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Water-Quality Assessment of the Eastern Iowa Basins: Hydrologic and Biologic Data, October 1996 through September 1998

Open-File Report 00-67

U.S. Department of the Interior
U.S. Geological Survey
National Water-Quality Assessment Program

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NATIONAL WATER QUALITY ASSESSMENT
EASTERN IOWA BASINS

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By KIMBERLEE K.B. AKERS, DENISE L. MONTGOMERY, DANIEL E. CHRISTIANSEN, MARK E. SAVOCA, DOUGLAS J. SCHNOEBELEN, KENT D. BECHER, *and* ERIC M. SADORF

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NATIONAL WATER QUALITY ASSESSMENT
EASTERN IOWA BASINS

Iowa City, Iowa
2000

U.S. Department of the Interior

Bruce Babbitt, Secretary

U.S. Geological Survey

Charles G. Groat, Director

For additional information write to:

District Chief
U.S. Geological Survey
P.O. Box 1230
Iowa City, IA 52244

Copies of this report can be purchased from:

U.S. Geological Survey
Information Services
Building 810, Federal Center
Box 25286
Denver, CO 80225–0286

FOREWORD

The mission of the U.S. Geological Survey (USGS) is to assess the quantity and quality of the earth resources of the Nation and to provide information that will assist resource managers and policymakers at Federal, State, and local levels in making sound decisions. Assessment of water-quality conditions and trends is an important part of this overall mission.

One of the greatest challenges faced by water-resources scientists is acquiring reliable information that will guide the use and protection of the Nation's water resources. That challenge is being addressed by Federal, State, interstate, and local water-resource agencies and by many academic institutions. These organizations are collecting water-quality data for a host of purposes that include compliance with permits and water-supply standards; development of remediation plans for specific contamination problems; operational decisions on industrial, wastewater, or water-supply facilities; and research on factors that affect water quality. An additional need for water-quality information is to provide a basis on which regional and national-level policy decisions can be made. Wise decisions must be based on sound information. As a society we need to know whether certain types of water-quality problems are isolated or ubiquitous, whether there are significant differences in conditions among regions, whether the conditions are changing over time, and why these conditions change from place to place and over time. The information can be used to help determine the efficacy of existing water-quality policies and to help analysts determine the need for and likely consequences of new policies.

To address these needs, the U.S. Congress appropriated funds in 1986 for the USGS to begin a pilot program in seven project areas to develop and refine the National Water-Quality Assessment (NAWQA) Program. In 1991, the USGS began full implementation of the program. The NAWQA Program builds upon an existing base of water-quality studies of the USGS, as well as those of other Federal, State, and local agencies. The objectives of the NAWQA Program are:

- Describe current water-quality conditions for a large part of the Nation's freshwater streams, rivers, and aquifers.
- Describe how water quality is changing over time.
- Improve understanding of the primary natural and human factors that affect water-quality conditions.

This information will help support the development and evaluation of management, regulatory, and monitoring decisions by other Federal, State, and local agencies to protect, use, and enhance water resources.

The goals of the NAWQA Program are being achieved through ongoing and proposed investigations of 59 of the Nation's most important river basins and aquifer systems, which are referred to as study units. These study units are distributed throughout the Nation and cover a diversity of hydrogeologic settings. More than two-thirds of the Nation's freshwater use occurs within the 59 study units and more than two-thirds of the people served by public water-supply systems live within their boundaries.

National synthesis of data analysis, based on aggregation of comparable information obtained from the study areas, is a major component of the program. This effort focuses on selected water-quality topics using nationally consistent information. Comparative studies will explain differences and similarities in observed water-quality conditions among study units and will identify changes and trends and their causes. The first topics addressed by the national synthesis are pesticides, nutrients, volatile organic compounds, and aquatic biology. Discussions on these and other water-quality topics will be published in periodic summaries of the quality of the Nation's ground and surface water as the information becomes available.

This report is an element of the comprehensive body of information developed as part of the NAWQA Program. The program depends heavily on the advice, cooperation, and information from many Federal, State, interstate, tribal, and local agencies and the public. The assistance and suggestions of all are greatly appreciated.

Robert M. Hirsch
Chief Hydrologist

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TABLES—Continued

CONVERSION FACTORS AND ABBREVIATIONS

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter
inch (in.)	2.54	centimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	Area	
acre	4,047	square meter
square mile (mi^2)	2.590	square kilometer
	Volume	
gallon (gal)	3.785	liter
gallon (gal)	3,785	milliliter

Temperature, in degrees Celsius (××°C) can be converted to degrees Fahrenheit (°F) by use of the following equation: °F=1.8(°C) + 32.

Abbreviated water-quality units: Chemical concentrations and temperature for water samples are given in metric units. Chemical concentration is given in milligrams per liter (mg/L) or microgram per liter (µg/L). Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to 1 milligram per liter. Chemical concentrations for fish-tissue samples also are given in metric units. Chemical concentrations are given in micrograms per gram (µg/g) or micrograms per kilogram (µg/kg). Micrograms per gram is a unit expressing the concentration of chemical constituent as weight (micrograms) of solute per unit mass (grams). One microgram per 1,000 grams is equivalent to 1 microgram per kilogram.

Other abbreviations used in this report:

DOC	Dissolved organic carbon
EIWA	Eastern Iowa Basins study unit
MDL	Method detection limit
MRL	Method reporting limit
NAWQA	National Water-Quality Assessment Program
NWQL	U.S. Geological Survey National Water-Quality Laboratory
PCB	Polychlorinated biphenyl
PVC	Polyvinyl chloride
SOC	Suspended organic carbon
UHL	University of Iowa Hygienic Laboratory
USGS	U.S. Geological Survey
VOC	Volatile organic compounds
cm	centimeter
col/100 mL	colonies per 100 milliliters
g	gram
L	liter
µm	micrometer
µS/cm	microsiemens per centimeter at 25 °C
mL	milliliter
mm	millimeter
pCi/L	picocuries per liter

Water-Quality Assessment of the Eastern Iowa Basins: Hydrologic and Biologic Data, October 1996 Through September 1998

By Kimberlee K.B. Akers, Denise L. Montgomery, Daniel E. Christiansen, Mark E. Savoca, Douglas J. Schnoebelen, Kent D. Becher, *and* Eric M. Sadorf

Abstract

Hydrologic and biologic data collected from October 1996 through September 1998 in the Eastern Iowa Basins study unit of the U.S. Geological Survey National Water-Quality Assessment Program are presented in this report. Monthly data collected from 12 sites on rivers and streams included measurements of physical properties and determinations of the concentrations of nutrients, major ions, organic carbon, trace elements, suspended sediment, and dissolved pesticides. Fish-tissue samples were collected at two sites in September 1997 and analyzed for organochlorine pesticides. In addition, water-quality assessments were made at 25 sites as part of a synoptic study in August 1997 and May 1998.

A ground-water study was conducted to evaluate the effects of agricultural and urban land use on the water quality of shallow alluvial aquifers in the study unit. Samples were collected and analyzed from wells in 31 agricultural and 30 urban land-use areas during June–August 1997. Samples were collected and analyzed from 32 domestic wells during June–July 1998 to provide a broad assessment of the water quality of shallow alluvial aquifers throughout the study unit. Samples were collected during August 1998 from 27 shallow monitoring wells completed in the Iowa River alluvial aquifer to evaluate the effects of changing land use on shallow ground-water quality. Ground-water samples were analyzed for physical properties, nutrients, major ions, organic carbon, trace elements, dissolved pesticides, volatile organic compounds, radon-222, and tritium.

INTRODUCTION

In 1991, the U.S. Geological Survey (USGS), U.S. Department of the Interior, began the National Water-Quality Assessment (NAWQA) Program. The long-term goals of this program are to describe the status of and trends in the quality of a large, representative part of the Nation's surface- and ground-water resources and to identify the major factors that affect the quality of the resources (Gilliom and others, 1995). In addressing these goals, the program provides water-quality information that can be useful to policymakers and managers at the national, State, and local levels. Studies of 59 hydrologic systems ranging in size from 1,200 to 62,000 mi^2 include parts of most major river basins and aquifer systems (study-unit investigations) and represent from 60 to 70 percent of the Nation's water use and population served by public water supplies.

Purpose and Scope

This report presents the results of data-collection activities from October 1996 through September 1998 in the Eastern Iowa Basins (EIWA) NAWQA study unit, which was selected as an important hydrologic system representative of an agricultural area in the Midwest. Included are the results of analyses of monthly water samples from 12 surface-water sites, analyses of samples from 25 synoptic surface-water sites, analyses of ground-water samples from 120 wells, and the analysis of fish-tissue samples from two sites. Surface- and ground-water samples were analyzed for physical properties, nutrients, major ions, organic carbon, trace elements, and pesticides. In addition, surface-water sample analyses included suspended-sediment concentration, and ground-water sample analyses included volatile organic compounds (VOCs), radon-222, and tritium. Fish-tissue samples were analyzed for organochlorine pesticides.

