Workshop Proceedings: Data Management Needs for Atmospheric Deposition

WS-79-163
Special Study Project WS 79-163

Workshop Report, August 1980
Work Completed, December 1979
Feb. 22-23, 1979

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ABSTRACT

With the recent organization of the National Atmospheric Deposition Program atmospheric chemistry monitoring network it became evident that there was a need for a data management system to store and make readily available the extensive data base that would be generated. Such a system needed to be designed to handle data from other U.S. atmospheric monitoring networks, as well as non-U.S. networks as for example the Canadian CANSAP program. A workshop was organized to address this question of data management requirements. The attendees representing major U.S. and Canadian studies agreed that a data management function was critical if assessment of the data with respect to the effects of atmospheric deposition was to be successful. In addition, the data are critical to those involved in the studies of atmospheric chemistry and transport. It was agreed that a single system could serve many programs and a statement was prepared stating the required characteristics and capabilities of the data management function. It was recommended that development and support of such a system should be the responsibility of a federal agency and the offer by the EPA to assume this responsibility was strongly endorsed.

EPRI PERSPECTIVE

PROJECT DESCRIPTION

The phenomenon of acidic deposition, popularly known as "acid rain," has received increasing public attention over the past three years. Many research and monitoring programs are underway at EPRI, at individual utilities, and at federal and international agencies to study where and when acid rain occurs and what ecological effects it may bring. The workshop, which this report (WS-79-163) describes, was sponsored by EPRI in recognition of the problems that will soon be faced in synthesizing the massive data on acid rain that are now being collected.

PROJECT OBJECTIVES

The purposes of the workshop were to review existing and planned programs in North America for collecting acidic deposition data and to identify specific needs to establish a coordinated, readily accessible data base. Workshop attendees, representing all major federal, utility, and academic interests, limited their discussions to physical deposition data. Ecological effects data were not considered.

PROJECT RESULTS

Workshop attendees concluded that a single data base system could be designed to meet the needs of all major programs. Specific characteristics and capabilities of the data management function were defined, including general data formats, accessibility, output representations, and quality control. Recognizing the national nature of acid deposition, it was further recommended that a federal agency assume responsibility for developing the data base system. The Environmental Protection Agency has assumed this responsibility. EPRI and others are preparing their data sets for entry into the system.

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ACKNOWLEDGMENTS

The author wishes to acknowledge the contributions of each of the workshop participants to these recommendations. Particular credit is given to Jeremy Hales, Pacific Northwest Laboratories, and Douglas Fox, Rocky Mountain Forest and Range Experiment Station for furnishing written summaries from the deliberations of the two working groups and to Van Baker of the Natural Resource Ecology Laboratory for development of background materials. We are all indebted to EPRI for its support, which made the workshop possible.

CONTENTS

SECTION 1

INTRODUCTION AND SUMMARY

The United States, like other industrialized nations, depends on fossil fuels for a major portion of its energy needs. In recent years the diminishing reserves of oil have promoted a renewed interest in the use of coal to meet a higher percentage of our requirements. At the same time it has been recognized that the combustion of fossil fuels, particularly coal, is a major contributor to air pollution. This problem has grown from one of concern over aesthetics to one of concern over measurable detrimental effects on human health, corrosion of materials, and both short-term and long-term effects on terrestrial and aquatic ecosystems, including agriculture and forest productivity. Currently, insufficient data and information are available to adequately define the problem in terms of the trade-offs that will have to be made. Efforts supported by both private and federal funds are underway to develop the data and information needed to assess the effects of various constituents added to the atmosphere. This requires not only research on the effects but also generation of an accessible data base on the quantities the various substances deposited on the earth's surface.

A critical factor in coping with increased atmospheric deposition is assessing the extent of the problem and the ability to follow future trends. Total sulfur emissions to the atmosphere have not increased substantially in the past twenty years. On the other hand emissions of nitrogen oxides have more than doubled, and at the same time rainfall acidity appears to have increased at some locations. It is obvious that there is a great deal we do not understand about emissions, atmospheric chemistry, transport, and deposition. Without the ability to determine regional deposition trends and to extrapolate into the future, we cannot adequately assess effects. For this reason, a major first step in addressing the whole question of atmospheric deposition, whether gaseous, particulate, or wet-fall, is an adequate atmospheric deposition monitoring network. A report prepared by the Federal

Interagency Work Group on Precipitation Quality* summarized the results of a survey of precipitation networks conducted by John Miller of NOAA in 1976.

It is interesting to note that only two networks have been operating continuously since the 1960s. The U.S. Geological Survey's (USGS) 10-station monitoring network in New York state began operating in 1965, and the Hubbard Brook study, which is limited to a single watershed, was established in 1962. In 1971, the Environmental Protection Agency (EPA) and National Oceanic and Atmospheric Administration (NOAA) initiated a 10-station network, the only continuing program with stations throughout the U.S. (also designated as World Meteorological Organization Sites (WMO)). Several new monitoring programs have been initiated recently. Three of these programs are designed as long-term monitoring networks: the Canadian Network for Sampling Atmospheric Pollutants (CANSAP), which has 50 stations across Canada; the Tennessee Valley Authority (TVA) network, which is concentrated in the Tennessee Valley region of the southeastern United States; and the National Atmospheric Deposition Program (NADP), which is operating 35 stations, mostly in the eastern U.S., with additional stations planned for the future across the entire U.S. Other studies, such as the Multi-State Atmospheric Power Production Pollution Study (MAP3S) program, the Electric Power Research Institute (EPRI) monitoring programs, and the National Aeronautic and Space Administration (NASA) Kennedy Space Center Network, are principally designed as short-term studies related to specific objectives. This increased monitoring activity poses questions about managing the vast amounts of data that will be generated. To provide an easily accessible repository for the data, participants in these projects have suggested that there should be a collective effort to develop a centralized data management function. The Electric Power Research Institute, which is conducting several large monitoring programs on its own, agreed to support initial planning efforts by providing funds for a workshop to discuss data management requirements and to formulate recommendations.

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*See "Research and Monitoring of Precipitation Chemistry in the United States--Present Status and Future Needs" by the Interagency Advisory Committee on Water Data, Chaired by Vance C. Kennedy, U.S. Department of the Interior, Geological Survey, Reston, Virginia, July 1978.

SECTION 2
BACKGROUND AND PURPOSE

A major item for discussion at the November Technical Committee Meeting of the National Atmospheric Deposition Program (NADP) was how to analyze and manage the data generated by the NADP network. At that time, the monitoring network had been in operation for only one month and approximately 20 stations were operational (total planned 75-100). It was recognized that the long-term success of the study would depend on ready access to the data by scientists conducting research on effects, atmospheric chemistry, and transport. Also it was recognized that a number of federal agencies, including EPA, DOE, USGS, USDA, were depending on the NADP Network as the major long-term regional monitoring effort in the U.S. Many of the participants in the NADP studies have been or are currently involved in other monitoring networks, including CANSAP, EPRI, TVA, and MAP3S. It was agreed that the question of data management should not be addressed solely by the NADP, so the NADP Technical Committee approached EPRI for support of a workshop of representatives from various monitoring studies to discuss data management alternatives. The NADP Technical Committee unanimously agreed that a coordinated approach was needed. A data management plan might be patterned after STORET (an EPA-sponsored system), which was developed to handle water quality data from a large and diverse group of water quality measurement studies.

