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National Water-Quality Assessment Program
Source Water-Quality Assessments

# Anthropogenic Organic Compounds in Source Water of Selected Community Water Systems that Use Groundwater, 2002–05

## Scientific Investigations Report 2009–5200

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

**Cover.** Photographs of a pump house and public supply wells that are typical for wells sampled for this study. Photographs by Nicholas Smith.

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KEN SALAZAR, Secretary

**U.S. Geological Survey**
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# Foreword

The U.S. Geological Survey (USGS) is committed to providing the Nation with credible scientific information that helps to enhance and protect the overall quality of life and that facilitates effective management of water, biological, energy, and mineral resources (http://www.usgs.gov/). Information on the Nation's water resources is critical to ensuring long-term availability of water that is safe for drinking and recreation and is suitable for industry, irrigation, and fish and wildlife. Population growth and increasing demands for water make the availability of that water, now measured in terms of quantity and quality, even more essential to the long-term sustainability of our communities and ecosystems.

The USGS implemented the National Water-Quality Assessment (NAWQA) Program in 1991 to support national, regional, State, and local information needs and decisions related to water-quality management and policy (http://water.usgs.gov/nawqa). The NAWQA Program is designed to answer: What is the condition of our Nation's streams and groundwater? How are conditions changing over time? How do natural features and human activities affect the quality of streams and groundwater, and where are those effects most pronounced? By combining information on water chemistry, physical characteristics, stream habitat, and aquatic life, the NAWQA Program aims to provide science-based insights for current and emerging water issues and priorities. From 1991-2001, the NAWQA Program completed interdisciplinary assessments and established a baseline understanding of water-quality conditions in 51 of the Nation's river basins and aquifers, referred to as Study Units (http://water.usgs.gov/nawqa/studyu.html).

Multiple national and regional assessments are ongoing in the second decade (2001–2012) of the NAWQA Program as 42 of the 51 Study Units are reassessed. These assessments extend the findings in the Study Units by determining status and trends at sites that have been consistently monitored for more than a decade, and filling critical gaps in characterizing the quality of surface water and groundwater. For example, increased emphasis has been placed on assessing the quality of source water and finished water associated with many of the Nation's largest community water systems. During the second decade, NAWQA is addressing five national priority topics that build an understanding of how natural features and human activities affect water quality, and establish links between sources of contaminants, the transport of those contaminants through the hydrologic system, and the potential effects of contaminants on humans and aquatic ecosystems. Included are topics on the fate of agricultural chemicals, effects of urbanization on stream ecosystems, bioaccumulation of mercury in stream ecosystems, effects of nutrient enrichment on aquatic ecosystems, and transport of contaminants to public-supply wells. These topical studies are conducted in those Study Units most affected by these issues; they comprise a set of multi-Study-Unit designs for systematic national assessment. In addition, national syntheses of information on pesticides, volatile organic compounds (VOCs), nutrients, selected trace elements, and aquatic ecology are continuing.

The USGS aims to disseminate credible, timely, and relevant science information to address practical and effective water-resource management and strategies that protect and restore water quality. We hope this NAWQA publication will provide you with insights and information to meet your needs, and will foster increased citizen awareness and involvement in the protection and restoration of our Nation's waters.

The USGS recognizes that a national assessment by a single program cannot address all water-resource issues of interest. External coordination at all levels is critical for cost-effective management, regulation, and conservation of our Nation's water resources. The NAWQA Program, therefore, depends on advice and information from other agencies—Federal, State, regional, interstate, Tribal, and local—as well as nongovernmental organizations, industry, academia, and other stakeholder groups. Your assistance and suggestions are greatly appreciated.

Matthew C. Larsen
Associate Director for Water

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## Conversion Factors and Datums

| Multiply | By | To obtain |
|---|---|---|
| | Length | |
| foot (ft) | 0.3048 | meter (m) |
| mile (mi) | 1.609 | kilometer (km) |
| | Area | |
| square mile ($mi^2$) | 2.590 | square kilometer ($km^2$) |
| | Volume | |
| gallon (gal) | 3.785 | liter (L) |
| million gallons (Mgal) | 3,785 | cubic meter ($m^3$) |
| cubic foot ($ft^3$) | 0.02832 | cubic meter ($m^3$) |
| | Flow rate | |
| cubic foot per second ($ft^3/s$) | 0.02832 | cubic meter per second ($m^3/s$) |
| million gallons per day (Mgal/d) | 0.04381 | cubic meter per second ($m^3/s$) |

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

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

## Abbreviations and Symbols

| | |
|---|---|
| < | less than |
| µg/L | micrograms per liter |
| 1,1,1-TCA | 1,1,1-trichloroethane |
| BQ | benchmark quotient |
| BTEX | benzene, toluene, ethylbenzene, and xylenes |
| CCR | Consumer Confidence Report |
| *cis*-1,2-DCE | *cis*-1,2-dichloroethene |
| CWS | community water system |
| DBP | disinfection by-product |
| DEET | N,N,-diethyl-*meta*-toluamide |
| E | estimated |
| GC/MS | gas chromatography/mass spectrometry |
| HBSL | Health-Based Screening Level |
| HPLC/MS | high-performance liquid chromatography/mass spectrometry |
| LRL | laboratory reporting level |
| MCL | Maximum Contaminant Level |
| MTBE | methyl *tert*-butyl ether |
| NAWQA | National Water-Quality Assessment |
| NWQL | National Water Quality Laboratory |
| OGRL | Organic Geochemistry Research Group Laboratory |
| PAH | polynuclear aromatic hydrocarbon |
| PCE | tetrachloroethene; perchloroethene |
| PVC | polyvinyl chloride |
| QC | quality control |
| SPE | solid-phase extraction |
| SWQA | Source Water-Quality Assessment |
| TCE | trichloroethene |
| THM | trihalomethane |
| USEPA | U.S. Environmental Protection Agency |
| USGS | U.S. Geological Survey |
| VOC | volatile organic compound |

# Definitions

| Term | Definition |
|---|---|
| Benchmark quotient (BQ) | Ratio of the concentration of a contaminant to its Maximum Contaminant Level (MCL) value for a regulated compound or to its Health-Based Screening Level (HBSL) value for an unregulated compound. Annual mean BQs greater than 1 identify concentrations of potential human-health concern. BQs greater than 0.1 identify compounds that may warrant inclusion in a low-concentration, trends-monitoring program. |
| Blended water | As used in this report, finished water that has been blended with one or more different groundwater sources. Community water systems that blend with surface water were not analyzed. |
| Community water system (CWS) | A public water system with 15 or more connections and serving 25 or more year-round residents and thus subject to USEPA and State regulations enforcing the Safe Drinking Water Act. A CWS serves a residential population, such as a municipality, mobile home park, or nursing home. |
| Concentration of potential human-health concern | As used in this report: (1) for a regulated compound with a U.S. Environmental Protection Agency (USEPA) drinking-water standard, a concentration greater than the MCL; and (2) for an unregulated compound, a concentration greater than the HBSL. |
| Drinking-water guideline | As used in this report, a threshold concentration that has no regulatory status but is issued in an advisory capacity by the USEPA or State agencies. |
| Drinking-water standard | As used in this report, a threshold concentration that is legally enforceable (such as MCLs) by the USEPA or State agencies. |
| Finished water | Water is “finished” when it has passed through all the processes in a water-treatment plant and is ready to be delivered to consumers. |
| Health-Based Screening Level (HBSL) | Benchmark concentrations of contaminants in water that may be of potential concern for human health, if exceeded. HBSLs are non-enforceable benchmarks that were developed by the U.S. Geological Survey (USGS) in collaboration with the USEPA and others using (1) USEPA Office of Water methodologies for establishing drinking-water guidelines, and (2) the most recent USEPA peer-reviewed, publicly available human-health toxicity information. |
| Human-health benchmarks | As used in this report, human-health benchmarks include USEPA MCL values and HBSL values. |
| Maximum Contaminant Level (MCL) | USEPA drinking-water standard that is legally enforceable, and that sets the maximum permissible level of a contaminant in water that is delivered to any user of a public water system. |
| Quench | Stop a chemical reaction; as used in this report, the addition of ascorbic acid to scavenge free chlorine in samples. |
| Regulated compound | As used in this report, a compound for which a Federal drinking-water standard has been established by the USEPA. |
| Source water | Source water is the raw (ambient) water collected at the supply well or surface-water intake prior to water treatment used to produce finished water. |
| Unregulated compound | As used in this report, a compound for which no Federal drinking-water standard has been established. Note that a compound that is unregulated by the USEPA in drinking water under the Safe Drinking Water Act may be regulated in other contexts and under other statutes. |

# Anthropogenic Organic Compounds in Source Water of Selected Community Water Systems that Use Groundwater, 2002–05

By Jessica A. Hopple, Gregory C. Delzer, and James A. Kingsbury

## Abstract

Source water, defined as groundwater collected from a community water system well prior to water treatment, was sampled from 221 wells during October 2002 to July 2005 and analyzed for 258 anthropogenic organic compounds. Most of these compounds are unregulated in drinking water and include pesticides and pesticide degradates, gasoline hydrocarbons, personal-care and domestic-use products, and solvents. The laboratory analytical methods used in the study have detection levels that commonly are 100 to 1,000 times lower than State and Federal standards and guidelines for protecting water quality. Detections of anthropogenic organic compounds do not necessarily indicate a concern to human health but rather help to identify emerging issues and track changes in occurrence and concentrations over time.

Less than one-half (120) of the 258 compounds were detected in at least one source-water sample. Chloroform, in 36 percent of samples, was the most commonly detected of the 12 compounds that were in about 10 percent or more of source-water samples. The herbicides atrazine, metolachlor, prometon, and simazine also were among the commonly detected compounds. The commonly detected degradates of atrazine—deethylatrazine and deisopropylatrazine—as well as degradates of acetochlor and alachlor, generally were detected at concentrations similar to or greater than concentrations of the parent herbicide. The compounds perchloroethene, trichloroethene, 1,1,1-trichloroethane, methyl *tert*-butyl ether, and *cis*-1,2-dichloroethene also were detected commonly. The most commonly detected compounds in source-water samples generally were among those detected commonly across the country and reported in previous studies by the U.S. Geological Survey's National Water-Quality Assessment Program.

Relatively few compounds were detected at concentrations greater than human-health benchmarks, and 84 percent of the concentrations were two or more orders of magnitude less than benchmarks. Five compounds (perchloroethene, trichloroethene, 1,2-dibromoethane, acrylonitrile, and dieldrin) were detected at concentrations greater than their human-health benchmark. The human-health benchmarks used for comparison were U.S. Environmental Protection Agency Maximum Contaminant Levels (MCLs) for regulated compounds and Health-Based Screening Levels developed by the U.S. Geological Survey in collaboration with the U.S. Environmental Protection Agency and other agencies for unregulated compounds. About one-half of all detected compounds do not have human-health benchmarks or adequate toxicity information to evaluate results in a human-health context.

Ninety-four source-water and finished-water (water that has passed through all the treatment processes but prior to distribution) sites were sampled at selected community water systems during June 2004 to September 2005. Most of the samples were analyzed for compounds that were detected commonly or at relatively high concentrations during the initial source-water sampling. The majority of the finished-water samples represented water blended with water from one or more other wells. Thirty-four samples were from water systems that did not blend water from sampled wells with water from other wells prior to distribution.

The comparison of source- and finished-water samples represents an initial assessment of whether compounds present in source water also are present in finished water and is not intended as an evaluation of water-treatment efficacy. The treatment used at the majority of the community water systems sampled is disinfection, which, in general, is not designed to remove the compounds monitored in this study.

Concentrations of all compounds detected in finished water were less than their human-health benchmarks. Two detections of perchloroethene and one detection of trichloroethene in finished water had concentrations within an order of magnitude of the MCL. Concentrations of disinfection by-products were expected to increase in finished water relative to source water because of disinfection. The MCL for concentrations of disinfection by-products analyzed in this study is for total trihalomethanes, and concentrations were within an order of magnitude of the MCL in finished water from nine sites, but only three detections of chloroform and one detection of bromoform were within an order of magnitude of the MCL. Concentrations of all other compounds were more than an order of magnitude less than human-health benchmarks.

About one-half (57 percent) of the detections from the 34 community water systems where finished water was not blended with other source water were in both source and finished water, and concentrations were similar, with the exception of disinfection by-products. Most of the detections were gasoline-related compounds, herbicides and herbicide degradates, and solvents. Results for blended finished-water samples generally were similar to nonblended finished-water samples, and blending did not always reduce concentrations to less than the laboratory reporting level. Differences in the occurrence of compounds in source and finished water could be the result of water treatment, volatilization, blending, or analytical variability at concentrations near or less than the laboratory reporting level. Large changes in concentration from source to finished water of solvents in a few samples likely are attributable to additional water treatment steps used by the CWS to treat water known to contain elevated concentrations of organic compounds.

Mixtures of two or more compounds were detected in about 70 percent of source-water samples and in 82 percent of finished-water samples. Mixtures occur more commonly in finished water than source water because of the formation of disinfection by-products in finished water. The potential human-health significance of the frequent presence of mixtures of organic compounds in finished water remains largely unknown.

# Introduction

Groundwater is an important supply of drinking water in the United States, and the study of aquifers is a large component of the U.S. Geological Survey's (USGS) National Water-Quality Assessment (NAWQA) Program. NAWQA studies have added to the understanding of the chemical quality of water in locally and regionally important aquifers. Many pesticides, volatile organic compounds (VOCs), and other compounds are monitored as part of these aquifer studies, which are designed to provide an overall representation of the water-quality condition of the Nation's aquifers.

The occurrence of anthropogenic organic compounds in groundwater has been documented for many years (for example, Westrick and others, 1984; U.S. Environmental Protection Agency, 2002) and recently reported by Gilliom and others (2006) and Zogorski and others (2006). Drinking water is monitored routinely for regulated compounds. However, relatively few studies have specifically focused on the quality of source water used by community water systems (CWSs) as well as the associated finished water, particularly for organic compounds that are not regulated under the Safe Drinking Water Act (U.S. Environmental Protection Agency, 2008). Collectively, findings from these studies highlight the need for continued monitoring and evaluation of organic compounds found in sources of drinking water, referred to as source waters, using nationally consistent analytical methods and assessment techniques. In the current study, source water is defined as groundwater withdrawn from a CWS well prior to water treatment, and finished water is defined as water that has passed through all treatment processes, prior to distribution.

From 1992 to 2001, the NAWQA Program assessed the quality of ambient surface-water and groundwater resources in 51 major river basins and aquifer systems across the Nation (*http://water.usgs.gov/nawqa/studies/study_units.html*). Beginning in 2002, NAWQA initiated "Source Water-Quality Assessments" (SWQAs) at selected CWSs across the United States. The long-term goal is to complete about 30 surface-water and 30 groundwater SWQAs by 2012 (Delzer and Hamilton, 2007; Kingsbury and others, 2008). The primary emphasis of SWQAs is to characterize the occurrence of a large number of anthropogenic organic compounds that are predominantly unregulated by the U.S. Environmental Protection Agency (USEPA) in sources of drinking water. In addition, SWQAs are intended to provide a preliminary, broad-based assessment of selected compounds found in source water and the associated finished water. These studies contribute to specific science goals and priorities of the USGS, which in part, include assessment of environmental risk to public health and the quality of water used for drinking water, as important aspects of accounting for the freshwater resources of the Nation (U.S. Geological Survey, 2007).

The laboratory analytical methods used in SWQA studies have relatively low detection levels—commonly 100 to 1,000 times lower than State and Federal standards and guidelines for protecting water quality. Detections, therefore, do not necessarily indicate a concern to human health, but rather help to identify emerging issues and track changes in occurrence and concentrations over time. SWQAs complement existing drinking-water monitoring required by Federal, State, and local programs, which focus primarily on post-treatment compliance monitoring of contaminants regulated by USEPA in drinking water to meet requirements of the Safe Drinking Water Act. Most of the compounds analyzed in SWQA studies are not included in other source-water and finished-water monitoring programs, such as the Unregulated Contaminant Monitoring Program (U.S. Environmental Protection Agency, 2007a) and the U.S. Department of Agriculture's Pesticide Data Program (U.S. Department of Agriculture, 2008).

Since 1999, the USEPA has required water suppliers to provide annual drinking-water quality reports called Consumer Confidence Reports (CCRs) to their customers (*http://www.epa.gov/safewater/ccr/*). CCRs are the centerpiece of the right-to-know provisions of the 1996 Amendments to the Safe Drinking Water Act. Each CCR provides consumers with fundamental information about their drinking water, including (1) the source of the drinking water, (2) a brief summary of the susceptibility to contamination of the local drinking-water source, (3) the concentrations (or range of concentrations) of any contaminants found in local drinking water, as well as their USEPA Maximum Contaminant Levels (MCLs), which are legally enforceable drinking-water standards and are the highest allowed concentrations of contaminants in drinking

water, and (4) telephone numbers for additional sources of information.

Information in CCRs is specific to a particular water utility. Water utilities analyze finished-water samples primarily for regulated compounds using USEPA analytical methods for compliance monitoring. Analytical methods used in SWQAs include many more compounds and typically have lower analytical reporting levels than those used in USEPA analytical methods; therefore, compound detection frequencies in SWQA reports may be higher than those reported in CCRs.

## Purpose and Scope

The primary purpose of this report is to characterize anthropogenic organic compounds in source water of selected CWSs that use groundwater. The focus of this report is on the first 15 groundwater SWQAs. The aquifers monitored (hereafter termed principal aquifers) as part of these efforts were studied because they account for the majority of the estimated withdrawals of groundwater for drinking-water supply in the United States (Lapham and others, 2005; Maupin and Barber, 2005). This report also compares findings to previous resource assessments. The occurrence of 258 anthropogenic organic compounds (Appendix 1) in source water from 221 wells sampled from 12 principal aquifers across the United States by the NAWQA Program during October 2002 to July 2005 is described. Source-water samples were analyzed for compounds that included pesticides and pesticide degradates, gasoline hydrocarbons, personal-care and domestic-use products, and solvents. An additional 3 herbicides and 16 herbicide degradates were analyzed in samples from 73 of the 221 wells located in areas where these compounds likely are used. The report describes (1) the occurrence of compounds in source water and highlights those that occur most commonly; (2) the comparison of concentrations of detected compounds to available human-health benchmarks; and (3) the characterization of the number of compounds co-occurring in source water as mixtures. Although this study was not designed to examine specific sources and (or) factors causing and affecting the occurrence and concentrations of compounds in source water, additional perspective is added by highlighting general patterns and associations as appropriate, including those related to geographic location, well depth, and general lithology.

A secondary purpose of this report is to provide comparisons of selected compounds in source water with their occurrence in finished water. Samples of source water, and associated samples of finished water, were collected during June 2004 to September 2005 from 94 of the 221 wells. Sampling during this period generally focused on analytical suites that included compounds found to occur most commonly or at relatively high concentrations in source water during the initial sampling (2002–05). The sampling design and resulting comparisons were not intended to characterize water-treatment efficacy, but to provide a preliminary indication of the potential importance of compounds found in source water and the quality of finished water prior to distribution. In general, the types of treatment used by the CWSs that were sampled were not specifically designed to remove most of the organic compounds monitored. Distinctions were made in the analyses for wells that did not blend water (34 of the 94) and wells that did blend water (60 of the 94) when comparing source- and finished-water concentrations. Analytical results for source-water and finished-water samples, as well as quality-assurance samples, are summarized in Carter and others (2007).

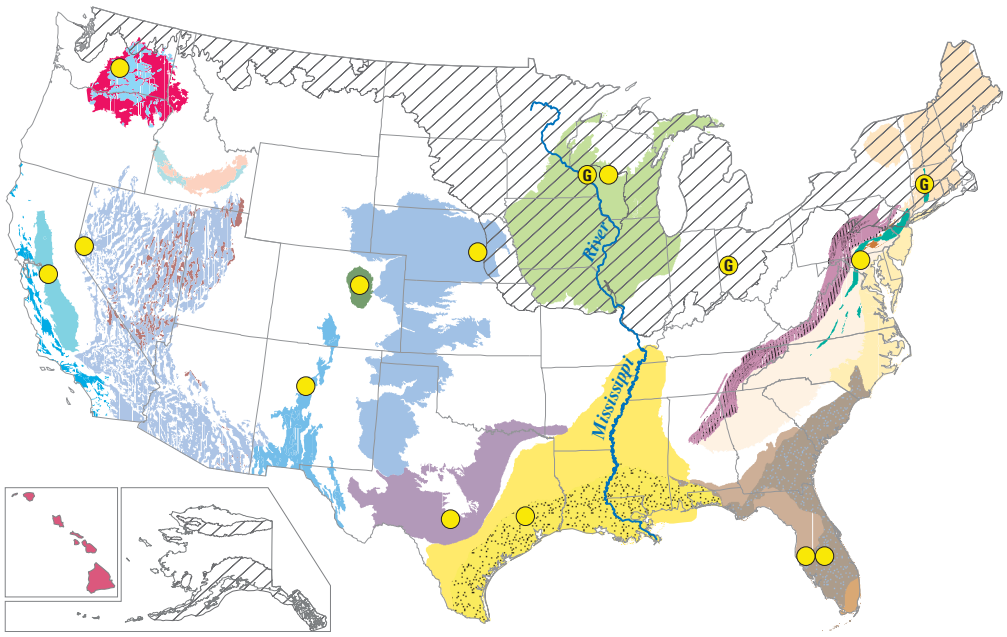
A screening-level assessment of the potential significance of detected compounds in source and finished waters to human health was made, when possible, by comparing measured concentrations to human-health benchmarks. Measured concentrations of compounds that are regulated in drinking water were compared to USEPA MCLs, and concentrations of unregulated compounds were compared to Health-Based Screening Levels (HBSLs) developed by the USGS in collaboration with USEPA and others (Toccalino and others, 2003). The screening-level assessment provides an initial perspective on the potential importance of anthropogenic organic compounds detected and is not a substitute for comprehensive risk assessment, which includes many more factors, such as additional avenues of exposure.

## Acknowledgments

The authors thank personnel at each of the CWSs for their assistance in the collection of samples. The authors also acknowledge Robert Gilliom, John Zogorski, William Wilber, Jeffrey Stoner, and Pixie Hamilton of the USGS and Philip Berger of the USEPA for their constructive review comments.

# Study Design and Methods

CWS wells selected for SWQA monitoring met several criteria. Specifically, wells are located in NAWQA study areas where SWQA data can be compared to groundwater resource-assessment data collected as part of the NAWQA Program during 1992–2001, and wells are screened in one of 62 principal aquifers (fig. 1). Selected wells generally have relatively high pumping rates (in comparison to other wells in the sampling area) and are at least 1,000 meters (0.62 mile) apart to minimize overlapping contributing areas. In general, wells sampled in this study are considered relatively susceptible to anthropogenic contamination because of the large pumping rates (generally greater than 500 gallons per minute) and large contributing areas. The results of this study are, therefore, not necessarily representative of many CWS wells, particularly those with relatively small pumping rates, less than 500 gallons per minute.




EXPLANATION

Principal aquifer (from U.S. Geological Survey, 2003)

Basin and Range
- Basin-fill aquifers
- Carbonate-rock aquifers

- Biscayne aquifer
- California Coastal Basin aquifers
- Cambrian-Ordovician aquifer system
- Central Valley aquifer system
- Coastal Lowlands aquifer system

Columbia Plateau
- Basin-fill aquifers
- Basaltic-rock aquifers

- Denver Basin aquifer system
- Edwards-Trinity aquifer system
- Floridan aquifer system
- Surficial aquifer system (overlying the Floridan)
- Glacial deposits aquifer system
- Hawaiian volcanic-rock aquifers—locally overlain by sedimentary deposits
- New England crystalline-rock aquifers
- High Plains aquifer
- Mississippi Embayment-Texas Coastal Uplands aquifer system
- Northern Atlantic Coastal Plain aquifer system

Piedmont and Blue Ridge
- Carbonate-rock aquifers
- Crystalline-rock aquifers

- Early Mesozoic aquifers
- Rio Grande aquifer system

Snake River Plain
- Basaltic-rock aquifers
- Basin-fill aquifers

- Valley and Ridge aquifers—Carbonate-rock aquifers are patterned

- Approximate location of groundwater SWQA study area
- G Wells completed in the glacial deposits aquifer system

**Figure 1.** Source water and finished water were assessed in 12 principal aquifers throughout the United States as part of the Source Water-Quality Assessment (SWQA) component of the National Water-Quality Assessment (NAWQA) Program during 2002–05.

The types of water treatment or prior monitoring results, including those for compliance monitoring, were not considered in the selection process. In addition, several criteria were used to eliminate wells, including (1) proximity to coastal or bay areas, which could be affected by saltwater intrusion; (2) wells with strong connections to streams (under the influence of surface water); and (3) wells used for injection or withdrawal for artificial recharge.

Typically, about 15 wells were sampled in each of the SWQA studies. In the Florida and Minnesota/Wisconsin SWQAs, 30 wells were sampled (table 1). Fifteen wells in both unconfined and semiconfined parts of the Floridan aquifer system were sampled for the Florida SWQA. For the Minnesota/Wisconsin SWQA, 15 of the sampled wells were completed in the Cambrian-Ordovician aquifer system, and 15 of the sampled wells were completed in the glacial deposits aquifer system.

The Kruskal-Wallis rank-sum test (Helsel and Hirsch, 1992) was used to identify differences between groups of sites for analyses presented in this report. A p-value less than 0.05 was used to indicate statistical significance.

## Characteristics of Selected Community Water System Wells

The principal aquifers sampled in this study range in areal extent from about 6,800 to more than 950,000 square miles (table 1); however, wells sampled for SWQAs typically were clustered around one or two urban or suburban areas. For the purpose of this study, the 221 sampled wells were grouped into four general lithology groups: (1) unconsolidated glacial deposits (44 wells); (2) unconsolidated and semiconsolidated sediments, which include sand, gravel, and to a lesser extent boulders and silt (77 wells); (3) sandstone and carbonate rocks (72 wells); and (4) igneous and metamorphic (crystalline) rocks (28 wells) (fig. 2*A*; table 1; Appendix 2). Wells completed in the unconsolidated glacial deposits were separated from wells completed in unconsolidated and semiconsolidated sediments because of significantly different well depths (median depths of 124 and 523 feet (ft) below land surface, respectively) (Kruskal-Wallis rank-sum test p-value less than 0.0001).

Depth to water, and consequently well depth, varies considerably among and within study areas (table 1; fig. 2*B*; Appendix 2). Median well depths within each principal aquifer range from 124 to 1,394 ft. The shallowest median well depth is for wells completed in the glacial deposits aquifer system, and the deepest median well depth is for wells completed in the Coastal Lowlands aquifer system (table 1; fig. 2*B*; Appendix 2). Many of the deepest wells are located in the western part of the Nation, and the shallowest wells are located east of the Mississippi River. Although wells in the unconsolidated and semiconsolidated group have the second shallowest median depth, the range in well depth is large (120 to 2,070 ft). Well depth and lithology for each well are presented in Appendix 2.

CWSs that participated in SWQAs include single-well systems and systems with multiple wells. In many cases where systems have multiple wells, the CWSs blend water before or after water treatment. The water-treatment process predominantly used by the CWSs was disinfection with chlorine. Additional water-treatment steps, including granular activated carbon and air-stripping towers, were used by CWSs when source water was known to be contaminated with organic compounds.

## Compounds Monitored

Compounds included for monitoring were selected on the basis of known or potential human-health concerns, analytical capabilities, and whether the compounds typically are not monitored in source and (or) finished water. Some compounds without known human-health concerns, such as caffeine, were included as potential indicators or surrogates for contaminants that were not monitored. Most of the 258 compounds monitored at all sites are not regulated in drinking water and typically are not monitored by CWSs; however, 38 compounds do have an established USEPA MCL for drinking water and are monitored in finished water by CWSs. Several inorganic compounds, such as arsenic and nitrate, were considered for monitoring but were not included because they typically are monitored by CWSs and, thus, would not have provided new information. Additionally, only compounds that could be analyzed using USGS approved analytical methods were considered for monitoring.

For the purposes of this report, the compounds were grouped into 13 categories on the basis of their primary use or source (table 2; Appendix 1). The number of compounds in each of the 13 categories (hereafter termed "use groups") ranges from 3 to 82. About one-half of the compounds analyzed are pesticides, which include three use groups—herbicides and herbicide degradates, insecticides and insecticide degradates, and fungicides. About 90 VOCs are categorized in six use groups, including disinfection by-products; fumigant-related compounds; gasoline hydrocarbons, oxygenates, and oxygenate degradates; organic synthesis compounds; refrigerants and propellants; and solvents. Pesticides and VOCs have been included routinely in data collection by the NAWQA Program since its inception (1991); however, most of the compounds in the remaining four groups have not been analyzed previously by the NAWQA Program. These four use groups are personal-care and domestic-use products, such as triclosan (an anti-bacterial agent in many hand soaps), detergent metabolites, and fragrance compounds; manufacturing additives, such as plasticizers and fire retardants; pavement- and combustion-derived compounds, which are predominantly polynuclear aromatic hydrocarbons; and plant- and animal-derived biochemicals, such as cholesterol.

**Table 1.** Characteristics of principal aquifers or aquifer systems and median well depth for sites included in Source Water-Quality Assessments, 2002–05.

[SWQA, Source Water-Quality Assessment; Mgal/d, million gallons per day]

| Principal aquifer or system in which SWQA was conducted | State(s) in which SWQA was located | General lithologies | Number of wells sampled | Median well depth (feet) | Approximate areal extent of aquifer (square miles) | Withdrawals for public supply in 2000[1] (Mgal/d) |
|---|---|---|---|---|---|---|
| Basin and Range basin-fill aquifers[2] | Nevada | Unconsolidated and semiconsolidated sediments | 15 | 470 | 163,386 | 1,081 |
| Cambrian-Ordovician aquifer system[3] | Minnesota, Wisconsin | Sandstone and carbonate rocks | 15 | 408 | 177,355 | 590 |
| Central Valley aquifer system | California | Unconsolidated and semiconsolidated sediments | 15 | 248 | 20,305 | 839 |
| Coastal Lowlands aquifer system | Texas | Unconsolidated and semiconsolidated sediments | 15 | 1,394 | 197,211 | 724 |
| Columbia Plateau basin-fill and basaltic-rock aquifers | Washington | Igneous and metamorphic rocks<br>Unconsolidated and semiconsolidated sediments | 13<br>2 | 750<br>[4]188; 1,171 | 43,521 | 223 |
| Denver Basin aquifer system | Colorado | Sandstone and carbonate rocks | 12 | 561 | 6,788 | 17 |
| Edwards-Trinity aquifer system | Texas | Sandstone and carbonate rocks | 15 | 848 | 75,012 | 411 |
| Floridan aquifer system[5] | Florida | Sandstone and carbonate rocks | 30 | 563 | 112,684 | 1,555 |
| Glacial deposits aquifer system[3,6,7] | Connecticut, Minnesota, Ohio, Wisconsin | Unconsolidated glacial deposits | 44 | 124 | 953,148 | 1,950 |
| High Plains aquifer | Nebraska | Unconsolidated and semiconsolidated sediments | 15 | 292 | 176,534 | 389 |
| Piedmont and Blue Ridge crystalline-rock aquifers[8] | Maryland, Virginia | Igneous and metamorphic rocks | 15 | 300 | 86,489 | 92 |
| Rio Grande aquifer system | New Mexico | Unconsolidated and semiconsolidated sediments | 15 | 1,287 | 29,249 | 240 |

[1]Maupin and Barber (2005).

[2]Rosen and others (2006).

[3]Tornes and others (2007).

[4]Depths for two wells; median not calculated.

[5]Metz and others (2006).

[6]Trombley and others (2007).

[7]Thomas (2007).

[8]Banks and Reyes (2009).

