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Dose Calculations for Severe LWR Accident Scenarios

U.S. Nuclear Regulatory Commission

Office of Nuclear Regulatory Research

T. S. Margulies, J. A. Martin, Jr.

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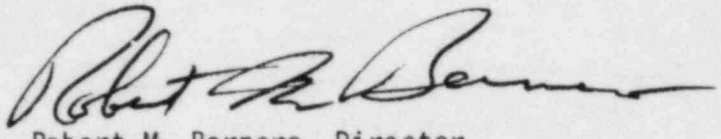
FOREWORD

The dose information presented in this report provides a valuable back-up to existing dose projection capabilities already available at nuclear power plants, NRC headquarters and regional incident response centers, and most States. This compilation should prove useful during an actual emergency or in preparation of an emergency response scenario, to those involved in radiological dose assessment.

It must be emphasized that the dose calculations presented herein rely upon the radioactivity releases ("source terms") taken from the 1975 Reactor Safety Study, WASH-1400, and do not reflect the considerable research effort which is underway, but presently incomplete, to reassess such accidental releases. Hence, this report contains no new source term information. When such new source term information becomes available, consideration will be given to revision of this report, if the results so warrant.



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ABSTRACT

This report presents a set of precalculated doses based on a set of postulated accident releases and intended for use in emergency planning and emergency response. Doses were calculated for the PWR (Pressurized Water Reactor) accident categories of the Reactor Safety Study (WASH-1400) using the CRAC (Calculations of Reactor Accident Consequences) code. Whole body and thyroid doses are presented for a selected set of weather cases. For each weather case these calculations were performed for various times and distances including three different dose pathways--cloud (plume) shine, ground shine and inhalation. During an emergency this information can be useful since it is immediately available for projecting offsite radiological doses based on reactor accident sequence information in the absence of plant measurements of emission rates (source terms). It can be used for emergency drill scenario development as well.

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PREFACE

This report is arranged as follows. First, postulated accident sequences leading to a radioactive release are summarized. The meteorology and atmospheric transport models used to perform the dose calculations are discussed. Finally, the set of accident scenarios (i.e., both accident category and weather conditions) that comprise this emergency response dose guidebook for light water reactors (LWRs) is presented. A discussion of the caveats regarding these computer simulations is also included. Because of the many assumptions inherent in the calculations, caution must be exercised in using and interpreting the calculated doses, especially at larger distances. With regard to "source terms", it must also be recognized that the source terms used for the dose calculations are current best engineering estimates only and are subject to change. They should not be considered as predictions in any sense of the word. Further, even if the character of a release were known perfectly the dose projections would be only approximate, i.e., order of magnitude estimates, because of the simplifying meteorological assumptions.

ACKNOWLEDGEMENTS

We greatfully acknowledge the State of Maryland Department of Natural Resources, Power Plant Siting Program which has given permission for the publication of the computer dose information in Appendix A.

Furthermore, the assistance and support of Roger M. Blond (now with Science Applications, Inc.) is greatly appreciated.

Finally, we give our thanks to our secretaries, Pamela Foust and Deborah Boyd, for typing and preparing the report.

1.0 INTRODUCTION

In the event of a radiological emergency at a nuclear power plant it would be necessary to obtain an early projection of doses that members of the public might receive in the event of a release of radioactivity. All nuclear power plants are required to develop and maintain dose projection capabilities.[1] Various methods are available to obtain such estimates. This report presents one such method of projection which is based on precalculated doses and dose rates for postulated accident sequences. This has been done for a spectrum of possible accidents and the results are plotted in Appendix A.

The spectrum of accidents considered is that represented by the so called PWR (Pressurized Water Reactor) accident sequences of the Reactor Safety Study (RSS).[2] These accidents encompass a full range of degraded core and core-melt accidents ranging from simple cladding failure, where the plant containment systems remain essentially intact, and for which the releases of radioactivity to the atmosphere would be relatively small, to extremely severe accidents for which large fractions of the core inventory of radionuclides are postulated to be released to the atmosphere. The release categories are designated PWR 1 through PWR 9. The most severe accident class, PWR 1, is comprised of two parts, PWR 1A and PWR 1B to cover the possible outcomes of a ground level release or a high energy release for which an elevated puff would be expected.

Although the "continuous" spectrum cannot be completely covered adequately by only nine discrete accident sequences, the discreteness is related to a finite number of basic reactor plant safety systems, the success or failure of which could have major impacts on the outcome of an accident. In particular, the success or failure, and the timing of the failure, of the containment and/or the engineered safety systems (ESFs) of the containment play a major role in the estimates of the fractions of the core inventory that can be released to the atmosphere. For example, in contrast to the PWR 1 accident sequences, for which all ESFs are presumed to fail catastrophically, the PWR 8 sequence would not involve containment failure, but the containment would leak at a relatively slow rate. The offsite or environmental consequences of these accidents would be markedly different, of course. In addition, the nine accident sequences cover various core damage states from major cladding failure to full core melt.

The potential for a variety of meteorological conditions during a release to the atmosphere and subsequent transport away from the release point provides the potential for a wide range of off-site consequences for each postulated release. This continuous spectrum was approximated by discrete meteorological conditions. Doses and dose rates were calculated for each of the postulated releases and for each of the meteorological conditions and sheltering cases chosen. The CRAC (Calculations of Reactor Accident Consequences) code[2,3,4] was used to generate the dose and dose rate information.

2.0 ACCIDENT CATEGORIES

A large portion of the work of the Reactor Safety Study[2] (WASH-1400) was devoted to determining the probability and magnitude of radioactive releases. In order to define the various releases that might occur, a series of release categories was identified for the accident sequences as well as the postulated types of containment failure in both Boiling Water Reactors (BWRs) and Pressurized Water Reactors (PWRs). The probability of each release category and the associated magnitude of radioactive releases (given as fractions of the initial core radioactivity that might leak from the containment structure) are used as input data to the CRAC consequence model.

Tables 1 and 2 list the parameters that characterize the PWR and BWR release categories. In addition to probability and release magnitude, other parameters that characterize the accident releases are time of release after accident initiation, duration of release, warning time for protective actions, height of release, and energy content of the released plume. A summary display of the release fraction information and associated probabilities is presented in Figure 1.[5]

The time of release refers to the time interval between the start of the hypothetical accident and the release of radioactive material from the containment building to the atmosphere; it is used to calculate the initial decay of radioactivity. The duration of release is the total time during which radioactive material is emitted into the atmosphere; it is used to account for continuous releases by adjusting for horizontal dispersion due to wind meander. These parameters, time and duration of release, represent the temporal behavior of the release in the dispersion model. The amount of radioactivity released to the environment is calculated for each release category in CRAC by taking the product of the radioactivity group release fractions and their respective fission product radioactive inventory (Table 3). Radioisotope decay and first daughter product in-growth during puff transport are also accounted for in CRAC.

The warning time for protective action is the postulated interval between awareness of an impending release and the actual release of radioactive material from the containment building. Finally, the height of release and the energy content of the released plume affect the manner in which the plume would be dispersed in the atmosphere.

It should be understood that these categories are composites of numerous event tree sequences with similiar characteristics, as discussed in WASH-1400. Tables 4 and 5 give the dominant release groupings and key to the symbols for the PWR categories. Tables 6 and 7 give the same information for the BWR categories. It is noted that the release fraction for each isotope group that was assigned to a category (Tables 1 and 2) generally was taken as the highest calculated

fraction from all of those accident sequences (Tables 4 and 6) assigned to a particular release catgeory. Therefore, the release category was only a synthesized way of covering a large number of the accident sequences assigned to the release category and generally represents conservative estimates of the possible release fractions for many of the assigned sequences. Further discussion of the LWR accident sequences and releases that define each category is given in Appendix B.

In this report, dose calculations are presented for the PWR accident categories. Estimates for BWR categories can be obtained by analogy or interpolation, using the tables and the accident descriptions as guides.

In dealing with an accident at BWRs, the following conversion table might be used:

BWR 1 = PWR 1
BWR 2 = PWR 2
BWR 3 = PWR 3
BWR 4 = PWR 6
BWR 5 = PWR 8

The estimated release fractions and timings of possible releases for the RSS accident categories have been questioned by some experts and major research efforts are underway to re-assess accident source terms. Since the PWR 1 and 2 sequences would involve very rapid releases and very high release fractions, revised source terms, if any, should be encompassed within the PWR 1-8 or BWR 1-5 accident categories. If more than minor interpolation is required for newer source terms, this report should be revised or supplemented in the future.[6]

It should be recognized that during an actual emergency it would be a very tenuous speculation to predict the actual eventual release fractions to the atmosphere even if the accident sequences were known perfectly.

3.0 DOSE CALCULATIONS

3.1 Meteorology and Atmospheric Transport

The figures in Appendix A are labeled, in part, according to certain meteorological assumptions, namely, wind speed, atmospheric stability class and rainfall. This section will discuss the rudiments of meteorological nomenclature.

Although the subject is complex, the modeling assumptions used in most atmospheric transport codes, such as CRAC, are simple ones. Moreover, a rudimentary explanation should suffice to interpret the graphs in the Appendix.

For these calculations it was assumed that any release to the atmosphere can be considered to be a "puff" release. This puff is allowed to grow in the vertical and horizontal directions as it is transported by the wind. Transport in a single, unwavering direction radially away from the release point is assumed.

Concentrations of radionuclides in the puff are assumed to be greatest at its center and to decrease monotonically in both horizontal and vertical directions as one moves away from the center. Although some dispersion in the radial direction (upwind and downwind) would occur as well, such dispersion is immaterial to the dose calculcations in the Appendix because doses for the direct exposure to materials in the puff are calculated for the full exposure to it. Models for partial exposures are available[7,8], but are not included herein.

As one moves away from the center of the puff, concentrations of radionuclides are assumed to decrease according to a normal or Gaussian equation. In this equation two parameters determine the concentration at any point in space. A parameter sigma-z (σ_z) governs the vertical dispersion and a parameter sigma-y (σ_y) governs the horizontal disperison. These "Pasquill-Gifford" dispersion parameters are displayed in Figures 2 and 3.[9,10] Sigma-y and Sigma-z are parameterized in CRAC by Martin and Tikvart.[11] The Gaussian, or normal, distribution curve is displayed in Figure 4[10].

The curves in Figures 2 and 3 are labeled by the letters A through F. These letters represent the stability "class" using the Pasquill-Gifford atmospheric dispersion classification scheme.[9,10] This scheme relates atmospheric turbulent dispersion according to easily observed conditions of the atmosphere: windspeed, day or night conditions, and cloud cover. This scheme is displayed in Table 8.

A few examples will illustrate how the information in Table 8 can be used to determine a stability class. First, read footnote 1 in Table 8: for heavy cloud cover, the Pasquill-Gifford stability class is D, or neutral. Further, for moderate to high windspeeds, the stability class is also D for the most part (see bottom line of Table 1). Indeed, D stability is the most prevalent stability class. Now note the area of the table below the dashed line. Here, higher windspeeds would prevail and the stability class would be neutral (D) under most conditions, day or night. However, given strong sunlight and moderate windspeeds better disperison than "normal" would be expected, and the stability class would be B or C. Additionally, given 5-10 mph windspeed and a cloudless night, poorer than average dispersion would be expected (E stability).

Low windspeed conditions can induce either greater or less than normal (D stability) dispersion. Observe the area above the dashed line in Table 8. For low windspeeds, dispersion would be greater than normal during the day and less than normal during the night. A long, narrow, concentrated plume is often observed in the late afternoon on a calm sunny evening, or on a cool calm, starry night (e.g., Class F stability). See Figure 5.

For emergency response purposes, considering all other variables and uncertainties, the information in Table 8 can be succinctly summarized as follows:

Atmospheric Condition	Stability Class
Windspeed 10 mph or greater, or heavy cloud cover anytime	D
Low windspeeed and few clouds -	
Daytime	B-C
Nightime	E-F
Very low windspeed, high noon, bright summer day	A

Theoretical full widths of D and F stability plumes versus distance are displayed in Figure 5. For reference, the full width of a 22.5^{0} sector is also shown in Figure 5. 22.5^{0} is the angle subtended by one of the sixteen cardinal compass directions (e.g., ENE). Windspeeds which produce commonly observed phenomena (e.g., tree leaves in motion) are listed in Table 9.

Rainfall could significantly alter the consequences of an accidental release comprised of water soluble or particulate material. Ground level dose rates in the wake of a plume could be orders of magnitude greater with rainfall, as compared to transport in dry weather.[12-17] Thus, separate graphs for dry and wet weather are included in Appendix A. One assumption used for the rainfall cases is important to note: it was assumed that rainfall was continuous and steady throughout the transport time at all "downwind" locations. Interception of rainfall after transport in dry weather was not included here, although it can be considered in the CRAC code. Other assumptions of note were: plumes (puffs) were depleted exponentially with travel time, ground runoff was ignored, and plume depletion and ground deposition were the same for all stability classes, for rain cases.

3.2 Unrealistic Meteorological Modeling Assumptions

A number of unrealistic assumptions are inherent in the meteorological models used for the calculations.[16] Some of the realities, as compared to the assumptions are as follows:

1. Plumes (puffs) do not travel in straight lines, yet the models used here, and by many others, assume line of sight travel. Thus, all distances displayed in the graphs should refer to the distance along the track of a puff, rather than "crow-flight" distances.

2. Windspeeds and stability classes are not invariant over the time scales inferred by the distances displayed in the graphs. It is not uncommon to find a thunderstorm over one area (D stability) and sunshine (e.g. B

stability) in an area only a few miles away, especially in summer. Yet, these calculations assumed constant stability class and windspeed everywhere, throughout the travel time (for a day in some cases).

For these calculations, no wind shifts during the presumed release period were allowed. Yet, there is a 50-50 chance of a significant wind shift at any time across the continental United States.[18,19] Van der Hoven has analyzed National Weather Station meteorological data across the United States and has presented results in the form of graphical displays of the probability of hours of wind persistence in 22.5° and 67.5° sectors (Figures 6 and 7).[18] The study concludes that there is an even chance of a significant wind shift occurring in the next two to four hours at any given location in the United States. A few general observations by Van der Hoven are of import to emergency planning and/or response:

"...the higher the wind speed, the greater is tendency for the wind to remain in a given direction.. Conversely, it is in the lowest wind speed categories of calm and 1 to 5 mph that the least direction persistence is found.

"...wind roses* (frequency) that favor a particular sector will also tend to persist in that sector."

A wind shift during a release period could significantly dilute a release and lower doses, as compared to doses presented in the Appendix.[19]

3. Numerous topological features, such as hills, river valleys, water masses, thermal islands (cities) and coasts, would significantly alter stability class and wind direction, i.e. atmospheric transport in general.[9] Generally, these would all disperse a puff to a greater extent than assumed for the calculations. This may or may not lower estimated doses, however. An elevated release could intercept a hill or a large building, resulting in higher ground level doses than estimated for an elevated release, for example. Nevertheless, at distances greater than ten miles, or so, doses would generally be less than calculated here because greater dilution would be expected. On the other hand, the areas involved would be greater than those implied by the widths of simple puffs as idealized by the sigma-y curves in Figures 2 and 5.

4. A significant plume rise could make transport estimates especially tenuous because of windspeed and direction differences at various altitudes. Plume rise would have to be observed rather than calculated because of the lack of a heating source term. The height of a steam cloud should be observable for certain very severe accident sequences.[5]

*Wind rose is the direction <u>from which</u> the wind blows.

With these caveats in mind, it is clear that should an actual release of sufficient magnitude ever occur, a reasonably accurate dose assessment would require monitoring teams to locate the release(s). Considering the high dose rates necessary for a Protective Action Guide (PAG) to be realized, the major offsite monitoring problems would involve finding and tracking a release.[20,21] Considering further the facts that windspeeds average 5 to 10 miles per hour, and that a two hour release could be ten to twenty miles long over areas where the wind directions could be considerably different, aircraft would be the preferred method for plume tracking where at all possible.[17] The wind directions at the release point may not be adequate to project atmospheric transport to distances of more than a few miles, especially in complex terrain.[20]

3.3 Pathways for Precalculated Doses

The graphs presented in Appendix A show projected doses to the whole body and thyroid for a 2550 thermal megawatt reactor.[4] Activities in Table 3 and doses in the Appendix would scale in proportion to thermal power.

Doses were calculated for three pathways: inhalation, external gamma irradiation from the plume (cloud) and external gamma irradiation from radionuclides deposited on the ground. Four graphs showing calculated doses at distances between 1 and 100 miles along the track of a plume (puff) are displayed for each of the postulated accident/meteorological conditions. Information in the graphs can be used to discern both dose rate and pathway contributions to doses.

Inputs to CRAC included a specification of the inventory of radionuclides and activities released to the atmosphere, the characteristics of the release (e.g., Tables 1, 2 and 3) and meteorological conditions following the accident. A finite cloud dosimetry model in CRAC was used for the cloud external gamma dose calculations. Standard wet and dry deposition models were used to transfer non-noble gaseous material from the atmosphere to the ground for the ground exposure dose calculations.

The calculations of whole body dose are very sensitive to the assumption of the length of time one remains in the vicinity of contaminated ground. Therefore, three time periods were used in the total dose versus distance calculations (i.e., 4-hour, 24 hour and 7 day). The cloud, ground and inhaled components of the total dose are explicitly plotted (on the right hand side of each figure) using the 24-hour ground exposure time assumption. The external gamma dose from the passing cloud is assumed to happen "instantaneously." Inhalation of radionuclides occurs over a very short time period ("instantaneously") and the dose builds up over time since the body continues to be irradiated for extended time periods by those inhaled radionuclides which remain in the body; i.e, which are not immediately exhaled. The dose commitment from inhaled radionuclides is calculated over an individual's lifespan.

3.4 Accident Category and Weather Scenarios

Doses and dose pathway contributions to an individual versus distance have been calculated for a selected set of weather conditions and release categories as shown in Table 10.

The individual in accident/weather scenarios 1 through 14 is unshielded, that is, the individual is not in a brick building, or basement, or other enclosure which could reduce the received dose. These calculations (i.e., cases 1 throught 14) are "projected doses" and can provide a perspective on "dose savings" to be afforded by various protective measures.

Several sheltering cases, i.e., 15 through 19, with and without the occurrence of rain are included for additional perspective. Shielding factors for these cases are 0.75 for the cloud pathway and 0.33 for the ground. Refer to Table 11 for a list of representative shielding factors.[2]

For illustration, Figure 8 presents dose plots from Appendix A for a PWR #2 release category during a typical weather condition (i.e., stability class D, 6 mph windspeed and no rain) and a 4-hour ground exposure time. The effects of different windspeed/stability class conditions are shown in Figure 9. Also, rain can significantly alter the dose versus distance curves as shown in Figure 10. The sensitivity of the results to different "source terms" or release categories is easily seen in Appendix A. Compare Figure 11 corresponding to a PWR #6 release category to Figure 9. The influence of plume rise is shown in Figure 12 for the same weather condition (PWR #1A versus #1B release).

4.0 DISCUSSIONS

In an actual emergency response situation it would be useful to base dose projections on actual radiological measurements as quickly as possible. However, for many postulated severe accident scenarios major radionuclide emissions would bypass at least some engineered safety features and routinely monitored release paths. For such cases precalculated dose projections could be immediately available when a real time dose projection model could not be used and field measurements are absent. Such information can be useful during emergency drills, in the emergency planning process and in the very early stages of an emergency response situation. These calculations can be especially useful during a response situation before a release occurs for purposes of contingency planning based on an assessment of the possible outcomes of the actual accident sequence.

All in all, then, these dose and dose rate calculations can be useful for emergency planning and in the early phases of an emergency response. However, in the post-release phase of an emergency response the best dose projections would be based on actual data obtained from radiological monitoring and the knowledge of plant system performance at the time.[2]

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TABLES AND FIGURES

Table 1a: SUMMARY OF RELEASE CATEGORIES REPRESENTING HYPOTHETICAL ACCIDENTS

(Reactor Safety Study, WASH-1400)

Release Category	Probability (reactor-yr^{-1})	Time Release (hr)	Duration of Release (hr)	Warning Time for Evacuation (hr)	Elevation of Release (c) (meters)	Energy Release (10^6 Btu/hr)
PWR 1	9×10^{-7}(a)	2.5	0.5	1.0	25	20 and 520(e)
PWR 2	8×10^{-6}	2.5	0.5	1.0	0	170
PWR 3	4×10^{-6}	5.0	1.5	2.0	0	6
PWR 4	5×10^{-7}	2.0	3.0	2.0	0	1
PWR 5	7×10^{-7}	2.0	4.0	1.0	0	0.3
PWR 6	6×10^{-6}	12.0	10.0	1.0	0	N/A
PWR 7	4×10^{-5}	10.0	10.0	1.0	0	N/A
PWR 8	4×10^{-5}	0.5	0.5	N/A(b)	0	N/A
PWR 9	4×10^{-4}	0.5	0.5	N/A	0	N/A

(a) Accident sequences within PWR 1 category have two distinct energy releases that affect consequences. PWR 1 category is subdivided into PWR 1A with a probability of 4×10^{-7} per reactor-year and 20×10^6 Btu/hr and PWR 1B with a probability of 5×10^{-7} per reactor-year and 520×10^6 Btu/hr.

(b) Not applicable.

(c) A 10 meter elevation is used in place of zero representing the mid-point of a potential containment break. Any impact on the results would be slight and conservative.

Table 1b: SUMMARY OF FISSION PRODUCT RELEASE FRACTIONS FOR PRESSURIZED WATER REACTOR (PWR) RELEASE CATEGORIES

(Reactor Safety Study, WASH-1400)

Release Category	Xe-Kr	Organic I[a]	I	Cs-Rb	Te[b]	Ba-Sr	Ru[c]	La[d]
PWR 1	0.9	6×10^{-3}	0.7	0.4	0.4	0.05	0.4	3×10^{-3}
PWR 2	0.9	7×10^{-3}	0.7	0.5	0.3	0.06	0.02	4×10^{-3}
PWR 3	0.8	6×10^{-3}	0.2	0.2	0.3	0.02	0.03	3×10^{-3}
PWR 4	0.6	2×10^{-3}	0.09	0.04	0.03	5×10^{-3}	3×10^{-3}	4×10^{-4}
PWR 5	0.3	2×10^{-3}	0.03	9×10^{-3}	5×10^{-3}	1×10^{-3}	6×10^{-4}	7×10^{-5}
PWR 6	0.3	2×10^{-3}	8×10^{-4}	8×10^{-4}	1×10^{-3}	9×10^{-5}	7×10^{-5}	1×10^{-5}
PWR 7	6×10^{-3}	2×10^{-5}	2×10^{-5}	1×10^{-5}	2×10^{-5}	1×10^{-6}	1×10^{-6}	2×10^{-7}
PWR 8	2×10^{-3}	5×10^{-6}	1×10^{-4}	5×10^{-4}	1×10^{-6}	1×10^{-8}	0	0
PWR 9	3×10^{-6}	7×10^{-9}	1×10^{-7}	6×10^{-7}	1×10^{-9}	1×10^{-11}	0	0

(a) Organic Iodide is included with elemental iodide in the calculations.
(b) Includes Te, Sb.
(c) Includes Mo, Pd, Rh, Tc.
(d) Includes Nd, Eu, Y, Ce, Pr, Pu, Sm, Np, Pu, Zr, Nb.

Table 2a: SUMMARY OF RELEASE CATEGORIES REPRESENTING HYPOTHETICAL ACCIDENTS

(Reactor Safety Study, WASH-1400)

Release Category	Probability (reactor-yr^{-1})	Time of Release (hr)	Duration of Release (hr)	Warning Time for Evacuation (hr)	Elevation of Release[c] (meter)	Energy Release (10^6 Btu/hr)
BWR 1	1×10^{-6}	2.	0.5	1.5	25.	130.
BWR 2	6×10^{-6}	30.	3.	2.	0	30.
BWR 3	2×10^{-5}	70.	3.	2.	25.	20.
BWR 4	2×10^{-6}	5.	2.	2.	25.	N/A
BWR 5	1×10^{-4}	3.5	5.	N/A	150.	N/A

Table 2b: SUMMARY OF FISSION PRODUCT RELEASE FRACTIONS FOR BOILING WATER REACTOR (BWR) RELEASE CATEGORIES

(Reactor Safety Study, WASH-1400)

Release Category	Xe-Kr	Organic I[a]	I	Cs-Rb	Te[b]	Ba-Sr	Ru[c]	La[d]
BWR 1	1.	7×10^{-3}	0.4	0.4	0.7	0.05	0.5	5×10^{-3}
BWR 2	1.	7×10^{-3}	0.9	0.5	0.3	0.1	0.03	4×10^{-3}
BWR 3	1.	7×10^{-3}	0.1	0.1	0.3	0.01	0.02	4×10^{-3}
BWR 4	0.6	7×10^{-4}	8×10^{-4}	5×10^{-3}	4×10^{-3}	6×10^{-4}	6×10^{-4}	1×10^{-4}
BWR 5	5×10^{-4}	2×10^{-9}	6×10^{-11}	4×10^{-9}	8×10^{-12}	8×10^{-14}	0	0

(a) Organic iodine is included with elemental iodine in the calculations.
(b) Includes Te, Sb
(c) Includes Mo, Pd, Rh, Tc.
(d) Includes Nd, Eu, Y, Ce, Pr, Pm, Sm, Np, Pu, Zr, Nb.

TABLE 3

ACTIVITY OF RADIONUCLIDES IN THE
REACTOR CORE ONE HALF HOUR AFTER SHUTDOWN
(2550 MW-th Power Level)

GROUP	ISOTOPE	ACTIVITY (M Ci)	HALF-LIFE (DAYS)
Xe-Kr	Kr-85	0.45	3950
	Kr-85m	19	0.183
	Kr-87	37	0.0528
	Kr-88	54	0.117
	Xe-133	135	5.28
	Xe-135	27	0.384
	TOTAL	273M Ci	
I	I-131	68	8.05
	I-132	96	0.0958
	I-133	135	0.875
	I-134	151	0.0366
	I-135	119	0.28
	TOTAL	569M Ci	
Cs-Rb	Cs-134	6.0	750.
	Cs-136	2.4	13.
	Cs-137	3.7	11,000.
	Rb-86	0.021	18.7
	TOTAL	12M Ci	
Te	Te-127	4.7	0.391
	Te-127m	0.88	109.
	Te-129	25.	0.048
	Te-129m	4.2	34.
	Te-131m	10.	1.25
	Te-132	96.	3.25
	Sb-127	4.9	3.88
	Sb-129	26.	0.179
	TOTAL	76M Ci + 96 M Ci Te-132	
Ba-Sr	Ba-140	128.	12.8
	Sr-89	75.	52.1
	Sr-90	2.9	10,300.
	Sr-91	88.	0.403
	TOTAL	293M Ci	

GROUP	ISOTOPE	ACTIVITY (M Ci)	HALF-LIFE (DAYS)
Ru	Co-58	0.62	71.
	Co-60	0.23	1920.
	Mo-99	128.	2.8
	Tc-99m	112.	0.25
	Ru-103	88.	39.5
	Ru-105	57	0.185
	Ru-106	20	366.
	Rh-105	39	1.5
	TOTAL	444M Ci	
La	Y-90	3.1	2.67
	Y-91	96.	59.
	Zr-95	120.	65.2
	Zr-97	120.	0.71
	Nb-95	120.	35.
	La-140	128.	1.67
	Ce-141	120.	32.3
	Ce-143	104.	1.38
	Ce-144	68.	284.
	Pr-143	104.	13.7
	Nd-147	48.	11.1
	Np-239	1307.	2.35
	Pu-238	0.045	32,500
	Pu-239	0.017	8.91M
	Pu-240	0.017	2.47M
	Pu-241	2.7	5350
	Am-241	0.0014	0.158M
	Cm-242	0.40	163.
	Cm-244	0.018	6630.
	TOTAL	1030M Ci + 1300 M Ci Np-239	

M Ci = MegaCuries

Table 4: PWR DOMINANT ACCIDENT SEQUENCES vs. RELEASE CATEGORIES

	RELEASE CATEGORIES						Core Melt	No Core Melt	
	1	2	3	4	5	6	7	8	9
LARGE LOCA A	$AB\text{-}\alpha$ 1×10^{-11} $AF\text{-}\alpha$ 1×10^{-10} $ACD\text{-}\alpha$ 5×10^{-11} $AG\text{-}\alpha$ 9×10^{-11}	$AB\text{-}\gamma$ 1×10^{-10} $AB\text{-}\delta$ 4×10^{-11} $AHF\text{-}\gamma$ 2×10^{-11}	$AD\text{-}\alpha$ 2×10^{-8} $AH\text{-}\alpha$ 1×10^{-8} $AF\text{-}\delta$ 1×10^{-8} $AG\text{-}\delta$ 9×10^{-9}	$ACD\text{-}\beta$ 1×10^{-11}	$AD\text{-}\beta$ 4×10^{-9} $AH\text{-}\beta$ 3×10^{-9}	$AB\text{-}\epsilon$ 1×10^{-9} $AHF\text{-}\epsilon$ 1×10^{-10} $ADF\text{-}\epsilon$ 2×10^{-10}	$AD\text{-}\epsilon$ 2×10^{-6} $AH\text{-}\epsilon$ 1×10^{-6}	$A\text{-}\beta$ 2×10^{-7}	A 1×10^{-4}
A Probabilities	2×10^{-9}	1×10^{-8}	1×10^{-7}	1×10^{-8}	4×10^{-8}	3×10^{-7}	3×10^{-6}	1×10^{-5}	1×10^{-4}
SMALL LOCA S_1	$S_1B\text{-}\alpha$ 3×10^{-11} $S_1CD\text{-}\alpha$ 7×10^{-11} $S_1F\text{-}\alpha$ 3×10^{-10} $S_1G\text{-}\alpha$ 3×10^{-10}	$S_1B\text{-}\gamma$ 4×10^{-10} $S_1B\text{-}\delta$ 1×10^{-10} $S_1HF\text{-}\gamma$ 6×10^{-11}	$S_1D\text{-}\alpha$ 3×10^{-8} $S_1H\text{-}\alpha$ 3×10^{-8} $S_1F\text{-}\delta$ 3×10^{-8} $S_1G\text{-}\delta$ 3×10^{-8}	$S_1CD\text{-}\beta$ 1×10^{-11}	$S_1H\text{-}\beta$ 5×10^{-9} $S_1D\text{-}\beta$ 6×10^{-9}	$S_1DF\text{-}\epsilon$ 3×10^{-10} $S_1B\text{-}\epsilon$ 2×10^{-9} $S_1HF\text{-}\epsilon$ 4×10^{-10}	$S_1D\text{-}\epsilon$ 3×10^{-6} $S_1H\text{-}\epsilon$ 3×10^{-6}	$S_1\text{-}\beta$ 6×10^{-7}	S_1 3×10^{-4}
S_1 Probabilities	3×10^{-9}	2×10^{-8}	2×10^{-7}	1×10^{-8}	8×10^{-8}	6×10^{-7}	6×10^{-6}	3×10^{-5}	3×10^{-4}
SMALL LOCA S_2	$S_2B\text{-}\alpha$ 1×10^{-10} $S_2F\text{-}\alpha$ 1×10^{-9} $S_2CD\text{-}\alpha$ 2×10^{-10} $S_2G\text{-}\alpha$ 9×10^{-10} $S_2C\text{-}\alpha$ 2×10^{-8}	$S_2B\text{-}\gamma$ 1×10^{-9} $S_2HF\text{-}\gamma$ 2×10^{-10} $S_2B\text{-}\delta$ 4×10^{-10}	$S_2D\text{-}\alpha$ 9×10^{-8} $S_2H\text{-}\alpha$ 6×10^{-8} $S_2F\text{-}\delta$ 1×10^{-7} $S_2C\text{-}\delta$ 2×10^{-6} $S_2G\text{-}\delta$ 9×10^{-8}	$S_2DG\text{-}\beta$ 1×10^{-12}	$S_2D\text{-}\beta$ 2×10^{-8} $S_2H\text{-}\beta$ 1×10^{-8}	$S_2B\text{-}\epsilon$ 8×10^{-9} $S_2CD\text{-}\epsilon$ 2×10^{-8} $S_2HF\text{-}\epsilon$ 1×10^{-9}	$S_2D\text{-}\epsilon$ 9×10^{-6} $S_2H\text{-}\epsilon$ 6×10^{-6}		
S_2 Probabilities	1×10^{-7}	3×10^{-7}	2×10^{-6}	3×10^{-7}	3×10^{-7}	2×10^{-6}	2×10^{-5}		
REACTOR VESSEL RUPTURE - R	$RC\text{-}\alpha$ 2×10^{-12}	$RC\text{-}\gamma$ 3×10^{-11} $RF\text{-}\delta$ 1×10^{-11} $RC\text{-}\delta$ 1×10^{-12}	$R\text{-}\alpha$ 1×10^{-9}				$R\text{-}\epsilon$ 1×10^{-7}		
R Probabilities	2×10^{-11}	1×10^{-10}	1×10^{-9}	2×10^{-10}	1×10^{-9}	1×10^{-8}	1×10^{-7}		
INTERFACING SYSTEMS LOCA (CHECK VALVE) - V		V 4×10^{-6}							
V Probabilities	4×10^{-7}	4×10^{-6}	4×10^{-7}	4×10^{-8}					
TRANSIENT EVENT - T	$TMLB'\text{-}\gamma_8$ 3×10^{-8}	$TMLB'\text{-}\gamma_7$ 7×10^{-7} $TMLB'\text{-}\delta$ 2×10^{-6}	$TML\text{-}\alpha$ 6×10^{-8} $TKQ\text{-}\alpha$ 3×10^{-8} $TKMQ\text{-}\alpha$ 1×10^{-8}		$TML\text{-}\beta$ 3×10^{-10} $TKQ\text{-}\beta$ 3×10^{-10}	$TMLB'\text{-}\epsilon_7$ 6×10^{-7}	$TML\text{-}\epsilon$ 6×10^{-6} $TKQ\text{-}\epsilon$ 3×10^{-6} $TKMQ\text{-}\epsilon$ 1×10^{-6}		
T Probabilities	3×10^{-7}	3×10^{-6}	4×10^{-7}	7×10^{-9}	2×10^{-7}	2×10^{-6}	1×10^{-5}		
(Σ) SUMMATION OF ALL ACCIDENT SEQUENCES PER RELEASE CATEGORY									
MEDIAN (50% VALUE)	9×10^{-7}	8×10^{-6}	4×10^{-6}	5×10^{-7}	7×10^{-7}	6×10^{-6}	4×10^{-5}	4×10^{-5}	4×10^{-4}
LOWER BOUND (5% VALUE)	9×10^{-8}	8×10^{-7}	6×10^{-7}	9×10^{-8}	2×10^{-7}	2×10^{-6}	1×10^{-5}	4×10^{-6}	4×10^{-5}
UPPER BOUND (95% VALUE)	9×10^{-6}	8×10^{-5}	4×10^{-5}	5×10^{-6}	4×10^{-6}	2×10^{-5}	2×10^{-4}	4×10^{-4}	4×10^{-3}

Note: The probabilities for each release category for each event tree and the Σ for all accident sequences are the median values of the dominant accident sequences summed by Monte Carlo simulation plus a 10% contribution from the adjacent release category probability (See Section 4.1).

1. From Reactor Safety Study, WASH-1400 (October, 1975)
2. Frequencies are $yr.^{-1}$

Table 5 Key to PWR accident sequence symbols

A	-	Intermediate to large LOCA.
B	-	Failure of electric power to ESFs.
B'	-	Failure to recover either onsite or offsite electrical power within about 1 to 3 hours following an initiating transient which is a loss of offsite AC power.
C	-	Failure of the containment spray injection system.
D	-	Failure of the emergneyc core cooling injection system.
F	-	Failure of the contianment spray recriculation system.
G	-	Failure of the containment heat removal system.
H	-	Failure of the emergency core cooling recirculation system.
K	-	Failure of the reactor protection system.
L	-	Failure fo the secondary system steam relief valves and the auxiliary feedwater system.
M	-	Failure of the secondary system steam relief valves and the power conversion system.
Q	-	Failure of the primary system safety relief valves to reclose after opening.
R	-	Massive rupture of the reactor vessel.
S_1	-	A small LOCA with an equivalent diameter of abut 2 to 6 inches.
S_2	-	A small LOCA with an equivalent diameter of about 1/2 to 2 inches.
T	-	Transient event.
V	-	LPIS (low-pressure injection system) check valve failure.
α	-	Contanment reupture due to a reactor vessel steam explosion.
β	-	Containment failure resulting from inadequate isolation of containment openings and penetrations.
γ	-	Containment failure due to hydrogen burning.
δ	-	Containment failure due to overpressure.
ε	-	Containment vessel melt-through.

Table 6: BWR DOMINANT ACCIDENT SEQUENCES OF EACH EVENT TREE vs. RELEASE CATEGORY

	Core Melt				No Core Melt
	RELEASE CATEGORIES				
	1	2	3	4	5
LARGE LOCA DOMINANT ACCIDENT SEQUENCES (A)	AE-α 2×10^{-9} AJ-α 1×10^{-10} AHI-α 1×10^{-10} AI-α 1×10^{-10}	AE-γ' 3×10^{-8} AE-δ 1×10^{-8} AJ-γ' 2×10^{-9} AI-γ' 2×10^{-9} AHI-γ' 2×10^{-9}	AE-γ 1×10^{-7} AJ-γ 1×10^{-8} AI-γ 1×10^{-8} AHI-γ 1×10^{-8}	AGJ-δ 6×10^{-11} AEG-δ 7×10^{-10} AGHI-δ 6×10^{-11}	A 1×10^{-4}
A Probabilities	8×10^{-9}	6×10^{-8}	2×10^{-7}	2×10^{-8}	1×10^{-4}
SMALL LOCA DOMINANT ACCIDENT SEQUENCES (S_1)	S_1E-α 2×10^{-9} S_1J-α 3×10^{-10} S_1I-α 4×10^{-10} S_1HI-α 4×10^{-10}	S_1E-γ' 4×10^{-8} S_1E-δ 1×10^{-8} S_1J-γ' 7×10^{-9} S_1I-γ' 7×10^{-9} S_1HI-γ' 6×10^{-9}	SE-γ 1×10^{-7} S_1J-γ 3×10^{-8} S_1I-γ 4×10^{-8} S_1HI-γ 2×10^{-8} S_1C-γ 3×10^{-9}	S_1GJ-δ 2×10^{-10} S_1GI-δ 2×10^{-10} S_1EI-ϵ 1×10^{-10} S_1GHI-δ 2×10^{-10}	
S_1 Probabilities	1×10^{-8}	9×10^{-8}	2×10^{-7}	2×10^{-8}	
SMALL LOCA DOMINANT ACCIDENT SEQUENCES (S_2)	S_2J-α 1×10^{-9} S_2I-α 1×10^{-9} S_2HI-α 1×10^{-9} S_2E-α 5×10^{-10}	S_2E-γ' 1×10^{-8} S_2E-δ 4×10^{-9} S_2J-γ' 2×10^{-8} S_2I-γ' 2×10^{-8} S_2HI-γ' 2×10^{-8}	S_2E-γ 4×10^{-8} S_2J-γ 8×10^{-8} S_2I-γ 9×10^{-8} S_2HI-γ 9×10^{-8} S_2C-γ 8×10^{-9}	S_2CG-δ 6×10^{-11} S_2GHI-δ 6×10^{-10} S_2EG-δ 3×10^{-10} S_2GJ-δ 6×10^{-10} S_2GI-δ 2×10^{-10}	
S_2 Probabilities	2×10^{-8}	$\times10^{-7}$	4×10^{-7}	4×10^{-8}	
TRANSIENT DOMINANT ACCIDENT SEQUENCES (T)	TW-α 2×10^{-7} TC-α 1×10^{-7} TQUV-α 5×10^{-9}	TW-γ' 3×10^{-6} TQUV-γ' 8×10^{-8}	TW-γ 1×10^{-5} TC-γ 1×10^{-5} TQUV-γ 4×10^{-7}		
T Probabilities	1×10^{-6}	6×10^{-6}	2×10^{-5}	2×10^{-6}	
PRESSURE VESSEL RUPTURE ACCIDENTS (R)		P.V. RUPT. 1×10^{-8} Oxidizing Atmosphere	P.V. RUPT. 1×10^{-7} Non-oxidizing Atmosphere		
R Probabilities	2×10^{-9}	2×10^{-8}	1×10^{-7}	1×10^{-8}	
SUMMATION OF ALL ACCIDENT SEQUENCES PER RELEASE CATEGORIES					
MEDIAN (50% VALUE)	1×10^{-6}	6×10^{-6}	2×10^{-5}	2×10^{-6}	1×10^{-4}
LOWER BOUND (5% VALUE)	1×10^{-7}	1×10^{-6}	5×10^{-6}	5×10^{-7}	1×10^{-5}
UPPER BOUND (95% VALUE)	6×10^{-6}	3×10^{-5}	8×10^{-5}	1×10^{-5}	1×10^{-3}

NOTE: The probabilities for each release category for each event tree and the Σ for all accident sequences are the median values of the dominant accident sequences summed by Monte Carlo simulation plus a 10% contribution from the adjacent release category probability (See Section 4.1).

1. From Reactor Safety Study, WASH-1400 (October, 1975)
2. Frequencies are yr^{-1}.

Table 7 Key to BWR accident sequence symbols

A	-	Rupture of reactor coolant boundary with an equivalent diameter of greater than six inches.
B	-	Failure of electric power to ESFs.
C	-	Failure of the reactor protection system.
D	-	Failure of vapor suppression.
E	-	Failure of emergency core cooling injection.
F	-	Failure of emergency core cooling functionability.
G	-	Failure of containment isolation to limit leakage to less than 100 volume percent per day.
H	-	Failure of core spray recirculation system.
I	-	Failure low pressure recirculation system.
J	-	Failure of high pressure service water system.
M	-	Failure of safety/relief valves to open.
P	-	Failure of safety/relief valves to reclose after opening.
Q	-	Failure of normal feedwater system to provide core make-up water.
S_1	-	A small pipe break with an equivalent diameter of about 2 inches to 6 inches.
S_2	-	Small pipe break with an equivalent diameter of about 1/2 inches to 2 inches.
T	-	Transient event.
U	-	Failure of HPCI (high-pressure coolant injection) or reactor core isolation cooling (RCIC) systems to provide core make-up water.
V	-	Failure of low pressure ECCS to provide core make-up water.
W	-	Failure to remove residual core heat.

Table 7 (Continued)

α	-	Containment failure due to steam explosion in vessel.
β	-	Containment failure due to steam explosion in containment.
γ	-	Containment failure due to overpressure - release through reactor building.
γ'	-	Containment failure due to overpressure - release direct to atmosphere.
δ	-	Containment isolation failure in drywell.
ε	-	Containment isolation failure in wetwell.
ζ	-	Containment leakage greater than 2400 volume percent per day.
η	-	Reactor building isolation failure.
θ	-	Standby gas treatment system failure.

Table 8 - RELATION OF STABILITY CLASSES
TO WEATHER CONDITIONS

A--Extremely unstable conditions
B--Moderately unstable conditions
C--Slightly unstable conditions
D--Neutral conditions[1]
E--Slightly stable conditions
F--Moderately stable conditions

Approximate Surface wind Speed		Daytime insolation[2]			Nighttime conditions	
					Thin overcast or ≥ 4/8 cloudiness[3]	≤ 3/8 cloudiness[3]
m/sec[4]	mph[4]					
<2	<5	A	A-B	B		
2	5	A-B	B	C	E	F
4	10	B	B-C	C	D	E
6	15	C	C-D	D	D	D
>6	>15	C	D	D	D	D

1. Applicable to heavy overcast, day or night (D, or neutral stability).
2. Insolation is proportional to the amount of solar energy reaching the surface of the earth.
3. The degree of cloudiness is defined as that fraction of the sky above the local apparent horizon which is covered by clouds.
4. m/sec = meters per second; mph = miles per hour.

Table 9: BEAUFORT SCALE FOR WINDSPEED

Observations	Windspeed m/sec	Windspeed mph
Smoke rises vertically	0.3	1
Smoke drift gives direction, but wind not felt on face	1	1-3
Wind felt on face: leaves rustle, vane moved by wind	2-3	4-7
Leaves and twigs in constant motion; wind extends light flag	4-5	8-11
Moves dust, loose paper and small branches	6-7	12-16
Small trees in leaf begin to sway	8-9	17-22
Large branches in motion; high wires whislte	10-12	23-27
Whole trees in motion	13-15	28-34
Twigs broken off trees; progress impeded	16-18	35-41
Slight structural damage occurs	19-21	42-48
Trees uprooted; considerable structural damage	22-25	49-56
Rare; widespread damage	26-29	57-67
Hurricane	30+	68+

Table 10: Accident Scenarios for Precalculated Doses in Appendix A

Case #	Stability Class	Wind Speed (mph)	Rain/Shelter Combinations	
1	A	3	No Rain	No Sheltering
2	A	9	No Rain	No Sheltering
3	D	2	No Rain	No Sheltering
4	D	6	No Rain	No Sheltering
5	D	16	No Rain	No Sheltering
6	E	2	No Rain	No Sheltering
7	E	9	No Rain	No Sheltering
8	F	1	No Rain	No Sheltering
9	F	3	No Rain	No Sheltering
10	D	2	Rain	No Sheltering
11	D	6	Rain	No Sheltering
12	D	16	Rain	No Sheltering
13	E	2	Rain	No Sheltering
14	E	9	Rain	No Sheltering
15	A	3	No Rain	Sheltering
16	D	6	No Rain	Sheltering
17	D	16	No Rain	Sheltering
18	F	1	No Rain	Sheltering
19	D	6	Rain	Sheltering

Shielding Factors for Sheltering Cases: Cloud (0.75); Ground (0.37).

Table 11a: REPRESENTATIVE SHIELDING FACTORS FOR SURFACE DEPOSITION

Structure of Location	Representative Shielding Factor[a]	Representative Range
1 m above an infinite smooth surface	1.00	--
1 m above ordinary ground	0.70	0.47-0.85
1 m above center of 50-ft roadways, half containiminated	0.55	0.4-0.6
Cars on 50-ft road:		
Road fully contaminated	0.5	0.4-0.7
Road 50% decontaminated	0.5	0.4-0.6
Road fully decontaminated	0.25	0.2-0.5
Trains	0.40	0.3-0.5
One-and two-story wood-frame house (no basement)	0.4[b]	0.2-0.5
One and two-story block and brick house (no basement)	0.2[b]	0.04-0.40
House basement, one or two walls fully exposed:	0.1[b]	0.03-0.15
One story, less than 2 ft of basement, walls exposed	0.5[b]	0.03-0.07
Two stories, less than 2 ft of basement, walls exposed	0.03[b]	0.02-0.05
Three or four-story structures, 5000 to 10,000 ft^2 per floor:		
First and second floors	0.05[b]	0.01-0.08

Table 11a (continued)

Basement	0.01[b]	0.001-0.07
Multistory structures, >10,000 ft^2 per floor:		
Upper floors	0.01[b]	0.001-0.02
Basement	0.005[b]	0.001-0.015

(a) The ratio of the interior dose to the exterior dose
(b) Away from doors and windows.

Source: Reactor Safety Study, WASH-1400, NUREG 75/014, October 1975.

Table 11b: Representative Shielding Factors from Gamma Cloud Source

Structure or Location	Shielding Factor[a]	Representative Range
Outside	1.0	--
Vehicles	1.0	--
Wood-frame house[b] (no basement)	0.9	--
Basement of wood house	0.6	0.1 to 0.7[c]
Masonry house (no basement)	0.6	0.4 to 0.7[c]
Basement of masonry house	0.4	0.1 to 0.5[c]
Large office or industrial building	0.2	0.1 to 0.3[c,d]

(a) The ratio of the interior dose to the exterior dose
(b) A wood frame house with brick or stone veneer is approximately equivalent to a masonry house for shielding purposes.
(c) This range is mainly due to different wall materials and different geometries.
(d) The reduction factor depends on where the personnel are located within the building (e.g., the basement or an inside room).

Source: Reactor Safety Study, WASH-1400, NUREG 75/014, October 1975.

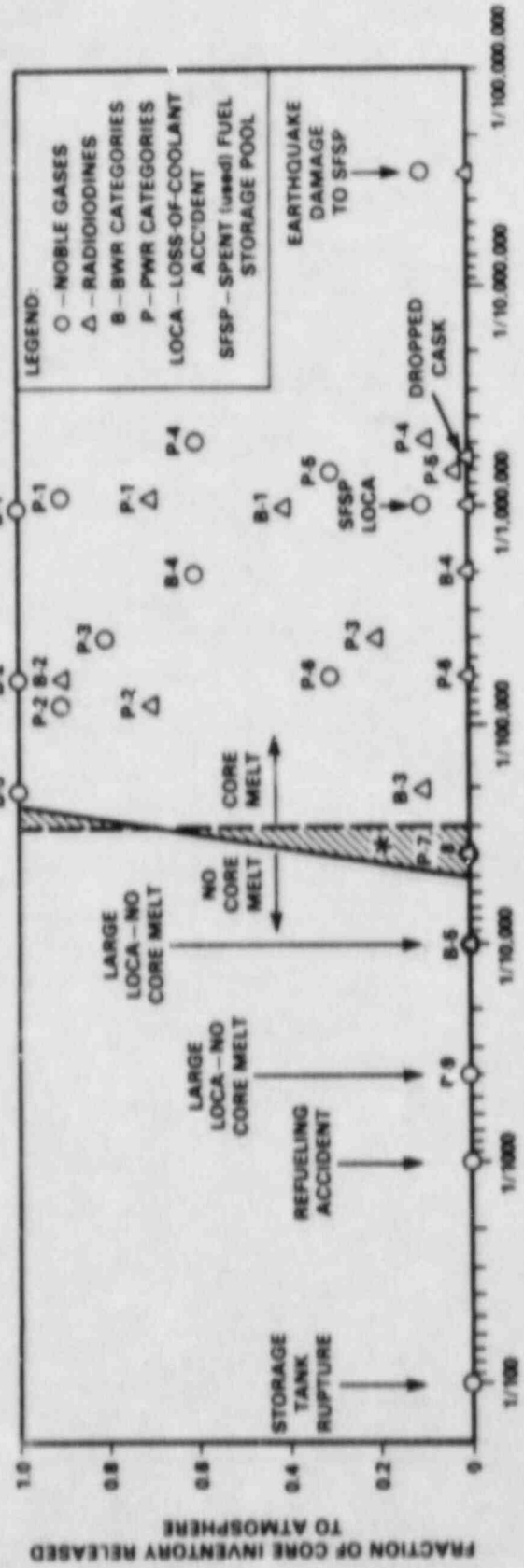


Figure 1 Release fractions vs. probabilities for nuclear power plant postulated accidents (taken from Table V2-1 and V2-2 of WASH-1400 Reactor Safety Study). Asterisk indicates partial core melt.

NOTE: There are large uncertainties in the estimated probabilities and release fractions in this figure.

Figure 1

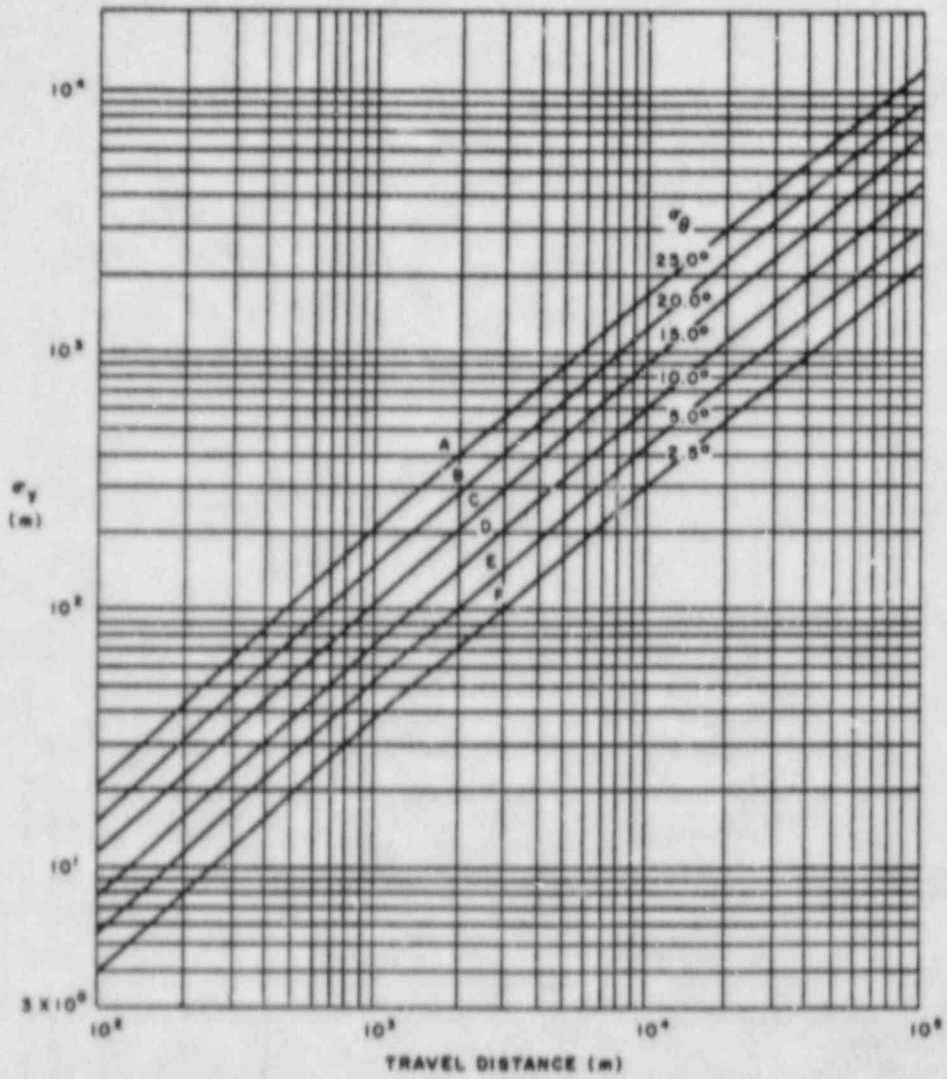


Figure 2: Sigma-y Plume Dispersion Parameter Versus Distance

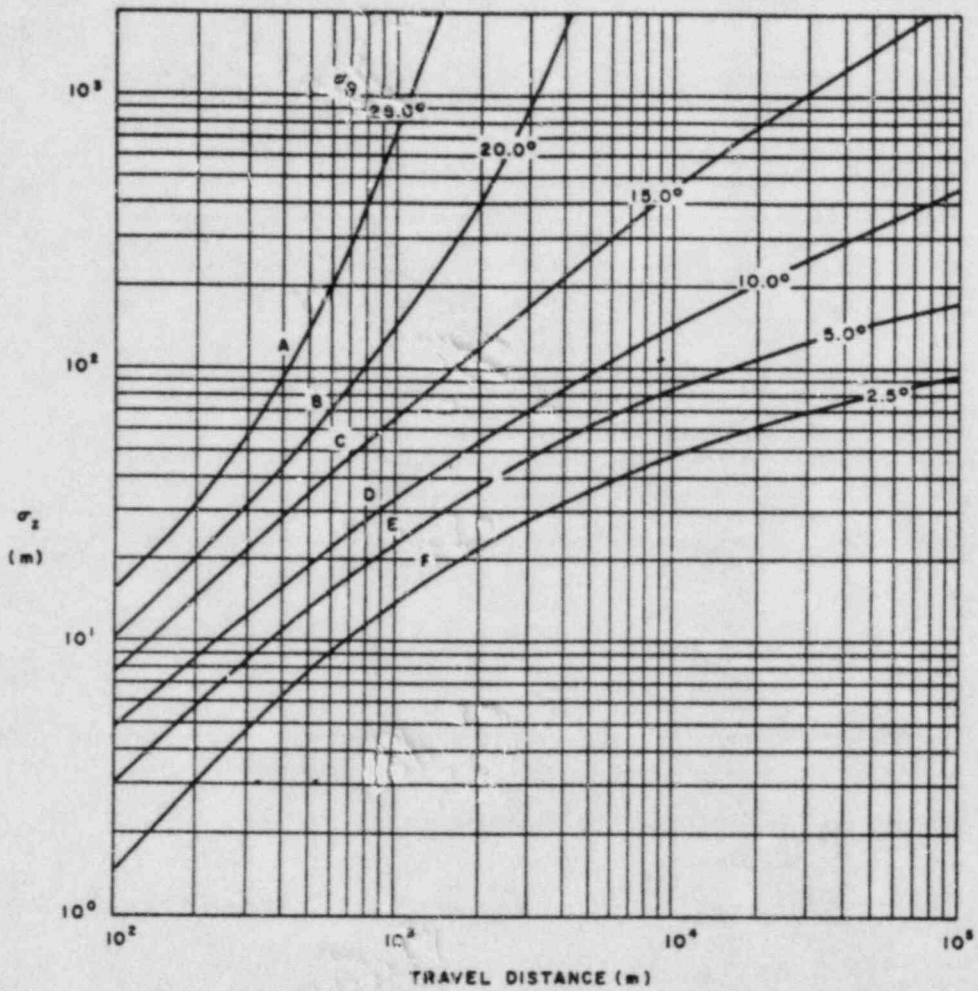


Figure 3: Sigma-z Plume Dispersion Parameter Versus Distance

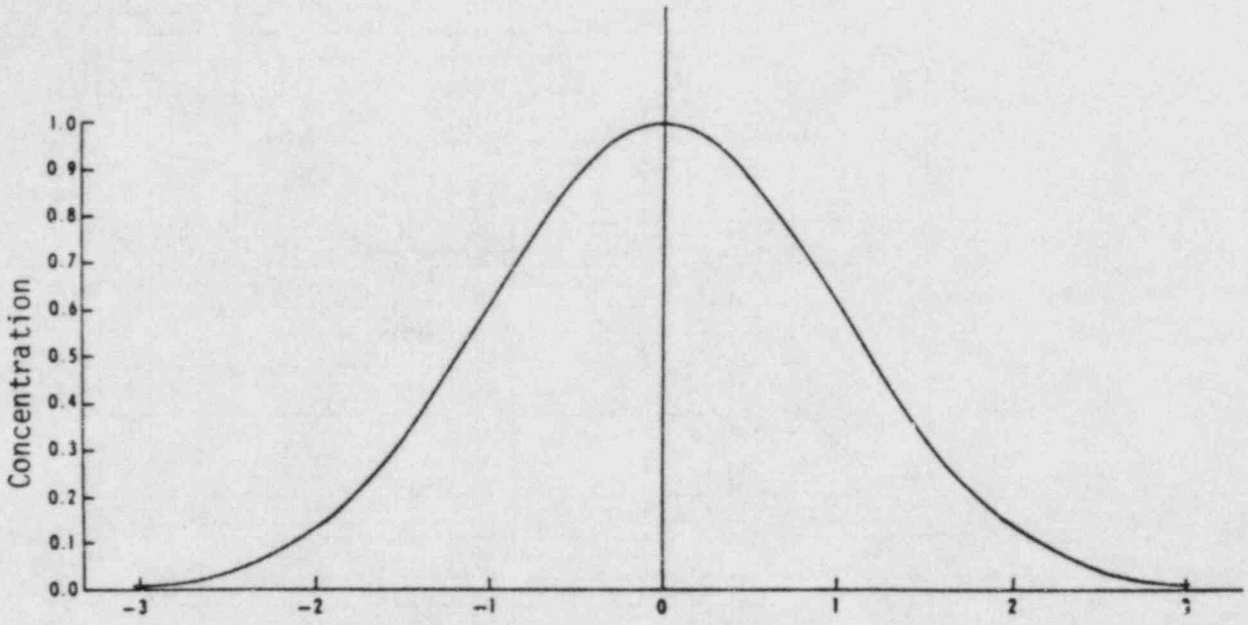


Figure 4: The Gaussian (Normal) distribution curve.

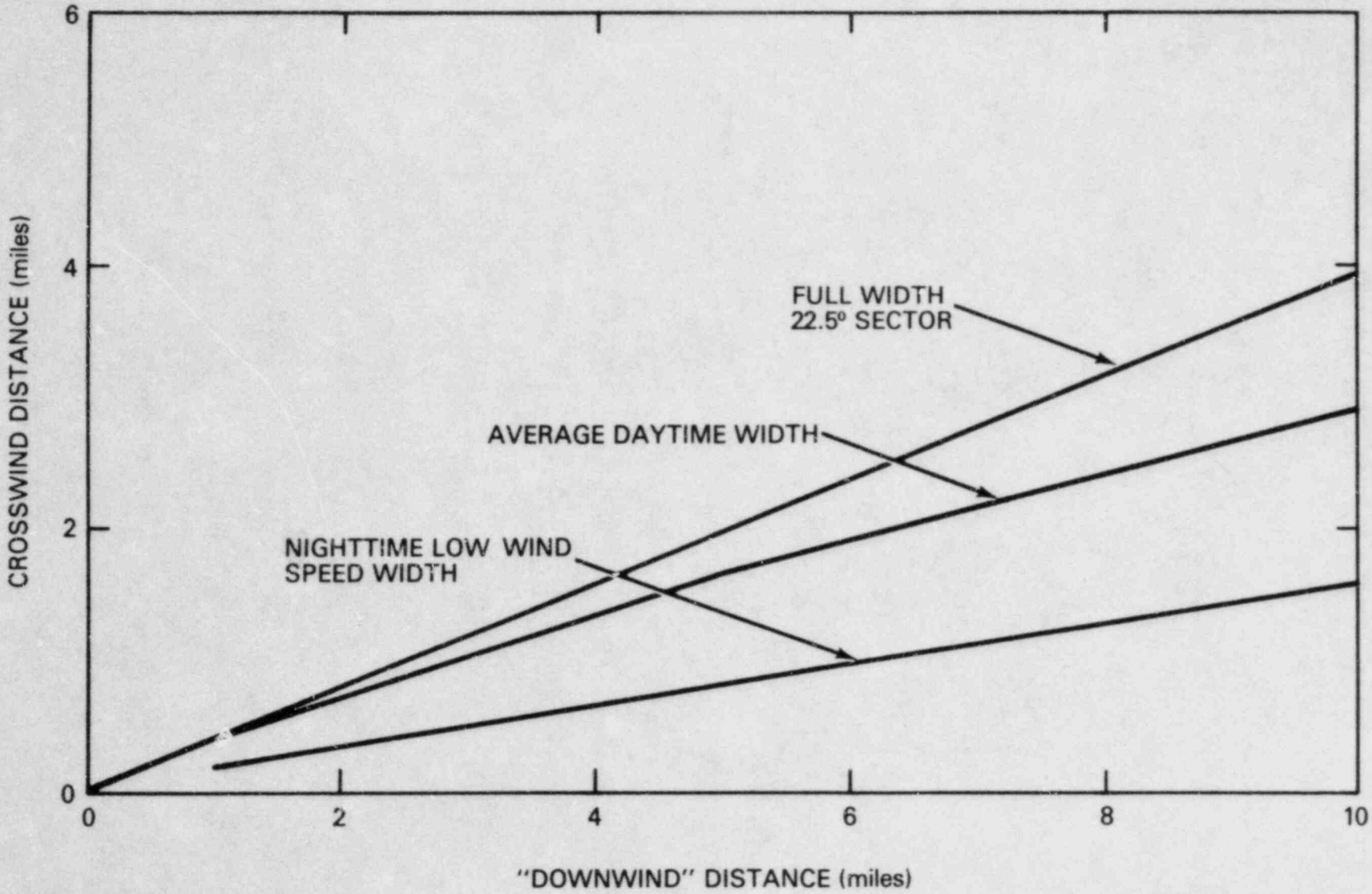
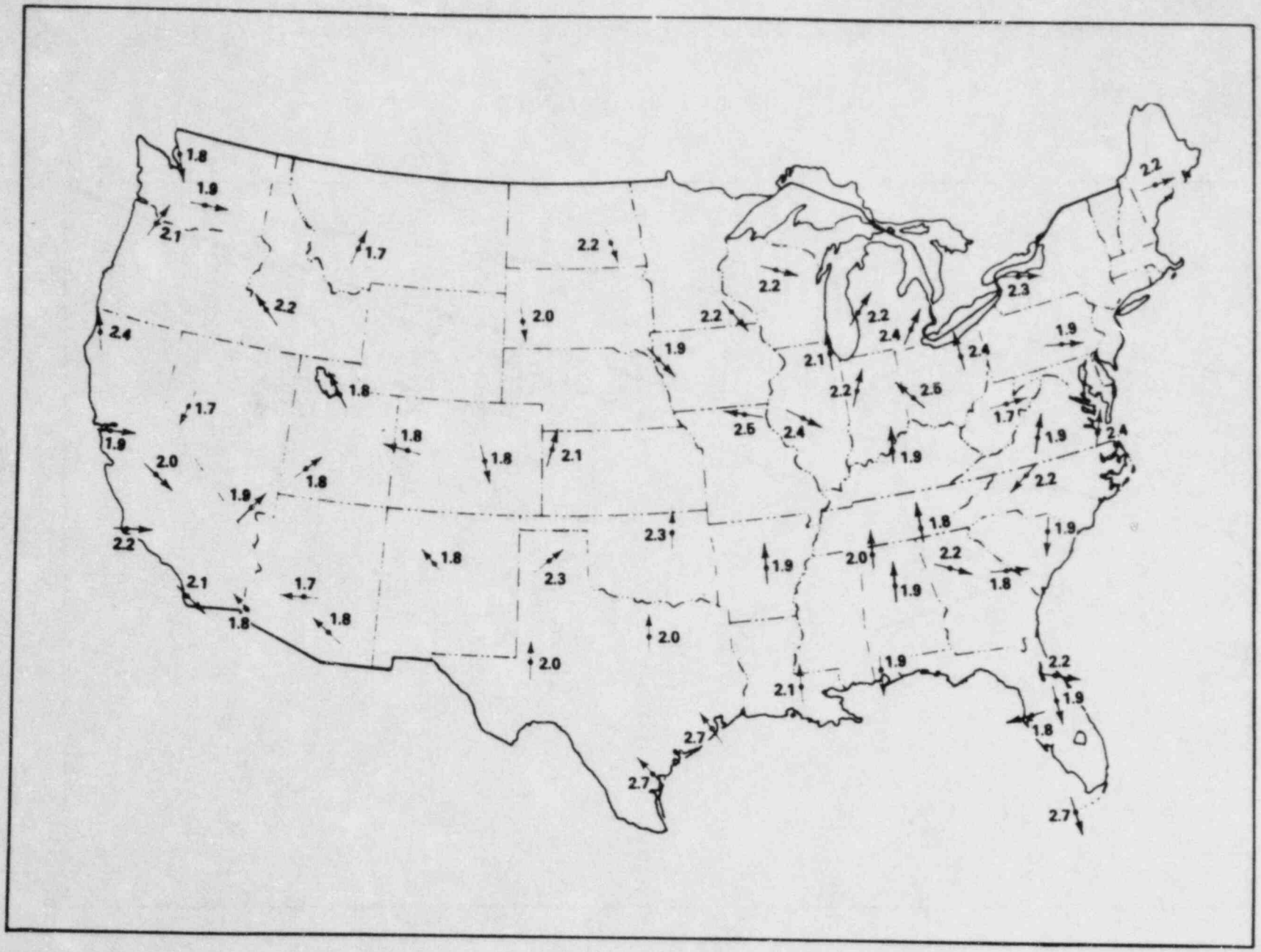
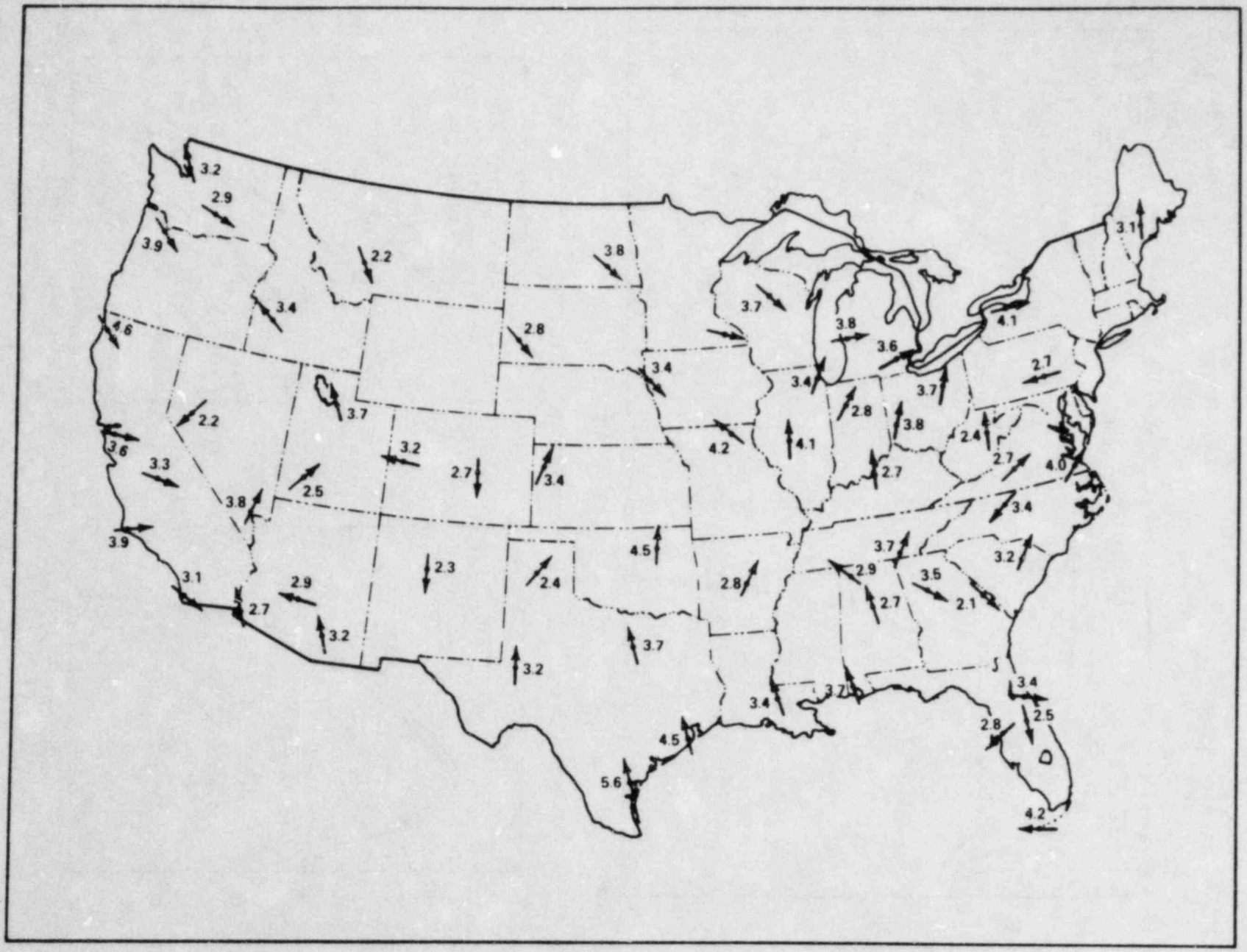


Figure 5: Theoretical full widths of puffs at one percent of maximum concentration vs distance along track of puff.



Highest 50-percent probability of hours of wind persistence in a 22½° sector centered on the indicated directions.

Figure 6 (Ref. 16)



Highest 50-percent probability of hours of wind persistence in a 67½° sector centered on the indicated directions.

