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ABSTRACTS OF PUBLICATIONS AND PRESENTATIONS

1985 - 1986

A Contribution to the
National Acid Precipitation Assessment Program

U.S. Environmental Protection Agency
Office of Research and Development
Washington, DC 20460

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Notice

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Preface

The Aquatic Effects Research Program (AERP) is a major component of the National Acid Precipitation Assessment Program's Task Group 6, a cooperative effort of seven federal agencies tasked with addressing important policy and assessment questions relating to acidic deposition and its effects. The AERP addresses four major policy questions relating to the effects of acidic deposition on aquatic ecosystems:

1. the extent and magnitude of change,
2. the change to be expected in the future under various rates of acidic deposition,
3. the maximum rates of deposition below which further change is not expected, and
4. the rate of change or recovery of aquatic ecosystems if deposition rates decrease.

This document contains bibliographic citations and brief descriptions of the publications and presentations authored or co-authored by AERP personnel in 1985 and 1986. It is intended to provide scientists and administrators, both within and outside the U.S. Environmental Protection Agency, with a concise reference to the available literature generated by the AERP. Development of additional issues of this document is planned on a biennial basis, with the exception of a single issue covering publications completed between 1980 and 1984. This document is one output of the AERP Technical Information Project, a component project of the AERP specifically charged with dissemination of available AERP information and technology to the scientific community.

Abstract

In 1980, the U.S. Environmental Protection Agency (EPA) implemented the Aquatic Effects Research Program (AERP) as part of the National Acid Precipitation Assessment Program. The AERP, a part of EPA's Office of Research and Development, is administered by the Acid Deposition and Research Division in the Office of Acid Deposition, Environmental Monitoring, and Quality Assurance. Six EPA Laboratories cooperate in AERP research: the Environmental Research Laboratories in Corvallis, Oregon, and Duluth, Minnesota; the Environmental Monitoring Systems Laboratories in Las Vegas, Nevada, Cincinnati, Ohio, and Research Triangle Park, North Carolina; and the Atmospheric Sciences Research Laboratory in Research Triangle Park, North Carolina.

This document contains information on publications and presentations authored or coauthored by AERP-EPA and contractor personnel in 1985 and 1986. Major activities during this time included field surveys in the National Surface Water Survey and the Direct/Delayed Response Project, pilot studies in the Episodic Response Project, and initiation of the Watershed Processes and Manipulation Project at Little Rock Lake, Wisconsin. Additionally, planning and design efforts were underway for other component projects, including the Watershed Manipulation Project, Regional Case Studies, and a long-term monitoring effort.

This document is one of a number of publications produced through the AERP Technical Information Project. Initiated in 1986, the Technical Information Project disseminates AERP information to the scientific community. This document was submitted in partial fulfillment of Contract No. 68-03-3249 by Lockheed Engineering and Sciences Company, Inc., under sponsorship of the U.S. Environmental Protection Agency. This report covers a period from January 1985 to December 1986, and work was completed as of July 1988.

Contents

Acronyms, Abbreviations, and Symbols

AERP	=	Aquatic Effects Research Program
Al	=	aluminum
ANC	=	acid neutralizing capacity
AQUARIUS	=	Automated Quality Assurance Review, Interactive User System
ASA	=	American Statistical Association
AWDB	=	Adirondack Watershed Data Base
BNC	=	base neutralizing capacity
BRC	=	Biologically Relevant Chemistry Project
DDRP	=	Direct/Delayed Response Project
DIC	=	dissolved inorganic carbon
DOC	=	dissolved organic carbon
ELS	=	Eastern Lake Survey
ELS-I	=	Eastern Lake Survey - Phase I
ELS-II	=	Eastern Lake Survey - Phase II
EPA	=	U.S. Environmental Protection Agency
ERL-C	=	Environmental Research Laboratory at Corvallis, Oregon
ERP	=	Episodic Response Project
NAPAP	=	National Acid Precipitation Assessment Program
NLS	=	National Lake Survey
NSS	=	National Stream Survey
NSS-I	=	National Stream Survey - Phase I
NSWS	=	National Surface Water Survey
NTIS	=	National Technical Information Service
ORNL	=	Oak Ridge National Laboratory
Pb	=	lead
PCV	=	pyrocatechol violet
QA	=	quality assurance
QC	=	quality control
RCS	=	Regional Case Studies
REAM	=	Regional Episodic and Acidic Manipulations Project
RIS	=	Regionalized Integrative Studies
SVS-P	=	Spring Variability Pilot Study
WLS	=	Western Lake Survey
WLS-I	=	Western Lake Survey - Phase I
WMP	=	Watershed Manipulation Project

Acknowledgements

Critical reviews by the following individuals were instrumental in the design of this document and are gratefully acknowledged: R. A. Linthurst, U.S. Environmental Protection Agency (Washington, D.C.), S. J. Christie, NSI (Corvallis, Oregon), P. E. Kellar, Kilkelly Environmental Associates (Raleigh, North Carolina), and M. L. Faber, Lockheed Engineering and Sciences Company, Inc. (Las Vegas, Nevada).

An initial draft of this document was prepared by M. Stockton, Radian Corporation (Research Triangle Park, North Carolina). Substantial changes and revisions were completed by D. J. Chaloud, Lockheed Engineering and Sciences Company, Inc. Technical assistance was provided by D. W. Sutton, J. M. Nicholson, J. E. Engels, and G. D. Merritt, Lockheed Engineering and Sciences Company, Inc. P. Suk, Kilkelly Environmental Associates, and J. Hartman, North Carolina State University (Raleigh, North Carolina) provided additional materials. Acknowledgement is also due to the authors and technical information coordinators for provision of the materials included in this document.

Finally, recognition belongs to the technical monitors, R. E. Crowe (retired) who created the Technical Information Project and W. L. Kinney who has served as technical monitor since 1987.

Section 1

Introduction

In 1980, the U.S. Environmental Protection Agency (EPA) implemented the Aquatic Effects Research Program (AERP) as part of the National Acid Precipitation Assessment Program (NAPAP). The AERP, a part of EPA's Office of Research and Development, is administered by the Acid Deposition and Research Division in the Office of Acid Deposition, Environmental Monitoring, and Quality Assurance. Six EPA Laboratories cooperate in AERP research: the Environmental Research Laboratories in Corvallis, OR, and Duluth, MN; the Environmental Monitoring Systems Laboratories in Las Vegas, NV, Cincinnati, OH, and Research Triangle Park, NC; and the Atmospheric Sciences Research Laboratory in Research Triangle Park, NC.

Four policy questions have guided the design, direction, and focus of the AERP:

1. What is the extent and magnitude of past change attributable to acidic deposition?

2. What change is expected in the future under various deposition scenarios?

3. What is the target loading level below which change would not be expected?

4. What is the rate of recovery if deposition decreases?

An integrated, stepwise approach is used within the AERP to provide the necessary data to answer these questions. The approach employs statistically based site selection, standardized sampling procedures and analytical methods, and rigorous quality assurance protocols. Collectively, AERP projects form an integrated effort to quantify the chemical status and extent of surface waters at risk, predict the response of biologically relevant water chemistry to variable rates of acidic deposition, and verify and validate the predictions.

This document contains information on publications and presentations authored or coauthored by AERP-EPA and contractor personnel in 1985 and 1986. Major activities during this time included field surveys in the National Surface Water Survey (NSWS) and the Direct/Delayed Response Project (DDRP), pilot studies in the Episodic Response Project (ERP), and initiation of the Watershed Processes and Manipulation Project at Little Rock Lake, Wisconsin. Additionally, planning and design efforts were underway for other component projects, including the Watershed Manipulation Project (WMP), Regional Case Studies (RCS), and a long-term monitoring effort. The integrated, stepwise approach used in AERP makes it important to view this document within the historical perspective of that time period. This historical perspective is provided in the following descriptions of the component project activities of this time period.

National Surface Water Survey

The National Surface Water Survey (NSWS) is divided into two components: the National Lake Survey (NLS) and the National Stream Survey (NSS). Phase I efforts of the NSWS provide information to assess the current chemical status of lakes and streams. Phase II activities of these surveys describe seasonal variability in regional water chemistry.

The NLS is further divided into the Eastern Lake Survey (ELS) and the Western Lake Survey (WLS). In Phase I of the NLS, samples from 1798 lakes were collected during fall of 1984 in the northeastern, southeastern, and upper midwestern United States (ELS). Another 757 lakes were sampled during fall of 1985 in the mountainous areas of the western United States (WLS). These data have served to classify lakes so that subsets can be identified for more detailed

studies in Phase II of the NLS and in other programs in the AERP.

Phase II (ELS-II) was initiated in the northeastern United States in 1986 and included three seasonal chemistry surveys. Each of 147 lakes, selected from lakes sampled during Phase I of ELS, was sampled during spring, summer, and fall. These surveys provide data necessary to characterize seasonal patterns in water chemistry and to relate these patterns to the baseline conditions of Phase I.

Address inquiries concerning NLS to:

Dixon Landers
EPA/Environmental Research Laboratory-Corvallis
200 S.W. 35th Street
Corvallis, OR 97333
(503) 757-4666 FTS: 420-4666

The NSS was implemented in 1985 with a pilot survey of 61 stream sites in the Southern Blue Ridge Province. Phase I was conducted in the spring and summer of 1986 in the Middle Atlantic region with the sampling of approximately 270 stream reaches. Information from the Southeastern Screening Survey (conducted on about 200 stream reaches in concert with the Middle Atlantic sampling) helped prioritize other stream sites for possible future survey activities. The screening covered areas of the Southern Appalachians, the Piedmont, the Ouachita Mountains, and parts of the Florida Panhandle and Florida Peninsula.

Address inquiries concerning NSS to:

Phil Kaufmann
EPA/Environmental Research Laboratory-Corvallis
200 S.W. 35th Street
Corvallis, OR 97333
(503) 757-4666 FTS 420-4666

Biologically Relevant Chemistry

Concurrent to ELS-II field activities, planning was underway to develop the Biologically Relevant Chemistry Project (BRC). Initial BRC field activities, which will provide assessment data on the risk that acidic deposition poses to aquatic biota, were conducted in the Upper Midwest in the summer of 1987. Several complementary studies will be incorporated as components of the BRC. One study will determine the present status of fish populations in a subset of lakes sampled during ELS-I and will quantify the chemical characteristics of these lakes. Another research effort will study the effects of episodic acidification on fish populations.

This document contains several entries about planning for BRC. Address inquiries concerning BRC to:

Robert Cusimano
EPA/Environmental Research Laboratory-Corvallis
200 S.W. 35th Street
Corvallis, OR 97333
(503) 757-4666 FTS: 420-4666

Direct/Delayed Response Project

Predicting how constant, increasing, or decreasing acidic inputs will affect the chemical and biological status of lakes and streams in the future requires knowledge of the current conditions and primary factors that influence surface water response. Accurate predictions also require an understanding of complex watershed-mediated processes and mechanisms, as well as the ability to quantify time frames within which responses are expected to occur. The DDRP was designed to provide the data needed to classify watersheds, based on the time frames during which surface waters would be expected to become acidic (i.e., the time frame expected for the annual average acid neutralizing capacity to decrease to zero), at various levels of sulfate deposition. The primary objectives of this research are to (1) characterize the regional variability of soil and watershed characteristics, (2) determine which soil and watershed characteristics are most strongly related to surface water chemistry, (3) estimate the relative importance of key watershed processes across the study regions, and (4) classify a sample of watersheds, according to the time frames during which they would reach acidic status,

and extrapolate the results from the sample to the study regions.

A DDRP survey was conducted in 1985 in the Northeast on the watersheds of 145 lakes. Eighty-nine percent of these lakes also were selected for ELS-II, and all were sampled in Phase I. In 1986, a second soil survey was completed on 35 watersheds in the Southern Blue Ridge Province, selected in conjunction with the pilot stream survey.

Three levels of data analyses are being used in DDRP. Level I analyses employ multivariate statistical procedures and steady-state calculations such as sulfur input-output budgets. When integrated with available data, including those from NSWS, the analyses evaluate possible correlations between watershed characteristics and surface water chemistry.

Level II analyses provide order-of-magnitude time estimates of the system response rates to various levels of acidic deposition. These analyses are being used to estimate changes in individual system components considered to be important in controlling surface water acidification, such as sulfate retention and base cation supply.

Level III analyses use dynamic models to integrate key mechanisms controlling surface water chemistry over a long period of acidic deposition. These mechanisms include soil-water interactions (including water contact time), replacement of base cations through mineral weathering, sulfate retention, and base cation buffering. The predicted response times assist in classifying watersheds and estimating the number and geographic distribution of each watershed class.

Address inquiries concerning DDRP to:

Robbins Church
EPA/Environmental Research
Laboratory-Corvallis
200 S.W. 35th Street
Corvallis, OR 97333
(503) 757-4666 FTS: 420-4666

Watershed Processes and Manipulations

Watershed studies focus on testing acidification hypotheses through experimental acidification of aquatic systems and investigations of soil processes. The artificial acidification of a lake in Wisconsin and the manipulation of a watershed in Maine are the key manipulation studies.

Little Rock Lake Project

Before Little Rock Lake in Wisconsin was artificially acidified in 1985, a number of hypotheses had been developed regarding the chemical changes and biological responses that might occur in a lake following the addition of acids. One-half of the lake is being acidified to decrease its pH incrementally over a six-year period. The other half of the lake also may receive the same treatment, lagged by a four-year period. The ongoing study is providing direct evidence that will allow the hypotheses to be tested and modified, if necessary, to increase the understanding of potential ecological effects of acidic deposition on an aquatic ecosystem, and to develop effective predictive models.

Address inquiries concerning the Little Rock Lake Project to:

John Eaton
EPA/Environmental Research
Laboratory-Duluth
6201 Congdon Blvd.
Duluth, MN 55804
(218) 720-5557 FTS: 780-5557

Watershed Manipulation Project

The Watershed Manipulation Project (WMP) was implemented in Maine in 1987 to evaluate watershed responses to artificial acidification. One watershed receives acid and a second, similar site serves as a control. This project, through a series of laboratory, plot, hillslope, and catchment scale experiments, is designed to (1) assess the quantitative and qualitative response of watershed soils and surface waters to altered deposition, (2) determine the interactions among biogeochemical mechanisms

controlling surface water response to acidic deposition, and (3) test the behavior of the DDRP models, evaluate model predictions of manipulation outcomes, and refine model structure to improve the reliability of model predictions. The DDRP models will serve as a framework for the hypothesis-testing experiments.

An integral component of this research area is soil process studies, which complement WMP as well as contribute to DDRP. These studies are investigating soil-related processes hypothesized to be key factors controlling the rate of surface water acidification. The processes include sulfate mobility, sulfate retention and release, cation exchange, cation supply and mineral weathering (including aluminum), organic acids, and nitrate mobility.

Address inquiries concerning the WMP to:

Parker J. Wigington, Jr.
EPA/Environmental Research Laboratory-Corvallis
200 S.W. 35th Street
Corvallis, OR 97333
(503) 757-4666 FTS: 420-4666

Episodic Response Project

The Episodic Response Project (ERP) is designed to investigate the regional response of surface waters to acidic episodes and to provide data on the level of acidic deposition below which biological effects would not occur. The risk to surface waters posed by short-term, acute exposure to acidic inputs will be examined through model-based, regional estimates of the duration, frequency, extent, and magnitude of acidic events, such as those accompanying storms and snowmelt.

As part of ELS-II and NSS-I, pilot studies were conducted to determine the feasibility of conducting episodes studies on a broad-scale, survey basis. The Spring Variability Pilot Study (SVS-P), designed to obtain data describing the spatial and temporal variability of lake chemistry during snowmelt, was conducted in early 1986. Because of the intensive sampling required and the difficult sampling conditions, only four lakes were included in the survey. For the same reasons, lake selection was strongly based on logistical considerations and was not random. A streams episodes pilot was conducted in conjunction with NSS-I in the Middle Atlantic. Results of these pilot studies led to the conclusion that a survey approach, similar to that used in NSWS, was not feasible for quantifying episodic effects.

As an alternative approach, ERP will develop an empirical model of catchment episodic response. The data for the model development will be collected from a few intensively monitored research sites, including sites funded as part of ERP plus sites jointly funded and coordinated by both ERP and WMP. This joint effort, termed the Regional Episodic and Acidic Manipulations Project (REAM), will involve both watershed manipulation experiments and episodes monitoring. It will be implemented at Fernow, West Virginia. Studies at REAM sites will focus on integrating hydrology, soil processes, water chemistry, and aquatic biology, and providing data for model development for ERP and model enhancement for WMP. Each proposed site will consist of a pair of watershed-stream systems for which water quality and flow data exist. One of the paired sites will be experimentally acidified while the second will serve as a control. Chronic and episodic acidification will be measured at each of the paired sites through intensive collection of stream chemical data. The model, which will include components addressing important site-specific factors such as deposition loadings and hydrologic factors, will be applied to empirical data from subregions of interest to estimate the regional extent of episodes.

Address inquiries concerning ERP to:

Parker J. Wigington, Jr.
EPA/Environmental Research Laboratory-Corvallis
200 S.W. 35th Street
Corvallis, OR 97333
(503) 757-4666 FTS: 420-4666

Regional Case Studies

Planning was also initiated in 1985 for the Regional Case Studies (RCS) Project. Using data from many sources, including NSWS, the RCS will provide an integrated evaluation of the potential and measured effects of acidic deposition on surface waters with low acid neutralizing capacity. Current chemical, physical, and biological characteristics of surface waters are being compared on a subregional basis to identify the key determinants of surface water chemistry. Past chemical and biological statuses are being inferred and future changes are being predicted. The focused, specific activities in RCS will help refine estimates of present chemical status and projections of future change.

This project is one of several activities within AERP targeted at synthesizing and integrating all project results. Other activities include providing information for a NAPAP Assessment to Congress in 1990 and disseminating information through the Technical Information Project (Section 2).

Address inquiries concerning RCS to:

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Corvallis, OR 97333
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Section 2

Purpose and Organization of this Document

Technical Information Project

This document is one of a number of publications produced through the AERP Technical Information Project. Initiated in 1986, the Technical Information Project disseminates AERP information to the scientific community. At present, the information distributed by Technical Information includes:

AERP *status*--In addition to providing information on current activities within AERP, the *status* highlights the activities of state agencies involved in projects related to aquatic effects of acidic deposition. The *status* provides a mechanism for obtaining documents resulting from the AERP research activities and from the Technical Information Project.

Project Overviews--Concise project descriptions inform regional EPA offices, state agencies, and other interested organizations about AERP projects prior to their implementation. A similar document, summarizing project conclusions, follows at the end of each project.

Project Descriptors--This document is a compilation of AERP project descriptions for activities to be performed in a given EPA fiscal year. The first issue covers the October 1987-September 1988 EPA fiscal year projects. The Project Descriptors document provides detailed information on each component project. Additionally, the Project Descriptors document provides the name, address, and telephone number for the technical contact for each AERP project.

Major Report with Companion Documents--These document sets are the manuals and reports used during or prepared as a result of a particular AERP component project. Companion documents to each major data report include field operations and quality assurance reports, quality assurance plans, and analytical methods manuals. Each set is identified by use of the project name in the title of each document, cover artwork, and colored covers.

Data Bases--Each data base consists of two components: a computer diskette or tape containing the validated data base for a particular AERP project and a user's guide with instructions on how to use the data base and how the quality of the data was assessed.

