Water-Quality Effects of Stormwater Runoff into Sand Pits on Ground Water in Sedgwick County, Kansas:
Phase I – Barefoot Bay, Ridge Port, Moorings, and Cropland Pits

A report for
Groundwater Management District No. 2 Task Force on Sand Pits,
Kansas Department of Agriculture, Division of Water Resources
Kansas Department of Health and Environment
and Sedgwick County

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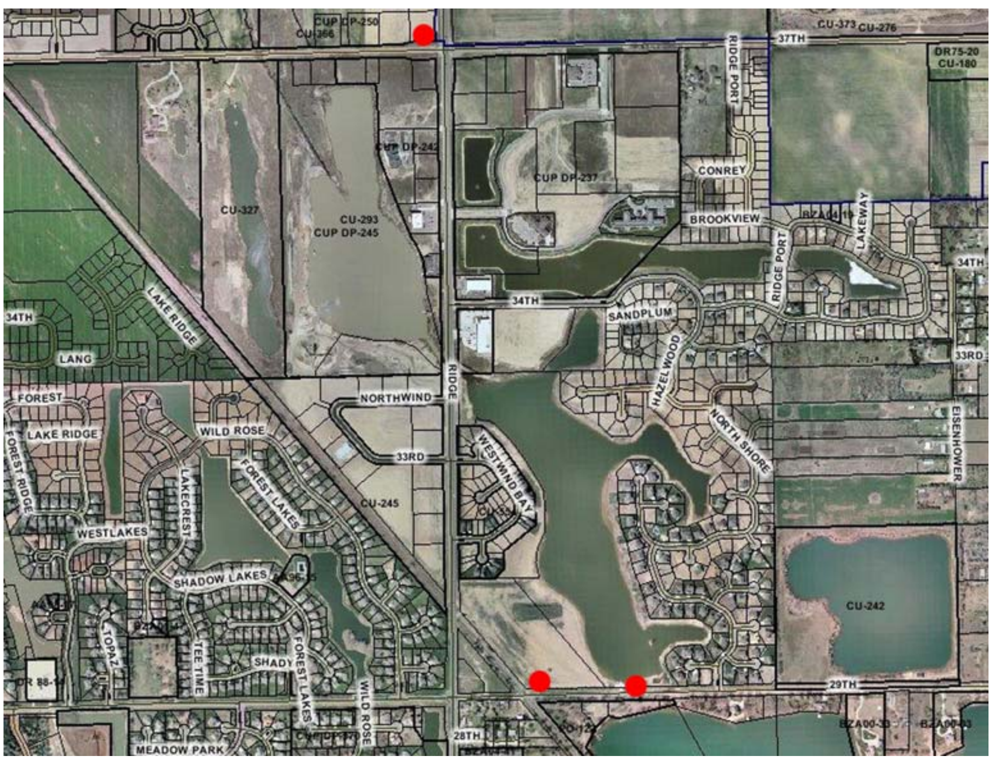

Aerial photograph of Ridge Port sand pit and the location of the three monitoring wells (from Sedgwick County Department of Environmental Resources report of June 2005)

Kansas Geological Survey
The University of Kansas
Lawrence, Kansas
April, 2007

Kansas Geological Survey Open-file Report No. 2007-9

KANSAS GEOLOGICAL SURVEY
OPEN-FILE REPORT

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ACKNOWLEDGMENTS

Individuals involved in the study planning, determination of the sand pits for detailed study, monitoring well installation and logistics, and other activities leading to this report included Thomas Huntzinger and Lane Letourneau, Division of Water Resources of the Kansas Department of Agriculture (KDA), Susan Erlenwein, Caroline Hosford, Jo Oliver, and Joe Renfro, Sedgwick County Department of Environmental Resources (SCDER), Andrew Megrail, Sedgwick County Conservation District, Donald Carlson, Kansas Department of Health and Environment (KDHE), Michael Dealy, Equus Beds Groundwater Management District No. 2 (GMD2), David Warren and Brian Fisher, the City of Wichita, Wess Gaylon, Wichita Area Builders Association (WABA), John Gage and Mike McNamee, U.S. Bureau of Reclamation, Andrew Ziegler and Larry M. Pope, U.S. Geological Survey (USGS), Debra Baker, Kansas Water Office (KWO), and Lawrence Skelton, Kansas Geological Survey (KGS). The USBR provided the drilling and well installation as a service. The KDHE, KWO, Sedgwick County, KDA, GMD2, WABA, and the City of Wichita provided funds, and the USGS included a cost share, for the sampling and analysis of the waters and sediment at the sand-pit sites by the USGS. Rex Buchanan, KGS, Lane Letourneau, KDA, Donald Carlson, KDHE, and Susan Erlenwein, SCDER, provided review comments on the report.

EXECUTIVE SUMMARY

In December 2002, Equus Beds Groundwater Management District No. 2 and representatives of the Wichita Area Builders Association formed a Groundwater Quality Task Force to address issues regarding use of sand pits for stormwater flow management. In April 2004, the Kansas Legislature passed and the Governor approved Senate Bill 364 that amended laws on the appropriation of water in sand and gravel pits. The bill introduced a new section that included studying and developing recommendations regarding the pollution control and flood control impacts of diverting water runoff into sand and gravel pits. State and local agencies already involved in the sand pit task force developed a plan of study on the impacts of runoff into sand pits. Sedgwick County Department of Environmental Resources organized and conducted much of the efforts to determine which sand pits to study in more detail. The study group obtained assistance from the U.S. Bureau of Reclamation in drilling and installing three monitoring wells around each of the six sites selected for study. Funds were obtained for the U.S. Geological Survey to sample and analyze surface water from the pits, ground water from the monitoring wells, and pit bottom sediment at four sites located at the northwest edge of Wichita. The USGS analyzed the water samples for 18 physical and chemical properties, five bacteriological values, 40 inorganic constituents, 118 pesticide and degradate compounds, and 134 organic compounds other than pesticides. The USGS analyzed the sediments for five physical and chemical properties, 45 inorganic constituents, and 32 organic compounds. This report discusses the results of the chemical analyses.

Surface waters sampled from the four sand pits contained many organic compounds of concern for drinking waters. However, none of the concentrations measured exceeded drinking water standards or recommended levels, and essentially all of the organic compounds for which standards exist were present at levels substantially below the standard. The most common organics of interest relative to drinking water that were detected were the herbicides atrazine and two of its degradates (deethylatrazine and hydroxyatrazine), metolachlor, and simazine. These compounds occurred in the greatest percentage of the pit and well water samples and generally in the highest concentrations. The concentrations of these five compounds were usually greater in the surface and ground waters at the three sand pits located in residential areas than at a control site in a cropland area. This could be partly related to the design of the residential sites to allow stormwater runoff entry, whereas no storm drains are directed into the control pit. In addition, there were fewer pesticides and organics other than pesticides detected at the control site than at the residential pit sites. The generally greater occurrence and concentration of organic compounds at the residential sites reflect the use of selected organics in urban areas, for example, weed control in lawns.

Nearly all of the surface and ground waters at the pit sites contained total dissolved solids (TDS) and chloride contents that exceeded the recommended drinking water standard. The high TDS and chloride levels are primarily natural and result from the interaction of saline Arkansas River water, and possibly deeper saline ground water, with the alluvial aquifer and sand-pit water. Dissolved iron and manganese concentrations also exceeded recommended drinking water levels in some of the pit and well waters. None of the pit or well waters sampled at the study sites had concentrations of inorganic constituents that exceeded a primary drinking water standard. All of the surface waters sampled contained measurable or estimable contents of E.

coli and total coliform bacteria and all but one of the pit water samples contained fecal coliform bacteria. One sample of residential pit water contained E. coli bacteria that exceeded the KDHE geometric mean criterion for primary contact recreation during the spring and summer. However, additional samples for E. coli measurement would have been needed to compute the geometric mean necessary for determination of a regulatory exceedance. All of the monitoring well samples contained measurable total coliform bacteria indicating that they would need to be treated if used for drinking water.

The bottom sediment samples of the four sand pits did not contain heavy metal concentrations high enough to be of concern to aquatic ecosystems. The only organic compounds detected in the sediments were three chemicals in the persistent insecticide chlordane, which was banned in the U.S. in 1988. The detections were for two samples from one of the residential pits.

The concentration distributions of pesticides and organics other than pesticides, as well as the general pattern in iron, manganese, and ammonium ion concentrations in the downgradient well waters relative to the upgradient well and pit waters, indicate that surface water in the sand pits enters the ground water in the southeast to south-southeast direction of the ground-water flow at the study sites. This would be expected to occur most prominently when surface runoff into the pits increases the hydraulic gradient between the pit surface and ground-water levels. Thus, stormwater runoff containing contaminants can enter ground water through the sand pits and impact the ground-water quality.

INTRODUCTION

In December 2002, Equus Beds Groundwater Management District No. 2 (GMD2) and representatives of the Wichita Area Builders Association (WABA) agreed to form a Groundwater Quality Task Force to address issues regarding use of sand pits for stormwater flow management. The stated purpose of the task force was summarized in a letter of December 24, 2002, from the manager of GMD2 to the Kansas Department of Health and Environment [KDHE]:

"1. Determining the utility of groundwater pits as stormwater runoff management system.
2. Determining surface-water and ground-water impacts from the use of such stormwater runoff management systems.
3. Identifying best management practices that protect the quality of ground water and allowing the use of ground-water pits as a stormwater runoff management system.
4. Reviewing existing permitting requirements and procedures for such systems in determining the effectiveness of such permitting requirements and procedures.
5. Developing either statewide or District-wide best management practices for use of ground-water pits as a stormwater runoff management system."

The letter indicated that the task force included members from the following areas of interest: a Wichita developer, Bureau of Water in the KDHE, Division of Water Resources (DWR) of the Kansas Department of Agriculture, Kansas Geological Survey (KGS), Kansas Water Office (KWO), Kansas Society of Professional Engineers, GMD2, City of Wichita - Stormwater Pollution Section, and the Sedgwick County Commission. The initial task force meeting was scheduled for January 8, 2003. The task force has been chaired by Senator Carolyn McGinn (Sedgwick County Commissioner in January 2003) of Wichita.

In April 2004, the Kansas Legislature passed and the Governor approved Senate Bill 364 that amended laws on the appropriation of water in sand and gravel pits. The Bill also introduced a new section into K.S.A. 82a-734 that addressed studies and recommendations related to sand and gravel pit issues:

> "New Sec. 2. The chief engineer of the division of water resources of the department of agriculture and the state geological survey shall study and develop recommendations regarding: (a) The use of water banking as it pertains to sand and gravel pits; (b) calculation of evapotranspiration and its effects on consumptive use from sand and gravel pits, with special emphasis on salt cedar (tamarisk); and (c) the pollution control and flood control impacts of diverting water runoff into sand and gravel pits. …"

The DWR and KDHE arranged meetings and conference calls for discussion of plans for the study of the pollution impacts of stormwater runoff into sand pits in response to part (c) in Section 2 of Senate Bill 364. The participants included several state and local agencies (including the DWR, KDHE, KGS, KWO, GMD2, Sedgwick County offices, and the City of Wichita) and the WABA. The KDHE awarded a Local Environmental Protection Program (LEPP) grant to Sedgwick County in May 2004 "for the purposes of initiating stormwater management policies for urban development activities in Sedgwick County with the primary focus on sensitive groundwater areas" (Sedgwick County Department of Environmental

Resources [SCER], 2005). The KDHE and DWR determined that SCER was best suited for selecting sand pits for the water-quality study. The SCER "developed a multi-step process to identify sand pits that could be tested to determine whether stormwater runoff into the sand pits impacted the quality of the ground water" (SCER, 2005).

The SCER produced a report "A Study to Determine the Effects on Groundwater of Stormwater Runoff into Sand Pits" (SCER, 2005) that described the procedures used in selecting the sand pits for further study, documented the steps taken to study the pit sites chosen, and included maps and data for the study. The DWR asked SCER to focus on sand pits located in the Big Slough watershed that is bounded on the west by Cowskin Creek and on the east by the Arkansas River. The SCER also investigated sand pits in areas of the alluvial aquifer to the east of the Big Slough watershed on the east side of the Arkansas River. They found 76 water bodies that had characteristics of sand pits in the study area, out of which they then selected nine pits that best represented characteristics most appropriate for the water-quality investigation. Representatives of state and local agencies toured the nine sites on October 15, 2004, and these individuals, along with representatives from the U.S. Geological Survey and WABA, met and chose the six top sites for study.

Four of the six sand-pit sites are located in the general area of northwest Wichita and the other two sites are in the southern part of Wichita (Figure 1). Three of the four sand pits located to the northwest of Wichita (Barefoot Bay, Ridge Port, and Moorings) are in residential areas and are designed to allow inflow of stormwater (SCER, 2005). The Barefoot Bay and Ridge Port pits receive both local runoff and stormflow from the Big Slough. Creek drainage from the Big Slough enters the northwest end of the Ridge Port pit. Water from the south end of the Ridge Port pit flows under a bridge on 29th Street into the northwest end of the Barefoot Bay pit. The watershed of Big Slough includes both residential and agricultural land use. The Moorings pit appears to receive runoff from primarily the local residential area. One of the sand pits in the northwest Wichita area, the Cropland pit, was chosen as a control site. Surface runoff is not directed into this pit. Staff of SCER determined the water surface area of the pits using aerial photographs and measured the depth of each pit at several locations (see Table 5 in SCER, [2005] for depth soundings). Characteristics of the sand pit sites are listed in Table 1. The SCER (2005) report includes aerial photographs of each of the sand pits.

The DWR contacted the U.S. Bureau of Reclamation (USBR) which agreed to drill and install 18 monitoring wells at the six pit sites. The USBR was asked to drill one monitoring well more than 500 feet in an upgradient direction of ground-water flow from the pit and two wells within 500 feet in a downgradient direction. The SCER assisted with the drilling logistics. The actual well locations depended on siting restrictions. The USBR drilled the wells during March 26 through April 4, 2005. The general direction of ground-water flow in the area is to the south-southeast. The depths of the wells ranged from 17.5 to 42.5 ft below land surface and were based on the elevation of the greatest depth measured in the pit in the area of the well plus an additional two feet (see Figure 26 in SCER, [2005]). The screened interval was the bottom 10 ft of each well. Due to the proximity of the Ridge Port and Barefoot Bay pits, the locations of the southeast downgradient well for the Ridge Port pit and the upgradient (north) well for Barefoot Bay were installed at the same location. However the depth of the southeast downgradient well for the Ridge Port pit was 17.5 ft, whereas the depth of the upgradient well for Barefoot Bay at

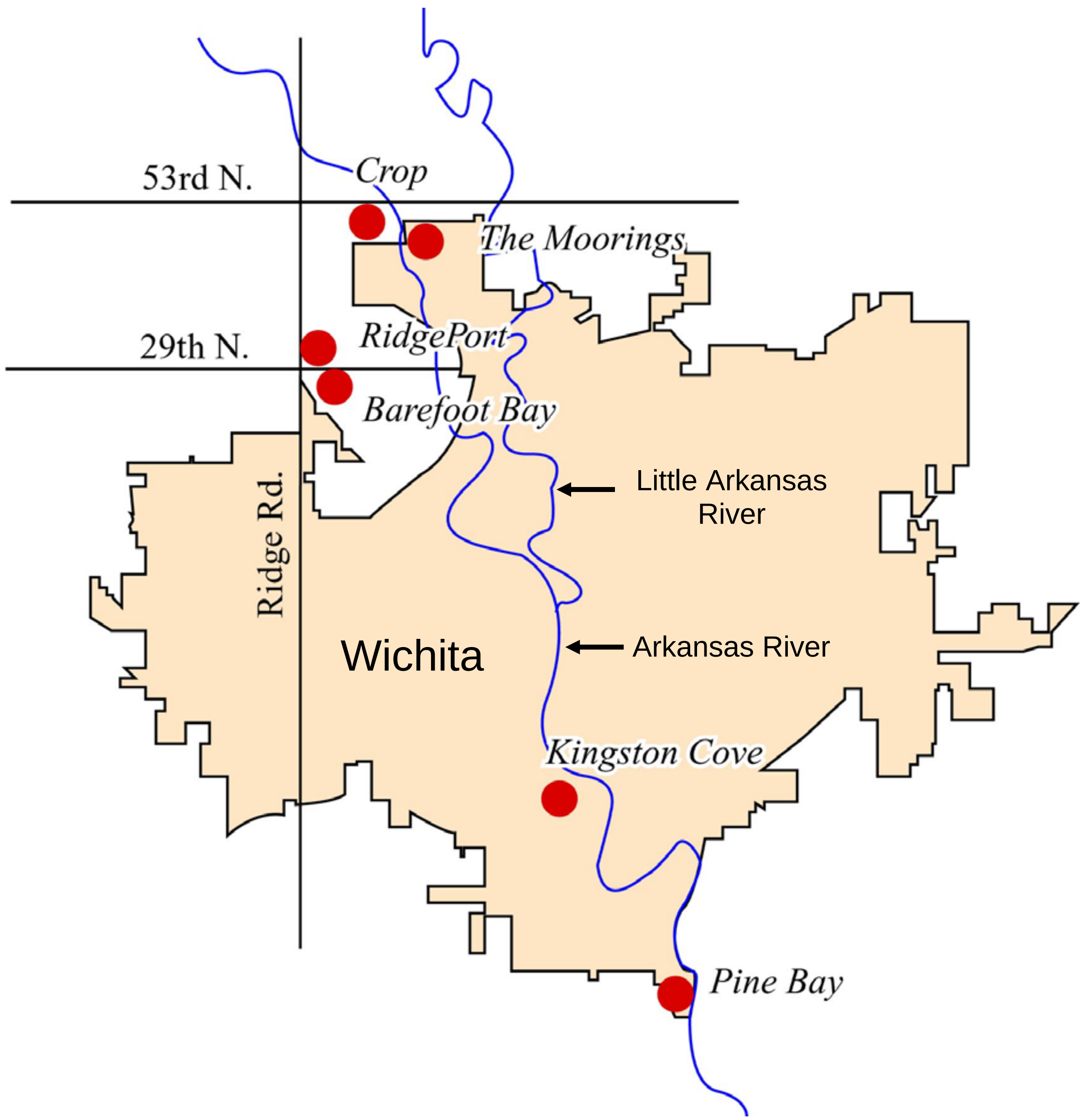

Figure 1. Location of the six sand-pit sites chosen for study in the Wichita area. The four sites in the northwest part of Wichita are discussed in this report. (Modified from Sedgwick County Department of Environmental Resources report of June 2005.)