Figure 7 (Ref. 16)

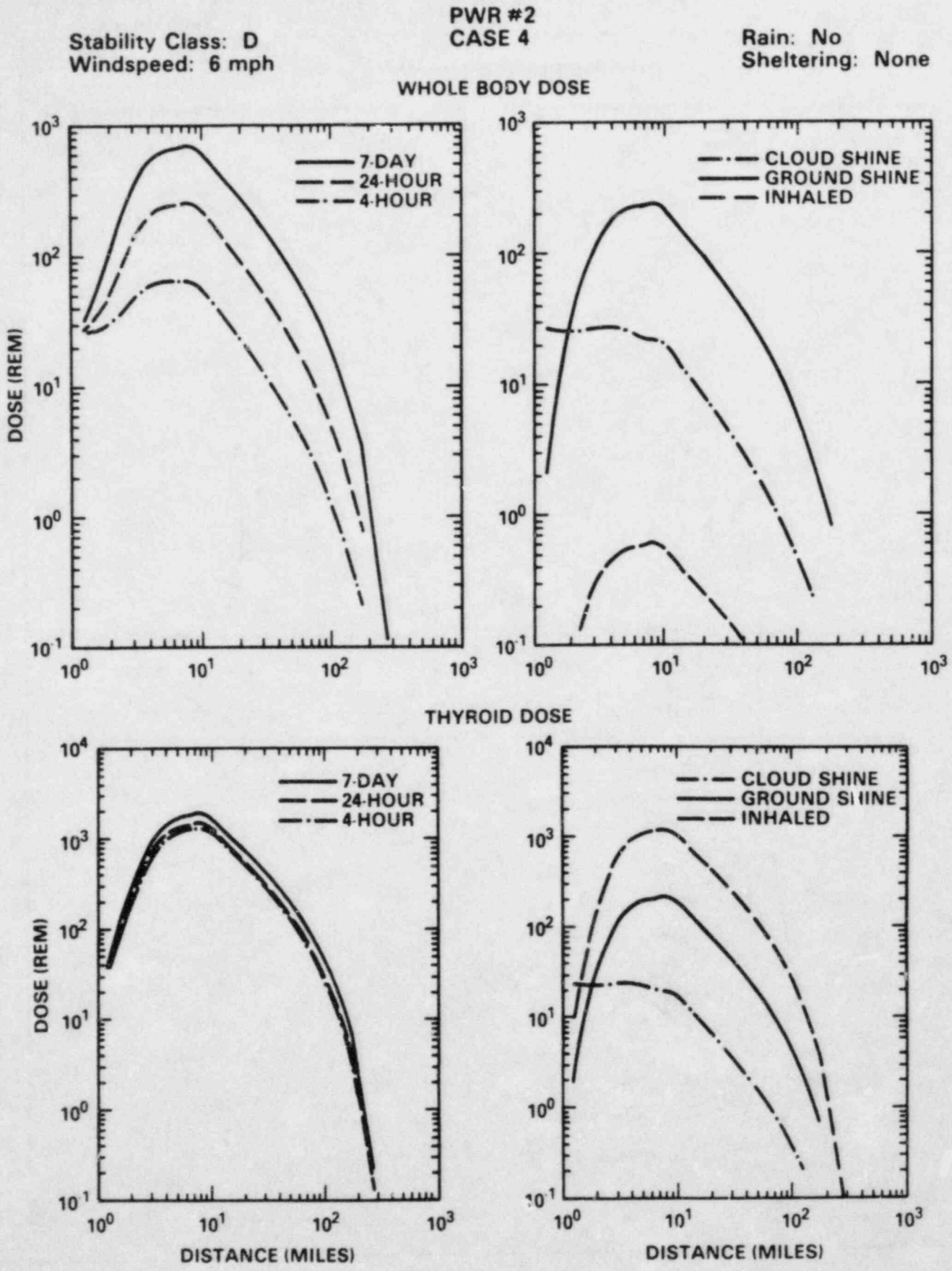

PRECALCULATED DOSES FOR EMERGENCY RESPONSE
PWR #2
CASE 4
Stability Class: D
Windspeed: 6 mph
Rain: No
Sheltering: None
WHOLE BODY DOSE
7-DAY
24-HOUR
4-HOUR
CLOUD SHINE
GROUND SHINE
INHALED
DOSE (REM)
THYROID DOSE
7-DAY
24-HOUR
4-HOUR
CLOUD SHINE
GROUND SHINE
INHALED
DOSE (REM)
DISTANCE (MILES)
DISTANCE (MILES)

Figure 8

PROJECTED WHOLE BODY DOSE vs DISTANCE
PWR #2 ACCIDENT

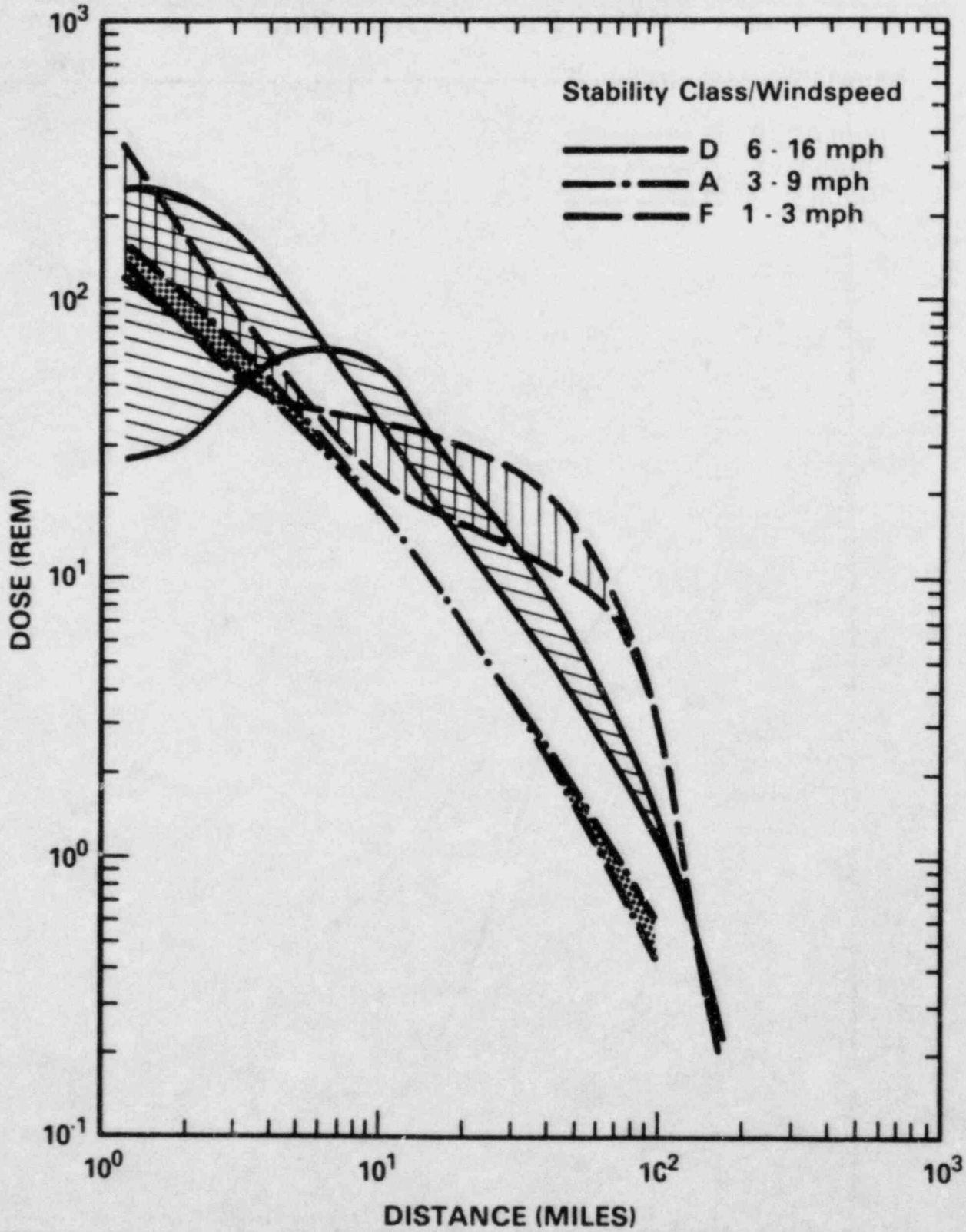


Figure 9

PROJECTED WHOLE BODY DOSE vs DISTANCE
PWR #2 ACCIDENT

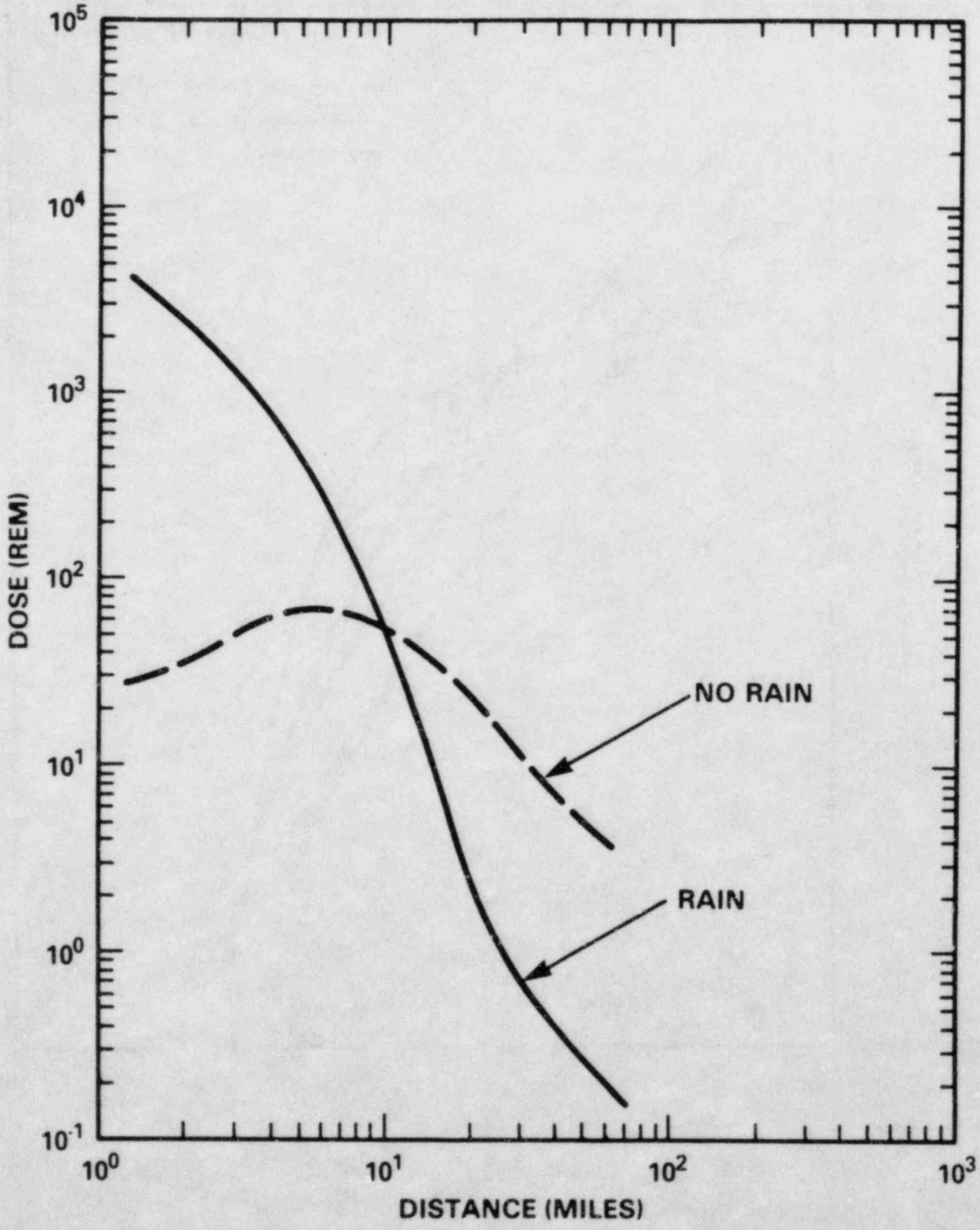


Figure 10

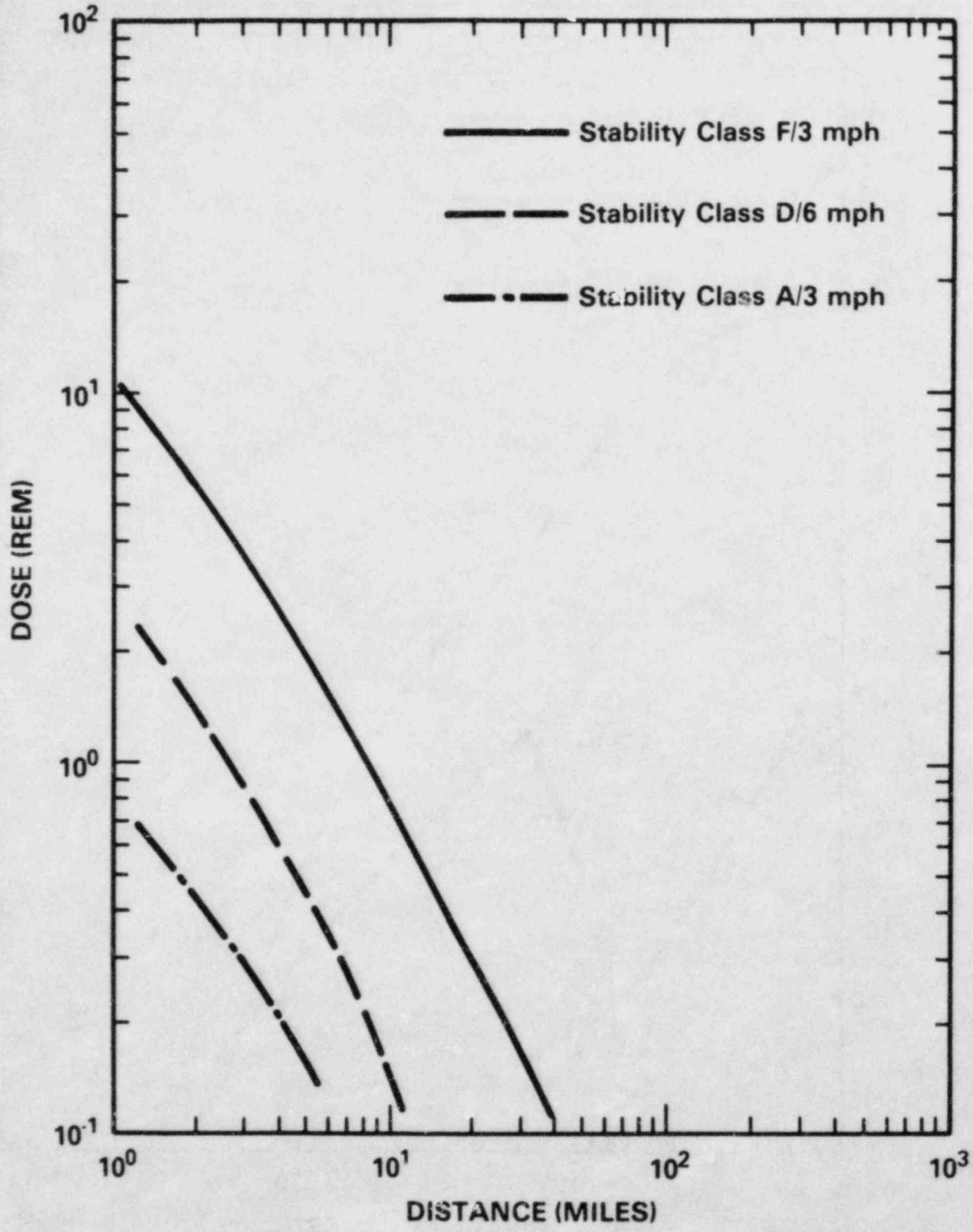

PROJECTED WHOLE BODY DOSE vs DISTANCE
PWR #6 ACCIDENT
Stability Class F/3 mph
Stability Class D/6 mph
Stability Class A/3 mph
DOSE (REM)
10^2
10^1
10^0
10^{-1}
10^0
10^1
10^2
10^3
DISTANCE (MILES)

Figure 11

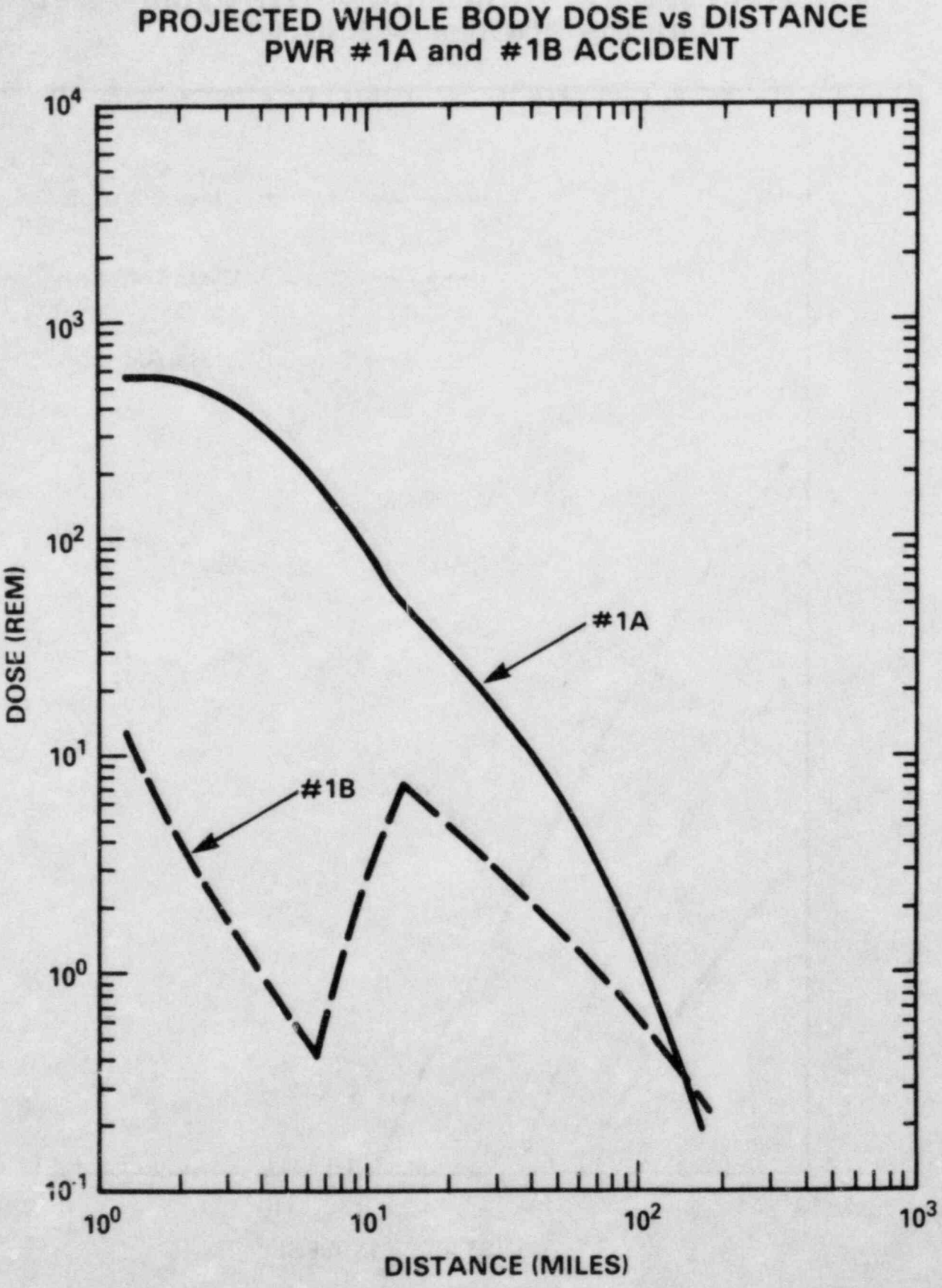

PROJECTED WHOLE BODY DOSE vs DISTANCE
PWR #1A and #1B ACCIDENT
DOSE (REM)
10^4
10^3
10^2
10^1
10^0
10^{-1}
#1A
#1B
10^0
10^1
10^2
10^3
DISTANCE (MILES)

Figure 12

Appendix A

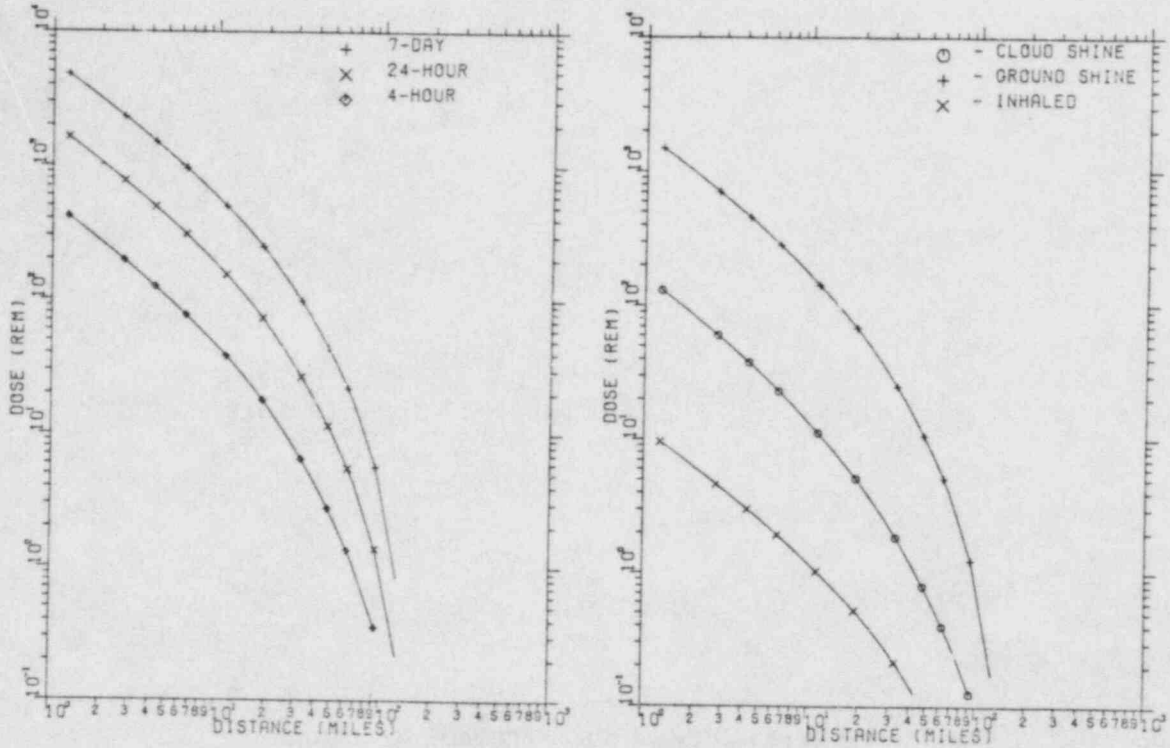
Precalculated Doses for Emergency Response

PWR #1A
CASE 1

Stability Class: A
Windspeed: 3 mph

Rain: No
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

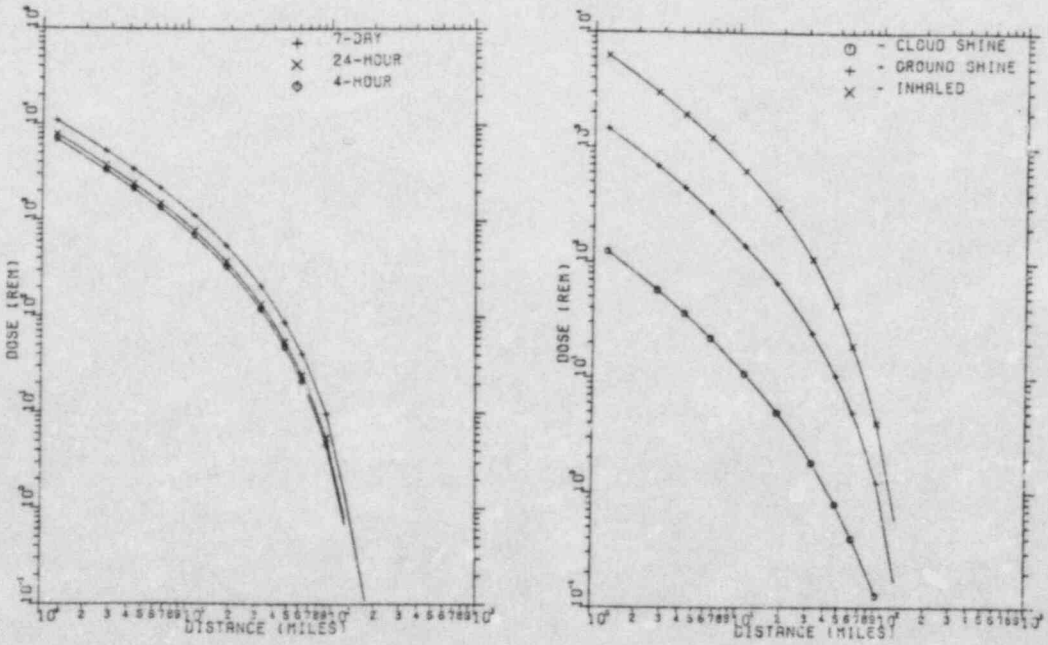


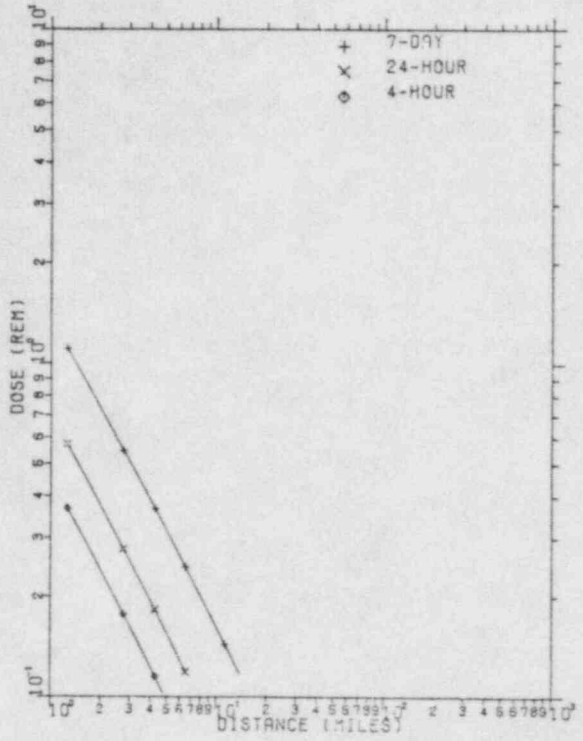
Figure 1A-1

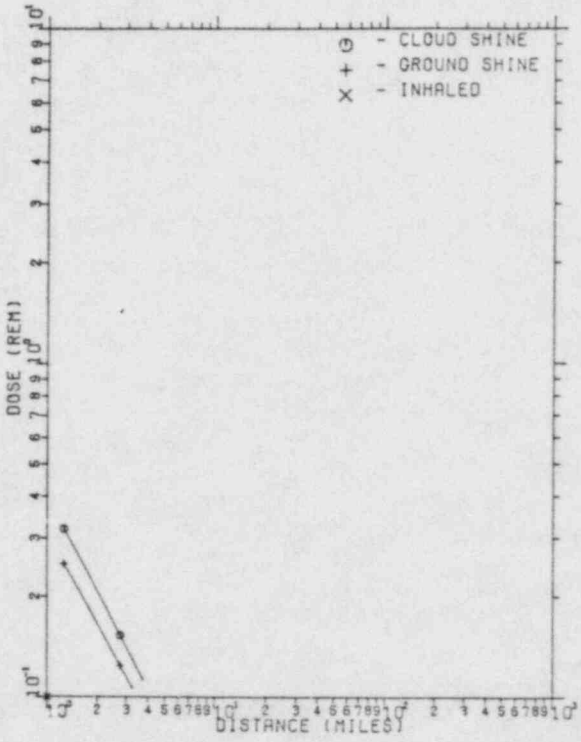
PWR #1B
CASE 1

Stability Class: A
Windspeed: 3 mph

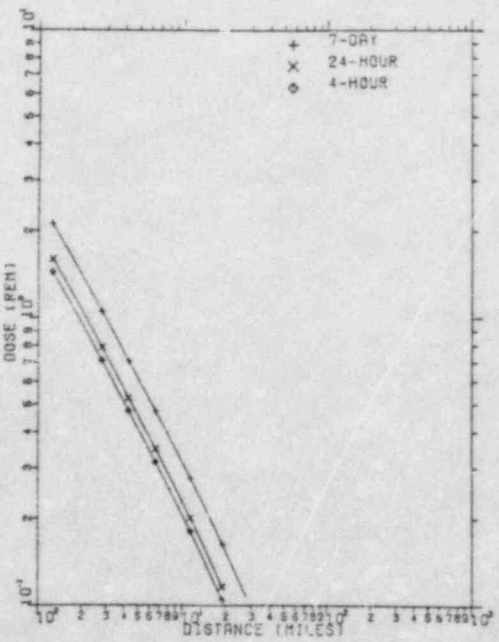
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



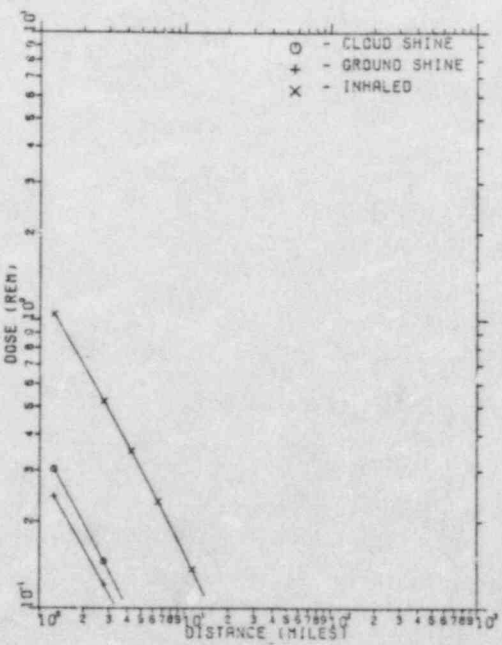


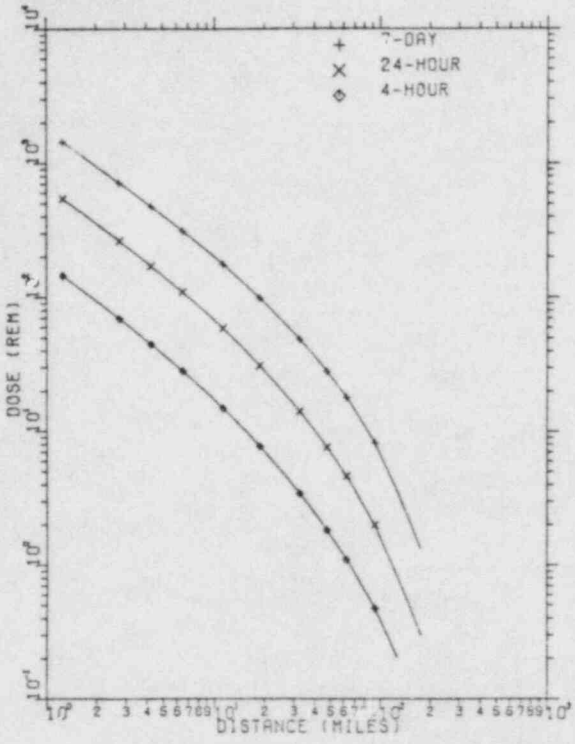
Figure 1B-1

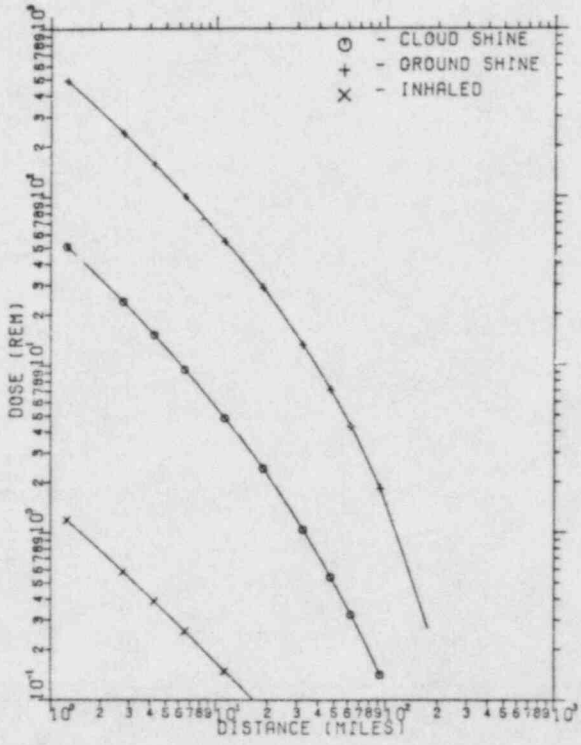
PWR #2
CASE 1

Stability Class: A
Windspeed: 3 mph

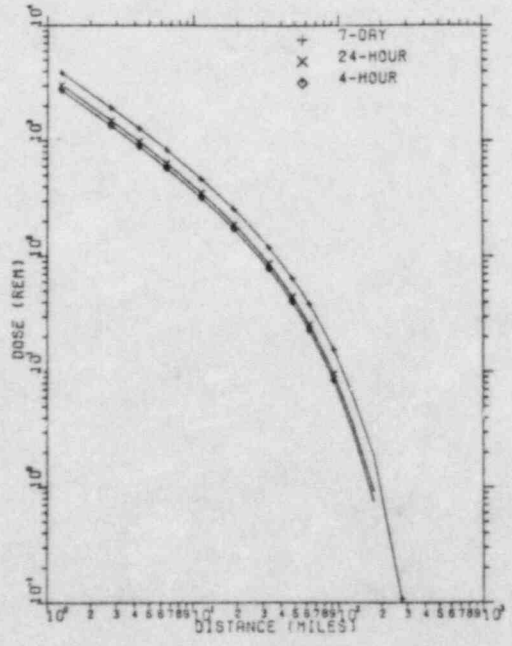
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



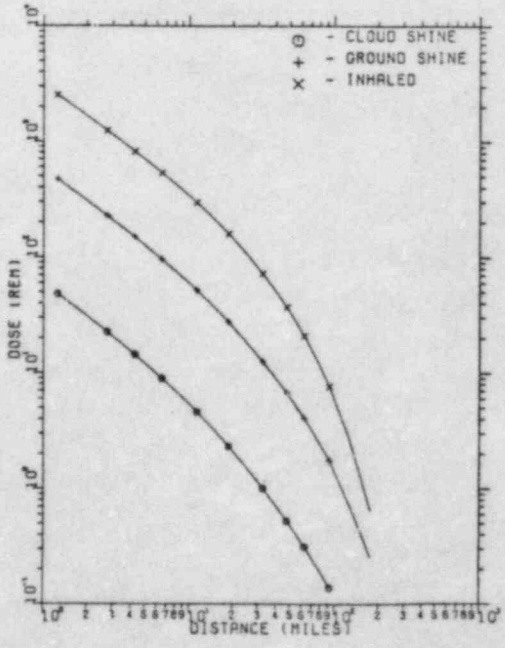


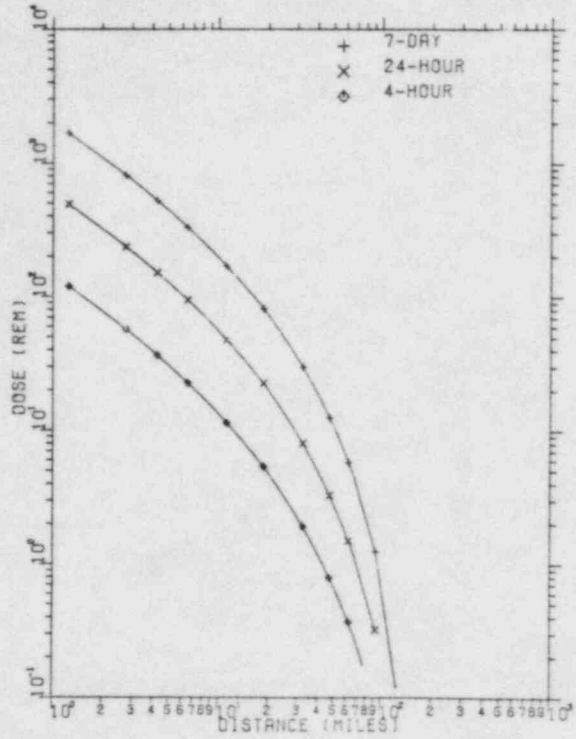
Figure 2-1

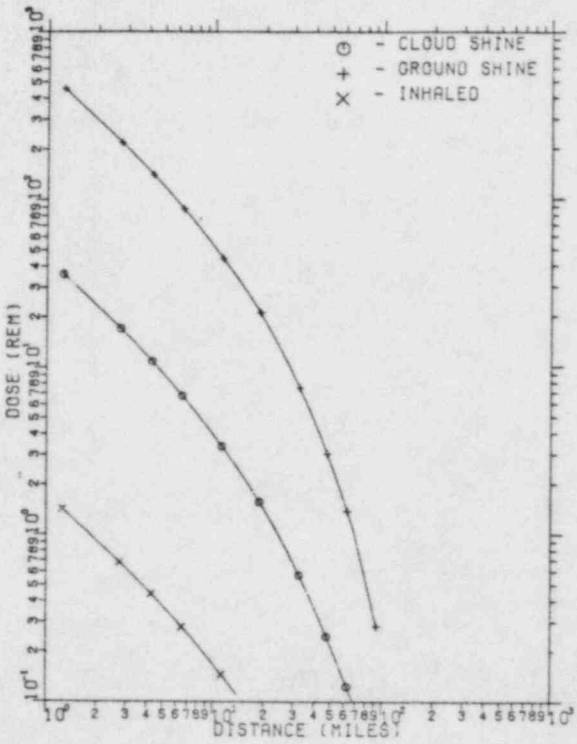
PWR #3
CASE 1

Stability Class: A
Windspeed: 3 mph

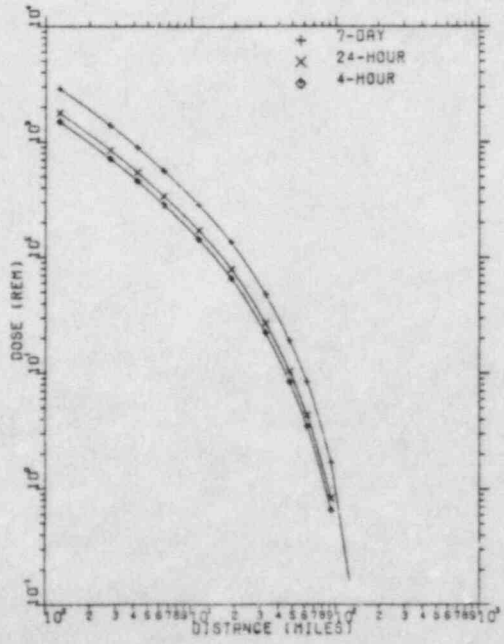
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



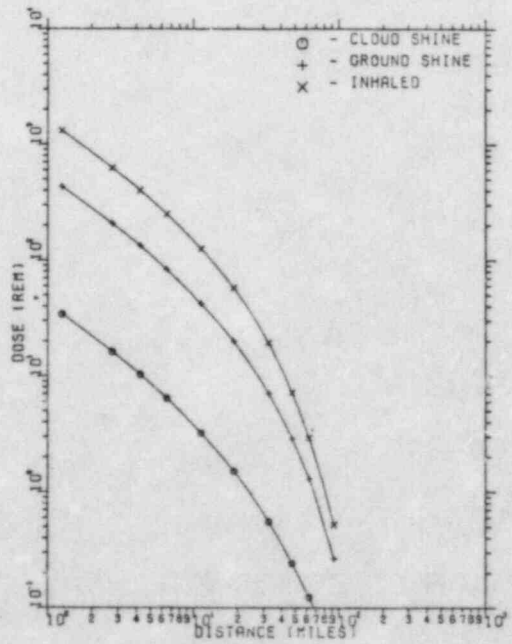


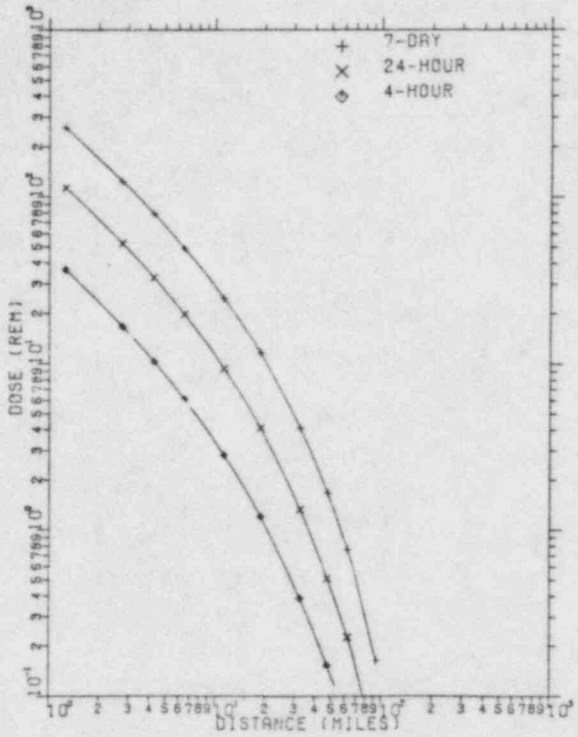
Figure 3-1

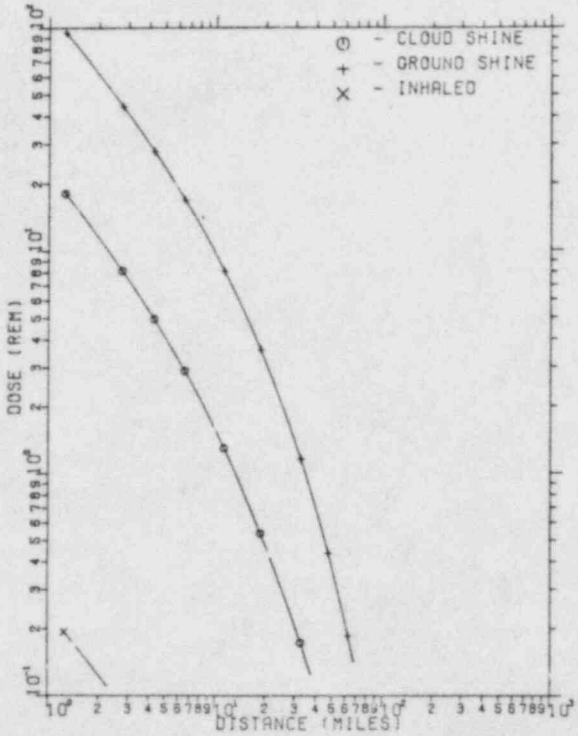
PWR #4
CASE 1

Stability Class: A
Windspeed: 3 mph

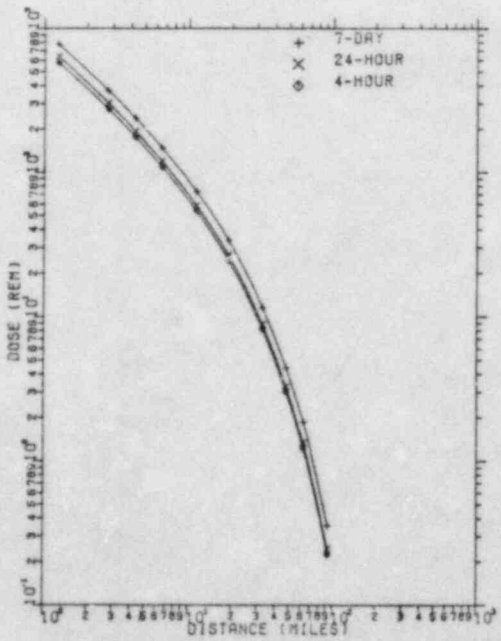
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



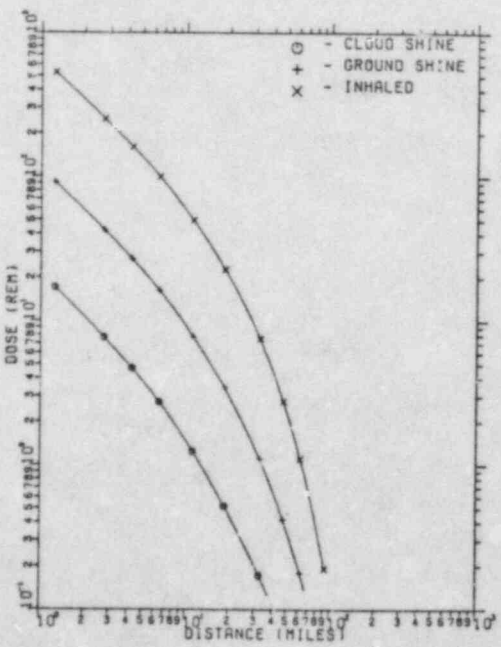


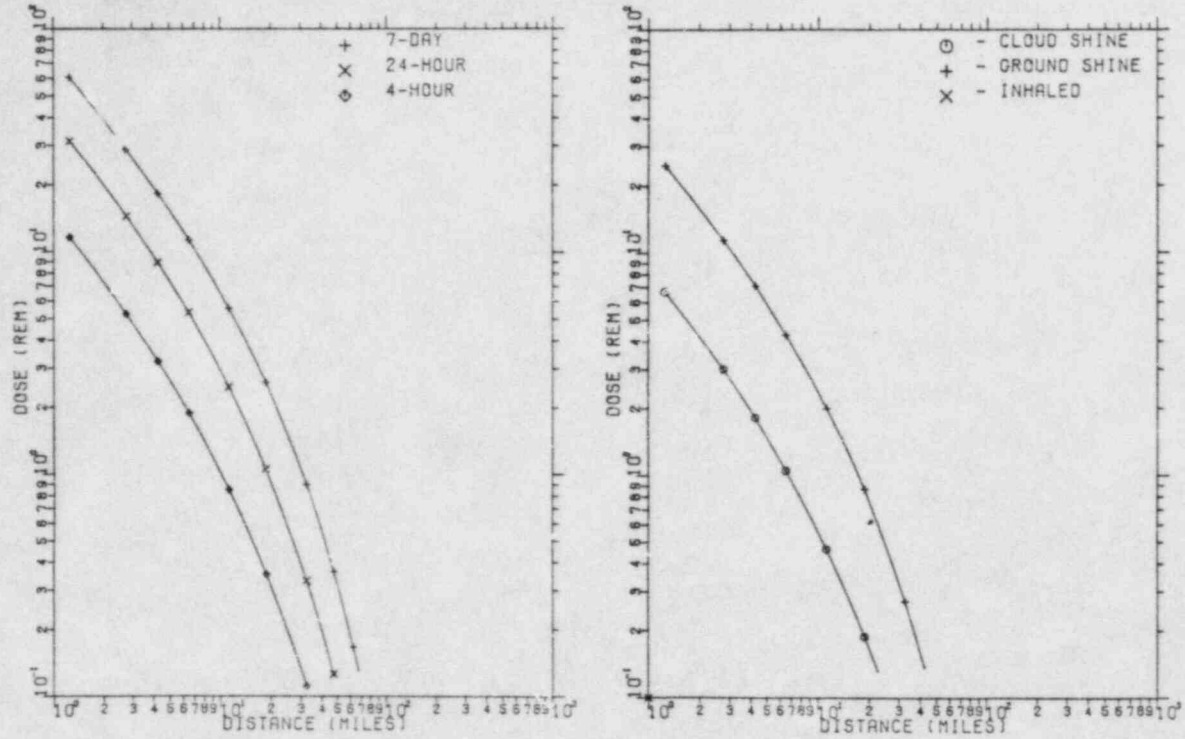
Figure 4-1

PWR #5
CASE 1

Stability Class: A
Windspeed: 3 mph

Rain: No
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

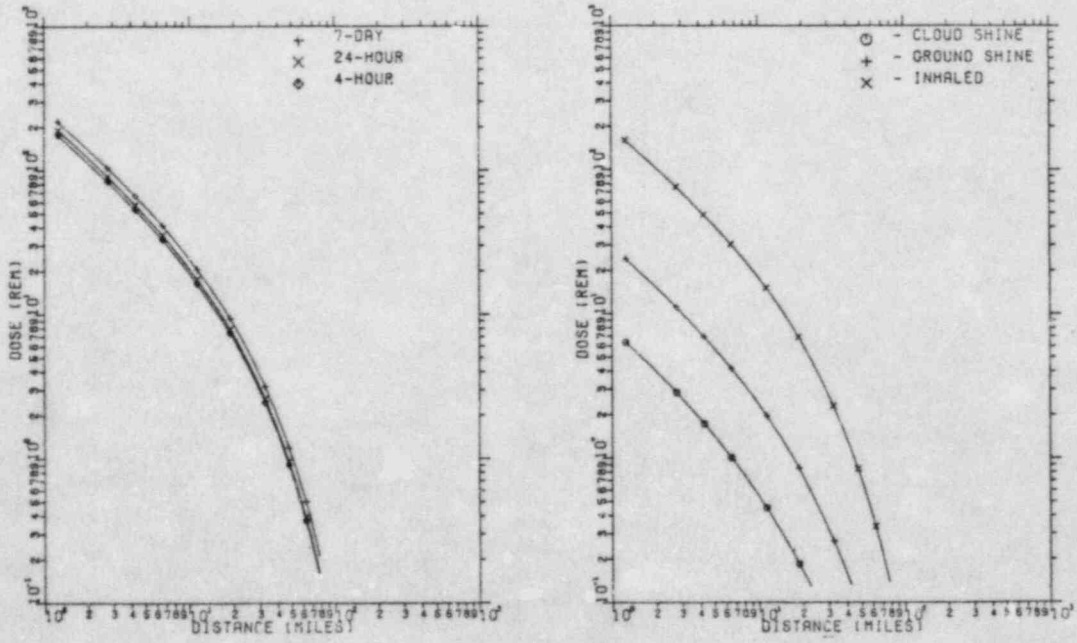


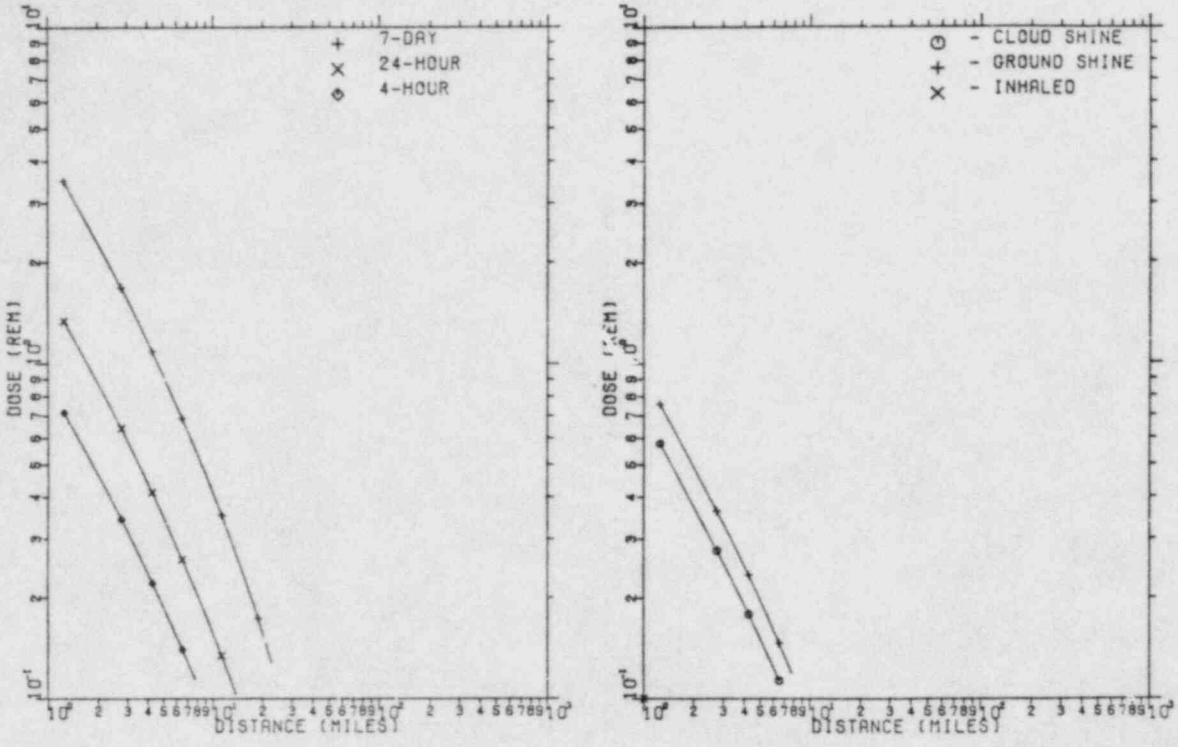
Figure 5-1

PWR #6
CASE 1

Stability Class: A
Windspeed: 3 mph

Rain: No
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

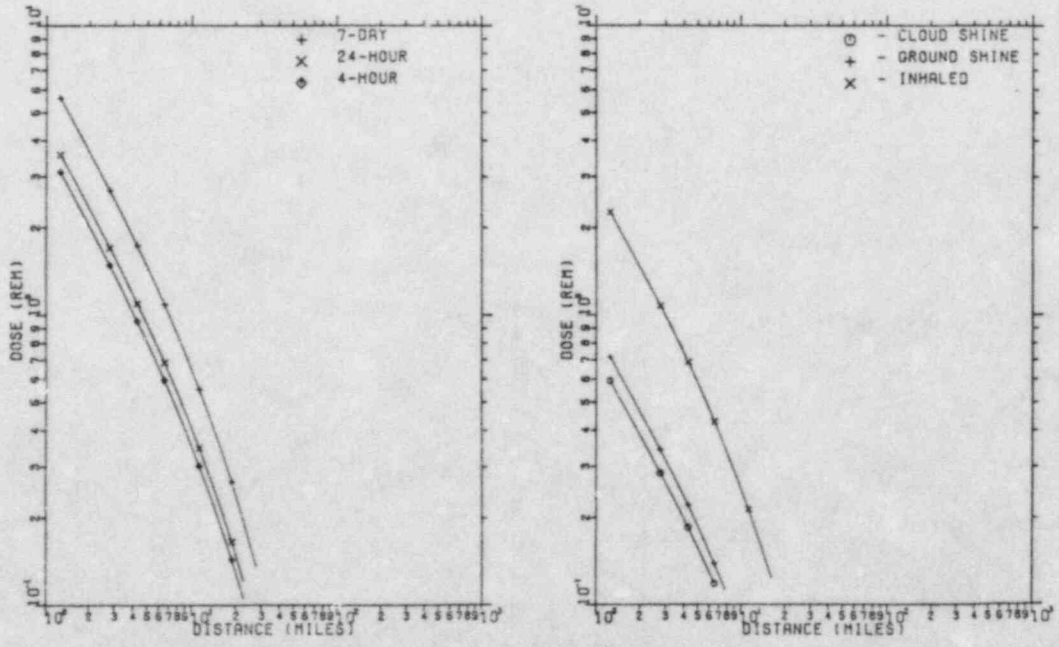


Figure 6-1

PWR #7

Case 1

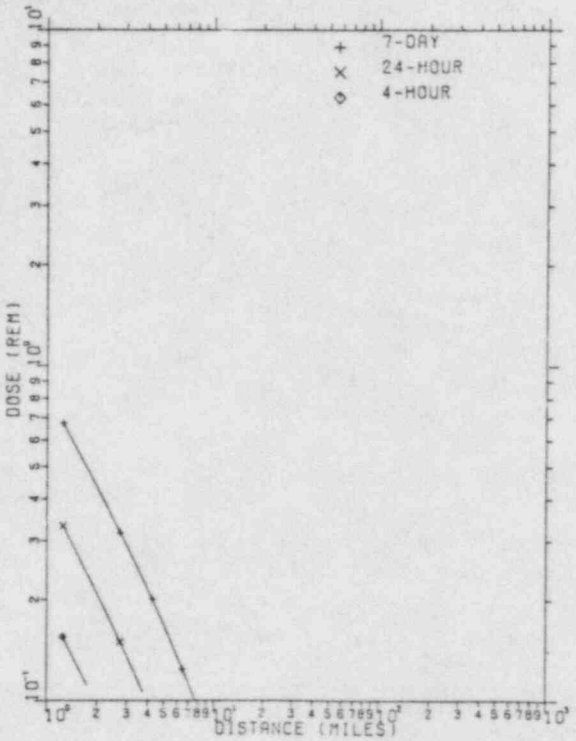
Doses less than 0.1 Rem

PWR #8
CASE 1

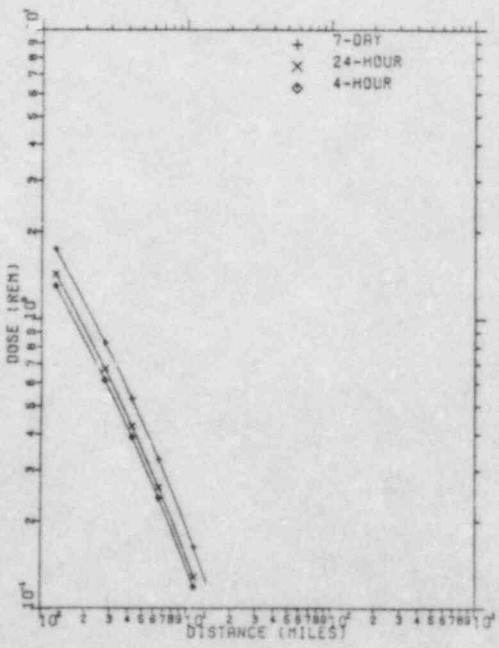
Stability Class: A
Windspeed: 3 mph

Rain: No
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE



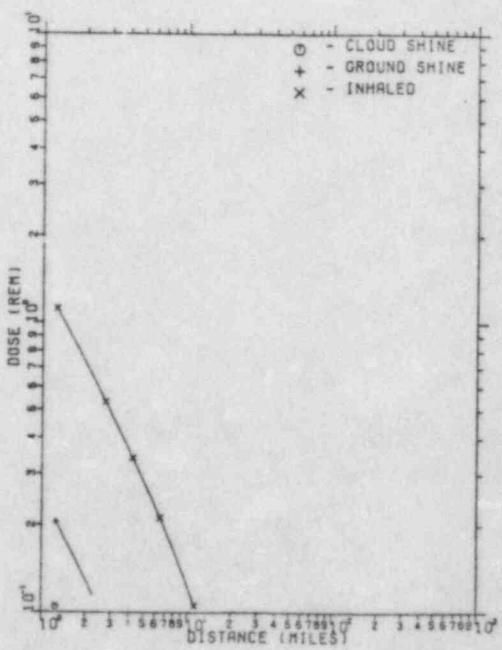


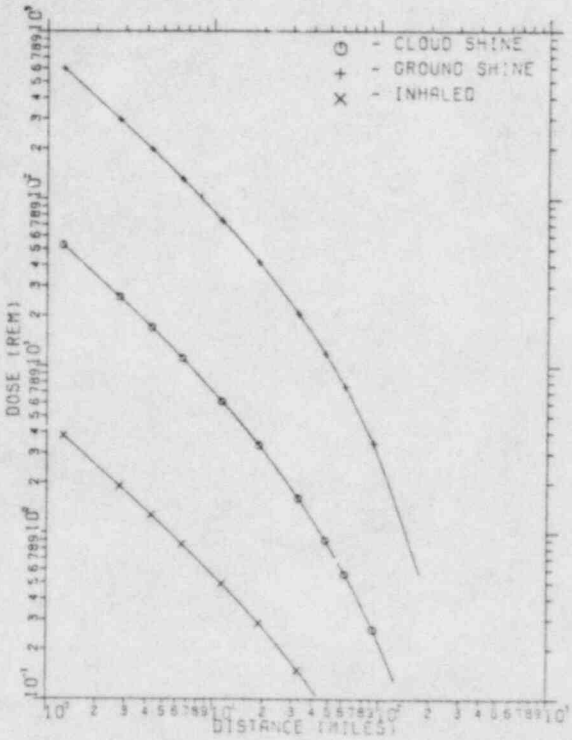
Figure 8-1

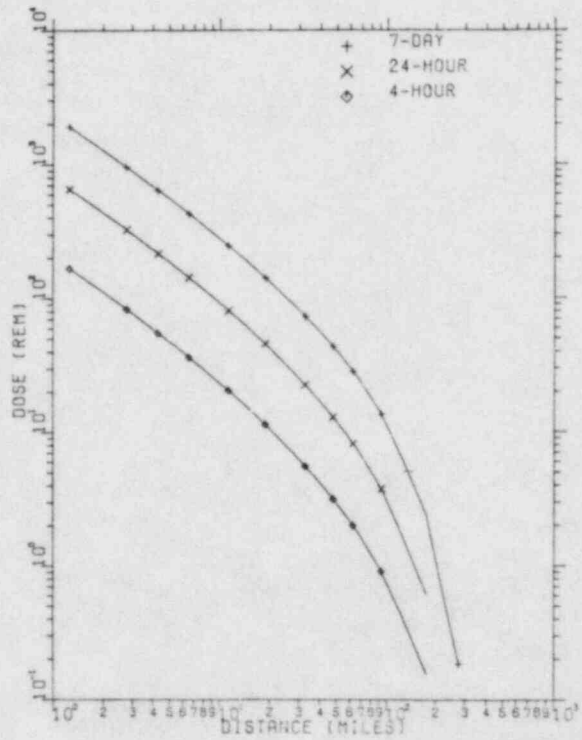
PWR #1A
CASE 2

Stability Class: A
Windspeed: 9 mph

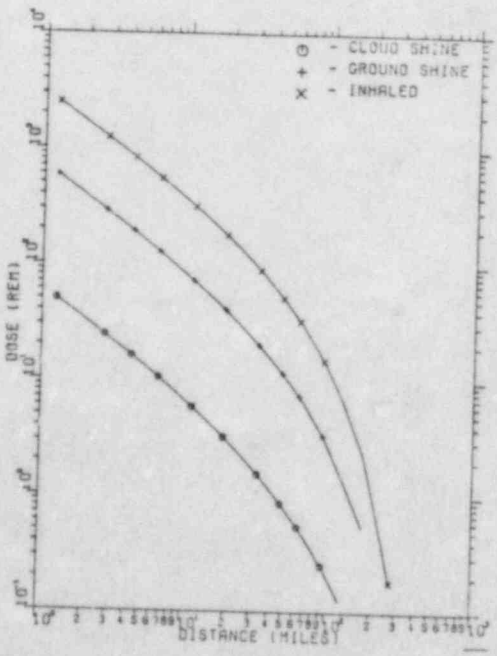
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



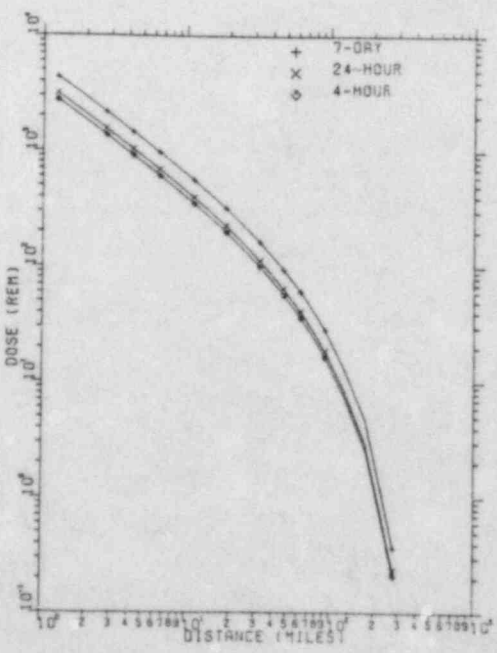


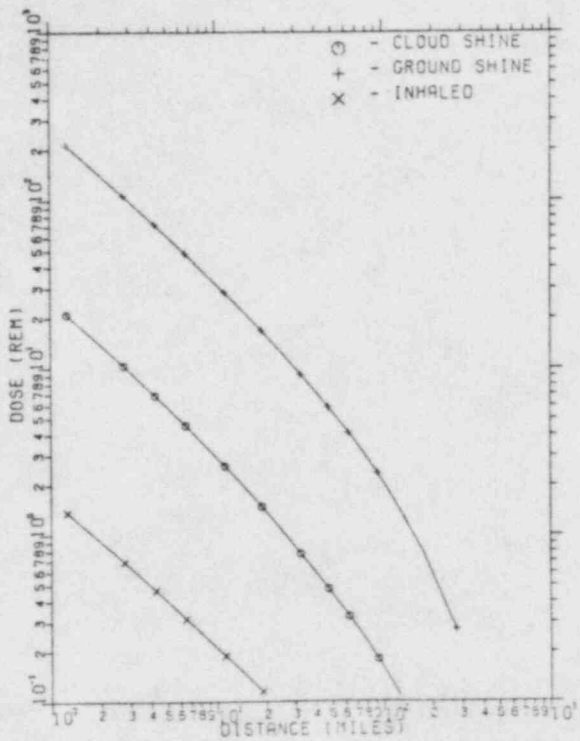
Figure 1A-2

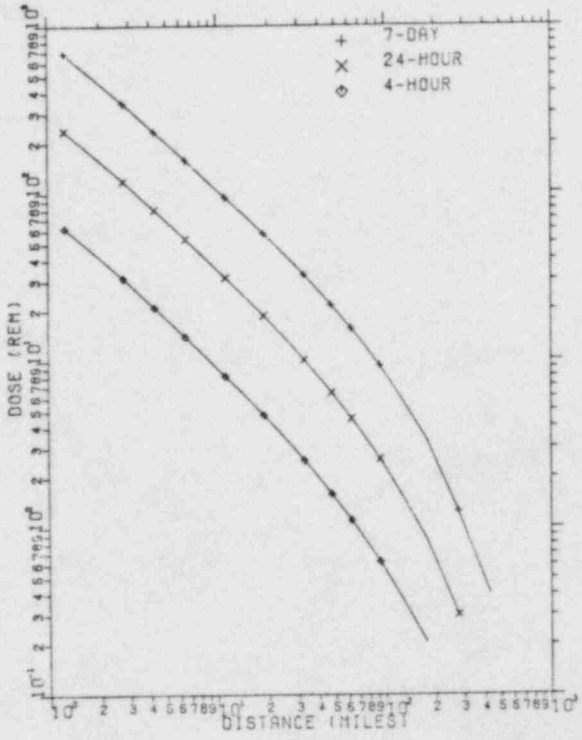
PWR #1B
CASE 2

Stability Class: A
Windspeed: 9 mph

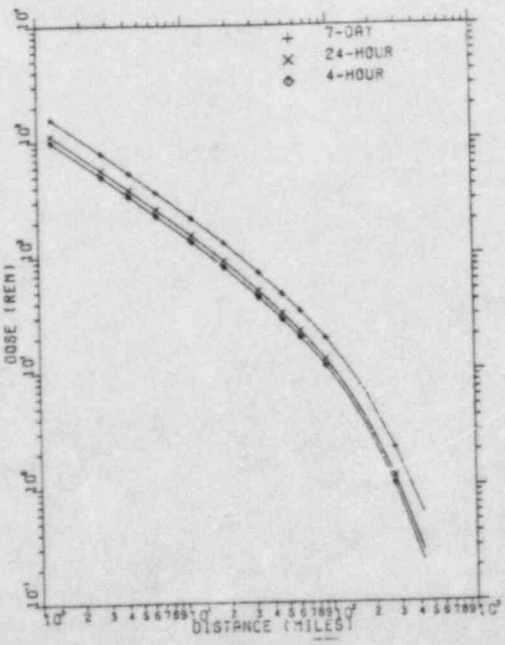
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



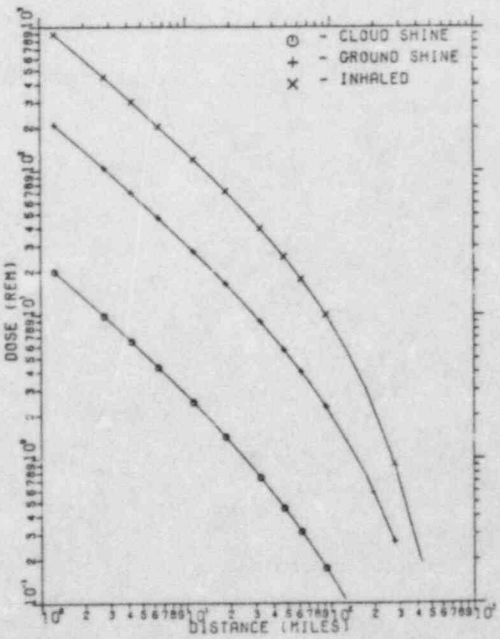


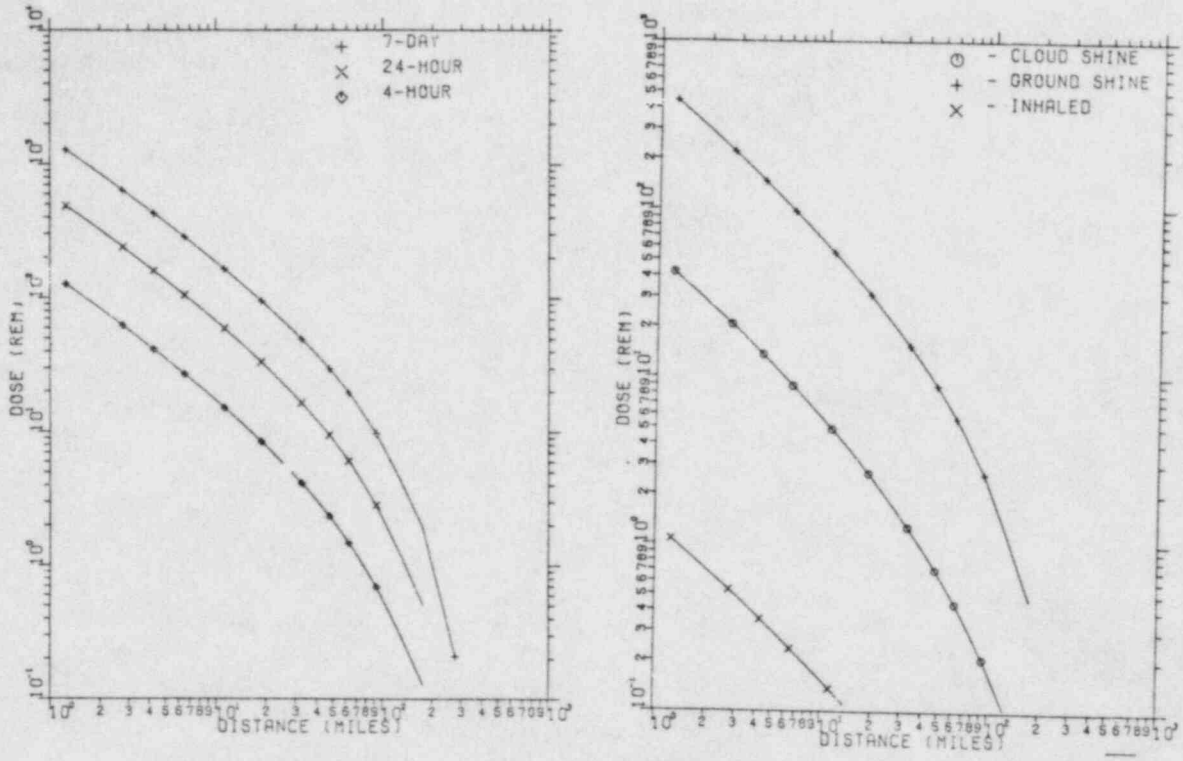
Figure 1B-2

PWR #2
CASE 2

Stability Class: A
Windspeed: 9 mph

Rain: No
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

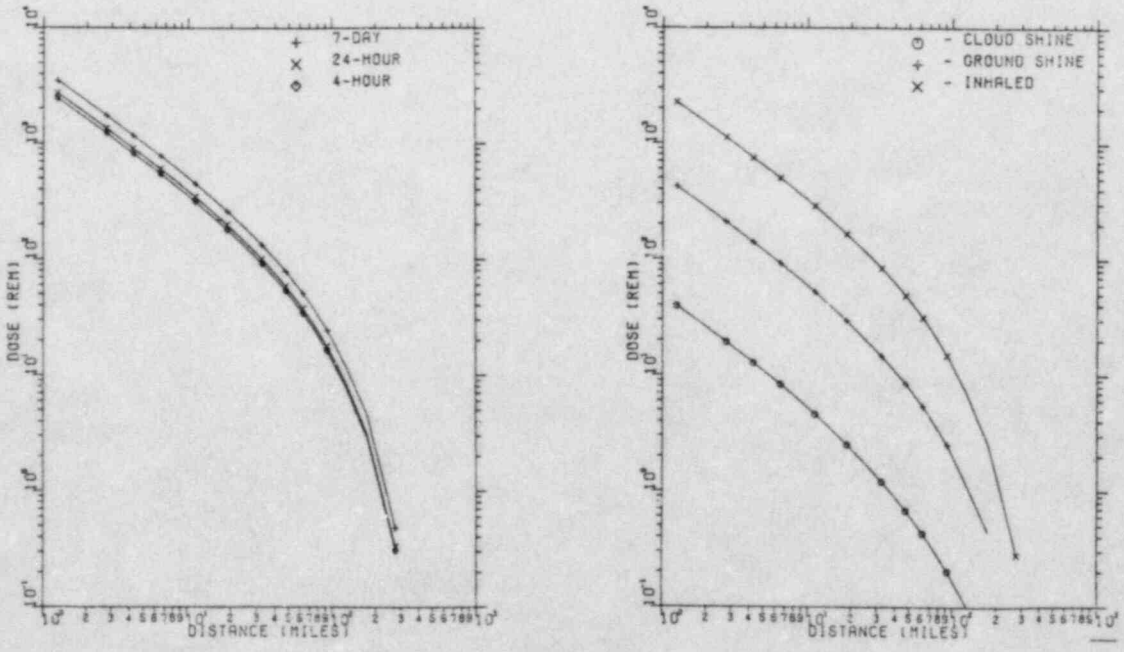


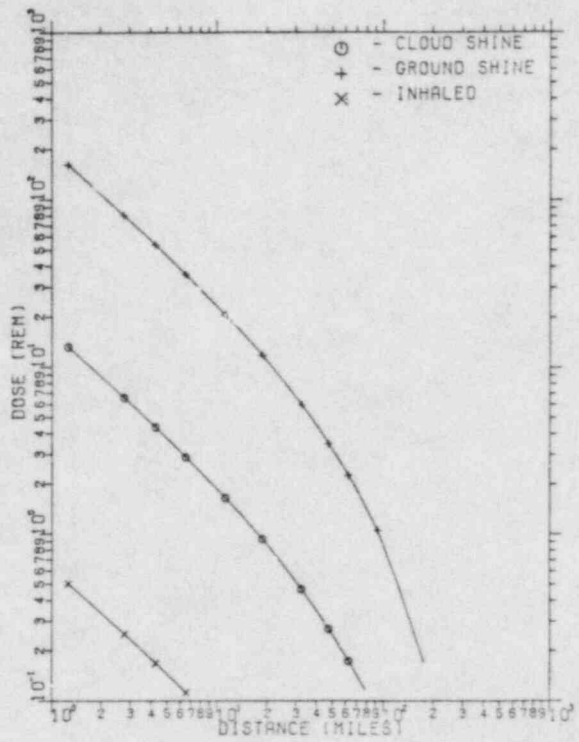
Figure 2-2

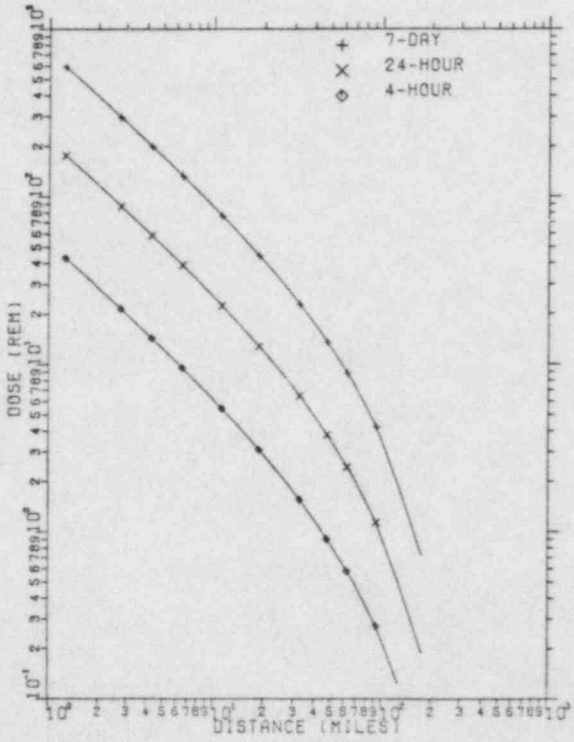
PWR #3
CASE 2

Stability Class: A
Windspeed: 9 mph

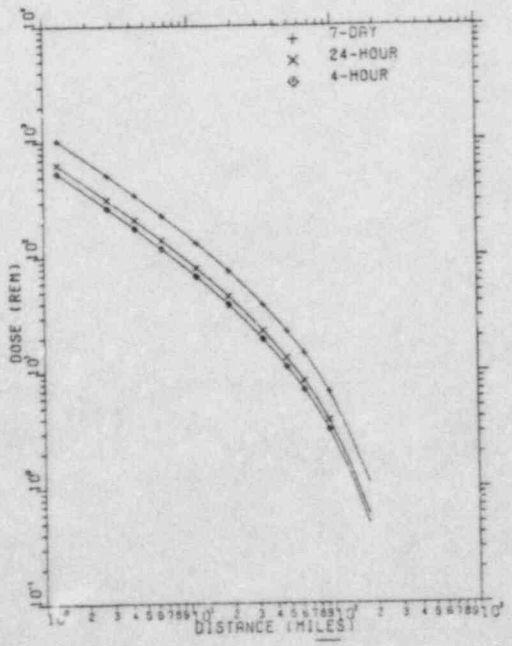
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



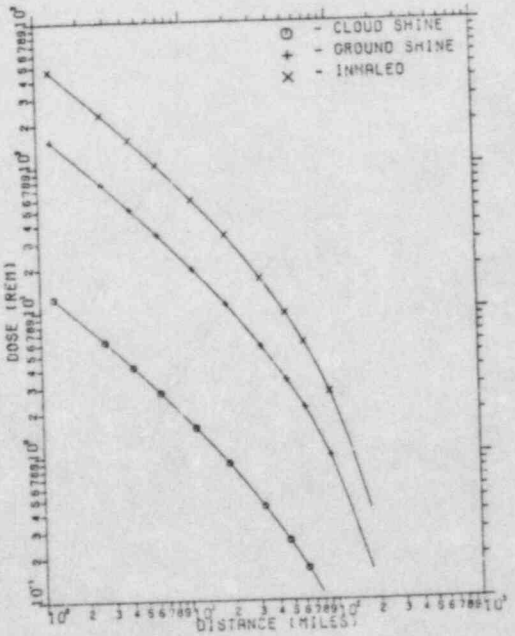


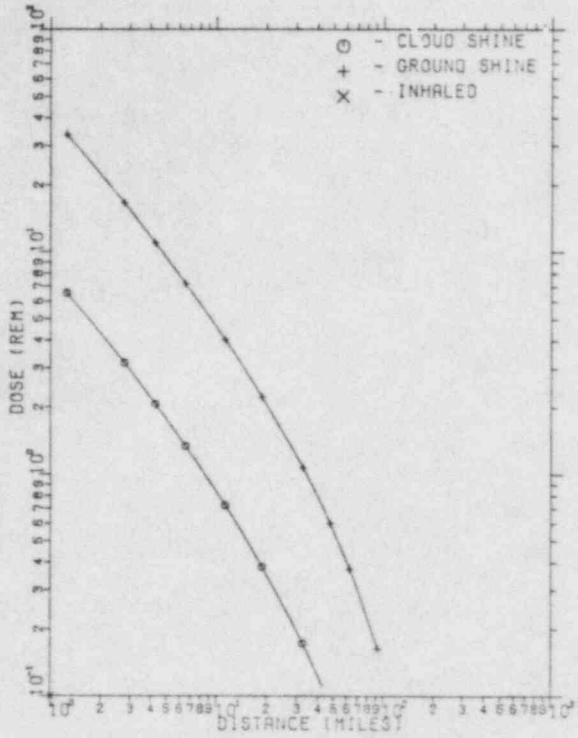
Figure 3-2

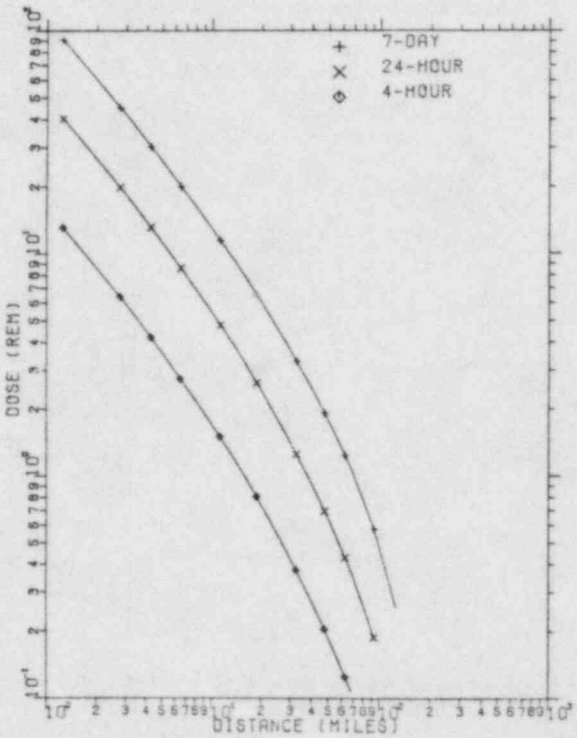
PWR #1
CASE 2

Stability Class: A
Windspeed: 9 mph

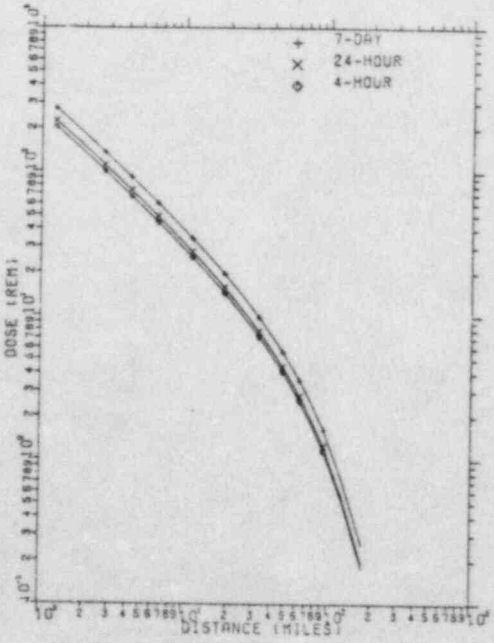
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