Handbooks--The handbooks are guidance documents that contain procedures for field operations, laboratory operations, and quality assurance for surface water and soils (six documents in all). They are especially helpful to organizations involved in designing and implementing monitoring activities related to acidic deposition. A loose-leaf format facilitates insertion of updates.

Biennial Publications and Presentations Journal--This document is a compilation of publications and presentations authored or coauthored by AERP personnnel, including EPA personnel and contractors. This issue covers 1985 and 1986. Future issues will cover remaining biennial periods through 1990. Additionally, an issue will list AERP publications completed prior to 1985.

Like the other AERP component projects, the Technical Information Project is a dynamic program that may change to better reflect the needs and priorities of AERP and the scientific community. New products may be added and some of those listed here may be changed or deleted. For further information on the Technical Information Project and its products, please contact:

W.L. Kinney
EPA/Environmental Monitoring
Systems Laboratory--Las Vegas
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Las Vegas, NV 89193-3478
(702) 798-2358

Document Organization

The remaining sections of this document contain the publication and presentation entries for 1985 and 1986. Section 3 contains book chapters, Section 4 delineates external reports, Section 5 lists internal reports, Section 6 lists journal articles, Section 7 contains symposium proceedings, and Section 8 is presentations/published abstracts. Within each section, entries are listed alphabetically by first author.

External reports are primarily EPA or other government publications. Some of these are available free of charge through the Technical Information Project. Most of the external reports, including those available through the Technical Information Project, are available through the National Technical Information Service (NTIS) for a small charge. Contact NTIS to obtain copies of these documents:

U.S. Department of Commerce
NTIS
5285 Port Royal Road
Springfield, VA 22161
(703) 487-4650

Internal reports are not generally available to the public. In some cases, copies may be obtained by contacting the primary author or the specific AERP component project contact listed in Section 1. Many of the internal reports are the manuals used on specific component projects. The AERP Handbooks are a compilation of the most up-to-date methods used in all of the component surveys and are publicly available through the Technical Information Project.

Books and journal articles are, generally, publicly available. The Symposium Proceedings section contains references to proceeding documents of conferences sponsored or partially sponsored by AERP and listings of papers authored by AERP personnel that appear in conference proceedings. The Presentations/Published Abstracts section contains references to conference proceedings in which only the abstract, rather than a full article, is published and references to presentations that have not, as yet, resulted in a publication. Presentations completed in 1986 may result in a published abstract or symposium proceeding paper in 1987; these publications will appear in the 1987-88 issue of this document. Alternately, contact the primary presenter or component project contact for further information on presentations.

Subject Index

Each entry consists of the full bibliographical citation, keywords, and a short description or abstract. The listed keywords are not necessarily those that would be found in scientific journals. Instead, these keywords are a cross-reference to the subject index located at the end of this document. The subject index has been structured with the AERP user in mind. Major headings include the individual component projects, soil-related terms, water chemistry-related terms, quality assurance terms, and computer model-related terms. Acronyms of project names and commonly used terms are used as keywords. These acronyms are included in the list of acronyms and abbreviations on page vi, are defined at their first usage within each section, and both the acronym and full name are listed in the index.

Redundancy in the index is provided by the use of subheadings from one category as major headings for another category. For example, one could find all references to the WLS-I by looking up WLS-I under the major heading of Program Area or by looking for Western Lake Survey - Phase I as a major heading. Under the Western Lake Survey - Phase I major heading, one will find the references separated into particular subjects, such as field operations, laboratory methods, wilderness lakes, and quality assurance.

Section 3

Book Chapters

Baker, J. P., and C. L. Schofield. 1985. Acidification Impacts on Fish Populations: A Review. *In*: Acid Deposition: Environmental, Economic, and Policy Issues. D. Adams, ed. Plenum Publishing Corp., New York. pp. 183-221.

Keywords: acidification effects, Adirondack Mountains, eastern Canada, fish populations, fishery decline, Nova Scotia, potential causative factors

The clearest evidence for impacts of acidic deposition is the documentation of adverse effects on fish populations. Loss of fish populations associated with acidification of surface waters has been documented for five areas--the Adirondack region of New York State, the LaCloche Mountain region of Ontario, Nova Scotia, southern Norway, and southern Sweden. In other regions of the world with low alkalinity waters receiving acidic deposition, acidification of surface waters does not appear to have progressed to levels clearly detrimental to fish. Three major mechanisms for the disappearance of fish populations with acidification have been proposed: (1) decreased food availability and/or quality, (2) fish kills during episodic acidification, and (3) recruitment failure. Each probably plays some role, although recruitment failure has been hypothesized as the most common cause of population loss.

Henriksen, A., W. Dickson, and D. F. Brakke. 1986. Critical Loads of Sulphur to Aquatic Systems. *In*: Critical Loads of Sulphur and Nitrogen to Soils, Groundwater and Surface Water. Nordic Council, Stockholm, Sweden. pp. 87-120.

Abstract not available.

Kanciruk, P., R. J. Olson, and R. A. McCord. 1986. Quality Control in Research Data Bases: The U.S. Environmental Protection Agency National Surface Water Survey experience. *In*: Research Data Management in Ecological Sciences. W. K. Michner, ed. GPO #DE86002249. pp. 193-208.

Keywords: data QA, data validation, data verification

This chapter describes the quality assurance (QA) procedures used during Phase I of the U.S. Environmental Protection Agency's National Surface Water Survey. The QA procedures used for this project include consultation on data forms design; input data screening; double data entry; range checking and relational scanning of data; data verification; and data validation using statistical, thematic, and graphic techniques.

Malanchuk, J. L., P. A. Mundy, R. J. Nesse, and D. A. Bennett. 1986. Assessment of Aquatic Effects due to Acid Deposition. *In*: Impact of Acid Rain and Deposition on Aquatic Biological Systems. B. G. Ison, S. E. Dennis, and J. M. Bates, eds. ASTM STP 928. Am. Soc. Test. Mater., Philadelphia, Pennsylvania.

Keywords: acidic deposition effects, NAPAP, recommendations

Increased concern over the impact of acid deposition on natural resources has caused the proliferation of substantial research in the area of effects. Often overlooked is the synthesis of this vast body of information into a coherent picture to be used for assessment and policy analysis. Relationships among research projects frequently are poorly defined or lacking, and problems of spatial and temporal resolution are abundant. The acquisition and use of historical data (for example, water quality and fish stocking data), to determine trends over time is problematical. Assessments of aquatic effects will be made in 1985, 1987, and 1989 under the National Acid Precipitation Assessment Program. A procedure is presented which attempts to organize existing information over space and time. Problems are highlighted and information needs made apparent.

Schnoor, J., and W. Stumm. 1985. Chemical Weathering. *In*: Acidification of Aquatic and Terrestrial Systems. W. Stumm, ed. John Wiley and Sons, New York.

Keywords: alkalinity generation, chemical weathering, ecological effects of aluminum, forest effects, lake sensitivity, metal uptake, soil processes, soil weathering, sulfate inputs, watershed properties

The authors have shown that aggrading biomass and humus and oxidation reactions serve to add protons to aqueous systems, while chemical weathering, ion exchange, and reduction reactions serve to consume protons (add ANC to the water). Atmospheric acid deposition creates an additional input of hydrogen and sulfate ions to the terrestrial and aquatic ecosystem which is partly neutralized by increased weathering and cation export. It is balanced by aluminum dissolution which causes negative effects in aquatic ecosystems on fish and possibly on forests. The lakes which have been acidified by acid precipitation are those with extremely sensitive hydrologic settings and with watersheds lacking carbonate minerals. They respond relatively rapidly to changes in acid loading (on the order of a few hydraulic detention times). The soils of these watersheds have not been greatly acidified by acid precipitation nor has podsolization occurred due to anthropogenic acid precipitation.

Schnoor, J., W. Palmer, Jr., and G. Glass. 1985. Modeling Impacts of Acid Precipitation for Northeastern Minnesota. *In*: Acid Precipitation: Modeling of Total Acid Precipitation Impacts. J. L. Schnoor, ed. Ann Arbor Sci., Ann Arbor, Michigan.

Keywords: bedrock geology, chemical weathering, lake sensitivity, regional watershed characteristics, trickle-down model, watershed properties

The hydrology and geochemistry of the watershed determine the chemical weathering rate and thus are key factors in the susceptibility of lakes to acidification. In this chapter, lakes in northeastern Minnesota serve as case studies, where igneous bedrock and a lack of calcareous overburden are sufficient to classify the region as sensitive to acid rain. The volume-weighted acidity of precipitation pH ranges from 4.6 to 4.85. These are threshold cases where it is not certain whether present acid loadings are acidifying lakes.

Section 4

External Reports

Best, M. D., S. K. Drousé, L. W. Creelman, and D. J. Chaloud. 1986. National Surface Water Survey, Eastern Lake Survey (Phase 1 - Synoptic Chemistry) Quality Assurance Report. EPA-600/4-86/011, U.S. Environmental Protection Agency, Las Vegas, Nevada. 168 pp.

Keywords: data quality, ELS-I data results, ELS-I QA, parameters, QA report, statistical testing

This quality assurance report is a retrospective, comprehensive overview of the quality assurance activities and results of the Eastern Lake Survey - Phase I. The report describes the chemical parameters measured, the sampling and analytical methods used, and the quality assurance procedures required for field, laboratory, and data base operations. The report also discusses the rationales and testing that led to the implementation of specific protocols. The statistical testing of the analytical and quality assurance data is explained, and the results of these tests are presented.

Brezonik, P. L., L. A. Baker, N. E. Detenbeck, J. G. Eaton, T. M. Frost, P. J. Garrison, M. D. Johnson, T. K. Kratz, J. J. Magnuson, J. H. McCormick, J. E. Perry, W. J. Rose, B. K. Shepard, W. A. Swenson, C. J. Watras, and K. E. Webster. 1986. Experimental Acidification of Little Rock Lake, Wisconsin: Baseline Studies and Predictions of Lake Responses to Acidification. Special Research Report #7, Water Resources Research Center, University of Minnesota, Minneapolis, Minnesota. 43 pp.

Keywords: artificial acidification, baseline studies, Little Rock Lake

The experimental acidification of a two-basin lake in northern Wisconsin is described. Background studies on the lake began in 1983, and the lake basins were separated by a vinyl curtain in August 1984; acidification of the north basin began in spring of 1985. Target pH values of 5.5, 5.0, and 4.5 are planned for two-year increments. Biotic and chemical responses and internal alkalinity generation are being studied. This report summarizes baseline studies on the lake, including acidification experiments in *in situ* enclosures.

Church, M. R., and R. S. Turner, eds. 1986. Factors Affecting the Long-term Response of Surface Waters to Acidic Deposition: State of Science. EPA 600/3-86/025, U.S. Environmental Protection Agency, Corvallis, Oregon.

Keywords: acidification model, alkalinity variability, DDRP, soil processes, terrestrial factors

Recent intensive study of the causes of surface water acidification has led to numerous hypothesized controlling mechanisms. Among these are the salt-effect reduction of alkalinity, the base cation buffering and sulfate adsorption capacities of soils, availability of weatherable minerals, depth of till, macropore flow, and type of forest cover. Correlative and predictive models have been developed to show the relationships (if any) between the hypothesized controlling mechanisms and surface water acidity, and to suggest

under what conditions additional surface waters might become acidic. The U.S. EPA is interested in surveying watershed characteristics to correlate with predictive model simulations in an effort to assess how many surface waters will become acid within certain time frames. The document is a review of our current knowledge of factors and processes controlling soil and surface water acidification, as well as an assessment of the adequacy of that knowledge for making predictions of future acidification.

Drousé, S. K., D. C. Hillman, J. L. Engels, L. W. Creelman, and S. J. Simon. 1986. National Surface Water Survey, National Stream Survey (Phase I Pilot, Mid-Atlantic Phase I, Southeast Screening, and Mid-Atlantic Episodes Pilot) Quality Assurance Plan. EPA-600/4-86/044, U.S. Environmental Protection Agency, Las Vegas, Nevada. 215 pp.

Keywords: NSS-I QA plan

The National Stream Survey is the first phase of the National Surface Water Survey Stream Study. This manual delineates the quality assurance plan for the National Stream Survey. It specifies measures to ensure that procedures are performed consistently and that the quality of the data generated can be determined.

Drousé, S. K., D. C. J. Hillman, L. W. Creelman, and S. J. Simon. 1986. National Surface Water Survey, Eastern Lake Survey (Phase I - Synoptic Chemistry) Quality Assurance Plan. EPA-600/4-86/008, U.S. Environmental Protection Agency, Las Vegas, Nevada. 211 pp.

Keywords: ELS-I QA plan

The Eastern Lake Survey is the first phase of the National Surface Water Survey lake study. This manual delineates the quality assurance plan for the Eastern Lake Survey. It specifies measures to ensure that procedures are performed consistently and that the quality of the data generated can be determined.

Haines, T. A., S. J. Pauwels, and C. H. Jagoe. 1986. Predicting and Evaluating the Effects of Acidic Precipitation on Water Chemistry and Endemic Fish Populations in the Northeastern United States. U.S. Environmental Protection Agency, Corvallis, Oregon. Air Pollution and Acid Rain Report, No. 23, 140 pp.

Keywords: acidic deposition effects, fish population status, Maine, metals, pH-stress

This study was conducted to assess the status of fish populations of 22 lakes in Maine representing a range of chemical conditions related to acidity. The results of this study show that fish species distribution and abundance were affected by acidity in Maine lakes. Lakes of pH less than 5.0 were devoid of fish. Lakes of pH about 5.5 and above contained relatively normal fish populations in terms of abundance and species richness. Fish from lakes between pH 5.4-6.0 contained elevated concentrations of trace metals, probably as a result of divalent cation mediation of metal uptake across gill membranes.

Hillman, D. C., J. F. Potter, and S. J. Simon. 1986. National Surface Water Survey, Eastern Lake Survey (Phase I - Synoptic Chemistry) Analytical Methods Manual. EPA-600/4-86/009, U.S. Environmental Protection Agency, Las Vegas, Nevada. 208 pp.

Keywords: analytical QA, ELS-I analytical methods

This manual provides details of the analytical methods and internal quality control used to process and analyze samples for the Eastern Lake Survey (ELS). Data collection activities are based on a program which ensures that the resulting data are of known quality and are suitable for the purpose for which they are intended. It is necessary that the data obtained be consistent and comparable. The same reliable, detailed analytical methodology must be available to and used by all analysts participating in the study.

Hunsaker, C. T., S. W. Christensen, J. J. Beauchamp, R. J. Olson, R. S. Turner, and J. L. Malanchuk. 1986. Empirical Relationships between Watershed Attributes and Headwater Lake Chemistry in the Adirondack Region. ORNL/TM-9838, Oak Ridge National Laboratory Technical Memorandum, Oak Ridge, Tennessee. 123 pp.

Keywords: Adirondack Mountains, Adirondack Watershed Data Base, ANC variability, pH variability, regional watershed characteristics, watershed model

This study focuses on the Adirondack Region of New York and has two purposes: (1) to develop empirical models that can be used to assess the chemical status of lakes for which no chemistry data exist and (2) to determine, on a regional scale, watershed attributes that account for variability in lake pH and acid neutralizing capacity (ANC). Headwater lakes, rather than lakes linked to upstream lakes, were selected for initial analysis. The Adirondack Watershed Data Base (AWDB) integrates data on physiography, bedrock, soils, land cover, wetlands, disturbances, beaver activity, land use, and atmospheric deposition with the water chemistry and morphology for the watersheds of 463 headwater lakes. Both bivariate and multivariate analyses were performed in developing the empirical models.

Kanciruk, P., J. M. Eilers, R. A. McCord, D. H. Landers, D. F. Brakke, and R. A. Linthurst. 1986. Characteristics of Lakes in the Eastern United States - Volume III, Data Compendium of Site Characteristics and Chemical Variables. EPA-600/4-86/007c, U.S. Environmental Protection Agency, Washington, D.C. 439 pp.

Keywords: ELS-I data base, index chemistry data

The primary goal of the Eastern Lake Survey - Phase I was to develop a geographically extensive data base that could be used as an initial framework to quantify the extent and chemical status of lakes potentially at risk due to the effects of acidic deposition. This volume is part of a three-volume report entitled, "Chemical Characteristics of Lakes in the Eastern United States." The purpose of this volume is to present additional data that were not shown in Volumes I or II. Because of the design requirement, the data presented in this volume must be viewed only as an index to the chemistry of the individual lake.

Kanciruk, P., M. Gentry, R. A. McCord, L. A. Hook, J. M. Eilers, and M. D. Best. 1986. National Surface Water Survey, Eastern Lake Survey (Phase I) Data Base Dictionary. ORNL/TM-10153. Oak Ridge National Laboratory Technical Memorandum, Oak Ridge, Tennessee. 85 pp.

Keywords: data set formats, ELS-I data dictionary

The Eastern Lake Survey - Phase I (ELS-I) involved a three-month field effort in the fall of 1984 in which 1,612 probability sample lakes and 186 special interest lakes in the northeast, southeast, and upper midwest regions of the United States were sampled. This document provides the information necessary for researchers to transfer the ELS-I data base accurately to their own computer systems. The data dictionary also includes complete descriptions of the variables in the data base and of the data set formats.

Kanciruk, P., M. Gentry, R. A. McCord, L. A. Hook, J. M. Eilers, and M. D. Best. 1986. National Surface Water Survey, Western Lake Survey (Phase I) Data Base Dictionary. ORNL/TM-10307, Oak Ridge National Laboratory Technical Memorandum, Oak Ridge, Tennessee. 90 pp.

Keywords: data set formats, WLS-I data dictionary

The Western Lake Survey - Phase I (WLS-I) involved a three-month field effort in the fall of 1985 in which 720 probability sample lakes and 32 special interest lakes in the western regions of the United States were sampled. This document provides the information necessary for researchers to transfer the WLS-I data base to their own computer systems. This data dictionary also includes complete descriptions of the variables in the data base and of the data set formats.

Linthurst, R. A., D. H. Landers, J. M. Eilers, D. F. Brakke, W. S. Overton, E. P. Meier, and R. E. Crowe. 1986. Characteristics of Lakes in the Eastern United States - Volume I, Population Descriptions and Physico-chemical Relationships. EPA-600/4-86/007a, U.S. Environmental Protection Agency, Washington, D.C. 136 pp.

Keywords: ELS-I data results, ELS-I survey design

The Eastern Lake Survey - Phase I (ELS-I) was conducted in the fall of 1984 as a part of the National Surface Water Survey (NSWS). It involved a three-month field effort in which 1,612 probability sample lakes and 186 special interest lakes in the northeast, southeast, and upper midwest regions of the United States were sampled. The purpose of this report is to describe the results of the survey and to make the ELS-I data available to researchers and policy makers. The use and interpretation of any data set are restricted by the design, the quality of the data obtained, and the sampling protocols, which are presented in detail.

Messer, J. J., C. W. Ariss, J. R. Baker, S. K. Drousé, K. N. Eshleman, P. R. Kaufmann, R. A. Linthurst, J. M. Omernik, W. S. Overton, M. J. Sale, R. D. Schonbrod, S. M. Stambaugh, and J. R. Tuschall, Jr. 1986. National Surface Water Survey National Stream Survey (Phase I - Pilot Survey). EPA-600/4-86/026, U.S. Environmental Protection Agency, Corvallis, Oregon. 321 pp.