It was agreed that the NADP should take the lead in organizing such a workshop and, specifically, that J. H. Gibson, the coordinator of the NADP, should prepare a proposal to EPRI. Such a proposal was submitted to EPRI on January 4, 1979. Approval was given by EPRI on February 15 to organize the workshop. The workshop was held in Washington, D.C., on February 22 and 23. (Appendix B lists the attendees at the workshop and the programs and/or agencies they represented.) As stated, the purpose of this workshop was to develop recommendations for the design of an atmospheric data management function by bringing together individuals representing various atmospheric monitoring networks and various agencies with interests and responsibilities in areas related to air quality. This included those with interest in, and knowledge of, atmospheric monitoring and data collection, those representing users of such data, and those involved in data management. It was felt that this mix was necessary in order to develop a balanced view of a data management function, since such a function had to be acceptable to both data generators and users, and their perceived requirements needed to be assessed by those involved with the mechanics of data management. The fact that each program or agency contacted sent a representative to the meeting indicates the extent of the support for a cooperative development effort. This enthusiasm is a major reason for the success of the workshop in developing a unified approach to the design.

In order to gain a better understanding of the various monitoring studies represented, each of the participants was asked to give a brief summary of the program with which he was associated and to prepare a written statement for distribution at the meeting. Abstracts of these program descriptions are presented in Appendix A. A study of the descriptions points out that, although the various studies are conducted for a variety of objectives, the measurements made and, importantly, the sample-collection techniques used have much in common. Those networks designed to assess regional deposition (for example, TVA, EPRI, NADP, and CANSAP) all use similar wet-fall/dry-fall collectors (HASL design). Although not all collectors are obtained from the same manufacturer, all operate on the same principle. In addition, these studies are measuring similar components in the wet-fall samples. Frequency of sampling is one of the major variants among the networks, ranging from event sampling to monthly sampling. The similarities of the networks prompted early agreement that a common data management system to serve the needs of these and other studies could be developed. Certain differences would have to be reflected in the design of the data system, but this did not seriously threaten agreement about the necessary characteristics and capabilities.

SECTION 3
DISCUSSIONS

NATURE OF INPUT AND USES

The development of a data management system depends on a number of factors that influence design. These can be grossly divided into two categories: input (characteristics of the data, volume of data, frequency of input, format) and output (physical media, data organization, data representation). The first can be considered requirements imposed on the system by the nature of the data itself; the second, requirements imposed by the various uses for the data. From a practical point of view, other factors must also be considered, such as the resources available, equipment limitations, development time, etc. However, because the purpose of this workshop was to develop recommendations for a system that would both archive data and provide a certain level of capability for assessing and mainpulating this data, these last factors were not given major consideration. In the discussion, however, consideration was given to establishing levels of importance and to distinguishing between what would be "nice to have" and the minimal requirements needed at this time.

Before a data management function itself is considered, it is necessary to review the nature of the data, the projected uses, and the frequency of access to the data base. The data itself consist of information from atmospheric monitoring stations, designed to assess the chemical composition of atmospheric deposition and operated to serve both long-term and short-term objectives. Programs such as MAP3S, the Kennedy Space Center, and the EPRI Adirondack sites are designed for short-term objectives. Other monitoring programs, such as the NADP, CANSAP, and TVA, are designed to provide long-term, regional information on atmospheric deposition. As indicated, the sampling methods and the basic chemical measurements made on the samples collected, particularly wet-fall samples, have much in common. The networks do differ in the collection of dry-fall samples, and some network studies include the collection of gaseous materials, particulates, and aerosols. There is a great deal of variation in the sampling period; some networks sampled by event; others, monthly. (Program descriptions in Appendix A list the chemical components measured and the sampling frequencies.) Developing a data management system requires that both the similarities and the differences of these programs be recognized. A decision has to be made about the adaptability of the system to differences in sampling frequency and technique, to different components measured on each sample, and to data from different sample types (for example, wet-fall, dry-fall, particulate, gaseous, and aerosol). Cost and complexity of a data management system typically increase as the generality of its design applications increases. On the other hand, limiting such a system to a very narrow set of sampling and measurement criteria will limit the number of monitoring studies that can be accommodated and hence the usefulness of the data. Cost, then, must be weighed against flexibility and user requirements.

Four general categories of use of atmospheric deposition information were considered in defining user requirements for data management. The purpose of this report is not to discuss such uses in detail but to give the reader an appreciation for the bases of its recommendations.

1. Physics and Chemistry of Atmospheric Deposition. This involves ion chemistry as related to precipitation amounts, precipitation types, storm types, etc., as influenced by various source and regional characteristics.

2. Transport and Source Receptor Relationships. Combining measured deposition amounts and composition with information on source strength and wind information provides information on long-range transport. Monitoring data provides the means for validating long-range transport models.

3. Deposition Patterns. Of concern are both seasonal and spatial variation. Seasonal variation is important when considering sources and possible variations in atmospheric chemistry. Spatial variation is related to transport and meteorological patterns.

4. Total Deposition. Total deposition and long-term studies are important in elucidating both long- and short-term effects of atmospheric deposition on such factors as human health, agricultural activity, soil fertility, forest productivity, and biological health of lakes and streams.

Although such information has other identifiable uses, these four categories were given primary consideration in determining the criteria recommended for design of a data management system.

LIMITATIONS

Because of the nature of the data and the four major use areas, it was decided early in the considerations that certain bounderies should be placed on the scope of the data management system. It was determined that the system should be for atmospheric deposition data and, more specifically, that the system would be concerned with wet-fall only. Dry-fall deposition data was discussed, but most of the participants are not satisfied with the interpretation of present dry-fall information and the relationship between the collection method and actual deposition processes. The question of whether dry-fall data should be included in the future was left open. Another limitation was placed on the type of wet-fall collection. The system would contain only data from direct precipitation collection and would not include, for example, through-fall sampling data. In addition, the system would contain original basic information, not derived information. This would assure homogeneity of the sets and eliminate any possibility of confusion in their use.

GENERAL SYSTEM CONSIDERATIONS

It was agreed that, within the limitations placed on the nature of the data to be archived in the system, data from qualified monitoring programs, whether supported by private or public funds, should be accepted. The exact nature of the qualifying factors was not discussed in detail. It was generally agreed that the data should be accessible to any qualified user and that participation of networks outside the United States would be welcomed. Of particular interest at the meeting was the inclusion of the Canadian CANSAP network.

It was generally agreed that archiving would have priority in the development of a data management function. It is imperative that there be a mechanism to store data in computer-retrievable form and that this data should be available to qualified users in the form of tapes. This would assure that the data would not be lost and that it would be readily, if not conveniently, accessible. This type of archiving and providing of computer-readable tapes is a function that, for example, is available from the National Climatic Center in Asheville, N.C. Any manipulation of the data, then, would be the responsibility of the individual user. It was deemed desirable, however, to have the data management function provide a greater level of service to the user community. Recommendations along this line were considered in detail. It should be emphasized that, barring the willingness of some federal organization or agency to support the development and maintenance of a data management system that would provide the capabilities recommended by this group, priority should be placed on archiving the data in computer-readable form and providing tapes.

SECTION 4
RECOMMENDATIONS

The workshop attendees were divided into two groups; one to consider input and output characteristics needed to meet the needs of both data generators and data users, the other to consider system design and administrative matters relating to the operation of the function and its interaction with data generators and users. Because these two general considerations obviously overlap, the two groups met together several times to exchange progress summaries. As mentioned, neither group was to consider the resources required to support their recommendations, but they were asked to determine priorities.

