United States General Accounting Office 131361

GAO

Report to the Chairman, Subcommittee on Investigations and Oversight, Committee on Public Works and Transportation, House of Representatives

September 1986

THE NATION'S WATER

Key Unanswered Questions About the Quality of Rivers and Streams

131361

GAO/PEMD-86-6

GAO

United States
General Accounting Office
Washington, D.C. 20548

Program Evaluation and
Methodology Division

B-221558

September 19, 1986

The Honorable James L. Oberstar
Chairman, Subcommittee on Investigations and
Oversight
Committee on Public Works and Transportation
House of Representatives

Dear Mr. Chairman:

Until recently, there was little information about certain issues affecting national policy on water quality. However, several important studies published within the past 2 years have attempted to address key questions related to the nation's water quality, how water quality has changed, what pollution sources exist, and whether the Construction Grants Program has helped improve water quality. Having recognized for this report that an information gap existed, we reviewed and synthesized the findings of these studies and assessed the technical strength of their methodologies. We report deficiencies in current knowledge about the nation's water quality. This report is the first of two studies that we plan to perform on the evaluation of water quality.

Copies of the report are being sent to the director of the Office of Management and Budget, the administrator of the U.S. Environmental Protection Agency, and the secretary of the U.S. Department of the Interior.

Sincerely yours,

Eleanor Chelimsky
Director

Executive Summary

Purpose

The federal government has spent approximately $37 billion under the Federal Water Pollution Control Act Amendments of 1972 to assist municipalities to construct and upgrade wastewater-treatment plants. The construction and upgrading are intended to improve water quality in the nation's rivers and streams. The Environmental Protection Agency (EPA) estimated in 1984 that $109 billion would be required by the year 2000 to meet the mandate that the Construction Grants Program limit pollution from wastewater-treatment plants.

Five studies published within the past 2 years attempted to address critical questions about trends in the nation's water quality since 1972. To assist the Congress and the administration in deciding the future of the national water-quality program, GAO conducted an information synthesis of the findings of these studies and assessed the technical strength of the methodologies they used to reach their conclusions. GAO reports on the gaps in current knowledge about the nation's water quality. In examining the five studies, GAO pursued answers to four evaluation questions:

1. What is the present condition of the nation's water quality?

2. How has the nation's water quality changed over time?

3. What pollution sources degrade water quality?

4. What has been the effect of the Construction Grants Program on water quality?

As is normal in an information synthesis, the studies GAO reviewed had differing objectives and did not individually provide information relevant to all four of GAO's questions. Taken collectively, however, they covered the four issues.

Background

The authority to obligate funds for the Construction Grants Program expired at the end of fiscal year 1985, and the administration and the Congress had significantly different opinions concerning reauthorization levels. The difference stemmed partly from the scarcity of information on how water quality has changed and the related contribution of the Construction Grants Program.

Results in Brief

GAO was not able to draw definitive, generalizable conclusions on any of the four evaluation questions, because evaluating changes in the nation's rivers and streams is inherently difficult, the empirical data produced by the studies are sparse, and methodological problems reduce the usefulness of their findings. Therefore, little conclusive information is available to the Congress to use in policy debates on the nation's water quality.

Principal Findings

Present Water Quality

When viewed together, three studies lend support to the conclusion that some of the nation's water is of fairly good quality while other water remains polluted. Viewed as a whole, the studies support this statement, despite their individual methodological limitations in establishing effects and permitting generalizations. (See pages 47-49.)

Changes in Water Quality

The evidence is strong that, nationally, the discharge of conventional water pollutants from point sources (sources of focused pollution) has been reduced. Pollution control efforts have had an effect. What is less clear from the reports GAO examined is the degree to which the reduction in pollutants has improved water quality. Data from the studies indicate no change in water quality for most of the rivers that were examined. In some instances, water quality has improved, but opinions differ on how much. However, it is not insignificant that the water quality in many rivers and streams has been maintained despite a growing population and economy. (See pages 65-67.)

Pollution Sources

Many pollution sources can and most likely do degrade water quality. Although the relative effects of separate factors are not clearly known for the nation as a whole, pollution from nonpoint sources (sources of diffused water pollution) may degrade more stream miles than point-source pollution. This opens the question of where and how funds should be spent to improve water quality most effectively. (See pages 83-85.)

Construction Grants Program

The Construction Grants Program has certainly reduced the discharge of pollutants from wastewater-treatment plants. However, little methodologically defensible work has been done to determine the program's effects on in-stream characteristics and other aspects of water quality. The question of whether the amount of pollution being discharged from wastewater-treatment plants has been reduced can be answered affirmatively. But the effect on water quality is not yet answerable because of significant data gaps, including the absence of any analysis of a national sample of projects funded by the program, the lack of data and analysis directly linking the funding of construction grants to in-stream water quality instead of to the reduction of pollutants from treatment plants, and the lack of information and analysis to rule out explanations for changes in water quality associated with nonpoint-source and other point-source pollution. (See pages 106-108.)

Recommendations

GAO recommends that EPA perform research to compare the cost-effectiveness of the Construction Grants Program to other means of abating water pollution, giving due consideration to both point and nonpoint sources of pollution. A second recommendation focusing on technical measurement is contained in this report. (See page 111.)

A subsequent GAO report will present a methodology for evaluating the cost-effectiveness of the Construction Grants Program, document its application to four cases, and discuss the need for research into the cost-effectiveness of water pollution control programs.

Agency Comments

EPA, the U.S. Department of the Interior, and the Association of State and Interstate Water Pollution Control Administrators commented on a draft of this report. GAO reviewed their comments and made appropriate changes in the final report (their letters are in appendixes IV-VI). Major areas of agreement and disagreement are highlighted below and discussed in chapter 7. (See pages 112-118.)

While EPA agrees that it is important to consider cost-effectiveness in the agency's decisions, it does not believe the proposed research is warranted for three reasons. First, EPA states that the research would not be useful, since the administration's position is that the Construction Grants Program should not be funded after fiscal year 1990. Second, EPA believes that the current legislation provides the states flexibility in controlling point and nonpoint pollution sources. Third, EPA believes that both point and nonpoint sources should be controlled.

In response, GAO notes first that after 14 years of program authority under the Federal Water Pollution Control Act Amendments and an expenditure of $37 billion, no adequate account of water-quality improvements has been derived from the Construction Grants Program. Second, under proposed legislation, additional billions of dollars would be spent through fiscal year 1990 within the program, and a revolving fund proposed through 1994 would make additional billions of federal dollars available to the states for upgrading treatment plants. GAO maintains that research designed to evaluate the cost-effectiveness of the Construction Grants Program not only would be useful but also is necessary. Third, GAO agrees that the control of both point and nonpoint sources is important. However, given that federal and other funds are limited, research on the cost-effectiveness of all control programs would be useful, so that given available funds, the most cost-effective program can be implemented. (See pages 112-115.)

The Department of the Interior indicated that GAO's conclusions are fundamentally correct. It commented that the existing data are too sparse and the methodological problems in recent programs and studies are too great to provide the amount and type of information necessary for making policy decisions about water-quality programs. The department's recognition of the inadequacy of the present collection and assessment of data on water quality has led the U. S. Geological Survey to propose the development of a national water-quality assessment program. GAO has not reviewed this proposal, because it is still early in its development stage. (See pages 115-117.)

The Association of State and Interstate Water Pollution Control Administrators expressed disagreement with GAO, especially on two points. It alleged a bias on the part of GAO against the use of expert judgment in assessing water quality, and it took issue with GAO on the appropriateness of generalizing from a judgment sample of rivers to the nation. GAO agrees with the appropriate use of judgment in water-quality assessment but is concerned about the lack of data-reliability checks on data collected through expert judgment. GAO continues to believe that the Association's sample of rivers has not been shown to resemble the nation's rivers and, therefore, that it is improper to draw conclusions about the nation's rivers from the sample. (See pages 117-118.)

Contents

Figures

Abbreviations

ASIWPCA	Association of State and Interstate Water Pollution Control Administrators
COGENT	Construction grants evaluation and network tracking system
DO	Dissolved oxygen
EPA	U.S. Environmental Protection Agency
FWS	U.S. Fish and Wildlife Service
GAO	U.S. General Accounting Office
NASQAN	National stream quality accounting network
NPDES	National pollutant discharge elimination system
STEP	States' Evaluation of Progress

Introduction

The rivers and streams of the freshwater ecosystem of the United States constitute a large, complex arena in which plants, fish, and microorganisms compete for food and interact within larger nutrient and energy cycles. The nation's surface-water resources comprise more than a million miles of rivers and streams, 78,267 square miles of inland water bodies (small lakes, reservoirs, and ponds of 440 or more acres), and 60,878 square miles of the Great Lakes (U.S. Council, 1984, p. 73).[1] Interest in maintaining the quality of this ecosystem has grown over the years.

In 1970, the U.S. Federal Water Quality Administration, then responsible for implementing federal laws on water pollution, acknowledged in Clean Water for the 1970's that

> "Almost any day, in the waters near any large population center in the United States and, increasingly, in the countryside, we can see the signs of water pollution . . . . Use of our waters to receive and carry away wastes has seriously damaged our ability to enjoy other water uses, such as swimming and boating, sport and commercial fishing." (U.S. Federal, 1970, p. 7)

In 1972, the Congress expressed its concern over the widespread deterioration of water quality by enacting comprehensive amendments to the Federal Water Pollution Control Act (amended again in 1977, the act became commonly known as the Clean Water Act). The 1972 amendments outlined a national water-quality program with two specific goals: (1) the nation's waterways were to be made fishable and swimmable and (2) pollutant discharge into the waterways was to be reduced to zero.

The 1972 legislation also greatly expanded the Construction Grants Program, which provides federal funding to construct and upgrade wastewater treatment plants to the best practicable technology—that is, to operating levels above primary treatment.[2] The program has become one of the nation's largest public works programs, channeling $37 billion in federal funds to the states since 1972.

Now, important decisions are being made about the future of the national water-quality program. In congressional reauthorization reviews of the Clean Water Act, differing views have been expressed

[1] Estimates of the total miles of rivers in the nation vary significantly, depending on definitions of rivers and streams, which differ because they include various sizes and types of streams. Some estimates are as high as almost 2 million miles. (Full bibliographical data for the interlinear citations are in appendix I.)

[2] This and other terms used in this report are defined in the glossary.

about the status and disposition of the Construction Grants Program. Moreover, the authority to obligate funds for construction grants expired at the end of fiscal year 1985, and reauthorization discussions in the Congress indicated differences of opinion concerning the appropriate funding levels for the program beyond 1986.

The Clean Water Act requires the administrator of the U.S. Environmental Protection Agency (EPA) to submit to the Congress every 2 years a "needs' survey" for the funding requirements that will enable communities to meet the goals of the act. The latest survey, prepared in 1984, reported an estimated budgetary need of $109 billion through the year 2000.

Because waterways can be polluted from several sources—municipal wastewater, agricultural runoff, and industrial discharges—the management of a water-quality program requires adequate information about water pollution. The Congress wrote into the 1972 law provisions for collecting and reporting information for assessing the effectiveness of water-quality programs. For example, the Clean Water Act requires that EPA

1. submit to the Congress biennial reports collected from the states on their progress in meeting the act's water-quality goals (section 305(b)),

2. prepare a survey that assesses the need for publicly owned wastewater treatment facilities in the United States (section 516(b)(1)), and

3. approve for each state a required and continuing planning process for all its navigable waters that includes information on effluent limitations and schedules of compliance, total maximum daily loads for pollutants, and an inventory of construction needs that is ranked by priority and includes upgrading wastewater-treatment works (section 303(e)).

The quality of the information produced since 1972 has given cause for concern, however, and raises the question of whether it supports continued spending of billions of federal dollars for construction grants or whether there are alternative, more cost-effective options for achieving the goals of the Clean Water Act. Three years after the 1972 amendments were passed, for example, a draft report of the National Commission on Water Quality pointed out that needed data were not yet available:

"We also find that there is still a major lack of adequate information. We simply do not know enough. There are not sufficient data to tell us how bad the water was and how much better it is getting. The measuring and analytical techniques are not good enough in many instances to tell us the value of incremental water quality improvements. If billions of dollars are to be invested wisely, we must have more and better data." (National Commission, 1975, p. iv)

To what extent has this situation improved in the last 10 years? Until recently, few studies were available that could help determine the progress that had been made in achieving the goals of the Clean Water Act. Within the past 2 years, however, five new studies have been published that address the issue and attempt to fill the information gap. (We discuss them in detail in chapter 2.)

Objectives, Scope, and Methodology

To assist the Congress and the administration in deciding the future course of the national water-quality program, we reviewed the findings of recent studies on the quality of water in U.S. rivers and streams and the progress that has been made toward the goals of the Clean Water Act. From our in-depth review and synthesis of the literature and the advice of expert consultants, we formulated four evaluation questions:

1. What is the present condition of the nation's water quality?

2. How has the nation's water quality changed over time?

3. What pollution sources degrade water quality?

4. What has been the effect of the Construction Grants Program on water quality?

In addition to reviewing and synthesizing relevant information from the studies that addressed these questions, we evaluated the methodologies they employed to reach their conclusions. It must be stressed that our examination of these studies was restricted to areas that provided information related to our evaluation questions.

Our effort focused on the five reports and research efforts described in chapter 2.[3] The research that was the basis for each of these reports was

[3]The five reports are EPA, National Water Quality Inventory: 1982 Report to Congress (Washington, D.C.: 1984); Association of State and Interstate Water Pollution Control Administrators (ASIWPCA), America's Clean Water: The States' Evaluation of Progress 1972-1982 (Washington, D.C.: 1984); EPA and U.S. Fish and Wildlife Service, 1982 National Fisheries Survey (Washington, D.C.: 1984); EPA, Before-and-After Case Studies: Comparisons of Water Quality Following Municipal Treatment Plant

designed for a particular purpose and with particular questions. Since some of these questions are different from ours, the studies should not be expected to provide complete information on the topics we examined. However, each of the five reports does address one or more of our evaluation questions. In addition to reviewing these reports, in order to supplement the information in our primary references, we interviewed experts in the area and reviewed other documents and information that contained analyses of rivers and streams.[4]

The method we used to answer the evaluation questions consisted of three steps. First, we identified and collected information sources relevant to our evaluation questions. Second, we developed a set of general guidelines for evaluating the adequacy of the information. Third, we identified the information that was best for addressing each question, synthesized the appropriate results, and identified remaining information gaps and inadequacies.

1. Identification and collection of information sources. We performed a literature search to identify major studies of water quality, changes in water quality, causes of water pollution, and the effects of the Construction Grants Program. To ensure that we had identified all the relevant information sources, we mailed a questionnaire to 77 persons whom we had identified as expert in water-quality policy, asking them, among other things, to list other studies addressing our evaluation questions. This led to the selection of the five studies and the other information sources cited in chapter 2. None of the 58 respondents identified an additional study with a national focus.

2. Development of guidelines to evaluate information. We reviewed the five reports along a set of general evaluation guidelines for assessing the quality of information. The guidelines directed our consideration of the reports' overall methodological soundness and the extent to which they addressed our evaluation questions, but we did not use the guidelines as hard criteria against which to include or exclude particular pieces of information. In discussing the individual reports and their findings in chapters 3-6, we describe our application of the guidelines, which are listed in table 1.1.

Improvements (Washington, D.C.: 1984); and U.S. Geological Survey, National Water Summary 1983—Hydrologic Events and Issues (Washington, D.C.: 1984).

[4]Our primary and secondary sources are listed in appendix I; a supplementary list of related GAO reports is in appendix II.

Table 1.1: Guidelines for Assessing the Quality of Information

Guideline	Explanation
Stated assumptions	Degree to which a study relied on credible assumptions that were explicitly presented
Type and size of sample	A sample's representativeness of the universe, a function of selection technique
Validity of water-quality measures	Appropriateness of the measures that were used as indicators of water quality
Comparison base	Appropriateness and accuracy of the comparison base against which changes were measured
Methods and conditions of data collection	Appropriateness and quality of data
Appropriateness of analyses	Logic of the analyses relative to the evaluation questions and data; whether the data supported or were limited by the techniques applied to them
Competing alternatives, for studies that attempted to show the factors that affect water quality	Extent to which other possible explanations were given for a study's findings
Disclosure of problems and limitations	The general transparency of the study's methodology
Degree to which the conclusions were supported by the findings	Extent to which the study went beyond the findings in reaching conclusions
Potential reporting bias	Incentive to overstate the results

In this approach, we differ from others who have examined the same information. For instance, the U.S. Council on Environmental Quality (1984) and the Conservation Foundation (1984) apparently accepted at face value the information in our primary sources. We specifically reviewed the methodological soundness of all five reports, in order to determine the evidence that lay behind the information and the findings that were most supportable.

3. Review and synthesis of the information. We analyzed the five studies and weighed the information in them against our evaluation guidelines. We also interviewed persons associated with the preparation of all the national studies as well as officials from every state in EPA's region III and the District of Columbia who had responded to ASIWPCA's questionnaire for its evaluation of its survey of the states' progress and had prepared section 305(b) reports for 1982.[5] (The complete list of the organizations with which we communicated is in appendix III.) We synthesized the general conclusions from the five studies on each of our evaluation questions.

[5]An in-depth review of the section 305(b) reports from all 50 states was beyond our resources. We selected reports from EPA's region III for detailed review because they were relevant to other studies we are conducting.

In the main body of our report (chapters 3-6), we address the four evaluation questions chapter by chapter, using a common format. In each chapter, we

1. present the evaluation question and the methodological basis for answering the question,

2. summarize our critical review of each of the available studies, and

3. synthesize the findings and conclusions that bear on the evaluation question.

A summary of our conclusions and our recommendations are in chapter 7.

Our Information Sources

In the past decade, a great deal of attention has been directed toward the quality of the nation's rivers and streams. However, little factual information has been available, aside from case studies and anecdotes, with which to gauge changes in water quality and the factors that affect it. Some of this information gap was filled by several studies published in 1984 that we elected to examine for this report:

1. National Water Quality Inventory: 1982 Report to Congress, published by EPA, and the section 305(b) reports from states in EPA's region III, which it summarizes;

2. America's Clean Water: The States' Evaluation of Progress 1972-1982, published by the Association of State and Interstate Water Pollution Control Administrators;

3. 1982 National Fisheries Survey, published in three volumes by EPA and the U.S. Fish and Wildlife Service;

4. Before-and-After Case Studies: Comparisons of Water Quality Following Municipal Treatment Plant Improvements, conducted by Hydro-Qual, Inc., researched under contract to EPA;

5. National Water Summary 1983—Hydrologic Events and Issues, published by the U.S. Geological Survey.

In addition, we examined two summary documents that reported information from our primary sources:

6. Environmental Quality 1983, published in 1984 by the U.S. Council on Environmental Quality, and

7. State of the Environment: An Assessment at Mid-Decade, published in 1984 by the Conservation Foundation. (An earlier edition was published in 1982.)

The first five studies formed the main information base of our report. In this chapter, we discuss them in terms of their objectives, sampling strategies, types of data, and methods of analysis. (See table 2.1.)

Table 2.1: Characteristics of the Five Reports We Reviewed

Report	Objective	Sampling strategy	Type of data	Method of analysis
Inventory	Evaluation of the states' progress toward the goals of the Clean Water Act	No uniform strategy; review of reports from 50 states, each with its own strategy	Objective and subjective; all available information, from intensive surveys of water quality as measured by chemical indicators to perceptions of state officials on individual water bodies	Wide assortment of methods, including statistical analyses and summation of quality measures
STEP	Uniform evaluation of national 10-year water-quality trends and factors affecting water quality	The 50 state directors of water quality and additional respondents	Objective and subjective; combined professional judgment and objective data such as that used in Inventory	Summation of responses to data collection instrument
Fisheries survey	Examination of ability of nation's rivers to support fish, 5-year trends, and factors affecting water quality	Stratified random sample of 1,303 U.S. continental river reaches	Perceptions of fisheries biologists, usually for each river reach	Summation of results and extrapolation of sample
Before-and-after case studies	Determination of how treatment-plant upgrades changed water quality	13 treatment plants with consistent conditions and data base adequate for analysis	Chemical measures such as dissolved oxygen; biological measures in 2 cases	Comparison of measures before and after upgrading
Geological survey	Examination of 1974-81 trends in water quality	About 300 monitoring stations around the nation	Chemical measures such as dissolved oxygen	Statistical trend analysis of water- quality monitoring data

The Five Primary Reports

State 305(b) Inventory

Section 305(b) of the Clean Water Act requires the EPA administrator to submit to the Congress biennial reports from each state on the condition of its water quality and the state's progress toward achieving the goals of the act. In February 1984, EPA submitted to the Congress the 1982 reports from the states and accompanied them with EPA's summary, entitled National Water Quality Inventory. Each state's report is required to include

1. an analysis of the extent to which the state's waters provide for healthy fish, shellfish, and wildlife populations and allow recreation;

2. an analysis of the extent to which pollution control actions have contributed to the level of water quality that has been achieved and recommendations for needed additional actions;

3. an estimate of the environmental effect and the economic and social costs and benefits of achieving this level of water quality; and

4. a description of the nature and extent of "nonpoint" sources of pollution (pollution from water runoff from urban areas, construction sites, agriculture, and the like) and recommendations for their control.

We examined in detail the section 305(b) reports from Delaware, Maryland, Pennsylvania, Virginia, West Virginia, and the District of Columbia. Neither the individual reports nor EPA's summary based the reported results on statistical samples. Rather, they typically described individual rivers and water basins or other water bodies. It is not possible to generalize from the results.

The reports of the five states and the District of Columbia presented a mixture of subjective and objective data, with analyses ranging from subjective judgments or perceptions on why or how water quality had changed to mathematical analyses of quantitative chemical measures. For some rivers, the analyses were thorough and based on a wealth of objective data; their judgments about water quality seemed quite reliable. For other rivers, however, the analyses were based on general impressions of state officials on the health of the water, making the judgments about water quality appear much weaker.[1] We realize that state officials possess significant expertise about some of their rivers and agree that such information is valuable for water-quality decisions. However, we believe that the optimal approach is to support subjective estimates by quantitative data and in-depth knowledge of particular rivers and streams.

The EPA 1982 national water quality inventory was intended to be a national summary of the state reports. But the wide variation in the quality of the data in the individual state reports made an effective summary impossible. Reflecting only the data in individual 305(b) reports, the inventory consisted primarily of

1. aggregate statistics, such as "47 states have approved agriculture nonpoint source programs";

2. partially complete statistics, such as "21 of the 35 states providing overall trend information cite continuing improvement in water quality"

[1]We have used the terms "river," "stream," and "water body" interchangeably in this report except where the context requires otherwise.

(leaving it to the reader to assume that 15 states did not report on overall trends); and

3. specific illustrations and anecdotes, such as "Georgia, for example, notes a decrease in water quality in the Satilla and Ochlocknee Rivers below certain cities" and "Michigan reports that toxic substances significantly affect water uses in the Great Lakes."

A major change was made between 1982 and 1984 in the section 305(b) reporting process. Data were solicited on a more uniform set of measures. This made comparability between the states less an issue. Thus, EPA was able to present in its 1984 report a broader summary of quantitative information. For example, it reported that 73 percent of stream miles met "designated uses" in the 40 states that reported information on this question.

The data-collection procedures and reporting format were much the same as those that ASIWPCA used in its questionnaire and report. We received EPA's 1984 section 305(b) report after we completed our evaluation. Because the EPA report was so similar to ASIWPCA's, we have not explicitly discussed EPA's 1984 methodology and findings.

States' Evaluation of Progress

Because the 1982 state 305(b) reports varied in format and contents and tended to be too technical or detailed for easy use by policymakers, EPA, in coordination with state authorities, decided that revised reporting requirements were necessary. Consequently, it awarded a grant of $211,915 to ASIWPCA in 1982 to analyze the nation's water quality and to develop common definitions for water-quality evaluations and a way of streamlining the states' reporting requirements. (ASIWPCA is the national professional organization of the state directors who implement the nation's clean-water program.)

ASIWPCA's effort, which we call "STEP," flowed from three important principles. First, the quality of a body of water is best measured by the extent to which it allows specific "designated uses." Second, much important information on water quality exists in a diverse set of forms that are infrequently used, such as biomonitoring reports and intensive surveys. Third, it is advisable to use uniform sampling designs, measures, and reporting formats when accumulating statewide information. We found these to be important principles, and we discuss them in the following chapters.

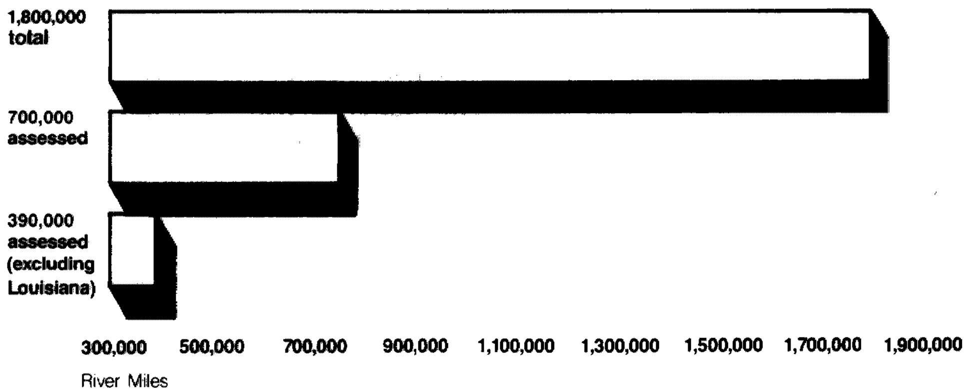
The result of ASIWPCA's work was a study issued in February 1984 entitled America's Clean Water: The States' Evaluation of Progress 1972-1982. It consisted of three documents: a summary report, an appendix of data, and a statistical summary. STEP attempted to provide a brief yet comprehensive report to the public on the progress being made toward cleaner water.

To gather data, ASIWPCA mailed a multipage data-collection instrument to its representatives (usually the heads of state environmental offices) throughout the nation, one questionnaire for each state. The state administrators called upon the professionals and experts in their organizations who had detailed knowledge of water quality to prepare the data for submission. ASIWPCA expected responses to consist of information that was already available.

ASIWPCA and each agency completing the data-collection instrument jointly chose the streams or segments of streams to be examined. ASIWPCA provided a map of major waterways (main-stem rivers) within each state to the ASIWPCA representative for that state. ASIWPCA asked for information on these rivers and others on which the state officials chose to provide information. According to STEP, there are 1.8 million miles of rivers and streams in the United States. The report reflects the states' evaluation of about 700,000 "assessed" stream miles, or 40 percent of this estimate of the national total.[2] These streams are not a statistically representative national sample. (See figure 2.1.)

[2]" 'Assessed' stream miles" is ASIWPCA's term. The definition is unclear and not understood by some states, as they reported in their responses. Rather generally, it appears that miles of water in a state may have been considered "assessed" if the respondent had any information at all about the water, whether quantitative chemical data or simply qualitative estimates about a particular river's condition made by someone felt by the respondent to have had some general knowledge of it. The STEP report combined all "assessed" miles in the 758,000 figure.

Figure 2.1: The Size of the STEP Data Base



Source: Derived from data in ASIWPCA, America's Clean Water: The States' Evaluation of Progress 1972-1982 (Washington, D.C.: 1984), p. 2.

Approximately 298,000 stream miles, about 40 percent of the miles STEP reported, were reported by Louisiana. It seems unlikely that Louisiana contains such a large portion of all the nation's stream miles, although STEP did not deal with this anomaly. In our analyses of the STEP data, we deleted the Louisiana data. This adjustment is not ideal, but we believe it leads to less distortion in the results.

The STEP estimates of water-quality levels were usually presented as summary statistics for each state—for example, the number of miles whose quality improved between 1972 and 1982. Some of the estimates were based on objective chemical, physical, or biological data and others were based on subjective data, such as professional judgments. Some states claimed to have reported primarily quantitative data; others relied extensively on best professional judgment. We were often unable to determine from a report and its supporting documents whether the numbers were based on quantitative or qualitative data. However, we knew from reviewing the ASIWPCA representatives' evaluations of the adequacy of the STEP data-collection instrument that the 1972 data were often based on professional estimates because quantitative data had not been available. Therefore, the validity of the comparison base in STEP is untested.

In the evaluation questionnaire, respondents were asked to identify "components of the report for which little or no data were available and that could therefore be completed only on the basis of professional judgment." Several states said that 1972 water-quality data were unavailable, and a number of the respondents expressed "minimal confidence" in their estimates. The respondent from Montana, while stating that she was "sufficiently confident of the numbers and statements made on the basis of professional judgment," said also that data from 1972 were "suspect." In a conversation we had with the STEP respondents from Maryland, we learned that their data on the efficiency of sewage-treatment plants were "theoretical" or "textbook values."

We found the question of systematic bias in the completion of the questionnaire to be of more interest than random inaccuracies stemming from weaknesses in the data. Bias was addressed by the Montana respondent to the STEP evaluation questionnaire, who remarked in reference to one of the questions that it had been "completed as instructed" but that this section of the questionnaire "significantly underestimates the number of stream miles in Montana not supporting or only partially supporting their designated uses."

These considerations suggest that the STEP report should be used with caution. Later in this report, we offer additional reasons for caution.

National Fisheries Survey

The 1982 National Fisheries Survey, published in June 1984 in three volumes, culminated a 5-year interagency agreement between EPA and the U.S. Fish and Wildlife Service (FWS). The report examined the current ability of the nation's rivers to support fish life and determined how this ability had changed over time. The survey covered all flowing freshwater rivers and streams and their associated impoundments—reservoirs, for example—but specifically excluded wetlands, the Great Lakes, coastal waters, and tidal estuaries.

EPA and FWS considered the survey a unique contribution to knowledge on water quality and its effects on water biology, differing from past approaches because

1. biological conditions rather than the usual physical and chemical measures were reported,

2. the information was provided by fish and wildlife biologists,

3. the study had used a rigorous sampling design upon which national estimates could be based, and

4. the report drew on available information rather than newly collected data.

The survey selected as biological indicators specific fish categories, particularly sport fish and species of special concern such as threatened and endangered species, because

1. they were believed especially sensitive to changes in water quality and quantity and to other factors (the observable responses include changes in migration, population composition, death rates, and reproduction rates);

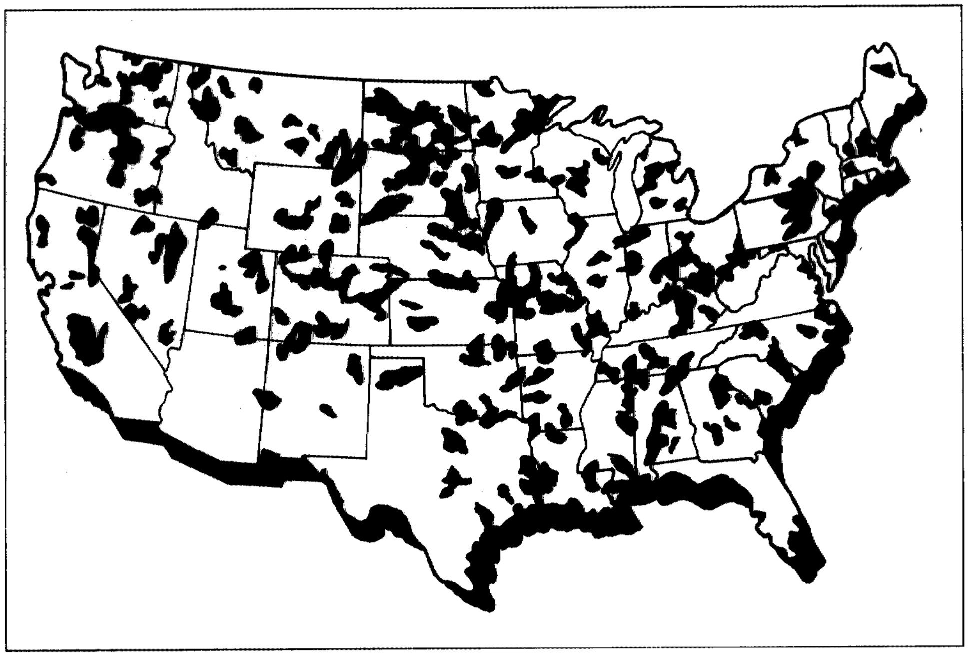
2. fish effectively represent the resident biological population of a waterway, and their presence, abundance, and habitat requirements reflect the physical and chemical conditions of the water; and

3. most state fish and game agencies have some data on sport-fish populations.

A questionnaire mailed to experts, usually fisheries' biologists, on 1,303 river segments across the nation requested information on fish communities, factors that adversely affected fish communities, and the ability of the nation's waters to support fish populations. The returned questionnaires provided data on 1,285 of the river segments, a 98.5-percent response rate. The biologists' estimates about water quality were based on a mixture of objective biological and chemical data and subjective, or perceptual, data. It is impossible to tell when or how the types of data were used.

This survey is the only one we found that was based on a statistically representative national sample of bodies of water, or, in this case, river reaches. The locations of the cataloging units from which sampled reaches were selected are shown in figure 2.2.

Figure 2.2: The Distribution of Cataloging Units in the National Fisheries Survey



Source: EPA and U.S. Fish and Wildlife Service, 1982 National Fisheries Survey (Washington, D.C.: 1984), vol. 1, p. 5.

The national fisheries survey analyzed the data by calculating national totals for the responses to the questions. A distinction was also drawn between perennial and intermittent streams. FWS considered the report's results to be only initial, because the sizable data base could be and was being further analyzed.