Table 1. Characteristics of the six sand and gravel pits selected for the water-quality study. The age of each site is based on appearance in aerial photographs.

Name of pit	Type of area	Location description	Legal location	Age of pit	Age of develop-ment	Water surface area, acres	Greatest depth measured, ft
Barefoot Bay	New residential area	About two miles west of the Arkansas River	N/2 Sec. 3, T.27S, R.1W.	Active in 1974	1991 to 2004	113	30
Ridge Port	New residential area	A little over two miles west of the Arkansas River	SW/4 Sec. 34, T.26S., R.1W.	Cropland in 1997	1999 to present	87 (58 east of Ridge Road)	6.7
The Moorings	Old residential area	Adjacent to and on the east side of the Arkansas River	center Sec. 24, T.26S., R.1W.	Active in 1968	1978 to present	111	31
Cropland	Control site, in cropland (wheat to north and south, corn to west)	Just to the northwest of Wichita in cropland to the west of the Arkansas River	N/2 Sec. 23, T.26S., R.1W.	Active in 1968	-	42	32
Kingston Cove	Apartments and commercial area	About one mile west of the Arkansas River	NE/4 SW/4 Sec. 5, T.28S., R.1E.	Active in 1960	1968 to 1974	18	19
Pine Bay Estates	New residential with septic systems and golf course	About one-half mile southwest of the Arkansas River and one-half mile northeast of the Wichita flood control canal	S/2 NW/4 Sec. 34, T.28S., R.1E.	Active in 1968	1986 to 2002	32	14

Table 2. Name, location, and characteristics of the monitoring wells. The screened interval for all wells is the bottom 10 ft.

Well name	USGS location and well number *	Altitude of land surface, ft	Well depth, ft below land surface	Distance from sand pit, ft
Barefoot Bay N	26S 01W 34CCDD02	1327	40	175
Barefoot Bay SE	27S 01W 03DABA01	1325	40	315
Barefoot Bay SW	24S 01W 03ACCC01	1330	42.5	168
Ridge Port N	26S 01W 28DDDD01	1333	17.5	596
Ridge Port SE	26S 01W 34CCDD01	1327	17.5	61
Ridge Port SW	26S 01W 34CCD 01	1330	19	786
Moorings Well N	26S 01W 24BBAA01	1338	46	1099
Moorings Well SE	26S 01W 25ADBA01	1331	47	530
Moorings Well SW	26S 01W 25ADCC01	1331	47.5	730
Cropland Well N	26S 01W 23BAAB01	1339	46.5	637
Cropland Well SE	26S 01W 23AACD01	1338	47.5	484
Cropland Well SW	26S 01W 23BCAA01	1337	45.3	181

* Township, Range, Section, quarter sections from largest to smallest (A = NE, B = NW, C = SW, D = SE), well number

this location was 40 ft because the Ridge Port pit depth (6.7 ft) was appreciably shallower than that (30 ft) of Barefoot Bay. Table 2 summarizes information for the monitoring wells. Additional information, including well logs and the locations of the wells on aerial photographs including the sand pits, is given in the SCER (2005) report.

The USGS recommended a suite of different chemical properties and inorganic and organic constituents for determination in waters and sediments of the sand-pit study sites. The task force then reviewed and approved the analytical list. The task force requested that the USGS sample and analyze surface waters from the sand pits, ground waters from the monitoring wells, and bottom sediments from the pits. The USGS provided a proposal with costs for the sampling and analysis. The KDHE, KWO, Sedgwick County, KDA, GMD2, WABA, and the City of Wichita provided funding for the sampling and analysis for the four pit sites located in the general northwestern part of Wichita in 2006. The KDHE plans to provide funds to the USGS for sampling and analysis of waters from the two pit locations in the southern part of Wichita in 2007.

The USGS provided the results of the chemical analyses of the surface- and ground-water and sediment samples from the sand pit study sites to the DWR in the latter part of January 2007, which then gave the results to the KGS for interpretation. This report describes and discusses these chemical data, and assesses the pollution impacts of diverting surface runoff into sand and gravel pits, including the quality of the sand-pit water and its impact on the quality of the adjacent ground water.

USGS WATER SAMPLING AND ANALYSIS PROCEDURES

The USGS collected the water and sediment samples according to procedures documented in the USGS *National Field Manual for the Collection of Water-Quality Data* (Techniques of Water-Resources Investigations Book 9, Handbooks for Water-Resources Investigations) that is available online at http://water.usgs.gov/owq/FieldManual/. Filtered samples were filtered on site through 0.45 µm filters and treated with preservative as required for individual analysis. Bottom sediment samples were collected with a box corer at one location in each pit. Samples for analysis then were collected from about the upper inch of material in the corer. Several drops were made at each site to get enough material for the various analyses. The material was composited, homogenized, and subsampled to meet each analytical requirement (L. Pope, USGS, personal communication).

All constituents for surface and ground water samples were analyzed at the USGS National Water-Quality Laboratory, Denver, CO, except for the following:

Triazine screen; USGS Organic Research Lab, Lawrence, KS.
Bacteria samples; USGS Wichita Field Office, processed within 6 hrs of collection.
Coliphage; USGS Ohio Microbiological Lab; Columbus, OH.
Suspended sediment; USGS Sediment Laboratory, Iowa City, IA.
Cyanide; Severn-Trent Laboratory, Denver, CO.

All constituents for bottom sediment samples were analyzed at the USGS National Water-Quality Laboratory, Denver, CO, except for the following:

Bulk density, percent moisture, percent sieve diameter <0.063 mm, and percent sieve diameter <2.0 mm; USGS Kansas Water Science Center Laboratory, Lawrence, KS.

USGS CHEMICAL DATA

The USGS determined physical and chemical properties (for example, temperature specific conductance, pH, oxidation-reduction potential, alkalinity) on site in the surface- and ground-water samples. These properties also included transparency and chlorophyll content of the surface waters in the pits. Analyses in the laboratory included measurement of bacteriological content (for example, fecal and total coliform bacteria), dissolved concentrations of major, minor, and trace inorganic constituents, and radioactivity. The laboratories determined the presence or concentration of a large number of pesticides in filtered samples and organic compounds other than pesticides in unfiltered samples. Table 3 lists all of the physical and chemical properties (18 parameters), bacteriological values (five parameters), inorganic constituents (40 parameters), pesticide compounds (119 parameters – 118 pesticides and degradates and an atrazine screen), and organic compounds other than pesticides (134 parameters) measured either on site or in the laboratory, along with information on the sampling site, such as depth to the bottom of the sand pit at the surface-water sample location, elevation of the pit water surface, and depth to and elevation of ground-water table in the monitoring wells for the water samples. Table 4 lists all of the physical and chemical properties (five parameters), carbon content and inorganic constituents (45 parameters), and organic compounds (33

Table 3. List of USGS parameters for water samples (site information, physical and chemical properties, bacterial content, inorganic constituents, radioactivity, pesticides, and organic compounds other than pesticides.

Sample site information
SNAME Station name
STAID Station number
DATES Date as yyyymmdd
TIMES Sample start time
STYPE Sample type code
P72025 Depth of reservoir, feet – only for surface water sample
P81903 Depth to bottom at sample location, feet – only for surface water sample
P62615 Lake or reservoir water surface elevation above NAVD 1988, feet
P72008 Depth of well, feet below land surface datum – only for ground-water sample
P72019 Depth to water level, feet below land surface – only for ground-water sample
P72000 Altitude of land surface, feet – only for ground-water sample
P62611 Ground-water level above NAVD 1988, feet – only for ground-water sample
P82398 Sampling method, code
P84164 Sampler type, code
P99105 Type of replicate, code

Physical and chemical properties
P00020 Temperature, air, degrees Celsius
P00010 Temperature, water, degrees Celsius
P00077 Transparency, water, unfiltered, Secchi disc, inches
P63676 Turbidity, water, unfiltered, broad band light source (400-680 nm), detectors at multiple angles including 90 +/- 30 degrees, ratiometric correction, NTRU
P63680 Turbidity, water, monochrome near infra-red LED light, 780-900 nm, detection angle 90 +/ -2.5 degrees, FNU
P00025 Barometric pressure, millimeters of mercury
P90095 Specific conductance, water, unfiltered, laboratory, microsiemens per centimeter at 25 degrees Celsius
P00095 Specific conductance, water, unfiltered, microsiemens per centimeter at 25 degrees Celsius
P63001 Oxidation reduction potential, raw emf, reference electrode not specified, millivolts
P63002 Oxidation reduction potential, relative to the standard hydrogen electrode (SHE), millivolts
P00300 Dissolved oxygen, water, unfiltered, milligrams per liter
P00400 pH, water, unfiltered, field, standard units
P00403 pH, water, unfiltered, laboratory, standard units
P00556 Oil and grease, water, unfiltered, □reon extraction, gravimetric, recoverable, milligrams per liter
P00680 Organic carbon, water, unfiltered, milligrams per liter
P62361 Chlorophyll, total, water, fluorometric, 650-700 nanometers, in-situ sensor, micrograms per liter
P01519 Gross alpha radioactivity, water, unfiltered, picocuries per liter
P85817 Gross beta radioactivity, water, unfiltered, picocuries per liter

Bacteriological analysis
P90903 Coliphage, E. coli, C13 host, MF method, water, plaques per 100 milliliters
P90904 Coliphage, E. coli, FAMP host, MF method, water, plaques per 100 milliliters
P90902 Escherichia coli, modified m-TEC MF method, water, colonies per 100 milliliters
P31625 Fecal coliform, M-FC MF (0.7 micron) method, water, colonies per 100 milliliters
P90900 Total coliform, MI MF method, water, colonies per 100 milliliters

Inorganic constituents and radioacivity
P00915 Calcium, water, filtered, milligrams per liter
P00925 Magnesium, water, filtered, milligrams per liter
P00935 Potassium, water, filtered, milligrams per liter
P00930 Sodium, water, filtered, milligrams per liter

Table 3. (continued) List of USGS parameters for water samples.

P90410 Acid neutralizing capacity, water, unfiltered, fixed endpoint (pH 4.5) titration, laboratory, milligrams per liter as calcium carbonate
P00419 Acid neutralizing capacity, water, unfiltered, incremental titration, field, milligrams per liter as calcium carbonate
P00450 Bicarbonate, water, unfiltered, incremental titration, field, milligrams per liter
P00447 Carbonate, water, unfiltered, incremental titration, field, milligrams per liter
P00940 Chloride, water, filtered, milligrams per liter
P00950 Fluoride, water, filtered, milligrams per liter
P00955 Silica, water, filtered, milligrams per liter
P00945 Sulfate, water, filtered, milligrams per liter
P70300 Residue on evaporation, dried at 180 degrees Celsius, water, filtered, milligrams per liter
P00530 Residue, total nonfilterable, milligrams per liter
P00608 Ammonia, water, filtered, milligrams per liter as nitrogen
P00631 Nitrite plus nitrate, water, filtered, milligrams per liter as nitrogen
P00613 Nitrite, water, filtered, milligrams per liter as nitrogen
P00671 Orthophosphate, water, filtered, milligrams per liter as phosphorus
P00665 Phosphorus, water, unfiltered, milligrams per liter
P01106 Aluminum, water, filtered, micrograms per liter
P01095 Antimony, water, filtered, micrograms per liter
P01000 Arsenic, water, filtered, micrograms per liter
P01005 Barium, water, filtered, micrograms per liter
P01010 Beryllium, water, filtered, micrograms per liter
P01020 Boron, water, filtered, micrograms per liter
P01025 Cadmium, water, filtered, micrograms per liter
P01030 Chromium, water, filtered, micrograms per liter
P01035 Cobalt, water, filtered, micrograms per liter
P01040 Copper, water, filtered, micrograms per liter
P00723 Cyanide, water, filtered, milligrams per liter
P01046 Iron, water, filtered, micrograms per liter
P01049 Lead, water, filtered, micrograms per liter
P01056 Manganese, water, filtered, micrograms per liter
P71890 Mercury, water, filtered, micrograms per liter
P01060 Molybdenum, water, filtered, micrograms per liter
P01065 Nickel, water, filtered, micrograms per liter
P01145 Selenium, water, filtered, micrograms per liter
P01075 Silver, water, filtered, micrograms per liter
P01090 Zinc, water, filtered, micrograms per liter
P22703 Uranium (natural), water, filtered, micrograms per liter

Pesticide and degradate compounds
P82626 1,2-Diphenylhydrazine, water, unfiltered, recoverable, micrograms per liter
P49295 1-Naphthol, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P50470 2,4-D methyl ester, water, filtered, recoverable, micrograms per liter
P39732 2,4-D, water, filtered, recoverable, micrograms per liter
P38746 2,4-DB, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P82660 2,6-Diethylaniline, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P61618 2-Chloro-2’,6’-diethylacetanilide, water, filtered, recoverable, micrograms per liter
P04040 2-Chloro-4-isopropylamino-6-amino-s-triazine, water, filtered, recoverable, micrograms per liter
P04038 2-Chloro-6-ethylamino-4-amino-s-triazine, water, filtered, recoverable, micrograms per liter
P61620 2-Ethyl-6-methylaniline, water, filtered, recoverable, micrograms per liter
P50355 2-Hydroxy-4-isopropylamino-6-ethylamino-s-triazine, water, filtered, recoverable, micrograms per liter
P61625 3,4-Dichloroaniline, water, filtered, recoverable, micrograms per liter
P49308 3-Hydroxy carbofuran, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P49260 Acetochlor, water, filtered, recoverable, micrograms per liter

Table 3. (continued) List of USGS parameters for water samples.

P49315 Acifluorfen, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P46342 Alachlor, water, filtered, recoverable, micrograms per liter
P49313 Aldicarb sulfone, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P49314 Aldicarb sulfoxide, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P49312 Aldicarb, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P39632 Atrazine, water, filtered, recoverable, micrograms per liter
P61635 Azinphos-methyl oxygen analog, water, filtered, recoverable, micrograms per liter
P82686 Azinphos-methyl, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P50299 Bendiocarb, water, filtered, recoverable, micrograms per liter
P82673 Benfluralin, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P50300 Benomyl, water, filtered, recoverable, micrograms per liter
P61693 Bensulfuron, water, filtered, recoverable, micrograms per liter
P38711 Bentazon, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P04029 Bromacil, water, filtered, recoverable, micrograms per liter
P49311 Bromoxynil, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P49310 Carbaryl, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P82680 Carbaryl, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P49309 Carbofuran, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P61188 Chloramben methyl ester, water, filtered, recoverable, micrograms per liter
P50306 Chlorimuron, water, filtered, recoverable, micrograms per liter
P04039 Chlorodiamino-s-triazine, water, filtered, recoverable, micrograms per liter
P61636 Chlorpyrifos oxygen analog, water, filtered, recoverable, micrograms per liter
P38933 Chlorpyrifos, water, filtered, recoverable, micrograms per liter
P82687 cis-Permethrin, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P49305 Clopyralid, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P04031 Cycloate, water, filtered, recoverable, micrograms per liter
P61585 Cyfluthrin, water, filtered, recoverable, micrograms per liter
P61586 Cypermethrin, water, filtered, recoverable, micrograms per liter
P49304 Dacthal monoacid, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P82682 DCPA, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P62170 Desulfinyl fipronil, water, filtered, recoverable, micrograms per liter
P39572 Diazinon, water, filtered, recoverable, micrograms per liter
P38442 Dicamba, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P49302 Dichlorprop, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P38454 Dicrotophos, water, filtered, recoverable, micrograms per liter
P39381 Dieldrin, water, filtered, recoverable, micrograms per liter
P82662 Dimethoate, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P49301 Dinoseb, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P04033 Diphenamid, water, filtered, recoverable, micrograms per liter
P49300 Diuron, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P61644 Ethion monoxon, water, filtered, recoverable, micrograms per liter
P82346 Ethion, water, filtered, recoverable, micrograms per liter
P61645 Fenamiphos sulfone, water, filtered, recoverable, micrograms per liter
P61646 Fenamiphos sulfoxide, water, filtered, recoverable, micrograms per liter
P61591 Fenamiphos, water, filtered, recoverable, micrograms per liter
P49297 Fenuron, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P62169 Desulfinylfipronil amide, water, filtered, recoverable, micrograms per liter
P62167 Fipronil sulfide, water, filtered, recoverable, micrograms per liter
P62168 Fipronil sulfone, water, filtered, recoverable, micrograms per liter
P62166 Fipronil, water, filtered, recoverable, micrograms per liter
P61694 Flumetsulam, water, filtered, recoverable, micrograms per liter
P38811 Fluometuron, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P04095 Fonofos, water, filtered, recoverable, micrograms per liter
P04025 Hexazinone, water, filtered, recoverable, micrograms per liter

Table 3. (continued) List of USGS parameters for water samples.

