United States
Environmental Protection
Agency

Office of Acid Deposition,
Environmental Monitoring and
Quality Assurance
Washington DC 20460

EPA/600/M-89/022
September 1989

Research and Development

EPA AERP status

The Aquatic Effects Research Program (AERP) *status* provides information on AERP projects dealing with the effects of acidic deposition on U.S. surface waters. Our objectives are to:

- assist organizations involved in acidic deposition research to avoid duplication of efforts and to make maximum use of related research,
- promote communication among the Environmental Protection Agency (EPA), state agencies, and organizations involved in acidic deposition monitoring activities, and
- provide a mechanism to distribute available AERP information.

AQUATIC EFFECTS RESEARCH PROGRAM, AN OVERVIEW

In 1980, Congress passed the Acid Precipitation Act, thus establishing the Interagency Task Force on Acid Precipitation. Given a 10-year mandate, the Task Force implemented the National Acid Precipitation Assessment Program (NAPAP) to investigate the causes and effects of acidic deposition. NAPAP includes task groups formed to study emissions and controls, atmospheric chemistry, atmospheric transport, atmospheric deposition and air quality, terrestrial effects, effects on materials and cultural resources, and aquatic effects.

The AERP, formed in 1983 as part of the NAPAP Aquatic Effects Task Group, is responsible for assessing the effects of acidic deposition on aquatic ecosystems. Already, published AERP reports have described the chemical characteristics of lake and stream resources in regions of the United States potentially sensitive to acidic deposition. Complementing these findings, a report summarizing correlative relationships between watershed and surface water chemical characteristics and projecting future conditions for two deposition scenarios in the Northeast and two in the Southern Blue Ridge Province will be published by the fall of 1989. (For a complete list of published AERP documents, see the mail order form attached to this *status*.) Current AERP field efforts focus primarily on watershed process studies and manipulations.

By 1990, the end of the 10-year mandate, Congress requires NAPAP to provide a full assessment of the acidic deposition phenomenon. An important aspect of current AERP efforts involves synthesizing results from past and current research to describe the state of science for acidic deposition effects on aquatic systems. Another aspect involves integrating the state of science information with illustrative emission control scenarios to provide an assessment useful for policy decisions concerning alternative control strategies. A group of AERP scientists is now working on this task, which will provide valuable aquatic information for the NAPAP reports to Congress. A summary of these activities can be found on page 8.

Status of AERP Activities--This issue of the *status* includes sections that provide information about recently published AERP materials and projects in progress. Table 1 summarizes the present status of projects within the AERP.

Project	Design	Implementation	Reporting
National Surface Water Survey			
National Lake Survey, Phase I (East and West)	Complete	Complete	Complete
National Lake Survey, Phase II (Northeast)	Complete	Complete	1990
National Stream Survey, Phase I	Complete	Complete	Complete
Direct/Delayed Response Project			
Northeast and Southern Blue Ridge Province Soil Survey	Complete	Complete	Fall 1989
Mid-Appalachian Soil Survey	Complete	Ongoing	Fall 1990
Watershed Processes and Manipulations			
Watershed Manipulation Project	Complete	Ongoing	Fall 1989
Watershed Recovery Project	Complete	Ongoing	Fall 1990
Little Rock Lake Experimental Acidification Project	Ongoing	1983	Annually
Episodic Response Project			
Episodes	Complete	Fall 1988	1990/1991
Regional Episodic and Acidic Manipulations Project	Complete	Ongoing	Summer 1990
Temporally Integrated Monitoring of Ecosystems	Ongoing	1991	Annually*
Biologically Relevant Chemistry	Ongoing	Ongoing	Winter 1988-89
Indirect Human Health Effects	Complete	Complete	Fall 1990

*See last paragraph in Temporally Integrated Monitoring of Ecosystems (TIME) project article, page 8.

Table 1. Present status and projected dates for stages of major AERP projects.

AERP FEATURE ARTICLE

Summary of Mercury Levels in Fish in the National Surface Water Survey (NSWS) Subregion 2B (Upper Peninsula of Michigan)

The accumulation of mercury in fish and the human health effects of eating mercury-contaminated fish have been well documented. Elevated mercury concentrations in fish from dilute, low-pH lakes have only recently been associated with increased lake acidity. There now is ample evidence to document that mercury is found in fish from lakes in remote regions of the world with no known current point sources of mercury and that fish mercury content is apparently linked to lake pH.

