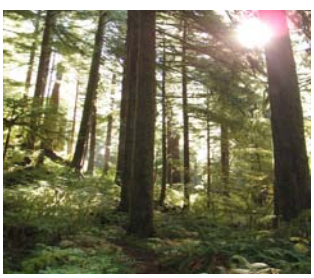
May 2009



# EVALUATION OF EPA'S TEMPORALLY INTEGRATED MONITORING OF ECOSYSTEMS (TIME) AND LONG-TERM MONITORING (LTM) PROGRAMS

Promoting Environmental Results

Through Evaluation

# Acknowledgements

This evaluation was conducted by Industrial Economics, Incorporated (IEc) and Ross & Associates Environmental Consulting, Ltd. (Ross & Associates) for EPA's Office of Policy, Economics, and Innovation under Contract EP-W-07-028. An Evaluation Team guided the effort consisting of David LaRoche, Jerry Kurtzweg, Michael Hadrick, and Michele McKeever of EPA's Office of Air and Radiation; Matt Keene of EPA's Office of Policy, Economics, and Innovation; and Nancy Tosta, Jennifer Major, Shawna McGarry, and Tim Larson of Ross & Associates. Matt Keene also served as the technical program evaluation advisor. Keith Sargent, EPA National Center for Environmental Economics; Jay Messer, EPA Office of Research and Development; and Kent Thornton, FTN Associates also provided important historical context and input regarding analysis of economic data. We would also like to thank TIME/LTM program principal investigators who agreed to be interviewed for this evaluation.

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# EXHIBITS

# ACRONYMS

| | |
|---|---|
| ALSC | Adirondack Lakes Survey Corporation |
| ANC | Acid neutralizing capacity |
| ARP | Acid Rain Program |
| CAAA | Clean Air Act Amendments of 1990 |
| CAMD | EPA Clean Air Markets Division |
| CASTNET | Clean Air Status and Trends Network |
| DOC | Dissolved organic carbon |
| EMAP | Environmental Monitoring and Assessment Program |
| ERP | Episodic Response Project |
| LTM | Long-term Monitoring |
| NADP | National Atmospheric Deposition Program |
| NAPAP | National Acid Precipitation Assessment Program |
| NPS | National Park Service |
| NSWS | National Surface Water Survey |
| NYSERDA | New York State Energy Research and Development Authority |
| OAR | EPA Office of Air and Radiation |
| OPEI | EPA Office of Policy, Economics, and Innovation |
| ORD | EPA Office of Research and Development |
| OWOW | EPA Office of Wetlands, Oceans, and Watersheds |
| TIME | Temporally Integrated Monitoring of Ecosystems |
| TMDL | Total Maximum Daily Load |
| USGS | US Geological Survey |

# EXECUTIVE SUMMARY

An evaluation of the Temporally Integrated Monitoring of Ecosystems and Long Term Monitoring (TIME/LTM) program was selected as one of five program evaluations in Fiscal Year (FY) 2009 under EPA's Office of Policy, Economics and Innovation (OPEI) 2008 Program Evaluation Competition. This evaluation includes an assessment of program design, implementation, costs, and other factors to determine program effectiveness.

TIME/LTM collects data to examine trends in surface water chemistry in response to changing air emissions and acid deposition. The program is currently managed by the EPA Office of Research and Development (ORD) which intends to discontinue funding for the program in FY 2010. The EPA Office of Air and Radiation (OAR) is likely to assume responsibility for the program and is considering needed changes and options for management. The evaluation was conducted between November 2008 and May 2009 based on approximately 25 formal interviews conducted with principal investigators working under cooperative agreements with EPA to collect TIME/LTM data, EPA managers, and other interested parties. Background research was conducted and literature reviewed.

The key findings of this evaluation were developed in response to several questions posed to interviewees, addressing program objectives, characteristics, uses, relationship to other monitoring efforts, costs, administration, and potential improvements. Summary findings are:

- The objectives of TIME/LTM have changed over time
- Current objectives are to measure patterns and trends in acidity of freshwater ecosystems and establish a long-term record of ecological conditions
- The TIME/LTM program design has changed over the years to focus on sites with long term data in the Eastern United States
- Similar chemical data are collected from current TIME/LTM sites but at different frequencies for different purposes
- TIME/LTM data are used for a broad range of purposes, but by relatively few people.
- TIME/LTM data are used to better understand patterns of and trends in acidification in freshwater ecosystems
- TIME/LTM data are used for reporting on the effectiveness of national and international programs to reduce acid deposition
- TIME/LTM data have contributed to policy development, implementation, and enforcement
- TIME/LTM data are used to contribute knowledge and understanding of interrelationships between acidification and other ecological conditions
- TIME/LTM evolved from a variety of environmental monitoring programs and continues to evolve as sites are added and deleted
- TIME/LTM is one monitoring effort among many, but is not integrated with others
- Program costs, in sum, have generally remained the same but EPA funding has declined

- Overall program costs and costs per site sampled and analyzed are difficult to ascertain
- Specific details on how cooperative agreements were established and are currently managed across sites are not clear
- TIME/LTM program data and documentation are not easily accessible
- Opportunities for cooperators to interact have been limited
- Cooperators believe that TIME/LTM data are collected and analyzed efficiently, but offered suggestions for future consideration
- Cooperators suggest additions to the types of data collected
- Expansion of sites into other geographic regions is of interest to some interviewees

Based on these findings, several conclusions were drawn. Overall TIME/LTM has been used for many purposes and appears to have met the original objectives of providing a long term data record and contributing to understanding the effectiveness of the Clean Air Act, but these objectives are currently poorly documented. While the long term data record is a valuable resource, access to the data are limited and publically available data documentation is non-existent. The years of staff experience invested in TIME/LTM represent a valuable scientific resource and this experience coupled with the long-term data record could be better used to shape future aspects of the program. The transfer of the program from ORD provides an opportunity to establish clearer management roles and responsibilities, but requires identification of stable funding. TIME/LTM is nearly invisible to most scientists other than those directly involved. TIME/LTM data frequently appear to be used in scientific publications addressing acid precipitation, but they are not always acknowledged as “TIME/LTM” and are selectively used or merged with and augmented by other lake and stream acidification measurements. TIME/LTM is a relatively small monitoring effort that could possibly be integrated with other monitoring efforts such as the emerging water quality monitoring efforts in the EPA Office of Water.

Several recommendations result from this evaluation as follows:

- Clarify the critical scientific question about acidification that needs addressing
- Provide a forum for scientists and experts with knowledge of acidification and TIME/LTM to discuss how best to collect data to address the critical question
- Examine monitoring methodologies, including frequency and parameters of data collection
- Explore options to link TIME/LTM to other long-term monitoring programs
- Provide funding to continue collection of at least a sub-sample of TIME/LTM data as program adjustments are made
- Continue to improve access to TIME/LTM data, publications, and tools
- Establish clear institutional roles and responsibilities for monitoring and data management

Appendices provide supporting information on the history of TIME/LTM, details of the program evaluation methodology, TIME/LTM publications, and an overview of other ecological monitoring programs.

# CHAPTER 1: INTRODUCTION

This program evaluation investigates the history, operations, costs, products, and perceptions of the Temporally Integrated Monitoring of the Environment (TIME) and Long Term Monitoring (LTM) programs to assess program effectiveness. TIME/LTM is currently managed as an integrated monitoring program to examine trends in surface water chemistry in response to changing air emissions and acid deposition. The evaluation was conducted between November 2008 and May 2009 based on interviews, background research, and discussions with numerous parties involved in TIME/LTM in some capacity. This report outlines the methodology used in the evaluation, summarizes the findings, and offers recommendations for possible future actions.

## I. PURPOSE/OBJECTIVES OF THE PROGRAM EVALUATION

An evaluation of TIME/LTM was selected as one of five program evaluations in FY 2009 under EPA's Office of Policy, Economics and Innovation (OPEI) 2008 Program Evaluation Competition. The evaluation entails an assessment of program design, implementation, costs, and other factors to determine TIME/LTM program effectiveness, long-term sustainability, and contributions to knowledge of ecological conditions affected by acid deposition. Assessment of these programmatic aspects of this environmental monitoring effort may also help to identify and develop performance measures for both TIME/LTM and other ecological monitoring programs, to improve overall relevance for environmental monitoring programs.

EPA's Office of Research and Development (ORD) is interested in discontinuing its funding and management of the TIME/LTM program. The Office of Air and Radiation (OAR) is a potential recipient for these responsibilities. OAR requested funds from OPEI to conduct this evaluation, in part to address opportunities for improved program effectiveness during and after this transition. The intended audience for the report and related products is both OPEI and OAR, but also includes other agencies that partner with EPA to collect and utilize ecological monitoring data, such as the National Park Service (NPS) and U.S. Geological Survey (USGS). OAR plans to use the results of the evaluation to assess the extent to which the program is meeting its objectives and identify opportunities for program improvement. OPEI may use the results and learning from this evaluation to inform planning, management and evaluations of other environmental monitoring efforts nationwide.

## II. EVALUATION QUESTIONS

The evaluation is designed to answer the following seven questions:

1. What is the purpose of the TIME/LTM program?
2. What are the key characteristics of the TIME/LTM program?
3. Who uses TIME/LTM data and for what purposes (e.g., basic research, policy development)?
4. What is the relationship of TIME/LTM to other ecological monitoring programs?

5. What are the costs associated with TIME/LTM?
6. How is TIME/LTM administered and managed?
7. What opportunities exist to improve TIME/LTM?

## III. OVERVIEW OF TIME/LTM PROGRAM

The TIME/LTM program has evolved from a variety of monitoring activities, originally started under the National Acid Precipitation Assessment Program (NAPAP)[1] in the early 1980s. Appendix A provides a history of the evolution of TIME/LTM from initial concerns about air pollution and acid precipitation. Additional details are included in the findings of this report. TIME/LTM currently supports data collection on chemical conditions in water bodies in the Northeast and Mid-Atlantic states to provide scientists and policy-makers data on patterns and trends in acidification. The principal investigators (cooperators) and other staff involved in the TIME/LTM program use EPA funding to collect and analyze data from lakes and streams in various regions susceptible to acidification. As described in more detail in Chapter 3, water samples are collected on a varied schedule, ranging from several times per month at LTM sites to once per year at TIME sites. The key chemical variables analyzed in each sample include the major acid anions (sulfate and nitrate), base cations (calcium and magnesium), pH and ANC, aluminum, and dissolved organic carbon. The data collected by the cooperators are compiled by ORD and made available for interpretation by EPA and other researchers. Numerous publications and reports addressing acid precipitation and ecological conditions have been generated based on TIME/LTM data (Appendix C).

## IV. STRUCTURE OF THE REPORT

The remainder of this document is organized into three chapters and a series of appendices. Appendix A provides background information on the history of TIME/LTM. Chapter 2 provides an overview of the methodology used in this evaluation. The entire methodology, including a list of interviewees, is provided in Appendix B. Chapter 3 describes the major findings based on the questions used in the interviews and background research conducted by the evaluators. Chapter 4 presents the conclusions resulting from the evaluation findings and the recommendations to OAR for improving the TIME/LTM program. Appendix C lists the numerous publications that have drawn on TIME/LTM data. Appendix D describes other monitoring programs potentially related to TIME/LTM.

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[1] NAPAP is a federal interagency program, originally created under the 1980 Acid Precipitation Act to conduct acid rain research and report findings to Congress for ten years. The research by NAPAP significantly contributed to the establishment of Title IV Clean Air Act Amendments of 1990 under which the Acid Rain Program was created. NAPAP member agencies include EPA, US Dept of Energy, US Dept of Agriculture, US Dept of the Interior, the National Aeronautics and Space Administration, and the National Oceanic and Atmospheric Administration

# CHAPTER 2: METHODOLOGY FOR THE TIME/LTM PROGRAM EVALUATION

## I. EVALUATION DESIGN

A Core Evaluation Team was established that consists of the contractor (Industrial Economics, Inc. and Ross & Associates Environmental Consulting, Ltd), managers and senior staff from OAR, and the evaluation lead from OPEI's National Center for Environmental Innovation, Evaluation Support Division. A Steering Committee was also established to provide broad input over the course of the evaluation. The Steering Committee was comprised of representatives from OAR, ORD, and other federal agencies that conduct ecological monitoring, including NPS and USGS. The Core Evaluation Team, with input from the Steering Committee, developed the evaluation questions referenced in Chapter 1. The following sections provide an overview of the key methodological components used to conduct this program evaluation. The entire methodology is included in Appendix B.

## II. TIME/LTM PROGRAM LOGIC MODEL

A logic model is a graphical representation of the relationships among program inputs, outputs, and outcomes (Exhibit 2-1). A logic model helps to elucidate the components, participants, and processes that affect a program and provides a key means to understand interactions and dependencies that are critical to the success of a program evaluation.

- **Inputs:** basic resources of funds, staffing, and knowledge dedicated to the program
- **Activities:** specific processes or results of the inputs needed to achieve program goals
- **Outputs:** immediate products that result from activities and often used to measure short-term progress
- **Customers:** groups and individuals targeted by TIME/LTM funding and associated activities and outputs
- **Short-Term Outcomes:** immediate uses of TIME/LTM data linked to outputs
- **Intermediate Outcomes:** changes in knowledge and understanding based on use of TIME/LTM data
- **Long-Term Outcomes:** changes in behavior based on TIME/LTM data; the overarching goals of the program

**Exhibit 2-1. TIME/LTM Logic Model Components**

Exhibit 2-2 depicts a high-level logic model of the TIME/LTM process as understood by the Core Evaluation Team prior to initiation of the evaluation. As the Team gained understanding throughout this evaluation, a more detailed logic model was developed, particularly focused on understanding the uses of TIME/LTM and is shown in Chapter 3 under evaluation Question #3.

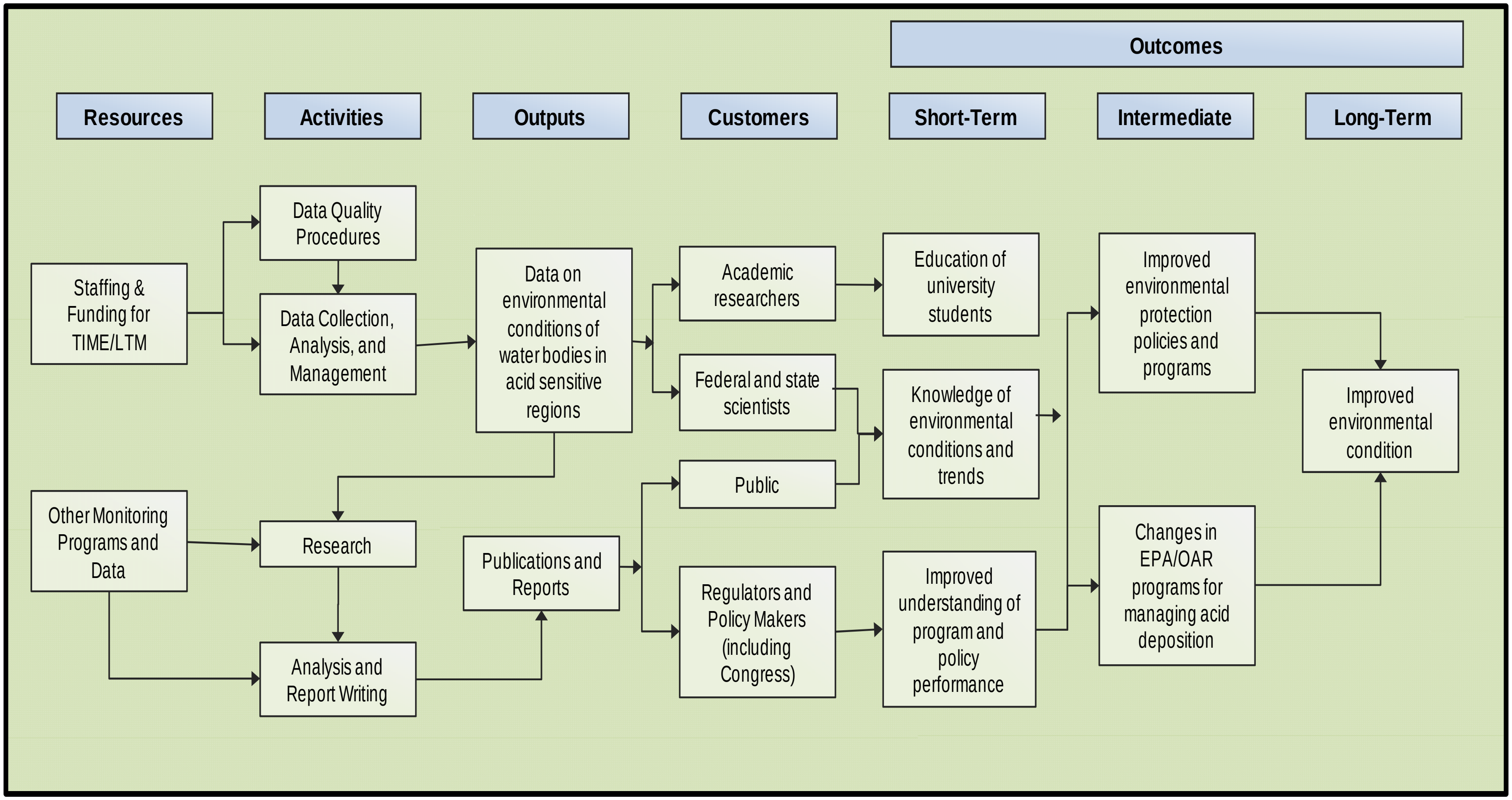


**Exhibit 2-2. TIME/LTM Logic Model**

## III. STEPS FOR CONDUCTING THE EVALUATION

Four major steps were taken to conduct this evaluation, utilizing a number of primary and secondary sources of information. These steps include: (1) identification and review of relevant documentation and literature; (2) collection of information from interviews; (3) analysis of data from documentation and interviews; and (4) preparation of the final evaluation report.

### 1. Identification and Review of Relevant Documentation

To describe the purpose, objectives, and general program characteristics of TIME/LTM, a literature search was conducted, based on program publications provided by OAR and OPEI, as well as other publicly accessible documents. Key data sources for this evaluation included:

- Research articles and other TIME/LTM-based publications from peer-reviewed scientific journals (1985-2007), compiled by ORD. The articles include a range of topics such as analysis of trends in surface water chemistry in specific geographic regions, applications of various models for detecting and predicting changes in analyte levels, and case studies on the effects of acid deposition on aquatic ecosystems. (See Appendix C)
- NAPAP reports, publicly accessible online. The most recent report (2005) is based on 2002 air emissions data, and uses quantitative and qualitative indicators to assess the effectiveness of the cap and trade approach to reduce emissions, improve air quality and reduce acid deposition while minimizing compliance costs. NAPAP also identifies emerging areas of acid rain research and long-term environmental monitoring.
- Pages of earlier NAPAP documents, as faxed and scanned from researchers' personal libraries (few are available electronically or from public libraries).
- Cooperative agreements, interagency agreements, and research proposals.
- Recent review articles and other relevant publications found through basic online literature search, using Google Scholar and University of Washington Library search engines. Key search terms included TIME, LTM, ecological monitoring, acid rain, and ecosystem acidification (Note: these searches yielded few new publications beyond the original 105 publications compiled by ORD, but the ones found provided useful information).

### 2. Collection of Information from Interviews

To identify specific uses of TIME/LTM data and the types of policy and research questions being answered, telephone interviews were conducted with a number of stakeholders from various program perspectives. The current cooperators from each of the six TIME/LTM regions were interviewed; they comprise the majority of TIME/LTM data collectors and users and publish regularly on the status and trends in surface water chemistry of acid-sensitive lakes and streams across the network. ORD contractors, funded through on-site research support contracts at both TIME/LTM laboratories (Corvallis and Cincinnati), were interviewed based on their experience with TIME/LTM data collection and analysis. Representatives from OAR, ORD, and other federal agencies and nongovernmental organizations identified by EPA were also interviewed to gather information on current and potential data uses, management and administration, and the relationship of TIME/LTM to other ecological monitoring systems. The Methodology in Appendix B provides a brief description of stakeholders selected for interviews and reasons for their selection, as well as the interview guide with detailed interview questions and sub-questions.

## 3. Analysis of Data from Documentation and Interviews

This evaluation was primarily based on a content analysis of data collected from document and literature review and interviews. The evaluation utilized qualitative interview and analysis methods. From comprehensive notes taken during interviews, responses were broadly categorized and summarized into common themes by stakeholder group. The framework for organizing information consisted of a series of summary documents to catalog themes and corresponding passages, generating support for findings, conclusions, and recommendations. Preliminary findings and recommendations were reviewed by the Core Evaluation Team.

Exhibit 2-3 below depicts the general data collection methods and sources that were used to answer each of the seven major question areas in this evaluation.

| **Evaluation Questions** | **Data Collection Method** | ***Data Source(s)*** |
|---|---|---|
| (1) What is the purpose of the TIME/LTM programs? | • Document review and literature search<br>• Interviews | • TIME/LTM bibliography<br>• ORD<br>OAR |
| (2) What are the key characteristics of the programs? | • Document review<br>• Interviews | • TIME/LTM bibliography<br>• ORD<br>OAR<br>TIME/LTM cooperators |
| (3) Who uses TIME/LTM data and for what purposes (e.g., basic research, policy development)? | • Document review and literature search<br>• Interviews | • TIME/LTM bibliography, EPA Acid Rain Progress Reports, NAPAP annual summary<br>Logic model for TIME/LTM program<br>• ORD<br>OAR<br>TIME/LTM cooperators and program managers<br>NPS, USGS, CEBC, Data Basin, etc. |
| (4) What is the relationship of TIME/LTM to other ecological monitoring programs? | • Literature search<br>• Interviews | • Publicly available documents online<br>• ORD, NPS, USGS, OW, etc. |
| (5) What are the costs associated with TIME/LTM? | • Document review<br>• Interviews | • Cooperative/interagency agreements, contracts<br>• ORD<br>TIME/LTM cooperators and program managers |
| (6) How are TIME/LTM | • Document review | • TIME/LTM bibliography |

| Evaluation Questions | Data Collection Method | *Data Source(s)* |
|---|---|---|
| administered and managed? | • Interviews | • ORD |
| (7) What opportunities exist to improve TIME/LTM? | • Analysis, development of findings and recommendations | • Information collected from 1-6 Discussions with Evaluation Team and Steering Committee |

**Exhibit 2-3. TIME/LTM Evaluation Methodological Approach**

### 4. Preparation of Final Evaluation Report

This report constitutes the final evaluation report, which has been prepared in accordance with EPA guidelines. Members of the Core Evaluation Team provided review and input on a draft of this report. Cooperators and other interviewees were also given the opportunity to review the findings and provide input on technical accuracy and completeness, prior to finalization of this document.

## IV. QUALITY ASSURANCE PROCEDURES

This evaluation required a quality assurance review of the analysis of qualitative information gathered through interviews. See the full Quality Assurance Project Plan for this analysis in methodology included in Appendix B. The following measures were taken to ensure consistency in the qualitative research process conducted for this evaluation.

1. Interview questions were emailed to the evaluation team and interview participants and followed the interview guide to ensure consistency in the way questions were asked during discussions with TIME/LTM interview participants.
2. At each interview, at least one staff person in addition to the person leading the interview was present to record notes.
3. Interview notes were compiled into summary documents, with responses to specific interview questions grouped together to facilitate their analysis and characterization.
4. For quality assurance, EPA staff, the Core Evaluation Team, and interviewees had opportunities to review the report for technical accuracy and completeness.

# CHAPTER 3: TIME/LTM EVALUATION FINDINGS

This chapter presents findings from the evaluation of TIME/LTM, organized around each of the seven evaluation questions. Based on the interviews and background research, findings are summarized below. Details are described in the remainder of this chapter.