This report is the second of two reports that document data collected as part of the high-intensity phase of the EIWA NAWQA study. Data collected from September 1995 through September 1996 are reported by Akers and others (1999).

Description of Eastern Iowa Basins

The EIWA study unit covers about 19,500 mi^2 in eastern Iowa and southern Minnesota and includes the Wapsipinicon, Cedar, Iowa, and Skunk River Basins (fig. 1). These four major rivers generally flow in a southeasterly direction toward eventual discharge into the Mississippi River. The Wapsipinicon River originates in southeastern Minnesota, has a drainage area of 2,540 mi^2, and is about 225 mi long. The Cedar River also originates in southern Minnesota and joins the Iowa River about 30 mi upstream from the confluence of the Iowa and Mississippi Rivers. Together, the Cedar River Basin and the Iowa River Basin encompass about 12,640 mi^2, more than 90 percent of which is in Iowa. The Skunk River Basin originates in central Iowa and drains about 4,350 mi^2.

There are three major landform regions and one subregion within the EIWA study unit—the Des Moines Lobe, the Southern Iowa Drift Plain, the Iowan Surface, and the Iowan Karst, which is a subdivision of the Iowan Surface (Prior, 1991). The Des Moines Lobe is characterized by low relief with some distinct ridges near the eastern boundary and occasional depressions that form lakes, ponds, and marshes. Glacial till is the dominant surficial material with alluvium along the streams. In the Southern Iowa Drift Plain, streams have eroded deeply into the glacial drift and loess mantle to produce a steeply rolling terrain with broad, flat drainage divides. The Iowan Surface has gently rolling topography with long slopes, low relief, and a dendritic (tree-like) drainage pattern. The surficial material is primarily glacial drift with thin layers of loess on the ridges and alluvium near the streams. In the Iowan Karst, glacial deposits are thin, and sinkholes are evidence of the soluble limestone beneath the land surface.

Land use and land cover in the EIWA study unit is primarily agricultural, with about 93 percent of the total area used for cropland or pasture. The principal crops are corn, soybeans, hay, and oats. The remaining land area consists of about 4 percent forests, about 2 percent urban, and about 1 percent water and wetlands (U.S. Geological Survey, 1990).

IMPLEMENTATION OF WATER-QUALITY STUDIES

Surface-Water-Quality Data Collection

Sampling Sites

The design of the surface-water-quality sampling program involved the selection of sites to increase the understanding of seasonal and spatial variability of physical and chemical water-quality characteristics in the EIWA study unit. The network of surface-water-quality sampling sites are referred to as basic fixed sites. The NAWQA basic-fixed-site network consists of two types of sites—integrator and indicator. Integrator basic fixed sites represent large subbasins in the study unit where the stream or river is affected by a combination of land-use types and natural factors. Indicator basic fixed sites are usually smaller basins and represent a specific combination of land-use and physiographic conditions. In the EIWA study unit, surface-water samples were collected at six integrator and six indicator sites (fig. 1 and table 1). The basic fixed sites were sampled monthly, and three sites (Iowa River near Rowan, Wolf Creek near Dysart, and Iowa River at Wapello) were designated as intensive sites and were sampled weekly to biweekly from April 1997 through November 1997. As part of the Iowa Department of Natural Resources monitoring network, additional samples for pesticide analysis were collected monthly at four sites by personnel from the University of Iowa Hygienics Laboratory. In addition, 25 sites were sampled as part of the Midwest regional synoptic study in August 1997 (Sorenson and others, 1999) and resampled in May 1998 (fig. 1). Supplemental samples from a tile drain located just upstream from the Iowa River near Rowan sampling site were also collected. Samples were also collected from three sites—Wheeler Creek near Rowan, Maynes Creek

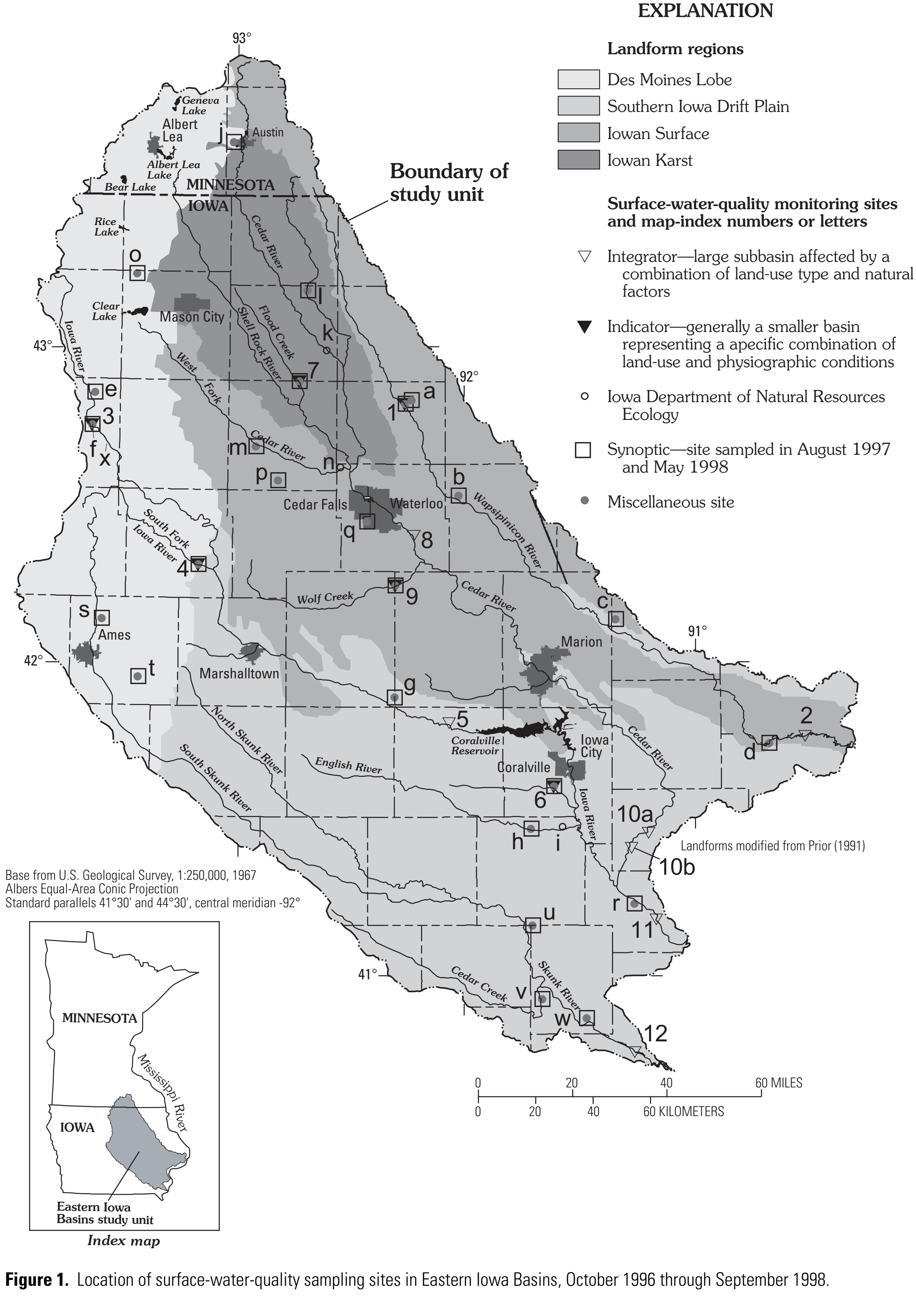

Figure 1. Location of surface-water-quality sampling sites in Eastern Iowa Basins, October 1996 through September 1998.

