals that naturally occur in ground water at concentrations significantly less than the natural concentrations of major ions in ground water. Within the group, some trace elements, such as iron and manganese, are much more abundant than the other trace elements, and are sometimes discussed with the major ions or classified as "minor elements" (Hem, 1985). Iron and manganese are discussed as both major ions and trace elements in this report and are reported in both tables 5 and 7.

A wide range of toxicity can be associated with different trace elements. The human body needs iron, copper, manganese, and zinc in trace quantities, whereas greater amounts of these elements in the body may be toxic. Other trace elements (such as arsenic, beryllium, and cadmium) are toxic even at trace quantities in the human body. Some of the more toxic trace elements (such as beryllium, cadmium, and lead) are cumulative, systemic poisons and are categorized as carcinogens. Chronic exposure to some trace elements (such as arsenic and lead) can cause damage to the digestive, respiratory, and nervous systems (Sittig, 1985).

Trace element concentrations in water from wells screened in the alluvial aquifer are summarized in table 7. Of the 18 analyzed trace elements, 13 were detected in water from wells screened in the Mississippi River Valley alluvial aquifer. Barium, iron, manganese, and chromium were detected in water from at least 96 percent of wells screened in the alluvial aquifer. Nine other trace elements were detected in water from at least one well screened in the alluvial aquifer: aluminum, arsenic, cobalt, copper, molybdenum, nickel, selenium, uranium, and zinc. The greatest concentration of a trace element, excluding iron, was 3,290 μg/L for zinc in water from VT-03. The greatest median concentration, excluding iron and manganese, was 438 μg/L for barium. Barium was detected in water from all 54 wells.

Water from one well (VT-11) had an arsenic concentration of 56 μg/L, which slightly exceeded the MCL of 50 μg/L for drinking water. The USEPA has revised the MCL for arsenic, reducing the MCL to 10 μg/L, effective 2006 January 23. The lowering of the arsenic MCL from 50 μg/L to 10 μg/L increases the number of wells that would exceed the MCL for arsenic from 1 to 5 wells, one of the added wells being a public-supply well. All other trace element concentrations were less than USEPA MCLs.

Concentrations of iron, barium, and chromium were greater in water from wells in the Holocene alluvium than in water from wells in the Pleistocene valley trains (fig. 7). Zinc was most frequently detected in the Holocene alluvium; selenium, copper, and aluminum, were detected in the Pleistocene valley trains but were not detected in the Holocene alluvium.

Previous investigations involved sampling for trace elements in water from the alluvial aquifer near some of the wells in this study. Mesko and Carlson (1988) reported arsenic, barium, iron, and manganese concentrations in water from wells in southeastern Missouri (median, <5; 410; 2,110; and 450 μg/L; respectively) that were similar to

Table 7. Summary of trace-element concentrations in water from 25 wells screened in the Holocene alluvium, and in water from 29 wells screened in the Pleistocene valley trains of the Mississippi River Valley alluvial aquifer, 1998

[Data for all these elements except for iron are in Appendix 1, tables 1-5a through 1-6b. Data for iron are in Appendix 1, tables 1-2a and 1-2b. Concentrations are in micrograms per liter. Maximum contaminant levels are from U.S. Enviornmental Protection Agency (2002); --, the U.S. Environmental Protection Agency did not have a maximum contaminant level set for this constituent during the writing of this report.]

Constituent	Reporting limit	Number of detections (percent detections)	Median	Maximum concentration	Maximum contaminant level
Mississippi River Valley alluvial aquifer (54 wells)					
Barium	1	54 (100)	438	877	2,000
Iron	10	53 (98)	6,200	19,400	300[1]
Manganese	4	52 (96)	588	1,930	50[1]
Chromium	1	52 (96)	3.1	8.1	100
Arsenic	1	35 (65)	2	56	50[2]
Molybdenum	1	18 (33)	<1	5	--
Nickel	1	16 (30)	<1	26	--
Zinc	5	7 (13)	<5	3,290	5,000[1]
Copper	1	3 (6)	<1	13	1,300
Cobalt	1	3 (6)	<1	1.9	--
Uranium	1	3 (6)	<1	1.3	--[3]
Selenium	1	2 (4)	<1	2	50[1]
Aluminum	5	1 (2)	<5	5	50[1]
Beryllium	1	0 (0)	<1	<1	4
Cadmium	1	0 (0)	<1	<1	5
Antimony	1	0 (0)	<1	<1	6
Lead	1	0 (0)	<1	<1	15[4]
Silver	1	0 (0)	<1	<1	100[1]
Wells screened in the Holocene alluvium (25 wells unless otherwise stated)					
Iron	10	25(100)	9,700	19,400	300[1]
Manganese	1	25(100)	619	1,380	50[1]
Barium	1	25(100)	461	876	2,000
Chromium	1	25(100)	3.5	8.1	100
Arsenic	1	16 (64)	2	33	50[2]
Molybdenum	1	10 (40)	<1	4.5	--
Nickel	1	7 (28)	<1	5.4	--
Zinc	5	4 (16)	<5	130	5,000[1]
Uranium	1	1 (4)	<1	1.1	--[3]
Cobalt	1	1 (4)	<1	1	--

Table 7. Summary of trace-element concentrations in water from 25 wells screened in the Holocene alluvium, and in water from 29 wells screened in the Pleistocene valley trains of the Mississippi River Valley alluvial aquifer, 1998--Continued

Constituent	Reporting limit	Number of detections (percent detections)	Median	Maximum concentration	Maximum contaminant level
Aluminum	5	0 (0)	<5	<5	50[1]
Beryllium	1	0 (0)	<1	<1	4
Cadmium	1	0 (0)	<1	<1	5
Antimony	1	0 (0)	<1	<1	6
Lead	1	0 (0)	<1	<1	15[4]
Selenium	1	0 (0)	<1	<1	50[1]
Silver	1	0 (0)	<1	<1	100[1]
Copper	1	0 (0)	<1	<1	1,300
Wells screened in the Pleistocene valley trains of the Mississippi River Valley alluvial aquifer (29 wells unless otherwise stated)					
Barium	1	29 (100)	402	877	2,000
Iron	10	28 (97)	3,800	10,700	300[1]
Manganese	1	27 (93)	543	1,920	50[1]
Chromium	1	27 (93)	2.9	7	100
Arsenic	1	19 (66)	2	56	50[2]
Nickel	1	9 (31)	<1	26	--
Molybdenum	1	8 (28)	<1	5	--
Zinc	5	3 (10)	<5	3,290	5,000[1]
Copper	1	3 (10)	<1	13	1,300
Selenium	1	2 (7)	<1	2	50[1]
Cobalt	1	2 (7)	<1	1.9	--
Uranium	1	2 (7)	<1	1.3	--[3]
Aluminum	5	1 (3)	<5	5	50[1]
Beryllium	1	0 (0)	<1	<1	4
Cadmium	1	0 (0)	<1	<1	5
Antimony	1	0 (0)	<1	<1	6
Lead	1	0 (0)	<1	<1	15[4]
Silver	1	0 (0)	<1	<1	100[1]

[1] Secondary maximum contaminant level

[2] Will be revised to 10 µg/L on January 23, 2006

[3] Is 30 µg/L as of December 8, 2003

[4] Action level

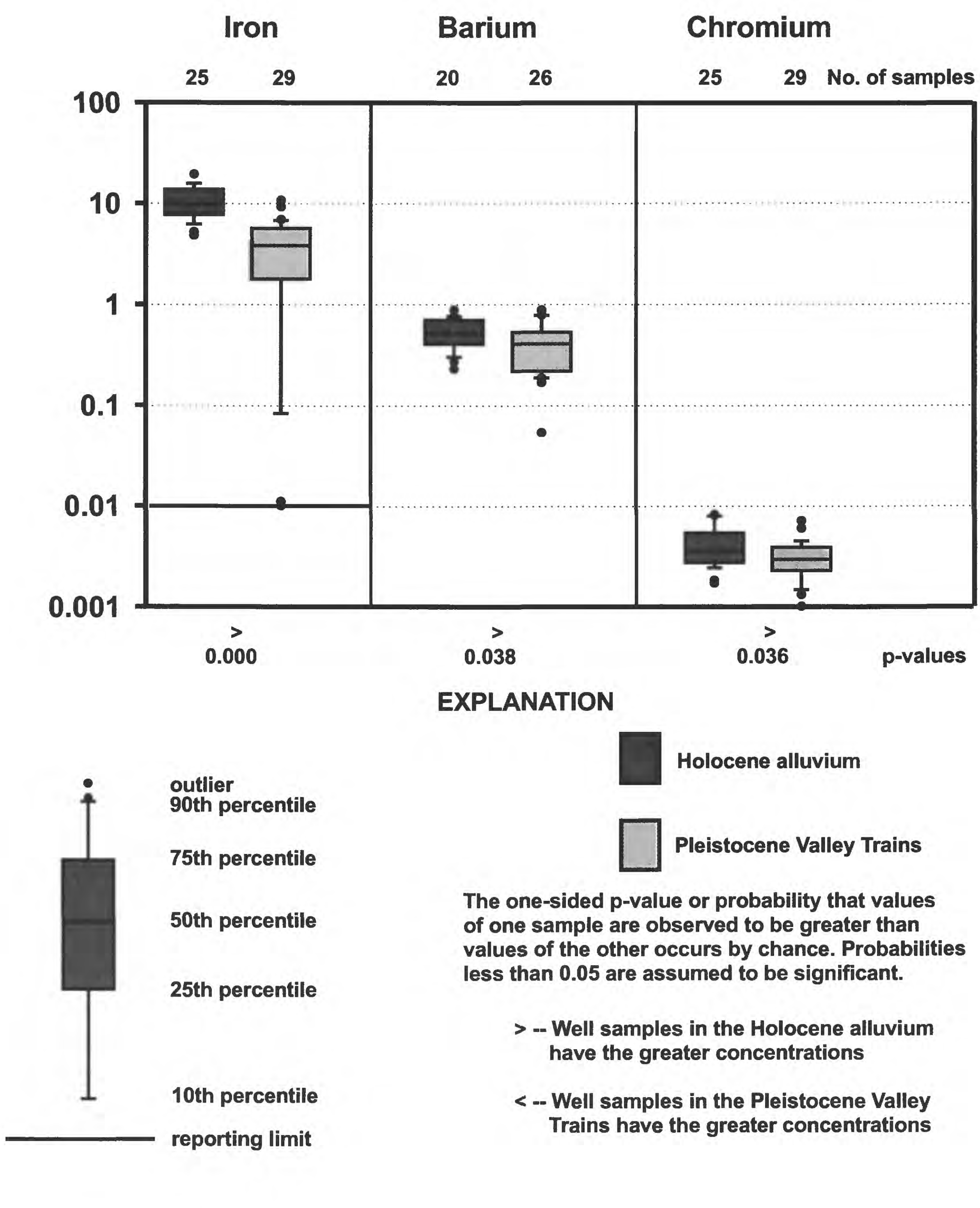

Figure 7. Iron, barium, and chromium concentrations in water from wells screened in the Mississippi River Valley alluvial aquifer by hydrogeologic subunit, 1998.

arsenic, barium, iron, and manganese concentrations in water from seven wells in southeastern Missouri sampled in this study (median, 2; 528; 4,900; and 588 µg/L; respectively). Mesko and Carlson (1988) reported zinc concentrations in water from wells in southeastern Missouri (median, 40 µg/L) that were greater than zinc concentrations in water from the seven wells in southeastern Missouri sampled in this study (median, less than 5 µg/L). Parks and others (1995) reported barium and iron concentrations in water from alluvial aquifer wells near Memphis (median, 330 and 4,400 µg/L, respectively) that were less than barium and iron concentrations in water from five wells near Memphis sampled for this study (median, 530 and 9,600 µg/L, respectively). Parks and others (1995) reported manganese concentrations in water from alluvial aquifer wells near Memphis (median, 360 µg/L) that were greater than manganese concentrations in water from five wells near Memphis sampled for this study (median, 207 µg/L). Wells with water-quality information reported by Parks and others (1995) were screened in the alluvial aquifer, near laterally adjacent older geologic formations of sand and clay. Gonthier (1998) reported iron concentrations were greater in water from wells screened in the Holocene alluvium than in water from wells screened in the Pleistocene valley trains, based on water-quality data from previous investigations.

Pesticides

Of the 83 pesticide compounds analyzed by the NWQL, 10 were detected in water from at least one of the 54 wells (table 8). At least one pesticide was detected in water from 19 of the 54 sampled wells. The 10 different pesticide compounds included 8 herbicides, 1 degradation product of the herbicide atrazine (deethylatrazine), and 1 degradation product of the organochlorine insecticide DDT (*p,p'*DDE). Bentazon was the most frequently detected pesticide, detected in water from 26 percent of the sampled wells. Nine other pesticide compounds detected in water from at least one of the 54 wells were molinate, fluometuron, 2,4-D, fenuron, atrazine, deethylatrazine, metolachlor, propanil, and *p,p'*DDE. The pesticide with the greatest concentration was bentazon, at an estimated concentration of 3.17 µg/L in the Holocene alluvium (well HA-25). No pesticide concentrations exceeded MCLs. Pesticide concentrations in water from wells screened in the Mississippi River Valley alluvial aquifer were not significantly different between the Holocene alluvium and the Pleistocene valley trains (table 8).

Water from wells near a notable presence of pesticides did not have a greater occurrence of pesticides than water from other wells. Eight wells were classified as wells with pesticides present during sampling. Pesticide presence included nearby crop dusting activities, dead vegetation near the well head, and strong pesticide odors coming from application or mixing operations.

Of the additional 30 pesticide compounds analyzed by the USGS Organic Geochemistry Research Laboratory in Lawrence, Kansas, 5 were detected in at least one of the 24 sampled wells (table 9). Only 2 of the 24 wells had detections of any of the pesticide compounds analyzed by the Organic Geochemistry Research Laboratory. Well VT-18 had detections of alachlor ESA, metolachlor ESA, metolachlor oxanilic acid, and fluometuron. Well VT-26 had detections of alachlor ESA and alachlor oxanilic acid. Results of pesticide analyses by the NWQL and the Organic Geochemistry Research Laboratory compared favorably. In particular, fluometuron was detected in VT-18 at a concentration of 0.07 µg/L based on NWQL analysis and at a concentration of 0.11 µg/L based on Organic Geochemistry Research Laboratory analysis.

Mesko and Carlson (1988) reported detections of 23 different pesticides in wells screened in the alluvial aquifer in southeastern Missouri. The most frequently detected pesticides in Missouri were 2,4,5-T, trifluralin, atrazine, alachlor, metribuzin, cyanazine, 2,4-D, and terbufos. Maximum concentrations of pesticides reported by Mesko and Carlson (1988) were typically much greater than maximum concentrations of pesticides detected in the wells sampled in this study. Maximum concentrations of pesticides reported

Table 8. Summary of pesticide concentrations in water from 25 wells screened in the Holocene alluvium and 29 wells screened in the Pleistocene valley trains of the Mississippi River Valley alluvial aquifer, 1998

[Data are in Appendix 1, tables 1-7a, 1-7b, and 1-8a through 1-9b. Samples were analyzed by NWQL. Concentrations are in micrograms per liter. Maximum contaminant levels are from U.S. Environmental Protection Agency (2002); --, the U.S. Environmental Protection Agency did not have a maximum contaminant level set for this constituent during the writing of this report; E, estimated value below lowest calibration standard]

Constituent	Reporting limit	Number of detections (percent detections)	Maximum concentration	Maximum contaminant level	Pesticide type
		Mississippi River Valley alluvial aquifer (54 wells)			
Bentazon	0.014	14 (26)	E3.17	--	Herbicide
Molinate	0.004	4 (7)	0.0528	--	Herbicide
Fluometuron	0.035	3 (6)	1.22	--	Herbicide
2, 4-D	0.15	1 (2)	E0.02	70	Herbicide
Fenuron	0.013	1 (2)	E0.02	--	Herbicide
Atrazine	0.001	1 (2)	0.019	3	Herbicide
Deethylatrazine	0.002	1 (2)	E0.0132	--	Herbicide[1]
Metolachlor	0.002	1 (2)	0.011	--	Herbicide
Propanil	0.004	1 (2)	E0.0028	--	Herbicide
p, p' DDE	0.006	1 (2)	E0.0015	--	Insecticide[2]
		Wells screened in the Holocene alluvium of the Mississippi River Valley alluvial aquifer (25 wells)			
Bentazon	0.014	6 (24)	E3.17	--	Herbicide
Molinate	0.004	2 (8)	0.0376	--	Herbicide
Fluometuron	0.035	1 (4)	0.28	--	Herbicide
Fenuron	0.013	1 (4)	E0.02	--	Herbicide
Propanil	0.004	1 (4)	E0.0028	--	Herbicide
p, p' DDE	0.006	1 (4)	E0.0015	--	Insecticide[2]
		Wells screened in the Pleistocene valley trains of the Mississippi River Valley alluvial aquifer (29 wells)			
Bentazon	0.014	8 (28)	0.31	--	Herbicide
Fluometuron	0.035	2 (7)	1.22	--	Herbicide
Molinate	0.004	2 (7)	0.0528	--	Herbicide
2, 4-D	0.15	1 (3)	E0.02	70	Herbicide
Atrazine	0.001	1 (3)	0.019	3	Herbicide
Deethylatrazine	0.002	1 (3)	E0.0132	--	Herbicide[1]
Metolachlor	0.002	1 (3)	0.011	--	Herbicide

[1] A degradation product of atrazine
[2] A degradation product of *p, p'* DDT

Table 9. Summary of pesticide and degradation product concentrations in water from 11 wells screened in the Holocene alluvium and in water from 13 wells screened in the Pleistocene valley trains of the Mississippi River Valley alluvial aquifer, 1998

[Data are in Appendix 1, tables 1-7c, 1-10a, and, 1-10b. Pesticide compounds were analyzed by the USGS laboratory in Lawrence, Kansas. Pesticide compounds were detected in two wells, VT-18 and VT-26. Concentrations are in micrograms per liter. Maximum contaminant levels are from U.S. Environmental Protection Agency (2002); --, the U.S. Environmental Protection Agency did not have a maximum contaminant level set for this constituent during the writing of this report]

Constituent	Reporting limit	Number of detections (percent detections)	Maximum concentration	Maximum contaminant level	Pesticide type
Wells screened in the Holocene alluvium of the Mississippi River Valley alluvial aquifer (11 wells)					
None were detected					
Wells screened in the Pleistocene valley trains of the Mississippi River Valley alluvial aquifer (13 wells)					
Alachlor ESA	0.20	2 (14)	0.47	--	Herbicide[1]
Fluometuron	0.05	1 (8)	0.11	--	Herbicide
Metolachlor ESA	0.20	1 (7)	0.94	--	Herbicide[2]
Alachlor oxanilic acid	0.20	1 (7)	0.45	--	Herbicide[1]
Metolachlor oxanilic acid	0.20	1 (7)	0.2	--	Herbicide[2]

[1] a degradation product of alachlor
[2] a degradation product of metolachlor

by Mesko and Carlson (1988) included 14 µg/L for metribuzin, 22 µg/L for alachlor, 120 µg/L for metolachlor, and 150 µg/L for atrazine.

Volatile Organic Compounds

Of the 85 analyzed volatile organic compounds (VOCs), 3 were detected at concentrations above the minimum reporting limit in water from at least one of 54 wells. Analyzed VOCs are listed in Appendix table 1-11. At least one VOC was detected in water from 4 of the 54 sampled wells. Methyl tert butyl ether (MTBE) was detected in water from wells VT-18 and VT-01 at 6.4 and 2.6 µg/L, respectively. MTBE, also called 2-methoxy-2-methylpropane by the International Union of Pure and Applied Chemistry (IUPAC), is used as an octane booster for unleaded gasoline and in the manufacture of isobutene (Lewis, 1992; Verschueren, 1983). Dichlorofluoromethane was detected in water from wells VT-14 and VT-05 at estimated concentrations of 1.2 and 1.1 µg/L, respectively. Dichlorofluoromethane, also known as CFC-12, is used as a refrigerant in air conditioners, in plastics, as a blowing agent, as a low-temperature solvent, and as a leak detecting agent (Lewis, 1992; Verschueren, 1983). The highest VOC detected was 22 µg/Lof diisopropyl ether in water from well VT-18. Diisopropyl ether, also called 2,2'-oxybis[propane] by the IUPAC and sometimes referred to as isopropyl ether, is used in several applications including a solvent for animal, vegetable, and mineral oils, waxes, and resins; in the extraction of acetic acid from aqueous solutions; and in paint and varnish removers (Lewis, 1992; Verschueren, 1983). No VOC concentrations exceeded MCLs.