Keywords: NSS pilot data results, NSS survey design

A pilot survey of streams in the Southern Blue Ridge Province was conducted by the U.S. EPA during the spring and summer of 1985 as part of the National Surface Water Survey (NSWS). It was designed for the purpose of testing a proposed methodology for (1) determining the present extent and location of acidic and low acid neutralizing capacity (ANC) streams in the United States and (2) classifying sampled streams that are representative of important classes of streams. This report describes the survey design and presents results from the data collected.

Morris, F. A., D. V. Peck, M. B. Bonoff, K. J. Cabble, and S. L. Pierett. 1986. National Surface Water Survey, Eastern Lake Survey (Phase I- Synoptic Chemistry) Field Operations Report. EPA-600/4-86/010, U.S. Environmental Protection Agency, Las Vegas, Nevada. 46 pp.

Keywords: ELS-I lake sampling methods

This document describes planning activities and summarizes field operations for the National Surface Water Survey. Field sampling methodologies are described in detail in the report. Pertinent results, observations, and recommendations for improvement regarding field operations are included. These recommendations and observations may be valuable to planners of similar projects.

Omernik, J. M., and A. J. Kinney. 1985. Total Alkalinity of Surface Waters: A Map of the New England and New York Region. EPA-600/D-84/216, U.S. Environmental Protection Agency, Corvallis, Oregon. 12 pp. plus map.

Keywords: alkalinity map, New England, New York

This map illustrates the regional patterns of mean annual alkalinity of surface waters in the New England and New York Region. As such, it affords a qualitative graphic overview of the relative potential sensitivity of surface waters to acidic input. The map is based on data from approximately 1,500 lakes and streams and the apparent spatial associations between these data and macrowatershed characteristics, especially land use.

Omernik, J. M., and G. E. Griffith. 1986. Total Alkalinity of Surface Waters: A Map of the Western Region. EPA-600/D-85/219, U.S. Environmental Protection Agency, Corvallis, Oregon. 38 pp. plus map.

Keywords: alkalinity map, Western U.S.

This map illustrates the regional patterns of mean annual alkalinity of surface waters in the western portion of the conterminous United States. As such, it provides a qualitative graphic overview of the potential sensitivity of surface waters to acidic inputs. The map is based on data from approximately 3,400 lakes and streams and apparent spatial associations between these data and macrowatershed characteristics that are thought to affect alkalinity.

Omernik, J. M., and G. E. Griffith. 1985. Total Alkalinity of Surface Waters: A Map of the Upper Midwest Region. EPA-600/D-85/043, U.S. Environmental Protection Agency, Corvallis, Oregon. 19 pp. plus map.

Keywords: alkalinity map, Upper Midwest

This map illustrates the regional patterns of mean annual alkalinity of surface waters in the northern portions of Minnesota, Wisconsin, and Michigan. As such, it provides a qualitative graphic overview of the relative potential sensitivity of surface waters to acidic input in the upper midwest portions of the United States. The map is based on data from approximately 14,000 lakes and streams and the apparent spatial associations between these data and macroscale watershed characteristics that are thought to affect alkalinity.

Overton, W. S. 1985. A Sampling Plan for Streams in the National Surface Water Survey. Oregon State University, Department of Statistics, Technical Report No. 114, Corvallis, Oregon. 18 pp.

Keywords: NSS survey design, stream sampling methods

This report contains a sampling plan for the U.S. EPA's National Stream Survey. It contains detailed information about the sample design, including methodology, and how it relates to the National Surface Water Survey as a whole.

Overton, W. S. 1986. A Sampling and Analysis Plan for Streams in the National Surface Water Survey. Oregon State University, Department of Statistics, Technical Report No. 117, Corvallis, Oregon. 50 pp.

Keywords: NSS survey design, population extrapolation

This report contains a sampling and data analysis plan for the U.S. EPA's National Stream Survey. It contains detailed information about the survey designs and algorithms that have been developed for extrapolating the data to larger populations.

Overton, W. S., P. Kanciruk, L. A. Hook, J. M. Eilers, D. H. Landers, D. F. Brakke, D. J. Blick, R. A. Linthurst, M. S. DeHaan, and J. M. Omernik. 1986. Characteristics of Lakes in the Eastern United States - Volume II, Lakes Sampled and Descriptive Statistics for Physical and Chemical Variables. EPA-600/4-86/007b, U.S. Environmental Protection Agency, Corvallis, Oregon. 374 pp.

Keywords: ELS-I data results, map, parameters, population estimates

The Eastern Lake Survey - Phase I (ELS-I) was designed to provide the information needed to assess the chemical status of lakes in areas of the eastern U.S. containing the majority of low alkalinity systems. The purpose of this report is to present the results obtained during the ELS-I Survey. Descriptions and definitions of parameters are presented. Maps of the eastern United States showing the three subregions where sampling was conducted are presented. Estimates of selected physical and chemical variables based on the probability sample lakes, for the subpopulation of lakes less than or equal to 2000 ha, are included.

Schofield, C. L., S. P. Gloss, and D. Josephson. 1986. Extensive Evaluation of Lake Liming, Restocking Strategies, and Fish Population Response in Acidic Lakes Following Neutralization by Liming. NEC-86/18, U.S. Fish and Wildlife Service, Department of the Interior, Washington, D.C. Interim Progress Report. 112 pp.

Keywords: Adirondack Mountains, fish population response, liming, toxicity to fish

Ten small acidic (pH less than 5) lakes in the Adirondack Mountains of New York State were selected for neutralization experiments to evaluate the response of stocked brook trout (*Salvelinus fontinalis*) populations to liming and re-acidification. Five lakes were treated with agricultural limestone in the fall of 1983 and the remaining lakes were treated in the fall of 1984. Equal numbers of two groups of brook trout were stocked in each lake during the fall periods of 1983-1985. One group had been selected for increased acid tolerance in an experimental breeding program. Caged trout were placed in each lake immediately before and after liming to evaluate acute toxicity.

Turner, R. S., J. L. Malanchuk, R. J. Olson, D. R. Marmorek, J. P. Baker, L. J. Allison, S. W. Christensen, C. T. Hunsaker, R. N. Nesse, P. J. McNamee, K. W. Thornton, G. L. Cunningham, and P. A. Mundy. 1986. Assessment of Acidic Deposition Effects on Aquatic Systems. ORNL/TM-6311, Oak Ridge National Laboratory Technical Memorandum, Oak Ridge, Tennessee. 176 pp.

Keywords: acidic deposition effects, fish population response, liming, NSWS results, regional watershed characteristics

Current knowledge of surface water acidification and its effects on aquatic life is used to assess the possible effects of acidic deposition on aquatic resources in the United States. Comparison of the National Surface Water Survey (NSWS) results with rates of acidic deposition and regional watershed characteristics suggests that there are regional differences in the relative roles of natural and anthropogenic factors in controlling lake chemistry. Empirical models are described for predicting changes in fish populations and communities resulting from acidification. Liming is discussed as an effective mitigation strategy for acidification. Finally, recommendations are presented for future research that will improve our understanding of aquatic effects.

Section 5

Internal Reports

Bonoff, M. B., K. J. Cabble, D. J. Chaloud, and L. A. Drewes. 1986. National Surface Water Survey, Eastern Lake Survey (Phase II - Spring Variability Study, Pilot) Training Manual. U.S. Environmental Protection Agency, Las Vegas, Nevada. Internal Report. 139 pp.

Keywords: SVS-P lake sampling methods, training manual, under-ice sampling

The Spring Variability Pilot Study (SVS-P) was conducted during winter 1986 to assess the impact of spring snowmelt runoff on lake chemistry. This manual contains detailed procedures for *in situ* measurements and collection of lake water samples during spring snowmelt conditions.

Cabble, K. J., and G. D. Merritt. 1986. National Surface Water Survey, Eastern Lake Survey (Phase II- Spring Variability Pilot Study and Spring Overturn Survey) Field Personnel Training Report. U.S. Environmental Protection Agency, Las Vegas, Nevada. Internal Report. 14 pp.

Keywords: ELS-II lake sampling methods, training report

Phase II of the Eastern Lake Survey (ELS-II) consisted of three seasonal chemistry surveys and the Spring Variability Pilot Study. Training programs were conducted for all field personnel to prepare them to take measurements, record data, collect samples, and become familiar with all aspects of the field station operations. This report summarizes training activities.

Chaloud, D. J., D. C. Hillman, G. J. Filbin, J. M. Henshaw, M. O. Morison, K. J. Cabble, F. A. Morris, J. R. Baker, B. B. Dickes, and D. V. Peck. 1986. National Surface Water Survey, National Stream Survey (Phase I Eastern Lake Survey, Phase II Spring Variability Pilot Study) Laboratory Training and Operations Manual. U.S. Environmental Protection Agency, Las Vegas, Nevada. Internal Report. 323 pp.

Keywords: processing methods, training manual

This manual presents detailed information on analytical methods, instrument calibration, and safety procedures for laboratory personnel involved in the National Stream Survey - Phase I (NSS-I), the Eastern Lake Survey Phase II, and the Spring Variability Pilot Study. The preliminary training program is also described.

Drewes, L. A., K. J. Cabble, D. J. Chaloud, A. W. Groeger, and M. B. Bonoff. 1986. National Surface Water Survey, Eastern Lake Survey (Phase II - Temporal Variability) Field Operations Manual for Summer Sampling. U.S. Environmental Protection Agency, Las Vegas, Nevada. Internal Report. 87 pp.

Keywords: ELS-II lake sampling methods

Phase II of the Eastern Lake Survey provided data necessary to characterize seasonal patterns in water chemistry and to relate these patterns to the Fall Index conditions of Phase I. This manual contains detailed procedures for collection of lake water samples. Types of activities and equipment needed for on-site sampling are discussed and a detailed field sampling schedule is presented.

Drousé, S. K., D. C. Hillman, L. W. Creelman, J. F. Potter, and S. J. Simon. 1985. National Surface Water Survey, Eastern Lake Survey (Phase IA) Quality Assurance Plan. U.S. Environmental Protection Agency, Las Vegas, Nevada. Internal Report. 213 pp.

Keywords: ELS pilot QA plan

The Quality Assurance project plan specifies the policies, organization, objectives, functional activities, quality assurance (QA) and quality control (QC) activities needed to achieve the data quality goals of the project. This manual contains detailed analytical QA/QC procedures.

Fountain, J., D. T. Hoff, and C. C. MacLeod. 1986. AQUARIUS Programmers and Users Guide, Volumes I and II. Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency, Las Vegas, Nevada. 323 pp.

Keywords: data verification, software

The purpose of this manual is to describe how the Automated Quality Assurance Review, Interactive User System (AQUARIUS) works and for what it is used. It has information that will allow the novice to obtain outputs as well as the proper explanations to allow the expert to make the most of the system. Included in this guide is a Programmer's Guide which contains the more specific information that a programmer would need to make modifications to the system.

Groeger, A. W., D. J. Chaloud, and M. B. Bonoff. 1986. National Surface Water Survey, Eastern Lake Survey (Phase II - Temporal Variability and Biological Resources) Field Operations Manual for Spring, Summer, and Fall Sampling. U.S. Environmental Protection Agency, Las Vegas, Nevada. Internal Report. 49 pp.

Keywords: ELS-II lake sampling methods

The Phase II probability sampling for the National Surface Water Survey focused on those lakes considered most susceptible to acidification (i.e., with acid neutralizing capacity (ANC) less than 400 μeq/L). This manual is directed specifically to the Phase II field samplers. It contains detailed procedures for collection and transport of lake water samples. Types of activities and equipment needed for on-site sampling are discussed in this manual.

Hagley, C. A. 1986. National Surface Water Survey National Stream Survey Summary of Training Activities. U.S. Environmental Protection Agency, Las Vegas, Nevada. Internal Report. 19 pp.

Keywords: stream sampling methods, training report

The National Stream Survey was conducted in spring 1986 in the Mid-Atlantic and Southeastern United States. Prior to any sampling, all field personnel completed a training session to prepare them to take measurements, record data, collect samples, and become familiar with all aspects of the field station operations. This report summarizes the training activities for the National Stream Survey.

Hagley, C. A., C. M. Knapp, C. L. Mayer, and F. A. Morris. 1986. National Surface Water Survey, National Stream Survey (Middle-Atlantic Phase I, Southeast Screening, and Middle-Atlantic Episodes Pilot) Field Training and Operations Manual. U.S. Environmental Protection Agency, Las Vegas, Nevada. Internal Report. 126 pp.

Keywords: stream sampling methods, training manual

The National Stream Survey was conducted during spring 1986. This manual contains detailed procedures for collection and transport of stream water samples. Types of activities and equipment involved in on-site sampling are discussed in this manual.

Haines, T. A., C. H. Jagoe, and S. J. Pauwels. 1985. A Comparison of Gear Effectiveness for Fish Population Sampling in Small Maine Lakes. U.S. Fish and Wildlife Service, National Fisheries Contaminants Research Center Field Research Station, Zoology Department, University of Maine, Orono, Maine.

Keywords: fish populations, Maine, sampling methods

The combination of gill nets and minnow traps effectively sampled the fish populations of small Maine lakes. The number of species caught (19) is representative of this area and lake type. The Indiana trap net was ineffective in these lakes and is not recommended. The experimental gill nets and Swedish gill nets were comparable in effectiveness. Swedish gill nets are lighter and more compact than standard gill nets, and thus are easily transported, but are more fragile and are easily damaged. Approximately 80 m of gill net and four minnow traps set overnight are sufficient to adequately sample lakes up to 40 ha in surface area. Two 40 m gill nets, one set in shallow water and one in deep water, may be slightly more effective than a single 80 m net set in an intermediate area.

Hillman, D. C., D. V. Peck, J. R. Baker, F. A. Morris, K. J. Cabble, and S. L. Pierett. 1985. National Stream Survey Pilot Study Field Training and Operations Manual. U.S. Environmental Protection Agency, Las Vegas, Nevada. Internal Report. 158 pp.

Keywords: stream sampling methods, training manual

This manual is directed specifically to the National Stream Survey field samplers. It contains detailed procedures for collection and transport of stream water samples. Types of activities and equipment involved in on-site sampling are discussed in this manual.

Hillman, D. C., J. F. Potter, and S. J. Simon. 1985. National Surface Water Survey, Eastern Lake Survey (Phase IA) Methods Manual. U.S. Environmental Protection Agency, Las Vegas, Nevada. Internal Report. 236 pp.

Keywords: analytical QA, ELS-I analytical methods, ELS-I lake sampling methods, parameters

This methods manual was written to guide personnel involved in the chemical analysis of lake water samples and covers both field and laboratory operations. The basic goals of the procedures are to collect representative samples without contamination, to preserve sample integrity for analysis, and to correctly analyze samples. Analytical methods must have the sensitivity, precision, and accuracy necessary for the data user's needs. Required detection limits, relative precision goals, and expected ranges of the parameters to be measured are listed.

Merritt, G. D. 1986. National Surface Water Survey Eastern Lake Survey (Phase II-Summer Stratification Survey) Training Report. U.S. Environmental Protection Agency, Las Vegas, Nevada. Internal Report. 8 pp.

Keywords: ELS-II lake sampling methods, training report

Phase II of the Eastern Lake Survey consisted of three seasonal chemistry surveys and the Spring Variability Pilot Study. Training programs were conducted for all field personnel to prepare them to take measurements, record data, collect samples, and become familiar with all aspects of the field station operations. This report summarizes the training activities for the summer stratification survey.

Metcalf, R. C., J. R. Wilson, G. D. Merritt, and M. E. Mitch. 1986. National Surface Water Survey, Eastern Lake Survey (Phase II - 1986 Spring Variability Pilot Survey) Field Operations Report. U.S. Environmental Protection Agency, Las Vegas, Nevada. Internal Report. 39 pp.

Keywords: SVS-P lake sampling methods, under-ice sampling

The Phase II Spring Variability Pilot Study was conducted during winter 1986 to assess the impact of spring snowmelt runoff on lake chemistry. Three groups of two lakes each were selected in New York, Maine, and Pennsylvania as primary study lakes in the pilot survey. Field sampling methods are described in this report. Safety systems for working on ice-covered lakes were developed specifically for this work. Pertinent observations and recommendations for improving such field operations are included.

Morris, F. A., L. A. Drewes, and D. V. Peck. 1986. National Surface Water Survey, Western Lake Survey (Phase I) Field Personnel Training Report. U.S. Environmental Protection Agency, Las Vegas, Nevada. Internal Report. 60 pp.

Keywords: training report, WLS-I lake sampling methods

This report summarizes the Western Lake Survey (WLS) field personnel training program. The training program for the WLS field laboratory personnel was modeled after the program developed for the Eastern Lake Survey to maintain consistency between operations. All trainees received intensive training and project orientation on sampling

protocols and equipment use. Examples of training materials, pertinent forms, quizzes, evaluation forms, and final notes are provided in this report.

Morris, F. A., D. C. Hillman, R. F. Cusimano, K. J. Cabble, S. L. Pierett, and W. L. Kinney. 1985. National Surface Water Survey, Phase IA1 - Field Training and Operations Manual. U.S. Environmental Protection Agency, Las Vegas, Nevada. Internal Report. 178 pp.

Keywords: ELS pilot lake sampling methods, training manual

Types of activities and equipment involved in on-site lake sampling are discussed in this manual. Laboratory and helicopter personnel requirements are presented with reference to safety procedures to be followed by all personnel. The schedule of field activities is presented, including dissolved inorganic carbon (DIC) analysis and field station pH determinations.

Morris, F. A., D. V. Peck, D. C. Hillman, K. J. Cabble, S. L. Pierett, and W. L. Kinney. 1985. National Surface Water Survey, Western Lake Survey (Phase I) Field Training and Operations Manual. U.S. Environmental Protection Agency, Las Vegas, Nevada. Internal Report. 201 pp.

Keywords: training manual, WLS-I lake sampling methods

This manual is directed specifically to the Western Lake Survey - Phase I field samplers. It contains detailed procedures for collection and transport of lake water samples. The schedule of field activities is presented.

Nicholson, J. M., and V. A. Sheppe. 1986. National Surface Water Survey, Eastern Lake Survey (Phase II) Fall Chemistry Survey Training Report. U.S. Environmental Protection Agency, Las Vegas, Nevada. Internal Report. 8 pp.

Keywords: ELS-II lake sampling methods, training report

Phase II of the Eastern Lake Survey consisted of three seasonal chemistry surveys and the Spring Variability Study. Training programs were conducted for all field personnel to prepare them to take measurements, record data, collect samples, and become familiar with all aspects of the field station operations. This report summarizes the training program for the fall chemistry survey.

Omernik, J. M. 1985. Total Alkalinity of Surface Waters: A Map of the Appalachian Region. U.S. Environmental Protection Agency, Corvallis, Oregon.

Keywords: alkalinity map, Appalachians

This map illustrates the spatial patterns of mean annual alkalinity of surface waters in the Appalachian Region. As such, it affords a qualitative graphic overview of the relative potential sensitivity of surface waters to acidic input. The map is based on data from regional lakes and streams and the apparent spatial associations between these data and macrowatershed characteristics, especially land use.

Overton, W. S. 1986. National Surface Water Survey, Eastern Lake Survey, Phase I- Data Analysis Plan. Oregon State University, Department of Statistics, Technical Report No. 113. Corvallis, Oregon. Internal Report. 62 pp.

Keywords: data analysis plan, ELS-I survey design, population extrapolation

This report contains a working draft data analysis plan for the National Lake Survey. It contains detailed information about the various survey designs and algorithms that have been developed for extrapolating the data to larger populations.

Peck, D. V., and C. M. Knapp. 1985. National Stream Survey Pilot Study, Summary of Training Activities. U.S. Environmental Protection Agency, Las Vegas, Nevada. Internal Report. 18 pp.