The group representing data users and data generators discussed type and format of data to be input, flexibility of the system to handle new classes of information in the future, requirements for data identifier "flags," various "hooks" to allow withdrawal of selected data, data formatting, and the form of output desired. The group concerned with the system itself and its administration discussed security, development of common input formats, the way the data would be submitted to the system, mechanisms for changing data, and individual program responsibility for input, output, and data editing. This group also assessed the ability of existing programs in federal agencies to support the recommendations. For clarity, data management function (DMF) refers to the entire process of data management, including administration. Data management system (DMS) refers to the hardware-software system and its capability. The following presents specific recommendations.

GENERAL ATTRIBUTES OF A DATA MANAGEMENT SYSTEM (DMS)

Although the following are not listed in any particular order, an attempt is made to move from more general to more specific system characteristics.

1. The system should have dial-up access throughout the country and from other contributing countries and should operate in both batch and interactive modes.

2. There should be no redundancy in the stored data. The same entity should not be stored in two locations (for example, in two different units of concentration). Units of output data should be controlled by the system's output module.

3. The output module of the system should be designed initially in a minimum configuration. It should be possible to add the "bells" and "whistles" at a later date, if necessary, without changing the primary system. Initially, the output module should

- be capable of providing output in a variety of designated units
- allow tabular reduction of output in a versatile format, so that computer output listings can be incorporated immediately into reports for specific projects, such as the NADP.

4. It is expected that other types and formats of data output requiring data manipulation within the system will be desirable. Plans should address the following possibilities:

   - a geographic display of monthly and yearly averages for a specific parameter
   - a time-series plot of parameter or combinations of parameters
   - basic statistics relating two or more variables, e.g., correlations, regressions, ratios
   - anion/cation sums, ratios, and plots
   - frequency distribution of parameter by site.

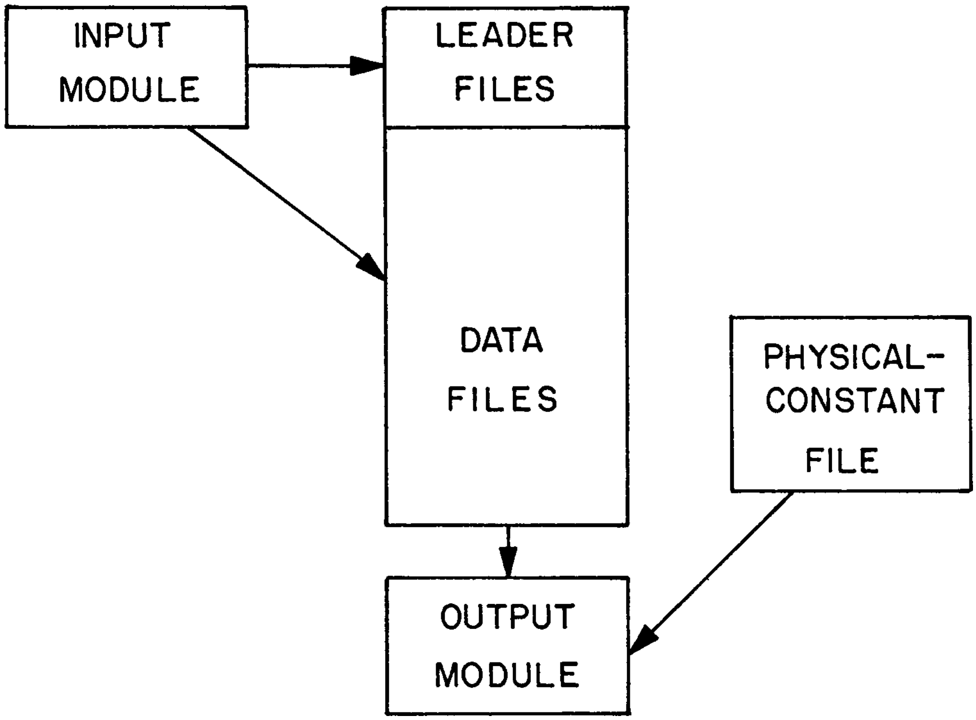
5. The system should have the ability to store data in an open-ended configuration, that is, the addition of a new species, precipitation amounts, etc. Parameters related to the interpretation of deposition should not be precluded simply because the initial system contains only a limited number. For example, a bank containing sulfate, hydrogen ion, and nitrate data should be able to accommodate data for mercury if such data become available.

6. The system should have several "hooks" to allow the user to search for and withdraw selected data. At a minimum, the user should have the ability to specify

   - geographical area of search (latitude, longitude window)
   - network names, e.g., NADP, MAP3S, JUNGE
   - time windows, e.g., 1972-1978
   - sample duration windows, e.g., 1 hour to 1 week
   - chemical species
   - filtered or unfiltered samples
   - precipitation type (rain, snow, etc.)
   - rainfall amount or rate limits.

7. The system should be able to accommodate numerous types of data pools. Ongoing pools are those such as NADP and CANSAP. Retrospective pools, such as NCAR and JUNGE, can be filled as resources permit.

To meet these general system requirements, we visualize a system with the general layout of the following schematic.



The layout consists essentially of input and output modules and three types of files. Although only one "leader file-data file" column is shown in the schematic, it is envisioned that several of these columns would be in the bank, one for each project. Some columns would be small (e.g., for short-term projects), while others would be extensive (e.g., for major programs like NADP). The various components of the systems are defined as follows.

Input Module

This module is the system for entering data into the bank. Little needs to be said about its form, except to emphasize the requirement for security to prevent inappropriate entries. It should be rather simply formatted so that depositors can enter data without undue difficulty. The input module allows data to be logged on two types of files.

Leader Files

Leader files contain individual records, including project code, data inventory, analytical procedures, detection limits, quality assurance procedures, site documentation, and site operations history.

Data File

Data files contain the actual precipitation chemistry data, subdivided into five categories:

- sample I.D. number
- concentrations of individual species, plus field and lab conductivity and pH values. This should be open ended.
- meteorological data, including rain amount, both rain gauge and sampler, precipitation type, temperature, and the possibility to add additional information to this open-ended category.
- time data, including date and time out, date and time in, and analysis date. This category should also be open ended.
- flags for identifying certain sample characteristics, such as quality, sample type, filtered or unfiltered.

Physical Constant File

The physical constant file would contain physical information, such as atomic weights, ion mobilities, etc., necessary for computations by the output module of unit conversions, conductivity calculations, and ion balances.

The physical units expressing concentrations of internally stored data should be as follows:

- Concentrations: micromoles per liter
- Conductivities: micromhos per centimeter
- Date: Julian calender
- Time: GMT
- Rainfall: millimeters

Output File

The general capabilities of the output module were discussed on pages 4-1 and 4-2, items 3 and 4. The exact capabilities will depend to a considerable degree on future uses of the data.

NATURE OF THE DATA MANAGEMENT FUNCTION (DMF)

The data management function includes not only the system, described in the preceding section, but also the management of the system and the interaction of the system with groups involved with data generation and usage. The data management function, therefore, would include not only the hardware and software, which define the management system, but also the personnel and their responsibilities. Specifically, the following recommendations were made for how the DMF should operate and interact with those involved in both data generation and use.

1. Data should be received by the DMF in machine-readable form (tapes, cards, etc.). Coding forms should therefore be put into machine-readable form by the program providing the data.

2. A common input format should be decided upon by the DMF after consultation with the various programs.

3. Input data should be flagged according to its level of editing or validation, ranging from simple parameter field checks (pH between 0 and 14, etc.) to defining reasonable levels.

4. Consideration must be given to data security. Programs submitting information should be able to limit the distribution of data until the data is considered valid (see 3 above). This limitation should, however, have a fixed time period, so that all data can be released within a month or so.

5. Each program submitting data will be responsible for providing the DMF with any changes in, or corrections of, its originally submitted data.