Mesko and Carlson (1988) reported detections of three different VOCs in wells screened in the alluvial aquifer in southeastern Missouri: chloroform, 1,1,1-trichloroethane, and trichlorfluoromethane. The most frequently detected VOC in southeastern Missouri was chloroform (Mesko and Carlson, 1988). Maximum concentration of VOCs reported by Mesko and Carlson (1988) was 2.3 μg/L for chloroform, which was greater than the maximum concentration of chloroform (0.19 μg/L, VT-03) for wells in this study.

Radioisotopes (Radium-226 and Radon-222)

Radium-226 and radon-222 are naturally occurring radioactive isotopes produced by the decay of uranium. Radium-226, produced by the decay of uranium-238, has a half-life of 1,620 years. Radon-222, produced by the decay of radium-226, has a half life of 3.8 days. Rocks and sediment commonly contain large enough concentrations of uranium-238 to cause the sediment to have significant concentrations of radium-226 and the ground water to have significant concentrations of radon-222 (Rogers, 1958). Radium is an alkaline earth metal and is soluble in ground water as a cation. Radon is soluble in ground water but exists in the gas phase; hence, water with radon quickly degasses when the water comes in contact with the atmosphere (Hem, 1985). Because radon and radium are radioactive, they can pose a health threat. The U.S. Environmental Protection Agency (2002) set a MCL for radium-226 plus radium-228 of 5 pCi/L. The USEPA had set a MCL for radon-222 of 300 pCi/L. At the time of the writing of this report (2002), the MCL for radon-222 had been withdrawn pending further study.

Radium-226 concentrations in water from the 22 wells that were screened in the alluvial aquifer ranged from 0.22 to 0.92 pCi/L, with a median of 0.46 pCi/L (Appendix table 1-12a and 1-12b). All radium-226 concentrations were less than the MCL for drinking water. Water from wells screened in the Holocene alluvium had greater concentrations of radium-226 than water from wells screened in the Pleistocene valley trains (fig. 8). Water from wells screened in the alluvial aquifer had increased concentrations of radium-226 with increasing concentrations of other alkaline earth metals: magnesium, calcium, and barium (Kendall's tau values of +0.35, +0.43, and +0.65; p-values of 0.028, 0.007, and <0.00005, respectively). The correlation between concentrations of radium-226 and other alkaline earth metals is highest for the heaviest alkaline earth metal, barium (fig. 9).

Radon-222 concentrations in water from 54 wells screened in the alluvial aquifer ranged from 119 to 348 pCi/L with a median of 229 pCi/L (Appendix table 1-12a and 1-12b). Concentrations of radon-222 were greater in water from wells screened in the Pleistocene valley trains than in water from wells screened in the Holocene alluvium (fig. 8; p-value = 0.038). In water from wells screened in the alluvial aquifer, radon-222 concentrations slightly decreased with increasing radium-226 concentrations (Kendall's tau = -0.26; p-value=0.102), a slight negative correlation. If radon-222 were produced from the decay of aqueous radium-226, it would be expected that there would be a positive correlation between radon-222 and radium-226. The negative correlation between these two radioisotopes in aqueous phase indicates that most radon-222 is produced from the decay of radium-226 that resides in the sediment.

Tritium Dating

Tritium was analyzed in water samples to date the water from the wells. Tritium is a radioactive isotope of hydrogen with a half-life of 12.43 years, produced naturally in the atmosphere in very small concentrations, and is incorporated into precipitation. Because tritium is not produced in water after infiltration into the soil, tritium can be used to determine the presence of young ground water (less than about 50 years old) in the alluvial aquifer. Understanding the distribution of ground water of different ages in the subunits provides understanding of how ground water flows in the alluvial aquifer, and of how ground-water chemistry is different between the two subunits. Tritium concentration in water is measured in tritium units (TU); a tritium unit is equivalent to 1 tritium atom for every 10^{18} hydrogen atoms.

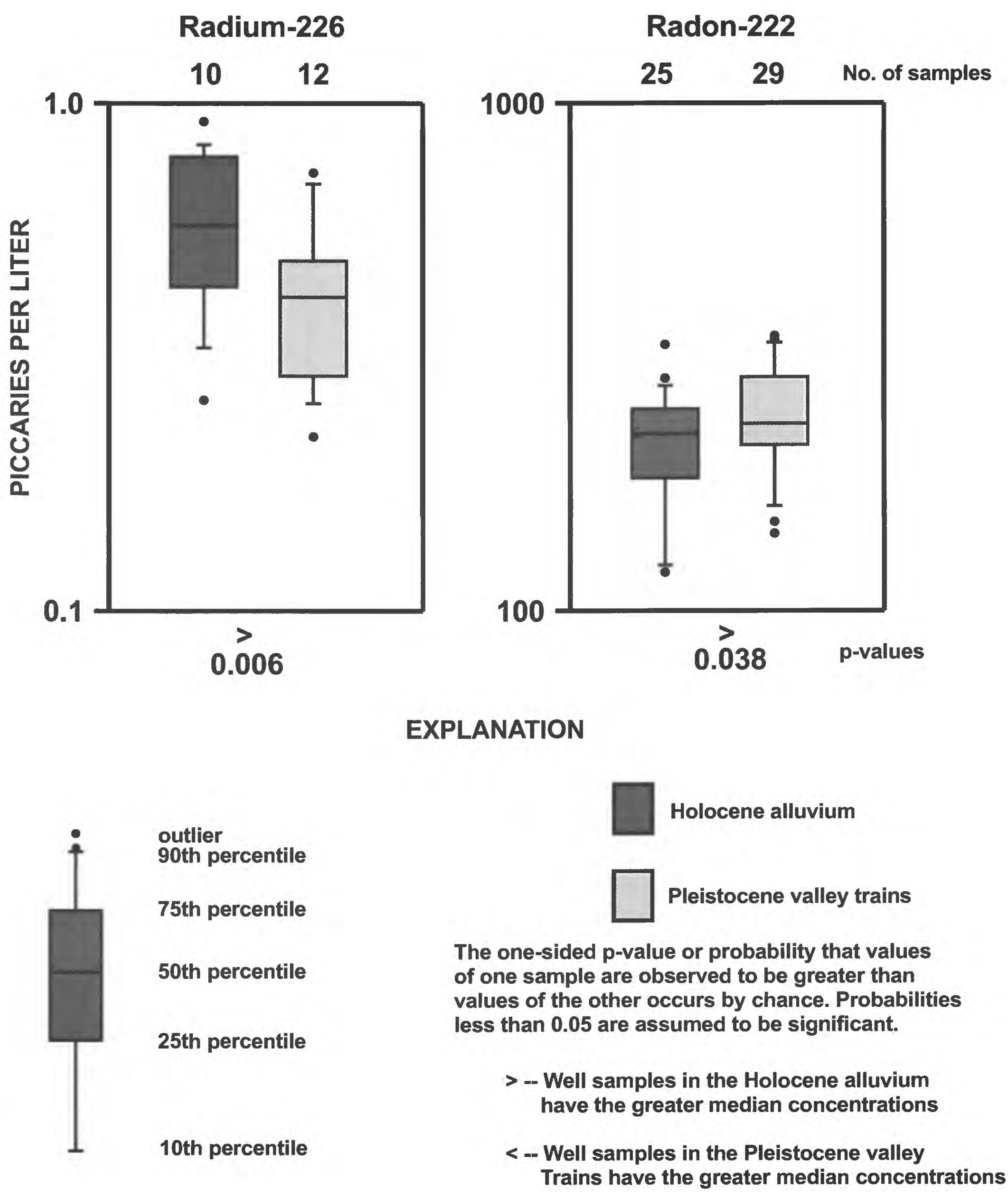

Figure 8. Radium-226 and radon-222 concentrations in water from wells screened in the Mississippi River Valley alluvial aquifer by hydrogeologic subunit, 1998.

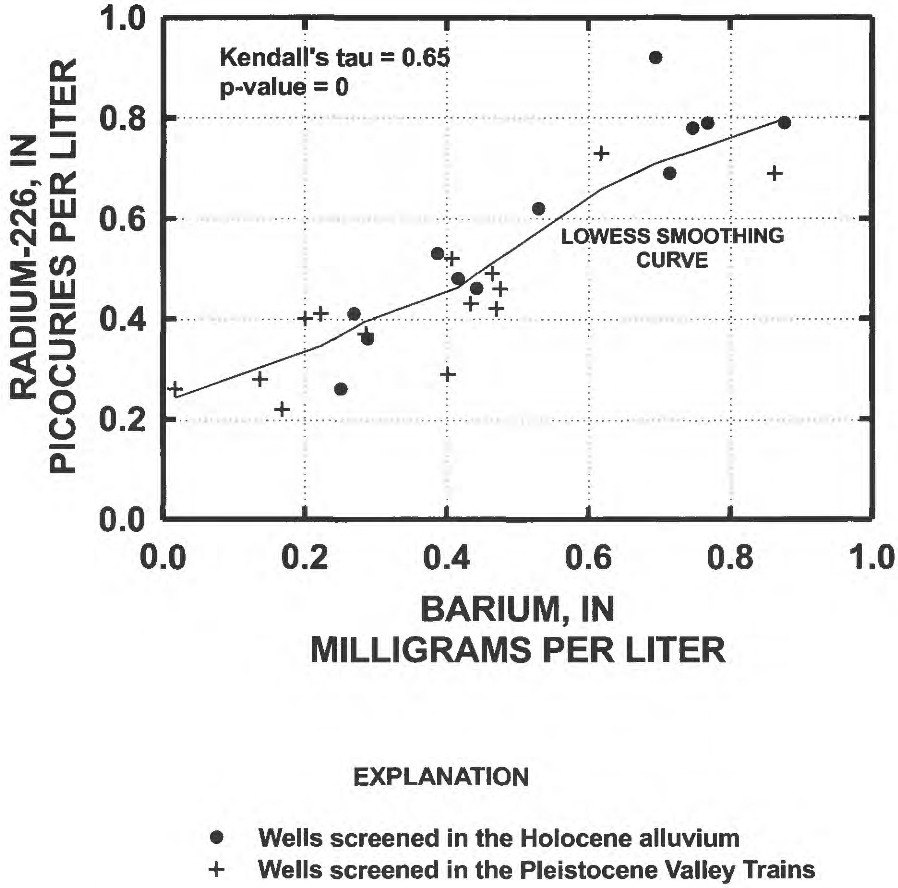

Figure 9. Relation of radium-226 concentrations with barium concentration in water from 12 wells screened in the Holocene alluvium and in water from 14 wells screened in the Pleistocene valley trains of the Mississippi River Valley alluvial aquifer, 1998.

The sources of tritium in ground water are very recently recharged precipitation, and relatively high concentrations of tritium from nuclear weapons testing in the middle of the 20th century. The concentration of naturally produced tritium in rainwater in the center of the study area is only about 5 TU (International Atomic Energy Agency, 1995). Nuclear weapons testing during the middle of the twentieth century produced tritium amounts much greater than natural processes. A peak concentration of tritium in precipitation occurred in 1963 (Stewart and Farnsworth, 1968). Ground water that recharged in the center of the study area during 1963 would theoretically have a tritium concentration in 1998 of about 220 TU (International Atomic Energy Agency, 1995; Faure, 1986). However, mixing of older and younger water probably reduces the maximum concentration of the tritium peak.

Tritium was detected in water from 49 of the 54 wells screened in the alluvial aquifer. Concentrations of tritium ranged from <0.31 to 13.4 TU with a median of 3.2 TU (Appendix 1 tables 1-12a and 1-12b). Concentrations of tritium were greater in water from wells screened in the Pleistocene valley trains than in water from wells screened in the Holocene alluvium (fig. 10; p-value = 0.015). Tritium concentrations in water from 29 wells screened in the Pleistocene valley trains ranged from <0.31 to 13.4 TU, with a median of 4.1 TU. Tritium concentrations in water from 25 wells screened in the Holocene alluvium ranged from <0.31 to 10 TU, with a median of 2.1 TU. Assuming that the presence of tritium indicates the presence of relatively young ground water, it could be

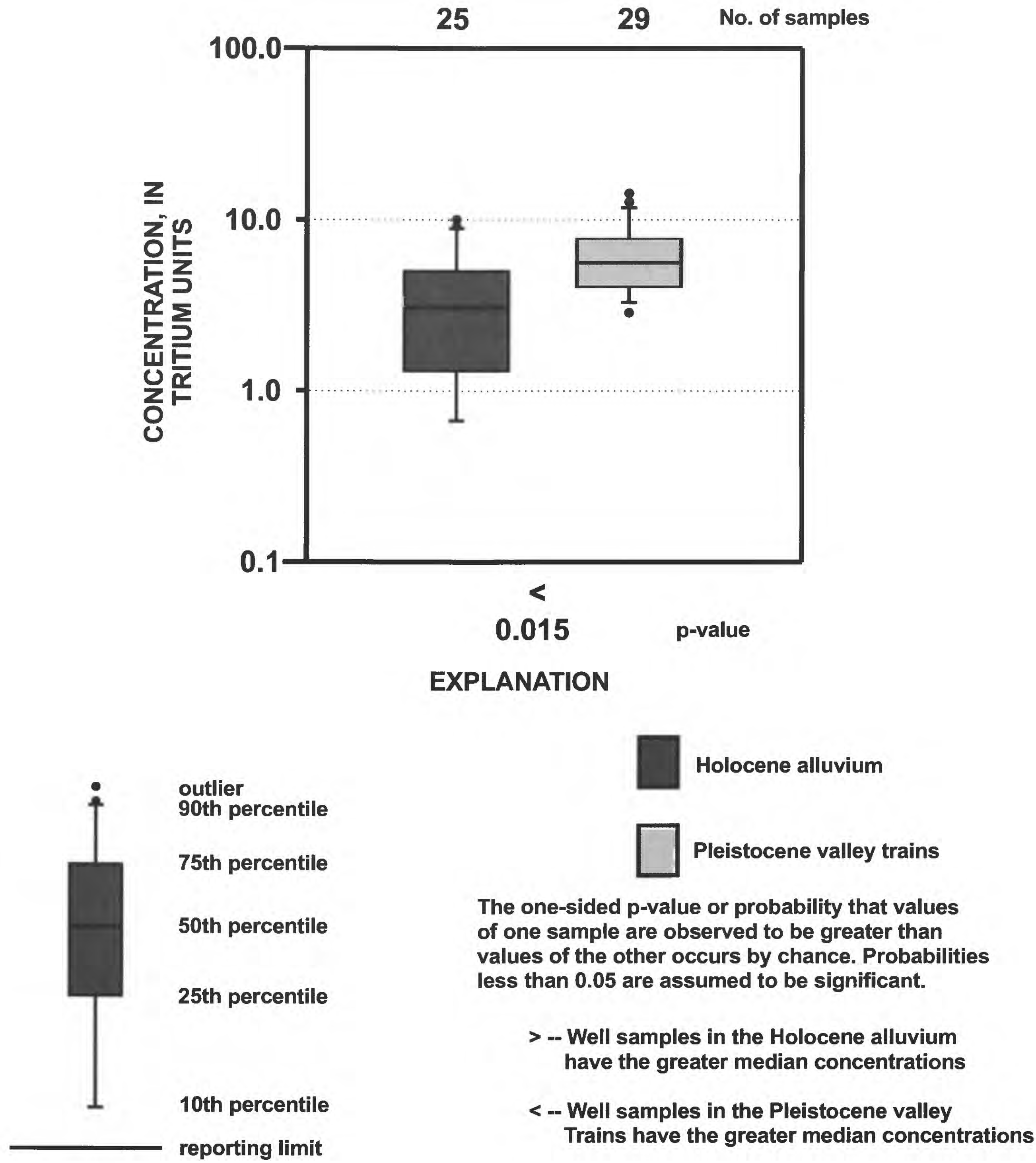

Figure 10. Tritium concentrations in water from wells screened in the Mississippi River Valley alluvial aquifer by hydrogeologic subunit, 1998.

determined that water from the Pleistocene valley trains is younger than water from the Holocene alluvium.

Anthropogenic compounds were present in water from four of the five wells with no detection of tritium (HA-12, HA-17, HA-27, and VT-07). One pesticide was detected in water from wells HA-27 and VT-07. One VOC was detected in wells HA-17, and HA-27. Two VOCs were detected in well HA-12. The presence of anthropogenic compounds with the absence of tritium may be due to direct leakage of water from the surface to the well screen. Direct leakage of small amounts of surface water with large concentrations of surface contaminants and modern tritium concentrations of about 5 TU (International Atomic Energy Agency, 1995) might increase the concentrations of surface contaminants to detectable levels while not increasing the tritium concentration above the detection level of 0.31 TU. Another explanation for the detection of anthropogenic compounds in water from wells with the absence of tritium is that anthropogenic compounds might be moving to the well screen in the form of non aqueous liquids that contain pesticides or VOCs.

Large concentrations of iron (greater than 5 mg/L) and large concentrations of tritium (greater than 4 TU) were present in water from 11 wells. As ground water gets older, dissolved oxygen reacts with decomposing organic matter in the aquifer. With the reduction of dissolved oxygen concentration in ground water and the presence of organic matter as an electron donor, ferric iron in iron oxide compounds can be reduced to soluble ferrous iron (Freeze and Cherry, 1979). The presence of large concentrations of iron in relatively young water (containing tritium) may provide a clue to the rate at which oxygen is consumed and iron is reduced and dissolved in water within the alluvial aquifer.

Stable Isotopes

The hydrogen and oxygen isotopes in water were used in this study to help verify that ground water came from recent, local precipitation. The important stable isotopes of the water molecule in stable-isotope hydrology are hydrogen-1 (^1H), deuterium-2 (^2H), oxygen-16 (^{16}O), and oxygen-18 (^{18}O). ^2H and ^{18}O are rare compared to ^1H and ^{16}O. The isotopic compositions of stable isotopes ^2H and ^{18}O are expressed in permil units, or parts per thousand, as a deviation of the isotopic ratio relative to a reference standard, by using the delta notation (δ):

$$\delta = [(R\text{sample})/(R\text{reference}) - 1] \times 1,000,$$

where R is the measured isotopic ratio. The delta symbol in this report is followed by the heavier isotope of the isotopic pair $^2H/^1H$ or $^{18}O/^{16}O$. Permil values in this report are presented relative to the standardized reference compound, Vienna Standard Mean Ocean Water (VSMOW) (Coplen, 1994). The more enriched a water sample is with ^2H or ^{18}O the greater the permil value will be for that water sample. Modern ocean water usually has δ^2H and $\delta^{18}O$ values close to zero, relative to VSMOW. Most precipitation and ground-water samples have negative δ^2H and $\delta^{18}O$ values, relative to VSMOW.

The isotopic composition of water samples from all 54 wells was similar to the expected isotopic composition of modern precipitation in the study area. In water from wells, δ^2H values ranged from -35 to -15 permil with a median of -28 permil, and $\delta^{18}O$ values ranged from -5.9 to -2.6 permil with a median of -5.0 permil (Appendix 1, tables 1-12a and 1-12b). The δ^2H and $\delta^{18}O$ values decreased with latitude, agreeing with the geographic variation of stable isotopes of precipitation in the region (Taylor and Margaritz, 1978: Faure, 1986). ^2H and ^{18}O in ground water were most depleted in the northern part of the study area and most enriched in the southern part of the study area. δ^2H and $\delta^{18}O$ values in water from wells were covariant, having a linear regression line of $\delta^2H = 5.93\ \delta^{18}O + 1.48$ ($R^2 = 0.95$).

WATER QUALITY IN SHALLOW GROUND WATER

The water quality for almost all wells screened in the Mississippi River Valley alluvial aquifer was below USEPA MCLs, though water from most wells exceeded at least one secondary standard. Water from all wells had pesticide and volatile organic compound concentrations below MCLs. One well had a concentration of arsenic just exceeding the current USEPA MCL of 50 µg/L. Secondary standards were exceeded for manganese, iron, and dissolved solids in water from 52, 49, and 10 wells, respectively.