Before-and-After Case Studies

In February 1982, EPA issued a work assignment to HydroQual, Inc., to assess the effect of wastewater treatment on water quality. The resulting report, entitled Before-and-After Case Studies: Comparisons of Water Quality Following Municipal Treatment Plant Improvements, was published in May 1984. It was directed at determining the responses of river systems to improvements in municipal wastewater-treatment facilities. The important feature of the study is that stream conditions were measured before and after each improvement (hence the title).

The study stated three basic objectives:

1. determine the extent of the water-quality data base for determining before-and-after improvements and compile the data,

2. compare the before-and-after data in order to determine changes in water quality after treatment improvements, and

3. evaluate the ability of allocation models to predict water quality after improved treatment.

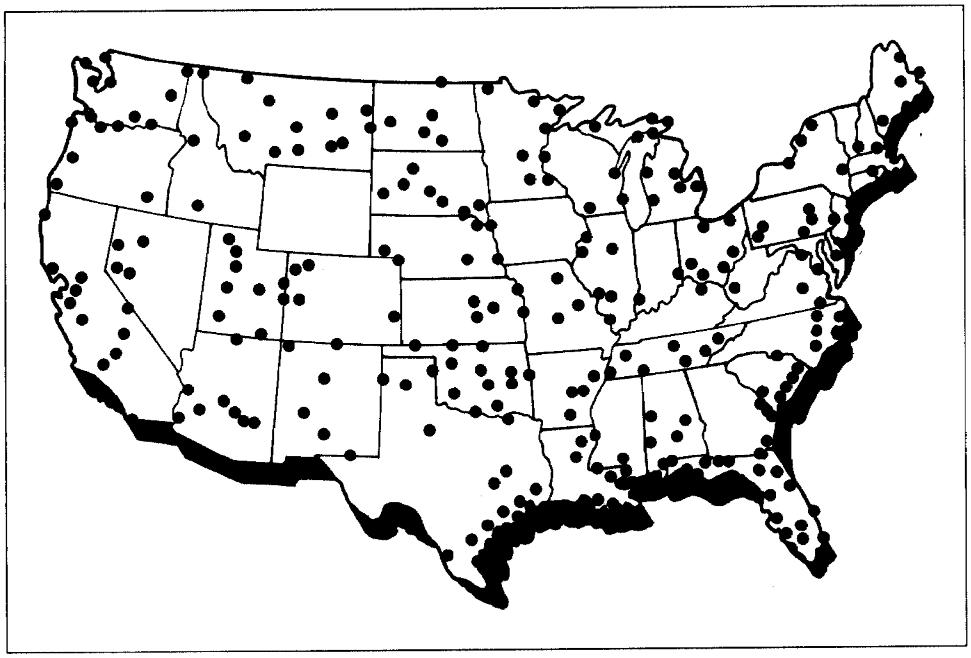
Unlike the national fisheries survey, Before-and-After Case Studies was not designed as a national study. The data base was drawn together after extensive interviews at state and regional levels. The primary criterion for including rivers was the presence of a data set deemed adequate for measuring changes in water quality. Also important were before-and-after measurements conducted at flow, temperature, and nonpoint loadings that were as similar as possible. No single agency had adequate data for the required analyses, so the contractor computed a partial data base for 52 water bodies that had treatment plants that had been constructed with funds from the Construction Grants Program. The data base was considered only partial, since not all but most of the data were available. After applying stringent screening criteria, Hydro-Qual selected 13 water bodies adequate for evaluation.

Data for the case studies were primarily chemical and biological measures. The chemical measures included dissolved oxygen, biochemical oxygen demand (BOD_5), ammonia, and un-ionized ammonia. Biological measures were used where they were available and included changes in in-stream benthic organisms and fish populations. In the analysis, changes were examined in the raw data between two time periods, both in absolute levels and in the extent to which water-quality standards were violated.

U.S. Geological Survey

In 1984, the U.S. Geological Survey published National Water Summary 1983—Hydrologic Events and Issues, summarizing hydrological issues of national concern. It examined trends in water quality between 1974 and 1981 by analyzing data from more than 300 national stream quality accounting network (NASQAN) monitoring stations, which are operated by the Geological Survey and regularly measure a large number of the water-quality characteristics of rivers and streams. (See figure 2.3.)

Figure 2.3: The NASQAN Stations in the Geological Survey Report



Source: U.S. Geological Survey, National Water Summary 1983—Hydrologic Events and Issues (Washington, D.C.: 1984), p. 67.

Although NASQAN stations are located all across the nation, they are not nationally representative. Their siting is not based on a probability sample of stream locations designed to reflect the water quality of U.S. rivers. Rather, NASQAN is a system of monitoring stations, usually located at river or tributary mouths, that has been developed over a decade to account for most of the nation's water draining into the oceans. NASQAN measurements indicate the quantity of the nation's surface water better than they indicate its quality.

Recognizing that the stations do not necessarily provide a representative sample of water quality for the nation's rivers, the Geological Survey does not characterize its findings as a representative sample. Typically, results are reported in terms of the number of stations that show a significant improvement or degradation in the water-quality measure under study.

In brief, water quality at the individual stations is not statistically representative of the river basins in which the stations are located, and, collectively, the river basins are not statistically representative of the nation's waters. However, an accumulation of similar results from a geographically dispersed network as large as this one could provide persuasive evidence of a national trend.

In recent years, the Geological Survey has attempted to identify trends in water-quality parameters during the period of NASQAN's existence. In performing these analyses, it has developed statistical methods to compensate for the characteristics of hydrologic data that commonly present problems. In particular, these methods are used to adjust for the extremely broad range of readings for some parameters, especially bacteriological, and the dependence of many observations on water flow.

Summary Studies

Two recent studies have extracted information from, collectively, four of our five primary reports, in order to address water-quality issues as part of overall environmental matters. One is Environmental Quality 1983, published in 1984 by the Council on Environmental Quality. The other is State of the Environment, published in 1982 and updated in 1984 by the Conservation Foundation.

Environmental Quality 1983

Environmental Quality 1983 is the 14th annual report of the Council on Environmental Quality. Authorized by the National Environmental Policy Act of 1969, the council formulates and recommends national policies to promote the improvement of the environment. Its three members are appointed by the president with the advice of the Senate.

The report covered the full spectrum of environmental issues: air, land, and water. For all three, it assessed the condition of the nation's major environmental resources by

1. examining various trends and their effects related to environmental quality and management,

2. considering the adequacy of available natural resources for fulfilling national economic requirements while respecting the human rights of future generations,

3. reviewing federal and nonfederal environmental programs and activities, and

4. outlining recommendations for future action.

Since we reviewed only the nation's waters, we focused on this topic in the council's report.

The council's report did not result from primary data collection. Rather, Environmental Quality 1983 represents a secondary data analysis. Its judgments were based on reviews of recent federal agency data and reports, including three of the five studies in our analysis: National Water Quality Inventory, 1982 National Fisheries Survey, and National Water Summary 1983.

State of the Environment

The Conservation Foundation, a nonprofit research organization, published a summary of available information on environmental issues in 1984, entitled State of the Environment: An Assessment at Mid-Decade. It considered the full spectrum of air, land, and water issues, but we focused only on water-quality issues.

The report attempted to record progress attributable to policies implemented 5, 7, or 10 years ago, by examining environmental conditions, trends, and long-range issues. Its subject matter cut across the categories traditionally used to describe environmental problems.

Like the report by the Council on Environmental Quality, the Conservation Foundation document was based on and summarized currently available data and reports rather than presenting new data. It included information from four of our primary reports: National Water Quality Inventory, STEP, 1982 National Fisheries Survey, and National Water Summary 1983.

Conclusion

Each study described in this chapter had as at least one of its objectives to measure water quality or water-quality changes over time. The extent to which their methodologies supported this objective and measured factors affecting water quality and the effects of the Construction Grants Program is explored in the following chapters. Whether each study offered information for each of our evaluation questions is summarized in table 2.2.

Table 2.2: Our Determination of Whether Reports Present Useful Information on the Evaluation Questions

	Question			
Report	**1. Present condition**	**2. Change**	**3. Pollution sources**	**4. Effect of Construction Grants Program**
Inventory	Yes	Yes	Yes	Yes
STEP	Yes	Yes	Yes	Yes
Fisheries survey	Yes	Yes	Yes	Yes
Before-and-after case studies	No	No	No	Yes
Geological survey	No	Yes	No	No

Present Water Quality

What is the present condition of the nation's water quality? The assessment is a complex task. Difficulties begin with differing views about the meaning of the term "water quality," extend to a consideration of the different ways of measuring the condition of the water, and are compounded by the many ways in which data can be collected, analyzed, and reported. It is therefore not surprising that in the five primary reports, we found differing opinions about the nation's water.

Methodological Issues

Given the many ways of assessing water quality, we developed systematic procedures for comparing and weighing the evidence from different reports. We set forth the general steps involved in assessment and then determined, for each of our information sources, how the steps were executed. The steps are

1. define water quality,

2. select measurable indicators,

3. collect data,

4. analyze data, and

5. generalize from cases or samples to the nation.

A general discussion of these steps follows.

Step 1: Define Water Quality

The notion of water quality can have a variety of meanings. For some, water quality may pertain to the amount of pollutants humans have discharged into the water. For others, the important consideration may be whether a community can safely and efficiently use the water for such purposes as swimming and fishing. Four broad constructs can be used to characterize a river's water quality.

1. Effluent load is the amount of effluent pollutants discharged into a river from point sources. With this construct, one can consider that a water body free of effluent pollutants has "good" water quality. However, effluent load represents quality only by the inference that effluent will significantly affect a water body. This may be a reasonable inference, but it requires a logic different from that of the three following constructs, which we consider to be more powerful.

2. In-stream water characteristics are the chemical, physical, and biological attributes of a water body. They are determined partly by the effluent load but also by other factors, such as natural pollutants and the amount and temperature of the water.

3. Designated use capability is the degree, largely determined by in-stream water characteristics, to which a river can serve the uses for which it is intended by officials of state or local governments. This construct implies setting a criterion for determining whether the designated use can be achieved, which is expressed by such terms as "fishability," "swimmability," and "drinkability." Determining whether a stream meets a designated use can involve a sophisticated process of measuring the level of several indicators of water quality.

"Designated use" generally means that a water body can potentially serve several functions. From this perspective, quality is best measured by the degree to which it serves these functions. For example, a person fishing for trout will tend to view the quality of a stream by how many fish it carries, while a municipality that takes river water for its public drinking supply will view quality in terms of how difficult it is to make the water fit for drinking.

4. Socioeconomic benefits and the costs associated with them—in terms of fishing for recreation or within an industry, in terms of health, and the like—make up the fourth construct. It is obviously linked to the capability for a designated use.

Step 2: Select Measurable Indicators

This step involves selecting indicators that correspond to different water-quality constructs. A particular indicator may characterize more than one construct, but each construct is measured by its own set of indicators. The four broad groups of indicators we associate with the four water-quality constructs we discussed above are summarized, and their pros and cons are highlighted, in table 3.1.

Table 3.1: Four Constructs Defining Water Quality and Their Indicators

Construct	Illustrative indicators	Strength of indicator	Weakness of indicator
Effluent load: physical, chemical, and biological characteristics of material discharged into water	Biochemical oxygen demand 5, toxins, suspended solids, fecal coliform, % of wastewater-treatment plants in compliance with permit requirements	Objective data often available; good for measuring efficiency of plant operations	Does not consider flow fluctuation
In-stream water characteristics: physical, biological, and chemical	Dissolved oxygen, pH, temperature, nitrogen, phosphorus, benthic organisms	Objective	Hard to isolate effects of program; dissolved oxygen must be measured at a specific point; sensitive to hydrological factors
Designated use: extent to which water can be used for purposes such as fishing, swimming, and drinking	Degree to which chemical standards are satisfied (e.g., swimmable at fecal coliform counts less than 200/100 ml or drinkable at less than 20/100 ml; fishable at dissolved oxygen levels at least 5 mg/l)	Measures stream quality in terms of end purposes	Fishability and swimmability often subjective; standards vary by state
Socioeconomic value: social benefits and costs such as recreational value or profitability of fishing industry	Number of recreation or fishing days	Deals with ultimate purposes; dollars often the common denominator	Often subjective; data often not available

Discharges from point sources generally contain many measurable pollutants, measures of which serve as indicators for effluent load. For example, within the discharges of municipalities or industries, levels of toxic substances such as lead can be measured in milligrams per liter. Similarly, researchers can measure other pollutants such as suspended solids, in milligrams per liter, and fecal coliform bacteria, in a count of the total in a sample. Permits issued through EPA's national pollutant discharge elimination system (NPDES) specify acceptable chemical limits for each point source. The system monitors the number of times effluent levels exceed these limits.

Effluent load is by itself not a good predictor of water quality. The concentration of effluent in a stream is determined by the stream's flow, which may vary over time by large intervals. Moreover, chemical reactions may quickly decompose an effluent's constituents.

If the aim is to define the quality of water by its more general physical, chemical, and biological in-stream properties, the amount of dissolved oxygen can be used as an indicator. Dissolved oxygen is an important indicator because fish need specific amounts of oxygen to survive, and point or nonpoint source pollution often depletes oxygen in a river segment. Other common indicators of general in-stream water characteristics include water temperature, pH, levels of nitrates and nitrites, and indexes of biological diversity.

A chemical reference point indicator attempts to determine end use by comparing chemical indicators to set reference points or standards. For example, water is considered treatable for drinking if the level of fecal coliform bacteria in the water is no greater than 2,000 per 100 milliliters. Chemical reference points are usually established by the states and approved by EPA. Traditionally, the states have assessed their water quality by measuring the frequency with which the chemical constituents of water violate established standards.

Analyzing and measuring the value of the goods and services "produced" by a river is another way of defining water quality. Indicators of this include the number of fish caught for sport or commerce and recreational time enjoyed by swimmers, boaters, and hikers. The sum of these gives some idea of the water quality.

It should be noted that ordinarily no single indicator of water quality is sufficient to represent the corresponding construct. For example, dissolved oxygen, although a good indicator, is not adequate to describe the quality of river water. Multiple indicators are preferred whenever it is possible to use them.

Step 3: Collect Data

There are two major concerns in data collection: how to acquire information and how to sample for the information that is needed. Each concern may seriously affect the kinds of conclusions that are possible.

1. Acquisition of data. Researchers on water quality acquire information from direct, objective measurements of the indicators in question or from authorities possessing subjective knowledge about water quality. An example of the first is in National Water Summary 1983, in which the Geological Survey researchers used chemical measurements from NASQAN stations, and an example of the second is in the 1982 National Fisheries Survey, in which EPA and FWS researchers used perceptions of fishability reported by biologists knowledgeable about specific river segments. The quality of information must be attended to with either procedure, but there is usually greater uncertainty about subjective knowledge.

2. Sampling. This is typically a concern in studying water quality because there are more than 1 million miles of rivers in the United States, and it is ordinarily not possible to acquire information about so many river miles. Therefore, some form of sampling is necessary. If conclusions are to be drawn about the nation's water as a whole, the sample of river segments for which we have information must in some sense represent all the river segments. Drawing samples may also involve time considerations, because water quality varies over time. It tends, for example, to be lower during periods of low flow.

Different studies take different approaches to sampling. STEP acquired information about the designated use of a sample of rivers in each state. Each state respondent was sent a map of the state on which the rivers that ASIWPCA considered important were highlighted and was asked to determine the designated use of these rivers as well as others that the respondent considered important. For the 1982 National Fisheries Survey, in contrast, information was acquired about a statistically representative sample of river segments.

Step 4: Analyze Data

Data analysis procedures can vary widely. In the simplest case, in which information is acquired from authorities, little more than a tabulation of responses is required. A further task might be to adjust the results for missing data. The STEP report exemplifies this kind of data analysis. More complex studies may require extensive statistical or mathematical analysis. The Geological Survey study, for example, required much analysis to remove unwanted fluctuations from the raw data.

Step 5: Generalize

Data analysis can produce information about a sample of river segments, but whether the findings can be extended to the nation's rivers as a whole depends on the degree to which the sample "represents" all the nation's river segments. Determining this requires judgment, although statistical arguments often play an important role as well. This step of generalizing from individual cases to the nation may not be reported or possible in all studies.

Knowledge Review

In this section, we report our assessment of the information provided by each of our five primary studies. We synthesize the pertinent information from them in the last section of the chapter. These studies employed a wide variety of methodological approaches. The key features of each study, summarized in terms of our assessment process, are outlined in table 3.2.

Table 3.2: Methodological Features of the Five Reports

Report	Definition of water quality	Indicator	Data collection	Analysis	Generalization
Inventory	Various (effluent load, in-stream characteristics, designated use)	Various (standards violations, fish kills)	Various (monitoring stations, intensive surveys, perceptions)	Raw data, stream-by-stream description, summary tables	No national summary; reports generalize to the state level
STEP	Capability for designated use	Various (state officials' perceptions of chemical and biological measures)	Instruments designated by state water-quality officials (who often relied on data similar to Inventory data)	Summation of responses	Yes
Fisheries survey	Capability for designated use, fishability	Biologists' estimates of presence of fish	Sample survey; questionnaires to experts	Summary tables and graphs	Yes
Before-and-after case studies	In-stream characteristics	Dissolved oxygen, dissolved oxygen deficit, ammonia, biological measures	Intensive surveys, computerized data base	Stream modeling and statistical techniques	No
Geological survey	In-stream characteristics	Chemical measures	Chemical data from monitoring stations	Statistical analysis with flow adjustment	No

Inventory

The reports submitted by the states to EPA under section 305(b) of the Clean Water Act presented substantial information on individual rivers. This information was sometimes based on perceptions or best professional judgments by state officials, but more often it was based on detailed chemical and biological analyses. For example, the Washington, D.C., Department of Environmental Services monitors the 11 miles of the Potomac River within its jurisdiction by periodic readings at 10 monitoring stations located along this length of the river and at 7 cross-river transects (that is, by taking a series of water-quality samples at two to four points across the width of the river). The department also conducts intensive studies of particular problems as needed. This is undoubtedly one of the most thorough and complete of the river analyses.

For some other rivers in other areas, water quality is also analyzed in detail. In still others, however, assessments of water quality are based solely on the physical observations or subjective perceptions of state officials. Some rivers are not analyzed at all. Since the rivers that are analyzed are not selected in a way that allows generalizations and are not analyzed consistently, we believe that summary descriptions of the overall water quality in the states we reviewed should not be made.

EPA's summary of the state reports, National Water Quality Inventory,, attempted to characterize water quality by reporting what 17 states estimated as the proportion of their waters that met a "fishable/swimmable" standard; other states did not provide this information. EPA pointed out that, for a variety of reasons including "varying methods of assessing goal attainment and because the number of stream miles assessed is only a small fraction of the nation's total miles of waterways," it could draw "no quantitative national conclusions" from the several assessments. There is a wide state-to-state variation in the percentage of streams meeting reported water-quality goals, from the 48 percent that Massachusetts reported to the 90 percent or more that 9 other states reported. The results for all 17 states that responded to the EPA question appear in table 3.3.

Table 3.3: The Percentage of Rivers Meeting Swimmable and Fishable Goals in 17 States in 1982

State	Basis for estimate[a]	Met goals
California[b]	27 major rivers	85%
Connecticut	963	70
Georgia	20,000	95
Kansas	62 stream segments	[c]
Maine	8,600	90
Maryland	2,684	90
Massachusetts	1,611	48
New Hampshire	14,500	96.5
New Mexico	3,500	90
Ohio	3,758	81
Pennsylvania	12,962	79
Rhode Island	329	66
South Carolina	88 segments	90
Texas	16,115	97
Vermont	1,126	84
Virginia[b]	27,240	95
Washington	170 segments	60[d]

[a]Assessed river miles, unless indicated otherwise.

[b]1980 estimates.

[c]97 fishable and 90 swimmable.

[d]Includes 39 upstream segments for which definitive information was not available but that were believed to have met goals.

Source: EPA, National Water Quality Inventory: 1982 Report to Congress (Washington, D.C.: 1984), p. 9.

Our major concern with the section 305(b) process in 1982 is the lack of uniformity in the way the state assessments were conducted and reported, making it impossible to draw supportable national conclusions from the reports for our evaluation question on the nation's water quality. EPA similarly pointed out that it is very difficult to summarize these documents, because they contain a wide variety of types of information and reporting formats and lack quantitative data.[1]

Our conclusion is that the state 305(b) reports summarized in EPA's National Water Quality Inventory provided sound evidence of levels of water quality for individual rivers but no statewide or national conclusions can be drawn from the data because of differing methods of data collection and analysis among the states.

STEP

The water-quality construct used in STEP was the extent to which water bodies met their designated uses—fully supporting, partially supporting, or not supporting the designated uses. ASIWPCA derived these criteria after reviewing state standards for designated uses. The assessment criteria the state officials used as indicators for making this determination (adapted from the STEP questionnaire instructions) appear in table 3.4.[2]

[1]Lack of uniformity was a motive for conducting STEP. The states appeared to accept its uniform format, some of which was used for the 1984 305(b) reports. For example, the guidelines for the 1984 reports borrowed extensively from STEP.

[2]Excluding Hawaii, Louisiana, and Nebraska.

Table 3.4: State Criteria for Evaluating the Support of a Designated Use

Support	Chemical information	Biological information	Direct observation and professional judgment
Supports	Standard exceeded in 0-10% of analyses, mean measured value less than standard, pollution not severe	Data show full support of designated aquatic life in all respects	Direct observation shows support; professional judgment shows no reason for the use not to be supported
Partly supports	Standard exceeded in 11-25% of analyses, mean measured value less than standard (or standard exceeded in 0-10% of analyses, mean measured value exceeds standard), minor pollution	Data uncertain as to full support of balanced aquatic life (some species not able to propagate in a stream with a put-and-take fishery)	Direct observation shows the use; professional judgment suggests it is not supported at maximum (e.g., citizens' complaints on record, fishing declining)
Does not support	Standard exceeded in more than 25% of analyses, mean measured value less than standard (or standard exceeded in more than 11% of analyses, mean measured value exceeds standard), pollution severe	Data show no support of designated aquatic life (it is imbalanced or severely stressed; few or no expected species in the water body)	Direct observation shows overt signs of obvious use impairment (e.g., severe or frequent fish kills) or no evidence of the use; professional judgment suggests the use cannot be supported because of known or suspected factors
Unknown	No representative data available	Limited or no data available	Limited or no direct observation

Source: ASIWPCA, America's Clean Water: The States' Evaluation of Progress 1972-1982 (Washington, D.C.: 1984).

STEP as a whole is part of the general movement in water-quality assessment away from predominantly chemical data and toward sophisticated screening and evaluation techniques and the use of a wider variety of indicators such as best professional judgment. Such indicators tend to be partially or entirely subjective and are not easily compared. Yet a number of the persons we spoke to believed that these indicators are useful and should be used more in water-quality assessment. The state authorities were encouraged to use their professional judgment when objective data were lacking. We are claiming not that this is necessarily bad but that if best professional judgment is to be relied upon, the extent to which a judgment reflects reality should be ascertained. This was not discussed in the STEP report.

The STEP results can be summarized as follows:

1. Forty-seven states assessed, of the total 1.5 million river miles STEP reported, about 26 percent of their river miles for the extent to which they supported designated uses.

2. Approximately 81 percent of the miles assessed were judged to fully support their designated uses, roughly 12 percent met their designated uses, at least partially, and about 6 percent failed to meet designated uses.

3. Few disparities in water quality were reported in different areas of the country. The high percentage of rivers failing to meet designated uses in region X was reportedly a result of "pollution arising from unforeseen or unpredictable natural resource development" in Alaska. (See table 3.5 and figure 3.1.)

Table 3.5: State Water Quality in 1982

State by EPA region		Total river miles	Number of river miles by degree of support of designated use: Total assessed	Full support	Partial support	No support
I	Connecticut	8,400	839	538	230	71
	Maine	31,806	2,011	1,275	727	9
	Massachusetts	10,704	1,611	780	673	158
	New Hampshire	14,544	14,544	14,037	264	243
	Rhode Island	724	724	667	22	35
	Vermont	4,863	4,863	4,698	121	44
	Total	**71,041**	**24,592**	**21,995**	**2,037**	**560**
II	New Jersey	6,448	1,100	365	640	95
	New York	70,000	3,400	2,176	379	845
	Total	**76,448**	**4,500**	**2,541**	**1,019**	**940**
III	Delaware	464	419	237	71	111
	District of Columbia	40	35	7	18	10
	Maryland	9,300	7,440	6,838	343	259
	Pennsylvania	12,962	12,962	10,219	468	2,275
	Virginia	27,240	4,500	1,383	1,146	1,971
	West Virginia	22,819	5,262	3,116	1,843	303
	Total	**72,825**	**30,618**	**21,800**	**3,889**	**4,929**
IV	Alabama	40,600	12,101	11,372	206	523
	Florida	12,659	11,585	5,865	4,075	1,645
	Georgia	20,000	17,000	16,147	383	470
	Kentucky	40,000	3,338	500	2,838	0
	Mississippi	10,274	10,274	9,260	1,014	0
	North Carolina	39,150	39,150	32,083	5,669	1,398
	South Carolina	9,679	2,765	1,417	646	702
	Tennessee	19,236	4,065	2,945	945	175
	Total	**191,598**	**100,278**	**79,589**	**15,776**	**4,913**
V	Illinois	13,200	7,270	2,792	4,231	247
	Indiana	90,000	45,000	44,000	750	250
	Michigan	46,350	811	348	213	250
	Minnesota	91,871	2,708	1,776	760	172
	Ohio	43,917	6,387	2,687	3,700	0
	Wisconsin	28,500	18,500	18,015	375	110
	Total	**313,838**	**80,676**	**69,618**	**10,029**	**1,029**

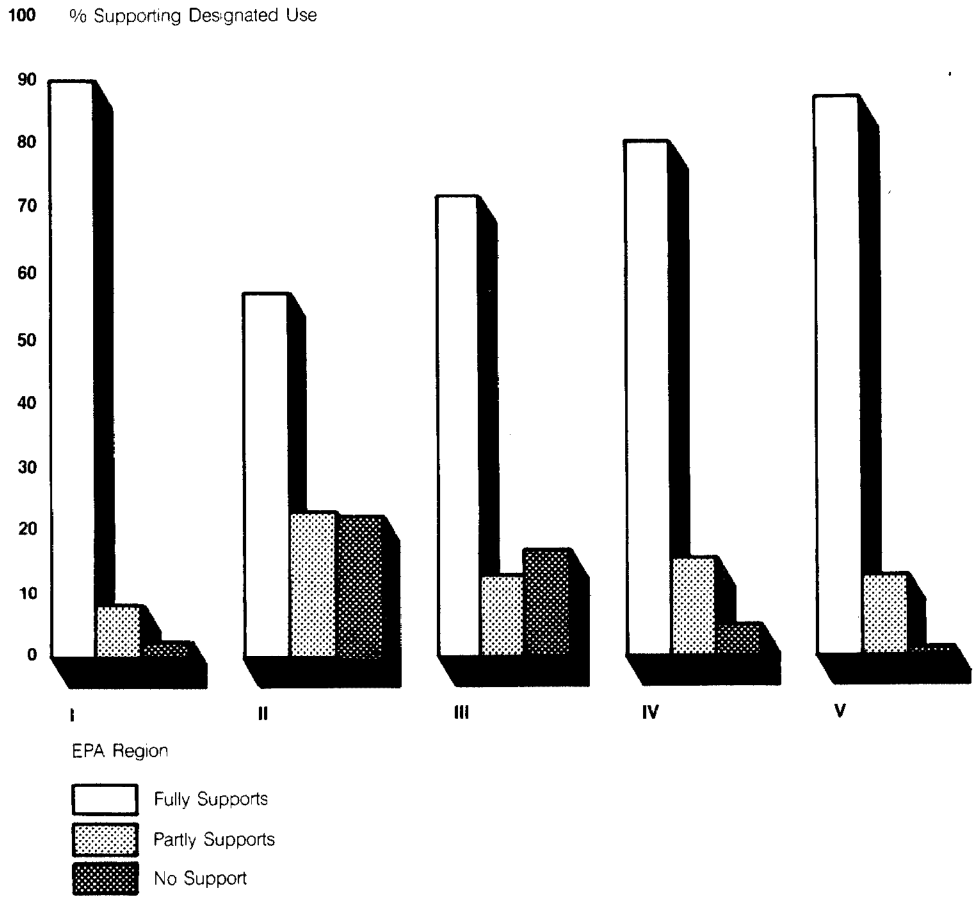
State by EPA region		Total river miles	Number of river miles by degree of support of designated use: Total assessed	Full support	Partial support	No support
VI	Arkansas	10,000	6,000	3,000	1,300	1,700
	Louisiana[a]					
	New Mexico	3,500	3,500	3,450	50	0
	Oklahoma	23,000	11,985	9,919	1,036	1,030
	Texas	80,000	14,003	9,679	1,902	2,422
	Total	**116,500**	**35,488**	**26,048**	**4,288**	**5,152**
VII	Iowa	17,464	943	794	144	5
	Kansas	20,570	3,404	1,838	617	949
	Missouri	18,448	18,448	18,055	51	342
	Nebraska[b]					
	Total	**56,482**	**22,795**	**20,687**	**812**	**1,296**
VIII	Colorado	14,100	10,000	9,394	171	435
	Montana	19,168	17,251	17,099	152	0
	North Dakota	5,109	5,109	4,518	591	0
	South Dakota	9,937	3,987	2,500	1,087	400
	Utah	6,855	3,531	949	2,501	81
	Wyoming	19,655	19,655	19,065	550	40
	Total	**74,824**	**59,533**	**53,525**	**5,052**	**956**
IX	Arizona	6,287	497	317	40	140
	California	37,000	9,184	8,733	285	166
	Hawaii	Unknown	39	0	0	39
	Nevada	1,122	1,325	807	458	60
	Total	**44,409**	**11,045**	**9,857**	**783**	**405**
X	Alaska	365,000	3,279	8	21	3,250
	Idaho	15,720	7,070	3,975	2,268	827
	Oregon	90,000	4,479	3,309	897	273
	Washington	40,492	5,952	4,913	874	165
	Total	**511,212**	**20,780**	**12,205**	**4,060**	**4,515**
National total		**1,529,177**	**390,305**	**317,865**	**47,745**	**24,695**
% of total			100%	81%	12%	6%

[a]Deleted for reasons explained in text.

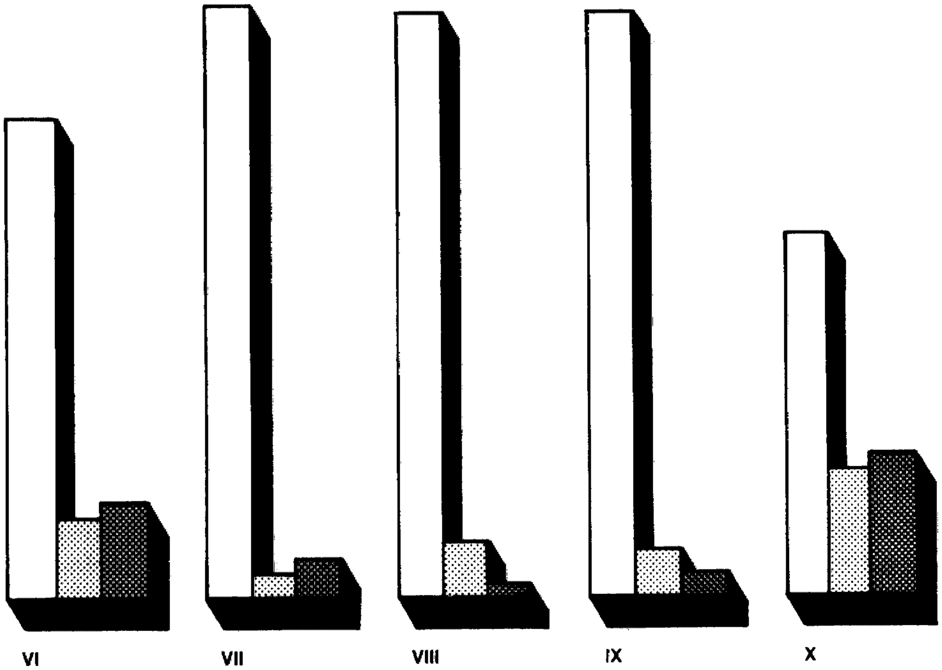
[b]Not available.

Source: ASIWPCA, America's Clean Water: The States' Evaluation of Progress 1972-1982 (Washington, D.C.: 1984).

Figure 3.1: The Extent to Which Water Quality Met Designated Uses in EPA's Regions I-X in 1982



Source: ASIWPCA, America's Clean Water: The States' Evaluation of Progress 1972–1982 (Washington, D.C.: 1984).



Although STEP offered some valuable information, it contains a number of unsupported statements, such as that 58 percent of the nation's stream miles are "generally free from known water quality pollution problems." This was inferred from the finding that the states had assessed only 42 percent of the stream miles in their states. The implicit assumption in STEP was that all rivers that had water-quality problems were assessed, but the assumption was neither tested nor proven, and it is likely to be indicative more of limited monitoring activities than of anything else. However, the wording makes it appear to readers that 58 percent of the nation's river miles were clean.

Our conclusion is that STEP's report that 81 percent of the river miles assessed fully supported designated uses depended on inferences from the data that were collected (conveyed in its title, America's Clean Water) but that the extent to which subjective judgment was used is uncertain: since only 26 percent of all rivers were assessed, we could make only limited use of the STEP results to determine national water quality.

