**A joint effort between USGS programs:
National Water Quality Assessment (NAWQA),
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Contaminant Biology**

Contaminants in Stream Sediments from Seven U.S. Metropolitan Areas: Data Summary of a National Pilot Study

Scientific Investigations Report 2011–5092

Cover: Collection of streambed sediment at Suwannee Creek in Suwannee, Georgia (U.S. Geological Survey streamflow-gaging station 02334885. Photograph taken by Alan Cressler, U.S. Geological Survey, May 23, 2007.)

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

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Conversion Factors, Datum, and Abbreviations and Acronyms

Multiply	By	To obtain
Length		
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
meter (m)	1.094	yard (yd)
Area		
square kilometer (km ²)	247.1	acre
square kilometer (km ²)	0.3861	square mile (mi ²)
Volume		
liter (L)	33.82	ounce, fluid (fl. oz)
liter (L)	2.113	pint (pt)
liter (L)	1.057	quart (qt)
liter (L)	0.2642	gallon (gal)
liter (L)	61.02	cubic inch (in ³)
milliliter (mL)	0.03382	ounce, fluid (fl. oz)
Mass		
gram (g)	0.03527	ounce, avoirdupois (oz)
kilogram (kg)	2.205	pound avoirdupois (lb)

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

$$^{\circ}\text{F}=(1.8\times^{\circ}\text{C})+32.$$

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

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

Concentrations of chemical constituents in bed sediments are given either in micrograms per kilogram (μg/kg), micrograms per gram (μg/g), or nanogram per gram (ng/g).

Toxicity thresholds are given in micromoles per gram of reference substance (μmol/g).

Datum

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

Abbreviations and Acronyms

AFDW	ash-free dry weight
CERC	Columbia Environmental Research Center
DDE	dichlorodiphenyldichloroethylene
DEM	digital elevation model
EDNA	Elevation Derivatives for National Applications
FCV	final chronic value
GC/MS	gas chromatography-mass spectroscopy
GIRAS	Geographic Information Retrieval and Analysis System
GPC	gel permeation chromatography
HNO ₃	nitric acid
ICP-MS	inductively coupled plasma mass spectroscopy
NAWQA	National Water Quality Assessment Program
OC	organochlorine pesticides
OP	organophosphate pesticides
PRISM	Parameter-elevation Regression Independent Slopes Model
NED	National Elevation Data
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyls
PEC	probable effect concentration
PECQ	probable effect concentration quotient
PFRG	Pesticide Fate Research Group
PTFE	polytetrafluoroethylene (Teflon)
RPD	relative percent difference
SE	standard error of the mean
SLC	Salt Lake City
SQG	sediment-quality guidelines
STATSGO	State Soil Geographic Database
TIGER	Topologically Integrated Geographic Encoding and Reference
TOC	total organic carbon
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

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Abstract

This report presents data collected as a part of a synoptic survey of stream sediment contaminants, associated watershed characteristics and invertebrate responses in laboratory sediment toxicity tests from 98 streams (sites) in seven metropolitan study areas across the continental United States. The report presents methods, data, and sediment-quality guidelines, including the derivation of a new sediment pyrethroid probable effects concentration, for the purposes of relating measured contaminants to land use and toxicity evaluation. The study evaluated sites that ranged in their degree of relative urbanization within the study areas of Atlanta, Boston, Dallas-Fort Worth, Denver, Milwaukee-Green Bay, Salt Lake City, and Seattle-Tacoma. In all, 108 chemical analytes quantified in the study are presented, by class and number of individual compounds, as follows: polycyclic aromatic hydrocarbons (PAHs) (28), organochlorine pesticides (OCs) (18), polychlorinated biphenyls (Aroclors) (3), pyrethroid insecticides (14), fipronil compounds (4), priority trace and other major elements (41). The potential of these sediments to cause toxicity to sediment-dwelling invertebrates was evaluated using two standard sediment toxicity tests: a 28-day growth and survival toxicity test with the amphipod *Hyalella azteca*, and a 10-day growth and survival toxicity test with the midge *Chironomus dilutus*. Further, approximately 95 relevant watershed and reach-level characteristics were generated and are presented to aid in interpretation and explanation of contaminant and toxicity patterns. Interpretation of the findings of this study, including the relationships with urbanization and other factors, the relationship between sediment toxicity and sediment chemistry in the seven study areas, and the sources and occurrence of pyrethroid insecticides, are discussed in detail in a forthcoming series of journal articles.

Introduction

The impact of urbanization on freshwater ecosystems has been the subject of several recent reviews (Paul and Meyer, 2001; Swackhamer and others, 2004; Brown and others, 2005; Alberti and others, 2007). Urbanization is also a current focus area of the U.S. Geological Survey (USGS) National Water-Quality Assessment (NAWQA) Program (<http://water.usgs.gov/nawqa/>). As summarized by Brown and others (2005), “almost all population growth expected in the next 30 years [from an estimated 3 billion in 2003 to 5 billion in 2030] is expected to occur by expansion of existing urban areas (United Nations, 2004).” One point common to discussions of impacts of urbanization is the increased frequency and delivery of contaminants to neighboring ecosystems. Sediments have long been recognized as an important repository of contaminants and have historically been evaluated by the USGS in numerous local, regional, and national studies. In addition, as stated in the U.S. Environmental Protection Agency (USEPA) second report to Congress summarizing the quality of sediments in the United States, “...results suggest that sediment contamination may be significant enough to pose potential risks to aquatic life and/or human health in some locations. Further, evaluation will be required to confirm that sediment contamination poses actual risks to aquatic life or human health for any given sampling station or watershed” (U.S. Environmental Protection Agency, 2004). The report to Congress made a number of recommendations, including further assessing targeted watersheds, improving monitoring and assessment tools and methodologies, expanding geographic coverage, and developing partnerships including with other Federal agencies. However, few of these previous programs explicitly focused on effects of land-use across a gradient of urban development, where the urban intensity in the watersheds ranged from

minimally to highly urbanized. To address this, the USGS NAWQA Program began a study of the effects of urbanization on stream ecosystems, which examines the magnitude and pattern of response in stream biological communities, hydrology, habitat, and water chemistry to watershed urbanization in 10 metropolitan study areas. (See Brown and others, 2005, and works cited therein, and also <http://water.usgs.gov/nawqa/urban/>.) The study presented here, the USGS National Stream Bed Sediment Pilot Study, applies the same study design to an investigation of sediment contamination and sediment toxicity in seven metropolitan study areas (also referred to herein simply as “study areas”). The underlying methods and data for this pilot study are presented below. Subsequent interpretative publications based on these data are forthcoming (see “[Related Pending Publications](#)” section near the end of this report).

One challenge in evaluating trends and concentrations of contaminants in the environment is the evolving production and use of the contaminants. For example, recent decisions by the USEPA to restrict the use of the once-common organophosphate (OP) pesticides diazinon and chlorpyrifos, beginning in 2000, have led to an increase in the use of pyrethroid insecticides, particularly by homeowners. As a class, pyrethroid insecticides tend to be hydrophobic ($\log K_{ow}$ 4–7), they are rarely detected in surface waters, they have been demonstrated to move in association with particulates in runoff, and they are highly toxic to fish (Clark and others 1989 (and works cited therein); Werner and others, 2000; Floyd and others, 2008). Environmental half-lives of pyrethroids in soil and sediment are moderate (for example, few to many months) and increase with pH. However, half

lives in air or water are much shorter (for example, hours) because photolysis is an important degradation pathway (Demoute, 1989). This study is the first time that pyrethroid insecticides have been characterized in wadeable urban stream sediments in different regions of the United States in a nationally consistent manner.

The objectives of this study were to assess levels of pyrethroids and co-occurring organic and trace element contaminants in bed sediments of selected urban areas in different regions of the United States, and to evaluate the toxicity of these bed sediment samples to benthic invertebrates. A total of 108 contaminants of interest in five chemical classes were analyzed: major and trace elements, polycyclic aromatic hydrocarbons (PAH), organochlorine pesticides (OC), polychlorinated biphenyls (PCB), pyrethroid insecticides, and fipronil and its degradates. Data are presented in this report on the concentrations of these contaminants in stream bed sediments from urban watersheds from seven study areas across the continental United States ([fig. 1](#)).

Two standard sediment toxicity tests were conducted on sediment subsamples for each study site and results are presented for a 28-day test with the amphipod *Hyaella azteca* and a 10-day test with the chironomid *Chironomus dilutus*. Ancillary data presented in this report include land use and land cover, hydrologic, climatic, and other data generated at multiple scales—site (that is, stream reach), segment, and watershed—from geographic information systems (GIS). This report further summarizes effects-based sediment quality guidelines (SQGs) that will be used in subsequent publications to interpret sediment chemistry and toxicity data and the relationships between them (see “[Related Pending Publications](#)” section near the end of this report).

Figure 1. Locations of the seven metropolitan areas examined in the U.S. Geological Survey National Bed Sediment Pilot Study.

Methods

Study Area and Site Selection

The seven metropolitan study areas (study areas) selected for this study were a part of an earlier NAWQA study, the Effects of Urbanization on Stream Ecosystems (EUSE) Study (<http://water.usgs.gov/nawqa/urban/>). They are in different regions of the continental United States (figs. 2–8), and they represent different natural environmental settings, such as potential natural vegetation, temperature, precipitation, basin relief, elevation, and basin slope (Cuffney and others, 2010).

A total of 98 sites (non-nested stream reaches) were sampled in the bed sediment study across the seven study areas nationally. Between 11 and 14 sites were sampled per study area except for the Seattle study area, where 21 sites were sampled. All sites were part of one (or both) of two NAWQA programs: the EUSE study or the Surface Water Status and Trends Network (<http://water.usgs.gov/nawqa/studies/mrb/>). A study site was defined as per the NAWQA habitat and biological protocols. Briefly, that protocol (Fitzpatrick and others, 1998) defines a reach as a section of a wadeable stream that extends 20 times the average wetted channel width, or a minimum of 150 m, and that is void of significant inflows or outflows over its length. Streams are defined in this study by the National Hydrography Dataset (NHDPlus at <http://www.crrw.utexas.edu/gis/gishydro06/ArcHydro/NHDPlus.htm>). Streams in this study had a Strahler stream order that ranged from 1 to 7, with an average and standard deviation of 2.5 ± 1 across the 98 sites (see [tables 1a](#) and [1b](#) for reach- or basin-specific details).

The sites targeted within a study area spanned a range in their relative degree of watershed urbanization. Watershed urbanization was defined as the degree of nonagricultural development within the watershed and was assessed by means of multiple measures, including percentage of developed land from land-use/land-cover data (discussed below), population density, road density, and impervious surface. Study sites within a given study area were stream reaches in basins with levels of nonagricultural development ranging from low (<5 percent urban land cover) to very high (>80 percent urban).

Within each study area, sites also were selected to minimize variability in natural landscape features so that natural factors would not confound the interpretation of contaminant response along the urban land-use gradient. In this respect, the present study followed the EUSE study

design, in which USEPA ecoregions (Omernik, 1987) provided a coarse initial framework of relatively homogeneous climate, elevation, soils, geology, and vegetation (Tate and others, 2005). Then, cluster analysis of climate, elevation, slope, soils, vegetation, and geology variables was performed to group the candidate basins on the basis of natural environmental characteristics. From the most similar clusters, a final set of sampling sites was selected to cover a gradient of urbanization from minimally to highly urbanized within the study area (McMahon and Cuffney, 2000). In the present study, as in the EUSE study, natural environmental setting varied substantially among study areas but comparatively little within a study area. (See [table 1a](#) for watershed ancillary parameters for individual sites; see [table 1b](#) for a list of sites, their location information, and watershed ancillary data.)

Site selection in the Salt Lake City (SLC) area differed from that of other metropolitan areas. Because of the aridity of the region and the substantial diversion of surface water for, and within, the irrigation system, the number of suitable sites was limited. This resulted in the need to nest some basins within larger ones. This was possible, while still meeting the gradient design objectives, because urbanization was confined to the Basin and Range Ecoregion of the valley floor and absent in the higher, upstream, elevations of the Wasatch and Uinta Mountain Ecoregion. SLC basin boundaries for this study were truncated along this ecoregion boundary and limited to the areas on the valley floor. Further discussion of the SLC area can be found in Tate and others (2005).

Sample Collection and Processing

Depositional zones within each stream reach (site) were targeted for sediment sampling. The sediment collection methods used in this study are adapted from the NAWQA bed sediment methods of Shelton and Capel (1994). That sediment sampling protocol calls for collecting a composite sample of surficial sediment from several depositional zones within the stream reach. Reaches were assessed before sampling as to the suitability and availability of multiple depositional zones for sampling a sufficient volume of sediment. Sediments were collected in four separate batches ([table 2](#)): (1) May 2007 (21 samples from the Seattle area), (2) May and June 2007 (13 samples from the Atlanta area), (3) May and June 2007 (13 samples from the Dallas area), and (4) August and September 2007 (51 total samples from the Salt Lake City, Denver, Milwaukee, and Boston areas).

Figure 2. General location of the Atlanta study area, Georgia and Alabama.

Figure 3. General location of the Boston study area, Massachusetts, New Hampshire, Connecticut, Maine, and Rhode Island.

Figure 4. General location of the Dallas/Fort Worth, Texas, study area.

Figure 5. General location of the Denver study area, Colorado and Wyoming.

Figure 6. General location of the Milwaukee/Green Bay, Wisconsin, study area.

Figure 7. General location of the Salt Lake City study area, Utah and Idaho.

Figure 8. General location of the Seattle/Tacoma, Washington, study area.

The top 2 cm of undisturbed, fine-grained material in these depositional zones was sampled by using a clean petri dish and a thin square of PTFE (Teflon) sheeting or a clean, small scoop. Sediment from each significant depositional zone within a reach was sampled, from downstream to upstream through the reach, and was composited into a large tempered-glass mixing bowl. A minimum of 4 L of sediment per reach was collected and composited in this fashion. Immediately after all depositional zones from the reach were sampled, the composite sediment sample was homogenized and split into several subsamples for various analyses. Subsamples for toxicity tests, particle size analysis, and all organic chemical analysis were sieved through a 2-mm stainless steel sieve. Subsamples for inorganic trace element analysis were sampled through a 63- μm nylon sieve. These sizes were selected to minimize the gravel (greater than 2 mm in size) in all samples and particles greater than 63 μm (sand and gravel) fractions for trace element analysis; these sieve sizes were selected to match historical grain sizes collected by the USGS for bottom-material analysis. Sieving was done in the field immediately after collection. After compositing and sieving, subsamples were placed in clean, weak acid- and deionized-water-rinsed, 4-L widemouth polyethylene jars for the toxicity test samples; clean and baked 500-mL amber glass jars for organic contaminants and total organic carbon analyses; and 500- or 1,000-mL polyethylene wide-mouth jars for trace element analyses. Samples were held in the dark at 4°C prior to shipment to various laboratories for analyses.

Measurements of basic field parameters (such as gage height, dissolved oxygen, specific conductance, water temperature, pH, and barometric pressure) were collected and recorded onsite at the time of the sediment collection and are presented in [tables 3a](#) and [3b](#). Recent antecedent hydrologic conditions were noted, and sampling during or immediately after high-flow events was avoided. All equipment was cleaned according to methods in Shelton and Capel (1994) and (or) chapter 8 of the USGS National Field Manual (Radtke, 2005). Briefly, those methods call for washing equipment with a phosphate-free detergent, rinsing with copious amounts of tap water, then rinsing with either dilute nitric acid (for nonmetallic utensils used for trace elements analysis) or pesticide-grade methanol (for nonplastic equipment used for organic contaminant analysis), each followed by copious rinsing with deionized water. Equipment was also rinsed in native stream water at the site before sampling.

Particle Size

Particle size was determined by following methods described in Foth and others (1982). Between 30 and 75 g of the less than 2-mm field-sieved sediment was used to determine particle size. (A larger sample size was used with sandy sediments to ensure that silt- and clay-sized particles were representative.) Sediments were dispersed

by means of methods described by Gee and Bauder (1986); briefly, sediment samples were soaked overnight in sodium hexametaphosphate solution (50 g/L), hand mixed for 3 to 5 minutes, and transferred to a settling tube (1,000-mL graduated cylinder). Deionized water was added to bring the volume to 1 L, and the sample was then mixed with a plunger. Hydrometer and temperature readings were taken after 40 seconds to determine sand-sized particle content of the sample and again at 2 hours to determine the amount of clay particles still in suspension (sand and silt-sized particles will have settled out). Samples were corrected for temperature by adding 0.25 to the hydrometer reading for temperatures above 18°C or by subtracting 0.25 from hydrometer readings below 18°C (sampling was conducted at room temperature). Percentages of sand, silt, and clay-sized particles were estimated by using the U.S. Department of Agriculture classification scheme (Foth and others, 1982): sand, greater than 50 to 2,000 μm (or 2 mm); silt, 2 to 50 μm ; and clay, less than 2 μm . All physical measurements, as well as particle-size analyses, included analyses of duplicate samples. The results of the particle-size analysis of the sediment samples are presented in [table 4](#).

Chemical Analysis

Analyses for PAHs, OC pesticides, PCBs, and major and trace elements in sediment were conducted by the USGS National Water Quality Laboratory in Lakewood, Colo. Major and trace element analyses followed methods by Biggs and Meier (1999) and Taggart (2002), except that mercury was determined by the cold-vapor atomic fluorescence spectroscopy method (Hageman, 2007). Briefly, sediments in the samples were digested with a multi-acid sequence (hydrochloric, nitric, perchloric, and hydrofluoric acids; Crock and others, 1983). Internal standards were prepared from a 2-L solution containing 500 $\mu\text{g/L}$ Lithium-6, 20 $\mu\text{g/L}$ rhodium, and 10 $\mu\text{g/L}$ iridium by performing serial dilutions of commercial aqueous standards in 1 percent nitric acid (HNO_3). This solution was mixed in a 1:1 ratio with the sample to be analyzed by using a dual-channel peristaltic pump equipped with a mixing manifold and coil. The inductively coupled plasma mass spectrometry (ICP-MS) was calibrated with a 1 percent nitric acid blank solution and two multi-element standard solutions, consisting of a “low standard” of 40 elements at low concentrations and a “high standard” of 9 major elements at higher concentrations (100–10,000 $\mu\text{g/L}$). Trace elements analysis involved analyses of 40 major and trace elements, plus inorganic and organic carbon.

See [table 5a](#) for a list of elements analyzed for and [table 5b](#) for elemental results.

PAHs in sediments were determined by gas chromatography-mass spectroscopy (GC/MS), as described by Olson and others (2004). A method for the determination of 28 PAHs, or PAH homolog groups, was summarized briefly by Olson and others (2004) as follows:

Sediment samples are centrifuged... and extracted overnight with dichloromethane (95 percent) and methanol (5 percent). The extract is concentrated and then filtered through a 0.2-micrometer polytetrafluoroethylene syringe filter. The PAH fraction is isolated by quantitatively injecting an aliquot of sample onto two polystyrene-divinylbenzene gel-permeation chromatographic columns connected in series. The compounds are eluted with dichloromethane, and a PAH fraction is collected, and a portion of the coextracted interferences, including elemental sulfur, is separated and discarded. The extract is solvent exchanged, the volume is reduced, and internal standard is added. Sample analysis is completed using a gas chromatograph/mass spectrometer and full-scan acquisition.

See [table 6a](#) for list of analytes and method detection limits and [table 6b](#) for analytical results.

Organochlorine pesticides and PCBs were analyzed by gas chromatography with electron-capture detection in accordance with methods described by Noriega and others (2004), who summarized the method as follows:

In brief, a bottom-sediment sample is centrifuged to remove excess water. A sample size of 25-g equivalent dry weight is extracted overnight with dichloromethane (93 percent) and methanol (7 percent). The sample extract is concentrated and first filtered through a 1.0- μ m polytetrafluoroethylene syringe filter, then through a 0.2- μ m polytetrafluoroethylene syringe filter connected in series. For the determination of OC pesticides and PCBs, a 1,100 μ L aliquot of the sample extract is injected quantitatively onto two serial polystyrene-divinylbenzene gel permeation chromatography (GPC) columns. Compounds are eluted with dichloromethane at a flow rate of 1 mL/min. The collected GPC fraction of OCs is concentrated and solvent exchanged, then undergoes cleanup using alumina/silica combined column adsorption chromatography and further split into two OC fractions. The second OC fraction undergoes additional cleanup using a Florisil column. Both OC fractions are analyzed by dual capillary-column gas chromatography with electron-capture detection (GC/ECD). The GC-ECD is calibrated for both capillary columns by the external standard method using multipoint calibration standards. The OCs subsequently are quantitated against the calibration curve processed for each column.

See [table 7a](#) for a list of OC and PCB analytes and detection limits and [table 7b](#) for analytical results.

Pyrethroids and fipronil-related compounds (a group of phenylpyrazole compounds that are not pyrethroids) were analyzed together in a common analytical method by the USGS Pesticide Fate Research Group (PFRG) in Sacramento, Calif., using GC/MS based methods described by Smalling and Kuivila (2008) and Hladik and others (2009). Prior to extraction, sediment samples were spiked with ring- $^{13}\text{C}_{12}$ labeled-*p,p'*-DDE and $^{13}\text{C}_6$ -*cis*-permethrin (Cambridge Isotope Laboratories Inc., Andover, Mass.) as recovery surrogates. Approximately 5 g sediment (dry weight) was extracted (at 50 percent moisture) with a microwave-assisted extraction system using a dichloromethane:methanol (9:1) solvent mix at 120°C. Sample clean-up was achieved with carbon and alumina cartridges to reduce the background matrix and gel permeation chromatography for sulfur removal. Sample extracts (1 μ L injection) were analyzed on a Varian (Walnut Creek, Calif.) CP-3800 gas chromatograph coupled to a Saturn 2000 ion-trap mass spectrometer in both single and tandem mass spectrometry modes. Fipronil compounds were added to the analyte list partway through the study, and data are available for only 30 samples. [Table 8a](#) lists the pyrethroid and fipronil-related analytes and their method detection limits, and [table 8b](#) lists the analytical results.

QA/QC Evaluation

The quality of the data presented here was assessed in several ways for this report.