None of the occurrences or concentrations of suspected surface contaminants (VOCs, pesticides, and nitrates) are significantly different between the Holocene alluvium and the Pleistocene valley trains. One would expect that the concentrations of surface contaminants would be greater in the Pleistocene valley trains than in the Holocene alluvium because water appears to be younger in the Pleistocene valley trains based on hydrogeology and perhaps tritium concentrations. Rank sum comparison tests do indicate that occurrences and concentrations of nitrite plus nitrate, pesticides, and VOCs are greater in the Pleistocene valley trains than in the Holocene alluvium, but the p-values range from 0.2 to 0.4, indicating no statistical significance.

GEOCHEMICAL HETEROGENEITY WITHIN THE MISSISSIPPI RIVER VALLEY ALLUVIAL AQUIFER

The results of this study indicate a significant difference in the ground-water geochemistry between the Holocene alluvium and the Pleistocene valley trains within the Mississippi River Valley alluvial aquifer. Seventeen chemical constituents, many of them major ions, were detected in concentrations significantly different between the two subunits (table 10). Barium, potassium, dissolved organic carbon, radium-226, chromium, iron, magnesium, calcium, bicarbonate, dissolved

Table 10. Summary of rank sum comparisons of constituent concentrations in water from wells screened in the Mississippi River Valley alluvial aquifer, 1998, by hydrogeologic subunit

[Data are from 25 wells screened in the Holocene alluvium and 29 wells screened in the Pleistocene valley trains. NO_2, nitrite; NO_3, nitrate; 124TMB, 1,2,4-trimethylbenzene; Pest, pesticide; VOC, volatile organic compound; _hit, the number of different pesticides or VOCs detected in water from a well; _sum, the sum of all pesticide or VOC concentrations measured in water from a well; DOC, dissolved organic carbon]

Greater concentrations			
Holocene alluvium		**Pleistocene valley trains**	
Concentrations are significantly greater in the Holocene alluvium than in the Pleistocene valley trains **p-values <0.05**	Concentrations are not significantly greater in the Holocene alluvium than in the Pleistocene valley trains **p-values from 0.05 - 0.5**	Concentrations are not significantly greater in the Pleistocene valley trains than in the Holocene alluvium **p-values from 0.05 - 0.5**	Concentrations are significantly greater in the Pleistocene valley trains than in the Holocene alluvium **p-values <0.05**
Barium Potassium DOC Radium-226 Chromium Iron Magnesium Calcium Bicarbonate Dissolved solids Ammonia Phosphorus Fluoride	NO_2 Bromide Orthophosphate Bentazon Arsenic Sulfide Silica Molybdenum	Aluminum $NO_2 + NO_3$ Oxygen Nickel Copper VOC_hit VOC_sum Pest_sum 124TMB Manganese Zinc Pest_hit Sodium	Tritium Radon-222 Sulfate pH Chloride

solids, ammonia, phosphorus, and fluoride were present in greater concentrations in water from wells screened in the Holocene alluvium than in water from wells screened in the Pleistocene valley trains. Tritium, radon-222, sulfate, pH, and, chloride were present in greater concentrations or values in water from wells screened in the Pleistocene valley trains than in water from wells screened in the Holocene alluvium.

The concentrations of the constituents discussed in the previoius paragraph indicate that water in the Holocene alluvium is older and is under more reducing conditions than water in the Pleistocene valley trains. The concentrations of some constituents provide information concerning differences in the aquifer material between the Holocene alluvium and the Pleistocene valley trains. Tritium concentrations indicate that water in the Holocene alluvium may be older than water in the Pleistocene valley trains. Iron and ammonia concentrations indicate the water in the Holocene alluvium is under more reducing conditions than water in the Pleistocene valley trains. Dissolved organic carbon concentrations indicate that organic matter may be more abundant in the Holocene alluvium than in the Pleistocene valley trains. The depositional environment that created the Holocene alluvium, mostly meandering streams, probably was more conducive to deposition of vegetation with sediment than the high-energy depositional environment that created the Pleistocene valley trains braided streams.

Differing hydrogeological characteristics between the Holocene alluvium and the Pleistocene valley trains can lead to significant differences in ground-water flow and ground-water chemistry. The Pleistocene valley trains would tend to have younger ground water than the Holocene alluvium, based on hydrogeologic characteristics. A combination of thinner confining unit thickness and higher land-surface altitude can make ground water in the Pleistocene valley trains generally more susceptible to surface contaminants than the Holocene alluvium. A combination of thicker confining unit thickness and lower land-surface altitude can make ground water in the Holocene alluvium generally older and have a lower oxygen concentration and higher dissolved solids concentration than the ground water in the Pleistocene valley trains.

On a local scale, Gonthier (1998) compared historical nitrate and iron concentrations between the two subunits within northeastern Louisiana and observed that within northeastern Louisiana, concentrations of nitrate, a suspected surface contaminant, were significantly higher in water from wells screened in the Pleistocene valley trains than in water from wells screened in the Holocene alluvium (p-value of 0.0008) and concentrations of iron were significantly higher in water from wells screened in the Holocene alluvium than in water from wells screened in the Pleistocene valley trains (p-value of <0.00005).

SUMMARY

In 1991, the U.S. Geological Survey began implementation of the National Water-Quality Assessment Program to provide a consistent description of the Nation's ground- and surface-water resources. The Mississippi Embayment Study Unit is one of 17 study units that began in 1994. Water use from the Mississippi River Valley alluvial aquifer is enormous; annual average pumpage from the aquifer is about 7 Bgal/d. The chemical analysis of water in the alluvial aquifer provides an opportunity to monitor the infiltration of potential contaminants into a vast ground-water system that not only affects drinking water supplies but also affects soil in farmland as a result of irrigation.

The Mississippi River Valley alluvial aquifer study area is the extent of the Holocene alluvium (16,400 mi^2) and Pleistocene valley train deposits (12,100 mi^2) within the Mississippi Alluvial Plain. The study area includes parts of eastern Arkansas, western Kentucky, northeastern Louisiana, northwestern Mississippi, southeastern Missouri, and western Tennessee.

During the Quaternary, as much as 300 ft of alluvial sediments filled the Mississippi Alluvial

Plain. The Quaternary alluvium overlies and is laterally adjacent to older Tertiary formations of sand and clay, and Paleozoic formations of limestone, dolostone, sandstone, and shale at the northwestern edge of the Mississippi Alluvial Plain. The Quaternary alluvium has been separated into more than 30 geologic units that can be grouped into three major units: Pleistocene Prairie complex, Pleistocene valley trains, and Holocene alluvium. The Prairie complex is older than the Pleistocene valley trains and the Holocene alluvium. The Pleistocene valley trains were mostly deposited as braided streams. Most recently, Holocene alluvium was deposited as meandering river deposits. The Pleistocene valley train deposits generally have coarser grain size and a thinner clay-and-silt surficial unit than the Holocene alluvium.

Land use in the Mississippi Alluvial Plain is mostly agriculture (80 percent) with some forest (16 percent), surface water (3 percent), and urban (1 percent). Annual pesticide application rate on agricultural land within the Mississippi Alluvial Plain was estimated to be 33 million pounds or about 2.3 lb/acre.

Water samples were collected during summer 1998 from 25 wells screened in the Holocene alluvium and 29 wells screened in the Pleistocene valley trains. Water samples were analyzed for turbidity, water temperature, pH, specific conductance, dissolved oxygen concentration, alkalinity, ferrous iron, sulfide, major ions, nutrients, trace elements, pesticides, volatile organic compounds, radioisotopes, and stable isotopes. Ancillary information such as land use within 164 and 1640 ft of each well, date of well installation, and well depth, also was collected.

Fifty-three wells had a calcium bicarbonate type water; one well in the southern part of the study area had a sodium chloride type water. The secondary standard (drinking water) was exceeded for manganese (50 μg/L) in 52 wells; iron (300 μg/L) in 49 wells; and dissolved solids (500 mg/L) in 10 wells. No nutrient concentrations exceeded MCLs. Ammonia was the nutrient with the greatest concentration (2.64 mg/L).

Of the 18 analyzed trace elements, 13 were detected in water from wells screened in the Mississippi river Valley alluvial aquifer. Barium, iron, manganese, and chromium were detected in water from at least 96 percent of wells screened in the alluvial aquifer. Nine other trace elements were detected in water from at least one well screened in the alluvial aquifer: arsenic, molybdenum, nickel, zinc, cobalt, uranium, selenium, copper, and aluminum. The greatest concentration of a trace element, excluding iron, was 3,290 μg/L for zinc.

Of the 83 pesticide compounds analyzed by the NWQL, 10 were detected in water from at least one of the 54 wells. Bentazon was the most frequently detected pesticide, being detected in water from 26 percent of the sampled wells. Nine other pesticide compounds were detected in water from at least one of the 54 wells; molinate, fluometuron, 2,4-D, fenuron, atrazine, deethylatrazine, metolachlor, propanil, and *p,p*'DDE. Bentazon was the pesticide with the greatest concentration (3.17 μg/L). No pesticide concentrations exceeded MCLs.

Of the 85 analyzed VOCs, 3 were detected at concentrations above the minimum reporting limit in water from at least one of 54 wells: MTBE, dichlorofluoromethane, and diisopropyl ether. At least one VOC was detected in water from 4 of the 54 sampled wells. No VOC concentrations exceeded MCLs.

Radium-226 concentrations in water from 22 wells that were screened in the alluvial aquifer ranged from 0.22 to 0.92 pCi/L. Radon-222 concentrations in water from 54 wells screened in the alluvial aquifer ranged from 119 to 348 pCi/L. Tritium was detected in water from 49 study wells. The ^{2}H and ^{18}O concentrations in water from wells were similar to the ^{2}H and ^{18}O concentrations of precipitation in the study area.

The results of this study indicate a significant difference in the ground-water geochemistry between the Holocene alluvium and the Pleistocene valley trains within the Mississippi River Valley alluvial aquifer. Barium, potassium, dissolved organic carbon, radium-226, chromium, iron, magnesium, calcium, bicarbonate, dissolved solids, ammonia, phosphorus, and fluoride were present in greater concentrations in water from wells screened in the Holocene alluvium than in water from wells screened in the Pleistocene valley trains. Tritium, radon-222, sulfate, pH, and chloride were present in greater concentrations or values in water from wells screened in the Pleistocene valley trains than in water from wells screened in the Holocene alluvium. The water-quality data indicate that water in the Holocene alluvium is older, more in contact with organic matter in the aquifer material, and under more reducing conditions than water in the Pleistocene valley trains. Differing hydrogeological characteristics between the Holocene alluvium and the Pleistocene valley trains can lead to significant differences in ground-water flow and ground-water chemistry.

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APPENDIXES

APPENDIX 1. WATER-QUALITY AND LAND-USE DATA

Table 1-1a. Field parameter data for water from 25 wells screened in the Holocene alluvium, NAWQA, 1998 [NTU, nephelometric turbidity units; DEG C, degrees Celsius; US/CM, microsiemens per centimeter; MG/L, milligrams per liter; UG/L micrograms per liter; Date format is first the month, then the day, then the last two digits of the year (1998); <, less than]

WELL NAME	SITE ID	DATE	TIME	TURBIDITY (NTU)	TEMPERATURE WATER* (DEG C)	PH WATER WHOLE FIELD (STANDARD UNITS)	SPECIFIC CONDUCTANCE (US/CM)	OXYGEN, DISSOLVED (MG/L)	ALKALINITY WAT DIS TOT IT FIELD MG/L AS CACO3	IRON FERROUS WATER UNFLTRD (UG/L)	SULFIDE TOTAL (MG/L AS S)
HA-03	340021091320101	07-28-98	1000	0.34	18.0	6.6	1240	0.1	320	11800	<0.001
HA-04	342304091500001	07-27-98	1000	.50	18.5	7.0	530	.2	248	6080	.003
HA-05	342657092013901	07-16-98	1000	2.0	19.0	6.8	1080	.2	362	15900	.013
HA-06	335442091163901	07-30-98	1000	.40	19.0	6.7	978	<.1	456	11000	.013
HA-07	335226091004201	06-25-98	1000	.32	19.0	7.2	593	<.1	310	3900	.019
HA-08	330142091000801	06-24-98	1500	.36	21.0	7.1	660	<.1	299	7550	.008
HA-09	324311091162801	05-14-98	1300	.07	20.5	6.9	560	.7	296	>3000	.011
HA-10	322358091110701	05-11-98	1500	.10	19.5	6.9	948	<.1	473	>3000	.006
HA-11	320732091181601	05-18-98	1400	1.0	21.0	7.0	619	.1	304	>3000	.003
HA-12	322934090493901	05-20-98	1300	.81	20.0	7.0	606	<.1	280	>3000	.017
HA-15	335429090415001	06-04-98	1000	26	23.5	6.9	699	.1	345	>3000	.005
HA-16	341233090393601	06-24-98	1000	1.4	17.5	7.1	512	<.1	245	6000	.008
HA-17	350942090194001	07-13-98	1300	1.4	17.5	7.2	522	.1	261	2280	.012
HA-18	345628090295701	07-14-98	1400	.67	17.0	7.1	492	<.1	253	2800	.014
HA-19	340413090340301	06-25-98	1100	.46	17.0	7.1	586	<.1	252	1400	.038
HA-20	335318090303001	06-23-98	1400	.47	18.5	6.9	558	<.1	234	2880	.014
HA-21	331037090404501	06-02-98	1200	11	23.0	7.2	840	.3	368	600	.001
HA-22	324355090391801	06-11-98	1000	.96	19.5	6.9	534	<.1	272	7000	.011
HA-25	335207090165501	06-23-98	1300	1.1	18.5	6.9	376	<.1	190	3300	.002
HA-26	343710090174501	06-10-98	1500	.56	18.5	7.2	644	<.1	312	5100	.025
HA-27	351204090124001	07-13-98	1500	1.5	17.5	7.0	651	<.1	335	7880	.007
HA-28	352104090182301	07-14-98	0900	.65	17.5	7.0	592	<.1	295	8480	.012
HA-29	355639089430201	07-20-98	1200	2.0	16.5	6.9	740	.3	394	5300	.036
HA-30	362501089290001	07-23-98	1000	1.0	16.5	6.9	883	<.1	471	12100	.028
HA-31	332730090280501	07-29-98	1000	.25	18.5	7.1	909	.2	294	7600	.031

*Sunlight on the sample line often increased water temperature, significantly.

Table 1-1b. Field parameter data for water from 29 wells screened in the Pleistocene Valley Trains, NAWQA, 1998
[NTU, nephelometric turbidity units; DEG C, degrees Celsius; US/CM, microsiemens per centimeter; MG/L, milligrams per liter; UG/L micrograms per liter; Date format is first the month, then the day, then the last two digits of the year (1998); <, less than; --, no data]

WELL NAME	SITE ID	DATE	TIME	TUR-BID-ITY (NTU)	TEMPER-ATURE WATER* (DEG C)	PH WATER WHOLE FIELD (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (US/CM)	OXYGEN, DIS-SOLVED (MG/L)	ALKA-LINITY WAT DIS TOT IT FIELD MG/L AS CACO3	IRON FERROUS WATER UNFLTRD (UG/L)	SULFIDE TOTAL (MG/L AS S)
VT-01	321011091431701	05-13-98	1000	0.11	19.5	7.0	1340	<0.1	299	3620	<0.001
VT-02	321547091443401	05-13-98	1500	.18	20.0	7.2	349	5.9	132	0	.002
VT-03	323723091462002	05-12-98	1300	.12	21.5	6.3	386	2.3	107	10	.002
VT-04	344242091103001	06-09-98	1200	.39	18.0	7.2	677	<.1	273	6500	.010
VT-05	351550091120101	06-15-98	1500	.17	17.5	7.2	399	<.1	166	3490	.007
VT-06	354341091120801	06-17-98	1300	.10	17.5	7.2	525	<.1	201	2740	.013
VT-07	354455091041501	06-17-98	0900	.07	17.5	7.1	718	<.1	283	4270	--
VT-08	352338091080501	06-16-98	0900	.40	17.0	7.0	601	<.1	247	6000	.018
VT-09	350944091051201	06-18-98	1200	.07	18.0	7.1	571	<.1	237	2210	.023
VT-10	345647091024500	07-06-98	1200	.60	22.0	7.1	956	1.1	418	375	.007
VT-11	331302090485901	06-24-98	0900	.08	19.0	7.0	791	<.1	384	3520	<.001
VT-13	344025090460401	07-15-98	1000	1.4	18.5	7.1	924	.1	427	3400	.014
VT-14	345631090522000	07-09-98	1000	.55	17.5	7.2	665	.4	333	220	.001
VT-15	353658090540801	06-16-98	1400	.20	17.5	7.1	716	<.1	328	2110	.020
VT-16	355839090515001	07-01-98	0900	.30	17.0	7.2	708	<.1	324	2800	.015
VT-17	362445090372901	06-29-98	1400	2.0	20.5	7.3	498	<.1	246	4370	.022
VT-18	361412090150301	06-30-98	1500	.10	16.0	6.8	386	.3	143	10	.008
VT-19	355813090213901	07-07-98	1400	.36	19.5	7.7	286	.2	116	360	.006
VT-20	355516090285600	06-30-98	0900	.11	17.0	7.3	744	<.1	373	885	.009
VT-21	353841090145901	07-08-98	1000	.70	17.5	7.1	485	<.1	237	880	.029
VT-22	352934090265401	07-08-98	1300	.38	18.5	7.0	759	.2	358	880	.009
VT-23	341827090080501	06-10-98	1000	.32	18.5	7.1	580	<.1	217	7200	.025
VT-24	360148090023801	07-07-98	0900	.23	17.5	7.0	514	.4	209	1720	.006
VT-25	361359090031001	07-23-98	1500	.30	18.5	7.6	393	<.1	155	600	.009
VT-26	362858089440901	07-22-98	1600	.95	16.0	6.9	434	.2	205	5400	.004
VT-27	363807089485001	07-22-98	1000	1.1	15.0	7.2	441	.3	184	1520	.009
VT-28	363956089584201	07-21-98	1300	.50	17.5	7.3	313	<.1	122	2940	.008
VT-29	365631089413001	07-21-98	0900	.30	16.5	7.0	459	<.1	198	2800	.004
VT-30	365430089265001	07-20-98	1600	.14	16.5	7.9	256	.2	92	220	.021

*Sunlight on the sample line often increased water temperature, significantly.

