# Environmental and Biological Data of the Nutrient Enrichment Effects on Stream Ecosystems Project of the National Water Quality Assessment Program, 2003–04



Data Series 345

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By Robin A. Brightbill and Mark D. Munn

National Water-Quality Assessment Program

Data Series 345

**U.S. Department of the Interior**
DIRK KEMPTHORNE, Secretary

**U.S. Geological Survey**
Mark D. Myers, Director

U.S. Geological Survey, Reston, Virginia: 2008

# Foreword

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

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

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

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

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

Matthew C. Larsen
Acting Associate Director for Water

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# Conversion Factors

| Multiply | By | To obtain |
|---|---|---|
| centimeter (cm) | 0.3937 | inch (in.) |
| millimeter (mm) | 0.03937 | inch (in.) |
| micrometer (µm) | 0.00003937 | inch (in.) |
| meter (m) | 3.281 | foot (ft) |
| kilometer (km) | 0.6214 | mile (mi) |
| square kilometer (km$^2$) | 247.1 | acre |
| square meter (m$^2$) | 10.76 | square foot (ft$^2$) |
| square kilometer (km$^2$) | 0.3861 | square mile (mi$^2$) |
| milliliter (mL) | 0.001 | liter (L) |
| liter (L) | 33.82 | ounce, fluid (fl. oz) |

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

$$°F = (1.8 \times °C) + 32.$$

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

$$°C = (°F - 32)/1.8.$$

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).

# Environmental and Biological Data of the Nutrient Enrichment Effects on Stream Ecosystems Project of the National Water Quality Assessment Program, 2003–04

By Robin A. Brightbill and Mark D. Munn

## Abstract

In 2000, the U.S. Environmental Protection Agency began the process of developing regional nutrient criteria for streams and rivers. In response to concerns about nutrients by the U.S. Environmental Protection Agency and others, the U.S. Geological Survey National Water Quality Assessment Program began studying the effects of nutrient enrichment on agricultural stream ecosystems to aid in the understanding of how nutrients affect the biota in agricultural streams. Streams within five study areas were sampled either in 2003 or 2004. These five study areas were located within six NAWQA study units: the combined Apalachicola-Chattahoochee-Flint River Basin (ACFB) and Georgia-Florida Coastal Plain Drainages (GAFL), Central Columbia Plateau–Yakima River Basin (CCYK), Central Nebraska Basins (CNBR), Potomac River–Delmarva Peninsula (PODL), and the White-Miami River Basin (WHMI). Data collected included nutrients (nitrogen and phosphorous) and other chemical parameters, biological samples (chlorophyll, algal assemblages, invertebrate assemblages, and some fish assemblages), stream habitat, and riparian and basin information. This report describes and presents the data collected from these study areas.

## Introduction

As part of the U.S. Geological Survey (USGS) National Water Quality Assessment (NAWQA) Program, a study assessing the effects of nutrient enrichment on agricultural stream ecosystems was implemented in 2001. The recent emphasis by the U.S. Environmental Protection Agency's (USEPA) effort to develop regional nutrient criteria and the development of nutrient total maximum daily loads has created a need for a better understanding of how nutrient conditions are affected by natural and human-related factors, and how nutrients affect aquatic biological communities (algae and invertebrates). The NAWQA program is designed to provide consistent methods leading to nationally comparable data and analysis. This consistent data collection and analysis were incorporated into the Nutrient Enrichment Effects Team (NEET) study of agriculturally affected streams in different geographic regions of the United States. More information about the NAWQA program can be accessed online at http://water.usgs.gov/nawqa and at http://wa.water.usgs.gov/neet/ for the NEET study.

Various types of data have been collected in the field and generated either in the laboratory or through computing efforts as part of the NEET program of NAWQA. The data are presented here for ease of reference for other NEET reports and for their use by other scientific investigators. Brief descriptions of methods and references are provided except where a protocol was altered and so a method's description is provided to aid in the understanding of how the data were collected.

## Site Selection

This study was conducted in five study areas that included six NAWQA study units (table 1). The five areas included the combined Apalachicola-Chattahoochee-Flint River Basin (ACFB) and Georgia-Florida Coastal Plain Drainages (GAFL) referred to here as ACFB/GAFL, Central Columbia Plateau–Yakima River Basin (CCYK), Central Nebraska Basins (CNBR), Potomac River–Delmarva Peninsula (PODL), and the White-Miami River Basin (WHMI). A single USEPA Level III Ecoregion (Omernik, 1987) within each area was selected for the study in order to capture similar hydrologic landscapes, soils, climate, land use, and biota in a single map classification. To be selected, a single ecoregion had to contain significant agricultural activities, a range in nutrient conditions, and a sufficient number of suitably sized streams for study (fig. 1).