Table 1. Surface-water sampling sites in Eastern Iowa Basins study unit

[Sites are listed in downstream order. mi^2, square miles; IDNR, Iowa Department of Natural Resources site; -- not determined]

Map-index number or letter (fig. 1)	Site identification number	Site	Location (degrees, minutes, seconds)		Drainage area (mi^2)	Type of data[1]	Site type
			Latitude	Longitude			
1	05420680	Wapsipinicon River near Tripoli, IA	42°50'10"	92°15'26"	346	F, N, M, P, S	Indicator/ synoptic
a	05420720	East Fork Wapsipinicon River near Tripoli, IA	42°50'51"	92°13'48"	144	F, N, M,P, S	Synoptic
b	05420900	Little Wapsipinicon River at Little-ton, IA	42°32'27"	92°01'30"	147	F, N, M P, S	Synoptic
c	05421700	Buffalo Creek near Stone City, IA	42°08'32"	91°20'44"	233	F, N, M, P, S	Synoptic
d	05421870	Mud Creek near Donahue, IA	41°44'17"	90°04'26"	119	F, N, M, P, S	Synoptic
2	05422000	Wapsipinicon River near DeWitt, IA	41°46'01"	90°32'05"	2,340	F, N, M, P, S	Integrator
e	05449200	East Branch Iowa River at Belmond, IA	42°51'48"	93°36'47"	195	F, N, M, P, S	Synoptic
3	05449500	Iowa River near Rowan, IA	42°45'36"	93°37'23"	418	F, N, M, P, S	Indicator/ intensive/ synoptic
f	05449600	Wheeler Creek near Rowan, IA	42°42'03"	93°33'28"	30	F, N, M, P, S, B	Miscella-neous
4	05451210	South Fork Iowa River northeast of New Providence, IA	42°18'54"	93°04'22"	224	F, N, M, P, S, B	Indicator/ synoptic
g	05452020	Salt Creek at Belle Plaine, IA	41°53'31"	92°17'60"	217	F, N, M, P, S	Synoptic
5	05453100	Iowa River at Marengo, IA	41°48'48"	92°03'51"	2,790	F, N, M, P, S	Integrator
6	05455100	Old Man's Creek near Iowa City, IA	41°36'23"	91°36'56"	201	F, N, M, P, S	Indicator/ synoptic
h	05455500	English River at Kalona, IA	41°28'11"	91°42'52"	574	F, N, M, P, S	Synoptic
i	05455570	English River at Riverside, IA	41°28'32"	91°34'49"	626	F, P	IDNR
j	05456510	Turtle Creek at Austin, MN	43°40'25"	93°01'11"	153	F, N, M, P, S	Synoptic
k	05457750	Cedar River near Carville, IA	43°00'23"	92°36'08"	1,075	F, P	IDNR
l	05457950	Little Cedar River near Floyd, IA	43°11'55"	91°41'14"	234	F, N, M, P, S	Synoptic
m	05458870	Maynes Creek near Kesley, IA	42°41'46"	92°54'28"	136	F, N, M, P, S, B	Synoptic
n	05458900	West Fork Cedar River near Finchford, IA	42°37'50"	92°32'24"	846	F, P	IDNR
o	05459300	Winnebago River near Fertile, IA	43°14'49"	93°26'16"	294	F, N, M, P, S	Synoptic
7	05461390	Flood Creek near Powersville, IA	42°54'26"	92°43'14"	150	F, N, M, P, S	Indicator/ synoptic
p	05462770	Beaver Creek near Parkersburg, IA	42°35'15"	92°48'37"	145	F, N, M, P, S	Synoptic
q	05463510	Black Hawk Creek at Waterloo, IA	42°27'24"	92°25'21"	327	F, N, M, P, S	Synoptic
8	05464020	Cedar River at Gilbertville, IA	42°24'57"	92°13'07"	5,240	F, N, M, P, S	Integrator

Table 1. Surface-water sampling sites in Eastern Iowa Basins study unit—Continued

Map-index number or letter (fig. 1)	Site identification number	Site	Location (degrees, minutes, seconds)		Drainage area (mi^2)	Type of data[1]	Site type
			Latitude	Longitude			
9	05464220	Wolf Creek near Dysart, IA	42°15'06"	92°17'55"	299	F, N, M, P, S,	Indicator/ intensive/ synoptic
10a	05464935	Cedar River near Nichols, IA	41°27'32"	91°12'90"	7,550	F, N, M, P, S	Integrator
10b	05465000	Cedar River near Conesville, IA	41°24'36"	91°17'06"	7,790	F, N, M, P, T, S	Integrator
r	05465310	Long Creek near Columbus Junction, IA	41°13'36"	91°16'32"	155	F, N, M, P, S	Synoptic
11	05465500	Iowa River at Wapello, IA	41°10'48"	91°10'57"	12,500	F, N, M, P, T, S	Indicator/ intensive
s	05469980	South Skunk River near Story City, IA	42°08'14"	93°34'02"	222	F, N, M, P, S	Synoptic
t	05471120	East Branch Indian Creek near Iowa Center, IA	41°57'08"	93°24'21"	128	F, N, M, P, S	Synoptic
u	05473060	Crooked Creek at Coppock, IA	41°09'31"	94°12'30"	284	F, N, M, P, S	Synoptic
v	05473400	Cedar Creek near Oakland Mills, IA	40°55'20"	91°40'10"	533	F, N, M, P, S	IDNR / synoptic
w	05473550	Big Creek near Lowell, IA	40°51'38"	91°28'49"	164	F, N, M, P, S	Synoptic
12	05474000	Skunk River at Augusta, IA	40°45'13"	91°16'40"	4,310	F, N, M, P, S	Integrator
x	42453909337200	Surface-water tile drain upstream from Iowa River near Rowan (site 3)	42°45'39"	93°37'20"	--	N	Tile drain

[1]Type of data: B, bed sediment; F, physical properties; M, major ions, N, nutrients; P, dissolved pesticides; S, suspended sediment; T, fish tissue.

near Kesley, and Iowa River near Rowan, in September 1998 to investigate water quality during low-flow conditions.

Surface-Water Sample Collection

A complete discussion of the collection and processing of stream-water samples is described in Shelton (1994). All surface-water samples were obtained by collecting depth-integrated subsamples at equally spaced vertical sections across the stream (Ward and Harr, 1990). At each surface-water site, a minimum of 10 equally spaced water samples were collected using cable-mounted or hand-held samplers (Shelton, 1994). Typically, a hand-held sampler was used when wading small streams, and a cable-mounted sampler was used from a bridge for sampling small streams during high flow and larger streams. All equipment used in sampling and processing was rinsed with native water before use. For sample splitting, a Teflon cone splitter was used. Sample water for pesticide analysis was passed through a 0.7-µm, baked-glass fiber filter using a Teflon diaphragm pump and Teflon tubing. Samples for organic carbon analysis were filtered through a 47-mm diameter, 0.45-µm silver membrane filter in a stainless-steel chamber pressurized by nitrogen gas. All samples were chilled and shipped by next-day air freight to the USGS National Water-Quality Laboratory (NWQL) for analysis. For chlorophyll analysis, 30 mL of sample water was filtered through a 47-mm-diameter, borosilicate glass fiber filter. The glass fiber filter was folded into quarters, wrapped in aluminum foil, and kept on ice and stored in the laboratory freezer until analyzed.

At each vertical section in the stream, surface-water measurements of specific conductance, pH, water temperature, and dissolved oxygen were obtained with a multiprobe instrument. The median value for each physical property was then calculated and stored in the data base. Alkalinity was determined at the time of sample collection by incremental titration (Wood, 1981; Shelton, 1994). All equipment used to collect and process samples (with the exception of carbon) was cleaned with a 0.1-percent non-phosphate detergent, rinsed with deionized water, rinsed with certified pesticide-free methanol, air dried, wrapped in aluminum foil, and stored in a dust-free environment prior to sample collection (Shelton, 1994). Equipment used in the collection of dissolved organic carbon (DOC) and suspended organic carbon (SOC) was not rinsed with detergent or methanol but rinsed with deionized water certified by the manufacturer to be free of both pesticides and VOC's. Water samples for fecal-coliform and fecal-streptococci bacteria were collected and analyzed at each site using membrane filtration procedures and incubation (Myers and Wilde, 1997). All bottles and equipment used in the collection of bacteria samples were sterilized in an autoclave and wrapped in foil before sample collection.

Biologic Sample Collection

Biological studies evaluate the effects of physical and chemical characteristics of water and hydrologic conditions on aquatic biota, and how biological and habitat characteristics differ among environmental settings in the study unit. Fish-tissue samples are the primary means by which trace elements and hydrophobic organic contaminants are initially assessed. Fish-tissue samples were collected at two sites in 1997.

Fish were collected using electroshocking equipment carried on either a backpack, barge, or boat. Flathead catfish (*Pylodictis olivaris*) was the target taxon at the sampling site on the Cedar River near Conesville (site 10b, fig. 1), and channel catfish (*Ictalurus punctatus*) was the target taxon at the sampling site on the Iowa River at Wapello (site 11, fig. 1).

Samples consisted of a composite of four to five fish of the same species and similar size. Each fish in a sample was measured, weighed, and examined for external anomalies such as parasites, lesions, tumors, and diseases. Powderless latex gloves were worn at all times during fish collection and processing. For analysis of organic compounds, fish were dissected with a stainless-steel scalpel blade (precleaned with methanol), examined for gender, and individually wrapped in heavy-duty aluminum foil (dull side towards fish) and then placed into a polyethylene bag. Following processing, all fish samples were placed on dry ice at the sampling site in preparation for shipment to the analytical laboratory. If long-term storage was necessary, the samples were stored in a freezer.

