Meteorological Monitoring Design and Operations at the Savannah River Site

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INTRODUCTION

The meteorological monitoring program at the Department of Energy's Savannah River Site (Parker and Addis, 1993) has been developed by the Environmental Technology Section (ETS) of the Savannah River Technology Center (SRTC) of Westinghouse Savannah River Company. The principal function of this program is to provide current, accurate meteorological data to be used as input for calculating the transport and diffusion of an accidental release of an atmospheric contaminant. For this reason, this program, called the Weather INformation and Display (WIND) System, is an integral part of the emergency response capability at SRS. There are, however, many other uses for meteorological data at SRS which require a longer term data base representative of the local climatology. These uses include dosimetric and air quality calculations, engineering analyses, and site environmental characterizations contained in Safety Analysis Reports (SAR), Environmental Impact Statements (EIS), and risk assessments. The WIND System is used to demonstrate compliance with DOE EH/0173T Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance--Chapter IV, "Meteorological Monitoring" (DOE, 1991) which references other relevant regulatory guides and industry standards.

A broad and detailed set of calibration and maintenance procedures has been developed for the meteorological monitoring program at the Savannah River Site. The framework of this program has evolved over many years into a practical, operational system which has fared well during recent audits. The following sections describe the SRS meteorological monitoring network, calibration and maintenance procedures, and the results of recent audits of the system.

MONITORING NETWORK DESIGN

To accomplish the many goals of the meteorological monitoring program at SRS, a network of instrumented towers has been erected over the 300 square mile complex. The siting of each tower is primarily based on the locations of the highest potential source terms on-site. Towers are located (see Figure 1 on page 10) in each of the following areas: A, C, D, F, H, K, L, and P. The specific locations of the eight towers (Area towers) were chosen using the following requirements:

- located within 0.5-1.0 mile of the primary production facility within an area,
- situated above relatively undisturbed forest (SRS is primarily covered by forest),
- raised at similar mean sea level (MSL) elevations to the nearby facility,
- measurements taken at the major facility stack height of 200 ft (61 m) above the ground surface to ensure representative dose calculations.

Additional meteorological instrumentation on the WJBF-TV tower near Beech Island, SC provides data at seven heights up to 304 m. For research purposes, another 61 m tower located in N Area (Central Climatology) was erected in an cleared area so that vertical profiles of several different variables could be measured.

METEOROLOGICAL INSTRUMENTATION

Instrumentation on the Area towers are located at 61 m (200 ft) and 2 m (7 ft). At 61 m, a Met One model 1585 (formerly Teledyne Geotech) bi-directional vane (bivane) is used to make measurements of horizontal (azimuth) and vertical (elevation) wind direction. The bivane also provides the most reliable and cost effective method to take accurate, direct measurements of turbulence (Hanna et. al., 1977), expressed as standard deviations of fluctuations about mean azimuth (σ_A) and elevation (σ_E) angles. Wind speed measurements are made with Met One model 1564B cup anemometers. Platinum resistance probes, Met One model T-200, measure temperature, and lithium-chloride resistance probes, Met One model DP-200B, measure dew point. Each probe is housed within fan aspirated solar radiation shields. A fan aspirated platinum resistance temperature probe is also mounted at the 2 m level. In D area, an additional level at 36 m (110 ft) is instrumented with a bivane and anemometer to measure local terrain induced wind flows.

For each Area tower, instruments at 61 m are mounted on a boom that extends 2 m, or approximately four tower diameters, from the tower. On one end of the boom a 1 m crossbar is attached and supports the bivane and cup anemometer. The open lattice towers are triangular in cross section with each face measuring approximately 0.5 m. The open structure of the tower results in air reaching the instruments with minimal influence from the tower structure. The temperature probe is housed in an aspirated shield which extends below the crossbar. The aspirated dew point probe housing is mounted to the support boom. The boom and supporting crossbar can be lowered to ground level by an electric winch. The temperature probe at 2 m is mounted to the main tower.