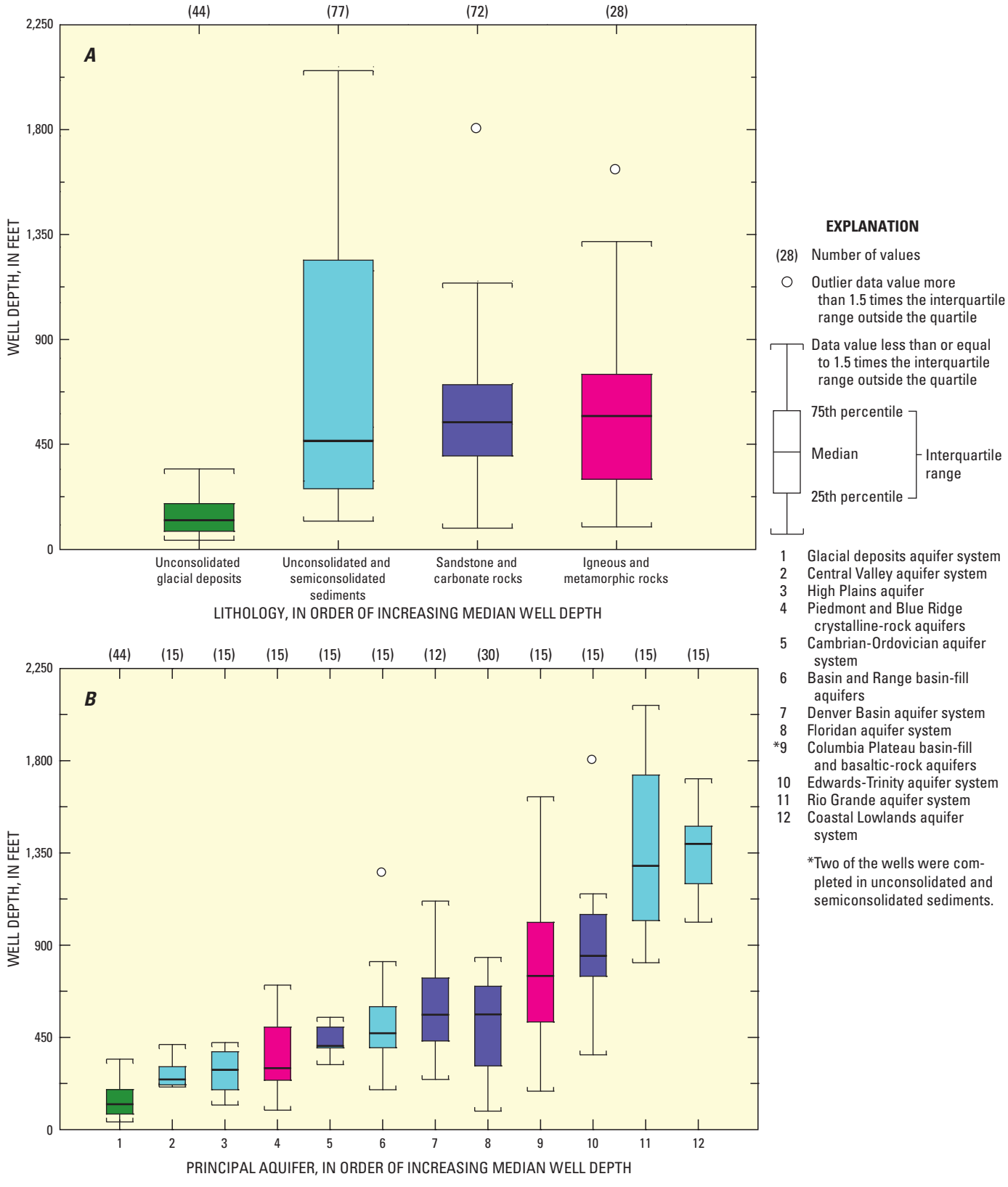



**Figure 2.** The distribution of well depths included in Source Water-Quality Assessments, 2002–05, varied by *A*, lithology; and *B*, principal aquifer. [Color-coding of principal aquifer corresponds to color-coding of the lithology group.]

**Table 2.** Primary-use groups for compounds analyzed for Source Water-Quality Assessment studies (from Carter and others, 2007).

[BTEX: benzene, toluene, ethylbenzene, and xylenes]

| Primary use or source group | Description | Number of compounds analyzed in each group |
|---|---|---|
| Disinfection by-products | Trihalomethanes, (poly)haloacetic acids, and other compounds that are produced from the transformation of organic compounds during the disinfection of water and wastewater through chlorination, ozonation, or other chemical methods. | 4 |
| Fumigant-related compounds | Chemicals that may be present in commercial fumigant products, which produce a gas, vapor, fumes, or smoke intended to destroy, repel, or control unwanted organisms, such as insects, bacteria, or rodents. These include fumigant active ingredients as well as their degradates and their manufacturing by-products. | 9 |
| Fungicides | Pesticides used to kill unwanted fungi. | 7 |
| Gasoline hydrocarbons, oxygenates, and oxygenate degradates | Gasoline hydrocarbons are straight, branched, and (or) cyclic organic compounds that are highly volatile, contain only carbon and hydrogen atoms, and are common ingredients in gasoline and other petroleum products. Of these compounds, BTEX compounds are among those present in the highest proportions in gasoline. Oxygenates, such as methyl *tert*-butyl ether (MTBE), are compounds that contain only carbon, hydrogen, and oxygen atoms and commonly are added to gasoline to improve the efficiency of combustion. Oxygenate degradates are formed during the production, storage, release, and (or) use of gasoline oxygenates or following their release into the environment. | 27 |
| Herbicides and herbicide degradates[1] | Pesticides designed to kill unwanted plants (herbicides) and compounds produced from the transformation of the parent herbicide following application (degradates). | 82 |
| Insecticides and insecticide degradates | Pesticides designed to kill unwanted insects (insecticides) and compounds produced from the transformation of the parent insecticide following application (degradates). | 51 |
| Manufacturing additives | Compounds used in commercial formulations of chemical products in order to improve the effectiveness of the product, including plasticizers (to increase the flexibility of plastics), fire retardants, corrosion inhibitors, and pesticide adjuvants. | 7 |
| Organic synthesis compounds | Chemicals used as precursors in the manufacture of other organic compounds. Chloroethylene (vinyl chloride), for example, is an organic synthesis compound used to produce polyvinyl chloride (PVC) plastics. | 18 |
| Pavement- and combustion-derived compounds | Organic substances, such as polynuclear aromatic hydrocarbons (PAHs), that are derived from either (1) the materials used to construct and seal parking lots and other paved surfaces or (2) the combustion of other non-halogenated organic compounds, most commonly gasoline, oil, coal, and other fossil fuels. | 5 |
| Personal-care and domestic-use products | Compounds that are present in commercial products sold for personal or residential use, such as fragrances, pharmaceuticals, insect repellants, dyes, detergents, disinfectants, shampoos, and chemicals used in fire extinguishers. | 26 |
| Plant- or animal-derived biochemicals | Naturally occurring compounds that are produced by plants or animals, either through direct biosynthesis or through the metabolic alteration of compounds ingested or taken up from other sources. These compounds are predominantly unsaturated solid alcohols of the steroid group naturally occurring in fatty tissues of plants and animals and present in animal fecal material. | 5 |
| Refrigerants and propellants | Volatile compounds that are used for commercial or domestic refrigeration, as blowing agents in the manufacture of packaging and other highly porous materials, or for dispensing other substances from spray cans and other aerosol delivery devices. | 3 |
| Solvents | Compounds used to dissolve other substances. Two of the more common solvents are trichloroethene (TCE) and perchloroethene (tetrachloroethene, PCE). | 33 |
| **Total number of compounds** | | **277** |

[1]Herbicides and herbicide degradates include 3 herbicides and 16 herbicide degradates monitored in additional samples collected at 73 selected sites. A total of 258 compounds were monitored at all sites.

## Sample Collection and Protocols

Source-water samples were collected at the wellhead before any treatment and processed using standard USGS sampling protocols (Koterba and others, 1995). The 221 wells were sampled one time during October 2002 to July 2005 and were analyzed for 258 compounds (Appendix 1). Samples from a subset of 73 wells also were analyzed for an additional 3 herbicides and 16 herbicide degradates in study areas where these herbicides likely are used.

During a second sampling phase from June 2004 to September 2005, source and finished water were sampled at 94 sites (Carter and others, 2007). Most of these source- and finished-water sample pairs (79) were from sites at which source water was sampled a second time. These 79 wells were selected for resampling source water and collecting a finished-water sample because several compounds were detected or compounds were detected at high concentrations in the first source-water sample. The source- and finished-water samples from these sites generally were analyzed by using the analytical methods that included the compounds detected in the first sample. Because relatively few compounds were detected in source-water samples collected during 2003 from the Denver Basin aquifer system, these sites were not sampled during the second phase, and thus, no finished-water samples were collected for these sites. Since 2005, the SWQA studies are now conducted in one sampling phase where both source water and finished water associated with 15 wells are sampled at the same time. All studies included in this report followed the two-phase sampling approach with the exception of the Rio Grande aquifer system.

Finished-water samples were collected following all of the treatment steps and prior to the water entering the distribution system. Finished-water samples typically contain free chlorine, which can degrade organic compounds that may be present in the samples. Therefore, a dechlorination reagent (ascorbic acid or sodium thiosulfate) and, for certain samples, pH buffers were added to finished-water samples during sample collection to "quench" free chlorine and stabilize the samples prior to analysis (Winslow and others, 2001). As a result, finished-water samples are considered to be representative of the quality of water prior to distribution but not necessarily representative of the quality of water at the tap. The additional contact time of the water with disinfectants in the distribution system may allow some compounds to be transformed or degraded, whereas other compounds, such as disinfection by-products, may continue to form in the distribution system.

## Analytical Methods

Samples were analyzed using USGS approved analytical methods at the USGS National Water Quality Laboratory (NWQL) in Denver, Colorado, including gas chromatography/mass spectrometry (GC/MS) and high-performance liquid chromatography/mass spectrometry (HPLC/MS). Samples for VOC analyses were chilled upon collection, and samples for one of the two VOC analytical methods was preserved with 1:1 hydrochloric acid. Samples for both VOC analytical methods were analyzed by purge and trap GC/MS (Connor and others, 1998; Rose and Sandstrom, 2003). Samples for analyses of pesticides and other semivolatile compounds were filtered in the field through a 0.7-micron baked glass-fiber filter and chilled. These samples were extracted at the NWQL on solid-phase extraction (SPE) cartridges to concentrate the analytes from the filtered samples. SPE cartridges then were eluted with a solvent, and the extracts were analyzed by either GC/MS or HPLC/MS methods (Zaugg and others, 1995, 2002; Lindley and others, 1996; Furlong and others, 2001; Sandstrom and others, 2001; Madsen and others, 2003). At a subset of sites, an additional sample was collected for the analysis of 3 herbicides and 16 herbicide degradates. These samples were analyzed using HPLC/MS by the Organic Geochemistry Research Group Laboratory (OGRL), in Lawrence, Kansas (Lee and Strahan, 2003).

The analytical methods used at the NWQL and OGRL allow for the identification and quantification of compounds at low concentrations, in some cases as low as a few parts per trillion. Each analytical method has different ranges in sensitivity for its suite of analytes. Thus, the laboratory reporting levels (LRLs) for the compounds analyzed for SWQAs span four orders of magnitude, from 0.003 to 6.0 micrograms per liter (µg/L) (Appendix 1) with a median of 0.06 µg/L. Some reported concentrations are qualified as estimated (indicated with an "E"), which means the identification of the compound is reliable, but the concentration has greater uncertainty than unqualified concentrations reported for the same compound. These concentrations are estimated for one of several reasons: (1) they are less than the lowest calibration standard; (2) the sample matrix interfered with measurement of the compound; (3) surrogates added to the sample indicated poor performance during the analysis; or (4) the compound consistently has poor recoveries, and therefore, concentrations are always reported as estimated.

The sensitivity of the analytical methods differs among compounds and can affect the detection frequencies of the compounds analyzed. Compounds with low LRLs likely will be detected more commonly than those with high reporting levels, given equal concentration distributions in the environment. In order to compare detection frequencies between compounds, a common assessment level is needed to account for the different LRLs. In this report, a common assessment level of 0.1 µg/L is used. This concentration is near the median LRL of 0.06 µg/L for all of the compounds analyzed. Analytical results for compounds detected in source water are presented both with and without an assessment level. Unless otherwise specified, no assessment level was used. When concentrations of individual compounds in source- and finished-water samples are compared, no assessment level is used and all concentrations are evaluated, including those qualified as estimated.

## Quality Assurance

Similar types and numbers of quality-control (QC) samples were collected in each of the study areas. These QC samples, including field blanks, replicates, and matrix spikes, were evaluated together because sampling equipment and cleaning procedures, as well as sample collection and processing, were the same for all sites. Field blanks were processed in the field in the same manner as environmental samples and consisted of nitrogen-purged organic-free blank water. Field-blank results are used to characterize the positive bias or contamination that may affect sample analytical results. Source-solution blanks, which also consisted of nitrogen-purged organic-free blank water, were analyzed for a subset of field blanks and analytical methods to assure the integrity of the water used for blanks. Replicate samples are used to characterize the amount of variability associated with sample collection, processing, and analysis. Matrix spikes provide information about recoveries of organic compounds.

The majority of the field-blank data did not indicate potential contamination that could bias the environmental data. Overall, 254 of the 277 compounds monitored either were not detected or were detected in less than 5 percent of field blanks. However, field blanks collected during this study indicated that some compounds potentially were affected by contamination that could bias the environmental data (table 3). Data for these compounds were removed from the dataset or results were censored to account for this potential bias as follows. Phenol and N,N-diethyl-*meta*-toluamide (DEET) were detected in 82 and 39 percent of field blanks, respectively, and were removed from the dataset because of pervasive contamination in field blanks. Although the field-blank data did not identify systematic error that affected sample results for these compounds, the quality of data for both compounds was unknown.

Three compounds—benzophenone, isophorone, and *para*-nonylphenol—were removed from the dataset because of systematic contamination from the "quenching" reagents added to finished-water samples (table 3). Most field blanks collected during the second phase of sampling included the ascorbic acid and buffer that were added to finished-water samples to quench the free chlorine. These three compounds were detected at low concentrations in most of the blanks, indicating that the "quenching" reagents are a source of contamination for the three compounds. Follow-up analyses by the NWQL confirmed the presence of these compounds in the buffer added to samples (Mark Sandstrom, U.S. Geological Survey, oral commun., 2005).

Nineteen additional compounds were detected in more than 5 percent of field blanks (table 3). The occurrence of these compounds in field blanks was evaluated to determine if potential bias was associated with specific SWQAs. If a compound was detected in 50 percent or more of field blanks from a SWQA, all of the data for that constituent from that SWQA were removed from the dataset. If a compound was detected in 5 percent or more of field blanks collected at the remaining sites, the environmental data for that compound were censored at the maximum field-blank concentration to account for the potential bias indicated by field blanks. If a compound was detected in less than 5 percent of the field blanks remaining after removal of the field blanks from SWQAs with greater than 50-percent occurrence, no additional censoring was done.

Twenty-one compounds were detected in less than 5 percent of field blanks and usually at concentrations less than the LRL (Appendix 1). Data for these compounds are included in this report because the potential for contamination in the environmental samples was considered to be low and did not affect the overall interpretation of the study.

Prior to implementation of the addition of ascorbic acid (quenching agent) to finished-water samples during the second phase of sampling, the NWQL evaluated the effect of this quenching agent and buffer on compound recoveries. Results indicated that recoveries were not affected by the addition of these reagents (Mark Sandstrom, U.S. Geological Survey, written commun., 2006). Additionally, during the second sampling phase, matrix spikes were collected to further characterize analytical method performance with the addition of ascorbic acid to finished-water samples. Results to date (2008) indicate that median spike recoveries generally were within acceptable limits for most compounds that are not always reported as estimated concentrations (Valder and others, 2008). Results of paired spiked finished-water samples, one with quenching reagents and the other without, indicate that several compounds degrade in the presence of free chlorine (Valder and others, 2008). These results highlight the fact that additional contact time of finished water in the distribution system would affect the concentrations of several compounds analyzed in this study. Environmental and selected quality-assurance data for this study are available in Carter and others (2007).

## Human-Health Benchmarks Used in a Screening-Level Assessment

Concentrations of regulated compounds—those with USEPA MCLs—were compared to MCLs, and concentrations of unregulated compounds—those without USEPA MCLs—were compared to Health-Based Screening Levels (HBSLs), when available (Toccalino, Norman, and others 2006). Comparisons to human-health benchmarks are used in this report to identify concentrations of potential human-health concern and to provide an initial perspective on the potential importance of the anthropogenic organic compounds detected. As of June 2008, 38 of the compounds monitored in this study have an established USEPA MCL (U.S. Environmental Protection Agency, 2006) and 112 have an HBSL (Toccalino and others, 2008). HBSLs have not been developed for the remaining 127 unregulated compounds because of a lack of toxicity information. Therefore, the potential human-health significance of these compounds cannot be evaluated at this time

**Table 3.** Summary of compounds detected in 5 percent or more of field blanks collected for Source Water-Quality Assessments, 2002–05.

[N, number of field blanks; USGS, U.S. Geological Survey; SWQAs, Source Water-Quality Assessments; µg/L, micrograms per liter; NA, not applicable]

| Compound (N) | USGS parameter code | Number of SWQAs for which compound was removed from all samples in the dataset | Number of detections censored at the maximum field-blank concentration | Maximum field-blank concentration (µg/L) |
|---|---|---|---|---|
| Compounds removed from dataset | | | | |
| Benzophenone (38) | 62067 | 15 | All data removed | 0.15 |
| Isophorone[1] | 34409 | 15 | All data removed | .006 |
| N,N-diethyl-*meta*-toluamide (DEET) (39) | 62082 | 15 | All data removed | 1.1 |
| *para*-Nonylphenol (total) (38) | 62085 | 15 | All data removed | 2.6 |
| Phenol (27) | 34466 | 15 | All data removed | 1.9 |
| Compounds removed from SWQA | | | | |
| 1,2,4-Trimethylbenzene (41) | 77222 | 2 | 0 | 0.036 |
| Alachlor ethane sulfonic acid (6) | 50009 | 1 | 0 | .03 |
| Benzene (41) | 34030 | 2 | 0 | .013 |
| Chlorobenzene (41) | 34301 | 1 | 0 | .028 |
| Chloroform (41) | 32106 | 3 | 0 | .198 |
| Ethylbenzene (41) | 34371 | 2 | 0 | .022 |
| *m*- and *p*-Xylene (41) | 85795 | 3 | 0 | .08 |
| Menthol (38) | 62080 | 1 | 0 | .043 |
| Methylene chloride (41) | 34423 | 2 | 0 | .094 |
| *o*-Xylene (41) | 77135 | 2 | 0 | .021 |
| Tri(2-butoxyethyl)phosphate (38) | 62093 | 1 | 0 | 2.8 |
| Triphenyl phosphate (38) | 62092 | 1 | 0 | .088 |
| Compounds removed from SWQA or censored at the maximum field-blank concentration | | | | |
| Acetone (41) | 81552 | 3 | 4 | 11.7 |
| Acetophenone (38) | 62064 | 2 | 1 | .3 |
| Caffeine (25) | 50305 | 3 | 2 | .004 |
| Carbon disulfide (41) | 77041 | 2 | 10 | .109 |
| Toluene (41) | 34010 | 6 | 6 | .05 |
| Compounds censored at the maximum field-blank concentration | | | | |
| Bisphenol A (34) | 62069 | NA | 19 | 0.94 |
| *p*-Cresol (38) | 62084 | NA | 2 | .013 |

[1]Detected in less than 5 percent of samples; however, the data were removed because of systematic contamination from reagents added to finished-water samples.

(Toccalino, Rowe, and Norman, 2006). These human-health benchmarks typically are concentrations in drinking water that are not anticipated to cause adverse effects from a lifetime of exposure (Toccalino, 2007; U.S. Environmental Protection Agency, 2008).

MCLs are legally enforceable USEPA drinking-water standards that set the maximum permissible level of a contaminant in water that is delivered by public water systems (U.S. Environmental Protection Agency, 2008). MCLs are applicable only to finished-water samples in the regulatory framework; however, an assessment of source-water concentrations in relation to benchmarks provides an indication to water-resource managers and CWSs of potential concerns in the absence of the effects of factors, such as water treatment and distribution.

HBSLs are benchmark concentrations of compounds in water that, if exceeded, may be of concern to human health. HBSLs are non-enforceable benchmarks that were developed by the USGS in collaboration with the USEPA and others using: (1) USEPA Office of Water methodologies for establishing drinking-water guidelines, and (2) the most recent, USEPA peer-reviewed, publicly available human-health toxicity information (Toccalino and others, 2003; Toccalino and others, 2006). As a result, HBSL values are equivalent to existing USEPA drinking-water guideline values, such as Lifetime Health Advisory and Cancer Risk Concentration values (when they exist), except for unregulated contaminants for which more recent toxicity information has become available (Toccalino, 2007).

Concentrations of compounds in single samples of both source water and finished water were compared to human-health benchmarks as a screening-level assessment. This comparison identifies compounds with concentrations that approached or were greater than benchmarks to aid in assessing their potential relevance to human health. For these comparisons, benchmark quotient (BQ) values—the ratio of a concentration of a compound to its benchmark—were calculated. A BQ value greater than 1 represents a concentration greater than a benchmark. A BQ value greater than 0.1 can be used to identify compounds that may warrant additional monitoring (Toccalino, Rowe, and Norman, 2006). A threshold BQ of 0.1 is consistent with various State and Federal practices (for example, see U.S. Environmental Protection Agency, 1998). Monitoring for these contaminants would enable analysis of trends in their occurrence and may provide an early indication if concentrations approach human-health benchmarks.

# Anthropogenic Organic Compounds in Source Water Used by Community Water Systems, 2002–05

Source-water samples were collected from 221 wells during October 2002 to September 2005. All samples were analyzed for 258 anthropogenic organic compounds, and samples from a subset of 73 wells were collected and analyzed for an additional 3 herbicides and 16 degradates in areas where these herbicides likely are used. Because these compounds were not monitored at all of the wells, the following characterization focuses on compounds that were monitored at all sites, and the 3 herbicides and 16 herbicide degradates are described separately.

More than one-half (138) of the 258 compounds monitored at all sites were not detected in any source-water samples (5 compounds were removed from the dataset because of data-quality concerns). Of the 120 compounds that were detected, 52 were detected only once (Appendix 1). Concentrations of compounds typically were less than 1 µg/L, and only 6 percent of the concentrations of detected compounds were greater than 1 µg/L. A variety of compounds were detected as indicated by the fact that at least two compounds from each of the 13 use groups in which the compounds were categorized were detected (Appendix 1). The laboratory analytical methods used in this study have detection levels that are commonly 100 to 1,000 times lower than State and Federal standards and guidelines for protecting water quality. Detections of these compounds do not necessarily indicate a concern to human health but rather help to identify emerging issues and track changes in occurrence and concentrations over time.

Detections of compounds in source water varied regionally, as shown by comparisons between wells located west of the Mississippi River (total of 117 wells) and those east of or near the Mississippi River (total of 104 wells; fig. 3); wells in Minnesota were included with wells east of the Mississippi River. Specifically, more compounds generally were detected per sample from wells in principal aquifers east of the Mississippi River than west of the Mississippi River (Kruskal-Wallis rank-sum test p-value = 0.0001; fig. 3*A*). Seventy-nine percent of samples from wells east of the Mississippi River had at least one compound detected and as many as 35 compounds (median = 3) detected in one sample. In contrast, 65 percent of samples from wells west of the Mississippi River had at least one compound detected and as many as 18 compounds (median = 1) detected in one sample. More herbicides and herbicide degradates were detected in samples from wells east

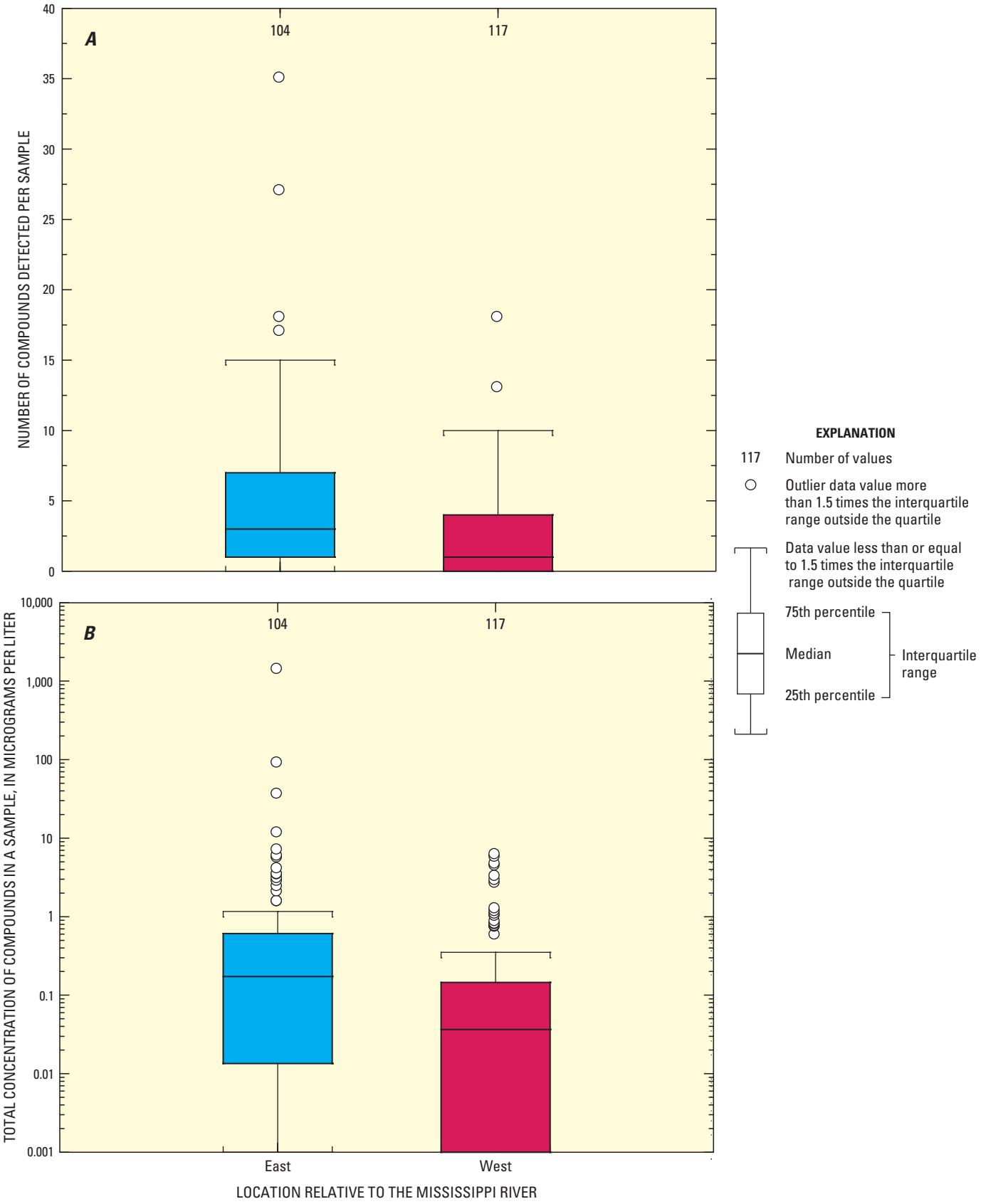



**Figure 3.** Source-water samples collected from wells east of the Mississippi River had *A*, more anthropogenic organic compounds detected; and *B*, greater total concentrations of compounds than did source-water samples collected from wells west of the Mississippi River during October 2002–July 2005.

of the Mississippi River than in samples from wells west of the Mississippi River. Some of the factors that may account for a larger number of detected compounds in the east include generally higher groundwater recharge rates, shallower well depths, shallower depths to groundwater, greater population densities, and a greater intensity of herbicide use in agricultural areas than in the west (Gilliom and others, 2006). The total concentrations of compounds detected in samples from wells east of the Mississippi River were greater (median of 0.172 µg/L) than those in the west (median of 0.036 µg/L; fig. 3*B*).

Compounds were characterized in this report as commonly occurring when they were detected in about 10 percent or more of samples using no assessment level. By this definition, 12 compounds were detected commonly (fig. 4; Appendix 1). The commonly detected compounds represented four of the use groups, including disinfection by-products; gasoline hydrocarbons, oxygenates, and oxygenate degradates; herbicides and herbicide degradates; and solvents.

## Commonly Detected Compounds

Most of the 258 compounds monitored at each site were detected infrequently; only 12 compounds were detected in about 10 percent or more of samples using no assessment level (fig. 4; Appendix 1). Chloroform, deethylatrazine (a degradate of atrazine), atrazine, and perchloroethene (PCE) were detected in about 20 percent or more of samples. Fewer compounds were detected when a common assessment level of 0.1 µg/L was used; only two compounds—chloroform and PCE—were detected in 10 percent or more of source-water samples (fig. 4). Detection frequencies of most of the other compounds were less than 5 percent when using a common assessment level. The smaller detection frequencies that were based on a common assessment level compared to using no assessment level illustrate the low concentrations at which many of these compounds were detected.

Samples from 5 of the 12 principal aquifers accounted for the majority of the detections of these compounds; the average detection frequencies for these 5 principal aquifers were greater than 20 percent and as large as 45 percent (table 4). Sampled wells in 4 of these 5 principal aquifers—the glacial deposits aquifer system, Central Valley aquifer system, High Plains aquifer, and Piedmont and Blue Ridge crystalline-rock aquifers—had the shallowest median well depths of the 12 aquifers (fig. 2*B*). Sampled wells in the fifth principal aquifer, the Edwards-Trinity aquifer system, were deeper and ranked 10 of 12 in median well depth.

Chloroform was the most commonly detected compound in this study and was detected in 36 percent of samples. Chloroform was detected in 8 of the 12 principal aquifers; chloroform was removed from the datasets for three of the SWQAs because of data-quality concerns (table 3) and was not detected in any wells in the Rio Grande aquifer system, which was the principal aquifer with wells with the second deepest median well depth (table 4; fig. 2*B*). In general, chloroform was detected more commonly in principal aquifers with the shallowest median well depths and less commonly in principal aquifers with the deepest median well depths. In samples from several of the principal aquifers, one or more additional disinfection by-products (DBPs)—bromodichloromethane, dibromochloromethane, and (or) bromoform—were detected when chloroform was detected. This co-occurrence indicates that recharge of chlorinated water to the aquifers is a possible source of chloroform and is consistent with previous findings from the NAWQA Program (Ivahnenko and Barbash, 2004; Ivahnenko and Zogorski, 2006). Potential sources of chloroform and other DBPs include chlorinated water used to irrigate lawns, golf courses, parks, gardens, and other areas; septic systems; regulated discharge of chlorinated waters to recharge facilities; and leakage of chlorinated water from swimming pools, spas, and distribution systems used for drinking water or wastewater sewers (Ivahnenko and Barbash, 2004).

One-half of the most commonly detected compounds were herbicides or herbicide degradates (table 4; fig. 4). The common detection of these compounds may be related to their widespread use, the large number of compounds analyzed in this use group compared to the other 12 use groups, and lower LRLs compared to other compounds (Appendix 1). Atrazine, simazine, prometon, and metolachlor have both agricultural and nonagricultural uses. Atrazine and metolachlor are two of the most heavily used agricultural herbicides with much of the use for corn production, but they also are used in urban areas (Gilliom and others, 2006). Simazine and prometon are used in nonagricultural areas for weed control and along rights-of-way, but simazine also is used for agriculture (Gilliom and other, 2006). Deethylatrazine, a degradate of atrazine, was detected more commonly than atrazine. Deisopropylatrazine, a degradate of both atrazine and simazine, was detected less commonly than either parent compound. Gilliom and others (2006) found that natural features, such as hydrogeology and soil characteristics, and agricultural management practices, such as irrigation and draining, are stronger factors than the influence of land use and pesticide use on the geographic distribution of pesticides in groundwater.

The remaining five commonly occurring compounds are in two use groups: gasoline hydrocarbons, oxygenates, and oxygenate degradates; and solvents (table 4; fig. 4). The gasoline oxygenate methyl *tert*-butyl ether (MTBE) was used voluntarily by refineries for the Nation's Reformulated Gasoline Program, and MTBE production peaked in the 1990s (Zogorski and others, 2006). In a national assessment of source waters used by CWSs, MTBE was one of the most commonly detected VOCs (Carter and others, 2006). Detections of MTBE in groundwater, after only being used since the 1990s, indicate how quickly mobile and persistent compounds can affect groundwater quality (Zogorski and others, 2006). Also, the occurrence of relatively recently introduced compounds in source water is a potential indicator of aquifer susceptibility because the presence of MTBE indicates that a component of recent recharge is contributing to a well.

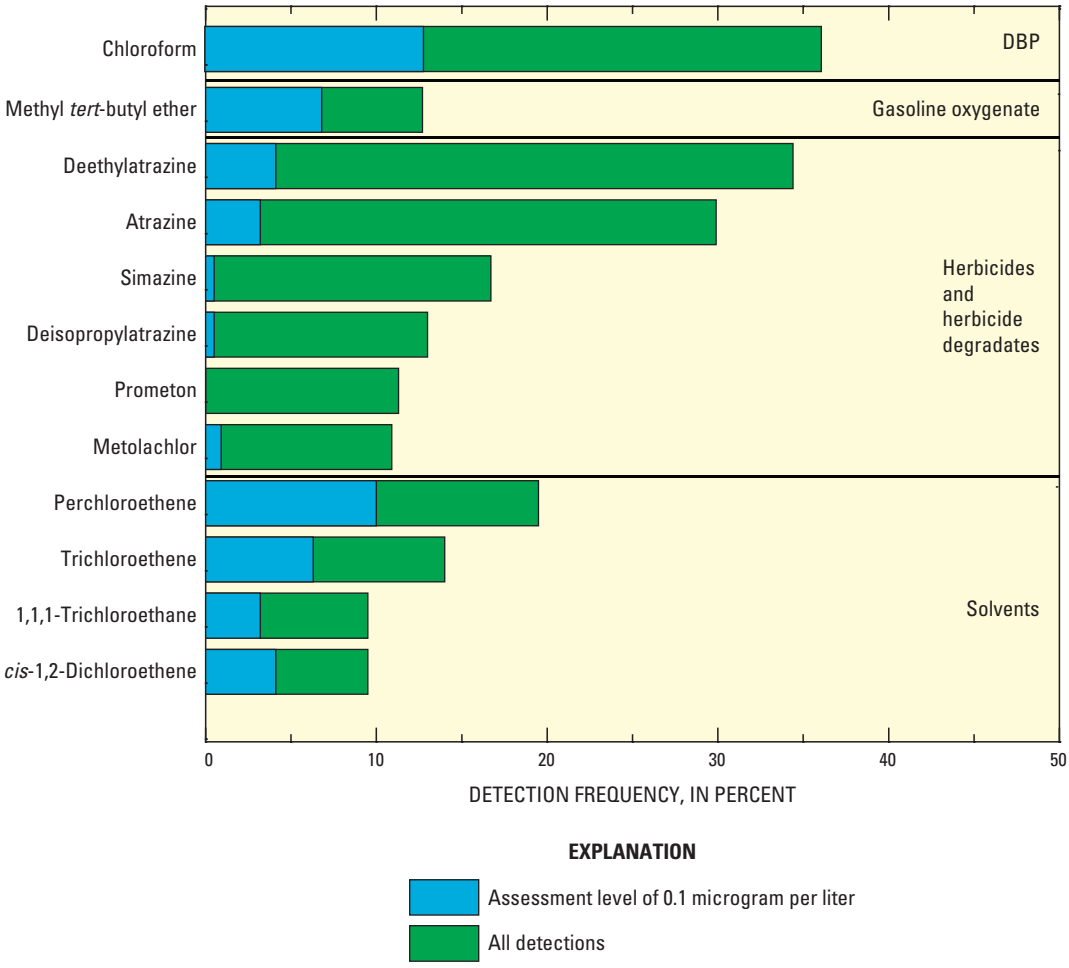



**Figure 4.** Twelve of 258 anthropogenic organic compounds analyzed at all sites were detected using no common assessment level in 10 percent or more of source-water samples collected from 221 community water system wells during October 2002–July 2005. Only two compounds were detected in 10 percent or more of samples when a common assessment level was used. [DBP, disinfection by-product; gasoline oxygenate is in the gasoline hydrocarbons, oxygenates, and oxygenate degradates use group.]

