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NATIONAL WATER-QUALITY ASSESSMENT PROGRAM

Estimation of Nitrogen Yields and Loads from Basins Draining to Long Island Sound, 1988–98

Water-Resources Investigations Report 02-4044

Prepared in cooperation with the
Connecticut Department of Environmental Protection

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

Cover: Landsat 7 thematic mapper image of southern New England, New York, and Long Island Sound.

U.S. Department of the Interior
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By John R. Mullaney, Gregory E. Schwarz, and Elaine C. Todd Trench

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East Hartford, Connecticut
2002

U.S. DEPARTMENT OF THE INTERIOR
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U.S. GEOLOGICAL SURVEY
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CONTENTS

FIGURES

TABLES

CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATIONS

Multiply	By	To obtain
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
inch per year (in/yr)	25.4	millimeter per year
pound per year (lb/yr)	0.4536	kilogram per year
pound per square mile (lb/mi^2)	0.175	kilogram per square kilometer
cubic foot (ft^3)	0.02832	cubic meter
million gallons per day (Mgal/d)	0.04381	cubic meter per second

Concentration of nitrogen is given in milligrams per liter (mg/L).

FOREWORD

The U.S. Geological Survey (USGS) is committed to serve the Nation with accurate and timely scientific information that helps enhance and protect the overall quality of life, and facilitates effective management of water, biological, energy, and mineral resources. Information on the quality of the Nation's water resources is of critical interest to the USGS because it is so integrally linked to the long-term availability of water that is clean and safe for drinking and recreation and that is suitable for industry, irrigation, and habitat for fish and wildlife. Escalating population growth and increasing demands for the multiple water uses make water availability, now measured in terms of quantity *and* quality, even more critical to the long-term sustainability of our communities and ecosystems.

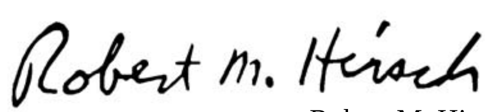
The USGS implemented the National Water-Quality Assessment (NAWQA) Program to support national, regional, and local information needs and decisions related to water-quality management and policy. Shaped by and coordinated with ongoing efforts of other Federal, State, and local agencies, the NAWQA Program is designed to answer: What is the condition of our Nation's streams and ground water? How are the 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. NAWQA results can contribute to informed decisions that result in practical and effective water-resource management and strategies that protect and restore water quality.

Since 1991, the NAWQA Program has implemented interdisciplinary assessments in more than 50 of the Nation's most important river basins and aquifers, referred to as Study Units. Collectively, these Study Units account for more than 60 percent of the overall water use and population served by public water supply, and are representative of the Nation's major hydrologic landscapes, priority ecological resources, and agricultural, urban, and natural sources of contamination.

Each assessment is guided by a nationally consistent study design and methods of sampling and analysis. The assessments thereby build local knowledge about water-quality issues and trends in a particular stream or aquifer while providing an understanding of how and why water quality varies regionally and nationally. The consistent, multi-scale approach helps to determine if certain types of water-quality issues are isolated or pervasive, and allows direct comparisons of how human activities and natural processes affect water quality and ecological health in the Nation's diverse geographic and environmental settings. Comprehensive assessments on pesticides, nutrients, volatile organic compounds, trace metals, and aquatic ecology are developed at the national scale through comparative analysis of the Study-Unit findings.

The USGS places high value on the communication and dissemination of credible, timely, and relevant science so that the most recent and available knowledge about water resources can be applied in management and policy decisions. We hope this NAWQA publication will provide you the needed insights and information to meet your needs, and thereby foster increased awareness and involvement in the protection and restoration of our Nation's waters.

The NAWQA Program 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 a fully integrated understanding of watersheds and for cost-effective management, regulation, and conservation of our Nation's water resources. The Program, therefore, depends extensively on the advice, cooperation, and information from other Federal, State, interstate, Tribal, and local agencies, non-government organizations, industry, academia, and other stakeholder groups. The assistance and suggestions of all are greatly appreciated.



Robert M. Hirsch
Chief Hydrologist

Estimation of Nitrogen Yields and Loads from Basins Draining to Long Island Sound, 1988–98

by John R. Mullaney, Gregory E. Schwarz, *and* Elaine C. Todd Trench

ABSTRACT

Monitoring data on total nitrogen concentrations and streamflow were used to estimate annual nonpoint nitrogen loads for 1988–98 at 28 monitoring sites and 26 unmonitored basins that drain to Long Island Sound. The estimated total nitrogen yields at monitoring sites were used with basin characteristics and ancillary data to develop a multiple-linear regression equation to estimate nonpoint nitrogen yields from monitored and unmonitored basins. The estimated nonpoint nitrogen load to Long Island Sound from the basins studied ranged from 21 million pounds in water year 1995 to 50 million pounds in water year 1990.

Statistically significant regression variables include time, population density, annual mean runoff (minus wastewater return flow), point-source nitrogen yields, percentage of basin area classified as urban/recreational grasses, percentage of the basin classified as agricultural land, and the ratio of deciduous to total forest area. Nonpoint nitrogen loads from monitored and unmonitored basins were computed using the regression equation by setting the point-source nitrogen yields and wastewater return variables to zero, and incorporating streamflow information from index stations in or near unmonitored basins. Nonpoint nitrogen load information obtained through use of this equation was summarized by six Long Island Sound management zones.

Estimates of nonpoint nitrogen loads from these basins can be improved by additional sampling, and by developing data on nitrogen loads from municipal wastewater-treatment facilities outside of Connecticut, compiling information on annual interbasin diversions of flow, studying instream losses of nitrogen, and analyzing the processing and storage of atmospheric nitrogen in different forest types.

INTRODUCTION

The Long Island Sound Study (LISS) was begun in 1985 (U.S. Environmental Protection Agency and others, 1985), under the sponsorship of the U.S. Environmental Protection Agency (USEPA) and the States of Connecticut and New York, to protect and restore the health of Long Island Sound (the Sound). Low concentrations (less than 3.5 milligrams per liter) of dissolved oxygen (hypoxia) caused by nitrogen enrichment during the summer are the highest priority issue in the western part of the Sound (Long Island Sound Study, 1998). Excess nitrogen promotes excessive growth of algae, which eventually die and sink to the bottom. Subsequent decomposition of this algae consumes dissolved oxygen in the bottom waters of the Sound. During the summer of 1989, 40 percent of the Sound's bottom waters were affected by hypoxia (New York Department of Environmental Conservation/Connecticut Department of Environmental Protection, 2000).

Nitrogen sources include direct and indirect discharges of wastewater (point sources) to Long Island Sound, nonpoint runoff from urban and agricultural land uses, and atmospheric deposition of nitrogen in precipitation and dry fall. Attempts to limit nitrogen loads to Long Island Sound have included a freeze on point and nonpoint nitrogen loads in designated areas at 1990 levels (New York Department of Environmental Conservation/Connecticut Department of Environmental Protection, 2000). Furthermore, in February 1998, the New York Department of Environmental Conservation (NYDEC), the Connecticut Department of Environmental Protection (CTDEP), and the USEPA adopted a plan to reduce nitrogen loads associated with human activities by 58.5 percent in 11 management zones in Connecticut and New York (Long Island Sound Study, 1998, p. 12).

A partnership of Federal, State and local agencies, universities, environmental groups, industry, and the public has helped develop management strategies to improve water quality and aquatic habitat for fish and shellfish populations in the Sound. As part of this study, the U.S. Geological Survey (USGS) began an investigation in 1998 in cooperation with the CTDEP to determine annual nonpoint-source nitrogen loads from basins that drain to Long Island Sound including most of Connecticut and parts of Massachusetts, New Hampshire, Vermont, Rhode Island, and New York. The data generated by the study will be useful for comparisons with nitrogen loads simulated in Long Island Sound water-quality models.

Purpose and Scope

This report provides estimates of nonpoint-source nitrogen loads and yields (loads normalized to basin area) for water years 1988–98[1] from basins that drain to Long Island Sound and a method for extrapolating annual total nitrogen yields calculated for 28 water-quality monitoring stations to 26 unmonitored basins using available data. This report provides estimates of nonpoint nitrogen loads for the six Long Island Sound management zones in the study area (fig. 1) and for the Pawcatuck River Basin in Rhode Island and eastern Connecticut. The report also includes estimates of discharge and nitrogen loads from selected municipal wastewater-treatment facilities and suggestions for improving future nitrogen load estimates.

Previous Studies

This investigation continues work conducted for the USGS National Water-Quality Assessment (NAWQA) Program. Trench (2000) provides a summary of previous investigations, estimates of nitrogen and phosphorus loads for 25 monitoring stations in the study area through 1995, and estimates of nonpoint nitrogen and phosphorus yields for basins with urban, agricultural, and forested land use. Some previously published load estimates for 10 stations where samples were collected during 1993–95 were used in this report. Nitrogen loads from ground water and streams that drain from the north shore of Long Island, New York, were estimated concurrently with this study (Scorca and Monti, 2001).

Acknowledgments

The authors would like to thank Paul Stacey, CTDEP, and Mark Tedesco, USEPA, for providing information and review comments on this report. The authors also would like to thank the following USGS employees: Marc Zimmerman, Douglas Burns, David Holtschlag, and Daniel Hippe for technical reviews; Barbara Korzendorfer, for editorial review and layout; and Jonathan Morrison and Richard Moore for technical assistance.

DATA COLLECTION AND ANALYSIS

Nitrogen and streamflow data[2] for water years 1988–98 from 28 monitoring stations were analyzed to estimate loads and yields of total nitrogen for each water year. Load estimates for monitoring stations were developed using the computer program ESTIMATOR (Cohn and others 1992a). Nitrogen yield estimates from monitoring stations were used to develop a Generalized-Least Squares (GLS) regression model so that estimates of nonpoint nitrogen loads could be made for some unmonitored and monitored basins. The GLS regression model is based on basin land-use and land-cover characteristics, population density, annual mean runoff, and the amount of annual return flow[3] from municipal wastewater-treatment facilities. Nonpoint nitrogen yields for unmonitored basins and monitoring stations (those with point sources of nitrogen discharge and (or) those with incomplete water-quality record) were estimated using the GLS equation.

[1]A water year is the 12-month period from October 1 through September 30. The water year is designated by the calendar year in which it ends. For example, the year beginning October 1, 1987 and ending September 30, 1988 is called the 1988 water year. A water year represents the complete annual hydrologic cycle.

[2]Data from USGS series of annual data reports for Connecticut, 1988–98; Massachusetts, 1993–95; New Hampshire/Vermont, 1993–95.

[3]Return flow is defined, in this report, as the amount of effluent discharge from municipal wastewater-treatment facilities upstream from water-quality monitoring stations.

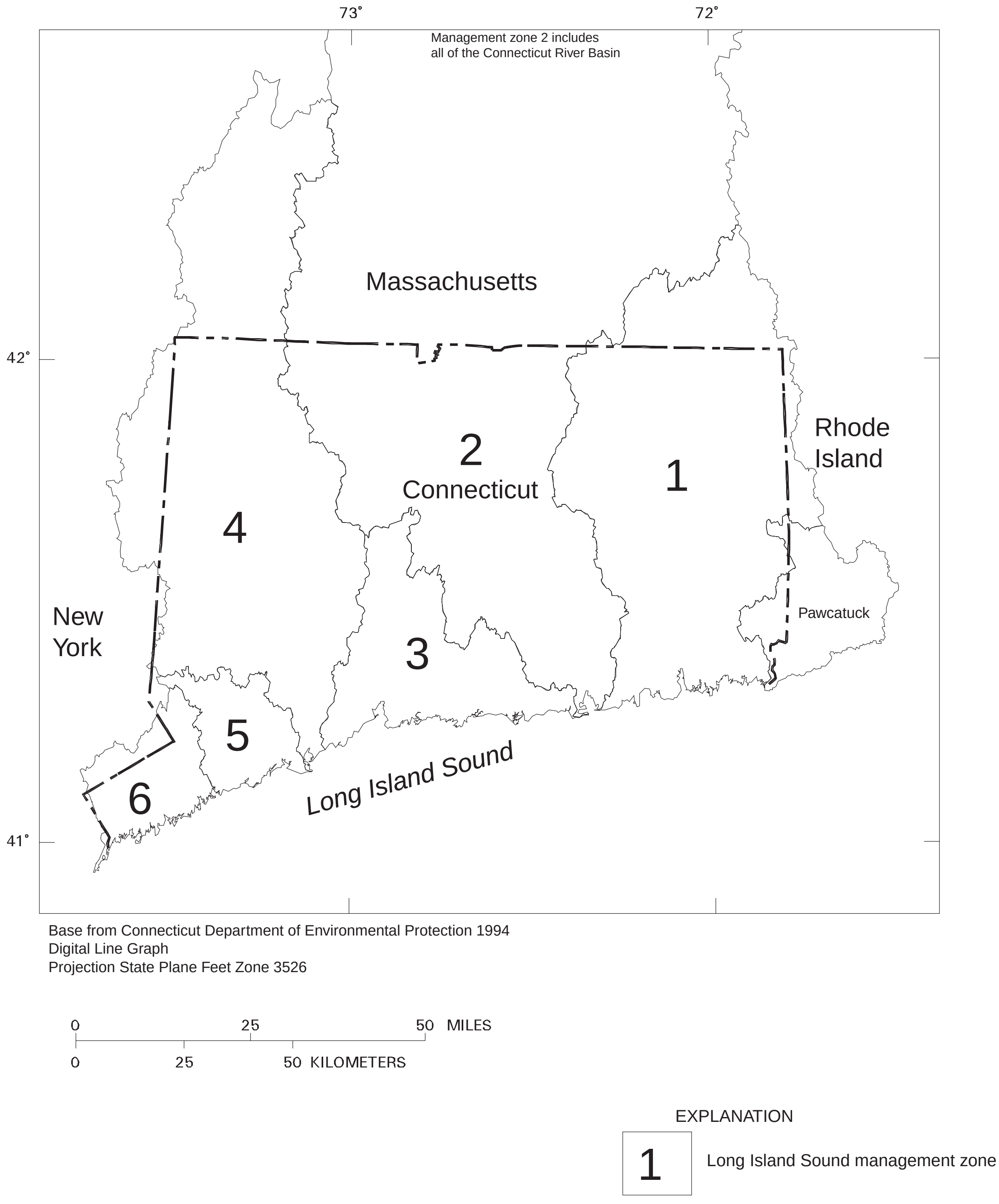


Figure 1. Long Island Sound management zones and the Pawcatuck River Basin.

Analysis of Nitrogen Loads from Monitored Basins

Nitrogen loads from monitored basins were estimated using the computer program ESTIMATOR (Cohn and others, 1992a). ESTIMATOR uses a minimum variance unbiased estimator to account for retransformation bias associated with log-linear regression modeling (Cohn and others, 1989; Gilroy and others, 1990; Cohn and others, 1992a). The applicability of this model for estimating fluvial transport of nutrients and sediment was tested using data for Chesapeake Bay tributaries with drainage areas of 70 mi^2 or larger (Cohn and others, 1992a). The ESTIMATOR program implements an adjusted maximum likelihood estimator for data sets that contain values below a detection limit (Cohn, 1988; Cohn and others, 1992b). The seven-variable regression equation selected for use in the ESTIMATOR program for most load estimates (appendix 1) in this report is

$$\ln[C \times Q] = \beta_0 + \beta_1 \ln[Q] + \beta_2 \ln[Q]^2 +$$

$$\beta_3 T + \beta_4 T^2 + \beta_5 \sin[2\pi T] + \beta_6 \cos[2\pi T] + \varepsilon , \quad (1)$$

where C is the concentration of total nitrogen, in milligrams per liter,
Q is streamflow, in cubic feet per second,
T is time, in years,
β_0 is a constant and $\beta_1..\beta_6$ are parameters estimated from the data, and
ε is assumed to be an independent random error.

Load data from several monitoring stations having a small number of samples and (or) many values below the reporting limit were calculated using an equation with fewer variables than eq. 1 (Trench, 2000, p. 15). For some monitoring stations, additional parameters were used, including: $\ln[Q]^{1/2}$ or sin $[4\pi T]$ and cos $[4\pi T]$ substituted for variables corresponding to $\beta5$ and $\beta6$ in the above equation (appendix 1).

The data used in this study are from long-term water-quality monitoring stations in the USGS Cooperative Water Program, water-quality stations sampled as part of the NAWQA study during 1993–95 (Trench, 2000), and from the National Stream Quality Accounting Network (NASQAN) (Ficke and Hawkinson, 1975). Water-quality and daily mean streamflow data for each monitoring station were retrieved from the USGS National Water-Information System (NWIS) (unpublished data accessed on 12/15/01 on the World Wide Web at URL http://water.usgs.gov/ct/nwis/). Available data from the farthest downstream nontidal station on each major river in the study area (fig. 2; table 1) were analyzed to estimate the total nitrogen load. Additional load data from subbasins in these drainage areas were used to estimate annual nonpoint nitrogen loads from 26 unmonitored basins and nonpoint loads at selected monitoring stations.

Modifications were necessary to represent total nitrogen data for some samples with censored values (concentrations less than the reporting limit). Total nitrogen concentrations are calculated by summing the components of nitrite-plus-nitrate and Kjeldahl nitrogen, if both components are not censored. If one component constituent was detected and one was censored, the concentration of total nitrogen was set equal to that of the detected component. If both components were censored, the concentration of total nitrogen was set at the higher reporting limit of the two. For streams with high nitrogen concentrations, the absence of calculated total nitrogen values may not substantially bias the distribution of values in the data set. For streams with low total nitrogen concentrations, the absence of calculated total nitrogen values at low concentrations may bias the data set toward high concentrations.

Reported concentrations of total nitrogen also may have been affected by the laboratory method used to analyze Kjeldahl nitrogen. A change in the digestion step of the method used to analyze Kjeldahl nitrogen was implemented on October 1, 1991 at the USGS National Water-Quality Laboratory in Arvada. Colo. Statistical analysis of paired data for about 1,500 samples during validation of the new method revealed a bias of about 0.1 mg/L of nitrogen in Kjeldahl nitrogen samples analyzed prior to implementation of the new method (Patton and Truitt, 2000). Kjeldahl nitrogen concentrations, and consequently total nitrogen concentrations, determined prior to this date are biased high by about 0.1 mg/L. For streams with the highest total nitrogen concentrations, this bias represents a small percentage of the concentration and may not have a substantial effect on estimated total nitrogen loads. For streams with the lowest total nitrogen concentrations, this bias represents a larger percentage of the total nitrogen concentration, and load estimates prior to the 1992 water year may be overestimated.

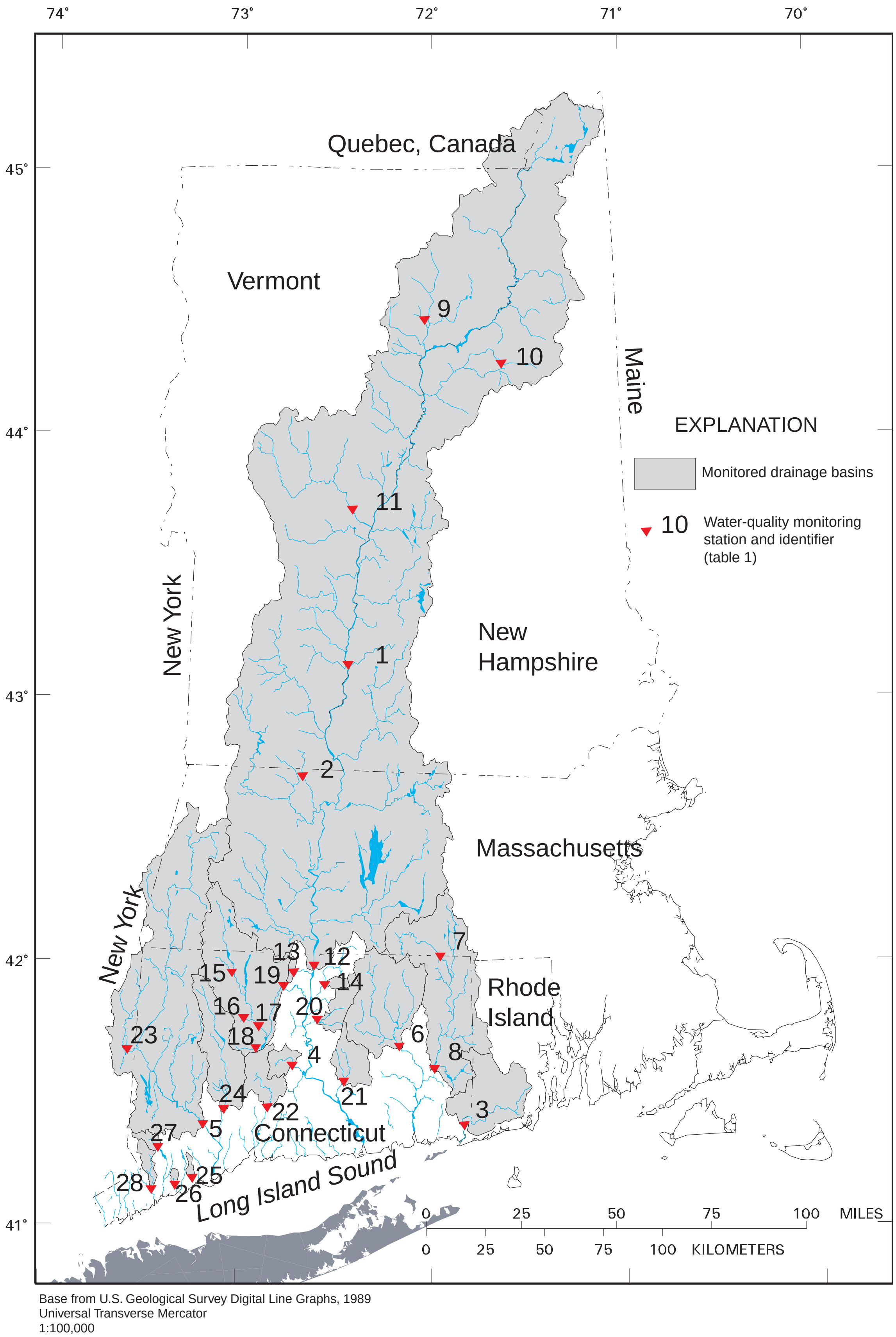


Figure 2. Selected water-quality monitoring stations in basins draining to Long Island Sound.

Table 1. Water-quality monitoring stations used for nitrogen load analysis in basins draining to Long Island Sound

[USGS, U.S. Geological Survey]

USGS station number	USGS station name	Site number (see figs. 2, 3)	Drainage area (square miles)	Period of record used (water years)
01154500	Connecticut River at North Walpole, N.H.	1	5,493	1988–94
01170100	Green River near Colrain, Mass.	2	41.4	1993–95
01118500	Pawcatuck River at Westerly, R.I.	3	295	1988–98
01192704	Mattabesset River at Route 372 East Berlin, Conn.	4	48.1	1996–98
01205500	Housatonic River at Stevenson, Conn.	5	1,544	1988–98
01122610	Shetucket River at South Windham, Conn.	6	408	1988–98
01124000	Quinebaug River at Quinebaug, Conn.	7	155	1988–98
01127000	Quinebaug River at Jewett City, Conn.	8	713	1988–98
01135300	Sleepers River near St. Johnsbury, Vt.	9	42.9	1993–95
01137500	Ammonoosuc River at Bethlehem Jct, N.H.	10	87.6	1993–95
01144000	White River at West Hartford, Vt.	11	690	1993–95
01184000	Connecticut River at Thompsonville, Conn.	12	9,660	1988–98
01184100	Stony Brook near West Suffield, Conn.	13	10.4	1988–91
01184490	Broad Brook at Broad Brook, Conn.	14	15.5	1993–95, 1997–98
01186800	Still River at Riverton, Conn.	15	86.2	1988–91
01188000	Burlington Brook near Burlington, Conn.	16	4.1	1988–98
01188090	Farmington River at Unionville, Conn.	17	378	1988–98
01189000	Pequabuck River at Forestville, Conn.	18	45.8	1993–95
01189995	Farmington River at Tariffville, Conn.	19	577	1988–98
01192500	Hockanum River near East Hartford, Conn.	20	73.4	1992–98
01193500	Salmon River near East Hampton, Conn.	21	100	1988–98
01196500	Quinnipiac River at Wallingford, Conn.	22	115	1988–98
01199900	Tenmile River at South Dover near Wingdale, N.Y.	23	194	1993–95
01208500	Naugatuck River at Beacon Falls, Conn.	24	260	1988–98
01208873	Rooster River at Fairfield, Conn.	25	10.6	1993–95
01208950	Sasco Brook near Southport, Conn.	26	7.4	1995–97
01208990	Saugatuck River near Redding, Conn.	27	21	1988–98
01209710	Norwalk River at Winnipauk, Conn.	28	33	1988–98

Analysis of Nonpoint-Source Nitrogen Loads from Monitored and Unmonitored Basins

A multiple regression model was developed and used to estimate annual nonpoint nitrogen yields for each of the 26 unmonitored basins (fig. 3) and to estimate nonpoint nitrogen loads from selected monitoring stations that have point-source discharges of nitrogen or periods with no nitrogen data during 1988–98.

Explanatory variables evaluated for use in the regression model included land-use/land-cover categories, population density, and annual mean runoff. In addition, the estimated annual return flow or nitrogen load per square mile of basin area (yield) from municipal wastewater-treatment facilities were included as explanatory variables. Explanatory variables were selected on the basis of physical plausibility, statistical significance, goodness of fit, and the reasonableness of model residuals. Correlation among model residuals is present because (1) data for multiple years from the same station were used in the regression, and (2) data for many of the explanatory variables were fixed and the same values were used for each year (land use/land cover, for example). To account for this correlation, a generalized-least squares model (GLS) with a serially correlated error structure was applied (appendix 2).

This structure allows for calculation of unbiased coefficient estimates and confidence intervals around estimates.

Data Sources Used in Regression Analysis

Land Use, Land Cover, and Population Density

Data on land-use and land-cover characteristics (table 2) were determined from LANDSAT Thematic Mapper (TM) images by the Multi-Resolution Land Characterization (MRLC) Consortium. These data, known as the National Land Cover Data (NLCD) set, consist of a 21-class land-cover classification scheme derived from early to mid-1990s LANDSAT TM data applied consistently over the United States (Vogelmann and others, 1998).

The NLCD land-use data set was selected for this study because of the consistency of the information across State boundaries. This consistency enabled land-use percentages to be estimated for all parts of the study area, except for one small tributary of the Connecticut River in Quebec, Canada. Because no other consistent land-use data set was available, the NLCD was used to represent the average conditions from 1988 to 1998.

Population density (table 2) for each basin was estimated from 1990 census block group data developed by Price and Clawges (1999). The 1990 data were used to represent the entire period of study from 1988 to 1998 because no intermediate estimates of population were available.

Streamflow Characteristics

The amount of water that discharges from a basin changes substantially from year to year and across the State. The mean annual runoff for 1930–60 was about 20 to 30 in/yr in Connecticut (Weiss, 1983). This range is caused primarily by long-term regional differences in precipitation.

Data from long-term (more than 10 years of record) streamflow-gaging stations was used to estimate annual mean streamflow in unmonitored and ungaged basins (table 3, appendix 3). Index gaging stations were used to estimate streamflow at ungaged sites and were selected on the basis of geographic proximity to each unmonitored basin and the absence of major diversions of water that might substantially change streamflow. Most index stations were selected from basins with no major municipal wastewater discharges; if there were discharges, this amount was subtracted from the annual mean runoff. The use of the index station approach does not account for diversions of water that might be present in each unmonitored basin; therefore, estimates may be biased low or high if substantial amounts of water are imported or exported to or from any unmonitored basin.

Return Flow and Nitrogen Load Data from Municipal Wastewater-Treatment Facilities

Estimates of return flow from 108 municipal wastewater-treatment facilities (fig. 4) and estimates of total nitrogen load from 27 facilities were used in the regression model to estimate nonpoint nitrogen loads in monitored and unmonitored basins. Data on return flow and the concentration of total nitrogen from municipal wastewater-treatment facilities were compiled from two sources.

In Connecticut, the annual load of nitrogen from 27 municipal wastewater-treatment facilities was estimated using measurements of return flow and total nitrogen concentration (Paul Stacey, Connecticut Department of Environmental Protection, written commun., 1999). The CTDEP database includes information on return flow and nutrient concentrations for samples collected monthly or more frequently from 1993 (or later) to 1999 at municipal wastewater-treatment facilities. Data for 1998 were used in this study, because data were not available for many wastewater-treatment plants in Connecticut prior to 1997. Nitrogen loads from wastewater-treatment facilities in Connecticut were estimated by averaging the daily load of nitrogen for each sample date at each wastewater-treatment facility for water year 1998. Estimates of nitrogen loads from point sources for water year 1998 were assumed to represent average conditions for water years 1988 to 1998 in the monitored basins. For some facilities in Connecticut, changes that might alter the annual load may have been made during the study period, including upgrades to, extensions of, or expansions of treatment facilities.

In areas with no monitoring data, information on return flow for 1990 (Medalie, 1996) was used. These data were plotted with return flow calculated from data reported by CTDEP (fig. 5). The discharges are comparable, and the two data sets generally are consistent (fig. 5). Estimates of annual return flow for each monitored basin were used as an explanatory variable in the multiple-linear-regression model. Errors associated with yield and return flow data are unquantified.

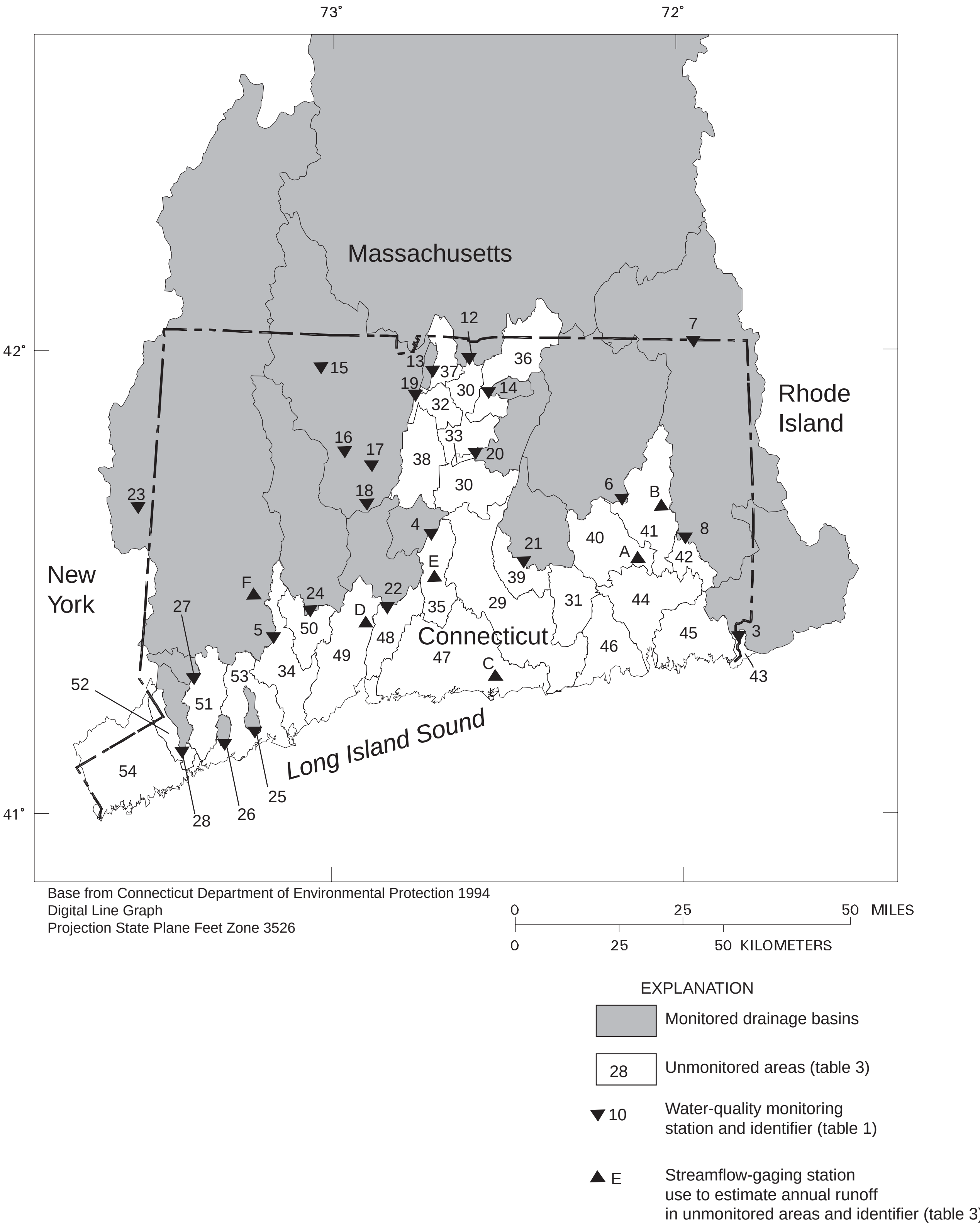


Figure 3. Monitored and unmonitored basins that drain to Long Island Sound.