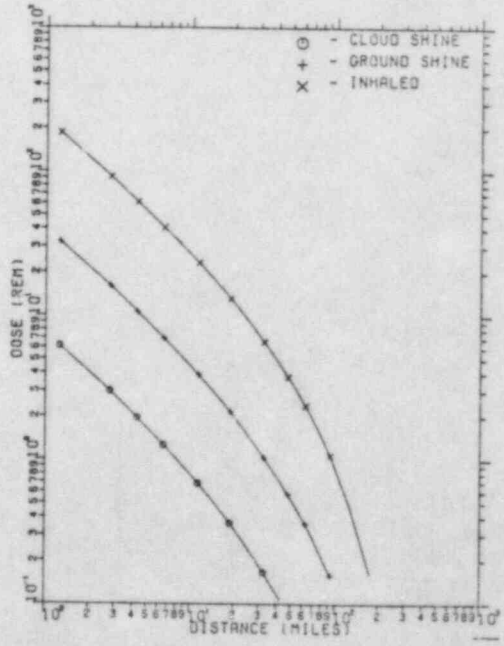


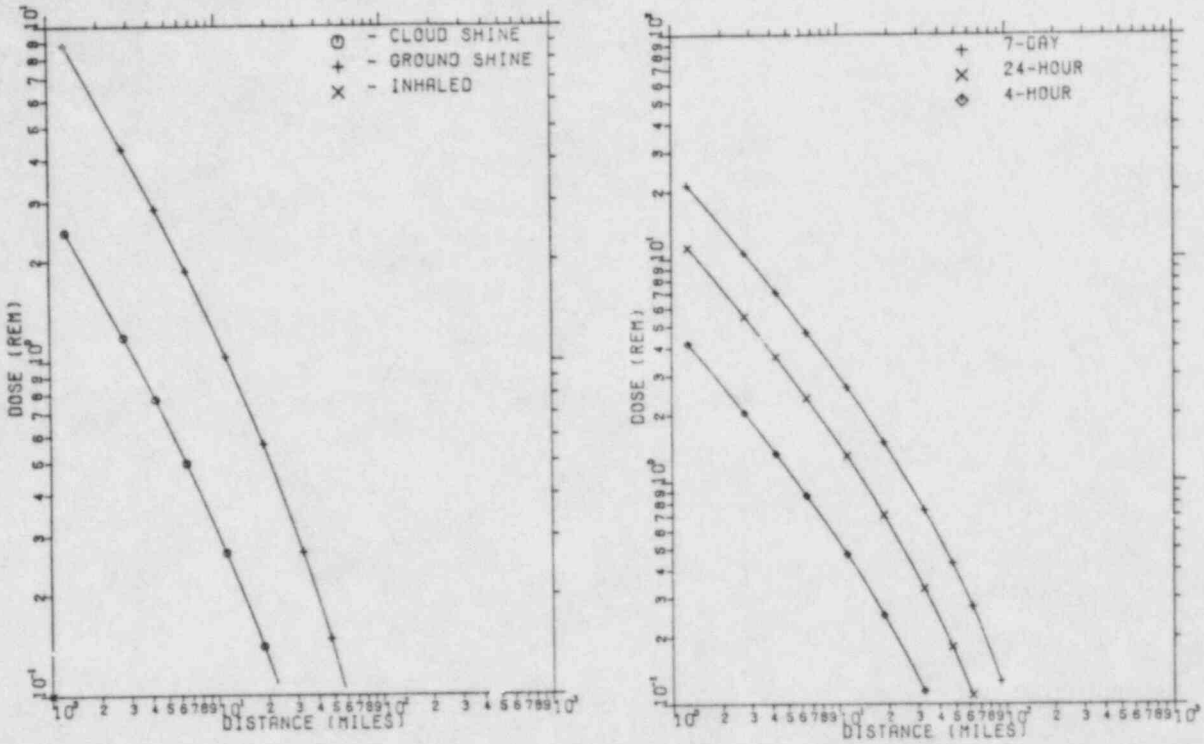
Figure 4-2

PWR #5
CASE 2

Stability Class: A
Windspeed: 9 mph

Rain: No
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

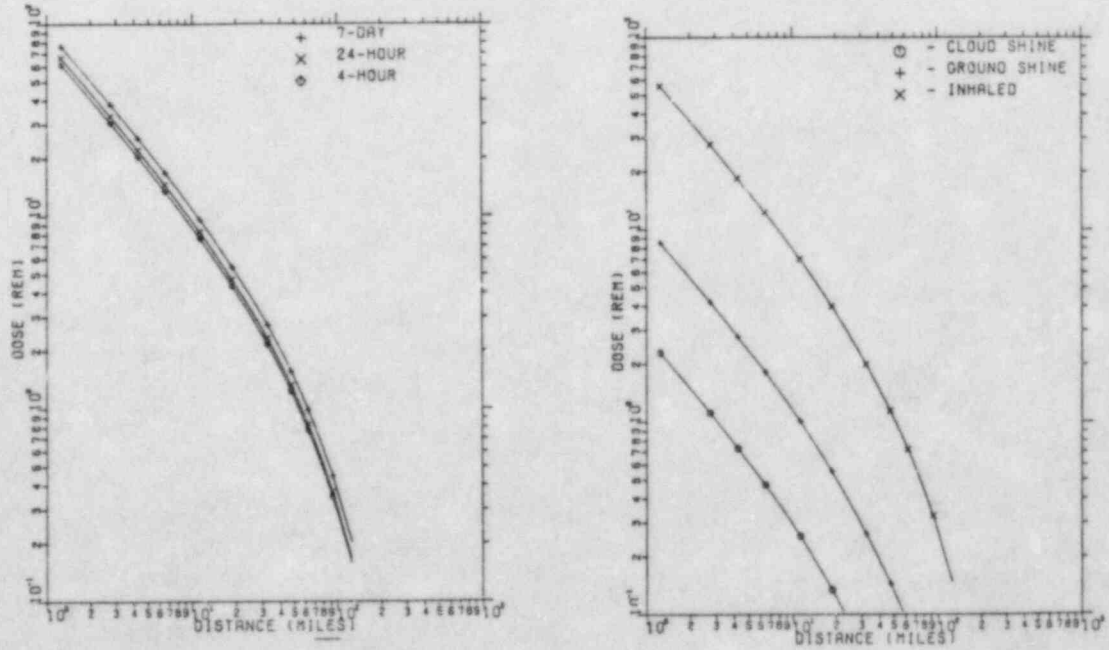


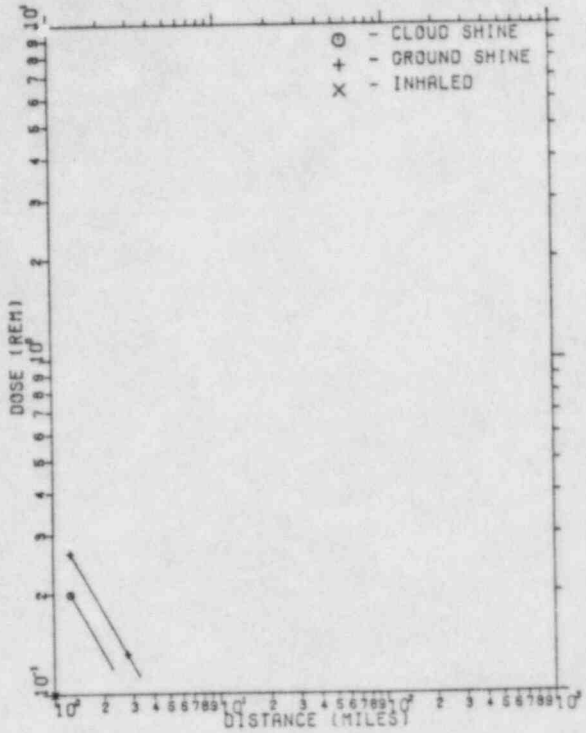
Figure 5-2

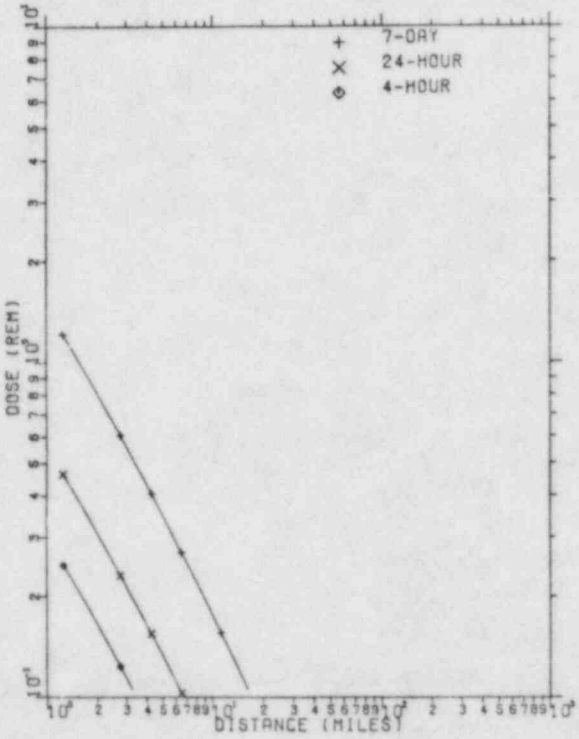
PWR #6
CASE 2

Stability Class: A
Windspeed: 9 mph

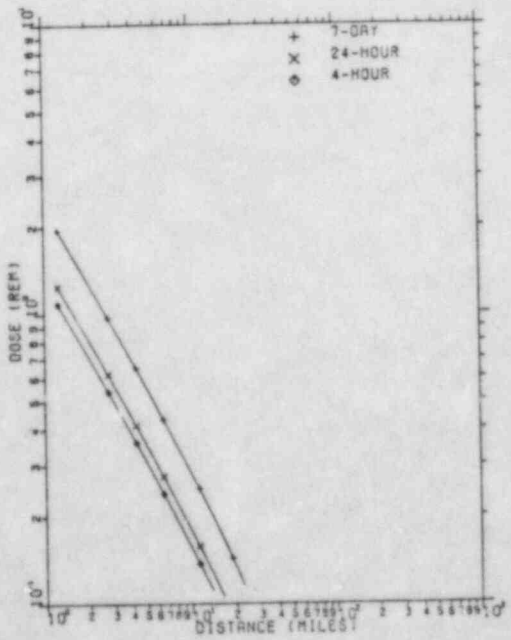
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



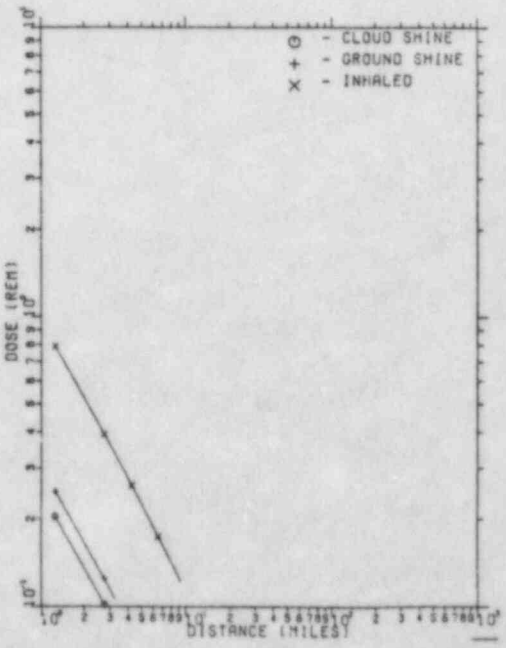


Figure 6-2

PWR #7

Case 2

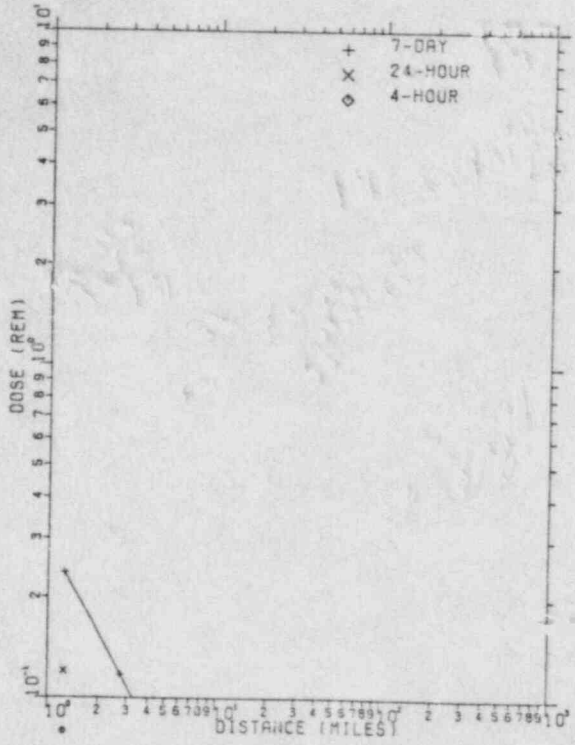
Doses less than 0.1 Rem

PWR #8
CASE 2

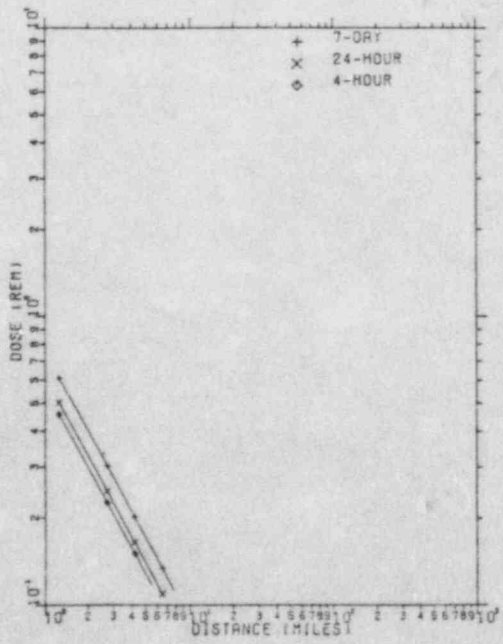
Stability Class: A
Windspeed: 9 mph

Rain: No
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE



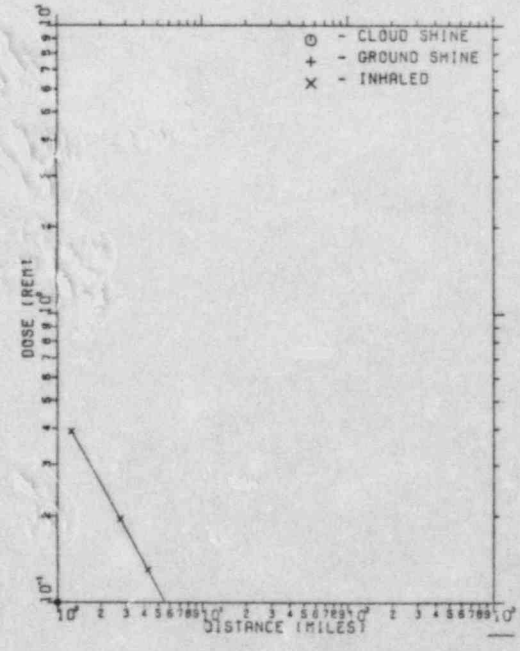


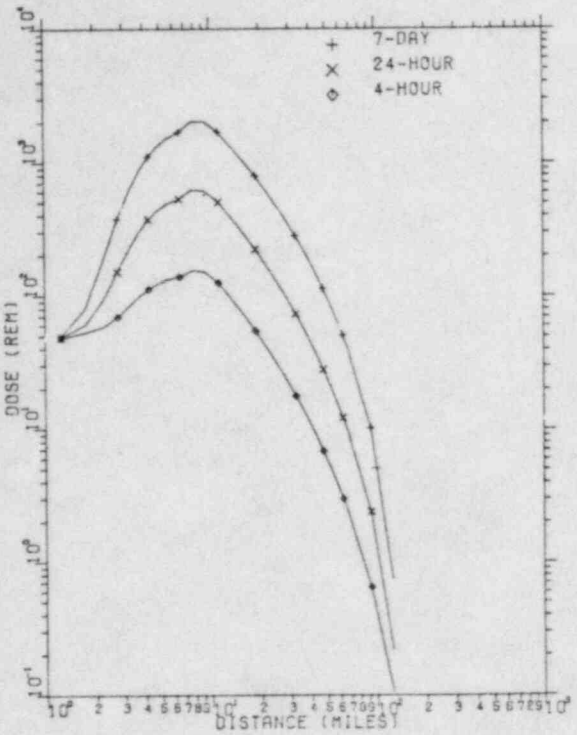
Figure 8-2

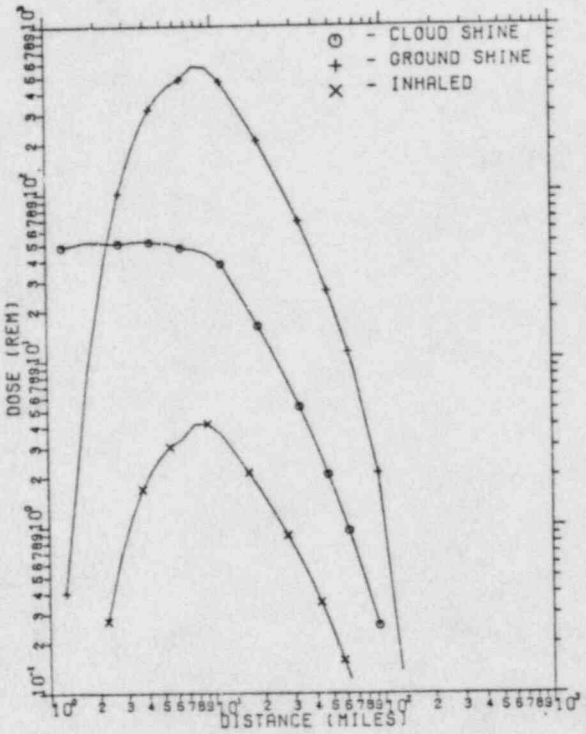
PWR #1A
CASE 3

Stability Class: D
Windspeed: 2 mph

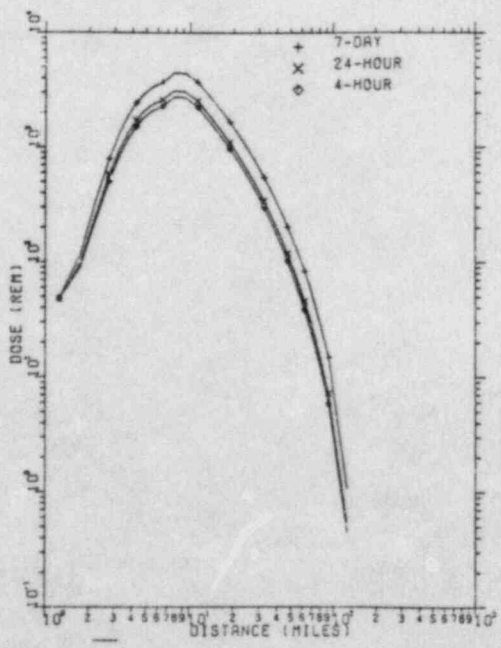
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



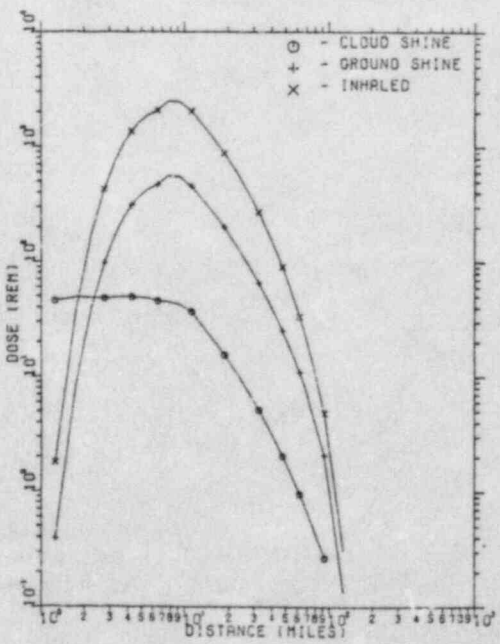


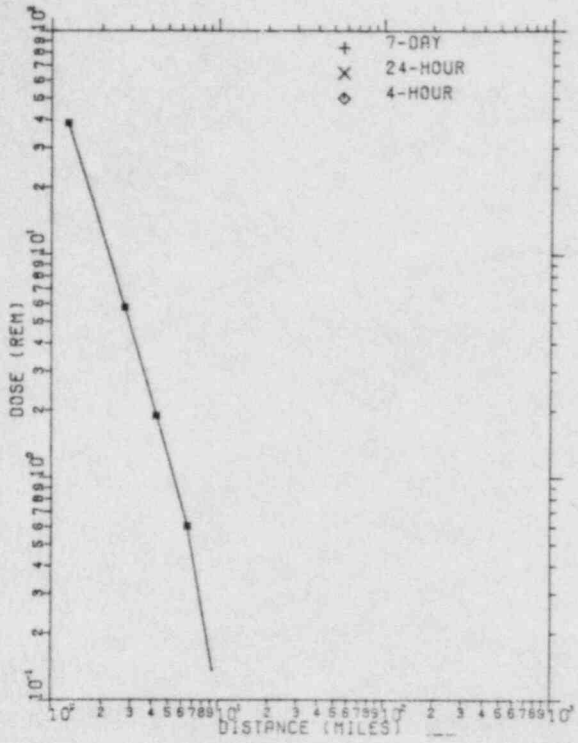
Figure 1A-3

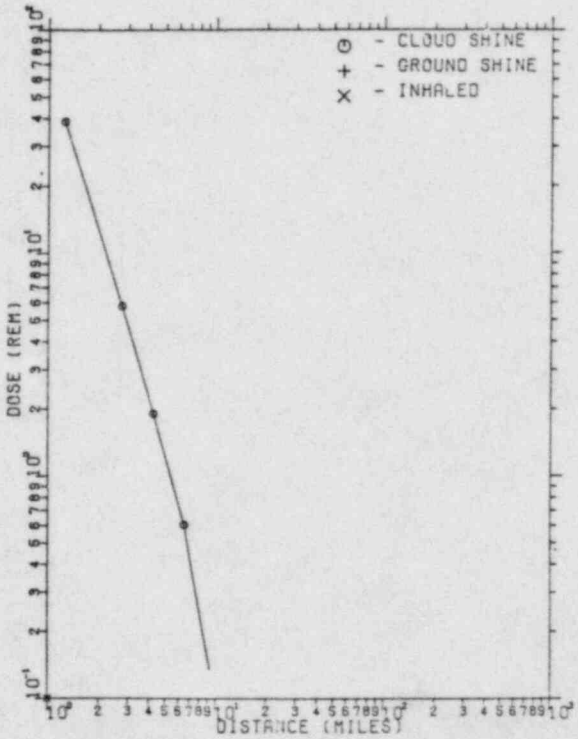
PWR #1B
CASE 3

Stability Class: D
Windspeed: 2 mph

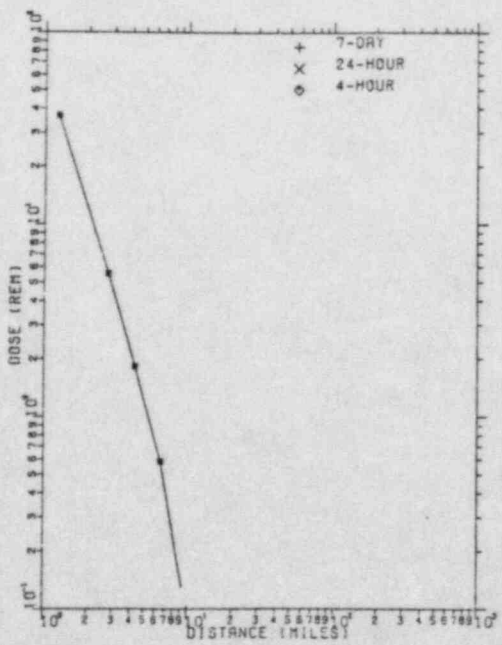
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



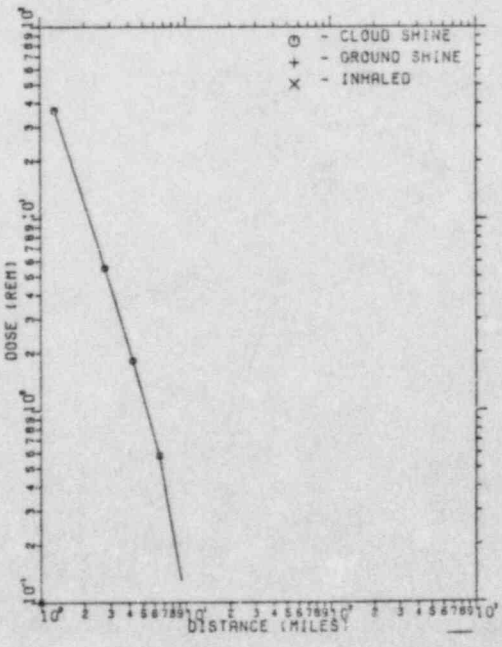


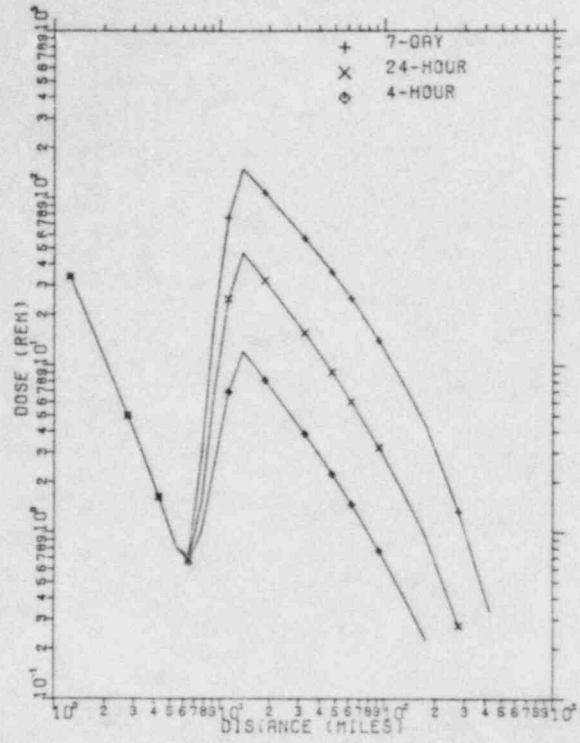
Figure 1B-3

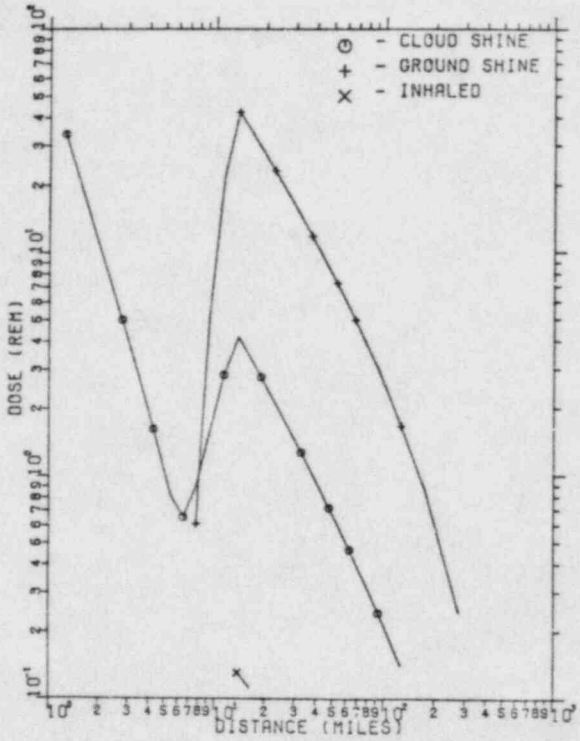
PWR #2
CASE 3

Stability Class: D
Windspeed: 2 mph

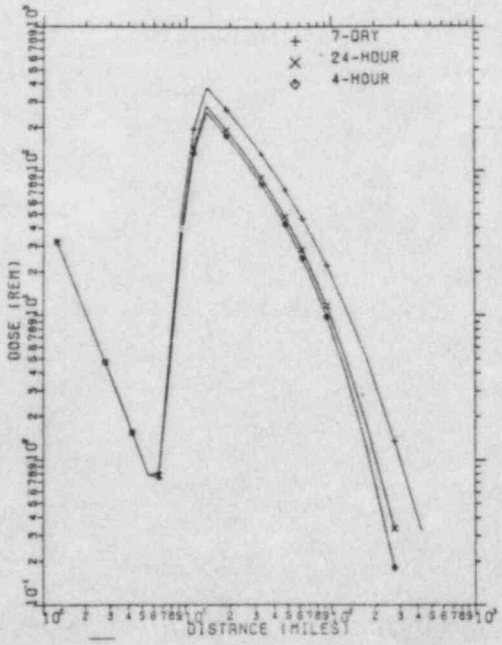
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



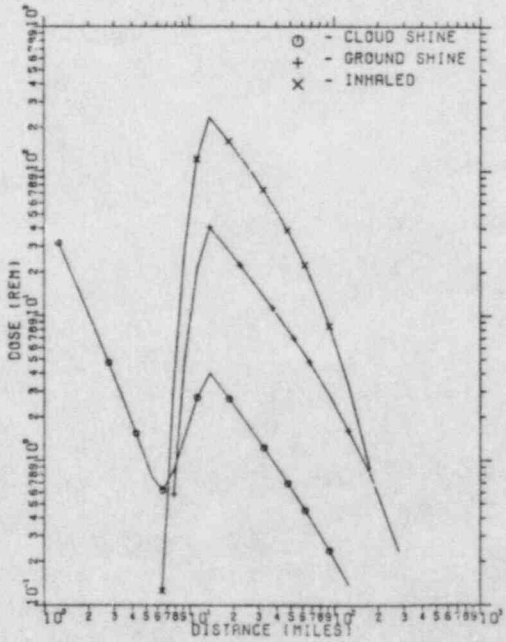


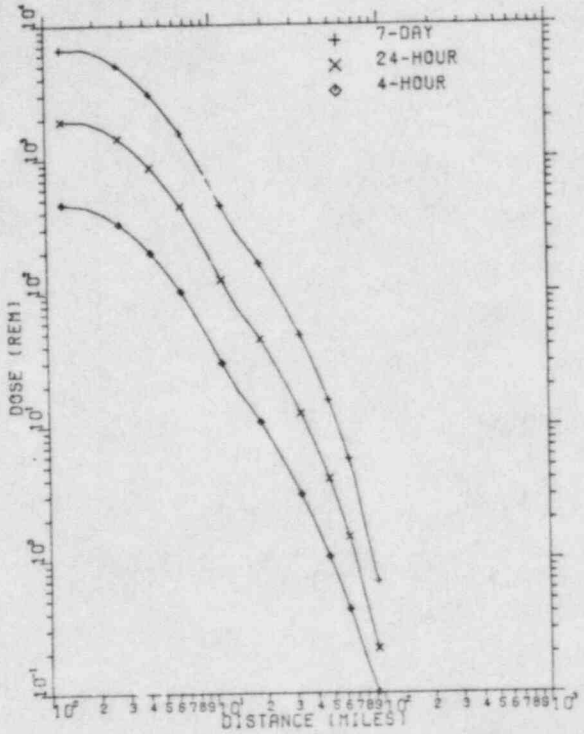
Figure 2-3

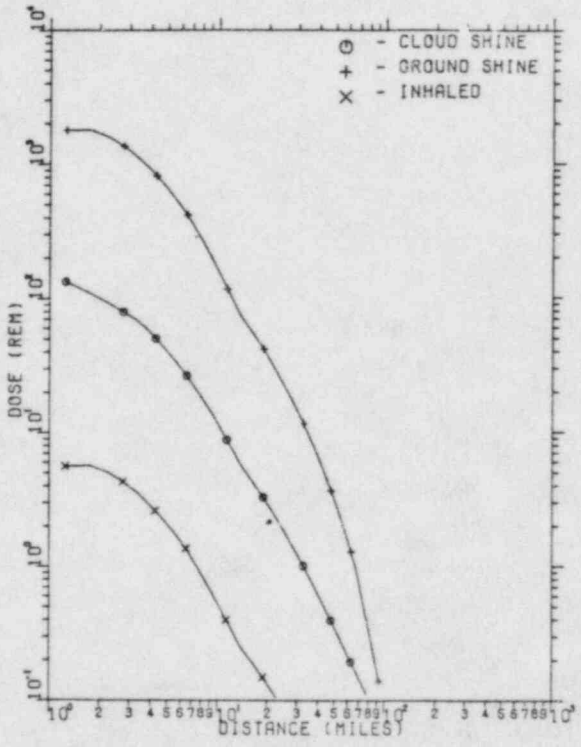
PWR #3
CASE 3

Stability Class: D
Windspeed: 2 mph

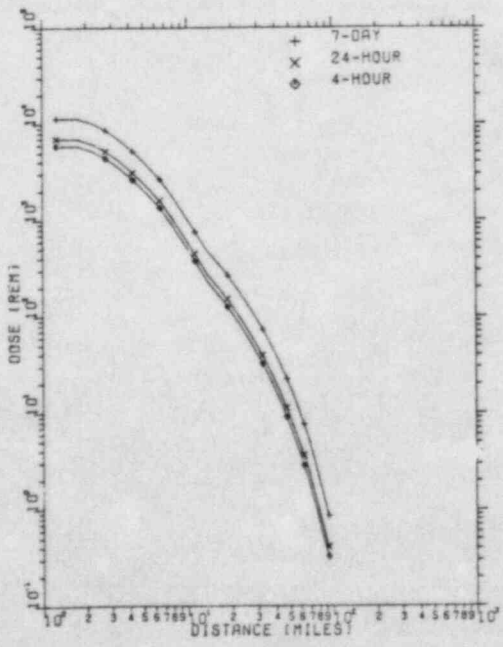
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



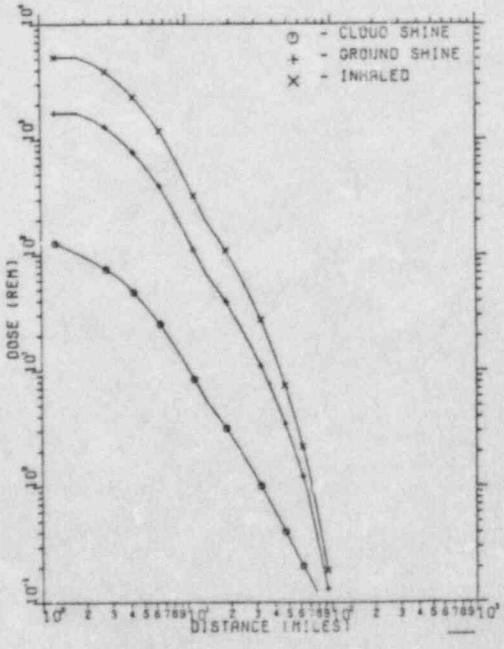


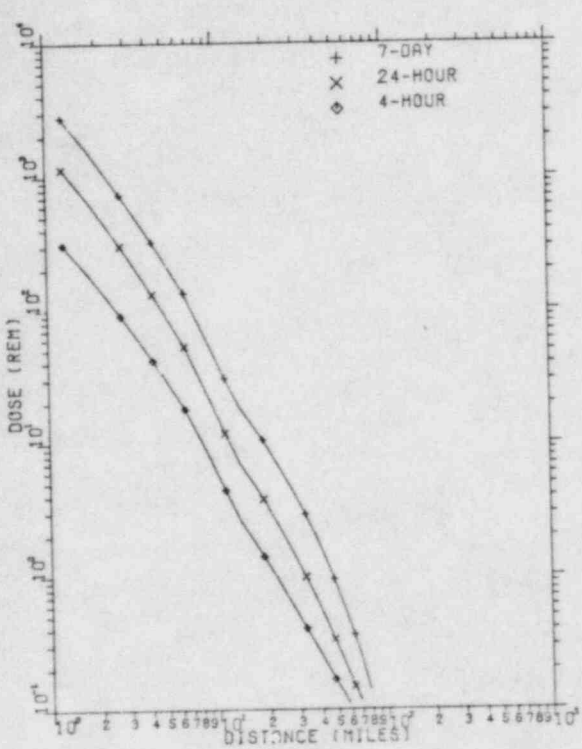
Figure 3-3

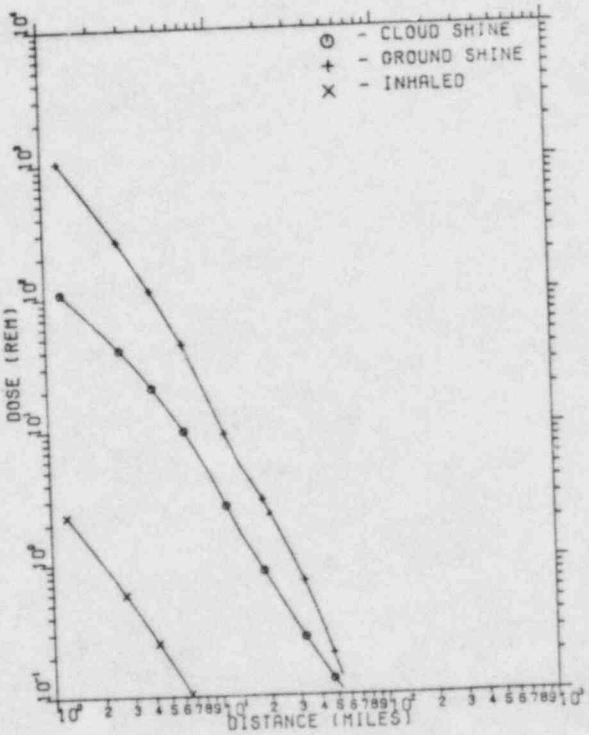
PWR #4
CASE 3

Stability Class: D
Windspeed: 2 mph

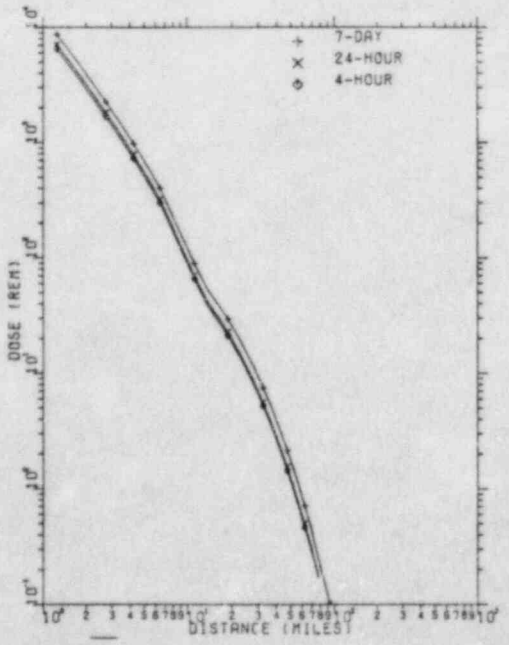
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



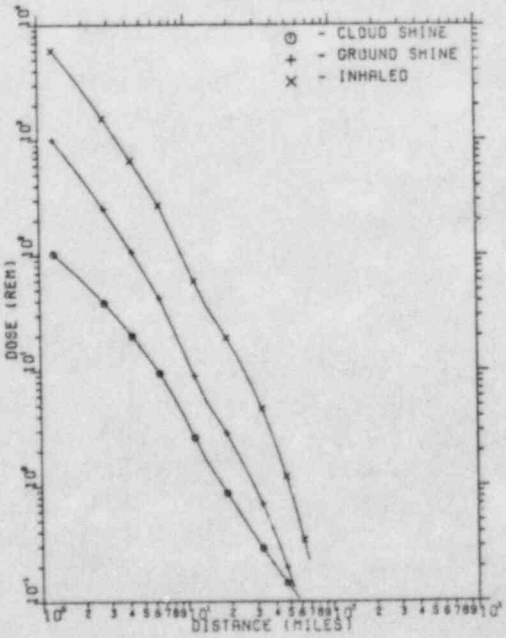


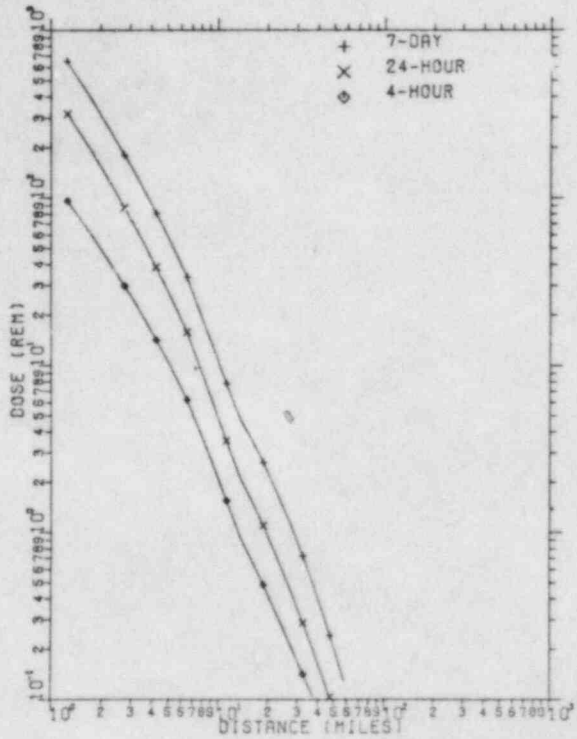
Figure 4-3

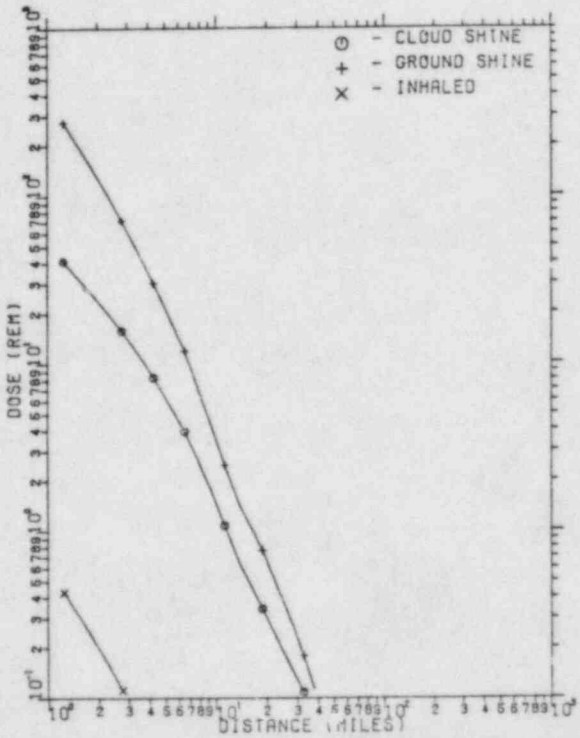
PWR #5
CASE 3

Stability Class: D
Windspeed: 2 mph

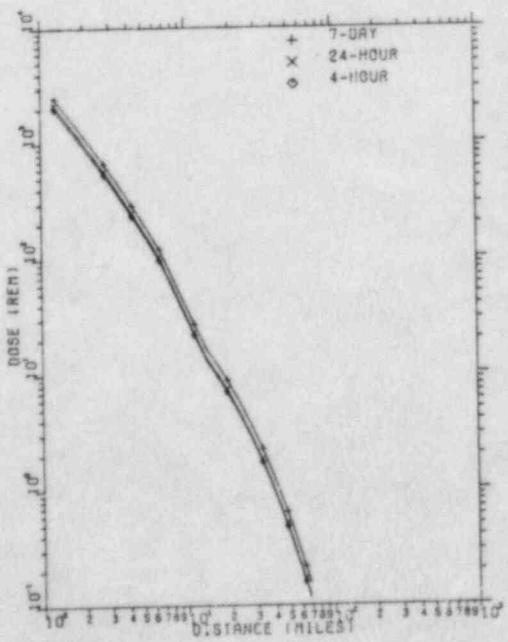
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



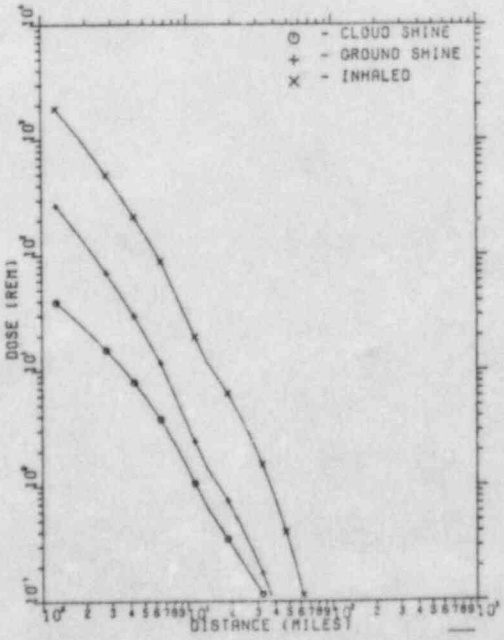


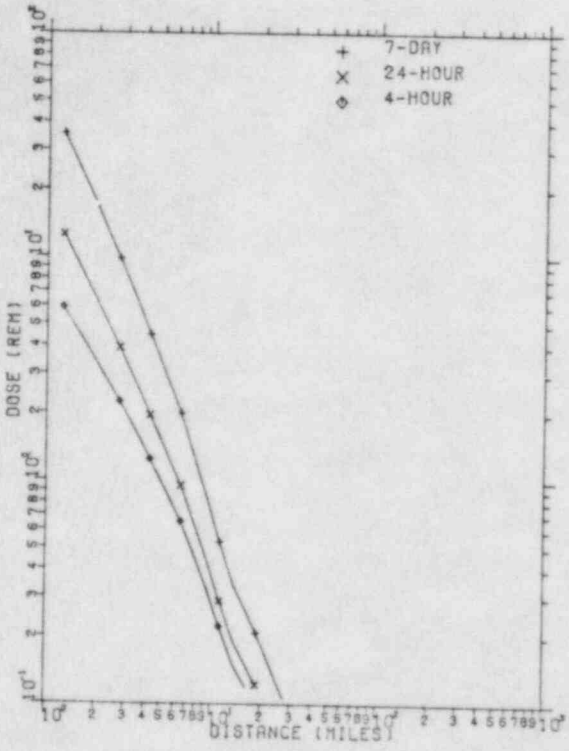
Figure 5-3

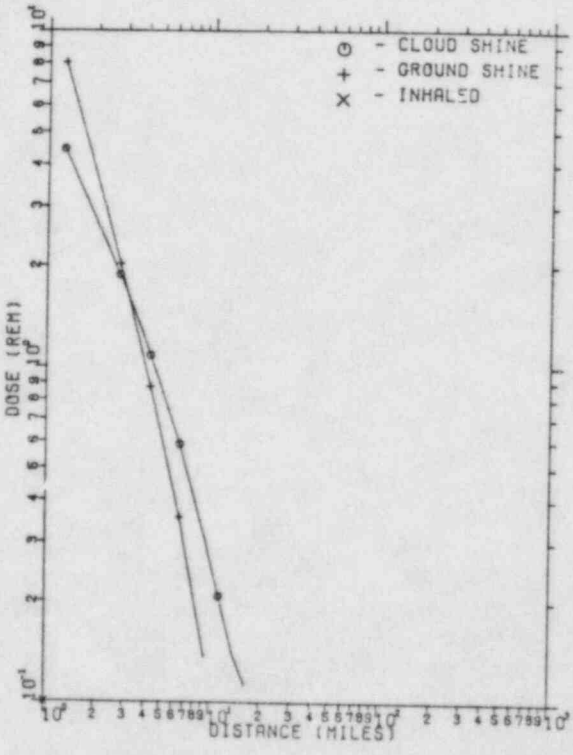
PWR #6
CASE 3

Stability Class: D
Windspeed: 2 mph

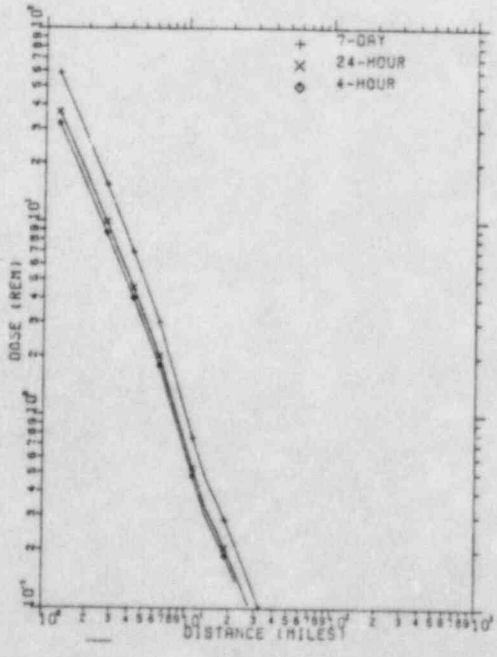
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



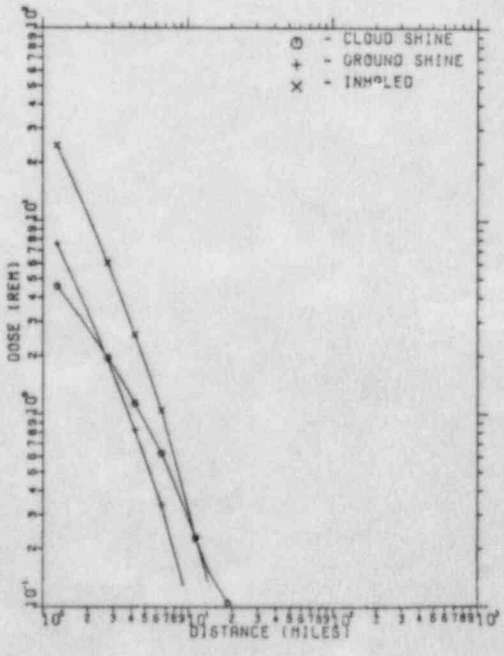


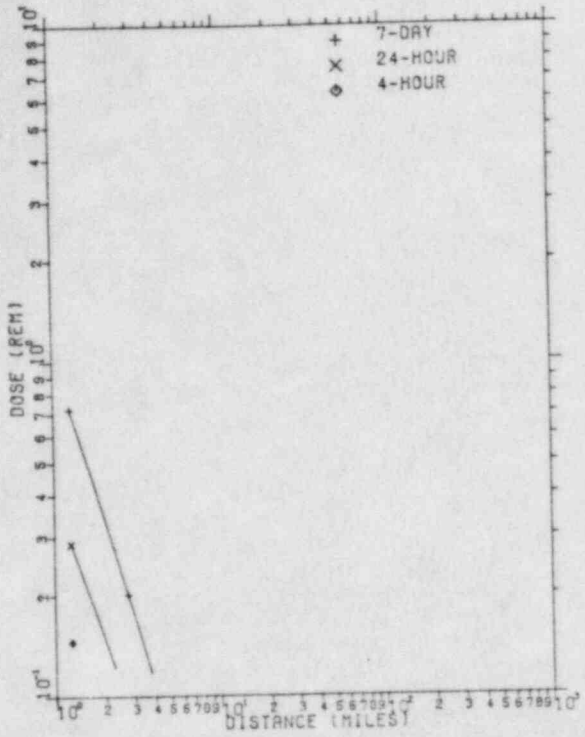
Figure 6-3

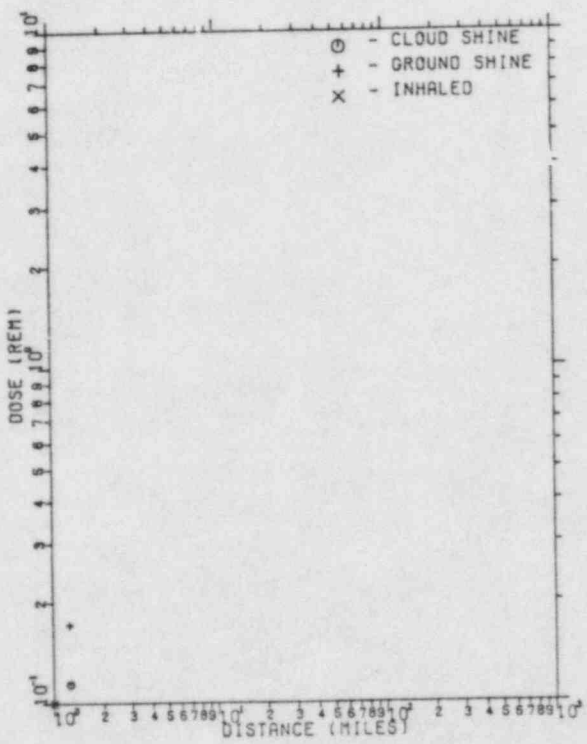
PWR #7
CASE 3

Stability Class: D
Windspeed: 2 mph

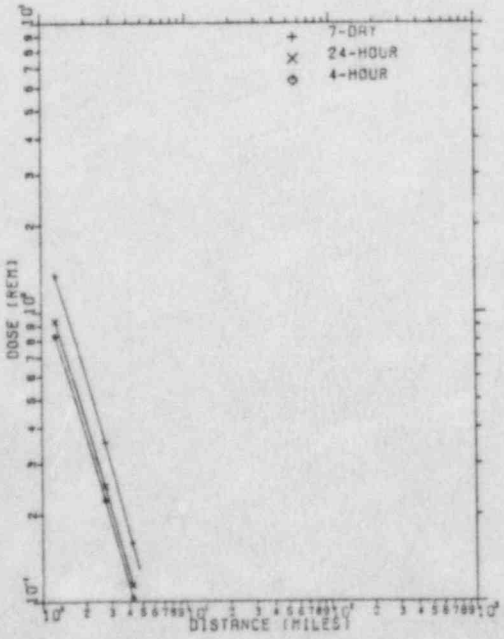
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



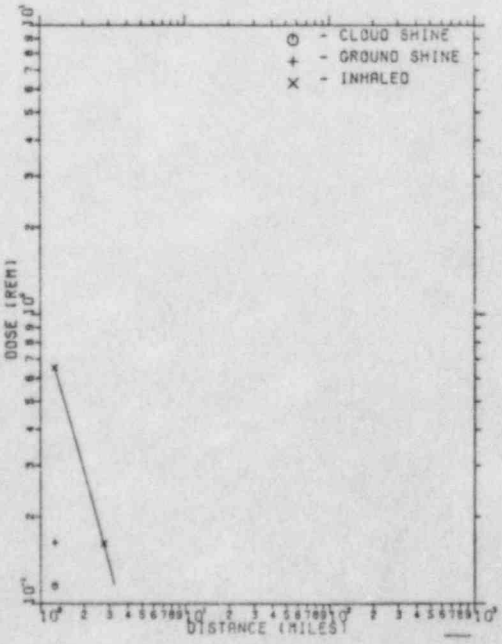


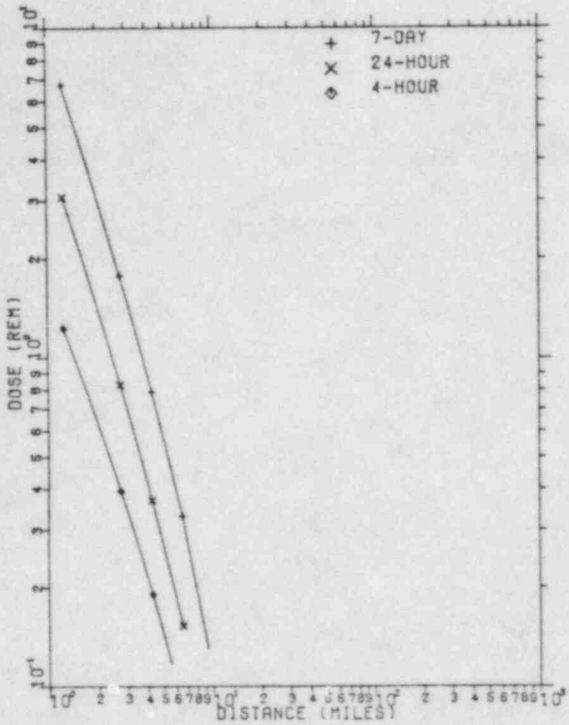
Figure 7-3

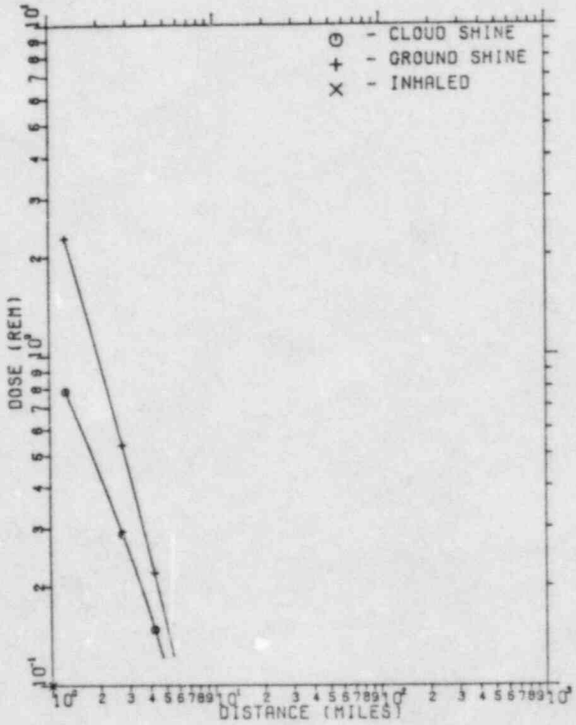
PWR #8
CASE 3

Stability Class: D
Windspeed: 2 mph

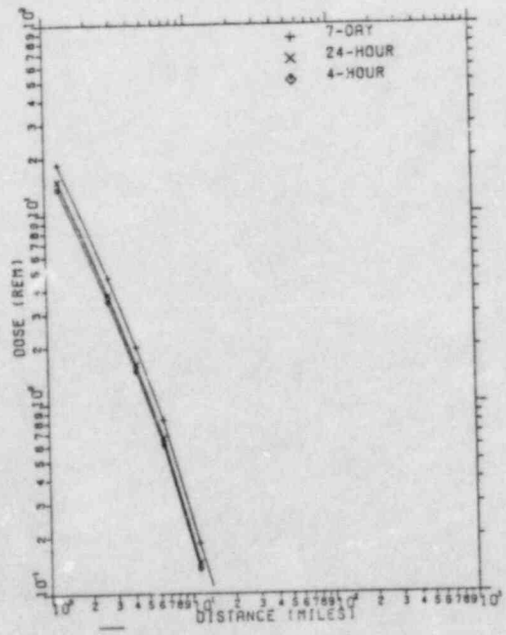
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



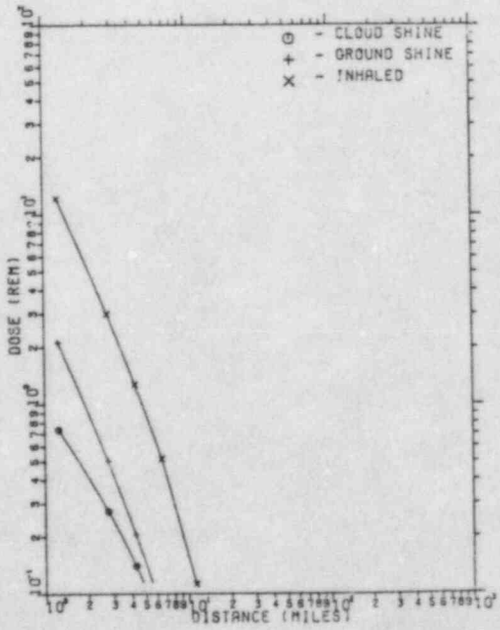


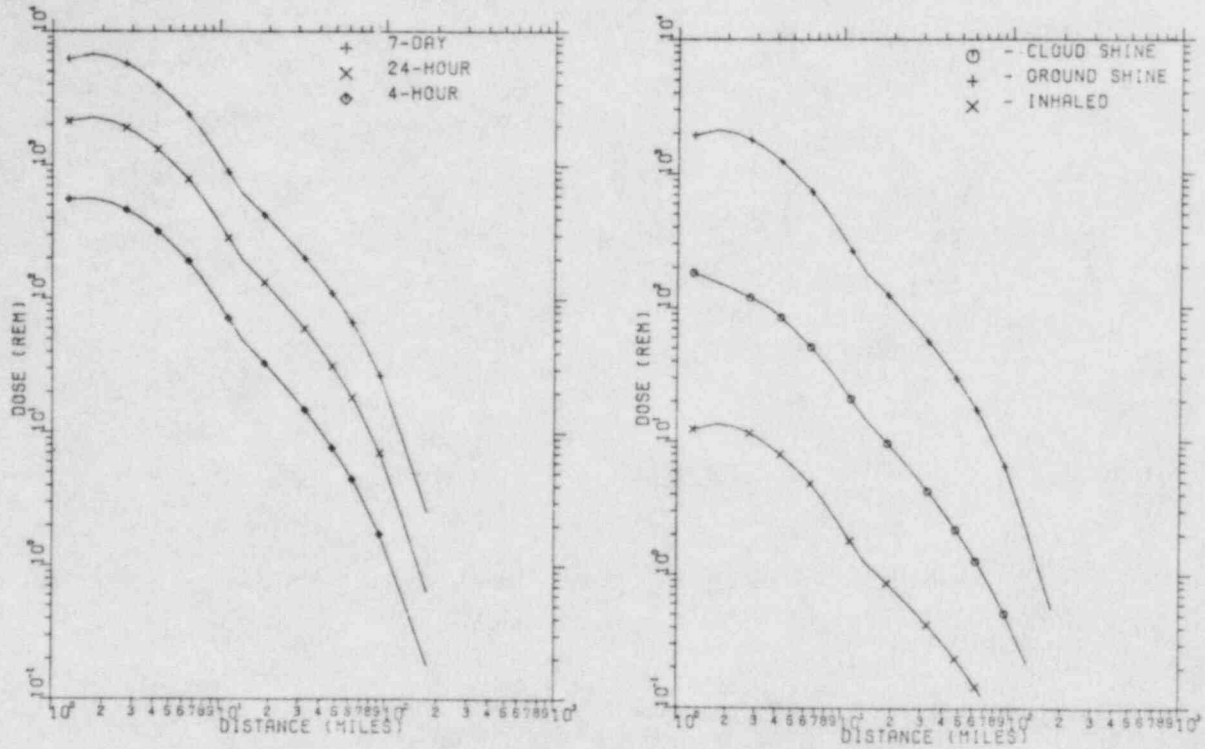
Figure 8-3

PWR #1A
CASE 4

Stability Class: D
Windspeed: 6 mph

Rain: No
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

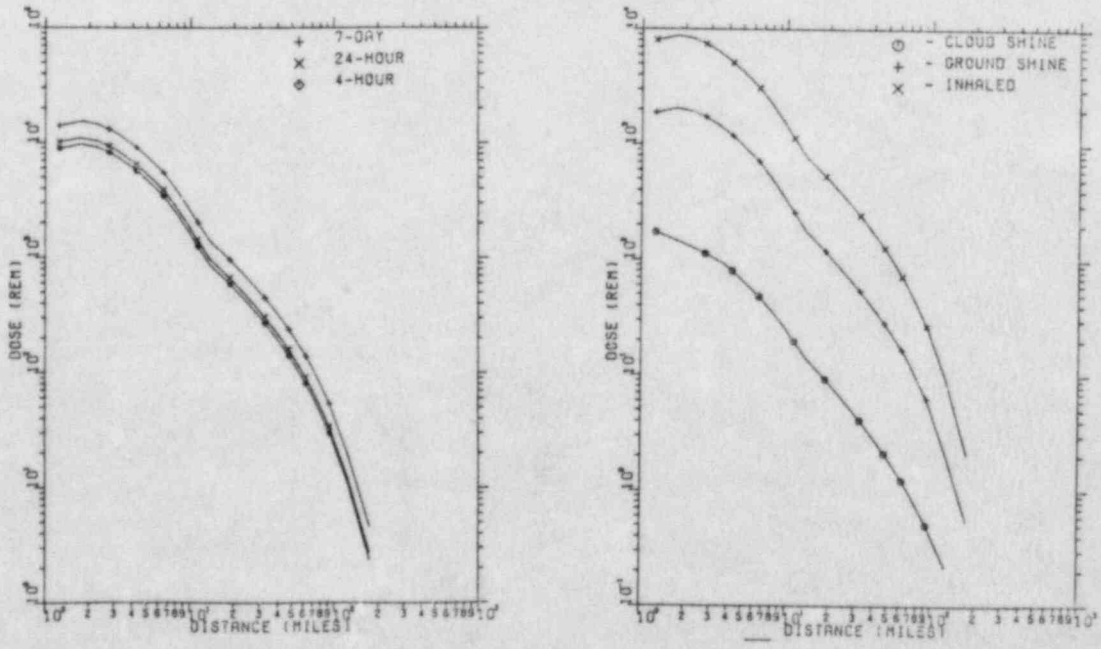


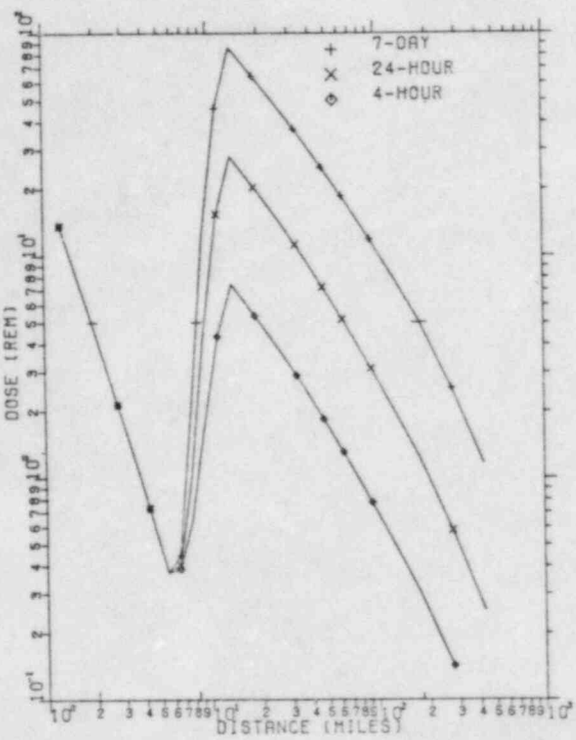
Figure 1A-4

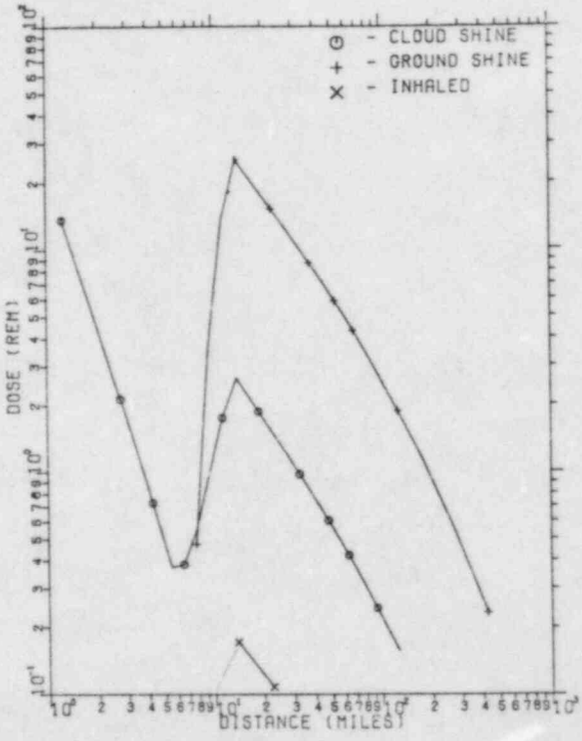
PWR #1B
CASE 4

Stability Class: D
Windspeed: 6 mph

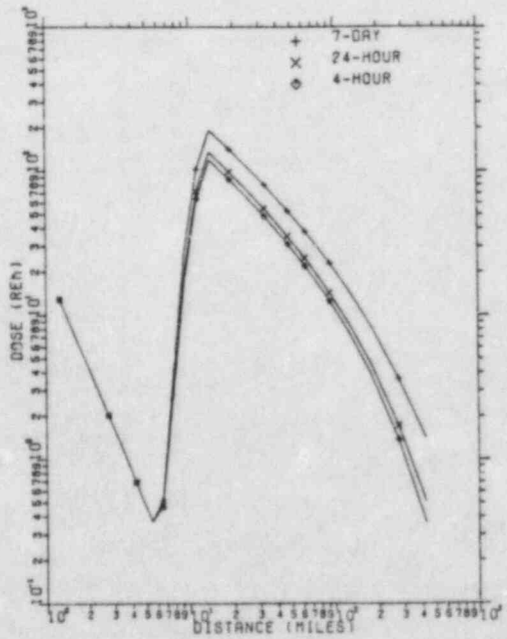
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



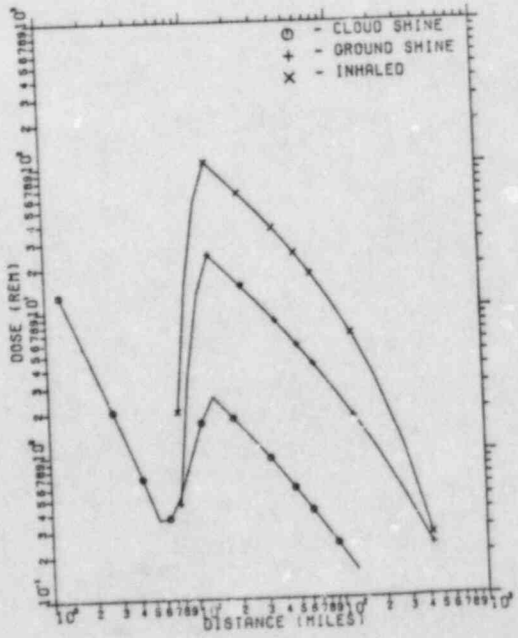


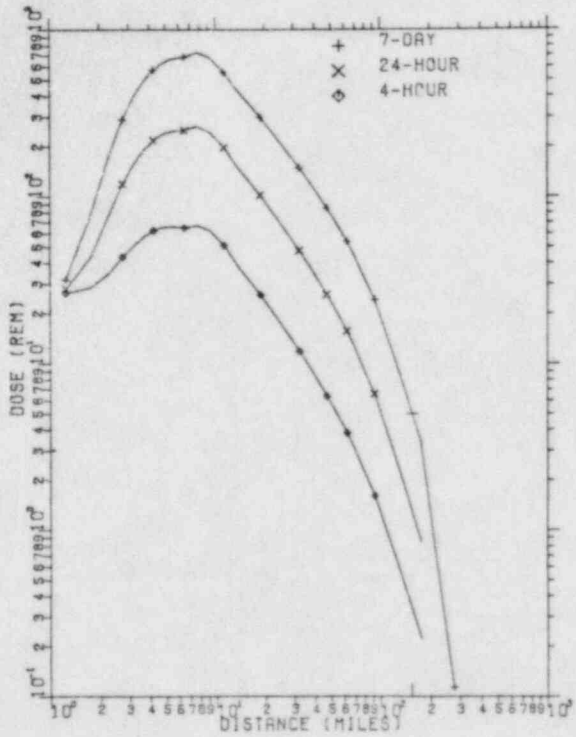
Figure 1B-4

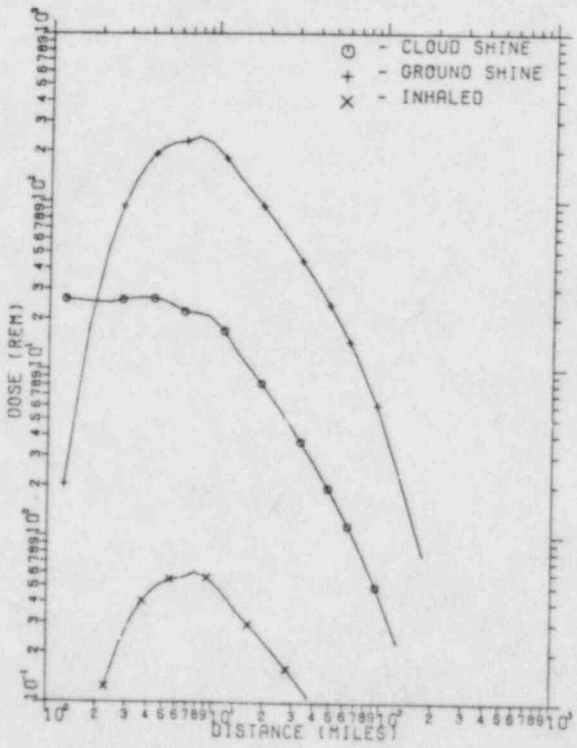
PWR #2
CASE 4

Stability Class: D
Windspeed: 6 mph

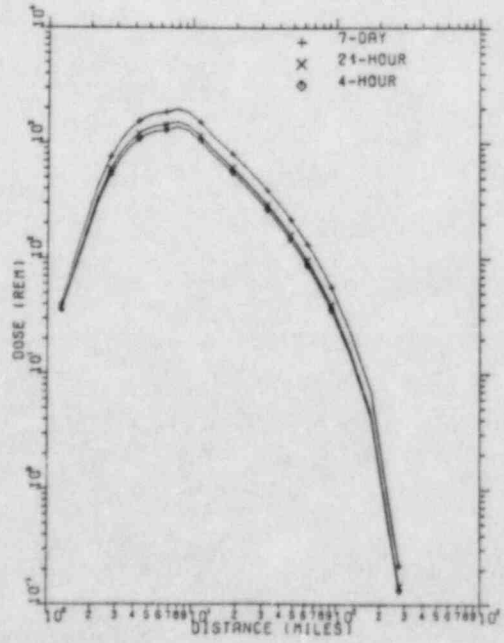
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



