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AN AUTOMATED DATA SYSTEM FOR EMERGENCY METEOROLOGICAL RESPONSE

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MASTER

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AN AUTOMATED DATA SYSTEM FOR EMERGENCY METEOROLOGICAL RESPONSE*

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ABSTRACT — The Savannah River Plant (SRP) releases small amounts of radioactive nuclides to the atmosphere as a consequence of the production of radioisotopes. The potential for larger accidental releases to the atmosphere also exists, although the probability for most accidents is low.

To provide for emergency meteorological response to accidental releases and to conduct research on the transport and diffusion of radioactive nuclides in the routine releases, a series of high-quality meteorological sensors have been located on towers in and about SRP. These towers are equipped with instrumentation to detect and record temperature and wind turbulence. Signals from the meteorological sensors are brought by land-line to the SRL Weather Center-Analysis Laboratory (WC-AL). At the WC-AL, a Weather Information and Display (WIND) system has been installed.

The WIND system consists of a minicomputer with graphical displays in the WC-AL and also in the emergency operating center

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(EOC) of SRP. In addition, data are available to the system from standard weather teletype services, which provide both routine surface weather observations and routine upper air wind and temperature observations for the southeastern United States.

Should there be an accidental release to the atmosphere, available recorded data and computer codes would allow the calculation and display of the location, time, and downwind concentration of the atmospheric release. These data are made available to decision makers in near real-time to permit rapid decisive action to limit the consequences of such accidental releases. The emergency response capabilities of the system can also be extended to more general offsite use, such as providing assistance to ERDA Savannah River Operations Personnel for fulfilling their responsibilities for general radiological assistance in the Southeast.

INTRODUCTION

The Savannah River Plant (SRP), managed and operated by the E. I. du Pont de Nemours & Co. for the U. S. Energy Research and Development Administration (ERDA), is located in western South Carolina along the Savannah River about 25 miles southeast of Augusta, Georgia. Small amounts of radioactive nuclides are released to the atmosphere as a consequence of SRP's mission as the chief producer of radionuclides for ERDA. The potential for larger accidental releases to the atmosphere also exists, although the probability for most accidents is low. The Savannah River Laboratory (SRL) has as its primary objective the performance of research and process development in support of SRP operations. As a part of this support, SRL is conducting research in the environmental sciences to improve the site's ability to respond in a meaningful way to an accidental release. Much of this research may be applied to the general problem of predicting effects from an accidental release of a pollutant. The objective of this research is to develop, test, and use mathematical models for evaluating transport, dispersion, and effects of materials released to environmental systems such as the atmosphere, streams, river, estuary, ocean, soils, plants, and groundwater, and to apply these models to problems of relevance to SRP and the energy industry of the southeastern United States.

To aid in the evaluation of releases to the atmosphere, high quality weather instruments have been placed on a nearby television tower and on towers in the seven primary operating areas of SRP. In addition, a modern minicomputer with graphical displays has been installed for research, for establishing archives of meteorological data, and for rapid calculation to predict paths and effects of accidental releases to the atmosphere in supporting the SRP Emergency Operating Center (EOC). The system, consisting of the minicomputer and inputs from the meteorological sensors, is called the Weather Information and Display (WIND) System. It is the WIND system that will be described in this paper.

The ERDA Division of Nuclear Fuel Cycle and Production provides funds for those portions of the environmental sciences research that is applied and is specific to SRP operations, and the ERDA Division of Biomedical and Environmental Research provides funds for overall method development and those research efforts which are of applicability to general ERDA needs. Some of this latter effort is being done in collaboration with the Lawrence Livermore Laboratory (LLL) to develop and evaluate the Atmospheric Release Advisory Concept (ARAC).

METEOROLOGICAL INSTRUMENTATION AT SRP

A television tower within 15 km of the plant boundary is instrumented at seven levels between 2 and 304 m above the ground surface with temperature sensors and turbulence quality wind sensors. The wind sensors are modified commercially available wind measuring instruments with bivanes (horizontal and vertical wind direction indicators) and fast-response cup anemometers. The time response of the wind sensors is less than 1 second; the time response of the associated platinum resistance thermometers is about 45 seconds.