First, field duplicates were generated as additional subsamples collected from the same compositing bowl after the homogenization step. For the 41 elements reported herein, the field-duplicate concentrations ranged within a relative percent difference (RPD) of less than 10 percent for all trace element analyses except thallium, for which the RPD was 11.4 percent. RPDs for organic carbon (<63 μ m) and total carbon (<63 μ m) were 4.5 and 3.5 percent, respectively, whereas the RPD for inorganic carbon was higher, at 19.8 percent. The RPDs for fipronil, fipronil degradates, and 14 pyrethroid insecticides in laboratory split samples were less than 25 percent. With the exception of molybdenum and yttrium, RPDs for the 30 trace and major elements reported here were within 25 percent of three different standard reference materials that were evaluated at the time of this analysis. The RPD values were higher for the 28 PAH compounds reported here than for trace and major elements; the RPD for PAH compounds averaged 33 percent but ranged by compound from 9 to 78 percent. However, the RPDs of three PAH surrogate compounds (listed below), which were added to field duplicates in the laboratory, were all less than 11 percent. This result suggests that, for these compounds at least, matrix interference might be less of an issue than sediment heterogeneity and (or) incomplete homogenization.

Replicate performance with the organochlorines in field samples could not be evaluated because of insufficient detection frequency; the organochlorine pesticides were undetected in both the main and duplicate sample above the detection limit in any of the field duplicate samples.

Second, analytical performance for the PAH, organochlorine, and pyrethroid methods were each evaluated with surrogate spikes (compounds with similar physical/chemical properties to the target analytes but that are not present in environmental samples), which were added to field samples prior to extraction. For the PAH method, the three surrogates (and their average recoveries) were 2-fluorobiphenyl (74 ± 12 percent), nitrobenzene-d5 (67 ± 15 percent), and terphenyl-d14 (91 ± 16 percent). For the organochlorine method, surrogate compounds (and their average recoveries) were isodrin (69.3 ± 18 percent), *alpha*-HCH-d6 (72.4 ± 16 percent), and nonachlorobiphenyl (89.6 ± 17 percent). Average percent recoveries of ring ¹³C-labeled *p,p'*-DDE and *-cis*-permethrin, used as surrogates in the pyrethroid method, were 87 ± 10 and 93 ± 13 percent, respectively. Matrix spikes for pyrethroids were analyzed as part of the method validation described by Hladik and others (2009) and ranged from 88 to 100 percent recovery.

Blank samples also were employed to test for laboratory contamination with pyrethroids and trace elements. No pyrethroids were detected in any of the blank samples. In 1 of the 17 assorted blanks associated in time with the metals data reported herein, there were detections at very low levels; however, in subsequent blanks, no detections were observed.

Data quality was assessed in the toxicity tests by the use of test replication (four replicates were used per sediment) and a control sediment (also with four replicates per control sediment). Response of midge and amphipods in the control sediment met test acceptability requirements outlined by ASTM International (2010) and U.S. Environmental Protection Agency (2000; discussed below). Further, the variability in toxicity-test endpoints of the sediments tested here is addressed through the application of "reference envelope" comparisons, also discussed below.

Test Organisms Used in Toxicity Tests

Whole-sediment toxicity tests were conducted with an amphipod (*Hyalella azteca*; 28-day exposures) and a midge (*Chironomus dilutus*; 10-d exposures) by following methods outlined in [table 9a](#) (based on U.S. Environmental Protection Agency, 2000; and ASTM International, 2010). Endpoints measured at the end of the amphipod exposures included 28-day survival, length, dry weight, and total biomass. Endpoints measured at the end of the midge exposures included 10-day survival, ash-free dry weight (AFDW), and total biomass. All sediment samples for toxicity tests were shipped on ice to the USGS Columbia Environmental Research Center (CERC) in Columbia, Mo., where the tests were conducted in four batches to match the timing of their field collection ([table 2](#)).

Amphipods were mass cultured at 23°C with a luminance of about 300 lux by using 80-L glass aquaria containing 50 L of onsite well water (hardness 283 mg/L as CaCO₃, alkalinity 255 mg/L as CaCO₃, and pH 7.8; Ingersoll and others, 1998). Approximately 7-day-old amphipods used to start the tests were obtained by collecting organisms that passed through a No. 35 U.S. Standard sieve (500-μm opening) and were collected on a No. 40 (425-μm opening) sieve placed under water (Ingersoll and others, 2002; ASTM International, 2010). Amphipods were held in 3 L of water with gentle aeration and with a small amount of Tetrafin fish food flakes and a maple leaf for 24 hours before the start of the test. Use of this sieving method resulted in mean amphipod lengths at the start of the exposures of 1.56 mm (0.05 standard error of the mean [SE]; Batch 1), 1.52 mm (0.11 SE; Batch 2), 1.50 mm (0.11 SE; Batch 3), and 1.89 mm (0.04 SE; Batch 4).

Midge were mass cultured in well water under static conditions in 5.7-L polyethylene cylindrical chambers containing about 3 L of water and 25 mL of silica sand as a substrate (U.S. Environmental Protection Agency, 2000; ASTM International, 2010). Cultures were maintained at a temperature of 25°C and a light intensity of about 300 lux. Midge in each culture chamber were fed 5 mL/d of a 100 g/L suspension of fish food flakes (Tetrafin®) and 5-mL *Chlorella* suspension (deactivated "Algae-Feast® Chlorella," Earthrise Corporation, Callpatria, Calif.) on alternating days. The age of midge at the start of the testing was 10 days for the first batch of sediments and 7 days for all subsequent batches of sediment. For the second, third and fourth batches of sediment, 7-day-old midge were used in order to improve their performance in the toxicity tests. Specifically, to improve performance of midge in control sediment, Ingersoll and others (2008) recommended two changes to the methods from ASTM International (2010) and U.S. Environmental Protection Agency (2000) for conducting 10-day sediment toxicity tests with *C. dilutus* that were likewise implemented in this study. These changes were as follows: (1) starting toxicity tests with less than 10-day-old midge larvae (to reduce the possibility of larvae emerging by the end of a 10-day sediment exposure) and (2) starting the exposures with midge larvae isolated from cultures still in their surrounding tubes, rather than with larvae that have left (or have been removed from) their culture tubes. Larvae outside of their tubes may not be as healthy as larvae still inside their tubes. Once in the sediment exposures, larvae will typically rebuild their tubes with material in the beakers within 24 hours (Dave Mount, U.S. Environmental Protection Agency, Duluth, Minn.; oral commun, 2006). Upon implementing these two revisions to the ASTM International (2010) and U.S. Environmental Protection Agency (2000) method for 10-day sediment toxicity tests with *C. dilutus*, the CERC laboratory has observed improved control survival of midge (for example, typically greater than 90 percent survival of midge in control sediment).

The mean (and SE) ash-free dry weight of individual midge at the start of the exposures were 0.25 mg (0.11 SE; Batch 1), 0.48 mg (SE not determined; Batch 2), 0.29 mg (0.06 SE; Batch 3), and 0.17 mg (0.01 SE; Batches 4a and 4b). Batch 4 samples were tested across two separate laboratory buildings and were designated Batches 4a and 4b because of space limitations. However, no significant differences were observed in control response between Batch 4a and Batch 4b midge tested in separate laboratories, so these data were combined in subsequent analyses and treated as one batch.

Sediment Toxicity Testing

Test sediments were homogenized with a plastic spoon in a stainless steel bowl and added to exposure beakers 1 day before test organisms were added (Day -1). In cases where there was sufficient sample, subsamples were collected for pore-water isolation. Pore waters were extracted by centrifugation (20 minutes at 7,000 g at 15°C; see Kemble and others, 1994). Amphipods and midge were exposed to 100 mL of sediment with 175 mL of overlying water in 300-mL beakers, with a total of four replicates per treatment for each species. The source of the overlying water was well water diluted with deionized water to a hardness of 100 mg/L as CaCO₃. Toxicity tests on the sediment samples were evaluated in four batches between May and October 2007, which matched the timing of their field collection (table 2). Batch 1 testing started in May 2007 and included 21 samples from the Seattle area. Batch 2 and 3 testing started in June 2007 and included 13 samples from each of the Atlanta and Dallas study areas, respectively. Batch 4 testing started in October 2007 and included the remaining 51 samples from four study areas: Atlanta, Salt Lake City, Boston, Denver, and Milwaukee-Green Bay (table 2). Four replicate treatments were run for each test sediment. Also, four replicate beakers of a control sediment, from West Bearskin Lake (about 3 percent total organic carbon), were tested with each batch of sediment for each species (Ingersoll and others, 1998). The photoperiod was 16 hours light:8 hours dark at an intensity of about 200 lux at the surface of the exposure beakers, and the exposure temperature was 23°C. Each beaker received 2-volume additions of overlying water daily, starting on Day-1 (Brunson and others 1998). Tests were started on Day 0 by placing 10 amphipods or 10 midge into each beaker by using an eyedropper. Amphipods in each beaker were fed 1.0 mL of Yeast-Cerophyll-trout chow (YCT; 1.7 to 1.9 g/L in a water suspension) daily. Midge in each of the beakers were fed 1.5 mL of Tetrafin (6.0 mg of dry solids in a water suspension) daily (U.S. Environmental Protection Agency, 2000; ASTM International, 2010).

At the end of the exposures, midge and amphipods were isolated from each beaker by pouring off most of the overlying water, gently swirling the remaining overlying water and upper layer of sediment and washing the sediment through a number 50 (300 µm) U.S. Standard stainless steel sieve.

The materials that were retained on the sieve were washed into a glass pan, and midge or amphipods were removed and counted.

Surviving amphipods were preserved in 8 percent sugar formalin for subsequent length measurements (Kemble and others, 1994). The lengths of amphipods were measured along the dorsal surface from the base of the first antenna to the tip of the third uropod along the curve of the dorsal surface by using an EPIX imaging system (PIXCI® SV4 imaging board and XCAP software; EPIX Inc., Buffalo Grove, Ill.) connected to a computer and a microscope (Ingersoll and others, 2002). Weights of individual amphipods and the total biomass of amphipods for each replicate were determined by estimating individual weights of amphipods from the length-weight relationship for *H. azteca* (Ingersoll and others, 2008).

Ash-free dry weights of surviving midge were obtained by drying the animals from all replicates in a treatment at 60°C in a drying oven and then recording the weights. The dried midge sample was then placed in an ashing oven (500°C) for 24 hours. Ash-free dry weight was determined by subtracting the ashed weight from the dry weight.

Methods used to characterize overlying water quality in the whole-sediment tests are described in Kemble and others (1994). Briefly, specific conductance, pH, alkalinity, hardness, dissolved oxygen, and total ammonia were measured in overlying test water on Day 0 (the day the test organisms were placed in the exposure beakers) and on Day 28. Specific conductance and dissolved oxygen in overlying water were also measured weekly. Temperature in the water baths holding the exposure beakers was monitored daily. Parameters describing overlying water and pore-water quality in the toxicity tests are presented in tables 9b and 9c.

Statistical analyses were performed by means of SAS statistical software (SAS/STAT version 9.2; SAS Institute, Cary, N.C.). Differences in toxicity endpoints relative to control sediment were determined by analysis of variance (ANOVA) with mean separation by Duncan's multiple-range test at $p < 0.05$ (table 10a and 10b and summarized in table 10e). Statistical analyses were conducted by using one-way ANOVA at $p = 0.05$ for all endpoints except length, which was analyzed by using a one-way nested ANOVA at $p = 0.05$ (amphipods nested within a beaker; Snedecor and Cochran, 1982). Before statistical analyses were performed, all data were tested for normality. Data for endpoints that were not normally distributed were either transformed by using arcsin transformation (survival) or log-transformation (length, weight, biomass) or by converting to ranks (if the endpoint data were heterogeneous) before statistical analysis. No significant differences were observed between subsamples of control sediment evaluated in Batches 4a and 4b of the midge test, discussed above, so those data were pooled to in all subsequent analysis (U.S. Environmental Protection Agency, 2000; ASTM International, 2010).

Reference Envelope

Toxicity endpoints were also evaluated using a reference envelope approach, comparing responses of test organisms in test sediments to responses of test organisms in reference sediments (Hunt and others, 2001; Ingersoll and MacDonald, 2002; and Ingersoll and others, 2009), discussed further below. The reference envelope, defined as the range of mean responses observed in reference sediments with minimal levels of contamination, was assumed to represent the normal range of responses of test organisms to uncontaminated sediments within a study area. The requirements for establishing a sample as a reference sediment include the following: (1) the mean Probable Effect Concentration Quotient (PECQ) for five classes of compounds evaluated in the sample is less than 0.1 (see below for a description of the PECQ calculation) and (2) the mean survival or weight of test organisms in a sample meets control test acceptability requirements: 80 percent survival of amphipods, 70 percent survival of midge, and a minimum of 0.48 mg AFDW per individual midge (U.S. Environmental Protection Agency, 2000; ASTM International, 2010). A test sediment was designated as toxic relative to reference conditions within a study area if the mean (of the four replicates) survival, growth, or biomass in that treatment (a sample) was less than the lowest mean for reference sediment treatment from that study area, as defined by the two criteria above. Toxicity was evaluated separately for each endpoint (survival, growth, biomass) and each species. A minimum of three reference samples needed to be identified in a study area in order to use the reference envelope approach and to classify a sediment as toxic. At least three reference sediments were identified for all study areas (see [tables 10c](#) and [10d](#), as summarized in [table 10f](#)). The median responses of test organisms in reference sediments within a study area ([tables 10c](#) and [10d](#)) were used to (1) normalize the responses of test organisms to reference and to test sediments within that study area and (2) compute the percent response of test organisms in test samples within a study area relative to the response of test organisms to reference sediments within a study area ([table 10d](#)). Normalizing the response of test organisms within a study area to the median response of test organisms in the reference sediment was done to help account for the potential influence on the test organisms of physical characteristics of the sediment samples within a study unit (for example, total organic carbon, grain size). The incidence of toxicity relative to reference conditions is compiled in [table 10f](#) by endpoint, species, and study area.

Use of Sediment Quality Guidelines in Toxicity Evaluation

Two approaches were used to evaluate relationships between sediment chemistry and sediment toxicity: (1) the Probable Effect Concentration (PEC) Quotient approach of MacDonald and others (2000) and (2) for classes that share a common mechanism of action (namely PAHs and pyrethroids), a toxic unit approach (for example, U.S. Environmental Protection Agency, 2003).

Probable Effect Concentration Quotient Approach

Probable effect concentrations are effect-based sediment-quality guidelines (SQG) from MacDonald and others (2000), intended to represent concentrations of contaminants in sediment above which adverse effects on sediment-dwelling organisms are expected to occur more often than not. The PECQ in a sample is calculated by dividing the measured concentration of the contaminant by its PEC. The mean PECQ for a sample is calculated by summing PECQ values for all contaminants in the sample mixture, which assumes additive joint toxic action (Ingersoll and others, 2001), then using the mean of those so that samples with different numbers of contaminants analyzed can be compared. The present study generally follows the method described by Ingersoll and others (2001), who computed a mean PECQ that equally weights the contribution of the major classes of contaminants being studied, as follows: First, the PECQ (or mean PECQ) is computed for each contaminant class (trace elements, PAHs, PCBs, and organochlorine pesticides in the study by Ingersoll and others, 2001), then the means for all classes are averaged to get an overall mean PECQ, which is a measure of potential toxicity for the entire sample mixture. A higher likelihood of toxicity is predicted for samples with PECQ values greater than 1 for individual contaminants or with mean PECQ values of greater than 0.1 to greater than 0.2 for sample mixtures (MacDonald and others, 2000; Ingersoll and others, 2001, 2009).

The present analysis corresponds to the PECQ procedure described by MacDonald and others (2000) and Ingersoll and others (2001), with five modifications.

- We evaluated PECQs normalized to the organic carbon content of the sediment samples, following procedures outlined by Ingersoll and others (2009). The PECs were originally developed on the basis of dry-weight concentrations of contaminants (MacDonald and others, 2000). However, sediment contaminants sorb to sediment organic carbon, which affects their bioavailability. The responses of test organisms to contaminants in sediments tend to differ among sediments when contaminant concentrations are expressed on a dry-weight (total-sediment) basis but may be more similar when concentrations are normalized to sediment organic carbon (Di Toro and others, 1991; U.S. Environmental Protection Agency, 2003). The original PECs (expressed on a dry-weight basis) were evaluated by using a dataset consisting of matching sediment chemistry and biological-effects data compiled from the scientific literature, in which the sediments represented a relatively narrow range in organic carbon content (MacDonald and others, 2000; Ingersoll and others, 2001). Because the original compiled dataset contained sediment samples that were close to 1 percent sediment organic carbon (Ingersoll and others, 2001), the PECs can be considered to apply to 1 percent total organic carbon (TOC) in sediment (Ingersoll and others, 2009). Therefore, on the premise that the predictive ability of the PECs may be improved by considering sediment organic carbon, the PECs can be assumed have units (for organic contaminants) of micrograms per kilogram sediment at 1 percent TOC or (for trace elements) milligrams per kilogram at 1 percent TOC. In the present study, measured concentrations were normalized by organic carbon (divided by the measured sediment organic carbon content, in percent) prior to comparison between PECs and observed toxicity of the sediment samples. See [tables 11c](#) and [11d](#) for normalized PEC values.
- As in Ingersoll and others (2001), PAHs were represented by the PECQ for total PAHs, except that the total PAH concentration was calculated by summing only 12 of the 13 PAH compounds specified in Ingersoll and others (2001). The 13th PAH (2-methylnaphthalene) was not analyzed for in the present study.
- We computed a mean PECQ for organochlorine pesticides by averaging PECQs for three organochlorine pesticides: DDE, chlordane, and dieldrin. Ingersoll and others (2001) used the PECQ for only one organochlorine pesticide (dichlorodiphenyldichloroethylene, DDE) because (1) other pesticides were rarely detected (Ingersoll and others 2001) and (2) DDE was the only organochlorine pesticide whose PEC met the criteria for “reliable” PECs (defined by MacDonald and others, 2000, as correctly predicting toxicity in more than 75 percent of sediment samples in a validation data set that contained a minimum of 20 samples). Chlordane and dieldrin were included in the calculation of PECQs in the present study because these compounds were frequently detected (in over 40 percent of sediment samples), and their PECs came close to meeting the reliability criteria from MacDonald and others (2000): the PEC for total chlordane correctly predicted toxicity in 73 percent of 37 samples, and the dieldrin PEC correctly predicted toxicity in 100 percent of 10 samples. Chlordane and (or) dieldrin also were included in PECQ calculations for other studies in which chlordane (Van Metre and Mahler, 2004) or chlordane and dieldrin (Tao and others, 2011) were considered major contaminants. In the present study, we defined total chlordane as the sum of *cis*-chlordane, *trans*-chlordane, *cis*-nonachlor, *trans*-nonachlor, and oxychlordane concentrations, and DDE as the sum of *o,p'*- and *p,p'*-DDE concentrations.
- For pyrethroids, we estimated 28-day sediment toxicity thresholds for *H. azteca* on the basis of results of published *H. azteca* 10-day lethality tests ([table 13](#)) conducted with spiked sediments by (1) dividing the 10-day lethal concentrations for pyrethroids by a factor of 2.5 to estimate sublethal effects (Amweg and others, 2005) and (2) further dividing by a factor of 2.0 to estimate 28-day effect thresholds from 10-day effect thresholds (Ingersoll and others, 2001). Although derived by using the results of spiked-sediment toxicity tests, these pyrethroid toxicity thresholds have a similar intent as PECs (that is, as estimates of concentrations above which toxicity is expected), so a pyrethroid toxicity quotient is analogous to a PECQ.

- For pyrethroids, we treated nondetections as zero concentrations, so that the summed PECQ values were minimum values. This is in contrast to the other four contaminant classes, for which nondetections were assumed equal to one-half of the reporting level, as specified by Ingersoll and others (2001). In the case of pyrethroids, the analytical reporting levels are not far below the PECs (within a factor of 2 to 5 for bifenthrin, cyhalothrin, and cypermethrin). If pyrethroid nondetections are assumed equal to one-half of the reporting level, the pyrethroids would dominate the overall mean PECQ, even in samples where no pyrethroids were detected, because pyrethroids are so toxic relative to the other contaminant classes. By assuming pyrethroid nondetections equal to zero, the overall mean PECQ underestimates the contribution of pyrethroids relative to other contaminant classes (especially organochlorine pesticides and PCBs, which have more frequent nondetections than PAHs or trace elements.) This bias will be considered in the subsequent interpretive reports; however, it underlines the importance of adequate method detection limits when considering pyrethroids in the environment.

We computed overall mean PECQ values for each sample mixture several ways:

1. PECQ-3, the mean of three contaminant classes: trace elements, PAHs, and PCBs. This was calculated as the overall mean of the mean PECQ for trace elements (As, Cd, Cr, Cu, Pb, Ni, Zn), the PECQ for total PAHs, and the PECQ for total PCBs (as per Ingersoll and others, 2001).
2. PECQ-4, the mean of four contaminant classes: trace elements, PAHs, PCBs, and organochlorine pesticides. This was calculated as the overall mean of the mean PECQ for trace elements, the PECQ for total PAHs, the PECQ for total PCBs, and the mean PECQ for organochlorine pesticides (DDE, dieldrin, total chlordane).
3. PECQ-5, the mean of five contaminant classes: trace elements, PAHs, PCBs, organochlorine pesticides, and pyrethroids. This was calculated three ways, each as in the PECQ-4 above, but with pyrethroids added as a fifth class. However, the pyrethroid contribution was incorporated in three different ways:
 - (a) PECQ-5M, as the mean of toxic units based on pyrethroid toxicity thresholds for four pyrethroids: bifenthrin, cypermethrin, cyhalothrin, and permethrin (see below). This follows the standard procedure for computing mean PECQs (MacDonald and others, 2000; Ingersoll and others, 2001); however, it averages, rather than sums, the toxic units for pyrethroids.
 - (b) PECQ-5P, as the sum of the toxic units based on the same four pyrethroids.
 - (c) PECQ-5B, as the toxicity unit based on bifenthrin (the most commonly detected pyrethroid). This effectively considers the toxic unit for bifenthrin only, ignoring the contribution of other pyrethroids.