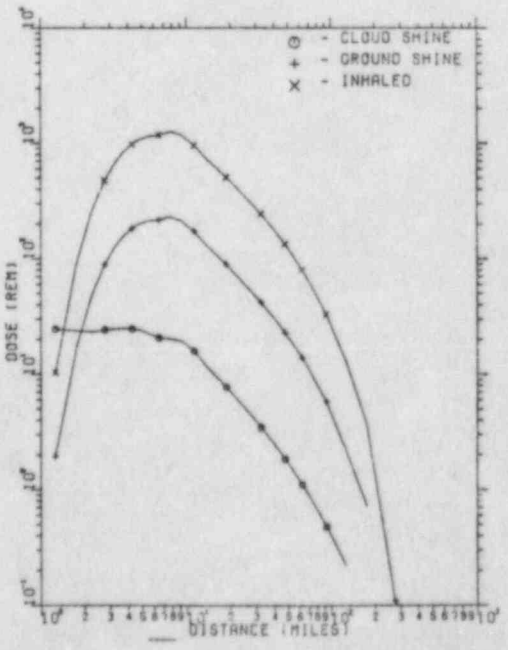


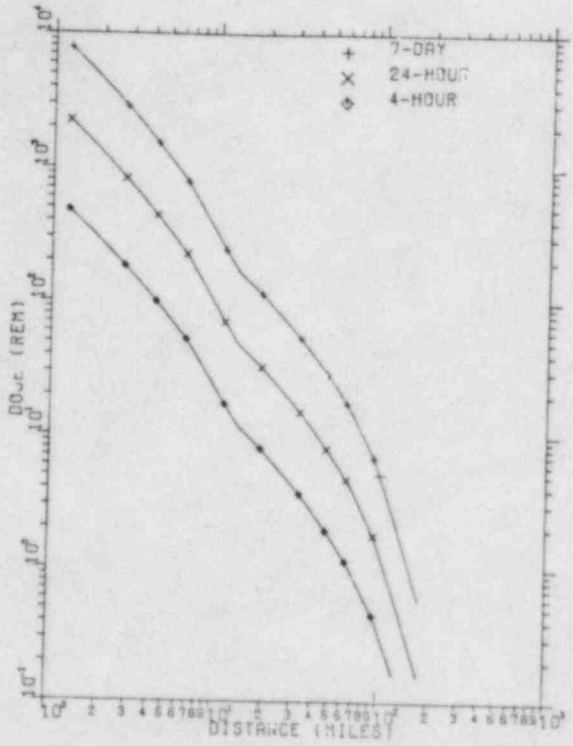
Figure 2-4

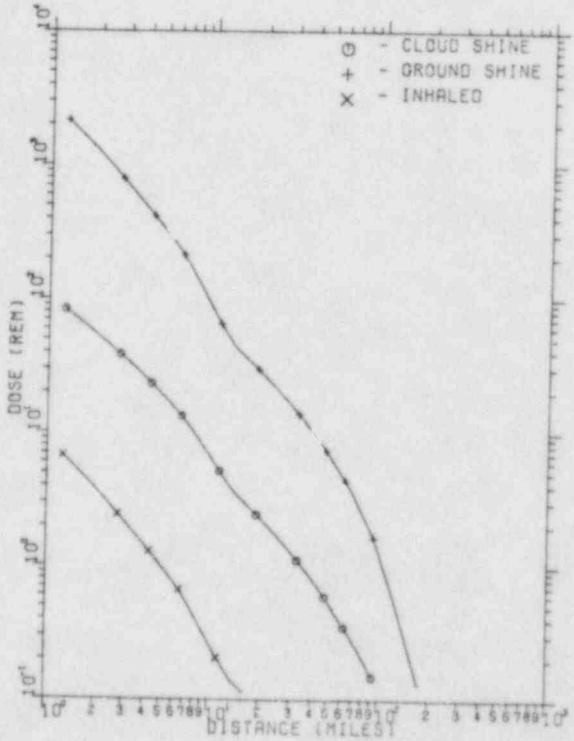
PWR #3
CASE 4

Stability Class: D
Windspeed: 6 mph

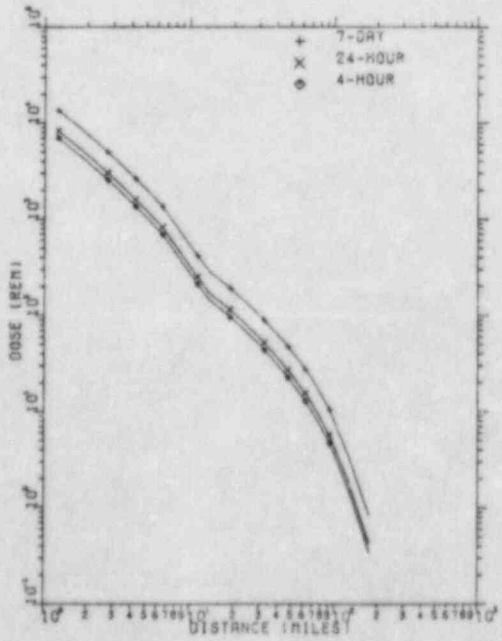
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



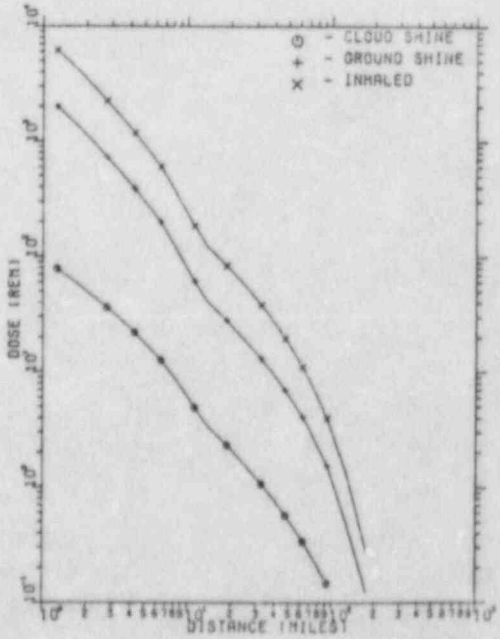


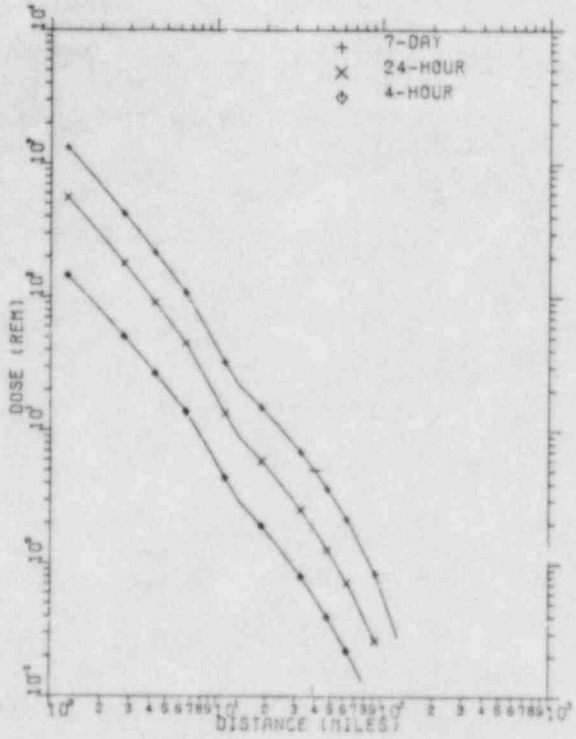
Figure 3-4

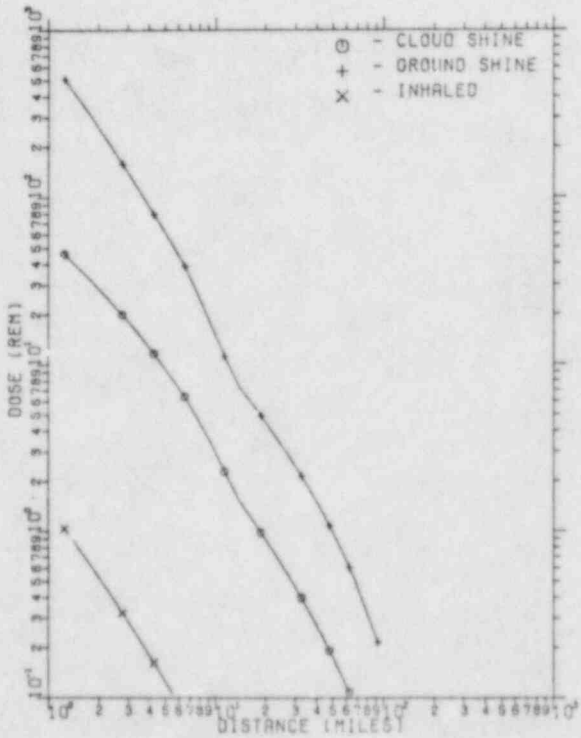
PWR #4
CASE 4

Stability Class: D
Windspeed: 6 mph

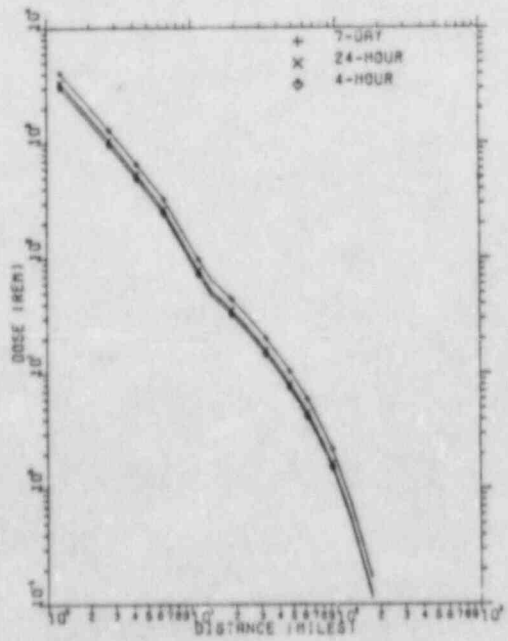
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



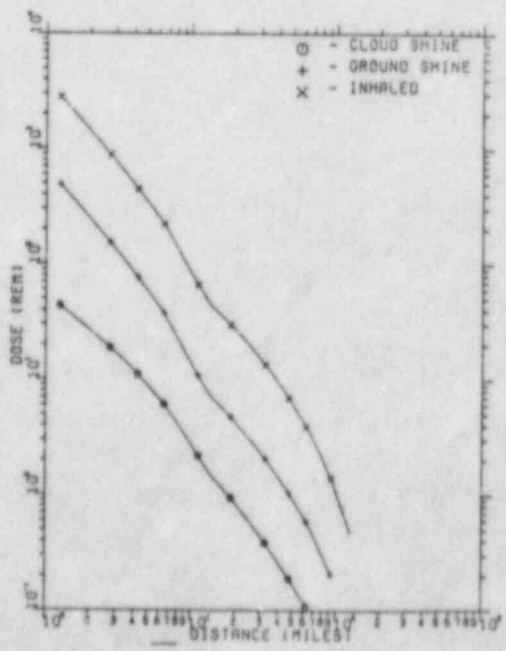


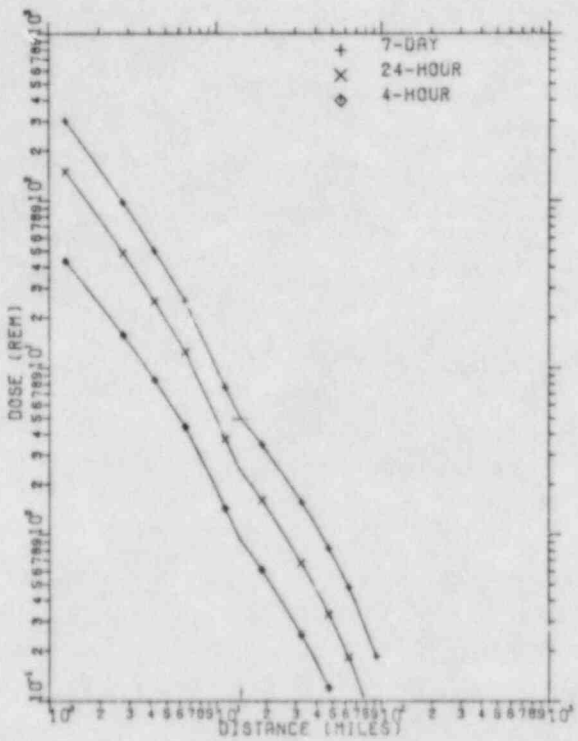
Figure 4-4

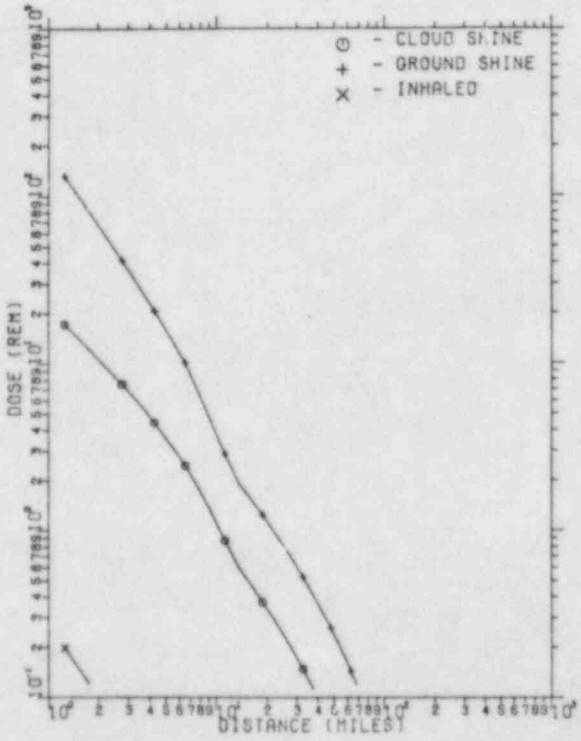
PWR #5
CASE 4

Stability Class: D
Windspeed: 6 mph

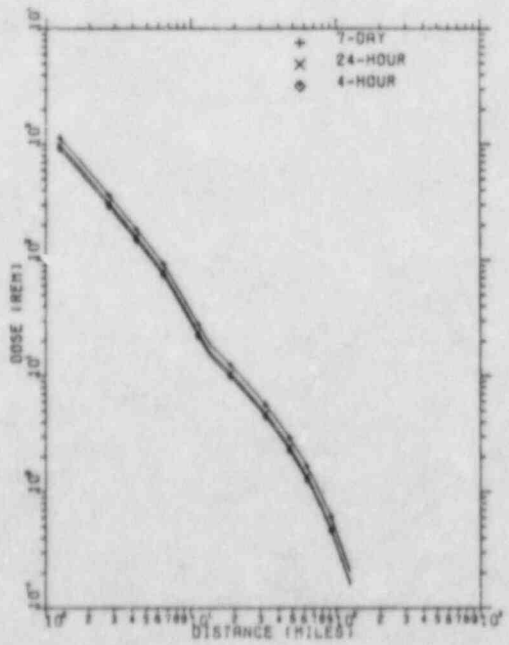
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



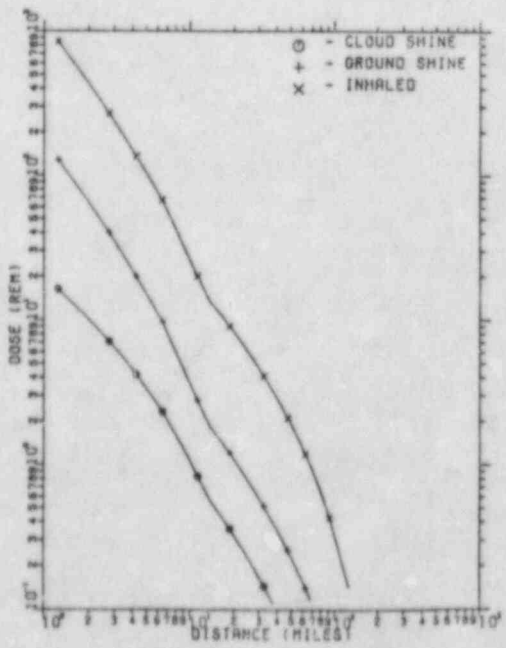


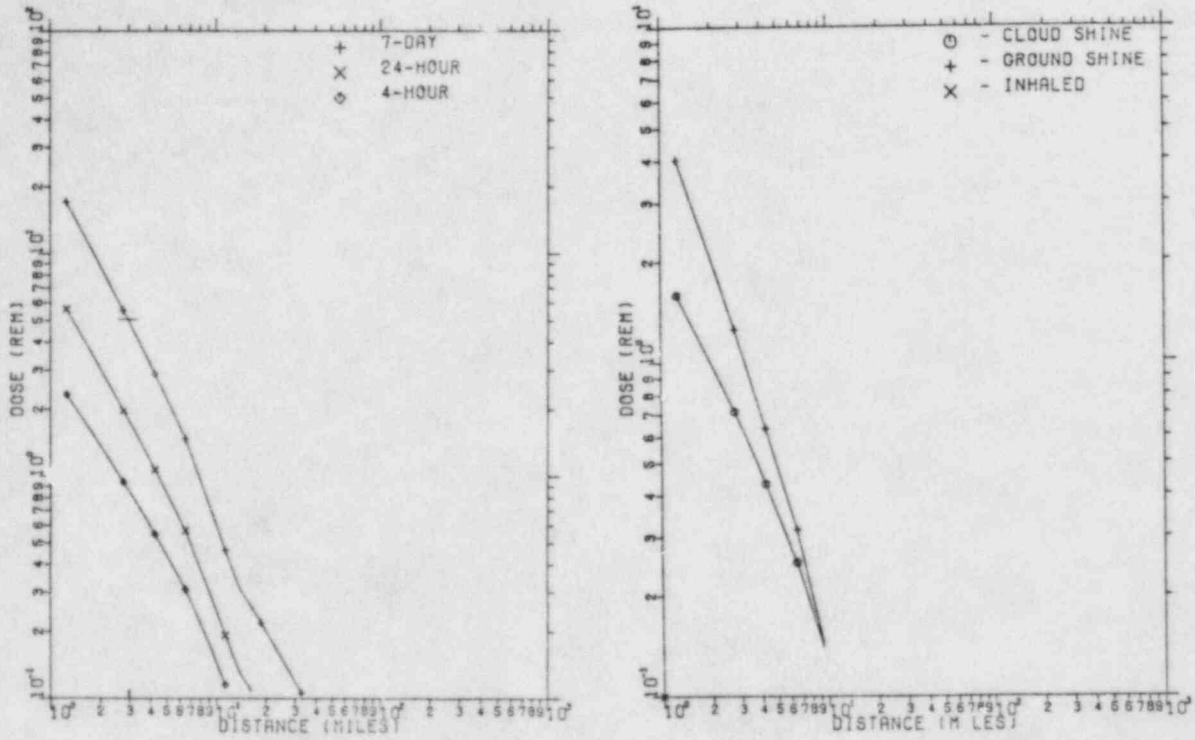
Figure 5-4

PWR #6
CASE 4

Stability Class: D
Windspeed: 6 mph

Rain: No
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

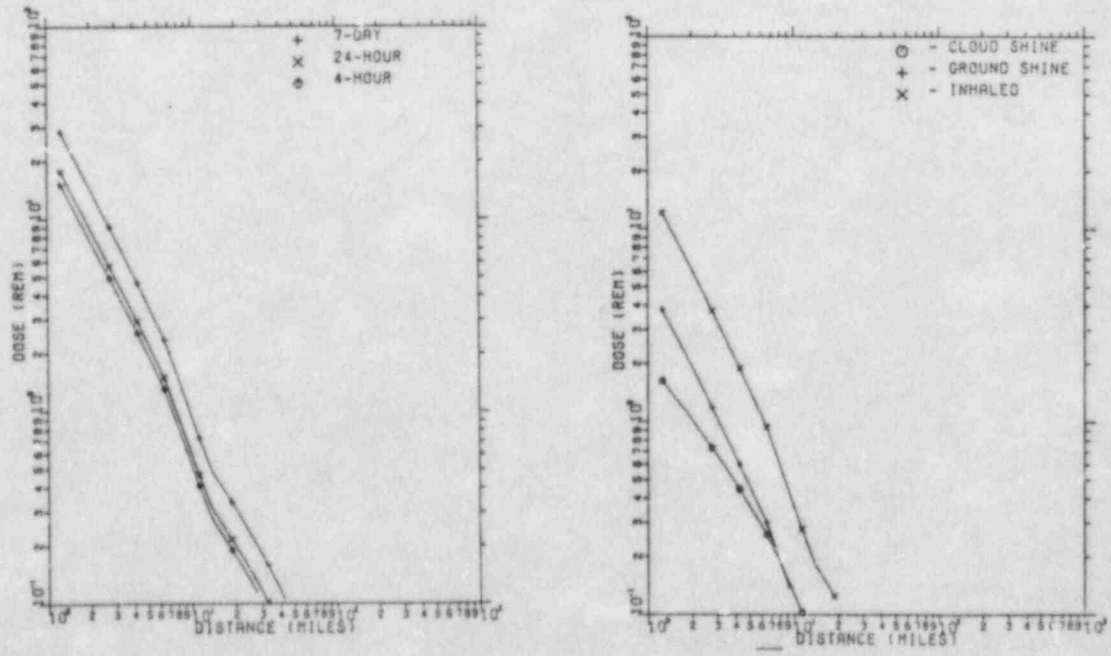


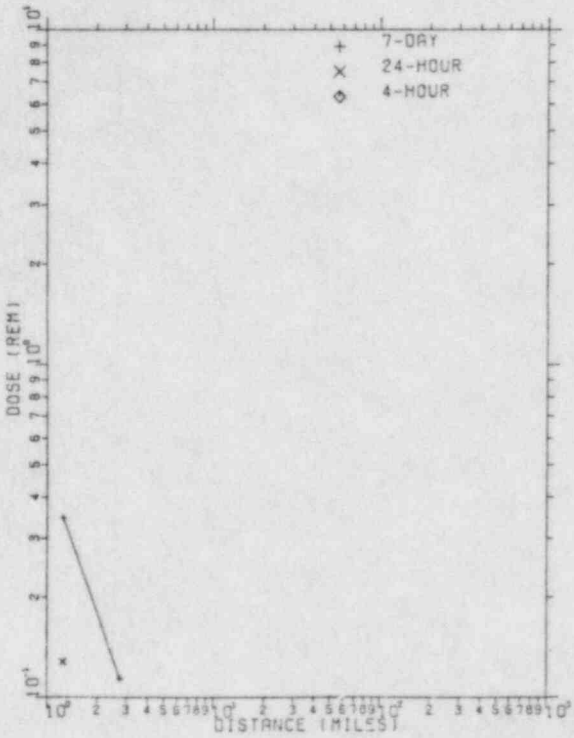
Figure 6-4

PWR #7
CASE 4

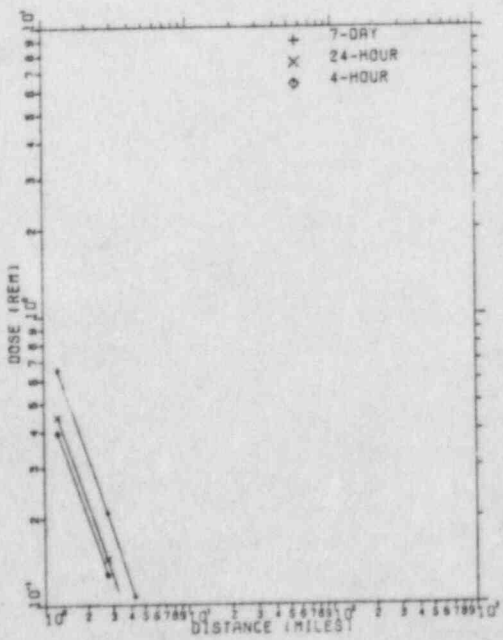
Stability Class: D
Windspeed: 6 mph

Rain: No
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE



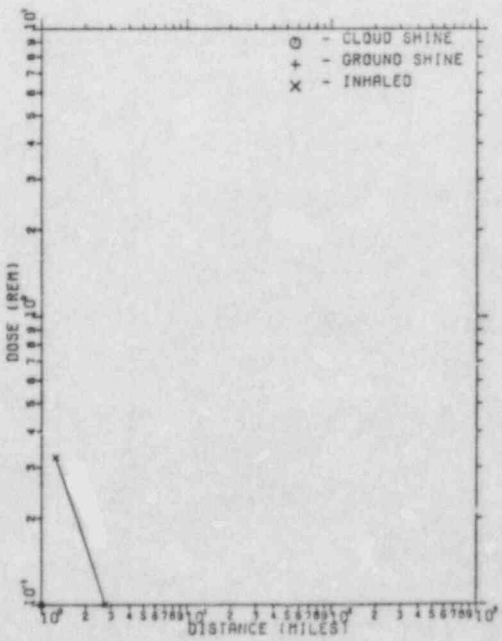


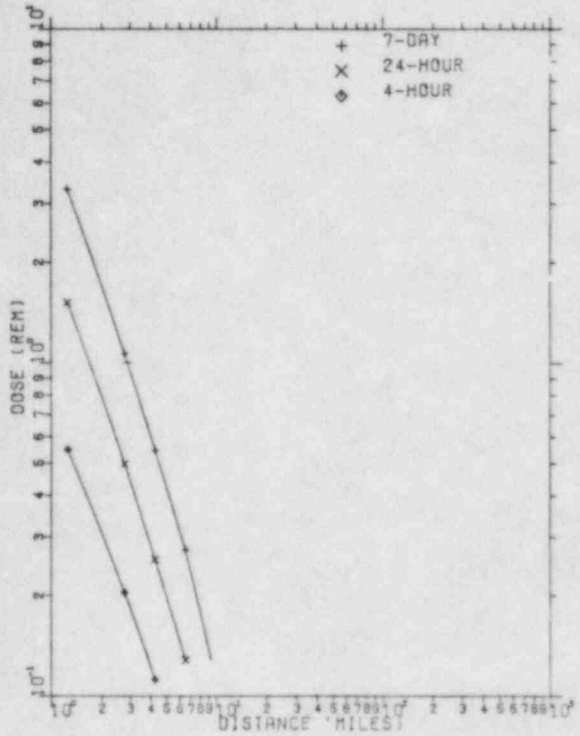
Figure 7-4

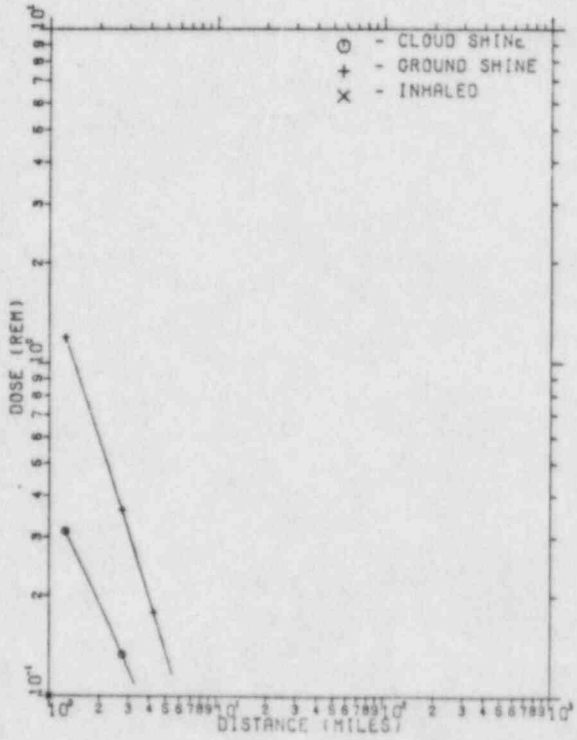
PWR #8
CASE 4

Stability Class: D
Windspeed: 6 mph

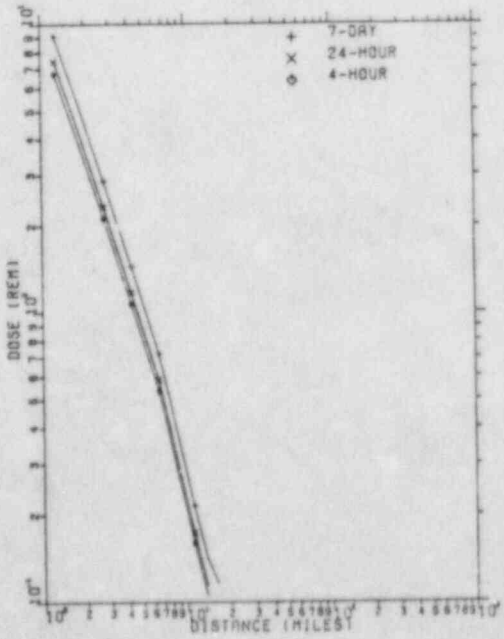
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



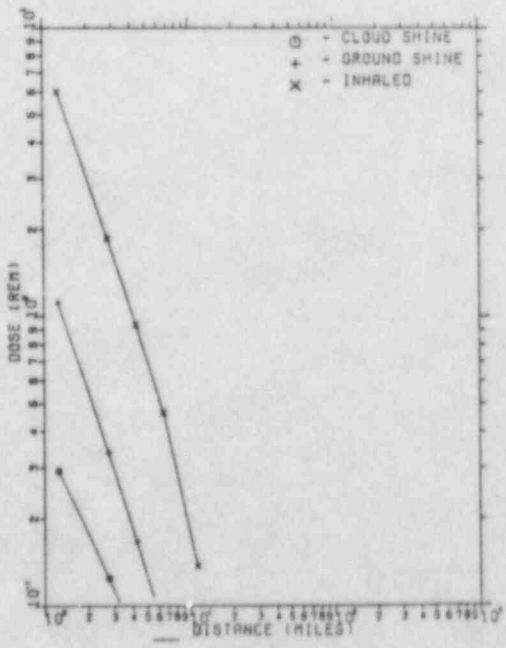


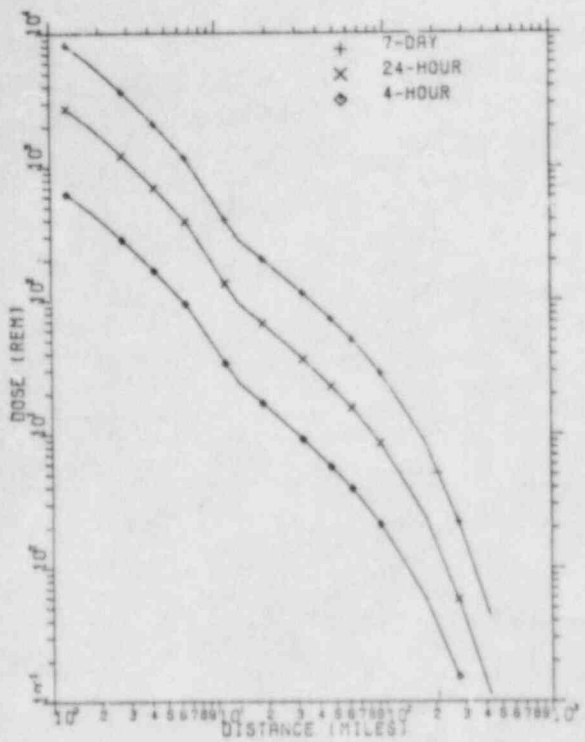
Figure 8-4

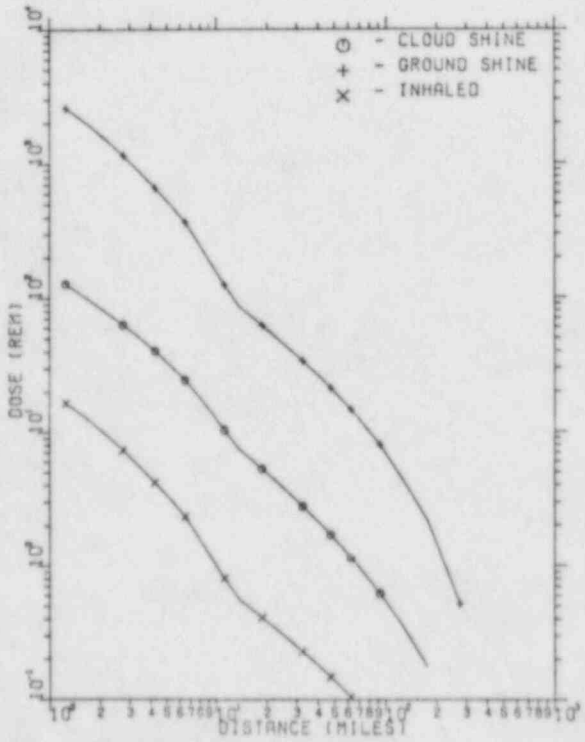
PWR #1A
CASE 5

Stability Class: D
Windspeed: 16 mph

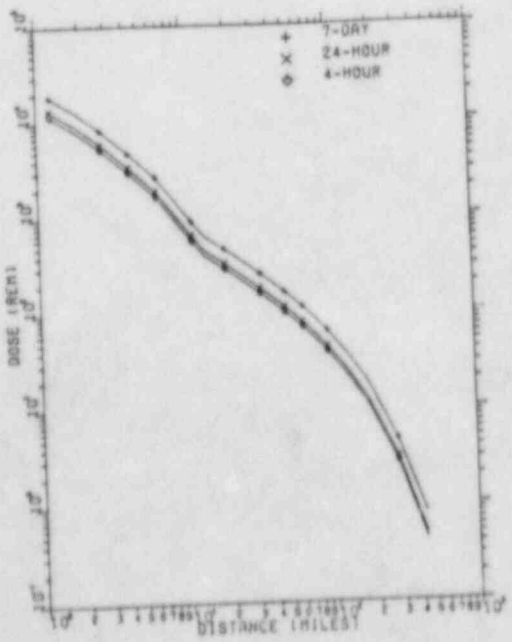
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



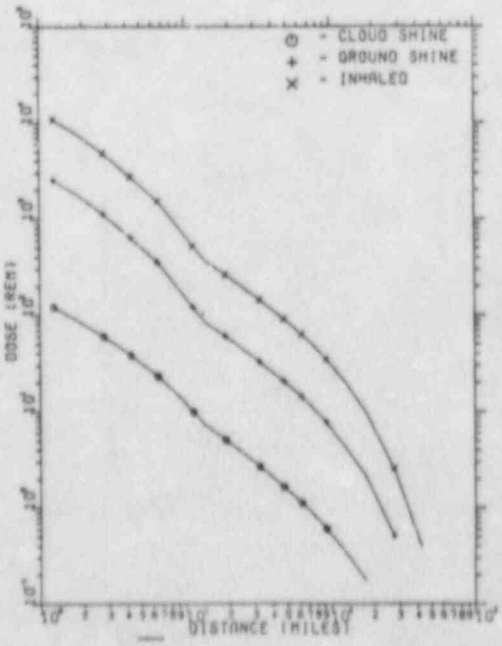


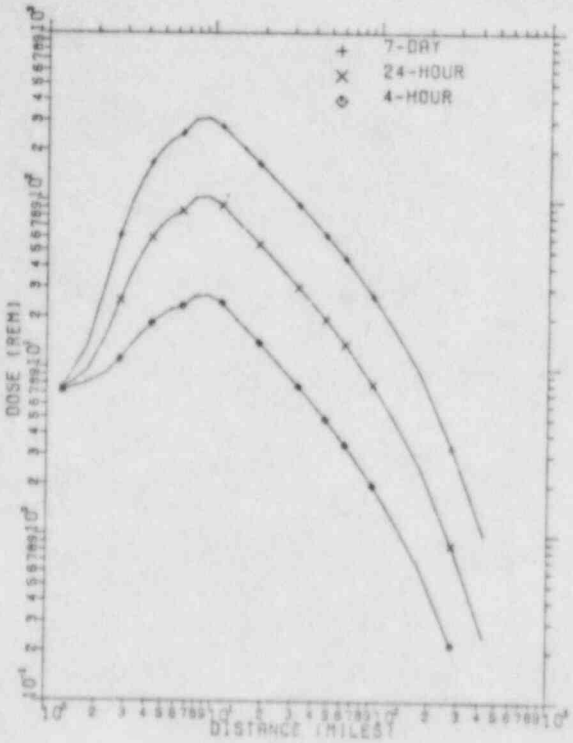
Figure 1A-5

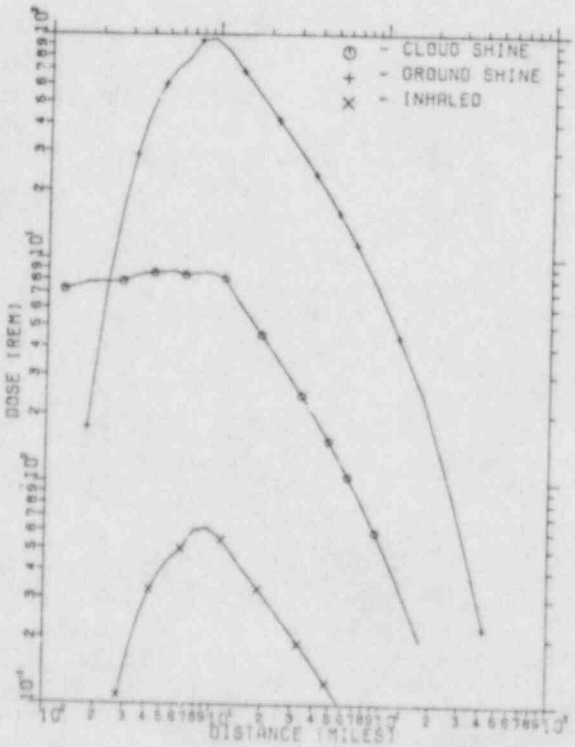
PWR #1B
CASE 5

Stability Class: D
Windspeed: 16 mph

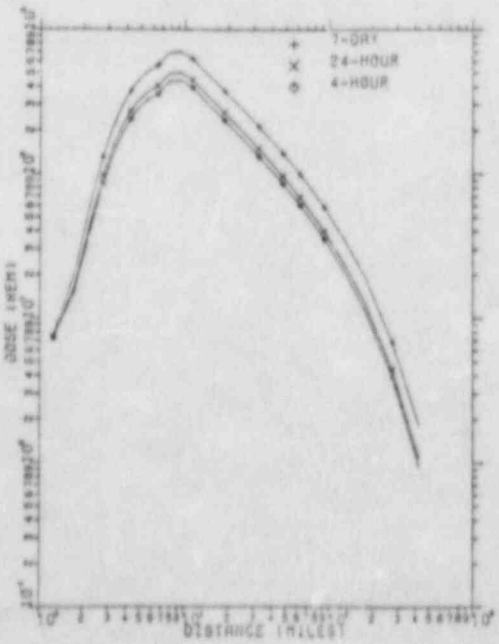
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



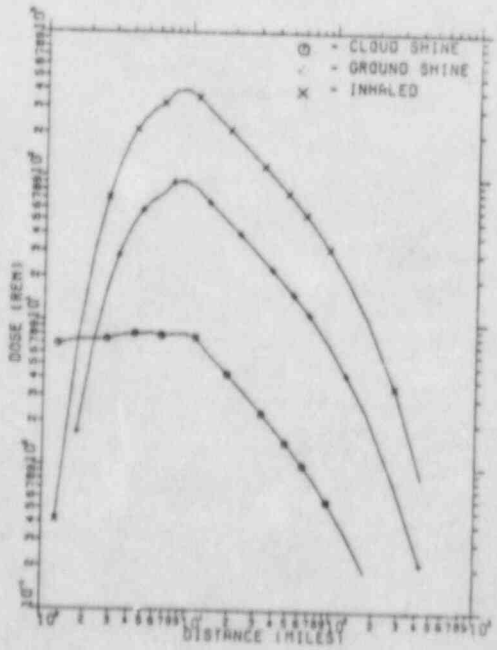


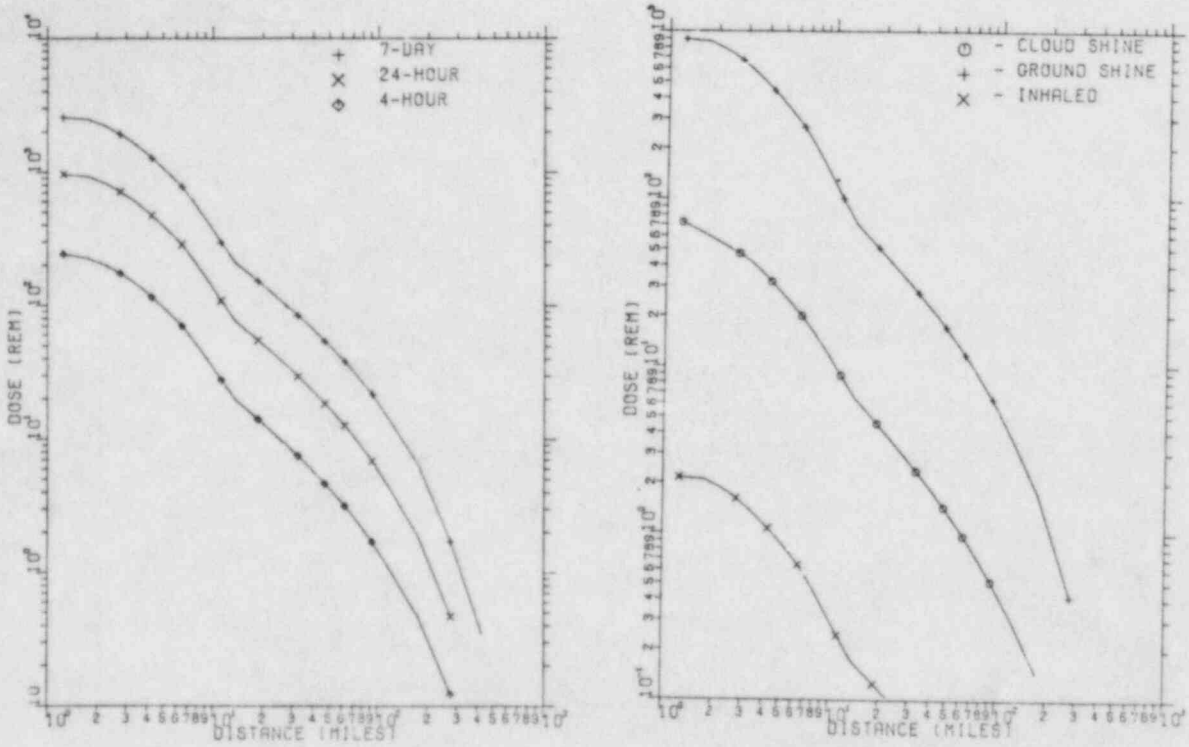
Figure 1B-5

PWR #2
CASE 5

Stability Class: D
Windspeed: 16 mph

Rain: No
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

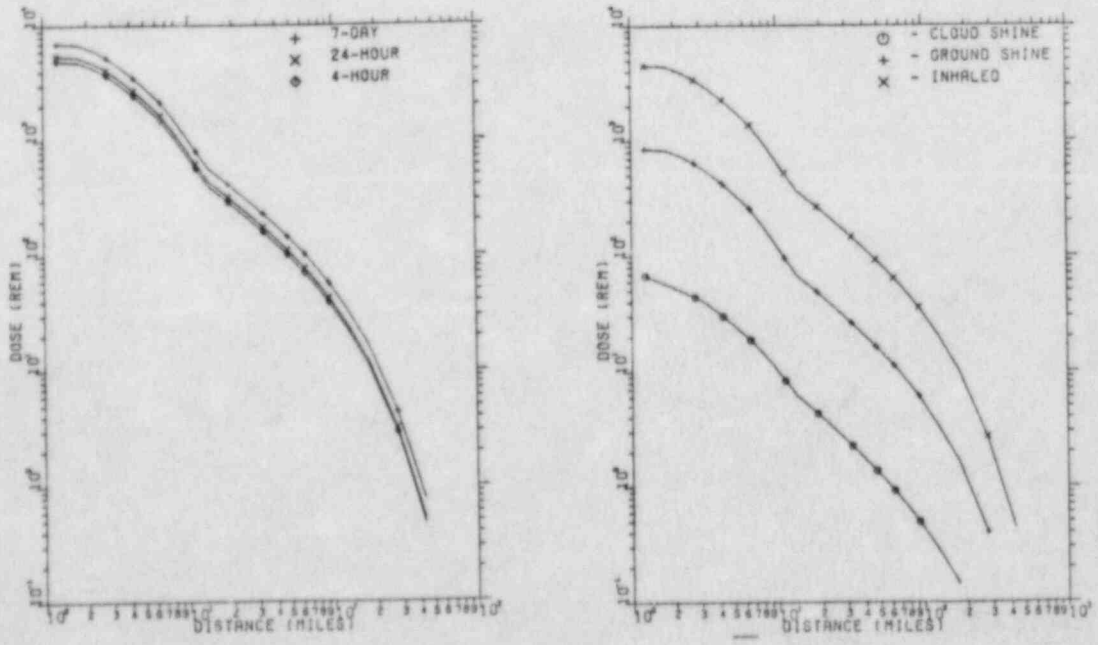


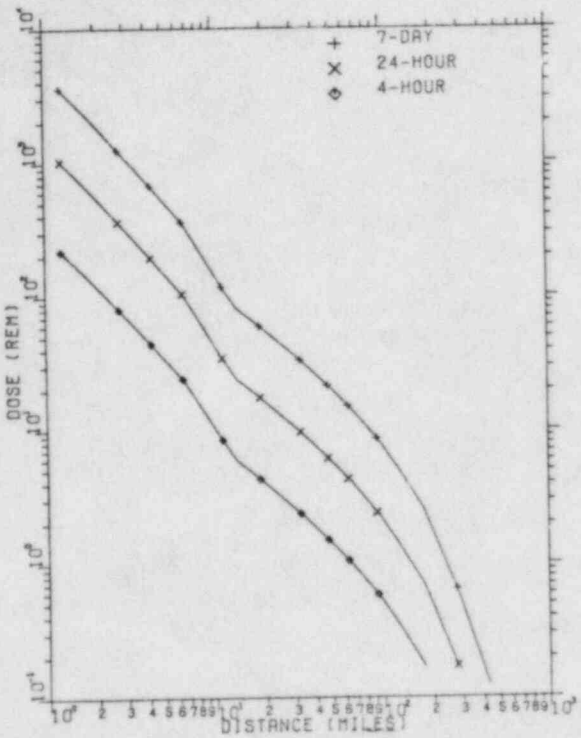
Figure 2-5

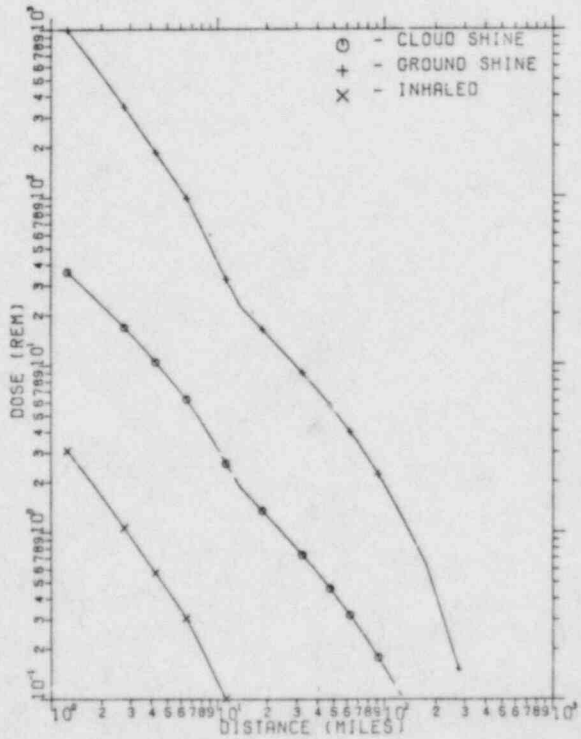
PWR #3
CASE 5

Stability Class: D
Windspeed: 16 mph

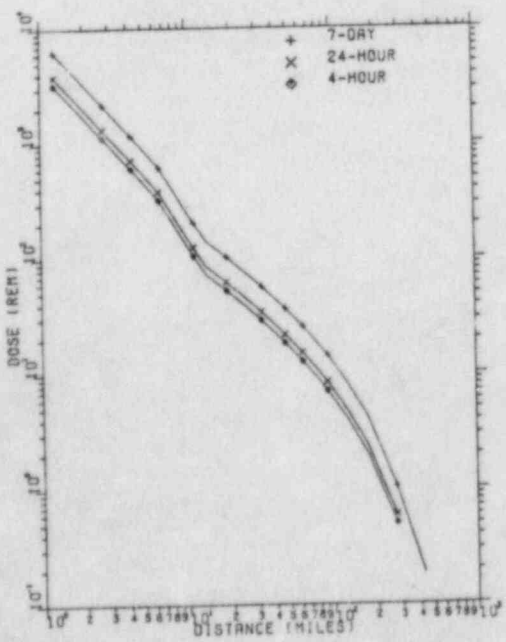
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



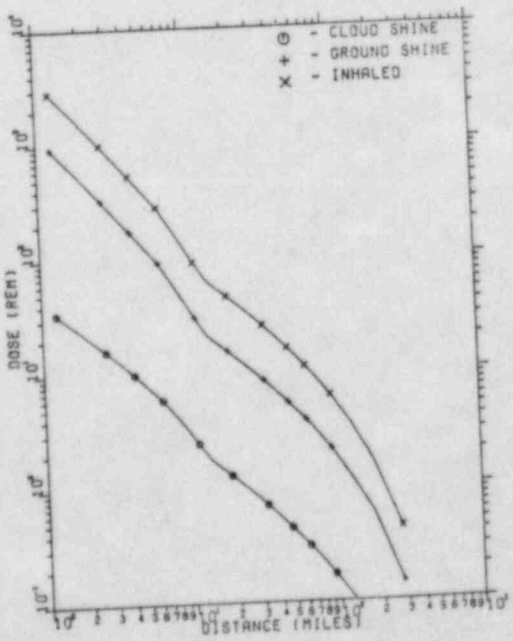


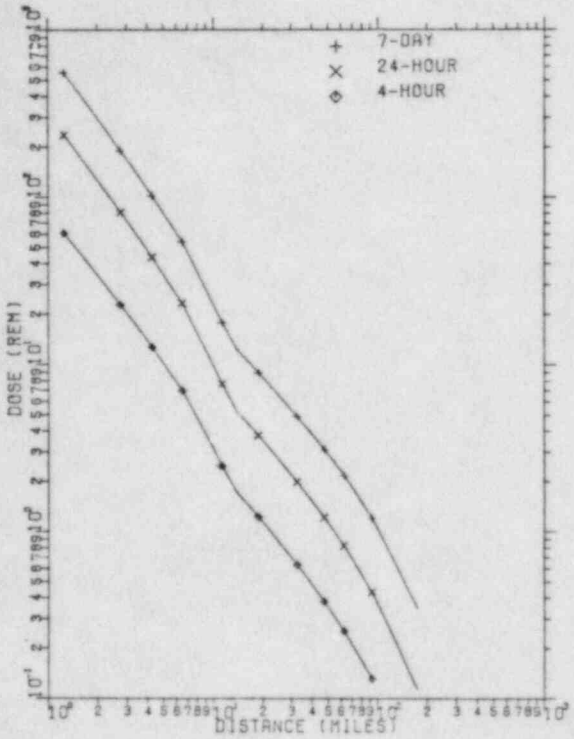
Figure 3-5

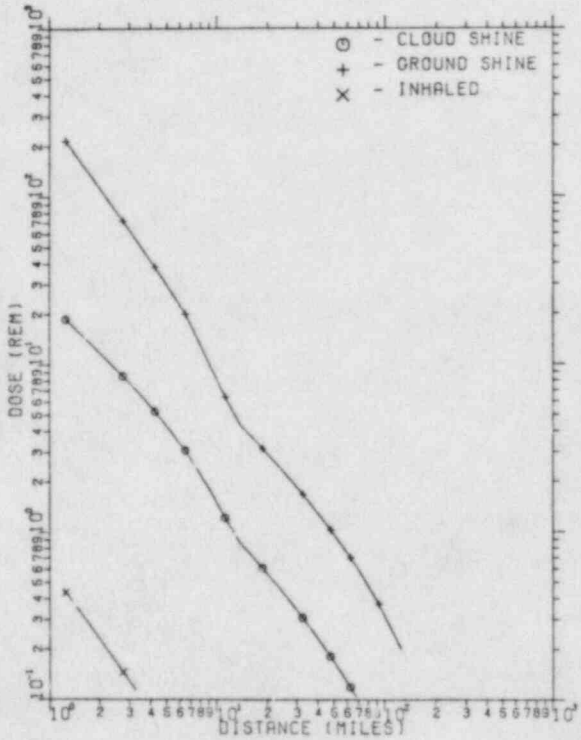
PWR #4
CASE 5

Stability Class: D
Windspeed: 16 mph

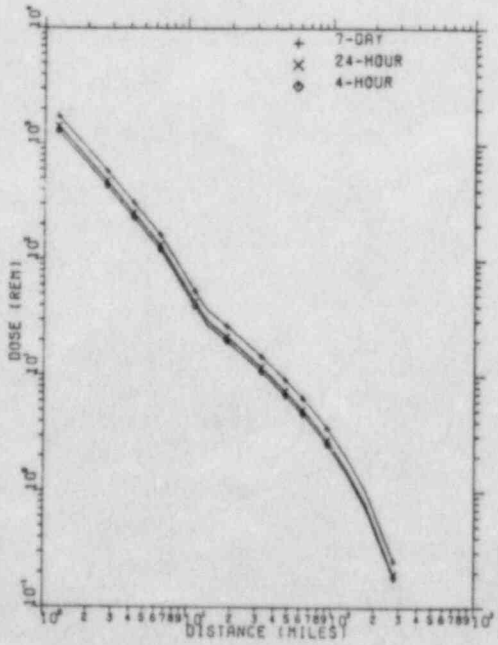
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



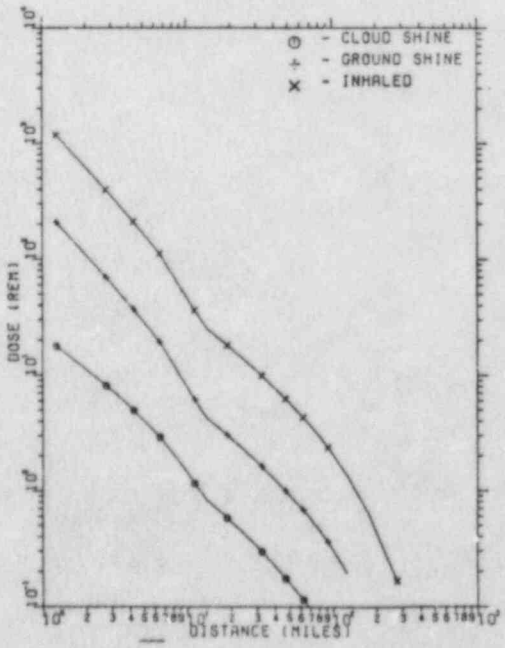


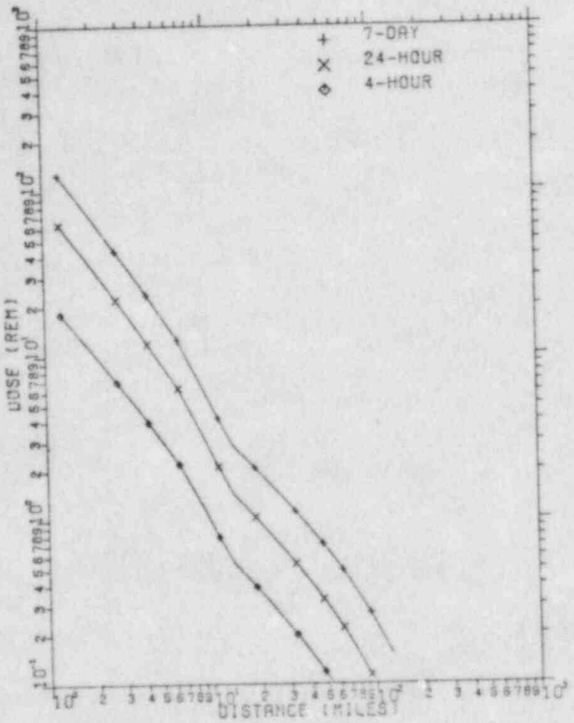
Figure 4-5

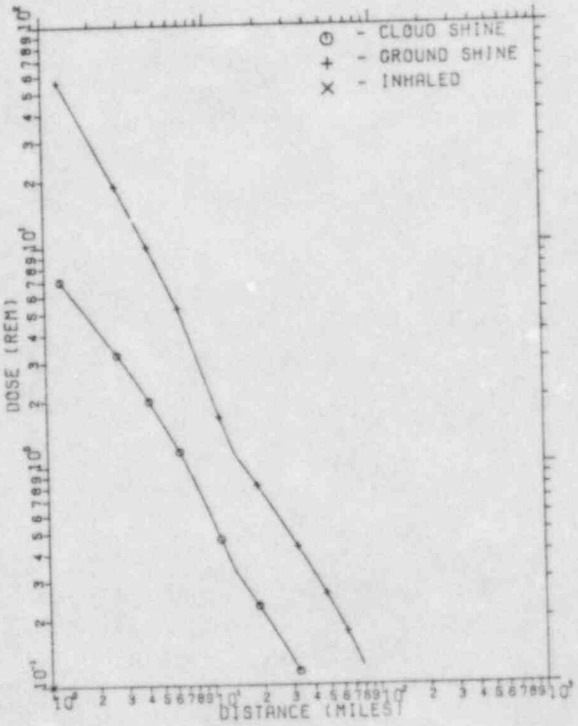
PWR #5
CASE 5

Stability Class: D
Windspeed: 16 mph

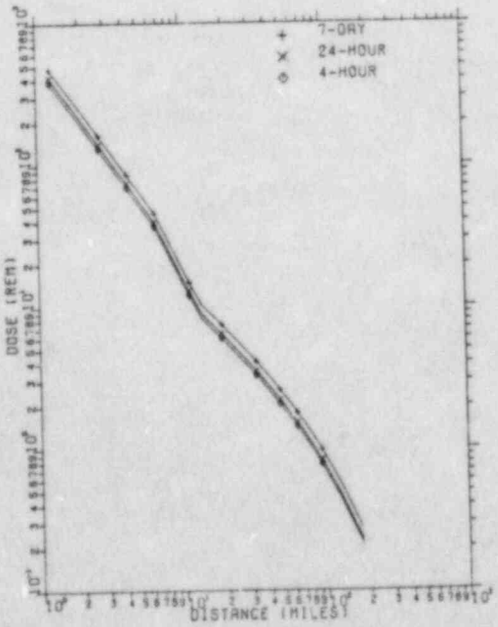
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



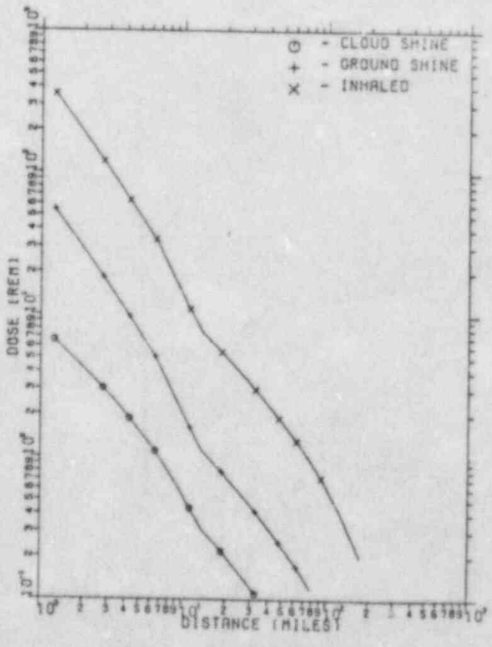


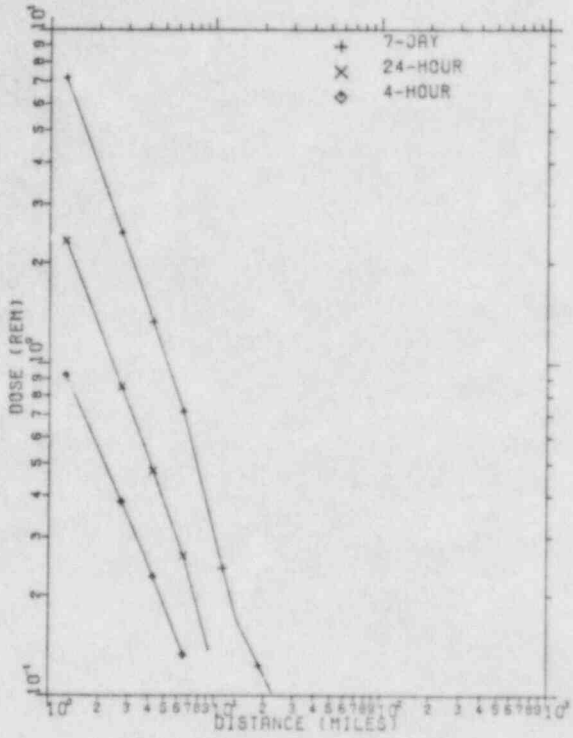
Figure 5-5

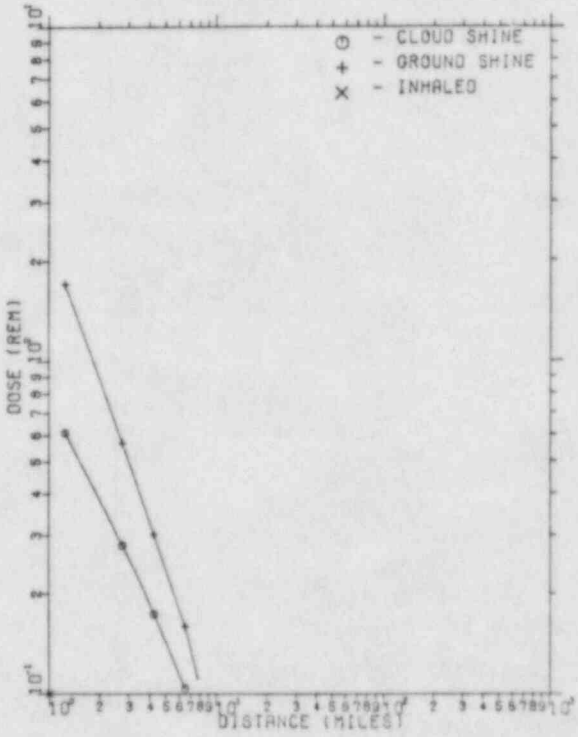
PWR #6
CASE 5

Stability Class: D
Windspeed: 16 mph

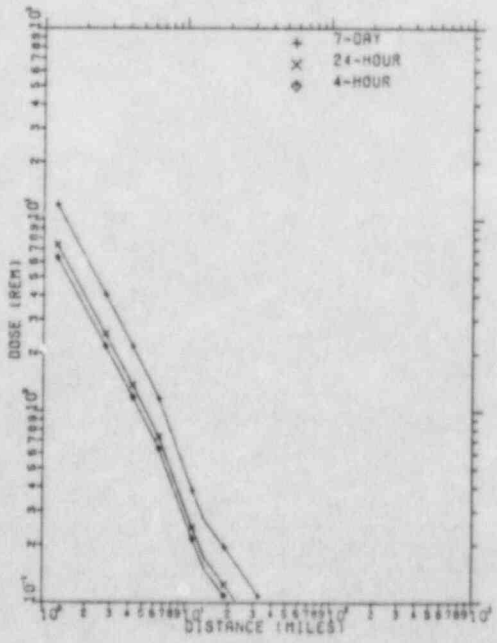
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



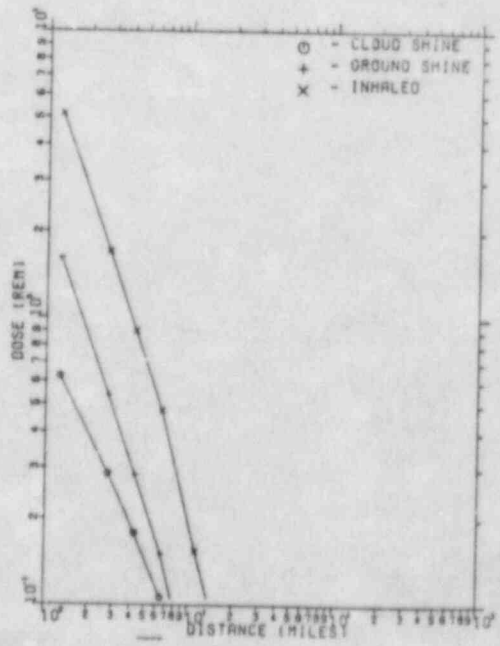


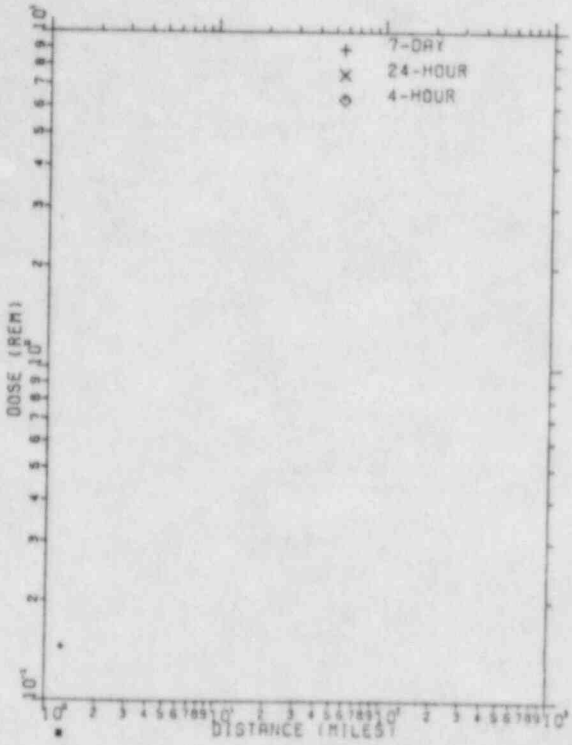
Figure 6-5

PWR #7
CASE 5

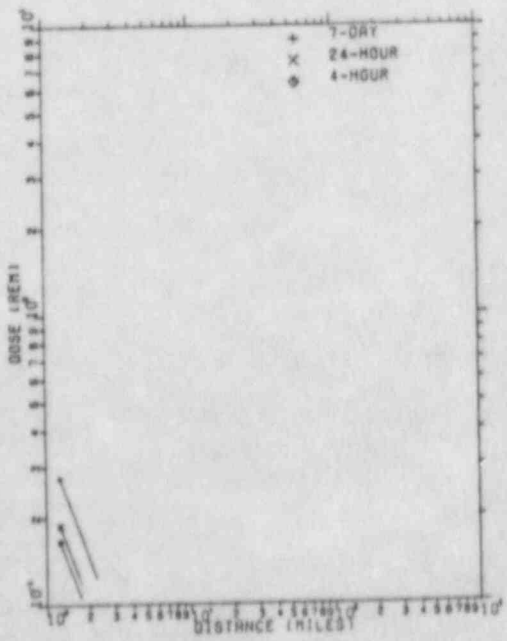
Stability Class: D
Windspeed: 16 mph

Rain: No
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE



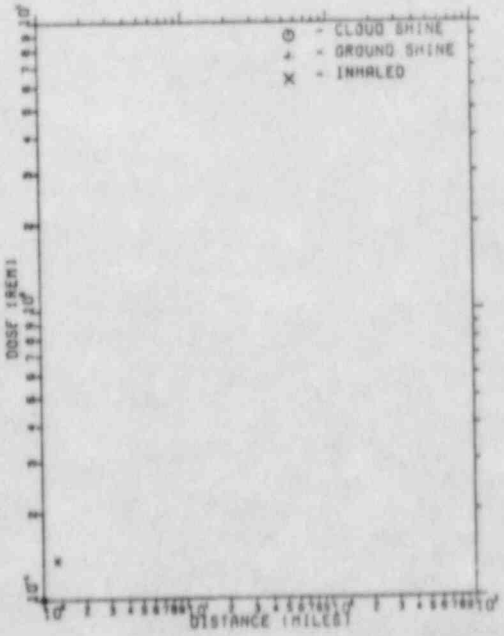


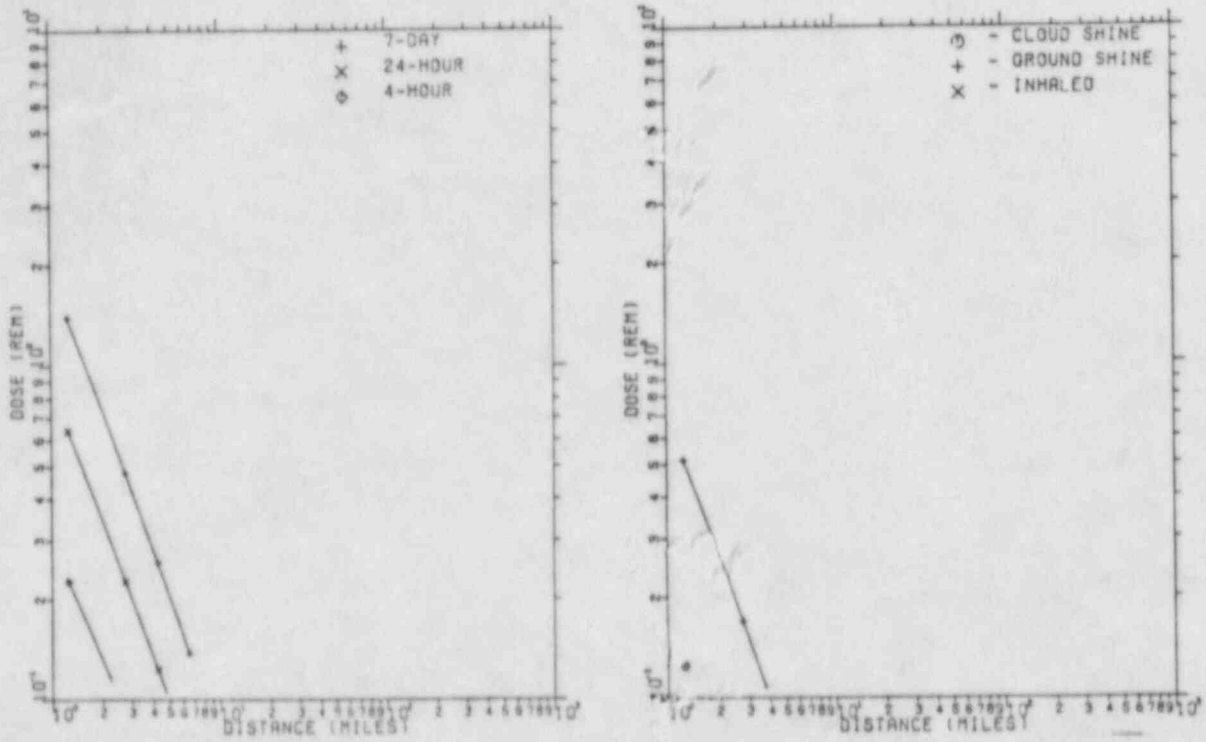
Figure 7-5

PWR #8
CASE 5

Stability Class: D
Windspeed: 6 mph

Rain: No
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

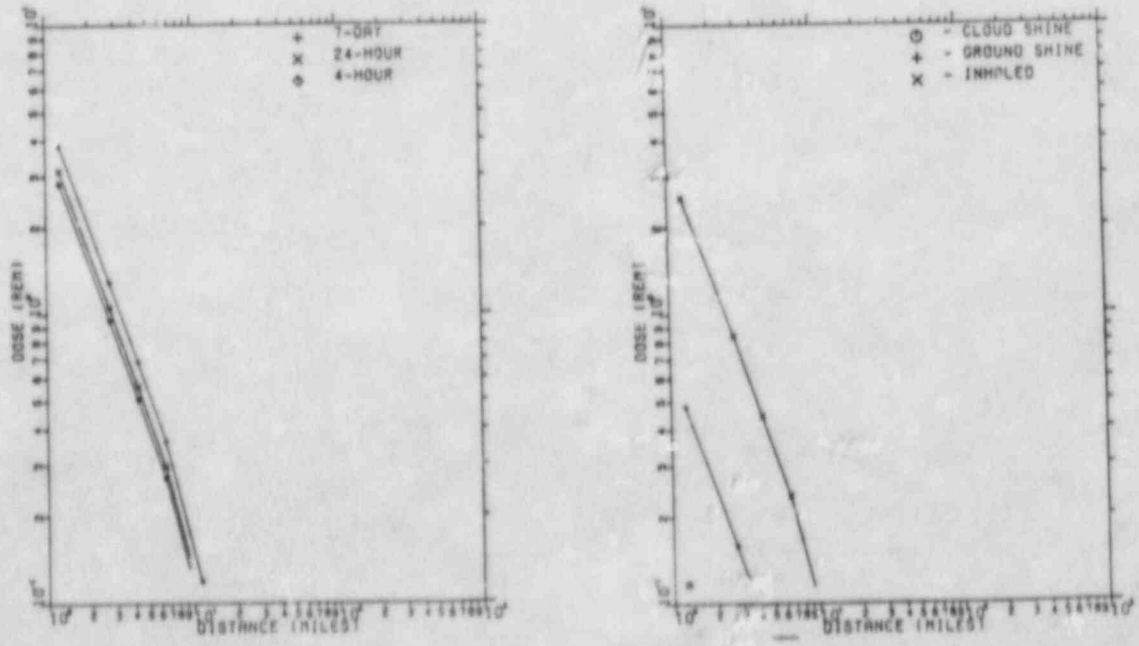


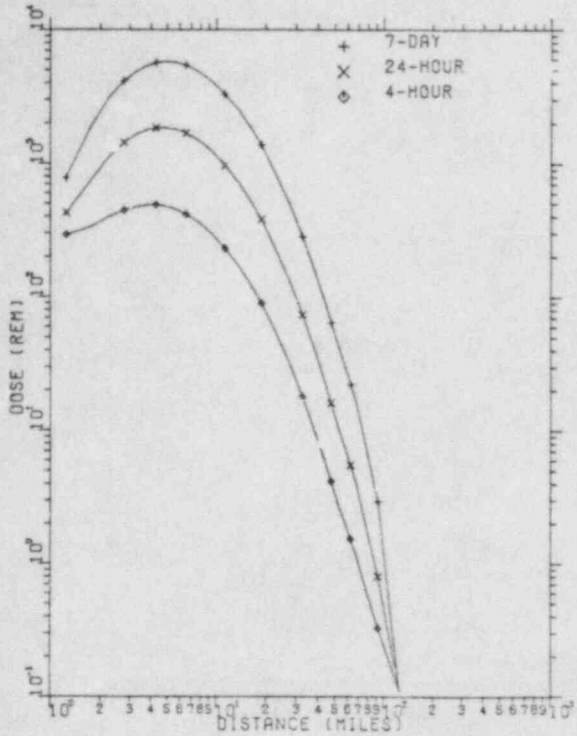
Figure 8-5

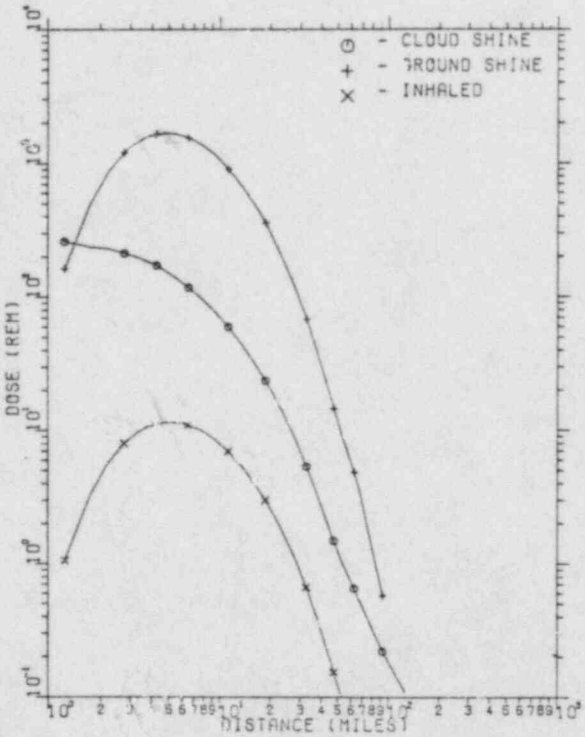
PWR #1A
CASE 6

Stability Class: E
Windspeed: 2 mph

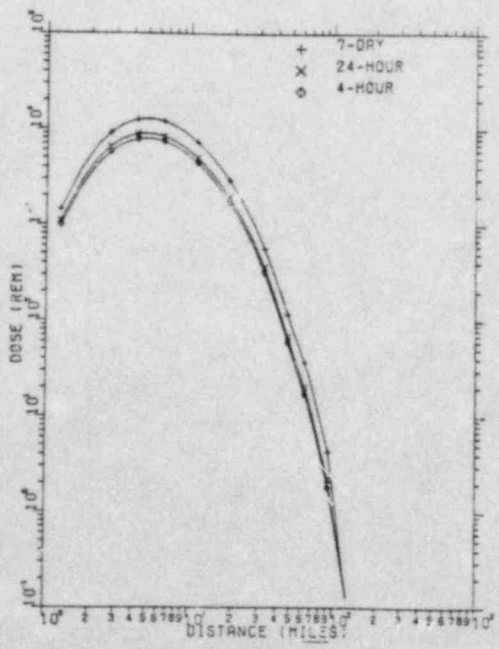
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