Adjacent to main SRP operating areas, seven 62-m high towers were erected in nearby pine forests. The 62 m height equals the stack heights in these operating areas. Mounted on each tower is a commercially available vector vane wind sensor which measures and transmits horizontal and vertical wind directions and total wind speed data. The time response of these instruments is less than one second. The locations of the TV tower, the seven SRP towers, and the Weather Center - Analysis Laboratory (WC-AL) can be seen in Figure 1.

In addition, an acoustic sounder provides continuous real-time measurements of the vertical mixing characteristics of the lowest 1 km of the atmosphere. The acoustic sounder provides information from within this layer concerning bouyant plumes, inversions, and depth of the well-mixed layer. Instrumentation is available from a tethered balloon to collect data of temperature, humidity, wind speed, and wind direction in the lower 1.5 km. The data from these sensors are brought to the WC-AL for storage and for subsequent computer processing.

The WC-AL also has a National Facsimile Circuit, which prints out large-scale observations and forecasts from the National Weather Service; an FAA Teletype Service A receiver, providing hourly surface weather observations and some forecasts; and a National Weather Service C receiver, providing upper air and surface synoptic information.

WEATHER INFORMATION AND DISPLAY (WIND) SYSTEM

A PDP-1140 (Digital Equipment Corp., Maynard, Mass.) minicomputer has been installed within the WC-AL. This system consists of a central processor, a 64,000 word high-speed memory (currently being expanded to 96,000 words), a 1.2-million word disc drive (being expanded to 3 disc drives), and a magnetic tape drive compatible with the SRL IBM 360-195 computer (International Business Machines, Armonk, N.Y.). Input channels collect meteorological data from sensors mounted on the nearby TV tower, the seven-tower system, and both teletype services. The minicomputer drives graphical display units both at the WC-AL and within the SRP-EOC. This system is shown schematically in Figure 2.

The DATACOM data acquisition system (DATACOM Corp., Ft. Walton Beach, Fla.) in that figure provides storage capability to supplement the WIND system. The DATACOM system stores the data from the TV tower and from the seven SRP towers in a form compatible with the SRL IBM 360-195 computer. The WIND system is used to perform environmental transport research, to store meteorological data in a summarized form for future processing with the SRL IBM 360-195 computer, and to provide a real-time system to support emergency response at the SRP site.

WIND SYSTEM AND EMERGENCY RESPONSE

For a system to support countermeasures for accidental atmospheric releases, it must be able to provide predictions of release behavior which are needed to:

1. Assess promptly the situation.
2. Provide a basis for actions to minimize immediate consequences to personnel and equipment.
3. Provide a basis for an environmental sampling plan.
4. Develop strategies and actions for recovery in such a way as to minimize consequences.

To provide this support, such a system must supply answers to the following questions:

1. What was released?
2. How much was released?
3. Where was it released?
4. Where is it going in the environment?
5. What will be the concentrations as a function of distance and time?
6. What will be the effects?

In the WIND system, the first three questions above must be answered by SRP personnel during a simulated or actual emergency release to the atmosphere. When this information is supplied, and the adequate meteorology is provided, then Questions 4 and 5 can be answered directly, and Question 6 can be answered for radionuclides with the appropriate dose program. These answers must be supplied quickly and in a form which is useful to the decision makers within the SRP-EOC.

The WIND system has some very simple graphical and computational programs. Dispersion of pollutants in the atmosphere is calculated using simple Gaussian puff and Gaussian plume equations. Outputs from the solution of these are expressed as listings and graphical plots of concentration versus distance. In addition, maps display trajectories and extent of the dispersion as calculated from time-dependent two-dimensional wind fields. Presently, the system works in a time-shared mode whereby the WIND minicomputer asks certain questions and, when supplied with the answers, provides graphical output. Figure 3 is a computer listing of such a time-shared program, whereby one line is followed by the response of an operator at one of the minicomputer consoles. When the last entry has been made, the program will proceed and provide tabular (Figure 4) and graphical outputs (Figure 5).