Keywords: NSS pilot, stream sampling methods, training report

A five-day training program was conducted in Las Vegas February 19-23, 1985. Additional training was conducted in North Carolina March 12-15, 1985. The training program was designed to prepare field samplers to take measurements, record data, and collect samples, and to cross-train personnel in all phases of field station operation. This summary report describes training activities and schedules.

Peck, D. V., R. F. Cusimano, and W. L. Kinney. 1985. National Surface Water Survey, Western Lake Survey (Phase I- Synoptic Chemistry) Ground Samplers Training and Operations Manual. U.S. Environmental Protection Agency, Las Vegas, Nevada. Internal Report. 44 pp.

Keywords: training manual, wilderness lakes, WLS-I lake sampling methods

This manual describes protocols for the collection of field data and water samples from wilderness area lakes by personnel of the U.S. Forest Service. These lakes are accessed by foot or pack animals, and samples are collected from inflatable boats, rather than by helicopter. Protocols for transport of samples to a mobile field laboratory are included. The objective of this protocol document is to ensure that the quality of data collected by ground sampling personnel is comparable to that of data collected by helicopter.

Permutt, T. and M. Moezzi. 1986. Relative Interlaboratory Bias in the Western Lake Survey. Systems Applications, Inc., San Rafael, California. 43 pp.

Keywords: data quality, measurement uncertainty, statistical testing, WLS-I QA

The design of WLS-I is such that even small interlaboratory biases may be of importance to users of the data. For example, samples from different regions are analyzed by different laboratories. A small interlaboratory bias therefore might counterfeit or obscure a small regional bias. This document examines the effect of interlaboratory bias on interpretation of the WLS-I data base.

Raab, G. A., K. A. Cappo, M. L. Papp, J. K. Bartz, and W. H. Cole. 1986. Rationale for the Selection of Sampling and Analytical Methods Employed in the Direct/Delayed Response Project Soil Survey. EPA-600/X-86-209, U.S. Environmental Protection Agency, Las Vegas, Nevada. Internal Report. 44 pp.

Keywords: soil analysis methods, soil sampling methods

The objective of the Direct/Delayed Response Project is to predict immediate, short-term and long-term responses of watersheds and surface waters to acidic deposition. Aspects of the project involve mapping soils, sampling soils, and performing physical, chemical, physico-chemical, and mineralogical analyses on collected materials. The selection of methods used during the study emphasized the need to generate comparable data.

Thornton, K. W., J. P. Baker, K. H. Reckhow, D. H. Landers, and P. J. Wigington, Jr. 1986. National Surface Water Survey, Eastern Lake Survey (Phase II) Research Plan. U.S. Environmental Protection Agency, Washington, D.C. Internal Report. 358 pp.

Keywords: ELS-II research plan, ELS-II survey design

Plans for Phase II of the Eastern Lake Survey are outlined in this document. The Phase II Research Plan is restricted to the northeastern U.S. (Region 1, ELS), but could be adapted for other regions as needed in future years.

Todechiney, L. R., K. J. Cabble, and J. R. Wilson. 1986. National Surface Water Survey, Eastern Lake Survey (Phase II - Temporal Variability) Field Operations Manual for Fall Sampling. U.S. Environmental Protection Agency, Las Vegas, Nevada. Internal Report. 87 pp.

Keywords: ELS-II lake sampling methods

Phase II of the Eastern Lake Survey provides data necessary to characterize seasonal patterns in water chemistry and to relate these patterns to the Fall Index conditions of Phase I sampling. This manual is directed specifically to the Phase II field samplers. It contains detailed procedures for collection and transportation of lake water samples.

Section 6

Journal Articles

Baker, L. A., P. L. Brezonik, E. S. Edgerton, and W. O. Ogburn, III. 1985. Sediment acid neutralization in softwater lakes. Water, Air, and Soil Pollut., 25:215-230.

Keywords: cation exchange, lake response, neutralization

Acid neutralizing capacities (ANC) of sediments from McCloud Lake, Florida, and seven other lakes in Wisconsin and Florida were as high as 10 meq/100 g over the pH range 4.5 to 5.5 in well-mixed batch experiments. Exchange of calcium and magnesium accounted for over 50% of the neutralizing capacity; aluminum solubilization and sulfate adsorption were unimportant in neutralizing H^+ additions. ANC was correlated with sediment volatile solids content. Sulfate reduction occurred in microcosms that simulated lakewater interactions and subsurface seepage; *in situ* pore water profiles and a whole-lake mass balance confirm the occurrence of this process in McCloud Lake. Sediment neutralization is important for lakes that receive most of their water from precipitation and thus are particularly susceptible to acidification.

Baker, L. A., P. L. Brezonik, and C. D. Pollman. 1986. Models of in-lake alkalinity generation: sulfate retention component. Water, Air, and Soil Pollut., 31:89-94.

Keywords: internal alkalinity generation model, Little Rock Lake, sulfate model

Internal alkalinity generation is modeled by an input-output approach in which equations to describe budgets for sulfate, nitrate, ammonium, and base cations are linked to an alkalinity budget equation. Calibration of the sulfate model using ion budgets for 14 softwater lakes shows that the sulfate sink coefficient is reasonably uniform and can be used to predict sulfate retention. For experimentally acidified Little Rock Lake, Wisconsin, the sulfate model predicts 90 percent recovery of sulfate thirteen years after acid additions stop.

Brakke, D. F., D. H. Landers, R. A. Linthurst, and J. J. Messer. 1985. National Surface Water Survey studies lakes and streams. Lakeline, National Association of Lake Managers, Vol. 5:2, pp. 14-17.

Keywords: AERP, NSWS survey design

The National Surface Water Survey (NSWS) is designed to provide data that will help document the chemical status of lakes and streams in regions of the United States. The Program has been designed to quantify the chemistry of lakes and streams throughout the United States, and to quantify water chemistry variability among regionally representative lakes and streams. A long-term monitoring program is being designed to quantify future changes in the chemistry and biology of aquatic ecosystems.

Brakke, D. F., and T. J. Loranger. 1986. Acid neutralizing capacity of lakes in the North Cascades area of Washington State. Water, Air, and Soil Pollut., 30:1045-1053.

Keywords: bedrock geology, Cascades, cations, low ANC

Thirty-three lakes were surveyed in 1983 in the North Cascades area of Washington State and 27 additional lakes were surveyed in 1984 to characterize lake chemistry in the area. Lakewater ANC was less than 100 μeq/L for 37% of the lakes and less than 200 μeq/L for 68% of the lakes. The North Cascades are very similar to unimpacted sensitive areas of North America and Northern Europe in mean alkalinity and cations (calcium and magnesium). Bedrock geology appears to have a significant influence on surface water ANC with lakes on granitic and metamorphic bedrocks having the lowest ANC.

Brezonik, P. L., L. A. Baker, J. R. Eaton, T. M. Frost, P. Garrison, T. K. Kratz, J. J. Magnuson, W. J. Rose, B. K. Shepard, W. A. Swenson, C. J. Watras, and K. E. Webster. 1986. Experimental acidification of Little Rock Lake, Wisconsin. Water, Air, and Soil Pollut., 31:115-121.

Keywords: acidification response, alkalinity generation, baseline studies, experimental acidification, Little Rock Lake, target pH values

The controlled acidification of a two-basin lake is described. The lake was divided by a vinyl curtain in 1984; acidification of one basin began in 1985. Target pH values of 5.5, 5.0, and 4.5 are planned for two-year increments. Biotic and chemical responses and internal alkalinity generation are being studied. Baseline studies, initial results at pH 5.5, and predictions of lake responses to acidification are described.

Cosby, B. J., G. M. Hornberger, J. N. Galloway, and R. F. Wright. 1985. Modeling the effects of acidic deposition: Assessment of a lumped parameter model of soil water and streamwater chemistry. Water Resour. Res., 21:51-63.

Keywords: acidification model, cation exchange, soil processes, watershed model

Quantitative predictions of the effects of acid deposition on terrestrial and aquatic systems require physically based, process-oriented models of catchment soil water and streamwater chemistry. A desirable characteristic of such models is that they include terms to describe the important phenomena controlling a system's chemical response to acidic deposition, yet be restricted in complexity so that they can be implemented on diverse systems with a minimum of *a priori* data. We present a conceptual model of soil water and streamwater chemistry based on soil cation exchange, dissolution of aluminum hydroxide, and solution of carbon dioxide. The model is constructed using an "average" or lumped representation of these spatially distributed catchment processes. The adequacy of the model is assessed by applying it to 3 years of soil water and streamwater chemistry data from White Oak Run, Virginia, a second-order stream in the Shenandoah National Park.

Cosby, B. J., G. M. Hornberger, and J. N. Galloway. 1985. Timescales of catchment acidification: A quantitative model for estimating freshwater acidification. Environ. Sci. and Technol., 19:1144-1149.

Keywords: acidification model, prediction uncertainty, regional estimates, sulfur deposition

There is empirical and theoretical evidence that surface waters are acidified by atmospheric deposition of sulfuric acid. Although the sensitivity of specific regions to potential damage by acid deposition can be defined on a relative scale, quantitative predictions have not been made of the time scales of water quality changes under different rates of deposition.

Cosby, B. J., R. F. Wright, G. M. Hornberger, and J. N. Galloway. 1985. Modeling the effects of acidic deposition: Estimation of long-term water quality responses in a small forested catchment. Water Resour. Res., 21:1591-1601.

Keywords: acidification model, chemical weathering, soil processes, small watersheds, watershed model

Research in recent years has led to conceptualizations of the long-term responses of catchment surface water quality to acidic deposition. That research has focused attention on certain soil processes as likely keys to catchment responses (anion retention, cation exchange, primary mineral weathering, aluminum dissolution, and CO_2 solubility). We present a mathematical model which uses quantitative descriptions of these soil chemical processes to estimate the long-term chemical changes that occur in the soil, soil water, and surface waters of catchments in response to changes in atmospheric deposition. The model is applied to a small forested catchment in the Shenandoah National Park, Virginia. The model provides a means of integrating the results of individual process level laboratory and field studies. Used this way, the model becomes a vehicle for examining the interactions and long-term implications of our conceptualization of the acidification process.

Cusimano, R. F., D. F. Brakke, and G. A. Chapman. 1986. Effects of pH on the toxicities of cadmium, copper, and zinc to steelhead trout (*Salmo gairdneri*). Can. J. Fish. Aq. Sci., Vol. 43:8, pp. 1497-1503.

Keywords: metals, pH-stress, toxicity to fish

Increased metal concentrations have been associated with freshwater acidification. Continuous-flow acute toxicity tests were conducted on soft water to determine the effect of pH on the toxicity of cadmium, copper, and zinc to small (1-6 g) steelhead trout (*Salmo gairdneri*). Test fish were significantly more tolerant of the metals at the lowest pH value than at higher pH's. The results indicated that for the metals tested, toxicity is ameliorated in depressed pH waters over short exposure periods, such as may occur during snowmelt runoff. The possibility of hydrogen ion interference with metal uptake is postulated.

Driscoll, C. T. 1985. Aluminum in acidic surface waters: Chemistry, transport, and effects. Environ. Health Perspectives, 63:93-104.

Keywords: ecological effects of aluminum

Ecologically significant concentrations of aluminum (Al) have been reported in surface waters draining "acid-sensitive" watersheds that are receiving elevated inputs of acidic deposition. It has been hypothesized that mineral acids from atmospheric deposition have remobilized Al previously precipitated within the soil. This Al is then thought to be transported to adjacent surface waters. The ecological effects of aluminum are presented, as well as the distribution and sources of aluminum. The equivalence of acidic cations to basic cations for surface water is discussed.

Effler, S. W., G. C. Schafran, and C. T. Driscoll. 1985. Partitioning light attenuation in an acidic lake. Can. J. Fish. Aq. Sci., 42:1701-11.

Keywords: acidic deposition effects, dissolved organic carbon, ecological effects of aluminum, lake characteristics

Although a number of researchers have reported that acidification of lakes is accompanied by an increase in transparency, there has been no systematic evaluation of the processes responsible for this transformation. In this study the authors partitioned the attenuation of light in acidic Darts Lake, located in the Adirondack region of New York, from May to September 1982. They observed that changes in light attenuation ($K_{(d)}$) and light absorption (α) were regulated largely by "gelbstoff." Substantial decreases in $K_{(d)}$ and α occurred through the study period and were correlated with a depletion in the concentration of dissolved organic carbon (DOC). In-lake concentrations of DOC were controlled by terrigeneous loading and in-lake processes. The decrease in DOC and the attendant decreases in α and $K_{(d)}$ were coupled to a loss of Al from the water column of the lake. They suggest that coagulation/adsorption of DOC by Al may have contributed to increases in lake clarity. Increased transparency is significant because it enhances hypolimnetic heating and decreases the thermal stability of lakes.

Eshleman, K. N., and H. F. Hemond. 1985. The role of organic acids in the acid base status of surface waters at Bickford Watershed, Massachusetts. Water Resour. Res., 21:1503-1510.

Keywords: anions, cation, dissolved organic carbon, organic acids, seasonal chemistry

An experimental field study of the alkalinity and major ion budgets of Bickford watershed in central Massachusetts indicates that organic acid production by the ecosystem contributes measurably to surface water acidification. Applying the concepts of alkalinity, electroneutrality of solutions, and mass balance, organic acids were found to comprise 20% of all strong acid sources on one subcatchment annually, a value half as large as the measured bulk mineral acid deposition. Inorganic cation to anion ratios in Provencial Brook varied between 1.0 in winter and 1.6 during summer, suggesting the presence of up to 100 μeq/L of unmeasured charge from organic anions during the growing season. Base titrations and ultraviolet photooxidation experiments confirmed the existence of low pK_a (3.5-5.0) acidic functional groups. A positive linear relationship between DOC and anion deficit for a group of surface and groundwater samples indicates DOC contains about 7.5 meq carboxylic groups per gram carbon. Biological factors related to both upland and wetland carbon metabolism apparently control this natural acidification phenomenon, which has not been documented on other watersheds in the northeastern United States for which annual alkalinity budgets have been determined.

Glass, G. E., and O. L. Loucks. 1986. Implications of a gradient in acid and ion deposition across the Northern Great Lakes States. Environ. Sci. and Technol., 20:35-43.

Keywords: depositional gradient, precipitation pH, temporal variability, Upper Midwest

Average precipitation pH from 1979-1982 declined from west to east along a cross section of sites in Minnesota, Wisconsin, and Michigan. Significant seasonal and geographic patterns in precipitation chemistry and deposition values were observed. Close correspondence of the sums of strong acid anions with the sums of hydrogen and ammonium ions in precipitation was observed, indicating anthropogenic sources of sulfur and nitrogen oxides. Present atmospheric inputs show close chemical correspondence when precipitation chemistry values are compared to the resulting ionic composition of weakly buffered lakes in north central Wisconsin and northern Michigan.

Glass, G. E., J. A. Sorensen, B. W. Liukkonen, G. R. Rapp, Jr., and O. L. Loucks. 1986. Ionic composition of acid lakes in relation to airborne inputs and watershed characteristics. Water, Air, and Soil Pollut., 31:1-15.

Keywords: deposition patterns, precipitation pH, Upper Midwest

Average precipitation pH from field measurements during 1979-1983 declined from west to east from 4.8, 4.6, and 4.3 along a cross section of sites in Minnesota, Wisconsin, and Michigan, respectively, where 990 lake and stream sampling sites were studied. Measurements of weakly buffered lakes show a parallel decline in lake pH in the same regions. The geographic patterns in ionic composition of airborne acids and bases, and the resultant surface water concentrations, are compared.

Haines, T. A., and J. P. Baker. 1986. Evidence of fish population responses to acidification in the Eastern United States. Water, Air, and Soil Pollut., 31:605-629.

Keywords: acidification effects, Adirondack Mountains, fish population response, fishery decline

The hypothesis that acidification has reduced or eliminated fish populations in certain areas of the eastern United States was investigated by examining present and historical fishery survey records. The number of usable data sets located was small. The strongest evidence for fisheries declines associated with acidification is provided by data for the Adirondack Mountains region of New York. In some lakes, fish populations have declined or disappeared; lakes experiencing fishery declines are now acidic. Alternative explanations for changes in fish communities over time were examined with no available explanation other than acidification.

Hornberger, G. M. and B. J. Cosby. 1985. Selection of parameter values in environmental models using sparse data: A case study. Applied Math. Computation, 17:335-355.

Keywords: data quality, model development, parameters

Models of environmental processes must often be constructed without the use of extensive data sets. This can occur because the exercise is preliminary (aimed at guiding future data collection) or because requisite data are extremely difficult, expensive, or even impossible to obtain. In such cases traditional, statistically based methods for

estimating parameters in the model cannot be applied; in fact, parameter estimation cannot be accomplished in a rigorous way at all. We examine the use of a regionalized sensitivity analysis procedure to select appropriate values for parameters in cases where only sparse, imprecise data are available. The utility of the method is examined in the context of equilibrium and dynamic models for describing water quality and hydrological data in a small catchment in Shenandoah National Park, Virginia. Results demonstrate that (1) models can be "tentatively calibrated" using this procedure; (2) the data most likely to provide a stringent test of the model can be identified; and (3) potential problems with model identifiability can be exposed in a preliminary analysis.

Hunsaker, C. T., J. L. Malanchuk, R. J. Olson, S. W. Christensen, and R. S. Turner. 1986. Adirondack headwater lake chemistry relationships with watershed characteristics. Water, Air, and Soil Pollut., 31:79-88.

Keywords: Adirondack Mountains, Adirondack Watershed Data Base, ANC variability, forest effects, pH variability, watershed characteristics

The Adirondack Region of New York State has been identified as having surface waters sensitive to acidic deposition and as receiving large annual inputs of acidic deposition. Compiled from a variety of sources, the Adirondack Watershed Data Base contains information on lake chemistry; lake elevation, area, and volume; and associated watershed data. Bivariate and multivariate procedures were used to examine relationships between watershed attributes and lake chemistry. Preliminary results indicate that wet deposition, lake elevation, and forest cover are the principal variables that are associated with variance in the data for lake pH and ANC in the Adirondacks.

Jeffries, D. S., D. L. Wales, J. R. M. Kelso, and R. A. Linthurst. 1986. Regional chemical characteristics of lakes in North America - Part I: Eastern Canada. Water, Air, and Soil Pollut., 31:551-567.

Keywords: Canada, deposition patterns, low ANC, regional data base

Data (collected from 1980 or later) defining the major ion chemistry of lakes located in eastern Canada have been compiled for the purpose of evaluating the current status of surface water quality in relation to acidic deposition. Acidic and low ANC waters in eastern Canada occur in a pattern explained by a combination of biogeochemical factors and atmospheric deposition. Nova Scotia contained the highest proportion of acidic and ultralow ANC lakes of any region surveyed in eastern North America. Compared to the rest of eastern Canada, lakes in Ontario have relatively high ANCs due to the influence of $CaCO_3$ contained in the glacial till of the area. Naturally occurring organic acids do not play a dominating role in the acidification of eastern Canadian lakes.

Lin, J. C. and J. S. Schnoor. 1986. Acid precipitation model for seepage lakes. J. Environ. Eng., 112:667-694.