Four solvents—PCE, trichloroethene (TCE), *cis*-1,2-dichloroethene (*cis*-1,2-DCE), and 1,1,1-trichloroethane (1,1,1-TCA)—were detected commonly, and generally at higher concentrations than herbicides and herbicide degradates (Appendix 1). PCE was detected in all principal aquifers with the exception of wells in the Coastal Lowlands aquifer system (table 4), which had some of the deepest wells sampled in this study. The common occurrence of these solvents in groundwater is related to widespread use, relatively high solubility, and the fact that they are not readily degraded in groundwater, except under reducing conditions (Pankow and Cherry, 1996; Beek, 2001). Generally, two or more of these solvents were detected in the same sample. The co-occurrence of TCE and *cis*-1,2-DCE with PCE in some cases could be the result of degradation of PCE to these compounds. However, both TCE and *cis*-1,2-DCE have the potential to be primary contaminants because of their use in industrial and commercial settings. Determining whether the occurrence of these compounds is related to degradation or use is beyond the scope of this report.

The compounds detected in 10 percent or more of samples in this study generally correspond to those detected most commonly in groundwater across the country as part of the NAWQA Program, although detection frequencies generally were higher in this study than in previous NAWQA studies (fig. 5). Deethylatrazine, atrazine, simazine, prometon, and metolachlor were the most commonly detected pesticides in groundwater sampled by the NAWQA Program during 1992–2001 (fig. 5*A*; Gilliom and others, 2006). Similarly, chloroform, which was the most commonly detected compound in this study, also was the most commonly detected VOC in aquifers sampled by the NAWQA Program

**Table 4.** Detection frequencies of compounds detected in 10 percent or more of source-water samples by principal aquifer using no assessment level, October 2002–July 2005.

[Principal aquifers are listed in order of shallowest to deepest median well depth. Numbers in **bold** type indicate detection in more than 50 percent of samples. DBP, disinfection by-product; MTBE, methyl *tert*-butyl ether; --, data removed from dataset because of data-quality concerns; NA, not applicable]

| Principal aquifer | Average detection frequency of the 12 commonly detected compounds (percent) | DBP | Gasoline oxygenate | Herbicides and herbicide degradates | | | | | | Solvents | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Chloroform | MTBE | Deethylatrazine | Atrazine | Simazine | Deisopropylatrazine | Prometon | Metolachlor | Perchloroethene | Trichloroethene | *cis*-1,2-Dichloroethene | 1,1,1-Trichloroethane |
| Glacial deposits aquifer system | 27 | 43 | 32 | 36 | 30 | 30 | 16 | 25 | 14 | 27 | 30 | 14 | 36 |
| Central Valley aquifer system | 33 | **87** | 7 | **67** | **60** | **60** | **53** | 0 | 13 | 40 | 7 | 0 | 7 |
| High Plains aquifer | 21 | 20 | 0 | **60** | **60** | 13 | 13 | 0 | 13 | 27 | 27 | 13 | 0 |
| Piedmont and Blue Ridge crystalline-rock aquifers | [1]45 | -- | **67** | **100** | **80** | 33 | **54** | 27 | **73** | 20 | 13 | 7 | 20 |
| Cambrian-Ordovician aquifer system | 13 | 20 | 0 | 20 | 20 | 0 | 0 | 7 | 7 | 7 | 33 | 40 | 7 |
| Basin and Range basin-fill aquifers | 9 | 33 | 7 | 20 | 20 | 7 | 7 | 0 | 0 | 13 | 0 | 7 | 0 |
| Denver Basin aquifer system | [1]4 | -- | 8 | 8 | 8 | 0 | 0 | 8 | 0 | 8 | 0 | 0 | 0 |
| Floridan aquifer system | 13 | 43 | 3 | 33 | 23 | 13 | 7 | 17 | 0 | 13 | 3 | 3 | 0 |
| Columbia Plateau basin-fill and basaltic-rock aquifers | 8 | 27 | 0 | 7 | 13 | 7 | 0 | 7 | 7 | 7 | 7 | 13 | 0 |
| Edwards-Trinity aquifer system | 22 | **60** | 0 | **53** | 47 | 13 | 7 | 13 | 7 | **53** | 13 | 0 | 0 |
| Rio Grande aquifer system | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 13 | 13 | 0 |
| Coastal Lowlands aquifer system | 1 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Number of principal aquifers in which the compound was detected | NA | 9 | 6 | 10 | 10 | 8 | 7 | 7 | 7 | 11 | 9 | 8 | 4 |

[1]Average calculated using 11 compounds.

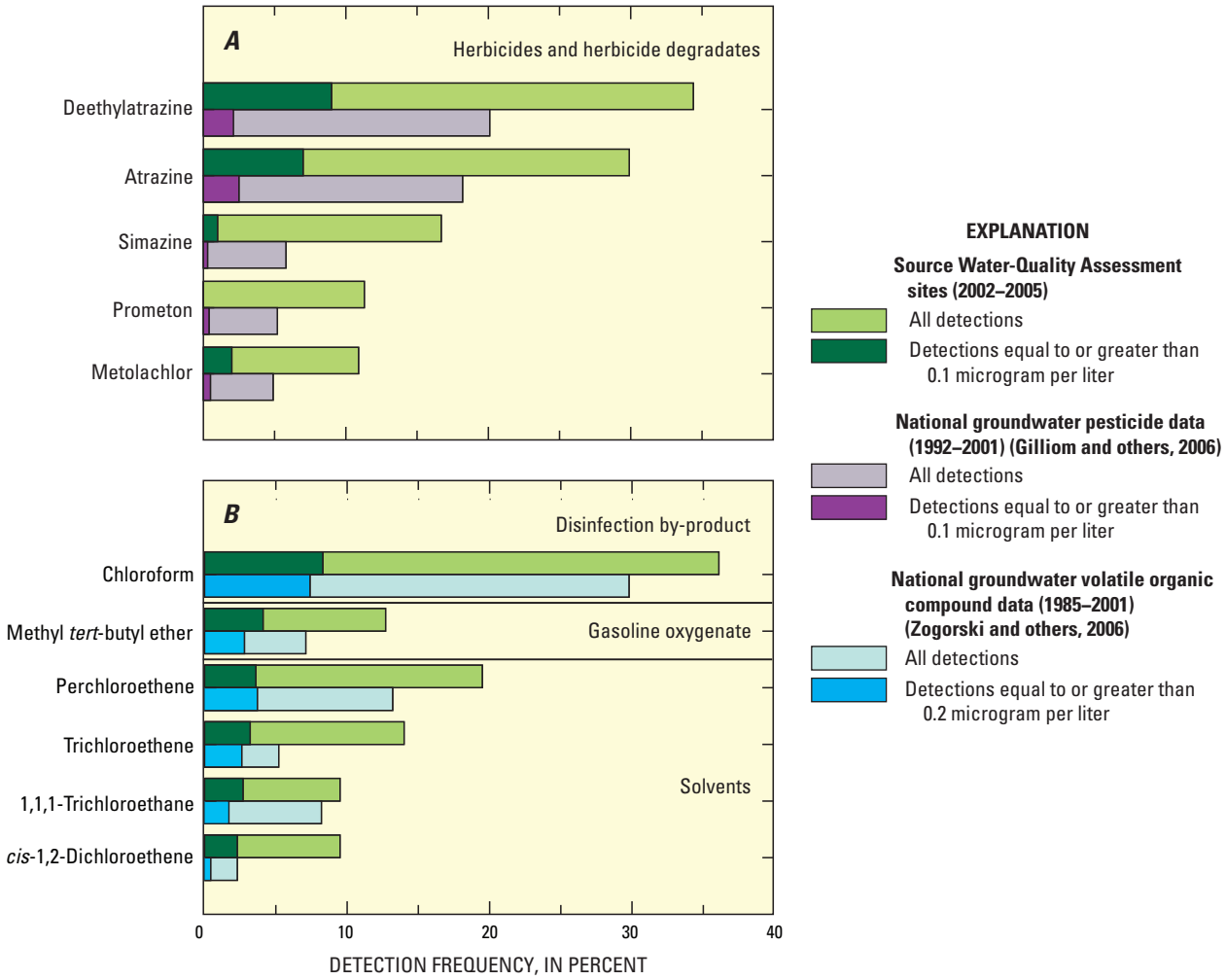



**Figure 5.** Similar compounds were detected but detection frequencies were greater for compounds detected commonly in source-water samples collected for Source Water-Quality Assessments during October 2002–July 2005 than in groundwater sampled for other National Water-Quality Assessment studies for *A*, herbicides and herbicide degradates; and *B*, the disinfection by-product chloroform, the gasoline oxygenate methyl *tert*-butyl ether, and solvents.

during 1985–2001 (Zogorski and others, 2006; fig. 5*B*) and in a national study of source water from CWSs that included groundwater and surface-water supplies (Grady, 2003). The compounds MTBE, PCE, TCE, and 1,1,1-TCA also were among the most commonly detected VOCs in aquifers sampled by the NAWQA Program (Zogorski and others, 2006; fig. 5*B*). Of the 12 commonly detected compounds in this study, *cis*-1,2-DCE is the only compound that was not among the most commonly detected VOCs in the national NAWQA VOC study during 1985–2001.

The higher detection frequencies for most of the commonly detected compounds in this study as compared to the detection frequencies in previous national studies (Gilliom and others, 2006; Zogorski and others, 2006; fig. 5) may be related to the type of wells sampled. Many of the wells sampled for the NAWQA Program were relatively low-capacity wells, such as domestic wells. The CWS wells sampled in this study are relatively high capacity and likely have larger contributing areas than do most domestic wells. Zogorski and others (2006) also observed larger detection frequencies in samples from public-supply wells than in samples from domestic wells.

## Herbicide Degradates at Selected Sites

Additional samples were collected from 73 wells in the Cambrian-Ordovician aquifer system, glacial deposits aquifer system, High Plains aquifer, Piedmont and Blue Ridge crystalline-rock aquifers, and Rio Grande aquifer system and analyzed for 3 herbicides and 16 degradates. These degradates were analyzed because parent herbicides had potential use in these study areas and because of the similar or greater persis-

tence of some degradates relative to the parent compound (Thurman and others, 1992; Kalkhoff and others, 1998).

Of the chloroacetanilide herbicides detected, alachlor and metolachlor degradates generally were detected more commonly, and summed degradate concentrations generally were greater than the parent herbicide concentration (fig. 6; Appendix 1). Acetochlor and its degradates were detected in a sample from one well. The summed degradate concentrations of the triazine herbicide atrazine generally were similar to or greater than atrazine concentrations (fig. 6). A similar relation was observed between concentrations of these same parent herbicides and their degradates in groundwater samples collected in the Upper Illinois River Basin (Groschen and others, 2004). These results highlight the fact that information on the occurrence and concentrations of degradates may be as important as information for the parent compound for some pesticides particularly if the degradate toxicity or mode of action is similar to that of the parent compound.

Acetochlor, alachlor, and metolachlor degradates do not have drinking-water standards but are listed on the USEPA drinking-water Contaminant Candidate List and are included in the Unregulated Contaminant Monitoring Program (U.S. Environmental Protection Agency, 2007a). The USEPA uses occurrence data along with information on health risks, analytical methods, and treatment technologies to determine

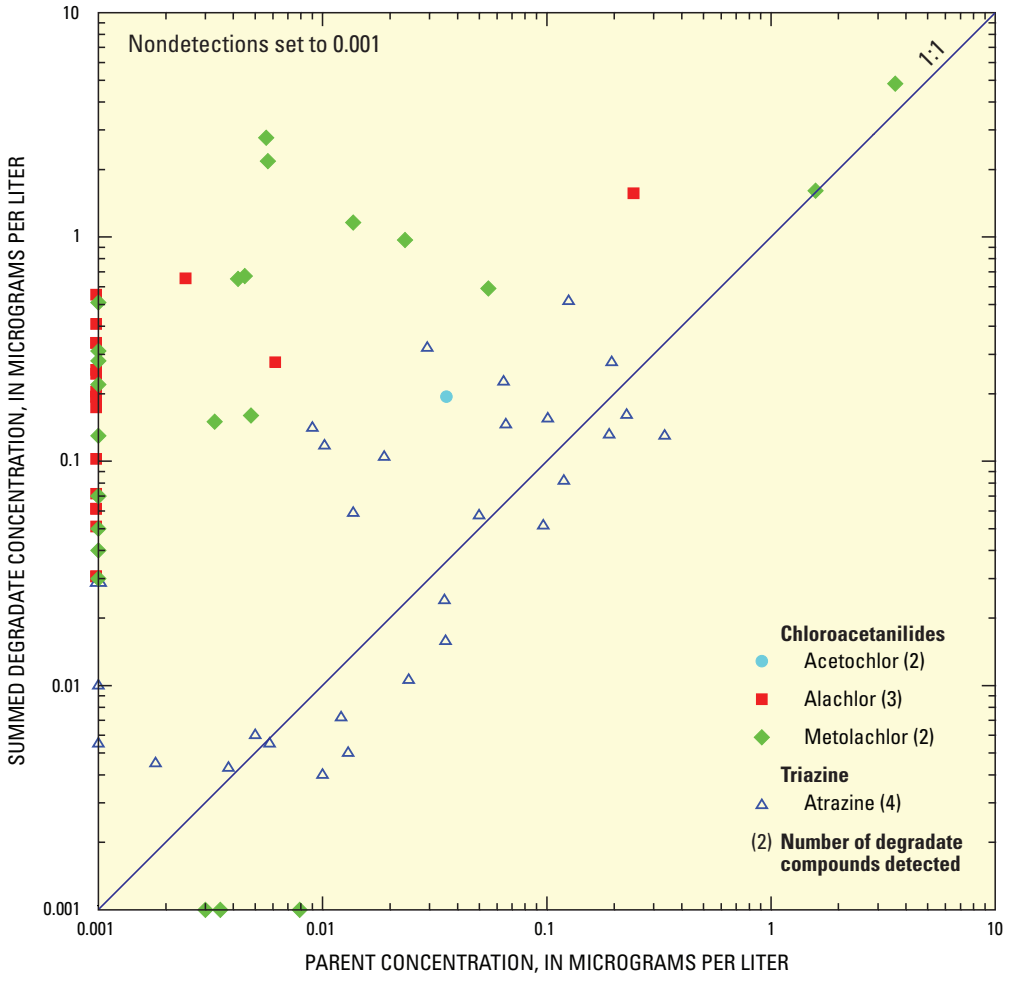



**Figure 6.** Summed concentrations of degradates generally were greater than concentrations of parent compounds for chloroacetanilide degradates and generally were similar to or greater than concentrations of parent compounds for triazine degradates in source-water samples collected October 2002–July 2005. [Sum of acetochlor degradates: acetochlor ethane sulfonic acid and acetochlor oxanilic acid; alachlor degradates: alachlor ethane sulfonic acid, alachlor ethane sulfonic acid 2nd amide, and alachlor oxanilic acid; metolachlor degradates: metolachlor ethane sulfonic acid and metolachlor oxanilic acid; atrazine degradates: deethylatrazine, deisopropylatrazine, 2-hydroxyatrazine, and deethyldeisopropylatrazine.]

whether any of the listed pesticide degradates are candidates for future drinking-water standards.

## Comparison to Human-Health Benchmarks

About one-half of the compounds detected in source water have a human-health benchmark to which concentrations in samples can be compared. Concentrations of compounds in source water were compared to human-health benchmarks, as part of a screening level assessment; however, MCLs are not directly applicable to source-water samples. Five compounds (1,2-dibromoethane, dieldrin, acrylonitrile, PCE, and TCE) were detected in source water at concentrations greater than their applicable human-health benchmark (BQ values greater than 1; Appendix 1). BQ values for all other detected compounds were one or more orders of magnitude less than 1, and 84 percent of the concentrations had BQ values that were two or more orders of magnitude less than 1.

Seven of the 12 commonly detected compounds have MCLs and two have HBSLs to which concentrations in samples were compared. Of these commonly detected compounds, only PCE and TCE were detected in samples at concentrations greater than the human-health benchmark (one sample for PCE and two samples for TCE; fig. 7). Although PCE and TCE were detected in more than 10 percent of the samples, few of the measured concentrations were within an order of magnitude of the MCL (BQ values greater than 0.1; fig. 7).

Concentrations of those compounds commonly detected that have human-health benchmarks generally are not high enough to be of human-health concern as individual contaminants. All chloroform concentrations and all summed trihalomethane (THM) concentrations were less than the 80 µg/L MCL for the sum of chloroform, bromodichloromethane, dibromochloromethane, and bromoform. All herbicide concentrations were less than their applicable human-health benchmark; only one atrazine concentration was within an order of magnitude of the MCL (fig. 7). The commonly detected herbicide degradates deethylatrazine and deisopropylatrazine do not have human-health benchmarks. The summed concentrations of atrazine and its chlorinated degradates were less than the MCL of 3 µg/L in all samples.

The gasoline oxygenate MTBE does not have a human-health benchmark; however, the USEPA Office of Water placed MTBE on the Contaminant Candidate List for further evaluation to determine whether a drinking-water standard should be established (U.S. Environmental Protection Agency, 2007b). MTBE is included in the Unregulated Contaminant Monitoring Program (U.S. Environmental Protection Agency, 2007a), which requires large public water systems and a selection of small and medium public water systems to monitor for selected compounds in their water supplies. The greatest measured concentration of MTBE (1.88 µg/L) was considerably less than the lower control level of 20 µg/L recommended by USEPA in 1997 to prevent taste and odor effects (U.S. Environmental Protection Agency, 1997).

Concentrations of compounds that were not detected commonly also were less than applicable human-health benchmarks in most samples (Appendix 1). Three compounds—1,2-dibromoethane, dieldrin, and acrylonitrile—were each detected once at concentrations greater than their human-health benchmark (BQ values greater than 1). The MCL for 1,2-dibromoethane is 0.05 µg/L, and the reported concentration was 0.072 µg/L. Dieldrin and acrylonitrile both have HBSLs with relatively low concentrations of 0.002 µg/L and 0.06 µg/L, respectively, and had reported concentrations of 0.024 µg/L and 0.504 µg/L, respectively (Appendix 1). Five compounds—benzene, alachlor, vinyl chloride, 1,1-dichloroethene, and carbon tetrachloride—were each detected once at concentrations within an order of magnitude of their human-health benchmark (BQ values greater than 0.1).

## Mixtures of Compounds

Mixtures can occur in groundwater because of the persistence of compounds, presence of parent compounds and their degradates, co-occurrence of compounds in the source material such as gasoline, and widespread use and overlapping sources of compounds (Squillace and others, 2002). The potential human-health effects of mixtures of organic compounds are largely unknown and have not been extensively studied. The effect of one compound on another's toxicity may be additive, antagonistic (one compound may lessen the effect of another), or synergistic; much of the growing concern about exposure to mixtures of compounds is related to the potential for synergistic effects (Carpenter and others, 2002). Synergism is when the effect of exposure to a mixture is greater than, or different from, the additive effect of the compounds. Drinking-water standards (MCLs) and other human-health benchmarks generally are based on toxicity data for individual compounds, and the effects of specific mixtures of compounds at low levels are not well understood. With a few exceptions for pesticides with common modes of action, human-health benchmarks generally are not available for specific mixtures. Continued research is needed on potential toxicity of such compound mixtures, and evaluation of the potential effects of mixtures is an increasingly important component of the risk assessment methods used by the USEPA, the Agency for Toxic Substances and Disease Registry (2004), and other agencies.

Although concentrations at which most compounds were detected were relatively low (less than 1 µg/L) and concentrations greater than the human-health benchmark were uncommon, 55 percent of the source-water samples contained mixtures of two or more compounds (fig. 8). The most common mixtures included those compounds detected most commonly, such as chloroform, MTBE, herbicides and herbicide degradates, and solvents.

Mixtures occurred more commonly, and with greater numbers of compounds, in samples from shallow wells than in

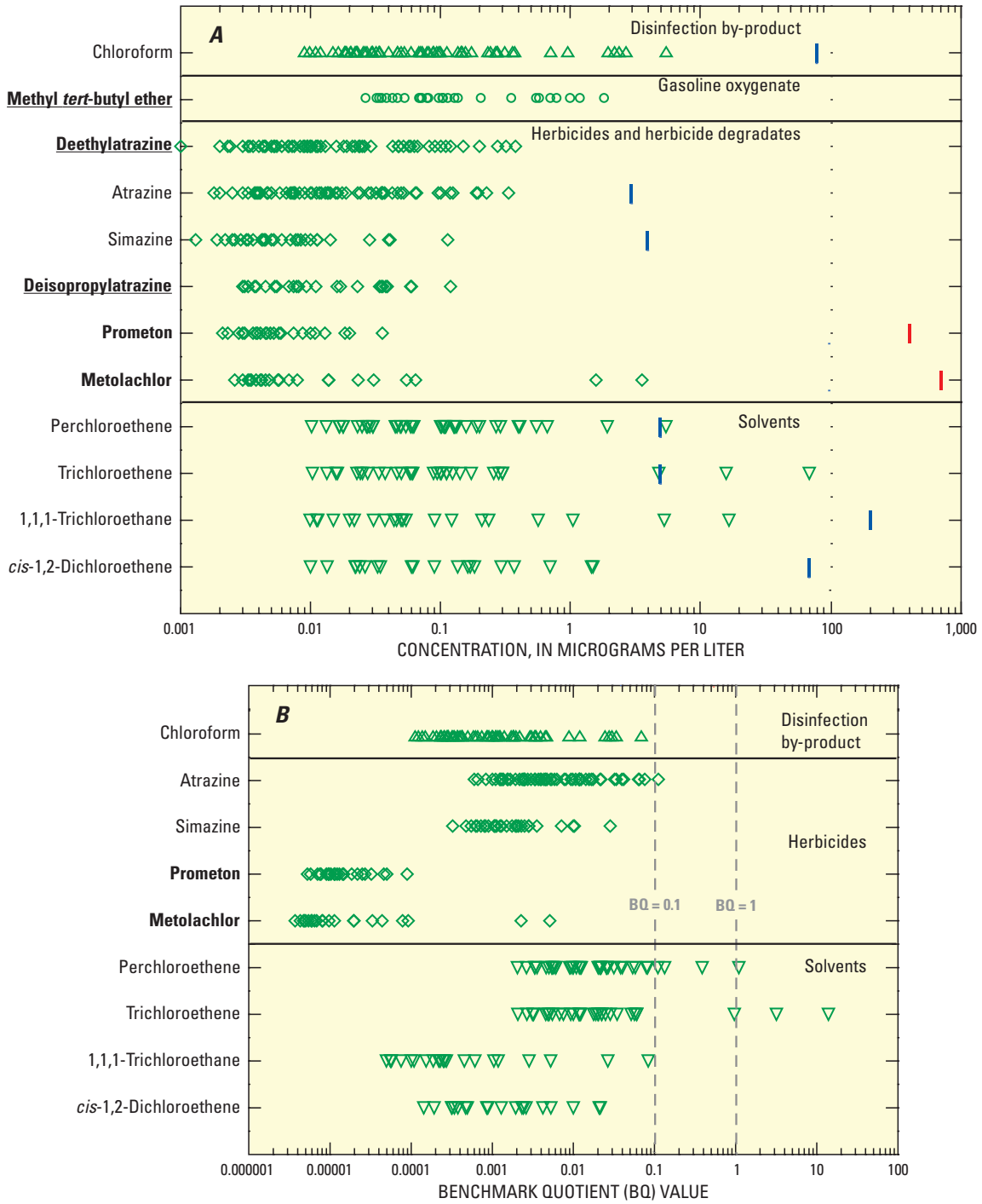



**Figure 7.** Concentrations of commonly detected compounds were *A*, generally less than 1 microgram per liter; and *B*, generally much less than one-tenth of human-health benchmarks for samples collected October 2002–July 2005.

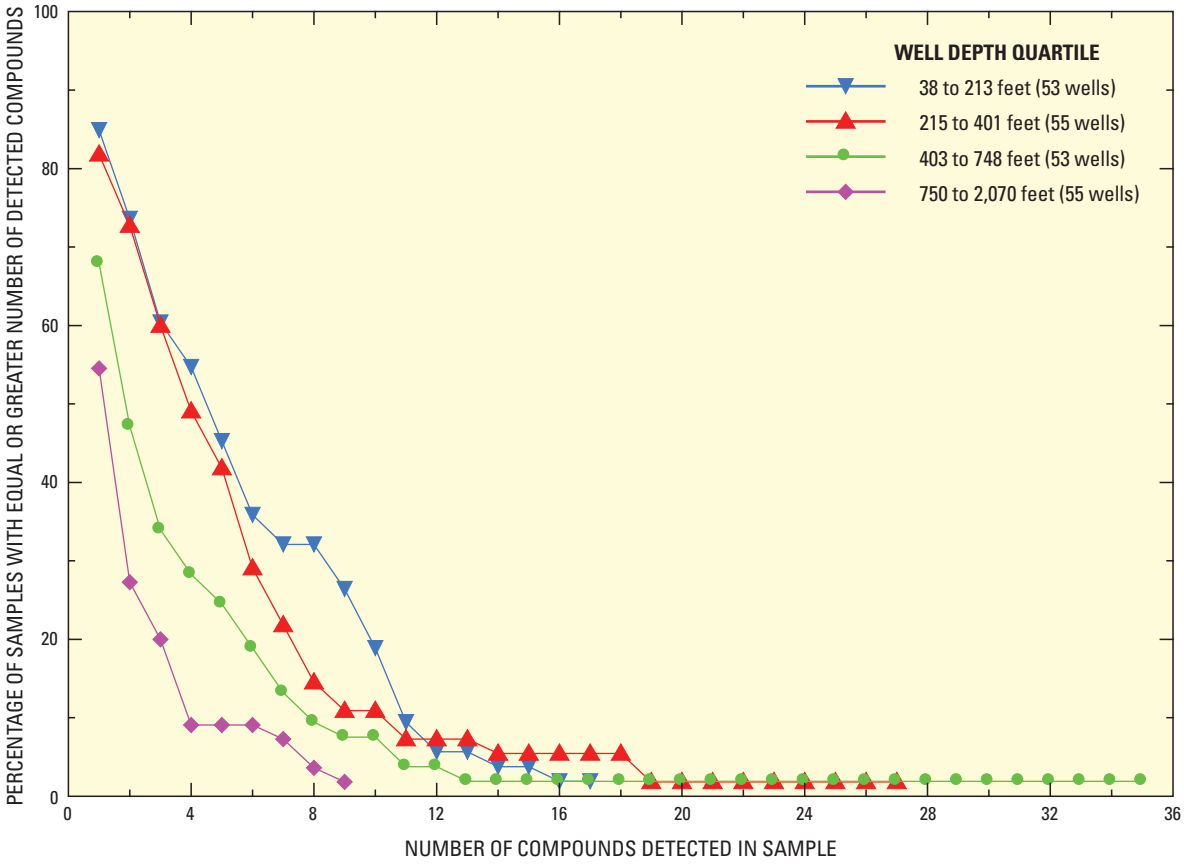



**Figure 8.** The number of anthropogenic organic compounds detected as mixtures in source-water samples collected during October 2002–July 2005 generally was greater in source water from shallow wells than from deep wells.

samples from deep wells (fig. 8). Wells were divided into four groups using well depth quartiles. Two or more compounds were detected in 74 and 73 percent of the samples from the two shallowest groups of wells (38–213 ft and 215–401 ft, respectively; fig. 8). Two or more compounds were detected in 47 and 27 percent of the samples from wells in the two deepest groups (403–748 ft and 750–2,070 ft, respectively). For the well groups with depths less than about 750 ft, a similar percentage of wells (4–9 percent) had 11 or more compounds detected in a sample (fig. 8). The maximum number of compounds in a sample from the deepest wells (750 ft and greater) was nine (fig. 8).

The common co-occurrence of organic compounds in source waters as mixtures indicates a need to better understand which specific combinations of compounds occur most commonly and which mixtures may be a potential concern for human health. Identification of specific combinations of compounds would provide perspective on patterns of co-occurrence that may be important as more is learned about sources and potential health effects of mixtures. These are important research topics for the future, but are beyond the scope of this report.

## Factors that May Affect Source-Water Quality

Many different factors may affect the occurrence of the anthropogenic organic compounds monitored in this study. Some of the most important factors likely related to source-water quality include the use of a compound in the contributing area of the well, pumping capacity of the well, recharge, average groundwater residence time, and aquifer geochemistry. A detailed evaluation of these factors was beyond the scope of this study. A general characterization of the occurrence of commonly detected compounds with respect to factors such as well depth and aquifer lithology helps to put the results into context and explain some of the differences in the occurrence of compounds among sites.

The occurrence of the 12 most commonly detected compounds was associated with well depth (Kruskal-Wallis rank-sum test p-value < 0.0001; fig. 9). One or more of the 12 most commonly detected compounds were found in 77 percent of samples from the shallowest well group (38–213 ft), and the occurrence decreased to 29 percent of samples from the deepest well group (750–2,070 ft; fig. 9*A*). Similarly, the number of compounds in a sample generally decreased as well depth increased (fig. 9*B*). No compounds

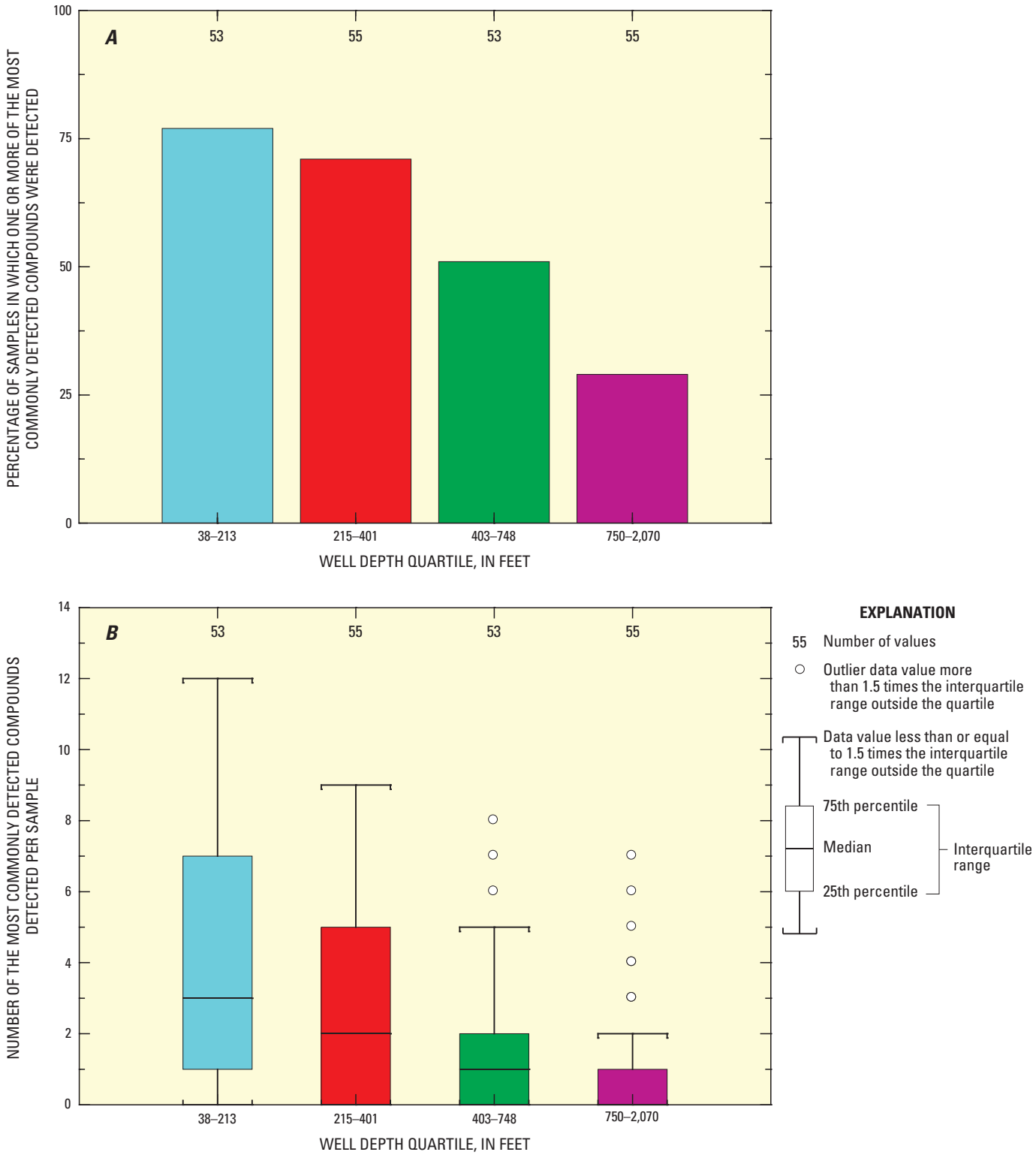



**Figure 9.** The 12 most commonly detected compounds had *A*, greater detection frequencies; and *B*, greater numbers of compounds detected in source-water samples from shallower wells than from deeper wells during October 2002–July 2005.

were detected in samples from one-half of the wells in the deepest well group. The more common occurrence of compounds in samples from shallow wells than deep wells likely is a result of shorter average groundwater residence times in shallow wells.

