Acc #250375

DP-MS-84-77

COMPARISON OF PREDICTED OFFSITE DOSES WITH MEASURED DOSES AT THE SAVANNAH RIVER PLANT

by

Carroll C. Zeigler, Roscoe M. Hall, Jr., and Allen H. Weber

E. I. du Pont de Nemours & Company
Savannah River Plant
Aiken, South Carolina 29808

A paper proposed for presentation at the
Midyear Symposium on Environmental Radiation
Colorado Springs, Colorado
January 6-10, 1985

and for publication in the proceedings

This paper was prepared in connection with work done under Contract No. DE-AC09-76SR00001 with the U.S. Department of Energy.

This document was prepared in conjunction with work accomplished under Contract No. DE-AC09-76SR00001 with the U.S. Department of Energy.

DISCLAIMER

COMPARISON OF PREDICTED OFFSITE DOSES WITH MEASURED DOSES AT THE SAVANNAH RIVER PLANT

by
Carroll C. Zeigler, Roscoe M. Hall, Jr., and Allen H. Weber

E. I. du Pont de Nemours & Co.
Savannah River Plant
Aiken, South Carolina 29808

ABSTRACT - An automated emergency response system for real-time predictions of offsite dose from unplanned atmospheric releases of radioactivity is maintained at the Savannah River Plant. The system consists of a minicomputer and associated peripherals necessary for acquisition and handling of large amounts of meteorological data from a local tower network and the National Weather Service. The minicomputer uses these data and predictive models to assess the impact of accidental releases.

The dose estimates from this system were compared to measured doses from bioassay samples on several occasions when unplanned releases of tritium have occurred. On all occasions, the calculated doses showed good agreement with the measured doses.

INTRODUCTION

The Savannah River Plant (SRP) produces tritium, plutonium and other special nuclear materials for the national defense, other governmental uses and for some civilian purposes. Operating facilities include a fuel and target fabrication plant, three nuclear reactors, two chemical separations plants, a process development laboratory and many other facilities necessary to support the operations.

An automated emergency response system, the Weather Information and Display (WIND) system was developed at SRP to predict offsite concentrations and doses that would result in the event of an unplanned release of radioactivity. Three recent unplanned releases of tritium have provided data for a comparison of predicted doses with doses measured by urine analysis. The WIND system and the emergency response following these unplanned tritium releases will be discussed.

METHODS

The WIND System

The WIND system consists of minicomputers and associated peripherals necessary for handling data from a local area network of instrumented towers and data from the National Weather System. These data are supplied to computer models that predict plume movement and dispersion, and calculate downwind concentrations and doses (Ga83).

The local area network consists of seven towers adjacent to SRP production areas (figure 1) and a television tower located 15 km northwest of SRP. The seven production area towers have a turbulence-quality vector vane at a height of 62 m. The 62 m height corresponds to the production area stack heights.

The vector vane provides meteorological data on wind speed and direction, and horizontal and vertical wind fluctuations. The television tower instruments provide meteorological data at seven levels between 10 and 304 m above the ground.

Data from the National Weather Service is obtained from a network of weather forecast offices throughout the United States. Data from any point within the National Weather Service network are available on a "store and foreward instant replay basis."

The meteological data from the local area network, the television tower and the National Weather service provide modeling data needed to calculate the dimensions and location of the downwind plume. The meteorological data are combined with the quantity of radioactivity released at the source to calculate downwind concentrations and dose.

The WIND system can also forecast downwind parameters for up to 30 hours. This 30 hour forecast is provided by correlating National Weather Service hydrodynamic models to site specific SRP weather data.

The WIND system atmospheric transport models have been verified by comparison of predicted downwind concentrations with empirical measurements of tritium and krypton-85.

Emergency Response

Operating incidents can cause SRP tritium releases to increase significantly above the routine release rate. These increases cause the initiation of emergency response procedures. When the magnitude of the release is expected to have a measureable offsite impact, the Emergency Operating Center is activated and teams are dispatched to collect environmental samples in the downwind direction of the plume as predicted by the WIND system.

Offsite impact assessment is influenced by the fraction of the released tritium that is in the oxide form. The oxide form is readily exchangeable with hydrogen in the environment while the elemental form interacts much more slowly.