1. What is the purpose of the TIME/LTM program?
   A. The objectives of TIME/LTM have changed over time
   B. Current objectives are to measure patterns and trends in acidity of freshwater ecosystems and establish a long-term record of ecological conditions
2. What are the key characteristics of the TIME/LTM program?
   A. The TIME/LTM program design has changed over the years to focus on sites with long term data in the Eastern United States
   B. Similar chemical data are collected from current TIME/LTM sites but at different frequencies for different purposes
3. Who uses TIME/LTM data and for what purposes (e.g., basic research, policy development)?
   A. TIME/LTM data are used for a broad range of purposes, but by relatively few people.
   B. TIME and LTM data are used to better understand patterns of and trends in acidification in freshwater ecosystems
   C. TIME/LTM data are used for reporting on the effectiveness of national and international programs to reduce acid deposition
   D. TIME/LTM data have contributed to policy development, implementation, and enforcement
   E. TIME/LTM data are used to contribute knowledge and understanding of interrelationships between acidification and other ecological conditions
4. What is the relationship of TIME/LTM to other ecological monitoring programs?
   A. TIME/LTM evolved from a variety of environmental monitoring programs and continues to evolve as sites are added and deleted
   B. TIME/LTM is one monitoring effort among many, but is not integrated with others
5. What are the costs associated with TIME/LTM?
   A. Program costs, in sum, have generally remained the same but EPA funding has declined
   B. Overall program costs and costs per site sampled and analyzed are difficult to ascertain
6. How is TIME/LTM administered and managed?
   A. Specific details on how cooperative agreements were established and are currently managed across sites are not clear
   B. TIME/LTM program data and documentation are not easily accessible
   C. Opportunities for cooperators to interact have been limited
7. What opportunities exist to improve TIME/LTM?

A. Cooperators believe that TIME/LTM data are collected and analyzed efficiently, but offered suggestions for future consideration
B. Cooperators suggest additions to the types of data collected
C. Expansion of sites into other geographic regions is of interest to some cooperators

## QUESTION 1: WHAT IS THE PURPOSE OF TIME/LTM PROGRAMS?

### FINDING 1A. THE OBJECTIVES OF TIME/LTM HAVE CHANGED OVER TIME

The objectives of LTM and of TIME/LTM have evolved since the inception of the programs. The primary current objective of TIME/LTM as a single program is to measure changing levels of acidification occurring in Northeastern and Mid-Atlantic watersheds as a means to assess the effectiveness of Title IV of the 1990 Clean Air Act Amendments (CAAA). A second purpose of the program, although not explicitly documented, is to maintain an established record of data collection for ecological research and modeling. TIME and LTM began as separate programs at different times, each with different but related purposes.

In 1982-83, under NAPAP, long term monitoring was initiated at a collection of sites previously managed by several universities and federal and state agencies. The goals of the long-term monitoring were initially to "detect and measure deposition related trends in the chemistry of low acid neutralizing capacity (ANC) surface waters, and to compare the response of these waters over geographic gradients of sulfate and hydrogen ion deposition as well as among major different geographic regions receiving comparable deposition."[2] (Exhibit 3-1)

[2] Newell, Powers, and Christie. Analysis of Data from Long-Term Monitoring of Lakes. 1987. EPA/600/4-87/014, U.S. Environmental Protection Agency, Washington, D.C.

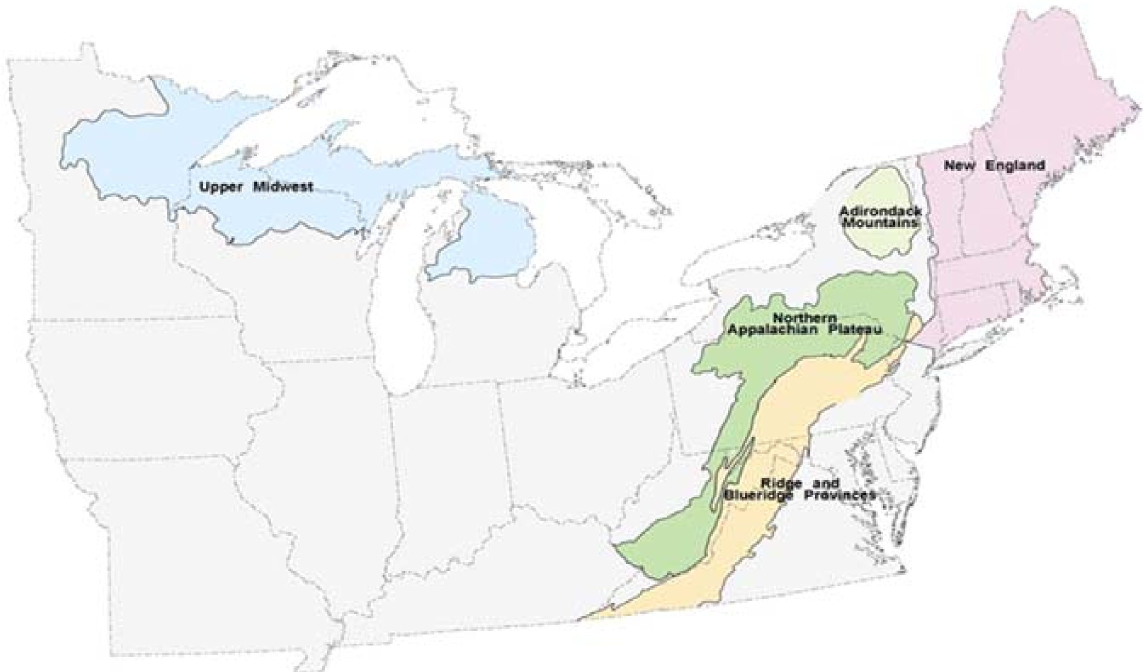


**Exhibit 3-1. Regions Identified as Acid-Sensitive in the Northern and Eastern United States**
*Source: US EPA, Office of Research and Development. Response of Surface Water Chemistry to the Clean Air Act Amendments of 1990 (2003)*

The 1986 NAPAP Annual Report describes the objectives of the "long-term monitoring effort" conducted from 1982-1986 as "(1) detect and measure long-term trends in the chemistry of surface waters with low ANC; and (2) compare chemical trends in these surface waters over gradients of acidic deposition and in different geographic areas that receive similar levels of deposition."[3] The sites comprising long-term monitoring, however, were not ideal for quantifying regional trends. Many of the sites were chosen based on availability of past sampling data and were not representative of specific regional conditions. Additionally, quality control protocols were not standardized among the study regions.

Between 1984 and 1986, the National Surface Water Survey (NSWS) was initiated under NAPAP, based on probability surveys, to document the status and extent of chronic acidification within acid sensitive regions throughout the United States. Using statistical techniques, the NSWS sampled a total of 2075 lakes in the East and 752 lakes in the West that allowed estimation of chemical conditions in 28,300 lakes and 56,000 stream reaches in all major acid-sensitive regions. The Adirondack Mountains in New York had the largest proportion of acidic surface waters (14%) in the NSWS.[4] The NSWS consisted of multiple phases that assessed not only the

[3] Herrick, Charles N. 1986. *Annual Report, National Acid Precipitation Assessment Program*. Office of the Director of Research, Washington, DC. 163pp.
[4] Stoddard, J.L., Kahl, J.S., et al. 2003. Response of Surface Water Chemistry to the Clean Air Ace Amendments of 1990. EPA 620/R-03/001.

extent of acidification, but examined periodicity of acid runoff in a subset of the original NSWS sites, based on quarterly sampling during one year.[5]

The results of the NSWS were used to consider design changes to the long-term monitoring sites, both to understand how well those sites represented changes in the regional population of surface waters and to determine measurement parameters for chemical variables (e.g., how much change must occur to indicate a trend). The 1986 NAPAP Annual Report indicates that the NSWS analyses were to be used to design the Long-Term Monitoring Project (LTMP).[6] The goal of the LTMP was to detect changes or trends in the biologically relevant chemistry of surface waters.

LTM was redesigned in 1987 with a goal "to detect and measure trends in the chemistry of low acid-neutralizing capacity surface waters over gradients of hydrogen ion and sulfate deposition and in different geographic regions receiving comparable deposition."[7] The LTM redesign selected lakes and streams in clusters, across sulfate and hydrogen ion depositional gradients, in different geographic regions of the United States. Sites for which data already existed as a part of other programs were preferentially chosen in an effort to extend the period of record for the program, and various sites were added to the LTM program at different times. For example, research in Pennsylvania watersheds began in 1988 as part of EPA's Episodic Response Project (ERP), which focused on stream chemistry during runoff events and the effects on aquatic biota. When ERP ended in 1991, the watersheds were adopted into the LTM program (as part of the Appalachian Plateau region) and the focus and sampling schedule changed to determine the effects on stream chemistry that were due to changes in atmospheric deposition. The new design allowed LTM to answer questions about the changes in individual freshwater systems related to seasonal chemistry and episodic acidification and to identify trends related to these changes over time.

TIME was planned in the late 1980s and implemented in 1991.[8] In 1990 the goals of TIME were identified as:

- Provide regional early warning signals of surface water acidification or recovery
- Provide ongoing assessment of regional patterns or trends in surface water acidification or recovery
- Assess the extent to which observed spatial and temporal patterns in surface water chemistry correspond with model forecasts

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[5] NAPAP Annual Report, 1986

[6] This appears to be the first reference to a formal program and shortly thereafter LTMP was referred to as LTM.

[7] Newell, Powers, and Christie. Analysis of Data from Long-Term Monitoring of Lakes. 1987. EPA/600/4-87/014, U.S. Environmental Protection Agency, Washington, D.C.

[8] While not explicitly mentioned by name, TIME, among other programs, was authorized in Section 7403(c)(2) of the Clean Air Act. The statute calls for the EPA Administrator to conduct a research program that includes "establishment of a national network to monitor, collect, and compile data with quantification of certainty in the status and trends of air emissions, deposition, air quality surface water quality, forest condition, and visibility impairment, and to ensure the comparability of air quality data collected in different States and obtained from different nations."

- Assess relationships between patterns in surface water chemistry and patterns in atmospheric deposition.[9]

The program was developed as a special study within EPA's Environmental Monitoring and Assessment Program (EMAP) to track in more detail the trends in acid relevant chemistry of particular classes of sensitive lakes in the northeast and streams in the mid-Appalachians. TIME was designed to enhance LTM by giving unbiased regional trend information through repeated probability surveys of surface water populations in acid-sensitive regions of the Eastern United States. As it was first described in 1987[10], the TIME program was to be a coordinated long-term monitoring effort that would obviate many of the criticisms associated with environmental monitoring systems, including those related to design and data comparability. Selected TIME sites were to include a small number of trend sites in each region, with spatially extensive, regional sites selected from a statistically distributed population. Many TIME sites were selected based on sampling done as part of the NSWS and other NAPAP-based assessments. Sites were selected to represent the regions shown in Exhibit 3-1. Some TIME sites were statistically representative of these regions and may change over time. Other TIME sites were based on longevity of record and have continued to be sampled.

TIME/LTM as a program does not represent a true probability sample as envisioned under EMAP principles. The TIME/LTM program monitors both probability and site-specific trends and seasonal variation from deliberately selected sites. With the exception of Florida, where the majority of lake acidity is due to natural organic acidity, the regions include the vast majority of acidic surface waters in the U.S. The TIME/LTM program design has changed over the years, primarily by elimination of dozens of LTM sites. All sites were eliminated in Colorado and the Upper Midwest (Michigan, Minnesota, and Wisconsin), as were almost two dozen sites in Vermont (see discussion and graphic in Finding #4). According to ORD, sites were dropped primarily because of funding cuts.

### FINDING 1B. CURRENT OBJECTIVES ARE TO MEASURE PATTERNS AND TRENDS IN ACIDITY OF FRESHWATER ECOSYSTEMS AND ESTABLISH A LONG-TERM RECORD OF ECOLOGICAL CONDITIONS.

There was consistent agreement among cooperators and officials from EPA and other federal and nonfederal agencies that the primary purpose of TIME/LTM is to measure patterns and trends in the acidity of freshwater ecosystems to determine the effectiveness of policy regulating atmospheric deposition. A second objective, if less specified or measureable, was often reported by interviewees as being of equal importance: TIME/LTM provides an established long term record of ecological conditions that can be used to track trends and develop hypotheses on ecological processes. Neither of these current objectives is consistently described in current documentation and publications.

[9] Aquatic Effects Research Program (AERP) Status, EPA, April 1990. EPA/600/M-90/001

[10] Thornton, Payne, Ford, and Landers. *The Concept of TIME*. 1987. U.S. Environmental Protection Agency, Corvallis Environmental Research Laboratory, Corvallis, OR.

In the ten-year period after the enactment of the 1990 CAAA, marked decreases in emissions of sulfur dioxide and, to a lesser extent, nitrogen oxide occurred. During this same time frame variability in climate increased and in many of the watersheds where TIME/LTM sites are found, forests matured. Atmospheric deposition and land use, vegetative cover, and soils are all known to influence the acid-base chemistry of surface water. At the TIME/LTM sites, decreased levels of sulfate and acidity were observed in three of five TIME/LTM regions. A number of cooperators interviewed expressed the view that TIME/LTM data are now providing policy-makers information on which to base decisions, but the program is only just beginning to realize its potential to increase understanding of complex ecological processes in forested watersheds.

## QUESTION 2: WHAT ARE THE KEY CHARACTERISTICS OF THE TIME/LTM PROGRAM?

Characteristics of TIME/LTM sites can be described from many perspectives. The following findings consider spatial and temporal characteristics and nature of the data collected at each site.

### FINDING 2A. THE TIME/LTM PROGRAM DESIGN HAS CHANGED OVER THE YEARS TO FOCUS ON SITES WITH LONG TERM DATA IN THE EASTERN UNITED STATES

The TIME/LTM program currently consists of fewer sites than when it began in the early 1980s. There are now approximately 286 lakes and streams[11] , collaboratively sampled and analyzed by state agencies, academic institutions, EPA, and other federal agencies. The program continues to collect a core set of chemical variables, with only minor modifications to the original TIME/LTM Quality Assurance/Quality Control protocol published in 1991.

As described under the TIME/LTM program objectives, the current TIME/LTM program began as a collection of cooperative efforts between EPA and several universities and federal and state agencies. Many sites were eliminated due to funding cuts, including all sites in Colorado and the Upper Midwest (Michigan, Minnesota, and Wisconsin), and almost two dozen sites in Vermont (see discussion and graphic in Finding #4).[12] The current program structure is a reflection of its evolution from a patchwork of monitoring sites to a cohesive network. Exhibit 3-2 shows locations of current TIME/LTM sites.

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[11] This estimate is based on data provided by cooperators and ORD for 2009, and at least six sites are sampled as both TIME and LTM. The ORD Database reports 303 current sites, more than cooperators identify. The number of sites can change year to year based on several factors, including inability to access sites due to property restrictions and weather events, and lack of funding.

[12] The Vermont region originally provided data on 36 LTM lakes. This number was subsequently reduced to 25 and then further reduced to 12, within approximately the last 10 years. According to the principal investigator in Vermont, the sampling scheme for the 12 lakes is more intensive, requiring about 80 samples per year with weekly monitoring of 7 lake outlets during spring runoff.

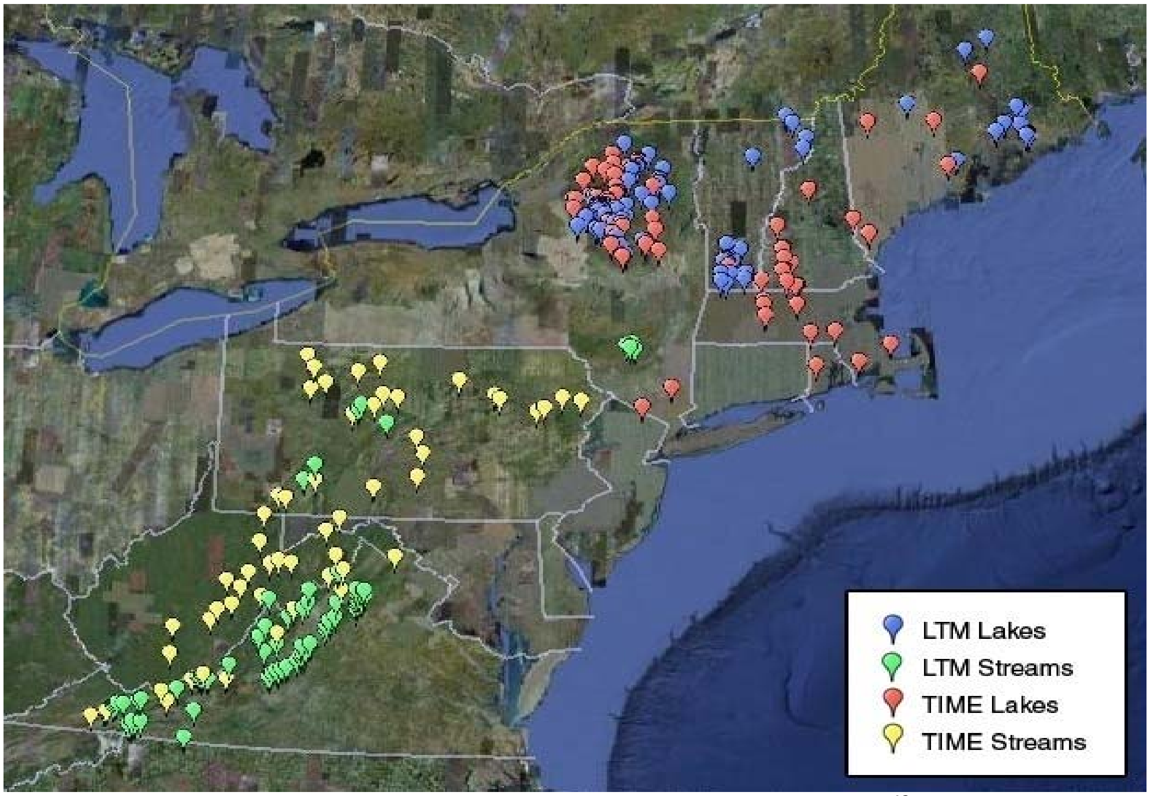

**Exhibit 3-2. Locations of TIME/LTM Sites Designated "Current" in ORD Database**[13]
*Source Map: Google Earth, Source Data: ORD*

The TIME/LTM sites represent a long term record of data. For LTM sampling, the average years of data collection for sites is 19 years and for TIME sites it is 11 years. As can be seen in Exhibit 3-3, for current sites within the ORD Database, there are significant numbers of TIME sites with more than ten years of data and LTM sites with more than 16 years of data.

[13] This mapping is based on latitude/longitude values provided for 303 sites in the ORD Database. These sites to not match the sites shown on the OAR/CAMD Web site: http://www.epa.gov/airmarkets/assessments/activesites.html

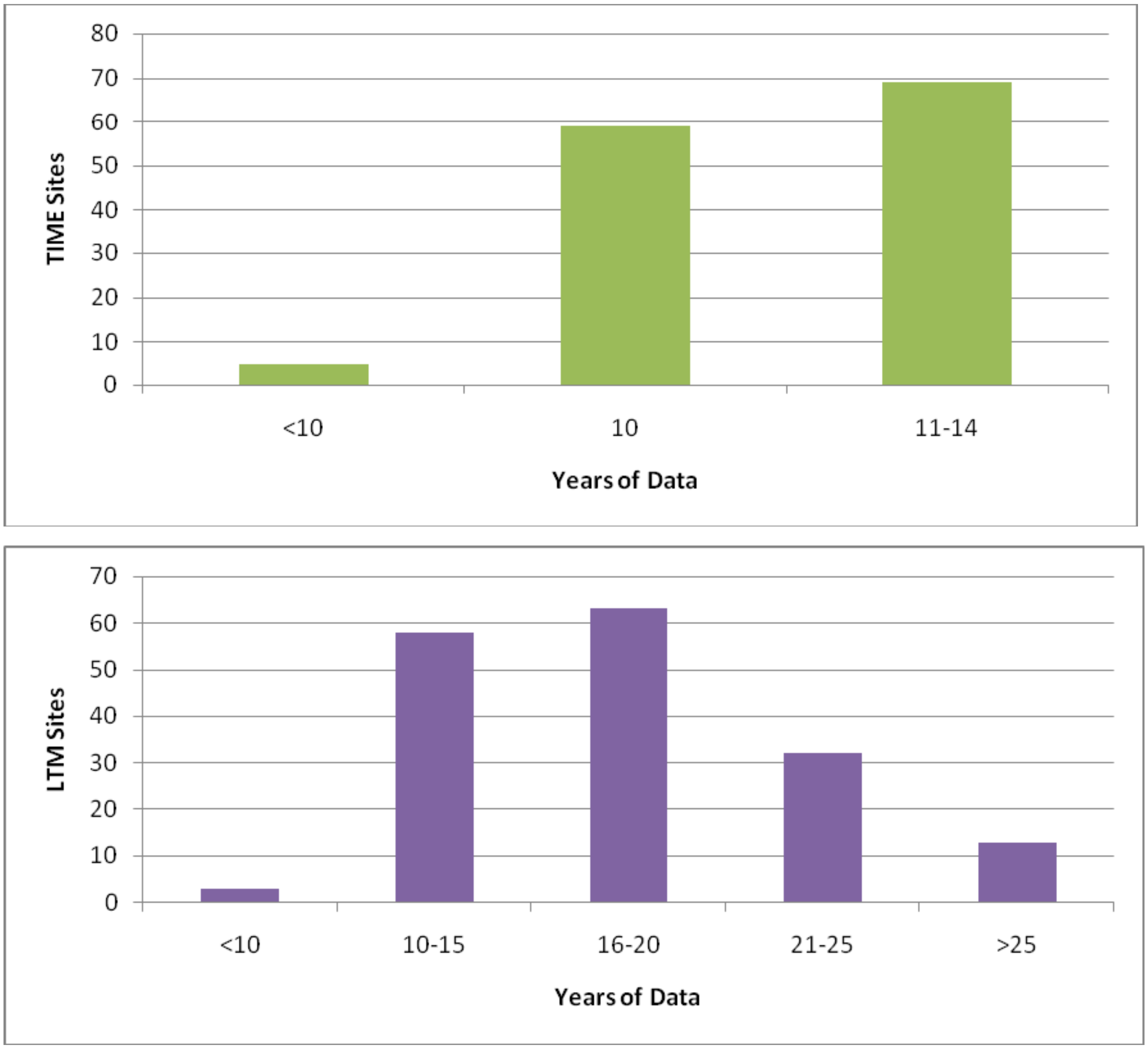


**Exhibit 3-3. Years of Record for TIME/LTM Sites**
*Source: ORD Database*

**FINDING 2B. SIMILAR CHEMICAL DATA ARE COLLECTED FROM CURRENT TIME/LTM SITES BUT AT DIFFERENT FREQUENCIES FOR DIFFERENT PURPOSES.**

The same chemical variable data are collected from all current TIME and LTM sites in each region, with the exceptions of stream flow and speciated aluminum. Exhibit 3-4 provides a summary of the sites by region, sampling frequency, and variables sampled. At each site, data on the following chemical variables are collected at least once per year: acid neutralizing capacity, aluminum, calcium, chloride, magnesium, nitrate, potassium, sodium, sulfate, and other variables including dissolved organic carbon and inorganic carbon, silicon, color, and conductivity.

**Exhibit 3-4.  Characteristics of TIME/LTM Sites**

| | Sites | Collection interval* | Major ions collected | Total $Al^-$ Collected | $Al^-$ Speciated | Limited $Al^-$ Speciation |
|---|---|---|---|---|---|---|
| **TIME Lakes**** | | | | | | |
| *Adirondacks (New York)* | 43 | Summer/Fall | X | X | X | -- |
| *Maine* | | | X | X | X | -- |
| - Massachusetts | 8 | Summer | | | | |
| - Maine | 5 | Summer | | | | |
| - New Hampshire | 14 | Summer | | | | |
| - Rhode Island | 1 | Summer | | | | |
| - Vermont | 1 | Summer | | | | |
| Total TIME Lakes | **72** | | | | | |
| **TIME Streams**** | | | | | | |
| *Northern Appalachians* | | | X | X | X | -- |
| - Pennsylvania | 22 | Spring | | | | |
| - West Virginia | 14 | Spring | | | | |
| *Ridge / Blue Ridge* | | | X | X | X | -- |
| - Maryland | 1 | Spring | | | | |
| - Pennsylvania | 3 | Spring | | | | |
| - Virginia | 14 | Spring | | | | |
| - West Virginia | 4 | Spring | | | | |
| Total TIME Streams | **58** | | | | | |
| **Total TIME Lakes and Streams** | **130** | | | | | |
| **LTM Lakes** | | | | | | |
| *Adirondacks (New York)* | 52 | Monthly | X | X | X | -- |
| *Maine* | 16 | Quarterly | X | X | -- | X |
| *Vermont* | 12 | Quarterly | X | X | X | -- |
| Total LTM Lakes | **80** | | | | | |
| **LTM Streams** | | | | | | |
| *Appalachians*<br>- Pennsylvania± | 5 | Monthly | X | X | -- | X |
| *Catskills*<br>*-New York ±* | 4 | Monthly/Episodes | X | X | X | -- |
| *Virginia Intensive ±* | 3 | Weekly/Episodes | X | -- | -- | X |
| *Virginia Extensive (Trout Streams)* | 64 | Quarterly | X | -- | -- | X |
| Total LTM Streams | **76** | | | | | |
| **Total LTM Lakes and Streams** | **156** | | | | | |
| **TOTAL TIME/LTM SITES** | **286** | | | | | |

* Samples are collected once per specified season/interval
** All TIME sites are monitored annually
± Stream flow data are collected from these sites

Exhibit 3-5 describes several of the key variables collected at current sites and their importance to ecological monitoring in undisturbed forested watersheds. Additional measurements, while not required for TIME/LTM, were established earlier by NSWS and continue to be collected by some cooperators. These measurements include titrated acidity, dissolved inorganic carbon, iron, manganese, silicates, and total phosphorus.

