USGS
science for a changing world

National Water-Quality Assessment Program

Nutrient and Suspended-Sediment Transport and Trends in the Columbia River and Puget Sound Basins, 1993–2003

Scientific Investigations Report 2007–5186

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

Cover: Photograph of Columbia River Gorge at sunrise, looking east. (Photograph courtesy of Columbia River USGS Interdisciplinary Science Explorer (CRUISE) website.)
Insets (from left to right): Mount Rainier, Washington. (Photograph by Jeremy Woodhouse through Getty Images, date unknown.)
Hop fields near Moxee, Washington. (Photograph taken by Hank Johnson, U.S. Geological Survey, 2001.)
Seattle, Washington skyline. (Photograph by Jeremy Woodhouse through Getty Images, date unknown.)

Nutrient and Suspended-Sediment Transport and Trends in the Columbia River and Puget Sound Basins, 1993–2003

By Daniel R. Wise, Frank A. Rinella, III, Joseph F. Rinella, Greg J. Fuhrer, Sandra S. Embrey, Gregory M. Clark, Gregory E. Schwarz, and Steven Sobieszczyk

National Water-Quality Assessment Program

Scientific Investigations Report 2007–5186

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

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

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

U.S. Geological Survey, Reston, Virginia: 2007

For product and ordering information:
World Wide Web: http://www.usgs.gov/pubprod
Telephone: 1-888-ASK-USGS

For more information on the USGS--the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment:
World Wide Web: http://www.usgs.gov
Telephone: 1-888-ASK-USGS

Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Although this report is in the public domain, permission must be secured from the individual copyright owners to reproduce any copyrighted materials contained within this report.

Suggested citation:
Wise, D.R., Rinella, F.A., III, Rinella, J.F., Fuhrer, G.J., Embrey, S.S., Clark, G.E., Schwarz, G.E., Sobieszczyk, S., 2007, Nutrient and suspended-sediment transport and trends in the Columbia River and Puget Sound Basins, 1993–2003: U.S. Geological Survey Scientific Investigations Report 2007–5186, 116 p.

Foreword

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

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

In the second decade of the Program (2001–2012), a major focus is on regional assessments of water-quality conditions and trends. These regional assessments are based on major river basins and principal aquifers, which encompass larger regions of the country than the Study Units. Regional assessments extend the findings in the Study Units by filling critical gaps in characterizing the quality of surface water and ground water, and by determining status and trends at sites that have been consistently monitored for more than a decade. In addition, the regional assessments continue to build an understanding of how natural features and human activities affect water quality. Many of the regional assessments employ modeling and other scientific tools, developed on the basis of data collected at individual sites, to help extend knowledge of water quality to unmonitored, yet comparable areas within the regions. The models thereby enhance the value of our existing data and our understanding of the hydrologic system. In addition, the models are useful in evaluating various resource-management scenarios and in predicting how our actions, such as reducing or managing nonpoint and point sources of contamination, land conversion, and altering flow and (or) pumping regimes, are likely to affect water conditions within a region.

Other activities planned during the second decade include continuing national syntheses of information on pesticides, volatile organic compounds (VOCs), nutrients, selected trace elements, and aquatic ecology; and continuing national topical studies on the fate of agricultural chemicals, effects of urbanization on stream ecosystems, bioaccumulation of mercury in stream ecosystems, effects of nutrient enrichment on stream ecosystems, and transport of contaminants to public-supply wells.

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

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

Robert M. Hirsch
Associate Director for Water

This page intentionally left blank.

Contents

Foreword iii
Abstract 1
Introduction 1
Purpose and Scope 2
Description of Columbia River and Puget Sound Basins 2
Columbia River Basin 2
Puget Sound Basin 4
Data Sources 4
Discrete Water-Quality Samples 5
Daily Mean Streamflow 5
Methods of Analysis 8
Load Estimation 8
Selection of Analysis Period 8
Criteria for Site Selection 10
Data Assumptions and Censoring Process 11
Influence of Sampling and Analytical Techniques 11
Trends in Streamflow, Load, and Concentration 13
Non-Flow-Adjusted Trend in Concentration 16
Trend in Load 16
Flow-Adjusted Trend in Concentration 16
Trend in Streamflow 17
Interpretation of Trends 17
Estimation of Point-Source Nutrient Loads 17
Transport of Nutrients and Suspended-Sediment in Columbia River and Puget Sound Basins 19
Summary of Direct Point-Source Nutrient Discharges to Columbia River and Largest Tributaries 20
Columbia River System 20
Willamette River System 29
Snake River System 37
Puget Sound Basin 37
Nutrients and Suspended-Sediment Yields 42
Regional Patterns in Yields 42
Influence of Point Sources 45
Influence of Catchment Characteristics on Nutrient and Suspended-Sediment Yields 48
Trends in Nutrients and Suspended-Sediment, 1993–2003 49
Trends in Streamflow 50
General Patterns in Concentration Trends 51
Total Nitrogen 52
Total Phosphorus 54
Suspended Sediment 56
Trends in Relation to Changes in Nutrient Sources and Landscape Characteristics 59

Contents—Continued

Summary and Conclusions....60
Transport of Nutrients and Suspended-Sediment....60
Trends in Nutrients and Suspended-Sediment, 1993–2003....61
Acknowledgments....62
References Cited....62
Appendix A. Results of Loadest Modeling, Flow-Weighted Concentrations, Yields, Drainage Areas, and Mean Annual Streamflows for Total Nitrogen, Total Phosphorus, and Suspended Sediment for Water Years 1997, 2000, and 2001....75
Appendix B. Methodology for Computing Trends in Annual Streamflow, Trends in Load, and Flow- and Non-Flow-Adjusted Trends in Concentration....113
References Cited....115

Figures

Figure 1. Map showing Columbia River and Puget Sound Basins and locations of water-quality monitoring site 3
Figure 2. Graph showing daily mean discharge for the Columbia River at Beaver Army Terminal, Oregon, water years 1993–2003 4
Figure 3. Graph showing annual mean daily streamflow in the Willamette River at Portland, Oregon, water years 1973–2003 9
Figure 4. Graph showing daily mean streamflow in the Willamette River at Portland, Oregon, water years 1993–2003 9
Figure 5. Graph showing comparison of monthly mean streamflow during water year 2000 with mean monthly streamflow during water years 1973–2003 for the Willamette River at Portland, Oregon 10
Figure 6. Graph showing statistical distribution of the 91 delineated catchment drainage areas in the Columbia River and Puget Sound basins 12
Figure 7. Graphs showing relations between concentrations of total nitrogen and suspended sediment and discharge for Willamette River at Portland, Oregon, water years 1993–2003 14
Figure 8. Graphs showing examples of data smoothing demonstrating temporal variability of daily mean streamflow and instantaneous total nitrogen concentrations for Willamette River at Portland, Oregon, water years 1993–2003 15
Figure 9. Maps showing estimated point-source loads divided into quartiles for total nitrogen and total phosphorus, Columbia River basin, water year 2000 18
Figure 10. Pie diagrams showing estimated discharges from point sources to the Columbia River that exceed the 75th percentile of all point sources for total nitrogen and total phosphorus, water year 2000 19
Figure 11. Maps showing locations of sampling sites in the Columbia River and its tributaries and selected point sources discharging directly to the Columbia River, Oregon and Washington, water year 2000 21
Figure 12. Graphs showing annual mean discharge of total nitrogen loads in the Columbia River, and relative total nitrogen load contributions from Columbia River monitored tributaries and point sources, Oregon and Washington, water year 2000 23

Figures—Continued

Figure 13. Graphs showing annual mean discharge of total phosphorus loads in the Columbia River, and relative total phosphorus load contributions from Columbia River monitored tributaries and point sources, Oregon and Washington, water year 2000 24
Figure 14. Graphs showing annual mean discharge of suspended-sediment loads in the Columbia River and relative suspended-sediment load contributions from Columbia River monitored tributaries, Oregon and Washington, water year 2000 28
Figure 15. Maps showing locations of sampling sites in the Willamette River and its tributaries, and selected point sources discharging directly to the Willamette River, Oregon, water year 2000 30
Figure 16. Graphs showing annual mean discharge of total nitrogen loads in the Willamette River and relative total nitrogen load contributions from Willamette River monitored tributaries and point sources, Oregon, water year 2000 34
Figure 17. Graphs showing annual mean discharge of total phosphorus loads in the Willamette River and relative total phosphorus contributions from Willamette River monitored tributaries and point sources, Oregon, water year 2000 35
Figure 18. Graphs showing Annual mean discharge of suspended-sediment loads in the Willamette River and relative suspended-sediment load contributions from Willamette River monitored tributaries, Oregon, water year 2000 36
Figure 19. Maps showing locations of sampling sites in the Snake River and its tributaries, and selected point sources discharging directly to the Snake River, Washington, Oregon, Idaho, and Wyoming, water year 2000 38
Figure 20. Graphs showing annual mean discharge of total nitrogen, total phosphorus, and suspended sediment loads in the Snake River, Wyoming, Idaho, and Washington, water year 2000 40
Figure 21. Maps showing locations of sampling sites in Puget Sound tributaries, and selected point sources discharging directly to the Puget Sound and its major tributaries, Washington, water year 2000 41
Figure 22. Pie diagrams showing contribution of monitored tributary and estimated point-source loads of total nitrogen, total phosphorus, and suspended sediment to the Puget Sound basin, Washington, water year 2000 42
Figure 23. Piper diagram showing land use for the 91 catchments with delineated drainage areas for the Columbia River and Puget Sound Basins, calendar year 2000 43
Figure 24. Maps showing estimated annual catchment yields divided into quartiles for total nitrogen, total phosphorus, and sediment for the Columbia River and Puget Sound Basins, water year 2000 44
Figure 25. Maps showing estimated annual point-source loads as a percentage of annual in stream loads for total nitrogen and total phosphorus, Columbia River and Puget Sound basins, water year 2000 46
Figure 26. Piper diagram showing summary of annual nutrient load to delineated catchments for total nitrogen and total phosphorus in the Columbia River and Puget Sound Basins, water year 2000 and calendar year 2002 47
Figure 27. Graphs showing distribution of flow-adjusted trends in concentration of total nitrogen in percentage per year and milligrams per liter per year, Columbia River and Puget Sound basins, water years 1993–2003 51

Figures—Continued

Figure 28. Graphs showing distribution of flow-adjusted trends in concentration of total phosphorous in percentage per year and milligrams per liter per year, Columbia River and Puget Sound basins, water years 1993–2003 51
Figure 29. Graphs showing distribution of flow-adjusted trends in concentration of suspended sediment in percentage per year and milligrams per liter per year, Columbia River and Puget Sound basins, for water years 1993–2003 52
Figure 30. Map showing flow-adjusted trends in concentration of total nitrogen, Columbia River and Puget Sound basins, water years 1993–2003 54
Figure 31. Map showing flow-adjusted trends in concentrations of total phosphorus, Columbia River and Puget Sound basins, water years 1993–2003 56
Figure 32. Map showing flow-adjusted trends in concentration of suspended sediment, Columbia River and Puget Sound basins, water years 1993–2003 58
Figure 33. Graph showing measured suspended-sediment concentrations, Hood River, Oregon, water years 1993–2003 58

Tables

Table 1. Description of water-quality monitoring sites in the Columbia and Puget Sound River Basins 6
Table 2. Streamflow sites used for nutrient and suspended-sediment load computations in the Columbia River and Puget Sound basins for selected water years 10
Table 3. Rules for computing total nitrogen concentration from total Kjeldahl nitrogen and dissolved nitrite plus nitrate as nitrogen 12
Table 4. Comparison of total nitrogen, total phosphorus, and suspended-sediment loads based on sampling results from co-located sites operated by U.S. Geological Survey and other agencies 13
Table 5. Industrial categories contributing to total nitrogen and total phosphorus loads in the Columbia and Puget Sound basins 18
Table 6. Quartile ranges for total nitrogen and total phosphorus point-source loads in the Columbia and Puget Sound basins, water year 2000 19
Table 7. Accounting for annual mean streamflow in the main stem of the Columbia River, water year 2000 22
Table 8. Annual mean discharge of total nitrogen, total phosphorus, and suspended sediment loads in the Columbia River, monitored Columbia River tributaries, and point sources discharging directly to the Columbia River, Oregon and Washington, water year 2000 25
Table 9. Relative discharge of total nitrogen, total phosphorus, and suspended sediment loads from three major tributaries to Columbia River between Vernita Bridge, Washington, and Warrendale, Oregon, water year 2000 29

Tables—Continued

Table 10. Mean annual discharge of total nitrogen, total phosphorus, and suspended sediment loads in the Willamette River, monitored Willamette River tributaries, and point sources discharging directly to the Willamette River, Oregon, water year 2000 31
Table 11. Accounting for annual mean streamflow in the Willamette River, Oregon, water year 2000 33
Table 12. Annual mean discharges of total nitrogen, total phosphorus, and suspended sediment loads in the Snake River, monitored Snake River tributaries, and point sources discharging directly to the Snake River, Wyoming, Idaho, and Washington, water year 2000 39
Table 13. Summary of annual yields for total nitrogen, total phosphorus, and suspended sediment in the Columbia River and Puget Sound basins, water years 1997, 2000, and 2001 43
Table 14. Quartile ranges for total nitrogen, total phosphorus, and suspended sediment annual yields for the Columbia River and Puget Sound basins, water year 2000 45
Table 15. Summary of total point-source annual nutrient loads as a percentage of predicted instream annual loads, Columbia River and Puget Sound basins, water year 2000 46
Table 16. Results from multiple linear regression of catchment characteristics on catchment yields in the Columbia River and Puget Sound basins, water year 2000 49
Table 17. Number of sites with significant decreasing, increasing, or no flow-adjusted trend in concentration by collecting/analyzing agency in the Columbia River and Puget Sound basins, water years 1993–2003 50
Table 18. Summary of flow-adjusted trends in concentration of total nitrogen, total phosphorus, and suspended sediment in the Columbia River and Puget Sound basins, water years 1993–2003 52
Table 19. Flow-adjusted trends in concentration, non-flow-adjusted trends in concentration, and trends in annual loads for total nitrogen in the Columbia River and Puget Sound basins, water years 1993–2003 53
Table 20. Flow-adjusted trends in concentration, non-flow-adjusted trends in concentration, and trends in annual loads for total phosphorus in the Columbia River and Puget Sound basins, water years 1993–2003 55
Table 21. Flow-adjusted trends in concentration, non-flow-adjusted trends in concentration, and trends in annual loads for suspended sediment in the Columbia River and Puget Sound basins, water years 1993–2003 57
Table 22. Summary of sources and stream annual loads for total nitrogen and total phosophorus in the Columbia River and Puget Sound basins, water year 2000 and calendar year 2002 64

Conversion Factors, Vertical Datums, and Abbreviations and Acronyms

Conversion Factors

Multiply	By	To obtain
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
inch per year (in/yr)	25.4	millimeter per year (mm/yr)
mile (mi)	1.609	kilometer (km)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
pound, avoirdupois (lb)	0.4536	kilogram (kg)
pound per day (lb/d)	0.4536	kilogram per day (kg/d)
pound per year (lb/yr)	0.4536	kilogram per year (kg/yr)
pound per year per square mile [(lb/yr)/mi^2]	0.1751	kilogram per year per square kilometer
square mile (mi^2)	2.590	square kilometer (km^2)
ton per day (ton/d)	0.9072	metric ton per day
ton per year (ton/yr)	0.9072	metric ton per year
ton per year per square mile [(ton/yr)/mi^2]	0.3503	metric ton per year per square kilometer

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

Datums

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

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

Projections are from the Lambert Conformal Conic (Oregon Lambert Projection).

Conversion Factors, Vertical Datums, and Abbreviations and Acronyms—Continued

Abbreviations and Acronyms

Abbreviations and Acronyms	Meaning
AMLE	Adjusted Maximum Likelihood Estimation
CWS	Clean Water Service
CY	calendar year
DMR	Discharge Monitoring Report
Exchange	Pacific Northwest Water-Quality Exchange
FATC	flow-adjusted trend in concentration
NAWQA	National Water-Quality Assessment
NFATC	non-flow-adjusted trend in concentration
NPDES	National Pollution Discharge Elimination System
NWIS	National Water Information System
ODEQ	Oregon Department of Environmental Quality
ORWD	Oregon Water Resources Division
Pcode	parameter code
PCS	Permit Compliance System
RM	river mile
SIC	standard industrial classification
SS	suspended sediment
STORET	STOret and RETrieval
TKN	total Kjeldahl nitrogen
TMDL	Total Maximum Daily Load
TN	total nitrogen as N
TP	total phosphorus as P
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WDOE	Washington State Department of Ecology
WWTP	wastewater treatment plant
WY	water year

This page intentionally left blank.

Nutrient and Suspended-Sediment Transport and Trends in the Columbia River and Puget Sound Basins, 1993–2003

By Daniel R. Wise, Frank A. Rinella III, Joseph F. Rinella, Greg J. Fuhrer, Sandra S. Embrey, Gregory M. Clark, Gregory E. Schwarz, and Steven Sobieszczyk

Abstract

This study focused on three areas that might be of interest to water-quality managers in the Pacific Northwest: (1) annual loads of total nitrogen (TN), total phosphorus (TP) and suspended sediment (SS) transported through the Columbia River and Puget Sound Basins, (2) annual yields of TN, TP, and SS relative to differences in landscape and climatic conditions between subbasin catchments (drainage basins), and (3) trends in TN, TP, and SS concentrations and loads in comparison to changes in landscape and climatic conditions in the catchments. During water year 2000, an average streamflow year in the Pacific Northwest, the Columbia River discharged about 570,000 pounds per day of TN, about 55,000 pounds per day of TP, and about 14,000 tons per day of SS to the Pacific Ocean. The Snake, Yakima, Deschutes, and Willamette Rivers contributed most of the load discharged to the Columbia River. Point-source nutrient loads to the catchments (almost exclusively from municipal wastewater treatment plants) generally were a small percentage of the total in-stream nutrient loads; however, in some reaches of the Spokane, Boise, Walla Walla, and Willamette River Basins, point sources were responsible for much of the annual in-stream nutrient load. Point-source nutrient loads generally were a small percentage of the total catchment nutrient loads compared to nonpoint sources, except for a few catchments where point-source loads comprised as much as 30 percent of the TN load and as much as 80 percent of the TP load. The annual TN and TP loads from point sources discharging directly to the Puget Sound were about equal to the annual loads from eight major tributaries.

Yields of TN, TP, and SS generally were greater in catchments west of the Cascade Range. A multiple linear regression analysis showed that TN yields were significantly ($p < 0.05$) and positively related to precipitation, atmospheric nitrogen load, fertilizer and manure load, and point-source load, and were negatively related to average slope. TP yields were significantly related positively to precipitation, and point-source load and SS yields were significantly related positively to precipitation.

Forty-eight percent of the available monitoring sites for TN had significant trends in concentration (2 increasing, 19 decreasing), 32 percent of the available sites for TP had significant trends in concentration (7 increasing, 9 decreasing), and 40 percent of the available sites for SS had significant trends in concentration (4 increasing, 15 decreasing). The trends in load followed a similar pattern, but with fewer sites showing significant trends. The results from this study indicate that inputs from nonpoint sources of nutrients probably have decreased over time in many of the catchments. Despite the generally small contribution of point-source nutrient loads, they still may have been partially responsible for the significant decreasing trends for nutrients at sites where the total point-source nutrient loads to the catchments equaled a substantial proportion of the in-stream load.

Introduction

Water-resource managers in the Pacific Northwest need information regarding the status of and trends in regional water-quality conditions. This information is useful in watershed planning, such as Total Maximum Daily Load (TMDL) development required by the Clean Water Act. Many streams in the Pacific Northwest have levels of nutrients (nitrogen and phosphorus) and suspended sediment that are elevated enough to cause adverse ecological effects, including excessive aquatic plant growth, reduced water clarity, reduced stream dissolved oxygen, and altered stream habitat. In addition, water-resource managers need information on the important sources of nutrients and sediment delivered to streams. This is especially true with regard to TMDL development, because source reduction is the main tool available to lower in-stream pollutant loads. There also is a need to quantify the relative contributions from tributaries and direct anthropogenic discharges (wastewater-treatment plants and industrial facilities) to the total nutrient and sediment load in the major rivers of the Pacific Northwest and, ultimately, to the Pacific Ocean.

To determine the extent of nutrient and sediment concerns in our Nation's streams, analysis of the information collected during Cycle I of the U.S. Geological Survey's (USGS) National Water-Quality Assessment Program (NAWQA) basin-specific water-quality studies in the United States, along with other Federal, State, and local agency studies, were assessed regionally (Gilliom and others, 2001). The addition of other agency data greatly extended our ability to understand contaminant occurrence and transport, especially during times of declining funding. This study is the culmination of a similar effort to assess the trends and the transport of total nitrogen (TN), total phosphorus (TP), and suspended sediment (SS), to provide water-quality managers in the Pacific Northwest the information they need to effectively develop watershed improvement plans. The work done for this study can be a resource to support future investigations by regional water-quality managers and will be the foundation for a more detailed and rigorous regional water-quality modeling effort by the USGS that will assess both pollutant transport and load allocation.

Purpose and Scope

This report summarizes (1) patterns in nutrient and suspended-sediment loads and yields and (2) trends in concentrations and loads in relation to landscape, management practices, and climate in the Columbia River and Puget Sound Basins during an 11-year period, water years (WYs) 1993 through 2003. (A water year begins on October 1 of the previous calendar year and ends on September 30). The report focuses on:

- Annual loads of TN, TP, and SS over a range of flow in the Columbia River and Puget Sound Basins, including transport along the main-stem Columbia River and two of its major tributaries, and to Puget Sound;
- Annual yields (loads divided by catchment areas) of TN, TP, and SS and relating differences in yields to differences in landscape and climatic conditions between the catchments;
- Trends in concentrations and loads of TN, TP, and SS in the Columbia River and Puget Sound Basins; and
- The relation of trends in concentrations and loads to changes in landscape, management practices, and climatic conditions.

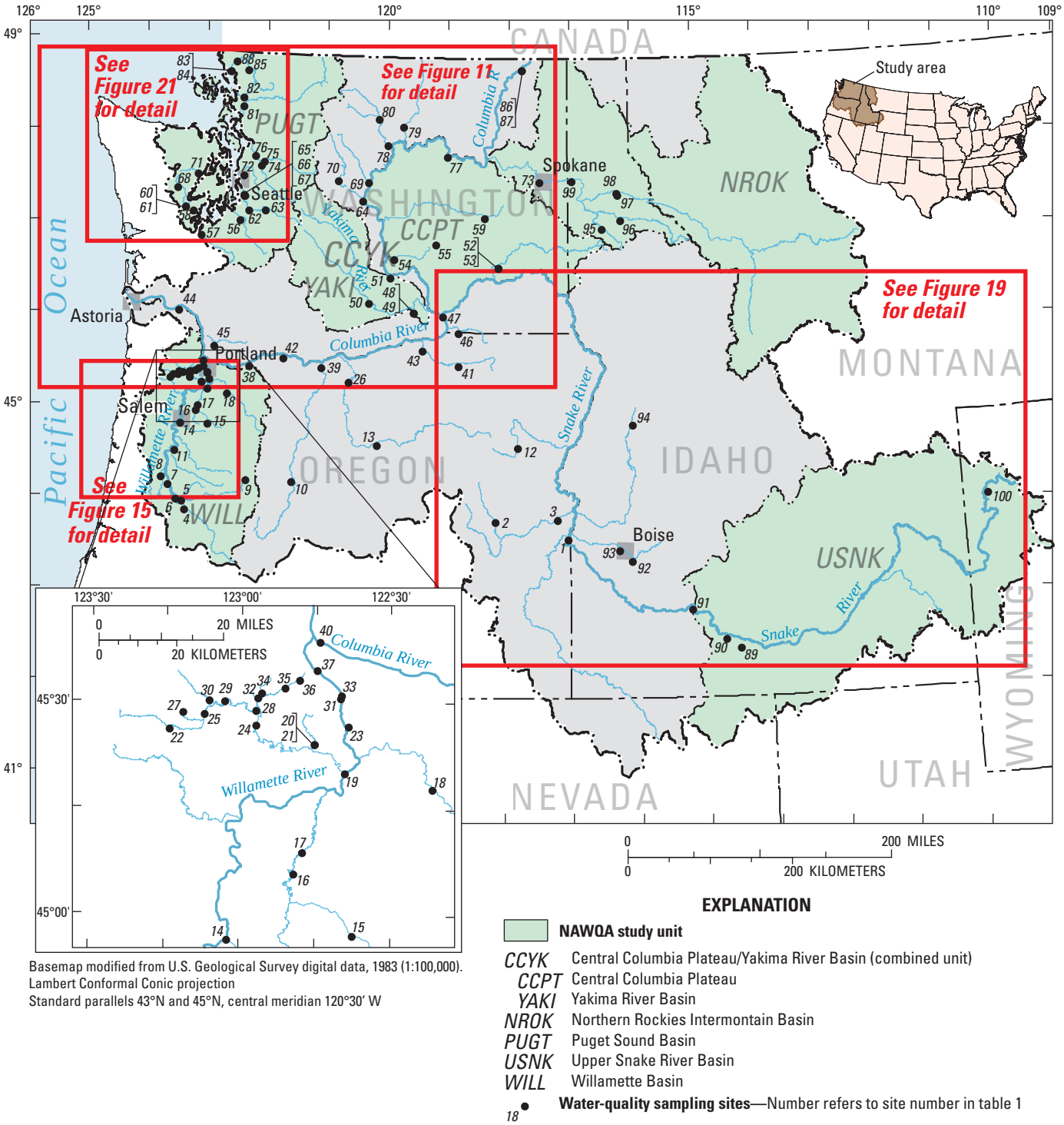
Description of Columbia River and Puget Sound Basins

Columbia River Basin

The Columbia River and its tributaries form the dominant water system in the Pacific Northwest (fig. 1). The main stem of the Columbia rises in Columbia Lake (not shown in fig. 1) on the west slope of the Rocky Mountains in Canada. After winding 1,942 km, of which 664 km are in Canada, the Columbia River flows into the Pacific Ocean near Astoria, Oregon. The river drains an area of about 567,000 km^2 in Washington, Oregon, Idaho, Montana, Wyoming, Nevada, and Utah (fig. 1). An additional 99,700 km^2 of the basin is in Canada.

Geographically, the Columbia River Basin borders the Rocky Mountains to the east and north, the Coast Range on the west and southwest, and the Great Basin to the southeast. The Columbia River flows through the basin from Canada's Rocky Mountains and ultimately becomes the border between Oregon and Washington. Along the way, several major tributaries feed into the Columbia. The three largest basins are the Snake River (267,000 km^2), the Clark Fork-Pend Oreille River (64,700 km^2), and the Kootenai River (46,600 km^2). Other contributing basins include the Willamette River (29,000 km^2), the Yakima River (16,100 km^2), the Payette River (8,390 km^2), and the Cowlitz River (6,220 km^2) (Foundation for Water and Energy Education, 2000).

The hydrologic cycle of the Columbia River reflects a unique relation between water flow and topography in the basin. In the United States, only the Missouri-Mississippi River system has annual runoff greater than that of the Columbia River. Precipitation, sunlight, and air temperature in the basin can vary from one year to the next and largely determine how much water the river will carry from year to year. West of the Cascade Mountains, precipitation falls largely as rain during the winter months, whereas in the Cascade Range and eastward, winter precipitation is mostly snow. Deep snow in the mountains eventually is released to the river during early to mid-spring. About 30 percent of the streamflow in the Columbia River occurs between January and March (primarily from rainfall) and about 30 percent occurs between April and June (from a combination of rainfall and melting snow). These values are based on the record of daily mean discharge for the Columbia River near the mouth at Beaver Army Terminal (fig. 2).



Basemap modified from U.S. Geological Survey digital data, 1983 (1:100,000).
Lambert Conformal Conic projection
Standard parallels 43°N and 45°N, central meridian 120°30' W

Figure 1. Columbia River and Puget Sound Basins and locations of water-quality monitoring sites. (Map index numbers refer to sites listed in table 1.)

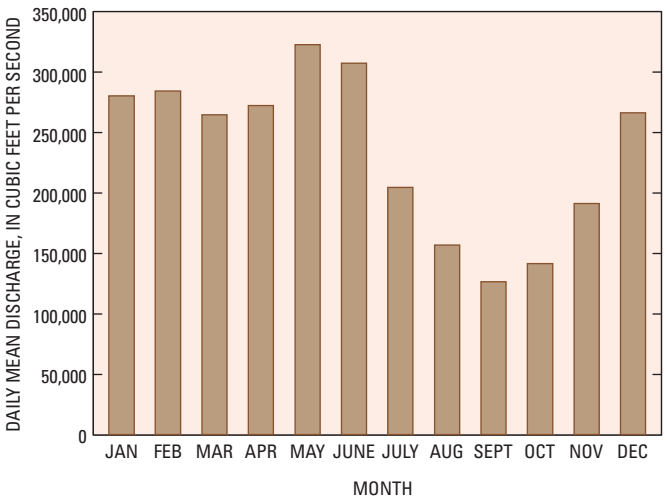


Figure 2. Daily mean discharge for the Columbia River at Beaver Army Terminal, Oregon, water years 1993–2003.

The population of the Columbia River Basin in the United States is about 4.6 million people (2000 census); this number is more than 20 percent greater than that recorded during the 1990 census, indicating that substantial growth is occurring in parts of the basin (U.S. Census Bureau, 2001). Land use of the basin in the United States is predominately forested (87 percent), with urban and agricultural land use comprising the remaining 2 and 11 percent of the basin, respectively. Land cover percentages are based on the enhanced National Land Cover Dataset (1992), further revised with 2000 population density by block group to indicate recent (2000) urban development (U.S. Geological Survey, 2006).

The two priorities for management of the Columbia River dam system historically have been hydroelectric power generation and flood control. Hydroelectric generation projects on the Columbia River provide upwards of 50 percent of the Pacific Northwest Region's electrical power needs (Bonneville Power Administration, 2005). Other uses, such as irrigation, navigation, and recreation, are largely carried out in the context of meeting the two main priorities. Enforcement of Federal environmental laws related to endangered fish species also have resulted in the National Marine Fisheries Service's indicating that anadromous fish recovery should receive priority over all river uses except flood control (Foundation for Water and Energy Education, 2000).

Puget Sound Basin

The Puget Sound Basin is a 13,500 km^2 area located mostly in western Washington, but also encompasses parts of British Columbia (fig. 1). The area consists mostly of mountains and coastal lowlands. In all, 12 major and numerous minor tributaries drain to the Puget Sound and adjoining waters. The streams and rivers in the basin drain three physiographic providences (1) the Olympic Mountains in the west, (2) the Cascade Range in the east, and (3) centrally, the Puget Lowlands (Ebbert and others, 2000). About 70 percent of the population in Washington (4 million people) resides in the Puget Sound Basin, primarily in the metropolitan areas of Seattle, Tacoma, Everett, Bellingham, and Olympia. The population is expected to increase by 1.1 million by the year 2020 (Staubitz, 1994).

The Puget Sound has a Pacific Coast marine climate characterized by wet, cool winters and dry, warm summers. Annual precipitation can vary from 16 to 53 in/yr in the lowland areas to upwards of 60 to 200 in/yr in the mountains (Staubitz, 1994). Streams with headwaters in the mountains generally have the highest monthly flows in December and January, typically associated with winter rains, and in May and June as a result of spring snowmelt. Streams originating in the lowlands typically have the highest flows in January and February. The land use of the basin is predominately forested (75 percent), with urban and agricultural land use encompassing 11 and 6 percent, respectively. The remaining land is covered by lakes, reservoirs, glaciers, and shorelands. Historically, roughly 56 percent of the 810 Mgal/d of water used in the basin has been supplied by surface water and the rest from ground water (Staubitz, 1994). Excluding water used for hydroelectric power generation, 41 percent of the water was used for domestic purposes in 1995, with irrigation, industry, commerce, and livestock using the remaining 11, 30, 9, and 1 percent of the water, respectively (Ebbert and others, 2000).

Data Sources

The historical water-quality and streamflow data used in this study were obtained from the USGS and other Federal, State, and local agencies. The two main types of data were (1) results of discrete intermittent collections of nutrient and SS samples from river and stream locations in the Columbia River and Puget Sound Basins in Oregon, Washington, and

Idaho, and (2) continuous measurements of streamflow at locations where the water-quality samples were collected or from nearby streamflow stations. Combining data from these agencies was important because no single agency had data of sufficient quantity or quality to be used alone for the analysis (Hirsch and others, 2006). To aid in explaining the trends in nutrients and sediment, and the spatial patterns in yields, ancillary information on individual stream catchments also was compiled (Hirsch and others, 2006). This ancillary information included basin climate, hydrology, drainage area, land cover, population and road densities, National Resources Inventory of agricultural management practices, ecoregions, nutrient ecoregions, hydrologic landscapes, physiographic divisions, bedrock and surficial geology, as well as catchment-specific estimates for atmospheric deposition, fertilizer, and manure loads (provided to the study by the USGS NAWQA Pesticide Synthesis Workgroup [http://ca.water.usgs.gov/pnsp/]). A technique described by Nakagaki and Wolock (2005) was used to reapportion the county-level ancillary data to the individual drainage areas upstream of the water-quality site used in the analysis.

Discrete Water-Quality Samples

Of the 100 water-quality sites used in our analysis, 36 sites were operated by the USGS (fig. 1, table 1). Figure 1 shows the NAWQA study areas in the Columbia River and Puget Sound Basins (the USGS sites considered for this analysis were not restricted to these areas). As part of the USGS program of disseminating water data to the public, a distributed network of computers and fileservers is maintained for the storage and retrieval of water data collected through its activities at about 1.4 million sites. This system is called the National Water Information System (NWIS). Many types of data are stored in NWIS, including site information, time-series (stage, streamflow, precipitation, and chemical), peak flow, ground water levels, water-quality data, and water-use data (U.S. Geological Survey, 1998). The USGS uses the 5-digit parameter code system developed by the U.S. Environmental Protection Agency (USEPA) in the 1960s for its STORET (STOrage and RETrieval) system. The parameter codes (Pcodes) are used to identify each measured constituent in the record, defined by a set of attributes.

Additional water-quality data were retrieved from monitoring sites operated by various local, State, and Federal environmental quality agencies. Data from 26 sites were obtained from the Washington State Department of Ecology (WDOE) through their River and Stream Water-Quality Network database (Washington State Department of Ecology, 2004). The goal of the WDOE network is to provide timely water-quality data for various purposes, including evaluation of the status of and trends in stream water quality statewide. Data from another 23 water-quality sites were obtained from the Pacific Northwest Water-Quality Exchange (Exchange) and from the Oregon Department of Environmental Quality (Gregory Pettit, Oregon Department of Environmental Quality, written commun., 2006). The Exchange comprises a number of related information management projects that collectively seek to facilitate the aggregation of and access to a comprehensive source of data related to water quality in the Pacific Northwest. (Pacific Northwest Water Quality Exchange, 2006). All 23 sites were operated by the Oregon Department of Environmental Quality (ODEQ). Data from an additional 13 sites were retrieved from a database maintained by Clean Water Services (CWS) (Janice Miller, Clean Water Services, written commun., 2005). CWS provides wastewater treatment and management of surface-water resources for the 712 mi^2 Tualatin River basin, in northwestern Oregon (Clean Water Services, 2006). Data from the remaining two sites were retrieved from the USEPA STORET data management system (U.S. Environmental Protection Agency, 2006b). These sites were operated by the Bureau of Reclamation in eastern Oregon (table 1).

Daily Mean Streamflow

The 100 daily mean streamflow files were obtained from several data sources: (1) 80 streamflow files were retrieved from the USGS NWIS database; (2) 7 streamflow files from the Oregon Water Resources Division (OWRD) database (Oregon Water Resources Division, 2006); (3) 10 streamflow files from the Washington County, Oreg., Watermaster (Washington County, Oregon, 2006); and (4) 3 streamflow files from the Bureau of Reclamation Hydromet database (Bureau of Reclamation, 2006).

Table 1. Description of water-quality monitoring sites in the Columbia and Puget Sound River Basins.

[Figure 1 shows site location by Map index No. **Abbreviations:** CWS, Clean Water Services; ODEQ, Oregon Department of Environmental Quality; USBR, Bureau of Reclamation; USGS, U.S. Geological Survey; WDOE, Washington State Department of Ecology; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; km², square kilometer; NA , not available]

Map index No.	Site No.	Agency	Site name	Drainage area (km²)	Trend sites	Load sites
1	10729	ODEQ	Owyhee River at Hwy 201 Bridge (Owyhee), OR	NA		X
2	MAL113	USBR	North Fork Malheur River approximately 2 miles upstream of Beulah Reservoir, OR	880		X
3	MAL144	USBR	Malheur River at Ford Street (1.1 miles) upstream of Bully Creek, OR	12,000		X
4	10386	ODEQ	Middle Fork Willamette River at Jasper Bridge, OR	3,490	X	X
5	10663	ODEQ	Mohawk River at Hill Road, OR	460		X
6	10376	ODEQ	McKenzie River at Coburg Road, OR	NA		X
7	10355	ODEQ	Willamette River at Hwy 99E (Harrisburg), OR	8,890	X	X
8	11140	ODEQ	Long Tom River at Stow Pit Road (Monroe), OR	1,080	X	X
9	12657	ODEQ	McKenzie River at Hwy 126 downstream of Clear Lake, OR	239		X
10	10508	ODEQ	Deschutes River at Lower Bridge, OR	5,440	X	X
11	10350	ODEQ	Willamette River at Albany (Eastbound Hwy 20 Bridge), OR	12,600	X	X
12	11490	ODEQ	Powder River at Hwy 7 (Baker City), OR	902		X
13	11478	ODEQ	John Day River at Service Creek, OR	13,300	X	X
14	10555	ODEQ	Willamette River at Marion Street (Salem), OR	19,100	X	X
15	14200400	USGS	Little Abiqua Creek near Scotts Mills, OR	25.5	X	X
16	14201300	USGS	Zollner Creek near Mt. Angel, OR	38.9	X	X
17	10640	ODEQ	Pudding River at Hwy 211 (Woodburn), OR	818		X
18	13070	ODEQ	Clackamas River at Mciver Park (Upper Boat Ramp), OR	1,760		X
19	3701002	CWS	Tualatin River at Weiss Bridge, OR	1,840	X	X
20	3840012	CWS	Fanno Creek at Durham Road, OR	80.7		X
21	14206950	USGS	Fanno Creek near Durham, OR	80.7		X
22	3701715	CWS	Tualatin River at Cherry Grove, OR	97.3		X
23	11321	ODEQ	Johnson Creek at SE 17th Avenue (Portland), OR	139	X	X
24	3701333	CWS	Tualatin River at Farmington Bridge Road, OR	1,460		X
25	3701612	CWS	Tualatin River at Springhill Road Bridge (Dilley), OR	327	X	X
26	11386	ODEQ	John Day River at Hwy 206, OR	NA		X
27	3805048	CWS	Scoggins Creek below Hagg Lake at Stimson Bridge, OR	103		X
28	3701391	CWS	Tualatin River at Rood Bridge Road, OR	1,230		X
29	3701528	CWS	Tualatin River at Golf Course Road, OR	561		X
30	3810015	CWS	Gales Creek at New Hwy 47, OR	195		X
31	10611	ODEQ	Willamette River at Hawthorne Bridge (Portland), OR	28,900	X	X
32	3820012	CWS	Rock Creek at Hwy 8, OR	193		X
33	14211720	USGS	Willamette River at Portland, OR	28,900	X	X
34	3850006	CWS	Dawson Creek at Brookwood, OR	9.66		X
35	3824020	CWS	Bronson Creek at Bronson Park downstream of Sunset Hwy, OR	10.2		X
36	3824072	CWS	Bronson Creek at Saltzman, OR	5.23		X
37	10332	ODEQ	Willamette River at SP&S Railroad Bridge, OR	NA	X	X
38	14128910	USGS	Columbia River at Warrendale, OR	616,000		X
39	10411	ODEQ	Deschutes River at Deschutes River Park, OR	27,800	X	X
40	10616	ODEQ	Columbia River at Marker #47 (upstream of Willamette River), OR	NA	X	X
41	10406	ODEQ	Umatilla River at Hwy 11 (Pendleton), OR	1,150		X
42	12012	ODEQ	Hood River at footbridge downstream of I-84, OR	NA	X	X
43	11489	ODEQ	Umatilla River at Westland Road (Hermiston), OR	NA	X	X
44	14246900	USGS	Columbia River at Beaver Army Terminal near Quincy, OR	658,000	X	X
45	27D090	WDOE	East Fork Lewis River near Dollar Corner, WA	405		X
46	32A070	WDOE	Walla Walla River near Touchet, WA	4,370	X	X
47	13353200	USGS	Snake River at Burbank, WA	262,000		X
48	37A090	WDOE	Yakima River at Kiona, WA	14,500	X	X
49	12510500	USGS	Yakima River at Kiona, WA	14,500		X
50	12505450	USGS	Granger Drain at Granger, WA	160		X

Table 1. Description of water-quality monitoring sites in the Columbia and Puget Sound River Basins. —Continued

[Figure 1 shows site location by Map index No. **Abbreviations:** CWS, Clean Water Services; ODEQ, Oregon Department of Environmental Quality; USBR, Bureau of Reclamation; USGS, U.S. Geological Survey; WDOE, Washington State Department of Ecology; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; km^2, square kilometer; NA , not available]

Map index No.	Site No.	Agency	Site name	Drainage area (km^2)	Trend sites	Load sites
51	12472900	USGS	Columbia River at Vernita Bridge near Priest Rapids Dam, WA	67,800	X	X
52	13351000	USGS	Palouse River at Hooper, WA	6,380	X	X
53	34A070	WDOE	Palouse River at Hooper, WA	6,380	X	X
54	41A070	WDOE	Crab Creek near Beverly, WA	999	X	X
55	12471400	USGS	Lind Coulee Wastway at SR 17 near Warden, WA	1,840		X
56	13A060	WDOE	Deschutes River at East Street Bridge, WA	267	X	X
57	10A070	WDOE	Puyallup River at Meridian Street, WA	2,380	X	X
58	12108500	USGS	Newaukum Creek near Black Diamond, WA	71.1		X
59	12464770	USGS	Crab Creek at Rocky Ford Road near Ritzville, WA	1,190		X
60	12061500	USGS	Skokomish River near Potlatch, WA	339		X
61	16A070	WDOE	Skokomish River near Potlatch, WA	339	X	X
62	12112600	USGS	Big Soos Creek above Hatchery near Auburn, WA	173		X
63	09A190	WDOE	Green River at Kanaskat, WA	616	X	X
64	45A070	WDOE	Wenatchee River at Wenatchee, WA	3,440	X	X
65	12113375	USGS	Springbrook Creek at Tukwila, WA	51.7		X
66	09A080	WDOE	Green River at Tukwila, WA	1,240	X	X
67	12113390	USGS	Duwamish River at Golf Course at Tukwila, WA	1,190		X
68	12056500	USGS	North Fork Skokomish River below Staircase Rapids near Hoodport, WA	147		X
69	46A070	WDOE	Entiat River near Entiat, WA	1,070		X
70	45A110	WDOE	Wenatchee River near Leavenworth, WA	1,720	X	X
71	16C090	WDOE	Duckabush River near Brinnon, WA	172	X	X
72	12128000	USGS	Thorton Creek near Seattle, WA	29.2		X
73	54A120	WDOE	Spokane River at Riverside State Park, WA	13,000	X	X
74	07D050	WDOE	Snoqualmie River near Monroe, WA	1,770	X	X
75	07C070	WDOE	Skykomish River at Monroe, WA	1,980	X	X
76	07A090	WDOE	Snohomish River at Snohomish, WA	4,440	X	X
77	53A070	WDOE	Columbia River at Grand Coulee, WA	28,900	X	X
78	48A070	WDOE	Methow River near Pateros, WA	4,660	X	X
79	49A070	WDOE	Okanogan River at Malott, WA	4,500	X	X
80	48A140	WDOE	Methow River at Twisp, WA	3,430	X	X
81	03A060	WDOE	Skagit River near Mount Vernon, WA	6,020	X	X
82	03B050	WDOE	Samish River near Burlington, WA	223		X
83	12213140	USGS	Nooksack River at Brennan, WA	2,020		X
84	01A050	WDOE	Nooksack River at Brennan, WA	1,910	X	X
85	12210700	USGS	Nooksack River at North Cedarville, WA	1,520		X
86	12400520	USGS	Columbia River at Northport, WA	156,000		X
87	61A070	WDOE	Columbia River at Northport, WA	156,000	X	X
88	12212100	USGS	Fishtrap Creek at Flynn Road at Lynden, WA	98.6		X
89	13092747	USGS	Rock Creek above Hwy 30/93 crossing at Twin Falls, ID	623	X	X
90	13094000	USGS	Snake River near Buhl, ID	76,100		X
91	13154500	USGS	Snake River at King Hill, ID	92,900	X	X
92	13203510	USGS	Boise River below Diversion Dam near Boise, ID	6,980		X
93	13206000	USGS	Boise River at Glenwood, ID	7,180	X	X
94	13238322	USGS	North Fork Payette River below Fischer Creek near McCall, ID	220		X
95	12414900	USGS	St. Maries River near Santa, ID	706		X
96	12414500	USGS	St. Joe River at Calder, ID	2,680		X
97	12413470	USGS	South Fork Coeur d'Alene River near Pinehurst, ID	738	X	X
98	12413000	USGS	North Fork Coeur d'Alene River at Enaville, ID	2,330		X
99	12419000	USGS	Spokane River near Post Falls, ID	10,200	X	X
100	13010065	USGS	Snake River at Flagg Ranch, WY	1,320		X

Methods of Analysis

Load Estimation

Annual mean loads for TN, TP, and SS were estimated using the USGS computer program Load Estimator, or LOADEST (Runkel and others, 2004). LOADEST uses a seven-parameter linear regression model that incorporates flow, time, and seasonal terms to estimate loads of mass over specified time periods (for this study, annual loads). The calibration and estimation procedures within LOADEST are based on three statistical estimation methods. However, the Adjusted Maximum Likelihood Estimation (AMLE) was most often used since the method is more appropriate when the calibration data set (time series of streamflow and concentration data) contains censored data. Once the model was calibrated, continuous daily mean values of streamflow were used as the independent variable to produce the annual load results for the specified years of interest (for this study, WYs 1997, 2000, and 2001). Mean load estimates, along with standard errors, and 95 percent confidence intervals were computed. The LOADEST output also included diagnostic tests and warnings to assist the user in determining the appropriate estimation method and in interpreting the estimated loads. LOADEST is available as a USGS module (David Lorenz, USGS library for S-PLUS, version 6.1, for Windows—Release 2.1) to the S-PLUS statistical software package (Insightful Corporation, 2002).

The focus of the load computations for the specified years of interest was two-fold:

- Transport of TN, TP, and SS in the Columbia River, Willamette River, Snake River and to the Puget Sound over a range of annual hydrologic conditions, and
- TN, TP, and SS yields for the Pacific Northwest for WY 2000, and relating differences in yields to differences in landscape and climatic conditions between catchments to understand how landscape and climate influence the transport of TN, TP, and SS.

Results of the LOADEST modeling are in appendix A. Included in the appendix are annual loads, annual average flow-weighted concentrations (defined as the annual load divided by the cumulative annual streamflow), annual yields (defined as the annual load divided by catchment drainage area) for TN, TP, and SS, and annual mean streamflow.

Selection of Analysis Period

The selection of the 11-year (WY 1993–2003) common time period for analysis of trends in streamflow, concentrations, and loads was based on a rigorous analysis of the temporal distribution of available USGS and non-USGS streamflow and water-quality datasets to optimize the number of sites spatially and temporally available for the analysis. An examination of annual mean streamflows for WY 1973–2003 in the Willamette Basin (fig. 3) illustrate how streamflows for WY 1993–2003 were representative of mean (average), high-flow, and low-flow years for the longer time period. This allowed the examination of water-quality trends and loads over a diverse and variable daily mean streamflow regime (Hirsch and others, 2006). The common time period occurred when the availability of ancillary data describing landscape, management practices, and climatic conditions were more accurately detailed. This ancillary information was important to the completion of the second and fourth study objectives. Attempts to extend the analysis period either forward or backward in time resulted in the loss of some sites considered important to the analysis. Comparison of streamflow during the selected 11-year period relative to the mean annual streamflow for WY 1973 (31 years of streamflow and water-quality data) also demonstrates the diverse nature of the common time period selected for the trend analysis (fig. 4).

Computation of annual mean loads of nutrients and SS in the Columbia and Puget Sound Basins was accomplished by selecting high, low, and mean streamflow years from the common period, WY 1993–2003. Six streamflow sites in Oregon, Idaho, and Washington were selected to characterize differences in climatic and hydrologic conditions in the eastern and western parts of each State within the basins (table 2). Although the peak daily streamflows generally occurred in WY 1996, the highest annual mean streamflows generally were during WY 1997, when streamflows ranked in the 93rd to 100th percentile of the highest annual streamflows in WYs 1973–2003. The lowest annual mean streamflows generally were during WY 2001, when streamflows ranked in the 1st to 14th percentile of the lowest annual streamflows in WYs 1973–2003. Selection of a mean annual water year representative of historical annual streamflow was more difficult because several water years in the common time period had annual streamflows similar to the historical mean annual streamflow. During the 1993–2003 period, WY 2000 best demonstrated monthly mean streamflows that were comparable to the means of the monthly streamflows from the historical time period (fig. 5). For these six index sites, the annual mean streamflows for WY 2000 ranked in the 48th to 76th percentile of the WY 1973–2003 mean annual streamflows.

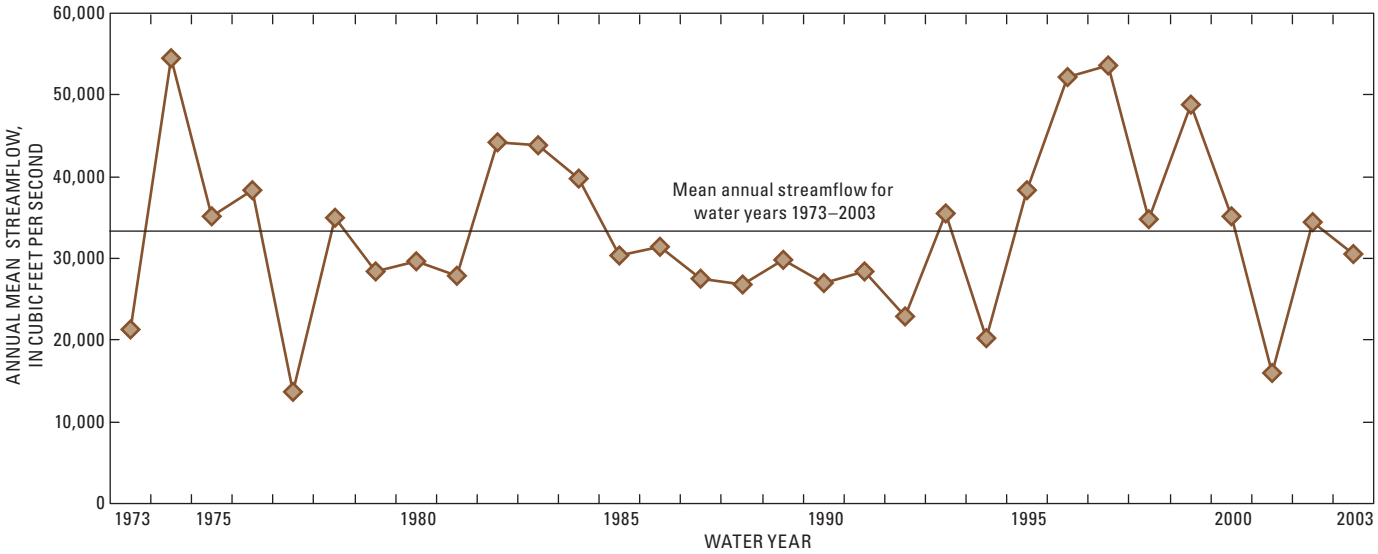


Figure 3. Annual mean daily streamflow in the Willamette River at Portland, Oregon, water years 1973–2003.

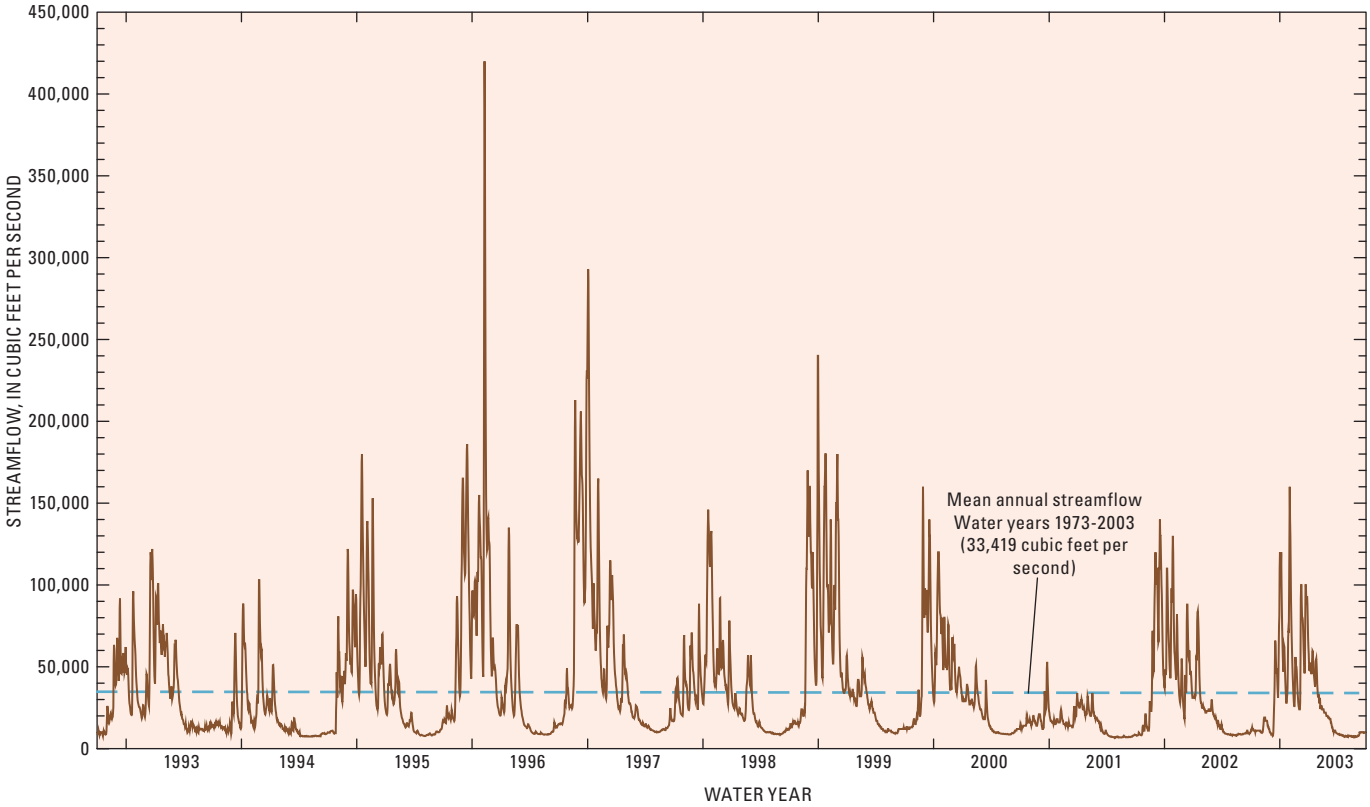


Figure 4. Daily mean streamflow in the Willamette River at Portland, Oregon, water years 1993–2003.

Table 2. Streamflow sites used for nutrient and suspended-sediment load computations in the Columbia River and Puget Sound basins for selected water years.

[All values are in cubic feet per second. **Common period:** Number in parenthesis beside streamflow value indicates the percentage of annual mean streamflows less than the 31 annual streamflows for water years 1973–2003. **Abbreviations**: ID, Idaho; OR, Oregon; WA, Washington]

Site No.	Site name	Water years 1973–2003	Common period (flow percentile water years 1993–2003)		
		Mean annual streamflow	Annual mean streamflow (water year 2000)	Low annual mean streamflow (water year 2001)	High annual mean streamflow (water year 1997)
14211720	Willamette River at Portland, OR	33,400	35,100 (65)	16,000 (3)	53,700 (97)
14103000	Deschutes River at Moody, OR	5,870	6,460 (76)	4,850 (14)	7,980 (100)
12413000	North Fork Coeur d'Alene River at Enaville, ID	1,810	2,040 (71)	759 (3)	2,730 (93)
13154500	Snake River at King Hill, ID	11,000	9,990 (48)	7,330 (11)	17,000 (96)
12510500	Yakima River at Kiona, WA	3,400	3,770 (66)	1,530 (6)	6,090 (96)
12150800	Snohomish River nr Monroe, WA	9,320	10,500 (68)	6,300 (0)	13,300 (100)

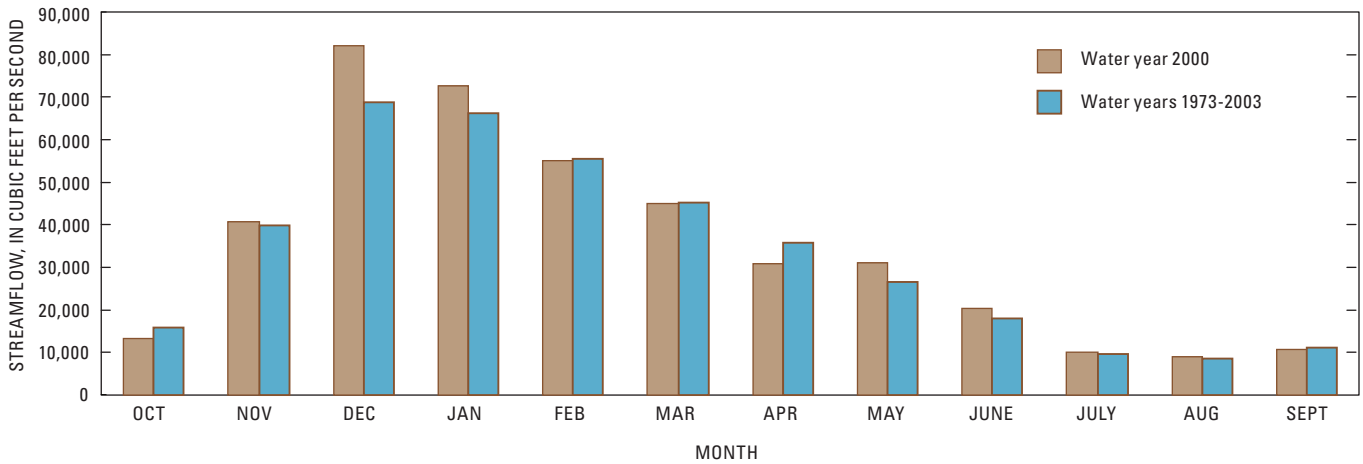


Figure 5. Comparison of monthly mean streamflow during water year 2000 with mean monthly streamflow during water years 1973–2003 for the Willamette River at Portland, Oregon.

Criteria for Site Selection

Two types of data compilations were used in our analysis based on different minimum data requirements. The first type considered the selection of a consistent timeframe of daily mean streamflows and periodic sampling of water-quality constituents of a sufficient duration for the computation of trends in concentrations and loads of nutrients and SS. The minimum data requirements for the selection of sites for trends in concentration included:

- Continuous daily streamflow for WY 1993–2003 (in some cases, for only WY 1994–2003 to increase the number of sites available for the analysis);
- At least quarterly water-quality samples in the two years at the beginning and end of the time period (WY 1993, 1994, 2002, and 2003); and
- At least quarterly water-quality samples in a minimum of 4 of the intermediate 7 water years, WY 1995—2001.

These data requirements provided a minimum of 32 or more water-quality samples for each site used for the trends analysis (David K. Mueller, U.S. Geological Survey, written commun., 2005). Streamflow and water-quality data from 50 sites (table 1) met the minimum requirements for the analysis of trends in concentrations and loads.

The second type of data compilation considered the selection of streamflow and water-quality sites for computing annual loads and yields of nutrients and SS over a range of years. The 50 sites that met the minimum data requirements for the analysis of trends in concentration and loads also met the minimum load and yield selection requirement. However, these sites provided insufficient coverage of the Columbia River and of the Puget Sound Basins. An additional 50 sites were identified that met the less rigorous requirements for the second type of data compilation analysis. All sites for the second type of data compilation met the following minimum requirements:

- Daily mean streamflow data existed for WY 1997 (high-flow year), 2000 (average-flow year), or 2001 (low-flow year);
- Data were available for about 30 samples over the range of seasonal flow described in the 3 water years of interest; and
- Data from six or more samples were available in each of the 3 years (for the site to qualify for computation of estimated annual nutrient and suspended-sediment loads).

One hundred sites met the minimum requirements for the second type of data analysis (fig. 1, table 1). The distribution of drainage areas for the 91 delineated catchments used in this study (delineations were not available for the other 9 sites) is shown in figure 6. The drainage areas ranged in size from 5 km^2 to more than 650,000 km^2; and, although the average drainage area was about 23,500 km^2, most catchment drainage areas (54 of 91) were between 100 and 5,000 km^2. All sites were reviewed for compliance with various modeling requirements (water-quality sampling representative of the flow regime for the period of interest, percentage of sampling results censored, confidence intervals, and other statistical measurements of model suitability).

Data Assumptions and Censoring Process

Analyses evaluated for this study consisted of a suite of nitrogen, phosphorus, and SS data collected and analyzed by the USGS, other Federal and State agencies in Oregon, Washington, and Idaho, and a wastewater- and stormwater-treatment public utility in Oregon. To aid in the interpretation of the data, assumptions concerning varying sample collection protocols, equipment, and analytical techniques were made. A detailed discussion concerning the first two assumptions is presented in the next section.

- Differences between collection techniques using grab sampling versus depth-width integrating sampling were assumed to be minor, resulting in similar precision and minimal bias;
- Differences in analytical techniques between the various agency laboratories were assumed to be minor; and
- Differences in the frequency of sample collection from one site to another were assumed to not significantly bias site-to-site comparisons in concentrations, trends, or loads as long as the minimum data requirements for selection of sites were met.

The chemical and physical parameters used in this study included:

- Dissolved nitrite plus nitrate as N [STORET Pcode: 00631],
- Total Kjeldahl nitrogen as N (TKN) [STORET Pcode: 00625],
- Total nitrogen as N (TN) [STORET Pcode: 00600],
- Total phosphorus as P (TP) [STORET Pcode: 00665], and
- Suspended-sediment or nonfilterable solids (SS) [STORET Pcode: 80154 or 00530]

The above parameters were used to model loads, and trends in concentrations and loads, for TN, TP, and SS in the Columbia River and Puget Sound Basins for WYs 1993–2003. Where direct measurements of TN were not available, TN was computed from the sum of TKN and nitrite plus nitrate, using the rules outlined in table 3. The most common analytical reporting levels during WY1993–2003 were 0.2 mg/L for TKN and 0.05 mg/L for nitrite plus nitrate. In recent years, some slightly lower TKN and nitrite plus nitrate reporting levels were measured at some USGS and non-USGS sites; however, the rules were not changed significantly because it affected only a small number of the more pristine TN sites.

Influence of Sampling and Analytical Techniques

To produce a data set with adequate spatial and temporal coverage, it was necessary to include water-quality results from non-USGS as well as USGS data bases. As mentioned in the previous section, the validity of this approach partly rested on two assumptions: (1) differences between collection techniques using grab sampling (non-USGS) versus depth-width integrating sampling (USGS) were minor during typical flow regimes; and (2) differences in analytical techniques between various agency laboratories were minor. The WDOE compared their water-quality data to water-quality data collected during the same months by the USGS for two stations that also are included in this study (Hallock, 2005). The ranges for data collection were

September 1982 through September 1994 for the Yakima River at Kiona, Wash. (Kiona), and December 1992 through September 2002 for the Palouse River at Hooper, Wash. (Hooper). USGS SS concentrations were significantly greater than the WDOE suspended-solids concentrations at Kiona on the basis of the central tendency of the data, but the difference in concentrations was not large and might have been due to differences in analytical techniques. In addition, concentrations were not significantly different between the two agencies' data from the Hooper site. However, even a small bias at high concentrations and during high-flow periods for constituents positively correlated with flow (for example, SS and TP), caused fluxes to be magnified. SS and TP fluxes calculated from WDOE data were equal to 80 percent of the fluxes calculated from USGS data at Kiona and 50 percent of the USGS fluxes at Hooper.

Martin and others (1992) compared water-quality data collected concurrently using surface-grab and depth-width integrating sampling. Although concentrations of dissolved constituents were not consistently different, concentrations of SS and constituents associated with sediment were significantly lower in the surface-grab samples than in the depth-width integrated samples, and the magnitude of the differences generally increased with streamflow. Gray and others (2000) evaluated 3,235 paired samples of suspended-sediment (used by USGS) and total suspended-solids (used by the ODEQ and WDOE) and concluded that data resulting from the suspended-sediment techniques were more reliable, but that the methods may be comparable when the amount of sand-sized material is less than about 25 percent. Comparisons of concurrent nutrient samples (TN and TP) using standard USGS methods of analysis and methods of analysis used by non-USGS laboratories were not available.

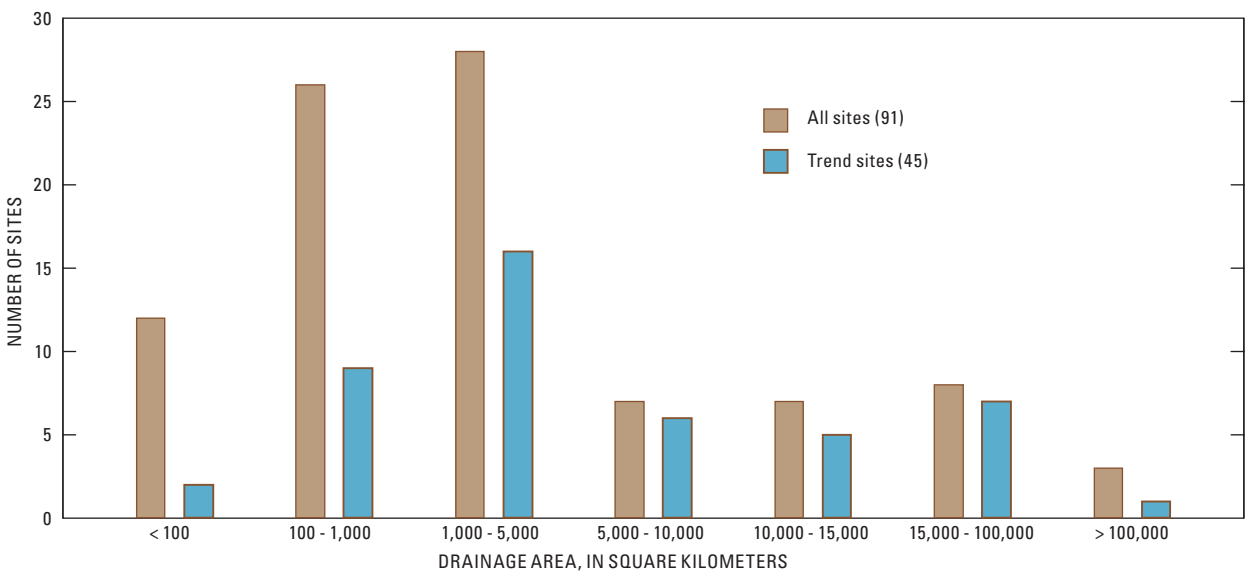


Figure 6. Statistical distribution of the 91 delineated catchment drainage areas in the Columbia River and Puget Sound basins.

Table 3. Rules for computing total nitrogen concentration from total Kjeldahl nitrogen and dissolved nitrite plus nitrate as nitrogen.

[Concentrations are in milligrams per liter. A notation of "Value(nitrite plus nitrate) greater than or equal to (≥) 0.05" means that the concentration (value) of the combined sum of the nitrite plus nitrate species is greater than or equal to 0.05 milligrams per liter. 0.05 is the detection limit selected for nitrite plus nitrate, 0.025 is one-half this value; 0.2 is the detection limit for TKN, and 0.1 is one-half this value. **Abbreviations:** TN, total nitrogen; TKN, total Kjeldahl nitrogen; <, less than]

Case No.	Nitrite plus nitrate	TKN	Condition	TN
1	<0.05	<0.20	Nitrite plus nitrate is <0.05 and TKN is <0.20	<0.25
2	Value(nitrite plus nitrate) ≥ 0.05	Value(TKN) ≥ 0.2	Value(nitrite plus nitrate) ≥ 0.05 and Value(TKN) ≥ 0.2	Value(nitrite plus nitrate) + Value(TKN)
3a	<0.05	Value(TKN) ≥ 0.2	Value(TKN) + 0.025 < 0.25	<0.25
3b	<0.05	Value(TKN) ≥ 0.2	Value(TKN) + 0.025 ≥ 0.25	Value(TKN) + 0.025
4a	Value(nitrite plus nitrate) ≥ 0.05	<0.20	Value(nitrite plus nitrate) + 0.1 < 0.25	<0.25
4b	Value(nitrite plus nitrate) ≥ 0.05	<0.20	Value(nitrite plus nitrate) + 0.1 ≥ 0.25	Value(nitrite plus nitrate) + 0.1
5	Missing	Missing	Nitrite plus nitrate is missing or TKN is missing	Missing

For this study, comparisons also were made between model-predicted annual loads from a minimum of three co-located sites for the 3 water years of interest—high flow in 1997 (three sites), mean flow in 2000 (three sites), and low flow in 2001 (four sites). Table 4 summarizes the results of these comparisons by showing the predicted annual non-USGS load as a percentage of the predicted annual USGS load. The water-quality data used for the predictions were not collected concurrently, but all data were collected between WYs 1993 and 2003. For TN, the differences between the USGS and non-USGS loads generally were small (less than 10 percent) for all 3 years. However, for TP and SS, the non-USGS loads were less than the USGS load at all the sites in 1997 and 2000 (as low as 38 percent for TP and 31 percent for SS). As expected, SS was the most sensitive to sampling methodology and (or) laboratory procedures with regard to loads.