**Table 1.** Summary of dominant study area features for the five study areas of the Nutrient Enrichment Effects on Stream Ecosystems Study of the National Water Quality Assessment Program, 2003–04.

[**Study areas:** ACFB/GAFL, Apalochicola-Chattahoochee-Flint River Basin and Georgia-Florida Coastal Plain Drainages; CCYK, Central Columbia Plateau-Yakima River Basin; CNBR, Central Nebraska Basins; PODL, Potomac River-Delmarva Peninsula; WHMI, White-Miami River Basin. Values in parentheses ( ) are the ranges (minimum and maximum. km², square kilometer]

| Dominant study area features | Study areas | | | | |
|---|---|---|---|---|---|
| | **ACFB/GAFL** | **CCYK** | **CNBR** | **PODL** | **WHMI** |
| Number of sites | 29 | 29 | 28 | 27 | 30 |
| Climate | Humid plains | Arid plains and plateaus | Semi-humid plains | Humid plains | Semi-humid plains |
| Agricultural region | Corn soybeans, peanuts, vegetables, pasture, cotton | Wheat grains, alfalfa, potatoes, vegetables | Corn, soybeans | Corn, alfalfa, soybeans, pasture | Corn, soybeans |
| EPA Level III Ecoregion | Southeastern Plains | Columbia Plateau | Central Great Plains | Middle Atlantic Coastal Plains | Eastern Cornbelt Plains |
| Basin size (km²) | 145.9 (54.7–300) | 652.0 (3.2–6,378.8) | 443.6 (49.6–1,759) | 14.5 (4.4–41.1) | 97.5 (36.6–340.1) |
| Percent agriculture | 42.9 (7–76) | 26.4 (0–95.4) | 58.1 (16.9–97.0) | 53.1 (9.9–89.5) | 90.2 (75.5–98.4) |
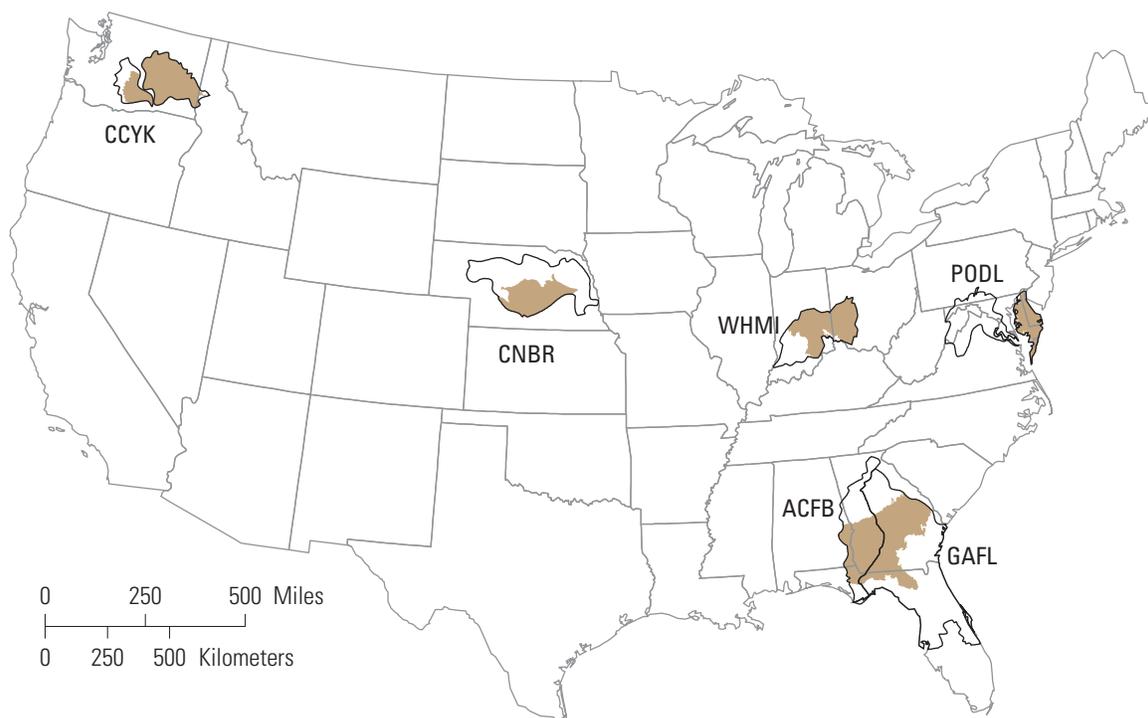


**Figure 1.** Agricultural nutrient gradient study areas of the Nutrient Enrichment Effects on Stream Ecosystems Study of the National Water Quality Assessment Program, 2003–04. Shaded portions of the study areas reflect the ecoregion where samples were collected.