P50356 Imazaquin, water, filtered, recoverable, micrograms per liter
P50407 Imazethapyr, water, filtered, recoverable, micrograms per liter
P61695 Imidacloprid, water, filtered, recoverable, micrograms per liter
P61593 Iprodione, water, filtered, recoverable, micrograms per liter
P61594 Isofenphos, water, filtered, recoverable, micrograms per liter
P38478 Linuron, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P61652 Malaoxon, water, filtered, recoverable, micrograms per liter
P39532 Malathion, water, filtered, recoverable, micrograms per liter
P38482 MCPA, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P38487 MCPB, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P50359 Metalaxyl, water, filtered, recoverable, micrograms per liter
P61596 Metalaxyl, water, filtered, recoverable, micrograms per liter
P61598 Methidathion, water, filtered, recoverable, micrograms per liter
P38501 Methiocarb, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P49296 Methomyl, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P61664 Methyl paraoxon, water, filtered, recoverable, micrograms per liter
P82667 Methyl parathion, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P39415 Metolachlor, water, filtered, recoverable, micrograms per liter
P82630 Metribuzin, water, filtered, recoverable, micrograms per liter
P61697 Metsulfuron, water, filtered, recoverable, micrograms per liter
P61599 Myclobutanil, water, filtered, recoverable, micrograms per liter
P61692 N-(4-Chlorophenyl)-N'-methylurea, water, filtered, recoverable, micrograms per liter
P49294 Neburon, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P50364 Nicosulfuron, water, filtered, recoverable, micrograms per liter
P49293 Norflurazon, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P49292 Oryzalin, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P38866 Oxamyl, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P82683 Pendimethalin, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P61666 Phorate oxygen analog, water, filtered, recoverable, micrograms per liter
P82664 Phorate, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P49291 Picloram, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P04037 Prometon, water, filtered, recoverable, micrograms per liter
P04036 Prometryn, water, filtered, recoverable, micrograms per liter
P82676 Propyzamide, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P49236 Propham, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P50471 Propiconazole, water, filtered, recoverable, micrograms per liter
P38538 Propoxur, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P38548 Siduron, water, filtered, recoverable, micrograms per liter
P04035 Simazine, water, filtered, recoverable, micrograms per liter
P50337 Sulfometuron, water, filtered, recoverable, micrograms per liter
P82670 Tebuthiuron, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P04032 Terbacil, water, filtered, recoverable, micrograms per liter
P61674 Terbufos oxygen analog sulfone, water, filtered, recoverable, micrograms per liter
P82675 Terbufos, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P04022 Terbuthylazine, water, filtered, recoverable, micrograms per liter
P34756 Triazine screen, water, filtered, enzyme link immuno sorbent assay, recoverable, micrograms per liter as atrazine
P61610 Tribuphos, water, filtered, recoverable, micrograms per liter
P49235 Triclopyr, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P82661 Trifluralin, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
P77041 Carbon disulfide, water, unfiltered, micrograms per liter
P38775 Dichlorvos, water, filtered, recoverable, micrograms per liter

Table 3. (continued) List of USGS parameters for water samples.

Organic compounds other than pesticides
P34621 2,4,6-Trichlorophenol, water, unfiltered, recoverable, micrograms per liter
P34601 2,4-Dichlorophenol, water, unfiltered, recoverable, micrograms per liter
P34606 2,4-Dimethylphenol, water, unfiltered, recoverable, micrograms per liter
P34616 2,4-Dinitrophenol, water, unfiltered, recoverable, micrograms per liter
P34611 2,4-Dinitrotoluene, water, unfiltered, recoverable, micrograms per liter
P34626 2,6-Dinitrotoluene, water, unfiltered, recoverable, micrograms per liter
P34581 2-Chloronaphthalene, water, unfiltered, recoverable, micrograms per liter
P34586 2-Chlorophenol, water, unfiltered, recoverable, micrograms per liter
P34657 2-Methyl-4,6-dinitrophenol, water, unfiltered, recoverable, micrograms per liter
P34591 2-Nitrophenol, water, unfiltered, recoverable, micrograms per liter
P34631 3,3'-Dichlorobenzidine, water, unfiltered, recoverable, micrograms per liter
P34636 4-Bromophenyl phenyl ether, water, unfiltered, recoverable, micrograms per liter
P61633 4-Chloro-2-methylphenol, water, filtered, recoverable, micrograms per liter
P34452 4-Chloro-3-methylphenol, water, unfiltered, recoverable, micrograms per liter
P34641 4-Chlorophenyl phenyl ether, water, unfiltered, recoverable, micrograms per liter
P34646 4-Nitrophenol, water, unfiltered, recoverable, micrograms per liter
P34381 9H-Fluorene, water, unfiltered, recoverable, micrograms per liter
P34205 Acenaphthene, water, unfiltered, recoverable, micrograms per liter
P34200 Acenaphthylene, water, unfiltered, recoverable, micrograms per liter
P34220 Anthracene, water, unfiltered, recoverable, micrograms per liter
P34526 Benzo[a]anthracene, water, unfiltered, recoverable, micrograms per liter
P34247 Benzo[a]pyrene, water, unfiltered, recoverable, micrograms per liter
P34230 Benzo[b]fluoranthene, water, unfiltered, recoverable, micrograms per liter
P34521 Benzo[ghi]perylene, water, unfiltered, recoverable, micrograms per liter
P34242 Benzo[k]fluoranthene, water, unfiltered, recoverable, micrograms per liter
P34292 Benzyl n-butyl phthalate, water, unfiltered, recoverable, micrograms per liter
P34278 Bis(2-chloroethoxy)methane, water, unfiltered, recoverable, micrograms per liter
P34273 Bis(2-chloroethyl) ether, water, unfiltered, recoverable, micrograms per liter
P34283 Bis(2-chloroisopropyl) ether, water, unfiltered, recoverable, micrograms per liter
P39100 Bis(2-ethylhexyl) phthalate, water, unfiltered, recoverable, micrograms per liter
P50305 Caffeine, water, filtered, recoverable, micrograms per liter
P34320 Chrysene, water, unfiltered, recoverable, micrograms per liter
P34556 Dibenzo[a,h]anthracene, water, unfiltered, recoverable, micrograms per liter
P34336 Diethyl phthalate, water, unfiltered, recoverable, micrograms per liter
P34341 Dimethyl phthalate, water, unfiltered, recoverable, micrograms per liter
P39110 Di-n-butyl phthalate, water, unfiltered, recoverable, micrograms per liter
P34596 Di-n-octyl phthalate, water, unfiltered, recoverable, micrograms per liter
P34376 Fluoranthene, water, unfiltered, recoverable, micrograms per liter
P39700 Hexachlorobenzene, water, unfiltered, recoverable, micrograms per liter
P34386 Hexachlorocyclopentadiene, water, unfiltered, recoverable, micrograms per liter
P34403 Indeno[1,2,3-cd]pyrene, water, unfiltered, recoverable, micrograms per liter
P34408 Isophorone, water, unfiltered, recoverable, micrograms per liter
P34447 Nitrobenzene, water, unfiltered, recoverable, micrograms per liter
P34438 N-Nitrosodimethylamine, water, unfiltered, recoverable, micrograms per liter
P34428 N-Nitrosodi-n-propylamine, water, unfiltered, recoverable, micrograms per liter
P34433 N-Nitrosodiphenylamine, water, unfiltered, recoverable, micrograms per liter
P39032 Pentachlorophenol, water, unfiltered, recoverable, micrograms per liter
P34461 Phenanthrene, water, unfiltered, recoverable, micrograms per liter
P34694 Phenol, water, unfiltered, recoverable, micrograms per liter
P34469 Pyrene, water, unfiltered, recoverable, micrograms per liter
P77562 1,1,1,2-Tetrachloroethane, water, unfiltered, recoverable, micrograms per liter
P34506 1,1,1-Trichloroethane, water, unfiltered, recoverable, micrograms per liter
P34516 1,1,2,2-Tetrachloroethane, water, unfiltered, recoverable, micrograms per liter

Table 3. (continued) List of USGS parameters for water samples.

P77652 1,1,2-Trichloro-1,2,2-trifluoroethane, water, unfiltered, recoverable, micrograms per liter
P34511 1,1,2-Trichloroethane, water, unfiltered, recoverable, micrograms per liter
P34496 1,1-Dichloroethane, water, unfiltered, recoverable, micrograms per liter
P34501 1,1-Dichloroethene, water, unfiltered, recoverable, micrograms per liter
P77168 1,1-Dichloropropene, water, unfiltered, recoverable, micrograms per liter
P49999 1,2,3,4-Tetramethylbenzene, water, unfiltered, recoverable, micrograms per liter
P50000 1,2,3,5-Tetramethylbenzene, water, unfiltered, recoverable, micrograms per liter
P77613 1,2,3-Trichlorobenzene, water, unfiltered, recoverable, micrograms per liter
P77443 1,2,3-Trichloropropane, water, unfiltered, recoverable, micrograms per liter
P77221 1,2,3-Trimethylbenzene, water, unfiltered, recoverable, micrograms per liter
P34551 1,2,4-Trichlorobenzene, water, unfiltered, recoverable, micrograms per liter
P77222 1,2,4-Trimethylbenzene, water, unfiltered, recoverable, micrograms per liter
P82625 1,2-Dibromo-3-chloropropane, water, unfiltered, recoverable, micrograms per liter
P77651 1,2-Dibromoethane, water, unfiltered, recoverable, micrograms per liter
P34536 1,2-Dichlorobenzene, water, unfiltered, recoverable, micrograms per liter
P32103 1,2-Dichloroethane, water, unfiltered, recoverable, micrograms per liter
P34541 1,2-Dichloropropane, water, unfiltered, recoverable, micrograms per liter
P77226 1,3,5-Trimethylbenzene, water, unfiltered, recoverable, micrograms per liter
P34566 1,3-Dichlorobenzene, water, unfiltered, recoverable, micrograms per liter
P77173 1,3-Dichloropropane, water, unfiltered, recoverable, micrograms per liter
P34571 1,4-Dichlorobenzene, water, unfiltered, recoverable, micrograms per liter
P77170 2,2-Dichloropropane, water, unfiltered, recoverable, micrograms per liter
P77275 2-Chlorotoluene, water, unfiltered, recoverable, micrograms per liter
P77220 2-Ethyltoluene, water, unfiltered, recoverable, micrograms per liter
P78109 3-Chloropropene, water, unfiltered, recoverable, micrograms per liter
P77277 4-Chlorotoluene, water, unfiltered, recoverable, micrograms per liter
P77356 4-Isopropyltoluene, water, unfiltered, recoverable, micrograms per liter
P81552 Acetone, water, unfiltered, recoverable, micrograms per liter
P34215 Acrylonitrile, water, unfiltered, recoverable, micrograms per liter
P34030 Benzene, water, unfiltered, recoverable, micrograms per liter
P81555 Bromobenzene, water, unfiltered, recoverable, micrograms per liter
P77297 Bromochloromethane, water, unfiltered, recoverable, micrograms per liter
P32101 Bromodichloromethane, water, unfiltered, recoverable, micrograms per liter
P50002 Bromoethene, water, unfiltered, recoverable, micrograms per liter
P34413 Bromomethane, water, unfiltered, recoverable, micrograms per liter
P34301 Chlorobenzene, water, unfiltered, recoverable, micrograms per liter
P34311 Chloroethane, water, unfiltered, recoverable, micrograms per liter
P34418 Chloromethane, water, unfiltered, recoverable, micrograms per liter
P77093 cis-1,2-Dichloroethene, water, unfiltered, recoverable, micrograms per liter
P34704 cis-1,3-Dichloropropene, water, unfiltered, recoverable, micrograms per liter
P32105 Dibromochloromethane, water, unfiltered, recoverable, micrograms per liter
P30217 Dibromomethane, water, unfiltered, recoverable, micrograms per liter
P34668 Dichlorodifluoromethane, water, unfiltered, recoverable, micrograms per liter
P34423 Dichloromethane, water, unfiltered, recoverable, micrograms per liter
P81576 Diethyl ether, water, unfiltered, recoverable, micrograms per liter
P81577 Diisopropyl ether, water, unfiltered, recoverable, micrograms per liter
P73570 Ethyl methacrylate, water, unfiltered, recoverable, micrograms per liter
P81595 Ethyl methyl ketone, water, unfiltered, recoverable, micrograms per liter
P34371 Ethylbenzene, water, unfiltered, recoverable, micrograms per liter
P39702 Hexachlorobutadiene, water, unfiltered, recoverable, micrograms per liter
P34396 Hexachloroethane, water, unfiltered, recoverable, micrograms per liter
P77424 Iodomethane, water, unfiltered, recoverable, micrograms per liter
P78133 Isobutyl methyl ketone, water, unfiltered, recoverable, micrograms per liter
P77223 Isopropylbenzene, water, unfiltered, recoverable, micrograms per liter

Table 3. (continued) List of USGS parameters for water samples.

P81593 Methyl acrylonitrile, water, unfiltered, recoverable, micrograms per liter
P49991 Methyl acrylate, water, unfiltered, recoverable, micrograms per liter
P81597 Methyl methacrylate, water, unfiltered, recoverable, micrograms per liter
P50005 Methyl tert-pentyl ether, water, unfiltered, recoverable, micrograms per liter
P85795 m-Xylene plus p-xylene, water, unfiltered, recoverable, micrograms per liter
P34696 Naphthalene, water, unfiltered, recoverable, micrograms per liter
P77103 n-Butyl methyl ketone, water, unfiltered, recoverable, micrograms per liter
P77342 n-Butylbenzene, water, unfiltered, recoverable, micrograms per liter
P77224 n-Propylbenzene, water, unfiltered, recoverable, micrograms per liter
P77135 o-Xylene, water, unfiltered, recoverable, micrograms per liter
P77350 sec-Butylbenzene, water, unfiltered, recoverable, micrograms per liter
P77128 Styrene, water, unfiltered, recoverable, micrograms per liter
P50004 tert-Butyl ethyl ether, water, unfiltered, recoverable, micrograms per liter
P78032 Methyl tert-butyl ether, water, unfiltered, recoverable, micrograms per liter
P77353 tert-Butylbenzene, water, unfiltered, recoverable, micrograms per liter
P34475 Tetrachloroethene, water, unfiltered, recoverable, micrograms per liter
P32102 Tetrachloromethane, water, unfiltered, recoverable, micrograms per liter
P81607 Tetrahydrofuran, water, unfiltered, recoverable, micrograms per liter
P34010 Toluene, water, unfiltered, recoverable, micrograms per liter
P34546 trans-1,2-Dichloroethene, water, unfiltered, recoverable, micrograms per liter
P34699 trans-1,3-Dichloropropene, water, unfiltered, recoverable, micrograms per liter
P73547 trans-1,4-Dichloro-2-butene, water, unfiltered, recoverable, micrograms per liter
P32104 Tribromomethane, water, unfiltered, recoverable, micrograms per liter
P39180 Trichloroethene, water, unfiltered, recoverable, micrograms per liter
P34488 Trichlorofluoromethane, water, unfiltered, recoverable, micrograms per liter
P32106 Trichloromethane, water, unfiltered, recoverable, micrograms per liter
P39175 Vinyl chloride, water, unfiltered, recoverable, micrograms per liter

Table 4. List of USGS parameters for sediment samples (site information, physical properties, inorganic constituents, pesticides, and chlorinated aromatic compounds).

Sample site information and physical properties of sediment sample

SNAME Station name
STAID Station number
DATES Date as yyyymmdd
TIMES Sample start time
STYPE Sample type code
P00028 Agency analyzing sample, code
P71999 Sample purpose, code
P82398 Sampling method, code
P84164 Sampler type, code
P49982 Bulk density, soil, dry, grams per cubic centimeter
P00495 Moisture content, fraction of dry weight, percent
P80164 Bed sediment, dry sieved, sieve diameter, percent smaller than 0.063 millimeters
P80169 Bed sediment, dry sieved, sieve diameter, percent smaller than 2 millimeters
P99853 Sample weight, Schedule 2501, grams

Carbon content and inorganic constituents

P49267 Carbon (inorganic plus organic), bed sediment smaller than 62.5 microns, wet sieved (native water), field, recoverable, dry weight, percent
P49269 Inorganic carbon, bed sediment smaller than 62.5 microns, wet sieved (native water), field, recoverable, dry weight, percent
P49266 Organic carbon, bed sediment smaller than 62.5 microns, wet sieved (native water), field, recoverable, dry weight, percent
P34970 Sulfur, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, percent
P00603 Total nitrogen, bed sediment, total, dry weight, milligrams per kilogram
P65170 Aluminum, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P34795 Antimony, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P34800 Arsenic, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P34805 Barium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P34810 Beryllium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P34816 Bismuth, bed sediment smaller than 177 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P34825 Cadmium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P65171 Calcium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P34835 Cerium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P65172 Cesium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P34840 Chromium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P34845 Cobalt, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram

Table 4. (continued) List of USGS parameters for sediment samples.

P34850 Copper, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P34860 Gallium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P65173 Iron, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P34885 Lanthanum, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P34890 Lead, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P34895 Lithium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P65174 Magnesium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P34905 Manganese, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P34910 Mercury, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P34915 Molybdenum, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P34925 Nickel, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P34930 Niobium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P65175 Phosphorus, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P65176 Potassium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P65177 Rubidium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P34945 Scandium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P34950 Selenium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P34955 Silver, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P65178 Sodium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P34965 Strontium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P04064 Thallium, bed sediment smaller than 62.5 microns, dry sieved, total digestion, dry weight, micrograms per gram
P34980 Thorium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P65179 Titanium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P35005 Vanadium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P35010 Yttrium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P35020 Zinc, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
P49978 Cesium-137, bed sediment, dry weight, picocuries per gram
P35000 Uranium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram

Organic compounds (primarily persistent pesticides, also chlorinated aromatic compounds)
P49319 Aldrin, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49332 alpha-Endosulfan, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49338 alpha-HCH, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49275 alpha-HCH-d6, surrogate, bed sediment smaller than 2 millimeters, wet sieved (native water), field, percent recovery
P49339 beta-HCH, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram

Table 4. (continued) List of USGS parameters for sediment samples.

P49322 Chloroneb, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49320 cis-Chlordane, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49316 cis-Nonachlor, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49349 cis-Permethrin, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49324 DCPA, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49331 Dieldrin, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49335 Endrin, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49342 Heptachlor epoxide, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49341 Heptachlor, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49343 Hexachlorobenzene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49344 Isodrin, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49345 Lindane, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49348 Mirex, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49325 o,p'-DDD, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49327 o,p'-DDE, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49329 o,p'-DDT, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49347 o,p'-Methoxychlor, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49318 Oxychlordane, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49326 p,p'-DDD, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49328 p,p'-DDE, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49330 p,p'-DDT, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49346 p,p'-Methoxychlor, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49459 PCBs, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49460 Pentachloroanisole, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49351 Toxaphene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49321 trans-Chlordane, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49317 trans-Nonachlor, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
P49350 trans-Permethrin, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram

parameters, primarily persistent pesticides and also chlorinated aromatic compounds) that the USGS determined in the sediment samples.