Stream flow data and speciated aluminum are collected from some, but not all, current TIME and LTM sites. Stream flow data are collected at 12 LTM streams in the Catskills, Northern Appalachians, and Virginia. Flow data enhances data interpretation because water can be much more acidic during times of heavy flow, such as spring runoff or after large storms. When measuring patterns and trends associated with episodic events, as LTM sampling frequencies are designed to do, the ability to control for flow as a confounding factor affecting acidity is important. Aluminum data, on the other hand, are collected from all current TIME and LTM lakes and streams, but the extent to which they are speciated into their various forms of dissolved compounds, including the toxic monomeric form, varies across the network. Total aluminum is collected and reported for all TIME sites and about half of the LTM sites. According to ORD, total aluminum as an individual measure is less important than various aluminum species as determinants of freshwater integrity.

**Exhibit 3-5. Major Variables Measured at Current TIME/LTM Sites**

*Acid neutralizing capacity (ANC)* - Widely used to measure the acidity of surface water, ANC is the amount of base in water that allows for the determination of the amount of acid required to make it acidic. The greater the ANC, the more acid is required to acidify it.

*Aluminum ($Al^-$)* - Inorganic Al- reacts with proteins and is toxic to fish and other aquatic animals. Al increases with increasing acidity and can be an indication that a watershed has been affected by atmospheric deposition.

*Calcium ($Ca^{2+}$)* - Watershed soils contain exchangeable Ca2+ ion. Soils in which Ca2+ has been depleted by atmospheric acids have a limited ability to neutralize acids, which can then travel to and increase the acidity of surface waters.

*Dissolved organic carbon (DOC)*- A mixture of organic compounds that are the major source of natural acidity in freshwater. Increasing DOC can be an indication of ecosystem recovery.

*Nitrate ($NO_3^-$)* - Negatively charged compound (anion) of nitric acid. Nitrate is used to measure the saturation of nitrogen in ecosystems that can result from atmospheric deposition.

*pH* – The concentration of hydrogen ion (H+) measured on a logarithmic scale. As pH decreases, water's acidity increases. Lakes with pHs below 6.0 (7.0 is neutral) are less diverse and lack many aquatic plant and animal groups.

*Sulfate ($SO_4^-$)* - Anion of sulfuric acid, a major acid supplied to ecosystems by acid deposition. Sulfate, as with nitrate, is usually found in low concentrations in undisturbed waters.

Sampling frequencies vary by TIME and LTM study sites for different purposes. All TIME sites are sampled annually—in fall for lakes and spring for streams.[14] Because TIME sites were chosen to statistically represent various populations of lakes, annual samples are sufficient to assess trends in the number of acidic lakes and streams within regions. LTM sites, on the other hand, are not statistically representative of other lake and stream populations. To answer specific questions about acid-sensitive ecosystems, such as factors related to nitrogen and sulfur cycling, sampling is conducted on an annual, quarterly, or monthly basis. To capture data during episodic events such as spring runoff, large storms, or droughts, sampling may occur more or less frequently. In Vermont, for example, to capture an entire runoff event, researchers sample one particular lake every two days, beginning in March and throughout the spring, using an Isco automatic water sampler. The value of having a combination of TIME and LTM sites within a region is important to understanding what TIME may not be capturing in seasonal conditions.

The holding time – the time between sample collection and sample analysis – varies for each chemical variable and is a significant factor affecting the timing and scheduling for cooperators and their field workers. For example, pH must be measured on site, nitrate can be measured up to seven days after collection, sulfate up to 28 days, and aluminum up to six months.

Generally the samples are collected by two-person teams who travel by foot, truck, boat, ski, and for particularly remote sites, helicopter. The two-person team records lake height and temperature, recent shore activities or other watershed disturbances, and whether there has been recent precipitation before collecting the water samples. Collection may be done by hand using a plastic Van Dorn sampling device or, at lakes sampled by boat or helicopter, a device such as the Kemmerer sampler. Samples are typically filtered and aliquoted for anion and cation analyses as soon as possible after collection, then iced or refrigerated for transportation back to the lab for analysis.

While each region had established protocols for data collection and analysis prior to initiation of a formal LTM program, a standard protocol, the Long Term Monitoring Quality Assurance Plan, was developed in 1985 that built upon existing protocols and that used for the NSWS. The ORD LTM protocol describes the general analytic methods to be used by each cooperator. In reality, however the cooperators use a range of different instruments and cite various different references for the methods they employ. The need for and development of a single, updated QA/QC protocol for use by all cooperators was raised by several interviewees as an important issue to discuss as a group.

According to the ORD LTM protocol, cooperators are required to perform tests of data quality, using estimates of precision and accuracy and results of blank analyses, and report them in the quality assurance reports sent to ORD Corvallis Laboratory along with the data for analysis. To monitor laboratory performance over time, laboratories collecting LTM have participated in the

[14] Water tends to be less acid when water levels are lowest. Because TIME sites are sampled in late summer or early fall when water levels are lowest, acidity patterns and trends must be interpreted cautiously as they are potentially higher at other times of the year.

Canada Centre for Inland Waters Long Range Transport of Airborne Pollutants Interlaboratory Comparability Studies, but current requirements to participate in these studies as part of the TIME/LTM network are unclear.[15]

## QUESTION 3: WHAT ARE THE USES OF TIME/LTM DATA?

TIME and LTM data have been used by a limited number of scientists and policy analysts at the national, regional, and state levels for a range of purposes, including increasing basic understanding of acidification in freshwater ecosystems; reporting on program effectiveness; policy development, implementation, and enforcement; and applied research and modeling. The primary data users are program cooperators who collect the data and ORD and OAR. The logic model (Exhibit 3-6) provides a more refined depiction of the TIME/LTM program (see Exhibit 3-6). This refined view shows with enhanced clarity, the flow of information from collection through use. The detailed logic model reflects information collected over the course of the evaluation and builds upon the basic model shown in Chapter 2. Specific components of the logic model, including outputs, customers, and outcomes, are detailed in the findings that follow. The "TIME/LTM Monitoring" Stage represents the set up and management of the monitoring program, as well as actual data collection. The "Post-Monitoring" Stage reflects actions taken and use of the data (e.g., research) once data have been processed and are available for distribution.

### FINDING 3A. TIME/LTM DATA ARE USED FOR A BROAD RANGE OF PURPOSES, BUT BY RELATIVELY FEW PEOPLE.

The majority of publications, such as peer-reviewed journal articles and assessments of EPA programs and policy, are generated by a small community of scientists and analysts already familiar with TIME/LTM and with connections to program data stewards. As detailed in the following sections, program cooperators and officials from ORD and OAR are the primary data users and have managed to produce over one hundred articles and reports during the past twenty years; but because data, metadata, and other relevant program documentation have not been publicly available, new and potential users must contact ORD or a cooperator to access data. Additional details on data access and documentation can be found in this chapter under Question #6.

### FINDING 3B. TIME/LTM DATA ARE USED TO BETTER UNDERSTAND PATTERNS OF AND TRENDS IN ACIDIFICATION IN FRESHWATER ECOSYSTEMS

Research and monitoring data collected for the TIME/LTM program has furthered the understanding of acidification in freshwater ecosystems since the first chemical surveys were conducted from about 1950-1979. By the 1980s, based on a number of studies in the

[15] Some cooperators participate in the National Water Research Institute's annual auditing program with approximately 60 freshwater research laboratories in Canada and the United States. The audit includes evaluation of the mean and standard deviation of specific chemical parameters tested; results are included in the annual data reports submitted to ORD.

Adirondacks, it was known that acid deposition from the combustion of fossil fuels had affected a number of lakes in the Northeastern United States, but the extent of regional deposition – the number of affected lakes and streams, the amount, and whether acidity was naturally occurring or anthropogenic – had not yet been described. According to a research summary prepared by the Adirondack Lakes Survey Corporation (ALSC), initial long term monitoring in 1983 was focused on measuring the level of acidification, the extent to which it might be caused by acid rain, and developing estimates of reductions in acid emissions that would be required to correct it.[16] Based on the current TIME/LTM program's design and ability to monitor both probability and site-specific trends and seasonal variation from deliberately selected sites, TIME/LTM has since allowed scientists to answer questions about the number of chronically acidic lakes in the Northeastern United States, how the number of episodically acidic lakes have changed through time, and more specifically, how nitrogen and sulfur cycle through ecosystems.

[16] Adirondack Lake Survey Corporation. *Acid Rain and the Adirondacks: A Research Summary*. 2005. Ray Brook, New York.

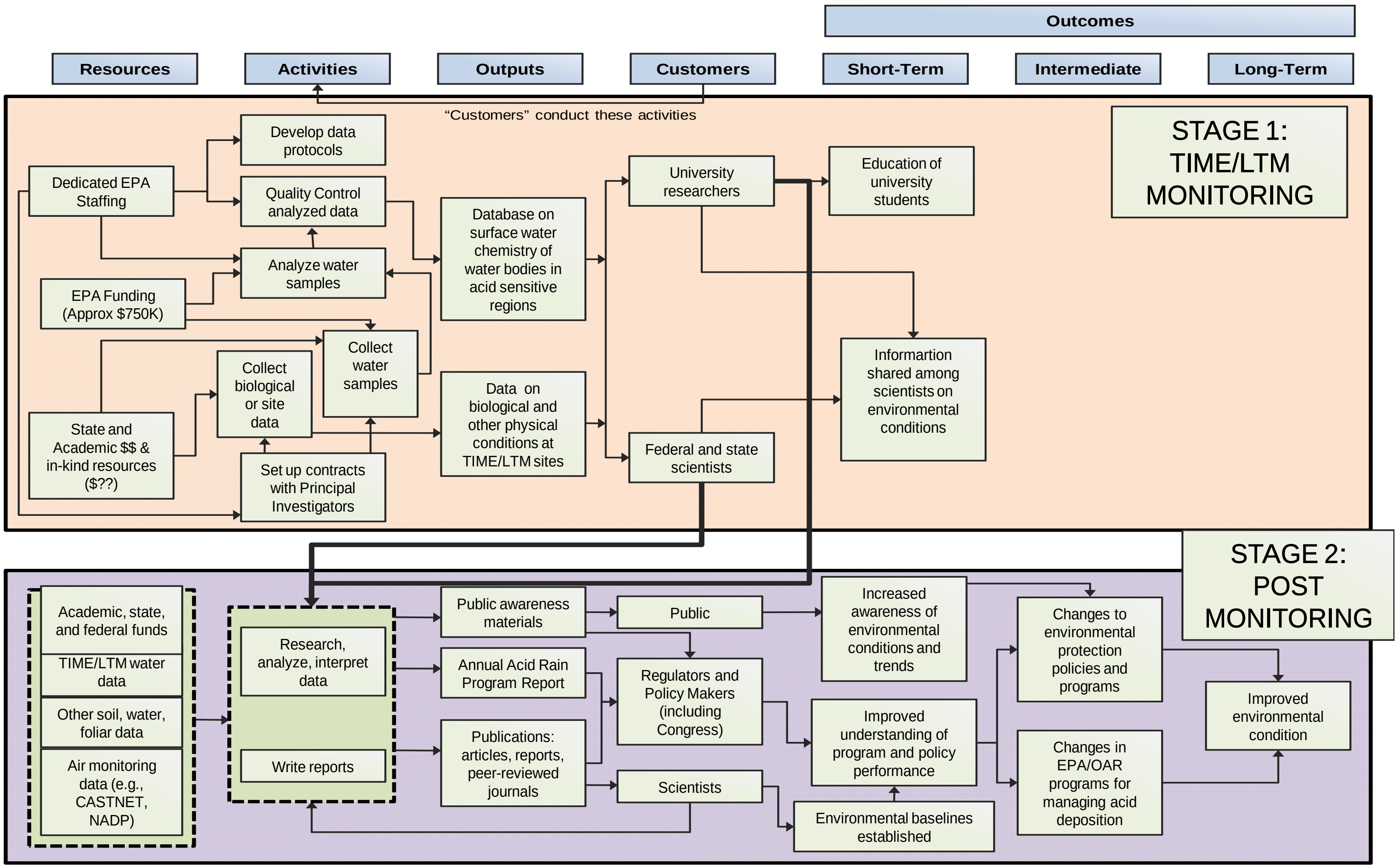


**Exhibit 3-6. Logic Model of TIME/LTM Program**

In the 2008 Report on the Environment,[17] EPA used TIME/LTM to derive an indicator to help answer questions about the trends in outdoor air quality and effects on human health and the environment. The indicator used data collected from TIME/LTM to correlate decreasing levels of air pollution to general improvements in watershed integrity. Specifically, ANC data collected during 1992-2005 were used to report patterns of increasing recovery from acidification in the Adirondack Mountains, New England (Maine, New Hampshire, and Vermont), and the relatively unchanged proportion of chronically acidic streams in the Ridge and Blue Ridge provinces of Virginia. Trend assessments beyond the borders of Northeastern U.S. watersheds and comparisons between North America and Europe have also been conducted using TIME/LTM data.[18] More recently, scientists have used TIME/LTM data to assess chemical variables other than the primary ones used to describe freshwater acidification trends (sulfate and nitrate)—including dissolved organic carbon (DOC).

### FINDING 3C. TIME/LTM DATA ARE USED FOR REPORTING ON THE EFFECTIVENESS OF NATIONAL AND INTERNATIONAL PROGRAMS TO REDUCE ACID DEPOSITION

TIME/LTM data, together with data from other EPA programs such as NADP and CASTNET, are used to help determine the effectiveness of the Acid Rain Program (ARP) as measured by specified program performance measures. Specifically, TIME/LTM data are used to measure the percent change in number of chronically acidic water bodies in acid-sensitive regions. The ARP, in turn, is one of several contributing programs in EPA's Performance and Accountability Reports, required by the Government Performance and Results Act, which help EPA to report on its progress in meeting its strategic goal related to clean air.[19]

In its 2005 *Report to Congress*, NAPAP used TIME/LTM data from 1990-2000 to describe trends in recovery among each of the acid-sensitive regions and concluded that many previously acidic lakes and streams were recovering due to reductions in acid deposition – primarily sulfate deposition – mandated by Title IV of the 1990 CAAA. The report also noted that not all areas were making a recovery, and even those with increasing ANC and decreasing sulfate and nitrate, key indicators of chemical recovery, may still be acidic enough to damage sensitive fish and other aquatic life.

Under Title IX of the 1990 CAA, NAPAP was reauthorized to continue research on the ecological effects of acid deposition and to provide Congress with periodic reports known as integrated assessments, the first of which was released in 1996. The major goal of the integrated

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[17] See the full 2008 *Report on the Environment* at http://www.epa.gov/Indicators/index.htm.

[18] Stoddard, et al. Regional trends in aquatic recovery from acidification in North America and Europe. *Nature*. 1999; 401:575-578.

[19] Other programs contributing to the clean air goal in EPA's Fiscal Year 2008 Performance and Accountability Report include AirNow, Air Toxics, Clean Air Allowance Trading Programs, Clean Air Research, National Ambient Air Quality Standards Development and Implementation, Mobile Sources, New Source Review, Regional Haze, Indoor Air Quality, Stratospheric Ozone Layer Protection Program, Radiation Programs, and Voluntary Climate Programs. See the full report at http://www.epa.gov/ocfo/par/2008par/index.htm.

assessments, of which aquatic ecosystems are one critical element, is to provide "structured, technical information in a format that enables decision makers to evaluate the effectiveness of current public policy and that provides a sound science base for future policy decisions." Officials from OAR and ORD report that a key accomplishment of the 2005 *Report to Congress*, the most recent integrated assessment, was the ability to ascertain that a market-based approach to controlling air emissions through a cap and trade system is effective. Specifically, they cite the TIME/LTM program as an example of a research-based effort with a robust outcomes-based design.

The data on freshwater acid-sensitive ecosystems used in the 2005 NAPAP *Report to Congress* were drawn from an earlier publication from ORD, *Response of Surface Water Chemistry to the Clean Air Amendments of 1990*. A key recommendation from this report states "the effectiveness of current or future amendments to the CAA can best be determined by monitoring the response of subpopulations of sensitive surface waters through time. Long-term records provide the benchmark for understanding trends in ecological responses. The reviewers of this report strongly urged the authors to recommend continuation of the long-term research program upon which this report is based and the addition of biological monitoring to begin documenting potential biotic recovery."

TIME/LTM data are also used extensively in EPA's annual ARP Progress Reports.[20] Published since the first phase of implementation of the ARP in 1995, the reports are used to update the public on the ARP and related programs, including emissions reductions, compliance, and environmental results. In the 2007 Report, the most recent publication, EPA cites TIME/LTM as "essential for tracking the ecological response to ARP emissions reductions." Using levels of sulfate, nitrate, and ANC as indicators of recovery for the 1990-2006 period, the report describes decreasing trends of sulfate in most regions, generally flat or increasing trends of nitrate concentrations, and generally increasing trends in ANC, suggesting changes in acidification not entirely commensurate with implementation of the ARP. Exhibit 3-7 below shows the trends for sulfate concentrations, based on LTM sites with complete records for the time period represented.

[20] From 1995-1999 EPA produced ARP Compliance Reports, but beginning in 2000 it stopped producing Compliance Reports and only released Progress Reports. See also http://www.epa.gov/airmarket/progress/progress-reports.html. Accessed 3/20/09.

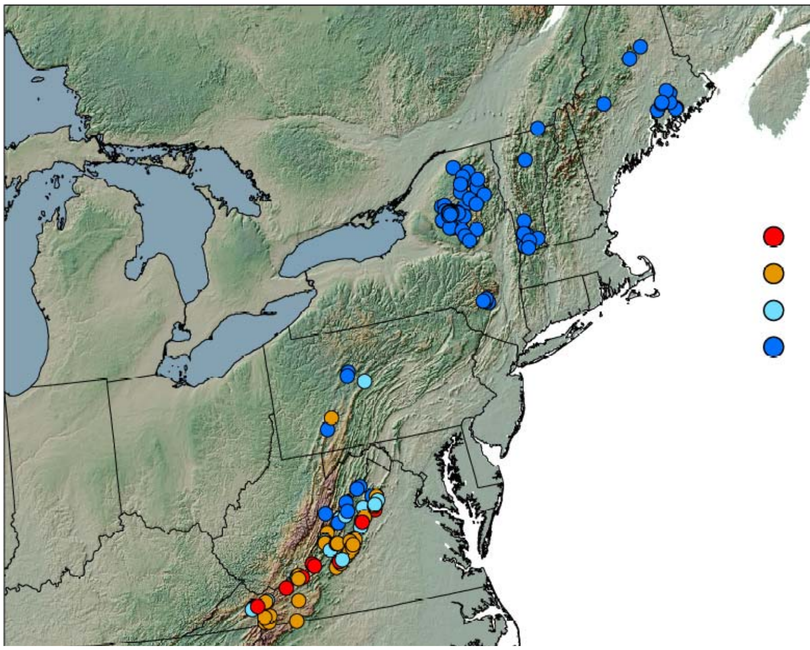


**Exhibit 3-7. Trends in Lake and Stream Sulfate Ion Concentrations at LTM sites, 1990-2006**
*Source: EPA, 2008*

TIME/LTM data have also been used in conjunction with data from the Canada Acid Rain Program under the US-Canada Air Quality Agreement, created in 1991 to reduce the impact of transboundary air pollution. In its 2008 Progress Report, the US-Canada Air Quality Committee used data from TIME/LTM to develop estimates of critical loads using the Steady-State Water Chemistry model to determine the combined deposition load of sulfur and nitrogen to which lakes could be exposed without significant harmful effects (as measured by a threshold level of ANC). The report found that the proportion of lakes receiving acid deposition greater than their estimated critical loads has improved over time, but consistent with NAPAP's 2005 *Report to Congress*, concluded that acid-sensitive ecosystems might still be at risk of acidification at current deposition levels.[21]

## FINDING 3D. TIME/LTM DATA HAVE CONTRIBUTED TO POLICY DEVELOPMENT, IMPLEMENTATION, AND ENFORCEMENT.

Managers with the National Park Service (NPS) Air Resources Division use TIME/LTM data in conjunction with air quality monitoring in Shenandoah National Park, as several sites are located within the park's boundaries. Of the 86 CASTNET monitoring stations across the United States (primarily in the east), 25 are operated by NPS in cooperation with EPA, one of which is located in Shenandoah NP. NPS officials report the importance of TIME/LTM data in understanding watershed response to changes in deposition, particularly when estimating the time needed for ecosystem recovery in areas adversely affected by acid rain. Notably, scientists have learned that the lag time between emissions of acid rain precursors and watershed recovery (as

[21] United States-Canada Air Quality Agreement, 2008 Progress Report http://www.epa.gov/airmarkt/progsregs/usca/docs/2008report.pdf Accessed March 20, 2009.

measured by increased ANC and other indicators of recovery) in Shenandoah could take up to one hundred years.[22]

In addition to using the data to directly measure trends in surface water chemistry in conjunction with dry deposition data from CASTNET and wet deposition data from NADP, the NPS and others have used TIME/LTM data to develop estimates of critical loads, or measures that determine how much pollutant an ecosystem can tolerate before it becomes degraded. Unlike a market-based cap-and-trade approach to controlling pollution emissions, critical loads focus on an ecosystem's capacity to withstand acidic deposition. Language about the use of critical loads as an assessment tool for ecological response and recovery is not included in the CAA, however in 2005, EPA included a provision in its Nitrogen Dioxide Increment Rule that individual states may propose the use of critical load information as part of their air quality management approach. In 2006 the Critical Loads Ad Hoc Committee was formed under NADP to provide a venue for discussion regarding the science and application of critical loads for atmospheric deposition in the United States. The NPS and US Forest Service (USFS) have since developed recommendations for using critical loads as a tool for managing federal lands. While the NPS has no regulatory authority over sources of pollution, they do have a consultative role in the regulatory process.[23] Land managers at NPS and other federal agencies have used TIME/LTM data to develop critical load estimates for setting resource protection and restoration goals on federal lands.[24]

States in which TIME/LTM data are collected have also adopted the critical load approach to resource management. Under Section 303(d) of the Federal Clean Water Act[25], states are required to identify and publish a list of waterways (lakes, ponds, rivers, and streams) that are "water quality impaired," meaning they do not meet EPA's water quality standards as described in regulation. In Vermont, LTM data are used to develop that state's Total Maximum Daily Load (TMDL) for the waterways on the impaired list. A TMDL is similar to a critical load in that it is a calculation of the maximum amount of a pollutant that a body of water can receive and still meet water quality standards. To estimate the TMDLs for 37 Vermont lakes, the Vermont Agency of Natural Resources implemented the Steady State Water Chemistry model using LTM chemical variable data.[26] Following Vermont's example, New Hampshire adopted the critical load TMDL format for its assessments; and the New York State Department of Environmental Conservation also uses available LTM data and modeling for assessing water quality changes.

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[22] Research has shown that acid deposition causes the progressive loss of biologically available calcium and magnesium, a process known as base cation depletion, which limits some watersheds' ability to effectively neutralize acid rain.

[23] Mandated by the Clean Air Act (42 USC 7470[2] and 42 USC 7475[d][2]), the Wilderness Act (16 USC 1131–1136), the NPS Organic Act of 1916 (16 USC 1–4), the National Wildlife Refuge System Improvement Act of 1997 (PL 105-57), and the National Forest Management Act (16 USC 1600–1614).