Analytical Procedures

For the analysis of major ions, nutrients, DOC, SOC, and pesticides, surface-water samples were sent to the NWQL in Arvada, Colorado. The NWQL was also used to analyze for pesticides in fish tissue. Whole fish were composited for pesticide analysis. The analytical methods used in all sample processing can be found in tables 6–9 at the end of this report.

Ground-Water-Quality Data Collection

Data were collected for three EIWA alluvial ground-water studies. A land-use study was conducted to evaluate the effects of agricultural and urban land use on the water quality of shallow alluvial aquifers in the EIWA study unit. Shallow ground-water monitoring wells were constructed by the USGS in alluvial aquifers at 31 agricultural and 30 urban sites (fig. 2, table 2). Urban areas in the study unit are typically small and often surrounded by agricultural cropland. Ground-water samples were collected from these 61 wells during June–August 1997. Surficial alluvial deposits in the study unit are restricted to Holocene-age river valleys (fig. 2) and commonly consist of 30 to 100 ft of unconsolidated sand and gravel interbeded with less permeable silt and clay (Steinhilber and Horick, 1970; Wahl and others, 1978; Hoyer and Hallberg, 1991; Olcott, 1992).

A study-unit survey was conducted to provide a broad assessment of the water quality of shallow alluvial aquifers in the EIWA study unit. Ground-water samples were collected from 32 domestic wells (fig. 3, table 3) during June–July 1998.

A ground-water study to investigate the effects of changing land use on shallow ground-water quality was conducted in the Iowa River alluvial aquifer (fig. 4, table 4). The study area for the Iowa River alluvial aquifer encompasses 83 mi^2 along a 16-mi reach of the Iowa River in east-central Iowa (Savoca and others, 1997). Samples were collected from 27 shallow ground-water monitoring wells during August 1998. The river valley is underlain by alluvial clay, silt, sand, and gravel of variable thickness (10 to 55 ft); the

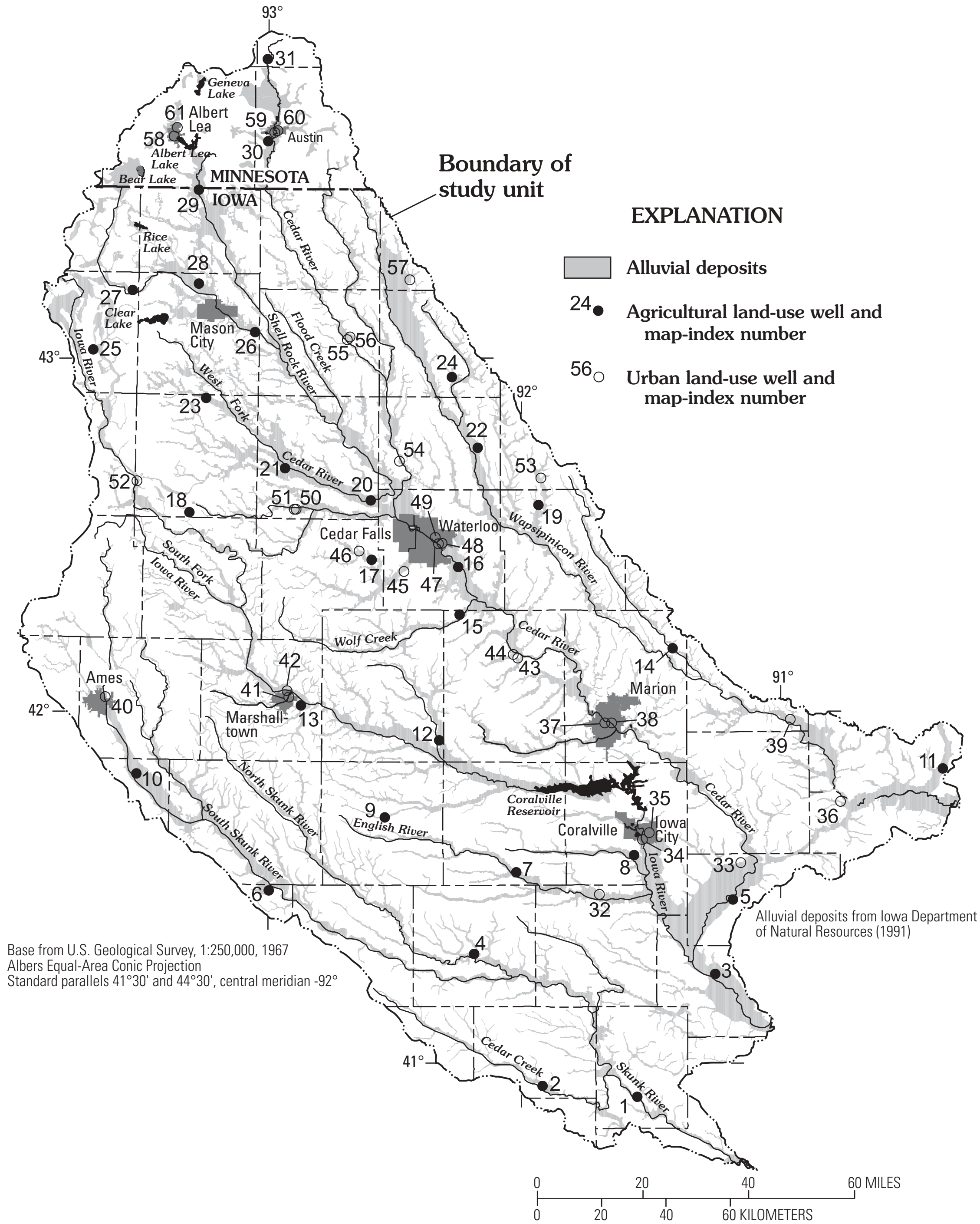

Figure 2. Distribution of alluvial deposits and location of sampling sites for land-use study.

Table 2. Land-use study wells sampled in 1997

Map-index number (fig. 2)	Well identification number	Local identifier[1]	Location (degrees, minutes, seconds) Longitude	Location (degrees, minutes, seconds) Latitude	Well depth (feet)	County, State
		Agricultural land-use wells				
1	405405091335001	070N 06W 04 BBB	40°54'04"	91°33'50"	10.0	Henry, IA
2	405601091551901	071N 09W 20 CDB	40°56'01"	91°55'19"	18.0	Jefferson, IA
3	411511091155101	075N 04W 36 DBC	41°15'10"	91°15'51"	18.5	Louisa, IA
4	411843092105101	075N 11W 07 CCB	41°18'43"	92°10'51"	26.0	Keokuk, IA
5	412755091114101	077N 03W 16 DDC	41°27'55"	91°11'41"	18.0	Muscatine, IA
6	412927092575201	077N 18W 08 BBD	41°29'27"	92°57'52"	17.0	Marion, IA
7	413248092011301	078N 10W 21 BCD	41°32'49"	92°01'13"	18.0	Iowa, IA
8	413540091341201	078N 06W 05 ACB	41°35'40"	91°34'12"	17.0	Johnson, IA
9	414208092312601	080N 14W 31 BAA	41°42'08"	92°31'26"	18.0	Poweshiek, IA
10	414912093284201	081N 23W 24 BBA	41°49'12"	93°28'42"	20.0	Polk, IA
11	414958090230301	081N 05E 09 CAD	41°49'58"	90°23'02"	22.5	Clinton, IA
12	415527092190301	082N 13W 12 CBC	41°55'27"	92°19'03"	22.5	Tama, IA
13	420117092505601	083N 17W 08 ABA	42°01'16"	92°50'56"	23.0	Marshall, IA
14	421115091250501	085N 05W 10 BDC	42°11'15"	91°25'05"	23.0	Linn, IA
15	421705092142501	086N 12W 04 DDD	42°17'06"	92°14'25"	17.5	Benton, IA
16	422518092144701	088N 12W 21 ACD	42°25'18"	92°14'48"	17.5	Black Hawk, IA
17	422629092345001	088N 15W 10 DAD	42°26'44"	92°34'27"	17.0	Grundy, IA
18	423419093172401	090N 21W 26 DCC	42°34'19"	93°17'24"	12.5	Franklin, IA
19	423557091560501	090N 09W 20 BAA	42°35'57"	91°56'05"	17.5	Buchanan, IA
20	423639092350901	090N 15W 14 BAC	42°36'39"	92°35'09"	17.5	Butler, IA
21	424203092551301	091N 18W 12 CDC	42°42'03"	92°55'12"	17.5	Butler, IA
22	424548092101701	092N 11W 20 CAD	42°45'48"	92°10'17"	15.0	Bremer, IA
23	425401093135201	093N 20W 05 ACB	42°54'01"	93°13'52"	20.0	Franklin, IA
24	425756092162401	094N 12W 09 CCD	42°57'56"	92°16'24"	16.0	Chickasaw, IA
25	430159093403201	095N 24W 21 ADA	43°01'59"	93°40'32"	26.5	Hancock, IA
26	430525093023501	096N 19W 36 CBB	43°05'25"	93°02'35"	11.5	Cerro Gordo, IA
27	431222093313301	097N 23W 23 ACC	43°12'22"	93°31'33"	21.5	Hancock, IA
28	431339093155901	097N 21W 13 ABA	43°13'39"	93°15'59"	12.0	Freeborn, MN
29	432946093161901	100N 20W 12 BDD	43°29'47"	93°16'18"	28.0	Worth, IA
30	433815093000001	102N 18W 16 CAA	43°38'15"	93°00'00"	16.0	Mower, MN
31	435221093001901	105N 18W 29 ADA	43°52'25"	93°00'20"	15.0	Dodge, MN
		Urban land-use wells				
32	412855091421601	077N 07W 07 DCC	41°28'55"	91°42'16"	25.0	Washington, IA
33	413414091095501	078N 03W 11 CDA	41°34'15"	91°09'55"	27.5	Muscatine, IA
34	413823091322301	079N 06W 22 BBC	41°38'23"	91°32'23"	27.5	Johnson, IA
35	413933091304701	079N 06W 11 CDA	41°39'34"	91°30'48"	37.5	Johnson, IA
36	414435090465101	080N 02E 07 CCD	41°44'35"	90°46'51"	27.5	Scott, IA