The USGS provided printed tables of all of the data for the water and sediment samples. The KGS requested and received from the USGS electronic files for the surface- and ground-water and sediment data. These Excel files are included on a CD in Appendix A of this report. The USGS Excel files are not in the same format as the USGS printout because the USGS used a non-Microsoft Windows computer system to generate the printed tables.

The KGS examined the analytical data for the water and sediment samples to determine which physical and chemical properties and inorganic and organic constituents were of particular value for characterizing the study sites and determining the pollution impact of runoff into the pits. Tables 5 and 6 list, for the surface and ground water samples, respectively, only the chemical properties and inorganic constituent concentrations discussed in the next section of this report. Tables 7 and 8 list all of the bacteriological parameters. Tables 9 and 10 list only those pesticide compounds that were detected or for which concentrations were measured or estimated in at least one sample. Tables 11 and 12 list only those organic compounds other than pesticides that were detected or for which concentrations were measured or estimated in at least one sample. Table 13 lists physical and chemical properties of the sediment samples collected from the sand pits, along with the three pesticide compounds that were detectable.

DISCUSSION OF CHEMICAL DATA – WATER

The USGS collected surface-water samples from the sand pits for chemical properties, inorganic constituent concentrations, and bacteriological analyses on three different dates (in April, May, and June, 2006) for each sand pit (Tables 5 and 7). They collected two samples of pit water from different depths on the same date from the Barefoot Bay (June 6) and Moorings Pits (June 7). They also conducted an atrazine screen on the same dates as for the sample collection for inorganic constituents (Table 9). They collected one surface water sample from each of the Barefoot Bay, Ridge Port, and Cropland pits and two samples from the Moorings pit in June 2006 for analyses of pesticides and organics other than pesticides (Tables 9 and 11, respectively).

The USGS collected one ground-water sample from each of the monitoring wells (except for duplicate samples from the Barefoot Bay N well) for chemical properties and inorganic constituents and pesticide determinations during June 19-22, 2006 (Tables 6 and 10). They collected one sample (except for duplicate samples from the Barefoot Bay N well) for determination of each of the different bacteriological parameters during June 19-27, 2006 (Table 8). They collected one water sample from each of the wells (except for duplicate samples from the Barefoot Bay N well) for measurement of organics other than pesticides during June 10-12, 2006 (Table 12). One of the organic compounds listed in Table 12 was determined in the sample collected for inorganic constituent measurements.

Table 5. Data for chemical properties and inorganic compounds for which there are drinking water standards (except redox potential, organic carbon, and ammonia) in surface-water samples collected from the sand pits. The letter E next to a value indicates estimated.

Station name	Station number	Date	Time	Reser-voir depth, feet P72025	Depth to bottom of sample, feet P81903	Lake eleva-tion, feet P62615	pH, water, unfil-tered, units P00400	Redox potential, rel to SHE, mV P63002	Organic carbon, water, unfil-tered, mg/L P00680	TDS, evapn residue, water, filtered, mg/L P70300	Chloride, water, filtered, mg/L P00940	Fluoride, water, filtered, mg/L P00950	Sulfate, water, filtered, mg/L P00945
27S 01W 03ADDC Barefoot Bay Pit	374303097243900	20060426	1010	23	19	1320.43	8.2	470		785	283	0.5	109
27S 01W 03ADDC Barefoot Bay Pit	374303097243900	20060511	950	23	21	1320.98	8.1	340		780	277	0.5	107
27S 01W 03ADDC Barefoot Bay Pit	374303097243900	20060606	1345	23	19	1321.01	8.2	420	4.8	784	282	0.5	108
27S 01W 03ADDC Barefoot Bay Pit	374303097243900	20060606	1355	23	19	1321.01	8.2	420		779	283	0.5	108
26S 01W 34CCD Ridgeport Pit	374432097252100	20060427	1015	7	3	1322.5	8.6	480		975	372	0.6	140
26S 01W 34CCD Ridgeport Pit	374432097252100	20060509	1010	6	3	1322.85	8.5	350		923	351	0.5	131
26S 01W 34CCD Ridgeport Pit	374432097252100	20060607	1410	6	3	1322.25	8.7	380	11.4	890	349	0.5	125
26S 01W 24DBCB Moorings Pit	374610097225200	20060427	1155	30	25	1321.1	8.2	470		1130	462	0.5	132
26S 01W 24DBCB Moorings Pit	374610097225200	20060511	1130	27	20	1321.3	8	350		1130	461	0.5	130
26S 01W 24DBCB Moorings Pit	374610097225200	20060607	1025	26	23	1320.85	7.5	36	4.6	1140	459	0.5	129
26S 01W 24DBCB Moorings Pit	374610097225200	20060607	1040	26	23	1320.85	7.5	36	4.9	1120	459	0.5	129
26S 01W 23ABCB Cropland Pit	374644097240800	20060426	1220	18	13	1327.32	8.3	440		995	287	0.7	225
26S 01W 23ABCB Cropland Pit	374644097240800	20060509	1135	26	21	1327.4	8.1	390		995	287	0.7	226
26S 01W 23ABCB Cropland Pit	374644097240800	20060606	1045	20	19	1327.06	7.7	380	5.4	995	289	0.6	227

Table 5. (continued) Data for chemical properties and inorganic compounds for which there are drinking water standards (except redox potential, organic carbon, and ammonia) in surface-water samples collected from the sand pits.

Station name	Date	Depth to bottom of sample, feet P81903	Ammonia, water, filtered, mg/L as N P00608	Nitrite & nitrate, water, filtered, mg/L as N P00631	Nitrate, water, filtered, mg/L as N P00613	Alum-inum, water, filtered, µg/L P01106	Antimony, water, filtered, µg/L P01095	Arsenic, water, filtered, µg/L P01000	Barium, water, filtered, µg/L P01005	Beryllium, water, filtered, µg/L P01010	Cadmium, water, filtered, µg/L P01025	Chromium, water, filtered, µg/L P01030	Copper, water, filtered, µg/L P01040
Barefoot Bay Pit	20060426	19		0.07				1.2					
Barefoot Bay Pit	20060511	21		0.08				1.3					
Barefoot Bay Pit	20060606	19	0.06	E.06	0.005	3	0.3	1.7	107	<.06	<.04	0.08	2.7
Barefoot Bay Pit	20060606	19		E.06				1.6					
Ridgeport Pit	20060427	3		<.06				1.1					
Ridgeport Pit	20060509	3		<.06				0.93					
Ridgeport Pit	20060607	3	<.010	<.06	<.002	2	0.33	1.3	86	<.06	E.03	E.02	2.6
Moorings Pit	20060427	25		<.06				2.3					
Moorings Pit	20060511	20		<.06				2.3					
Moorings Pit	20060607	23	0.462	<.06	<.002	E1	0.22	2.5	110	<.06	<.04	E.03	0.9
Moorings Pit	20060607	23	0.525	<.06	<.002	2	0.23	2.5	106	<.06	0.04	E.03	1.7
Cropland Pit	20060426	13		<.06				0.87					
Cropland Pit	20060509	21		<.06				0.87					
Cropland Pit	20060606	19	0.01	<.06	<.002	2	E.16	1	71	<.06	<.04	E.03	3.8

Table 5. (continued) Data for chemical properties and inorganic compounds for which there are drinking water standards (except redox potential, organic carbon, and ammonia) in surface-water samples collected from the sand pits.

Station name	Date	Depth to bottom of sample, feet P81903	Cyanide, water, filtered, µg/L P00723	Iron, water, filtered, µg/L P01046	Lead, water, filtered, µg/L P01049	Mangan-ese, water, filtered, µg/L P01056	Mercury, water, filtered, µg/L P71890	Nickel, water, filtered, µg/L P01065	Selenium, water, filtered, µg/L P01145	Silver, water, filtered, µg/L P01075	Uranium, natural, water, filtered, µg/L P22703	Zinc, water, filtered, µg/L P01090	Gross alpha radioact, water, unfiltered, pCi/L P01519	Gross beta radioact, water, unfiltered, pCi/L P85817
Barefoot Bay Pit	20060426	19		<6		12.8								
Barefoot Bay Pit	20060511	21		<6		2								
Barefoot Bay Pit	20060606	19	<.01	<6	0.11	2.3	E.01	3.46	0.78	<.2	5.78	2	1.3	5
Barefoot Bay Pit	20060606	19		<6		2.5								
Ridgeport Pit	20060427	3		E4		0.5								
Ridgeport Pit	20060509	3		E3		0.3								
Ridgeport Pit	20060607	3	<.01	E4	0.1	0.4	<.01	1.68	0.76	<.2	6.23	1.9	5.1	5.8
Moorings Pit	20060427	25		E12		2.4								
Moorings Pit	20060511	20		<6		0.5								
Moorings Pit	20060607	23	<.01	25	0.13	300	<.01	2.93	0.28	0.2	5.22	1.6	3.4	9.7
Moorings Pit	20060607	23	<.01	24	0.1	299	<.01	2.65	0.3	<.2	5.1	2.2	-4	8.2
Cropland Pit	20060426	13		<6		0.5								
Cropland Pit	20060509	21		E3		50.8								
Cropland Pit	20060606	19	<.01	<6	0.15	1.5	0.01	4.25	2.9	<.2	10.4	3	5	9.7

Table 6. Data for chemical properties and inorganic compounds for which there are drinking water standards (except redox potential, organic carbon, and ammonia) in ground-water samples collected from monitoring wells near the sand pits. The letter E next to a value indicates estimated.

Station name	Station number	Date	Time	Depth of well, feet below LSD P72008	Depth to water level, feet below LSD P72019	Altitude of land surface, feet P72000	Ground water level above NAVD, ft P62611	Lake elevation NAVD, feet P62615	pH, water, unfiltered, units P00400	Redox potential, rel to SHE, mV P63002	Organic carbon, water, unfil-tered, mg/L P00680	TDS, evapn residue, water, filtered, mg/L P70300
26S 01W 34CCDD02 Barefoot Bay Well N	374417097251702	20060619	1055	40	5.05	1327	1321.35	1320.89	6.8	320	1.9	886
26S 01W 34CCDD02 Barefoot Bay Well N	374417097251702	20060619	1105	40	5.05	1327	1321.35	1320.89	6.8	320	2.4	881
27S 01W 03DABA01 Barefoot Bay Well SE	374350097243701	20060619	1455	40	7.18	1325	1317.92	1320.89	7.4	160	2.0	794
24S 01W 03ACCC01 Barefoot Bay Well SW	374351097250101	20060619	1040	42.5	9.87	1330	1319.83	1320.89	7.5	220	1.8	790
26S 01W 28DDDD01 Ridgeport Well N	374509097253601	20060620	1300	17.5	7.68	1333	1325.62	1322.38	6.9	390	1.6	865
26S 01W 34CCDD01 Ridgeport Well SE	374417097251701	20060620	945	17.5	5.23	1327	1321.37	1322.38	7.3	127	2.2	926
26S 01W 34CCD 01 Ridgeport Well SW	374417097252501	20060620	945	19	8.23	1330	1321.77	1322.38	7	160	1.8	535
26S 01W 24BBAA01 Moorings Well N	374653097230901	20060622	1210	46	14.73	1338	1322.87	1320.71	7.4	270	1.2	1210
26S 01W 25ADBA01 Moorings Well SE	374557097222801	20060622	955	47	12.49	1331	1318.61	1320.71	7.3	280	1.6	1070
26S 01W 25ADCC01 Moorings Well SW	374537097223401	20060622	940	47.5	12.85	1331	1318.05	1320.71	7.4	300	1.5	1020
26S 01W 23BAAB01 Cropland Well N	374653097240401	20060621	950	46.5	11.67	1339	1327.23	1326.84	7.2	410	0.7	1030
26S 01W 23AACD01 Cropland Well SE	374640097233501	20060621	1210	47.5	12.84	1338	1325.06	1326.84	7.5	160	1.7	992
26S 01W 23BCAA01 Cropland Well SW	374640097241401	20060621	945	45.3	11.03	1337	1326.17	1326.84	7.3	350	1.3	987

Table 6. (continued) Data for chemical properties and inorganic compounds for which there are drinking water standards (except redox potential, organic carbon, and ammonia) in ground-water samples collected from monitoring wells near the sand pits.

Station name	Date	Chloride, water, filtered, mg/L P00940	Fluoride, water, filtered, mg/L P00950	Sulfate, water, filtered, mg/L P00945	Ammonia, water, filtered, mg/L as N P00608	Nitrite & nitrate, water, filtered, mg/L as N P00631	Nitrate, water, filtered, mg/L as N P00613	Alum-inum, water, filtered, µg/L P01106	Antimony, water, filtered, µg/L P01095	Arsenic, water, filtered, µg/L P01000	Barium, water, filtered, µg/L P01005	Beryllium, water, filtered, µg/L P01010	Cadmium, water, filtered, µg/L P01025	Chromium, water, filtered, µg/L P01030
Barefoot Bay Well N	20060619	299	0.5	65.8	1.21	<.06	<.002	<2	<.20	2.8	65	<.06	0.1	0.04
Barefoot Bay Well N	20060619	299	0.5	66	1.21	<.06	<.002	<2	<.20	2.7	65	<.06	0.1	E.03
Barefoot Bay Well SE	20060619	276	0.4	102	0.696	<.06	<.002	2	<.20	4.6	79	<.06	0.05	<.04
Barefoot Bay Well SW	20060619	275	0.4	105	0.156	<.06	<.002	<2	<.20	0.66	62	<.06	E.02	0.19
Ridgeport Well N	20060620	124	0.7	206	E.010	0.67	0.006	M	0.35	0.47	118	<.06	0.05	0.04
Ridgeport Well SE	20060620	354	0.6	94.1	0.79	<.06	<.002	<2	E.14	10	115	E.03	0.11	<.04
Ridgeport Well SW	20060620	65.3	0.7	70.1	0.108	0.2	0.019	E1	E.15	2.2	202	E.04	0.06	0.13
Moorings Well N	20060622	387	0.5	180	<.010	2.82	0.156	E1	E.20	0.27	49	<.06	0.56	<.04
Moorings Well SE	20060622	438	0.6	125	0.281	<.06	<.002	<2	E.12	0.21	47	<.06	0.08	<.04
Moorings Well SW	20060622	399	0.5	135	0.243	<.06	<.002	M	E.16	0.44	51	<.06	0.19	0.04
Cropland Well N	20060621	300	0.4	237	<.010	0.22	<.002	<2	E.12	0.29	37	<.06	0.04	0.14
Cropland Well SE	20060621	281	0.6	205	0.783	<.06	<.002	M	<.20	7.8	122	<.06	<.04	<.04
Cropland Well SW	20060621	286	0.7	202	0.154	<.06	<.002	<2	<.20	0.38	53	<.06	0.07	0.05

Table 6. (continued) Data for chemical properties and inorganic compounds for which there are drinking water standards (except redox potential, organic carbon, and ammonia) in ground-water samples collected from monitoring wells near the sand pits.

Station name	Date	Copper, water, filtered, µg/L P01040	Cyanide, water, filtered, µg/L P00723	Iron, water, filtered, µg/L P01046	Lead, water, filtered, µg/L P01049	Mangan-ese, water, filtered, µg/L P01056	Mercury, water, filtered, µg/L P71890	Nickel, water, filtered, µg/L P01065	Selenium, water, filtered, µg/L P01145	Silver, water, filtered, µg/L P01075	Uranium, natural, water, filtered, µg/L P22703	Zinc, water, filtered, µg/L P01090	Gross alpha radioact, water, unfiltered, pCi/L P01519	Gross beta radioact, water, unfiltered, pCi/L P85817
Barefoot Bay Well N	20060619	1.8	<.01	24	0.08	112	0.02	3.85	0.09	<.2	1.85	2.1	1.4	4.4
Barefoot Bay Well N	20060619	1.4	<.01	23	E.06	110	0.02	3.81	0.1	<.2	1.87	1.3	-1.8	4.7
Barefoot Bay Well SE	20060619	0.7	<.01	285	0.09	313	<.01	3.15	0.2	<.2	0.93	1.9	1.3	4
Barefoot Bay Well SW	20060619	1.1	<.01	8	0.25	115	<.01	1.07	0.12	<.2	5.03	4.9	2.8	7.1
Ridgeport Well N	20060620	2.8	M	<6	E.07	110	<.01	5.59	7.1	<.2	18.4	1.8	13	9.1
Ridgeport Well SE	20060620	1.2	<.01	519	E.06	405	<.01	2.68	0.38	<.2	1.47	0.9	0.3	4.7
Ridgeport Well SW	20060620	2.6	<.01	269	0.1	738	<.01	4.04	1.1	<.2	6.66	2.9	3.5	5.5
Moorings Well N	20060622	4.8	<.01	<18	0.21	254	E.01	3.5	2.3	<.2	9.36	2.8	-2	8.5
Moorings Well SE	20060622	3	<.01	E3	0.16	35.3	<.01	2.74	0.11	<.2	2.83	2	-7	7.3
Moorings Well SW	20060622	2.5	<.01	<6	0.1	60.1	<.01	3.24	E.07	<.2	1.83	2.1	-5.2	6.5
Cropland Well N	20060621	1.7	<.01	<6	E.04	0.4	<.01	0.69	4.7	<.2	2.27	2	-1.1	5.5
Cropland Well SE	20060621	1	<.01	107	<.08	908	<.01	1	0.21	<.2	1.38	1.3	-3.4	6.4
Cropland Well SW	20060621	1.5	<.01	<6	<.08	87.8	<.01	1.2	0.18	<.2	8.79	1.1	6.5	7.9

Table 7. Data for Bacteriological Analyses for Surface-Water Samples Collected from the Sand Pits. The letter E next to a value indicates estimated.