Large differences in the occurrence of the 12 most commonly detected compounds generally were not attributable to aquifer lithology. Wells were divided into four lithology groups. Most samples from all four lithology groups contained fewer than three of the most commonly detected compounds (fig. 10). The number of compounds detected was significantly different between the sandstone and carbonate rocks group and the other three lithology groups (Kruskal-Wallis rank-sum test p-value = 0.02), and one-half of the samples from the sandstone and carbonate rocks group did not have a detection of any commonly detected compound. Wells in this lithology group, however, include some of the deepest wells that were sampled; one-half of the sampled wells are deeper than 548 ft

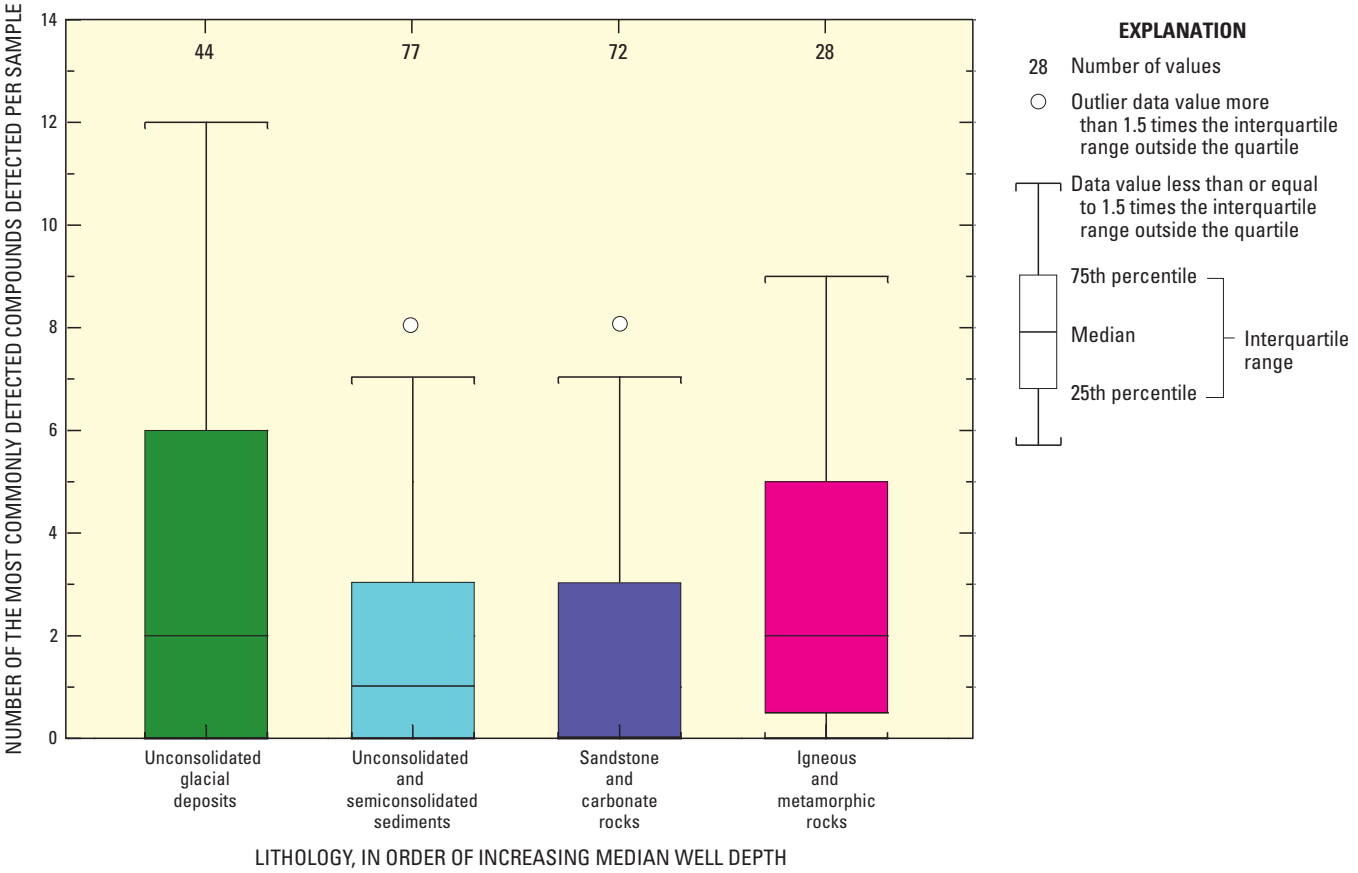



**Figure 10.** Large differences in occurrence of the 12 most commonly detected compounds were not attributable to aquifer lithology although fewer compounds generally were detected in source-water samples from wells completed in sandstone and carbonate rocks than from wells completed in other lithology groups. Most samples collected during October 2002–July 2005 contained fewer than three compounds for each of the four lithology groups.

and the deepest well is 1,800 ft (fig. 2*A*). Samples from wells completed in unconsolidated glacial deposits generally had the largest number of detections (fig. 10), but these wells were among the shallowest sampled (median well depth of 124 ft).

# Comparisons of Selected Organic Compounds in Source Water and Finished Water Sampled in 2004 and 2005

In addition to characterizing the occurrence of these compounds in source water, a secondary purpose of this report is to provide comparisons of selected compounds in source water with their occurrence in finished water (water that has passed through treatment processes but prior to distribution). During June 2004–September 2005, samples of source water and finished water were collected from 94 wells. Sampling of most (79) of these wells during this timeframe generally focused on analytical suites that included compounds found to occur most commonly or at relatively high concentrations during the initial source-water sampling from October 2002 to July 2005. The remaining 15 sites were those in the Rio Grande aquifer system, where source-water samples were only collected one time, and all samples (both source and finished) were analyzed for all 258 compounds plus the additional 3 herbicides and 16 herbicide degradates. The source-water results for wells in the Rio Grande aquifer system were included in the source-water characterization presented previously for 2002–05 and are included in this section along with the associated finished-water results. In general, the number of compounds analyzed in most source- and finished-water samples was less than the 258 compounds that were analyzed in all source-water samples during 2002–05. As a result of the more targeted sampling, the detection frequencies of compounds in source water would be expected to be greater than during the previous sampling. Finished-water samples were analyzed for the same compounds that were analyzed for in the associated source-water samples.

Finished-water samples were collected following all water-treatment processes and before the water entered the distribution system at each CWS. Finished-water samples from 34 CWS wells were not blended with water from other wells prior to distribution; however, 60 finished-water samples represented water blended with water from one or more wells at the CWS. In either case, only one well was sampled for source-water characterization. Differences in occurrence and concentrations of compounds between source and finished water might be expected for blended finished-water samples because of dilution or addition of compounds from wells not monitored. Other possible factors, in addition to blending, that could cause differences in occurrence between source- and finished-water samples include inadequate time allowed between collecting source- and finished-water samples, the inadvertent addition of compounds in finished water from pipes and other plumbing, treatment-plant maintenance, volatilization, or potential analytical variability associated with low concentrations at or near LRLs.

The comparison of source- and finished-water samples in this report is not intended as an evaluation of water-treatment efficacy at CWSs, which would require precise timing of sampling at different stages of water treatment; rather, the results represent an initial assessment of whether compounds present in source water also are present in finished water. The CWSs sampled generally are typical of many systems across the Nation where chlorine disinfection is the primary water-treatment process used. It is important to note that, in general, disinfection is not designed to remove the organic compounds detected in this study. However, when source water is known to contain regulated compounds at concentrations near or greater than an MCL, CWSs may blend with cleaner water sources or use additional water treatment, such as granular activated carbon or air-stripping towers, to remove organic compounds.

The formation of disinfection by-products as a result of the disinfection of drinking water is well documented (Rook, 1974). Disinfection by-products include, for example, the THMs chloroform, bromodichloromethane, dibromochloromethane, and bromoform. Other common disinfection by-products include chlorate, chloral hydrate, haloacetic acids, and haloacetonitriles; however, these other disinfection by-products were not monitored in this study. Disinfection by-products form when organic matter in source water reacts with the added disinfectant used to protect the drinking supply against water-borne pathogens such as *Escherichia coli* and *Norovirus*. Consequently, concentrations of THMs are expected to be greater in finished water than in source water.

Finished-water samples were "quenched" with ascorbic acid at the time of sample collection to scavenge the free chlorine that might react with any compounds present in the sample. Therefore, finished-water data are not necessarily representative of drinking-water quality at the tap (or point of delivery) because additional contact time with free chlorine in the distribution system may change concentrations of some of the constituents detected in the finished water at the sample collection point.

## Commonly Detected Compounds

When all compounds from the 2004–05 sampling of source water and finished water are considered, 99 compounds were detected. Of these 99 compounds, 84 compounds were detected in source water and 75 compounds were detected in finished water; however, 33 and 24 of those compounds, respectively, were detected only once. Thirty-one compounds were detected commonly (defined as detected in 10 percent or more of samples) in either source- or finished-water samples (table 5). The majority of these compounds were in the herbicide and herbicide degradates and solvents use

**Table 5.** Detection frequency of compounds detected in 10 percent or more of source- and (or) finished-water samples collected during June 2004–September 2005.

[**Bold** type indicates compounds that were detected commonly in samples collected during October 2002–July 2005. ND, not detected]

| Compound (number of source-water samples/number of finished-water samples) | Detection frequency (percent) | |
|---|---|---|
| | Source water | Finished water |
| Disinfection by-products | | |
| Bromodichloromethane (71/71) | 13 | 79 |
| Bromoform (71/71) | 7.0 | 62 |
| **Chloroform (56/56)** | 57 | 88 |
| Dibromochloromethane (71/71) | 7.0 | 72 |
| Fumigant-related compound | | |
| 1,4-Dichlorobenzene (71/71) | 11 | 11 |
| Gasoline hydrocarbons, oxygenates, and oxygenate degradates | | |
| *m*- and *p*-Xylene (64/64) | ND | 14 |
| **Methyl *tert*-butyl ether (71/71)** | 16 | 16 |
| Herbicides and herbicide degradates | | |
| 2-Hydroxyatrazine (61/59) | 28 | 29 |
| Acetochlor ethane sulfonic acid (32/32) | 19 | 19 |
| Acetochlor oxanilic acid (32/32) | 9.4 | 19 |
| Acetochlor/metolachlor ethane sulfonic acid 2nd amide (32/32) | 3.1 | 13 |
| Alachlor ethane sulfonic acid (17/17) | 77 | 77 |
| Alachlor ethane sulfonic acid 2nd amide (32/32) | 13 | 13 |
| Alachlor oxanilic acid (32/32) | 25 | 28 |
| **Atrazine (66/66)** | 59 | 55 |
| Bentazon (61/59) | 13 | 6.8 |
| **Deethylatrazine (66/66)** | 56 | 53 |
| **Deisopropylatrazine (61/59)** | 31 | 20 |
| **Metolachlor (64/65)** | 13 | 11 |
| Metolachlor ethane sulfonic acid (32/32) | 47 | 41 |
| Metolachlor oxanilic acid (32/32) | 38 | 34 |
| Metsulfuron methyl (61/59) | ND | 12 |
| **Prometon (61/62)** | 25 | 19 |
| **Simazine (48/48)** | 46 | 46 |
| Manufacturing additive | | |
| Triphenyl phosphate (53/55) | 1.9 | 20 |
| Solvents | | |
| **1,1,1-Trichloroethane (71/71)** | 20 | 14 |
| 1,1-Dichloroethane (71/71) | 13 | 8.5 |
| 1,1-Dichloroethene (71/71) | 11 | 8.5 |
| ***cis*-1,2-Dichloroethene (71/71)** | 20 | 18 |
| **Perchloroethene (71/71)** | 39 | 37 |
| **Trichloroethene (71/71)** | 27 | 23 |

groups. Detection frequencies of all compounds detected in source or finished water are summarized in Appendix 3. The characterization of results in this section of the report focuses on the 31 commonly detected compounds because relatively little information can be inferred from compounds that were detected in only a few samples.

In general, the 12 compounds that were detected commonly in source water during the October 2002–July 2005 sampling also were detected commonly in source water during the June 2004–September 2005 sampling and at greater detection frequencies (table 5; Appendix 1). Nineteen additional compounds were detected in more than 10 percent of either source- or finished-water samples (table 5). This, however, is to be expected based on the well selection strategy followed for the 2004–05 source- and finished-water sampling for this study, which focused on wells that had samples with compounds detected commonly or at large concentrations during the initial (2002–05) source-water sampling. Two compounds, *m*- and *p*-xylene and metsulfuron methyl, were detected only in finished water. However, detection of *m*- and *p*-xylene and metsulfuron methyl was primarily in blended finished-water samples (6 of 9 samples and 6 of 7 samples, respectively). The occurrence of these compounds primarily in blended finished-water samples may be the result of their presence in water from wells that were not sampled as part of this study.

With the exception of the disinfection by-products, detection frequencies of most (17) of the commonly detected compounds were similar (difference of 5 percent or less) between source water and finished water (table 5), even though 60 of the 94 finished-water samples were from CWSs that blend water. For the eight compounds with detection frequencies in finished water that differed by 6 percent or more from detection frequencies in source water, about two-thirds of the sites were CWSs with blended finished water. The detection frequencies for bentazon differed by 6 percent between source and finished water; however, all of these finished-water samples were nonblended. The four THMs were detected in source water, but detection frequencies were much greater in finished water. Chloroform was the most commonly detected disinfection by-product in finished water (88 percent), followed by bromodichloromethane (79 percent), dibromochloromethane (72 percent), and bromoform (62 percent; table 5).

## Comparison to Human-Health Benchmarks

Concentrations of all compounds commonly detected in finished water were less than their human-health benchmarks. More than one-half of the commonly detected compounds have a human-health benchmark to which concentrations were compared; 13 compounds have an MCL and 5 compounds have an HBSL (fig. 11). Eight of the commonly detected compounds (1,4-dichlorobenzene, *m*- and *p*-xylene, 2-hydroxyatrazine, bentazon, metolachlor, metsulfuron methyl, prometon, and 1,1,1-TCA) had finished-water concentrations that were two to six orders of magnitude less than the human-heath benchmarks. Concentrations of compounds detected in fewer than 10 percent of finished-water samples were more than an order of magnitude less than their applicable benchmarks (BQ values of 0.1 or less; Appendix 1).

Concentrations of disinfection by-products were expected to increase in finished water relative to source water because of disinfection. The MCL for total THMs is 80 µg/L, and summed concentrations were less than this benchmark in finished water from all wells sampled (fig. 11; Appendix 1). The concentrations of total THMs were within an order of magnitude (BQ values greater than 0.1) of the MCL in finished water from nine sites, but only three detections of chloroform and one detection of bromoform were within an order of magnitude of the MCL (fig. 11; Appendix 3). The solvents PCE (two detections) and TCE (one detection) were the only other compounds detected in finished water at concentrations within an order of magnitude of the MCL.

## Comparison of Source- and Finished-Water Quality

Finished water from 60 of the source-water sites included in this study consisted of a blend of water from the sampled source-water well and from one or more additional wells located in the well field. The blending of water from additional wells complicates the comparison of occurrence of compounds between source water and the associated finished water. Source and blended finished water are compared using no assessment level to generally characterize how occurrence in samples from CWSs that blend water may differ from systems that do not blend water. The comparisons of occurrence between source and finished water are not intended to be an evaluation of water-treatment efficacy at CWSs. Rather, the results characterize the extent to which compounds present in source water also are present in finished water. Disinfection by-products are not included in the following sections comparing source- and finished-water quality; however, they are included in the discussion of mixtures.

### Nonblended Finished Water

Sixty-six compounds were detected in source- and (or) finished-water samples from the 34 sites where finished water was not blended with other source water. Of these 66 compounds, 51 were detected in at least one source-water sample and 49 were detected in at least one finished-water sample. Some compounds were detected only one time; 15 compounds were detected one time in source water only and 12 compounds were detected one time in finished water only. Relatively little information can be inferred from compounds that were detected only once in either source or finished water.

More than one-half (57 percent) of the detections were in both source and finished water, and the concentrations were similar (fig. 12). The difference in concentrations

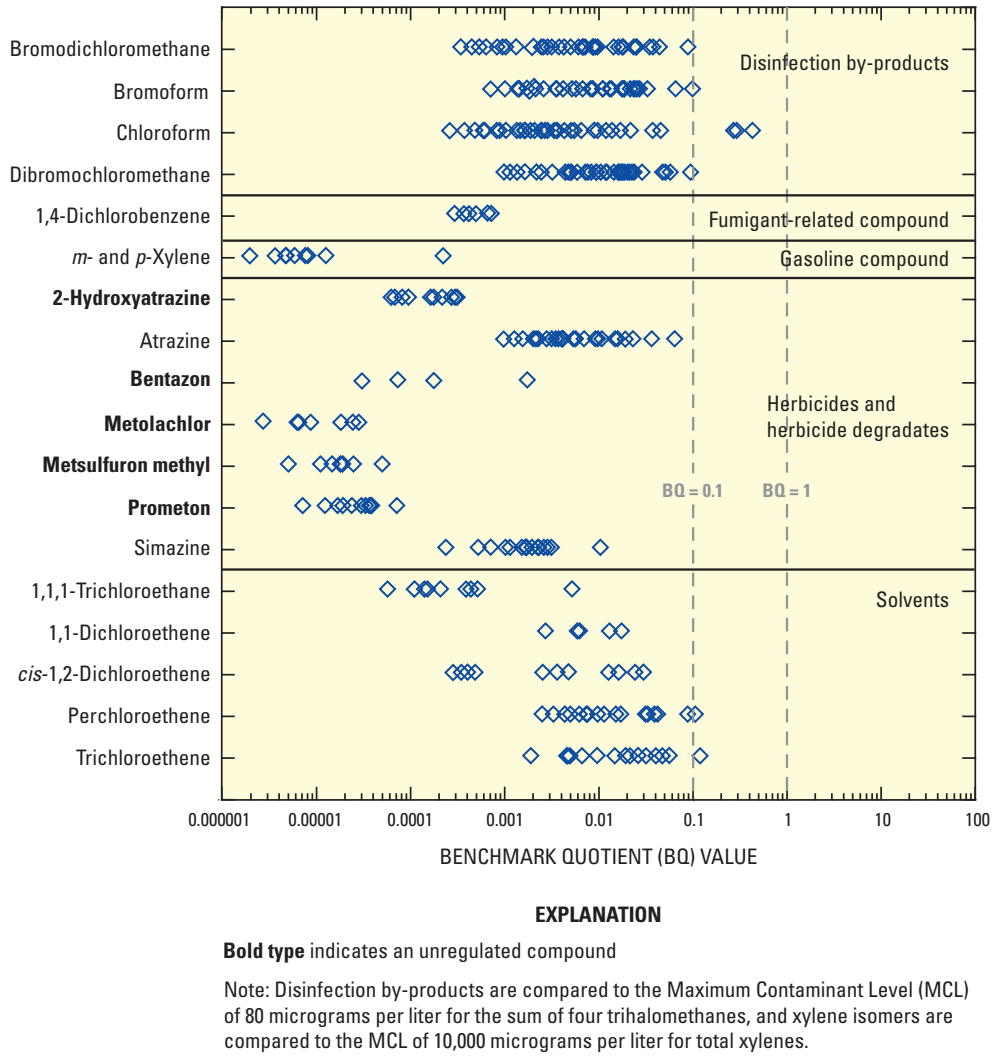



**Figure 11.** Concentrations of commonly detected anthropogenic organic compounds were less than human-health benchmarks in finished-water samples collected during June 2004–September 2005.

generally was less than 50 percent with a median difference of 13 percent. Most of the detections in both source and finished water were for gasoline-related compounds (gasoline hydrocarbons, oxygenates, and oxygenate degradates), herbicides and herbicide degradates, and solvents (fig. 12).

In some cases where compounds were present in both source and finished water, concentrations were much lower (percentage difference greater than 100) in finished water than in source water (fig. 12). For example, three solvents—1,1,1-TCA, PCE, and TCE, which were detected in source water at concentrations greater than 3 µg/L—had concentrations less than 1 µg/L in finished water (fig. 12). This decrease in concentration between source and finished water likely is attributable to additional water-treatment steps, such as granular activated carbon and (or) air-stripping towers, used by a CWS to treat water known to contain elevated concentrations of organic compounds. Other detections of these compounds in source water at concentrations less than 1 µg/L typically had a similar concentration in finished water.

Twenty-seven percent of the detections of compounds in source water did not have a corresponding detection in finished water (fig. 12). The majority of compounds were detected at concentrations less than 1 µg/L, and many were detected at concentrations near or less than the LRL and were estimated concentrations. Several possibilities, such as transformation or removal during water treatment, particularly if additional treatment steps are used to treat the water because of known contamination, volatilization, accidental introduction at the wellhead from plumbing or fixtures, or analytical variability at concentrations near or less than the LRL, may account for the detection of a compound in source water only. Disinfection of source water may reduce concentrations of

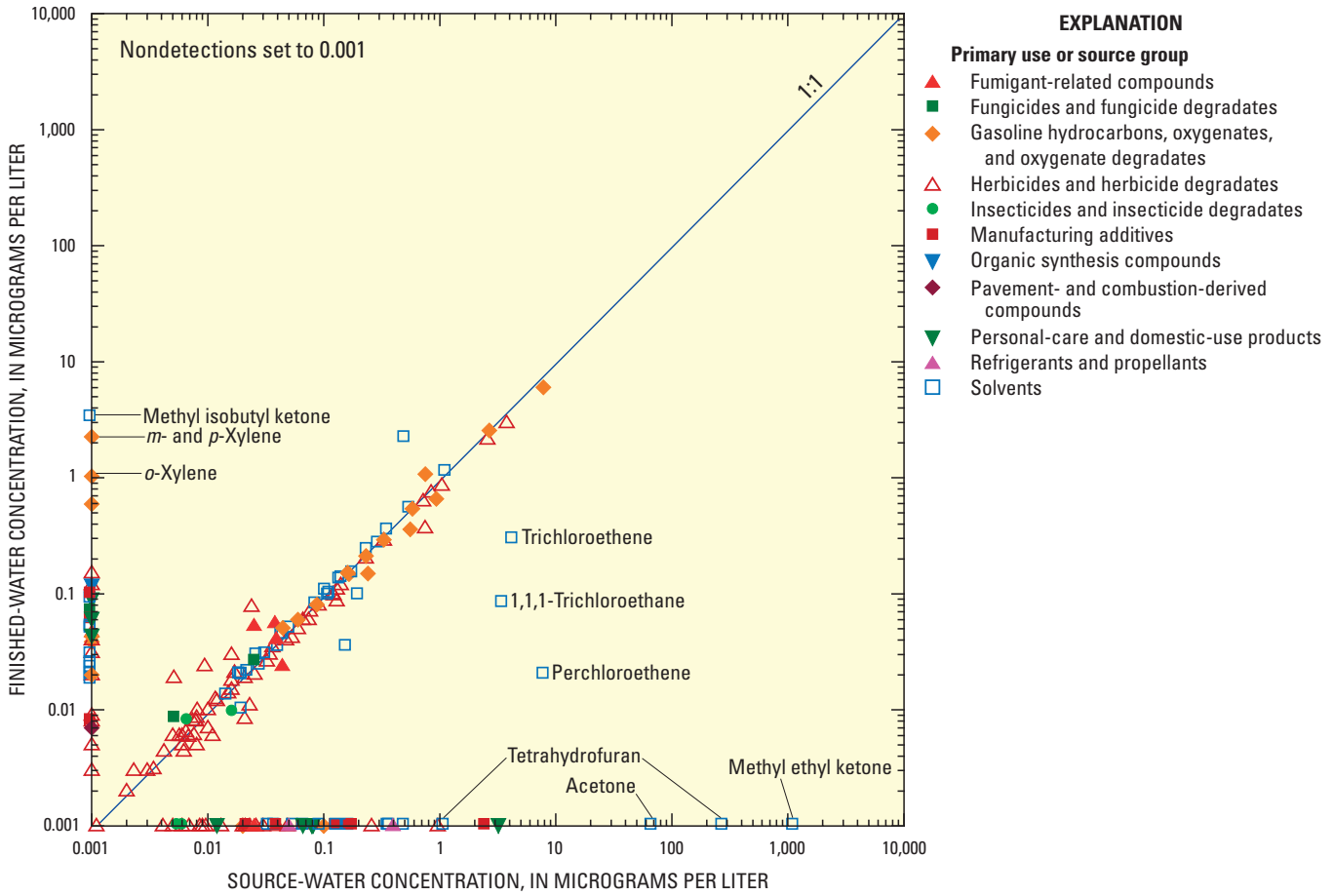



**Figure 12.** Concentrations of anthropogenic organic compounds (excluding disinfection by-products) in source and associated nonblended finished water generally were similar when detected in both source and finished water for samples collected during June 2004–September 2005.

some compounds through degradation or transformation. For example, degradation of organophosphate pesticides as a result of chlorination has been documented (Aizawa and others, 1994). Although finished-water samples were quenched to inhibit the effect of free chlorine on the compounds monitored by SWQAs, some reactions may occur quickly within the water-treatment system, before the finished-water sample was collected. For those compounds monitored by SWQAs, Valder and others (2008) documented the degradation of several compounds as a result of chlorination of source water. In addition, some compounds, particularly solvents and other VOCs, may be volatilized at the CWS during the treatment process, especially if water treatment includes aeration.

Occurrence in source water and not in finished water may not necessarily reflect a change as a result of water treatment but may result from maintenance at the wellhead. For example, acetone, methyl ethyl ketone, and tetrahydrofuran were detected in source water at concentrations greater than 50 µg/L but not in the associated finished-water sample (fig. 12; Appendix 3). These three compounds were not detected in source water from the same well in the initial sample collected during October 2002–July 2005. In samples from another well, tetrahydrofuran and methyl ethyl ketone were detected in the intial source water sample at concentrations greater than 300 µg/L, but only tetrahydrofurn was detected in the second sample at a concentration of 1.1 µg/L. The presence of these compounds at high concentrations in only one source-water sample may be the result of maintenance at the sampling point at the well; however, this possible source was not confirmed.

Less than one-quarter (16 percent) of the detections in finished water (excluding disinfection by-products) did not have a corresponding detection in source water (fig. 12). Concentrations generally were low (near the LRL); however, concentrations of methyl isobutyl ketone, *m*- and *p*-xylene, and *o*-xylene were greater than 1 µg/L in one sample. Determining the possible sources of the compounds that were detected only in finished water was beyond the scope of this

study. However, possible sources of these compounds include sealants used at pipe connections or minor components of chemicals used for water treatment. Several herbicides or herbicide degradates also were detected only in finished water, and most were detected at concentrations less than 0.1 µg/L. Given the low concentrations of these detections and the unlikely event that herbicides would be introduced to the finished water, analytical variability of concentrations near the LRL is a possible explanation for these unmatched detections.

## Blended Finished Water

Water from 60 of the 94 source-water wells was blended with water from other wells before distribution. Although the comparison between source and blended finished water is complicated by the addition of water that has not been monitored, the occurrence of compounds for CWSs that blended water (fig. 13) generally was similar to the occurrence of compounds for CWSs that did not blend water (fig. 12) in that one-half of all detections of compounds were in both source and finished water. Compounds from the herbicides and herbicide degradates and the solvents use groups were detected most commonly when a compound was detected in both source and finished water (fig. 13).

The variability in concentrations between source water and the associated finished water (scatter around the 1:1 line) generally was greater for blended than for nonblended finished water (figs. 12, 13). For the CWSs that blended water, deviation from the 1:1 line for detections in both source and finished water (fig. 13) may largely be due to blending or to some extent the result of water treatment, particularly where additional treatment steps are used to reduce concentrations of known contaminants. Determining the cause for these changes was beyond the scope of this study.

One-half of the detections of compounds were either in source or finished water only. Blending could account for many of these unmatched detections especially at low concentrations (less than 0.1 µg/L), but other factors, such as maintenance and chemical use at the CWS, also could account for

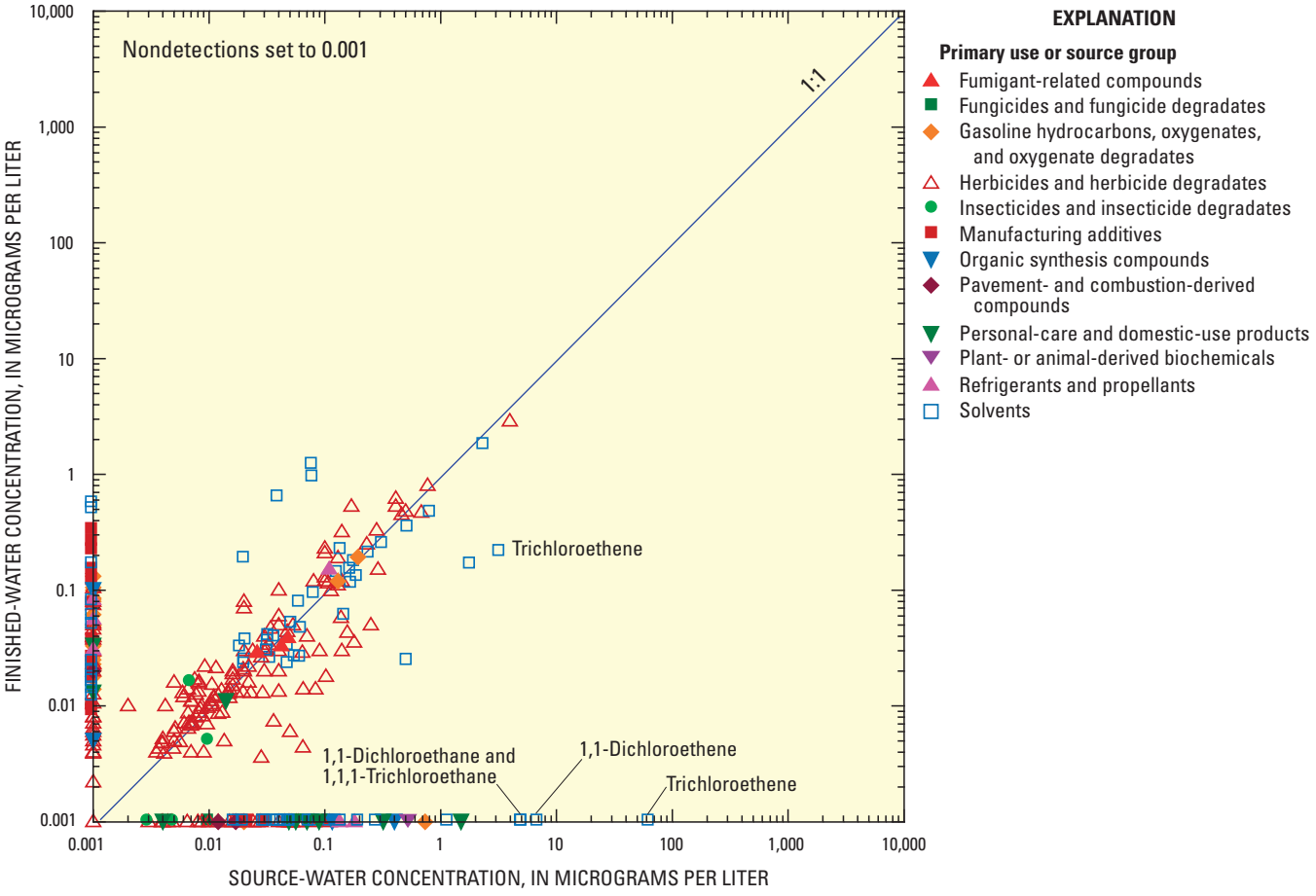



**Figure 13.** Concentrations of anthropogenic organic compounds (excluding disinfection by-products) in source and associated blended finished water generally were similar when detected in both source and finished water for samples collected during June 2004–September 2005.

unmatched detections. Some solvents (1,1,1-TCA, 1,1-dichloroethane, 1,1-dichloroethene, and TCE) detected at concentrations greater than 5 µg/L in source water from one well were not detected in the finished-water sample (fig. 13). The CWS where this sample was collected treats the drinking water with granular activated carbon to reduce concentrations of contaminants known to be present in the source water (Jim Stark, U.S. Geological Survey, written commun., 2008). These large decreases in concentration likely are predominantly the result of the additional water-treatment processes used at this CWS; however, in some cases blending may contribute to reducing concentrations.

The frequent occurrence of several compounds in both source water and the associated blended finished water further demonstrates the importance of source-water characterization and wellhead protection. About one-half of the detections of compounds in source water had corresponding detections in the associated finished water and generally were similar to results for nonblended water. Finished water from more than one-half of the CWSs in the study was blended; however, blending did not always reduce concentrations to less than the LRL. These findings indicate that the protection of source-water quality may be the most effective mechanism to ensure high-quality drinking water. That is, preventing or minimizing the possibility of occurrence of contaminants may be preferable to treating the water after source-water contamination has occurred.