Fisheries Survey

Like STEP, the 1982 National Fisheries Survey attempted to supplement long-term monitoring data on chemical parameters with characterizations of water quality based on perceptions of biological conditions within rivers. This approach had two advantages: (1) it addressed the degree to which a declared goal of the Clean Water Act had been achieved, in terms of providing water quality sufficient for the protection and propagation of fish, and (2) it conformed with scientific opinion that biological indicators are sensitive to environmental change.

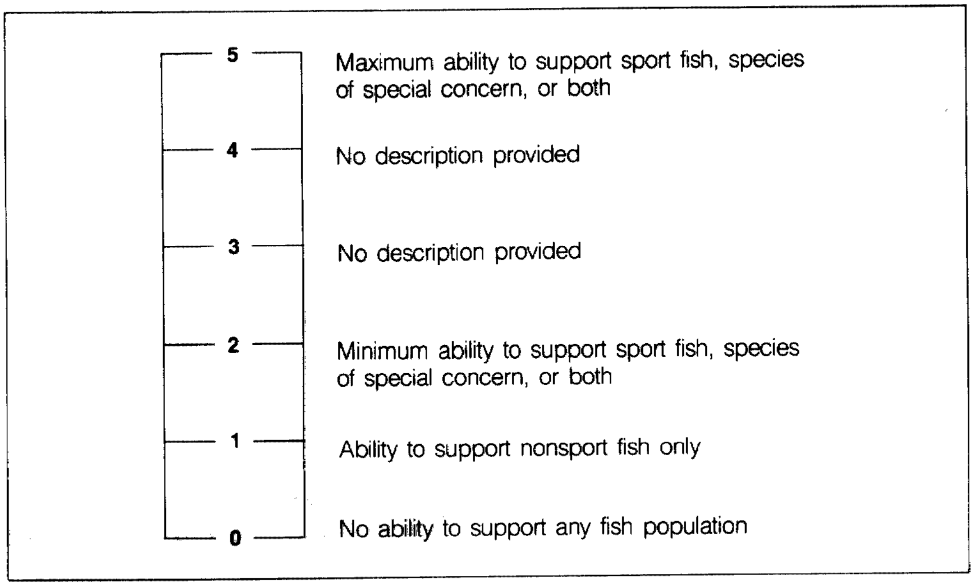
Our main problem with the results of this survey was that they were based to an unknown degree upon the perceptions of fisheries biologists. How well their perceptions of fishability were correlated with actual levels of fish life is uncertain. Although the respondents to the questionnaire were the persons who were the most knowledgeable about individual river reaches, we have no evidence that shows how well their perceptions of fish life matched actual levels.

In one respect, the survey seems an ideal assessment of national water quality. It ensured the ability to generalize to the nation by using a random sample of river reaches throughout the country. In order to strengthen representativeness, the researchers divided the universe into 14 strata. Moreover, they sought uniformity in the data by using one questionnaire for all respondents.

We were somewhat concerned that the rating scale might have placed undue importance on the establishment of sport fisheries for all sampled reaches. There may be around the nation reaches to which sport fish are naturally unsuited—that is, in which their absence is not the result of human activities.

In the survey, respondents were asked to rate the condition of a sampled reach on a 6-point scale from 0 ("The reach has no ability to support any fish population") to 5 ("The reach exhibits a maximum ability to support a community of sport fish, species of special concern, or both"). The scale is shown in figure 3.2.

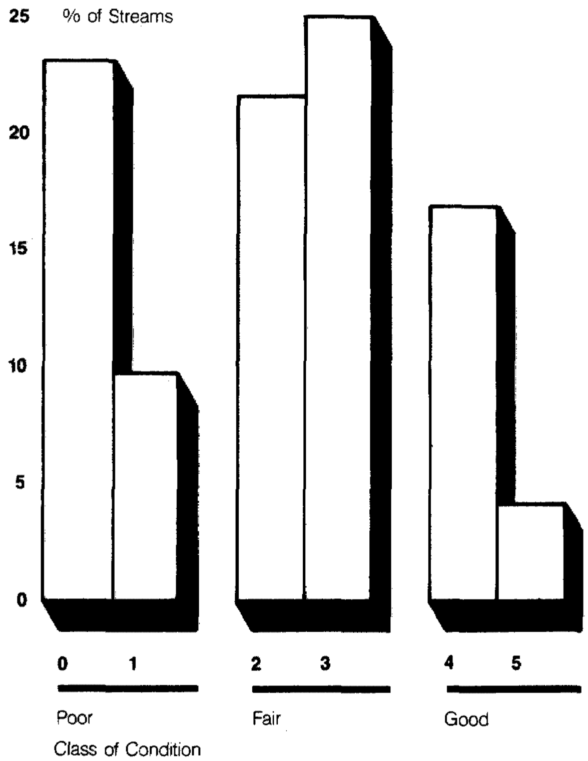
Figure 3.2: A Survey Scale for Determining a River's Support of Fish Life



Source: EPA and U.S. Fish and Wildlife Service, 1982 National Fisheries Survey (Washington, D.C.: 1984), vol. 1, p. 63.

Although only approximately 4 percent of the streams that were surveyed were given the highest rating (category 5), more than 67 percent of the surveyed river reaches were said to have had at least "a minimum ability to support a community of sport fish, species of special concern, or both," as indicated by their ranking in categories 2-5, showing fair to good water quality. Many of the remaining reaches failed to support fish life because they were intermittent streams, which periodically go dry. The results of the survey appear in figure 3.3.

Figure 3.3: Biologists' Perceptions of the Ability of a Nationally Representative Sample of Rivers to Support Fish



Source: EPA and U.S. Fish and Wildlife Service, 1982 National Fisheries Survey (Washington, D.C.: 1984), vol. 1, p. 46.

Our conclusion is that the 1982 National Fisheries Survey may provide a gross measure of the nation's water quality in terms of the support of fish life but that the results relied on subjective judgments and must be used with caution.

Before-and-After Case Studies

Insofar as it examined only 13 nonrandomly selected cases, Before-and-After Case Studies provided no information on our evaluation question about national water quality.

Geological Survey

The work of the Geological Survey used monitoring-station data for analyses of changes but did not attempt to make a statement from these data on the overall condition of the nation's water quality.

Summary Studies

Basing their judgments on the conclusions in some of the reports that we reviewed, both the Council on Environmental Quality and the Conservation Foundation argued that the water quality of the nation's rivers was good. Phrasing this in terms of fish habitability, the council remarked that "The nation's waters . . . to a large extent, are able to support viable fish populations" (U.S. Council, 1984, p. 89). The Conservation Foundation pointed to STEP's conclusion that "the large majority of the U.S. surface waters satisfy their designated uses" and the 1982 National Fisheries Survey's finding that "73 percent of the U.S. inland waters are clean enough to support sport fish" (Conservation, 1984, pp. 106 and 107).

Synthesis

The only reports that offered much information on the nation's water quality, STEP and the 1982 National Fisheries Survey, presented conclusions that were roughly consistent. STEP concluded that 4 of every 5 stream miles nationwide fully satisfied water-quality standards. The 1982 National Fisheries Survey concluded that sport fish, generally thought to be intolerant of poor water quality, inhabited 73 percent of the nation's waters.

Our analysis of the available evidence leads to the conclusion that information is insufficient for making strong statements about the nation's water quality. Our evaluation of the results of the five reports is summarized in table 3.6.

Table 3.6: Our Evaluation of Five Reports on the Question of Present Water Quality

Report	Results	Our evaluation
Inventory	No national conclusions; most waters reported on were said to have met water-quality goals	Data limited on some waters and quality often questionable; not possible to combine data to derive a national estimate
STEP	81% of assessed miles fully supported designated use; only 26% of miles assessed	% probably somewhat overstated; no national sample
Fisheries survey	77% of streams had at least minimum ability to support fish; sport fish found in 73% of the nation's waters	Rough approximation of water quality as measured by fishability
Before-and-after case studies	Not addressed	None
Geological survey	Not addressed	None

Of the 390,000 stream miles assessed by STEP's respondents in 1982, 81 percent were judged to fully support their designated uses. Only about 6 percent failed to at least partially support their designated uses. We question the use of subjective judgments (subjectivity in the assessment measures and statements without demonstrated support), believing that these may have affected the report's accuracy. For STEP results to be more useful, more should have been done to validate the data.

After examining the written record and interviewing officials involved in planning, as well as other state officials, we believe that STEP may have overestimated 1982 water quality to some degree. Rather than examining a random sample of rivers or river reaches, the STEP researchers used whatever information the states provided. For instance, the concept of "designated use" appears to make sense intuitively, but an EPA official told us that many states, when determining whether or not their rivers met a "designated use," substituted "secondary contact recreation." That is, they substituted fishing, wading, and boating for the stricter and almost universal "fishable/swimmable" standard. This would produce an overestimate of the condition of the nation's water quality.

Officials of Maryland also informed us that if they did not possess information to the contrary, they assumed that a river met its designated use. They told us that some streams in rural areas were rarely if ever visited by members of the state agency for water pollution control. Since they had no reason to believe otherwise, they assumed that these waters met the standards.

However, ASIWPCA contended in its comments to a draft of this report that its sample "represents the vast majority of rivers with current and historic water pollution problems" (see appendix VI). If this contention is correct, all else being equal, the aggregate figures in the STEP report could underestimate present water quality, although ASIWPCA did not provide documentation of this. At best, the STEP data, if taken at face value, provide an indication of how state water-quality officials said they viewed the quality of their state's waters.

Thus, we cannot accept as accurate STEP's conclusions in the area of this evaluation question. For reasons of inadequate sampling design and the subjectivity inherent in the measurement instrument, the STEP report did not, in our judgment, fulfill its intended goal, which was to assess the quality of the nation's surface water.

The other report that provided information on this evaluation question, the 1982 National Fisheries Survey, was designed with a national perspective in mind. Although we have some reservations of a technical nature about its survey question on water quality, we believe that the survey responses presented in the report are probably fairly accurate and unbiased. One of our concerns has to do with the wording of answer choices. The response scale that was used was somewhat vague, and two response categories were left unspecified. (We see no reason why instituting a sport fishery should be the goal at all the nation's rivers and streams, for example.) However, the attempt of EPA and FWS to locate the person most familiar with each river reach and to direct the questions to that official lends some credibility to the responses.

Because the fisheries survey was composed of a stratified sample of river reaches throughout the nation, it is possible to generalize from the results of the sample to the nation as a whole. But the survey addressed only fishing, not swimming and drinking, for which the standards are different on some measures. At the national level, water must support all three activities.

Despite the methodological difficulties with the five studies when they are viewed individually, together they lend some support to the conclusion that some of the nation's waters are of fairly good quality while others remain polluted. Three studies addressed this evaluation question. In all three, qualitative judgments that were not tested for reliability were widespread. Two of these three studies lacked nationally representative samples. Therefore, the numerical measures intended to quantify the nation's water quality were highly uncertain, and it is difficult to generalize beyond the cases they studied. We believe that additional studies are needed if the weaknesses of the earlier attempts to measure and report on water quality at the national level are to be surmounted.

Water-Quality Change

In this chapter, we address our second evaluation question, on how the nation's water quality has changed in the recent past, by presenting (1) a discussion of the methodological issues relevant to measuring change, (2) the major findings of the five primary reports as the findings pertain to change in water quality, and (3) our evaluation and synthesis of the pertinent information.

Methodological Issues

The logic underlying this evaluation question differs from that of the question in chapter 3 only in that it considers more than one point-in-time measurement and an analysis of change in the time intervals. Sampling and measurement issues are still prominent, as is the problem of ensuring the quality of baseline data.

Problems that did not appear in chapter 3 include the appropriate length of time intervals for assessing change in water quality. This is a function of several factors, especially the ability of evaluation methods to detect small changes in water quality. A study that bases its information on a single before-and-after comparison may not detect small yet significant changes. It may also mistake a cyclical trend (a periodic or recurring change in water quality) or a unique change (one occurring solely because of aspects peculiar to either of two data points) for a structural one (an actual long-term change in water quality).

Some statistical techniques used to detect small changes in water quality require a large number of data points. If changes are measured by a change over time in the value of an in-stream water-quality variable, and the variable is measured monthly or in some other recurring period, the interval has to be long enough to provide the number of data points that will allow an assessment. One real virtue of information from monitoring networks is that it can provide a series of data on which to base meaningful assessments. The level of detail available from in-depth periodic surveys may be lost, however.

Another important issue is the timing of the data collection. For example, the hydrological and environmental context affecting water quality in the 1980's may be very different from that of the 1970's. The level or type of industrial production may differ significantly during different time periods, potentially influencing the amount of industrial pollutants discharged into the nation's waters. This is an important evaluative issue for our study, since the reports we considered measured water-quality changes during different periods of time. Another critical consideration is the extent to which each of the five reports employed a consistent methodology across time periods.

Knowledge Review

In this section, we review evidence about changes in the nation's water quality in the recent past. The samples, indicators, and time periods of the five primary reports are summarized in table 4.1.

Table 4.1: Design Components in the Five Reports

Report	Sample	Indicator	Period
Inventory	Various	Chemical, biological, expert judgment	1981–82[a]
STEP	351,235 river miles	Chemical, biological, anecdotal	1972–82
Fisheries survey	1,285 river reaches	Perception of suitability for fish	1977–82
Before-and-after case studies	13 water bodies	Dissolved oxygen, biochemical oxygen demand, ammonia, biological	Various
Geological survey	313 monitoring stations	22 chemical measures	1974–81

[a]Some variability among the states.

Inventory

The states used several different approaches to measuring water quality change in their section 305(b) reports. EPA's national summary of the reports in National Water Quality Inventory simply totaled the number of states reporting improvement, degradation, and no change. Except for a few examples, the report did not reference the time periods for which these judgments were made. Individual states derived their conclusions from either subjective judgments of experts or statistical analyses for a variety of chemical measures.

The report pointed out that 21 state reports cited a general trend of improvement in water quality between 1980 and 1982 but that 14 reported no change. The remaining states failed to address this issue. The inventory did not, however, define the conditions that would have to be satisfied for a finding of a "general" statewide trend.

Further, the overall implication that water quality improved in most states is at variance with the generally accepted view that a 2-year interval is too short for significant change. Officials from 4 of the states that we visited (Maryland, Pennsylvania, Virginia, and West Virginia) pointed out that they saw little value in issuing 305(b) reports every 2 years, because change in water quality cannot be discerned in so short a period, unless it is caused by some sudden catastrophic event such as a chemical leak. Some states may have derived their trends from data over a period longer than 2 years, but they gave no indication of this in their reports. EPA's 1984 and 1986 guidance explicitly requested trend information only once every 6 years.

The National Water Quality Inventory also said that 29 states reported a decline in "localized areas," although no state reported a general trend of declining water quality. The reliability of the process for judging the presence of either statewide or localized trends was not discussed.

The types of indicators the states used to estimate trends in water quality varied greatly within the 305(b) reports and from one to another. Some analyses were based on subjective estimates, others on quantitative chemical measures. Three of the states we reviewed used a simple rating scale to summarize water quality in each of their hydrological regions. For each of about 9 or 10 measures, watersheds were rated by hydrologists or other officials knowledgeable about their conditions as having improved, diminished, or not significantly changed in quality. Virginia, for example, summarized water quality this way for 48 watersheds. It reported that dissolved oxygen levels showed an improvement in 4 watersheds, while 37 evidenced no significant trend. There were no data on the remaining 7.

West Virginia attempted to calculate statistical changes in chemical measures of water quality. West Virginia's time-series analyses failed to indicate significant change over the 2 years covered by its most recent 305(b) report.

Our conclusion is that the estimate in the National Water Quality Inventory of a general trend in water quality was based on state-by-state data that made generalization unwarranted. The individual state reports that we reviewed presented many examples of water bodies whose water quality improved or was degraded. However, since they were not discussed in the context of all water bodies in a state, no overall statements about them can be made.

STEP

For an indicator of change in water quality, the STEP report used estimates made by ASIWPCA representatives of the number of stream miles improved, maintained, or degraded in water quality with respect to designated uses between 1972 and 1982. These estimates were based on chemical and biological indicators and the subjective perceptions of the respondents.

The conclusion that ASIWPCA drew from these data was clearly stated in the first two sentences of the body of the report: "The news is good. The water is cleaner" (ASIWPCA, 1984, p. 2). ASIWPCA representatives reported 351,000 river miles for which trend information was available.[1] This was 23 percent of all river miles reported. Of these miles, 296,000 (or 84 percent) maintained the same quality in 1982 that they exhibited in 1972, 45,000 miles (or 13 percent) improved in water quality, and 10,000 (or 3 percent) had worse water quality in 1982 than in 1972. These results are shown by EPA region in table 4.2 and figure 4.1.

[1]For reasons explained in chapter 2, we excluded Louisiana's data from our national estimates.

Table 4.2: State Change in Water Quality in 1972-82

State by EPA region		Total river miles	Total miles: Assessed	Maintained	Improved	Degraded
I	Connecticut	8,400	839	367	447	25
	Maine	31,806	2,018	844	1,168	6
	Massachusetts	10,704	1,611	1,046	565	0
	New Hampshire	14,544	1,322	754	544	24
	Rhode Island	724	724	660	64	0
	Vermont	4,863	4,863	4,692	165	6
	Total	**71,041**	**11,377**	**8,363**	**2,953**	**61**
	% of total		100%	73.51%	25.96%	0.54%
II	New Jersey	6,448	1,150	450	550	150
	New York	70,000	3,400	2,692	708	0
	Total	**76,448**	**4,550**	**3,142**	**1,258**	**150**
	% of total		100%	69.05%	27.65%	3.30%
III	Delaware	464	236	140	63	33
	District of Columbia	40	21	6	15	0
	Maryland	9,300	7,440	7,038	210	192
	Pennsylvania	12,962	12,962	12,716	246	0
	Virginia	27,240	0	[a]	0	0
	West Virginia	22,819	5,262	3,420	1,810	32
	Total	**72,825**	**25,921**	**23,320**	**2,344**	**257**
	% of total		100%	89.97%	9.04%	0.99%
IV	Alabama	40,600	12,101	10,641	1,249	211
	Florida	12,659	10,511	7,089	2,647	775
	Georgia	20,000	17,000	16,576	424	0
	Kentucky	40,000	6,687	5,674	697	316
	Mississippi	10,274	10,274	9,874	400	0
	North Carolina	39,150	39,150	28,265	10,885	0
	South Carolina	9,679	1,685	607	775	303
	Tennessee	19,236	6,381	4,980	1,294	107
	Total	**191,598**	**103,789**	**83,706**	**18,371**	**1,712**
	% of total		100%	80.65%	17.70%	1.65%
V	Illinois	13,200	7,270	4,706	2,544	20
	Indiana	90,000	45,000	44,189	811	0
	Michigan	46,350	669	215	244	210
	Minnesota	91,871	2,708	2,240	468	0
	Ohio	43,917	5,700	5,000	600	100
	Wisconsin	28,500	18,500	18,165	335	0
	Total	**313,838**	**79,847**	**74,515**	**5,002**	**330**
	% of total		100%	93.32%	6.26%	0.41%

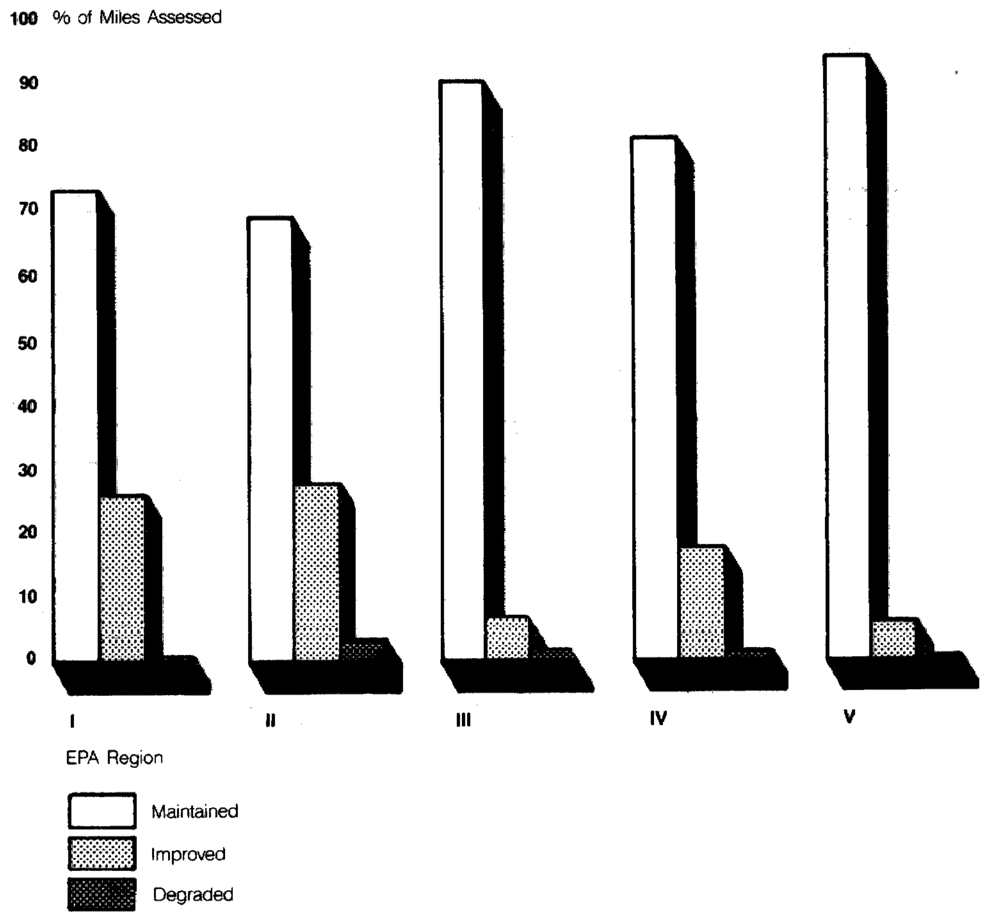
State by EPA region		Total river miles	Total miles: Assessed	Maintained	Improved	Degraded
VI	Arkansas	10,000	6,000	5,400	100	500
	Louisiana[b]					
	New Mexico	3,500	3,500	3,500	0	0
	Oklahoma	23,000	11,986	11,163	823	0
	Texas	80,000	12,525	2,692	7,445	2,388
	Total	**116,500**	**34,011**	**22,755**	**8,368**	**2,888**
	% of total		100%	66.90%	24.60%	8.49%
VII	Iowa	17,464	602	250	282	70
	Kansas	20,570	1,158	616	231	311
	Missouri	18,448	18,440	18,039	386	15
	Nebraska[a]					
	Total	**56,482**	**20,200**	**18,905**	**899**	**396**
	% of total		100%	93.59%	4.45%	1.96%
VIII	Colorado	14,100	10,110	9,421	540	149
	Montana	19,168	3,663	3,249	374	40
	North Dakota	5,109	5,109	3,398	1,711	0
	South Dakota	9,937	3,987	3,685	302	0
	Utah	6,855	4,222	2,383	1,430	409
	Wyoming	19,655	19,270	19,065	205	0
	Total	**74,824**	**46,361**	**41,201**	**4,562**	**598**
	% of total		100%	88.87%	9.84%	1.29%
IX	Arizona	6,287	357	315	42	0
	California	37,000	9,184	8,501	683	0
	Hawaii	Unknown	39	0	0	39
	Nevada	1,122	1,325	1,325	0	0
	Total	**44,409**	**10,905**	**10,141**	**725**	**39**
	% of total		100%	92.99%	6.65%	0.36%
X	Alaska	365,000	3,462	0	8	3,454
	Idaho	15,720	765	428	88	249
	Oregon	90,000	4,117	3,221	831	65
	Washington	40,492	5,930	5,930	0	0
	Total	**511,212**	**14,274**	**9,579**	**927**	**3,768**
	% of total		100%	67.11%	6.49%	26.40%
	National total	**1,529,177**	**351,235**	**295,627**	**45,409**	**10,199**
	% of total		100%	84%	13%	3%

[a]Not available.

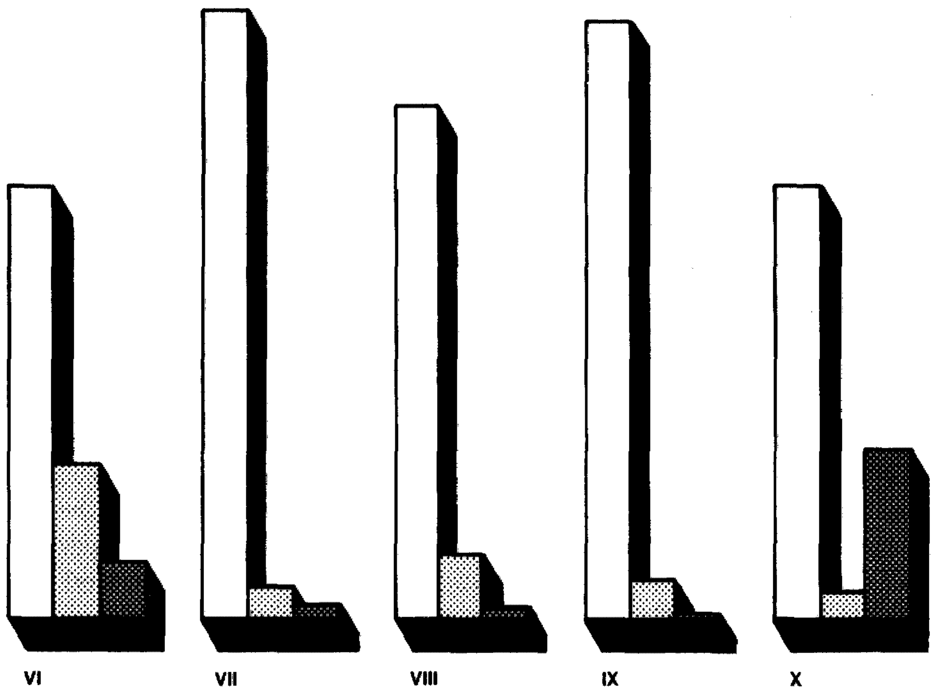
[b]Deleted for reasons explained in text.

Source: ASIWPCA, America's Clean Water: The States' Evaluation of Progress 1972-1982 (Washington, D.C.: 1984).

Figure 4.1: Water-Quality Change in EPA's Regions I-X in 1972-82



Source: ASIWPCA, America's Clean Water: The States' Evaluation of Progress 1972-1982 (Washington, D.C.: 1984).



ASIWPCA did not demonstrate that the 23-percent figure constituted miles in the nation that were representative of the total universe of rivers and streams. It gave no indication that the rivers that were assessed within a state were randomly distributed with respect to water-pollution abatement activities.

The data presented in the STEP report and the conclusions drawn from them have some shortcomings. Trend assessments were limited in several instances by data problems. Even though ASIWPCA encouraged the states to supplement their monitoring results with professional judgments and direct observation, records were limited or unavailable (especially for 1972 data). In these instances, the 1972 estimates became simply "best guesses." Thirty-seven state and other water-quality agencies completed forms evaluating the STEP study, and 25 of them mentioned problems in making assessments because of the lack of 1972 data, often their greatest difficulty. Several of these respondents reported that they were only minimally confident of the statements and numbers that could thus be reported.

Although STEP was an attempt at uniform reporting by all states, the states varied considerably in their assessment techniques. The balance between physical, chemical, and biological indicators and best professional judgment varied significantly. Some states also had problems categorizing their data to conform to STEP's measures, such as identifying whether waters met different designated uses or whether they supported designated uses fully, partially, or not at all.

We believe that a report that 13 percent of the nation's stream miles exhibited improvement is not adequate to support the broad statement, "The water is cleaner." This belief rests on two arguments. First, the statement glosses over the rest of the evidence: the remaining 87 percent of the nation's stream miles did not improve (84 percent maintained their quality and 3 percent were degraded) over the 10-year period. According to the data collected for STEP, the water is generally not cleaner, although segments of certain of the nation's rivers no doubt are cleaner.

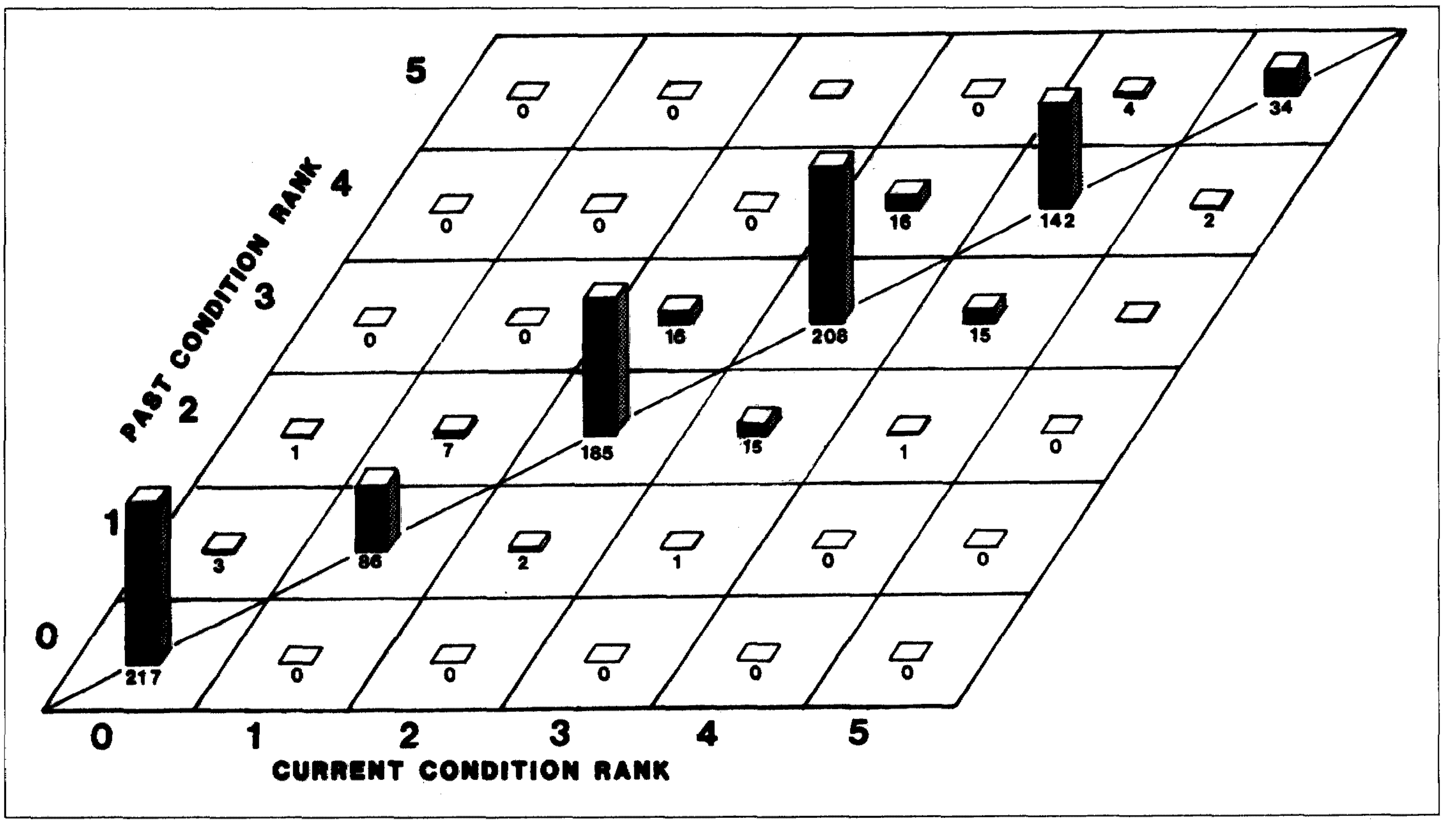
Second, we are concerned that the nonrandom sample ASIWPCA employed seriously weakened the strength of the conclusion that the nation's waters are cleaner. The importance of taking a random sample rests on the need to ensure that the sample adequately reflects the population it is meant to represent. There is the danger that the STEP "judgment sample" is not representative of the nation's rivers and streams.

Our conclusion is that the STEP statement, "The news is good. The water is cleaner," is unwarranted because of the report's unspecified reliance on subjective estimates, baseline data that were often poor in quality, and a nonrandom sample.

Fisheries Survey

The 1982 National Fisheries Survey dealt with change in water quality by asking fish biologists to rate the water quality of a random sample of river reaches for 1977 and again for 1982 (the 6-point response scale in figure 3.2 was used). The survey concluded that "The ability of the nation's waters to support sport fish has not changed appreciably during the last 5 years" (EPA and U.S. Fish and Wildlife Service, 1984b, vol. 1, p. vii). Overall, 91 percent of the streams did not change in the respondents' perceptions of their ability to support sport-fish life, while 4 percent improved and 5 percent declined. The results for total stream miles are shown in figure 4.2.

Figure 4.2: The Comparative Ability of the Nation's River Reaches to Support Sport Fish in 1977 and 1982[a]



[a]All numbers are thousands of stream miles.

Source: Adapted from EPA and U.S. Fish and Wildlife Service, 1982 National Fisheries Survey (Washington, D.C.: 1984), vol. 1, p. 48.

Reading along the diagonal of the figure gives the number of stream miles, in thousands, that remained the same over the 5-year period. For example, 217,000 miles were rated in category 0 (no ability to support fish) in both 1977 and 1982. All the boxes of the matrix to the right of the diagonal show thousands of stream miles that improved—moving, for example, from category 1 (supporting only nonsport fish) up to category 2 (a minimum ability to support sport fish). The boxes to the left of the diagonal show thousands of miles whose water quality fell.