Table 2. Land-use and land-cover percentages, 1990 population density, and drainage areas for monitored and unmonitored basins that drain to Long Island Sound

[USGS, U.S. Geological Survey; mi^2, square mile]

USGS station number or unmonitored basin name	Site number (figs. 2 and (or) 3)	Drainage area (mi^2)	Population density (1990) people/mi^2	Land-use and land-cover category as a percentage of basin area						
				Urban	Urban/recreational grasses	Agricultural	Forest	Water	Wetlands	Other
MONITORED BASINS										
01154500	1	5,493	39	1.5	0.1	8.7	83.2	1.5	3.5	1.2
01170100	2	41.4	26	.0	.1	5.3	91.4	.5	2.6	.0
01118500	3	295	182	3.4	4.1	4.8	76.6	1.9	8.8	.4
01192704	4	48.1	863	35.6	4.3	12.5	38.6	3.4	5.0	.6
01205500	5	1,544	212	6.6	1.8	13.7	68.7	2.9	6.0	.4
01122610	6	408	231	5.7	1.6	11.0	70.2	2.0	8.8	.6
01124000	7	155	236	7.8	1.2	7.2	70.2	3.5	9.5	.6
01127000	8	713	228	6.8	1.4	11.3	67.9	3.0	8.9	.7
01135300	9	42.9	38	.8	.0	16.8	78.3	.1	2.9	1.0
01137500	10	87.6	11	.2	.4	.4	88.6	.1	6.4	3.3
01144000	11	690	30	.7	.0	12.5	83.9	.4	1.7	.6
01184000	12	9,660	116	3.7	.6	8.4	79.4	2.2	4.6	.9
01184100	13	10.4	198	5.6	2.7	31.9	49.3	1.2	8.9	.4
01184490	14	15.5	290	9.7	1.4	39.0	43.8	.5	5.2	.4
01186800	15	86.2	215	4.6	.7	6.4	75.3	3.2	10.2	.4
01188000	16	4.1	131	4.7	.8	18.7	66.2	1.1	7.7	.8
01188090	17	378	139	3.1	.6	4.8	80.7	4.7	5.8	.3
01189000	18	45.8	1,244	29.9	1.9	7.9	52.5	2.1	5.0	.7
01189995	19	577	306	9.1	1.4	6.7	72.4	3.7	6.3	.4
01192500	20	73.4	1,335	33.9	2.7	11.3	42.6	1.9	7.0	.6
01193500	21	100	236	6.1	2.3	12.3	68.2	1.5	9.1	.6
01196500	22	115	1,279	39.1	11.3	.6	40.3	1.7	5.9	1.0
01199900	23	194	102	2.9	.7	26.3	64.1	1.4	4.2	.4
01208500	24	260	907	19.2	1.9	10.2	59.3	2.3	6.6	.5
01208873	25	10.6	4,671	83.5	6.6	.0	6.5	.9	2.4	.1
01208950	26	7.4	743	15.0	22.5	.2	54.0	.1	8.0	.2
01208990	27	21	348	5.4	2.7	4.5	79.9	2.6	5.0	.1
01209710	28	33	784	21.7	5.7	2.9	62.4	1.3	5.8	.2

Table 2. Land-use and land-cover percentages, 1990 population density, and drainage areas for monitored and unmonitored basins that drain to Long Island Sound—Continued

USGS station number or unmonitored basin name	Site number (figs. 2 and (or) 3)	Drainage area (mi^2)	Population density (1990) people/mi^2	Land-use and land-cover category as a percentage of basin area						
				Urban	Urban/recreational grasses	Agricultural	Forest	Water	Wetlands	Other
UNMONITORED BASINS										
Connecticut mainstem South	29	227.5	325	9.0	3.5	5.2	65.9	8.4	7.5	0.6
Connecticut mainstem North	30	138.9	1,385	44.2	4.5	9.6	26.5	4.7	9.8	.8
Eightmile	31	62.4	81	2.1	1.3	8.6	79.5	1.8	6.1	.5
Farmington	32	30.9	758	29.7	4.2	18.4	35.6	3.4	7.7	1.1
Hockanum	33	3.5	2,021	69.6	3.9	1.7	11.7	3.9	8.8	.3
Housatonic	34	94.4	1,105	32.5	6.3	5.0	45.1	4.0	6.6	.6
Mattabesset	35	62.0	666	21.0	3.4	20.1	45.3	2.3	7.2	.8
Scantic	36	99.0	382	11.9	4.2	20.5	56.9	.5	5.2	.7
Stony Brook	37	35.1	363	16.0	8.2	30.6	35.0	.6	8.4	1.2
Park River	38	77.2	3,318	56.3	6.9	5.6	23.9	1.6	5.0	.7
Salmon	39	44.3	212	5.7	2.1	7.6	70.7	6.9	6.7	.5
Yantic	40	97.8	227	5.5	2.0	19.2	61.9	2.9	7.7	.8
Shetucket	41	114.9	321	5.8	1.9	14.6	67.7	1.7	7.5	.8
Quinebaug	42	29.5	129	2.4	1.3	19.7	64.1	1.0	11.1	.6
Pawcatuck	43	9.8	691	44.2	11.1	.0	24.2	8.9	11.2	.4
Thames mainstem	44	107.7	683	15.7	6.0	3.3	62.2	5.4	6.7	.6
East of Thames	45	87.1	533	13.6	6.4	6.5	61.1	3.3	8.4	.7
West of Thames	46	76.2	387	16.1	7.7	2.1	61.0	5.3	6.8	1.1
Central	47	216.1	495	14.9	4.8	3.5	63.0	3.3	9.4	1.1
Quinnipiac	48	55.2	1,412	40.3	11.7	6.7	28.9	3.0	8.3	1.2
West-Central	49	130.5	2,067	43.3	8.0	1.1	39.2	1.6	6.3	.6
Naugatuck	50	50.8	1,021	19.6	2.7	7.3	63.0	1.7	4.9	.6
Saugatuck	51	68.7	627	16.0	5.0	3.9	67.3	2.9	4.9	.1
Norwalk	52	29.5	1,864	38.7	5.2	1.5	47.6	2.1	4.8	.2
Southwest east	53	99.5	2,102	50.3	6.5	2.2	30.4	3.3	6.2	1.2
Southwest west	54	180.3	1,369	36.5	5.9	2.4	46.7	2.6	5.7	.3

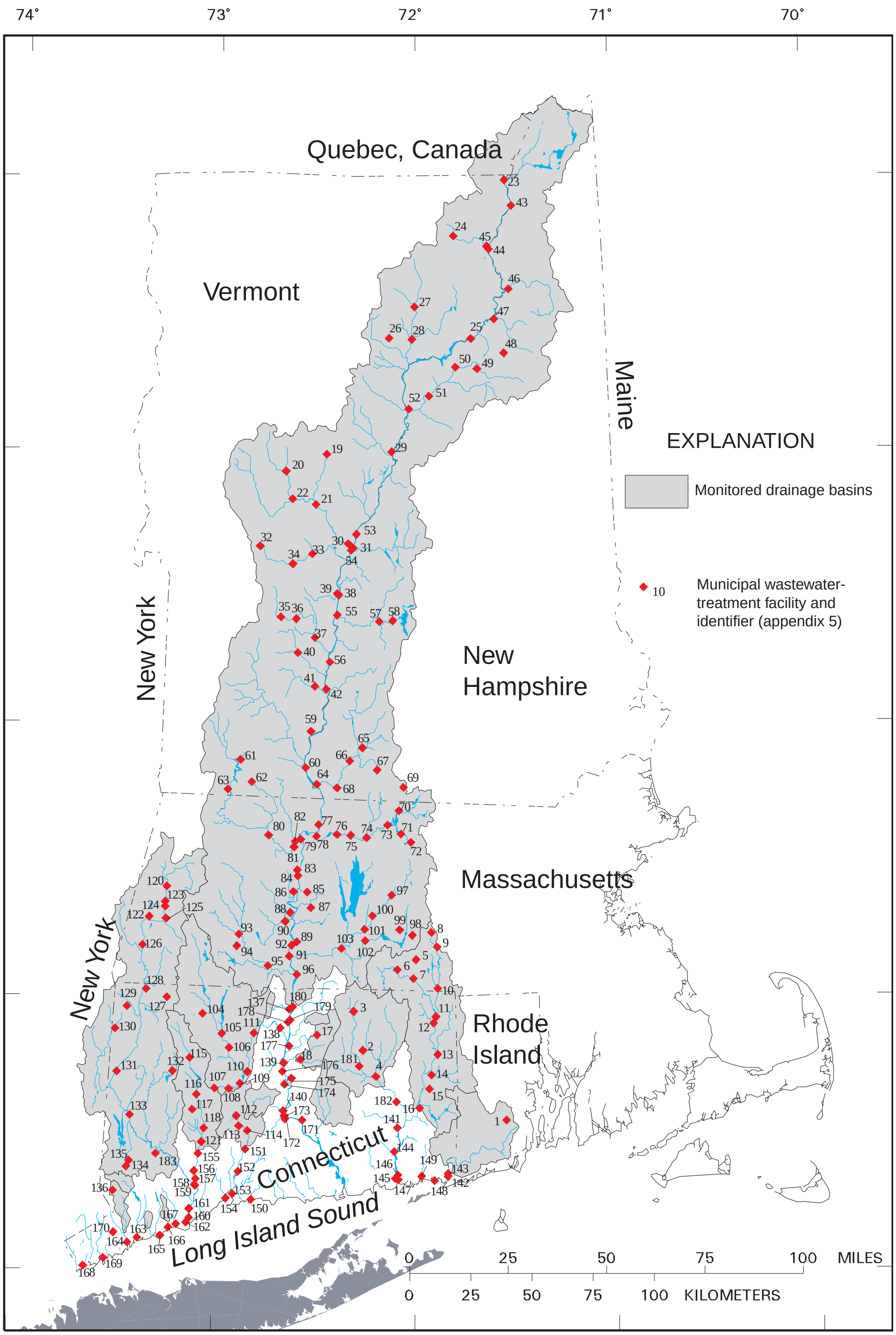
Table 3. Index streamflow-gaging stations selected to represent unmonitored basins that drain to Long Island Sound

[USGS, U.S. Geological Survey]

Site number (fig. 3)	Unmonitored basin/ part of basin	Index station		
		USGS station number	Site number (figs. 2 or 3)	USGS station name
29	Connecticut mainstem South	01193500	20	Salmon River near East Hampton, Conn.
30	Connecticut mainstem North	01184490	14	Broad Brook at Broad Brook, Conn.
31	Eightmile	01193500	20	Salmon River near East Hampton, Conn.
32	Farmington	01184100	13	Stony Brook near West Suffield, Conn.
33	Hockanum	01192500[1]	19	Hockanum River at East Hartford, Conn.
34	Housatonic	01204000	F	Pomperaug River at Southbury, Conn.
35	Mattabesset	01192883	E	Coginchaug River at Middlefield, Conn.
4	01192704[2]	01192883	E	Coginchaug River at Middlefield, Conn.
36	Scantic	01184490	14	Broad Brook at Broad Brook, Conn.
37	Stony Brook	01184100	13	Stony Brook near West Suffield, Conn.
38	Park River	01184100	13	Stony Brook near West Suffield, Conn.
39	Salmon	01193500	20	Salmon River near East Hampton, Conn.
40	Yantic	01127500	A	Yantic River at Yantic, Conn.
41	Shetucket	01193500	20	Salmon River near East Hampton, Conn.
42	Quinebaug	01123000	B	Little River near Hanover, Conn.
43	Pawcatuck	01118500[1]	3	Pawcatuck River at Westerly, R.I.
44	Thames mainstem	01127500	A	Yantic River at Yantic, Conn.
45	East of Thames	01127500	A	Yantic River at Yantic, Conn.
46	West of Thames	01127500	A	Yantic River at Yantic, Conn.
47	Central	01195100	C	Indian River near Clinton, Conn.
48	Quinnipiac	01196500[1]	21	Quinnipiac River at Wallingford, Conn.
49	West-Central	01196620	D	Mill River near Hamden, Conn.
50	Naugatuck	01208500[1]	23	Naugatuck R. at Beacon Falls, Conn.
51	Saugatuck	01208990	26	Saugatuck River near Redding, Conn.
52	Norwalk	01209710[1]	27	Norwalk River at Winnipauk, Conn.
53	Southwest east	01208950	25	Sasco Brook near Southport, Conn.
54	Southwest west	01209710[1]	27	Norwalk River at Winnipauk, Conn.

[1]Estimated return flow from municipal wastewater-treatment facilities subtracted prior to use as an index flow station.

[2]Flow data for station 01192704 estimated for water years 1988–95, prior to existence of USGS streamflow-gaging station.



Base from U.S. Geological Survey Digital Line Graphs, 1989
Universal Transverse Mercator
1:100,000

Locations of municipal wastewater treatment plants from Medalie, 1996

Figure 4. Municipal wastewater-treatment facilities in basins draining to Long Island Sound.

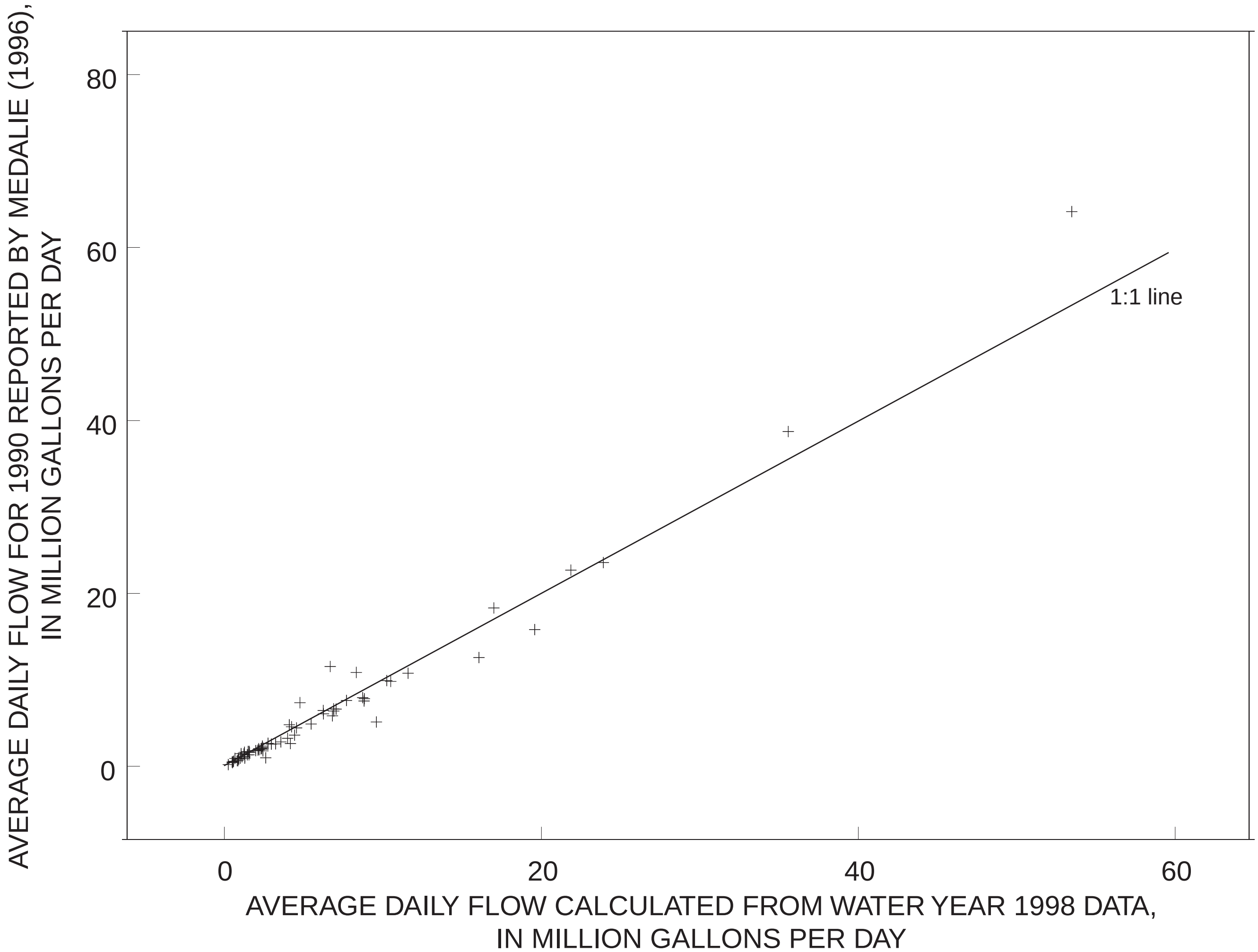


Figure 5. Comparison of effluent-discharge data from two sources for wastewater-treatment facilities in Connecticut.

NITROGEN LOADS AND YIELDS FROM BASINS DRAINING TO LONG ISLAND SOUND, 1988–98

Total nitrogen loads and yields were estimated at 28 monitoring stations (appendix 3). These estimates were used in a regression model to estimate nonpoint nitrogen loads for each monitoring station and unmonitored basin (appendix 4). Nitrogen loads are summarized by the six Long Island Sound management zones described previously.

Nitrogen Loads from Monitored Basins

Total nitrogen loads from monitored basins were divided by basin area and expressed as units of yield ($lb/mi^2/yr$) to normalize the load estimates. Average total nitrogen yields from the 28 monitored basins ranged from about 1,100 $lb/mi^2/yr$ in basins that mostly are forested to about 15,000 $lb/mi^2/yr$ in a basin dominated by urban land use in which a large percentage of the mean annual runoff is derived from municipal wastewater-treatment facilities (fig. 6, appendix 3). The 95-percent confidence interval on load estimates from the farthest downstream stations (stations used in the estimation of load to Long Island Sound) ranged from 4 to 45 percent of the annual load. The 95-percent confidence intervals on load estimates presented by Trench (2000) for other water-quality monitoring stations used in this report are as high as 69.5 percent.

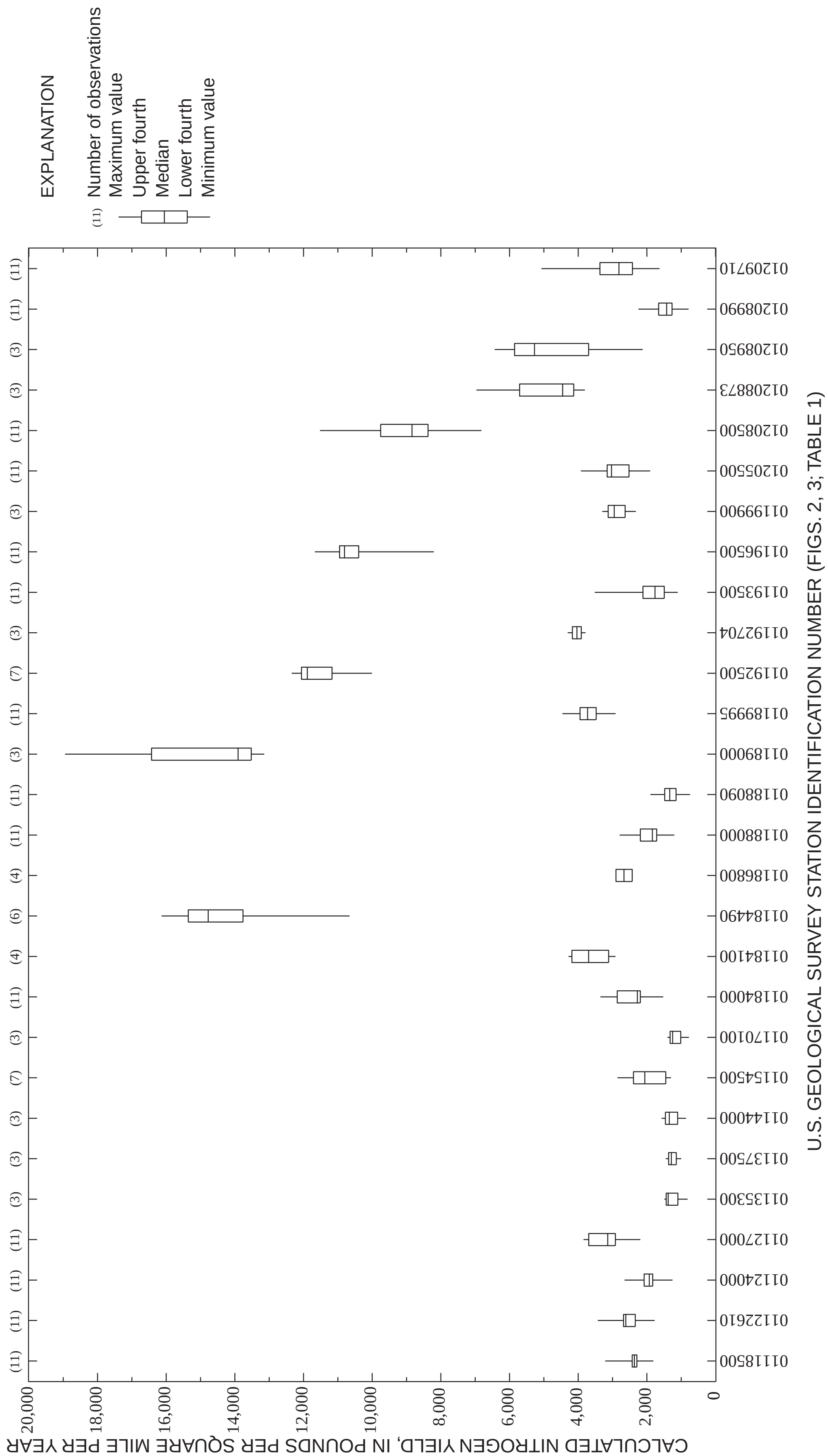


Figure 6. Total nitrogen yields from monitored basins draining to Long Island Sound based on ESTIMATOR calculations, 1988–98.

Nonpoint Nitrogen Yields from Unmonitored and Monitored Basins

Multiple Linear Regression Modeling to Estimate Nitrogen Yields

The variable of the regression model estimated in this analysis was total nitrogen yield, determined by analyzing the data for total nitrogen concentration and flow in the program ESTIMATOR and other explanatory variables (table 4).

The GLS method transforms the regression data so that the resulting errors are independent and identically distributed. The linear transformation consists of pre-multiplying all regression variables by the square root of the inverse of the error covariance matrix, estimated from the residuals of a first-stage ordinary least squares (OLS) model. (See appendix 2 for a detailed description of this method.) The effect of the transformation is to ensure the resulting model residuals from a second-stage OLS regression are independent and identically distributed. The estimated coefficients and standard errors of the second-stage regression are unbiased and efficient. Because the final regression is based on transformed data, all plots of fit (fig. 7) and of the distribution of model residuals also are transformed.

Most explanatory variables in the model were fixed in time because annual data generally were not available. The only variables that account for annual differences in annual nitrogen yield are "annual mean runoff" and "water year." Years with higher annual mean runoff generally have higher nitrogen yields. The "water year" variable accounts for trends in nitrogen yield with time that may relate to factors such as differences in land-use and population density, concentration of total nitrogen in wastewater return flow, atmospheric nitrogen deposition, and other unexplained annual variability.

Of the fixed variables, the significance of the variable "urban/recreational grasses (turf)" may be related to areas that receive regular applications of nitrogen fertilizer, or may be a surrogate for the extent that the land in a basin is developed. The variable "agriculture" includes pasture, hay, row crops, and orchards and is highly significant. The Broad Brook Basin (site 14 on figs. 2, 3) has the largest percentage of agricultural land of any of the monitored basins. The yields from this basin are much higher than would be estimated by the regression model, indicating that further investigation of the nitrogen yields from agricultural basins would be useful to determine if other predominantly agricultural basins have similar yields. A variable identifying this station was included in the regression model to estimate the nitrogen yield for water years with missing record. The variable "ratio of deciduous forest to total forest" may indicate that basins that are dominantly deciduous forest are more effective in storing or using nitrogen than are basins with coniferous or mixed forest cover. Lewis and others (2000) found that red oak forests yield less nitrate-nitrogen than other forest types, possibly because the soil type found in red oak forests may limit nitrate concentrations.

Data from municipal wastewater-treatment facilities were entered in the regression model as two variables: (1) the sum of return flows if total nitrogen concentration data were unavailable, and (2) the sum of nitrogen loads estimated for facilities normalized to drainage area of the basin (yield), if both flow and concentration data were available. To estimate nonpoint nitrogen loads in monitored and unmonitored basins, the two terms for municipal wastewater discharge were set to zero in the regression. In preliminary regressions, only the return flow term was used; however, negative estimates for some monitored basins, where the total nitrogen load is dominated by point sources, indicated that this approach resulted in implausible values.

Nonpoint Nitrogen Yields from Unmonitored Basins

Median estimates of nonpoint nitrogen yield from unmonitored basins for 1988–98 ranged from about 1,500 to 6,000 lb/mi^2/yr (fig. 8, appendix 4). To account for uncertainties in the estimates caused by measurement error, a range of confidence intervals is provided, bounded by what is referred to as "inner" and "outer" confidence intervals (explained in appendix 2). The average inner 90-percent confidence interval was +/-28.8 percent and the average outer 90-percent confidence interval was +/- 52.7 percent (appendix 4, fig. 9). Additional error, unaccounted for by these confidence intervals, could be present in the estimates because of the increased uncertainty of streamflow estimated by use of index streamflow stations in the regression model input.

Table 4. Generalized least squares (GLS) estimates of model coefficients and standard errors, with asymptotically valid t-statistics and p-values

Transformed variable	Units	Parameter estimate	Standard error	t-statistic	p-value
Intercept	dimensionless	306	855	0.360	0.721
Drainage area	square mile	.013	.045	.300	.766
Urban/recreational grasses	percent	83.4	39.5	2.11	.036
Agricultural land use	percent	73.7	13.2	5.59	<.0001
Population density	people/square mile	1.22	.255	4.79	<.0001
Annual mean runoff[1]	inch/year	194	36.3	5.36	<.0001
Annual mean runoff squared[1]	(inch/year) squared	-2.06	.725	-2.84	.005
Point source return flow[2]	inch/year	1,300	799	1.62	.107
Point source yield[3]	pound per square mile per year	1.05	0.048	22.1	<.0001
Ratio of deciduous forest to total forest[4]	dimensionless	-1,560	783	-1.99	.048
Year	water year minus 1980	-225	98.8	-2.28	.024
Year squared	(water year minus 1980) squared	4.86	3.76	1.29	.197
Indicator for station 01184490[5]	dimensionless	10,800	1,036	10.4	<.0001

[1]Estimated return flow from municipal wastewater-treatment facilities subtracted.

[2]Estimated return flow from municipal wastewater-treatment facilities with only flow data available (Medalie, 1996), normalized by basin area to inches per year. See appendix 5.

[3]Estimated annual basin yield from municipal wastewater-treatment facilities using concentration and flow data for water year 1998 from Paul Stacey, Connecticut Department of Environmental Protection, written commun., 1999. See appendix 5.

[4]The ratio of deciduous forest to total forest based on the National Land Cover Data data set.

[5]Nitrogen yields for station 01184490, Broad Brook at Broad Brook, Connecticut, are much higher than generally would be estimated by this regression model; therefore, a variable was added to identify this station in the model.

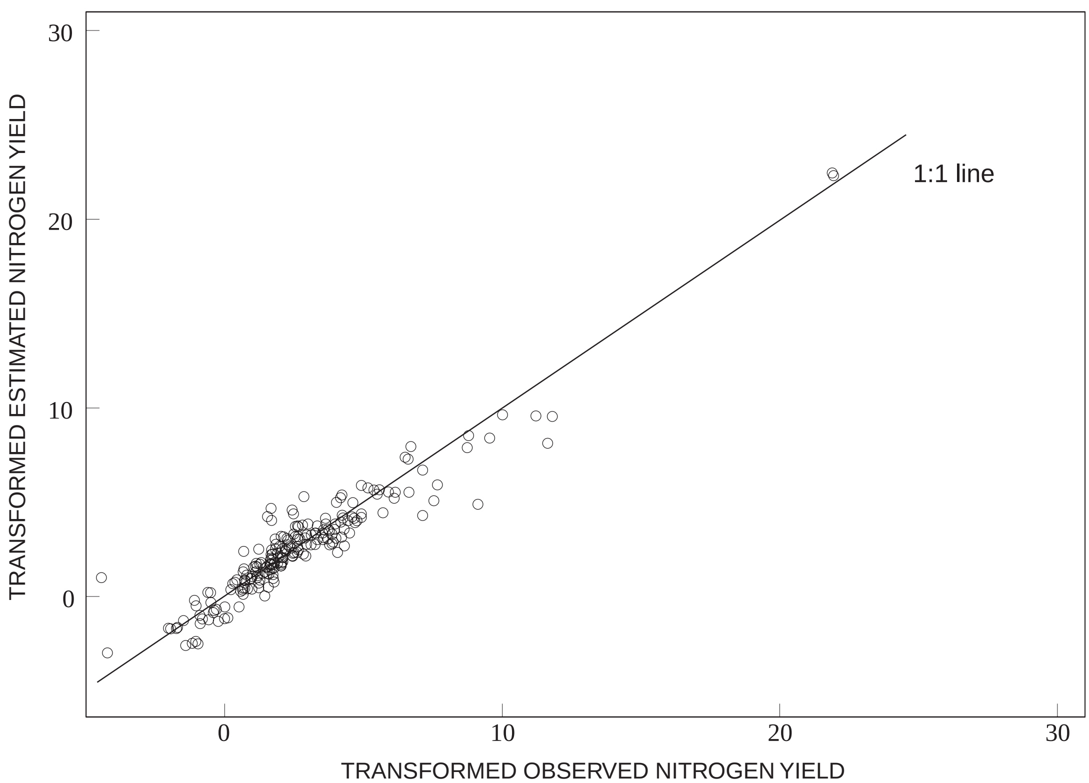


Figure 7. Transformed estimated total nitrogen yield and transformed observed total nitrogen yield for 28 monitored basins draining to Long Island Sound.

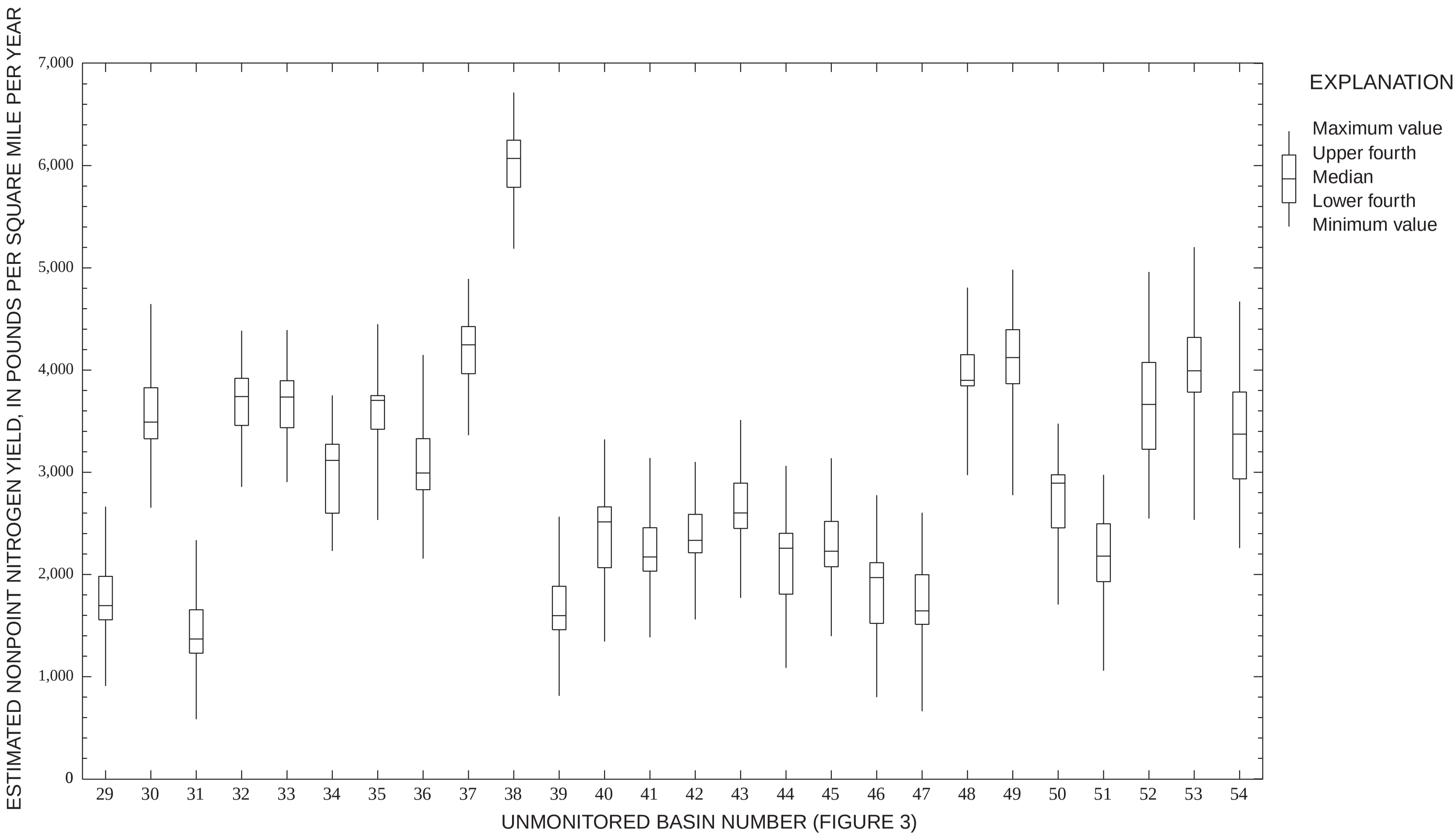


Figure 8. Nonpoint nitrogen yields from unmonitored basins draining to Long Island Sound, based on multiple regression model estimates, 1988–98.

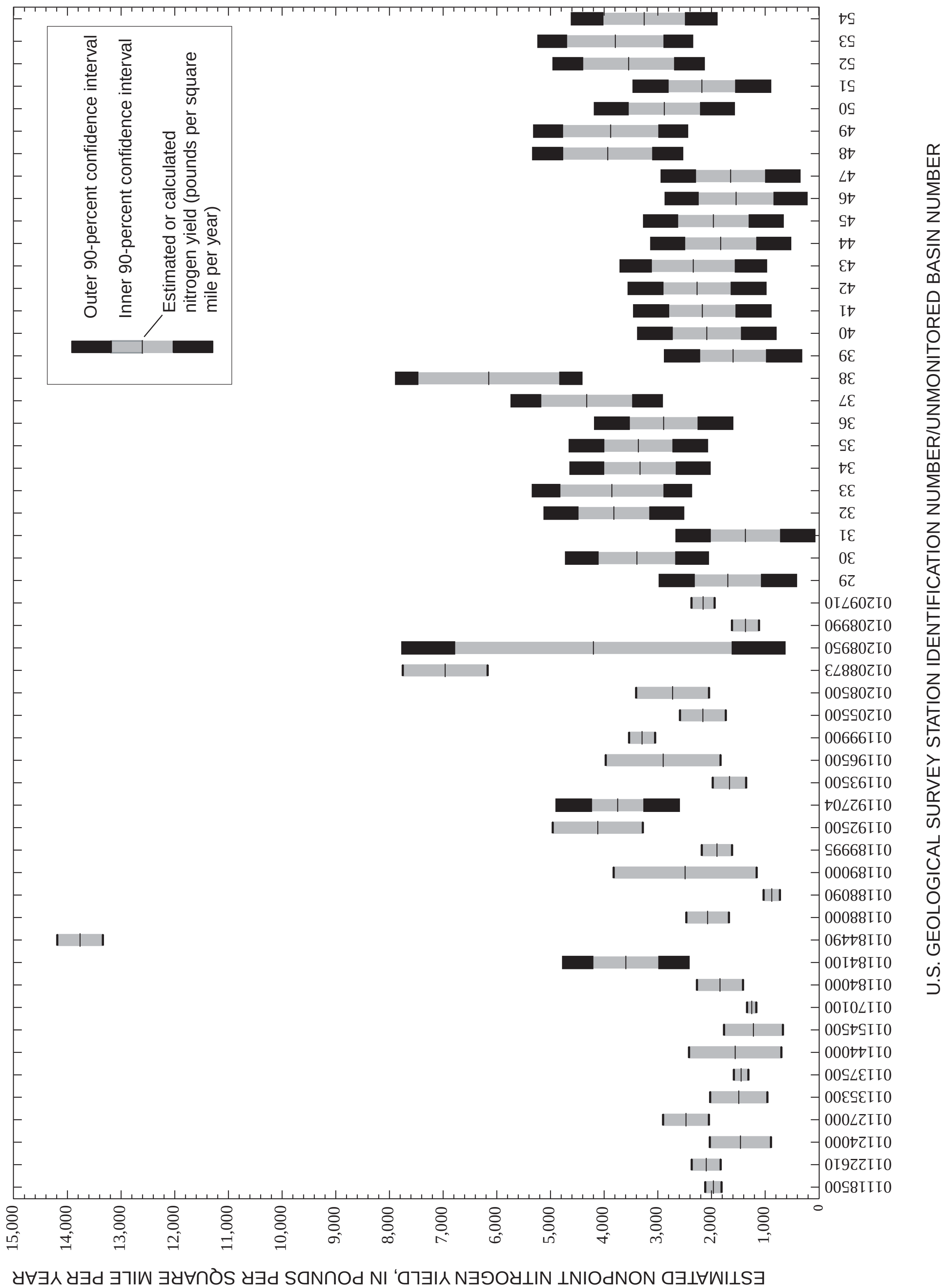


Figure 9. Estimates and confidence intervals for nonpoint nitrogen yield for unmonitored basins draining to Long Island Sound, water year 1994.