The sample collection teams collect environmental samples along several transects at selected intervals downwind from the point of release. On each transect samples are collected at intervals that range from one-fourth mile to several miles depending upon the predicted dimensions of the plume. A typical illustration of monitoring routes is presented in figure 2.

Sample collection teams typically collect vegetation along with surface water and milk where available.

In addition, atmospheric moisture and rainwater are collected from routine continuous monitoring stations that were in or near the predicted downwind plume.

The tritium oxide concentration observed in these samples are used to verify the direction and ground level dimensions of the plume.

To verify doses to individuals living in the vicinity of SRP, dose data are obtained from analyses of urine samples from family members of SRP employees who live in or near the downwind direction of the plume. Dose estimates are also made from concentrations of tritium observed in milk samples collected in the downwind plume.

Offsite vegetation, surface water, air, urine and milk samples were collected and analyzed on March 27, 1981, July 16, 1983 and March 23, 1984 following unplanned tritium releases.

RESULTS

Relative concentrations of tritium oxide in vegetation and surface water samples along predicted plume path transects have verified that the WIND system provides a rapid assessment of the downwind direction when unplanned tritium releases have occurred. A typical example of maximum concentration in vegetation and predicted plume path is shown in figure 2.

Consistently dependable methods were not available, however, to assess downwind doses using vegetation and surface water tritium concentrations.

Therefore, bioassay samples were collected from individuals living in or near the downwind plume to verify the accuracy of the dose assessment. Doses determined from these bioassay data agreed well with WIND system calculated doses on three recent occassions.

Calculated and measured maximum doses at the SRP boundary were essentially the same for a March 27, 1981 release. The calculated dose was 0.3 mrem compared to a measured dose of 0.2 mrem (Ga81).

On July 16, 1983 good agreement was again observed when the maximum calculated dose was 0.04 mrem compared to a maximum measured dose of 0.03 mrem (Ga83a).

On the third occasion, March 23, 1984, the calculated maximum dose of 0.06 mrem at the SRP boundary was somewhat higher than the maximum measured dose of 0.02 mrem. However, at 45 km from SRP, the calculated dose of 0.02 mrem agreed with the measured dose of 0.02 mrem.

The difference in calculated and measured doses at the SRP boundary on March 23, 1984 was attributed to meteorological conditions which caused most of the release plume to remain aloft in a fairly narrow band until the plume was several miles beyond the SRP boundary (Ev84).

Data on the three releases are presented in table 1. A graphic illustration of the range of doses determined from urine analyses compared to the predicted path of the plume following the March 27, 1981 tritium release are presented in figure 3. Figures 4 and 5 show graphic comparisons of the doses determined from bioassay data compared to the WIND system calculated doses for the July 16, 1983 and March 23, 1984 tritium releases.

Offsite doses calculated from tritium concentrations in milk have also generally shown reasonable agreement with the WIND system calculated doses as shown in table 1. However, the maximum dose of 0.17 mrem calculated from possible milk consumption following the March 23, 1984 release was approximately three times greater than the WIND system calculated maximum dose and nine times greater than the maximum measured dose. This difference likely reflects conservative assumptions used in the milk dose calculations or meteorological conditions which caused the release plume to remain in a fairly narrow band.

The calculated doses were greater than measured doses on all occassions. Higher calculated doses show that the methodology and assumptions used in the WIND system calculated doses are conservative and provide an estimate that is likely to be greater than the actual dose.

Doses from these unplanned releases have been measurable, however, they are insignificant when compared to the annual natural radiation dose near SRP which averages 93 mrem.

CONCLUSION

The Savannah River Plant automated emergency response system for real-time predictions of offsite concentrations and dose from atmospheric releases has provided an accurate assessment when unplanned tritium releases have occurred.

Followup field surveys and bioassay samples from persons in the path of the plume have confirmed the accuracy of the ground level dimensions of the plume, wind direction and offsite dose from the release. This system insures that SRP can rapidly and accurately assess the impact of unplanned releases on the surrounding environment. This system provides emergency management personnel with the data necessary to provide for the safety of persons who live near SRP in the unlikely event that a significant release of radioactivity should occur.