Keywords: alkalinity generation, lake characteristics, lake pH, Trickle-down model

The Trickle-Down model has been developed and applied to Vandercook Lake, Wisconsin, for an acidic deposition assessment. Three years of field data were simulated. Field data of lake stage and groundwater level at the nearshore piezometer were used for hydrological model calibration. Field alkalinity and pH data were used for alkalinity/pH

model calibration. Hydrological budget calculations showed that almost all of the water in the lake came from precipitation falling directly on its surface. Alkalinity budget calculations indicated that 76% of the alkalinity produced came from internal processes, and the remainder of the alkalinity (24%) was supplied from groundwater inputs. Model results were within one standard deviation of field data for alkalinity at all times except the winter period of 1981-82. Simulations of a doubling of the acid deposition to Vandercook Lake indicate that an acidification of the lake would occur over a 5-20 year period.

Linthurst, R. A., D. H. Landers, J. M. Eilers, P. E. Kellar, D. F. Brakke, W. S. Overton, R. Crowe, E. P. Meier, P. Kanciruk, and D. S. Jeffries. 1986. Regional chemical characteristics of lakes in North America - Part II: Eastern United States. Water, Air, and Soil Pollut., 31:577-591.

Keywords: ELS-I data results, ELS-I survey design, regional comparisons

This paper summarizes information presented in the three-volume report entitled, *Chemical Characteristics of Lakes in the Eastern United States*, and contains results of the Eastern Lake Survey (ELS). The study area included three regions of the eastern United States (Northeast, Upper Midwest, and Southeast). The design of the survey provides statistically reliable estimates of the number, location, and chemical characteristics of lakes in the study area. The highest percentages and numbers of acidic lakes occurred in Florida, the Adirondack Mountains, and the Upper Peninsula of Michigan. The highest percentages and numbers of lakes with high sulfate concentrations and high organic anion concentrations are described. The acidic lakes occur with the highest frequency in the lowest organic anion concentration class.

Linthurst, R. A., and W. S. Overton. 1985. Response to ASA Coordinating Committee's comments on Project 3B: National Surface Water Survey, National Lake Survey, Phase I Research Plan. Amer. Stat., Vol. 39:4, Part 1.

Keywords: NSWS survey design, research plan

The purpose of this article is to respond to the American Statistical Association's (ASA) comments on the NSWS design. Changes in the NSWS design were implemented after the ASA review and numerous other technical reviews.

Loranger, T. J., D. F. Brakke, M. B. Bonoff, and B. F. Gall. 1986. Temporal variability of lake waters in the North Cascades Mountains (Washington, U.S.A.). Water, Air, and Soil Pollut., 31:123-129.

Keywords: ANC variability, Cascades, lake monitoring, nitrate, sulfate variability, temporal variability, western U.S.

Five lakes in the North Cascades were sampled at regular time and depth intervals during the open water period in 1984. Surface water ANC was depressed during snowmelt and then increased as summer and fall progressed. Shallow lakes circulated completely in the fall, whereas deep lakes (> 75 m) did not. Sulfate and nitrate (NO_3) concentrations in the lakes increased during the snowmelt period and then decreased until iceover. No significant differences were found between surface ANC measurements during fall circulation in successive years.

Loucks, O. L., G. E. Glass, J. A. Sorensen, B. W. Liukkonen, J. A. Allert, and G. Rapp, Jr. 1986. Role of precipitation chemistry versus other watershed properties in Wisconsin lake acidification. Water, Air, and Soil Pollut., 31:67-77.

Keywords: ANC variability, color, precipitation chemistry, sulfate variability, watershed properties

Data for over 100 watershed properties have been developed since 1980 for 316 watersheds in northern Wisconsin. Regression analysis was performed to determine the variables that would explain observed variability in color, sulfate, and ANC levels in Wisconsin lakes. For color, the variables appear to be vegetative characteristics, mean depth, and water renewal times. For sulfate, the variables appear to be precipitation concentration of sulfur, evaporative concentration, and lake water renewal time. ANC appears to be controlled by the size of the watershed, lake depth or water renewal time, and the intensity of anthropogenic inputs and cultural developments in the watershed. These results differ from previous studies in Wisconsin and nearby areas of Michigan and Minnesota by indicating that in some lakes acidity may not be in equilibrium with current precipitation chemistry.

Malanchuk, J. L., D. A. Bennett, P. A. Mundy, and G. J. Mallon. 1986. A comparative regional analysis of the status of aquatic resources with respect to acidic deposition. Water, Air, and Soil Pollut., 31:1061-1068.

Keywords: acidic deposition effects, Adirondack Mountains, aquatic resource effects, Southern Blue Ridge, Upper Midwest

A limited assessment of the effects of acidic deposition on aquatic resources has been performed in three potentially sensitive geographical regions: the Adirondack Mountains of New York; the Southern Blue Ridge Province of North Carolina, Tennessee, and Georgia; and the upper midwestern United States. In general, the impact of acidic deposition on aquatic resources is difficult to detect but positive correlations between atmospheric deposition and effects do exist. Thus, there is evidence to suggest that acidic deposition is at least partially responsible for the acidification of aquatic resources.

Omernik, J. M., and G. E. Griffith. 1986. Total alkalinity of surface waters: A map of the western region of the United States. J. Soil Water Conserv., 41(6):374-378.

Keywords: alkalinity map, spatial patterns, western U.S.

This map illustrates the regional patterns of mean annual alkalinity of surface waters in the western portion of the conterminous United States. As such, it provides a qualitative graphic overview of the potential sensitivity of surface waters to acidic inputs. The map is based on data from approximately 3,400 lakes and streams and apparent spatial associations between these data and macrowatershed characteristics that are thought to affect alkalinity.

Omernik, J. M., and G. E. Griffith. 1986. Total alkalinity of surface waters: A map of the upper midwest region of the United States. Environ. Management, 10(6):829-839.

Keywords: alkalinity map, spatial patterns, Upper Midwest

This map illustrates the regional patterns of mean annual alkalinity of surface waters in the northern portions of Minnesota, Wisconsin, and Michigan. As such, it provides a qualitative graphic overview of the relative potential sensitivity of surface waters to acidic input in the upper midwest portions of the United States. The map is based on data from approximately 14,000 lakes and streams and the apparent spatial associations between these data and macroscale characteristics that are thought to affect alkalinity.

Pauwels, S. J. and T. A. Haines. 1986. Fish species distribution in relation to water chemistry in selected Maine waters. Water, Air, and Soil Pollut., 30:477-488.

Keywords: acidification effects, ecological effects of aluminum, fish population status, fishery decline, lake characteristics, statistical testing, toxicity to fish

We examined the possible effects of acidity on the number of fish species in 22 lakes in Maine, ranging in pH from 4.4 to 7.0 (mean values). We caught no fish in three lakes with pH < 5.0, but collected 1 to 9 species in the remaining 19 lakes (pH 5.4 to 7.0). Brook trout (*Salvelinus fontinalis*), golden shiners (*Notemigonus crysoleucas*), and white suckers (*Catostomus commersoni*) were ubiquitous, but no common shiners (*Notropis cornutus*) or creek chubs (*Semotilus atromaculatus*) were collected from lakes with pH below 6.0 and 5.9, respectively. The fishless lakes differed from the others primarily in water chemistry variables related to acidity, i.e., pH, aluminum, and concentration of divalent cations. Among lakes that contained fish, the factors related to the number of species collected were lake surface area and maximum depth, which may be related to habitat quantity and diversity. Cluster analysis identified two distinct fish species groups --depauperate and cyprinid-sucker--but multiple comparison analysis failed to relate any measured chemical or physical variable to these two groups, probably because water chemistry was suitable for reproduction by these species.

Rapp, G., Jr., J. D. Allert, B. W. Liukkonen, J. A. Illse, O. L. Loucks, and G. E. Glass. 1985. Acid deposition and watershed characteristics in relation to lake chemistry in northeastern Minnesota. Environment International, 11:425-440.

Keywords: ANC variability, color, lake sensitivity, precipitation chemistry, sulfate inputs

The relationship between lake sensitivity to atmospheric acidic inputs and the neutralization capacity of watersheds is examined for 267 lakes in northeastern Minnesota. Three water chemistry/sensitivity measures (color, sulfate, and alkalinity) are correlated with variables representative of precipitation and sulfate inputs, hydrology, and the ANC of various watershed components.

Reuss, J. O., and D. W. Johnson. 1985. Effects of soil processes on the acidification of water by acid deposition. J. Environ. Qual., 14:26-31.

Keywords: alkalinity variability, cation exchange, pH variability, Reuss-Johnson model, soil processes, sulfate concentration

The mechanism whereby acid deposition can cause acidification of surface waters via equilibrium processes in soil solution was investigated using chemical equilibrium models. These models show that for soils with low to moderately low exchangeable bases, the soil solution pH is only slightly affected by CO_2 partial pressures over the range likely to be found in soils, but the alkalinity of the soil solution increases rapidly with increasing

CO_2 partial pressure. In contrast, solutions that are not in contact with the soil's cation exchange complex maintain alkalinity independently of CO_2 partial pressure. Waters having positive alkalinity will undergo a rapid rise in pH when released from the soil due to CO_2 degassing, while waters with negative alkalinity (net acidity) remain acid when degassed. In acid soils, ion exchange reactions that take place in response to increasing sulfate from 25 to 250 μmol (e^-)/L can be expected to depress soil solution pH by 0.2 to 0.4 units. This depression is sufficient to cause a switch from positive to negative alkalinity in many soil solutions and when waters with negative alkalinity are released from the soil they remain acid when degassed. This mechanism could easily account for a change in pH of surface waters from 6.25 to 5.0 or less, while the associated change in soil solution would be < 0.3 units.

Rogalla, J., P. L. Brezonik, and G. E. Glass. 1986. Evaluation of empirical models to predict acidity in lakes of the Upper Great Lakes Region. Water, Air, and Soil Pollut., 31:95-100.

Keywords: acidification model, precipitation acidity, Upper Great Lakes Region data base

A large data base on inland lakes in the Upper Great Lakes Region was used to evaluate assumptions and relationships of empirical acidification models. Significant relationships were found between lake acidification estimated as change in sulfate and precipitation acidity but not between changes in lake alkalinity and precipitation acidity in this lightly impacted region.

Schafran, G. C., and C. T. Driscoll. 1986. Spatial and temporal variations in aluminum chemistry of dilute acidic lakes. Biogeochemistry, 3:105-119.

Keywords: acidic deposition effects, dissolved organic carbon, ecological effects of aluminum, lake response, neutralization, nitrate stability, temporal variability

Elevated concentrations of Al have been observed in acidic surface waters. An assessment of the chemistry of aqueous Al is of interest because of its role as a toxicant to aquatic organisms, a pH buffer, and an adsorbent of orthophosphate and organic carbon. In this investigation we evaluated the spatial and temporal fluctuations of Al forms in an acidic drainage lake. High concentrations of NO_3, H^+, and Al were introduced to Darts Lake through drainage water during the snowmelt period. During low flow periods microbially mediated depletions of nitrate served to neutralize H^+ and aluminum base neutralizing capacity (BNC). Thus in Darts Lake, NO_3 transformations were extremely important in regulating short-term changes in pH and subsequent changes in the inorganic forms of Al. Alumino-organic solutes were correlated with dissolved organic carbon concentrations. Alumino-organic substances appear to be introduced to the lake from both drainage water and sediments.

Schnoor, J. L., A. G. Dahlberg, W. C. Ferguson, M. R. Hoffman, H. M. Liljestrand, and C. Murphy. 1986. Water Pollution Control Federation Issue Paper: Acid precipitation. Water Pollution Control Federation, 58(11):1030-1033.

Keywords: acidic deposition effects, acidic precipitation, ELS-I data results, population estimates

This Issues Paper summarizes existing information on acidification of lakes and streams in the United States. A considerable body of technical information supports the conclusion that some lakes and streams have been acidified, at least in part, by acidic precipitation. The recent completion by the U.S. Environmental Protection Agency of the Eastern Lake Survey of the National Surface Water Survey indicates that approximately 5 percent of the regions' lakes and 2 percent of the lakes' surface areas are presently acidic.

Schnoor, J. L., S. Lee, N. P. Nikolaidis, and D. R. Nair. 1986. Lake resources at risk to acidic deposition in the eastern United States. Water, Air, and Soil Pollut., 31:1091-1101.

Keywords: alkalinity model, depositional gradient, statistical testing, watershed descriptors

Watershed descriptors have been obtained or compiled for 1,439 watersheds in the northeastern and upper midwestern United States. A methodology, which combines multiple linear regression procedures with a simple deterministic model for alkalinity shows promise as a tool for acid precipitation assessments. Mean absolute errors in predicted lake alkalinity concentrations of approximately plus or minus 100 μeq/L were obtained with no significant difference (at the 0.05 significance level) between predicted and observed alkalinity histograms. Estimates of the lake resources at risk across the depositional gradient from Minnesota to the Adirondack Mountains of New York were established.

Schnoor, J. L., N. P. Nikolaidis, and G. E. Glass. 1986. Lake resources at risk to acidic deposition in the Upper Midwest. J. Water Pollut. Control Assoc., 58:139-148.

Keywords: cations, chemical weathering, neutralization, population extrapolation, Trickle-down model, Upper Midwest

Simple and complex models have been used to assess the impact of acidic deposition on lakes and streams. One model development (the Trickle-down model) places particular emphasis on the kinetics of chemical weathering in the watershed as a primary mechanism that produces cations and neutralizes acid inputs. In this study, the Trickle-down model was used to simulate lake response and to predict the percentage of lakes in the upper midwest of the United States at risk at various levels of acidic deposition.

Schnoor, J. L., and W. Stumm. 1986. The role of chemical weathering in the neutralization of acidic deposition. Schweiz. Z. Hydrol., Vol. 48:2, 24 pp.

Keywords: chemical weathering, precipitation acidity, steady-state model, sulfur deposition

The kinetics of chemical weathering have not been determined in the field, but based on laboratory experiments, the rate of weathering has a fractional order dependency on hydrogen ion and organic ligand concentration in bulk solution. Watersheds with the greatest degree of hydrologic and geologic sensitivity can produce only 200-500 eq/ha.yr of cations or alkalinity for export. This is equivalent to 100 cm/yr of precipitation with a pH of 4.3-4.6, or an annual sulfur deposition of 1.0-2.5 g/m^{2}yr. When acid and sulfur deposition are greater than these levels, extremely sensitive lakes may become acidified. To illustrate this point, a simple steady-state model is applied to lakes in regions where acidification of lakes has been reported.

White, J. F., and C. T. Driscoll. 1985. Lead cycling in an acidic Adirondack lake. Environ. Sci. and Technol., 19:1182-1187.

Keywords: aluminum, dissolved organic carbon, metals, temporal variability

Temporal and spatial variations in the concentration and transport of lead (Pb) were observed in acidic Darts Lake (Adirondack State Park, New York). Vertical deposition of Pb through the water column was most pronounced during stratification periods (winter and summer), while during high flow (spring and autumn) Pb was more conservative within the lake. Deposition of particulate Pb was strongly correlated with Al and organic carbon deposition. Increases in metal (Pb and Al) deposition occurred during periods of increasing pH. It appears that in-lake formation of particulate Al enhances the vertical transport of Pb in Darts Lake.

Section 7

Symposium Proceedings

Cosby, B. J., G. M. Hornberger, R. F. Wright, E. B. Rastetter, and J. N. Galloway. 1985. Estimating catchment water quality response to acid deposition using mathematical models of soil ion exchange processes. *In*: Workshop on Mechanisms of Ion Transport in Soils. May 20-23, 1985, Swiss Federal Institute of Technology, Zurich, Switzerland.

Keywords: acidification model, soil processes, sulfate adsorption, watershed model

A mechanistic, process-oriented model of the effects of acidic deposition on the chemistry of waters delivered from terrestrial systems to associated streams is presented. The model is based on quantitative representations of soil processes that are considered to be most important in determining surface water quality in small forested catchments in temperate, humid climates: anion retention (e.g., sulfate adsorption), cation exchange, alkalinity generation by carbonic acid dissociation, dissolution of aluminum minerals, and mineral weathering. The implications of point models of soil ion exchange processes on catchment dynamics are explored by applying the model to an intensively studied catchment in Shenandoah National Park, Virginia (USA).

Haines, T. A. 1985. Acidic precipitation and fisheries effects in the northeastern U.S.: 1984 Update. *In*: Symposium Proceedings. F. Richardson and R. Hamre, eds. September 24-25, 1985, Wild Trout III, Yellowstone National Park, Wyoming. pp. 127-132.

Keywords: fish population response, fishery decline, low ANC, metal uptake, Northeast

The first reports of surface water acidification from precipitation and resulting adverse effects on fish populations were from the Adirondack Mountains. Subsequent investigations have confirmed the presence of acid, clearwater lakes in remote regions of the northeastern United States. Surveys of streams have confirmed that clearwater streams undergo a pH depression associated with snowmelt or precipitation events. Investigations of fish populations have documented that the number of fish species declines with declining pH and that acid, freshwater, fishless lakes or streams exist in the Northeast. There is some evidence that surviving fish in moderately acidic waters accumulate increased body burdens of potentially toxic trace metals, including mercury, cadmium, lead, zinc, and aluminum. However, there is no evidence that organochlorine compounds, such as polychlorinated biphenyls (PCBs), are elevated above background levels in fish from acidic lakes. Water chemistry surveys in this region have consistently demonstrated that a large proportion of the coldwater resource is very low in acid neutralizing capacity and theoretically at risk from continued or increased atmospheric deposition of acid. Estimates of the future risks to coldwater fish resources under various air pollution emission scenarios must await further research.

Johnson, D. W., ed. 1985. Predicting Soil and Water Acidification: Proceedings of a Workshop. ORNL/TM-9258, Oak Ridge National Laboratory Technical Memorandum, Oak Ridge, Tennessee. 56 pp.

Keywords: nitrogen cycling, sensitivity criteria, soil weathering

A three-day workshop was held in Knoxville, Tennessee, on March 27-29, 1984. One of the goals of this workshop was to develop sensitivity criteria for acidic deposition effects on both soils and surface waters. Two major areas were identified as most in need of further research: nitrogen cycling and soil weathering. The workshop discussions are summarized in this document.

Malanchuk, J. L., W. E. Fallon, D. Carpenter, and G. J. Foley. 1986. Application of lake survey data to evaluate the role of acidic deposition in determining lake chemical status. *In*: Proceedings of the International Association of Ecology. August 10-16, 1986, Fourth Congress of Ecology, Syracuse, New York.

Keywords: NSWS results, parameters, potential causative factors

The major objective of the analysis was to determine what, if any, is the minimum population of lakes for which acidic deposition is the only plausible explanation for current lake acidification. A logical decision tree was developed to allow an orderly progression through the data base drawing upon various chemical parameters collected in the National Surface Water Survey. In addition to lake chemical data, other evidence that narrows the possible number of explanations for low lake pH includes the presence of wetlands, land use, marine influences, dominant anions, and so forth. Ultimately, a subset of lakes is identified for which no explanation exists to account for current acidity other than acidic deposition.

Malanchuk, J. L., G. L. Mallon, and R. J. Olson. 1985. Exploration of the relationships among acidic deposition, land use, and water chemistry. *In*: Proceedings of the Fifth Annual International Symposium of Applied Lake and Watershed Management. November 13-16, North American Lake Management Society, Lake Geneva, Wisconsin. pp. 337-343.

Keywords: Adirondack Mountains, elevation, watershed characteristics, wet deposition

Many watershed characteristics, either by themselves or in combination with acidic deposition, have been shown to influence the acidification of lakes. This study included a subset of 46 headwater lakes in the Adirondack Mountain region of New York State. Wet deposition and lake elevation showed strong, negative relationships with both lake pH and alkalinity. Several hypotheses concerning the association of watershed attributes with lake acidification are supported and should be given further consideration in research planning, field surveys, and assessment activities.