Results from other studies and the comparison of our co-located sites showed that surface-grab samples were biased low for elevated concentrations of sediment by as much as 70 percent and biased low for total phosphorous associated with high-flow conditions by as much as 60 percent. This deficiency might compromise load calculations if a stream is further stratified (fine particles and less mass near the top and heavy particles and more mass near the bottom). However, the results also showed that no persistent bias existed for total nitrogen (the differences were less than 8 percent). The value of using non-USGS load data to fill the spatial gaps in the USGS data outweighed the potential underestimation problems for TP and SS loads.

Table 4. Comparison of total nitrogen, total phosphorus, and suspended-sediment loads based on sampling results from co-located sites operated by U.S. Geological Survey and other agencies.

[Values represent the ratio of predicted non-USGS (U.S. Geological Survey) load to predicted USGS load (expressed as a percentage). **Abbreviations**: TN, total nitrogen; TP, total phosphorus; SS, suspended sediment; OR, Oregon; WA, Washington; –, insufficient data]

Site name	Load (percentage USGS)		
	TN	TP	SS
Water year 1997			
Willamette River at Portland, OR	94.2	96.0	34.0
Palouse River at Hooper, WA	95.4	38.3	31.4
Yakima River at Kiona, WA	92.6	75.3	53.9
Water year 2000			
Willamette River at Portland, OR	94.6	101	48.0
Palouse River at Hooper, WA	98.5	76.1	70.1
Yakima River at Kiona, WA	92.4	91.9	80.2
Water year 2001			
Willamette River at Portland, OR	106	108	70.0
Palouse River at Hooper, WA	93.6	120	103
Yakima River at Kiona, WA	94.8	95.9	104
Fanno Creek at Durham Road, OR	101	93.8	–

Trends in Streamflow, Load, and Concentration

Changes over time in the concentration and load of a constituent can be used to evaluate the potential effects on water quality of changes in pollution sources or management activities in a watershed. However, the concentration and load of a constituent in a stream is influenced by the volumetric flow at the time of sampling (for example, higher concentrations and loads are generally associated with higher flows). This association is stronger for sediment and sediment-adsorbed constituents, like phosphorus, than for constituents that tend to dissolve in water, such as nitrate. However, an inverse relation may occur when a stream's major source of nutrients is from point sources.

The relations of discharge to total nitrogen and discharge to suspended-sediment concentrations for Willamette River at Portland (fig. 1, site 33) for WY 1993–2003 are shown in figure 7. A locally weighted scatter plot smoothing (LOWESS) curve was fit to the data to indicate the relation between the parameters in the plots. Changes over time (trends) in the measured concentrations for a constituent (referred to as non-flow-adjusted trends in concentration) give an indication of water-quality changes streams have undergone. This is important with regard to possible effects on biota (for example, eutrophication). However, to determine whether a stream has experienced a trend in water quality due to changes in catchment activities, the effect of streamflow may need to be removed from the measured concentrations (because the streamflow itself might exhibit a trend). This is done by calculating the flow-adjusted trend in concentration, which gives insight into whether a trend in measured concentrations is potentially caused by management activities or reflects a trend in streamflow due to climatological or hydrological changes.

A detailed description of the method used in this study for estimating trends in streamflow, load, and concentration is provided in appendix B. Trends in load and concentration are defined as the model-estimated, smoothed trend in load and concentration over the period of water-quality record, divided by the length of record.

Smoothing of data is necessary when a measured variable is slowly varying and also influenced by random noise. In such a case, it is sometimes useful to replace each measured value with some kind of local average of the surrounding data points, thus reducing the level of variation without biasing the value of interest. An example of data smoothing (using a LOWESS curve) is shown in figure 8 which contains the measured daily mean streamflow and total nitrogen concentrations for the Willamette River at Portland for water years 1993–2003. Although LOWESS smoothing was used as an example in these plots, a different data smoothing routine was used for the analytical aspects of this study (see appendix B).

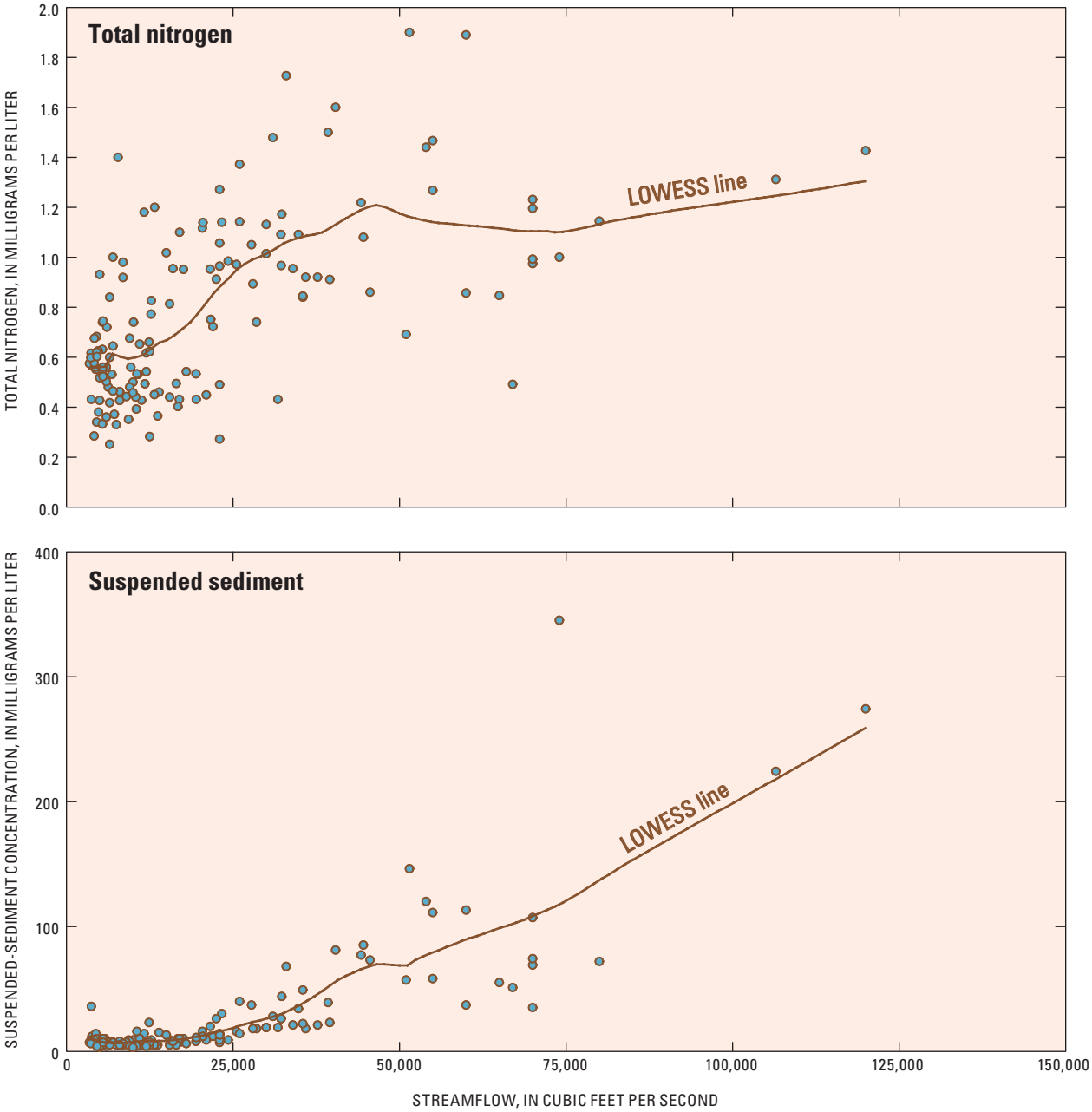


Figure 7. Relations between concentrations of total nitrogen and suspended sediment and discharge for Willamette River at Portland, Oregon, water years 1993–2003. (LOWESS, locally weighted scatter plot smoothing.)

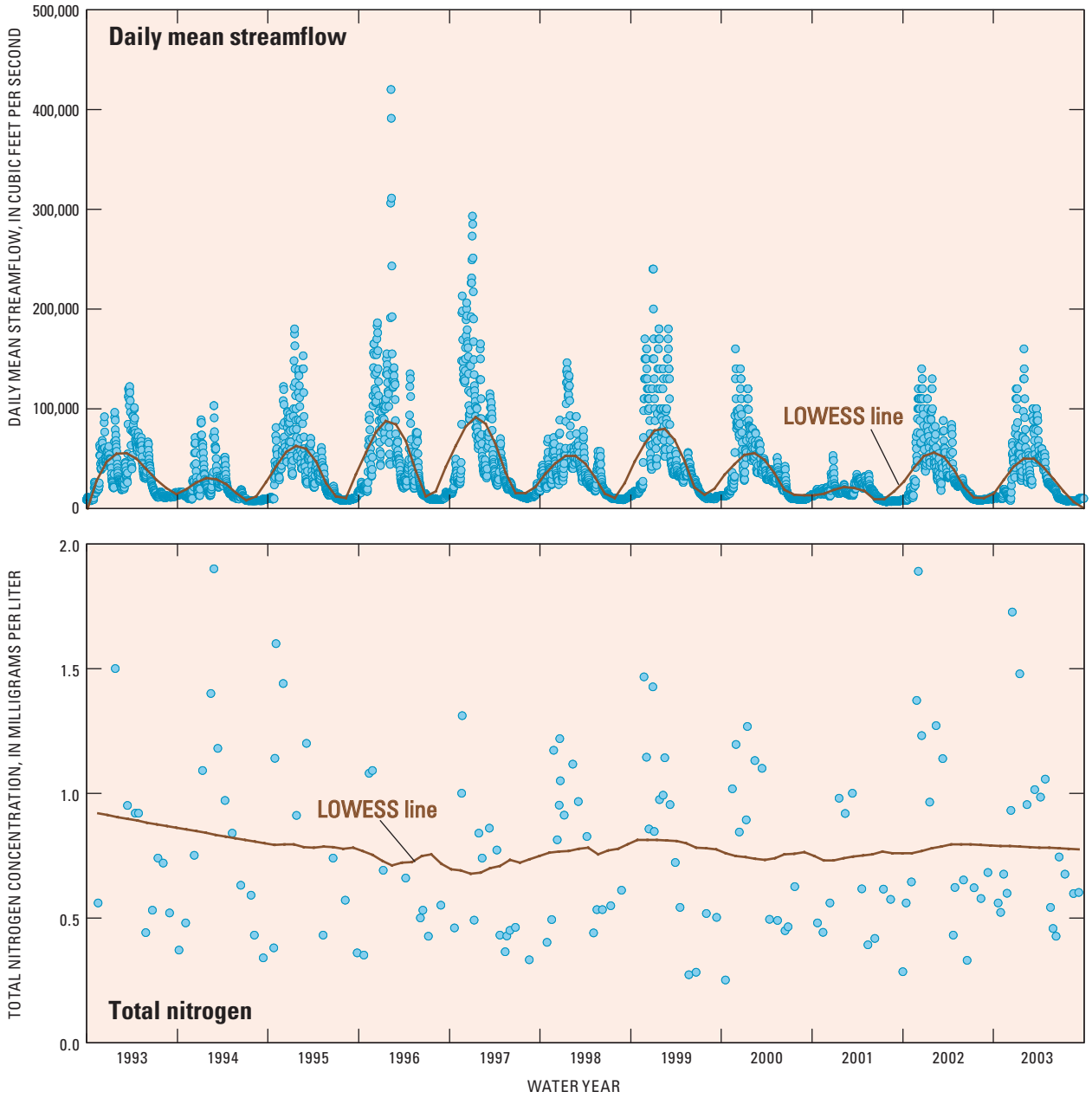


Figure 8. Examples of data smoothing demonstrating temporal variability of daily mean streamflow and instantaneous total nitrogen concentrations for Willamette River at Portland, Oregon, water years 1993–2003. (LOWESS, locally weighted scattered plot smoothing.)

Because the water-quality record for most sites does not include enough data to assess trends in load and concentration, a mathematical model is needed to "fill in" the gaps in the water-quality record by estimating concentrations based on streamflow. The model-estimated trend in load and concentration is determined by fitting separate trend models for streamflow and water-quality concentration. The model for trend in streamflow relates the natural logarithm of daily mean streamflow to an intercept, a linear trend term (measured by time expressed as a decimal, such as 1995.5), and sine and cosine seasonal factors (also functions of decimal time). In this study, the trend was based on all daily streamflow measurements available over the analysis period WY 1993–2003 (except for the four sites where the record started in WY 1994). Below is a summary of the methods used to calculate non-flow-adjusted trend in concentration, trend in load, flow-adjusted trend in concentration, and trend in streamflow. Appendix B contains a formal description of the methods described below, with additional discussion of the estimation of the streamflow and water-quality models, and an explanation of the associated statistical tests for trend.

Non-Flow-Adjusted Trend in Concentration

The water-quality model used to determine nonflow-adjusted trend in concentration (percent per year), estimated from all water-quality measurements collected during the analysis period, is represented by the following linear equation:

$$c_t = b_0 + m(q_t)b_q + h(T_t)b_T + x_t b_x + e_t, \qquad (1)$$

where:

c_t is the natural logarithm of a constituent concentration in period t;

b_0 is an intercept value;

q_t is the natural logarithm of streamflow;

T_t is decimal time;

x_t is vectors of ancillary predictors such as sine and cosine functions of decimal time to account for seasonality;

b_q, b_T, b_x is coefficients determined from model fitting;

$m(.)$ is multi-element vector function consisting of the natural logarithm of streamflow and the square of the natural logarithm of streamflow;

$h(.)$ is multi-element vector function consisting of the second order polynomial and step functions of decimal time; and

e_t is random error term.

The smoothed trend in the natural logarithm of water-quality concentration (non-flow-adjusted trend in concentration) is determined by the streamflow and time trend components of the water-quality model (equation 1), where the smoothed trend in the natural logarithm of streamflow is substituted for the actual natural logarithm of streamflow in the model. The smoothed trend in the natural logarithm of streamflow is given by the following equation:

$$\tilde{q}_t = \bar{q} + a\left(T_t - \bar{T}\right), \qquad (2)$$

where:

$\tilde{q}_t$ is smoothed trend in the natural logarithm of flow in the period t;

$\bar{q}$ is average of the natural logarithm of flow over the trend period;

$\bar{T}$ is average, or midpoint, of the decimal time over the trend period;

T is decimal time; and

a is coefficient determined from the model fitting.

Non-flow-adjusted trend in concentration is obtained by transforming the model-estimated, smoothed water-quality trend from logarithmic space to real space, computing the percentage change corresponding to the first and last dates of the water-quality record period, and normalizing by the decimal time length of this period.

Trend in Load

Trend in load (percent per year) is computed in a similar manner as non-flow-adjusted trend in concentration, except that the smoothed trend in the natural logarithm of streamflow is added to the smoothed trend in the natural logarithm of water quality prior to retransformation to real space (addition in logarithmic space is equivalent to multiplication in real space).

Flow-Adjusted Trend in Concentration

The estimation of flow-adjusted trend in concentration (percent per year) is similar to the approach used for non-flow-adjusted trend in concentration, except the streamflow component of the water-quality model is not included in the determination of the smoothed water-quality trend. Otherwise, the estimation methods are the same; that is, although flow is used to estimate the parameters of the water-quality model, implying that the trend parameters of the model exclude the effects of trend in flow, the flow component of the model is held constant and, therefore, does not enter into the evaluation of flow-adjusted trend.

Trend in Streamflow

The estimation of the trend in streamflow is based on the smoothed streamflow trend corresponding to the simple linear function of decimal time described by equation 2. The conversion of this smoothed trend to a trend estimate follows the same procedure described for non-flow-adjusted trend in adjusted concentration—the only difference is the period of the trend is taken to be the beginning and ending dates for the flow record within the analysis period, rather than the beginning and ending dates of the water-quality record.

Interpretation of Trends

Trend results also are reported as unit trends (for example, kilograms per day per year for load or milligrams per liter per year for concentration). The unit trends in load and concentration are determined by multiplying the load and concentration trend estimates (expressed as rates rather than percentages) by the appropriate reference values of load and concentration. The reference value for the natural logarithm of concentration is obtained by evaluating the water-quality model given by equation 1 at reference conditions consistent with the trend in water quality at the beginning of the water-quality period of record. These conditions include setting the natural logarithm of streamflow to the smoothed trend value given by equation 2 to the first day of the water-quality period, setting the trend term to the decimal equivalent of the first day of the water-quality period, and setting the sine and cosine seasonal factors to their average values over the full water-quality period. The natural logarithm value of the reference concentration is transformed to real space and a multiplicative retransformation factor is applied to correct for statistical bias arising from sample error in the water-quality model coefficients (see appendix B for additional details). The reference load is computed similarly, except that the natural logarithm of streamflow trend, as determined by the linear streamflow equation evaluated at the starting date of the water-quality period, is added to the natural logarithm value of the reference concentration prior to transformation to real space. In addition, a conversion factor is used to convert the result to the appropriate load units. The same reference concentration is used to derive non-flow-adjusted unit trend and flow-adjusted unit trend in concentration, and the same reference load is used in the evaluation of unit trend in load.

If streamflow demonstrates no trend over time, the non-flow-adjusted and flow-adjusted trends concentration will be equivalent. Because the water-quality model used to derive these trends includes streamflow as a predictor, the estimates of trend are immune to bias arising from preferential water-quality sampling during high-streamflow events. Care should be taken, however, in interpolating or extrapolating these trend estimates within or beyond a site's period of record, or in making comparisons of trend across sites with different periods of record. Due to the possible nonlinearity of trend, as may arise from nonlinear specifications of the water-quality model streamflow or trend components, trends of shorter duration within the water-quality period of record, or trends occurring outside this period could be different from the trends reported here. In addition, the method used to evaluate trend is sensitive to changes in the variability of streamflow and to changes in the unexplained variability of water quality (both changes may potentially cause trends in water quality arising from nonlinearity in the specification of the water-quality model). Accommodation of these properties of the variance in the data effects awaits future research.

Estimation of Point-Source Nutrient Loads

Annual TN and TP point-source loads were estimated for WY 2000 for the 91 delineated catchments (9 sites did not have delineated catchments). SS point-source loads were assumed to be negligible compared to in-stream SS loads and, therefore, were not estimated. Facility-specific average discharge, TN concentrations, and TP concentrations for WY 2000 were used to estimate the annual nutrient loads from each point source. Point sources without a measured discharge were assigned a discharge equal to the design flow rate. When WY 2000 nutrient concentrations were not available, facility-specific values for water years that were as close as possible to WY 2000 were used instead in an attempt to represent typical WY 2000 operations. When facility-specific nutrient concentrations were not available, region-wide average concentrations for the applicable standard industrial classification (SIC) category were used. When region-wide average nutrient concentrations for a SIC category were not available or the regional data set was not large enough, national typical concentrations for the applicable SIC code were used (obtained from the USEPA [Gerard McMahan, U.S. Geological Survey, written commun., 2006]). Loads were not calculated for facilities without a measured discharge, design discharge, or any available nutrient concentrations (site-specific, regional average, or typical national). In most cases, TN was not measured directly, so the components of TN (total Kjeldahl nitrogen [TKN] and dissolved nitrite plus nitrate as N) were summed to obtain a TN concentration. If the average WY 2000 value for a measured component of TN or TP was greater than the region-wide average for TN or TP, the facility-specific average value for the component was used (since the values for TN and TP cannot be less than their individual components). Water-quality and discharge monitoring reports were obtained directly from the facilities or from the USEPA Permit Compliance System (PCS) (U.S. Environmental Protection Agency, 2006a), a database containing State discharge monitoring reports (DMRs) (NPDES Discharge Monitoring Reports) submitted by the facilities.

All municipal wastewater-treatment plants (WWTPs) designated as major sources (design flow greater than 1.0 Mgal/d) were included in the analysis. The potential underestimation of loads caused by not including the minor WWTPs was determined by estimating the minor WWTPs

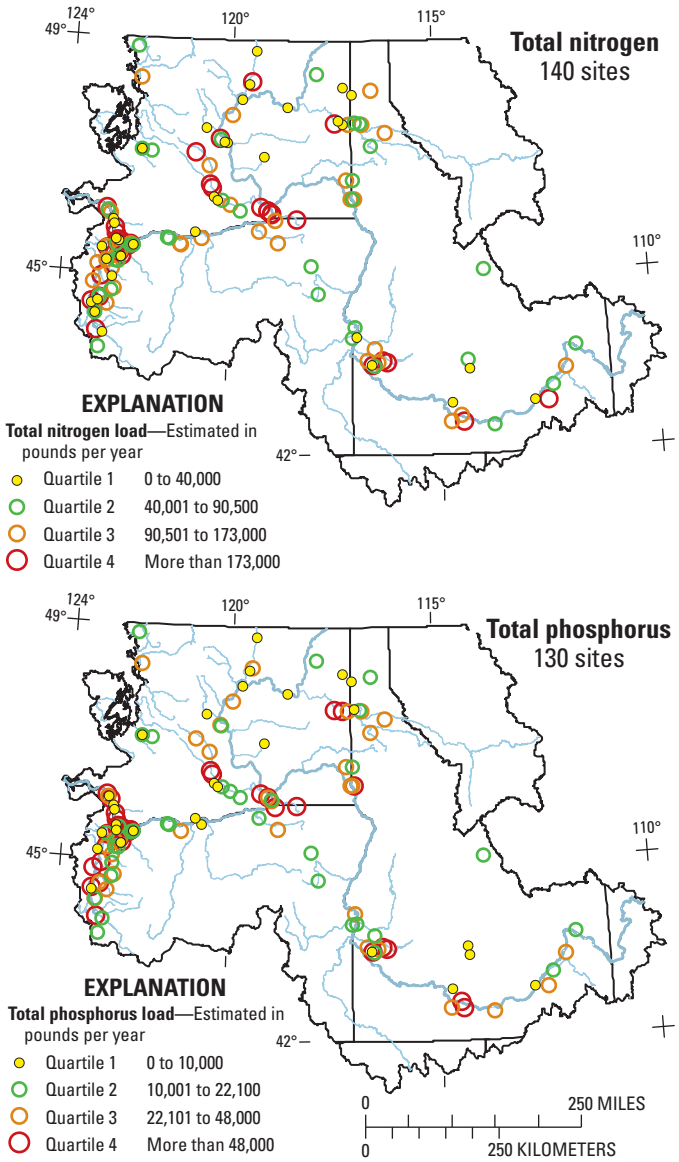
contribution to the total annual discharge for all of the facilities in the Columbia Basin. If all the minor WWTPs were operating at 1.0 Mgal/d (an unlikely situation), they would comprise about 20 percent of the total annual WWTP discharge (and load). However, if all the minor WWTPs were operating at 0.5 Mgal/d (probably still a high estimate), they would comprise about 12 percent of the total annual WWTP discharge (and load). All non-WWTP facilities in the PCS falling under the SIC categories in table 5 were included in the analysis (regardless of size). The USEPA has determined that these SIC categories are large sources of industrial nutrient loads (Tetra Tech, Inc., 1998).

Locations of the 140 point sources with estimated TN loads and 130 point sources with estimated TP loads in the catchments included in this study for WY 2000 are shown in figure 9. Point sources discharging directly to the Puget Sound are not shown in figure 9, but are discussed in the section describing that system. The sources are color-coded and sized to represent their relative loads based on the quartiles for annual TN and TP loads. Table 6 shows the ranges for the annual WY 2000 point-source load quartiles. The point sources with the largest nutrient loads were located around major population centers (lower Columbia River Basin, Willamette River Basin, Snake River Plain, near Spokane, Yakima River Basin, and the confluence of the Yakima, Snake, and Columbia Rivers).

Table 5. Industrial categories contributing to total nitrogen and total phosphorus loads in the Columbia and Puget Sound basins.

[From documentation of Phase I and Phase II activities and U.S. Environmental Protection Agency Permit Compliance System. **Abbreviation:** SIC, standard industrial classification]

Industrial category	SIC code
Plastics materials and resins	2821
Nitrogenous fertilizers	2873
Primary aluminum	3334
Wet corn milling	2046
Blast furnaces and steel mills	3312
Industrial inorganic chemicals,	2819
Petroleum refining	2911
Meat packing plants	2011
Paper mills	2621
Pulp mills	2611
Paints and allied products	2851
Primary nonferrous metals	3339
Paperboard mills	2631
Poultry slaughtering and processing	2015



Basemap modified from U.S. Geological Survey digital data, 1983 (1:100,000).
Lambert Conformal Conic projection
Standard parallels 43°N and 45°N, central meridian 120°30′ W

Figure 9. Estimated point-source loads divided into quartiles for total nitrogen and total phosphorus, Columbia River basin, water year 2000.

Table 6. Quartile ranges for total nitrogen and total phosphorus point-source loads in the Columbia and Puget Sound basins, water year 2000.

[All loads are in pounds per year. **Abbreviations:** TN, total nitrogen; TP, total phosphorus]

Point-source loads	Quartile range			
	1st	2nd	3rd	4th
TN	550–38,500	44,900–90,500	90,900–173,000	175,000–6,310,000
TP	26.0–9,070	10,300–22,100	22,300–48,000	49,200–899,000

Transport of Nutrients and Suspended-Sediment in Columbia River and Puget Sound Basins

Water year 2000 was selected to compare the discharges of TN, TP, and SS in the Columbia River and Puget Sound Basins. The discharge was the annual mean load in WY 2000, expressed in units of pounds per day for TN and TP, and tons per day for SS. Annual mean load is defined as the average load for each day of one year. WY 2000 was selected because it represented a typical or average stream flow condition in the Pacific Northwest (see earlier section of report titled “Selection of Analysis Period”). The following three sections provide detailed descriptions of the load and transport of nutrients and sediment in the Columbia River, Willamette River, and Snake Rivers. Estimated annual main-stem, monitored tributary, and point-source loads for the three river systems are included in tables 8, 9, and 10. Although only the tributaries for which loads were calculated could be included in the analysis, the tables and the information shown in figures 11 through 21 provide some insight into the relative contribution of tributary and point source loads to rivers.

In WY 2000, the Snake, Yakima, Deschutes, and Willamette Rivers contributed most of the load discharged to the Columbia River, while point-source loads to the river (almost exclusively from municipal wastewater treatment plants) generally equaled a small percentage of the total in-stream nutrient load. Annual loads from point sources discharging directly to the Columbia River in WY 2000 represented about 6 percent and 9 percent, respectively, of the estimated annual mean TN and TP load near the mouth of the river at Beaver Army Terminal (site 44, fig. 1). These loads also were equal to 10 percent and 14 percent, respectively, of the combined annual mean TN and TP loads discharged from the Snake, Yakima, Deschutes, and Willamette Rivers. Annual WY 2000 TN and TP loads from the largest point sources discharging directly to the Columbia River, which are in the fourth quartile in figure 9 (defined as those with loads exceeding 75 percent of the loads from all the facilities) are shown in figure 10. The City of Portland’s WWTP is the largest point-source discharger in the Columbia Basin. The annual TN and TP loads from this facility, which discharges directly to the Columbia River instead of the Willamette River, equaled 2.3 percent and 2.9 percent, respectively, of the annual in-stream TN and TP load at Beaver Army Terminal (site 44, table 1) in water year 2000.

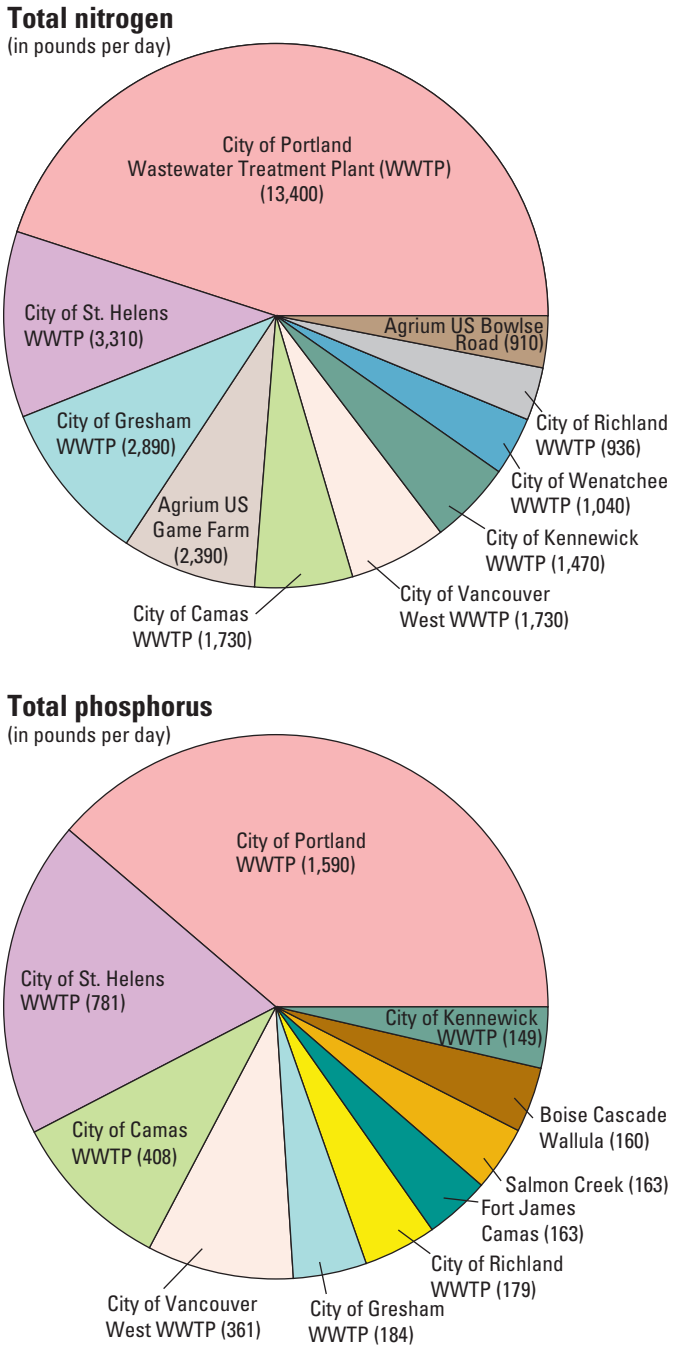


Figure 10. Estimated discharges from point sources to the Columbia River that exceed the 75th percentile of all point sources for total nitrogen and total phosphorus, water year 2000.

Annual point-source loads of TN and TP discharged directly to the Willamette River were 11 percent and 36 percent, respectively, of the annual mean load discharged from the Willamette to the Columbia River. Combining the nutrient load from the City of Portland's WWTP with the point-source nutrient load to the Willamette River increased these contributions to the Columbia River to 18 and 42 percent, respectively. Because most of the City of Portland lies within the Willamette Basin, these percentages represent the Willamette Basin's total contribution to the Columbia River in WY 2000. Annual point-source loads of TN and TP discharged directly to the Snake River were 2 and 12 percent, respectively, of the annual mean load discharged from the Snake to the Columbia River. Although the drainage area for the Snake River is about 9 times larger than that for the Willamette, the Snake River's point-source contribution to the Columbia River was about one half of the Willamette River's contribution. The predicted annual mean loads for each of the main-stem sites on the Columbia River, the Willamette River, and the Snake River, as well as for sites located near the mouths of the Puget Sound tributaries for WY 2000 are included in appendix A. Further details regarding these loads are described in the following sections. An interpretation of nutrient and sediment transport in relation to landscape characteristics can be found in the section titled "Nutrient and Suspended-Sediment Yields".

Columbia River System

Six water-quality monitoring stations were used to assess nutrient and sediment transport on the main stem of the Columbia River. Stations in Washington were at Northport (RM 735, fig. 1, site 86), Grand Coulee (RM 596; fig. 1, site 77), and Vernita Bridge near Priest Rapids Dam (RM 388, fig. 1, site 51). Stations in Oregon were at Warrendale (RM 189; fig. 1., site 38), river marker 47 upstream of the Willamette River (RM 103; fig. 1, site 40), and Beaver Army Terminal (RM 54; fig. 1, site 44). In addition, 11 water-quality stations located on or near the mouths of Columbia River tributaries and 35 point sources discharging directly to the Columbia River, were used to assess nutrient and sediment load to the main stem of the river (fig. 11).

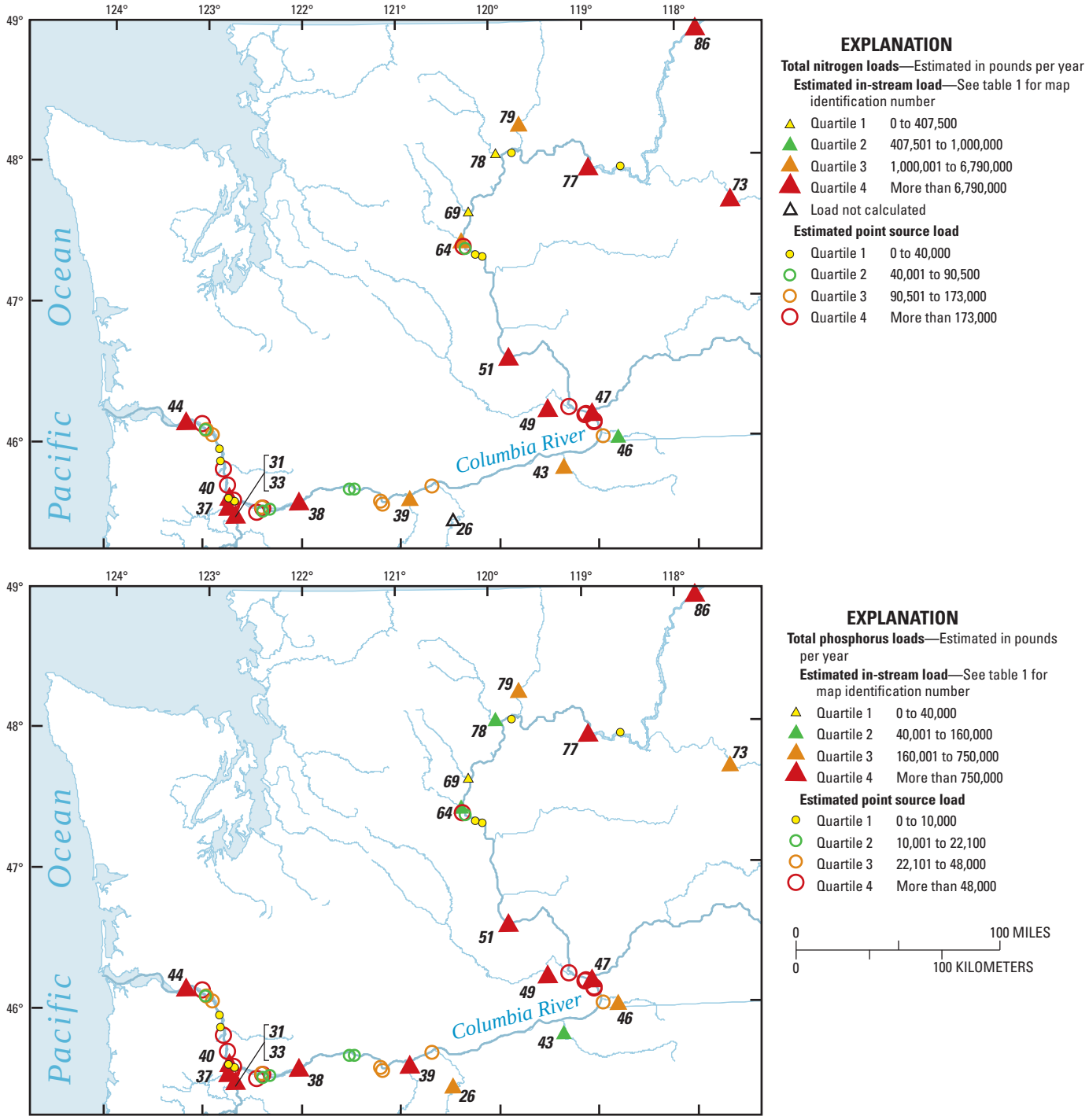
In WY 2000, the Columbia River discharged an average of 570,000 lb/d of TN to the Pacific Ocean (on the basis of the annual mean load at Columbia River at Beaver Army Terminal, fig. 1, site 44). In addition, an average of nearly 55,000 lb/d of TP, and about 14,000 ton/d of SS were discharged at Beaver Army Terminal. Tributary inputs to the Columbia River downstream of this site were small and did not appreciably affect the estimated load (Fuhrer and others, 1996). Nutrient and suspended-sediment discharges from the Columbia River represent contributions to the main

Summary of Direct Point-Source Nutrient Discharges to Columbia River and Largest Tributaries

Annual loads from point sources discharging directly to the Columbia River in WY 2000 represented about 6 percent and 9 percent, respectively, of the annual mean TN and TP load near the mouth of the Columbia River at Beaver Army Terminal (site 44, fig. 1). These point-source loads also were small compared to annual mean loads discharged from the Snake and Willamette Rivers to the Columbia River. Annual WY 2000 TN and TP loads from the largest point sources discharging directly to the Columbia River (those in the fourth quartile in figure 9, or with loads exceeding 75 percent of the loads from all the facilities) are shown in figure 10. The City of Portland's WWTP is the largest point-source discharger in the basin. The annual TN and TP loads from this facility, which discharges directly to the Columbia River instead of the Willamette River, equaled 2.3 percent and 2.9 percent, respectively, of the annual in-stream TN and TP load at Beaver Army Terminal (site 44, table 1) in water year 2000.

Annual point-source loads of TN discharged directly to the Willamette River were 11 percent of the annual mean load discharged to the Columbia River from the Willamette River, and the annual point-source loads of TP were 36 percent of the annual mean load discharged to the Columbia River. Aggregating the nutrient load from the City of Portland's WWTP with the point-source nutrient load to the Willamette River increased the contributions to 18 and 42 percent, respectively. These percentages represent the total contribution of the Willamette Basin to the Columbia River in WY 2000. The population density (based on 2000 census data) was six times greater in the Willamette Basin compared to the population density in the Columbia River Basin overall.

Annual point-source discharges of TN and TP made up 2 and 12 percent, respectively, of the annual mean load discharged from the Snake River to the Columbia River. Although the Snake River drainage area is greater than the Willamette River drainage area, the Snake River point-source contribution to the Columbia River was considerably less than that of the Willamette River.



Basemap modified from U.S. Geological Survey digital data, 1983 (1:100,000).
Lambert Conformal Conic projection
Standard parallels 43°N and 45°N, central meridian 120°30′ W

Figure 11. Locations of sampling sites in the Columbia River and its tributaries and selected point sources discharging directly to the Columbia River, Oregon and Washington, water year 2000.

stem over a distance of 700 river miles, but permanent losses and temporary storage also occur during transport over this distance. Nitrogen and phosphorus, important nutrients in aquatic ecosystems, are removed by plants and other forms of aquatic life. Nitrogen also can be lost to the atmosphere as a gas (denitrification), and nitrogen and phosphorus can be incorporated into the streambed sediment as a solid through settling of algae and sediment particles. All these processes can affect the transport of nutrients through rivers and to estuaries. Therefore, the total quantity of nutrients delivered to the Columbia River is not conservative and may not necessarily exit through the Columbia estuary. Similarly, sediment (and sorbed nutrients) can become trapped behind main-stem dams and delivered to the surrounding land through irrigation diversions.

Water-quality stations along the main stem of the Columbia River were used to delineate five reaches for analysis (table 7). An attempt to account for the streamflow was made on each of these reaches by summing the monitored streamflow contributions to the reach by the tributaries and comparing that value to the accumulation of flow at the end of the reach (table 7). This exercise was not done to account for the gain and loss in streamflow within each reach: such an accounting would require information from all streamflow management actions and natural processes that divert water, return water, or otherwise consume water (including evaporative losses). Instead, the accounting was performed to provide some perspective on the tributary discharges of TN, TP, and SS for the monitored tributaries (those meeting the screening criteria for load estimation). This accounting provided a basic understanding of a tributary's significance as a nutrient or suspended-sediment source. Although the sum of the measured tributary inflows for reach 1 was nearly equal to the gain within this reach during WY 2000, the total contribution from tributary inflows was actually greater than the gain if the diversion of irrigation water from the reach was included (annual mean of about 3,700 ft^3/s for WY 2000 for the diversion at Grand Coulee Dam). In reach 2, the total contribution from tributary streamflow also was greater than the gain in streamflow over the reach. The results on the flow accounting for reaches 1 and 2 indicate that the Columbia River may have been losing water to the regional ground-water system between Northport and Grand Coulee. A load balance was determined to be appropriate for reaches 3 and 4 because these reaches had no monitored tributary inputs. A load balance for reach 5 also was appropriate, with some caution regarding SS. An earlier study of the lower Columbia River (Fuhrer and others, 1996) determined that, except for the Willamette River, the streamflow and nutrient load contributions from the tributaries in this reach generally were minor (less than 5 percent in aggregate of the main-stem values). The one exception was the SS load from the Cowlitz River (the second largest tributary in the reach), which was about 22 percent of the main-stem SS load and was comparable to the load from the Willamette River. Because the Cowlitz River did not meet the screening criteria for load estimation, contributions of SS from this tributary were not considered in the load balance.

Discharge of TN and TP increased in reach 1, a distance of 139 river miles from Northport to Grand Coulee (fig. 12 and 13, and table 8). In this reach, the discharge of TN from the Spokane River accounted for nearly two-thirds of the gain in the annual mean load of TN (fig. 12) and slightly less than one-third of the gain in the annual load of TP (fig. 13).

Table 7. Accounting for annual mean streamflow in the main stem of the Columbia River, water year 2000.

[**Abbreviations:** OR, Oregon; WA, Washington; ft^3/s, cubic foot per second; NA, indicates an assumption was made that no flow accumulation was in the reach]

Map index No.	Main-stem site name and reach	Reach	River mile	Annual mean streamflow (ft^3/s)	Gain in reach (ft^3/s)	Sum of measured annual mean tributary inflows (ft^3/s)	Measured tributary inflows as percentage of main-stem gain
86	Northport, WA		735	106,000			
		1			7,800	7,020	90.0
77	Grand Coulee, WA		596	113,000			
		2			6,600	8,270	125
51	Vernita Bridge, WA		388	120,000			
		3			65,400	59,700	91.2
38	Warrendale, OR		189	185,000			
		4			0	0	NA
40	Upstream of Willamette River, OR		103	185,000			
		5			46,500	35,100	75.5
44	Beaver Army Terminal, OR		54	232,000			

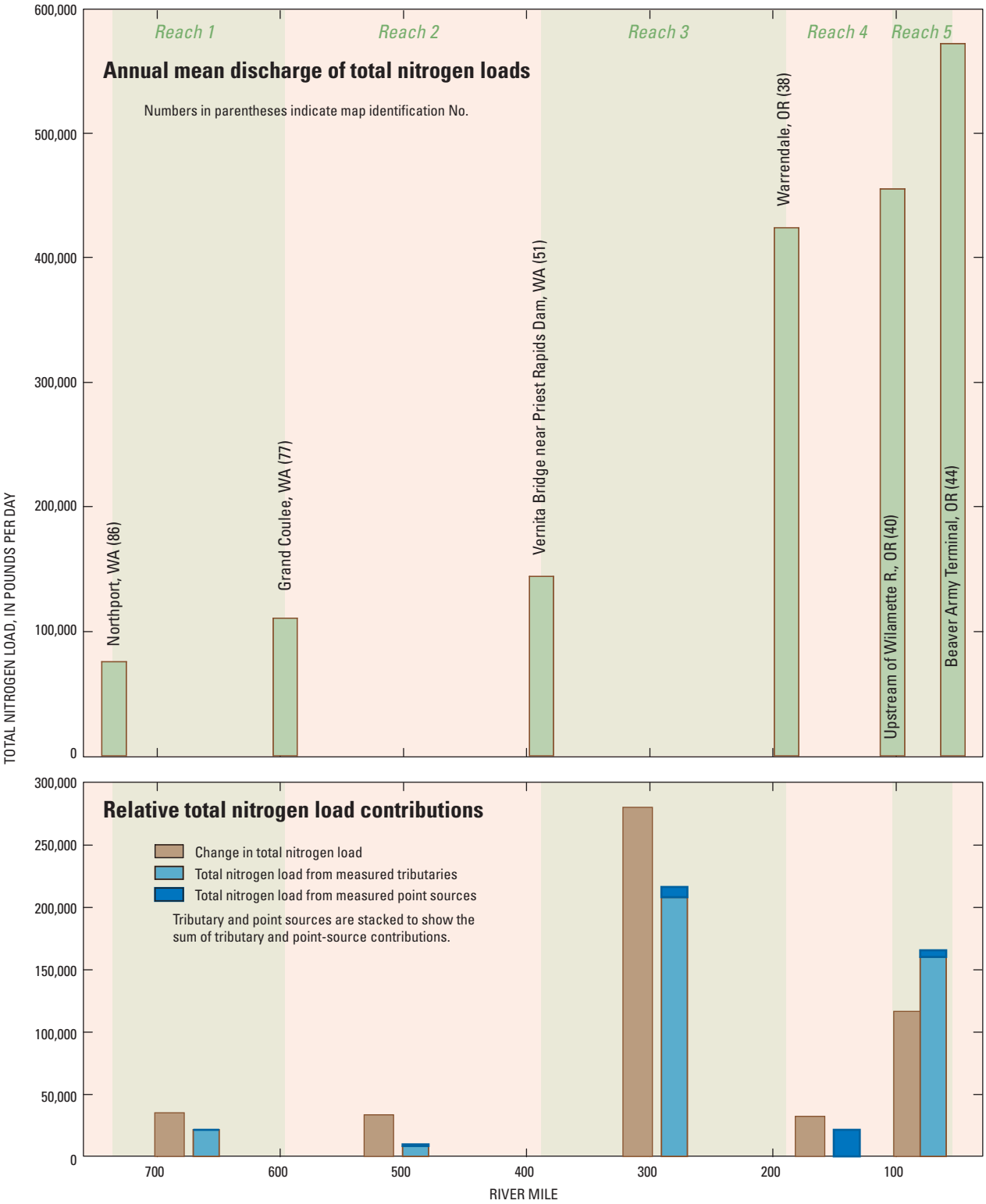


Figure 12. Annual mean discharge of total nitrogen loads in the Columbia River, and relative total nitrogen load contributions from Columbia River monitored tributaries and point sources, Oregon and Washington, water year 2000. (Vertical scales on graphs are identical.)

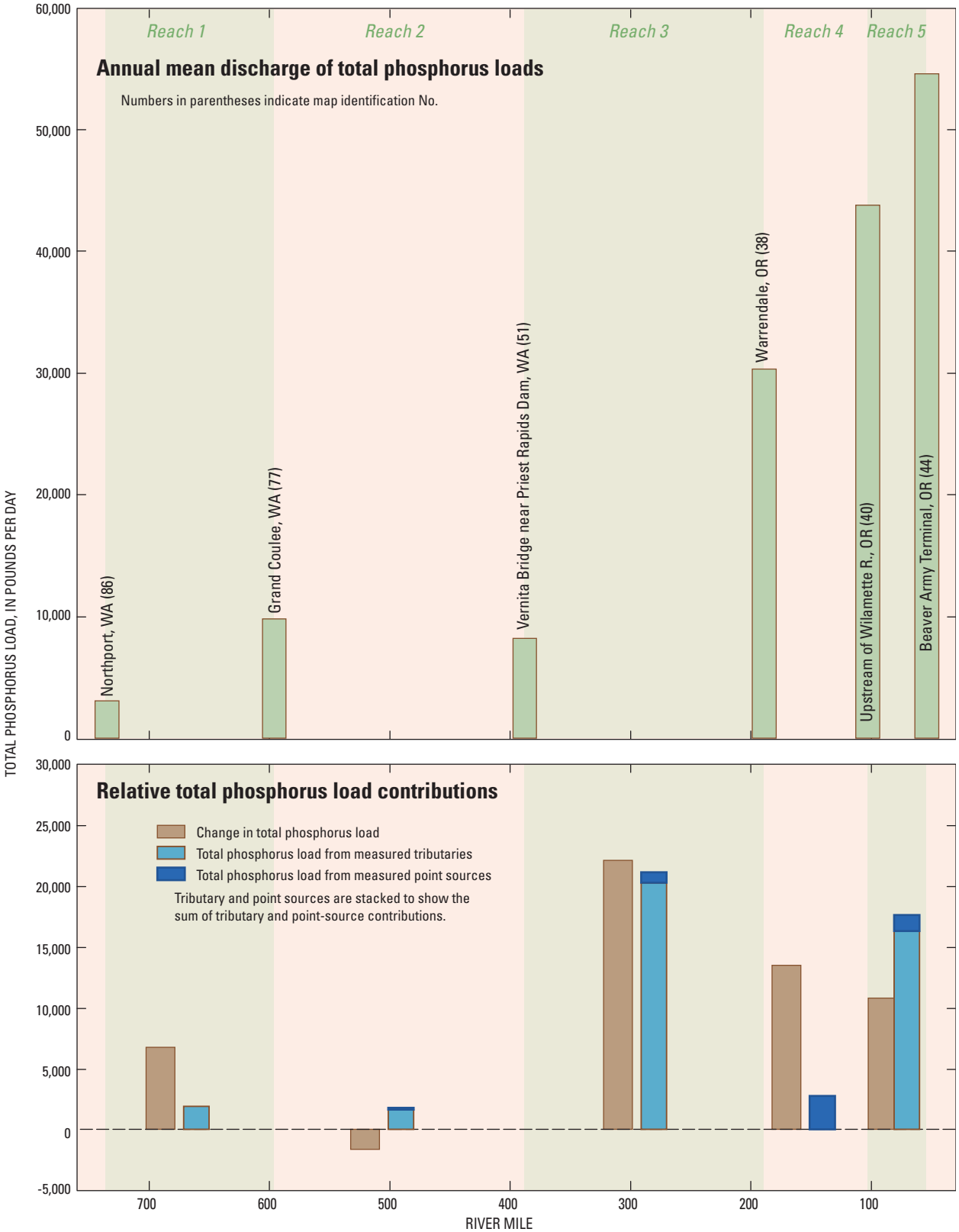


Figure 13. Annual mean discharge of total phosphorus loads in the Columbia River, and relative total phosphorus load contributions from Columbia River monitored tributaries and point sources, Oregon and Washington, water year 2000. (Vertical scales on graphs are identical.)

Table 8. Annual mean discharge of total nitrogen, total phosphorus, and suspended sediment loads in the Columbia River, monitored Columbia River tributaries, and point sources discharging directly to the Columbia River, Oregon and Washington, water year 2000.

[**Bold** type indicates start of reach (see figure 12); shaded rows indicate monitoring site (see table 1); *italicized* type indicates point-source discharge source. **Abbreviations:** WA, Washington; OR, Oregon; ft³/s, cubic foot per second; -, not applicable]

Map index No.	Site No.	Site name	River mile			Annual mean streamflow (ft³/s)		Total nitrogen load (pounds per day, estimated)		
			Columbia River	Tributaries	Point source	Columbia River	Tributary inflowing	Columbia River	Tributary inflowing	Point source
86	**12400520**	**Columbia River at Northport, WA (reach 1)**	**735**	–	–	**106,000**	–	**75,700**	–	–
73	54A120	Spokane River at Riverside State Park	639	66	–	–	7,020	–	21,600	–
	WA0020281	*Town of Coulee Dam Wastewater Treatment Plant*	–	–	604	–	.31	–	–	24.7
77	**53A070**	**Columbia River at Grand Coulee (reach 2)**	**596**	–	–	**113,000**	–	**111,000**	–	–
	WA0021008	*Brewster Wastewater Treatment Plant*	–	–	530	–	.47	–	–	65.6
79	49A070	Okanogan River at Malott	532				2,930		2,780	
78	48A070	Methow River near Pateros	524	5			1,440		1,100	
69	46A070	Entiat River near Entiat					522		315	
64	45A070	Wenatchee River at Wenatchee	465	1			3,370		2,780	
	WA0023949	*Wenatchee Wastewater Treatment Plant*	–	–	465	–	5.12	–	–	1,040
	WA0020621	*East Wenatchee Douglas County Wastewater Treatment Plant*	–	–	464	–	2.02	–	–	161
	WA0002976	*K.B. Alloys, Inc.*	–	–	463	–	.47	–	–	21.3
	WA0000680	*Alcoa, Inc. Wenatchee Works*	–	–	462	–	1.70	–	–	78.1
51	**12472900**	**Columbia River at Vernita Bridge near Priest Rapids Dam, WA (reach 3)**	**388**	–	–	**120,000**	–	**144,000**	–	–
49	12510500	Yakima River at Kiona, WA	335	30	–	–	3,770	–	21,000	–
	WA0020419	*Richland Wastewater Treatment Plant*	–	–	337	–	9.52	–	–	936
	WA0044784	*Kennewick Wastewater Treatment Plant*	–	–	328	–	7.90	–	–	1,460
	WA0044962	*Pasco Wastewater Treatment Plant*	–	–	328	–	4.18	–	–	500
	WA0003671	*Agrium US, Inc. Bowles Road*	–	–	322	–	38.8	–	–	918
	WA0003727	*Agrium US, Inc. Game Farm*	–	–	322	–	101	–	–	2,390
	WA0003697	*Boise Cascade Wallula*	–	–	312	–	46.7	–	–	352
47	13353200	Snake River at Burbank, WA	324	9	–	–	46,600	–	171,000	–
46	32A070	Walla Walla River near Touchet	315	5	–	–	572	–	2,430	–
43	11489	Umatilla River at Westland Road (Hermiston)	289	9	–	–	545	–	3,980	–
26	11386	John Day River at Hwy 206	216	40	–	–	1,770	–	NA	–
	WA0000540	*Columbia Gorge Aluminum Company*	–	–	208	–	5.74	–	–	263
39	10411	Deschutes River at Deschutes River Park	205	1	–	–	6,450	–	10,600	–
	OR0001708	*Northwest Aluminum Co.*	–	–	190	–	10.40	–	–	473
	OR0020885	*City of The Dalles Wastewater Treatment Plant*	–	–	190	–	3.88	–	–	309
	WA0022373	*Bingen Wastewater Treatment Plant*	–	–	169	–	2.79	–	–	223
	OR0020788	*City of Hood River Wastewater Treatment Plant*	–	–	169	–	1.80	–	–	143
38	**14128910**	**Columbia River at Warrendale, OR (reach 4)**	**143**	–	–	**185,000**	—	**424,000**	–	–
	WA0037427	*Washougal Wastewater Treatment Plant*	–	–	122	–	2.02	–	–	161
	WA0000256	*Fort James Camas L.L.C.*	–	–	121	–	47.6	–	–	359
	WA0020249	*City of Camas Wastewater Treatment Plant*	–	–	118	–	21.7	–	–	1,730
	OR0000060	*Reynolds Metals Co.*	–	–	119	–	4.57	–	–	209
	OR0026131	*City of Gresham Wastewater Treatment Plant*	–	–	118	–	18.1	–	–	2,890
	WA0000264	*Boise Cascade Vancouver*	–	–	106	–	5.42	–	–	40.9
	OR0026905	*City of Portland Wastewater Treatment Plant*	–	–	106	–	109	–	–	13,400
	WA0024350	*Vancouver West Wastewater Treatment Plant*	–	–	105	–	19.2	–	–	1,730

Table 8. Annual mean discharge of total nitrogen, total phosphorus, and suspended sediment loads in the Columbia River, monitored Columbia River tributaries, and point sources discharging directly to the Columbia River, Oregon and Washington, water year 2000.—Continued

[**Bold** type indicates start of reach (see figure 12); shaded rows indicate monitoring site (see table 1); *italicized* type indicates point-source discharge source. **Abbreviations:** WA, Washington; OR, Oregon; ft^3/s, cubic foot per second; –, not applicable]

Map index No.	Site No.	Site Name	Total phosphorus load (pounds per day, estimated)			Suspended sediment load (tons per day, estimated)		
			Columbia River	Tributary inflowing	Point source	Columbia River	Tributary inflowing	Point source
86	**12400520**	**Columbia River at Northport, WA (reach 1)**	**3,140**	**–**	**–**	**928**	**–**	**–**
73	54A120	Spokane River at Riverside State Park	–	1,870	–	–	201	–
	WA0020281	*Town of Coulee Dam Wastewater Treatment Plant*	–	–	5.83	–	–	–
77	**53A070**	**Columbia River at Grand Coulee (reach 2)**	**9,880**	**–**	**–**	**393**	**–**	**–**
	WA0021008	*Brewster Wastewater Treatment Plant*	–	–	8.74	–	–	–
79	49A070	Okanogan River at Malott	–	659	–	–	242	–
78	48A070	Methow River near Pateros	–	166	–	–	32.9	–
69	46A070	Entiat River near Entiat	–	74	–	–	18.1	–
64	45A070	Wenatchee River at Wenatchee	–	420	–	–	127	–
	WA0023949	*Wenatchee Wastewater Treatment Plant*	–	–	96.2	–	–	–
	WA0020621	*East Wenatchee Douglas County Wastewater Treatment Plant*	–	–	37.9	–	–	–
	WA0002976	*K.B. Alloys, Inc.*	–	–	–	–	–	–
	WA0000680	*Alcoa, Inc. Wenatchee Works*	–	–	–	–	–	–
51	**12472900**	**Columbia River at Vernita Bridge near Priest Rapids Dam, WA (reach 3)**	**8,220**	**–**	**–**	**906**	**–**	**–**
49	12510500	Yakima River at Kiona, WA	–	2,630	–	–	468	–
	WA0020419	*Richland Wastewater Treatment Plant*	–	–	179	–	–	–
	WA0044784	*Kennewick Wastewater Treatment Plant*	–	–	149	–	–	–
	WA0044962	*Pasco Wastewater Treatment Plant*	–	–	78.7	–	–	–
	WA0003671	*Agrium US, Inc. Bowles Road*	–	–	37.6	–	–	–
	WA0003727	*Agrium US, Inc. Game Farm*	–	–	97.7	–	–	–
	WA0003697	*Boise Cascade Wallula*	–	–	160	–	–	–
47	13353200	Snake River at Burbank, WA	–	13,300	–	–	1,220	–
46	32A070	Walla Walla River near Touchet	–	499	–	–	162	–
43	11489	Umatilla River at Westland Road (Hermiston)	–	379	–	–	70.2	–
26	11386	John Day River at Hwy 206	–	808	–	–	120	–
	WA0000540	*Columbia Gorge Aluminum Company*						–
39	10411	Deschutes River at Deschutes River Park	–	3,170	–	–	192	–
	OR0001708	*Northwest Aluminum Co.*	–	–	–	–	–	–
	OR0020885	*City of The Dalles Wastewater Treatment Plant*	–	–	72.9	–	–	–
	WA0022373	*Bingen Wastewater Treatment Plant*	–	–	52.5	–	–	–
	OR0020788	*City of Hood River Waste Water Treatment Plant*	–	–	33.8	–	–	–
38	**14128910**	**Columbia River at Warrendale, OR (reach 4)**	**30,400**	**–**	**–**	**3,560**	**–**	**–**
	WA0037427	*Washougal Wastewater Treatment Plant*	–	–	37.9	–	–	–
	WA0000256	*Fort James Camas L.L.C.*	–	–	163	–	–	–
	WA0020249	*City of Camas Wastewater Treatment Plant*	–	–	408	–	–	–
	OR0000060	*Reynolds Metals Co.*	–	–	–	–	–	–
	OR0026131	*City of Gresham Wastewater Treatment Plant*	–	–	184	–	–	–
	WA0000264	*Boise Cascade Vancouver*	–	–	18.6	–	–	–
	OR0026905	*City of Portland Wastewater Treatment Plant*	–	–	1,590	–	–	–
	WA0024350	*Vancouver West Wastewater Treatment Plant*	–	–	361	–	–	–

Table 8. Annual mean discharge of total nitrogen, total phosphorus, and suspended sediment loads in the Columbia River, monitored Columbia River tributaries, and point sources discharging directly to the Columbia River, Oregon and Washington, water year 2000.—Continued

[**Bold** type indicates start of reach (see figure 12); shaded rows indicate monitoring site (see table 1); *italicized* type indicates point-source discharge source. **Abbreviations:** WA, Washington; OR, Oregon; ft³/s, cubic foot per second; –, not applicable]

Map index No.	Site No.	Site name	River mile			Annual mean streamflow (ft³/s)		Total nitrogen load (pounds per day, estimated)		
			Columbia River	Tributaries	Point source	Columbia River	Tributary inflowing	Columbia River	Tributary inflowing	Point source
40	**10616**	**Columbia River at Marker #47 (upstream of Willamette River) (reach 5)**	**102**	**–**	**–**	**185,000**	**–**	**455,000**	**–**	**–**
37	10332	Willamette River at SP&S Railroad Bridge	101	7	–	–	35,100	–	157,000	–
31	10611	Willamette River at Hawthorne Bridge	101	13	–	–	35,100	–	152,000	–
33	14211720	Willamette River at Portland, OR	101	13	–	–	35,100	–	160,000	–
	WA0000299	*Evergreen Aluminum L.L.C.*	–	–	100	–	1.40	–	–	63.9
	WA0023639	*Salmon Creek Wastewater Treatment Plant*	–	–	95	–	8.68	–	–	734
	OR0020834	*City of Saint Helens Wastewater Treatment Plant*	–	–	86	–	41.5	–	–	3,310
	OR0001635	*Dyno Nobel, Inc.*	–	–	84	–	.12	–	–	2.94
	WA0000353	*Chemtrade Performance Chemical*	–	–	75	–	4.65	–	–	47.6
	WA0000078	*Longview Fibre Longview*	–	–	59	–	39.2	–	–	296
	WA0000086	*Chinook Ventures, Inc. Longview*	–	–	58	–	5.42	–	–	248
	WA0000124	*Weyerhaeuser Longview*	–	–	58	–	24.0	–	–	181
	WA0037311	*Longview Wastewater Treatment Plant*	–	–	56	–	7.75	–	–	618
44	**14246900**	**Columbia River at Beaver Army Terminal near Quincy, OR**	**54**	**–**	**–**	**232,000**	**–**	**572,000**	**–**	**–**

Map index No.	Site No.	Site Name	Total phosphorus load (pounds per day, estimated)			Suspended sediment load (tons per day, estimated)		
			Columbia River	Tributary inflowing	Point source	Columbia River	Tributary inflowing	Point source
40	**10616**	**Columbia River at Marker #47 (upstream of Willamette River) (reach 5)**	**43,800**	**–**	**–**	**4,800**	**–**	**–**
37	10332	Willamette River at SP&S Railroad Bridge	–	18,100	–	–	1,440	–
31	10611	Willamette River at Hawthorne Bridge	–	16,500	–	–	1,340	–
33	14211720	Willamette River at Portland, OR	–	16,300	–	–	2,780	–
	WA0000299	*Evergreen Aluminum L.L.C.*	–	–	–	–	–	–
	WA0023639	*Salmon Creek Wastewater Treatment Plant*	–	–	163	–	–	–
	OR0020834	*City of Saint Helens Wastewater Treatment Plant*	–	–	781	–	–	–
	OR0001635	*Dyno Nobel, Inc.*	–	–	–	–	–	–
	WA0000353	*Chemtrade Performance Chemical*	–	–	5.26	–	–	–
	WA0000078	*Longview Fibre Longview*	–	–	135	–	–	–
	WA0000086	*Chinook Ventures, Inc. Longview*	–	–	–	–	–	–
	WA0000124	*Weyerhaeuser Longview*	–	–	82.4	–	–	–
	WA0037311	*Longview Wastewater Treatment Plant*	–	–	146	–	–	–
44	**14246900**	**Columbia River at Beaver Army Terminal near Quincy, OR**	**54,600**	**–**	**–**	**14,600**	**–**	**–**

Point-source contributions of TN and TP in this reach, however, were negligible. The SS discharged at Northport decreased by more than 40 percent in reach 1 to downstream of Grand Coulee, likely the result of sediment deposition in the backwater impoundment behind Grand Coulee (Lake Roosevelt) and irrigation diversions (table 8 and fig. 14). The discharges in reach 2 increased for TN and SS, and decreased for TP (figs. 12, 13, and 14). Point-source discharges of TN and TP to the main stem in this reach were negligible.

Several large tributaries join the Columbia River in reach 3, which has a length of more than 200 river miles between Vernita Bridge and Warrendale. Most of these tributaries were monitored and, in aggregate, accounted for 91 percent of the gain in streamflow within the reach. The tributaries in reach 3 accounted for 74 percent of the TN discharged to the reach (excluding the John Day River), 92 percent of the TP, and 78 percent of the SS. These percentages can be viewed qualitatively by comparing the relative heights of the paired bar graphs for reach 3 in figures 12, 13, and 14.

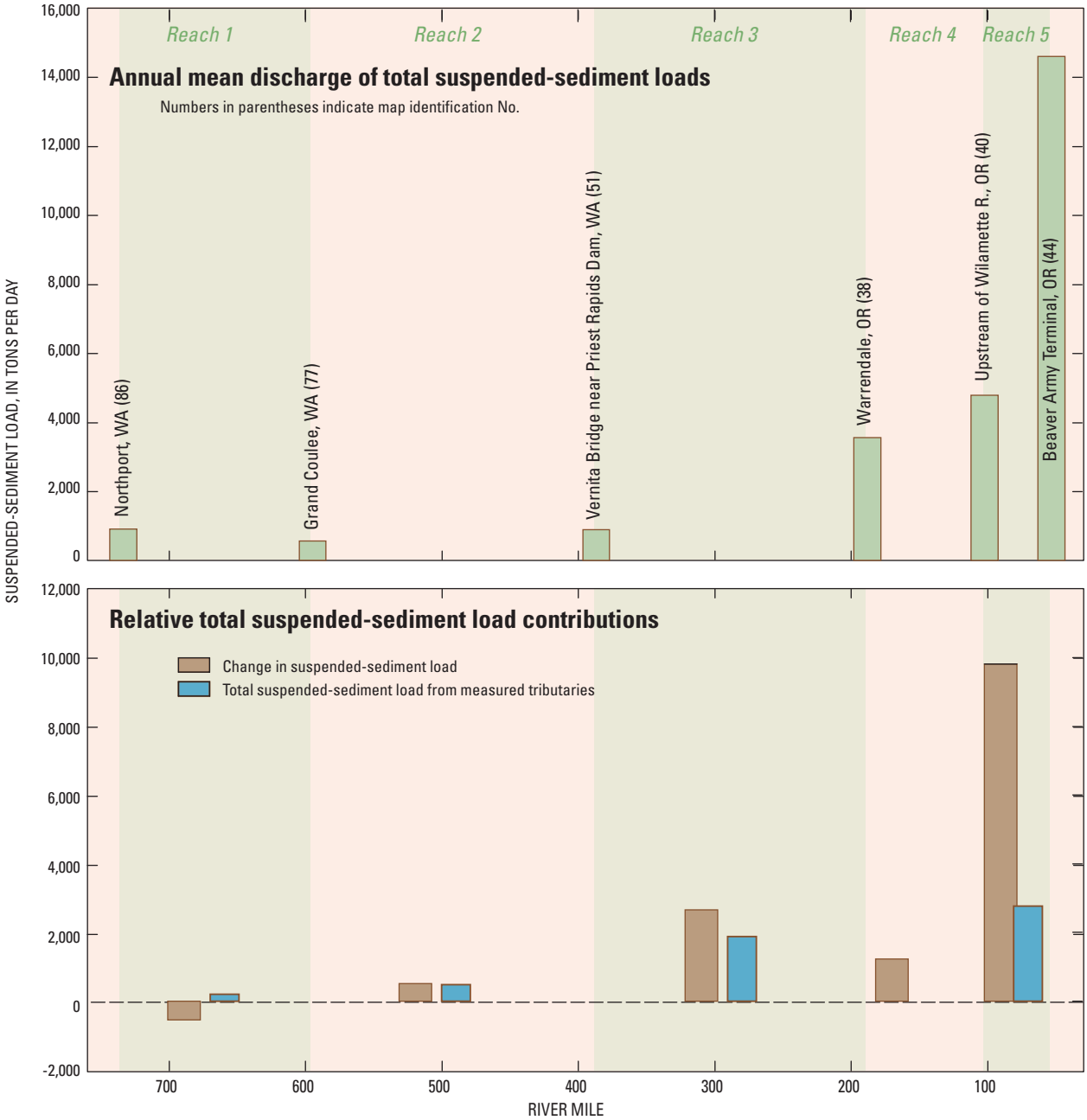


Figure 14. Annual mean discharge of suspended-sediment loads in the Columbia River and relative suspended-sediment load contributions from Columbia River monitored tributaries, Oregon and Washington, water year 2000. (Vertical scales on graphs are identical.)

