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Project Summary

Summary Report for the National Atmospheric Deposition Program/National Trends Network (NADP/NTN) Site Visitation Program – December 1984 through September 1986

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The proper collection of precipitation and the accurate measurement of its constituents are important steps in attaining a better understanding of the distribution and effects of "acid rain" in the United States. NAPAP Task Group IV project 4A-15, "Quality Assurance Support for Wet Deposition Monitoring" is sponsored by EPA to evaluate the sample collection process of the NADP/NTN networks through a site visitation program.

This document is a summary report of the findings from the 1985-1986 Site Visitation Program to the 195 sites that comprise the National Atmospheric Deposition Program and National Trends Network precipitation networks, referred to collectively as the NADP/NTN network. The visits were conducted by Research Triangle Institute.

Protocols and procedures followed in conducting the site visits are described. Results of systems and performance audits are discussed for siting, collection equipment, and the field support laboratories.

Where exceptions are found, the potential effects of nonstandard siting, improperly operating equipment, and improper sample handling or analysis technique on the data base are discussed. Recommendations are given for improvement and standardization of individual sites and the network as a whole.

This Project Summary was developed by EPA's Environmental Monitoring Systems Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Wet deposition collection networks in the United States have grown in number and size in the last decade in response to the need for data to determine the extent and nature of acidic precipitation. As the networks have grown, so has the development of protocols and procedures for quality assurance assistance through site visitation programs. The goals of the visitation program to the NADP/NTN collection sites are to:

(1) Provide a qualitative assessment of each site and its surroundings, the operator's adherence to sample collection and analysis procedures, and the condition of the site's collection and analysis equipment through an on-site systems survey;

(2) Provide a quantitative assessment of the operation of the precipitation collector and the accuracy of response of field and laboratory measurement devices for precipitation depth, mass, temperature, conductivity, and pH through an on-site performance survey;

(3) Provide technical assistance to the operator by verbal explanation, minor trouble-shooting, repair and calibration of equipment, and by making recommendations for sources of corrective action;

(4) Prepare brief reports for each site detailing site characteristics, results of quality assurance tests, and technical assistance provided;

(5) Computerize results of all information gathered from each site and submit this to the NADP/NTN Quality Assurance Manager on a quarterly basis; and

(6) Document the sites and their surroundings by assembling a collection of site maps and color photographs.

This Project Summary describes procedures and results from quality assurance visits made to the sites in 1985 and 1986. Recommendations for improvement are also given.

Procedures

Each NADP/NTN site was to be visited once in a two-year period. About one-half of the 1985 sites were visited each year during the period 1985-1986. Prior to the scheduling of site visits, RTI consulted with the NADP/NTN Quality Assurance Manager and CAL personnel to determine which sites, if any, should be seen on a priority basis. Whenever possible, visits were planned so that several sites in the same vicinity could be seen in the same trip. A listing of the activities carried out in preparation for, conduct of, and reporting of a site visit is given in Figure 1.

Systems Survey

A quality assurance systems survey was conducted at each site to qualitatively assess the site, its surroundings, and the operator's adherence to procedures specified in the NADP/NTN site operator's instruction manuals[1,2] and the NTN design document[3]. The operator was asked to demonstrate sample collection and analysis procedures. These were observed with special attention given to calibration procedures and sample handling technique. Site equipment was examined for signs of wear or faulty operation. It was noted whether solutions and equipment were properly stored. Site logbooks and rain gauge charts were examined for legibility, completeness, and accuracy. Photographs of the site were taken.