Olem, H., ed. 1985. Proceedings of the Second Annual Acid Rain Conference for the Southern Appalachians. TVA/ONRED/AWR-86/11, Tennessee Valley Authority, Office of Natural Resources and Economic Development, Chattanooga, Tennessee. 63 pp.

Keywords: Southern Appalachians, symposium proceedings

A series of abstracts of presentations made at the conference appears in these proceedings.

Olem, H., ed. 1986. Proceedings of the Third Annual Acid Rain Conference for the Southern Appalachians. TVA/ONRED/AWR-87/15, Tennessee Valley Authority, Office of Natural Resources and Economic Development, Chattanooga, Tennessee. 87 pp.

Keywords: Southern Appalachians, symposium proceedings

A series of abstracts of presentations made at the conference appears in these proceedings.

Perry, T. E., L. A. Baker, and P. L. Brezonik. 1986. Comparison of sulfate reduction rates in laboratory microcosms, field mesocosms, and *in situ* at Little Rock Lake, Wisconsin. Proceedings of the Fifth Annual Conference and International Symposium. November, 1985, Application of Lake and Watershed Management, Lake Geneva, Wisconsin. pp. 309-312.

Keywords: Little Rock Lake, mesocosm, sulfate retention

Abstract not available.

Rosen, A. E., and P. Kanciruk. 1985. A generic data entry quality assurance tool. *In*: Proceedings of the Tenth Annual SAS Users Group International Conference. March 10-13, 1985, Reno, Nevada. pp. 434-436.

Keywords: data management, data QA, software

This paper describes a software package called COMPARE, which is an important SAS quality assurance tool for data base management. Data are directly and independently entered into two SAS data sets. COMPARE then automatically compares the data sets and prints out the observation number, variable name, and values for any nonmatching observations.

Section 8

Presentations/Published Abstracts

Abbruzzese, B., and S. A. Teague. 1986. Relationship between land characteristics and acid neutralizing capacity in the northeastern United States. (Abstract). *In*: Proceedings of the Sixth Annual International Symposium on Lake and Reservoir Management: Influences of Nonpoint Source Pollutants and Acid Precipitation. November 5-8, 1986, North American Lake Management Society, Portland, Oregon. p. 13.

Keywords: ANC map, ELS-I data results, Northeast, spatial patterns, terrestrial factors

Spatial patterns of land use and related land characteristics in the northeastern United States associated with lake acid neutralizing capacity (ANC) were evaluated. A map showing ANC values derived from the Eastern Lake Survey was compared with maps of terrestrial factors including land use, land surface form, vegetation, forest cover, bedrock geology, and soils. Map units were delineated where associations between land characteristics and ANC could be identified. Spatial relationships were apparent for ANC and agriculture, urbanization, and ungrazed high elevation forests among other factors, indicating that land characteristics do have some predictive value with regard to lake ANC.

Baker, J. P. 1985. Estimating the extent of fisheries resources impacted by or susceptible to acidification of surface waters in eastern North America. Presented at the International Symposium on Acidic Precipitation, September 15-20, 1985, Muskoka, Ontario, Canada.

Keywords: Adirondack Mountains, fish population status

Quantitative, regional estimates of current and future losses of fisheries resources resulting from surface water acidification and acidic deposition are needed in order to evaluate the potential benefits of emission controls. Laboratory and field experiments have confirmed that chemical conditions associated with acidification are toxic to fish. Synoptic surveys have been used to determine the current status of fish populations in waters apparently acidified by acidic deposition and in low alkalinity waters. While a number of such surveys have been conducted, none has involved a statistically valid subsample of waters specifically for regional extrapolations. Surveys of this type are underway in the Adirondack Region of New York and are planned as part of Phase II of the National Surface Water Survey.

Bennett, D. A. 1985. The 1985 Assessment of the U.S. National Acid Precipitation Assessment Program. Presented at the International Symposium on Acidic Precipitation, September 15-20, 1985, Muskoka, Ontario, Canada.

Keywords: NAPAP, 1985 assessment

This presentation describes the 1985 Assessment Report which is the first major assessment of the National Acid Precipitation Assessment Program. This document analyzes natural and man-made emissions, costs and performance of technologies for control of emissions, wet and dry atmospheric deposition, and atmospheric phenomena and source-receptor relationships. Physical, biological, and, where possible, economic effects are

assessed for aquatic, forest, agricultural, and material systems. A brief health effects assessment is also included.

Best, M. D., M. J. Miah, and R. D. Schonbrod. 1986. Quality assurance program design for lake monitoring. (Abstract). *In*: Proceedings of the Sixth Annual International Symposium on Lake and Reservoir Management: Influences of Nonpoint Source Pollutants and Acid Precipitation. November 5-8, 1986, North American Lake Management Society, Portland, Oregon. p. 11.

Keywords: ELS-I QA, ELS-II QA, QA program design

Adequate planning and rigorous implementation of quality assurance (QA) activities are essential for successful lake monitoring. A well-designed QA program provides a maximum amount of information regarding data variability from a minimum number of QA samples. The amount of quality assurance input for a preliminary investigation should be high in relation to the total amount of sampling effort. The initial results can then be evaluated to determine the intensity of QA input required for a given level of confidence in the survey data. This approach was used to optimize the quality assurance program for the U.S. EPA National Surface Water Survey. Results from the Eastern Lake Survey Phase I were used to determine the quality assurance program needs for Phase II of the Survey.

Blick, D. J., W. S. Overton, J. J. Messer, and D. H. Landers. 1986. Statistical basis for selection and interpretation of National Surface Water Survey lakes and streams. (Abstract). *In*: Proceedings of the Sixth Annual International Symposium on Lake and Reservoir Management: Influences of Nonpoint Source Pollutants and Acid Precipitation. November 5-8, 1986, North American Lake Management Society, Portland, Oregon. p. 13.

Keywords: NSWS survey design, probability sample

The primary objectives of Phase I of the National Surface Water Survey were to determine the number of acidic or potentially acidic lakes and streams, their locations, and their physical and chemical characteristics. To meet these objectives, a statistically designed survey was implemented. For both lakes and streams, probability samples were drawn to make population estimates within known confidence bounds. Strata were defined on the basis of region, subregion, and mapped alkalinity classes.

Brakke, D. F., D. H. Landers, R. A. Linthurst, R. E. Crowe, and E. P. Meier. 1985. Regional surface water chemical characteristics based on the Eastern Lake Survey. Presented at the National Acid Deposition Program Annual Meeting, October 10, 1985, Ft. Collins, Colorado.

Keywords: ELS-I data results, Northeast, probability sample, Southeast, sulfate concentration, Upper Midwest

During the Eastern Lake Survey, 1,612 lakes were sampled in three regions of the United States: Northeast, Upper Midwest, and Southeast. Lakes were selected to provide for a probability sample of the total population of lakes occurring within areas known to contain lakes having alkalinities less than 400 μeq/L. Significant differences in chemical characteristics, including the numbers of acidic lakes and low ANC lakes, were found between regions and subregions related to watershed factors and lake type. Major dif-

ferences were observed in the concentration of sulfate and other variables in clearwater and darkwater lakes.

Brezonik, P. L., L. A. Baker, N. E. Detenbeck, and T. E. Perry. 1985. Use of mesocosms to predict whole-lake responses to acidification. (Abstract). *In*: Proceedings of the Forty-eighth Annual Meeting. June 18-21, 1985, American Society of Limnology and Oceanography, Minneapolis, Minnesota. p. 12.

Keywords: artificial acidification, Little Rock Lake, mesocosm, prediction uncertainty

Advantages and limitations of enclosures (mesocosms) to evaluate effects of acidification on aquatic biota and biogeochemical processes are discussed. Littoral and pelagic mesocosms are being used to predict effects of experimental acidification of Little Rock Lake, Wisconsin. Sources of uncertainty in predictions of whole-lake responses are described.

Brezonik, P. L., N. E. Detenbeck, and T. M. Frost. 1986. Little Rock Lake acidification study II: Predicting acidification effects from pelagic mesocosm experiments. (Abstract). *In*: Proceedings of the Forty-ninth Annual Meeting. June 23-25, 1986, American Society of Limnology and Oceanography, Kingston, Rhode Island. p. 13.

Keywords: acidification effects, artificial acidification, Little Rock Lake, mesocosm

Abstract not available in time for printing.

Brezonik, P. L., J. G. Eaton, J. J. Magnuson, W. A. Swenson, J. A. Perry, W. Rose, and C. Waters. 1985. Experimental acidification of Little Rock Lake, Wisconsin. Presented at the International Symposium on Acidic Precipitation, September 15-20, 1985, Muskoka, Ontario, Canada.

Keywords: acidification response, alkalinity generation, artificial acidification, Little Rock Lake

The controlled acidification of a two-basin lake is described. The lake was divided by a vinyl curtain in 1984; acidification of one basin began in 1985. Target pH values of 5.5, 5.0, and 4.5 are planned for two-year increments. Biotic and chemical responses and internal alkalinity generation are being studied. Baseline studies, initial results at pH 5.5, and predictions of lake responses to acidification are described.

Burke, E. M., D. C. Hillman, and E. M. Heithmar. 1986. Stability of pH and DIC in sealed syringe samples. (Abstract). *In*: Proceedings of the Rocky Mountain Conference on Analytical Chemistry. August 3-5, 1986, Denver, Colorado. Abstract No. 157.

Keywords: dissolved inorganic carbon, holding time, pH samples, syringe samples

Logistics in future phases of the National Surface Water Survey may necessitate a holding time for pH and dissolved inorganic carbon (DIC) determinations in syringe samples of up to 7 days. Therefore, a series of experiments was performed which measured the pH and DIC of synthetic and natural samples over approximately a 7-day time period. This study indicated that it is necessary to store samples in sealed containers. When contained

in sealed syringes, the pH and DIC of synthetic and natural samples stored at 4 °C did not change significantly over a 7-day period, regardless of initial dissolved CO_2 concentration. The results from samples stored in aliquot bottles were not so definitive.

Church, M. R. 1986. Predicting the future effects of acidic deposition on surface water chemistry - The Direct/Delayed Response Project. (Abstract). *In*: Proceedings of the Sixth Annual International Symposium on Lake and Reservoir Management: Influences of Nonpoint Source Pollutants and Acid Precipitation. November 5-8, 1986, North American Lake Management Society, Portland, Oregon. p. 21.

Keywords: DDRP, sulfur deposition, watershed model

The Direct/Delayed Response Project (DDRP) is one component of the Aquatic Effects Research Program conducted by the U.S. Environmental Protection Agency. The purpose of the DDRP is to predict the long-term response of watersheds and surface waters to acidic deposition. The response is assumed to be driven by sulfur deposition, and the average annual alkalinity is assumed to be the primary system response. The DDRP uses a variety of approaches to estimate these watershed response times, including system descriptions, input-output budgets, multivariate analyses, single-factor response time estimates, and dynamic watershed models.

Corbett, E. S., and J. A. Lynch. 1985. Frequency and magnitude of episodic stream pH depressions on a forested watershed. Presented at the International Symposium on Acidic Precipitation, September 15-20, 1985, Muskoka, Ontario, Canada.

Keywords: acidic stream episodes, long-term monitoring, pH depression

Acidification of surface waters may have serious consequences for the aquatic biota inhabiting these ecosystems. Although the effect of long-term acidification on the chemistry and biota of lakes has received much attention, the impact of short-term depressions of streamflow pH is less well known. Of particular significance are episodic events which cause rapid changes in water chemistry. The potential impacts of episodic pH depressions have been recognized, but there is a lack of information on their frequency, their magnitude, and the time of the year they occur. A forested experimental watershed in central Pennsylvania was monitored for four years and is discussed here.

Detenbeck, N. E., and M. Johnson. 1986. Periphyton growth in experimentally acidified Little Rock Lake, Wisconsin. (Abstract). *In*: Proceedings of the Forty-ninth Annual Meeting. June 23-25, 1986, American Society of Limnology and Oceanography, Kingston, Rhode Island. p. 14.

Keywords: acidification response, Little Rock Lake, periphyton

Abstract not available in time for printing.

Detenbeck, N. E., and M. G. Johnson. 1985. Effects of acidification on attached filamentous algal communities in Little Rock Lake. (Abstract). *In*: Proceedings of the Forty-eighth Annual Meeting. June 18-21, 1985, American Society of Limnology and Oceanography, Minneapolis, Minnesota. p. 24.

Keywords: acidification response, Little Rock Lake, mesocosm, periphyton

Preliminary investigations of periphyton growth and community structure were made using artificial substrates in an array of duplicate, littoral mesocosms maintained for 16 weeks. Initial results indicate that biomass accumulation was affected only at pH 5.0, perhaps because a phytoplankton bloom reduced available light. No significant differences in phosphatase activity or herbivory were detected.

Dobb, D. E., T. E. Lewis, E. M. Heithmar, and J. R. Kramer. 1986. Simple quantitative determination of dissolved monomeric aluminum in surface waters using fluoride complexation kinetics. (Abstract). *In*: Proceedings of the Thirteenth Annual Meeting of the Federation of Analytical Chemistry Spectroscopy Societies Meeting. September 28-October 3, 1986, Federation of Analytical Chemistry Spectroscopy Societies, St. Louis, Missouri. Abstract No. 612.

Keywords: aluminum analysis

A simple, sensitive method for determination of aqueous aluminum in natural surface waters has been developed. The method is based on the relatively slow and accurately measurable reaction kinetics of aluminum complexation with fluoride. A sample is first acidified to a pH of 3.5 to release rapidly equilibrating aluminum species that would be released as a result of acidic deposition in the environment. The sample is then spiked with fluoride, and the rate of consumption of fluoride is monitored with an ion selective electrode. The rate of consumption is related to the available aluminum.

Eaton, J. G., P. L. Brezonik, T. M. Frost, P. J. Garrison, T. M. Kratz, J. J. Magnuson, J. H. McCormick, J. A. Perry, W. J. Rose, B. K. Shepard, W. A. Swenson, C. J. Watras, and K. E. Webster. 1986. Experimental acidification of a lake in north-central Wisconsin: Initial results. Presented at a conference on the Effects of Contaminants on Ecological Systems, November 17-19, 1986, Virginia Polytechnical Institute and State University, Blacksburg, Virginia.

Keywords: artificial acidification, Little Rock Lake

Abstract not available in time for printing.

Eshleman, K. N., D. J. Blick, P. R. Kaufmann, S. M. Stambaugh, and J. J. Messer. 1986. Acid-base status of surface waters in the Southern Blue Ridge: A comparison of results from the National Surface Water Survey. (Abstract). *In*: Proceedings of the Sixth Annual International Symposium on Lake and Reservoir Management: Influences of Nonpoint Source Pollutants and Acid Precipitation. November 5-8, 1986, North American Lake Management Society, Portland, Oregon. p. 13.

Keywords: acidification model, NSWS results, precipitation pH, Southern Blue Ridge

Both the Eastern Lake Survey and the National Stream Survey have completed Phase I sampling of surface waters in the Southern Blue Ridge, thereby providing a unique opportunity to compare and contrast the "index" chemistry of lakes and streams in the region. The Southern Blue Ridge is a region known to receive wet deposition with a pH less than 4.6, and was previously thought to contain predominantly low ANC waters. Empirical models of acidification, including those proposed by Henriksen, are also evaluated using National Surface Water Survey data.

Eshleman, K. N., and J. J. Messer. 1986. National Stream Survey: A study of acidic episodes in streams in the Middle Atlantic Region. (Abstract). *In*: EOS Trans. Amer. Geophys. Union, 67:281. May 19-22, 1986, American Geophysical Union, Baltimore, Maryland.

Keywords: acidic stream episodes, Mid-Atlantic, NSS pilot, pH depression

A pilot survey of acidic episodes that accompany major frontal storm events in Mid-Atlantic streams is being conducted as part of the National Stream Survey 1986 field activities. The National Stream Survey is sponsored by the U.S. Environmental Protection Agency under the auspices of the National Acid Precipitation Assessment Program (NAPAP). Data from approximately 30 sampled events are being used to assess the extent to which meteorologic events cause temporary depressions in streamwater pH that could be harmful to aquatic biota in regions receiving acidic atmospheric deposition.

Eshleman, K. N., M. E. Mitch, and J. J. Messer. 1986. Feasibility of assessing the regional impact of acid deposition on surface waters of the Southern Blue Ridge from synoptic survey data. (Abstract). *In*: Proceedings of the Third Annual Acid Rain Conference for the Southern Appalachians. October 27-29, 1986, TVA/ONRED/AWR-87/15, Tennessee Valley Authority, Office of Natural Resources and Economic Development, Chattanooga, Tennessee. p. 38.

Keywords: acidification model, NSS pilot, population estimates, Southern Blue Ridge

Data from the National Stream Survey Phase I-Pilot Survey, conducted during the spring and summer of 1985 in the Southern Blue Ridge region, provide a statistically unbiased "snapshot" of chemical conditions of a target population of streams in that region. A method for quantifying the chronic acidification of the stream population was developed which uses the synoptic survey data and an empirical model of acidification. Several important assumptions inherent in the model formulation are discussed. Possible refinements of the model that use site-specific data on watershed hydrology, geochemistry, and soils are also discussed.

Griffith, G. E., and A. J. Kinney. 1986. Interpreting patterns of lake alkalinity in the Upper Midwest Region of the United States. (Abstract). *In*: Proceedings of the Sixth Annual International Symposium on Lake and Reservoir Management: Influences of Non-point Source Pollutants and Acid Precipitation. November 5-8, 1986, North American Lake Management Society, Portland, Oregon. p. 44.

Keywords: alkalinity map, spatial patterns, Upper Midwest

To clarify the extent of sensitivity of surface waters to acidification in the Upper Midwest Region, the spatial patterns of lake alkalinity were analyzed and mapped. Mapping

and classification were accomplished by: (1) assembling available alkalinity data on as many surface waters as possible, (2) plotting these data on large-scale maps, and (3) analyzing the patterns of the plotted data for spatial correlations with causal or integrating factors helpful in extrapolating the data. Alkalinity patterns in the region were found to be extremely varied and complex.

Haines, T. A., and J. P. Baker. 1985. Fish population responses to acidification by atmospheric deposition in northeastern North America: Evidence and alternatives. Presented at the International Symposium on Acidic Precipitation, September 15-20, 1985, Muskoka, Ontario, Canada.

Keywords: Adirondack Mountains, fish population response, fishery decline, pH-stress

The hypothesis that increased acidity of surface waters by long range transport has reduced or eliminated fish populations in northeastern North America was evaluated by examination of fishery survey data. The number of statistically valid data sets located was remarkably low. The strongest evidence in support of the hypothesis consists of temporal association data from Adirondack Mountain lakes and Nova Scotia rivers. Both data sets clearly demonstrate declines in populations of acid-sensitive fish species over the past 20-40 years. Limited water chemistry data indicate that the water bodies in question are more acidic than formerly, and fish population status is clearly correlated with present pH.

Hawkins, R. H. 1986. Rainfall-runoff response classification. (Abstract). *In*: Proceedings of the Third Annual Acid Rain Conference for the Southern Appalachians. October 27-29, 1986, TVA/ONRED/AWR-87/15, Tennessee Valley Authority, Office of Natural Resources and Economic Development, Chattanooga, Tennessee.

Keywords: rainfall-runoff, small watersheds

This study is an attempt to explore the variety and order (if any) in the rainfall-runoff response patterns of small watersheds. Eighty small watershed data sets, averaging 63 rainfall-runoff events, were fitted to an empirical equation by an interactive least-squares procedure.