The tabular information in Figure 4 is self-explanatory. It contains a short message describing what is being output, plus a listing of the input parameters provided the program, and then a columnar listing of concentrations at the centerline and at two standard deviations from the centerline as a function of both distance and time. A map of the local area with each square representing 10 km (Figure 5) shows a simulated release from the A Area with the circle centered on the location at the end of each hour of travel of the puff. The circle radius represents a two-sigma deviation from the centerline concentration.

The individual locations are shown on Figure 5. Comparing Figure 5 with Figure 4, it is possible to know the centerline concentration at the end of each hour plus the concentration value within the two-sigma limit. This information provides SRP personnel with the information necessary to decide what consequence-limiting action, if any, need be taken. The time to execute this program is minimal in the minicomputer (a few milliseconds), whereas the bulk of the time is taken in answering the time-shared questions and displaying the graphical output. The overall program from start to finish takes less than two minutes for an accomplished operator. These displays are available within the WC-AL or within the EOC on call from that location. As time goes on and additional capability is added, many of the meteorological parameters will be obtained automatically. In the future, the minicomputer will be connected to the SRL IBM 360-195 where complex processing, display, and forecasting codes can be run for subsequent display at the WC-AL minicomputer and the EOC without recourse to the time-shared mode of operation.

SUMMARY

A Weather Information and Display System (WIND) has been established at SRP which, while even in the embryonic stages, is capable of producing useful and timely support for predicting effects of accidental releases to the atmosphere, and is also capable of performing research and data storage. This system is capable of expansion to meet the needs of the emergency decision maker and the individual research scientist, and to support pathways other than the atmospheric pathways (e.g., releases to rivers and streams of radionuclides or other elements).

As time goes on, individual source terms could be automatically supplied to such a system, which would allow for a continuously running dose-to-man program from routine atmospheric releases. In addition, such source terms could be supplied automatically to the system by actual sensors at the site of an accidental release.