Toxic Units Approach

For a class of contaminants with a common mechanism of action, toxicity may be assumed to be additive. Therefore, a benchmark for these contaminants must represent their combined toxicities in order to be protective (U.S. Environmental Protection Agency, 2003). In general, a toxic unit is defined as the proportion of one or more compounds with concentrations exceeding a corresponding toxicity benchmark; toxic units greater than 1 are considered toxic, whereas toxic units (that is, proportions) less than 1 are inferred as not toxic. The toxic unit approach was used in the present study as a tool for evaluating potential toxicity of two classes, each with a common mode of action: PAHs and pyrethroid insecticides.

For PAHs, the contribution to sediment toxicity was also evaluated by using the sum of chronic equilibrium-partitioning sediment benchmark toxic units (Σ ESBTUs). The Σ ESBTU for 18 of the 28 parent and alkylated PAHs was estimated from measured, parent PAHs (U.S. Environmental Protection Agency, 2003). As recommended by U.S. Environmental Protection Agency (2003), a 50-percent certainty factor was applied to the Σ ESBTU that was calculated from the data on the 18 parent PAH compounds, rather than the optimal list of 34 PAH compounds (Scott Ireland, U.S. Environmental Protection Agency, Chicago, Ill., oral commun., 2007). The Σ ESBTU approach was developed to account for the biological availability of non-ionic organic compounds in different sediments and incorporates select biological-effects concentrations in pore water (that is, final chronic values (FCVs); U.S. Environmental Protection Agency, 2003). The Σ ESBTU approach is intended to support integration of benchmarks for 34 PAHs into a toxic unit model that accounts for the joint toxicity of various PAHs with the same mode of toxicity (that is, non-polar narcosis). A Σ ESBTU threshold of 1.0 was established on the basis of an estimated critical body burden of about 2 μ mol total PAHs/g lipid for 28-day growth of *H. azteca* in water-only exposures and a FCV of about 2.2 μ mol total PAHs/goc (grams of organic carbon) in sediment (Dave Mount, U.S. Environmental Protection Agency, Duluth, Minn., oral commun., 2007; Ingersoll and others, 2009). By using this approach, sediment samples with Σ ESBTUs of less than 1.0 were predicted to be not toxic due to PAHs, whereas those with Σ ESBTUs greater than 1.0 were predicted to be toxic to *H. azteca* in 28-day whole-sediment exposures; see [tables 12a](#) and [12b](#).

For pyrethroids, the USEPA is currently evaluating whether some or all pyrethroids share a common mechanism of toxicity (<http://www.epa.gov/oppsrrd1/reevaluation/pyrethroids-pyrethrins.html>). However, in sediment toxicity tests with *H. azteca*, an additive model successfully predicted toxicity (within a factor of 2) for binary mixtures of pyrethroids (Trimble and others, 2009). In light of this finding, it was reasonable to hypothesize that considering the toxicity one pyrethroid at a time may underestimate the combined effects of pyrethroids at sites where multiple pyrethroids were present. Therefore, the toxic unit approach was applied to assess potential toxicity of pyrethroids in the present study.

The sum of pyrethroid toxic units was calculated by dividing the organic-carbon-normalized concentration of each pyrethroid in a sediment sample by that pesticide's estimated 28-day Lowest Observed Effect Concentration (LOEL)—also expressed in units of organic carbon—and taking the sum for all pyrethroids in the sample. Because suitable toxicity values were available for only four pyrethroids, the summed toxic units (Σ PyrTU) for pyrethroids represented only bifenthrin, cypermethrin, cyhalothrin, and permethrin (see “Derivation of Pyrethroid Probable Effect Concentrations” below and [table 13](#)). The Σ PyrTU is used as the pyrethroid contribution to the mean PECQ-5P, whereas the average pyrethroid toxic unit was included in the mean PECQ-5M, and the bifenthrin toxic unit was included in the mean PECQ-5B.

Derivation of Pyrethroid Toxicity Thresholds

Probable effect concentrations for pyrethroids were not developed by MacDonald and others (2000). However, pyrethroids are highly toxic, hydrophobic pesticides, and their use in urban applications has increased since about 2000 (Spurlock and Lee, 2008). Therefore, omission of pyrethroids from the overall mean PECQ for urban sediment samples may result in underprediction of toxicity. Therefore, in the present study, pyrethroid toxicity thresholds were estimated from spiked sediment toxicity data compiled from a review of the literature. For each pyrethroid compound, LC_{50} values based on results of 10-day spiked-sediment toxicity tests with *H. azteca* were converted to an organic carbon basis, and the lower 95-percent confidence interval of those values was calculated ([table 13](#)). Sufficient toxicity data were available to compute pyrethroid toxicity thresholds and the 95th percentile of this distribution in this manner only for bifenthrin ($n=11$ LC_{50} values) and permethrin ($n=8$ LC_{50} values; [table 14](#)). For cyfluthrin, cyhalothrin, cypermethrin, deltamethrin, and esfenvalerate, organic carbon-normalized LC_{50} values were estimated from spiked sediment toxicity tests presented in the literature.

For the pesticides bifenthrin and permethrin, numerous (eleven and eight, respectively) studies in the literature reported spiked sediment toxicity test results suitable for interpretation of the toxicity tests presented here. Those studies spiked otherwise unadulterated, or “reference” sediments with measured concentrations of one of these two

pesticides and measured amphipod (*Hyalella azteca*) survival in 10-day tests. Sediment toxicity test response may vary by 2–3 fold, depending on numerous factors, and therefore, a distributional approach was taken to derive a predictive threshold for expected toxicity. The studies listed in [table 14](#) were selected to represent (1) the temperature, 23°C, and (2) the range of organic carbon content, 0.8–16.9 percent, in samples collected for this study. The lower 95th confidence limit around the mean LC_{50} from the eleven bifenthrin studies and eight permethrin studies was 0.25 and 9.8 $\mu\text{g/g}$ of organic carbon, respectively. These values were then used in the derivation “PEC analogous” toxicity threshold value for inclusion in [table 13](#), thus enabling the comparison of relative toxicity of pyrethroids to the other four major classes of contaminants evaluated in this study. [It should be noted that 2–3 additional studies reported spiked sediment toxicity values for these compounds, but their sediment characteristics and (or) test conditions differed markedly from those in this study (for example, test performed at 18°C). Nevertheless, inclusion of those additional studies would have a minimal effect on the lower 95th confidence limit reported and used here.]

In order to calculate pyrethroid toxicity thresholds that are as analogous as possible to PECs from MacDonald and others (2000), as well as applicable to the toxicity tests conducted in the present study (28-day tests with *Hyalella azteca*), the 10-day LC_{50} *H. azteca* values available from the literature were converted to toxicity threshold values for chronic exposure (28 days) and to sublethal endpoints (growth). This was accomplished by dividing the 10-day LC_{50} value by a “safety factor” (as was done in Ingersoll and others, 2001). A factor of 5 was used to correct for both (1) study duration (a factor of 2 for conversion from a 10-day test to a 28-day test; Ingersoll and others 2001) and (2) for study endpoint (a factor of 2.5 for conversion from an LC_{50} to an LOEL for survival or growth, as indicated in Amweg and others, 2005). Pyrethroid toxicity threshold PECs for four pyrethroids—bifenthrin, cyhalothrin, cypermethrin, and permethrin—were used in the present study because these four were the only pyrethroids detected in the present study that had sufficient toxicity data and detection limits to estimate pyrethroid toxicity thresholds.

For the pyrethroid resmethrin, no sediment toxicity data were available; so, a sediment toxicity threshold could not be calculated, and resmethrin was not included in Σ PyrTU or mean PECQ calculations in the present study. However, a screening-level toxicity value for resmethrin that was used by U.S. Environmental Protection Agency (2005a) in the Registration Eligibility Decision is available for resmethrin, and this was used by Hladik and others, 2008 (see also Kuivila and others in the “[Related Pending Publications](#)” section) to discuss the potential toxicity of resmethrin relative to other pyrethroids. This screening value (2.17 micrograms per gram of sediment organic carbon) was computed by using the equilibrium sediment partitioning approach (U.S. Environmental Protection Agency, 2005b,c), which assumes that (1) concentrations of a non-ionic chemical in interstitial

(pore) water and sediment organic carbon are at equilibrium and are related to each other by the sediment organic carbon partitioning coefficient (K_{oc}) and (2) the toxicity of the chemical to benthic organisms is equivalent to its toxicity to water-column species. The U.S. Environmental Protection Agency (2005b,c) computed the screening value using the LC₅₀ for the most sensitive invertebrate (pink shrimp, 96-hour LC₅₀ of 1.34 µg/L) and a mean K_{oc} value of 1,620 L/kg, using the equation below:

$$LC_{50} \left(\frac{\mu g}{L} \right) \times \left(\frac{L}{kg\ oc} \right) \times 0.001 \left(\frac{kg\ oc}{g\ oc} \right) = LC_{50} \left(\frac{\mu g}{g\ oc} \right). \quad (1)$$

The following toxicity thresholds were applied to predict toxicity of the sampled sediments and to identify which contaminants or classes are likely contribute to observed toxicity (Kemble and others, 2009; see also Kemble and others, in review, in the “[Related Pending Publications](#)” section):

- Samples with overall mean PECQ-3, PECQ-4, and(or) PECQ-5 values greater than 0.1 have a high likelihood of toxicity (Kemble and others, 2009; see also Kemble and others, in review, in the “[Related Pending Publications](#)” section).
- Individual contaminants with PECQ values greater than 1 are expected to be contributors to the observed toxicity.
- Pyrethroids are likely contributors to toxicity in samples with the ΣPyrTU value greater than 1.
- PAHs are likely contributors to toxicity in samples with the ΣESBTU value greater than 1.

Ancillary Data for Study Sites and Watersheds

Various ancillary GIS datasets were processed to characterize approximately 95 stream habitat features and human influences within the study basins ([tables 1a](#) and [1b](#)). For most variables, the basin boundaries gridded at 30-m resolution were intersected with each national ancillary data layer to calculate a basin average for the ancillary data feature of interest, as discussed below.

Boundaries of the watershed (drainage basin) upstream from each bed sediment collection site were delineated by USGS geographers, typically working at local offices and familiar with the sampling sites. Most of the boundaries were compiled previously for the USGS NAWQA program, in digital topographic and hydrologic maps at a scale of

between 1:24,000 and 1:250,000 (Nakagaki and Wolock, 2005). The remaining watershed boundaries were generated by using 30-m-resolution Elevation Derivatives for National Applications (EDNA) reach catchments (U.S. Geological Survey, 2002). All of the digital basin boundaries were managed both as vector datasets (coverages) and as 30-m-resolution raster datasets (grids). Drainage areas for the basins were calculated from the coverages.

Most variables were derived on the basis of basin boundaries (basin-level variables); however, several categories of variables were calculated at finer scales (riparian, segment, and mainstem-level variables). Streams were based on the USGS National Hydrography Dataset 1:100,000-scale stream set (U.S. Geological Survey and U.S. Environmental Protection Agency, 2003, <http://nhd.usgs.gov/>, accessed October 2003). In the Great Salt Lake study area, sampling sites are located on the valley floor, where the source of streamflow is typically more urban than would be represented by the total drainage land cover, because streamflow from the upper (undeveloped) portions of the basins are often impounded or diverted (Waddell and others, 2004). Therefore, basin delineation and basin characteristics for sampling sites in the Great Salt Lake study area were estimated on the basis of the valley floor drainage areas.

Land-Cover Data

The 2001 land-use data were based on the National Land Cover Database (NLCD) 2001 (U.S. Geological Survey, 2005). The NLCD 2001 is a 16-class, 30-m-resolution dataset based primarily on Landsat 7 Enhanced Thematic Mapper imagery covering the period from 1999 to 2002. The NLCD 2001 program also contains a subpixel-percentage impervious-surface data layer, which was acquired or derived from imagery. Earlier (approximately 1992) land-cover data were based on Landsat Thematic Mapper imagery for the 1990s from Vogelmann and others (2001).

The NLCD was used to derive percentages of land-cover classes in each basin. For the purposes of data analysis here, these 16 NLCD categories were classified into three broader land-use categories, as follows: agriculture (sum of NLCD categories 81 and 82), urban (21–24), not developed (11–12, 31, 41–43, 52, 71, 90, 95). To address the possibility that conditions observed at the sampling site were influenced more by land cover closer to the site than by land cover farther away from the site, we also evaluated land cover within two buffer widths adjacent to the stream, at 100 m (riparian buffer) and 800 m (mainstem buffer) from the stream centerline. Certain variables were determined for the stream segment, defined such that the segment length is $1,000 \times \log_{10}(\text{drainage area})$ and the segment width is 100 m on each side of the stream centerline.

Population Density, Roads, and Impervious Surface

The 2000 Census block group boundaries (U.S. Census Bureau, 2001), gridded at 30-m resolution with 2000 block group population density (as calculated from the Census Summary File 1 published by GeoLytics, 2001), were used to derive a weighted average 2000 population density by block group for each basin. Basin population density was calculated as both 1990 and 2000 Census block-level data (GeoLytics, 2001) regridded to 100 m. Housing-unit density was calculated on the basis of 2000 Census block-group data and also regridded at 100 m. The source of impervious surface area was a 1-km resolution grid prepared by Elvidge and others (2004). Where available, percent impervious surface was also generated from 1-km data from the National Oceanographic and Atmospheric Administration (NOAA; <http://www.csc.noaa.gov/crs/lca/pacificcoast.html>). Road data were based on Census 2000 Topologically Integrated Geographic Encoding and Reference (TIGER) line roads (GeoLytics, 2001). These data were used to generate road density, as kilometers of roads per square kilometer of basin area, and as number of road-stream intersections per kilometer of total basin stream length, where the stream course was defined from the National Hydrography Dataset.

Termite-Urban Pesticide Use Data

A termite-urban pesticide use score was developed as a surrogate for insecticide use to control termites (Nowell and others, 2006) because estimates of past or present termiticide use at the state or county scale are not available nationally. Two versions of the termite-urban score were derived to represent historical (1970s) and present-day (2001) termiticide use. These were derived from the urban land in the basin weighted by the zone of subterranean termite density, on the premise that termiticides are most likely applied to buildings in parts of the country where termites occur. The 1970s land-use data are in Geographic Information Retrieval and Analysis System (GIRAS) format and are based on aerial photography taken from the 1970s through the mid-1980s (U.S. Geological Survey, 1999, as enhanced by Price and others, 2007). The 2001 land-use data were NLCD 2001 data (U.S. Geological Survey, 2005). Termite-density zones are from Beal and others (1994). The specific procedure for calculating the weighted termite-urban score is described in Nowell and others (2006).

Hydrography and Precipitation Data

Stream centerlines were based on stream lines from the National Hydrography Dataset (U.S. Geological Survey and U.S. Environmental Protection Agency, 2003). This dataset was also used to calculate total stream length within each basin, as well as a dam and hydrologic modifications inventory. These inventories were used to generate metrics of hydrologic modifications at various scales: reach, basin, narrow riparian buffers (100 m), and large mainstem buffers (800 m). We used 1-km national grids (David Wolock, U.S. Geological Survey, written commun., 2007) to calculate a mean for each basin for base-flow index, potential and actual evapotranspiration, and topographic wetness index. Base flow, the component of streamflow that can be attributed to groundwater discharge into streams, was compiled from a 1-km raster dataset created by interpolating base-flow index (BFI) values estimated at USGS streamflow-gaging stations (Wolock, 2003a). Temperature data from the Parameter-elevation Regressions on Independent Slopes Model (PRISM) model (Daly, 2006) and the Hamon equation (Hamon, 1961) were used by Wolock to generate a 1-km grid of mean annual potential evapotranspiration. The PRISM data were obtained from the Spatial Climate Analysis Service at Oregon State University. The PRISM model also uses a digital elevation model and point data to generate estimates of precipitation and other climatic parameters (Daly and others, 1994; Daly and others, 1997). PRISM mean annual precipitation (1961–1990) at 2-km resolution and other PRISM climate data were used in a water-balance model to estimate actual evapotranspiration (Wolock and McCabe, 1999). Average topographic wetness index was developed from 1-km-resolution digital elevation model (DEM) data (Wolock and McCabe, 2000). The source dataset, compiled by Gebert and others (1987) at 1-km resolution, was used to compute mean annual runoff (1971–2000) for the basins.

Soil Characteristics of the Watersheds

Key soil characteristics for each basin include percent organic matter content by weight, soil erodibility factor, rainfall and runoff factor, percent hydric soils, soil permeability, and soil drainage class, and they were compiled from State Soil Geographic (STATSGO) data for the areas surrounding each reach sampled. The percent organic matter and soil erodibility factor were obtained from the tabular data files presented in Wolock (1997) and were linked by mapping unit identification code to a 100-m-resolution national grid of STATSGO geographic mapping units. Soil drainage class was compiled from Schwarz and Alexander (1995), who converted the categorical classes into numeric values. Hydric soils, soil porosity, and soil drainage class also were linked to the 100-m soils mapping unit grid. For each basin, a weighted average was calculated for each soil characteristic on the basis of areas of the soils mapping units within the basin.

Elevation

Various basin and site elevation datasets at 30-m resolution were extracted from USGS National Elevation Data (NED; U.S. Geological Survey, 2001). These 30-m data were resampled to 100-m resolution, and the 100-m data were used to calculate the elevation of each sampling site and the mean and maximum elevation and the mean slope of each basin.

Pesticide Applications and Mineral Data

Pesticide use estimates were taken from Thelin and Gianessi (2000), who estimated pesticide application for 42 major pesticides, in kilograms of pesticide applied per square kilometer, from Census of Agriculture data, based on countywide sales and percent agricultural land cover in basin. The density and total number of mining operations in the study basins were taken from the National Atlas 2003 database (U.S. Geological Survey, 2003) of 7,090 mineral-operations point locations. These included copper, gold, iron and salt mines, as well as phosphate plants, sand and gravel operations, cement plants, and so forth. Energy mineral operations (for example, coal mines) are not included. Density is in units of number of operations per 100 square kilometers.

Conclusion

This USGS National Stream Bed Sediment Pilot Study was designed to evaluate the effects of urbanization on sediment contamination and toxicity in streams. This study sampled bed sediment from 98 sites in streams ranging from undeveloped to highly urbanized basins, in each of seven metropolitan study areas across the United States. Toxicity tests conducted with the same samples include 28-day exposures with the amphipod *Hyaella azteca* and 10-day exposures with the midge *Chironomus dilutus*. Toxicity was established as a reduction in survival, growth, or biomass of test organisms relative to reference conditions within each study area. Sediment contaminants (organics and (or) trace

elements) were found at every site sampled in this study. Contaminant concentrations tended to increase with the degree of urbanization in the watershed and with organic carbon content of the sediments. However, contaminant types and concentrations differed markedly between metropolitan study areas (Moran and others, 2008; see also Nowell and others, in review, in the “[Related Pending Publications](#)” section). Data from scientific literature was located and reviewed during the study to estimate chronic sediment toxicity thresholds for several pyrethroid pesticides—including bifenthrin, cyfluthrin, cyhalothrin, cypermethrin, deltamethrin, esfenvalerate, permethrin—and for fipronil, fipronil sulfide, and fipronil sulfone ([table 13](#)). However, the thresholds presented here are from very limited datasets, and additional spiked sediment toxicity tests for pyrethroids are needed (including 28-day tests with the amphipod *Hyaella azteca*). Sediment-quality guidelines, such as Probable Effect Concentration Quotients (PECQ), calculated for a sample can be used to predict whether that sample is expected to be toxic to sediment-dwelling invertebrates or to evaluate relationships between sediment chemistry and observed toxicity. Of the 108 sediment contaminants examined in this study, bifenthrin was the best *single* predictor of toxicity to *H. azteca*. Overall, PECQs based on five contaminant classes (trace elements, PAHs, PCBs, organochlorine pesticides, and pyrethroid pesticides, especially bifenthrin) explained the toxicity (or lack of) observed in sediment samples for over 80 percent of samples (Kemble and others, 2009; see also Kemble and others, in review, in the “[Related Pending Publications](#)” section). Regional differences in pyrethroid concentrations observed in the seven metropolitan areas studied suggests regional differences in pyrethroid use (Kuivila and others, in review; see “[Related Pending Publications](#)” section). Interpretation of the findings of this study, including land-use relationships, sediment toxicity in relation to contamination, and pyrethroid sources, are discussed in detail in the forthcoming publications by Nowell and others (in review), Kemble and others (in review), and Kuivila and others (in review), respectively, listed in the “[Related Pending Publications](#)” section of this report.

Table Overview

All data for this study are presented herein in [tables 1–13](#). Data for most topical areas of the study are in at least two tables per topic. Tables denoted with an “a” (or in some cases, “c”) are descriptive tables defining the column headers and other coding and/or formatting applicable to the main table that follows, as denoted with a “b” (or in some cases, “d”), which generally contain the applicable raw data.

In accordance with this labeling convention, tables 1a and 1b present the variable (or column) descriptors regarding ancillary site location information for each of the study reaches in this study and the values, respectively. [Table 2](#) presents the timing of the various toxicity tests. [Table 3](#) presents the water-quality parameters and [table 4](#) the physical conditions of the sediment sample at the time of collection. [Tables 5a](#) and [5b](#) present the trace element chemistry determined for 41 different elements. [Tables 6a](#) and [6b](#) present data on the 29 PAHs analyzed for. [Table 7a](#) and [7b](#) present analytical results for what are now largely historical-use organochlorine pesticides. [Tables 8a](#) and [8b](#) present pyrethroid analytical chemistry results. [Table 9a](#) presents a overview of the experimental conditions for the toxicity

tests, and [Tables 9b](#) and [9c](#) present physical and chemical parameters regarding test conditions before and during the sediment toxicity tests. [Tables 10a](#) through [10f](#) present the results of the toxicity biosassays in various formats; [tables 10a](#) and [10b](#) present mean organism response relative to control, whereas [tables 10c](#) and [10d](#) present toxicity responses relative to a reference envelope approach. [Tables 10e](#) and [10f](#) are summary toxicity tables, summarizing the two approaches described above—relative to control and relative to a reference envelope—by study area. [Tables 11a–11d](#) present sediment toxicity thresholds (for example, PECs or pyrethroid toxicity thresholds), reported on a dry-weight basis and ([tables 11a](#) and [11b](#)) on an organic-carbon-normalized basis ([tables 11c](#) and [11d](#)). [Tables 12a](#) and [12b](#) describe the equilibrium-partitioning sediment benchmark toxic units (Σ ESBTU) calculated for polycyclic aromatic hydrocarbons mixtures from the study sediments. [Table 13](#) lists relevant toxicity values from pyrethroid spiked sediment toxicity tests, as well as the assumptions made in converting those reported effects values to a probable effect concentration for pyrethroids.