In each of the five study areas, basin and reach coverages were derived from the Elevation Derivatives for National Applications project using 30-m Digital Elevation Model data. Independent basins between 50 and 2,500 km$^2$ were selected and the National Hydrologic Dataset (NHD) was used to verify the locations of streams. A number of independent basins were selected to represent a range in the estimated loadings of nitrogen and phosphorus to each basin. Estimates were based on atmospheric data, animal populations, and fertilizer sales (Ruddy and others, 2006).

The following measurements were made as part of the field reconnaissance to select specific sampling sites:

- nutrient concentrations,
- specific conductance,
- pH,
- water temperature,
- dissolved oxygen,
- estimates of average channel width,
- depth,
- riparian buffer width,
- canopy cover, and
- observations of stream habitat types and adjacent land use.

This process resulted in the selection of 27–30 sites in each study area for a total of 143 sites—ACFB/GAFL, 29 sites; CCYK, 29 sites; CNBR, 28 sites; PODL, 27 sites; and WHMI, 30 sites. Each site (or reach) had to be at least 150 m in length and was defined by a repetition of a geomorphic sequence (for example, 2 riffles and 2 pools) or 20 channel widths if repetitive units were not available (Fitzpatrick and others, 1998). All sites selected and sampled are shown in appendix 1.

# Sample Collection and Laboratory Analysis

Samples were collected within the CCYK and CNBR study units in 2003 and in the ACFB/GAFL, PODL, and WHMI in 2004. Field parameters of water quality, water chemistry, benthic and seston algae, chlorophyll *a* and biomass, algal communities, macroinvertebrate communities, habitat parameters, riparian data and basin features were collected or measured at all 143 sites. Fish community data were collected only in the WHMI study area.

## Field Parameters

Field parameters were collected at a cross section within a reach. Water temperature and dissolved oxygen were measured directly from the stream at several locations across the cross section for a stream average (U.S. Geological Survey, variously dated). Discharge was calculated at the same cross section where the other field parameters were collected (U.S. Geological Survey, variously dated). Specific conductance, alkalinity, pH, and turbidity measurements, were measured from a churn splitter (U.S. Geological Survey, variously dated).

## Water Chemistry Samples

Water chemistry samples also were subsampled from the churn splitter. Ammonia, nitrite, nitrate plus nitrite, and orthophosphate samples were filtered through a 0.45–µm glass fiber filter, chilled and maintained at 4°C, and immediately shipped to the USGS National Water Quality Laboratory (NWQL) in Lakewood, Colo., and analyzed according to methods in Fishman (1993). Unfiltered total nitrogen ($NH_3+NO_2+NO_3+$ organic) and phosphorus samples were acidified with 1 mL of 4.5 normality sulfuric acid, chilled and maintained at 4°C, and immediately shipped to NWQL to be analyzed according to the methods described by the U.S. Environmental Protection Agency (1993). Nutrients (nitrogen and phosphorus) were collected about 30 days prior to and again at the time of biological sampling.

The dissolved organic carbon samples were filtered using a SUPOR® filter. The filtered water sample was placed in a 125-mL amber glass bottle. The sample was acidified to a pH of less than 2 with sulfuric acid, chilled and maintained at 4°C, and immediately shipped to NWQL for analysis (Brenton and Arnett, 1993).

Water was filtered through 25-mm glass fiber filters for inorganic carbon, organic carbon, inorganic plus organic carbon, and total nitrogen. These filters were folded in half, wrapped in aluminum foil, placed in Whirlpak bags, chilled and maintained at 4°C, and immediately shipped to NWQL. Laboratory analysis was completed according to guidelines as stated in the Office of Water Quality Technical Memorandum, 2000.08 (U.S. Geological Survey, 2000).