## Mixtures

One objective of the comparison between source and finished water was to evaluate potential differences in the frequency of occurrence and complexity of mixtures of organic compounds. The characterization of mixtures presented in this section includes disinfection by-products in both nonblended and blended finished water. About 70 and 82 percent of source- and finished-water samples, respectively, contained mixtures of two or more compounds (fig. 14). About one-half of the source-water samples contained mixtures of five or more compounds (median = 12), and about one-half of the finished-water samples contained mixtures of six or more compounds (median = 13). Mixtures occur more commonly in finished water than in source water partly because of the formation of disinfection by-products in finished water, which increases the number of compounds detected in finished water relative to source water (fig. 14). The percentages of mixtures of organic compounds were greater in source-water samples collected during the second phase of sampling (June 2004–September 2005) than during the initial phase of sampling (October 2002–July 2005), because sampling during the second phase focused on wells where compounds were detected most commonly or at relatively higher concentrations during the initial phase. However, the characterization of mixtures in source and finished water represents a minimum number of compounds in a sample because most samples were not analyzed for all of the analytical suites used in the initial sampling. In particular, not all samples were analyzed for the suite of compounds that included the disinfection by-products.

As described previously in relation to mixture occurrence in source water, the potential human-health significance of the common occurrence of mixtures of organic compounds remains largely unknown. The common occurrence of mixtures in both source- and finished-water samples points to a need for identifying the specific combinations of compounds that occur most commonly and identifying the compounds that may be a potential concern for human health. Identification of specific combinations of compounds would provide initial perspective on co-occurrence that may be important as more is learned about sources and potential health effects of mixtures. Again, these are important research topics, but are beyond the scope of this report.

# Summary

During October 2002 to July 2005, source-water samples were collected from 221 wells completed in 12 principal aquifers in the United States as part of the Source Water-Quality Assessment (SWQA) component of the U.S. Geological Survey's National Water-Quality Assessment (NAWQA) Program. Each community water system (CWS) well was sampled once for analysis of 258 anthropogenic organic compounds to characterize the quality of the source water. Most of these compounds are unregulated in drinking water and include pesticides and pesticide degradates, gasoline hydrocarbons, personal-care and domestic-use products, and solvents. Source- and finished-water (after treatment and before distribution) samples were collected during June 2004 to September 2005 from selected sites to characterize the extent to which compounds detected in the source water were present in the finished water.

The CWSs that participated in SWQAs ranged in size from single-well systems to systems with multiple wells. In many cases where CWSs have multiple wells, the CWSs blend water before or after water treatment. The water-treatment process predominantly used by the CWSs was disinfection with chlorine. Additional water-treatment steps were used by CWSs when source water was known to be contaminated with organic compounds. These additional water-treatment steps included granular activated carbon and air-stripping towers.

Of the 258 compounds analyzed in samples from all 221 wells, 120 compounds were detected in at least one source-water sample. However, 52 compounds were detected only once, and many were detected infrequently and at concentrations less than 0.1 microgram per liter (µg/L). The laboratory analytical methods used in this study have detection levels that are commonly 100 to 1,000 times lower than State and Federal standards and guidelines for protecting water quality. Detections of these compounds do not necessarily indicate a concern to human health but rather help to identify

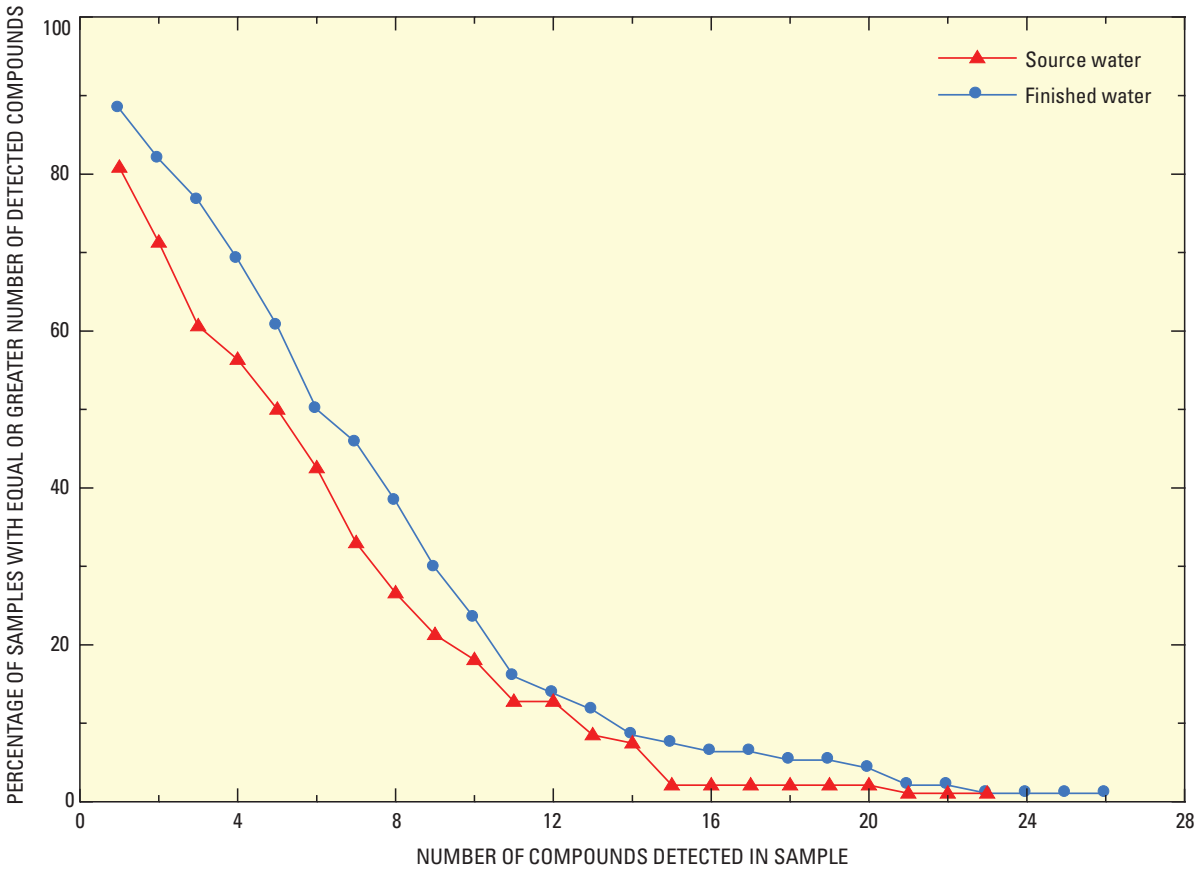



**Figure 14.** Both source- and finished-water samples collected during the June 2004–September 2005 sampling typically contained mixtures of two or more compounds.

emerging issues and track changes in occurrence and concentrations over time.

The occurrence of compounds in source water varied regionally. More compounds and greater total concentrations generally were detected in samples from wells east of the Mississippi River than in samples from wells west of the Mississippi River. Factors that may account for these differences in occurrence include generally higher groundwater recharge rates, shallower well depths, shallower depths to groundwater, greater population densities, and more intense use of agricultural herbicides east of the Mississippi River than west of the Mississippi River.

Twelve compounds were detected in about 10 percent or more of source-water. Chloroform was the most commonly detected compound in this study and was detected in 36 percent of samples. One-half of the commonly detected compounds in this study were herbicides and herbicide degradates (deethylatrazine, atrazine, simazine, prometon, metolachlor, and deisopropylatrazine) likely because of their widespread use, the large number of compounds analyzed in this group, and the low levels at which these compounds were analyzed. The compounds perchloroethene (PCE), trichloroethene (TCE), 1,1,1-trichloroethane, methyl *tert*-butyl ether, and *cis*-1,2-dichloroethene also were detected commonly. The most commonly detected compounds in source-water samples generally were among those detected commonly across the country and reported in previous studies by the NAWQA Program.

Samples were collected from a subset of 73 wells and analyzed for an additional 3 herbicides and 16 degradates in locations where the parent herbicides had potential use. Degradates of both alachlor and metolachlor were detected more commonly and at similar or greater concentrations than concentrations of the parent herbicide. These results highlight the fact that information about the occurrence and concentrations of degradates may be as important as information about the parent compound for some pesticides, particularly if the degradate toxicity or mode of action is similar to that of the parent compound.

Detections of compounds at concentrations greater than a human-health benchmark were infrequent, and only five compounds were detected in source water at a concentration greater than the human-health benchmark. Concentration of compounds in source water were compared to human-health

benchmarks as part of a screening level assessment; however, Maximum Contaminant Levels (MCLs) are not directly applicable to source-water samples. Measured concentrations of compounds that are regulated in drinking water were compared to U.S. Environmental Protection Agency (USEPA) MCLs, and concentrations of unregulated compounds were compared to Health-Based Screening Levels developed by the U.S. Geological Survey in collaboration with USEPA and others. Concentrations of TCE were greater than the MCL in two samples, and 1,2-dibromoethane and PCE were detected in one sample each at a concentration greater than the MCL. Acrylonitrile and dieldrin were detected at concentrations greater than their respective Health-Based Screening Levels in one sample each. All other compounds were detected at concentrations less than available human-health benchmarks, and 84 percent of the concentrations were two or more orders of magnitude less than the benchmark. About one-half of all detected compounds do not have human-health benchmarks or adequate toxicity information to evaluate results in a human-health context.

About 55 percent of source-water samples contained mixtures of two or more compounds. The most common mixtures included those compounds detected most commonly, such as chloroform, MTBE, herbicides and herbicide degradates, and solvents. Mixtures of compounds occurred more commonly and with greater numbers of compounds in water from shallow wells than in water from deep wells. Two or more compounds were detected in 74 and 73 percent of the samples from the two shallowest groups of wells (38–213 feet and 215–401 feet, respectively).

The comparison of source- and finished-water quality in this report represents an initial assessment of whether compounds present in source water also are present in finished water. Source-water samples from 94 wells and associated finished-water samples were collected from June 2004 to September 2005. Most of these samples were analyzed for fewer compounds than during the initial source-water sampling. Samples were analyzed for those compounds detected commonly or at relatively high concentrations during the initial source-water sampling. Finished-water samples were collected following all of the treatment steps and before distribution. The assessment of compounds detected in source- and finished-water samples is not intended as an evaluation of water-treatment efficacy at CWS. In general, the types of treatment used by the CWSs that were sampled were not specifically designed to remove most of the organic compounds monitored in this study. Finished-water data are not necessarily representative of drinking-water quality at the tap (or point of delivery). Additional contact time with disinfectants in the distribution system may change concentrations of some of the compounds detected in the finished water at the sample-collection point.

Thirty-one compounds were detected commonly (defined as detected in 10 percent or more of samples) in either source- or finished-water samples during June 2004–September 2005 and included the 12 compounds detected commonly during the initial sampling from October 2002 to July 2005. The majority of the compounds were in the herbicide and herbicide degradates and solvents use groups. With the exception of the disinfection by-products, which are expected to form in finished water, the detection frequencies of most (17) of the commonly detected compounds were similar (difference of 5 percent or less) between source and finished water. For those compounds with detection frequencies that differed by 6 percent or more between source and finished water, about two-thirds of the sites were CWSs with blended finished water.

Concentrations of all compounds commonly detected in finished water were less than their human-health benchmarks, which are available for about one-half of the compounds detected in finished-water samples. Eight of the commonly detected compounds (1,4-dichlorobenzene, *m*- and *p*-xylene, 2-hydroxyatrazine, bentazon, metolachlor, metsulfuron methyl, prometon, and 1,1,1-trichloroethane) had finished-water concentrations that were two to six orders of magnitude less than the human-health benchmarks. The summed concentrations of the trihalomethanes for all of the finished-water samples were less than the MCL of 80 µg/L. The concentrations of total trihalomethanes were within an order of magnitude of the MCL in finished water from nine sites, but only three detections of chloroform and one detection of bromoform were within an order of magnitude of the MCL. Two detections of PCE and one detection of TCE in finished water had concentrations within an order of magnitude of the MCL, and concentrations of all other compounds were more than an order of magnitude less than the benchmark.

Differences in the occurrence of compounds in source or finished water could result from water treatment, blending, volatilization, or analytical variability at concentrations near or less than the laboratory reporting level. At the 34 sites where finished water was not blended, about one-half (57 percent) of the detections were in both source and finished water, and concentrations were similar. Large changes in concentrations from source to finished water in a few samples likely are attributable to additional water treatment steps used by the CWS to treat water known to contain elevated concentrations of organic compounds. Finished water from 60 of the source-water wells sampled in the study was a blend of water from two or more wells. Although the comparison between source and blended finished water is complicated by the addition of water that has not been monitored, the occurrence of compounds for CWSs that blended water generally was similar to the occurrence of compounds for CWSs that did not blend water in that one-half of all detections of compounds were in both source and finished water.

Compounds occur more commonly as mixtures in finished water than in source water because of the formation of disinfection by-products in finished water. Mixtures of two or more compounds were detected in about 70 percent of source-water samples and in 82 percent of finished-water samples. Although concentrations of compounds detected typically were considerably less than human-health benchmarks, the frequent occurrence of mixtures in finished waters indicates a

need for identifying mixtures that are most common and most likely to have potential human-health effects.

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# Appendixes

**Appendix 1.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source-water samples collected during October 2002–July 2005 (use groups obtained from Carter and others, 2007).

[Compounds within each primary-use category are listed in order from highest to lowest detection frequency. CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; MCL, Maximum Contaminant Level; --, none; ND, not detected; E, estimated value; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); HBSL, Health-Based Screening Level; MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset]

| Compound | CASRN[1] | Number of detections for groundwater | Number of samples | Detection frequency (percent) | | Laboratory reporting level (µg/L) | Maximum concentration for groundwater (µg/L) | Human-health benchmark (µg/L) | Type of human-health benchmark | Number of concentrations with BQ >0.1; (1) number of concentrations with BQ >1 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | All data | Censored at 0.1 µg/L | | | | | |
| **Disinfection by-products** | | | | | | | | | | |
| Chloroform | 67–66–3 | 65 | 180 | 36.1 | 12.8 | 0.024 | 5.48 | [2]80 | MCL | -- |
| Bromodichloromethane | 75–27–4 | 17 | 221 | 7.7 | 2.7 | .028 | .788 | [2]80 | MCL | -- |
| Bromoform | 75–25–2 | 10 | 221 | 4.5 | 3.6 | .1 | 1.9 | [2]80 | MCL | -- |
| Dibromochloromethane | 124–48–1 | 8 | 221 | 3.6 | 3.6 | .1 | 1.01 | [2]80 | MCL | -- |
| **Fumigant-related compounds** | | | | | | | | | | |
| 1,2-Dichloropropane | 78–87–5 | 3 | 221 | 1.4 | ND | 0.029 | E0.092 | 5 | MCL | -- |
| 1,2-Dibromoethane | 106–93–4 | 1 | 221 | .5 | ND | .036 | E.072 | .05 | MCL | 1(1) |
| 1,2-Dibromo-3-chloropropane | 96–12–8 | 0 | 221 | ND | ND | .51 | ND | .2 | MCL | -- |
| 1,3-Dichloropropane (CCL) | 142–28–9 | 0 | 221 | ND | ND | .06 | ND | -- | -- | -- |
| 1,4-Dichlorobenzene[3] | 106–46–7 | 0 | 221 | ND | ND | .034 | ND | 75 | MCL | -- |
| 2,2-Dichloropropane (CCL) | 594–20–7 | 0 | 221 | ND | ND | .05 | ND | -- | -- | -- |
| Bromomethane (CCL) | 74–83–9 | 0 | 221 | ND | ND | .33 | ND | 100 | HBSL | -- |
| *cis*-1,3-Dichloropropene (CCL) | 10061–01–5 | 0 | 221 | ND | ND | .05 | ND | [4,5].3 | HBSL | -- |
| *trans*-1,3-Dichloropropene (CCL) | 10061–02–6 | 0 | 221 | ND | ND | .09 | ND | [4,5].3 | HBSL | -- |
| **Fungicides and fungicide degradates** | | | | | | | | | | |
| Metalaxyl | 57837–19–1 | 2 | 221 | 0.9 | ND | 0.007 | 0.035 | 600 | HBSL | -- |
| Myclobutanil | 88671–89–0 | 1 | 221 | .5 | ND | .033 | .011 | 200 | HBSL | -- |
| Propiconazole | 60207–90–1 | 1 | 215 | .5 | ND | .01 | E.005 | 70 | HBSL | -- |
| Benomyl | 17804–35–2 | 0 | 215 | ND | ND | .022 | ND | 40 | HBSL | -- |
| Chlorothalonil | 1897–45–6 | 0 | 215 | ND | ND | .035 | ND | 5 | HBSL | -- |

**Appendix 1.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source-water samples collected during October 2002–July 2005 (use groups obtained from Carter and others, 2007).—Continued

[Compounds within each primary-use category are listed in order from highest to lowest detection frequency. CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; MCL, Maximum Contaminant Level; --, none; ND, not detected; E, estimated value; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); HBSL, Health-Based Screening Level; MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset]

| Compound | CASRN[1] | Number of detections for groundwater | Number of samples | Detection frequency (percent) | | Laboratory reporting level (µg/L) | Maximum concentration for groundwater (µg/L) | Human-health benchmark (µg/L) | Type of human-health benchmark | Number of concentrations with BQ >0.1; (1) number of concentrations with BQ >1 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | All data | Censored at 0.1 µg/L | | | | | |
| Fungicides and fungicide degradates—Continued | | | | | | | | | | |
| Iprodione | 36734–19–7 | 0 | 221 | ND | ND | 0.026 | ND | [4]0.8 | HBSL | -- |
| Pentachlorophenol | 87–86–5 | 0 | 211 | ND | ND | 2 | ND | 1 | MCL | -- |
| Gasoline hydrocarbons, oxygenates, and oxygenate degradates | | | | | | | | | | |
| Methyl *tert*-butyl ether (MTBE) (CCL) | 1634–04–4 | 28 | 221 | 12.7 | 6.8 | 0.1 | 1.88 | -- | -- | -- |
| 1,2,4-Trimethylbenzene (CCL) | 95–63–6 | 4 | 176 | 2.3 | .6 | .056 | 2.37 | -- | -- | -- |
| Benzene | 71–43–2 | 4 | 192 | 2.1 | 1.0 | .021 | .631 | 5 | MCL | 1 |
| *tert*-Amyl methyl ether (TAME) | 994–05–8 | 3 | 221 | 1.4 | .9 | .04 | .281 | -- | -- | -- |
| *m*- and *p*-Xylene | 106–42–3; 108–38–3 | 2 | 161 | 1.2 | .6 | .06 | 3.28 | [6]10,000 | MCL | -- |
| 1,2,3,4-Tetramethylbenzene | 488–23–3 | 2 | 221 | .9 | .5 | .14 | .921 | -- | -- | -- |
| 1-Ethyl-2-methylbenzene (*o*-Ethyl toluene) | 611–14–3 | 2 | 221 | .9 | .9 | .06 | .666 | -- | -- | -- |
| Isopropylbenzene[3] | 98–82–8 | 2 | 221 | .9 | ND | .038 | E.073 | 700 | HBSL | -- |
| Ethylbenzene | 100–41–4 | 1 | 176 | .6 | .6 | .03 | .517 | 700 | MCL | -- |
| *o*-Xylene | 95–47–6 | 1 | 176 | .6 | .6 | .038 | 2.84 | [6]10,000 | MCL | -- |
| 1,2,3,5-Tetramethylbenzene | 527–53–7 | 1 | 221 | .5 | .5 | .18 | 1.48 | -- | -- | -- |
| 1,2,3-Trimethylbenzene | 526–73–8 | 1 | 221 | .5 | .5 | .09 | 1.51 | -- | -- | -- |
| 1,3,5-Trimethylbenzene | 108–67–8 | 1 | 221 | .5 | .5 | .044 | .942 | -- | -- | -- |
| 1-Methylnaphthalene[3] | 90–12–0 | 1 | 217 | .5 | .5 | .5 | E.12 | -- | -- | -- |

**Appendix 1.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source-water samples collected during October 2002–July 2005 (use groups obtained from Carter and others, 2007).—Continued

[Compounds within each primary-use category are listed in order from highest to lowest detection frequency. CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; MCL, Maximum Contaminant Level; --, none; ND, not detected; E, estimated value; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); HBSL, Health-Based Screening Level; MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset]

| Compound | CASRN[1] | Number of detections for groundwater | Number of samples | Detection frequency (percent) | | Laboratory reporting level (µg/L) | Maximum concentration for groundwater (µg/L) | Human-health benchmark (µg/L) | Type of human-health benchmark | Number of concentrations with BQ >0.1; (1) number of concentrations with BQ >1 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | All data | Censored at 0.1 µg/L | | | | | |
| Gasoline hydrocarbons, oxygenates, and oxygenate degradates—Continued | | | | | | | | | | |
| 2,6-Dimethylnaphthalene | 581–42–0 | 1 | 217 | 0.5 | ND | 0.5 | E0.003 | -- | -- | -- |
| 2-Methylnaphthalene[3] | 91–57–6 | 1 | 217 | .5 | .5 | .5 | E.23 | 30 | HBSL | -- |
| Diisopropyl ether (DIPE) | 108–20–3 | 1 | 221 | .5 | .5 | .1 | .159 | -- | -- | -- |
| Naphthalene (CCL) | 91–20–3 | 1 | 221 | .5 | .5 | .52 | .956 | 100 | HBSL | -- |
| *n*-Butylbenzene | 104–51–8 | 1 | 221 | .5 | ND | .14 | E.069 | -- | -- | -- |
| *p*-Isopropyltoluene (CCL) | 99–87–6 | 1 | 221 | .5 | ND | .08 | E.063 | -- | -- | -- |
| *sec*-Butylbenzene | 135–98–8 | 1 | 221 | .5 | ND | .06 | E.065 | -- | -- | -- |
| *tert*-Amyl alcohol (2-Methyl-2-butanol) | 75–85–4 | 0 | 119 | ND | ND | 1 | ND | -- | -- | -- |
| Ethyl *tert*-butyl ether (ETBE) | 637–92–3 | 0 | 221 | ND | ND | .03 | ND | -- | -- | -- |
| Styrene[3] | 100–42–5 | 0 | 221 | ND | ND | .042 | ND | 100 | MCL | -- |
| *tert*-Butyl alcohol | 75–65–0 | 0 | 119 | ND | ND | 1 | ND | -- | -- | -- |
| *tert*-Butylbenzene | 98–06–6 | 0 | 221 | ND | ND | .08 | ND | -- | -- | -- |
| Toluene | 108–88–3 | 0 | 117 | ND | ND | .02 | ND | 1,000 | MCL | -- |
| Herbicides and herbicide degradates | | | | | | | | | | |
| Alachlor ethane sulfonic acid | -- | 20 | 58 | 34.5 | 22.4 | 0.02 | 0.64 | -- | -- | -- |
| Deethylatrazine (DEA) (CCL) | 6190–65–4 | 76 | 221 | 34.4 | 4.1 | .014 | .38 | -- | -- | -- |
| Atrazine | 1912–24–9 | 66 | 221 | 29.9 | 3.2 | .007 | .335 | 3 | MCL | 1 |
| Metolachlor ethane sulfonic acid | -- | 21 | 73 | 28.8 | 21.9 | .02 | 2.72 | -- | -- | -- |

**Appendix 1.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source-water samples collected during October 2002–July 2005 (use groups obtained from Carter and others, 2007).—Continued

[Compounds within each primary-use category are listed in order from highest to lowest detection frequency. CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; MCL, Maximum Contaminant Level; --, none; ND, not detected; E, estimated value; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); HBSL, Health-Based Screening Level; MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset]

| Compound | CASRN[1] | Number of detections for groundwater | Number of samples | Detection frequency (percent) | | Laboratory reporting level (µg/L) | Maximum concentration for groundwater (µg/L) | Human-health benchmark (µg/L) | Type of human-health benchmark | Number of concentrations with BQ >0.1; (1) number of concentrations with BQ >1 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | All data | Censored at 0.1 µg/L | | | | | |
| Herbicides and herbicide degradates—Continued | | | | | | | | | | |
| Simazine | 122–34–9 | 37 | 221 | 16.7 | 0.5 | 0.005 | 0.114 | 4 | MCL | -- |
| Metolachlor oxanilic acid | -- | 11 | 73 | 15.1 | 9.6 | .02 | 2.96 | -- | -- | -- |
| Deisopropylatrazine (DIA) | 1007–28–9 | 28 | 215 | 13.0 | .5 | .08 | .12 | -- | -- | -- |
| Prometon (CCL) | 1610–18–0 | 25 | 221 | 11.3 | ND | .01 | .036 | 400 | HBSL | -- |
| Metolachlor (CCL)[3] | 51218–45–2 | 24 | 221 | 10.9 | .9 | .006 | 3.58 | 700 | HBSL | -- |
| 2-Hydroxyatrazine | 2163–68–0 | 20 | 215 | 9.3 | ND | .032 | E.035 | 70 | HBSL | -- |
| Alachlor ethane sulfonic acid 2nd amide | -- | 4 | 43 | 9.3 | ND | .02 | .05 | -- | -- | -- |
| Alachlor oxanilic acid | -- | 4 | 73 | 5.5 | 2.7 | .02 | 1.23 | -- | -- | -- |
| Bentazon | 25057–89–0 | 8 | 215 | 3.7 | .5 | .024 | E.49 | 200 | HBSL | -- |
| Diuron (CCL) | 330–54–1 | 7 | 215 | 3.3 | .5 | .016 | E.166 | [4]2 | HBSL | -- |
| Bromacil | 314–40–9 | 7 | 216 | 3.2 | .5 | .018 | .338 | 70 | HBSL | -- |
| 3,4-Dichloroaniline | 95–76–1 | 3 | 221 | 1.4 | ND | .0045 | .009 | -- | -- | -- |
| Acetochlor ethane sulfonic acid | -- | 1 | 73 | 1.4 | ND | .02 | .07 | -- | -- | -- |
| Acetochlor oxanilic acid | -- | 1 | 73 | 1.4 | 1.4 | .02 | .12 | -- | -- | -- |
| Alachlor | 15972–60–8 | 3 | 221 | 1.4 | .5 | .005 | .249 | 2 | MCL | 1 |
| Metsulfuron methyl[3] | 74223–64–6 | 3 | 214 | 1.4 | ND | .067 | E.035 | 2,000 | HBSL | -- |
| Dinoseb | 88–85–7 | 2 | 215 | .9 | ND | .038 | E.005 | 7 | MCL | -- |
| Hexazinone | 51235–04–2 | 1 | 113 | .9 | ND | .026 | E.008 | 400 | HBSL | -- |
| Imazaquin | 81335–37–7 | 2 | 215 | .9 | ND | .036 | E.01 | 2,000 | HBSL | -- |

**Appendix 1.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source-water samples collected during October 2002–July 2005 (use groups obtained from Carter and others, 2007).—Continued

[Compounds within each primary-use category are listed in order from highest to lowest detection frequency. CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; MCL, Maximum Contaminant Level; --, none; ND, not detected; E, estimated value; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); HBSL, Health-Based Screening Level; MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset]

| Compound | CASRN[1] | Number of detections for groundwater | Number of samples | Detection frequency (percent) | | Laboratory reporting level (µg/L) | Maximum concentration for groundwater (µg/L) | Human-health benchmark (µg/L) | Type of human-health benchmark | Number of concentrations with BQ >0.1; (1) number of concentrations with BQ >1 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | All data | Censored at 0.1 µg/L | | | | | |
| Herbicides and herbicide degradates—Continued | | | | | | | | | | |
| Imazethapyr[3] | 81335–77–5 | 2 | 215 | 0.9 | ND | 0.038 | E0.007 | 2,000 | HBSL | -- |
| Norflurazon | 27314–13–2 | 2 | 215 | .9 | ND | .02 | E.026 | 10 | HBSL | -- |
| Picloram | 1918–02–1 | 2 | 215 | .9 | ND | .032 | .085 | 500 | MCL | -- |
| Sulfometuron-methyl | 74222–97–2 | 2 | 215 | .9 | ND | .09 | E.004 | 2,000 | HBSL | -- |
| Tebuthiuron | 34014–18–1 | 2 | 218 | .9 | ND | .026 | E.03 | 1,000 | HBSL | -- |
| 2,4–D | 94–75–7 | 1 | 215 | .5 | ND | .038 | E.009 | 70 | MCL | -- |
| Acetochlor (CCL) | 34256–82–1 | 1 | 221 | .5 | ND | .006 | .037 | [4]1 | HBSL | -- |
| Clopyralid | 1702–17–6 | 1 | 215 | .5 | ND | .067 | E.013 | -- | -- | -- |
| Deethyldeisopropyl-atrazine (DDA) | 3397–62–4 | 1 | 213 | .5 | ND | .04 | E.069 | -- | -- | -- |
| Fluometuron | 2164–17–2 | 1 | 215 | .5 | ND | .016 | E.004 | 4 | HBSL | -- |
| Metribuzin (CCL) | 21087–64–9 | 1 | 221 | .5 | ND | .028 | .01 | 90 | HBSL | -- |
| Siduron | 1982–49–6 | 1 | 215 | .5 | ND | .02 | E.012 | 1,000 | HBSL | -- |
| Terbacil (CCL) | 5902–51–2 | 1 | 215 | .5 | ND | .026 | E.06 | 90 | HBSL | -- |
| 2,4–D methyl ester | 1928–38–7 | 0 | 215 | ND | ND | .19 | ND | -- | -- | -- |
| 2,4–DB | 94–82–6 | 0 | 215 | ND | ND | .02 | ND | 200 | HBSL | -- |
| 2,6-Diethylaniline | 579–66–8 | 0 | 221 | ND | ND | .006 | ND | -- | -- | -- |
| 2-Chloro-2,6-diethyl-acetanilide | 6967–29–9 | 0 | 221 | ND | ND | .0065 | ND | -- | -- | -- |
| 2-Ethyl-6-methylaniline | 24549–06–2 | 0 | 221 | ND | ND | .01 | ND | -- | -- | -- |
| 3(4-Chlorophenyl)-1-methyl urea | 5352–88–5 | 0 | 215 | ND | ND | .036 | ND | -- | -- | -- |
| 4-Chloro-2-methyl-phenol | 1570–64–5 | 0 | 221 | ND | ND | .005 | ND | -- | -- | -- |

**Appendix 1.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source-water samples collected during October 2002–July 2005 (use groups obtained from Carter and others, 2007).—Continued

[Compounds within each primary-use category are listed in order from highest to lowest detection frequency. CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; MCL, Maximum Contaminant Level; --, none; ND, not detected; E, estimated value; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); HBSL, Health-Based Screening Level; MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset]

| Compound | CASRN[1] | Number of detections for groundwater | Number of samples | Detection frequency (percent) | | Laboratory reporting level (µg/L) | Maximum concentration for groundwater (µg/L) | Human-health benchmark (µg/L) | Type of human-health benchmark | Number of concentrations with BQ >0.1; (1) number of concentrations with BQ >1 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | All data | Censored at 0.1 µg/L | | | | | |
| Herbicides and herbicide degradates—Continued | | | | | | | | | | |
| Acetochlor sulfynil-acetic acid | -- | 0 | 73 | ND | ND | 0.02 | ND | -- | -- | -- |
| Acetochlor/metolachlor ethane sulfonic acid 2nd amide | -- | 0 | 43 | ND | ND | .02 | ND | -- | -- | -- |
| Acifluorfen | 50594–66–6 | 0 | 215 | ND | ND | .028 | ND | 90 | HBSL | -- |
| Alachlor sulfynilacetic acid | 140939–16–8 | 0 | 73 | ND | ND | .02 | ND | -- | -- | -- |
| Benfluralin | 1861–40–1 | 0 | 221 | ND | ND | .01 | ND | 4 | HBSL | -- |
| Bensulfuron-methyl | 83055–99–6 | 0 | 215 | ND | ND | .018 | ND | 1,000 | HBSL | -- |
| Bromoxynil | 1689–84–5 | 0 | 215 | ND | ND | .044 | ND | 10 | HBSL | -- |
| Chloramben, methyl ester | 7286–84–2 | 0 | 215 | ND | ND | .024 | ND | -- | -- | -- |
| Chlorimuron-ethyl | 90982–32–4 | 0 | 215 | ND | ND | .032 | ND | 600 | HBSL | -- |
| Cycloate | 1134–23–2 | 0 | 215 | ND | ND | .014 | ND | 40 | HBSL | -- |
| Dacthal | 1861–32–1 | 0 | 221 | ND | ND | .003 | ND | 70 | HBSL | -- |
| Dacthal monoacid (CCL) | 887–54–7 | 0 | 215 | ND | ND | .028 | ND | -- | -- | -- |
| Dicamba | 1918–00–9 | 0 | 213 | ND | ND | .036 | ND | 3,000 | HBSL | -- |
| Dichlorprop | 120–36–5 | 0 | 215 | ND | ND | .028 | ND | 300 | HBSL | -- |
| Dimethenamid | 87674–68–8 | 0 | 43 | ND | ND | .02 | ND | -- | -- | -- |
| Dimethenamid ethane sulfonic acid | -- | 0 | 73 | ND | ND | .02 | ND | -- | -- | -- |
| Dimethenamid oxanilic acid | -- | 0 | 73 | ND | ND | .02 | ND | -- | -- | -- |
| Diphenamid | 957–51–7 | 0 | 215 | ND | ND | .01 | ND | 200 | HBSL | -- |