[Table 14](#) lists studies reviewed from the literature, and used in derivation of threshold values in [table 13](#), for 10-day sediment toxicity tests with the amphipod *H. azteca* and the pesticides bifenthrin and permethrin.

Table 1a. Variable descriptions for sampling locations and watershed ancillary information for [table 1b](#).

[**Abbreviations:** CERC, Columbia Environmental Research Center; HLR, Hydrologic Landscape Region; NAD83, North American Datum of 1983; NAWQA, National Water Quality Assessment; NED, National Elevation Dataset; NHDPlus, National Hydrography Dataset Plus; NID, National Inventory of Dams; NLCD, National Land Cover Data; NOAA, National Oceanic and Atmospheric Administration; NPDES, National Pollutant Discharge Elimination System; NWIS, National Water Information System; STATSGO, State Soil Geographic database; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; cm, centimeter; kg, kilogram; kg/km², kilogram per square kilometer; km, kilometer; km², square kilometer; m, meter; mm/yr, millimeter per year; ft, foot; ft-tonf-in-(ac-h-yr)⁻¹, units of modeling factor (RFACT) as hundreds of acre-feet of tonnes (long) of force in inches of rainfall per hour per acre per year; N/A, not applicable; <, less than; >, greater than]

Variable category	Variable name	Variable description	Extent	Units (numeric values)	Processing method	Additional note on processing or dataset	Nominal resolution/scale of source data	Reference	Source data and web site
BasinID	MRA (used in report tables)	Metropolitan areas of each regional study (ATL, Atlanta; BOS, Boston; DAL, Dallas; DEN, Denver; MGB, Milwaukee-Green Bay; SEA, Seattle; SLC, Salt Lake City).	N/A	N/A	N/A		1:250,000	Termite density zones from Beal (1994), GIRAS land cover (1970s) from Price and others (2007).	Various, see citation
BasinID	SMRA (Used in data tables throughout report)	Site code based on metropolitan regional area and a sequential number.	N/A	N/A	N/A	N/A	30-m grid	McGarigal and others, 2002	USGS
BasinID	SNAME (Used in data tables throughout report)	USGS station name.	Site	N/A	N/A	N/A	1:24,000 - 1:100,000	U.S. Geological Survey, 2008b; U.S. Geological Survey, 2008a	USGS NWIS and NAWQA, http://waterdata.usgs.gov/nwis/ and http://water.usgs.gov/nawqa/
BasinID	STAIID (Used in data tables throughout report)	USGS station identification number.	N/A	N/A	N/A	N/A	Census block	SILVIS Lab, 2008	SILVIS Lab, http://silvis.forest.wisc.edu/projects/WUI_Main.asp
BasinID	SUID	USGS National Water-Quality Assessment (NAWQA) Study Unit ID.	N/A	N/A	N/A	N/A	Census block	SILVIS Lab, 2008	SILVIS Lab, http://silvis.forest.wisc.edu/projects/WUI_Main.asp
BasinID	CERC ID	USGS Columbia Environmental Research Center (CERC) Identification Number.	N/A	N/A	N/A	N/A	Census block	SILVIS Lab, 2008	SILVIS Lab, http://silvis.forest.wisc.edu/projects/WUI_Main.asp
BasinID	STATE	State in which sampling site is located.	N/A	N/A	Vector point	2000	1:100,000	GeoLytics, 2001	Census, repackaged by GeoLytics, http://www.geolytics.com/ (http://www.esri.com/data/download/census2000-tigerline/index.html).

Table 1a. Variable descriptions for sampling locations and watershed ancillary information for [table 1b.](#)—Continued

[**Abbreviations:** CERC, Columbia Environmental Research Center; HLR, Hydrologic Landscape Region; NAD83, North American Datum of 1983; NAWQA, National Water Quality Assessment; NED, National Elevation Dataset; NHDPlus, National Hydrography Dataset Plus; NID, National Inventory of Dams; NLCD, National Land Cover Data; NOAA, National Oceanic and Atmospheric Administration; NPDES, National Pollutant Discharge Elimination System; NWIS, National Water Information System; STATSGO, State Soil Geographic database; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; cm, centimeter; kg, kilogram; kg/km², kilogram per square kilometer; km, kilometer; km², square kilometer; m, meter; mm/yr, millimeter per year; ft, foot; ft-tonf-in-(ac-h-yr)⁻¹, units of modeling factor (RFACT) as hundreds of acre-feet of tonnes (long) of force in inches of rainfall per hour per acre per year; N/A, not applicable; <, less than; >, greater than]

Variable category	Variable name	Variable description	Extent	Units (numeric values)	Processing method	Additional note on processing or dataset	Nominal resolution/scale of source data	Reference	Source data and web site
BasinID	COUNTY_FIPS	Federal Information Processing Standard (FIPS) code of the county at sampling site.	N/A	N/A	Vector point	2000	1:100,000	GeoLytics, 2001 and U.S. EPA, 2008	Roads from Census, repackaged by GeoLytics; streams from NHDPlus, circa 2006-2007, http://www.geolytics.com/ and http://www.horizon-systems.com/nhdplus/
BasinID	LATITUDE_NAD83	Latitude at sampling site, decimal degrees, North American Datum of 1983.	Site	decimal degrees, datum NAD83.	N/A	N/A	1-km grid	Elvidge and others (2004), http://dmisp.ngdc.noaa.gov/html/download_isa2000_2001.html	
BasinID	LONGITUDE_NAD83	Longitude at sampling site, decimal degrees, North American Datum of 1983.	Site	decimal degrees, datum NAD83.	N/A	N/A	30-m grid	Nakagaki and others, 2007	USGS NLCD92e, http://water.usgs.gov/lookup/getspatial?hlcde92

Variables listed alphabetically by variable name below

HydroMod_ Other	ARTIFFLOW_PCT	Percent of stream kilometers coded as "Artificial" in NHDPlus, lengths of streams that flow through water bodies. A possible indication of hydro-modification to the extent that many water bodies are manmade.	Watershed	Percent	Vector line	These are lengths of streams that flow through water bodies, a possible indication of hydro-modification to the extent that many water bodies are manmade.	The base data layer is built on the STATSGO mapping units, the average size of which is about 750 km ² .	Wolock, 1997	USGS NAWQA, http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
Soils	AWCAVE	Average value for the range of available water capacity for the soil layer or horizon (inches of water per inches of soil depth).	Watershed	unitless (fractionGrid inches of water per inches of soil depth)		Each STATSGO mapping unit contains multiple soil components, and each component can have multiple soil layers. The average value for each mapping unit is a weighted average based on soil layer thickness and component area.	1:7,500,000	Omernik, 1987	USEPA Ecoregions, http://www.epa.gov/web/pages/ecoregions.htm

Table 1a. Variable descriptions for sampling locations and watershed ancillary information for [table 1b](#).—Continued

[Abbreviations: CERC, Columbia Environmental Research Center; HLR, Hydrologic Landscape Region; NAD83, North American Datum of 1983; NAWQA, National Water Quality Assessment; NED, National Elevation Dataset; NHDPlus, National Hydrography Dataset Plus; NID, National Inventory of Dams; NLCD, National Land Cover Data; NOAA, National Oceanic and Atmospheric Administration; NPDES, National Pollutant Discharge Elimination System; NWIS, National Water Information System; STATSGO, State Soil Geographic database; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; cm, centimeter; kg, kilogram; kg/km², kilogram per square kilometer; km, kilometer; km², square kilometer; m, meter; mm/yr, millimeter per year; ft, foot; ft-tonf-in-(ac-h-yr)⁻¹, units of modeling factor (RFACT) as hundreds of acre-feet of tonnes (long) of force in inches of rainfall per hour per acre per year; N/A, not applicable; <, less than; >, greater than]

Variable category	Variable name	Variable description	Extent	Units (numeric values)	Processing method	Additional note on processing or dataset	Nominal resolution/scale of source data	Reference	Source data and web site
Bas_Morph	BAS_COMPACTNESS	Basin compactness ratio, = area/perimeter ² ; higher number = more compact shape.	Watershed	Unitless	Vector polygon area	Basin grids were reconverted to polygons for calculation, because original perimeters could be of inconsistent detail, depending on method used to delineate basins (some were from NAWQA).	1:100,000	U.S. Census Bureau, 2008	Census, http://www.census.gov/geo/www/cob/index.html
Bas_Morph	BAS_SHAPE_INDEX	Basin shape index, unitless, as calculated by FRAGSTATS. Index of how "compact" or "irregular" perimeter to area is. Range is 1.0 (very compact) to infinity (very irregular).	Watershed	Unitless	Grid	Basin shape index, unitless, as calculated by FRAGSTATS. Index of how "compact" or "irregular" basin area is. Range is 1.0 (very compact) to infinity (very irregular).	1:100,000	U.S. Census Bureau, 2008	Census, http://www.census.gov/geo/www/cob/index.html
LC92_Basin	BASSUM_AG	Basin percent "agriculture". Percent of total basin area as sum of classes 61, 62, 81, 82, 83 and 84.	Watershed	percent	Grid	1992	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php
LC92_Basin	BASSUM_MINING_TRANS	Basin percent "mining/ transitional". Percent of total basin area as sum of classes 32 and 33).	Watershed	percent	Grid	1992	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php
LC92_Basin	BASSUM_NOTDEVEL	Basin percent "undeveloped". Percent of total basin area as sum of classes 11, 12, 31, 41, 42, 43, 51, 71, 72, 91, and 92.	Watershed	percent	Grid	1992	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php
LC92_Basin	BASSUM_URBAN	Basin percent "urban". Percent of total basin area as sum of classes 21, 22, 23, 25, 26, and 85. Land cover from National Land Cover Database (NLCD).	Watershed	percent	Grid	1992	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php
Hydro	BFI	Base Flow Index (BFI), percent. The BFI is a ratio of base flow to total flow, expressed as a percentage, range 0-100.	Watershed	percent	Grid	Grid generated by inverse-distance-weighting of base-flow index values computed at USGS streamgages; long term average.	1:100,000	U.S. Environmental Protection Agency, 2008	NHDPlus, http://www.horizon-systems.com/nhdplus/

Table 1a. Variable descriptions for sampling locations and watershed ancillary information for [table 1b.](#)—Continued

[Abbreviations: CERC, Columbia Environmental Research Center; HLR, Hydrologic Landscape Region; NAD83, North American Datum of 1983; NAWQA, National Water Quality Assessment; NED, National Elevation Dataset; NHDPlus, National Hydrography Dataset Plus; NID, National Inventory of Dams; NLCD, National Land Cover Data; NOAA, National Oceanic and Atmospheric Administration; NPDES, National Pollutant Discharge Elimination System; NWIS, National Water Information System; STATSGO, State Soil Geographic database; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; cm, centimeter; kg, kilogram; kg/km², kilogram per square kilometer; km, kilometer; km², square kilometer; m, meter; mm/yr, millimeter per year; ft, foot; ft-tonf-in-(ac-h-yr)⁻¹, units of modeling factor (R/FACT) as hundreds of acre-feet of tonnes (long) of force in inches of rainfall per hour per acre per year; N/A, not applicable; <, less than; >, greater than]

Variable category	Variable name	Variable description	Extent	Units (numeric values)	Processing method	Additional note on processing or dataset	Nominal resolution/scale of source data	Reference	Source data and web site
HydroMod_ Other	CANAL_ARTIF_ MAINSTEM_PCT	Percent of mainstem stream(s) coded as "Canal", "Ditch", "Pipeline" or "Artificial" in NHDPlus.	Mainstem	percent	Vector line	N/A	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php
HydroMod_ Other	CANALS_PCT	Percent of stream kilometers coded as "Canal", "Ditch", or "Pipeline" in NHDPlus.	Watershed	percent	Vector line	N/A	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php
Soils	CLAYAVE	Average value of clay content (percentage).	Watershed	percent	Grid	Each STATSGO mapping unit contains multiple soil components, and each component can have multiple soil layers. The average value for each mapping unit is a weighted average based on soil layer thickness and component area.	1:7,500,000	U.S. Environmental Protection Agency, 1998	USEPA, http://www.epa.gov/waterscience/criteria/nutrient/ecoregions/
Hydro	CONTACT	Subsurface flow contact time index. The subsurface contact time index estimates the number of days that infiltrated water resides in the saturated subsurface zone of the basin before discharging into the stream.	Watershed	Days	Grid	The contact time index is computed as a function of basin topographic and soil characteristics. The base data layer is a 1-km-resolution grid and is computed from STATSGO soil parameters (Wolock, 1997) and 3-arcsecond digital elevation data (USGS, 2005).	The base data layer is built on the STATSGO mapping units, the average size of which is about 750 km ² .	Wolock, 1997	USGS NAWQA, http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
HydroMod_ Dams	DAMS_PER_ MAINS_100KM	Number of dams in the mainstem buffer per 100 km of mainstem length.	Mainstem 800-m	Number of dams per 100 km of mainstem length	Vector point	All dams data from National Inventory of Dams (NID); downloaded summer 2006; data currency varies.	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php
BasinID	DRN_SQKM	Basin drainage area, square kilometer (km ²).	Watershed	km ²	N/A	Vector polygon area.	1:24,000 - 1:100,000	USGS NWIS and NAWQA	N/A
Regions	ECO2_SITE	U.S. Environmental Protection Agency Level II ecoregion at the sampling site.	Site	N/A	Vector point	From June 2006 download of EPA ecoregions.	1:100,000	U.S. Environmental Protection Agency, 2008	NHDPlus, http://www.horizon-systems.com/nhdplus/

Table 1a. Variable descriptions for sampling locations and watershed ancillary information for [table 1b](#).—Continued

[**Abbreviations:** CERC, Columbia Environmental Research Center; HLR, Hydrologic Landscape Region; NAD83, North American Datum of 1983; NAWQA, National Water Quality Assessment; NED, National Elevation Dataset; NHDPlus, National Hydrography Dataset Plus; NID, National Inventory of Dams; NLCD, National Land Cover Data; NOAA, National Oceanic and Atmospheric Administration; NPDES, National Pollutant Discharge Elimination System; NWIS, National Water Information System; STATSGO, State Soil Geographic database; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; cm, centimeter; kg, kilogram; kg/km², kilogram per square kilometer; km, kilometer; km², square kilometer; m, meter; mm/yr, millimeter per year; ft, foot; ft-tonf-in-(ac-h-yr)⁻¹, units of modeling factor (RFACT) as hundreds of acre-feet of tonnes (long) of force in inches of rainfall per hour per acre per year; N/A, not applicable; <, less than; >, greater than]

Variable category	Variable name	Variable description	Extent	Units (numeric values)	Processing method	Additional note on processing or dataset	Nominal resolution/scale of source data	Reference	Source data and web site
Regions	ECO3_SITE	U.S. Environmental Protection Agency Level III ecoregion at the sampling site.	Site	N/A	Vector point	From June 2006 download of EPA ecoregions.	2-km grid	PRISM, 2008	PRISM, http://www.prism.oregonstate.edu/
Topo	ELEV_SITE_M	Elevation at sampling site (meters) from 100-m National Elevation Dataset.	Site	Meters	Grid	Original source of elevation data were 30-m tiles of USGS NED data assembled by Roland Viger and Curtis Price of the USGS in the early 2000 period. Because of size and processing constraints, those tiles were merged and resampled (bilinear) to 100-m to make a national grid. Parameters are: projection Albers Equal Area, Datum NAD83, Spheroid GRS1980, 29:30, 45:30, -96:00, 23:00, 0, 0.	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php
Topo	ELEV_STD_M_BASIN	Standard deviation of elevation (meters) across the watershed from 100-m National Elevation Dataset.	Watershed	Meters	Grid	Original source of elevation data were 30-m tiles of USGS NED data assembled by Roland Viger and Curtis Price of the USGS in the early 2000 period. Because of size and processing constraints, those tiles were merged and resampled (bilinear) to 100-m to make a national grid. Parameters are: projection Albers Equal Area, Datum NAD83, Spheroid GRS1980, 29:30, 45:30, -96:00, 23:00, 0, 0.	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php

Table 1a. Variable descriptions for sampling locations and watershed ancillary information for [table 1b.](#)—Continued

[Abbreviations: CERC, Columbia Environmental Research Center; HLR, Hydrologic Landscape Region; NAD83, North American Datum of 1983; NAWQA, National Water Quality Assessment; NED, National Elevation Dataset; NHDPlus, National Hydrography Dataset Plus; NID, National Inventory of Dams; NLCD, National Land Cover Data; NOAA, National Oceanic and Atmospheric Administration; NPDES, National Pollutant Discharge Elimination System; NWIS, National Water Information System; STATSGO, State Soil Geographic database; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; cm, centimeter; kg, kilogram; kg/km², kilogram per square kilometer; km, kilometer; km², square kilometer; m, meter; mm/yr, millimeter per year; ft, foot; ft-tonf-in-(ac-h-yr)⁻¹, units of modeling factor (RFACT) as hundreds of acre-feet of tonnes (long) of force in inches of rainfall per hour per acre per year; N/A, not applicable; <, less than; >, greater than]

Variable category	Variable name	Variable description	Extent	Units (numeric values)	Processing method	Additional note on processing or dataset	Nominal resolution/scale of source data	Reference	Source data and web site
Landscape_Pat	FRAGUN_BASIN	Fragmentation Index of "undeveloped" land in the basin. High numbers = little undeveloped and unfragmented land cover in basin.	Watershed	Unitless	Grid	Based on Ritters and others (2000) method, using 3x3 processing window. Number given here is: (1 - percent "interior" pixels); that is, all pixels in basin which are neither disturbed nor fragmented. Definition of "undeveloped" land = all land which is not urban nor agriculture, from NLCD01 data.	N/A	U.S. Geological Survey, 2008a	USGS NAWQA, http://water.usgs.gov/nawqa
Landscape_Pat	FRAGUN_MAINSTEM	Fragmentation Index of "undeveloped" land in the mainstem buffer (800 m each side of stream centerline for mainstem). High numbers = little undeveloped and unfragmented land cover in buffer.	Mainstem	Unitless	Grid	Based on Ritters and others (2000) method, using 3x3 processing window. Number given here is: (1 - percent "interior" pixels); that is, all pixels in basin which are neither disturbed nor fragmented. Definition of "undeveloped" land = all land which is not urban nor agriculture, from NLCD01 data.	N/A		
Geology	GEOLOG_DOMINANT	Geology type with largest percent coverage within the watershed derived from a simplified version of Reed and Bush (2007) - Generalized Geologic Map of the Conterminous United States.	Watershed	N/A	Grid		30-m grid	Nakagaki and others, 2007	USGS NLCD92e, http://water.usgs.gov/lookup/getspatial?nlcd92
Geology	GEOLOG_SITE	Geology type at the sampling site derived from a simplified version of Reed and Bush (2007).	Site	N/A	Grid		30-m grid	Nakagaki and others, 2007	USGS NLCD92e, http://water.usgs.gov/lookup/getspatial?nlcd92

Table 1a. Variable descriptions for sampling locations and watershed ancillary information for [table 1b](#).—Continued

[Abbreviations: CERC, Columbia Environmental Research Center; HLR, Hydrologic Landscape Region; NAD83, North American Datum of 1983; NAWQA, National Water Quality Assessment; NED, National Elevation Dataset; NHDPlus, National Hydrography Dataset Plus; NID, National Inventory of Dams; NLCD, National Land Cover Data; NOAA, National Oceanic and Atmospheric Administration; NPDES, National Pollutant Discharge Elimination System; NWIS, National Water Information System; STATSGO, State Soil Geographic database; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; cm, centimeter; kg, kilogram; kg/km², kilogram per square kilometer; km, kilometer; km², square kilometer; m, meter; mm/yr, millimeter per year; ft, foot; ft-tonf-in-(ac-h-yr)⁻¹, units of modeling factor (RFACT) as hundreds of acre-feet of tonnes (long) of force in inches of rainfall per hour per acre per year; N/A, not applicable; <, less than; >, greater than]

Variable category	Variable name	Variable description	Extent	Units (numeric values)	Processing method	Additional note on processing or dataset	Nominal resolution/scale of source data	Reference	Source data and web site
Regions	HLR_SITE_100M	Hydrologic Landscape Region at the sampling site. (http://ks.water.usgs.gov/pubs/abstracts/of.03-145.htm).	Site	HLR region (1-20)	Vector point	HLRs are aggregates of watersheds that have been grouped according to their similarities in land-surface form, geologic texture, and climate characteristics. Hydrologic landscapes (Winter, 2001) in the same region are expected to be more similar to each other compared to hydrologic landscapes in different regions. Based on Wolock 20 classes, 100-m resolution version. No Data values = -9999. These were areas of "water" in the original STATSGO coverage used by Wolock in processing, which translated to No Data in the resultant grid.	5-km grid	Wolock, 2003c	USGS, http://water.usgs.gov/GIS/metadata/usgswrd/XML/ieof48.xml
Census_ Block	HUDEN_2000_BLOCK	Housing-unit density in the basin, persons per km ² , from 2000 Census block data regridded to 100-m.	Watershed	housing units/km ²	Grid	Block data is the most detailed Census scale, 2000. Original SILVIS data in polygon form (all U.S. Census blocks), subsequently gridded at 100 m.	N/A	USEPA, 2008	NHDPlus, http://www.horizon-systems.com/nhdplus/
Infrastructure	IMPERV_1KM_NOAA	Percent impervious surfaces, from 1km resolution NOAA landscape data.	Watershed	percent	Grid	1990s	30-m grid	Nakagaki and others, 2007	USGS NLCD92e, http://water.usgs.gov/lookup/getspatial?nlcd92
Soils	KFACT_UP	Average K-factor value for uppermost soil horizon. ³	Watershed	unitless	Grid	Each STATSGO mapping unit contains multiple soil components, and each component can have multiple soil layers. The average value for each mapping unit is a weighted average based on soil layer thickness and component area.	800-m grid	PRISM, 2008	PRISM, http://www.prism.oregonstate.edu/