Water samples from the churn splitter were collected for suspended-sediment analysis. Concentrations of suspended sediments were analyzed at USGS sediment laboratories according to methods described by Guy (1969) and the American Society for Testing and Materials (2002).

## Seston Algae

Seston (water column) algae also were sampled from the churn splitter. The water sample was filtered through a 47-mm glass fiber filter. The filter was folded into quarters, wrapped in aluminum foil, placed in a labeled Petri dish, placed in a plastic bag, and frozen on dry ice for shipment to NWQL (Moulton and others, 2002). Both chlorophyll *a* and pheophytin *a* were analyzed by NWQL using protocols outlined in Arar and Collins (1997).

## Benthic Algae

Benthic algae were sampled within the richest targeted habitat (RTH) areas consisting of coarse rocks or woody debris using methods as described in Moulton and others (2002). A subsample of the RTH sample was filtered for chlorophyll *a* concentration (Moulton and others, 2002), frozen on dry ice, and sent to NWQL for analysis (Britton and Greeson, 1987), and what was not filtered was retained and preserved for community composition (Moulton and others, 2002) and sent to the Academy of Natural Sciences of Philadelphia for identification and enumeration processing (Charles and others, 2002).

Benthic algae also were sampled in the depositional habitat (DTH) areas of organically rich or sandy sediment along stream margins using methods as described in Moulton and others (2002). NAWQA does not have a standardized method for the field processing of DTH chlorophyll concentrations, therefore, methods were modified from Stevenson and Stoermer (1981). In order to filter the DTH chlorophyll sample and not clog the filters with sand, an elutriation process was used to separate the algae from the fine-grained material. Drinking water, 100 mL, was added to the sample. The sample bottle was capped and the bottle was inverted 15 times. The cap was removed and the sample was allowed to settle for 5 seconds. The algal-water mixture was pored into a clean 1-L plastic container, taking care not to introduce sand into the clean container. This process was repeated two more times for a total of three elutriations. The elutriated sample was then homogenized by shaking the algal-water mixture in the 1-L container, and then a 10-mL subsample was withdrawn from the mixture and filtered as described in Moulton and others (2002). If relatively few solids were present on the filter surface, then the filtering process was repeated until a thin, pigmented film was deposited on the filter. The filter was then removed and processed as described in Moulton and others (2002), frozen on dry ice, and sent to NWQL for analysis (Britton and Greeson, 1987). The remaining DTH sample was preserved according to Moulton and others (2002) and sent to the Academy of Natural Sciences of Philadelphia for identification and enumeration processing (Charles and others, 2002).

## Benthic Invertebrates

Benthic invertebrates were collected from RTH habitats—areas of coarse-grained riffles or woody snags—for identification and enumeration (Moulton and others, 2002). RTH samples were collected using a 500-µm mesh Nitex slack-sampler with an attached 500-µm mesh Dolphin bucket (Moulton and others, 2002). Samples were collected at five discrete locations and composited, rinsed, and elutriated by pouring the sample through a 500-µm mesh sieve to retain the sample but not the water. The retained sample was placed in a jar and preserved with 10-percent buffered formalin (Moulton and others, 2002). If woody snags were used as the RTH, five snag locations were selected (if present) and two lengths of the snags from each location were collected by placing a 500-µm mesh sampler just downstream of the snag while removing the length of snag using a saw or lopping shears (Moulton and others, 2002). The snag was cleaned, the area cleaned was recorded, and the sample was composited and preserved (Moulton and others, 2002). Samples were sent to NWQL for identification and enumeration (Moulton and others, 2000).

## Fish

The WHMI staff sampled fish communities as part of this assessment. Fish were collected by electrofishing (Moulton and others, 2002). These fish were identified to species, which was recorded along with the number of fish of each species. The fish were then released back into the stream.

## Habitat

Habitat data were collected along the sample reach. A total of 11 equidistant transects oriented perpendicular to streamflow were established throughout the reach, with channel width measured at each transect. Water depth, water velocity, and substrate type (bedrock, boulder, cobble, gravel, sand, and silt) were measured at three points across each transect. Fitzpatrick and others (1998) provides additional details on methods used to collect habitat data.

Water temperature was recorded every 30 minutes using an internal logging meter. The meters were either suspended in the middle of the water column or anchored to the stream bottom depending on the depth of the stream. The internal logging meters were installed about 3 months prior to the biological sampling.