Forty-nine drainage and seepage lakes in the Upper Peninsula of Michigan (NSWS Subregion 2B) were sampled in conjunction with Phase II of the EPA Eastern Lake Survey to explore the relationship between chemical and physical characteristics of lakes and mercury concentrations in fish tissue. The lakes were selected using a stratified random design weighted for low pH so that acidification effects on mercury accumulation could be statistically evaluated and extrapolated to the entire population of lakes in this region. By coupling this study to the EPA Eastern Lake Survey Phase I and Phase II (ELS-I and ELS-II), it was possible to examine the role of chemical and physical lake variables as related to the assimilation of mercury by fish. Both game fish and other nongame species were the targets for this regional research effort. Specific objectives of this study were to:

1. archive tissue samples for representative ages of fish species collected during Phase II of the EPA Eastern Lake Survey;

2. measure total mercury concentrations in selected fish samples;

3. identify by using statistical and deterministic approaches the relationships between fish

tissue mercury concentrations and water quality and lake-watershed characteristics; and

4. estimate the number and percentage of lakes in the region that have game fish with mercury concentrations exceeding human health guidelines.

Although the numbers of fish analyzed differed for each species and each age class, a general trend of increasing mean mercury concentration as a function of age was evident for all species. This trend was also evident in the proportion of samples that exceeded various health criteria (0.5 ppm for World Health Organization and many states, 1.0 ppm for U.S. Food and Drug Administration). For example, 7.5 percent of the age-4 yellow perch sampled had mercury concentrations greater than 0.5 ppm, while 26.2 percent of the age-7 yellow perch sampled had concentrations greater than this value. Overall, mercury concentrations in a large proportion of the sampled yellow perch, northern pike, and largemouth bass exceeded the Michigan health advisory criterion (0.5 ppm). For thirty-three percent of the northern pike samples and 26 percent of the largemouth bass samples the concentrations exceeded 0.5 ppm.

It is apparent from these results that the concentrations of mercury in a high percentage of sampled game fish, which are the species most likely to be consumed by humans, exceed various health guidelines. The perception of the severity and extent of mercury contamination depends upon whether the 1.0 ppm or 0.5 ppm standard for mercury is used.

Because of the study design, the data collected on fish mercury concentrations for the 49 ELS-II lakes can be extrapolated to estimate fish mercury characteristics for Subregion 2B as a whole. This study provides regional estimates for the total number and area of lakes in a defined target population of lakes for which fish mercury levels are expected to exceed 0.5 and 1.0 ppm. Nearly 54 percent of all lakes in this subregion (nearly 82 percent of the surface area) is estimated to have one or more fish (sport fish and others) exceeding the 0.5 ppm mercury health advisory. Over 18 percent of all lakes would have one or more fish exceeding 1.0 ppm mercury. Game fish other than yellow perch (walleye, northern pike, and largemouth bass) are estimated to have at least one fish with mercury concentrations exceeding the 1.0 ppm limit in 58 percent of the 457 lakes in which they occur.

Many statistical relationships have been shown to exist between fish mercury concentrations and water

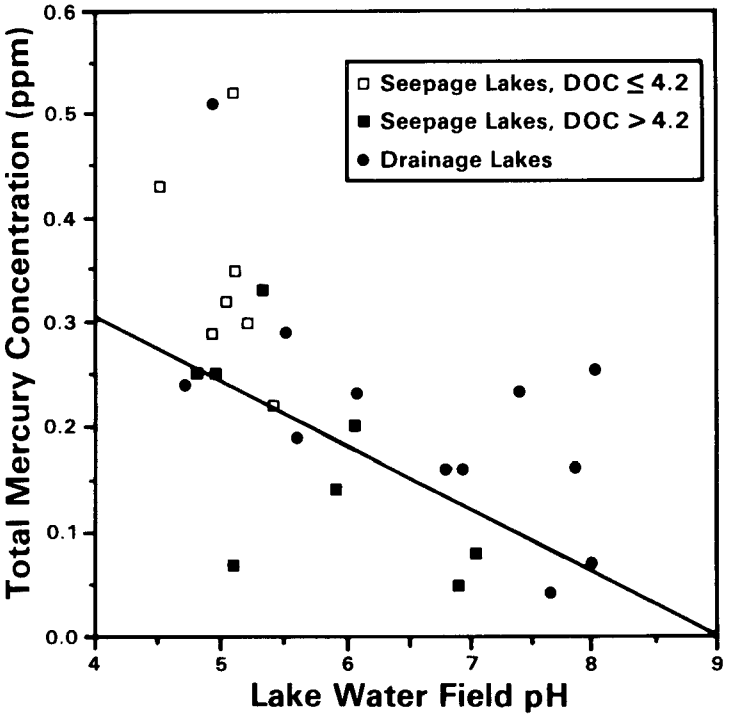

Figure 1. Relationship between lake pH and total mercury concentration for age 2-4 yellow perch in 27 Eastern Lake Survey-Phase II (ELS-II) lakes. [The dissolved organic carbon (DOC) value of 4.2 mg/L is the mean value for all seepage lakes.]

chemistry variables. For this study, the relationships between lake pH and total mercury concentration for age 2-4 yellow perch in the 27 ELS-II lakes in which they were captured are shown in Figure 1. Points are coded by hydrologic lake type (seepage or drainage) and by dissolved organic carbon (DOC) classes for seepage lakes. Seepage lakes generally have lower pH values than drainage lakes due to the minimal watershed contributions of acid buffering materials such as base cations. Moreover, some studies have concluded that elevated DOC levels tend to complex forms of dissolved mercury making them unavailable for fish uptake. In this study there is a tendency for seepage lakes with low DOC ($\leq$4.2 mg/L) to contain fish with relatively high mercury concentrations (Figure 1). However, there is no basis in this survey study from which to imply strict causal mechanisms between acidic deposition and fish mercury content.