Table 1a. Variable descriptions for sampling locations and watershed ancillary information for [table 1b.](#)—Continued

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Variable category	Variable name	Variable description	Extent	Units (numeric values)	Processing method	Additional note on processing or dataset	Nominal resolution/scale of source data	Reference	Source data and web site
Landscape_Pat	LC_SHANNON_DIVERS	Shannon Diversity Index for Anderson Level I land cover in basin. High numbers = more diversity of major land cover types (Water, Barren, Urban, Forest, Range, Agriculture, Wetlands).	Watershed	Unitless	Grid	1992	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php
LC01_Mains800	MAI01_AG	Percent "agriculture" land cover/use in the mainstem buffer area (within 800 m of stream), 2001 era. Sum of MAI01_81 and 82.	Mainstem 800-m	Percent	Grid	These are sums of Level II classes; 2000-2002.	1:250,000	Termite density zones from Beal and others (1994), GIRAS land cover (1970s) from Price and others (2007).	Various, see citation
LC01_Mains800	MAI01_NOTDEVEL	Percent "undeveloped" land cover/use in the mainstem buffer area (within 800 m of stream), 2001 era. Sum of MAI01_11, 12, 31, 41, 42, 43, 52, 71, 90, and 95.	Mainstem 800-m	Percent	Grid	These are sums of Level II classes; 2000-2002.	1:250,000	Termite density zones from Beal and others (1994), GIRAS land cover (1970s) from Price and others (2007).	Various, see citation
LC01_Mains800	MAI01_URBAN	Percent "urban" land cover/use in the mainstem buffer area (within 800 m of stream), 2001 era. Sum of MAI01_21, 22, 23, and 24.	Mainstem 800-m	Percent	Grid	These are sums of Level II classes; 2000-2002.	The base data layer is built on the STATSGO mapping units, the average size of which is about 750 km ² .	Wolock, 1997 and U.S. Department of Agriculture, 2008.	USGS NAWQA. Data are based on STATSGO, but as aggregated by Wolock, 1997, http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
Hydro	MAINSTEM_LEN_KM	Length of mainstem, km.	Mainstem	percent	Vector line	Mainstem delineations also described in Falcone and others, 2010.	1-km grid	Wolock and McCabe, 1999	USGS

Table 1a. Variable descriptions for sampling locations and watershed ancillary information for [table 1b.](#)—Continued

[Abbreviations: CERC, Columbia Environmental Research Center; HLR, Hydrologic Landscape Region; NAD83, North American Datum of 1983; NAWQA, National Water Quality Assessment; NED, National Elevation Dataset; NHDPlus, National Hydrography Dataset Plus; NID, National Inventory of Dams; NLCD, National Land Cover Data; NOAA, National Oceanic and Atmospheric Administration; NPDES, National Pollutant Discharge Elimination System; NWIS, National Water Information System; STATSGO, State Soil Geographic database; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; cm, centimeter; kg, kilogram; kg/km², kilogram per square kilometer; km, kilometer; km², square kilometer per year; ft, foot; ft-tonf-in-(ac-h-yr)⁻¹, units of modeling factor (RFACT) as hundreds of acre-feet of tonnes (long) of force in inches of rainfall per hour per acre per year; N/A, not applicable; <, less than; >, greater than]

Variable category	Variable name	Variable description	Extent	Units (numeric values)	Processing method	Additional note on processing or dataset	Nominal resolution/scale of source data	Reference	Source data and web site
LC92_ Mainstem	MAISUM_AG	Mainstem buffer percent "agriculture". Percent of total mainstem buffer segment as sum of classes 61, 62, 81, 82, 83 and 84, in area ~ 800 m (1/2 mile) each side of stream centerline.	Mainstem 800-m	percent	Grid	1992	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php
	MAISUM_MINING_TRANS	Mainstem buffer percent "mining/transitional". Percent of total mainstem buffer segment as sum of classes 32 and 33, in area ~ 800 m (1/2 mile) each side of stream centerline.	Mainstem 800-m	percent	Grid	1992	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php
	MAISUM_NOTDEVEL	Mainstem buffer percent "undeveloped". Percent of total mainstem buffer segment as sum of classes 11, 12, 31, 41, 42, 43, 51, 71, 72, 91, and 92, in area ~ 800 m (1/2 mile) each side of stream centerline.	Mainstem 800-m	percent	Grid	1992	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php
LC92_ Mainstem	MAISUM_URBAN	Mainstem buffer percent "urban". Percent of total mainstem buffer segment as sum of classes 21, 22, 23, 25, 26, and 85, in area ~ 800 m (0.5 mile) each side of stream centerline.	Mainstem 800-m	percent	Grid	1992	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php
Infrastructure	MINOPS_DENS	Density of Mineral Operations points; number per 100 km ² .	Watershed	Number of point locations per 100 km ²	Vector point	2003	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php
Infrastructure	MINOPS_NPOINTS	Number of mineral operations in the basin. From USGS 2003 database of 7,090 Mineral Operations point locations. ²	Watershed	Number of point locations	Vector point	2003	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php

Table 1a. Variable descriptions for sampling locations and watershed ancillary information for [table 1b.](#)—Continued

[**Abbreviations:** CERC, Columbia Environmental Research Center; HLR, Hydrologic Landscape Region; NAD83, North American Datum of 1983; NAWQA, National Water Quality Assessment; NED, National Elevation Dataset; NHDPlus, National Hydrography Dataset Plus; NID, National Inventory of Dams; NLCD, National Land Cover Data; NOAA, National Oceanic and Atmospheric Administration; NPDES, National Pollutant Discharge Elimination System; NWIS, National Water Information System; STATSGO, State Soil Geographic database; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; cm, centimeter; kg, kilogram; kg/km², kilogram per square kilometer; km, kilometer; km², square kilometer; m, meter; mm/yr, millimeter per year; ft, foot; ft-tonf-in-(ac-h-yr)⁻¹, units of modeling factor (RFACT) as hundreds of acre-feet of tonnes (long) of force in inches of rainfall per hour per acre per year; N/A, not applicable; <, less than; >, greater than]

Variable category	Variable name	Variable description	Extent	Units (numeric values)	Processing method	Additional note on processing or dataset	Nominal resolution/scale of source data	Reference	Source data and web site
HydroMod_ Dams	NDAMS_MAINSTEM_BUF	Number of dams in mainstem buffer (800 m on each side of stream centerline; same buffer as used for mainstem land cover).	Mainstem 800-m	number of dams	Vector point	All dam data from National Inventory of Dams (NID); downloaded summer 2006; data currency vary.	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php
LC01_Basin	NLCD01_11	Watershed percent Open Water.	Watershed	Percent	Grid	See http://www.mrlc.gov/nlcd_definitions.php for all NLCD01 land cover class definitions, 2000-2002.	1:100,000	USEPA, 2006	USEPA NPDES, http://cfpub.epa.gov/npdes/
LC01_Basin	NLCD01_12	Watershed percent Perennial Ice/Snow.	Watershed	Percent	Grid	See http://www.mrlc.gov/nlcd_definitions.php for all NLCD01 land cover class definitions, 2000-2002.	1:100,000	USEPA, 2008	NHDPlus, http://www.horizon-systems.com/nhdplus/
LC01_Basin	NLCD01_21	Watershed percent Developed, Open Space.	Watershed	Percent	Grid	See http://www.mrlc.gov/nlcd_definitions.php for all NLCD01 land cover class definitions, 2000-2002.	1:100,000	USEPA, 2008	NHDPlus, http://www.horizon-systems.com/nhdplus/
LC01_Basin	NLCD01_22	Watershed percent Developed, Low Intensity.	Watershed	Percent	Grid	See http://www.mrlc.gov/nlcd_definitions.php for all NLCD01 land cover class definitions, 2000-2002.	1:100,000	U.S. Army Corps of Engineers, 2006	National Inventory of Dams, http://crunch.ice.army.mil/nidpublic/webpages/nid.cfm
LC01_Basin	NLCD01_23	Watershed percent Developed, Medium Intensity.	Watershed	Percent	Grid	See http://www.mrlc.gov/nlcd_definitions.php for all NLCD01 land cover class definitions, 2000-2002.	1:100,000	U.S. Army Corps of Engineers, 2006	National Inventory of Dams, http://crunch.ice.army.mil/nidpublic/webpages/nid.cfm
LC01_Basin	NLCD01_24	Watershed percent Developed, High Intensity.	Watershed	Percent	Grid	See http://www.mrlc.gov/nlcd_definitions.php for all NLCD01 land cover class definitions, 2000-2002.	1:100,000	USEPA, 2008	NHDPlus, http://www.horizon-systems.com/nhdplus/
LC01_Basin	NLCD01_31	Watershed percent Natural Barren.	Watershed	Percent	Grid	See http://www.mrlc.gov/nlcd_definitions.php for all NLCD01 land cover class definitions, 2000-2002.	1:100,000	Falcone and others, 2007; and USEPA, 2008	NHDPlus, http://www.horizon-systems.com/nhdplus/
LC01_Basin	NLCD01_41	Watershed percent Deciduous Forest.	Watershed	Percent	Grid	See http://www.mrlc.gov/nlcd_definitions.php for all NLCD01 land cover class definitions, 2000-2002.	1:100,000	Falcone and others, 2007; and USEPA, 2008	NHDPlus, http://www.horizon-systems.com/nhdplus/

Table 1a. Variable descriptions for sampling locations and watershed ancillary information for [table 1b](#).—Continued

[Abbreviations: CERC, Columbia Environmental Research Center; HLR, Hydrologic Landscape Region; NAD83, North American Datum of 1983; NAWQA, National Water Quality Assessment; NED, National Elevation Dataset; NHDPlus, National Hydrography Dataset Plus; NID, National Inventory of Dams; NLCD, National Land Cover Data; NOAA, National Oceanic and Atmospheric Administration; NPDES, National Pollutant Discharge Elimination System; NWIS, National Water Information System; STATSGO, State Soil Geographic database; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; cm, centimeter; kg, kilogram; kg/km², kilogram per square kilometer; km, kilometer; km², square kilometer; m, meter; mm/yr, millimeter per year; ft, foot; ft-tonf-in-(ac-h-yr)⁻¹, units of modeling factor (RFACT) as hundreds of acre-feet of tonnes (long) of force in inches of rainfall per hour per acre per year; N/A, not applicable; <, less than; >, greater than]

Variable category	Variable name	Variable description	Extent	Units (numeric values)	Processing method	Additional note on processing or dataset	Nominal resolution/scale of source data	Reference	Source data and web site
LC01_Basin	NLCD01_42	Watershed percent Evergreen Forest.	Watershed	Percent	Grid	See http://www.mnrlc.gov/nlcd_definitions.php for all NLCD01 land cover class definitions, 2000-2002.	1:100,000	Falcone and others, NHDPlus, 2007; and USEPA, 2008	http://www.horizon-systems.com/nhdplus/
LC01_Basin	NLCD01_43	Watershed percent Mixed Forest.	Watershed	Percent	Grid	See http://www.mnrlc.gov/nlcd_definitions.php for all NLCD01 land cover class definitions, 2000-2002.	1:100,000	Falcone and others, NHDPlus, 2007; and USEPA, 2008	http://www.horizon-systems.com/nhdplus/
LC01_Basin	NLCD01_52	Watershed percent Shrubland.	Watershed	Percent	Grid	See http://www.mnrlc.gov/nlcd_definitions.php for all NLCD01 land cover class definitions, 2000-2002.	1:100,000	Falcone and others, NHDPlus, 2007; and USEPA, 2008	http://www.horizon-systems.com/nhdplus/
LC01_Basin	NLCD01_71	Watershed percent Herbaceous (grassland).	Watershed	Percent	Grid	See http://www.mnrlc.gov/nlcd_definitions.php for all NLCD01 land cover class definitions, 2000-2002.	1-km grid	Nakagaki and Wolock, 2005	USGS NAWQA, http://water.usgs.gov/GIS/metadata/usgswrd/XML/agp97grd.xml
LC01_Basin	NLCD01_81	Watershed percent Pasture/Hay.	Watershed	Percent	Grid	See http://www.mnrlc.gov/nlcd_definitions.php for all NLCD01 land cover class definitions, 2000-2002.	1:100,000	U.S. Geological Survey, 2010	USGS Mineral Resources, http://tin.er.usgs.gov/metadata/mineplant.faq.html
LC01_Basin	NLCD01_82	Watershed percent Cultivated Crops.	Watershed	Percent	Grid	See http://www.mnrlc.gov/nlcd_definitions.php for all NLCD01 land cover class definitions, 2000-2002.	1:100,000	U.S. Geological Survey, 2010	USGS Mineral Resources, http://tin.er.usgs.gov/metadata/mineplant.faq.html
LC01_Basin	NLCD01_90	Watershed percent Woody Wetlands.	Watershed	Percent	Grid	See http://www.mnrlc.gov/nlcd_definitions.php for all NLCD01 land cover class definitions, 2000-2002.	30-m grid	Riitters and others, 2000; Nakagaki and others, 2007	USGS NLCD92e, http://water.usgs.gov/lookup/getspatial?nlcd92
LC01_Basin	NLCD01_95	Watershed percent Emergent Herbaceous Wetlands.	Watershed	Percent	Grid	See http://www.mnrlc.gov/nlcd_definitions.php for all NLCD01 land cover class definitions, 2000-2002.	30-m grid	Riitters and others, 2000; Nakagaki and others, 2007	USGS NLCD92e, http://water.usgs.gov/lookup/getspatial?nlcd92

Table 1a. Variable descriptions for sampling locations and watershed ancillary information for [table 1b.](#)—Continued

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Variable category	Variable name	Variable description	Extent	Units (numeric values)	Processing method	Additional note on processing or dataset	Nominal resolution/scale of source data	Reference	Source data and web site
LC01_Basin	NLCD01_AG	Percent "agriculture" land cover/use in the basin, 2001 era. Sum of NLCD01 as sum of classes 81 and 82.	Watershed	Percent	Grid	These are sums of Level II classes; 2000-2002.	The base data layer is built on the STATSGO mapping units, the average size of which is about 750 km ²	Wolock, 1997	USGS NAWQA, http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
LC01_Basin	NLCD01_MHURB	Percent medium to high intensity "urban" land cover/use in the basin, 2001 era. Sum of NLCD01 as sum of classes 23 and 24.	Watershed	Percent	Grid	These are sums of Level II classes; 2000-2002.	4-km grid	PRISM, 2008	PRISM, http://www.prism.oregonstate.edu/pub/prism/maps/Precipitation/rfactor/U.S./for_data_and_metadata
LC01_Basin	NLCD01_NOTDEVEL	Percent "undeveloped" land cover/use in the basin, 2001 era. Sum of NLCD01 as sum of classes 11, 12, 31, 41, 42, 43, 52, 71, 90, and 95.	Watershed	Percent	Grid	These are sums of Level II classes; 2000-2002.	The base data layer is built on the STATSGO mapping units, the average size of which is about 750 km ²	Wolock, 1997	USGS NAWQA, http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
LC01_Basin	NLCD01_URBAN	Percent "urban" land cover/use in the basin, 2001 era. Sum of NLCD01 as sum of classes 21, 22, 23, and 24.	Watershed	Percent	Grid	These are sums of Level II classes; 2000-2002.	The base data layer is built on the STATSGO mapping units, the average size of which is about 750 km ²	Wolock, 1997	USGS NAWQA, http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
HydroMod_Other	NPDES_ALL_DENS	Density of NPDES point locations in basin; as number per 100 km ² .	Watershed	number of sites/100 km ²	Vector point	NPDES point locations, downloaded summer 2006.	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php

Table 1a. Variable descriptions for sampling locations and watershed ancillary information for [table 1b](#).—Continued

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Variable category	Variable name	Variable description	Extent	Units (numeric values)	Processing method	Additional note on processing or dataset	Nominal resolution/scale of source data	Reference	Source data and web site
HydroMod_ Other	NPDES_MAJ_DENS	Density of NPDES "major" point locations in basin; number per 100 km ²	Watershed	Number of sites/100 km ²	Vector point	About 2/3 of major NPDES locations are coded Sewerage Systems. Major locations are defined by an EPA-assigned major flag. From download of NPDES national database, summer 2006, by Rick Jodoin.	N/A	N/A	USGS
Regions	NUTR_ECO_SITE	Nutrient ecoregion at the sampling site.	Site	Nutrient ecoregion (1-14)	Vector point	N/A	30-m grid	Nakagaki and others, 2007	USGS NLCD92e, http://water.usgs.gov/lookup/getspatial?nlcd92e
Soils	OMAVE	Average value of organic matter content (percent by weight).	Watershed	percent	Grid	Each STATSGO mapping unit contains multiple soil components, and each component can have multiple soil layers. The average value for each mapping unit is a weighted average based on soil layer thickness and component area.	100-m grid	Winter, 2001; Wolock, 2003d	USGS NAWQA, see http://water.usgs.gov/GIS/metadata/usgswrd/XML/hlrs.xml ; however note that these data are derived from an unpublished 100-m version of the HLRs
HydroMod_ Other	PCT_OW_SQRT_ORDER	Percent Open Water land cover in the mainstem buffer, divided by the square root of the Strahler stream order.	Mainstem	percent	Grid	More open water = greater likelihood of dam/other flow modification, particularly for smaller streams. Potentially catches dams missing from NID data.	1-km grid	Krug and others, 1989	USGS
Census_ Block	PDEN_1990_BLOCK	Population density in the basin, persons per km ² , from 1990 Census block data regridded to 100 m.	Watershed	Persons/km ²	Grid	Block data is the most detailed Census scale, 1990. Original SILVIS data in polygon form (all U.S. Census blocks), subsequently gridded at 100-m.	N/A	U.S. Geological Survey, 2008b	USGS NWIS, http://waterdata.usgs.gov/nwis/
Census_ Block	PDEN_2000_BLOCK	Population density in the basin, persons per km ² , from 2000 Census block data regridded to 100 m.	Watershed	Persons/km ²	Grid	Block data is the most detailed Census scale, 2000. Original SILVIS data in polygon form (all U.S. Census blocks), subsequently gridded at 100-m.	N/A	U.S. Geological Survey, 2008b	USGS NWIS, http://waterdata.usgs.gov/nwis/

Table 1a. Variable descriptions for sampling locations and watershed ancillary information for [table 1b.](#)—Continued

[**Abbreviations:** CERC, Columbia Environmental Research Center; HLR, Hydrologic Landscape Region; NAD83, North American Datum of 1983; NAWQA, National Water Quality Assessment; NED, National Elevation Dataset; NHDPlus, National Hydrography Dataset Plus; NID, National Inventory of Dams; NLCD, National Land Cover Data; NOAA, National Oceanic and Atmospheric Administration; NPDES, National Pollutant Discharge Elimination System; NWIS, National Water Information System; STATSGO, State Soil Geographic database; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; cm, centimeter; kg, kilogram; kg/km², kilogram per square kilometer; km, kilometer; km², square kilometer; m, meter; mm/yr, millimeter per year; ft, foot; ft-tonf-in-(ac-h-yr)⁻¹, units of modeling factor (R/FACT) as hundreds of acre-feet of tonnes (long) of force in inches of rainfall per hour per acre per year; N/A, not applicable; <, less than; >, greater than]

Variable category	Variable name	Variable description	Extent	Units (numeric values)	Processing method	Additional note on processing or dataset	Nominal resolution/scale of source data	Reference	Source data and web site
Hydro	PERDUN	Percent Dume overland flow from TOPMODEL (percent of total streamflow).	Watershed	Percentage of total streamflow	Grid	The data are estimated from a watershed simulation model called TOPMODEL (Wolock, 1993). The model was run throughout the conterminous U.S. and estimated percentage of Dunne overland flow in total streamflow was quantified (Wolock, 2003b); data are long-term averages.	The base data layer is built on the STATSGO mapping units, the average size of which is about 750 km ² .	Wolock, 1997	USGS NAWQA, http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
Hydro	PERHOR	Percent Horton overland flow from TOPMODEL (percent of total streamflow).	Watershed	Percentage of total streamflow	Grid	The data are estimated from a watershed simulation model called TOPMODEL (Wolock, 1993). The model was run throughout the conterminous U.S. and estimated percentage of Horton overland flow in total streamflow was quantified (Wolock, 2003c); data are long-term averages.	The base data layer is built on the STATSGO mapping units, the average size of which is about 750 km ² .	Wolock, 1997	USGS NAWQA, http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
Soils	PERMAVE	Average permeability (inches/hour).	Watershed	inches/hour	Grid	Each STATSGO mapping unit contains multiple soil components, and each component can have multiple soil layers. The average value for each mapping unit is a weighted average based on soil layer thickness and component area.	1:7,500,000	Reed and Bush, 2007	USGS, http://pubs.usgs.gov/circ/1300/pdf/Cir1300_508.pdf
Pest_App	PESTAPP_KG	Estimate of pesticide application (42 most major chemicals), kg applied/km ² , from Census of Agriculture, based on county-wide sales and percent agricultural land cover in basin.	Watershed	kg/km ²	Grid	Note: based on county-level data. Grids from Naomi Nakagaki: 219 1-km grids summed, 1997.	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php
Soils	POORLY.DR	Percent of poorly drained soils in basin. See citation for more details.	Watershed	Percent	Grid	Based on soils variables in Falcone and others, 2010.	N/A	U.S. Geological Survey, 2008b	USGS NWIS, http://waterdata.usgs.gov/nwis/

Table 1a. Variable descriptions for sampling locations and watershed ancillary information for [table 1b](#).—Continued

[Abbreviations: CERC, Columbia Environmental Research Center; HLR, Hydrologic Landscape Region; NAD83, North American Datum of 1983; NAWQA, National Water Quality Assessment; NED, National Elevation Dataset; NHDPlus, National Hydrography Dataset Plus; NID, National Inventory of Dams; NLCD, National Land Cover Data; NOAA, National Oceanic and Atmospheric Administration; NPDES, National Pollutant Discharge Elimination System; NWIS, National Water Information System; STATSGO, State Soil Geographic database; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; cm, centimeter; kg, kilogram; kg/km², kilogram per square kilometer; km, kilometer; km², square kilometer; m, meter; mm/yr, millimeter per year; ft, foot; ft-tonf-in-(ac-h-yr)⁻¹, units of modeling factor (RFACT) as hundreds of acre-feet of tonnes (long) of force in inches of rainfall per hour per acre per year; N/A, not applicable; <, less than; >, greater than]