6. One individual per program should be responsible for providing and correcting data from that program to the DMF. The DMF should have to deal with only one individual per program.

7. Data from the archive must be available without restrictions to everyone. This does not imply that it would be provided free of charge to all users.

8. It is suggested that the DMF be available at no cost through one terminal to each program. This terminal would be the responsibility of the individual designated for that program (see paragraph 6 above). Other users of the system would be responsible for costs associated with access to data.

REVIEW OF ESTABLISHED DATA MANAGEMENT FUNCTIONS

In an earlier report, Van Baker of the NADP reviewed the capabilities of a number of other federally supported data management systems. Several of these were discussed by the workshop group:

- The National Climatic Center (NCC)- NOAA
- EPA/NEDS
- USGS
- Brookhaven/MAP3S (not reviewed by Baker)

Of these systems, only the National Climatic Center (NCC) and EPA/NEDS appeared to provide long-term archiving capabilities. The NCC data management function could support only archiving and making tapes available to the user. No data manipulation or other capabilities would be available. The EPA/NEDS, which is based on a coding system known as SAROAD, although not "an enlightened data-based management system," appeared to provide most of the requirements developed by the two working groups. It appeared to be considerably better suited to meeting the needs of atmospheric monitoring than any other extant system considered.

SECTION 5
SUMMARY AND FUTURE ACTIVITY

The workshop, although representing a number of different programs, both short and long term and with different monitoring objectives, was able to quickly agree on the required capabilities of a data management function. It is believed that the recommendations are reasonable with respect to costs and capabilities of various data base management systems. It was also agreed that it was imperative to develop a data management function in order to meet the objectives of the various monitoring efforts. Not to do so would seriously cripple the efforts of the scientific community in understanding and assessing atmospheric deposition, both transport and atmospheric chemistry and the much larger question of long- and short-term effects.

During these discussions, the representatives of EPA indicated that it could support most, if not all, of the requirements documented by the workshop. Consequently, it was agreed that EPA representatives Franz Burmann and Gerald Akland would present an outline of an EPA-supported data management function to the workshop participants for their suggestions. The workshop participants recommended that, if EPA were to offer to develop and sponsor such a data management function, a small group of individuals representing each of the major programs should be organized to work with EPA to define in detail system capabilities and function operation. EPA has circulated a draft outline describing a function it can support. Because EPA has made such an offer, the next step will be to organize a committee to meet with EPA representatives. (Such a meeting was held June 13, 1979. A permanent advisory committee to EPA will be established, initially including representatives from NADP, MAP3S, WMO-NOAA, CANSAP, EPRI, and TVA.)

APPENDIX A

NATIONAL ATMOSPHERIC DEPOSITION PROGRAM MONITORING NETWORK

The National Atmospheric Deposition Program was organized by the U.S. Department of Agriculture and the State Agricultural Experiment Stations of the North Central Region to assess the quality of atmospheric deposition on a regional basis. The major objective of the program is to determine the magnitude of the atmospheric deposition of both beneficial and injurious substances and subsequently the effect of these substances on terrestrial and aquatic ecosystems. The first stage, begun in October of 1978, was to establish a national monitoring network to determine spatial and temporal trends of deposition in precipitation and dry particulate matter. The second phase of the program will focus on effects of changes of atmospheric deposition on productivity of agricultural crops, forests, rangelands, wetlands, and surface waters, including the health and productivity of domestic food animals, wildlife and fish.

The NADP now has 35 active sites and is encouraging the establishment of additional sites, particularly in areas of the country not now well represented. In addition to USDA, various phases of the program are supported by USGS and EPA, with contributions from other federal agencies. The sampler used is the Aerochem Metrics wet-fall/dry-fall sampler, which, ideally, is located in areas not strongly influenced by specific sources of atmospheric pollution. To the extent possible, stations are located to provide regional representation. The sampling period is weekly for wet-fall and every other month for dry-fall deposition. Paramenters now measured are pH, conductivity, acidity/alkalinity, $SO_4^{=}$, NO_3^{-}, $PO_4^{\equiv}$, Cl^{-}, NH_4^{-}, K^{+}, Na^{+}, Ca^{++}, and Mg^{++}. Because the program has been in operation for only a short period of time, data are not now archived. Each site receives composition data on its samples every month. Data from all sites will be available quarterly to program participants and other interested parties. This will be in a tabular form, listing composition as well as deposition amount. A listing of the network stations is presented on the accompanying map.

THE CANADIAN NETWORK FOR SAMPLING PRECIPITATION (CANSAP)

The Atmospheric Environment Service (AES) of Canada established a network in 1973 to monitor the background levels of certain chemical species in precipitation (the Background Air Pollution Monitoring Network). The network was part of a long-term global network initiated by the World Meteorological Organization. The purpose of