LIST OF FIGURES

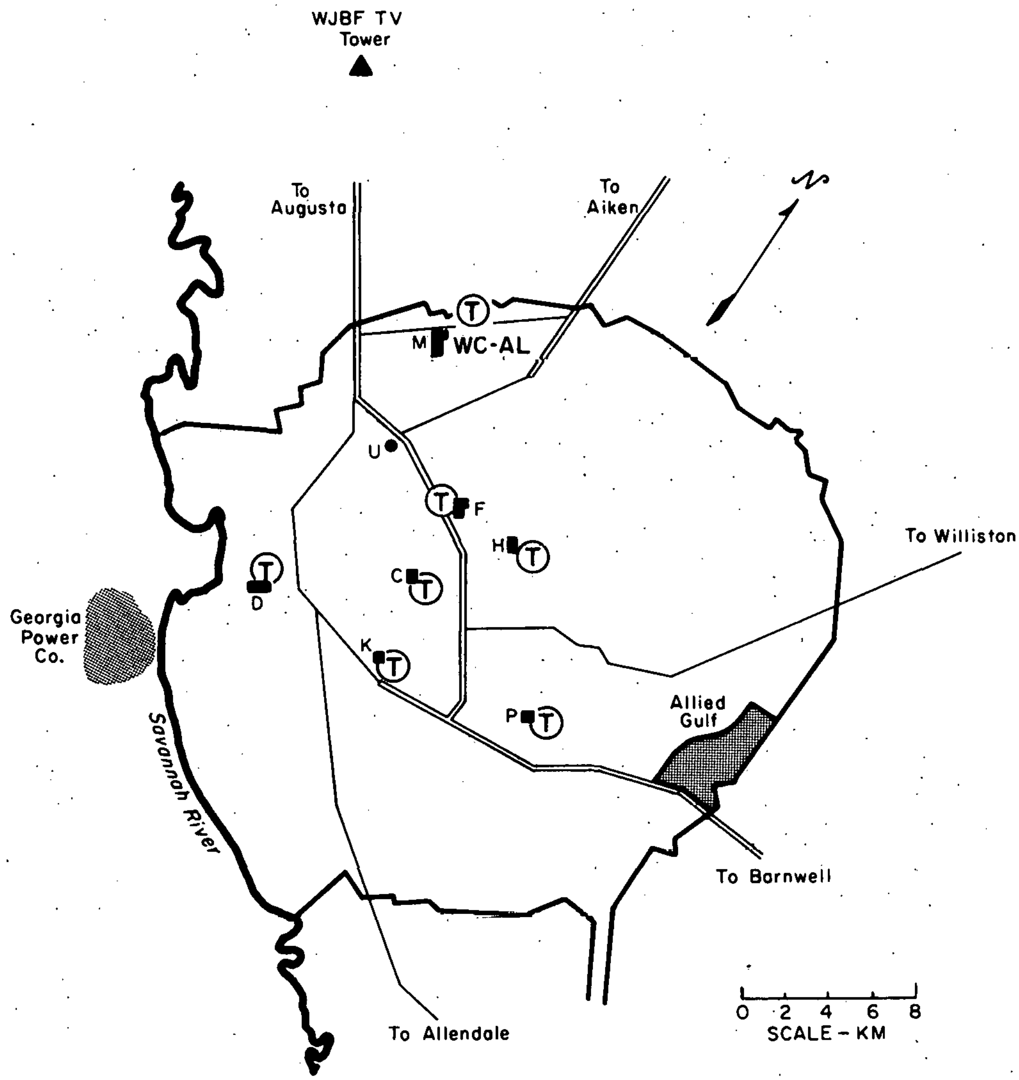


FIGURE 1. Locations of the Seven Area Meteorological Towers, the WJBF-TV Tower, the Weather Center Analysis Laboratory (WC-AL), and the Wind Tunnel (U)