Meteorological instrumentation on the WJBF-TV tower is located at 2 m, 18 m, 36 m, 91 m, 137 m, 243 m, and 304 m. All levels above 2 m, are instrumented with a Climet model 012-8A bivane, Climet model 011-1 cup anemometer, and a Rosemont model 78 temperature sensor in a wind aspirated housing. The 2 m level is instrumented with a fan aspirated temperature sensor only. The Climet bivanes have been modified to improve their reliability and performance. The TV tower is not equipped with an elevator like the SRS Area towers. Consequently, installation, maintenance, and sensor exchanges are performed on the tower by professional tower climbers.

Instruments at the WJBF-TV tower are mounted on a boom which extends 3 m from the tower to the southwest (225°). On one end of the boom a 1 m crossbar is attached and supports the bivane and cup anemometer. The open lattice tower is triangular with each cross section face measuring approximately 3.0 m, and, like the Area towers, air reaches the instruments with minimal influence from the tower structure.

Central Climatology is equipped with Met One instrumentation at each of four levels (2m, 18m, 36m, and 61m) with a similar configuration as the 61m level of the Area towers. Profiles of wind and temperature are made with this instrumentation to observe local boundary layer structure. Atmospheric pressure, rainfall, evaporation, solar and long wave radiation, and soil temperature measurements are made to create a data base of the local climatology of SRS.

DATA COLLECTION AND PROCESSING

Data acquisition is accomplished by μMac-4000 processors, Micom error controllers, and Universal Data Systems modems which digitize and send instrument signals from a data building near the base of each tower to a central computer, the Weather INformation and Display (WIND) System computers (VAX 8550's in Building 773-A), via dedicated, conditioned phone lines. Signals are sampled by the VAX at the rate of one per every 1.5 seconds which yields 600 data points per fifteen minute period. Processing involves range checks of data points (voltages) from the meteorological instrumentation. Acceptable values are used to create fifteen minute averages, and out of range values are discarded. The number of values which were used to compute each average is also archived.

A SUM-X 445 data logger is used as a back-up data acquisition system at each Area tower. Signals are processed in a similar manner as the VAX processing system except that samples are taken every one second. The SUM-X can provide up to two weeks of archived data and can be accessed remotely through a modem and computer terminal. Data from the SUM-X has been used to supply missing data for archive files during extended WIND System outages.

Archived data are maintained through the use of a relational data base (RDB) and storage tapes and disks on the WIND System. Data are available back to 1979 on the RDB, and storage tapes contain data back to the inception of the WIND System in the early 1970's. Three separate quality assured five year data bases have been created from 1975-1979 (Hoel, 1983), 1982-1986 (Laurinat, 1987), and 1987-1991 (Parker, et al., 1992). For the 1987-1991 data base, joint recovery of H Area wind data consisting of wind speed, wind direction, and σ_A was 92.29% for the 1987-1991 period.

CALIBRATION AND MAINTENANCE PROCEDURES

A full complement of detailed calibration and maintenance procedures has been developed to calibrate and maintain the meteorological monitoring system at the SRS (WSRC, 1991). The initial design of the entire procedural system was made by Tom Lockhart of the Meteorological Standards Institute, and each procedure was adapted for use specifically at the SRS. When necessary, new revisions of the procedures are made to ensure that workable and up-to-date information is incorporated into the procedural process. One of the most important features of the entire procedural process is the use of log books to document each activity that is conducted to maintain the meteorological monitoring system. In many cases, further documentation such as completed calibration forms or inspection sheets are kept as records.

Three major types of procedures form the basis of day-to-day operations; standard installation procedures, field calibration procedures, and standard maintenance procedures. Wind tunnel operations are described in a calibration procedure, an operating procedure, and instrument performance calibration procedures. Other procedures have been written for tower winch operation, calibration verification of test fixtures and torque-watches, and for reading rain gages. The following sections describe the three major types of procedures.

Standard Installation Procedures

Standard installation procedures provide guidance for the proper orientation of wind, temperature, and dew point sensors. Proper siting with respect to true north and several methods to determine true north are given. Tests for maintaining sensor levelness through the use of a bubble level and telescope are also given.