The major monitored tributaries discharging to this reach are the Yakima River, the Snake River, and the Deschutes River (table 8). In aggregate, the contributions of these three tributaries accounted for at least 94 percent of the TN, TP, and SS discharged to reach 3 from all of the monitored tributaries, with the Snake River by far the largest (table 9). As with reaches 1 and 2, point-source discharges of TN and TP to the main stem were small by comparison.

Reach 4 was different from the other reaches in that it had only minor tributary inputs, the most notable being the Sandy River (which was not included in the analysis). Reach 4 is affected primarily by point-source contributions (table 8). This reach spans about 41 river miles between Warrendale (immediately downstream of Bonneville Dam) and Marker 47 (located upstream of the confluence of the Willamette and Columbia Rivers). Within this reach, the point-source discharge of TN represented most of the nitrogen gain (figure 12), whereas the relative contribution for TP was notable, but smaller (figure 13).

Reach 5 began at Marker 47 and ended at Beaver Army Terminal (river mile 53.8). The gain within the reach for both TN and TP was less than the discharge of TN and TP from the Willamette River (figures 12 and 13). Without some in-stream loss or storage (for example, biological uptake or settling), the discharge of nutrients from the Willamette River should not have contributed more than the total of the gain in nutrients in this reach, especially since the tributary discharges from the Cowlitz River, Kalama River, and the Lewis River were not included in the analysis. Aside from the possibility of in-stream loss or storage, a reason for the discrepancy between TN and TP load and gain in this reach is not apparent. The discharge of SS from the Willamette represented slightly less than one third of the SS gain within the reach. This was to be expected considering the SS inputs from the other tributaries in this reach (particularly the Cowlitz River).

Table 9. Relative discharge of total nitrogen, total phosphorus, and suspended sediment loads from three major tributaries to Columbia River between Vernita Bridge, Washington, and Warrendale, Oregon, water year 2000.

[Discharge expressed as a percentage of all measured tributary loads for the reach]

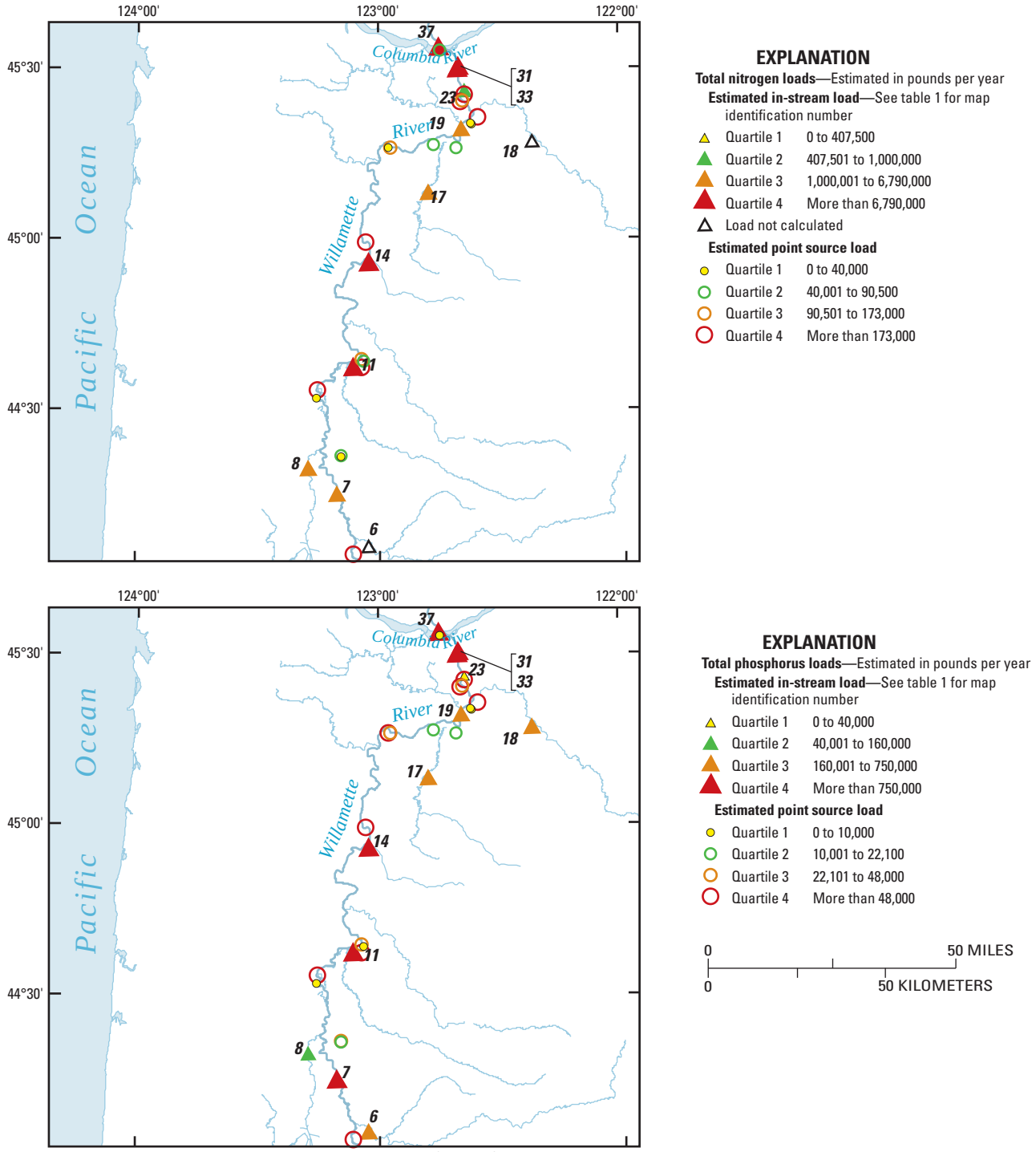
Discharge	Load (percentage)		
	Snake River	Yakima River	Deschutes River
Total nitrogen	82.8	10.2	5.10
Total phosphorus	65.5	13.0	15.6
Suspended sediment	82.8	10.2	5.10

Willamette River System

Four water-quality monitoring stations in Oregon were used to assess nutrient and sediment transport on the main stem of the Willamette River (fig. 15): Harrisburg, (RM 161, fig. 1, site 7), Albany (RM 119, fig. 1, site 11), Salem (RM 84, fig. 1, site 14), and Portland (RM 13, fig. 1, site 33). In addition, 6 water-quality stations on Willamette River tributaries and 20 point sources were used to assess nutrient and sediment load to the river.

The Willamette River discharged an annual mean load of 160,000 lb/d of TN (table 10), 16,300 lb/d of TP, and 2,780 ton/d of SS to the Columbia River in WY 2000 (on the basis of annual mean loads at Portland, Oreg.; fig. 1, site 33). These contributions represented discharges from all tributaries and point sources, ground-water systems, and the environmental processing of nutrients as Willamette waters flowed to the Columbia River. As was done with the main stem of the Columbia River, an accounting of streamflow gains was made for the reaches defined by the main-stem sites on the Willamette River (table 11). None of the reaches had tributaries that accounted for more than one-half the streamflow gain (table 11). Discharge of TN, TP, and SS increased steadily down the main stem, with the largest increase occurring in reach 3 between Salem and Portland (figs. 16, 17, and 18). Because they accounted for so little of the streamflow gain, the discharge of TN, TP, and SS from the six monitored tributaries to the Willamette River accounted for only a small part (within their respective reaches) of the gain in TN, TP, and SS in reaches 1 through 3 (figs. 16, 17, and 18).

Reach 1 spans a distance of 42 river miles and is bounded upstream by Harrisburg and downstream by Albany (fig. 17). About 10 river miles upstream from Harrisburg, the Willamette River receives point-source runoff from the Eugene/Springfield Water Pollution Control Facility and non-point source runoff from the McKenzie River. These two sources, with about equal annual TP loads, accounted for 59 percent of the annual mean TP load discharge at Harrisburg (table 10). Contributions of TN from the Eugene/Springfield WWTP represented 32 percent of the load at Harrisburg. In reach 1, the Willamette River receives urban runoff from Corvallis, as well as discharge from the Corvallis WWTP. It also receives nonpoint-source runoff from the Long Tom River, in addition to the Calapooya River and Mary’s River (the latter two of which were not included in the analysis).



Basemap modified from U.S. Geological Survey digital data, 1983 (1:100,000).
Lambert Conformal Conic projection
Standard parallels 43°N and 45°N, central meridian 120°30' W

Figure 15. Locations of sampling sites in the Willamette River and its tributaries, and selected point sources discharging directly to the Willamette River, Oregon, water year 2000.

Table 10. Mean annual discharge of total nitrogen, total phosphorus, and suspended sediment loads in the Willamette River, monitored Willamette River tributaries, and point sources discharging directly to the Willamette River, Oregon, water year 2000.

[**Bold** type indicates start of reach (see figure 16); shaded rows indicate monitoring site (see table 1); *italicized* type indicates point-source discharge source. **Abbreviations:** WA, Washington; OR, Oregon; ft3/s, cubic foot per second; –, not applicable]

Map index No.	Site No.	Site name	River mile			Annual mean streamflow (ft^3/s)		Total nitrogen load (pounds per day, estimated)		
			Willamette River	Tributaries	Point source	Willamette River	Tributary inflowing	Willamette River	Tributary inflowing	Point source
	OR0020559	*City of Cottage Grove Wastewater Treatment Plant*	–	–	187	–	2.87	–	–	160
	OR0031224	*Eugene/Springfield Water Pollution Control Facility*	–	–	172	–	62.6	–	–	4,980
6	10376	McKenzie River at Coburg Road	–	172	–	–	5,070	–	–	–
7	**10355**	**Willamette River at Hwy 99E (Harrisburg) (reach 1)**	**161**	**–**	**–**	**11,300**	**–**	**15,800**	**–**	**–**
	OR0033405	*Fort James Operating Co.*	–	–	148	–	5.12	–	–	38.6
	OR0001074	*Pope & Talbot, Inc.*	–	–	147	–	17.6	–	–	133
8	11140	Long Tom River at Stow Pit Road (Monroe)	–	146		–	743	–	3,040	
	OR0000299	*Evanite Fiber Corp.*	–	–	20	–	1.02	–	–	33.8
	OR0026361	*City of Corvallis Wastewater Treatment Plant*	–	–	20	–	16.4	–	–	602
11	**10350**	**Willamette River at Albany (Eastbound Hwy 20 Bridge) (reach 2)**	**119**	**–**	**–**	**14,200**	**–**	**38,100**	**–**	**–**
	OR0028801	*City of Albany Wastewater Treatment Plant*	–	–	117	–	12.2	–	–	580
	OR0000442	*Weyerhaeuser Co.*	–	–	116	–	8.06	–	–	319
	OR0001112	*Tdy Industries, Inc.*	–	–	116	–	3.21	–	–	148
14	**10555**	**Willamette River at Marion Street (Salem) (reach 3)**	**84**	**–**		**23,700**	**–**	**65,900**	**–**	**–**
	OR0026409	*City of Salem Wastewater Treatment Plant*	–	–	83	–	64.6	–	–	5,920
	OR0032352	*City of Newberg Wastewater Treatment Plant*	–	–	–	–	4.34	–	–	346
	OR0000558	*SP Newsprint*	–	–	–	–	10.1	–	–	76.0
17	10640	Pudding River at Hwy 211 (Woodburn)	–	36	–	–	825	–	11,700	–
	OR0022764	*Wilsonville, City of*	–	–	–	–	2.99	–	–	154
	OR0020214	*Canby City Wastewater Treatment Plant*	–	–	34	–	1.60	–	–	127
19	3701002	Tualatin River at Weiss Bridge	–	28	–	–	1,410	–	16,600	–
	OR0000566	*Blue Heron Paper Co.*	–	–	28	–	4.57	–	–	58.0
	OR0000787	*West Linn Paper Co.*	–	–	28	–	4.57	–	–	34.5
	OR0031259	*Tri-City Service District*	–	–	25	–	12.6	–	–	994
18	13070	Clackamas River at Mciver Park (upper boat ramp)	–	25		–	2,830	–	–	–
	OR0026891	*Tryon Creek Wastewater Treatment Plant*	–	–	20	–	12.80	–		1,200
	OR0026221	*Kellogg Creek Wastewater Treatment Plant*	–	–	19	–	12.60	–		1,000
23	11321	Johnson Creek at SE 17th Avenue (Portland)	–	18	–	–	69	–	1,300	–
31	**10611**	**Willamette River at Hawthorne Bridge**	**13**	**–**	**–**	**35,100**	**–**	**152,000**	**–**	**–**
33	**14211720**	**Willamette River at Portland, OR**	**13**	**–**	**–**	**35,100**	**–**	**160,000**	**–**	**–**
	OR0001597	*Atofina Chemicals, Inc.*	–	–	7		12.5		–	128
37	**10332**	**Willamette River at SP&S Railroad Bridge**	**7**	**—**	**–**	**35,100**	**–**	**157,000**	**–**	**–**

Table 10. Mean annual discharge of total nitrogen, total phosphorus, and suspended sediment loads in the Willamette River, monitored Willamette River tributaries, and point sources discharging directly to the Willamette River, water year 2000.—Continued

[**Bold** type indicates start of reach (see figure 16); shaded rows indicate monitoring site (see table 1); *italicized* type indicates point-source discharge source. **Abbreviations:** WA, Washington; OR, Oregon; ft3/s, cubic foot per second; -, not applicable]

Map index No.	Site No.	Site name	Total phosphorus load (pounds per day, estimated)			Suspended sediment load (tons per day, estimated)		
			Willamette River	Tributary inflowing	Point source	Willamette River	Tributary inflowing	Point source
	OR0020559	*City of Cottage Grove Wastewater Treatment Plant*	–	–	53.9	–	–	–
	OR0031224	*Eugene/Springfield Water Pollution Control Facility*	–	–	1,130	–	–	–
6	10376	Mckenzie River at Coburg Road	–	1,200	–	–	88.1	–
7	**10355**	**Willamette River at Hwy 99E (Harrisburg) (reach 1)**	**3,980**	**–**	**–**	**227**	**–**	**–**
	OR0033405	*Fort James Operating Co.*	–	–	28.1	–	–	–
	OR0001074	*Pope & Talbot, Inc.*	–	–	60.4	–	–	–
8	11140	Long Tom River at Stow Pit Road (Monroe)	–	337	–	–	60.3	–
	OR0000299	*Evanite Fiber Corp.*	–	–	3.51	–	–	–
	OR0026361	*City Of Corvallis Wastewater Treatment Plant*	–	–	1,650	–	–	–
11	**10350**	**Willamette River at Albany (Eastbound Hwy. 20 Bridge) (reach 2)**	**6,140**	**–**	**–**	**521**	**–**	**–**
	OR0028801	*City of Albany Wastewater Treatment Plant*	–	–	237	–	–	–
	OR0000442	*Weyerhaeuser Co.*	–	–	68.2	–	–	–
	OR0001112	*Tdy Industries, Inc.*	–	–	–	–	–	–
14	**10555**	**Willamette River at Marion Street (Salem) (reach 3)**	**9,360**	**–**	**–**	**1,050**	**–**	**–**
	OR0026409	*City of Salem Wastewater Treatment Plant*	–	–	1,220	–	–	–
	OR0032352	*City of Newberg Wastewater Treatment Plant*	–	–	81.6	–	–	–
	OR0000558	*Sp Newsprint*	–	–	701	–	–	–
17	10640	Pudding River at Hwy. 211 (Woodburn)	–	575	–	–	27.5	–
	OR0022764	*Wilsonville, City of*	–	–	31.1	–	–	–
	OR0020214	*Canby City Wastewater Treatment Plant*	–	–	30.0	–	–	–
19	3701002	Tualatin River at Weiss Bridge	–	1,160		–	–	–
	OR0000566	*Blue Heron Paper Co.*	–	–	27.0	–	–	–
	OR0000787	*West Linn Paper Co.*	–	–	15.7	–	–	–
	OR0031259	*Tri-City Service District*	–	–	236	–	–	–
18	13070	Clackamas River At Mciver Park (upper boat ramp)	–	450		–	264	
	OR0026891	*Tryon Creek Wastewater Treatment Plant*	–	–	143	–	–	–
	OR0026221	*Kellogg Creek Wastewater Treatment Plant*	–	–	236	–	–	–
23	11321	Johnson Creek at SE 17th Avenue (Portland)	–	47	–	–	3.74	–
31	**10611**	**Willamette River at Hawthorne Bridge**	**16,500**	**–**	**–**	**1,340**	**–**	**–**
33	**14211720**	**Willamette River at Portland, OR**	**16,300**	**–**		**2,780**	**–**	
	OR0001597	*Atofina Chemicals, Inc.*		–	14.1		–	–
37	**10332**	**Willamette River at SP&S Railroad Bridge**	**18,100**	**–**	**–**	**1,440**	**–**	**–**

Table 11. Accounting for annual mean streamflow in the Willamette River, Oregon, water year 2000.

[**Abbreviation:** ft^3/s, cubic foot per second]

Map index No.	Main-stem site name and reach	Reach	River mile	Annual mean streamflow (ft^3/s)	Gain in reach (ft^3/s)	Sum of measured annual mean tributary inflows (ft^3/s)	Measured tributary inflows as percentage of main-stem gain
7	Harrisburg		161	11,300			
		1			2,820	743	26.3
11	Albany		119	14,200			
		2			9,590	0	0
14	Salem		84	23,700			
		3			11,300	5,130	45.4
33	Portland		13	35,100			

The annual load of TP discharged to the Willamette River from the City of Corvallis' WWTP represented 27 percent of annual mean load in the Willamette River at Albany (about 5 times the annual mean load discharged from the Long Tom River), and 80 percent of the increase in TP annual mean load between Harrisburg and Albany. However, the annual TN load from the city's WWTP was less than 2 percent of the annual mean load in this reach. Although tributary inflow increased streamflow by only 25 percent in the reach from Harrisburg to Albany, the tributaries, nonpoint-source runoff, and point source discharges were responsible for increasing the annual mean TN load by nearly 140 percent, increasing the annual mean TP load by about 11 percent, and increasing the annual mean SS load by 130 percent.

Reach 2 covered the 35 river miles between Albany and Salem, where annual mean streamflow increased by nearly 10,000 ft^3/s owing to inputs from the Luckiamute River, the Santiam River, and several smaller streams (none were included in the analysis). Within reach 2, TN and TP from point sources discharging directly to the Willamette River were small and negligible in comparison to tributary discharges of TN and TP (table 10, fig. 16 and 17). Therefore, discharges from the Luckiamute River and the Santiam River, although not measured directly, were likely important sources of nutrients and SS to the Willamette.

In the more than 70 river miles from Salem to Portland (reach 3), the Willamette River receives discharges from point sources resulting from high-density urbanization in Portland and the surrounding metropolitan areas, as well as Salem. This reach also is affected by nonpoint sources, principally agricultural runoff. Annual mean streamflow in reach 3 increased by 11,300 ft^3/s. About 45 percent of this increase was from monitored tributaries. This reach also received tributary inputs from the Yamhill and Molalla Rivers (not included in the analysis), Pudding, Tualatin, and Clackamas Rivers, in addition to several small creeks. In this reach, monitored tributaries and point sources accounted for nearly one-half the 85,600 lb/d gain of annual mean TN load and about 70 percent of the 7,000 pounds per day gain in annual mean TP load. The largest annual mean loads of TN were from the Tualatin River (16,600 lb/d) and the Pudding River (11,700 lb/d). Annual mean point-source loads within this reach (which did not include the City of Portland's main WWTP) equaled almost 10,000 lb/d of TN. The largest point-source annual mean load of TN was 5,900 lb/d from the City of Salem's WWTP. Of the tributaries with estimated SS loads, the Clackamas River was the largest monitored tributary in the entire Willamette basin. However, the estimated load from the Clackamas River may have been biased low because of interagency differences in field sampling protocols. Annual mean point-source loads within the reach equaled about 2,700 lb/d of TP.

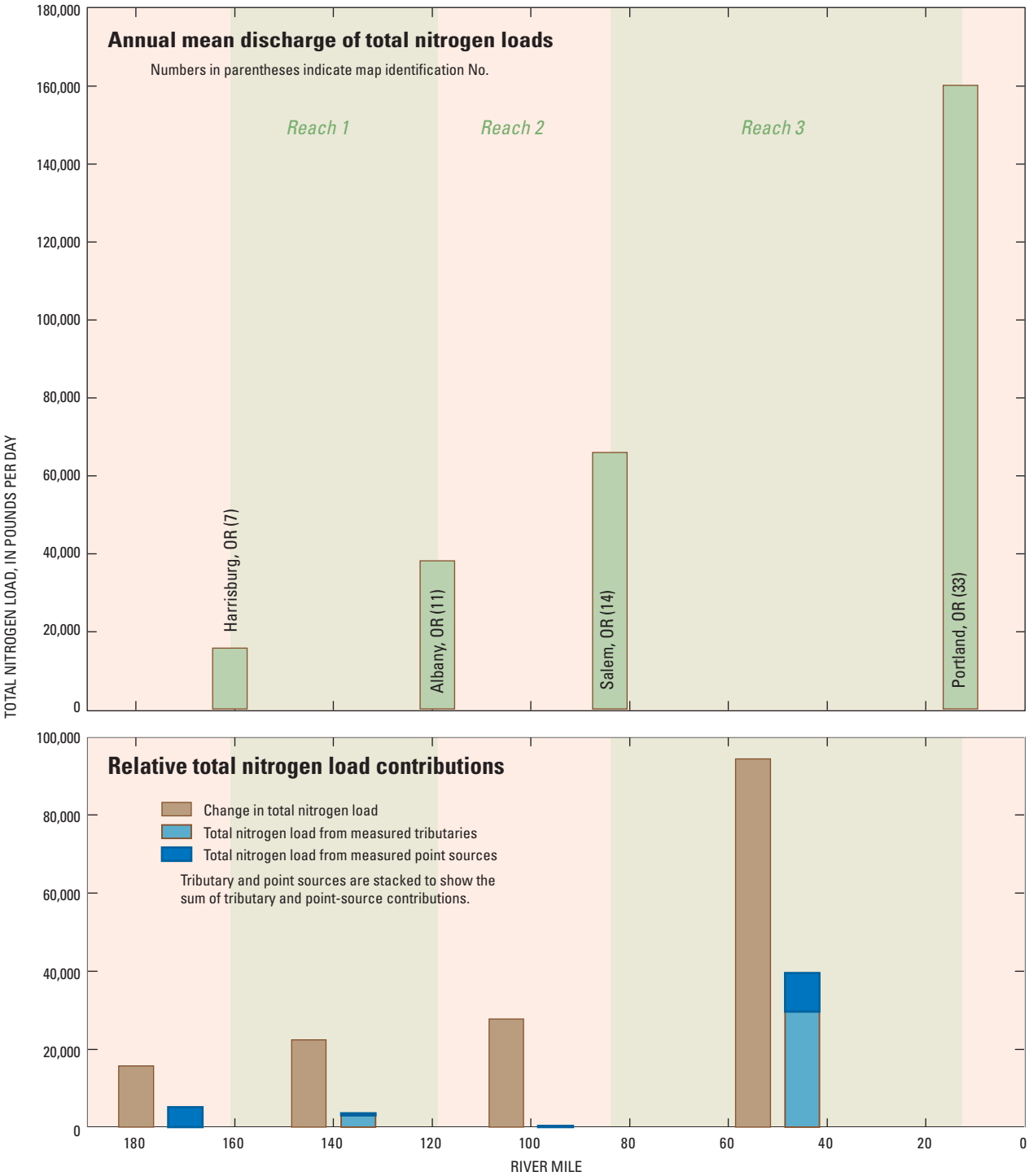


Figure 16. Annual mean discharge of total nitrogen loads in the Willamette River and relative total nitrogen load contributions from Willamette River monitored tributaries and point sources, Oregon, water year 2000. (Vertical scales on graphs are identical.)

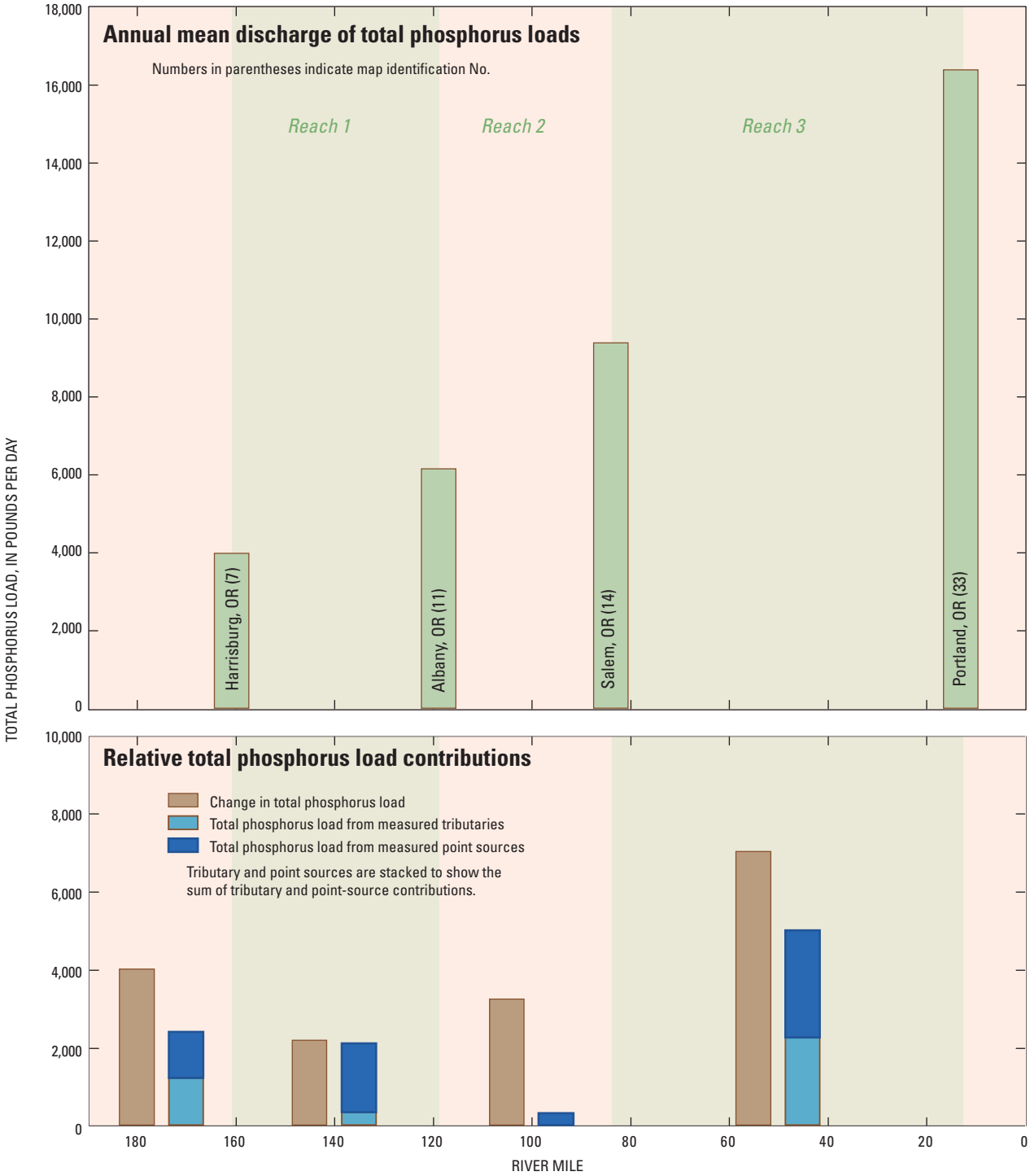


Figure 17. Annual mean discharge of total phosphorus loads in the Willamette River and relative total phosphorus contributions from Willamette River monitored tributaries and point sources, Oregon, water year 2000. (Vertical scales on graphs are identical.)

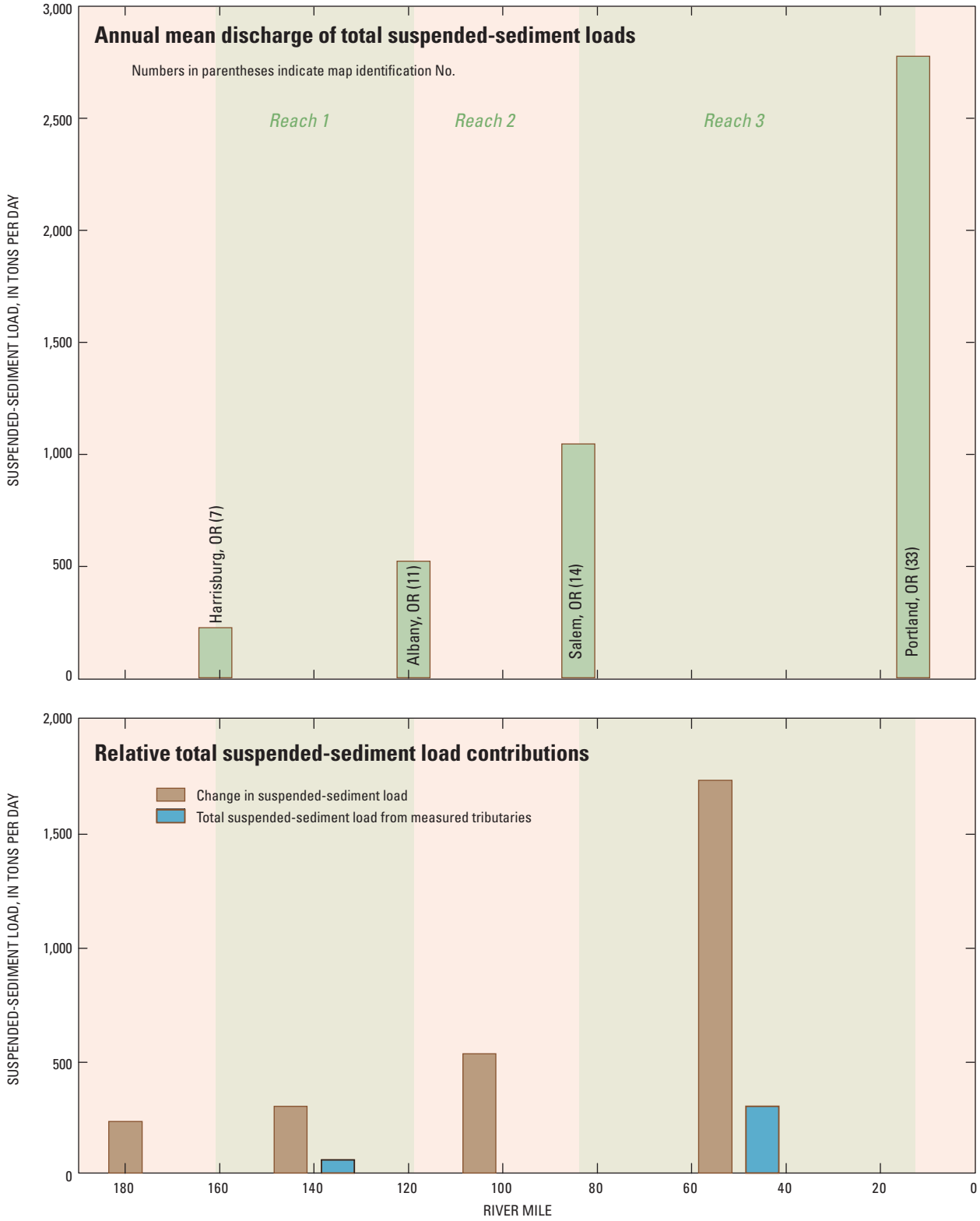


Figure 18. Annual mean discharge of suspended-sediment loads in the Willamette River and relative suspended-sediment load contributions from Willamette River monitored tributaries, Oregon, water year 2000. (Vertical scales on graphs are identical.)

Snake River System

The Snake River travels more than 1,000 river miles from its headwaters and drains parts of Oregon, Washington, Idaho, and Wyoming. Its drainage basin represents about 42 percent of the Columbia Basin's drainage area. The uppermost site for load estimation was the Snake River at Flagg Ranch, WY. (RM 1,050, fig. 1, site 100); the lowermost site was the Snake River at Burbank, WA (RM 8.7, fig. 1, site 47). Two intermediate sites were at Snake River at Buhl, ID (RM 597, fig. 1, site 90) and Snake River at King Hill, ID (RM 546, fig. 1, site 91) [fig. 19].

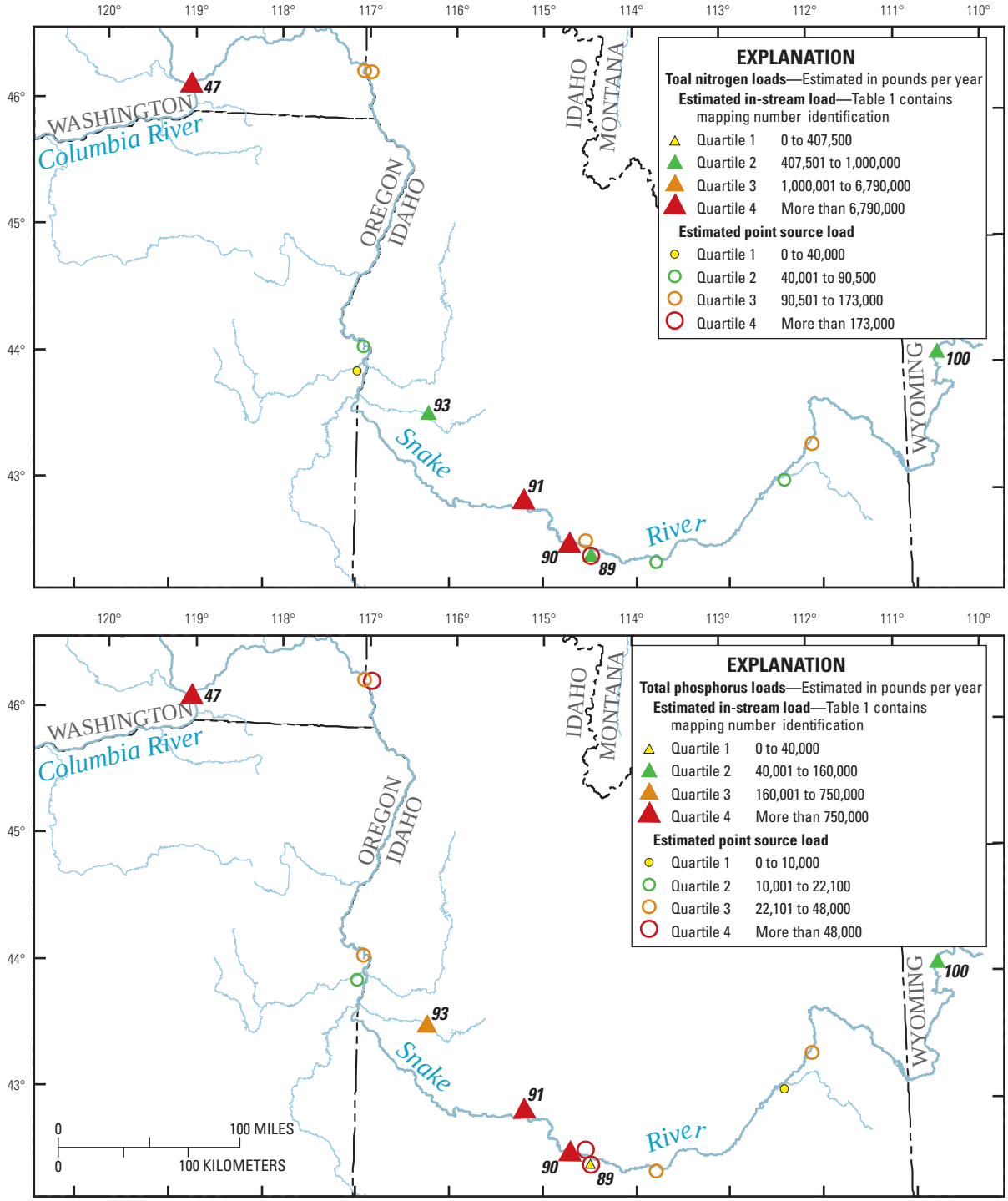
The Snake River was a major source of nutrients and sediment to the Columbia River, discharging an annual mean load of 171,000 lb/d of TN, 13,300 lb/d of TP, and 1,220 ton/d of SS (table 12). Characterizing nutrient and sediment deliveries from tributaries to the Snake River was difficult because only 2 of the 32 major Snake River tributaries met the screening criteria for estimating loads. Although water-quality records were available for several tributaries, most water-quality data were only seasonal instead of the required coverage throughout the water year. The annual mean load of TN, TP, and SS increased 151 fold, 50 fold, and 9 fold, respectively, from the headwaters at Flagg Ranch to the mouth (fig. 20). In reach 2, between Buhl and King Hill, a distance of 51 mi, streamflow and TN discharge nearly doubled, TP increased by slightly more than one-third, and SS remained essentially unchanged. The Snake River between Buhl and King Hill received a large amount of nutrient-rich and sediment-free ground-water discharge, in addition to some phosphorus discharges from aquaculture activities. These sources could explain the patterns in streamflow, nutrients, and sediment observed in this reach.

Puget Sound Basin

Nutrient and sediment delivery to Puget Sound was assessed by using water-quality monitoring stations near the mouths of 8 major tributaries and estimated nutrient loads from 28 point sources. Figure 21 shows the location of water-quality stations on 8 major tributaries to the Sound and the 2 point sources that discharge directly to those tributaries (but not directly to the Sound). The water-quality stations were on the Duckabush River near Brinnon, Wash. (fig. 1, site 71), the Skokomish River near Potlatch, Wash. (fig. 1, site 61), the Deschutes River at East Street Bridge, Wash. (fig. 1, site 56), the Puyallup River at Meridan Street, Wash. (fig. 1, site 57), the Duwamish River at Golf course at Tukwilla, Wash. (fig. 1, site 67), the Snohomish River at Snohomish, Wash. (fig. 1, site 76), the Skagit River near Mount Vernon, Wash. (fig. 1, site 81), and the Nooksack River at Brennan, Wash. (fig. 1, site 84). The areas draining to these eight tributaries account for about 50 percent of the surface area of the Puget Sound basin. A study by Embrey and Inkpen (1998) determined that these tributaries delivered 65 percent of the surface-water inflow and accounted for about 75 percent of the inorganic nitrogen (nitrite plus nitrate nitrogen and ammonia nitrogen) and TP loads to the Puget Sound. In WY 2000, the total discharge of these tributaries to Puget Sound equaled 61,000 lb/d of TN, 13,000 lb/d of TP, and 11,500 ton/d of SS (fig. 22).

Figure 22 shows the WY 2000 monitored tributary and estimated point-source loads of TN, TP, and SS discharged to the Puget Sound. The contribution of nutrients to the eight monitored tributaries from point sources located within their catchments was very small (six tributaries had no direct point-source contributions and the estimated point-source contribution to the other two tributaries was never more than 6 percent of the predicted in-stream load for WY 2000). However, the sum of the nutrient loads from point sources discharging either directly to the Puget Sound or very close to the mouths of tributaries was comparable to the sum of the monitored tributary loads. Point sources contributed almost 50 percent of the annual TN and TP load discharged to the Sound in WY 2000, with WWTPs accounting for more than 90 percent of the point-source load. The largest tributary loads of TN in WY 2000 were from the Snohomish River and the Skagit River. Together, they accounted for about 57 percent of the total monitored tributary TN load to the Sound. With the addition of the TN load from the Nooksack River, the contribution increased to 77 percent of the total TN load. The Skagit River was the single largest tributary contributor to the Sound for TP, accounting for more than 31 percent of the monitored tributary load. These tributaries are on the east side of the Sound, in areas where the intensity of urbanization and agricultural activity is greatest.

Monitored WY 2000 tributary nutrient loads to the Puget Sound were only a fraction of those discharged from the Columbia River. The TN and TP loads from all of the monitored Puget Sound tributaries were equal to about 11 percent and 24 percent of the TN and TP load, respectively, at the Columbia River at Beaver Army Terminal, Oreg. (fig. 1, site 44). The smaller loads are because Puget Sound's drainage area is only one-seventh of the Columbia River Basin and the sum of the mean streamflow for the eight monitored tributaries in WY 2000 was about 17 percent of the value in the Columbia River at Beaver Army Terminal. However, the total annual mean SS load discharged from all monitored tributaries to the sound (fig. 22) represented about three-quarters of the annual mean SS load discharged from the Columbia River.



Basemap modified from U.S. Geological Survey digital data, 1983 (1:100,000).
Lambert Conformal Conic projection
Standard parallels 43°N and 45°N, central meridian 120°30′ W

Figure 19. Locations of sampling sites in the Snake River and its tributaries, and selected point sources discharging directly to the Snake River, Washington, Oregon, Idaho, and Wyoming, water year 2000.

Table 12. Annual mean discharges of total nitrogen, total phosphorus, and suspended sediment loads in the Snake River, monitored Snake River tributaries, and point sources discharging directly to the Snake River, Wyoming, Idaho, and Washington, water year 2000.

[**Bold** type indicates start of reach (see figure 20); shaded rows indicate monitoring site (see table 1); *italicized* type indicates point-source discharge source. **Abbreviations:** ID, Idaho; WA, Washington; WY, Wyoming; ft³/s, cubic foot per second; –, not applicable]

Map index No.	Site No.	Site name	River mile location			Annual mean streamflow (ft³/s)		Total nitrogen (pounds per day, estimated)		
			Snake River	Tributaries	Point source	Snake River	Tributary inflowing	Snake River	Tributary inflowing	Point source
100	**13010065**	**Snake River at Flagg Ranch, WY (reach 1)**	**1,050**	**–**	**–**	**839**	**–**	**1,130**	**–**	**–**
	ID0021261	*Idaho Falls, City of*	–	–	798	–	15.20	–	–	265
	ID0020044	*Blackfoot, City of*	–	–	764	–	1.71	–	–	221
	ID0020095	*Burley, City of*	–	–	652	–	2.02	–	–	143
	ID0021270	*Twin Falls, City of*	–	–	608	–	11.9	–	–	1,670
	ID0020168	*Jerome, City of*	–	–	608	–	2.17	–	–	305
89	13092747	Rock Creek above Hwy 30/93 crossing at Twin Falls, ID	–	606	–	–	115	–	1,370	–
90	**13094000**	**Snake River near Buhl, ID (reach 2)**	**597**	**–**	**–**	**4,660**	**–**	**42,300**	**–**	**–**
91	**13154500**	**Snake River at King Hill, ID (reach 3)**	**546**	**–**	**–**	**9,990**	**–**	**82,200**	**–**	**–**
93	13206000	Boise River at Glenwood, ID	–	392	–	–	865	–	2,040	–
	OR0020621	*Ontario, City of*	–	–	372	–	3.04	–	–	123
	ID0020290	*Weiser, City of*	–	–	352	–	2.79	–	–	223
47	**13353200**	**Snake River at Burbank, WA (reach 4)**	**9**	**–**	**–**	**46,600**	**–**	**171,000**	**–**	**–**
	ID0001163	*Potlatch Corp.*	–	–	39	–	57.2	–	–	431
	WA0021113	*Clarkston Wastewater Treatment Plant*	–	–	38	–	4.03	–	–	322

Map index No.	Site No.	Site name	Total phosphorus (pounds per day, estimated)			Suspended sediment (tons per day, estimated)		
			Snake River	Tributary inflowing	Point source	Snake River	Tributary inflowing	Point source
100	**13010065**	**Snake River At Flagg Ranch, WY (reach 1)**	**266**	**–**	**–**	**137**	**–**	**–**
	ID0021261	*Idaho Falls, City of*	–	–	90.0	–	–	–
	ID0020044	*Blackfoot, City of*	–	–	35.5	–	–	–
	ID0020095	*Burley, City of*	–	–	83.1	–	–	–
	ID0021270	*Twin Falls, City of*	–	–	727	–	–	–
	ID0020168	*Jerome, City of*	–	–	229	–	–	–
89	13092747	Rock Creek above Hwy 30/93 crossing at Twin Falls, ID	–	55.1	–	–	17.6	–
90	**13094000**	**Snake River near Buhl, ID (reach 2)**	**2,690**	**–**	**–**	**362**	**–**	**–**
91	**13154500**	**Snake River at King Hill, ID (reach 3)**	**3,710**	**–**	**–**	**354**	**–**	**–**
93	13206000	Boise River at Glenwood, ID	–	458	–	–	22.1	–
	OR0020621	*Ontario, City of*	–	–	51.4	–	–	–
	ID0020290	*Weiser, City of*	–	–	60.9	–	–	–
47	**13353200**	**Snake River at Burbank, WA (reach 4)**	**13,300**	**–**	**–**	**1,220**	**–**	**–**
	ID0001163	*Potlatch Corp.*	–	–	231	–	–	–
	WA0021113	*Clarkston Wastewater Treatment Plant*	–	–	75.8	–	–	–

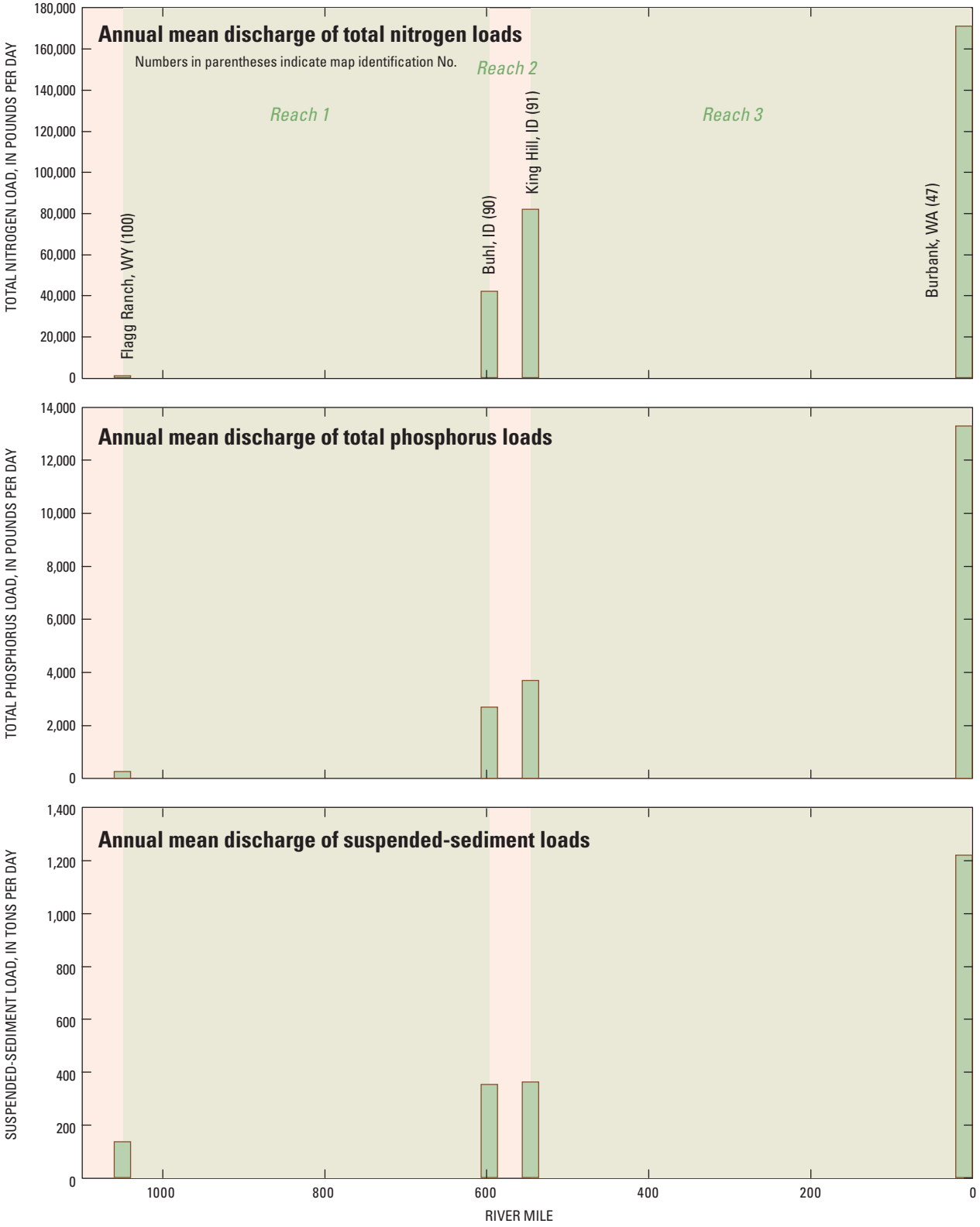
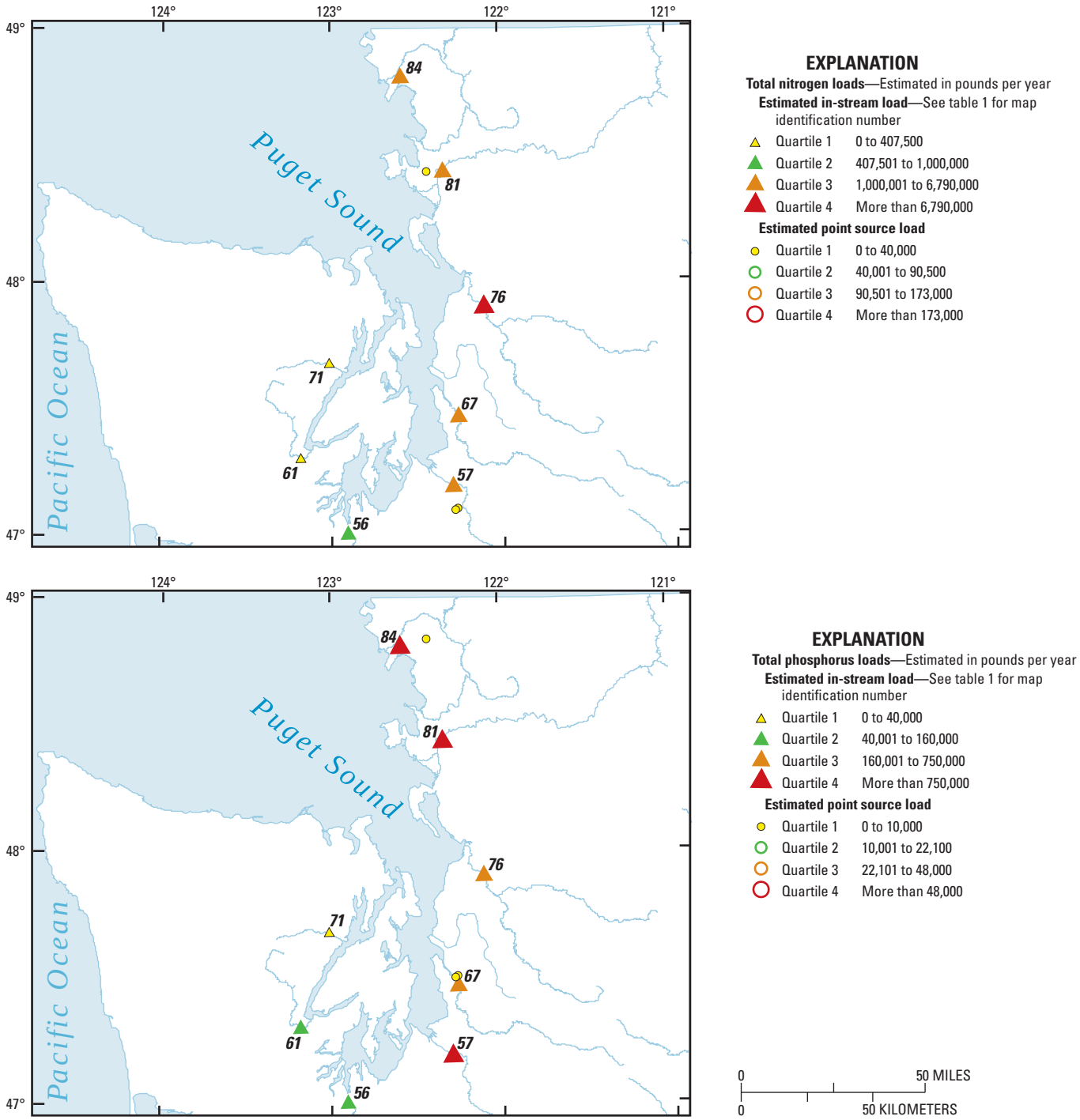


Figure 20. Annual mean discharge of total nitrogen, total phosphorus, and suspended sediment loads in the Snake River, Wyoming, Idaho, and Washington, water year 2000.



Basemap modified from U.S. Geological Survey digital data, 1983 (1:100,000).
Lambert Conformal Conic projection
Standard parallels 43°N and 45°N, central meridian 120°30′ W

Figure 21. Locations of sampling sites in Puget Sound tributaries, and selected point sources discharging directly to the Puget Sound and its major tributaries, Washington, water year 2000.

Figure 22. Contribution of monitored tributary and estimated point-source loads of total nitrogen, total phosphorus, and suspended sediment to the Puget Sound basin, Washington, water year 2000.

Nutrients and Suspended-Sediment Yields

Regional Patterns in Yields

Yields are useful when making comparisons between catchments because the yield calculation normalizes loads for catchment area (for example, pounds per square mile of catchment). This provides a measure of the "intensity" of pollutant sources, which is useful for watershed management. Although drainage areas were available for 91 of the 100 catchments, WY 2000 yield estimates were made for only 70, 81, and 65 catchments for TN, TP, and SS, respectively, because of either a lack of adequate data to build a model or poor model performance. Basic land-use characteristics for the 91 delineated catchments are shown in figure 23. The catchments tended to have large percentages of forested and undeveloped land and small percentages of agricultural and urban land. The amount of agricultural and urban land in one-half of the catchments was less than 5 percent and 2 percent of the total land area, respectively, whereas the amount of forested or undeveloped land in one-half of the catchments was greater than 86 percent of the total land area. However, some catchments included relatively large areas of agricultural and urban land: in eight catchments, agricultural areas made up more than 50 percent of the total land area; and in five catchments, urban areas made up more than 50 percent of the

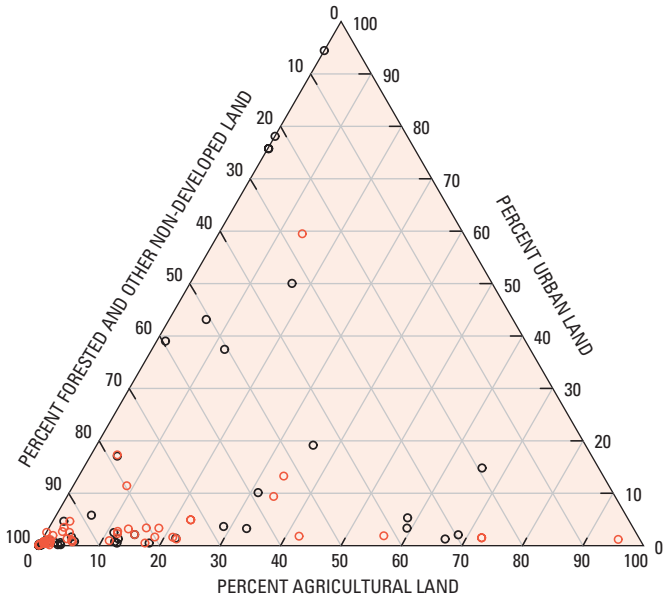


Figure 23. Land use for the 91 catchments with delineated drainage areas for the Columbia River and Puget Sound Basins, calendar year 2000. Trend sites are designated with red circles, whereas all circled sites were used for load estimates.

total land area. Appendix A contains the predicted yields for WY 1997, 2000, and 2001 for TN, TP, and SS, and table 13 summarizes the annual yields for the 3 water years. For TN, TP, and SS, respectively, the median yields were 2.2, 2.7, and 3.8 times greater in 1997 (the high-flow year) compared to 2000 and 2.2, 2.4, and 5.0 times greater in 2000 compared to 2001 (the low-flow year).

The values for yields and annual catchment nutrient loads were not normally distributed. For these variables, the log-transformed (base 10) values were used when relations between catchment yields and catchment characteristics were evaluated. This transformation resulted in approximately normally-distributed values. The two-sided Pearson's correlation coefficient (r) was calculated for all comparisons. The Pearson's correlation coefficient expresses the similarity between two sets of data. The significance of each correlation coefficient (p-value) also was calculated. A 5 percent significance level was selected.

Figure 24 shows the TN, TP, and SS yields estimated for the 91 catchments. In this figure, catchments are represented by the monitoring station location (catchment outlet). Table 14 shows the ranges for the WY 2000 yield quartiles used in figure 24. TP yields were highly correlated with SS yields (r=0.84, $p \leq 0.05$), whereas TN yields were less correlated with SS yields (r=0.65, $p \leq 0.05$). This reflects the fact that phosphorus can adsorb onto and be transported by soil particles, whereas the predominant species of nitrogen do not exhibit this property as strongly. TN yields were highly correlated with TP yields (r=0.81, $p \leq 0.05$), which probably is explained by the similarities in the sources of nitrogen and phosphorus in the catchments. The yields for TN, TP and SS generally were greater on the western side of the Cascade Mountains (the Willamette River and the Puget Sound basins) compared to the eastern side of the Cascade Mountains (t-test p-value = 0.00 for all three constituents). The median yield (untransformed) for the western-side catchments was 5.6 times greater for TN, 4.6 times greater for TP, and 5.8 times greater for SS than the median yield for the eastern-side catchments. The western side of the Cascades experiences much more precipitation and surface runoff than the eastern side. When the annual mean streamflows for WY 2000 were normalized for catchment area, the median value for the western-side catchments was 4.7 times greater than the value for the eastern-side catchments, and the two groups were significantly different. This probably explains most of the difference in the regional pattern for yields, because stream loads (and yields) are dependent on flow and, therefore, should be highly correlated with spatial patterns in precipitation.

Table 13. Summary of annual yields for total nitrogen, total phosphorus, and suspended sediment in the Columbia River and Puget Sound basins, water years 1997, 2000, and 2001.

[**Abbreviations**: TN, total nitrogen; TP, total phosphorus; SS, suspended sediment; lb/yr/mi^2, pound per year per square mile; ton/yr/mi^2, ton per year per square mile]

	Yields		
	TN (lb/yr/mi^2)	TP (lb/yr/mi^2)	SS (ton/yr/mi^2)
Water year 1997 (high flow year)			
Count	66	67	63
Minimum	292	58.4	1.72
Median	3,790	490	132
Maximum	81,900	3,780	13,500
Water year 2000 (average flow year)			
Count	70	81	65
Minimum	177	16.8	1.57
Median	1,740	180	35
Maximum	32,300	1,460	1490
Water year 2001 (low flow year)			
Count	71	81	64
Minimum	79.9	9.51	.23
Median	803	74.6	6.82
Maximum	7,210	433	194

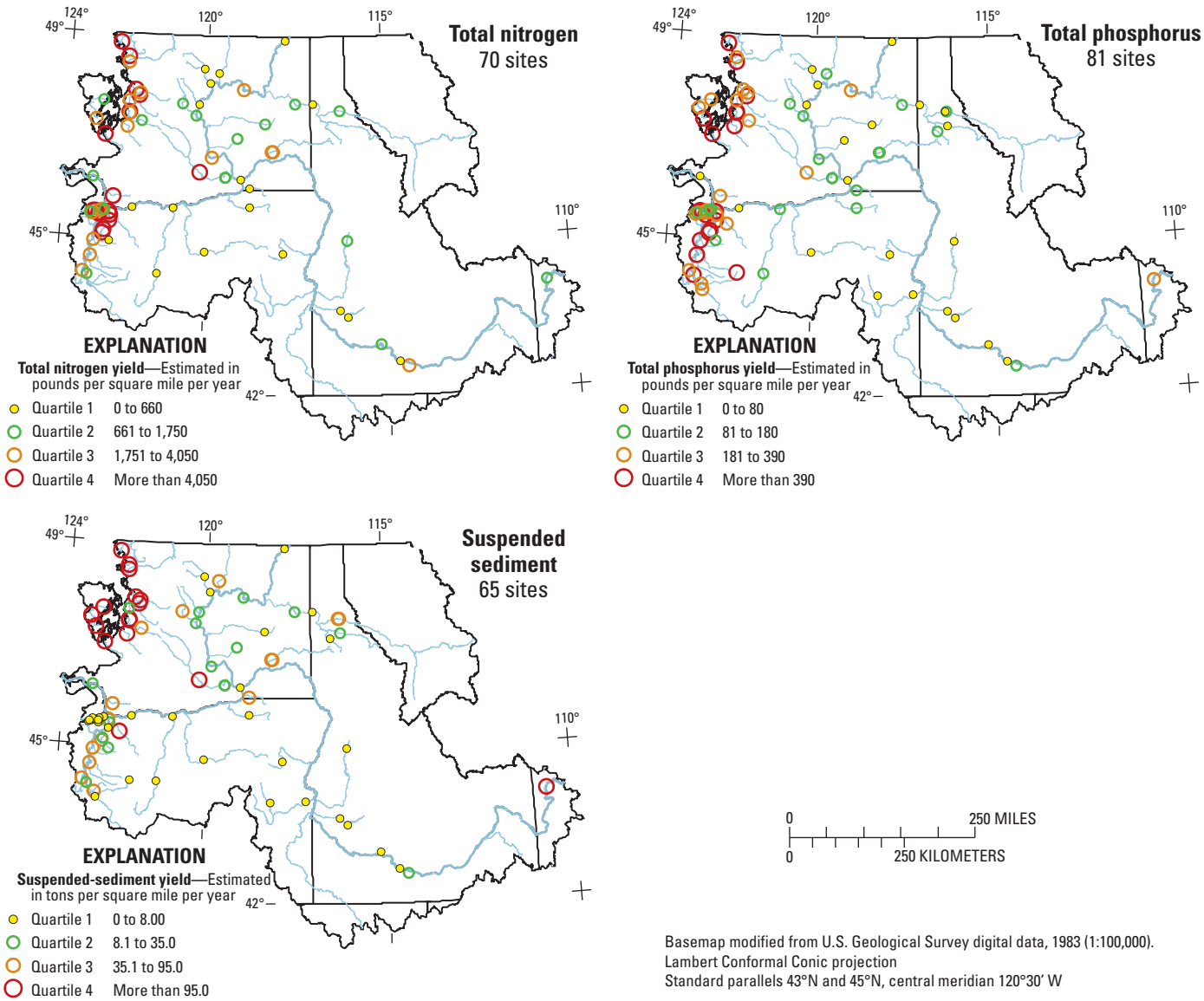


Figure 24. Estimated annual catchment yields divided into quartiles for total nitrogen, total phosphorus, and sediment for the Columbia River and Puget Sound Basins, water year 2000.

Notable exceptions to the regional pattern in yields were Granger Drain in the lower Yakima Basin, Granger, Wash. (fig. 1, site 50), which was in the 4th quartile for TN and SS yields and in the 3rd quartile for TP yields, and the Snake River at Flagg Ranch, Wyo., WY 2000 (fig. 1, site 100), which was in the 4th quartile for SS yields. The Granger Drain catchment contains intensive agricultural activity that relies almost exclusively on irrigation during the growing season. In addition, the agricultural activity is near the drain. With 60 percent agricultural land, it was the 6th most agricultural catchment of the 91 catchments with land-use data. This probably explains the relatively high yields for this catchment. The catchment characteristics available for the Snake River at Flagg Ranch, Wyo., could not explain the high SS yield for WY 2000. Of the remaining 14 catchments in the 4th quartile for SS yield, 13 were in the Puget Sound watershed, and 1 was in the upper Willamette Basin.

Table 14. Quartile ranges for total nitrogen, total phosphorus, and suspended sediment annual yields for the Columbia River and Puget Sound basins, water year 2000.

[All TN and TP loads are in pounds per year per square mile; suspended-sediment loads are in tons per year per square mile. **Abbreviations**: TN, total nitrogen, TP, total pohosphorus, SS, suspended sediment]

Yields	Quartile range			
	1st	2nd	3rd	4th
TN	177–651	663–1,710	1,780–4,050	4,050–32,300
TP	16.8–78.6	83.6–180	190–387	390–1,460
SS	1.57–6.68	8.89–35.0	35.0–90.7	97.6–1,490

Influence of Point Sources

Thirty-one of the 70 delineated catchments with annual in-stream TN loads predicted for WY 2000 had non-zero estimates for annual WY 2000 point-source TN load, and 31 of the 81 delineated catchments with annual in-stream TP loads predicted for WY 2000 had non-zero estimates for annual WY 2000 point-source TP load. The catchments with point-source nutrient loads of zero could have contained nutrient point sources, but these point sources either were not identified in the available data bases or did not meet the criteria for inclusion in the analysis. Table 22 (at back of report) lists the total WY 2000 estimated point-source TN and TP loads for the catchments. Estimated annual point-source loads as a percentage of the annual in-stream loads are also listed in table 22. For each catchment, the annual loads for all point sources were expressed as a percentage of the annual in-stream WY 2000 nutrient load at the catchment outlet. Because nutrients can undergo many transformations in a stream (for example, settling or uptake by plants), a direct comparison between point-source and annual in-stream load in a catchment is not possible. However, a determination of the relative importance of point-sources in a catchment is possible. Using this approach allowed for the following statement—During WY 2000, the estimated annual point-source load for TN in catchment A was at least X percent of the annual in-stream TN load at the outlet of catchment A.

The annual point-source nutrient loads in the catchments ranged from zero to 85 percent of the predicted annual in-stream TN loads and 98 percent of the predicted annual in-stream TP loads. The annual point-source loads from industrial sources (not WWTPs) generally were a small percentage of the annual in-stream loads (less than 5 percent). The one exception was the Spokane River (fig. 1, site 73), where the annual TP loads from paper mills were 17 percent of the annual in-stream load. Figure 25 shows the point-source nutrient loads for each catchment as a percentage of the annual in-stream load. In this figure, the catchments are represented by the location of the monitoring station. The percentage of the annual in-stream load is represented by four symbol size classes: less than 25 percent, 25–50 percent, 50–75 percent, and greater than 75 percent (table 15 shows the number of sites with these percentages for TN and TP).

The one catchment with point-source annual TN loads greater than 75 percent of the annual in-stream load, the Walla Walla River near Touchet, Wash. (fig. 1, site 46), contained a WWTP that discharged relatively large annual loads of TN (ranking 13th of 140 TN point sources). Five of the six catchments with annual point-source TN loads between 25 and 50 percent of the annual in-stream loads were in the more developed areas of the basin (the Willamette basin, Spokane, and Boise). Although no sites with point-source contributions were in the Seattle-Tacoma area, this does not mean that the streams in that area are necessarily free from point-source effects. Rather, the results likely reflect the lack of water-quality sampling sites downstream of major point sources in the area. The other catchment in this group contained the WWTP for Page, Idaho, which ranked 61st of 140 TN point sources.

As with TN, the one catchment where annual point-source TP loads were greater than 75 percent of the annual in-stream load, the Spokane River (fig. 1, site 73), contained a WWTP that discharged relatively large annual loads (ranking 5th of 130 sources for TP). One of the two catchments with point-source annual TP loads between 50 and 75 percent of the annual in-stream loads, another Spokane River site (fig. 1, site 99), contained WWTPs that discharged relatively large annual loads of TP (if they were aggregated into one point-source, they would rank 14th of 130 TP point sources). The other catchment in this group contained the WWTP for Page, Idaho (fig.1, site 97), which ranked 63rd of 130 TP point sources. All 15 catchments with annual point-source TP loads between 25 and 50 percent of the annual in-stream loads were in some of the more developed areas (Willamette River/lower Columbia River basins, Spokane River, Snake River Plain, and lower Yakima River/lower Snake River/Colombia River confluence). No sites with annual TP point-source loads between 25 and 50 percent were in the Seattle-Tacoma area.

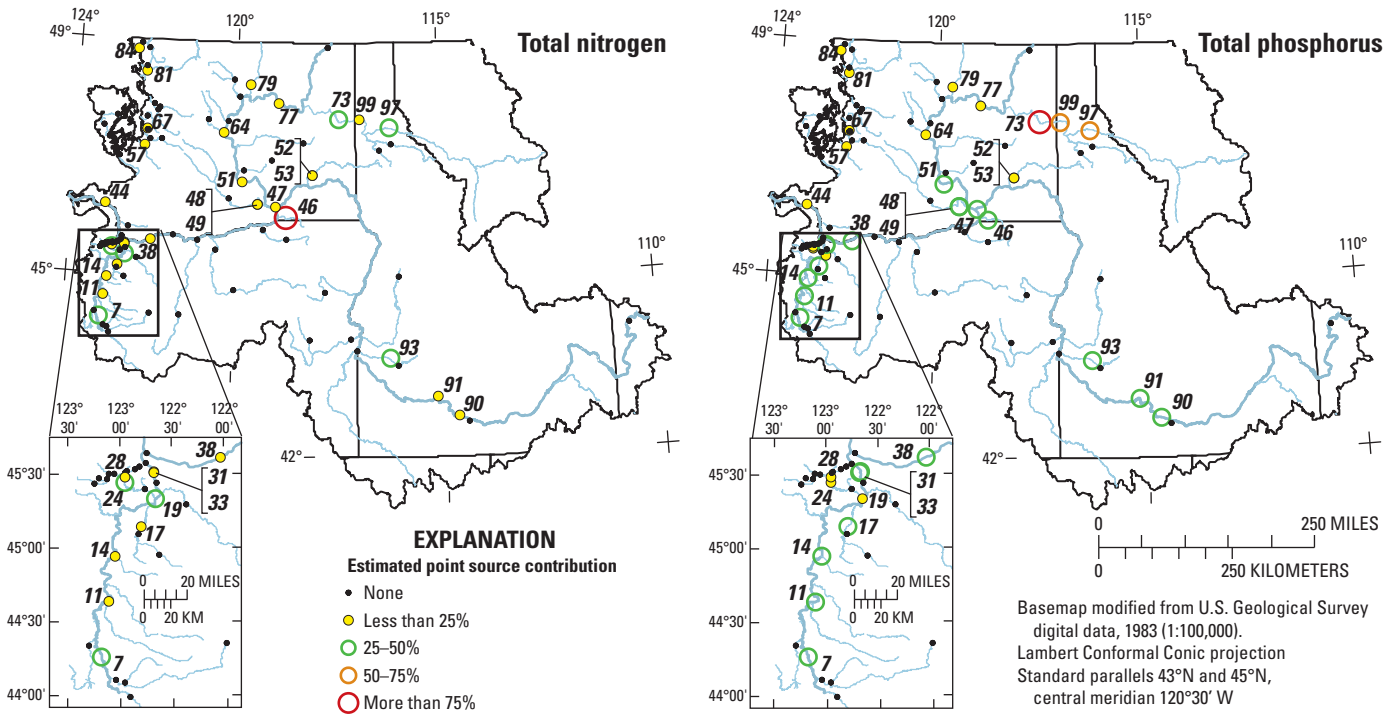


Figure 25. Estimated annual point-source loads as a percentage of annual in stream loads for total nitrogen and total phosphorus, Columbia River and Puget Sound basins, water year 2000.