Hillman, D. C., S. J. Simon, J. R. Kramer, and E. P. Meier. 1986. Application of carbonate equilibria to the evaluation of pH, DIC, ANC, and BNC data. (Abstract). *In*: Proceedings of the Sixth Annual International Symposium on Lake and Reservoir Management: Influences of Nonpoint Source Pollutants and Acid Precipitation. November 5-8, 1986, North American Lake Management Society, Portland, Oregon. p. 48.

Keywords: analytical QA, ANC calculation, statistical testing

The lakes studied during the National Surface Water Survey (NSWS) can be characterized by low ionic strength and buffering capacity. By assuming that a lake is a carbonate system, the measured pH, dissolved inorganic carbon (DIC), acid neutralizing capacity (ANC), and base neutralizing capacity (BNC) of a lake can be checked for analytical error. Also, the validity of the carbonate assumption can be tested and the presence of noncarbonate protolytes detected. Flow charts detailing the calculations and tests are presented, as well as typical results from the National Surface Water Survey.

Jeffries, D. S., B. LaZerte, R. A. Linthurst, and D. H. Landers. 1985. Effect of acidic deposition on the chemistry of aquatic ecosystems in eastern North America. Presented at the International Symposium on Acidic Precipitation, September 15-20, 1985, Muskoka, Ontario, Canada.

Keywords: acidic deposition effects, Canada, eastern U.S., metals, organic acids, pH variability

Data defining the major ion chemistry of lakes located in eastern Canada and in the eastern United States have been collated for the purpose of evaluating the current status of surface water quality in relation to acidic deposition. Frequency distribution statistics were obtained for pH, alkalinity, sulfate, and calcium and magnesium for different regions of eastern North America. In addition to the major ion chemistry, the potential importance of organic acids in the lakewaters and the influence of acidification and/or atmospheric deposition on metal levels were assessed.

Johnson, M. G., G. R. Holdren, Jr., D. L. Stevens, Jr., and M. R. Church. 1986. The influence of soils on surface water chemistry: A model based analysis. (Abstract). *In*: Proceedings of the Sixth Annual International Symposium on Lake and Reservoir Management: Influences of Nonpoint Source Pollutants and Acid Precipitation. November 5-8, 1986, North American Lake Management Society, Portland, Oregon. p. 22.

Keywords: Bloom-Grigal model, cation exchange, cation supply, Reuss-Johnson model, soil weathering

Cation supply processes are a major factor affecting the pH and alkalinity of surface waters. Two processes are currently thought to dominate cation supplies: weathering reactions and cation exchange processes. Two models were employed in this study: the Reuss-Johnson (1985) model and the Bloom-Grigal (1985) model. In conjunction with mass-balance calculations, these models can predict the time zero alkalinity for elutriate waters from a given soil. The utility of these models in predicting future effects of acidic deposition on surface water chemistry is discussed.

Johnson, M. G., G. R. Holdren, D. L. Stevens, Jr., and M. R. Church. 1986. Cation supply in watersheds: Relationship to effects of acidic deposition on surface water chemistry. Presented at the Sixth Annual International Symposium on Lake and Reservoir Management: Influences of Nonpoint Source Pollutants and Acid Precipitation. November 5-8, 1986, North American Lake Management Society, Portland, Oregon.

Keywords: acidification model, cation exchange, cation supply, watershed model

Cation supply processes in soils are a major factor affecting the pH and alkalinity of surface waters. Two processes are thought to dominate soil cation supplies: mineral weathering and cation exchange. Two models were used to examine the role of selected soil chemical parameters in buffering surface water pH and alkalinities. A third model was developed that incorporates characteristics of both existing models. The utility of these models in predicting future effects of soils and acidic deposition on surface water chemistry is discussed.

Johnson, M. G., D. L. Stevens, Jr., D. A. Lammers, J. J. Lee, and M. R. Church. 1986. Relationships among watershed physical characteristics and surface water chemistry. (Abstract). *In*: Proceedings of the 1986 Annual Meeting of the Soil Science Society of America. November 30-December 5, 1986, Soil Society of America, New Orleans, Louisiana. p. 227.

Keywords: New England, New York, soil sampling classes

As part of the EPA effort to make regional inferences about the influence of soils on surface water chemistry, soils and other physical characteristics of 145 randomly selected watersheds in New England and New York were mapped. By aggregating soils with similar chemical and physical characteristics, the soil components were grouped into 38 unique soil sampling classes. These data, in conjunction with lake chemistry data, were used to determine the relationships among mapped soil characteristics and surface water chemistry.

Kanciruk, P., L. Hook, and R. McCord. 1986. Research data management for a large environmental survey. Presented at the Tenth International CODATA Conference, July 1-3, 1986, Ottawa, Ontario, Canada.

Keywords: data management

Poster session, abstract not available.

Kanciruk, P., and R. J. Olson. 1985. National lake survey data base. Presented at the International Symposium on Acidic Precipitation, September 15-20, 1985, Muskoka, Ontario, Canada.

Keywords: Atmospheric Dry Deposition Network Data Base, data QA, ELS-I data base, parameters

The NSWS data base consists of 15 data sets that contain more than 1,000 variables. Major emphasis is placed on data base quality control. The data sets contain information on lake characteristics, water quality parameters measured *in situ* and in the analytical laboratory, and quality assurance and quality control information documenting the accuracy of the data. The validated NSWS data base will become part of the Oak Ridge National Laboratory (ORNL) Atmospheric Dry Deposition Network Data Base.

Kaufmann, P. W., W. S. Overton, Y. Jager, M. Sale, and J. J. Messer. 1986. Regional distribution estimates for spring and summer chemistry in Southern Blue Ridge streams. (Abstract). *In*: Proceedings of the Third Annual Acid Rain Conference for the Southern Appalachians. October 27-29, 1986, TVA/ONRED/AWR-87/15, Tennessee Valley Authority, Office of Natural Resources and Economic Development, Chattanooga, Tennessee. p. 37.

Keywords: ANC variability, NSS-I data results, pH variability, Southern Blue Ridge

The results of the National Stream Survey Phase I - Pilot in the Southern Blue Ridge were presented. The survey targeted blue-line stream reaches that are not grossly polluted, that drain land areas less than or equal to 155 square kilometers, and that do not flow into or out of a reservoir. Cumulative frequency distributions with upper 95 percent confidence limits were graphically presented for 31 chemical variables relevant to acidic

deposition impact, including pH, acid neutralizing capacity (ANC), extractable aluminum, sulfate, and nitrate. The spatial distributions of pH, ANC, chlorine, and sulfate were discussed with reference to regional geography.

Lackey, R. T., J. J. Messer, and R. A. Linthurst. 1985. Aquatic and terrestrial research program at the EPA Corvallis Laboratory. (Abstract). *In*: Proceedings of the Second Annual Acid Rain Conference for the Southern Appalachians. October 28-30, 1985, TVA/ONRED/AWR-86/11, Tennessee Valley Authority, Office of Natural Resources and Economic Development, Chattanooga, Tennessee.

Keywords: acidic deposition effects, forest effects, Regionalized Integrative Studies

The purpose of this presentation was to outline the scope and approach of acidic deposition effects research ongoing at the U.S. EPA Environmental Research Laboratory at Corvallis, Oregon (ERL-C). Aquatic effects research at EPA is structured around the concept of Regionalized Integrative Studies (RIS) in which synoptic surveys are conducted as a first step in quantifying present environmental conditions. More intensive studies of subsets of systems of interest are planned for the future. Forest effects research at ERL-C was also presented.

Lammers, D. A., D. J. Bogucki, G. H. Gruendling, D. L. Stevens, Jr., and M. R. Church. 1986. Comparison of depth-to-bedrock determined from soil mapping and seismic techniques. (Abstract). *In*: Proceedings of the 1986 Annual Meeting of the Soil Science Society of America. November 30-December 5, 1986, Soil Society of America, New Orleans, Louisiana. p. 228.

Keywords: DDRP, soil classes, soil mapping

Thickness of the unconsolidated soil mantle, the depth-to-bedrock, is an important parameter used when assessing water flow or soil-water interactions in a watershed. During the soil mapping of 145 watersheds in the northeastern United States, soil scientists prepared depth-to-bedrock maps using six classes. Standard seismic refraction techniques were also used to determine depth-to-bedrock along selected transects in 15 of the watersheds. Results from the two methods are compared.

Landers, D. H. 1986. National Lake Survey: Regional characteristics of lakes in the eastern United States. Presented at the Forty-ninth Annual Meeting, American Society of Limnology and Oceanography, June 23-25, 1986, Kingston, Rhode Island..

Keywords: eastern U.S., lake characteristics

No abstract available.

Landers, D. H., D. F. Brakke, and R. A. Linthurst. 1985. The distribution of pH, alkalinity and sulfate concentrations in the Northeast, Southeast, and Upper Midwest. Presented at the North American Lake Management Society Annual Meeting, November 13-16, 1985, Lake Geneva, Wisconsin.

Keywords: alkalinity variability, deposition patterns, ELS-I data results, pH variability

The National Surface Water Survey (Phase I - Lakes) was designed to determine the number of acidic and low alkalinity lakes in areas of the United States potentially sensitive to acidic deposition. Lakes were sampled during fall circulation to minimize temporal and spatial variability. A total of 25 parameters was measured on the samples. Results define the distributions of pH, alkalinity, sulfate, and other constituents in each area and allow for extrapolations to the total population of lakes as defined by the sampling design. The distributions of aqueous chemical constituents relative to regional patterns of atmospheric deposition are discussed.

Landers, D. H., J. M. Eilers, D. F. Brakke, and W. S. Overton. 1986. The National Lake Survey: Comparison of results from Eastern and Western Lake Surveys. Presented at the Society of Environmental Toxicology and Chemistry Annual Meeting, November 2-5, 1986, Alexandria, Virginia.

Keywords: ELS-I, regional comparisons, WLS-I

The eastern and western portions of the National Lake Survey were conducted in the autumn of 1984 and 1985, respectively. The surveys can be directly compared to examine the current chemical status of surface waters in regions receiving markedly different deposition values for sulfate and hydrogen ion. Western lakes contained substantially lower concentrations of sulfate, aluminum, and dissolved organic carbon compared to eastern lakes. Modest numbers of acidic lakes were sampled in the East whereas no acidic lakes were found in the West.

Landers, D. H., R. A. Linthurst, D. F. Brakke, S. W. Overton, R. Crowe, E. P. Meier, and J. Eilers. 1985. Regional lake chemistry in the eastern United States. Presented at the International Symposium on Acidic Precipitation, September 15-20, 1985, Muskoka, Ontario, Canada.

Keywords: ELS-I data results, regional distribution

The first phase of the National Surface Water Survey (NSWS), a synoptic survey of lake chemistry, has been completed in the eastern United States. This presentation described the regional distribution of low alkalinity and acidic lakes in the areas of the eastern United States potentially sensitive to acidic deposition. The distribution of chemical variables was analyzed by region, subregion, and alkalinity class. These analyses lead to a quantification of the number of acidic and low alkalinity lakes in the eastern United States and correlations between water chemistry variables and patterns of atmospheric deposition.

Lewis, T. E., J. M. Henshaw, and E. M. Heithmar. 1986. A comparison of PCV-reactive and 8-hydroxyquinoline-extractable aluminum in lake and stream waters. (Abstract). *In*: Proceedings of the Sixth Annual International Symposium on Lake and Reservoir Management: Influences of Nonpoint Source Pollutants and Acid Precipitation. November 5-8, 1986, North American Lake Management Society, Portland, Oregon. p. 44.

Keywords: aluminum analysis, extractable aluminum, methylisobutylketone, monomeric aluminum, pyrocatechol violet

During Phase I of the National Surface Water Survey - National Lake Survey, the toxic fraction of aluminum was estimated by complexation with 8-hydroxyquinoline (8-

oxine) and extraction into methylisobutylketone followed by aluminum analysis on the atomic absorption spectrophotometer. During Phase II of the National Lake Survey and Phase I of the National Stream Survey, a new method was evaluated for the speciation of aluminum in water samples. The method involves the complexation of monomeric aluminum with pyrocatechol violet (PCV) with subsequent colorimetric determination of the complex. Results of the intercomparability between the two methods were presented.

Lewis, T. E., D. C. Hillman, M. E. Silverstein, K. A. Cougan, and R. D. Schronbrod. 1986. Chemical status of lakes in national parks sampled during Phase-I of the National Surface Water Survey-Western Lakes. *In*: Conference on Science in the National Parks. July 13-18, 1986, Fort Collins, Colorado. p. 256.

Keywords: WLS-I QA

During Phase I of the National Surface Water Survey - Western Lake Survey, 92 lakes in 12 National Parks were sampled. Twenty-four chemical variables were determined. A rigorous quality assurance and quality control plan ensured data quality. The QA/QC samples consisted of field blanks, duplicates, and audits and equivalent checks at field and contract laboratories. A summary of the quality assurance protocols was presented.

Liggett, W. 1986. Designs for assessment of measurement uncertainty: Experience in the Eastern Lake Survey. Presented at the XIIIth International Biometric Conference, July 28-31, 1986, Seattle, Washington.

Keywords: ELS-I QA, measurement uncertainty, model development

The quality assurance samples that were analyzed as part of the EPA Eastern Lake Survey permit the development of models that show the dominant error components and the heteroscedasticity of some of these components. Nevertheless, these samples leave some questions about the error components. Of the various measurements included in the survey, this presentation considered the nitrate and sulfate measurements made by ion chromatography. Based on this experience, ideas were presented on how more definitive models might be obtained in future studies through better design.

Linthurst, R. A., P. E. Kellar, D. H. Landers, D. F. Brakke, and J. M. Eilers. 1986. Chemical characteristics of lakes in the eastern United States: Results of the Eastern Lake Survey - Phase I. Presented at the American Institute of Hydrology Conference on Water Problems of National Concern - Hydrologic Perspectives, October 14-17, 1986, Washington, D.C.

Keywords: ELS-I data results, ELS-I survey design, regional distribution, sulfate deposition

In the fall of 1984, the U.S. Environmental Protection Agency implemented an extensive synoptic chemical survey designed to assess the extent and magnitude of the effects of acidic deposition on aquatic resources in the United States. Phase I of the Eastern Lake Survey was conducted in the Northeastern, Southeastern, and Upper Midwestern Regions of the United States, areas expected to contain the majority of lakes potentially sensitive to acidic deposition. Chemical characteristics of the population of lakes considered within each region were estimated with known precision using results from samples collected from 1,612 lakes. Based on reported sulfate deposition gradients in the eastern

United States, regional distribution of sulfate in lakes is consistent with the hypothesis that sulfate deposition has altered lake water chemistry in some areas.

Linthurst, R. A., D. H. Landers, D. F. Brakke, and W. S. Overton. 1985. National Surface Water Survey: A program overview. Presented at the North American Lake Management Society Annual Meeting, November 13-16, 1985, Lake Geneva, Wisconsin.

Keywords: NSWS program overview, regional classification

The National Surface Water Survey (NSWS) was initiated by the U.S. Environmental Protection Agency (EPA) to document the present chemical status of lakes and streams in regions of the United States believed to be potentially susceptible to acidic deposition. The program was designed to provide an unbiased and complete data base of known quality from regionally representative surface waters. The program uses a "regional classification" approach in which the chemistry of a subset of surface waters is initially characterized, providing the basis to select a smaller, regionally "typical" subset for Phase II studies. These additional studies will document the chemical temporal variability, providing the means to select systems for a long-term monitoring program.

Linthurst, R. A., K. W. Thornton, P. E. Kellar, and D. H. Landers. 1986. Long-term monitoring of acidification trends in lakes: A regional perspective. Presented at the US-USSR Symposium on Comprehensive Analysis of the Environment, December 10-13, 1986, Washington, D.C.

Keywords: long-term monitoring, NSWS program overview, QA program design

Understanding and detecting subtle changes in regional lake water chemistry as affected by regional acidic deposition patterns requires a high quality, long-term data record over broad geographic areas. Previous attempts to investigate acidification of lakes in the United States have focused primarily on comparisons of historical data to recent records. The limitations of these analyses have been dissimilar methods, unclear analytical and quality assurance protocols, and questions regarding regional representativeness of the available data sets. A sound long-term monitoring program is being designed which incorporates representative site selection, standardized methodologies, and quality assurance protocols. The historical limitations of existing data, an assessment of regionalization concepts, and a proposed approach are discussed.

Loucks, O. L., and G. E. Glass. 1985. Cross-sectional assessment of watershed factors controlling effects of acidic deposition: Minnesota, Wisconsin, and Michigan. Presented at the International Symposium on Acidic Precipitation, September 15-20, 1985, Muskoka, Ontario, Canada.

Keywords: alkalinity variability, color, sulfate variability, Upper Midwest, watershed properties, WMP

Quantitative data for nearly 100 watershed properties (including topography, hydrology, geology, soils, vegetation, lake morphometry, and wet deposition of chemicals) on watersheds in Minnesota, Wisconsin, and Michigan have been developed since 1980. The hypothesis being evaluated is that the observed chemistry of the water in the receiving system (lake) is a composite function of antecedent water and chemical inputs (and losses) and the chemical exchange processes in pathways by which the water and chemicals reach the lake. Watershed variables were found by regression analysis to account for the largest percentage of observed variability in color, sulfate, and alkalinity levels in the lake.

Magnuson, J. J., P. L. Brezonik, J. G. Eaton, J. A. Perry, W. Rose, W. Swenson, and K. Watras. 1985. Experimental acidification of Little Rock Lake, Wisconsin. (Abstract). *In*: Proceedings of the Forty-eighth Annual Meeting. June 18-21, 1985, American Society of Limnology and Oceanography, Minneapolis, Minnesota. p. 66.

Keywords: acidification effects, Little Rock Lake, mesocosm

A 16-hectare, 2-basin lake was divided by a sea curtain in the fall of 1984. The pH of one side of the lake is being lowered from 6.0 to 5.5 in spring 1985, to approximately 5.1 in spring 1987, and to approximately 4.6 in spring 1989 with the addition of sulfuric acid. The other side is receiving the same manipulation but with a two-year lag. An interdisciplinary team is using the manipulations to test predictions of the limnological effects of cultural acidification based on the literature and mesocosm experiments.

Malanchuk, J. L., D. A. Bennett, and P. A. Mundy. 1985. A comparative regional analysis of the status of aquatic resources with respect to acid deposition. Presented at the International Symposium on Acidic Precipitation, September 15-20, 1985, Muskoka, Ontario, Canada.

Keywords: acidic deposition effects, Adirondack Mountains, aquatic resource effects, Southern Blue Ridge, Upper Midwest

A limited assessment of the effects of acidic deposition on aquatic resources has been performed in three potentially sensitive geographical regions: the Adirondack Mountains of New York; the Southern Blue Ridge Province of North Carolina, Tennessee and Georgia; and the Upper Midwestern United States. In general, the impact of acidic deposition on aquatic resources is difficult to detect but positive correlations between atmospheric deposition and effects do exist. Thus, there is evidence to suggest that acidic deposition is at least partially responsible for the acidification of aquatic resources.

Malanchuk, J. L., P. A. Mundy, G. J. Mallon, and R. J. Olson. 1985. Development of surrogate relationships among environmental variables for use in acid deposition assessments. Presented at the International Symposium on Acidic Precipitation, September 15-20, 1985, Muskoka, Ontario, Canada.