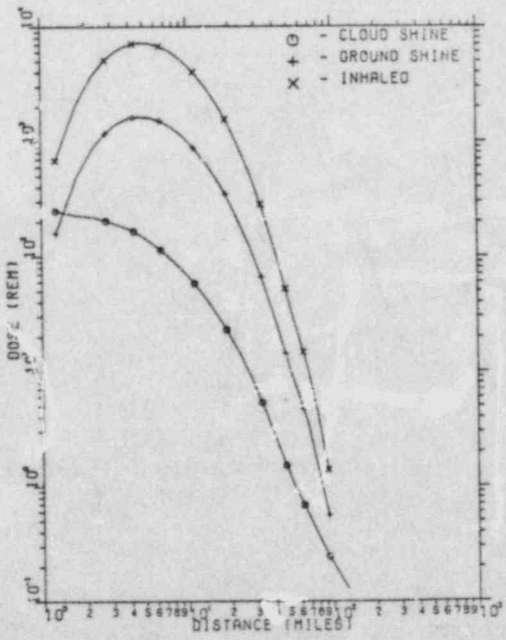


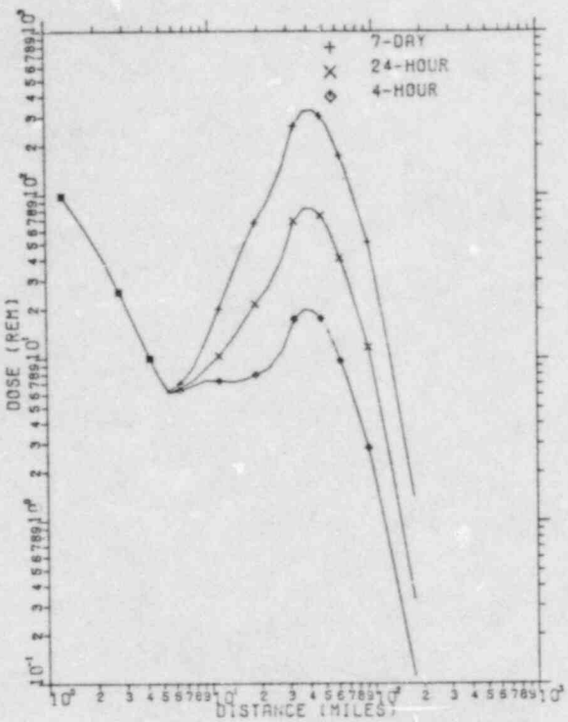
Figure 1A-6

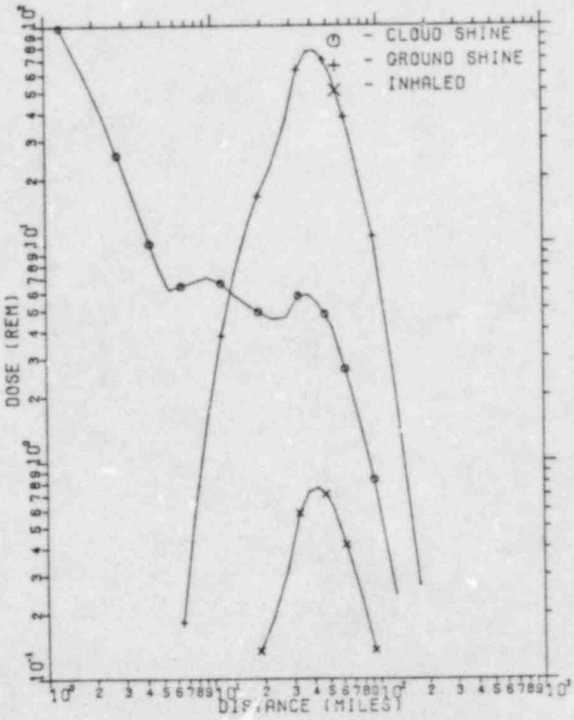
PWR #1B
CASE 6

Stability Class: E
Windspeed: 2 mph

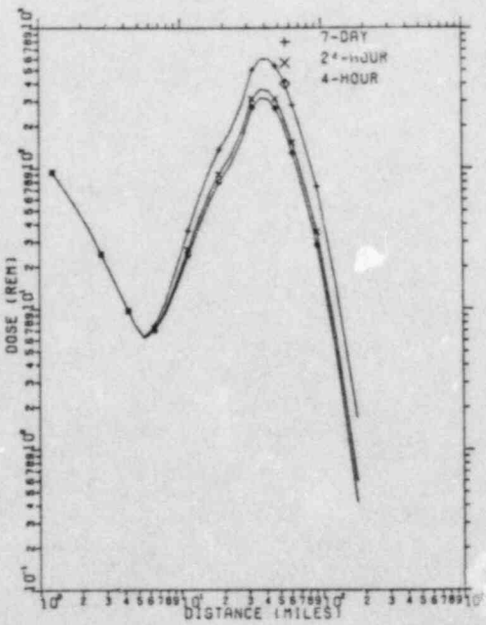
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



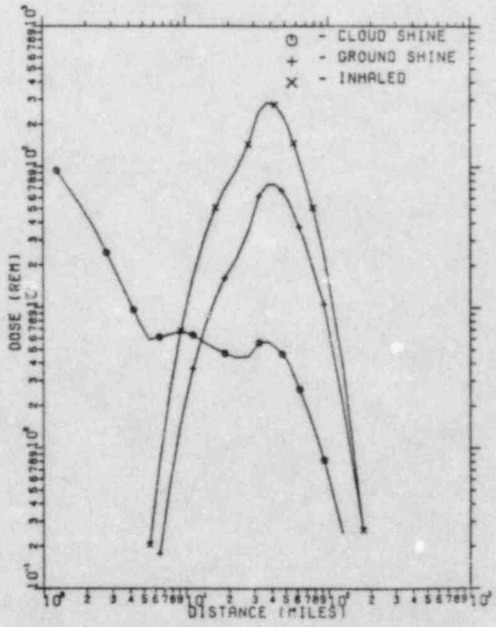


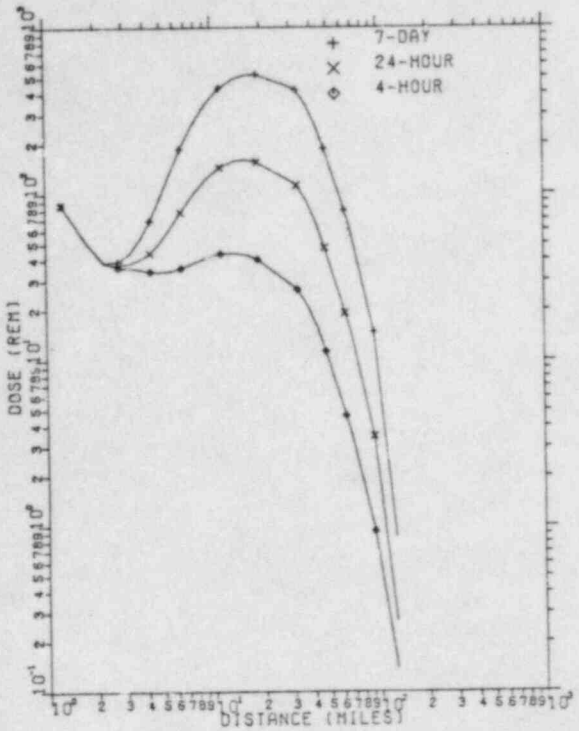
Figure 1B-6

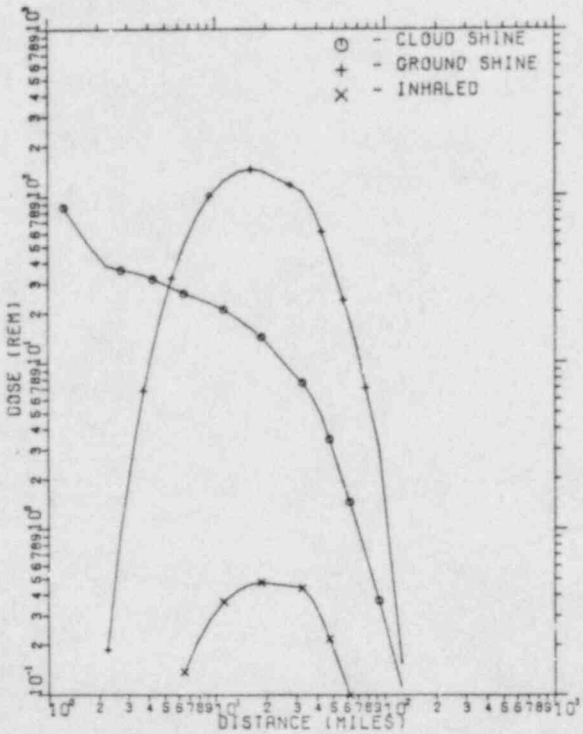
PWR #2
CASE 6

Stability Class: E
Windspeed: 2 mph

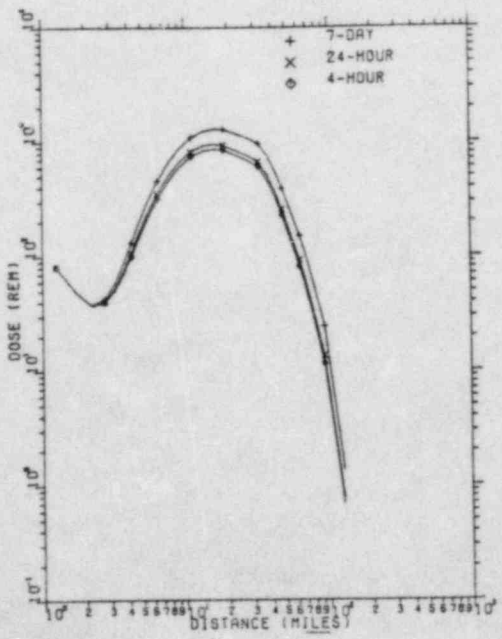
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



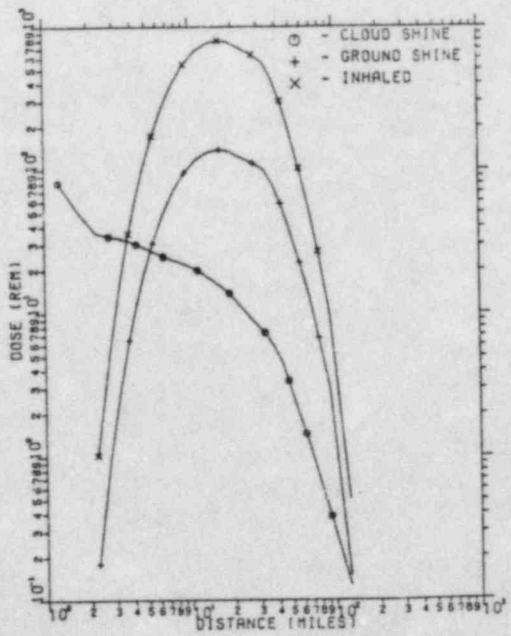


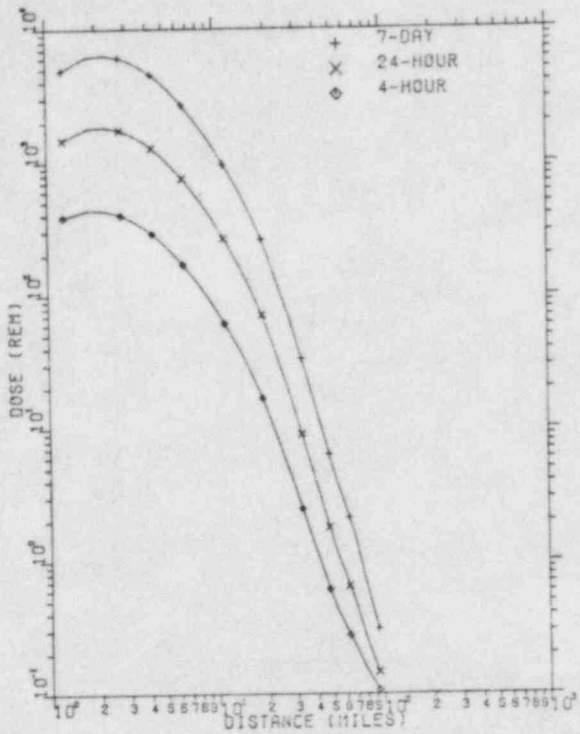
Figure 2-6

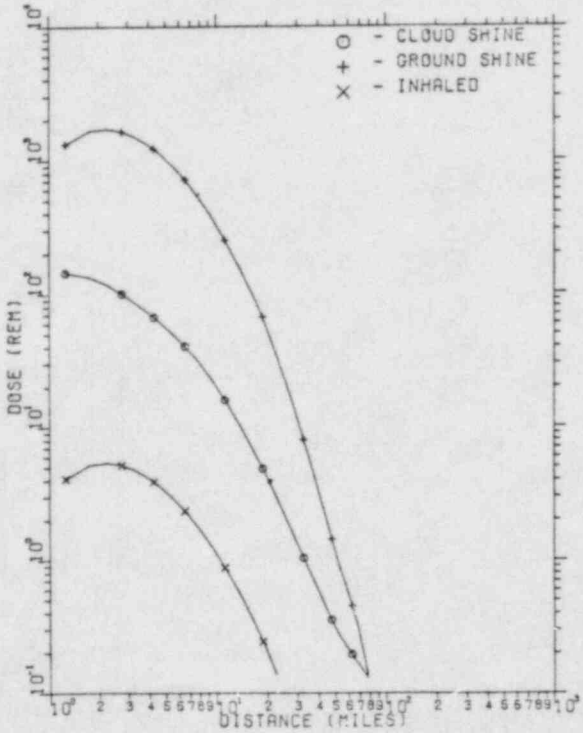
PWR #3
CASE 6

Stability Class: E
Windspeed: 2 mph

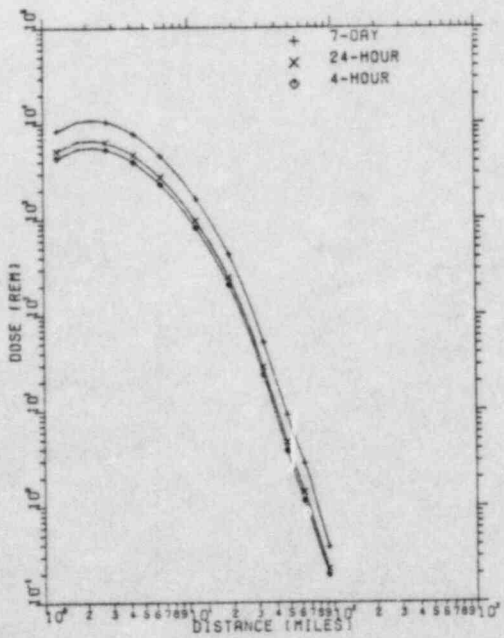
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



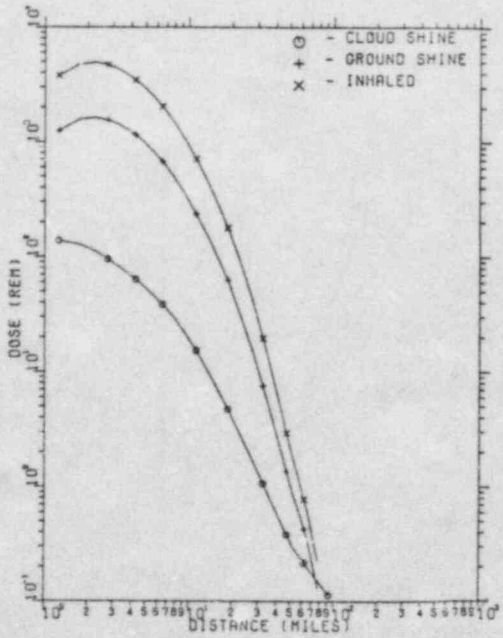


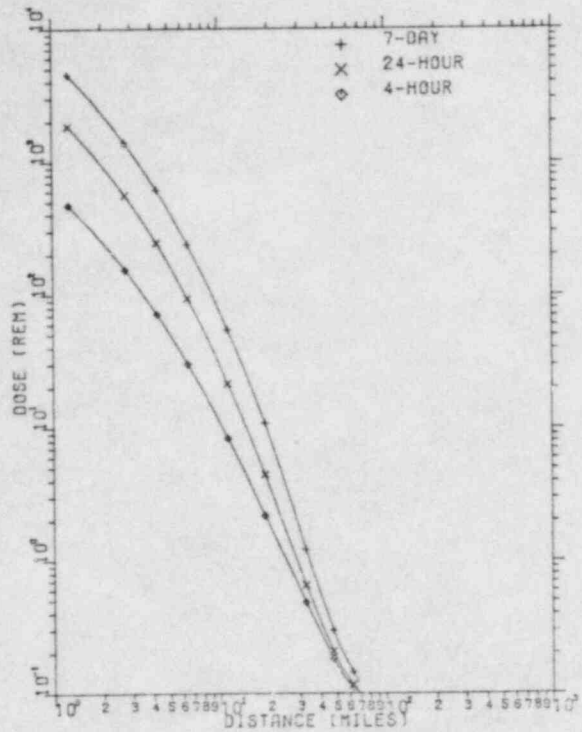
Figure 3-6

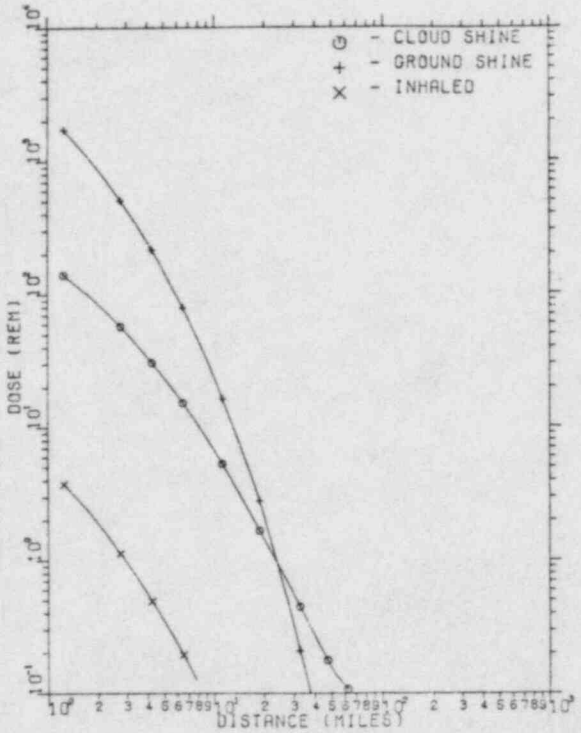
PWR #4
CASE 6

Stability Class: E
Windspeed: 2 mph

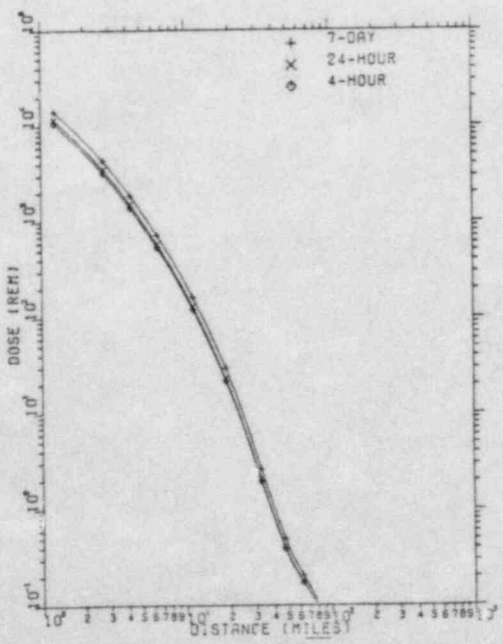
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



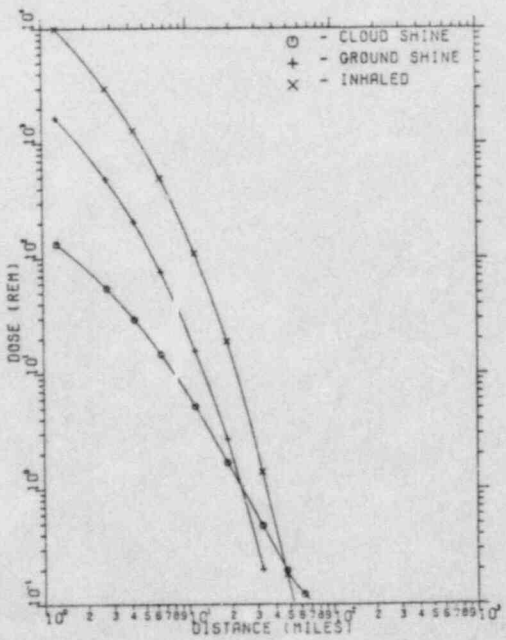


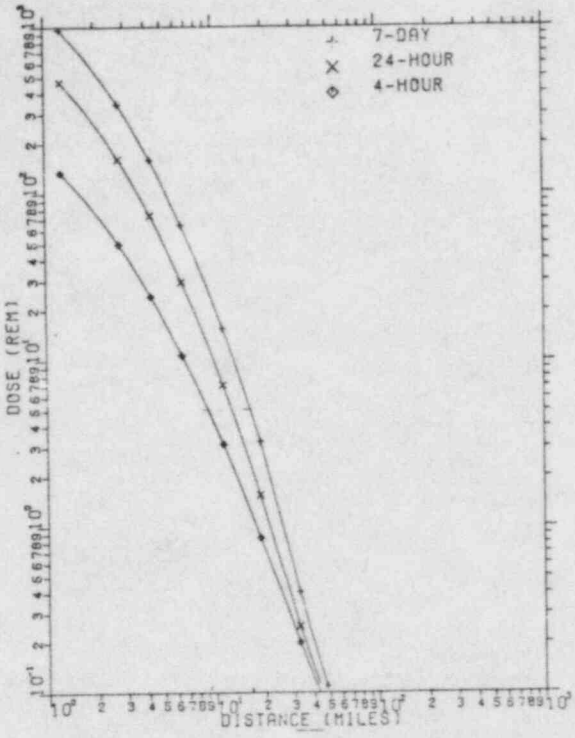
Figure 4-6

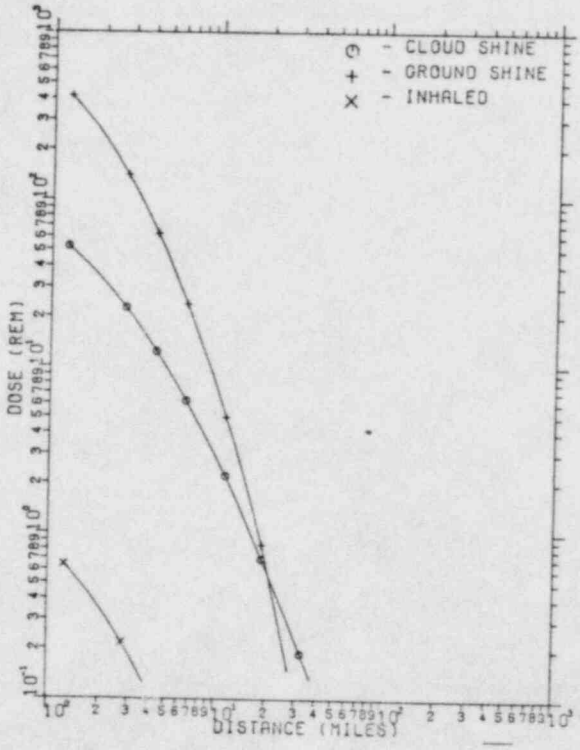
PWR #5
CASE 6

Stability Class: E
Windspeed: 2 mph

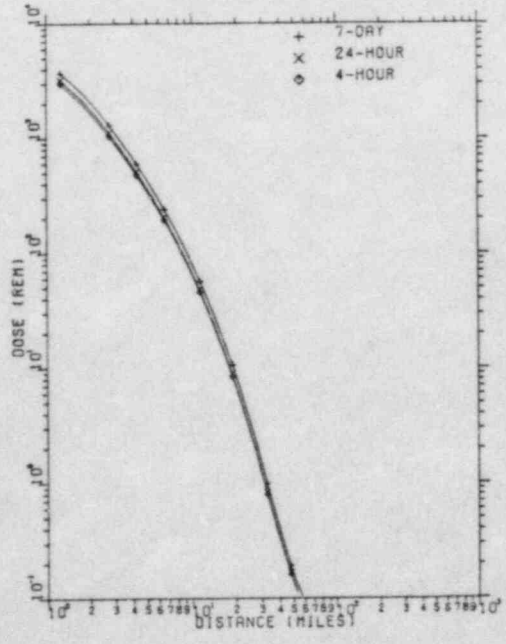
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



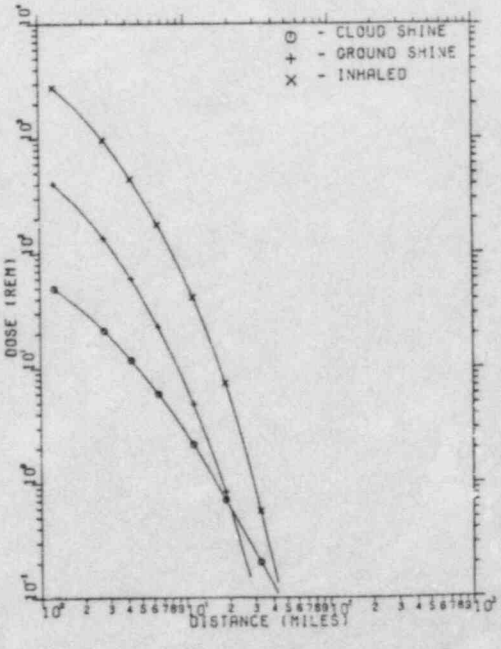


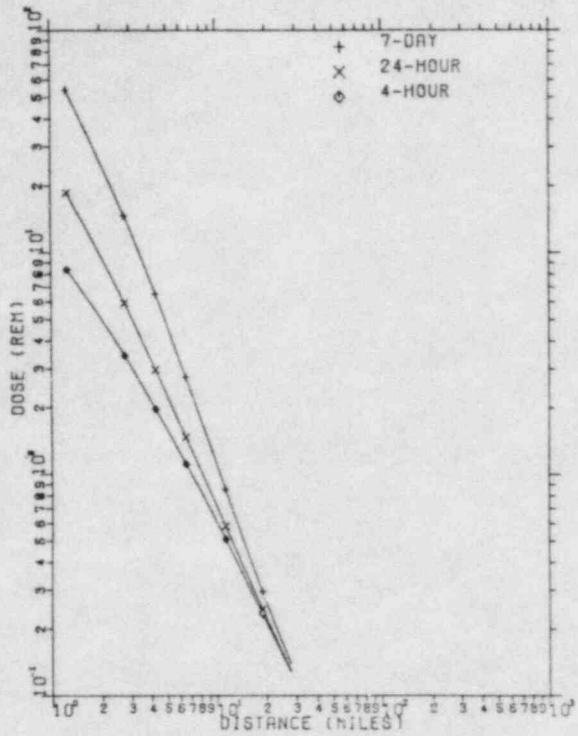
Figure 5-6

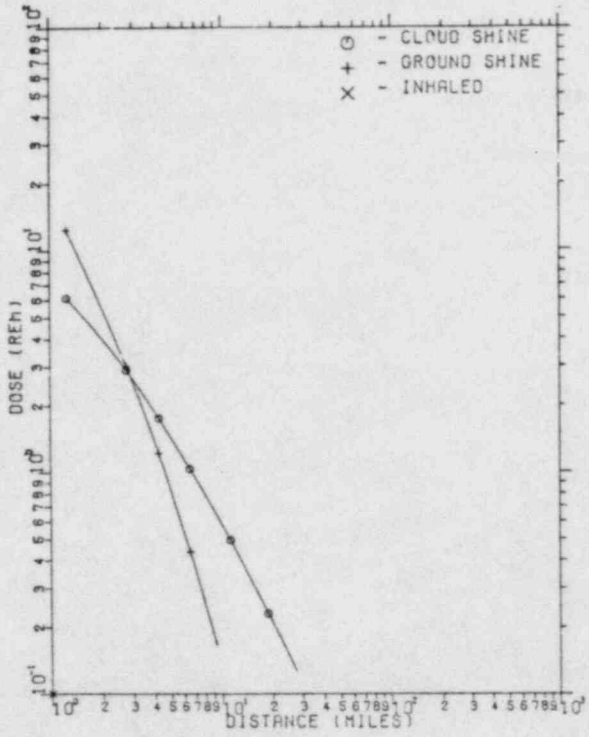
PWR #6
CASE 6

Stability Class: E
Windspeed: 2 mph

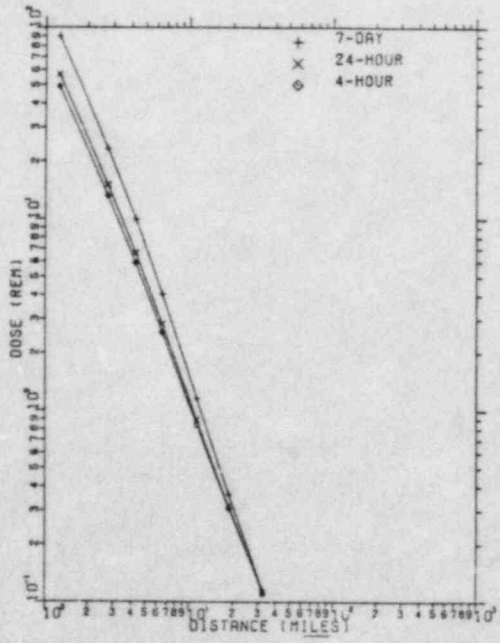
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



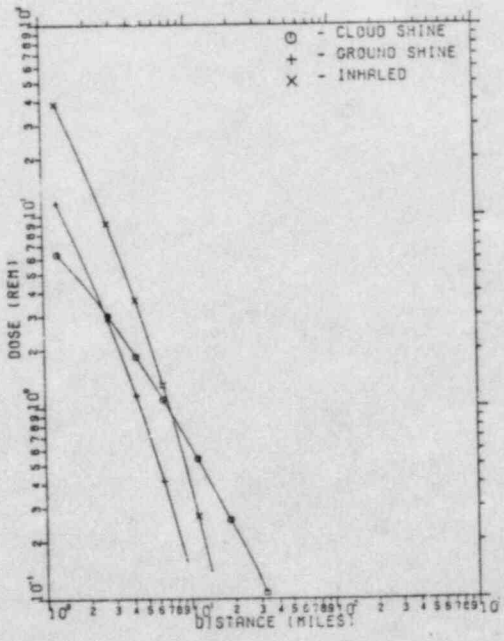


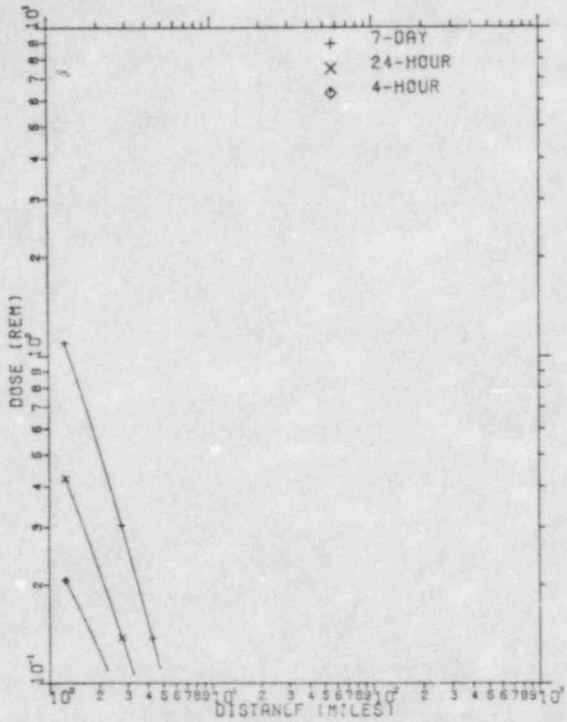
Figure 6-6

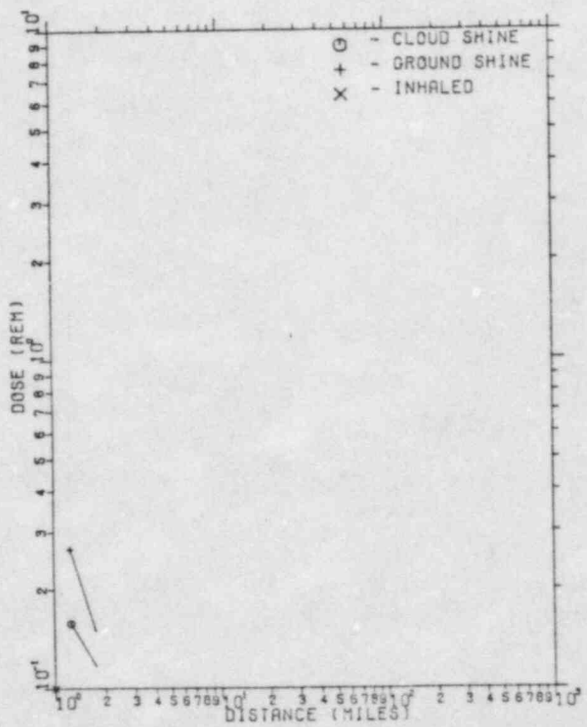
PWR #7
CASE 6

Stability Class: E
Windspeed: 2 mph

Rain: No
Sheltering: None

WHOLE BODY DOSE





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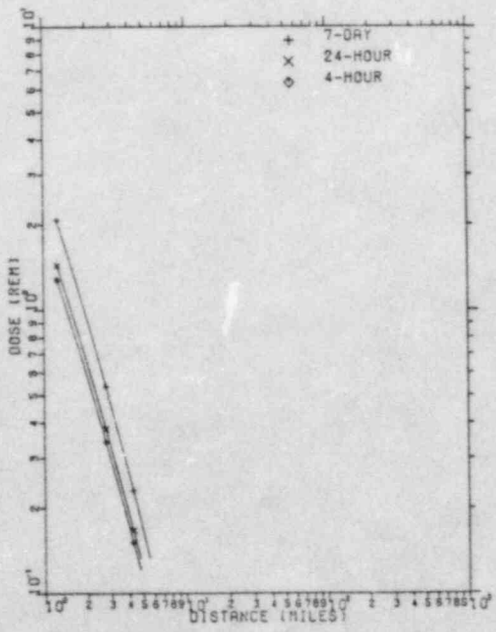


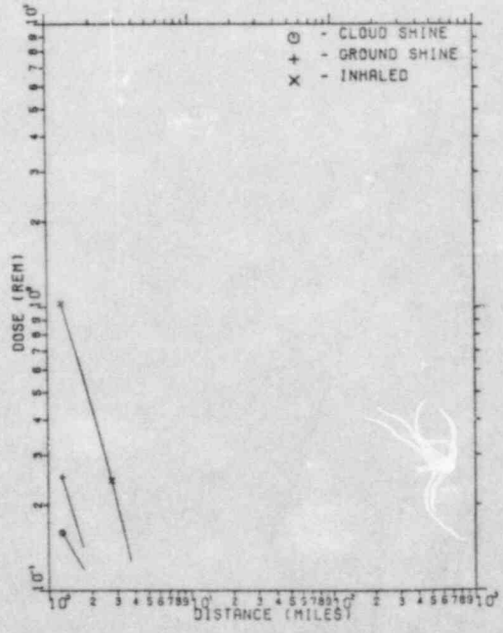


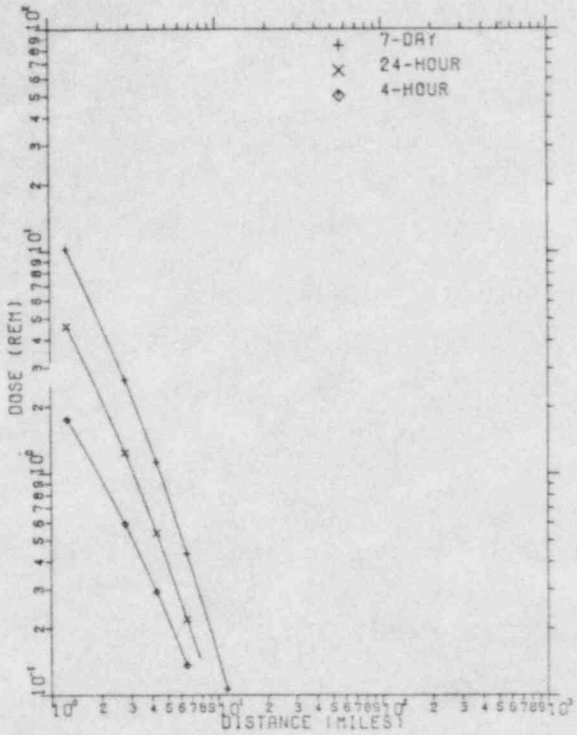
Figure 7-6

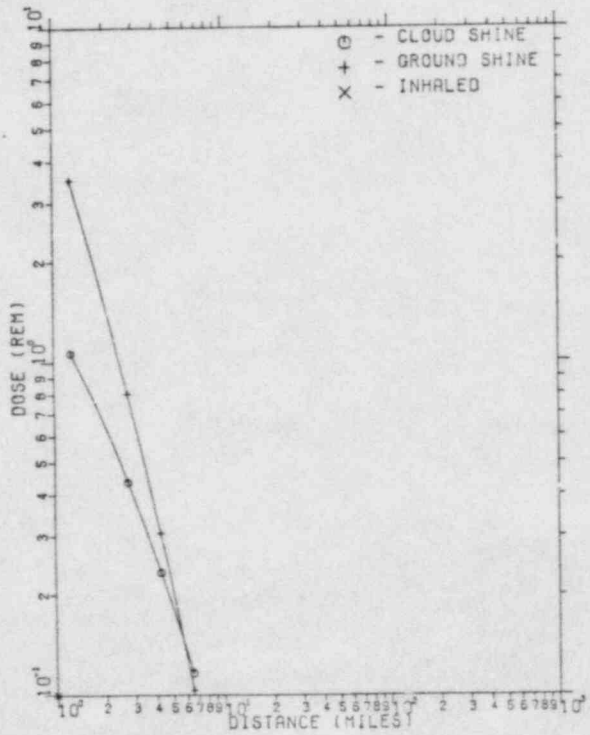
PWR #8
CASE 6

Stability Class: E
Windspeed: 2 mph

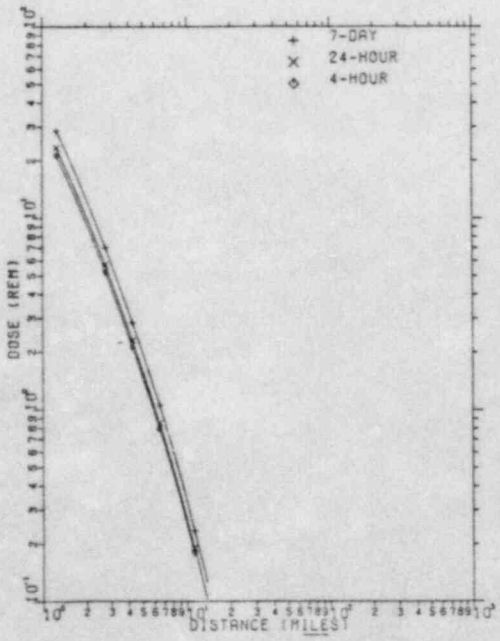
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



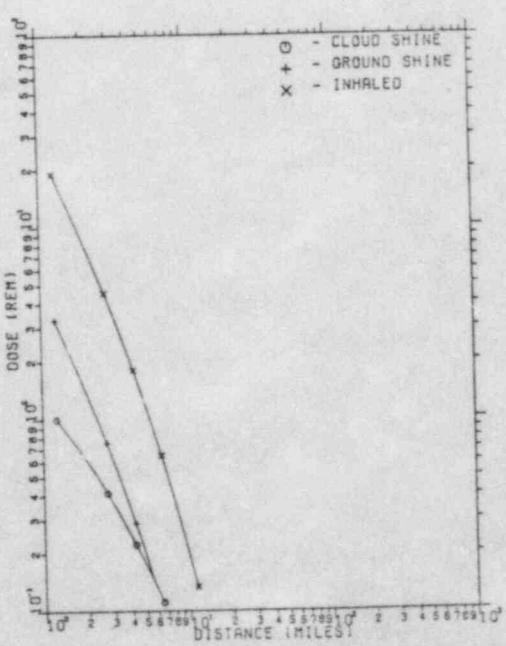


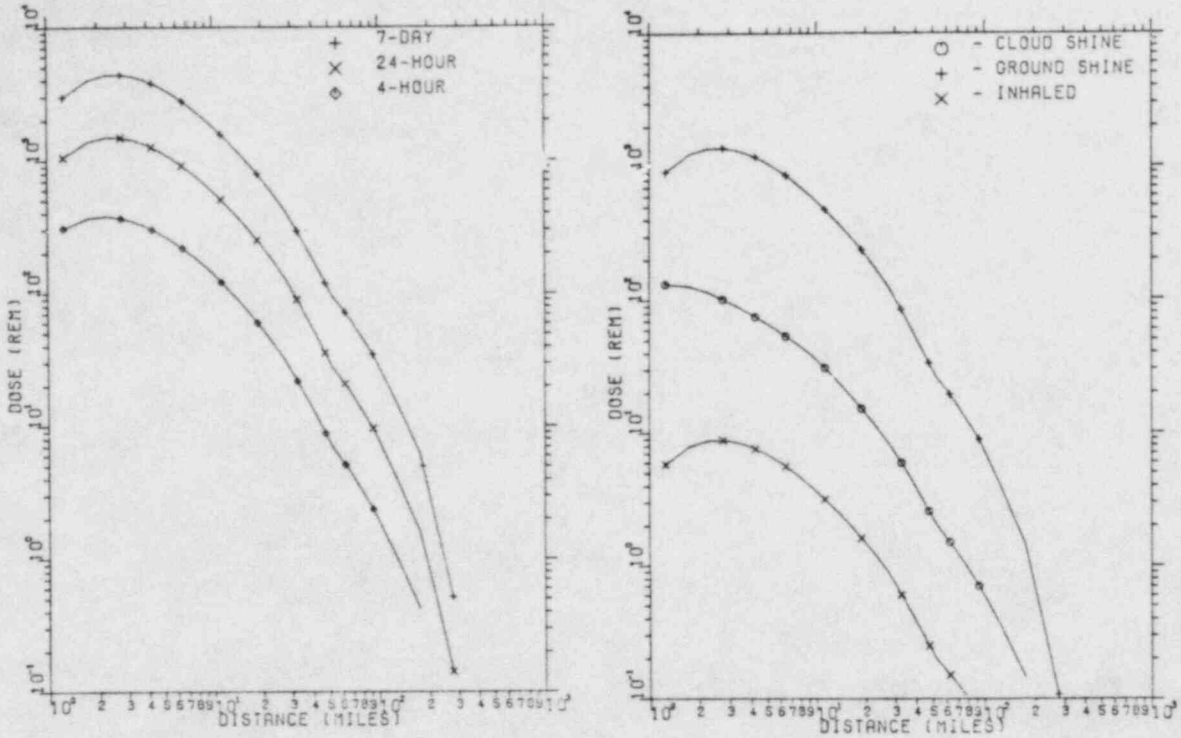
Figure 8-6

PWR #1A
CASE 7

Stability Class: E
Windspeed: 9 mph

Rain: No
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

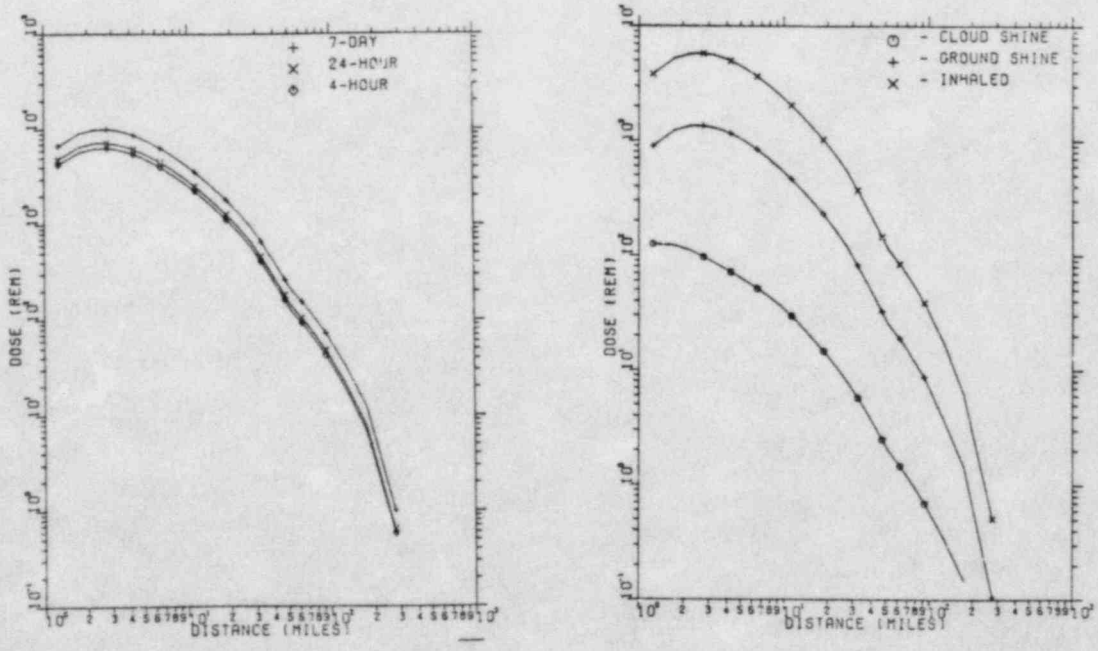


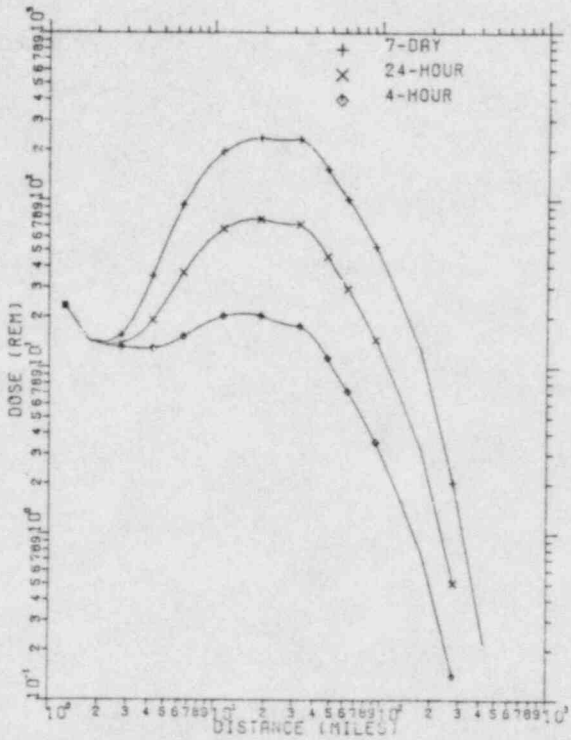
Figure 1A-7

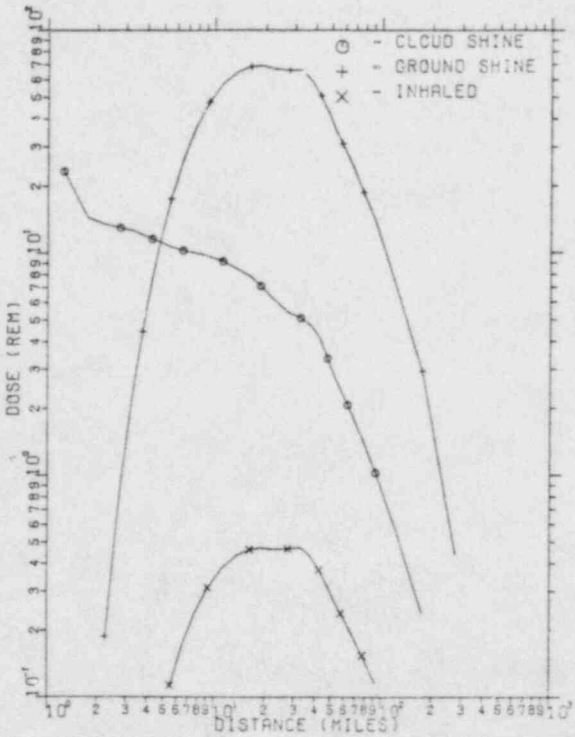
PWR #1B
CASE 7

Stability Class: E
Windspeed: 9 mph

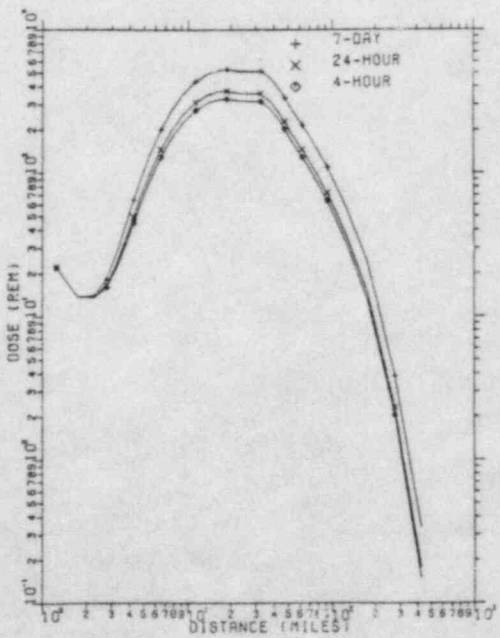
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



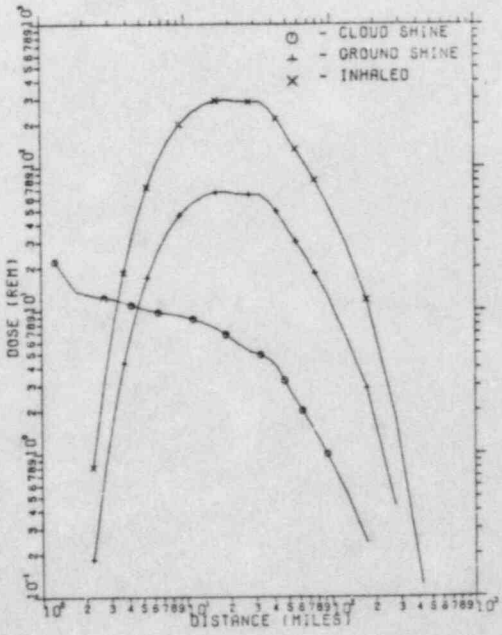


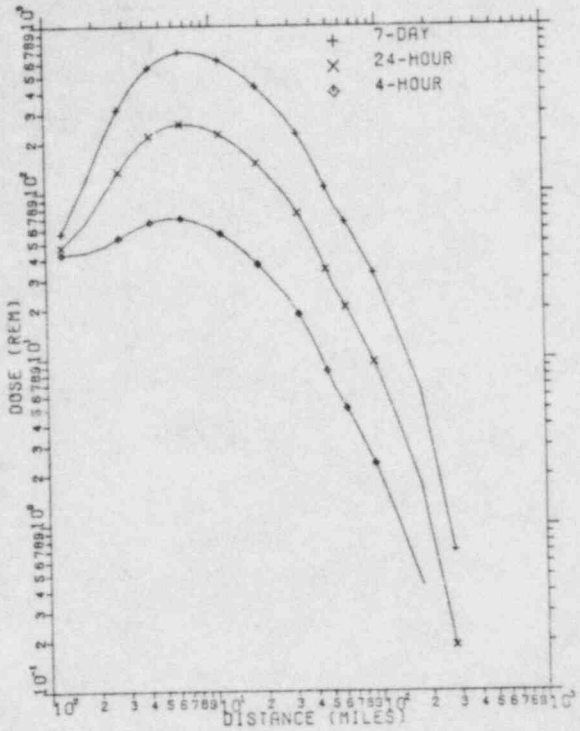
Figure 1B-7

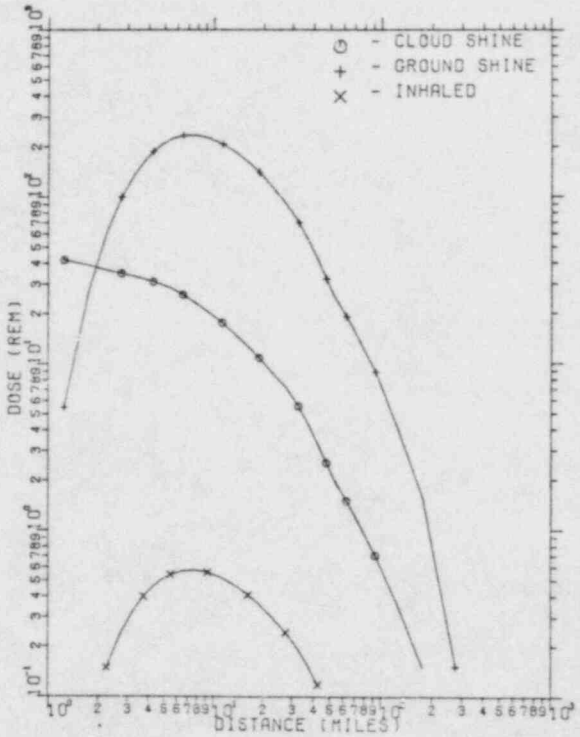
PWR #2
CASE 7

Stability Class: E
Windspeed: 9 mph

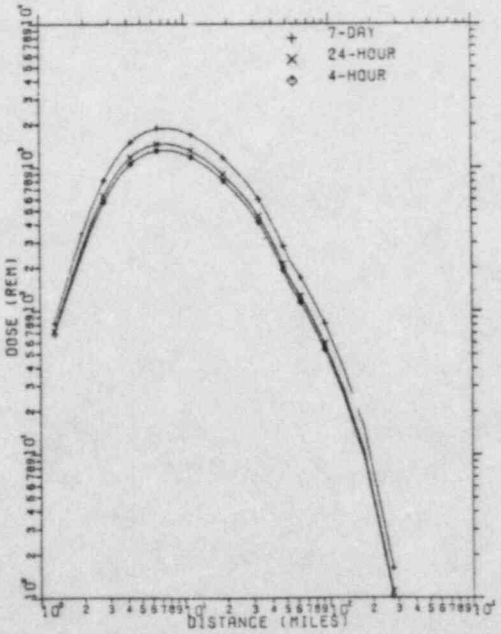
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



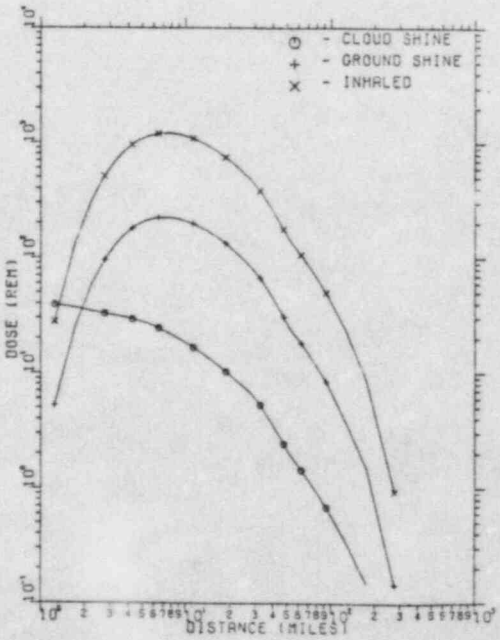


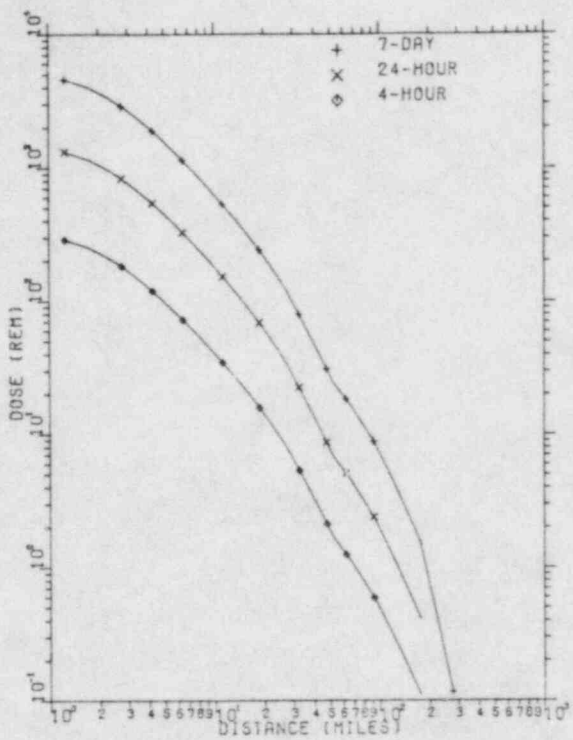
Figure 2-7

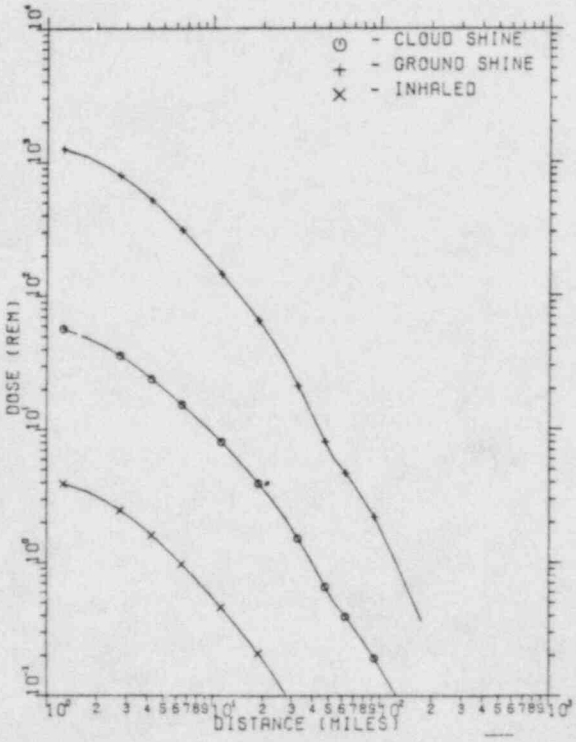
PWR #3
CASE 7

Stability Class: E
Windspeed: 9 mph

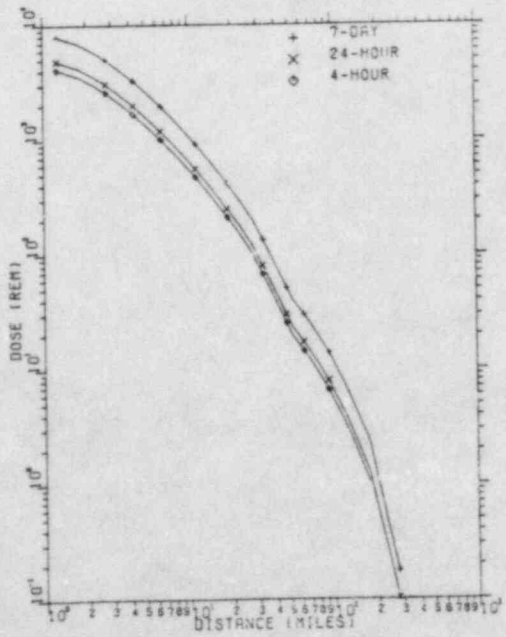
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



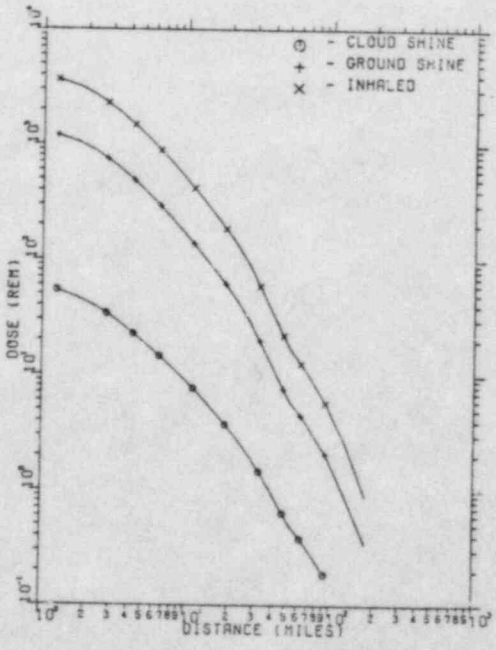


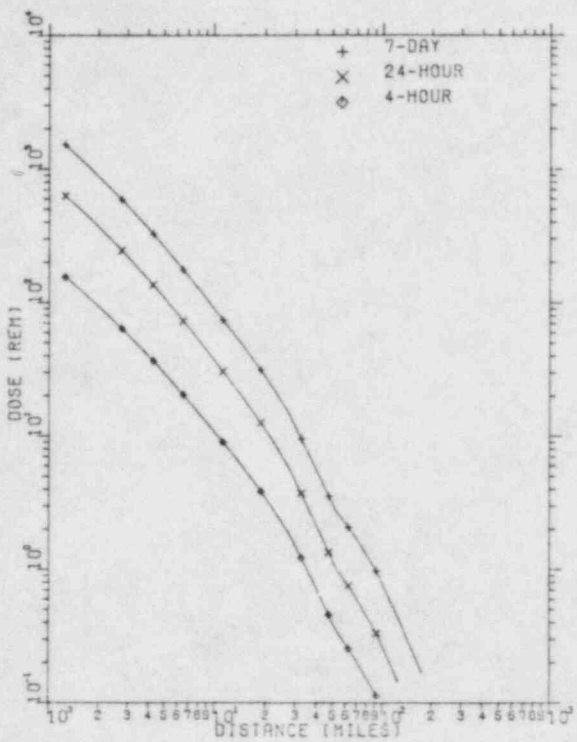
Figure 3-7

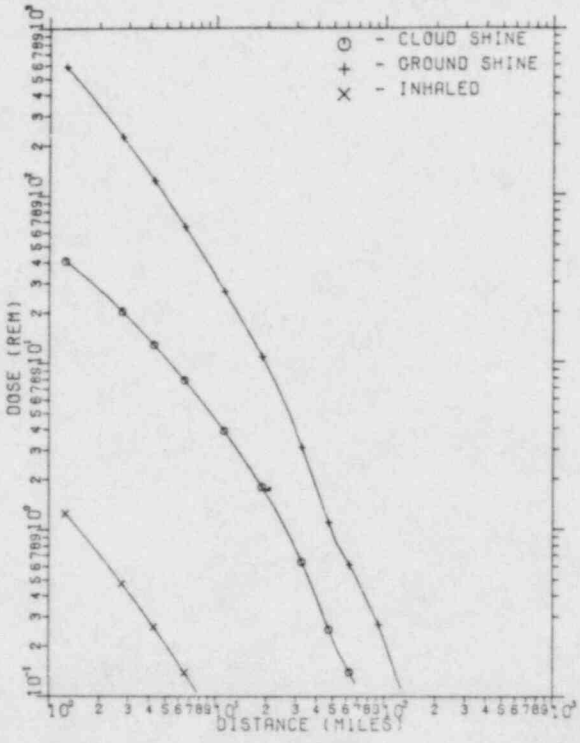
PWR #4
CASE 7

Stability Class: E
Windspeed: 9 mph

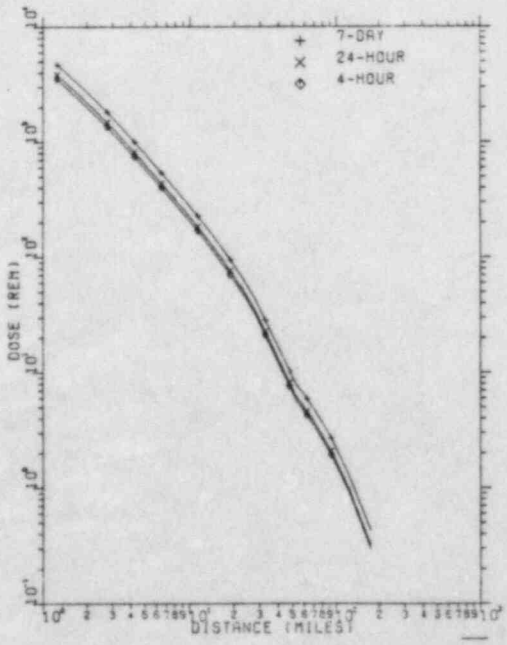
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



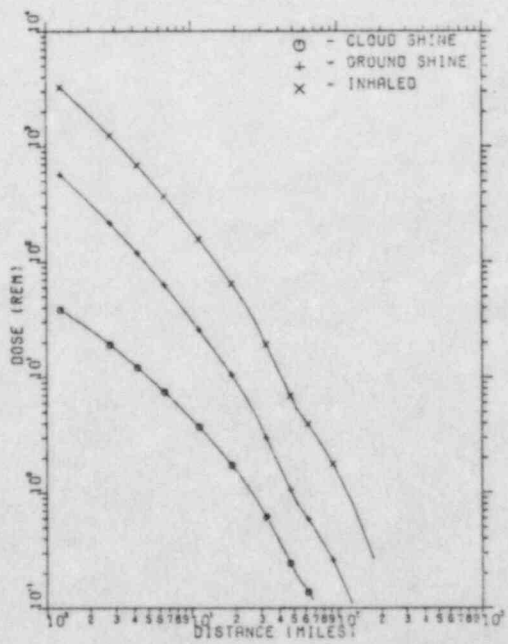


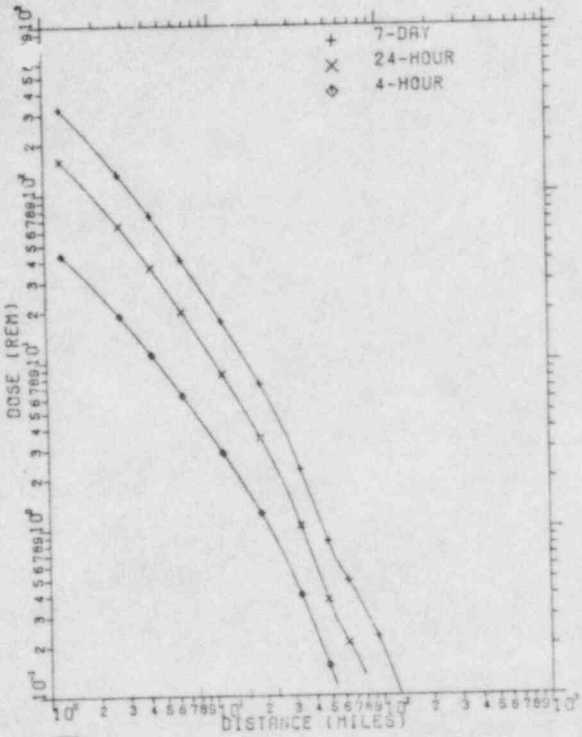
Figure 4-7

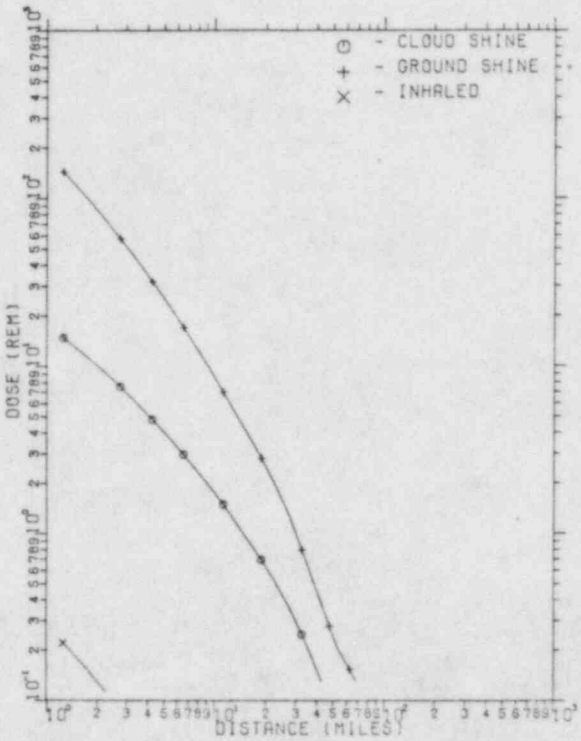
PWR #5
CASE 7

Stability Class: E
Windspeed: 9 mph

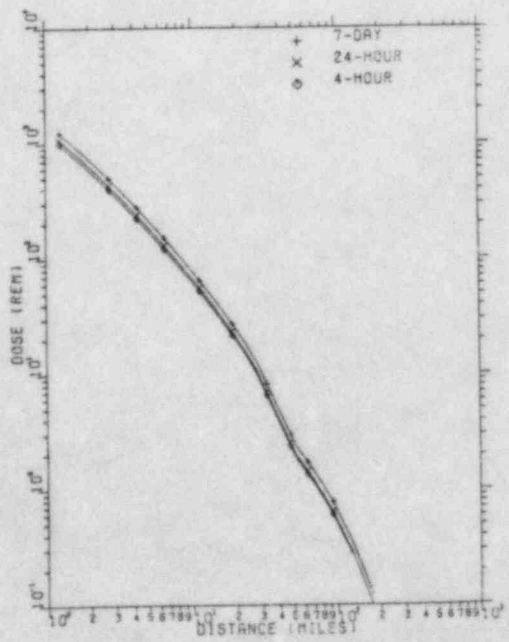
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



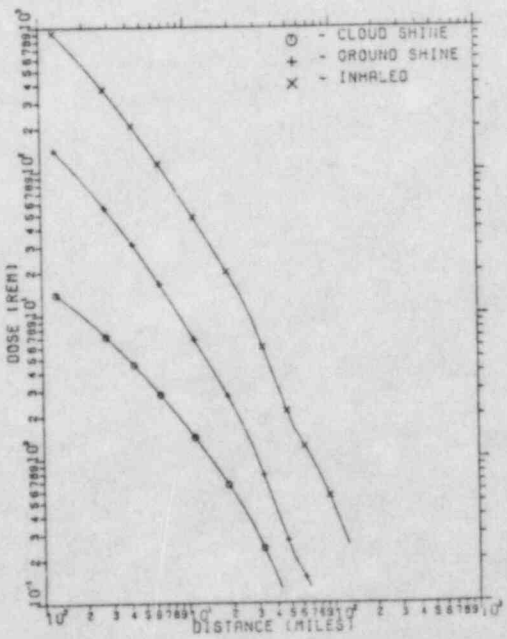


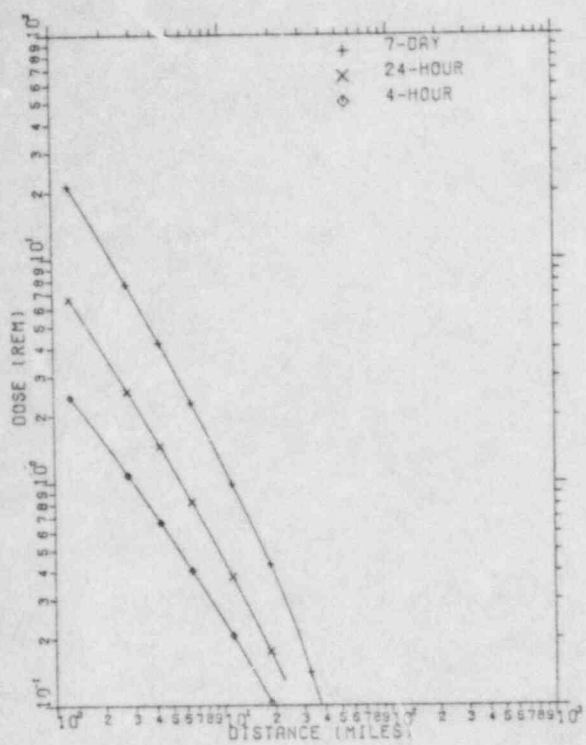
Figure 5-7

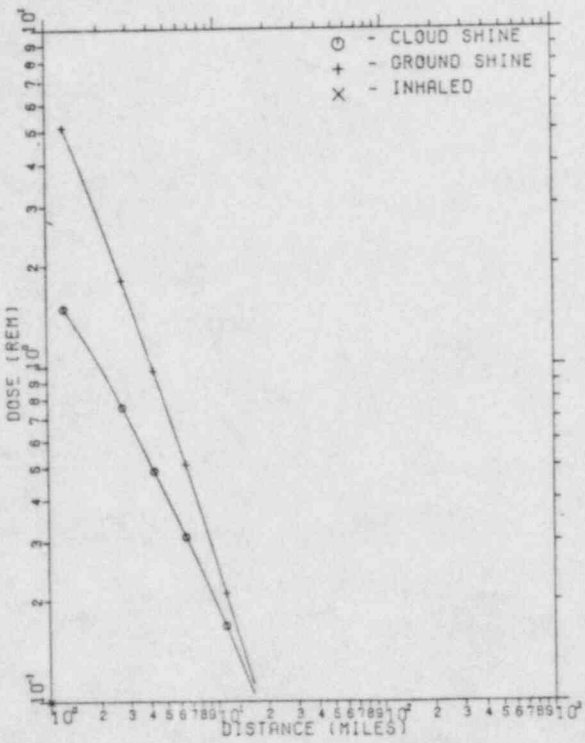
PWR #6
CASE 7

Stability Class: E
Windspeed: 9 mph

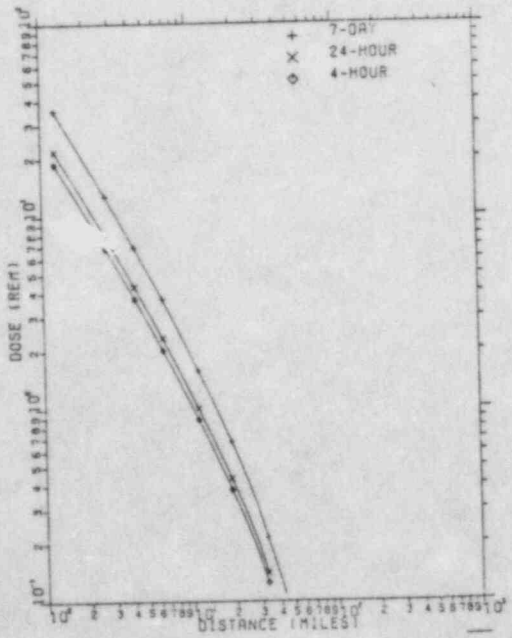
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