Table 15. Summary of total point-source annual nutrient loads as a percentage of predicted instream annual loads, Columbia River and Puget Sound basins, water year 2000.

[**Abbreviations:** TN, total nitrogen; TP, toal phosphorus; <, less than; >, greater than]

Constituent	Number of sites with total annual point-source catchment nutrient loads (percent)			
	< 25	25 – 50	50 – 75	> 75
TN	24	6	0	1
TP	13	15	2	1

The results from the point-source analysis showed that streams away from major population centers and large point sources can still be significantly affected by point sources, if the annual in-stream load is relatively low. The results also showed that streams downstream from many large point sources are not necessarily largely affected by those upstream point sources. An example of this was the Columbia River at Beaver Army Terminal (fig. 1, site 44). Although this water-quality station is the integrator site for the Columbia River basin (the site is downstream of a large and complex drainage basin and contains multiple environmental settings and point sources), the annual WY 2000 TN load for all estimated point sources in the Columbia River basin was 11.8 percent of the annual in-stream TN load, and the estimated annual TP point-source load was 22.5 percent of the annual in-stream TP load. These results indicate that, in large catchments with a well-mixed land-use profile, nonpoint sources, such as fertilizer, manure, and atmospheric deposition, are responsible for most in-stream load. The 12 largest catchments generally had a diverse mix of urban and agricultural land (1–6.5 percent urban [mean of 3.1 percent] and 1.8–22.7 percent agricultural [mean of 13.7 percent]). The annual point-source loads for these catchments, as a percentage of annual in-stream loads, ranged from 0 to 22.6 percent for TN (mean of 8.9 percent) and from 0 to 42.1 percent for TP (mean of 26.2 percent). For these catchments, all annual point-source loads were less than the mean value of 27 percent for the catchments with an estimated point-source TN load, and all but one annual point-source load were less than the mean value of 39 percent for the catchments with an estimated point-source TP load.

Table 22 shows the predicted annual in-stream TN and TP loads and the estimated annual TN and TP loads from point sources for WY 2000, and the estimated annual fertilizer and manure nitrogen and phosphorus loads and atmospheric nitrogen deposition for calendar year (CY) 2002. The data for CY 2002 were used because manure data were available

for that year but not CY 2000. Table 22 also includes (1) annual point-source loads expressed as a percentage of the annual in-stream load, (2) annual fertilizer and manure loads expressed as a percentage of the annual in-stream load, (3) annual atmospheric nitrogen deposition expressed as a percentage of the annual in-stream load, (4) annual point-source loads expressed as a percentage of the annual fertilizer and manure loads, (5) annual point-source TN load expressed as a percentage of the annual atmospheric deposition of nitrogen, and (6) annual point-source TN loads expressed as a percentage of the land-applied nitrogen loads.

Relative allocations of annual TN and TP loads to the catchments from fertilizer and manure, point sources, and atmospheric deposition (nitrogen only) are shown in figure 26. For TN, values ranged from near 0 to nearly 100 percent for both fertilizer and manure (median of 86 percent) and atmospheric deposition (median of 12 percent), and from 0 to close to 50 percent for point sources (median of 0 percent). For TP, values ranged from near 0 to close to 100 percent for fertilizer and manure, and from 0 to close to 80 percent for point sources (median of 0 percent). However, 60 of the 91 catchments had no estimated point-source TN or TP loads. The sites are generally located at the left sides of each plot, indicating that the estimated point source loads tended to be a small percentage of total TN and TP loads in the catchments compared to fertilizer and manure application and atmospheric deposition.

One catchment, the South Fork Coeur d'Alene River (fig. 1, site 97), had annual point-source TP loads greater than the total land-applied phosphorus loads, and 10 catchments had annual point-source TP loads greater than 10 percent of the land-applied phosphorus loads. Annual point-source loads for TP in the South Fork Coeur d'Alene River were equal to 60 percent of the annual in-stream load (the median value was 10.5 percent for all 31 catchments with point-source TP loads). Higher values of annual point-source nutrient loads as a percentage of annual land-applied loads were positively related to higher values of annual point-source nutrient loads as a percentage of annual in-stream loads. In smaller, urbanized catchments, point sources tended to contribute more to the total nutrient load than in larger, less urbanized catchments.

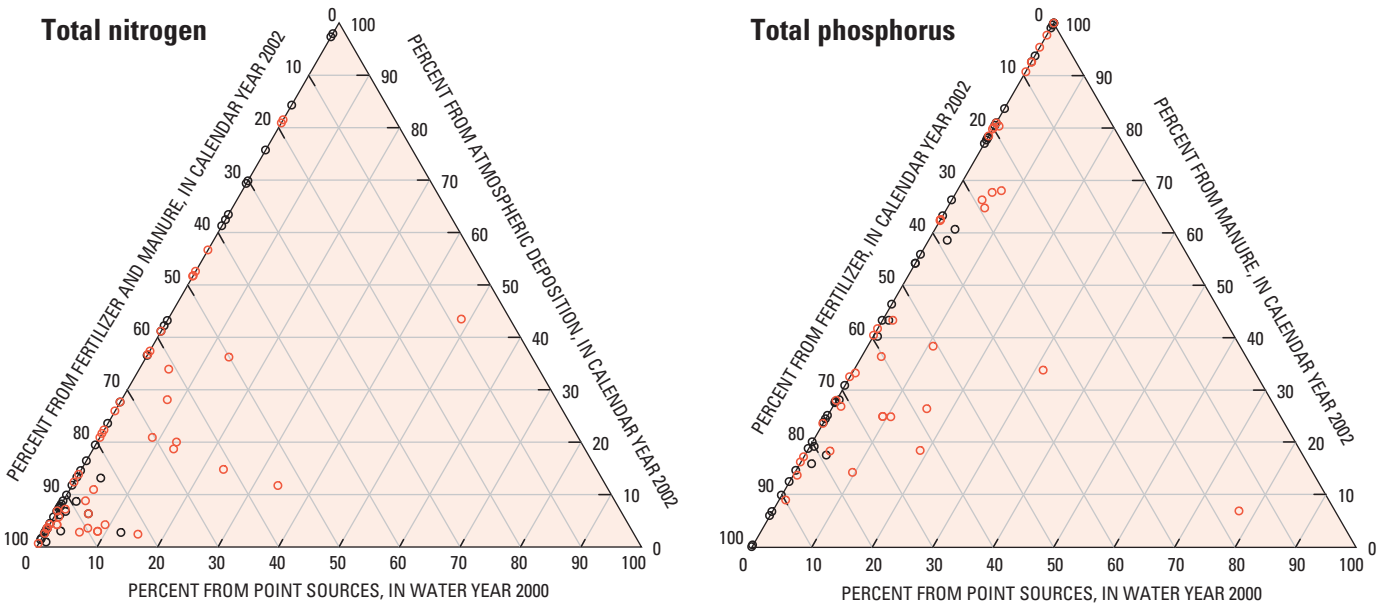


Figure 26. Summary of annual nutrient load to delineated catchments for total nitrogen and total phosphorus in the Columbia River and Puget Sound Basins, water year 2000 and calendar year 2002. Trend sites are designated with red circles, whereas all circled sites were used for load estimates.

Influence of Catchment Characteristics on Nutrient and Suspended-Sediment Yields

A multiple linear regression of catchment yields (the response variable) on catchment characteristics (the explanatory variables) was performed to determine which characteristics best explained the variability in TN, TP, and SS yields. Seven explanatory variables were used in the regressions for TN and TP: (1) percentage of the catchment land area categorized as urban; (2) percentage of the catchment land area categorized as agricultural; (3) mean slope for the catchment in percent; (4) mean annual precipitation for the catchment for 1980–1997; (5) annual load of nitrogen or phosphorus to the catchment from fertilizer and manure application (CY 2002), normalized for catchment area and log-transformed; (6) annual load of nitrogen to the catchment from atmospheric deposition (CY 2002), normalized for catchment area and log transformed; and (7) annual load of nitrogen or phosphorus to the catchment from point sources (WY 2000), normalized for catchment area and log-transformed. The linear model selected provided the best estimate of the response variable using some linear combination of the explanatory variables, based on the model standard error (a measure of the differences between the measured and the predicted values). The linear model took the form: $Y = aX_1 + bX_2 + cX_3 + dX_4 + eX_5 + fX_6 + gX_7$, where Y was the predicted yield, X_1- X_7 were values for the catchment characteristics, and a–g were the coefficients. The statistically significant predictive capability of each explanatory variable in the presence of the other variables was provided by the p-values. The magnitude of each regression coefficient indicated the response of the yields to a particular catchment characteristic. The results from the multiple linear regressions are summarized in table 16. Also, included in the table are standardized regression coefficients. To obtain these coefficients, all variables (response and explanatory) were standardized before fitting the multiple regression equation by subtracting the mean for that variable and dividing by the standard deviation. Each standardized regression coefficient represents the change in the response of yield in standardized units to a unit change in the standardized explanatory variable (for example, one standard deviation unit change in precipitation corresponds to some standard deviation unit change in yield). Because standardized regression coefficients are independent of scale units, they are useful in interpreting the results from multiple linear regressions.

Although average annual precipitation was the major explanatory factor for TN, TP, and SS yields, the relation was slightly stronger for TP (on the basis of the standardized regression coefficients). However, precipitation was only one factor that influenced catchment yields; for TN and TP yields another important factor was the amount of nutrients applied to the catchments from point and nonpoint sources. The results from this analysis showed that, although a unit change in point-source loads of phosphorus tended to have about twice the effect on TP yields as a unit change in nonpoint-source loads (fertilizer and manure), a unit change in point-source loads of nitrogen tended to have only about two-thirds the effect on TN yields as a unit change in nonpoint-source loads (fertilizer and manure or atmospheric deposition). The decrease in TN and TP yields with an increase in mean slope may have been an indication of the importance of topography and subsurface flow paths on nutrient delivery to streams. These results might indicate, for example, that greater overland flow and nutrient transport and delivery occurred in catchments dominated by relatively flat topography. However, slope also could have been acting as a surrogate for the percentage of forested land in the catchments because mean slope was strongly correlated with the percentage of forested land. Land use in the catchments also was a factor that influenced nutrient yields—the percentage of agricultural land influenced TN, TP, and SS yields (about as much as point-source loads for TN yields), whereas the percentage of urban and agricultural land influenced TP yields (with the percentage of urban land having a stronger influence). The analysis described above provided an estimation of the factors affecting nutrient and sediment transport in some of the catchments of the Pacific Northwest. A more complete analysis would include many more water-quality monitoring sites, all the catchments, and a more rigorous geospatial statistical approach. A study is planned that will incorporate all of those components. This study will use the SPARROW model to estimate nutrient and sediment sources and transport in the surface waters of the Pacific Northwest that have been mapped on the RF1 hydrologic network (U.S. Environmental Protection Agency, 1996). The SPARROW model makes these estimates by correlating water-quality data with data on pollutant sources (for example, atmospheric deposition, fertilizers, and human and animal wastes) and climatic and hydrogeologic properties (for example, precipitation, topography, vegetation, soils, and water routing) that affect contaminant transport (Schwarz and others, 2006). Much of the data collected for the study described in this report will be used in the upcoming SPARROW study.

Table 16. Results from multiple linear regression of catchment characteristics on catchment yields in the Columbia River and Puget Sound basins, water year 2000.

[**Abbreviations:** TN, total nitrogen; TP, total phosphorus; SS, suspended sediment; CY, calendar year; WY, water year; kg/km^2, kilogram per square kilometer; cm, centimeter; NA, not available]

Catchment characteristic	Coefficient unit	Yield (kg/km^2)					
		TN			TP		
		p-value	Regression coefficient	Standardized regression coefficient	*p*-value	Regression coefficient	Standardized regression coefficient
Urban land	Percent	0.471	0.002	0.078	0.085	0.004	0.186
Agricultural land	Percent	.055	.005	.202	.167	.003	.142
Mean slope	Percent	.028	-.013	-.341	.094	-.008	-.220
Mean annual precipitation (CY 1980–97)	cm	.000	.414	.650	.000	.453	.800
CY 2002 fertilizer and manure application	log(kg/km^2)	.045	.179	.279	.142	.102	.159
CY 2002 atmospheric deposition	log(kg/km^2)	.000	.962	.301	NA	NA	NA
WY 2000 point-source loading	log(kg/km^2)	.011	.108	.186	.000	.228	.258

Catchment characteristic	Coefficient unit	Yields (kg/km^2)		
		SS		
		p-value	Regression coefficient	Standardized regression coefficient
Urban land	Percent	0.519	0.004	0.105
Agricultural land	Percent	.057	.008	.246
Mean slope	Percent	.762	-.003	-.051
Mean annual precipitation (CY 1980–97)	cm	.000	.006	.667
CY 2002 fertilizer and manure application	log(kg/km^2)	NA	NA	NA
CY 2002 atmospheric deposition	log(kg/km^2)	NA	NA	NA
WY 2000 point-source loading	log(kg/km^2)	NA	NA	NA

Trends in Nutrients and Suspended-Sediment, 1993–2003

For this study, trend sites were selected based on the availability of data collected from 1993 to 2003, meaning that data for each site generally were available for most seasons in each year during this period. Consequently, data for the sites were not necessarily statistically representative of water-quality trends in each of the Pacific Northwest states. The results represent conditions at the sites used in this study and should not be extrapolated to other areas in each of the states. Table 17 shows the breakdown of the trend sites by collecting/analyzing agency. There were 11 USGS sites, 14 ODEQ sites, 23 WDOE sites, 2 CWS sites, and, depending on the constituent, 18–20 sites in Oregon, 20–25 sites in Washington, and 4–5 sites in Idaho. Figure 6 shows the distribution of drainage areas for the 45 trend sites with delineated catchments (indicated by blue bars). Delineated drainage areas ranged from 25 to 658,000 km^2, although most catchments had drainage areas between 1,000 and 5,000 square km^2. Only two catchments had drainage areas less than 100 km^2, and only one had a drainage area greater than 100,000 km^2. Consequently, the trend results were not necessarily representative of conditions occurring in the smallest and largest basins.

The distribution of land use for the trend sites with delineated catchments is shown in figure 23 (red circles). Total agricultural land use ranged from 0 to 95 percent, with most sites less than 20 percent; total urban land use ranged from 0.5 to 60 percent, with most sites less than 10 percent; and total forest land use ranged from 4 to 100 percent, with most sites greater than 70 percent. The many forested watersheds in the study area, especially in the mountainous parts of the basin where rainfall is high and nutrient concentrations are relatively low, likely provided dilution of nutrient concentrations from point sources and agricultural runoff downstream. Depending on forest activities, the forested areas also may have contributed significantly to the suspended-sediment loads, especially during winter storms and high-flow, snow-melt periods.

Table 17. Number of sites with significant decreasing, increasing, or no flow-adjusted trend in concentration by collecting/analyzing agency in the Columbia River and Puget Sound basins, water years 1993–2003.

[**Abbreviations:** CWS, Clean Water Services; FATC, flow-adjusted trend in concentration; ODEQ, Oregon Department of Environmental Quality; WDOE, Washington State Department of Ecology; USGS, U.S. Geological Survey]

Constituent	Number of sites with data for trend testing					Number of sites with decreasing FATC				
	USGS	ODEQ	WDOE	CWS	Total sites	USGS	ODEQ	WDOE	CWS	Total sites (percent)
Total nitrogen	11	13	18	2	44	1	9	8	1	19 (43)
Total phosphorus	11	14	23	2	50	1	6	0	2	9 (18)
Suspended sediment	11	14	23	0	48	8	1	6	0	15 (31)

Constituent	Number of sites with increasing FATC					Number of sites with no FATC				
	USGS	ODEQ	WDOE	CWS	Total sites (percent)	USGS	ODEQ	WDOE	CWS	Total sites (percent)
Total nitrogen	2	0	0	0	2 (5)	8	4	10	1	23 (52)
Total phosphorus	1	0	6	0	7 (14)	9	8	17	0	34 (68)
Suspended sediment	0	4	0	0	4 (8)	3	9	17	0	29 (60)

For the statistical trend analysis used in this study, the null hypothesis being tested is “There is not a trend in the constituent concentrations for either flow-adjusted trend in concentrations (FATC) or non-flow-adjusted trend in concentration (NFATC) at a site.” A type 1 error in the analyses occurs if the null hypothesis is rejected when it is true. For this study, the tolerable probability level—level of significance—for committing a type 1 error was set at p=0.05; that is, there is a 5-percent chance of rejecting the null hypothesis when it is true (Ott, 1993). As p becomes smaller, the data show more evidence for rejecting the null hypothesis. For example, at p=0.20, there is a 20-percent chance of rejecting the null hypothesis when it is true, and at a $p \leq 0.051$, there is only a 0.1-percent chance of rejecting the null hypothesis when it is true. The time span from 1993–2003 for assessing trends in this report is relatively short, considering that the data used in this analysis could be far fewer than 12 samples per year (for example, as few as 56 samples over an 11 year period). Given the paucity of the data, significant trends could have actually existed in the streams even when the reported p-level in this report was computed to be greater than 0.05 because the amount of data analyzed may have been insufficient to reveal the significant trend. In an attempt to compensate for the relatively small data sets, the direction of the trends in the basin that were not significant (p>0.05) also are mentioned in the text to further paint a picture of basin-wide trends. Although not significant, the majority of these trends often were consistent with the direction of the significant trends; thereby indicating that the patterns in trends could be wider spread throughout the basin, and might have been apparent if more data had been available for analysis.

Trends in Streamflow

Only streamflow at 2 of the 50 sites: Crab Creek near Beverly, Wash. (fig. 1, site 54) and Rock Creek above Hwy 30/93 crossing at Twin Falls, Idaho, (site 89), had significant trends (decreasing). Unlike the data from most sites, which extended from October 1992 through September 2003, the streamflow data for these sites began in October 1993 (WY 1994). Three of the other four sites with streamflow data starting in WY 1994 rather than WY 1993 also showed a decreasing (but not significant) trend in streamflow. A re-analysis of all trends in streamflow, using WYs 1994 through 2003, showed only one additional site, the Okanogan

River at Malott, Wash. (fig. 1, site 79), with a significant trend in streamflow (decreasing). In addition, changing the analytical time period did not substantially change the results for flow-adjusted trend in concentration, nonflow-adjusted trend in concentration, or trend in load. Except at the two sites where there was a trend in streamflow, any site showing a FATC could only show a significant NFATC that was in the same direction (increasing or decreasing).

General Patterns in Concentration Trends

Because significant NFATC occurred at about 90 percent of the sites with significant FATC for all three constituents, and the values for the NFATC and FATC were generally close in magnitude, only the results for FATC are presented in this section. Overall distributions of FATC for TN, TP, and SS, expressed in percentage per year and milligrams per liter per year, are shown in figures 27, 28, and 29. The figures show distributions for the sites where the FATC was significant ($p < 0.05$) and the sites where it was not significant. Although many sites showed relatively large FATC for TN based on percentage change, more than 90 percent of the sites had relatively small FATC for TN based on absolute change in concentration (≤ 0.05 mg/L/yr). Most sites showed relatively small FATC for TP based on both percentage change and absolute change in concentration (≤ 0.003 mg/L/yr). Although many sites showed relatively large FATC for SS based on percentage change, more than 90 percent of the sites had relatively small FATC for SS based on absolute change in concentration (≤ 2 mg/L/yr).

The numbers of sites with significant FATC for TN, TP, and SS are shown in table 17. Unless indicated otherwise, all the FATC results presented in the remainder of this section were significant (some FATC results that were not significant also are described to provide a more complete picture of the patterns in trends). For most catchments, the net change in nonhydrologic characteristics (land use and other human activities) was not great enough to cause any FATC for TN (52 percent), TP (68 percent), or SS (60 percent) during this relatively short time period (WY's 1993–2003). However, some nonhydrologic changes might still have occurred in these catchments, but either they cancelled out (for example,

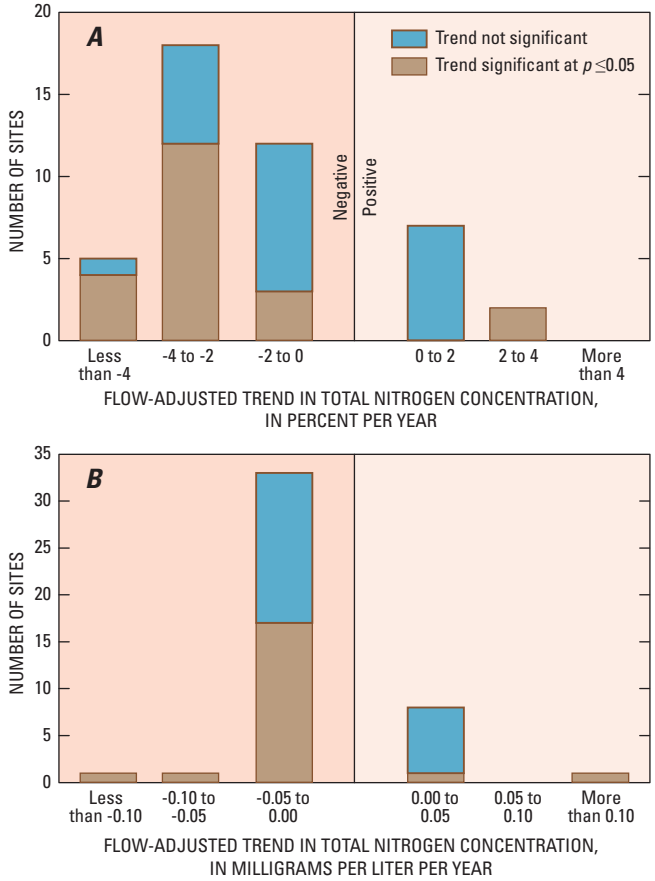


Figure 27. Distribution of flow-adjusted trends in concentration of total nitrogen in percentage per year and milligrams per liter per year, Columbia River and Puget Sound basins, water years 1993–2003.

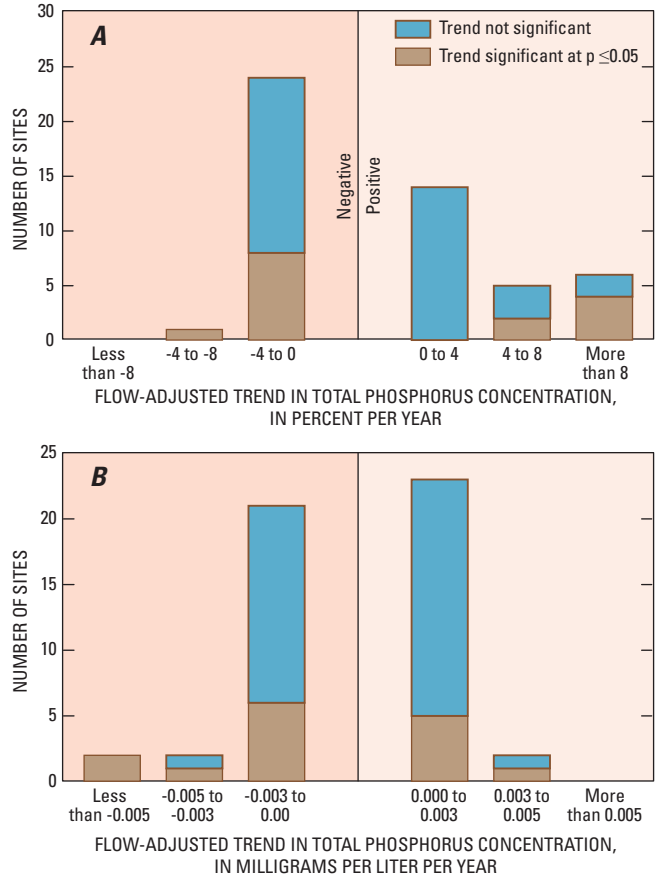


Figure 28. Distribution of flow-adjusted trends in concentration of total phosphorous in percentage per year and milligrams per liter per year, Columbia River and Puget Sound basins, water years 1993–2003.

decreasing nonpoint source loads and increasing point-source loads) or were too far upstream to have much effect on water quality. Although a few sites had increasing FATC for TN, TP, and (or) SS (5, 14, and 8 percent of the sites, respectively), more sites showed decreasing FATC (43, 18, and 31 percent of the sites for TN, TP, and SS, respectively).

Some differences in trend results were observed among the agencies (table 17), which might have been due to each agency having sampled sites with different land uses and hydrologic characteristics, using different sampling protocols and (or) laboratory methods, and targeted sampling of problem areas by the State regulatory agencies. For example, USGS data showed decreasing FATC for SS at 73 percent of sites (8 of the 11 sampled), whereas ODEQ and WDOE data showed decreasing FATC for SS at 7 and 26 percent of sites, respectively. In addition, decreasing FATC for TP were measured at only one USGS site and no WDOE sites, compared to 43 percent of the ODEQ sites (table 17). In all three states, the number of decreasing FATC frequently exceeded the number of increasing FATC, except for TP in Idaho and Washington (table 18).

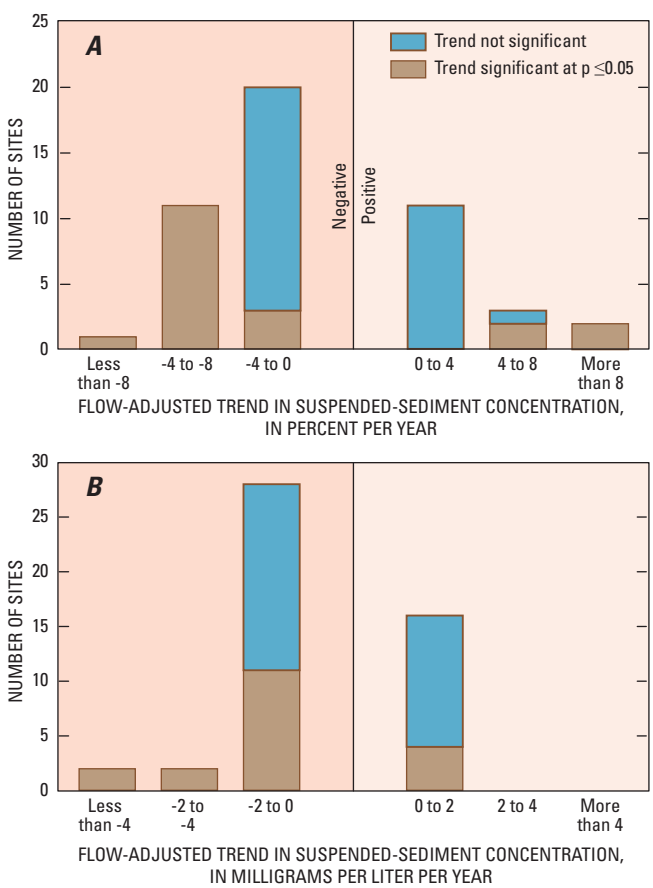


Figure 29. Distribution of flow-adjusted trends in concentration of suspended sediment in percentage per year and milligrams per liter per year, Columbia River and Puget Sound basins, for water years 1993–2003.

Table 18. Summary of flow-adjusted trends in concentration of total nitrogen, total phosphorus, and suspended sediment in the Columbia River and Puget Sound basins, water years 1993–2003.

[FATC, Flow-adjusted trend in concentration]

Constituent	Sites with			Total number of sites
	Significant increasing FATC	Significant decreasing FATC	No significant FATC	
Idaho				
Total nitrogen	1	1	3	5
Total phosphorus	1	0	4	5
Suspended sediment	0	4	1	5
Oregon				
Total nitrogen	1	10	8	19
Total phosphorus	0	8	12	20
Suspended sediment	4	4	10	18
Washington				
Total nitrogen	0	8	12	20
Total phosphorus	6	1	18	25
Suspended sediment	0	7	18	25
Summary				
Total nitrogen	2	19	23	44
Total phosphorus	7	9	34	50
Suspended sediment	4	15	29	48

Total Nitrogen

Complete results from the trend analysis for TN are shown in table 19, and figure 30 shows the FATC for TN at each available trend site in the study area. Figure 30 indicates whether there was a significant FATC at each site and, if there was, shows the direction of the trend and indicates its magnitude in percentage per year and milligrams per liter per year (some sites with relatively large percentage change in FATC had small changes in concentration). Twenty-one (48 percent) of the 44 sites had FATC for TN (2 increasing, 19 decreasing, and 6 sites had insufficient water-quality data to determined trends). Trends in load for TN were observed at 10 sites (all decreasing), and 77 percent of the sites had decreasing (but not necessarily significant) FATC and trends in load for TN. The decreasing trends in load for TN generally corresponded to decreasing FATC but not decreasing trends in streamflow, indicating that the decreasing loads resulted solely from decreasing FATC. However, at Rock Creek (fig. 1, site 89) the decreasing trend in load for TN may have been caused by the decreasing FATC and (or) the decreasing trend in streamflow.

Table 19. Flow-adjusted trends in concentration, non-flow-adjusted trends in concentration, and trends in annual loads for total nitrogen in the Columbia River and Puget Sound basins, water years 1993–2003.

[Sites can be located in figure 1 by the Map index No. **Bold** values indicate trends significant at a less than or equal to 0.05 *p*-level. **Abbreviations:** FATC, flow-adjusted trends in concentration; NFATC, non-flow-adjusted trends in concentration]

Map index No.	Site No.	Water quality				FATC		NFATC		Load trend	
		Start date	End date	Number of observations	Number of observations below reporting limit	Percent per year	Milligrams per liter per year	Percent per year	Milligrams per liter per year	Percent per year	Kilograms per day per year
7	10355	10-20-92	08-12-03	126	57	**-4.58**	**-0.020**	**-4.53**	**-0.020**	**-5.06**	**-497**
8	11140	10-20-92	08-12-03	55	0	**-4.16**	**-.042**	**-4.01**	**-.040**	**-5.36**	**-42.9**
10	10508	11-01-93	09-22-03	69	49	-2.55	-.005	-2.57	-.005	-2.43	-9.70
11	10350	10-21-92	08-12-03	126	22	**-4.63**	**-.037**	**-4.53**	**-.036**	**-5.24**	**-1,180**
13	11478	10-14-92	09-03-03	63	32	**-3.38**	**-.010**	**-3.48**	**-.010**	**-6.07**	**-52.5**
14	10555	10-21-92	08-12-03	128	10	**-4.81**	**-.044**	**-4.74**	**-.043**	**-5.41**	**-2,260**
15	14200400	10-14-93	09-03-03	98	1	-.17	-.001	-.580	-.003	-2.40	-.564
16	14201300	10-04-93	09-03-03	129	0	**2.40**	**.221**	1.10	.102	-3.97	-5.88
19	3701002	10-05-92	09-29-03	404	0	.58	.016	.550	.015	.798	39.6
23	11321	10-28-92	08-11-03	56	0	**-2.82**	**-.128**	**-2.47**	**-.112**	**-4.00**	**-24.6**
25	3701612	10-01-92	09-29-03	430	80	**-3.07**	**-.017**	**-2.91**	**-.016**	-2.04	-6.69
31	10611	10-21-92	08-11-03	132	0	**-3.61**	**-.042**	**-3.57**	**-.042**	**-4.42**	**-3,400**
33	14211720	11-16-92	09-10-03	145	1	-.225	-.002	-.330	-.003	-1.65	-845
37	10332	10-21-92	08-06-03	57	0	-2.04	-.020	-2.012	-.019	-3.09	-1,970
39	10411	10-26-92	08-18-03	63	19	-2.26	-.007	-2.261	-.007	-2.25	-97.2
40	10616	10-21-92	08-06-03	57	13	-2.63	-.012	-2.630	-.012	-3.10	-6,000
42	12012	06-21-93	08-18-03	60	16	**-3.34**	**-.013**	**-3.35**	**-.013**	-3.63	-27.0
43	11489	10-26-92	08-18-03	76	0	**-3.56**	**-.095**	**-3.98**	**-.106**	-2.87	-38.6
44	14246900	11-19-92	09-08-03	118	22	-.665	-.003	-0.832	-.004	-1.89	-5,080
46	32A070	10-11-93	09-10-03	118	0	**-3.81**	**-.043**	**-3.84**	**-.044**	-4.07	-30.2
48	37A090	10-12-93	09-10-03	119	0	**-2.23**	**-.026**	**-2.40**	**-.028**	-1.64	-128
51	12472900	11-17-92	09-25-03	70	52	-2.21	-.005	-2.20	-.005	-2.48	-1,580
52	13351000	12-21-92	09-03-03	164	0	.214	.004	.631	.011	3.03	27.4
53	34A070	10-04-93	09-09-03	116	0	-1.53	-.023	-1.08	-.017	.905	7.24
54	41A070	10-12-93	09-10-03	117	0	-.624	-.012	.167	.003	**-2.82**	**-36.9**
57	10A070	10-27-93	09-24-03	118	0	**-2.70**	**-.008**	**-2.70**	**-.007**	-2.02	-36.0
61	16A070	10-25-93	09-23-03	118	1	-5.00	-.005	-5.00	-.005	-4.48	-7.48
63	09A190	10-18-93	09-24-03	119	1	-.762	-.001	-.666	-.001	-1.76	-3.27
64	45A070	10-12-93	09-08-03	118	0	**-2.54**	**-.004**	-2.43	-.004	-2.73	-19.9
66	09A080	10-20-93	09-24-03	117	0	**-2.47**	**-.013**	**-2.35**	**-.012**	-3.15	-38.2
70	45A110	10-12-93	09-08-03	114	3	-2.14	-.001	-2.23	-.001	-2.54	-7.98
71	16C090	10-25-93	09-23-03	115	13	.736	.000	.658	.000	.256	.067
73	54A120	10-05-93	09-08-03	118	0	1.84	.008	2.36	.011	1.62	76.7
76	07A090	10-19-93	09-22-03	120	0	-1.00	-.003	-.996	-.003	-1.07	-55.6
78	48A070	10-13-93	09-09-03	119	0	**-1.88**	**-.003**	-1.26	-.002	-2.55	-7.78
79	49A070	10-13-93	09-09-03	117	0	**-2.12**	**-.003**	**-2.17**	**-.003**	**-4.94**	**-42.7**
81	03A060	10-19-93	09-22-03	118	1	.079	.000	.090	.000	.147	6.60
84	01A050	10-19-93	09-23-03	118	0	-.005	-.000	-.021	-.000	.512	12.8
87	61A070	10-06-93	09-07-03	119	0	**-1.45**	**-.002**	**-1.45**	**-.002**	-1.29	-402
89	13092747	10-14-93	09-23-03	105	0	**-1.93**	**-.038**	.129	.003	**-4.53**	**-29.4**
91	13154500	11-04-92	09-24-03	138	0	-.487	-.007	.193	.003	-1.71	-658
93	13206000	11-02-92	09-16-03	93	6	**2.09**	**.012**	2.12	.012	2.05	19.5
97	12413470	11-18-92	09-08-03	115	47	1.541	.004	1.63	.004	1.38	2.52
99	12419000	10-07-92	09-03-03	111	88	1.288	.002	1.44	.002	.091	1.20

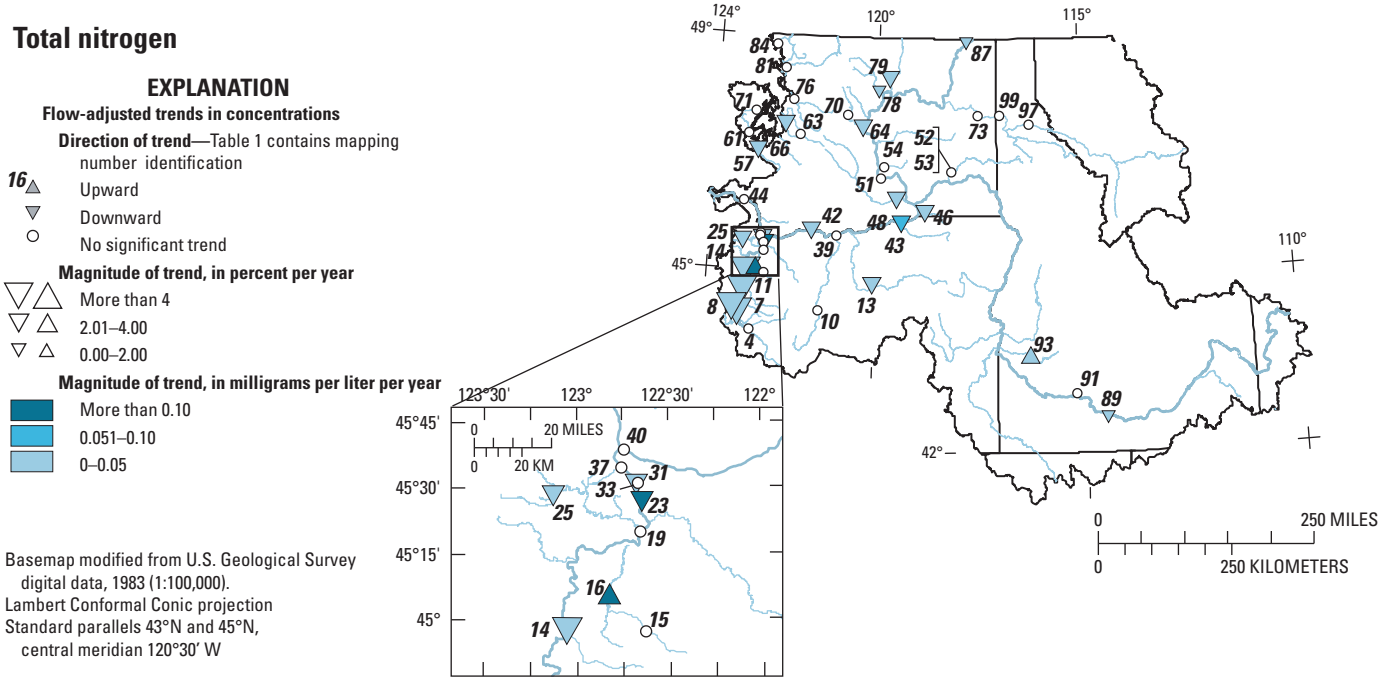


Figure 30. Flow-adjusted trends in concentration of total nitrogen, Columbia River and Puget Sound basins, water years 1993–2003.

Seven sites in the Willamette River Basin had decreasing FATC for TN: the Willamette River main-stem sites at Harrisburg (fig. 1, site 7), Albany (fig. 1, site 11), Salem (fig. 1, site 14), and Portland (fig. 1, site 31), and tributary sites on the Long Tom River (fig. 1, site 8), Johnson Creek (fig. 1, site 23) and the Tualatin River (fig. 1, site 25). Although not significant, the FATC at Little Abiqua Creek (fig. 1, site 15), the Willamette River at Portland (fig. 1, site 33), and the Willamette River at SP&S Railroad Bridge (fig. 1, site 37) also were decreasing.

Other sites in Oregon, Washington, and Idaho with decreasing FATC for TN were in catchments with a wide range of agricultural activity, covering as little as 0.8 percent to as much as 56 percent. The two sites with increasing FATC for TN had different land-use profiles. Agricultural land covered 95 percent of the catchment for Zollner Creek near Mt. Angel, Oreg. (fig. 1, site 16), whereas agricultural land covered only 0.5 percent of the catchment for the Boise River at Glenwood, Idaho (fig. 1, site 93). However, the Boise River at this location received a large point-source load of nitrogen (estimated to be about 40 percent of the in-stream TN load), which indicates that changes in point-source load could have been responsible for the increasing FATC for TN.

Total Phosphorus

Complete results from the trend analysis for TP are shown in table 20, and figure 31 shows the FATC for TP at each available trend site in the study area. Sixteen (32 percent) of the 50 sites had significant FATC for TP (7 increasing and 9 decreasing). Trend in load for TP was observed at six sites (3 increasing and 3 decreasing). The number of sites with decreasing FATC for TP was about one-half of those for TN. Much of this difference can be attributed to the WDOE data, which showed eight sites with decreasing FATC for TN but no sites with decreasing FATC for TP (table 17). About 50 percent of the sites had decreasing (but not necessarily significant) FATC and trend in load for TP.

Six sites in the Willamette River Basin, Oregon: Willamette main-stem sites at Albany (fig. 1, site 11), Salem (fig. 1, site 14), and Portland (fig. 1, site 31), and tributary sites on the Long Tom River (fig. 1, site 8) and the Tualatin River (fig. 1, sites 19 and 25) had decreasing FATC for TP. The four other sites in the Willamette River Basin had decreasing (but not significant) FATC for TP. Increasing FATC for TP was measured in the Puget Sound at four sites: Deschutes River (fig. 1, site 56), Green River (fig. 1, site 63),

Table 20. Flow-adjusted trends in concentration, non-flow-adjusted trends in concentration, and trends in annual loads for total phosphorus in the Columbia River and Puget Sound basins, water years 1993–2003.

[Sites can be located in figure 1 by the Map index No. **Bold** values indicate trends significant at a less than or equal to 0.05 *p*-level. **Abbreviations:** FATC, flow-adjusted trends in concentration; NFATC, non-flow-adjusted trends in concentration]

Map index No.	Site No.	Water quality				FATC		NFATC		Load trend	
		Start date	End date	Number of observations	Number of observations below reporting limit	Percent per year	Milligrams per liter per year	Percent per year	Milligrams per liter per year	Percent per year	Kilograms per day per year
4	10386	10-20-92	08-12-03	57	0	-1.27	-0.000	-1.42	-0.000	-2.09	-4.99
7	10355	10-20-92	08-12-03	130	0	-.244	-.000	-.457	-.000	-1.43	-14.9
8	11140	10-20-92	08-12-03	56	0	**-2.01**	**-.002**	**-1.99**	**-.002**	-3.85	-2.46
10	10508	11-01-93	09-22-03	69	0	1.13	.001	1.17	.001	1.39	2.12
11	10350	10-21-92	08-12-03	129	0	**-1.74**	**-.001**	**-1.86**	**-.001**	-2.97	-63.2
13	11478	10-14-92	09-03-03	64	0	-1.76	-.001	**-3.01**	**-.001**	**-5.82**	**-6.91**
14	10555	10-21-92	08-12-03	129	0	**-1.72**	**-.001**	**-1.90**	**-.001**	-2.99	-87.1
15	14200400	10-14-93	09-03-03	99	19	6.36	.001	6.01	.001	2.92	.019
16	14201300	10-04-93	09-03-03	129	0	-1.31	-.004	-2.16	-.006	-5.75	-.264
19	3701002	10-05-92	09-29-03	423	0	**-2.92**	**-.005**	**-2.91**	**-.005**	-2.75	-8.79
23	11321	10-28-92	08-11-03	57	0	-.726	-.001	-.958	-.001	-2.84	-.341
25	3701612	10-01-92	09-29-03	449	92	**-3.81**	**-.001**	**-3.72**	**-.001**	-2.96	-.689
31	10611	10-21-92	08-11-03	133	0	**-2.12**	**-.002**	**-2.00**	**-.002**	-3.08	-166
33	14211720	11-16-92	09-10-03	145	0	1.24	.001	1.28	.001	-.284	-11.3
37	10332	10-21-92	08-06-03	57	0	-.704	-.000	-.680	-.000	-1.95	-89.9
39	10411	10-26-92	08-18-03	64	0	-.823	-.001	-.823	-.001	-.806	-8.84
40	10616	10-21-92	08-06-03	57	0	**-2.03**	**-.001**	-2.30	-.001	-2.79	-471
42	12012	06-21-93	08-18-03	60	0	3.988	.001	3.71	.001	3.12	2.08
43	11489	10-26-92	08-18-03	75	0	**-3.41**	**-.004**	**-3.12**	**-.003**	-1.82	-.940
44	14246900	11-19-92	09-08-03	118	6	1.37	.000	.725	.000	-.524	-93.0
46	32A070	10-05-92	09-10-03	128	0	-.381	-.000	-.409	-.000	-.766	-.545
48	37A090	10-12-92	09-10-03	130	0	.280	.000	.347	.000	1.39	8.98
51	12472900	11-17-92	09-25-03	70	38	11.17	.001	10.9	.001	10.1	151
52	13351000	12-21-92	09-03-03	164	0	**-5.08**	**-.010**	**-4.83**	**-.009**	-3.74	-3.80
53	34A070	10-06-92	09-09-03	126	0	-1.22	-.001	-1.34	-.001	.586	.246
54	41A070	10-12-93	09-10-03	116	0	-1.34	-.001	-.672	-.000	**-3.42**	**-1.67**
56	13A060	10-26-92	09-22-03	120	1	**7.87**	**.001**	**7.70**	**.001**	7.01	.829
57	10A070	10-27-92	09-24-03	130	3	**7.30**	**.003**	**8.01**	**.003**	**9.76**	**22.3**
61	16A070	10-28-92	09-23-03	130	25	**9.61**	**.001**	**10.3**	**.001**	**12.5**	**1.98**
63	09A190	10-19-92	09-24-03	131	34	**23.2**	**.001**	**22.3**	**.001**	**18.3**	**1.35**
64	45A070	10-12-92	09-08-03	127	34	4.90	.000	4.82	.000	4.21	.745
66	09A080	10-21-92	09-24-03	128	1	1.76	.000	1.70	.000	.474	.277
70	45A110	10-12-92	09-08-03	126	50	1.24	.000	1.13	.000	.675	.138
71	16C090	10-25-93	09-23-03	115	65	1.06	.000	.939	.000	.527	.016
73	54A120	10-06-92	09-08-03	130	8	3.65	.001	3.85	.001	3.00	5.85
74	07D050	10-19-92	09-22-03	119	19	4.86	.001	4.69	.001	4.06	2.89
75	07C070	10-19-92	09-22-03	117	48	-.050	-.000	.177	.000	1.11	.436
76	07A090	10-19-92	09-22-03	131	27	2.41	.000	2.38	.000	2.27	3.47
77	53A070	10-14-92	09-08-03	119	56	-1.19	-.000	-1.19	-.000	-1.20	-27.9
78	48A070	10-13-92	09-09-03	129	53	**9.12**	**.000**	**8.74**	**.000**	5.89	.371
79	49A070	10-13-92	09-09-03	126	9	1.48	.000	-.196	-.000	-3.58	-3.54
80	48A140	10-13-92	09-09-03	118	53	**13.9**	**.000**	**13.3**	**.000**	9.50	.422
81	03A060	10-21-92	09-22-03	130	24	.508	.000	0.552	.000	.612	3.17
84	01A050	10-20-92	09-23-03	128	3	3.46	.001	3.99	.001	4.75	7.25
87	61A070	10-07-92	09-07-03	132	69	-3.07	-.000	-3.04	-.000	-2.92	-73.5
89	13092747	10-14-93	09-23-03	106	0	-.158	-.000	-1.44	-.001	**-5.38**	**-1.46**
91	13154500	11-04-92	09-24-03	136	0	-1.21	-.001	-.804	-.001	-2.50	-44.0
93	13206000	11-02-92	09-16-03	93	1	3.34	.003	3.40	.003	3.32	4.71
97	12413470	11-18-92	09-08-03	117	8	**8.61**	**.001**	**8.75**	**.001**	8.32	.719
99	12419000	10-07-92	09-03-03	112	22	-3.42	-.000	-3.30	-.000	-4.04	-4.36

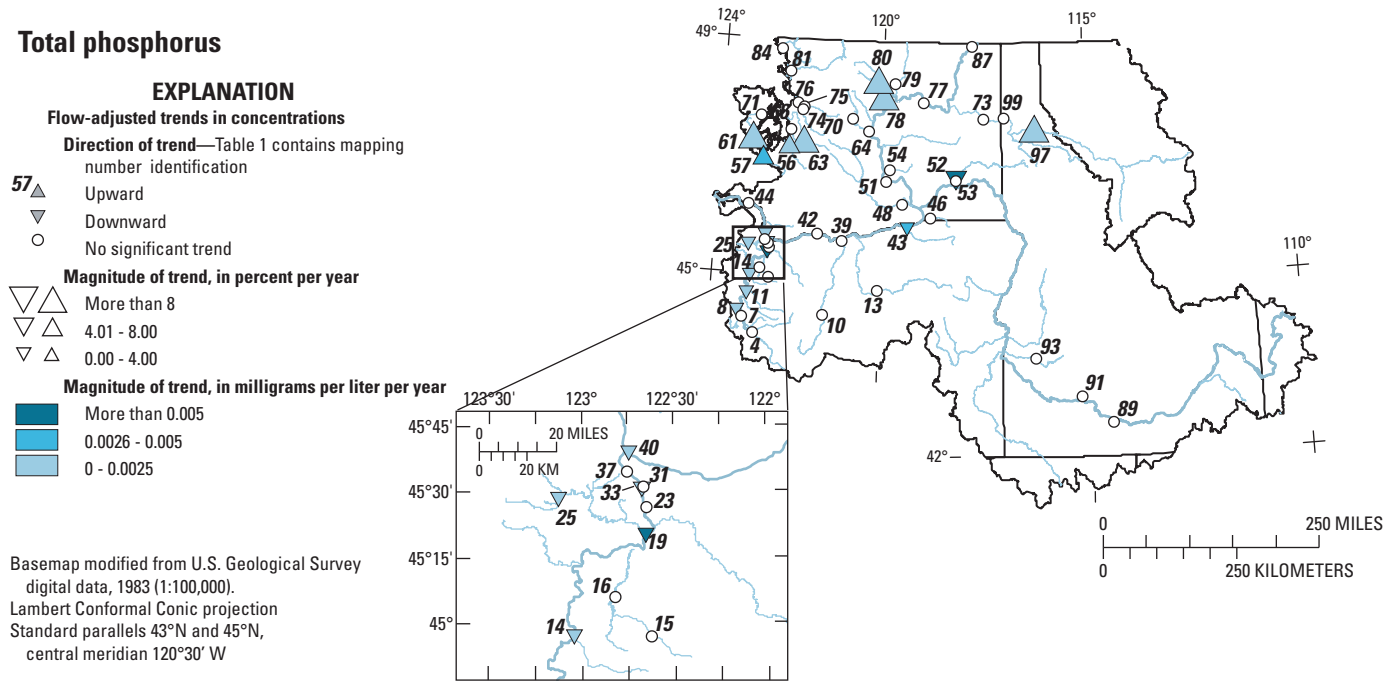


Figure 31. Flow-adjusted trends in concentrations of total phosphorus, Columbia River and Puget Sound basins, water years 1993–2003.

Puyallup River (fig. 1, site 57), and Skokomish River (fig. 1, site 61). In these catchments, more than 14 percent of the land cover was urban, and less than 9 percent was agriculture. In the eastern side of the Columbia Basin, increasing FATCs for TP were observed in the Methow River (fig. 1, sites 78 and 80) and South Fork Coeur d'Alene River (fig. 1, site 97). These catchments were predominately forested with low agricultural and urban use. Twenty-two of the 24 sites with increasing (but not necessarily significant) FATC for TP were in catchments with less than 15 percent agricultural land, whereas the FATC for TP at 14 sites in catchments with more than about 15 percent agricultural land generally decreased (one-half were significant). Increasing FATC for TP was measured (but not significant) at two larger integrator sites (the Columbia River at Vernita Bridge [fig. 1, site 51] and the Willamette River at Portland [fig. 1, site 33], located in catchments with 18.4 and 22.7 percent agricultural land, respectively).

Suspended Sediment

Complete results from the trend analysis for SS are shown in table 21, and figure 32 shows the FATC for SS at each available trend site in the study area. Nineteen (40 percent) of the 48 sites had significant FATC for SS (4 increasing, 15 decreasing, and 2 sites had insufficient water-quality data to determine trends). Trend in load for SS was observed at seven sites (one increasing, six decreasing). More than 65 percent of the sites had decreasing (but not necessarily significant) FATC and trend in load for SS. All six sites with decreasing trends in load for SS also had decreasing FATC for SS, and one site with an increasing trend in load for SS also had an increasing FATC for SS. Five of the six sites with decreasing trend in load for SS had no trend in streamflow, indicating that the decreasing FATC for SS at these sites was the cause of the decreasing trend in load. At the sixth site, Rock Creek [fig. 1, site 89]), both FATC and trend in streamflow were decreasing, meaning that either could have contributed to the decreasing trend in load at this site.

Significant increasing FATC for SS were measured at four sites: Long Tom River (fig. 1, site 8, with an average increase of 0.6 mg/L/yr from 1993 to 2003) and Hood River (fig. 1, site 42, 1.1 mg/L/yr), which are agricultural catchments; Deschutes River (fig. 1, site 10, 0.1 mg/L/year), a predominately forested and undeveloped catchment; and Willamette River at Salem (fig. 1, site 14, 0.2 mg/L/yr), which integrates runoff from a mix of forested, agricultural, and urban lands. The increasing FATC for SS in the Hood River (fig. 33) was most likely the result of high elevation rain on Mt. Hood in late September, early October 2000. The rain caused a glacial outwash of sediment that filled the Hood River channel and took several years to wash out. This increase in trend probably will not continue at this site, unless another glacial outwash occurs.

Table 21. Flow-adjusted trends in concentration, non-flow-adjusted trends in concentration, and trends in annual loads for suspended sediment in the Columbia River and Puget Sound basins, water years 1993–2003.

[Sites can be located in figure 1 by the Map index No. **Bold** values indicate trends significant at a less than or equal to 0.05 *p*-level. **Abbreviations:** FATC, flow-adjusted trends in concentration; NFATC, non-flow-adjusted trends in concentration]

Map index No.	Site No.	Water quality				FATC		NFATC		Load trend	
		Start date	End date	Number of observations	Number of observations below reporting limit	Percent per year	Milligrams per liter per year	Percent per year	Milligrams per liter per year	Percent per year	Kilograms per day per year
4	10386	10-20-92	08-12-03	60	4	2.16	0.034	1.58	0.025	0.653	88.9
7	10355	10-20-92	08-12-03	128	0	3.28	.061	2.23	.042	.958	405
8	11140	10-20-92	08-12-03	59	0	**11.4**	**.581**	**10.0**	**.509**	5.07	202
10	10508	11-01-93	09-22-03	68	6	**5.98**	**.092**	6.16	.094	6.47	211
11	10350	10-21-92	08-12-03	127	0	1.48	.070	.335	.016	-1.11	-1,470
13	11478	10-14-92	09-03-03	62	0	2.15	.068	-.932	-.029	-4.68	-429
14	10555	10-21-92	08-12-03	126	0	**4.74**	**.186**	3.16	.124	1.32	2,340
15	14200400	10-14-93	09-03-03	98	1	**-6.58**	**-.355**	**-7.04**	**-.380**	**-7.63**	**-19.9**
16	14201300	100-4-93	09-03-03	130	1	**-4.48**	**-.608**	**-5.94**	**-.806**	**-7.82**	**-16.8**
23	11321	10-28-92	08-11-03	59	0	2.28	.093	1.53	.063	-.907	-4.96
31	10611	10-21-92	09-09-03	132	0	.607	.030	-.179	-.009	-1.52	-4,960
33	14211720	11-16-92	09-10-03	144	0	**-3.15**	**-.343**	**-3.79**	**-.412**	-4.60	-32,500
37	10332	10-21-92	08-06-03	60	0	.651	.031	.038	.002	-1.34	-4,180
39	10411	10-26-92	08-18-03	63	0	3.80	.204	3.85	.207	3.87	2,820
40	10616	10-21-92	08-06-03	57	0	-1.14	-.069	-1.94	-.117	-2.46	-61,700
42	12012	06-21-93	08-18-03	67	4	**76.0**	**1.07**	**72.4**	**1.02**	**68.8**	**1,770**
43	11489	10-26-92	08-18-03	99	0	**-4.15**	**-.283**	-3.26	-.221	-1.99	-66.5
44	14246900	11-19-92	09-08-03	142	1	1.77	.243	-.480	-.066	-1.58	-121,000
46	32A070	10-05-92	09-10-03	128	0	**-6.31**	**-3.43**	**-6.35**	**-3.45**	**-6.47**	**-2,230**
48	37A090	10-12-92	09-10-03	132	0	**-4.89**	**-1.27**	-4.44	-1.15	-3.93	-6,230
51	12472900	11-17-92	09-25-03	70	2	-.547	-.012	-.669	-.014	-1.01	-5,900
52	13351000	12-21-92	09-03-03	171	0	**-8.26**	**-8.27**	**-8.04**	**-8.04**	-7.72	-3,870
53	34A070	10-06-92	09-09-03	129	0	**-6.00**	**-2.16**	**-5.55**	**-2.00**	-4.67	-829
54	41A070	10-12-93	09-10-03	117	0	-1.33	-.344	.439	.113	-2.63	-454
56	13A060	10-26-92	09-22-03	119	2	-.113	-.005	-.519	-.025	-.872	-26.1
57	10A070	10-27-92	09-24-03	131	0	4.03	1.89	6.13	2.88	7.69	22,500
61	16A070	10-28-92	09-23-03	131	9	**-3.90**	**-.161**	-3.19	-.132	-2.52	-174
63	09A190	10-19-92	09-24-03	131	10	-1.84	-.034	-2.36	-.043	-3.22	-86.5
64	45A070	10-12-92	09-08-03	128	1	-2.04	-.063	-2.19	-.068	-2.49	-355
66	09A080	10-21-92	09-24-03	129	0	-1.51	-.137	-2.09	-.190	-2.89	-601
70	45A110	10-12-92	09-08-03	128	18	-2.62	-.072	-2.83	-.078	-3.11	-388
71	16C090	10-25-93	09-23-03	116	42	3.98	.046	3.36	.039	2.86	25.1
73	54A120	10-06-92	09-08-03	132	9	-.558	-.014	-.779	-.020	-1.33	-348
74	07D050	10-19-92	09-22-03	119	1	.167	.012	-.273	-.020	-.680	-318
75	07C070	10-19-92	09-22-03	117	3	**-5.46**	**-.286**	**-5.18**	**-.271**	-4.79	-1,620
76	07A090	10-19-92	09-22-03	131	1	-1.81	-.122	-1.88	-.127	-1.95	-2,240
77	53A070	10-14-92	09-08-03	119	51	-1.60	-.016	-1.60	-.017	-1.61	-3,920
78	48A070	10-13-92	09-09-03	130	21	**-2.96**	**-.074**	**-3.33**	**-.083**	-4.26	-214
79	49A070	10-13-92	09-09-03	127	3	-1.75	-.197	-4.34	-.489	-6.16	-4,000
80	48A140	10-13-92	090-9-03	118	24	-1.32	-.020	-1.73	-.027	-2.98	-78.1
81	03A060	10-21-92	09-22-03	130	1	-1.74	-.421	-1.67	-.403	-1.63	-13,600
84	01A050	10-20-92	09-23-03	128	0	-.752	-.216	.016	.005	.553	1,140
87	61A070	10-07-92	09-07-03	132	14	-.986	-.019	-.852	-.016	-.682	-2,910
89	13092747	10-14-93	09-23-03	106	0	**-6.03**	**-4.29**	**-7.95**	**-5.67**	**-8.92**	**-2,070**
91	13154500	11-04-92	09-24-03	135	0	**-6.10**	**-1.53**	**-6.60**	**-1.65**	**-7.12**	**-45,500**
93	13206000	11-02-92	09-16-03	92	0	**-6.84**	**-1.44**	**-6.85**	**-1.44**	-6.87	-2,270
97	12413470	11-18-92	09-08-03	208	0	**-5.58**	**-.225**	**-5.60**	**-.226**	**-5.69**	**-180**
99	12419000	11-10-92	09-03-03	75	1	-3.00	-.053	-3.18	-.056	-3.94	-660

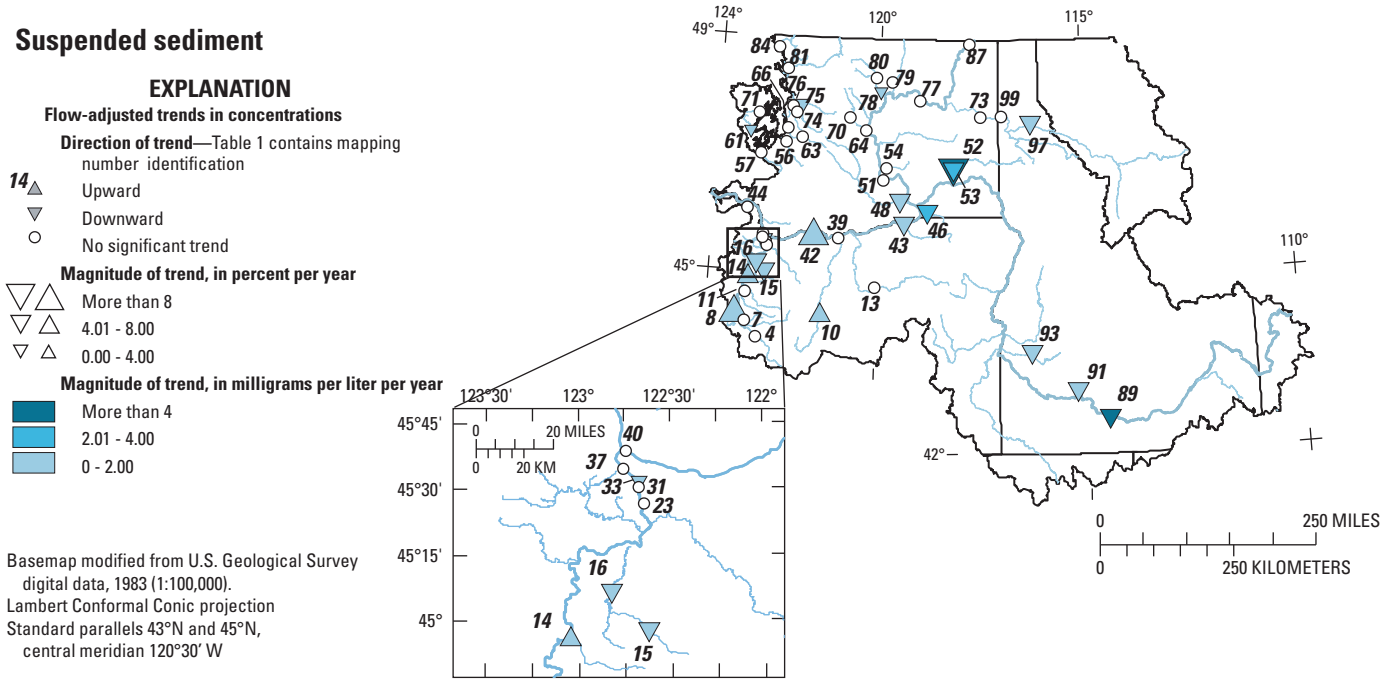


Figure 32. Flow-adjusted trends in concentration of suspended sediment, Columbia River and Puget Sound basins, water years 1993–2003.

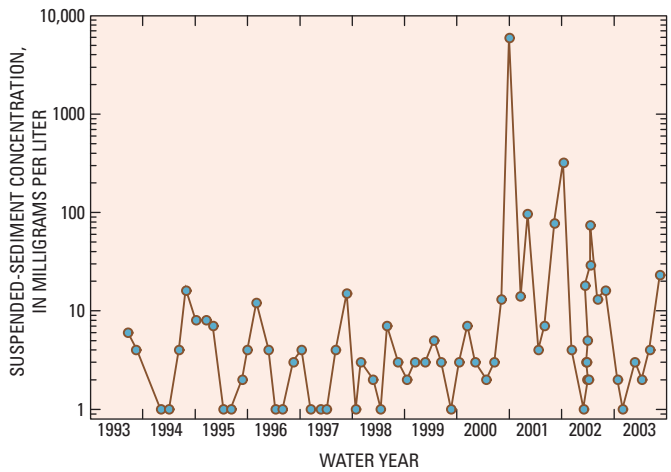


Figure 33. Measured suspended-sediment concentrations, Hood River, Oregon, water years 1993–2003.

Decreasing FATC for SS were measured at four of the five sites in Idaho: Boise River (fig. 1, site 93), Snake River (fig. 1, site 91), Rock Creek (fig. 1, site 89), and South Fork Coeur d'Alene River (fig. 1, site 97). The fifth site, the Spokane River (fig. 1, site 99), also had a decreasing (but not significant) FATC for SS. Three sites in the Willamette River Basin had significant decreasing FATC for SS: Willamette River at Portland (fig. 1, site 33), Zollner Creek (fig. 1, site 16), and Little Abiqua Creek (fig. 1, site 15). Two sites had significant increasing FATC for SS: Long Tom River (fig. 1, site 8) and Willamette River at Salem (fig. 1, site 14). Six sites in the Willamette River Basin had increasing (but not significant) FATC for SS: Middle Fork Willamette River (fig. 1, site 4), Willamette River at Harrisburg (fig. 1, site 7), Albany (fig. 1, site 11), Hawthorne Bridge (fig. 1, site 31), and SP&S Railroad Bridge (fig. 1, site 37), and Johnson Creek (fig. 1, site 23).

Decreasing FATC for SS were measured at three of the four sites with the largest percentages of agricultural land, ranging from about 42 to 95 percent: Zollner Creek (fig. 1, site 16, 95.2 percent agricultural land); Palouse River (fig. 1, sites 52 and 53, 72.5 percent); and Walla Walla River (fig. 1, site 46, 56.1 percent). One site (Crab Creek [fig. 1, site 54, 42.2 percent]), showed decreasing FATC for SS that was not significant. The Walla Walla River, Palouse River, and Crab Creek are in southeastern Washington, and Zollner Creek is in the Willamette River Basin, Oregon. Other than at these four sites, the percentage of agricultural land in a basin did not appear to be related to the increasing or decreasing FATC for SS.

Trends in Relation to Changes in Nutrient Sources and Landscape Characteristics

Ancillary data on (1) nitrogen and phosphorus loads for fertilizer and manure use for farm and on-farm applications, (2) nitrogen loads from atmospheric deposition, and (3) nitrogen and phosphorus loads from point sources (table 22) were acquired for 45 trend catchments. For this study, point-source nutrient loads were estimated only for CY 2000, and total fertilizer and manure applications were estimated only for CYs 1992, 1997, and 2002, because manure estimates were available only for those 3 years. Because of the scarcity of nutrient data from point sources for the 1993–2003 period, temporal changes in point-source input trends generally were not assessed in this report; however, the relative importance of point-source discharges, on the basis of CY 2000 data, is addressed in relation to their potential effect on the trend results.

Estimates of point- and nonpoint-source contributions of nitrogen and phosphorus are shown in table 22 and figure 26. Point-source loads could have an immediate effect on water quality and trends, because the effluent generally is piped directly into the stream, whereas the transport of nutrients from nonpoint sources (for example, land applications of inorganic fertilizers and manure) generally is delayed by the timing of erosional processes or by way of seepage into the ground water, which eventually discharges to the streams. Nutrients from nonpoint sources first contact the land surface (for example, impervious surfaces, soil particles, and vegetation) and their transport to the stream is delayed by sorption, biological uptake, and (or) degassing to the atmosphere (for example, denitrification). Eventually, part of the nonpoint-source nutrients will flow into the streams, but the process could take hours to decades depending on the characteristics of the flow path. Soluble nitrate fertilizer not taken up by plants likely will move through the soils into the ground water and gradually seep back to the stream. In contrast, phosphorus fertilizer is more likely to adsorb to soils and erode to streams during periods of intense irrigation or precipitation events, especially during high-flow years. Therefore, land-applied nutrients will likely show a temporal delay in being transported to streams. To some extent, the transport to streams of atmospheric nitrogen also may be delayed; however, during the cold, wet winters in the Pacific Northwest when the soils are saturated and biological uptake is minimal, transport of atmospheric nitrogen is likely to be greater during the large rainfall/snowmelt events.