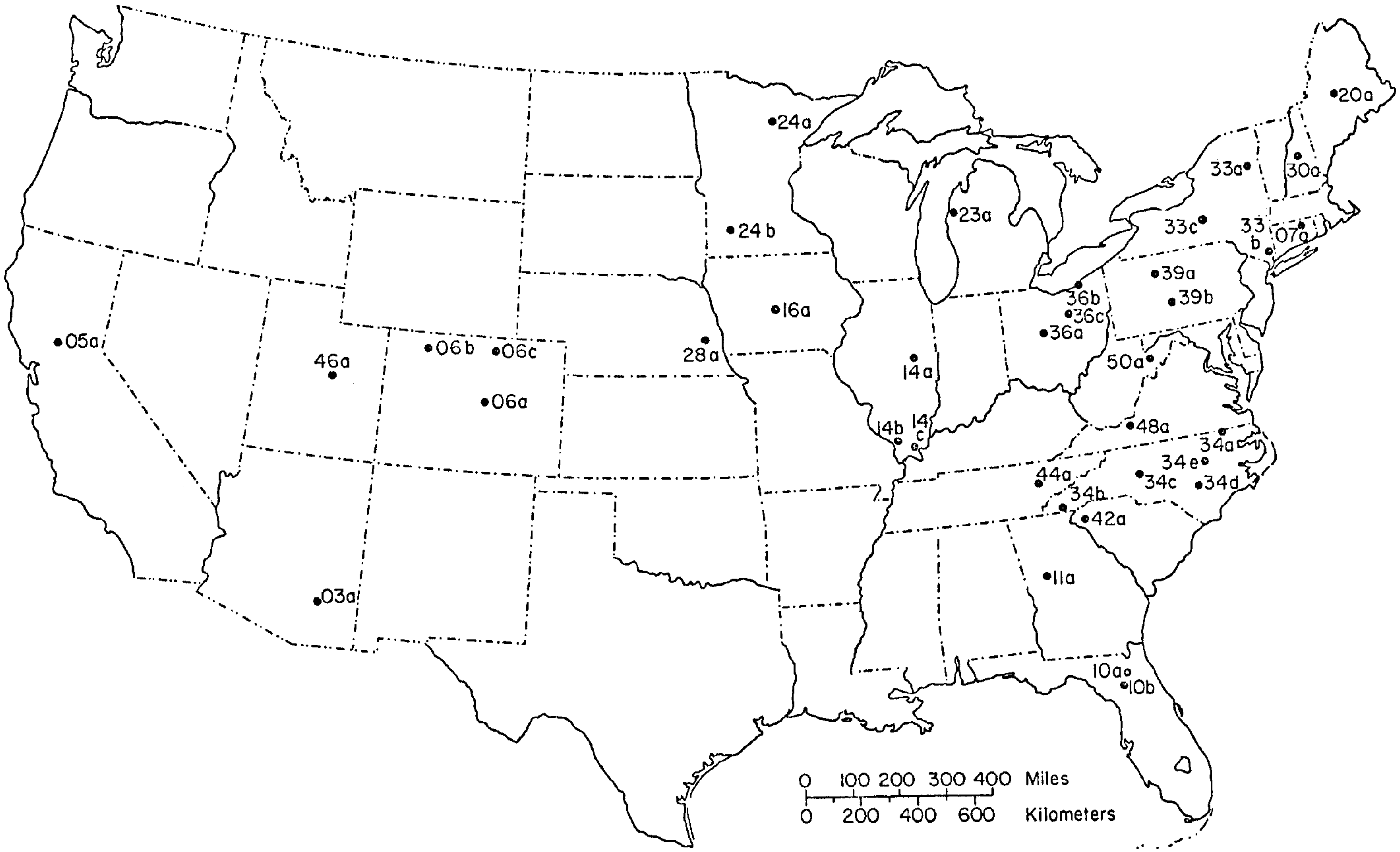


FIGURE A-1 NADP Precipitation Collector Sites

TABLE A-1

NATIONAL ATMOSPHERIC DEPOSITION PROJECT SITE LOCATION

Map #	Site Name	State	County	Agency	Code #	Individual	Latitude	Longitude
03a	Tombstone	Arizona	Cochise	Univ. of Arizona	030180	H. Bohn		
05a.	Davis Site	California	Yolo	U. of CA	058840	R.H. Burgy	38°32'	121°46'
06a.	Manitou	Colorado	Teller	Forest Service	062120	D.G. Fox	39°06'	105°05'
06b.	Sand Spring	Colorado	Moffat	USDI-BLM	061560	David Bray	40°30'	107°42'
06c.	Pawnee	Colorado	Weld	NREL-CSU	062220	J.H. Gibson	40°47'	104°45'
07a.	Coventry	Connecticut	Tolland	U. of Ct.	071155	D.R. Miller	41°47'	72°22'
10a.	Bradford Forest	Florida	Bradford	U. of Fl.	100360	W.H. Smith	29°58'	82°12'
10b.	Austin-Cary Forest	Florida	Alachua	U. of FL	100020	W.L. Pritchett	29°45'	82°15'
11a.	Georgia Station	Georgia	Pike	U. of GA Exp. Stn.	114140	J.T. Walker	33°11'	84°24'
14a.	Bondville	Illinois	Champaign	IL St. Water Survey	141160	G.J. Stensland	40°03'	88°22'
14b.	SIU	Illinois	Jackson	So. IL Univ.	143580	G.M. Aubertin	37°42'	89°16'
14c.	Dixon Springs Ag. Ctr.	Illinois	Pope	U. of IL	146340	C.J. Kaiser	37°26'	88°40'
14d.	DeKalb	Illinois	DeKalb	U. of IL	141800	R. Bell		
16a.	Ames	Iowa	Boone	Iowa State Univ.	160400	M.A. Tabatabai	42°02'	93°48'
20a.	Greenville Station	Maine	Piscataquis	U. of ME Exp. Stn.	200935	V. Thornton	45°29'	69°40'
23a.	Wellston	Michigan	Wexford	N. Central For. Exp. Stn.	235340	D.H. Urie	44°13'	85°51'
24a.	Marcell Exp. Forest	Minnesota	Itasca	N. Central For. Exp. Stn.	241660	E.S. Verry	47°30'	93°28'
24b.	Lamberton	Minnesota	Redwood	S.W. Exp. Station	242720	S.V. Krupa	44°15'	95°19'
28a.	Mead	Nebraska	Saunders	U. of NB Exp. Station	281520	S.B. Verma	41°09'	96°30'
30a.	Hubbard Brook	New Hampshire	Grafton	For. Serv. Exp. Stn.	300240	J. Hornbeck	43°57'	71°42'
33a.	Huntington Wildlife	New York	Essex	State U. of NY, Syracuse	332020	D.J. Raynal	44°00'	74°13'
33b.	Stillwell Lake	New York	Putnam	West Point Military Acad.	335640	Cpt. J.K. Robertson	41°21'	74°02'
33c.	Aurora	New York	Cayuga	Cornell - College of Agric.	330860	W.W. Knapp	42°44'	76°39'
34a.	Lewiston	N. Carolina	Bertie	NC Exp. Station	340320	R.D. Coltrain	36°08'	77°10'
34b.	Coweeta	N. Carolina	Macon	USDA-FS	342500	J.E. Douglass	35°03'	83°27'
34c.	Piedmont Research Stn.	N. Carolina	Rowan	NC Exp. Stn.	343460	C.Z. McSwain	35°40'	80°34'
34d.	Clinton Crops Res. Stn.	N. Carolina	Sampson	NC Exp. Station	343560	B.N. Ayscue	35°01'	78°17'
34e.	Finley (Raleigh)	N. Carolina	Wake	USDA-SEA	344160	A.S. Heagle	35°44'	78°41'
36a.	Delaware	Ohio	Delaware	USDA-FS	361760	L.S. Dochinger	40°17'	83°04'
36b.	Caldwell	Ohio	Noble	OH Agric. Res. & Dev. Ctr.	364900	T.C. Weidensaul	41°48'	81°31'
36c.	Wooster	Ohio	Wayne	OH Agric. Res. & Dev. Ctr.	367160	T.C. Weidensaul	40°46'	81°56'
39a.	Kane Exp. For.	Pennsylvania	Elk	Forest Service	392940	D.A. Marquis	41°33'	78°46'
39b	Leading Ridge	Pennsylvania	Huntingdon	Penn. State Univ.	394200	J.A. Lynch	40°39'	77°56'
42a.	Clemson	S. Carolina	Pickens	Clemson University	421875	U.S. Jones	34°40'	82°50'
44a.	Walker Branch Watershed	Tennessee	Roane	Oak Ridge	442880	S. E. Lindberg	35°58'	84°17'
46a	Cedar Mountain	Utah		BLM		W. W. Wagner		
48a.	Horton's Station	Virginia	Giles	VPI & SU Exp. Stn.	481300	J. Skelly	37°11'	80°25'
50a.	Parsons	W. Virginia	Tucker	NE For. Exp. Station	501860	J.H. Patric	39°06'	79°39'

the network was to monitor changes in the background levels, regionally and globally, of certain atmospheric constituents that could affect the quality of the environment and possibly induce climatic changes. This network had a total of nine stations. Because certain areas of Canada require a much finer resolution than that provided by the background network, the Canadian Network For Sampling Precipitation (CANSAP) was established. The CANSAP network consists of 51 sampling stations, indicated on the attached map. All sampling sites are located at AES surface or upper-air weather stations, except for the Kejimkujik Site, in Nova Scotia. The sampling sites are generally in rural to semi-urban environments. Stations are somewhat more concentrated in southern Ontario and Quebec and downwind from the foothills of the Alberta Rockies because of the high sulfur loading that frequently occurs in these areas.

Each site is equipped with a Sangamo Type A wet-fall/dry-fall precipitation collector (of the HASL design). Samples are taken monthly and sent to the Atmos pheric Environment Service in Downsview, Ontario, where they are logged and stored in the dark at 4°C for about one month. The sample is then sent to the NWRI Laboratory at Burlington, Ontario, for chemical analysis. Analyses include pH, conductance, acidity, $SO_4^{=}$, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Mg^{++}, Ca^{++}. Trace-metal analysis is also carried out routinely by the laboratory and the results sent directly to the data bank (AES does not report). Data are stored in a data bank, NAQUADAT, and arc available at cost.