Nonpoint Nitrogen Yields from Monitored Basins

Nonpoint nitrogen yields from monitored basins were determined either by the use of the ESTIMATOR program, in the case of the monitored basins with no municipal wastewater-treatment facilities, or through the use of the GLS regression model. Estimates of nonpoint nitrogen yield outside the available period of record were made only for the farthest downstream monitoring stations. The average inner 90-percent confidence interval of estimates was +/- 24.7 percent and the average outer 90-percent confidence interval was +/- 27.9 percent (fig. 9). Median or average nitrogen yields from monitored basins ranged from about 1,100 to 15,000 lb/mi^2/yr (figs. 10, 11).

Delivery of Nitrogen to Long Island Sound

Instream losses of nitrogen contribute to uncertainty regarding the delivery of nitrogen to Long Island Sound. Instream losses include uptake of nitrogen by biota, storage of nitrogen in streambed and impoundment sediments, volatilization of ammonia nitrogen, and denitrification. Estimates of nitrogen loads for monitored and unmonitored basins take into account the average rate of nitrogen loss for the monitored basins because losses of nitrogen likely have taken place upstream from the monitoring stations. The GLS model was used to estimate nonpoint nitrogen loads from monitored basins and includes the effect of upstream losses of nitrogen. It is possible that unaccounted nitrogen loss takes place from the point of measurement at the furthest downstream monitoring station or unmonitored basin to Long Island Sound.

Smith and others (1997) developed a spatially referenced regression model on watershed attributes (SPARROW) to estimate nitrogen and phosphorus delivery to estuaries. This model estimates the delivery of total nitrogen by accounting for instream loss based on the travel time and streamflow for each stream reach in a 1:500,000-scale digital stream network in the continental United States for 1987. In this model, streamflow served as a surrogate for channel depth. The SPARROW model assumes a reduction in the rate of nitrogen loss with increasing channel depth.

The SPARROW model output (Richard Moore, U.S. Geological Survey, written commun., 2001) was used to evaluate delivered nitrogen loads from the farthest downstream reaches with water-quality monitoring stations. The nitrogen-delivery percentage for the selected water-quality monitoring stations in the study area ranged from 81 percent for the Quinnipiac River monitoring station (01196500) to 100 percent for the Pawcatuck River station (01118500) (table 5). This range would indicate that, based on available studies, the loss of nitrogen downstream from selected water-quality monitoring stations is minimal and probably is within the confidence intervals of estimation for nonpoint nitrogen loads.

Table 5. Delivery of nitrogen to Long Island Sound based on the SPARROW model for the continental United States

Site number (see figs. 2, 3)	U.S. Geological Survey station identification number	U.S. Geological Survey station name	SPARROW model predicted delivery to Long Island Sound (percentage of total load)
3	01118500	Pawcatuck River at Westerly, R.I.	100
4	01192704	Mattabesset River at Route 372 East Berlin, Conn.	97
5	01205500	Housatonic River at Stevenson, Conn.	95
6	01122610	Shetucket River at South Windham, Conn.	94
8	01127000	Quinebaug River at Jewett City, Conn.	92
12	01184000	Connecticut River at Thompsonville, Conn.	97
13	01184100	Stony Brook near West Suffield, Conn.	97
14	01184490	Broad Brook at Broad Brook, Conn.	97
19	01189995	Farmington River at Tariffville, Conn.	97
20	01192500	Hockanum River near East Hartford, Conn.	98
21	01193500	Salmon River near East Hampton, Conn.	90
22	01196500	Quinnipiac River at Wallingford, Conn.	81
24	01208500	Naugatuck River at Beacon Falls, Conn.	97
25	01208873	Rooster River at Fairfield, Conn.	100[1]
26	01208950	Sasco Brook near Southport, Conn.	100[1]
27	01208990	Saugatuck River near Redding, Conn.	87
28	01209710	Norwalk River at Winnipauk, Conn.	91

[1]River reach at streamflow-gaging station not included on the 1:500,000-scale river reach network. Delivery is probably nearly 100 percent based on the proximity to Long Island Sound.

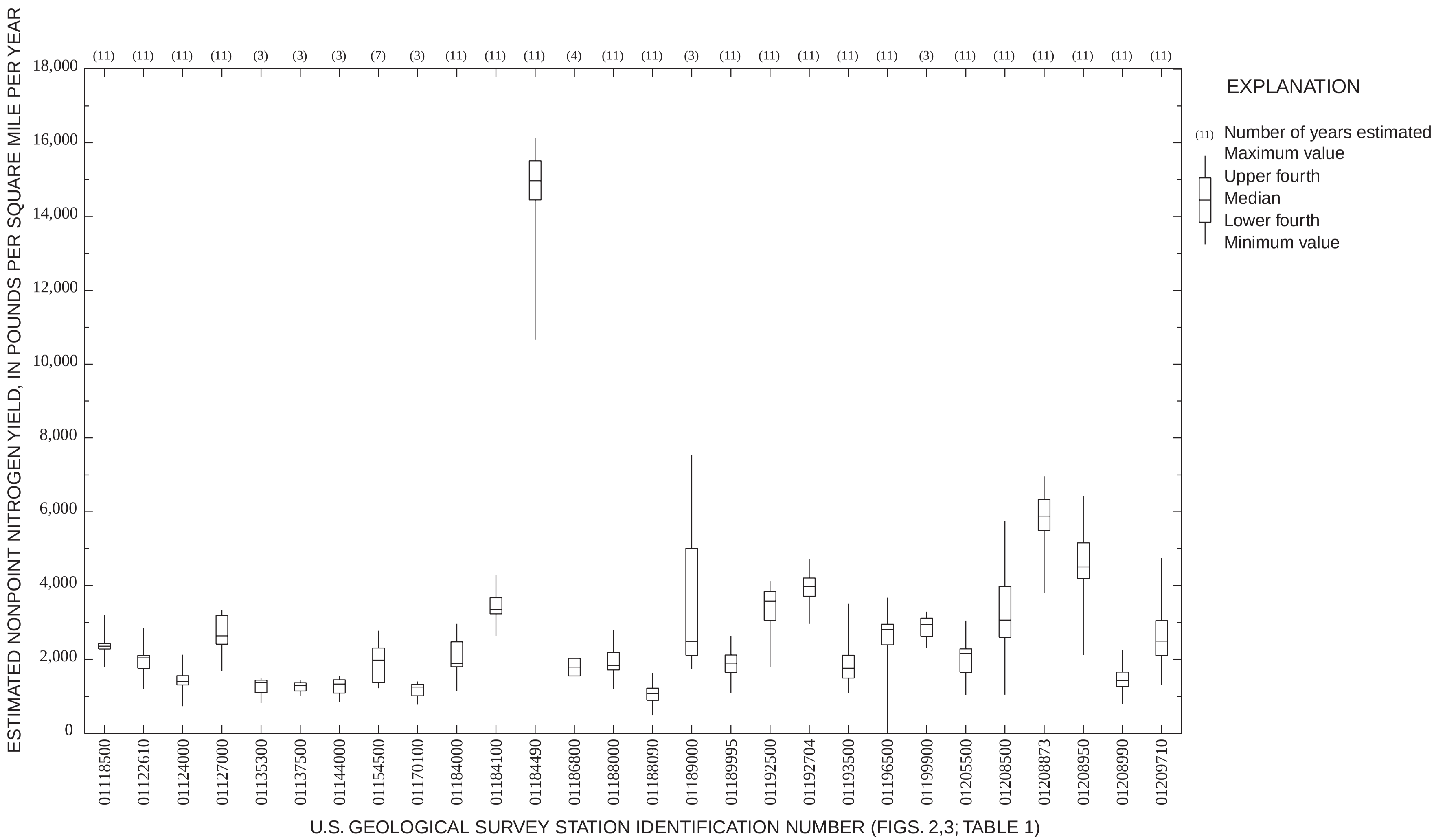


Figure 10. Nonpoint nitrogen yields from monitored basins draining to Long Island Sound, based on ESTIMATOR calculations and multiple regression model estimates, 1988–98.

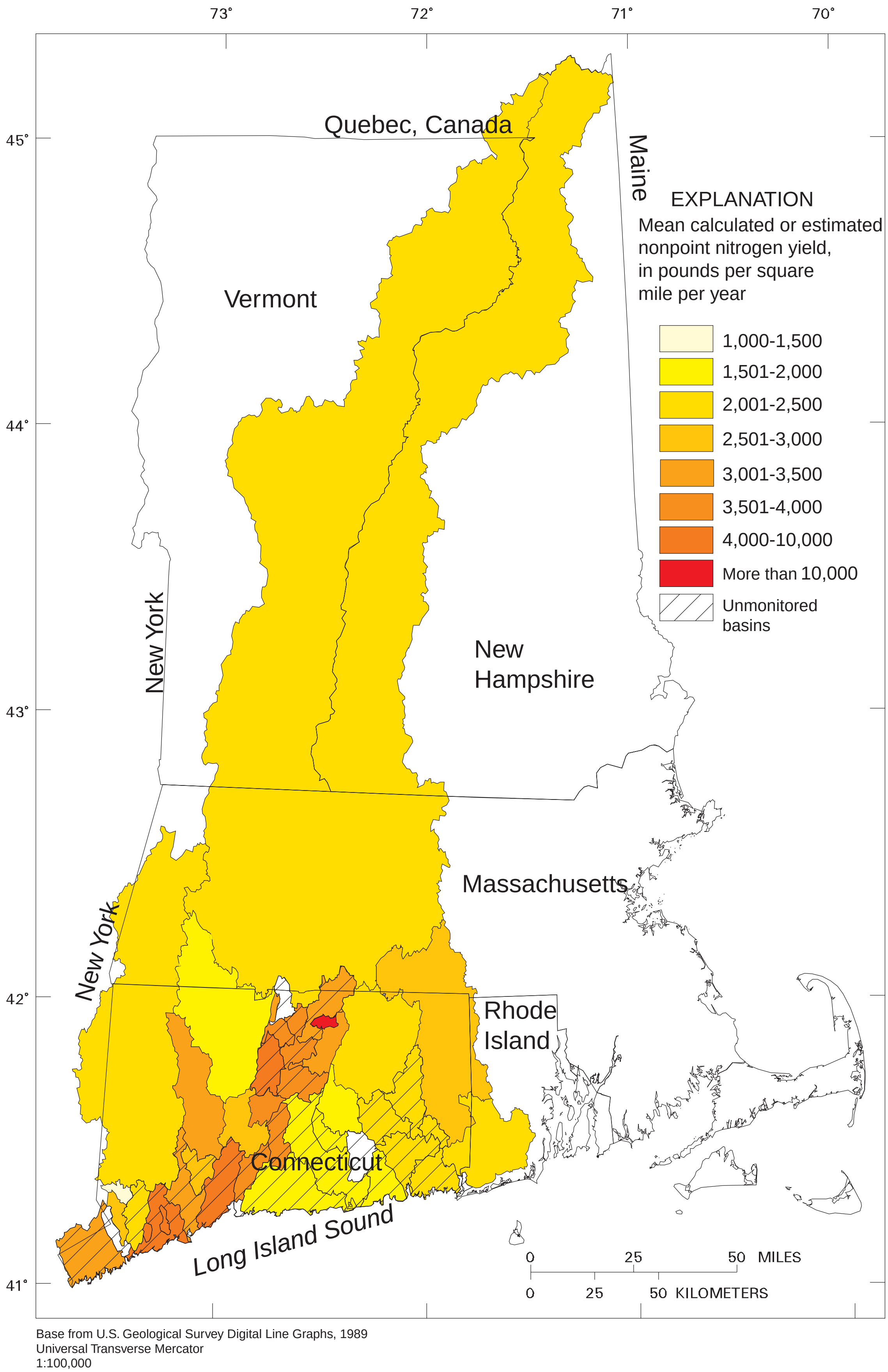


Figure 11. Average nonpoint nitrogen yields from monitored and unmonitored basins draining to Long Island Sound, 1988–98.

Nonpoint nitrogen loads are summarized by the six Long Island Sound management zones (table 6) for 1988–98. The estimated nonpoint nitrogen load during water years 1988–98 ranged from about 21 million lb/yr during water year 1995 to 50 million lb/yr in water year 1990 (table 6). The pattern of nonpoint nitrogen load was similar in all six Long Island Sound management zones (fig. 12). In general, water years 1989 or 1990 had the largest loads. These variations in load generally are related to the amount of total annual runoff from each zone, but this relation is not true in every case. For instance, in management zone 2, the Connecticut River Basin, the largest estimated loads were in water years 1989 and 1990, but the largest total runoff was during water year 1996. The smallest nonpoint nitrogen loads were during water year 1995, a dry year.

Mitchell and others (1996) note increased losses of nitrate to streams at the beginning of water year 1990 at four forested study sites in northern New England and New York. They suggest that high nitrate concentrations at that time related to an unusually cold period with limited snow cover in December 1989 that caused widespread soil freezing and the release of nitrate that previously was immobilized by soil microorganisms. This event was followed by a thawing period, which may have released excess nitrogen to streams. This excess may explain the large nitrogen loads observed in water year 1990 in the Connecticut and Housatonic River Basins (management zones 2 and 4).

Based on annual flow conditions, three water years during the study period may represent normal flow conditions, depending on which Long Island Sound management zone is selected. The total runoff for water years 1991, 1993, and 1994 at selected streamflow-gaging stations is similar to the median total runoff (fig. 13) for water years 1968–1998; therefore, the nonpoint nitrogen loads are likely to be in the normal range during those years. In some cases, however, factors other than annual total runoff also may control the amount of nonpoint nitrogen loads from year to year. These factors include changes in land-use practices over time, variations in the amount and source of atmospheric deposition of nitrogen with time, occurrence of particularly intense or long-duration storm events that may cause extensive erosion, temporal distribution of precipitation in a water year, and soil temperature. Because of these variations, users of these data should be cautious about interpreting apparent trends in the data presented in table 6 and figure 12.

INFORMATION TO IMPROVE NITROGEN LOAD ESTIMATES

Nitrogen load estimates to Long Island Sound can be improved with additional water-quality sampling data. A large percentage of the Connecticut, Housatonic, and Thames Basins (zones 2, 4, 1) is monitored; whereas coastal basins of western Long Island Sound (zones 3, 5, and 6) have limited monitoring (figs. 3, 12). Additional water-quality monitoring stations in these areas would improve the confidence in annual load estimates from these management zones, would assist in understanding nonpoint load estimates from a larger subset of urbanized basins, and would be useful to enhance a regression model designed to estimate nonpoint nitrogen loads for unmonitored basins. It is clear from the results of this study that the confidence intervals on nonpoint nitrogen load estimates for monitored basins (including those with documented wastewater return flow) generally are smaller than for any unmonitored basin. Additional sampling sites in heavily urbanized and (or) high-intensity agricultural basins (with no point sources of nitrogen) would be useful to complement the available data and to confirm estimates from this investigation.

The confidence in nitrogen load estimates from monitored basins also would improve with increased sampling frequency. During 1988–98, sampling frequency at water-quality monitoring stations decreased from 11 or 12 samples per year to 8 samples per year or to 4 samples per year at some stations. The calibration for load calculations using ESTIMATOR is weighted heavily with more frequently collected data from the early part of the study period (water years 1988–93), and high-flow storm events from the latter part of the study period probably are undersampled. Accurate load estimates from stations with quarterly data are not possible because the ESTIMATOR program requires a minimum of 25 samples (but preferably 60 samples) to compute load estimates.

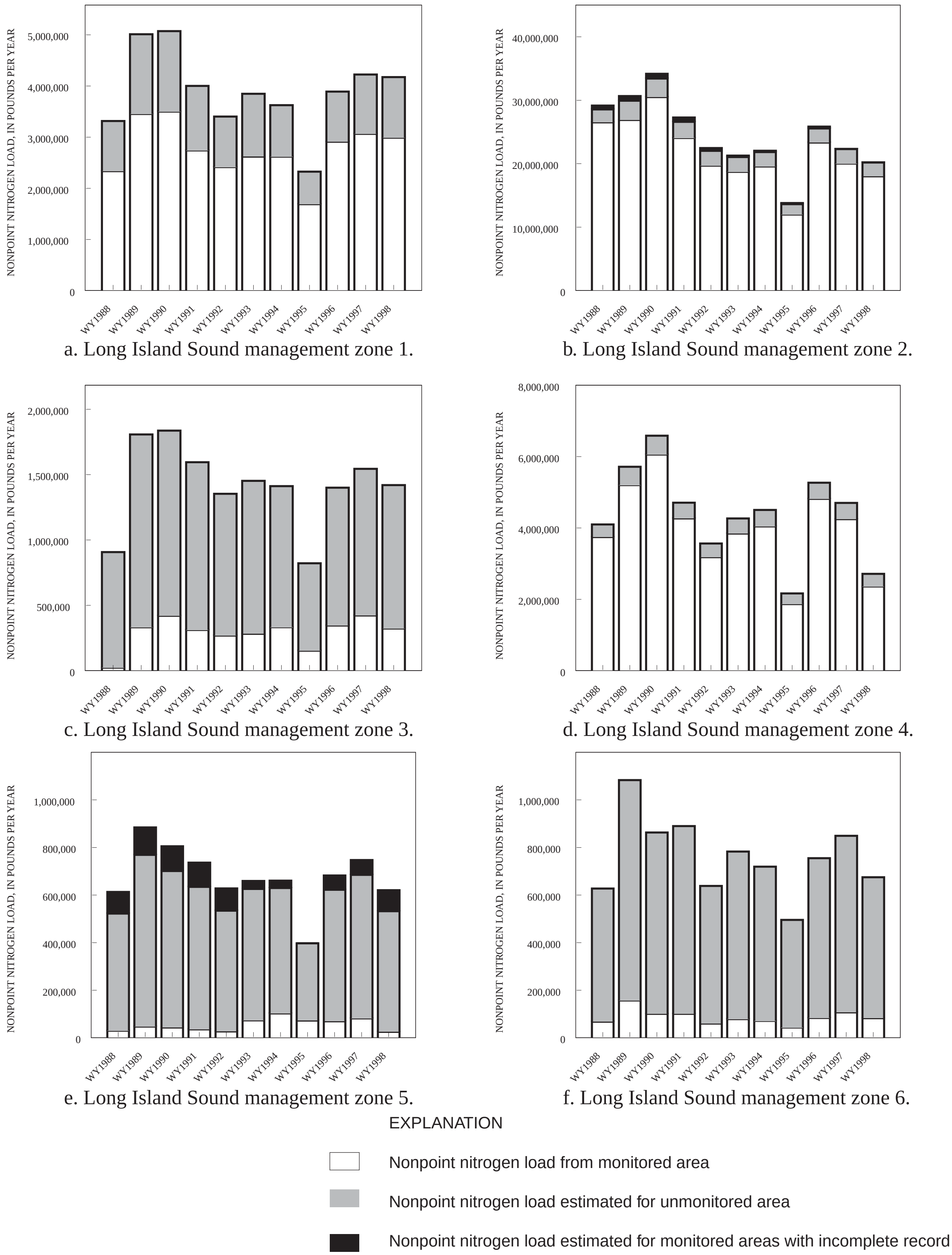


Figure 12. Estimated nonpoint nitrogen loads from Long Island Sound management zones for water years 1988–98.

Table 6. Summary of nonpoint-source nitrogen load estimates from Long Island Sound management zones and the Pawcatuck River, 1988–98

[Numbers have been independently rounded]

Water year	Pawcatuck	Long Island Sound management zones (fig. 1)						Totals
		Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	
			Nonpoint-source nitrogen load, in pounds per year					
1988	720,000	3,300,000	29,000,000	910,000	4,100,000	610,000	630,000	39,000,000
1989	930,000	5,000,000	31,000,000	1,800,000	5,700,000	880,000	1,100,000	46,000,000
1990	980,000	5,100,000	34,000,000	1,800,000	6,600,000	810,000	860,000	50,000,000
1991	740,000	4,000,000	27,000,000	1,600,000	4,700,000	740,000	890,000	40,000,000
1992	740,000	3,400,000	22,000,000	1,400,000	3,600,000	630,000	640,000	33,000,000
1993	720,000	3,800,000	21,000,000	1,500,000	4,300,000	660,000	780,000	33,000,000
1994	600,000	3,600,000	22,000,000	1,400,000	4,500,000	660,000	720,000	34,000,000
1995	550,000	2,300,000	14,000,000	820,000	2,200,000	400,000	500,000	21,000,000
1996	680,000	3,900,000	26,000,000	1,400,000	5,300,000	680,000	760,000	39,000,000
1997	720,000	4,200,000	22,000,000	1,500,000	4,700,000	750,000	850,000	35,000,000
1998	740,000	4,200,000	20,000,000	1,400,000	2,700,000	620,000	670,000	31,000,000

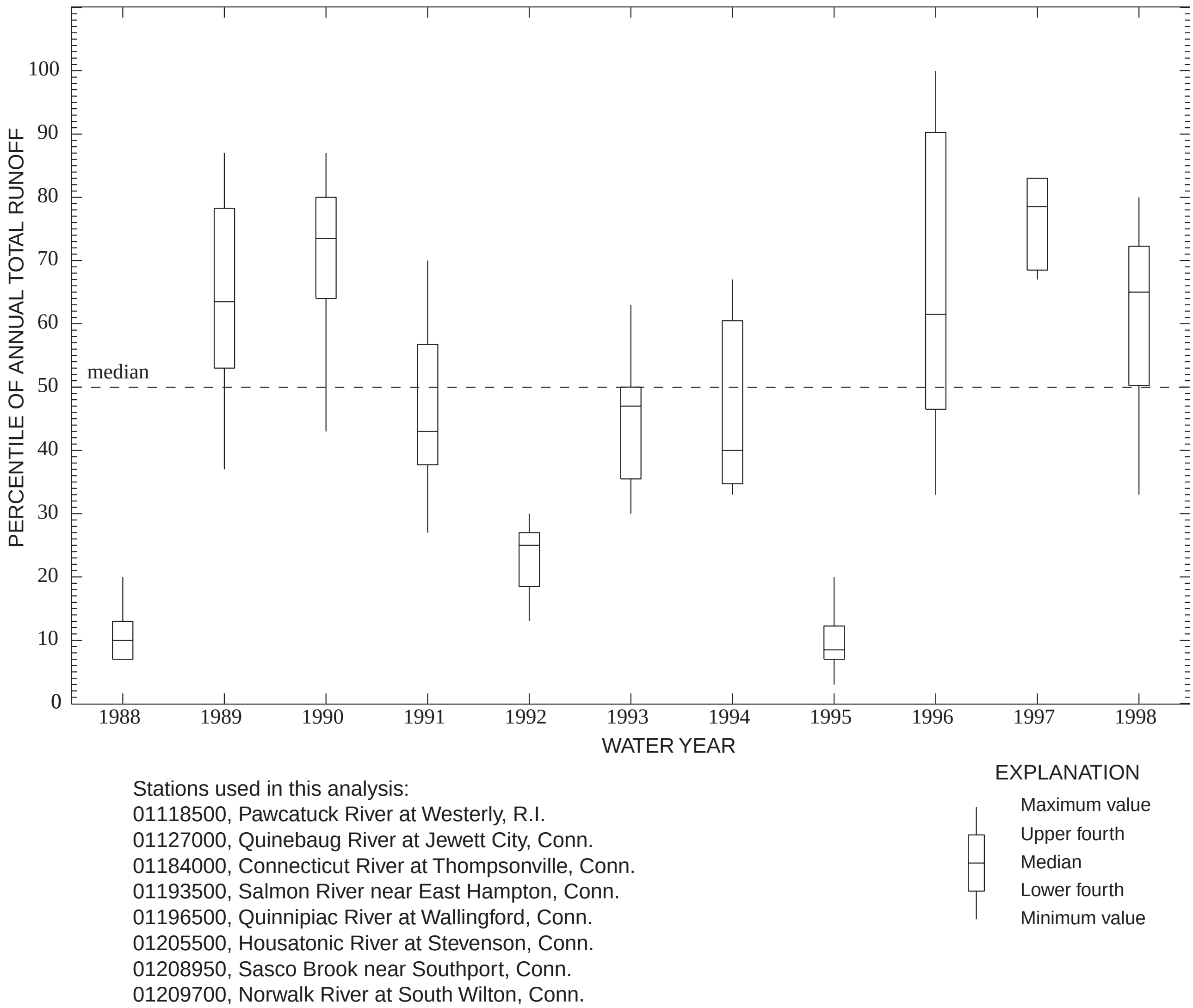


Figure 13. Percentiles of total annual runoff for water years 1988–98 for eight streamflow-gaging stations based on data for water years 1968–98.

The effects of typical sampling strategies on the precision and bias of computing annual loads of sediment-related constituents, including total phosphorus, sediment, and suspended solids, were studied in small basins in Wisconsin (Robertson and Roerish, 1999). They determined that when using the ESTIMATOR model, the best median absolute error for annual loads was about 30 percent. Robertson and Roerish determined (for the sampling frequencies tested) that for studies of 2 or more years, sampling twice per month provided the most precise and unbiased load estimates. With this number of annual samples, a sufficient number of high-flow events will be sampled over time. Additional samples targeted to define concentration during high-flow events, especially peak flow, often result in additional bias in the data because the sampled concentration during a storm may not represent the average flow and concentration during the day on which the storm took place. The ESTIMATOR program uses mean daily flow to compute loads; therefore, the creation of a load model that uses instantaneous discharge may help to improve load estimates during storm events.

Nitrogen concentration data were collected at 10 water-quality stations without streamflow gages. The addition of flow data for these basins would add to the understanding of nonpoint nitrogen loads; however, at some stations, the stage-discharge relation may not be adequate because of unsteady hydraulic conditions or stations may be in tidal river reaches.

Developing a method to determine nitrogen loads in tidal reaches of major rivers also would improve load estimates. For example, stage data and nitrogen concentration data have been collected on the tidal portions of the Connecticut River. A model could be constructed to compute loads; alternatively, accurate discharge and concentration data could be collected over a complete tidal cycle to compute the net downstream load of nitrogen.

Estimates of nonpoint nitrogen loads for monitored and unmonitored basins would be improved by using the detailed temporal data that now are available on flow and nitrogen concentrations from municipal wastewater-treatment facilities in Connecticut. Estimates also would improve if comparable data were available for municipal wastewater-treatment facilities outside Connecticut. Additional data sets that would improve the confidence in nonpoint load estimates for monitored and unmonitored basins, such as land use and population density data for each year, would be useful but may not be available in the near future.

Annual data on atmospheric nitrogen deposition in each management zone might improve the output of a multiple-regression model if it were added as an extra variable. The significance of the variable “ratio of deciduous forest to total forest” indicates that there may be differences in the way nitrogen is stored in and (or) exported from in forested parts of basins in the study area; therefore, there may not be a strong relation between annual atmospheric deposition and annual export from forested basins. The yield data from forested basins show that, based on atmospheric nitrogen deposition estimates presented by Trench (2000), much less nitrogen is exported from forested basins than is deposited. Additional information on the relations among forest history, forest type, and nitrogen export may be useful in understanding the way in which forested basins store, process, and release nitrogen to streams.

Index streamflow stations were used to estimate nitrogen loads from unmonitored basins. To improve the load estimates based on these flows, a water-diversion tracking system is necessary. In many cases, water has been diverted into or out of a basin. Information on the net loss or gain of water from each unmonitored basin would improve estimates of nonpoint nitrogen loads.

Finally, studies of instream loss of nitrogen would help to refine current estimates. Field-scale studies or models such as SPARROW may be useful in estimating the amount of nitrogen that reaches Long Island Sound.

SUMMARY AND CONCLUSIONS

Nitrogen loads from 28 monitored and 26 unmonitored basins draining to Long Island Sound were estimated for water years 1988–98 to assist in understanding hypoxia in Long Island Sound and to provide information on the annual variability and relative contribution of nonpoint nitrogen loads from different basins and Long Island Sound management zones.

Total nitrogen loads from monitored basins were estimated using a regression model that relates constituent concentrations to streamflow and time. Total average nitrogen yields ranged from 1,100 lb/mi^2/yr in basins that primarily were forested to 15,000 lb/mi^2/yr in two basins—one dominated by agriculture and one with a relatively large percentage of the annual flow derived from the input of treated wastewater.

Nonpoint nitrogen loads from 26 unmonitored basins for 1988–98 were estimated through the use of a GLS multiple-linear regression model coupled with an analysis of error components. The regression model relates calculated annual yield of nitrogen from monitored basins to basin characteristics. The model also was used to estimate nonpoint nitrogen loads from monitored basins with point sources and for stations with incomplete water-quality records. Explanatory variables that were statistically significant in the GLS model included percentage of urban/recreational grasses (turf), percentage of agricultural land, population density, annual mean runoff (minus wastewater return flow), point-source nitrogen yield from wastewater-treatment facilities with flow and concentration data for water year 1998, percentage of forested area classified as strictly deciduous, and water year.

Estimates of average nonpoint nitrogen yields ranged from 1,500 to 6,000 lb/mi^2/yr from unmonitored basins and 1,100 to 15,000 lb/mi^2/yr from monitored basins. The largest nonpoint nitrogen yield from a monitored basin was from the Broad Brook Basin. The largest estimated nonpoint nitrogen yield from an unmonitored basin was from the Park River Basin. The average inner 90-percent confidence intervals for predictions of nonpoint nitrogen yield was 29 percent from unmonitored basins and 25 percent from monitored basins, including those with missing data.

Estimated nonpoint nitrogen loads from the study area ranged from 21 million lb in water year 1995 to 50 million lb in water year 1990. Larger annual nonpoint nitrogen loads generally were related to years with the largest total runoff. Variations in nitrogen load with time also may be caused by land-use changes, variations in atmospheric deposition of nitrogen, and the timing and intensity of precipitation.

To improve nitrogen load estimates from basins draining to Long Island Sound and compute nitrogen loads in the future, some changes in the monitoring program would be useful, including (1) additional (more frequent) water-quality samples at sites where sampling has been reduced to quarterly; (2) additional water-quality monitoring stations in southwestern Connecticut where monitoring is limited; (3) additional monitoring stations in basins with high-intensity urban and agricultural land use; (4) additional streamflow-gaging stations at or near selected water-quality stations to determine mean daily discharge; (5) information on nitrogen loads in tidally affected areas, including the lower Connecticut River; (6) availability of consistent annual data sets for land use, population density, and nitrogen flow and concentration data for municipal wastewater-treatment facilities outside Connecticut; and (7) studies on nitrogen-source identification, including how atmospheric nitrogen is processed in different forest types, urban areas, and agricultural areas.

REFERENCES CITED

(includes references cited in appendix 2)

Amemiya, Takeshi, 1985, Advanced econometrics: Cambridge, Mass., Harvard University, 521 p.

Anderson, T.W., and Hsiao, C., 1982, Formulation and estimation of dynamic models using panel data: Journal of Econometrics, v. 18, no. 1, p. 47-82.

Cervione, M.A., Jr., Davies, B.S. 3rd, Bohr, J.R., and Bingham, J.W., 1989, Water resources data, Connecticut, water year 1988: U.S. Geological Survey Water-Data Report CT-88-1, 346 p.

Cervione, M.A., Jr., Davies, B.S. 3rd, Bohr, J.R., and Hunter, B.W., 1990, Water resources data, Connecticut, water year 1989: U.S. Geological Survey Water-Data Report CT-89-1, 321 p.

———1991, Water resources data, Connecticut, water year 1990: U.S. Geological Survey Water-Data Report CT-90-1, 265 p.

———1992, Water resources data, Connecticut, water year 1991: U.S. Geological Survey Water-Data Report CT-91-1, 255 p.

———1993, Water resources data, Connecticut, water year 1992, U.S. Geological Survey Water-Data Report CT-92-1, 261 p.

Cohn, T.A., 1988, Adjusted maximum likelihood estimation of the moments of lognormal populations from Type 1 censored samples: U.S. Geological Survey Open-File Report 88-350, 34 p.

Cohn, T.A., Caulder, D.L., Gilroy, E.J., Zynjuk, L.D., and Summers, R.M., 1992a, The validity of a simple statistical model for estimating fluvial constituent loads—an empirical study involving nutrient loads entering Chesapeake Bay: Water Resources Research, v. 28, no. 9, p. 2353-2363.

Cohn, T.A., DeLong, L.L., Gilroy, E.J., Hirsch, R.M., and Wells, D.K., 1989, Estimating constituent loads: Water Resources Research, v. 25, no. 5, p. 937-942.

Cohn, T.A., Gilroy, E.J., and Baier, W.G., 1992b, Estimating fluvial transport of trace constituents using a regression model with data subject to censoring: Proceedings of the Joint Statistical Meeting, Boston, August 9-13, 1992, p. 142-152.

Cramer, J.S., 1986, Econometric applications of maximum likelihood methods: Cambridge, Cambridge University Press, 208 p.

Davies, B.S., 3rd, Bohr, J.R., and Hunter, B.W., 1994, Water resources data, Connecticut, water year 1993: U.S. Geological Survey Water-Data Report CT-93-1, 273 p.

Davies, B.S., 3rd, Bohr, J.R., Mullaney, J.R., and Morrison, Jonathan, 1995, Water resources data, Connecticut, water year 1994: U.S. Geological Survey Water-Data Report 94-1, 333 p.

Davies, B.S., 3rd, Bohr, J.R., Morrison, Jonathan, Kiesman, S.S., and Loos, D.A., 1996, Water resources data, Connecticut, water year 1995: U.S. Geological Survey Water-Data Report 95-1, 367 p.

Davies, B.S., 3rd, Morrison, Jonathan, Kiesman, S.S., and Colombo, M.J., 1997, Water resources data, Connecticut, water year 1996: U.S. Geological Survey Water-Data Report 96-1, 275 p.

Davies, B.S., 3rd, Morrison, Jonathan, Bohr, J.R., and Sargent, T.C., 1998, Water resources data, Connecticut, water year 1997: U.S. Geological Survey Water-Data Report 97-1, 328 p.

Davies, B.S., 3rd, Morrison, Jonathan, Norris, J.R., and Organek, J.A., 1999, Water resources data, Connecticut, water year 1998: U.S. Geological Survey Water-Data Report 98-1, 340 p.

Ficke, J.F., and Hawkinson, R.O., 1975, The national stream quality accounting network (NASQAN)—some questions and answers: U.S. Geological Survey Circular 719, 23 p.