Of the 43 trend sites with in-stream and point-source TN load estimates, point-source loads accounted for less than 25 percent of the in-stream nitrogen load at 37 sites (86 percent). Of the 44 sites with in-stream and point-source TP load estimates, point-source loads accounted for less than 25 percent of the in-stream phosphorus load at 31 (70 percent) of the sites (table 22). Assuming that (1) a point-source load accounted for 25 percent (or less) of the in-stream load for a catchment, and (2) a decreasing trend in the in-stream nutrient load was 3–4 percent per year (which was typical), the decrease in the point-source load would have to be 12–16 percent or more per year to account for the decreasing trend observed in the stream. Over an 11 year period, this would equal 132–176 percent. Because point-source nutrient loads in most catchments during this period probably increased due to increases in population, a decrease in point-source loads of this magnitude does not seem likely. Consequently, in catchments with point-source loads equal to less than 25 percent of the in-stream load, the trends observed were not likely caused solely by reduced point-source nutrient loads. If this study had focused on seasonal rather than annual trends, the effect of point-source nutrient discharges might have been apparent during periods of low flows, because this is when point-source loads can often contribute a larger part to the in-stream nutrient load. Additionally, seasonal trends would not necessarily be consistent with the annual trend results shown in this report. For example, FATC for TN during summer low flows might have been increasing at a number of sites because of increasing populations, rather than generally decreasing (as was shown in the annual data).

Results from this study indicate that nonpoint-source loads of nutrients probably have decreased over time in many of the catchments. Some data for the Willamette River Basin support this hypothesis. Between 1991 and 2000 the sum of the annual average flows for the largest nutrient point sources in the basin (those contributing close to 90 percent of the total measured point-source flow in 2000) increased from 199 Mgal/d (Tetra Tech, Inc., 1992) to 233 Mgal/d, an increase of 17.3 percent. This increase in total annual average flow corresponded to an increase in population in the basin during this period. In addition, the estimated total annual TP load from a subset of these sources increased by 130 percent from the early 1990's (Tetra Tech, Inc., 1992) to 2000. Although this subset represented only 37 percent of the total TP load in 2000, the trend indicates that total TP load from point sources in the Willamette River Basin increased overall since the early 1990's.

Point sources generally accounted for less than 20 percent of the total load (from point and nonpoint sources) of nitrogen and phosphorus to the trend-site catchments (fig. 26). Except for a few sites, point-source loads were equivalent to less than 10 percent of the land-applied nutrients in fertilizers and manure. In all the trend-site catchments, nonpoint sources of nutrients from land applications of fertilizers and manure exceeded point-source loads and, generally, even nitrogen loads due solely to atmospheric deposition exceeded point-source loads. The few exceptions are shown in table 22.

In spite of the generally small contribution of point-source nutrient loads, they still may have been partially responsible for the significant trends at several sites assessed in this study, especially those sites where the point-source nutrient loads exceeded 25 percent of the in-stream load. These sites were the Willamette River at Highway 99E, Oreg. (Harrisburg) (fig. 1, site 7), the Walla Walla River near Touchet, Wash. (fig. 1, site 46), and the Boise River at

Glenwood, Idaho (fig. 1, site 93) for TN, and the Willamette River at Albany (fig. 1, site 11), at Marion Street (Salem) (fig. 1, site 14), and at Hawthorne Bridge (Portland) (fig. 1, site 31), and the South Fork Coeur d'Alene River near Pinehurst, Idaho (fig. 1, site 97) for TP. The catchment for the Boise River site had the following characteristics: (1) the point-source TN load was 40 percent of the in-stream load, (2) the population increased by about 20 percent from 1990 to 2000 (about 2 percent per year), and (3) the FATC for TN was significant at 2.1 percent per year. These observations indicate that a possible increase in nitrogen load from point sources could have accounted for the increasing FATC for TN. Although the FATC for TP at this site was not significant, it did increase by 3.3 percent per year, indicating that a possible increase in phosphorus load from point sources could have accounted for the increasing FATC for TP. Except for the limited data for the Willamette River basin, temporal point-source data were not available from 1993 through 2003 to accurately assess water-quality trends throughout the region in relation to changes in point-source loads.

Sixteen of the 19 sites with decreasing FATC for TN also had decreasing annual loads of atmospheric nitrogen in their catchments between CY's 1992 and 2002 (ancillary data were not available for three of the catchments). However, no consistent temporal pattern in the load of nitrogen from fertilizers and manure was observed across the 16 catchments during this time period. Zollner Creek near Mt Angel, OR (fig. 1, site 16) and the Boise River at Glenwood, ID (fig. 1, site 93) were the two sites that showed increasing FATC for TN. More than 99 percent of the nitrogen in the Zollner Creek catchment came from land-applied fertilizers and manure, which also had an upward trend in nitrogen application from 1992 to 2002. The increasing FATC for TN in the Boise River catchment could not be explained with the available fertilizer and manure data. However, as discussed above, the increasing FATC for TN and TP at this site might have been due to the influence of point sources. Although data on annual phosphorus loads from fertilizers and manure were available for 13 of the 15 sites having FATC for TP, the trends could not be explained by the annual patterns in the application of phosphorus from fertilizers and manure. However, the limited data on point sources showing large increases in TP loads to the Willamette River Basin between 1991 and 2000 strongly indicate that an overall decrease in nonpoint-source phosphorus load was the reason for the decreasing significant FATC for TP at the three lower Willamette River sites.

Summary and Conclusions

In 1991, the U.S. Geological Survey (USGS) implemented the National Water-Quality Assessment (NAWQA) Program to support national, regional, State, and local information needs and decisions related to water-quality management and policy (http://water.usgs.gov/nawqa). NAWQA was designed to answer the following types of questions: What is the condition of our streams? What are the factors (contaminant sources, loads, and yields) affecting the conditions? Is the water quality changing over time? From 1991 to 2001, the NAWQA Program completed interdisciplinary assessments and established a baseline understanding of water-quality conditions in 51 of the Nation's river basins and aquifers. In the Pacific Northwest, the NAWQA Program has collected long-term water-quality data for the Columbia River and Puget Sound Basins in Oregon, Washington, and Idaho. In addition, other Federal, State, and local agencies also have collected water-quality data in these areas. For this study, multiagency data were compiled and used to provide insights into the recent status of water-quality conditions in the Pacific Northwest; how these conditions have changed over time; and how natural features and (or) human activities may have contributed to these changes.

This study examined three topics that might be of interest to water-resource managers in the Pacific Northwest: (1) Annual loads of total nitrogen (TN), total phosphorus (TP), and suspended sediment (SS) transported through the Columbia River and Puget Sound Basins were estimated for water years 1997 (high-flow), 2000 (average-flow), and 2001 (low-flow); (2) Annual yields (loads divided by catchment areas) of TN, TP, and SS for water year 2000 were compared to differences in landscape and climatic conditions between sub-basin catchments; and (3) Trends in TN, TP, and SS concentrations and loads were calculated for WY 1993–2003 and compared to changes in landscape and climatic conditions in the catchments. Trends in concentrations were determined in two ways: (1) flow-adjusted trend in concentration (FATC) was used to determine water-quality trends in the absence of trends in natural streamflow and (2) non-flow adjusted trend in concentration (NFATC) was used to express the overall trend of exposure to biota resulting from natural and anthropogenic changes. Depending on the constituent, annual loads were estimated for as many as 88 water-quality sites; annual yields were estimated for as many as 81 catchments; and trends were estimated for as many as 50 water-quality sites. The catchments ranged in size from 5 km^2 to more than 650,000 km^2, with most sites between 100 and 10,000 km^2. Although the catchments tended to have large percentages of forested and undeveloped land and small percentages of agricultural and urban land, there were a few catchments where agricultural and/or urban land made up most of the watershed.

Transport of Nutrients and Suspended-Sediment

During WY 2000, total point-source nutrient loads to the catchments generally were equal to a small percentage of the estimated in-stream loads. In 10 percent of the catchments, annual point-source TN loads were greater than 25 percent of the estimated annual in-stream TN load discharged from the catchment, and in 22 percent of the catchments, annual point-source TP loads were greater than 25 percent of the

estimated annual in-stream TP load discharged from the catchment. Point-source nutrient loads generally also were a small percentage of the total nutrient load to the catchments compared to nonpoint sources, such as fertilizer and manure and atmospheric deposition, and loads from sources other than municipal wastewater treatment plants were never more than 5 percent of the total point-source load. However, there were a few examples where point sources comprised as much as 30 percent of the TN load and as much as 80 percent of the TP load to a catchment. In smaller urbanized catchments, point sources tended to contribute more of the total nutrient load when compared to larger catchments with less urbanization. Although point sources contributed very little to the in-stream load of TN and TP in the eight tributaries delivering most of the nutrients to the Puget Sound, the nitrogen and phosphorus loads from point sources discharging directly to the Puget Sound were about equal to the annual loads from those tributaries.

The annual mean load discharged from the Columbia River to the Pacific Ocean was about 570,000 pounds per day of TN, about 55,000 pounds per day of TP, and about 14,000 tons per day of SS. The monitored tributaries contributing the most to the annual nutrient loads in the Columbia River were the Yakima, Snake, Deschutes, and Willamette Rivers (in downstream order). Total annual loads of TN and TP from these tributaries were equal to about 63 percent of the load near the mouth of the Columbia River, whereas the annual SS load from these four tributaries was equal to about 32 percent of the load near the mouth. The estimated annual loads from point sources discharging directly into the Columbia River were equal to less than 10 percent of the annual TN and TP loads near the mouth. Generally, direct point-source discharges of nutrients to the Willamette and Snake Rivers were relatively small when compared to the total nutrient loads these rivers discharged to the Columbia. However, in some reaches of the Willamette River, point sources were responsible for much of the gain in phosphorus load.

The yields of TN, TP, and SS were generally greater in catchments west of the Cascade Range, where precipitation and runoff were greater. A multiple linear regression analysis was performed to determine the relative importance of specific catchment characteristics on yields. Based on the standardized regression coefficients, TN yields were significantly ($p \leq 0.05$) and positively related to precipitation, atmospheric nitrogen loads, fertilizer and manure loads, point-source loads, and were negatively related to average slope. TP yields were significantly and positively related to precipitation and point-source loads, and SS yields were significantly and positively related to precipitation.

Trends in Nutrients and Suspended-Sediment, 1993–2003

For most catchments, the net change in non-hydrologic characteristics (land use and other human activities) was not great enough to cause any significant ($p \leq 0.05$) flow-adjusted trend in concentration (FATC) for TN (52 percent), TP (68 percent), or SS (60 percent) between WY 1993–2003. However, some non-hydrologic changes might still have occurred in these catchments, but either they cancelled out (for example, decreasing non-point source loads and increasing point-source loads) or were too far upstream to have much effect on water quality. Twenty-one of the 44 sites available for TN trend analysis had significant FATC for TN (2 increasing, 19 decreasing). Ten sites showed significant trend in load for TN (all decreasing), and more than 70 percent of the sites had decreasing (but not necessarily significant) FATC and trend in load for TN. Sixteen of the 50 sites available for TP trend analysis had significant FATC for TP (7 increasing and 9 decreasing). Six sites had significant trend in load for TP (3 increasing, 3 decreasing), and about 50 percent of the sites had decreasing (but not necessarily significant) FATC and significant trend in load for TP. Nineteen of the 48 sites available for SS trend analysis had significant FATC for SS (4 increasing, 15 decreasing). Seven sites showed significant trend in load for SS (1 increasing, 6 decreasing), and more than 65 percent of the sites had decreasing (but not necessarily significant) FATC and trend in load for SS. Streamflow at only two of the 50 trend sites had significantly decreasing trends, indicating that almost all trends in load resulted from FATC. The values for NFATC for TN, TP, and SS were similar in magnitude to the values for FATC.

The results from this study indicate that nonpoint sources of nutrients probably have decreased over time in many of the catchments. For the Willamette River Basin, some data supported this hypothesis (total annual flow and TP loads from the major WWTPs in the basin increased between 1991 and 2000). Despite the generally small contribution of point-source nutrient loads, point sources still may have been partially responsible for the significant decreasing FATC for TN at the six sites where the total point-source nutrient loads to the catchments exceeded 25 percent of the in-stream load. Although the decreasing FATC for TP at three lower Willamette River sites could not be explained by the available data on phosphorus load from fertilizer and manure, the limited data on point sources showing large increases in TP loads to the basin between 1991 and 2000 indicate that an overall decrease in nonpoint-source phosphorus load may have been the cause.

Acknowledgments

Technical Review—Richard Alexander (U.S. Geological Survey, Reston, Virginia) and Stuart McKenzie (ret.) and John Williams (U.S. Geological Survey, Portland, Oregon).

Data Compilation—Bruce Fisher, Tana Haluska, Thomas Herrett, Matt Johnston, and Suzanne Miller (U.S. Geological Survey, Portland, Oregon), Naomi Nakagaki (U.S. Geological Survey, Sacramento, California), and Alan Rea (U.S. Geological Survey, Boise, Idaho).

Water Quality and Point-Source Data—Ranei Nomura and Greg Pettit (Oregon Department of Environmental Quality, Portland, Oregon), Carol Johnston (WA Department of Ecology, Olympia, Washington), Jan Miller (Clean Water Services, Hillsboro, Oregon), Janet Gillaspie (Oregon Association of Clean Water Agencies, Portland, Oregon), Dean Marriot (City of Portland, Oregon), Dan Hanthorne (City of Corvallis, Oregon), Ernie Strahm (City of McMinnville, Oregon), Thomas Mendes (City of Eugene, OR), and Alan Johnston (City of Gresham, Oregon).

Streamflow Data—Robert Harmon and Ken Stahr (Oregon Department of Water Resources, Salem, Oregon), and Darrell Hedin (Washington County, Oregon).

References Cited

Bonneville Power Administration, 2005, BPA fast facts, 2005: Bonneville Power Administration, 2 p.

Bureau of Reclamation, 2006, Hydromet: Pacific Northwest Region: Bureau of Reclamation, accessed June 1, 2006, at http://www.usbr.gov/pn/hydromet/.

Clean Water Services, 2006, At a glance: Clean Water Services fact sheet, revised January 2006.

Cohn, T.A., 2005, Estimating contaminant loads in rivers—An application of adjusted maximum likelihood to type 1 censored data: Water Resources Research, v. 41, n. 7, W07003, 13 p.

Ebbert, J.C., Embrey, S.S., Black, R.W., Tesoriero, A.J., and Haggland, A.L., 2000, Water-quality in the Puget Sound Basin, Washington and British Columbia, 1996–98: U.S. Geological Survey Circular 1216, 31 p.

Embrey, S.S., and Inkpen, E.L., 1998, Nutrient transport in rivers of the Puget Sound Basin, Washington 1980–1993: U.S. Geological Survey Water-Resources Investigations Report 97-4270, 30 p.

Foundation for Water and Energy Education, 2000, What makes the Columbia River Basin unique and how we benefit: accessed June 1, 2006, at http://www.fwee.org/c-basin.html.

Fuhrer, G.J., Tanner, D.Q., Morace, J.L., McKenzie, S.W., and Skach, K.A., 1996, Water quality of the lower Columbia River Basin: Analysis of current and historical water-quality data through 1994: Water-Resources Investigations Report 95-4294, 157 p.

Gilliom, R.J., Hamilton, P.A., and Miller, T.L., 2001, The National Water-Quality Assessment Program—Entering a new decade of investigations: U.S. Geological Survey Fact Sheet 071-01, 6 p.

Gray, J.R., Glysson, G.D., Turcios, L.M., and Schwarz, G.E., 2000, Comparability of suspended-sediment concentration and total suspended solids data: U.S. Geological Survey Water-Resources Investigations Report, 00-4191, 14 p.

Hallock, D., 2005, A comparison of water quality data collected from two Washington rivers by the Department of Ecology and the U.S. Geological Survey: Washington State Department of Ecology, Environmental Assessment Program, Publication No. 05-03-009, 22 p.

Hirsch, R.M., Hamilton, P.A., and Miller, T.L., 2006, U.S. Geological Survey perspective on water-quality monitoring and assessment: Journal of Environmental Monitoring, v. 8, p. 512-518.

Insightful Corporation, 2002, S-PLUS for Windows professional edition—Release 1: Seattle, Wash., Insightful Corporation, original copyright, 1988.

Martin, G.R., Smoot, J.L., and White, K.D., 1992, A comparison of surface-grab and cross sectionally integrated streamwater-quality sampling methods: Water Environment Research, v. 64, no. 7, p. 866-879.

Nakagaki, Naomi, and Wolock, D.M., 2005, Estimation of agricultural pesticide use in drainage basins using land cover maps and county pesticide data: U.S. Geological Survey Open-File Report 2005-1188, 46 p.

Oregon Water Resources Division, 2006, Oregon surface water resources: Oregon Water Rresources Department, accessed June 1, 2006, at http://www.wrd.state.or.us/OWRD/SW/index.shtml

Ott, R.L., 1993, An introduction to statistical methods and data analysis, 4th ed.: Belmont, Calif., Wadsworth, Inc., 1051 p.

Pacific Northwest Water Quality Exchange, 2006, A National Environmental Information Exchange Network Project: accessed June 1, 2006, at http://deq12.deq.state.or.us/pnwwqx/.

Runkel, R.L., Crawford, C.G., and Cohn, T.A., 2004, Load estimator (LOADEST)—A FORTRAN program for estimating constituent loads in streams and rivers: U.S. Geological Survey Techniques and Methods Book 4, Chap. A5, 69 p.

Schwarz, G.E., Hoos, A.B., Alexander, R.B., and Smith, R.A., 2006, The SPARROW surface water-quality model—Theory, applications and user documentation: U.S. Geological Survey, Techniques and Methods Book 6, Chap. B3, 248 p., CD-ROM, accessed December 19, 2006, at http://pubs.usgs.gov/tm/2006/tm6b3/

Staubitz, W.W., 1994, National Water-Quality Assessment Program—Puget Sound Basin, Washington: U.S. Geological Survey Open-File Report 94-108, 2 p.

Tetra Tech, Inc., 1992, Willamette River Basin water quality study, Component 7—Point source discharges and waste loading to the Willamette River Basin during 1991: Tetra Tech, Inc., 61 p.

Tetra Tech, Inc., 1998, Documentation of phase I and phase II activities in support of point source nutrient loading analysis in the Mississippi River system: Tetra Tech, Inc., 19 p.

U.S. Census Bureau, 2001, Population change and distribution: U.S. Census Bureau, 7 p.

U.S. Environmental Protection Agency, 1996, The USEPA Reach File Version 1.0 (RF1) for the Conterminous United States (CONUS): U.S. Environmental Protection Agency.

U.S. Environmental Protection Agency, 2006a, Envirofacts data warehouse: U.S. Environmental Protection Agency, accessed August 21, 2006, at http://www.epa.gov/enviro/html/pcs/pcs_overview.html

U.S. Environmental Protection Agency, 2006b, STORET database access: U.S. Environmental Protection Agency, accessed June 1, 2006, at http://www.epa.gov/storet/dbtop.html

U.S. Geological Survey, 1998, National water information system (NWIS): U.S. Geological Survey Fact Sheet FS-027-98, 2 p.

U.S. Geological Survey, 2002, Monitoring and assessing our Nation's water quality: U.S. Geological Survey Fact Sheet FS-076-02, 4 p.

U.S. Geological Survey, 2006, NAWQA surface water ancillary data: U.S. Geological Survey National Land Cover Data 1992 enhanced with GIRAS then revised with 2000 Population.

Washington County, Oregon, 2006, Tualatin River watershed: Watermaster, District 18, accessed June 1, 2006, at http://www.co.washington.or.us/deptmts/wtr_mstr/wtr_mstr.htm

Washington State Department of Ecology, 2004, River and stream water quality monitoring: Washington State Department of Ecology, accessed June 1, 2006, at http://www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html

Table 22. Summary of sources and stream annual loads for total nitrogen and total phosophorus in the Columbia River and Puget Sound basins, water year 2000 and calendar year 2002.

[**Abbreviations:** TN, total nitrogen; lb, pound; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; NA, either an annual instream load was not calculated or no catchment delineation was available to base point-source and nonpoint-source loads]

Map index No.	Site No.	Trend site	Site name	Water year 2000 (lb)		Calendar year 2002 (lb)		Catchment point-source TN load as a percentage of in-stream load
				Estimated annual instream load	Estimated annual total catchment point-source load	Estimated annual nitrogen load from fertilizer and manure	Estimated annual nitrogen load from atmospheric deposition	
			Total nitrogen					
1	10729		Owyhee River at Hwy 201 Bridge (Owyhee), OR	634,000	NA	NA	NA	NA
2	MAL113		North Fork Malheur River approximately 2 miles upstream of Beulah Reservoir, OR	NA	NA	367,000	88,500	NA
3	MAL144		Malheur River at Ford south of Vale 1.1 miles upstream of Bully Creek, OR	NA	NA	13,000,000	1,150,000	NA
4	10386	X	Middle Fork Willamette River at Jasper Bridge, OR	NA	NA	934,000	541,000	NA
5	10663		Mohawk River at Hill Road, OR	NA	NA	428,000	84,100	NA
6	10376		McKenzie River at Coburg Road, OR	NA	NA	NA	NA	NA
7	10355	X	Willamette River at Hwy 99E (Harrisburg), OR	5,770,000	1,920,000	6,720,000	1,440,000	33.2
8	11140	X	Long Tom River at Stow Pit Road (Monroe), OR	1,110,000	0	6,380,000	226,000	.00
9	12657		McKenzie River at Hwy 126 downstream Clear Lake, OR	NA	NA	16,700	38,700	NA
10	10508	X	Deschutes River at Lower Bridge, OR	447,000	0	2,360,000	650,000	.00
11	10350	X	Willamette River at Albany (Eastbound Hwy 20 Bridge), OR	14,000,000	2,220,000	46,000,000	2,240,000	15.9
12	11490		Powder River at Hwy 7 (in Baker City), OR	78,000	0	1,110,000	93,400	.00
13	11478	X	John Day River at Service Creek, OR	912,000	0	5,640,000	1,490,000	.00
14	10555	X	Willamette River at Marion Street (Salem), OR	24,100,000	3,110,000	91,400,000	3,610,000	12.9
15	14200400	X	Little Abiqua Creek near Scotts Mills, OR	47,000	0	23,100	6,620	.00
16	14201300	X	Zollner Creek near Mt. Angel, OR	486,000	0	1,820,000	11,000	.00
17	10640		Pudding River at Hwy 211 (Woodburn), OR	43,000,000	123,000	23,600,000	211,000	2.87
18	13070		Clackamas River at Mciver Park. (Upper Boat Ramp), OR	NA	NA	372,000	587,000	NA
19	3701002	X	Tualatin River at Weiss Bridge, OR	6,060,000	1,780,000	20,600,000	603,000	29.3
20	3840012		Fanno Creek at Durham Road, OR	NA	NA	400,000	28,900	NA
21	14206950		Fanno Creek near Durham, OR	NA	NA	400,000	28,900	NA
22	3701715		Tualatin River at Cherry Grove, OR	NA	NA	37,400	28,400	NA
23	11321	X	Johnson Creek at SE 17th Avenue (Portland), OR	476,000	0	1,410,000	52,600	.00
24	3701333		Tualatin River at Farmington Bridge Road, OR	3,840,000	1,010,000	15,000,000	473,000	26.3
25	3701612	X	Tualatin River at Springhill Road Bridge (Dilley), OR	512,000	0	2,200,000	98,300	.00
26	11386		John Day River at Hwy 206, OR	NA	NA	NA	NA	NA
27	3805048		Scoggins Creek below Hagg Lake at Stimson Bridge, OR	68,400	0	101,000	31,200	.00
28	3701391		Tualatin River at Rood Bridge Road, OR	2,630,000	1,520,000	12,400,000	392,000	5.77
29	3701528		Tualatin River at Golf Course Road, OR	934,000	0	3,770,000	171,000	.00
30	3810015		Gales Creekk at New Hwy 47, OR	308,000	0	766,000	60,400	.00
31	10611	X	Willamette River at Hawthorne Bridge (Portland), OR	55,500,000	8,900,000	201,000,000	6,650,000	16.1
32	3820012		Rock Creek at Hwy 8, OR	NA	NA	1,850,000	68,100	NA
33	14211720	X	Willamette River at Portland, OR	58,600,000	8,900,000	201,000,000	6,650,000	15.2
34	3850006		Dawson Creekk at Brookwood, OR	14,600	0	203,000	3,330	.00
35	3824020		Bronson Creek at Bronson Park Downstream of Sunset Hwy, OR	7,350	0	78,800	3,650	.00
36	3824072		Bronson Creek at Saltzman, OR	2,750	0	54,200	1,880	.00
37	10332	X	Willamette River at SP&S Railroad Bridge, OR	57,400,000	NA	NA	NA	NA
38	14128910		Columbia River at Warrendale,OR	155,000,000	14,500,000	1,260,000,000	122,000,000	9.31
39	10411	X	Deschutes River at Deschutes River Park, OR	3,870,000	0	33,200,000	4,680,000	.00

Table 22. Summary of sources and stream annual loads for total nitrogen and total phosophorus in the Columbia River and Puget Sound basins, water year 2000 and calendar year 2002.—Continued

[**Abbreviations:** lb, pound; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; NA, either an annual instream load was not calculated or no catchment delineation was available to base point-source and nonpoint-source loads]

Map index No.	Site No.	Trend site	Site name	Catchment				
				Fertilizer and manure nitrogen load as a percentage of instream load	Atmospheric nitrogen deposition as a percentage of instream load	Point-source loads (percentage)		
						Fertilizer and manure nitrogen application	Atmos-pheric nitrogen deposition	Total land-applied nitrogen
			Total nitrogen—Continued					
1	10729		Owyhee River at Hwy 201 Bridge (Owyhee), OR	NA	NA	NA	NA	NA
2	MAL113		North Fork Malheur River approximately 2 miles upstream of Beulah Reservoir, OR	NA	NA	NA	NA	NA
3	MAL144		Malheur River at Ford south of Vale 1.1 miles upstream of Bully Creek, OR	NA	NA	NA	NA	NA
4	10386	X	Middle Fork Willamette River at Jasper Bridge, OR	NA	NA	NA	NA	NA
5	10663		Mohawk River at Hill Road, OR	NA	NA	NA	NA	NA
6	10376		McKenzie River at Coburg Road, OR	NA	NA	NA	NA	NA
7	10355	X	Willamette River at Hwy 99E (Harrisburg), OR	116	25.0	28.5	133	23.5
8	11140	X	Long Tom River at Stow Pit Road (Monroe), OR	575	20.3	.00	.00	.00
9	12657		McKenzie R. at Hwy 126 downstream Clear Lake, OR	NA	NA	NA	NA	NA
10	10508	X	Deschutes River at Lower Bridge, OR	528	146	.00	.00	.00
11	10350	X	Willamette River at Albany (Eastbound Hwy 20 Bridge), OR	329	16.0	4.83	99.1	4.60
12	11490		Powder River at Hwy.7 (in Baker City), OR	1,423	120	.00	.00	.00
13	11478	X	John Day River at Service Creek, OR	618	163	.00	.00	.00
14	10555	X	Willamette River at Marion Street (Salem), OR	379	15.0	3.40	86.1	3.27
15	14200400	X	Little Abiqua Creek near Scotts Mills, OR	49.1	14.1	.00	.00	.00
16	14201300	X	Zollner Creek near Mt. Angel, OR	374	2.27	.00	.00	.00
17	10640		Pudding River at Hwy. 211 (Woodburn), OR	54.9	4.90	.52	58.3	.52
18	13070		Clackamas River at Mciver Park (Upper Boat Ramp), OR	NA	NA	NA	NA	NA
19	3701002	X	Tualatin River at Weiss Bridge, OR	340	9.95	8.61	295	8.36
20	3840012		Fanno Creek at Durham Road, OR	NA	NA	NA	NA	NA
21	14206950		Fanno Creek near Durham, OR	NA	NA	NA	NA	NA
22	3701715		Tualatin River at Cherry Grove, OR	NA	NA	NA	NA	NA
23	11321	X	Johnson Creek at SE 17th Avenue (Portland), OR	296	11.0	.00	.00	.00
24	3701333		Tualatin River at Farmington Bridge Road, OR	391	12.3	6.75	214	6.54
25	3701612	X	Tualatin River at Springhill Road Bridge (Dilley), OR	430	19.2	.00	.00	.00
26	11386		John Day River at Hwy 206, OR	NA	NA	NA	NA	NA
27	3805048		Scoggins Creek below Hagg Lake at Stimson Bridge, OR	148	45.6	.00	.00	.00
28	3701391		Tualatin River at Rood Bridge Road, OR	471	14.9	1.22	388	1.18
29	3701528		Tualatin River at Golf Course Road, OR	404	18.3	.00	.00	.00
30	3810015		Gales Creekk at New Hwy 47, OR	249	19.6	.00	.00	.00
31	10611	X	Willamette River at Hawthorne Bridge (Portland), OR	362	12.0	4.42	134	4.28
32	3820012		Rock Creek at Hwy 8, OR	NA	NA	NA	NA	NA
33	14211720	X	Willamette River at Portland, OR	343	11.3	4.42	134	4.28
34	3850006		Dawson Creekk at Brookwood, OR	1,390	22.9	.00	.00	.00
35	3824020		Bronson Creek at Bronson Park downstream of Sunset Hwy, OR	1,072	49.7	.00	.00	.00
36	3824072		Bronson Creek at Saltzman, OR	1,971	68.3	.00	.00	.00
37	10332	X	Willamette River at SP&S Railroad Bridge, OR	NA	NA	NA	NA	NA
38	14128910		Columbia River at Warrendale, OR	813	78.5	1.15	11.9	1.05
39	10411	X	Deschutes River at Deschutes River Park, OR	858	121	.00	.00	.00

Table 22. Summary of sources and stream annual loads for total nitrogen and total phosophorus in the Columbia River and Puget Sound basins, water year 2000 and calendar year 2002.—Continued

[**Abbreviations:** lb, pound; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; NA, either an annual instream load was not calculated or no catchment delineation was available to base point-source and nonpoint-source loads]

Map index No.	Site No.	Trend site	Site name	Water year 2000 (lb)		Calendar year 2002 (lb)		Catchment point-source TN load as a percentage of in-stream load
				Estimated annual instream load	Estimated annual total catchment point-source load	Estimated annual nitrogen load from fertilizer and manure	Estimated annual nitrogen load from atmospheric deposition	
			Total nitrogen—Continued					
40	10616	X	Columbia River at Marker #47 (upstream of Willamette River), OR	167,000,000	NA	NA	NA	NA
41	10406		Umatilla River at Hwy 11 (Pendleton), OR	280,000	0	1,110,000	121,000	0.00
42	12012	X	Hood River at footbridge downstream of I-84, OR	NA	NA	NA	NA	NA
43	11489	X	Umatilla River at Westland Road (Hermiston), OR	1,460,000	NA	NA	NA	NA
44	14246900	X	Columbia River at Beaver Army Terminal near Quincy, OR	209,000,000	24,700,000	1,270,000,000	127,000,000	11.8
45	27D090		East Fork Lewis River near Dollar Corner, WA	675,000	0	208,000	152,000	.00
46	32A070	X	Walla Walla River near Touchet, WA	889,000	759,000	26,800,000	807,000	85.4
47	13353200		Snake River at Burbank, WA	62,700,000	5,000,000	692,000,000	50,600,000	7.98
48	37A090	X	Yakima River at Kiona, WA	7,100,000	1,740,000	62,100,000	4,420,000	24.4
49	12510500		Yakima River at Kiona, WA	7,690,000	1,740,000	62,100,000	4,420,000	22.6
50	12505450		Granger Drain at Granger, WA	299,000	0	2,930,000	39,900	.00
51	12472900	X	Columbia River at Vernita Bridge near Priest Rapids Dam, WA	52,900,000	3,500,000	165,000,000	21,100,000	6.63
52	13351000	X	Palouse River at Hooper, WA	6,790,000	239,000	39,400,000	1,740,000	3.52
53	34A070	X	Palouse River at Hooper. WA	6,690,000	239,000	39,400,000	1,740,000	3.58
54	41A070	X	Crab Creek near Beverly, WA	NA	NA	9,680,000	255,000	NA
55	12471400		Lind Coulee Wasteway at SR 17 near Warden, WA	996,000	0	18,500,000	482,000	.00
56	13A060	X	Deschutes River at E. Street Bridge, WA	633,000	0	1,040,000	76,000	.00
57	10A070	X	Puyallup River at Meridian Street, WA	2,380,000	146,000	2,580,000	760,000	6.12
58	12108500		Newaukum Creek near Black Diamond, WA	NA	NA	812,000	22,700	NA
59	12464770		Crab Creek at Rocky Ford Road near Ritzville, WA	320,000	0	5,400,000	324,000	.00
60	12061500		Skokomish River near Potlatch, WA	NA	NA	109,000	76,100	NA
61	16A070	X	Skokomish River near Potlatch, WA	234,000	0	109,000	76,100	.00
62	12112600		Big Soos Creek above hatchery near Auburn, WA	NA	NA	414,000	54,900	NA
63	09A190	X	Green River at Kanaskat, WA	387,000	0	46,700	206,000	.00
64	45A070	X	Wenatchee River at Wenatchee, WA	1,020,000	550	2,150,000	1,280,000	.05
65	12113375		Springbrook Creek at Tukwila, WA	NA	NA	105,000	16,000	NA
66	09A080	X	Green River at Tukwila, WA	1,410,000	0	2,500,000	402,000	.00
67	12113390		Duwamish River at golf course at Tukwila, WA	1,900,000	54,300	2,460,000	389,000	2.85
68	12056500		North Fork Skokomish River below Staircase Rapids near Hoodport, WA	NA	NA	14,200	32,100	NA
69	46A070		Entiat River near Entiat, WA	115,000	0	233,000	404,000	.00
70	45A110	X	Wenatchee River near Leavenworth, WA	595,000	0	157,000	664,000	.00
71	16C090	X	Duckabush River near Brinnon, WA	44,200	0	35,800	38,500	.00
72	12128000		Thorton Creek near Seattle, WA	33,900	0	97,900	9,370	.00
73	54A120	X	Spokane River at Riverside State Park, WA	7,900,000	2,590,000	15,000,000	3,570,000	32.8
74	07D050	X	Snoqualmie River near Monroe, WA	2,950,000	0	1,820,000	635,000	.00
75	07C070	X	Skykomish River at Monroe, WA	1,690,000	0	683,000	757,000	.00
76	07A090	X	Snohomish River at Snohomish, WA	6,960,000	0	4,320,000	1,650,000	.00
77	53A070	X	Columbia River at Grand Coulee, WA	40,600,000	2,690,000	30,100,000	8,260,000	6.62
78	48A070	X	Methow River near Pateros, WA	402,000	0	1,690,000	1,800,000	.00
79	49A070	X	Okanogan River at Malott, WA	1,020,000	199,000	3,710,000	1,620,000	19.5
80	48A140	X	Methow River at Twisp, WA	307,000	0	1,020,000	1,340,000	.00
81	03A060	X	Skagit River near Mount Vernon, WA	5,730,000	158,000	4,340,000	2,400,000	2.76
82	03B050		Samish River near Burlington, WA	557,000	0	507,000	86,300	0.00
83	12213140		Nooksack River at Brenan, WA	NA	NA	9,720,000	794,000	NA
84	01A050	X	Nooksack River at Brennan, WA	4,540,000	54,300	9,570,000	748,000	1.20

Table 22. Summary of sources and stream annual loads for total nitrogen and total phosophorus in the Columbia River and Puget Sound basins, water year 2000 and calendar year 2002.—Continued

[**Abbreviations:** lb, pound; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; NA, either an annual instream load was not calculated or no catchment delineation was available to base point-source and nonpoint-source loads]

Map index No.	Site No.	Trend site	Site name	Catchment				
				Fertilizer and manure nitrogen load as a percentage of instream load	Atmospheric nitrogen deposition as a percentage of instream load	Point-source loads (percentage)		
						Fertilizer and manure nitrogen application	Atmos-pheric nitrogen deposition	Total land-applied nitrogen
			Total nitrogen—Continued					
40	10616	X	Columbia River at Marker #47 (upstream of Willamette River), OR	NA	NA	NA	NA	NA
41	10406		Umatilla River at Hwy 11 (Pendleton), OR	396	43.3	0.00	0.00	0.00
42	12012	X	Hood River at footbridge downstream of I-84, OR	NA	NA	NA	NA	NA
43	11489	X	Umatilla River at Westland Road (Hermiston), OR	NA	NA	NA	NA	NA
44	14246900	X	Columbia River at Beaver Army Terminal near Quincy, OR	608	60.4	1.94	19.4	1.76
45	27D090		East Fork Lewis River near Dollar Corner, WA	30.8	22.5	.00	.00	.00
46	32A070	X	Walla Walla River near Touchet, WA	3,015	90.7	2.83	94.1	2.75
47	13353200		Snake River at Burbank, WA	1,104	80.8	.72	9.88	.67
48	37A090	X	Yakima River at Kiona, WA	875	62.2	2.79	39.4	2.61
49	12510500		Yakima River at Kiona, WA	808	57.5	2.79	39.4	2.61
50	12505450		Granger Drain at Granger, WA	980	13.4	.00	.00	.00
51	12472900	X	Columbia River at Vernita Bridge near Priest Rapids Dam, WA	312	40.0	2.13	16.6	1.88
52	13351000	X	Palouse River at Hooper, WA	580	25.6	.61	13.7	.58
53	34A070	X	Palouse River at Hooper, WA	589	26.0	.61	13.7	.58
54	41A070	X	Crab Creek near Beverly, WA	NA	NA	NA	NA	NA
55	12471400		Lind Coulee Wasteway at SR 17 near Warden, WA	1,857	48.4	.00	.00	.00
56	13A060	X	Deschutes River at E. Street Bridge, WA	164	12.0	.00	.00	.00
57	10A070	X	Puyallup River at Meridian Street, WA	108	32.1	5.65	19.2	4.36
58	12108500		Newaukum Creek near Black Diamond, WA	NA	NA	NA	NA	NA
59	12464770		Crab Creek at Rocky Ford Road near Ritzville, WA	1,688	102	.00	.00	.00
60	12061500		Skokomish River near Potlatch, WA	NA	NA	NA	NA	NA
61	16A070	X	Skokomish River near Potlatch, WA	46.6	32.6	.00	.00	.00
62	12112600		Big Soos Creek above hatchery near Auburn, WA	NA	NA	NA	NA	NA
63	09A190	X	Green River at Kanaskat, WA	12.1	53.2	.00	.00	.00
64	45A070	X	Wenatchee River at Wenatchee, WA	211	126	.03	.04	.02
65	12113375		Springbrook Creek at Tukwila, WA	NA	NA	NA	NA	NA
66	09A080	X	Green River at Tukwila, WA	177	28.5	.00	.00	.00
67	12113390		Duwamish River at golf course at Tukwila, WA	129	20.4	2.21	14.0	1.92
68	12056500		North Fork Skokomish River below Staircase Rapids near Hoodport, WA	NA	NA	NA	NA	NA
69	46A070		Entiat River near Entiat, WA	203	351	.00	.00	.00
70	45A110	X	Wenatchee River near Leavenworth, WA	26.4	112	.00	.00	.00
71	16C090	X	Duckabush River near Brinnon, WA	81.0	87.1	.00	.00	.00
72	12128000		Thorton Creek near Seattle, WA	289	27.6	.00	.00	.00
73	54A120	X	Spokane River at Riverside State Park, WA	190	45.2	17.3	72.5	14.0
74	07D050	X	Snoqualmie River near Monroe, WA	61.7	21.5	.00	.00	.00
75	07C070	X	Skykomish River at Monroe, WA	40.4	44.9	.00	.00	.00
76	07A090	X	Snohomish River at Snohomish, WA	62.1	23.7	.00	.00	.00
77	53A070	X	Columbia River at Grand Coulee, WA	74.1	20.3	8.93	32.6	7.01
78	48A070	X	Methow River near Pateros, WA	420	448	.00	.00	.00
79	49A070	X	Okanogan River at Malott, WA	364	159	5.36	12.3	3.73
80	48A140	X	Methow River at Twisp, WA	332	436	.00	.00	.00
81	03A060	X	Skagit River near Mount Vernon, WA	75.7	41.9	3.65	6.58	2.35
82	03B050		Samish River near Burlington, WA	91.0	15.5	0.00	0.00	0.00
83	12213140		Nooksack River at Brennan, WA	NA	NA	NA	NA	NA
84	01A050	X	Nooksack River at Brennan, WA	211	16.5	.57	7.26	.53

Table 22. Summary of sources and stream annual loads for total nitrogen and total phosophorus in the Columbia River and Puget Sound basins, water year 2000 and calendar year 2002.—Continued

[**Abbreviations:** lb, pound; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; NA, either an annual instream load was not calculated or no catchment delineation was available to base point-source and nonpoint-source loads]

Map index No.	Site No.	Trend site	Site name	Water year 2000 (lb)		Calendar year 2002 (lb)		Catchment point-source TN load as a percentage of in-stream load
				Estimated annual instream load	Estimated annual total catchment point-source load	Estimated annual nitrogen load from fertilizer and manure	Estimated annual nitrogen load from atmospheric deposition	
			Total nitrogen—Continued					
85	12210700		Nooksack River at North Cedarville, WA	NA	NA	1,050,000	604,000	NA
86	12400520		Columbia River at Northport, WA	27,700,000	NA	NA	NA	NA
87	61A070	X	Columbia River at Northport, WA	29,400,000	NA	NA	NA	NA
88	12212100		Fistrap Creek at Flynn Road at Lynden, WA	NA	NA	1,190,000	37,000	NA
89	13092747	X	Rock Creek above Hwy 30/93 crossing at Twin Falls, ID	501,000	0	4,030,000	151,000	.00
90	13094000		Snake River near Buhl, ID	15,500,000	1,280,000	318,000,000	20,600,000	8.30
91	13154500	X	Snake River at King Hill, ID	30,100,000	1,580,000	396,000,000	24,200,000	5.26
92	13203510		Boise River below Diversion Dam near Boise, ID	613,000	0	2,530,000	966,000	.00
93	13206000	X	Boise River at Glenwood, ID	746,000	295,000	3,300,000	985,000	39.6
94	13238322		North Fork Payette River below Fisher Creek near McCall, ID	103,000	0	11,800	36,700	.00
95	12414900		St. Maries River near Santa, ID	NA	NA	115,000	192,000	NA
96	12414500		St. Joe River at Calder, ID	NA	NA	15,100	735,000	NA
97	12413470	X	South Fork Coeur d'Alene River near Pinehurst, ID	347,000	104,000	37,900	205,000	30.0
98	12413000		North Fork Coeur d'Alene River at Enaville, ID	NA	NA	18,000	657,000	NA
99	12419000	X	Spokane River near Post Falls, ID	2,420,000	483,000	3,890,000	2,810,000	20.0
100	13010065		Snake River at Flagg Ranch, WY	413,000	0	60,700	326,000	.00

Map index No.	Site No.	Trend site	Site name	Catchment				
				Fertilizer and manure nitrogen load as a percentage of instream load	Atmospheric nitrogen deposition as a percentage of instream load	Point-source loads (percentage)		
						Fertilizer and manure nitrogen application	Atmospheric nitrogen deposition	Total land-applied nitrogen
			Total nitrogen—Continued					
85	12210700		Nooksack River at North Cedarville, WA	NA	NA	NA	NA	NA
86	12400520		Columbia River at Northport, WA	NA	NA	NA	NA	NA
87	61A070	X	Columbia River at Northport, WA	NA	NA	NA	NA	NA
88	12212100		Fistrap Creek at Flynn Road at Lynden, WA	NA	NA	NA	NA	NA
89	13092747	X	Rock Creek above Hwy. 30/93 crossing at Twin Falls, ID	804	30.2	.00	.00	.00
90	13094000		Snake River near Buhl, ID	2,052	133	.40	6.21	.38
91	13154500	X	Snake River at King Hill, ID	1,316	80.3	.40	6.53	.38
92	13203510		Boise River below Diversion Dam near Boise, ID	413	158	.00	.00	.00
93	13206000	X	Boise River at Glenwood, ID	442	132	8.95	29.9	6.89
94	13238322		North Fork Payette River below Fisher Creek near McCall, ID	11.5	35.7	.00	.00	.00
95	12414900		St. Maries River near Santa, ID	NA	NA	NA	NA	NA
96	12414500		St. Joe River at Calder, ID	NA	NA	NA	NA	NA
97	12413470	X	South Fork Coeur d'Alene River near Pinehurst, ID	10.9	59.1	275	50.7	42.9
98	12413000		North Fork Coeur d'Alene River at Enaville, ID	NA	NA	NA	NA	NA
99	12419000	X	Spokane River near Post Falls, ID	161	116	12.4	17.2	7.21
100	13010065		Snake River at Flagg Ranch, WY	14.7	78.9	.00	.00	.00

Table 22. Summary of sources and stream annual loads for total nitrogen and total phosophorus in the Columbia River and Puget Sound basins, water year 2000 and calendar year 2002.—Continued

[**Abbreviations:** lb, pound; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; NA, either an annual instream load was not calculated or no catchment delineation was available-to base point-source and nonpoint-source loads]

Map index No.	Site No.	Trend site	Site name	Water year 2000 (lb)		Calendar year 2002 (lb)
				Estimated annual instream load	Estimated annual total catchment point-source load	Phosphorus from fertilizer and manure
			Total phosphorus			
1	10729		Owyhee River at Hwy 201 Bridge (Owyhee)	70,500	NA	NA
2	MAL113		North Fork Malheur River approximately 2 miles upstream of Beulah Reservoir	25,200	0	112,000
3	MAL144		Malheur River at Ford south of Vale 1.1 miles upstream of Bully Creek	144,000	0	2,700,000
4	10386	X	Middle Fork Willamette at Jasper Bridge	271,000	0	155,000
5	10663		Mohawk River at Hill Road	35,300	0	66,500
6	10376		McKenzie River at Coburg Road	440,000	NA	NA
7	10355	X	Willamette River at Hwy 99E (Harrisburg)	1,460,000	449,000	984,000
8	11140	X	Long Tom River at Stow Pit Road (Monroe)	124,000	0	866,000
9	12657		McKenzie R. at Hwy 126 downstream Clear Lake	38,100	0	4,300
10	10508	X	Deschutes River at Lower Bridge	187,000	0	494,000
11	10350	X	Willamette River at Albany (Eastbound Hwy 20 Bridge)	2,250,000	1,090,000	5,800,000
12	11490		Powder River at Hwy.7 (in Baker City)	12,600	0	302,000
13	11478	X	John Day River at Service Creek	224,000	0	1,600,000
14	10555	X	Willamette River at Marion Street (Salem)	3,420,000	1,330,000	11,200,000
15	14200400	X	Little Abiqua Creek near Scotts Mills, OR	1,660	0	2,790
16	14201300	X	Zollner Creek near Mt. Angel, OR	13,200	0	205,000
17	10640		Pudding River at Hwy 211 (Woodburn)	210,000	53,700	2,660,000
18	13070		Clackamas River at Mciver Park (upper boat ramp)	164,000	0	64,400
19	3701002	X	Tualatin River at Weiss Bridge	426,000	96,700	2,390,000
20	3840012		Fanno Creek at Durham Road	NA	NA	45,200
21	14206950		Fanno Creek near Durham, OR	NA	NA	45,200
22	3701715		Tualatin River at Cherry Grove	14,100	0	4,480
23	11321	X	Johnson Creek at SE 17th Ave (Portland)	17,100	0	170,000
24	3701333		Tualatin River at Farmington Bridge Road	360,000	64,100	1,720,000
25	3701612	X	Tualatin River at Springhill Road Bridge (Dilley)	46,500	0	261,000
26	11386		John Day River at Hwy 206	296,000	NA	NA
27	3805048		Scoggins Creek below Hagg Lake at Stimson Bridge	5,430	0	12,100
28	3701391		Tualatin River at Rood Bridge Road	174,000	11,300	1,440,000
29	3701528		Tualatin River at Golf Course Road	84,700	0	438,000
30	3810015		Gales Creekk at New Hwy 47	40,900	0	85,200
31	10611	X	Willamette River at Hawthorne Bridge (Portland)	6,030,000	2,510,000	24,700,000
32	3820012		Rock Creek at Hwy 8	NA	NA	209,000
33	14211720	X	Willamette River at Portland, OR	5,980,000	2,510,000	24,700,000
34	3850006		Dawson Creekk at Brookwood	1,380	0	23,400
35	3824020		Bronson Creek at Bronson Park downstream of Sunset Hwy	712	0	8,850
36	3824072		Bronson Creek at Saltzman	269	0	6,070
37	10332	X	Willamette River at SP&S Railroad Bridge	6,610,000	NA	NA
38	14128910		Columbia River at Warrendale, OR	11,100,000	2,850,000	253,000,000
39	10411	X	Deschutes River at Deschutes River Park	1,160,000	0	5,810,000
40	10616	X	Columbia River at Marker #47 (upstream of Willamette River)	16,000,000	NA	NA
41	10406		Umatilla River at Hwy 11 (Pendleton)	53,600	0	164,000

Table 22. Summary of sources and stream annual loads for total nitrogen and total phosophorus in the Columbia River and Puget Sound basins, water year 2000 and calendar year 2002.—Continued

[**Abbreviations:** lb, pound; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; NA, either an annual instream load was not calculated or no catchment delineation was available-to base point-source and nonpoint-source loads]

Map index No.	Site No.	Trend site	Site name	Catchment		
				Point-source load as a percentage of instream load	Fertilizer and manure phosphorus load as a percentage of instream TN load	Point-source load as percentage of fertilizer and manure phosphorus application
			Total phosphorus			
1	10729		Owyhee River at Hwy 201 Bridge (Owyhee)	NA	NA	NA
2	MAL113		North Fork Malheur River approximately 2 miles upstream of Beulah Reservoir	0.00	444	0.00
3	MAL144		Malheur River at Ford south of Vale 1.1 miles upstream of Bully Creek	.00	1,875	.00
4	10386	X	Middle Fork Willamette at Jasper Bridge	.00	57.2	.00
5	10663		Mohawk River at Hill Road	.00	188	.00
6	10376		McKenzie River at Coburg Road	NA	NA	NA
7	10355	X	Willamette River at Hwy 99E (Harrisburg)	30.8	67.4	45.6
8	11140	X	Long Tom River at Stow Pit Road (Monroe)	.00	698	.00
9	12657		McKenzie R. at Hwy 126 downstream Clear Lake	.00	11.3	.00
10	10508	X	Deschutes River at Lower Bridge	.00	264	.00
11	10350	X	Willamette River at Albany (Eastbound Hwy 20 Bridge)	48.4	258	18.7
12	11490		Powder River at Hwy 7 (in Baker City)	.00	2,397	.00
13	11478	X	John Day River at Service Creek	.00	714.3	.00
14	10555	X	Willamette River at Marion Street (Salem)	38.9	327	11.9
15	14200400	X	Little Abiqua Creek near Scotts Mills, OR	.00	168	.00
16	14201300	X	Zollner Creek near Mt. Angel, OR	.00	1,553	.00
17	10640		Pudding River at Hwy. 211 (Woodburn)	25.5	1,267	2.01
18	13070		Clackamas River at Mciver Park (upper boat ramp)	.00	39.3	.00
19	3701002	X	Tualatin River at Weiss Bridge	22.7	561	4.04
20	3840012		Fanno Creek at Durham Road	NA	NA	NA
21	14206950		Fanno Creek near Durham, OR	NA	NA	NA
22	3701715		Tualatin River at Cherry Grove	.00	31.8	.00
23	11321	X	Johnson Creek at SE 17th Ave (Portland)	.00	994	.00
24	3701333		Tualatin River at Farmington Bridge Road	17.8	478	3.72
25	3701612	X	Tualatin River at Springhill Road Bridge (Dilley)	.00	561	.00
26	11386		John Day River at Hwy 206	NA	NA	NA
27	3805048		Scoggins Creek below Hagg Lake at Stimson Bridge	.00	223	.00
28	3701391		Tualatin River at Rood Bridge Road	6.54	828	.79
29	3701528		Tualatin River at Golf Course Road	.00	517	.00
30	3810015		Gales Creekk at New Hwy 47	.00	208	.00
31	10611	X	Willamette River at Hawthorne Bridge (Portland)	41.7	410	10.2
32	3820012		Rock Creek at Hwy 8	NA	NA	NA
33	14211720	X	Willamette River at Portland, OR	42.1	413	10.2
34	3850006		Dawson Creekk at Brookwood	.00	1,696	.00
35	3824020		Bronson Creek at Bronson Park downstream of Sunset Hwy	.00	1,243	.00
36	3824072		Bronson Creek at Saltzman	.00	2,254	.00
37	10332	X	Willamette River at SP&S Railroad Bridge	NA	NA	NA
38	14128910		Columbia River at Warrendale, OR	25.7	2,279	1.13
39	10411	X	Deschutes River at Deschutes River Park	.00	501	.00
40	10616	X	Columbia River at Marker #47 (upstream of Willamette River)	NA	NA	NA
41	10406		Umatilla River at Hwy 11 (Pendleton)	.00	306	.00

Table 22. Summary of sources and stream annual loads for total nitrogen and total phosophorus in the Columbia River and Puget Sound basins, water year 2000 and calendar year 2002.—Continued

[**Abbreviations:** lb, pound; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; NA, either an annual instream load was not calculated or no catchment delineation was available-to base point-source and nonpoint-source loads]

Map index No.	Site No.	Trend site	Site name	Water year 2000 (lb)		Calendar year 2002 (lb)
				Estimated annual instream load	Estimated annual total catchment point-source load	Phosphorus from fertilizer and manure
			Total phosphorus—Continued			
42	12012	X	Hood River at footbridge downstream of I-84	NA	NA	NA
43	11489	X	Umatilla River at Westland Road (Hermiston)	139,000	NA	NA
44	14246900	X	Columbia River at Beaver Army Terminal near Quincy, OR	20,000,000	4,500,000	256,000,000
45	27D090		East Fork Lewis River near Dollar Corner	46,400	0	41,500
46	32A070	X	Walla Walla River near Touchet	182,000	48,000	3,410,000
47	13353200		Snake River at Burbank, WA	4,860,000	1,220,000	159,000,000
48	37A090	X	Yakima River at Kiona	885,000	313,000	9,750,000
49	12510500		Yakima River at Kiona, WA	963,000	313,000	9,750,000
50	12505450		Granger Drain at Granger, WA	23,800	0	458,000
51	12472900	X	Columbia River at Vernita Bridge near Priest Rapids Dam, WA	3,010,000	818,000	23,800,000
52	13351000	X	Palouse River at Hooper, WA	408,000	39,600	5,620,000
53	34A070	X	Palouse River at Hooper	311,000	39,600	5,620,000
54	41A070	X	Crab Creek near Beverly	NA	NA	1,270,000
55	12471400		Lind Coulee Wasteway at SR 17 near Warden, WA	48,300	0	2,340,000
56	13A060	X	Deschutes River at E. Street Bridge	65,300	0	212,000
57	10A070	X	Puyallup River at Meridian Street	1,006,000	34,500	437,000
58	12108500		Newaukum Creek near Black Diamond, WA	NA	NA	132,000
59	12464770		Crab Creek at Rocky Ford Road near Ritzville, WA	16,300	0	699,000
60	12061500		Skokomish River near Potlatch, WA	NA	NA	17,500
61	16A070	X	Skokomish River near Potlatch	145,000	0	17,500
62	12112600		Big Soos Creek above hatchery near Auburn, WA	NA	NA	51,400
63	09A190	X	Green River at Kanaskat	59,400	0	10,700
64	45A070	X	Wenatchee River at Wenatchee	154,000	2,870	241,000
65	12113375		Springbrook Creek at Tukwila, WA	NA	NA	12,000
66	09A080	X	Green River at Tukwila	223,000	0	375,000
67	12113390		Duwamish River at golf course at Tukwila, WA	266,000	12,800	369,000
68	12056500		North Fork Skokomish River below Staircase Rapids near Hoodport, WA	12,000	0	4,000
69	46A070		Entiat River near Entiat	27,100	0	30,400
70	45A110	X	Wenatchee River near Leavenworth	115,000	0	20,700
71	16C090	X	Duckabush River near Brinnon	17,700	0	9,540
72	12128000		Thorton Creek near Seattle, WA	2,280	0	10,900
73	54A120	X	Spokane River at Riverside State Park	685,000	675,000	2,930,000
74	07D050	X	Snoqualmie River near Monroe	287,000	0	311,000
75	07C070	X	Skykomish River at Monroe	194,000	0	143,000
76	07A090	X	Snohomish River at Snohomish	665,000	0	779,000
77	53A070	X	Columbia River at Grand Coulee	3,610,000	690,000	5,660,000
78	48A070	X	Methow River near Pateros, WA	60,600	0	450,000
79	49A070	X	Okanogan River at Malott, WA	241,000	46,800	739,000
80	48A140	X	Methow River at Twisp	56,100	0	272,000
81	03A060	X	Skagit River near Mount Vernon, WA	1,490,000	37,300	709,000
82	03B050		Samish River near Burlington	21,000	0	72,200
83	12213140		Nooksack River at Brenan, WA	NA	NA	1,590,000
84	01A050	X	Nooksack River at Brennan	1,080,000	12,800	1,560,000
85	12210700		Nooksack River at North Cedarville, WA	NA	NA	179,000
86	12400520		Columbia River at Northport, WA	1,150,000	NA	NA

Table 22. Summary of sources and stream annual loads for total nitrogen and total phosophorus in the Columbia River and Puget Sound basins, water year 2000 and calendar year 2002.—Continued

[**Abbreviations:** lb, pound; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; NA, either an annual instream load was not calculated or no catchment delineation was available-to base point-source and nonpoint-source loads]

Map index No.	Site No.	Trend site	Site name	Catchment		
				Point-source load as a percentage of instream load	Fertilizer and manure phosphorus load as a percentage of instream TN load	Point-source load as percentage of fertilizer and manure phosphorus application
			Total phosphorus—Continued			
42	12012	X	Hood River at footbridge downstream of I-84	NA	NA	NA
43	11489	X	Umatilla River at Westland Road (Hermiston)	NA	NA	NA
44	14246900	X	Columbia River at Beaver Army Terminal near Quincy, OR	22.5	1,280	1.76
45	27D090		East Fork Lewis River near Dollar Corner	.00	89.4	.00
46	32A070	X	Walla Walla River near Touchet	26.3	1,874	1.41
47	13353200		Snake River at Burbank, WA	25.1	3,272	.77
48	37A090	X	Yakima River at Kiona	35.3	1,102	3.21
49	12510500		Yakima River at Kiona, WA	32.5	1,012	3.21
50	12505450		Granger Drain at Granger, WA	.00	1,924	.00
51	12472900	X	Columbia River at Vernita Bridge near Priest Rapids Dam, WA	27.2	791	3.43
52	13351000	X	Palouse River at Hooper, WA	9.70	1,377	.70
53	34A070	X	Palouse River at Hooper	12.7	1,807	.70
54	41A070	X	Crab Creek near Beverly	NA	NA	NA
55	12471400		Lind Coulee Wasteway at SR 17 near Warden, WA	.00	4,845	.00
56	13A060	X	Deschutes River at E. Street Bridge	.00	325	.00
57	10A070	X	Puyallup River at Meridian Street	3.43	43.4	7.90
58	12108500		Newaukum Creek near Black Diamond, WA	NA	NA	NA
59	12464770		Crab Creek at Rocky Ford Road near Ritzville, WA	.00	4,288	.00
60	12061500		Skokomish River near Potlatch, WA	NA	NA	NA
61	16A070	X	Skokomish River near Potlatch	.00	12.1	.00
62	12112600		Big Soos Creek above hatchery near Auburn, WA	NA	NA	NA
63	09A190	X	Green River at Kanaskat	.00	18.0	.00
64	45A070	X	Wenatchee River at Wenatchee	1.87	156	1.19
65	12113375		Springbrook Creek at Tukwila, WA	NA	NA	NA
66	09A080	X	Green River at Tukwila	.00	168	.00
67	12113390		Duwamish River at golf course at Tukwila, WA	4.81	139	3.44
68	12056500		North Fork Skokomish River below Staircase Rapids near Hoodport, WA	.00	33.3	.00
69	46A070		Entiat River near Entiat	.00	112	.00
70	45A110	X	Wenatchee River near Leavenworth	.00	18.0	.00
71	16C090	X	Duckabush River near Brinnon	.00	53.9	.00
72	12128000		Thorton Creek near Seattle, WA	.00	478	.00
73	54A120	X	Spokane River at Riverside State Park	98.5	428	23.0
74	07D050	X	Snoqualmie River near Monroe	.00	108	.00
75	07C070	X	Skykomish River at Monroe	.00	73.7	.00
76	07A090	X	Snohomish River at Snohomish	.00	117	.00
77	53A070	X	Columbia River at Grand Coulee	19.1	157	12.2
78	48A070	X	Methow River near Pateros, WA	.00	743	.00
79	49A070	X	Okanogan River at Malott, WA	19.4	307	6.33
80	48A140	X	Methow River at Twisp	.00	485	.00
81	03A060	X	Skagit River near Mount Vernon, WA	2.51	47.6	5.27
82	03B050		Samish River near Burlington	.00	344	.00
83	12213140		Nooksack River at Brenan, WA	NA	NA	NA
84	01A050	X	Nooksack River at Brennan	1.19	144	.82
85	12210700		Nooksack River at North Cedarville, WA	NA	NA	NA
86	12400520		Columbia River at Northport, WA	NA	NA	NA

Table 22. Summary of sources and stream annual loads for total nitrogen and total phosophorus in the Columbia River and Puget Sound basins, water year 2000 and calendar year 2002.—Continued

[**Abbreviations:** lb, pound; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; NA, either an annual instream load was not calculated or no catchment delineation was available to base point-source and nonpoint-source loads]

Map index No.	Site No.	Trend site	Site name	Water year 2000 (lb)		Calendar year 2002 (lb)
				Estimated annual instream load	Estimated annual total catchment point-source load	Phosphorus from fertilizer and manure
			Total phosphorus—Continued			
87	61A070	X	Columbia River at Northport	2,400,000	NA	NA
88	12212100		Fishtrap Creek at Flynn Road at Lynden, WA	NA	NA	19,400
89	13092747	X	Rock Creek above Hwy 30/93 crossing at Twin Falls, ID	20,200	0	967,000
90	13094000		Snake River near Buhl, ID	985,000	410,000	79,300,000
91	13154500	X	Snake River at King Hill, ID	1,360,000	534,000	97,000,000
92	13203510		Boise River below Diversion Dam near Boise, ID	45,500	0	721,000
93	13206000	X	Boise River at Glenwood, ID	168,000	57,500	868,000
94	13238322		North Fork Payette River below Fisher Creek near McCall, ID	3,700	0	2,800
95	12414900		St. Maries River near Santa, ID	32,000	0	29,000
96	12414500		St. Joe River at Calder, ID	43,500	0	3,500
97	12413470	X	South Fork Coeur d'Alene River near Pinehurst, ID	40,300	24,500	7,250
98	12413000		North Fork Coeur d'Alene River at Enaville, ID	70,800	0	4,100
99	12419000	X	Spokane River near Post Falls, ID	161,000	96,700	912,000
100	13010065		Snake River at Flagg Ranch, WY	97,400	0	13,800

Map index No.	Site No.	Trend site	Site name	Catchment		
				Point-source load as a percentage of instream load	Fertilizer and manure phosphorus load as a percentage of instream TN load	Point-source load as percentage of fertilizer and manure phosphorus application
			Total phosphorus—Continued			
87	61A070	X	Columbia River at Northport	NA	NA	NA
88	12212100		Fishtrap Creek at Flynn Road at Lynden, WA	NA	NA	NA
89	13092747	X	Rock Creek above Hwy 30/93 crossing at Twin Falls, ID	0.00	4,787	0.00
90	13094000		Snake River near Buhl, ID	41.6	8,051	.52
91	13154500	X	Snake River at King Hill, ID	39.4	7,132	.55
92	13203510		Boise River below Diversion Dam near Boise, ID	.00	1,585	.00
93	13206000	X	Boise River at Glenwood, ID	34.3	517	6.63
94	13238322		North Fork Payette River below Fisher Creek near McCall, ID	.00	75.7	.00
95	12414900		St. Maries River near Santa, ID	.00	90.6	.00
96	12414500		St. Joe River at Calder, ID	.00	8.0	.00
97	12413470	X	South Fork Coeur d'Alene River near Pinehurst, ID	60.8	18.0	338
98	12413000		North Fork Coeur d'Alene River at Enaville, ID	.00	5.8	.00
99	12419000	X	Spokane River near Post Falls, ID	60.1	566	10.6
100	13010065		Snake River at Flagg Ranch, WY	.00	14.2	.00

This page intentionally left blank.

Appendix A. Results of Loadest Modeling, Flow-Weighted Concentrations, Yields, Drainage Areas, and Mean Annual Streamflows for Total Nitrogen, Total Phosphorus, and Suspended Sediment for Water Years 1997, 2000, and 2001

Table A1. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for total nitrogen in the Columbia River and Puget Sound basins, water year 1997.