THE TVA REGION MONITORING NETWORK

Monitoring and improving the quality of life within the Tennessee Valley region is the charge of the Tennessee Valley Authority. As a segment of this charge, studies have been initiated to understand the short- and long-term fate and ecological effects of atmospheric inputs from power production in particular and diminishing air quality in general on terrestrial and aquatic ecosystems.

The need to quantify the effects of power plant emissions on atmospheric deposition in the Tennessee Valley was recognized as early as 1955, when Martin and Ensminger reported an increase in the sulfur content of rainfall during the initial operation of the TVA Colbert Steam Plant. In 1975, a report by Oppold, Hickey, and Jones suggested that acidity increased significantly in the Cumberland area during the second and third years of the operation of the Cumberland Steam Plant but that precipitation sulfate concentration did not increase concomitantly.

Based on the results of these and other studies, an extended precipitation quality monitoring program was proposed and approved in late 1975. Since that time, considerable effort has been made to evaluate, select, and construct the necessary sampling devices and to establish an expanded sampling program. All stations,

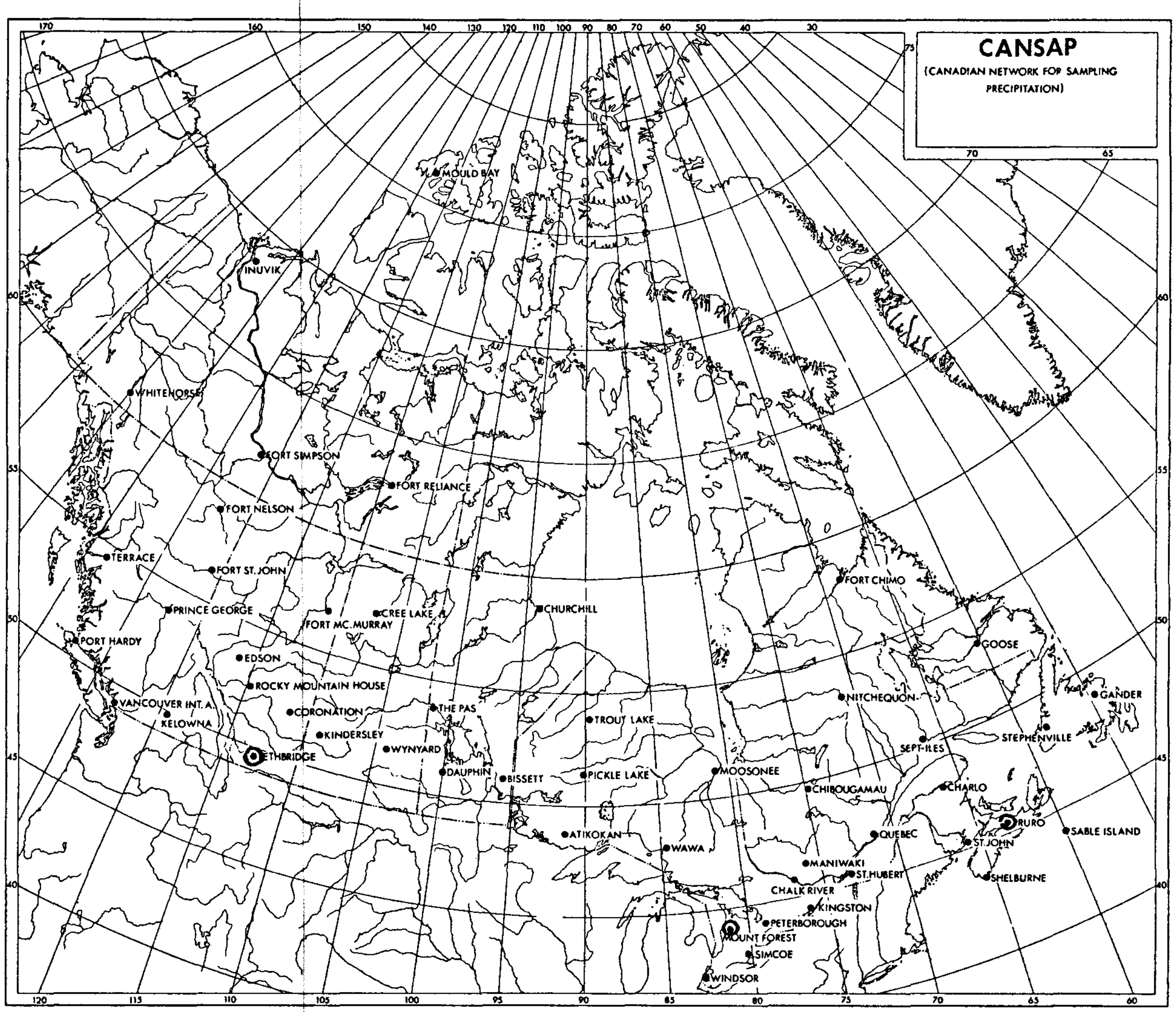


FIGURE A-2 CANSAP Precipitation Collector Sites

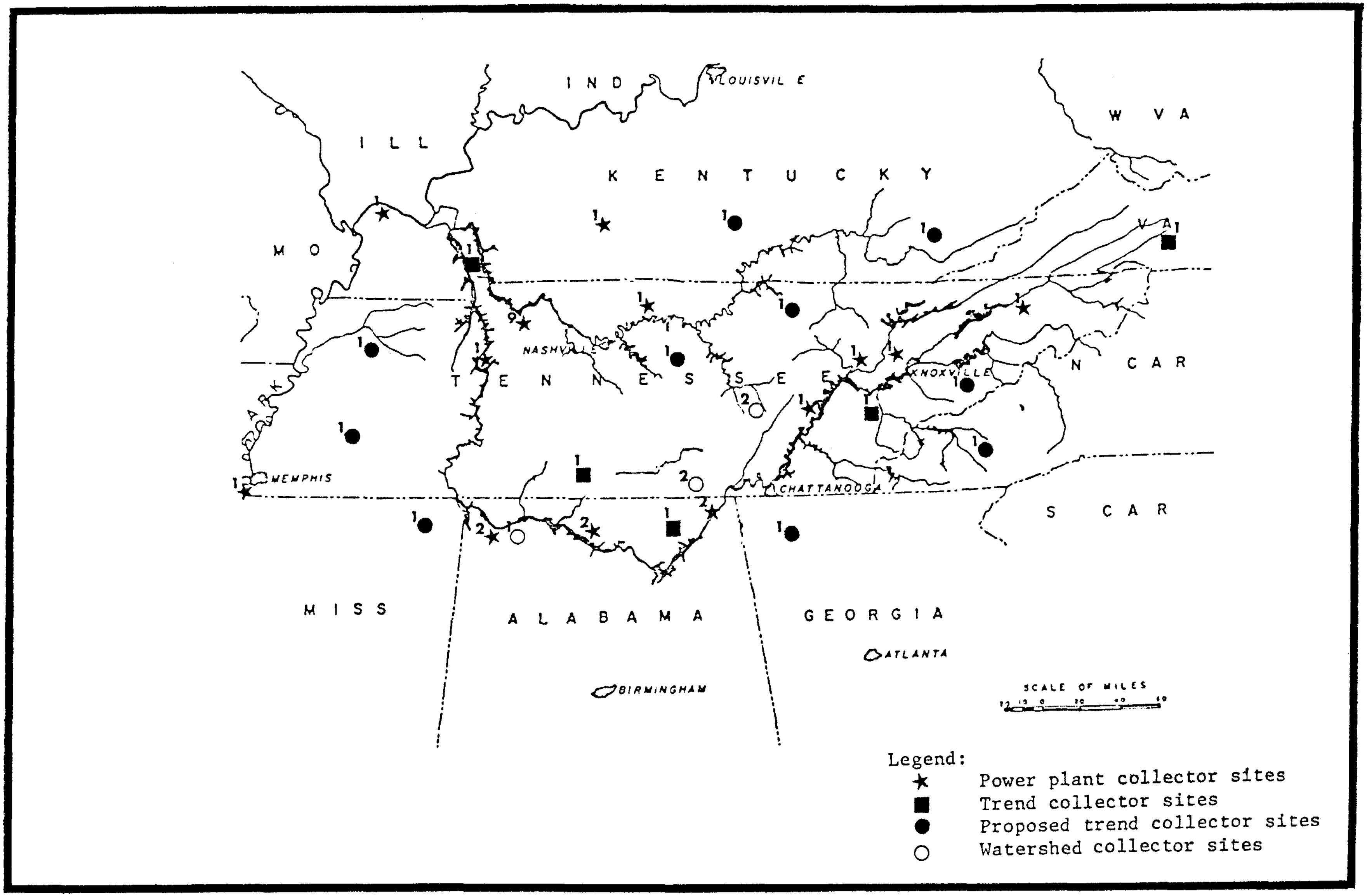


FIGURE A-3 TVA Precipitation Collector Sites except for the proposed trend collector sites, became operational in mid- to late 1978.

Samples of wet and dry atmospheric deposition are collected biweekly with collectors of the AEC or HASL design. The wet and dry samples are sent to the laboratory, where the following parameters are measured: weak acid acidity, strong acid acidity, pH, conductivity, NH_4^+, Mg^{++}, F^-, K^+, $SO_4^=$, Cl^-, Na^+, NO_3^-, Al^{+++}, Ca^{++}, $PO_4^{\equiv}$. Laboratory forms are then forwarded to the Air Quality Research Section, where the data are reviewed and the information on sample condition evaluated. Sample validity is designated as one of three categories (valid, questionable, invalid), based on the observations noted and the chemical analysis data. These data are then key-punched directly from the form and subsequently transferred from cards to magnetic tape. A yearly data compilation by sample period is generated for each location, along with weighted annual means for each parameter. These data are then compiled into an annual data report available for public use.

WORLD METEOROLOGICAL ORGANIZATION MONITORING NETWORK

In 1970, NOAA selected 10 of the U.S. National Weather Service stations in non-industrial areas as regional sites for the World Meteorological Organization Network. In 1972, WMO baseline stations at Samoa, Mauna Loa, and Point Barrow were added to this network. The operation of this network has been a joint effort of EPA and NOAA, with EPA responsible for supporting the chemical analysis services. The purpose of this network is to support a worldwide effort, under the auspices of the World Meteorological Organization, to assess possible long-term consequences of changes in the composition of the atmosphere by establishing a network of background air pollution stations.