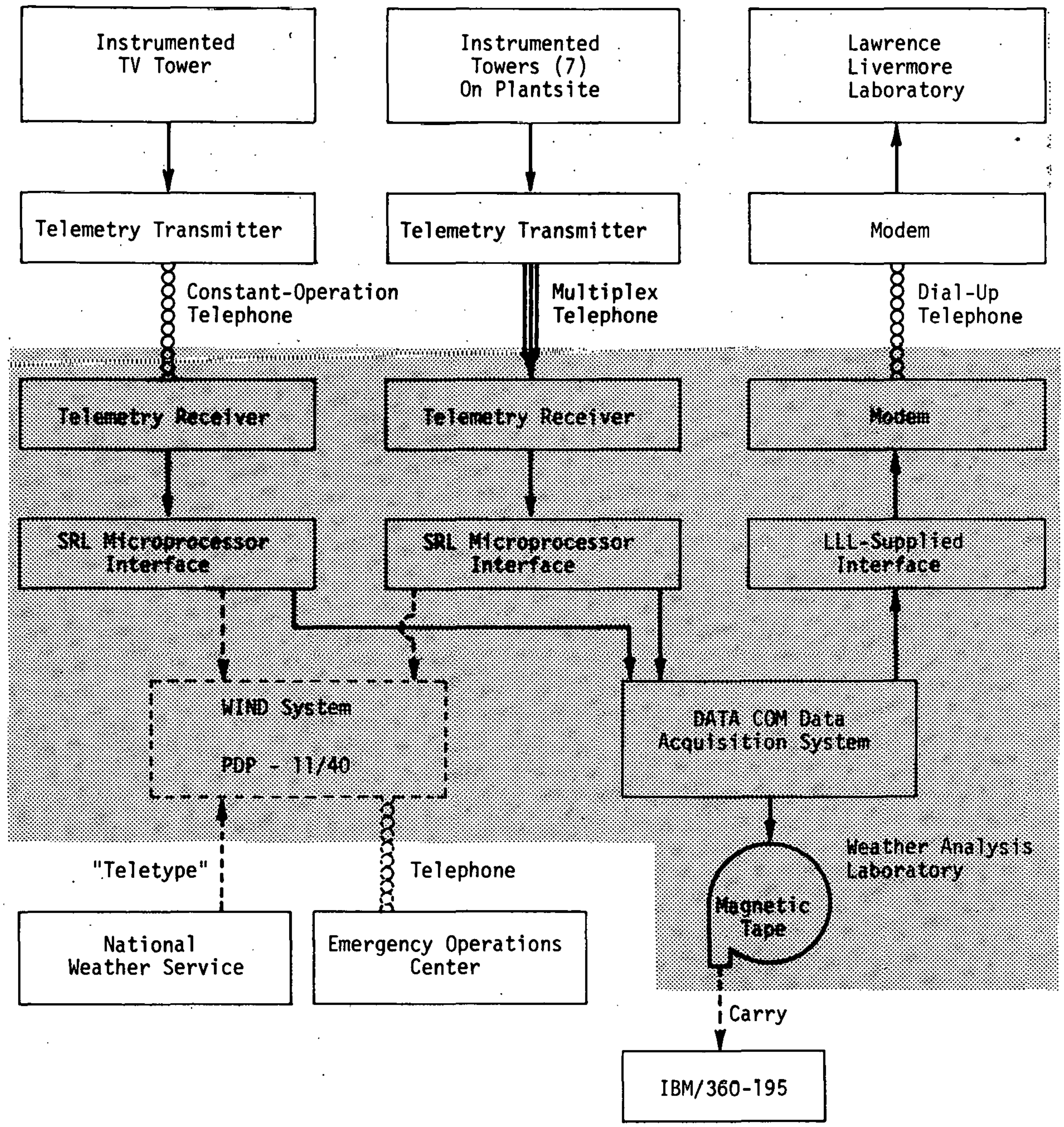


FIGURE 2. Schematic Representation of WIND System

```
 . RUN PUF
ENTER'PF' FOR PUFF OR 'PL' FOR PLUME, THEN HIT
RETURN.

PF
  ENTER TIME AND DATE OF INITIAL RELEASE, EX= 1635 03/07/75

1245 05/02/74
                IF IN THE FOLLOWING REQUESTS THE (RETURN) KEY IS DEPRESSED
 IN, THE VARIABLE REQUESTED WILL DEFAULT TO DATA THATS
 ALREADY IN THE PROGRAM AS FOLLOWS.....DIR=270.0  SPD=  5.5
 SIGE= 15.0  SIGA= 10.0  SIGYO=100.0  SIGZO=100.0  HSTK= 65.0
 Q=  1.0  HTLID=900.0  HAFLFE=0.10E 11  (HIT RETURN AFTER ENTERIES)


 ENTER SOURCE RATE IN P CI, EX=1.0E+10

5.0E+17
        ENTER WIND DIRECTION IN DEGREES, EX= 270.

235.
 ENTER SPEED IN METERS/SEC, EX=5.5

4.6
 ENTER STANDARD DEVIATION OF ELEVATION ANGLE IN
 DEGREES, EX=15.0

15.
 ENTER STANDARD DEVIATION OF AZIMUTH IN DEGREES, EX=10.

10.
 ENTER INITIAL HORIZ. SIZE OF PUFF IN METERS, EX=100.

100.
 ENTER INITIAL VERTICAL SIZE OF PUFF IN METERS, EX=100.

10.
 ENTER STACK HEIGHT IN METERS, EX=65.

70.
 ENTER HEIGHT OF INVERSION IN METERS, EX=900.

800.
 ENTER HALFLIFE IN HOURS, EX=1.83
```

FIGURE 3. Time-Shared Question/Answer for Execution of Simple Gausian Puff/Plume Program

THE FOLLOWING DATA CAN BE USED TO DETERMINE THE GROUND LEVEL CONC. AT CLOUD CENTERLINE AS A FUNCTION OF TIME AND TRAVEL DIST. ALSO PRESENTED IS THE CONC. AT A DIST. EQUAL TO 2 SIGY FROM THE CLOUD CENTERLINE. THE INPUT DATA CONSIST OF HOURLY AVERAGE WIND DATA. A MAX. OF SIX HOURS OF DATA IS INPUT BUT OUTPUT IS COMPUTED EVERY 10 MIMUTES IN P CI/M3.