Variable category	Variable name	Variable description	Extent	Units (numeric values)	Processing method	Additional note on processing or dataset	Nominal resolution/scale of source data	Reference	Source data and web site
Climate	PPTAVG_BASIN	Mean annual precipitation (cm) for the watershed, from 800-m Parameter-elevation Regressions on Independent Slopes Model (PRISM) data.	Watershed	cm	Grid	1971-2000	30-m grid	Nakagaki and others, 2007	USGS NLCD92e, http://water.usgs.gov/lookup/getspatial?nldc92
Climate	PPTAVG_SITE	Mean annual precipitation (cm) at the sampling site, from 800-m PRISM data.	Site	cm	Grid	Gridspot command, data from 1971-2000.	1-km grid	Wolock, 2003a	USGS, http://water.usgs.gov/lookup/getspatial?bf48grid
Infrastructure	RD_STR_INTERS	Number of road/stream intersections, per km of total basin stream length (Census 2000 TIGER roads and NHD 1:100,000 streams).	Watershed	number per stream km	Vector line	2000	30-m grid	Nakagaki and others, 2007	USGS NLCD92e, http://water.usgs.gov/lookup/getspatial?nldc92
Soils	RFACT	Rainfall and Runoff factor ("R factor" of Universal Soil Loss Equation); average annual value for period 1971-2000.	Watershed	100s ft-tonf-in-(ac-h-yr) ⁻¹	Grid	R factor data source from PRISM, 1971-2000.	1:100,000	USEPA, 2006	USEPA NPDES, http://cfpub.epa.gov/npdes/
LC01_Rip100	RIP01_AG	Percent "agriculture" land cover/use in the riparian buffer area (within 100 m of stream) 2001 era.	Riparian 100-m	Percent	Grid	These are sums of Level II classes; 2000-2002.	The base data layer is built on the STATSGO mapping units, the average size of which is about 750 km ² .	Wolock, 1997 and U.S. Department of Agriculture, 2008.	USGS NAWQA. Data are based on STATSGO, but as aggregated by Wolock, 1997, http://water.usgs.gov/GIS/metadata/usgswrld/XML/muid.xml
LC01_Rip100	RIP01_NOTDEVEL	Percent "undeveloped" land cover/use in the riparian buffer area (within 100 m of stream), 2001 era. Sum of RIP01_11, 12, 31, 41, 42, 43, 52, 71, 90, and 95.	Riparian 100-m	Percent	Grid	These are sums of Level II classes; 2000-2002.	1-km grid	Wolock and others, 1989; Wolock, 1997	USGS

Table 1a. Variable descriptions for sampling locations and watershed ancillary information for [table 1b.](#)—Continued

[Abbreviations: CERC, Columbia Environmental Research Center; HLR, Hydrologic Landscape Region; NAD83, North American Datum of 1983; NAWQA, National Water Quality Assessment; NED, National Elevation Dataset; NHDPlus, National Hydrography Dataset Plus; NID, National Inventory of Dams; NLCD, National Land Cover Data; NOAA, National Oceanic and Atmospheric Administration; NPDES, National Pollutant Discharge Elimination System; NWIS, National Water Information System; STATSGO, State Soil Geographic database; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; cm, centimeter; kg, kilogram; kg/km², kilogram per square kilometer; km, kilometer; km², square kilometer; m, meter; mm/yr, millimeter per year; ft, foot; ft-tonf-in-(ac-h-yr)⁻¹, units of modeling factor (RFACT) as hundreds of acre-feet of tonnes (long) of force in inches of rainfall per hour per acre per year; N/A, not applicable; <, less than; >, greater than]

Variable category	Variable name	Variable description	Extent	Units (numeric values)	Processing method	Additional note on processing or dataset	Nominal resolution/scale of source data	Reference	Source data and web site
LC01_Rip 100	RIP01_URBAN	Percent "urban" land cover/use in the riparian buffer area (within 100 m of stream) from 2001 era NLCD data. Sum of RIP01_21, 22, 23, and 24.	Riparian 100-m	Percent	Grid	These are sums of Level II classes; 2000-2002.	1-km grid	Wolock and McCabe, 1995	USGS, http://ks.water.usgs.gov/Kansas/pubs/reports/wtr-99-4242.html
LC92_Riparian	RIPSUM_AG	Riparian buffer percent "agriculture". Percent of total riparian area as sum of classes 61, 62, 81, 82, 83 and 84. Riparian zone used here is ~ 100 m each side of stream centerline.	Riparian 100-m	percent	Grid	1992	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php
LC92_Riparian	RIPSUM_MINING_TRANS	Riparian buffer percent "mining/transitional". Percent of total riparian area as sum of classes 32 and 33. Riparian zone used here is ~ 100 m each side of stream centerline.	Riparian 100-m	percent	Grid	1992	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php
LC92_Riparian	RIPSUM_NOTDEVEL	Riparian buffer percent "undeveloped". Percent of total riparian area as sum of classes 11, 12, 31, 41, 42, 43, 51, 71, 72, 91, and 92, in area ~ 100 m each side of stream centerline.	Riparian 100-m	percent	Grid	1992	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php
LC92_Riparian	RIPSUM_URBAN	Riparian buffer percent "urban". Percent of total riparian area as sum of classes 21, 22, 23, 25, 26, and 85. Riparian zone used here is ~ 100 m each side of stream centerline.	Riparian 100-m	percent	Grid	1992	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php
Infrastructure	ROADS_KM_SQ_KM	Road density, km of roads per basin area, km ² , from Census 2000 TIGER roads.	Watershed	km/km ²	Vector line	2000	30-m grid	Nakagaki and others, 2007	USGS NLCD92e, http://water.usgs.gov/lookup/getspatial?nlcd92

Table 1a. Variable descriptions for sampling locations and watershed ancillary information for [table 1b.](#)—Continued

[**Abbreviations:** CERC, Columbia Environmental Research Center; HLR, Hydrologic Landscape Region; NAD83, North American Datum of 1983; NAWQA, National Water Quality Assessment; NED, National Elevation Dataset; NHDPlus, National Hydrography Dataset Plus; NID, National Inventory of Dams; NLCD, National Land Cover Data; NOAA, National Oceanic and Atmospheric Administration; NPDES, National Pollutant Discharge Elimination System; NWIS, National Water Information System; STATSGO, State Soil Geographic database; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; cm, centimeter; kg, kilogram; kg/km², kilogram per square kilometer; km, kilometer; km², square kilometer; m, meter; mm/yr, millimeter per year; ft, foot; ft-tonf-in-(ac-h-yr)⁻¹, units of modeling factor (RFACT) as hundreds of acre-feet of tonnes (long) of force in inches of rainfall per hour per acre per year; N/A, not applicable; <, less than; >, greater than]

Variable category	Variable name	Variable description	Extent	Units (numeric values)	Processing method	Additional note on processing or dataset	Nominal resolution/scale of source data	Reference	Source data and web site
Hydro	RUN9100_WB	Average annual runoff for a basin, mm/yr, estimated from Wolock and McCabe (1999) for the period 1991-2000.	Watershed	mm/yr	Grid	Estimated basin annual runoff, mm/yr, mean for the period 1991-2000, from Wolock and McCabe (1999) water balance model. Models effect of precipitation and temperature, but not other factors (land use, water use, regulation, etc.)	2-km grid	PRISM, 2008	PRISM, http://www.prism.oregonstate.edu/
Hydro	RUNAVE7100	Average annual runoff for a basin, mm/y, mean for the period 1971-2000. Models integrated effects of climate, land use, water use, regulation, etc.	Watershed	mm/year	Grid	The base data layer was estimated from historical USGS streamflow data and hydrologic cataloging units in the conterminous U.S., following the approach of Krug and others (1989), data from 1971-2000.	30-m grid	Nakagaki and others, 2007	USGS NLCD92e, http://water.usgs.gov/lookup/getspatial?nlcd92
Soils	SANDAVE	Average value of sand content (percentage).	Watershed	percent	Grid	Each STATSGO mapping unit contains multiple soil components, and each component can have multiple soil layers. The average value for each mapping unit is a weighted average based on soil layer thickness and component area.	800-m grid	PRISM, 2008	PRISM, http://www.prism.oregonstate.edu/
Hydro	SEG_GRADIENT_M_KM	Segment Gradient, m per km (meters of elevation drop change per stream kilometer between segment endpoints).	Segment	meters change per stream km	Vector line	Description of segment-scale calculations given in Falcone and others, 2007.	100-m grid (resampled from 30-m)	U.S. Geological Survey, 2008c	USGS, http://ned.usgs.gov/
Hydro	SEG_INTERS_PER_SEG_KM	Number of intersections of roads/per kilometer of stream segment, (number/km).	Segment	number of intersections per km of segment	Vector line	Description of segment-scale calculations given in Falcone and others, 2007.	100-m grid (resampled from 30-m)	U.S. Geological Survey, 2008c	USGS, http://ned.usgs.gov/
Hydro	SEG_MEAN_DIST_NEAREST_RD	Average distance from the stream to nearest road (meters) within the segment.	Segment	meters	Vector line	Description of segment-scale calculations given in Falcone and others, 2007.	1:7,500,000	Reed and Bush, 2007	USGS, http://pubs.usgs.gov/circ/1300/pdf/Cir1300_508.pdf

Table 1a. Variable descriptions for sampling locations and watershed ancillary information for [table 1b.](#)—Continued

[**Abbreviations:** CERC, Columbia Environmental Research Center; HLR, Hydrologic Landscape Region; NAD83, North American Datum of 1983; NAWQA, National Water Quality Assessment; NED, National Elevation Dataset; NHDPlus, National Hydrography Dataset Plus; NID, National Inventory of Dams; NLCD, National Land Cover Data; NOAA, National Oceanic and Atmospheric Administration; NPDES, National Pollutant Discharge Elimination System; NWIS, National Water Information System; STATSGO, State Soil Geographic database; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; cm, centimeter; kg, kilogram; kg/km², kilogram per square kilometer; km, kilometer; km², square kilometer; m, meter; mm/yr, millimeter per year; ft, foot; ft-tonf-in-(ac-h-yr)⁻¹, units of modeling factor (RFACT) as hundreds of acre-feet of tonnes (long) of force in inches of rainfall per hour per acre per year; N/A, not applicable; <, less than; >, greater than]

Variable category	Variable name	Variable description	Extent	Units (numeric values)	Processing method	Additional note on processing or dataset	Nominal resolution/scale of source data	Reference	Source data and web site
Hydro	SEG_RD_STR_INTERS	Segment Total number of road/stream intersections between segment endpoints.	Segment	number of intersections	Vector line	Description of segment-scale calculations given in Falcone and others, 2007.	100-m grid (resampled from 30-m)	U.S. Geological Survey, 2008c	USGS, http://ned.usgs.gov/
Hydro	SEG_SINUOSITY	Segment sinuosity, unitless (curvilinear length/straight length between segment endpoints).	Segment	unitless	Vector line	Description of segment-scale calculations given in Falcone and others, 2007.	1:24,000 - 1:100,000	U.S. Geological Survey, 2008b; U.S. Geological Survey, 2008a	USGS NWIS and NAWQA, http://waterdata.usgs.gov/nwis/ and http://water.usgs.gov/nawqa/
Soils	SILTAVE	Average value of silt content (percentage).	Watershed	percent	Grid	Each STATSGO mapping unit contains multiple soil components, and each component can have multiple soil layers. The average value for each mapping unit is a weighted average based on soil layer thickness and component area.	1:7,500,000	Omernik, 1987	USEPA Ecoregions, http://www.epa.gov/web/pages/ecoregions.htm
Topo	SLOPE_PCT	Mean basin slope, percent. Derived from 100-m-resolution National Elevation Dataset.	Watershed	Percent	Grid	Original source of elevation data were 30-m tiles of USGS NED data assembled by Roland Viger and Curtis Price of the USGS in the early 2000 period. Because of size and processing constraints, those tiles were merged and resampled (bilinear) to 100 m to make a national grid. Parameters are: projection Albers Equal Area, Datum NAD83, Spheroid GRS1980, 29:30, 45:30, -96:00, 23:00, 0, 0.	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php
Hydro	STRAHLER_MAX	Maximum Strahler stream order in basin, from NHDPlus. (-99 used for streams in basin that are canals, ditches, pipelines, etc.).	Watershed	Unitless	Vector line	-99 usually means all streams in basin are canals/ditches/pipelines.	N/A	N/A	USGS

Table 1a. Variable descriptions for sampling locations and watershed ancillary information for [table 1b](#).—Continued

[Abbreviations: CERC, Columbia Environmental Research Center; HLR, Hydrologic Landscape Region; NAD83, North American Datum of 1983; NAWQA, National Water Quality Assessment; NED, National Elevation Dataset; NHDPlus, National Hydrography Dataset Plus; NID, National Inventory of Dams; NLCD, National Land Cover Data; NOAA, National Oceanic and Atmospheric Administration; NPDES, National Pollutant Discharge Elimination System; NWIS, National Water Information System; STATSGO, State Soil Geographic database; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; cm, centimeter; kg, kilogram; kg/km², kilogram per square kilometer; km, kilometer; km², square kilometer; m, meter; mm/yr, millimeter per year; ft, foot; ft-tonf-in-(ac-h-yr)⁻¹, units of modeling factor (RFACT) as hundreds of acre-feet of tonnes (long) of force in inches of rainfall per hour per acre per year; N/A, not applicable; <, less than; >, greater than]

Variable category	Variable name	Variable description	Extent	Units (numeric values)	Processing method	Additional note on processing or dataset	Nominal resolution/scale of source data	Reference	Source data and web site
Hydro	STREAMS_KM_SQ_KM	Stream density, km of streams per basin area (km ²), from NHD 1:100,000 streams.	Watershed	km/km ²	Vector line	N/A	30-m grid	Nakagaki and others, 2007	USGS NLCD92e, http://water.usgs.gov/lookup/getspatial?nldc92
Infrastructure	TermUrb01.High	High Termitic-Urban Score, 2001.	Watershed	Percent	Grid	Summed percentage of urban land (medium and high intensity urban from 2001 NLCD) in the top 2 termitic density zones; various dates, see citations.	30-m grid	Nakagaki and others, 2007	USGS NLCD92e, http://water.usgs.gov/lookup/getspatial?nldc92
Infrastructure	TermUrb70.High	High Termitic-Urban Score, 1970s.	Watershed	Percent	Grid	Summed percentage of urban land (1970s) in the top 2 termitic density zones; various dates, see citations.	30-m grid	Nakagaki and others, 2007	USGS NLCD92e, http://water.usgs.gov/lookup/getspatial?nldc92
Infrastructure	TermUrb01.Wtd	Weighted Termitic-Urban Score, 2001.	Watershed	Unitless	Grid	Percentage of urban land (medium and high intensity urban from 2001 NLCD) in the top 3 termitic density zones, weighted as follows: 2*(TZ1) + TZ2 + 0.5*TZ3, where TZ# is the percent of urban land in Termitic Zone #; various dates, see citations.	1:100,000	USEPA, 2008	NHDPlus, http://www.horizon-systems.com/nhdplus/
Infrastructure	TermUrb70.Wtd	Weighted Termitic-Urban Score, 1970s.	Watershed	Unitless	Grid	Percentage of urban land (1970s) in the top 3 termitic density zones, weighted as follows: 2*(TZ1) + TZ2 + 0.5*TZ3, where TZ# is the percent of urban land in Termitic Zone #; various dates, see citations.	1:100,000	USEPA, 2008	NHDPlus, http://www.horizon-systems.com/nhdplus/
Hydro	TOPWET	Topographic wetness index, ln(a/S); where "ln" is the natural log, "a" is the upslope area per unit contour length, and "S" is the slope at that point.	Watershed	ln(m)	Grid	TWI is computed as ln(a/S), where "ln" is the natural log, "a" is the upslope area per unit contour length and "S" is the slope at that point. A single flow direction algorithm was used to compute this version of the TWI (Wolock and McCabe, 1995); TWI values were derived from 1-km USGS digital elevation data.	1:250,000	Termitic density zones from Beal and others (1994), GIRAS land cover (1970s) from Price and others (2007).	Various, see citation

Table 1a. Variable descriptions for sampling locations and watershed ancillary information for [table 1b.](#)—Continued

[Abbreviations: CERC, Columbia Environmental Research Center; HLR, Hydrologic Landscape Region; NAD83, North American Datum of 1983; NAWQA, National Water Quality Assessment; NED, National Elevation Dataset; NHDPlus, National Hydrography Dataset Plus; NID, National Inventory of Dams; NLCD, National Land Cover Data; NOAA, National Oceanic and Atmospheric Administration; NPDES, National Pollutant Discharge Elimination System; NWIS, National Water Information System; STATSGO, State Soil Geographic database; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; cm, centimeter; kg, kilogram; kg/km², kilogram per square kilometer; km, kilometer; km², square kilometer per year; ft, foot; ft-tonf-in-(ac-h-yr)⁻¹, units of modeling factor (RFACT) as hundreds of acre-feet of tonnes (long) of force in inches of rainfall per hour per acre per year; N/A, not applicable; <, less than; >, greater than]

Variable category	Variable name	Variable description	Extent	Units (numeric values)	Processing method	Additional note on processing or dataset	Nominal resolution/scale of source data	Reference	Source data and web site
Landscape_Pat	UN_DIS_MAX_RATIO	Ratio of maximum stream length that is > 70 m from a disturbance pixel ("undisturbed" stream lengths) to maximum stream length that is <70 m from a disturbance pixel ("disturbed" stream lengths); that is, high numbers = "good".	Watershed	Unitless	Grid	1992	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php
Landscape_Pat	UN_DIS_SUM_RATIO	Ratio of sum of stream lengths that are > 70 m from a disturbance pixel ("undisturbed" stream lengths) to sum of stream lengths that are < 70 m from a disturbance pixel ("disturbed" stream lengths); that is, high numbers = "good".	Watershed	Unitless	Grid	1992	30-m grid	U.S. Geological Survey, 2005	USGS NLCD01, http://www.mrlc.gov/nlcd01_leg.php
BasinID	WATER_REGION	National Hydrology Database (NHD) Plus Water Region (Hydrologic Unit Code, HUC, Level 2 classes; 01 = New England, 02 = Mid-Atlantic, etc.) (http://nhd.usgs.gov/data.html).	N/A	N/A	N/A	N/A	N/A	NHDPlus	N/A
BasinID	WATER_REGION	National Hydrology Database (NHD) Plus Water Region (Hydrologic Unit Code, HUC, Level 2 classes; 01 = New England, 02 = Mid-Atlantic, etc.) (http://nhd.usgs.gov/data.html).	N/A	N/A	N/A	N/A	30-m grid	Nakagaki and others, 2007	USGS NLCD92e, http://water.usgs.gov/lookup/getspatial?nlcd92
Climate	WD_BASIN	Average of annual number of days (days) of measurable precipitation in the watershed, derived from 30 years of record (1961-1990), gridded at 2 km.	Watershed	days	Grid	1961-1990	30-m grid	Nakagaki and others, 2007	USGS NLCD92e, http://water.usgs.gov/lookup/getspatial?nlcd92

Table 1a. Variable descriptions for sampling locations and watershed ancillary information for [table 1b](#).—Continued

[**Abbreviations:** CERC, Columbia Environmental Research Center; HLR, Hydrologic Landscape Region; NAD83, North American Datum of 1983; NAWQA, National Water Quality Assessment; NED, National Elevation Dataset; NHDPlus, National Hydrography Dataset Plus; NID, National Inventory of Dams; NLCD, National Land Cover Data; NOAA, National Oceanic and Atmospheric Administration; NPDES, National Pollutant Discharge Elimination System; NWIS, National Water Information System; STATSGO, State Soil Geographic database; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; cm, centimeter; kg, kilogram; kg/km², kilogram per square kilometer; km, kilometer; km², square kilometer; m, meter; mm/yr, millimeter per year; ft, foot; ft-tonf-in-(ac-h-yr)⁻¹, units of modeling factor (RFACT) as hundreds of acre-feet of tonnes (long) of force in inches of rainfall per hour per acre per year; N/A, not applicable; <, less than; >, greater than]

Variable category	Variable name	Variable description	Extent	Units (numeric values)	Processing method	Additional note on processing or dataset	Nominal resolution/scale of source data	Reference	Source data and web site
Climate	WD_SITE	Average of annual number of days (days) of measurable precipitation at the sampling site, derived from 30 years of record (1961-1990), gridded at 2-km.	Site	days	Grid	Gridspot command, data from 1961-1990.	5-km grid	Wolock, 2003b	USGS, http://water.usgs.gov/lookup/getspatial?satof48
Soils	WELL.DR	Percent of well-drained soils in basin. See citation for more details.	Watershed	Percent	Grid	Based on soils variables in Falcone and others, 2010.	N/A	U.S. Geological Survey, 2008b	USGS NWIS, http://waterdata.usgs.gov/nwis/

¹ (ACFB, Appalachian-Chattahoochee-Flint Basin; GRSL, Great Salt Lake Basins; NECB, New England Coastal Basins; PUGT, Puget Sound Basins; SPLT, South Platte River Basin; TRIN, Trinty River Basin; WMIC, Western Lake Michigan Drainages.)

² These include metal and salt mines, phosphate plants, sand and gravel operations, cement plants, etc. Energy mineral operations (for example, coal mines) are not included.

³ Each K-factor is an erodibility factor to quantify the susceptibility of soil particles to detachment and movement by water. The K-factor is used in the Universal Soil Loss Equation (USLE) to estimate soil loss by water. Higher values of K-factor indicate greater potential for erosion.

Table 1b. Sampling location and watershed ancillary information.

Data are available for download at <http://pubs.usgs.gov/sir/2011/5092/>

Table 2. Timing and locations of bed sediment sampling and toxicity testing.