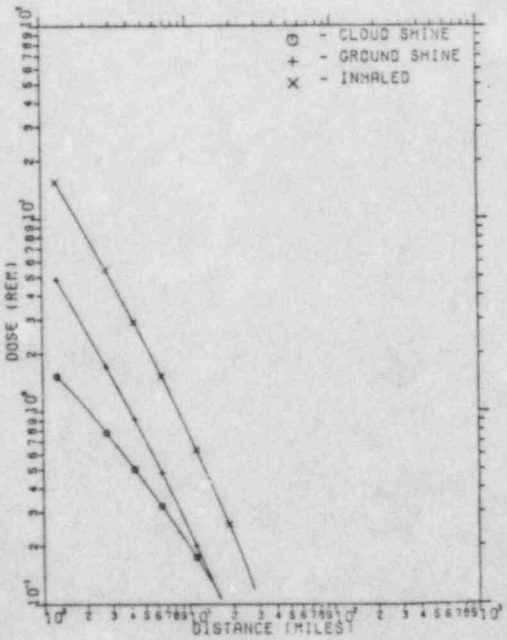


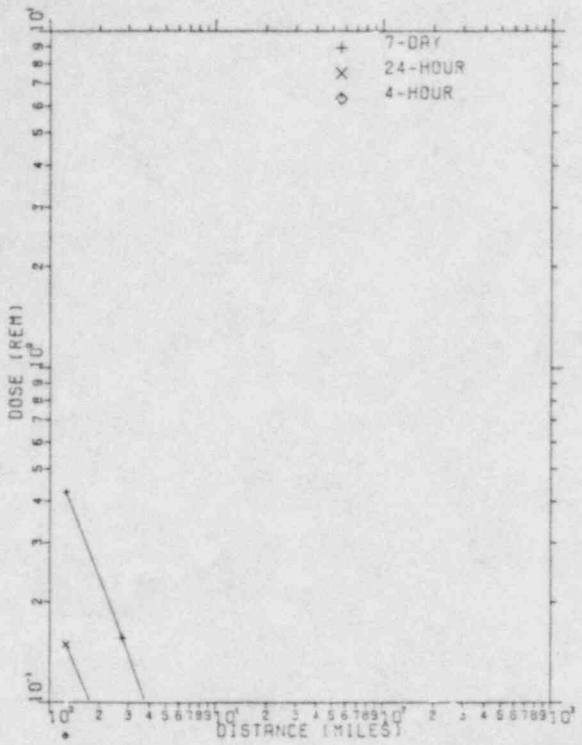
Figure 6-7

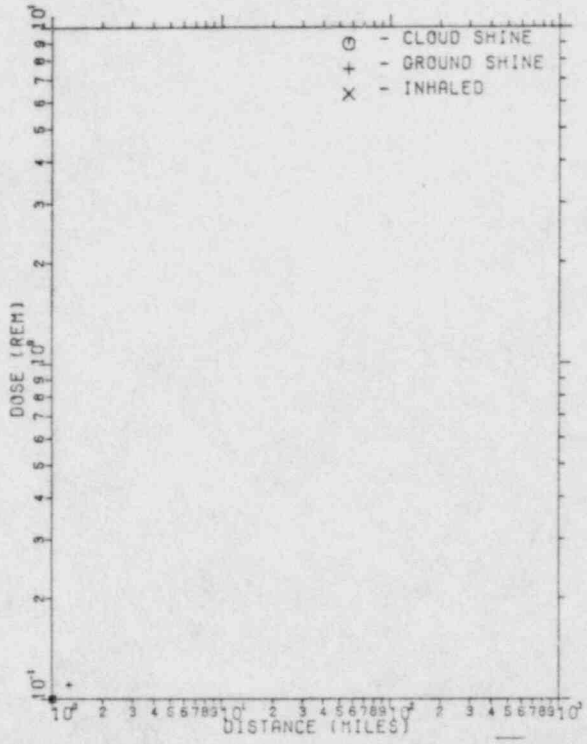
PWR #7
CASE 7

Stability Class: E
Windspeed: 9 mph

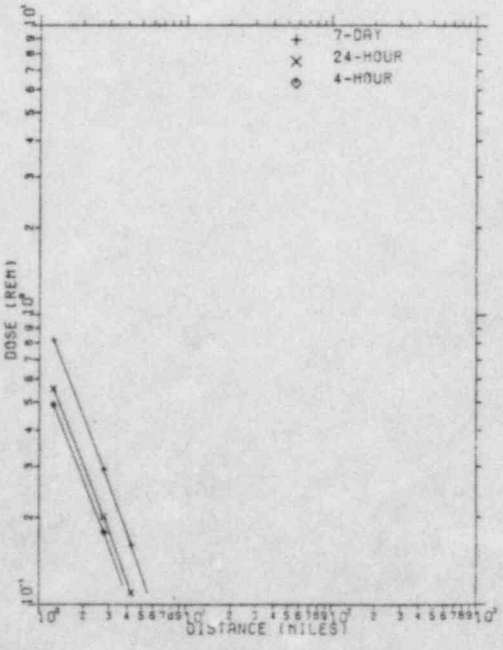
Rain: No
Sheltering. None

WHOLE BODY DOSE





THYROID DOSE



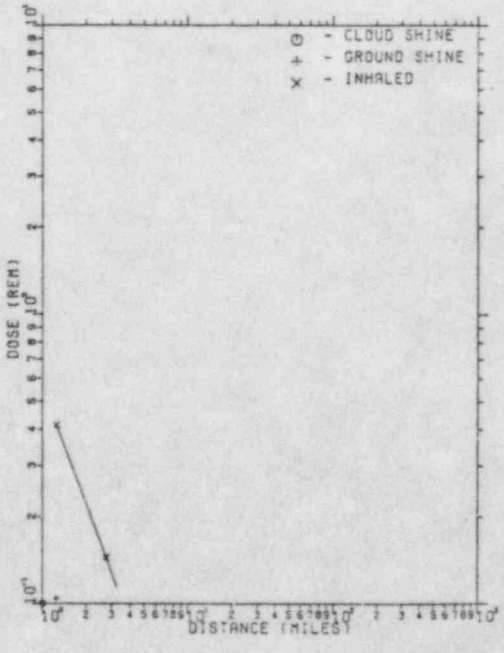


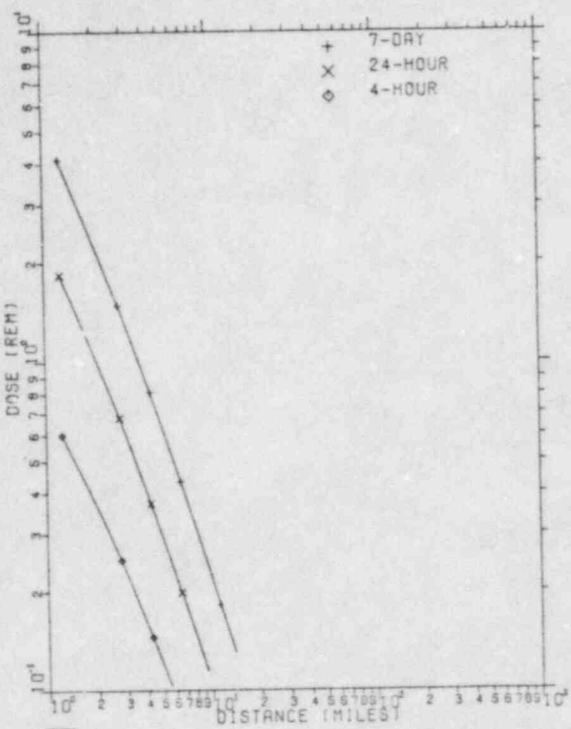
Figure 7-7

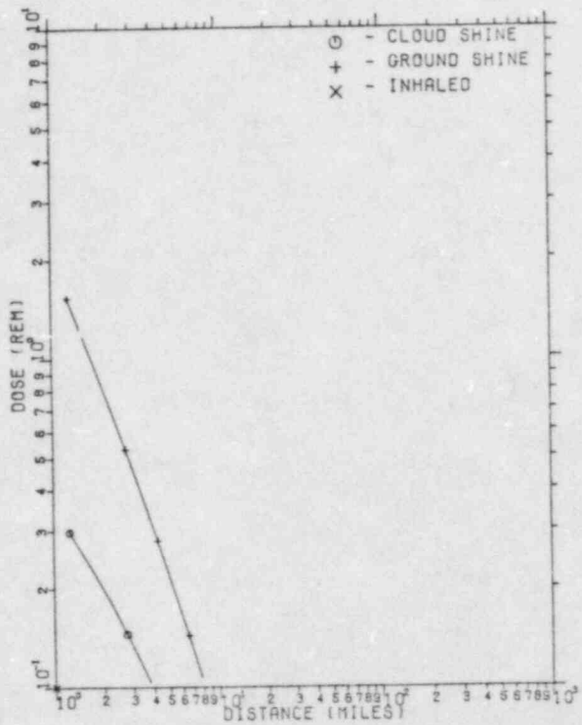
PWR #8
CASE 7

Stability Class: E
Windspeed: 9 mph

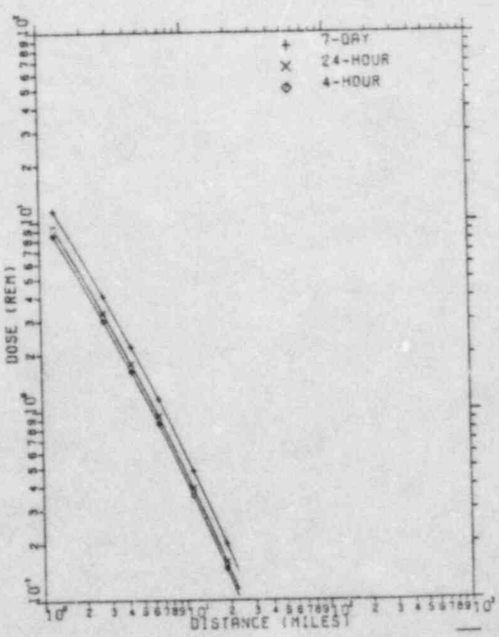
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



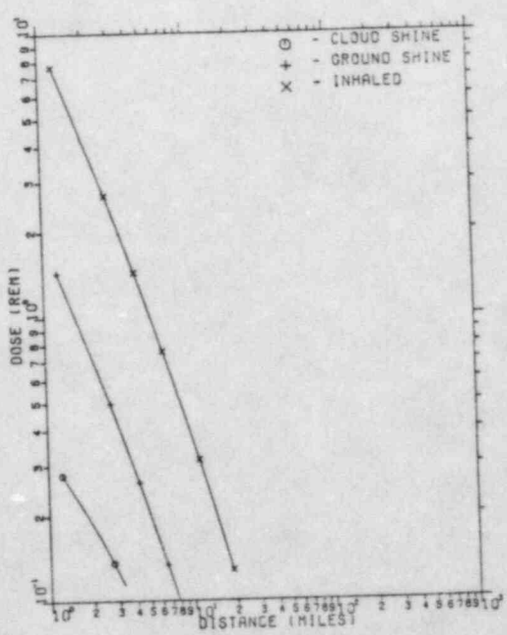


Figure 8-7

PWR #9
CASE 7

Stability Class: E
Windspeed: 9 mph

Rain: No
Sheltering: None

WHOLE BODY DOSE

THYROID DOSE

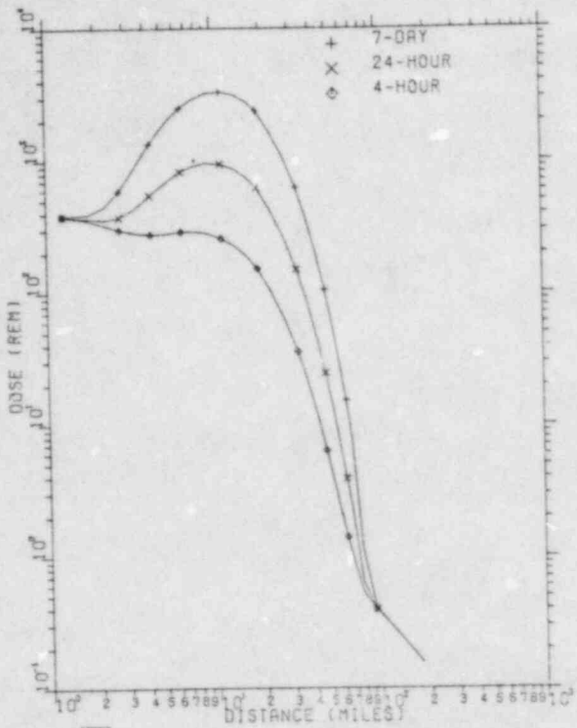
Figure 9-7

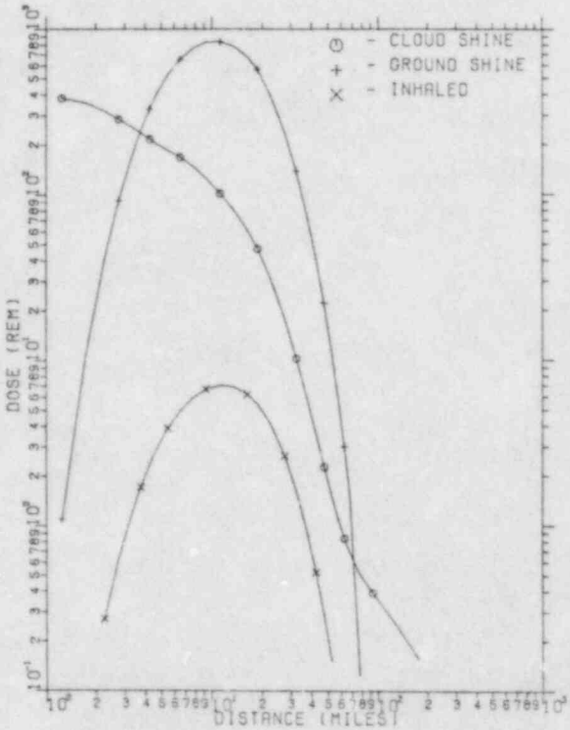
PWR #1A
CASE 9

Stability Class: F
Windspeed: 3 mph

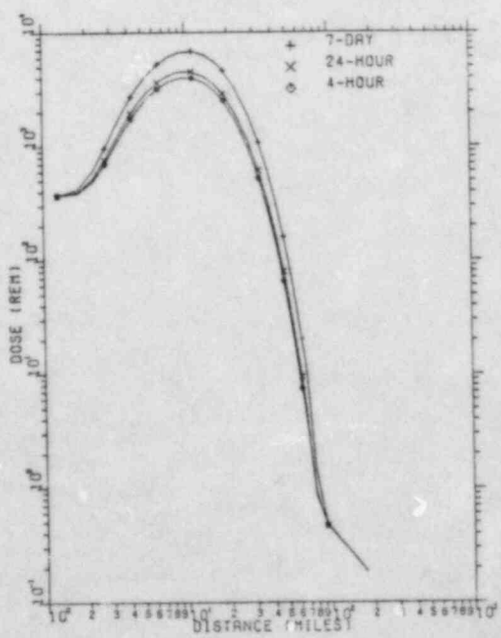
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



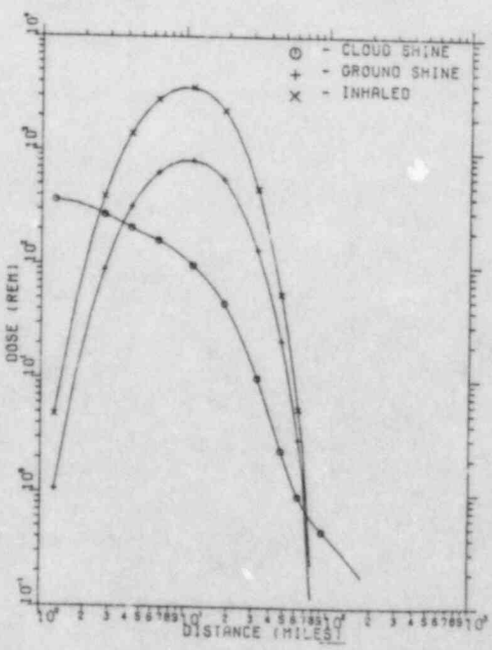


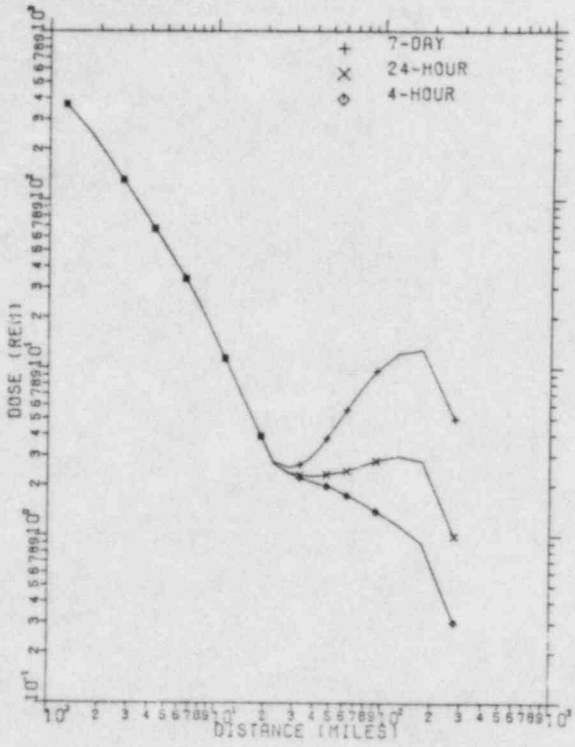
Figure 1A-9

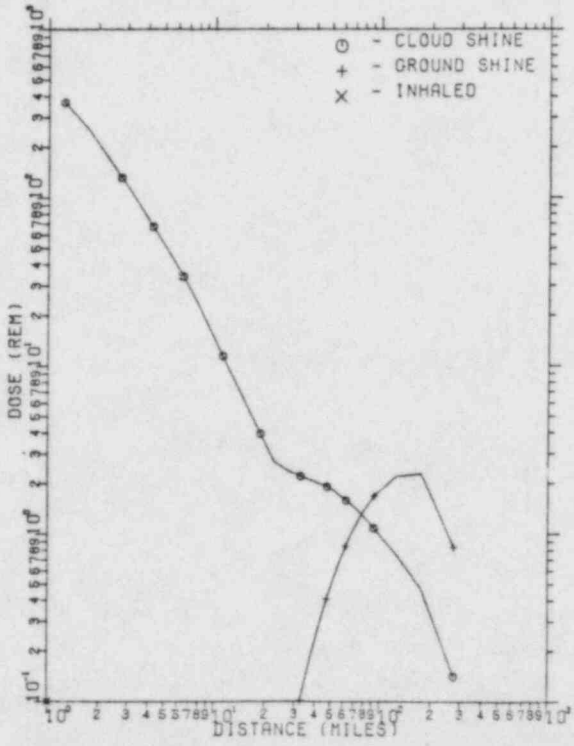
PWR #1B
CASE 9

Stability Class: F
Windspeed: 3 mph

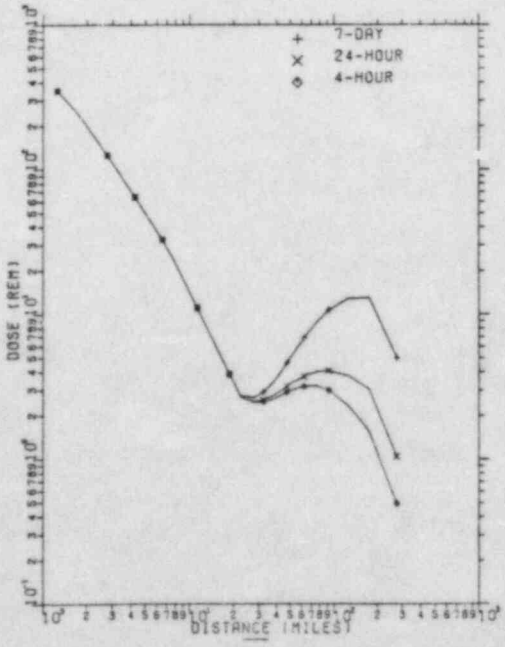
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



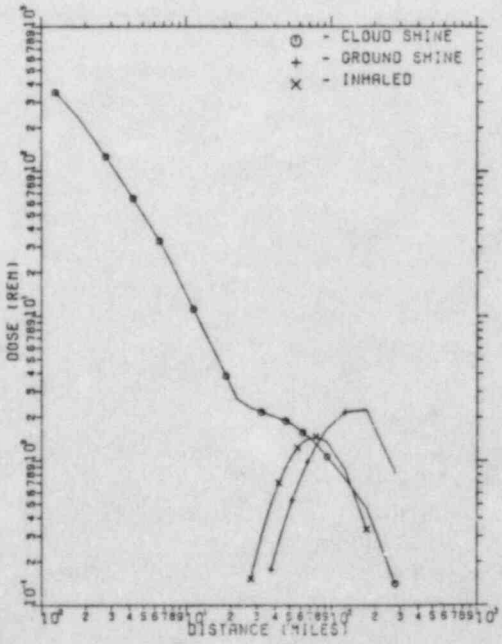


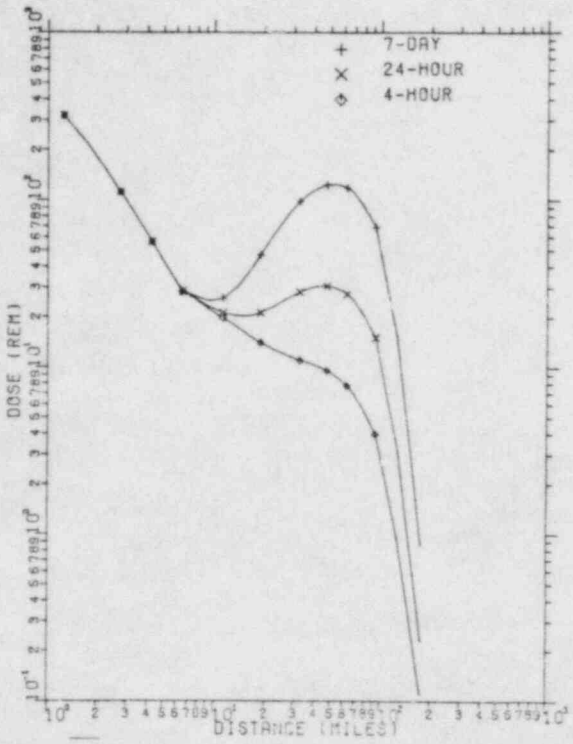
Figure 1B-9

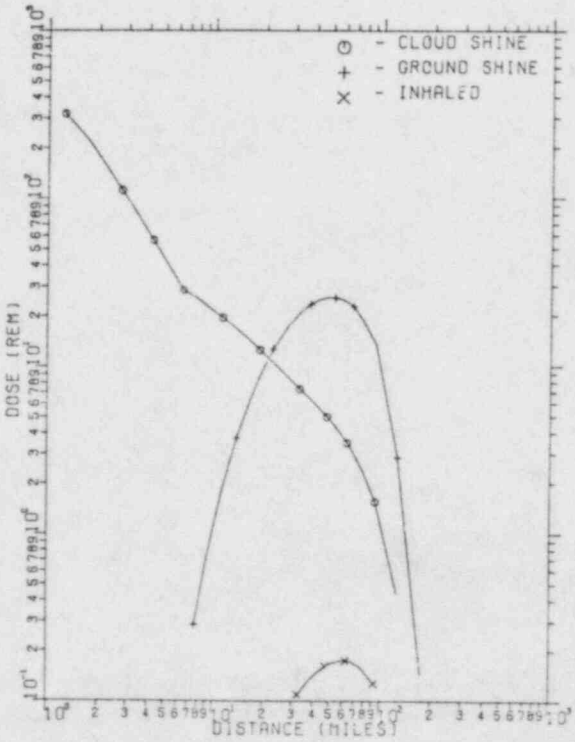
PWR #2
CASE 9

Stability Class: F
Windspeed: 3 mph

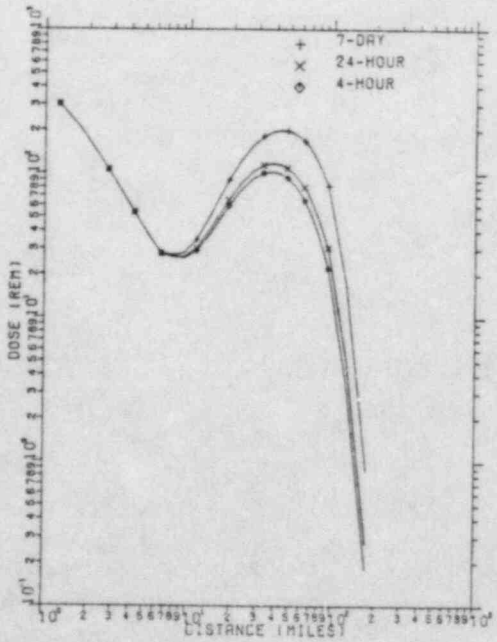
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



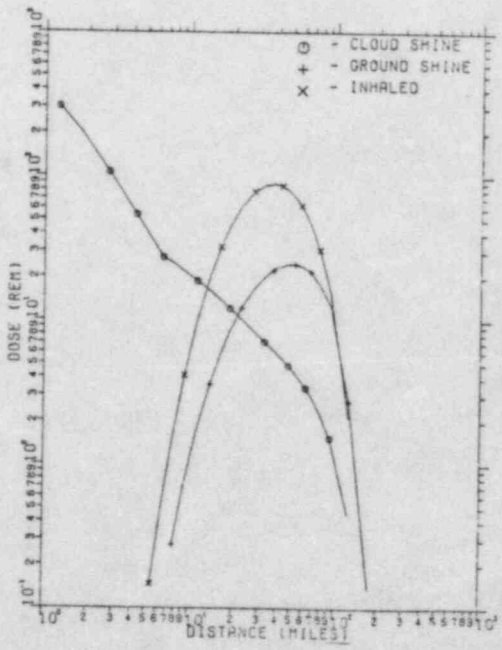


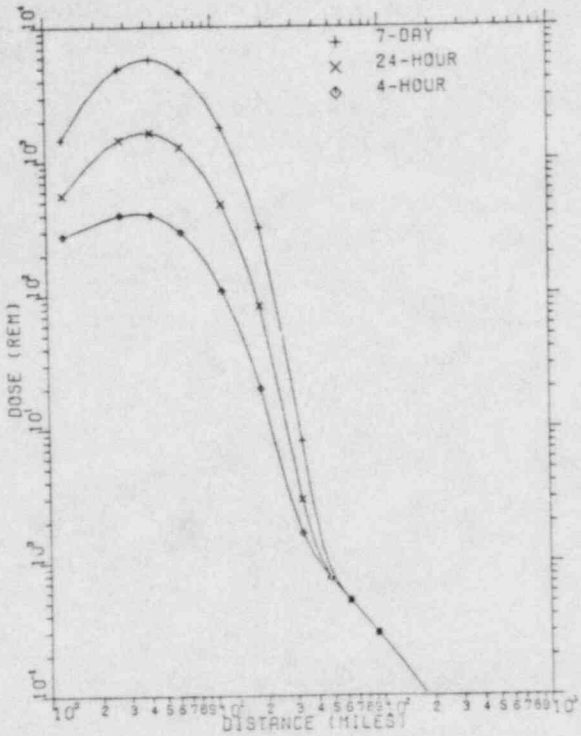
Figure 2-9

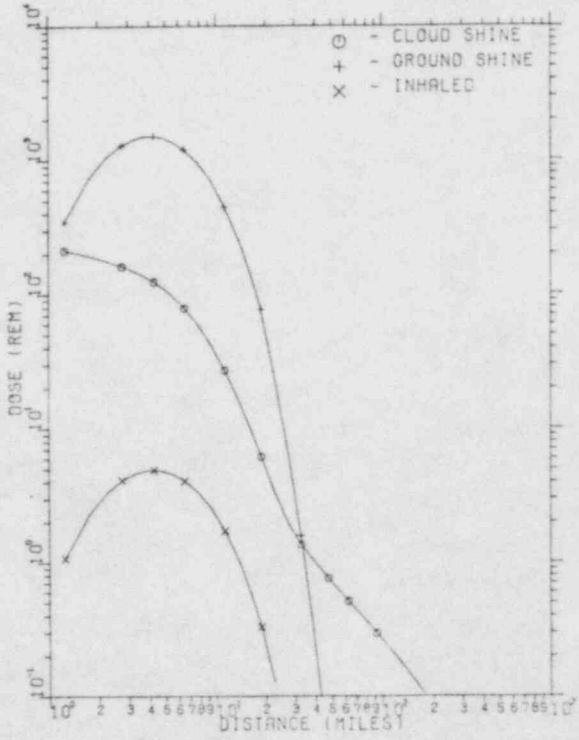
PWR #3
CASE 9

Stability Class: F
Windspeed: 3 mph

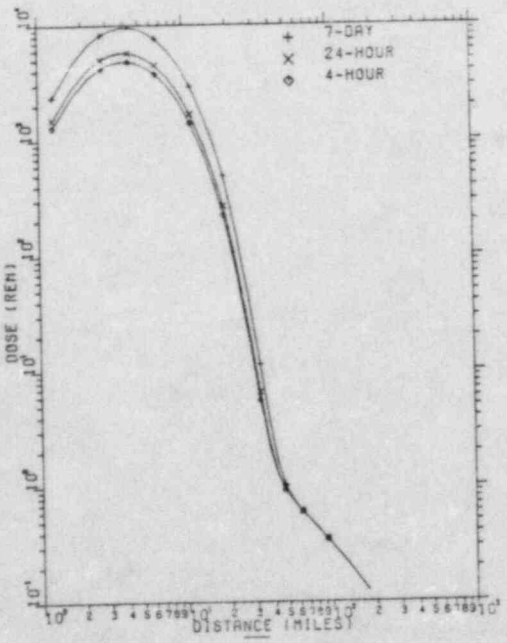
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



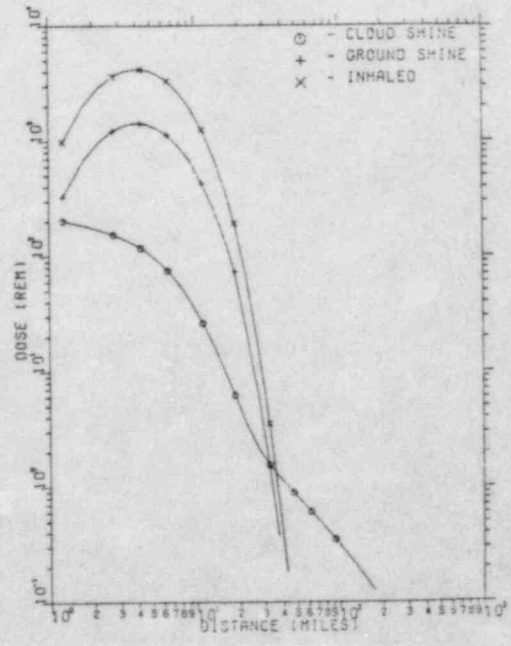


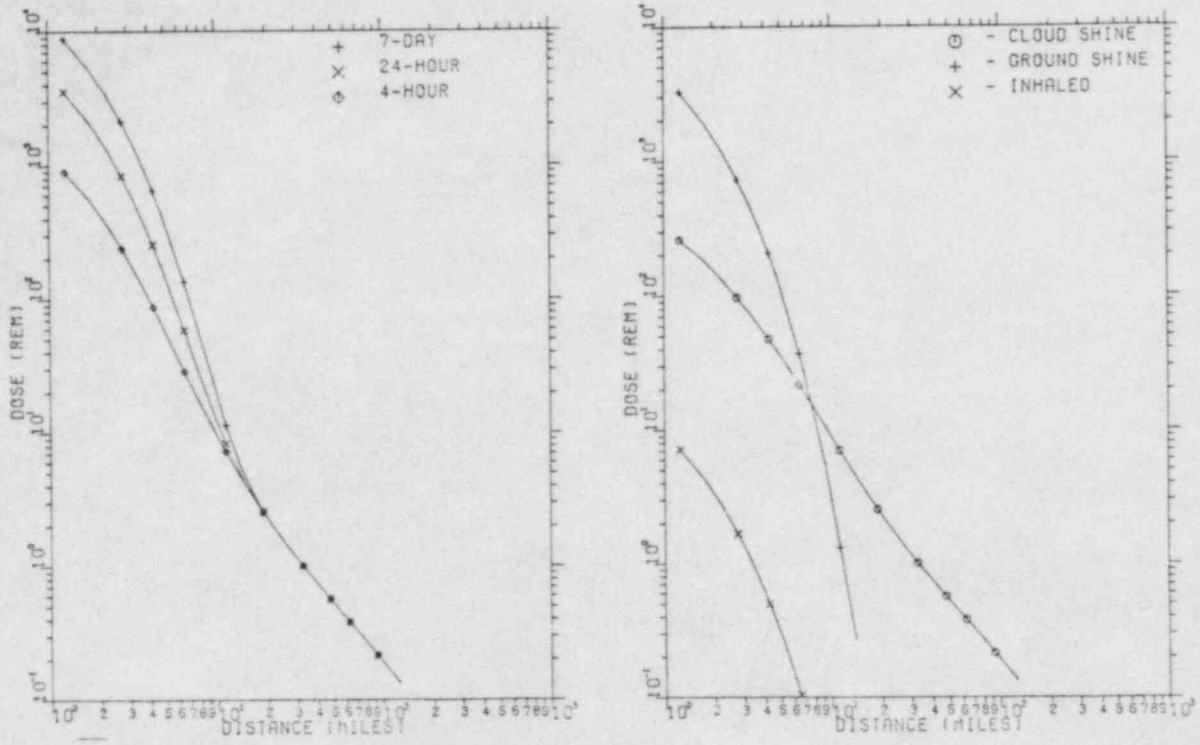
Figure 3-9

PWR #4
CASE 9

Stability Class: F
Windspeed: 3 mph

Rain: No
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

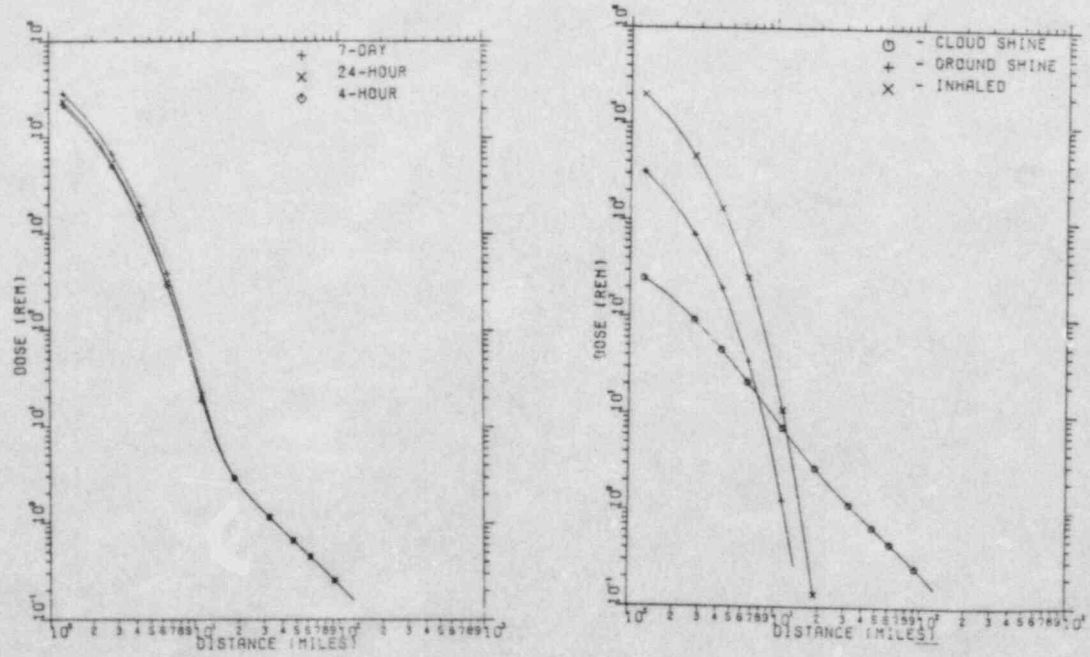


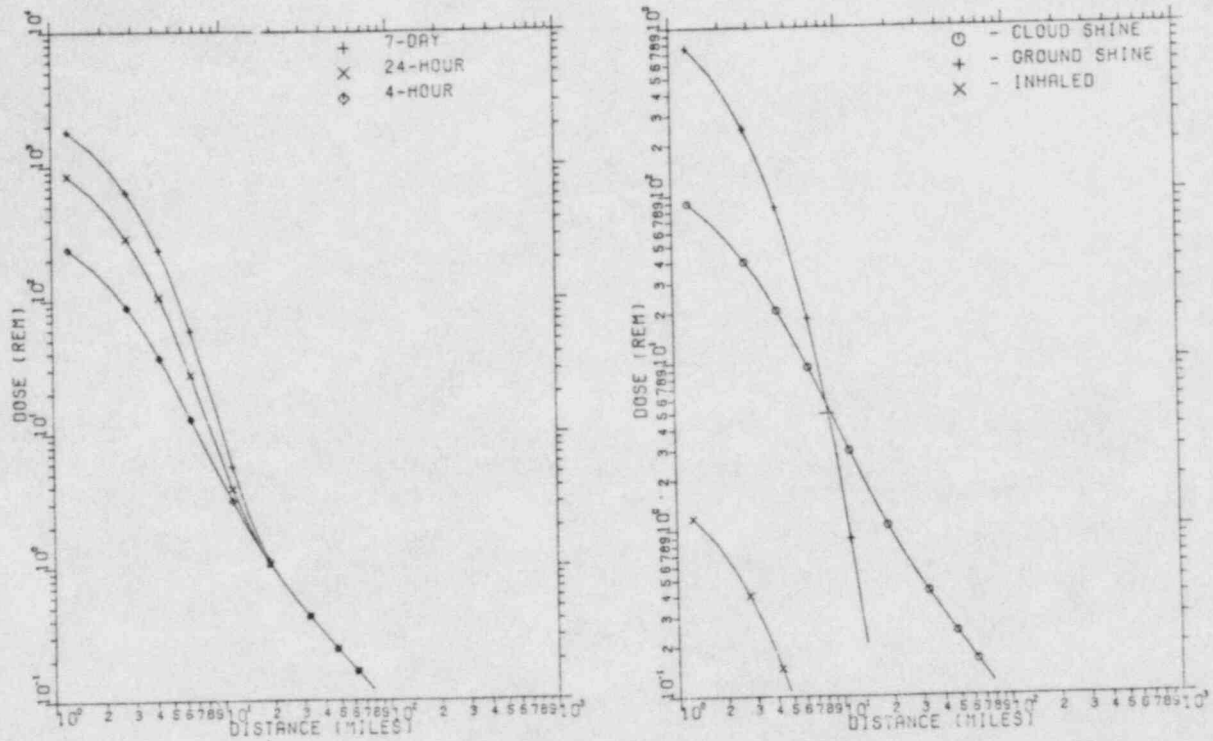
Figure 4-9

PWR #5
CASE 9

Stability Class: F
Windspeed: 3 mph

Rain: No
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

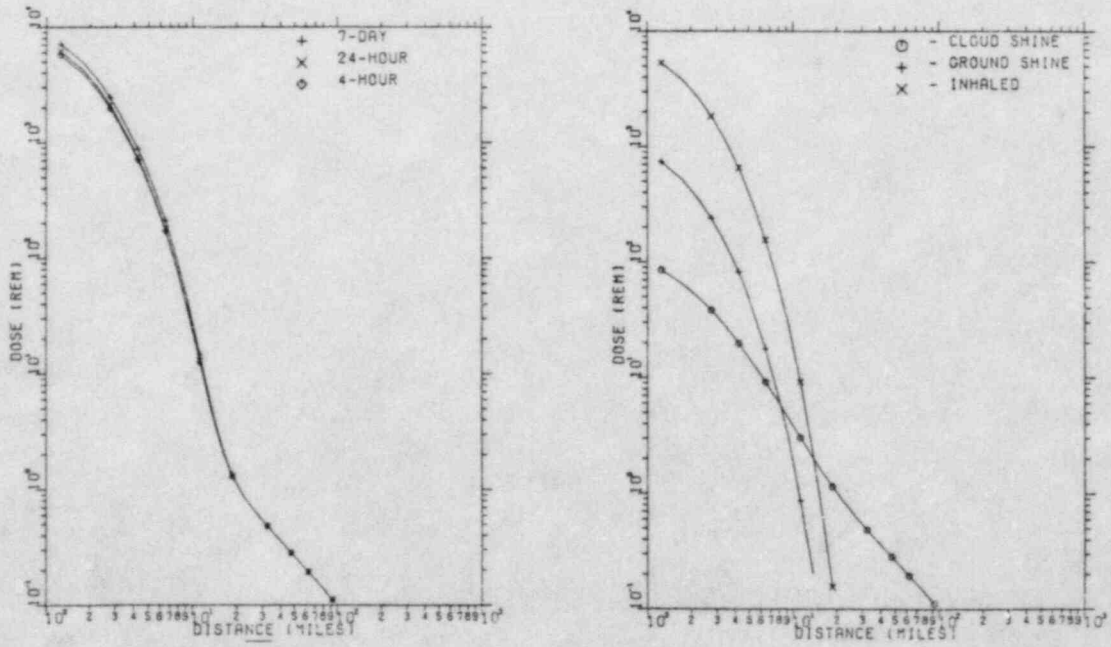


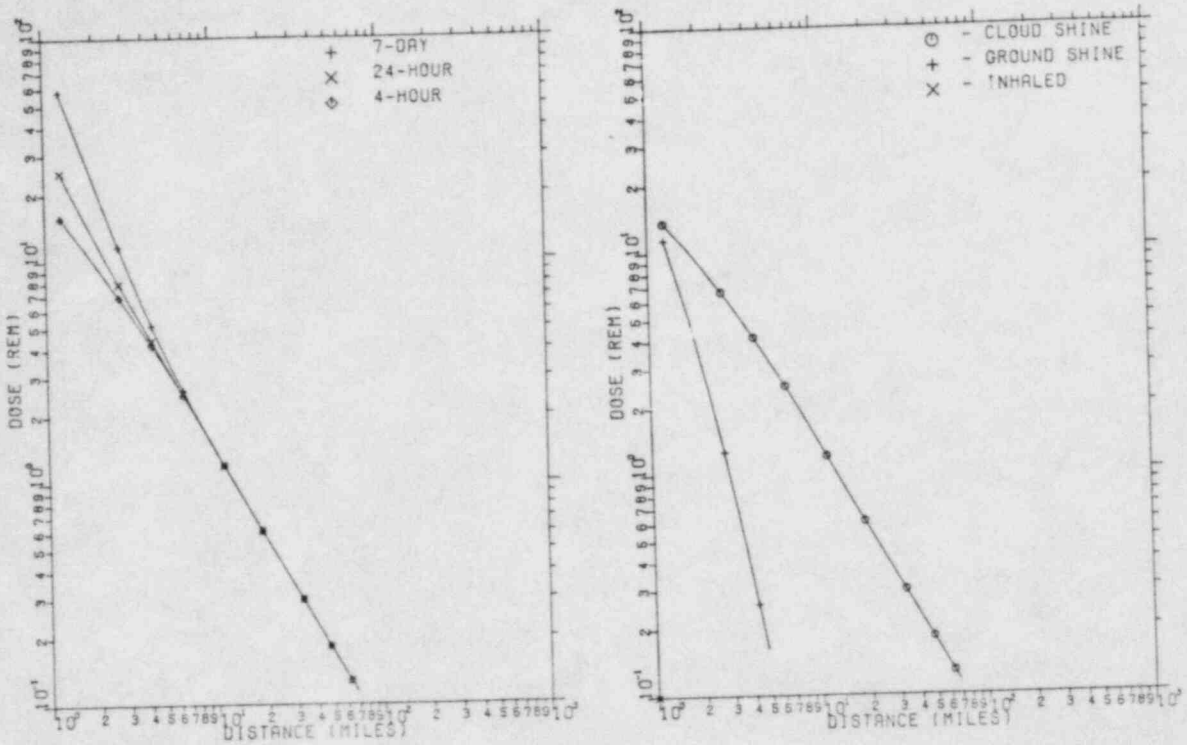
Figure 5-9

PWR #6
CASE 9

Stability Class: F
Windspeed: 3 mph

Rain: No
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

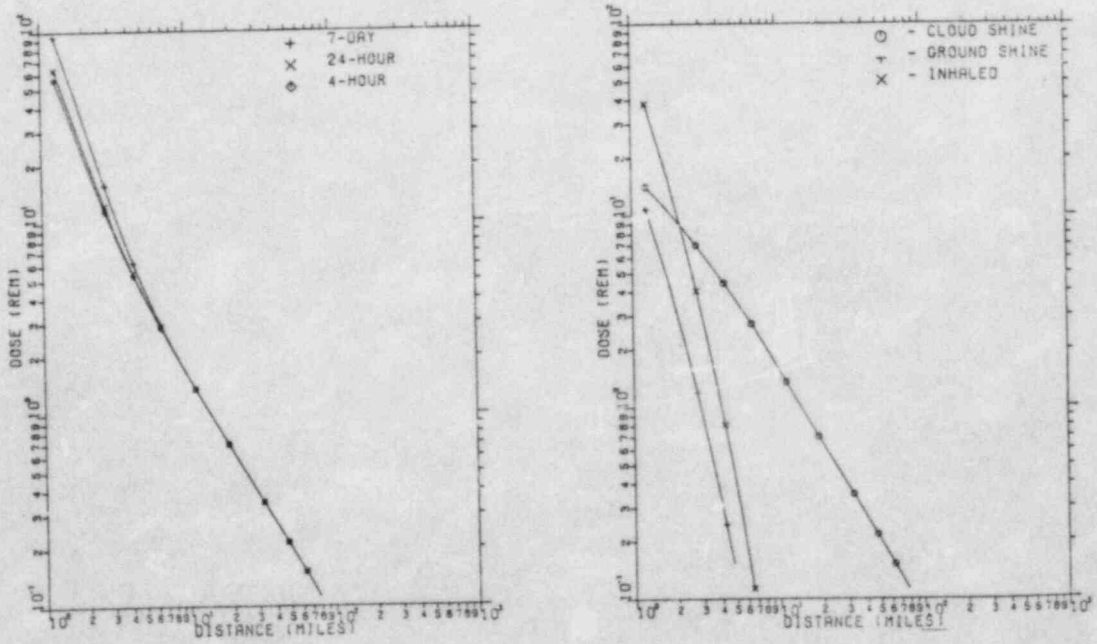


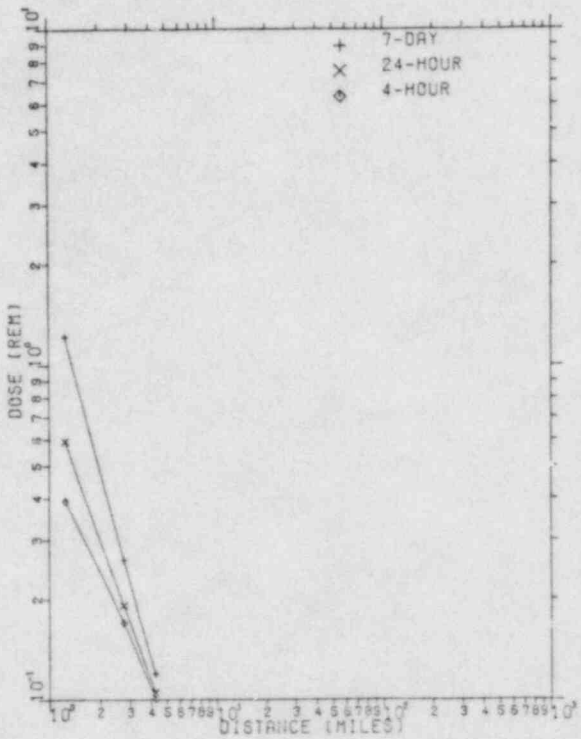
Figure 6-9

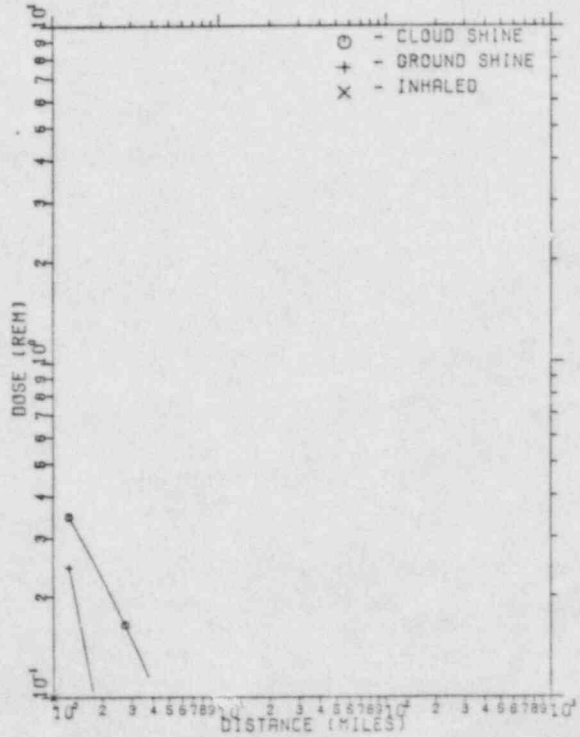
PWR #7
CASE 9

Stability Class: F
Windspeed: 3 mph

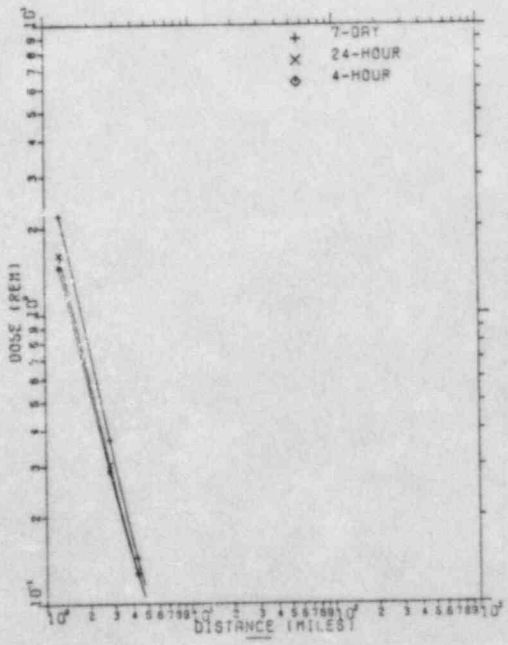
Rain: No
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



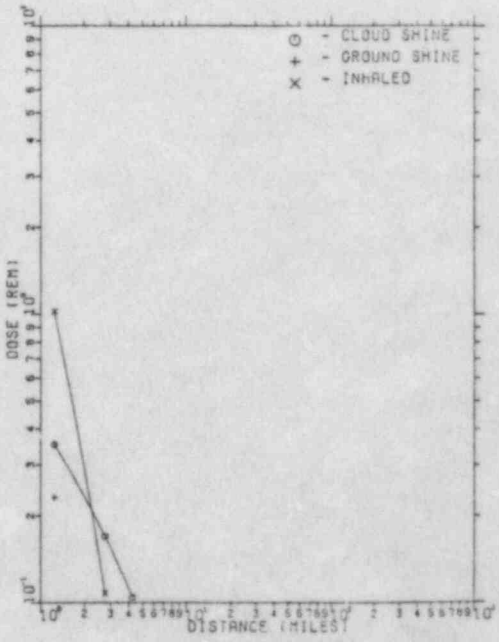


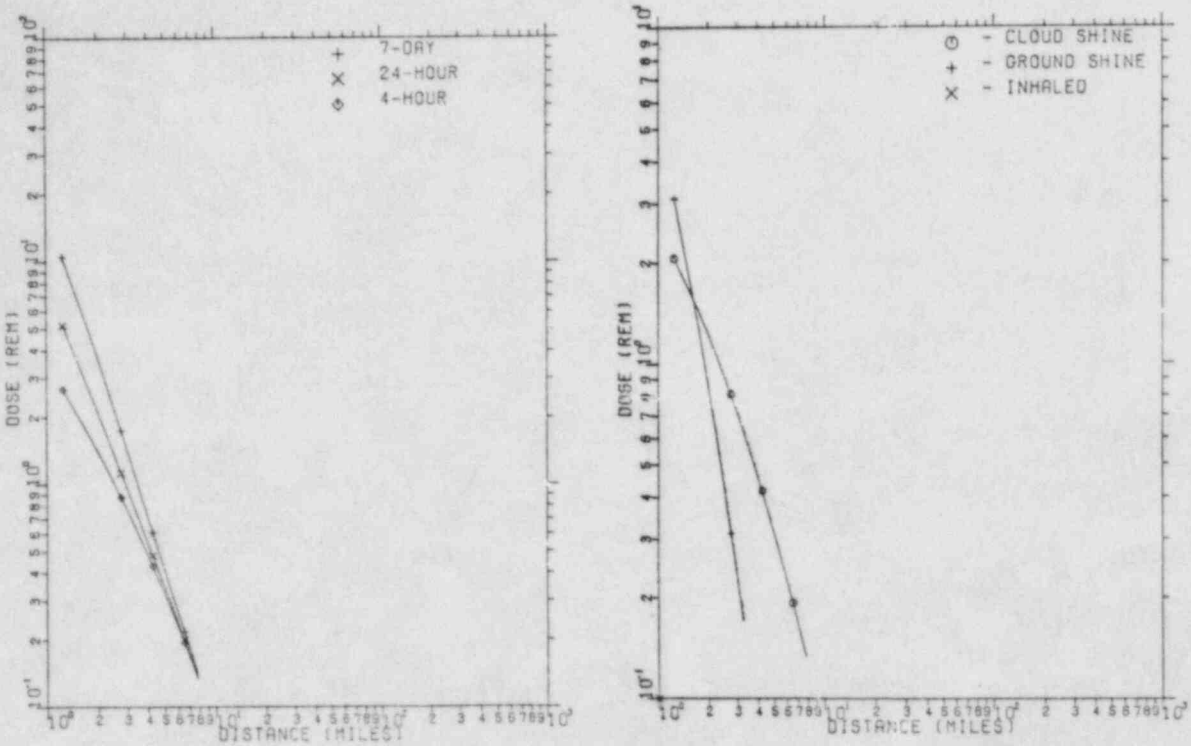
Figure 7-9

PWR #8
CASE 9

Stability Class: F
Windspeed: 3 mph

Rain: No
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

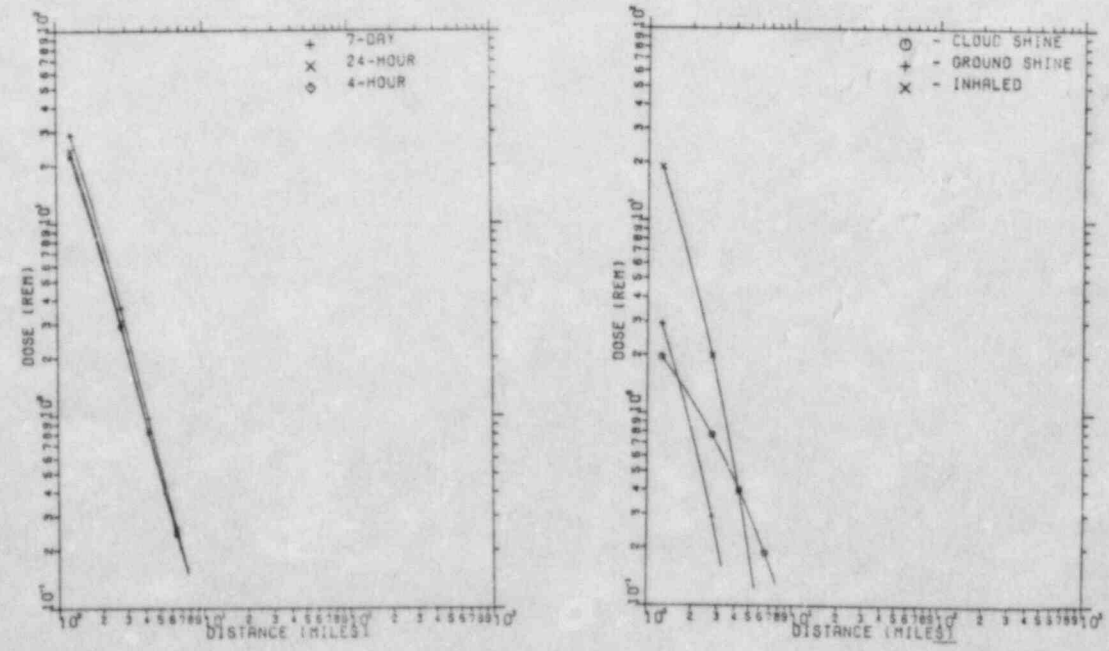


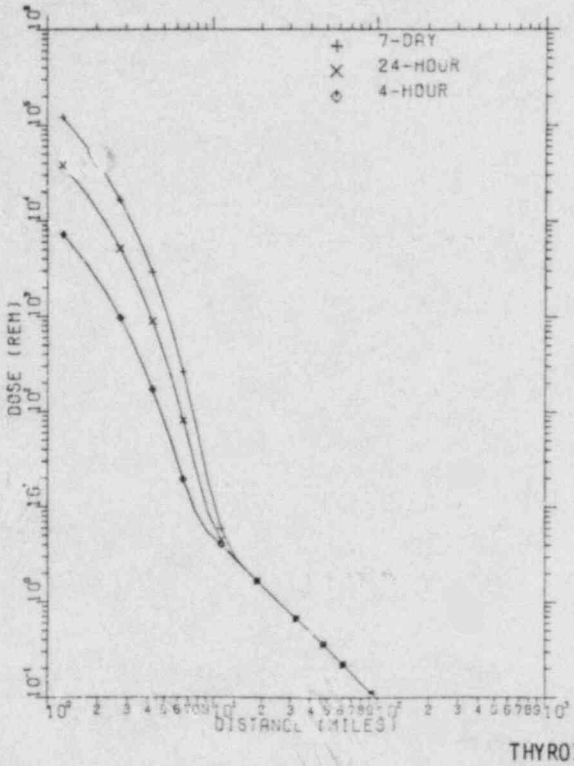
Figure 8-9

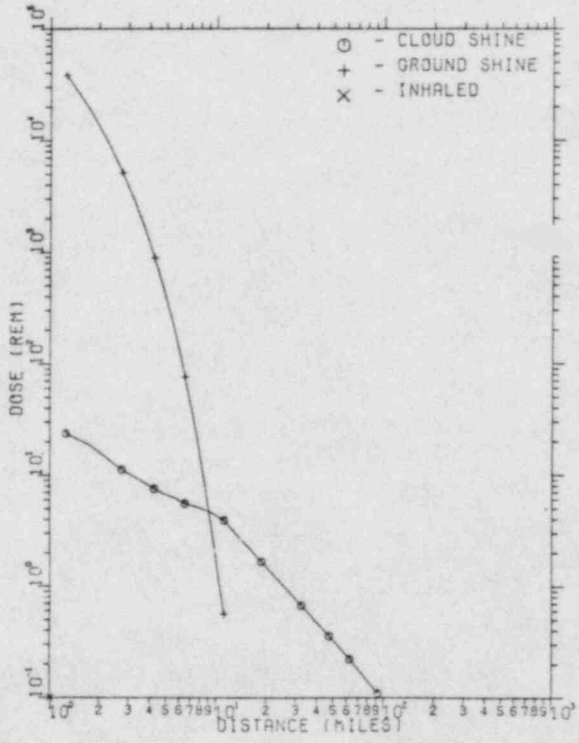
PWR # 1A
CASE TO

Stability Class: D
Windspeed: 2 mph

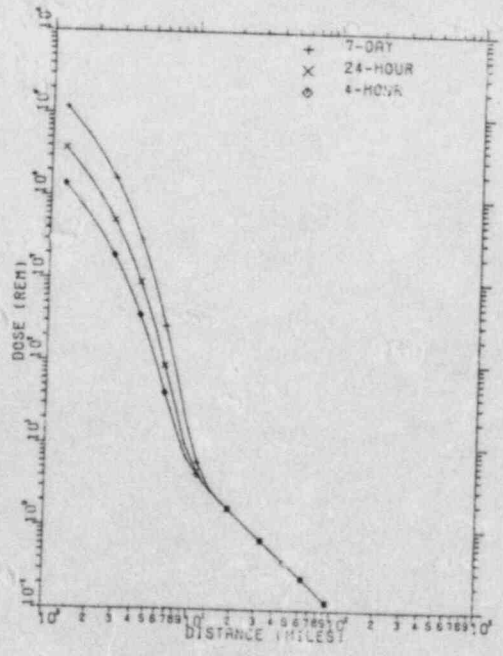
Rain: Yes
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



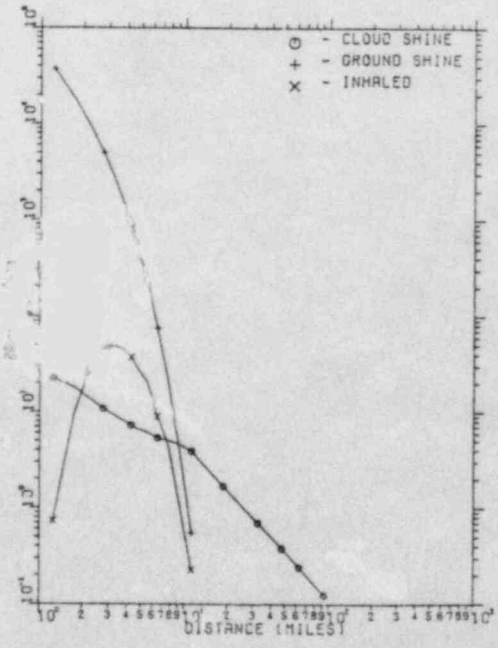


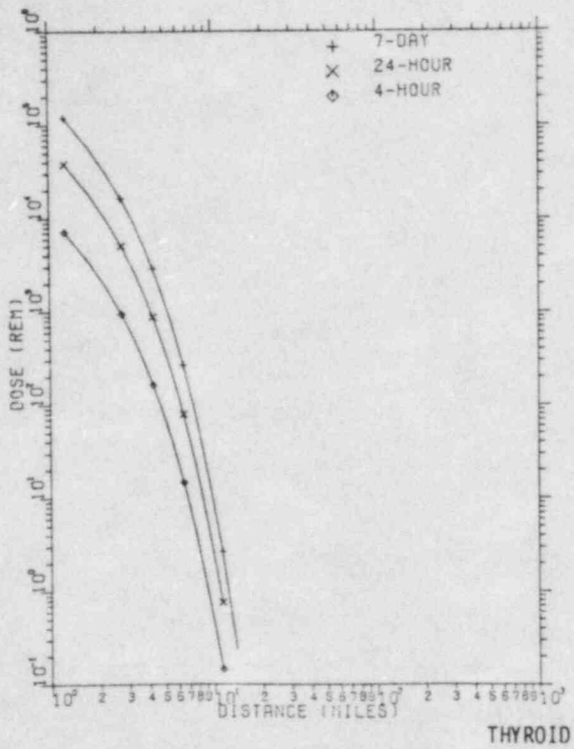
Figure 1A-10

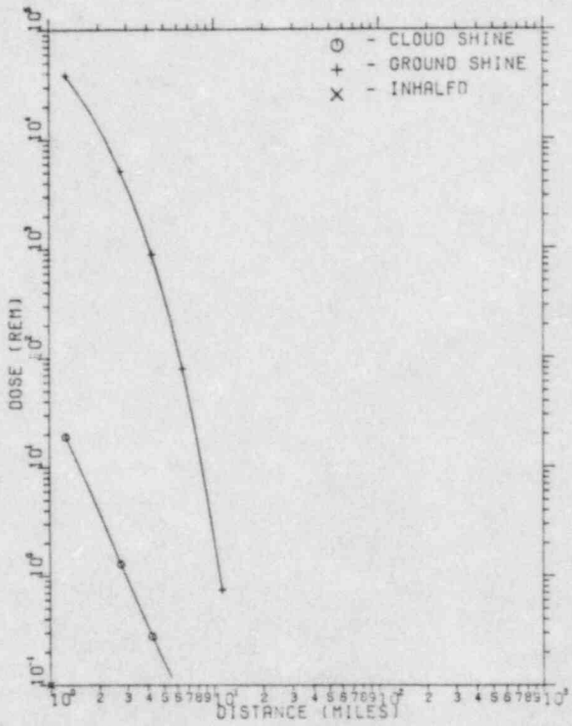
PWR #1B
CASE 10

Stability Class: D
Windspeed: 2 mph

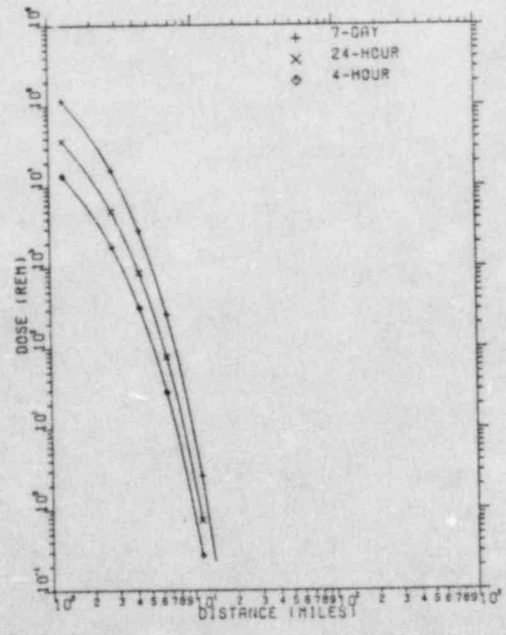
Rain: Yes
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



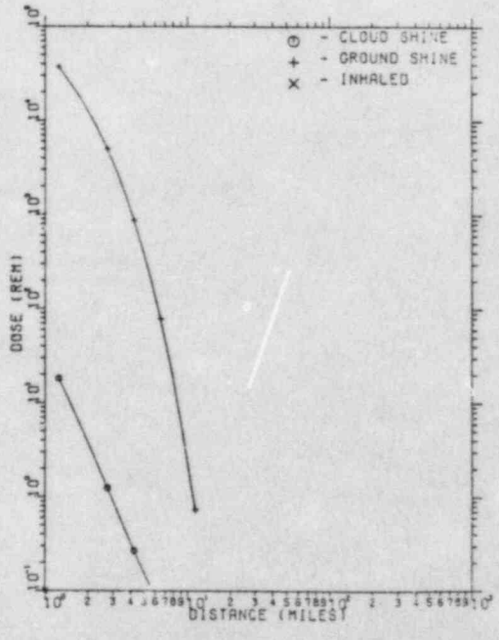


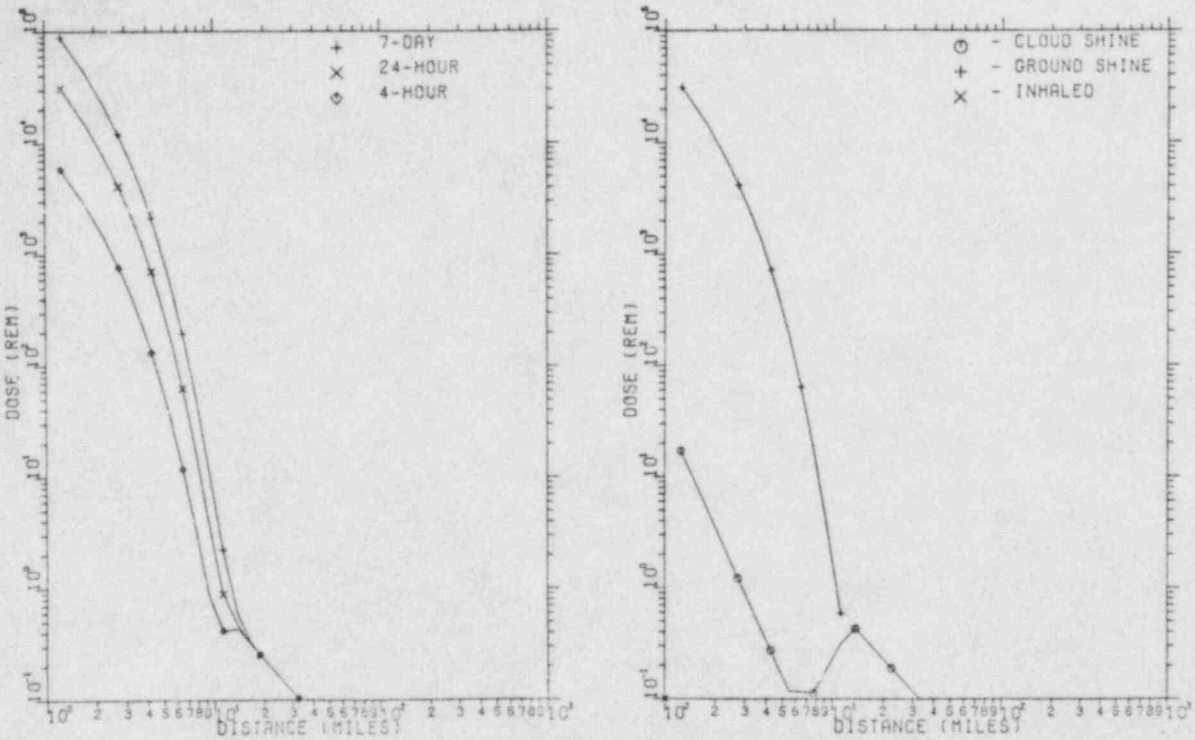
Figure 1B-10

PWR # 2
CASE 10

Stability Class: D
Windspeed: 2 mph

Rain: Yes
Sheltering: Yes

WHOLE BODY DOSE



THYROID DOSE

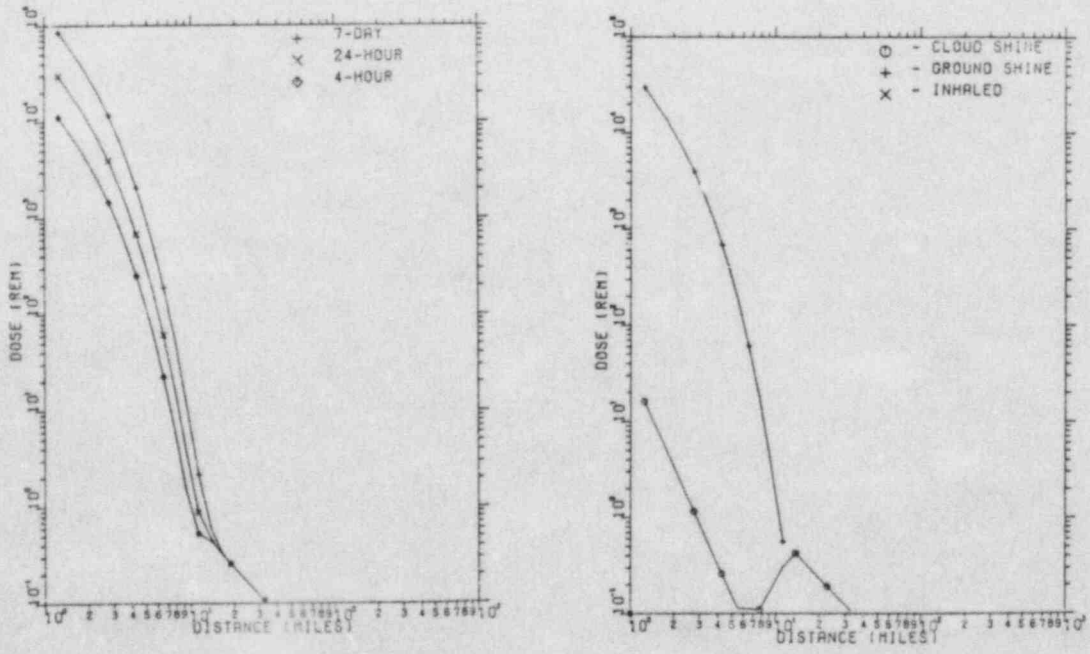


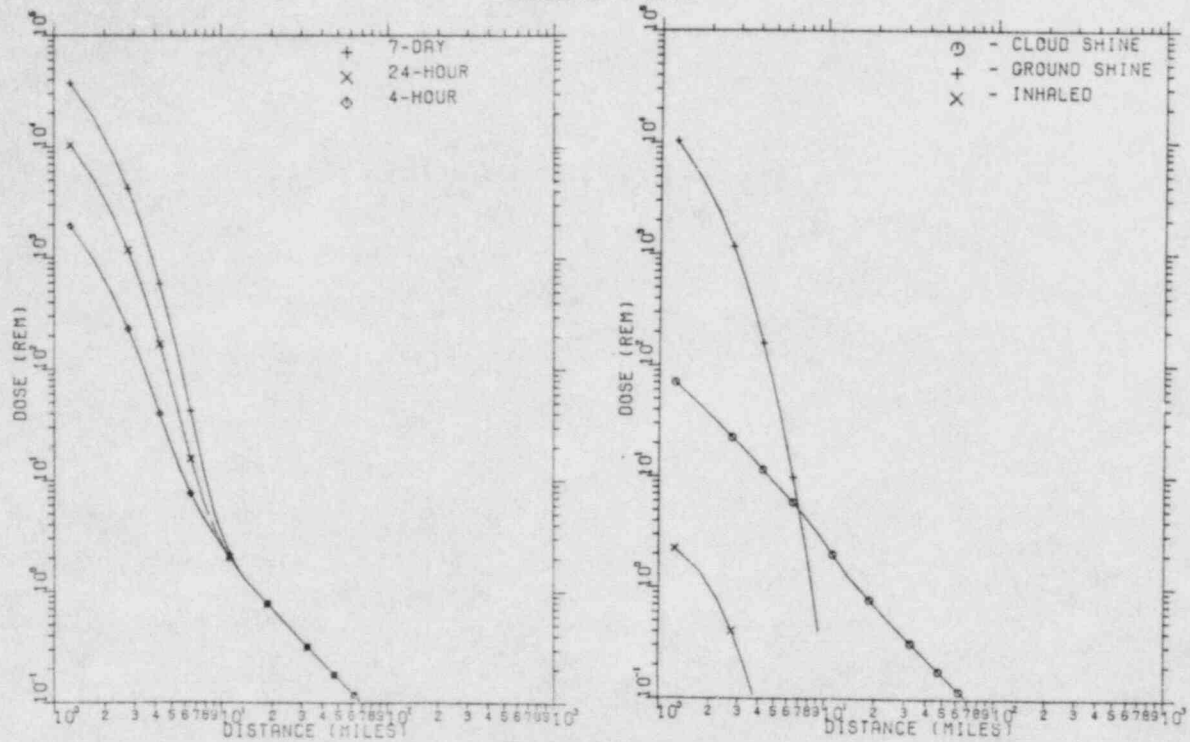
Figure 2-10

PWR # 3
CASE 10

Stability Class: D
Windspeed: 2 mph

Rain: Yes
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

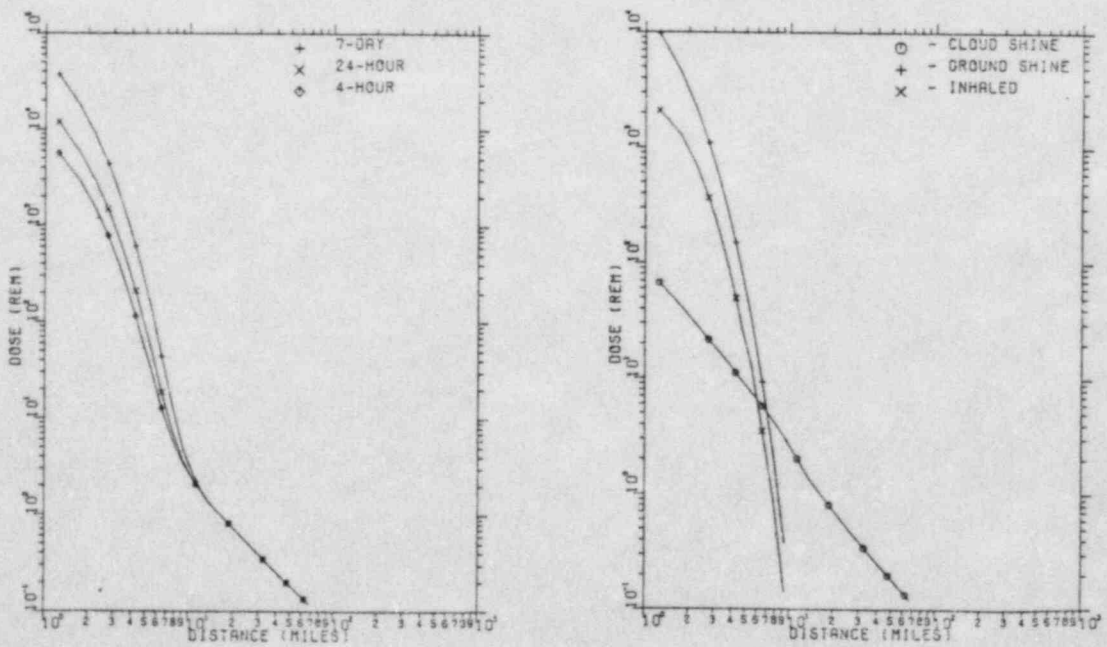


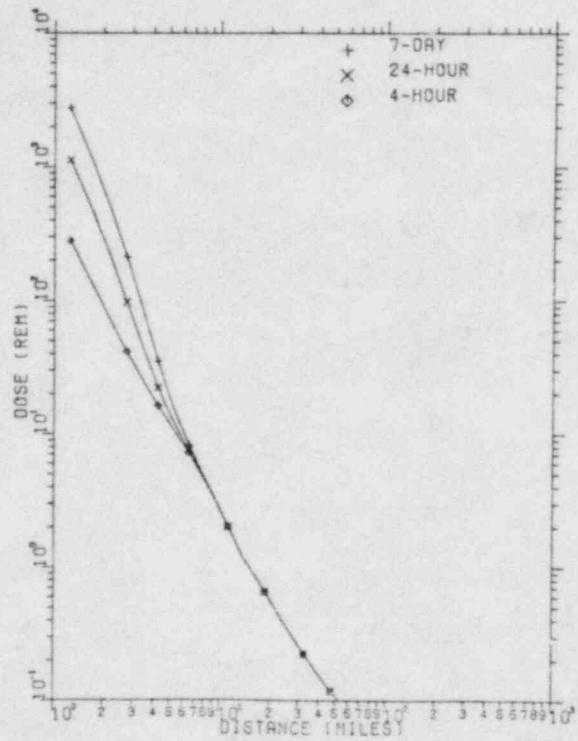
Figure 3-10

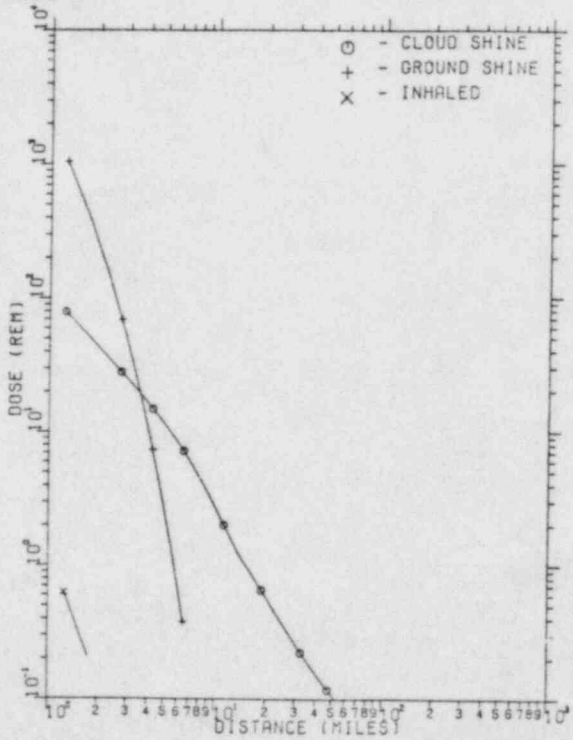
PWR # 4
CASE 10

Stability Class: D
Windspeed: 2 mph

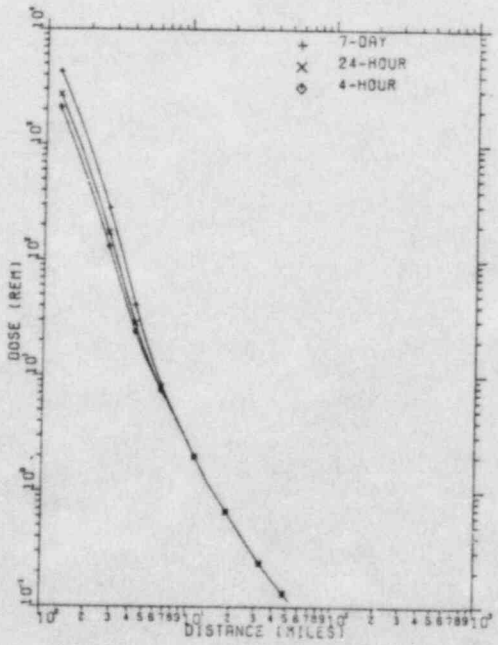
Rain: Yes
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