Shade analysis was determined using a Solar Pathfinder© (2003). This device was used to estimate solar energy along the study reach at the time biological samples were collected. Data were collected midchannel at 5 of the 11 habitat transects.

The method used for determining the percentage of either submerged macrophytes or macroalgae cover or both was modified from Biggs and Kilroy (2000). Five points along each of the 11 transects were sampled. A 0.09-m$^2$ quadrat (a measured and marked rectangle used to isolate a sample area for the purpose of counting the population of different species in that area) was placed at each sampling point. The cover of filamentous algae and/or submerged macrophytes greater than 3 cm in length was estimated to the nearest 10 percent. These 55 values were then averaged to obtain an estimate of the average percentage of cover of the site by macroalgae and macrophytes.

## Basin GIS Ancillary Data

The basin coverages were aggregated by the NAWQA Geographic Information System (GIS) team. Basin and riparian data were calculated for each site using a nationally consistent approach from various national data sources and methods. Variables included drainage area, land cover, ecoregions, physiography, geology, hydrologic landscape regions, and various climatic, soil, and hydrology. The GIS software used for processing the ancillary data was the Environmental Systems Research Institute's ArcInfo Workstation and all GIS data were stored in the Albers Conical Equal-Area projection.

The area of each drainage basin was determined from the area of the polygon that represented the drainage basin boundary. Geographers in the USGS determined the drainage basin delineations from digital topographic and hydrologic maps ranging from 1:24,000 to 1:250,000 scale, depending on the size of the drainage basin. The digital maps of each drainage basin were converted from vector to raster format at 30-m resolution.

Land cover, ecoregions, physiography, geology, and hydrologic landscape regions were characterized by component percentage of the drainage basin. The source for land-cover data was an enhanced version of the USGS 1992 National Landuse Cover Database (NLCD) (Vogelmann and others, 2001; Nakagaki and Wolock, 2005). The 30-m resolution satellite-imagery-based land-cover data were used to compile percentages of drainage basins by land classification as well as the drainage basin percentages of riparian areas as much as 90 m from the stream centerline. The national datasets of (1) land cover (U.S. Geological Survey, 1999), (2) level III ecoregions (Omernik, 1987) aggregated for national nutrient assessment (Omernik, 2000), (3) physiography (Fenneman and Johnson, 1946), (4) bedrock geology (King and Beikman, 1974a, 1974b; Schruben and others, 1998), and (5) surficial geology (Hunt, 1979; Clawges and Price, 1999) were all gridded at 30-m resolution, then overlaid with the 30-m resolution drainage basin boundaries

to determine the area of each classification in the drainage basin. The hydrologic landscape regions (Wolock, 2003a) were gridded at 100-m resolution prior to the overlay process with the drainage basin boundary. The drainage basin areas of each classification were then divided by the drainage area to compute the percentage of drainage basin by classification.

Stream density was computed for a drainage basin by clipping the coverage of the national streams data by the polygon defining the basin boundary and summing of the length of all streams in the basin divided by the area of the drainage basin. The source for nationwide streams data was the 1:100,000-scale National Hydrography Dataset (U.S. Geological Survey and U.S. Environmental Protection Agency, 2003).

The basin estimates for the climatic variables—runoff, the $R$ factor of the Universal Soil Loss Equation, altitude, and the baseflow index [total volume of base flow divided by total volume of runoff for a period (Wahl and Wahl, 1995)]—were determined by overlaying the 30-m resolution basin boundary with the national data layers to compute the average of the grid cell data values in the drainage basin. The source for mean annual and monthly precipitation and temperature was the 1-km resolution grid data from the Daymet conterminous United States database (Thorton and Running, 1999). Potential evapotranspiration for drainage basins was estimated using 1-km resolution national temperature data (David W. Wolock, U.S. Geological Survey, written commun., 2005) derived from the Parameter-Elevation Regressions on Independent Slopes Model (Daly, 2006) and the equation for potential evapotranspiration (Hamon, 1961). The source for estimating average annual runoff from 1990 through 2002 in drainage basins was a time series of runoff (streamflow per unit area), computed for the hydrologic cataloging units in the conterminous United States (Steeves and Nebert, 1994) following the approach of Krug and others (1987). The mean annual (1971–2000) $R$ factor (rainfall erosivity) of the Universal Soil Loss Equation was based on a national 2.5-minute (about 4-km) resolution grid GIS coverage developed by Daly and Taylor (2002). The average altitude in the drainage basin was based on the USGS National Elevation Dataset (U.S. Geological Survey, 2003) gridded at the 100-m resolution. Baseflow, the component of streamflow that can be attributed to ground-water discharge into streams, was estimated for drainage basins from the national baseflow index 1-km resolution dataset developed by Wolock (2003b).