Keywords: Adirondack Watershed Data Base, NAPAP, watershed characteristics

As part of the National Acid Precipitation Assessment Program's 1985 Assessment of Aquatic Effects, regional data bases have been developed. The most extensive regional data base developed by the Aquatic Effects Research Program is the Adirondack Watershed Data Base (AWDB). Compiled from a variety of sources, the AWDB contains information on lake chemistry, lake area and volume, wetland type, and associated watershed data. Since the variables in the data base possess varying degrees of bias, the relationships between lake volume and lake area, for example, should be considered somewhat speculative. However, the relationships strongly suggest those factors that should be considered important in the acidification of surface waters.

Malanchuk, J. M., K. W. Thornton, W. Fallon, M. R. Church, B. J. Cosby, and G. M. Hornberger. 1986. Selection and analysis of models appropriate for acid deposition assessment and policy analysis. Presented at the Society for Computer Simulation, March 10-13, 1986, Norfolk, Virginia.

Keywords: model selection

Abstract not available.

McCormick, J. H., B. K. Shepard, and J. G. Eaton. 1985. Toxicological studies of fish and zooplankton from Little Rock Lake. (Abstract). *In*: Proceedings of the Forty-eighth Annual Meeting. June 18-21, 1985, American Society of Limnology and Oceanography, Minneapolis, Minnesota. p. 67.

Keywords: Little Rock Lake, pH-stress

Field and laboratory experiments are being used to determine the relative importance of some direct and indirect effects of pH on fish. Preliminary results indicate that increased numbers of chloride cells and changes in the appearance of apical crypts occur at low pH. pH-related changes in the osmotic pressure of fish blood are also being investigated to further define a potentially useful set of pH-stress indicators.

Meier, E. P., L. W. Creelman, and D. C. Hillman. 1985. Application of quality assurance information to evaluate field and laboratory performance and data quality. Presented at the Association of Analytical Chemists, International Meeting, Symposium on Practical Application of Quality Assurance Principles in the Analytical Laboratory, October, 1985, Washington, D.C.

Keywords: ELS-I QA, QA program design

The QA approach for the National Surface Water Survey provided data to evaluate field, lab, and method performance. Six mobile labs operated out of eight different field stations during the survey of the eastern United States. Samples were collected from a helicopter platform and transported to a field station for processing. QA audit samples were added at the field station and sent with routine samples to an analytical lab for more detailed analysis. Four different analytical labs were involved during various phases of the survey. During the survey, 1,807 lake samples, 126 field duplicates, 245 field blanks, and 187 audit samples were analyzed. Audit sample data were used to verify lab performance and evaluate methods performance across labs.

Meier, E. P., and L. W. Creelman. 1985. Quality assurance in the National Surface Water Survey. Presented at the North American Lake Management Society Annual Meeting, November 13-16, 1985, Lake Geneva, Wisconsin.

Keywords: NSWS QA, QA program design

Quality assurance (QA) is an important factor that is often neglected or even ignored in the collection of data from research and monitoring activities. It is especially important when the data are to be used for regulatory efforts where the impact of wrong decisions due to bad data can be costly either to the regulated community or to the environment. A strong QA effort is included in the National Surface Water Survey (NSWS) being con-

ducted by the U.S. Environmental Protection Agency as part of its Acid Deposition Research Program. The QA approach being used in the NSWS can be an example for other monitoring and research efforts, especially those related to surface water. Details about the QA procedures used in the NSWS were presented.

Mericas, C. E., and R. D. Schonbrod. 1986. Measurement uncertainty in the National Surface Water Survey. (Abstract). *In*: Proceedings of the Sixth Annual International Symposium on Lake and Reservoir Management: Influences of Nonpoint Source Pollutants and Acid Precipitation. November 5-8, 1986, North American Lake Management Society, Portland, Oregon. p. 12.

Keywords: ELS-I QA, measurement uncertainty, parameters, statistical testing

The National Surface Water Survey is a project conducted by the U.S. Environmental Protection Agency designed to document the chemical and biological condition of surface waters considered susceptible to acidic deposition. During the Eastern Lake Survey-Phase I, 1,612 routine lake samples, 127 field duplicates, and 245 field blanks were collected. Duplicate and blank samples were used to estimate system precision, detection limits, and quantitation limits for each of 24 chemical parameters. Calculations and examples of the application of measurement uncertainty estimates to water quality models are presented.

Messer, J. J. 1986. The U.S. Environmental Protection Agency's Aquatic Effects Research Program. (Abstract). *In*: Proceedings of the Third Annual Acid Rain Conference for the Southern Appalachians. October 27-29, 1986, TVA/ONRED/AWR-87/15, Tennessee Valley Authority, Office of Natural Resources and Economic Development, Chattanooga, Tennessee. p. 9.

Keywords: AERP

Abstract not received in time for printing.

Messer, J. J., C. W. Ariss, K. N. Eshleman, J. M. Omernik, S. M. Stambaugh, J. R. Baker, S. K. Drousé, R. D. Schonbrod, M. J. Sale, J. M. Coe, H. I. Jager, and W. S. Overton. 1986. The National Stream Survey - Phase I: Synoptic Chemical Survey. (Abstract). *In*: EOS Trans. Amer. Geophys. Union, 67:281. May 19-22, 1986, American Geophysical Union, Baltimore, MD.

Keywords: NSS survey design

No abstract available.

Messer, J. J., C. W. Ariss, A. Kinney, J. R. Baker, R. D. Schonbrod, W. S. Overton, M. J. Sale, and J. R. Tuschall. 1985. National Stream Survey Phase I Pilot: Some preliminary findings. (Abstract). *In*: Proceedings of the Second Annual Acid Rain Conference for the Southern Appalachians. October 28-30, 1985, TVA/ONRED/AWR-86/11, Tennessee Valley Authority, Office of Natural Resources and Economic Development, Chattanooga, Tennessee.

Keywords: NSS pilot data results, NSS survey design, pH variability

The U.S. Environmental Protection Agency completed the National Stream Survey-Pilot Study in the Southern Blue Ridge Mountains in July of 1985. The results of the Survey indicated that a synoptic survey of streams selected without regard to their apparent accessibility is logistically feasible. The pilot survey also pointed the way to improvements in the statistical sampling design and chemical handling and analytical protocols that are expected to yield more and better information at a lower cost in future field work. The analysis also indicated small but significant effects of hydrological events, upstream/downstream sampling site location, and spring/summer season on pH and/or acid neutralizing capacity in the stream reach sample.

Messer, J. J., D. H. Landers, and R. A. Linthurst. 1986. Regional evaluation of the status of surface waters in areas of the United States potentially susceptible to the effects of acid deposition. Presented at the Sixth Annual International Symposium on Lake and Reservoir Management: Influences of Nonpoint Source Pollutants and Acid Precipitation. November 5-8, 1986, North American Lake Management Society, Portland, Oregon.

Keywords: NSWS program overview

The primary goal of Phase I of the National Surface Water Survey is to estimate the chemical status of surface waters over large geographic areas potentially susceptible to the effects of acidic deposition. The National Lake Survey targeted four regions of the United States (Northeast, Upper Midwest, Southeast, and West), while the National Stream Survey focused on regions in the southeastern and mid-Atlantic states where there are few lakes but large numbers of streams. The Phase I surveys provide a classificatory, quantitative, statistical framework for interpreting and extrapolating results from past and future intensive studies into a regional context.

Messer, J. J., W. S. Overton, J. M. Omernik, K. N. Eshleman, and P. R. Kaufmann. 1986. Design issues for regional stream surveys. Presented at the Conference for the International Association of Ecology, Fourth Congress of Ecology, August 11-16, 1986, Syracuse, New York.

Keywords: NSS survey design

No abstract available.

Overton, W. S. 1986. Analysis of calibration of ground crew data to helicopter data, for lakes in the wilderness areas of the Western Lake Survey. Presented at the Society for Industrial and Applied Mathematics; Institute for Mathematics Society, May, 1986, Ottawa, Canada.

Keywords: calibration study, statistical testing, wilderness lakes, WLS-I

During the EPA Western Lake Survey, 45 lakes in wilderness areas were sampled by helicopter and also by ground crews. The purpose of these duplicate samples was to compare measurements of key water chemistry variables from water samples collected using both protocols. The majority of wilderness lakes were sampled by ground crews due to restrictions in accessing these lakes by motorized vehicles. Statistical techniques used to analyze the duplicate samples were presented.

Overton, W. S., and D. J. Blick. 1986. Effects of measurement and other extraneous errors on estimated cumulative distributions in the National Lake Survey. Presented at the XIIIth International Biometrics Conference, July 28-31, 1986, Seattle, Washington.

Keywords: ELS-I QA, measurement uncertainty, parameters, WLS-I QA

The National Lake Survey was conducted by the U.S. EPA in the eastern United States in the fall of 1984, and in the western United States in the fall of 1985. This survey had the objective of describing the chemical status of lakes in regions that are judged potentially sensitive to acidic deposition. The primary parameters of the lake survey are the distributions of the variables, and estimates of these parameters are biased by any extraneous error. Therefore, considerations of the incurred bias become a critical design issue. In this presentation the different types of error or bias were described, and the effects they have on the use of the data were discussed. Procedures for correcting incurred biases were also presented.

Raschke, R. L., and R. A. Linthurst. 1985. U.S. Environmental Protection Agency National Lake Survey. Presented at the North American Lake Management Society Annual Meeting, November 13-16, 1985, Lake Geneva, Wisconsin.

Keywords: ELS-I program overview

The U.S. Environmental Protection Agency, in cooperation with the National Acid Precipitation Assessment Program (NAPAP), designed a National Lake Survey (NLS) within regions of the United States containing large numbers of low alkalinity waters that are presumed to be most susceptible to change as a result of acidic deposition. The design of the program began in 1983, and was directed towards development of a survey program which would quantify the temporal and spatial variability in the chemistry of the nation's surface waters. The presentation focused on the interpretation and conclusions drawn from the data collected. Alternative approaches for further research were also discussed.

Rochelle, B. P., J. E. Eilers, M. R. Church, D. H. Landers, and J. J. Messer. 1986. Sulfur retention in watersheds: Relationship to effects of acidic deposition on surface water chemistry. (Abstract). *In*: Proceedings of the Sixth Annual International Symposium on Lake and Reservoir Management: Influences of Nonpoint Source Pollutants and Acid Precipitation. November 5-8, 1986, North American Lake Management Society, Portland, Oregon. p. 22.

Keywords: DDRP, soil weathering, sulfate mobility, sulfur budgets, sulfur retention

Sulfate mobility within watersheds is a major factor affecting response of surface waters to deposition. The hypothesis that the degree of weathering of soils influences sulfur retention was examined in two ways. First, sulfur input-output budgets were reviewed for 36 watersheds in the United States and Canada. Sulfur input-output budgets were also calculated using high-quality water chemistry data. For most of the systems retaining sulfur, Ultisols are the dominant soil order, whereas for most of the systems in steady state, Spodosols are dominant.

Rudensky, K. M., and J. A. Perry. 1985. The influence of acidification on litter decomposition in Little Rock Lake, Wisconsin. (Abstract). *In*: Proceedings of the Forty-eighth Annual Meeting. June 18-21, 1985, American Society of Limnology and Oceanography, Minneapolis, Minnesota. p. 92.

Keywords: litter decomposition, Little Rock Lake, mesocosm

Aerial input of organic material to Little Rock Lake has been estimated using an array of floating litter baskets. Decomposition of this material is being studied using litter bags anchored in mesocosms and in the open lake. Initial mesocosm experiments suggest that the decomposition rates decline at low pH (4.5) but are not demonstrably affected at higher pH. Laboratory experiments using microcosms are in progress to augment future field investigations.

Schnoor, J. L. 1985. Lake resources at risk to acidic deposition in the eastern United States. Presented at the International Symposium on Acidic Precipitation, September 15-20, 1985, Muskoka, Ontario, Canada.

Keywords: alkalinity model, depositional gradient, watershed descriptors

Watershed descriptors have been obtained or compiled for 1,439 watersheds in the northeastern and upper midwestern United States. A methodology that combines multiple linear regression procedures with a simple deterministic model for alkalinity shows promise as a tool for acid precipitation assessments. Mean absolute errors in predicted lake alkalinity concentrations of approximately plus or minus 100 μeq/L were obtained with no significant difference between predicted and observed alkalinity histograms. Estimates of the lake resources-at-risk across the depositional gradient from Minnesota to the Adirondack Mountains of New York were established.

Sierszen, M. E., and T. M. Frost. 1985. Mechanisms regulating community change during acidification: Selective feeding by zooplankton and its consequences in Little Rock Lake, Wisconsin. (Abstract). *In*: Proceedings of the Forty-eighth Annual Meeting. June 18-21, 1985, American Society of Limnology and Oceanography, Minneapolis, Minnesota. p. 102.

Keywords: acidification response, Little Rock Lake, phytoplankton, toxicity, zooplankton

Changes in the composition of plankton communities during lake acidification may result from trophic interactions as well as direct toxic effects. The interactions between zooplankton and phytoplankton are being investigated as part of the Little Rock Lake whole-lake acidification project.

Silverstein, M. E., K. A. Cougan, T. E. Lewis, and R. D. Schonbrod. 1986. Quality assurance plan used to determine chemical status of lakes in National Parks sampled during Phase I of the National Surface Water Survey Western Lake Survey. Presented at the Conference on Science in the National Parks, July 13-18, 1986, Ft. Collins, Colorado.

Keywords: WLS-I QA

Poster session, abstract not available.

Stevens, D. L., Jr., K. W. Thornton, G. M. Hornberger, B. J. Cosby, and M. R. Church. 1986. Regionalization in the Direct/Delayed Response Project. Presented at the XIIIth International Biometric Conference, July 28-31, 1986, Seattle, Washington.

Keywords: DDRP

Abstract not available.

Suarez, F. X., D. C. Hillman, and E. M. Heithmar. 1986. Stability of nitrate in preserved and unpreserved natural surface waters. (Abstract). *In*: Proceedings of the Rocky Mountain Conference on Analytical Chemistry. August 3-5, 1986, Denver, Colorado. Abstract No. 141.

Keywords: holding time, nitrate stability, processing methods, sample preservation

During the Eastern Lake Survey - Phase I, the holding time for nitrate analysis was seven days. However, for a number of samples the holding time was exceeded. As a result, a project was initiated to review the literature on the stability and the preservation of nitrate and to evaluate the holding time for nitrate analysis in natural surface waters. The evaluation consisted of two experiments to study the effect of mercuric chloride ($HgCl_2$) preservation, of post-sampling filtration, and of storage temperature on low level nitrate stability. The experimental design for this study is described and results are presented.

Swenson, W. A., and M. Balcer. 1985. Fish population changes and associated mechanisms in an acidified lake: Little Rock Lake, Wisconsin. (Abstract). *In*: Proceedings of the Forty-eighth Annual Meeting. June 18-21, 1985, American Society of Limnology and Oceanography, Minneapolis, Minnesota. p. 109.

Keywords: fish population response, Little Rock Lake

This study involves measuring changes in the success of Little Rock Lake fish populations in completing life stages and processes important to year-class formation. Pre-acidification phase research suggests reproductive behavior and predator-prey relationships may play a major role in determining sensitivity of fish species to lake acidification.

Teague, S. A., and D. H. Landers. 1985. U.S. Environmental Protection Agency National Lake Survey. Presented at the Rocky Mountain States Section of Air Pollution Control Association, August 3-5, 1985, Denver, Colorado.

Keywords: NSWS program overview

The U.S. Environmental Protection Agency, in cooperation with the National Acid Precipitation Assessment Program, has designed and is undertaking a National Surface Water Survey (NSWS) within regions of the United States containing the majority of low alkalinity waters and presumed to be most susceptible to change as a result of acidic deposition. Existing data are insufficient to determine how many lakes and streams are in danger of becoming acidic or how soon this may happen. The NSWS was designed to provide methodologically consistent, quality assured, regionally representative, and chemically complete data. The objectives and goals of the NSWS are discussed and an overview of the sampling and analysis design is presented.

Thornton, K. W., D. L. Stevens, Jr., M. R. Church, B. J. Cosby, Jr., and G. M. Hornberger. 1986. Regional predictive modeling in the Direct/Delayed Response Project. (Abstract). *In*: Proceedings of the Sixth Annual International Symposium on Lake and Reservoir Management: Influences of Nonpoint Source Pollutants and Acid Precipitation. November 5-8, 1986, North American Lake Management Society, Portland, Oregon. p. 23.

Keywords: DDRP, Northeast, Southern Blue Ridge, watershed model

The Direct/Delayed Response Project (DDRP), one component of the Aquatic Effects Research Program, is designed to predict the future effects of acidic deposition on surface water chemistry. The project focuses on categories of response defined as the time in the future at which average annual alkalinity might become less than 0 μeq/L. This presentation discusses the use of dynamic watershed models. The procedure used for extrapolating from individual watersheds to population estimates of the number of watersheds in each response class for the Northeast and the Southern Blue Ridge Province is presented.

Watras, C. J., T. K. Kratz, W. J. Rose, B. Mok, and J. Wachtler. 1985. The Little Rock Lake acidification experiment: Site general activities. (Abstract). *In*: Proceedings of the Forty-eighth Annual Meeting. June 18-21, 1985, American Society of Limnology and Oceanography, Minneapolis, Minnesota. p. 122.

Keywords: artificial acidification, Little Rock Lake

This whole-lake acidification experiment, funded by the U.S. Environmental Protection Agency, is a multi-institutional project designed to assess some of the potential ecological effects of acid rain. Little Rock Lake is a small, low-alkalinity (25 μeq/L), slightly acidic (pH 6.1) lake situtated on glacial till in northern Wisconsin. The lake has been divided in half and acidification of one half of the lake is scheduled for spring 1985.

Webster, K. E., and P. J. Garrison. 1985. Benthic invertebrate responses to acidification: the Little Rock Lake experiment. (Abstract). *In*: Proceedings of the Forty-eighth Annual Meeting. June 18-21, 1985, American Society of Limnology and Oceanography, Minneapolis, Minnesota. p. 122.

Keywords: acidification response, Little Rock Lake, mesocosm, zoobenthos

As part of an interdisciplinary study of ecosystem responses to acidification, the influence of direct and indirect effects on zoobenthos is being evaluated. The experimental design is to acidify one basin of Little Rock Lake in steps of 0.5 pH units from the present pH of 6.0 to 4.5. In the preacidification year (1984) the baseline community and degree of interbasin similarity was defined, and mesocosm experiments were conducted to preview community responses across the planned acidification regime.

Wiener, J. G., and J. M. Eilers. 1986. Sensitivity and responses of aquatic resources in the Upper Midwest to acid deposition. (Abstract). *In*: Proceedings of the Sixth Annual International Symposium on Lake and Reservoir Management: Influences of Nonpoint Source Pollutants and Acid Precipitation. November 5-8, 1986, North American Lake Management Society, Portland, Oregon. p. 10.

Keywords: fishery decline, potential causative factors, Upper Midwest

Available information on the extent of acid-sensitive and acidic surface waters in the Upper Midwest and potential implications of acidification for fishery resources of the region are summarized in this presentation. Three areas in the Upper Midwest contain poorly buffered inland lakes considered sensitive to damage by acidic deposition. Several of these acidic lakes exhibit chemical status and biological changes consistent with those observed elsewhere in waters acidified by acidic deposition; however, in most cases natural sources of acidity and alternative ecological processes have not been conclusively eliminated as potential causative factors.

Subject Index

All acronyms used in this index are defined on page vi.

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