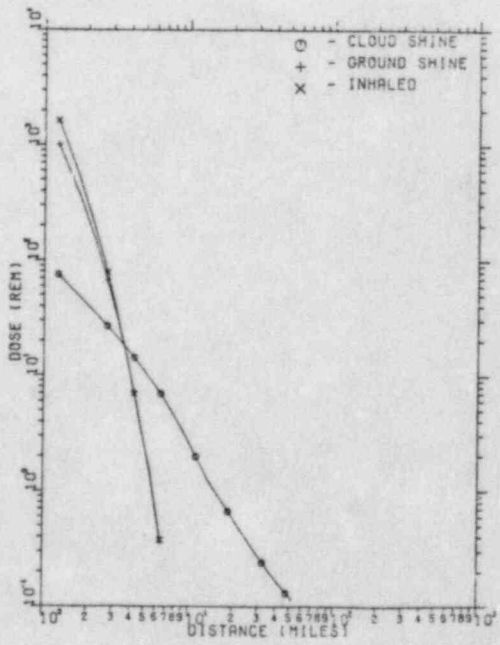


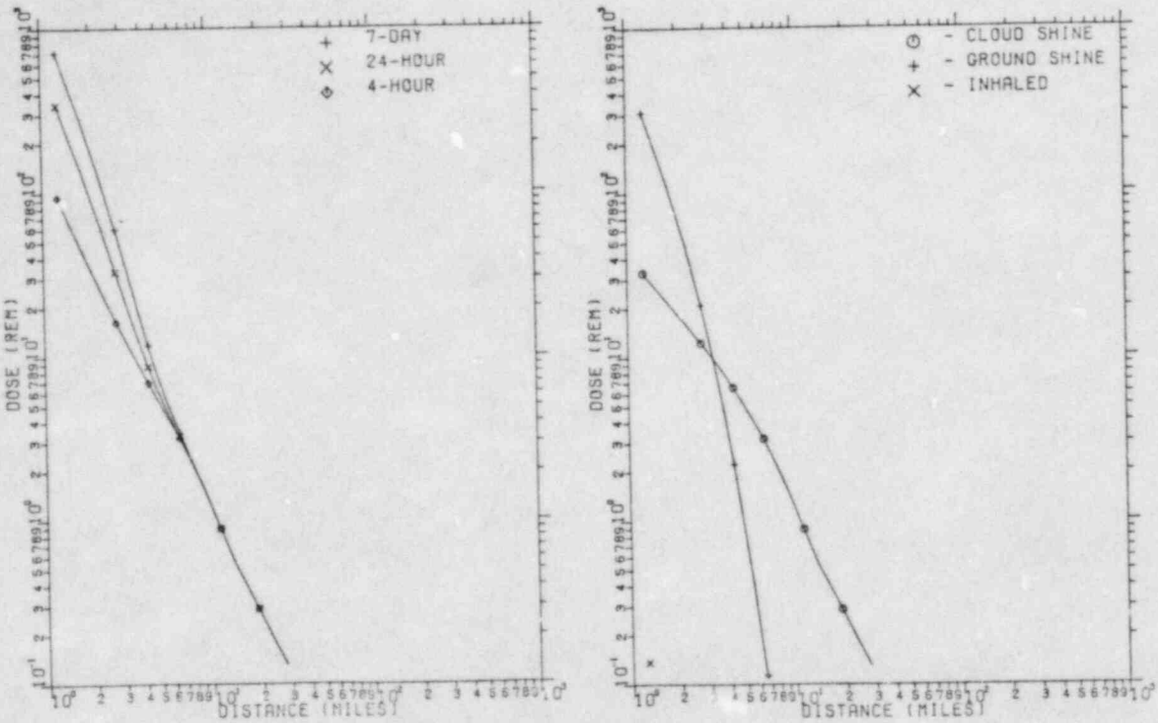
Figure 4-10

PWR # 5
CASE TO

Stability Class: D
Windspeed: 2 mph

Rain: Yes
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

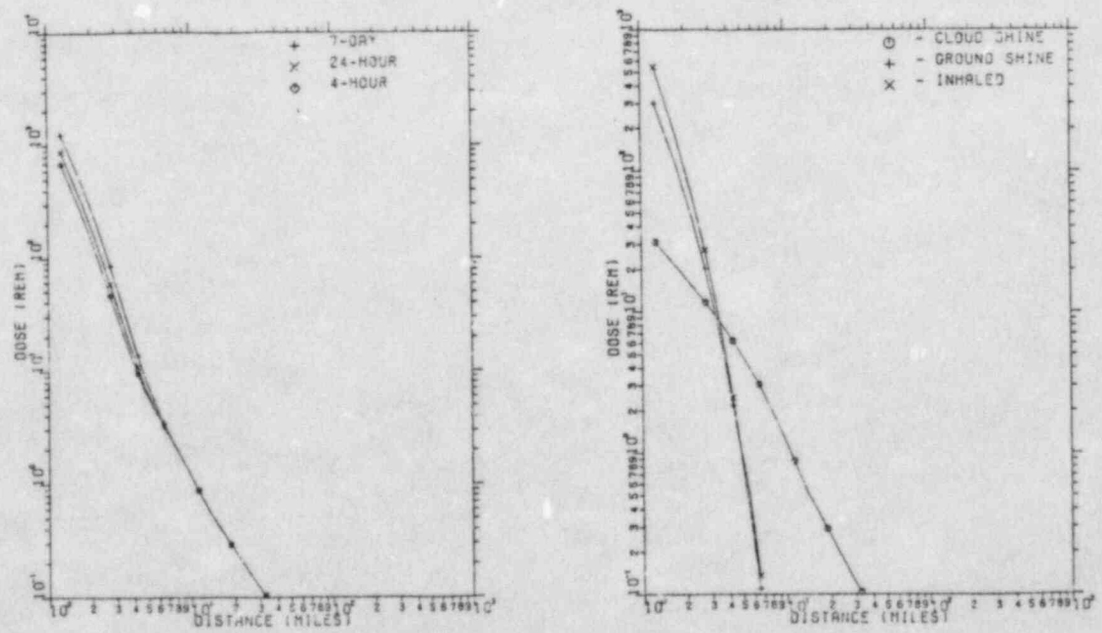


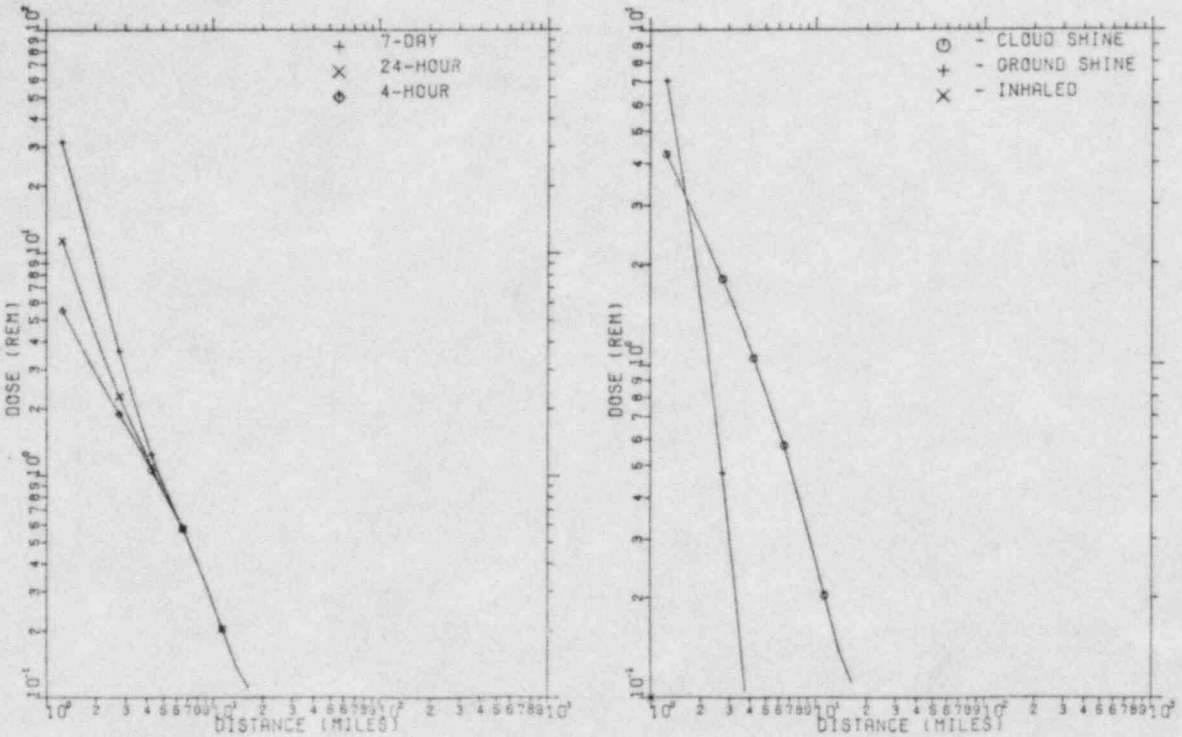
Figure 5-10

PWR #6
CASE 10

Stability Class: D
Windspeed: 2 mph

Rain: Yes
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

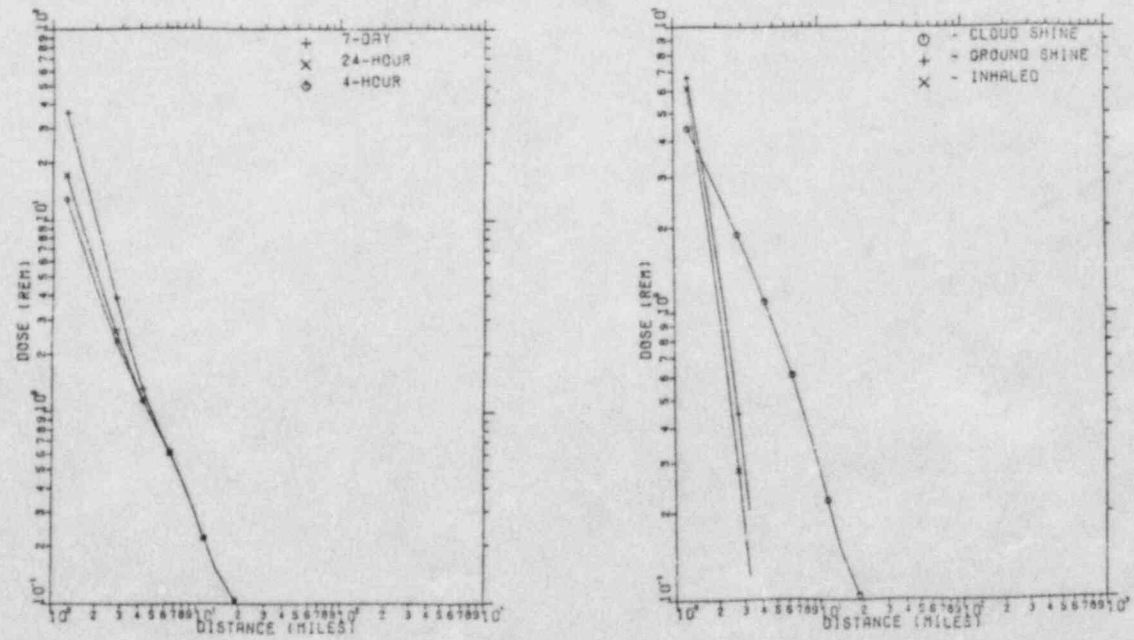


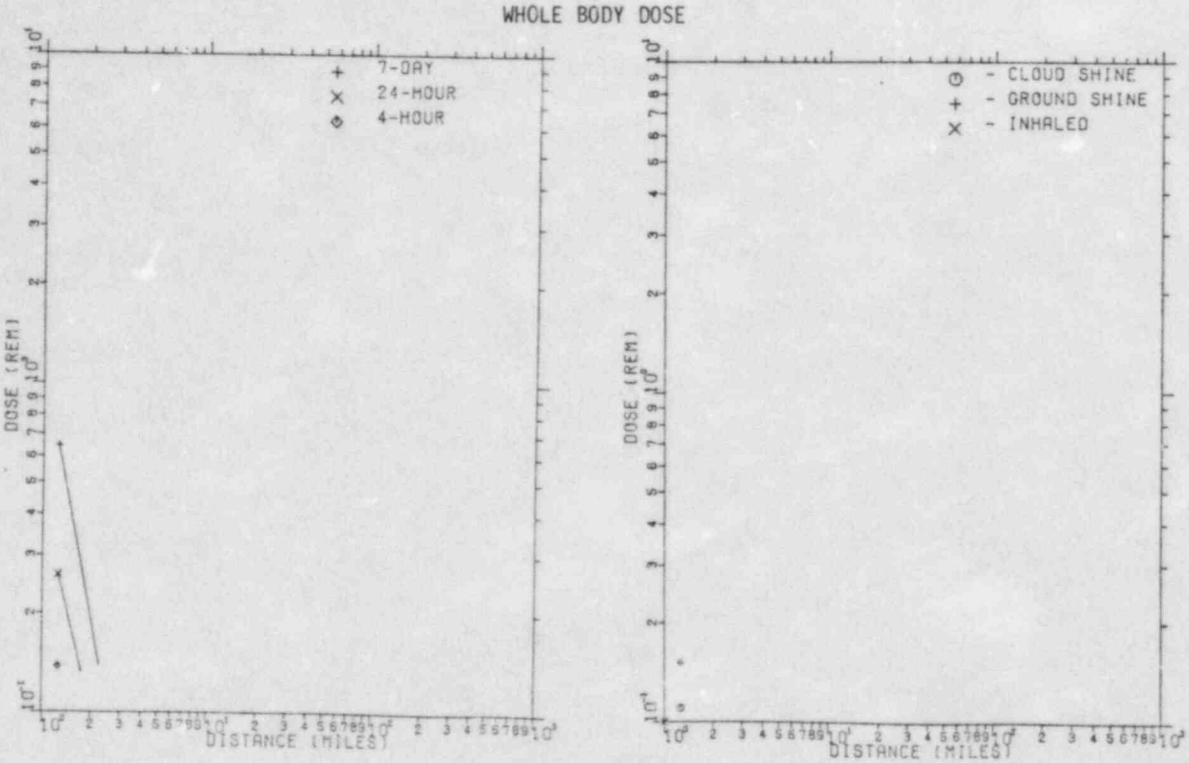
Figure 6-10

PWR # 7
CASE 10

Stability Class: D
Windspeed: 2 mph

Rain: Yes
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

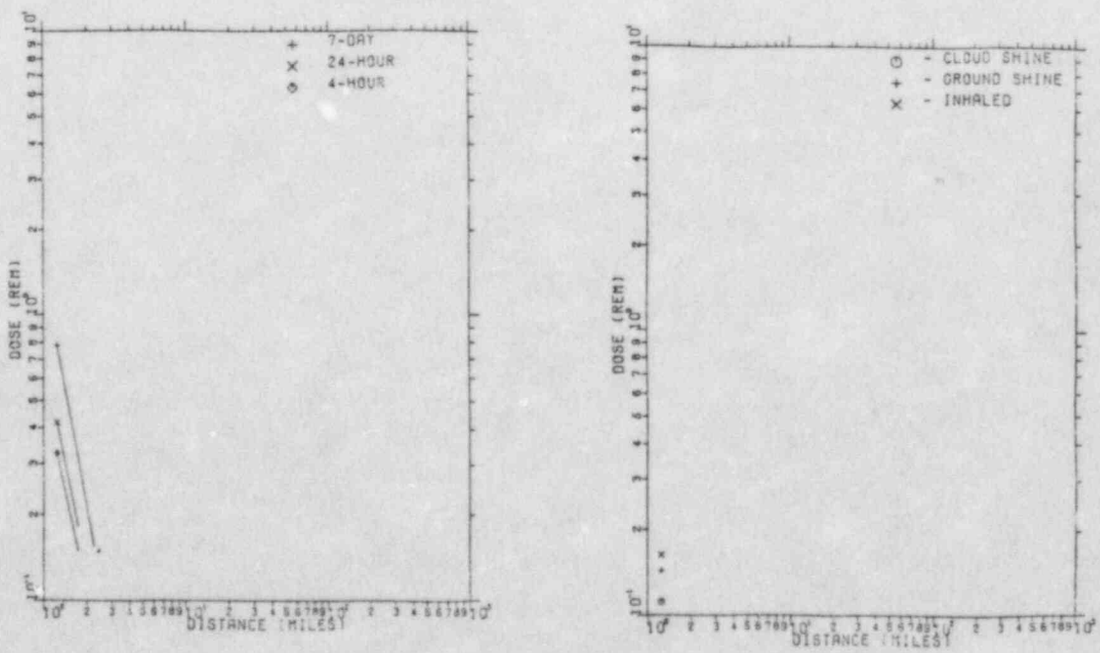


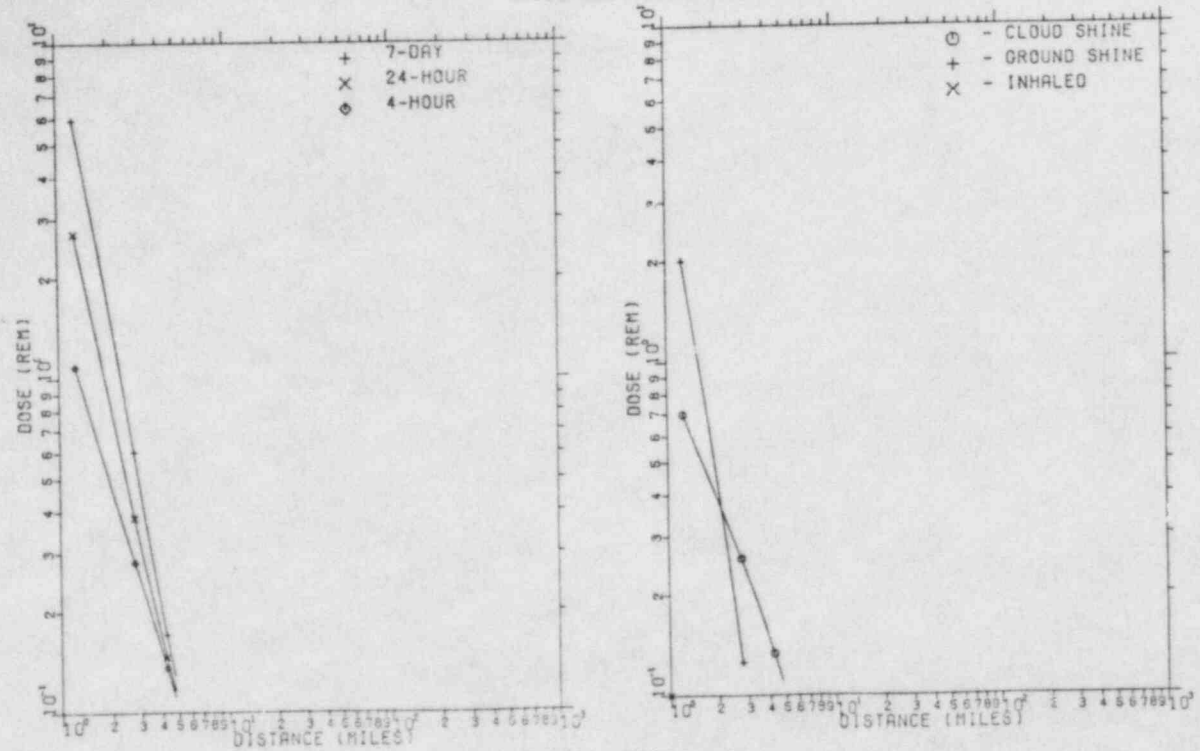
Figure 7-10

PWR # 8
CASE 10

Stability Class: D
Windspeed: 2 mph

Rain: Yes
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

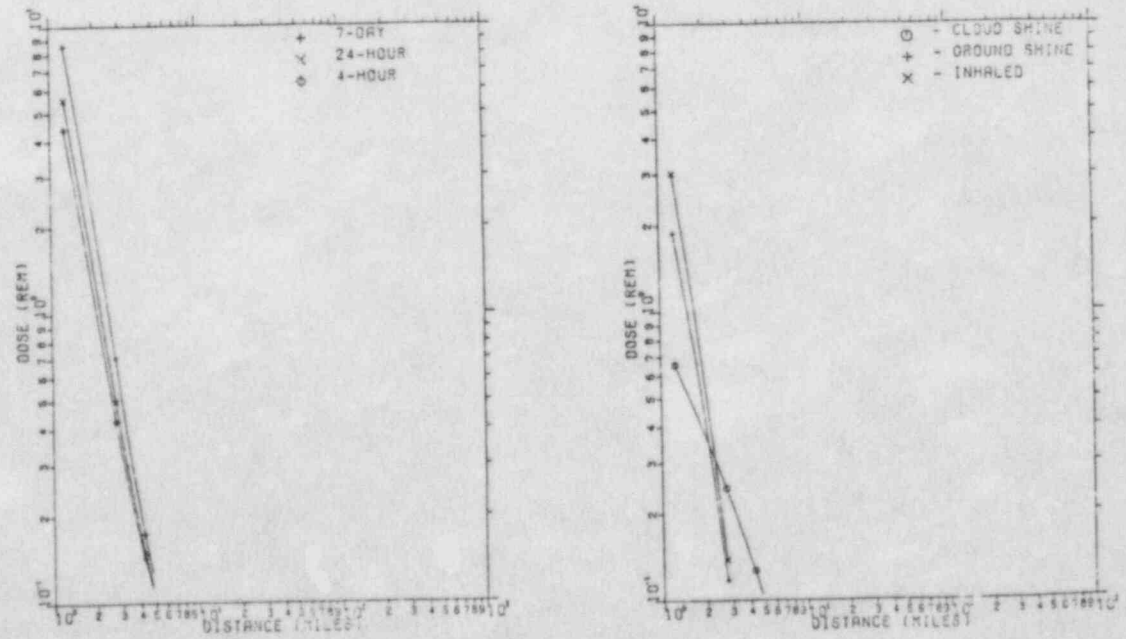


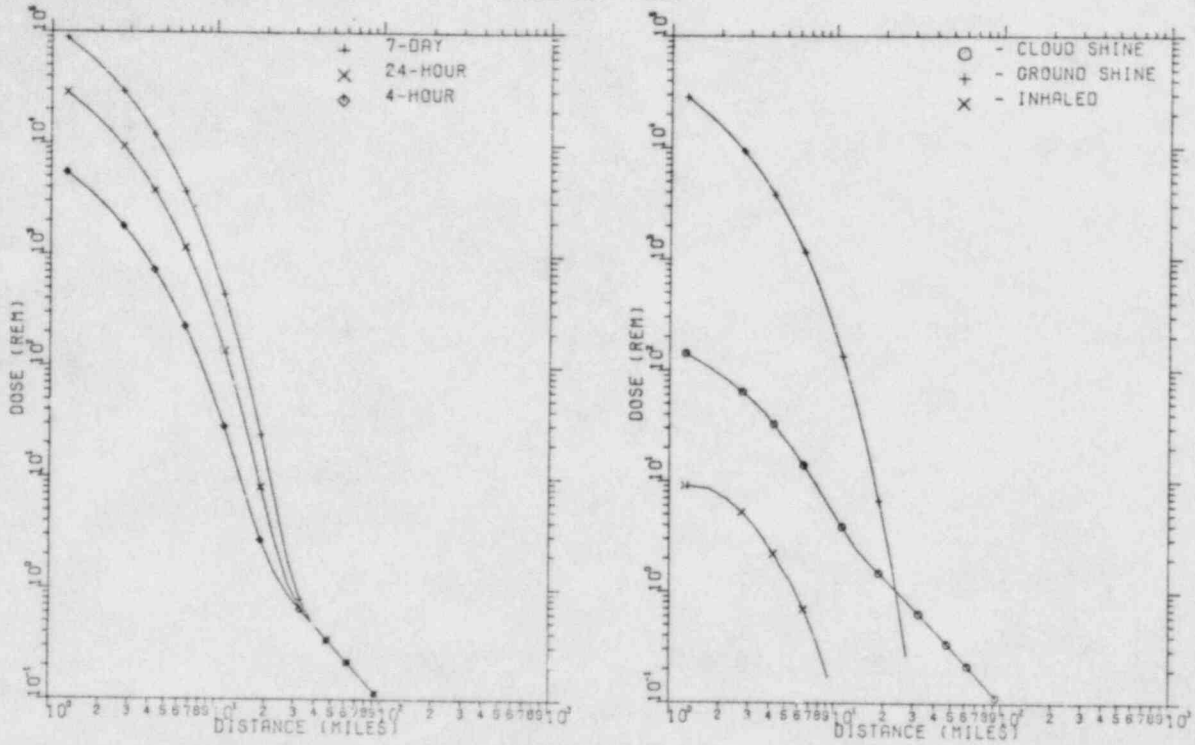
Figure 8-10

PWR #1A
CASE 1T

Stability Class: D
Windspeed: 6 mph

Rain: yes
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

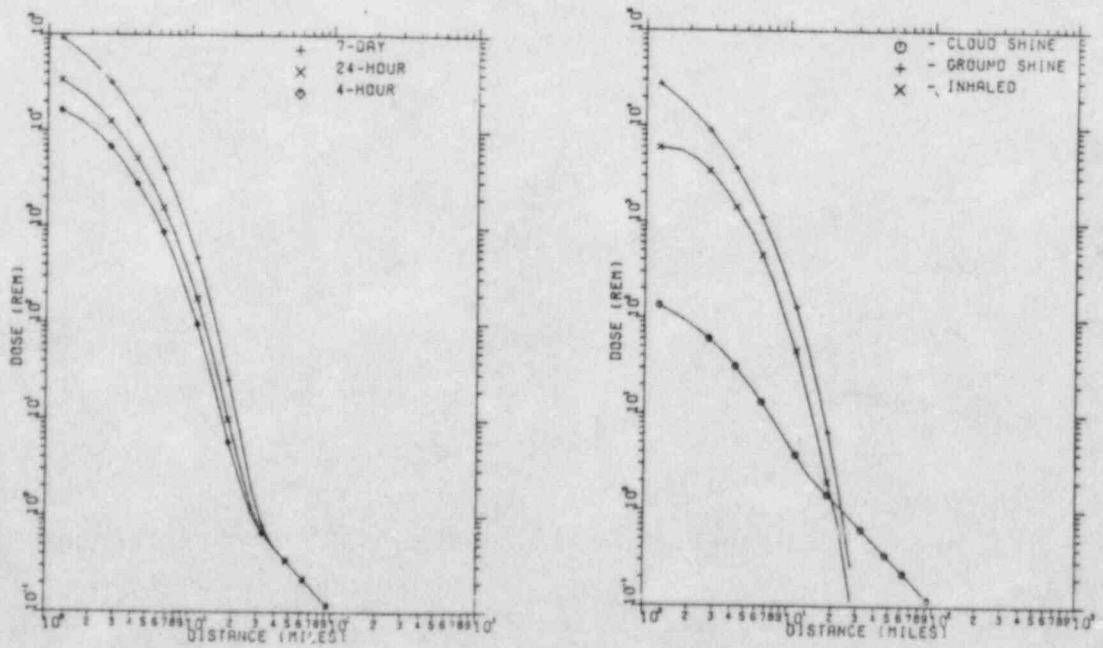


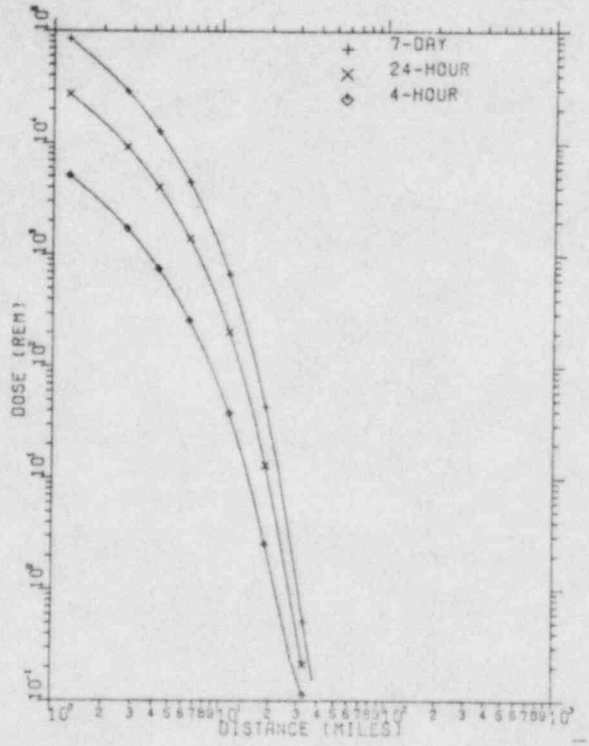
Figure 1A-11

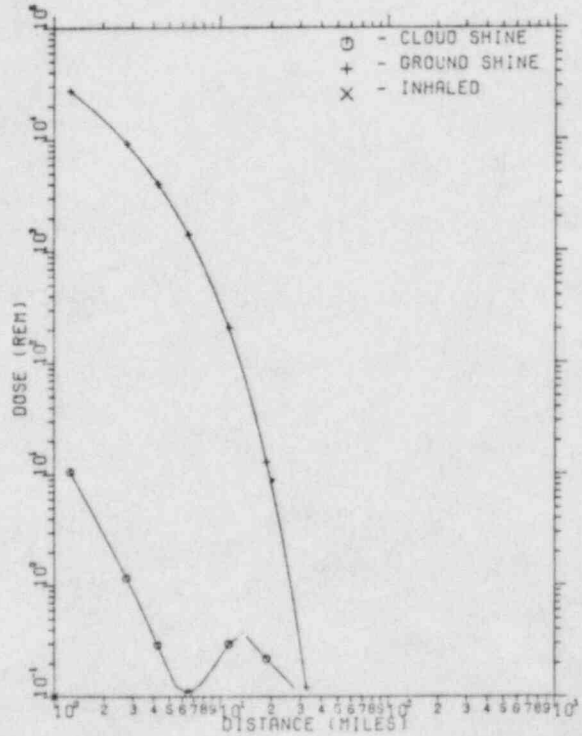
PWR # 1B
CASE 11

Stability Class: D
Windspeed: 6 mph

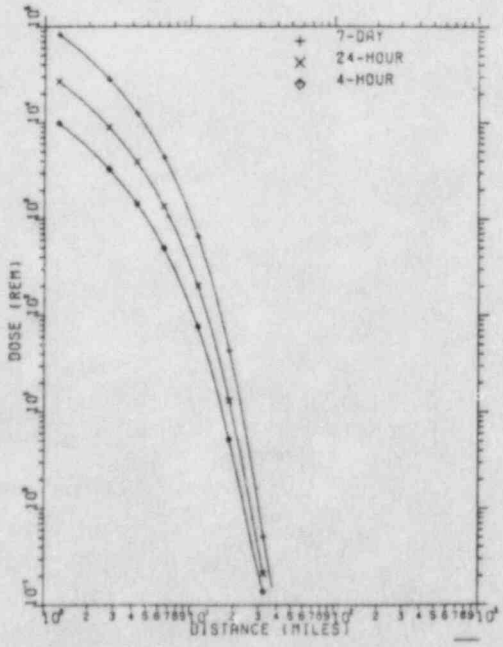
Rain: yes
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



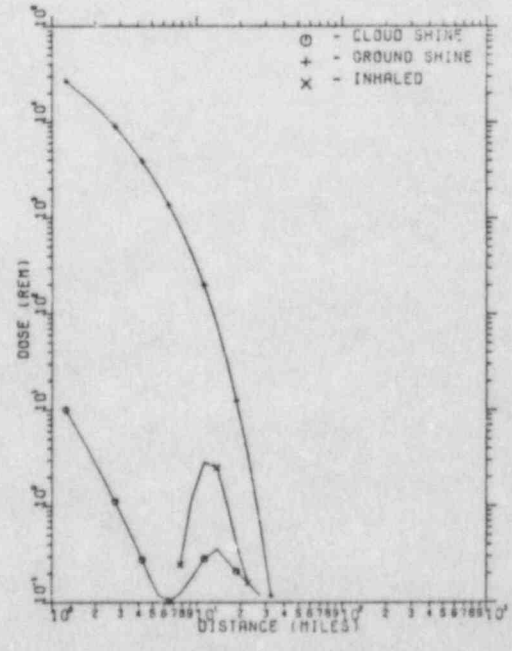


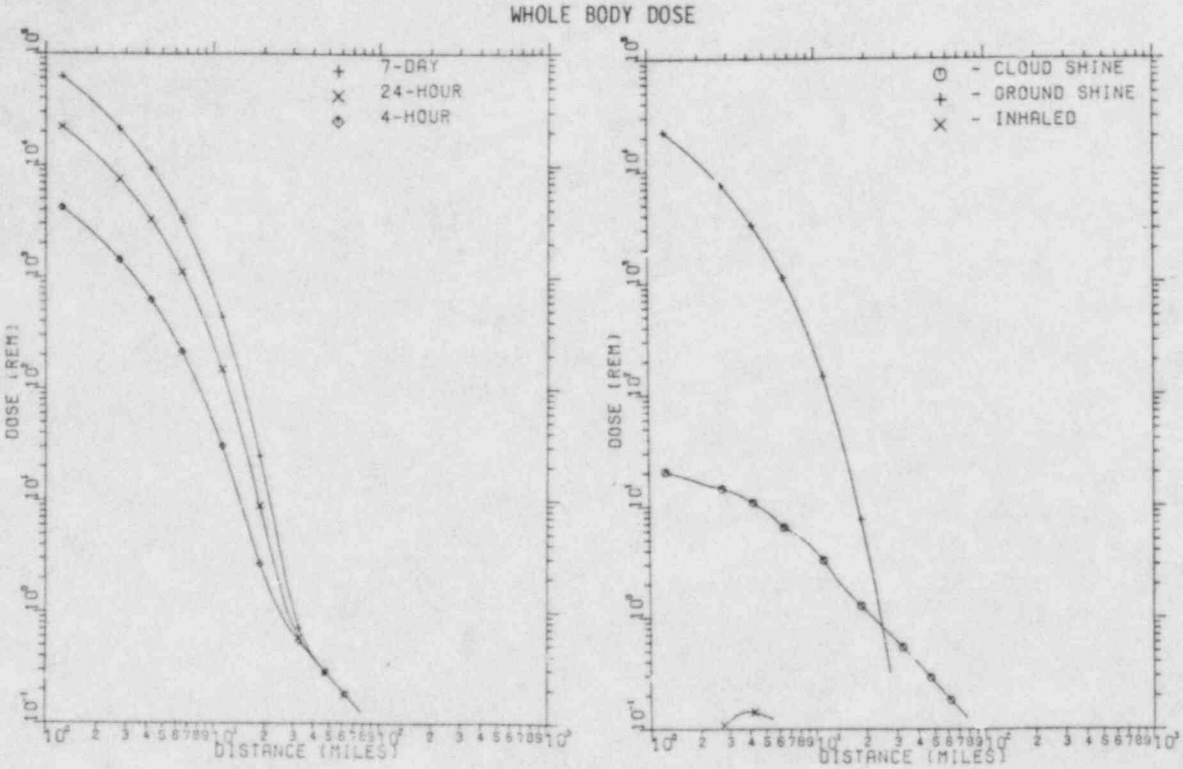
Figure 1B-11

PWR #2
CASE 11

Stability Class: D
Windspeed: 6 mph

Rain: yes
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

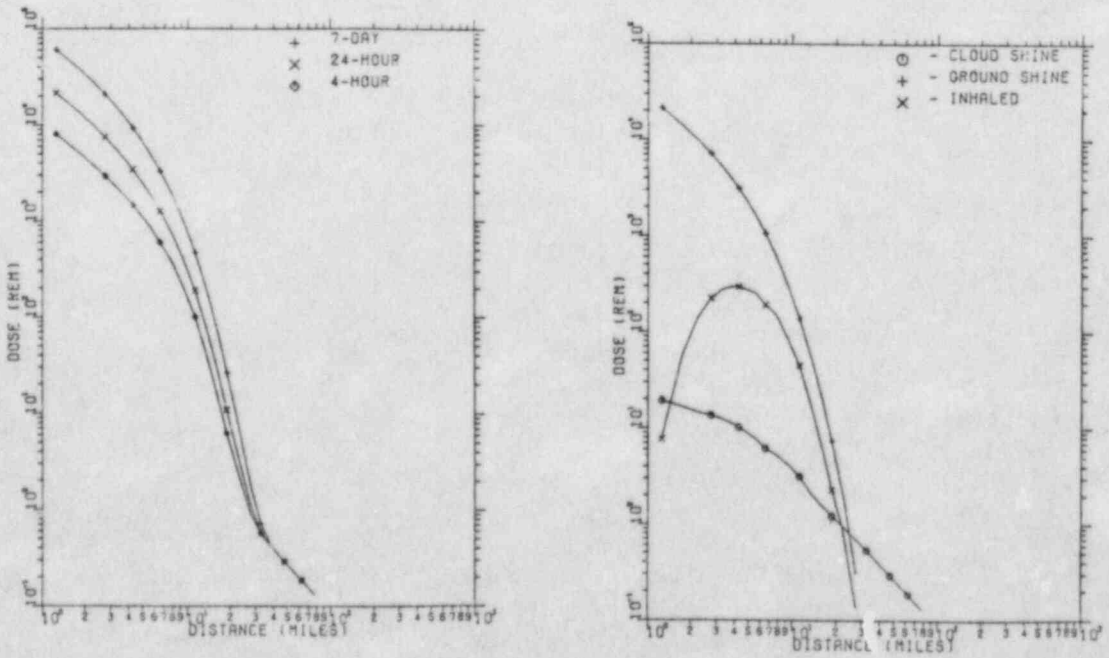


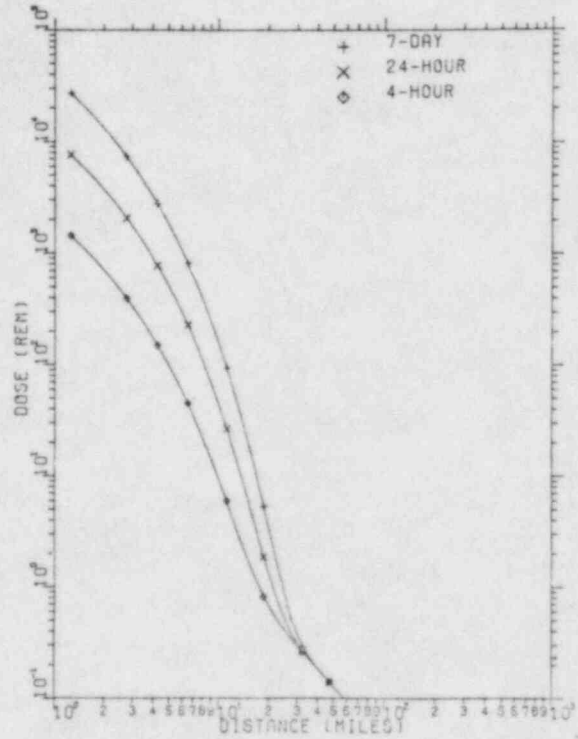
Figure 2-11

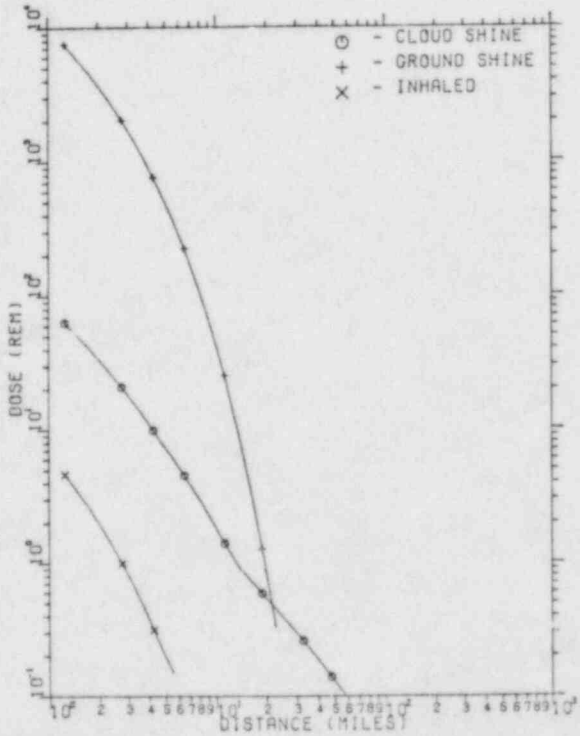
PWR #3
CASE 11

Stability Class: D
Windspeed: 6 mph

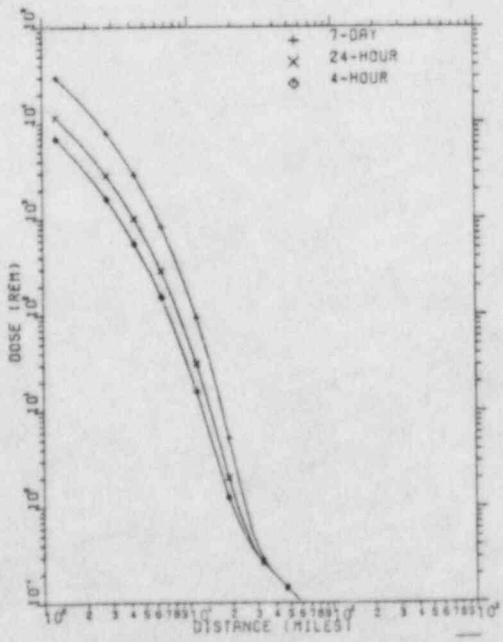
Rain: yes
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



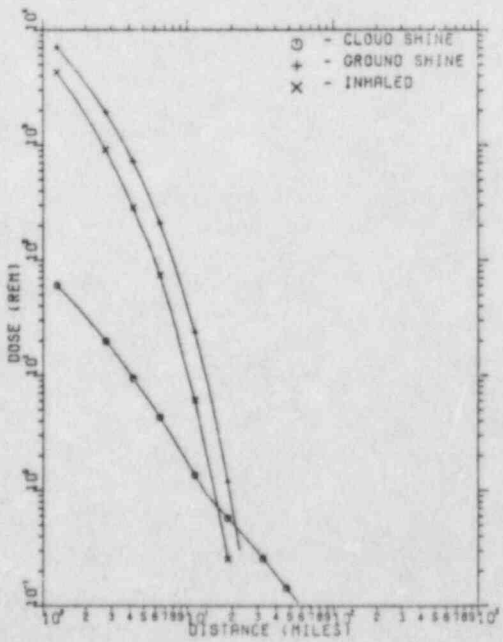


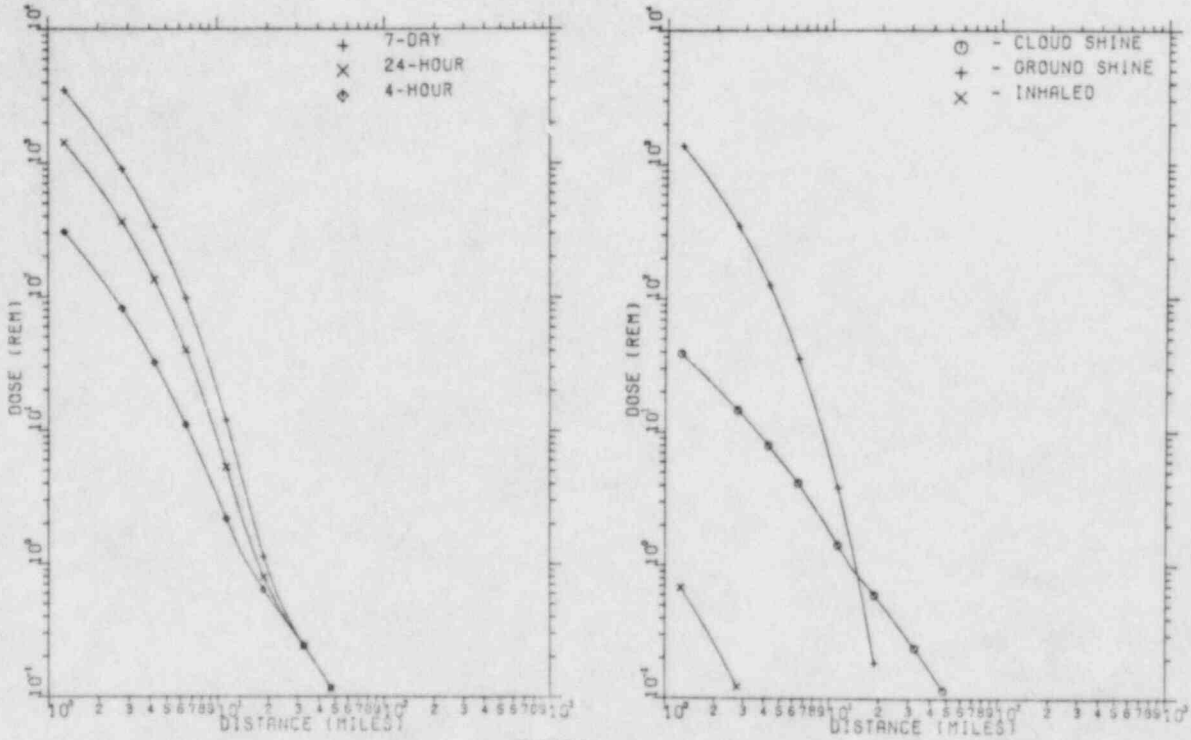
Figure 3-11

PWR #4
CASE 11

Stability Class: D
Windspeed: 6 mph

Rain: yes
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

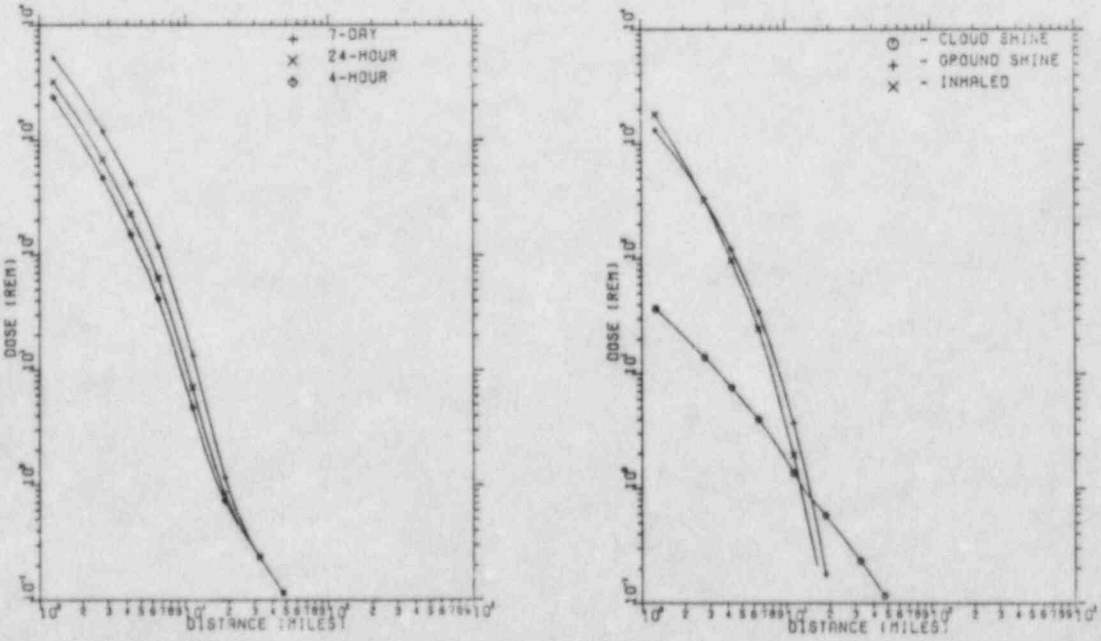


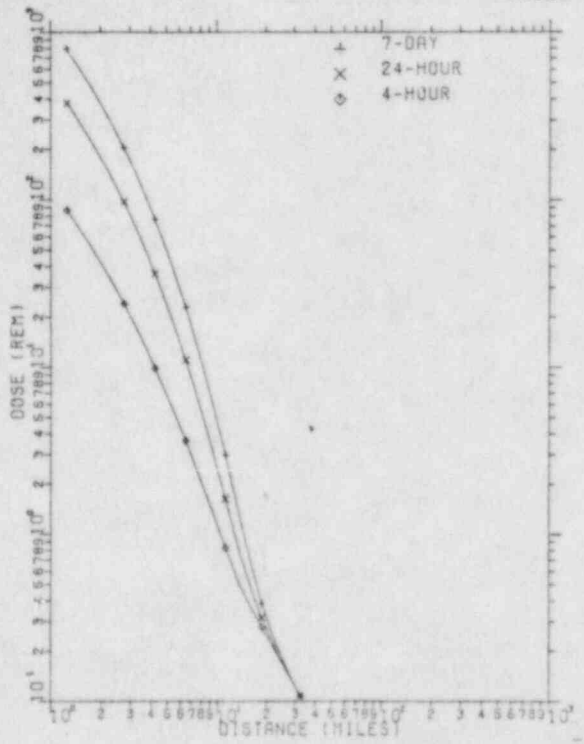
Figure 4-11

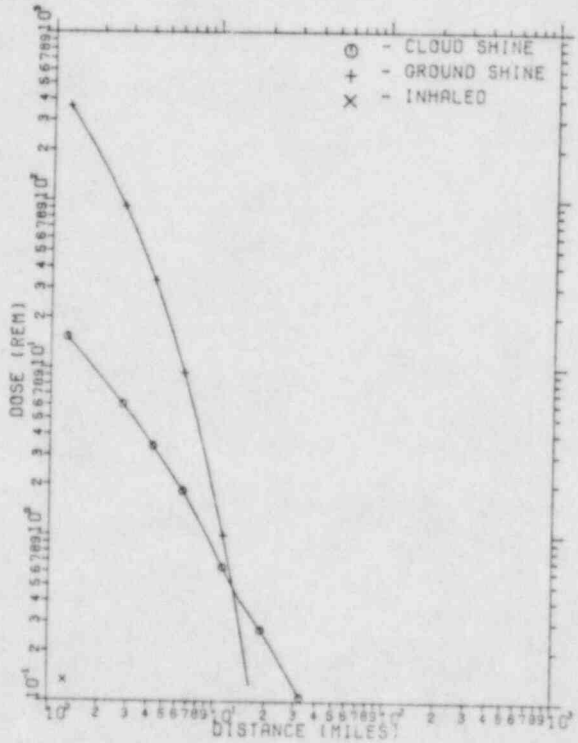
PWR #5
CASE 11

Stability Class: D
Windspeed: 6 mph

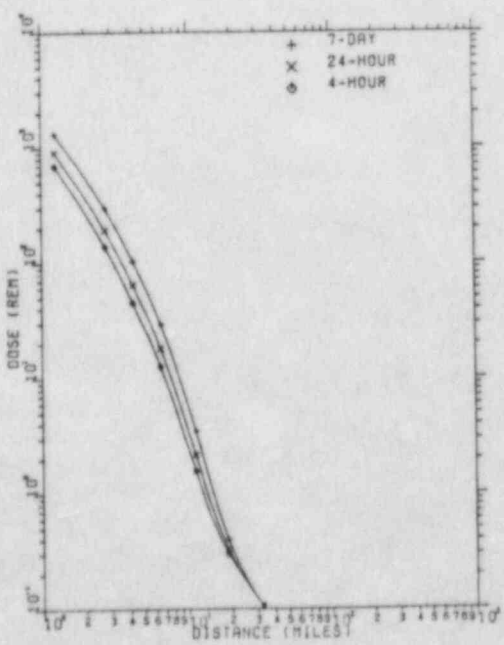
Rain: yes
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



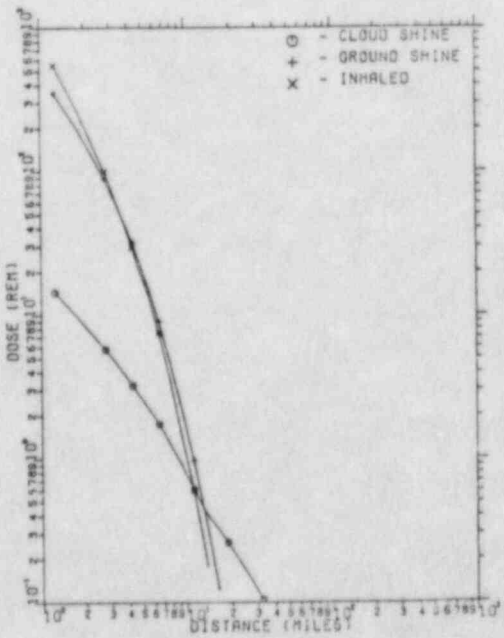


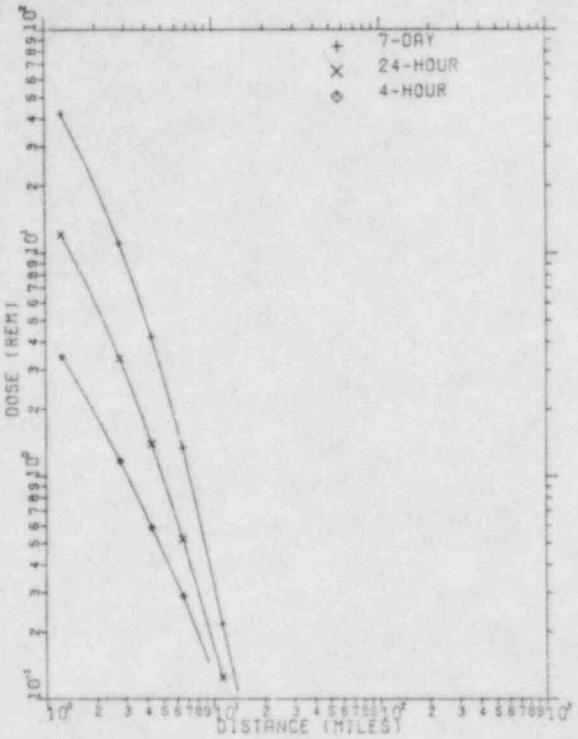
Figure 5-11

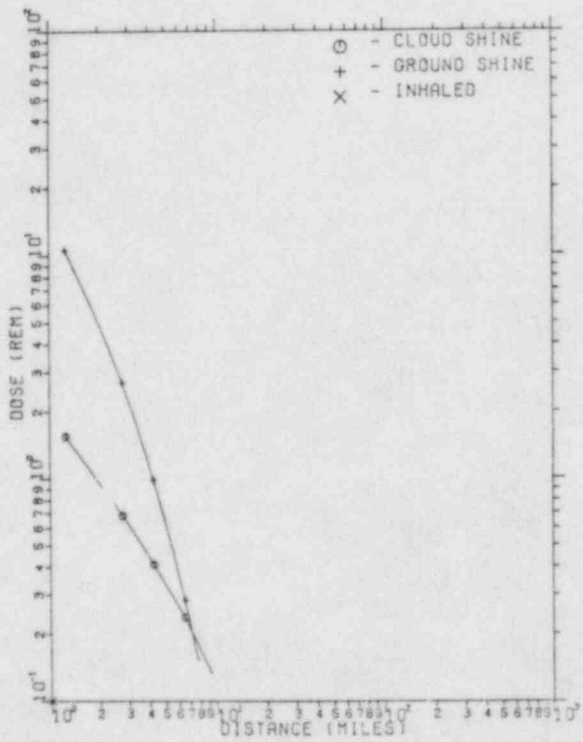
PWR # 6
CASE 11

Stability Class: D
Windspeed: 6 mph

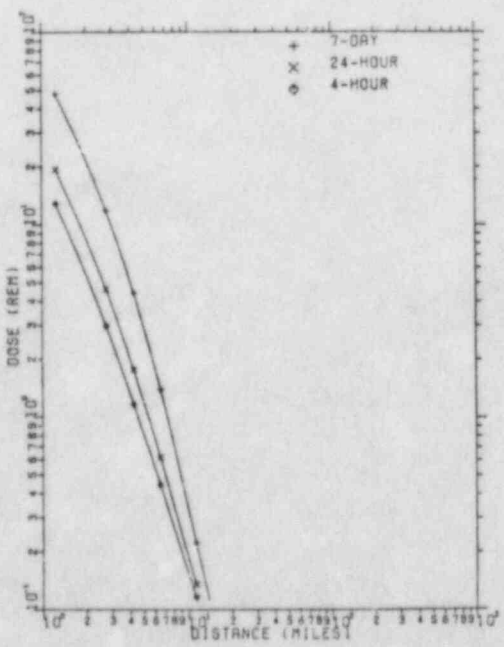
Rain: yes
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



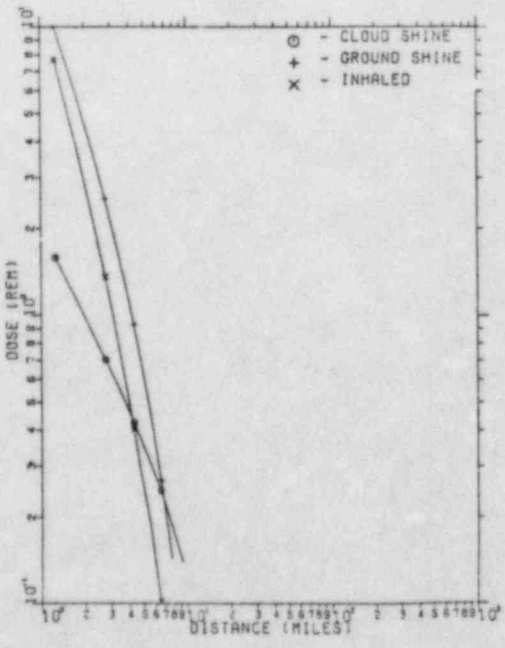


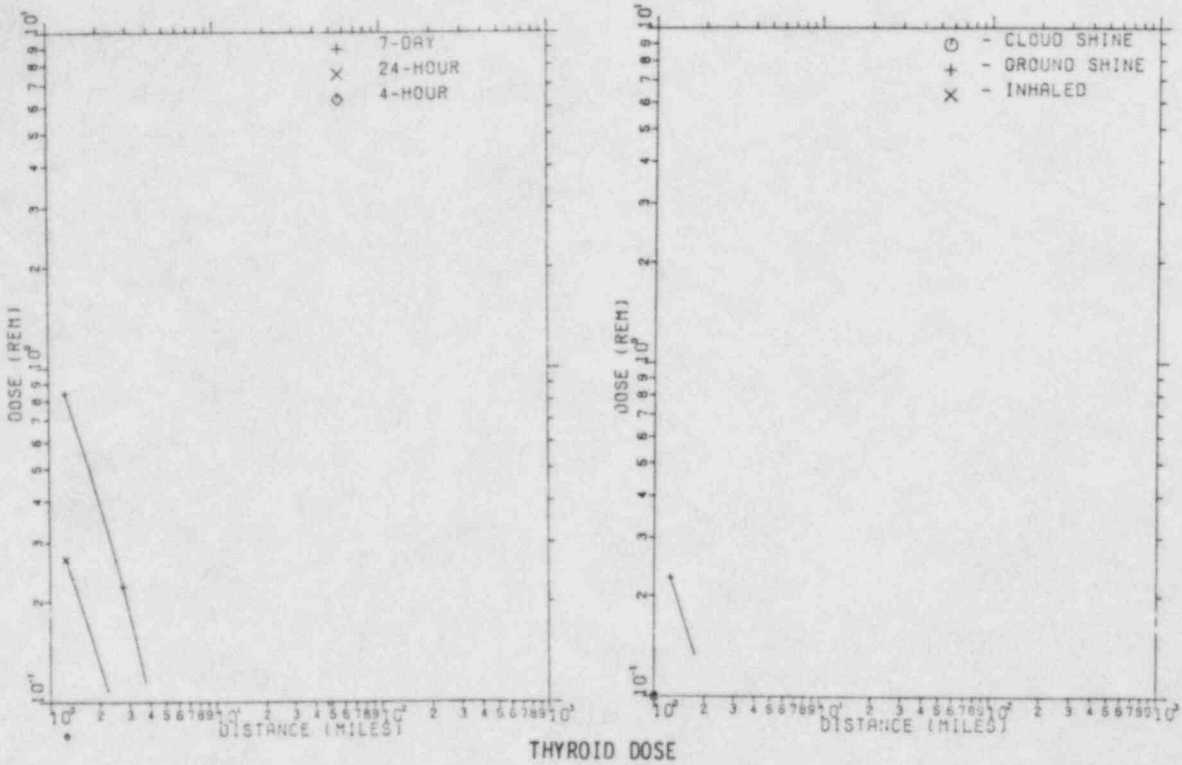
Figure 6-11

PWR # 7
CASE 11

Stability Class: D
Windspeed: 6 mph

Rain: yes
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

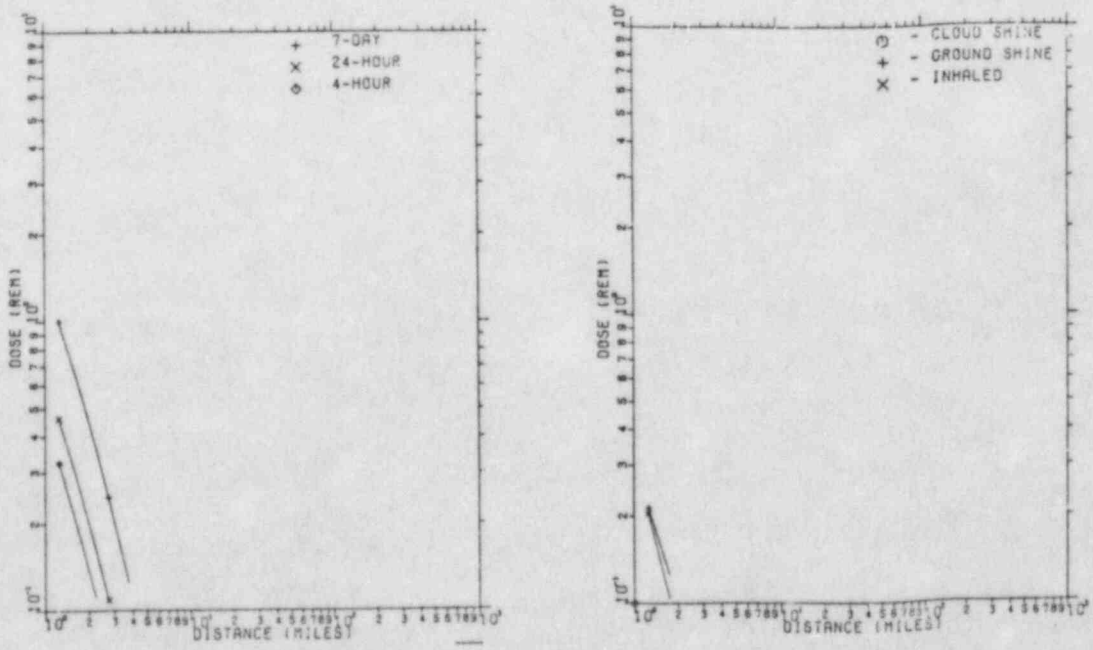


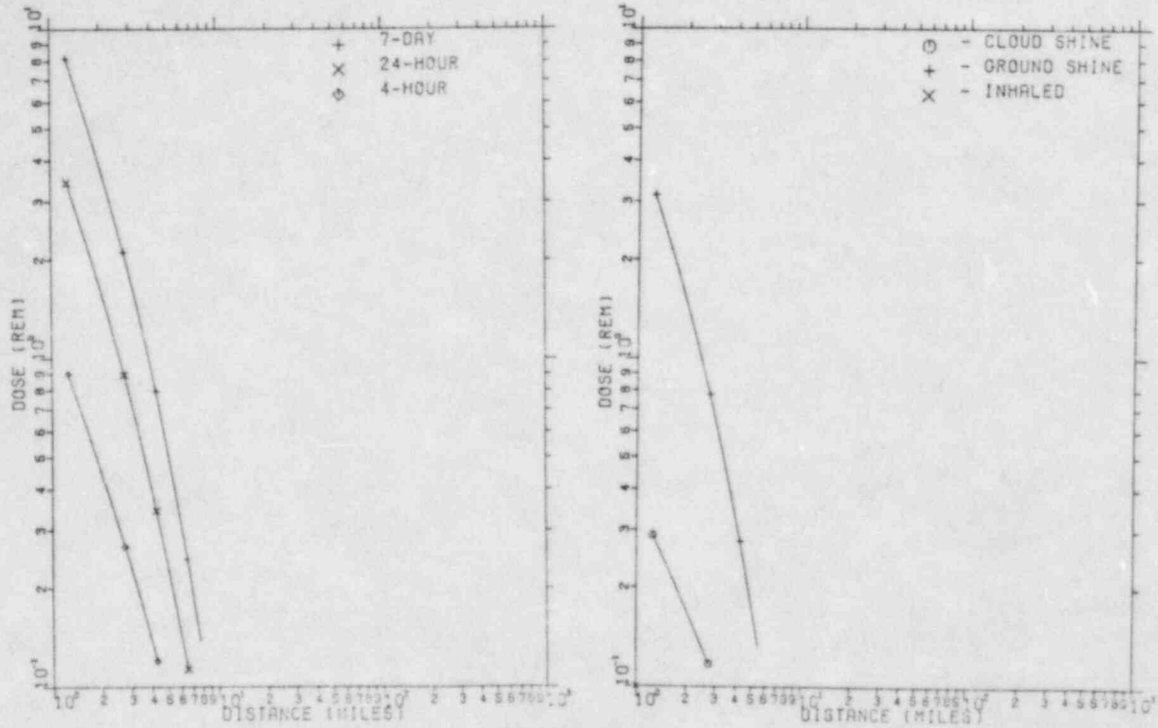
Figure 7-11

PWR #8
CASE T1

Stability Class: D
Windspeed: 6 mph

Rain: yes
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

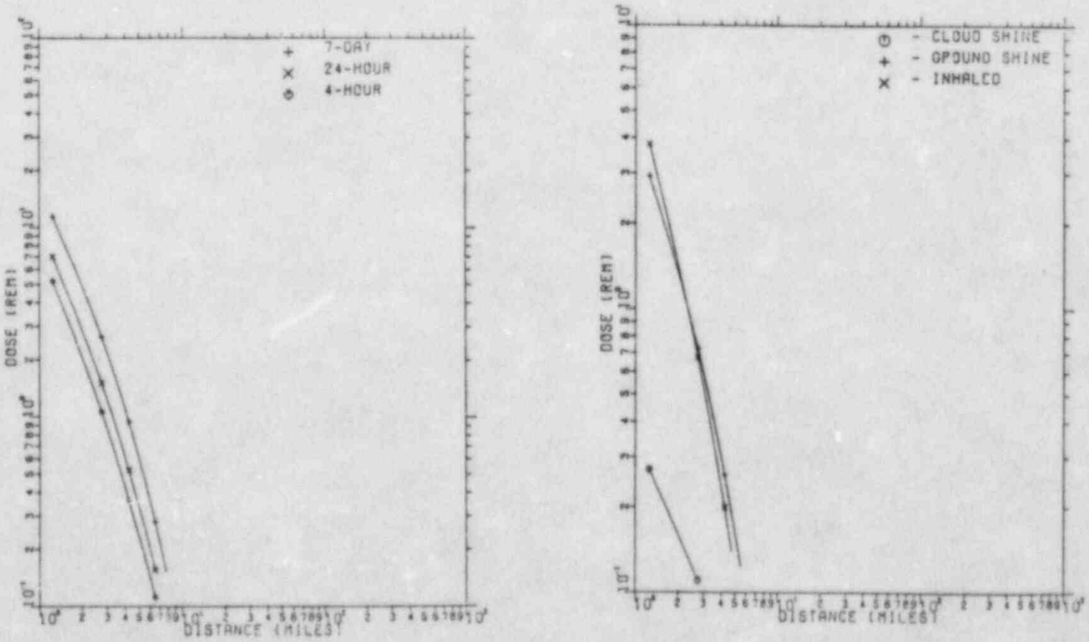


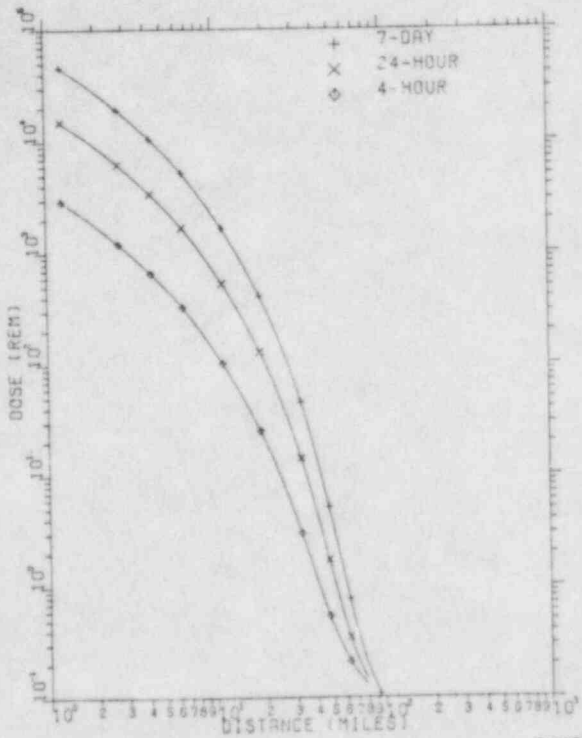
Figure 8-11

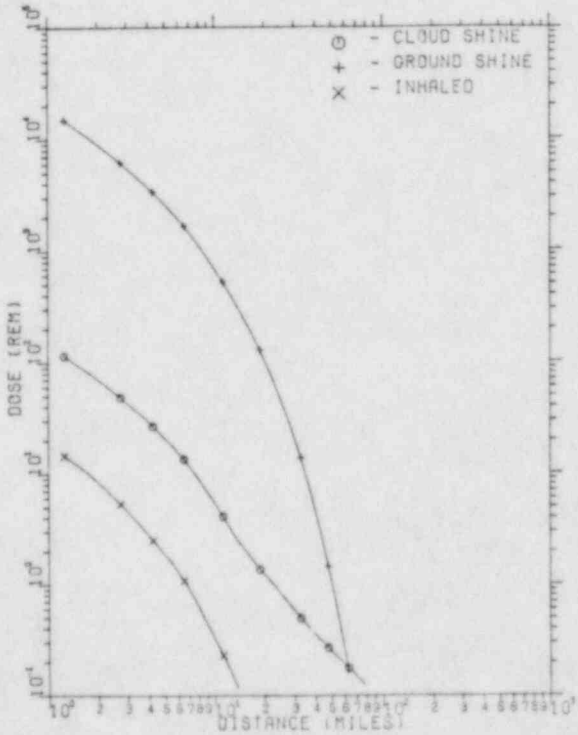
PWR # 1A
CASE 12

Stability Class: D
Windspeed: 16 mph

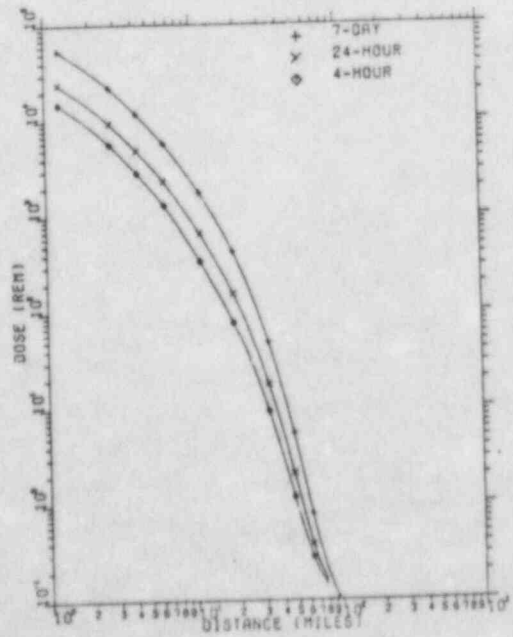
Rain: yes
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