Performance Survey

A quantitative performance survey was conducted at each site. Table 1 lists the equipment that was checked fo performance and the type of test used. Criteria for evaluating performance are specified in the NADP Quality Assurance

I. SELECT SITE FOR VISIT AND INITIAL COMMUNICATIONS
- *Advise QA manager, CAL, site sponsor of plans; request site information; receive go-ahead*
- *Contact site supervisor, site operator*
- *Send letter of confirmation to supervisor, operator*
- *Advise EPA that trip plans are complete*

II. PRE-TRIP PREPARATION
- *Make travel arrangements (air, car, hotel)*
- *Prepare and test quality assurance materials*
- *Review site-specific quality control information (maps, QC test results, etc.)*
- *Check equipment and supplies*
- *Prepare site visit notebooks with survey questionnaires*

III. CONDUCT SITE VISIT
- *Outline activities to supervisor and operator*
- *Assess site and surroundings (map, photographs, obstructions, sources)*
- *QA tests of precipitation collector and rain gauge*
- *Adjust or calibrate collection equipment as required*
- *Assess operator handling and transport of collection bucket*
- *QA tests of conductivity and pH meters, temperature, balance*
- *Examination of site records, rain gauge charts*
- *Answer questions; provide instruction*
- *Prepare short report; conduct exit interview*

IV. REPORTING
- *Short report prepared; left with supervisor or operator*
- *Copy of short report forwarded to NADP/NTN QA manager, to CAL, and to EPA project officer*
- *Copy of site visit notebook sent to NADP/NTN, QA manager; file original*
- *Questionnaire contents placed in computer file; sent to QA manager*
- *Annual report presented to NADP/NTN committee*

Figure 1. *Sequence of Site Visitation Activities*

lan[4] and report[5]. All survey notes and instrument responses were recorded in the performance survey questionnaire.

Results and Discussion

Siting Criteria Survey

Collector Height Standard. The collector should be installed on its standard 1-meter-high aluminum base. The bucket height of the collector should not exceed this standard height by more than 0.5 m. An exception to this criterion is permitted in areas with significant accumulations of snow. Twenty-six (12%) of 194 collectors checked were on platforms. In most cases, the platforms were short, not more than 1 m in height. The sites were located in the snow belt. The effect of this extra height on the sample is believed to be minimal.

Wet Bucket Orientation. The collector should be mounted with the wet-side bucket to the West and the sensor facing North. In this way, the wet bucket is generally upwind of the dry-side bucket and the sensor is downwind of the wet-side bucket. One hundred and forty collectors (72%) were correctly installed. For the 37 collectors that were installed with the collection bucket facing N or E, a statistical study of the long-term data base would be required to discern if the collection efficiency or sample chemistry were affected.

Ground Slope. The collector should not be located on ground with a slope greater than 15 degrees or 27 percent. The slope at 33 sites (17% of the total) exceeded this criterion. Note, however, that all of these sites were located in mountainous regions and the sites were representative.

Collector and Rain Gauge at Same Height. The heights above ground of the collection bucket and the rain gauge orifice should be within 0.3 m of each other. Twenty-two sites (11%) did not meet this criterion. In all cases, the criterion was exceeded by small amounts and the effect is probably negligible.

Distance from Rain Gauge. The collector should be located within a distance of 30 m from the rain gauge but no closer than 5 m. Fifty-eight sites (30%) had rain gauges less than 4.9 m from the collector. None of the sites exceeded the recommended separation distance of 30 m.

Site Surroundings. Site evaluation results relative to criteria addressing potential pollutant sources are discussed below.

Industry and Urban Areas -- Sites should not be located within 10 km of an industry or urban area or within 20 km of an upwind industry or urban area. Based on the site visitor's best estimates, 54 sites (28%) were too close to industries and 42 sites (22%) were too near cities with respect to the siting criteria. The impact of these influences will vary considerably. It is difficult to assess the impact of these siting criteria variances on the data base.

Grazing Animals or Feedlots -- Site should be more than 30 m from grazing animals and more than 500 m from feedlots, dairy farms, or poultry farms. Thirty-one of the sites (16%) were too near such sources.

Vegetation within 30 m and the 45 Degree Rule -- Vegetation within 30 m of the collector should not be more than two feet tall and no object should project on the collector from an angle greater than 45 degrees. The most frequent exception was the occurrence of broomstraw at or just above the 2-ft. height limit. This is not considered a major source of sample bias. Eighteen sites (9%) had trees or meteorological towers too near the collectors.