**Appendix 1.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source-water samples collected during October 2002–July 2005 (use groups obtained from Carter and others, 2007).—Continued

[Compounds within each primary-use category are listed in order from highest to lowest detection frequency. CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; MCL, Maximum Contaminant Level; --, none; ND, not detected; E, estimated value; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); HBSL, Health-Based Screening Level; MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset]

| Compound | CASRN[1] | Number of detections for groundwater | Number of samples | Detection frequency (percent) | | Laboratory reporting level (µg/L) | Maximum concentration for groundwater (µg/L) | Human-health benchmark (µg/L) | Type of human-health benchmark | Number of concentrations with BQ >0.1; (1) number of concentrations with BQ >1 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | All data | Censored at 0.1 µg/L | | | | | |
| Herbicides and herbicide degradates—Continued | | | | | | | | | | |
| Fenuron | 101–42–8 | 0 | 215 | ND | ND | 0.1 | ND | -- | -- | -- |
| Flufenacet | 142459–58–3 | 0 | 43 | ND | ND | .02 | ND | -- | -- | -- |
| Flufenacet ethane sulfonic acid | -- | 0 | 73 | ND | ND | .02 | ND | -- | -- | -- |
| Flufenacet oxanilic acid | -- | 0 | 73 | ND | ND | .02 | ND | -- | -- | -- |
| Flumetsulam | 98967–40–9 | 0 | 215 | ND | ND | .04 | ND | 7,000 | HBSL | -- |
| Linuron (CCL) | 330–55–2 | 0 | 215 | ND | ND | .014 | ND | 5 | HBSL | -- |
| MCPA | 94–74–6 | 0 | 207 | ND | ND | .07 | ND | 30 | HBSL | -- |
| MCPB | 94–81–5 | 0 | 215 | ND | ND | .1 | ND | 100 | HBSL | -- |
| Neburon | 555–37–3 | 0 | 215 | ND | ND | .012 | ND | -- | -- | -- |
| Nicosulfuron | 111991–09–4 | 0 | 215 | ND | ND | .04 | ND | 9,000 | HBSL | -- |
| Oryzalin | 19044–88–3 | 0 | 215 | ND | ND | .023 | ND | [4]4 | HBSL | -- |
| Pendimethalin | 40487–42–1 | 0 | 221 | ND | ND | .022 | ND | 70 | HBSL | -- |
| Prometryn | 7287–19–6 | 0 | 221 | ND | ND | .0059 | ND | 300 | HBSL | -- |
| Propachlor | 1918–16–7 | 0 | 17 | ND | ND | .02 | ND | [4]1 | HBSL | -- |
| Propachlor ethane sulfonic acid | -- | 0 | 73 | ND | ND | .05 | ND | -- | -- | -- |
| Propachlor oxanilic acid | -- | 0 | 73 | ND | ND | .02 | ND | -- | -- | -- |
| Propham | 122–42–9 | 0 | 215 | ND | ND | .03 | ND | 100 | HBSL | -- |
| Propyzamide | 23950–58–5 | 0 | 221 | ND | ND | .004 | ND | [4]1 | HBSL | -- |
| Terbuthylazine | 5915–41–3 | 0 | 221 | ND | ND | .0083 | ND | 2 | HBSL | -- |
| Triclopyr | 55335–06–3 | 0 | 215 | ND | ND | .026 | ND | 400 | HBSL | -- |
| Trifluralin | 1582–09–8 | 0 | 221 | ND | ND | .009 | ND | 20 | HBSL | -- |

**Appendix 1.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source-water samples collected during October 2002–July 2005 (use groups obtained from Carter and others, 2007).—Continued

[Compounds within each primary-use category are listed in order from highest to lowest detection frequency. CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; MCL, Maximum Contaminant Level; --, none; ND, not detected; E, estimated value; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); HBSL, Health-Based Screening Level; MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset]

| Compound | CASRN[1] | Number of detections for groundwater | Number of samples | Detection frequency (percent) | | Laboratory reporting level (µg/L) | Maximum concentration for groundwater (µg/L) | Human-health benchmark (µg/L) | Type of human-health benchmark | Number of concentrations with BQ >0.1; (1) number of concentrations with BQ >1 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | All data | Censored at 0.1 µg/L | | | | | |
| Insecticides and insecticide degradates | | | | | | | | | | |
| Carbofuran | 1563–66–2 | 3 | 215 | 1.4 | ND | 0.016 | 0.005 | 40 | MCL | -- |
| Imidacloprid | 138261–41–3 | 3 | 215 | 1.4 | ND | .02 | .023 | 400 | HBSL | -- |
| 1-Naphthol | 90–15–3 | 1 | 221 | .5 | ND | .0882 | E.006 | -- | -- | -- |
| Aldicarb sulfone | 1646–88–4 | 1 | 215 | .5 | ND | .018 | E.007 | [7]7 | HBSL | -- |
| Carbaryl | 63–25–2 | 1 | 215 | .5 | ND | .018 | E.012 | [4]40 | HBSL | -- |
| Chlorpyrofos, oxygen analog | 5598–15–2 | 1 | 221 | .5 | ND | .0562 | E.017 | -- | -- | -- |
| Dieldrin | 60–57–1 | 1 | 221 | .5 | ND | .009 | .024 | [4].002 | HBSL | 1(1) |
| Fipronil | 120068–37–3 | 1 | 221 | .5 | ND | .016 | E.008 | -- | -- | -- |
| Fipronil sulfide | 120067–83–6 | 1 | 221 | .5 | ND | .013 | .007 | -- | -- | -- |
| Fipronil sulfone | 120068–36–2 | 1 | 221 | .5 | ND | .024 | .02 | -- | -- | -- |
| Fonofos, oxygen analog | 944–21–8 | 1 | 206 | .5 | ND | .0029 | .002 | -- | -- | -- |
| 3-Hydroxycarbofuran | 16655–82–6 | 0 | 215 | ND | ND | .008 | ND | -- | -- | -- |
| 3-Ketocarbofuran | 16709–30–1 | 0 | 213 | ND | ND | 1.5 | ND | -- | -- | -- |
| Aldicarb | 116–06–3 | 0 | 215 | ND | ND | .15 | ND | [7]9 | HBSL | -- |
| Aldicarb sulfoxide | 1646–87–3 | 0 | 215 | ND | ND | .1 | ND | [7]7 | HBSL | -- |
| Azinphos-methyl | 86–50–0 | 0 | 221 | ND | ND | .05 | ND | 10 | HBSL | -- |
| Azinphos-methyl-oxon | 961–22–8 | 0 | 221 | ND | ND | .042 | ND | -- | -- | -- |
| Bendiocarb | 22781–23–3 | 0 | 215 | ND | ND | .08 | ND | 9 | HBSL | -- |
| Chlorpyrifos | 2921–88–2 | 0 | 221 | ND | ND | .005 | ND | 2 | HBSL | -- |
| *cis*-Permethrin | 54774–45–7 | 0 | 221 | ND | ND | .006 | ND | [4,8]4 | HBSL | -- |
| Cyfluthrin | 68359–37–5 | 0 | 221 | ND | ND | .053 | ND | 200 | HBSL | -- |
| Cypermethrin | 52315–07–8 | 0 | 221 | ND | ND | .046 | ND | 40 | HBSL | -- |
| Desulfinylfipronil | -- | 0 | 221 | ND | ND | .012 | ND | -- | -- | -- |

**Appendix 1.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source-water samples collected during October 2002–July 2005 (use groups obtained from Carter and others, 2007).—Continued

[Compounds within each primary-use category are listed in order from highest to lowest detection frequency. CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; MCL, Maximum Contaminant Level; --, none; ND, not detected; E, estimated value; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); HBSL, Health-Based Screening Level; MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset]

| Compound | CASRN[1] | Number of detections for groundwater | Number of samples | Detection frequency (percent) | | Laboratory reporting level (µg/L) | Maximum concentration for groundwater (µg/L) | Human-health benchmark (µg/L) | Type of human-health benchmark | Number of concentrations with BQ >0.1; (1) number of concentrations with BQ >1 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | All data | Censored at 0.1 µg/L | | | | | |
| Insecticides and insecticide degradates—Continued | | | | | | | | | | |
| Desulfinylfipronil amide | -- | 0 | 221 | ND | ND | 0.029 | ND | -- | -- | -- |
| Diazinon (CCL) | 333–41–5 | 0 | 221 | ND | ND | .005 | ND | 1 | HBSL | -- |
| Diazinon, oxygen analog | 962–58–3 | 0 | 221 | ND | ND | .006 | ND | -- | -- | -- |
| Dichlorvos | 62–73–7 | 0 | 221 | ND | ND | .013 | ND | .4 | HBSL | -- |
| Dicrotophos | 141–66–2 | 0 | 221 | ND | ND | .0843 | ND | .05 | HBSL | -- |
| Dimethoate | 60–51–5 | 0 | 221 | ND | ND | .0061 | ND | 2 | HBSL | -- |
| Ethion | 563–12–2 | 0 | 221 | ND | ND | .016 | ND | 4 | HBSL | -- |
| Ethion monoxon | 17356–42–2 | 0 | 221 | ND | ND | .021 | ND | -- | -- | -- |
| Fenamiphos | 22224–92–6 | 0 | 221 | ND | ND | .029 | ND | .7 | HBSL | -- |
| Fenamiphos sulfone | 31972–44–8 | 0 | 221 | ND | ND | .053 | ND | -- | -- | -- |
| Fenamiphos sulfoxide | 31972–43–7 | 0 | 200 | ND | ND | .04 | ND | -- | -- | -- |
| Fonofos (CCL) | 944–22–9 | 0 | 221 | ND | ND | .0053 | ND | 10 | HBSL | -- |
| Isofenphos | 25311–71–1 | 0 | 221 | ND | ND | .011 | ND | 6 | HBSL | -- |
| Malaoxon | 1634–78–2 | 0 | 221 | ND | ND | .039 | ND | -- | -- | -- |
| Malathion | 121–75–5 | 0 | 221 | ND | ND | .027 | ND | 50 | HBSL | -- |
| Methidathion | 950–37–8 | 0 | 221 | ND | ND | .0087 | ND | 1 | HBSL | -- |
| Methiocarb | 2032–65–7 | 0 | 215 | ND | ND | .034 | ND | 40 | HBSL | -- |
| Methomyl | 16752–77–5 | 0 | 215 | ND | ND | .07 | ND | 200 | HBSL | -- |
| Oxamyl | 23135–22–0 | 0 | 215 | ND | ND | .05 | ND | 200 | MCL | -- |
| Paraoxon-methyl | 950–35–6 | 0 | 221 | ND | ND | .019 | ND | -- | -- | -- |
| Parathion-methyl | 298–00–0 | 0 | 221 | ND | ND | .015 | ND | 1 | HBSL | -- |
| Phorate | 298–02–2 | 0 | 221 | ND | ND | .055 | ND | 4 | HBSL | -- |
| Phorate oxon | 2600–69–3 | 0 | 221 | ND | ND | .027 | ND | -- | -- | -- |

**Appendix 1.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source-water samples collected during October 2002–July 2005 (use groups obtained from Carter and others, 2007).—Continued

[Compounds within each primary-use category are listed in order from highest to lowest detection frequency. CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; MCL, Maximum Contaminant Level; --, none; ND, not detected; E, estimated value; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); HBSL, Health-Based Screening Level; MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset]

| Compound | CASRN[1] | Number of detections for groundwater | Number of samples | Detection frequency (percent) | | Laboratory reporting level (µg/L) | Maximum concentration for groundwater (µg/L) | Human-health benchmark (µg/L) | Type of human-health benchmark | Number of concentrations with BQ >0.1; (1) number of concentrations with BQ >1 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | All data | Censored at 0.1 µg/L | | | | | |
| Insecticides and insecticide degradates—Continued | | | | | | | | | | |
| Phosmet | 732–11–6 | 0 | 211 | ND | ND | 0.0079 | ND | 8 | HBSL | -- |
| Phosmet oxon | 3735–33–9 | 0 | 201 | ND | ND | .0511 | ND | -- | -- | -- |
| Propoxur | 114–26–1 | 0 | 215 | ND | ND | .008 | ND | [4]9 | HBSL | -- |
| Terbufos (CCL) | 13071–79–9 | 0 | 221 | ND | ND | .017 | ND | .4 | HBSL | -- |
| Terbufos-oxygen-analog sulfone | 56070–15–6 | 0 | 221 | ND | ND | .045 | ND | -- | -- | -- |
| Manufacturing additives | | | | | | | | | | |
| Triphenyl phosphate | 115–86–6 | 6 | 202 | 3.0 | ND | 0.5 | E0.095 | -- | -- | -- |
| Tributyl phosphate | 126–73–8 | 5 | 217 | 2.3 | 0.5 | .5 | E.12 | -- | -- | -- |
| Bisphenol A | 80–05–7 | 2 | 212 | .9 | .9 | 1 | 6.4 | 400 | HBSL | -- |
| Tri(2-chloroethyl) phosphate[3] | 115–96–8 | 2 | 217 | .9 | ND | .5 | E.049 | -- | -- | -- |
| Tris(dichlorisopropyl)-phosphate | 13674–87–8 | 2 | 217 | .9 | ND | .5 | E.022 | -- | -- | -- |
| Tri(2-butoxyethyl)-phosphate | 78–51–3 | 1 | 203 | .5 | .5 | .5 | E.14 | -- | -- | -- |
| 5-Methyl-1H-benzo-triazole | 136–85–6 | 0 | 215 | ND | ND | 2 | ND | -- | -- | -- |
| Organic synthesis compounds | | | | | | | | | | |
| Carbon disulfide | 75–15–0 | 3 | 175 | 1.7 | 1.7 | 0.038 | 12.7 | 700 | HBSL | -- |
| Vinyl chloride | 75–01–4 | 2 | 221 | .9 | .9 | .08 | .7 | 2 | MCL | 1 |
| Acrylonitrile | 107–13–1 | 1 | 221 | .5 | .5 | .8 | E.504 | [4].06 | HBSL | 1(1) |
| Anthraquinone | 84–65–1 | 1 | 217 | .5 | .5 | .5 | E.11 | -- | -- | -- |
| Carbazole | 86–74–8 | 1 | 217 | .5 | ND | .5 | E.081 | -- | -- | -- |

**Appendix 1.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source-water samples collected during October 2002–July 2005 (use groups obtained from Carter and others, 2007).—Continued

[Compounds within each primary-use category are listed in order from highest to lowest detection frequency. CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; MCL, Maximum Contaminant Level; --, none; ND, not detected; E, estimated value; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); HBSL, Health-Based Screening Level; MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset]

| Compound | CASRN[1] | Number of detections for groundwater | Number of samples | Detection frequency (percent) | | Laboratory reporting level (µg/L) | Maximum concentration for groundwater (µg/L) | Human-health benchmark (µg/L) | Type of human-health benchmark | Number of concentrations with BQ >0.1; (1) number of concentrations with BQ >1 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | All data | Censored at 0.1 µg/L | | | | | |
| Organic synthesis compounds—Continued | | | | | | | | | | |
| 1,1-Dichloropropene (CCL) | 563–58–6 | 0 | 221 | ND | ND | 0.026 | ND | -- | -- | -- |
| 1,2,3-Trichlorobenzene | 87–61–6 | 0 | 221 | ND | ND | .18 | ND | -- | -- | -- |
| 1,2,3-Trichloropropane | 96–18–4 | 0 | 221 | ND | ND | .18 | ND | 40 | HBSL | -- |
| 3-Chloro-1-propene | 107–05–1 | 0 | 221 | ND | ND | .5 | ND | -- | -- | -- |
| Chloromethane | 74–87–3 | 0 | 221 | ND | ND | .17 | ND | 30 | HBSL | -- |
| Ethyl methacrylate (Ethyl 2-methyl-2-propanoate) | 97–63–2 | 0 | 221 | ND | ND | .18 | ND | -- | -- | -- |
| Hexachlorobutadiene (CCL) | 87–68–3 | 0 | 221 | ND | ND | .14 | ND | [4].9 | HBSL | -- |
| Iodomethane | 74–88–4 | 0 | 221 | ND | ND | .5 | ND | -- | -- | -- |
| Methyl acrylate (Methyl-2-propenoate) | 96–33–3 | 0 | 221 | ND | ND | 1 | ND | -- | -- | -- |
| Methyl acrylonitrile (2-Methyl-2-propenenitrile) | 126–98–7 | 0 | 221 | ND | ND | .4 | ND | .7 | HBSL | -- |
| Methyl methacrylate (Methyl 2-methyl-2-propenoate) | 80–62–6 | 0 | 221 | ND | ND | .2 | ND | 10,000 | HBSL | -- |
| *trans*-1,4-Dichloro-2-butene | 110–57–6 | 0 | 221 | ND | ND | .7 | ND | -- | -- | -- |
| Vinyl bromide | 593–60–2 | 0 | 221 | ND | ND | .1 | ND | -- | -- | -- |

**Appendix 1.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source-water samples collected during October 2002–July 2005 (use groups obtained from Carter and others, 2007).—Continued

[Compounds within each primary-use category are listed in order from highest to lowest detection frequency. CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; MCL, Maximum Contaminant Level; --, none; ND, not detected; E, estimated value; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); HBSL, Health-Based Screening Level; MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset]

| Compound | CASRN[1] | Number of detections for groundwater | Number of samples | Detection frequency (percent) | | Laboratory reporting level (µg/L) | Maximum concentration for groundwater (µg/L) | Human-health benchmark (µg/L) | Type of human-health benchmark | Number of concentrations with BQ >0.1; (1) number of concentrations with BQ >1 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | All data | Censored at 0.1 µg/L | | | | | |
| Pavement- and combustion-derived compounds | | | | | | | | | | |
| Fluoranthene | 206–44–0 | 5 | 217 | 2.3 | ND | 0.5 | E0.044 | 300 | HBSL | -- |
| Pyrene | 129–00–0 | 5 | 216 | 2.3 | ND | .5 | E.046 | 200 | HBSL | -- |
| Phenanthrene[3] | 85–01–8 | 3 | 217 | 1.4 | ND | .5 | E.016 | -- | -- | -- |
| Anthracene | 120–12–7 | 1 | 217 | .5 | ND | .5 | E.024 | 2,000 | HBSL | -- |
| Benzo[a]pyrene | 50–32–8 | 0 | 217 | ND | ND | .5 | ND | .2 | MCL | -- |
| Personal-care and domestic-use products | | | | | | | | | | |
| Caffeine | 58–08–2 | 10 | 168 | 6.0 | ND | 0.018 | 0.0171 | -- | -- | -- |
| Hexahydrohexamethylcyclopentabenzopyran (HHCB)[3] | 1222–05–5 | 7 | 217 | 3.2 | ND | .5 | E.036 | -- | -- | -- |
| Menthol | 89–78–1 | 6 | 203 | 3.0 | 1 | .5 | E.2 | -- | -- | -- |
| Octylphenol diethoxylate (total)[3] | -- | 4 | 217 | 1.8 | .9 | 1 | E.12 | -- | -- | -- |
| 4-*tert*-Octylphenol | 140–66–9 | 3 | 217 | 1.4 | ND | 1 | E.087 | -- | -- | -- |
| Methyl salicylate[3] | 119–36–8 | 3 | 217 | 1.4 | .5 | .5 | E.11 | 4,000 | HBSL | -- |
| Octylphenol monoethoxylate (total) | -- | 3 | 217 | 1.4 | 1.4 | 1 | E.59 | -- | -- | -- |
| 4-Cumylphenol | 599–64–4 | 1 | 217 | .5 | .5 | 1 | E.18 | -- | -- | -- |
| Acetyl hexamethyl tetrahydronaphthalene (AHTN)[3] | 21145–77–7 | 1 | 217 | .5 | ND | .5 | E.005 | -- | -- | -- |
| Indole | 120–72–9 | 1 | 217 | .5 | ND | .5 | E.08 | -- | -- | -- |
| Triclosan | 3380–34–5 | 1 | 217 | .5 | ND | 1 | E.065 | -- | -- | -- |
| 3-*tert*-Butyl-4-hydroxy anisole (BHA) | 25013–16–5 | 0 | 217 | ND | ND | 5 | ND | -- | -- | -- |
| 4-*n*-Octylphenol | 1806–26–4 | 0 | 217 | ND | ND | 1 | ND | -- | -- | -- |

**Appendix 1.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source-water samples collected during October 2002–July 2005 (use groups obtained from Carter and others, 2007).—Continued

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| Compound | CASRN[1] | Number of detections for groundwater | Number of samples | Detection frequency (percent) | | Laboratory reporting level (µg/L) | Maximum concentration for groundwater (µg/L) | Human-health benchmark (µg/L) | Type of human-health benchmark | Number of concentrations with BQ >0.1; (1) number of concentrations with BQ >1 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | All data | Censored at 0.1 µg/L | | | | | |
| Personal-care and domestic-use products—Continued | | | | | | | | | | |
| Nonylphenol diethoxylate (total) | 26027–38–2 | 0 | 217 | ND | ND | 5 | ND | -- | -- | -- |
| Acetophenone | 98–86–2 | 0 | 187 | ND | ND | .5 | ND | 700 | HBSL | -- |
| Benzophenone | 119–61–9 | -- | R | -- | -- | .5 | ND | -- | -- | -- |
| Bromochloromethane | 74–97–5 | 0 | 221 | ND | ND | .12 | ND | 90 | HBSL | -- |
| Camphor[3] | 76–22–2 | 0 | 217 | ND | ND | .5 | ND | -- | -- | -- |
| Cotinine | 486–56–6 | 0 | 118 | ND | ND | 1 | ND | -- | -- | -- |
| *d*-Limonene | 5989–27–5 | 0 | 217 | ND | ND | .5 | ND | -- | -- | -- |
| Isoborneol | 124–76–5 | 0 | 217 | ND | ND | .5 | ND | -- | -- | -- |
| Isoquinoline | 119–65–3 | 0 | 217 | ND | ND | .5 | ND | -- | -- | -- |
| N,N-diethyl-*meta*-toluamide (DEET) | 134–62–3 | -- | R | -- | -- | .5 | ND | -- | -- | -- |
| *para*-Nonylphenol (total) | 84852–15–3 | -- | R | -- | -- | 5 | ND | -- | -- | -- |
| Phenol | 108–95–2 | -- | R | -- | -- | .5 | ND | 2,000 | HBSL | -- |
| Triethyl citrate (Ethyl citrate) | 77–93–0 | 0 | 217 | ND | ND | .5 | ND | -- | -- | -- |
| Plant- or animal-derived biochemicals | | | | | | | | | | |
| 3-*beta*-Coprostanol | 360–68–9 | 2 | 217 | 0.9 | 0.9 | 2 | E0.34 | -- | -- | -- |
| Cholesterol[3] | 57–88–5 | 2 | 217 | .9 | .9 | 2 | E.53 | -- | -- | -- |
| 3-Methyl-1(H)-indole (Skatole) | 83–34–1 | 1 | 217 | .5 | ND | 1 | E.027 | -- | -- | -- |
| *beta*-Sitosterol | 83–46–5 | 1 | 217 | .5 | .5 | 2 | E.39 | -- | -- | -- |
| *beta*-Stigmastanol | 19466–47–8 | 1 | 217 | .5 | .5 | 2 | E.36 | -- | -- | -- |

**Appendix 1.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source-water samples collected during October 2002–July 2005 (use groups obtained from Carter and others, 2007).—Continued

[Compounds within each primary-use category are listed in order from highest to lowest detection frequency. CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; MCL, Maximum Contaminant Level; --, none; ND, not detected; E, estimated value; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); HBSL, Health-Based Screening Level; MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset]

| Compound | CASRN[1] | Number of detections for groundwater | Number of samples | Detection frequency (percent) | | Laboratory reporting level (µg/L) | Maximum concentration for groundwater (µg/L) | Human-health benchmark (µg/L) | Type of human-health benchmark | Number of concentrations with BQ >0.1; (1) number of concentrations with BQ >1 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | All data | Censored at 0.1 µg/L | | | | | |
| **Refrigerants and propellants** | | | | | | | | | | |
| Trichlorofluoromethane (CFC-11)[3] | 75–69–4 | 5 | 221 | 2.3 | 0.5 | 0.08 | 0.275 | 2,000 | HBSL | -- |
| 1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113) | 76–13–1 | 4 | 221 | 1.8 | .9 | .038 | 1.06 | 200,000 | HBSL | -- |
| Dichlorodifluoromethane (CFC-12) | 75–71–8 | 3 | 221 | 1.4 | .5 | .18 | E.145 | 1,000 | HBSL | -- |
| **Solvents** | | | | | | | | | | |
| Perchloroethene (PCE)[3] | 127–18–4 | 43 | 221 | 19.5 | 10 | 0.03 | 5.47 | 5 | MCL | 4(1) |
| Trichloroethene (TCE) | 79–01–6 | 31 | 221 | 14.0 | 6.3 | .038 | 69.5 | 5 | MCL | 3(2) |
| 1,1,1-Trichloroethane | 71–55–6 | 21 | 221 | 9.5 | 3.2 | .032 | 16.7 | 200 | MCL | -- |
| *cis*-1,2-Dichloroethene | 156–59–2 | 21 | 221 | 9.5 | 4.1 | .024 | 1.5 | 70 | MCL | -- |
| 1,1-Dichloroethane (CCL) | 75–34–3 | 13 | 221 | 5.9 | 2.7 | .035 | 4.88 | -- | -- | -- |
| 1,1-Dichloroethene | 75–35–4 | 11 | 221 | 5.0 | 1.8 | .024 | 6.53 | 7 | MCL | 1 |
| 1,2-Dichloroethane | 107–06–2 | 4 | 221 | 1.8 | 1.4 | .13 | .2 | 5 | MCL | -- |
| *p*-Cresol | 106–44–5 | 4 | 217 | 1.8 | .9 | 1 | E.19 | -- | -- | -- |
| *trans*-1,2-Dichloroethene | 156–60–5 | 4 | 221 | 1.8 | .5 | .032 | E.11 | 100 | MCL | -- |
| Carbon tetrachloride (Tetrachloromethane) | 56–23–5 | 3 | 221 | 1.4 | .5 | .06 | .677 | 5 | MCL | 1 |
| 1,1,2-Trichloroethane | 79–00–5 | 1 | 220 | .5 | ND | .04 | E.08 | 5 | MCL | -- |
| Methyl isobutyl ketone (4-Methyl-2-pentanone; MIBK) | 108–10–1 | 1 | 221 | .5 | .5 | .37 | E.766 | -- | -- | -- |
| Dibromomethane | 74–95–3 | 1 | 221 | .5 | ND | .05 | E.065 | -- | -- | -- |

**Appendix 1.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source-water samples collected during October 2002–July 2005 (use groups obtained from Carter and others, 2007).—Continued

[Compounds within each primary-use category are listed in order from highest to lowest detection frequency. CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; MCL, Maximum Contaminant Level; --, none; ND, not detected; E, estimated value; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); HBSL, Health-Based Screening Level; MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset]

| Compound | CASRN[1] | Number of detections for groundwater | Number of samples | Detection frequency (percent) | | Laboratory reporting level (µg/L) | Maximum concentration for groundwater (µg/L) | Human-health benchmark (µg/L) | Type of human-health benchmark | Number of concentrations with BQ >0.1; (1) number of concentrations with BQ >1 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | All data | Censored at 0.1 µg/L | | | | | |
| Solvents—Continued | | | | | | | | | | |
| Methyl ethyl ketone (MEK)[3] | 78–93–3 | 1 | 221 | 0.5 | 0.5 | 2 | 330.2 | 4,000 | HBSL | -- |
| *n*-Propylbenzene | 103–65–1 | 1 | 221 | .5 | .5 | .042 | .108 | -- | -- | -- |
| Tetrahydrofuran[3] | 109–99–9 | 1 | 221 | .5 | .5 | 1.2 | 1,020 | -- | -- | -- |
| 1,1,1,2-Tetrachloroethane | 630–20–6 | 0 | 221 | ND | ND | .03 | ND | 70 | HBSL | -- |
| 1,1,2,2-Tetrachloroethane (CCL) | 79–34–5 | 0 | 221 | ND | ND | .08 | ND | .3 | HBSL | -- |
| Diethyl ether (1,1'-Oxybisethane) | 60–29–7 | 0 | 221 | ND | ND | .08 | ND | 1,000 | HBSL | -- |
| 1,2,4-Trichlorobenzene | 120–82–1 | 0 | 221 | ND | ND | .12 | ND | 70 | MCL | -- |
| 1,2-Dichlorobenzene | 95–50–1 | 0 | 221 | ND | ND | .048 | ND | 600 | MCL | -- |
| 1,3-Dichlorobenzene | 541–73–1 | 0 | 221 | ND | ND | .03 | ND | 600 | HBSL | -- |
| 2-Chlorotoluene | 95–49–8 | 0 | 221 | ND | ND | .04 | ND | 100 | HBSL | -- |
| 2-Hexanone | 591–78–6 | 0 | 221 | ND | ND | .4 | ND | -- | -- | -- |
| 4-Chlorotoluene | 106–43–4 | 0 | 221 | ND | ND | .05 | ND | 100 | HBSL | -- |
| Acetone | 67–64–1 | 0 | 161 | ND | ND | 6 | ND | 6,000 | HBSL | -- |
| Bromobenzene (CCL) | 108–86–1 | 0 | 221 | ND | ND | .028 | ND | -- | -- | -- |
| Chlorobenzene | 108–90–7 | 0 | 206 | ND | ND | .028 | ND | 100 | MCL | -- |
| Chloroethane | 75–00–3 | 0 | 221 | ND | ND | .12 | ND | -- | -- | -- |
| Hexachloroethane | 67–72–1 | 0 | 221 | ND | ND | .14 | ND | .7 | HBSL | -- |
| Isophorone[3] | 78–59–1 | -- | R | -- | -- | .5 | ND | 100 | HBSL | -- |
| Methyl acetate | 79–20–9 | 0 | 119 | ND | ND | .43 | ND | -- | -- | -- |
| Methylene chloride (Dichloromethane) | 75–09–2 | 0 | 192 | ND | ND | .06 | ND | 5 | MCL | -- |

[1]This report contains CASRNs, which is a Registered Trademark of the American Chemical Society. The Chemical Abstracts Service (CAS) recommends the verification of the CASRNs through CAS Client Services[SM].

[2]The U.S. Environmental Protection Agency's MCL of 80 µg/L is for the sum of the concentrations of four trihalomethanes.

[3]Compound was detected in only one field blank.

[4]HBSL values shown for carcinogens represent the low end ($10^{-6}$) of the HBSL range ($10^{-6}$ to $10^{-4}$ cancer risk level) (Toccalino, Norman, and others, 2006).

[5]The sum of concentrations from *cis*-1,3- and *trans*-1,3-dichloropropene may be compared to the HBSL range (0.3–30 µg/L) for the mixed isomer of 1,3-dichloropropene, CASRN 542–75–6.

[6]The concentrations from *m*- and *p*-xylene and *o*-xylene may be compared to the MCL (10,000 µg/L) for mixed xylenes, CASRN 1330–20–7.

[7]U.S. Environmental Protection Agency Office of Water recommends that the concentration of any combination of two or more of the three aldicarb compounds should not be greater than 7 µg/L because of similar mode of action.

[8]Concentrations of *cis*-permethrin may be compared to the HBSL range (4–400 µg/L) for permethrin, CASRN 52645–53–1.

**Appendix 2.** Selected characteristics of community water system wells sampled for Source Water-Quality Assessments, 2002–05.