Gadoury, R.A., Socolow, R.S., Girouard, G.G., and Ramsbey, L.R., 1994, Water resources data, Massachusetts, water year 1993: U.S. Geological Survey Water-Data Report MA-93-1, 266 p.

———1995, Water resources data, Massachusetts, water year 1994: U.S. Geological Survey Water-Data Report MA-94-1, 314 p.

Gilroy, E.J., Hirsch, R.M., and Cohn, T.A., 1990, Mean square error of regression-based constituent transport estimates: Water Resources Research, v. 26, no. 9, p. 2069-2077.

Hammond, R.E., Coakley, M.F., Keirstead, Chandlee, and Kiah, R.G., 1996, Water resources data, New Hampshire and Vermont, water year 1995: U.S. Geological Survey Water-Data Report NH-VT-95-1, 205 p.

Judge, G.G., Griffiths, W. E., Hill, R.C., Lütkepohl, Helmut, and Lee, Tsoung-Chao, 1985, The theory and practice of econometrics, 2nd ed.: New York, Wiley, 1019 p.

Lewis, L.P., and Likens, G.E., 2000, Low stream nitrate concentrations associated with oak forest on the Allegheny high plateau of Pennsylvania: Water Resources Research, v. 36, no. 10, p. 3091-3094.

Lillard, L.A., and Willis, R.J., 1978, Dynamic aspects of earning mobility: Econometrica, v. 46, no. 5, p. 985-1012.

Long Island Sound Study, 1998, Phase III actions for hypoxia management: U.S. Environmental Protection Agency, 28 p.

Medalie, Laura, 1996, Wastewater collection and return flow in New England, 1990: U.S. Geological Survey Water-Resources Investigations Report 95-4144, 79 p.

Mitchell, M.J., Driscoll, C.T., Kahl, J.S., Likens, G.E., Murdoch, P.S., Pardo, L.H., 1996, Climate control of nitrate loss from forested watersheds in the northeast United States: Environmental Science and Technology, v. 30, no. 8, p. 2609-2612.

New York State Department of Environmental Conservation/Connecticut Department of Environmental Protection, 2000, A total maximum daily load analysis to achieve water-quality standards for dissolved oxygen in Long Island Sound: Albany, N.Y., and Hartford, Conn., 73 p.

Patton, C.J., and Truitt, E.P**.,** 2000, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—determination of ammonium plus organic nitrogen by a Kjeldahl digestion method and an automated photometric finish that includes digest cleanup by gas diffusion: U.S. Geological Survey Open-File Report 00-170, 31 p.

Price, C.V., and Clawges, R.M., 1999, Digital data set describing water use, toxic chemical releases, metropolitan areas, and population density of the conterminous United States: U.S. Geological Survey Open-File Report 99-78, scale 1:2,000,000 [CD-ROM disk].

Robertson, D.M., and Roerish, E.D., 1999, Influence of various water quality sampling strategies on load estimates for small streams: Water Resources Research, v. 35, no. 12, p. 3747-3759.

Scorca, M.P., and, Monti, J.,Jr., 2001, Estimates of nitrogen loads entering Long Island Sound from ground water and streams on Long Island, New York, 1985-96: U.S. Geological Survey Water-Resources Investigations Report 00-4196, 29 p.

Socolow, R.S., Comeau, L.Y., Casey, R.G., and Ramsbey, L.R., 1996, Water resources data, Massachusetts, water year 1995: U.S. Geological Survey Water-Data Report MA-95-1, 428 p.

Smith, R.A., Schwarz, G.E., Alexander, R.B., 1997, Regional interpretation of water-quality monitoring data: Water Resources Research, v. 33, no. 12, p. 2781-2798.

Taub, A.J., 1979, Prediction in the context of the variance-components model: Journal of Econometrics, v. 10, p. 103-108.

Toppin, K.W., McKenna, K.E., Cotton, J.E., and Flanagan, S.M., 1994, Water resources data, New Hampshire and Vermont, water year 1993: U.S. Geological Survey Water-Data Report NH-VT-93-1, 174 p.

Toppin, K.W., Coakley, M.F., Keirstead, C., and Flanagan, S.M., 1995, Water resources data, New Hampshire and Vermont, water year 1994: U.S. Geological Survey Water-Data Report NH-VT-94-1, 210 p.

Trench, E.C.T., 2000, Nutrient sources and loads in the Connecticut, Housatonic, and Thames River Basins: U.S. Geological Survey Water-Resources Investigations Report 99-4236, 66 p.

U.S. Environmental Protection Agency, State of Connecticut, State of New York, Interstate Sanitation Commission, and National Oceanic and Atmospheric Administration, 1985, Long Island Sound estuarine study, water quality management strategy: 10 p.

Vogelmann, J.E., Sohl, T.L., Campbell, P.V., Shaw, D.M., 1998, Regional land cover characterization using LANDSAT thematic mapper data and ancillary data sources: Environmental Monitoring and Assessment, v. 51, p. 415-428.

Weiss, L.A., 1983, Evaluation and design of a streamflow data network for Connecticut: Connecticut Water Resources Bulletin 36, 30 p.

APPENDIXES

Appendix 1. Parameter estimates and coefficient of determination for explanatory variables used in ESTIMATOR total nitrogen load calculations at monitoring stations in basins draining to Long Island Sound

Q, discharge; T vel]

U.S. Geological Survey station identification number	Site number (see figs. 2, 3)	Regression intercept	Explanatory variables and parameter estimates									
			ln[Q]	ln[Q]^2	ln[Q]$^{1/2}$	T	T^2	sin[$2\pi T$]	cos[$2\pi T$]	sin[$4\pi T$]	cos[$4\pi T$]	Coefficient of determination (R^2)
01154500[1]	1	9.3885	0.9697	0.1379	--	-0.0543	-0.0097	0.2925	0.0205	--	--	77.9
01170100	2	3.3686	.9290	.0542	--	-.0640	--	.1936	.2027	--	--	98.9
01118500	3	6.5883	.7506	-.1183	--	-.0340	.0028	-.0385	-.0050	--	--	85.5
01192704	4	4.9766	.9950	-.0544	--	-.0161	-.0084	-.0132	-.0642	--	--	97.4
01205500	5	7.5507	1.0046	.0165	--	-.0407	-.0025	-.0201	.0946	--	--	93.4
01122610	6	6.5464	.7838	.0796	--	-.0470	.0009	-.0636	.0114	--	--	86.3
01124000	7	5.2867	.7266	.0130	--	-.0489	.0082	--	--	.1051	.1089	87.5
01127000	8	7.3122	.8971	-.0323	--	-.0112	.0055	-.0516	-.0156	--	--	90.3
01135300[1]	9	3.5115	1.2976	--	--	-.0663	--	.1612	.2818	--	--	83.1
01137500[1]	10	4.7607	.9596	.0655	--	-.0080	--	.1302	.0882	--	--	97.7
01144000[1]	11	6.2201	1.0016	.1515	--	--	--	.1707	.2316	--	--	72.7
01184000	12	10.0134	.7854	.0245	--	-.0565	.0060	.0615	.0537	--	--	79.8
01184100[1]	13	3.4725	.9114	-.0276	--	-.0389	-.0054	-.0590	-.0908	--	--	95.5
01184490	14	-.4951	-2.4707	-0.7726	1.0847	-.0030	.0174	.0344	.1177	--	--	97.9
01186800[1]	15	5.6225	.6021	.0060	--	-.0017	-.0050	-.0761	.0184	--	--	74.9
01188000	16	2.3063	.9101	.0168	--	-.0051	-.0079	.0059	-.0085	--	--	76.8
01188090	17	6.1641	1.0621	.1333	--	-.0680	.0078	-.1520	-.0605	--	--	66.7
01189000[1]	18	6.6660	.3224	.0192	--	-.1032	.1961	.0173	.0395	--	--	70.6
01189995	19	8.3106	.8797	.0984	-.0166	-.0299	--	-.0410	.0369	--	--	71.5
01192500	20	7.0229	.6308	-.0235	--	-.0284	0.0007	-.0234	.0647	--	--	87.8
01193500	21	4.3697	1.1608	-.0334	--	-.0894	.0036	-.0166	-.1670	--	--	88.4
01196500	22	7.1866	.4926	.0298	--	.0047	-.0024	.0167	.0320	--	--	56.0
01199900[1]	23	5.7341	.9887	.0169	--	.0180	-.0300	.1338	.1421	--	--	97.9
01208500	24	7.7197	.4512	.0698	--	-.0406	.0077	-.1265	-.0175	--	--	70.1
01208873[1]	25	4.2785	.9922	-.0739	--	-.0692	-.3153	.0998	-.0121	--	--	96.6
01208950	26	2.1798	1.0476	-.0014	--	.0229	-.1216	.2127	.2115	--	--	98.0
01208990	27	2.1355	.9561	-.0449	.0523	-.0585	.0080	-.1530	-.1761	--	--	86.0
01209710	28	3.8824	1.0659	-.0353	--	-.0403	.0113	-.0167	-.0802	--	--	90.5

[1]Total nitrogen load estimates for these stations are from Trench (2000).

Appendix 2. Model calibration and prediction

by G.E. Schwarz

This appendix provides a rigorous derivation of the statistical model used in this report and methods applied in its estimation. The estimation methods are standard approaches described in the literature for addressing models with serially correlated error components. The calibrated model is used to make yearly basin-specific estimates of total nitrogen yield, excluding nitrogen of point-source origin. Various methods of prediction are described to accommodate basins either with monitoring data for all years, with monitoring data for some years, or without any monitoring data. Additionally, a new approach is described to determine confidence intervals under conditions in which estimated annual loads are measured with error that cannot be observed. The resulting method produces inner and outer limits on the estimated confidence intervals.

Model Description

The model describing annual total nitrogen (TN) yield for basin i, $i = 1,\ldots, N$, in year t, $t = 1,\ldots, T_i$, is given by the equation

$$y_{it} = X_{it}\beta + w_{it} \ , \qquad (1)$$

where y is TN yield, X is a vector of explanatory variables, β is a vector of coefficients, and w is a normally distributed error assumed to be independent of X at all leads and lags and assumed to be independent across basins. The vector of residuals w_i within basin i is not assumed to be independent and has a corresponding error covariance matrix Σ_i. The dependence of this covariance matrix on i is assumed to arise from different basins having different periods of record and is not a presumed consequence of a different underlying covariance structure.

In practice, the dependent variable TN yield in (1) never is directly observed and must be estimated from a basin-specific regression model calibrated with infrequently collected measurements of TN concentration. Let $\tilde{y}_{it}$ represent the t-th annual prediction of TN yield from the basin i-specific regression. Under the assumption that the predicted annual yield is unbiased as

$$y_{it} = \tilde{y}_{it} + v_{it} \ , \qquad (2)$$

where v_{it} is an error term assumed to be normally distributed and independent of $\tilde{y}_{it}$ with covariance matrix Ψ_i. If we make the additional assumption that v_{it} is independent across basins and uncorrelated with X at all leads and lags, then we may substitute (2) into (1) for y_{it} to obtain the valid, and estimable regression model

$$\tilde{y}_{it} = X_{it}\beta + z_{it} \ , \qquad (3)$$

where $z_{it} = w_{it} - v_{it}$ is a normally distributed error, independent across basins but serially correlated within a basin according to the covariance matrix Σ_i.

A commonly used covariance structure for time-series, cross-sectional models is the error components model (Judge and others, 1985, p. 521-525; Amemiya, 1985, p. 211-217). This model is appropriate if it is suspected that errors within a cross section are correlated due to a common, unspecified cause. Generally, this type of correlation could be easily corrected by including a set of indicator variables for each cross-sectional unit among the predictor variables (X). However, if the X variables already include variables that are constant over time, the inclusion of these indicator variables will be collinear with the X variables, making it impossible to obtain estimates of the coefficients for the time-constant variables. Additionally, indicator variables introduce a conceptual difficulty when the model is to be used to predict for cross-sectional units not included in the calibration model, raising the question, what values should be assigned to the indicators for the excluded units?

The error components model assumes the error term z_{it} is composed of two component errors—a fixed error that is common to all observations in a given cross-sectional unit and an idiosyncratic error that varies across time. The simplest error components model assumes the idiosyncratic error is independent across time. However, experience has shown that the idiosyncratic component typically indicates additional serial correlation over time. In this case, the error components model can be generalized by assuming a first-order autocorrelation process for the idiosyncratic error. The resulting generalized error components model takes the form

$$z_{it} = u_i + e_{it} \ , \qquad (4)$$

where u_i is the fixed-effect error common to all observations in basin i, and e_{it} is an idiosyncratic error. The common error u_i is assumed to be normally distributed, independent across i, with a mean of zero and variance σ_u^2. The idiosyncratic error also is normally distributed, independent across i, with a mean of zero and covariance within basin i given by

$$E(e_{it}e_{is}) = \begin{cases} \sigma_e^2, & \text{for } s = t \\ \sigma_e^2 \rho^{|t-s|}, & \text{for } s \neq t \end{cases}, \qquad (5)$$

where ρ is a serial correlation parameter bounded between -1 and 1. Therefore, the error covariance structure for the vector of basin i errors, z_i, can be expressed in matrix notation as

$$\Sigma_i = \sigma_e^2 A_i + \sigma_u^2 j_{T_i} j'_{T_i}, \qquad (6)$$

where

$$A_i = \begin{bmatrix} 1 & \rho & \rho^2 & \dots & \rho^{T_i - 1} \\ \rho & 1 & \rho & \dots & \rho^{T_i - 2} \\ \rho^2 & \rho & 1 & \dots & \rho^{T_i - 3} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \rho^{T_i - 1} & \rho^{T_i - 2} & \rho^{T_i - 3} & \dots & 1 \end{bmatrix} \qquad (7)$$

and j_{T_i} is a $T_i \times 1$ vector of ones.

Estimation Methodology

The presence of a non-scalar error covariance matrix Σ_i leads to a number of complications in the estimation of the regression model (3). First, although ordinary least squares (OLS) estimates of β are unbiased, they are not efficient—meaning that there are alternative estimators that also are unbiased but produce a smaller error variance for the coefficient estimates. Additionally, the standard OLS estimate of the coefficient covariance matrix is biased leading to potential errors in deciding the statistical significance of the estimated coefficients.

An alternative estimation method that is unbiased, efficient, and produces unbiased estimates of the coefficient covariance matrix is generalized least squares (GLS) (Judge and others, 1985, p. 522-523). The GLS method is implemented by invoking a linear transformation of the regression data such that the resulting errors are independent and identically distributed. The linear transformation consists of pre-multiplying all regression variables by the root of the inverse of the error covariance matrix, $\Sigma^{-1/2}$. Given the independence of observations across basins, the transformation can be done on a basin-by-basin basis to obtain

$$\tilde{y}_i^* = \Sigma_i^{-1/2} \tilde{y}_i \text{ , } X_i^* = \Sigma_i^{-1/2} X_i, \text{ and } z_i^* = \Sigma_i^{-1/2} z_i \qquad (8)$$

where an asterisk denotes the transformed vector or matrix of the corresponding original model variables. The GLS estimator for β is obtained by performing an OLS regression using the transformed data. The transformed error vector z_i^* has zero mean and a scalar covariance matrix, implying the standard estimate of the coefficient covariance vector is unbiased.

To implement the GLS method, it is necessary to have knowledge of the transformation matrix $\Sigma^{-1/2}$. Generally, such knowledge is not available and an estimate of $\Sigma^{-1/2}$ must be formed from estimates of the underlying error covariance parameters σ_e^2, σ_u^2, and ρ. The use of an estimated transformation matrix implies GLS obtains its desirable properties only in large samples; however, an improvement in estimation generally is realized even for a finite sample, as is available in the present case.

Estimation of the error covariance parameters is achieved in three steps. In the first step, an OLS regression is run to estimate the OLS residuals. From these residuals, it was determined that five stations had a much larger error variance than the remaining stations. Consequently, to provide proper weighting among the observations, the second step consisted of multiplying the OLS residuals from the high-variance stations by the ratio of the root mean squared error of the low-variance stations to the root mean squared error of the five high-variance stations. The validity of this transformation for the subsequent estimation of the error covariance parameters depends on an additional assumption that the ratio of the component variances, σ_e^2/σ_u^2, is the same for both high- and low-variance stations. Finally, in the third step, following the procedure of Lillard and Willis (1978), the transformed OLS residuals, $\hat{z}$, are substituted into the normal log-likelihood function (excluding the constant term)

$$l = -\frac{1}{2}\sum_{i}^{N}\{\ln(\det\Sigma_i) + \hat{z}_i'\Sigma_i^{-1}\hat{z}_i\} \quad (9)$$

which subsequently is maximized with respect to the parameters σ_e^2, σ_u^2, and ρ using a quasi-Newton nonlinear optimization algorithm supplied with the SAS IML procedure.

A further modification of the algorithm was made to accommodate gaps in the time series that existed for some of the stations (that is, missing annual observations in the middle of a station's record). The effect of this modification is to eliminate rows and columns from the correlation matrix in (7) corresponding to years where no observation is available. Anderson and Hsiao (1982) show that the full maximum likelihood estimates are consistent and asymptotically efficient as both T_i ($i = 1,\ldots, N$) and N go to infinity. These results carry over to the present analysis.

The covariances of the error covariance parameters can be computed by taking the inverse of the information matrix, H. The information matrix is estimated by taking the negative of the expectation of the second derivative of l with respect to the parameter vector $\theta = \{\sigma_e^2, \sigma_u^2, \rho\}$ and evaluating the result at the estimated parameter vector $\hat{\theta}$ (Cramer, 1986, p. 27). The resulting covariance matrix is asymptotically unbiased.

Estimation Results

The estimates of the error covariance parameters, with asymptotic standard errors, are shown in table 2-1. The results show that the fixed and idiosyncratic errors roughly have equal variance, and the serial correlation coefficient is quantitatively significant at a value of approximately 0.5. Moreover, both the variance of the fixed error and the serial correlation coefficient are statistically significant at 0.005 levels of significance—providing additional justification for the error structure assumed in this analysis. Included in the table is an estimate, k, of the ratio of the root mean squared error for high-variance basins relative to low-variance basins.

Given the estimates of the covariance parameters, the data are then transformed per equation (8) and substituted into the regression model given in (3). The subsequent model, consisting of 210 observations, is estimated using OLS to obtain consistent and asymptotically efficient estimates of the slope coefficients and associated standard errors given in table 4 (see p. 16). The R^2 of the regression, although not easily interpreted under GLS estimation, is 0.94.

A plot of predicted TN yield (transformed) and actual TN yield (also transformed) is shown in figure 7 (see p. 16). The plot shows good agreement across the range of TN yield values. Evidence that the transformations applied to the data indeed have resulted in a scalar error covariance structure is provided in figures 2-1 and 2-2. The boxplots across basins (fig. 2-1) and across years (fig. 2-2) show the transformed residuals are generally both positive and negative within a given basin or year and reasonably homoscedastic. Additionally, a regression of transformed residuals on lagged transformed residuals yields a statistically insignificant serial correlation coefficient (the p-value equals 0.74).

Table 2-1. Maximum likelihood estimates of error covariance parameters and the ratio of the ordinary least squares (OLS) root mean square error (RMSE) between high- and low-variance basins draining to Long Island Sound

[--, not applicable]

Statistic	Variance of idiosyncratic error component (σ_e^2)	Variance of fixed-effect error component (σ_u^2)	Serial correlation coefficient (ρ)	Ratio of OLS RMSE for high- and low-variance basins (k)
Parameter estimate	129,048	114,896	0.487	4.053
Standard error of estimate	22,137	44,411	.090	--
P-value	2.8E-9	.0048	4.0E-8	--

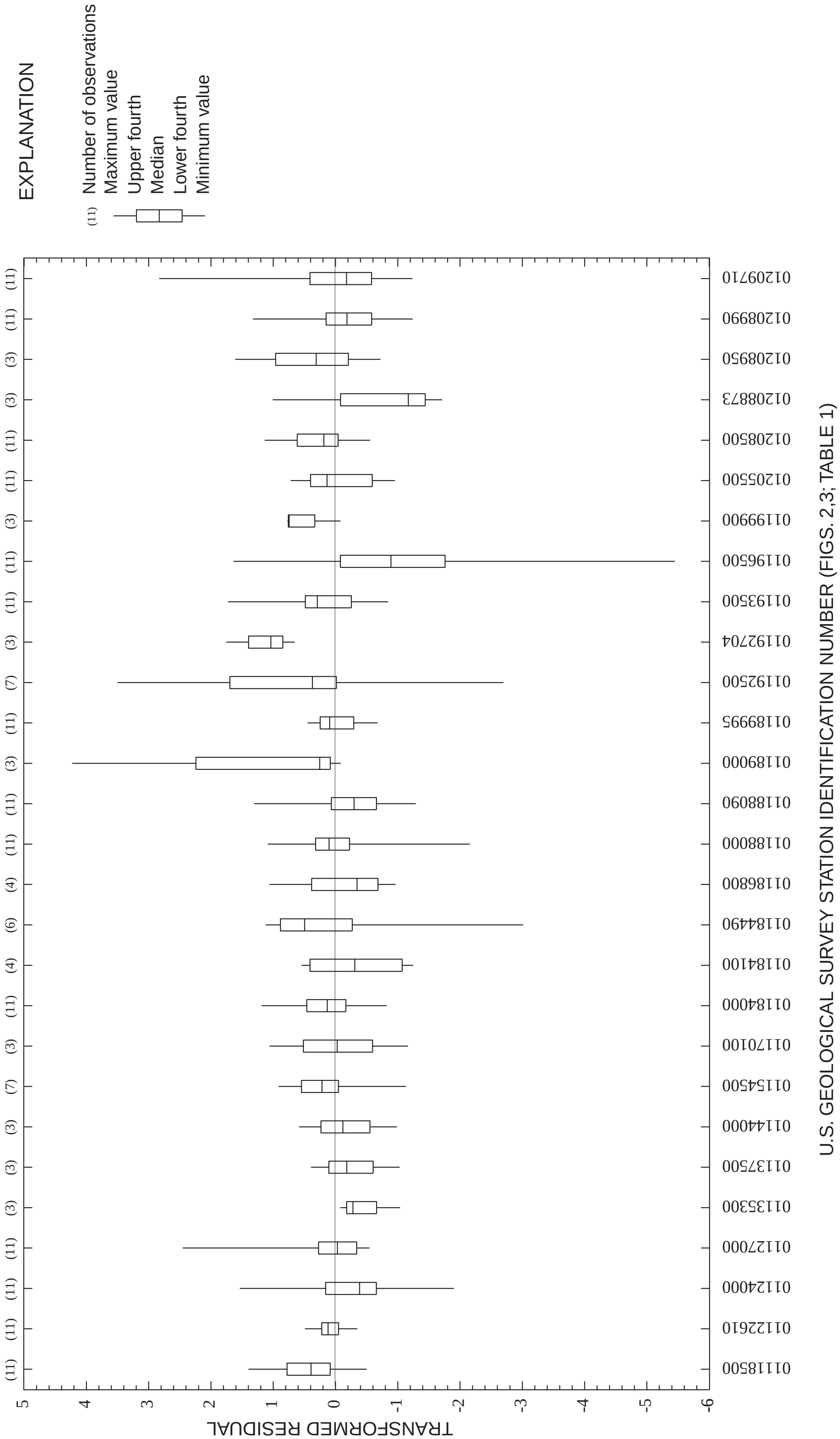


Figure 2-1. Transformed residuals by station in basins draining to Long Island Sound.

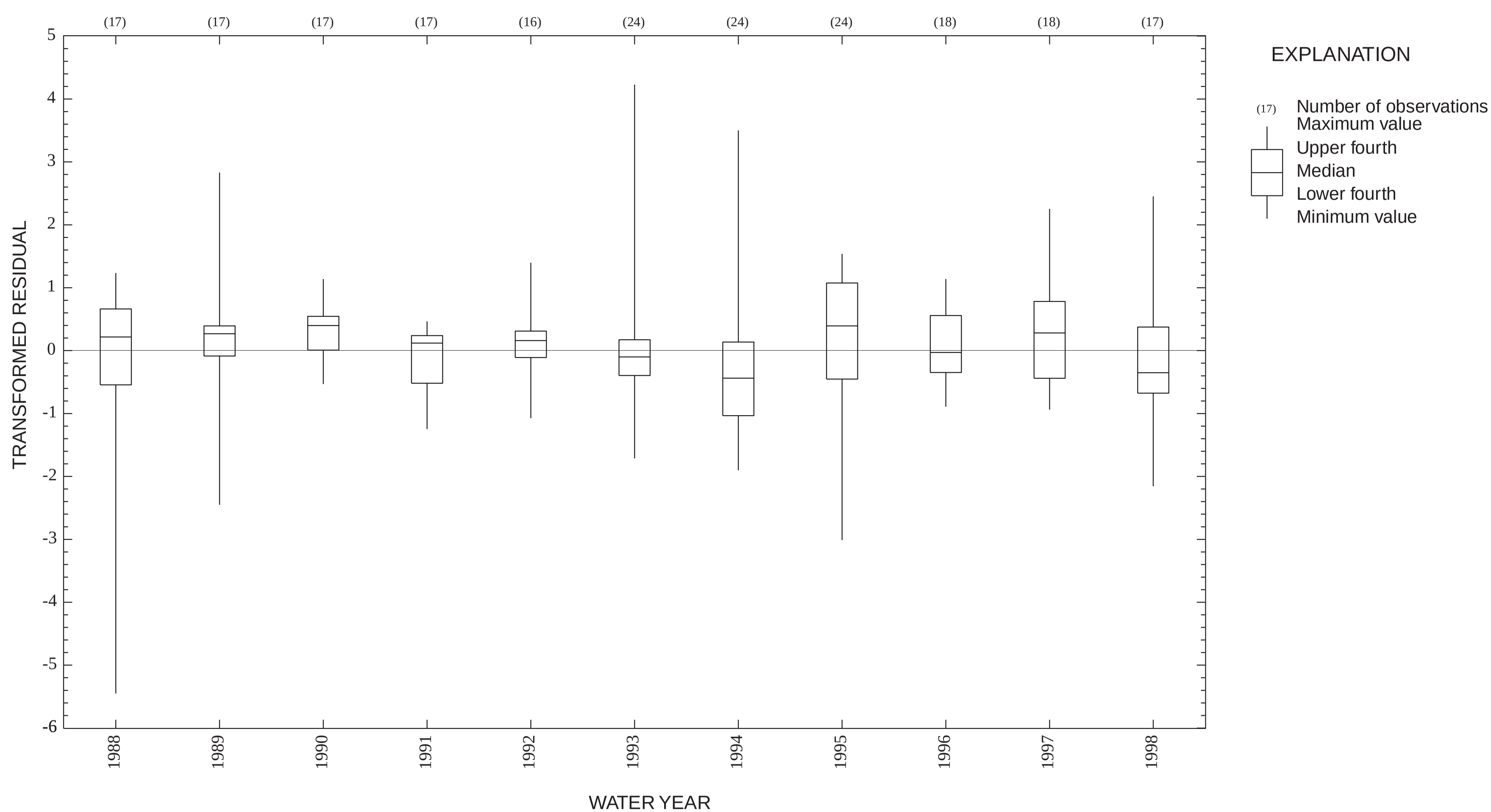


Figure 2-2. Transformed residuals by year, in basins draining to Long Island Sound.

A plot of the histogram of the transformed residuals is shown in figure 2-3. The transformed errors nearly are symmetrically distributed; however, as indicated by the best fit to a normal density function (shown in fig. 2-3 by the curve), the transformed residuals have a greater concentration of values near the mean than should arise if the distribution were truly normal. In the subsequent analysis, the assumption of normality is retained for purposes of estimating confidence intervals around predictions. Given the narrowness of the empirical distribution of errors, this assumption results in confidence intervals that are biased large. The assumption of normality is not required for assessing coefficient significance, as all standard errors are valid only for large samples, in which case normality is assured, regardless of the distribution of the residuals.

Prediction

The final step of the analysis is to make predictions for monitored and unmonitored basins. To assess the likely nitrogen yield arising from nonpoint sources alone, the point- source contribution variables in the model are set to zero. For basins without any monitoring data, the predicted yield in period *t* is given by

$$\hat{y}_{it} = \bar{X}_{it}\hat{\beta} , \qquad (10)$$

where $\bar{X}_{it}$ is the vector of untransformed predictor variables in basin *i* and period *t* with point-source return flow and point-source yield set to zero.

The variance of the prediction error consists of two components—the sample error associated with the error in the estimation of β and the variance of the model error *w* (see equation (1)). Estimation of the sampling error variance is straightforward and is given by $\tilde{X}_{it}V(\hat{\beta})\tilde{X}'_{it}$, where $V(\hat{\beta})$ is the GLS covariance matrix for $\hat{\beta}$. However, estimation of the variance of *w* is not straightforward due to the absence of direct observations of the dependent variable *y*.

In lieu of a direct estimate of the variance of *w*, an alternative method is proposed whereby upper and lower bounds on the variance are determined. From equations (1)-(4), *w* can be written as the sum of three terms,

$$w = u + e + v . \qquad (11)$$

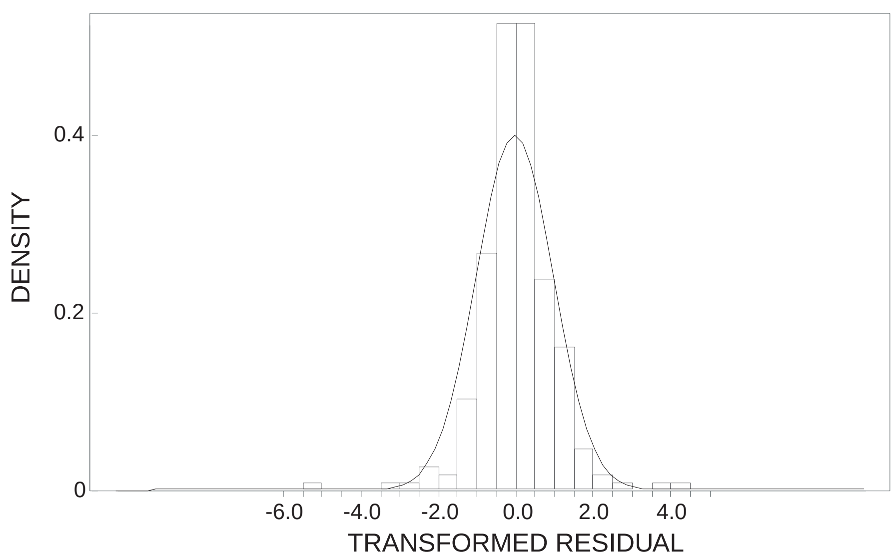


Figure 2-3. The frequency distribution for the transformed residuals and the “best-fit” normal distribution approximation.

In assessing the contributions of each variable to the overall variance of *w*, it is necessary to determine the variance of *v* as well as the covariance between *v* and the other error terms *u* and *e*, a determination that is complicated by the lack of any direct observations on *v*. With respect to potential covariance, note that the basin-specific regressions used to estimate $\tilde{y}$ each include a basin-specific intercept. This intercept implies that *v* cannot have a fixed error component and, therefore, must be independent of the fixed component *u*: all correlation between *v* and *z* must arise from the correlation between *v* and *e* alone. The resulting expression for the variance of *w* is

$$\sigma_w^2 = \sigma_u^2 + \sigma_e^2 + \sigma_v^2 + 2\rho_{ve}\sigma_v\sigma_e \ , \qquad (12)$$

where ρ_{ve} is the correlation coefficient between *v* and *e*.

Without direct knowledge of ρ_{ve}, an upper and lower bound to σ_w^2 can be determined by observing that ρ_{ve} is required to be between -1 and 1. By setting ρ_{ve} at its minimum and maximum possible values, it is seen that

$$\sigma_u^2 + (\sigma_v - \sigma_e)^2 \le \sigma_w^2 \le \sigma_u^2 + (\sigma_v + \sigma_e)^2 \ . \qquad (13)$$

The last obstacle to obtaining a bound for σ_w^2 concerns the estimation of σ_v^2—a variance for which an estimate is supplied from the basin-specific regressions used to estimate $\tilde{y}$ in monitored basins but remains unknown in unmonitored basins. For unmonitored basins, therefore, we make the assumption that σ_v^2 is equal to $\bar{\sigma}_v^2$, an average of σ_v^2 among the monitored basins.

Inner and outer prediction confidence intervals, corresponding to the upper and lower bounds on σ_w^2 defined in eq. (13), are based on a standard formula that assumes normally distributed errors. For an unmonitored basin, these intervals are expressed as

$$\text{Confidence interval for } \hat{y}_{it} = \bar{X}_{it}\hat{\beta} \pm$$

$$t_p\sqrt{\bar{X}_{it}V(\hat{\beta})\bar{X}'_{it} + \sigma_u^2 + \sigma_e^2 + \bar{\sigma}_v^2 \pm 2\sigma_e\bar{\sigma}_v} \qquad (14)$$

where t_p is the *p*-th quantile of the standard normal distribution. For a 90-percent confidence interval, *p* is set to 0.95 (=(1+.90)/2) and t_p equals 1.645. The variances of *u* and *e* are obtained from the maximum-likelihood estimates. Their insertion in eq. (14) implies that all unmonitored basins also are low-variance basins. The term within the radical that is either added or subtracted $(\sigma_e\bar{\sigma}_v)$ defines the outer or inner limits of the upper bound of the confidence interval and the inner or outer limits for the confidence interval's lower bound.

The estimation of confidence intervals for monitored basins must address two possible situations: whether or not the basin has an estimate of $\tilde{y}$ in the given year. If $\tilde{y}$ is known in year *t*, then the prediction is formed by subtracting from $\bar{y}_{it}$ the amount of yield that is estimated to be generated from the two point-source variables. Therefore,

$$. \ \hat{y}_{it} = \tilde{y}_{it} - (X_{it} - \bar{X}_{it})\hat{\beta} \qquad (15)$$

The error in this prediction includes the sampling error in the estimation of $\hat{\beta}$ and the error *v* between y_{it} and $\tilde{y}_{it}$. The equation for the confidence interval of the prediction in eq. (15) is

$$\text{Confidence interval for } \hat{y}_{it} = \tilde{y}_{it} - (X_{it} - \bar{X}_{it})\hat{\beta} \pm$$

$$t_p\sqrt{(X_{it} - \bar{X}_{it})V(\hat{\beta})(X_{it} - \bar{X}_{it})' + \sigma_{vit}^2} \qquad (16)$$

where σ_{vit}^2 is the variance estimate for the prediction of $\tilde{y}_{it}$ from the basin-specific regressions. Technically, because the sampling error is a function of *e*, and *e* is correlated serially, the sampling error and *v* are correlated—a complication that is not reflected in eq. (16).