ACKNOWLEDGEMENT

The information contained in this article was developed during the course of work under Contract No. DE-AC09-76SR00001 with the U. S. Department of Energy.

REFERENCES

Ga83. A. J. Garrett, M. R. Buckner and R. A. Mueller. "The Weather Information and Display Emergency Response System." Nuclear Technology 60, 50 (1983).

Ga81. A. J. Garrett, E. L. Wilhite and M. R. Buckner. Environmental Effects of a Tritium Gas Release from the Savannah River Plant. USDOE Report DP-1613, E. I. du Pont de Nemours & Co., Savannah River Laboratory, Aiken, SC (November 1981).

Ga83a. A. J. Garrett, C. C. Zeigler, D. R. Carver and D. L. Stevenson. Environmental Aspects of a Tritium Gas Release from the Savannah River Plant on July 16, 1983. USDOE Report DP-1613, E. I. du Pont de Nemours & Co., Savannah River Laboratory, Aiken, SC (July 1983).

Ev84. A. G. Evans, D. D. Hoel, M. V. Kantelo. Environmental Aspects of a Tritium Release from the Savannah River Plant on March 23, 1984. USDOE Report DP-1695, E. I. du Pont de Nemours & Co., Savannah River Laboratory, Aiken, SC (To be published).

TABLE 1

COMPARISON OF DATA FOLLOWING UNPLANNED RELEASES OF TRITIUM

Dates of Releases	3/27/81	7/16/83	3/23/84
Total Tritium Released, Curies	33,000	56,000	7,500
Tritium Oxide Released, Curies	32,700	600	5,250
Maximum Calculated Individual Dose from WIND System, mrem	0.3	0.04	0.06
Maximum Individual Dose from Bioassay Samples, mrem	0.2	0.03	0.02
Maximum Calculated Possible Dose from Milk Consumption, mrem[a]	0.03	b	0.17

[a]Based on possible consumption of milk by an infant (the most critical population group) from the cow with the maximum tritium concentration.

[b]Within normal concentration ranges.