[NA, not available; -- not applicable]

| Primary lithology | Site name | Well depth (feet) | Blended |
|---|---|---|---|
| Basin and Range basin-fill aquifers | | | |
| Unconsolidated and semiconsolidated sediments | NVBR-0001 | 510 | -- |
| Unconsolidated and semiconsolidated sediments | NVBR-0002 | 590 | -- |
| Unconsolidated and semiconsolidated sediments | NVBR-0003 | 560 | -- |
| Unconsolidated and semiconsolidated sediments | NVBR-0004 | 195 | -- |
| Unconsolidated and semiconsolidated sediments | NVBR-0005 | 820 | -- |
| Unconsolidated and semiconsolidated sediments | NVBR-0006 | 470 | -- |
| Unconsolidated and semiconsolidated sediments | NVBR-0007 | 470 | Yes[1] |
| Unconsolidated and semiconsolidated sediments | NVBR-0008 | 1,250 | -- |
| Unconsolidated and semiconsolidated sediments | NVBR-0009 | 400 | Yes[1] |
| Unconsolidated and semiconsolidated sediments | NVBR-0010 | 455 | -- |
| Unconsolidated and semiconsolidated sediments | NVBR-0011 | 200 | -- |
| Unconsolidated and semiconsolidated sediments | NVBR-0012 | 620 | -- |
| Unconsolidated and semiconsolidated sediments | NVBR-0013 | 600 | -- |
| Unconsolidated and semiconsolidated sediments | NVBR-0014 | 400 | -- |
| Unconsolidated and semiconsolidated sediments | NVBR-0015 | 330 | -- |
| Cambrian-Ordovician aquifer system | | | |
| Sandstone and carbonate rock | UMIS-0001 | 403 | Yes[1] |
| Sandstone and carbonate rock | UMIS-0002 | 493 | Yes[1] |
| Sandstone and carbonate rock | UMIS-0003 | 500 | -- |
| Sandstone and carbonate rock | UMIS-0004 | 399 | Yes[1] |
| Sandstone and carbonate rock | UMIS-0005 | 407 | -- |
| Sandstone and carbonate rock | UMIS-0006 | 408 | -- |
| Sandstone and carbonate rock | UMIS-0007 | 500 | -- |
| Sandstone and carbonate rock | UMIS-0008 | 401 | -- |
| Sandstone and carbonate rock | UMIS-0009 | 495 | Yes[1] |
| Sandstone and carbonate rock | UMIS-0010 | 548 | Yes[1] |
| Sandstone and carbonate rock | UMIS-0011 | 387 | Yes[1] |
| Sandstone and carbonate rock | UMIS-0012 | 507 | No[1] |
| Sandstone and carbonate rock | UMIS-0013 | 513 | -- |
| Sandstone and carbonate rock | UMIS-0014 | 345 | Yes[1] |
| Sandstone and carbonate rock | UMIS-0015 | 317 | -- |
| Central Valley aquifer system | | | |
| Unconsolidated and semiconsolidated sediments | SANJ-0001 | 215 | Yes[1] |
| Unconsolidated and semiconsolidated sediments | SANJ-0002 | 208 | -- |
| Unconsolidated and semiconsolidated sediments | SANJ-0003 | 250 | Yes[1] |
| Unconsolidated and semiconsolidated sediments | SANJ-0004 | 220 | -- |
| Unconsolidated and semiconsolidated sediments | SANJ-0005 | 216 | Yes[1] |
| Unconsolidated and semiconsolidated sediments | SANJ-0006 | 262 | Yes[1] |
| Unconsolidated and semiconsolidated sediments | SANJ-0007 | 220 | Yes[1] |
| Unconsolidated and semiconsolidated sediments | SANJ-0008 | 218 | -- |

**Appendix 2.** Selected characteristics of community water system wells sampled for Source Water-Quality Assessments, 2002–05.—Continued

[NA, not available; -- not applicable]

| Primary lithology | Site name | Well depth (feet) | Blended |
|---|---|---|---|
| Central Valley aquifer system—Continued | | | |
| Unconsolidated and semiconsolidated sediments | SANJ-0009 | 302 | Yes[1] |
| Unconsolidated and semiconsolidated sediments | SANJ-0010 | 245 | -- |
| Unconsolidated and semiconsolidated sediments | SANJ-0011 | 391 | Yes[1] |
| Unconsolidated and semiconsolidated sediments | SANJ-0012 | 220 | Yes[1] |
| Unconsolidated and semiconsolidated sediments | SANJ-0013 | 307 | Yes[1] |
| Unconsolidated and semiconsolidated sediments | SANJ-0014 | 385 | -- |
| Unconsolidated and semiconsolidated sediments | SANJ-0015 | 415 | Yes[1] |
| Coastal Lowlands aquifer system | | | |
| Unconsolidated and semiconsolidated sediments | TRIN-0001 | 1,012 | -- |
| Unconsolidated and semiconsolidated sediments | TRIN-0002 | 1,394 | -- |
| Unconsolidated and semiconsolidated sediments | TRIN-0003 | 1,370 | -- |
| Unconsolidated and semiconsolidated sediments | TRIN-0004 | 1,665 | -- |
| Unconsolidated and semiconsolidated sediments | TRIN-0005 | 1,135 | -- |
| Unconsolidated and semiconsolidated sediments | TRIN-0006 | 1,712 | Yes[1] |
| Unconsolidated and semiconsolidated sediments | TRIN-0007 | 1,374 | Yes[1] |
| Unconsolidated and semiconsolidated sediments | TRIN-0008 | 1,200 | -- |
| Unconsolidated and semiconsolidated sediments | TRIN-0009 | 1,379 | -- |
| Unconsolidated and semiconsolidated sediments | TRIN-0010 | 1,480 | -- |
| Unconsolidated and semiconsolidated sediments | TRIN-0011 | 1,438 | -- |
| Unconsolidated and semiconsolidated sediments | TRIN-0012 | 1,444 | -- |
| Unconsolidated and semiconsolidated sediments | TRIN-0013 | 1,480 | -- |
| Unconsolidated and semiconsolidated sediments | TRIN-0014 | 1,050 | Yes[1] |
| Unconsolidated and semiconsolidated sediments | TRIN-0015 | 1,630 | Yes[1] |
| Columbia Plateau basin-fill and basaltic-rock aquifers | | | |
| Igneous and metamorphic rocks | CCYK-0001 | 954 | -- |
| Igneous and metamorphic rocks | CCYK-0002 | 919 | -- |
| Unconsolidated and semiconsolidated sediments | CCYK-0003 | 188 | No[1] |
| Unconsolidated and semiconsolidated sediments | CCYK-0004 | 1,171 | -- |
| Igneous and metamorphic rocks | CCYK-0005 | 1,624 | -- |
| Igneous and metamorphic rocks | CCYK-0006 | 1,011 | -- |
| Igneous and metamorphic rocks | CCYK-0007 | 718 | No[1] |
| Igneous and metamorphic rocks | CCYK-0008 | 900 | -- |
| Igneous and metamorphic rocks | CCYK-0009 | 1,320 | -- |
| Igneous and metamorphic rocks | CCYK-0010 | 368 | -- |
| Igneous and metamorphic rocks | CCYK-0011 | 617 | -- |
| Igneous and metamorphic rocks | CCYK-0012 | 750 | No[1] |
| Igneous and metamorphic rocks | CCYK-0013 | 380 | No[1] |
| Igneous and metamorphic rocks | CCYK-0014 | 618 | -- |
| Igneous and metamorphic rocks | CCYK-0015 | 525 | -- |

**Appendix 2.** Selected characteristics of community water system wells sampled for Source Water-Quality Assessments, 2002–05.—Continued

[NA, not available; -- not applicable]

| Primary lithology | Site name | Well depth (feet) | Blended |
|---|---|---|---|
| Denver Basin aquifer system | | | |
| Sandstone and carbonate rock | SPLT-0001 | 536 | -- |
| Sandstone and carbonate rock | SPLT-0002 | 1,115 | -- |
| Sandstone and carbonate rock | SPLT-0003 | 390 | -- |
| Sandstone and carbonate rock | SPLT-0004 | 850 | -- |
| Sandstone and carbonate rock | SPLT-0005 | 575 | -- |
| Sandstone and carbonate rock | SPLT-0006 | 740 | -- |
| Sandstone and carbonate rock | SPLT-0007 | NA | -- |
| Sandstone and carbonate rock | SPLT-0008 | NA | -- |
| Sandstone and carbonate rock | SPLT-0009 | 433 | -- |
| Sandstone and carbonate rock | SPLT-0010 | 561 | -- |
| Sandstone and carbonate rock | SPLT-0011 | 245 | -- |
| Sandstone and carbonate rock | SPLT-0012 | NA | -- |
| Edwards-Trinity aquifer system | | | |
| Sandstone and carbonate rock | SCTX-0001 | 525 | -- |
| Sandstone and carbonate rock | SCTX-0002 | 1,800 | -- |
| Sandstone and carbonate rock | SCTX-0003 | 1,040 | -- |
| Sandstone and carbonate rock | SCTX-0004 | 1,114 | -- |
| Sandstone and carbonate rock | SCTX-0005 | 1,150 | Yes[1] |
| Sandstone and carbonate rock | SCTX-0006 | 748 | No[1] |
| Sandstone and carbonate rock | SCTX-0007 | 760 | -- |
| Sandstone and carbonate rock | SCTX-0008 | 808 | Yes[1] |
| Sandstone and carbonate rock | SCTX-0009 | 1,050 | Yes[1] |
| Sandstone and carbonate rock | SCTX-0010 | 877 | -- |
| Sandstone and carbonate rock | SCTX-0011 | 848 | Yes[1] |
| Sandstone and carbonate rock | SCTX-0012 | 870 | -- |
| Sandstone and carbonate rock | SCTX-0013 | 811 | Yes[1] |
| Sandstone and carbonate rock | SCTX-0014 | 710 | Yes[1] |
| Sandstone and carbonate rock | SCTX-0015 | 365 | No[1] |
| Floridan aquifer system | | | |
| Sandstone and carbonate rock | GAFL-0001 | 405 | -- |
| Sandstone and carbonate rock | GAFL-0002 | 305 | Yes[1] |
| Sandstone and carbonate rock | GAFL-0003 | 105 | -- |
| Sandstone and carbonate rock | GAFL-0004 | 174 | Yes[1] |
| Sandstone and carbonate rock | GAFL-0005 | 700 | -- |
| Sandstone and carbonate rock | GAFL-0006 | 350 | -- |
| Sandstone and carbonate rock | GAFL-0007 | 590 | -- |
| Sandstone and carbonate rock | GAFL-0008 | 601 | -- |
| Sandstone and carbonate rock | GAFL-0009 | 610 | Yes[1] |
| Sandstone and carbonate rock | GAFL-0010 | 550 | -- |
| Sandstone and carbonate rock | GAFL-0011 | 700 | -- |

**Appendix 2.** Selected characteristics of community water system wells sampled for Source Water-Quality Assessments, 2002–05.—Continued

[NA, not available; -- not applicable]

| Primary lithology | Site name | Well depth (feet) | Blended |
|---|---|---|---|
| | Floridan aquifer system—Continued | | |
| Sandstone and carbonate rock | GAFL-0012 | 311 | -- |
| Sandstone and carbonate rock | GAFL-0013 | 575 | No[1] |
| Sandstone and carbonate rock | GAFL-0014 | 90 | Yes[1] |
| Sandstone and carbonate rock | GAFL-0015 | 840 | No[1] |
| Sandstone and carbonate rock | GAFL-0016 | 750 | Yes[1] |
| Sandstone and carbonate rock | GAFL-0017 | 300 | -- |
| Sandstone and carbonate rock | GAFL-0018 | 705 | -- |
| Sandstone and carbonate rock | GAFL-0019 | 121 | -- |
| Sandstone and carbonate rock | GAFL-0020 | 702 | -- |
| Sandstone and carbonate rock | GAFL-0021 | 150 | -- |
| Sandstone and carbonate rock | GAFL-0022 | 710 | -- |
| Sandstone and carbonate rock | GAFL-0023 | 710 | -- |
| Sandstone and carbonate rock | GAFL-0024 | 430 | No[1] |
| Sandstone and carbonate rock | GAFL-0025 | 350 | No[1] |
| Sandstone and carbonate rock | GAFL-0026 | 625 | No[1] |
| Sandstone and carbonate rock | GAFL-0027 | 484 | -- |
| Sandstone and carbonate rock | GAFL-0028 | 400 | No[1] |
| Sandstone and carbonate rock | GAFL-0029 | 600 | -- |
| Sandstone and carbonate rock | GAFL-0030 | 602 | -- |
| | Glacial deposits aquifer system | | |
| Unconsolidated glacial deposits | WHMI-0001 | 123 | Yes[1] |
| Unconsolidated glacial deposits | WHMI-0002 | 151 | -- |
| Unconsolidated glacial deposits | WHMI-0003 | 125 | -- |
| Unconsolidated glacial deposits | WHMI-0004 | 77 | -- |
| Unconsolidated glacial deposits | WHMI-0005 | 80 | -- |
| Unconsolidated glacial deposits | WHMI-0006 | 83 | -- |
| Unconsolidated glacial deposits | WHMI-0007 | 152 | -- |
| Unconsolidated glacial deposits | WHMI-0008 | 60 | Yes[1] |
| Unconsolidated glacial deposits | WHMI-0009 | 157 | -- |
| Unconsolidated glacial deposits | WHMI-0010 | 137 | -- |
| Unconsolidated glacial deposits | WHMI-0011 | 61 | Yes[1] |
| Unconsolidated glacial deposits | WHMI-0012 | 146 | Yes[1] |
| Unconsolidated glacial deposits | WHMI-0013 | 94 | -- |
| Unconsolidated glacial deposits | WHMI-0014 | 84 | Yes[1] |
| Unconsolidated glacial deposits | CONN-0001 | 83 | -- |
| Unconsolidated glacial deposits | CONN-0002 | 70 | -- |
| Unconsolidated glacial deposits | CONN-0003 | 76 | Yes[1] |
| Unconsolidated glacial deposits | CONN-0004 | 64 | Yes[1] |
| Unconsolidated glacial deposits | CONN-0005 | 40 | No[1] |
| Unconsolidated glacial deposits | CONN-0006 | 38 | -- |

**Appendix 2.** Selected characteristics of community water system wells sampled for Source Water-Quality Assessments, 2002–05.—Continued

[NA, not available; -- not applicable]

| Primary lithology | Site name | Well depth (feet) | Blended |
|---|---|---|---|
| Glacial deposits aquifer system—Continued | | | |
| Unconsolidated glacial deposits | CONN-0007 | 54 | No[1] |
| Unconsolidated glacial deposits | CONN-0008 | 102 | No[1] |
| Unconsolidated glacial deposits | CONN-0009 | 126 | No[1] |
| Unconsolidated glacial deposits | CONN-0010 | 90 | No[1] |
| Unconsolidated glacial deposits | CONN-0011 | 40 | Yes[1] |
| Unconsolidated glacial deposits | CONN-0012 | 70 | No[1] |
| Unconsolidated glacial deposits | CONN-0013 | 130 | -- |
| Unconsolidated glacial deposits | CONN-0014 | 93 | No[1] |
| Unconsolidated glacial deposits | CONN-0015 | 58 | -- |
| Unconsolidated glacial deposits | UMIS-0016 | 292 | -- |
| Unconsolidated glacial deposits | UMIS-0017 | 152 | Yes[1] |
| Unconsolidated glacial deposits | UMIS-0018 | 215 | -- |
| Unconsolidated glacial deposits | UMIS-0019 | 194 | -- |
| Unconsolidated glacial deposits | UMIS-0020 | 100 | -- |
| Unconsolidated glacial deposits | UMIS-0021 | 205 | -- |
| Unconsolidated glacial deposits | UMIS-0022 | 199 | Yes[1] |
| Unconsolidated glacial deposits | UMIS-0023 | 213 | -- |
| Unconsolidated glacial deposits | UMIS-0024 | 270 | Yes[1] |
| Unconsolidated glacial deposits | UMIS-0025 | 197 | Yes[1] |
| Unconsolidated glacial deposits | UMIS-0026 | 157 | -- |
| Unconsolidated glacial deposits | UMIS-0027 | 310 | -- |
| Unconsolidated glacial deposits | UMIS-0028 | 250 | -- |
| Unconsolidated glacial deposits | UMIS-0029 | 217 | -- |
| Unconsolidated glacial deposits | UMIS-0030 | 344 | No[1] |
| High Plains aquifer | | | |
| Unconsolidated and semiconsolidated sediments | HPGW-0001 | 190 | Yes[1] |
| Unconsolidated and semiconsolidated sediments | HPGW-0002 | 381 | -- |
| Unconsolidated and semiconsolidated sediments | HPGW-0003 | 195 | -- |
| Unconsolidated and semiconsolidated sediments | HPGW-0004 | 253 | -- |
| Unconsolidated and semiconsolidated sediments | HPGW-0005 | 292 | -- |
| Unconsolidated and semiconsolidated sediments | HPGW-0006 | 356 | -- |
| Unconsolidated and semiconsolidated sediments | HPGW-0007 | 340 | -- |
| Unconsolidated and semiconsolidated sediments | HPGW-0008 | 369 | -- |
| Unconsolidated and semiconsolidated sediments | HPGW-0009 | 218 | -- |
| Unconsolidated and semiconsolidated sediments | HPGW-0010 | 380 | -- |
| Unconsolidated and semiconsolidated sediments | HPGW-0011 | 228 | -- |
| Unconsolidated and semiconsolidated sediments | HPGW-0012 | 394 | -- |
| Unconsolidated and semiconsolidated sediments | HPGW-0013 | 120 | Yes[1] |
| Unconsolidated and semiconsolidated sediments | HPGW-0014 | 425 | -- |
| Unconsolidated and semiconsolidated sediments | HPGW-0015 | 136 | -- |

**Appendix 2.** Selected characteristics of community water system wells sampled for Source Water-Quality Assessments, 2002–05.—Continued

[NA, not available; -- not applicable]

| Primary lithology | Site name | Well depth (feet) | Blended |
|---|---|---|---|
| Piedmont and Blue Ridge crystalline-rock aquifers | | | |
| Igneous and metamorphic rocks | PODL-0001 | 400 | -- |
| Igneous and metamorphic rocks | PODL-0002 | 705 | -- |
| Igneous and metamorphic rocks | PODL-0003 | 386 | -- |
| Igneous and metamorphic rocks | PODL-0004 | NA | No[1] |
| Igneous and metamorphic rocks | PODL-0005 | 280 | No[1] |
| Igneous and metamorphic rocks | PODL-0006 | 200 | -- |
| Igneous and metamorphic rocks | PODL-0007 | 95 | Yes[1] |
| Igneous and metamorphic rocks | PODL-0008 | 182 | No[1] |
| Igneous and metamorphic rocks | PODL-0009 | 300 | Yes[1] |
| Igneous and metamorphic rocks | PODL-0010 | NA | Yes[1] |
| Igneous and metamorphic rocks | PODL-0011 | 642 | Yes[1] |
| Igneous and metamorphic rocks | PODL-0012 | 500 | No[1] |
| Igneous and metamorphic rocks | PODL-0013 | 623 | No[1] |
| Igneous and metamorphic rocks | PODL-0014 | 241 | -- |
| Igneous and metamorphic rocks | PODL-0015 | 300 | No[1] |
| Rio Grande aquifer system | | | |
| Unconsolidated and semiconsolidated sediments | RIOG-0001 | 1,400 | No[1] |
| Unconsolidated and semiconsolidated sediments | RIOG-0002 | 1,166 | Yes[1] |
| Unconsolidated and semiconsolidated sediments | RIOG-0003 | 996 | Yes[1] |
| Unconsolidated and semiconsolidated sediments | RIOG-0004 | 1,191 | Yes[1] |
| Unconsolidated and semiconsolidated sediments | RIOG-0005 | 1,670 | Yes[1] |
| Unconsolidated and semiconsolidated sediments | RIOG-0006 | 1,287 | Yes[1] |
| Unconsolidated and semiconsolidated sediments | RIOG-0007 | 814 | Yes[1] |
| Unconsolidated and semiconsolidated sediments | RIOG-0008 | 984 | Yes[1] |
| Unconsolidated and semiconsolidated sediments | RIOG-0009 | 1,194 | Yes[1] |
| Unconsolidated and semiconsolidated sediments | RIOG-0010 | 1,730 | No[1] |
| Unconsolidated and semiconsolidated sediments | RIOG-0011 | 2,070 | No[1] |
| Unconsolidated and semiconsolidated sediments | RIOG-0012 | 1,957 | No[1] |
| Unconsolidated and semiconsolidated sediments | RIOG-0013 | 1,020 | No[1] |
| Unconsolidated and semiconsolidated sediments | RIOG-0014 | 2,010 | No[1] |
| Unconsolidated and semiconsolidated sediments | RIOG-0015 | 1,487 | No[1] |

[1]Site re-sampled during the second phase for source water and finished water.

**Appendix 3.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source- and finished-water samples collected during June 2004–September 2005 (use groups obtained from Carter and others, 2007).

[Compounds within each primary-use category are listed in order from highest to lowest source-water detection frequency. Human-health benchmarks in **bold** type are Maximum Contaminant Levels (MCLs); CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; --, none; E, estimated value; ND, not detected; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset; HBSL, Health-Based Screening Level]

| Compound | CASRN[1] | Number of samples | Detection frequency (percent) | | Maximum concentration (µg/L) | | Human-health benchmark (µg/L) | Number of concentrations with BQ > 0.1; (1) number of concentrations with BQ >1 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Source water/ Finished water | Source water | Finished water | Source water | Finished water | | Source water | Finished water |
| **Disinfection by-products** | | | | | | | | | |
| Chloroform | 67–66–3 | 56/56 | 57 | 88 | 3.25 | 36.3 | [2]**80** | -- | 3 |
| Bromodichloromethane | 75–27–4 | 71/71 | 13 | 79 | .204 | 7.48 | [2]**80** | -- | -- |
| Dibromochloromethane | 124–48–1 | 71/71 | 7.0 | 72 | .433 | 7.95 | [2]**80** | -- | -- |
| Bromoform | 75–25–2 | 71/71 | 7.0 | 62 | .396 | 8.37 | [2]**80** | -- | 1 |
| Trihalomethanes | -- | 71/71 | 57 | 88 | 3.28 | 45.3 | **80** | -- | 9 |
| **Fumigant-related compounds** | | | | | | | | | |
| 1,4-Dichlorobenzene | 106–46–7 | 71/71 | 11 | 11 | E0.048 | E0.056 | **75** | -- | -- |
| 1,2-Dichloropropane | 78–87–5 | 71/71 | 1.4 | ND | E.025 | ND | **5** | -- | -- |
| 1,2-Dibromo-3-chloropropane | 96–12–8 | 71/71 | ND | ND | ND | ND | **.2** | -- | -- |
| 1,2-Dibromoethane | 106–93–4 | 71/71 | ND | ND | ND | ND | **.05** | -- | -- |
| 1,3-Dichloropropane (CCL) | 142–28–9 | 71/71 | ND | ND | ND | ND | -- | -- | -- |
| 2,2-Dichloropropane (CCL) | 594–20–7 | 71/71 | ND | ND | ND | ND | -- | -- | -- |
| Bromomethane (CCL) | 74–83–9 | 71/71 | ND | ND | ND | ND | 100 | -- | -- |
| *cis*-1,3-Dichloropropene (CCL) | 10061–01–5 | 71/71 | ND | ND | ND | ND | [3,4].3 | -- | -- |
| *trans*-1,3-Dichloropropene (CCL) | 10061–02–6 | 71/71 | ND | ND | ND | ND | [3,4].3 | -- | -- |
| **Fungicides and fungicide degradates** | | | | | | | | | |
| Benomyl | 17804–35–2 | 61/59 | 3.3 | 3.4 | E0.026 | E0.026 | 40 | -- | -- |
| Metalaxyl | 57837–19–1 | 48/48 | 2.1 | 2.1 | .01 | .071 | 600 | -- | -- |
| Chlorothalonil | 1897–45–6 | 61/59 | ND | ND | ND | ND | 5 | -- | -- |
| Iprodione | 36734–19–7 | 48/48 | ND | ND | ND | ND | [3].8 | -- | -- |
| Myclobutanil | 88671–89–0 | 48/48 | ND | ND | ND | ND | 200 | -- | -- |

**Appendix 3.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source- and finished-water samples collected during June 2004–September 2005 (use groups obtained from Carter and others, 2007).—Continued

[Compounds within each primary-use category are listed in order from highest to lowest source-water detection frequency. Human-health benchmarks in **bold** type are Maximum Contaminant Levels (MCLs); CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; --, none; E, estimated value; ND, not detected; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset; HBSL, Health-Based Screening Level]

| Compound | CASRN[1] | Number of samples | Detection frequency (percent) | | Maximum concentration (µg/L) | | Human-health benchmark (µg/L) | Number of concentrations with BQ > 0.1; (1) number of concentrations with BQ >1 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Source water/ Finished water | Source water | Finished water | Source water | Finished water | | Source water | Finished water |
| Fungicides and fungicide degradates—Continued | | | | | | | | | |
| Pentachlorophenol | 87–86–5 | 42/44 | ND | ND | ND | ND | **1** | -- | -- |
| Propiconazole | 60207–90–1 | 61/59 | ND | ND | ND | ND | 70 | -- | -- |
| Gasoline hydrocarbons, oxygenates, and oxygenate degradates | | | | | | | | | |
| Methyl *tert*-butyl ether (MTBE) (CCL) | 1634–04–4 | 71/71 | 16 | 16 | 7.84 | 6.03 | -- | -- | -- |
| Benzene | 71–43–2 | 66/66 | 4.5 | 1.5 | .13 | .12 | **5** | -- | -- |
| *tert*-Amyl methyl ether (TAME) | 994–05–8 | 71/71 | 4.2 | 4.2 | .935 | .66 | -- | -- | -- |
| Diisopropyl ether (DIPE) | 108–20–3 | 71/71 | 2.8 | 2.8 | .165 | .148 | -- | -- | -- |
| Ethyl *tert*-butyl ether (ETBE) | 637–92–3 | 71/71 | 1.4 | 1.4 | .241 | .15 | -- | -- | -- |
| *m*- and *p*-Xylene | 106–42–3; 108–38–3 | 64/64 | ND | 14 | ND | 2.26 | [5]**10,000** | -- | -- |
| Ethylbenzene | 100–41–4 | 64/64 | ND | 9.4 | ND | .593 | **700** | -- | -- |
| *o*-Xylene | 95–47–6 | 66/66 | ND | 9.1 | ND | 1.03 | [5]**10,000** | -- | -- |
| 1-Methylnaphthalene | 90–12–0 | 55/57 | ND | 1.8 | ND | E.014 | -- | -- | -- |
| 2-Methylnaphthalene | 91–57–6 | 55/57 | ND | 1.8 | ND | E.025 | 30 | -- | -- |
| 1,2,3,4-Tetramethylbenzene | 488–23–3 | 71/71 | ND | ND | ND | ND | -- | -- | -- |
| 1,2,3,5-Tetramethylbenzene | 527–53–7 | 71/71 | ND | ND | ND | ND | -- | -- | -- |
| 1,2,3-Trimethylbenzene | 526–73–8 | 71/71 | ND | ND | ND | ND | -- | -- | -- |
| 1,2,4-Trimethylbenzene (CCL) | 95–63–6 | 64/64 | ND | ND | ND | ND | -- | -- | -- |
| 1,3,5-Trimethylbenzene | 108–67–8 | 71/71 | ND | ND | ND | ND | -- | -- | -- |

**Appendix 3.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source- and finished-water samples collected during June 2004–September 2005 (use groups obtained from Carter and others, 2007).—Continued

[Compounds within each primary-use category are listed in order from highest to lowest source-water detection frequency. Human-health benchmarks in **bold** type are Maximum Contaminant Levels (MCLs); CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; --, none; E, estimated value; ND, not detected; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset; HBSL, Health-Based Screening Level]

| Compound | CASRN[1] | Number of samples | Detection frequency (percent) | | Maximum concentration (µg/L) | | Human-health benchmark (µg/L) | Number of concentrations with BQ > 0.1; (1) number of concentrations with BQ >1 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Source water/ Finished water | Source water | Finished water | Source water | Finished water | | Source water | Finished water |
| Gasoline hydrocarbons, oxygenates, and oxygenate degradates—Continued | | | | | | | | | |
| 1-Ethyl-2-methylbenzene (*o*-Ethyl toluene) | 611–14–3 | 71/71 | ND | ND | ND | ND | -- | -- | -- |
| 2,6-Dimethylnaphthalene | 581–42–0 | 55/57 | ND | ND | ND | ND | -- | -- | -- |
| *tert*-Amyl alcohol (2-Methyl-2-butanol) | 75–85–4 | 15/15 | ND | ND | ND | ND | -- | -- | -- |
| Isopropylbenzene | 98–82–8 | 71/71 | ND | ND | ND | ND | 700 | -- | -- |
| Naphthalene (CCL) | 91–20–3 | 71/71 | ND | ND | ND | ND | 100 | -- | -- |
| *n*-Butylbenzene | 104–51–8 | 71/71 | ND | ND | ND | ND | -- | -- | -- |
| *p*-Isopropyltoluene (CCL) | 99–87–6 | 71/71 | ND | ND | ND | ND | -- | -- | -- |
| *sec*-Butylbenzene | 135–98–8 | 71/71 | ND | ND | ND | ND | -- | -- | -- |
| Styrene | 100–42–5 | 71/71 | ND | ND | ND | ND | **100** | -- | -- |
| *tert*-Butyl alcohol | 75–65–0 | 15/15 | ND | ND | ND | ND | -- | -- | -- |
| *tert*-Butylbenzene | 98–06–6 | 71/71 | ND | ND | ND | ND | -- | -- | -- |
| Toluene | 108–88–3 | 34/34 | ND | ND | ND | ND | **1,000** | -- | -- |
| Herbicides and herbicide degradates | | | | | | | | | |
| Alachlor ethane sulfonic acid | -- | 17/17 | 77 | 77 | 0.68 | 0.53 | -- | -- | -- |
| Atrazine | 1912–24–9 | 66/66 | 59 | 55 | .23 | .203 | **3** | -- | -- |
| Deethylatrazine (DEA) (CCL) | 6190–65–4 | 66/66 | 56 | 53 | .288 | .151 | -- | -- | -- |
| Metolachlor ethane sulfonic acid | -- | 32/32 | 47 | 41 | 3.95 | 2.89 | -- | -- | -- |
| Simazine | 122–34–9 | 48/48 | 46 | 46 | .047 | .044 | **4** | -- | -- |

**Appendix 3.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source- and finished-water samples collected during June 2004–September 2005 (use groups obtained from Carter and others, 2007).—Continued

[Compounds within each primary-use category are listed in order from highest to lowest source-water detection frequency. Human-health benchmarks in **bold** type are Maximum Contaminant Levels (MCLs); CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; --, none; E, estimated value; ND, not detected; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset; HBSL, Health-Based Screening Level]

| Compound | CASRN[1] | Number of samples | Detection frequency (percent) | | Maximum concentration (µg/L) | | Human-health benchmark (µg/L) | Number of concentrations with BQ > 0.1; (1) number of concentrations with BQ >1 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Source water/ Finished water | Source water | Finished water | Source water | Finished water | | Source water | Finished water |
| Herbicides and herbicide degradates—Continued | | | | | | | | | |
| Metolachlor oxanilic acid | -- | 32/32 | 38 | 34 | 3.77 | 2.99 | -- | -- | -- |
| Deisopropylatrazine (DIA) | 1007–28–9 | 61/59 | 31 | 20 | .138 | .058 | -- | -- | -- |
| 2-Hydroxyatrazine | 2163–68–0 | 61/59 | 28 | 29 | E.029 | E.023 | 70 | -- | -- |
| Alachlor oxanilic acid | -- | 32/32 | 25 | 28 | .84 | .75 | -- | -- | -- |
| Prometon (CCL) | 1610–18–0 | 61/62 | 25 | 19 | .024 | .03 | 400 | -- | -- |
| Acetochlor ethane sulfonic acid | -- | 32/32 | 19 | 19 | .77 | .8 | -- | -- | -- |
| Bentazon | 25057–89–0 | 61/59 | 13 | 6.8 | E.748 | E.37 | 200 | -- | -- |
| Alachlor ethane sulfonic acid 2nd amide | -- | 32/32 | 13 | 13 | .1 | .21 | -- | -- | -- |
| Metolachlor (CCL) | 51218–45–2 | 64/65 | 13 | 11 | .04 | .021 | 700 | -- | -- |
| Acetochlor oxanilic acid | -- | 32/32 | 9.4 | 19 | .41 | .53 | -- | -- | -- |
| Bromacil | 314–40–9 | 79/78 | 7.6 | ND | .258 | ND | 70 | -- | -- |
| Diuron (CCL) | 330–54–1 | 61/59 | 6.6 | 1.7 | .113 | .099 | [3]2 | -- | -- |
| Flufenacet | 142459–58–3 | 32/32 | 6.2 | 3.1 | .02 | .04 | -- | -- | -- |
| Flumetsulam | 98967–40–9 | 60/59 | 3.3 | 5.1 | E.122 | E.098 | 7,000 | -- | -- |
| Acetochlor/metolachlor ethane sulfonic acid 2nd amide | -- | 32/32 | 3.1 | 13 | .1 | .12 | -- | -- | -- |
| Dimethenamid ethane sulfonic acid | -- | 32/32 | 3.1 | ND | .02 | ND | -- | -- | -- |
| 3,4-Dichloroaniline | 95–76–1 | 48/48 | 2.1 | 4.2 | E.002 | .01 | -- | -- | -- |
| Hexazinone | 51235–04–2 | 48/48 | 2.1 | ND | .017 | ND | 400 | -- | -- |

**Appendix 3.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source- and finished-water samples collected during June 2004–September 2005 (use groups obtained from Carter and others, 2007).—Continued