Parking Lots, Transit Sources, or Chemical Storage -- The site should not be within 100 m of chemical storage facilities, parking lots, or transit sources. Thirty-six sites (18%) did not meet these criteria.

Equipment And Sample Collection Survey

System and performance checks were made at each site to assess the operational fitness of the Aerochem Metrics precipitation collector and the Belfort rain gauge. The process of sample retrieval and care was also examined.

Precipitation Collector System Checks. The precipitation collector should be level. Only 13 collectors (7%) were slightly unlevel. The effect of this variance on collection efficiency is probably not measurable. The collector's sensor should be clean. Only six collector sensors were dirty. Thirty collectors (15%) had evidence of excessive clutch wear. This is one of the clearer indications that a site's data set may be incomplete. The usual result of clutch slippage is that a sample is not collected because the cover fails to move off the wet bucket at the start of a precipitation event.

Precipitation Collector Performance Checks. The collector's bucket cover should fit tightly and evenly on the rim of the wet (and dry) bucket so that dust cannot enter during dry periods. Only four collectors were noted to have bucket-lid seal problems. A measure of adequate lid/bucket seal tension is the lid drop distance -- the distance the lid drops when the wet bucket is momentarily removed. A distance of 3 mm or greater is required to give good, dust-free seals. Of 167 site collectors checked, only four (2%) had lid drops of 3 mm or less.

The temperature of the precipitation collector sensor should be at ambient level when there is no precipitation unless the ambient air temperature is below 4°C, during which time the low power sensor heater should come on to melt ice or snow. When precipitation occurs, the high power heater should come on and sensor temperature should rise to about 50 to 70°C within 10 minutes. Thirty-two collector sensors (16%) were found to have malfunctioning sensor heaters based on one or more of the above performance characteristics.

Rain Gauge System Checks. The rain gauge should be level. Fifteen rain gauges (8%) were off level by small amounts. The chart recorder should indicate the correct time within one hour. Recorders were off by more than 1 hour at 12 sites (6%). The damping fluid reservoir should be filled to reduce pen "noise" created by strong winds. The damping fluid levels were low at 29 sites (15%).

Rain Gauge Performance Check. Rain gauge calibration was checked using Belfort gauge calibration weights. One hundred and one of 195 gauges were in calibration (within ± 0.1 inch) up to at least 10 inches of rain. Sixty-nine gauges had calibration errors in the 0 to 6 inch range but of these, only 19 were out of calibration below four inches. Because most rain amounts are measured in the 0 to 4 inch range and because the depth is measured as the difference in chart reading before and after the event, few measurable errors in precipitation depth measurements are expected due to inaccurate rain gauge calibration.

Sample Collection Procedures. Most operators were using proper collection procedures and no instances of contamination were noted. The most frequently neglected procedure was the check of the bucket and sample for contamination during the visit to the site. Another check that was not done with

Table 1. *NADP/NTN Site Measurements and Performance Survey Methods*

Site Measurement	*Measurement Device*	*Performance Survey Method*	*Designated Performance Criteria*
Rain depth	*Rain gauge (Belfort)*	*Challenge with known weights that simulate depth.*	*Agreement within ±0.1 inch of test weight value.*
Precipitation sample collection	*Precipitation collector (Aerochem Metrics)*	*Measure resistance across sensor, measure tension and drop of bucket lid, measure temperature and voltage of activated sensor.*	*Lid drop distance > 3mm. Sensor temperature ambient prior to activation; temperature of 50 - 70 °C after activation.*
Mass	*Triple beam balance*	*Challenge with traceable weights.*	*Agreement within ±5 g of test weight value.*
pH	*pH meter and electrode*	*Challenge with simulated precipitation sample of known pH.*	*Agreement within ±0.1 pH unit of test solution's designated value.*
Conductivity	*Conductivity meter and cell*	*Challenge with simulated precipitation sample of known pH.*	*Agreement within ±4µS/cm of test solution's designated value.*

regularity was to ascertain if the sensor heater is working five minutes after activation by touching the baseplate lightly with a finger.