[24] Porter, et al. Protecting Resources on Federal Lands: Implications of Critical Loads for Atmospheric Deposition of Nitrogen and Sulfur. *BioScience*. 2005; 55:603-612.

[25] 33 U.S.C. §1251 et seq. (1972)

[26] Vermont 2008 303(d) List of Waters http://www.anr.state.vt.us/dec/waterq/planning/docs/pl_2008.303d_Final.pdf Accessed March 23, 2009.

TIME/LTM data have also been used to enforce CAA regulations. In 1999, Connecticut, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Vermont, and Rhode Island successfully brought litigation against the American Electric Power Corporation, the nation's largest operator of coal-fired power plants, for violating the CAA by emitting nitrogen oxides and sulfur dioxides at levels known to contribute to the formation of ozone and acid rain.[27] Two other major settlements were brought by the US Department of Justice and EPA against Midwestern power companies. Researchers were able to use 20 years of stream monitoring data in Virginia and the central Appalachian region to demonstrate that the companies had contributed significantly to water quality degradation in the state's native trout streams. Both companies were required to install pollution control equipment required by the CAA, and to conduct other measures to decrease air pollution.

### FINDING 3E. TIME/LTM DATA ARE USED TO CONTRIBUTE KNOWLEDGE AND UNDERSTANDING OF INTERRELATIONSHIPS BETWEEN ACIDIFICATION AND OTHER ECOLOGICAL CONDITIONS

In some states where TIME/LTM data are collected, agencies and other organization have partnered to use the data for a range of multidisciplinary purposes. For example, LTM data collected by the Vermont Agency of Natural Resources is shared among the University of Vermont and USFS through the Vermont Monitoring Cooperative. Through this partnership, the Agency for Natural Resources carried out a number of studies on mercury, using datasets from LTM and other datasets to show that increases in levels of mercury were due to increased hydrogen ion (i.e., increased acidity), and that the trend was occurring on a regional level. Mercury studies have also been carried out in New York using LTM data, by way of data collection conducted by the ALSC and others with funding from the New York State Energy Research and Development Authority (NYSERDA), including a statewide mercury survey on lake fish and associated chemistry; an assessment of DOC in wetlands; and mercury deposition in lake sediments.[28] Cooperators interviewed reported the value of having historically important records that span twenty or more years to make such assessments.

Cooperators and other scientists have used TIME/LTM data to answer research questions about acidification that indirectly relate to atmospheric deposition, yet provide contextual information needed to better understand the effects of air pollution in forested watersheds. For example, defoliation caused by insect infestation affects a forest's ability to process and utilize nitrogen that is added to the system from nitrogen fixation or atmospheric deposition. Before gypsy

[27] From the settlement, after eight years since AEP was first brought to trial in 1999, Vermont will receive five installments, each for approximately $360,000. In future years, the money will be used to fund programs that improve Vermont's air quality, public health and the environment. Under a joint project with Vermont, New York has agreed to dedicate $500,000 of its 2009 share of the settlement to be spent on a fish and habitat restoration project for Lake Champlain. See also http://governor.vermont.gov/tools/index.php?topic=GovPressReleases&id=3245&v=Article. Accessed Feb. 9, 2009.

28 NYSERDA. (2008). *Strategic Monitoring of Mercury in New York State Fish*. http://www.nyserda.org/programs/Environment/EMEP/Final%20%20Report%20revised%2008-27-08.pdf; NYSERDA. (2004). *Effects of Atmospheric Deposition of Sulfur, Nitrogen, and Mercury on Adirondack Ecosystems*. Accessed May 3, 2009.

moths were found on long term monitoring sites in Virginia in 1984, nitrogen levels had been steadily low, but increased dramatically during moth infestation. Nitrogen levels returned to near pre-infestation levels after the moth infestation subsided and forests began to recover. Cooperators report that without the long term data to provide a baseline for nitrogen levels in the area, and depending on the timing of the sampling (before, during, or after infestation), it would have been difficult to determine the direction of the trend and contributing factors. Cross-sectional sampling at a time of particularly high or low nitrogen levels would not have provided a basis for trend description or pattern identification. Similarly, comparisons of chloride levels in undisturbed TIME/LTM lakes with urbanized lakes have highlighted the importance of factoring in anthropogenically introduced chloride when assessing surface water recovery from acid rain; a salt-affected watershed will alter base cation geochemistry and complicate assessment of the ecological effect of atmospheric deposition.[29] Using USGS Water Center funding, scientists in Pennsylvania have conducted a survey of mercury in a number of LTM and other headwater brook trout streams in 2008. Research has also shown that an indicator of acidification recovery may hinder the return of biota to some lakes and streams. Using LTM data from several Maine sites, researchers concluded that increasing dissolved organic carbon, generally believed to be a sign of ecosystem recovery, may actually offset the return of salmon in certain classes of streams.[30]

Researchers use TIME/LTM data to develop and test new models and methods that in turn help improve the science used to make decisions around policy for air emissions. Interviewees from OAR discussed plans to use TIME/LTM data for PnET-BCG[31] modeling, which requires the data for model inputs and model calibration. PnET-BCG is able to simulate the response of soil and surface waters in northern forest ecosystems to different types of disturbances, including acid deposition. The models generate critical load estimates that are used to make predictions about response under various emission scenarios. Cooperators and other researchers have used TIME/LTM data for model development and application for more than 20 years. Appendix C provides a comprehensive bibliography of TIME and LTM publications.

## QUESTION 4: WHAT IS THE RELATIONSHIP OF TIME/LTM TO OTHER ECOLOGICAL MONITORING PROGRAMS?

Ecological monitoring is of critical importance to understanding the effects of stressors and pollutants in the environment. Ecological monitoring, like human health monitoring and assessment, provides a means to examine the outcomes or results of activities that impact the environment and potentially actions or policies that mitigate the activities. Researchers suggest

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[29] Rosfjord, Webster, Kahl, et. al. Anthropogenically Driven Changes in Chloride Complicate Interpretation of Base Cation Trends in Lakes Recovering from Acidic Deposition. 2007. *Environmental Science and Technology*; 41:7688-7693.

[30] Kahl and Johnson. Streamwater chemistry and Recovery of Maine Atlantic Salmon. March 2004. Water Quality Fact Sheet. Center for Environmental and Watershed Research, University of Maine, Orono, ME.

[31] PnET-BGC is an integrated biogeochemical model developed to simulate forest and aquatic ecosystems that allows simultaneous simulation of major element cycles in forest and interconnected aquatic ecosystems. http://www.ecs.syr.edu/faculty/driscoll/personal/PnET%20BGC.asp

that the success of ecological monitoring programs such as TIME/LTM are dependent on several factors, including: (1) addressing a clearly articulated question, (2) using consistent and accepted methods to produce high quality data, (3) providing a data management systems that ensures long-term data accessibility and optimizes data use, and (4) integrating the monitoring effort into programs that foster continual examination and use of the data.[32] Many interviewees acknowledged that TIME/LTM, while unique in addressing the ecological effects of acid precipitation, is one of an array of monitoring efforts examining acid precipitation specifically and ecological conditions generally. Interviewees mentioned water quality monitoring programs for acidification in some of their states that augment information collected as part of TIME/LTM.[33] The EPA Office of Water in the last several years launched both lake and stream surveys. These surveys are based on a random sample design as described by EMAP. Several interviewees noted the need to consider approaches for integrating TIME/LTM and other national monitoring programs for both cost savings and development of more comprehensive environmental understanding, but none were aware of any current efforts to do so.

**FINDING 4A. TIME/LTM EVOLVED FROM A VARIETY OF ENVIRONMENTAL MONITORING PROGRAMS AND CONTINUES TO EVOLVE AS SITES ARE ADDED AND DROPPED.**

As described in Finding 1A and Appendix A, LTM evolved under NAPAP from many water quality monitoring efforts that existed in the early 1980s. LTM sites in many cases were already being sampled as part of state, university, or federal efforts to understand the extent of acid precipitation. A selection of sites was brought under the umbrella of a Long Term Monitoring Program (LTMP) originally in 1983, with quality assurance protocols later developed for sampling by the EPA/ORD Laboratory in Corvallis, OR. These sites were frequently selected because they had a record of measurements. They did not represent a probabilistic sample and findings from these sites could not be extrapolated to describe broader regional conditions.

Studies done under the NSWS provided the foundation to conceptualize an integrated approach to the needed monitoring, based on use of sites drawn from past monitoring efforts, sites representative of various regions, and sites that could indicate seasonal variability, etc. The 1986 NAPAP Annual Report states the following: *"The design of LTMP is multitiered, with each tier representing an increasing degree of detail as needed to assess trends in regional scale aquatic conditions…. The base of the tier represents broad-scale data collected infrequently on a subpopulation for which their relationship to the total regional population is known. Seasonal variability studies could be conducted on a subset of systems selected from those represented by the base tier. Successive tiers represent successively smaller subpopulations and increased complexity and intensity of the studies. In most cases existing Task Group [Aquatic Effects Task Group] water studies would be included in these tiers. At each level, the relationship of the subpopulation to the resource base established at the base tier is known; hence the results of the special studies, for example, rates of mineral weathering or artificial acidification of watersheds*

[32] Lovett, G.M., et al. 2007. Who Needs Environmental Monitoring? Front Ecol Environ; 5(5): 253-260.
[33] An example of this is described in "Results from the 2003-2005 Western Adirondack Stream Survey," Lawrence, GB, et al. November 2008.

*would be applicable to regions."* The AETG envisioned the potential to integrate various types of monitoring and data from different monitoring programs to describe more completely the effects of acidification. More details on the evolution of these efforts and the integration of TIME sites with LTM are described in Finding #1A.

Over the last 25 years the collection of sites comprising LTM has changed. As can be seen in Exhibit 3-8, many sites were added in 1987 as a result of the analyses done based on the NSWS. Other sites were added in 1992, perhaps as a function of integration with TIME (although Exhibit 3-8 does not depict TIME sites). Sites have been dropped over the years as shown by the red bars in the graphic. Sites from 2002-2005 are still considered "current" in the ORD database, but data have not yet been processed.

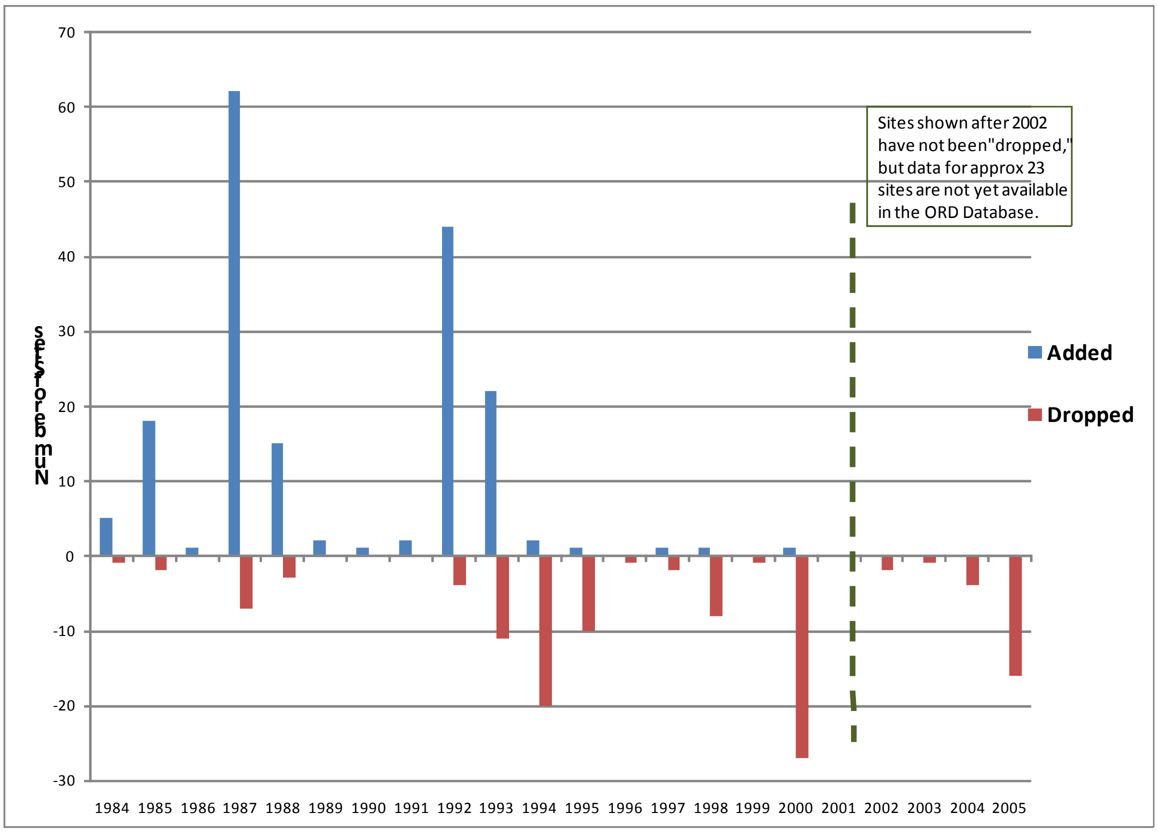


**Exhibit 3-8. LTM Sites Added or Removed Based on First and Last Observations at Each Site**
*Source: ORD Database*

TIME sites represent both the probabilistic sites established as part of EMAP and sites that had been measured as part of other surveys and were considered important to incorporate.

**FINDING 4B: TIME/LTM IS ONE MONITORING EFFORT AMONG MANY, BUT IS NOT DIRECTLY INTEGRATED WITH OTHERS**

Numerous environmental monitoring programs exist across the U.S., managed by many different federal agencies. TIME/LTM is focused on measurements specifically representing lake and stream water chemistry to understand acidification. Other monitoring programs assess both water chemistry and other measures of environmental conditions that may play a role in acidification. Exhibit 3-9 depicts various existing monitoring programs and the medium of focus. Exhibit 3-10 provides some additional detail on each of these programs and the agencies with management responsibilities. Appendix D describes of the programs.

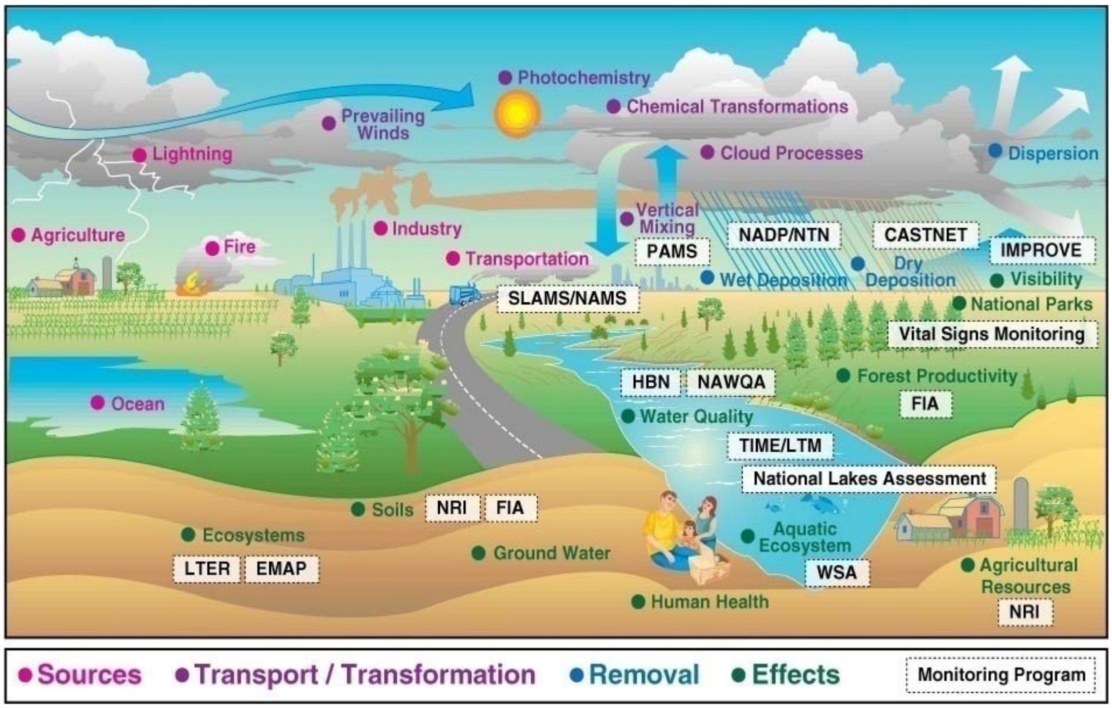


**Exhibit 3-9. Examples of Environmental Monitoring Programs**

*Source: Adapted from "The Role of Monitoring Networks in the Management of the Nation's Air Quality," National Science and Technology Council, CENR, 1999)*

| Name | Lead Agency | Number of Sites | Date Begun |
|---|---|---|---|
| Vital Signs Monitoring | NPS | 32 inventory and monitoring networks over 270 park units | 2007 |
| Forest Inventory and Assessment (FIA) | USFS | 125,000 | 1930 |
| Environmental Monitoring and Assessment Program (EMAP) | EPA | 12,600 | 1988 |
| Long Term Ecological Research (LTER) | NSF | 26 | 1979 |
| National Resources Inventory (NRI) | NRCS | 800,000 | 1956 |
| Air Quality Monitoring:<br>• National Air Monitoring Stations (NAMS)<br>• State and Local Air Monitoring | EPA<br>States/Local<br><br>States/Local | <br>1080<br><br>~4000 | <br>1979<br><br>1979 |

| Name | Lead Agency | Number of Sites | Date Begun |
|---|---|---|---|
| Stations (SLAMS)<br>• Photochemical Assessment Monitoring Stations (PAMS)<br>• Special Purpose Monitoring Stations (SPMS) | States/Local<br>States/Local | 57+ | 1994<br>?? |
| Interagency Monitoring of Protected Visual Environments (IMPROVE) | NPS | 156 | 1985 |
| Clean Air Status and Trends Network (CASTNET) | EPA | 86 | 1991 |
| National Atmospheric Deposition Program (NADP)/National Trends Network (NTN) | Interagency | 250 | 1978 |
| National Water Quality Assessment (NAWQA) | USGS | 42 River Basins | 1991 |
| National Lakes Assessment | EPA | 1200 Lakes | 2007 |
| Wadeable Streams Assessment (WSA) | EPA | 1392 | 2000 |
| Hydrologic Benchmark Network | USGS | 15-58 (varies over time) | 1963 |
| TIME/LTM | EPA | 303 (ORD Database) | 1983 |

**Exhibit 3-10. Terrestrial, Air, and Aquatic Monitoring Programs (Federal)**

Interviewees acknowledged and recognized that they and the agencies they work with frequently support a variety of monitoring networks. They also mentioned that some environmental variables (e.g., soils and vegetation) that could be helpful in understanding transport and behavior of sulfates and nitrates are not extensively monitored in the watersheds supporting TIME/LTM sites. EPA's Office of Water noted that the initiation of the Wadeable Streams Assessment (WSA) and the National Lakes Assessment (NLA) may provide opportunities to work closely with TIME/LTM sites. Both the WSA and the NLA are built on statistical designs defined by EMAP. Many of these monitoring efforts have detailed and comprehensive Web sites describing the history and methodologies of the programs and means to access data. The IMPROVE Web site (http://vista.cira.colostate.edu/improve/ ) is an example of an interactive site supporting interactive use of tools and publications based on the monitoring activities.

Interviewees also recognized that integrating and using data from multiple monitoring efforts to understand environmental conditions is challenging due to factors such as:

- variability in questions being addressed and statistical requirements to adequately sample populations
- temporal and spatial characteristics of sampling
- variability in parameters measured
- variability in site characteristics of interest (e.g., undisturbed, prone to acidification, accessible to road)

Despite these challenges, interviewees indicated strong interest in exploring opportunities for coordination, integration, and sharing information across monitoring networks. This support aligns with recent recommendations made by The Nature Conservancy and the Cary Institute of Ecosystem Studies in their publication: "Threats From Above." The report discusses the impacts of air pollution on ecosystems and biodiversity in the Eastern United States and points out that *"Many important monitoring programs exist in the U.S., but there is currently no comprehensive integrated network to measure atmospheric deposition, soil and surface water concentrations of pollutants and biological effects."*[34] The Report makes recommendations to continue to support existing monitoring efforts, but also develop a more comprehensive, integrated effort to ensure that the information needed to evaluate critical loads for sulfur, nitrogen, and mercury and to track responses of ecosystems to these loads is made available. The Report strongly recommends expansion of air pollution monitoring to create a comprehensive national program as soon as possible, with expanded funding to address multiple pollutants.

## QUESTION 5: WHAT ARE THE COSTS ASSOCIATED WITH THE TIME/LTM PROGRAM?

TIME/LTM support from EPA has been on a declining trend for most of the program's duration as a single integrated network, while operational costs have not significantly changed. Cost comparisons by region are difficult for a number of reasons, including the pooling of EPA and non-EPA resources and differential costs associated with specific sites, but there was general agreement among interviewees that data collection and analysis are conducted relatively cost-efficiently and approaches to improve efficiency are likely to be few at current EPA funding levels.

### FINDING 5A. PROGRAM COSTS, IN SUM, HAVE GENERALLY REMAINED THE SAME BUT EPA FUNDING HAS DECLINED.

Since EPA began investing in long-term monitoring in the early 1980s, ORD has provided the majority of funding required for program operation, as well as data quality assurance and overall database management. Over time, ORD funding levels for TIME/LTM have generally declined from a high of $1.2 million in 1993 to a low of $720,000 in 2009, as shown in Exhibit 3-11.[35] At the same time, according to cooperators, costs for program operation have remained the same or in some cases increased.

[34] Lovett, G.M., and T.H. Tear. 2008. *Threats from Above: Air Pollution Impacts on Ecosystems and Biological Diversity in the Eastern United States*. The Nature Conservancy and the Cary Institute of Ecosystem Studies.

[35] NAPAP 1986-88 Operating Research Plan (pp V1-2) documents budget amounts for the LTM program at $700,00 in 1986 and $638,700 in 1987.

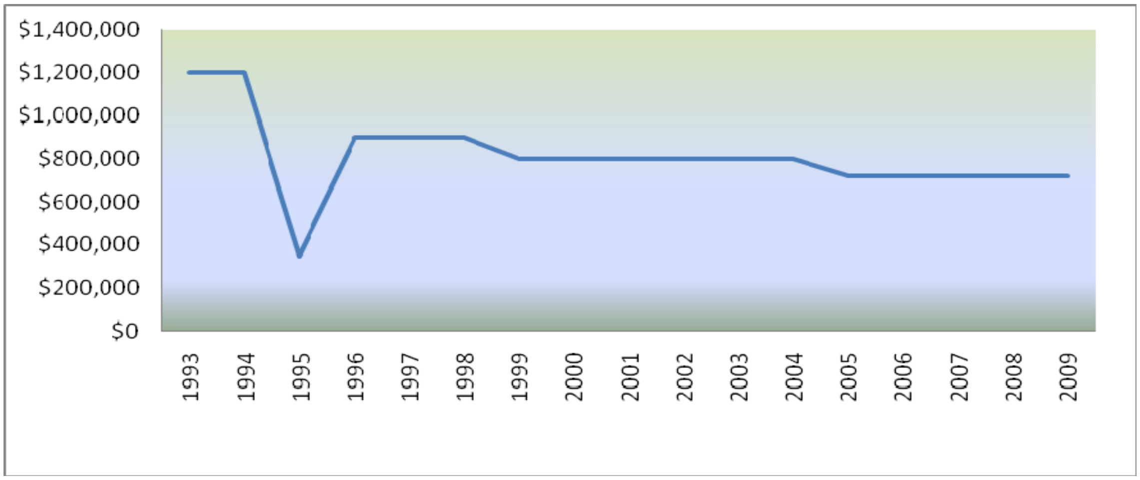


**Exhibit 3-11. EPA funding for TIME/LTM program, 1993-2009.**
*Source: ORD*

In addition to an overall funding decline, the uncertainty of funding availability from year to year has presented challenges to cooperators. Several cooperators interviewed reported that the constant hunt for funding has detracted from effective program planning and operation, including potential staff hiring and training graduate students. During certain years of the program's history, funding shortages have resulted in fewer sites sampled and in some cases incomplete data for a given region or group of sites. Funding shortages do not, however, appear to have significantly affected generation and use of program data. In contrast, during some years, ORD has provided supplemental funding to cooperators based on funds remaining at year-end. For example, in fiscal year 2009, supplemental funding raised available funding from $720,000 to approximately $975,000. Additionally, funds from other federal and nonfederal sources must also be taken into consideration when estimating total TIME/LTM program costs. The following section provides additional cost details.