Soil characteristics included but were not limited to soil hydrologic groups, available water capacity, permeability, and the $K$ factor (soil erodibility) of the Universal Soil Loss Equation, which were all based on State Soil Geographic (STATSGO) database (Natural Resources Conservation Service, 1994). The STATSGO database is organized by geographic soil map units based on the proportionate extent

of the component soils and their properties [Soil Survey Geographic (SSURGO) Database, 2006]. Each map unit is associated with many tabular files of soil characteristics. Soil map units were gridded at 100-m resolution and overlaid with 30-m resolution basin boundaries to first determine the areal weights of solid characteristics by using soil map units for each drainage basin, followed by the computation of the weighted average value for each soil characteristic. Soil hydrologic groups were extracted from an enhanced version of STATSGO (Barbara C. Ruddy and William A. Battaglin, U.S. Geological Survey, written commun., 1998), in which missing soil hydrologic group values were populated based on soil characteristics described by Foth and Schafer (1980). Many of the remaining STATSGO soil parameters in this study were compiled by Wolock (1997); soil parameters not included in Wolock (1997) were assembled using the same methods (David M. Wolock, U.S. Geological Survey, written commun., 2004). The mean $K$ factor was estimated for the uppermost soil horizon.

## Reach and Segment-Scale Riparian GIS Data

Riparian zone characteristics were determined at both the reach and segment scales based on the site locations in GIS. Protocols used for this work are described in Johnson and Zelt (2005). The riparian area was characterized using several different fixed-width buffer zones along the stream segment. At the segment scale, four specific buffer zones were delimited on the basis of respective buffer distances from the stream centerline—50, 100, 150, and 250 m. The relative extent of various categories of land use and land cover (LULC) in each buffer zone was estimated by delimiting and classifying polygons of contrasting LULC on aerial digital orthophotographic quadrangles (DOQ) on the basis of standard methods for photograph interpretation (U.S. Fish and Wildlife Service, 1995). LULC data, primarily woody vegetation, were used in evaluating nutrient-enrichment conditions at the segment and reach scales for a subset of the NAWQA major river basins.

## Environmental and Biological Data

The electronic datasets available in this report are listed in table 2 and appendixes 1-12. Much of the data presented in this report are stored in established USGS databases, but some data are unique to the study and therefore are not in a database. All water chemistry and chlorophyll data were obtained through the NAWQA Data-Warehouse (http://water.usgs.gov/nawqa/data.html). Habitat and biological data were retrieved from the Biological Transactional Database (Bio-TDB). The remaining data, including GIS riparian and land-use data, were entered into spreadsheets for long-term storage and archive and are included in this report.

Ancillary data for this study included basin-level data and reach and segment-scale riparian data. Each study unit team was responsible for determining the geographic location of their sampling sites and for delineating the contributing drainage areas for sampling sites. This information was generated for all NEET sampling sites.

**Table 2.** Brief description of the datasets collected and analyzed as part of the National Water Quality Assessment Nutrient Enrichment Effects Team Study.

[seston, water column; RTH, richest targeted habitat (for example, rock or wood); DTH, depositional targeted habitat (for example, fine grain substrate); GIS, geographic information system]

| Dataset | Brief description |
|---|---|
| Sites | List of sites by study area and associated data (appendix 1). |
| Nutrients | Nitrogen and phosphorus data from the water column (appendix 2). |
| Carbon and nitrogen | Carbon and nitrogen data in the water column and on the suspended sediment in the water column (appendix 3). |
| Field parameters | Data includes water temperature, instantaneous stream discharge, specific conductance, suspended-sediment concentration, and turbidity alkalinity, dissolved oxygen, etc. (appendix 4). |
| Chlorophyll | Includes seston chlorophyll *a*, along with chlorophyll *a* and ash-free dry weight for both RTH and DTH  (appendix 5). |
| RTH algae | Benthic algal assemblage data from RTH substrate (appendix 6). |
| DTH algae | Benthic algal assemblage data from DTH substrate (appendix 7). |
| RTH invertebrates | Benthic invertebrate assemblage data from RTH substrate (appendix 8). |
| Fish | Fish assemblage data from White-Miama River Basins study unit only (appendix 9). |
| Habitat | Summary of reach-scale in-stream habitat data (appendix 10). |
| GIS riparian data | GIS derived riparian buffer data at various scales (appendix 11). |
| GIS basin features | GIS derived data on basin features including land use, soils, nutrient loadings, precipitation, runoff, geology, and ecoregions (appendix 12). |