Our main concern about the survey is that the respondents were asked to compare a reach's present condition with its condition 5 years earlier. The fallibility of memory adds an element of unreliability to the estimates. Determining the extent to which these perceptions reflected actual conditions would considerably strengthen the estimates. We found no evidence that this was done.

Our conclusion is that there is some credibility to the 1982 National Fisheries Survey report that there was almost no change, at least for the fishability construct, in the ability of the nation's rivers to support fish life between 1977 and 1982, because of the strength of the sample and the effort to find respondents familiar with the river reaches. But this finding must be tempered somewhat because the accuracy of the experts' recollections of baseline conditions was not validated.

Before-and-After Case Studies

In Before-and-After Case Studies, EPA made no judgments on water-quality change at the national level. It did, however, provide detailed information on changes for 13 water bodies where sewage-treatment plants had been built or upgraded.

The results of each case study were based on two data points, but the time span between them differed considerably from case to case. At one extreme, the Blackstone River case study compared data from one date in 1977 to data from one date in 1978—a 1-year difference. At the other extreme, the Clinton River case study compared data from one date in 1958 to data from one date in 1976—18 years apart.

This study's principal indicators of water-quality trends were changes in dissolved oxygen, biochemical oxygen demand, and ammonia and in biological measures. In summary, water quality was said to have improved for 12 of the 13 water bodies, as measured by average dissolved oxygen, from one period or data point to another, later period or data point; what this means is unclear, since tests of statistical significance were not reported. Maximum biochemical oxygen demand decreased by 15 milligrams per liter or more in five cases, and ammonia concentrations decreased in every case—in several instances by significant percentages. Changes in biological conditions, measured by changes in in-stream benthic organisms, were estimable for only two cases, because there were problems with the availability of data. In these cases, the results were mixed: one showed some improvement, the other no noticeable change. (See table 4.3.)

Table 4.3: Summary of the Before-and-After Case Study Findings on Three Water-Quality Indicators

				Average dissolved oxygen		Maximum biochemical oxygen demand		Maximum ammonia	
Treatment plant	**Before**	**Upgrade**	**After**	**Before**	**After[a]**	**Before**	**After[a]**	**Before**	**After[a]**
Fitchburg East, Mass.	1973	1975	1977	5.1	5.5 +	65.0	45.0 −	4.0	2.4 −
Woonsocket, R.I.	1977	late 1977	1978	5.9	8.7 +	7.0	5.0 −	0.48	0.28 −
Albany Area, N.Y.	1964	mid-1970s	1977	3.9	7.0 +	9.0	4.0 −	2.3	0.25 −
Laurel Parkway, Md.	1968	1974	1978	5.5	7.9 +	18.0	<1.0 −	2.2	0.1 −
Blue Plains, Md.	1977	[b]	1981	4.3	7.6 +	7.6	5.6 −	1.8	0.5 −
Dupont, Va.	1974	[b]	1976	6.4	8.7 +	[c]	[c]	1.4	0.45 −
Hurricane, W. Va.	1972	late 1970s	1981	5.6	6.3 +	5.6	5.1 −	5.4	1.3 −
Pontiac, Auburn, Mich.	1958	mid-1970s	1976	3.8	7.1 +	32.0	3.2 −	[c]	[c]
Lima, Ohio	1974-75	[b]	1977	5.4	7.5 +	10.5	21.0 +	38.0	17.0 −
Augusta, Wis.	1978	1980	1981	7.5	8.2 +	5.6	6.8 +	0.9	0.15 −
Tomah, Wis.	1978	1979	1981	4.7	4.3 −	21.0	6.1 −	6.9	0.28 −
Odo J. Reidel, Tex.	1974-75	[b]	1980	1.4	1.6 +[d]	[c]	[c]	11.4	5.0 −
Springfield S.W., Mo.	1968	1977	1979	6.4	8.2 +	26.0	5.0 −	22.2	<1.0 −

[a]Plus (+) and minus (−) signs indicate the direction of change.

[b]Not reported.

[c]Not computed.

[d]Minimum dissolved oxygen reading substituted for average.

Source: HydroQual, Inc., Before-and-After Case Studies: Comparisons of Water Quality Following Municipal Treatment Plant Improvements (Washington, D.C.: U.S. Environmental Protection Agency, 1984).

Two brief cautions are in order. First, data comparisons were made for two separate points in time; they were not trend analyses. Given the extreme variability that can occur in river conditions from day to day or hour to hour, comparing only two points in time without correcting for this variability can lead to faulty conclusions. The analysts of Before-and-After Case Studies decided not to make this correction, which they might have done through modeling. However, they did cast out cases that revealed glaring differences in background conditions from one data point to the other. Second, the interval between the two time points was relatively short in some cases. In five cases, it was 3 years or less, decreasing the confidence that can be placed in a report of long-term effects.

Our conclusion is that the Before-and-After Case Studies documentation of changes in water quality for several cases is useful as a supplement to other studies, but the report was not intended, nor can it be used, for generalizations to the nation as a whole.

Geological Survey

The U.S. Geological Survey analyzed data collected from its NASQAN monitoring network from 1974 through 1981. In part of the study, the researchers used a statistical technique to judge whether a significant change in water quality occurred in this period of time. They found that for most of the common water-quality constituents that had been sampled, the number of stations where degradation was statistically significant was greater than the number where improvement was significant but that by far the greatest number of stations exhibited no statistically significant change. (See table 4.4.)

Table 4.4: Changes in 22 Indicators of Water Quality in 1974-81

Indicator	Total no. of stations[a]	Stations: With increase No.	%	With decrease No.	%	With no change No.	%
Ten widely used							
Nitrate-nitrite as N	304	76	25.0	25	8.2	203	66.8
Ammonia	282	31	11.0	30	10.6	221	78.4
Organic carbon	279	36	12.9	13	4.7	230	82.4
Phosphorus	301	39	13.0	30	10.0	232	77.0
Dissolved solids	302	68	22.5	51	16.9	183	60.6
Suspended sediment	289	44	15.2	41	14.2	204	70.6
Conductivity	305	69	22.6	43	14.1	193	63.3
Fecal coliform	269	19	7.1	34	12.6	216	80.3
Fecal streptococci	270	2	0.7	78	28.9	190	70.4
Dissolved oxygen	276	31	11.2	17	6.2	228	82.6
Total		**415**		**362**		**2,100**	
Average			14.4		12.6		73.0
Additional							
Temperature	303	39	12.9	46	15.2	218	71.9
pH	304	74	24.5	56	18.4	174	57.2
Alkalinity	304	18	5.9	79	26.0	207	68.1
Sulfate	304	82	27.0	40	13.2	182	59.9
Calcium	304	23	7.6	83	27.3	198	65.1
Magnesium	304	50	16.4	46	15.1	208	68.4
Sodium	304	103	33.9	28	9.2	173	56.9
Potassium	304	69	22.7	42	13.8	193	63.5
Chloride	304	104	34.2	36	11.8	164	53.9
Silica	302	48	15.9	41	13.6	213	70.5
Turbidity	259	42	16.2	18	6.9	199	76.8
Phytoplankton	300	22	7.3	44	14.7	234	78.0
Total		**674**		**559**		**2,363**	
Average			18.7		15.5		65.7

[a]Totals differ because not all chemical parameters are always measured at all monitoring stations.

Source: U.S. Geological Survey, National Water Summary 1983—Hydrologic Events and Issues (Washington, D.C.: 1984), p. 46.

For example, phosphorus levels increased significantly at 13.0 percent of the stations and decreased at 10.0 percent while failing to change significantly at 77.0 percent. Similar results were found for other important constituents, including ammonia, dissolved solids, and suspended sediment. However, many more stations (28.9 percent) declined in fecal streptococci than increased (0.7 percent).

The Geological Survey measured water-quality changes in 10 of the most widely used indicators: nitrate-nitrite, ammonia, organic carbon, phosphorus, dissolved solids, suspended sediment, conductivity, fecal coliform, fecal streptococci, and dissolved oxygen. An increase in the concentration of any of these indicators except dissolved oxygen signifies degraded water quality and a decrease signifies improved water quality. The reverse holds for dissolved oxygen: an increase signifies improvement and a decrease signifies degradation. The finding was as follows. In 401 instances (13.9 percent), water quality was degraded (in table 4.4, this is seen as 415 minus 31 plus 17); in 376 instances (13.3 percent), water quality improved (362 minus 17 plus 31); and, in 2,100 instances (73 percent), there was no change.

Although a later Geological Survey report, National Water Summary 1984, was published after we completed our work, we reviewed it for information that would further our evaluation. The later report presented findings from a review of data on the concentration of 22 pesticides at approximately 150 monitoring stations around the country from 1975 to 1980. The review showed a decreasing trend in the number of stations detecting the presence of 11 organochlorine pesticides (including aldrin, dieldrin, DDT, chlordane, and heptachlor) during this period of time. This finding could have been expected because the imposition of controls on the use of these pesticides increased during the period.

Our conclusion is that, given a variety of physical and chemical indicators, there appears to have been no major change in water quality between 1974 and 1981 at Geological Survey monitoring stations, but while the stations provided data on many geographical areas, they did not provide information on a random sample of the nation's rivers.

Summary Studies

The U.S. Council on Environmental Quality and the Conservation Foundation examined the question of change in water quality by reviewing some of the same studies we used. The council concluded that the quality of the nation's waters was generally improving, and the Conservation Foundation pointed out that the studies painted a picture of only modest improvement.

Synthesis

Some water bodies exhibited either improved or degraded water quality from the recent past to the present, but we concluded that there is little evidence of significant change at the national level. In combining information from the reports, we depended heavily on the judgments we made about their methodological strengths and weaknesses. Since these were quite different from report to report, their ability to answer our evaluation question, "How has the nation's water quality changed?" must be given different weights. A synopsis of each report's stated conclusions and our evaluation of their validity appears in table 4.5.

Table 4.5: Our Evaluation of Five Reports on the Question of Change in Water Quality

Report	Conclusion	Our evaluation
Inventory	National trend toward improvement; most state waters show no change	Emphasis on extremes of improvement and degradation; may not accurately portray overall conditions
STEP	News is good; the water is cleaner	Possible bias; overstatement; weakness in sample design does not support
Fisheries survey	Most rivers show no major change in ability to support fish	Fairly good basis for this conclusion
Before-and-after case studies	Improvement from wastewater-treatment in 12 cases	Case selection limits generalization
Geological survey	Most monitoring stations show no change on most indicators	Not a national sample; many instances of predominantly no change on physical and chemical indicators

The results from Before-and-After Case Studies cannot be given much weight on this evaluation question, because the study examined only 13 water bodies and their selection was purposely not random. To some extent, the selection of cases biased the study toward a finding of improved water quality. The cases were specifically selected along stretches of rivers where an intervention—an improvement in sewage treatment—had been made in order to raise the water quality. As might have been expected, therefore, some level of improvement was reported, at least for dissolved oxygen, at most of the sites.

Many of the results from the state 305(b) reports and the national summary EPA derived from them must be viewed with caution. To the extent that EPA's results were based on the comparison of conditions within a 2-year reporting interval, changes in water quality could not be expected, since it is generally agreed that 2 years is too short a period in which to detect long-term, structural changes. Also, since the data measures, data collection, and data analysis, as well as reporting methods, varied significantly between the states, deriving true national estimates from the section 305(b) reports is difficult, if not impossible.

This leaves three studies that, in our opinion, did provide a basis for determining changes in water quality. All three, examined for their raw data instead of their conclusions, supported the finding that there was no significant change in most of the nation's waters in the last 5 to 10 years.

Our overall assessment of STEP's conclusions with respect to our evaluation question is that STEP provided some insight into nationwide changes in water quality. We could place more reliance on the STEP data were it not for the weakness of the 1972 baseline data. Several respondents to the STEP questionnaire reported that they believed the 1972 data to be the weakest area of their data collection, and some reported only minimal confidence in their 1972 estimates.

There are a number of reasons for this. Data-collection protocols could have changed between 1972 and 1982. The Illinois respondent pointed out that when data from 1972 were available, they were "not always compatible with current station locations or reporting format and content." Another problem was that, in some instances, great reliance was placed on expert judgment. Given the total absence of quantitative data from 1972, Vermont relied completely on "best professional judgment" to assess the water quality of its 4,863 stream miles. However, the reliability of the subjective estimates was not tested.

We are reluctant to place much confidence in the accuracy of memory over a 10-year period for as complicated an endeavor as water-quality assessment. We believe that the ability to draw definitive conclusions from the STEP data on this evaluation question is somewhat limited.

The results from EPA's 1982 National Fisheries Survey of a random sample of river reaches showed essentially no change in fishability. The survey reported that 91 percent of the nation's river miles did not change in their ability to support fish populations from 1977 to 1982.

The survey relied heavily on subjective estimation to determine the presence and abundance of fish species. Estimates for 60 percent of the reaches in the sample were not based on actual measurement. For 33 percent of the river reaches, the biologists reported perceptions of conditions of other rivers in the general locale rather than the river reach in question. For the remaining 27 percent of the reaches, neither objective nor subjective data were available. Respondents to the survey were generally fish biologists and other experts who were the most knowledgeable on particular river reaches. But however expert a respondent may be, reliance on perception alone means an unquantifiable element of error in the results. Nonetheless, we do not believe that bias among the responses was consistent enough to shift the 91-percent figure significantly in either direction.

The Geological Survey data portrayed a pattern of predominantly no change for every chemical parameter the study analyzed. No parameter had more stations showing change than not (whether improvement or degradation). Of 10 widely used indicators, only 1 showed significant improvement in more than one fifth of the stations. Although water quality may not in fact have improved during the period surveyed, to have at least held the line on water pollution was an important accomplishment.

There had been a consistent and long-term degradation in the quality of many rivers before the 1970's. The waste materials of the growing population and economy of the 1970's and 1980's would lead one to expect further degradation of water quality, in the absence of mitigating factors. For example, STEP pointed out a 12-percent increase in the amount of oxygen-demanding pollutants entering the nation's sewage-treatment plants between 1972 and 1982. This line of reasoning is closely tied to the effluent-load construct we discussed in chapter 3 and appears reasonable. From a logical and statistical point of view, reversing or halting a declining trend should be considered something of an improvement.

From the studies we examined, we conclude that water quality probably improved in particular streams but, in general, the nation's water quality did not significantly change. But it must be stressed that a finding of no appreciable change does not mean that efforts to improve water quality have had no effect. It could be that abatement efforts are just roughly keeping pace with new sources of pollution. Our conclusion that there was little significant change in water quality is not by itself a conclusion about the effectiveness of water-pollution control efforts.

From this perspective, it is important to examine (as we do in chapters 5 and 6) the factors that may affect water quality and the effect the Construction Grants Program has had on the quality of streams where wastewater-treatment plants are located.

Sources of Pollution

The effect people have on the nation's water quality is widespread and in places seems severely negative. On the most fundamental level, all pollution sources degrade water quality by adding substances—that is, pollutants—to the water. Sources of water pollution are often dichotomized into point and nonpoint sources, as we explain below. In this chapter, we draw from our five primary reports information concerning pollution sources and their relative effects on water quality.

Point-source pollution, which is discharged through a pipe or other discrete source, is often reported as either a municipal or an industrial discharge. Most wastewater from human sewage is discharged into wastewater-treatment plants, which in turn discharge an effluent into rivers and streams. The effluent is treated in order to remove wastes but still contains some pollutants. Thus, treatment plants are often referred to as pollution sources.

But because treatment plants localize or act as a screening conduit for municipal wastes that would still be released, they should not be viewed in the same way as other pollution sources. While it might be suggested that pollution should be reduced by removing other kinds of point sources, such as industrial discharges, it would be unreasonable to suggest that removing a wastewater-treatment plant would reduce pollution and improve water quality. This is partly because wastewater-treatment plants are usually built or have been modified to reduce municipal pollution.

Industries create wastes that are often discharged into rivers through pipes leaving an industrial plant. This is point-source pollution: the pipes disgorge pollutant-laden effluent at one or more points along a river. EPA attempts to control the negative effects of industrial discharges by setting effluent standards, requiring all dischargers to report on the characteristics of their effluents, and imposing penalties for violations of the effluent standards.

Nonpoint-source pollution is diffused pollution that arises from such sources as agricultural runoff, runoff from natural woodlands, and acid mine-drainage. Because the pollution is diffused, its levels are difficult to quantify and its specific sources are hard to identify. Nonpoint-source pollution is also difficult to control. For example, acid mine-drainage may be the most widespread water-quality problem that Pennsylvania faces. The drainage is difficult to detect because it may originate in many different coal mines and at many points within each mine. Most wastewater-treatment plants do little to alleviate this problem.

In a public policy context, two factors are important: the effect of each pollution group, point and nonpoint, and the existence of or potential for developing a corrective mechanism. The studies included in our information synthesis dealt mostly with wastewater-treatment plants as the major corrective mechanism (and this is the area on which we focused most of our attention).

Methodological Issues

Determining the cause of a known pollution problem is often straightforward. For example, a highly localized depletion of dissolved oxygen may easily be traced to the nutrient-rich effluent from a poorly functioning sewage-treatment plant upstream. In some cases, it can be more difficult. For example, there may be several industrial dischargers and wastewater-treatment plants along a river that borders an agricultural area. Determining precisely the relative contribution, if any, of each of these pollution sources may not be straightforward at all. To account for a change in water quality, one must find that three conditions have been satisfied:

1. Association: A change in one factor (the elimination of a source of pollutant, for example) is associated with a change in another (for example, an improvement in water quality); in other words, they are correlated.

2. Temporal order: Cause preceded effect; that is, a change in the presumed cause (the construction of a wastewater-treatment plant, for example) occurred prior to the presumed effect (water-quality improvement).

3. Alternative causes: All alternative causal explanations but one have been accounted for and ruled out.

The first two conditions are relatively easy to satisfy, but the third is often difficult. Sometimes expert judgment can be used to establish causation with reasonable confidence, but water-pollution problems are often so complex that only systematic evaluations involving complex measurements and analyses can sort out the probable causes.

Meeting the causal conditions and thus establishing a cause-and-effect relationship requires an adequate study design, supporting data, and careful analyses. We found widespread use of expert judgment rather than systematic evaluations among the states whose records we reviewed. This may be because state authorities lack the time and funding needed for more rigorous determinations. Given the more than 1 million miles of rivers and streams in the nation, developing more powerful estimates on a large scale could be very complex and expensive.

Knowledge Review

What pollution sources can be said to have degraded the nation's water quality? As with our first two evaluation questions, the five reports we reviewed took various approaches to identifying the sources of pollution. The sources they discussed and how they determined the relative contribution of the sources are listed in table 5.1.

Table 5.1: Five Reports' Examination of Pollution Sources and Their Determination of How the Sources Degraded Water Quality

Report	Pollution	Determination of relative contributions
Inventory	Municipal, industrial, nonpoint	Expert judgment and systematic evaluation
STEP	Municipal, industrial, nonpoint, other	Judgment of state officials; summation of responses
Fisheries survey	Municipal, industrial, nonpoint, other	Judgment of biologists; summation of responses
Before-and-after case studies	Municipal	Systematic evaluation; comparison of data on chemical and biological measures at 2 points in time; sources other than wastewater-treatment plants assumed to have had no effect
Geological survey	Not considered	No findings

Inventory

The state 305(b) reports addressed the causal explanation for pollution in a variety of ways. However, the design of the 305(b) reporting system did not allow defensible national estimates of the causes of poor water quality, even had causality been established for individual river reaches.

Nevertheless, in its national summary of the 305(b) reports, EPA attempted to address causality in a number of ways. Of 20 states indicating reasons why they did not achieve water-quality goals, 18 indicated nonpoint sources and 13 indicated point-source pollution as the major problem. Seven specifically cited municipal sources, and 6 cited industrial sources. EPA's summary interpreted these reports by stating that a variety of point and nonpoint sources negatively affected water quality. (See table 5.2.)

Table 5.2: Point and Nonpoint Pollution Reported by 20 States as Reasons for Not Attaining Water-Quality Goals

	Point source				Nonpoint source		
State	**General**	**Municipal**	**Industrial**	**Combined sewer**	**General**	**Natural**	**Other**
Arkansas					X		
California[a]					X		
Connecticut			X	X	X		
Georgia		X		X	X		
Kansas						X	X
Louisiana							X
Maine		X		X	X		
Maryland							X
Massachusetts		X	X	X	X		
New Hampshire		X	X	X			X
New Mexico	X				X		
North Dakota						X	
Ohio	X						X
Pennsylvania							X
Rhode Island		X	X	X			
Tennessee	X				X		X
Texas		X	X				
Vermont		X		X	X		
Virginia[a]			X		X		
Washington	X				X	X	

[a]1980 estimates.

Source: EPA, National Water Quality Inventory: 1982 Report to Congress (Washington, D.C.: 1984), p. 9.

EPA also reviewed the state 305(b) reports to determine pollution sources for each state's "waters of concern." This review was not tied to pollution's causing a state to fail to meet its water-quality goals. Of the 31 states for which the review could be made, 27 cited nonpoint-source problems and 28 reported some type of municipal or industrial point-source problem.

For individual rivers, the state 305(b) reports allocated pollution causes by examining chemical and physical data and using the observations and judgments of persons familiar with the rivers. The allocation was frequently straightforward. Major changes in pollution levels are often the result of catastrophic events, such as toxic waste leaks and treatment-plant malfunctions, and often there is only one dominant pollution source on a river, so that the cause is clear-cut.

As the states and EPA, in National Water Quality Inventory, moved from discussions of individual streams to discussions of the major pollution sources for states and the nation in the aggregate, some of the quantitative basis for their findings was lost and replaced with qualitative estimates. To some extent, the states informally combined the results of quantitative studies and, to a lesser extent, qualitative studies of various rivers and their pollution sources. These estimates were not based on statistical samples of rivers within the states, but in our opinion they surely reflected most of, if not all, the most polluted rivers. Further, to the extent that they were based on the more quantitative studies of individual rivers, the statewide or aggregate results provided gross rankings, at least, of the seriousness of a state's pollution sources. It seems reasonable to believe, for example, that many of Pennsylvania's streams were affected by acid mine-drainage, because the problem was spread widely throughout the state.

The 305(b) reports and the national summary of them cited specific instances in which water quality had been degraded and expressed judgments about what caused the degradation.

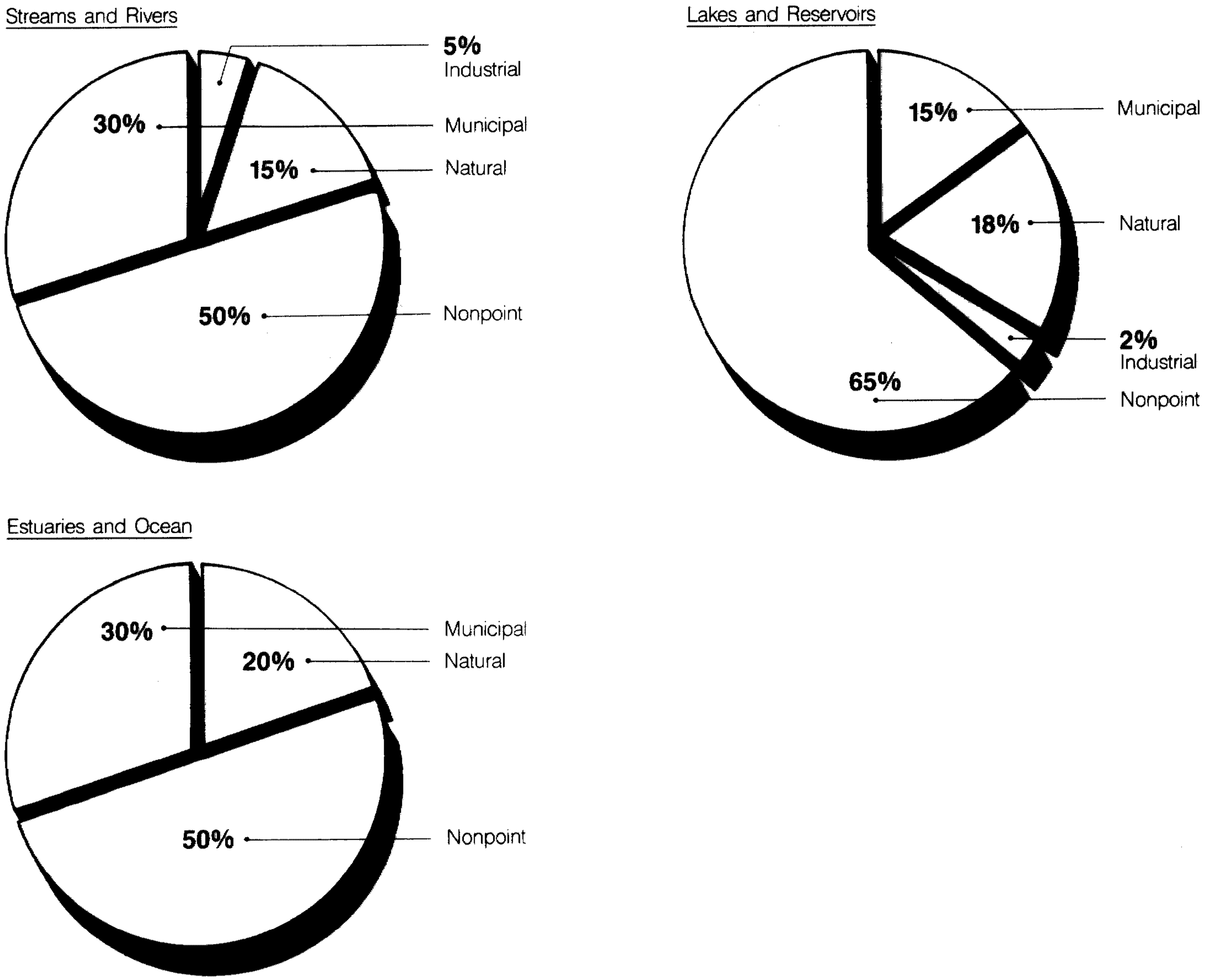
Our conclusion is that rivers were affected in major ways by both point and nonpoint pollution in all the states but that the 305(b) data did not make clear the relative contributions of the several pollution sources at the national level.

STEP

The STEP study asked respondents to give their opinion of the cause of the degradation of waters that failed to meet designated uses. The respondents were instructed to say whether waters were "partially supporting" or "not supporting" their designated uses. For bodies of water whose use was impaired by more than one factor, the respondents were to apportion the relative contribution of each factor "by use of professional judgment." We found that the respondents in a great many states used subjective judgment to determine the causes of known pollution.

Each state was asked to complete a pie chart, each wedge representing one of the major pollution sources that STEP listed. Rather than giving nationwide totals for each source of pollution, The States' Evaluation of Progress simply reported how often the states cited each source as the most significant cause of pollution. It is unclear how accurate these gross estimates are, since rivers often have many pollution sources. An example of the states' responses is shown in figure 5.1.

Figure 5.1: Maryland's Identification of Pollution Sources Preventing the Designated Uses of the State's Water Bodies in 1982



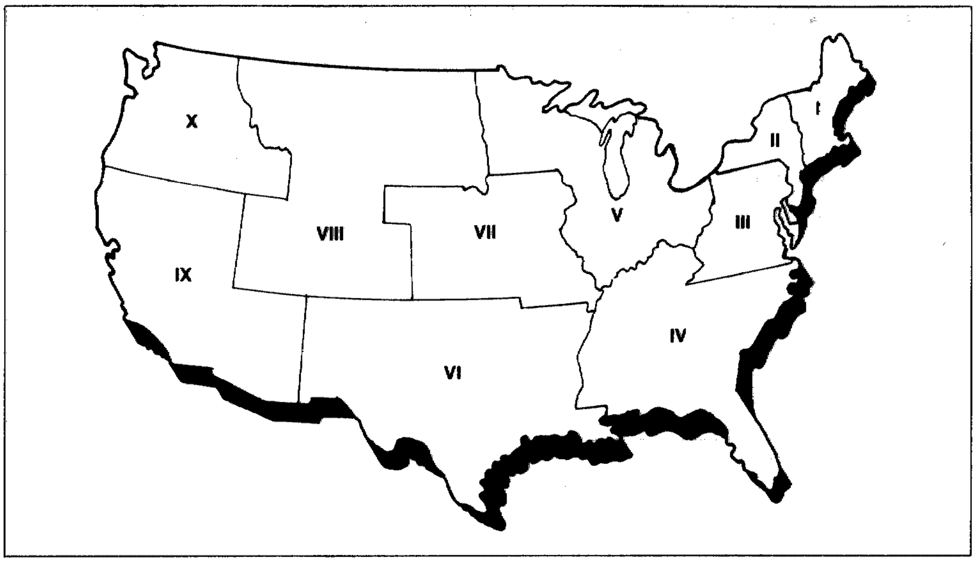
Source: ASIWPCA, America's Clean Water: The States' Evaluation of Progress 1972–1982 (Washington, D.C.: 1984).

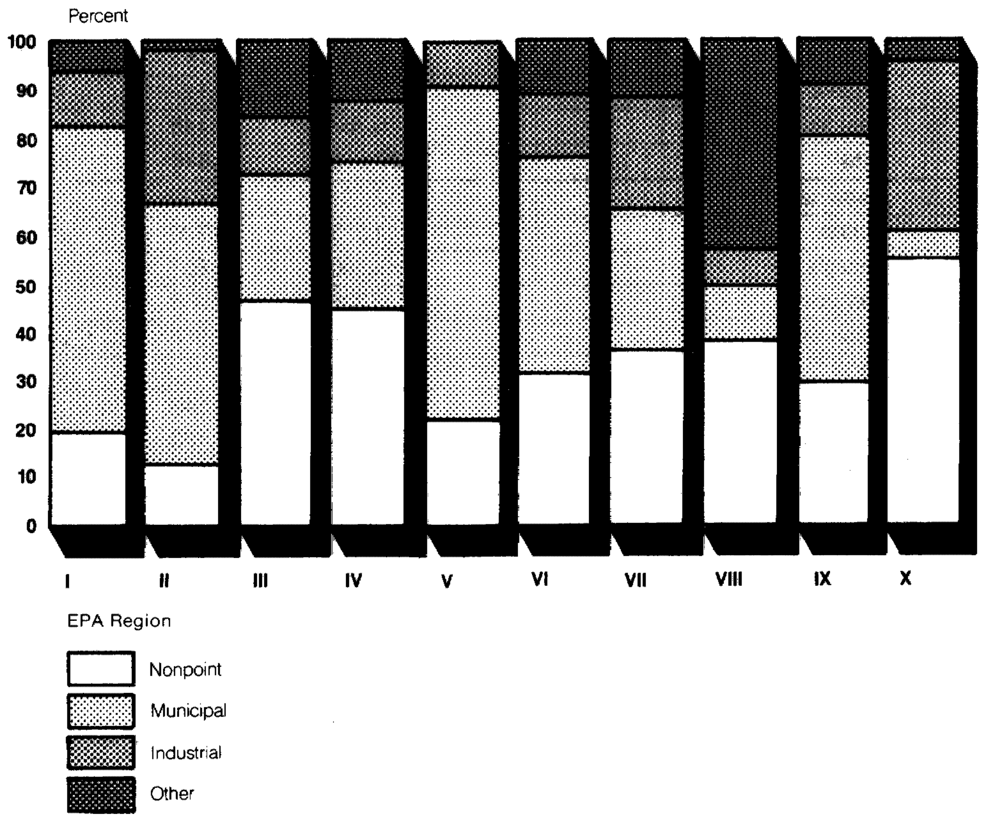
Where multiple pollution sources existed simultaneously, STEP's allocation of river miles to the various pollution categories appeared somewhat arbitrary. For example, Kentucky assigned 710 river miles, one fourth of its total, to each of the four pollution sources listed in STEP—

industrial, municipal, natural, and nonpoint. The question that arises is whether all miles that did not meet designated uses were affected equally by all pollution sources or whether the restrictions inherent in using pie charts meant that all pollution sources were designated equal in value. In 7 other states, pollution sources were equally distributed between two categories, and this distribution too may indicate the roughness of the measurement technique rather than actual pollution, since it is unlikely that exactly equal distributions occur.

STEP reported that 19 states ranked municipal sources first as a cause for their rivers' not fully meeting their designated uses. Industrial sources were ranked first by 3 states, and nonpoint sources were ranked first by 26 others. To expand on this information, we extracted the raw data from the STEP report and categorized the percentage of river miles that did not meet designated uses by the pollution sources that had been identified. Our results are shown in figure 5.2 and table 5.3.

Figure 5.2: Water-Pollution Sources in EPA's Regions I-X in 1982





Source: ASIWPCA, America's Clean Water: The States' Evaluation of Progress 1972-1982 (Washington, D.C.: 1984).