### FINDING 5B: OVERALL PROGRAM COSTS AND COSTS PER SITE SAMPLED AND ANALYZED ARE DIFFICULT TO ASCERTAIN

Several aspects of TIME/LTM funding complicate analysis of the actual costs required to operate and maintain the program as currently designed. A comparison of costs across regions must take into account the unique mix of site characteristics and cooperator responsibilities in each region. Also, other sources, including federal and state agencies and nongovernmental organizations, contribute funding and in-kind resources to varying degrees. Exhibit 3-12 provides a general description of total program resources reported for TIME/LTM activities in fiscal year 2009; the data were compiled from interviews with ORD, cooperators, and analysis of cooperative agreements. The amount ORD allocates to each cooperator generally reflects cost requirements based on the combination of factors detailed in the following subsections and assumes some amount of resources contributed by state agencies and other organizations. Based on the data provided by cooperators and ORD, it is not meaningful to estimate a per site cost.

The Office of Water mentioned that for cost allocation purposes, they estimate costs for the WSA at approximately $6000 per site visit and $250 for data analysis per site. These sampling protocols differ from TIME/LTM sample collection and analysis.

| | **Sites** | | **Funding** | | | **Costs** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Type of Site | Sites | ORD Annual Funding | Other Funding | TOTAL | Personnel | Travel | Analysis, supplies | Other [5] | TOTAL |
| Adirondacks | | | | | | | | | | |
| | TIME[1] | 43 | $225,400 | $24,700 | $250,100 | $225,400 | $0 | $14,440 | $10,260 | $250,100 |
| | LTM[3] | 52 | $0 | NR | | NR | NR | NR | NR | |
| | TOTAL | 95 | $225,400 | $24,700 | $250,100 | | | | | |
| Catskills | | | | | | | | | | |
| | TIME | 0 | | | | | | | | |
| | LTM[3] | 4 | $79,000 | NR | $79,000 | | | | | |
| | TOTAL | 4 | $79,000 | $0 | $79,000 | $29,535 | $3,688 | $24,633 | $21,144 | $79,000 |
| Vermont | | | | | | | | | | |
| | TIME | 0 | | | | | | | | |
| | LTM[2] | 12 | $120,346 | $6,334 | $126,680 | | | | | |
| | TOTAL | 12 | $120,346 | $6,334 | $126,680 | $68,414 | $4,745 | $27,695 | $25,826 | $126,680 |
| Maine | | | | | | | | | | |
| | TIME[1] | 29 | NR | NR | | NR | NR | NR | NR | |
| | LTM[2] | 16 | NR | NR | | NR | NR | NR | NR | |
| | TOTAL | 45 | $210,000 | $0 | $210,000 | | | | | |
| Pennsylvania | | | | | | | | | | |
| | TIME | 0 | | | | | | | | |
| | LTM[3] | 5 | $110,000 | NR | $110,000 | | | | | |
| | TOTAL | 5 | $110,000 | $0 | $110,000 | $62,000 | $7,600 | $19,000 | $21,400 | $110,000 |
| Virginia | | | | | | | | | | |
| | TIME | 0 | | | | | | | | |
| | LTM[2,4] | 67 | $125,000 | $50,000 | $175,000 | | | | | |
| | TOTAL | 67 | $125,000 | $50,000 | $175,000 | $107,773 | $5,000 | $4,840 | $57,387 | $175,000 |
| Mid-Atlantic | | | | | | | | | | |
| | TIME[1] | 50 | $106,000 | $0 | $106,000 | | | | | |
| | LTM | 0 | | | | | | | | |
| | TOTAL | 50 | $106,000 | $0 | $106,000 | | | | | $106,000 |
| **TOTAL** | | **278** | **$975,746** | **$81,034** | **$1,056,780** | **$493,122** | **$21,033** | **$90,608** | **$136,017** | **$1,056,780** |

**Exhibit 3-12. TIME/LTM Resource Allocation by Region**

*Source: ORD, Cooperators*

Estimated Sampling Frequency

[1] Annual

[2] Quarterly

[3] Monthly

[4] Weekly/Episodic

Other

[5] Includes fringe benefits, contractual costs

NR = not reported

***Cooperators pool ORD and non-ORD funding to support program operations***

With the exception of the Adirondack region, most funding to support TIME/LTM data collection and analysis has come from ORD. In the Adirondack region, the majority of the TIME/LTM program is supported by funds from NYSERDA and the New York State Department of Environmental Conservation (NYSDEC). The NYSDEC provides in-kind support for the annual collection of samples from 43 TIME lakes and funds are pooled with those from ORD.[36] But for collection of monthly samples from 52 LTM lakes in the Adirondacks, NYSERDA and NYSDEC provide 100 percent of the funding and supply the complete LTM dataset to ORD at no cost. In other regions where data are collected by university researchers, graduate students, and staff, or researchers affiliated with state agencies, smaller percentages of total program costs are provided and combined with ORD funding to support TIME/LTM data collection and analysis.

***Variation in site type and sampling frequency complicate regional cost comparisons***

As described under the program characteristics for Question #2 and illustrated in Exhibit 3-3, TIME/LTM sites are sampled at different frequencies, although the chemical parameters measured at each are generally the same. Fiscal burden can largely be driven by sampling frequency. Several LTM streams, for example, are sampled monthly, in contrast with TIME lakes that are typically sampled on an annual basis. Some cooperators also collect samples from particular lakes or streams during episodic events such as spring runoff or floods, requiring sampling on a weekly or biweekly basis. Each time a site is sampled, regardless of the method or equipment used to collect water samples (e.g., by hand or by use of an automatic sampler), samples must be physically collected, transported, and processed by field workers according to the chemical holding times defined in QA/QC protocols. The location of a lake or stream also plays a role in the expense to sample it. Because TIME/LTM sites are generally remote and in undisturbed watersheds, they can be difficult to access. A region with mostly remote sites requiring aviation for sample collection would probably incur higher costs; but these costs may still be less than sampling a stream 12 times or more per year that can be reached by truck or hiking a short distance.

***Federal and state agencies contribute funding for collection of data from TIME/LTM sites for other program purposes***

At least two regions are supported in part by funds from state and federal agencies that use selected TIME/LTM sites as part of other ecological monitoring efforts. The NPS contributed $50,000 in fiscal year 2009 for the continuation of integrated surface water monitoring in the Ridge and Blue Ridge Provinces of Virginia, including watersheds in Shenandoah National Park. In the Catskills Mountains, the New York City Department of Environmental Protection (NYCDEP) conducts water quality monitoring in three LTM streams that overlap with sites used for monitoring New York City's drinking water supply. NYCDEP funds pay for field workers' salaries and sample analysis (amount not specified).

[36] The ALSC, a non-profit corporation established in 1983 to gather baseline environmental monitoring data, has responsibility for TIME/LTM field and laboratory work. See also http://www.adirondacklakessurvey.org/

***Some cooperators analyze samples collected by other cooperators***
Some cooperators collect samples but send them to other cooperators for analysis. For example, all TIME lake samples, approximately 75 in 2009, are analyzed by the principal investigator in Maine.

***In-kind contributions are important assets***
At least four regions in the network rely on the work of volunteers, graduate students, and other staff who are not paid with TIME/LTM program funds for sample collection and analysis. For some regions, significant data are collected for the program at minimal cost. For example, TIME/LTM data are collected as part of monitoring efforts in Shenandoah National Park, known as the Shenandoah Watershed Study-Virginia Trout Stream Sensitivity Study.[37] Sample collection and logistical support on about 60 streams is provided by state and federal resource managers, as well as trained volunteers associated with Trout Unlimited. Similarly, in the Adirondacks, in-kind support is provided by the NYSDEC Division of Air Resources, which includes office and storage facilities, helicopter and vehicle support, personnel, laboratory, and computer equipment. Work done in conjunction with universities is also carried out in part by unpaid graduate students and volunteers who in turn train new students and volunteers.

## QUESTION 6: HOW IS THE TIME/LTM PROGRAM CURRENTLY ADMINISTERED AND MANAGED?

In each region the principal investigator or cooperator is generally responsible for sampling, analysis, quality assurance and quality control procedures, and data validation for their sites. They report these data to EPA ORD in Corvallis, OR where they are quality assured before being added to the overall database. ORD also analyzes the samples from the 58 TIME streams in the Ridge, Blue Ridge, and Northern Appalachian regions. The ORD staff in Corvallis is responsible for data management, final reporting of TIME/LTM data, and general TIME/LTM coordination across the network. According to ORD, most of these tasks are accomplished through the dedication of one staff person for 10 percent of his time. Minimal resources are available for overall management and administration of TIME/LTM, meaning that activities not directly related to data collection are difficult to accomplish such as managing and providing access to the data, planning, strategy development, or collaborating with other monitoring efforts. Additionally, ORD has indicated its intent to withdraw program support, creating a funding and management vacuum for the program.

### FINDING 6A. SPECIFIC DETAILS ON HOW COOPERATIVE AGREEMENTS WERE ESTABLISHED AND ARE CURRENTLY MANAGED ACROSS SITES ARE NOT CLEAR.

Several interviewees commented that the cooperative agreement process might be simplified and made more transparent. EPA uses cooperative agreements to provide benefits to cooperators as much as or more than to EPA. Agreements exist for different time frames for

[37] See also http://swas.evsc.virginia.edu/ accessed April 22, 2009.

various cooperators and varying amounts, with little clarity of how costs were determined. EPA and cooperators are very aware that in-kind contributions are made by the cooperators (as described in Question #5), with cases such as the Adirondacks, where funds other than EPA's are primarily responsible for ensuring TIME/LTM data collection. Some cooperators would like to better understand how funds are allocated. Additionally, ORD would like to optimize the process of managing cooperative agreements.

### FINDING 6B. TIME/LTM PROGRAM DATA AND DOCUMENTATION ARE NOT EASILY ACCESSIBLE.

The primary TIME/LTM data users are the program cooperators who collect the data and EPA, specifically ORD and OAR (see Question #3 for detailed discussion of data use). In general, all interviewees for this report acknowledged the significant amount of work by ORD over the last two decades to manage the data, involving careful observation and data validation before the data can be used for reporting, often on a constrained budget. For most of the last two decades, ORD has made the data available by responding to specific requests from cooperators, other researchers, and/or EPA. The data have not been available for download on the Internet. Detailed metadata describing the TIME/LTM data are also not available. A few cooperators have made data from their study sites publicly available on university or state agency Web sites. More recently, OAR/CAMD has made program-wide data accessible on EPA's Web site. There is currently a "gentlemen's agreement" to not publicly release data until three years after collection (unless it's an EPA publication). While it is unclear whether this is documented in existing agreements, this is a policy that all cooperators agreed should be revisited. All interviewees agreed that data should be more easily accessible. Additionally, data are not current. Cooperators indicated that while, for the most part, they provide the data to ORD in a timely manner, there can be a three to five year lag time in the data being available.

In the course of conducting this evaluation, it was extremely difficult to track and document the history, decisions, and goals of the program given the lack of documentation on the program by EPA. Creating the history and descriptions of the program in this evaluation required extensive searching and requests of individuals to peruse personal libraries to fax pages from documents.

The lack of documentation about decisions such as adding or dropping sites makes it extremely difficult to develop a complete and accurate picture of the number of sites, their history, and reasons for inclusion or elimination. In many cases, cooperators provided numbers for sites sampled and timing of samples that differed from numbers shown in the ORD Database, making it difficult to reconcile actual sampling and costs for the program. Some cooperators expressed a desire to better understand decisions such as dropping or adding sites for the surveys.

### FINDING 6C. OPPORTUNITIES FOR COOPERATORS TO INTERACT HAVE BEEN LIMITED.

All primary stakeholders interviewed for this report strongly supported regular opportunities to meet and share ideas and concerns about TIME/LTM, but cooperators in particular identified a number of potential benefits to be realized in doing so. This could take the form of an annual conference or workshop that would allow program stakeholders to share current work and better understand patterns and trends on a regional level, something that is currently accomplished by reading journal articles often years after data are collected. The ability to share ideas for standardizing and improving data quality and quality control procedures was also cited as a need and program benefit. Alternatively, a steering committee or leadership task force could provide a forum for collective thinking and strategic planning to fully leverage TIME/LTM and help set direction. Cooperators expressed an interest in establishing more effective means for "give and take" dialog to address issues and explore new ideas. Many other environmental monitoring programs have conducted periodic reviews to assess objectives, protocols, and assumptions about monitoring. TIME/LTM has not conducted such an assessment in nearly two decades.

Additionally, many other environmental monitoring efforts are built on a collaboration model of contributions from multiple parties. ORD has funded and managed TIME/LTM for decades. Opportunities to discuss how other entities, such as states, other federal agencies, or other EPA programs, might engage more directly, provide leadership, expertise, and funds, could help ensure the long term viability of TIME/LTM.

OAR/CAMD is organizing a workshop for TIME/LTM cooperators in early June 2009. Cooperators expressed keen interest in participating in this event.

## QUESTION 7: WHAT OPPORTUNITIES EXIST TO IMPROVE THE TIME/LTM PROGRAM?

Interviewees identified several areas for program improvement, including changes to the sampling design and parameters measured, a need for improved access to data, and more opportunities for data collector and user interactions. These latter two were discussed under the previous question.

### FINDING 7A. COOPERATORS BELIEVE THAT TIME/LTM DATA ARE COLLECTED AND ANALYZED EFFICIENTLY, BUT OFFERED SUGGESTIONS FOR FUTURE CONSIDERATION

Cooperators reported that the program has operated efficiently and produced a significant amount of data with a relatively small and often unreliable budget. Interviewees were not able to identify many ways in which efficiency could be improved or costs reduced based on current levels of funding. Some suggestions were offered by cooperators and interviewees as possible approaches to improve efficiency as follows:

- Develop a matrix mapping each individual site and the frequency of sampling; in some cases it may be possible to sample less frequently (e.g., quarterly versus monthly) without compromising dataset integrity or representativeness.
- Contracting with a single collection entity is a possibility, although cooperators noted the program would lose the expertise that has been established over two decades by having the same group of principal investigators collect data, with intimate local site knowledge.
- Similarly, new methods for data collection, based on remote sensing or other more advanced technologies could conceivably be adapted to TIME/LTM, but are not likely to be

less expensive; furthermore, details on site characteristics and condition currently captured in field workers' notes would go unrecorded.

## FINDING 7B. COOPERATORS SUGGEST ADDITIONS TO THE TYPES OF DATA COLLECTED.

Cooperators and EPA staff acknowledged that the addition of data collected or analyzed would be challenging unless the funding to support it was made available. Nonetheless, they made a number of suggestions that would improve the breadth and depth of the TIME/LTM dataset for potentially small incremental costs. A suggestion made by nearly all cooperators was the collection of biological data. Biological data, taken together with water chemistry, would provide the strongest indication of freshwater integrity and the ability to support life. A number of cooperators currently collect (or have collected in the past when funding has allowed) data on fish and macroinvertebrate populations from TIME/LTM sites, and report that the data can be collected within the existing program with little additional effort for the wealth of information it can provide about the effects of acid rain on freshwater biota. For example, researchers in Vermont collected data from the mid-1980s on fish and macroinvertebrate populations from 29 of the original lakes selected from long term monitoring, as well as plankton data from acidic lakes during from the early 1980s and 1990s. Some of these data have been analyzed and published (e.g., fish and macroinvertebrate), but the plankton data have not. Data on aquatic biota and native fishes continue to be collected from several Pennsylvania LTM sites, but not as formal EPA-funded work; and the Adirondack Effects Assessment Program—a separate but related EPA-funded program— currently collects annual plankton data from 28 LTM lakes, but has yet to publish any results.

Data on stream flow were also cited as an important variable to understanding acidification. Acidity can vary widely during transient events including large storms or spring runoff. During high streamflow, the pH or ANC of a stream or lake decreases to a value significantly below its baseline. At sites where flow data are collected, scientists can better interpret pH and ANC values in the dataset and tease out confounding variables. Currently, flow is measured at 12 LTM sites in the TIME/LTM program, but cooperators report they would like to see it used in the analysis and interpretation of TIME/LTM data in reports where the data are used for national assessments of the CAA or elsewhere. Researchers also cite the importance of flow data for interpreting trends during droughts and floods that may be related to climate change.

Detailed documentation of vegetation and soil conditions in each watershed of the network was reported by some EPA interviewees as an area for program improvement. Field workers collecting samples are required to document a fair amount of detail, based on field notes from TIME stream assessments in the northern Appalachians we reviewed, including watershed activities and disturbances, reach characteristics, water clarity and character, and general assessments of area wildlife and vegetation diversity; yet OAR officials noted that greater detail is needed for site characterizations as these additional inputs are helpful for interpretation of the long-term trend data and enhance data comparability across the network. In addition to more thorough site depictions, updated or verified latitudinal and longitudinal coordinates were also cited as needed improvements. For example, coordinates in the current database should be at the centroid of the lake or at sampling locations, some however are at parking areas or access points to the lake.

A number of cooperators suggested the addition of mercury, another atmospheric deposition component, would be a beneficial variable to include as part of the TIME/LTM program. While mercury is not an atmospheric acid, it originates from many of the same sources as sulfuric and nitric acids and accumulates in watersheds where it is converted to its toxic derivative methylmercury. According to research conducted in the Adirondacks, mercury deposition rates are currently the highest they have ever been, and since mercury emissions are not controlled by the CAA, mercury deposition is expected to continue. Some TIME/LTM researchers collect mercury data at a number of sites in New Hampshire, New York, and Vermont, but suggested a more uniform approach to collecting it would be beneficial. It is unclear what level of resources would be required to support mercury data collection across the TIME/LTM network, and some have noted the technically demanding aspect of mercury sample collection.

### FINDING 7C. EXPANSION OF SITES INTO OTHER GEOGRAPHIC REGIONS IS OF INTEREST TO SOME COOPERATORS.

The addition of TIME and LTM sites to the network has been reported by some cooperators as a needed improvement to the program, but OAR officials emphasized the importance of increased precision and additional study variables over adding more sites (see discussion under 7A). Cooperators in support of adding sites acknowledged the value of having focused on Eastern watersheds for most of the programs' existence, due to demonstrated acid sensitivity in those regions, making them an excellent cohort to study relatively small changes in chemistry over time; but given increased interest in climate change, the addition of sites could provide a more complete picture of freshwater acid-base chemistry across a nationwide gradient of systems not limited by current TIME/LTM site inclusion criteria. But aside from an expansion of current TIME/LTM program objectives to address emerging concerns such as climate change, NAPAP supported the idea of site expansion in 2005 by reporting that additional sites in acid-sensitive regions of the Southeast, Midwest, and West would make more complete assessments possible.

# CHAPTER 4: CONCLUSIONS AND RECOMMENDATIONS

This evaluation describes the development of the TIME/LTM program from a collection of preexisting water quality /aquatic monitoring programs with differing but related objectives and protocols to the current integrated program that is primarily used to assess ecosystem response to reduced air emissions mandated by the 1990 CAAA. Over the last two decades, the program has undergone a number of design modifications resulting in expansion of sites within some regions and elimination of sites altogether in others. Despite these changes and shifts, TIME/LTM has established a laudable long-term record for use by both policy makers and researchers to contribute to understanding the effectiveness of air pollution policies and the science of acidification in forested watersheds. The following general conclusions can be made:

- Overall TIME/LTM has served a valuable purpose and appears to have met the original objectives of providing a long term data record and contributing to understanding the effectiveness of the Clean Air Act.
- The long term data record is a valuable resource, but access to these data are very limited and metadata are non-existent.
- The years of staff experience invested in TIME/LTM represent a valuable scientific resource, as does the long-term data record. Both of these assets could be used to shape future aspects of the program such as determining specific data needed to better understand acidification processes, frequency of data collection, priority sites for measurements, etc.
- Business is <u>not</u> as usual for TIME/LTM. The transfer of the program from ORD brings challenges and opportunities. It is not always clear who makes decisions for TIME/LTM or how those decisions are or will be made (e.g., sites dropped), or sources of funding. While numerous publications have been generated using TIME/LTM data, the objectives, scope, funding, and aspects of management of the program are poorly documented. The transition provides an opportunity to reassess numerous aspects of the program, including identification of more stable funding options.
- TIME/LTM is nearly invisible to most scientists other than those directly involved. While data appear to be frequently incorporated in scientific publications, they are not always acknowledged as "TIME/LTM" and appear to be selectively used or merged with and augmented by other lake and stream acidification measurements.
- In light of the expanded interest in and development of long term environmental monitoring programs, including the recent launch of stream and lake surveys by the Office of Water, it is appropriate to consider how a relatively small effort such as TIME/LTM might be effectively integrated with other monitoring programs.

Based on these conclusions the following recommendations are offered. The June 2009 TIME/LTM Cooperator Workshop can provide a logical forum to initiate discussion on several of these recommendations.

### Recommendation 1: Clearly articulate and document the scientific question of current interest relative to acidification of fresh water lakes and streams.

It is clear that TIME/LTM has contributed to the science and policy of fresh water acidification. It is less clear what the specific question(s) are that TIME/LTM is currently addressing and whether the most critical questions about acidification are being addressed by TIME/LTM. An assessment of TIME/LTM's objectives has not been done in nearly twenty years. Based on many of the findings and conclusions in this evaluation, as well as increasing interest in data collection for other major issues such as climate change and interest in understanding the effectiveness of EPA policies and programs (e.g., acid rain), the time is opportune for an examination and validation of the critical questions relative to acidification.

### Recommendation 2: Establish a forum for interaction and discussion among the appropriate individuals with expertise to identify the right question(s) and knowledge of data needed to answer the question.

Original efforts to consider acid precipitation as a national issue were benefited by the formation and operation of NAPAP that brought together scientists and policy makers from diverse disciplines. While acid precipitation is just one of several air quality concerns today, it continues to be a significant issue in several geographic regions. As TIME/LTM management responsibility is shifted within EPA, an opportunity exists for stakeholders, cooperators, EPA scientists, and other relevant parties to engage and determine needed and effective paths forward. A structured forum to promote such engagement is needed.

### Recommendation 3: Based on the critical question and data gathered over the history of TIME/LTM, examine the methodologies and protocols to affirm approaches to ensure relevance of data collected to the question being addressed.

TIME/LTM data have been gathered and analyzed over significant time frames. These data are not only valuable for understanding specific trends in the environmental conditions being monitored, but also provide information on requirements for monitoring – how frequently must sites be visited (e.g., seasonally, annually, biennially), what parameters must be measured at each visit, how many sites require measurement, etc. Clarifying the critical scientific question should then allow an analysis of existing data to determine optimal protocols for continued sampling. Examination of individual site records may be step in this process. This type of assessment has not been done for TIME/LTM in many years. In the late 1980s/early 1990s when TIME was established to supplement LTM, the theory and needs for specific data were examined. An adaptive approach to data collection is beneficial to continually refine and improve both data collection relevance and cost. Some cooperators suggested that changes could be made to the benefit of TIME/LTM.

### Recommendation 4: Explore other long term monitoring options and how TIME/LTM can leverage or benefit them

Detailed analyses of all other monitoring programs was not conducted as part of this evaluation, but based on interviews and the continued evolution of water quality monitoring programs, opportunities to integrate TIME/LTM sites into larger surveys appear to exist. The EPA Office of Water and USGS both expressed interest in exploring these opportunities. Cooperators also suggested that these opportunities may exist. Additionally, given current challenges of overarching issues such as climate change, examination of ways that site data such as collected in TIME/LTM might contribute to understanding ecological effects would be timely. Again, however, TIME/LTM should be considered as a potential component of larger and better funded efforts rather than a stand-alone monitoring program.

### Recommendation 5: While engaging in the above activities, identify short term funding to continue data collection at some level to ensure the integrity of the long-term TIME/LTM data record.

OAR, OW, and ORD should consider approaches to identify funding to ensure that the value of the TIME/LTM data record is preserved. This may mean funding to continue to collect data on a subset of existing sites or less frequently on all sites than is currently supported. The approach in the interim may not be the best long-term solution, but can help TIME/LTM remain functional until needed longer term protocols are known and more stable funding identified.

### Recommendation 6: Continue to develop the OAR/CAMD Web site to include not only TIME/LTM data sets in usable formats, but also literature and documentation.