# Review and Revision of Environmental and Biological Sample Data

Because this report includes a wide array of data types, different approaches were used for the review and revision of sample data. Most data were entered into various USGS databases and reviewed by study unit personnel. After review and verification, data were retrieved and compiled. These datasets were reviewed again by NEET members in order to check for consistency between study units. This standardized process occurred for the following datasets: nutrients, field parameters, chlorophyll, and habitat. The algal and invertebrate data were standardized by a laboratory review and revision processes prior to release (Moulton and others, 2000). All ancillary data were generated using standardized GIS procedures and reviewed prior to release.

Quality-control samples designed to measure bias and variability in the field included blank and replicate samples (Mueller and others, 1997). Field blanks are used to monitor for possible contamination or bias during sample collection and consist of subjecting analyte-free water to all aspects of normal sample collection, processing, and handling. Replicate samples are subsamples of a single, larger sample and are used to characterize the reproducibility of sample processing and the analytical process. Quality-control samples in the laboratory are routinely analyzed as part of the quality-assurance plan described by Maloney (2005). These samples include standard reference materials, laboratory reagent blanks, spikes, and surrogates. Biological community data were collected, as presented above, using standardized protocols (Moulton and others, 2002). These protocols address all field procedures to ensure that a sample is collected, processed, and shipped in an appropriate manner.

The laboratory procedures used to process all algal samples, including all quality-control procedures, are presented in Charles and others (2002). Invertebrate samples were processed using standard quality-control procedures outlined in Moulton and others (2000).

A total of 16 blank samples were analyzed for nutrients and 15 for carbon. Reported values for all blank samples were near or less than detection limits. The mean percentage of differences between nutrient replicate samples ranged from 1.6 to 5.6 for all nutrient species (table 3). Thus, the variation in sample results due to variability in handling or laboratory analysis was small. The mean percentage of difference between particulate carbon-nitrogen replicate samples ranged from 0.4 to 6.8 percent. Thus, the variation in particulate carbon-nitrogen sample results due to variability in handling or laboratory analysis was larger than the variation for nutrient samples.

**Table 3.** Quality control results from nutrient and carbon analyses, along with benthic and seston chlorophyll *a* and ash-free dry weight as part of the National Water Quality Assessment Nutrient Enrichment Effects Team Study.

[RTH chlorophyll *a*, chlorophyll *a* occurring on rock or wood; RTH-AFDW, organic matter ash-free dry weight on rock or wood; DTH chlorophyll *a*, chlorophyll *a* on fine-grained substrate from depositional habitats; DTH-AFDW, organic matter ash-free dry weight on fine-grained material collected from depositional habitat; SES chlorophyll *a*, chlorophyll *a* from seston (water column) sample]

| Constituent | Number of samples | Percentage of difference between replicate samples | | |
| --- | --- | --- | --- | --- |
| | | Minimum | Maximum | Mean |
| Nutrients | | | | |
| Nitrogen, ammonia, filtered | 16 | 0 | 11 | 1.8 |
| Nitrogen, nitrite, filtered | 16 | 0 | 14 | 3 |
| Nitrogen, ammonia plus organic (Kjeldahl), unfiltered | 9 | 0 | 3 | 1.6 |
| Nitrogen, nitrite plus nitrate, filtered | 16 | 0 | 17 | 1.6 |
| Total nitrogen, nitrate plus nitrite plus ammonia plus organic-N, unfiltered | 7 | 0 | 9 | 2 |
| Phosphorus, orthophosphate, filtered | 16 | 0 | 5 | 1.2 |
| Total phosphorus, unfiltered | 16 | 0 | 42 | 5.6 |
| Carbon | | | | |
| Organic carbon in filtered water | 15 | 0 | 14 | 1.9 |
| Inorganic carbon in suspended sediment | 15 | 0 | 6 | 0.4 |
| Organic carbon in suspended sediment | 15 | 1 | 20 | 6.8 |
| Inorganic plus organic carbon in suspended sediment | 15 | 1 | 19 | 6.7 |
| Particulate nitrogen in suspended sediment | 15 | 0 | 13 | 5.1 |
| Benthic and seston | | | | |
| Richest targeted habitat periphyton chlorophyll *a* | 8 | 2 | 24 | 7.9 |
| Richest targeted habitat periphyton biomass as ash-free dry weight | 6 | 1 | 13 | 6.5 |
| Depositional targeted habitat periphyton chlorophyll *a* | 8 | 2 | 20 | 6.1 |
| Depositional targeted habitat periphyton biomass as ash-free dry weight | 6 | 0 | 35 | 11.4 |
| Seston chlorophyll *a* | 12 | 2 | 16 | 4.8 |