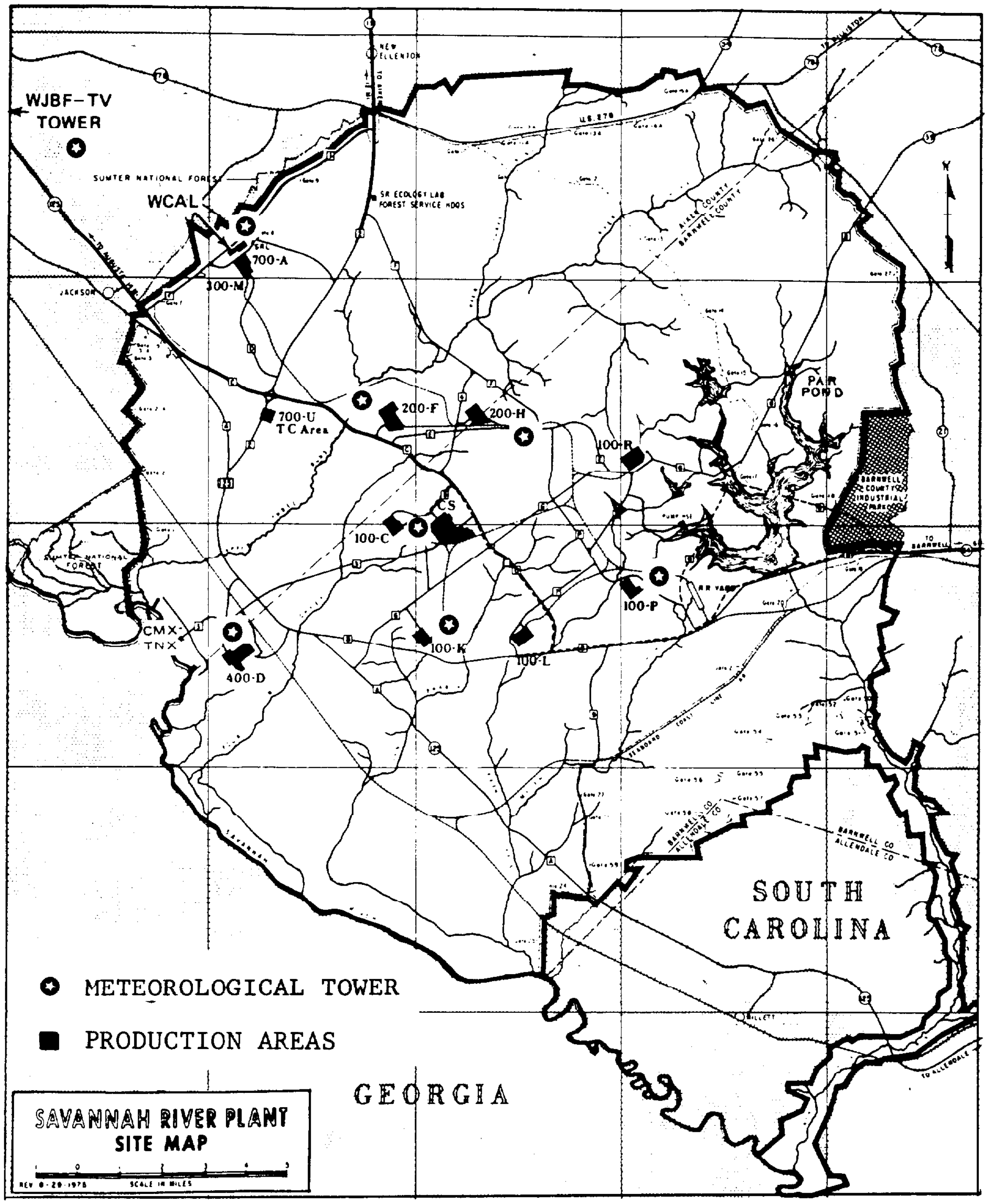

FIGURE 1. METEOROLOGICAL TOWER LOCATIONS AT THE SAVANNAH RIVER PLANT

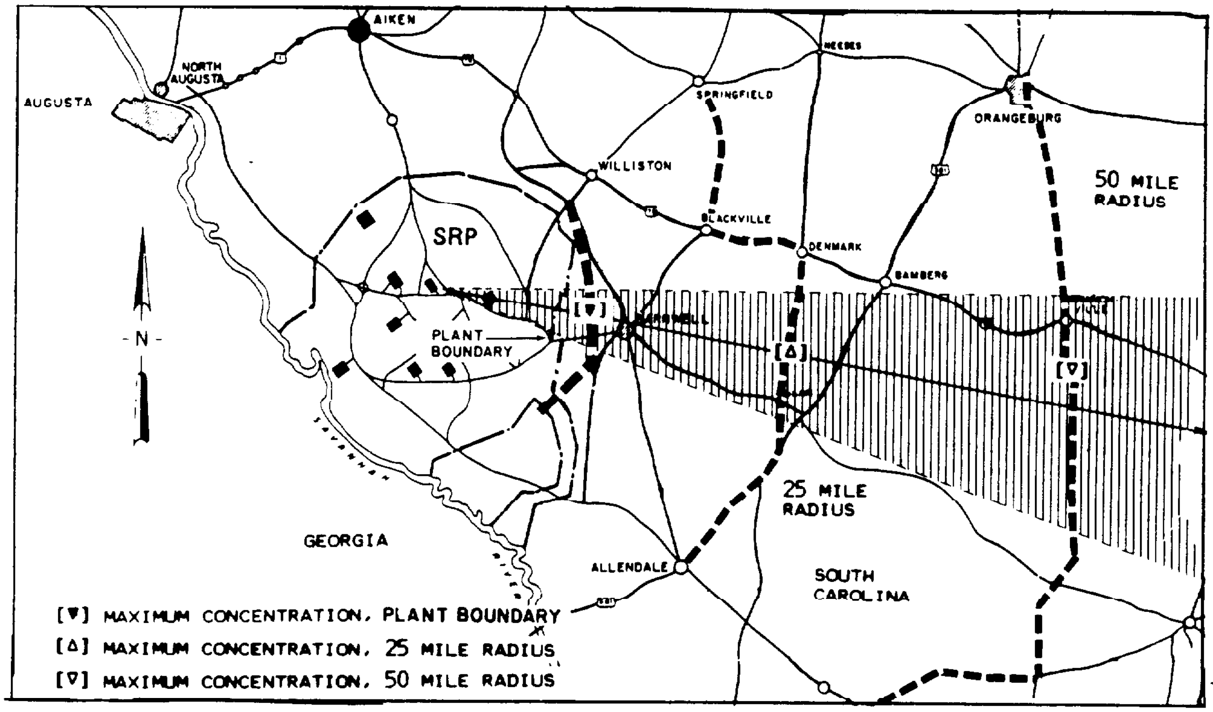

FIGURE 2. PATH OF RELEASE PLUME AND ENVIRONMENTAL SAMPLE TRANSECTS FOLLOWING