The variables most consistently related to the mercury concentrations found in fish were total length, weight, and age. Of secondary importance were variables related to lake acidity status. Figure 2 shows a plot of mercury concentration in yellow perch plotted against pH and total length (Length). In general, the highest mercury concentrations were from long fish in low pH waters; yet some fish with mercury concentrations in excess of 0.5 ppm were found in the highest pH class.

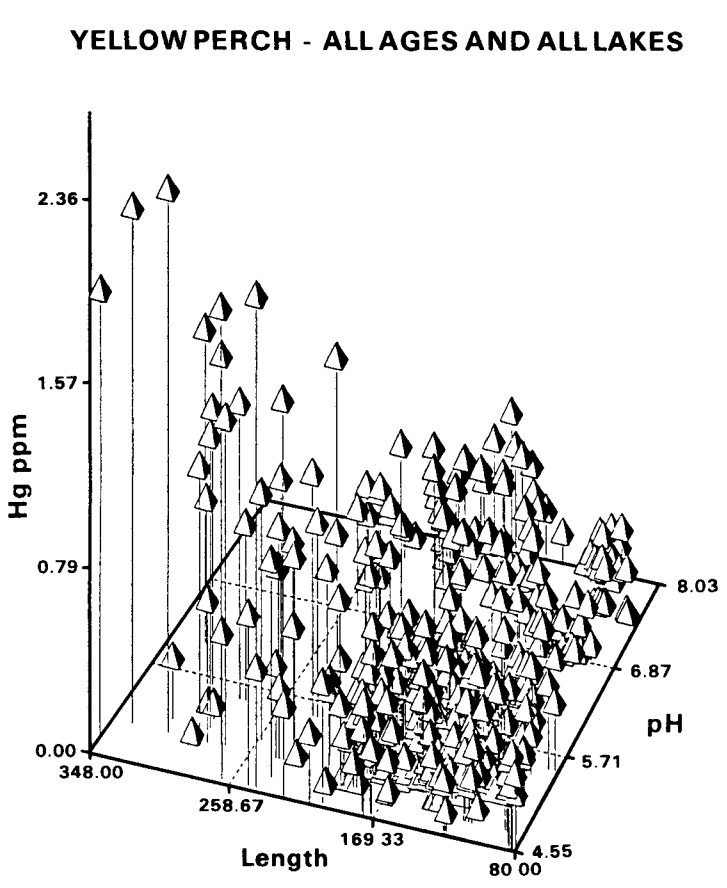

Figure 2. Plot of individual yellow perch mercury concentrations (Hg ppm) as a function of lake pH (pH) and total length (Length).

The principal benefits from this study have been to establish a quantitative baseline for mercury concentration in fish in a subregion surveyed in the ELS and to suggest some possible relationships that may warrant further investigation as to the possible cause and effect relationships of mercury accumulation in fish.

Additional research needed to reduce the current uncertainty about the quantitative relationships between acidic deposition, bioaccumulation of mercury in fish, and human health risks includes: (1) systematic surveys designed to identify the extent and levels of mercury bioaccumulation in fish taken from lakes in regions potentially affected by acidic deposition; (2) studies to identify and quantify the factors affecting bioaccumulation; and (3) studies to quantify the consumption by humans of fish from waters with low acid neutralizing capacity (ANC) and the demography of angler populations.

For further information about this project, address inquiries to:

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CURRENT AERP ACTIVITIES

The following summaries describe the status of acidic deposition research projects currently in progress.

Direct/Delayed Response Project (DDRP)

Data from DDRP study watersheds in the Northeast (NE) and Southern Blue Ridge Province (SBRP) (see April 1989 *status*) have been analyzed on three levels. Level I Analyses include examination of statistical associations among atmospheric deposition, watershed characteristics, and surface water chemistry. Level II Analyses consider estimates of the time required for key watershed characteristics to reach critical levels. Level III Analyses use three dynamic, integrated watershed models to project future responses to acidic deposition under scenarios (two for each region) of long-term sulfur deposition (Figure 3).

