Water Quality of the Mississippian Carbonate Aquifer in Parts of Middle Tennessee and Northern Alabama, 1999

Water-Resources Investigations Report 02-4083
National Water-Quality Assessment Program
Cover illustration: Conceptual diagram depicting ground-water wells completed in the Mississippian carbonate aquifer. Left photograph is a turbine pump at a municipal water supply in northern Alabama. Right photograph is a domestic well near Huntsville, Alabama.
Water Quality of the Mississippian Carbonate Aquifer in Parts of Middle Tennessee and Northern Alabama, 1999

By JAMES A. KINGSBURY and JOHN M. SHELTON

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 02-4083

Nashville, Tennessee
2002
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 and priorities. 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
## CONTENTS

Abstract ...................................................................................................................... ........................................................... 1
Introduction ................................................................................................................... ........................................................ 2
  Purpose and Scope ............................................................................................................. ......................................... 2
  Description of the Study Area ............................................................................................................. ................................... 2
    Hydrogeology .................................................................................................................. ......................... 4
    Land Use ...................................................................................................................... ..................................... 5
Approach ........................................................................................................................................................................... 6
  Analytical Methods .............................................................................................................. ......................................... 8
  Quality Assurance and Quality Control ................................................................................................. 8
  Delineation of Land Use and Soil Properties Near Sites ........................................................................ 9
  Statistical Methods .............................................................................................................. .................................... 9
Water Quality of the Mississippian Carbonate Aquifer ................................................................................. 9
  Nutrients and Bacteria ......................................................................................................... ........................................ 14
  Pesticides ..................................................................................................................... ................................................ 15
  Volatile Organic Compounds ..................................................................................................... .................................. 19
Factors That Affect Water Quality of the Mississippian Carbonate Aquifer ..................................................... ................. 20
  Relation of Natural Setting to Water Quality ......................................................................................... 20
  Relation of Land Use to Water Quality ......................................................................................... 23
Summary and Conclusions ....................................................................................................... ............................................ 25
References .................................................................................................................... ........................................................ 26
Appendixes ...................................................................................................................................................... 29
  1. Pesticides and pesticide metabolites analyzed, common name, and use ......................................................... 31
  2. Volatile organic compounds analyzed ........................................................................................................ 35
FIGURES

1. Map showing location of the lower Tennessee River Basin and delineated subunits, physiographic provinces in the study unit, and National Water-Quality Assessment Program study units nationwide .................................................. 3
2. Map showing generalized geology of the Eastern Highland Rim subunit and location of ground-water sites ........................................................................................................................ 4
3. Chart showing stratigraphic units and their hydrologic significance in the Eastern Highland Rim subunit .......................................................................................... 5
4. Diagram showing conceptual model of ground-water flow in the Mississippian carbonate aquifer .......................................................... 6
5. Map showing land use in the Eastern Highland Rim subunit, 1992 .......................................................................................................................... 7
6-9. Box plots showing:
   6. Selected characteristics of ground-water wells sampled in the Mississippian carbonate aquifer by geologic unit ................................................................. 11
   7. Selected water-quality properties and constituents in water samples from the Mississippian carbonate aquifer by geologic unit .......................................... 14
   8. Concentrations of nitrate in water samples from the Mississippian carbonate aquifer by geologic unit .................................................................................. 15
   9. Concentrations of *Escherichia coli* bacteria in water samples from the Mississippian carbonate aquifer by geologic unit ................................................. 16
10. Map showing land use and total pesticide concentrations in water samples from the Mississippian carbonate aquifer in the Eastern Highland Rim subunit ........................................ 17
11-13. Graphs showing:
   11. Detection frequency and estimated use of selected pesticides detected in water samples from the Mississippian carbonate aquifer ........................................... 19
   12. Concentrations of atrazine and its metabolites in water samples from the Mississippian carbonate aquifer ................................................................. 20
   13. Comparisons of frequencies of detections greater than 0.05 µg/L and maximum concentrations of selected pesticides detected in water samples from the Mississippian carbonate aquifer and other National Water-Quality Assessment Program study units ........................................ 20
14. Box plot showing total volatile organic compound concentrations in water samples from the Mississippian carbonate aquifer by geologic unit ........................................ 22
15-17. Graphs showing:
   15. Comparisons of frequencies of detections and median concentrations of volatile organic compounds greater than 0.2 µg/L in water samples from the Mississippian carbonate aquifer and in ambient ground water across the United States ........................................................................................................ 22
   16. Percentage of cropland near each site in relation to nitrate concentration in water samples from the Mississippian carbonate aquifer, 1999 ........................................... 23
   17. Total pesticide concentration in relation to the percentage of cropland and soil hydrologic group near a site ............................................................................ 24

TABLES

1. Volatile organic compounds detected in field and trip blanks, 1999 ............................................... 8
2. Well depth, water level, and geologic unit of sites sampled in the Mississippian carbonate aquifer, 1999 .......................................................................................................................... 10
3. Water-quality properties and major inorganic constituent concentrations in samples from 32 wells and 2 springs in the Mississippian carbonate aquifer, 1999 .................... 12
4. Summary statistics of selected nutrients in the Mississippian carbonate aquifer, 1999 ........................ 15
5. Summary statistics for pesticides detected in water samples from the Mississippian carbonate aquifer in 1999 and estimated use of detected and high-use pesticides ........................................ 18
6. Summary statistics for volatile organic compounds detected in water samples from the Mississippian carbonate aquifer, 1999 .......................................................... 21
7. Environmental factors evaluated that may affect water quality of the Mississippian carbonate aquifer ............................................................................................... 23
Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows: 

\[ ^\circ F = (1.8 \times ^\circ C) + 32 \]

**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 the United States and Canada, formerly called Sea Level Datum of 1929.

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

**Horizontal datum**: Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

**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) or micrograms per liter (µg/L).