Table 5.3: State Estimates of Water-Pollution Sources in 1982

	State by EPA region	Miles assessed	Miles not fully supporting designated use	Miles allotted to each source[a] Nonpoint	Municipal	Industrial	Other
I	Connecticut	839	301	9	211	0	81
	Maine	2,011	736	199	405	132	0
	Massachusetts	1,611	831	291	416	83	42
	New Hampshire	14,544	507	5	456	46	0
	Rhode Island	724	57	5	29	23	0
	Vermont	4,863	165	7	116	9	33
	Total	**24,592**	**2,597**	**516**	**1,631**	**294**	**156**
II	New Jersey	1,100	735	257	257	184	37
	New York	3,400	1,224	0	789	435	0
	Total	**4,500**	**1,959**	**257**	**1,047**	**618**	**37**
III	Delaware	419	182	49	4	46	84
	District of Columbia	35	28	23	5	0	0
	Maryland	7,440	602	301	181	30	90
	Pennsylvania	12,962	2,743	2,030	466	247	0
	Virginia	4,500	3,117	1,029	1,091	623	374
	West Virginia	5,262	2,146	687	558	86	815
	Total	**30,618**	**8,818**	**4,118**	**2,304**	**1,032**	**1,364**
IV	Alabama	12,101	729	98	487	144	0
	Florida	11,585	5,720	2,860	1,144	229	1,487
	Georgia	17,000	853	9	836	9	0
	Kentucky	3,338	2,838	710	710	710	710
	Mississippi	10,274	1,014	732	228	54	0
	North Carolina	39,150	7,067	3,887	2,120	1,060	0
	South Carolina	2,765	1,348	337	431	162	418
	Tennessee	4,065	1,120	616	336	168	0
	Total	**100,278**	**20,689**	**9,248**	**6,292**	**2,535**	**2,615**
V	Illinois	7,270	4,478	448	3,582	448	0
	Indiana	45,000	1,000	150	750	100	0
	Michigan	811	463	[b]	[b]	[b]	[b]
	Minnesota	2,708	932	699	233	0	0
	Ohio	6,387	3,700	[b]	[b]	[b]	[b]
	Wisconsin	18,500	485	223	184	78	0
	Total	**80,676**	**11,058**	**1,520**	**4,750**	**625**	**0**

State by EPA region		Miles assessed	Miles not fully supporting designated use	Miles allotted to each source[a] Nonpoint	Municipal	Industrial	Other
VI	Arkansas	6,000	3,000	2,700	150	150	0
	Louisiana[c]						
	New Mexico	3,500	50	0	0	0	50
	Oklahoma	11,985	2,066	289	1,074	702	0
	Texas	14,003	4,324	0	2,979	353	991
	Total	**35,488**	**9,440**	**2,989**	**4,204**	**1,206**	**1,041**
VII	Iowa	943	149	64	14	14	57
	Kansas	3,404	1,566	532	431	431	172
	Missouri	18,448	393	169	162	42	21
	Nebraska[d]						
	Total	**22,795**	**2,108**	**765**	**606**	**487**	**250**
VIII	Colorado	10,000	606	97	158	30	321
	Montana	17,251	152	152	0	0	0
	North Dakota	5,109	591	236	89	30	236
	South Dakota	3,987	1,487	937	268	283	0
	Utah	3,531	2,582	775	129	129	1,549
	Wyoming	19,655	590	112	18	18	443
	Total	**59,533**	**6,008**	**2,309**	**661**	**489**	**2,549**
IX	Arizona	497	180	20	59	101	0
	California	9,184	451	203	135	23	90
	Hawaii	39	39	28	0	0	11
	Nevada	1,325	518	104	409	5	0
	Total	**11,045**	**1,188**	**355**	**604**	**129**	**101**
X	Alaska	3,279	3,271	425	33	2,813	0
	Idaho	7,070	3,095	2,816	186	93	0
	Oregon	4,479	1,170	667	117	35	351
	Washington	5,952	1,039	831	104	104	0
	Total	**20,780**	**8,575**	**4,740**	**439**	**3,045**	**351**
National total[e]		**390,305**	**72,440**	**26,817**	**22,538**	**10,459**	**12,626**
% of total			100%	37%	31%	14%	17%

[a]Rows and columns may not total because of rounding.

[b]Did not specify causes for failure to meet support.

[c]Deleted for reasons explained in text.

[d]Not available.

[e]The 4,163 miles unspecified in Michigan and Ohio are in "other."

Source: ASIWPCA, America's Clean Water: The States' Evaluation of Progress 1972-1982 (Washington, D.C.: 1984).

According to the STEP data, about 27,000 river miles (37 percent) did not support their designated uses because of nonpoint sources of pollution. Municipal treatment plants were the cause for about 23,000 miles, or 31 percent, and industrial discharges were the cause for about 10,000 miles, or 14 percent. Our calculations were not exactly equivalent to STEP's rank ordering of results, but they moved in the same general direction.

We believe that STEP overstated the proportion of river miles adversely affected by municipal and industrial sources and understated those affected by nonpoint sources. The reason is the suggestion of a consistent bias toward point-source pollution, since the rivers reported in STEP were not randomly selected. STEP examined most of the nation's major rivers. Most major rivers have significant populations living along them. Most have water-monitoring stations, and in all likelihood, they have municipal treatment plants and industrial plants located on or discharging into them. Thus, to the extent that rivers that had industrial and wastewater-treatment facilities located on them were overrepresented in STEP's sample, and rivers in rural areas were underrepresented, we believe the nationwide significance of point sources was overstated, and nonpoint sources understated. We believe this assumption is reasonable, given information from our interviews with state officials.

The estimates of pollution from the various sources constituted one of the weaker aspects of the STEP report. Realizing this, EPA has made a major effort to compile additional data on nonpoint sources of pollution.

Our conclusion is that the STEP data on pollution sources have limited value and should be treated cautiously. Some of the data appear to have been based on the subjective judgments of the persons who completed the questionnaire, and the data seem to have a built-in bias toward point sources. To the extent that those who completed the questionnaire made reasonably informed judgments, it is reasonable to conclude that nonpoint sources of pollution were at least as prevalent as municipal sources, if not more so. However, to the extent that the credibility of the data base is called into question, the findings STEP reported are of limited utility.

Fisheries Survey

For each river reach, the 1982 National Fisheries Survey researchers requested judgments about the number of miles affected by several factors, including pollution, and additional information on the causes of pollution. The number of miles said to be affected by each pollution source were then summed in order to get a national estimate. We show the survey results in table 5.4 on the next page.

Table 5.4: Probable Sources of National Water Pollution Reported for 1982

Probable source[a]	River miles Total	Percent
All streams		
Nonpoint		
Agricultural	281,241	29.5
Natural	212,389	22.2
Silviculture and logging	71,736	7.5
Feedlots	59,947	6.3
Individual sewage disposal	47,823	5.0
Urban runoff	40,376	4.2
Mining	31,847	3.3
Construction	29,110	3.1
Grazing[b]	21,970	2.3
Landfill leachate	5,504	0.6
Bedload movement[b]	5,299	0.6
Roads	3,569	0.4
Total	**367,244**	**38.4**
Point		
Municipal	63,816	6.7
Industrial	47,097	4.9
Combined sewers	29,246	3.1
Mining	28,686	3.0
Dam releases	19,314	2.0
Total	**117,684**	**12.3**
Other	19,445	2.0

Probable source[a]	River miles Total	River miles Percent
Perennial streams		
Nonpoint		
Agricultural	250,637	26.3
Natural	149,893	15.7
Silviculture and logging	68,891	7.2
Feedlots	53,775	5.6
Individual sewage disposal	46,069	4.8
Urban runoff	38,027	4.0
Mining	30,894	3.2
Construction	29,110	3.1
Grazing[b]	19,515	2.0
Landfill leachate	5,504	0.6
Bedload movement[b]	5,299	0.6
Roads	3,569	0.4
Total	**330,840**	**34.6**
Point		
Municipal	62,703	6.6
Industrial	47,097	4.9
Combined sewers	29,246	3.1
Mining	28,686	3.0
Dam releases	19,314	2.0
Total	**116,572**	**12.2**
Other	18,524	1.9

[a]Subcategories are not additive.

[b]Category developed from clarification by respondents under "other."

Source: EPA and U.S. Fish and Wildlife Service, 1982 National Fisheries Survey (Washington, D.C.: 1984), p. 28.

According to the summary statement of findings, U.S. waters are to a large extent able to support viable fish populations, although they are widely affected by pollutants, especially from nonpoint sources, and by problems of quantity, primarily low natural flow. As reported, water quality affected fish adversely in 56 percent of the nation's waters. The probable sources, according to the survey, included a wide variety of point and nonpoint pollutants. Total nonpoint-source pollution was considered the major adverse factor, at 38.4 percent, and agricultural and natural sources were the most significant nonpoint sources, at 29.5 and 22.2 percent, respectively. (The components of a category sum to more than the category's percentage, because the respondents were allowed to identify multiple sources.) Only 6.7 percent of the stream miles were attributed to municipal point sources and 4.9 percent to industrial point sources.

Our conclusion is that it is unclear, because of the subjective nature of the responses in the 1982 National Fisheries Survey, just how much reliance can be placed on the identification of nonpoint sources as having affected a higher proportion of the nation's stream miles than point sources. Even to the extent that the results are acceptable, they may apply predominantly or only to fishability, since the biologists who were the survey respondents were not queried about what pollution sources affected swimming and the drinkability of the water.

Before-and-After Case Studies

Before-and-After Case Studies provided no information on this evaluation question. The report was directed at determining how water quality had improved because of upgraded wastewater-treatment plants on 13 streams. The selection of streams and treatment plants was intended to minimize variations in water flow and pollution sources at two points in time. Therefore, the report minimized the potential effect of all factors other than wastewater-treatment plants.

Geological Survey

The Geological Survey's National Water Summary 1983 gave us no information on this question. Its treatment of water-quality factors was restricted to a discussion of typical problems that stemmed from various activities. The Geological Survey is attempting to combine monitoring-station data with ancillary data in order to interpret change or its absence in the data, but this effort is too far from completion to allow us to evaluate it.

Summary Studies

The Council on Environmental Quality cited data from STEP and the 1982 National Fisheries Survey to support its contention that "The nation's waters . . . are widely affected by pollution from point and nonpoint sources" (U.S. Council, 1984, p. 89).

The Conservation Foundation, citing various sources, drew a number of conclusions about the causes of pollution. It claimed that municipal wastewater discharges contributed a significant portion of the pollutants in U.S. rivers and streams. The foundation concluded that industrial point sources were less a problem than they had been previously, citing EPA estimates that, on the whole, industries reduced their discharge of most of the conventional pollutants by 70 percent or more between 1972 and 1977. The Conservation Foundation reported that nonpoint source pollution is still a major problem and that

"Agricultural lands are the most pervasive nonpoint pollution problem, in themselves contributing most of the sediment, nitrogen, phosphorus, and BOD entering U.S. surface waters." (Conservation, 1984, pp. 123 and 125)

The foundation concluded that nonpoint sources may have had a greater polluting effect than point sources, whether municipal or industrial. This is not too surprising, since much of the Conservation Foundation's section on water quality was based on and agreed with EPA documents, particularly the STEP report.

Synthesis

Most of the studies we reviewed identifed the same major pollution sources (indicated in table 5.1). Using very different methods, The State's Evaluation of Progress and the 1982 National Fisheries Survey found that both municipal and industrial discharges affected adversely only a very small portion of the nation's rivers and streams. The STEP report, the 1982 National Fisheries Survey, and the section 305(b) reports all reported pollution from municipal, industrial, and nonpoint sources. Our evaluation of their conclusions is summarized in table 5.5.

Table 5.5: Our Evaluation of Five Reports on the Question of the Sources of Pollution

Report	Municipal	Industrial	Nonpoint	Our evaluation
Inventory	Reported by 7 of 20 states as reason for not meeting goals; no national conclusion	Reported by 6 of 20 states as reason for not meeting goals; no national conclusion	Reported by 18 of 20 states as reason for not meeting goals; cited by 27 of 31 reports on problems in "waters of concern"; no national conclusion	Nonpoint sources mentioned most frequently but cannot generalize
STEP	31% of river miles do not support designated use because of municipal sources	14% of river miles do not support designated use because of industrial sources	37% of river miles do not support designated use because of nonpoint sources	Nonpoint sources allocated highest % of pollution sources in subjective and questionable pie-chart technique
Fisheries survey	Affects 6.7% of all stream miles	Affects 4.9% of all stream miles	Affects 38.4% of all stream miles	Nonpoint sources mentioned most frequently; conclusions on adverse effects on fishability can be generalized to the extent expert perceptions are good indicators
Before-and-after case studies	No national conclusion	No national conclusion	No national conclusion	None
Geological survey	No significant findings	No findings	No findings	Relative pollution not discussed

All the study designs had methodological limitations. They relied substantially on untested best professional judgments, which made their findings on the relative contributions of various pollution sources uncertain. The studies presented basically similar rankings of the relative contribution of various pollution sources, even though they used different designs and relied on different respondent groups.

The three studies that attempted to estimate the relative contribution of different pollution sources to the degradation of water quality all identified nonpoint sources as the greatest problem. According to the STEP study, nonpoint sources contributed slightly more than municipal sources (37 and 31 percent, respectively) to the failure of rivers to meet designated uses. In National Water Quality Inventory, 18 of 20 states cited nonpoint-source problems for not meeting water-quality goals and 13 of the 20 cited point sources (7 citing municipal and 6 citing industrial discharges). In the 1982 National Fisheries Survey, the respondents identified nonpoint pollution problems more than five times as often as municipal pollution (38.4 percent nonpoint, 6.7 percent municipal, 4.9 percent industrial).

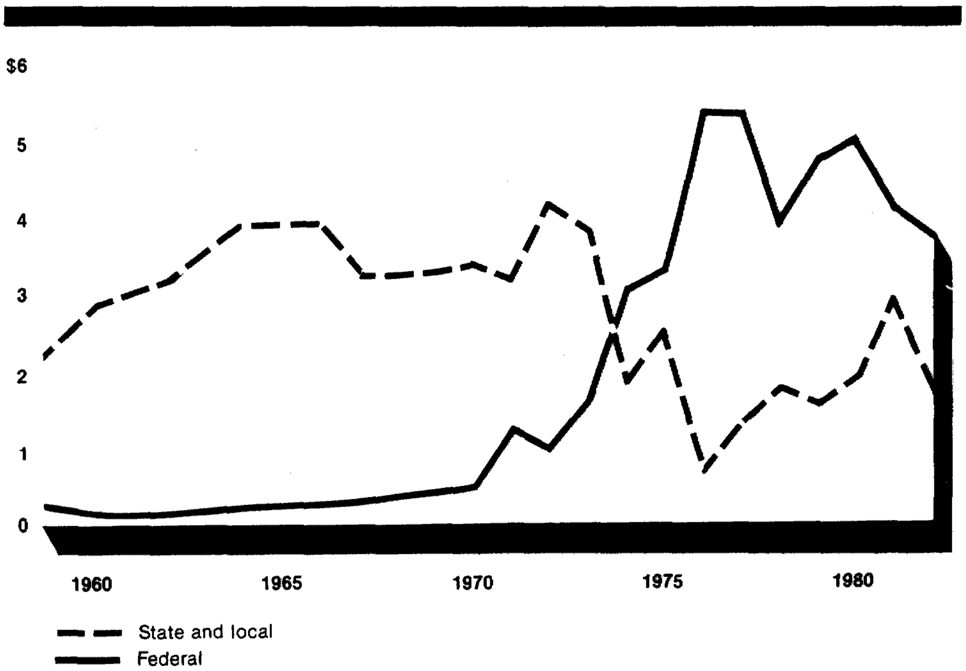
Despite our problems with the studies, we conclude that a variety of pollution sources, point (particularly municipal and industrial) and nonpoint, have lowered the quality of the nation's rivers but that the relative contribution of these pollution sources is not known with any degree of certainty. The effect of nonpoint-source pollution may be larger in terms of river miles than that of point sources in the form of municipal discharges. There is even less information on the relative intensity with which these sources affect rivers and the communities that depend on them.

For the most part, only pollution from municipal sources (to a much smaller extent, pollution from industrial and nonpoint sources) can be mitigated by upgrading wastewater-treatment plants. Therefore, it may not be reasonable to expect upgraded wastewater treatment to improve water quality greatly (or prevent its further degradation). In chapter 6, we continue our discussion of this issue by examining the evidence on the relationship between water quality and the funding under the Construction Grants Program of new treatment plants and the upgrading of old ones.

The Effect of the Construction Grants Program

How has the Construction Grants Program affected water quality? More than $113 billion (constant 1982 dollars) from federal, state, and local sources has been spent on the construction of wastewater-treatment facilities. Federal expenditures between 1957 and 1972 totaled $1.86 billion; most of the costs were incurred by state and local governments. Federal involvement, under several laws, was limited. Since the authorization of the Construction Grants Program in 1972, federal funding for wastewater facilities has predominated. (See figure 6.1.)

Figure 6.1: Federal, State, and Local Funding for the Construction of Wastewater-Treatment Plants in 1959-82[a]



[a]1982 constant dollars in billions. The state and local data are in doubt.

Source: EPA, Study of the Future Federal Role in Municipal Wastewater Treatment (Washington, D.C.: 1984), p. 3-2.

The Federal Water Pollution Control Act Amendments of 1972 constituted the most comprehensive U.S. water-quality legislation that had ever been enacted. To restore and maintain the physical, chemical, and biological integrity of the nation's water, among other things, the 1972 legislation provided a national policy and federal financial assistance for the construction of publicly owned wastewater-treatment plants. It also established the Construction Grants Program, which required and assisted in the development and implementation of wastewater-treatment management plans and practices, in order to achieve its goals. The administrator of EPA was authorized to make grants to any municipal, intermunicipal, state, or interstate agency for the construction of publicly owned treatment works.

The 1972 legislation significantly increased the federal share of the cost of constructing treatment works from 30 to 75 percent. A total of $18 billion in federal grants was authorized for fiscal years 1973 to 1975. Subsequent congressional actions, among them the Clean Water Act of 1977, changed the authorization levels and federal contributions. (See table 6.1.)

Table 6.1: Federal Assistance to Municipal Wastewater Treatment in 1948-84

Public law	Annual authorization	Type of funding	Maximum federal share
80-845 (1948)	$22.5 million	Loans	Lesser of 331/3% or $250,000
84-660 (1956)	$50 million	Grants	30% or $250,000
87-88 (1961)	$ 80 million FY 1962 $ 90 million FY 1963 $100 million each FY 1964-67	Grants	30% or $600,000
89-234 (1965)	$100 million	Grants	Greater of 30% or $1.2 million
92-500 (1972)	$18 billion FY 1973-75	Grants	75%
95-217 (1977)	$1 billion FY 1977 $4.5 billion FY 1978 $5 billion each FY 1979-82	Grants	75% or 85% for "innovative or alternative processes"
97-35 (1981)	$2.548 billion FY 1981	Grants	75% or 85% for "innovative or alternative processes"
97-117 (1981)	$2.4 billion each FY 1982-85	Grants	55% starting in FY 1985

Since 1957, the federal government has spent approximately $39 billion to help municipalities construct wastewater-treatment facilities. The greatest part of this, $37 billion, was spent after the implementation of the Federal Water Pollution Control Act Amendments of 1972, making the Construction Grants Program one of the nation's largest nonmilitary public construction programs.

When authority to obligate funds under the Clean Water Act expired at the end of fiscal year 1985, there had already been significant disagreement as to what level of funding should be reauthorized, if any. For example, at the October 1983 meeting of the management advisory group for EPA's sewage-treatment construction-grants program, the executive director of the Association of Metropolitan Sewage Agencies said that the current authorization for $2.4 billion in annual grants was not enough to enable communities to achieve federally mandated clean-water goals within the specified time. At the other extreme, officials of the Water Pollution Control Federation proposed in 1982 that the Construction Grants Program be phased out in the next 10 years, arguing at an April 7, 1983, ASIWPCA seminar on financing sewage treatment that the Congress never intended the program to continue indefinitely (Feinthel, 1984, pp. 6 and 18). EPA is currently attempting to identify feasible alternatives for financing the program, in order to gradually remove the federal government from the financing of wastewater-treatment plants. The administration's fiscal year 1986 budget proposed phasing out the programs by 1990.

In the Congress, bills reauthorizing the Construction Grants Program at various levels were being considered. For example, H.R. 8 was introduced on January 3, 1985, proposing the Water Quality Renewal Act of 1985. Passed by the House in July 1985, the bill provided for the retention of authorization at $2.4 billion annually through fiscal year 1990. It would add a supplement of $600 million in grants for loans to municipalities, intermunicipalities, and interstate agencies. The $600 million revolving loan program provided for in the bill would replace construction grants after fiscal year 1990. In all, $21 billion would be authorized under the grant and loan programs through 1994.

On June 13, 1985, the Senate passed S. 1128, proposing the Clean Water Act Amendments of 1985. This bill would phase out federal grant assistance to states for the construction of sewage-treatment plants by fiscal year 1990. Funding would be set at $2.4 billion annually through 1988 and at $1.2 billion in fiscal years 1989 and 1990. This bill would also create a revolving loan fund, a total of $8.4 billion to be authorized between fiscal years 1989 and 1994. Total grant and loan funds through 1994 would come to $18 billion. The differences between the House and Senate bills had not been resolved in conference by August 1986.

Methodological Issues

To determine the effect of the Construction Grants Program on water quality, one must consider three broad methodological issues:

1. making distinctions about the level of wastewater treatment as a cause of change in water quality,

2. using water-quality constructs to show the effects of treatment, and

3. establishing cause-and-effect relationships.

Wastewater-Treatment Levels

The legislation authorizing the Construction Grants Program focused on achieving secondary wastewater-treatment levels, but funding from the program has been used for many types of construction. It has been used to build a community's first wastewater-treatment plant—so that instead of being discharged into waterways, raw sewage is moved through primary and secondary treatment levels—and to upgrade a plant from primary to secondary treatment or from secondary to advanced treatment. Therefore, evaluations of the program's effectiveness should distinguish between treatment levels and separate the effects by level. Because the introduction of primary treatment should result in the greatest change in water quality, successively higher levels of treatment producing marginally less change, and because big changes are the easiest to detect, the evaluation methods for examining primary treatment levels can be more crude than those for looking at secondary and advanced levels of treatment.

Water-Quality Constructs

Effluent load, in-stream water characteristics, the capability for designated use, and socioeconomic value become progressively more difficult to relate to a change in wastewater treatment. Therefore, it becomes increasingly difficult, from the less to the more powerful of these constructs, to show the effects of treatment plants. Primary treatment plants reduce effluent load, without doubt. Even studies that do not examine this relationship seem to assume it, and we believe the assumption is reasonable. At higher treatment levels, there is greater reason to seek empirical evidence of the reduction in effluent load as an indicator of treatment effectiveness. But in terms of the more powerful constructs, a reduction in effluent load is not automatically associated with measurable effects.

We believe that choosing in-stream water characteristics, the capability for designated use, or socioeconomic value to represent water quality with respect to the effectiveness of a treatment plant requires an empirical demonstration of evidence. Factors other than municipal wastewater-treatment can affect these constructs, perhaps to a greater degree than the treatment. If funds for abatement are to be divided between several polluting sources, the effectiveness of the treatment plant must be seen in the context of the other sources and their contribution, whether positive or negative, to water quality.

Cause-and-Effect Relationships

Although we are willing to assume that there is a causal relationship between the presence of a wastewater-treatment plant and effluent load, at least three important considerations make it difficult to establish a causal relationship between the construction of a treatment plant and the more powerful water-quality constructs: (1) the multiple factors that influence water quality, (2) uncertainty about when treatment-plant improvements take place, and (3) insufficient data about effluents and water quality. In this discussion, we refer only to in-stream water characteristics, but the principles also apply to the capability for designated use and socioeconomic value.

The Presence of Multiple Factors

In-stream water can be influenced by many factors other than wastewater-treatment plants, and almost any stretch of river is subject to a variety of pollutant sources. Moreover, the concentrations of pollutants (relative amounts, as opposed to absolute amounts) are clearly influenced by diurnal and seasonal changes in the amount of water flowing in a river. The independent effects of the several other factors can conceal or distort the apparent effect of a wastewater-treatment plant. To isolate the actual effect of a treatment plant usually requires systematic evaluations. Expert judgment can be untrustworthy in sorting through the complex interplay of causal factors.

The Timing of Treatment-Plant Improvements

Constructing an individual treatment plant or upgrading one takes time for documenting the need for funding, designing or redesigning the plant, doing the actual construction, testing, and obtaining certification. Typically, there is also a "break-in" period, during which plant operators become familiar with the equipment and mechanical or operational problems are corrected. There is no set or required timetable for this process. Moreover, treatment plants are rarely shut down during construction and upgrading. Rather, as construction goes on, operations continue. Therefore, some effect from a construction grant should be expected before the project has been officially certified complete.

These complexities make it difficult to decide what date to use as the border between "before" and "after." Should it be the date EPA certified the construction complete or a date at the end of some "break-in" period? Should the demarcation between before and after be a single date or a range of dates? For example, all the data from before the construction began could be considered relevant to the "before-construction" period, all the data from after the treatment plant was certified to the "after-construction" period. These questions have no clearly right or wrong answers. Analysts must base their decisions on the logic of each individual situation, and they should consider the possibility of undertaking supplemental and exploratory data analysis.

The Quantity of Data

To show that the Construction Grants Program has an effect on water quality as measured, for example, by in-stream water characteristics, it would be necessary to show that a change in a treatment-plant effluent was associated with a downstream change in water quality. The demonstration of an association such as this is regarded as a necessary but not a sufficient condition for asserting a causal connection.

Data on the performance of treatment plants are fairly abundant after the completion of construction-grant upgrades but fairly sparse before that time. This makes before-and-after comparisons difficult. Much the same problem pertains, in reverse, to the evaluation of data from water-quality monitoring stations. Consistent and complete sets of water-quality monitoring data from before and after the construction of a construction-grant project are rare. For example, a Virginia state official told us that it is a general policy in Virginia to remove a monitoring station immediately downstream from a treatment plant after the plant's construction has been completed. Virginia maintains monitoring stations only as long as data are required to justify the need for additional treatment-plant funding.

Knowledge Review

Most of the reports we reviewed focused on wastewater-treatment plants in general, not just those funded by the Construction Grants Program. Because treatment plants built or upgraded since 1972 were funded in large part with money from this program, conclusions about treatment plants in general probably apply also to plants funded by the program.

Inventory

In discussing the findings of state 305(b) reports in National Water Quality Inventory, EPA argued that the massive investment in resources and effort during more than a decade had been effective in improving water quality and that the basic approach to pollution control envisioned in the Clean Water Act was working. EPA believed the evidence showed a substantial reduction in the amount of pollutants that would otherwise have entered the nation's waters after 1972 and asserted that many water-quality improvements could be directly attributed to pollution-control programs. However, it did not single out the Construction Grants Program for discussion.

According to the 1982 National Water Quality Inventory, national regulations requiring wastewater-treatment facilities to use the best practical technology substantially reduced the discharge of six key pollutants. For instance, between 1972 and 1977, biochemical oxygen-demand loading (the level of oxygen-demanding pollutants released into a river) was reduced by 71 percent.

According to the 1982 inventory, sewage-treatment plants were removing daily about 13,600 tons of pollutants, by the two principal measures, biochemical oxygen demand and suspended solids, an improvement of 65 percent over 1973 levels. This was, reportedly, because the Construction Grants Program helped municipal treatment plants achieve secondary treatment levels.

The program's national effectiveness cannot be directly inferred from the section 305(b) information. Many of the 305(b) reports that we reviewed appeared to contain estimates of effectiveness based on subjective judgment rather than quantitative evidence. Thus, their credibility is less than that of more rigorously designed studies combining subjective judgments with objective measures.

Moreover, the reports we reviewed generally failed to explain how alternative hypotheses for possible causes of improvement in water quality were disproven. Unless it is accounted for, an effect associated with other point or nonpoint sources could mask or be mistaken for an effect of a wastewater-treatment plant. If alternative causes are not addressed, there can be certainty neither that an improvement in water quality was wholly caused by the project nor that the program's effect was fully detected by the evaluation.

EPA's summary of the state reports listed what EPA claimed were several examples of the effect of wastewater-treatment plants, or the program, on water quality. The information in the section 305(b) reports on the program's effectiveness is site-specific, not a national estimate. For example, in 1982, 36 states said that improvements in their water resulted directly from their projects under the program. But it is impossible to tell from the summary report whether all or only some percentage of plants the states funded under the program were associated with an improvement in water quality. (Although all the states received some funding, 14 states were not mentioned in the inventory's discussion of the program's effects.)

Maryland reported that a trend toward increasing the number of acres open to shellfishing was tied to improvements in and the expansion of wastewater-treatment facilities. In the District of Columbia, reduced levels of certain pollutants in the Potomac River were reportedly the result of improvements in effluent quality from the Blue Plains sewage-treatment plant. In the Delaware River Basin, below Philadelphia, dissolved oxygen and fecal coliform levels were reported to have improved after a wastewater-treatment plant upgrade. Individual success stories may be accurate, but they should not be generalized to all treatment plants.

Each state 305(b) report discussed the program to some extent, but the findings varied. For example, Pennsylvania's report attributed progress in water-pollution control to treatment-plant investments at local, state, and federal levels. To support this argument, the report listed streams that the state claimed had improved in quality and gave the primary reason for improvement. Among other things attributed to improved wastewater-treatment plant operation were the improvement of 1.5 miles on the Schuylkill River in Berks County in 1980, of 6.5 miles of Lititz Run in 1982, and of 4 miles along Neshaminy Creek in 1982.

These changes were reported as having happened from one year to the next. Although Pennsylvania's 305(b) report listed year-to-year improvements from 1979 to 1983, it did not present cumulative changes for the 5-year period. Some rivers may have improved in one year only to have gotten worse in the following year. Without additional analysis, we found it impossible to get from the report any direct sense of long-term change in the quality of the water in Pennsylvania's rivers. (A source at Pennsylvania's Department of Environmental Resources observed that the report's presentation had limited value.)

Inadequate documentation of the evidence in some of the state 305(b) reports may make it impossible to evaluate the decision that led to an assessment of water-quality trends in some areas. Documentation was lacking in Pennsylvania's report, and the data were not available at Pennsylvania's Department of Environmental Resources headquarters. We were told that only one of its nine regions (the level at which assessments were made) indexed the source of evidence for each assessment decision. We can only conclude that the data were made up of some combination of objective and subjective sources.

The results reported by Virginia and the District of Columbia were not as straightforward. In the 1984 Virginia report, temperature and the level of and changes in the water-quality measures of dissolved oxygen and pH were attributed mostly to undefined natural rather than human causes.[1] The District of Columbia's report similarly attributed changes in fecal coliform bacteria and dissolved oxygen more to water flow and weather than to wastewater treatment. District officials stated that the small level of change in water quality that had recently been discerned and the relatively large influence of natural causes may have indicated that vast improvements in water quality resulting from large expenditures of money and labor over previous years had "bottomed out."

The argument is similar to the economic concept of diminishing marginal returns, in which each additional unit of input produces fewer additional units of output. Earlier improvements in wastewater treatment brought about sizable improvements in water quality, according to the District of Columbia report. Now, however, the District officials believed that spending additional dollars on treatment-plant improvements brought about less and less observable improvement in water quality. We did not test this assertion.

Our conclusion is that, on the basis of the effluent-load construct, the state 305(b) reports provided evidence that sewage-treatment plants funded under the Construction Grants Program reduced the level of pollutants entering the nation's rivers and streams but that they offered little information on the program's national effectiveness aside from this evidence and nonsystematic evidence from nonrandomly selected case studies.

STEP

STEP reported that 13 percent of the 1,529,177 miles of rivers sampled in the nation improved in quality. However, it did not directly address the effect of the Construction Grants Program on water quality. STEP concluded that water quality improved throughout the country and that the change had been achieved by a combination of federal, state, and local programs. In our interviews with the ASIWPCA staff responsible for producing the STEP report, we were told that it had to have been the program that brought about the water-quality improvements. They argued that there was no other explanation.

[1] However, by the "designated use" construct, Virginia's 305(b) report found that sewage-treatment plants were the leading reason (36 percent) that 3,597 miles failed to meet designated uses.

In this context, several statements from the STEP report taken together could lead readers to infer an unwarranted conclusion about the effect of the program. The STEP report stated that $34.9 billion of the more than $56 billion in public funds spent on wastewater treatment came from the program. Further, it said that upgrading the level of treatment directly reduced pollution discharges to waterways. To give evidence of a reduction in pollution level, the report cited data showing that between 1972 and 1982, the amount of oxygen-demanding pollutants entering wastewater-treatment plants increased by 12 percent and that the amount of oxygen-demanding pollutants released into the waterways decreased by 46 percent.

Although STEP did not specifically conclude that the program caused the improvement, the STEP data clearly lead to this conclusion by implying the following sequence:

1. most sewage-treatment plants built since 1972 were funded predominantly by program funds;

2. sewage-treatment plants removed oxygen-demanding pollutants from the water;

3. the level of oxygen-demanding pollutants discharged by treatment plants into the nation's waters decreased;

4. therefore, water quality improved.

Some might conclude from this logic that the program is one reason the nation's water quality improved. The causal link may seem intuitively attractive, but given the STEP data, it is not methodologically defensible, for several reasons. The judgmental nature of the assessments of water quality, especially in view of the sparseness of 1972 data, makes the validity of the fourth statement questionable. Further, even assuming that the statements are accurate, most of the STEP data showed that the water quality of most rivers did not change between 1972 and 1982 (as we noted in chapter 4).

The set of conditions necessary to imply causality—association, temporal order, and the elimination of alternative hypotheses—must be considered. The STEP data do not show that any of these conditions was met. Whatever their defects, the STEP data do show that for a small proportion of streams, oxygen-demanding pollutants discharged from treatment plants decreased and water quality improved. However, we cannot tell from the data whether the streams where pollutant discharges decreased were the same streams where water quality improved, so that it is impossible to determine whether association has been demonstrated.

Temporal order was not discussed in STEP. Changes indicated for all the measures were merely reported for one period, 1972 to 1982. Thus, the condition of temporal order was implied but not necessarily satisfied.