The network began operation in July of 1970 and now includes about 110 stations in 47 countries. Samples are collected monthly in the U.S. and shipped to the EPA reference laboratory at Research Triangle Park. The sampler used is a MISCO open-close collector. Measurements include pH, conductivity, acidity/alkalinity, $SO_4^=$, NO_3^-, NH_4^+, Cl^-, Fl^-, Ca^{++}, K^+, Mg^{++}, and Na^+. Trace elements determined include cadmium, copper, iron, manganese, nickel, lead, and zinc. All data from the WMO regional network in the United States are archived in the "Atmospheric Turbidity and Precipitation Chemistry Data for the World," published by the Environmental Data Service, National Climatic Center in Asheville, N.C.

ELECTRIC POWER RESEARCH INSTITUTE (EPRI) MONITORING OF PRECIPITATION CHEMISTRY

EPRI sponsors two research projects to monitor precipitation chemistry in the eastern United States. Each project measures the quantity and chemical nature of wet-only deposition daily at several locations with an Aerochem Metrics wet-fall/dry-fall sampler of the HASL design. One objective of each project is to identify spatial and temporal distribution of precipitation acidity and the major ionic constituents contributing to acidity.

Adironack Lake Acidification Investigations

Rensselaer Polytechnic Institute (under EPRI project RP 1155) is conducting intensive spatial sampling of precipitation at seven locations within a 500-km^2 area of the southwest section of New York's Adironack State Park. Sampling began in March 1978 and is expected to continue for at least 3 years. The prime objective is to document acidic deposition to three lake watersheds having different resposes to acidic inputs.

This project will be expanded in 1979 to include measurements of throughfall chemistry, evapotranspiration, and dry deposition of submicron particles and gases.

Eastern Regional Precipitation Chemistry

The second project (EPRI # RP 1376) involves wet-only deposition monitoring at nine locations in the eastern United States. Two precipitation collectors and one recording rain gauge are sited near each of the 9 Class I SURE (Sulfate Regional Experiment) air quality stations. Rockwell International is the prime contractor for this study. Daily sampling began in August 1978 and is expected to continue for at least one year.

The prime objective of this project is to document temporal and spatial characteristics of acidic precipitation in the eastern United States. The data will be used to calculate deposition in the SURE regional air quality models and to correlate acidic deposition with synoptic meteorological conditions. Measurements include H^+ (both strong acid and total acid), NH_4^+, Na^+, K^+, Ca^{++}, Mg^{++}, Al^{+++}, $SO_4^=$, NO_3^-, Cl^-, $PO_4^{\equiv}$, and dissolved organic carbon.

Both projects submit their data to ERPI semi-annually on 9-track magnetic tape for archival. Each contractor also prepares standard statistical evaluations of his data for project reports. Rockwell will perform some trajectory-type analyses of the data, using NOAA-supplied back trajectories. RPI will compute total acidic deposition to the three Adirondack lake watersheds for other investigators in that program.

The Rockwell data will be provided to MAP3S for its data bank. The RPI data can be requested from EPRI.

THE MAP3S PRECIPITATION CHEMISTRY NETWORK

The Multi-State Atmospheric Power Production Pollution Study (MAP3S) is a large-scale atmospheric research program initiated by ERDA (now DOE), Division of Biomedical and Environmental Research. Administration of the program has recently