Field Calibration Procedures

Field calibration procedures (Parker, 1993) are used for every semi-annual calibration or during sensor replacement. Detailed steps for the calibration of cup anemometers, bivanes, temperature probes, and dew point probes are given in the field calibration procedures. Figure 2 highlights the activities performed to each instrument during the field calibration procedures. A complete set of forms are completed and stored as permanent records after each calibration. Similar field calibration procedures have been written for the instrumentation at

Bivane (18 month recall plan)

- Levelness
- North siting
- Relative accuracy for horizontal 30° increments at north–adjustments
- Relative accuracy for vertical 10° increments at north–adjustments
- Relative accuracy for vertical at -40°, 0°, +40° through 360° horizontal
- Threshold / balancing
- Signal conditioning / data acquisition / data averaging

Cup anemometer

- Bearings replaced every six months
- Cup assembly replaced every six month for re-certification
- Constant RPM motor checks
- Signal conditioning / data acquisition / data averaging

Temperature probes

- Probes placed in same ice bath for ΔT
- Ice point bath
- Warm bath (35-40°C)
- Clean aspirator housing
- Signal conditioning / data acquisition / data averaging

Dew point probes

- Replace bobbins every six months
- Multiple measurements made against co-located standard
- Signal conditioning / data acquisition / data averaging

Figure 2. Field calibration procedure highlights.

the Central Climatology site and for the WJBF TV tower.

Maintenance Procedures

Maintenance procedures have been developed to designate the policies and practices used to ensure that the operation of the WIND System is within required standards. There are several different types of maintenance categories which have been identified. A general time-line for maintenance activities is given in Figure 3.

Reactive maintenance consists of a same-day type response to instrument problems. These problems are detected through twice-daily examinations of data which are recorded on check sheets or any other casual data inspection.

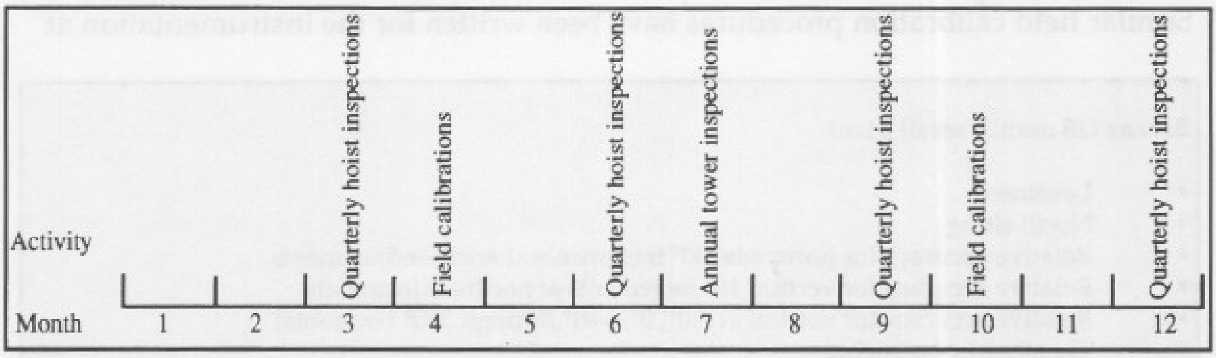

Figure 3. Yearly timeline of calibration and maintenance activities.

Technicians are dispatched verbally, by radio, or pager communications by their supervisor.

Routine maintenance is basically an informal visit to a tower facility with visual checks of the instrumentation in a normal operating mode, and an examination of instrument raw voltages and mean engineering values. Non-instrumentation items are also checked such as the tower grounds, guy wires, and strobe lights to ensure that the tower site is in good working condition. Routine maintenance is not set to a strict schedule and can be performed at any time.

Routine calibrations are those that are required at six month intervals or when a replacement instrument is installed. Routine calibrations ensure that the meteorological monitoring system is properly maintained from instrument, through signal processing, to data manipulation and archival. Explicit steps have been outlined for all calibrations in one manual, Meteorological Monitoring Procedures (WSRC, 1991).

Routine tower inspections are made by qualified personnel outside of the ETS. Quarterly inspections of the tower winch and cabling are made by trained company personnel. Annual inspections of the tower structure, tower straightness, guy wire tensions, strobe light, winch cable, and pulleys are made by off-site contracted personnel. Records from all inspections are maintained.