Table 2. Land-use study wells sampled in 1997

Map-index number (fig. 2)	Well identification number	Local identifier[1]	Location (degrees, minutes, seconds) Longitude	Latitude	Well depth (feet)	County, State
			Urban land-use wells—Continued			
37	415825091405601	083N 07W 29 AAC	41°58'25"	91°40'56"	27.5	Linn, IA
38	415827091392401	083N 07W 27 BBC	41°58'27"	91°39'24"	27.5	Linn, IA
39	415850090572201	083N 01W 22 CBC	41°58'50"	90°57'22"	18.5	Jones, IA
40	420219093361301	084N 24W 36 CBC	42°02'19"	93°36'13"	27.5	Story, IA
41	420240092535001	084N 18W 36 BDB	42°02'40"	92°53'51"	32.5	Marshall, IA
42	420347092541601	084N 18W 26 AAA	42°03'47"	92°54'16"	22.5	Marshall, IA
43	420936092005701	084N 10W 21 ACC	42°09'36"	92°00'57"	22.5	Benton, IA
44	421012092020101	085N 10W 17 DCA	42°10'12"	92°02'01"	27.0	Benton, IA
45	422426092272401	088N 14W 27 ADD	42°24'26"	92°27'25"	27.5	Black Hawk, IA
46	422754092375301	088N 15W 05 BCB	42°27'55"	92°37'53"	17.5	Grundy, IA
47	422913092192501	089N 13W 25 DDB	42°29'13"	92°19'25"	28.0	Black Hawk, IA
48	422918092183901	089N 12W 30 CDB	42°29'19"	92°18'39"	23.0	Black Hawk, IA
49	423018092200901	089N 13W 24 CBB	42°30'18"	92°20'09"	22.5	Black Hawk, IA
50	423459092523701	090N 17W 29 ABB	42°34'59"	92°52'37"	22.5	Butler, IA
51	423459092530501	090N 17W 29 BBA	42°34'59"	92°53'05"	20.5	Butler, IA
52	423930093294901	091N 22W 31 BBB	42°39'30"	93°29'49"	17.5	Franklin, IA
53	424034091553401	091N 09W 20 DAC	42°40'34"	91°55'34"	18.5	Fayette, IA
54	424322092283901	091N 14W 03 ADC	42°43'23"	92°28'41"	23.5	Bremer, IA
55	430414092405801	095N 16W 01 CDA	43°04'13"	92°40'59"	18.5	Floyd, IA
56	430442092402201	095N 16W 01 ADA	43°04'42"	92°40'22"	17.5	Floyd, IA
57	431438092262201	097N 14W 01 DDC	43°14'38"	92°26'22"	18.0	Howard, IA
58	433855093222401	102N 21W 08 DAC	43°38'55"	93°22'25"	18.0	Freeborn, MN
59	433944092583501	102N 18W 03 DCA	43°39'45"	92°58'35"	18.0	Mower, MN
60	434003092575401	102N 18W 02 BCD	43°40'05"	92°57'55"	18.0	Mower, MN
61	434023093214201	102N 21W 04 BAB	43°40'25"	93°21'40"	18.0	Freeborn, MN

[1]The local identifier is in accordance with the Bureau of Land Management's system of land subdivision. Each identifier is made up of three segments. The first segment indicates the township, the second the range, and the third the section in which the well is located. The letters after the section represent subdivisions of the section and are assigned in a counterclockwise direction. The first letter denotes a 160-acre tract, the second a 40-acre tract, and the third a 10-acre tract.

alluvial deposits are underlain by glacial till (Detroy and Kuzniar, 1988).

Site Selection

Potential land-use and study-unit survey well locations were identified using a stratified random selection process (Scott, 1990) and geographic-information-system land-use and hydrogeologic coverages. Onsite reconnaissance within a 1-mi radius of each potential well location was conducted to determine if a suitable drilling site or domestic well could be found. Land-use-study site-selection criteria included the presence of a selected land-use and hydrogeologic setting, no known point source of contamination in the vicinity of site, whether the site was accessible to a drill rig, and whether permission to drill and sample the well could be obtained from the landowner. Well depths ranged from 10 to 37.5 ft. Study-

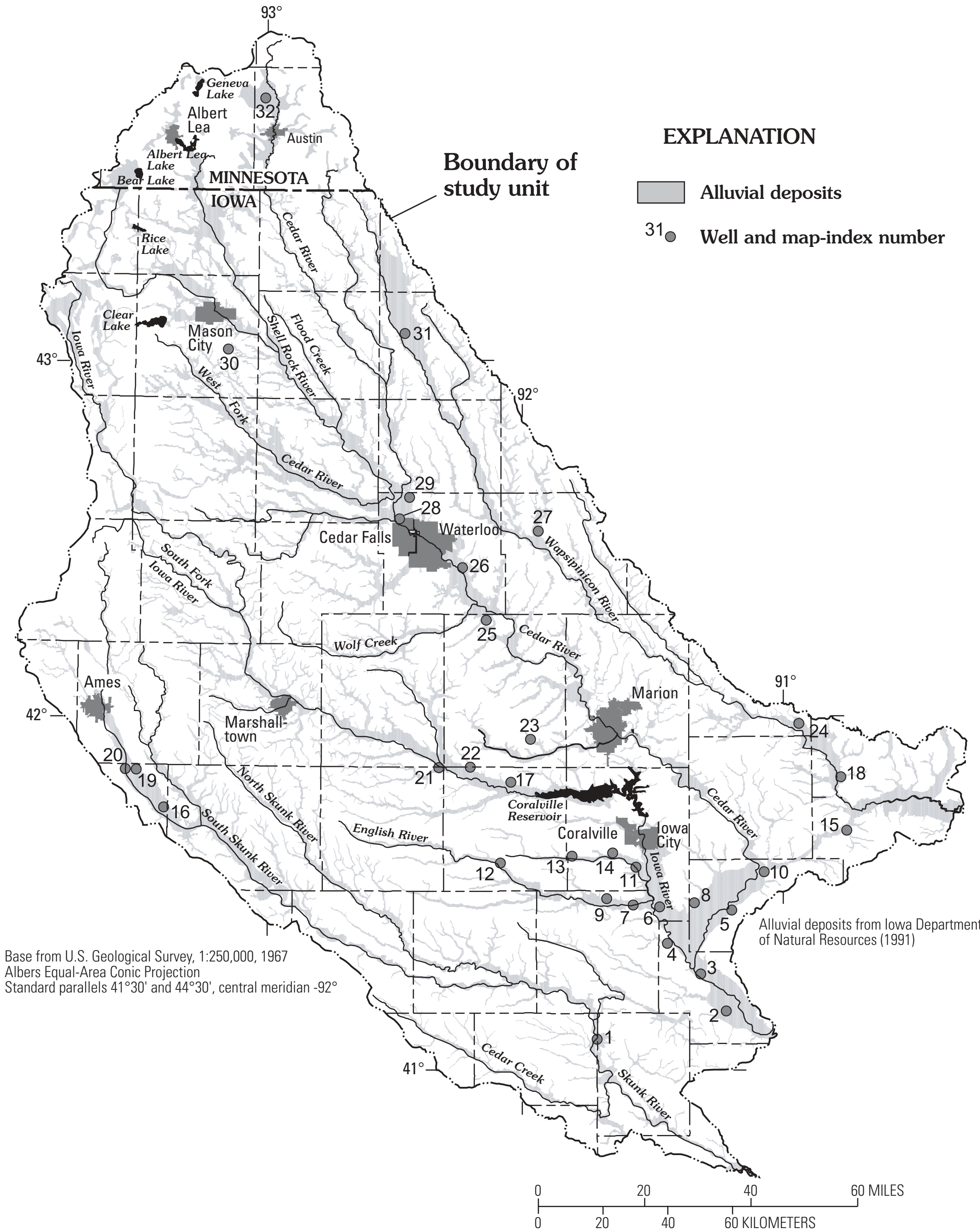

Figure 3. Distribution of alluvial deposits and location of alluvial study-unit survey wells.