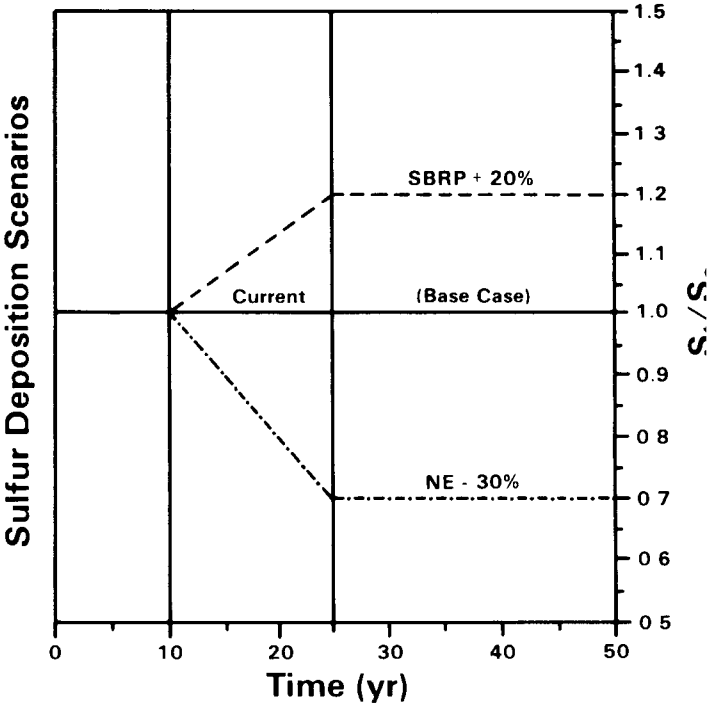

Figure 3. Sulfur deposition scenarios for the Northeast (NE) and Southern Blue Ridge Province (SBRP) for Level II and Level III Analyses. Ratio of total sulfur deposition at time t (S_t) to current total sulfur deposition (S_c).

Briefly, Level I statistical analyses indicate that the processes represented within the Level II and Level III models appear to be the most important with regard to explaining current relationships among deposition, watershed factors, and surface water chemistry. Results from the simplified single-factor Level II models support projections made with the more integrated Level III watershed models.

Projections using one of the Level III models [the Model of Acidification of Groundwater In Catchments (MAGIC)] of changes in median ANC of surface waters (lakes in the NE, stream reaches in the SBRP) are given in tables 2 and 3. Projections of the three watershed models are highly comparable.

Time from Present (years)	Number of Lakes[a] Constant Deposition ANC <0	Constant Deposition ANC <50	Decreased Deposition ANC <0	Decreased Deposition ANC <50
0	162[b] 5%	880[b] 27%	162[b] 5%	880[b] 27%
20	161 (134) 5% (4%)	648 (246) 20% (8%)	136 (124) 4% (4%)	621 (242) 19% (18%)
50	186 (143) 5% (4%)	648 (246) 20% (8%)	87 (100) 3% (3%)	586 (237) 18% (7%)

[a] % is percent of the target population of 3,227 lakes; () indicates 95 percent confidence estimates.
[b] Indicates estimate from NSWS Phase I sample for the same 123 lakes; target population = 3,227 lakes
[c] Projections are based on 123 lake/watersheds successfully calibrated by MAGIC.
[d] See Figure 3 for definition of the deposition scenarios used.

Table 2. Lakes in the Northeast Projected to have Acid Neutralizing Capacity (ANC) Values <0 and <50 μeq/L for Constant and Decreased Sulfur Deposition [c,d]

Model projections indicate a mixed response of northeastern lake systems at current levels of sulfur deposition. Slight decreases in median ANCs are projected for all ANC groups, along with a slight increase in the number of systems with ANC <0 μeq/L. The number of systems having ANC <50 μeq/L, however, is projected to decrease. Projected responses to decreased sulfur deposition show a clearer pattern; MAGIC projects surface water ANCs to increase and the number of lakes with ANC <0 μeq/L and ANC <50 μeq/L to decrease. Such a response would be consistent qualitatively with reported changes in the chemistry of lakes near Sudbury, Ontario, following reductions of sulfur dioxide emissions from the Sudbury smelter.

Time from Present (years)	Number of Stream Reaches[a] Constant Deposition ANC <0	Constant Deposition ANC <50	Increased Deposition ANC <0	Increased Deposition ANC <50
0	0[b] 0%	3[b] 0.2%	0[b] 0%	3[b] 0.2%
20	0 0%	187 (228) 14% (17%)	0 0%	187 (228) 14% (17%)
50	129 (195) 10% (15%)	203 (236) 15% (18%)	159 (213) 12% (16%)	340 (286) 26% (22%)

[a] % is percent of the target population of 1,323 stream reaches; () indicates 95 percent confidence estimates.
[b] Indicates estimate from NSWS Phase I Pilot Stream Survey sample for the same 30 streams; target population = 1,323 stream reaches.
[c] Projections are based on 30 stream/watersheds successfully calibrated by MAGIC.
[d] See Figure 3 for definition of the deposition scenarios used.