The prediction for monitored basins in years without an observation of $\tilde{y}_{it}$ is similar to the prediction equation shown in (10) with an additional term representing the conditional prediction of the fixed-effect error u_i. The equation for the predicted value of the fixed-effect error is derived from Bayes Law applied to the probability for u_i conditioned on the vector of untransformed errors for basin *i*, z_i,

$$p(u_i|z_i) = \frac{p(z_i|u_i)p(u_i)}{p(z_i)} \qquad (17)$$

Given the assumptions of normality for z_i and u_i, the three probability functions given on the right-hand side of the equal sign in (17) can be written as

$$p(z_i|u_i) = (2\pi)^{-T_i/2}|\sigma_e^2 A_i|^{-1/2}\exp\left(-\frac{1}{2\sigma_e^2}(z_i - u_i j_{T_i})' A_i^{-1}(z_i - u_i j_{T_i})\right) \quad (18)$$

$$p(u_i) = (2\pi\sigma_u^2)^{-1/2}\exp\left(-\frac{u_i^2}{2\sigma_u^2}\right)$$

$$p(z_i) = (2\pi)^{-T_i/2}|\Sigma_i|^{-1/2}\exp\left(-\frac{1}{2}z'_i\Sigma_i^{-1}z_i\right) .$$

Upon substituting these expressions into eq. (17) and simplifying, the conditional density for u_i is shown to be normal with mean $\hat{u}_i$ and variance $\sigma_{\hat{u}_i}^2$ given by

$$\hat{u}_i = \frac{\sigma_u^2 j'_{Ti} A_i^{-1} z_i}{\sigma_e^2 + \sigma_u^2 + j'_{Ti} A_i^{-1} j_{Ti}} \quad (19)$$

$$\sigma_{\hat{u}_i}^2 = \frac{\sigma_u^2 \sigma_e^2}{\sigma_e^2 + \sigma_u^2 j'_{Ti} A_i^{-1} j_{Ti}} \quad (20)$$

These equations are generalizations of standard results obtained for error components models without serially correlated idiosyncratic errors (see Taub, 1979). In evaluating eqs. (19) and (20), the maximum-likelihood estimates of the error covariance parameters are substituted for the actual parameter values. In eq. (19), the error vectors z_i are estimated from the GLS coefficient estimates applied to the *untransformed* data (with the two point-source variables included). From eq. (20), it is obvious that $\sigma_{\hat{u}_i}^2 < \sigma_u^2$, implying that prediction error is reduced by including $\hat{u}_i$ in the prediction. A histogram of the estimated fixed-effect errors is shown in figure 2-4.

The conditional prediction of TN yield within monitored basin i in year t (with return flow excluded) in which an observation of $\tilde{y}_{it}$ is not available is formed by adding eq. (19) to eq. (10) to obtain

$$\hat{y}_{it} = \bar{X}_{it}\hat{\beta} + \hat{u}_i . \quad (21)$$

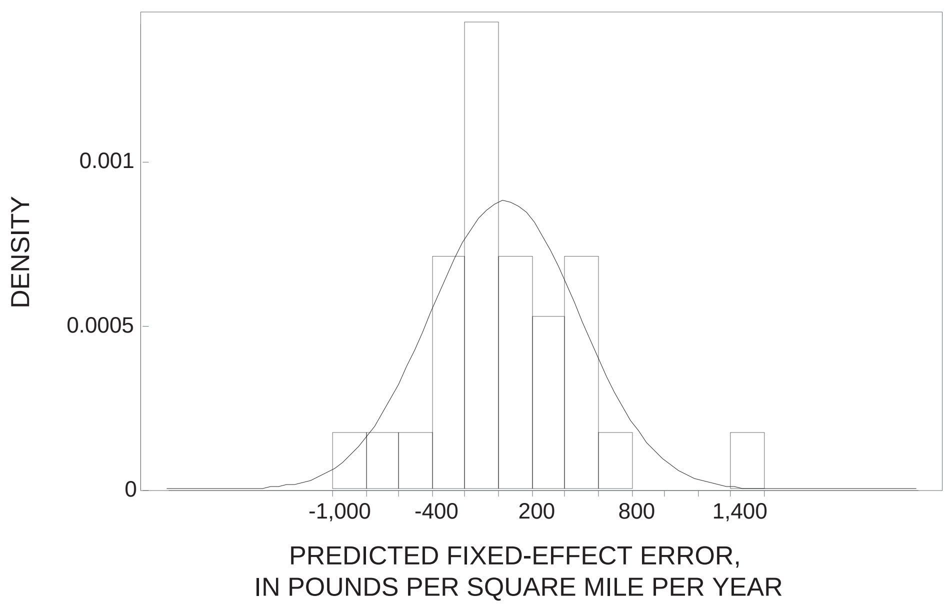


Figure 2-4. The frequency distribution for the estimated fixed-effect errors (μ) and the “best-fit” normal distribution approximation.

The error in this prediction is similar to the errors factored into the computation of the confidence interval shown in (14). Because of the potential correlation between *e* and *v* it is necessary to impose upper and lower bounds on the variance of *w*. The variance for *u* is replaced with the variance for $\hat{u}_i$ given in eq. (20). Although a direct estimate of the variance of *v* is not available for year *t*, a reasonable estimate is $\bar{\sigma}^2_{vi}$, the average of σ^2_{vit} in basin *i* for the years in which $\tilde{y}_{it}$ is estimated. The resulting confidence interval for the prediction given in (21) is shown in eq. 22 below.

In eq. 22, *k* is the ratio of the OLS root mean squared error for high variance basins to the OLS root mean squared error for low variance basins (see table 1) and d_i is 1 for high variance basins and 0, otherwise.

On average, for unmonitored basins, the inner confidence intervals are ± 30 percent of the predicted yield and the outer confidence intervals are ± 53 percent. For monitored basins the inner and outer confidence intervals are ± 22 percent and ± 26 percent of the predicted yield. Predictions and confidence intervals for all basins in the arbitrary year 1995 are shown in figure 2-5.

Confidence interval for $\hat{y}_{it}$ (22)

$$= \bar{X}_{it}\hat{\beta} + \hat{u}_i \pm t_p\sqrt{\bar{X}_{it}V(\hat{\beta})\overline{X'}_{it} + k^{2d_i}(\sigma^2_{\hat{u}i} + \sigma^2_e) + \bar{\sigma}^2_{vi} \pm 2k^{d_1}\sigma_e\bar{\sigma}_{vi}}$$

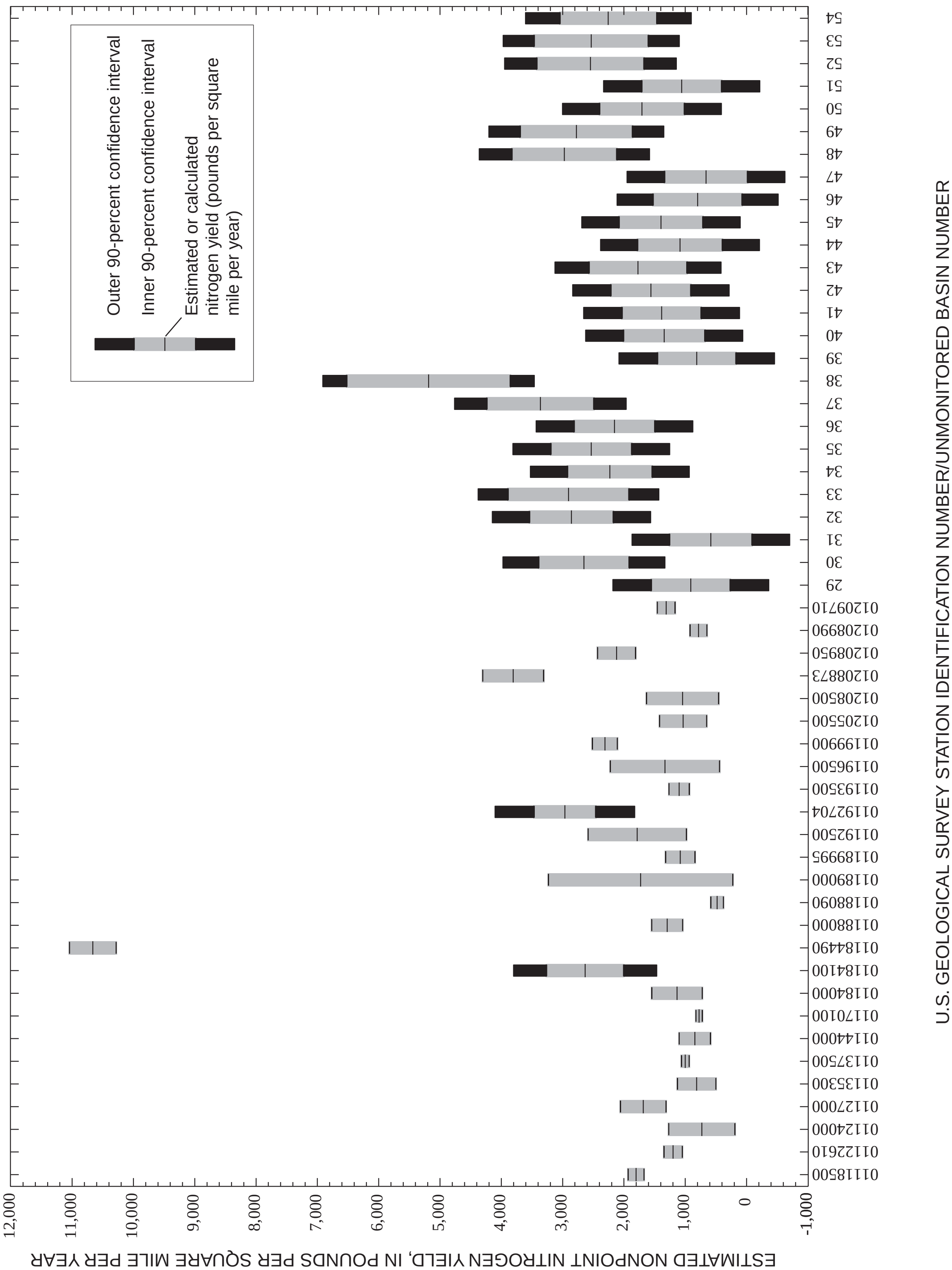


Figure 2-5. Basin predictions in water year 1995 with inner and outer 90-percent confidence intervals.

Appendix 3. Regression model input data and nitrogen loads from monitored basins draining to Long Island Sound, 1988–98

[Numbers have been independently rounded. Total nitrogen yield from ESTIMATOR program. USGS station ID number, U.S. Geological Survey station identification number; mi^2, square mile; in., inches; in/yr, inch per year; lb/mi^2/yr, pound per square mile per year; lb/yr, pound per year; --, data not applicable]

USGS station ID or map number (fig. 3; table 1)	Water year	Drainage area (mi^2)	Percentage of urban and recreational grasses	Percentage of agricultural land	1990 population density (people per mi^2)	Total runoff minus return flow (in.)	Return flow (in/yr)	Yield from wastewater-treatment facilities (lb/mi^2/yr)	Ratio of deciduous to forested area	Total nitrogen yield (lb/mi^2/yr)	Standard error of total nitrogen yield (lb/mi^2/yr)	Total nitrogen load (lb/yr)
						Monitored basins						
01154500	1988	5,493	0.1	8.7	39	23.0	0.06	0	0.4	2,400	280	13,000,000
01154500	1989	5,493	.1	8.7	39	23.3	.06	0	.4	2,400	280	13,000,000
01154500	1990	5,493	.1	8.7	39	31.8	.06	0	.4	2,900	340	16,000,000
01154500	1991	5,493	.1	8.7	39	26.9	.06	0	.4	2,100	250	11,000,000
01154500	1992	5,493	.1	8.7	39	22.6	.06	0	.4	1,500	210	8,500,000
01154500	1993	5,493	.1	8.7	39	21.7	.06	0	.4	1,400	270	7,500,000
01154500	1994	5,493	.1	8.7	39	25.3	.06	0	.4	1,300	330	7,100,000
01170100	1993	41.4	.1	5.3	26	25.5	0	0	.6	1,400	87	58,000
01170100	1994	41.4	.1	5.3	26	25.6	0	0	.6	1,300	52	52,000
01170100	1995	41.4	.1	5.3	26	16.9	0	0	.6	770	31	32,000
01118500	1988	295	4.1	4.8	180	19.1	.004	0	.6	2,400	140	690,000
01118500	1989	295	4.1	4.8	180	27.8	.004	0	.6	3,000	130	900,000
01118500	1990	295	4.1	4.8	180	33.3	.004	0	.6	3,200	140	950,000
01118500	1991	295	4.1	4.8	180	23.2	.004	0	.6	2,400	91	710,000
01118500	1992	295	4.1	4.8	180	23.2	.004	0	.6	2,400	100	720,000
01118500	1993	295	4.1	4.8	180	29.1	.004	0	.6	2,300	120	690,000
01118500	1994	295	4.1	4.8	180	23.7	.004	0	.6	2,000	93	580,000
01118500	1995	295	4.1	4.8	180	19.2	.004	0	.6	1,800	79	530,000
01118500	1996	295	4.1	4.8	180	26.3	.004	0	.6	2,200	110	660,000
01118500	1997	295	4.1	4.8	180	30.2	.004	0	.6	2,400	150	700,000
01118500	1998	295	4.1	4.8	180	35.0	.004	0	.6	2,400	220	720,000
01192704	1996	48.1	4.3	13	860	30.3	0	0	.6	4,300	310	210,000
01192704	1997	48.1	4.3	13	860	27.2	0	0	.6	4,000	230	190,000
01192704	1998	48.1	4.3	13	860	26.3	0	0	.6	3,800	270	180,000
01205500	1988	1,544	1.8	14	210	18.7	.265	500	.7	2,500	150	3,900,000
01205500	1989	1,544	1.8	14	210	24.9	.265	500	.7	3,300	150	5,100,000

Appendix 3. Regression model input data and nitrogen loads from monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. Total nitrogen yield from ESTIMATOR program. USGS station ID number, U.S. Geological Survey station identification number; mi^2, square mile; in., inches; in/yr, inch per year; $lb/mi^2/yr$, pound per square mile per year; lb/yr, pound per year; --, data not applicable]

USGS station ID or map number (fig. 3; table 1)	Water year	Drainage area (mi^2)	Percentage of urban and recreational grasses	Percent-age of agricul-tural land	1990 pop-ulation density (people per mi^2)	Total runoff minus return flow (in.)	Return flow (in/yr)	Yield from wastewater-treatment facilities ($lb/mi^2/yr$)	Ratio of decidu-ous to forested area	Total nitrogen yield ($lb/mi^2/yr$)	Standard error of total nitrogen yield ($lb/mi^2/yr$)	Total nitrogen load (lb/yr)
01205500	1990	1,544	1.8	14	210	30.0	0.265	500	0.7	3,900	160	6,100,000
01205500	1991	1,544	1.8	14	210	23.6	.265	500	.7	3,000	110	4,700,000
01205500	1992	1,544	1.8	14	210	20.6	.265	500	.7	2,500	97	3,800,000
01205500	1993	1,544	1.8	14	210	24.2	.265	500	.7	2,900	150	4,500,000
01205500	1994	1,544	1.8	14	210	27.0	.265	500	.7	3,000	150	4,700,000
01205500	1995	1,544	1.8	14	210	17.3	.265	500	.7	1,900	89	2,900,000
01205500	1996	1,544	1.8	14	210	34.1	.265	500	.7	3,500	210	5,400,000
01205500	1997	1,544	1.8	14	210	30.8	.265	500	.7	3,000	220	4,700,000
01205500	1998	1,544	1.8	14	210	22.7	.265	500	.7	2,000	190	3,100,000
01122610	1988	408	1.6	11	230	17.3	0	550	.7	2,300	140	920,000
01122610	1989	408	1.6	11	230	28.9	0	550	.7	3,400	190	1,400,000
01122610	1990	408	1.6	11	230	29.3	0	550	.7	3,300	170	1,400,000
01122610	1991	408	1.6	11	230	24.8	0	550	.7	2,700	120	1,100,000
01122610	1992	408	1.6	11	230	23.2	0	550	.7	2,400	110	980,000
01122610	1993	408	1.6	11	230	26.4	0	550	.7	2,600	180	1,100,000
01122610	1994	408	1.6	11	230	28.7	0	550	.7	2,700	160	1,100,000
01122610	1995	408	1.6	11	230	19.3	0	550	.7	1,800	87	720,000
01122610	1996	408	1.6	11	230	30.8	0	550	.7	2,600	150	1,100,000
01122610	1997	408	1.6	11	230	31.0	0	550	.7	2,600	150	1,000,000
01122610	1998	408	1.6	11	230	29.3	0	550	.7	2,300	170	930,000
01124000	1988	155	1.2	7.2	240	17.0	.404	0	.6	2,100	150	330,000
01124000	1989	155	1.2	7.2	240	27.3	.404	0	.6	2,700	150	410,000
01124000	1990	155	1.2	7.2	240	29.1	.404	0	.6	2,500	140	380,000
01124000	1991	155	1.2	7.2	240	22.2	.404	0	.6	1,900	89	290,000
01124000	1992	155	1.2	7.2	240	23.7	.404	0	.6	1,900	92	290,000
01124000	1993	155	1.2	7.2	240	25.1	.404	0	.6	1,700	110	270,000
01124000	1994	155	1.2	7.2	240	30.5	.404	0	.6	2,000	130	310,000

Appendix 3. Regression model input data and nitrogen loads from monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. Total nitrogen yield from ESTIMATOR program. USGS station ID number, U.S. Geological Survey station identification number; mi^2, square mile; in., inches; in/yr, inch per year; $lb/mi^2/yr$, pound per square mile per year; lb/yr, pound per year; --, data not applicable]

USGS station ID or map number (fig. 3; table 1)	Water year	Drainage area (mi^2)	Percentage of urban and recreational grasses	Percentage of agricultural land	1990 population density (people per mi^2)	Total runoff minus return flow (in.)	Return flow (in/yr)	Yield from wastewater-treatment facilities ($lb/mi^2/yr$)	Ratio of deciduous to forested area	Total nitrogen yield ($lb/mi^2/yr$)	Standard error of total nitrogen yield ($lb/mi^2/yr$)	Total nitrogen load (lb/yr)
01124000	1995	155	1.2	7.2	240	16.3	0.404	0	0.6	1,300	60	190,000
01124000	1996	155	1.2	7.2	240	32.6	.404	0	.6	2,000	130	310,000
01124000	1997	155	1.2	7.2	240	30.5	.404	0	.6	1,900	130	300,000
01124000	1998	155	1.2	7.2	240	26.3	.404	0	.6	1,800	150	280,000
01127000	1988	713	1.4	11	230	18.5	.25	170	.7	2,800	160	2,000,000
01127000	1989	713	1.4	11	230	27.1	.25	170	.7	3,700	160	2,600,000
01127000	1990	713	1.4	11	230	30.1	.25	170	.7	3,800	180	2,700,000
01127000	1991	713	1.4	11	230	24.7	.25	170	.7	3,100	140	2,200,000
01127000	1992	713	1.4	11	230	22.1	.25	170	.7	2,900	120	2,000,000
01127000	1993	713	1.4	11	230	26.6	.25	170	.7	3,000	190	2,100,000
01127000	1994	713	1.4	11	230	25.8	.25	170	.7	3,000	170	2,100,000
01127000	1995	713	1.4	11	230	17.3	.25	170	.7	2,200	100	1,600,000
01127000	1996	713	1.4	11	230	29.0	.25	170	.7	3,400	180	2,400,000
01127000	1997	713	1.4	11	230	30.6	.25	170	.7	3,700	230	2,600,000
01127000	1998	713	1.4	11	230	30.2	.25	170	.7	3,700	290	2,700,000
01135300	1993	42.9	0	17	38	18.0	0	0	.4	1,400	360	59,000
01135300	1994	42.9	0	17	38	20.9	0	0	.4	1,500	320	64,000
01135300	1995	42.9	0	17	38	13.5	0	0	.4	810	190	35,000
01137500	1993	87.6	.4	.4	11	24.9	0	0	.3	1,300	87	110,000
01137500	1994	87.6	.4	.4	11	28.5	0	0	.3	1,400	82	130,000
01137500	1995	87.6	.4	.4	11	20.3	0	0	.3	1,000	38	88,000
01144000	1993	690	0	13	30	20.4	.012	0	.6	1,300	380	930,000
01144000	1994	690	0	13	30	24.0	.012	0	.6	1,600	520	1,100,000
01144000	1995	690	0	13	30	14.8	.012	0	.6	860	150	590,000
01184000	1988	9,660	.6	8.4	120	21.1	.301	0	.5	3,000	200	29,000,000
01184000	1989	9,660	.6	8.4	120	24.5	.301	0	.5	3,000	140	29,000,000
01184000	1990	9,660	.6	8.4	120	31.1	.301	0	.5	3,400	150	32,000,000

Appendix 3. Regression model input data and nitrogen loads from monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. Total nitrogen yield from ESTIMATOR program. USGS station ID number, U.S. Geological Survey station identification number; mi^2, square mile; in., inches; in/yr, inch per year; $lb/mi^2/yr$, pound per square mile per year; lb/yr, pound per year; --, data not applicable]

USGS station ID or map number (fig. 3; table 1)	Water year	Drainage area (mi^2)	Percentage of urban and recreational grasses	Percentage of agricultural land	1990 population density (people per mi^2)	Total runoff minus return flow (in.)	Return flow (in/yr)	Yield from wastewater-treatment facilities ($lb/mi^2/yr$)	Ratio of deciduous to forested area	Total nitrogen yield ($lb/mi^2/yr$)	Standard error of total nitrogen yield ($lb/mi^2/yr$)	Total nitrogen load (lb/yr)
01184000	1991	9,660	0.6	8.4	120	26.3	.301	0	0.5	2,700	110	26,000,000
01184000	1992	9,660	.6	8.4	120	23.2	.301	0	.5	2,300	95	22,000,000
01184000	1993	9,660	.6	8.4	120	23.7	.301	0	.5	2,100	100	21,000,000
01184000	1994	9,660	.6	8.4	120	26.1	.301	0	.5	2,200	100	22,000,000
01184000	1995	9,660	.6	8.4	120	16.5	.301	0	.5	1,500	69	15,000,000
01184000	1996	9,660	.6	8.4	120	34.8	.301	0	.5	2,600	140	25,000,000
01184000	1997	9,660	.6	8.4	120	29.0	.301	0	.5	2,300	130	22,000,000
01184000	1998	9,660	.6	8.4	120	26.6	.301	0	.5	2,100	160	20,000,000
01184100	1988	10.4	2.7	32	200	17.3	0	0	.6	2,900	150	30,000
01184100	1989	10.4	2.7	32	200	29.4	0	0	.6	4,300	300	45,000
01184100	1990	10.4	2.7	32	200	29.9	0	0	.6	4,100	280	42,000
01184100	1991	10.4	2.7	32	200	26.2	0	0	.6	3,300	250	34,000
01184490	1993	15.5	1.4	39	290	24.1	0	0	.8	15,000	510	240,000
01184490	1994	15.5	1.4	39	290	24.2	0	0	.8	14,000	260	210,000
01184490	1995	15.5	1.4	39	290	18.1	0	0	.8	11,000	230	170,000
01184490	1996	15.5	1.4	39	290	28.1	0	0	.8	16,000	560	250,000
01184490	1997	15.5	1.4	39	290	27.9	0	0	.8	15,000	450	230,000
01184490	1998	15.5	1.4	39	290	25.9	0	0	.8	15,000	460	230,000
01186800	1988	86.2	.7	6.4	220	17.8	0	830	.5	2,400	99	210,000
01186800	1989	86.2	.7	6.4	220	28.6	0	830	.5	2,900	140	250,000
01186800	1990	86.2	.7	6.4	220	30.6	0	830	.5	2,900	170	250,000
01186800	1991	86.2	.7	6.4	220	26.1	0	830	.5	2,400	180	210,000
01188000	1988	4.1	.8	19	130	20.1	0	0	.9	1,800	180	7,300
01188000	1989	4.1	.8	19	130	31.5	0	0	.9	2,600	310	11,000
01188000	1990	4.1	.8	19	130	34.2	0	0	.9	2,800	310	11,000
01188000	1991	4.1	.8	19	130	28.6	0	0	.9	2,300	240	9,200
01188000	1992	4.1	.8	19	130	28.6	0	0	.9	2,100	220	8,700

Appendix 3. Regression model input data and nitrogen loads from monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. Total nitrogen yield from ESTIMATOR program. USGS station ID number, U.S. Geological Survey station identification number; mi^2, square mile; in., inches; in/yr, inch per year; $lb/mi^2/yr$, pound per square mile per year; lb/yr, pound per year; --, data not applicable]

USGS station ID or map number (fig. 3; table 1)	Water year	Drainage area (mi^2)	Percentage of urban and recreational grasses	Percent-age of agricul-tural land	1990 pop-ulation density (people per mi^2)	Total runoff minus return flow (in.)	Return flow (in/yr)	Yield from wastewater-treatment facilities ($lb/mi^2/yr$)	Ratio of decidu-ous to forested area	Total nitrogen yield ($lb/mi^2/yr$)	Standard error of total nitrogen yield ($lb/mi^2/yr$)	Total nitrogen load (lb/yr)
01188000	1993	4.1	0.8	19	130	25.9	0	0	0.9	1,800	200	7,300
01188000	1994	4.1	.8	19	130	33.5	0	0	.9	2,100	240	8,500
01188000	1995	4.1	.8	19	130	22.3	0	0	.9	1,300	150	5,300
01188000	1996	4.1	.8	19	130	37.9	0	0	.9	1,800	290	7,500
01188000	1997	4.1	.8	19	130	38.5	0	0	.9	1,600	290	6,700
01188000	1998	4.1	.8	19	130	32.9	0	0	.9	1,200	250	4,900
01188090	1988	378	.6	4.8	140	15.2	.003	240	.5	1,200	130	450,000
01188090	1989	378	.6	4.8	140	22.7	.003	240	.5	1,700	160	640,000
01188090	1990	378	.6	4.8	140	28.6	.003	240	.5	1,900	170	720,000
01188090	1991	378	.6	4.8	140	23.9	.003	240	.5	1,400	100	510,000
01188090	1992	378	.6	4.8	140	22.0	.003	240	.5	1,200	90	440,000
01188090	1993	378	.6	4.8	140	25.2	.003	240	.5	1,300	160	500,000
01188090	1994	378	.6	4.8	140	24.8	.003	240	.5	1,100	92	430,000
01188090	1995	378	.6	4.8	140	17.0	.003	240	.5	740	60	280,000
01188090	1996	378	.6	4.8	140	31.8	.003	240	.5	1,500	160	560,000
01188090	1997	378	.6	4.8	140	31.9	.003	240	.5	1,500	190	560,000
01188090	1998	378	.6	4.8	140	26.0	.003	240	.5	1,100	190	430,000
01189000	1993	45.8	1.9	7.9	1,200	18.6	0	11,000	.8	19,000	2,100	870,000
01189000	1994	45.8	1.9	7.9	1,200	22.7	0	11,000	.8	14,000	620	640,000
01189000	1995	45.8	1.9	7.9	1,200	14.4	0	11,000	.8	13,000	750	600,000
01189995	1988	577	1.4	6.7	310	16.6	.002	1,700	.6	3,400	200	1,900,000
01189995	1989	577	1.4	6.7	310	25.7	.002	1,700	.6	4,000	180	2,300,000
01189995	1990	577	1.4	6.7	310	30.8	.002	1,700	.6	4,500	180	2,600,000
01189995	1991	577	1.4	6.7	310	25.9	.002	1,700	.6	3,900	150	2,300,000
01189995	1992	577	1.4	6.7	310	24.7	.002	1,700	.6	3,700	140	2,100,000
01189995	1993	577	1.4	6.7	310	26.6	.002	1,700	.6	3,600	170	2,100,000
01189995	1994	577	1.4	6.7	310	28.0	.002	1,700	.6	3,700	150	2,200,000

Appendix 3. Regression model input data and nitrogen loads from monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. Total nitrogen yield from ESTIMATOR program. USGS station ID number, U.S. Geological Survey station identification number; mi^2, square mile; in., inches; in/yr, inch per year; $lb/mi^2/yr$, pound per square mile per year; lb/yr, pound per year; --, data not applicable]

USGS station ID or map number (fig. 3; table 1)	Water year	Drainage area (mi^2)	Percentage of urban and recreational grasses	Percent-age of agricul-tural land	1990 pop-ulation density (people per mi^2)	Total runoff minus return flow (in.)	Return flow (in/yr)	Yield from wastewater-treatment facilities ($lb/mi^2/yr$)	Ratio of decidu-ous to forested area	Total nitrogen yield ($lb/mi^2/yr$)	Standard error of total nitrogen yield ($lb/mi^2/yr$)	Total nitrogen load (lb/yr)
01189995	1995	577	1.4	6.7	310	19.2	0.002	1,700	0.6	2,900	120	1,700,000
01189995	1996	577	1.4	6.7	310	34.7	.002	1,700	.6	3,900	180	2,300,000
01189995	1997	577	1.4	6.7	310	33.6	.002	1,700	.6	3,800	200	2,200,000
01189995	1998	577	1.4	6.7	310	28.0	.002	1,700	.6	3,300	230	1,900,000
01192500	1992	73.4	2.7	11	1,300	17.3	0	7,800	.7	12,000	540	840,000
01192500	1993	73.4	2.7	11	1,300	21.2	0	7,800	.7	12,000	350	880,000
01192500	1994	73.4	2.7	11	1,300	23.4	0	7,800	.7	12,000	350	910,000
01192500	1995	73.4	2.7	11	1,300	15.8	0	7,800	.7	10,000	310	730,000
01192500	1996	73.4	2.7	11	1,300	25.5	0	7,800	.7	12,000	370	890,000
01192500	1997	73.4	2.7	11	1,300	24.5	0	7,800	.7	12,000	410	870,000
01192500	1998	73.4	2.7	11	1,300	22.6	0	7,800	.7	11,000	580	800,000
01193500	1988	100	2.3	12	240	17.5	0	0	.8	2,000	230	200,000
01193500	1989	100	2.3	12	240	31.6	0	0	.8	3,500	400	350,000
01193500	1990	100	2.3	12	240	31.3	0	0	.8	3,000	310	300,000
01193500	1991	100	2.3	12	240	26.7	0	0	.8	2,200	220	220,000
01193500	1992	100	2.3	12	240	23.3	0	0	.8	1,800	150	180,000
01193500	1993	100	2.3	12	240	27.8	0	0	.8	1,900	250	190,000
01193500	1994	100	2.3	12	240	26.2	0	0	.8	1,700	190	170,000
01193500	1995	100	2.3	12	240	19.3	0	0	.8	1,100	100	110,000
01193500	1996	100	2.3	12	240	24.2	0	0	.8	1,300	150	130,000
01193500	1997	100	2.3	12	240	29.5	0	0	.8	1,500	220	150,000
01193500	1998	100	2.3	12	240	29.4	0	0	.8	1,500	300	150,000
01196500	1988	115	11	.6	1,300	15.3	0	7,600	.7	8,200	450	940,000
01196500	1989	115	11	.6	1,300	29.3	0	7,600	.7	11,000	550	1,300,000
01196500	1990	115	11	.6	1,300	31.4	0	7,600	.7	12,000	550	1,300,000
01196500	1991	115	11	.6	1,300	25.2	0	7,600	.7	11,000	450	1,200,000
01196500	1992	115	11	.6	1,300	23.0	0	7,600	.7	10,000	440	1,200,000

Appendix 3. Regression model input data and nitrogen loads from monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. Total nitrogen yield from ESTIMATOR program. USGS station ID number, U.S. Geological Survey station identification number; mi^2, square mile; in., inches; in/yr, inch per year; $lb/mi^2/yr$, pound per square mile per year; lb/yr, pound per year; --, data not applicable]

USGS station ID or map number (fig. 3; table 1)	Water year	Drainage area (mi^2)	Percentage of urban and recreational grasses	Percentage of agricultural land	1990 population density (people per mi^2)	Total runoff minus return flow (in.)	Return flow (in/yr)	Yield from wastewater-treatment facilities ($lb/mi^2/yr$)	Ratio of deciduous to forested area	Total nitrogen yield ($lb/mi^2/yr$)	Standard error of total nitrogen yield ($lb/mi^2/yr$)	Total nitrogen load (lb/yr)
01196500	1993	115	11	0.6	1,300	23.5	0	7,600	0.7	10,000	520	1,200,000
01196500	1994	115	11	.6	1,300	25.7	0	7,600	.7	11,000	540	1,300,000
01196500	1995	115	11	.6	1,300	17.4	0	7,600	.7	9,300	400	1,100,000
01196500	1996	115	11	.6	1,300	27.1	0	7,600	.7	11,000	550	1,300,000
01196500	1997	115	11	.6	1,300	30.6	0	7,600	.7	12,000	700	1,300,000
01196500	1998	115	11	.6	1,300	28.2	0	7,600	.7	11,000	840	1,200,000
01199900	1993	194	.7	26	100	20.6	.006	0	.6	3,000	140	570,000
01199900	1994	194	.7	26	100	23.2	.006	0	.6	3,300	150	640,000
01199900	1995	194	.7	26	100	16.5	.006	0	.6	2,300	120	450,000
01208500	1988	260	1.9	10	910	16.4	0	5,500	.7	10,000	480	2,700,000
01208500	1989	260	1.9	10	910	29.7	0	5,500	.7	12,000	450	3,000,000
01208500	1990	260	1.9	10	910	30.9	0	5,500	.7	11,000	380	2,900,000
01208500	1991	260	1.9	10	910	25.6	0	5,500	.7	9,300	300	2,400,000
01208500	1992	260	1.9	10	910	23.3	0	5,500	.7	8,400	280	2,200,000
01208500	1993	260	1.9	10	910	28.4	0	5,500	.7	8,300	380	2,200,000
01208500	1994	260	1.9	10	910	29.3	0	5,500	.7	8,500	320	2,200,000
01208500	1995	260	1.9	10	910	18.1	0	5,500	.7	6,800	240	1,800,000
01208500	1996	260	1.9	10	910	33.1	0	5,500	.7	8,800	370	2,300,000
01208500	1997	260	1.9	10	910	34.4	0	5,500	.7	9,300	460	2,400,000
01208500	1998	260	1.9	10	910	26.2	0	5,500	.7	8,200	520	2,100,000
01208873	1993	10.6	6.6	0	4,700	19.6	0	0	.6	4,500	600	47,000
01208873	1994	10.6	6.6	0	4,700	21.3	0	0	.6	7,000	480	74,000
01208873	1995	10.6	6.6	0	4,700	13.7	0	0	.6	3,800	300	40,000
01208950	1995	7.4	22	.2	740	13.7	0	0	.6	2,100	190	16,000
01208950	1996	7.4	22	.2	740	27.8	0	0	.6	5,300	380	39,000
01208950	1997	7.4	22	.2	740	34.6	0	0	.6	6,400	490	47,000
01208990	1988	21	2.7	4.5	350	17.5	0	0	.7	1,400	210	30,000

Appendix 3. Regression model input data and nitrogen loads from monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. Total nitrogen yield from ESTIMATOR program. USGS station ID number, U.S. Geological Survey station identification number; mi^2, square mile; in., inches; in/yr, inch per year; $lb/mi^2/yr$, pound per square mile per year; lb/yr, pound per year; --, data not applicable]