Station name	Station number	Date	Time	Reservoir depth, feet P72025	Depth to sample location, feet P81903	Lake elevation, NAVD, feet P62615	Coliphage, E. coli, C13 host, plaques per 100 mL P90903	Coliphage, E. coli, FAMP host, plaques per 100 mL P90904	E. coli, colonies per 100 mL P90902	Fecal coliform, colonies per 100 mL P31625	Total coliform, colonies per 100 mL P90900
27S 01W 03ADDC Barefoot Bay Pit	374303097243900	20060426	1011	23	1	1320.43			3	<2	E2800
27S 01W 03ADDC Barefoot Bay Pit	374303097243900	20060511	951	23	1	1320.98			E1	E6	E1400
27S 01W 03ADDC Barefoot Bay Pit	374303097243900	20060606	1346	23	1	1321.01	<1	<1	E2	E2	E86
27S 01W 03ADDC Barefoot Bay Pit	374303097243900	20060606	1356	23	1	1321.01			E2	E2	E100
26S 01W 34CCD Ridge Port Pit	374432097252100	20060427	1016	7	1	1322.5			E31	E23	E3400
26S 01W 34CCD Ridge Port Pit	374432097252100	20060509	1011	6	1	1322.85			310	270	E15000
26S 01W 34CCD Ridge Port Pit	374432097252100	20060607	1411	6	1	1322.25	<1	<1	E5	E15	970
26S 01W 24DBCB Moorings Pit	374610097225200	20060427	1156	30	1	1321.1			E4	E2	E540
26S 01W 24DBCB Moorings Pit	374610097225200	20060511	1131	27	1	1321.3			E4	E9	880
26S 01W 24DBCB Moorings Pit	374610097225200	20060607	1026	26	1	1320.85	<1	<1	E2	E4	600
26S 01W 24DBCB Moorings Pit	374610097225200	20060607	1041	26	1	1320.85	<1	<1	E2	E4	E620
26S 01W 23ABCB Cropland Pit	374644097240800	20060426	1221	18	1	1327.32			E20	E16	940
26S 01W 23ABCB Cropland Pit	374644097240800	20060509	1136	26	1	1327.4			E13	E13	1000
26S 01W 23ABCB Cropland Pit	374644097240800	20060606	1046	20	1	1327.06	<1	<1	E9	E14	450

Table 8. Data for Bacteriological Analyses for Ground-Water Samples Collected from Monitoring Wells near the Sand Pits. The letter E next to a value indicates estimated.

Station name	Station number	Date	Time	Depth of well, feet below LSD P72008	Depth to water level, feet below LSD P72019	Coliphage, E. coli, C13 host, plaques per 100 mL P90903	Coliphage, E. coli, FAMP host, plaques per 100 mL P90904	E. coli, colonies per 100 mL P90902	Fecal coliform, colonies per 100 mL P31625	Total coliform, colonies per 100 mL P90900
26S 01W 34CCDD02 Barefoot Bay Well N	374417097251702	20060619	1055	40	5.05	<1	<1	<1	<1	72
26S 01W 34CCDD02 Barefoot Bay Well N	374417097251702	20060619	1105	40	5.05	<1	<1	<1	<1	47
27S 01W 03DABA01 Barefoot Bay Well SE	374350097243701	20060619	1455	40	7.18	<1	<1	<1	<1	E2
24S 01W 03ACCC01 Barefoot Bay Well SW	374351097250101	20060619	1040	42.5	9.87	<1	<1	<1	<1	49
26S 01W 28DDDD01 Ridgeport Well N	374509097253601	20060620	1300	17.5	7.68	<1	<1	<1	<1	8
26S 01W 34CCDD01 Ridgeport Well SE	374417097251701	20060620	945	17.5	5.23	<1	<1	<1	<1	170
26S 01W 34CCD 01 Ridgeport Well SW	374417097252501	20060620	945	19	8.23	<1	<1	<1	<1	13
26S 01W 24BBAA01 Moorings Well N	374653097230901	20060622	1210	46	14.73			<1	E8	70
26S 01W 24BBAA01 Moorings Well N	374653097230901	20060627	950	46	14.91	<1	<1			
26S 01W 25ADBA01 Moorings Well SE	374557097222801	20060622	955	47	12.49			<1	<1	74
26S 01W 25ADBA01 Moorings Well SE	374557097222801	20060627	1120	47	12.39	<1	<1			
26S 01W 25ADCC01 Moorings Well SW	374537097223401	20060622	940	47.5	12.85			<1	59	150
26S 01W 25ADCC01 Moorings Well SW	374537097223401	20060627	1240	47.5	12.69	<1	<1			
26S 01W 23BAAB01 Cropland Well N	374653097240401	20060621	950	46.5	11.67	<1	<1	<1	E4	E160
26S 01W 23AACD01 Cropland Well SE	374640097233501	20060621	1210	47.5	12.84	<1	<1	<1	<1	29
26S 01W 23BCAA01 Cropland Well SW	374640097241401	20060621	945	45.3	11.03	<1	<1	<1	<1	>800

Table 9. Data for pesticides and degradate compounds in surface-water samples collected from the sand pits. Only those pesticides and degradates are listed that were detected in at least one sample of surface or ground water, thus, the pesticide headings for this table and that for ground-water samples (Table 10) are the same. The letter E next to a value indicates estimated. The letter M in a cell indicates that the pesticide presence was verified but not quantified. Blank cells indicate that the sample was not analyzed for the pesticide. Columns for pesticides with dashes indicate that the pesticide was not detected in any surface-water sample but was detected in at least one ground-water sample.

Station name	Station number	Date	Time	SType	Reservoir depth feet P72025	Depth to sample location feet P81903	Lake elevation NAVD feet P62615	Triazine screen, water, filtered, ELISA, µg/L as atrazine P34756
27S 01W 03ADDC Barefoot Bay Pit	374303097243900	20060426	1010	9	23	19	1320.43	0.4
27S 01W 03ADDC Barefoot Bay Pit	374303097243900	20060511	950	9	23	21	1320.98	0.4
27S 01W 03ADDC Barefoot Bay Pit	374303097243900	20060606	1345	9	23	19	1321.01	0.3
27S 01W 03ADDC Barefoot Bay Pit	374303097243900	20060606	1355	7	23	19	1321.01	0.3
26S 01W 34CCD Ridgeport Pit	374432097252100	20060427	1015	9	7	3	1322.5	0.1
26S 01W 34CCD Ridgeport Pit	374432097252100	20060509	1010	9	6	3	1322.85	0.2
26S 01W 34CCD Ridgeport Pit	374432097252100	20060509	1012	7			1322.85	0.1
26S 01W 34CCD Ridgeport Pit	374432097252100	20060607	1410	9	6	3	1322.25	0.1
26S 01W 24DBCB Moorings Pit	374610097225200	20060427	1155	9	30	25	1321.1	0.6
26S 01W 24DBCB Moorings Pit	374610097225200	20060511	1130	9	27	20	1321.3	0.7
26S 01W 24DBCB Moorings Pit	374610097225200	20060607	1025	9	26	23	1320.85	0.5
26S 01W 24DBCB Moorings Pit	374610097225200	20060607	1040	7	26	23	1320.85	0.4
26S 01W 23ABCB Cropland Pit	374644097240800	20060426	1220	9	18	13	1327.32	<.1
26S 01W 23ABCB Cropland Pit	374644097240800	20060509	1135	9	26	21	1327.4	<.1
26S 01W 23ABCB Cropland Pit	374644097240800	20060606	1045	9	20	19	1327.06	0.1

Table 9. (continued) Data for pesticides and degradate compounds in surface-water samples collected from the sand pits.

Station name	Date	Depth to sample location feet P81903	Atrazine, water, filtered, µg/L P39632	Deethyl-atrazine, water, filtered, µg/L P04040	Hydroxy-atrazine, water, filtered, µg/L P50355	Deiso-propyl s-triazine, water, filtered, µg/L P04038	Metola-chlor, water, filtered, µg/L P39415	Simazine, water, filtered, µg/L P04035	Desulfinyl fipronil, water, filtered, µg/L P62170	Diuron, water, filtered, µg/L P49300	Hexa-zinone, water, filtered, µg/L P04025	Prometon, water, filtered, µg/L P04037
Barefoot Bay Pit	20060426	19										
Barefoot Bay Pit	20060511	21										
Barefoot Bay Pit	20060606	19	0.234	E.049	0.075	<.08	0.025	0.028	E.004	0.02	0.029	0.01
Barefoot Bay Pit	20060606	19										
Ridgeport Pit	20060427	3										
Ridgeport Pit	20060509	3										
Ridgeport Pit	20060509											
Ridgeport Pit	20060607	3	0.094	E.027	0.032	E.03	0.028	0.015	E.005	<.02	E.022	E.01
Moorings Pit	20060427	25										
Moorings Pit	20060511	20										
Moorings Pit	20060607	23	0.467	E.054	0.131	<.08	0.036	0.012	E.005	<.02	E.009	0.02
Moorings Pit	20060607	23	0.456	E.053	0.131	<.08	0.035	0.012	E.005	<.02	E.009	0.02
Cropland Pit	20060426	13										
Cropland Pit	20060509	21										
Cropland Pit	20060606	19	0.038	E.014	E.006	<.08	0.019	0.008	<.012	<.02	<.026	<.01

Table 9. (continued) Data for pesticides and degradate compounds in surface-water samples collected from the sand pits.

Station name	Date	Depth to sample location feet P81903	2,4-D methyl ester, water, filtered, µg/L P50470	2,4-D, water, filtered, µg/L P39732	Aceto-chlor, water, filtered, µg/L P49260	Alachlor, water, filtered, µg/L P46342	Benomyl, water, filtered, µg/L P50300	Desulfinyl fipronil amide, water, filtered, µg/L P62169	Myclo-butanil, water, filtered, µg/L P61599	Siduron, water, filtered, µg/L P38548	Carbon disulfide, water, unfiltered, µg/L P77041	3,4-Di-chloro-aniline, water, filtered, µg/L P61625
Barefoot Bay Pit	20060426	19										-
Barefoot Bay Pit	20060511	21										-
Barefoot Bay Pit	20060606	19	<.190	0.08	E.015	E.007	E.004	<.029	E.009	<.02	<.10	-
Barefoot Bay Pit	20060606	19										-
Ridgeport Pit	20060427	3										-
Ridgeport Pit	20060509	3										-
Ridgeport Pit	20060509											-
Ridgeport Pit	20060607	3	<.190	0.38	<.015	0.009	E.003	E.005	<.033	<.02	<.10	-
Moorings Pit	20060427	25										-
Moorings Pit	20060511	20										-
Moorings Pit	20060607	23	E.065	0.9	<.019	<.005	E.004	<.029	<.033	M	0.36	-
Moorings Pit	20060607	23	E.064	0.95	<.018	<.005	<.022	<.029	<.033	M	0.14	-
Cropland Pit	20060426	13										-
Cropland Pit	20060509	21										-
Cropland Pit	20060606	19	<.190	<.04	<.006	0.009	<.022	<.029	<.033	<.02	<.10	-

Table 10. Data for pesticides and degradate compounds in ground-water samples collected from monitoring wells near the sand pits. Only those pesticides and degradates are listed that were detected in at least one sample of surface or ground water, thus, the pesticide headings for this table and that for surface-water samples (Table 9) are the same. The letter E next to a value indicates estimated. The letter M in a cell indicates that the pesticide presence was verified but not quantified. Blank cells indicate that the sample was not analyzed for the pesticide. Columns for pesticides with dashes indicate that the pesticide was not detected in any ground-water sample but was detected in at least one surface-water sample.

Station name	Station number	Date	Time	SType	Depth of well, feet below LSD P72008	Depth to water level, feet below LSD P72019	Altitude of land surface feet P72000	Ground water level above NAVD, ft P62611	Lake elevation NAVD feet P62615	Triazine screen, water, filtered, ELISA, µg/L as atrazine P34756
26S 01W 34CCDD02 Barefoot Bay Well N	374417097251702	20060619	1055	9	40	5.05	1327	1321.35	1320.89	<.1
26S 01W 34CCDD02 Barefoot Bay Well N	374417097251702	20060619	1105	7	40	5.05	1327	1321.35	1320.89	<.1
27S 01W 03DABA01 Barefoot Bay Well SE	374350097243701	20060619	1455	9	40	7.18	1325	1317.92	1320.89	0.4
24S 01W 03ACCC01 Barefoot Bay Well SW	374351097250101	20060619	1040	9	42.5	9.87	1330	1319.83	1320.89	0.3
26S 01W 28DDDD01 Ridgeport Well N	374509097253601	20060620	1300	9	17.5	7.68	1333	1325.62	1322.38	<.1
26S 01W 34CCDD01 Ridgeport Well SE	374417097251701	20060620	945	9	17.5	5.23	1327	1321.37	1322.38	0.1
26S 01W 34CCD 01 Ridgeport Well SW	374417097252501	20060620	945	9	19	8.23	1330	1321.77	1322.38	<.1
26S 01W 24BBAA01 Moorings Well N	374653097230901	20060622	1210	9	46	14.73	1338	1322.87	1320.71	0.2
26S 01W 25ADBA01 Moorings Well SE	374557097222801	20060622	955	9	47	12.49	1331	1318.61	1320.71	0.4
26S 01W 25ADCC01 Moorings Well SW	374537097223401	20060622	940	9	47.5	12.85	1331	1318.05	1320.71	0.4
26S 01W 23BAAB01 Cropland Well N	374653097240401	20060621	950	9	46.5	11.67	1339	1327.23	1326.84	<.1
26S 01W 23AACD01 Cropland Well SE	374640097233501	20060621	1210	9	47.5	12.84	1338	1325.06	1326.84	<.1
26S 01W 23BCAA01 Cropland Well SW	374640097241401	20060621	945	9	45.3	11.03	1337	1326.17	1326.84	<.1

Table 10. (continued) Data for pesticides and degradate compounds in ground-water samples collected from monitoring wells near the sand pits.

Station name	Date	Atrazine, water, filtered, µg/L P39632	Deethyl-atrazine, water, filtered, µg/L P04040	Hydroxy-atrazine, water, filtered, µg/L P50355	Deiso-propyl s-triazine, water, filtered, µg/L P04038	Metola-chlor, water, filtered, µg/L P39415	Simazine, water, filtered, µg/L P04035	Desulfinyl fipronil, water, filtered, µg/L P62170	Diuron, water, filtered, µg/L P49300	Hexa-zinone, water, filtered, µg/L P04025	Prometon, water, filtered, µg/L P04037
Barefoot Bay Well N	20060619	0.031	E.011	E.011	-	E.006	0.01	<.012	0.03	0.031	E.01
Barefoot Bay Well N	20060619	0.029	E.009	E.011	-	E.006	0.009	<.012	0.03	0.028	E.01
Barefoot Bay Well SE	20060619	0.207	E.046	0.091	-	0.011	0.022	<.012	0.02	0.026	0.01
Barefoot Bay Well SW	20060619	0.203	E.043	0.07	-	0.011	0.018	<.012	0.02	0.027	0.01
Ridgeport Well N	20060620	E.006	E.005	E.003	-	0.009	<.005	<.012	<.02	E.010	<.01
Ridgeport Well SE	20060620	0.069	E.017	0.084	-	0.011	0.009	E.005	0.02	E.022	E.01
Ridgeport Well SW	20060620	E.008	E.007	E.012	-	<.006	<.005	<.012	<.02	E.011	<.01
Moorings Well N	20060622	0.144	E.017	E.026	-	0.02	E.007	<.012	<.02	<.026	0.02
Moorings Well SE	20060622	0.301	E.043	0.104	-	0.013	E.007	E.004	<.02	<.026	0.01
Moorings Well SW	20060622	0.255	E.033	0.081	-	0.008	E.006	<.012	<.02	<.026	0.01
Cropland Well N	20060621	0.015	E.013	<.032	-	<.006	<.005	<.012	<.02	<.026	<.01
Cropland Well SE	20060621	0.013	E.007	E.008	-	<.006	E.004	<.012	<.02	<.026	<.01
Cropland Well SW	20060621	0.015	E.007	<.032	-	E.006	<.005	<.012	<.02	<.026	<.01

Table 10. (continued) Data for pesticides and degradate compounds in ground-water samples collected from monitoring wells near the sand pits.

Station name	Date	2,4-D methyl ester, water, filtered, µg/L P50470	2,4-D, water, filtered, µg/L P39732	Aceto-chlor, water, filtered, µg/L P49260	Alachlor, water, filtered, µg/L P46342	Benomyl, water, filtered, µg/L P50300	Desulfinyl fipronil amide, water, filtered, µg/L P62169	Myclo-butanil, water, filtered, µg/L P61599	Siduron, water, filtered, µg/L P38548	Carbon disulfide, water, unfiltered, µg/L P77041	3,4-Di-chloro-aniline, water, filtered, µg/L P61625
Barefoot Bay Well N	20060619	-	-	-	-	-	-	-	-	-	<.004
Barefoot Bay Well N	20060619	-	-	-	-	-	-	-	-	-	<.004
Barefoot Bay Well SE	20060619	-	-	-	-	-	-	-	-	-	E.007
Barefoot Bay Well SW	20060619	-	-	-	-	-	-	-	-	-	E.004
Ridgeport Well N	20060620	-	-	-	-	-	-	-	-	-	<.004
Ridgeport Well SE	20060620	-	-	-	-	-	-	-	-	-	E.009
Ridgeport Well SW	20060620	-	-	-	-	-	-	-	-	-	<.004
Moorings Well N	20060622	-	-	-	-	-	-	-	-	-	<.004
Moorings Well SE	20060622	-	-	-	-	-	-	-	-	-	<.004
Moorings Well SW	20060622	-	-	-	-	-	-	-	-	-	<.004
Cropland Well N	20060621	-	-	-	-	-	-	-	-	-	<.004
Cropland Well SE	20060621	-	-	-	-	-	-	-	-	-	<.004
Cropland Well SW	20060621	-	-	-	-	-	-	-	-	-	<.004

Table 11. Data for organic compounds other than pesticides in surface-water samples collected from the sand pits. Only those organic compounds are listed that were detected in at least one sample of surface or ground water, thus, the compound headings for this table and those for ground-water samples (Table 12) are the same. The letter E next to a value indicates estimated. The letter M in a cell indicates that the compound presence was verified but not quantified. Blank cells indicate that the sample was not analyzed for the compound. Columns for compounds with dashes indicate that the compound was not detected in any surface-water sample but was detected in at least one ground-water sample.