Table 1-2a. Major cation and silica concentrations in water from 25 wells screened in the Holocene alluvium, NAWQA, 1998 [MG/L, milligrams per liter; UG/L micrograms per liter; Date format is first the month, then the day, then the last two digits of the year (1998)]

WELL NAME	SITE ID	DATE	TIME	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	IRON, DIS-SOLVED (UG/L AS FE)	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	SILICA, DIS-SOLVED (MG/L AS SIO2)
HA-03	340021091320101	07-28-98	1000	110	29	77	14400	2.2	1270	25
HA-04	342304091500001	07-27-98	1000	65	13	17	10500	1.5	630	22
HA-05	342657092013901	07-16-98	1000	120	25	54	19400	2.6	1370	25
HA-06	335442091163901	07-30-98	1000	130	24	35	13600	2.6	707	35
HA-07	335226091004201	06-25-98	1000	77	25	7.6	6200	2.1	583	26
HA-08	330142091000801	06-24-98	1500	81	24	7.7	13000	2.6	433	32
HA-09	324311091162801	05-14-98	1300	68	22	14	7800	1.8	812	33
HA-10	322358091110701	05-11-98	1500	96	27	53	14100	3.3	680	34
HA-11	320732091181601	05-18-98	1400	72	26	12	11300	2.6	773	39
HA-12	322934090493901	05-20-98	1300	70	23	11	8000	2.8	579	39
HA-15	335429090415001	06-04-98	1000	87	24	13	15500	4.4	516	45
HA-16	341233090393601	06-24-98	1000	62	18	10	8400	3.2	360	42
HA-17	350942090194001	07-13-98	1300	62	20	10	9600	3.0	157	29
HA-18	345628090295701	07-14-98	1400	61	20	7.2	7700	2.2	255	36
HA-19	340413090340301	06-25-98	1100	72	23	12	5200	2.7	304	27
HA-20	335318090303001	06-23-98	1400	68	16	18	9700	2.2	696	34
HA-21	331037090404501	06-02-98	1200	94	28	36	4800	4.2	166	30
HA-22	324355090391801	06-11-98	1000	56	23	13	10700	2.6	409	39
HA-25	335207090165501	06-23-98	1300	49	12	4.5	7400	2.3	1020	33
HA-26	343710090174501	06-10-98	1500	79	25	14	6800	2.8	173	28
HA-27	351204090124001	07-13-98	1500	78	25	14	14600	2.9	971	34
HA-28	352104090182301	07-14-98	0900	71	23	13	11900	3.5	212	29
HA-29	355639089430201	07-20-98	1200	98	32	7.3	7600	2.5	544	29
HA-30	362501089290001	07-23-98	1000	130	33	5.0	15700	2.4	616	30
HA-31	332730090280501	07-29-98	1000	110	30	29	8600	2.9	777	33

Table 1-2b. Major cation and silica concentrations in water from 29 wells screened in the Pleistocene Valley Trains, NAWQA, 1998 [MG/L, milligrams per liter; UG/L micrograms per liter; Date format is first the month, then the day, then the last two digits of the year (1998); <, less than]

WELL NAME	SITE ID	DATE	TIME	CALCIUM DIS- SOLVED (MG/L AS CA)	MAGNE- SIUM, DIS- SOLVED (MG/L AS MG)	SODIUM, DIS- SOLVED (MG/L AS NA)	IRON, DIS- SOLVED (UG/L AS FE)	POTAS- SIUM, DIS- SOLVED (MG/L AS K)	MANGA- NESE, DIS- SOLVED (UG/L AS MN)	SILICA, DIS- SOLVED (MG/L AS SIO2)
VT-01	321011091431701	05-13-98	1000	90	35	124	6900	2.7	516	28
VT-02	321547091443401	05-13-98	1500	38	15	13	<10	.70	<4.0	42
VT-03	323723091462002	05-12-98	1300	28	10	27	11	2.4	<4.0	33
VT-04	344242091103001	06-09-98	1200	89	22	14	3700	2.6	1140	39
VT-05	351550091120101	06-15-98	1500	48	13	11	3900	1.8	885	38
VT-06	354341091120801	06-17-98	1300	65	13	23	3600	1.9	1930	42
VT-07	354455091041501	06-17-98	0900	82	18	39	4500	3.1	887	38
VT-08	352338091080501	06-16-98	0900	79	19	14	5700	1.9	1200	42
VT-09	350944091051201	06-18-98	1200	79	15	13	2200	.97	513	32
VT-10	345647091024500	07-06-98	1200	120	38	27	2000	1.5	388	33
VT-11	331302090485901	06-24-98	0900	98	27	21	5900	1.2	578	32
VT-13	344025090460401	07-15-98	1000	96	45	26	5600	2.2	122	30
VT-14	345631090522000	07-09-98	1000	74	32	18	190	1.3	605	32
VT-15	353658090540801	06-16-98	1400	93	23	23	1900	1.2	511	33
VT-16	355839090515001	07-01-98	0900	90	20	30	3800	2.1	519	33
VT-17	362445090372901	06-29-98	1400	66	12	19	5000	2.8	1430	33
VT-18	361412090150301	06-30-98	1500	50	12	7.1	11	4.0	181	21
VT-19	355813090213901	07-07-98	1400	40	7.8	4.2	410	1.1	293	25
VT-20	355516090285600	06-30-98	0900	95	32	19	3000	1.3	393	30
VT-21	353841090145901	07-08-98	1000	67	13	6.8	6200	1.4	1040	30
VT-22	352934090265401	07-08-98	1300	100	26	12	6500	2.2	563	28
VT-23	341827090080501	06-10-98	1000	68	11	28	9200	2.2	1910	28
VT-24	360148090023801	07-07-98	0900	61	15	15	5500	4.0	257	27
VT-25	361359090031001	07-23-98	1500	51	11	12	1400	2.7	560	25
VT-26	362858089440901	07-22-98	1600	51	13	11	10700	.98	790	34
VT-27	363807089485001	07-22-98	1000	55	11	13	4900	1.5	601	30
VT-28	363956089584201	07-21-98	1300	41	8.2	6.5	3100	1.6	754	27
VT-29	365631089413001	07-21-98	0900	61	11	13	5100	1.9	605	25
VT-30	365430089265001	07-20-98	1600	34	6.5	5.6	240	2.0	337	26

Table 1-3a. Major anion and dissolved solids concentrations in water from 25 wells screened in the Holocene alluvium, NAWQA, 1998 [MG/L, milligrams per liter; Date format is first the month, then the day, then the last two digits of the year (1998); <, less than; --, no data]

WELL NAME	SITE ID	DATE	TIME	BICARBONATE WATER DIS IT FIELD MG/L AS HCO3	SULFATE DISSOLVED (MG/L AS SO4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	BROMIDE DISSOLVED (MG/L AS BR)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L)
HA-03	340021091320101	07-28-98	1000	390	87	140	0.23	--	728
HA-04	342304091500001	07-27-98	1000	303	2.9	20	.31	--	287
HA-05	342657092013901	07-16-98	1000	441	80	71	.30	.36	607
HA-06	335442091163901	07-30-98	1000	556	.55	35	.12	--	544
NA-07	335226091004201	06-25-98	1000	378	1.2	2.7	.23	.058	335
HA-08	330142091000801	06-24-98	1500	365	<.10	4.8	.24	.046	360
HA-09	324311091162801	05-14-98	1300	361	1.1	3.1	.19	.30	318
HA-10	322358091110701	05-11-98	1500	577	<.10	25	.26	.18	537
HA-11	320732091181601	05-18-98	1400	371	1.3	3.5	.36	.36	355
HA-12	322934090493901	05-20-98	1300	342	18	3.4	.29	.046	359
HA-15	335429090415001	06-04-98	1000	421	18	6.4	.30	.066	444
HA-16	341233090393601	06-24-98	1000	299	12	2.7	.32	.070	305
HA-17	350942090194001	07-13-98	1300	318	<.10	2.5	.34	.058	279
HA-18	345628090295701	07-14-98	1400	308	3.5	2.1	.30	--	282
HA-19	340413090340301	06-25-98	1100	308	32	8.7	.23	.096	342
HA-20	335318090303001	06-23-98	1400	285	41	6.4	.16	.30	339
HA-21	331037090404501	06-02-98	1200	449	54	16	.26	.12	508
HA-22	324355090391801	06-11-98	1000	332	5.6	4.4	.30	.086	334
HA-25	335207090165501	06-23-98	1300	232	8.8	3.8	.26	.48	224
HA-26	343710090174501	06-10-98	1500	380	18	9.3	.23	.10	372
HA-27	351204090124001	07-13-98	1500	409	<.10	5.4	.33	--	349
HA-28	352104090182301	07-14-98	0900	360	5.4	6.6	.25	--	325
HA-29	355639089430201	07-20-98	1200	481	4.1	2.1	.19	--	415
HA-30	362501089290001	07-23-98	1000	574	5.0	7.1	.20	--	511
HA-31	332730090280501	07-29-98	1000	359	120	37	.17	--	568

Table 1-3b. Major anion and dissolved solids concentrations in water from 29 wells screened in the Pleistocene Valley Trains, NAWQA, 1998 [MG/L, milligrams per liter; Date format is first the month, then the day, then the last two digits of the year (1998); <, less than; --, no data]

WELL NAME	SITE ID	DATE	TIME	BICAR- BONATE WATER DIS IT FIELD MG/L AS HCO3	SULFATE DIS- SOLVED (MG/L AS SO4)	CHLO- RIDE, DIS- SOLVED (MG/L AS CL)	FLUO- RIDE, DIS- SOLVED (MG/L AS F)	BROMIDE DIS- SOLVED (MG/L AS BR)	SOLIDS, RESIDUE AT 180 DEG. C DIS- SOLVED (MG/L)
VT-01	321011091431701	05-13-98	1000	365	24	230	0.16	0.84	730
VT-02	321547091443401	05-13-98	1500	161	4.6	12	<.10	.069	217
VT-03	323723091462002	05-12-98	1300	131	37	19	.10	.087	251
VT-04	344242091103001	06-09-98	1200	333	63	12	.17	.11	424
VT-05	351550091120101	06-15-98	1500	203	18	6.4	.16	.067	252
VT-06	354341091120801	06-17-98	1300	245	48	6.9	.23	.069	344
VT-07	354455091041501	06-17-98	0900	345	22	41	.37	.25	434
VT-08	352338091080501	06-16-98	0900	301	52	5.5	<.10	.15	312
VT-09	350944091051201	06-18-98	1200	289	44	8.9	.22	.084	358
VT-10	345647091024500	07-06-98	1200	510	75	26	.19	.22	614
VT-11	331302090485901	06-24-98	0900	468	44	18	.18	.054	476
VT-13	344025090460401	07-15-98	1000	521	54	10	.29	.13	549
VT-14	345631090522000	07-09-98	1000	406	6.7	11	.25	.13	387
VT-15	353658090540801	06-16-98	1400	400	30	11	.23	.12	441
VT-16	355839090515001	07-01-98	0900	395	28	7.2	.21	.058	415
VT-17	362445090372901	06-29-98	1400	300	4.1	5.7	.33	.11	289
VT-18	361412090150301	06-30-98	1500	174	24	9.1	.10	.032	232
VT-19	355813090213901	07-07-98	1400	141	17	4.4	<.10	.013	186
VT-20	355516090285600	06-30-98	0900	455	24	7.9	.15	.072	446
VT-21	353841090145901	07-08-98	1000	289	24	2.6	.13	.059	286
VT-22	352934090265401	07-08-98	1300	437	34	7.0	.14	.095	444
VT-23	341827090080501	06-10-98	1000	265	22	30	<.10	.55	334
VT-24	360148090023801	07-07-98	0900	255	48	4.8	.15	.060	313
VT-25	361359090031001	07-23-98	1500	189	24	7.0	<.10	--	203
VT-26	362858089440901	07-22-98	1600	250	9.6	6.4	.35	.089	253
VT-27	363807089485001	07-22-98	1000	225	19	13	.21	--	266
VT-28	363956089584201	07-21-98	1300	146	17	8.5	.12	.060	195
VT-29	365631089413001	07-21-98	0900	242	27	9.4	.13	.096	273
VT-30	365430089265001	07-20-98	1600	112	20	6.3	<.10	--	167

Table 1-4a. Nutrient and dissolved organic carbon concentrations in water from 25 wells screened in the Holocene alluvium, NAWQA, 1998 [MG/L, milligrams per liter; Date format is first the month, then the day, then the last two digits of the year (1998); <, less than; --, no data]

WELL NAME	SITE ID	DATE	TIME	NITROGEN, NITRITE DISSOLVED (MG/L AS N)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA + ORGANIC DIS. (MG/L AS N)	PHOSPHORUS DISSOLVED (MG/L AS P)	PHOSPHORUS ORTHO, DISSOLVED (MG/L AS P)	CARBON, ORGANIC DISSOLVED (MG/L AS C)
HA-03	340021091320101	07-28-98	1000	<.010	0.090	0.459	0.46	1.27	0.020	1.5
HA-04	342304091500001	07-27-98	1000	<.010	.055	.314	.33	.164	.026	1.5
HA-05	342657092013901	07-16-98	1000	.012	<.050	.787	1.0	.514	.027	2.0
HA-06	335442091163901	07-30-98	1000	<.010	<.050	2.64	3.1	1.32	<.010	5.1
HA-07	335226091004201	06-25-98	1000	<.010	<.050	.235	.26	.717	.025	1.7
HA-08	330142091000801	06-24-98	1500	<.010	<.050	1.42	1.5	1.22	.885	2.1
HA-09	324311091162801	05-14-98	1300	<.010	<.050	.766	.83	.148	.054	1.0
HA-10	322358091110701	05-11-98	1500	<.010	<.050	1.53	1.6	.953	.033	2.8
HA-11	320732091181601	05-18-98	1400	.011	<.050	.833	.81	.772	.447	3.0
HA-12	322934090493901	05-20-98	1300	<.010	.057	.578	.64	--	.240	.90
HA-15	335429090415001	06-04-98	1000	.038	.057	1.01	1.1	--	.530	3.0
HA-16	341233090393601	06-24-98	1000	<.010	<.050	.958	1.0	.267	.112	1.2
HA-17	350942090194001	07-13-98	1300	<.010	<.050	.768	.83	1.29	.679	1.4
HA-18	345628090295701	07-14-98	1400	<.010	<.050	.221	.22	.975	.124	1.3
HA-19	340413090340301	06-25-98	1100	.010	<.050	.584	.52	1.04	.017	1.4
HA-20	335318090303001	06-23-98	1400	.011	<.050	.209	.18	.056	.032	1.1
HA-21	331037090404501	06-02-98	1200	.015	.062	.831	1.0	--	.408	2.1
HA-22	324355090391801	06-11-98	1000	.012	<.050	.320	.31	.484	.085	2.1
HA-25	335207090165501	06-23-98	1300	.016	<.050	.143	<.10	.304	.212	1.4
HA-26	343710090174501	06-10-98	1500	.012	<.050	.522	.47	.388	.257	2.0
HA-27	351204090124001	07-13-98	1500	.014	<.050	.922	1.0	1.17	.421	1.7
HA-28	352104090182301	07-14-98	0900	<.010	<.050	.571	.57	1.16	.085	1.7
HA-29	355639089430201	07-20-98	1200	<.010	<.050	.484	.61	.647	.029	2.2
HA-30	362501089290001	07-23-98	1000	.013	.346	.716	.74	.842	.194	2.0
HA-31	332730090280501	07-29-98	1000	<.010	.058	.452	.48	<.010	<.010	1.4

Table 1-4b. Nutrient and dissolved organic carbon concentrations in water from 29 wells screened in the Pleistocene Valley Trains, NAWQA, 1998 [MG/L, milligrams per liter; Date format is first the month, then the day, then the last two digits of the year (1998); <, less than]

WELL NAME	SITE ID	DATE	TIME	NITROGEN, NITRITE DISSOLVED (MG/L AS N)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA + ORGANIC DIS. (MG/L AS N)	PHOSPHORUS DISSOLVED (MG/L AS P)	PHOSPHORUS ORTHO, DISSOLVED (MG/L AS P)	CARBON, ORGANIC DISSOLVED (MG/L AS C)
VT-01	321011091431701	05-13-98	1000	<0.010	<0.050	0.357	0.35	0.222	0.032	1.1
VT-02	321547091443401	05-13-98	1500	<.010	2.61	.041	<.10	.169	.181	.10
VT-03	323723091462002	05-12-98	1300	<.010	2.11	.097	<.10	1.03	1.00	.60
VT-04	344242091103001	06-09-98	1200	.013	<.050	.248	.28	.220	.120	.70
VT-05	351550091120101	06-15-98	1500	.010	<.050	.061	<.10	.186	.037	.50
VT-06	354341091120801	06-17-98	1300	<.010	<.050	.132	<.10	.048	.039	1.0
VT-07	354455091041501	06-17-98	0900	<.010	<.050	.395	.33	.028	.017	1.0
VT-08	352338091080501	06-16-98	0900	.010	<.050	.339	.34	.270	.157	1.8
VT-09	350944091051201	06-18-98	1200	<.010	<.050	.389	.25	.335	.169	.90
VT-10	345647091024500	07-06-98	1200	<.010	<.050	.202	.32	.023	.028	.70
VT-11	331302090485901	06-24-98	0900	<.010	<.050	.128	.16	.089	.046	1.0
VT-13	344025090460401	07-15-98	1000	.012	<.050	1.50	1.7	.416	.102	1.3
VT-14	345631090522000	07-09-98	1000	<.010	.195	.050	<.10	.062	.058	.50
VT-15	353658090540801	06-16-98	1400	<.010	<.050	.516	.50	.288	.261	1.2
VT-16	355839090515001	07-01-98	0900	<.010	<.050	.518	.54	<.010	<.010	1.8
VT-17	362445090372901	06-29-98	1400	<.010	<.050	.233	.24	.159	.161	1.1
VT-18	361412090150301	06-30-98	1500	.011	1.56	.024	<.10	.086	.074	.90
VT-19	355813090213901	07-07-98	1400	.059	.331	.079	<.10	.112	.122	.60
VT-20	355516090285600	06-30-98	0900	<.010	<.050	.058	<.10	.011	.015	1.3
VT-21	353841090145901	07-08-98	1000	<.010	<.050	.104	<.10	.190	.042	1.2
VT-22	352934090265401	07-08-98	1300	<.010	<.050	.217	.19	.264	.049	1.6
VT-23	341827090080501	06-10-98	1000	.015	<.050	.404	.38	.213	.202	1.5
VT-24	360148090023801	07-07-98	0900	<.010	<.050	.290	.31	.067	.025	1.9
VT-25	361359090031001	07-23-98	1500	<.010	.138	.094	<.10	.158	.155	.80
VT-26	362858089440901	07-22-98	1600	<.010	.077	.160	.20	.046	.034	1.9
VT-27	363807089485001	07-22-98	1000	<.010	.775	.117	.13	<.010	.017	1.1
VT-28	363956089584201	07-21-98	1300	.010	.141	.061	<.10	.035	.031	.60
VT-29	365631089413001	07-21-98	0900	<.010	<.050	.140	.17	<.010	.014	1.3
VT-30	365430089265001	07-20-98	1600	<.010	<.050	.037	<.10	.108	.111	.50

Table 1-5a. Trace element concentrations in water from 25 wells screened in the Holocene alluvium, NAWQA, 1998
[UG/L, micrograms per liter; Date format is first the month, then the day, then the last two digits of the year (1998); <, less than]

WELL NAME	SITE ID	DATE	TIME	ARSENIC DIS- SOLVED (UG/L AS AS)	ALUM- INUM, DIS- SOLVED (UG/L AS AL)	ANTI- MONY, DIS- SOLVED (UG/L AS SB)	BARIUM, DIS- SOLVED (UG/L AS BA)	BERYL- LIUM, DIS- SOLVED (UG/L AS BE)	CADMIUM DIS- SOLVED (UG/L AS CD)	CHRO- MIUM, DIS- SOLVED (UG/L AS CR)	COBALT, DIS- SOLVED (UG/L AS CO)	COPPER, DIS- SOLVED (UG/L AS CU)
HA-03	340021091320101	07-28-98	1009	3	3.1	<1.0	700	<1.0	<1.0	8.1	<1.0	<1.0
HA-04	342304091500001	07-27-98	1009	4	4.4	<1.0	269	<1.0	<1.0	2.7	<1.0	<1.0
HA-05	342657092013901	07-16-98	1009	11	3.5	<1.0	584	<1.0	<1.0	2.9	<1.0	<1.0
HA-06	335442091163901	07-30-98	1009	5	3.3	<1.0	768	<1.0	<1.0	7.8	<1.0	<1.0
HA-07	335226091004201	06-25-98	1009	4	3.1	<1.0	330	<1.0	<1.0	2.7	<1.0	<1.0
HA-08	330142091000801	06-24-98	1509	6	3.2	<1.0	289	<1.0	<1.0	3.0	<1.0	<1.0
HA-09	324311091162801	05-14-98	1309	<1	2.5	<1.0	461	<1.0	<1.0	4.7	<1.0	<1.0
HA-10	322358091110701	05-11-98	1509	3	3.0	<1.0	715	<1.0	<1.0	7.0	<1.0	<1.0
HA-11	320732091181601	05-18-98	1409	3	2.6	<1.0	286	<1.0	<1.0	3.8	<1.0	<1.0
HA-12	322934090493901	05-20-98	1309	<1	3.0	<1.0	332	<1.0	<1.0	3.8	<1.0	<1.0
HA-15	335429090415001	06-04-98	1009	1	3.4	<1.0	535	<1.0	<1.0	5.3	<1.0	<1.0
HA-16	341233090393601	06-24-98	1009	<1	2.9	<1.0	251	<1.0	<1.0	2.5	<1.0	<1.0
HA-17	350942090194001	07-13-98	1309	18	3.4	<1.0	498	<1.0	<1.0	3.7	<1.0	<1.0
HA-18	345628090295701	07-14-98	1409	1	2.9	<1.0	416	<1.0	<1.0	1.7	<1.0	<1.0
HA-19	340413090340301	06-25-98	1109	<1	3.2	<1.0	370	<1.0	<1.0	2.6	<1.0	<1.0
HA-20	335318090303001	06-23-98	1409	<1	3.8	<1.0	387	<1.0	<1.0	2.4	<1.0	<1.0
HA-21	331037090404501	06-02-98	1209	<1	3.5	<1.0	552	<1.0	<1.0	6.3	<1.0	<1.0
HA-22	324355090391801	06-11-98	1009	<1	2.8	<1.0	442	<1.0	<1.0	3.3	<1.0	<1.0
HA-25	335207090165501	06-23-98	1309	2	3.3	<1.0	228	<1.0	<1.0	1.8	<1.0	<1.0
HA-26	343710090174501	06-10-98	1509	<1	3.9	<1.0	530	<1.0	<1.0	3.0	<1.0	<1.0
HA-27	351204090124001	07-13-98	1509	33	3.2	<1.0	628	<1.0	<1.0	4.1	<1.0	<1.0
HA-28	352104090182301	07-14-98	0909	3	3.2	<1.0	876	<1.0	<1.0	3.5	<1.0	<1.0
HA-29	355639089430201	07-20-98	1209	3	3.7	<1.0	453	<1.0	<1.0	5.4	1.0	<1.0
HA-30	362501089290001	07-23-98	1009	2	4.2	<1.0	747	<1.0	<1.0	7.9	<1.0	<1.0
HA-31	332730090280501	07-29-98	1009	<1	3.5	<1.0	695	<1.0	<1.0	2.8	<1.0	<1.0