SPECIAL MAINTENANCE PROCEDURES

At the SRS, eight of the nine on-site towers are located above the existing forest canopy to provide representative measurements of the site's meteorological conditions since the site is primarily covered by forest. With the siting of the towers in mind, a 2,000 ft radius buffer zone (2,000 ft = 200 ft (measuring height) x 10 (downwind distance buffer)) around the towers has been incorporated into the land use plan for the entire SRS. Any proposed construction or similar activities which require the removal of trees within the buffer zone must be approved by ETS. The Savannah River Forest Station of the United States Forest

Service provides specialized thinning and planting practices to maintain the canopy's height over time. In general, only projects which require the removal of a few mature trees are approved. Conflicts do arise and, in some cases, a compromise on the number of trees to be removed is made between ETS and the group in-charge of the proposed project. Under no circumstances are large clear-cuts allowed within the 2,000 ft buffer zones.

MAINTENANCE CONTRACTS

Although the staff of the Environmental Transport Group can perform many different functions, additional expertise is needed to provide proper maintenance for the entire meteorological monitoring system. On-site (within the company) and off-site maintenance agreements are used for this purpose.

Several on-site groups provide key support to the meteorological monitoring program. The Savannah River Standards Laboratory provides traceability to NIST for measuring and test equipment such as gram-scales, constant RPM motors, digital voltmeters, temperature standards, and humidity standards. Electrical and mechanical data building maintenance is performed by on-site personnel. Quarterly winch and cable inspections are performed by trained on-site personnel. Groundskeeping and bug spraying is scheduled through on-site groups who utilize contractors that also maintain other site facilities.

Off-site contracted personnel are employed for annual tower structure inspections, tower climbing at the WJBF-TV tower, and site tower repairs. A service contract with Met One Instruments is used to refurbish sensors and related equipment. Uninterruptable power supplies, back-up data loggers, etc. are sent off-site for repair as needed.

RECENT AUDITS OF THE ETS METEOROLOGICAL MONITORING PROGRAM

Being a government facility, the ETS meteorological monitoring program is subject to audits. The most common type of audit is the In-Depth Safety Audit in which site personnel who are totally unfamiliar with the audited facility are asked to review the safety posture of the facility. These reviews are helpful in detecting subtle safety items can be overlooked by operating personnel. Recent In-Depth Safety Audits of the wind tunnel facility and the A-Area tower revealed only minor findings. Additional safety walk-downs are conducted several times a year by management and technical personnel who are familiar with the towers but are not day-to-day users. Ideas for improvements are incorporated into procedures where appropriate.

A Comprehensive Compliance Assurance Review (CCAR) of the meteorological monitoring program operated by ETS was conducted during 1993 (DOE, 1993). The review was performed by Halliburton/NUS at the request of the

Department of Energy. The CCAR is used to assess the adequacy of policies, and procedures which are used to maintain a program, in this case the meteorological monitoring program, when compared to DOE directives, Federal and state regulations, and accepted industry practices. The first phase of the CCAR covered many topics in detail. Each of the ten meteorological tower facilities was inspected and assessed for representative measurement techniques, appropriate configuration, and proper maintenance practices. The Weather Center Analysis Laboratory in 773-A and the Meteorological Engineering Facility, which includes the wind tunnel, in 735-7A were also visited. An interview process followed the tour of the facilities and covered many areas of procedures and documentation. Specifically, documentation related to training, north marker siting verification, calibration procedures, instrument accuracies, data logging and back-up procedures, five year data base quality assurance, data acquisition software quality assurance, and maintenance procedures were analyzed during the interviews. The second phase of the CCAR involved the procedures and methodology used to calibrate the meteorological instrumentation at an area tower. These procedures covered the following equipment: cup anemometer, bi-directional vane (bivane), temperature sensor, and dew point sensor. Also, the traceability of each piece of measuring and test equipment was reviewed. The review process involved lengthy discussions with the auditor on the actual performance of each procedure as conducted by trained personnel. The final report on the entire CCAR revealed no major deficiencies and cited five proficiencies. Corrective actions for five minor deficiencies and ten recommendations were implemented by January, 1994. The overall effect of the CCAR on the ETS meteorological monitoring program was favorable since the program was cited as being very well-run and several improvements were incorporated into the system.