Table 3. Alluvial study-unit survey wells sampled in 1998

Map-index number (fig. 3)	Well identification number	Local identifier[1]	Location (degrees, minutes, seconds)		Well depth (feet)	County, State
			Latitude	Longitude		
1	410513091430401	073N 08W 36 AAD	41°05'15"	91°43'05"	14.0	Jefferson, IA
2	410956091135601	074N 03W 32 CBD	41°09'55"	91°19'35"	25.0	Louisa, IA
3	411622091193401	075N 04W 28 BDB	41°16'20"	91°19'35"	70.0	Louisa, IA
4	412136091270501	076N 05W 29 ACD	41°21'35"	91°27'05"	54.0	Louisa, IA
5	412711091122401	077N 03W 21 CDD	41°27'10"	91°12"25"	193.0	Muscatine, IA
6	412748091285101	077N 05W 19 BCB	41°27'50"	91°28"50"	94.0	Johnson, IA
7	412808091345001	077N 06W 18 DDD	41°28'10"	91°34'50"	20.0	Washington, IA
8	412831091205601	077N 04W 18 ADD	41°28'30"	91°20'55"	40.0	Muscatine, IA
9	412916091405101	077N 07W 08 DBA	41°29'15"	91°40'50"	125.0	Washington, IA
10	413338091045601	078N 06W 08 ACC	41°33'40"	91°04'55"	12.0	Muscatine, IA
11	413438091341201	078N 02W 16 ACA	41°34'40"	91°34'10"	80.0	Johnson, IA
12	413523092050501	078N 11W 23 DDD	41°35'25"	92°05'05"	30.0	Iowa, IA
13	413634091484301	079N 08W 32 BCB	41°36'35"	91°48'45"	177.0	Johnson, IA
14	413705091392701	079N 07W 28 DAD	41°37'05"	91°39'25"	40.0	Johnson, IA
15	414036090460001	079N 02E 06 ADC	41°40'35"	90°46'00"	94.0	Scott, IA
16	414430093220001	080N 22W 13 BCB	41°44'30"	93°22'00"	20.0	Polk, IA
17	414914092024001	081N 10W 17 CCB	41°49'15"	92°02'40"	40.0	Iowa, IA
18	414944090470901	081N 01E 13 AAB	41°49'45"	90°47'10"	65.0	Clinton, IA
19	415053093282401	081N 23W 12 BAA	41°50'55"	93°28'25"	70.0	Polk, IA
20	415057093304801	081N 23W 10 BAA	41°50'55"	93°30'50"	50.0	Polk, IA
21	415139092190801	081N 13W 02 AAA	41°51'40"	92°19'10"	25.0	Poweshiek, IA
22	415147092115301	082N 12W 36 CCC	41°51'45"	92°11'55"	28.0	Benton, IA
23	415637091581001	082N 10W 02 ADA	41°56'35"	91°58'10"	20.0	Benton, IA
24	415859090563901	083N 01W 22 ACC	41°59'00"	90°56'40"	22.0	Jones, IA
25	421657092081801	086N 11W 09 BBA	42°16'55"	92°08'20"	60.0	Benton, IA
26	422555092135201	088N 12W 15 CAC	42°25'55"	92°13'50"	48.0	Black Hawk, IA
27	423208091562101	089N 09W 08 BCA	42°32'10"	91°56'20"	54.0	Buchanan, IA
28	423409092283001	090N 14W 35 BBB	42°34'10"	92°28'30"	150.0	Black Hawk, IA
29	423749092260801	090N 13W 06 CCB	42°37'50"	92°26'10"	55.0	Black Hawk, IA
30	430255093083301	092N 20W 13 AAD	43°02'55"	93°08'35"	43.0	Cerro Gordo, IA
31	430549092272301	096N 14W 35 AAA	43°05'50"	92°27'25"	80.0	Chickasaw, IA
32	434556093003501	104N 18W 32 DAD	43°45'55"	93°00'35"	150.0	Mower, MN

[1]The local identifier is in accordance with the Bureau of Land Management's system of land subdivision. Each identifier is made up of three segments. The first segment indicates the township, the second the range, and the third the section in which the well is located. The letters after the section represent subdivisions of the section and are assigned in a counterclockwise direction. The first letter denotes a 160-acre tract, the second a 40-acre tract, and the third a 10-acre tract.

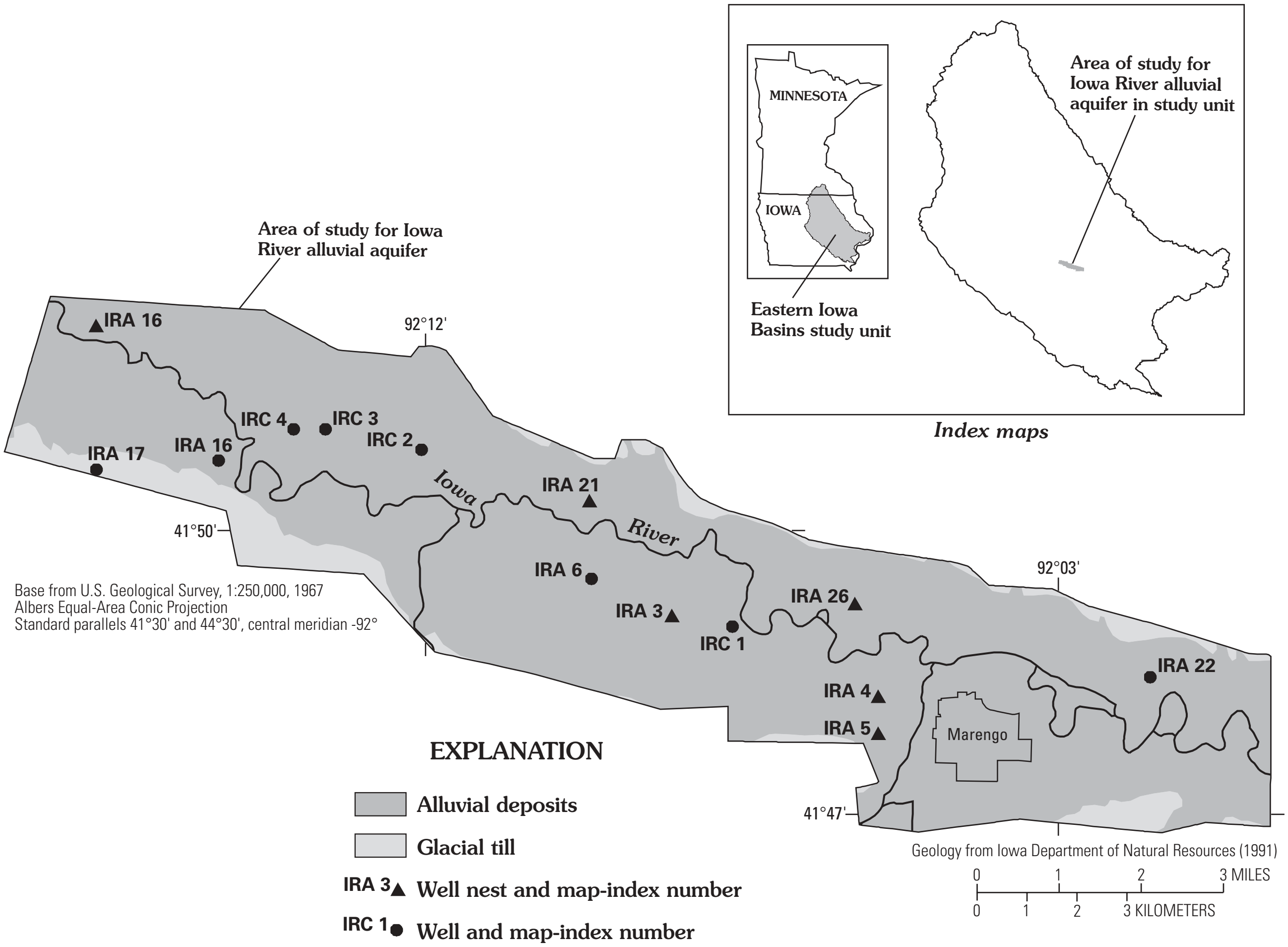

Figure 4. Location of ground-water-quality sampling sites in Iowa River alluvial aquifer, 1998.

unit survey well-selection criteria included whether an existing domestic well was completed in an alluvial aquifer, whether permission to sample the well could be obtained from the landowner, whether the depth of the well was known, whether the well was equipped with a submersible pump, and whether a sample could be obtained upgradient from a pressure tank or treatment system. Well depths range from 12 to 193 ft. Information about the well was obtained from well-owner interviews and driller's logs. If a suitable site or well could not be found at a primary location, a search was initiated at the closest alternate location.