Table 1-5b. Trace element concentrations in water from 29 wells screened in the Pleistocene Valley Trains, NAWQA, 1998 [UG/L, micrograms per liter; Date format is first the month, then the day, then the last two digits of the year (1998); <, less than]

WELL NAME	SITE ID	DATE	TIME	ARSENIC DIS-SOLVED (UG/L AS AS)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ANTI-MONY, DIS-SOLVED (UG/L AS SB)	BARIUM, DIS-SOLVED (UG/L AS BA)	BERYL-LIUM, DIS-SOLVED (UG/L AS BE)	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COBALT, DIS-SOLVED (UG/L AS CO)	COPPER, DIS-SOLVED (UG/L AS CU)
VT-01	321011091431701	05-13-98	1009	2	2.7	<1.0	185	<1.0	<1.0	7.0	1.9	<1.0
VT-02	321547091443401	05-13-98	1509	<1	3.2	<1.0	17	<1.0	<1.0	5.9	<1.0	9.9
VT-03	323723091462002	05-12-98	1309	1	2.7	<1.0	53	<1.0	<1.0	2.5	<1.0	13
VT-04	344242091103001	06-09-98	1209	<1	3.2	<1.0	464	<1.0	<1.0	2.3	<1.0	<1.0
VT-05	351550091120101	06-15-98	1509	2	3.4	<1.0	213	<1.0	<1.0	1.3	<1.0	<1.0
VT-06	354341091120801	06-17-98	1309	<1	3.0	<1.0	476	<1.0	<1.0	2.3	<1.0	<1.0
VT-07	354455091041501	06-17-98	0909	<1	3.4	<1.0	469	<1.0	<1.0	2.5	<1.0	<1.0
VT-08	352338091080501	06-16-98	0909	<1	4.0	<1.0	200	<1.0	<1.0	2.8	<1.0	<1.0
VT-09	350944091051201	06-18-98	1209	3	3.4	<1.0	217	<1.0	<1.0	3.8	<1.0	<1.0
VT-10	345647091024500	07-06-98	1209	3	3.2	<1.0	407	<1.0	<1.0	3.9	<1.0	<1.0
VT-11	331302090485901	06-24-98	0909	56	3.0	<1.0	388	<1.0	<1.0	2.9	<1.0	<1.0
VT-13	344025090460401	07-15-98	1009	3	3.8	<1.0	344	<1.0	<1.0	3.1	<1.0	<1.0
VT-14	345631090522000	07-09-98	1009	2	3.3	<1.0	168	<1.0	<1.0	3.7	<1.0	<1.0
VT-15	353658090540801	06-16-98	1409	3	3.1	<1.0	211	<1.0	<1.0	4.4	<1.0	<1.0
VT-16	355839090515001	07-01-98	0909	<1	4.5	<1.0	222	<1.0	<1.0	3.8	<1.0	<1.0
VT-17	362445090372901	06-29-98	1409	1	3.0	<1.0	547	<1.0	<1.0	2.8	<1.0	<1.0
VT-18	361412090150301	06-30-98	1509	<1	3.6	<1.0	137	<1.0	<1.0	2.1	1.2	5.1
VT-19	355813090213901	07-07-98	1409	<1	5.0	<1.0	274	<1.0	<1.0	1.7	<1.0	<1.0
VT-20	355516090285600	06-30-98	0909	3	3.5	<1.0	434	<1.0	<1.0	4.4	<1.0	<1.0
VT-21	353841090145901	07-08-98	1009	2	3.0	<1.0	530	<1.0	<1.0	2.6	<1.0	<1.0
VT-22	352934090265401	07-08-98	1309	2	3.4	<1.0	863	<1.0	<1.0	3.9	<1.0	<1.0
VT-23	341827090080501	06-10-98	1009	2	3.5	<1.0	721	<1.0	<1.0	2.1	<1.0	<1.0
VT-24	360148090023801	07-07-98	0909	<1	3.6	<1.0	618	<1.0	<1.0	3.6	<1.0	<1.0
VT-25	361359090031001	07-23-98	1509	2	4.1	<1.0	528	<1.0	<1.0	<1.0	<1.0	<1.0
VT-26	362858089440901	07-22-98	1609	9	3.6	<1.0	286	<1.0	<1.0	4.0	<1.0	<1.0
VT-27	363807089485001	07-22-98	1009	9	3.8	<1.0	783	<1.0	<1.0	3.0	<1.0	<1.0
VT-28	363956089584201	07-21-98	1309	2	3.4	<1.0	470	<1.0	<1.0	2.1	<1.0	<1.0
VT-29	365631089413001	07-21-98	0909	27	2.8	<1.0	877	<1.0	<1.0	3.3	<1.0	<1.0
VT-30	365430089265001	07-20-98	1609	<1	4.0	<1.0	402	<1.0	<1.0	<1.0	<1.0	<1.0

Table 1-6a. Trace element concentrations in water from 25 wells screened in the Holocene alluvium, NAWQA, 1998 (continued) [UG/L, micrograms per liter; Date format is first the month, then the day, then the last two digits of the year (1998); <, less than]

WELL NAME	SITE ID	DATE	TIME	LEAD, DIS- SOLVED (UG/L AS PB)	MANGA- NESE, DIS- SOLVED (UG/L AS MN)	MOLYB- DENUM, DIS- SOLVED (UG/L AS MO)	NICKEL, DIS- SOLVED (UG/L AS NI)	SELE- NIUM, DIS- SOLVED (UG/L AS SE)	SILVER, DIS- SOLVED (UG/L AS AG)	URANIUM NATURAL DIS- SOLVED (UG/L AS U)	ZINC, DIS- SOLVED (UG/L AS ZN)
HA-03	340021091320101	07-28-98	1009	<1.0	1360	<1.0	<1.0	<1	<1.0	<1.0	7.0
HA-04	342304091500001	07-27-98	1009	<1.0	620	1.7	<1.0	<1	<1.0	<1.0	<1.0
HA-05	342657092013901	07-16-98	1009	<1.0	1380	3.0	<1.0	<1	<1.0	<1.0	1.0
HA-06	335442091163901	07-30-98	1009	<1.0	675	<1.0	<1.0	<1	<1.0	<1.0	<1.0
HA-07	335226091004201	06-25-98	1009	<1.0	588	<1.0	<1.0	<1	<1.0	<1.0	2.0
HA-08	330142091000801	06-24-98	1509	<1.0	611	<1.0	1.4	<1	<1.0	<1.0	<1.0
HA-09	324311091162801	05-14-98	1309	<1.0	834	<1.0	<1.0	<1	<1.0	<1.0	<1.0
HA-10	322358091110701	05-11-98	1509	<1.0	726	1.4	1.5	<1	<1.0	<1.0	6.1
HA-11	320732091181601	05-18-98	1409	<1.0	767	<1.0	5.4	<1	<1.0	<1.0	90
HA-12	322934090493901	05-20-98	1309	<1.0	625	<1.0	1.0	<1	<1.0	<1.0	3.1
HA-15	335429090415001	06-04-98	1009	<1.0	571	1.1	<1.0	<1	<1.0	<1.0	2.6
HA-16	341233090393601	06-24-98	1009	<1.0	360	1.1	<1.0	<1	<1.0	<1.0	130
HA-17	350942090194001	07-13-98	1309	<1.0	156	4.5	<1.0	<1	<1.0	<1.0	<1.0
HA-18	345628090295701	07-14-98	1409	<1.0	241	<1.0	<1.0	<1	<1.0	<1.0	<1.0
HA-19	340413090340301	06-25-98	1109	<1.0	305	<1.0	<1.0	<1	<1.0	<1.0	<1.0
HA-20	335318090303001	06-23-98	1409	<1.0	693	<1.0	<1.0	<1	<1.0	<1.0	<1.0
HA-21	331037090404501	06-02-98	1209	<1.0	182	1.1	1.3	<1	<1.0	<1.0	<1.0
HA-22	324355090391801	06-11-98	1009	<1.0	412	<1.0	<1.0	<1	<1.0	<1.0	<1.0
HA-25	335207090165501	06-23-98	1309	<1.0	973	<1.0	<1.0	<1	<1.0	<1.0	<1.0
HA-26	343710090174501	06-10-98	1509	<1.0	173	1.6	<1.0	<1	<1.0	<1.0	<1.0
HA-27	351204090124001	07-13-98	1509	<1.0	955	4.3	<1.0	<1	<1.0	<1.0	<1.0
HA-28	352104090182301	07-14-98	0909	<1.0	207	1.2	<1.0	<1	<1.0	<1.0	<1.0
HA-29	355639089430201	07-20-98	1209	<1.0	539	<1.0	2.8	<1	<1.0	1.1	<1.0
HA-30	362501089290001	07-23-98	1009	<1.0	619	<1.0	1.2	<1	<1.0	<1.0	2.5
HA-31	332730090280501	07-29-98	1009	<1.0	741	<1.0	<1.0	<1	<1.0	<1.0	<1.0

Table 1-6b. Trace element concentrations in water from 29 wells screened in the Pleistocene Valley Trains, NAWQA, 1998 (continued) [UG/L, micrograms per liter; Date format is first the month, then the day, then the last two digits of the year (1998); <, less than; --, no data]

WELL NAME	SITE ID	DATE	TIME	LEAD, DIS-SOLVED (UG/L AS PB)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	MOLYB-DENUM, DIS-SOLVED (UG/L AS MO)	NICKEL, DIS-SOLVED (UG/L AS NI)	SELE-NIUM, DIS-SOLVED (UG/L AS SE)	SILVER, DIS-SOLVED (UG/L AS AG)	URANIUM NATURAL DIS-SOLVED (UG/L AS U)	ZINC, DIS-SOLVED (UG/L AS ZN)
VT-01	321011091431701	05-13-98	1009	<1.0	510	1.4	4.0	<1	<1.0	<1.0	4.2
VT-02	321547091443401	05-13-98	1509	<1.0	<1.0	<1.0	1.6	<1	<1.0	<1.0	4.9
VT-03	323723091462002	05-12-98	1309	<1.0	<1.0	<1.0	26	1	<1.0	<1.0	3290
VT-04	344242091103001	06-09-98	1209	<1.0	1190	<1.0	<1.0	<1	<1.0	<1.0	<1.0
VT-05	351550091120101	06-15-98	1509	<1.0	878	<1.0	<1.0	<1	<1.0	<1.0	2.0
VT-06	354341091120801	06-17-98	1309	<1.0	1920	<1.0	<1.0	<1	<1.0	<1.0	4.8
VT-07	354455091041501	06-17-98	0909	<1.0	893	<1.0	<1.0	<1	<1.0	<1.0	<1.0
VT-08	352338091080501	06-16-98	0909	<1.0	1220	<1.0	<1.0	<1	<1.0	<1.0	<1.0
VT-09	350944091051201	06-18-98	1209	<1.0	531	<1.0	<1.0	<1	<1.0	<1.0	<1.0
VT-10	345647091024500	07-06-98	1209	<1.0	392	<1.0	<1.0	<1	<1.0	1.3	<1.0
VT-11	331302090485901	06-24-98	0909	<1.0	471	3.4	<1.0	<1	<1.0	<1.0	<1.0
VT-13	344025090460401	07-15-98	1009	<1.0	120	1.6	1.0	<1	<1.0	<1.0	<1.0
VT-14	345631090522000	07-09-98	1009	<1.0	598	<1.0	1.1	<1	<1.0	<1.0	<1.0
VT-15	353658090540801	06-16-98	1409	<1.0	524	<1.0	<1.0	<1	<1.0	<1.0	<1.0
VT-16	355839090515001	07-01-98	0909	<1.0	497	<1.0	<1.0	<1	--	<1.0	1.9
VT-17	362445090372901	06-29-98	1409	<1.0	1430	5.0	<1.0	<1	<1.0	<1.0	12
VT-18	361412090150301	06-30-98	1509	<1.0	185	<1.0	4.1	2	<1.0	1.1	6.8
VT-19	355813090213901	07-07-98	1409	<1.0	292	<1.0	<1.0	<1	<1.0	<1.0	<1.0
VT-20	355516090285600	06-30-98	0909	<1.0	400	1.4	<1.0	<1	<1.0	<1.0	<1.0
VT-21	353841090145901	07-08-98	1009	<1.0	1040	<1.0	<1.0	<1	<1.0	<1.0	<1.0
VT-22	352934090265401	07-08-98	1309	<1.0	579	<1.0	<1.0	<1	<1.0	<1.0	<1.0
VT-23	341827090080501	06-10-98	1009	<1.0	1890	<1.0	1.1	<1	<1.0	<1.0	1.6
VT-24	360148090023801	07-07-98	0909	<1.0	253	<1.0	<1.0	<1	<1.0	<1.0	<1.0
VT-25	361359090031001	07-23-98	1509	<1.0	543	<1.0	<1.0	<1	<1.0	<1.0	2.0
VT-26	362858089440901	07-22-98	1609	<1.0	784	2.6	<1.0	<1	<1.0	<1.0	<1.0
VT-27	363807089485001	07-22-98	1009	<1.0	597	1.0	1.3	<1	<1.0	<1.0	<1.0
VT-28	363956089584201	07-21-98	1309	<1.0	734	<1.0	<1.0	<1	<1.0	<1.0	<1.0
VT-29	365631089413001	07-21-98	0909	<1.0	588	1.6	1.0	<1	<1.0	<1.0	1.8
VT-30	365430089265001	07-20-98	1609	<1.0	318	<1.0	<1.0	<1	<1.0	<1.0	<1.0

Table 1-7a. Pesticides analyzed in water from 25 wells screened in the Holocene alluvium and 29 wells screened in the Pleistocene valley trains, NAWQA, 1998 [Pesticides were analyzed using gas chromatography/mass spectrometry by the National Water Quality Laboratory in Denver, Colorado; UG/L, micrograms per liter]

Pesticide name	Chemical Abstract Services Registry Number	Minimum Reporting Limit (UG/L)	Pesticide name	Chemical Abstract Services Registry Number	Minimum Reporting Limit (UG/L)
2,6-Diethylaniline	579-66-8	0.003	Malathion	121-75-5	0.005
Acetochlor	34256-82-1	0.002	Metolachlor	51218-45-2	0.002
Alachlor	15972-60-8	0.002	Metribuzin	21087-64-9	0.004
alpha-BHC	319-84-6	0.002	Molinate	2212-67-1	0.004
Atrazine	1912-24-9	0.001	Napropamide	15299-99-7	0.003
Azinphos-methyl	86-50-0	0.001	p,p'-DDE	72-55-9	0.006
Benfluralin	1861-40-1	0.002	Parathion	56-38-2	0.004
Butylate	2008-41-5	0.002	Parathion-methyl	298-00-0	0.006
Carbaryl	63-25-2	0.003	Pebulate	1114-71-2	0.004
Carbofuran	1563-66-2	0.003	Pendimethalin	40487-42-1	0.004
Chlorpyrifos	2921-88-2	0.004	Phorate	298-02-2	0.002
cis-Permethrin	54774-45-7	0.005	Prometon	1610-18-0	0.018
Cyanazine	21725-46-2	0.004	Propachlor	1918-16-7	0.007
Dacthal	1861-32-1	0.002	Propanil	709-98-8	0.004
Deethylatrazine	6190-65-4	0.002	Propargite	2312-35-8	0.013
Diazinon	333-41-5	0.002	Propyzamide (Pronamide)	23950-58-5	0.003
Dieldrin	60-57-1	0.001	Simazine	122-34-9	0.005
Disulfoton	298-04-4	0.017	Tebuthiuron	34014-18-1	0.01
EPTC	759-94-4	0.002	Terbacil	5902-51-2	0.007
Ethalfluralin	55283-68-6	0.004	Terbufos	13071-79-9	0.013
Ethoprophos	13194-48-4	0.003	Thiobencarb	28249-77-6	0.002
Fonofos	944-22-9	0.003	Tri-allate	2303-17-5	0.001
Lindane	58-89-9	0.004	Trifluralin	1582-09-8	0.002
Linuron	330-55-2	0.002			

Table 1-7b. Pesticides analyzed in water from 25 wells screened in the Holocene alluvium and 29 wells screened in the Pleistocene valley trains, NAWQA, 1998 [Pesticides were analyzed using liquid chromatography with UV detection by the National Water Quality Laboratory in Denver, Colorado; UG/L, micrograms per liter; ----, not available]

Pesticide name	Chemical Abstract Services Registry Number	Minimum Reporting Limit (UG/L)	Pesticide name	Chemical Abstract Services Registry Number	Minimum Reporting Limit (UG/L)
2,4,5-T	93-76-5	0.035	Dichlorprop	120-36-5	0.032
2,4-D	94-75-7	0.15	Dinoseb	88-85-7	0.035
2,4-DB	94-82-6	5.	Diuron	330-54-1	0.21
Silvex	93-72-1	0.021	DNOC	----	0.42
3-Hydroxycarbofuran	16655-82-6	0.014	Fenuron	101-42-8	0.013
Acifluorfen	50594-66-6	0.035	Fluometuron	2164-17-2	0.035
Aldicarb	116-06-3	0.55	Linuron	330-55-2	0.018
Aldicarb sulfone	1646-88-4	0.1	MCPA	94-74-6	0.17
Aldicarb sulfoxide	1646-87-3	0.021	MCPB	94-81-5	0.36
Bentazon	25057-89-0	0.014	Methiocarb	2032-65-7	0.026
Bromacil	314-40-9	0.035	Methomyl	16752-77-5	3.56
Bromoxynil	1689-84-5	0.035	Neburon	555-37-3	0.015
Carbaryl	63-25-2	0.008	Norflurazon	27314-13-2	0.024
Carbofuran	1563-66-2	0.12	Oryzalin	19044-88-3	0.310
Chloramben	7286-84-2	0.42	Oxamyl	23135-22-0	0.018
Chlorothalonil	1897-45-6	0.48	Picloram	1918-02-1	0.005
Clopyralid	1702-17-6	0.23	Propham	122-42-9	0.035
Dacthal monoacid	887-54-7	0.017	Propoxur	114-26-1	0.035
Dicamba	1918-00-9	0.035	Triclopyr	55335-06-3	0.25
Dichlobenil	1194-65-6	1.2			

Table 1-7c. Pesticides analyzed in water from 25 wells screened in the Holocene alluvium and 29 wells screened in the Pleistocene valley trains, NAWQA, 1998 [Pesticides were analyzed using gas chromatography/mass spectrometry by the Organic Geochemistry Research Laboratory in Lawrence, Kansas; UG/L, micrograms per liter; ----, not available]

Pesticide name	Chemical Abstract Services Registry Number	Minimum Reporting Limit (UG/L)	Pesticide name	Chemical Abstract Services Registry Number	Minimum Reporting Limit (UG/L)
1,3-Dichloroanaline	----	0.05	Fluometuron	----	0.05
Acetochlor	34256-82-1	0.05	Hydroxyatrazine	----	0.02
Acetochlor ESA	----	0.02	Metolachlor	51218-45-2	0.05
Acetochlor Oxanilic acid	----	0.02	Metolachlor ESA	----	0.02
Alachlor	15972-60-8	0.05	Metolachlor Oxanilic acid	----	0.02
Alachlor ESA	----	0.02	Metribuzin	21087-64-9	0.05
Alachlor Oxanilic acid	----	0.02	Molinate	2212-67-1	0.05
Atrazine	1912-24-9	0.05	Norfluorazon	----	0.05
Cyanazine	21725-46-2	0.05	Prometryn	----	0.05
Cyanazine-amide	----	0.05	Propanil	709-98-8	0.05
Deethylatrazine	6190-65-4	0.05	Propazine	----	0.05
Deisopropylatrazine	----	0.05	Simazine	122-34-9	0.05
Deisopropylprometryn	----	0.05	Trifluralin	1582-09-8	0.05
Demethylfluometuron	----	0.05	Trifluoromethylanalin	----	0.05
Demethylnorfluorazon	----	0.05	Trifluoromethylphenyl urea	----	0.05