The efforts of OAR/CAMD to provide a Web site that gives access to data and other resources is an important evolution in TIME/LTM data management. This effort should continue and be enhanced by adding comprehensive program information, such as peer-reviewed literature, studies, and related publications from all contributing sources. Additional information on each TIME/LTM site and metadata for data records would also be valuable, although potentially beyond scope without additional funding. Improved access and usability of TIME/LTM data and research can increase program visibility and are important to preservation of the decades of data.

### Recommendation 7: Based on the outcome of the above recommendations, determine optimal institutional arrangements for program oversight and data management.

Consideration of institutional arrangements for TIME/LTM should be based on addressing the above recommendations. Depending on decisions to refocus the scientific question and evolve the program with other monitoring efforts, various options may be considered. Ideally, an infrastructure that supports a collaborative approach across science and policy interests, with opportunities for partner engagement can evolve. A single office such as a program in OAR may optimally manage data, but other offices, such as OW may best oversee data collection. ORD should continue to play a role in determining research needs and monitoring design. Alternatively, interagency approaches such as supports the NADP could be considered. Another option is a model such as the National Water Quality Monitoring Council (http://acwi.gov/monitoring/). These alternatives should be explored with consideration to approaches to ensure stable funding to support the needs of long-term monitoring.

# APPENDICES

# APPENDIX A: HISTORY AND CONTEXT FOR TIME/LTM

Various issues, efforts, programs, and interests have intersected to contribute to the current state of TIME/LTM. TIME/LTM crosses several disciplinary lines of interest, including acid precipitation, acid deposition, ecological conditions, surface water quality, science and policy interaction, and inter-agency interactions. These multi-disciplinary perspectives were a foundation of the National Acid Precipitation Assessment Program (NAPAP) that spawned TIME/LTM. The following timeline provides a brief overview of the events and activities that brought TIME/LTM to where it is today.

## TIME/LTM Timeline

### 1950s

- 1955: The Air Pollution Control Act of 1955 was passed as the first federal legislation involving air pollution (California had passed the first state air pollution law in 1947). The 1955 Act mandated that federal research programs investigate the health and welfare effects of air pollution. This was recognition that air pollutants may have effects on health and the environment.

### 1960s

- 1960: The Hubbard Brook (New Hampshire) Ecosystem Study (HBES) was initiated as a small watershed approach to study element flux and cycling (Exhibit A-1).
- 1963: The US Forest Service and Dartmouth College establish a cooperative agreement and the National Science Foundation provides funding for Hubbard Brook studies. These efforts have had continuous funding ever since.
- 1963: The Clean Air Act of 1963 was the first federal legislation regarding air pollution control. It established a federal program within the U.S. Public Health Service and authorized research into techniques for monitoring and controlling air pollution.
- 1967: Acid Rain becomes a policy issue based on Swedish scientists calling attention to the phenomenon at the United Nation's Conference on the Human Environment. Norway was the first European country to initiate a national program of research
- 1967: The Air Quality Act was enacted to expand federal government activities, including enforcement proceedings in areas subject to interstate air pollution transport. For the first time extensive ambient monitoring studies and stationary source inspections were conducted by the federal government. Air pollutant mission inventories, ambient monitoring, and control techniques were authorized.

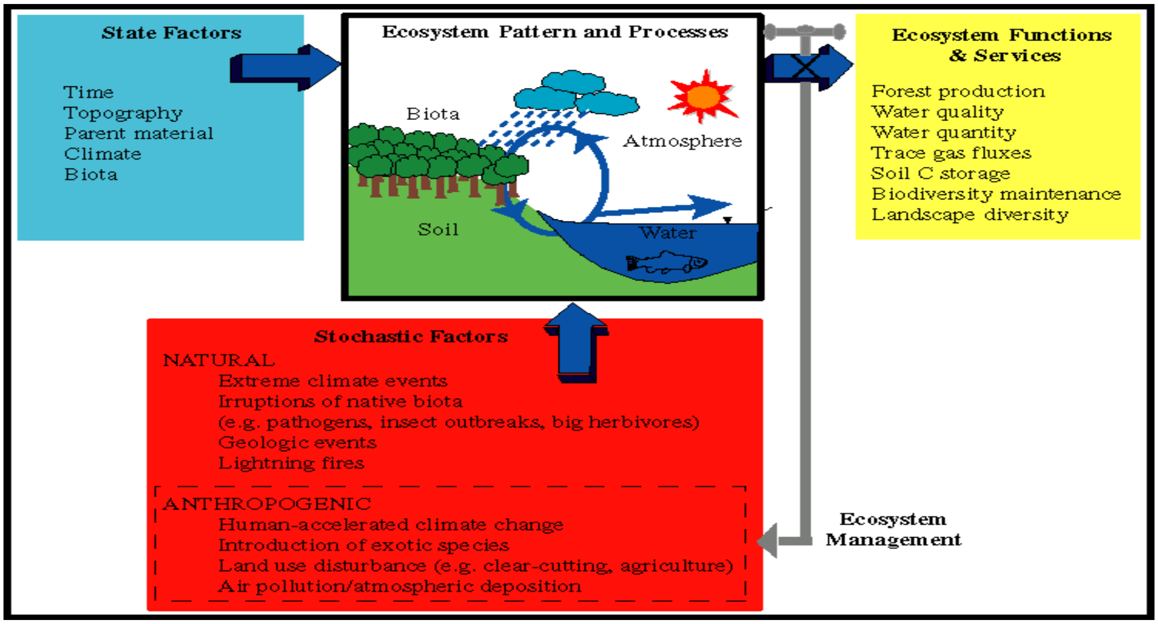


**Exhibit A-1: Initial Concepts of Ecosystem Studies**

*Source: http://www.hubbardbrook.org/overview/historical_perspective.htm*

## 1970s

- 1970: The Clean Air Act was enacted, authorizing the development of comprehensive federal and state regulations to limit emissions from stationary (industrial) sources and mobile sources of air pollutants. Four major regulatory programs affecting stationary sources were initiated: the National Ambient Air Quality Standards (NAAQS), State Implementation Plans (SIPs), New Source Performance Standards (NSPS), and National Emission Standards for Hazardous Air Pollutants (NESHAPs).
- 1970: The Environmental Protection Agency was created by Executive Order from President Nixon, with a key responsibility of implementing the Clean Air Act.
- Early 1970s: US scientists assert that lakes in the Adirondack Park and other pristine areas of upper New York, Vermont, and New Hampshire were suffering from the effects of "acid rain"
- Mid -1970s: Sulfur deposition peaks at Hubbard Brook based on ongoing surface water quality surveys
- 1975: The New York State Department of Health and the New York State Department of Environmental Conservation sample the chemistry of 57 remote lakes in the Adirondack Mountains.
- 1977: Major amendments added to the Clean Air Act to address the Prevention of Significant Deterioration (PSD) of air quality in areas attaining the NAAQS. National goals were established for carbon monoxide, ozone, particulate matter, oxides of nitrogen, oxides of sulfur, and lead.
- 1978: Initiation of the National Atmospheric Deposition Program/National Trends Network (NADP/NTN) as a nationwide network of precipitation monitoring sites (22 sites in 1978).

**1980s**

- 1980: Vermont Department of Environmental Conservation began monitoring the chemistry of lakes which later become monitoring in cooperation with EPA through its LTM Program in 1983.
- 1980: The Acid Precipitation Act of 1980 (Title VII of the Energy Security Act of 1980, P.L. 96-294) established an Interagency Task Force on Acid Precipitation. The Task Force implemented the National Acid Precipitation Assessment Program (NAPAP) to do the following:
  - Identify the causes and sources of acid precipitation
  - Evaluate the environmental, social, and economic effects of acid precipitation, and (based on the results of the research program) authorize action to the extent necessary and practicable to (A) limit or eliminate the identified sources of acid precipitation and (B) remedy or otherwise ameliorate the harmful effects that may result from acid precipitation.
- 1982[38]-83[39]: The LTM Program (LTMP) was established as part of NAPAP by incorporating sites already under study or planned in the Adirondacks, Vermont, Maine, Upper Midwest, Rocky Mountains, and Catskill Mountains. The objectives, as listed in NAPAP 1984[40] (these changed somewhat in subsequent years) were to:
  - "detect and measure long-term chemistry trends of surface waters with low alkalinity and
  - compare the response of low alkalinity waters over a geographic gradient of hydrogen ion and sulfate deposition"
- 1983: The Aquatic Effects Task Group (EPA, USGS, USFWS, the Tennessee Valley Authority, and various state agencies and universities) under NAPAP formed the Aquatic Effects Research Program (AERP). The AERP was EPA's primary contribution to NAPAP and examined the effects of acid precipitation on aquatic ecosystems.
- 1984: As part of the LTM - 127 lake and stream sites were monitored in 11 states. The data were stored in the Acidic Deposition Assessment Data Network (ADDNET) at the Department of Energy Oak Ridge National Laboratory. Preliminary analyses were expected to establish baseline conditions of alkalinity.
- 1984: Also as part of the LTM - studies of the effects of storm and snowmelt events were initiated in the Catskills, SW PA, the Southern Blue Ridge Province, and the Ouachita Mountains of Arkansas. Studies were continued on aluminum in acid lakes.
- 1984-85– The National Surface Water Survey (NSWS) was funded under NAPAP to address the question of "how many lakes are affected by acidification?" A total of 2075 lakes were selected for sampling in the Eastern US and 752 lakes in the Western US in 1984 and 1985 respectively.

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[38] Newell, Powers, and Christie. Analysis of Data from Long-Term Monitoring of Lakes. 1987. EPA/600/4-87/014, U.S. Environmental Protection Agency, Washington, D.C.
[39] Aquatic Effects Research Program (AERP) Status, EPA, April 1990. EPA/600/M-90/001
[40] National Acid Precipitation Program Annual Report, 1984

- 1985: As part of the LTM, 117 lakes and 23 streams in the mountainous West, Upper Midwest, New England, New York, the Appalachians, and Piedmont Plateau were monitored. Additionally, the USGS monitored watersheds in Washington, North Dakota, Wisconsin, and the Appalachians and cooperated with the NPS in studies in Rocky Mountain NP and Sequoia NP. The NPS conducts watershed scale research in Isle Royale NP and Olympic NP. The objectives of these efforts were to:
  - "detect long term trends in the chemistry and surface waters with low acid neutralizing capacity, and
  - compare the response of low acid neutralizing capacity waters over a geographic gradient of hydrogen ion and sulfate deposition."[41]
- 1986: EPA establishes the National Dry Deposition Network and CASTNET
- 1987: The Concept of TIME paper is published stating the following: "The purpose of the TIME project is to design and implement, through NAPAP, a coordinated long-term monitoring effort that will obviate many of the criticisms associated with environmental monitoring programs."
- 1988-91: EPA Episodic Response Project (ERP) was conducted to determine the nature of episodic changes in stream chemistry and how they affect aquatic biota, especially fish, in 13 streams in Pennsylvania Appalachians, and Catskills and Adirondacks of New York. The effort documented for first time in US that episodic stream acidification can lead to fish mortality.
- 1989: TIME and LTM projects were transferred from the AERP to the EPA Environmental Monitoring and Assessment Program (EMAP).

**1990s**

- 1990: Congress passes Title IV of the Clean Air Act Amendments (Acid Deposition Control). This Act calls for major reductions of sulfur and dioxides and nitrogen oxides, the pollutants that cause acid rain. The Act established the Acid Rain Program, which authorized EPA to limit emissions of these pollutants.
- 1991: NAPAP releases its Integrated Assessment Report and is reauthorized by Congress as an open-ended program to continue acid rain research, set targets for emissions reductions, and make periodic assessments on the effectiveness of these measures. A total of $530M was expended over the decade of NAPAP work (1980-1990).
- 1991: TIME program began sampling Northeast lakes
- 1993: TIME program begins sampling Mid-Atlantic streams
- 1995: CAAA Title IV Phase I implemented
- 1995: The Mercury Deposition Network (MDN)was formed to collect weekly samples of precipitation to monitor the amount of mercury in precipitation on a regional basis;
- 1997: NAPAP began to operate under the auspices of the Committee on Environment and Natural Resources (CENR) of the National Science and Technology Council. NAPAP's goal continued to be providing credible technical findings on acid deposition and its

[41] NAPAP Annual Report 1985

effects to inform the public decision-making process. To ensure that this goal was met, NAPAP coordinated its activities through the Air Quality Research Subcommittee of CENR.

**2000s**

- 2000: CAAA Title IV Phase II implemented
- 2003: ORD issues Response of Surface Water Chemistry to the Clean Air Act Amendments of 1990, which showed large decreases in sulfate and base cations, smaller decreases in nitrates, widespread increases in ANC, and almost no changes in hydrogen ion, concluding that a market-based approach to pollution control is effective.
- 2005: NAPAP Report to Congress describes small but significant increases in ANC of surface water in the Upper Midwest, Adirondacks, and northern Appalachians, but smaller increases in New England (Maine and Vermont).
- 2007: The decision was made to redefine the scope of NAPAP in advance of the next report. Parts of previous NAPAP reports essentially duplicate what is already covered in annual progress reports issued by the Clean Air Markets Division of the Office of Atmospheric Programs of EPA. These EPA progress reports include annual data on emissions, air quality and deposition, market indicators (e.g. allowance prices), and health benefits, as well as information on the status of acid-sensitive lakes and streams as a result of implementation of Title IV. Future plans call for EPA to continue to issue these annual reports as a means of reporting progress on new legislation such as the Clean Air Interstate Rule (CAIR) and Clean Air Visibility Rule (CAVR). In light of these ongoing EPA reports, a decision was made that future NAPAP reports should focus on providing an integrated assessment of the effects of acid precipitation on sensitive ecosystems.
- 2008: The EPA Office of Research and Development determines that they will stop supporting the TIME/LTM effort and makes plans to transfer the program to OAR.
- 2008: OAR requests funding from OPEI to conduct a performance evaluation on TIME/LTM
- 2009: TIME/LTM cooperators and EPA conduct a workshop to discuss the future of TIME/LTM, including the results of the performance evaluation

## APPENDIX B: TIME/LTM PROGRAM EVALUATION METHODOLOGY

# Evaluation of EPA's Temporally Integrated Monitoring of Ecosystems (TIME) and Long-Term Monitoring (LTM) Programs: Evaluation Methodology

# Table of Contents

# Introduction and Purpose

This document describes the methodology to be used to evaluate the effectiveness of the Temporally Integrated Monitoring of Ecosystems (TIME) and Long-Term Monitoring (LTM) programs. The TIME/LTM programs were established to measure changes in ecological conditions in response to changing air emissions and acid deposition. An evaluation of TIME/LTM was selected as one of five program evaluations in FY 2009 under EPA's Office of Policy, Economics and Innovation (OPEI) 2008 Program Evaluation Competition. The evaluation entails an assessment of program design, implementation, costs, and other factors to determine TIME/LTM program effectiveness, long-term sustainability, and contributions to knowledge of ecological conditions affected by acid deposition. Assessment of these programmatic aspects of this environmental monitoring effort may also help to identify and develop performance measures for both TIME/LTM and other ecological monitoring programs, to improve monitoring relevance for environmental protection programs.

EPA's Office of Research and Development (ORD) is transferring the responsibilities for funding and managing the TIME/LTM programs to the Office of Air and Radiation (OAR). This is expected to occur by the end of fiscal year 2009. OAR requested funds from OPEI to conduct this evaluation, in part to address opportunities for improved program effectiveness during and after this transition. The intended audience for the report and related products is both OPEI and OAR, but also includes other agencies that partner with EPA to collect and utilize ecological monitoring data, such as the National Park Service and U.S. Geological Survey. OAR plans to use the results of the evaluation to assess the extent to which the program is meeting its objectives and identify opportunities for program improvement. OPEI may use the results to help structure other evaluations to improve environmental monitoring efforts nationwide.

# Evaluation Team and Steering Committee

An Evaluation Team was established that consists of the contractor (Industrial Economics, Inc. and Ross & Associates Environmental Consulting, Ltd), managers and senior staff from OAR, and the evaluation lead from OPEI's National Center for Environmental Innovation, Evaluation Support Division. A Steering Committee was also established to provide broad input over the course of the evaluation. It is comprised of representatives from OAR, ORD, and other federal agencies that conduct ecological monitoring, including the National Park Service and U.S. Geological Survey (USGS).

# Background

LTM was initiated in 1983 as part of the National Acid Precipitation Assessment Program (NAPAP) and specifically focused on sampling sites prone to acid deposition in the Rocky Mountains, Adirondacks, Catskills, the upper Midwest, Maine, and Vermont. In 1990, Title IV of the Clean Air Act Amendments (CAAA) set target reductions for sulfur and nitrogen emissions from electric utilities to help reduce the acidity of atmospheric deposition. One purpose of such reductions was to protect ecosystems from acidifying deposition of nitrogen and sulfur. TIME was established to provide a more random sample of water bodies in the Northeast and Mid-Atlantic regions to better understand the percentage affected by acidification and changes over time. Since then the focus of both programs has been on acid-prone water bodies, with chemical data collected such as acid neutralizing capacity (ANC), pH, sulfates, nitrates, various cations, some toxic metals, dissolved organic carbon, conductivity, and color.

Data collected as part of TIME/LTM have contributed to documentation of declines in surface water sulfates in most regions (except Ridge/Blue Ridge Provinces). Acid neutralizing capacity (ANC), a key indicator of recovery, has been measured as increasing in three of the regions (Adirondacks, Northern Appalachian Plateau and Upper Midwest). TIME/LTM data have also documented increased amounts of Dissolved Organic Carbon (DOC). These trends, being seen in many areas around the world, are considered by scientists to be a function of processes associated with recovery from acidification or a potential ecological response to climate change.

Other monitoring programs such as the Clean Air Status and Trends Network (CASTNET) and the National Atmospheric Deposition Program/National Trends Network (NADP/NTN) measure precipitation chemistry and dry deposition, respectively, providing status and trends of pollutants being released to the environment. EPA, a primary data user, integrates TIME/LTM data collected by a network of cooperators from various state agencies, academic institutions, and other federal agencies with data from CASTNET and NADP to help determine whether changes in atmospheric emissions affect ecological response.

# Evaluation Questions

The following questions were included in the work assignment to form the basis for preliminary discussions with the core evaluation team and Steering Committee:

- Why were the TIME/LTM programs established? Do their program objectives remain valid? Have the objectives changed over time?
- What data/information do TIME/LTM collect, and how do the TIME/LTM data contribute to, overlap with, and/or enhance the understanding and relevance of other monitoring efforts?
- How are TIME/LTM data accessed? Who uses them and for what purposes (e.g., ecological research, environmental modeling, program performance measurement)?
- What changes, if any (e.g., data parameters, data accessibility, geographic coverage, timeliness), are needed in TIME/LTM to make the monitoring data more useful to EPA and other users of the data? Are environmental conditions changing (e.g., climate change) and if so, how do they affect the relevance and usefulness of TIME/LTM and any changes that should be made to TIME/LTM?

- Are there now more cost-effective and efficient methods (e.g., new technologies) for assessing the impacts or obtaining data comparable to or better than those currently provided by TIME/LTM? What are they?
- What is the most effective means within EPA/OAR to administer TIME/LTM? Is the current approach used by ORD - grants, interagency agreements, and direct funding to EPA labs – the most effective or are there alternatives such as one contract for monitoring?

The Steering Committee and the evaluation team used these original questions to develop a set of refined evaluation questions. The refined evaluation questions encompass a number of programmatic and administrative areas and can be answered with available data (see the section on Steps for Conducting the Evaluation for description of data sources), including program objectives, data use and access, cost-effectiveness, and administrative approaches; and give rise to a number of sub-questions that will be asked of selected interviewees. Details on interview questions and sub-questions and the individuals selected to address them can be found in the following section and the interview guide in appendix M-2.

The refined evaluation questions below reflect consideration of program context in relation to other ecological monitoring programs and also deconstruct TIME/LTM program aspects (data collection, use, costs, etc.) into sufficient detail for analysis of their contributions to overall program effectiveness.

## Refined Evaluation Questions

1. What is the purpose of the TIME/LTM programs?
    a. What are the TIME/LTM objectives?
    b. Have the objectives changed over time?
2. What are the key characteristics of the TIME/LTM programs?
3. Who uses TIME/LTM data and for what purposes (e.g., basic research, policy development)?
4. What is the relationship of TIME/LTM to other ecological monitoring programs?
5. What are the costs associated with TIME/LTM?
    a. Are there more cost-effective approaches to data collection and analysis?
    b. What other resources does TIME/LTM help to leverage?
6. How are TIME/LTM administered and managed?
7. What opportunities exist to improve TIME/LTM?

***1. What is the purpose of the TIME/LTM programs? 1a. What are the programs' objectives? 1b. Have program objectives changed over time?***

The purpose of this evaluation question is to gain an understanding of TIME/LTM objectives as initially established, determine whether and in what ways they have evolved over time, and whether the program objectives remain valid. For example, new questions about emerging environmental issues, such as climate change, as well as an increasing emphasis on performance management may affect the relevance and use of the programs' long-term record of acidification in freshwater ecosystems.  This question will establish context for information gathered to address evaluation question 7.

***2.  What are the key characteristics of TIME/LTM?***

Information gathered from this evaluation question will be used to describe the major TIME/LTM program components including contractual agreements and requirements, the type(s) and number of sites monitored, and sampling frequencies for the data collected. Information collected from this question complements evaluation question 5 (program costs) by (1) illustrating the full spectrum of TIME/LTM data collected, on which objective discussion of program costs can be based, and (2) identifying program strengths and/or weakness made apparent by assessing regions separately and as part of a monitoring network .

***3.  Who uses TIME/LTM data and for what purposes (e.g., basic research, policy development)?***

This evaluation question will be used to describe the current and potential users of TIME/LTM data and the purposes for which they are used. Beyond basic monitoring and its application to national policy, TIME/LTM may have other uses at the global, regional, state, and local level. This evaluation question also probes users' access to data; ways in which access could be expanded; benefits and challenges associated with expanding TIME/LTM data access to a broader audience.

***4.  What is the relationship of TIME/LTM to other ecological monitoring programs?***

This evaluation question examines the role of TIME/LTM in relation to other ecological monitoring programs, such as CASTNET and NADP; as part of EMAP and broader ecological monitoring; and at the regional and state levels.

***5.  What are the costs associated with TIME/LTM? 5a. Are there more cost-effective approaches to data collection and analysis? 5b. What other resources does TIME/LTM help to leverage?***

The purpose of this evaluation question is to explore the EPA and non-EPA resources required to maintain program operations, and perspectives on other approaches to data collection and/or analysis that could represent cost savings to the program.

***6. How are TIME/LTM administered and managed?***

A thorough understanding of current TIME/LTM program administration and management is needed to help identify opportunities for program improvement in these areas, as EPA considers the transfer of the program from ORD to OAR.

***7.  What opportunities exist to improve TIME/LTM?***

The purpose of this evaluation question is to tie together multiple aspects of program effectiveness (e.g., meeting objectives, increasing program visibility through data access) and gather perspectives from a range of stakeholders on various opportunities EPA can consider for overall program improvement.