ACKNOWLEDGMENTS

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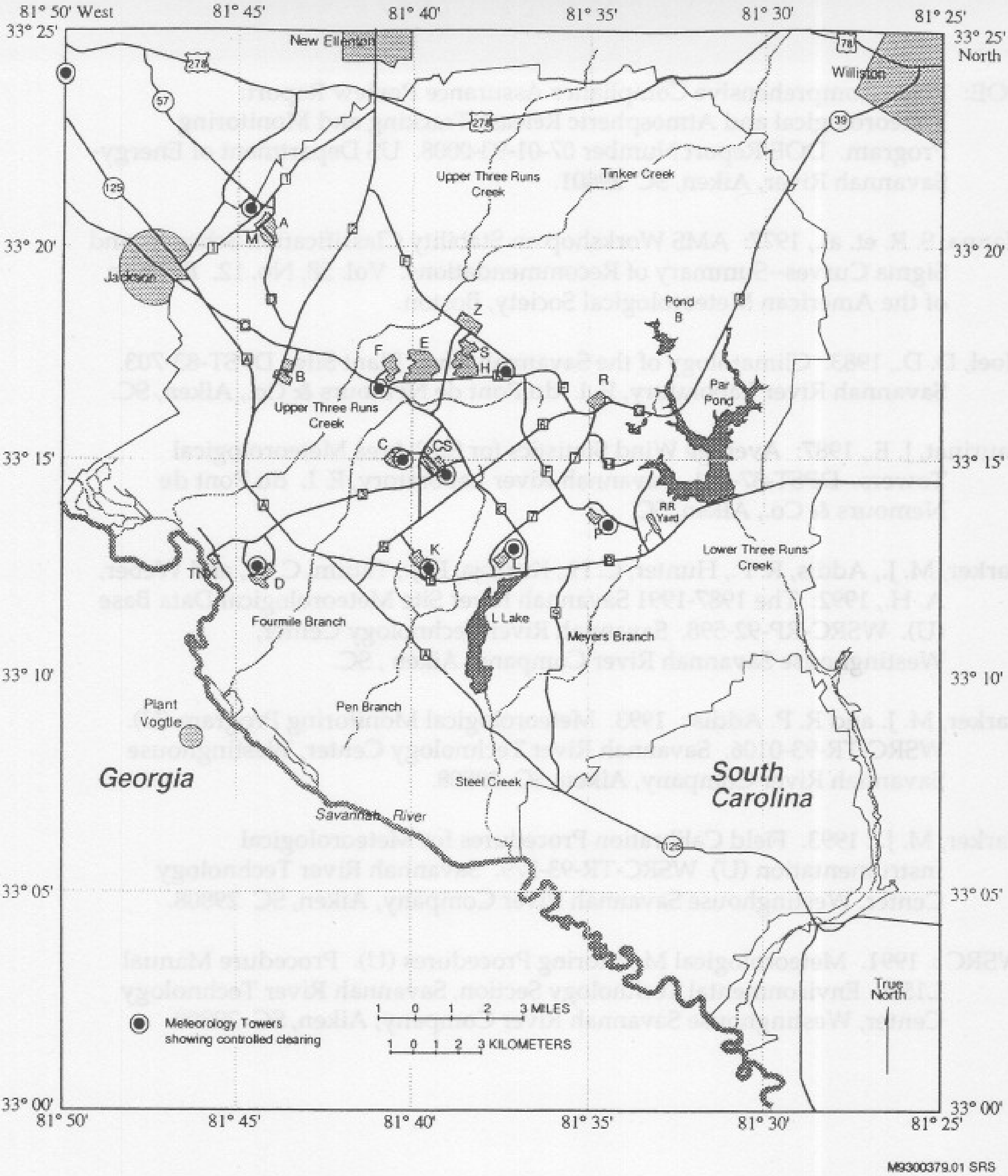

Figure 1. Meteorological tower locations at the Savannah River Site.