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; lb/yr, pound per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Flux (lb/d)	Variance (lb/d)	Lower 95 (lb/d)	Upper 95 (lb/d)	SEP (lb/d)	Number of days
1	10729	Owyhee River at Hwy. 201 Bridge (Owyhee), OR	3,370	57,900	2,910	3,870	245	365
2	MAL113	North Fork Malheur River approximately 2 miles upstream of Beulah Reservoir, OR	NA	NA	NA	NA	NA	–
3	MAL144	Malheur River at Ford Street (1.1 miles) upstream of Bully Creek, OR	NA	NA	NA	NA	NA	–
4	10386	Middle Fork Willamette River at Jasper Bridge, OR	NA	NA	NA	NA	NA	–
5	10663	Mohawk River at Hill Road, OR	NA	NA	NA	NA	NA	–
6	10376	McKenzie River at Coburg Road, OR	NA	NA	NA	NA	NA	–
7	10355	Willamette River at Hwy 99E (Harrisburg), OR	31,200	8,240,000	25,700	37,500	3,020	365
8	11140	Long Tom River at Stow Pit Road (Monroe), OR	5,930	345,000	4,820	7,210	612	365
9	12657	McKenzie River at Hwy 126 downstream of Clear Lake, OR	NA	NA	NA	NA	NA	–
10	10508	Deschutes River at Lower Bridge, OR	1,820	73,200	1,340	2,410	273	365
11	10350	Willamette River at Albany (Eastbound Hwy 20 Bridge), OR	75,100	57,300,000	60,700	92,000	8,000	365
12	11490	Powder River at Hwy 7 (Baker City), OR	279	499	237	326	22.9	365
13	11478	John Day River at Service Creek, OR	6,310	1,020,000	4,510	8,600	1,050	365
14	10555	Willamette River at Marion Street (Salem), OR	140,000	142,000,000	117,000	167,000	12,600	365
15	14200400	Little Abiqua Creek near Scotts Mills, OR	178	38.5	164	192	6.92	365
16	14201300	Zollner Creek near Mt. Angel, OR	3,370	75,900	2,800	4,020	311	365
17	10640	Pudding River at Hwy 211 (Woodburn), OR	NA	NA	NA	NA	NA	–
18	13070	Clackamas River at Mciver Park (Upper Boat Ramp), OR	NA	NA	NA	NA	NA	–
19	3701002	Tualatin River at Weiss Bridge, OR	25,300	406,000	23,800	26,800	763	365
20	3840012	Fanno Creek at Durham Road, OR	NA	NA	NA	NA	NA	–
21	14206950	Fanno Creek near Durham, OR	NA	NA	NA	NA	NA	–
22	3701715	Tualatin River at Cherry Grove, OR	NA	NA	NA	NA	NA	–
23	11321	Johnson Creek at SE 17th Avenue (Portland), OR	2,280	10,800	2,080	2,490	105	365
24	3701333	Tualatin River at Farmington Bridge Road, OR	17,200	795,000	15,400	19,150	955	365
25	3701612	Tualatin River at Springhill Road Bridge (Dilley), OR	2,400	13,200	2,120	2,710	150	365
26	11386	John Day River at Hwy 206, OR	NA	NA	NA	NA	NA	–
27	3805048	Scoggins Creek below Hagg Lake at Stimson Bridge, OR	416	2,075	332	516	47.2	365
28	3701391	Tualatin River at Rood Bridge Road, OR	15,300	584,000	13,600	17,200	916	365
29	3701528	Tualatin River at Golf Course Road, OR	4,480	39,700	4,000	5,000	254	365
30	3810015	Gales Creek at New Hwy 47, OR	1,480	5,270	1,310	1,660	89.6	365
31	10611	Willamette River at Hawthorne Bridge (Portland), OR	294,000	344,000,000	256,000	336,000	20,500	365
32	3820012	Rock Creek at Hwy 8, OR	NA	NA	NA	NA	NA	–
33	14211720	Willamette River at Portland, OR	312,000	420,000,000	270,000	359,000	22,500	365
34	3850006	Dawson Creek at Brookwood, OR	NA	NA	NA	NA	NA	–
35	3824020	Bronson Creek at Bronson Park downstream of Sunset Hwy, OR	NA	NA	NA	NA	NA	–
36	3824072	Bronson Creek at Saltzman, OR	NA	NA	NA	NA	NA	–
37	10332	Willamette River at SP&S Railroad Bridge, OR	295,000	1,240,000,000	230,000	373,000	36,500	365
38	14128910	Columbia River at Warrendale, OR	514,000	997,000,000	453,000	582,000	33,000	365
39	10411	Deschutes River at Deschutes River Park, OR	29,800	899,000,000	4,070	108,000	30,000	365
40	10616	Columbia River at Marker #47 (upstream of Willamette River), OR	719,000	6,260,000,000	573,000	892,000	81,500	365
41	10406	Umatilla River at Hwy 11 (Pendleton), OR	1,180	24,700	887	1,540	167	365
42	12012	Hood River at footbridge downstream of I-84, OR	3,350	143,000	2,650	4,180	392	365
43	11489	Umatilla River at Westland Road (Hermiston), OR	5,690	204,000	4,830	6,660	468	365
44	14246900	Columbia River at Beaver Army Terminal near Quincy, OR	868,000	1,110,000,000	799,000	940,000	35,900	365
45	27D090	East Fork Lewis River near Dollar Corner, WA	2,560	17,000	2,290	2,850	144	365
46	32A070	Walla Walla River near Touchet, WA	3,680	43,900	3,250	4,160	235	365
47	13353200	Snake River at Burbank, WA	310,000	180,000,000	283,000	339,000	14,300	365
48	37A090	Yakima River at Kiona, WA	27,300	1,460,000	24,800	30,000	1,300	365
49	12510500	Yakima River at Kiona, WA	29,500	4,100,000	25,600	33,800	2,070	365
50	12505450	Granger Drain at Granger, WA	NA	NA	NA	NA	NA	–

Table A1. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for total nitrogen in the Columbia River and Puget Sound basins, water year 1997.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; lb/yr, pound per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Load (lb/yr)	Flow-weighted concentration (mg/L)	Yield (lb/mi^2/yr)	Drainage area (km^2)	Annual mean flow (ft^3/s)
1	10729	Owyhee River at Hwy. 201 Bridge (Owyhee), OR	1,230,000	0.80	NC	NA	779
2	MAL113	North Fork Malheur River approximately 2 miles upstream of Beulah Reservoir, OR	NC	NC	NC	880	162
3	MAL144	Malheur River at Ford Street (1.1 miles) upstream of Bully Creek, OR	NC	NC	NC	12,000	434
4	10386	Middle Fork Willamette River at Jasper Bridge, OR	NC	NC	NC	3,490	6,720
5	10663	Mohawk River at Hill Road, OR	NC	NC	NC	460	883
6	10376	McKenzie River at Coburg Road, OR	NC	NC	NC	NA	6,900
7	10355	Willamette River at Hwy 99E (Harrisburg), OR	11,400,000	.34	3,320	8,890	17,200
8	11140	Long Tom River at Stow Pit Road (Monroe), OR	2,160,000	.91	5,200	1,080	1,210
9	12657	McKenzie River at Hwy 126 downstream of Clear Lake, OR	NC	NC	NC	239	688
10	10508	Deschutes River at Lower Bridge, OR	663,000	.23	316	5,440	1,460
11	10350	Willamette River at Albany (Eastbound Hwy 20 Bridge), OR	27,400,000	.65	5,650	12,600	21,600
12	11490	Powder River at Hwy 7 (Baker City), OR	102,000	.33	292	902	158
13	11478	John Day River at Service Creek, OR	2,300,000	.36	449	13,300	3,230
14	10555	Willamette River at Marion Street (Salem), OR	51,200,000	.71	6,940	19,100	36,600
15	14200400	Little Abiqua Creek near Scotts Mills, OR	64,800	.68	6,590	25.5	48.7
16	14201300	Zollner Creek near Mt. Angel, OR	1,230,000	12.8	81,900	38.9	48.8
17	10640	Pudding River at Hwy 211 (Woodburn), OR	NC	NC	NC	818	NA
18	13070	Clackamas River at Mciver Park (Upper Boat Ramp), OR	NC	NC	NC	1,760	4,080
19	3701002	Tualatin River at Weiss Bridge, OR	9,240,000	1.93	13,000	1,840	2,430
20	3840012	Fanno Creek at Durham Road, OR	NC	NC	NC	80.7	–
21	14206950	Fanno Creek near Durham, OR	NC	NC	NC	80.7	–
22	3701715	Tualatin River at Cherry Grove, OR	NC	NC	NC	97.3	292
23	11321	Johnson Creek at SE 17th Avenue (Portland), OR	831,000	3.09	15,500	139	137
24	3701333	Tualatin River at Farmington Bridge Road, OR	6,280,000	1.61	11,200	1,460	1,980
25	3701612	Tualatin River at Springhill Road Bridge (Dilley), OR	876,000	.84	6,950	327	530
26	11386	John Day River at Hwy 206, OR	NC	NC	NC	NA	–
27	3805048	Scoggins Creek below Hagg Lake at Stimson Bridge, OR	152,000	.42	3,810	103	182
28	3701391	Tualatin River at Rood Bridge Road, OR	5,590,000	1.62	11,800	1,230	1,760
29	3701528	Tualatin River at Golf Course Road, OR	1,640,000	.93	7,550	561	893
30	3810015	Gales Creek at New Hwy 47, OR	541,000	.82	7,180	195	335
31	10611	Willamette River at Hawthorne Bridge (Portland), OR	107,000,000	1.01	9,610	28,900	53,800
32	3820012	Rock Creek at Hwy 8, OR	NC	NC	NC	193	–
33	14211720	Willamette River at Portland, OR	114,000,000	1.08	10,200	28,900	53,800
34	3850006	Dawson Creek at Brookwood, OR	NC	NC	NC	9.7	–
35	3824020	Bronson Creek at Bronson Park downstream of Sunset Hwy, OR	NC	NC	NC	10.2	–
36	3824072	Bronson Creek at Saltzman, OR	NC	NC	NC	5.23	–
37	10332	Willamette River at SP&S Railroad Bridge (Portland), OR	108,000,000	1.02	NC	NA	53,800
38	14128910	Columbia River at Warrendale, OR	188,000,000	.36	789	616,000	264,000
39	10411	Deschutes River at Deschutes River Park, OR	10,900,000	.69	1,010	27,800	7,970
40	10616	Columbia River at Marker #47 (upstream of Willamette River), OR	263,000,000	.49	NC	624,000	272,000
41	10406	Umatilla River at Hwy 11 (Pendleton), OR	431,000	.28	968	1,150	777
42	12012	Hood River at footbridge downstream of I-84, OR	1,220,000	.41	NC	NA	1,520
43	11489	Umatilla River at Westland Road (Hermiston), OR	2,080,000	1.03	NC	NA	1,030
44	14246900	Columbia River at Beaver Army Terminal near Quincy, OR	317,000,000	.48	1,250	658,000	338,000
45	27D090	East Fork Lewis River near Dollar Corner, WA	934,000	.50	5,980	405	957
46	32A070	Walla Walla River near Touchet, WA	1,340,000	.64	798	4,370	1,060
47	13353200	Snake River at Burbank, WA	317,000,000	.48	1,250	658,000	338,000
48	37A090	Yakima River at Kiona, WA	9,970,000	.83	1,780	14,500	6,070
49	12510500	Yakima River at Kiona, WA	5,380	.90	1,920	14,500	6,070
50	12505450	Granger Drain at Granger, WA	NC	NC	NC	160	–

Table A1. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for total nitrogen in the Columbia River and Puget Sound basins, water year 1997.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; lb/yr, pound per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Flux (lb/d)	Variance (lb/d)	Lower 95 (lb/d)	Upper 95 (lb/d)	SEP (lb/d)	Number of days
51	12472900	Columbia River at Vernita Bridge near Priest Rapids Dam, WA	162,000	462,000,000	124,000	208,000	21,800	365
52	13351000	Palouse River at Hooper, WA	54,400	15,700,000	45,900	64,000	4,630	365
53	34A070	Palouse River at Hooper, WA	51,900	46,000,000	39,300	67,300	7,150	365
54	41A070	Crab Creek near Beverly, WA	3,630	14,700	3,380	3,880	127	365
55	12471400	Lind Coulee Wastway at SR 17 near Warden, WA	NA	NA	NA	NA	NA	–
56	13A060	Deschutes River at East Street Bridge, WA	2,370	6,810	2,200	2,550	88.1	365
57	10A070	Puyallup River at Meridian Street, WA	9,480	286,000	8,400	10,700	576	365
58	12108500	Newaukum Creek near Black Diamond, WA	1,360	5,230	1,220	1,520	77.1	365
59	12464770	Crab Creek at Rocky Ford Road near Ritzville, WA	NA	NA	NA	NA	NA	–
60	12061500	Skokomish River near Potlatch, WA	NA	NA	NA	NA	NA	–
61	16A070	Skokomish River near Potlatch, WA	829	6,160	676	1,000	84.6	365
62	12112600	Big Soos Creek above Hatchery near Auburn, WA	1,350	4,540	1,210	1,490	71.9	365
63	09A190	Green River at Kanaskat, WA	1,480	13,600	1,240	1,740	128	365
64	45A070	Wenatchee River at Wenatchee, WA	4,150	54,700	3,680	4,660	251	365
65	12113375	Springbrook Creek at Tukwila, WA	257	49.3	243	272	7.60	365
66	09A080	Green River at Tukwila, WA	5,620	66,200	5,100	6,190	278	365
67	12113390	Duwamish River at Golf Course at Tukwila, WA	7,880	169,000	7,030	8,800	451	365
68	12056500	North Fork Skokomish River below Staircase Rapids near Hoodport, WA	NA	NA	NA	NA	NA	–
69	46A070	Entiat River near Entiat, WA	463	2,900	360	585	57.3	365
70	45A110	Wenatchee River near Leavenworth, WA	2,830	80,300	2,270	3,480	308	365
71	16C090	Duckabush River near Brinnon, WA	138	204	107	174	17.0	365
72	12128000	Thorton Creek near Seattle, WA	120	22.1	110	130	5.16	365
73	54A120	Spokane River at Riverside State Park, WA	23,300	1,240,000	21,000	25,700	1,190	365
74	07D050	Snoqualmie River near Monroe, WA	10,400	122,000	9,680	11,200	382	365
75	07C070	Skykomish River at Monroe, WA	5,310	48,900	4,840	5,830	253	365
76	07A090	Snohomish River at Snohomish, WA	23,100	938,000	21,000	25,300	1,090	365
77	53A070	Columbia River at Grand Coulee, WA	153,000	47,400,000	139,000	168,000	7,400	365
78	48A070	Methow River near Pateros, WA	1,780	12,700	1,550	2,030	122	365
79	49A070	Okanogan River at Malott, WA	5,700	194,000	4,840	6,660	465	365
80	48A140	Methow River at Twisp, WA	1,320	9,090	1,120	1,530	104	365
81	03A060	Skagit River near Mount Vernon, WA	20,500	1,180,000	18,200	22,900	1,210	365
82	03B050	Samish River near Burlington, WA	1,750	4,880	1,620	1,900	72.9	365
83	12213140	Nooksack River at Brennan, WA	21,900	2,140,000	18,900	25,100	1,570	365
84	01A050	Nooksack River at Brennan, WA	15,600	561,000	14,000	17,300	812	365
85	12210700	Nooksack River at North Cedarville, WA	10,500	1,020,000	8,490	12,800	1,100	365
86	12400520	Columbia River at Northport, WA	NA	NA	NA	NA	NA	–
87	61A070	Columbia River at Northport, WA	108,000	17,600,000	99,700	117,000	4,370	365
88	12212100	Fishtrap Creek at Flynn Road at Lynden, WA	2,370	8,400	2,190	2,570	95.9	365
89	13092747	Rock Creek above Hwy 30/93 crossing at Twin Falls, ID	NA	NA	NA	NA	NA	–
90	13094000	Snake River near Buhl, ID	67,800	4,880,000	63,400	72,400	2,290	365
91	13154500	Snake River at King Hill, ID	112,000	6,330,000	107,000	117,000	2,690	365
92	13203510	Boise River below Diversion Dam near Boise, ID	6,470	382,000	5,330	7,790	628	365
93	13206000	Boise River at Glenwood, ID	6,190	245,000	5,250	7,240	507	365
94	13238322	North Fork Payette River below Fischer Creek near McCall, ID	745	7,800	572	953	97.4	365
95	12414900	St. Maries River near Santa, ID	NA	NA	NA	NA	NA	–
96	12414500	St. Joe River at Calder, ID	NA	NA	NA	NA	NA	–
97	12413470	South Fork Coeur d' Alene River near Pinehurst, ID	NA	NA	NA	NA	NA	–
98	12413000	North Fork Coeur d' Alene River at Enaville, ID	NA	NA	NA	NA	NA	–
99	12419000	Spokane River near Post Falls, ID	NA	NA	NA	NA	NA	–
100	13010065	Snake River at Flagg Ranch, WY	3,770	894,000	2,130	6,190	1,050	365

Table A1. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for total nitrogen in the Columbia River and Puget Sound basins, water year 1997.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; lb/yr, pound per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Load (lb/yr)	Flow-weighted concentration (mg/L)	Yield (lb/mi^2/yr)	Drainage area (km^2)	Annual mean flow (ft^3/s)
51	12472900	Columbia River at Vernita Bridge near Priest Rapids Dam, WA	29,500	0.18	2,260	67,800	164,000
52	13351000	Palouse River at Hooper, WA	9,930	6.32	8,060	6,380	1,600
53	34A070	Palouse River at Hooper, WA	19,000,000	6.03	7,700	6,380	1,600
54	41A070	Crab Creek near Beverly, WA	1,320,000	2.29	3,430	999	293
55	12471400	Lind Coulee Wastway at SR 17 near Warden, WA	NC	NC	NC	1,840	–
56	13A060	Deschutes River at East Street Bridge, WA	866,000	.76	8,410	267	575
57	10A070	Puyallup River at Meridian Street, WA	346,000	.41	3,760	2,380	4,340
58	12108500	Newaukum Creek near Black Diamond, WA	498,000	3.02	18,200	71.1	83.7
59	12464770	Crab Creek at Rocky Ford Road near Ritzville, WA	NC	NC	NC	1,190	40.1
60	12061500	Skokomish River near Potlatch, WA	NC	NC	NC	339	1,500
61	16A070	Skokomish River near Potlatch, WA	303,000	.10	2,310	339	1,500
62	12112600	Big Soos Creek above Hatchery near Auburn, WA	491,000	1.28	7,350	173	195
63	09A190	Green River at Kanaskat, WA	539,000	.20	2,270	616	1,390
64	45A070	Wenatchee River at Wenatchee, WA	1,520,000	.17	1,140	3,440	4,540
65	12113375	Springbrook Creek at Tukwila, WA	93,900	1.05	4,700	51.7	45.2
66	09A080	Green River at Tukwila, WA	2,050,000	.55	4,300	1,240	1,900
67	12113390	Duwamish River at Golf Course at Tukwila, WA	2,880,000	.68	6,240	1,190	2,150
68	12056500	North Fork Skokomish River below Staircase Rapids near Hoodport, WA	NC	NC	NC	147	677
69	46A070	Entiat River near Entiat, WA	169,000	.12	407	1,070	700
70	45A110	Wenatchee River near Leavenworth, WA	1,030,000	.13	1,550	1,720	4,190
71	16C090	Duckabush River near Brinnon, WA	50,300	.05	757	172	507
72	12128000	Thorton Creek near Seattle, WA	43,800	1.75	3,880	29.2	12.7
73	54A120	Spokane River at Riverside State Park, WA	8,500,000	.42	1,700	13,000	10,400
74	07D050	Snoqualmie River near Monroe, WA	3,800,000	.38	5,550	1,770	5,040
75	07C070	Skykomish River at Monroe, WA	1,940,000	.18	2,530	1,980	5,580
76	07A090	Snohomish River at Snohomish, WA	8,440,000	.32	4,930	4,440	13,300
77	53A070	Columbia River at Grand Coulee, WA	55,700,000	.20	5,000	28,900	155,000
78	48A070	Methow River near Pateros, WA	650,100	.16	362	4,660	2,130
79	49A070	Okanogan River at Malott, WA	2,080,000	.21	1,200	4,500	5,120
80	48A140	Methow River at Twisp, WA	480,000	.13	363	3,430	1,920
81	03A060	Skagit River near Mount Vernon, WA	7,470,000	.17	3,210	6,020	21,800
82	03B050	Samish River near Burlington, WA	641,000	.96	7,430	223	340
83	12213140	Nooksack River at Brennan, WA	7,980,000	.42	10,200	2,020	9,720
84	01A050	Nooksack River at Brennan, WA	5,700,000	.55	7,730	1,910	5,280
85	12210700	Nooksack River at North Cedarville, WA	3,820,000	.45	6,500	1,520	4,340
86	12400520	Columbia River at Northport, WA	NC	NC	NC	156,000	131,000
87	61A070	Columbia River at Northport, WA	39,400,000	.15	650	156,000	131,000
88	12212100	Fishtrap Creek at Flynn Road at Lynden, WA	870,000	4.03	22,700	98.6	109
89	13092747	Rock Creek above Hwy 30/93 crossing at Twin Falls, ID	NC	NC	NC	623	175
90	13094000	Snake River near Buhl, ID	24,700,000	1.14	842	76,100	11,100
91	13154500	Snake River at King Hill, ID	40,800,000	1.22	1,140	92,900	16,900
92	13203510	Boise River below Diversion Dam near Boise, ID	2,360,000	.32	877	6,980	3,690
93	13206000	Boise River at Glenwood, ID	2,260,000	.34	814	7,180	3,380
94	13238322	North Fork Payette River below Fischer Creek near McCall, ID	272,000	.33	3,200	220	416
95	12414900	St. Maries River near Santa, ID	NC	NC	NC	706	–
96	12414500	St. Joe River at Calder, ID	NC	NC	NC	2,680	–
97	12413470	South Fork Coeur d' Alene River near Pinehurst, ID	NC	NC	NC	738	846
98	12413000	North Fork Coeur d' Alene River at Enaville, ID	NC	NC	NC	2,330	2,740
99	12419000	Spokane River near Post Falls, ID	NC	NC	NC	10,200	10,300
100	13010065	Snake River at Flagg Ranch, WY	1,370,000	.45	2,690	1,320	1,540

Table A2. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for total phosphorus in the Columbia River and Puget Sound basins, water year 1997.

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 9**5, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; lb/yr, pound per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Flux (lb/d)	Variance (lb/d)	Lower 95 (lb/d)	Upper 95 (lb/d)	SEP (lb/d)	Number of days
1	10729	Owyhee River at Hwy. 201 Bridge (Owyhee), OR	515	3,960	401	652	64.1	365
2	MAL113	North Fork Malheur River approximately 2 miles upstream of Beulah Reservoir, OR	NA	NA	NA	NA	NA	–
3	MAL144	Malheur River at Ford Street (1.1 miles) upstream of Bully Creek, OR	NA	NA	NA	NA	NA	–
4	10386	Middle Fork Willamette River at Jasper Bridge, OR	2,060	60,700	1,620	2,590	250	365
5	10663	Mohawk River at Hill Road, OR	307	1,520	235	395	40.8	365
6	10376	McKenzie River at Coburg Road, OR	2,300	41,400	1,920	2,740	209	365
7	10355	Willamette River at Hwy 99E (Harrisburg), OR	9,750	896,000	7,940	11,800	999	365
8	11140	Long Tom River at Stow Pit Road (Monroe), OR	668	3,240	559	791	59.1	365
9	12657	McKenzie River at Hwy 126 downstream of Clear Lake, OR	124	26.9	114	135	5.35	365
10	10508	Deschutes River at Lower Bridge, OR	547	815	492	606	29.1	365
11	10350	Willamette River at Albany (Eastbound Hwy 20 Bridge), OR	14,100	1,420,000	11,700	16,700	1,260	365
12	11490	Powder River at Hwy 7 (Baker City), OR	55.8	53.6	42.5	71.8	7.50	365
13	11478	John Day River at Service Creek, OR	1,750	78,400	1,250	2,396	294	365
14	10555	Willamette River at Marion Street (Salem), OR	24,400	3,950,000	20,518	28,800	2,110	365
15	14200400	Little Abiqua Creek near Scotts Mills, OR	6.38	.92	4.60	8.62	1.03	365
16	14201300	Zollner Creek near Mt. Angel, OR	155	398	111	211	25.6	365
17	10640	Pudding River at Hwy 211 (Woodburn), OR	NA	NA	NA	NA	NA	–
18	13070	Clackamas River at Mciver Park (Upper Boat Ramp), OR	NA	NA	NA	NA	NA	–
19	3701002	Tualatin River at Weiss Bridge, OR	2,110	9,370	1,890	2,350	117	365
20	3840012	Fanno Creek at Durham Road, OR	NA	NA	NA	NA	NA	–
21	14206950	Fanno Creek near Durham, OR	NA	NA	NA	NA	NA	–
22	3701715	Tualatin River at Cherry Grove, OR	72.2	118	51.5	98.4	12.0	365
23	11321	Johnson Creek at SE 17th Avenue (Portland), OR	189	1,960	116	292	45.0	365
24	3701333	Tualatin River at Farmington Bridge Road, OR	1,580	17,600	1,312	1,880	145	365
25	3701612	Tualatin River at Springhill Road Bridge (Dilley), OR	240	248	204	281	19.7	365
26	11386	John Day River at Hwy 206, OR	NA	NA	NA	NA	NA	–
27	3805048	Scoggins Creek below Hagg Lake at Stimson Bridge, OR	29.2	142	12.3	59.0	12.2	365
28	3701391	Tualatin River at Rood Bridge Road, OR	1,070	1,830	973	1,180	51.5	365
29	3701528	Tualatin River at Golf Course Road, OR	482	541	428	540	28.5	365
30	3810015	Gales Creek at New Hwy 47, OR	235	166	204	268	16.3	365
31	10611	Willamette River at Hawthorne Bridge (Portland), OR	41,500	2,920,000	37,910	45,400	1,910	365
32	3820012	Rock Creek at Hwy 8, OR	NA	NA	NA	NA	NA	–
33	14211720	Willamette River at Portland, OR	43,300	13,900,000	35,600	52,000	4,160	365
34	3850006	Dawson Creek at Brookwood, OR	NA	NA	NA	NA	NA	–
35	3824020	Bronson Creek at Bronson Park downstream of Sunset Hwy, OR	NA	NA	NA	NA	NA	–
36	3824072	Bronson Creek at Saltzman, OR	NA	NA	NA	NA	NA	–
37	10332	Willamette River at SP&S Railroad Bridge, OR	42,500	9,730,000	36,600	49,200	3,240	365
38	14128910	Columbia River at Warrendale, OR	54,300	28,800,000	43,900	66,400	5,750	365
39	10411	Deschutes River at Deschutes River Park, OR	6,260	97,400,000	374	30,000	9,870	365
40	10616	Columbia River at Marker #47 (upstream of Willamette River), OR	162,000	500,000,000	122,000	211,000	22,700	365
41	10406	Umatilla River at Hwy 11 (Pendleton), OR	245	351	207	287	20.2	365
42	12012	Hood River at footbridge downstream of I-84, OR	803	71,600	389	1,480	282	365
43	11489	Umatilla River at Westland Road (Hermiston), OR	1,300	49,900	897	1,820	235	365
44	14246900	Columbia River at Beaver Army Terminal near Quincy, OR	111,000	76,900,000	94,000	131,300	9,530	365
45	27D090	East Fork Lewis River near Dollar Corner, WA	137	506	93.7	194	25.6	365
46	32A070	Walla Walla River near Touchet, WA	774	12,600	563	1,040	121	365
47	13353200	Snake River at Burbank, WA	31,900	7,290,000	26,600	38,000	2,900	365
48	37A090	Yakima River at Kiona, WA	4,760	88,800	4,170	5,410	315	365
49	12510500	Yakima River at Kiona, WA	6,320	743,000	4,780	8,210	876	365
50	12505450	Granger Drain at Granger, WA	NA	NA	NA	NA	NA	–

Table A2. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for total phosphorus in the Columbia River and Puget Sound basins, water year 1997.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; lb/yr, pound per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Flux (lb/d)	Variance (lb/d)	Lower 95 (lb/d)	Upper 95 (lb/d)	SEP (lb/d)	Number of days
1	10729	Owyhee River at Hwy. 201 Bridge (Owyhee), OR	515	3,960	401	652	64.1	365
2	MAL113	North Fork Malheur River approximately 2 miles upstream of Beulah Reservoir, OR	NA	NA	NA	NA	NA	–
3	MAL144	Malheur River at Ford Street (1.1 miles) upstream of Bully Creek, OR	NA	NA	NA	NA	NA	–
4	10386	Middle Fork Willamette River at Jasper Bridge, OR	2,060	60,700	1,620	2,590	250	365
5	10663	Mohawk River at Hill Road, OR	307	1,520	235	395	40.8	365
6	10376	McKenzie River at Coburg Road, OR	2,300	41,400	1,920	2,740	209	365
7	10355	Willamette River at Hwy 99E (Harrisburg), OR	9,750	896,000	7,940	11,800	999	365
8	11140	Long Tom River at Stow Pit Road (Monroe), OR	668	3,240	559	791	59.1	365
9	12657	McKenzie River at Hwy 126 downstream of Clear Lake, OR	124	26.9	114	135	5.35	365
10	10508	Deschutes River at Lower Bridge, OR	547	815	492	606	29.1	365
11	10350	Willamette River at Albany (Eastbound Hwy 20 Bridge), OR	14,100	1,420,000	11,700	16,700	1,260	365
12	11490	Powder River at Hwy 7 (Baker City), OR	55.8	53.6	42.5	71.8	7.50	365
13	11478	John Day River at Service Creek, OR	1,750	78,400	1,250	2,396	294	365
14	10555	Willamette River at Marion Street (Salem), OR	24,400	3,950,000	20,518	28,800	2,110	365
15	14200400	Little Abiqua Creek near Scotts Mills, OR	6.38	.92	4.60	8.62	1.03	365
16	14201300	Zollner Creek near Mt. Angel, OR	155	398	111	211	25.6	365
17	10640	Pudding River at Hwy 211 (Woodburn), OR	NA	NA	NA	NA	NA	–
18	13070	Clackamas River at Mciver Park (Upper Boat Ramp), OR	NA	NA	NA	NA	NA	–
19	3701002	Tualatin River at Weiss Bridge, OR	2,110	9,370	1,890	2,350	117	365
20	3840012	Fanno Creek at Durham Road, OR	NA	NA	NA	NA	NA	–
21	14206950	Fanno Creek near Durham, OR	NA	NA	NA	NA	NA	–
22	3701715	Tualatin River at Cherry Grove, OR	72.2	118	51.5	98.4	12.0	365
23	11321	Johnson Creek at SE 17th Avenue (Portland), OR	189	1,960	116	292	45.0	365
24	3701333	Tualatin River at Farmington Bridge Road, OR	1,580	17,600	1,312	1,880	145	365
25	3701612	Tualatin River at Springhill Road Bridge (Dilley), OR	240	248	204	281	19.7	365
26	11386	John Day River at Hwy 206, OR	NA	NA	NA	NA	NA	–
27	3805048	Scoggins Creek below Hagg Lake at Stimson Bridge, OR	29.2	142	12.3	59.0	12.2	365
28	3701391	Tualatin River at Rood Bridge Road, OR	1,070	1,830	973	1,180	51.5	365
29	3701528	Tualatin River at Golf Course Road, OR	482	541	428	540	28.5	365
30	3810015	Gales Creek at New Hwy 47, OR	235	166	204	268	16.3	365
31	10611	Willamette River at Hawthorne Bridge (Portland), OR	41,500	2,920,000	37,910	45,400	1,910	365
32	3820012	Rock Creek at Hwy 8, OR	NA	NA	NA	NA	NA	–
33	14211720	Willamette River at Portland, OR	43,300	13,900,000	35,600	52,000	4,160	365
34	3850006	Dawson Creek at Brookwood, OR	NA	NA	NA	NA	NA	–
35	3824020	Bronson Creek at Bronson Park downstream of Sunset Hwy, OR	NA	NA	NA	NA	NA	–
36	3824072	Bronson Creek at Saltzman, OR	NA	NA	NA	NA	NA	–
37	10332	Willamette River at SP&S Railroad Bridge, OR	42,500	9,730,000	36,600	49,200	3,240	365
38	14128910	Columbia River at Warrendale, OR	54,300	28,800,000	43,900	66,400	5,750	365
39	10411	Deschutes River at Deschutes River Park, OR	6,260	97,400,000	374	30,000	9,870	365
40	10616	Columbia River at Marker #47 (upstream of Willamette River), OR	162,000	500,000,000	122,000	211,000	22,700	365
41	10406	Umatilla River at Hwy 11 (Pendleton), OR	245	351	207	287	20.2	365
42	12012	Hood River at footbridge downstream of I-84, OR	803	71,600	389	1,480	282	365
43	11489	Umatilla River at Westland Road (Hermiston), OR	1,300	49,900	897	1,820	235	365
44	14246900	Columbia River at Beaver Army Terminal near Quincy, OR	111,000	76,900,000	94,000	131,300	9,530	365
45	27D090	East Fork Lewis River near Dollar Corner, WA	137	506	93.7	194	25.6	365
46	32A070	Walla Walla River near Touchet, WA	774	12,600	563	1,040	121	365
47	13353200	Snake River at Burbank, WA	31,900	7,290,000	26,600	38,000	2,900	365
48	37A090	Yakima River at Kiona, WA	4,760	88,800	4,170	5,410	315	365
49	12510500	Yakima River at Kiona, WA	6,320	743,000	4,780	8,210	876	365
50	12505450	Granger Drain at Granger, WA	NA	NA	NA	NA	NA	–

Table A2. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for total phosphorus in the Columbia River and Puget Sound basins, water year 1997.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; lb/yr, pound per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Flux (lb/d)	Variance (lb/d)	Lower 95 (lb/d)	Upper 95 (lb/d)	SEP (lb/d)	Number of days
51	12472900	Columbia River at Vernita Bridge near Priest Rapids Dam, WA	12,100	5,320,000	8,090	17,500	2,420	365
52	13351000	Palouse River at Hooper, WA	5,500	699,000	3,700	7,860	1,070	365
53	34A070	Palouse River at Hooper, WA	2,110	126,000	1,470	2,930	373	365
54	41A070	Crab Creek near Beverly, WA	156	94	137	177	10.2	365
55	12471400	Lind Coulee Wastway at SR 17 near Warden, WA	NA	NA	NA	NA	NA	–
56	13A060	Deschutes River at East Street Bridge, WA	214	701	163	275	28.7	365
57	10A070	Puyallup River at Meridian Street, WA	3,180	400,000	2,000	4,810	723	365
58	12108500	Newaukum Creek near Black Diamond, WA	157	848	102	231	32.8	365
59	12464770	Crab Creek at Rocky Ford Road near Ritzville, WA	NA	NA	NA	NA	NA	NA
60	12061500	Skokomish River near Potlatch, WA	893	187,000	209	2,540	632	365
61	16A070	Skokomish River near Potlatch, WA	451	15,300	243	768	135	365
62	12112600	Big Soos Creek above Hatchery near Auburn, WA	67.6	196	42.5	102	15.4	365
63	09A190	Green River at Kanaskat, WA	199	441	158	248	22.8	365
64	45A070	Wenatchee River at Wenatchee, WA	769	13,700	551	1,040	126	365
65	12113375	Springbrook Creek at Tukwila, WA	40.7	9.32	34.6	47.56	3.31	365
66	09A080	Green River at Tukwila, WA	787	4,200	657	934	70.8	365
67	12113390	Duwamish River at Golf Course at Tukwila, WA	1,000	10,600	790	1,254	119	365
68	12056500	North Fork Skokomish River below Staircase Rapids near Hoodport, WA	80.2	684	34.3	161	32.9	365
69	46A070	Entiat River near Entiat, WA	152	728	103	216	28.9	365
70	45A110	Wenatchee River near Leavenworth, WA	573	10,200	390	813	109	365
71	16C090	Duckabush River near Brinnon, WA	60.3	719	23.1	130	28.0	365
72	12128000	Thorton Creek near Seattle, WA	8.25	1.98	5.48	11.94	1.66	365
73	54A120	Spokane River at Riverside State Park, WA	2,410	70,900	1,900	3,020	286	365
74	07D050	Snoqualmie River near Monroe, WA	958	9,210	762	1,190	109	365
75	07C070	Skykomish River at Monroe, WA	734	9,900	542	973	110	365
76	07A090	Snohomish River at Snohomish, WA	2,450	72,300	1,920	3,080	297	365
77	53A070	Columbia River at Grand Coulee, WA	14,500	5,740,000	10,000	20,300	2,620	365
78	48A070	Methow River near Pateros, WA	475	8,830	306	706	102	365
79	49A070	Okanogan River at Malott, WA	2,220	129,000	1,570	3,050	381	365
80	48A140	Methow River at Twisp, WA	331	4,720	208	500	75.1	365
81	03A060	Skagit River near Mount Vernon, WA	5,600	795,000	3,870	7,830	1,010	365
82	03B050	Samish River near Burlington, WA	111	280	80.5	148	17.4	365
83	12213140	Nooksack River at Brennan, WA	6,200	2,320,000	3,510	10,160	1,710	365
84	01A050	Nooksack River at Brennan, WA	5,550	1,790,000	3,120	9,160	1,550	365
85	12210700	Nooksack River at North Cedarville, WA	4,530	9,170,000	1,030	13,100	3,270	365
86	12400520	Columbia River at Northport, WA	6,770	956,000	4,970	9,000	1,030	365
87	61A070	Columbia River at Northport, WA	9,800	1,500,000	7,470	12,600	1,320	365
88	12212100	Fishtrap Creek at Flynn Road at Lynden, WA	64.0	321	34.2	110	19.5	365
89	13092747	Rock Creek above Hwy 30/93 crossing at Twin Falls, ID	NA	NA	NA	NA	NA	–
90	13094000	Snake River near Buhl, ID	6,090	419,000	4,880	7,520	674	365
91	13154500	Snake River at King Hill, ID	7,750	346,000	6,620	9,020	612	365
92	13203510	Boise River below Diversion Dam near Boise, ID	NA	NA	NA	NA	NA	NA
93	13206000	Boise River at Glenwood, ID	843	12,900	638	1,090	116	365
94	13238322	North Fork Payette River below Fischer Creek near McCall, ID	19.1	3.64	15.2	23.80	2.21	365
95	12414900	St. Maries River near Santa, ID	NA	NA	NA	NA	NA	–
96	12414500	St. Joe River at Calder, ID	NA	NA	NA	NA	NA	–
97	12413470	South Fork Coeur d' Alene River near Pinehurst, ID	194	626	144	255	28.2	365
98	12413000	North Fork Coeur d' Alene River at Enaville, ID	450	77,709	286	676	100	365
99	12419000	Spokane River near Post Falls, ID	NA	NA	NA	NA	NA	–
100	13010065	Snake River at Flagg Ranch, WY	1,230	138,000	614	2,210	413	365

Table A2. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for total phosphorus in the Columbia River and Puget Sound basins, water year 1997.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; lb/yr, pound per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Flux (lb/d)	Variance (lb/d)	Lower 95 (lb/d)	Upper 95 (lb/d)	SEP (lb/d)	Number of days
51	12472900	Columbia River at Vernita Bridge near Priest Rapids Dam, WA	12,100	5,320,000	8,090	17,500	2,420	365
52	13351000	Palouse River at Hooper, WA	5,500	699,000	3,700	7,860	1,070	365
53	34A070	Palouse River at Hooper, WA	2,110	126,000	1,470	2,930	373	365
54	41A070	Crab Creek near Beverly, WA	156	94	137	177	10.2	365
55	12471400	Lind Coulee Wastway at SR 17 near Warden, WA	NA	NA	NA	NA	NA	–
56	13A060	Deschutes River at East Street Bridge, WA	214	701	163	275	28.7	365
57	10A070	Puyallup River at Meridian Street, WA	3,180	400,000	2,000	4,810	723	365
58	12108500	Newaukum Creek near Black Diamond, WA	157	848	102	231	32.8	365
59	12464770	Crab Creek at Rocky Ford Road near Ritzville, WA	NA	NA	NA	NA	NA	NA
60	12061500	Skokomish River near Potlatch, WA	893	187,000	209	2,540	632	365
61	16A070	Skokomish River near Potlatch, WA	451	15,300	243	768	135	365
62	12112600	Big Soos Creek above Hatchery near Auburn, WA	67.6	196	42.5	102	15.4	365
63	09A190	Green River at Kanaskat, WA	199	441	158	248	22.8	365
64	45A070	Wenatchee River at Wenatchee, WA	769	13,700	551	1,040	126	365
65	12113375	Springbrook Creek at Tukwila, WA	40.7	9.32	34.6	47.56	3.31	365
66	09A080	Green River at Tukwila, WA	787	4,200	657	934	70.8	365
67	12113390	Duwamish River at Golf Course at Tukwila, WA	1,000	10,600	790	1,254	119	365
68	12056500	North Fork Skokomish River below Staircase Rapids near Hoodport, WA	80.2	684	34.3	161	32.9	365
69	46A070	Entiat River near Entiat, WA	152	728	103	216	28.9	365
70	45A110	Wenatchee River near Leavenworth, WA	573	10,200	390	813	109	365
71	16C090	Duckabush River near Brinnon, WA	60.3	719	23.1	130	28.0	365
72	12128000	Thorton Creek near Seattle, WA	8.25	1.98	5.48	11.94	1.66	365
73	54A120	Spokane River at Riverside State Park, WA	2,410	70,900	1,900	3,020	286	365
74	07D050	Snoqualmie River near Monroe, WA	958	9,210	762	1,190	109	365
75	07C070	Skykomish River at Monroe, WA	734	9,900	542	973	110	365
76	07A090	Snohomish River at Snohomish, WA	2,450	72,300	1,920	3,080	297	365
77	53A070	Columbia River at Grand Coulee, WA	14,500	5,740,000	10,000	20,300	2,620	365
78	48A070	Methow River near Pateros, WA	475	8,830	306	706	102	365
79	49A070	Okanogan River at Malott, WA	2,220	129,000	1,570	3,050	381	365
80	48A140	Methow River at Twisp, WA	331	4,720	208	500	75.1	365
81	03A060	Skagit River near Mount Vernon, WA	5,600	795,000	3,870	7,830	1,010	365
82	03B050	Samish River near Burlington, WA	111	280	80.5	148	17.4	365
83	12213140	Nooksack River at Brennan, WA	6,200	2,320,000	3,510	10,160	1,710	365
84	01A050	Nooksack River at Brennan, WA	5,550	1,790,000	3,120	9,160	1,550	365
85	12210700	Nooksack River at North Cedarville, WA	4,530	9,170,000	1,030	13,100	3,270	365
86	12400520	Columbia River at Northport, WA	6,770	956,000	4,970	9,000	1,030	365
87	61A070	Columbia River at Northport, WA	9,800	1,500,000	7,470	12,600	1,320	365
88	12212100	Fishtrap Creek at Flynn Road at Lynden, WA	64.0	321	34.2	110	19.5	365
89	13092747	Rock Creek above Hwy 30/93 crossing at Twin Falls, ID	NA	NA	NA	NA	NA	–
90	13094000	Snake River near Buhl, ID	6,090	419,000	4,880	7,520	674	365
91	13154500	Snake River at King Hill, ID	7,750	346,000	6,620	9,020	612	365
92	13203510	Boise River below Diversion Dam near Boise, ID	NA	NA	NA	NA	NA	NA
93	13206000	Boise River at Glenwood, ID	843	12,900	638	1,090	116	365
94	13238322	North Fork Payette River below Fischer Creek near McCall, ID	19.1	3.64	15.2	23.80	2.21	365
95	12414900	St. Maries River near Santa, ID	NA	NA	NA	NA	NA	–
96	12414500	St. Joe River at Calder, ID	NA	NA	NA	NA	NA	–
97	12413470	South Fork Coeur d' Alene River near Pinehurst, ID	194	626	144	255	28.2	365
98	12413000	North Fork Coeur d' Alene River at Enaville, ID	450	77,709	286	676	100	365
99	12419000	Spokane River near Post Falls, ID	NA	NA	NA	NA	NA	–
100	13010065	Snake River at Flagg Ranch, WY	1,230	138,000	614	2,210	413	365

Table A3. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for suspended sediment in the Columbia River and Puget Sound basins, water year 1997.

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; ton/yr, ton per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Flux (lb/d)	Variance (lb/d)	Lower 95 (lb/d)	Upper 95 (lb/d)	SEP (lb/d)	Number of days
1	10729	Owyhee River at Hwy. 201 Bridge (Owyhee), OR	39.1	28.5	29.4	50.9	5.50	365
2	MAL113	North Fork Malheur River approximately 2 miles upstream of Beulah Reservoir, OR	NA	NA	NA	NA	NA	–
3	MAL144	Malheur River at Ford Street (1.1 miles) upstream of Bully Creek, OR	NA	NA	NA	NA	NA	–
4	10386	Middle Fork Willamette River at Jasper Bridge, OR	80.6	450	46.3	131	21.7	365
5	10663	Mohawk River at Hill Road, OR	71.1	650	32.3	137	27.1	365
6	10376	McKenzie River at Coburg Road, OR	267	12,900	108	556	117	365
7	10355	Willamette River at Hwy 99E (Harrisburg), OR	1,150	66,200	709	1,780	274	365
8	11140	Long Tom River at Stow Pit Road (Monroe), OR	121	851	72.0	191	30.5	365
9	12657	McKenzie River at Hwy 126 downstream of Clear Lake, OR	NA	NA	NA	NA	NA	–
10	10508	Deschutes River at Lower Bridge, OR	9.9	2.27	7.2	13.3	1.55	365
11	10350	Willamette River at Albany (Eastbound Hwy 20 Bridge), OR	2,080	239,000	1,240	3,280	523	365
12	11490	Powder River at Hwy 7 (Baker City), OR	7.01	3.03	4.2	11.1	1.78	365
13	11478	John Day River at Service Creek, OR	321	22,600	113	725	161	365
14	10555	Willamette River at Marion Street (Salem), OR	3,780	597,000	2,410	5,640	828	365
15	14200400	Little Abiqua Creek near Scotts Mills, OR	1.92	.16	1.2	2.92	.44	365
16	14201300	Zollner Creek near Mt. Angel, OR	36.9	97.2	15.3	75.3	15.6	365
17	10640	Pudding River at Hwy 211 (Woodburn), OR	NA	NA	NA	NA	NA	–
18	13070	Clackamas River at Mciver Park (Upper Boat Ramp), OR	NA	NA	NA	NA	NA	–
19	3701002	Tualatin River at Weiss Bridge, OR	NA	NA	NA	NA	NA	–
20	3840012	Fanno Creek at Durham Road, OR	NA	NA	NA	NA	NA	–
21	14206950	Fanno Creek near Durham, OR	NA	NA	NA	NA	NA	–
22	3701715	Tualatin River at Cherry Grove, OR	NA	NA	NA	NA	NA	–
23	11321	Johnson Creek at SE 17th Avenue (Portland), OR	69.9	4,020	10.5	244	66.4	365
24	3701333	Tualatin River at Farmington Bridge Road, OR	NA	NA	NA	NA	NA	–
25	3701612	Tualatin River at Springhill Road Bridge (Dilley), OR	NA	NA	NA	NA	NA	–
26	11386	John Day River at Hwy 206, OR	NA	NA	NA	NA	NA	–
27	3805048	Scoggins Creek below Hagg Lake at Stimson Bridge, OR	NA	NA	NA	NA	NA	–
28	3701391	Tualatin River at Rood Bridge Road, OR	NA	NA	NA	NA	NA	–
29	3701528	Tualatin River at Golf Course Road, OR	NA	NA	NA	NA	NA	–
30	3810015	Gales Creek at New Hwy 47, OR	NA	NA	NA	NA	NA	–
31	10611	Willamette River at Hawthorne Bridge (Portland), OR	6,430	823,000	4,600	8,770	1,070	365
32	3820012	Rock Creek at Hwy 8, OR	NA	NA	NA	NA	NA	–
33	14211720	Willamette River at Portland, OR	18,900	6,960,000	13,700	25,400	3,010	365
34	3850006	Dawson Creek at Brookwood, OR	NA	NA	NA	NA	NA	–
35	3824020	Bronson Creek at Bronson Park downstream of Sunset Hwy, OR	NA	NA	NA	NA	NA	–
36	3824072	Bronson Creek at Saltzman, OR	NA	NA	NA	NA	NA	–
37	10332	Willamette River at SP&S Railroad Bridge, OR	9,300	4,440,000	5,700	14,300	2,220	365
38	14128910	Columbia River at Warrendale, OR	19,600	3,390,000	16,100	23,700	1,950	365
39	10411	Deschutes River at Deschutes River Park, OR	439	31,500	184	891	184	365
40	10616	Columbia River at Marker #47 (upstream of Willamette River), OR	32,000	101,000,000	16,600	56,100	10,200	365
41	10406	Umatilla River at Hwy 11 (Pendleton), OR	25.6	529	4.1	87.0	23.4	365
42	12012	Hood River at footbridge downstream of I-84, OR	61.1	1,100	18.4	152	35.5	365
43	11489	Umatilla River at Westland Road (Hermiston), OR	1,100	150,000	442	2,290	482	365
44	14246900	Columbia River at Beaver Army Terminal near Quincy, OR	58,800	29,900,000	47,700	71,800	6,150	365
45	27D090	East Fork Lewis River near Dollar Corner, WA	33.7	83.1	16.9	60.4	11.2	365
46	32A070	Walla Walla River near Touchet, WA	477	111,000	104	1,410	355	365
47	13353200	Snake River at Burbank, WA	5,120	221,000	4,190	6,190	510	365
48	37A090	Yakima River at Kiona, WA	2,430	165,000	1,690	3,390	435	365
49	12510500	Yakima River at Kiona, WA	4,520	1,710,000	2,460	7,640	1,330	365
50	12505450	Granger Drain at Granger, WA	NA	NA	NA	NA	NA	–

Table A3. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for suspended sediment in the Columbia River and Puget Sound basins, water year 1997.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; ton/yr, ton per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Load (ton/yr)	Flow-weighted concentration (mg/L)	Yield (lb/mi^2/yr)	Drainage area (km^2)	Annual mean flow (ft^3/s)
1	10729	Owyhee River at Hwy. 201 Bridge (Owyhee), OR	14,300	18.6	NC	NA	779
2	MAL113	North Fork Malheur River approximately 2 miles upstream of Beulah Reservoir, OR	NC	NC	NC	880	162
3	MAL144	Malheur River at Ford Street (1.1 miles) upstream of Bully Creek, OR	NC	NC	NC	12,000	434
4	10386	Middle Fork Willamette River at Jasper Bridge, OR	29,400	4.45	21.9	3,490	6,720
5	10663	Mohawk River at Hill Road, OR	25,900	29.9	146	460	883
6	10376	McKenzie River at Coburg Road, OR	97,500	14.4	NC	NA	6,900
7	10355	Willamette River at Hwy 99E (Harrisburg), OR	421,000	24.9	123	8,890	17,200
8	11140	Long Tom River at Stow Pit Road (Monroe), OR	44,100	37.0	106	1,080	1,210
9	12657	McKenzie River at Hwy 126 downstream of Clear Lake, OR	NC	NC	NC	239	688
10	10508	Deschutes River at Lower Bridge, OR	3,610	2.51	1.72	5,440	1,460
11	10350	Willamette River at Albany (Eastbound Hwy 20 Bridge), OR	760,000	35.8	157	12,600	21,600
12	11490	Powder River at Hwy 7 (Baker City), OR	2,560	16.4	7.35	902	158
13	11478	John Day River at Service Creek, OR	117,000	36.8	22.8	13,300	3,230
14	10555	Willamette River at Marion Street (Salem), OR	1,380,000	38.3	187	19,100	36,600
15	14200400	Little Abiqua Creek near Scotts Mills, OR	700	14.6	71.1	25.5	48.7
16	14201300	Zollner Creek near Mt. Angel, OR	13,500	365	13,500	38.9	48.8
17	10640	Pudding River at Hwy 211 (Woodburn), OR	NC	NC	NC	818	–
18	13070	Clackamas River at Mciver Park (Upper Boat Ramp), OR	NC	NC	NC	1,760	4,080
19	3701002	Tualatin River at Weiss Bridge, OR	NC	NC	NC	1,840	2,430
20	3840012	Fanno Creek at Durham Road, OR	NC	NC	NC	80.7	–
21	14206950	Fanno Creek near Durham, OR	NC	NC	NC	80.7	–
22	3701715	Tualatin River at Cherry Grove, OR	NC	NC	NC	97.3	292
23	11321	Johnson Creek at SE 17th Avenue (Portland), OR	25,500	190	476	139	137
24	3701333	Tualatin River at Farmington Bridge Road, OR	NC	NC	NC	1,460	1,990
25	3701612	Tualatin River at Springhill Road Bridge (Dilley), OR	NC	NC	NC	327	530
26	11386	John Day River at Hwy 206, OR	NC	NC	NC	NA	–
27	3805048	Scoggins Creek below Hagg Lake at Stimson Bridge, OR	NC	NC	NC	103	182
28	3701391	Tualatin River at Rood Bridge Road, OR	NC	NC	NC	1,230	1,760
29	3701528	Tualatin River at Golf Course Road, OR	NC	NC	NC	561	893
30	3810015	Gales Creek at New Hwy 47, OR	NC	NC	NC	195	335
31	10611	Willamette River at Hawthorne Bridge (Portland), OR	2,350,000	44.4	210	29,000	53,800
32	3820012	Rock Creek at Hwy 8, OR	NC	NC	NC	193	–
33	14211720	Willamette River at Portland, OR	6,890,000	130	617	29,000	53,800
34	3850006	Dawson Creek at Brookwood, OR	NC	NC	NC	9.7	–
35	3824020	Bronson Creek at Bronson Park downstream of Sunset Hwy, OR	NC	NC	NC	10.2	–
36	3824072	Bronson Creek at Saltzman, OR	NC	NC	NC	5.23	–
37	10332	Willamette River at SP&S Railroad Bridge, OR	3,390,000	64.1	NC	NA	53,800
38	14128910	Columbia River at Warrendale, OR	7,160,000	27.6	30.1	616,000	264,000
39	10411	Deschutes River at Deschutes River Park, OR	160,000	20.4	14.9	28,800	7,970
40	10616	Columbia River at Marker #47 (upstream of Willamette River), OR	11,700,000	43.7	NC	NA	272,000
41	10406	Umatilla River at Hwy 11 (Pendleton), OR	9,330	12.2	21.0	1,150	777
42	12012	Hood River at footbridge downstream of I-84, OR	22,300	14.9	NC	NA	1,520
43	11489	Umatilla River at Westland Road (Hermiston), OR	401,000	397	NC	NA	1,030
44	14246900	Columbia River at Beaver Army Terminal near Quincy, OR	21,500,000	64.5	84.5	658,000	338,000
45	27D090	East Fork Lewis River near Dollar Corner, WA	12,300	13.1	78.7	405	957
46	32A070	Walla Walla River near Touchet, WA	174,000	166	103	4,370	1,060
47	13353200	Snake River at Burbank, WA	1,870,000	22.5	18.4	262,000	84,200
48	37A090	Yakima River at Kiona, WA	888,000	149	158	14,500	6,070
49	12510500	Yakima River at Kiona, WA	1,650,000	276	294	14,500	6,070
50	12505450	Granger Drain at Granger, WA	NC	NC	NC	160	–

Table A3. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for suspended sediment in the Columbia River and Puget Sound basins, water year 1997.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; ton/yr, ton per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Flux (lb/d)	Variance (lb/d)	Lower 95 (lb/d)	Upper 95 (lb/d)	SEP (lb/d)	Number of days
51	12472900	Columbia River at Vernita Bridge near Priest Rapids Dam, WA	2,020	56,400	1,580	2,550	248	365
52	13351000	Palouse River at Hooper, WA	10,800	9,240,000	3,410	26,200	6,020	365
53	34A070	Palouse River at Hooper, WA	3,390	3,100,000	946	8,790	2,100	365
54	41A070	Crab Creek near Beverly, WA	33.1	6.77	27.9	38.9	2.81	365
55	12471400	Lind Coulee Wastway at SR 17 near Warden, WA	NA	NA	NA	NA	NA	–
56	13A060	Deschutes River at East Street Bridge, WA	107	1,360	47.5	209	42.0	365
57	10A070	Puyallup River at Meridian Street, WA	3,520	3,590,000	951	9,300	2,240	365
58	12108500	Newaukum Creek near Black Diamond, WA	5.92	1.87	3.5	9.38	1.51	365
59	12464770	Crab Creek at Rocky Ford Road near Ritzville, WA	NA	NA	NA	NA	NA	–
60	12061500	Skokomish River near Potlatch, WA	1,840	1,032,417	268	6,520	1,790	365
61	16A070	Skokomish River near Potlatch, WA	1,360	842,000	281	4,120	1,050	365
62	12112600	Big Soos Creek above Hatchery near Auburn, WA	38.8	253	14.4	85.1	18.5	365
63	09A190	Green River at Kanaskat, WA	55.0	89.2	36.2	80.0	11.2	365
64	45A070	Wenatchee River at Wenatchee, WA	406	11,400	224	680	118	365
65	12113375	Springbrook Creek at Tukwila, WA	5.39	.95	3.5	8.01	1.17	365
66	09A080	Green River at Tukwila, WA	218	943	157	295	35.3	365
67	12113390	Duwamish River at Golf Course at Tukwila, WA	525	5,910	370	725	91.0	365
68	12056500	North Fork Skokomish River below Staircase Rapids near Hoodport, WA	43.6	343	14.3	103	23.3	365
69	46A070	Entiat River near Entiat, WA	43.8	61.6	28.8	63.9	8.98	365
70	45A110	Wenatchee River near Leavenworth, WA	165	1,250	102	254	39.1	365
71	16C090	Duckabush River near Brinnon, WA	34.2	1,520	3.5	139	40.9	365
72	12128000	Thorton Creek near Seattle, WA	2.39	1.22	.7	6.02	1.41	365
73	54A120	Spokane River at Riverside State Park, WA	393	13,300	202	691	126	365
74	07D050	Snoqualmie River near Monroe, WA	581	11,500	360	888	136	365
75	07C070	Skykomish River at Monroe, WA	520	18,300	261	933	174	365
76	07A090	Snohomish River at Snohomish, WA	1,520	54,300	1,050	2,130	275	365
77	53A070	Columbia River at Grand Coulee, WA	679	7,250	522	869	88.8	365
78	48A070	Methow River near Pateros, WA	204	2,330	118	328	54.0	365
79	49A070	Okanogan River at Malott, WA	961	13,600	724	1,250	134	365
80	48A140	Methow River at Twisp, WA	118	822	67.6	193	32.3	365
81	03A060	Skagit River near Mount Vernon, WA	4,550	1,130,000	2,610	7,400	1,230	365
82	03B050	Samish River near Burlington, WA	31.1	43.0	19.0	48.1	7.48	365
83	12213140	Nooksack River at Brennan, WA	6,690	1,570,000	4,340	9,880	1,420	365
84	01A050	Nooksack River at Brennan, WA	4,280	1,460,000	2,190	7,590	1,400	365
85	12210700	Nooksack River at North Cedarville, WA	7,260	11,900,000	2,220	17,900	4,150	365
86	12400520	Columbia River at Northport, WA	3,600	390,000	2,480	5,050	659	365
87	61A070	Columbia River at Northport, WA	2,100	169,000	1,390	3,040	424	365
88	12212100	Fishtrap Creek at Flynn Road at Lynden, WA	14.8	11.4	9.0	22.9	3.58	365
89	13092747	Rock Creek above Hwy 30/93 crossing at Twin Falls, ID	NA	NA	NA	NA	NA	–
90	13094000	Snake River near Buhl, ID	2,100	219,000	1,280	3,160	482	365
91	13154500	Snake River at King Hill, ID	2,140	129,000	1,500	2,960	373	365
92	13203510	Boise River below Diversion Dam near Boise, ID	78.0	392	45.6	125	20.4	365
93	13206000	Boise River at Glenwood, ID	311	7,480	173	518	88.8	365
94	13238322	North Fork Payette River below Fischer Creek near McCall, ID	NA	NA	NA	NA	NA	–
95	12414900	St. Maries River near Santa, ID	NA	NA	NA	NA	NA	–
96	12414500	St. Joe River at Calder, ID	NA	NA	NA	NA	NA	–
97	12413470	South Fork Coeur d' Alene River near Pinehurst, ID	NA	NA	NA	NA	NA	–
98	12413000	North Fork Coeur d' Alene River at Enaville, ID	333	8,270	168	593	110	365
99	12419000	Spokane River near Post Falls, ID	NA	NA	NA	NA	NA	–
100	13010065	Snake River at Flagg Ranch, WY	1,740	245,000	881	3,100	572	365

Table A3. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for suspended sediment in the Columbia River and Puget Sound basins, water year 1997.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; ton/yr, ton per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Load (ton/yr)	Flow-weighted concentration (mg/L)	Yield (lb/mi^2/yr)	Drainage area (km^2)	Annual mean flow (ft^3/s)
51	12472900	Columbia River at Vernita Bridge near Priest Rapids Dam, WA	737,000	4.56	28.2	67,800	164,000
52	13351000	Palouse River at Hooper, WA	3,940,000	2,510	1,601	6,380	1,600
53	34A070	Palouse River at Hooper, WA	1,240,000	788	503	6,380	1,600
54	41A070	Crab Creek near Beverly, WA	12,100	41.9	31.3	999	293
55	12471400	Lind Coulee Wastway at SR 17 near Warden, WA	NC	NC	NC	1,840	–
56	13A060	Deschutes River at East Street Bridge, WA	39,100	69.0	380	267	575
57	10A070	Puyallup River at Meridian Street, WA	1,290,000	301	1,400	2,380	4,340
58	12108500	Newaukum Creek near Black Diamond, WA	2,160	26.2	78.8	71.1	83.7
59	12464770	Crab Creek at Rocky Ford Road near Ritzville, WA	NC	NC	NC	1,190	40.1
60	12061500	Skokomish River near Potlatch, WA	672,000	455	5,130	339	1,500
61	16A070	Skokomish River near Potlatch, WA	497,000	336	3,790	339	1,500
62	12112600	Big Soos Creek above Hatchery near Auburn, WA	14,200	73.8	212	173	195
63	09A190	Green River at Kanaskat, WA	20,100	14.6	84.4	616	1,390
64	45A070	Wenatchee River at Wenatchee, WA	148,000	33.2	112	3,440	4,540
65	12113375	Springbrook Creek at Tukwila, WA	1,970	44.2	98.6	51.7	45.2
66	09A080	Green River at Tukwila, WA	79,600	42.5	167	1,240	1,900
67	12113390	Duwamish River at Golf Course at Tukwila, WA	192,000	90.5	416	1,190	2,150
68	12056500	North Fork Skokomish River below Staircase Rapids near Hoodport, WA	15,900	23.8	280	147	677
69	46A070	Entiat River near Entiat, WA	16,000	23.2	38.6	1,080	700
70	45A110	Wenatchee River near Leavenworth, WA	60,300	14.6	90.8	1,720	4,190
71	16C090	Duckabush River near Brinnon, WA	12,500	25.0	188	172	507
72	12128000	Thorton Creek near Seattle, WA	874	69.9	77.5	29.2	12.7
73	54A120	Spokane River at Riverside State Park, WA	143,000	14.1	28.7	13,000	10,400
74	07D050	Snoqualmie River near Monroe, WA	212,000	42.7	310	1,770	5,040
75	07C070	Skykomish River at Monroe, WA	190,000	34.5	248	1,980	5,580
76	07A090	Snohomish River at Snohomish, WA	555,000	42.4	324	4,440	13,300
77	53A070	Columbia River at Grand Coulee, WA	248,000	1.74	22.2	28,900	145,000
78	48A070	Methow River near Pateros, WA	74,400	35.5	41.4	4,660	2,130
79	49A070	Okanogan River at Malott, WA	351,000	69.6	202	4,500	5,120
80	48A140	Methow River at Twisp, WA	43,200	22.8	32.7	3,430	1,920
81	03A060	Skagit River near Mount Vernon, WA	1,660,000	77.3	715	6,020	21,800
82	03B050	Samish River near Burlington, WA	11,400	33.9	132	223	340
83	12213140	Nooksack River at Brennan, WA	2,440,000	255	3,130	2,020	9,720
84	01A050	Nooksack River at Brennan, WA	1,560,000	301	2,120	1,910	5,280
85	12210700	Nooksack River at North Cedarville, WA	2,650,000	621	4,500	1,530	4,340
86	12400520	Columbia River at Northport, WA	1,310,000	10.2	21.7	156,000	131,000
87	61A070	Columbia River at Northport, WA	765,000	5.95	12.7	156,000	131,000
88	12212100	Fishtrap Creek at Flynn Road at Lynden, WA	5,400	50.3	142	98.6	109
89	13092747	Rock Creek above Hwy 30/93 crossing at Twin Falls, ID	NC	NC	NC	623	175
90	13094000	Snake River near Buhl, ID	754,000	69.2	25.6	76,100	11,100
91	13154500	Snake River at King Hill, ID	782,000	46.9	21.8	92,900	16,900
92	13203510	Boise River below Diversion Dam near Boise, ID	28,500	7.83	10.6	6,980	3,690
93	13206000	Boise River at Glenwood, ID	114,000	34.1	41.0	7,180	3,380
94	13238322	North Fork Payette River below Fischer Creek near McCall, ID	NC	NC	NC	220	416
95	12414900	St. Maries River near Santa, ID	NC	NC	NC	706	–
96	12414500	St. Joe River at Calder, ID	NC	NC	NC	2,680	–
97	12413470	South Fork Coeur d' Alene River near Pinehurst, ID	NC	NC	NC	738	846
98	12413000	North Fork Coeur d' Alene River at Enaville, ID	122,000	45.0	135	2,320	2,740
99	12419000	Spokane River near Post Falls, ID	NC	NC	NC	10,200	10,300
100	13010065	Snake River at Flagg Ranch, WY	635,000	419	1,240	1,320	1,540

Table A4. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for total nitrogen in the Columbia River and Puget Sound basins, water year 2000.