USGS station ID or map number (fig. 3; table 1)	Water year	Drainage area (mi^2)	Percentage of urban and recreational grasses	Percentage of agricultural land	1990 population density (people per mi^2)	Total runoff minus return flow (in.)	Return flow (in/yr)	Yield from wastewater-treatment facilities ($lb/mi^2/yr$)	Ratio of deciduous to forested area	Total nitrogen yield ($lb/mi^2/yr$)	Standard error of total nitrogen yield ($lb/mi^2/yr$)	Total nitrogen load (lb/yr)
01208990	1989	21	2.7	4.5	350	29.7	0	0	0.7	2,200	330	47,000
01208990	1990	21	2.7	4.5	350	30.1	0	0	.7	2,100	230	43,000
01208990	1991	21	2.7	4.5	350	27.5	0	0	.7	1,700	190	36,000
01208990	1992	21	2.7	4.5	350	21.9	0	0	.7	1,300	120	27,000
01208990	1993	21	2.7	4.5	350	24.9	0	0	.7	1,300	170	26,000
01208990	1994	21	2.7	4.5	350	26.8	0	0	.7	1,400	150	29,000
01208990	1995	21	2.7	4.5	350	16.9	0	0	.7	780	83	16,000
01208990	1996	21	2.7	4.5	350	29.9	0	0	.7	1,400	210	30,000
01208990	1997	21	2.7	4.5	350	33.7	0	0	.7	1,600	300	34,000
01208990	1998	21	2.7	4.5	350	25.0	0	0	.7	1,200	260	25,000
01209710	1988	33	5.7	2.9	780	14.1	0	300	.7	2,400	190	78,000
01209710	1989	33	5.7	2.9	780	36.3	0	300	.7	5,100	460	170,000
01209710	1990	33	5.7	2.9	780	25.8	0	300	.7	3,400	180	110,000
01209710	1991	33	5.7	2.9	780	28.9	0	300	.7	3,400	190	110,000
01209710	1992	33	5.7	2.9	780	18.9	0	300	.7	2,100	99	70,000
01209710	1993	33	5.7	2.9	780	26.3	0	300	.7	2,700	160	89,000
01209710	1994	33	5.7	2.9	780	24.2	0	300	.7	2,500	130	82,000
01209710	1995	33	5.7	2.9	780	16.0	0	300	.7	1,600	87	54,000
01209710	1996	33	5.7	2.9	780	27.3	0	300	.7	2,800	170	94,000
01209710	1997	33	5.7	2.9	780	33.4	0	300	.7	3,600	280	120,000
01209710	1998	33	5.7	2.9	780	24.1	0	300	.7	2,800	280	93,000
Unmonitored basins or monitored basins with incomplete record												
29	1988	227.5	3.5	5.2	320	17.5	--	--	.7	--	--	--
29	1989	227.5	3.5	5.2	320	31.6	--	--	.7	--	--	--
29	1990	227.5	3.5	5.2	320	31.3	--	--	.7	--	--	--
29	1991	227.5	3.5	5.2	320	26.7	--	--	.7	--	--	--
29	1992	227.5	3.5	5.2	320	23.3	--	--	.7	--	--	--

Appendix 3. Regression model input data and nitrogen loads from monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. Total nitrogen yield from ESTIMATOR program. USGS station ID number, U.S. Geological Survey station identification number; mi^2, square mile; in., inches; in/yr, inch per year; $lb/mi^2/yr$, pound per square mile per year; lb/yr, pound per year; --, data not applicable]

USGS station ID or map number (fig. 3; table 1)	Water year	Drainage area (mi^2)	Percentage of urban and recreational grasses	Percent-age of agricul-tural land	1990 pop-ulation density (people per mi^2)	Total runoff minus return flow (in.)	Return flow (in/yr)	Yield from wastewater-treatment facilities ($lb/mi^2/yr$)	Ratio of decidu-ous to forested area	Total nitrogen yield ($lb/mi^2/yr$)	Standard error of total nitrogen yield ($lb/mi^2/yr$)	Total nitrogen load (lb/yr)
29	1993	227.5	3.5	5.2	320	27.8	--	--	0.7	--	--	--
29	1994	227.5	3.5	5.2	320	26.2	--	--	.7	--	--	--
29	1995	227.5	3.5	5.2	320	19.3	--	--	.7	--	--	--
29	1996	227.5	3.5	5.2	320	24.2	--	--	.7	--	--	--
29	1997	227.5	3.5	5.2	320	29.5	--	--	.7	--	--	--
29	1998	227.5	3.5	5.2	320	29.4	--	--	.7	--	--	--
30	1988	138.9	4.5	9.6	1,400	15.9	--	--	.6	--	--	--
30	1989	138.9	4.5	9.6	1,400	33.3	--	--	.6	--	--	--
30	1990	138.9	4.5	9.6	1,400	33.4	--	--	.6	--	--	--
30	1991	138.9	4.5	9.6	1,400	26.9	--	--	.6	--	--	--
30	1992	138.9	4.5	9.6	1,400	25.6	--	--	.6	--	--	--
30	1993	138.9	4.5	9.6	1,400	24.1	--	--	.6	--	--	--
30	1994	138.9	4.5	9.6	1,400	24.2	--	--	.6	--	--	--
30	1995	138.9	4.5	9.6	1,400	18.1	--	--	.6	--	--	--
30	1996	138.9	4.5	9.6	1,400	28.1	--	--	.6	--	--	--
30	1997	138.9	4.5	9.6	1,400	27.9	--	--	.6	--	--	--
30	1998	138.9	4.5	9.6	1,400	25.9	--	--	.6	--	--	--
31	1988	62.4	1.3	8.6	81	17.5	--	--	.8	--	--	--
31	1989	62.4	1.3	8.6	81	31.6	--	--	.8	--	--	--
31	1990	62.4	1.3	8.6	81	31.3	--	--	.8	--	--	--
31	1991	62.4	1.3	8.6	81	26.7	--	--	.8	--	--	--
31	1992	62.4	1.3	8.6	81	23.3	--	--	.8	--	--	--
31	1993	62.4	1.3	8.6	81	27.8	--	--	.8	--	--	--
31	1994	62.4	1.3	8.6	81	26.2	--	--	.8	--	--	--
31	1995	62.4	1.3	8.6	81	19.3	--	--	.8	--	--	--
31	1996	62.4	1.3	8.6	81	24.2	--	--	.8	--	--	--
31	1997	62.4	1.3	8.6	81	29.5	--	--	.8	--	--	--

Appendix 3. Regression model input data and nitrogen loads from monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. Total nitrogen yield from ESTIMATOR program. USGS station ID number, U.S. Geological Survey station identification number; mi^2, square mile; in., inches; in/yr, inch per year; $lb/mi^2/yr$, pound per square mile per year; lb/yr, pound per year; --, data not applicable]

USGS station ID or map number (fig. 3; table 1)	Water year	Drainage area (mi^2)	Percentage of urban and recreational grasses	Percentage of agricultural land	1990 population density (people per mi^2)	Total runoff minus return flow (in.)	Return flow (in/yr)	Yield from wastewater-treatment facilities ($lb/mi^2/yr$)	Ratio of deciduous to forested area	Total nitrogen yield ($lb/mi^2/yr$)	Standard error of total nitrogen yield ($lb/mi^2/yr$)	Total nitrogen load (lb/yr)
31	1998	62.4	1.3	8.6	81	29.4	--	--	0.8	--	--	--
32	1988	30.3	4.3	19	760	17.3	--	--	.6	--	--	--
32	1989	30.3	4.3	19	760	29.4	--	--	.6	--	--	--
32	1990	30.3	4.3	19	760	29.9	--	--	.6	--	--	--
32	1991	30.3	4.3	19	760	26.2	--	--	.6	--	--	--
32	1992	30.3	4.3	19	760	26.0	--	--	.6	--	--	--
32	1993	30.3	4.3	19	760	24.5	--	--	.6	--	--	--
32	1994	30.3	4.3	19	760	29.4	--	--	.6	--	--	--
32	1995	30.3	4.3	19	760	20.0	--	--	.6	--	--	--
32	1996	30.3	4.3	19	760	34.2	--	--	.6	--	--	--
32	1997	30.3	4.3	19	760	29.2	--	--	.6	--	--	--
32	1998	30.3	4.3	19	760	27.8	--	--	.6	--	--	--
33	1988	3.5	3.9	1.7	2,000	12.5	--	--	.4	--	--	--
33	1989	3.5	3.9	1.7	2,000	19.4	--	--	.4	--	--	--
33	1990	3.5	3.9	1.7	2,000	24.5	--	--	.4	--	--	--
33	1991	3.5	3.9	1.7	2,000	20.9	--	--	.4	--	--	--
33	1992	3.5	3.9	1.7	2,000	17.3	--	--	.4	--	--	--
33	1993	3.5	3.9	1.7	2,000	21.2	--	--	.4	--	--	--
33	1994	3.5	3.9	1.7	2,000	23.4	--	--	.4	--	--	--
33	1995	3.5	3.9	1.7	2,000	15.8	--	--	.4	--	--	--
33	1996	3.5	3.9	1.7	2,000	25.5	--	--	.4	--	--	--
33	1997	3.5	3.9	1.7	2,000	24.5	--	--	.4	--	--	--
33	1998	3.5	3.9	1.7	2,000	22.6	--	--	.4	--	--	--
35	1988	62.0	3.4	20	670	15.5	--	--	.6	--	--	--
35	1989	62.0	3.4	20	670	33.5	--	--	.6	--	--	--
35	1990	62.0	3.4	20	670	31.3	--	--	.6	--	--	--
35	1991	62.0	3.4	20	670	26.6	--	--	.6	--	--	--

Appendix 3. Regression model input data and nitrogen loads from monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. Total nitrogen yield from ESTIMATOR program. USGS station ID number, U.S. Geological Survey station identification number; mi^2, square mile; in., inches; in/yr, inch per year; $lb/mi^2/yr$, pound per square mile per year; lb/yr, pound per year; --, data not applicable]

USGS station ID or map number (fig. 3; table 1)	Water year	Drainage area (mi^2)	Percentage of urban and recreational grasses	Percent-age of agricul-tural land	1990 pop-ulation density (people per mi^2)	Total runoff minus return flow (in.)	Return flow (in/yr)	Yield from wastewater-treatment facilities ($lb/mi^2/yr$)	Ratio of decidu-ous to forested area	Total nitrogen yield ($lb/mi^2/yr$)	Standard error of total nitrogen yield ($lb/mi^2/yr$)	Total nitrogen load (lb/yr)
35	1992	62.0	3.4	20	670	28.9	--	--	0.6	--	--	--
35	1993	62.0	3.4	20	670	29.5	--	--	.6	--	--	--
35	1994	62.0	3.4	20	670	26.2	--	--	.6	--	--	--
35	1995	62.0	3.4	20	670	18.9	--	--	.6	--	--	--
35	1996	62.0	3.4	20	670	29.6	--	--	.6	--	--	--
35	1997	62.0	3.4	20	670	34.3	--	--	.6	--	--	--
35	1998	62.0	3.4	20	670	31.6	--	--	.6	--	--	--
36	1988	98.7	4.2	21	380	15.9	--	--	.7	--	--	--
36	1989	98.7	4.2	21	380	33.3	--	--	.7	--	--	--
36	1990	98.7	4.2	21	380	33.4	--	--	.7	--	--	--
36	1991	98.7	4.2	21	380	26.9	--	--	.7	--	--	--
36	1992	98.7	4.2	21	380	25.6	--	--	.7	--	--	--
36	1993	98.7	4.2	21	380	24.1	--	--	.7	--	--	--
36	1994	98.7	4.2	21	380	24.2	--	--	.7	--	--	--
36	1995	98.7	4.2	21	380	18.1	--	--	.7	--	--	--
36	1996	98.7	4.2	21	380	28.1	--	--	.7	--	--	--
36	1997	98.7	4.2	21	380	27.9	--	--	.7	--	--	--
36	1998	98.7	4.2	21	380	25.9	--	--	.7	--	--	--
37	1988	35.1	8.2	31	360	17.3	--	--	.7	--	--	--
37	1989	35.1	8.2	31	360	29.4	--	--	.7	--	--	--
37	1990	35.1	8.2	31	360	29.9	--	--	.7	--	--	--
37	1991	35.1	8.2	31	360	26.2	--	--	.7	--	--	--
37	1992	35.1	8.2	31	360	26.0	--	--	.7	--	--	--
37	1993	35.1	8.2	31	360	24.5	--	--	.7	--	--	--
37	1994	35.1	8.2	31	360	29.4	--	--	.7	--	--	--
37	1995	35.1	8.2	31	360	20.0	--	--	.7	--	--	--
37	1996	35.1	8.2	31	360	34.2	--	--	.7	--	--	--

Appendix 3. Regression model input data and nitrogen loads from monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. Total nitrogen yield from ESTIMATOR program. USGS station ID number, U.S. Geological Survey station identification number; mi^2, square mile; in., inches; in/yr, inch per year; $lb/mi^2/yr$, pound per square mile per year; lb/yr, pound per year; --, data not applicable]

USGS station ID or map number (fig. 3; table 1)	Water year	Drainage area (mi^2)	Percentage of urban and recreational grasses	Percentage of agricultural land	1990 population density (people per mi^2)	Total runoff minus return flow (in.)	Return flow (in/yr)	Yield from wastewater-treatment facilities ($lb/mi^2/yr$)	Ratio of deciduous to forested area	Total nitrogen yield ($lb/mi^2/yr$)	Standard error of total nitrogen yield ($lb/mi^2/yr$)	Total nitrogen load (lb/yr)
37	1997	35.1	8.2	31	360	29.2	--	--	0.7	--	--	--
37	1998	35.1	8.2	31	360	27.8	--	--	.7	--	--	--
38	1988	77.2	6.9	5.6	3,300	17.3	--	--	.6	--	--	--
38	1989	77.2	6.9	5.6	3,300	29.4	--	--	.6	--	--	--
38	1990	77.2	6.9	5.6	3,300	29.9	--	--	.6	--	--	--
38	1991	77.2	6.9	5.6	3,300	26.2	--	--	.6	--	--	--
38	1992	77.2	6.9	5.6	3,300	26.0	--	--	.6	--	--	--
38	1993	77.2	6.9	5.6	3,300	24.5	--	--	.6	--	--	--
38	1994	77.2	6.9	5.6	3,300	29.4	--	--	.6	--	--	--
38	1995	77.2	6.9	5.6	3,300	20.0	--	--	.6	--	--	--
38	1996	77.2	6.9	5.6	3,300	34.2	--	--	.6	--	--	--
38	1997	77.2	6.9	5.6	3,300	29.2	--	--	.6	--	--	--
38	1998	77.2	6.9	5.6	3,300	27.8	--	--	.6	--	--	--
39	1988	44.3	2.1	7.6	210	17.5	--	--	.8	--	--	--
39	1989	44.3	2.1	7.6	210	31.6	--	--	.8	--	--	--
39	1990	44.3	2.1	7.6	210	31.3	--	--	.8	--	--	--
39	1991	44.3	2.1	7.6	210	26.7	--	--	.8	--	--	--
39	1992	44.3	2.1	7.6	210	23.3	--	--	.8	--	--	--
39	1993	44.3	2.1	7.6	210	27.8	--	--	.8	--	--	--
39	1994	44.3	2.1	7.6	210	26.2	--	--	.8	--	--	--
39	1995	44.3	2.1	7.6	210	19.3	--	--	.8	--	--	--
39	1996	44.3	2.1	7.6	210	24.2	--	--	.8	--	--	--
39	1997	44.3	2.1	7.6	210	29.5	--	--	.8	--	--	--
39	1998	44.3	2.1	7.6	210	29.4	--	--	.8	--	--	--
40	1988	97.8	2	19	230	16.1	--	--	.8	--	--	--
40	1989	97.8	2	19	230	30.7	--	--	.8	--	--	--
40	1990	97.8	2	19	230	33.4	--	--	.8	--	--	--

Appendix 3. Regression model input data and nitrogen loads from monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. Total nitrogen yield from ESTIMATOR program. USGS station ID number, U.S. Geological Survey station identification number; mi^2, square mile; in., inches; in/yr, inch per year; $lb/mi^2/yr$, pound per square mile per year; lb/yr, pound per year; --, data not applicable]

USGS station ID or map number (fig. 3; table 1)	Water year	Drainage area (mi^2)	Percentage of urban and recreational grasses	Percentage of agricultural land	1990 population density (people per mi^2)	Total runoff minus return flow (in.)	Return flow (in/yr)	Yield from wastewater-treatment facilities ($lb/mi^2/yr$)	Ratio of deciduous to forested area	Total nitrogen yield ($lb/mi^2/yr$)	Standard error of total nitrogen yield ($lb/mi^2/yr$)	Total nitrogen load (lb/yr)
40	1991	97.8	2	19	230	26.6	--	--	0.8	--	--	--
40	1992	97.8	2	19	230	2.8	--	--	.8	--	--	--
40	1993	97.8	2	19	230	27.8	--	--	.8	--	--	--
40	1994	97.8	2	19	230	23.1	--	--	.8	--	--	--
40	1995	97.8	2	19	230	17.2	--	--	.8	--	--	--
40	1996	97.8	2	19	230	25.2	--	--	.8	--	--	--
40	1997	97.8	2	19	230	30.9	--	--	.8	--	--	--
40	1998	97.8	2	19	230	32.5	--	--	.8	--	--	--
41	1988	114.9	1.9	15	320	17.5	--	--	.8	--	--	--
41	1989	114.9	1.9	15	320	31.6	--	--	.8	--	--	--
41	1990	114.9	1.9	15	320	31.3	--	--	.8	--	--	--
41	1991	114.9	1.9	15	320	26.7	--	--	.8	--	--	--
41	1992	114.9	1.9	15	320	23.3	--	--	.8	--	--	--
41	1993	114.9	1.9	15	320	27.8	--	--	.8	--	--	--
41	1994	114.9	1.9	15	320	26.2	--	--	.8	--	--	--
41	1995	114.9	1.9	15	320	19.3	--	--	.8	--	--	--
41	1996	114.9	1.9	15	320	24.2	--	--	.8	--	--	--
41	1997	114.9	1.9	15	320	29.5	--	--	.8	--	--	--
41	1998	114.9	1.9	15	320	29.4	--	--	.8	--	--	--
42	1988	28.9	1.3	20	130	20.3	--	--	.8	--	--	--
42	1989	28.9	1.3	20	130	28.9	--	--	.8	--	--	--
42	1990	28.9	1.3	20	130	31.1	--	--	.8	--	--	--
42	1991	28.9	1.3	20	130	28.1	--	--	.8	--	--	--
42	1992	28.9	1.3	20	130	20.8	--	--	.8	--	--	--
42	1993	28.9	1.3	20	130	26.4	--	--	.8	--	--	--
42	1994	28.9	1.3	20	130	25.9	--	--	.8	--	--	--
42	1995	28.9	1.3	20	130	19.7	--	--	.8	--	--	--

Appendix 3. Regression model input data and nitrogen loads from monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. Total nitrogen yield from ESTIMATOR program. USGS station ID number, U.S. Geological Survey station identification number; mi^2, square mile; in., inches; in/yr, inch per year; $lb/mi^2/yr$, pound per square mile per year; lb/yr, pound per year; --, data not applicable]

USGS station ID or map number (fig. 3; table 1)	Water year	Drainage area (mi^2)	Percentage of urban and recreational grasses	Percent-age of agricul-tural land	1990 pop-ulation density (people per mi^2)	Total runoff minus return flow (in.)	Return flow (in/yr)	Yield from wastewater-treatment facilities ($lb/mi^2/yr$)	Ratio of decidu-ous to forested area	Total nitrogen yield ($lb/mi^2/yr$)	Standard error of total nitrogen yield ($lb/mi^2/yr$)	Total nitrogen load (lb/yr)
42	1996	28.9	1.3	20	130	26.5	--	--	0.8	--	--	--
42	1997	28.9	1.3	20	130	29.5	--	--	.8	--	--	--
42	1998	28.9	1.3	20	130	29.3	--	--	.8	--	--	--
43	1988	9.8	11	0	690	19.1	--	--	.6	--	--	--
43	1989	9.8	11	0	690	27.8	--	--	.6	--	--	--
43	1990	9.8	11	0	690	33.3	--	--	.6	--	--	--
43	1991	9.8	11	0	690	23.2	--	--	.6	--	--	--
43	1992	9.8	11	0	690	23.2	--	--	.6	--	--	--
43	1993	9.8	11	0	690	29.1	--	--	.6	--	--	--
43	1994	9.8	11	0	690	23.7	--	--	.6	--	--	--
43	1995	9.8	11	0	690	19.2	--	--	.6	--	--	--
43	1996	9.8	11	0	690	26.3	--	--	.6	--	--	--
43	1997	9.8	11	0	690	30.2	--	--	.6	--	--	--
43	1998	9.8	11	0	690	35.1	--	--	.6	--	--	--
44	1988	107.7	6	3.3	680	16.1	--	--	.8	--	--	--
44	1989	107.7	6	3.3	680	30.7	--	--	.8	--	--	--
44	1990	107.7	6	3.3	680	33.4	--	--	.8	--	--	--
44	1991	107.7	6	3.3	680	26.6	--	--	.8	--	--	--
44	1992	107.7	6	3.3	680	20.8	--	--	.8	--	--	--
44	1993	107.7	6	3.3	680	27.8	--	--	.8	--	--	--
44	1994	107.7	6	3.3	680	23.1	--	--	.8	--	--	--
44	1995	107.7	6	3.3	680	17.2	--	--	.8	--	--	--
44	1996	107.7	6	3.3	680	25.2	--	--	.8	--	--	--
44	1997	107.7	6	3.3	680	30.9	--	--	.8	--	--	--
44	1998	107.7	6	3.3	680	32.5	--	--	.8	--	--	--
45	1988	87.2	6.4	6.5	530	19.1	--	--	.8	--	--	--
45	1989	87.2	6.4	6.5	530	27.8	--	--	.8	--	--	--

Appendix 3. Regression model input data and nitrogen loads from monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. Total nitrogen yield from ESTIMATOR program. USGS station ID number, U.S. Geological Survey station identification number; mi^2, square mile; in., inches; in/yr, inch per year; $lb/mi^2/yr$, pound per square mile per year; lb/yr, pound per year; --, data not applicable]

USGS station ID or map number (fig. 3; table 1)	Water year	Drainage area (mi^2)	Percentage of urban and recreational grasses	Percent-age of agricul-tural land	1990 pop-ulation density (people per mi^2)	Total runoff minus return flow (in.)	Return flow (in/yr)	Yield from wastewater-treatment facilities ($lb/mi^2/yr$)	Ratio of decidu-ous to forested area	Total nitrogen yield ($lb/mi^2/yr$)	Standard error of total nitrogen yield ($lb/mi^2/yr$)	Total nitrogen load (lb/yr)
45	1990	87.2	6.4	6.5	530	33.3	--	--	0.8	--	--	--
45	1991	87.2	6.4	6.5	530	23.2	--	--	.8	--	--	--
45	1992	87.2	6.4	6.5	530	23.2	--	--	.8	--	--	--
45	1993	87.2	6.4	6.5	530	29.1	--	--	.8	--	--	--
45	1994	87.2	6.4	6.5	530	23.7	--	--	.8	--	--	--
45	1995	87.2	6.4	6.5	530	19.2	--	--	.8	--	--	--
45	1996	87.2	6.4	6.5	530	26.3	--	--	.8	--	--	--
45	1997	87.2	6.4	6.5	530	30.2	--	--	.8	--	--	--
45	1998	87.2	6.4	6.5	530	35.1	--	--	.8	--	--	--
46	1988	76.2	7.7	2.1	390	16.1	--	--	.8	--	--	--
46	1989	76.2	7.7	2.1	390	30.7	--	--	.8	--	--	--
46	1990	76.2	7.7	2.1	390	33.4	--	--	.8	--	--	--
46	1991	76.2	7.7	2.1	390	26.6	--	--	.8	--	--	--
46	1992	76.2	7.7	2.1	390	20.8	--	--	.8	--	--	--
46	1993	76.2	7.7	2.1	390	27.8	--	--	.8	--	--	--
46	1994	76.2	7.7	2.1	390	23.1	--	--	.8	--	--	--
46	1995	76.2	7.7	2.1	390	17.2	--	--	.8	--	--	--
46	1996	76.2	7.7	2.1	390	25.2	--	--	.8	--	--	--
46	1997	76.2	7.7	2.1	390	30.9	--	--	.8	--	--	--
46	1998	76.2	7.7	2.1	390	32.5	--	--	.8	--	--	--
47	1988	216.3	4.8	3.5	500	14.0	--	--	.8	--	--	--
47	1989	216.3	4.8	3.5	500	28.8	--	--	.8	--	--	--
47	1990	216.3	4.8	3.5	500	26.9	--	--	.8	--	--	--
47	1991	216.3	4.8	3.5	500	26.4	--	--	.8	--	--	--
47	1992	216.3	4.8	3.5	500	21.2	--	--	.8	--	--	--
47	1993	216.3	4.8	3.5	500	25.3	--	--	.8	--	--	--
47	1994	216.3	4.8	3.5	500	24.2	--	--	.8	--	--	--

Appendix 3. Regression model input data and nitrogen loads from monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. Total nitrogen yield from ESTIMATOR program. USGS station ID number, U.S. Geological Survey station identification number; mi^2, square mile; in., inches; in/yr, inch per year; $lb/mi^2/yr$, pound per square mile per year; lb/yr, pound per year; --, data not applicable]

USGS station ID or map number (fig. 3; table 1)	Water year	Drainage area (mi^2)	Percentage of urban and recreational grasses	Percent-age of agricul-tural land	1990 pop-ulation density (people per mi^2)	Total runoff minus return flow (in.)	Return flow (in/yr)	Yield from wastewater-treatment facilities ($lb/mi^2/yr$)	Ratio of decidu-ous to forested area	Total nitrogen yield ($lb/mi^2/yr$)	Standard error of total nitrogen yield ($lb/mi^2/yr$)	Total nitrogen load (lb/yr)
47	1995	216.3	4.8	3.5	500	16.1	--	--	0.8	--	--	--
47	1996	216.3	4.8	3.5	500	24.2	--	--	.8	--	--	--
47	1997	216.3	4.8	3.5	500	26.4	--	--	.8	--	--	--
47	1998	216.3	4.8	3.5	500	28.8	--	--	.8	--	--	--
48	1988	55.2	12	6.7	1,400	15.3	--	--	.6	--	--	--
48	1989	55.2	12	6.7	1,400	29.3	--	--	.6	--	--	--
48	1990	55.2	12	6.7	1,400	31.4	--	--	.6	--	--	--
48	1991	55.2	12	6.7	1,400	25.2	--	--	.6	--	--	--
48	1992	55.2	12	6.7	1,400	23.0	--	--	.6	--	--	--
48	1993	55.2	12	6.7	1,400	23.5	--	--	.6	--	--	--
48	1994	55.2	12	6.7	1,400	25.7	--	--	.6	--	--	--
48	1995	55.2	12	6.7	1,400	17.4	--	--	.6	--	--	--
48	1996	55.2	12	6.7	1,400	27.1	--	--	.6	--	--	--
48	1997	55.2	12	6.7	1,400	30.6	--	--	.6	--	--	--
48	1998	55.2	12	6.7	1,400	28.2	--	--	.6	--	--	--
49	1988	130.5	8	1.1	2,100	14.1	--	--	.7	--	--	--
49	1989	130.5	8	1.1	2,100	31.7	--	--	.7	--	--	--
49	1990	130.5	8	1.1	2,100	34.3	--	--	.7	--	--	--
49	1991	130.5	8	1.1	2,100	28.5	--	--	.7	--	--	--
49	1992	130.5	8	1.1	2,100	25.6	--	--	.7	--	--	--
49	1993	130.5	8	1.1	2,100	29.1	--	--	.7	--	--	--
49	1994	130.5	8	1.1	2,100	25.1	--	--	.7	--	--	--
49	1995	130.5	8	1.1	2,100	15.8	--	--	.7	--	--	--
49	1996	130.5	8	1.1	2,100	28.0	--	--	.7	--	--	--
49	1997	130.5	8	1.1	2,100	31.8	--	--	.7	--	--	--
49	1998	130.5	8	1.1	2,100	28.0	--	--	.7	--	--	--
50	1988	50.8	2.7	7.3	1,000	16.4	--	--	.8	--	--	--

Appendix 3. Regression model input data and nitrogen loads from monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. Total nitrogen yield from ESTIMATOR program. USGS station ID number, U.S. Geological Survey station identification number; mi^2, square mile; in., inches; in/yr, inch per year; $lb/mi^2/yr$, pound per square mile per year; lb/yr, pound per year; --, data not applicable]

USGS station ID or map number (fig. 3; table 1)	Water year	Drainage area (mi^2)	Percentage of urban and recreational grasses	Percent-age of agricul-tural land	1990 pop-ulation density (people per mi^2)	Total runoff minus return flow (in.)	Return flow (in/yr)	Yield from wastewater-treatment facilities ($lb/mi^2/yr$)	Ratio of decidu-ous to forested area	Total nitrogen yield ($lb/mi^2/yr$)	Standard error of total nitrogen yield ($lb/mi^2/yr$)	Total nitrogen load (lb/yr)
50	1989	50.8	2.7	7.3	1,000	29.7	--	--	0.8	--	--	--
50	1990	50.8	2.7	7.3	1,000	30.9	--	--	.8	--	--	--
50	1991	50.8	2.7	7.3	1,000	25.6	--	--	.8	--	--	--
50	1992	50.8	2.7	7.3	1,000	23.3	--	--	.8	--	--	--
50	1993	50.8	2.7	7.3	1,000	28.4	--	--	.8	--	--	--
50	1994	50.8	2.7	7.3	1,000	29.3	--	--	.8	--	--	--
50	1995	50.8	2.7	7.3	1,000	18.1	--	--	.8	--	--	--
50	1996	50.8	2.7	7.3	1,000	33.1	--	--	.8	--	--	--
50	1997	50.8	2.7	7.3	1,000	34.4	--	--	.8	--	--	--
50	1998	50.8	2.7	7.3	1,000	26.2	--	--	.8	--	--	--
34	1988	94.4	6.3	5	1,100	15.7	--	--	.7	--	--	--
34	1989	94.4	6.3	5	1,100	27.0	--	--	.7	--	--	--
34	1990	94.4	6.3	5	1,100	31.1	--	--	.7	--	--	--
34	1991	94.4	6.3	5	1,100	24.6	--	--	.7	--	--	--
34	1992	94.4	6.3	5	1,100	21.5	--	--	.7	--	--	--
34	1993	94.4	6.3	5	1,100	24.9	--	--	.7	--	--	--
34	1994	94.4	6.3	5	1,100	31.3	--	--	.7	--	--	--
34	1995	94.4	6.3	5	1,100	19.9	--	--	.7	--	--	--
34	1996	94.4	6.3	5	1,100	32.0	--	--	.7	--	--	--
34	1997	94.4	6.3	5	1,100	33.0	--	--	.7	--	--	--
34	1998	94.4	6.3	5	1,100	24.3	--	--	.7	--	--	--
51	1988	68.7	5	3.9	630	17.5	--	--	.7	--	--	--
51	1989	68.7	5	3.9	630	29.7	--	--	.7	--	--	--
51	1990	68.7	5	3.9	630	30.1	--	--	.7	--	--	--
51	1991	68.7	5	3.9	630	27.5	--	--	.7	--	--	--
51	1992	68.7	5	3.9	630	21.9	--	--	.7	--	--	--
51	1993	68.7	5	3.9	630	24.9	--	--	.7	--	--	--

Appendix 3. Regression model input data and nitrogen loads from monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. Total nitrogen yield from ESTIMATOR program. USGS station ID number, U.S. Geological Survey station identification number; mi^2, square mile; in., inches; in/yr, inch per year; $lb/mi^2/yr$, pound per square mile per year; lb/yr, pound per year; --, data not applicable]

USGS station ID or map number (fig. 3; table 1)	Water year	Drainage area (mi^2)	Percentage of urban and recreational grasses	Percent-age of agricul-tural land	1990 pop-ulation density (people per mi^2)	Total runoff minus return flow (in.)	Return flow (in/yr)	Yield from wastewater-treatment facilities ($lb/mi^2/yr$)	Ratio of decidu-ous to forested area	Total nitrogen yield ($lb/mi^2/yr$)	Standard error of total nitrogen yield ($lb/mi^2/yr$)	Total nitrogen load (lb/yr)
51	1994	68.7	5	3.9	630	26.8	--	--	0.7	--	--	--
51	1995	68.7	5	3.9	630	16.9	--	--	.7	--	--	--
51	1996	68.7	5	3.9	630	29.9	--	--	.7	--	--	--
51	1997	68.7	5	3.9	630	33.7	--	--	.7	--	--	--
51	1998	68.7	5	3.9	630	25.0	--	--	.7	--	--	--
52	1988	29.5	5.2	1.5	1,900	14.1	--	--	.6	--	--	--
52	1989	29.5	5.2	1.5	1,900	36.3	--	--	.6	--	--	--
52	1990	29.5	5.2	1.5	1,900	25.8	--	--	.6	--	--	--
52	1991	29.5	5.2	1.5	1,900	28.9	--	--	.6	--	--	--
52	1992	29.5	5.2	1.5	1,900	18.9	--	--	.6	--	--	--
52	1993	29.5	5.2	1.5	1,900	26.3	--	--	.6	--	--	--
52	1994	29.5	5.2	1.5	1,900	24.2	--	--	.6	--	--	--
52	1995	29.5	5.2	1.5	1,900	16.0	--	--	.6	--	--	--
52	1996	29.5	5.2	1.5	1,900	27.3	--	--	.6	--	--	--
52	1997	29.5	5.2	1.5	1,900	33.4	--	--	.6	--	--	--
52	1998	29.5	5.2	1.5	1,900	24.1	--	--	.6	--	--	--
53	1988	99.6	6.5	2.2	2,100	15.8	--	--	.7	--	--	--
53	1989	99.6	6.5	2.2	2,100	35.3	--	--	.7	--	--	--
53	1990	99.6	6.5	2.2	2,100	28.3	--	--	.7	--	--	--
53	1991	99.6	6.5	2.2	2,100	25.4	--	--	.7	--	--	--
53	1992	99.6	6.5	2.2	2,100	21.6	--	--	.7	--	--	--
53	1993	99.6	6.5	2.2	2,100	26.0	--	--	.7	--	--	--
53	1994	99.6	6.5	2.2	2,100	23.7	--	--	.7	--	--	--
53	1995	99.6	6.5	2.2	2,100	13.7	--	--	.7	--	--	--
53	1996	99.6	6.5	2.2	2,100	27.8	--	--	.7	--	--	--
53	1997	99.6	6.5	2.2	2,100	34.6	--	--	.7	--	--	--
53	1998	99.6	6.5	2.2	2,100	28.1	--	--	.7	--	--	--