Table 3. Southern Blue Ridge Province Stream Reaches Projected to have Acid Neutralizing Capacity (ANC) Values <0 and <50 μeq/L for Constant and Increased Sulfur Deposition [c,d]

Model projections for the SBRP stream reaches indicate decreasing ANC and increasing sulfate under scenarios of either current or increased sulfur deposition. Due to the fact that soils in this region are much less organic in nature than those in the NE (e.g., wetlands in the SBRP are virtually nonexistent; mean stream DOC at lower stream nodes was <1 mg/L), these model projections are uncomplicated by potential effects of organic acid leaching. Model projections for the increased sulfur deposition scenario indicate the potential for about one quarter of the target population of stream reaches in the SBRP to reach an ANC of <50 μeq/L in 50 years, and thus may have the potential to reach an ANC ~0 μeq/L during storm event episodes.

The DDRP will also be making projections for watersheds in the Mid-Appalachian Region of the eastern United States. Thirty-six watersheds in that region have been mapped; soil samples taken to represent those watersheds have been processed and analyzed. Projections of potential future responses of those watersheds will be reported in the NAPAP Integrated Assessment.

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Watershed Processes and Manipulations

Watershed studies conducted as part of the AERP are using three approaches to further the understanding of the effects of acidic deposition on surface waters. Process-oriented research on natural systems is designed to improve our understanding of the nature and function of specific watershed mechanisms that contribute to surface water acidification. Watershed manipulations focus on understanding the integrated response of the biogeochemical processes that operate within a watershed and contribute to surface water quality. Developing and testing surface water acidification models combines current understanding of surface water acidification with the results of the other two areas of research to help quantify the uncertainties associated with projecting future surface water chemistries with models. The Watershed Manipulation Project, Watershed Recovery Project, and Little Rock Lake Acidification Project are watershed studies currently in progress. Status reports on the first two projects follow.

Watershed Manipulation Project (WMP)--The WMP involves process-oriented research designed to assess the responses of watershed soils, biota, and streams to altered levels of acidic deposition. An integrated set of manipulation studies is being conducted at the laboratory, plot, and catchment scales. Hypotheses concerning sulfur and nitrogen dynamics, base cation supply, aluminum mobility, organic acids, hydrology, and catchment responses are being tested.

The laboratory and plot studies have yielded several findings. These are being incorporated into a "findings report" due in December 1989.

At the catchment scale, a paired-catchment approach is being used. One catchment will be artificially acidified by application of ammonium sulfate, while the second (adjacent) catchment will serve as a control. The catchments have been fully instrumented, and baseline data have been obtained. Manipulation is scheduled to begin in September 1989.

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Watershed Recovery Project (WRP)--The WRP is studying the reversibility of sulfate adsorption by soils. The practice of using dried and stored samples to characterize soil chemical response parameters has long been questioned. Recently, studies conducted in conjunction with the Direct/Delayed Response Project indicated that air drying of soil samples resulted in 30-45% increases in the sulfate adsorption capacity of six soils from the eastern United States. This finding led to renewed concern about sample storage effects on measured soil properties.

Wet and dry sulfate adsorption and desorption isotherms have been determined for 100 soil samples, obtained from 10 sites in the Northeast and 20 sites in the Southern Blue Ridge Province. Analysis of the samples for other properties such as cation exchange capacity, pH, exchangeable bases, organic matter, and extractable iron and aluminum is almost complete. These results will be used to develop regression equations that relate sulfate desorption to sulfate adsorption and wet sulfate isotherms to dry sulfate isotherms. Because the dry isotherms and the nonisotherm analyses use DDRP procedures, the results will be applicable to the DDRP data base.

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Episodic Response Project (ERP)

Several approaches to understanding acidic episodes (events related to weather conditions that produce snowmelt and rainfall) in surface water have had only partial success for a number of reasons. Both intensive studies and survey approaches have been limited in terms of the data produced, primarily as a result of the unpredictable nature of snowmelt and rainstorm events. Most of these studies have employed manual sampling as the principal field sampling approach, and thus episodes that begin on weekends or at night are typically missed. Survey approaches have had limited success because of logistical difficulties associated with sampling unfamiliar systems. Therefore, a more intensive approach is being employed at 5 streams in Pennsylvania and 10 streams in New York. Biological

and chemical characterization will be conducted during snowmelt and rainstorm events by means of automated and manual sampling techniques.

Eastern Episodes--The ERP goals are to identify and quantify short-term acidic episodes in four to five streams in each of three regions (the Northern Appalachian Plateau in Pennsylvania and the Adirondack and Catskill mountains in New York State) and describe biological responses to episodes and to synthesize the results of the studies in these areas into regional models that will describe and predict both the chemical and biological effects of these short-term events.