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; lb/yr, pound per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Flux (lb/d)	Variance (lb/d)	Lower 95 (lb/d)	Upper 95 (lb/d)	SEP (lb/d)	Number of days
1	10729	Owyhee River at Hwy. 201 Bridge (Owyhee), OR	1,730	4,100	1,600	1,870	67.6	366
2	MAL113	North Fork Malheur River approximately 2 miles upstrean of Beulah Reservoir, OR	NA	NA	NA	NA	NA	–
3	MAL144	Malheur River at Ford Street (1.1 miles) upstream of Bully Creek, OR	NA	NA	NA	NA	NA	–
4	10386	Middle Fork Willamette River at Jasper Bridge, OR	NA	NA	NA	NA	NA	–
5	10663	Mohawk River at Hill Road, OR	NA	NA	NA	NA	NA	–
6	10376	McKenzie River at Coburg Road, OR	NA	NA	NA	NA	NA	–
7	10355	Willamette River at Hwy 99E (Harrisburg), OR	15,800	809,000	13,900	17,800	991	366
8	11140	Long Tom River at Stow Pit Road (Monroe), OR	3,040	55,200	2,580	3,560	250	366
9	12657	McKenzie River at Hwy 126 downstream of Clear Lake, OR	NA	NA	NA	NA	NA	–
10	10508	Deschutes River at Lower Bridge, OR	1,220	18,400	974	1,510	137	366
11	10350	Willamette River at Albany (Eastbound Hwy 20 Bridge), OR	38,100	5,060,000	33,400	43,300	2,540	366
12	11490	Powder River at Hwy 7 (Baker City), OR	213	154	189	240	13.0	366
13	11478	John Day River at Service Creek, OR	2,490	58,700	2,020	3,040	260	366
14	10555	Willamette River at Marion Street (Salem), OR	65,900	10,600,000	59,000	73,400	3,670	366
15	14200400	Little Abiqua Creek near Scotts Mills, OR	129	16.0	120	138	4.66	366
16	14201300	Zollner Creek near Mt. Angel, OR	1,330	4,900	1,170	1,510	87.1	366
17	10640	Pudding River at Hwy 211 (Woodburn), OR	11,700	1,170,000	9,660	14,100	1,140	366
18	13070	Clackamas River at Mciver Park (Upper Boat Ramp), OR	NA	NA	NA	NA	NA	–
19	3701002	Tualatin River at Weiss Bridge, OR	16,600	92,800	15,800	17,300	392	366
20	3840012	Fanno Creek at Durham Road, OR	NA	NA	NA	NA	NA	–
21	14206950	Fanno Creek near Durham, OR	NA	NA	NA	NA	NA	–
22	3701715	Tualatin River at Cherry Grove, OR	NA	NA	NA	NA	NA	–
23	11321	Johnson Creek at SE 17th Avenue (Portland), OR	1,300	838	1,240	1,360	30.3	366
24	3701333	Tualatin River at Farmington Bridge Road, OR	10,500	180,000	9,630	11,400	460	366
25	3701612	Tualatin River at Springhill Road Bridge (Dilley), OR	1,400	3,170	1,250	1,560	77.8	366
26	11386	John Day River at Hwy 206, OR	NA	NA	NA	NA	NA	–
27	3805048	Scoggins Creek below Hagg Lake at Stimson Bridge, OR	187	50.3	172	203	7.92	366
28	3701391	Tualatin River at Rood Bridge Road, OR	7,190	82,600	6,500	7,920	362	366
29	3701528	Tualatin River at Golf Course Road, OR	2,560	8,710	2,320	2,820	128	365
30	3810015	Gales Creek at New Hwy 47, OR	842	993	756	934	45.6	366
31	10611	Willamette River at Hawthorne Bridge (Portland), OR	152,000	53,100,000	136,000	168,000	8,270	366
32	3820012	Rock Creek at Hwy 8, OR	NA	NA	NA	NA	NA	–
33	14211720	Willamette River at Portland, OR	160,000	38,000,000	146,000	175,000	7,340	366
34	3850006	Dawson Creek at Brookwood, OR	39.8	2.44	36.3	43.6	1.88	366
35	3824020	Bronson Creek at Bronson Park downstream of Sunset Hwy, OR	20.1	.47	18.5	21.8	.84	366
36	3824072	Bronson Creek at Saltzman, OR	7.51	.05	6.96	8.09	.29	366
37	10332	Willamette River at SP&S Railroad Bridge, OR	157,000	132,000,000	134,000	182,000	12,200	366
38	14128910	Columbia River at Warrendale, OR	424,000	1,030,000,000	363,000	493,000	33,000	366
39	10411	Deschutes River at Deschutes River Park, OR	10,600	332,000	9,430	11,800	604	366
40	10616	Columbia River at Marker #47 (upstream of Willamette River), OR	455,000	1,120,000,000	389,000	529,000	35,600	366
41	10406	Umatilla River at Hwy 11 (Pendleton), OR	766	6,700	608	951	87.7	366
42	12012	Hood River at footbridge downstream of I-84, OR	NA	NA	NA	NA	NA	–
43	11489	Umatilla River at Westland Road (Hermiston), OR	3,980	52,400	3,530	4,480	243	366
44	14246900	Columbia River at Beaver Army Terminal near Quincy, OR	572,000	423,000,000	529,000	617,000	22,300	366
45	27D090	East Fork Lewis River near Dollar Corner, WA	1,850	8,740	1,650	2,060	105	366
46	32A070	Walla Walla River near Touchet, WA	2,430	15,900	2,160	2,730	145	366
47	13353200	Snake River at Burbank, WA	171,000	56,900,000	156,000	187,000	7,970	366
48	37A090	Yakima River at Kiona, WA	19,400	489,000	17,900	21,000	780	366
49	12510500	Yakima River at Kiona, WA	21,000	817,000	19,200	22,900	955	366
50	12505450	Granger Drain at Granger, WA	816	645	766	868	26.2	366

Table A4. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for total nitrogen in the Columbia River and Puget Sound basins, water year 2000.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; lb/yr, pound per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Flux (lb/d)	Variance (lb/d)	Lower 95 (lb/d)	Upper 95 (lb/d)	SEP (lb/d)	Number of days
1	10729	Owyhee River at Hwy. 201 Bridge (Owyhee), OR	1,730	4,100	1,600	1,870	67.6	366
2	MAL113	North Fork Malheur River approximately 2 miles upstrean of Beulah Reservoir, OR	NA	NA	NA	NA	NA	–
3	MAL144	Malheur River at Ford Street (1.1 miles) upstream of Bully Creek, OR	NA	NA	NA	NA	NA	–
4	10386	Middle Fork Willamette River at Jasper Bridge, OR	NA	NA	NA	NA	NA	–
5	10663	Mohawk River at Hill Road, OR	NA	NA	NA	NA	NA	–
6	10376	McKenzie River at Coburg Road, OR	NA	NA	NA	NA	NA	–
7	10355	Willamette River at Hwy 99E (Harrisburg), OR	15,800	809,000	13,900	17,800	991	366
8	11140	Long Tom River at Stow Pit Road (Monroe), OR	3,040	55,200	2,580	3,560	250	366
9	12657	McKenzie River at Hwy 126 downstream of Clear Lake, OR	NA	NA	NA	NA	NA	–
10	10508	Deschutes River at Lower Bridge, OR	1,220	18,400	974	1,510	137	366
11	10350	Willamette River at Albany (Eastbound Hwy 20 Bridge), OR	38,100	5,060,000	33,400	43,300	2,540	366
12	11490	Powder River at Hwy 7 (Baker City), OR	213	154	189	240	13.0	366
13	11478	John Day River at Service Creek, OR	2,490	58,700	2,020	3,040	260	366
14	10555	Willamette River at Marion Street (Salem), OR	65,900	10,600,000	59,000	73,400	3,670	366
15	14200400	Little Abiqua Creek near Scotts Mills, OR	129	16.0	120	138	4.66	366
16	14201300	Zollner Creek near Mt. Angel, OR	1,330	4,900	1,170	1,510	87.1	366
17	10640	Pudding River at Hwy 211 (Woodburn), OR	11,700	1,170,000	9,660	14,100	1,140	366
18	13070	Clackamas River at Mciver Park (Upper Boat Ramp), OR	NA	NA	NA	NA	NA	–
19	3701002	Tualatin River at Weiss Bridge, OR	16,600	92,800	15,800	17,300	392	366
20	3840012	Fanno Creek at Durham Road, OR	NA	NA	NA	NA	NA	–
21	14206950	Fanno Creek near Durham, OR	NA	NA	NA	NA	NA	–
22	3701715	Tualatin River at Cherry Grove, OR	NA	NA	NA	NA	NA	–
23	11321	Johnson Creek at SE 17th Avenue (Portland), OR	1,300	838	1,240	1,360	30.3	366
24	3701333	Tualatin River at Farmington Bridge Road, OR	10,500	180,000	9,630	11,400	460	366
25	3701612	Tualatin River at Springhill Road Bridge (Dilley), OR	1,400	3,170	1,250	1,560	77.8	366
26	11386	John Day River at Hwy 206, OR	NA	NA	NA	NA	NA	–
27	3805048	Scoggins Creek below Hagg Lake at Stimson Bridge, OR	187	50.3	172	203	7.92	366
28	3701391	Tualatin River at Rood Bridge Road, OR	7,190	82,600	6,500	7,920	362	366
29	3701528	Tualatin River at Golf Course Road, OR	2,560	8,710	2,320	2,820	128	365
30	3810015	Gales Creek at New Hwy 47, OR	842	993	756	934	45.6	366
31	10611	Willamette River at Hawthorne Bridge (Portland), OR	152,000	53,100,000	136,000	168,000	8,270	366
32	3820012	Rock Creek at Hwy 8, OR	NA	NA	NA	NA	NA	–
33	14211720	Willamette River at Portland, OR	160,000	38,000,000	146,000	175,000	7,340	366
34	3850006	Dawson Creek at Brookwood, OR	39.8	2.44	36.3	43.6	1.88	366
35	3824020	Bronson Creek at Bronson Park downstream of Sunset Hwy, OR	20.1	.47	18.5	21.8	.84	366
36	3824072	Bronson Creek at Saltzman, OR	7.51	.05	6.96	8.09	.29	366
37	10332	Willamette River at SP&S Railroad Bridge, OR	157,000	132,000,000	134,000	182,000	12,200	366
38	14128910	Columbia River at Warrendale, OR	424,000	1,030,000,000	363,000	493,000	33,000	366
39	10411	Deschutes River at Deschutes River Park, OR	10,600	332,000	9,430	11,800	604	366
40	10616	Columbia River at Marker #47 (upstream of Willamette River), OR	455,000	1,120,000,000	389,000	529,000	35,600	366
41	10406	Umatilla River at Hwy 11 (Pendleton), OR	766	6,700	608	951	87.7	366
42	12012	Hood River at footbridge downstream of I-84, OR	NA	NA	NA	NA	NA	–
43	11489	Umatilla River at Westland Road (Hermiston), OR	3,980	52,400	3,530	4,480	243	366
44	14246900	Columbia River at Beaver Army Terminal near Quincy, OR	572,000	423,000,000	529,000	617,000	22,300	366
45	27D090	East Fork Lewis River near Dollar Corner, WA	1,850	8,740	1,650	2,060	105	366
46	32A070	Walla Walla River near Touchet, WA	2,430	15,900	2,160	2,730	145	366
47	13353200	Snake River at Burbank, WA	171,000	56,900,000	156,000	187,000	7,970	366
48	37A090	Yakima River at Kiona, WA	19,400	489,000	17,900	21,000	780	366
49	12510500	Yakima River at Kiona, WA	21,000	817,000	19,200	22,900	955	366
50	12505450	Granger Drain at Granger, WA	816	645	766	868	26.2	366

Table A4. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for total nitrogen in the Columbia River and Puget Sound basins, water year 2000.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; lb/yr, pound per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Flux (lb/d)	Variance (lb/d)	Lower 95 (lb/d)	Upper 95 (lb/d)	SEP (lb/d)	Number of days
51	12472900	Columbia River at Vernita Bridge near Priest Rapids Dam, WA	144,000	121,000,000	123,000	168,000	11,400	366
52	13351000	Palouse River at Hooper, WA	18,500	983,000	16,300	21,000	1,210	366
53	34A070	Palouse River at Hooper, WA	18,300	1,860,000	15,400	21,500	1,540	366
54	41A070	Crab Creek near Beverly, WA	NA	NA	NA	NA	NA	–
55	12471400	Lind Coulee Wastway at SR 17 near Warden, WA	2,720	4,320	2,590	2,860	69.3	366
56	13A060	Deschutes River at East Street Bridge, WA	1,730	2,250	1,630	1,830	52.5	366
57	10A070	Puyallup River at Meridian Street, WA	6,500	89,800	5,880	7,170	330	366
58	12108500	Newaukum Creek near Black Diamond, WA	NA	NA	NA	NA	NA	–
59	12464770	Crab Creek at Rocky Ford Road near Ritzville, WA	874	911	810	942	33.9	366
60	12061500	Skokomish River near Potlatch, WA	NA	NA	NA	NA	NA	–
61	16A070	Skokomish River near Potlatch, WA	638	3,070	527	766	61.0	366
62	12112600	Big Soos Creek above Hatchery near Auburn, WA	NA	NA	NA	NA	NA	–
63	09A190	Green River at Kanaskat, WA	1,060	7,480	874	1,270	101	366
64	45A070	Wenatchee River at Wenatchee, WA	2,780	12,600	2,540	3,030	124	366
65	12113375	Springbrook Creek at Tukwila, WA	NA	NA	NA	NA	NA	–
66	09A080	Green River at Tukwila, WA	3,850	25,500	3,510	4,210	179	366
67	12113390	Duwamish River at Golf Course at Tukwila, WA	5,200	59,700	4,680	5,770	278	366
68	12056500	North Fork Skokomish River below Staircase Rapids near Hoodport, WA	NA	NA	NA	NA	NA	–
69	46A070	Entiat River near Entiat, WA	315	836	259	379	30.5	366
70	45A110	Wenatchee River near Leavenworth, WA	1,630	11,500	1,400	1,880	122	366
71	16C090	Duckabush River near Brinnon, WA	121	154	94.8	152	14.5	366
72	12128000	Thorton Creek near Seattle, WA	92.7	8.17	86.5	99.2	3.20	366
73	54A120	Spokane River at Riverside State Park, WA	21,600	764,000	19,800	23,500	952	366
74	07D050	Snoqualmie River near Monroe, WA	8,060	62,600	7,520	8,630	282	366
75	07C070	Skykomish River at Monroe, WA	4,610	40,500	4,170	5,090	235	366
76	07A090	Snohomish River at Snohomish, WA	19,000	574,000	17,400	20,800	878	366
77	53A070	Columbia River at Grand Coulee, WA	111,000	16,900,000	102,000	120,000	4,540	366
78	48A070	Methow River near Pateros, WA	1,100	2,170	1,000	1,200	50.8	366
79	49A070	Okanogan River at Malott, WA	2,780	15,700	2,520	3,060	138	366
80	48A140	Methow River at Twisp, WA	838	1,730	751	932	46.2	366
81	03A060	Skagit River near Mount Vernon, WA	15,700	561,000	14,000	17,500	879	366
82	03B050	Samish River near Burlington, WA	1,520	2,240	1,420	1,620	51.0	366
83	12213140	Nooksack River at Brennan, WA	NA	NA	NA	NA	NA	–
84	01A050	Nooksack River at Brennan, WA	12,400	266,000	11,300	13,500	567	366
85	12210700	Nooksack River at North Cedarville, WA	NA	NA	NA	NA	NA	–
86	12400520	Columbia River at Northport, WA	75,700	288,000,000	47,700	114,000	17,100	366
87	61A070	Columbia River at Northport, WA	80,300	4,290,000	76,000	84,700	2,230	366
88	12212100	Fishtrap Creek at Flynn Road at Lynden, WA	NA	NA	NA	NA	NA	–
89	13092747	Rock Creek above Hwy 30/93 crossing at Twin Falls, ID	1,370	838	1,310	1,430	31.5	366
90	13094000	Snake River near Buhl, ID	42,300	1,120,000	40,100	44,500	1,120	366
91	13154500	Snake River at King Hill, ID	82,200	1,330,000	79,600	84,900	1,340	366
92	13203510	Boise River below Diversion Dam near Boise, ID	1,670	8,420	1,490	1,870	95.9	366
93	13206000	Boise River at Glenwood, ID	2,040	6,670	1,870	2,210	87.5	366
94	13238322	North Fork Payette River below Fischer Creek near McCall, ID	281	1,590	205	375	43.5	366
95	12414900	St. Maries River near Santa, ID	NA	NA	NA	NA	NA	–
96	12414500	St. Joe River at Calder, ID	NA	NA	NA	NA	NA	–
97	12413470	South Fork Coeur d' Alene River near Pinehurst, ID	947	1,940	855	1,050	49.1	366
98	12413000	North Fork Coeur d' Alene River at Enaville, ID	NA	NA	NA	NA	NA	–
99	12419000	Spokane River near Post Falls, ID	6,600	327,000	5,510	7,850	600	366
100	13010065	Snake River at Flagg Ranch, WY	1,130	30,900	763	1,610	216	366

Table A4. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for total nitrogen in the Columbia River and Puget Sound basins, water year 2000.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; lb/yr, pound per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Flux (lb/d)	Variance (lb/d)	Lower 95 (lb/d)	Upper 95 (lb/d)	SEP (lb/d)	Number of days
51	12472900	Columbia River at Vernita Bridge near Priest Rapids Dam, WA	144,000	121,000,000	123,000	168,000	11,400	366
52	13351000	Palouse River at Hooper, WA	18,500	983,000	16,300	21,000	1,210	366
53	34A070	Palouse River at Hooper, WA	18,300	1,860,000	15,400	21,500	1,540	366
54	41A070	Crab Creek near Beverly, WA	NA	NA	NA	NA	NA	–
55	12471400	Lind Coulee Wastway at SR 17 near Warden, WA	2,720	4,320	2,590	2,860	69.3	366
56	13A060	Deschutes River at East Street Bridge, WA	1,730	2,250	1,630	1,830	52.5	366
57	10A070	Puyallup River at Meridian Street, WA	6,500	89,800	5,880	7,170	330	366
58	12108500	Newaukum Creek near Black Diamond, WA	NA	NA	NA	NA	NA	–
59	12464770	Crab Creek at Rocky Ford Road near Ritzville, WA	874	911	810	942	33.9	366
60	12061500	Skokomish River near Potlatch, WA	NA	NA	NA	NA	NA	–
61	16A070	Skokomish River near Potlatch, WA	638	3,070	527	766	61.0	366
62	12112600	Big Soos Creek above Hatchery near Auburn, WA	NA	NA	NA	NA	NA	–
63	09A190	Green River at Kanaskat, WA	1,060	7,480	874	1,270	101	366
64	45A070	Wenatchee River at Wenatchee, WA	2,780	12,600	2,540	3,030	124	366
65	12113375	Springbrook Creek at Tukwila, WA	NA	NA	NA	NA	NA	–
66	09A080	Green River at Tukwila, WA	3,850	25,500	3,510	4,210	179	366
67	12113390	Duwamish River at Golf Course at Tukwila, WA	5,200	59,700	4,680	5,770	278	366
68	12056500	North Fork Skokomish River below Staircase Rapids near Hoodport, WA	NA	NA	NA	NA	NA	–
69	46A070	Entiat River near Entiat, WA	315	836	259	379	30.5	366
70	45A110	Wenatchee River near Leavenworth, WA	1,630	11,500	1,400	1,880	122	366
71	16C090	Duckabush River near Brinnon, WA	121	154	94.8	152	14.5	366
72	12128000	Thorton Creek near Seattle, WA	92.7	8.17	86.5	99.2	3.20	366
73	54A120	Spokane River at Riverside State Park, WA	21,600	764,000	19,800	23,500	952	366
74	07D050	Snoqualmie River near Monroe, WA	8,060	62,600	7,520	8,630	282	366
75	07C070	Skykomish River at Monroe, WA	4,610	40,500	4,170	5,090	235	366
76	07A090	Snohomish River at Snohomish, WA	19,000	574,000	17,400	20,800	878	366
77	53A070	Columbia River at Grand Coulee, WA	111,000	16,900,000	102,000	120,000	4,540	366
78	48A070	Methow River near Pateros, WA	1,100	2,170	1,000	1,200	50.8	366
79	49A070	Okanogan River at Malott, WA	2,780	15,700	2,520	3,060	138	366
80	48A140	Methow River at Twisp, WA	838	1,730	751	932	46.2	366
81	03A060	Skagit River near Mount Vernon, WA	15,700	561,000	14,000	17,500	879	366
82	03B050	Samish River near Burlington, WA	1,520	2,240	1,420	1,620	51.0	366
83	12213140	Nooksack River at Brennan, WA	NA	NA	NA	NA	NA	–
84	01A050	Nooksack River at Brennan, WA	12,400	266,000	11,300	13,500	567	366
85	12210700	Nooksack River at North Cedarville, WA	NA	NA	NA	NA	NA	–
86	12400520	Columbia River at Northport, WA	75,700	288,000,000	47,700	114,000	17,100	366
87	61A070	Columbia River at Northport, WA	80,300	4,290,000	76,000	84,700	2,230	366
88	12212100	Fishtrap Creek at Flynn Road at Lynden, WA	NA	NA	NA	NA	NA	–
89	13092747	Rock Creek above Hwy 30/93 crossing at Twin Falls, ID	1,370	838	1,310	1,430	31.5	366
90	13094000	Snake River near Buhl, ID	42,300	1,120,000	40,100	44,500	1,120	366
91	13154500	Snake River at King Hill, ID	82,200	1,330,000	79,600	84,900	1,340	366
92	13203510	Boise River below Diversion Dam near Boise, ID	1,670	8,420	1,490	1,870	95.9	366
93	13206000	Boise River at Glenwood, ID	2,040	6,670	1,870	2,210	87.5	366
94	13238322	North Fork Payette River below Fischer Creek near McCall, ID	281	1,590	205	375	43.5	366
95	12414900	St. Maries River near Santa, ID	NA	NA	NA	NA	NA	–
96	12414500	St. Joe River at Calder, ID	NA	NA	NA	NA	NA	–
97	12413470	South Fork Coeur d' Alene River near Pinehurst, ID	947	1,940	855	1,050	49.1	366
98	12413000	North Fork Coeur d' Alene River at Enaville, ID	NA	NA	NA	NA	NA	–
99	12419000	Spokane River near Post Falls, ID	6,600	327,000	5,510	7,850	600	366
100	13010065	Snake River at Flagg Ranch, WY	1,130	30,900	763	1,610	216	366

Table A5. Results of loadest modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for total phosphorus in the Columbia River and Puget Sound basins, water year 2000.

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; lb/yr, pound per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Flux (lb/d)	Variance (lb/d)	Lower 95 (lb/d)	Upper 95 (lb/d)	SEP (lb/d)	Number of days
1	10729	Owyhee River at Hwy. 201 Bridge (Owyhee), OR	193	151	168	219	13.0	366
2	MAL113	North Fork Malheur River approximately 2 miles upstream of Beulah Reservoir, OR	69.0	21.3	59.9	79.0	4.87	366
3	MAL144	Malheur River at Ford Street (1.1 miles) upstream of Bully Creek, OR	393	613	344	447	26.3	366
4	10386	Middle Fork Willamette River at Jasper Bridge, OR	741	1,160	673	815	36.3	366
5	10663	Mohawk River at Hill Road, OR	96.5	87.2	78.3	118	10.1	366
6	10376	McKenzie River at Coburg Road, OR	1,200	2,030	1,110	1,300	49.9	366
7	10355	Willamette River at Hwy 99E (Harrisburg), OR	3,980	27,600	3,600	4,380	200	366
8	11140	Long Tom River at Stow Pit Road (Monroe), OR	337	465	295	385	23.0	366
9	12657	McKenzie River at Hwy 126 downstream of Clear Lake, OR	104	10.6	97.6	111	3.44	366
10	10508	Deschutes River at Lower Bridge, OR	510	322	474	547	18.7	366
11	10350	Willamette River at Albany (Eastbound Hwy 20 Bridge), OR	6,140	70,500	5,570	6,760	305	366
12	11490	Powder River at Hwy 7 (Baker City), OR	34.3	10.2	28.2	41.4	3.37	366
13	11478	John Day River at Service Creek, OR	612	2,480	511	727	55.1	366
14	10555	Willamette River at Marion Street (Salem), OR	9,360	152,000	8,510	10,300	449	366
15	14200400	Little Abiqua Creek near Scotts Mills, OR	4.54	.34	3.40	5.95	.65	366
16	14201300	Zollner Creek near Mt. Angel, OR	36.0	5.88	30.0	42.8	3.26	366
17	10640	Pudding River at Hwy 211 (Woodburn), OR	575	3,490	462	706	62.4	366
18	13070	Clackamas River at Mciver Park (Upper Boat Ramp), OR	449	4,900	317	619	77.3	366
19	3701002	Tualatin River at Weiss Bridge, OR	1,170	1,500	1,070	1,270	50.9	366
20	3840012	Fanno Creek at Durham Road, OR	NA	NA	NA	NA	NA	–
21	14206950	Fanno Creek near Durham, OR	NA	NA	NA	NA	NA	–
22	3701715	Tualatin River at Cherry Grove, OR	38.5	21.1	28.8	50.4	5.51	366
23	11321	Johnson Creek at SE 17th Avenue (Portland), OR	46.7	8.76	40.7	53.2	3.17	366
24	3701333	Tualatin River at Farmington Bridge Road, OR	983	3,380	858	1,120	67.5	366
25	3701612	Tualatin River at Springhill Road Bridge (Dilley), OR	127	36.6	111	145	8.52	366
26	11386	John Day River at Hwy 206, OR	808	12,000	598	1,070	120	366
27	3805048	Scoggins Creek below Hagg Lake at Stimson Bridge, OR	14.8	5.96	10.4	20.6	2.63	366
28	3701391	Tualatin River at Rood Bridge Road, OR	474	223	439	512	18.7	366
29	3701528	Tualatin River at Golf Course Road, OR	232	87.1	209	257	12.1	365
30	3810015	Gales Creek at New Hwy 47, OR	112	32.3	96.1	129	8.50	366
31	10611	Willamette River at Hawthorne Bridge (Portland), OR	16,500	190,000	15,500	17,500	504	366
32	3820012	Rock Creek at Hwy 8, OR	NA	NA	NA	NA	NA	–
33	14211720	Willamette River at Portland, OR	16,300	483,000	14,700	18,100	854	366
34	3850006	Dawson Creek at Brookwood, OR	3.78	.01	3.57	4.00	.11	366
35	3824020	Bronson Creek at Bronson Park downstream of Sunset Hwy, OR	1.95	.00	1.81	2.09	.07	366
36	3824072	Bronson Creek at Saltzman, OR	.74	.00	.65	.82	.04	366
37	10332	Willamette River at SP&S Railroad Bridge, OR	18,100	383,000	16,800	19,400	680	366
38	14128910	Columbia River at Warrendale, OR	30,400	5,430,000	25,700	35,600	2,550	366
39	10411	Deschutes River at Deschutes River Park, OR	3,170	41,300	2,770	3,610	216	366
40	10616	Columbia River at Marker #47 (upstream of Willamette River), OR	43,800	3,810,000	39,900	48,000	2,080	366
41	10406	Umatilla River at Hwy 11 (Pendleton), OR	146	81.1	128	166	9.76	366
42	12012	Hood River at footbridge downstream of I-84, OR	NA	NA	NA	NA	NA	–
43	11489	Umatilla River at Westland Road (Hermiston), OR	379	925	318	448	33.2	366
44	14246900	Columbia River at Beaver Army Terminal near Quincy, OR	54,600	9,360,000	48,100	61,800	3,490	366
45	27D090	East Fork Lewis River near Dollar Corner, WA	127	483	83.5	185	26.0	366
46	32A070	Walla Walla River near Touchet, WA	499	2,510	398	617	56.2	366
47	13353200	Snake River at Burbank, WA	13,300	1,130,000	11,200	15,600	1,130	366
48	37A090	Yakima River at Kiona, WA	2,420	6,230	2,240	2,600	91.1	366
49	12510500	Yakima River at Kiona, WA	2,630	22,300	2,330	2,960	159	366
50	12505450	Granger Drain at Granger, WA	65.0	14.5	57.5	73.1	3.97	366

Table A5. Results of loadest modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for total phosphorus in the Columbia River and Puget Sound basins, water year 2000.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; lb/yr, pound per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Load (lb/yr)	Flow-weighted concentration (mg/L)	Yield (lb/mi^2/yr)	Drainage area (km^2)	Annual mean flow (ft^3/s)
1	10729	Owyhee River at Hwy. 201 Bridge (Owyhee), OR	70,500	0.21	NC	NA	166
2	MAL113	North Fork Malheur River approximately 2 miles upstream of Beulah Reservoir, OR	25,200	.10	74.0	880	134
3	MAL144	Malheur River at Ford Street (1.1 miles) upstream of Bully Creek, OR	144,000	.24	31.1	12,000	302
4	10386	Middle Fork Willamette River at Jasper Bridge, OR	271,000	.03	201	3,490	4,200
5	10663	Mohawk River at Hill Road, OR	35,300	.03	198	460	554
6	10376	McKenzie River at Coburg Road, OR	440,000	.04	NC	NA	5,070
7	10355	Willamette River at Hwy 99E (Harrisburg), OR	1,460,000	.07	423	8,890	11,300
8	11140	Long Tom River at Stow Pit Road (Monroe), OR	124,000	.08	296	1,080	743
9	12657	McKenzie River at Hwy 126 downstream of Clear Lake, OR	38,100	.04	412	239	515
10	10508	Deschutes River at Lower Bridge, OR	187,000	.08	88.6	5,440	1,250
11	10350	Willamette River at Albany (Eastbound Hwy 20 Bridge), OR	2,250,000	.08	462	12,600	14,200
12	11490	Powder River at Hwy 7 (Baker City), OR	12,600	.06	36.0	902	109
13	11478	John Day River at Service Creek, OR	224,000	.07	43.5	13,300	1,680
14	10555	Willamette River at Marion Street (Salem), OR	3,420,000	.07	463	19,100	23,700
15	14200400	Little Abiqua Creek near Scotts Mills, OR	1,660	.02	168	25.5	37.1
16	14201300	Zollner Creek near Mt. Angel, OR	13,200	.36	875	38.9	18.4
17	10640	Pudding River at Hwy 211 (Woodburn), OR	210,000	.13	664	818	825
18	13070	Clackamas River at Mciver Park (Upper Boat Ramp), OR	164,000	.03	241	1,760	2,830
19	3701002	Tualatin River at Weiss Bridge, OR	426,000	.15	599	1,840	1,410
20	3840012	Fanno Creek at Durham Road, OR	NC	NC	NC	80.7	–
21	14206950	Fanno Creek near Durham, OR	NC	NC	NC	80.7	–
22	3701715	Tualatin River at Cherry Grove, OR	14,100	.05	374	97.3	148
23	11321	Johnson Creek at SE 17th Avenue (Portland), OR	17,100	.12	318	139	69.3
24	3701333	Tualatin River at Farmington Bridge Road, OR	360,000	.16	638	1,460	1,130
25	3701612	Tualatin River at Springhill Road Bridge (Dilley), OR	46,500	.06	368	327	392
26	11386	John Day River at Hwy 206, OR	296,000	.08	NC	NA	1,770
27	3805048	Scoggins Creek below Hagg Lake at Stimson Bridge, OR	5,430	.02	136	103	111
28	3701391	Tualatin River at Rood Bridge Road, OR	174,000	.09	365	1,230	972
29	3701528	Tualatin River at Golf Course Road, OR	84,700	.07	391	561	610
30	3810015	Gales Creek at New Hwy 47, OR	40,900	.09	543	195	221
31	10611	Willamette River at Hawthorne Bridge (Portland), OR	6,030,000	.09	539	28,900	35,100
32	3820012	Rock Creek at Hwy 8, OR	NC	NC	NC	193	–
33	14211720	Willamette River at Portland, OR	5,980,000	.09	533	28,900	35,100
34	3850006	Dawson Creek at Brookwood, OR	1,380	.13	370	9.66	5.44
35	3824020	Bronson Creek at Bronson Park downstream of Sunset Hwy, OR	712	.11	180	10.2	3.36
36	3824072	Bronson Creek at Saltzman, OR	269	.14	133	5.23	1.00
37	10332	Willamette River at SP&S Railroad Bridge, OR	6,610,000	.10	NC	NA	35,100
38	14128910	Columbia River at Warrendale, OR	11,100,000	.03	46.6	616,000	185,000
39	10411	Deschutes River at Deschutes River Park, OR	1,160,000	.09	108	27,800	6,450
40	10616	Columbia River at Marker #47 (upstream of Willamette River), OR	16,000,000	.05	NC	NA	177,000
41	10406	Umatilla River at Hwy 11 (Pendleton), OR	53,600	.05	120	1,150	518
42	12012	Hood River at footbridge downstream of I-84, OR	NC	NC	NC	NA	1,030
43	11489	Umatilla River at Westland Road (Hermiston), OR	139,000	.13	NC	NA	545
44	14246900	Columbia River at Beaver Army Terminal near Quincy, OR	20,000,000	.04	78.5	658,000	232,000
45	27D090	East Fork Lewis River near Dollar Corner, WA	46,400	.03	296	405	771
46	32A070	Walla Walla River near Touchet, WA	182,000	.16	108	4,370	572
47	13353200	Snake River at Burbank, WA	4,860,000	.05	47.9	262,000	46,600
48	37A090	Yakima River at Kiona, WA	885,000	.12	157	14,500	3,770
49	12510500	Yakima River at Kiona, WA	963,000	.13	171	14,500	3,770
50	12505450	Granger Drain at Granger, WA	23,800	.30	384	160	40.4

Table A5. Results of loadest modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for total phosphorus in the Columbia River and Puget Sound basins, water year 2000.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; lb/yr, pound per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Flux (lb/d)	Variance (lb/d)	Lower 95 (lb/d)	Upper 95 (lb/d)	SEP (lb/d)	Number of days
51	12472900	Columbia River at Vernita Bridge near Priest Rapids Dam, WA	8,220	1,360,000	6,040	10,900	1,250	366
52	13351000	Palouse River at Hooper, WA	1,110	10,600	869	1,410	138	366
53	34A070	Palouse River at Hooper, WA	849	7,180	677	1,050	95.8	366
54	41A070	Crab Creek near Beverly, WA	NA	NA	NA	NA	NA	–
55	12471400	Lind Coulee Wastway at SR 17 near Warden, WA	132	390	96.5	176	20.4	366
56	13A060	Deschutes River at East Street Bridge, WA	178	310	143	220	19.7	366
57	10A070	Puyallup River at Meridian Street, WA	2,750	317,000	1,650	4,300	680	366
58	12108500	Newaukum Creek near Black Diamond, WA	NA	NA	NA	NA	NA	–
59	12464770	Crab Creek at Rocky Ford Road near Ritzville, WA	44.5	12.1	37.1	53.1	4.09	366
60	12061500	Skokomish River near Potlatch, WA	NA	NA	NA	NA	NA	–
61	16A070	Skokomish River near Potlatch, WA	396	5,030	262	576	80.4	366
62	12112600	Big Soos Creek above Hatchery near Auburn, WA	NA	NA	NA	NA	NA	–
63	09A190	Green River at Kanaskat, WA	162	283	128	203	19.2	366
64	45A070	Wenatchee River at Wenatchee, WA	420	1,550	339	514	44.7	366
65	12113375	Springbrook Creek at Tukwila, WA	NA	NA	NA	NA	NA	–
66	09A080	Green River at Tukwila, WA	608	3,420	488	749	66.5	366
67	12113390	Duwamish River at Golf Course at Tukwila, WA	726	6,850	550	942	100	366
68	12056500	North Fork Skokomish River below Staircase Rapids near Hoodport, WA	32.8	31.8	19.8	51.3	8.10	366
69	46A070	Entiat River near Entiat, WA	74.1	84.3	56.7	95.2	9.83	366
70	45A110	Wenatchee River near Leavenworth, WA	314	1,270	243	399	40.0	366
71	16C090	Duckabush River near Brinnon, WA	48.4	145	27.5	79.2	13.3	366
72	12128000	Thorton Creek near Seattle, WA	6.24	.44	4.85	7.90	.78	366
73	54A120	Spokane River at Riverside State Park, WA	1,870	25,600	1,550	2,250	179	366
74	07D050	Snoqualmie River near Monroe, WA	784	5,890	624	973	89.2	366
75	07C070	Skykomish River at Monroe, WA	531	4,040	403	688	73.0	366
76	07A090	Snohomish River at Snohomish, WA	1,820	32,000	1,450	2,250	206	366
77	53A070	Columbia River at Grand Coulee, WA	9,880	1,340,000	7,510	12,800	1,340	366
78	48A070	Methow River near Pateros, WA	166	280	132	206	19.0	366
79	49A070	Okanogan River at Malott, WA	659	2,240	558	772	54.6	366
80	48A140	Methow River at Twisp, WA	153	380	115	200	21.8	366
81	03A060	Skagit River near Mount Vernon, WA	4,070	605,000	2,480	6,310	985	366
82	03B050	Samish River near Burlington, WA	57.4	67.6	42.3	76.1	8.65	366
83	12213140	Nooksack River at Brennan, WA	NA	NA	NA	NA	NA	–
84	01A050	Nooksack River at Brennan, WA	2,940	154,000	2,130	3,970	471	366
85	12210700	Nooksack River at North Cedarville, WA	NA	NA	NA	NA	NA	–
86	12400520	Columbia River at Northport, WA	3,140	512,000	1,950	4,790	729	366
87	61A070	Columbia River at Northport, WA	6,550	359,000	5,340	7,950	666	366
88	12212100	Fishtrap Creek at Flynn Road at Lynden, WA	NA	NA	NA	NA	NA	–
89	13092747	Rock Creek above Hwy 30/93 crossing at Twin Falls, ID	55.1	2.53	51.5	59.0	1.91	366
90	13094000	Snake River near Buhl, ID	2,690	30,200	2,340	3,080	187	366
91	13154500	Snake River at King Hill, ID	3,710	16,500	3,430	4,000	145	366
92	13203510	Boise River below Diversion Dam near Boise, ID	124	1,120	70.8	203	34.0	366
93	13206000	Boise River at Glenwood, ID	458	686	404	517	28.7	366
94	13238322	North Fork Payette River below Fischer Creek near McCall, ID	10.1	.96	8.03	12.6	1.16	366
95	12414900	St. Maries River near Santa, ID	87.3	213	61.0	121	15.4	366
96	12414500	St. Joe River at Calder, ID	119	263	88.6	156	17.4	366
97	12413470	South Fork Coeur d' Alene River near Pinehurst, ID	110	61.2	91.9	131	10.0	366
98	12413000	North Fork Coeur d' Alene River at Enaville, ID	193	828	127	282	39.5	366
99	12419000	Spokane River near Post Falls, ID	439	1,180	367	521	39.3	366
100	13010065	Snake River at Flagg Ranch, WY	266	2,290	167	402	60.2	366

Table A5. Results of loadest modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for total phosphorus in the Columbia River and Puget Sound basins, water year 2000.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; lb/yr, pound per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Load (lb/yr)	Flow-weighted concentration (mg/L)	Yield (lb/mi^2/yr)	Drainage area (km^2)	Annual mean flow (ft^3/s)
51	12472900	Columbia River at Vernita Bridge near Priest Rapids Dam, WA	3,010,000	0.01	115	67,800	120,000
52	13351000	Palouse River at Hooper, WA	408,000	.28	165	6,380	736
53	34A070	Palouse River at Hooper, WA	311,000	.21	126	6,380	736
54	41A070	Crab Creek near Beverly, WA	NC	NC	NC	999	–
55	12471400	Lind Coulee Wastway at SR 17 near Warden, WA	48,300	.12	67.7	1,840	209
56	13A060	Deschutes River at East Street Bridge, WA	65,300	.07	632	267	449
57	10A070	Puyallup River at Meridian Street, WA	1,010,000	.15	1,090	2,380	3,430
58	12108500	Newaukum Creek near Black Diamond, WA	NC	NC	NC	71.1	61.9
59	12464770	Crab Creek at Rocky Ford Road near Ritzville, WA	16,300	.13	35.4	1,190	61.6
60	12061500	Skokomish River near Potlatch, WA	NC	NC	NC	339	1,310
61	16A070	Skokomish River near Potlatch, WA	145,000	.06	1,100	339	1,310
62	12112600	Big Soos Creek above Hatchery near Auburn, WA	NC	NC	NC	173	124
63	09A190	Green River at Kanaskat, WA	59,400	.03	249	616	953
64	45A070	Wenatchee River at Wenatchee, WA	154,000	.02	115	3,440	3,370
65	12113375	Springbrook Creek at Tukwila, WA	NC	NC	NC	51.7	45.6
66	09A080	Green River at Tukwila, WA	223,000	.08	465	1,240	1,400
67	12113390	Duwamish River at Golf Course at Tukwila, WA	266,000	.08	575	1,190	1,590
68	12056500	North Fork Skokomish River below Staircase Rapids near Hoodport, WA	12,000	.01	211	147	535
69	46A070	Entiat River near Entiat, WA	27,100	.03	65.2	1,070	522
70	45A110	Wenatchee River near Leavenworth, WA	115,000	.02	172	1,720	3,190
71	16C090	Duckabush River near Brinnon, WA	17,700	.02	266	172	432
72	12128000	Thorton Creek near Seattle, WA	2,280	.11	202	29.2	10.5
73	54A120	Spokane River at Riverside State Park, WA	685,000	.05	137	13,000	7,030
74	07D050	Snoqualmie River near Monroe, WA	287,000	.04	418	1,770	3,930
75	07C070	Skykomish River at Monroe, WA	194,000	.02	253	1,980	4,620
76	07A090	Snohomish River at Snohomish, WA	665,000	.03	387	4,440	10,500
77	53A070	Columbia River at Grand Coulee, WA	3,610,000	.02	323	28,900	113,000
78	48A070	Methow River near Pateros, WA	60,600	.02	33.6	4,660	1,440
79	49A070	Okanogan River at Malott, WA	241,000	.04	138	4,500	2,930
80	48A140	Methow River at Twisp, WA	56,100	.02	42.3	3,430	1,310
81	03A060	Skagit River near Mount Vernon, WA	1,490,000	.04	639	6,020	17,500
82	03B050	Samish River near Burlington, WA	21,000	.04	243	223	288
83	12213140	Nooksack River at Brennan, WA	NC	NC	NC	2,020	4,250
84	01A050	Nooksack River at Brennan, WA	1,080,000	.13	1,460	1,910	4,250
85	12210700	Nooksack River at North Cedarville, WA	NC	NC	NC	1,520	–
86	12400520	Columbia River at Northport, WA	1,150,000	.01	19.0	156,000	106,000
87	61A070	Columbia River at Northport, WA	2,400,000	.01	39.8	156,000	106,000
88	12212100	Fishtrap Creek at Flynn Road at Lynden, WA	NC	NC	NC	98.6	–
89	13092747	Rock Creek above Hwy 30/93 crossing at Twin Falls, ID	20,200	.09	83.6	623	115
90	13094000	Snake River near Buhl, ID	985,000	.11	33.4	76,100	4,670
91	13154500	Snake River at King Hill, ID	1,360,000	.07	37.7	92,900	9,990
92	13203510	Boise River below Diversion Dam near Boise, ID	45,500	.02	16.8	6,980	1,300
93	13206000	Boise River at Glenwood, ID	168,000	.10	60.2	7,180	865
94	13238322	North Fork Payette River below Fischer Creek near McCall, ID	3,700	.01	43.4	220	231
95	12414900	St. Maries River near Santa, ID	32,000	.04	117	706	391
96	12414500	St. Joe River at Calder, ID	43,500	.01	42.0	2,680	2,380
97	12413470	South Fork Coeur d' Alene River near Pinehurst, ID	40,300	.03	141	738	584
98	12413000	North Fork Coeur d' Alene River at Enaville, ID	70,800	.02	78.6	2,330	2,030
99	12419000	Spokane River near Post Falls, ID	161,000	.01	40.9	10,200	6,850
100	13010065	Snake River at Flagg Ranch, WY	97,400	.06	190	1,320	839

Table A6. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for suspended sediment in the Columbia River and Puget Sound basins, water year 2000.

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; ton/d, ton per day; ton/yr, ton per year; mg/L, milligram per liter; ton/mi^2/yr, ton per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Flux (ton/d)	Variance (ton/d)	Lower 95 (ton/d)	Upper 95 (ton/d)	SEP (ton/d)	Number of days
1	10729	Owyhee River at Hwy. 201 Bridge (Owyhee), OR	30.8	11.2	24.4	38.3	3.54	366
2	MAL113	North Fork Malheur River approximately 2 miles upstream of Beulah Reservoir, OR	NA	NA	NA	NA	NA	–
3	MAL144	Malheur River at Ford Street (1.1 miles) upstream of Bully Creek, OR	NA	NA	NA	NA	NA	–
4	10386	Middle Fork Willamette River at Jasper Bridge, OR	32.8	21.4	24.2	43.5	4.94	366
5	10663	Mohawk River at Hill Road, OR	20.4	34.2	10.4	36.1	6.62	366
6	10376	McKenzie River at Coburg Road, OR	88.1	393	51.4	141	23.2	366
7	10355	Willamette River at Hwy 99E (Harrisburg), OR	227	594	173	293	30.9	366
8	11140	Long Tom River at Stow Pit Road (Monroe), OR	60.3	120	40.2	87.1	12.0	366
9	12657	McKenzie River at Hwy 126 downstream of Clear Lake, OR	NA	NA	NA	NA	NA	–
10	10508	Deschutes River at Lower Bridge, OR	9.04	1.11	7.08	11.4	1.09	366
11	10350	Willamette River at Albany (Eastbound Hwy 20 Bridge), OR	521	2,760	402	664	67.0	366
12	11490	Powder River at Hwy 7 (Baker City), OR	4.61	.61	3.20	6.42	0.82	366
13	11478	John Day River at Service Creek, OR	64.3	139	42.1	94.1	13.3	366
14	10555	Willamette River at Marion Street (Salem), OR	1,050	11,400	816	1,320	129	366
15	14200400	Little Abiqua Creek near Scotts Mills, OR	.93	.03	0.58	1.42	0.22	366
16	14201300	Zollner Creek near Mt. Angel, OR	3.07	.13	2.15	4.24	0.53	366
17	10640	Pudding River at Hwy 211 (Woodburn), OR	27.5	11.6	21.1	35.3	3.63	366
18	13070	Clackamas River at Mciver Park (Upper Boat Ramp), OR	264	73,500	29.2	1,040	300	366
19	3701002	Tualatin River at Weiss Bridge, OR	NA	NA	NA	NA	NA	–
20	3840012	Fanno Creek at Durham Road, OR	NA	NA	NA	NA	NA	–
21	14206950	Fanno Creek near Durham, OR	NA	NA	NA	NA	NA	–
22	3701715	Tualatin River at Cherry Grove, OR	NA	NA	NA	NA	NA	–
23	11321	Johnson Creek at SE 17th Avenue (Portland), OR	3.74	.55	2.30	5.75	0.88	366
24	3701333	Tualatin River at Farmington Bridge Road, OR	NA	NA	NA	NA	NA	–
25	3701612	Tualatin River at Springhill Road Bridge (Dilley), OR	NA	NA	NA	NA	NA	–
26	11386	John Day River at Hwy 206, OR	120	706	71.9	189	30.1	366
27	3805048	Scoggins Creek below Hagg Lake at Stimson Bridge, OR	NA	NA	NA	NA	NA	–
28	3701391	Tualatin River at Rood Bridge Road, OR	NA	NA	NA	NA	NA	–
29	3701528	Tualatin River at Golf Course Road, OR	NA	NA	NA	NA	NA	–
30	3810015	Gales Creek at New Hwy 47, OR	NA	NA	NA	NA	NA	–
31	10611	Willamette River at Hawthorne Bridge (Portland), OR	1,340	8,180	1,110	1,600	124	366
32	3820012	Rock Creek at Hwy 8, OR	NA	NA	NA	NA	NA	–
33	14211720	Willamette River at Portland, OR	2,780	29,500	2,340	3,270	239	366
34	3850006	Dawson Creek at Brookwood, OR	NA	NA	NA	NA	NA	–
35	3824020	Bronson Creek at Bronson Park downstream of Sunset Hwy, OR	NA	NA	NA	NA	NA	–
36	3824072	Bronson Creek at Saltzman, OR	NA	NA	NA	NA	NA	–
37	10332	Willamette River at SP&S Railroad Bridge, OR	1,440	14,900	1,180	1,740	143	366
38	14128910	Columbia River at Warrendale, OR	3,560	116,000	2,930	4,300	351	366
39	10411	Deschutes River at Deschutes River Park, OR	192	642	144	250	27.2	366
40	10616	Columbia River at Marker #47 (upstream of Willamette River), OR	4,800	138,000	4,050	5,650	410	366
41	10406	Umatilla River at Hwy 11 (Pendleton), OR	8.04	3.26	4.90	12.5	1.94	366
42	12012	Hood River at footbridge downstream of I-84, OR	NA	NA	NA	NA	NA	–
43	11489	Umatilla River at Westland Road (Hermiston), OR	70.2	101	49.1	97.3	12.3	366
44	14246900	Columbia River at Beaver Army Terminal near Quincy, OR	14,600	746,000	12,700	16,700	1,040	366
45	27D090	East Fork Lewis River near Dollar Corner, WA	27.9	76.8	11.5	57.3	11.9	366
46	32A070	Walla Walla River near Touchet, WA	162	3,880	65.3	336	70.5	366
47	13353200	Snake River at Burbank, WA	1,220	9,750	1,020	1,450	108	366
48	37A090	Yakima River at Kiona, WA	375	872	311	449	35.2	366
49	12510500	Yakima River at Kiona, WA	468	2,730	366	589	56.9	366
50	12505450	Granger Drain at Granger, WA	18.1	8.88	12.8	24.9	3.11	366

Table A6. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for suspended sediment in the Columbia River and Puget Sound basins, water year 2000.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; ton/d, ton per day; ton/yr, ton per year; mg/L, milligram per liter; ton/mi^2/yr, ton per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Load (ton/yr)	Flow-weighted concentration (mg/L)	Yield (ton/mi^2/yr)	Drainage area (km^2)	Annual mean flow (ft^3/s)
1	10729	Owyhee River at Hwy. 201 Bridge (Owyhee), OR	11,300	68.7	NC	NA	166
2	MAL113	North Fork Malheur River approximately 2 miles upstream of Beulah Reservoir, OR	NC	NC	NC	880	134
3	MAL144	Malheur River at Ford Street (1.1 miles) upstream of Bully Creek, OR	NC	NC	NC	12,000	302
4	10386	Middle Fork Willamette River at Jasper Bridge, OR	12,000	2.89	8.89	3,490	4,200
5	10663	Mohawk River at Hill Road, OR	7,470	13.7	41.9	460	554
6	10376	McKenzie River at Coburg Road, OR	32,300	6.45	NC	NA	5,070
7	10355	Willamette River at Hwy 99E (Harrisburg), OR	83,100	7.43	24.2	8,890	11,300
8	11140	Long Tom River at Stow Pit Road (Monroe), OR	22,100	30.1	52.9	1,080	743
9	12657	McKenzie River at Hwy 126 downstream of Clear Lake, OR	NC	NC	NC	239	515
10	10508	Deschutes River at Lower Bridge, OR	3,310	2.69	1.57	5,440	1,250
11	10350	Willamette River at Albany (Eastbound Hwy 20 Bridge), OR	191,000	13.6	39.2	12,600	14,200
12	11490	Powder River at Hwy 7 (Baker City), OR	1,690	15.7	4.83	902	109
13	11478	John Day River at Service Creek, OR	23,500	14.2	4.57	13,300	1,680
14	10555	Willamette River at Marion Street (Salem), OR	383,000	16.3	51.8	19,100	23,700
15	14200400	Little Abiqua Creek near Scotts Mills, OR	342	9.34	34.7	25.5	37.1
16	14201300	Zollner Creek near Mt. Angel, OR	1,120	61.8	74.6	38.9	18.4
17	10640	Pudding River at Hwy 211 (Woodburn), OR	10,100	12.4	31.7	818	825
18	13070	Clackamas River at Mciver Park (Upper Boat Ramp), OR	96,400	34.5	141	1,760	2,830
19	3701002	Tualatin River at Weiss Bridge, OR	NC	NC	NC	1,840	1,410
20	3840012	Fanno Creek at Durham Road, OR	NC	NC	NC	80.7	–
21	14206950	Fanno Creek near Durham, OR	NC	NC	NC	80.7	–
22	3701715	Tualatin River at Cherry Grove, OR	NC	NC	NC	97.3	148
23	11321	Johnson Creek at SE 17th Avenue (Portland), OR	1,370	20.0	25.4	139	69.3
24	3701333	Tualatin River at Farmington Bridge Road, OR	NC	NC	NC	1,460	1,130
25	3701612	Tualatin River at Springhill Road Bridge (Dilley), OR	NC	NC	NC	327	392
26	11386	John Day River at Hwy 206, OR	44,000	25.2	NC	NA	1,770
27	3805048	Scoggins Creek below Hagg Lake at Stimson Bridge, OR	NC	NC	NC	103	111
28	3701391	Tualatin River at Rood Bridge Road, OR	NC	NC	NC	1,230	972
29	3701528	Tualatin River at Golf Course Road, OR	NC	NC	NC	561	610
30	3810015	Gales Creek at New Hwy 47, OR	NC	NC	NC	195	221
31	10611	Willamette River at Hawthorne Bridge (Portland), OR	490,000	14.2	43.8	28,900	35,100
32	3820012	Rock Creek at Hwy 8, OR	NC	NC	NC	193	–
33	14211720	Willamette River at Portland, OR	1,020,000	29.3	90.7	28,900	35,100
34	3850006	Dawson Creek at Brookwood, OR	NC	NC	NC	9.66	5.44
35	3824020	Bronson Creek at Bronson Park downstream of Sunset Hwy, OR	NC	NC	NC	10.2	3.36
36	3824072	Bronson Creek at Saltzman, OR	NC	NC	NC	5.23	1.00
37	10332	Willamette River at SP&S Railroad Bridge, OR	527,000	15.2	NC	NA	35,100
38	14128910	Columbia River at Warrendale, OR	1,300,000	7.13	5.47	616,000	185,000
39	10411	Deschutes River at Deschutes River Park, OR	70,200	11.0	6.53	27,800	6,450
40	10616	Columbia River at Marker #47 (upstream of Willamette River), OR	1,760,000	10.0	NC	NA	177,000
41	10406	Umatilla River at Hwy 11 (Pendleton), OR	2,940	5.75	6.59	1,150	518
42	12012	Hood River at footbridge downstream of I-84, OR	NC	NC	NC	NA	1,030
43	11489	Umatilla River at Westland Road (Hermiston), OR	25,700	47.7	NC	NA	545
44	14246900	Columbia River at Beaver Army Terminal near Quincy, OR	5,350,000	23.4	21.0	658,000	232,000
45	27D090	East Fork Lewis River near Dollar Corner, WA	10,200	13.4	65.2	405	771
46	32A070	Walla Walla River near Touchet, WA	59,100	105	35.0	4,370	572
47	13353200	Snake River at Burbank, WA	447,000	9.72	4.40	262,000	46,600
48	37A090	Yakima River at Kiona, WA	137,000	36.9	24.4	14,500	3,770
49	12510500	Yakima River at Kiona, WA	171,000	46.1	30.4	14,500	3,770
50	12505450	Granger Drain at Granger, WA	6,630	166	107	160	40.4

Table A6. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for suspended sediment in the Columbia River and Puget Sound basins, water year 2000.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; ton/d, ton per day; ton/yr, ton per year; mg/L, milligram per liter; ton/mi^2/yr, ton per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Flux (ton/d)	Variance (ton/d)	Lower 95 (ton/d)	Upper 95 (ton/d)	SEP (ton/d)	Number of days
51	12472900	Columbia River at Vernita Bridge near Priest Rapids Dam, WA	906	2,450	805	1,020	54.2	366
52	13351000	Palouse River at Hooper, WA	363	3,360	189	634	115	366
53	34A070	Palouse River at Hooper, WA	254	2,640	144	418	70.5	366
54	41A070	Crab Creek near Beverly, WA	NA	NA	NA	NA	NA	–
55	12471400	Lind Coulee Wastway at SR 17 near Warden, WA	65.7	898	24.7	143	31.0	366
56	13A060	Deschutes River at East Street Bridge, WA	69.9	353	36.2	123	22.3	366
57	10A070	Puyallup River at Meridian Street, WA	3,760	4,760,000	807	11,200	2,840	366
58	12108500	Newaukum Creek near Black Diamond, WA	NA	NA	NA	NA	NA	–
59	12464770	Crab Creek at Rocky Ford Road near Ritzville, WA	7.35	3.16	3.38	14.0	2.76	366
60	12061500	Skokomish River near Potlatch, WA	NA	NA	NA	NA	NA	–
61	16A070	Skokomish River near Potlatch, WA	450	37,300	157	1,030	229	366
62	12112600	Big Soos Creek above Hatchery near Auburn, WA	NA	NA	NA	NA	NA	–
63	09A190	Green River at Kanaskat, WA	38.5	60.2	22.8	60.8	9.76	366
64	45A070	Wenatchee River at Wenatchee, WA	127	325	90.8	174	21.2	366
65	12113375	Springbrook Creek at Tukwila, WA	NA	NA	NA	NA	NA	–
66	09A080	Green River at Tukwila, WA	164	944	105	246	36.3	366
67	12113390	Duwamish River at Golf Course at Tukwila, WA	267	2,060	172	397	57.7	366
68	12056500	North Fork Skokomish River below Staircase Rapids near Hoodport, WA	16.3	18.5	6.90	32.9	6.77	366
69	46A070	Entiat River near Entiat, WA	18.1	5.01	13.5	23.7	2.60	366
70	45A110	Wenatchee River near Leavenworth, WA	66.9	75.1	48.9	89.2	10.3	366
71	16C090	Duckabush River near Brinnon, WA	19.3	145	4.38	56.0	14.0	366
72	12128000	Thorton Creek near Seattle, WA	1.04	.04	.64	1.61	.25	366
73	54A120	Spokane River at Riverside State Park, WA	201	1,460	125	308	46.8	366
74	07D050	Snoqualmie River near Monroe, WA	385	3,780	256	559	77.6	366
75	07C070	Skykomish River at Monroe, WA	287	4,100	159	478	82.0	366
76	07A090	Snohomish River at Snohomish, WA	899	14,600	641	1,230	150	366
77	53A070	Columbia River at Grand Coulee, WA	393	531	344	447	26.3	366
78	48A070	Methow River near Pateros, WA	32.9	13.2	25.1	42.4	4.41	366
79	49A070	Okanogan River at Malott, WA	242	365	200	291	23.3	366
80	48A140	Methow River at Twisp, WA	22.3	6.44	16.8	29.0	3.13	366
81	03A060	Skagit River near Mount Vernon, WA	3,700	1,450,000	1,540	7,550	1,570	366
82	03B050	Samish River near Burlington, WA	31.1	43.1	18.5	49.2	7.89	366
83	12213140	Nooksack River at Brennan, WA	NA	NA	NA	NA	NA	–
84	01A050	Nooksack River at Brennan, WA	2,300	162,000	1,480	3,410	496	366
85	12210700	Nooksack River at North Cedarville, WA	NA	NA	NA	NA	NA	–
86	12400520	Columbia River at Northport, WA	928	11,600	728	1,170	112	366
87	61A070	Columbia River at Northport, WA	729	1,660	643	824	46.1	366
88	12212100	Fishtrap Creek at Flynn Road at Lynden, WA	NA	NA	NA	NA	NA	–
89	13092747	Rock Creek above Hwy 30/93 crossing at Twin Falls, ID	17.6	3.25	13.8	22.1	2.12	366
90	13094000	Snake River near Buhl, ID	362	4,470	247	514	68.5	366
91	13154500	Snake River at King Hill, ID	354	581	306	409	26.3	366
92	13203510	Boise River below Diversion Dam near Boise, ID	16.8	5.09	12.5	22.2	2.47	366
93	13206000	Boise River at Glenwood, ID	22.1	9.21	16.1	29.6	3.45	366
94	13238322	North Fork Payette River below Fischer Creek near McCall, ID	NA	NA	NA	NA	NA	–
95	12414900	St. Maries River near Santa, ID	NA	NA	NA	NA	NA	–
96	12414500	St. Joe River at Calder, ID	36.2	60.3	23.0	54.4	8.04	366
97	12413470	South Fork Coeur d' Alene River near Pinehurst, ID	34.6	21.0	19.0	58.1	10.1	366
98	12413000	North Fork Coeur d' Alene River at Enaville, ID	102	628	44.5	201	40.7	366
99	12419000	Spokane River near Post Falls, ID	36.5	10.2	30.0	43.9	3.56	366
100	13010065	Snake River at Flagg Ranch, WY	137	593	82.0	215	34.1	366

Table A6. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for suspended sediment in the Columbia River and Puget Sound basins, water year 2000.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; ton/d, ton per day; ton/yr, ton per year; mg/L, milligram per liter; ton/mi^2/yr, ton per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Load (ton/yr)	Flow-weighted concentration (mg/L)	Yield (ton/mi^2/yr)	Drainage area (km^2)	Annual mean flow (ft^3/s)
51	12472900	Columbia River at Vernita Bridge near Priest Rapids Dam, WA	332,000	2.80	12.6	67,800	120,000
52	13351000	Palouse River at Hooper, WA	133,000	183	53.8	6,380	736
53	34A070	Palouse River at Hooper, WA	93,100	128	37.7	6,380	736
54	41A070	Crab Creek near Beverly, WA	NC	NC	NC	999	–
55	12471400	Lind Coulee Wastway at SR 17 near Warden, WA	24,100	117	33.7	1,840	209
56	13A060	Deschutes River at East Street Bridge, WA	25,600	57.8	248	267	449
57	10A070	Puyallup River at Meridian Street, WA	1,380,000	407	1,490	2,380	3,430
58	12108500	Newaukum Creek near Black Diamond, WA	NC	NC	NC	71.1	61.9
59	12464770	Crab Creek at Rocky Ford Road near Ritzville, WA	2,690	44.2	5.85	1,190	61.6
60	12061500	Skokomish River near Potlatch, WA	NC	NC	NC	339	1,310
61	16A070	Skokomish River near Potlatch, WA	165,000	128	1,250	339	1,310
62	12112600	Big Soos Creek above Hatchery near Auburn, WA	NC	NC	NC	173	124
63	09A190	Green River at Kanaskat, WA	14,100	15.0	59.1	616	953
64	45A070	Wenatchee River at Wenatchee, WA	46,600	14.0	35.0	3,440	3,370
65	12113375	Springbrook Creek at Tukwila, WA	NC	NC	NC	51.7	45.6
66	09A080	Green River at Tukwila, WA	60,200	43.6	126	1,240	1,400
67	12113390	Duwamish River at Golf Course at Tukwila, WA	97,800	62.5	211	1,190	1,590
68	12056500	North Fork Skokomish River below Staircase Rapids near Hoodport, WA	5,970	11.3	105	147	535
69	46A070	Entiat River near Entiat, WA	6,610	12.8	15.9	1,070	522
70	45A110	Wenatchee River near Leavenworth, WA	24,500	7.76	36.7	1,720	3,190
71	16C090	Duckabush River near Brinnon, WA	7,080	16.6	106	172	432
72	12128000	Thorton Creek near Seattle, WA	380	36.7	33.6	29.2	10.5
73	54A120	Spokane River at Riverside State Park, WA	73,700	10.6	14.7	13,000	7,030
74	07D050	Snoqualmie River near Monroe, WA	141,000	36.3	206	1,770	3,930
75	07C070	Skykomish River at Monroe, WA	105,000	23.0	137	1,980	4,620
76	07A090	Snohomish River at Snohomish, WA	329,000	31.8	191	4,440	10,500
77	53A070	Columbia River at Grand Coulee, WA	144,000	1.29	12.9	28,900	113,000
78	48A070	Methow River near Pateros, WA	12,000	8.48	6.68	4,660	1,440
79	49A070	Okanogan River at Malott, WA	88,700	30.6	50.9	4,500	2,930
80	48A140	Methow River at Twisp, WA	8,160	6.33	6.15	3,430	1,310
81	03A060	Skagit River near Mount Vernon, WA	1,360,000	78.5	581	6,020	17,500
82	03B050	Samish River near Burlington, WA	11,400	40.1	132	223	288
83	12213140	Nooksack River at Brennan, WA	NC	NC	NC	2,020	4,250
84	01A050	Nooksack River at Brennan, WA	840,000	200	1,140	1,910	4,250
85	12210700	Nooksack River at North Cedarville, WA	NC	NC	NC	1,520	–
86	12400520	Columbia River at Northport, WA	340,000	3.26	5.63	156,000	106,000
87	61A070	Columbia River at Northport, WA	267,000	2.56	4.43	156,000	106,000
88	12212100	Fishtrap Creek at Flynn Road at Lynden, WA	NC	NC	NC	98.6	–
89	13092747	Rock Creek above Hwy 30/93 crossing at Twin Falls, ID	6,460	56.9	26.8	623	115
90	13094000	Snake River near Buhl, ID	133,000	28.8	4.50	76,100	4,670
91	13154500	Snake River at King Hill, ID	130,000	13.1	3.60	92,900	9,990
92	13203510	Boise River below Diversion Dam near Boise, ID	6,150	4.80	2.28	6,980	1,300
93	13206000	Boise River at Glenwood, ID	8,090	9.47	2.91	7,180	865
94	13238322	North Fork Payette River below Fischer Creek near McCall, ID	NC	NC	NC	220	231
95	12414900	St. Maries River near Santa, ID	NC	NC	NC	706	391
96	12414500	St. Joe River at Calder, ID	13,300	5.64	12.8	2,680	2,380
97	12413470	South Fork Coeur d' Alene River near Pinehurst, ID	12,700	21.9	44.3	738	584
98	12413000	North Fork Coeur d' Alene River at Enaville, ID	37,300	18.6	41.4	2,330	2,030
99	12419000	Spokane River near Post Falls, ID	13,400	1.97	3.39	10,200	6,850
100	13010065	Snake River at Flagg Ranch, WY	50,100	60.5	97.6	1,320	839

Table A7. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for total nitrogen in the Columbia River and Puget Sound basins, water year 2001.

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; lb/yr, pound per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Flux (lb/d)	Variance (lb/d)	Lower 95 (lb/d)	Upper 95 (lb/d)	SEP (lb/d)	Number of days
1	10729	Owyhee River at Hwy. 201 Bridge (Owyhee), OR	1,380	2,870	1,270	1,490	56.5	365
2	MAL113	North Fork Malheur River approximately 2 miles upstream of Beulah Reservoir, OR	NA	NA	NA	NA	NA	–
3	MAL144	Malheur River at Ford Street (1.1 miles) upstream of Bully Creek, OR	NA	NA	NA	NA	NA	–
4	10386	Middle Fork Willamette River at Jasper Bridge, OR	NA	NA	NA	NA	NA	–
5	10663	Mohawk River at Hill Road, OR	NA	NA	NA	NA	NA	–
6	10376	McKenzie River at Coburg Road, OR	NA	NA	NA	NA	NA	–
7	10355	Willamette River at Hwy 99E (Harrisburg), OR	7,550	232,000	6,610	8,600	508	365
8	11140	Long Tom River at Stow Pit Road (Monroe), OR	767	2,660	666	880	54.8	365
9	12657	McKenzie River at Hwy 126 downstream of Clear Lake, OR	NA	NA	NA	NA	NA	–
10	10508	Deschutes River at Lower Bridge, OR	806	7,720	646	993	88.7	365
11	10350	Willamette River at Albany (Eastbound Hwy 20 Bridge), OR	17,000	1,330,000	14,700	19,500	1,230	365
12	11490	Powder River at Hwy 7 (Baker City), OR	121	46.2	107	135	7.28	365
13	11478	John Day River at Service Creek, OR	1,120	11,200	917	1,360	114	365
14	10555	Willamette River at Marion Street (Salem), OR	28,600	2,360,000	25,500	32,000	1,640	365
15	14200400	Little Abiqua Creek near Scotts Mills, OR	48.2	1.29	45.6	50.9	1.34	365
16	14201300	Zollner Creek near Mt. Angel, OR	296	179	266	329	16.1	365
17	10640	Pudding River at Hwy 211 (Woodburn), OR	3,440	98,300	2,850	4,120	326	365
18	13070	Clackamas River at Mciver Park (Upper Boat Ramp), OR	NA	NA	NA	NA	NA	–
19	3701002	Tualatin River at Weiss Bridge, OR	6,070	18,200	5,770	6,380	155	365
20	3840012	Fanno Creek at Durham Road, OR	122	5.88	115	128	3.16	365
21	14206950	Fanno Creek near Durham, OR	120	18.5	111	131	5.20	365
22	3701715	Tualatin River at Cherry Grove, OR	62.3	17.9	53.5	72.2	4.76	365
23	11321	Johnson Creek at SE 17th Avenue (Portland), OR	815	263	783	849	17.0	365
24	3701333	Tualatin River at Farmington Bridge Road, OR	4,240	34,200	3,870	4,630	193	365
25	3701612	Tualatin River at Springhill Road Bridge (Dilley), OR	290	147	263	319	14.5	365
26	11386	John Day River at Hwy 206, OR	NA	NA	NA	NA	NA	–
27	3805048	Scoggins Creek below Hagg Lake at Stimson Bridge, OR	59.5	12.8	52.6	67.1	3.68	365
28	3701391	Tualatin River at Rood Bridge Road, OR	1,160	2,840	1,040	1,290	62.3	365
29	3701528	Tualatin River at Golf Course Road, OR	482	381	437	530	23.8	365
30	3810015	Gales Creek at New Hwy 47, OR	139	25.3	127	151	6.14	365
31	10611	Willamette River at Hawthorne Bridge (Portland), OR	63,200	10,900,000	56,600	70,500	3,560	365
32	3820012	Rock Creek at Hwy 8, OR	217	23.0	205	229	6.24	365
33	14211720	Willamette River at Portland, OR	59,500	6,790,000	54,200	65,300	2,840	365
34	3850006	Dawson Creek at Brookwood, OR	11.3	.13	10.4	12.3	.48	365
35	3824020	Bronson Creek at Bronson Park downstream of Sunset Hwy, OR	5.91	.03	5.51	6.33	.21	365
36	3824072	Bronson Creek at Saltzman, OR	1.50	.00	1.39	1.62	.06	365
37	10332	Willamette River at SP&S Railroad Bridge, OR	65,100	35,200,000	54,000	77,800	6,090	365
38	14128910	Columbia River at Warrendale, OR	514,000	996,000,000	453,000	582,000	33,000	365
39	10411	Deschutes River at Deschutes River Park, OR	7,070	172,000	6,270	7,950	430	365
40	10616	Columbia River at Marker #47 (upstream of Willamette River), OR	266,000	877,000,000	212,000	331,000	30,400	365
41	10406	Umatilla River at Hwy 11 (Pendleton), OR	498	2,180	405	607	51.6	365
42	12012	Hood River at footbridge downstream of I-84, OR	917	6,460	764	1,090	83.9	365
43	11489	Umatilla River at Westland Road (Hermiston), OR	3,070	33,700	2,710	3,470	194	365
44	14246900	Columbia River at Beaver Army Terminal near Quincy, OR	316,000	234,000,000	286,000	349,000	16,000	365
45	27D090	East Fork Lewis River near Dollar Corner, WA	781	836	720	847	32.4	365
46	32A070	Walla Walla River near Touchet, WA	788	1,090	718	864	37.2	365
47	13353200	Snake River at Burbank, WA	NA	NA	NA	NA	NA	–
48	37A090	Yakima River at Kiona, WA	9,990	210,000	9,060	11,000	491	365
49	12510500	Yakima River at Kiona, WA	10,500	203,000	9,640	11,500	476	365
50	12505450	Granger Drain at Granger, WA	644	303	609	680	18.1	365

Table A7. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for total nitrogen in the Columbia River and Puget Sound basins, water year 2001.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; lb/yr, pound per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Load (lb/yr)	Flow-weighted concentration (mg/L)	Yield (lb/mi^2/yr)	Drainage area (km^2)	Annual mean flow (ft^3/s)
1	10729	Owyhee River at Hwy. 201 Bridge (Owyhee), OR	502,000	2.27	NC	NA	112
2	MAL113	North Fork Malheur River approximately 2 miles upstream of Beulah Reservoir, OR	NC	NC	NC	880	67.1
3	MAL144	Malheur River at Ford Street (1.1 miles) upstream of Bully Creek, OR	NC	NC	NC	12,000	94.6
4	10386	Middle Fork Willamette River at Jasper Bridge, OR	NC	NC	NC	3,490	2,400
5	10663	Mohawk River at Hill Road, OR	NC	NC	NC	460	193
6	10376	McKenzie River at Coburg Road, OR	NC	NC	NC	NA	2,900
7	10355	Willamette River at Hwy 99E (Harrisburg), OR	2,760,000	.24	803	8,890	5,820
8	11140	Long Tom River at Stow Pit Road (Monroe), OR	280,000	.64	673	1,080	221
9	12657	McKenzie River at Hwy 126 downstream of Clear Lake, OR	NC	NC	NC	239	260
10	10508	Deschutes River at Lower Bridge, OR	294,000	.17	140	5,440	883
11	10350	Willamette River at Albany (Eastbound Hwy 20 Bridge), OR	6,210,000	.47	1,280	12,600	6,750
12	11490	Powder River at Hwy 7 (Baker City), OR	44,000	.37	126	902	60.3
13	11478	John Day River at Service Creek, OR	410,000	.24	79.9	13,300	877
14	10555	Willamette River at Marion Street (Salem), OR	10,400,000	.47	1,420	19,100	11,200
15	14200400	Little Abiqua Creek near Scotts Mills, OR	17,600	.49	1,790	25.5	18.1
16	14201300	Zollner Creek near Mt. Angel, OR	108,000	11.4	7,210	38.9	4.83
17	10640	Pudding River at Hwy 211 (Woodburn), OR	1,260,000	1.91	3,980	818	334
18	13070	Clackamas River at Mciver Park (Upper Boat Ramp), OR	NC	NC	NC	1,760	1,500
19	3701002	Tualatin River at Weiss Bridge, OR	2,210,000	2.62	3,120	1,840	429
20	3840012	Fanno Creek at Durham Road, OR	44,400	1.17	1,420	80.7	19.3
21	14206950	Fanno Creek near Durham, OR	44,000	1.16	1,410	80.7	19.3
22	3701715	Tualatin River at Cherry Grove, OR	22,800	.18	606	97.3	65.5
23	11321	Johnson Creek at SE 17th Avenue (Portland), OR	298,000	3.91	5,550	139	38.7
24	3701333	Tualatin River at Farmington Bridge Road, OR	1,550,000	2.58	2,750	1,460	305
25	3701612	Tualatin River at Springhill Road Bridge (Dilley), OR	106,000	.41	839	327	130
26	11386	John Day River at Hwy 206, OR	NC	NC	NC	NA	916
27	3805048	Scoggins Creek below Hagg Lake at Stimson Bridge, OR	21,700	.22	545	103	50.0
28	3701391	Tualatin River at Rood Bridge Road, OR	424,000	.93	894	1,230	231
29	3701528	Tualatin River at Golf Course Road, OR	176,000	.58	811	561	155
30	3810015	Gales Creek at New Hwy 47, OR	50,700	.43	674	195	60.6
31	10611	Willamette River at Hawthorne Bridge (Portland), OR	23,100,000	.73	2,070	28,900	16,000
32	3820012	Rock Creek at Hwy 8, OR	79,200	1.06	1,060	193	37.8
33	14211720	Willamette River at Portland, OR	21,700,000	.69	1,940	28,900	16,000
34	3850006	Dawson Creek at Brookwood, OR	4,120	1.16	1,100	9.7	1.80
35	3824020	Bronson Creek at Bronson Park downstream of Sunset Hwy, OR	2,160	.82	547	10.2	1.34
36	3824072	Bronson Creek at Saltzman, OR	548	1.39	272	5.23	0.20
37	10332	Willamette River at SP&S Railroad Bridge, OR	23,800,000	.75	NC	NA	16,000
38	14128910	Columbia River at Warrendale, OR	188,000,000	.81	NC	616,000	118,000
39	10411	Deschutes River at Deschutes River Park, OR	2,580,000	.27	241	27,800	4,850
40	10616	Columbia River at Marker #47 (upstream of Willamette River), OR	97,200,000	.44	NC	NA	112,000
41	10406	Umatilla River at Hwy 11 (Pendleton), OR	182,000	.27	409	1,150	343
42	12012	Hood River at footbridge downstream of I-84, OR	335,000	.31	NC	NA	541
43	11489	Umatilla River at Westland Road (Hermiston), OR	1,120,000	1.53	NC	NA	372
44	14246900	Columbia River at Beaver Army Terminal near Quincy, OR	115,000,000	.42	454	658,000	140,000
45	27D090	East Fork Lewis River near Dollar Corner, WA	285,000	.35	1,820	405	411
46	32A070	Walla Walla River near Touchet, WA	288,000	.36	171	4,370	409
47	13353200	Snake River at Burbank, WA	NC	NC	NC	262,000	24,700
48	37A090	Yakima River at Kiona, WA	3,650,000	1.21	650	14,500	1,530
49	12510500	Yakima River at Kiona, WA	3,850,000	1.28	686	14,500	1,530
50	12505450	Granger Drain at Granger, WA	235,000	4.32	3,810	160	27.6