SOURCE TERM IS 5.0E 17 P CI HALFLIFE IS 1.0E 10

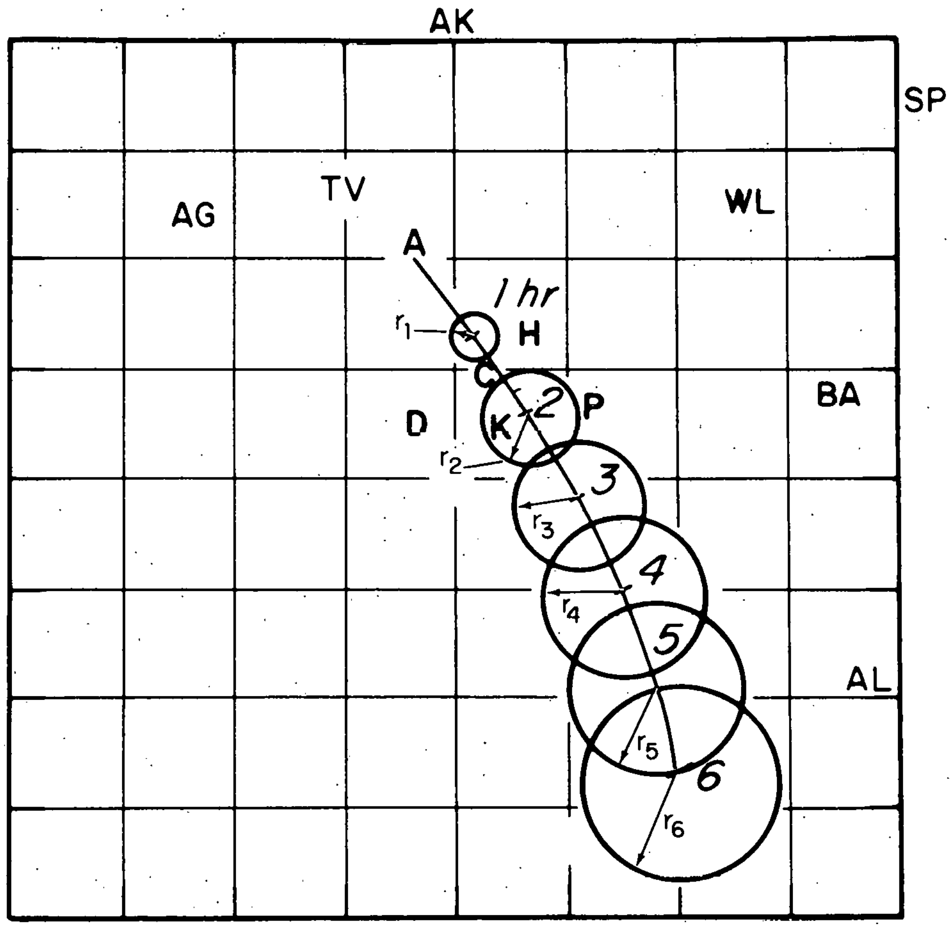
KZMAX = 1.0E 05 KYMAX = 5.0E 06 SIGYO = 100.0 SIGZO = 10.0