Large rainstorms swept through the Pennsylvania region during March, resulting in very high streamflows in these study streams. The intensive biological monitoring period was well coordinated with these storms and negative effects of episodes on fish were observed. Pennsylvania State University researchers noted that there was a net downstream movement of radio-tagged fish during episodes--fish that survived these episodes were the ones able to find tributaries with relatively good quality water. Preliminary results from population-level work on brook trout in the Adirondacks show that there may be a significant natural depletion of fish population levels during episodes. Results in the Catskill region indicate that resident brook trout within acidic streams are more tolerant of episodes than nonresident brook trout.

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Regional Episodic and Acidic Manipulations Project (REAM)--REAM is designed to provide data on the effects of increased acidic deposition on surface water quality following whole catchment manipulation. Scientists are monitoring the response of streams to acidification on both chronic and episodic time scales at the Fernow Experimental Forest [administered by the United States Department of Agriculture (USDA) Forest Service] near Parsons, West Virginia.

A paired catchment approach is being used, with one catchment being artificially acidified by application of ammonium sulfate and the other serving as a control. Catchment manipulations were initiated in January 1989 and are continuing. Application rates are set at approximately three times the seasonal ambient rates.

Episodic depressions in pH and increases in sulfate concentrations associated with storms have been observed in both streams at the site. Oxygen-18 data for stream water, soil water, and precipitation have been received and are being used to evaluate hydrologic routing in the catchments. The Forest Service has funded and initiated biological studies at the site.

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Temporally Integrated Monitoring of Ecosystems (TIME) Project

The objectives of the TIME project are to:

- provide early warning of changes in surface water acidification or recovery,
- assess the extent to which observed trends in surface water chemistry correspond with model projections of chemical change, and
- relate observed trends in surface water biology and chemistry to trends in atmospheric deposition.

The manuscript described in the last *status* "Biological Monitoring for Acidification Effects: Results of a U.S.-Canadian Workshop," has been reviewed and is undergoing revision. It will be published as an EPA report this fall.

A technical paper has been submitted to *Limnology and Oceanography* describing an ambient chemical classification system based on ion ratios. The system described in the paper helps identify lakes that are pH sensitive and responsive to recent deposition. The sensitivity-response indices were verified through use of data bases from the National Surface Water Survey, the Paleoecological Investigation of Recent Lake Acidification and the

Long-Term Monitoring Project (LTMP). Lakes most likely to provide early warning of change in acid-base chemistry can now be easily identified for study. Seven papers describing aspects of the TIME data analysis plan have been submitted for publication in the proceedings of the International Symposium on the Design of Water Quality Information Systems. The papers included descriptions of selecting "hand-picked" sites, deposition monitoring, biological monitoring, and univariate trend analyses. A paper describing preliminary results of the LTMP has been submitted to *Environmental Management*. The results indicate that chemical trends can be detected with available univariate statistical techniques applied to seasonal data collected for five years.

TIME-Environmental Monitoring and Assessment Program (EMAP)--EPA remains committed to continuing monitoring activities which address the acidic deposition issue. At the same time, the Agency is in the process of developing an Environmental Monitoring and Assessment Program (EMAP) with which TIME will interact. EMAP is being designed to provide information on ecological conditions at national and regional scales. More specifically, EMAP will characterize and classify the ecological resources at risk, quantify baseline conditions and trends in their status, and identify probable causes by examining corresponding patterns and trends in pollutant exposure and other stressors. TIME, on the other hand, is a very specialized program which will address specific questions related to acidic deposition, such as the effectiveness of emissions reduction programs and the validation of predictive models similar to those developed in the DDRP. Currently, the Agency is evaluating the best way to design special study programs such as TIME and EMAP so that they complement each other. The relative roles and value of spatially extensive surveys, annually monitored trend sites, and temporally integrated monitored trend sites are being evaluated. It is the current intent to continue during this evaluation process.

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SYNTHESIS AND INTEGRATION ACTIVITIES

Regional Case Studies (RCS)--The RCS Project synthesizes a large body of information related to acidic deposition (collected by a variety of agencies, institutions, and universities) with newly acquired information from the AERP. This synthesis provides regional comparisons of surface water quality, including chemistry and biology, in areas of the United States and Canada identified as potentially sensitive to, changed by, or at risk because of acidic deposition.

The major product of the RCS Project will be a book entitled *Acidic Deposition and Aquatic Ecosystems: Regional Case Studies*. A major conclusion of the book is that the important factors and processes controlling acid-base chemistry of surface waters vary considerably among regions of the United States.

Final versions of most chapters were submitted in May. Final manuscript preparation, including editing and graphics, was carried out during the summer. With a publication date set for early 1990, the book will support the Aquatics State-of-Science reports being prepared for the NAPAP.