Station name	Station number	Date	Time	SType	Reservoir depth feet P72025	Depth to sample location feet P81903	Lake elevation NAVD feet P62615	Isophorone, water, unfiltered, µg/L P34408
27S 01W 03ADDC Barefoot Bay Pit	374303097243900	20060606	1350	9	23	19	1321.01	M
26S 01W 34CCD Ridgeport Pit	374432097252100	20060607	1415	9	6	3	1322.25	M
26S 01W 24DBCB Moorings Pit	374610097225200	20060607	1030	9	26	23	1320.85	M
26S 01W 24DBCB Moorings Pit	374610097225200	20060607	1045	7	26	23	1320.85	M
26S 01W 23ABCB Cropland Pit	374644097240800	20060606	1050	9	20	19	1327.06	M

Table 11. (continued) Data for organic compounds other than pesticides in surface-water samples collected from the sand pits.

Station name	Date	2,4-Dimethyl-phenol, water, unfiltered, µg/L P34606	2-Nitro-phenol, water, unfiltered, µg/L P34591	Penta-chloro-phenol, water, unfiltered, µg/L P39032	2,4-Di-chloro-phenol, water, unfiltered, µg/L P34601	2-Chloro-phenol, water, unfiltered, µg/L P34586	4-Chloro-2-methyl-phenol, water, filtered, µg/L P61633	Fluor-anthene, water, unfiltered, µg/L P34376	Phenol, water, unfiltered, µg/L P34694	Pyrene, water, unfiltered, µg/L P34469
Barefoot Bay Pit	20060606	M	M	<.87	-	-	-	-	-	-
Ridgeport Pit	20060607	M	<.30	<.87	-	-	-	-	-	-
Moorings Pit	20060607	<.4	<.30	<.87	-	-	-	-	-	-
Moorings Pit	20060607	<.4	<.30	M	-	-	-	-	-	-
Cropland Pit	20060606	<.4	<.30	<.87	-	-	-	-	-	-

Table 12. Data for organic compounds other than pesticides in ground-water samples collected from wells near the sand pits. Only those organic compounds are listed that were detected in at least one sample of surface or ground water, thus, the compound headings for this table and those for surface-water samples (Table 11) are the same. The letter E next to a value indicates estimated. The letter M in a cell indicates that the compound presence was verified but not quantified. Blank cells indicate that the sample was not analyzed for the compound. Columns for compounds with dashes indicate that the compound was not detected in any ground-water sample but was detected in at least one surface-water sample.

Station name	Station number	Date	Time	SType	Depth of well, feet below LSD P72008	Depth to water level, feet below LSD P72019	Altitude of land surface feet P72000	Ground water level above NAVD, ft P62611	Lake elevation NAVD feet P62615	Isophorone, water, unfiltered, µg/L P34408
26S 01W 34CCDD02 Barefoot Bay Well N	374417097251702	20060619	1055	9	40	5.05	1327	1321.35	1320.89	
26S 01W 34CCDD02 Barefoot Bay Well N	374417097251702	20060619	1105	7	40	5.05	1327	1321.35	1320.89	
26S 01W 34CCDD02 Barefoot Bay Well N	374417097251702	20060710	1055	9	40	5.42	1327	1321.09	1320.64	M
26S 01W 34CCDD02 Barefoot Bay Well N	374417097251702	20060710	1100	7	40	5.42	1327	1321.09	1320.64	<.60
27S 01W 03DABA01 Barefoot Bay Well SE	374350097243701	20060619	1455	9	40	7.18	1325	1317.92	1320.89	
27S 01W 03DABA01 Barefoot Bay Well SE	374350097243701	20060710	1105	9	40	7.33	1325	1317.73	1320.64	<.60
24S 01W 03ACCC01 Barefoot Bay Well SW	374351097250101	20060619	1040	9	42.5	9.87	1330	1319.83	1320.89	
24S 01W 03ACCC01 Barefoot Bay Well SW	374351097250101	20060710	1225	9	42.5	10.19	1330	1319.53	1320.64	M
26S 01W 28DDDD01 Ridgeport Well N	374509097253601	20060620	1300	9	17.5	7.68	1333	1325.62	1322.38	
26S 01W 28DDDD01 Ridgeport Well N	374509097253601	20060710	1220	9	17.5	7.77	1333	1325.54	1322.25	<.60
26S 01W 34CCDD01 Ridgeport Well SE	374417097251701	20060620	945	9	17.5	5.23	1327	1321.37	1322.38	
26S 01W 34CCDD01 Ridgeport Well SE	374417097251701	20060710	950	9	17.5	5.56	1327	1321.06	1322.25	M
26S 01W 34CCD 01 Ridgeport Well SW	374417097252501	20060620	945	9	19	8.23	1330	1321.77	1322.38	
26S 01W 34CCD 01 Ridgeport Well SW	374417097252501	20060710	950	9	19	8.55	1330	1321.43	1322.25	<.60
26S 01W 24BBAA01 Moorings Well N	374653097230901	20060622	1210	9	46	14.73	1338	1322.87	1320.71	
26S 01W 24BBAA01 Moorings Well N	374653097230901	20060712	940	9	46	15.22	1338	1322.37	1322.09	<.60
26S 01W 25ADBA01 Moorings Well SE	374557097222801	20060622	955	9	47	12.49	1331	1318.61	1320.71	
26S 01W 25ADBA01 Moorings Well SE	374557097222801	20060712	1100	9	47	12.24	1331	1318.86	1322.09	M
26S 01W 25ADCC01 Moorings Well SW	374537097223401	20060622	940	9	47.5	12.85	1331	1318.05	1320.71	
26S 01W 25ADCC01 Moorings Well SW	374537097223401	20060712	1210	9	47.5	12.96	1331	1317.91	1322.09	<.60
26S 01W 23BAAB01 Cropland Well N	374653097240401	20060621	950	9	46.5	11.67	1339	1327.23	1326.84	
26S 01W 23BAAB01 Cropland Well N	374653097240401	20060711	1140	9	46.5	11.83	1339	1327.03	1326.66	<.60
26S 01W 23AACD01 Cropland Well SE	374640097233501	20060621	1210	9	47.5	12.84	1338	1325.06	1326.84	
26S 01W 23AACD01 Cropland Well SE	374640097233501	20060711	1015	9	47.5	13.03	1338	1324.91	1326.66	<.60
26S 01W 23BCAA01 Cropland Well SW	374640097241401	20060621	945	9	45.3	11.03	1337	1326.17	1326.84	
26S 01W 23BCAA01 Cropland Well SW	374640097241401	20060711	1305	9	45.3	11.07	1337	1326.13	1326.66	<.60

Table 12. (continued) Data for organic compounds other than pesticides in ground-water samples collected from wells near the sand pits.

Station name	Date	2,4-Di-methyl-phenol, water, unfiltered, µg/L P34606	2-Nitro-phenol, water, unfiltered, µg/L P34591	Penta-chloro-phenol, water, unfiltered, µg/L P39032	2,4-Di-chloro-phenol, water, unfiltered, µg/L P34601	2-Chloro-phenol, water, unfiltered, µg/L P34586	4-Chloro-2-methyl-phenol, water, filtered, µg/L P61633	Fluor-anthene, water, unfiltered, µg/L P34376	Phenol, water, unfiltered, µg/L P34694	Pyrene, water, unfiltered, µg/L P34469
Barefoot Bay Well N	20060619	-	-	-			<.005			
Barefoot Bay Well N	20060619	-	-	-			<.005			
Barefoot Bay Well N	20060710	-	-	-	<.39	<.42		<.30	<.4	<.35
Barefoot Bay Well N	20060710	-	-	-	<.39	<.42		<.30	<.4	<.35
Barefoot Bay Well SE	20060619	-	-	-			<.005			
Barefoot Bay Well SE	20060710	-	-	-	<.39	<.42		<.30	<.4	<.35
Barefoot Bay Well SW	20060619	-	-	-			<.005			
Barefoot Bay Well SW	20060710	-	-	-	<.39	<.42		<.30	<.4	<.35
Ridgeport Well N	20060620	-	-	-			<.005			
Ridgeport Well N	20060710	-	-	-	<.39	<.42		<.30	<.4	<.35
Ridgeport Well SE	20060620	-	-	-			E.006			
Ridgeport Well SE	20060710	-	-	-	M	<.42		<.30	<.4	<.35
Ridgeport Well SW	20060620	-	-	-			<.005			
Ridgeport Well SW	20060710	-	-	-	M	<.42		<.30	<.4	<.35
Moorings Well N	20060622	-	-	-			<.005			
Moorings Well N	20060712	-	-	-	<.39	<.42		<.30	<.4	<.35
Moorings Well SE	20060622	-	-	-			<.005			
Moorings Well SE	20060712	-	-	-	<.39	<.42		M	<.4	M
Moorings Well SW	20060622	-	-	-			<.005			
Moorings Well SW	20060712	-	-	-	<.39	<.42		<.30	<.4	<.35
Cropland Well N	20060621	-	-	-			<.005			
Cropland Well N	20060711	-	-	-	<.39	M		<.30	15.2	<.35
Cropland Well SE	20060621	-	-	-			<.005			
Cropland Well SE	20060711	-	-	-	<.39	<.42		<.30	<.4	<.35
Cropland Well SW	20060621	-	-	-			<.005			
Cropland Well SW	20060711	-	-	-	<.39	<.42		<.30	<.4	<.35

Table 13. Physical and chemical properties of the sediment samples collected from the sand pits and the organic compounds detected in the samples. The letter M in a cell indicates that the compound presence was verified but not quantified.

Station name	Station number	Date	Time	Bed sediment, dry sieved, % <0.063 mm P80164	Bed sediment, dry sieved, % <2 mm P80169	Carbon, inorganic plus organic, sediment <62.5 µm, wet seived, dry wt, % P49267	Inorganic carbon, sediment <62.5 µm, wet seived, dry wt, % P49269	Organic carbon, sediment <62.5 µm, wet seived, dry wt, % P49266	Total nitrogen, sediment total, dry wt, mg/kg P00603	cis-Chlordane, sediment <2 mm, wet seived, dry wt, µg/kg P49320	trans-Chlordane, sediment <2 mm, wet seived, dry wt, µg/kg P49321	trans-Nonachlor, sediment <2 mm, wet seived, dry wt, µg/kg P49317
27S 01W 03ADDC Barefoot Bay Pit	374303097243900	20060427	1700	44	100	3.4	1.5	1.9	1200	M	M	M
27S 01W 03ADDC Barefoot Bay Pit	374303097243900	20060427	1705	44	100	3.5	1.5	1.9	1200	M	M	M
26S 01W 34CCD Ridgeport Pit	374432097252100	20060427	1500	40	100	4.8	2.7	2.1	1400	<1	<1	<1
26S 01W 24DBCB Moorings Pit	374610097225200	20060427	1300	72	100	5.9	2.8	3.1	3100	<3	<3	<3
26S 01W 23ABCB Cropland Pit	374644097240800	20060428	900	94	100	1.5	0.72	0.78	720	<1	<1	<1

Chemical Properties and Inorganic Constituents

The data for chemical properties (including radioactivity) and inorganic constituents for which there are drinking water standards are listed, along with oxidation-reduction potential and organic carbon and ammonia contents, for the surface- and ground-water samples in Tables 5 and 6, respectively. Table 14 summarizes the highest concentrations of inorganic constituents and the highest radioactivity measured in the surface and ground waters, along with maximum contaminant levels (MCL) and secondary maximum contaminant levels (SMCL). The MCL is the highest level of a constituent that is allowed in drinking water according to public water supply regulations. The SMCL is a recommended level that is not regulated.

The pH ranges for the surface and ground waters were 7.5-8.7 and 6.8-7.5, respectively (Tables 5 and 6). Both of these ranges are typical for surface and ground waters in Kansas. The ground waters have lower pH values than the surface waters due to the generation of carbon dioxide from organic matter decomposition in the subsurface. The carbon dioxide dissolves and forms carbonic acid that equilibrates with the water primarily as bicarbonate ion within the near neutral pH range of the waters. The surface waters have higher pH because carbon dioxide generated from organic matter oxidation is lost to the atmosphere during the process of equilibrating with the partial pressure of the gas in the atmosphere. The national secondary drinking water standard (recommended but not mandatory value) for pH is that the water should have a value within the range 6.5-8.5. The highest value of 8.7 observed in one of the pits is only slightly higher than 8.5 and not unusual for a surface water in Kansas.

The total dissolved solids (TDS) concentration of all the surface and ground waters exceeds the SMCL of 500 mg/L (Tables 5 and 6). Water in the Arkansas River between the confluence with Rattlesnake Creek (upstream of Hutchinson) and Wichita is saline. The salinity source is primarily natural based on geochemical studies by the KGS (see for example, Whittemore [2003]). Saltwater derived from the dissolution of rock salt (halite, NaCl) in the Permian bedrock underlying the eastern part of the Great Bend Prairie and the western part of the Equus Beds intrudes into the overlying High Plains aquifer and discharges into Rattlesnake and other creeks and the Arkansas River. Stream-aquifer interactions in the area between Wichita and Hutchinson cause saline Arkansas River water to increase the salinity of ground water in the alluvial aquifer adjacent to the river. Upward movement of deeper saline water also increases the TDS of shallow ground water in the alluvial aquifer. Pumping of ground water from large capacity wells, such as for irrigation and the City of Wichita water supply, increase the distance that saline water in the alluvial aquifer travels in the subsurface outward from the Arkansas River. Surface water and shallow ground water in the area, especially in the Big Slough watershed, is also affected by evapotranspiration concentration whereby water is lost to the atmosphere leaving residual salts dissolved in a smaller amount of water. Thus, the high TDS contents of the pit and monitoring well waters of the four study sites discussed in this report are expected for the area. The Moorings pit site is the closest and the Cropland site the next closest to the Arkansas River of the four study sites. The TDS concentrations at the Moorings site are generally the highest of the four sites and those at the Cropland site the next highest, in keeping with proximity to the Arkansas River as the main control on dissolved solids content.

Table 14. Information summary for inorganic compounds and radioactivity for which there are drinking-water standards in surface and ground waters of the sand-pit study sites. Values in parentheses are Kansas surface water criteria (which also address ground water in alluvial aquifers under a recharge provision) if different from U.S. EPA standards (U.S. EPA, 2006).

Chemical property or constituent concentration	Highest concentration detected in pit or well water, mg/L	Highest concentration detected in pit or well water, µg/L	Drinking water MCL, mg/L	Drinking water secondary standard, mg/L	Drinking water MCL, µg/L	Drinking water secondary standard, µg/L
TDS, evaporation residue	1,210			500		
Chloride	462			250		
Fluoride	0.7		4	2		
Sulfate	237			250		
Ammonia as N	1.21					
Nitrite & nitrate, as N	2.82		10			
Nitrate, as N	0.156		10			
Alluminum		3				50-200
Antimony		0.35			6	
Arsenic		10			10	
Barium		202			2000 (1,000)	
Beryllium		E 0.04			4	
Cadmium		0.56			5	
Chromium (total)		0.19			100	
Copper		4.8			1300*	
Cyanide (as free CN)		M			200	
Iron		519				300
Lead		0.21			15*	
Manganese		908				50
Mercury (inorganic)		0.02			2	
Nickel		5.59			(610)	
Selenium		7.1			50 (170)	
Silver		0.2				100 (50)
Uranium		18.4			30	
Zinc		4.9				5000 (7,400)
Radioactivity		pCi/L			Drinking water MCL	
Gross alpha radioactivity		6.5			15 pCi/L	
Gross beta radioactivity		9.1			4 mrem/yr#	

* Action level (violation if >10 % of values exceed level)
# Kansas surface water criterion is 50 pCi/L

The TDS values for the surface and ground waters at each site were generally within about 100 mg/L or less. However, the TDS content of the southwest monitoring well at the Ridge Port site on June 20, 2006 (535 mg/L), was substantially less than that of the pit water on June 7, 2006 (890 mg/L). The wells at the Ridge Port site are the shallowest of any of the sites. A possible explanation for the fresher water could be local recharge of precipitation or runoff that had not yet mixed sufficiently with the deeper ground water to give the general range of TDS usual for the area. The depth to water on the date of sampling of the well was 8.2 ft, whereas the depth of the well is 19 ft. Thus, the top of the screened interval was only 1.2 ft below the top of the water table. The heterogeneity of the sediments at this site might result in more water being drawn in from the shallowest part of the screened interval during pumping, thereby reflecting water near the water table.

The saline water in the Arkansas River and adjacent alluvial aquifer is sodium-chloride in chemical type. Therefore, the chloride concentration in nearly all of the pit and well waters is relatively high and exceeds the SMCL of 250 mg/L for drinking water (Tables 5 and 6). The two water samples with less than 250 mg/L dissolved chloride were from the north and southwest wells at the Ridge Port site, again suggesting some effect of shallow ground-water recharge that had not fully mixed with the deeper water in the alluvial aquifer.

The saltwater in the Permian bedrock that is the primary source of dissolved solids in the Arkansas River water and the adjacent alluvial aquifer contains high concentrations of sulfate because gypsum ($CaSO_4 \cdot 2H_2O$) and anhydrite ($CaSO_4$) are associated with the salt deposits that dissolve to produce the saltwater. Therefore, some of the dissolved sulfate in the pit and well waters is expected to come from Arkansas River water. The sulfate concentrations in the pit and well waters are not as well correlated with TDS content as is the chloride concentration (Tables 5 and 6). Some sulfate is probably derived more locally from the surface or from interaction with underlying bedrock from which rock salt has been completely dissolved but that still includes some gypsum or anhydrite that is still dissolving. Sulfate concentration is greater than chloride content in the shallow ground water yielded by the north and southwest wells at the Ridge Port site in comparison with chloride exceeding sulfate in all of the other site wells and the pit surface waters. None of the sulfate concentrations exceeds the SMCL of 250 mg/L for drinking water.