STACK HEIGHT IS 70.0 M MAXIMUM MIXING DEPTH IS 800.0 M

START TIME IS 1245 DATE=05/02/74

DIST(KM)	T(HRS)	UMEAN	SIGX=SIGY	SIGZ	CLCPC	GLC2SY	TYPE
2.760	1255	0.46E 01	0.26E 03	0.10E 03	0.75E 10	0.10E 10	PF
5.520	13 5	0.46E 01	0.62E 03	0.15E 03	0.97E 09	0.13E 09	PF
8.280	1315	0.46E 01	0.96E 03	0.19E 03	0.34E 09	0.46E 08	PF
11.040	1325	0.46E 01	0.13E 04	0.22E 03	0.18E 09	0.24E 08	PF
13.800	1335	0.46E 01	0.15E 04	0.24E 03	0.11E 09	0.15E 08	PF
16.560	1345	0.46E 01	0.17E 04	0.27E 03	0.79E 08	0.11E 08	PF
19.320	1355	0.46E 01	0.19E 04	0.29E 03	0.60E 08	0.81E 07	PF
22.080	14 5	0.46E 01	0.21E 04	0.31E 03	0.47E 08	0.64E 07	PF
24.840	1415	0.46E 01	0.22E 04	0.33E 03	0.39E 08	0.52E 07	PF
27.600	1425	0.46E 01	0.24E 04	0.35E 03	0.33E 08	0.44E 07	PF
30.360	1435	0.46E 01	0.25E 04	0.36E 03	0.28E 08	0.38E 07	PF
33.120	1445	0.46E 01	0.26E 04	0.38E 03	0.24E 08	0.33E 07	PF
35.880	1455	0.46E 01	0.27E 04	0.39E 03	0.21E 08	0.29E 07	PF
38.640	15 5	0.46E 01	0.28E 04	0.41E 03	0.19E 08	0.26E 07	PF
41.400	1515	0.46E 01	0.29E 04	0.42E 03	0.17E 08	0.23E 07	PF
44.160	1525	0.46E 01	0.30E 04	0.44E 03	0.15E 08	0.21E 07	PF
46.920	1535	0.46E 01	0.31E 04	0.45E 03	0.14E 08	0.19E 07	PF
49.680	1545	0.46E 01	0.32E 04	0.46E 03	0.13E 08	0.17E 07	PF
52.440	1555	0.46E 01	0.33E 04	0.48E 03	0.12E 08	0.16E 07	PF
55.200	16 5	0.46E 01	0.34E 04	0.49E 03	0.11E 08	0.15E 07	PF
57.960	1615	0.46E 01	0.35E 04	0.50E 03	0.10E 08	0.14E 07	PF
60.720	1625	0.46E 01	0.36E 04	0.51E 03	0.94E 07	0.13E 07	PF
63.480	1635	0.46E 01	0.37E 04	0.53E 03	0.88E 07	0.12E 07	PF
66.240	1645	0.46E 01	0.38E 04	0.54E 03	0.83E 07	0.11E 07	PF
69.000	1655	0.46E 01	0.38E 04	0.55E 03	0.78E 07	0.11E 07	PF
71.760	17 5	0.46E 01	0.39E 04	0.56E 03	0.73E 07	0.99E 06	PF
74.520	1715	0.46E 01	0.40E 04	0.57E 03	0.69E 07	0.94E 06	PF
77.280	1725	0.46E 01	0.41E 04	0.58E 03	0.65E 07	0.89E 06	PF
80.040	1735	0.46E 01	0.41E 04	0.59E 03	0.62E 07	0.84E 06	PF
82.800	1745	0.46E 01	0.42E 04	0.60E 03	0.59E 07	0.80E 06	PF
85.560	1755	0.46E 01	0.43E 04	0.61E 03	0.56E 07	0.76E 06	PF
88.320	18 5	0.46E 01	0.44E 04	0.62E 03	0.53E 07	0.72E 06	PF
91.080	1815	0.46E 01	0.44E 04	0.63E 03	0.51E 07	0.69E 06	PF
93.840	1825	0.46E 01	0.45E 04	0.64E 03	0.49E 07	0.66E 06	PF
96.600	1835	0.46E 01	0.46E 04	0.64E 03	0.47E 07	0.64F 06	PF
99.360	1845	0.46E 01	0.46E 04	0.64E 03	0.46E 07	0.62E 06	PF

FIGURE 4. Tabular Output of Execution of Puff/Plume Program



AG = Bush Field
TV = WJBF Tower
AK = Aiken
WL = Williston
SP = Springfield
BA = Barnwell
AL = Allendale
Grid = 10-km squares

D, H, K, P = SRP Areas

r_1 through r_6 = 2σ of horizontal dispersion per hour along puff trajectory

FIGURE 5. Graphical Output from WIND System Simple Gausian Puff/Plume Trajectory