Appendix 3. Regression model input data and nitrogen loads from monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. Total nitrogen yield from ESTIMATOR program. USGS station ID number, U.S. Geological Survey station identification number; mi^2, square mile; in., inches; in/yr, inch per year; $lb/mi^2/yr$, pound per square mile per year; lb/yr, pound per year; --, data not applicable]

USGS station ID or map number (fig. 3; table 1)	Water year	Drainage area (mi^2)	Percentage of urban and recreational grasses	Percent-age of agricul-tural land	1990 pop-ulation density (people per mi^2)	Total runoff minus return flow (in.)	Return flow (in/yr)	Yield from wastewater-treatment facilities ($lb/mi^2/yr$)	Ratio of decidu-ous to forested area	Total nitrogen yield ($lb/mi^2/yr$)	Standard error of total nitrogen yield ($lb/mi^2/yr$)	Total nitrogen load (lb/yr)
54	1988	167.1	5.9	2.4	1,400	14.1	--	--	0.4	--	--	--
54	1988	167.1	5.9	2.4	1,400	36.3	--	--	.4	--	--	--
54	1988	167.1	5.9	2.4	1,400	25.8	--	--	.4	--	--	--
54	1988	167.1	5.9	2.4	1,400	28.9	--	--	.4	--	--	--
54	1988	167.1	5.9	2.4	1,400	18.9	--	--	.4	--	--	--
54	1988	167.1	5.9	2.4	1,400	26.3	--	--	.4	--	--	--
54	1988	167.1	5.9	2.4	1,400	24.2	--	--	.4	--	--	--
54	1988	167.1	5.9	2.4	1,400	16.0	--	--	.4	--	--	--
54	1988	167.1	5.9	2.4	1,400	27.3	--	--	.4	--	--	--
54	1988	167.1	5.9	2.4	1,400	33.4	--	--	.4	--	--	--
54	1988	167.1	5.9	2.4	1,400	24.1	--	--	.4	--	--	--
01192704	1988	48.1	4.3	13	860	17.5	--	--	.6	--	--	--
01192704	1989	48.1	4.3	13	860	31.6	--	--	.6	--	--	--
01192704	1990	48.1	4.3	13	860	31.3	--	--	.6	--	--	--
01192704	1991	48.1	4.3	13	860	26.7	--	--	.6	--	--	--
01192704	1992	48.1	4.3	13	860	23.3	--	--	.6	--	--	--
01192704	1993	48.1	4.3	13	860	27.8	--	--	.6	--	--	--
01192704	1994	48.1	4.3	13	860	26.2	--	--	.6	--	--	--
01192704	1995	48.1	4.3	13	860	19.3	--	--	.6	--	--	--
01184100	1992	10.4	2.7	32	200	26.0	--	--	.6	--	--	--
01184100	1993	10.4	2.7	32	200	24.5	--	--	.6	--	--	--
01184100	1994	10.4	2.7	32	200	29.4	--	--	.6	--	--	--
01184100	1995	10.4	2.7	32	200	20.0	--	--	.6	--	--	--
01184100	1996	10.4	2.7	32	200	34.2	--	--	.6	--	--	--
01184100	1997	10.4	2.7	32	200	29.2	--	--	.6	--	--	--
01184100	1998	10.4	2.7	32	200	27.8	--	--	.6	--	--	--
01184490	1988	15.5	1.4	39	290	15.9	--	--	.8	--	--	--

Appendix 3. Regression model input data and nitrogen loads from monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. Total nitrogen yield from ESTIMATOR program. USGS station ID number, U.S. Geological Survey station identification number; mi^2, square mile; in., inches; in/yr, inch per year; $lb/mi^2/yr$, pound per square mile per year; lb/yr, pound per year; --, data not applicable]

USGS station ID or map number (fig. 3; table 1)	Water year	Drainage area (mi^2)	Percentage of urban and recreational grasses	Percent-age of agricul-tural land	1990 pop-ulation density (people per mi^2)	Total runoff minus return flow (in.)	Return flow (in/yr)	Yield from wastewater-treatment facilities ($lb/mi^2/yr$)	Ratio of decidu-ous to forested area	Total nitrogen yield ($lb/mi^2/yr$)	Standard error of total nitrogen yield ($lb/mi^2/yr$)	Total nitrogen load (lb/yr)
01184490	1989	15.5	1.4	39	290	33.3	--	--	0.8	--	--	--
01184490	1990	15.5	1.4	39	290	33.4	--	--	.8	--	--	--
01184490	1991	15.5	1.4	39	290	26.9	--	--	.8	--	--	--
01184490	1992	15.5	1.4	39	290	25.6	--	--	.8	--	--	--
01192500	1988	73.4	2.7	11	1,300	12.5	0	7,800	.7	--	--	--
01192500	1989	73.4	2.7	11	1,300	19.4	0	7,800	.7	--	--	--
01192500	1990	73.4	2.7	11	1,300	24.5	0	7,800	.7	--	--	--
01192500	1991	73.4	2.7	11	1,300	20.9	0	7,800	.7	--	--	--
01208873	1988	10.6	6.6	0	4,700	15.7	--	--	.6	--	--	--
01208873	1989	10.6	6.6	0	4,700	28.8	--	--	.6	--	--	--
01208873	1990	10.6	6.6	0	4,700	22.8	--	--	.6	--	--	--
01208873	1991	10.6	6.6	0	4,700	24.7	--	--	.6	--	--	--
01208873	1992	10.6	6.6	0	4,700	21.4	--	--	.6	--	--	--
01208873	1996	10.6	6.6	0	4,700	22.3	--	--	.6	--	--	--
01208873	1997	10.6	6.6	0	4,700	25.3	--	--	.6	--	--	--
01208873	1998	10.6	6.6	0	4,700	20.2	--	--	.6	--	--	--
01208950	1988	7.4	22	.2	740	15.8	--	--	.6	--	--	--
01208950	1989	7.4	22	.2	740	35.3	--	--	.6	--	--	--
01208950	1990	7.4	22	.2	740	28.3	--	--	.6	--	--	--
01208950	1991	7.4	22	.2	740	25.4	--	--	.6	--	--	--
01208950	1992	7.4	22	.2	740	21.6	--	--	.6	--	--	--
01208950	1993	7.4	22	.2	740	26.0	--	--	.6	--	--	--
01208950	1994	7.4	22	.2	740	23.7	--	--	.6	--	--	--
01208950	1998	7.4	22	.2	740	28.1	--	--	.6	--	--	--

Appendix 4. Nonpoint nitrogen yields and 90-percent confidence intervals for unmonitored and monitored basins draining to Long Island Sound, 1988–98

[Numbers have been independently rounded. lb/mi^2/yr, pound per square mile per year]

U.S. Geological Survey station identification number or map number (fig. 3; table 1)	Water year	Estimated nonpoint nitrogen yield (lb/mi^2/yr)	Lower boundary of the outer 90-percent confidence interval (lb/mi^2/yr)	Lower boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the outer 90-percent confidence interval (lb/mi^2/yr)
29	1988	1,500	220	850	2,100	2,800
29	1989	2,700	1,400	2,000	3,300	3,900
29	1990	2,500	1,200	1,900	3,200	3,800
29	1991	2,000	770	1,400	2,700	3,300
29	1992	1,600	350	980	2,300	2,900
29	1993	1,900	650	1,300	2,600	3,200
29	1994	1,700	420	1,100	2,300	3,000
29	1995	910	0	270	1,500	2,200
29	1996	1,400	86	720	2,000	2,600
29	1997	1,700	460	1,100	2,400	3,000
29	1998	1,700	390	1,000	2,300	2,900
30	1988	3,200	1,800	2,400	3,900	4,500
30	1989	4,600	3,300	3,900	5,400	6,000
30	1990	4,500	3,200	3,800	5,300	5,800
30	1991	3,900	2,600	3,200	4,700	5,300
30	1992	3,700	2,400	3,000	4,400	5,000
30	1993	3,500	2,200	2,700	4,200	4,800
30	1994	3,400	2,100	2,700	4,100	4,700
30	1995	2,700	1,300	1,900	3,400	4,000
30	1996	3,600	2,200	2,800	4,300	4,900
30	1997	3,500	2,200	2,800	4,200	4,800
30	1998	3,300	1,900	2,500	4,000	4,600
31	1988	1,200	0	500	1,800	2,500
31	1989	2,300	1,100	1,700	3,000	3,600
31	1990	2,200	910	1,500	2,900	3,500
31	1991	1,700	430	1,100	2,400	3,000
31	1992	1,300	5	630	2,000	2,600
31	1993	1,600	310	930	2,300	2,900
31	1994	1,400	83	700	2,000	2,700
31	1995	580	0	0	1,300	1,900
31	1996	1,000	0	360	1,700	2,300
31	1997	1,400	120	740	2,100	2,700
31	1998	1,300	50	670	2,000	2,600
32	1988	3,300	2,000	2,600	4,000	4,600
32	1989	4,400	3,100	3,700	5,100	5,700
32	1990	4,300	3,000	3,600	5,000	5,600
32	1991	3,900	2,600	3,200	4,600	5,200
32	1992	3,700	2,400	3,100	4,400	5,000
32	1993	3,500	2,200	2,800	4,200	4,800

Appendix 4. Nonpoint nitrogen yields and 90-percent confidence intervals for unmonitored and monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. lb/mi^2/yr, pound per square mile per year]

U.S. Geological Survey station identification number or map number (fig. 3; table 1)	Water year	Estimated nonpoint nitrogen yield (lb/mi^2/yr)	Lower boundary of the outer 90-percent confidence interval (lb/mi^2/yr)	Lower boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the outer 90-percent confidence interval (lb/mi^2/yr)
32	1994	3,800	2,500	3,100	4,500	5,100
32	1995	2,900	1,600	2,200	3,500	4,100
32	1996	4,000	2,700	3,300	4,700	5,300
32	1997	3,600	2,300	2,900	4,300	4,900
32	1998	3,400	2,100	2,700	4,100	4,700
33	1988	3,300	1,800	2,200	4,300	4,700
33	1989	4,000	2,500	3,000	5,000	5,500
33	1990	4,400	2,900	3,400	5,400	5,900
33	1991	3,900	2,400	2,900	4,900	5,400
33	1992	3,400	1,900	2,400	4,400	4,900
33	1993	3,700	2,200	2,700	4,700	5,200
33	1994	3,900	2,400	2,900	4,800	5,300
33	1995	2,900	1,400	1,900	3,900	4,400
33	1996	3,900	2,400	2,900	4,900	5,400
33	1997	3,700	2,300	2,800	4,700	5,200
33	1998	3,500	2,000	2,500	4,500	5,000
34	1988	2,500	1,200	1,800	3,200	3,800
34	1989	3,600	2,300	2,900	4,300	4,900
34	1990	3,800	2,500	3,100	4,400	5,000
34	1991	3,100	1,800	2,400	3,800	4,400
34	1992	2,700	1,400	2,000	3,400	4,000
34	1993	2,900	1,600	2,200	3,600	4,200
34	1994	3,300	2,000	2,600	4,000	4,600
34	1995	2,200	930	1,500	2,900	3,500
34	1996	3,200	1,900	2,500	3,900	4,500
34	1997	3,200	1,900	2,500	3,900	4,500
34	1998	2,500	1,200	1,800	3,200	3,800
35	1988	2,900	1,600	2,200	3,600	4,200
35	1989	4,400	3,200	3,800	5,100	5,700
35	1990	4,200	2,900	3,500	4,800	5,500
35	1991	3,700	2,400	3,100	4,400	5,000
35	1992	3,800	2,500	3,100	4,400	5,100
35	1993	3,700	2,400	3,100	4,400	5,000
35	1994	3,400	2,100	2,700	4,000	4,600
35	1995	2,500	1,300	1,900	3,200	3,800
35	1996	3,500	2,200	2,800	4,100	4,800
35	1997	3,700	2,400	3,000	4,400	5,000
35	1998	3,500	2,200	2,800	4,200	4,800
36	1988	2,700	1,400	2,000	3,300	4,000

Appendix 4. Nonpoint nitrogen yields and 90-percent confidence intervals for unmonitored and monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. lb/mi^2/yr, pound per square mile per year]

U.S. Geological Survey station identification number or map number (fig. 3; table 1)	Water year	Estimated nonpoint nitrogen yield (lb/mi^2/yr)	Lower boundary of the outer 90-percent confidence interval (lb/mi^2/yr)	Lower boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the outer 90-percent confidence interval (lb/mi^2/yr)
36	1989	4,100	2,900	3,500	4,800	5,400
36	1990	4,000	2,700	3,400	4,700	5,300
36	1991	3,400	2,200	2,800	4,100	4,700
36	1992	3,200	1,900	2,600	3,900	4,500
36	1993	3,000	1,700	2,300	3,600	4,300
36	1994	2,900	1,600	2,200	3,500	4,200
36	1995	2,200	880	1,500	2,800	3,400
36	1996	3,100	1,800	2,400	3,700	4,400
36	1997	3,000	1,700	2,300	3,600	4,300
36	1998	2,800	1,500	2,100	3,400	4,100
37	1988	3,800	2,400	3,000	4,700	5,300
37	1989	4,900	3,500	4,000	5,800	6,300
37	1990	4,800	3,400	3,900	5,700	6,200
37	1991	4,400	3,000	3,500	5,200	5,800
37	1992	4,200	2,800	3,400	5,100	5,600
37	1993	4,000	2,600	3,100	4,900	5,400
37	1994	4,300	2,900	3,500	5,200	5,700
37	1995	3,400	2,000	2,500	4,200	4,800
37	1996	4,500	3,100	3,600	5,300	5,900
37	1997	4,100	2,700	3,200	5,000	5,500
37	1998	3,900	2,500	3,000	4,800	5,300
38	1988	5,700	3,900	4,300	7,000	7,400
38	1989	6,700	5,000	5,400	8,100	8,400
38	1990	6,600	4,900	5,300	8,000	8,300
38	1991	6,200	4,500	4,900	7,500	7,900
38	1992	6,100	4,300	4,700	7,400	7,800
38	1993	5,800	4,100	4,500	7,200	7,600
38	1994	6,100	4,400	4,800	7,500	7,900
38	1995	5,200	3,500	3,900	6,500	6,900
38	1996	6,300	4,600	5,000	7,600	8,000
38	1997	5,900	4,200	4,600	7,200	7,600
38	1998	5,700	4,000	4,400	7,100	7,500
39	1988	1,400	130	760	2,000	2,700
39	1989	2,600	1,300	1,900	3,200	3,800
39	1990	2,400	1,200	1,800	3,100	3,700
39	1991	1,900	680	1,300	2,600	3,200
39	1992	1,500	250	890	2,200	2,800
39	1993	1,800	550	1,200	2,500	3,100
39	1994	1,600	330	960	2,200	2,900

Appendix 4. Nonpoint nitrogen yields and 90-percent confidence intervals for unmonitored and monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. lb/mi^2/yr, pound per square mile per year]

U.S. Geological Survey station identification number or map number (fig. 3; table 1)	Water year	Estimated nonpoint nitrogen yield (lb/mi^2/yr)	Lower boundary of the outer 90-percent confidence interval (lb/mi^2/yr)	Lower boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the outer 90-percent confidence interval (lb/mi^2/yr)
39	1995	810	0	180	1,400	2,100
39	1996	1,300	0	630	1,900	2,500
39	1997	1,600	360	1,000	2,300	2,900
39	1998	1,600	300	930	2,200	2,800
40	1988	2,000	720	1,300	2,700	3,300
40	1989	3,300	2,000	2,600	3,900	4,600
40	1990	3,300	2,000	2,700	4,000	4,600
40	1991	2,700	1,400	2,100	3,400	4,000
40	1992	2,000	770	1,400	2,700	3,300
40	1993	2,600	1,300	1,900	3,300	3,900
40	1994	2,100	810	1,400	2,700	3,400
40	1995	1,300	62	690	2,000	2,600
40	1996	2,100	840	1,500	2,800	3,400
40	1997	2,500	1,200	1,900	3,200	3,800
40	1998	2,600	1,300	1,900	3,200	3,800
41	1988	2,000	700	1,300	2,600	3,200
41	1989	3,100	1,900	2,500	3,800	4,400
41	1990	3,000	1,700	2,400	3,600	4,300
41	1991	2,500	1,200	1,900	3,200	3,800
41	1992	2,100	820	1,500	2,700	3,400
41	1993	2,400	1,100	1,800	3,000	3,700
41	1994	2,200	900	1,500	2,800	3,400
41	1995	1,400	110	750	2,000	2,700
41	1996	1,800	560	1,200	2,500	3,100
41	1997	2,200	930	1,600	2,800	3,500
41	1998	2,100	870	1,500	2,800	3,400
42	1988	2,400	1,100	1,800	3,100	3,700
42	1989	3,100	1,800	2,400	3,700	4,400
42	1990	3,100	1,800	2,500	3,700	4,400
42	1991	2,800	1,500	2,100	3,400	4,000
42	1992	2,000	690	1,300	2,600	3,200
42	1993	2,400	1,100	1,800	3,000	3,700
42	1994	2,300	990	1,600	2,900	3,500
42	1995	1,600	280	910	2,200	2,800
42	1996	2,200	890	1,500	2,800	3,400
42	1997	2,300	1,100	1,700	3,000	3,600
42	1998	2,300	980	1,600	2,900	3,500
43	1988	2,600	1,200	1,800	3,300	3,900
43	1989	3,300	1,900	2,500	4,100	4,600

Appendix 4. Nonpoint nitrogen yields and 90-percent confidence intervals for unmonitored and monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. lb/mi^2/yr, pound per square mile per year]

U.S. Geological Survey station identification number or map number (fig. 3; table 1)	Water year	Estimated nonpoint nitrogen yield (lb/mi^2/yr)	Lower boundary of the outer 90-percent confidence interval (lb/mi^2/yr)	Lower boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the outer 90-percent confidence interval (lb/mi^2/yr)
43	1990	3,500	2,200	2,700	4,300	4,900
43	1991	2,600	1,200	1,800	3,400	4,000
43	1992	2,500	1,100	1,700	3,300	3,800
43	1993	2,900	1,500	2,100	3,700	4,200
43	1994	2,300	980	1,500	3,100	3,700
43	1995	1,800	410	980	2,600	3,100
43	1996	2,400	1,100	1,600	3,200	3,800
43	1997	2,700	1,300	1,900	3,400	4,000
43	1998	2,900	1,500	2,100	3,700	4,300
44	1988	1,700	440	1,100	2,400	3,000
44	1989	3,000	1,700	2,300	3,700	4,300
44	1990	3,100	1,800	2,400	3,700	4,400
44	1991	2,500	1,200	1,800	3,100	3,800
44	1992	1,800	490	1,100	2,500	3,100
44	1993	2,300	1,100	1,700	3,000	3,600
44	1994	1,800	530	1,100	2,500	3,100
44	1995	1,100	0	400	1,800	2,400
44	1996	1,900	570	1,200	2,500	3,200
44	1997	2,300	960	1,600	2,900	3,500
44	1998	2,300	1,000	1,600	3,000	3,600
45	1988	2,200	880	1,500	2,900	3,500
45	1989	2,900	1,600	2,200	3,600	4,200
45	1990	3,100	1,800	2,500	3,800	4,400
45	1991	2,200	940	1,600	2,900	3,500
45	1992	2,100	820	1,400	2,800	3,400
45	1993	2,500	1,200	1,800	3,200	3,800
45	1994	2,000	670	1,300	2,600	3,300
45	1995	1,400	100	720	2,100	2,700
45	1996	2,000	750	1,400	2,700	3,300
45	1997	2,300	990	1,600	3,000	3,600
45	1998	2,500	1,200	1,800	3,200	3,800
46	1988	1,500	140	730	2,200	2,800
46	1989	2,700	1,400	2,000	3,500	4,000
46	1990	2,800	1,500	2,100	3,500	4,100
46	1991	2,200	860	1,500	2,900	3,500
46	1992	1,500	190	780	2,200	2,800
46	1993	2,100	750	1,300	2,800	3,400
46	1994	1,500	230	820	2,300	2,900
46	1995	800	0	78	1,500	2,100

Appendix 4. Nonpoint nitrogen yields and 90-percent confidence intervals for unmonitored and monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. lb/mi^2/yr, pound per square mile per year]

U.S. Geological Survey station identification number or map number (fig. 3; table 1)	Water year	Estimated nonpoint nitrogen yield (lb/mi^2/yr)	Lower boundary of the outer 90-percent confidence interval (lb/mi^2/yr)	Lower boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the outer 90-percent confidence interval (lb/mi^2/yr)
46	1996	1,600	270	860	2,300	2,900
46	1997	2,000	660	1,300	2,700	3,300
46	1998	2,000	700	1,300	2,700	3,300
47	1988	1,200	0	500	1,800	2,500
47	1989	2,600	1,300	1,900	3,300	3,900
47	1990	2,300	1,000	1,700	3,000	3,600
47	1991	2,200	870	1,500	2,800	3,400
47	1992	1,500	250	870	2,200	2,800
47	1993	1,800	550	1,200	2,500	3,100
47	1994	1,600	360	980	2,300	2,900
47	1995	660	0	0	1,300	1,900
47	1996	1,500	200	820	2,100	2,800
47	1997	1,600	340	960	2,300	2,900
47	1998	1,800	470	1,100	2,400	3,000
48	1988	3,500	2,100	2,600	4,400	4,900
48	1989	4,800	3,400	3,900	5,600	6,200
48	1990	4,800	3,400	4,000	5,700	6,200
48	1991	4,200	2,800	3,400	5,100	5,600
48	1992	3,900	2,500	3,000	4,700	5,300
48	1993	3,800	2,400	3,000	4,700	5,200
48	1994	3,900	2,500	3,100	4,800	5,300
48	1995	3,000	1,600	2,100	3,800	4,400
48	1996	3,900	2,500	3,100	4,700	5,300
48	1997	4,100	2,700	3,300	4,900	5,500
48	1998	3,900	2,500	3,000	4,700	5,300
49	1988	3,300	1,900	2,400	4,300	4,800
49	1989	5,000	3,500	4,000	5,900	6,400
49	1990	5,000	3,600	4,100	5,900	6,400
49	1991	4,500	3,100	3,600	5,400	5,900
49	1992	4,100	2,700	3,200	5,000	5,500
49	1993	4,300	2,900	3,400	5,200	5,700
49	1994	3,900	2,500	3,000	4,800	5,300
49	1995	2,800	1,300	1,900	3,700	4,200
49	1996	4,000	2,500	3,100	4,900	5,400
49	1997	4,200	2,800	3,300	5,100	5,600
49	1998	3,900	2,400	2,900	4,800	5,300
50	1988	2,300	1,000	1,600	3,000	3,600
50	1989	3,500	2,200	2,800	4,200	4,800
50	1990	3,400	2,100	2,700	4,100	4,700

Appendix 4. Nonpoint nitrogen yields and 90-percent confidence intervals for unmonitored and monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. lb/mi^2/yr, pound per square mile per year]

U.S. Geological Survey station identification number or map number (fig. 3; table 1)	Water year	Estimated nonpoint nitrogen yield (lb/mi^2/yr)	Lower boundary of the outer 90-percent confidence interval (lb/mi^2/yr)	Lower boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the outer 90-percent confidence interval (lb/mi^2/yr)
50	1991	2,900	1,600	2,200	3,600	4,200
50	1992	2,600	1,300	1,900	3,200	3,900
50	1993	2,900	1,600	2,200	3,600	4,200
50	1994	2,900	1,600	2,200	3,600	4,200
50	1995	1,700	410	1,000	2,400	3,000
50	1996	3,000	1,700	2,300	3,700	4,300
50	1997	3,000	1,700	2,300	3,700	4,300
50	1998	2,400	1,100	1,700	3,000	3,600
51	1988	1,900	660	1,300	2,600	3,200
51	1989	3,000	1,700	2,300	3,600	4,200
51	1990	2,900	1,600	2,200	3,500	4,100
51	1991	2,600	1,300	1,900	3,200	3,800
51	1992	1,900	650	1,300	2,600	3,200
51	1993	2,100	830	1,500	2,700	3,400
51	1994	2,200	910	1,500	2,800	3,500
51	1995	1,100	0	410	1,700	2,300
51	1996	2,300	990	1,600	2,900	3,500
51	1997	2,400	1,200	1,800	3,100	3,700
51	1998	1,700	460	1,100	2,400	3,000
52	1988	3,100	1,700	2,200	4,000	4,500
52	1989	5,000	3,500	4,100	5,800	6,400
52	1990	4,100	2,700	3,300	5,000	5,500
52	1991	4,300	2,900	3,400	5,100	5,700
52	1992	3,200	1,800	2,300	4,100	4,600
52	1993	3,800	2,400	3,000	4,700	5,200
52	1994	3,500	2,100	2,700	4,400	4,900
52	1995	2,500	1,100	1,700	3,400	3,900
52	1996	3,700	2,300	2,800	4,500	5,100
52	1997	4,000	2,600	3,200	4,900	5,400
52	1998	3,300	1,900	2,400	4,100	4,700
53	1988	3,600	2,200	2,700	4,500	5,100
53	1989	5,200	3,800	4,300	6,100	6,600
53	1990	4,600	3,200	3,700	5,500	6,100
53	1991	4,300	2,800	3,300	5,200	5,700
53	1992	3,800	2,300	2,900	4,700	5,200
53	1993	4,100	2,700	3,200	5,000	5,500
53	1994	3,800	2,400	2,900	4,700	5,200
53	1995	2,500	1,100	1,600	3,500	4,000
53	1996	4,000	2,600	3,100	4,900	5,400

Appendix 4. Nonpoint nitrogen yields and 90-percent confidence intervals for unmonitored and monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. lb/mi^2/yr, pound per square mile per year]

U.S. Geological Survey station identification number or map number (fig. 3; table 1)	Water year	Estimated nonpoint nitrogen yield (lb/mi^2/yr)	Lower boundary of the outer 90-percent confidence interval (lb/mi^2/yr)	Lower boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the outer 90-percent confidence interval (lb/mi^2/yr)
53	1997	4,400	2,900	3,500	5,300	5,800
53	1998	3,900	2,500	3,000	4,800	5,300
54	1988	2,800	1,400	2,000	3,600	4,200
54	1989	4,700	3,300	3,900	5,500	6,000
54	1990	3,800	2,500	3,000	4,600	5,200
54	1991	4,000	2,600	3,200	4,800	5,300
54	1992	2,900	1,600	2,100	3,700	4,200
54	1993	3,500	2,200	2,800	4,300	4,900
54	1994	3,300	1,900	2,500	4,000	4,600
54	1995	2,300	910	1,500	3,000	3,600
54	1996	3,400	2,000	2,600	4,200	4,700
54	1997	3,700	2,400	2,900	4,500	5,100
54	1998	3,000	1,600	2,200	3,800	4,300
01118500	1988	2,300	2,100	2,100	2,600	2,600
01118500	1989	3,000	2,800	2,800	3,300	3,300
01118500	1990	3,200	3,000	3,000	3,400	3,400
01118500	1991	2,400	2,300	2,300	2,600	2,600
01118500	1992	2,400	2,200	2,200	2,600	2,600
01118500	1993	2,300	2,100	2,100	2,500	2,500
01118500	1994	2,000	1,800	1,800	2,100	2,100
01118500	1995	1,800	1,700	1,700	1,900	1,900
01118500	1996	2,200	2,100	2,100	2,400	2,400
01118500	1997	2,400	2,100	2,100	2,600	2,600
01118500	1998	2,400	2,100	2,100	2,800	2,800
01122610	1988	1,700	1,500	1,500	1,900	1,900
01122610	1989	2,900	2,500	2,500	3,200	3,200
01122610	1990	2,700	2,500	2,500	3,000	3,000
01122610	1991	2,100	1,900	1,900	2,300	2,300
01122610	1992	1,800	1,600	1,600	2,000	2,000
01122610	1993	2,000	1,700	1,700	2,300	2,300
01122610	1994	2,100	1,800	1,800	2,400	2,400
01122610	1995	1,200	1,000	1,000	1,300	1,300
01122610	1996	2,000	1,800	1,800	2,300	2,300
01122610	1997	2,000	1,700	1,700	2,200	2,200
01122610	1998	1,700	1,400	1,400	2,000	2,000
01124000	1988	1,600	1,000	1,000	2,200	2,200
01124000	1989	2,100	1,500	1,500	2,700	2,700
01124000	1990	2,000	1,400	1,400	2,500	2,500
01124000	1991	1,400	820	820	1,900	1,900

Appendix 4. Nonpoint nitrogen yields and 90-percent confidence intervals for unmonitored and monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. $lb/mi^2/yr$, pound per square mile per year]

U.S. Geological Survey station identification number or map number (fig. 3; table 1)	Water year	Estimated nonpoint nitrogen yield ($lb/mi^2/yr$)	Lower boundary of the outer 90-percent confidence interval ($lb/mi^2/yr$)	Lower boundary of the inner 90-percent confidence interval ($lb/mi^2/yr$)	Upper boundary of the inner 90-percent confidence interval ($lb/mi^2/yr$)	Upper boundary of the outer 90-percent confidence interval ($lb/mi^2/yr$)
01124000	1992	1,300	790	790	1,900	1,900
01124000	1993	1,200	640	640	1,800	1,800
01124000	1994	1,500	890	890	2,000	2,000
01124000	1995	730	190	190	1,300	1,300
01124000	1996	1,500	930	930	2,100	2,100
01124000	1997	1,400	830	830	2,000	2,000
01124000	1998	1,300	680	680	1,900	1,900
01127000	1988	2,300	1,900	1,900	2,700	2,700
01127000	1989	3,200	2,800	2,800	3,600	3,600
01127000	1990	3,300	2,900	2,900	3,800	3,800
01127000	1991	2,600	2,200	2,200	3,000	3,000
01127000	1992	2,300	2,000	2,000	2,700	2,700
01127000	1993	2,500	2,100	2,100	3,000	3,000
01127000	1994	2,500	2,000	2,000	2,900	2,900
01127000	1995	1,700	1,300	1,300	2,100	2,100
01127000	1996	2,900	2,500	2,500	3,400	3,400
01127000	1997	3,200	2,700	2,700	3,700	3,700
01127000	1998	3,200	2,600	2,600	3,800	3,800
01135300	1993	1,400	790	790	2,000	2,000
01135300	1994	1,500	960	960	2,000	2,000
01135300	1995	810	500	500	1,100	1,100
01137500	1993	1,300	1,100	1,100	1,400	1,400
01137500	1994	1,400	1,300	1,300	1,600	1,600
01137500	1995	1,000	940	940	1,100	1,100
01144000	1993	1,300	710	710	2,000	2,000
01144000	1994	1,600	700	700	2,400	2,400
01144000	1995	840	590	590	1,100	1,100
01154500	1988	2,300	1,900	1,900	2,800	2,800
01154500	1989	2,300	1,800	1,800	2,800	2,800
01154500	1990	2,800	2,200	2,200	3,300	3,300
01154500	1991	2,000	1,600	1,600	2,400	2,400
01154500	1992	1,500	1,100	1,100	1,800	1,800
01154500	1993	1,300	830	830	1,700	1,700
01154500	1994	1,200	670	670	1,800	1,800
01170100	1993	1,400	1,300	1,300	1,500	1,500
01170100	1994	1,300	1,200	1,200	1,300	1,300
01170100	1995	770	720	720	830	830
01184000	1988	2,600	2,100	2,100	3,100	3,100
01184000	1989	2,600	2,200	2,200	3,100	3,100

Appendix 4. Nonpoint nitrogen yields and 90-percent confidence intervals for unmonitored and monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. lb/mi^2/yr, pound per square mile per year]

U.S. Geological Survey station identification number or map number (fig. 3; table 1)	Water year	Estimated nonpoint nitrogen yield (lb/mi^2/yr)	Lower boundary of the outer 90-percent confidence interval (lb/mi^2/yr)	Lower boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the outer 90-percent confidence interval (lb/mi^2/yr)
01184000	1990	3,000	2,500	2,500	3,400	3,400
01184000	1991	2,300	1,900	1,900	2,800	2,800
01184000	1992	1,900	1,500	1,500	2,300	2,300
01184000	1993	1,800	1,300	1,300	2,200	2,200
01184000	1994	1,800	1,400	1,400	2,300	2,300
01184000	1995	1,100	720	720	1,500	1,500
01184000	1996	2,200	1,800	1,800	2,700	2,700
01184000	1997	1,900	1,400	1,400	2,300	2,300
01184000	1998	1,700	1,200	1,200	2,200	2,200
01184100	1988	2,900	2,700	2,700	3,200	3,200
01184100	1989	4,300	3,800	3,800	4,800	4,800
01184100	1990	4,100	3,600	3,600	4,500	4,500
01184100	1991	3,300	2,900	2,900	3,700	3,700
01184100	1992	3,500	2,300	2,900	4,100	4,700
01184100	1993	3,300	2,100	2,700	3,900	4,400
01184100	1994	3,600	2,400	3,000	4,200	4,800
01184100	1995	2,600	1,500	2,000	3,300	3,800
01184100	1996	3,700	2,600	3,100	4,400	4,900
01184100	1997	3,400	2,200	2,700	4,000	4,500
01184100	1998	3,200	2,000	2,500	3,800	4,400
01184490	1988	14,000	11,000	12,000	17,000	18,000
01184490	1989	16,000	12,000	13,000	18,000	19,000
01184490	1990	16,000	12,000	13,000	18,000	19,000
01184490	1991	15,000	11,000	12,000	18,000	19,000
01184490	1992	15,000	11,000	12,000	17,000	19,000
01184490	1993	15,000	15,000	15,000	16,000	16,000
01184490	1994	14,000	13,000	13,000	14,000	14,000
01184490	1995	11,000	10,000	10,000	11,000	11,000
01184490	1996	16,000	15,000	15,000	17,000	17,000
01184490	1997	15,000	14,000	14,000	15,000	15,000
01184490	1998	15,000	14,000	14,000	16,000	16,000
01186800	1988	1,500	1,400	1,400	1,700	1,700
01186800	1989	2,000	1,800	1,800	2,300	2,300
01186800	1990	2,000	1,700	1,700	2,300	2,300
01186800	1991	1,600	1,300	1,300	1,900	1,900
01188000	1988	1,800	1,500	1,500	2,100	2,100
01188000	1989	2,600	2,100	2,100	3,200	3,200
01188000	1990	2,800	2,300	2,300	3,300	3,300
01188000	1991	2,300	1,900	1,900	2,600	2,600

Appendix 4. Nonpoint nitrogen yields and 90-percent confidence intervals for unmonitored and monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. lb/mi^2/yr, pound per square mile per year]