All of the highest concentrations of minor inorganic and trace metal constituents observed in the pit and well waters, as well as radioactivity, listed in Tables 5 and 6 and for which there are MCLs are substantially lower than their respective drinking water standards. Concentrations for two of the inorganic constituents (dissolved iron and manganese) for which there are SMCLs for drinking water exceed their respective standards in some of the pit and well waters. The SMCLs for iron and manganese, 0.3 and 0.05 mg/L (300 and 50 µg/L), respectively, were established to prevent problems such as staining of plumbing and clothing, undesirable water taste, scaling in pipes, and deterioration of water-softener exchange media. For dissolved iron and manganese to exceed the SMCLs, either the oxidation-reduction potential or the pH must be low, or both must be somewhat low. The pH values for the sand pit and well waters are in the near neutral to slightly alkaline range. For this pH range, the oxidation-reduction potential must therefore be low for high dissolved iron and manganese concentrations to occur. The dissolved iron and manganese in this condition exists primarily as the ferrous (Fe^{2+}) and manganous (Mn^{2+}) species.

The dissolved manganese concentration slightly exceeded 50 µg/L in the May 2006 sample for the Cropland pit and substantially exceeded this level in the two June 2006 samples for the Moorings pit (Table 5). The dissolved iron for the two June samples from the Moorings pit did not exceed 300 µg/L but were the highest of all the pit water samples. The oxidation-reduction potential for the two June samples from the Moorings pit was substantially lower than for all of the other pit waters. The depth of the Moorings pit is the greatest of all of the pits. The low oxidation potential indicates that the pit water became stratified during the early summer. This decreased the amount of dissolved oxygen that could reach the deeper water. Oxidation of the dissolved organic matter present in the deeper water consumed most of the available dissolved oxygen, resulting in the low oxidation potential. Some of the iron and manganese oxyhydroxides present in suspended and bottom sediment then were dissolved as the metals were reduced from the oxidized to the reduced state. Additional evidence for the oxygen deficient bottom layer in the pit is the substantially greater ammonium ion (NH_4^+) concentration (listed as ammonia in Table 5) in the two June samples from the Moorings pit. Nitrogen in dissolved nitrate and nitrate was reduced and also released during the oxidation of the dissolved organic matter to produce the ammonium ion.

Dissolved iron exceeded the SMCL of 300 µg/L in one of the monitoring well waters, and dissolved manganese exceeded the SMCL of 50 µg/L in all but two of the well waters (Table 6). Ammonia was measurable in water samples from nine of the 12 wells. This indicates that a mildly reducing environment existed in many locations of the alluvial aquifer of the study sites, a condition that is not unusual for such aquifers in Kansas due to the presence of dissolved organic matter in recharge as well as solid organic matter in the fine-grained alluvial sediments. The dissolved iron concentration was highest (out of the three wells at each site) in the southeast well at the Barefoot Bay, Ridge Port, and Cropland pit sites. The dissolved manganese content was also greatest in the southeast well at the Barefoot Bay and Cropland sites, highest in the southwest well at the Ridge Port site, and largest at the north well at the Moorings site. The ammonia content of the upgradient north well at the Ridge Port, Moorings, and Cropland sites was substantially lower than that for the downgradient wells at these sites. The generally greater concentrations of iron, manganese, and ammonium ion in the ground waters at the downgradient wells, and the higher concentration of organic matter in the pit than the well samples, suggests that runoff with dissolved organic matter that entered the pits and flowed in the subsurface to the well locations explains part of the reducing condition.

Bacteriological Analysis

The MCL for bacteria in public drinking water supplies in Kansas is "based on the presence or absence of total coliforms in a sample, rather than coliform density" (Code of Federal Regulations, Chapter 40, Section 141.63 as adopted by KDHE). This section states "For a system which collects at least 40 samples per month, if no more than 5.0 percent of the samples collected during a month are total coliform-positive, the system is in compliance with the MCL for total coliforms. For a system which collects fewer than 40 samples/month, if no more than one sample collected during a month is total coliform-positive, the system is in compliance with the MCL for total coliforms. Any fecal coliform-positive repeat sample or *E. coli*-positive repeat sample, or any total coliform-positive repeat sample following a fecal coliform-positive or *E. coli*-positive routine sample constitutes a violation of the MCL for total coliforms."

The KDHE also has water-quality standards for surface waters used for recreation. Tables 1i and 1j in the Kansas Surface Water Quality Standards, Tables of Numeric Criteria (available from the KDHE at http://www.kdheks.gov/water/download/swqs_numeric_criteria.pdf) list standards for E. coli bacteria for classified stream segments and classified surface waters other than classified stream segments, respectively. The criteria for class B (public access open to and accessible by law or written permission of the landowner) of primary contact recreation for classified stream segments are geometric means of 262 E. coli colony forming units per 100 mL (CFU/100 mL) during the recreation season (April 1 to October 31) and 2,358 CFU/100 mL during the non-recreation season (November 1 to March 31). The criteria for public access to primary contact recreation in classified surface waters other than classified stream segments are a geometric mean of 262 E. coli CFU/100 mL and a single sample maximum of 1,198 CFU/100 mL for the recreation season. For restricted access during the recreation season, the criteria are a geometric mean of 427 CFU/100 mL and a single sample maximum of 1,950 CFU/100 mL. The criteria for public and restricted access during the non-recreation season are substantially higher values than for the recreation season. The geometric mean calculation is for a minimum of five water samples, each collected on a different day within a 30-day period.

The surface waters in the Ridge Port and Barefoot Bay pits are considered as part of a classified stream segment because they include drainage from Big Slough, which is a classified stream segment in the stretch that is downstream of an NPDES (National Pollutant Discharge Elimination System) permitted discharge (City of Maize treated wastewater) (D. Carlson, personal communication). The KDHE online document for the TMDL (Total Maximum Daily Load) for fecal coliform bacteria in the Lower Arkansas River basin, Middle Arkansas-Slate subbasin, Cowskin Creek (http://www.kdheks.gov/tmdl/la/cowskinFCB.pdf) includes a map of the Big Slough watershed within the TMDL area along with information on the Maize NPDES discharge.

The USGS analyzed the surface- and ground-water samples from the pit sites for E. coli coliphage, E. coli (Escherichia coli), fecal coliform, and total coliform bacteria content (Tables 7 and 8). Coliphage are bacteriophage that infect E. coli. Although they are indicators for sewage, their detection does "not indicate that pathogenic viruses also will be detected in the water; rather, the coliphage detection is more an indication of the potential for the transport of other viruses into the subsurface" (USGS, 2006).

Coliphage were not detected in any of the surface- and ground-water samples analyzed for this parameter (Tables 7 and 8). E. coli was estimated or measured in all of the pit water samples but in none of the well water samples. The concentration of E. coli was particularly high in the May 2006 sample from the Ridge Port pit (310 CFU/100 mL). This value exceeded the geometric mean criterion of 262 CFU/100 mL for class B of primary contact recreation for the spring and summer period for a classified stream segment. However, at least four additional samples on different days during a 30-day period would have been needed to compute the geometric mean for determination of a regulatory exceedance. Fecal coliform bacteria were estimated or measured in all of the pit waters except the April 2006 sample from Barefoot Bay. The fecal coliform count was also high in the May 2006 sample from the Ridge Port pit. Fecal coliform bacteria were measurable in the sample from the southwest well at the Moorings pit and estimable for the samples from the north wells of the Moorings and Cropland pits. Total coliform bacteria counts were either estimated or measured at levels greater than 400 colonies per 100 mL in all of the pit samples except those collected from Barefoot Bay in June 2006. The highest total coliform count occurred in the same sample in which the high E. coli and fecal coliform bacteria were measured (May sample from the Ridge Port pit).

Fecal coliform bacteria were measurable or estimable in three of the well water samples (Moorings north and southwest wells, Cropland north well) (Table 8). Total coliform bacteria were present in all of the ground-water samples and ranged from an estimate of 2 colonies to >800 colonies per 100 mL. There is no pattern in the general distribution of coliform bacteria in the upgradient versus the downgradient wells. Therefore, the sediments in the alluvial aquifer appear to filter any high levels of bacteria in pit surface waters that enter the subsurface and flow to the downgradient wells. The coliform bacteria observed in the well waters are probably related mainly to the bacterial content of surface or drilling waters that entered the subsurface during well installation or of microbial communities present in the subsurface at the well locations.

Pesticide and Degradate Compounds

There are detections, estimates, or concentration values for 20 different pesticide or degradate compounds (out of the 118 compounds for which the USGS analyzed the samples) in at least one surface or ground water at the four pit sites (Tables 9 and 10). Table 15 lists the highest concentrations of the pesticide compounds detected in either the surface or ground waters at the four study sites along with water-quality standards related to humans. There were several more pesticide or degradate compounds detected in the surface-water than in the ground-water samples. In general, the concentrations of pesticides and degradates detected in ground waters were lower than for the same pesticides found in the surface waters.

The most commonly detected compounds were atrazine and two of its degradates, deethylatrazine and hydroxyatrazine, and metolachlor and simazine. Concentrations of all five of these compounds were measured or estimated in all of the pit water samples (Table 9). Atrazine concentrations ranged from 0.038 to 0.467 µg/L, which are all well below the drinking water MCL of 3 µg/L (Table 15). Concentrations of the atrazine degradates were lower than the atrazine content in each pit. In general, the greater the atrazine content, the higher the concentration of the degradates. The concentration range for metolachlor was 0.019-0.036 µg/L; the values were generally correlated with the atrazine contents of the samples. Metolachlor is a pesticide registered by the U.S. Environmental Protection Agency (EPA) and has a lifetime health advisory level of 700 µg/L but does not currently have a drinking water MCL. Simazine concentration ranged from 0.008 to 0.028 µg/L, substantially below the drinking water MCL of 4 µg/L, and was not as well correlated with atrazine content.

All of the other pesticide or degradate compounds detected, except for 2,4-D and carbon disulfide, had measured or estimated concentrations <0.2 µg/L (Table 9). The pesticide 2,4-D was detected in all the pit samples except that from the Cropland pit. The duplicate samples from the Moorings pit contained 0.9-0.95 µg/L 2,4-D and 0.14-0.36 µg/L carbon disulfide. The highest concentration of 2,4-D measured was substantially smaller than the drinking water MCL

Table 15. Information summary for pesticides measured or detected in surface waters, ground waters, and sediment of the sand-pit study sites. Values for MCL (maximum contaminant level), MCLG (maximum contaminant level goal), and lifetime health advisory are from U.S. EPA (2006). The lifetime health advisory is the concentration that is not expected to cause any adverse noncarcinogenic effects for a lifetime of exposure. The letter M in a cell indicates that the pesticide presence was verified but not quantified.

Pesticide compound	Highest concentration detected in pit or well water, µg/L	U.S. EPA drinking water MCL, µg/L	U.S. EPA drinking water MCLG, µg/L	U.S. EPA drinking water lifetime health advisory, µg/L	U.S. EPA registered pesticide	Notes	Use
Atrazine	0.467	3	3		yes		herbicide
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-s-triazine)	E 0.054					atrazine degradate	
Hydroxyatrazine (2-Hydroxyamino-6-ethylamino-s-triazine)	E 0.131					atrazine degradate	
Deisopropylatrazine (2-Chloro-6-ethylamino-4-amino-s-triazine)	E 0.03					atrazine degradate	
Metolachlor	0.036			700	yes		herbicide
Simazine	0.028	4	4		yes		herbicide
Desulfinyl fipronil	E 0.005					fipronil degradate	(fipronil - insecticide)
Diuron	0.03				yes		herbicide
Hexazinone	0.031			400	yes		herbicide
Prometon	0.02			100	yes		herbicide
2,4-D methyl ester	E 0.065				yes		
2,4-D (2,4-dichlorophenoxyacetic acid)	0.95	70	70	200	yes		herbicide
Acetochlor	E 0.015				yes		herbicide
Alachlor	0.009	2	zero		yes		herbicide
Benomyl	E 0.004				no		fungicide
Desulfinylfipronil amide	E 0.005					fipronil degradate	(fipronil - insecticide)
Myclobutanil	E 0.009				yes		fungicide
Siduron	M				yes		herbicide
Carbon disulfide	0.36				no	on CERCLA hazardous list	fumigant; nematicide; solvent
3,4-Dichloroaniline (1-amino-3,4-dichlorobenzene)	E 0.009						used to make other chemicals
cis-Chlordane, trans-chlordane	M*	2	zero		yes		insecticide
trans-Nonachlor	M*					constituent of commercial chlordane	insecticide

* In sediment as µg/kg

of 70 µg/L for that compound (Table 15). There is one additional pesticide that was detected for which a drinking water MCL exists: alachlor. Alachlor was detected in all of the surface-water samples except those from the Moorings pit. The greatest alachlor content observed was 0.009 µg/L, which is more than two orders of magnitude less than the MCL of 2 µg/L. The EPA maximum contaminant level goal for alachlor is zero.

Fewer pesticide compounds were detected in the surface-water sample from the Cropland pit than in the samples from the other pits, and, expect for alachlor, the concentrations of those measured were all less than for the other pits (Table 9). Only atrazine (and its two common degradates), metolachlor, simazine, and alachlor were detected in the Cropland pit sample. The other three pit samples contained six to eight detectable pesticides or degradates in addition to those detected in the Cropland pit.

The pesticides in the highest concentrations and present in all the pit water samples (atrazine, metolachlor, and simazine) are herbicides usually used for weed control for agricultural crops. However, they are also sometimes used for control of weeds along roads and in selected lawn grasses. For example, a Kansas State University (KSU) publication "Turfgrass pesticide selection guide for professional applicators" (Fagerness et al., 2001) lists atrazine for pre-emergent control of annual bluegrass and winter annual broadleaf weeds in dormant bermuda grass, simazine for pre-emergent control of annual bluegrass and winter annual broadleaf weeds in bermuda and zoysia lawns, and metolachor for pre-emergent control of crabgrass, goosegrass, foxtails, and annual bluegrass in established bermuda and zoysia. The guide also lists atrazine in a mixture with the pesticide bentazon for post-emergent control of winter and summer annual broadleaf weeds in bermuda and zoysia lawns. The KSU publication lists siduron for pre-emergent weed control, 2,4-D for post-emergent weed control, and myclobutanil for control of many turfgrass diseases. Siduron and 2,4-D methyl ester were detected in the samples from the Moorings pit, 2,4-D was measurable in the samples from all of the residential pits, and myclobutanil was detected in the water sample from Barefoot Bay. The other pesticides detected in the water samples from the residential pits are generally used either as herbicides for weeds and mosses or as an insecticide, fungicide, or nematacide. The compounds desulfinyl fipronil (detected in all three residential pits) and desulfinyl fipronil amide (detected in the Ridge Port pit) are degradation products of the insecticide fipronil.

The same five pesticide or degradate compounds occurring most frequently and in the highest concentrations in the pit water samples also were present in all or most of the monitoring well samples (Table 10). Atrazine and its degradate deethylatrazine were measurable or estimable in all 13 well samples, and hydroxyatrazine, metolachlor, and simazine were detected in 11, 10, and nine samples, respectively, out of the 13 well samples. In general, the concentrations of these compounds were either substantially greater in the downgradient well samples or were only detected in the downgradient wells at the pit sites. Atrazine, deethylatrazine, and hydroxyatrazine contents were substantially greater in the two downgradient well samples than in the north well sample at the Barefoot Bay and Moorings sites. The highest concentration of atrazine and these two degradates in the three wells at each of the Barefoot Bay and Moorings sites occurred in the southeast wells. Metolachlor and simazine levels at the Barefoot Bay pit and metolachlor at the Moorings pit were noticeably greater in the waters from the two downgradient wells than in the north well sample. Atrazine, deethylatrazine, and hydroxyatrazine concentrations were substantially greater in the southeast well water and slightly greater in the southwest well sample than in the north well at the Ridge Port site. Metolachlor content was slightly greater in the southeast well than in the north well sample, and not detected in the southwest well water at the Ridge Port pit. Simazine was only detected in the southeast well sample at the Ridge Port site. The concentrations of these herbicides and degradates detected in well water samples at the Cropland site were generally lower than in those samples from the residential pit sites even though these pesticides could have been used on crops in the area around the sand pit. This could be related to the design of the residential pits to allow stormwater runoff entry, whereas no storm drains are directed into the Cropland pit. Although hydroxyatrazine and simazine were only detected in the southeast well sample and metolachlor in the southwest well water at the Cropland site, the concentrations of atrazine and deethylatrazine were slightly greater in the north well sample than in the waters from the other two wells.

Three other pesticides and two degradate compound were detected in some of the monitoring well samples (Table 10). The herbicides diuron, hexazinone, and prometon were measurable or estimable in all of the well samples at the Barefoot Bay site, and 3,4-dichloroaniline, a degradation product of diuron, was detected in the two downgradient well samples at this site. The degradate 3,4-dichloroaniline was the only pesticide-related compound that was detected in the ground-water samples but not in any of the surface water samples. Hexazinone was estimated in all three well samples and had the highest level in the southeast well at the Ridge Port pit. Desulfinyl fipronil, diuron, prometon, and 3,4-dichloroaniline were detected in the southeast well sample at the Ridge Port site. Prometon was detected in all three well samples and desulfinyl fipronil in the southeast well at the Moorings pit site. None of the compounds discussed in this paragraph were detected in any of the well samples at the Cropland site.

Organic Compounds Other than Pesticides

Four organic compounds other than pesticides were detected in the surface-water samples and seven compounds were found in the ground-water samples at the sand-pit sites (Tables 11 and 12) out of a total of 134 compounds for which the USGS conducted analyses. Only one of the detected compounds, isophorone, was found in both the pit and well water samples. Isophorone was detected in all of the pit water samples, in one of the duplicate well samples from the north well and in the southwest well sample at Barefoot Bay, and in the southeast well waters at the Ridge Port and Moorings sites. A fact sheet (http://www.atsdr.cdc.gov/tfacts138.html) of the Agency for Toxic Substances and Disease Registry, an agency of the U.S. Department of Health and Human Services, states that isophorone "is an industrial chemical used as a solvent in some printing inks, paints, lacquers, and adhesives. It is also used as an intermediate in the production of certain chemicals. Although isophorone is an industrial chemical, it also occurs naturally in cranberries." The EPA lifetime health advisory level and the 10^{-6} carcinogen risk for isophorone in drinking water are 100 µg/L and 8.4 µg/L, respectively (Table 16). The USGS detection limit for isophorone in the water samples was 0.6 µg/L (Table 12). Thus, the detected amount (indicated by the M in Tables 11 and 12) for isophorone is expected to be substantially below both the health advisory and 10^{-6} carcinogen risk.