Table A7. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for total nitrogen in the Columbia River and Puget Sound basins, water year 2001.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; lb/yr, pound per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Flux (lb/d)	Variance (lb/d)	Lower 95 (lb/d)	Upper 95 (lb/d)	SEP (lb/d)	Number of days
51	12472900	Columbia River at Vernita Bridge near Priest Rapids Dam, WA	92,200	91,000,000	74,600	113,000	9,740	365
52	13351000	Palouse River at Hooper, WA	4,180	53,700	3,690	4,720	264	365
53	34A070	Palouse River at Hooper, WA	3,910	76,900	3,350	4,540	305	365
54	41A070	Crab Creek near Beverly, WA	2,570	4,460	2,430	2,720	72.5	365
55	12471400	Lind Coulee Wastway at SR 17 near Warden, WA	NA	NA	NA	NA	NA	–
56	13A060	Deschutes River at East Street Bridge, WA	695	240	663	729	16.9	365
57	10A070	Puyallup River at Meridian Street, WA	3,470	17,900	3,190	3,760	146	365
58	12108500	Newaukum Creek near Black Diamond, WA	NA	NA	NA	NA	NA	–
59	12464770	Crab Creek at Rocky Ford Road near Ritzville, WA	250	54.3	234	265	7.95	365
60	12061500	Skokomish River near Potlatch, WA	NA	NA	NA	NA	NA	–
61	16A070	Skokomish River near Potlatch, WA	259	189	230	291	15.6	365
62	12112600	Big Soos Creek above Hatchery near Auburn, WA	NA	NA	NA	NA	NA	–
63	09A190	Green River at Kanaskat, WA	474	510	424	528	26.5	365
64	45A070	Wenatchee River at Wenatchee, WA	1,510	3,610	1,390	1,650	66.3	365
65	12113375	Springbrook Creek at Tukwila, WA	NA	NA	NA	NA	NA	–
66	09A080	Green River at Tukwila, WA	2,170	6,490	2,000	2,350	88.1	365
67	12113390	Duwamish River at Golf Course at Tukwila, WA	2,930	17,000	2,660	3,220	143	365
68	12056500	North Fork Skokomish River below Staircase Rapids near Hoodport, WA	NA	NA	NA	NA	NA	–
69	46A070	Entiat River near Entiat, WA	166	169	140	195	13.8	365
70	45A110	Wenatchee River near Leavenworth, WA	660	1,890	563	770	52.9	365
71	16C090	Duckabush River near Brinnon, WA	55.2	13.8	46.7	64.8	4.63	365
72	12128000	Thorton Creek near Seattle, WA	68.8	4.01	64.3	73.4	2.31	365
73	54A120	Spokane River at Riverside State Park, WA	15,400	576,000	13,900	17,000	802	365
74	07D050	Snoqualmie River near Monroe, WA	4,790	20,400	4,490	5,110	157	365
75	07C070	Skykomish River at Monroe, WA	2,350	5,900	2,180	2,530	90.6	365
76	07A090	Snohomish River at Snohomish, WA	10,900	136,000	10,100	11,800	427	365
77	53A070	Columbia River at Grand Coulee, WA	72,200	9,010,000	66,000	78,800	3,260	365
78	48A070	Methow River near Pateros, WA	600	594	549	653	26.5	365
79	49A070	Okanogan River at Malott, WA	1,140	2,190	1,040	1,250	53.1	365
80	48A140	Methow River at Twisp, WA	428	345	388	470	21.1	365
81	03A060	Skagit River near Mount Vernon, WA	7,130	115,000	6,420	7,890	373	365
82	03B050	Samish River near Burlington, WA	769	251	735	804	17.4	365
83	12213140	Nooksack River at Brennan, WA	NA	NA	NA	NA	NA	–
84	01A050	Nooksack River at Brennan, WA	6,740	74,400	6,180	7,350	299	365
85	12210700	Nooksack River at North Cedarville, WA	NA	NA	NA	NA	NA	–
86	12400520	Columbia River at Northport, WA	NA	NA	NA	NA	NA	–
87	61A070	Columbia River at Northport, WA	54,300	2,300,000	51,200	57,500	1,620	365
88	12212100	Fishtrap Creek at Flynn Road at Lynden, WA	NA	NA	NA	NA	NA	–
89	13092747	Rock Creek above Hwy 30/93 crossing at Twin Falls, ID	1,050	502	1,000	1,100	24.5	365
90	13094000	Snake River near Buhl, ID	29,700	741,000	27,900	31,500	897	365
91	13154500	Snake River at King Hill, ID	66,500	1,210,000	64,100	68,900	1,230	365
92	13203510	Boise River below Diversion Dam near Boise, ID	947	4,600	818	1,090	69.5	365
93	13206000	Boise River at Glenwood, ID	1,620	4,680	1,480	1,770	72.1	365
94	13238322	North Fork Payette River below Fischer Creek near McCall, ID	133	478	91.8	185	24.0	365
95	12414900	St. Maries River near Santa, ID	NA	NA	NA	NA	NA	–
96	12414500	St. Joe River at Calder, ID	NA	NA	NA	NA	NA	–
97	12413470	South Fork Coeur d' Alene River near Pinehurst, ID	472	606	422	525	26.3	365
98	12413000	North Fork Coeur d' Alene River at Enaville, ID	NA	NA	NA	NA	NA	–
99	12419000	Spokane River near Post Falls, ID	2,590	41,900	2,190	3,040	216	365
100	13010065	Snake River at Flagg Ranch, WY	525	7,000	339	776	112	365

Table A7. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for total nitrogen in the Columbia River and Puget Sound basins, water year 2001.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; lb/yr, pound per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Load (lb/yr)	Flow-weighted concentration (mg/L)	Yield (lb/mi^2/yr)	Drainage area (km^2)	Annual mean flow (ft^3/s)
51	12472900	Columbia River at Vernita Bridge near Priest Rapids Dam, WA	33,700,000	0.21	1,290	67,800	80,700
52	13351000	Palouse River at Hooper, WA	1,530,000	2.96	620	6,380	262
53	34A070	Palouse River at Hooper, WA	1,430,000	2.77	580	6,380	262
54	41A070	Crab Creek near Beverly, WA	939,000	2.37	2,430	999	201
55	12471400	Lind Coulee Wastway at SR 17 near Warden, WA	NC	NC	NC	1,840	–
56	13A060	Deschutes River at East Street Bridge, WA	254,000	.72	2,460	267	178
57	10A070	Puyallup River at Meridian Street, WA	1,270,000	.27	1,380	2,380	2,350
58	12108500	Newaukum Creek near Black Diamond, WA	NC	NC	NC	71.1	33.7
59	12464770	Crab Creek at Rocky Ford Road near Ritzville, WA	91,100	1.72	199	1,190	26.8
60	12061500	Skokomish River near Potlatch, WA	NC	NC	NC	339	646
61	16A070	Skokomish River near Potlatch, WA	94,600	.07	722	339	646
62	12112600	Big Soos Creek above Hatchery near Auburn, WA	NC	NC	NC	173	71.9
63	09A190	Green River at Kanaskat, WA	173,000	.15	728	616	573
64	45A070	Wenatchee River at Wenatchee, WA	552,000	.18	416	3,440	1,590
65	12113375	Springbrook Creek at Tukwila, WA	NC	NC	NC	51.7	29.7
66	09A080	Green River at Tukwila, WA	793,000	.47	1,660	1,240	851
67	12113390	Duwamish River at Golf Course at Tukwila, WA	1,070,000	.56	2,320	1,190	965
68	12056500	North Fork Skokomish River below Staircase Rapids near Hoodport, WA	NC	NC	NC	147	300
69	46A070	Entiat River near Entiat, WA	60,600	.15	146	1,070	209
70	45A110	Wenatchee River near Leavenworth, WA	241,000	.08	363	1,720	1,570
71	16C090	Duckabush River near Brinnon, WA	20,100	.04	303	172	229
72	12128000	Thorton Creek near Seattle, WA	25,100	1.57	2,220	29.2	8.11
73	54A120	Spokane River at Riverside State Park, WA	5,620,000	.95	1,120	13,000	3,010
74	07D050	Snoqualmie River near Monroe, WA	1,750,000	.36	2,560	1,770	2,440
75	07C070	Skykomish River at Monroe, WA	858,000	.16	1,120	1,980	2,690
76	07A090	Snohomish River at Snohomish, WA	3,990,000	.32	2,330	4,440	6,310
77	53A070	Columbia River at Grand Coulee, WA	26,400,000	.18	2,360	28,900	74,400
78	48A070	Methow River near Pateros, WA	219,000	.19	122	4,660	576
79	49A070	Okanogan River at Malott, WA	418,000	.16	240	4,500	1,330
80	48A140	Methow River at Twisp, WA	156,000	.16	118	3,430	508
81	03A060	Skagit River near Mount Vernon, WA	2,600,000	.13	1,120	6,020	10,500
82	03B050	Samish River near Burlington, WA	281,000	.90	3,260	223	158
83	12213140	Nooksack River at Brennan, WA	NC	NC	NC	2,020	2,540
84	01A050	Nooksack River at Brennan, WA	2,460,000	.49	3,340	1,910	2,540
85	12210700	Nooksack River at North Cedarville, WA	NC	NC	NC	1,520	–
86	12400520	Columbia River at Northport, WA	NC	NC	NC	156,000	74,000
87	61A070	Columbia River at Northport, WA	19,800,000	.14	329	156,000	74,000
88	12212100	Fishtrap Creek at Flynn Road at Lynden, WA	NC	NC	NC	98.6	–
89	13092747	Rock Creek above Hwy 30/93 crossing at Twin Falls, ID	383,000	2.50	1,590	623	77.7
90	13094000	Snake River near Buhl, ID	10,800,000	2.56	368	76,100	2,150
91	13154500	Snake River at King Hill, ID	24,300,000	1.68	676	92,900	7,330
92	13203510	Boise River below Diversion Dam near Boise, ID	346,000	.21	128	6,980	817
93	13206000	Boise River at Glenwood, ID	592,000	.60	213	7,180	503
94	13238322	North Fork Payette River below Fischer Creek near McCall, ID	48,400	.19	570	220	132
95	12414900	St. Maries River near Santa, ID	NC	NC	NC	706	155
96	12414500	St. Joe River at Calder, ID	NC	NC	NC	2,680	1,130
97	12413470	South Fork Coeur d' Alene River near Pinehurst, ID	172,000	.38	604	738	232
98	12413000	North Fork Coeur d' Alene River at Enaville, ID	NC	NC	NC	2,330	763
99	12419000	Spokane River near Post Falls, ID	945,000	.18	241	10,200	2,690
100	13010065	Snake River at Flagg Ranch, WY	192,000	.18	375	1,320	528

Table A8. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for total phosphorus in the Columbia River and Puget Sound Basins, water year 2001.

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; lb/yr, pound per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Flux (lb/d)	Variance (lb/d)	Lower 95 (lb/d)	Upper 95 (lb/d)	SEP (lb/d)	Number of days
1	10729	Owyhee River at Hwy. 201 Bridge (Owyhee), OR	137	95.7	118	158	10.3	365
2	MAL113	North Fork Malheur River approximately 2 miles upstream of Beulah Reservoir, OR	29.5	2.31	26.5	32.8	1.60	365
3	MAL144	Malheur River at Ford Street (1.1 miles) upstream of Bully Creek, OR	128	34.4	116	141	6.43	365
4	10386	Middle Fork Willamette River at Jasper Bridge, OR	332	146	307	357	12.8	365
5	10663	Mohawk River at Hill Road, OR	18.8	1.18	16.6	21.1	1.15	365
6	10376	McKenzie River at Coburg Road, OR	600	393	560	643	21.1	365
7	10355	Willamette River at Hwy 99E (Harrisburg), OR	1,470	3,330	1,350	1,600	64.2	365
8	11140	Long Tom River at Stow Pit Road (Monroe), OR	87.1	23.9	77.2	97.8	5.27	365
9	12657	McKenzie River at Hwy 126 downstream of Clear Lake, OR	58.0	7.77	52.6	63.8	2.85	365
10	10508	Deschutes River at Lower Bridge, OR	364	124	342	388	11.8	365
11	10350	Willamette River at Albany (Eastbound Hwy 20 Bridge), OR	2,270	10,300	2,060	2,490	108	365
12	11490	Powder River at Hwy 7 (Baker City), OR	16.7	1.91	14.0	19.9	1.50	365
13	11478	John Day River at Service Creek, OR	231	160	202	262	15.5	365
14	10555	Willamette River at Marion Street (Salem), OR	3,050	14,600	2,800	3,310	130	365
15	14200400	Little Abiqua Creek near Scotts Mills, OR	1.75	.03	1.41	2.15	0.19	365
16	14201300	Zollner Creek near Mt. Angel, OR	6.01	.09	5.31	6.77	0.37	365
17	10640	Pudding River at Hwy 211 (Woodburn), OR	196	306	163	234	18.3	365
18	13070	Clackamas River at Mciver Park (Upper Boat Ramp), OR	160	129	139	185	11.8	365
19	3701002	Tualatin River at Weiss Bridge, OR	313	159	285	342	14.7	365
20	3840012	Fanno Creek at Durham Road, OR	14.3	.14	13.3	15.3	.50	365
21	14206950	Fanno Creek near Durham, OR	15.2	.59	13.7	16.8	.79	365
22	3701715	Tualatin River at Cherry Grove, OR	6.17	.23	5.19	7.28	.54	365
23	11321	Johnson Creek at SE 17th Avenue (Portland), OR	18.8	.37	17.5	20.2	.67	365
24	3701333	Tualatin River at Farmington Bridge Road, OR	366	846	309	431	31.2	365
25	3701612	Tualatin River at Springhill Road Bridge (Dilley), OR	26.1	1.40	23.4	28.9	1.41	365
26	11386	John Day River at Hwy 206, OR	213	541	164	270	27.1	365
27	3805048	Scoggins Creek below Hagg Lake at Stimson Bridge, OR	6.47	.62	4.96	8.29	0.85	365
28	3701391	Tualatin River at Rood Bridge Road, OR	96.8	10.9	89.5	104	3.81	365
29	3701528	Tualatin River at Golf Course Road, OR	38.3	2.50	34.8	42.1	1.86	365
30	3810015	Gales Creek at New Hwy 47, OR	11.8	.17	10.8	12.8	.50	365
31	10611	Willamette River at Hawthorne Bridge (Portland), OR	6,320	28,500	5,970	6,680	182	365
32	3820012	Rock Creek at Hwy 8, OR	28.5	.18	27.5	29.6	.55	365
33	14211720	Willamette River at Portland, OR	5,850	72,700	5,300	6,440	292	365
34	3850006	Dawson Creek at Brookwood, OR	1.12	.00	1.06	1.18	.03	365
35	3824020	Bronson Creek at Bronson Park downstream of Sunset Hwy, OR	.70	.00	.66	.74	.02	365
36	3824072	Bronson Creek at Saltzman, OR	.16	.00	.14	.17	.01	365
37	10332	Willamette River at SP&S Railroad Bridge, OR	6,610	66,900	6,100	7,150	268	365
38	14128910	Columbia River at Warrendale, OR	14,800	2,800,000	11,700	18,500	1,740	365
39	10411	Deschutes River at Deschutes River Park, OR	2,230	17,300	1,970	2,520	140	365
40	10616	Columbia River at Marker #47 (upstream of Willamette River), OR	21,900	2,050,000	19,200	24,900	1,460	365
41	10406	Umatilla River at Hwy 11 (Pendleton), OR	91.0	24.6	80.5	102	5.59	365
42	12012	Hood River at footbridge downstream of I-84, OR	191	1,370	122	285	41.8	365
43	11489	Umatilla River at Westland Road (Hermiston), OR	205	216	176	238	16.0	365
44	14246900	Columbia River at Beaver Army Terminal near Quincy, OR	26,800	4,550,000	22,600	31,500	2,270	365
45	27D090	East Fork Lewis River near Dollar Corner, WA	42.5	18.8	33.6	53.0	4.95	365
46	32A070	Walla Walla River near Touchet, WA	125	38.7	112	140	6.96	365
47	13353200	Snake River at Burbank, WA	NA	NA	NA	NA	NA	NA
48	37A090	Yakima River at Kiona, WA	930	1,210	858	1,010	38.1	365
49	12510500	Yakima River at Kiona, WA	970	2,330	874	1,070	50.8	365
50	12505450	Granger Drain at Granger, WA	33.6	3.17	30.0	37.4	1.88	365

Table A8. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for total phosphorus in the Columbia River and Puget Sound Basins, water year 2001.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; lb/yr, pound per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Load (lb/yr)	Flow-weighted concentration (mg/L)	Yield (lb/mi^2/yr)	Drainage area (km^2)	Annual mean flow (ft^3/s)
1	10729	Owyhee River at Hwy. 201 Bridge (Owyhee), OR	50,000	0.23	NC	NA	112
2	MAL113	North Fork Malheur River approximately 2 miles upstream of Beulah Reservoir, OR	10,800	.08	31.7	880	67.1
3	MAL144	Malheur River at Ford Street (1.1 miles) upstream of Bully Creek, OR	46,700	.25	10.1	12,000	94.6
4	10386	Middle Fork Willamette River at Jasper Bridge, OR	121,000	.03	89.9	3,490	2,400
5	10663	Mohawk River at Hill Road, OR	6,850	.02	38.5	460	193
6	10376	McKenzie River at Coburg Road, OR	219,000	.04	NC	NA	2,900
7	10355	Willamette River at Hwy 99E (Harrisburg), OR	537,000	.05	157	8,890	5,820
8	11140	Long Tom River at Stow Pit Road (Monroe), OR	31,800	.07	76.4	1,080	221
9	12657	McKenzie River at Hwy 126 downstream of Clear Lake, OR	21,200	.04	229	239	260
10	10508	Deschutes River at Lower Bridge, OR	133,000	.08	63.3	5,440	883
11	10350	Willamette River at Albany (Eastbound Hwy 20 Bridge), OR	827,000	.06	171	12,600	6,750
12	11490	Powder River at Hwy 7 (Baker City), OR	6,110	.05	17.5	902	60.3
13	11478	John Day River at Service Creek, OR	84,200	.05	16.4	13,300	877
14	10555	Willamette River at Marion Street (Salem), OR	1,110,000	.05	151	19,100	11,200
15	14200400	Little Abiqua Creek near Scotts Mills, OR	640	.02	65.0	25.5	18.1
16	14201300	Zollner Creek near Mt. Angel, OR	2,190	.23	146	38.9	4.83
17	10640	Pudding River at Hwy 211 (Woodburn), OR	71,500	.11	226	818	334
18	13070	Clackamas River at Mciver Park (Upper Boat Ramp), OR	58,500	.02	86.0	1,760	1,500
19	3701002	Tualatin River at Weiss Bridge, OR	114,000	.14	161	1,840	429
20	3840012	Fanno Creek at Durham Road, OR	5,210	.14	167	80.7	19.3
21	14206950	Fanno Creek near Durham, OR	5,550	.15	178	80.7	19.3
22	3701715	Tualatin River at Cherry Grove, OR	2,250	.02	60.0	97.3	65.5
23	11321	Johnson Creek at SE 17th Avenue (Portland), OR	6,870	.09	128	139	38.7
24	3701333	Tualatin River at Farmington Bridge Road, OR	134,000	.22	237	1,460	305
25	3701612	Tualatin River at Springhill Road Bridge (Dilley), OR	9,510	.04	75.4	327	130
26	11386	John Day River at Hwy 206, OR	77,600	.04	NC	NA	916
27	3805048	Scoggins Creek below Hagg Lake at Stimson Bridge, OR	2,360	.02	59.2	103	50.0
28	3701391	Tualatin River at Rood Bridge Road, OR	35,300	.08	74.6	1,230	231
29	3701528	Tualatin River at Golf Course Road, OR	14,000	.05	64.6	561	155
30	3810015	Gales Creek at New Hwy 47, OR	4,310	.04	57.3	195	60.6
31	10611	Willamette River at Hawthorne Bridge (Portland), OR	2,310,000	.07	207	28,900	16,000
32	3820012	Rock Creek at Hwy 8, OR	10,400	.14	140	193	37.8
33	14211720	Willamette River at Portland, OR	2,140,000	.07	191	28,900	16,000
34	3850006	Dawson Creek at Brookwood, OR	409	.12	110	9.7	1.80
35	3824020	Bronson Creek at Bronson Park downstream of Sunset Hwy, OR	257	.10	65.1	10.2	1.34
36	3824072	Bronson Creek at Saltzman, OR	57.1	.15	28.3	5.23	.20
37	10332	Willamette River at SP&S Railroad Bridge, OR	2,410,000	.08	NC	NA	16,000
38	14128910	Columbia River at Warrendale, OR	5,410,000	.02	NC	616,000	118,000
39	10411	Deschutes River at Deschutes River Park, OR	815,000	.09	76.0	27,800	4,850
40	10616	Columbia River at Marker #47 (upstream of Willamette River), OR	8,010,000	.04	NC	NA	112,000
41	10406	Umatilla River at Hwy 11 (Pendleton), OR	33,200	.05	74.6	1,150	343
42	12012	Hood River at footbridge downstream of I-84, OR	69,600	.07	NC	NA	541
43	11489	Umatilla River at Westland Road (Hermiston), OR	74,900	.10	NC	NA	372
44	14246900	Columbia River at Beaver Army Terminal near Quincy, OR	9,780,000	.04	38.5	658,000	140,000
45	27D090	East Fork Lewis River near Dollar Corner, WA	15,500	.02	99.2	405	411
46	32A070	Walla Walla River near Touchet, WA	45,800	.06	27.2	4,370	409
47	13353200	Snake River at Burbank, WA	NC	NC	NC	262,000	24,700
48	37A090	Yakima River at Kiona, WA	340,000	.11	60.5	14,500	1,530
49	12510500	Yakima River at Kiona, WA	354,000	.12	63.1	14,500	1,530
50	12505450	Granger Drain at Granger, WA	12,300	.23	199	160	27.6

Table A8. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for total phosphorus in the Columbia River and Puget Sound Basins, water year 2001.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; lb/yr, pound per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Flux (lb/d)	Variance (lb/d)	Lower 95 (lb/d)	Upper 95 (lb/d)	SEP (lb/d)	Number of days
51	12472900	Columbia River at Vernita Bridge near Priest Rapids Dam, WA	4,370	833,000	2,810	6,490	943	365
52	13351000	Palouse River at Hooper, WA	204	367	163	253	22.9	365
53	34A070	Palouse River at Hooper, WA	245	539	199	299	25.6	365
54	41A070	Crab Creek near Beverly, WA	102	25.0	91.5	113	5.45	365
55	12471400	Lind Coulee Wastway at SR 17 near Warden, WA	NA	NA	NA	NA	NA	–
56	13A060	Deschutes River at East Street Bridge, WA	36.4	3.30	32.7	40.4	1.97	365
57	10A070	Puyallup River at Meridian Street, WA	1,090	9,110	890	1,320	111	365
58	12108500	Newaukum Creek near Black Diamond, WA	NA	NA	NA	NA	NA	–
59	12464770	Crab Creek at Rocky Ford Road near Ritzville, WA	13.0	.63	11.4	14.8	0.86	365
60	12061500	Skokomish River near Potlatch, WA	NA	NA	NA	NA	NA	–
61	16A070	Skokomish River near Potlatch, WA	85.1	28.7	73.4	98	6.34	365
62	12112600	Big Soos Creek above Hatchery near Auburn, WA	NA	NA	NA	NA	NA	–
63	09A190	Green River at Kanaskat, WA	74.0	27.0	63.0	86.5	6.00	365
64	45A070	Wenatchee River at Wenatchee, WA	138	142	113	168	14.1	365
65	12113375	Springbrook Creek at Tukwila, WA	NA	NA	NA	NA	NA	–
66	09A080	Green River at Tukwila, WA	210	107	188	233	11.7	365
67	12113390	Duwamish River at Golf Course at Tukwila, WA	291	413	247	340	23.7	365
68	12056500	North Fork Skokomish River below Staircase Rapids near Hoodport, WA	8.75	1.77	6.15	12.1	1.52	365
69	46A070	Entiat River near Entiat, WA	22.3	4.88	17.8	27.5	2.47	365
70	45A110	Wenatchee River near Leavenworth, WA	105	132	80.7	134	13.5	365
71	16C090	Duckabush River near Brinnon, WA	13.9	2.27	10.8	17.7	1.77	365
72	12128000	Thorton Creek near Seattle, WA	4.67	.23	3.61	5.95	.60	365
73	54A120	Spokane River at Riverside State Park, WA	821	6,290	666	1,000	85.5	365
74	07D050	Snoqualmie River near Monroe, WA	311	332	272	355	21.1	365
75	07C070	Skykomish River at Monroe, WA	185	200	155	218	16.2	365
76	07A090	Snohomish River at Snohomish, WA	677	2,100	581	786	52.4	365
77	53A070	Columbia River at Grand Coulee, WA	5,310	411,000	4,000	6,910	742	365
78	48A070	Methow River near Pateros, WA	46.9	18.0	37.6	57.7	5.14	365
79	49A070	Okanogan River at Malott, WA	204	191	173	240	17.2	365
80	48A140	Methow River at Twisp, WA	42.4	22.3	32.2	54.9	5.78	365
81	03A060	Skagit River near Mount Vernon, WA	970	4,500	824	1,130	78.9	365
82	03B050	Samish River near Burlington, WA	24.0	3.17	20.4	28.1	1.95	365
83	12213140	Nooksack River at Brennan, WA	NA	NA	NA	NA	NA	–
84	01A050	Nooksack River at Brennan, WA	668	1,830	568	780	54.3	365
85	12210700	Nooksack River at North Cedarville, WA	NA	NA	NA	NA	NA	–
86	12400520	Columbia River at Northport, WA	NA	NA	NA	NA	NA	–
87	61A070	Columbia River at Northport, WA	4,040	208,000	3,160	5,080	490	365
88	12212100	Fishtrap Creek at Flynn Road at Lynden, WA	NA	NA	NA	NA	NA	–
89	13092747	Rock Creek above Hwy 30/93 crossing at Twin Falls, ID	32.0	1.04	29.8	34.3	1.16	365
90	13094000	Snake River near Buhl, ID	1,580	14,600	1,340	1,840	127	365
91	13154500	Snake River at King Hill, ID	2,920	11,800	2,690	3,160	120	365
92	13203510	Boise River below Diversion Dam near Boise, ID	74.5	580	38.0	132	24.3	365
93	13206000	Boise River at Glenwood, ID	402	807	346	464	30.2	365
94	13238322	North Fork Payette River below Fischer Creek near McCall, ID	5.18	.28	4.00	6.61	.67	365
95	12414900	St. Maries River near Santa, ID	25.5	14.5	18.3	34.6	4.17	365
96	12414500	St. Joe River at Calder, ID	51.3	35.5	39.4	65.8	6.75	365
97	12413470	South Fork Coeur d' Alene River near Pinehurst, ID	48.2	13.7	40.8	56.6	4.04	365
98	12413000	North Fork Coeur d' Alene River at Enaville, ID	32.8	8.06	25.2	42.0	4.31	365
99	12419000	Spokane River near Post Falls, ID	152	140	128	181	13.5	365
100	13010065	Snake River at Flagg Ranch, WY	126	501	76.0	198	31.2	365

Table A8. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for total phosphorus in the Columbia River and Puget Sound Basins, water year 2001.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; lb/d, pound per day; lb/yr, pound per year; mg/L, milligram per liter; lb/mi^2/yr, pound per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Load (lb/yr)	Flow-weighted concentration (mg/L)	Yield (lb/mi^2/yr)	Drainage area (km^2)	Annual mean flow (ft^3/s)
51	12472900	Columbia River at Vernita Bridge near Priest Rapids Dam, WA	1,590,000	0.01	60.9	67,800	80,700
52	13351000	Palouse River at Hooper, WA	74,600	.14	30.3	6,380	262
53	34A070	Palouse River at Hooper, WA	89,400	.17	36.3	6,380	262
54	41A070	Crab Creek near Beverly, WA	37,100	.09	96.3	999	201
55	12471400	Lind Coulee Wastway at SR 17 near Warden, WA	NC	NC	NC	1,840	–
56	13A060	Deschutes River at East Street Bridge, WA	13,300	.04	129	267	178
57	10A070	Puyallup River at Meridian Street, WA	398,000	.09	433	2,380	2,350
58	12108500	Newaukum Creek near Black Diamond, WA	NC	NC	NC	71.1	33.7
59	12464770	Crab Creek at Rocky Ford Road near Ritzville, WA	4,760	.09	10.4	1,190	26.8
60	12061500	Skokomish River near Potlatch, WA	NC	NC	NC	339	646
61	16A070	Skokomish River near Potlatch, WA	31,100	.02	237	339	646
62	12112600	Big Soos Creek above Hatchery near Auburn, WA	NC	NC	NC	173	71.9
63	09A190	Green River at Kanaskat, WA	27,000	.02	114	616	573
64	45A070	Wenatchee River at Wenatchee, WA	50,500	.02	38.1	3,440	1,590
65	12113375	Springbrook Creek at Tukwila, WA	NC	NC	NC	51.7	29.7
66	09A080	Green River at Tukwila, WA	76,500	.05	160	1,240	851
67	12113390	Duwamish River at Golf Course at Tukwila, WA	106,000	.06	230	1,190	965
68	12056500	North Fork Skokomish River below Staircase Rapids near Hoodport, WA	3,200	.01	56.3	147	300
69	46A070	Entiat River near Entiat, WA	8,140	.02	19.6	1,070	209
70	45A110	Wenatchee River near Leavenworth, WA	38,200	.01	57.5	1,720	1,570
71	16C090	Duckabush River near Brinnon, WA	5,080	.01	76.5	172	229
72	12128000	Thorton Creek near Seattle, WA	1,710	.11	151	29.2	8.11
73	54A120	Spokane River at Riverside State Park, WA	300,000	.05	59.9	13,000	3,010
74	07D050	Snoqualmie River near Monroe, WA	114,000	.02	166	1,770	2,440
75	07C070	Skykomish River at Monroe, WA	67,400	.01	88.0	1,980	2,690
76	07A090	Snohomish River at Snohomish, WA	247,000	.02	144	4,440	6,310
77	53A070	Columbia River at Grand Coulee, WA	1,940,000	.01	174	28,900	74,400
78	48A070	Methow River near Pateros, WA	17,100	.02	9.5	4,660	576
79	49A070	Okanogan River at Malott, WA	74,500	.03	42.9	4,500	1,330
80	48A140	Methow River at Twisp, WA	15,500	.02	11.7	3,430	508
81	03A060	Skagit River near Mount Vernon, WA	354,000	.02	152	6,020	10,500
82	03B050	Samish River near Burlington, WA	8,760	.03	102	223	158
83	12213140	Nooksack River at Brennan, WA	NC	NC	NC	2,020	2,540
84	01A050	Nooksack River at Brennan, WA	244,000	.05	331	1,910	2,540
85	12210700	Nooksack River at North Cedarville, WA	NC	NC	NC	1,520	–
86	12400520	Columbia River at Northport, WA	NC	NC	NC	156,000	74,000
87	61A070	Columbia River at Northport, WA	1,470,000	.01	24.4	156,000	74,000
88	12212100	Fishtrap Creek at Flynn Road at Lynden, WA	NC	NC	NC	98.6	–
89	13092747	Rock Creek above Hwy 30/93 crossing at Twin Falls, ID	11,700	.08	48.5	623	77.7
90	13094000	Snake River near Buhl, ID	576,000	.14	19.6	76,100	2,150
91	13154500	Snake River at King Hill, ID	1,060,000	.07	29.7	92,900	7,330
92	13203510	Boise River below Diversion Dam near Boise, ID	27,200	.02	10.1	6,980	817
93	13206000	Boise River at Glenwood, ID	147,000	.15	52.9	7,180	503
94	13238322	North Fork Payette River below Fischer Creek near McCall, ID	1,890	.01	22.3	220	132
95	12414900	St. Maries River near Santa, ID	9,320	.03	34.2	706	155
96	12414500	St. Joe River at Calder, ID	18,700	.01	18.1	2,680	1,130
97	12413470	South Fork Coeur d' Alene River near Pinehurst, ID	17,600	.04	61.8	738	232
98	12413000	North Fork Coeur d' Alene River at Enaville, ID	12,000	.01	13.3	2,330	763
99	12419000	Spokane River near Post Falls, ID	55,600	.01	14.2	10,200	2,690
100	13010065	Snake River at Flagg Ranch, WY	46,100	.04	90.1	1,320	528

Table A9. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for suspended sediment in the Columbia River and Puget Sound basins, water year 2001.

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; ton/d, ton per day; ton/yr, ton per year; mg/L, milligram per liter; ton/mi^2/yr, ton per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Flux (ton/d)	Variance (ton/d)	Lower 95 (ton/d)	Upper 95 (ton/d)	SEP (ton/d)	Number of days
1	10729	Owyhee River at Hwy. 201 Bridge (Owyhee), OR	24.0	7.82	18.7	30.3	2.95	365
2	MAL113	North Fork Malheur River approximately 2 miles upstream of Beulah Reservoir, OR	NA	NA	NA	NA	NA	–
3	MAL144	Malheur River at Ford Street (1.1 miles) upstream of Bully Creek, OR	NA	NA	NA	NA	NA	–
4	10386	Middle Fork Willamette River at Jasper Bridge, OR	12.8	1.49	10.3	15.6	1.34	365
5	10663	Mohawk River at Hill Road, OR	1.82	.05	1.38	2.36	.25	365
6	10376	McKenzie River at Coburg Road, OR	15.0	2.75	11.9	18.8	1.77	365
7	10355	Willamette River at Hwy 99E (Harrisburg), OR	38.0	8.05	32.1	44.6	3.18	365
8	11140	Long Tom River at Stow Pit Road (Monroe), OR	8.77	1.06	6.63	11.4	1.21	365
9	12657	McKenzie River at Hwy 126 downstream of Clear Lake, OR	NA	NA	NA	NA	NA	–
10	10508	Deschutes River at Lower Bridge, OR	5.58	.25	4.60	6.70	.54	365
11	10350	Willamette River at Albany (Eastbound Hwy 20 Bridge), OR	91.0	37.6	77.6	106	7.27	365
12	11490	Powder River at Hwy 7 (Baker City), OR	1.62	.06	1.13	2.24	.28	365
13	11478	John Day River at Service Creek, OR	17.5	4.28	12.9	23.4	2.69	365
14	10555	Willamette River at Marion Street (Salem), OR	156	173	129	187	14.6	365
15	14200400	Little Abiqua Creek near Scotts Mills, OR	.19	.00	.14	.25	.03	365
16	14201300	Zollner Creek near Mt. Angel, OR	.18	.00	.14	.22	.02	365
17	10640	Pudding River at Hwy 211 (Woodburn), OR	7.43	.48	6.05	9.02	.76	365
18	13070	Clackamas River at Mciver Park (Upper Boat Ramp), OR	5.48	.25	4.47	6.65	.56	365
19	3701002	Tualatin River at Weiss Bridge, OR	NA	NA	NA	NA	NA	–
20	3840012	Fanno Creek at Durham Road, OR	NA	NA	NA	NA	NA	–
21	14206950	Fanno Creek near Durham, OR	1.45	.07	.96	2.11	.29	365
22	3701715	Tualatin River at Cherry Grove, OR	NA	NA	NA	NA	NA	–
23	11321	Johnson Creek at SE 17th Avenue (Portland), OR	.72	.00	.59	0.87	.07	365
24	3701333	Tualatin River at Farmington Bridge Road, OR	NA	NA	NA	NA	NA	–
25	3701612	Tualatin River at Springhill Road Bridge (Dilley), OR	NA	NA	NA	NA	NA	–
26	11386	John Day River at Hwy 206, OR	27.6	18.1	18.2	40.1	5.59	365
27	3805048	Scoggins Creek below Hagg Lake at Stimson Bridge, OR	NA	NA	NA	NA	NA	–
28	3701391	Tualatin River at Rood Bridge Road, OR	NA	NA	NA	NA	NA	–
29	3701528	Tualatin River at Golf Course Road, OR	NA	NA	NA	NA	NA	–
30	3810015	Gales Creek at New Hwy 47, OR	NA	NA	NA	NA	NA	–
31	10611	Willamette River at Hawthorne Bridge (Portland), OR	228	129	202	256	13.8	365
32	3820012	Rock Creek at Hwy 8, OR	NA	NA	NA	NA	NA	–
33	14211720	Willamette River at Portland, OR	326	323	288	368	20.3	365
34	3850006	Dawson Creek at Brookwood, OR	NA	NA	NA	NA	NA	–
35	3824020	Bronson Creek at Bronson Park downstream of Sunset Hwy, OR	NA	NA	NA	NA	NA	–
36	3824072	Bronson Creek at Saltzman, OR	NA	NA	NA	NA	NA	–
37	10332	Willamette River at SP&S Railroad Bridge, OR	237	208	208	269	15.5	365
38	14128910	Columbia River at Warrendale, OR	904	28,300	617	1,280	169	365
39	10411	Deschutes River at Deschutes River Park, OR	88.6	122	67.7	114	11.8	365
40	10616	Columbia River at Marker #47 (upstream of Willamette River), OR	1,430	15,700	1,190	1,700	131	365
41	10406	Umatilla River at Hwy 11 (Pendleton), OR	4.26	.53	2.86	6.12	.84	365
42	12012	Hood River at footbridge downstream of I-84, OR	24.0	82.2	8.50	54.3	12.0	365
43	11489	Umatilla River at Westland Road (Hermiston), OR	21.5	6.87	15.8	28.7	3.30	365
44	14246900	Columbia River at Beaver Army Terminal near Quincy, OR	3,600	68,400	3,070	4,200	288	365
45	27D090	East Fork Lewis River near Dollar Corner, WA	4.09	.18	3.05	5.37	.59	365
46	32A070	Walla Walla River near Touchet, WA	23.4	15.6	15.7	33.5	4.56	365
47	13353200	Snake River at Burbank, WA	NA	NA	NA	NA	NA	–
48	37A090	Yakima River at Kiona, WA	46.8	16.9	38.7	56.1	4.45	365
49	12510500	Yakima River at Kiona, WA	44.9	13.2	37.8	53.0	3.88	365
50	12505450	Granger Drain at Granger, WA	6.60	0.79	4.91	8.67	0.96	365

Table A9. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for suspended sediment in the Columbia River and Puget Sound basins, water year 2001.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; ton/d, ton per day; ton/yr, ton per year; mg/L, milligram per liter; ton/mi^2/yr, ton per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Load (ton/yr)	Flow-weighted concentration (mg/L)	Yield (ton/mi^2/yr)	Drainage area (ft^3/s)	Annual mean flow (ft^3/s)
1	10729	Owyhee River at Hwy. 201 Bridge (Owyhee), OR	8,750	79.4	NC	NA	112
2	MAL113	North Fork Malheur River approximately 2 miles upstream of Beulah Reservoir, OR	NC	NC	NC	880	67.1
3	MAL144	Malheur River at Ford Street (1.1 miles) upstream of Bully Creek, OR	NC	NC	NC	12,000	94.6
4	10386	Middle Fork Willamette River at Jasper Bridge, OR	4,660	1.98	3.46	3,490	2,400
5	10663	Mohawk River at Hill Road, OR	665	3.50	3.74	460	193
6	10376	McKenzie River at Coburg Road, OR	5,490	1.92	NC	NA	2,900
7	10355	Willamette River at Hwy 99E (Harrisburg), OR	13,900	2.42	4.04	8,890	5,820
8	11140	Long Tom River at Stow Pit Road (Monroe), OR	3,200	14.7	7.69	1,080	221
9	12657	McKenzie River at Hwy 126 downstream of Clear Lake, OR	NC	NC	NC	239	260
10	10508	Deschutes River at Lower Bridge, OR	2,040	2.34	.97	5,440	883
11	10350	Willamette River at Albany (Eastbound Hwy 20 Bridge), OR	33,200	5.00	6.85	12,600	6,750
12	11490	Powder River at Hwy 7 (Baker City), OR	590	9.96	1.69	902	60.3
13	11478	John Day River at Service Creek, OR	6,410	7.40	1.25	13,300	877
14	10555	Willamette River at Marion Street (Salem), OR	57,000	5.16	7.72	19,100	11,200
15	14200400	Little Abiqua Creek near Scotts Mills, OR	67.6	3.89	6.86	25.5	18.1
16	14201300	Zollner Creek near Mt. Angel, OR	65.7	13.8	4.38	38.9	4.83
17	10640	Pudding River at Hwy 211 (Woodburn), OR	2,710	8.25	8.58	818	334
18	13070	Clackamas River at Mciver Park (Upper Boat Ramp), OR	2,000	1.35	2.94	1,760	1,500
19	3701002	Tualatin River at Weiss Bridge, OR	NC	NC	NC	1840	429
20	3840012	Fanno Creek at Durham Road, OR	NC	NC	NC	80.7	19.3
21	14206950	Fanno Creek near Durham, OR	529	27.9	17.0	80.7	19.3
22	3701715	Tualatin River at Cherry Grove, OR	NC	NC	NC	97.3	65.5
23	11321	Johnson Creek at SE 17th Avenue (Portland), OR	262	6.90	4.89	139	38.7
24	3701333	Tualatin River at Farmington Bridge Road, OR	NC	NC	NC	1460	305
25	3701612	Tualatin River at Springhill Road Bridge (Dilley), OR	NC	NC	NC	327	130
26	11386	John Day River at Hwy 206, OR	10,100	11.2	NC	NA	916
27	3805048	Scoggins Creek below Hagg Lake at Stimson Bridge, OR	NC	NC	NC	103	50.0
28	3701391	Tualatin River at Rood Bridge Road, OR	NC	NC	NC	1,230	231
29	3701528	Tualatin River at Golf Course Road, OR	NC	NC	NC	561	155
30	3810015	Gales Creek at New Hwy 47, OR	NC	NC	NC	195	60.6
31	10611	Willamette River at Hawthorne Bridge (Portland), OR	83,200	5.28	7.45	28,900	16,000
32	3820012	Rock Creek at Hwy 8, OR	NC	NC	NC	193	37.8
33	14211720	Willamette River at Portland, OR	119,000	7.55	10.7	28,900	16,000
34	3850006	Dawson Creek at Brookwood, OR	NC	NC	NC	9.7	1.80
35	3824020	Bronson Creek at Bronson Park downstream of Sunset Hwy, OR	NC	NC	NC	10.2	1.34
36	3824072	Bronson Creek at Saltzman, OR	NC	NC	NC	5.23	.20
37	10332	Willamette River at SP&S Railroad Bridge, OR	86,500	5.49	NC	NA	16,000
38	14128910	Columbia River at Warrendale, OR	330,000	2.84	1.39	616,000	118,000
39	10411	Deschutes River at Deschutes River Park, OR	32,300	6.77	3.02	27,800	4,850
40	10616	Columbia River at Marker #47 (upstream of Willamette River), OR	521,000	4.73	NC	NA	112,000
41	10406	Umatilla River at Hwy 11 (Pendleton), OR	1,560	4.60	3.49	1,150	343
42	12012	Hood River at footbridge downstream of I-84, OR	8,770	16.4	NC	NA	541
43	11489	Umatilla River at Westland Road (Hermiston), OR	7,850	21.4	NC	NA	372
44	14246900	Columbia River at Beaver Army Terminal near Quincy, OR	1,320,000	9.53	5.18	658,000	140,000
45	27D090	East Fork Lewis River near Dollar Corner, WA	1,490	3.69	9.6	405	411
46	32A070	Walla Walla River near Touchet, WA	8,530	21.2	5.06	4,370	409
47	13353200	Snake River at Burbank, WA	NC	NC	NC	262000	24,700
48	37A090	Yakima River at Kiona, WA	17,100	11.3	3.04	14,500	1,530
49	12510500	Yakima River at Kiona, WA	16,400	10.9	2.92	14,500	1,530
50	12505450	Granger Drain at Granger, WA	2,410	88.7	39.0	160	27.6

Table A9. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for suspended sediment in the Columbia River and Puget Sound basins, water year 2001.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; ton/d, ton per day; ton/yr, ton per year; mg/L, milligram per liter; ton/mi^2/yr, ton per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Flux (ton/d)	Variance (ton/d)	Lower 95 (ton/d)	Upper 95 (ton/d)	SEP (ton/d)	Number of days
51	12472900	Columbia River at Vernita Bridge near Priest Rapids Dam, WA	511	2,340	421	616	49.7	365
52	13351000	Palouse River at Hooper, WA	20.8	9.57	13.0	31.7	4.82	365
53	34A070	Palouse River at Hooper, WA	21.5	9.74	14.6	30.5	4.09	365
54	41A070	Crab Creek near Beverly, WA	24.2	3.02	20.7	28.2	1.91	365
55	12471400	Lind Coulee Wastway at SR 17 near Warden, WA	NA	NA	NA	NA	NA	–
56	13A060	Deschutes River at East Street Bridge, WA	1.92	.01	1.65	2.22	.14	365
57	10A070	Puyallup River at Meridian Street, WA	489	5,380	305	743	112	365
58	12108500	Newaukum Creek near Black Diamond, WA	NA	NA	NA	NA	NA	–
59	12464770	Crab Creek at Rocky Ford Road near Ritzville, WA	.29	0.00	.21	0.41	.05	365
60	12061500	Skokomish River near Potlatch, WA	NA	NA	NA	NA	NA	–
61	16A070	Skokomish River near Potlatch, WA	11.6	1.19	8.49	15.6	1.81	365
62	12112600	Big Soos Creek above Hatchery near Auburn, WA	NA	NA	NA	NA	NA	–
63	09A190	Green River at Kanaskat, WA	5.09	.10	4.19	6.12	.49	365
64	45A070	Wenatchee River at Wenatchee, WA	36.2	22.2	25.2	50.5	6.47	365
65	12113375	Springbrook Creek at Tukwila, WA	NA	NA	NA	NA	NA	–
66	09A080	Green River at Tukwila, WA	30.9	3.60	26.1	36.3	2.60	365
67	12113390	Duwamish River at Golf Course at Tukwila, WA	57.2	34.6	44.6	72.2	7.04	365
68	12056500	North Fork Skokomish River below Staircase Rapids near Hoodport, WA	1.88	.07	1.21	2.79	.40	365
69	46A070	Entiat River near Entiat, WA	3.63	.18	2.62	4.91	.59	365
70	45A110	Wenatchee River near Leavenworth, WA	21.0	5.81	15.0	28.5	3.44	365
71	16C090	Duckabush River near Brinnon, WA	1.65	.04	1.00	2.57	.40	365
72	12128000	Thorton Creek near Seattle, WA	.65	.01	.39	1.02	.16	365
73	54A120	Spokane River at Riverside State Park, WA	44.9	40.7	30.1	64.4	8.77	365
74	07D050	Snoqualmie River near Monroe, WA	78.9	20.1	65.9	93.6	7.08	365
75	07C070	Skykomish River at Monroe, WA	41.9	12.6	33.4	51.8	4.71	365
76	07A090	Snohomish River at Snohomish, WA	165	122	138	196	14.6	365
77	53A070	Columbia River at Grand Coulee, WA	209	202	180	241	15.6	365
78	48A070	Methow River near Pateros, WA	7.46	.62	5.45	9.96	1.15	365
79	49A070	Okanogan River at Malott, WA	64.5	22.2	51.9	79.2	6.99	365
80	48A140	Methow River at Twisp, WA	5.06	.26	3.64	6.87	.83	365
81	03A060	Skagit River near Mount Vernon, WA	385	1,310	307	477	43.4	365
82	03B050	Samish River near Burlington, WA	6.36	.45	4.87	8.16	.84	365
83	12213140	Nooksack River at Brennan, WA	NA	NA	NA	NA	NA	–
84	01A050	Nooksack River at Brennan, WA	329	512	259	412	38.9	365
85	12210700	Nooksack River at North Cedarville, WA	NA	NA	NA	NA	NA	–
86	12400520	Columbia River at Northport, WA	NA	NA	NA	NA	NA	–
87	61A070	Columbia River at Northport, WA	380	413	337	427	23.1	365
88	12212100	Fishtrap Creek at Flynn Road at Lynden, WA	NA	NA	NA	NA	NA	–
89	13092747	Rock Creek above Hwy 30/93 crossing at Twin Falls, ID	5.21	.20	4.31	6.25	.49	365
90	13094000	Snake River near Buhl, ID	108	306	77.2	147	18.0	365
91	13154500	Snake River at King Hill, ID	190	158	165	219	13.7	365
92	13203510	Boise River below Diversion Dam near Boise, ID	10.4	2.18	7.65	13.9	1.59	365
93	13206000	Boise River at Glenwood, ID	6.70	.71	5.10	8.65	.91	365
94	13238322	North Fork Payette River below Fischer Creek near McCall, ID	NA	NA	NA	NA	NA	–
95	12414900	St. Maries River near Santa, ID	NA	NA	NA	NA	NA	–
96	12414500	St. Joe River at Calder, ID	11.7	4.77	7.87	16.9	2.30	365
97	12413470	South Fork Coeur d' Alene River near Pinehurst, ID	3.30	.10	2.47	4.33	.48	365
98	12413000	North Fork Coeur d' Alene River at Enaville, ID	7.27	.96	4.68	10.8	1.57	365
99	12419000	Spokane River near Post Falls, ID	11.4	.90	9.39	13.7	1.10	365
100	13010065	Snake River at Flagg Ranch, WY	46.5	70.1	25.1	79.1	13.9	365

Table A9. Results of LOADEST modeling, flow-weighted concentrations, yields, drainage areas, and mean annual streamflows for suspended sediment in the Columbia River and Puget Sound basins, water year 2001.—Continued

[**Flux**, estimate of average daily load for water year. **Variance**, variance of the flux. **Lower 95**, lower estimate of 95 percent confidence interval for flux. **Upper 95**, upper estimate of 95 percent confidence interval for flux. **Abbreviations:** SEP, standard error of prediction; ID, Idaho; OR, Oregon; WA, Washington; WY, Wyoming; ton/d, ton per day; ton/yr, ton per year; mg/L, milligram per liter; ton/mi^2/yr, ton per square mile per year; km^2, square kilometer; ft^3/s, cubic foot per second; NA, not available; NC, not calculated; –, not applicable]

Map index No.	Site No.	Site name	Load (ton/yr)	Flow-weighted concentration (mg/L)	Yield (ton/mi^2/yr)	Drainage area (ft^3/s)	Annual mean flow (ft^3/s)
51	12472900	Columbia River at Vernita Bridge near Priest Rapids Dam, WA	187,000	2.35	7.13	67,800	80,700
52	13351000	Palouse River at Hooper, WA	7,590	29.4	3.08	6,380	262
53	34A070	Palouse River at Hooper, WA	7,830	30.4	3.18	6,380	262
54	41A070	Crab Creek near Beverly, WA	8,840	44.6	22.9	999	201
55	12471400	Lind Coulee Wastway at SR 17 near Warden, WA	NC	NC	NC	1,840	–
56	13A060	Deschutes River at East Street Bridge, WA	701	4.00	6.81	267	178
57	10A070	Puyallup River at Meridian Street, WA	178,000	77.1	194	2,380	2,350
58	12108500	Newaukum Creek near Black Diamond, WA	NC	NC	NC	71.1	33.7
59	12464770	Crab Creek at Rocky Ford Road near Ritzville, WA	108	4.01	.23	1,190	26.8
60	12061500	Skokomish River near Potlatch, WA	NC	NC	NC	339	646
61	16A070	Skokomish River near Potlatch, WA	4,250	6.66	32.4	339	646
62	12112600	Big Soos Creek above Hatchery near Auburn, WA	NC	NC	NC	173	71.9
63	09A190	Green River at Kanaskat, WA	1,860	3.29	7.81	616	573
64	45A070	Wenatchee River at Wenatchee, WA	13,200	8.44	10.0	3,440	1,590
65	12113375	Springbrook Creek at Tukwila, WA	NC	NC	NC	51.7	29.7
66	09A080	Green River at Tukwila, WA	11,300	13.5	23.7	1,240	851
67	12113390	Duwamish River at Golf Course at Tukwila, WA	20,900	22.0	45.3	1,190	965
68	12056500	North Fork Skokomish River below Staircase Rapids near Hoodport, WA	685	2.32	12.1	147	300
69	46A070	Entiat River near Entiat, WA	1,330	6.44	3.20	1,070	209
70	45A110	Wenatchee River near Leavenworth, WA	7,650	4.96	11.5	1,720	1,570
71	16C090	Duckabush River near Brinnon, WA	603	2.67	9.07	172	229
72	12128000	Thorton Creek near Seattle, WA	237	29.7	21.0	29.2	8.11
73	54A120	Spokane River at Riverside State Park, WA	16,400	5.53	3.28	13,000	3,010
74	07D050	Snoqualmie River near Monroe, WA	28,800	12.0	42.1	1,770	2,440
75	07C070	Skykomish River at Monroe, WA	15,300	5.77	20.0	1,980	2,690
76	07A090	Snohomish River at Snohomish, WA	60,300	9.69	35.2	4,440	6,310
77	53A070	Columbia River at Grand Coulee, WA	76,200	1.04	6.83	28,900	74,400
78	48A070	Methow River near Pateros, WA	2,720	4.80	1.51	4,660	576
79	49A070	Okanogan River at Malott, WA	23,500	18.0	13.5	4,500	1,330
80	48A140	Methow River at Twisp, WA	1,850	3.69	1.40	3,430	508
81	03A060	Skagit River near Mount Vernon, WA	141,000	13.6	60.5	6,020	10,500
82	03B050	Samish River near Burlington, WA	2,320	14.9	26.9	223	158
83	12213140	Nooksack River at Brennan, WA	NC	NC	NC	2,020	2,540
84	01A050	Nooksack River at Brennan, WA	120,000	48.0	163	1,910	2,540
85	12210700	Nooksack River at North Cedarville, WA	NC	NC	NC	1,520	–
86	12400520	Columbia River at Northport, WA	NC	NC	NC	156,000	74,000
87	61A070	Columbia River at Northport, WA	139,000	1.90	2.3	156,000	74,000
88	12212100	Fishtrap Creek at Flynn Road at Lynden, WA	NC	NC	NC	98.6	–
89	13092747	Rock Creek above Hwy 30/93 crossing at Twin Falls, ID	1,900	24.9	7.91	623	77.7
90	13094000	Snake River near Buhl, ID	39,500	18.6	1.34	76,100	2,150
91	13154500	Snake River at King Hill, ID	69,400	9.61	1.94	92,900	7,330
92	13203510	Boise River below Diversion Dam near Boise, ID	3,800	4.72	1.41	6,980	817
93	13206000	Boise River at Glenwood, ID	2,450	4.94	0.88	7,180	503
94	13238322	North Fork Payette River below Fischer Creek near McCall, ID	NC	NC	NC	220	132
95	12414900	St. Maries River near Santa, ID	NC	NC	NC	706	155
96	12414500	St. Joe River at Calder, ID	4,290	3.84	4.14	2,680	1,130
97	12413470	South Fork Coeur d' Alene River near Pinehurst, ID	1,210	5.27	4.23	738	232
98	12413000	North Fork Coeur d' Alene River at Enaville, ID	2,650	3.53	2.96	2,330	763
99	12419000	Spokane River near Post Falls, ID	4,160	1.57	1.06	10,200	2,690
100	13010065	Snake River at Flagg Ranch, WY	17,000	32.7	33.2	1,320	528

This page intentionally left blank.

Appendix B. Methodology for Computing Trends in Annual Streamflow, Trends in Load, and Flow- and Non-Flow-Adjusted Trends in Concentration

The non-flow adjusted trend estimates are derived from parameter estimates, and associated covariances, obtained from a model of flow and model of water-quality concentration, both models being estimated in logarithm space. The model of flow consists of an intercept, a linear trend term (decimal time), sine and cosine functions of decimal time (the seasonal component of flow), and a serially correlated error term; the flow residual is assumed to follow a 30-order autoregressive (AR(30)) process. The flow model is estimated using maximum likelihood methods as employed by the SAS AUTOREG procedure (SAS Institute, 1989). The high order autoregressive process is necessary to remove as much serial correlation as possible from the residuals, thereby reducing bias in the estimated coefficient covariance matrix of the flow model.

The water-quality model relates the natural logarithm of contaminant concentration to various predictors. An abstract representation of the model is given by

$$c_t = b_0 + m\left(q_t\right)b_q + h\left(T_t\right)b_T + x_t b_x + e_t, \qquad \text{(B1)}$$

where:

c_t is the natural logarithm of contaminant concentration in period t;

q_t is natural logarithm of streamflow;

T is decimal time, in years;

x_t is a vector of ancillary predictors such as the sine and cosine functions of decimal time;

e_t is an independent and identically normallly distributed random error;

$m(.)$ and $h(.)$ are multi-element vector functions of q and T; and

b_0, b_q, b_T and b_x are associated coefficients to be estimated.

The multi-element vector function of the natural logarithm of streamflow, $m(.)$, consists of the natural logarithm of flow and the square of the natural logarithm of flow; the multi-element vector function of decimal time, $h(.)$, consists of second-order polynomial terms and step functions of decimal time.

The water-quality model estimates values using either ordinary least squares, if the water-quality data contain no censored observations, or the maximum likelihood method, if censored observations are present. The exact methods differ slightly from those employed by LOADEST (Runkel and others, 2004) and small discrepancies can be expected in the coefficient and covariance estimates. In particular, LOADEST uses exact analytic derivatives to estimate the covariance and maximum likelihood bias adjustment, whereas the method employed in this model uses a numerical central-difference approach. The maximum likelihood bias adjustment requires estimates of the detection level even for uncensored observations. If the detection level is not supplied, a default detection level is used that equals the maximum of the parameter's median detection level for all censored observations across all stations or the reported, uncensored value.

The estimate of non-flow adjusted trend (NFAT) is based on the flow and trend coefficients from the water quality model (b_q and b_T), and the coefficient on decimal time in the flow model, subsequently denoted a. Let t_1 and t_2 define the beginning and ending dates of the trend period (in this case, the dates of the first and last water-quality sample collected during the analysis period October 1, 1992, to September 30, 2004). The trend in the natural logarithm of flow in period t, $\tilde{q}_t$, is given by

$$\tilde{q}_t = \bar{q} + a\left(T_t - \bar{T}\right), \qquad \text{(B2)}$$

where:

$\bar{q}$ and $\bar{T}$ are the averages of the natural logarithm of flow and decimal time over the trend period.

If flow is upward trending, then a will be positive and trend in the natural logarithm of flow will be less than the mean value of the natural logarithm of flow for the first one-half of the analysis period and greater than the mean value thereafter. Note that the average of the natural logarithm of flow, $\bar{q}$, implicitly accounts for the intercept and average of the seasonal terms that are included in the flow model but not otherwise apparent in the formulation of equation (B2).

The full trend in water quality in period t, $\tilde{c}_t$, is defined as

$$\tilde{c}_t = b_0 + m\left(\tilde{q}_t\right)b_q + h\left(T_t\right)b_T + \bar{x}b_x, \qquad \text{(B3)}$$

where:

$\bar{x}$ is an average, over the trend period t_1 to t_2, of the non-flow/non-trend variables in the water-quality model given in equation 1, and the average of the error term is absent because it is set to its expected value of zero.

Note that in forming this estimate of $\tilde{c}_t$, the trend in the natural logarithm of flow is substituted for the actual natural logarithm of flow in the function $m(.)$. This implies that variations in streamflow not reflected in trend do not determine the proposed measure of full trend in water quality. Because of the nonlinearity of the function $m(.)$, this might lead to a bias in the evaluation of full water-quality trend if flows are becoming more or less variable over time.

The full trend in water-quality concentration, τ_c, over the trend period, t_1 to t_2, is given by

$$\begin{aligned}\tau_c &= \tilde{c}_{t_2} - \tilde{c}_{t_1} \\ &= \left(m\left(\tilde{q}_{t_2}\right) - m\left(\tilde{q}_{t_1}\right)\right)b_q + \left(h\left(T_{t_2}\right) - h\left(T_{t_1}\right)\right)b_T \\ &= \left(m\left(\bar{q} + a\left(T_{t_2} - \bar{T}\right)\right) - m\left(\bar{q} + a\left(T_{t_1} - \bar{T}\right)\right)\right)b_q \\ &\quad + \left(h\left(T_{t_2}\right) - h\left(T_{t_1}\right)\right)b_T.\end{aligned} \qquad \text{(B4)}$$

The full trend in water-quality concentration depends on the trend and flow coefficients from the water-quality model, b_q and b_T, as well as the trend coefficient a from the streamflow model. The trend in load, τ_L, is similarly defined but includes an additional term to reflect the direct effect streamflow has on the determination of load

$$\begin{aligned}\tau_L &= a\left(T_{t_2} - T_{t_1}\right) \\ &\quad + \left(m\left(\bar{q} + a\left(T_{t_2} - \bar{T}\right)\right) - m\left(\bar{q} + a\left(T_{t_1} - \bar{T}\right)\right)\right)b_q \\ &\quad + \left(h\left(T_{t_2}\right) - h\left(T_{t_1}\right)\right)b_T.\end{aligned} \qquad \text{(B5)}$$

The full trend, expressed in percent per year, is given by

$$\text{Percent Trend} = 100\frac{\left(\exp\left(\tau\right) - 1\right)}{T_{t_2} - T_{t_1}}, \qquad \text{(B6)}$$

where:

τ is either τ_c or τ_L.

The estimator of full trend is obtained by evaluating the coefficients a, b_q and b_T in (B4) and (B5) at their estimated values, where the water-quality parameter estimates are obtained using the adjusted maximum likelihood method (Cohn, 2005). Generally, the transformation of the estimated values of τ_c or τ_L into real space, via the exponential function appearing in (B6), induces a small degree of bias. No correction of this bias was applied in this case to ensure agreement between the sign of the percent trend and the sign of the test statistic used to evaluate the statistical significance of trend

A statistical test of the null hypothesis that trend is zero can be undertaken by forming t-statistics from the estimates of either τ_c or τ_L, and dividing by their respective standard error. Standard errors of the estimated values of τ_c and τ_L are complicated to derive owing to the nonlinear manner in which the flow trend coefficient and the water-quality flow coefficients interact in the determination of full trend. An approximation to the standard error, which is suitable for large samples, is obtained by taking a first-order Taylor approximation of the full trend estimate (either equation (B4) or (B5)) with respect to the flow and water-quality model coefficients. Let $b = \left\{b'_q \;\; b'_r\right\}$ represent the vector of combined flow and trend coefficients from the water-quality model and let V_b be the covariance matrix of this vector. Under the plausible assumption that streamflow is exogenous with respect to water quality, meaning that changes in streamflow cause changes in water quality but changes in water quality do not cause changes in streamflow, the covariance between the estimated values of a and b is zero. Consequently, the standard error of τ_c and τ_L, denoted σ_c and σ_L, are given by

$$\sigma_c = \sqrt{V_a\left(\frac{\partial \Delta m}{\partial a}b_q\right)^2 + AV_bA'}, \qquad \text{(B7)}$$

and

$$\sigma_L = \sqrt{V_a\left(\frac{\partial \Delta m}{\partial a}b_q + \left(T_{t_2} - T_{t_1}\right)\right)^2 + AV_bA'}, \qquad \text{(B8)}$$

where

V_a is the variance of the estimated flow trend coefficient, a,

$$\frac{\partial \Delta m}{\partial a} = \frac{\partial m\left(\bar{q} + a\left(T_{t_2} - \bar{T}\right)\right)}{\partial a} - \frac{\partial m\left(\bar{q} + a\left(T_{t_1} - \bar{T}\right)\right)}{\partial a} \qquad \text{(B9)}$$

and

$$\begin{aligned}A = &\left\{m\left(\bar{q} + a\left(T_{t_2} - \bar{T}\right)\right) \quad h\left(T_{t_2}\right)\right\} \\ &-\left\{m\left(\bar{q} + a\left(T_{t_1} - \bar{T}\right)\right) \quad h\left(T_{t_1}\right)\right\}\end{aligned} \qquad \text{(B10)}$$

In large samples, the t-statistics τ_c/σ_c and τ_c/σ_c are distributed standard normal. Therefore, the two-sided *p*-value for significance of trend is given by

$$p = 2\left(1-\Phi\left(\left|\tau/\sigma\right|\right)\right), \qquad \text{(B11)}$$

where:

τ/σ is either τ_c/σ_c or τ_L/σ_L, and

$\Phi(.)$ is the standard normal cumulative distribution.

The unit trend is the change in concentration or load over a given period, expressed in the units of concentration or load, divided by the length of the period, expressed in years. Both the unit trend in concentration and the unit trend in load are based on trend-denominated variations in the logarithm-transformed water-quality and flow models given in equations (B1) and (B2). The unit trend in concentration, denoted τ_c^u, is given by

$$t_c^u = \frac{\exp\left(\tilde{c}_{t_2}\right)-\exp\left(\tilde{c}_{t_1}\right)}{T_{t_2}-T_{t_1}} = \exp\left(\tilde{c}_{t_1}\right)\left(\frac{\exp\left(t_c\right)-1}{T_{t_2}-T_{t_1}}\right), \qquad \text{(B12)}$$

where

$\tilde{c}_t$ is given by equation (B3), and

t_c is given by equation (B4).

The units of τ_c^u are milligrams per liter per year (mg/L^{-1}/y^{-1}). A similar expression applies to the determination of the unit trend in load, τ_L^u,

$$t_L^u = k\exp\left(\tilde{c}_{t_1}+\tilde{q}_{t_1}\right)\left(\frac{\exp\left(t_L\right)-1}{T_{t_2}-T_{t_1}}\right), \qquad \text{(B13)}$$

where

k is a conversion factor that expresses t_L^u in units of kilograms per year per year (kg/y^{-2}), and

$\tilde{q}_{t_1}$ is given by equation (B2), evaluated at the date of the first water-quality sample in the analysis period.

The estimators of τ_c^u and τ_L^u, given by (B12) and (B13), are based on the sample estimates of τ_c and τ_L described above, and on estimates of $\tilde{c}_{t_1}$ and $\tilde{q}_{t_1}$, given in equations (B3) and (B2), with coefficients evaluated at their sample estimates (see above), and with the period set to t_1, the date of the first water-quality sample in the analysis period. A correction was applied to account for the transformation bias arising from the exponential transformation of $\tilde{c}_{t_1}$ in equation (B12) and $\tilde{c}_{t_1}+\tilde{q}_{t_1}$ in (B13). The correction was applied only to these terms, and not to the terms involving τ_c and τ_L, because correction of the latter could affect the sign of the unit trend estimate as compared to the sign of the test statistic used to statistically evaluate the significance of trend. The transformation bias correction is based on a first-order Taylor approximation that linearizes the expressions for $\tilde{c}_{t_1}$ and $\tilde{c}_{t_1}+\tilde{q}_{t_1}$ with respect to all model coefficients. The estimation of the variance of $\tilde{c}_{t_1}$ and $\tilde{c}_{t_1}+\tilde{q}_{t_1}$ then follows by evaluating the quadratic form implied by this linearization, similar to the quadratic forms appearing inside the square-root radicals in equations (B7) and (B8) above, employing the estimated variance of *a* and the covariance matrix of the estimated values of b_0, b_q, b_T and b_x. Let the estimated variances of $\tilde{c}_{t_1}$ and $\tilde{c}_{t_1}+\tilde{q}_{t_1}$ be denoted $V\left(\tilde{c}_{t_1}\right)$ and $V\left(\tilde{c}_{t_1}\right)$. Under the assumption that the estimated coefficients are approximately normally distributed, as occurs in large samples, the transformation bias correction is obtained by multiplying the expressions for τ_c^u and τ_L^u by the respective factors $\exp\left(-V\left(\tilde{c}_{t_1}\right)/2\right)$ and $\exp\left(-V\left(\tilde{c}_{t_1}+\tilde{q}_{t_1}\right)/2\right)$.

References Cited

Cohn, T.A., 2005, Estimating contaminant loads in rivers—An application of adjusted maximum likelihood to type 1 censored data: Water Resources Research, v. 41, no. 7, W07003.

Runkel, R.L., Crawford, C.G., and Cohn, T.A., 2004, Load estimator (LOADEST)—A FORTRAN program for estimating constituent loads in streams and rivers: U.S. Geological Survey Techniques and Methods Book 4, Chap. A5, 69 p.

SAS Institute, Inc., 1989, SAS version 6, original copyright, 1989: SAS Institute, Inc., Cary, N.C.

This page intentionally left blank.

Manuscript approved for publication August 30, 2007
Prepared by the USGS Publishing Network,
Publishing Service Center, Tacoma, Washington
Bill Gibbs
Debra Grillo
Donita Parker
Bobbie Jo Richey
Sharon Wahlstrom
For more information concerning the research in this report, contact the
Director, Oregon Water Science Center
U.S. Geological Survey
2130 SW 5th Avenue
Portland, Oregon 97201
http://or.water.usgs.gov

Printed on recycled paper