The wells sampled for the Iowa River alluvial aquifer study were selected from a previous USGS and Iowa Department of Natural Resources monitoring-well network (Detroy and Kuzniar, 1988) and four wells drilled by the USGS in 1996 (Savoca and others, 1997). Well locations were selected on the basis of proximity to areas of anticipated changes in land use, proximity to areas of continuing agricultural activity, and a desire for broad distribution throughout the study area. Well depths ranged from 8 to 40 ft. Six wells locations consisted of well nests of two to six wells that were screened at various depths within the alluvial aquifer.

Well Installation

Ground-water monitoring wells were completed in alluvial aquifers during August 1996–July 1997 at 31 agricultural and 30 urban land-use sites using procedures described by Lapham and others (1995). Boreholes were drilled using 4.25-in. inside-diameter, continuous-flight hollow-stem augers. The augers were left in place during well construction to prevent borehole collapse. Samples of surficial deposits obtained during well drilling were analyzed for particle size and organic carbon content. Wells were

Table 4. Iowa River alluvial aquifer wells sampled in 1998

Map-index number (fig. 4)	Well identification number	Local identifier[1]	Location (degrees, minutes, seconds)		Well depth (feet)	County, State
			Latitude	Longitude		
IRA 5	414752092053201	081N 11W 26 ACC	41°47'52"	92°05'32"	30.0	Iowa, IA
	414752092053202	081N 11W 26 ACC	41°47'52"	92°05'32"	13.0	Iowa, IA
	414752092053203	081N 11W 26 ACC	41°47'52"	92°05'32"	10.0	Iowa, IA
IRC 4	414816092053401	081N 11W 23 DCC	41°48'16"	92°05'34"	31.0	Iowa, IA
	414816092053402	081N 11W 23 DCC	41°48'16"	92°05'34"	13.5	Iowa, IA
	414816092053403	081N 11W 23 DCC	41°48'16"	92°05'34"	11.0	Iowa, IA
IRA 26	414818092055401	081N 11W 14 CCA	41°49'15"	92°05'54"	22.5	Iowa, IA
	414818092055402	081N 11W 14 CCA	41°49'15"	92°05'54"	13.5	Iowa, IA
	414818092055403	081N 11W 14 CCA	41°49'15"	92°05'54"	11.0	Iowa, IA
IRA 22	414828092014201	081N 10W 20 DAC	41°48'28"	92°01'42"	25.0	Iowa, IA
IRC 1	414900092073801	081N 11W 21 ABD	41°49'00"	92°07'38"	22.5	Iowa, IA
IRA 3	414907092083001	081N 11W 20 AAA	41°49'07"	92°08'30"	29.0	Iowa, IA
	414907092083003	081N 11W 20 AAA	41°49'07"	92°08'30"	15.5	Iowa, IA
	414907092083004	081N 11W 20 AAA	41°49'07"	92°08'30"	8.0	Iowa, IA
IRA 6	414930092093801	081N 11W 17 CBB	41°49'30"	92°09'38"	30.0	Iowa, IA
IRA 21	415020092094001	081N 11W 07 DAA	41°50'20"	92°09'40"	25.0	Iowa, IA
	415020092094002	081N 11W 07 DAA	41°50'20"	92°09'40"	18.0	Iowa, IA
	415020092094003	081N 11W 07 DAA	41°50'20"	92°09'40"	15.0	Iowa, IA
	415020092094004	081N 11W 07 DAA	41°50'20"	92°09'40"	12.0	Iowa, IA
	415020092094005	081N 11W 07 DAA	41°50'20"	92°09'40"	8.0	Iowa, IA
	415020092094010	081N 11W 07 DAA	41°50'20"	92°09'40"	32.0	Iowa, IA
IRA 17	415039092164001	081N 12W 05 CCC	41°50'39"	92°16'40"	40.0	Iowa, IA
IRA 19	415045092145601	081N 12W 09 ABC	41°50'45"	92°14'56"	25.0	Iowa, IA
IRC 2	415052092120301	081N 12W 11 AAD	41°50'52"	92°12'03"	27.5	Iowa, IA
IRC 3	415105092132501	081N 12W 03 DDB	41°51'05"	92°13'25"	22.5	Iowa, IA
IRC 4	415105092135201	081N 12W 03 CDA	41°51'05"	92°13'52"	22.5	Iowa, IA
IRA 16	415211092164101	082N 12W 31 DAD	41°52'11"	92°16'41"	26.0	Benton, IA
	415211092164102	082N 12W 31 DAD	41°52'11"	92°16'41"	15.0	Benton, IA

[1]The local identifier is in accordance with the Bureau of Land Management's system of land subdivision. Each identifier is made up of three segments. The first segment indicates the township, the second the range, and the third the section in which the well is located. The letters after the section represent subdivisions of the section and are assigned in a counterclockwise direction. The first letter denotes a 160-acre tract, the second a 40-acre tract, and the third a 10-acre tract.

constructed of 2-in. outside-diameter, flush-threaded polyvinyl-chloride (PVC) casing and 5 ft of 0.02-in. slotted PVC screen at the base of each well. Well depths ranged from 10 to 37.5 ft below land surface. Aquifer material was allowed to fill the annular space around the screen during removal of the augers to form a natural filter pack extending about 2 ft above the top of the screen. An artificial sand-filter pack was placed around the screen in wells containing fine-grained material adjacent to the screened interval. A bentonite annular seal was placed above the filter pack, and the remainder of the borehole was backfilled with well cuttings to within a few feet of land surface. A lockable, protective steel casing set in a concrete pad was installed at land surface to protect the well casing and to prevent infiltration of surface water down the well. Wells were developed after completion. The augers and associated drilling equipment were steam cleaned between well sites.

Ground-Water Sample Collection

The sampling procedures for the ground-water studies are described by Koterba and others (1995). Before sample collection, all sampling equipment was thoroughly cleaned. Sampling lines and hoses were cleaned by circulating a 0.1-percent, nonphosphate detergent solution through the entire system with a peristaltic pump for 10 minutes. The lines then were rinsed with 3 to 4 gal of deionized water. All sampling and preservation chamber stands were rinsed with deionized water. All filter assemblies were also washed with a 0.1-percent, nonphosphate detergent solution and rinsed with deionized water, with the exception of the DOC filter, which was washed and rinsed with certified pesticide- and VOC-free deionized water. Cleaned equipment was wrapped in aluminum foil and placed in clean plastic bags.

Before sample collection, the static water level was recorded, and the wells were purged of at least three casing volumes of water. Pumping continued until measured values of specific conductance, pH, water temperature, and dissolved oxygen stabilized. Samples then were collected by filling containers in a sampling chamber made by placing a polyethylene bag over a PVC frame. All bottles were filled inside the sampling chamber to minimize the potential for contamination. Holes were cut in the bag for the inflow hose, waste discharge, and access for sampling. Powderless latex gloves were worn during sampling. To begin sampling, flow valves were switched to route the water into the sampling chamber, and the sampling lines were flushed for several minutes. For organic-analyses samples, all sampling lines and connections between the faucet and the sampling chamber were Teflon or stainless steel. Except for the baked glass bottles, all bottles were rinsed three times with pumped sample water before filling. Samples were collected at each site for analysis of alkalinity, nutrients, major ions, DOC, pesticides, VOC's, radon-222, tritium, and stable isotopes.

Samples for pesticide analyses were filtered using a 142-mm-diameter, 0.7-µm glass fiber filter. DOC samples were collected and filtered with a stainless-steel filter assembly and a 47-mm-diameter, 0.45-µm silver membrane filter. Filtration was done under pressure from nitrogen gas.

All samples were preserved and treated immediately after collection. Samples for VOC's were treated with a 1:1 hydrochloric acid solution (HCl). Samples for major ions were treated with 1 mL of nitric acid. All samples then were chilled for shipment to NWQL.