Table 16. Information summary for organic compounds other than pesticides measured or detected in surface and ground waters of the sand-pit study sites. Values for MCL (maximum contaminant level), MCLG (maximum contaminant level goal), and lifetime health advisory are from U.S. EPA (2006). Values for carcinogen risk are from the Code of Federal Regulations 40CFR 131.36. CERCLA is Comprehensive Environmental Response, Compensation, and Liability Act (commonly known as SuperFund). The letter M in a cell indicates that the pesticide presence was verified but not quantified.

Chemical compound	Highest concentration detected in pit or well water, µg/L	U.S. EPA drinking water MCL, µg/L	U.S. EPA drinking water MCLG, µg/L	U.S. EPA drinking water lifetime health advisory, µg/L	U.S. EPA , drinking water 10^{-6} carcinogen risk, µg/L	Kansas water-quality criterion, recommended lifetime exposure, µg/L	CERCLA registered hazardous substance	Use or source
Isophorone	M			100	8.4			solvent in inks, paints, adhesives
2,4-Dimethylphenol	M					380	yes	
2-Nitrophenol	M						yes	used to make other chemicals
Pentachlorophenol	M	1	zero				yes	wood preservative
2,4-Dichlorophenol	M				93		yes	miscellaneous industries
2-Chlorophenol	M			40		81	yes	miscellaneous industries
4-Chloro-2-methylphenol	E 0.006							from production of phenoxy herbicides
Fluoranthene	M				300		yes	incomplete combustion of fossil fuel
Phenol	15.2			2,000	21,000		yes	used to make other chemicals; in disinfectants and antiseptics
Pyrene	M				960		yes	incomplete combustion of fossil fuel

The compound 2,4-dimethylphenol was detected in the Barefoot Bay and Ridge Port pit samples, 2-nitrophenol in the Ridge Port pit sample, and pentachlorophenol in one of the duplicate Moorings pit samples (Table 11). None of the 134 organic compounds other than pesticides for which analyses were conducted was detected in the Cropland pit sample. There is a drinking water standard for only one of the compounds, pentachlorophenol, detected in one of the residential pit samples; the MCL is 1 µg/L and the MCLG is zero (Table 16). The detection limit that the USGS reported for pentachlorophenol is 0.87 µg/L, which is close to the MCL. Thus, the detected, but unquantified concentration of this compound in one of the Mooring pit samples is expected to have been close to the MCL.

In addition to isophorone, the six organics other than pesticides detected in some of the monitoring well waters were 2,4-dichlorophenol, 2-chlorophenol, 4-chloro-2-methylphenol, phenol, fluoranthene, and pyrene. None of these compounds was detected in the upgradient well samples of the residential pit sites. Two of the six compounds were detected in the southeast well samples and one in the southwest well sample at the Ridge Port pit. Two other of the six compounds were detected in the southeast well sample at the Moorings site. Two of the six compounds were detected in the north well sample at the Cropland site. Table 16 indicates that EPA health advisory or 10^{-6} carcinogen risk values or Kansas water-quality criteria exist for five of the six organic compounds. The estimated or expected (based on detection limit for compounds verified but not quantified) concentrations of all of these five organics detected in the water samples were substantially smaller than any of the human health values or criteria.

DISCUSSION OF CHEMICAL DATA – SEDIMENT

The particle size of all of the sediment in the samples collected from the bottoms of the sand pits was <2 mm, the upper limit of the range for classification as sand (Table 13). The sediment at the Cropland site was nearly all fine-grained sediment (<0.063 mm, smaller than the lower limit for the sand classification), whereas the sediment at the Moorings pit was a little less than three-fourths fine-grained and at the Barefoot Bay and Ridge Port pits a little less than half fine-grained. Sediment from the Cropland pit contained less than half the total, inorganic, and organic carbon content in the fine-grained sediment than did the residential pits. The total nitrogen content (and also sulfur content, not shown in Table 13) of the sediment was approximately proportional to the organic carbon concentration in all the samples, suggesting a similar composition of organic matter in the sediment at all of the pits.

The USGS analyzed the sediments for inorganic constituents, including heavy metals. Burton and Pitt (2002) include a table of sediment quality guidelines for freshwater ecosystems that summarizes information on metal and organic effects on ecosystems. One of the more recent references that they cite is Smith et al. (1996), who reported concentration values for a probable effect level of the metals arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc. The concentrations of these metals in the sand-pit sediments were all lower than the probable effects levels.

The USGS also analyzed the sediments for toxic organic compounds, primarily persistent pesticides but also chlorinated aromatic compounds such as PCBs. The analyses were for 32 organic compounds. The USGS included a determination for an organic surrogate compound (alpha-HCH-d6) added to the sediment as a test of the percentage recovery of organochlorine compounds. The percent recovery for the five sediment samples ranged from 66 to 87% and averaged 76%. The USGS found that only three out of the 32 organic compounds determined in the sediment samples were detectable. All three are compounds that are found in the mixture of chemicals in technical grade chlordane, which was used as an insecticide in the U.S. from 1948 to 1988 (fact sheet for chlordane [http://www.atsdr.cdc.gov/tfacts31.html] of the Agency for Toxic Substances and Disease Registry). The U.S. EPA banned the use of chlordane in 1988 due to its damaging impact on human health and the environment. The USGS found (presence verified but not quantified) chlordane and an associated compound only in the two bottom sediment samples from the Barefoot Bay pit (Table 13). The detection level for the three chlordane compounds in the other three sediment samples ranged from <1 to <3 µg/kg dry weight. The probable effect level of chlordane in sediment on freshwater ecosystems as listed in Burton and Pitt (2002) (cited from Smith et al., 1996) is 8.9 µg/kg dry weight. If the presence of the chlordane compounds detected is no more than about twice the detection level, then the concentration is expected to be below the probable effects level.

ASSESSMENT OF SAND-PIT AND GROUND-WATER INTERACTION

Water-level data collected at the pit study sites (Table 6) indicate that the ground-water flow direction is towards the southeast to south-southeast. The water-level elevation in all of the four study pits was between the elevations of the upgradient and downgradient wells. The following conditions clearly indicate flow of surface water from the pits into ground water at the sites: 1) the generally higher concentration of pesticide and pesticide degradate compounds in the sand-pit waters than in the monitoring well samples, 2) usually higher concentrations of pesticides and degradates in the downgradient well samples than in the upgradient wells at the residential pit sites, including the highest content commonly occurring in the southeast well, and 3) the detection of organic compounds other than pesticides generally in one or two of the downgradient wells but not in the upgradient well samples at the residential pit sites. The surface- and ground-water interaction is also supported by the generally greater concentrations of iron, manganese, and ammonium ion in the ground waters at the downgradient wells, along with the higher concentration of organic matter in the pit than the well samples, which suggests that higher dissolved organic matter that entered the pits and flowed in the subsurface to the well locations explains part of the reducing condition found at the downgradient wells. The movement of surface water into the subsurface is expected to occur primarily when storm runoff raises the water level in the pits to an elevation higher than that of the ground water. During periods when evapotranspiration consumes water in the pits and lowers the pit water level, ground water could flow into the pits. This is supported by the fact that the chloride concentration is substantial in the pit waters; the expected source is stream-aquifer interaction with saline Arkansas River water and possibly upward flow of deeper saline ground water.

The concentrations of atrazine found in the water samples from the residential pit sites provides a good example of the surface-water and ground-water connection. The atrazine contents in the June 2006 pit samples were 0.234, 0.094, and 0.456 µg/L at the Barefoot Bay, Ridge Port, and Moorings sites, respectively. The atrazine contents in the June 2006 samples from the north upgradient wells were 0.030, E0.006, and 0.144 µg/L, respectively, at these same sites, where E indicates a USGS estimate. The atrazine levels in the June samples from the southwest wells at these sites were 0.203, E0.008, and 0.255 µg/L, respectively, in comparison with the even greater concentrations of 0.207, 0.069, and 0.301 µg/L, respectively, in the southeast wells at these sites. The concentration patterns of the atrazine degradates deethylatrazine and hydroxyatrazine in the well water samples are generally similar to that for atrazine.

COMPARISON WITH EARLY 1990S STUDY

The KGS, GMD2, and the Wichita-Sedgwick County Department of Community Health (WSCDCH) conducted a study in the early 1990s to assess the impact on ground-water quality in the Equus Beds aquifer of stormwater recharge from unlined earthen pits (Whittemore et al., 1993). Two sites were studied that were at or near the north boundary of Wichita and south of Valley Center. One site received drainage from a new residential area (Fox Meadows, located in N/2 Sec 13, T. 26 S., R. 1 W.) and the other (Miles sand pit, SW/4 Sec. 19, T. 26 S., R. 1 E.) drained a more urban area that included the heavily traveled Meridian Street. The Fox Meadows stormwater retention area is about 1.5 mile north and the Miles sand pit approximately 0.5 mile east of the Moorings pit. In cooperation with the City of Wichita Water Department, GMD2 installed three monitoring wells at different locations around the Fox Meadows pit and three wells at two locations (two shallow and one deeper well at one location) next to the Miles sand pit.

The WSCDCH collected water samples according to EPA sampling protocols and sent them to the KGS for measurement of dissolved inorganic constituents and to GTEL Environmental Laboratories, Inc., in Wichita for determination of selected volatile organic compounds and triazine herbicides (Whittemore et al., 1993). The sampling sites included the six observation wells, the two stormwater pits, a road ditch routing drainage to the Miles sand pit, and snow melt in a roadside puddle. The sampling period was August 8, 1991, to July 7, 1992.

Like the Moorings pit site, surface water in the Miles sand pit and the adjacent ground waters were saline. The Fox Meadows site is far enough to north and east of the Arkansas River, and also closer to the Little Arkansas River, that the ground waters were fresh, with chloride concentrations that were always below 100 mg/L. The surface waters sampled from the Fox Meadow retention area were always fresh but varied substantially in dissolved solids content. Ground waters at the Fox Meadows site contained a higher nitrate concentration (3.6-8.1 mg/L as nitrate-N) than the those at the Miles sand pit and the four pit sites discussed in this report. Whittemore et al. (1993) attributed the source of greater nitrate as agricultural activities that occurred prior to the residential development of the area. The dissolved concentrations of the metals copper, lead, and manganese in all the surface and ground waters sampled at the two sites were below MCL or SMCL levels. Two out of the 35 samples in which arsenic was determined contained 11 µg/L, near the recently revised MCL of 10 µg/L for this constituent. The other arsenic concentrations were generally well below the MCL. In comparison, the highest arsenic observed in the surface- and ground-water samples from the four pits examined in the current study were 2.5 and 10 µg/L, respectively.

The analysis for volatile organic compounds in the early 1990s study was based on modified method 8240 of the U.S. EPA. The analysis included 38 compounds, mainly chlorinated hydrocarbons and simple aromatic hydrocarbons of concern for drinking water supplies. No concentrations of the compounds determined were found to be above the practical quantification limits of the methods (Whittemore et al., 1993). Three compounds were detected at levels below the practical quantification limit in the 24 surface- and ground-water samples from the two sites: toluene (one sample of Miles sand pit water), methylene chloride (one sample from a monitoring well to the southeast of Miles sand pit), and acetone (one sample from the Miles sand pit drainage ditch and one sample from the Fox Meadow pond).

GTEL Environmental Laboratories analyzed ten samples collected in 1991 for the triazine herbicides atrazine, simazine, and propazine. No samples contained detectable amounts. However, their quantification limits for the compounds were 5 µg/L for eight of the samples and 20 µg/L for two of the samples. These quantification limits are higher than the drinking water MCLs for atrazine (3 µg/L) and simazine (4 µg/L) (Table 15). GTEL sent ten samples collected in 1992 to Pace Incorporated of Lenexa for analysis for atrazine, simazine, propazine, and prometon. Their method detection limit was 1 µg/L. None of these ten samples contained detectable concentrations of these triazines. In comparison, the USGS laboratory that determined triazines in the samples for the current study was able to detect atrazine, simazine, and prometon down to 0.006, 0.005, and 0.01 µg/L, respectively. The USGS did not analyze samples for propazine. The USGS found that all of the atrazine, simazine, and prometon concentrations measurable in the samples of the current study were below the 1 µg/L detection limit of the Pace Incorporated lab. The substantially lower detection limits for the 2006 samples in comparison with those for the 1992 samples indicates the improvements in the analytical methods over the 14-year period, as well as the fact that the USGS laboratory is set up for research purposes with generally lower detection limits than for most commercial laboratories.

CONCLUSIONS

Surface waters sampled from the four sand pits studied contained many organic compounds of concern for drinking waters. However, none of the concentrations measured exceeded drinking water standards or recommended levels, and essentially all of the organic compounds for which standards exist were present at levels substantially below the standard. The most common organics of interest relative to drinking water were pesticide and pesticide degradates, especially triazine compounds used as herbicides. Atrazine and two of its degradates (deethylatrazine and hydroxyatrazine), metolachlor, and simazine occurred in the greatest percentage of samples and generally in the highest concentrations of all of the pit and well water samples. The concentrations of these five compounds were usually greater in the surface and ground waters at the residential pits (Barefoot Bay, Ridge Port, and Moorings) than at the Cropland control pit. In addition, there were fewer pesticides and organics other than pesticides detected at the Cropland than at the residential pit sites. The generally greater occurrence and concentration of organic compounds at the residential sites reflect the use of selected herbicides on lawns and landscaping, as well as of insecticides and other organics in urban areas. In addition, the concentrations of the herbicides commonly associated with crops may have been smaller at the Cropland site than at the residential sites because the design of the residential pits allows the entry of stormwater runoff, whereas no storm drains are directed into the Cropland pit.

The surface and ground waters at the pit sites had TDS contents that exceeded the recommended or secondary drinking water standard. All of the surface waters and nearly all of the ground waters at the sites exceeded the recommended drinking water level for chloride concentration. The high chloride and TDS levels are primarily natural and result from the interaction of saline Arkansas River water, and possibly deeper saline ground water, with the alluvial aquifer and sand-pit water at the sites, primarily when evapotranspiration lowers the pit water level below the adjacent ground-water level. Dissolved iron and manganese concentrations also exceeded recommended drinking water levels in some of the pit and well waters. None of the pit or well waters sampled at the study sites had concentrations of inorganic constituents that exceeded an MCL (primary drinking water standard).

All of the surface waters sampled contained measurable or estimable contents of E. coli and total coliform bacteria and all but one of the pit water samples contained fecal coliform bacteria. One sample of residential pit water (Ridge Port) contained E. coli bacteria that exceeded the KDHE geometric mean criterion for primary contact recreation in a classified stream segment during the spring and summer. However, additional samples would have been necessary to compute the geometric mean necessary for determination of a regulatory exceedance. All of the monitoring well samples contained measurable total coliform bacteria indicating that they would need to be treated if used for drinking water.

The bottom sediments of the four sand pits did not have heavy metal concentrations high enough to be of concern to aquatic ecosystems. However, the insecticide chlordane was detected in the sediment of the Barefoot Bay pit. If the presence of chlordane detected is not much greater than the detection limit for the analyses, then the chlordane level is probably not high enough to be of concern to freshwater ecosystems. The chlordane presence indicates the persistent nature of this insecticide, which was banned by the U.S. EPA in 1988.

The concentration distributions of pesticides and organics other than pesticides, as well as the general pattern in iron, manganese, and ammonium ion concentrations in the downgradient well waters relative to the upgradient well and pit waters, indicate that surface water in the sand pits flows into the ground water in the southeast to south-southeast direction of the ground-water flow at the study sites. This would be expected to occur most prominently when surface runoff into the pits increases the hydraulic gradient between the pit surface and ground-water levels. Thus, stormwater runoff containing contaminants can enter ground water through the sand pits and impact ground-water quality.

RECOMMENDATIONS

The KDHE has indicated that funds will be provided for the USGS to sample and analyze surface waters from the sand pits and ground waters from the monitoring wells at two locations in southern Wichita, the Kingston Cove and Pine Bay Estates sites. An assessment of the chemical data from these two sites should be made and compared to the examination provided in this report. Sedgwick County staff indicated that they plan to collect and analyze additional samples from the sand pit sites discussed in this report. They should consider sampling Big Slough stormflow entering the northwest end of the Ridge Port pit, as well as surface water at the southern end of this pit, to determine whether there is a substantial difference in the quality of the Big Slough stormwater and the local residential runoff. It is recommended that they focus on analyses of the pesticides and organic compounds other than pesticides that were detected at the four study sites examined in this report, along with fecal and total coliform bacteria and major inorganic parameters to determine the general chemical character of the waters. As an alternative, they could further focus on collecting more frequent samples for atrazine, metolachlor, and simazine content during different seasons and runoff conditions. Analysis for selected organic compounds rather than the complete suite determined by the USGS for the four study sites would decrease analytical cost and allow a greater number of samples to be analyzed for the same funding. It would be good to include determination of pentachlorophenol in a few of the samples because the USGS detected this compound in one of the residential pit samples at a level near the MCL for drinking water.

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APPENDIX A

The appendix is a CD that contains the complete data set from the U.S. Geological Survey for analyses of surface waters from the four sand pits, ground waters from the twelve monitoring wells, and bottom sediment samples from the four sand pits. The data are in three Excel files. The two files for surface-water and ground-water data each include three worksheets, one for physical and chemical properties and inorganic constituent concentrations (Inorganics tab), one for pesticide and degradate compounds (Pesticides tab), and one for organic compounds other than pesticides (Other organics tab). At the beginning of each worksheet in all three spreadsheet files is a list describing the column headings and analytical parameters for the data part of the worksheet.