Field Laboratory Survey

Systems Check of Field Laboratory. Laboratories that support the field collection sites were generally clean with adequate space and temperature control. Required records were kept and report forms were filled out correctly in all but a few cases.

pH and Conductivity Measurement Techniques. Field personnel were observed while making pH and conductivity measurements and key elements of their technique were noted. In general, specified procedures were adhered to and laboratory technique was good.

Results of Field Site Analysis of Simulated Precipitation. Each field laboratory was asked to analyze a performance audit solution for conductivity and pH. These solutions were prepared by dilution of EPA-supplied performance test solutions; the audit value is that designated by EPA. Designated quality limits are ± 0.1 unit for pH and ±4µS/cm for conductivity. Eighty-seven percent of the laboratories had pH results within ±0.1 unit of the designated value. Ninety-five percent obtained conductivity values which did not vary by more than ±4µS/cm from the designated value.

Laboratory Balance Results. The balances were checked with weights ranging from 800 to 3200 grams. Ninety-seven percent of the sites had errors of less than 5 grams over the range of test weights. In terms of precipitation, this translates into a measurement error of less than 0.003 inch of rain.

Conclusions

Siting

All 195 sites had at least one variance with respect to siting criteria. Most of the variances, due to the nature of certain criteria and/or the degree to which the criteria were exceeded, are expected to have minimal effects on the data base. Variances with respect to pollutant sources may have measurable effects on the data, but because the type, magnitude, and proximity of the sources vary widely from site to site, a measure of the effects is not possible from the data gathered in this site visitation program.

Sample Collection

Designated sample collection procedures are adhered to at almost all the sites in the network. To ensure accurate precipitation data, it is most important that the precipitation collector and rain gauge are properly working and well-maintained. A properly working precipitation collector should uncover the wet bucket at the beginning of a precipitation event, recover the wet bucket shortly after the event stops, and keep dust, etc. out of the wet bucket when there is no precipitation. There were indications at 66 sites that the Aerochem Metrics precipitation collectors could not properly perform all these functions.

Field Laboratory Procedures

For the most part, correct procedures were used by operators, especially those who had attended the field operations training course. Eighty-seven percent of the sites agreed with the audit solution's designated pH value within ± 0.1 pH unit. Ability to measure conductivity accurately within ±4µS/cm was outstanding; ninety-five percent of the sites were within ±4 µS/cm of the audit solution's designated conductivity value. The precipitation collector and rain gauge are central to the successful operation of the network. Based on noted problems with collector operation and rain gauge calibration, it is recommended that the importance of weekly equipment checks, such as sensor heater operation, be re-emphasized to site operators. It is also recommended that a calibratio check of the rain gauge be instituted and carried out every six months with a copy of the gauge chart used for the check forwarded to the central analytical laboratory.

Sample collection procedures are generally well understood and adhered to across the network. One procedure, inspection for sample contamination at the site, is frequently omitted. The importance of this check should be restated to site operators.

It was observed that those site operators who had attended the field operations training course generally had a better understanding of procedures. It is recommended that this course be continued and that site operators be encouraged to attend.

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5. Bigelow, D. S. *Quality Assurance Report; NADP/NTN Deposition Monitoring. Field Operations, July 1978 through December, 1983*. National Atmospheric Deposition Program, Coordinator's Office, NREL, Colorado State University, Fort Collins, CO. (August 1986).

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The complete report, entitled "Summary Report for the National Atmospheric Deposition Program/National Trends Network (NADP/NTN) Site Visitation Program (December 1984 through September 1986)," (Order No. PB 88-132 519/AS; Cost: $19.95, subject to change) will be available only from:

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