Radon-222 samples were collected by inserting a syringe through a gas-impermeable membrane in the gas-collection tube and withdrawing 15 mL of sample water. To allow the withdrawal of sample water without degassing, sufficient backpressure was created by closing a valve in the sample-collection tube. The syringe then was inverted (needle up) and voided until all air bubbles were gone and only 10 mL of sample remain in the barrel. The sample then was injected (needle down) into a vial at the base of a mineral oil layer. The vial was capped and shaken for approximately 10 seconds. Radon-222 samples were shipped by next-day air freight the day of collection.

Analytical Procedures

For the analysis of major ions, nutrients, DOC, pesticides, VOC's, and radon, ground-water samples were sent to the NWQL in Arvada, Colorado. Ground-water samples were analyzed for tritium at the USGS Isotope Tracers Project Laboratory in Menlo Park, California, and for environmental isotopes at the USGS National Research Program in Reston, Virginia. The analytical methods used in all sample processing are listed in tables 6–9 at the end of this report.

Water-Quality Analysis and Quality Control

Analytical results are evaluated in the context of minimum reporting levels (MRLs) and method detection limits (MDLs) established by NWQL. The MRL is the minimum concentration of an analyte that can be reliably measured and reported by the laboratory using a specific analytical method. MRLs are commonly reported with analytical results for major ions, nutrients, DOC, radiochemicals, and VOCs. The MDL is the minimum concentration of a substance that can be identified, measured, and reported with 99-percent confidence that the analyte concentration is greater than zero. MDLs are generally smaller and better defined statistically than MRLs, and are commonly reported with analytical results for pesticides (Zaugg and others, 1995). MRLs and MDLs provide information about relative analytical precision and detection sensitivity but do not constitute low concentration reporting limits for conclusively identified analytes (Zaugg and others, 1995). Concentration values less than the lowest calibration standard are reported as estimated by NWQL. Estimated values indicate analyte detection; however, the reported concentration value is uncertain.

Surface Water

The NAWQA surface-water quality-control design philosophy is described in detail by Mueller and others (1997). About 15 percent of the total samples collected for the EIWA were analyzed for quality control. Quality-control samples submitted for October 1996 through September 1998 included equipment blank samples done on two sets of sampling equipment, 15 field blank samples, 28 replicate samples, 19 spike samples, three of which were for a high-spike experiment, and laboratory surrogate recoveries. Equipment blank samples of deionized water certified by the manufacturer to be free of pesticides and VOC's and deionized water certified by the manufacturer to be free of inorganic compounds were passed through all sampling equipment at the beginning of the data-collection season to verify the initial cleanliness of the sampling equipment. Field blank samples of the same deionized water that was used with equipment blank samples, were collected by passing the deionized water through all pumps, filter plates, and filters to verify cleanliness of sampling equipment and technique. Field blank samples verified that the surface-water samples were not contaminated from either the sampling equipment, transport of the equipment, or the cleaning procedures done between sites. Blank samples (equipment and field) indicated that all constituent concentrations were less than the MDL for all samples.

The objective of the replicate samples was to estimate the precision of concentration values from sample processing and analysis. Analysis of organic constituents are generally more variable than analyses of inorganic constituents. In particular, replicate samples for pesticides were an important way to evaluate the consistency of the identifying target constituent. Each replicate sample is an aliquot of the native sample water processed through the cone splitter, passed through the same sample equipment, and prepared in the same way.

A spike sample is a water sample to which a laboratory-certified concentration of selected analytes has been added. Spike samples were used to estimate percentage recovery and possible degradation of the analyte concentration during sample processing and analysis. Table 5 summarizes the percentage recovery data for commonly detected pesticides from 16 water samples that were spiked at the sampling sites from October 1996 through September 1997. The mean spike recoveries ranged from 76 to 106 percent, and the median spike recoveries ranged from 82 to 106 percent.

In addition, a high-spike recovery experiment was performed to check the recovery of selected pesticide compounds at higher spike concentrations (3.0 and 6.0 μg/L) in sample water. Three water samples collected at Old Man's Creek near Iowa City (site 6, fig. 1) on May 8, 1998, were spiked at low (0.1 μg/L), medium (3.0 μg/L), and high (6.0 μg/L) concentrations. The spike recoveries at the higher concentrations (3.0 and 6.0 μg/L) were not significantly different than those done at the lower (0.1 μg/L) concentrations.

A surrogate compound is an organic compound that has physical and chemical properties similar to the analytes being measured but typically is not present in the sample. A surrogate compound is added to each pesticide sample that is processed at the NWQL as part of their quality-control protocols. The percentage recovery of the surrogate compounds allows a quality check on the amount of recovery for the pesticide sample. Surrogate recoveries were typically between 80 and 120 percent for the pesticide compounds and are listed in table 15 later in this report.

Table 5. Summary of percentage recovery data for commonly detected pesticides spiked at sampling sites for Eastern Iowa Basins study unit, October 1996 through September 1998

Constituent	Spiked recovery percentage			
	Minimum	Maximum	Mean	Median
Acetochlor	78	142	103	99
Alachlor	84	139	106	106
Atrazine	83	132	106	104
Cyanazine	35	162	86	82
Metolachlor	19	163	101	102
Metribuzin	57	110	78	82
Prometon	83	118	91	99
Simazine	84	124	90	97
Trifluralin	67	116	76	88

Ground Water

Quality-control samples were collected during the ground-water studies to evaluate the effects of sample collection and laboratory methods on analytical results. Quality-control samples consisted of equipment blank samples, field blanks samples, replicate samples (sequential samples), and laboratory surrogate and spike recoveries. During the land-use study, one equipment blank sample was analyzed for pesticides, and two equipment blank samples were analyzed for VOCs. Three field blank samples were analyzed for nutrients, major ions, and pesticides; four field blank samples were analyzed for VOCs; and two field blank samples were analyzed for DOC. Three replicate samples were analyzed for nutrients, major ions, DOC, pesticides, VOCs, radon-222, tritium, and environmental isotopes. Laboratory surrogate recoveries were performed on selected pesticides and VOCs for all ground-water samples. One spike sample was analyzed for pesticides and VOCs.

During the alluvial study-unit survey, one equipment blank sample was analyzed for nutrients, major ions, pesticides, and VOCs. Two field blank samples were analyzed for nutrients, major ions, DOC, pesticides, and VOCs. Two replicate samples were analyzed for common ions, nutrients, DOC, pesticides, and VOCs. Laboratory surrogate recoveries were performed on selected pesticides and VOCs for all ground-water samples. One spike sample was analyzed for pesticides and VOCs.

During the Iowa River alluvial aquifer study, one field blank sample was analyzed for nutrients, major ions, DOC, and pesticides. One replicate sample was analyzed for nutrients, major ions, DOC, and pesticides.

ACKNOWLEDGMENTS

Data collection on the magnitude of the EIWA NAWQA could not be accomplished without the assistance of many dedicated people. The authors would like to acknowledge the assistance of those who collected many of the water samples during routine and event sampling in 1997 and 1998. From USGS offices in Iowa, these include Jim Cerveny, Jon Nania, Joel Galloway, Matt Bobier, Jim Klaus, Jennifer Tobias, Jeff Harms, S. Michael Linhart, and Pat Sweeney.

Biological and synoptic sampling, planned and coordinated by Linda Roberts, was done with the assistance of Jeffery Copa, Deb Sneck-Fahrer, Pat Lustgraaf, Scott Thul, and Josh Eash from USGS offices in Iowa and Dwain Curtis and John Miller from the USGS office in Nebraska. Stephen Porter, USGS NAWQA biologist from Lakewood, Colorado, provided important assistance in the planning and collection of biological samples during the synoptic study. Assistance in training of sample-collection protocols was provided by Robert Goldstein, Upper Mississippi River NAWQA biologist from the USGS office in Mounds View, Minnesota. Scott Yess and Ann Runstrom of the U.S. Fish and Wildlife Service in Rock Island, Illinois, provided assistance in the collection of fish.

The drilling and construction of monitoring wells was done with the assistance of Ron Kuzniar, and stream-gaging and monitoring equipment installation were done by Dave Conell, Alvin Conkling, Jr., Joe Gorman, and Mike Turco, all USGS personnel from offices in Iowa.

The following students from the University of Iowa in Iowa City also provided assistance: Trevor Birkenholtz, Kelli DeBrower, Demarius George, Sandra Kautz, Brian Lanning, Laura McClain, Julie Noe, and Nancy Reilly. Miscellaneous assistance was provided by Ed Fischer, Craig Harvey, and Von Miller from USGS offices in Iowa.

In addition to samples collected for the Iowa Department of Natural Resources, Mike Schueler, Mike Birmingham, employees of the University of Iowa Hygienics Laboratory (Iowa City), collected

samples at four surface-water sampling sites for the analysis of pesticides.

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