Address inquiries about RCS to:

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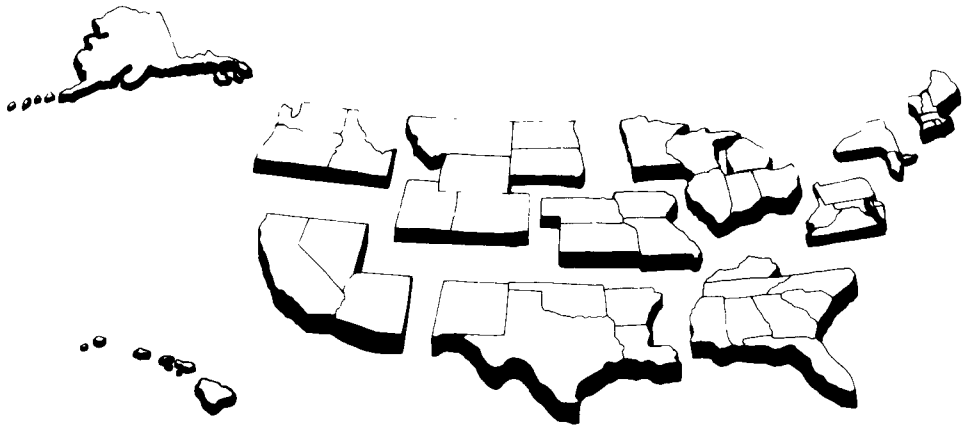
1990 Report Activities--AERP scientists are making major contributions to the 1990 NAPAP Final Assessment, which consists of State-of-Science/ Technology (SOS/T) reports and an Integrated Assessment (IA). NAPAP was created by Congress in 1980 as a 10-year program to provide scientific, technological, and economic information on the causes and effects of acidic deposition and periodically report these findings to Congress and the President. The 1990 IA, based on information presented in the SOS/T, fulfills this final obligation and represents the conclusion of NAPAP.

The Aquatic Effects Task Group is preparing seven SOS/T reports on topics such as the current status of



STATE INFORMATION

The AERP status provides a forum for states to exchange information and update activities. Highlighted state activities are presented below.

California

On July 1, 1989 the Air Resources Board (ARB)-Research Division received funding for the Atmospheric Acidity Protection Program (AAPP), authorized by the State Legislature. This is a 5-year, $15 million continuation of the Kapiloff Acid Deposition Research and Monitoring Program. The aquatic effects program will focus on the following research areas: snow monitoring and snowpack processes in the Sierra Nevada, episodic acidification at high-elevation watersheds, and identification of sensitive biological populations in lakes, streams, and ponds.

A number of reports summarizing results of the Kapiloff Program are available. These include:

- *The Health and Welfare Effects of Acid Deposition in California: Technical Assessment.* 176 pp. June 1989.
- *Atmospheric Acidity Protection Program: Five-Year Research Plan.* 28 pp. June 1989.
- Final reports for each of the projects funded under the Kapiloff Program.

These reports are available by writing to Susie Stadtman, ARB-Research Division, P.O. Box 2815, Sacramento, California 95812.

The Division began to issue Requests for Proposals for the AAPP in July 1989. Long-term monitoring of watersheds and deposition will be the priority areas for funding in the first year of the program.

Address inquiries about the above information to:

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Florida

The Florida Department of Environmental Regulation is conducting studies of Florida's sensitive lakes in order to characterize their chemistry and biology and to evaluate factors contributing to their ANC. The Florida Soft Water Lakes Study project, to be completed in the early fall, is evaluating the water chemistry and status of fish populations in twelve acidic soft water lakes. The Florida Lakes Reassessment Study project will evaluate whether historical water chemistry changes have occurred among Florida lakes. The Florida Seepage Lakes Study is evaluating the factors that regulate ANC, including ground-water contributions. This project is being conducted by a cooperative effort of the Florida Department of Environmental Regulation, the U.S. Geological Survey, the U.S. Environmental Protection Agency, the Florida Electric Power Coordinating Group, the Electric Power Research Institute, and Southern Company Services.

Address inquiries about the above information to:

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Pennsylvania

A final report has been issued on the *Effects of Neutralization and Acidification in Pocono Mountain Lakes.* The report documents the chemistry and biology of two

northeastern Pennsylvania lakes from 1984 to 1988. Limestone was added to one lake and the other lake remained untreated. The lakes were similar biologically and chemically prior to treatment. Following the addition of 100 tons of agricultural limestone to the ice in February 1985, the treated lake experienced statistically significant increases in ANC, specific conductance, calcium, magnesium, and silica. However, by 1987 it was evident that the lake was reacidifying and a smaller limestone dose (15.1 tons) was added as a slurry in October 1987.