[Species: HA, indicates the amphipod (*Hyallela azteca*) test; CD, indicates the midge (*Chironomus dilutus*) test]

Batch no.	Date sampled	Date toxicity testing started	Species	Metropolitan areas							Total samples tested
				Atlanta	Boston	Dallas	Denver	Milwaukee	Salt Lake City	Seattle	
1	May 2007	05-25-07	HA	0	0	0	0	0	0	21	21
1	May 2007	05-25-07	CD	0	0	0	0	0	0	21	21
2	May and June 2007	06-08-07	HA	13	0	0	0	0	0	0	13
2	May and June 2007	06-08-07	CD	13	0	0	0	0	0	0	13
3	May and June 2007	06-15-07	HA	0	0	13	0	0	0	0	13
3	May and June 2007	06-15-07	CD	0	0	13	0	0	0	0	13
4	August and September 2007	09-25-07	HA	0	14	0	13	12	12	0	51
4a	August and September 2007	09-25-07	CD	0	13	0	7	8	12	0	40
4b	August and September 2007	09-25-07	CD	0	1	0	6	4	0	0	11
Total samples tested				13	14	13	13	12	12	21	98

Table 3a. Variable names used to describe measurements of water-quality parameters and physical characteristics at time of sample in [table 3b](#).

[Abbreviation: USGS, U.S. Geological Survey]

Variable name	Variable description
MRA	Metropolitan areas of each regional study (ATL, Atlanta; BOS, Boston; DAL, Dallas; DEN, Denver; MGB, Milwaukee Green Bay; SEA, Seattle; SLC, Salt Lake City)
SMRA	Site code based on metropolitan regional area and a sequential number.
SNAME	USGS station name
STAD	USGS station identification number
DATETIME	Date and time of all in situ measurements and water and sediment samples for this study and in this report.
Temp	Temperature, water, degrees Celsius
BP	Barometric pressure, millimeters of mercury
Q_r	Discharge, instantaneous, cubic feet per second_remark
Q	Discharge, instantaneous, cubic feet per second
GH	Gage height, feet
SC	Specific conductance, water, unfiltered, microsiemens per centimeter at 25 degrees Celsius
DO	Dissolved oxygen, water, unfiltered, milligrams per liter
DO_pct	Dissolved oxygen, water, unfiltered, percent of saturation
pH	pH, water, unfiltered, field, standard units

Table 3b. Measurements of water-quality parameters and physical characteristics at time of sample.

Data are available for download at <http://pubs.usgs.gov/sir/2011/5092/>

Table 4a. Variable names used for the measurements of physical properties of bed sediments in [table 4b](#).

[Abbreviations: mm, millimeters; USGS, U.S. Geological Survey]

Variable name	Variable description
MRA	Metropolitan areas of each regional study (ATL, Atlanta; BOS, Boston; DAL, Dallas; DEN, Denver; MGB, Milwaukee-Green Bay; SEA, Seattle; SLC, Salt Lake City)
SMRA	Site code based on metropolitan regional area and a sequential number
SNAME	USGS station name
STAIID	USGS station identification number
CERC ID	USGS Columbia Environmental Research Center (CERC) Identification Number
Water_pct	Percentage of sediment sample that was water
Sand_pct	Percentage of sediment sample that was in the size class of sand (between 2.0 and 0.05 mm).
Silt_pct	Percentage of sediment sample that was in the size class of silt (between 0.05 and 0.002 mm).
Clay_pct	Percentage of sediment sample that was in the size class of clay (less than 0.002 mm).
Sed_type	Classification of sediment type

Table 4b. Measurements of physical properties of bed sediment sampled.

Data are available for download at <http://pubs.usgs.gov/sir/2011/5092/>

Table 5a. Constituent names for bed sediment major element and trace element schedule in [table 5b](#).

[Chemical variable name from SRS, Substance Registry Service, U.S. Environmental Protection Agency. **Abbreviations:** CAS, Chemical Abstract Service; USGS, U.S. Geological Survey; µg/g, microgram per gram]

Variable name	Variable description	CAS No.	USGS parameter code	Reporting level (µg/g)
MRA	Metropolitan areas of each regional study (ATL, Atlanta; BOS, Boston; DAL, Dallas; DEN, Denver; MGB, Milwaukee-Green Bay; SEA, Seattle; SLC, Salt Lake City).			
SMRA	Site code based on metropolitan regional area and a sequential number.			
SNAME	USGS station name.			
STAD	USGS station identification number.			
Thallium	Thallium, bed sediment smaller than 62.5 micrometers, dry sieved, total digestion, dry weight, micrograms per gram.	7440-28-0	04064	0.08
Antimony	Antimony, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-36-0	34795	0.04
Arsenic	Arsenic, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-38-2	34800	1.0
Barium	Barium, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-39-3	34805	0.2
Beryllium	Beryllium, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-41-7	34810	0.03
Bismuth	Bismuth, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-69-9	34816	0.06
Cadmium	Cadmium, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-43-9	34825	0.007
Cerium	Cerium, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-45-1	34835	0.1
Chromium	Chromium, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-47-3	34840	0.5
Cobalt	Cobalt, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-48-4	34845	0.03
Copper	Copper, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-50-8	34850	2.0
Gallium	Gallium, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-55-3	34860	0.02
Lanthanum	Lanthanum, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7439-91-0	34885	0.05
Lead	Lead, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7439-92-1	34890	0.4
Lithium	Lithium, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7439-93-2	34895	0.3
Manganese	Manganese, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7439-96-5	34905	0.7
Mercury	Mercury, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7439-97-6	34910	0.01
Molybdenum	Molybdenum, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7439-98-7	34915	0.05
Nickel	Nickel, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram..	7440-02-0	34925	0.3
Niobium	Niobium, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-03-1	34930	0.1
Scandium	Scandium, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-20-2	34945	0.04
Selenium	Selenium, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7782-49-2	34950	0.1

Table 5a. Constituent names for bed sediment trace element schedule in [table 5b](#).—Continued

[Chemical variable name from SRS, Substance Registry Service, U.S. Environmental Protection Agency. **Abbreviations:** CAS, Chemical Abstract Service; USGS, U.S. Geological Survey; µg/g, microgram per gram]

Variable name	Variable description	CAS No.	USGS parameter code	Reporting level (µg/g)
Silver	Silver, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-22-4	34955	1
Strontium	Strontium, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-24-6	34965	0.8
Sulfur	Sulfur, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, percent.	7704-34-9	34970	0.05
Thorium-232	Thorium, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-29-1	34980	0.1
Uranium-238	Uranium, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-61-1	35000	0.02
Vanadium	Vanadium, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-62-2	35005	0.2
Yttrium	Yttrium, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-65-5	35010	0.05
Zinc	Zinc, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-66-6	35020	3.0
Organic carbon	Organic carbon, bed sediment smaller than 62.5 micrometers, wet sieved (native water), field, recoverable, dry weight, percent.		49266	0.01
Carbon	Carbon (inorganic plus organic), bed sediment smaller than 62.5 micrometers, wet sieved (native water), field, recoverable, dry weight, percent.	7440-44-0	49267	0.01
Inorganic carbon	Inorganic carbon, bed sediment smaller than 62.5 micrometers, wet sieved (native water), field, recoverable, dry weight, percent.		49269	0.01
Aluminum	Aluminum, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7429-90-5	65170	50
Calcium	Calcium, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-70-2	65171	100
Cesium	Cesium, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-46-2	65172	0.003
Iron	Iron, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7439-89-6	65173	50
Magnesium	Magnesium, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7439-95-4	65174	6
Phosphorus	Phosphorus, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7723-14-0	65175	5
Potassium	Potassium, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-09-7	65176	20
Rubidium	Rubidium, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-17-7	65177	0.01
Sodium	Sodium, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-23-5	65178	20
Titanium	Titanium, bed sediment smaller than 62.5 micrometers, wet sieved, field, total digestion, dry weight, micrograms per gram.	7440-32-6	65179	40

Table 5b. Elemental chemistry of major and trace elements in sediment samples.

Data are available for download at <http://pubs.usgs.gov/sir/2011/5092/>

Table 6a. Variable names for bed sediment polycyclic aromatic hydrocarbon chemistry schedule in [table 6b](#).

[Chemical variable name from SRS, Substance Registry Service, U.S. Environmental Protection Agency. **Abbreviations:** CAS, Chemical Abstract Service; PAH, polycyclic aromatic hydrocarbon; USGS, U.S. Geological Survey; µg/kg, microgram per kilogram]

Variable name	Variable description	CAS No.	USGS parameter code	Reporting level (µg/kg)
MRA	Metropolitan areas of each regional study (ATL, Atlanta; BOS, Boston; DAL, Dallas; DEN, Denver; MGB, Milwaukee-Green Bay; SEA, Seattle; SLC, Salt Lake City).			
SMRA	Site code based on metropolitan regional area and a sequential number.			
SNAME	USGS station name.			
STAID	USGS station identification number.			
OC_pct_2mm	Sediment organic carbon content (percent) in 2 mm fraction.			
1,2-Dimethylnaphthalene	1,2-Dimethylnaphthalene, bed sediment, recoverable, dry weight, micrograms per kilogram.	573-98-8	62538	10
1,6-Dimethylnaphthalene	1,6-Dimethylnaphthalene, bed sediment, recoverable, dry weight, micrograms per kilogram.	575-43-9	62539	10
1-Methylfluorene	1-Methyl-9H-fluorene, bed sediment, recoverable, dry weight, micrograms per kilogram.	1730-37-6	62540	10
1-Methylphenanthrene	1-Methylphenanthrene, bed sediment, recoverable, dry weight, micrograms per kilogram.	832-69-9	62541	10
1-Methylpyrene	1-Methylpyrene, bed sediment, recoverable, dry weight, micrograms per kilogram.	2381-21-7	62542	10
2,3,6-Trimethylnaphthalene	2,3,6-Trimethylnaphthalene, bed sediment, recoverable, dry weight, micrograms per kilogram.	829-26-5	62543	10
2,6-Dimethylnaphthalene	2,6-Dimethylnaphthalene, bed sediment, recoverable, dry weight, micrograms per kilogram.	581-42-0	62544	10
2-Ethyl-naphthalene	2-Ethyl-naphthalene, bed sediment, recoverable, dry weight, micrograms per kilogram.	939-27-5	62545	10
2-Methylanthracene	2-Methylanthracene, bed sediment, recoverable, dry weight, micrograms per kilogram.	613-12-7	62546	10
4H-Cyclopenta[def]phenanthrene	4H-Cyclopenta[def]phenanthrene, bed sediment, recoverable, dry weight, micrograms per kilogram.	203-64-5	62547	10
Fluorene	9H-Fluorene, bed sediment, recoverable, dry weight, micrograms per kilogram.	86-73-7	62548	10
Acenaphthene	Acenaphthene, bed sediment, recoverable, dry weight, micrograms per kilogram.	83-32-9	62549	10
Acenaphthylene	Acenaphthylene, bed sediment, recoverable, dry weight, micrograms per kilogram.	208-96-8	62550	10
Anthracene	Anthracene, bed sediment, recoverable, dry weight, micrograms per kilogram.	120-12-7	62551	10
Benz[a]anthracene	Benzo[a]anthracene, bed sediment, recoverable, dry weight, micrograms per kilogram.	56-55-3	62552	10
Benzo[a]pyrene	Benzo[a]pyrene, bed sediment, recoverable, dry weight, micrograms per kilogram.	50-32-8	62553	10
Benzo[b]fluoranthene	Benzo[b]fluoranthene, bed sediment, recoverable, dry weight, micrograms per kilogram.	205-99-2	62554	10
Benzo[e]pyrene	Benzo[e]pyrene, bed sediment, recoverable, dry weight, micrograms per kilogram.	192-97-2	62555	10

Table 6a. Variable names for bed sediment polycyclic aromatic hydrocarbon chemistry schedule in [table 6b](#).—Continued

[Chemical variable name from SRS, Substance Registry Service, U.S. Environmental Protection Agency. **Abbreviations:** CAS, Chemical Abstract Service; PAH, polycyclic aromatic hydrocarbon; USGS, U.S. Geological Survey; µg/kg, microgram per kilogram]

Variable name	Variable description	CAS No.	USGS parameter code	Reporting level (µg/kg)
Benzo[ghi]perylene	Benzo[g,h,i]perylene, bed sediment, recoverable, dry weight, micrograms per kilogram.	191-24-2	62556	10
Benzo[k]fluoranthene	Benzo[k]fluoranthene, bed sediment, recoverable, dry weight, micrograms per kilogram.	207-08-9	62557	10
Chrysene	Chrysene, bed sediment, recoverable, dry weight, micrograms per kilogram.	218-01-9	62558	10
Dibenz[a,h]anthracene	Dibenzo[a,h]anthracene, bed sediment, recoverable, dry weight, micrograms per kilogram.	53-70-3	62560	10
Fluoranthene	Fluoranthene, bed sediment, recoverable, dry weight, micrograms per kilogram.	206-44-0	62561	10
Indeno[1,2,3-cd]pyrene	Indeno[1,2,3-cd]pyrene, bed sediment, recoverable, dry weight, micrograms per kilogram.	193-39-5	62562	10
Naphthalene	Naphthalene, bed sediment, recoverable, dry weight, micrograms per kilogram.	91-20-3	62563	10
Perylene	Perylene, bed sediment, recoverable, dry weight, micrograms per kilogram.	198-55-0	62565	10
Phenanthrene	Phenanthrene, bed sediment, recoverable, dry weight, micrograms per kilogram.	85-01-8	62566	10
Pyrene	Pyrene, bed sediment, recoverable, dry weight, micrograms per kilogram.	129-00-0	62568	10
Sample weight	Sample weight, PAH method, bed sediment, grams.		62597	

Table 6b. PAH chemistry of bed sediment samples.

Data are available for download at <http://pubs.usgs.gov/sir/2011/5092/>

Table 7a. Variable names for bed sediment organochlorine chemistry schedule in [table 7b](#).

[Chemical variable name from SRS, Substance Registry Service, U.S. Environmental Protection Agency. **Abbreviations:** CAS, Chemical Abstract Service; USGS, U.S. Geological Survey; µg/kg, microgram per kilogram]

Variable name	Variable description	CAS No.	USGS parameter code	Reporting level (µg/kg)
MRA	Metropolitan areas of each regional study (ATL, Atlanta; BOS, Boston; DAL, Dallas; DEN, Denver; MGB, Milwaukee-Green Bay; SEA, Seattle; SLC, Salt Lake City).			
SMRA	Site code based on metropolitan regional area and a sequential number.			
SNAME	USGS station name.			
STAIID	USGS station identification number.			
OC_pct_2mm	Sediment organic carbon content (percent) in 2-mm fraction.			
<i>beta</i> -HCH	<i>beta</i> -HCH (Hexachlorocyclohexane), bed sediment, recoverable, dry weight, micrograms per kilogram.	319-85-7	34257	0.5
<i>alpha</i> -HCH	<i>alpha</i> -HCH (Hexachlorocyclohexane), bed sediment, recoverable, dry weight, micrograms per kilogram.	319-84-6	39076	1.5
Aldrin	Aldrin, bed sediment, recoverable, dry weight, micrograms per kilogram.	309-00-2	39333	2.0
Lindane	Lindane, bed sediment, recoverable, dry weight, micrograms per kilogram.	58-89-9	39343	0.5
<i>p,p'</i> -DDD	<i>p,p'</i> -DDD, bed sediment, recoverable, dry weight, micrograms per kilogram.	72-54-8	39363	2.5
<i>p,p'</i> -DDE	<i>p,p'</i> -DDE, bed sediment, recoverable, dry weight, micrograms per kilogram.	72-55-9	39368	1.5
<i>p,p'</i> -DDT	<i>p,p'</i> -DDT, bed sediment, recoverable, dry weight, micrograms per kilogram.	50-29-3	39373	1.0
Dieldrin	Dieldrin, bed sediment, recoverable, dry weight, micrograms per kilogram.	60-57-1	39383	0.5
<i>alpha</i> -Endosulfan	<i>alpha</i> -Endosulfan, bed sediment, recoverable, dry weight, micrograms per kilogram.	959-98-8	39389	0.5
Endrin	Endrin, bed sediment, recoverable, dry weight, micrograms per kilogram.	72-20-8	39393	1.0
Toxaphene	Toxaphene, bed sediment, recoverable, dry weight, micrograms per kilogram.	8001-35-2	39403	200
Heptachlor epoxide	Heptachlor epoxide, bed sediment, recoverable, dry weight, micrograms per kilogram.	1024-57-3	39423	1.5
<i>p,p'</i> -Methoxychlor	<i>p,p'</i> -Methoxychlor, bed sediment, recoverable, dry weight, micrograms per kilogram.	72-43-5	39481	3.5
Aroclor 1254	Aroclor 1254, bed sediment, recoverable, dry weight, micrograms per kilogram.	11097-69-1	39507	5.0
Aroclor 1260	Aroclor 1260, bed sediment, recoverable, dry weight, micrograms per kilogram.	11096-82-5	39511	5.0
Hexachlorobenzene	Hexachlorobenzene, bed sediment, recoverable, dry weight, micrograms per kilogram.	118-74-1	39701	3.0
Mirex	Mirex, bed sediment, recoverable, dry weight, micrograms per kilogram.	2385-85-5	39758	1.5
Aroclors 1016 + 1242	Aroclor 1016 plus Aroclor 1242, bed sediment, recoverable, dry weight, micrograms per kilogram.		46343	5.0
<i>cis</i> -Chlordane	<i>cis</i> -Chlordane, bed sediment, recoverable, dry weight, micrograms per kilogram.	5103-71-9	62802	1.0
<i>trans</i> -Chlordane	<i>trans</i> -Chlordane, bed sediment, recoverable, dry weight, micrograms per kilogram.	5103-74-2	62803	0.5
<i>trans</i> -Nonachlor	<i>trans</i> -Nonachlor, bed sediment, recoverable, dry weight, micrograms per kilogram.	39765-80-5	62804	1.0
Sample wt_ Sch OCBS	Sample weight, Schedule OCBS, grams.		99962	

Table 7b. Organochlorine chemistry of bed sediments.

Data are available for download at <http://pubs.usgs.gov/sir/2011/5092/>

Table 8a. Variable names for pyrethroid and fipronil sediment organic chemistry in [table 8b](#).

[Abbreviations: CAS, Chemical Abstract Service; USGS, U.S. Geological Survey; µg/kg, microgram per kilogram]

Variable name	Variable description	CAS No.	USGS parameter code	Method detection level (µg/kg)
MRA	Metropolitan areas of each regional study (ATL, Atlanta; BOS, Boston; DAL, Dallas; DEN, Denver; MGB, Milwaukee-Green Bay; SEA, Seattle; SLC, Salt Lake City).			
SMRA	Site code based on metropolitan regional area and a sequential number.			
SNAME	USGS station name.			
STAD	USGS station identification number.			
OC_pct	Sediment organic carbon content, in percent.			
ON_pct	Sediment organic nitrogen content, in percent.			
Allethrin	Allethrin, bed sediment, recoverable, dry weight, micrograms per kilogram.	584-79-2	66588	0.20
Bifenthrin	Bifenthrin, bed sediment, recoverable, dry weight, micrograms per kilogram.	82657-04-3	64151	0.20
Cyfluthrin	Cyfluthrin, bed sediment, recoverable, dry weight, micrograms per kilogram.	68359-37-5	65109	0.50
Cyhalothrin	Cyhalothrin, bed sediment, recoverable, dry weight, micrograms per kilogram.	91465-08-6	64162	0.20
Cypermethrin	Cypermethrin, bed sediment, recoverable, dry weight, micrograms per kilogram.	52315-07-8	64156	0.40
Deltamethrin	Deltamethrin, bed sediment, recoverable, dry weight, micrograms per kilogram.	52918-63-5	65110	0.20
Esfenvalerate	Esfenvalerate, bed sediment, recoverable, dry weight, micrograms per kilogram.	66230-04-4	64159	0.20
Fenprothrin	Fenprothrin, bed sediment, recoverable, dry weight, micrograms per kilogram.	39515-41-8	65111	0.20
Fluvalinate	Fluvalinate, bed sediment, recoverable, dry weight, micrograms per kilogram.	102851-06-9	65114	0.20
Permethrin	Permethrin, bed sediment, recoverable, dry weight, micrograms per kilogram.	52645-53-1	64168	0.20
Resmethrin	Resmethrin, bed sediment, recoverable, dry weight, micrograms per kilogram.	10453-86-8	65113	0.50
Sumithrin (Phenothrin)	Sumithrin (Phenothrin), bed sediment, recoverable, dry weight, micrograms per kilogram.	26002-80-2	65112	0.30
Tefluthrin	Tefluthrin, bed sediment, recoverable, dry weight, micrograms per kilogram.	79538-32-2	67733	0.20
Tetramethrin	Tetramethrin, bed sediment, recoverable, dry weight, micrograms per kilogram.	7696-12-0	66659	0.20
Fipronil	Fipronil, bed sediment, recoverable, dry weight, micrograms per kilogram.	120068-37-3		1.90
Fipronil desulfinyl	Fipronil desulfinyl, bed sediment, recoverable, dry weight, micrograms per kilogram.	205650-65-3		2.80
Fipronil sulfide	Fipronil sulfide, bed sediment, recoverable, dry weight, micrograms per kilogram.	120067-83-6		2.20
Fipronil sulfone	Fipronil sulfone, bed sediment, recoverable, dry weight, micrograms per kilogram.	120068-36-2		1.10

Table 8b. Pyrethroid and fipronil organic sediment chemistry.Data are available for download at <http://pubs.usgs.gov/sir/2011/5092/>

Table 9a. Summary of test conditions for conducting whole-sediment toxicity tests with the amphipod *Hyalella azteca* and with the midge *Chironomus dilutus*.