Alternative causes were also not directly considered. In other words, "What else besides program funding could have improved water quality?" was not asked. STEP discussed several possible alternative causes, including improvements in limiting nonpoint sources of pollution, improvements in discharges from private industry, natural assimilation and mixing in rivers and streams, improvements in compliance and enforcement, and a greater ecological awareness among the public. But a direct link was not made between these and the effect of the program on ambient water quality.

Our conclusion is that the STEP report's implication that the program had a demonstrable effect applies only to effluent load. Reduced effluent load may very well have had some bearing on in-stream water quality, but it is not possible from the STEP report to isolate or determine the magnitude of its effect at a national level.

Fisheries Survey

Measured by the ability of the streams to support fish species, the nation's waters changed very little in the period covered by the 1982 National Fisheries Survey, and the report did not address reasons for the small changes it noted. In particular, it did not consider the effects of the Construction Grants Program. However, in seeking respondents for the survey on water-quality factors affecting the nation's fisheries and sources associated with water-quality problems, the study's authors attempted to identify the biologists who were most knowledgeable about a river, in order to help improve the survey's accuracy. The respondents' judgments are shown in tables 6.2 and 6.3.

Table 6.2: Factors Adversely Affecting the Nation's Fisheries in 1982

Factor	Percent
Turbidity	29.0
High water temperature	19.1
Nutrient surplus	11.3
Toxic substances	9.1
Dissolved oxygen deficiency	7.9
Nutrient deficiency	3.9
Low water temperature	2.9
pH too acidic	2.5
Salinity	1.5
Sedimentation	1.5
Siltation	0.8
Low flow	0.7
Gas supersaturation	0.6
Herbicides and pesticides	0.5
pH too basic	0.3
Channelization	0.2

Source: EPA and U.S. Fish and Wildlife Service, 1982 National Fisheries Survey (Washington, D.C.: 1984), p. 25.

Table 6.3: Sources Associated With Water-Quality Problems in 1982

Source[a]	Percent
Nonpoint	
Agricultural	26.3
Natural sources	15.7
Silviculture and logging	7.2
Feedlots	5.6
Individual sewage disposal	4.8
Urban runoff	4.0
Mining	3.2
Construction	3.1
Grazing	2.0
Dam releases	2.0
Landfill leachate	0.6
Bedload movement	0.6
Roads	0.4
Total	**34.6**
Point	
Municipal	6.6
Industrial	4.9
Combined sewers	3.1
Mining	3.0
Total	**12.2**
Other	1.9

[a]Totals do not necessarily reflect major category subtotals, since respondents could either indicate multiple sources or select the major category source.

Source: EPA and U.S. Fish and Wildlife Service, 1982 National Fisheries Survey (Washington, D.C.: 1984), p. 28.

From the survey data, at least one observation can be made about the potential effects of construction-grant projects: Some of the major pollution problems reported by the fisheries biologists were not directly affected to a major extent by wastewater-treatment plants, as table 6.2 makes clear. For example, turbidity was the factor most often listed as adversely affecting the nation's fisheries. Turbidity is the water's opacity or cloudiness from small suspended particles of solid pollution that limit the amount of light passing through. Building a new wastewater-treatment plant may significantly affect the turbidity of the water by removing suspended pollutants, but upgrading an existing plant is likely to have less effect. Upgrading generally removes only a small additional amount of suspended solids and usually does not significantly increase or decrease the flow of effluent from the treatment plant, thus changing the turbidity of the water little, if at all.

High water temperature came next in frequency as a factor affecting the fisheries. Since many of the problems caused by high temperature have sources such as electric power plants, not sewage plants, only a limited effect would be expected from treatment-plant upgrades.

The top three sources associated in table 6.3 with water-quality problems are affected very little, if at all, by wastewater treatment. Since controlling nonpoint-source pollution usually requires measures such as making improvements in agricultural techniques, we infer from the fisheries survey data that factors other than wastewater treatment probably had more direct effect on the nation's fish.

Our conclusion is that the 1982 National Fisheries Survey provided no information on the possible effect of the Construction Grants Program on water quality at a national level, and the report's expert findings identified problems that are generally not subject to resolution by wastewater-treatment plants.

Before-and-After Case Studies

Before-and-After Case Studies is the only report we examined that had as its major objective the evaluation of aspects of the Construction Grants Program. The report quite accurately pointed out that, while there had been massive expenditures on constructing wastewater-treatment plants, there had been little or no evaluation of the program's direct effect on water quality. The report indicated that the effectiveness of most treatment plants had been judged on whether a plant met the effluent limits set by the national pollutant discharge elimination system. Since the goal of wastewater-treatment plants is to improve the quality of the nation's waters beyond simply controlling effluents, the effectiveness of treatment plants should be measured in terms of the other, higher-level indicators of water quality.

The project began by making contact with 31 states, 4 EPA regions, and 4 regional planning boards. This yielded data on 52 water bodies, and from this base, 13 treatment plants in 11 states were chosen for study. The criteria were completeness of data (nowhere were all the requested data available) and other factors. (See table 6.4.)

Table 6.4 Wastewater-Treatment Plants in EPA's Before-and-After Case Studies

River	Treatment plant	Treatment change[a]
Nashua, Mass.	Fitchburg East	Secondary to advanced
Blackstone, R.I.	Woonsocket	Primary to secondary
Hudson, N.Y.	Albany Area	Primary to secondary
Patuxent, Md.	Laurel Parkway	Secondary to advanced
Potomac, Md.	Blue Plains	Secondary to advanced
South, Va.	Dupont	Secondary to nitrification
Hurricane, W. Va.	Hurricane	Secondary to upgraded secondary
Clinton, Mich.	Pontiac, Auburn	Secondary to advanced
Ottawa, Ohio	Lima	Secondary to nitrification
Bridge, Wis.	Augusta	Secondary to nitrification
Lemonweir, Wis.	Tomah	Secondary to nitrification
Cibolo, Tex.	Odo J. Riedel	Secondary to upgraded secondary
Wilsons, Mo.	Springfield S.W.	Secondary to advanced

[a]Nitrification is the biochemical process in which ammonia is oxidized to nitrate compounds. Advanced nitrification has the goal of reducing ammonia levels in water. Primary and secondary treatments of sewage and wastewater remove floating material with filters and reduce organic content with the help of bacteria.

The report focused on treatment plants that had been upgraded from primary to secondary or from secondary to advanced treatment levels with at least 75-percent funding from the federal program. The report accepted the general assumption that eliminating raw discharges by primary treatment is highly cost-effective in most cases; therefore, primary treatment was not included in the analysis.

Before-and-After Case Studies reported improvements on at least one water-quality indicator for 12 of the 13 cases. Most noticeable were changes in average dissolved oxygen—12 of the 13 rivers evidenced improvements. Improvement in maximum biochemical oxygen demand of more than 15 milligrams per liter was reported in 5 cases. In every case, maximum ammonia concentrations decreased, in several instances by significant percentages. These results are summarized in table 4.3 (see page 61 in chapter 4).

We found this report to be more sound methodologically than the other reports with respect to explaining causality, but still it had some shortcomings. The data showing an association between changes in various water-quality measures and program funding for improvement in wastewater-treatment levels were presented clearly. In almost all cases, the changes in water-quality measures were consistent with the hypothesis that improvements in water would stem from improvements in the level of treatment.

For the most part, temporal order was clearly presented. Simply stated, the finding was that improvements in water quality were preceded by treatment-plant upgrades. In other words, the hypothesized cause did in fact precede the effect.

However, alternative causes were not empirically ruled out. The case studies were selected so that all other influences, such as stream flow and industrial discharge, would vary as little as possible from "before" to "after." Therefore, the report assumed that all changes in water quality were the result of upgrades funded by construction grants. We question the validity of this assumption on the three points discussed below.

1. The comparison of data at two separate points in time is not a trend analysis. The characteristics of flowing water can vary from day to day or hour to hour with no relationship to effluent from treatment plants. Consequently, comparing only two points years apart can lead to incorrect inferences.

2. In 1 of the 13 cases, the time between the completion of the upgrade and the "after" measurement was relatively short—less than 1 year. Thus, even if the change was in the proper direction, there can be little confidence in anything other than that a short-term variation was being measured. In 2 other cases, the "before" data preceded the treatment-plant upgrade by 10 years or more, causing some doubt as to the relevance of the data, especially as an isolated data point.

3. With time intervals of 9 years or more between the "before" and "after" data in 5 of the cases (the longest interval was 18 years), the reasonableness of assuming that all other variables remained constant is open to question. Further, there may have been a selection bias in the choice of dates for the "before" data. The "before" data point for 5 of the 13 cases was before the passage of the 1972 legislation. Since there is general agreement that the waters were heavily polluted before 1972, selecting pre-1972 data increased the chances of "finding" an improvement or, at a minimum, no further deterioration.

However, the causes of improvements after 1972 are not clear. For example, industrial-effluent standards, permits, and enforcement actions had been established, and these and other actions related to the Construction Grants Program should have been considered. Unfortunately, Before-and-After Case Studies did not try to account for causes of water-quality improvement that did not have to do with the program.

Our conclusion is that Before-and-After Case Studies attempted direct measurement of the effect of upgrading treatment plants through construction grants, but we found some methodological problems that limit the evidence that the upgrades were the cause of improved in-stream water characteristics.

Geological Survey

The Geological Survey's National Water Summary 1983 provided no information on this evaluation question.

Summary Studies

Neither of the two summary studies directly addressed the effect of the Construction Grants Program on water quality.

Studies in Progress

Before attempting to synthesize the information we have presented in this chapter, we examined several other efforts in progress. EPA has under way an attempt to model the effects of the Construction Grants Program on the management of municipal wastewater treatment. The state of Maryland is conducting before-and-after studies on sewage-treatment plants. The U.S. Geological Survey is extending the information reported in National Water Summary 1983. And we are in the process of developing a method for evaluating the Construction Grants Program (in which the present report is a first step).

Municipal Wastewater

EPA has developed a new tool to relate municipal wastewater-treatment management directly to water quality and designated uses. Known as the "construction grants evaluation and network tracking system" (COGENT), the tool consists of (1) a quantitative data base for stream systems, pollution sources, and water-quality conditions and standards; (2) a water-quality model that bases simulations of dissolved oxygen and ammonia levels in streams on different hypotheses about treatment-plant funding; and (3) a reporting system that displays the results of the simulations and the contents of the data base. As stated by EPA, COGENT is expected to help answer the following questions:

1. How can initial estimates of the effect of treatment-plant construction funds on water quality under the Federal Water Pollution Control Act Amendments of 1972 be established?

2. What improvements in water quality and water use were achieved by construction-grant funding between 1972 and 1984?

3. What improvements in the use of water could result from meeting the remaining needs of the population for municipal wastewater treatment?

4. What are the relative contributions of municipal point sources, combined sewer overflows, and nonpoint pollution sources to water quality and water use?

5. How do the distribution and magnitude of the need for municipal wastewater treatment relate to stream flow, hydrological regions, and state water-quality standards?

With COGENT, EPA intends to establish, for 1984, baseline water-quality conditions resulting from existing industrial and municipal discharges. EPA intends also to estimate the extent to which past and present changes in municipal effluent loads affect the baseline water-quality conditions. Unfortunately, the draft analysis we reviewed gave little information about how the figures had been derived. In our opinion, the full use of COGENT for evaluation depends on the extent to which the model's data and methods can be tailored to retrospective analysis.

Sewage Treatment in Maryland

Officials of Maryland's Office of Environmental Programs told us of their venture in designing and implementing methodologically sophisticated case studies for determining water quality both before and after the construction of sewage-treatment plants and plant upgrades. The office has developed plans for or has already begun studies on the treatment of 16 water bodies. (See table 6.5.)

Table 6.5: Maryland Before-and-After Studies in Progress

	Measurement	
Area	**Before**	**After**
Ongoing		
Sewage treatment plant		
Ocean Pines	Completed 1983	Unknown
Pittsville	Completed 1983	Projected 1986
Emmitsburg	Completed 1983	Projected 1987
Manchester	Completed 1983	Projected 1988
Perryville	Completed 1983	Projected 1988
Hampstead	Completed 1984	Projected 1987
Oakland	Completed 1984	Projected 1988
Delmar	Completed 1985	Unknown
Smithburg	Completed 1985	Unknown
River system		
Antietam Creek	Not applicable	Completed 1985
George's Creek	Completed 1984	Projected 1987
Port Tobacco	Completed 1984	Unknown
Bennett Creek	Completed 1985	Unknown
Mattawoman Creek	Completed 1985	Unknown
Expected		
Sewage treatment plant		
Old Town	Anticipated 1986	Unknown
Westminster	Anticipated 1986	Unknown

Source: Maryland State Office of Environmental Programs.

The studies will be similar to one another in several respects. All will attempt to carefully collect a range of physical, chemical, and biological indicators before and after the intervention at sampling locations that remain consistent for each treatment plant. This will allow appropriate comparisons. Measurements will be taken under strict quality-control guidelines delineated in a quality-control plan.

Although the several studies will have different sampling periods and frequency, all are designed for measurements throughout a period of time rather than merely at two points in time. Therefore, it is more likely that incorrect inferences about causes of change in water quality can be avoided.

All the studies will be based on measurements taken from an extensive series of sampling stations running along the length of a stream. In some cases, these will be augmented by transect sampling, which measures across the width of a stream rather than along its length. This too will help rule out alternative explanations for observed changes in water quality.

Each study is designed to employ multiple outcome measures (physical, chemical, biological, or bacteriological). Most include physical and chemical measures such as flow, temperature, pH, and dissolved oxygen. The biological measures are typically benthos and fish species. Bacteriological measures include coliform and fecal coliform bacteria.

The Maryland studies differ from one another in the following respects: (1) the type of intervention, some being new treatment plants and others upgrades; (2) the number of sampling stations will vary from 6 to 54 per intervention; (3) the length of the sampling period will be as short as 2 weeks or as long as 2 years; (4) the frequency of sampling will be weekly in some cases and quarterly in others; (5) some studies will measure chemical factors unique to a site (such as total aluminum, nonfilterable residues, orthophosphate, or pheophytin).

Maryland estimates that it will probably be 1987 or 1988 before enough case studies have been completed to determine the success of the project. But it seems reasonable to expect that when these studies have been completed, they will permit better estimates of the effectiveness of sewage-treatment plants than are now available.

In-Stream Chemical Parameters

Data the Geological Survey presented in National Water Summary 1983 show whether in-stream chemical parameters at water-quality monitoring stations changed between 1974 and 1981; the analysts are working on a study that will expand this work. To the data from about 300 Geological Survey stations, this effort will add data from approximately 100 EPA monitoring stations.

The study is an attempt also to expand the previous analyses with ancillary data in the hopes of better interpreting why changes in in-stream water quality did or did not occur. For example, data on the characteristics of sewage-treatment effluents will be compared with in-stream chemical measures to test the hypothesis that levels of point-source treatment-plant pollution are associated with in-stream water-quality changes. Similarly, nonpoint-source pollution is being analyzed by a comparison of data on agricultural practices with in-stream chemical measures. The results of this effort are still preliminary and cannot be reported here.

GAO Case Study Project: A Proposed Evaluation Method for the Construction Grants Program

At GAO, we are developing a methodology for evaluating the effects of upgrading sewage-treatment plants with funds from construction grants. Our approach is to relate in-stream chemical and biological indicators of water quality, measured at fixed monitoring stations, with the intervention of construction-grant funding and indicators of treatment-plant effluent, as reported in EPA's discharge-monitoring reports. The methodology is being tested on a number of river reaches in Pennsylvania.

We intend to rely most heavily on dissolved oxygen (expressed as a deficit). We are also examining other in-stream measures (biochemical oxygen demand, total organic carbon, fecal coliform bacteria, suspended solids) where they are available, relevant, and reliable.

We will compare preconstruction and postconstruction in-stream water-quality indicators and examine effluent-load records for other discharges on the river reach. Two discrete sets of indicators—measurements taken both upstream and downstream of the sewage treatment plant—will be compared and the difference tested for statistical significance. We expect to apply the flow-adjustment procedures developed by the Geological Survey to the raw data and statistically reduce the before-and-after data to the same flow level. To attribute any change discovered by this procedure to treatment-plant upgrades, we will have to exclude alternative explanations. We expect to do this quantitatively, by accounting for effluents discharged by other sources.

Synthesis

What is known about the effects of the Construction Grants Program on the quality of the water in the nation's rivers and streams? Published before 1984, some assessments have been made of the effect of individual treatment-plant construction on local water quality, and some national studies have related program funding to effluent loads and its removal but not to in-stream water quality. The five primary reports that we reviewed provided little information beyond that presented in the previous assessments.

Taken together, the studies we reviewed may tentatively indicate some effect of the program, but they reveal little if any knowledge of the extent of this effect. Their failure to identify and control for or eliminate alternative explanations of observed changes in water quality severely limits the usefulness of their findings. Our evaluation of results of the five studies on this question is summarized in table 6.6.

Table 6.6: Our Evaluation of Five Reports on the Question of the Effect of the Construction Grants Program

Report	Conclusions	Our evaluation
Inventory	Evidence of national change in effluents; funded plants not separated from others; some states report using funded plants	Some defensible judgments that funded plants reduced pollution discharge and some examples of effects on chemical indicators or designated use
STEP	Noticeable nationwide improvement in water quality; modest per capita expenditure for municipal sewage systems	Evidence that funded plants reduced pollution discharge but no evidence of link to in-stream characteristics; thus, no direct evidence of improved water quality
Fisheries survey	Not addressed; some data from which inferences can be drawn	Survey may be used to infer that sources other than treatment plants probably have a greater effect on fish
Before-and-after case studies	Dissolved oxygen and ammonia improved in 12 cases, biochemical oxygen demand in 9, biological measures in 1	Results fairly well supported by data; design and case selection do not permit generalization to the nation or examination of alternative causes
Geological survey	Not addressed	None

The state 305(b) reports cited individual examples of successful effects from the program. These examples cannot, however, be assumed to represent national effects. Too many projects were not addressed, and the projects that were addressed may have been biased toward "success stories."

The STEP report and Before-and-After Case Studies suffered from the failure to consider alternative causes for water-quality improvements, although their conclusions rested on different methodological strengths in addressing the effectiveness of the program. In STEP, most rivers were found not to have improved in their ability to meet designated uses; where some improvement was noted, it had occurred during a period of increased and quite substantial program funding. However, the analysis did not match rivers that improved in their ability to meet designated uses against rivers where projects were upgraded with construction-grant funds. In looking for causality, STEP did not test for alternative factors, whether point or nonpoint, that could have affected water quality.

Before-and-After Case Studies attempted to avoid this problem by selecting for analysis rivers where the differences in various factors, such as water flow, were minimal and by providing some qualitative explanations of the conditions relevant to each case study. In our opinion, however, alternative causes of change in water quality were not adequately addressed. This is especially a weakness because the analysis considered only two data points rather than the many data points of a trend analysis.

Overall, we conclude that after 13 years and $37 billion of federal funding, there seems valid reason to believe that the Construction Grants Program reduced the discharge of effluents into the nation's rivers and streams, but there is almost no systematic evidence on the program's effect on in-stream water characteristics, capability for designated use, or socioeconomic value. Other ongoing efforts mentioned in this chapter may help explain the relationship between treatment-plant construction and upgrading and in-stream water quality, but this remains to be demonstrated.

Conclusions, Recommendations, Agency Comments, and Our Response

Conclusions

What is the present condition of the nation's water quality? The water in some of the nation's rivers and streams is fairly good in quality, although some water bodies are polluted. Viewed as a whole, the studies we reviewed support this statement, even though individually they have methodological limitations in their establishment of effects and in the generalizations they permit.

How has the nation's water quality changed over time? The evidence is strong that nationally the discharge of conventional water pollutants from point sources has been reduced. Pollution control efforts have had an effect. What is less clear from the reports we examined is the effect this has had on water quality. Data from the studies indicate no change in water quality for most of the rivers that were examined. In some instances, water quality has improved, but opinions differ on how much. However, it is not insignificant that the water quality in many rivers has been maintained, despite a growing population and economy.

What pollution sources degrade water quality? Many factors can and most likely do degrade water quality. Although the relative effects of separate factors are not clearly known for the nation as a whole, nonpoint-source pollution may affect more stream miles than point-source pollution. This opens the question of where and how funds should be spent to improve water quality the most effectively.

What has been the effect of the Construction Grants Program on water quality? The Construction Grants Program has certainly reduced the discharge of pollutants from wastewater-treatment plants into the nation's rivers and streams. Little methodologically defensible work has been done to determine the program's effects on in-stream water characteristics and other aspects of water quality. The question of whether the amount of pollution being discharged from wastewater-treatment plants has been reduced can be answered in the affirmative. But the effect on water quality is not yet answerable.

This evaluation question has not been fully addressed because of significant data gaps. One gap is the absence of any analysis of a national sample of construction-grant projects. Another is the lack of data and analysis directly linking the funding of construction grants to in-stream water quality instead of to effluent load from treatment plants. A third and related problem is the lack of information and analysis to rule out plausible alternative explanations for changes in water quality such as nonpoint-source and industrial pollution.

Some of STEP's reporting format was included in the most recent section 305(b) report. The water-quality experts we interviewed generally agreed that a more uniform reporting process, such as that used in the STEP report, is important if attempts to determine water quality are to succeed. In our opinion, however, uniformity of format alone is not enough. A greater and more uniform use of quantitative data is also required.

Any future effort to repeat the STEP process will have the benefit of fairly complete 1982 data as a baseline for comparison, avoiding some of the problems that arose in the 1984 STEP report because baseline data were missing. However, there is general agreement that a period as long as 5 to 10 years is required for water-quality changes to be evidenced. Therefore, 1987 may be the earliest date for which the 1982 data could usefully serve as a baseline. We believe nonetheless that future STEP efforts are likely to provide much useful information on water quality.

Despite the publication of the five studies we examined, the sparseness of empirical data means that little information is available for legislative decisions regarding the reauthorization of the Clean Water Act. As a result, policymakers will have to rely on considerations other than the cost-effectiveness of the Construction Grants Program.

Recommendations

If one assumes that some level of Construction Grants Program funding will be reauthorized, information will be needed on the effects of the program. We recommend that EPA

1. perform methodologically sound research that will allow a comparison of the cost-effectiveness of the Construction Grants Program with other abatement possibilities such as industrial point-source control and nonpoint-source abatement programs and

2. encourage the states to use multiple measures and standardized objective data in preparing information for future section 305(b) and STEP reports. The states might identify the sources of critical data, indicating, for example, whether their data were derived from objective physical, chemical, or biological measures, subjective judgments by experts, or a combination of these.

Agency Comments and Our Response

The U.S. Environmental Protection Agency, the U.S. Department of the Interior, and the Association of State and Interstate Water Pollution Control Administrators provided general and specific comments on a draft of this report. Their letters are printed in appendixes IV-VI. In response to some of their comments, we made specific changes where appropriate in the final draft of the report or noted them in the appendixes. The general comments are discussed below.

EPA

The Environmental Protection Agency attributes two premises to our work that we did not rely on and then comments that it disagrees with each premise. First, EPA states that it does not believe that the authorization level for federal financial assistance should be commensurate with water-quality improvements derived from municipal treatment works. Instead, EPA believes that financial assistance should be commensurate with the nation's ability to continue to fund such programs in the face of a budgetary deficit. However, EPA is mistaken in attributing to us the argument that funding should be linked to water-quality effects. Rather, we agree that funding limitations are a major consideration, and it is for this very reason that we are suggesting that the results of a methodologically defensible evaluation of the Construction Grants Program would help target the scarce funds that are available. There is a need for better data and evaluation, irrespective of whether funding for wastewater treatment comes from the federal government or other sources.

Second, EPA believes that the Clean Water Act gives the states the flexibility to pursue nonpoint-source pollution controls and believes that it is not necessary for the Congress to choose between point-source and nonpoint-source controls in authorizing federal funds. We do not suggest that the Congress make an exclusive choice. We do, however, realize that funding is not unlimited, even for solving major and significant problems, and we recognize that EPA may have to direct more of the limited funds to abate pollution at one source rather than another.

We did not begin our effort with any specific beliefs regarding the degree of effort that should be devoted within EPA to devising strategies to mitigate pollution from nonpoint sources. But none of the studies that we examined presented evidence to suggest that voluntary controls have served in the past to mitigate pollution from nonpoint sources. The recognition by the Congress of the significant effect of nonpoint sources on water quality is reflected in H.R. 8, which would amend section 101(a) to make it a national policy that "plans for the control of nonpoint sources of pollution be developed and implemented in an expeditious manner so as to enable the goals of this Act to be met through the control of both point and nonpoint sources of pollution."

Moreover, other Senate and House bills would add important new authority and responsibility for EPA and the states to come to grips with nonpoint-source pollution. In this regard, we commend EPA for its efforts to collect much-needed data on the extent and severity of nonpoint pollution.

We state in our report that we identified some methodological limitations in the studies we reviewed, but EPA does not believe these to be methodological flaws. EPA comments that in most instances, the studies met their design objectives and accurately reported their findings and the limitations of the findings. EPA believes, therefore, that we would be more accurate if we stated that the studies have methodological limitations relative to the purposes of our investigation. In our draft, we had already acknowledged that the studies we reviewed were designed with objectives different from those of our study and that not all the studies should be expected to, nor did they, address all our evaluation questions. Nonetheless, this does not change the fact that several of the studies have major methodological problems. Generalizing to the nation from a biased sample, for example, is inappropriate.

EPA also directly addresses our recommendations (in the draft, we called them matters for consideration), agreeing with us that funds should be allocated for evaluations and that multiple measures should be used. EPA states that it has already begun work in these areas. We believe that EPA's efforts are laudable, but we suggest that further work is required on how to address the four evaluation questions we have posed in this report.

EPA disagrees that it should perform research comparing the cost-effectiveness of the Construction Grants Program and other pollution abatement possibilities. In its comments, EPA argues that both point and nonpoint pollution must be controlled. This is exactly our belief. Unfortunately, in an era of limited funds (federal or state funds) and major pollution problems, difficult choices have to be made. In particular instances, this may require the decision that one pollution source is more harmful than another, and to be abated sooner, and a determination of where pollution-abatement funds would be the most cost-effective. Better data and analyses may not make these difficult choices easier, but they would increase the likelihood of making the most informed decisions.

EPA disagrees with our conclusion that the studies that are available do not document that the Construction Grants Program has improved water quality throughout the nation. To the contrary, EPA says that Before-and-After Case Studies, the rigorous study of 13 wastewater-treatment plant upgrades around the country, does document an improvement. We agree with EPA that the Construction Grants Program may be considered a success by one measure, the amount of pollutants discharged into rivers. The wastewater-treatment plants funded under the program have diverted massive quantities of material from the nation's waters and, as we have stated in our report, the degree of change appears to be so large that water quality must have improved in many instances. But there is little evidence to indicate the degree of improvement.

We believe that Before-and-After Case Studies constitutes an important methodological advance in designing studies to determine whether, in individual cases, sewage-treatment plants have brought about improvements in water quality. But the case studies report should not be mistaken for something that it is not. It is not an evaluation of the Construction Grants Program. The cases for study were selected ad hoc, and we find it surprising that EPA would consider that a single review of 13 sewage-treatment plants could provide evidence sufficient to demonstrate the effectiveness of the Construction Grants Program, in light of the fact that the 13 plants are a very small segment of the total universe of projects for constructing sewage-treatment plants that have been completed under the 1972 Federal Water Pollution Control Act Amendments. And the case studies report does not indicate whether there may have been alternative explanations for the results that were found.

Although EPA agrees with our belief that the results from the section 305(b) reports cannot be generalized to all bodies of water in the nation, it contends that the reports "include a reasonable, though not necessarily statistically-based, sample of waters with known or suspected water quality problems."[1]

[1]This reinforces our response to what we believe is ASIWPCA's major criticism of our report. STEP, like the section 305(b) data, claims to have been based on a sample of rivers with water-quality problems. Therefore, in EPA's words, its "results are not generalizable to all waters."

The 305(b) process serves a number of important functions, most notably as an archive for each state's views on progress toward meeting the goals of the Clean Water Act. But because of its varying sampling designs and differing standards of measurement, it does not adequately address our four evaluation questions. This is not a criticism of the 305(b) format; it is only a statement that the aims of section 305(b) studies diverge from our own.

EPA contends that we overstate the role of subjective judgment in water-quality assessment in the 305(b) process. We say in our report that for certain rivers, water-quality assessments were based on the general impressions of state officials. Our interviews with state officials, and our review of the literature, including the 305(b) reports, support this statement.

The Department of the Interior

The comments from the Department of the Interior were developed by the Geological Survey. The Geological Survey agrees that the conclusions we reach are fundamentally correct. It comments that the data are too sparse and that all the existing programs and studies have methodological problems that prevent them from providing the amount and type of information needed for making the necessary policy decisions about water-quality programs.

One important area of disagreement raised by the Geological Survey is our characterization of the NASQAN monitoring system and the interpretation of its data. The Geological Survey comments that although the NASQAN monitoring system is not nationally representative, NASQAN would probably give a better approximation of the effectiveness of the Construction Grants Program than a random sample. We are not convinced by this argument.

First, the Geological Survey has not released a study reporting how far downstream NASQAN stations are from the wastewater-treatment plants that have received federal funds. Whether the 300 NASQAN stations downstream from treatment plants are situated well enough to determine changes in water quality resulting from treatment-plant construction is therefore unknown to us. A direct sample of the river reaches on which the plants are located would be preferable to NASQAN data. Second, for evaluation questions about the condition of the nation's waters and how they have changed over time, we continue to believe that a statistically representative sample of rivers or other water would give more valid and reliable answers. This is meant not as a criticism of

NASQAN but only as a statement of its limitations with respect to the evaluation questions we posed for our study.

The Department of Interior, through the Geological Survey, also finds fault with our treatment of the National Water Summary 1983 discussion of trends in water quality between 1974 and 1981 at Geological Survey monitoring stations. We conclude in our report that the published findings demonstrate that there was no major change in water quality during the period of study at the stations that were sampled. The Geological Survey argues that nitrate showed increases at many more stations than it showed decreases at and observes that fecal bacteria counts showed far more decreases than increases. In chapter 4, we cite the improvement in fecal streptococci (which is much more notable than that for fecal coliform bacteria), and we include the figures on the trend in nitrate and nitrite in table 4.4, although we do not discuss the latter in the report, because the overall trend is far less clear. There was a significant decrease at 8.2 percent of the stations and at the same time there was a significant increase at 25 percent.

The Geological Survey argues that National Water Summary 1983 provides some information relevant to evaluating the Construction Grants Program, pointing out that the decrease in fecal bacteria at many stations "suggests the possibility that the widespread improvements in sewage treatment during that period [1974-81] have had a positive effect on stream sanitation." The Geological Survey also observes that statistically significant changes in dissolved oxygen levels were uncommon at NASQAN stations during that period and draws the conclusion that "the effects of the [Construction Grants Program] on water quality may have been different with respect to different measures of water quality."

We acknowledge in our discussion of National Water Summary 1983 in chapter 4 that it is significant that close to 29 percent of the NASQAN stations showed a significant decrease in fecal streptococci during the 7-year period. The point we make is that no detailed assessment of effectiveness has been conducted. It has not been shown that NASQAN stations are particularly well situated with respect to treatment plants funded by construction grants to detect changes in their effluent load. There is no evidence in Department of the Interior data showing that either (1) wastewater-treatment plants are located on the streams and are close enough to the NASQAN stations to produce measurable effects at those stations or (2) treatment plants located on streams were upgraded through construction-grant funding during the period of study. It is possible that changes in the NASQAN stations that showed improved levels of contaminants were caused by an abatement of pollution from industrial discharge. In summary, the evidence from the NASQAN network contained in National Water Summary 1983 is too equivocal to be cited as evidence either for or against the assertion that the Construction Grants Program has had an effect on the nation's water quality.

ASIWPCA

The Association of State and Interstate Water Pollution Control Administrators raises four general objections to our draft report. It alleges a bias on our part against the use of expert judgment in water-quality assessment. It supports the propriety of generalizing to the nation from a judgment sample of rivers. It argues that we fail to recognize that state officials are expert on the issues in question. It asserts that we take a "negative tone" with regard to the STEP report.

We have no problem with the appropriate use of judgment in water-quality assessment. Rather, we are concerned about the lack of data-reliability checks. Nowhere in our report do we condemn, nor do we intend to condemn, the proper use of best professional judgment in conducting water-quality assessments. We do question too great a reliance on best professional judgment without adequately controlling for measurement error, especially to ensure that reliability issues are addressed. In the STEP report, we found an absence of reliability checks, particularly the development of the estimates for water quality in 1972, a point 10 years prior to when the questionnaires were distributed. Our report contains a number of illustrations of our argument that the conclusions drawn in the STEP report were weakened by the unknown reliability of responses. Our review of the 37 evaluation questionnaires returned to ASIWPCA indicated that 25 states had problems estimating water quality in 1972 and raised serious concerns about the validity of the data.

ASIWPCA raises a rather surprising methodological issue when arguing that it is not necessary to draw a random sample in order to generalize to the nation with regard to water quality. We are unable to find a similar claim in any other literature on methodology. On the contrary, it is quite generally accepted that a random sample must be drawn from a population if a generalization is to be made to that population. The STEP report draws a generalized conclusion about all the nation's waters: "The water is cleaner." Even its title, America's Clean Water, makes a generalized statement. We appreciate that STEP represents a secondary data analysis and that the original data were not representative. Our point is that such data cannot support STEP's conclusion on the nation's water quality. In other words, the problem we have is not with the data and their judgmental nature but, rather, with the drawing of a conclusion from them without a notation of their limitations.