[Compounds within each primary-use category are listed in order from highest to lowest source-water detection frequency. Human-health benchmarks in **bold** type are Maximum Contaminant Levels (MCLs); CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; --, none; E, estimated value; ND, not detected; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset; HBSL, Health-Based Screening Level]

| Compound | CASRN[1] | Number of samples | Detection frequency (percent) | | Maximum concentration (µg/L) | | Human-health benchmark (µg/L) | Number of concentrations with BQ > 0.1; (1) number of concentrations with BQ >1 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Source water/ Finished water | Source water | Finished water | Source water | Finished water | | Source water | Finished water |
| Herbicides and herbicide degradates—Continued | | | | | | | | | |
| Imazaquin | 81335–37–7 | 61/59 | 1.6 | 3.4 | E0.016 | E0.017 | 2,000 | -- | -- |
| 3(4-Chlorophenyl)-1-methyl urea | 5352–88–5 | 61/59 | 1.6 | 1.7 | E.004 | E.004 | -- | -- | -- |
| Chlorimuron-ethyl | 90982–32–4 | 61/59 | 1.6 | 1.7 | E.016 | E.019 | 600 | -- | -- |
| Oryzalin | 19044–88–3 | 61/59 | 1.6 | 1.7 | E.01 | E.075 | [3]4 | -- | -- |
| Sulfometuron-methyl | 74222–97–2 | 61/59 | 1.6 | 1.7 | .036 | E.007 | 2,000 | -- | -- |
| Triclopyr | 55335–06–3 | 61/59 | 1.6 | 1.7 | .032 | .026 | 400 | -- | -- |
| Deethyldeisopropyl-atrazine (DDA) | 3397–62–4 | 61/59 | 1.6 | ND | E.052 | ND | -- | -- | -- |
| Nicosulfuron | 111991–09–4 | 61/59 | 1.6 | ND | E.006 | ND | 9,000 | -- | -- |
| Terbacil (CCL) | 5902–51–2 | 61/59 | 1.6 | ND | E.023 | ND | 90 | -- | -- |
| Tebuthiuron | 34014–18–1 | 66/66 | 1.5 | 3 | .034 | .03 | 1,000 | -- | -- |
| Metsulfuron methyl | 74223–64–6 | 61/59 | ND | 12 | ND | E.105 | 2,000 | -- | -- |
| 4-Chloro-2-methyl-phenol | 1570–64–5 | 48/48 | ND | 4.2 | ND | E.006 | -- | -- | -- |
| Metribuzin (CCL) | 21087–64–9 | 48/48 | ND | 2.1 | ND | E.004 | 90 | -- | -- |
| Imazethapyr | 81335–77–5 | 61/59 | ND | 1.7 | ND | E.004 | 2,000 | -- | -- |
| Picloram | 1918–02–1 | 61/59 | ND | 1.7 | ND | .151 | **500** | -- | -- |
| 2,4–D | 94–75–7 | 61/59 | ND | ND | ND | ND | **70** | -- | -- |
| 2,4–D methyl ester | 1928–38–7 | 61/59 | ND | ND | ND | ND | -- | -- | -- |
| 2,4–DB | 94–82–6 | 61/59 | ND | ND | ND | ND | 200 | -- | -- |
| 2,6-Diethylaniline | 579–66–8 | 48/48 | ND | ND | ND | ND | -- | -- | -- |
| 2-Chloro-2,6-diethyl-acetanilide | 6967–29–9 | 48/48 | ND | ND | ND | ND | -- | -- | -- |
| 2-Ethyl-6-methylaniline | 24549–06–2 | 48/48 | ND | ND | ND | ND | -- | -- | -- |

**Appendix 3.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source- and finished-water samples collected during June 2004–September 2005 (use groups obtained from Carter and others, 2007).—Continued

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|---|---|---|---|---|---|---|---|---|---|
| | | Source water/ Finished water | Source water | Finished water | Source water | Finished water | | Source water | Finished water |
| Herbicides and herbicide degradates—Continued | | | | | | | | | |
| Acetochlor (CCL) | 34256–82–1 | 51/51 | ND | ND | ND | ND | [3]1 | -- | -- |
| Acetochlor sulfynil-acetic acid | -- | 32/32 | ND | ND | ND | ND | -- | -- | -- |
| Acifluorfen | 50594–66–6 | 61/59 | ND | ND | ND | ND | 90 | -- | -- |
| Alachlor | 15972–60–8 | 51/51 | ND | ND | ND | ND | **2** | -- | -- |
| Alachlor sulfynilacetic acid | 140939–16–8 | 32/32 | ND | ND | ND | ND | -- | -- | -- |
| Benfluralin | 1861–40–1 | 48/48 | ND | ND | ND | ND | 4 | -- | -- |
| Bensulfuron-methyl | 83055–99–6 | 61/59 | ND | ND | ND | ND | 1,000 | -- | -- |
| Bromoxynil | 1689–84–5 | 61/59 | ND | ND | ND | ND | 10 | -- | -- |
| Chloramben, methyl ester | 7286–84–2 | 61/59 | ND | ND | ND | ND | -- | -- | -- |
| Clopyralid | 1702–17–6 | 61/59 | ND | ND | ND | ND | -- | -- | -- |
| Cycloate | 1134–23–2 | 61/59 | ND | ND | ND | ND | 40 | -- | -- |
| Dacthal | 1861–32–1 | 48/48 | ND | ND | ND | ND | 70 | -- | -- |
| Dacthal monoacid (CCL) | 887–54–7 | 61/59 | ND | ND | ND | ND | -- | -- | -- |
| Dicamba | 1918–00–9 | 61/59 | ND | ND | ND | ND | 3,000 | -- | -- |
| Dichlorprop | 120–36–5 | 61/59 | ND | ND | ND | ND | 300 | -- | -- |
| Dimethenamid | 87674–68–8 | 32/32 | ND | ND | ND | ND | -- | -- | -- |
| Dimethenamid oxanilic acid | -- | 32/32 | ND | ND | ND | ND | -- | -- | -- |
| Dinoseb | 88–85–7 | 61/59 | ND | ND | ND | ND | **7** | -- | -- |
| Diphenamid | 957–51–7 | 61/59 | ND | ND | ND | ND | 200 | -- | -- |
| Fenuron | 101–42–8 | 61/59 | ND | ND | ND | ND | -- | -- | -- |

**Appendix 3.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source- and finished-water samples collected during June 2004–September 2005 (use groups obtained from Carter and others, 2007).—Continued

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|---|---|---|---|---|---|---|---|---|---|
| | | Source water/ Finished water | Source water | Finished water | Source water | Finished water | | Source water | Finished water |
| Herbicides and herbicide degradates—Continued | | | | | | | | | |
| Flufenacet ethane sulfonic acid | -- | 32/32 | ND | ND | ND | ND | -- | -- | -- |
| Flufenacet oxanilic acid | -- | 32/32 | ND | ND | ND | ND | -- | -- | -- |
| Fluometuron | 2164–17–2 | 61/59 | ND | ND | ND | ND | 4 | -- | -- |
| Linuron (CCL) | 330–55–2 | 61/59 | ND | ND | ND | ND | 5 | -- | -- |
| MCPA | 94–74–6 | 58/57 | ND | ND | ND | ND | 30 | -- | -- |
| MCPB | 94–81–5 | 61/59 | ND | ND | ND | ND | 100 | -- | -- |
| Neburon | 555–37–3 | 61/59 | ND | ND | ND | ND | -- | -- | -- |
| Norflurazon | 27314–13–2 | 61/59 | ND | ND | ND | ND | 10 | -- | -- |
| Pendimethalin | 40487–42–1 | 48/48 | ND | ND | ND | ND | 70 | -- | -- |
| Prometryn | 7287–19–6 | 48/48 | ND | ND | ND | ND | 300 | -- | -- |
| Propachlor | 1918–16–7 | 20/20 | ND | ND | ND | ND | [3]1 | -- | -- |
| Propachlor ethane sulfonic acid | -- | 32/32 | ND | ND | ND | ND | -- | -- | -- |
| Propachlor oxanilic acid | -- | 32/32 | ND | ND | ND | ND | -- | -- | -- |
| Propham | 122–42–9 | 61/59 | ND | ND | ND | ND | 100 | -- | -- |
| Propyzamide | 23950–58–5 | 48/48 | ND | ND | ND | ND | [3]1 | -- | -- |
| Siduron | 1982–49–6 | 61/59 | ND | ND | ND | ND | 1,000 | -- | -- |
| Terbuthylazine | 5915–41–3 | 48/48 | ND | ND | ND | ND | 2 | -- | -- |
| Trifluralin | 1582–09–8 | 48/48 | ND | ND | ND | ND | 20 | -- | -- |
| Insecticides and insecticide degradates | | | | | | | | | |
| Imidacloprid | 138261–41–3 | 61/59 | 6.6 | 5.1 | 0.017 | 0.016 | 400 | -- | -- |
| Fipronil | 120068–37–3 | 48/48 | 4.2 | ND | E.006 | ND | -- | -- | -- |

**Appendix 3.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source- and finished-water samples collected during June 2004–September 2005 (use groups obtained from Carter and others, 2007).—Continued

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| Compound | CASRN[1] | Number of samples | Detection frequency (percent) | | Maximum concentration (µg/L) | | Human-health benchmark (µg/L) | Number of concentrations with BQ > 0.1; (1) number of concentrations with BQ >1 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Source water/ Finished water | Source water | Finished water | Source water | Finished water | | Source water | Finished water |
| Insecticides and insecticide degradates—Continued | | | | | | | | | |
| Fipronil sulfide | 120067–83–6 | 48/48 | 2.1 | 2.1 | E0.007 | E0.008 | -- | -- | -- |
| Diazinon (CCL) | 333–41–5 | 61/62 | 1.6 | 1.6 | .01 | .005 | [2]1 | -- | -- |
| 1-Naphthol | 90–15–3 | 48/48 | ND | ND | ND | ND | -- | -- | -- |
| 3-Hydroxycarbofuran | 16655–82–6 | 61/59 | ND | ND | ND | ND | -- | -- | -- |
| 3-Ketocarbofuran | 16709–30–1 | 59/57 | ND | ND | ND | ND | -- | -- | -- |
| Aldicarb | 116–06–3 | 61/59 | ND | ND | ND | ND | [6]9 | -- | -- |
| Aldicarb sulfone | 1646–88–4 | 61/59 | ND | ND | ND | ND | [6]7 | -- | -- |
| Aldicarb sulfoxide | 1646–87–3 | 61/59 | ND | ND | ND | ND | [6]7 | -- | -- |
| Azinphos-methyl | 86–50–0 | 48/48 | ND | ND | ND | ND | [2]10 | -- | -- |
| Azinphos-methyl-oxon | 961–22–8 | 48/48 | ND | ND | ND | ND | -- | -- | -- |
| Bendiocarb | 22781–23–3 | 61/59 | ND | ND | ND | ND | 9 | -- | -- |
| Carbaryl | 63–25–2 | 61/59 | ND | ND | ND | ND | [3]40 | -- | -- |
| Carbofuran | 1563–66–2 | 61/59 | ND | ND | ND | ND | **40** | -- | -- |
| Chlorpyrifos | 2921–88–2 | 61/62 | ND | ND | ND | ND | 2 | -- | -- |
| Chlorpyrofos, oxygen analog | 5598–15–2 | 48/48 | ND | ND | ND | ND | -- | -- | -- |
| *cis*-Permethrin | 54774–45–7 | 48/48 | ND | ND | ND | ND | [3,7]4 | -- | -- |
| Cyfluthrin | 68359–37–5 | 48/48 | ND | ND | ND | ND | 200 | -- | -- |
| Cypermethrin | 52315–07–8 | 48/48 | ND | ND | ND | ND | 40 | -- | -- |
| Desulfinylfipronil | -- | 48/48 | ND | ND | ND | ND | -- | -- | -- |
| Desulfinylfipronil amide | -- | 48/48 | ND | ND | ND | ND | -- | -- | -- |
| Diazinon, oxygen analog | 962–58–3 | 38/38 | ND | ND | ND | ND | -- | -- | -- |
| Dichlorvos | 62–73–7 | 49/49 | ND | ND | ND | ND | .4 | -- | -- |

**Appendix 3.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source- and finished-water samples collected during June 2004–September 2005 (use groups obtained from Carter and others, 2007).—Continued

[Compounds within each primary-use category are listed in order from highest to lowest source-water detection frequency. Human-health benchmarks in **bold** type are Maximum Contaminant Levels (MCLs); CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; --, none; E, estimated value; ND, not detected; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset; HBSL, Health-Based Screening Level]

| Compound | CASRN[1] | Number of samples | Detection frequency (percent) | | Maximum concentration (µg/L) | | Human-health benchmark (µg/L) | Number of concentrations with BQ > 0.1; (1) number of concentrations with BQ >1 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Source water/ Finished water | Source water | Finished water | Source water | Finished water | | Source water | Finished water |
| Insecticides and insecticide degradates—Continued | | | | | | | | | |
| Dicrotophos | 141–66–2 | 48/48 | ND | ND | ND | ND | 0.05 | -- | -- |
| Dieldrin | 60–57–1 | 48/48 | ND | ND | ND | ND | [3].002 | -- | -- |
| Dimethoate | 60–51–5 | 48/48 | ND | ND | ND | ND | 2 | -- | -- |
| Ethion | 563–12–2 | 48/48 | ND | ND | ND | ND | 4 | -- | -- |
| Ethion monoxon | 17356–42–2 | 48/48 | ND | ND | ND | ND | -- | -- | -- |
| Fenamiphos | 22224–92–6 | 48/48 | ND | ND | ND | ND | .7 | -- | -- |
| Fenamiphos sulfone | 31972–44–8 | 48/48 | ND | ND | ND | ND | -- | -- | -- |
| Fenamiphos sulfoxide | 31972–43–7 | 48/48 | ND | ND | ND | ND | -- | -- | -- |
| Fipronil sulfone | 120068–36–2 | 48/48 | ND | ND | ND | ND | -- | -- | -- |
| Fonofos (CCL) | 944–22–9 | 48/48 | ND | ND | ND | ND | 10 | -- | -- |
| Fonofos, oxygen analog | 944–21–8 | 23/23 | ND | ND | ND | ND | -- | -- | -- |
| Isofenphos | 25311–71–1 | 48/48 | ND | ND | ND | ND | 6 | -- | -- |
| Malaoxon | 1634–78–2 | 48/48 | ND | ND | ND | ND | -- | -- | -- |
| Malathion | 121–75–5 | 48/48 | ND | ND | ND | ND | 50 | -- | -- |
| Methidathion | 950–37–8 | 48/48 | ND | ND | ND | ND | 1 | -- | -- |
| Methiocarb | 2032–65–7 | 61/59 | ND | ND | ND | ND | 40 | -- | -- |
| Methomyl | 16752–77–5 | 61/59 | ND | ND | ND | ND | 200 | -- | -- |
| Oxamyl | 23135–22–0 | 61/59 | ND | ND | ND | ND | **200** | -- | -- |
| Paraoxon-methyl | 950–35–6 | 48/48 | ND | ND | ND | ND | -- | -- | -- |
| Parathion-methyl | 298–00–0 | 48/48 | ND | ND | ND | ND | 1 | -- | -- |
| Phorate | 298–02–2 | 48/48 | ND | ND | ND | ND | 4 | -- | -- |
| Phorate oxon | 2600–69–3 | 48/48 | ND | ND | ND | ND | -- | -- | -- |
| Phosmet | 732–11–6 | 34/34 | ND | ND | ND | ND | [2]8 | -- | -- |
| Phosmet oxon | 3735–33–9 | 32/33 | ND | ND | ND | ND | -- | -- | -- |

**Appendix 3.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source- and finished-water samples collected during June 2004–September 2005 (use groups obtained from Carter and others, 2007).—Continued

[Compounds within each primary-use category are listed in order from highest to lowest source-water detection frequency. Human-health benchmarks in **bold** type are Maximum Contaminant Levels (MCLs); CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; --, none; E, estimated value; ND, not detected; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset; HBSL, Health-Based Screening Level]

| Compound | CASRN[1] | Number of samples | Detection frequency (percent) | | Maximum concentration (µg/L) | | Human-health benchmark (µg/L) | Number of concentrations with BQ > 0.1; (1) number of concentrations with BQ >1 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Source water/ Finished water | Source water | Finished water | Source water | Finished water | | Source water | Finished water |
| Insecticides and insecticide degradates—Continued | | | | | | | | | |
| Propoxur | 114–26–1 | 61/59 | ND | ND | ND | ND | [3]9 | -- | -- |
| Terbufos (CCL) | 13071–79–9 | 48/48 | ND | ND | ND | ND | .4 | -- | -- |
| Terbufos-oxygen-analog sulfone | 56070–15–6 | 48/48 | ND | ND | ND | ND | -- | -- | -- |
| Manufacturing additives | | | | | | | | | |
| Tributyl phosphate | 126–73–8 | 55/57 | 9.1 | 1.8 | E0.16 | E0.009 | -- | -- | -- |
| Tri(2-chloroethyl) phosphate | 115–96–8 | 55/57 | 5.5 | 1.8 | E.13 | E.099 | -- | -- | -- |
| Tris(dichlorisopropyl) phosphate | 13674–87–8 | 55/57 | 5.5 | ND | E.081 | ND | -- | -- | -- |
| Tri(2-butoxyethyl) phosphate | 78–51–3 | 41/43 | 2.4 | 4.7 | E.18 | E.33 | -- | -- | -- |
| Bisphenol A | 80–05–7 | 43/47 | 2.3 | ND | 2.5 | ND | 400 | -- | -- |
| Triphenyl phosphate | 115–86–6 | 53/55 | 1.9 | 20 | E.083 | E.26 | -- | -- | -- |
| 5-Methyl-1H-benzo-triazole | 136–85–6 | 53/55 | ND | ND | ND | ND | -- | -- | -- |
| Organic synthesis compounds | | | | | | | | | |
| Carbon disulfide | 75–15–0 | 63/64 | 1.6 | ND | 0.116 | ND | 700 | -- | -- |
| Vinyl chloride | 75–01–4 | 71/71 | 1.4 | ND | .4 | ND | **2** | 1 | -- |
| Chloromethane | 74–87–3 | 71/71 | ND | 2.8 | ND | E.116 | 30 | -- | -- |
| Carbazole | 86–74–8 | 55/57 | ND | 1.8 | ND | E.005 | -- | -- | -- |
| 1,1-Dichloropropene (CCL) | 563–58–6 | 71/71 | ND | ND | ND | ND | -- | -- | -- |
| 1,2,3-Trichlorobenzene | 87–61–6 | 71/71 | ND | ND | ND | ND | -- | -- | -- |
| 1,2,3-Trichloropropane | 96–18–4 | 71/71 | ND | ND | ND | ND | 40 | -- | -- |
| 3-Chloro-1-propene | 107–05–1 | 71/71 | ND | ND | ND | ND | -- | -- | -- |

**Appendix 3.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source- and finished-water samples collected during June 2004–September 2005 (use groups obtained from Carter and others, 2007).—Continued

[Compounds within each primary-use category are listed in order from highest to lowest source-water detection frequency. Human-health benchmarks in **bold** type are Maximum Contaminant Levels (MCLs); CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; --, none; E, estimated value; ND, not detected; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset; HBSL, Health-Based Screening Level]

| Compound | CASRN[1] | Number of samples | Detection frequency (percent) | | Maximum concentration (µg/L) | | Human-health benchmark (µg/L) | Number of concentrations with BQ > 0.1; (1) number of concentrations with BQ >1 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Source water/ Finished water | Source water | Finished water | Source water | Finished water | | Source water | Finished water |
| Organic synthesis compounds—Continued | | | | | | | | | |
| Acrylonitrile | 107–13–1 | 71/71 | ND | ND | ND | ND | [3]0.06 | -- | -- |
| Anthraquinone | 84–65–1 | 55/57 | ND | ND | ND | ND | -- | -- | -- |
| Ethyl methacrylate (Ethyl 2-methyl-2-propanoate) | 97–63–2 | 71/71 | ND | ND | ND | ND | -- | -- | -- |
| Hexachlorobutadiene (CCL) | 87–68–3 | 71/71 | ND | ND | ND | ND | [3].9 | -- | -- |
| Iodomethane | 74–88–4 | 71/71 | ND | ND | ND | ND | -- | -- | -- |
| Methyl acrylate (Methyl-2-propenoate) | 96–33–3 | 71/71 | ND | ND | ND | ND | -- | -- | -- |
| Methyl acrylonitrile (2-Methyl-2-propenenitrile) | 126–98–7 | 71/71 | ND | ND | ND | ND | .7 | -- | -- |
| Methyl methacrylate (Methyl 2-methyl-2-propenoate) | 80–62–6 | 71/71 | ND | ND | ND | ND | 10,000 | -- | -- |
| *trans*-1,4-Dichloro-2-butene | 110–57–6 | 71/71 | ND | ND | ND | ND | -- | -- | -- |
| Vinyl bromide | 593–60–2 | 71/71 | ND | ND | ND | ND | -- | -- | -- |
| Pavement- and combustion-derived compounds | | | | | | | | | |
| Phenanthrene | 85–01–8 | 55/57 | 3.6 | 5.3 | E0.017 | E0.02 | -- | -- | -- |
| Anthracene | 120–12–7 | 55/57 | ND | ND | ND | ND | 2,000 | -- | -- |
| Benzo[a]pyrene | 50–32–8 | 55/57 | ND | ND | ND | ND | **.2** | -- | -- |
| Fluoranthene | 206–44–0 | 55/57 | ND | ND | ND | ND | 300 | -- | -- |
| Pyrene | 129–00–0 | 55/57 | ND | ND | ND | ND | 200 | -- | -- |

**Appendix 3.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source- and finished-water samples collected during June 2004–September 2005 (use groups obtained from Carter and others, 2007).—Continued

[Compounds within each primary-use category are listed in order from highest to lowest source-water detection frequency. Human-health benchmarks in **bold** type are Maximum Contaminant Levels (MCLs); CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; --, none; E, estimated value; ND, not detected; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset; HBSL, Health-Based Screening Level]

| Compound | CASRN[1] | Number of samples | Detection frequency (percent) | | Maximum concentration (µg/L) | | Human-health benchmark (µg/L) | Number of concentrations with BQ > 0.1; (1) number of concentrations with BQ >1 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Source water/ Finished water | Source water | Finished water | Source water | Finished water | | Source water | Finished water |
| Personal-care and domestic-use products | | | | | | | | | |
| Hexahydrohexamethyl-cyclopentabenzo-pyran (HHCB) | 1222–05–5 | 55/57 | 5.5 | 3.5 | E0.081 | E0.088 | -- | -- | -- |
| Caffeine | 58–08–2 | 40/38 | 5.0 | ND | E.006 | ND | -- | -- | -- |
| Acetyl hexamethyl tetrahydronaphtha-lene (AHTN) | 21145–77–7 | 55/57 | 3.6 | ND | E.079 | ND | -- | -- | -- |
| Nonylphenol diethoxyl-ate (total) | 26027–38–2 | 55/57 | 3.6 | ND | E3.2 | ND | -- | -- | -- |
| Octylphenol diethoxyl-ate (total) | -- | 55/57 | 3.6 | ND | E.089 | ND | -- | -- | -- |
| Octylphenol mono-ethoxylate (total) | -- | 55/57 | 3.6 | ND | E.32 | ND | -- | -- | -- |
| Methyl salicylate | 119–36–8 | 55/57 | 1.8 | 3.5 | E.014 | E.06 | 4,000 | -- | -- |
| Camphor | 76–22–2 | 55/57 | 1.8 | 1.8 | E.004 | E.013 | -- | -- | -- |
| 4-*tert*-Octylphenol | 140–66–9 | 55/57 | 1.8 | ND | E.079 | ND | -- | -- | -- |
| Menthol | 89–78–1 | 41/43 | ND | 2.3 | ND | E.033 | | -- | -- |
| 3-*tert*-Butyl-4-hydroxy anisole (BHA) | 25013–16–5 | 55/57 | ND | ND | ND | ND | -- | -- | -- |
| 4-Cumylphenol | 599–64–4 | 55/57 | ND | ND | ND | ND | -- | -- | -- |
| 4-*n*-Octylphenol | 1806–26–4 | 55/57 | ND | ND | ND | ND | -- | -- | -- |
| Acetophenone | 98–86–2 | 49/51 | ND | ND | ND | ND | 700 | -- | -- |
| Benzophenone | 119–61–9 | R | -- | -- | -- | -- | -- | -- | -- |
| Bromochloromethane | 74–97–5 | 71/71 | ND | ND | ND | ND | 90 | -- | -- |
| Cotinine | 486–56–6 | 54/55 | ND | ND | ND | ND | -- | -- | -- |
| *d*-Limonene | 5989–27–5 | 55/57 | ND | ND | ND | ND | -- | -- | -- |

**Appendix 3.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source- and finished-water samples collected during June 2004–September 2005 (use groups obtained from Carter and others, 2007).—Continued

[Compounds within each primary-use category are listed in order from highest to lowest source-water detection frequency. Human-health benchmarks in **bold** type are Maximum Contaminant Levels (MCLs); CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; --, none; E, estimated value; ND, not detected; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset; HBSL, Health-Based Screening Level]

| Compound | CASRN[1] | Number of samples | Detection frequency (percent) | | Maximum concentration (µg/L) | | Human-health benchmark (µg/L) | Number of concentrations with BQ > 0.1; (1) number of concentrations with BQ >1 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Source water/ Finished water | Source water | Finished water | Source water | Finished water | | Source water | Finished water |
| Personal-care and domestic-use products—Continued | | | | | | | | | |
| Indole | 120–72–9 | 55/57 | ND | ND | ND | ND | -- | -- | -- |
| Isoborneol | 124–76–5 | 55/57 | ND | ND | ND | ND | -- | -- | -- |
| Isoquinoline | 119–65–3 | 55/57 | ND | ND | ND | ND | -- | -- | -- |
| N,N-diethyl-*meta*-toluamide (DEET) | 134–62–3 | R | -- | -- | -- | -- | -- | -- | -- |
| para-Nonylphenol (total) | 84852–15–3 | R | -- | -- | -- | -- | -- | -- | -- |
| Phenol | 108–95–2 | R | -- | -- | -- | -- | 2,000 | -- | -- |
| Triclosan | 3380–34–5 | 55/57 | ND | ND | ND | ND | -- | -- | -- |
| Triethyl citrate (Ethyl citrate) | 77–93–0 | 55/57 | ND | ND | ND | ND | -- | -- | -- |
| Plant- or animal-derived biochemicals | | | | | | | | | |
| *beta*-Stigmastanol | 19466–47–8 | 55/57 | 1.8 | ND | E0.52 | ND | -- | -- | -- |
| 3-*beta*-Coprostanol | 360–68–9 | 55/57 | ND | ND | ND | ND | -- | -- | -- |
| 3-Methyl-1(H)-indole (Skatole) | 83–34–1 | 55/57 | ND | ND | ND | ND | -- | -- | -- |
| *beta*-Sitosterol | 83–46–5 | 55/57 | ND | ND | ND | ND | -- | -- | -- |
| Cholesterol | 57–88–5 | 55/57 | ND | ND | ND | ND | -- | -- | -- |
| Refrigerants and propellants | | | | | | | | | |
| Trichlorofluoromethane (CFC-11) | 75–69–4 | 71/71 | 2.8 | 2.8 | E0.134 | 0.152 | 2,000 | -- | -- |
| 1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113) | 76–13–1 | 71/71 | 2.8 | ND | .394 | ND | 200,000 | -- | -- |
| Dichlorodifluoromethane (CFC-12) | 75–71–8 | 71/71 | 1.4 | 2.8 | E.05 | E.083 | 1,000 | -- | -- |

**Appendix 3.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source- and finished-water samples collected during June 2004–September 2005 (use groups obtained from Carter and others, 2007).—Continued

[Compounds within each primary-use category are listed in order from highest to lowest source-water detection frequency. Human-health benchmarks in **bold** type are Maximum Contaminant Levels (MCLs); CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; --, none; E, estimated value; ND, not detected; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset; HBSL, Health-Based Screening Level]

| Compound | CASRN[1] | Number of samples | Detection frequency (percent) | | Maximum concentration (µg/L) | | Human-health benchmark (µg/L) | Number of concentrations with BQ > 0.1; (1) number of concentrations with BQ >1 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Source water/ Finished water | Source water | Finished water | Source water | Finished water | | Source water | Finished water |
| | | | | Solvents | | | | | |
| Perchloroethene (PCE) | 127–18–4 | 71/71 | 39 | 37 | 8.02 | 0.561 | **5** | 4(1) | 2 |
| Trichloroethene (TCE) | 79–01–6 | 71/71 | 27 | 23 | 64 | .63 | **5** | 3(1) | 1 |
| *cis*-1,2-Dichloroethene | 156–59–2 | 71/71 | 20 | 18 | 2.4 | 2.19 | **70** | -- | -- |
| 1,1,1-Trichloroethane | 71–55–6 | 71/71 | 20 | 14 | 5.07 | 1.12 | **200** | -- | -- |
| 1,1-Dichloroethane (CCL) | 75–34–3 | 71/71 | 13 | 8.5 | 5.11 | .347 | -- | -- | -- |
| 1,1-Dichloroethene | 75–35–4 | 71/71 | 11 | 8.5 | 7.02 | .129 | **7** | 1(1) | -- |
| *trans*-1,2-Dichloroethene | 156–60–5 | 71/71 | 4.2 | 5.6 | .18 | .15 | **100** | -- | -- |
| Carbon tetrachloride (Tetrachloromethane) | 56–23–5 | 71/71 | 2.8 | 8.5 | .52 | .5 | **5** | 1 | -- |
| Tetrahydrofuran | 109–99–9 | 71/71 | 2.8 | ND | 278.9 | ND | -- | -- | -- |
| Acetone | 67–64–1 | 56/56 | 1.8 | ND | 68.4 | ND | 6,000 | -- | -- |
| 1,2-Dichloroethane | 107–06–2 | 71/71 | 1.4 | ND | E.084 | ND | **5** | -- | -- |
| Methyl ethyl ketone (MEK) | 78–93–3 | 71/71 | 1.4 | ND | 1,142 | ND | 4,000 | 1 | -- |
| Chlorobenzene | 108–90–7 | 61/61 | ND | 1.6 | ND | E.014 | **100** | -- | -- |
| Methyl isobutyl ketone (4-Methyl-2-pentanone) | 108–10–1 | 71/71 | ND | 1.4 | ND | 3.3 | -- | -- | -- |
| 1,1,1,2-Tetrachloroethane | 630–20–6 | 71/71 | ND | ND | ND | ND | 70 | -- | -- |
| 1,1,2,2-Tetrachloroethane (CCL) | 79–34–5 | 71/71 | ND | ND | ND | ND | .3 | -- | -- |
| 1,1,2-Trichloroethane | 79–00–5 | 71/71 | ND | ND | ND | ND | **5** | -- | -- |
| Diethyl ether (1,1'-Oxybisethane) | 60–29–7 | 71/71 | ND | ND | ND | ND | 1,000 | -- | -- |

**Appendix 3.** Summary statistics and human-health benchmarks for anthropogenic organic compounds analyzed in source- and finished-water samples collected during June 2004–September 2005 (use groups obtained from Carter and others, 2007).—Continued

[Compounds within each primary-use category are listed in order from highest to lowest source-water detection frequency. Human-health benchmarks in **bold** type are Maximum Contaminant Levels (MCLs); CASRN, Chemical Abstracts Service Registry Number®; µg/L, micrograms per liter; BQ, benchmark quotient; >, greater than; --, none; E, estimated value; ND, not detected; CCL, U.S. Environmental Protection Agency's Contaminant Candidate List 2 (U.S. Environmental Protection Agency, 2005); MCPA, 2-methyl-4-chlorophenoxyacetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy) butyric acid; R, compound removed from the dataset; HBSL, Health-Based Screening Level]

| Compound | CASRN[1] | Number of samples | Detection frequency (percent) | | Maximum concentration (µg/L) | | Human-health benchmark (µg/L) | Number of concentrations with BQ > 0.1; (1) number of concentrations with BQ >1 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Source water/ Finished water | Source water | Finished water | Source water | Finished water | | Source water | Finished water |
| Solvents—Continued | | | | | | | | | |
| 1,2,4-Trichlorobenzene | 120–82–1 | 71/71 | ND | ND | ND | ND | **70** | -- | -- |
| 1,2-Dichlorobenzene | 95–50–1 | 71/71 | ND | ND | ND | ND | **600** | -- | -- |
| 1,3-Dichlorobenzene | 541–73–1 | 71/71 | ND | ND | ND | ND | 600 | -- | -- |
| 2-Chlorotoluene | 95–49–8 | 71/71 | ND | ND | ND | ND | 100 | -- | -- |
| 2-Hexanone | 591–78–6 | 71/71 | ND | ND | ND | ND | -- | -- | -- |
| 4-Chlorotoluene | 106–43–4 | 71/71 | ND | ND | ND | ND | 100 | -- | -- |
| Bromobenzene (CCL) | 108–86–1 | 71/71 | ND | ND | ND | ND | -- | -- | -- |
| Chloroethane | 75–00–3 | 71/71 | ND | ND | ND | ND | -- | -- | -- |
| Dibromomethane | 74–95–3 | 71/71 | ND | ND | ND | ND | -- | -- | -- |
| Hexachloroethane | 67–72–1 | 71/71 | ND | ND | ND | ND | .7 | -- | -- |
| Isophorone | 78–59–1 | R | -- | -- | -- | -- | 100 | -- | -- |
| Methyl acetate | 79–20–9 | 15/15 | ND | ND | ND | ND | -- | -- | -- |
| Methylene chloride (Dichloromethane) | 75–09–2 | 56/56 | ND | ND | ND | ND | **5** | -- | -- |
| *n*-Propylbenzene | 103–65–1 | 71/71 | ND | ND | ND | ND | -- | -- | -- |
| *p*-Cresol | 106–44–5 | 55/57 | ND | ND | ND | ND | -- | -- | -- |

[1]This report contains CASRNs, which is a Registered Trademark of the American Chemical Society. The Chemical Abstracts Service (CAS) recommends the verification of the CASRNs through CAS Client Services℠.

[2]The U.S. Environmental Protection Agency's MCL of 80 µg/L is for the sum of the concentrations of four trihalomethanes.

[3]HBSL values shown for carcinogens represent the low end ($10^{-6}$) of the HBSL range ($10^{-6}$ to $10^{-4}$ cancer risk level) (Toccalino, Norman, and others, 2006).

[4]The sum of concentrations from *cis*-1,3- and *trans*-1,3-dichloropropene may be compared to the HBSL range (0.3–30 µg/L) for the mixed isomer of 1,3-dichloropropene, CASRN 542–75–6.

[5]The concentrations from *m*- and *p*-xylene and *o*-xylene may be compared to the MCL (10,000 µg/L) for mixed xylenes, CASRN 1330–20–7.

[6]U.S. Environmental Protection Agency Office of Water recommends that the concentration of any combination of two or more of the three aldicarb compounds should not be greater than 7 µg/L because of similar mode of action.

[7]Concentrations of *cis*-permethrin may be compared to the HBSL range (4–400 µg/L) for permethrin, Chemical Abstract Service Registry Number 52645–53–1.

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