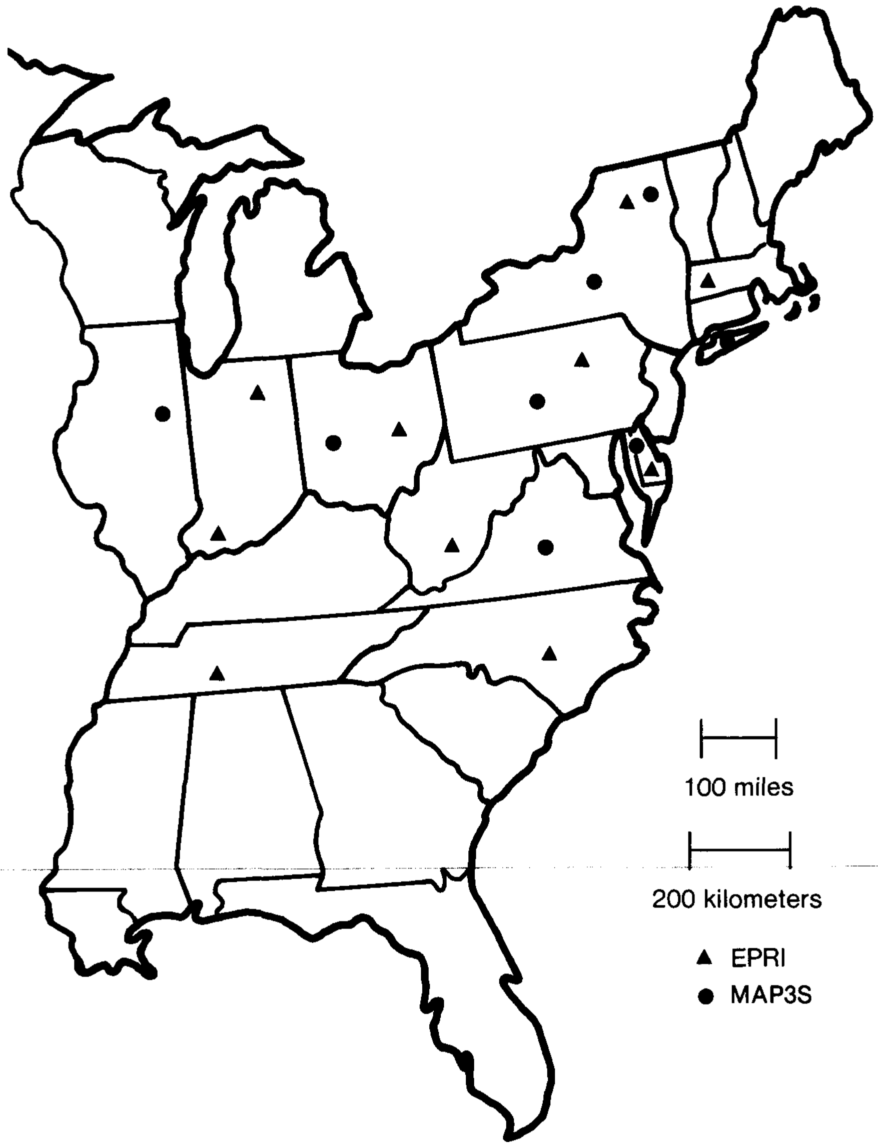


Figure A-4. EPRI and MAP3S Precipitation Collector Sites been shifted to EPA. Responsibility for various segments of the program has been divided among the DOE National Laboratories, universities, and contract research organizations throughout the United States. The overall goal of the project is to develop the means for modeling and predicting the atmospheric effects of present and future pollutant emissions from power production processes. Because the short- to medium-term emphasis of electric power expansion is on coal burning and because the present density of such sources is in the upper midwest and northeastern United States, MAP3S is concerned primarily with emissions from coal burning and the research is concentrated in the northeastern U.S.

The MAP3S network was planned with a number of specific requirements and objectives in mind, summarized in Table A-1. The network initially consisted of four regional sites (as defined in Table A-1) and has since been expanded to eight sites, summarized in Table A-2. (Details of the network operating procedures are in two annual summary reports issued by Pacific Northwest Laboratory (PNL). Event samples are collected in a refrigerated sampler (Battelle collector) and air mailed to the Battelle Laboratory (PNL) for chemical analysis. Analyses include pH, H^+ calculated, conductivity, SO_2, $SO_4^=$, NO_2^-, NO_3^-, Cl^-, $PO_4^=$, NH_4^+, Na^+, K^+, Al^{+++}, Ca^{++}, and Mg^{++}.

The data are now stored both on punched cards in the "reduced" form mentioned and on magnetic tapes. One tape file consists of card images of the reduced cards. The other contains the data in the standard data exchange form proposed by the Interlaboratory Working Group for Data Exchange. Copies of the latter tape may be obtained from Brookhaven National Laboratories. This tape is updated quarterly with new data and thus may be three to six months out of date. This lag is unavoidable because of the time required for shipping and analyzing samples and because the tape is intended to provide a complete record of network results. More timely, but less complete, results are in the monthly reports issued by PNL.

KENNEDY SPACE CENTER, FLORIDA PRECIPITATION STUDIES

The National Aeronautics and Space Administration (NASA) precipitation chemistry program is conducted by the University of Central Florida (UCF) using NASA facilities. The program began in the summer of 1977 and consisted initially of four sites within a 200-km^2 area at the Kennedy Space Center (KSC), Florida, and a fifth site at UCF, about 50 km west of KSC. The present network includes 14 sites, with a total area of 800 km^2 area (at KSC and the UCF site).

The baseline study is intended to assess the existing quality of precipitation, flora, and fauna at KSC during the period immediately before launch of the space shuttle. A potential environmental problem may be associated with the space shuttle program because of the solid rocket motor (SRM) booster that will be used.

Table A-2

REQUIREMENTS AND OBJECTIVES OF THE MAP3S PRECIPITATION CHEMISTRY NETWORK

Need/Objective	Implementation
Regional Collection Sites	Careful selection to avoid urban and nearby source effects
Precipitation Event Sampling	Individual samples collected for each hours duration)
Rapid Chemical Analysis and Reporting of Results	Samples delivered to laboratory promptly, chemical analyses performed, and data distributed to interested parties normally within two months of sample collection
Technical	
Wet deposition-only samples	Use of automatic, wet deposition-only, collectors
Preservation of sulfite and other violite species	Use of specially developed samplers that prevent desorption (funnel-and-bottle collectors) and slow chemical reaction by onsite refrigeration
Future Monitoring of Precipitation Quality (beyond the MAP3S)	Establishment of a high-quality, stable network that could be the core of a national or regional monitoring network

Table A-3

NETWORK SITE DETAILS

Site No.	Name	Location Longitude	Location Latitude	Elevation (m, msl)	Date of First Sample Collected
1	WHITEFACE	73°, 51.5'	44°, 23.5'	604	October 11, 1976
2	ITHACA	76°, 43'	42°, 23'	503	October 26, 1976
3	PENN STATE	77°, 57'	40°, 47'	396	September, 22, 1976
4	VIRGINIA	78°, 32.5'	38°, 2.5'	171	December 12, 1976
5	ILLINOIS	88°, 22'	40°, 3'	213	November 20, 1977
6	BROOKHAVEN	72°, 53'	40°, 52'	24	February 9, 1978
7	LEWES, DE	75°, 0'	38°, 46'	0	March 1, 1978
8	OXFORD, OH	84°, 44'	39°, 32'	283	October 1, 1978

Each launch will generate and release approximately 10^5 kg HCl below 4 km altitude. Precipitation during or immediately after launch may lead to scavenging of HCl and result in acid rain. Predictions indicate that acid rain of pH less than 1.0 could occur near the launch site and that acid rain of pH less than 3.0 could occur at extended distances, depending on meteorology and exhaust cloud dynamics during and after launch.

The precipitation chemistry baseline study is designed to document the variability and general chemical composition of precipitation at KSC. Rain samples are collected during events with the Aerochem Metrics wet-fall/dry-fall collector. Samples are analyzed to determine the general composition properties and major chemical species. Measurements include sample volume, conductivity, pH, pHNV (pH after removal of volatile acids), strong acid, titratable acidity, Na^+, K^+, Ca^{++}, Mg^{++}, NH_4^+, Cl^-, F^-, NO_3^-, $SO_4^=$, $PO_4^{\equiv}$. All data are stored on disk as 80-character card images. Punched cards are retained as security. Data are processed (stored, retrieved, and archived) with an IBM 360/370 computer, a Harris minicomputer with 256K CPU memory, and a Hewlett-Packard minicomputer.

The tentative launch date for the first shuttle is November 9, 1979. Funding for the present program will expire in August 1979. At present, prospects for continued funding from NASA are tenuous. There is a realistic possibility that funding for this project or a continuation project of similar scope may lapse.

APPENDIX B

ATTENDANCE ROSTER

EPRI-NADP WORKSHOP ON DATA MANAGEMENT

for

ATMOSPHERIC DEPOSITION

Dulles-Marriott, Washington D.C., 2/22-23/79

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