We recognize the fact that state officials possess expertise about some rivers and that it is important to seek information from individuals who are sufficiently familiar with water quality to make informed judgments. We do not in the least contest ASIWPCA's assertion that state officials possess important and underutilized information on water quality and its trends. However, judgments are judgments, and methodologically they must be recognized as judgments.

The point in the preceding paragraph is related to another point that ASIWPCA raises in its comments. In a number of places, ASIWPCA comments that the state respondents to its questionnaire are very familiar with rivers and streams whose water quality is poor. It argues that its judgment sample is, therefore, well suited to offering information on national issues on the waterways that have or have had most of the problems with quality. However, ASIWPCA provides no support for this argument. The STEP document does not refer to the representativeness of its sample. It does not provide evidence that the sampled waters were representative of (1) all the nation's water, (2) water that fails to meet water-quality standards, (3) water that failed to meet water-quality standards some time between 1972 and 1982, (4) water that underwent some adverse change in quality during that decade, or (5) water whose quality is adversely affected by human activity. Depending on how the study's universe was defined, the sample would be relevant to different analytical conclusions. In fact, as we point out in chapter 2, ASIWPCA requested that each state provide information on its major rivers and streams, but we have no reason to believe that the resultant sample was representative.

In answer to ASIWPCA's fourth point, we do not have a negative view of the STEP study. In principle, the notion of using a standardized format to gather information of all kinds on water quality from the states is worth while. But there were some problems with the execution of this methodology, as often happens in a first endeavor, which, if addressed, would improve similar future endeavors. Our work was intended to make this methodology as productive as possible.

Bibliography

This bibliography consists of the following categories: (1) primary sources and (2) secondary sources arranged as (a) reports by government agencies, (b) reports by states, and (c) books and articles.

Primary Sources

ASIWPCA (Association of State and Interstate Water Pollution Control Administrators). America's Clean Water: The States' Evaluation of Progress 1972-1982. Washington, D.C.: 1984.

DELAWARE Department of Natural Resources. 1982 Water Quality Inventory, 3 vols. Dover, Del.: 1982.

———. Water Quality Inventory, 3 vols. Dover, Del.: 1984.

DISTRICT of Columbia. 1982 Water Quality Assessment and Pollution Control Status Report. Washington, D.C.: 1982.

EPA (U.S. Environmental Protection Agency). National Water Quality Inventory: 1982 Report to Congress. Washington, D.C.: 1984a.

——— and U.S. Fish and Wildlife Service. 1982 National Fisheries Survey, 3 vols. Washington, D.C.: 1984b.

GEORGIA Department of Natural Resources. Water Quality Control in Georgia 1980-1981. Atlanta: 1984a.

———. Water Quality Control in Georgia 1982-1983. Atlanta: 1984b.

HYDROQUAL, Inc. Before-and-After Case Studies: Comparisons of Water Quality Following Municipal Treatment Plant Improvements. Washington, D.C.: U.S. Environmental Protection Agency, 1984.

MARYLAND Department of Health and Mental Hygiene. Water Quality Inventory. Baltimore: 1982.

———. Water Quality Inventory. Baltimore: 1984.

PENNSYLVANIA Department of Environmental Resources. 1982 Water Quality Inventory. Harrisburg: 1982.

———. 1984 Water Quality Inventory. Harrisburg: 1984.

U.S. GEOLOGICAL Survey. National Water Summary 1983—Hydrologic Events and Issues. Washington, D.C.: 1984.

VIRGINIA Water Control Board. Water Quality Inventory. Richmond: 1982.

———. Water Quality Inventory, 2 vols. Richmond: 1984.

WEST VIRGINIA Department of Natural Resources. Water Quality Status Assessment 1979-1981. Charleston: n.d.

———. Water Quality Status Assessment 1981-1983. Charleston: n.d.

Secondary Sources

Reports by Government Agencies

EPA (U.S. Environmental Protection Agency). Activities of the Grants Assistance Programs. Washington, D.C.: December 1984c.

———. Environmental Progress and Challenges: An EPA Perspective. Washington, D.C.: 1984d.

———. Guidance 1982 State Section 305(b) Reports. Washington, D.C.: 1981.

———. Guidance 1984 State Section 305(b) Reports. Washington, D.C.: 1983.

———. National Water Quality Inventory: 1974 Report to Congress. Vol. 1. Washington, D.C.: 1974.

———. National Water Quality Inventory: 1984 Report to Congress. Washington, D.C.: 1985.

———. Study of the Future Federal Role in Municipal Wastewater Treatment. Washington, D.C.: 1984e.

GAO (U.S. General Accounting Office). Better Data Collection and Planning Is Needed to Justify Advanced Waste Treatment Construction, CED-77-12. Washington, D.C.: 1976.

GAO (U.S. General Accounting Office). Better Monitoring Techniques Are Needed to Assess the Quality of Rivers and Streams, CED-81-30. Washington, D.C.: 1981.

———. Costly Wastewater Treatment Plants Fail to Perform as Expected, CED-81-9. Washington, D.C.: 1980.

———. Examination into the Effectiveness of the Construction Grant Program for Abating, Controlling, and Preventing Water Pollution, B-166506. Washington, D.C.: 1969.

———. Secondary Treatment of Municipal Wastewater in the St. Louis Area—Minimal Impact Expected, CED-78-76. Washington, D.C.: 1978.

NATIONAL COMMISSION on Water Quality. "Issues and Findings," staff draft, Washington, D.C., November 1975.

U.S. COUNCIL on Environmental Quality. Environmental Quality 1983. Washington, D.C.: 1984.

U.S. FEDERAL Water Quality Administration. Clean Water for the 1970's. Washington, D.C.: 1970.

———. Water Quality Criteria. Washington, D.C.: 1968.

U.S. GEOLOGICAL Survey. National Water Summary 1984—Hydrologic Events. Washington, D.C.: 1985.

Reports by States

ALABAMA Department of Environmental Management. Water Quality Report to Congress for Calendar Years 1980 and 1981. Montgomery: 1982.

INDIANA Stream Pollution Control Board. 1982-83 305(b) Report. Indianapolis: 1984.

Books and Articles

CONSERVATION Foundation. State of the Environment. Washington, D.C.: 1982.

———. State of the Environment: An Assessment at Mid-Decade. Washington, D.C.: 1984.

COSTLE, Douglas M. "EPA's Construction Grants Program: Perspectives on Costs." Pollution Engineering, September 1978, pp. 40-43.

DELAND, Michael R. "Sewage Treatment Construction Grants: Classic Case of Government Failure." Environmental Science and Technology, August 1981, p. 865.

ELLIS, Franklin W., et al. "Integrating Water Quality and Construction Grants Management." Journal of the Water Pollution Control Federation, September 1984, pp. 1022-29.

FEINTHEL, Roger. "Outlook for Financing Construction of Sewage Treatment Facilities." Environment Reporter, monograph 32, August 3, 1984.

LONGEST, Henry L. "The Construction Grants Program: Getting It All Together for the 80's." Water and Sewage Works, March 1980, pp. 36 and 52.

WOLMAN, M. Gordon. "The Nation's Rivers." Science, November 26, 1971, pp. 905-18.

GAO Reports Related to Water-Quality Issues

This report supplements five earlier GAO studies on the general subject of the administration of the Federal Water Pollution Control Act:

1. Examination into the Effectiveness of the Construction Grants Program for Abating, Controlling, and Preventing Water Pollution, B-166506, November 3, 1969. We found that the Federal Water Pollution Control Administration, which was then responsible for distributing Construction Grants Program funds, was not doing so in the most cost-effective manner.

2. Better Data Collection and Planning Is Needed to Justify Advanced Waste Treatment Construction, CED-77-12, December 21, 1976. We found that state and EPA data-gathering efforts on water quality were generally inadequate.

3. Secondary Treatment of Municipal Wastewater in the St. Louis Area—Minimal Impact Expected, CED-78-76, May 12, 1978. We found that the secondary treatment projects planned for St. Louis, Missouri, would have only a minimal effect on the quality of the water of the Mississippi River. We recommended that the Congress amend the Clean Water Act to eliminate the mandate that wastewater-treatment plants meet the minimum of secondary treatment.

4. Costly Wastewater Treatment Plants Fail to Perform as Expected, CED-81-9, November 14, 1980. We found that many wastewater-treatment plants had seldom if ever met their permit requirements.

5. Better Monitoring Techniques Are Needed to Assess the Quality of Rivers and Streams, CED-81-30, April 30, 1981. We examined the monitoring networks that play a central role in water-quality assessment. We concluded that too much reliance had been placed on these networks. We based this conclusion on the difficulty of assessing a stream's quality from a small number of samples from a set of widely dispersed stations.

Organizations We Contacted for This Report

We contacted two federal agencies: the U.S. Environmental Protection Agency and the U.S. Geological Survey under the U.S. Department of the Interior.

We contacted seven state agencies: the Delaware Department of Natural Resources and Environmental Control, the District of Columbia Department of Environmental Services, the Georgia Department of Natural Resources, the Maryland Office of Environmental Programs, the Pennsylvania Department of Environmental Resources, the Virginia State Water Control Board, and the West Virginia Department of Natural Resources.

We contacted two other organizations: the Association of State and Interstate Water Pollution Administrators and HydroQual, Inc.

Advance Comments From the U.S. Environmental Protection Agency

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

NOV 25 19--

OFFICE OF
POLICY, PLANNING AND EVALUATION

Mr. J. Dexter Peach
Director
Resources, Community, and Economic
Development Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Peach:

On October 11, 1985, the General Accounting Office (GAO) issued a draft report to the Environmental Protection Agency (EPA) entitled "The Nation's Water Quality: Many Unanswered Questions". This report was sent to EPA for review and comment as required by Public Law 96-226. Our general comments are provided in this letter, and technical comments on the draft report are addressed in the enclosure.

EPA found the report to contain a thoughtful and serious evaluation of some problems which we in the Agency have recognized and are attempting to address. At the same time, the Agency has some serious concerns about some of its premises and conclusions. These issues as well as the three "Matters for Consideration" presented in the report are discussed below.

See comment 1.

Premises and Conclusion: EPA disagrees with GAO's premise that the authorization level for Federal financial assistance should be commensurate with water quality improvements derived from municipal treatment works. Instead, EPA believes that it should be commensurate with the Nation's ability to continue to fund such programs in the face of our present budgetary deficit. As the Administrator pointed out in his October 8 letter to the House and Senate Conferees, the Administration believes that Federal financial assistance for the construction of municipal treatment works must be phased out as a portion of the Nation's efforts to bring its budget deficits under control.

- 2 -

See comment 2.

EPA disagrees with GAO's second premise that the Act currently does not give the States the flexibility to pursue nonpoint source pollution controls in situations where technology-based controls are insufficient to attain water quality standards. The Act and EPA's implementing regulations currently do give States the flexibility to allocate waste load reduction requirements among point and nonpoint pollution sources. However, it should be noted that such waste load allocations are limited to those instances where the pollutants in question are discharged by both sources. Such instances generally involve only a few conventional and nonconventional pollutants, and do not include many toxic pollutants. Thus, in most instances of this kind, EPA believes both point and nonpoint pollution sources will need to be controlled and we believe that it is not necessary, as GAO suggests, for Congress to choose between point and nonpoint source pollution controls in authorizing Federal funds.

Federal financial assistance for the implementation of nonpoint source pollution controls is not appropriate. As the Administrator pointed out in his October 8 letter to the House and Senate Conferees, a construction-grant type program to implement nonpoint source is not appropriate because it probably would delay voluntary implementation of controls.

See comment 3.

EPA disagrees with GAO's conclusion that available studies do not document that the Construction Grants Program has resulted in water quality improvements. As discussed in more detail in the enclosed technical comments, EPA believes that the available studies do demonstrate that point source controls are achieving significant water quality improvements. In particular, in 12 of the 13 "Before and After Case Studies", dissolved oxygen levels increased after municipal treatment works began operation. The report discounts the more probable conclusion from these significant findings by hypothesizing that this water quality improvement could have resulted from some pollution control measures other than municipal treatment.

See comment 4.

Moreover, both the House and Senate have passed bills which would reauthorize the Construction Grants Program. Neither bill contains any provision which would weaken the Act's requirement for municipalities to provide wastewater treatment sufficient to meet technology-based standards, or, if necessary, any more stringent water quality-based requirements. Neither bill contains any provision which would change the statutory deadline for achieving these standards. Thus, the Congress apparently has decided that municipal wastewater treatment should continue to be an essential part of the statutory scheme to protect the Nation's waters.

- 3 -

Now I would like to turn to the three "Matters for Consideration" presented in the study. I will address each of these separately.

1. Congress should consider developing legislative language requiring evaluation of the Construction Grants Program (CGP).

See comment 5.

EPA agrees with evaluating the environmental results of the Construction Grants Program, whether or not it is required by law. We are currently working with our Regional and State offices to assess past progress and to project future progress as the CGP strives toward the water quality and public health improvement goals of the Clean Water Act. We are also considering ways to continue measuring progress through our formal program accountability systems.

2. Congress should consider requiring EPA to perform research comparing the cost-effectiveness of the CGP and other water pollution abatement possibilities.

See comment 6.

While EPA agrees it is important to consider cost-effectiveness in the Agency's decisions, EPA does not believe the proposed research is warranted. First, the results of the proposed research would not be useful, since under the House and Senate bills, Construction Grants will not be funded after FY 1990. Second, as discussed above, the Act presently provides States with the flexibility to allocate any necessary water quality-based load reductions among point and nonpoint pollution sources. Third, as discussed above, EPA believes both point and nonpoint sources will need to be controlled in most instances where technology-based controls are insufficient to achieve water quality standards and where the pollutants in question are discharged by both point and nonpoint sources.

3. EPA should consider encouraging states to use multiple measures and standardized objective data in preparing future 305(b) and States' Evaluation of Progress (STEP) report inputs.

See comment 7.

EPA agrees with this recommendation, and had some activities underway to accomplish its goal even before we received this report. As one example, our Guidance for 1986 State Water Quality Assessments, issued June 26, 1985, contains specific instructions for States to identify the extent to which assessments were based on regular and repeated chemical and biological sampling. EPA believes this will satisfy the GAO's suggestion "to identify the sources of critical information" in future reports. In addition, the Agency held an Environmental Indicators Workshop on September 5, 1985, which resulted in a number of recommendations by the Agency's technical staff for using

- 4 -

See comment 8.

multiple measures and reporting standardized objective data to supplement current §305(b) report information. The Agency is now considering how to implement these recommendations.

EPA has two technical concerns about the study's findings. First, while the GAO has identified some methodological limitations of the studies reviewed, EPA does not believe these represent "methodological flaws." In most instances, EPA believes the studies met their design objectives, and accurately reported their findings and the limitations of the findings. It would probably be more accurate to state that the studies have methodological limitations relative to the purposes of the GAO's investigation.

See comment 9.

Second, there is an unstated implication that EPA needs always to be able to extrapolate study results to the Nation's waters as a whole. We agree it is useful (but not essential) to know with some rigor what proportion of U.S. waters are "clean" or "dirty." EPA likely will continue to focus most water quality monitoring activities on identifying and evaluating those waters with current or potential problems, since we believe this is the mandate of the Clean Water Act. Assessment efforts in waters where problems are not likely to occur will be much more limited, probably relying more heavily on statistical sampling approaches.

EPA appreciates the opportunity to comment on the draft report, and would be happy to assist GAO with revising the report.

Sincerely,

John M Campbell for

Milton Russell
Assistant Administrator
for Policy, Planning and Evaluation

Enclosure

TECHNICAL COMMENTS ON THE GAO DRAFT REPORT,
"THE NATION'S WATER QUALITY: MANY UNANSWERED QUESTIONS"

See comment 10.

Page viii, definition of Dissolved Oxygen: The second sentence could be improved to read, "It is often used as a measure of the water's ability to support fish."

See comment 11.

Page ix, definition of NPDES: This should say, "...based on technology based effluent limitations or on water quality standards."

See comment 12.

Page x, definition of point source: This should say, "Pollutants discharged through a pipe or other discrete source, usually from municipal wastewater treatment..."

See comment 13.

Page x, definition of Publicly Owned Treatment Works: This definition could be improved to read, "Publicly Owned devices and systems for the storage, treatment, recylcling and reclamation of municipal sewage, domestic sewage, or liquid industrial wastes used to implement section 201 of the Clean Water Act."

See comment 14.

Page 2-1, first paragraph, and elsewhere including pages 2-2 through 2-4, Table 3, pages 3-9 and 3-10: EPA is disappointed that the study bases its evaluation of the Section 305(b) reports on the States' and EPA's 1982 reports. Most State Section 305(b) reports improved substantially between 1982 and 1984, since EPA greatly revised its guidance for the 1984 reports (including incorporating the more meaningful measures from STEP), and since most Regions held workshops with their States in 1983 to help improve the reports. EPA published 1984 guidance on September 16, 1983. The full set of 1984 State Water Quality Inventory Reports was available in mid-1984. EPA's 1984 National Water Quality Inventory was drafted in December 1984 and published in August 1985. EPA published 1986 guidance on June 26, 1985.

See comment 15.

Page 2-3, first full paragraph: EPA agrees the Section 305(b) results are not generalizable to all waters. However, EPA believes they include a reasonable, though not necessarily statistically-based, sample of waters with known or suspected water quality problems. Many States report in detail on a 100 percent sample of waters with known or suspected problems.

See comment 16.

Page 2-3, second paragraph, and elsewhere including page 3-9: The study is incorrect in implying that major portions of the §305(b) reports are based on "general impressions of state officials" on the health of water-bodies. By far the largest source of information for §305(b) reports is actual field monitoring data -- that is, chemical/physical observations of water quality. The next most important sources of information are biological field surveys and reconnaissance surveys, followed by other forms of direct observations by water quality experts, such as fish kill investigations. We believe it is relatively rare that §305(b) assessments are based on information from a "state official" other than a water quality expert with first-hand knowledge of a river basin.

-2-

See comment 17.

Page 2-4: This page appears to be a description of the 1982 National Water Quality Inventory published in February 1984, not the 1984 National Water Quality Inventory as implied on page 2-1 and in the Bibliography. As noted above, the 1984 report is significantly improved over the 1982 report.

See comment 18.

Page 2-5, first paragraph: The amount of the grant was $211,915.

See comment 19.

Page 2-5, last paragraph: This paragraph creates an erroneous impression that the STEP report was based on multi-page mail-out "questionnaires" filled in by "heads of state environmental offices." It is true that the project developed a multi-page format for collecting data uniformly, and that the administrators of the state water pollution control programs submitted the forms when completed. However, the State administrators in turn called upon the professionals and experts in their organizations who had detailed knowledge of water quality to actually prepare the data for submission. This data compilation process took several weeks for most States. Also, the ASIWPCA staff held 2-day workshops in each Region to assist the State water quality experts in understanding and applying the reporting instructions.

See comment 20.

Page 2-6, footnote: The definition of "assessed" waters designates three categories of information for assessing waters. These are: chemical information, biological information, and professional judgment/direct observation. In no case was the State to use anything less than "direct or indirect findings" by water pollution control staff.

See comment 21.

Page 2-10, third full paragraph: The term "preliminary" findings is misleading. The published National Fisheries Survey results are "initial findings," not because they are subject to change, but rather because there may be additional findings if the existing data are further analyzed.

See comment 22.

Page 2-10, first sentence of last paragraph: This sentence could be improved to read, "In February 1982, the Environmental Protection Agency issued a work assignment to Hydroqual, Inc. to conduct an assessment of the effect of wastewater treatment on water quality."

See comment 23.

Page 2-16, first complete sentence: According to page 3-20, the State of the Environment report used the National Fisheries Survey results as well as the others mentioned.

See comment 24.

Pages 3-2, 3-5, and throughout the report: The study appears to omit or underemphasize one important category of information -- biological monitoring, including biological field assessments. Since the objective of the Clean Water Act specifically mentions "biological integrity" as well as chemical and physical integrity, this information is an essential component of water quality analysis. Biological evaluations go well beyond what a "trout fisherman" may think of the water, as implied on page 3-3, and "counts of fish caught" on page 3-5. Biological field assessments are objective scientific investigations by trained aquatic biologists. They are generally reliable and produce replicable results. EPA encourages the use of biomonitoring not only in §305(b) assessments, but also in use attainability studies and in developing water quality-based controls for toxic pollutants.

-3-

See comment 25.

Page 3-2, last paragraph, and related entry in Table 4: The most important construct should be the analysis of designated use support. Designated uses are not simply "a rough criterion" or a "construct" for water quality assessments, but are in fact the legal definition of good water quality under the Clean Water Act. The designated uses are further defined by specific numeric and narrative water quality criteria adopted in State standards and approved by EPA. They can be measured objectively by both chemical-specific measurements and by trained biologists through field surveys. The other "constructs" listed are more limited in scope and are merely approximations or surrogates to determining the actual support of the designated use. EPA fails to see why evaluating use support is any more "subjective" than assessments based on the other constructs. On the contrary, since it usually entails evaluation of more types of data than the other constructs, it can be viewed as a more robust analytical approach.

See comment 26.

Page 3-3, bottom paragraph: The discussion could be improved by pointing out that effluent concentrations alone are not good predictors of water quality. Other factors, such as streamflow and instream chemical reactions affect the in-stream concentrations of pollutants and their potency.

See comment 27.

Page 3-7, first continuation paragraph: The implication that the National Fisheries Survey is based on "subjective perceptions of fishability reported by biologists" is misleading. This was not a survey of sports fishermen on where the "good fishing" is. It was, in fact, a scientific assessment of the balance and biological integrity of the nation's fishery resources, including limiting factors of water quality, water quantity, habitat, and fish community. The consensus of the aquatic biologists who helped design the study is that such information is reproducible and reliable.

See comment 28.

Page 3-12, top bullet, and elsewhere including pages 3-10 and Table 9: EPA disagrees that the National Water Quality Inventory data allow no quantitative national conclusions. The 1984 report does provide aggregate statistics, and explains in some detail the limitations of the information. EPA agrees, however, that we need to clarify that the assessed waters are strongly biased toward waters known or suspected to have water quality problems.

See comment 29.

Page 3-12, bottom paragraph: EPA agrees there is a "general movement ... away from predominantly chemical data," but not solely to "best professional judgment." The main trend is to an integrated scientific analysis of chemical, physical, and biological data, often using tiered screening and evaluation techniques. For instance, EPA's recent guidance on use attainability analyses and on water quality-based controls for toxic pollutants stress these approaches.

See comment 30.

Page 3-17, bottom paragraph, as well as page 2-10, first complete sentence: The statement that the results of the National Fisheries Survey are "based to an unknown extent on the perceptions of fisheries biologists" is incorrect. Page iv of the EPA report, 1982 National Fisheries Survey,

-4-

Volume I Technical Report: Initial Findings, states that "40% of the reaches had been quantitatively or qualitatively sampled," and that "sampling occurred in surrounding cataloging units for an additional 33% of reaches." With regard to any future surveys, EPA agrees it would be desirable to supplement survey information with more field observations, but not to eliminate the existing survey information. Field observations, which fluctuate with time and location, do not substitute for the long-term knowledge of experienced fisheries biologists.

See comment 31.

Page 3-21, bottom paragraph: EPA is not aware of any States who based their designated use assessments solely on "secondary contact recreation" criteria. If they did, they were not following EPA guidance. Furthermore, the study is incorrect in implying that secondary contact recreation use equates to "fishing" -- it usually means activities such as boating or wading.

See comment 32.

Page 3-23, bottom paragraph: The National Fisheries Survey collected information on all fish species, not just sport fish. The aquatic biologists who designed and peer reviewed the questionnaire believed that distinguishing sport fish and other species of concern was useful, since they tend to be more sensitive indicators of problems. Nevertheless, the Survey report provides data and findings on the full range of fish species.

See comment 33.

Page 3-24, first full paragraph and page 5-17: For almost all pollutants, the water quality criteria to protect drinking water use are <u>less</u> stringent than those to protect aquatic life, not <u>more</u> stringent as stated by the report. Even when human health effects are the major concern for a particular pollutant, the criterion to protect human health from fish contaminated through bioaccumulation is often more stringent then the criterion to protect human health from drinking contaminated water. EPA is now conducting a Bioaccumulation Study which will look more carefully at pollutants which can affect human health through fish consumption.

See comment 34.

Pages 4-1, 4-2, and 4-14: The discussion implies that a time series analysis (i.e. trend analysis) is always preferable to a change analysis (i.e. comparing water quality between two or more time periods). This is not always true, since there are techniques for controlling for non-water quality variables in both types of analysis. For instance, as a 1981 GAO report (CED 81-30) pointed out, well designed intensive surveys can often provide more meaningful information than the simple time series generated by a fixed station.

See comment 35.

Page 4-5, first paragraph, and page 4-21: EPA agrees that 2 years is usually too short to detect water quality trends, but the study is incorrect in inferring that water quality improvements reported by States are only for 2-year intervals. The States that report trends are usually referring to much longer trend intervals, although they often unfortunately do not indicate what the interval is. EPA's 1984 and 1986 guidance explicitly requests trend information only once every six years rather than once every two years, in recognition of the longer term nature of trends.

-5-

See comment 36.

Page 4-23, first paragraph and page 7-1, bottom paragraph: EPA agrees that the STEP analysis of changes from 1972 to 1982 may be limited by the scarcity of comparable chemical and biological data. However, we believe the GAO study gives too little weight to the overwhelming observations by professional water quality experts that the Nation made great progress in reducing overt, egregious, point source-dominated conventional pollutant problems over the decade. Our concern now is whether efforts to control toxic pollutants and nonpoint sources have begun to show results: we do not yet have the data to address these issues.

See comment 37.

Page 5-1, bottom paragraph: The point of this discussion of POTWs is unclear.

See comment 38.

Page 5-15, first full paragraph: The National Fisheries Survey requested information on a number of factors which may limit fisheries, not just pollution.

See comment 39.

Page 5-17: The GAO conclusion overstates the National Fisheries Survey results. The first sentence could be improved to read, "The National Fisheries Survey found that the major causes of water quality problems in order of stream miles affected are total nonpoint sources, agricultural sources, natural sources, and total point sources."

See comment 40.

Page 5-22 and page 7-2, first paragraph: EPA agrees that nonpoint source appear to affect more stream miles than do point sources. However, this does not by itself mean that "nonpoint sources may have a larger degradin impact on water quality than does point source pollution," nor that continued strong emphasis on controlling both municipal and industrial point sources is not warranted. There are at least three reasons for this: First, we have anecdotal evidence that point source pollution where it occurs often has caused more severe effects than nonpoint source pollution, though it may be more localized. Second, the bulk of point sources tends to be clustered on about 20 percent of the Nation's stream miles, the same waters closest to population centers. Nonpoint sources tend to be more broadly distributed. Third, both municipal and industrial dischargers contribute significant levels of toxic pollutants which must be controlled regardless of nonpoint sources.

See comment 41.

Page 6-10, first full paragraph: Both the 1982 and 1984 National Water Quality Inventory reports do single out the construction grants program for discussion. The discussion in the bottom paragraph on page 6-10 and the bottom of page 6-11 show that this is true.

See comment 42.

Pages 6-18 and 6-19: The study apears to be selectively interpreting the data in Table 21 in a way which downgrades the importance of controlling POTWs. In fact, the Table can be used to make the opposite case. For instance, at least three of the top five parameters (nutrient surplus, toxic substances, dissolved oxygen and perhaps turbidity as well) are POTW-related. Furthermore, despite the fact that point sources are clustered on only 20 percent of the Nation's streams, POTWs affect the fourth largest number of stream miles (ranking behind agriculture, natural sources and silviculture/logging).

-6-

See comment 43.

Page 6-21b, Table 23: Should include the State for each facility.

See comment 44.

Page 6-22 through 6-24 and page 6-32: The purpose of the report was to present a valid methodology for assessing water quality improvements from construction of municipal treatment facilities. This required elimination of projects where other pollutant sources (e.g., nonpoint) were affecting water quality. Therefore, the comments concerning the "validity" of this approach are not appropriate.

See comment 45.

Page 6-25, second sentence: Eliminate parenthetical phrase. Second paragraph, eliminate "a new computerized model." COGENT is a data base rather than a model.

See comment 46.

Page 6-31a, Table 25: The results of the Before and After Case Studies could be improved to say "9 of 11 cases show improved biochemical oxygen demand"; and "1 of 2 showed improved biological measures." Two cases did not have data on BOD, and 13 cases did not have data on biological measures.

See comment 47.

Page 7-1, second paragraph: The statement that each of the five studies has "methodological flaws" is misleading. A "methodological flaw" implies that a study failed to meet its design criteria in some way, or misused its data. EPA believes that, with a few exceptions, all five studies met their design objectives, and accurately reported both the findings and the limitations of those findings. EPA believes it would be more accurate for GAO to say that all five studies had "methodological limitations relative to the purposes of the GAO's investigation."

See comment 48.

Page 7-3, first full paragraph: EPA is unaware of additional STEP reports being planned for the future, other than the Nonpoint Source Assessment currently underway. EPA will continue to involve the States and ASIWPCA in designing future §305(b) report guidance, however.

The following items are our specific responses to EPA's November 25, 1985, letter and are keyed to the numbers in the margins of that letter.

GAO's Comments

1. We addressed this comment in chapter 7.

2. Addressed in chapter 7.

3. Addressed in chapter 7.

4. We do not suggest that the Construction Grants Programs has been ineffective and that its provisions should be weakened.

5. Addressed in chapter 7. The three matters for consideration that appeared in the draft were revised to the recommendations that appear in the published report.

6. Addressed in chapter 7.

7. Addressed in chapter 7.

8. In our reviews of the studies, we sought to determine the methodological strengths and weaknesses with respect to our objectives but only when the objectives of the studies being reviewed matched ours. We did not find fault with the methodological work in studies that had objectives different from our own. We have modified some of the discussion in our report to avoid confusion.

9. EPA is not the only user of information on water quality. While national studies may seem "useful but not essential" to EPA, they are critical to the Congress for making environmental policy. Thus, although we agree that regional and local studies can be helpful to EPA policymaking, our objective was to critically survey the literature for studies of national water quality, water-quality trends, the sources of water pollution, and the effect of the Construction Grants Program. We endorse the use of randomized statistical techniques to acquire information on water quality that is intended for generalization to the nation, and we believe EPA should rethink this issue.

10. Change made; page viii is now page 161.

11. Change made; page ix is now page 162.

12. Change made; page x is now page 162.

13. Change made; page x is now page 162.

14. We have made the changes that are relevant. The first paragraph on page 2-1 is now on page 16; pages 2-2 through 2-4 are now pages 17-19; table 3 is now table 2.1; pages 3-9 and 3-10 are now pages 35-36.

15. Addressed in chapter 7. The first paragraph on page 2-3 is now on page 18.

16. Addressed in chapter 7. The second paragraph on page 2-3 is now on page 18; page 3-9 is now page 35.

17. Change made; page 2-4 is now pages 18-19; page 2-1 is now page 16.

18. Change made; the first paragraph on page 2-5 is now on page 19.

19. Changes made as appropriate; the last paragraph on page 2-5 is now on page 20.

20. We agree that STEP's instructions suggested that nothing less than "direct or indirect findings" were to be used to support water-quality assessments. The question is what sort of evidence would be less than indirect and therefore prohibited. Although the instructions provided a number of examples of what would be considered acceptable, they did not disclose the type of evidence that would be considered less credible than indirect findings. We are not alone in being uncertain about this point. On the evaluation questionnaire, several states commented that they had to rely on professional judgment for significant portions of it. Although some of them appeared to be confident in their accuracy, others expressed misgivings. The respondent from Arkansas stated that "Almost all of the water quality report was pure judgment, which is why we stated that the report is of limited value." The respondent from North Carolina was also only "minimally" confident in the water-quality estimates for that state. The respondent from Hawaii remarked that professional judgment had to be used for 1972 data and that only "minimal" confidence had been placed in the correctness of the results. It appears from these examples that some states were uncomfortable using "indirect findings" to assess water quality. They apparently completed the STEP questionnaire but may have given a different interpretation than EPA did to what types of data (indirect evidence) should have been used. (The footnote on page 2-6 is now footnote 2 on page 20.)

21. Change made, although "preliminary" is the term used in the national fisheries report. The third paragraph on page 2-10 is now on page 24.

22. Change made; the first sentence of the last paragraph on page 2-10 is now on page 24.

23. Change made; the first complete sentence on page 2-16 is now on page 28. Page 3-20 is now page 47.

24. We have made a reference on page 33 to indexes of biological diversity as indicators of water quality. Pages 3-2, 3-3, and 3-5 are now pages 31-33.

25. In the section of chapter 3 that EPA refers to, we presented only an outline of one system for categorizing different approaches for assessing water quality. We believe that we brought out the strengths and weaknesses of each method in the course of our report. (The last paragraph on page 3-2 is now on page 31; table 4 is now table 3.1.)

26. We do refer to the "indirectness" of effluent load measures of water quality in our discussion on page 30 (the passage on page 3-3 is now on page 32). We raise the issue again in greater depth in sections in which we examine the use in some studies of changes in effluent load as a measure of water-quality change.

27. The statement is not misleading (the passage on page 3-7 is now on page 33). The study results were based on perceptions reported by biologists, and we say the judgments were made by biologists knowledgeable about specific water segments. EPA's point about "sports fishermen" is pure rhetoric. If we erred at all, it was in attributing too much familiarity on the part of the respondents with the river segments.