Most of the significant biological changes were not evident until 2 to 3 years after the limestone additions. Some of these changes include: decrease in blue-green algae (*Cyanobacteria*), increases in diatoms (*Bacillariophyceae*), euglenophytes (*Euglenophyta*), mayflies (*Ephemeroptera*), dragonflies (*Odonata*), caddisflies (*Trichoptera*), aquatic earthworms (*Oligochaeta*), benthic macroinvertebrate total numbers, taxa richness and wet weight and numbers of bacteria in the water column.

Over the study period, the reference lake became acidic (ANC $\leq$0.0 μeq/L) in summer 1987. Significant decreases in the lake were recorded for ANC, specific conductance, and total organic carbon. Biological changes included decreases in diatoms, fire algae (*Pyrrhophyta*), phytoplankton taxa richness and biovolume, and Rotifera numbers, and increases in Copepoda (especially *Diaptomus minutus*), crustacean biomass, and benthic *Ceratopogonidae*.

The limestoning was effective in maintaining water quality adequate for acid-sensitive invertebrates and algae. The limestone remained effective for approximately 2.5 years, 3 times the lake's retention time of 276 days. The lake reacidified due to dilution and/or neutralization of incoming acidic precipitation.

Once water quality has improved, less acidic water should be maintained because many acid-sensitive algae and invertebrates take 2 to 4 years to increase their populations. Fish populations take even longer. The lake must be regularly relimestoned if acid-sensitive biotic communities are to thrive.

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Virginia

A survey of 344 streams in the Appalachian Mountain region of Virginia that support reproducing populations of native brook trout (*Salvelinus fontinalis*) was conducted in the spring of 1987. The surveyed streams represent about 76% of the identified trout streams in the region. Relative to commonly applied sensitivity criteria, 93% of the streams are sensitive (alkalinity $\leq$ 200 μeq/L), 49% of the streams are extremely sensitive (alkalinity $\leq$50 μeq/L) and 10% of the streams are currently acidic (alkalinity $\leq$0.0 μeq/L). Sulfate is the dominant anion in the streams, but all catchments associated with the streams are retaining significant amounts of atmospherically deposited sulfur (median retention = 68%). Estimates of past and potential future acidification were obtained using a simple linear model relating changes in concentrations of base cations to changes in concentration of sulfate. Sulfate concentration changes were determined as the difference between currently observed concentrations and estimated past and future steady-state concentrations. Changes in concentrations of base cations were calculated, assuming base cation increase factors equal to 0.4 and 0.8 times the sulfate increase. The median historical alkalinity loss for the sampled population is estimated as 29 and 9 μeq/L for the two assumed factors, with 3% and 0% of the streams estimated to have had historical alkalinities <0.0 μeq/L. The median future alkalinity loss is estimated as 90 and 30 μeq/L for the two assumed factors, with 88% and 32% of the streams estimated to have future alkalinities <0.0 μeq/L.

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Wisconsin

In 1987, a project was undertaken to study the effects of acidic deposition on

Wisconsin streams. Thirty-eight potentially acid-sensitive streams were sampled at base-flow to characterize their water chemistry and sensitivity to acidic deposition. Three of the 38 were sampled during snowmelt and/or rainfall events to characterize water chemistry changes which may have been caused by acidic deposition. Samples were taken during 11 rainfall and/or snowmelt events at the 3 streams.

Most of the base-flow samples and some of the episodic samples were taken manually (grab samples). An automatic sampler was installed at Otter Creek in Southern Wisconsin to collect episodic samples. Six episodes were sampled using the automatic sampler. The stream-water samples were analyzed for all major cations and anions, nutrients, pH, alkalinity, conductivity, color, turbidity, dissolved organic and inorganic carbon, iron, manganese, and aluminum. Concentrations of labile monomeric aluminum were estimated using the ALCHEMI model developed by Schecher and Driscoll. A few snow and rain samples were analyzed in addition to the stream-water samples.

The study found that Wisconsin streams are not susceptible to acidification because they contain relatively high levels of alkalinity, base cations, and organic acids. Wisconsin streams also have low concentrations (<5 μeq/L) of labile monomeric aluminum. These concentrations are lower than concentrations associated with harmful effects on biota. Depressions in alkalinity and pH and other changes in water chemistry which occurred in streams during snowmelt and rainfall events were caused by natural processes (primarily dilution), not by acidic deposition.

The major conclusion of the study is that streams in Wisconsin are not being adversely affected by acidic deposition.

The details of the study are contained in three reports:

1. Eilers and Bernert, 1989. *Acid-Base Chemistry of Selected Streams in Wisconsin*, Report 89-02.

2. Wisconsin DNR, 1988. *Water Chemistry of Selected Streams in Wisconsin Relative to Potential Effects of Acid Deposition, An Interim Report*, PUBL-AM-027-88.

3. Wisconsin DNR, 1989. *Effects of Acid Deposition on Wisconsin Streams*, PBL-AM-032-89.

For copies of the reports or inquiries about the above information, please contact:

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