# Logic Models

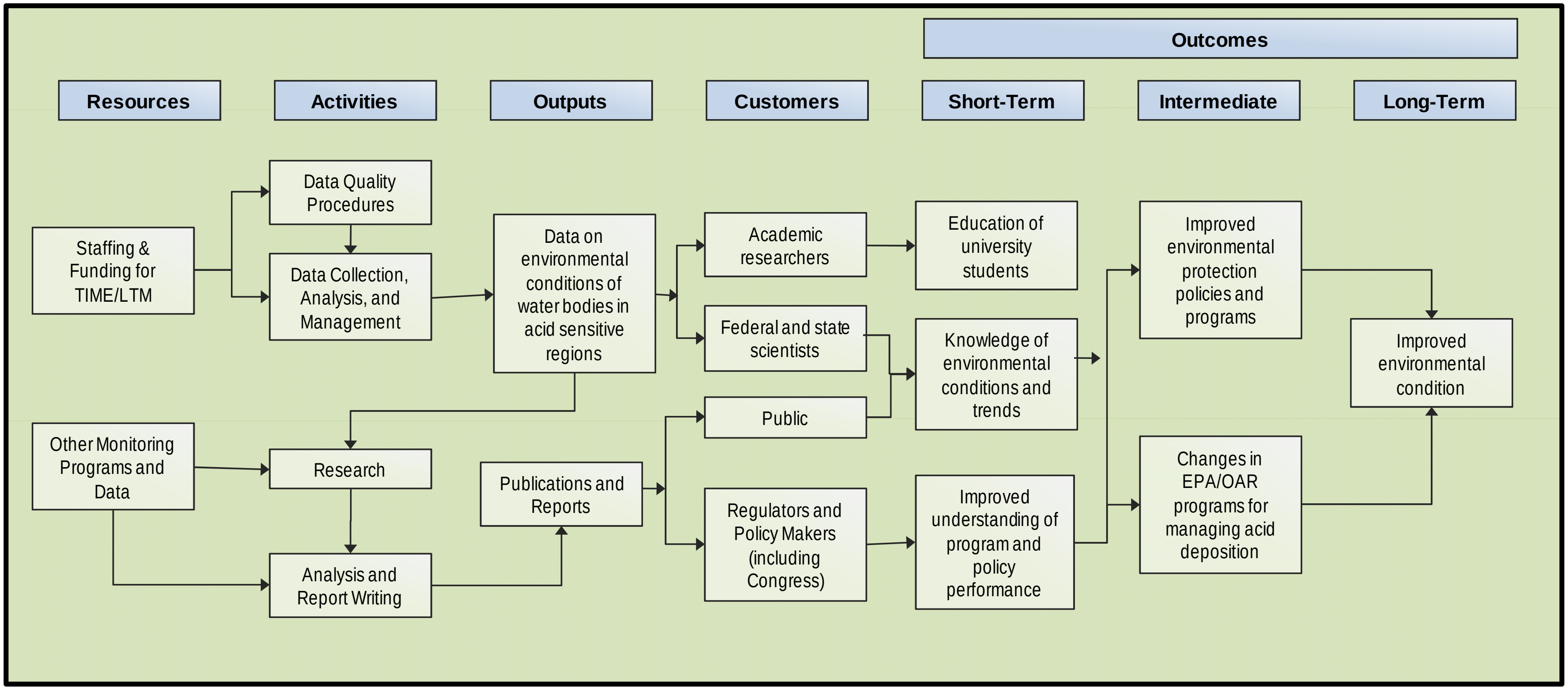
A logic model is a graphical representation of the relationships among program inputs, outputs, and outcomes (Exhibit 1). A logic model helps to elucidate the components, participants, and processes that affect a program and provides a key means to understand interactions and dependencies that are critical to the success of a program evaluation.

- **Resources:** basic inputs of funds, staffing, and knowledge dedicated to the program
- **Activities:** specific processes or results of the inputs needed to achieve program goals
- **Outputs:** immediate products that result from activities and often used to measure short-term progress
- **Customers:** groups and individuals targeted by TIME/LTM funding and associated activities and outputs
- **Short-Term Outcomes:** immediate uses of TIME/changes data linked to outputs
- **Intermediate Outcomes:** changes in knowledge and understanding based on use of TIME/LTM data
- **Long-Term Outcomes:** changes in behavior based on TIME/LTM data; the overarching goals of the program

**Exhibit 1. TIME/LTM Program Logic Model Components**

Logic models can contain varying levels of detail, ranging from simple depictions of flows of information to more detailed nuances of processes and interactions. Exhibit 2 depicts a high-level model to show the general interactions among TIME/LTM monitoring efforts, other monitoring data, and expected outcomes. It captures the various customers (e.g., researchers, scientists, and policy-makers) who have contributed to and utilized TIME/LTM data for over two decades. A more detailed logic model will be developed as interviews are conducted and the program evaluation proceeds, to show specific aspects of funding and resources that EPA commits to TIME/LTM, including how resources are used, by whom, and for what purposes, as well as how TIME/LTM results are used.

## EXHIBIT 2: HIGH-LEVEL TIME/LTM PROGRAM EVALUATION LOGIC MODEL



# Steps for Conducting the Evaluation

Four major steps are planned to conduct this evaluation, utilizing a number of primary and secondary sources of information. These steps include: (1) identifying and reviewing relevant documentation and literature; (2) collecting information from interviews; (3) analysis of data from documentation and interviews; and (4) preparation of the final evaluation report. Table A below depicts the basic design of the evaluation research methodology, followed by discussion of each step in detail.

**Table A. TIME/LTM Evaluation Methodology**

| Evaluation Questions | Data Collection Method | *Data Source(s)* |
|---|---|---|
| (1) What is the purpose of the TIME/LTM programs? | Document review and literature search<br><br>Interviews | TIME/LTM bibliography<br><br>ORD – Stoddard<br>OAR – Haeuber |
| (2) What are the key characteristics of the programs? | Document review<br><br>Interviews | TIME/LTM bibliography<br><br>ORD –Stoddard<br>OAR – Haeuber<br>TIME/LTM cooperators |
| (3) Who uses TIME/LTM data and for what purposes (e.g., basic research, policy development)? | Document review and literature search<br><br>Interviews | TIME/LTM bibliography, EPA Acid Rain Progress Reports, NAPAP annual summary<br>Logic model for TIME/LTM program<br><br>ORD -Stoddard, Linthurst<br>OAR – Haeuber<br>TIME/LTM cooperators and program managers<br>NPS, USGS, CEBC, Data Basin, etc. |
| (4) What is the relationship of TIME/LTM to other ecological monitoring programs? | Literature search<br><br>Interviews | Publicly available documents online<br><br>ORD, NPS, USGS, CEBC, Data Basin, etc. |
| (5) What are the costs associated with TIME/LTM? | Document review<br><br>Interviews | Cooperative/interagency agreements, contracts<br><br>ORD – Stoddard<br>TIME/LTM cooperators and program managers |
| (6) How are TIME/LTM administered and managed? | Document review<br><br>Interviews | TIME/LTM bibliography<br><br>ORD – Stoddard, Washburn, Teichman, Linthurst |
| (7) What opportunities exist to improve TIME/LTM? | Analysis, development of findings and recommendations | Information collected from 1-6<br>Discussions with Evaluation Team and Steering Committee |

## Identify and Review Relevant Documentation

To describe the purpose, objectives, and general program characteristics of TIME/LTM, Ross & Associates will conduct a literature search and review program publications provided by OAR and OPEI, and other publicly accessible documents. Key data sources at this stage of the evaluation include:

- Research articles and other TIME/LTM-based publications from peer-reviewed scientific journals (1984-2007), provided by OAR and OPEI. The primary focus of each article ranges from trends in surface water chemistry in specific geographic regions, applications of various models for detecting and predicting changes in analyte levels, and case studies on the effects of acid deposition on aquatic ecosystems.
- NAPAP reports, publicly accessible online. The most recent report (2005) is based on 2002 air emissions data, and uses quantitative and qualitative indicators to assess the effectiveness of the cap and trade approach to reduce emissions, improve air quality and reduce acid deposition while minimizing compliance costs. NAPAP also identifies emerging areas of acid rain research and long-term environmental monitoring.
- Data quality reports and annual summaries reported by TIME/LTM cooperators as a requirement of cooperative agreements with EPA.
- Cooperative agreements, interagency agreements, and research proposals.
- Recent review articles and other relevant publications found through basic online literature search, using Google Scholar and University of Washington Library search engines. Key search terms included TIME/LTM, ecological monitoring, acid rain, and ecosystem acidification (Note: these searches yielded very few articles outside of the 105 publications sent by OAR and OPEI).

A preliminary analysis of the literature suggests that the following components are critical to the success of ecological monitoring programs such as TIME/LTM: (1) Clearly articulated program objectives; (2) maintenance of high quality data through careful documentation of data collected, collection methods, and measurements; (3) data management systems that are compatible with long-term data accessibility and optimize use; (4) flexibility/capacity to adapt to changing research questions and new technologies without compromising core measures of target analytes or conditions; and (5) sufficient funding base for continuity of data collection, data management, data use, and publication. These components strongly align with the evaluation questions and provide fertile ground for the development of detailed interview questions and sub-questions shown in appendix M-2.

## Conduct Interviews with Key Stakeholders

To identify specific uses of TIME/LTM data and the types of policy and research questions they answer Ross & Associates will conduct telephone interviews (approximately one hour each) with a number of stakeholders from various program perspectives. The current principal investigators from each of the six TIME/LTM regions will be interviewed because they comprise the majority of TIME/LTM data collectors and users and publish regularly on the status and trends in surface water chemistry of acid-sensitive lakes and streams across the network. ORD contractors, funded through on-site research support contracts at both TIME/LTM laboratories (Corvallis and Cincinnati), will be interviewed based on their experience with TIME/LTM data collection and analysis. Representatives from OAR, ORD, and other federal agencies and nongovernmental organizations identified by EPA will also be interviewed to gather information on current and potential data uses, management and administration, and the relationship of TIME/LTM to other ecological monitoring systems. Table C in appendix M-2 provides a brief description of stakeholders selected for interviews and reasons for their selection. The focus of each interview will vary depending on the extent of interviewees' involvement with TIME/LTM and perspectives sought (see Tables B-D). Interviews will directly follow the questions in the interview guides; however, interviewees who skip ahead to other topics/questions will be allowed to continue as long as all questions are answered during the course of the interview. This approach was chosen over other types of qualitative interviewing techniques to allow the systematic collection of data while giving the interviewers flexibility to probe for in-depth responses when necessary. Ross & Associates will facilitate the interviews to ensure they remain focused and do not exceed the allocated interview time. Appendix M-2 is the interview guide with detailed interview questions and sub-questions. Appendix M-3 lists the interviewees selected for this evaluation and the rationale for selecting them.

**TABLE B. Information Gathered in Interviews with TIME/LTM Cooperators and Contractors**

| Evaluation Question | Information Sought to Help Answer Evaluation Question |
|---|---|
| 1. What is the purpose of the TIME/LTM program? | • What are the program's goals and objectives? Have they been consistently communicated across the network (and documented)?<br>• How have goals changed over time and why?<br>• Perspectives on the validity of the research questions TIME/LTM currently addresses. |
| 2. What are the key characteristics of the program? | • How were TIME/LTM contracts initially established? What are cooperators required to do or provide to EPA as contractual requirements?<br>• What data are collected by the program, and what methods are used for data collection? |
| 3. Who uses TIME/LTM data and for what purposes (e.g., basic research, policy development)? | • What other TIME/LTM data users may exist that currently do not have access (internal to EPA, external)?<br>• Based on type of users identified, perspectives on ways in which data/data access can be improved to meet needs. |
| 5. What are the costs associated with TIME/LTM? | • Proportion of funding received from ORD versus other resources needed to maintain data collection efforts.<br>• Adequacy of funding to regularly carry out data collection and analysis<br>• Approaches taken by cooperators to leverage other resources and resulting program benefits (if any).<br>• Ability to implement new technologies or methods for collecting data.<br>• Overall value of TIME/LTM data for the funding required to sustain the program. |
| 6. How are TIME/LTM administered and managed? | • How data are managed and stored; the extent to which metadata is captured.<br>• Are there ways to optimize data accessibility and use?<br>• Perspectives on necessity of data hold-back times<br>• Perspectives on ways in which OAR could improve management/administration of TIME/LTM |
| 7. What opportunities exist to improve TIME/LTM? | • Perspectives on various approaches OAR should consider to improve program effectiveness across a range of areas (e.g., program design, costs, data access and use). |

**TABLE C. Information Gathered in Interviews with EPA (OAR, ORD, and OW)**

| Evaluation Question | Information Sought to Help Answer Evaluation Question |
|---|---|
| 1. What is the purpose of the TIME/LTM programs? | • What are the program's goals and objectives? Are they consistently communicated across the network (and documented)?<br>• How have goals changed over time and why?<br>• Perspectives on the validity of the research questions TIME/LTM currently addresses. |
| 3. Who uses TIME/LTM data and for what purposes (e.g., basic research, policy development)? | • What other TIME/LTM data users may exist that currently do not have access (internal to EPA, external)?<br>• Based on type of users identified, perspectives on ways in which data/data access can be improved to meet needs. |
| 4. What is the relationship of TIME/LTM to other ecological monitoring programs? | • The role of TIME/LTM in relation to other EPA ecological monitoring programs or aspects thereof (e.g., CASTNET, NADP, National Aquatic Resource Surveys); how TIME/LTM data are integrated with other program data. |
| 5. What are the costs associated with TIME/LTM? | • Proportion of funding received from ORD versus other resources needed to maintain data collection efforts.<br>• EPA perspective on adequacy of funding to regularly carry out data collection and analysis<br>• Options to improve cost-effectiveness.<br>• Overall value of TIME/LTM data for the funding required to sustain the program. |
| 6. How are TIME/LTM administered and managed? | • How data are managed and stored; the extent to which metadata is captured.<br>• Are there ways to optimize data accessibility and use?<br>• Perspectives on necessity of data hold-back times<br>• Perspectives on ways in which OAR could improve management/administration of TIME/LTM |
| 7. What opportunities exist to improve TIME/LTM? | • Perspectives on divisions within OAR that may inherit TIME/LTM. How will the program be managed, by whom, and to what extent will ORD continue to be involved?<br>• Perspectives on various approaches OAR should consider to improve program effectiveness across a range of areas (e.g., program design, costs, data access and use). |

**TABLE D. Information Gathered in Interviews with Officials from Other Federal Agencies and Nongovernmental Organizations**

| Evaluation Question | Information Sought to Help Answer Evaluation Question |
|---|---|
| 3. Who uses TIME/LTM data and for what purposes (e.g., basic research, policy development)? | • What other TIME/LTM data users may exist that currently do not have access (internal to EPA, external)?<br>• Based on type of user, perspectives on ways in which data/data access can be improved to meet needs. |
| 4. What is the relationship of TIME/LTM to other ecological monitoring programs? | • Information on non-EPA ecological monitoring programs (including international programs) and what can be learned from these efforts and applied to TIME/LTM, with respect to acid deposition. |
| 7. What opportunities exist to improve TIME/LTM? | • External perspective on benefits and challenges of expanding data accessibility. |

| | |
|---|---|
| | • Approaches for improving data access and using data to improve program effectiveness and inform decisions around policy making. |

### Data Management and Analysis

Content analysis of data collected from document and literature review and interviews will be the general analytic approach used for the evaluation, based on a number of factors. The evaluation is qualitative and descriptive in nature; different sets of interview questions will be asked of each stakeholder group resulting in varied responses and perspectives within and across each group; and interpretation of testimonial data is likely to require a degree of subjectivity for theme development that is not easily supported by a complex database or development of quantitative indicators for statistical analysis. Analysis of information will begin with the first interviews. From comprehensive notes taken during interviews, Ross & Associates will begin to broadly categorize and summarize responses into common themes using an appropriate coding scheme that facilitates identification of patterns. The framework for organizing coded information will consist of a simple spreadsheet or summary document to catalog themes and corresponding coded passages, providing a record to support findings, conclusions, and recommendations. As themes and common issues are developed, the core evaluation team and Steering Committee will meet via teleconference to discuss preliminary findings, gather input, and identify areas for follow-up.  Ross & Associates will develop a report outline based on preliminary findings and guidance from the core evaluation team and Steering Committee, from which the find evaluation report will be drafted.

### Prepare Final Evaluation Report

Ross & Associates will synthesize the information collected through background research, document and literature review, and interviews into a final report that addresses the evaluation questions and supports fully developed recommendations for approaches to improve the effectiveness of the TIME/LTM program. The Evaluation Team and Steering Committee will guide report development and provide direction on areas of focus during periodic conference calls.  For quality assurance, EPA staff, the Steering Committee, and others that provided information through interviews will have opportunities to review the report for technical accuracy and completeness. In addition to the evaluation report, a fact sheet and materials for an oral presentation will be developed as directed by EPA.

## Program Evaluation Timeline

The program evaluation will be conducted from November 2008 to May 2009.  Table E below provides a general timeline for collection and analysis of information and preparation of evaluation products.

**Table E. TIME/LTM Program Evaluation Timeline**

| Timeframe | Activities |
|---|---|
| Nov. 10 – Dec. 12 | $ Finalize evaluation questions<br>$ Develop bibliography database<br>$ Identify interviewees<br>$ Continue background research<br>$ Draft logic models |
| Dec. 15 – Jan. 9 | $ Develop program effectiveness criteria<br>$ Draft evaluation methodology<br>$ Finalize logic models<br>$ Complete background research<br>$ Schedule and begin conducting interviews |
| Jan. 12 – Feb. 20 | $ Finalize evaluation methodology<br>$ Complete remaining interviews<br>$ Begin to synthesize information from background research and interviews<br>$ Develop draft report outline<br>$ Hold teleconference with core evaluation team and Steering Committee to discuss information gathered, analytic approaches, and need for follow-up interviews |
| Feb. 23 – Mar. 13 | $ Refine outline based on findings from data collection and input from core EPA team<br>$ Begin developing initial draft of report |
| Mar. 16 – Apr. 10 | $ Schedule and conduct follow-up interviews as necessary<br>$ Complete draft report<br>$ Submit draft report to core evaluation team and Steering Committee for review and to others as needed for technical review |
| Apr. 13 – May 5 | $ Refine draft report, solicit and incorporate final comments<br>$ Develop fact sheet and briefing and/or presentation materials as needed<br>$ Present report findings as requested |

*Note – A TIME/LTM Cooperator's Workshop has been scheduled for June 3-4, 2009 at Penn State University.*

# Appendix M-1: Initial Contact Emails Sent to Interviewees

**Message to TIME/LTM Principal Investigators and Cooperators**

From: Laroche.David@epamail.epa.gov
Sent: Fri 12/12/2008
Subject: Interview Phase of the TIME/LTM Program Evaluation

Hi Everyone,

Some of you may know, and others not, of a study that EPA is undertaking to assess EPA's Temporally Integrated Monitoring of Ecosystems and Long Term Monitoring (TIME/LTM) programs. As you may also know, the administration of the TIME/LTM programs may be transferred, within EPA, from the Office of Research and Development (ORD), where these programs have been managed since their inception, to the Office of Air and Radiation (OAR), one of the principal users of the data generated under the programs. OAR is taking this opportunity to take a closer look at the programs, understand their value to some OAR core programs, and assess whether they might be improved or augmented to provide a better assessment of the impact of reduced deposition on ecosystem conditions.

Planning for this study has been underway for some time and data collection is to begin at the start of calendar year 2009. We are alerting you to this activity because you will be contacted to provide information about the programs from your perspective (e.g., how you collect data and how you use it), as well as any other insights to the programs you want to provide. EPA has hired Ross & Associates (a contractor) to assist with the project and they will lead the data collection effort. To give you a better sense of how this project is organized, we have attached a copy of the project proposal, which includes a series of questions that will provide structure for the data collection effort.

Our plan is complete the project in early spring 2009 and provide the results to stakeholders in April. However, in the meantime, we welcome your questions or comments at any time during the process. Please feel free to call with questions, comments, or suggestions at the number provided below.

David R. LaRoche
Senior Advisor
U.S. EPA
Office of Air & Radiation 6102-A
Washington, DC 20460
Phone: (202) 564-3926
Fax: (202) 564-1327

**Message to TIME/LTM Steering Committee**

From: Laroche.David@epamail.epa.gov
Sent: Fri 12/12/2008
Subject: Interview Phase of the TIME/LTM Program Evaluation

Hi Everyone,

I am writing to give you a heads up about the next phase in our program evaluation process. As you may recall, we have been in the organizing and planning phase of the program evaluation for the last couple of months. In the next few weeks, our contractor (Ross & Associates of Seattle, WA) will begin the interview phase of the project and will be contacting you to set up a time to talk by phone. These conversations will be focused primarily on collecting background information about the TIME/LTM programs, other ecological monitoring programs you may be aware of, and other information you may be aware of that would be helpful in our assessment of the programs.

Once again, thank you for agreeing to help us out and don't hesitate to give me a call if you have any questions.

David R. LaRoche
Senior Advisor
U.S. EPA
Office of Air & Radiation 6102-A
Washington, DC 20460

Phone: (202) 564-3926
Fax: (202) 564-1327

# Appendix M-2: Interview Guide

[Introductions] Thank you for taking the time to talk with us today. We (Ross & Associates) are working under contract with EPA to help them assess the Temporally Integrated Monitoring of Ecosystems and Long Term Monitoring (TIME/LTM) programs. As you may know, the administration of the TIME/LTM programs may be transferred within EPA from the Office of Research and Development (ORD), where these programs have been managed since their inception, to the Office of Air and Radiation (OAR). OAR is taking this opportunity to take a closer look at the programs, understand their value to some OAR core programs, and assess whether they might be improved or augmented to provide a better assessment of the impact of reduced deposition on ecosystem conditions.

[For interviewees less familiar with TIME/LTM, the programs collect surface water chemistry data that is used to assess the ecological response of acid-sensitive watersheds most impacted by acidic deposition. Both programs are operated cooperatively among state agencies, academic institutions, EPA, and other federal agencies].

Your perspective on TIME/LTM is critical to this effort. Upon completion of the data collection and analysis phase of the evaluation, we will compile the results and our conclusions in a report to EPA, which will be available for you to review. We anticipate that the results of this evaluation will help EPA better understand the TIME/LTM programs and identify opportunities for improvement. Finally, we will maintain the confidentiality of your responses to the interview questions; any data obtained through this interview will be analyzed and reported in aggregate with other interview data without individual attribution.

Together with information gathered from principal investigators, cooperators, EPA staff, and others knowledgeable of ecological monitoring programs, we will draft a report to be completed in early May 2009.

Do you have any questions to ask before we start the interview?

To begin with, please provide us with some background information on your involvement with TIME/LTM (including length of time with the program, if applicable).

### Interview Questions

**Evaluation Question 1: What is the purpose of the TIME/LTM program? 1a. What are the program's objectives? 1b. Have program objectives changed over time?**

*The first set of questions relates to the TIME/LTM programs' goals and objectives.*

1. To your knowledge, why was TIME/LTM originally established? [If the interviewee was involved with monitoring efforts prior to the establishment of LTM or TIME/LTM, ask them to describe the objectives of that program and any overlap with LTM or TIME/LTM].

2. What is your understanding of the programs' current stated objectives?

3. How have program objectives changed over time and why?

4. Would you say that, given the current design of TIME/LTM, it is meeting its objectives? [If not, why not?]

**Evaluation Question 2: What are the key characteristics of the TIME/LTM programs?**

*The next three questions are about the design of the TIME/LTM programs and the data collected.*

5. To your knowledge, how was the TIME/LTM contract initially established with your facility? [If the interviewee has no knowledge of the contract origin, ask to follow-up at a later time when such information can be made available].

6. [For principal investigators and other cooperators] What types (TIME or LTM) of sites and how many of each do you monitor?

7. What methods do you use to collect data? Do you also do any of the data analysis, or is it all sent to the Corvallis laboratory?

8. What data do you collect for TIME/LTM? Are there data on other chemical (or physical) variables you collect in addition to the primary ones (e.g., N, S, ANC, DOC)? [Ask the interviewee to point to particular publications they have authored in this arena, if applicable].

**Evaluation Question 3: Who uses TIME/LTM data and for what purposes (e.g., basic research, policy development)?**

*The next five questions will help us understand the ways in which TIME/LTM data are used and, potentially, the ways in which certain program aspects such as data access and use, could be modified to meet current and potential users' needs.*

9. To your knowledge, who—both internal and external to EPA—uses the data generated by TIME/LTM and what do they use the data for (e.g., to support scientific investigations, evaluate ARP, develop policies)?

10. [For each type of user identified] In what ways can the data be easily improved to meet current users' needs?

**11.** Do you know of other potential users of the data? Are there programs in OAR or the EPA not currently using the data collected through TIME/LTM that have a need for the data?

**12.** To what extent have the TIME/LTM data been used to support the development of new or modification of existing policy (at the federal, state or local levels)? [If applicable, ask for documentation].

**13.** From your perspective, how does TIME/LTM contribute to assessing and understanding the effectiveness of the Acid Rain Program?

**Evaluation Question 4: What is the relationship of TIME/LTM to other ecological monitoring programs?**

*The next set of questions pertains to TIME/LTM in relation to other ecological monitoring efforts at the national, regional, state and local levels.*

**14.** To your knowledge, what is the relationship between the data and information that the TIME/LTM programs collect and other monitoring efforts/programs? Please tell us about any state or local monitoring efforts that relate to or otherwise leverage those of TIME/LTM.