[From U.S. Environmental Protection Agency (2000) and ASTM International, (2010). **Abbreviations:** $\mu\text{S}/\text{cm}$, microsiemens per centimeter; CaCO_3 , calcium carbonate; USGS, U.S. Geological Survey; mg/L , milligram per liter; $\mu\text{g}/\text{kg}$, microgram per kilogram; g, gram; mm, millimeter]

Variable name	Variable description	Test invertebrate	Water source
MRA	Metropolitan areas of each regional study (ATL, Atlanta; BOS, Boston; DAL, Dallas; DEN, Denver; MGB, Milwaukee-Green Bay; SEA, Seattle; SLC, Salt Lake City).		
SMRA	Site code based on metropolitan regional area and a sequential number.		
SNAME	USGS station name.		
STAD	USGS station identification number.		
CERC ID	USGS Columbia Environmental Research Center (CERC) identification number.		
HA_DO	Dissolved oxygen (mg/L)	<i>Hyalella azteca</i> (HA)	Overlying water
HA_SC	Specific conductance ($\mu\text{S}/\text{cm}$)	<i>Hyalella azteca</i> (HA)	Overlying water
HA_hardness	Hardness (mg/L as CaCO_3)	<i>Hyalella azteca</i> (HA)	Overlying water
HA_ALK	Alkalinity (mg/L as CaCO_3)	<i>Hyalella azteca</i> (HA)	Overlying water
HA_pH	pH	<i>Hyalella azteca</i> (HA)	Overlying water
HA_TNH3	Total ammonia (mg/L)	<i>Hyalella azteca</i> (HA)	Overlying water
HA_UINH3	Un-ionized ammonia (mg/L)	<i>Hyalella azteca</i> (HA)	Overlying water
CD_DO	Dissolved oxygen (mg/L)	<i>Chironomus dilutus</i> (CD)	Overlying water
CD_SC	Specific conductance ($\mu\text{S}/\text{cm}$)	<i>Chironomus dilutus</i> (CD)	Overlying water
CD_hardness	Hardness (mg/L as CaCO_3)	<i>Chironomus dilutus</i> (CD)	Overlying water
CD_ALK	Alkalinity (mg/L as CaCO_3)	<i>Chironomus dilutus</i> (CD)	Overlying water
CD_pH	pH	<i>Chironomus dilutus</i> (CD)	Overlying water
CD_TNH3	Total ammonia (mg/L)	<i>Chironomus dilutus</i> (CD)	Overlying water
CD_UINH3	Unionized ammonia (mg/L)	<i>Chironomus dilutus</i> (CD)	Overlying water
HA_CD_PWDO	Dissolved oxygen (mg/L)	HA or CD	Pore water
HA_CD_PWT	Average incubation temperature	HA or CD	Pore water
HA_CD_PWSC	Specific conductance ($\mu\text{S}/\text{cm}$)	HA or CD	Pore water
HA_CD_PWpH	pH	HA or CD	Pore water
HA_CD_PWAlk	Alkalinity (mg/L as CaCO_3)	HA or CD	Pore water
HA_CD_PW_hardness	Hardness (mg/L as CaCO_3)	HA or CD	Pore water
HA_CD_PW_TNH3	Total ammonia (mg/L)	HA or CD	Pore water
HA_CD_PW_UINH3	Un-ionized ammonia (mg/L)	HA or CD	Pore water

Table 9b. Variable descriptions of water chemistry during sediment toxicity tests at Columbia Environmental Research Center (CERC), reported in [table 9c](#).

Data are available for download at <http://pubs.usgs.gov/sir/2011/5092/>

Table 9c. Water chemistry during sediment toxicity tests at Columbia Environmental Research Center (CERC).

Data are available for download at <http://pubs.usgs.gov/sir/2011/5092/>

Table 10a. Variable descriptions for the response of the amphipod *Hyalella azteca* in 28-day whole-sediment exposures and the midge *Chironomus dilutus* in 10-day whole-sediment exposures to bed material and to a control sediment in [table 10b](#).

[**Abbreviations:** (*), denotes samples significantly reduced relative to the control response ($p < 0.05$); SEM, standard error of the mean; USGS, U.S. Geological Survey; mm, millimeter; mg, milligram]

Variable name	Variable description
MRA	Metropolitan areas of each regional study (ATL, Atlanta; BOS, Boston; DAL, Dallas; DEN, Denver; MGB, Milwaukee-Green Bay; SEA, Seattle; SLC, Salt Lake City)
SMRA	Site code based on metropolitan regional area and a sequential number
SNAME	USGS station name
STAIID	USGS station identification number
CERC ID	USGS Columbia Environmental Research Center (CERC) identification number
Set	Sample set batch number
HA_survive_pct	<i>Hyalella azteca</i> (HA) survival (percent)
HA_SEM	HA survival (percent), SEM
HA_surv_pct_ctrl	HA survival (percent of control)
HA_r	HA survival significantly reduced compared to control (*)
HA_length	HA Length (mm/individual)
HA_length_SEM	HA Length (mm/individual), SEM
HA_length_r	HA length (percent of control)
HA_length_pct_ctrl	HA length (remark)
HA_weight	HA weight (mg/individual)
HA_weight_SEM	HA weight (mg/individual), SEM
HA_weight_pct_ctrl	HA weight (percent of control)
HA_weight_r	HA weight (*)
HA_biomass	HA total biomass (mg)
HA_biomass_SEM	HA total biomass (mg), SEM
HA_biomass_pct_ctrl	HA total biomass (percent of control)
HA_biomass_r	HA total biomass (*)
CD_survive_pct	<i>Chironomus dilutus</i> (CD) survival (percent)
CD_SEM	CD survival (percent), SEM
CD_surv_pct_ctrl	CD survival (percent of control)
CD_r	CD survival (*)
CD_weight	CD weight (mg/individual)
CD_weight_SEM	CD weight (mg/individual), SEM
CD_weight_pct_ctrl	CD weight (percent of control)
CD_weight_r	CD weight (*)
CD_biomass	CD total biomass (mg)
CD_biomass_SEM	CD total biomass (mg), SEM
CD_biomass_pct_ctrl	CD total biomass (percent of control)
CD_biomass_r	CD biomass (*)

Table 10b. Response of the amphipod *Hyalella azteca* (HA) in 28-day whole-sediment exposures and the midge *Chironomus dilutus* (CD) in 10-day whole-sediment exposures to stream sediments and to a control sediment.

Data are available for download at <http://pubs.usgs.gov/sir/2011/5092/>

Table 10c. Variable descriptions for the response of the amphipod *Hyalella azteca* in 28-day whole-sediment exposures and the midge *Chironomus dilutus* in 10-day whole-sediment exposures to stream sediments and to a reference envelope sediment in [table 10d](#).

Data are available for download at <http://pubs.usgs.gov/sir/2011/5092/>

Table 10d. Reference normalized (rn) responses of the amphipod *Hyalella azteca* in 28-day whole-sediment exposures and the midge *Chironomus dilutus* in 10-day whole-sediment exposures to 2007 NAWQA samples collected from across the United States.

Data are available for download at <http://pubs.usgs.gov/sir/2011/5092/>

Table 10e. Samples shown to be “toxic” by different endpoints compared to control sediments, within and across the study areas.

Data are available for download at <http://pubs.usgs.gov/sir/2011/5092/>

Table 10f. Samples shown to be “toxic” by different endpoints compared to reference sediments, within and across the study areas.

Data are available for download at <http://pubs.usgs.gov/sir/2011/5092/>

Table 11a. Mean Probable Effect Concentration Quotient (PECQ) variable descriptions for PECQ values in [table 11b](#).

[Units of PEC value used: All PECQ values are unitless ratios. **Abbreviations:** NA, not applicable; DL, detection level; ND, nondetection; PAH, polycyclic aromatic hydrocarbon; PCB, polychlorinated biphenyl; PEC, Probable Effect Concentration; PECQ, Probable Effect Concentration Quotient; TE, trace element; TOC, total organic carbon in sediment; USGS, U.S. Geological Survey; µg/kg, microgram per kilogram; µg/g, microgram per gram]

Variable name	Variable description	PEC values used for individual constituents	Units of PEC value used
MRA	Metropolitan areas of each regional study (ATL, Atlanta; BOS, Boston; DAL, Dallas; DEN, Denver; MGB, Milwaukee-Green Bay; SEA, Seattle; SLC, Salt Lake City).	NA	NA
SMRA	Site code based on metropolitan regional area and a sequential number.	NA	NA
SNAME	USGS station name.	NA	NA
STAIID	USGS station identification number.	NA	NA
Overall meanPECQ3_ notnorm	Mean PECQ for 3 classes: Take the mean of the mean PECQ for TEs; PECQ for total PCB; and PECQ for total PAH. Not normalized; assume ND=1/2*DL.	NA	NA
Overall meanPECQ4_ notnorm	Mean PECQ for 4 classes: Take the mean of the mean PECQ for TEs; mean PECQ for 3 organochlorine pesticides; PECQ for total PCB; and PECQ for total PAH. Not normalized; assume ND=1/2*DL.	NA	NA
Overall meanPECQ5B_ notnorm	Mean PECQ for 5 classes, with pyrethroids represented by bifenthrin PECQ: Take the mean of the mean PECQ for TEs; mean PECQ for 3 organochlorine pesticides; PECQ for total PCB; PECQ for total PAH; and PECQ for bifenthrin. Not normalized; assume ND=0 for bifenthrin and ND=1/2*DL for all other contaminants.	NA	NA
Overall meanPECQ5P_ notnorm	Mean PECQ for 5 classes, with pyrethroids represented by sum of pyrethroid PECQs: Take the mean of the mean PECQ for TEs; mean PECQ for 3 organochlorine pesticides; PECQ for total PCB; PECQ for total PAH; and sum of PECQs for 4 pyrethroids. Not normalized; assume ND=0 for pyrethroids and ND=1/2*DL for all other contaminants.	NA	NA
Overall meanPECQ5M_ notnorm	Mean PECQ for 5 classes, with pyrethroids represented by the mean PECQ for pyrethroids: Take the mean of the mean PECQ for TEs; mean PECQ for 3 organochlorine pesticides; PECQ for total PCB; PECQ for total PAH; and mean PECQ for 4 pyrethroids. Not normalized; assume ND=0 for pyrethroids and ND=1/2*DL for all other contaminants.	NA	NA
As_PECQ_nn	PECQ for arsenic, not normalized (assume ND=1/2*DL).	33.0	µg/g at 1 percent TOC
Cd_PECQ_nn	PECQ for cadmium, not normalized (assume ND=1/2*DL).	4.98	µg/g at 1 percent TOC
Cr_PECQ_nn	PECQ for chromium, not normalized (assume ND=1/2*DL).	111	µg/g at 1 percent TOC
Cu_PECQ_nn	PECQ for copper, not normalized (assume ND=1/2*DL).	149	µg/g at 1 percent TOC
Pb_PECQ_nn	PECQ for lead, not normalized (assume ND=1/2*DL).	128	µg/g at 1 percent TOC
Ni_PECQ_nn	PECQ for nickel, not normalized (assume ND=1/2*DL).	48.6	µg/g at 1 percent TOC
Zn_PECQ_nn	PECQ for zinc, not normalized (assume ND=1/2*DL).	459	µg/g at 1 percent TOC
TE_meanPECQ_nn	Mean PECQ for TEs (As, Cd, Cr, Cu, Pb, Ni, Zn), not normalized (assume ND=1/2*DL).	NA	NA
Fluor9_PECQ_nn	PECQ for fluorene, not normalized (assume ND=1/2*DL).	536	µg/kg at 1 percent TOC

Table 11a. Mean Probable Effect Concentration Quotient variable descriptions for PECQ values in [table 11b](#).—Continued

[Units of PEC value used: All PECQ values are unitless ratios. Abbreviations: DL, detection level; ND, non-detection; PAH, polycyclic aromatic hydrocarbon; PCB, polychlorinated biphenyl; PEC, Probable Effect Concentration; PECQ, Probable Effect Concentration Quotient; TE, trace element; TOC, total organic carbon in sediment; USGS, U.S. Geological Survey; g, gram; µg/kg, microgram per kilogram; µg/g, microgram per gram; NA, not applicable]

Variable name	Variable description	PEC values used for individual constituents	Units of PEC value used
Anthr_PECQ_nn	PECQ for anthracene, not normalized (assume ND=1/2*DL).	845	µg/kg at 1 percent TOC
BaA_PECQ_nn	PECQ for benzo[a]anthracene, not normalized (assume ND=1/2*DL).	1,050	µg/kg at 1 percent TOC
BaP_PECQ_nn	PECQ for benzo[a]pyrene, not normalized (assume ND=1/2*DL).	1,450	µg/kg at 1 percent TOC
Chrys_PECQ_nn	PECQ for chrysene, not normalized (assume ND=1/2*DL).	1,290	µg/kg at 1 percent TOC
Fluorant_PECQ_nn	PECQ for fluoranthene, not normalized (assume ND=1/2*DL).	2,230	µg/kg at 1 percent TOC
Naph_PECQ_nn	PECQ for naphthalene, not normalized (assume ND=1/2*DL).	561	µg/kg at 1 percent TOC
Phen_PECQ_nn	PECQ for phenanthrene, not normalized (assume ND=1/2*DL).	1,170	µg/kg at 1 percent TOC
Pyr_PECQ_nn	PECQ for pyrene, not normalized (assume ND=1/2*DL).	1,520	µg/kg at 1 percent TOC
TotPAH_PECQ_nn	PECQ for total-PAH, not normalized (assume ND=1/2*sum of DLs). Total PAH is sum of 12 PAHs (acenaphthene, acenaphthylene, anthracene, benz[a]anthracene, benzo[a]pyrene, chrysene, fluoranthene, naphthalene, phenanthrene, pyrene).	22,800	µg/kg at 1 percent TOC
pDDE_PECQ_nn	PECQ for DDE, not normalized (assume ND=1/2*DL). DDE is <i>p,p'</i> -DDE only.	31.3	µg/kg at 1 percent TOC
Dield_PECQ_nn	PECQ for dieldrin, not normalized (assume ND=1/2*DL).	61.8	µg/kg at 1 percent TOC
TotChlord_PECQ_nn	PECQ for total chlordane, not normalized (assume ND=1/2*DL), chlordane is sum of <i>cis</i> -chlordane, <i>trans</i> -chlordane, <i>trans</i> -nonachlor.	17.6	µg/kg at 1 percent TOC
OCP_meanPECQ_nn	Mean PECQ for organochlorine pesticides (DDE, dieldrin, chlordane), not normalized (assume ND=1/2*DL).	NA	NA
TotPCB_PECQ_nn	PECQ for total PCBs, not normalized (assume ND=1/2*sum of DLs). Total PCBs is sum of Aroclors 1254, 1260, 1016+1242.	676	µg/kg at 1 percent TOC
Bifenthrin_PECQ_nn	PECQ for bifenthrin, not normalized (assume ND=0).	0.49	µg/kg at 1 percent TOC
Cyhalothrin_PECQ_nn	PECQ for cyhalothrin, not normalized (assume ND=0).	0.87	µg/kg at 1 percent TOC
Cypermethrin_PECQ_nn	PECQ for cypermethrin, not normalized (assume ND=0).	0.76	µg/kg at 1 percent TOC
Permethrin_PECQ_nn	PECQ for permethrin, not normalized (assume ND=0).	19.6	µg/kg at 1 percent TOC
Pyreth_sumPECQ_nn	Sum of PECQs (toxic units) for pyrethroids (bifenthrin, cyhalothrin, cypermethrin, permethrin), not normalized (assume ND=0).	NA	NA
Pyreth_meanPECQ_nn	Mean of PECQs for pyrethroids (bifenthrin, cyhalothrin, cypermethrin, permethrin), not normalized (assume ND=0).	NA	NA

Table 11b. Mean Probable Effect Concentration Quotient (PECQ) values from bed sediment chemistry.

Data are available for download at <http://pubs.usgs.gov/sir/2011/5092/>

Table 11c. Mean Probable Effect Concentration Quotient (PECQ), normalized to specific fraction of organic carbon, variable descriptions for values in [table 11d](#).

Data are available for download at <http://pubs.usgs.gov/sir/2011/5092/>

Table 11d. Mean Probable Effect Concentration Quotient (PECQ) values from bed sediment chemistry normalized to specific fraction of organic carbon.

Data are available for download at <http://pubs.usgs.gov/sir/2011/5092/>

Table 12a. Variable descriptions for equilibrium-partitioning sediment benchmark toxic units (ESBTU) for polycyclic aromatic hydrocarbons in [table 12b](#).

[Abbreviations: USGS, U.S. Geological Survey; PAH, polycyclic aromatic hydrocarbon]

Variable name	Variable description
MRA	Metropolitan areas of each regional study (ATL, Atlanta; BOS, Boston; DAL, Dallas; DEN, Denver; MGB, Milwaukee-Green Bay; SEA, Seattle; SLC, Salt Lake City).
SMRA	Site code based on metropolitan regional area and a sequential number.
SNAME	USGS station name.
STAIID	USGS station identification number.
CERC ID	USGS Columbia Environmental Research Center (CERC) identification number.
Σ ESBTU	Sum of equilibrium-partitioning sediment benchmark toxic units for polycyclic aromatic hydrocarbons, calculated for 18 parent PAHs and extrapolated to total PAHs by using a 50 percent certainty factor.

Table 12b. Equilibrium-partitioning sediment benchmark toxic units (Σ ESBTU) for polycyclic aromatic hydrocarbons.

Data are available for download at <http://pubs.usgs.gov/sir/2011/5092/>

Table 13. Derivation of Chronic Toxicity Thresholds values for pyrethroid and fipronil compounds determined in this study.

[CAS No.: Chemical Abstracts Registry number. **PFRG**: USGS Pesticide Fate Research Group, Sacramento, Calif. See also Hladik and others, 2009. **LC₅₀ value**: Calculation was converted from units of (µg/g OC) to (µg/kg at 1 percent OC) as follows: LC₅₀ (µg/g OC) * (10 g OC/kg sediment dry weight). The LC₅₀ value used is the “USGS” value (the lower confidence interval of the available LC₅₀ values) if available, or (otherwise) a LC₅₀ value available from the cited literature. **Chronic toxicity threshold**: LC₅₀ (µg/kg at 1 percent OC) / 5, where 5 is a safety factor derived as follows: (a) the LC₅₀ value is converted to a LOEL using a factor of 2.5 from Amweg and others (2005), and (b) the 10-day endpoint is converted to a 28-day endpoint by using a factor of 2. **Abbreviations**: C.I., confidence interval; D, day; dw, dry weight; LC₅₀, lethal concentration to 50 percent of test organisms; LOEL, Lowest Observed Effect Concentration; OC, sediment organic carbon; g, gram; kg, kilogram; µg/g, microgram per gram; µg/kg, microgram per kilogram; USGS, U.S. Geological Survey; NA, not available; *, indicates average of two or more reported values]

Pyrethroid	CAS No.	USGS review: lower 95-percent C.I. of LC ₅₀ values (µg/g OC) (number of studies)	LC ₅₀ value available from the literature (µg/g OC)	Source of individual LC ₅₀ value	LC ₅₀ value at 1 percent OC (µg/kg at 1 percent OC)	Chronic toxicity threshold for <i>Hyaella</i> <i>azteca</i> (µg/kg dw at 1 percent OC)
Bifenthrin	82657-04-3	0.25 (9)		See table 14	2.5	0.49
Cyfluthrin	68359-37-5		1.08	Amweg and others (2005)	10.8	2.16
Cyhalothrin	91465-08-6		.44*	Amweg and others (2005) and Weston and others (2009)	4.37	.87
Cypermethrin	52315-07-8		.38	Maund and others (2002)	3.8	.76
Deltamethrin	52918-63-5		.79	Amweg and others (2005)	7.9	1.6
Esfenvalerate	66230-04-4		1.65*	Amweg and others (2005) and Weston and others (2009)	16.5	3.30
Permethrin	52645-53-1	9.8 (7)		See table 14	98	19.6
Fipronil	120068-37-3		4.1	Hintzen and others (2009)	41	8.2
Fipronil desulfinyl	205650-65-3				NA	
Fipronil sulfide	120067-83-6		7.7	Hintzen and others (2009)	77	15
Fipronil sulfone	120068-36-2		9.7	Hintzen and others (2009)	97	19

Table 14. Summary of peer reviewed literature reporting 10-day spiked sediment toxicity tests with *H. azteca* used in calculating 'USGS Review' value in [table 13](#).

[Abbreviations: OC, organic carbon; µg, microgram; g, gram]

Author	Year	OC (percent)	Organic carbon normalized (µg/g OC)
Bifenthrin			
Weston and others	2009	1.87	0.99
Weston and others	2007	2	.22
Amweg and others	2005	1.1	.57
	2005	1.4	.63
	2005	6.5	.37
	2007	1.7–2.1	.26
Weston and others	2006	.21	.62
Maul and others	2008	.69	.105
	2008	1.3	.152
			0.37 Median LC ₅₀
			.44 Mean LC ₅₀
			.29 Standard deviation of the LC ₅₀
			.25 Lower 95th percentile of the LC ₅₀
Permethrin			
Weston and others	2009	1.87	17.39
Amweg and others	2005	1.40	17.87
	2005	1.10	11.1
	2005	6.50	3.51
	2006	1.87	14.2
	2006	1.87	21.3
	2006	1.87	13.2
			14.20 Median LC ₅₀
			14.08 Mean LC ₅₀
			5.76 Standard deviation of the LC ₅₀
			9.82 Lower 95th percentile of the LC ₅₀

Related Pending Publications

Currently (January 2012), the following papers are pending publication:

Kemble, N.E., Hardesty, D.K., Ingersoll, C.G., Kunz, J.L., Sibley, P.K., Calhoun, D.L., Gilliom, R.J., Kuivila, K.M., Nowell, L.H., and Moran, P.W., in review, Contaminants in stream sediments from seven U.S. metropolitan areas—II. Sediment toxicity to the amphipod *Hyaella azteca* and the midge *Chironomus dilutus*: Archives of Environmental Contamination and Toxicology.

Kuivila, K.M., Hladik, M.L., Ingersoll, C.G., Kemble, N.E., Moran, P.W., Calhoun, D.L., Nowell, L.H., and Gilliom, R.J., in press, Occurrence and potential sources of pyrethroid insecticides in stream sediments from seven U.S. metropolitan areas: Environmental Science and Technology, accepted for publication 2012.

Nowell, L.H., Moran, P.W., Gilliom, R.J., Calhoun, D.L., Ingersoll, C.G., Kemble, N.E., Kuivila, K.M., and Phillips, P.J., in review, Contaminants in stream sediments from seven U.S. metropolitan areas—I. Distribution in relation to urbanization: Archives of Environmental Contamination and Toxicology.

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