28. The 1982 National Water Quality Inventory states on page 10 that "no quantitative national conclusions should be drawn from these assessments." (The passage on page 3-12 is now on page 37; page 3-10 is now page 36; table 9 is now table 3.2.)

29. We say that there is a movement toward a wider variety of measures and give best professional judgment as only one example. We have, nonetheless, made some changes in the wording on page 38. (The passage on page 3-12 is now on page 38.)

30. 1982 National Fisheries Survey reported the percentage of rivers that were quantitatively or qualitatively sampled (or of the surrounding reaches that were sampled) but did not report the proportion that were qualitative estimates, or perceptions, and the proportion that were quantitative data. (The passage on page 3-17 is now on page 44; the first complete sentence on page 2-10 is now on page 23.)

31. Some states did, in fact, substitute "secondary contact recreation" for "primary contact recreation" in making use designations. We have modified our language, however, to reflect EPA's concern regarding our description of "secondary contact recreation." (The passage on page 3-21 is now on page 48.)

32. Change made; the passage on page 3-23 is now on page 49.

33. Change made; the first full paragraph on page 3-24 is now on page 49, and page 5-17 is now page 82.

34. We agree that these approaches are different and that each is appropriate under different circumstances. Pages 4-1 and 4-2 are now page 50; page 4-14 is now page 61.

35. We acknowledge that some states probably look at intervals greater than 2 years. We have added some of EPA's suggested wording. (The first paragraph on page 4-5 is now on page pages 51 and 52; page 4-21 is now pages 65 and 66.)

36. We agree that all the information points to an improvement in the quality of the water in some rivers and streams throughout the nation. However, we had problems determining the geographical extent of improvement. Our difficulty was how to determine how much confidence to place in the findings of a report that presents methodological limitations. (The first paragraph on page 4-23 is now on page 66; the passage on page 7-1 is now on page 110.)

37. In the passage referred to, we made the observation that in certain instances, a new sewage-treatment plant may increase the amount of effluent entering a stream—for example, when the plant accepts wastes that were previously disposed of elsewhere. In other words, in the specific area in which the plant is discharging effluent, water quality may diminish, but on a broader scale it may improve. The point is that determining the marginal effect of a change is not always straightforward. (The passage on page 5-1 is now on page 68.)

38. We list all the possible causes in table 5.4. The first full paragraph on page 5-15 is now on pages 78-79.

39. These specific findings are discussed in previous paragraphs in chapter 5. Page 5-17 is now pages 81-82.

40. Changes made; page 5-22 is now page 85, and the first paragraph on page 7-2 is now on page 110.

41. We disagree. The 305(b) reports cite massive federal efforts, not just the Construction Grants Program, that could include activities such as permitting and regulating industrial discharge, which may significantly affect water quality. The 305(b) reports mention tons of pollutant removed but do not attempt to link this to in-stream water-quality changes. (The two passages on page 6-10 are now on page 92; the passage on page 6-11 is now on page 92.)

42. Some factors of pollution such as nutrient surplus and dissolved oxygen are related to wastewater-treatment plants, but turbidity and high water temperature may not be. These first two factors make up almost half the total. Further, when the second column of table 21 (now table 6.3) is examined, it can be seen that only 6.6 percent of the respondents listed municipal sources in association with water-quality problems. Many more listed factors such as agricultural and natural sources, which may not be significantly affected by wastewater treatment. (Pages 6-18 and 6-19 are now pages 98-99.)

43. Change made; table 23 on page 6-21b is now table 6.4 on page 100.

44. Our concern was not that some projects were eliminated but, rather, that for the projects that were not eliminated, no work was done to validate the assumption that no important changes occurred other than the upgrading of treatment plants. (Pages 6-22 through 6-24 are now pages 101-102; page 6-32 is now page 107.)

45. Change made; the second sentence on page 6-25 is now on page 102.

46. Our numbers and presentation are accurate. No change is needed. Table 25 on page 6-31a is now table 6.6 on page 107.

47. We have made some changes for clarification. The second paragraph on page 7-1 is now on page 110.

48. STEP updates are reflected in the 1984 section 305(b) reports, as we say in our report. We also say that all future efforts would benefit from better baseline data. (The first full paragraph on page 7-3 is now on page 111.)

Advance Comments From the U.S. Department of the Interior

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

NOV 26 1985

Mr. J. Dexter Peach
Director, Resources, Community and Economic
Development Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Peach:

This is in response to your request of October 15, 1985, for our comments on the draft of your proposed report entitled The Nation's Water Quality: Many Unanswered Questions. Enclosed are the comments prepared by the U.S. Geological Survey on this report. We concur with these comments and made them available to the Fish and Wildlife Service for their review. The Fish and Wildlife Service informed us that they have no further comments to offer on the draft report.

Sincerely yours,

Acting Assistant Secretary--Water and Science

Enclosure

United States Department of the Interior

GEOLOGICAL SURVEY
RESTON, VA. 22092

OFFICE OF THE DIRECTOR

In Reply Refer To:
WGS-Mail Stop 105

NOV 26 1985

Mr. J. Dexter Peach
Director, Resources, Community, and
Economic Development Division
General Accounting Office
Washington, D.C. 20548

Dear Mr. Peach:

Enclosed is the review you requested of the draft General Accounting Office Report "The Nation's Water Quality: Many Unanswered Questions." If you have any questions regarding the review, please call the Survey's Chief Hydrologist, Philip Cohen, 860-6921.

Sincerely yours,

Doyle G. Frederick
Associate Director

Enclosure

November 13, 1985

U.S. Geological Survey Review

U.S. General Accounting Office Draft Report

"The Nation's Water Quality: Many Unanswered Questions"

The General Accounting Office (GAO) draft report examines five key studies of the Nation's surface-water quality. The draft report considers the ability of each of these studies to fill the "information gap" concerning current water quality, water-quality changes, sources of pollution, and the effects of the sewage treatment plant Construction Grant Program (CGP). All five of the studies examined by the GAO were conducted by, or funded by, Federal agencies. One of the five studies is the U.S. Geological Survey's (USGS) 1983 National Water Summary. The basic conclusion of the draft report (as stated in the executive summary) is "The sparseness of the empirical data, the existence of a number of methodological problems in each study, and the inherent difficulties in evaluating changes in the Nation's rivers and streams mean that little conclusive information is available for the coming policy debate on the Clean Water Act."

See comment 1.

The Geological Survey agrees that the GAO examined, with one exception (see below), the most relevant set of recent studies on the subject of the Nation's surface-water quality and that the GAO reached conclusions that are fundamentally correct. The data are indeed too sparse, and all existing programs and studies have methodological problems which make them unable to provide the amount and type of information needed for making the necessary policy decisions about the Clean Water Act. In fact, the U.S. Geological Survey has stated essentially this conclusion in a number of Congressional hearings. Recognition of the inadequacy of existing programs of water-quality data-collection and assessment has led the Geological Survey to develop a proposal for a "National Water Quality Assessment Program." This program is designed to provide an improved

2

information base for evaluating the need for, and effectiveness of, a variety of costly Federal or State programs related to water quality.

The following comments, organized by chapter, relate to the interpretations of data from the USGS National Stream Quality Accounting Network (NASQAN), and to the content of the 1983 USGS National Water Summary, which served as one of the primary sources for the GAO draft report. The comments also mention two other activities of the Geological Survey which the GAO draft report does not mention. One is the 1984 National Water Summary which was not available when GAO made its analysis. The other is the proposed program of the Geological Survey in the area of water quality. Consideration of these comments and inclusion of these additional topics would strengthen the GAO's report and make it more complete, but would not substantially alter its final conclusions. These general comments are followed by a short list of detailed editorial comments.

Chapter II states that NASQAN is not nationally representative, i.e., that station location is not based on a probability sample of streams nationwide. We agree that NASQAN station locations are not based on a probability sample. However, most river reaches in the Nation are rural in nature, and a random sample of all streams is probably not desirable for evaluating the success of the Construction Grants Program (CGP) in meeting the goals of the Clean Water Act. NASQAN stations are both widely distributed geographically and located on large rivers relatively close to populated areas. In this respect, NASQAN is probably superior to a random sample of all reaches in terms of its utility in examining the effects of human activity on water quality, and of water quality on water use.

See comment 2.

3

See comment 3.

Updating the GAO report to incorporate the 1984 Water Summary findings along with those of the 1983 Water Summary would be appropriate. In fact, the 1984 National Water Summary contains a more detailed description of trends in selected water-quality measures, and includes an attempt to relate trends to recorded changes in sources of pollution. Although these analyses were not designed to evaluate the effectiveness of the CGP, they do demonstrate that major changes have occurred in certain water-quality constituents, especially nutrient loads which are potentially affected by upgrading of sewage treatment plants (STP's).

See comment 4.

Chapter III states that the 1983 Water Summary does not provide any information on current water-quality conditions in U.S. rivers. It is true that NASQAN data were used in the 1983 National Water Summary to assess water-quality changes rather than current water-quality conditions. However, the 1983 Water Summary includes rather extensive State-by-State summaries of current water-quality conditions. It should also be noted that NASQAN data have been used in a variety of other publications to describe current water-quality conditions.

See comment 5.

Chapter IV concludes that there has been "no major change in water quality between 1974 and 1981 at USGS monitoring stations" based on the fact that, for each water-quality constituent examined, less than a majority of stations showed a significant change over the study period. However, for certain important water-quality measures, more than one-quarter of the stations do show significant trends. For example, nitrate, which is an important nutrient contained in waste-treatment discharges, showed increases at far more stations that it showed decreases. In contrast, fecal bacteria counts showed far more decreases than increases, which may have been related to the quality of sewage discharges.

The conclusion reached in Chapter IV that no change has occurred in water quality is also based on the proposition that examples of degradation in some measures of water quality are balanced by improvements in other measures. Over the last decade, STP upgrading has encompassed a variety of technologies and could be expected to affect different aspects of water quality in different ways. In summary, Chapter IV (also Chapters V and VI) would benefit from a more detailed assessment of the chemical and biological trends presented in the 1983 and 1984 National Water Summaries.

See comment 6.

See comment 7.

According to Chapter V, the 1983 National Water Summary provides no information on the question of what pollution sources are currently degrading water quality. While an interpretation of the causes of water-quality trends at NASQAN monitoring stations is not provided in the 1983 Water Summary, the 1984 Water Summary does include an analysis of the influence of nonpoint-source pollution on four key water-quality measures. Moreover, the 1983 National Water Summary does discuss the important factors responsible for water-quality degradation within each State.

See comment 8.

Chapter VI concludes that the 1983 Water Summary provides no information for evaluating the effect of the CGP on water quality. It is true that the causes of trends presented in the 1983 Water Summary are not known with certainty. However, the high frequency of decreases in fecal bacteria counts from 1974 to 1981 at NASQAN stations suggests the possibility that the widespread improvements in sewage treatment during that period have had a positive effect on stream sanitation. Conversely, trends in dissolved-oxygen concentrations at NASQAN stations are uncommon, and preliminary analyses indicate that the relatively few trends that did occur are not well correlated with recorded changes in sewage-treatment plant discharges. This suggests that the effects of the CGP on water quality may have been different with respect to different measures of water quality.

See comment 9.

Inasmuch as Chapter VI deals with the plans of the various agencies to remedy the shortcomings in existing water-quality data bases, it would be appropriate for the GAO report to include a brief discussion of the proposed National Water Quality Assessment Program mentioned above. The purpose of this program is to provide a much more detailed and consistent description of the status of water quality; to detect trends in quality, and to relate the trends to changes in land use, waste treatment, and other factors; and to provide predictive information useful for making water-quality management decisions in specific problem areas. The proposed program considers the quality of surface water, ground water, and precipitation.

For surface water, the proposed program builds on the fixed-station monitoring approach used in NASQAN, increasing the density of stations in a large number of river basins to facilitate detection of trends and the tracking of the transport of substances through the river system. It also uses synoptic sampling techniques to objectively identify and determine the extent of river reaches with certain catagories of water-quality problems. Finally, it involves the use of intensive sampling and modeling of the processes occurring in selected problem reaches, leading to an evaluation of problem-solving alternatives.

There has been no formal publication on this proposal, and it was only in the early stages of discussion at the time the GAO report authors made their contacts with the Geological Survey. However, during the past several months this proposed program has been subjected to review internally in the USGS, by the Department of the Interior, the Environmental Protection Agency, the Department of Agriculture, the National Academy of Sciences, and a wide variety of other interested agencies and groups. Most of the reviewing

6

agencies and individuals have commented that, if implemented, the program would make a significant contribution to future evaluations of the effectiveness of, and need for, the CGP and other significant Federal water-quality programs.

List of Detailed Editorial Comments

	Location	Correction
See comment 10.	Table 3	"Approximately 500 monitoring stations" should read "Approximately 300 monitoring stations"
	"	"between 1975 and 1981" should read "between 1974 and 1981"
	"	"Non-parametric Statistics" should read "Statistical trend analysis of water-quality monitoring data"
See comment 11.	Page 2-12 line 20	"more than 500" should read "more than 300."
See comment 12.	Table 10	"504 USGS monitoring stations" should read "313 USGS monitoring stations"
	"	"1977-81" should read "1974-81"
	"	"11 chemical parameters" should read "22 chemical parameters"

The following items are our specific responses to the November 26, 1985, letters from the U.S. Department of the Interior and the U.S. Geological Survey, and they are keyed to the numbers in the margins of the letters.

GAO's Comments

1. We reviewed National Water Summary 1984 after we completed our analysis. It presented important information on pesticide contamination at 150 monitoring stations that we summarize on page 64.

2. We addressed this comment in chapter 7.

3. We did not include this new information because we did not find that it would change our conclusions.

4. We did not find the state-by-state summaries to be of assistance in answering our evaluation questions.

5. We addressed this comment (which refers to chapter 4) in chapter 7.

6. We chose not to do this analysis (the comment refers to chapters 4-6) because of the difficulty of associating trends at NASQAN stations with sewage-treatment plant upgrades (we address the comment further in chapter 7). We understand that this kind of detailed assessment is the focus of work under way at the Geological Survey.

7. Although there may be an association between nonpoint sources of pollution and trends in dissolved solids, suspended sediments, phosphorus, and inorganic nitrogen, it does not provide direct information on our evaluation questions.

8. Addressed in chapter 7.

9. Doing as the Geological Survey suggests would require our performing substantial additional work on a system that currently is only being proposed.

10. All the suggested changes to table 3 (now table 2.1) have been made.

11. The change to page 2-12 (now page 25) has been made.

12. All the suggested changes to table 10 (now table 4.1) have been made.

Advance Comments From ASIWPCA

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

ASIWPCA

ASSOCIATION OF STATE AND INTERSTATE WATER POLLUTION CONTROL ADMINISTRATORS

November 7, 1985

J. Dexter Peach, Director
Division of Resources, Community
and Economic Development
and
Eleanor Chelimsky, Director
Division of Program Evaluation
and Methodology
US General Accounting Office
Washington, DC 20548

Dear Mr. Peach and Ms. Chelimsky:

In response to your request regarding the draft report, The Nation's Water Quality: Many Unanswered Questions, the following comments are provided. ASIWPCA appreciates this opportunity to review the document.

As you know, ASIWPCA represents the State officials responsible for implementing the Clean Water Programs. The ASIWPCA leadership does not concur with the very negative tone of your report. The conclusions rely on a small sample of State staff and unsubstantiated subjective judgements such as "we believe," "we feel," and "we assume." It is incongruous that your major objection to our document, America's Clean Water, The States Evaluation of Progress, is its alleged "subjectivity."

Your report's bias against "best professional judgment" is not supported by the facts. The States used primarily a combination of chemical, physical and biological information to complete the America's Clean Water survey format. This was supplemented by best professional judgment. Some of the data States used are no doubt further evaluated elsewhere in your report. It is important to note that several States completed the format using only hard, statistically verified data, but they found that the results were not consistent with actual water conditions. Therefore, best professional judgment and direct observation are valid assessment techniques.

HALL OF THE STATES • 444 NORTH CAPITOL STREET, NW • SUITE 330 • WASHINGTON, DC 20001-1512 • (202) 624-7782

J. Dexter Peach and Eleanor Chelimsky
November 7, 1985
Page 2

GAO's suggestion that States randomly assess waters is not a useful approach to achievement of the Clean Water Act goals. America's Clean Water is a more meaningful sample because it is highly representative of the polluted waters of the nation. States and the US EPA have collected data using standards methods on these waters for many years; large automated data bases have been developed for storing and analyzing that information. Although historical data is limited, the report does not acknowledge that significant progress has been made in understanding and controlling water pollution using this information.

ASIWPCA appreciates GAO's review of our effort and agrees that more effective monitoring and data collection is necessary to enhance the information base. However, State Water Pollution Control Agencies represent the largest most knowledgeable repository of expertise this nation has on water quality. Until America's Clean Water, information available nationally was generally anecdotal. The data consolidated and arrayed by ASIWPCA provides the most complete compilation ever published. Whatever limitations there may be in current water quality data, America's Clean Water is an effective tool for States' management of the Clean Water Programs. The GAO report fails to acknowledge these significant achievements.

A list of our specific comments on the draft proposed report is attached. We would be pleased to work with you and your staffs to assure that your critique of America's Clean Water is as accurate as possible.

Sincerely,

Robbi Savage

Roberta (Robbi) J. Savage
Executive Director

Attachment

Comments on the Draft GAO Report

See comment 1.

1. Table 3. This table indicates the data evaluated was a "Combination of subjective and objective data." Also a "combination of professional judgement and objective data." The STEP project concentrated on the use of objective data first with best professional judgement used only where objective data was not available. The way Table 3 is worded would lead the reader to believe the opposite was true.

See comment 2.

2. Page 2-5. The STEP process was a State initiative carried out by the ASIWPCA. The statement "...EPA decided that revised reporting requirements were necessary...Consequently, it awarded..." is thoroughly misleading indicating EPA was the originator and prime force behind this project.

See comment 3.

3. Page 2-6. The assessed sample of rivers and streams represents a natural selection process carried out by State water pollution control agencies over the ten to twenty year evolution of monitoring, assessment, and enforcement programs. State agencies are regulatory by nature, thus monitoring strategies (with the exception of trend monitoring networks) necessarily focus on problem areas. The stream miles assessed in the STEP project represent the waterways in the nation which historically and currently have the vast majority of water quality problems both from point and nonpoint sources of pollution. The criticims in the GAO report concerning the lack of a random, statistically representative national sample are unfounded in this case.

See comment 4.

4. Page 2-7. The report makes a great deal of the response of "several States" concerning 1972 data. How many respondents had objective data for 1972? How many did not? Is not equal time from a respondent with objective data appropriate to balance the quote from the respondent in Montana?

See comment 5.

5. Page 2-8. The reliance on the responses from one respondent, in this case Montana, threatens the objectivity of the GAO report conclusion. Was this the only state to have such problems with the STEP format?

See comment 6.

6. Page 3-1. The assumption that there are unlimited ways in which data can be collected and analyzed is difficult to accept with respect to such basic analyses as dissolved oxygen, temperature, pH, and fecal coliform; the basic parameters on which water quality standards are assessed. Standard methods have been established for these parameters for many years.

See comment 7.

7. Page 3-12. The STEP project "as a whole" was not a movement away from objective chemical and biological data. Objective data was the primary focus with professional judgement a secondary position. This can be seen by a review of Table 7. Two-thirds of the criteria was based on objective chemical and biological information.

See comment 8.

8. Page 3-12. State water pollution control agencies represent the most knowledgeable resource to evaluate water quality conditions in the United States. In many states staff have been with the agency since the late 1960s. Monitoring programs were initiated in the late 1960s and early 1970s in most states and have been ongoing since that time. Based on

a 10-15 year evaluation period it is likely that the vast majority of water quality problems have been identified and assessed in most states.

See comment 9.

9. Page 3-14. Considering the fact that State water pollution control agencies are regulatory by nature and focus on problem areas, it can be assumed that the vast majority of all water quality problems have been assessed over the past 15-20 years of monitoring program history.

See comment 10.

10. Page 3-17. The GAO conclusion does not take into consideration that the "26 percent" assessed represents the majority of all water quality problems and the focus of monitoring efforts over the past 15-20 years. The GAO conclusion could state that "Considering the 26 percent of rivers assessed represents the vast majority of rivers with current and historic water pollution problems, the STEP report presents a useful evaluation of current water quality."

See comment 11.

11. Page 4-1. The fact that the majority of the nation's waters have not been improved or degraded is a major accomplishment. This point was emphasized in the STEP report. The wording presenting this point in the GAO report, "they may have only kept up with new sources of pollution" is a negative way of presenting a significant accomplishment.

See comment 12.

12. Table 10. We assume the word "ancecdotal" is a typographical error and the word anecdotal was intended. We do not believe that "anecdotal" represents the intent of best professional judgement.

See comment 13.

13. Page 4-7. The GAO report fails to accept the fact that the streams assessed by the STEP project are those with water quality problems. Water pollution control professionals nationwide accept this fact. This basic disagreement creates the skepticism expressed in the GAO Report. The "STEP judgement sample" is highly representative of the polluted waters in America.

See comment 15.

15. Page 4-11. The GAO conclusion is unwarranted due to a failure to understand the significance of the STEP sample and the disagreement concerning the relative worth of the best professional judgement of experienced water pollution control engineers and scientists.

See comment 16.

16. Page 5-1. The last paragraph on the page is unclear. The elimination of a poorly treated municipal or industrial point source by pumping to a well operated plant obviously reduces pollution.

See comment 17.

17. Pages 5-11,14,15. The GAO uses a small sample of eight states to support conclusions concerning the objectivity of pollution source determinations. In any case, ASIWPCA and EPA agreed following the STEP project that a similar project was needed to more fully define nonpoint source problems. The SNAAP project was conducted to more fully evaluate nonpoint source problems. This could be noted in the GAO report.

See comment 18.

18. Pages 6-15,6-18. The STEP report is unfairly critized for not directly addressing the impact of the construction grants program on water quality. This was not the goal of the STEP project.

See comment 19.

19. Page 6-17. The GAO report states that the STEP report "discusses several possible extraneous variables or alternative causes." The STEP report

very clearly states that "Great progress has been made in national water cleanup during the past decade. It has been a combined effort. State, Federal, and Local agencies have together carried out the mandate set by Congress in 1972 The public has been supportive and industries have contributed and complied." These are not extraneous variables. Industry and municipal (Construction Grants Program) clean-up efforts are the primary reasons behind improved water quality in 1982.

The following items are our specific responses to ASIWPCA's November 7, 1985, letter. The first page of the letter contains, in paragraphs 2 and 3, comments about "very negative tone," "unsubstantiated subjective judgments," and " 'best professional judgment' " that we have responded to in chapter 7. The rest of our responses are keyed to the numbered comments on the attachment to ASIWPCA's letter.

GAO's Comments

1. We have interchanged "subjective" and "objective" in table 3, now table 2.1.

2. We have changed the wording of this passage to reflect the important role that representatives of state governments had in initiating the STEP project. (Page 2-5 is now page 19.)

3. We addressed this comment in chapter 7; page 2-6 is now page 20.

4. In fact, 25 of the 37 state respondents to ASIWPCA's evaluation questionnaire cited some problem with the 1972 data. One respondent indicated that "It was hard to find useable data for 1972. Data was sparse and scattered in many sources. Comparison of units between '72 and '82 was not difficult, but information was so limited it was hardly worthwhile." Another state raised an objection to using 10-year-old judgments: "In most cases 1972 data was not available and professional judgment had to be used. Unfortunately, most of the staff working with this questionnaire were not working for the state in 1972." One respondent went so far as to say, "Since such judgments cannot be defended with hard data, they are subject to legitimate criticism and challenge." This sample represents the trend of the comments in the 25 responses. Subjective data would be useful if they were reliable, but ASIWPCA did not verify that the states were providing reliable subjective information. (Page 2-7 is now page 21.)

5. Nine of the 37 respondents to ASIWPCA's evaluation questionnaire stated that they had only minimal confidence in at least some components of the STEP report where little or no objective data were available. One state respondent argued that "almost all of the water quality report was pure judgment." We used Montana as an example. (Page 2-8 is now page 22.)

6. We take issue with ASIWPCA's characterization of this point, made in chapter 3 (page 3-1 is now page 30). We argued not that there are "unlimited" ways to collect and analyze water-quality data but that

there are many ways in which water quality can be defined. We believe that ASIWPCA's comment is somewhat surprising, given that the STEP report was written partly because of dissatisfaction with traditional measures. We reiterate what ASIWPCA must already accept—that although water-quality standards focus on a certain set of "conventional" measures, there are other "objective" measures. Evidence throughout the country shows that rivers have been degraded by high concentrations of heavy metals, pesticides, and other organic chemicals. Moreover, diurnal and seasonal fluctuations in stream flow, temperature, and sunlight are important mediating influences on the nominal values of conventional chemical measures such as dissolved oxygen. Whether to judge water quality by measures taken only during periods of high stress to the ecosystem or by average measures from several time periods is an important consideration, and the suitability of making flow adjustments for dissolved oxygen measurements is another. As one state official observed, data format and contents sometimes change over time, making time-series comparisons difficult. ASIWPCA's comment seems to reflect a preference for objective measures, but we believe it is advisable to supplement data from objective measures with expert opinion when it is reliable. Thus, the possible presence of standard analytical techniques for certain parameters does not necessarily mean that they are the most appropriate measures in all cases.

7. We believe ASIWPCA misunderstood our statement. The STEP analysis is a part of the movement away from predominantly chemical data and toward the use of a wider variety of indicators. We say in a number of places in our report that, properly managed, the movement is a movement forward. (Page 3-12 is now page 38; table 7 is now table 3.4.)

8. We see nothing wrong with the active use of diverse information sources, but limitations should be recognized and described. Many of the reports we reviewed contained some statement of limitations. ASIWPCA's did not. (Page 3-12 is now page 38.)

9. We do not believe ASIWPCA's assumption is valid. But even if it were, the bias caused by focusing on problem rivers should have been mentioned in the STEP report. If the statement is correct, the estimate of present water quality is biased downward; the nation's waters in 1982 were better in quality than the numbers suggest. The danger of using a nonrandom sample is that one is forced to use assumptions to estimate what the universe looks like. If the direction of a bias is known, this should be stated. (Page 3-14 is now page 43.)

10. Refer to comment 9; page 3-17 is now page 44.

11. We agree that simply having kept up with increasing pollution is an important accomplishment. We say in our report that a finding of no appreciable change does not mean that efforts to improve water quality have had no effect, but the finding that there has been little significant change is not in itself a finding about the effectiveness of efforts to control water pollution. The STEP report goes beyond asserting that there was no change in the 10-year period. It states, "The water is cleaner." We cannot agree with this conclusion, since the work that was conducted shows no improvement. (Page 4-1 is now page 50.)

12. Professional judgments from 10 years ago may be problematic. We believe that "anecdotal" is appropriate in this instance but have added "best professional judgment" to the report text. (Table 10 is now table 4.1.)

13. Refer to response 9. The STEP report did not point out the consensus among state officials that there is a close correspondence between polluted waters and monitored waters; if it had, we would have wanted to know the evidence for the assertion. One state admitted a concern regarding representativeness: "Because of the way we chose to report only 10 percent of our total river mileage, we may be understating the extent of individual toxic discharges to smaller streams." The issue in this evaluation question is the extent to which water quality changed, whether positively or negatively, during the 10 years between 1972 and 1982. The evidence would have to show that monitored rivers were representative not simply of polluted rivers but also of rivers exhibiting a nonmarginal change in water quality during that time. Evidence for the representativeness of the STEP sample is lacking. (Page 4-7 is now page 58.)

14. There is no number 14 in ASIWPCA's comments.

15. Refer to comment 13; page 4-11 is now page 58.

16. This is our point; the last paragraph on page 5-1 is now on page 68.

17. We used our findings from our extensive review of the data and all our interviews, not simply the interviews with 8 states, to support our statements of concern about the methodology. In addition to interviewing the respondents in Georgia, the District of Columbia, and the states in EPA's region III, we interviewed the ASIWPCA officials responsible

for preparing the questionnaire and the staff members who summarized its data. We reviewed STEP responses from around the country and the responses from the 37 states that completed ASIWPCA's evaluation. We checked much of the data for internal consistency and compared the responses with other data bases that were part of the public record. When we prepared our draft report, the SNAAP report was not yet published. (Pages 5-11, 5-14, and 5-15 are now pages 72 and 78.)

18. The assertion that we criticized the STEP report is incorrect. We made a statement of fact. The STEP study was not intended to directly address the issue of the effectiveness of the Construction Grants Program. But in an interview with ASIWPCA officials, we were told that the program must be responsible for water-quality improvements because there was no other reasonable explanation. Moreover, the preface to the STEP report remarked that it "portrays the State perspective on the accomplishments of the Clean Water Program and the value derived from the tax dollars and private investments made by the American people to restore and enhance the quality of our Nation's waters" (page 1). The Construction Grants Program is a major component of the Clean Water Program. The discussion in the STEP report headed "Treating Municipal Wastewater" contained the following comment: "With only a modest $260 per capita expenditure for municipal sewage system capital costs, noticeable improvement in water quality can be demonstrated nationwide between 1972 and 1982" (page 6). This statement certainly implies a direct cause-and-effect relationship between expenditures for treatment plants and improvements in water quality. We are saying not that wastewater treatment is not an influence but, rather, that it is only one of many influences whose relative contributions were not addressed in the STEP report. (Our pages 6-15 and 6-18 are now pages 94 and 96.)

19. We agree that no evidence is presented in the STEP report to indicate that the major share of any water-quality gains in the past is attributable to any single source. We used the term "extraneous variable" correctly in its methodological sense: an extraneous variable influences dependent variables but is not considered in a discussion of probable causes. To make our report clearer to the general reader, we have substituted "alternative cause" for "extraneous variable." (Page 6-17 is now page 96.)

Glossary

Advanced Treatment	Wastewater treatment beyond the secondary, or biological, stage that includes the removal of nutrients such as phosphorus and nitrogen and a high percentage of suspended solids.
Benthos	The plants and animals that inhabit the bottom of a water body.
Biochemical Oxygen Demand, or BOD	A measure of the oxygen consumed in the biological processes that break down organic matter in water. Therefore, it indicates the quantity of organic waste; large quantities of organic waste "demand" large amounts of dissolved oxygen for decomposition, posing a strain on the ecosystem. BOD_5 is a 5-day measure of biochemical oxygen demand.
Cataloging Unit	A watershed; there are 2,101 cataloging units in the 48 contiguous states.
Combined Sewers	A system that carries sewage and storm-water runoff. In dry weather, all flow goes to the wastewater-treatment plant. During a storm, only part of the flow is intercepted, because of overloading; the remaining mixture of sewage and storm water overflows, untreated, into the receiving streams.
Designated Use	The predominant use to which a body of water is put.
Dissolved Oxygen (DO)	A measure of the concentration of oxygen dissolved within a body of water, often used as a measure of the water's ability to support fish.
Effluent	The discharge from an industrial or municipal wastewater-treatment plant into water such as a river or stream.
Effluent Load	A measure of the quantity of pollution being discharged from a point source into a body of water.
Impoundment	A body of water collected and contained by damming a river.

NASQAN	National stream quality accounting network, more than 300 monitoring stations around the country at which many water-quality characteristics are measured at regular intervals.
Nitrification	The biochemical process in which ammonia is oxidized to nitrate compounds. Some treatment plant upgrades are classified as advanced nitrification treatment, with the goal of reducing high ammonia levels in the water.
Nonpoint-Source Pollution	Diffused pollution resulting from water runoff from urban areas, construction sites, agricultural and silvicultural operations, and the like.
NPDES	National pollutant discharge elimination system, a permit program that imposes discharge limitations on point sources, basing them on a technology's effluent limitation or on water-quality standards.
pH	A chemical measure of acidity and alkalinity; in water, the lower the pH is, the more acid is the water. A pH measure of 7 is neutral.
Point-Source Pollution	Pollution discharged through a pipe or some other discrete source from municipal wastewater-treatment plants, factories, confined animal feedlots, or combined sewers.
Primary Treatment	The first stage in the treatment of sewage that uses screens and settling tanks to remove material that settles or floats.
Publicly Owned Treatment Works	Publicly owned devices and systems for the treatment of municipal sewage.
River Reach	A segment of a river or stream of specific length. Most reaches extend between the points of confluence with other streams.

Secondary Treatment	The second stage in wastewater-treatment systems in which bacteria consume the organic content of wastes in trickling filters or activated sludge.
Tertiary Treatment	See Advanced treatment.
Transect	A line, strip, or profile chosen for charting and study.
Water-Quality Criterion	A scientific requirement on which may be based a decision or judgment about the ability of water to support a designated use.
Water-Quality Standard	A regulation established by government mandating enforceable limits on water quality.

☆U.S. GOVERNMENT PRINTING OFFICE:1986-491-234/02

Requests for copies of GAO reports should be sent to:

U.S. General Accounting Office
Post Office Box 6015
Gaithersburg, Maryland 20877

Telephone 202-275-6241

The first five copies of each report are free. Additional copies are $2.00 each.

There is a 25% discount on orders for 100 or more copies mailed to a single address.

Orders must be prepaid by cash or by check or money order made out to the Superintendent of Documents.

United States
General Accounting Office
Washington, D.C. 20548

Official Business
Penalty for Private Use $300

Address Correction Requested

First-Class Mail
Postage & Fees Paid
GAO
Permit No. G100