Table 1-8a. Pesticide detections in water from 24 wells screened in the Holocene alluvium, NAWQA, 1998
[GC/MS analyses were performed by the National Water Quality Laboratory in Denver, Colorado; UG/L, micrograms per liter; Date format is first the month, then the day, then the last two digits of the year (1998); <, less than; --, no data; E, estimated value]

WELL NAME	SITE ID	DATE	TIME	ATRAZINE, WATER, DISS, REC (UG/L)	P,P' DDE DISSOLVED (UG/L)	METOLACHLOR WATER DISSOLVED (UG/L)	MOLINATE WATER FLTRD 0.7 U GF, REC (UG/L)	PROPANIL WATER FLTRD 0.7 U GF, REC (UG/L)	DEETHYL ATRAZINE, WATER DISS, REC (UG/L)
HA-03	340021091320101	07-28-98	1000	<0.001	<0.0060	<0.002	0.0376	<0.0040	<0.002
HA-04	342304091500001	07-27-98	1000	<0.001	<.0060	<.002	<.004	<.004	<.002
HA-05	342657092013901	07-16-98	1000	<0.001	<.0060	<.002	<.004	<.004	<.002
HA-06	335442091163901	07-30-98	1000	<0.001	<.0060	<.002	<.004	<.004	<.002
HA-07	335226091004201	06-25-98	1000	<0.001	<.0060	<.002	<.004	<.004	<.002
HA-08	330142091000801	06-24-98	1500	<0.001	<.0060	<.002	<.004	<.004	<.002
HA-09	324311091162801	05-14-98	1300	<0.001	<.0060	<.002	<.004	<.004	<.002
HA-10	322358091110701	05-11-98	1500	<0.001	<.0060	<.002	<.004	<.004	<.002
HA-11	320732091181601	05-18-98	1400	<0.001	<.0060	<.002	<.004	<.004	<.002
HA-12	322934090493901	05-20-98	1300	<0.001	<.0060	<.002	<.004	<.004	<.002
HA-15	335429090415001	06-04-98	1000	<0.001	<.0060	<.002	<.004	<.004	<.002
HA-16	341233090393601	06-24-98	1000	<0.001	<.0060	<.002	<.004	<.004	<.002
HA-17	350942090194001	07-13-98	1300	<0.001	<.0060	<.002	<.004	<.004	<.002
HA-18	345628090295701	07-14-98	1400	<0.001	<.0060	<.002	<.004	<.004	<.002
HA-19	340413090340301	06-25-98	1100	<0.001	<.0060	<.002	.0138	E.0028	<.002
HA-20	335318090303001	06-23-98	1400	<0.001	<.0060	<.002	<.004	<.004	<.002
HA-21	331037090404501	06-02-98	1200	<0.001	<.0060	<.002	<.004	<.004	<.002
HA-22	324355090391801	06-11-98	1000	<0.001	<.0060	<.002	<.004	<.004	<.002
HA-25	335207090165501	06-23-98	1300	--	--	--	--	--	--
HA-26	343710090174501	06-10-98	1500	<0.001	E.0015	<.002	<.004	<.004	<.002
HA-27	351204090124001	07-13-98	1500	<0.001	<.0060	<.002	<.004	<.004	<.002
HA-28	352104090182301	07-14-98	0900	<0.001	<.0060	<.002	<.004	<.004	<.002
HA-29	355639089430201	07-20-98	1200	<0.001	<.0060	<.002	<.004	<.004	<.002
HA-30	362501089290001	07-23-98	1000	<0.001	<.0060	<.002	<.004	<.004	<.002
HA-31	32730090280501	07-29-98	1000	<0.001	<.0060	<.002	<.004	<.004	<.002

Table 1-8b. Pesticide detections in water from 29 wells screened in the Pleistocene Valley Trains, NAWQA, 1998 [GC/MS analyses were performed by the National Water Quality Laboratory in Denver, Colorado; UG/L, micrograms per liter; Date format is first the month, then the day, then the last two digits of the year (1998); <, less than; E, estimated value]

WELL NAME	SITE ID	DATE	TIME	ATRAZINE, WATER, DISS, REC (UG/L)	P,P' DDE DISSOLVED (UG/L)	METOLACHLOR WATER DISSOLVED (UG/L)	MOLINATE WATER FLTRD 0.7 U GF, REC (UG/L)	PROPANIL WATER FLTRD 0.7 U GF, REC (UG/L)	DEETHYL ATRAZINE, WATER DISS, REC (UG/L)
VT-01	321011091431701	05-13-98	1000	<0.001	<0.0060	<0.002	<0.004	<0.004	<0.002
VT-02	321547091443401	05-13-98	1500	<.001	<.0060	<.002	<.004	<.004	<.002
VT-03	323723091462002	05-12-98	1300	<.001	<.0060	<.002	<.004	<.004	<.002
VT-04	344242091103001	06-09-98	1200	<.001	<.0060	<.002	<.004	<.004	<.002
VT-05	351550091120101	06-15-98	1500	<.001	<.0060	<.002	<.004	<.004	<.002
VT-06	354341091120801	06-17-98	1300	<.001	<.0060	<.002	.0073	<.004	<.002
VT-07	354455091041501	06-17-98	0900	<.001	<.0060	<.002	.0528	<.004	<.002
VT-08	352338091080501	06-16-98	0900	<.001	<.0060	<.002	<.004	<.004	<.002
VT-09	350944091051201	06-18-98	1200	<.001	<.0060	<.002	<.004	<.004	<.002
VT-10	345647091024500	07-06-98	1200	<.001	<.0060	<.002	<.004	<.004	<.002
VT-11	331302090485901	06-24-98	0900	<.001	<.0060	<.002	<.004	<.004	<.002
VT-13	344025090460401	07-15-98	1000	<.001	<.0060	<.002	<.004	<.004	<.002
VT-14	345631090522000	07-09-98	1000	<.001	<.0060	<.002	<.004	<.004	<.002
VT-15	353658090540801	06-16-98	1400	<.001	<.0060	<.002	<.004	<.004	<.002
VT-16	355839090515001	07-01-98	0900	<.001	<.0060	<.002	<.004	<.004	<.002
VT-17	362445090372901	06-29-98	1400	<.001	<.0060	<.002	<.004	<.004	<.002
VT-18	361412090150301	06-30-98	1500	.019	<.0060	.011	<.004	<.004	E.0132
VT-19	355813090213901	07-07-98	1400	<.001	<.0060	<.002	<.004	<.004	<.002
VT-20	355516090285600	06-30-98	0900	<.001	<.0060	<.002	<.004	<.004	<.002
VT-21	353841090145901	07-08-98	1000	<.001	<.0060	<.002	<.004	<.004	<.002
VT-22	352934090265401	07-08-98	1300	<.001	<.0060	<.002	<.004	<.004	<.002
VT-23	341827090080501	06-10-98	1000	<.001	<.0060	<.002	<.004	<.004	<.002
VT-24	360148090023801	07-07-98	0900	<.001	<.0060	<.002	<.004	<.004	<.002
VT-25	361359090031001	07-23-98	1500	<.001	<.0060	<.002	<.004	<.004	<.002
VT-26	362858089440901	07-22-98	1600	<.001	<.0060	<.002	<.004	<.004	<.002
VT-27	363807089485001	07-22-98	1000	<.001	<.0060	<.002	<.004	<.004	<.002
VT-28	363956089584201	07-21-98	1300	<.001	<.0060	<.002	<.004	<.004	<.002
VT-29	365631089413001	07-21-98	0900	<.001	<.0060	<.002	<.004	<.004	<.002
VT-30	365430089265001	07-20-98	1600	<.001	<.0060	<.002	<.004	<.004	<.002

Table 1-9a. Pesticide detections in water from 25 wells screened in the Holocene alluvium, NAWQA, 1998
[HPLC/UV analyses were performed by the National Water Quality Laboratory in Denver, Colorado; UG/L, micrograms per liter; Date format is first the month, then the day, then the last two digits of the year (1998); <, less than; E, estimated value]

WELL NAME	SITE ID	DATE	TIME	2,4-D, DIS-SOLVED (UG/L)	BENTA-ZON, WATER, FLTRD, GF 0.7U REC (UG/L)	FEN-URON, WATER, FLTRD, GF 0.7U REC (UG/L)	FLUO-METURON WATER, FLTRD, GF 0.7U REC (UG/L)
HA-03	340021091320101	07-28-98	1000	<0.15	0.760	<0.0130	<0.0350
HA-04	342304091500001	07-27-98	1000	<.15	<.014	<.0130	<.0350
HA-05	342657092013901	07-16-98	1000	<.15	E.0200	<.0130	<.0350
HA-06	335442091163901	07-30-98	1000	<.15	<.014	<.0130	<.0350
HA-07	335226091004201	06-25-98	1000	<.15	<.014	<.0130	<.0350
HA-08	330142091000801	06-24-98	1500	<.15	.280	<.0130	<.0350
HA-09	324311091162801	05-14-98	1300	<.15	<.014	E.0200	<.0350
HA-10	322358091110701	05-11-98	1500	<.15	<.014	<.0130	<.0350
HA-11	320732091181601	05-18-98	1400	<.15	<.014	<.0130	<.0350
HA-12	322934090493901	05-20-98	1300	<.15	<.014	<.0130	<.0350
HA-15	335429090415001	06-04-98	1000	<.15	<.014	<.0130	<.0350
HA-16	341233090393601	06-24-98	1000	<.15	<.014	<.0130	<.0350
HA-17	350942090194001	07-13-98	1300	<.15	<.014	<.0130	<.0350
HA-18	345628090295701	07-14-98	1400	<.15	<.014	<.0130	<.0350
HA-19	340413090340301	06-25-98	1100	<.15	.0500	<.0130	<.0350
HA-20	335318090303001	06-23-98	1400	<.15	<.014	<.0130	<.0350
HA-21	331037090404501	06-02-98	1200	<.15	<.014	<.0130	<.0350
HA-22	324355090391801	06-11-98	1000	<.15	<.014	<.0130	<.0350
HA-25	335207090165501	06-23-98	1300	<.15	E3.17	<.0130	.280
HA-26	343710090174501	06-10-98	1500	<.15	<.014	<.0130	<.0350
HA-27	351204090124001	07-13-98	1500	<.15	E.0200	<.0130	<.0350
HA-28	352104090182301	07-14-98	0900	<.15	<.014	<.0130	<.0350
HA-29	355639089430201	07-20-98	1200	<.15	<.014	<.0130	<.0350
HA-30	362501089290001	07-23-98	1000	<.15	<.014	<.0130	<.0350
HA-31	332730090280501	07-29-98	1000	<.15	<.014	<.0130	<.0350

Table 1-9b. Pesticide detections in water from 29 wells screened in the Pleistocene Valley Trains, NAWQA, 1998 [HPLC/UV analyses were performed by the National Water Quality Laboratory in Denver, Colorado; UG/L, micrograms per liter; Date format is first the month, then the day, then the last two digits of the year (1998); <, less than; E, estimated value]

WELL NAME	SITE ID	DATE	TIME	2,4-D, DIS-SOLVED (UG/L)	BENTA-ZON, WATER, FLTRD, GF 0.7U REC (UG/L)	FEN-URON, WATER, FLTRD, GF 0.7U REC (UG/L)	FLUO-METURON WATER, FLTRD, GF 0.7U REC (UG/L)
VT-01	321011091431701	05-13-98	1000	<0.15	<0.014	<0.0130	<0.0350
VT-02	321547091443401	05-13-98	1500	<.15	<.014	<.0130	<.0350
VT-03	323723091462002	05-12-98	1300	<.15	<.110	<.0130	1.22
VT-04	344242091103001	06-09-98	1200	<.15	<.014	<.0130	<.0350
VT-05	351550091120101	06-15-98	1500	<.15	E.0070	<.0130	<.0350
VT-06	354341091120801	06-17-98	1300	<.15	E.0100	<.0130	<.0350
VT-07	354455091041501	06-17-98	0900	<.15	<.014	<.0130	<.0350
VT-08	352338091080501	06-16-98	0900	<.15	<.014	<.0130	<.0350
VT-09	350944091051201	06-18-98	1200	<.15	<.014	<.0130	<.0350
VT-10	345647091024500	07-06-98	1200	<.15	<.014	<.0130	<.0350
VT-11	331302090485901	06-24-98	0900	E.020	<.014	<.0130	<.0350
VT-13	344025090460401	07-15-98	1000	<.15	<.014	<.0130	<.0350
VT-14	345631090522000	07-09-98	1000	<.15	E.0090	<.0130	<.0350
VT-15	353658090540801	06-16-98	1400	<.15	<.014	<.0130	<.0350
VT-16	355839090515001	07-01-98	0900	<.15	E.0200	<.0130	<.0350
VT-17	362445090372901	06-29-98	1400	<.15	<.014	<.0130	<.0350
VT-18	361412090150301	06-30-98	1500	<.15	<.014	<.0130	.0700
VT-19	355813090213901	07-07-98	1400	<.15	<.014	<.0130	<.0350
VT-20	355516090285600	06-30-98	0900	<.15	E.0200	<.0130	<.0350
VT-21	353841090145901	07-08-98	1000	<.15	<.014	<.0130	<.0350
VT-22	352934090265401	07-08-98	1300	<.15	.0500	<.0130	<.0350
VT-23	341827090080501	06-10-98	1000	<.15	<.014	<.0130	<.0350
VT-24	360148090023801	07-07-98	0900	<.15	E.0800	<.0130	<.0350
VT-25	361359090031001	07-23-98	1500	<.15	<.014	<.0130	<.0350
VT-26	362858089440901	07-22-98	1600	<.15	.310	<.0130	<.0350
VT-27	363807089485001	07-22-98	1000	<.15	<.014	<.0130	<.0350
VT-28	363956089584201	07-21-98	1300	<.15	<.014	<.0130	<.0350
VT-29	365631089413001	07-21-98	0900	<.15	<.014	<.0130	<.0350
VT-30	365430089265001	07-20-98	1600	<.15	<.014	<.0130	<.0350

Table 1-10a. Detections of pesticides and pesticide degradation products in water from 13 wells screened in the Holocene alluvium, NAWQA, 1998

[GC/MS analyses were performed at the Organic Geochemistry Research Laboratory in Lawrence, Kansas; UG/L, micrograms per liter; Date format is first the month, then the day, then the last two digits of the year (1998); <, less than; --, no data]

WELL NAME	SITE ID	DATE	TIME	FLUO-METURON (UG/L)	ALA-CHLOR ESA (UG/L)	ALA-CHLOR OX-ANILIC ACID (UG/L)	METOLA-CHLOR ESA (UG/L)	METOLA-CHLOR OX-ANILIC ACID (UG/L)
HA-04	342304091500001	07-27-98	1000	<0.05	<0.20	<0.20	<0.20	<0.20
HA-06	335442091163901	07-30-98	1000	<0.05	<0.20	<0.20	<0.20	<0.20
HA-08	330142091000801	06-24-98	1500	<0.05	<0.20	<0.20	<0.20	<0.20
HA-10	322358091110701	05-11-98	1500	<0.05	--	--	--	--
HA-12	322934090493901	05-20-98	1300	<0.05	<0.20	<0.20	<0.20	<0.20
HA-16	341233090393601	06-24-98	1000	<0.05	<0.20	<0.20	<0.20	<0.20
HA-18	345628090295701	07-14-98	1400	<0.05	<0.20	<0.20	<0.20	<0.20
HA-20	335318090303001	062-3-98	1400	<0.05	<0.20	<0.20	<0.20	<0.20
HA-22	324355090391801	06-11-98	1000	--	<0.20	<0.20	<0.20	<0.20
HA-26	343710090174501	06-10-98	1500	--	<0.20	<0.20	<0.20	<0.20
HA-28	352104090182301	07-14-98	900	<0.05	<0.20	<0.20	<0.20	<0.20
HA-30	362501089290001	07-23-98	1000	<0.05	<0.20	<0.20	<0.20	<0.20
HA-31	332730090280501	07-29-98	1000	<0.05	<0.20	<0.20	<0.20	<0.20

Table 1-10b. Detections of pesticides and pesticide degradation products in water from 14 wells screened in the Pleistocene Valley Trains, NAWQA, 1998 (continued)

[GC/MS analyses were performed at the Organic Geochemistry Research Laboratory in Lawrence, Kansas; UG/L, micrograms per liter; Date format is first the month, then the day, then the last two digits of the year (1998); <, less than; --, no data]

WELL NAME	SITE ID	DATE	TIME	FLUO-METURON (UG/L)	ALA-CHLOR ESA (UG/L)	ALA-CHLOR OX-ANILIC ACID (UG/L)	METOLA-CHLOR ESA (UG/L)	METOLA-CHLOR OX-ANILIC ACID (UG/L)
VT-02	321547091443401	05-13-98	1500	<0.05	--	--	--	--
VT-04	344242091103001	06-09-98	1200	--	<0.20	<0.20	<0.20	<0.20
VT-06	354341091120801	06-17-98	1300	<0.05	<0.20	<0.20	<0.20	<0.20
VT-08	352338091080501	06-16-98	900	<0.05	<0.20	<0.20	<0.20	<0.20
VT-10	345647091024500	07-06-98	1200	<0.05	<0.20	<0.20	<0.20	<0.20
VT-14	345631090522000	07-09-98	1000	<0.05	<0.20	<0.20	<0.20	<0.20
VT-16	355839090515001	07-01-98	900	<0.05	<0.20	<0.20	<0.20	<0.20
VT-18	361412090150301	06-30-98	1500	0.11	0.47	<0.20	0.94	0.2
VT-20	355516090285600	06-30-98	900	<0.05	<0.20	<0.20	<0.20	<0.20
VT-22	352934090265401	07-08-98	1300	<0.05	<0.20	<0.20	<0.20	<0.20
VT-24	360148090023801	07-07-98	900	<0.05	<0.20	<0.20	<0.20	<0.20
VT-26	362858089440901	07-22-98	1600	<0.05	0.29	0.45	<0.20	<0.20
VT-28	363956089584201	07-21-98	1300	<0.05	<0.20	<0.20	<0.20	<0.20
VT-30	365430089265001	07-20-98	1600	<0.05	<0.20	<0.20	<0.20	<0.20

Table 1-11. Volatile organic compounds analyzed for in water from 25 wells screened in the Holocene alluvium and in water from 29 wells screened in the Pleistocene valley trains, NAWQA, 1998 [ug/L, micrograms per liter; ----, not available]