TRITIUM RELEASE ON MARCH 23, 1984

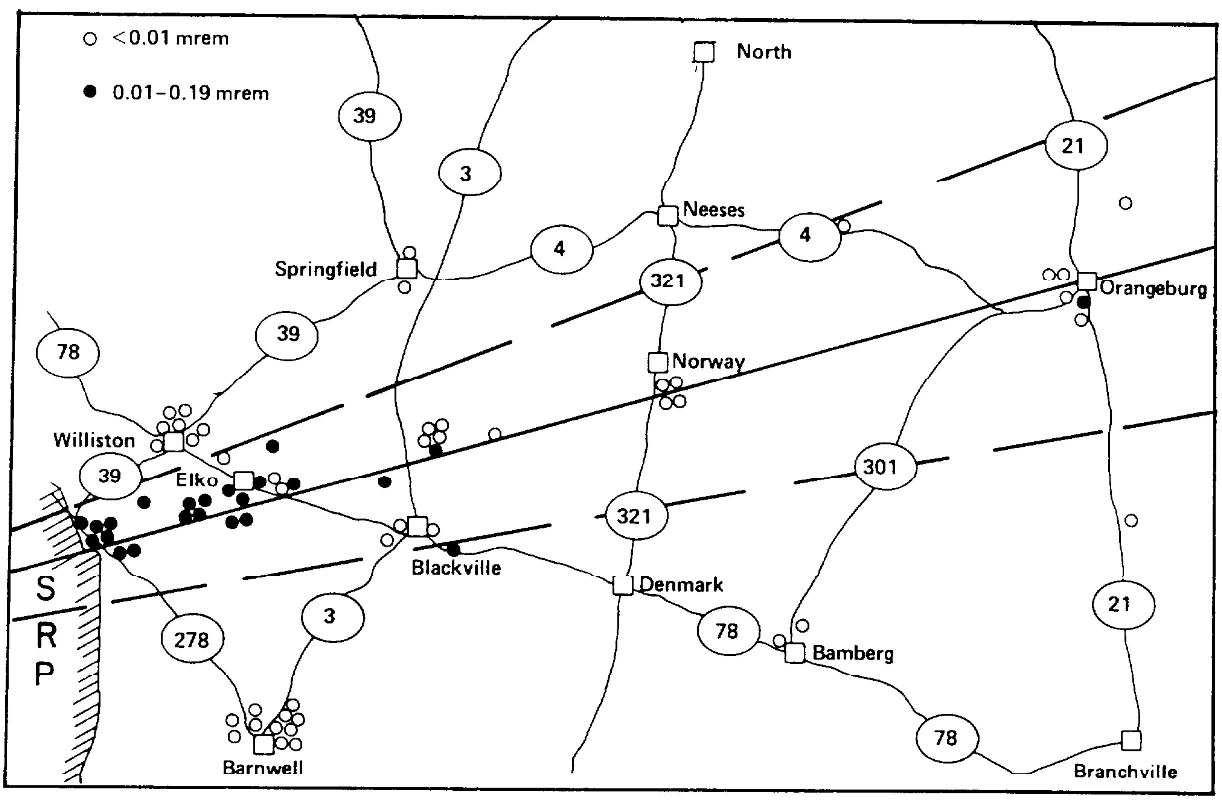

FIGURE 3. MEASURED DOSE RANGES FOLLOWING THE MARCH 27, 1981 TRITIUM RELEASE

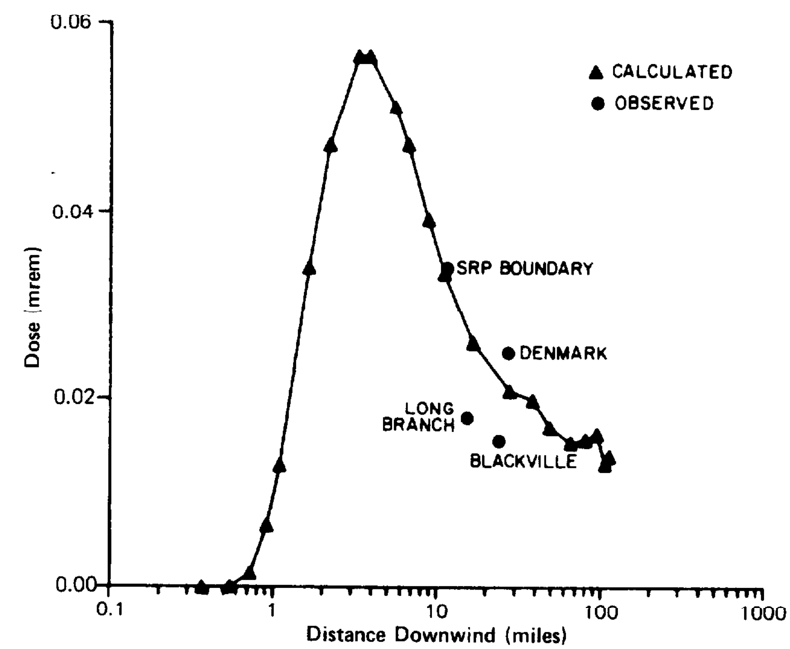