Variability in concentrations of replicate benthic and seston chlorophyll *a* samples also was examined (table 3). The mean percentage of difference for replicate benthic samples ranged from 6.5 to 11.4. The variation in values between replicate samples was small and was not very different from the variability in the nutrient and carbon-nutrient replicate samples. The mean percentage of difference for seston chlorophyll *a* replicate samples was only 4.8 percent.

## Summary

Data presented in this report are from the National Water Quality Assessment Program Nutrient Enrichment Effects Team study. Five study areas across the United States were sampled either in 2003 or 2004. Data collected included water quality (nutrients, carbon), biology (chlorophyll, benthic algal and invertebrate assemblages, limited fish assemblages), habitat, and ancillary data. Basic methods and references for more detailed sampling procedures also are presented to enhance the use of the data by the reader.

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# Appendixes

The electronic datasets available in this report are listed in appendixes 1-12 and are available at <u>http://pubs.usgs.gov/ds/345/</u>

**Appendix 1.**    Sites in the Nutrient Enrichment Effects Team (NEET) Study by Study Area, Collection Year, and What Was Sampled at Each Site.

**Appendix 2.**    Nitrogen and Phosphorus Data from the Water Column by Study Area and Stream as Part of the Nutrient Enrichment Effects on Stream Ecosystems Study of the National Water Quality Assessment Program, 2003–04.

**Appendix 3.**    Carbon and Nitrogen Data by Study Area, Stream, Sample Date, and Time Collected as Part of the Nutrient Enrichment Effects on Stream Ecosystems Study of the National Water Quality Assessment Program, 2003–04.

**Appendix 4.**    Field Parameters Including Water Temperature, Instantaneous Discharge, Specific Conductance, and Other Parameters as Part of the Nutrient Enrichment Effects on Stream Ecosystems Study of the National Water Quality Assessment Program, 2003–04.

**Appendix 5.**    Periphyton and Seston Chlorophyll a and Ash Free Dry Weight by Study Area, Stream, Sample Date, and Time Collected as Part of the Nutrient Enrichment Effects on Stream Ecosystems Study of the National Water Quality Assessment Program, 2003–04.

**Appendix 6.**    Epilithic and Woody Debris, Richest Targeted Habitat (RTH), Algal Taxa by Study Area, Stream, Sample Date and Time Collected as Part of the Nutrient Enrichment Effects on Stream Ecosystems Study of the National Water Quality Assessment Program, 2003–04.

**Appendix 7.**    Fine Grain, Depositional Habitat (DTH), Algal Taxa by Study Area, Stream, Date, and Time as Part of the Nutrient Enrichment Effects on Stream Ecosystems Study of the National Water Quality Assessment Program, 2003–04.

**Appendix 8.**    Macroinvertebrate Taxa and Density Numbers Data by Study Area and Stream as Part of the Nutrient Enrichment Effects on Stream Ecosystems Study of the National Water Quality Assessment Program, 2003–04.

**Appendix 9.**    Number and Species of Fish Collected Within the White-Miami River Basin on the Sample Date Provided as Part of the Nutrient Enrichment Effects on Stream Ecosystems Study of the National Water Quality Assessment Program, 2003–04.

**Appendix 10.**    Reach-Scale In-Stream Habitat Data by Study Area and Stream as Part of the Nutrient Enrichment Effects on Stream Ecosystems Study of the National Water Quality Assessment Program, 2003–04.

**Appendix 11.**    GIS Derived Riparian Buffer Data at Various Scales by Study Area and Stream as Part of the Nutrient Enrichment Effects on Stream Ecosystems Study of the National Water Quality Assessment Program, 2003–04.

**Appendix 12.**    GIS Derived Nutrient Loading Data by Study Area and Stream as Part of the Nutrient Enrichment Effects on Stream Ecosystems Study of the National Water Quality Assessment Program, 2003–04.

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