Volatile Organic Compound Name	Chemical Abstract Services Registry Number	Minimum Reporting limit (ug/L)	Volatile Organic Compound Name	Chemical Abstract Services Registry Number	Minimum Reporting limit (ug/L)
1,1,1,2-Tetrachloroethane	630-20-6	1	Chloroform	67-66-3	1
1,1,1-Trichloroethane	71-55-6	1	Chloromethane	74-87-3	1
1,1,2,2-Tetrachloroethane	79-34-5	1	cis-1,2-Dichloroethylene	156-59-2	1
1,1,2-Trichloroethane	79-00-5	1	cis-1,3-Dichloropropene	10061-01-5	1
1,1,2-Trichlorotrifluoroethane	76-13-1	1	Dibromochloromethane	124-48-1	1
1,1-Dichloroethane	75-34-3	1	Dibromomethane	74-95-3	1
1,1-Dichloroethylene	75-35-4	1	Dichlorodifluoromethane	75-71-8	1
1,1-Dichloropropene	563-58-6	1	Dichloromethane	75-09-2	2
1,2,3,4-Tetramethylbenzene	488-23-3	1	Diethyl ether	60-29-7	2
1,2,3,5-Tetramethylbenzene	527-53-7	1	Diisopropyl ether	108-20-3	1
1,2,3-Trichlorobenzene	87-61-6	2	Ethyl methacrylate	97-63-2	2
1,2,3-Trichloropropane	96-18-4	1	Ethyl tert-butyl ether	637-92-3	1
1,2,3-Trimethylbenzene	526-73-8	1	Ethylbenzene	100-41-4	1
1,2,4-Trichlorobenzene	120-82-1	1	Hexachlorobutadiene	87-68-3	1
1,2,4-Trimethylbenzene	95-63-6	1	Hexachloroethane	67-72-1	2
1,2-Dibromo-3-chloropropane	96-12-8	1	Isopropylbenzene	98-82-8	1
1,2-Dibromoethane	106-93-4	1	m- and p-Xylene	----	1
1,2-Dichlorobenzene	95-50-1	1	Methyl acrylate	96-33-3	10
1,2-Dichloroethane	107-06-2	1	Methyl acrylonitrile	126-98-7	5
1,2-Dichloropropane	78-87-5	1	Methyl iodide	74-88-4	1
1,3,5-Trimethylbenzene	108-67-8	1	Methyl methacrylate	80-62-6	2
1,3-Dichlorobenzene	541-73-1	1	n-Propylbenzene	103-65-1	1
1,3-Dichloropropane	142-28-9	1	Naphthalene	91-20-3	1
1,4-Dichlorobenzene	106-46-7	1	o-Ethyl toluene	611-14-3	1
2,2-Dichloropropane	594-20-7	1	o-Xylene	95-47-6	1

Table 1-11 (continued). Volatile organic compounds analyzed for in water from 25 wells screened in the Holocene alluvium and in water from 29 wells screened in the Pleistocene valley trains, NAWQA, 1998 [ug/L, micrograms per liter]

Volatile Organic Compound Name	Chemical Abstract Services Registry Number	Minimum Reporting limit (ug/L)	Volatile Organic Compound Name	Chemical Abstract Services Registry Number	Minimum Reporting limit (ug/L)
2-Butanone	78-93-3	10	sec-Butylbenzene	135-98-8	1
2-Chlorotoluene	95-49-8	1	Styrene	100-42-5	1
2-Hexanone	591-78-6	5	tert-Butyl methyl ether	1634-04-4	1
3-Chloropropene	107-05-1	1	tert-Butylbenzene	98-06-6	1
4-Chlorotoluene	106-43-4	1	tert-Pentyl methyl ether	994-05-8	1
4-Isopropyl-1-methylbenzene	99-87-6	1	Tetrachloroethylene	127-18-4	1
4-Methyl-2-pentanone	108-10-1	2	Tetrachloromethane	56-23-5	1
Acetone	67-64-1	20	Tetrahydrofuran	109-99-9	50
Acrylonitrile	107-13-1	5	Toluene	108-88-3	1
Benzene	71-43-2	1	trans-1,2-Dichloroethylene	156-60-5	1
Bromobenzene	108-86-1	1	trans-1,3-Dichloropropene	10061-02-6	1
Bromochloromethane	74-97-5	1	trans-1,4-Dichloro-2-butene	110-57-6	5
Bromodichloromethane	75-27-4	1	Trichloroethylene	79-01-6	1
Bromoethene	593-60-2	1	Trichlorofluoromethane	75-69-4	1
Bromoform	75-25-2	1	Vinyl chloride	75-01-4	1
Bromomethane	74-83-9	1			
Butylbenzene	104-51-8	1			
Carbon disulfide	75-15-0	2			
Chlorobenzene	108-90-7	1			
Chloroethane	75-00-3	1			

Table 1-12a. Radioisotope concentrations and relative stable-isotope ratios in water from 25 wells screened in the Holocene alluvium, NAWQA, 1998 [PCI/L, picoCuries per liter; Date format is first the month, then the day, then the last two digits of the year (1998); <, less than; --, no data]

WELL NAME	SITE ID	DATE	TIME	RADIUM 226, DIS- SOLVED, RADON METHOD (PCI/L)	RADON 222 TOTAL (PCI/L)	TRITIUM TOTAL (TRIT- IUM UNITS)	O-18 / O-16 STABLE ISOTOPE RATIO PER MIL	H-2 / H-1 STABLE ISOTOPE RATIO PER MIL
HA-03	340021091320101	07-28-98	1000	--	127	3.	-4.85	-26.0
HA-04	342304091500001	07-27-98	1000	.41	215	0.69	-3.82	-22.5
HA-05	342657092013901	07-16-98	1000	--	169	10.	-3.94	-22.8
HA-06	335442091163901	07-30-98	1000	.79	206	1.6	-4.10	-22.2
HA-07	335226091004201	06-25-98	1000	--	242	2.1	-4.76	-26.2
HA-08	330142091000801	06-24-98	1500	.36	211	3.8	-3.99	-22.3
HA-09	324311091162801	05-14-98	1300	--	334	2.9	-3.66	-20.8
HA-10	322358091110701	05-11-98	1500	.69	119	1.	-4.46	-25.9
HA-11	320732091181601	05-18-98	1400	--	287	9.1	-3.76	-19.5
HA-12	322934090493901	05-20-98	1300	--	180	<0.31	-4.23	-24.6
HA-15	335429090415001	06-04-98	1000	--	203	4.7	-4.88	-26.6
HA-16	341233090393601	06-24-98	1000	.26	268	3.4	-4.74	-26.0
HA-17	350942090194001	07-13-98	1300	--	185	<0.31	-5.23	-28.5
HA-18	345628090295701	07-14-98	1400	.48	253	2.1	-5.07	-28.4
HA-19	340413090340301	06-25-98	1100	--	235	2.9	-5.00	-27.1
HA-20	335318090303001	06-23-98	1400	.53	241	0.31	-5.00	-28.0
HA-21	331037090404501	06-02-98	1200	--	260	2.3	-4.55	-25.4
HA-22	324355090391801	06-11-98	1000	.46	246	0.81	-4.22	-22.1
HA-25	335207090165501	06-23-98	1300	--	231	5.3	-3.91	-22.3
HA-26	343710090174501	06-10-98	1500	.62	207	0.31	-4.79	-26.3
HA-27	351204090124001	07-13-98	1500	--	168	<0.31	-5.35	-29.6
HA-28	352104090182301	07-14-98	0900	.79	126	0.69	-5.28	-30.3
HA-29	355639089430201	07-20-98	1200	--	198	6.6	-5.12	-28.8
HA-30	362501089290001	07-23-98	1000	.78	225	8.8	-5.63	-32.2
HA-31	332730090280501	07-29-98	1000	.92	172	0.69	-4.00	-22.9

Table 1-12b. Radioisotope concentrations and relative stable-isotope ratios in water from 29 wells screened in the Pleistocene Valley Trains, NAWQA, 1998 [PCI/L, picoCuries per liter; Date format is first the month, then the day, then the last two digits of the year (1998); --, no data]

WELL NAME	SITE ID	DATE	TIME	RADIUM 226, DIS-SOLVED, RADON METHOD (PCI/L)	RADON 222 TOTAL (PCI/L)	TRITIUM TOTAL (PCI/L)	O-18 / O-16 STABLE ISOTOPE RATIO PER MIL	H-2 / H-1 STABLE ISOTOPE RATIO PER MIL
VT-01	321011091431701	05-13-98	1000	--	142	1.9	-4.30	-22.7
VT-02	321547091443401	05-13-98	1500	.26	306	5	-4.72	-25.4
VT-03	323723091462002	05-12-98	1300	--	333	5.9	-4.61	-25.0
VT-04	344242091103001	06-09-98	1200	.49	274	5.3	-4.82	-26.4
VT-05	351550091120101	06-15-98	1500	--	348	4.4	-5.29	-29.4
VT-06	354341091120801	06-17-98	1300	.46	220	3.4	-5.69	-33.0
VT-07	354455091041501	06-17-98	0900	--	229	<0.31	-5.21	-30.9
VT-08	352338091080501	06-16-98	0900	.40	260	9.7	-4.62	-26.3
VT-09	350944091051201	06-18-98	1200	--	264	3.4	-5.47	-30.2
VT-10	345647091024500	07-06-98	1200	.52	220	0.69	-5.22	-29.3
VT-11	331302090485901	06-24-98	0900	--	172	2.8	-3.59	-18.8
VT-13	344025090460401	07-15-98	1000	--	211	0.41	-5.23	-28.2
VT-14	345631090522000	07-09-98	1000	.22	233	4.1	-5.16	-28.8
VT-15	353658090540801	06-16-98	1400	--	342	<0.31	-5.30	-29.5
VT-16	355839090515001	07-01-98	0900	.41	189	1.1	-5.18	-30.2
VT-17	362445090372901	06-29-98	1400	--	264	1.9	-4.62	-27.9
VT-18	361412090150301	06-30-98	1500	.28	303	5.9	-5.86	-32.7
VT-19	355813090213901	07-07-98	1400	--	234	10.3	-5.52	-31.2
VT-20	355516090285600	06-30-98	0900	.43	150	5.	-5.65	-33.0
VT-21	353841090145901	07-08-98	1000	--	213	3.	-5.16	-29.9
VT-22	352934090265401	07-08-98	1300	.69	250	4.1	-5.30	-30.4
VT-23	341827090080501	06-10-98	1000	--	176	4.1	-2.58	-15.3
VT-24	360148090023801	07-07-98	0900	.73	201	7.8	-5.30	-31.2
VT-25	361359090031001	07-23-98	1500	--	254	7.8	-5.81	-32.5
VT-26	362858089440901	07-22-98	1600	.37	233	1.1	-5.77	-34.8
VT-27	363807089485001	07-22-98	1000	--	229	13.4	-5.46	-31.6
VT-28	363956089584201	07-21-98	1300	.42	145	7.8	-5.87	-33.1
VT-29	365631089413001	07-21-98	0900	--	308	6.9	-5.78	-33.5
VT-30	365430089265001	07-20-98	1600	.29	256	12.2	-5.88	-34.3

Table 1-13a. Land-use percentage within 164 ft (50 m) of 25 wells screened in the Holocene alluvium [-, Significant area of land use was not detected within 164 ft (50 m) of the well.]

WELL NAME	SITE ID	DATE YYYY-MM-DD	URBAN RESI-DENT-IAL	URBAN COMM-ERC-IAL	URBAN INDU-STRIAL	URBAN OTHER	AGRI-CULT-URE CROPS	AGRI-CULT-URE PAST-URE	AGRI-CULT-URE NON PRO-DUCT-IVE	AQUA-CULT-URE	AGRI-CULT-URE INDU-STRIAL	FOREST	RANGE-LAND UNDE-VELO-PED	WET-LAND	WATER
HA-03	340021091320101	1998-07-30	-	-	-	22	72	-	4	-	2	-	-	-	-
HA-04	342304091500001	1998-07-29	-	-	-	11	80	-	7	-	-	2	-	-	-
HA-05	342657092013901	1998-07-29	6	-	-	33	48	13	-	-	-	-	-	-	-
HA-06	335442091163901	1998-07-30	34	-	-	16	21	-	3	-	26	-	-	-	-
HA-07	335226091004201	1998-06-30	-	-	-	-	26	-	-	-	73	-	1	-	-
HA-08	330142091000801	1998-06-24	30	-	-	1	18	-	-	-	51	-	-	-	-
HA-09	324311091162801	1998-05-14	35	-	-	3	43	-	-	-	-	3	-	-	16
HA-10	322358091110701	1998-05-11	37	-	63	-	-	-	-	-	-	-	-	-	-
HA-11	320732091181601	1998-06-26	28	-	-	9	39	-	16	-	-	8	-	-	-
HA-12	322934090493901	1998-06-29	49	-	-	-	24	-	-	-	27	-	-	-	-
HA-15	335429090415001	1998-06-30	-	21	-	22	23	-	-	-	-	-	-	34	-
HA-16	341233090393601	1998-06-29	44	-	-	3	45	-	-	-	8	-	-	-	-
HA-17	350942090194001	1998-07-13	-	-	-	20	71	-	-	-	4	2	3	-	-
HA-18	345628090295701	1998-07-15	-	-	-	7	52	-	24	-	12	5	-	-	-
HA-19	340413090340301	1998-06-24	-	-	-	17	48	-	8	-	1	11	10	-	5
HA-20	335318090303001	1998-06-23	-	-	-	9	60	-	-	-	31	-	-	-	-
HA-21	331037090404501	1998-06-30	-	-	-	20	1	-	18	61	-	-	-	-	-
HA-22	324355090391801	1998-06-11	-	-	-	14	56	-	30	-	-	-	-	-	-
HA-25	335207090165501	1998-06-23	-	-	3	-	-	-	-	-	91	2	2	2	-
HA-26	343710090174501	1998-06-10	-	-	-	-	-	-	-	76	24	-	-	-	-
HA-27	351204090124001	1998-07-13	-	-	-	16	83	-	-	-	1	-	-	-	-
HA-28	352104090182301	1998-07-14	-	-	-	20	43	-	34	-	3	-	-	-	-
HA-29	355639089430201	1998-07-20	-	38	-	62	-	-	-	-	-	-	-	-	-
HA-30	362501089290001	1998-07-22	-	-	-	-	94	-	-	-	6	-	-	-	-
HA-31	332730090280501	1998-07-28	4	-	-	15	-	-	-	40	38	-	-	3	-

Table 1-13b. Land-use percentage within 164 ft (50 m) of 29 wells screened in the Pleistocene valley trains [-, Significant land-use area was not detected within 164 ft (50 m) of the well.]

WELL NAME	SITE ID	DATE	URBAN RESI-DENT-IAL	URBAN COMM-ERC-IAL	URBAN INDU-STRIAL	URBAN OTHER	AGRI-CULT-URE CROPS	AGRI-CULT-URE PAST-URE	AGRI-CULT-URE NON PRO-DUCT-IVE	AQUA-CULT-URE	AGRI-CULT-URE INDU-STRIAL	FOREST	RANGE-LAND UNDE-VELO-PED	WET-LAND	WATER
VT-01	321011091431701	1998-05-13	-	2	-	52	-	-	-	-	-	46	-	-	-
VT-02	321547091443401	1998-05-13	70	-	-	5	19	-	-	-	-	-	6	-	-
VT-03	323723091462002	1998-05-12	-	37	11	13	-	-	-	-	6	28	5	-	-
VT-04	344242091103001	1998-06-09	3	-	-	9	55	-	33	-	-	-	-	-	-
VT-05	351550091120101	1998-06-15	7	-	-	11	63	-	-	-	-	8	11	-	-
VT-06	354341091120801	1998-06-17	31	-	7	27	-	-	-	-	30	-	-	-	5
VT-07	354455091041501	1998-06-17	-	-	-	19	71	-	3	-	2	5	-	-	-
VT-08	352338091080501	1998-06-16	17	-	-	15	56	-	12	-	-	-	-	-	-
VT-09	350944091051201	1998-06-18	25	-	-	8	62	-	-	-	5	-	-	-	-
VT-10	345647091024500	1998-07-13	-	-	-	12	69	-	4	-	4	4	7	-	-
VT-11	331302090485901	1998-06-24	-	-	-	14	-	-	-	86	-	-	-	-	-
VT-13	344025090460401	1998-07-15	-	-	-	21	74	-	-	-	5	-	-	-	-
VT-14	345631090522000	1998-07-13	-	-	-	11	89	-	-	-	-	-	-	-	-
VT-15	353658090540801	1998-06-16	7	-	30	34	-	-	-	-	-	9	20	-	-
VT-16	355839090515001	1998-07-14	16	28	14	42	-	-	-	-	-	-	-	-	-
VT-17	362445090372901	1998-07-14	18	-	-	-	-	-	-	59	23	-	-	-	-
VT-18	361412090150301	1998-07-15	71	-	-	-	5	-	-	-	24	-	-	-	-
VT-19	355813090213901	1998-07-15	-	-	-	7	80	-	12	-	1	-	-	-	-
VT-20	355516090285600	1998-07-15	-	-	-	31	68	-	-	-	1	-	-	-	-
VT-21	353841090145901	1998-07-15	23	-	-	18	48	-	4	-	7	-	-	-	-
VT-22	352934090265401	1998-07-14	37	-	-	18	45	-	-	-	-	-	-	-	-
VT-23	341827090080501	1998-06-10	-	-	-	-	-	-	-	79	21	-	-	-	-
VT-24	360148090023801	1998-07-15	32	-	-	25	33	-	2	-	8	-	-	-	-
VT-25	361359090031001	1998-08-03	11	-	54	35	-	-	-	-	-	-	-	-	-
VT-26	362858089440901	1998-07-21	14	-	-	-	29	-	7	25	19	6	-	-	-
VT-27	363807089485001	1998-07-21	-	-	-	-	95	-	-	-	5	-	-	-	-
VT-28	363956089584201	1998-07-21	21	-	-	61	1	-	-	-	11	6	-	-	-
VT-29	365631089413001	1998-07-21	-	10	66	22	2	-	-	-	-	-	-	-	-
VT-30	365430089265001	1998-07-21	16	24	28	28	-	3	-	-	-	-	1	-	-

Table 1-14a. Land-use percentage within 1,641 ft (500 m) of 25 wells screened in the Holocene alluvium [-, Significant area of land use was not detected within 1,641 ft (500 m) of the well.]

WELL NAME	SITE ID	DATE YYYY-MM-DD	URBAN RESI-DENT-IAL	URBAN COMM-ERC-IAL	URBAN INDU-STRIAL	URBAN OTHER	AGRI-CULT-URE CROPS	AGRI-CULT-URE PAST-URE	AGRI-CULT-URE NON PRO-DUCT-IVE	AQUA-CULT-URE	AGRI-CULT-URE INDU-STRIAL	FOREST	RANGE-LAND UNDE-VELO-PED	WET-LAND	WATER
HA-03	340021091320101	1998-07-30	-	-	-	-	98	-	2	-	-	-	-	-	-
HA-04	342304091500001	1998-07-29	5	-	-	-	85	-	-	-	-	4	-	5	1
HA-05	342657092013901	1998-07-29	-	-	-	-	49	8	17	-	-	5	-	21	-
HA-06	335442091163901	1998-07-30	1	-	-	-	94	-	-	-	1	1	1	2	-
HA-07	335226091004201	1998-06-30	1	-	-	-	86	-	11	-	2	-	-	-	-
HA-08	330142091000801	1998-06-24	2	3	-	2	80	-	-	-	8	4	-	-	1
HA-09	324311091162801	1998-05-14	5	-	-	-	41	-	31	-	1	-	-	19	3
HA-10	322358091110701	1998-05-11	60	33	-	7	-	-	-	-	-	-	-	-	-
HA-11	320732091181601	1998-06-26	3	-	-	-	82	-	-	-	-	5	-	10	-
HA-12	322934090493901	1998-06-29	2	-	-	-	72	-	-	-	2	17	-	-	7
HA-15	335429090415001	1998-06-30	1	1	-	-	70	-	2	-	1	17	-	8	-
HA-16	341233090393601	1998-06-29	2	-	-	-	90	-	-	-	-	8	-	-	-
HA-17	350942090194001	1998-07-13	-	-	-	-	90	-	-	-	-	10	-	-	-
HA-18	345628090295701	1998-07-15	1	-	-	-	86	-	-	-	2	3	-	8	-
HA-19	340413090340301	1998-06-24	-	-	-	-	70	-	1	-	1	11	12	1	4
HA-20	335318090303001	1998-06-23	2	-	-	-	93	2	1	-	2	-	-	-	-
HA-21	331037090404501	1998-06-30	-	-	-	-	34	-	-	53	1	5	-	-	7
HA-22	324355090391801	1998-06-11	1	-	-	4	70	-	6	-	1	4	1	-	13
HA-25	335207090165501	1998-06-23	1	-	-	3	57	-	5	-	5	3	-	11	15
HA-26	343710090174501	1998-06-10	-	-	-	-	51	-	-	48	1	-	-	-	-
HA-27	351204090124001	1998-07-13	11	-	-	1	83	-	1	-	-	4	-	-	-
HA-28	352104090182301	1998-07-14	-	-	-	-	74	-	25	-	1	-	-	-	-
HA-29	355639089430201	1998-07-20	-	10	49	22	11	-	8	-	-	-	-	-	-
HA-30	362501089290001	1998-07-22	2	-	-	-	95	-	-	-	1	1	1	-	-
HA-31	332730090280501	1998-07-28	-	3	-	4	15	-	-	73	4	-	-	1	-

Table 1-14b. Land-use percentage within 1,641 ft (500 m) of 29 wells screened in the Pleistocene valley trains [-, Significant land-use area was not detected within 1,641 ft (500 m) of the well.]