FIGURE 4. COMPARISON OF CALCULATED DOSES WITH OBSERVED DOSES FOLLOWING THE JULY 16, 1983 TRITIUM RELEASE

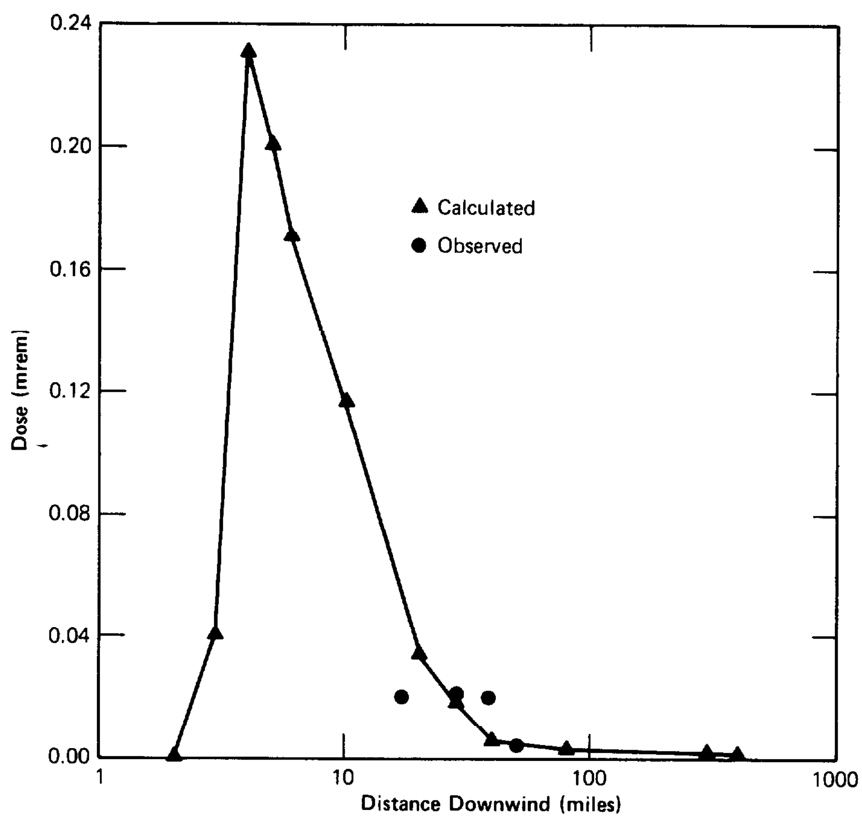

FIGURE 5. COMPARISON OF CALCULATED DOSES WITH OBSERVED DOSES FOLLOWING THE MARCH 23, 1984 TRITIUM RELEASE