U.S. Geological Survey station identification number or map number (fig. 3; table 1)	Water year	Estimated nonpoint nitrogen yield (lb/mi^2/yr)	Lower boundary of the outer 90-percent confidence interval (lb/mi^2/yr)	Lower boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the outer 90-percent confidence interval (lb/mi^2/yr)
01188000	1992	2,100	1,800	1,800	2,500	2,500
01188000	1993	1,800	1,500	1,500	2,100	2,100
01188000	1994	2,100	1,700	1,700	2,500	2,500
01188000	1995	1,300	1,000	1,000	1,500	1,500
01188000	1996	1,800	1,400	1,400	2,300	2,300
01188000	1997	1,600	1,200	1,200	2,100	2,100
01188000	1998	1,200	780	780	1,600	1,600
01188090	1988	920	700	700	1,100	1,100
01188090	1989	1,400	1,200	1,200	1,700	1,700
01188090	1990	1,600	1,400	1,400	1,900	1,900
01188090	1991	1,100	930	930	1,300	1,300
01188090	1992	900	750	750	1,100	1,100
01188090	1993	1,100	820	820	1,300	1,300
01188090	1994	880	720	720	1,000	1,000
01188090	1995	480	380	380	580	580
01188090	1996	1,200	950	950	1,500	1,500
01188090	1997	1,200	910	910	1,500	1,500
01188090	1998	870	550	550	1,200	1,200
01189000	1993	7,500	4,000	4,000	11,000	11,000
01189000	1994	2,500	1,200	1,200	3,800	3,800
01189000	1995	1,700	220	220	3,200	3,200
01189995	1988	1,500	1,200	1,200	1,900	1,900
01189995	1989	2,200	1,900	1,900	2,500	2,500
01189995	1990	2,600	2,300	2,300	3,000	3,000
01189995	1991	2,100	1,800	1,800	2,400	2,400
01189995	1992	1,900	1,600	1,600	2,100	2,100
01189995	1993	1,800	1,500	1,500	2,100	2,100
01189995	1994	1,900	1,600	1,600	2,200	2,200
01189995	1995	1,100	840	840	1,300	1,300
01189995	1996	2,100	1,800	1,800	2,400	2,400
01189995	1997	2,000	1,600	1,600	2,300	2,300
01189995	1998	1,400	1,000	1,000	1,800	1,800
01192500	1988	2,800	1,400	2,200	3,400	4,300
01192500	1989	3,600	2,200	3,000	4,200	5,000
01192500	1990	4,000	2,600	3,400	4,500	5,400
01192500	1991	3,500	2,100	2,900	4,100	4,900
01192500	1992	3,300	2,200	2,200	4,400	4,400
01192500	1993	3,700	2,900	2,900	4,600	4,600
01192500	1994	4,100	3,300	3,300	5,000	5,000

Appendix 4. Nonpoint nitrogen yields and 90-percent confidence intervals for unmonitored and monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. lb/mi^2/yr, pound per square mile per year]

U.S. Geological Survey station identification number or map number (fig. 3; table 1)	Water year	Estimated nonpoint nitrogen yield (lb/mi^2/yr)	Lower boundary of the outer 90-percent confidence interval (lb/mi^2/yr)	Lower boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the outer 90-percent confidence interval (lb/mi^2/yr)
01192500	1995	1,800	980	980	2,600	2,600
01192500	1996	3,900	3,100	3,100	4,800	4,800
01192500	1997	3,700	2,700	2,700	4,600	4,600
01192500	1998	2,600	1,500	1,500	3,800	3,800
01192704	1988	3,500	2,400	3,000	4,100	4,700
01192704	1989	4,700	3,600	4,200	5,200	5,900
01192704	1990	4,600	3,400	4,100	5,100	5,700
01192704	1991	4,100	3,000	3,600	4,600	5,200
01192704	1992	3,700	2,500	3,200	4,200	4,800
01192704	1993	4,000	2,800	3,500	4,500	5,100
01192704	1994	3,700	2,600	3,200	4,200	4,900
01192704	1995	3,000	1,800	2,500	3,500	4,100
01192704	1996	4,300	3,800	3,800	4,800	4,800
01192704	1997	4,000	3,700	3,700	4,400	4,400
01192704	1998	3,800	3,300	3,300	4,200	4,200
01193500	1988	2,000	1,600	1,600	2,400	2,400
01193500	1989	3,500	2,900	2,900	4,200	4,200
01193500	1990	3,000	2,500	2,500	3,500	3,500
01193500	1991	2,200	1,900	1,900	2,600	2,600
01193500	1992	1,800	1,500	1,500	2,000	2,000
01193500	1993	1,900	1,500	1,500	2,300	2,300
01193500	1994	1,700	1,400	1,400	2,000	2,000
01193500	1995	1,100	930	930	1,300	1,300
01193500	1996	1,300	1,100	1,100	1,600	1,600
01193500	1997	1,500	1,100	1,100	1,900	1,900
01193500	1998	1,500	990	990	2,000	2,000
01196500	1988	210	0	0	1,200	1,200
01196500	1989	2,900	1,800	1,800	4,000	4,000
01196500	1990	3,700	2,600	2,600	4,700	4,700
01196500	1991	2,700	1,800	1,800	3,700	3,700
01196500	1992	2,300	1,400	1,400	3,300	3,300
01196500	1993	2,500	1,400	1,400	3,500	3,500
01196500	1994	2,900	1,800	1,800	4,000	4,000
01196500	1995	1,300	440	440	2,200	2,200
01196500	1996	3,000	1,900	1,900	4,100	4,100
01196500	1997	3,700	2,400	2,400	5,000	5,000
01196500	1998	2,800	1,300	1,300	4,300	4,300
01199900	1993	2,900	2,700	2,700	3,200	3,200
01199900	1994	3,300	3,100	3,100	3,500	3,500

Appendix 4. Nonpoint nitrogen yields and 90-percent confidence intervals for unmonitored and monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. lb/mi^2/yr, pound per square mile per year]

U.S. Geological Survey station identification number or map number (fig. 3; table 1)	Water year	Estimated nonpoint nitrogen yield (lb/mi^2/yr)	Lower boundary of the outer 90-percent confidence interval (lb/mi^2/yr)	Lower boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the outer 90-percent confidence interval (lb/mi^2/yr)
01199900	1995	2,300	2,100	2,100	2,500	2,500
01205500	1988	1,700	1,300	1,300	2,100	2,100
01205500	1989	2,400	2,000	2,000	2,800	2,800
01205500	1990	3,000	2,600	2,600	3,500	3,500
01205500	1991	2,200	1,800	1,800	2,600	2,600
01205500	1992	1,600	1,200	1,200	2,000	2,000
01205500	1993	2,100	1,600	1,600	2,500	2,500
01205500	1994	2,200	1,700	1,700	2,600	2,600
01205500	1995	1,000	650	650	1,400	1,400
01205500	1996	2,600	2,100	2,100	3,100	3,100
01205500	1997	2,200	1,700	1,700	2,700	2,700
01205500	1998	1,100	640	640	1,600	1,600
01208500	1988	4,400	3,500	3,500	5,300	5,300
01208500	1989	5,700	4,900	4,900	6,600	6,600
01208500	1990	5,200	4,400	4,400	6,000	6,000
01208500	1991	3,500	2,900	2,900	4,200	4,200
01208500	1992	2,600	2,000	2,000	3,300	3,300
01208500	1993	2,600	1,800	1,800	3,300	3,300
01208500	1994	2,700	2,000	2,000	3,400	3,400
01208500	1995	1,000	460	460	1,600	1,600
01208500	1996	3,100	2,300	2,300	3,800	3,800
01208500	1997	3,500	2,600	2,600	4,400	4,400
01208500	1998	2,400	1,500	1,500	3,400	3,400
01208873	1988	5,800	1,900	3,000	8,500	9,700
01208873	1989	7,000	3,100	4,200	9,700	11,000
01208873	1990	6,300	2,400	3,500	9,100	10,000
01208873	1991	6,400	2,500	3,600	9,100	10,000
01208873	1992	5,900	2,000	3,100	8,700	9,800
01208873	1993	4,500	3,500	3,500	5,400	5,400
01208873	1994	7,000	6,200	6,200	7,800	7,800
01208873	1995	3,800	3,300	3,300	4,300	4,300
01208873	1996	5,700	1,800	2,900	8,400	9,600
01208873	1997	5,900	2,000	3,100	8,700	9,800
01208873	1998	5,300	1,400	2,500	8,100	9,200
01208950	1988	4,000	460	1,400	6,600	7,600
01208950	1989	5,600	2,000	3,000	8,200	9,200
01208950	1990	5,000	1,500	2,400	7,600	8,600
01208950	1991	4,700	1,100	2,100	7,300	8,200
01208950	1992	4,200	620	1,600	6,800	7,700

Appendix 4. Nonpoint nitrogen yields and 90-percent confidence intervals for unmonitored and monitored basins draining to Long Island Sound, 1988–98—Continued

[Numbers have been independently rounded. lb/mi^2/yr, pound per square mile per year]

U.S. Geological Survey station identification number or map number (fig. 3; table 1)	Water year	Estimated nonpoint nitrogen yield (lb/mi^2/yr)	Lower boundary of the outer 90-percent confidence interval (lb/mi^2/yr)	Lower boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the inner 90-percent confidence interval (lb/mi^2/yr)	Upper boundary of the outer 90-percent confidence interval (lb/mi^2/yr)
01208950	1993	4,500	940	1,900	7,100	8,100
01208950	1994	4,200	640	1,600	6,800	7,800
01208950	1995	2,100	1,800	1,800	2,400	2,400
01208950	1996	5,300	4,600	4,600	5,900	5,900
01208950	1997	6,400	5,600	5,600	7,200	7,200
01208950	1998	4,300	750	1,700	6,900	7,900
01208990	1988	1,400	1,100	1,100	1,800	1,800
01208990	1989	2,200	1,700	1,700	2,800	2,800
01208990	1990	2,100	1,700	1,700	2,400	2,400
01208990	1991	1,700	1,400	1,400	2,000	2,000
01208990	1992	1,300	1,100	1,100	1,500	1,500
01208990	1993	1,300	970	970	1,500	1,500
01208990	1994	1,400	1,100	1,100	1,600	1,600
01208990	1995	780	650	650	920	920
01208990	1996	1,400	1,100	1,100	1,800	1,800
01208990	1997	1,600	1,100	1,100	2,100	2,100
01208990	1998	1,200	750	750	1,600	1,600
01209710	1988	2,000	1,700	1,700	2,400	2,400
01209710	1989	4,800	4,000	4,000	5,500	5,500
01209710	1990	3,100	2,800	2,800	3,300	3,300
01209710	1991	3,000	2,700	2,700	3,400	3,400
01209710	1992	1,800	1,600	1,600	2,000	2,000
01209710	1993	2,400	2,100	2,100	2,600	2,600
01209710	1994	2,200	1,900	1,900	2,400	2,400
01209710	1995	1,300	1,200	1,200	1,500	1,500
01209710	1996	2,500	2,200	2,200	2,800	2,800
01209710	1997	3,200	2,800	2,800	3,700	3,700
01209710	1998	2,500	2,000	2,000	3,000	3,000

Appendix 5. Estimates of total nitrogen load from municipal wastewater-treatment facilities (1998) and estimates of return flow (1990) used in multiple regression analysis

[Data from Medalie, 1996; Paul Stacey, Connecticut Department of Environmental Protection, written commun., 1999. NPDES, National Pollution Discharge Elimination System; WY, water year; Mgal/d, million gallons per day; mg/L as N, milligram per liter as nitrogen; lb/yr, pound per year; --, data not available; NA, not applicable]

Wastewater-treatment facility	Long Island Sound management zone	Water-quality station/ unmonitored basin	Site number (fig. 4)	NPDES permit number	Receiving water body	Date	Return flow (Mgal/d)	Average total nitrogen concentration (mg/L as N)	Nitrogen load (lb/yr)
Ladd School	NA	01118500	1	RI0100081	Queen River	1990	0.05	--	--
Stonington-Pawcatuck	NA	Pawcatuck	142	CT0101290	Long Island Sound	1990	.33	--	-
Westerly	NA	Pawcatuck	143	RI0110006	Pawcatuck River	1990	2.1	--	--
University of Conn.	1	01122610	2	CT0101320	Willimantic River	WY98	1.1	5.3	16,000
Stafford	1	01122610	3	CT0101214	Willimantic River	WY98	1.5	18.0	77,000
Willimantic	1	01122610	4	CT0101001	Willimantic River	WY98	3.0	14.0	130,000
Coventry	1	01122610	181	--	Willimantic River (gw)	1990	.06	--	--
Charlton	1	01124000/01127000	5	MA0101141	Cady Brook	1990	.09	--	--
Sturbridge	1	01124000/01127000	6	MA0100421	Quinebaug River	1990	.41	--	--
Southbridge	1	01124000/01127000	7	MA0100901	Quinebaug River	1990	2.5	--	--
Leicester	1	01127000	8	MA0101796	Rawson Brook	1990	.14	--	--
Oxford-Rochdale	1	01127000	9	MA0100170	French River Tributary	1990	.16	--	--
Webster	1	01127000	10	MA0100439	French River	1990	4.4	--	--
Thompson	1	01127000	11	CT0100706	Quinebaug River	1990	.21	--	--
Putnam	1	01127000	12	CT0100960	Quinebaug River	WY98	1.2	12.0	41,000
Killingly	1	01127000	13	CT0101257	Quinebaug River	WY98	3.2	4.0	36,000
Plainfield North	1	01127000	14	CT0100447	Moosup River	WY98	.86	13.0	31,000
Plainfield Village	1	01127000	15	CT0100439	Mill Brook	WY98	.57	8.4	14,000
Jewett City	1	01127000	16	CT0100269	Quinebaug River	1990	.55	--	--
Stonington Borough	1	East of Thames	148	CT0101281	Pawcatuck River	WY98	.24	37.0	31,000
Mystic	1	East of Thames	149	CT0100544	Mystic River	5/13/93	.54	30.0	48,000
Sprague	1	Shetucket	182	CT0100978	Shetucket River	1990	.18	--	--
Montville	1	Thames	144	CT0100935	Thames River	WY98	2.6	21.0	150,000
New London	1	Thames	145	CT0100382	Thames River	WY98	9.6	12.0	360,000
Groton City	1	Thames	146	CT0101184	Thames River	WY98	2.4	13.0	97,000

Appendix 5. Estimates of total nitrogen load from municipal wastewater-treatment facilities (1998) and estimates of return flow (1990) used in multiple regression analysis—Continued

[Data from Medalie, 1996; Paul Stacey, Connecticut Department of Environmental Protection, written commun., 1999. NPDES, National Pollution Discharge Elimination System; WY, water year; Mgal/d, million gallons per day; mg/L as N, milligram per liter as nitrogen; lb/yr, pound per year; --, data not available; NA, not applicable]

Wastewater-treatment facility	Long Island Sound manage-ment zone	Water-quality station/ unmonitored basin	Site number (fig. 4)	NPDES permit number	Receiving water body	Date	Return flow (Mgal/d)	Average total nitrogen concentra-tion (mg/L as N)	Nitrogen load (lb/yr)
Groton Town	1	Thames	147	CT0100242	Thames River	WY98	3.6	14.0	160,000
Norwich	1	Yantic	141	CT0100412	Yantic River	WY98	4.8	21.0	270,000
Chelsea	2	01144000/01184000	19	VT0100943	White River First Branch	1990	.03	--	--
Randolph	2	01144000/01184000	20	VT0100285	White River Third Branch	1990	.26	--	--
Royalton	2	01144000/01184000	21	VT0100854	White River	1990	.03	--	--
Bethel	2	01144000/01184000	22	VT0100048	Connecticut River	1990	.07	--	--
Canaan	2	01154500/01184000	23	VT0100625	Connecticut River	1990	.15	--	--
Brighton	2	01154500/01184000	24	VT0100072	Clyde River	1990	.10	--	--
Lunenburg Fire District 2	2	01154500/01184000	25	VT0101061	Connecticut River	1990	.05	--	--
Danville	2	01154500/01184000	26	VT0100633	Water Andric	1990	.03	--	--
Lyndonville	2	01154500/01184000	27	VT0100595	Passumpsic River	1990	.65	--	--
St. Johnsbury	2	01154500/01184000	28	VT0100579	Passumpsic River	1990	1.1	--	--
Bradford	2	01154500/01184000	29	VT0100803	Waits River	1990	.06	--	--
Hartford-Quechee	2	01154500/01184000	30	VT0100978	Ottauquechee River	1990	.16	--	--
Hartford-White River Jct	2	01154500/01184000	31	VT0101010	White And Connecticut Rivers	1990	.91	--	--
Sherburne Fire Dist. 1	2	01154500/01184000	32	VT0101141	Ottauquechee River	1990	.09	--	--
Woodstock Main	2	01154500/01184000	33	VT0100757	Ottauquechee River	1990	.25	--	--
Bridgewater	2	01154500/01184000	34	VT0100846	Ottauquechee River	1990	.01	--	--
Ludlow	2	01154500/01184000	35	VT0100145	Black River	1990	.43	--	--
Cavendish	2	01154500/01184000	36	VT0100862	Black River	1990	.07	--	--
Springfield (Clinton)	2	01154500/01184000	37	VT0100374	Black River	1990	1.7	--	--
Windsor Main	2	01154500/01184000	38	VT0100919	Connecticut River	1990	.47	--	--
Windsor Weston Heights	2	01154500/01184000	39	VT0100447	Connecticut River	1990	.01	--	--

Appendix 5. Estimates of total nitrogen load from municipal wastewater-treatment facilities (1998) and estimates of return flow (1990) used in multiple regression analysis—Continued

[Data from Medalie, 1996; Paul Stacey, Connecticut Department of Environmental Protection, written commun., 1999. NPDES, National Pollution Discharge Elimination System; WY, water year; Mgal/d, million gallons per day; mg/L as N, milligram per liter as nitrogen; lb/yr, pound per year; --, data not available; NA, not applicable]

Wastewater-treatment facility	Long Island Sound manage-ment zone	Water-quality station/ unmonitored basin	Site number (fig. 4)	NPDES permit number	Receiving water body	Date	Return flow (Mgal/d)	Average total nitrogen concentra-tion (mg/L as N)	Nitrogen load (lb/yr)
Chester	2	01154500/01184000	40	VT0100081	Williams River	1990	0.08	--	--
Saxtons River	2	01154500/01184000	41	VT0100609	Saxtons River	1990	.04	--	--
Bellows Falls	2	01154500/01184000	42	VT0100013	Connecticut River	1990	.47	--	--
Colebrook	2	01154500/01184000	43	NH0100315	Connecticut River	1990	.34	--	--
Stratford Mill House	2	01154500/01184000	44	NH0101214	Kimball Brook	1990	.02	--	--
Stratford Village	2	01154500/01184000	45	NH0100536	Connecticut River	1990	.03	--	--
Groveton-Northumberland	2	01154500/01184000	46	NH0100226	Ammonoosuc River	1990	.24	--	--
Lancaster	2	01154500/01184000	47	NH0100145	Connecticut River	1990	.86	--	--
Whitefield	2	01154500/01184000	48	NH0100510	Johns River	1990	.11	--	--
Bethlehem	2	01154500/01184000	49	NH0100501	Ammonoosuc River	1990	.21	--	--
Littleton	2	01154500/01184000	50	NH0100153	Ammonoosuc River	1990	.87	--	--
Lisbon	2	01154500/01184000	51	NH0100421	Ammonoosuc River	1990	.07	--	--
Woodsville	2	01154500/01184000	52	NH0100978	Ammonoosuc River	1990	.13	--	--
Hanover	2	01154500/01184000	53	NH0100099	Connecticut River	1990	1.4	--	--
Lebanon	2	01154500/01184000	54	NH0100366	Mascoma River	1990	1.7	--	--
Claremont	2	01154500/01184000	55	NH0101257	Sugar River	1990	1.6	--	--
Charlestown	2	01154500/01184000	56	NH0100765	Connecticut River	1990	.12	--	--
Newport	2	01154500/01184000	57	NH0100200	Sugar River	1990	.72	--	--
Sunapee-New London	2	01154500/01184000	58	NH0100544	Sugar River	1990	.37	--	--
Putney	2	01184000	59	VT0100277	Sacketts Brook	1990	.04	--	--
Brattleboro	2	01184000	60	VT0100064	Connecticut River	1990	1.9	--	--
Wilmington	2	01184000	61	VT0100706	Deerfield River	1990	.09	--	--
Whitingham-Jacksonville	2	01184000	62	VT0101044	North River East Branch	1990	.02	--	--
Readsboro	2	01184000	63	VT0100731	Deerfield River	1990	.02	--	--

Appendix 5. Estimates of total nitrogen load from municipal wastewater-treatment facilities (1998) and estimates of return flow (1990) used in multiple regression analysis—Continued

[Data from Medalie, 1996; Paul Stacey, Connecticut Department of Environmental Protection, written commun., 1999. NPDES, National Pollution Discharge Elimination System; WY, water year; Mgal/d, million gallons per day; mg/L as N, milligram per liter as nitrogen; lb/yr, pound per year; --, data not available; NA, not applicable]

Wastewater-treatment facility	Long Island Sound management zone	Water-quality station/ unmonitored basin	Site number (fig. 4)	NPDES permit number	Receiving water body	Date	Return flow (Mgal/d)	Average total nitrogen concentration (mg/L as N)	Nitrogen load (lb/yr)
Hinsdale	2	01184000	64	NH0100382	Ashuelot River	1990	0.32	--	--
Keene	2	01184000	65	NH0100790	Ashuelot River	1990	3.5	--	--
Swanzey	2	01184000	66	NH0101150	Ashuelot River	1990	0.05	--	--
Troy	2	01184000	67	NH0101052	Ashuelot River	1990	.13	--	--
Winchester	2	01184000	68	NH0100404	Ashuelot River	1990	.15	--	--
Franklin Pierce College	2	01184000	69	NH0101044	Tributary Pearly Lake	1990	.03	--	--
Winchendon	2	01184000	70	MA0100862	Millers River	1990	.71	--	--
Templeton	2	01184000	71	MA0100340	Otter River	1990	1.4	--	--
Gardner	2	01184000	72	MA0100994	Otter River	1990	3.3	--	--
Royalston	2	01184000	73	MA0100161	Millers River	1990	.03	--	--
Athol	2	01184000	74	MA0100005	Millers River	1990	1.6	--	--
Orange	2	01184000	75	MA0101257	Millers River	1990	1.2	--	--
Erving Center	2	01184000	76	MA0101052	Millers River	1990	1.9	--	--
Northfield	2	01184000	77	MA0100200	Connecticut River	1990	.33	--	--
Millers Falls Village	2	01184000	78	MA0101516	Millers River	1990	.54	--	--
Montague	2	01184000	79	MA0100137	Connecticut River	1990	1.2	--	--
Shelburne Falls	2	01184000	80	MA0101044	Deerfield River	1990	.21	--	--
Old Deerfield	2	01184000	81	MA0101940	Deerfield River	1990	.15	--	--
Greenfield	2	01184000	82	MA0101214	Green River	1990	3.7	--	--
South Deerfield	2	01184000	83	MA0101648	Connecticut River	1990	.91	--	--
Sunderland	2	01184000	84	MA0101079	Connecticut River	1990	.16	--	--
Amherst	2	01184000	85	MA0100218	Connecticut River	1990	4.6	--	--
Hatfield	2	01184000	86	MA0101290	Connecticut River	1990	.16	--	--
Indian Hill Hadley	2	01184000	87	MA0100099	Connecticut River	1990	.31	--	--
Northhampton	2	01184000	88	MA0101818	Connecticut River	1990	5.3	--	--

Appendix 5. Estimates of total nitrogen load from municipal wastewater-treatment facilities (1998) and estimates of return flow (1990) used in multiple regression analysis—Continued

[Data from Medalie, 1996; Paul Stacey, Connecticut Department of Environmental Protection, written commun., 1999. NPDES, National Pollution Discharge Elimination System; WY, water year; Mgal/d, million gallons per day; mg/L as N, milligram per liter as nitrogen; lb/yr, pound per year; --, data not available; NA, not applicable]

Wastewater-treatment facility	Long Island Sound management zone	Water-quality station/ unmonitored basin	Site number (fig. 4)	NPDES permit number	Receiving water body	Date	Return flow (Mgal/d)	Average total nitrogen concentration (mg/L as N)	Nitrogen load (lb/yr)
South Hadley	2	01184000	89	MA0100455	Connecticut River	1990	3.4	--	--
Easthampton	2	01184000	90	MA0101478	Connecticut River	1990	2.5	--	--
Chicopee	2	01184000	91	MA0101508	Chicopee River	1990	13	--	--
Holyoke	2	01184000	92	MA0101630	Connecticut River	1990	12	--	--
Huntington	2	01184000	93	MA0101265	Westfield River	1990	.09	--	--
Russell	2	01184000	94	MA0100960	Westfield River	1990	.13	--	--
Westfield	2	01184000	95	MA0101800	Westfield River	1990	3.2	--	--
Springfield Bondi Island	2	01184000	96	MA0101613	Connecticut, Chicopee, Mill Rivers and Tributary	1990	48	--	--
Barre	2	01184000	97	MA0103152	Ware River	1990	.14	--	--
Spencer	2	01184000	98	MA0100919	Seven Mile River	1990	.69	--	--
North Brookfield	2	01184000	99	MA0101061	Dunn Brook	1990	.47	--	--
Hardwick	2	01184000	100	MA0100102	Ware River	1990	.03	--	--
Ware	2	01184000	101	MA0100889	Ware River	1990	.76	--	--
Warren	2	01184000	102	MA0101567	Quaboag River	1990	.58	--	--
Palmer	2	01184000	103	MA0101168	Chicopee River	1990	3.6	--	--
Winchester-Winsted	2	01188090/01189995	104	CT0101222	Still River	WY98	1.5	17.0	71,000
New Hartford	2	01188090/01189995	105	CT0100331	Farmington River	1990	.06	--	--
Canton	2	01188090/01189995	106	CT0100072	Farmington River	WY98	.49	14.0	20,000
Plymouth	2	01189000/01189995	107	CT0100463	Pequabuck River	WY98	1.0	13.0	36,000
Bristol	2	01189000/01189995	108	CT0100374	Pequabuck River	WY98	12	16.0	460,000
Plainville	2	01189995	109	CT0100455	Pequabuck River	WY98	2.2	15.0	97,000
Farmington	2	01189995	110	CT0100218	Farmington River	WY98	4.0	18.0	210,000
Simsbury	2	01189995	111	CT0100919	Farmington River	WY98	2.4	14.0	100,000
Vernon	2	01192500	17	CT0100609	Hockanum River	WY98	4.2	16.0	200,000

Appendix 5. Estimates of total nitrogen load from municipal wastewater-treatment facilities (1998) and estimates of return flow (1990) used in multiple regression analysis—Continued

[Data from Medalie, 1996; Paul Stacey, Connecticut Department of Environmental Protection, written commun., 1999. NPDES, National Pollution Discharge Elimination System; WY, water year; Mgal/d, million gallons per day; mg/L as N, milligram per liter as nitrogen; lb/yr, pound per year; --, data not available; NA, not applicable]

Wastewater-treatment facility	Long Island Sound management zone	Water-quality station/ unmonitored basin	Site number (fig. 4)	NPDES permit number	Receiving water body	Date	Return flow (Mgal/d)	Average total nitrogen concentration (mg/L as N)	Nitrogen load (lb/yr)
Manchester	2	01192500	18	CT0100293	Hockanum River	WY98	6.8	18.0	380,000
Rocky Hill	2	Connecticut Mainstem N.	174	CT0100480	Connecticut River	WY98	7.0	11.0	230,000
Glastonbury	2	Connecticut Mainstem N.	175	CT0100226	Connecticut River	WY98	2.1	15.0	94,000
Hartford	2	Connecticut Mainstem N.	176	CT0100251	Connecticut River	WY98	53	11.0	1,900,000
South Windsor	2	Connecticut Mainstem N.	177	CT0100510	Connecticut River	WY98	2.4	20.0	150,000
Windsor Locks	2	Connecticut Mainstem N.	178	CT0101591	Connecticut River	WY98	1.6	19.0	92,000
East Windsor	2	Connecticut Mainstem N.	179	CT0100196	Connecticut River	WY98	1.3	5.9	23,000
Enfield	2	Connecticut Mainstem N.	180	CT0100200	Connecticut River	WY98	5.5	21.0	340,000
Cromwell (MDC)	2	Connecticut Mainstem S.	140	CT0100307	Connecticut River	WY98	17	17.0	890,000
East Hampton	2	Connecticut Mainstem S.	171	CT0024694	Connecticut River	WY98	1.3	18.0	67,000
Middletown	2	Connecticut Mainstem S.	172	CT0100323	Connecticut River	WY98	4.1	12.0	140,000
Portland	2	Connecticut Mainstem S.	173	CT0101150	Connecticut River	WY98	.80	16.0	36,000
Windsor Poquonock (MDC)	2	Farmington	138	CT0100994	Farmington River	WY98	2.4	23.0	160,000
East Hartford	2	Hockanum	139	CT0100170	Hockanum River	WY98	6.7	14.0	280,000
Suffield	2	Stony Brook	137	CT0100552	Stony Brook	WY98	.88	20.0	52,000
Southington	3	01196500	112	CT0100536	Quinnipiac River	WY98	4.6	20.0	270,000
Cheshire	3	01196500	113	CT0100081	Quinnipiac River	WY98	2.4	23.0	150,000
Meriden	3	01196500	114	CT0100315	Quinnipiac River	WY98	10	15.0	450,000
Branford	3	Central	150	CT0100048	Branford River	WY98	4.2	25.0	310,000
Wallingford	3	Quinnipiac	151	CT0100617	Quinnipiac River	WY98	6.3	12.0	220,000
North Haven	3	Quinnipiac	152	CT0100404	Quinnipiac River	WY98	4.4	16.0	200,000
New Haven East Shore	3	West Central	153	CT0100366	New Haven Harbor	WY98	36	9.5	1,000,000
West Haven	3	West Central	154	CT0101079	Long Island Sound	WY98	8.8	8.0	220,000
Sharon	4	01199900/01205500	130	CT0101052	Ten Mile River	1990	.06	--	--
Pittsfield	4	01205500	120	MA0101681	Housatonic River	1990	15	--	--

Appendix 5. Estimates of total nitrogen load from municipal wastewater-treatment facilities (1998) and estimates of return flow (1990) used in multiple regression analysis—Continued

[Data from Medalie, 1996; Paul Stacey, Connecticut Department of Environmental Protection, written commun., 1999. NPDES, National Pollution Discharge Elimination System; WY, water year; Mgal/d, million gallons per day; mg/L as N, milligram per liter as nitrogen; lb/yr, pound per year; --, data not available; NA, not applicable]

Wastewater-treatment facility	Long Island Sound management zone	Water-quality station/ unmonitored basin	Site number (fig. 4)	NPDES permit number	Receiving water body	Date	Return flow (Mgal/d)	Average total nitrogen concentration (mg/L as N)	Nitrogen load (lb/yr)
Stockbridge	4	01205500	122	MA0101087	Housatonic River	1990	0.23	--	--
Lenox Center	4	01205500	123	MA0100935	Housatonic River	1990	.65	--	--
Lenox #2	4	01205500	124	MA0100943	Housatonic River	1990	.08	--	--
Lee	4	01205500	125	MA0100153	Housatonic River	1990	.90	--	--
Great Barrington	4	01205500	126	MA0101524	Housatonic River	1990	3.0	--	--
Norfolk	4	01205500	127	CT0101231	Blackberry River	1990	.35	--	--
Canaan Fire District	4	01205500	128	CT0100064	Blackberry River	1990	.23	--	--
Salisbury	4	01205500	129	CT0100498	Factory Brook	1990	.37	--	--
Kent	4	01205500	131	CT0100277	Housatonic River	1990	.06	--	--
Litchfield	4	01205500	132	CT0100803	Bantam River	1990	.61	--	--
New Milford	4	01205500	133	CT0100391	Housatonic River	WY98	.51	17.0	26,000
Bethel	4	01205500	134	CT0100021	Shepaug Brook	1990	1.1	--	--
Danbury	4	01205500	135	CT0100145	East Swamp Brook	WY94	8.7	28.0	750,000
Newtown	4	01205500		--	Pootatuck River	WY98	.31	16.3	13,000
Torrington	4	01208500	115	CT0100579	Naugatuck River	WY98	6.2	8.8	160,000
Thomaston	4	01208500	116	CT0100781	Naugatuck River	WY98	1.1	11.0	35,000
Watertown Fire District	4	01208500	117	CT0100633	Steele Brook	WY98	.91	18.0	48,000
Waterbury	4	01208500	118	CT0100625	Naugatuck River	WY98	22	15.0	980,000
Naugatuck	4	01208500	121	CT0100641	Naugatuck River	WY98	6.9	10.0	210,000
Derby	4	Housatonic	158	CT0100161	Housatonic River	WY98	1.6	10.0	48,000
Shelton	4	Housatonic	159	CT0100714	Housatonic River	WY98	2.2	16.0	100,000
Milford--Beaver Brook	4	Housatonic	160	CT0100749	Housatonic River	WY98	2.3	7.1	51,000
Milford--Housatonic	4	Housatonic	161	CT0101656	Housatonic River	WY98	6.9	10.0	200,000
Stratford	4	Housatonic	162	CT0101036	Housatonic River	WY98	7.7	9.3	220,000
Beacon Falls	4	Naugatuck	155	CT0101061	Naugatuck River	WY98	.25	20.0	14,000

Appendix 5. Estimates of total nitrogen load from municipal wastewater-treatment facilities (1998) and estimates of return flow (1990) used in multiple regression analysis—Continued

[Data from Medalie, 1996; Paul Stacey, Connecticut Department of Environmental Protection, written commun., 1999. NPDES, National Pollution Discharge Elimination System; WY, water year; Mgal/d, million gallons per day; mg/L as N, milligram per liter as nitrogen; lb/yr, pound per year; --, data not available; NA, not applicable]

Wastewater-treatment facility	Long Island Sound manage-ment zone	Water-quality station/ unmonitored basin	Site number (fig. 4)	NPDES permit number	Receiving water body	Date	Return flow (Mgal/d)	Average total nitrogen concentra-tion (mg/L as N)	Nitrogen load (lb/yr)
Seymour	4	Naugatuck	156	CT0100501	Naugatuck River	WY98	1.3	5.7	21,000
Ansonia	4	Naugatuck	157	CT0100013	Naugatuck River	WY98	2.8	10.0	77,000
Westport	5	Saugatuck	163	CT0100684	Saugatuck River	WY98	2.0	5.2	30,000
Fairfield	5	Southwest East	165	CT0101044	Long Island Sound	WY98	8.8	8.7	230,000
Bridgeport West Side	5	Southwest East	166	CT0100056	Cedar Creek	WY98	24	13.0	880,000
Bridgeport East Side	5	Southwest East	167	CT0101010	Pequonnock River	WY98	8.3	16.0	380,000
Ridgefield Main	6	01209710	136	CT0100854	Ridgefield Brook	WY98	.66	4.9	10,000
Norwalk	6	Norwalk	164	CT0101249	Norwalk River	WY98	16	7.7	370,000
Greenwich	6	Southwest West	168	CT0100234	Greenwich Harbor	WY98	10	8.8	270,000
Stamford	6	Southwest West	169	CT0101087	Long Island Sound	WY98	20	9.9	590,000
New Canaan	6	Southwest West	170	CT0101273	Fivemile River	WY98	1.6	8.2	37,000