WELL NAME	SITE ID	DATE	URBAN RESI-DENT-IAL	URBAN COMM-ERC-IAL	URBAN INDU-STRIAL	URBAN OTHER	AGRI-CULT-URE CROPS	AGRI-CULT-URE PAST-URE	AGRI-CULT-URE NON PRO-DUCT-IVE	AQUA-CULT-URE	AGRI-CULT-URE INDU-STRIAL	FOREST	RANGE-LAND UNDE-VELO-PED	WET-LAND	WATER
VT-01	321011091431701	1998-05-13	14	14	22	6	-	19	-	-	-	25	-	-	-
VT-02	321547091443401	1998-05-13	22	9	-	-	8	6	50	-	-	4	1	-	-
VT-03	323723091462002	1998-05-12	34	11	-	1	28	16	6	-	4	-	-	-	-
VT-04	344242091103001	1998-06-09	4	-	-	-	62	1	16	-	1	4	-	12	-
VT-05	351550091120101	1998-06-15	37	16	2	4	20	-	11	-	-	4	-	6	-
VT-06	354341091120801	1998-06-17	64	17	7	5	7	-	-	-	-	-	-	-	-
VT-07	354455091041501	1998-06-17	-	-	-	-	100	-	-	-	-	-	-	-	-
VT-08	352338091080501	1998-06-16	3	-	-	-	84	1	8	-	4	-	-	-	-
VT-09	350944091051201	1998-06-18	4	-	-	-	92	-	-	-	1	3	-	-	-
VT-10	345647091024500	1998-07-13	-	-	-	15	85	-	-	-	-	-	-	-	-
VT-11	331302090485901	1998-06-24	13	-	-	5	16	-	-	59	7	-	-	-	-
VT-13	344025090460401	1998-07-15	4	1	-	-	91	3	-	-	-	1	-	-	-
VT-14	345631090522000	1998-07-13	3	-	-	-	79	6	3	-	-	8	-	1	-
VT-15	353658090540801	1998-06-16	31	19	12	4	31	-	-	-	-	-	3	-	-
VT-16	355839090515001	1998-07-14	30	1	-	11	51	1	2	-	3	1	-	-	-
VT-17	362445090372901	1998-07-14	16	-	-	-	37	-	24	15	4	4	-	-	-
VT-18	361412090150301	1998-07-15	2	-	-	-	95	1	-	-	2	-	-	-	-
VT-19	355813090213901	1998-07-15	4	-	-	-	96	-	-	-	-	-	-	-	-
VT-20	355516090285600	1998-07-15	2	-	-	-	94	-	-	-	2	1	-	1	-
VT-21	353841090145901	1998-07-15	2	1	-	-	94	-	-	-	3	-	-	-	-
VT-22	352934090265401	1998-07-14	6	-	-	-	92	-	1	-	1	-	-	-	-
VT-23	341827090080501	1998-06-10	-	-	-	-	13	-	5	81	-	-	-	1	-
VT-24	360148090023801	1998-07-15	5	-	-	-	92	-	-	-	3	-	-	-	-
VT-25	361359090031001	1998-08-03	64	23	9	1	3	-	-	-	-	-	-	-	-
VT-26	362858089440901	1998-07-21	1	-	-	-	92	1	-	3	3	-	-	-	-
VT-27	363807089485001	1998-07-21	2	-	-	-	97	-	-	-	1	-	-	-	-
VT-28	363956089584201	1998-07-21	23	17	4	16	34	-	-	-	5	-	1	-	-
VT-29	365631089413001	1998-07-21	44	10	16	5	14	-	-	-	1	6	3	1	-
VT-30	365430089265001	1998-07-21	37	6	-	10	42	1	-	-	3	-	1	-	-

APPENDIX 2. QUALITY-ASSURANCE DATA

Table 2-1. Quality-assurance data for major cations and silica of sampled wells screened in the Mississippi River Valley alluvium, NAWQA, 1998 [EQ.BLK, field-equipment blank; REPLCT, replicate; MG/L, milligrams per liter; UG/L, micrograms per liter; <, less than]

WELL NAME	SITE ID	DATE	TIME	QUALITY ASSURANCE SAMPLE TYPE	CALCIUM DIS- SOLVED (MG/L AS CA)	MAGNE- SIUM, DIS- SOLVED (MG/L AS MG)	SODIUM, DIS- SOLVED (MG/L AS NA)	IRON, DIS- SOLVED (UG/L AS FE)	POTAS- SIUM, DIS- SOLVED (MG/L AS K)	MANGA- NESE, DIS- SOLVED (UG/L AS MN)	SILICA, DIS- SOLVED (MG/L AS SIO2)
HA-19	340413090340301	06-25-98	1101	REPLCT	69	23	12	5100	2.6	297	27
HA-22	324355090391801	06-11-98	1001	REPLCT	56	23	13	10700	2.5	408	39
HA-23*	330413090192501	06-04-98	1506	EQ.BLK	.28	.068	.13	46	<.10	<4.0	.12
HA-27	351204090124001	07-14-98	0806	EQ.BLK	.046	.006	<.10	<10	<.10	<4.0	<.10
HA-31	332730090280501	07-30-98	0906	EQ.BLK	.034	.005	.19	<10	<.10	<4.0	<.10
VT-02	321547091443401	05-14-98	1006	EQ.BLK	<.020	<.004	<.10	<10	<.10	<4.0	<.10
VT-07	354455091041501	06-18-98	1006	EQ.BLK	.022	<.004	<.10	<10	<.10	<4.0	<.10
VT-13	344025090460401	07-15-98	1001	REPLCT	98	46	26	5700	2.2	123	30
VT-20	355516090285600	07-01-98	1306	EQ.BLK	<.020	<.004	<.10	<10	<.10	<4.0	<.10
VT-27	363807089485001	07-22-98	1001	REPLCT	55	11	13	4900	1.6	596	30
VT-29	365631089413001	07-21-98	0901	REPLCT	61	11	13	5100	1.6	607	25

* -- Well was not screened in the Mississippi River Valley alluvial aquifer but had quality-assurance data that were useful to the Mississippi River Valley alluvial aquifer study.

Table 2-2. Quality-assurance data for major anions and dissolved solids residue of sampled wells screened in the Mississippi River Valley alluvium, NAWQA, 1998 [EQ.BLK, field-equipment blank; REPLCT, replicate; MG/L, milligrams per liter; <, less than; --, no data]

WELL NAME	SITE ID	DATE	TIME	QUALITY ASSURANCE SAMPLE TYPE	SULFATE DIS- SOLVED (MG/L AS SO4)	CHLO- RIDE, DIS- SOLVED (MG/L AS CL)	FLUO- RIDE, DIS- SOLVED (MG/L AS F)	BROMIDE DIS- SOLVED (MG/L AS BR)	SOLIDS, RESIDUE AT 180 DEG. C DIS- SOLVED (MG/L)
HA-19	340413090340301	06-25-98	1101	REPLCT	32	8.8	0.22	.089	343
HA-22	324355090391801	06-11-98	1001	REPLCT	4.9	4.0	.30	.51	331
HA-23*	330413090192501	06-04-98	1506	EQ.BLK	<.10	<.10	<.10	<.010	<10
HA-27	351204090124001	07-14-98	0806	EQ.BLK	<.10	<.10	<.10	<.010	<10
HA-31	332730090280501	07-30-98	0906	EQ.BLK	<.10	<.10	<.10	--	<10
VT-02	321547091443401	05-14-98	1006	EQ.BLK	<.10	<.10	<.10	<.010	<10
VT-07	354455091041501	06-18-98	1006	EQ.BLK	<.10	<.10	<.10	<.010	<10
VT-13	344025090460401	07-15-98	1001	REPLCT	54	10	.28	.10	547
VT-20	355516090285600	07-01-98	1306	EQ.BLK	<.10	<.10	<.10	<.010	<10
VT-27	363807089485001	07-22-98	1001	REPLCT	19	13	.21	--	261
VT-29	365631089413001	07-21-98	0901	REPLCT	26	8.9	.13	.067	273

* -- Well was not screened in the Mississippi River Valley alluvial aquifer but had quality-assurance data that were useful to the Mississippi River Valley alluvial aquifer study.

Table 2-3. Quality-assurance data for nutrients and dissolved organic carbon of sampled wells screened in the Mississippi River Valley alluvium, NAWQA, 1998 [EQ.BLK, field-equipment blank; SC.BLK, source solution blank; REPLCT, replicate; MG/L, milligrams per liter; <, less than; --, no data]

WELL NAME	SITE ID	DATE	TIME	QUALITY ASSURANCE SAMPLE TYPE	NITROGEN, NITRITE DISSOLVED (MG/L AS N)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA + ORGANIC DIS. (MG/L AS N)	PHOSPHORUS DISSOLVED (MG/L AS P)	PHOSPHORUS ORTHO, DISSOLVED (MG/L AS P)	CARBON, ORGANIC DISSOLVED (MG/L AS C)
HA-19	340413090340301	06-25-98	1101	REPLCT	<0.010	<0.050	0.579	0.51	0.297	0.012	1.3
HA-22	324355090391801	06-11-98	1001	REPLCT	.016	<.050	.329	.31	1.08	.300	1.8
HA-23*	330413090192501	06-04-98	1505	EQ.BLK	--	--	--	--	--	--	.20
		06-04-98	1506	EQ.BLK	.016	.060	.030	<.10	.010	.013	--
		06-04-98	1507	SC.BLK	--	--	--	--	--	--	<.10
		06-04-98	1514	SC.BLK	.038	<.050	.033	<.10	<.010	.012	--
HA-27	351204090124001	07-14-98	0805	EQ.BLK	--	--	--	--	--	--	.30
		07-14-98	0806	EQ.BLK	<.010	<.050	.037	<.10	.029	.018	--
		07-14-98	0807	SC.BLK	--	--	--	--	--	--	.20
		07-14-98	0814	SC.BLK	<.010	<.050	.029	<.10	<.010	.020	--
HA-31	332730090280501	07-30-98	0905	EQ.BLK	--	--	--	--	--	--	.20
		07-30-98	0906	EQ.BLK	<.010	<.050	<.020	<.10	<.010	<.010	--
		07-30-98	0907	SC.BLK	--	--	--	--	--	--	<.10
		07-30-98	0914	SC.BLK	<.010	<.050	<.020	<.10	<.010	<.010	--
VT-02	321547091443401	05-14-98	1005	EQ.BLK	--	--	--	--	--	--	<.10
		05-14-98	1006	EQ.BLK	<.010	<.050	<.020	<.10	<.010	<.010	--
		05-14-98	1007	SC.BLK	--	--	--	--	--	--	<.10
		05-14-98	1014	SC.BLK	<.010	<.050	.025	<.10	<.010	.010	--
VT-07	354455091041501	06-18-98	1005	EQ.BLK	--	--	--	--	--	--	.20
		06-18-98	1006	EQ.BLK	<.010	<.050	.047	<.10	<.010	.010	--
		06-18-98	1007	SC.BLK	--	--	--	--	--	--	.10
		06-18-98	1014	SC.BLK	<.010	<.050	.060	<.10	<.010	<.010	--
VT-13	344025090460401	07-15-98	1001	REPLCT	.012	<.050	1.49	1.8	.374	.242	1.5
VT-20	355516090285600	07-01-98	1305	EQ.BLK	--	--	--	--	--	--	.20
		07-01-98	1306	EQ.BLK	<.010	<.050	<.020	<.10	<.010	.015	--
		07-01-98	1307	SC.BLK	--	--	--	--	--	--	.10
		07-01-98	1314	SC.BLK	<.010	<.050	.030	<.10	<.010	<.010	--
VT-27	363807089485001	07-22-98	1001	REPLCT	<.010	.178	.114	.12	.059	.022	1.0
VT-29	365631089413001	07-21-98	0901	REPLCT	<.010	<.050	.140	.17	<.010	.015	1.4

* -- Well was not screened in the Mississippi River Valley alluvial aquifer but had quality-assurance data that were useful to the Mississippi River Valley alluvial aquifer study.

Table 2-4. Quality-assurance data for trace elements of sampled wells screened in the Mississippi River Valley alluvium, NAWQA, 1998 [EQ.BLK, field-equipment blank; REPLCT, replicate; UG/L, micrograms per liter; <, less than]

WELL NAME	SITE ID	DATE	TIME	QUALITY ASSURANCE SAMPLE TYPE	ARSENIC DIS-SOLVED (UG/L AS AS)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ANTI-MONY, DIS-SOLVED (UG/L AS SB)	BARIUM, DIS-SOLVED (UG/L AS BA)	BERYL-LIUM, DIS-SOLVED (UG/L AS BE)	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COBALT, DIS-SOLVED (UG/L AS CO)	COPPER, DIS-SOLVED (UG/L AS CU)
HA-19	340413090340301	06-25-98	1110	REPLCT	<1	3.0	<1.0	367	<1.0	<1.0	2.0	<1.0	<1.0
HA-22	324355090391801	06-11-98	1010	REPLCT	<1	3.0	<1.0	447	<1.0	<1.0	3.2	<1.0	<1.0
HA-23*	330413090192501	06-04-98	1511	EQ.BLK	<1	2.8	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
HA-27	351204090124001	07-14-98	0811	EQ.BLK	<1	3.6	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
HA-31	332730090280501	07-30-98	0911	EQ.BLK	<1	3.2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
VT-02	321547091443401	05-14-98	1011	EQ.BLK	<1	3.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
VT-07	354455091041501	06-18-98	1011	EQ.BLK	<1	3.3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
VT-13	344025090460401	07-15-98	1010	REPLCT	3	3.0	<1.0	333	<1.0	<1.0	5.9	<1.0	<1.0
VT-20	355516090285600	07-01-98	1311	EQ.BLK	<1	5.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
VT-27	363807089485001	07-22-98	1010	REPLCT	8	3.9	<1.0	781	<1.0	<1.0	3.2	<1.0	<1.0
VT-29	365631089413001	07-21-98	0910	REPLCT	27	2.6	<1.0	830	<1.0	<1.0	1.4	<1.0	<1.0

* -- Well was not screened in the Mississippi River Valley alluvial aquifer but had quality-assurance data that were useful to the Mississippi River Valley alluvial aquifer study.

Table 2-5. Quality-assurance data for trace elements of sampled wells screened in the Mississippi River Valley alluvium, NAWQA, 1998 (continued) [EQ.BLK, field-equipment blank; REPLCT, replicate; UG/L, micrograms per liter; <, less than]

WELL NAME	SITE ID	DATE	TIME	QUALITY ASSURANCE SAMPLE TYPE	LEAD, DIS-SOLVED (UG/L AS PB)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	MOLYB-DENUM, DIS-SOLVED (UG/L AS MO)	NICKEL, DIS-SOLVED (UG/L AS NI)	SELE-NIUM, DIS-SOLVED (UG/L AS SE)	SILVER, DIS-SOLVED (UG/L AS AG)	URANIUM NATURAL DIS-SOLVED (UG/L AS U)	ZINC, DIS-SOLVED (UG/L AS ZN)
HA-19	340413090340301	06-25-98	1110	REPLCT	<1.0	305	<1.0	<1.0	<1	<1.0	<1.0	<1.0
HA-22	324355090391801	06-11-98	1010	REPLCT	<1.0	410	<1.0	<1.0	<1	<1.0	<1.0	<1.0
HA-23*	330413090192501	06-04-98	1511	EQ.BLK	<1.0	<1.0	<1.0	<1.0	<1	<1.0	<1.0	<1.0
HA-27	351204090124001	07-14-98	0811	EQ.BLK	<1.0	<1.0	<1.0	<1.0	<1	<1.0	<1.0	<1.0
HA-31	332730090280501	07-30-98	0911	EQ.BLK	<1.0	<1.0	<1.0	<1.0	<1	<1.0	<1.0	1.2
VT-02	321547091443401	05-14-98	1011	EQ.BLK	<1.0	<1.0	<1.0	<1.0	<1	<1.0	<1.0	14
VT-07	354455091041501	06-18-98	1011	EQ.BLK	<1.0	<1.0	<1.0	<1.0	<1	<1.0	<1.0	<1.0
VT-13	344025090460401	07-15-98	1010	REPLCT	<1.0	117	1.6	<1.0	<1	<1.0	<1.0	<1.0
VT-20	355516090285600	07-01-98	1311	EQ.BLK	<1.0	<1.0	<1.0	<1.0	<1	<1.0	<1.0	<1.0
VT-27	363807089485001	07-22-98	1010	REPLCT	<1.0	597	<1.0	1.3	<1	<1.0	<1.0	<1.0
VT-29	365631089413001	07-21-98	0910	REPLCT	<1.0	584	1.6	<1.0	<1	<1.0	<1.0	<1.0

* -- Well was not screened in the Mississippi River Valley alluvial aquifer but had quality-assurance data that were useful to the Mississippi River Valley alluvial aquifer study.

Table 2-6. Quality-assurance data for volatile organic compounds of sampled wells screened in the Mississippi River Valley alluvium, NAWQA, 1998

[EQ.BLK, field-equipment blank; SC.BLK, source solution blank; UG/L, micrograms per liter; <, less than; E, estimated value; --, no data]

WELL NAME	SITE ID	DATE	TIME	QUALITY ASSURANCE SAMPLE TYPE	TEBU-THIURON WATER FLTRD 0.7 U GF, REC (UG/L)	BENZENE TOTAL (UG/L)	TOLUENE TOTAL (UG/L)	META/PARA-XYLENE WATER UNFLTRD REC (UG/L)	BENZENE 124-TRI METHYL UNFILT RECOVER (UG/L)	TRI-CHLORO-FLUORO-METHANE TOTAL (UG/L)	METHYL ENE CHLO-RIDE TOTAL (UG/L)
HA-23*	330413090192501	06-04-98	1505	EQ.BLK	E0.0041	<.032	E.045	<.064	E.035	E.040	<0.382
		06-04-98	1507	SC.BLK	--	E.010	E.051	E.013	E.041	E.042	<.382
HA-27	351204090124001	07-14-98	0805	EQ.BLK	<.0100	<.100	<.054	<.064	.097	<.092	<.382
		07-14-98	0807	SC.BLK	--	<.100	<.054	<.064	.108	<.092	<.382
HA-31	332730090280501	07-30-98	0905	EQ.BLK	<.0100	<.100	E.027	<.064	<.056	<.092	<.382
		07-30-98	0907	SC.BLK	--	<.100	E.032	<.064	E.031	<.092	E.036
VT-02	321547091443401	05-14-98	1005	EQ.BLK	<.0100	<.032	E.027	<.064	<.056	<.092	<.382
		05-14-98	1007	SC.BLK	--	<.032	E.026	<.064	<.056	<.092	<.382
VT-07	354455091041501	06-18-98	1005	EQ.BLK	<.0100	E.011	E.043	<.064	<.056	<.092	<.382
		06-18-98	1007	SC.BLK	--	E.014	E.060	<.064	<.056	<.092	<.382
VT-20	355516090285600	07-01-98	1305	EQ.BLK	<.0100	<.100	E.033	<.064	E.066	<.092	<.382
		07-01-98	1307	SC.BLK	--	<.100	E.040	<.064	E.018	<.092	<.382

* -- Well was not screened in the Mississippi River Valley alluvial aquifer but had quality-assurance data that were useful to the Mississippi River Valley alluvial aquifer study.

Table 2-7. Quality-assurance data for radio- and stable-isotopes of sampled wells screened in the Mississippi River Valley alluvium, NAWQA, 1998 [REPLCT, replicate; PCI/L, picocuries per liter]

WELL NAME	SITE ID	DATE	TIME	QUALITY ASSURANCE SAMPLE TYPE	RADON 222 TOTAL (PCI/L)	O-18 / O-16 STABLE ISOTOPE RATIO PER MIL	H-2 / H-1 STABLE ISOTOPE RATIO PER MIL
HA-19	340413090340301	06-25-98	1101	REPLCT	234	-4.98	-27.7
HA-22	324355090391801	06-11-98	1001	REPLCT	241	-4.22	-23.3
VT-13	344025090460401	07-15-98	1001	REPLCT	219	-5.27	-29.1
VT-27	363807089485001	07-22-98	1001	REPLCT	203	-5.47	-30.8
VT-29	365631089413001	07-21-98	0901	REPLCT	320	-5.87	-35.4

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