**15.** Are there surface water chemistry or acidification data collection efforts in other government (federal or state) agencies you know of that could complement the TIME/LTM data or broaden the EPA's understanding of pollution deposition? (e.g., broaden the understanding over wider geography and/or broaden the understanding of acidification).

**16.** To your knowledge, what other ecological monitoring systems (government and nongovernment?) collect data that would be helpful in expanding/deepening our understanding of the impact of reduced acidic deposition on ecosystem conditions?

**Evaluation Question 5: What are the costs associated with TIME/LTM? 5a. Are there more cost-effective approaches to data collection and analysis? 5b. What other resources does TIME/LTM help to leverage?**

*The following four questions concern TIME/LTM funding sources (from EPA and other sources), activities supported, and the advantages and disadvantages of current funding model as compared to other options (e.g., using a contractor).*

17. How much funding does EPA provide to support TIME/LTM and how have these costs changed over time? How are costs likely to change going forward?

18. What are other the resources (funding or otherwise) and/or in-kind contributions that TIME/LTM helps to leverage (e.g., PI dollars)?

19. To your knowledge, are there more cost-effective and efficient methods (e.g., new technologies) for collecting comparable data? [In either case, ask for specific examples that supports their response]

20. What are the options for contracting with data collectors and for lab analyses that would cost-effectively gather appropriate information that might serve multiple program requirements? Are there particular pros and cons to using contractors to collect and analyze TIME/LTM data versus using the university/state agency model currently in place?

**Evaluation Question 6: How are TIME/LTM administered and managed?**

*This set of questions asks about the way in which TIME/LTM is currently administered and managed in EPA's ORD, including the way in which data are housed and accessed and the extent to which these and other aspects can be improved if the programs migrate to EPA's OAR.*

21. Where are the data located? How are the data managed?

22. To what extent are there metadata? How are metadata managed, accessed, searched, etc?

23. How do users of the TIME/LTM data access the data, and within what time frames are they given access to the data?

24. Based on your experiences, what other approaches to allocating TIME/LTM resources should be considered?

**Evaluation Question 7: What opportunities exist to improve TIME/LTM?**

*The last set of questions seeks to tie much of the preceding information together and identify key factors of the TIME/LTM programs that may contribute to overall program improvement.*

25. From your perspective, to what extent are TIME/LTM program objectives being met?

26. How can data access be improved? How will expanding data access to a broader audience enhance the programs' effectiveness?

**27.** Who should/will establish objectives for the programs and on what basis? Does OAR have different objectives for the programs than ORD and if so, what are they?

**28.** Based on OAR objectives for TIME/LTM, are there more effective means to administer TIME/LTM (e.g., as is currently done by ORD - grants, interagency agreements, and direct funding to EPA labs; one contract)?

**29.** How should/will OAR manage and change the programs to optimize the usability of the data being collected?

**30.** Based on your experiences, what suggestions would you make to improve the effectiveness of the TIME/LTM programs?

# Appendix M-3: Interviewees for TIME/LTM Program Evaluation

| | | |
|---|---|---|
| **TIME/LTM Monitoring Network – Principal Investigators** | | |
| Karen Roy | Adirondack Lakes Survey Corporation | TIME/LTM cooperators and contractors collect and use the data and form the monitoring network itself. As principal investigators, they publish regularly on the status and trends in surface water chemistry of acid-sensitive lakes and streams across the network. In addition to monitoring, their research contributes to understanding broader aspects of the effects of pollution on ecosystem health. Principal investigators and cooperators receive a significant portion of funding to support TIME/LTM data collection and analysis from ORD, but may also leverage other sources of funding to keep region-specific programs viable. |
| Michael McHale | USGS District Office (Catskills) | |
| Jim Kellogg | Vermont Agency of Natural Resources | |
| Bill McDowell | University of New Hampshire | |
| Steve Kahl | Plymouth State University (Maine) | |
| David DeWalle | Penn State University | |
| John Karish | NPS | |
| Rick Webb | University of Virginia (Blueridge/VA) | |
| **EPA/OAR –Potential Program Managers** | | |
| Rick Haeuber | OAR, Clean Air Markets Division | As OAR prepares to inherit TIME/LTM from ORD, perspectives on the management of the programs and capacity for OAR to effectively manage, administer, and address current program challenges are critical. |
| Michael Kolian | OAR, Clean Air Markets Division | |
| Jerry Kurtzweg | EPA OAR, OPMO | |
| **EPA/ORD – Current Program Managers and Historians** | | |
| John Stoddard | Western Ecology Division | ORD has provided most of the funding for TIME/LTM since the programs' inception. ORD has been responsible for overall quality assurance, database management, and verification and validation of data, ensuring that data are comparable across regions and through time. ORD officials have thorough knowledge of TIME/LTM's history. |
| Michael Moeykens | Work assignment manager (sample collection) Cincinnati, OH laboratory | |
| Dave Peck | Work assignment manager (sample analysis), Corvallis, OR laboratory | |
| Ed Washburn | Branch Chief, Office of Science Policy | |
| Kevin Teichman | Director, Office of Science Policy | |
| Rick Linthurst | National Program Director for Ecology | |
| **Monitoring Experts (various agencies)** | | |
| Susan Holdsworth | EPA, Office of Water (OWOW) Branch Chief, Monitoring | OWOW conducts EPA's National Aquatic Resource Surveys, statistically-representative surveys of U.S. aquatic resources designed to identify national priorities and evaluate the effectiveness of pollution control actions. USGS studies effects of acidification on undeveloped watersheds. NPS and USGS, as part of the NADP, coordinate efforts to better understand the effects of acid deposition on ecosystem health. |
| Mark Nilles | Office of Water Quality, USGS | |
| **Other Agencies and Organizations – Potential TIME/LTM Users** | | |
| Chris Shaver | Director, Air Resources Division, National Park Service | NPS and USGS, as part of the NADP, coordinate efforts to better understand the effects of acid deposition on ecosystem health. NPS uses TIME/LTM to assess water quality in Shenandoah National Park. |
| Tosha Comendant | Conservation Biology Institute | Dr. Comendant developed Data Basin, an |

| | | |
|---|---|---|
| | | innovative tool that provides access to data about complex ecological, political, and economic systems, and fosters collaboration between policymakers, conservationists, activists, and scientists by facilitating the exchange of environmental information. |
| Christine Negra | Environmental Reporting Program, Heinz Center | The Environmental Reporting Program publishes *The State of the Nation's Ecosystems: Measuring the Lands, Waters, and Living Resources of the United States.* |

# APPENDIX B Continued: TIME/LTM Program Quality Assurance Plan

Quality Assurance Plan for EPA Contract 68-W-07-028,
Work Assignment B-28
Supporting EPA's Program Evaluation on Temporally Integrated Monitoring of Ecosystems and Long-Term Monitoring (TIME/LTM) Programs

**Purpose of the Evaluation:**

An evaluation of TIME/LTM was selected as one of five program evaluations in FY 2009 under EPA's Office of Policy, Economics and Innovation (OPEI) Evaluation Support Division (ESD) 2008 Program Evaluation Competition.[42] The evaluation entails an assessment of program design, implementation, costs, and other factors to determine TIME/LTM program effectiveness, long-term sustainability, and contributions to knowledge of ecological conditions affected by acid deposition. Assessment of these programmatic aspects of this environmental monitoring effort may also help to identify and develop performance measures for both TIME/LTM and other ecological monitoring programs, to improve monitoring relevance for environmental protection programs. Details of the evaluation approach can be found in the "Evaluation Methodology" for this project.

**Design:**

Ross & Associates designed its data collection and analysis approach in consultation with OPEI/ESD and OAR. These individuals comprise a core evaluation team. The approach is primarily based on use of publications and interviews of individuals involved in the conduct of TIME/LTM or in the use of TIME/LTM data. A logic model to show relationships among inputs, activities, outputs, customers, and outcomes was developed, as were interview questions. Both the model and evaluation questions are outlined in detail in the "Evaluation Methodology." The general approach to analysis will be qualitative, based on responses to the questions and information that can be derived from review of publications and reports. Content analysis will begin with the first interviews. The core evaluation team and others who provided information through interviews will have opportunities to review the final summary of data for technical accuracy and completeness.

**Rationale:**

This evaluation does not lend itself to a quantitative analysis given the nature of the program.

**Data Sources:**

Key data sources to be used in the evaluation include:

- Primary Data Sources:
    - Interviews with TIME/LTM principal investigators and contractors, stakeholders from OAR and ORD, and stakeholders from other federal agencies (e.g., U.S. Geological Survey, National Park Service).
- Secondary Data Sources:

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[42] ESD's mission is to enable its partners to more effectively conduct program evaluations and analyses that inform management decisions, enhance organizational learning, promote innovation and foster environmental results. As part of the effort to encourage the effective use of program evaluations throughout the Agency, ESD promotes program evaluation through a Program Evaluation Competition (PEC). The competition is part of an ongoing, long-term effort to build capacity in EPA headquarters and regional offices to evaluate activities and to improve measures of program performance. For the 2008 PEC, evaluation of the TIME/LTM Programs was chosen for support.

- Articles and other publications from peer-reviewed scientific journals (1984-2007) based on the use of TIME/LTM data. These reports are derived from:
  - ORD, OAR, and OPEI
  - Online literature searches
  - State and agency websites citing TIME/LTM as primary data sources
  - References provided by interviewees
- Reports from the National Acid Precipitation Assessment Program
- Cooperative and interagency agreements and research proposals

**Consistency:**
A structured interview approach is described in the "Evaluation Methodology" with different questions for different interviewees, depending on expertise and involvement with TIME/LTM. From comprehensive notes taken during interviews, Ross & Associates will categorize and summarize responses to identify patterns. Given the relatively small number of individuals, all with significant variation in experience with TIME/LTM (e.g., EPA personnel overseeing contracts or laboratory analysis, EPA program managers using data, academics collecting data, scientists from academic and federal agencies interpreting data) every attempt will be made to validate statements and information provided. New information derived in later interviews may be corroborated with earlier interviewees or with individuals with more years of program experience to ensure that results are accurately recorded.

**Data Limitations:**
This evaluation is based on analysis of qualitative information and will therefore be limited by accurate characterization and summarization of data collected be from the different stakeholder groups (e.g., data collectors, data consumers, others).

**Audience:**
The final evaluation report will be useful to a variety of stakeholders, including: OPEI, ORD, and OAR program managers and administrators; TIME/LTM principal investigators and their staff, and data consumers from other federal and state agencies.

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**EPA Quality Manager:** Matt Keene, OPEI

**Ross & Associates Evaluators:** Nancy Tosta, Jennifer Major

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# APPENDIX C: PUBLICATIONS DRAWING ON TIME/LTM DATA, 1985-2007


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# APPENDIX D: OVERVIEW OF ENVIRONMENTAL MONITORING PROGRAMS

Summary details on a wide variety of national monitoring and site-specific monitoring activities can be found at: http://www.epa.gov/monitor/programs/index2.html and http://www.epa.gov/monitor/programs/index3.html. Summary descriptions of several programs are included below.

**TERRESTRIAL MONITORING**

**Vital Signs Monitoring – National Park Service**: – The National Park Service has initiated a long-term ecological monitoring program, known as "Vital Signs Monitoring", to provide the minimum infrastructure to allow more than 270 national park system units to identify and implement long-term monitoring of their highest-priority measurements of resource condition. The NPS has used the term "vital signs monitoring" to refer to a relatively small set of physical, chemical, and biological elements and processes of park ecosystems that represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values.[43] While this is listed under the "terrestrial monitoring" category, NPS is also measuring various water quality components, including temperature, specific conductance, pH, dissolved oxygen, quantity, flow and discharge. See: http://acwi.gov/monitoring/conference/2008/presentations/sessionC/C4A_Long.pdf. The overall Vital Signs Monitoring effort is described at: http://science.nature.nps.gov/im/monitor/index.cfm

**Forest Inventory and Analysis (FIA) – US Forest Service:** The FIA classifies land into forest and non-forest and examines fragmentation, urbanization, and distance variables. This is done using aerial photography/satellite data. Field sample locations are then distributed across the landscape with approximately one sample location (FIA plot) every 6,000 acres. Forested sample locations are visited by field crews who collect a variety of forest ecosystem data. There are approximately 125,000 sampled plots. Non forest locations are also visited as necessary to quantify rates of land use change. Forest health as part of the Forest Health Monitoring (FHM) Program is measured on a subset of field plots (approx 1/96,000 acres or 8000 plots). Parameters measured include plant species diversity, leaf area index, tree regeneration, lichen, mortality, air pollution, soils, etc[44]. More details are available at: http://fia.fs.fed.us/library/fact-sheets/

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[43] S. G. Fancy, J. E. Gross, S. L. Carter; *Monitoring the Condition of Natural Resources in US National Parks,* Environmental Monitoring and Assessment (2009) Vol. 151, pages 161-174.

[44] US EPA, Clean Air Markets Division, How to Measure the Effects of Acid Deposition: A Framework for Ecological Assessments, June 2001. EPA 430-R-01-005

**Environmental Monitoring and Assessment Program (EMAP) – US EPA:** The Environmental Monitoring and Assessment Program (EMAP) is a research program to develop the tools necessary to monitor and assess the status and trends of national ecological resources. EMAP's goal is to develop the scientific understanding for translating environmental monitoring data from multiple spatial and temporal scales into assessments of ecological condition and forecasts of the future risks to the sustainability of our natural resources. EMAP's research supports the National Environmental Monitoring Initiative of the CENR. The objectives are to advance the science of ecological monitoring and ecological risk assessment, guide national monitoring with improved scientific understanding of ecosystem integrity and dynamics, and demonstrate the CENR framework through large regional projects. EMAP has defined a component structure. See: http://www.epa.gov/emap/html/components/index.html and http://www.epa.gov/nheerl/arm/

**Long Term Ecological Research (LTER) – NSF:** Twenty-six research sites currently comprise the LTER Network (having grown from 6 sites in 1980). These include a diverse array of ecosystem types spanning broad ranges of environmental conditions and human domination of the landscape. Each site develops individual research programs in five core areas: pattern and control of primary production; spatial and temporal distribution of populations selected to represent trophic structure; pattern and control of organic matter accumulation in surface layers and sediments; patterns of inorganic inputs and movements of nutrients through soils, groundwater and surface waters; and patterns and frequency of site disturbances. See: http://www.lternet.edu/

**National Resources Inventory (NRI) – USDA Natural Resources Conservation Service (NRCS):** The National Resources Inventory (NRI), originally initiated in 1956, is a statistical survey of natural resource conditions and trends on non-Federal land in the United States — non-Federal land includes privately owned lands, tribal and trust lands, and lands controlled by state and local governments. Data collected include visibility/fine particulates; sediment load; soil texture, chemistry, toxicity, mineralogy, climate, structure, strength, erodability; vegetation growth rate/above-ground biomass, species/cover/range. The NRI provides nationally consistent statistical data on how lands are used and on changes in the lands for the period 1982 - 2003. The NRI is a longitudinal sample survey based on scientific statistical principles and procedures. From 1982-1997, the NRI was conducted on a five-year cycle on 800,000 sample sites. It is now sampled annually at slightly less than 25 percent of the same sample sites. The same sample sites have been studied since 1982, with the same data collection protocols. http://www.nrcs.usda.gov/technical/NRI/

**AIR MONITORING**

Many national air quality and deposition monitoring networks have evolved to provide scientists and policymakers with data on the fate and transport of regional sources of emissions. Much of the information in these networks is used to contribute to understanding the effectiveness of air pollution control strategies.

**Air Quality Monitoring – US EPA:** The EPA's ambient air quality monitoring program is carried out by State and local agencies and consists of three major categories of monitoring stations:

- **State and Local Air Monitoring Stations (SLAMS) -** The SLAMS consist of a network of ~ 4,000 monitoring stations whose size and distribution is largely determined by the needs of State and local air pollution control agencies to meet their respective State implementation plan (SIP) requirements.
- **National Air Monitoring Stations (NAMS) -** The NAMS (1,080 stations) are a subset of the SLAMS network with emphasis being given to urban and multi-source areas. In effect, they are key sites under SLAMS, with emphasis on areas of maximum concentrations and high population density
- **Special Purpose Monitoring Stations (SPMS)** – The SPMS are established for special studies needed by the State and local agencies to support State implementation plans and other air program activities. The SPMS supplement the fixed monitoring network as circumstances require and resources permit.

Additionally, a fourth category of a monitoring station, the **Photochemical Assessment Monitoring Stations (PAMS)**, which measures ozone precursors (approximately 60 volatile hydrocarbons and carbonyl) has been required by the 1990 Amendments to the Clean Air Act. A PAMS network is required in each ozone nonattainment area designated serious, severe, or extreme. The required networks will have from two to five sites, depending on the population of the area. See: http://www.epa.gov/air/oaqps/qa/monprog.html

**Interagency Monitoring of Protected Visual Environments (IMPROVE) - Interagency**: IMPROVE is a cooperative measurement program overseen by an interagency-intergovernmental steering committee. The monitoring was established in 1985 to aid creation of federal and state implementation plans for protection of visibility in Class I areas (156 parks and wilderness areas) as stipulated under the 1977 amendments to the Clean Air Act. The objectives of IMPROVE are to: establish current visibility and aerosol conditions in mandatory Class I areas, identify chemical species and emission sources responsible for existing man-made visibility impairment, document long-term trends for assessing progress toward the national visibility goal, and provide regional haze monitoring. The effort is supported by a Web site that provides access to data, publications, documentation, etc: http://vista.cira.colostate.edu/improve/ (example of interagency effort)

**Clean Air Status and Trends Network (CASTNET) – US EPA**: CASTNET is a regional long-term environmental monitoring program administered and operated by EPA's Clean Air Markets Division (CAMD). Developed from the existing National Dry Deposition Network (NDDN), CASTNET was established in 1991 under the Clean Air Act Amendments. The regional monitoring network was formed to assess trends in acidic deposition due to emission reduction regulations, such as the Acid Rain Program (ARP) and NOx Budget Trading Program (NBP). CASTNET has since become the nation's primary monitoring network for measuring concentrations of air pollutants involved in acidic deposition affecting regional ecosystems and rural ambient ozone levels. CASTNET provides data needed to assess and report on geographic patterns and long-term temporal trends in ambient air pollution and dry atmospheric deposition. CASTNET can also be used to track changes in measurements associated with climate change (such as temperature and precipitation). Presently there are a total of 86 operational CASTNET sites located in or near rural areas and sensitive ecosystems collecting data on ambient levels of pollutants where urban influences are minimal. As part of an interagency agreement, the National Park Service (NPS) sponsors 27 sites which are located in national parks and other Class-I areas designated as deserving special protection from air pollution. CASTNET data support various modeling efforts, including PNIT and Magic and CMAQ models. The current CASTNET budget is approximately $3.9 million. See: http://www.epa.gov/castnet/docs/CASTNET_factsheet_2007.pdf

**The National Atmospheric Deposition Program/National Trends Network (NADP/NTN) – Interagency:** is a nationwide network of over 250 precipitation monitoring sites. The network is a cooperative effort among USGS, USDA, EPA, and other governmental and private entities. The NADP/NTN started in 1978 with a network of 22 stations. Sites currently span the US, Puerto Rico, and the Virgin Islands. The purpose of the network is to collect data on the chemistry of precipitation for monitoring geographical and temporal long-term trends. The sites measure atmospheric deposition dissolved in cloud droplets and deposited during rain and other forms of precipitation (wet deposition). Data are collected weekly and analyzed for hydrogen (acidity as pH), sulfate, nitrate, ammonium, chloride, and base cations (such as calcium, magnesium, potassium and sodium). The current budget for NADP is approximately $5.5 million annually. The NADP has expanded sampling to two additional networks. The Mercury Deposition Network http://nadp.isws.illinois.edu/mdn/), currently with over 90 sites, was formed in 1995 and analyzes weekly precipitation samples for mercury. The Atmospheric Integrated Research Monitoring Network (AIRMoN), was formed to study precipitation chemistry trends with greater temporal resolution. Precipitation samples are collected daily from a network of seven sites and analyzed for the same constituents as the NADP/NTN samples. See: http://nadp.isws.illinois.edu/. The Atmospheric Integrated Research Monitoring Network (AirMON) managed by NOAA is a subset of NADP. AirMON dry-data is managed under CASTNET. AIRMoN-wet precipitation sampling maintains rigorous sampling procedures, developed in conjunction with NADP, that ensure that AIRMoN precipitation chemistry and wet deposition estimates are timely and accurate. Currently, AIRMoN consists of several collocated operational research establishments (CORE sites) throughout the eastern U.S. The daily precipitation sampling protocol facilitates quantification of deposition estimates for several species, including ammonium, which is an important consideration to the role of atmospheric deposition in coastal eutrophication. The CORE site operated near NOAA/ARL/ATDD is located in the Walker Branch Watershed, a long-term environmental research area. The watershed is forest ecosystem typical of Southern Blue Ridge Mountains. See: http://www.atdd.noaa.gov/?q=node/46.

**WATER MONITORING**

**National Water-Quality Assessment Program (NAWQA) - USGS:** The USGS implemented the National Water-Quality Assessment (NAWQA) Program in 1991 to develop long-term consistent and comparable information on streams, rivers, ground water, and aquatic systems in support of national, regional, State, and local information needs and decisions related to water-quality management and policy. The NAWQA program was designed to address the following questions:

What is the condition of the Nation's streams, rivers, and groundwaters?, How are these conditions changing over time?, How do natural features and human activities affect these conditions, and where are those effects most pronounced? From 1991 to 2001, NAWQA examined 51 river basins and aquifers to establish a national baseline. More than 1000 reports were developed describing water quality conditions, including pesticides, nutrients, volatile organic compounds, etc. From 2001-2012 the focus is to build on the data from the previous decade in 42 units looking at a continuation of the work just outlined, including aquatic ecology, to examine national priority topics such as agricultural chemicals, urbanization, mercury, and public supply wells. See: http://water.usgs.gov/nawqa/

**National Lakes Assessment - US EPA:** During summer 2007, States, Tribes, and U.S. EPA collaboratively sampled over 1,200 lakes across the country in pursuit of a National Lakes Assessment (NLA). Completion of the NLA marks the first comprehensive, nationwide evaluation of lakes since the National Eutrophication Survey of the 1970s. The NLA is set apart from other national-scale lake assessment initiatives in that it is statistically designed and focuses on multiple indicators of water quality, ecological integrity, and recreational suitability. See: http://www.epa.gov/owow/lakes/lakessurvey/.

**Wadeable Streams Assessment (WSA) – US EPA:** The Wadeable Streams Assessment (WSA) is a statistically-valid survey of the biological condition of small streams throughout the U.S. EPA and states conducted the assessment in 2000-2004. Approximately, 1,392 sites were randomly selected based on protocols established as part of EMAP to represent the condition of all streams in regions that share similar ecological characteristics. Wadeable streams were chosen for study because they are a critical natural resource and a well-established set of methods for monitoring them exist. Data were collected on chemical (phosphorus, nitrogen, acidity, and salinity) and physical properties (streambed sediments, in-stream fish habitat, riparian vegetative cover, and riparian disturbance) as well as benthic macroinvertebrates. The protocols allow for national comparability. The WSA establishes a national baseline for future studies. The WSA also provides funding and expertise that will enhance each state's ability to monitor and assess the quality of its waters in the future. The annual budget for WSA is approximately $8 million. See: http://www.epa.gov/owow/streamsurvey/

**Hydrologic Benchmark Network (HBN) – USGS:** The Hydrologic Benchmark Network (HBN) was established in 1963 to provide long-term measurements of streamflow and water quality in areas that are minimally affected by human activities. These data are used to study long-term trends in surface water flow and water chemistry and as a benchmark against which to compare changes in flow and chemistry in developed watersheds. At its peak the network consisted of 58 drainage basins in 39 States. Changes in funding and land use within the watersheds reduced the number of stations and samples collected by HBN. In the mid-1990s, the USGS conducted a complete review of the network, and selected 5 eastern stations to conduct a pilot study to assess the optimum sampling strategy for assessing long-and short-term trends. In 2003, the USGS re-established a 15-station water-quality and 36-station discharge monitoring network with a new design that allows tracking of trends in water quality at a range of river flow conditions. Additional stations are anticipated to be added to the network as funding allows.

See:  http://ny.cf.er.usgs.gov/hbn/.  One of the HBN sites – the Neversink River in NY is also sampled as an LTM site by the USGS.  See: http://ny.cf.er.usgs.gov/hbn/siteinfo.cfm?ID=Neversink%20River