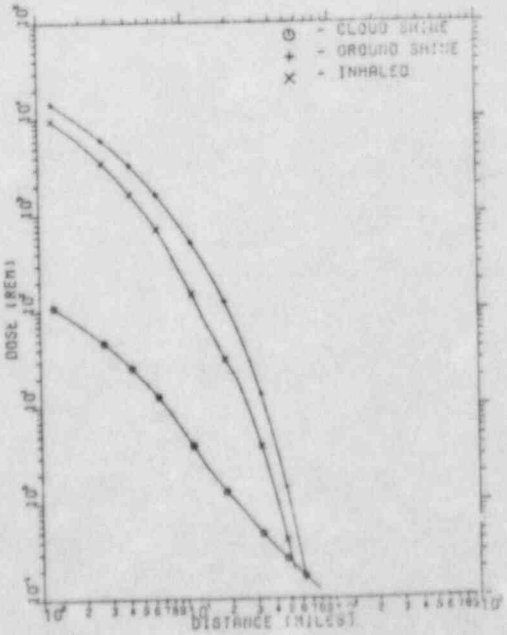


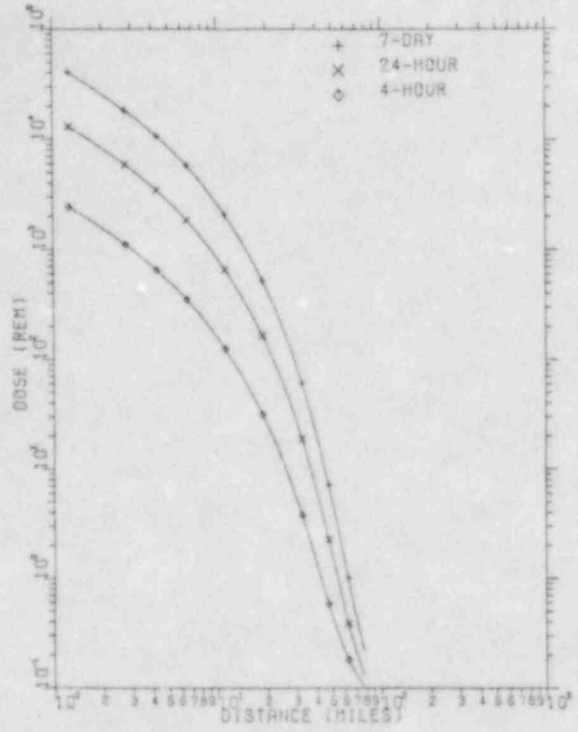
Figure 1A-12

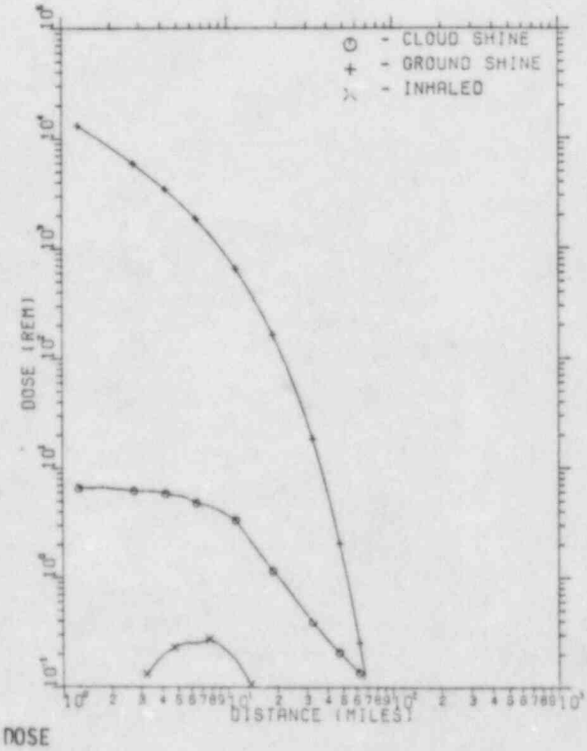
PWR #1B
CASE 12

Stability Class: D
Windspeed: 16 mph

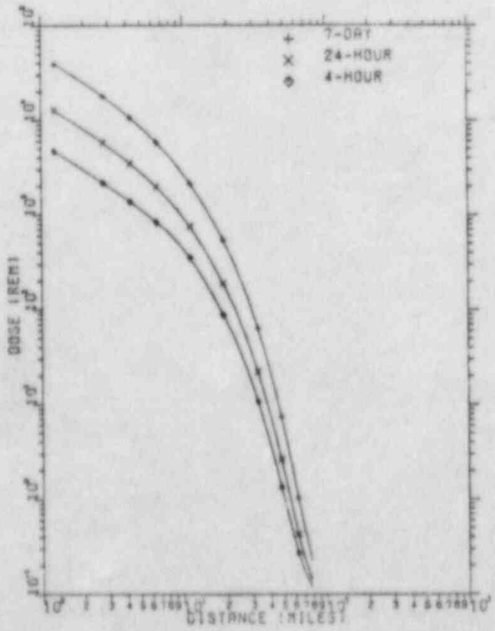
Rain: yes
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



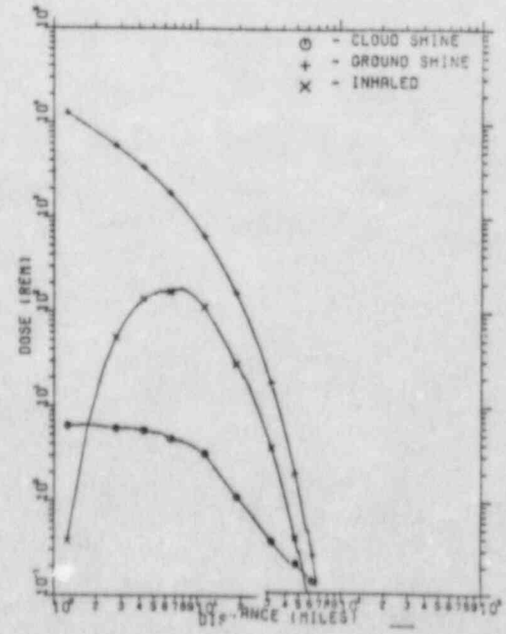


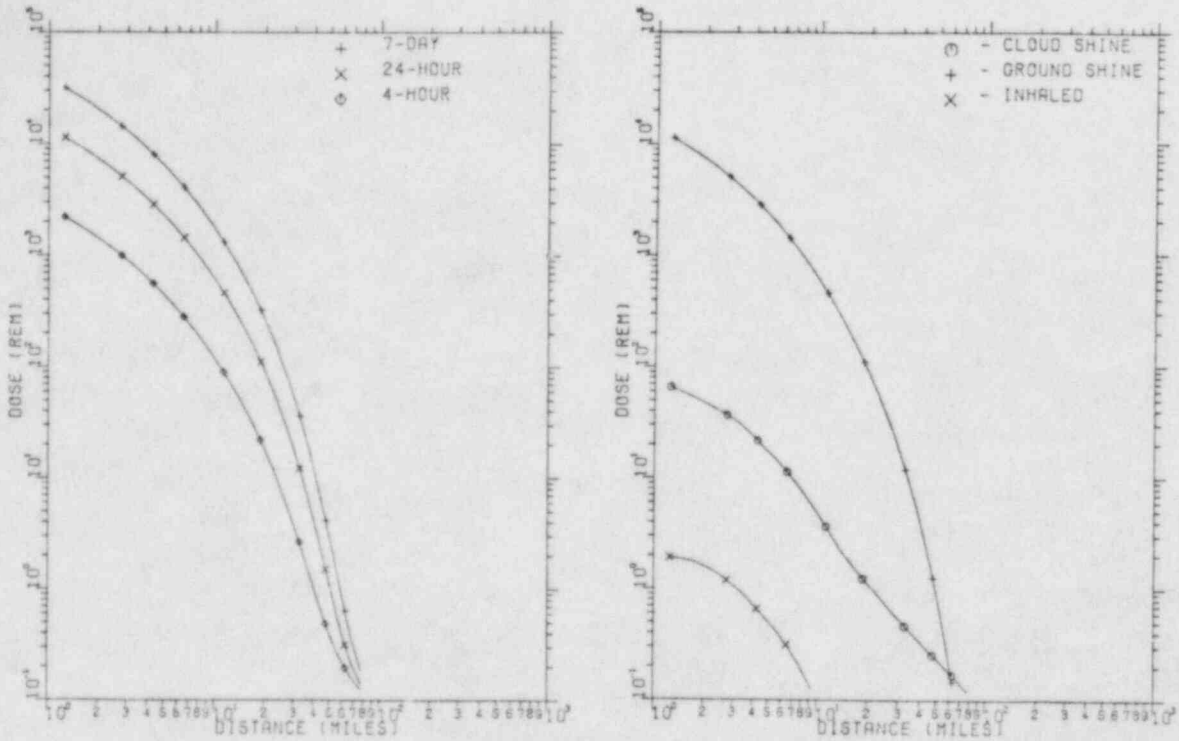
Figure 1B-12

PWR # 2
CASE 12

Stability Class: D
Windspeed: 16 mph

Rain: yes
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

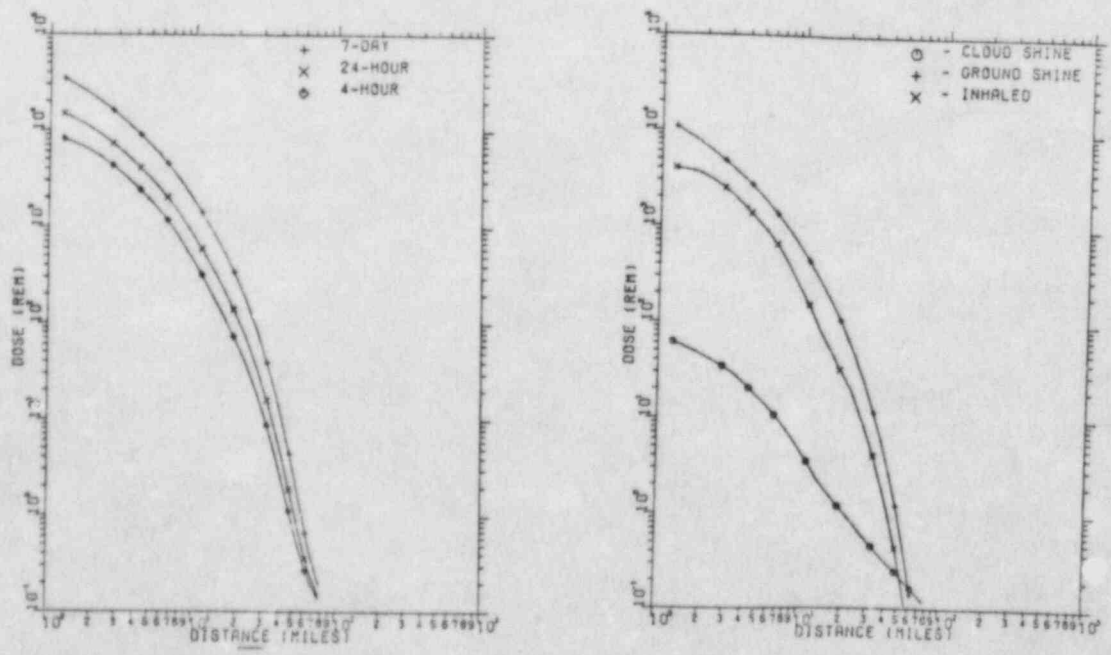


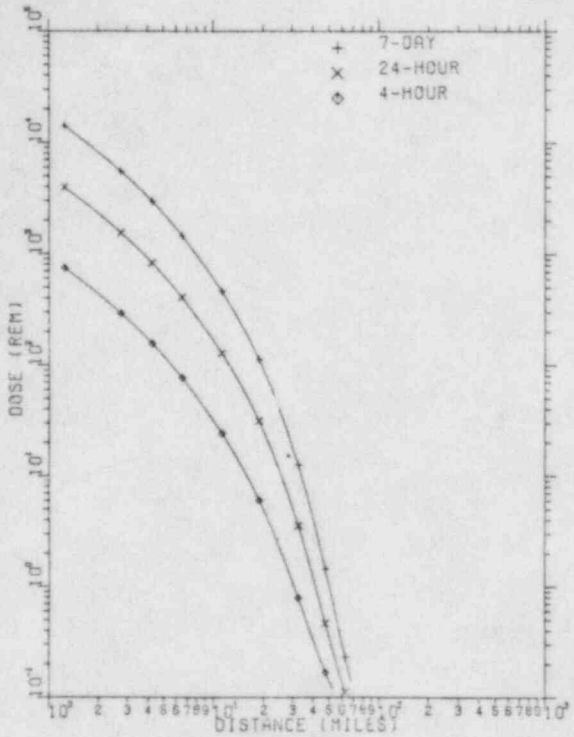
Figure 2-12

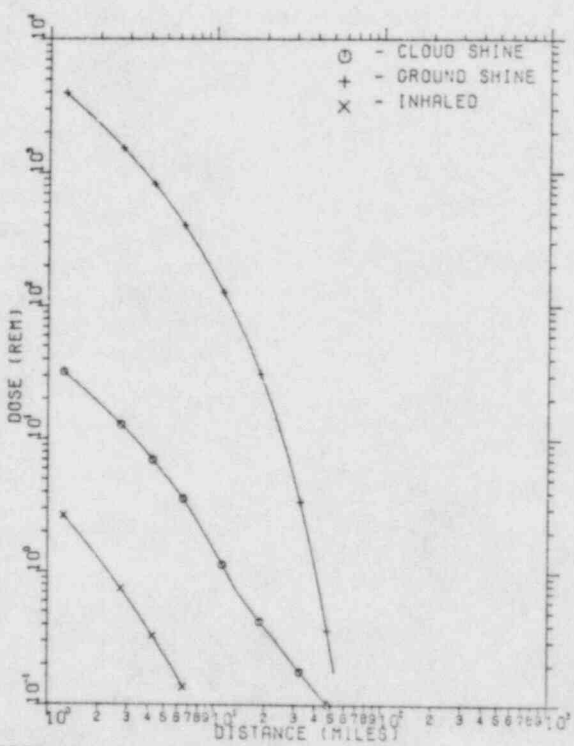
PWR # 3
CASE 12

Stability Class: D
Windspeed: 16 mph

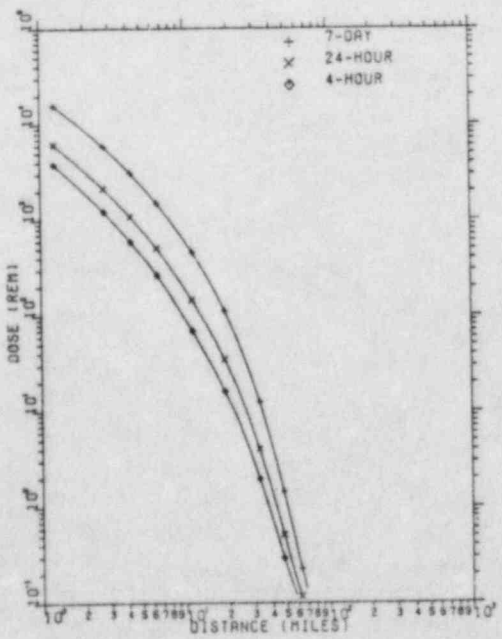
Rain: yes
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



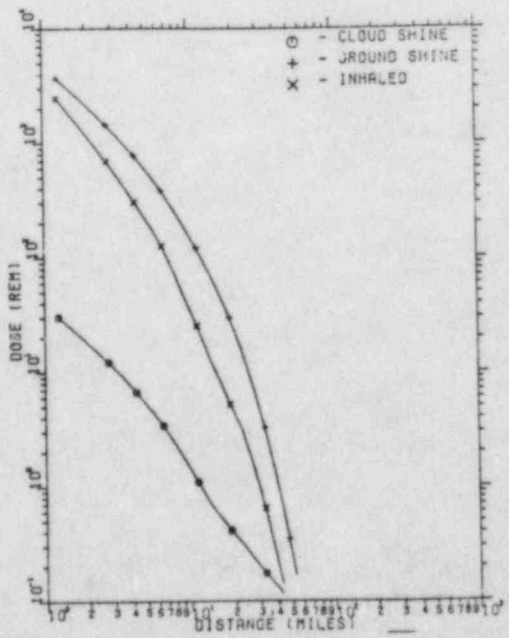


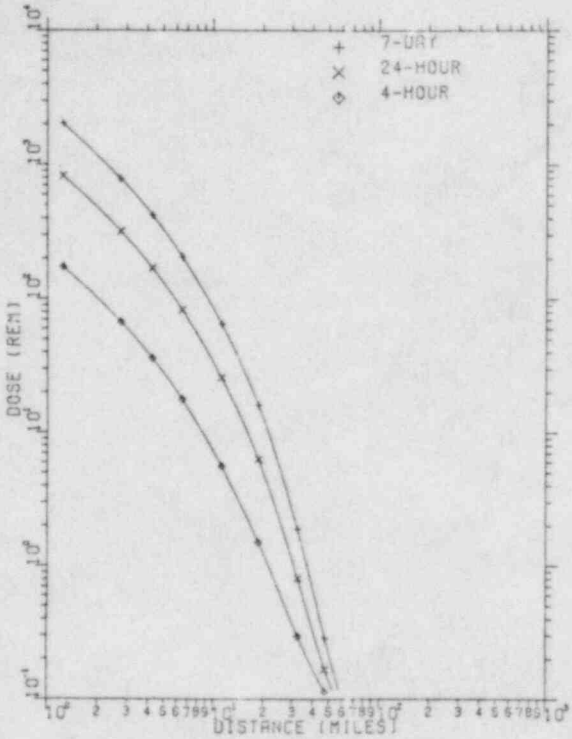
Figure 3-12

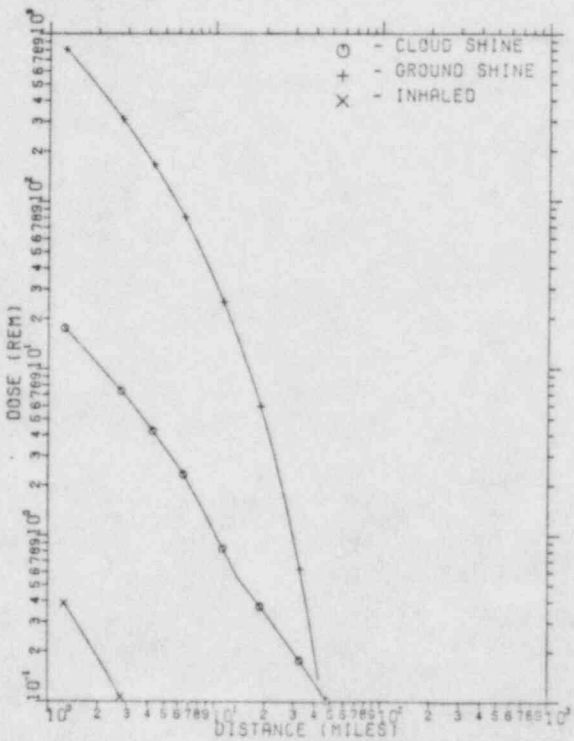
PWR # 4
CASE 12

Stability Class: D
Windspeed: 16 mph

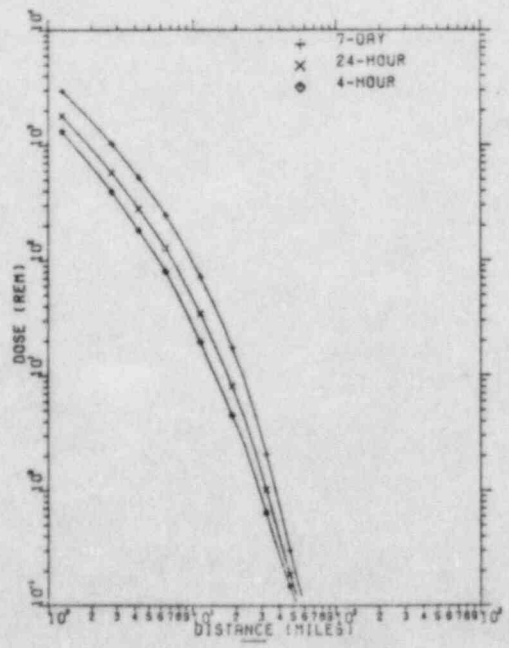
Rain: yes
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



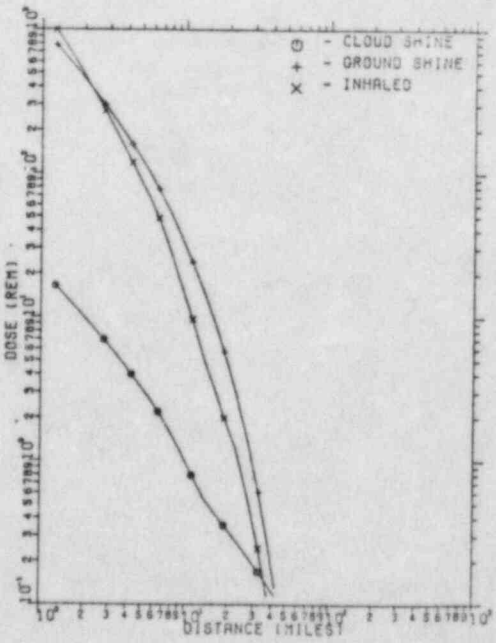


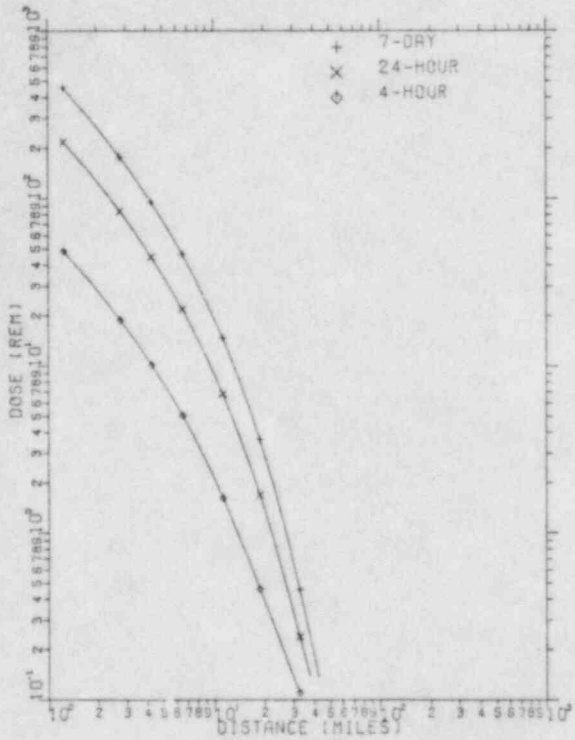
Figure 4-12

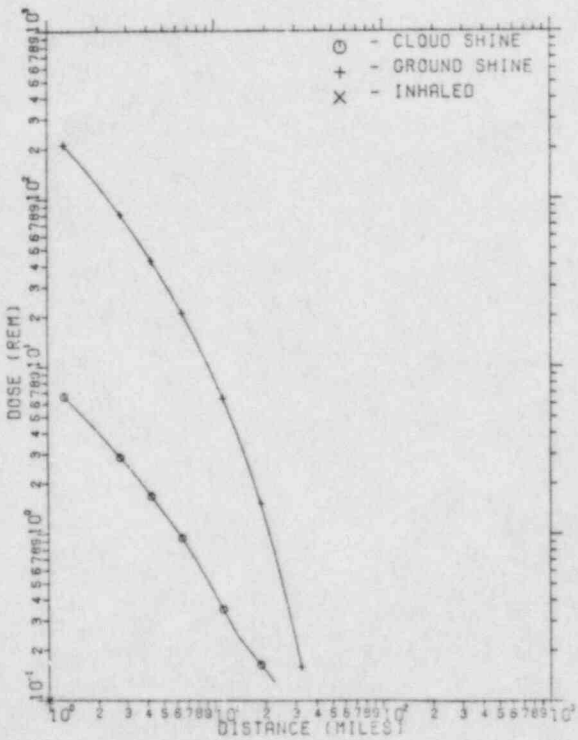
PWR #5
CASE 12

Stability Class: D
Windspeed: 16 mph

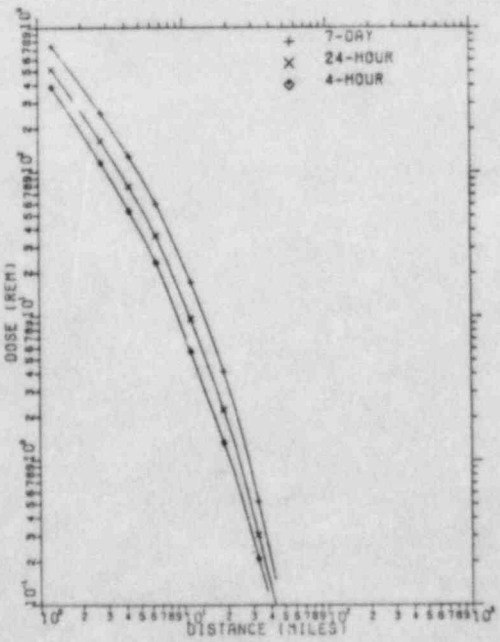
Rain: yes
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



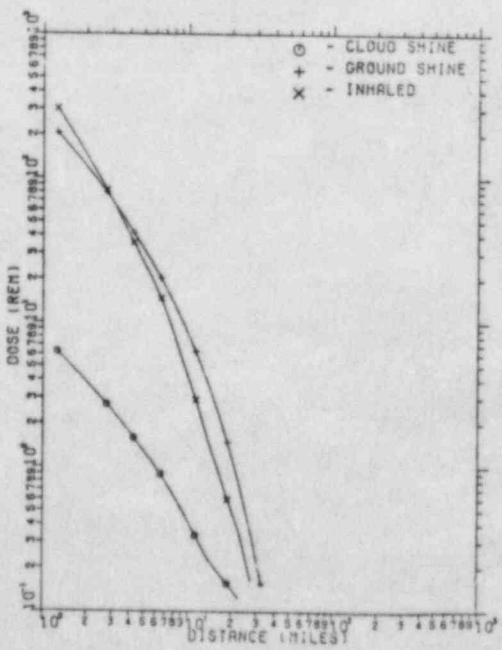


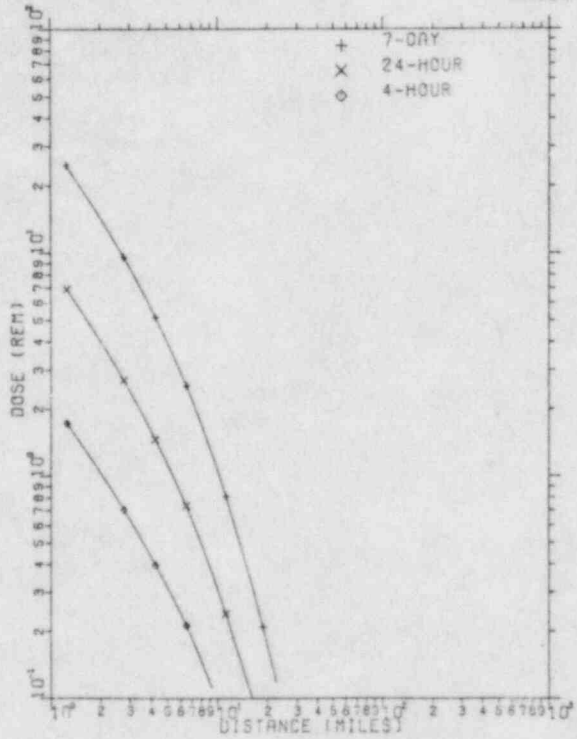
Figure 5-12

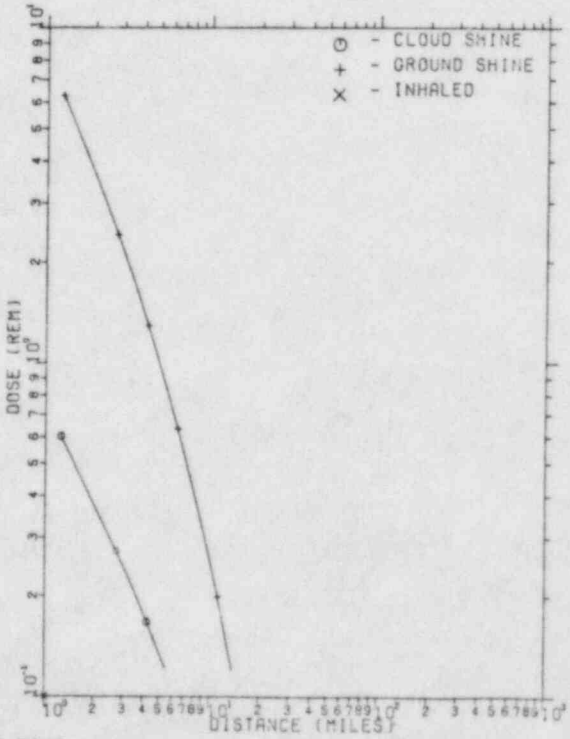
PWR # 6
CASE 12

Stability Class: D
Windspeed: 16 mph

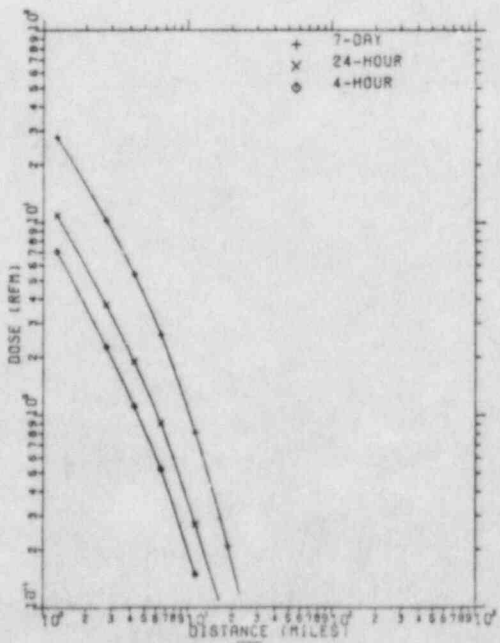
Rain: yes
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



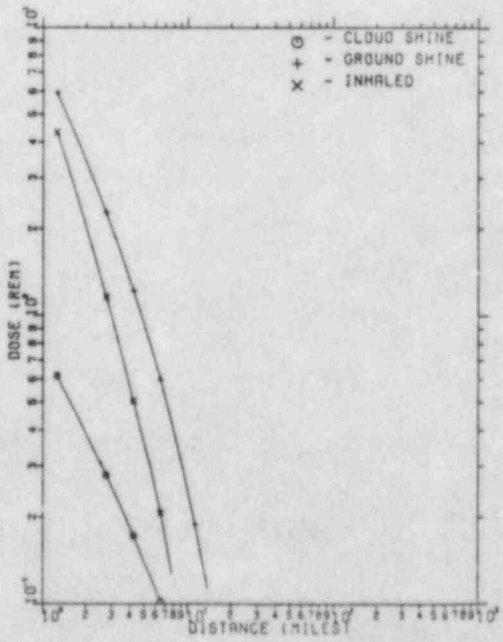


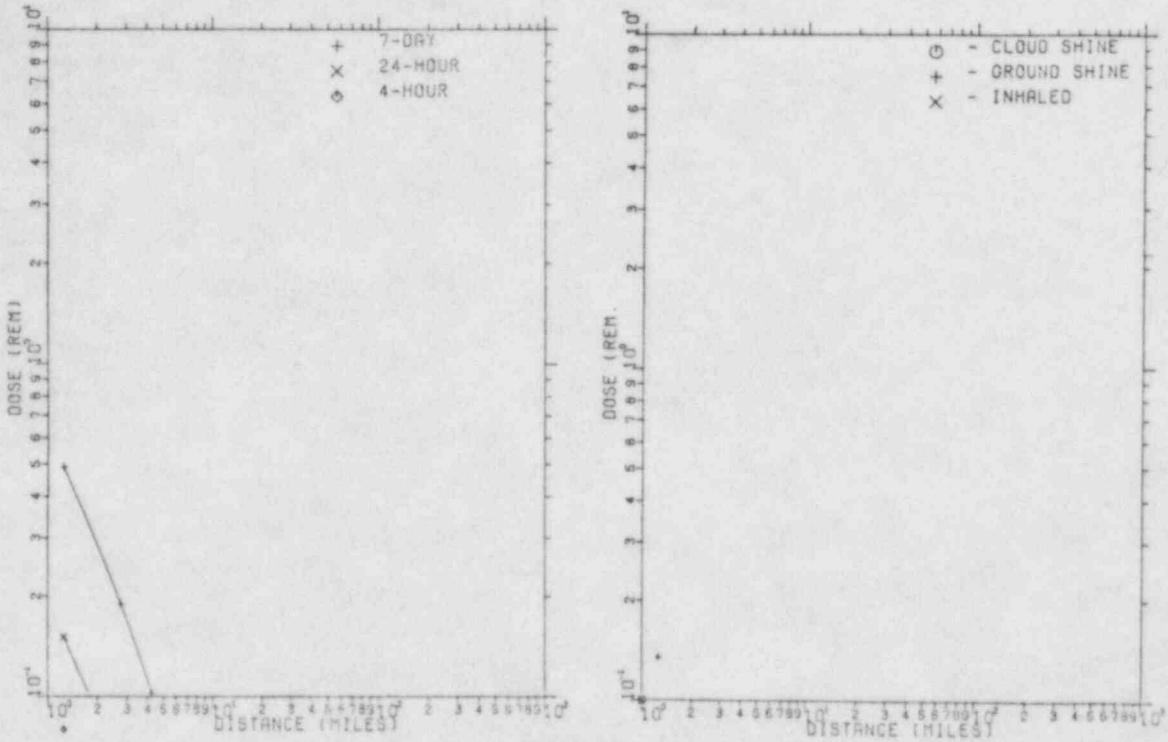
Figure 6-12

PWR #7
CASE 12

Stability Class: D
Windspeed: 16 mph

Rain: yes
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

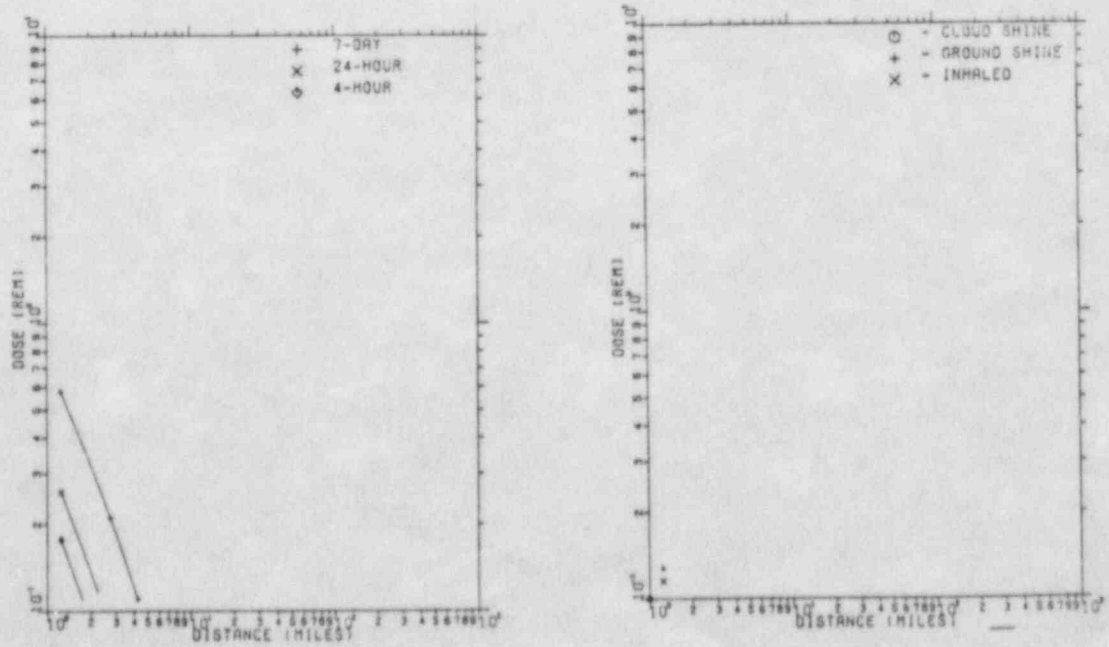


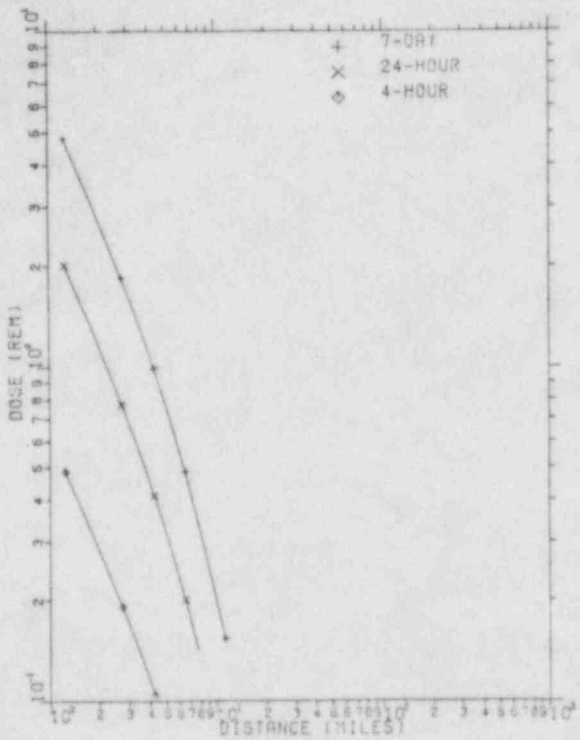
Figure 7-12

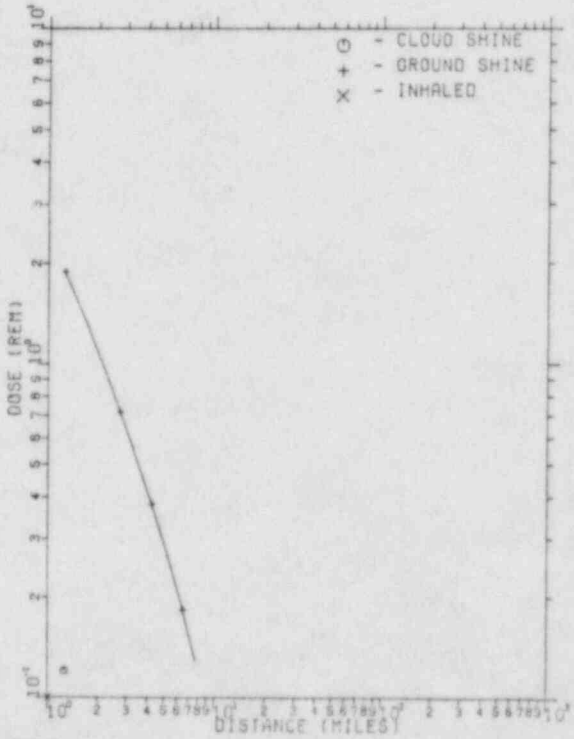
PWR #8
CASE 12

Stability Class: D
Windspeed: 16 mph

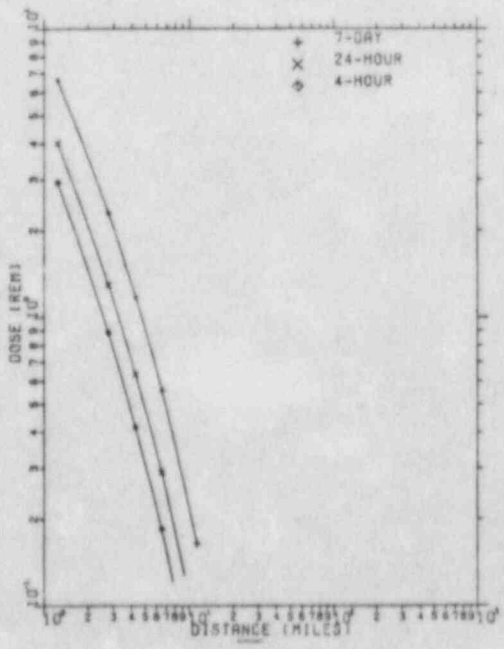
Rain: yes
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



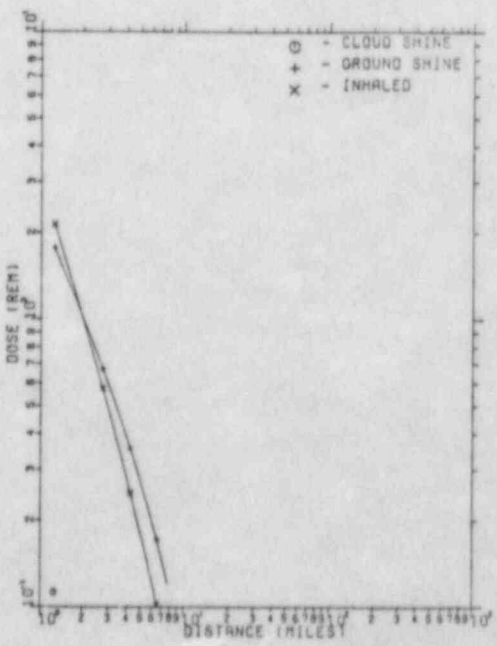


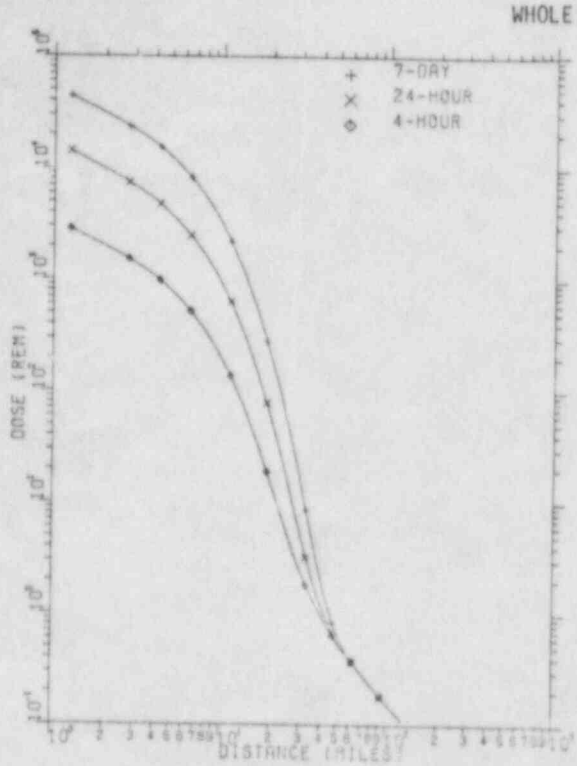
Figure 8-12

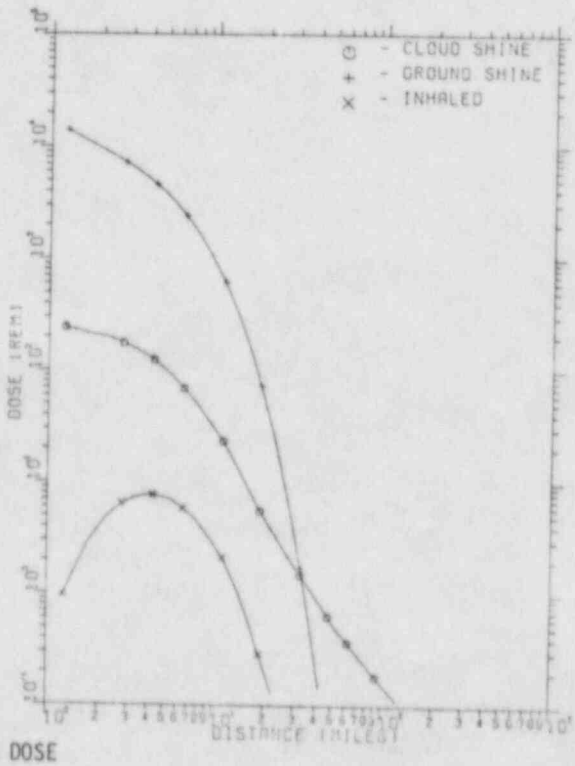
PWR #1A
CASE 13

Stability Class: E
Windspeed: 2 mph

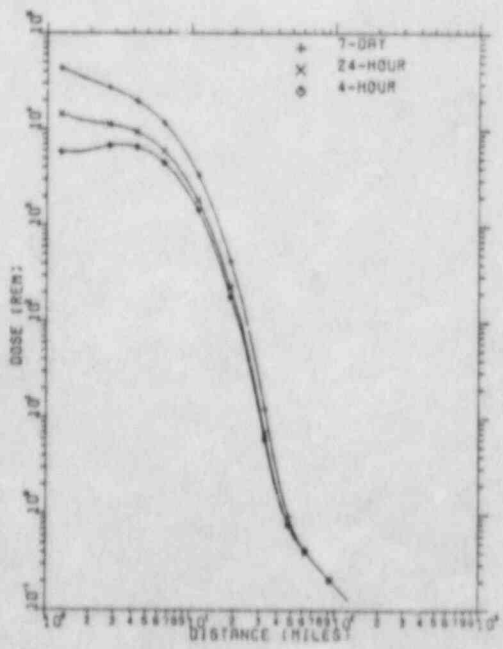
Rain: yes
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



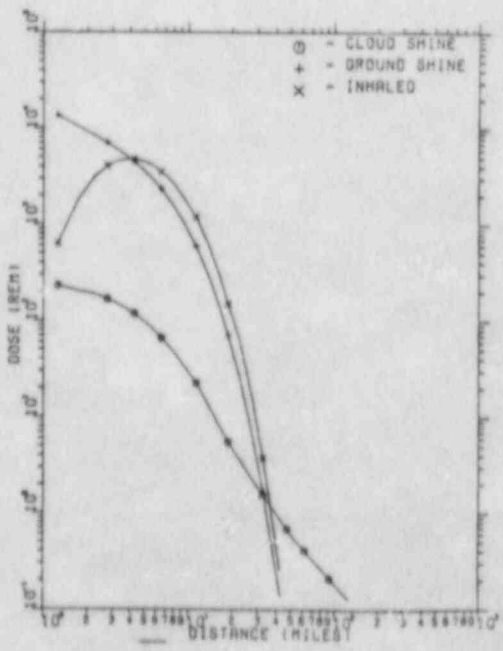


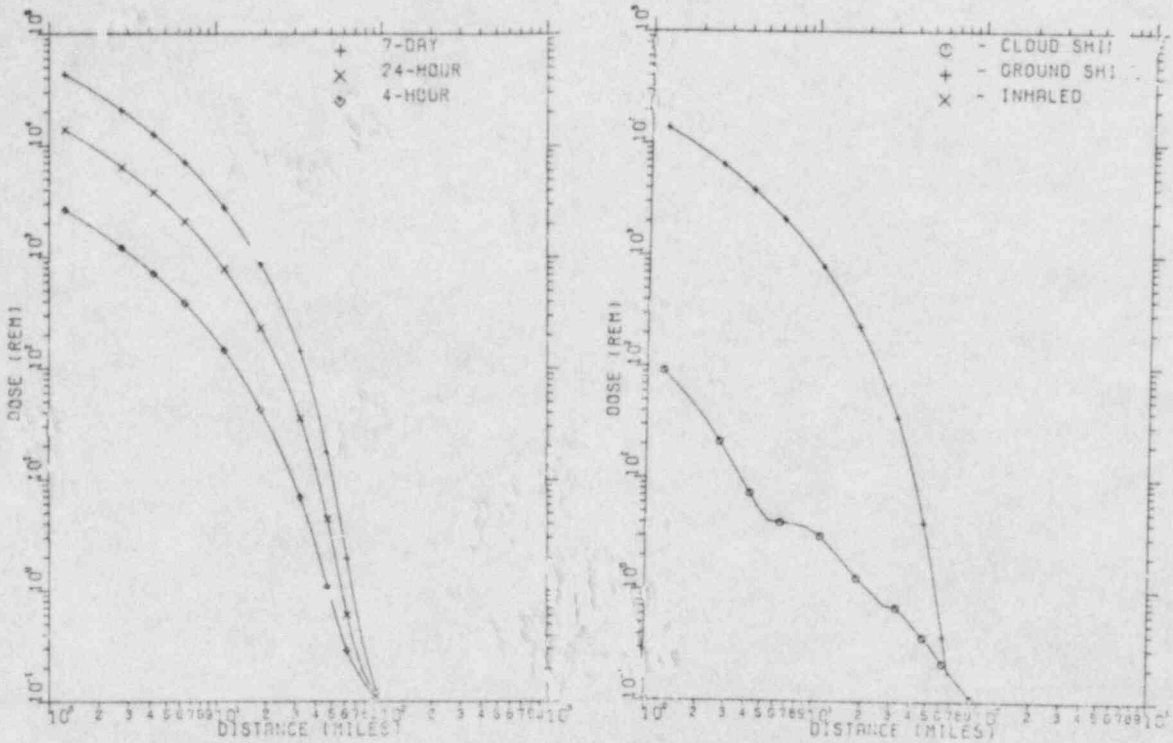
Figure 1A-13

PWR #1B
CASE 13

Stability Class: E
Windspeed: 2 mph

Rain: yes
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

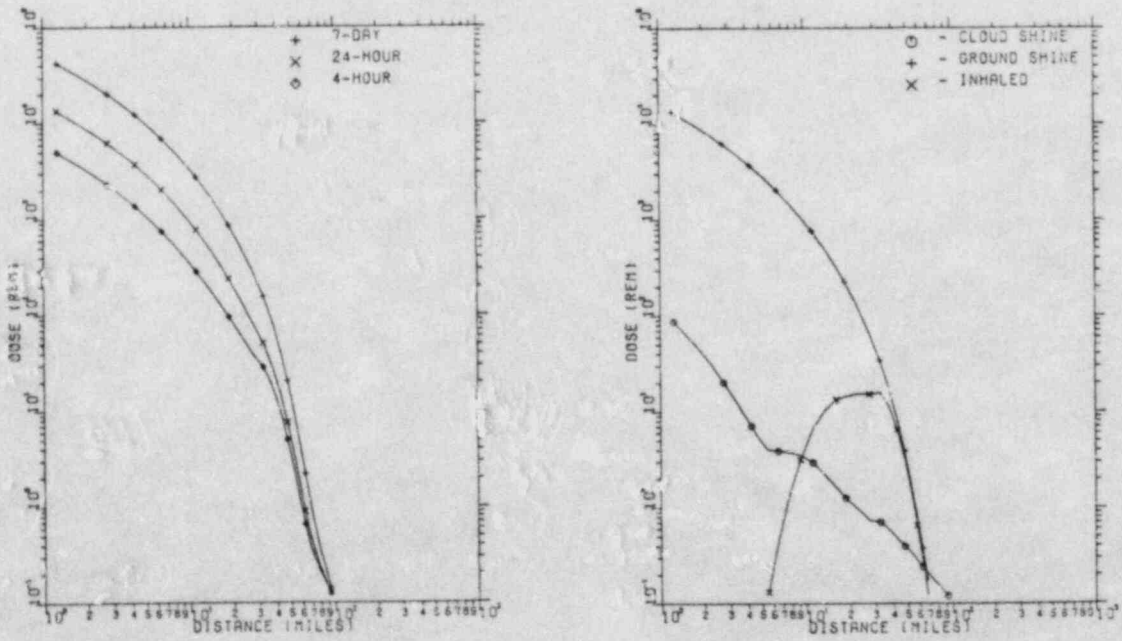


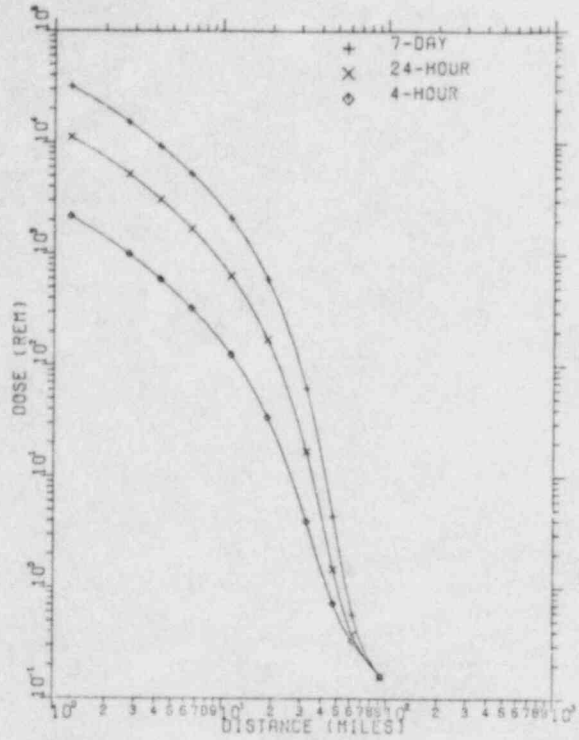
Figure 1B-13

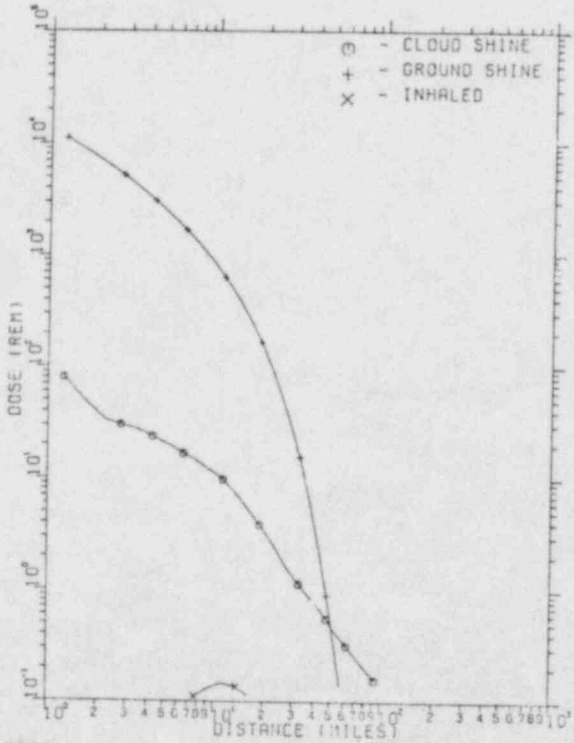
PWR #2
CASE 13

Stability Class: E
Windspeed: 2 mph

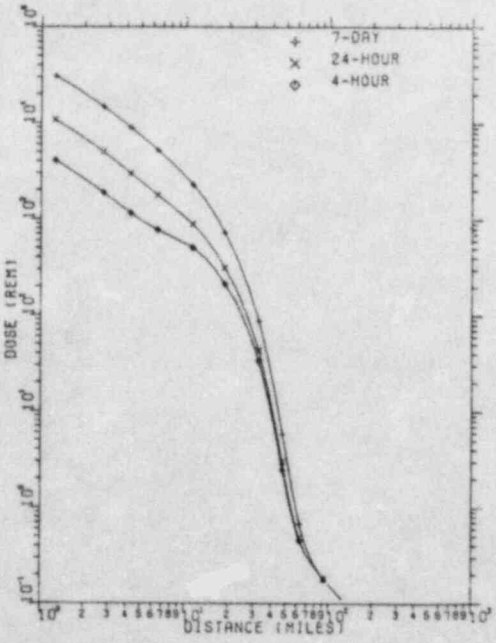
Rain: yes
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



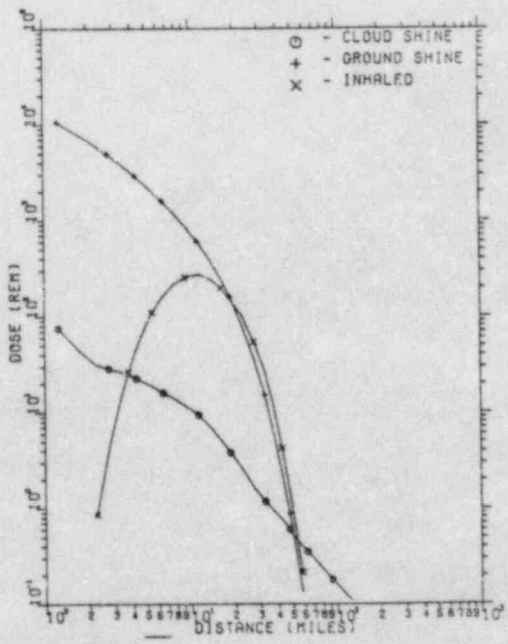


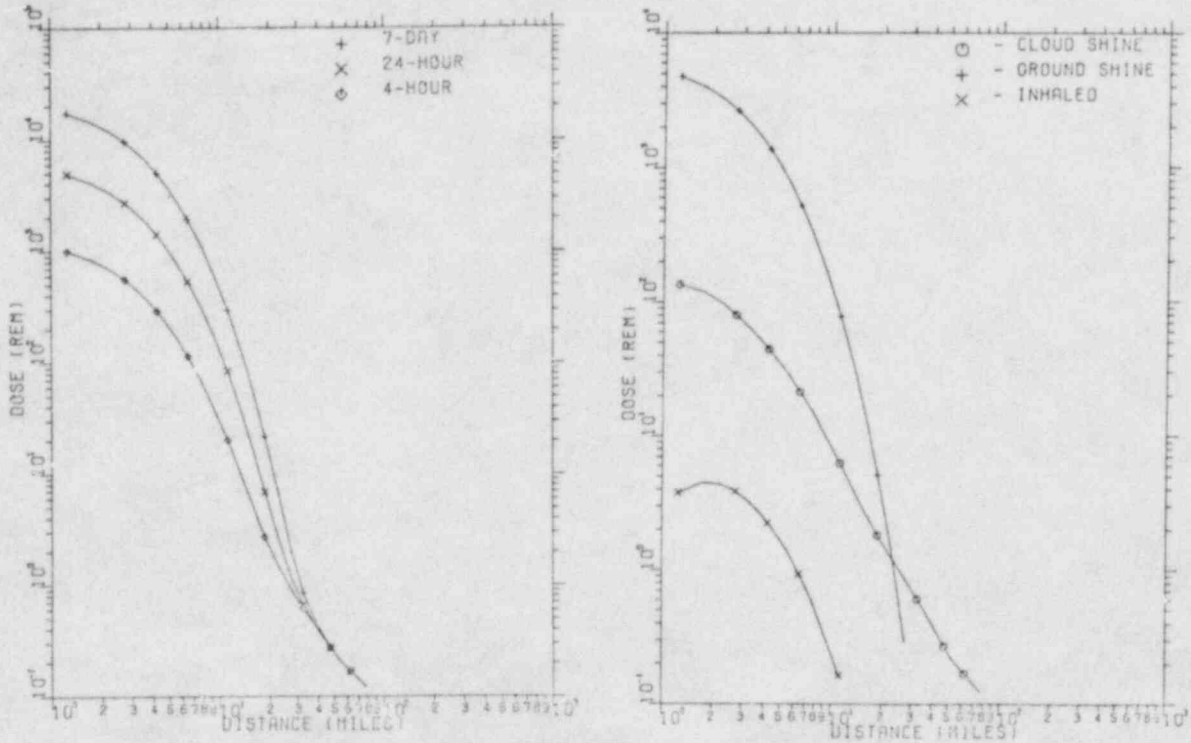
Figure 2-13

PWR #3
CASE 13

Stability Class: E
Windspeed: 2 mph

Rain: yes
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

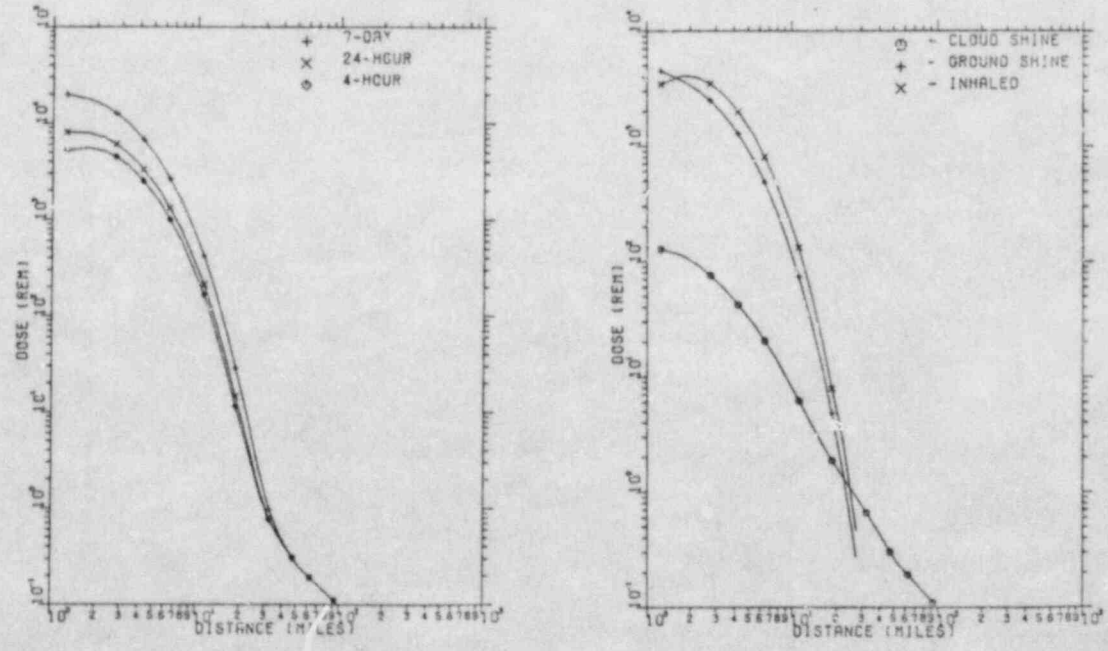


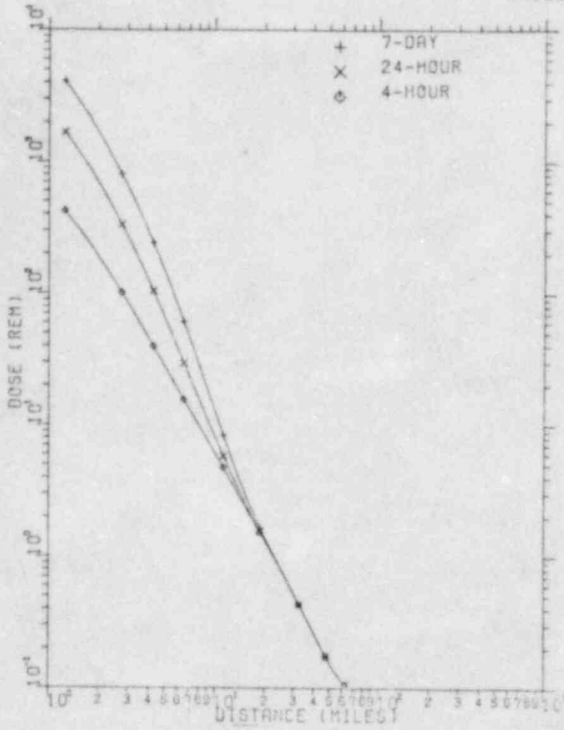
Figure 3-13

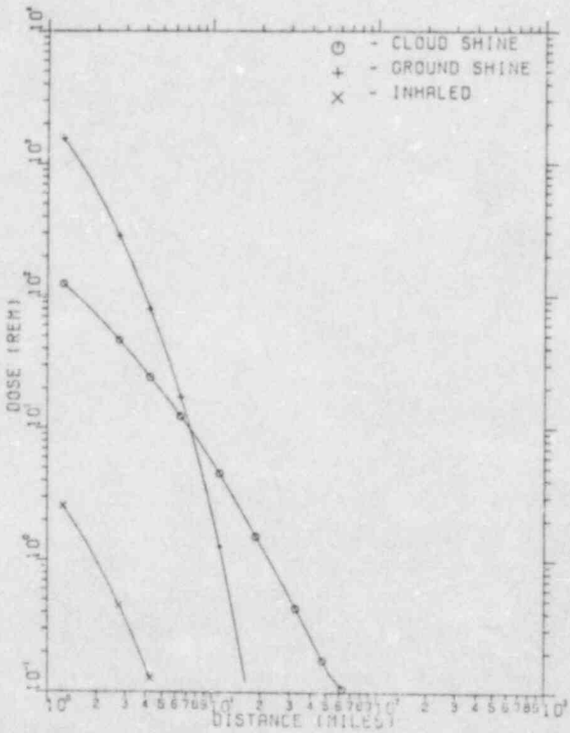
PWR #4
CASE 13

Stability Class: E
Windspeed: 2 mph

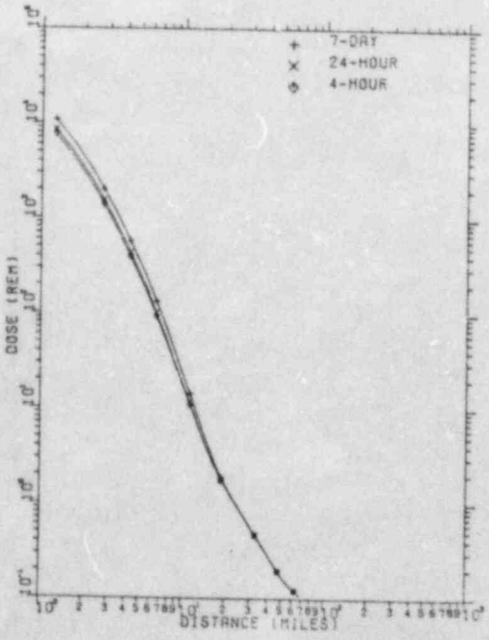
Rain: yes
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



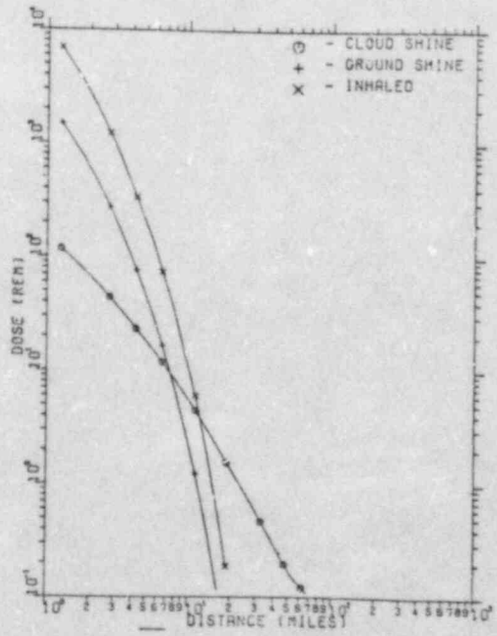


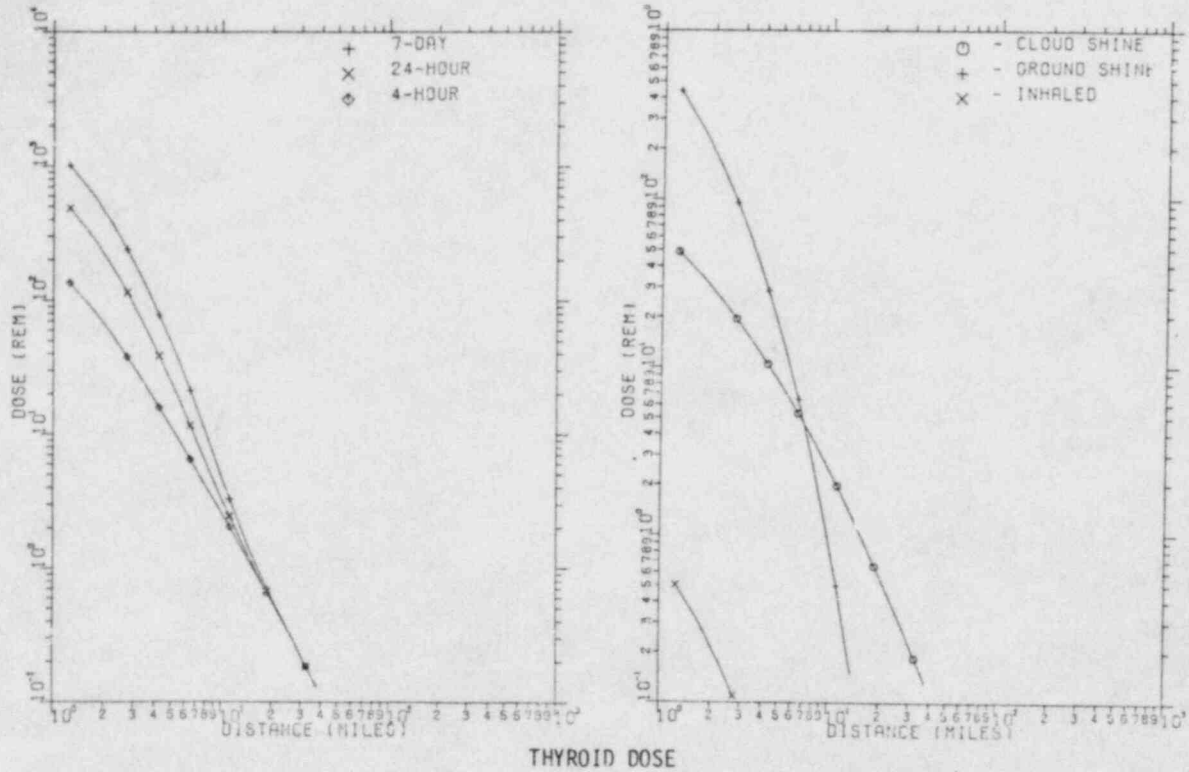
Figure 4-13

PWR #5
CASE T3

Stability Class: E
Windspeed: 2 mph

Rain: yes
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

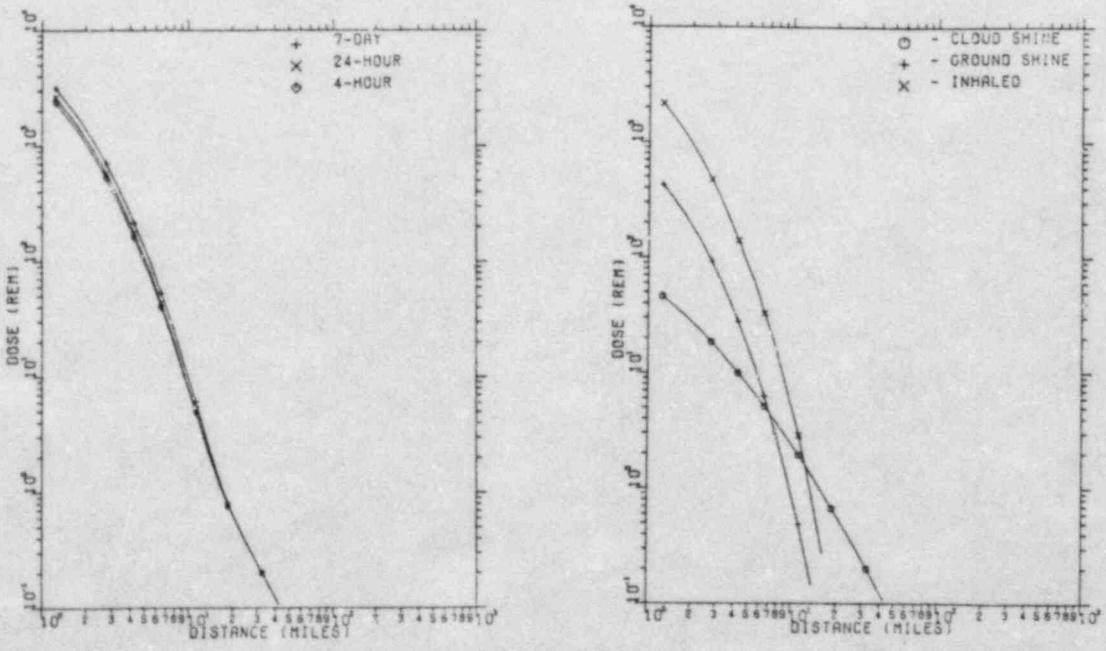


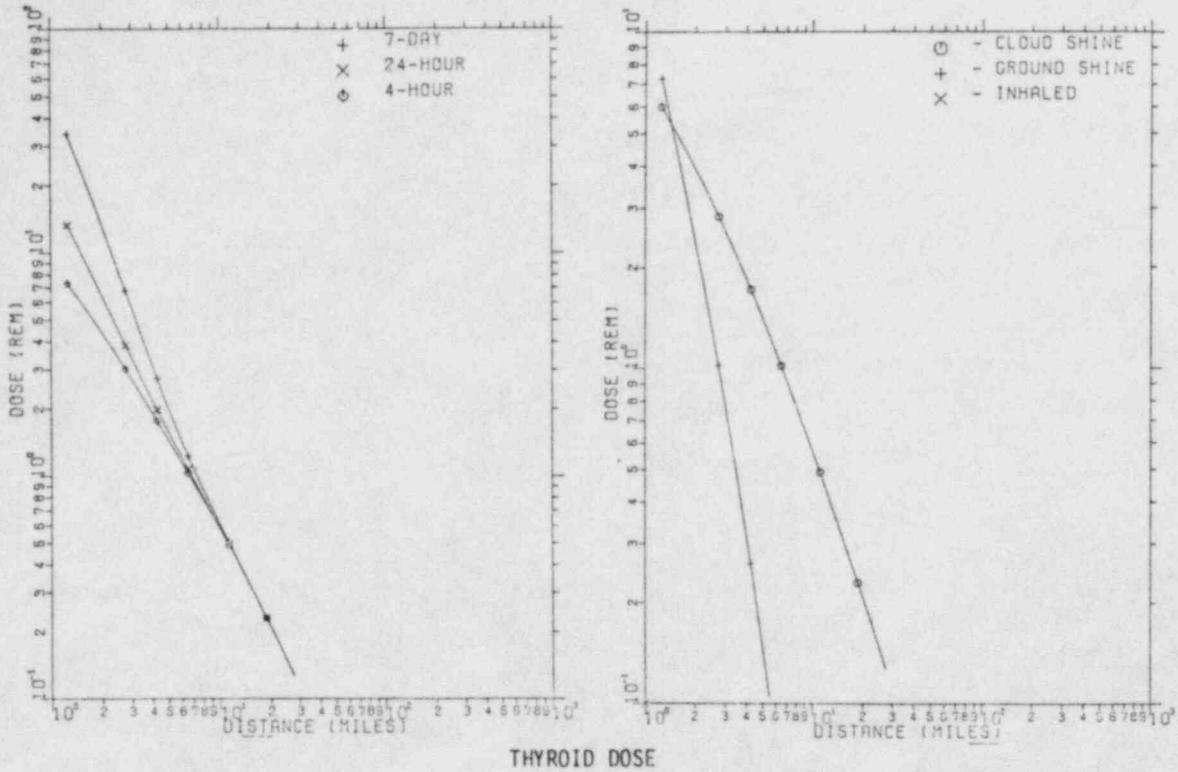
Figure 5-13

PWR # 6
CASE 13

Stability Class: E
Windspeed: 2 mph

Rain: yes
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

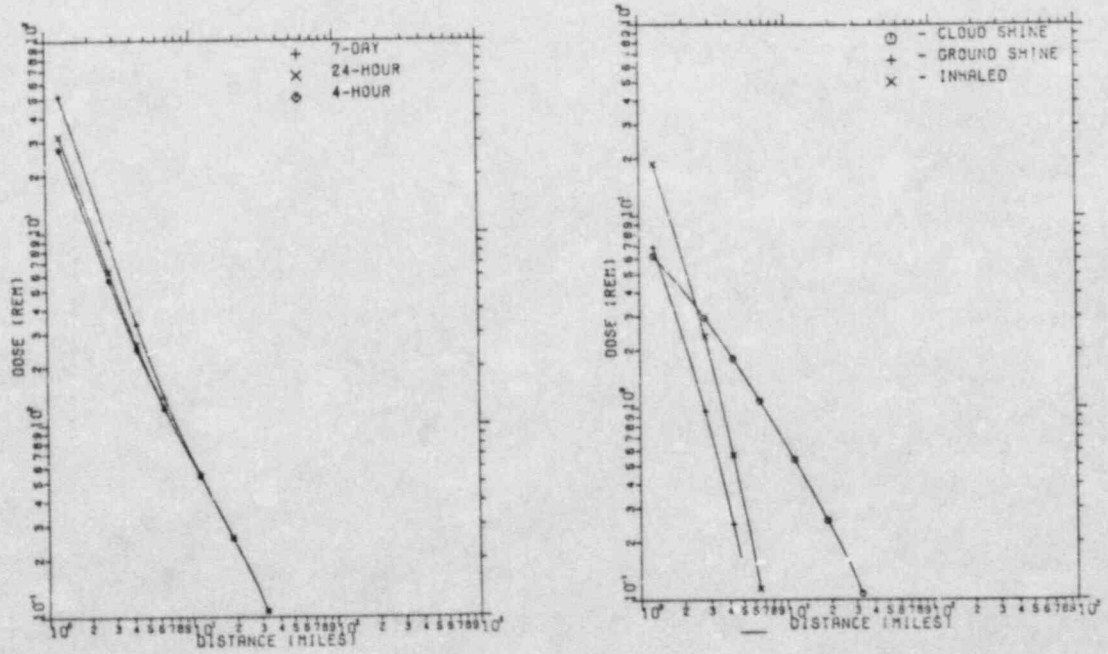


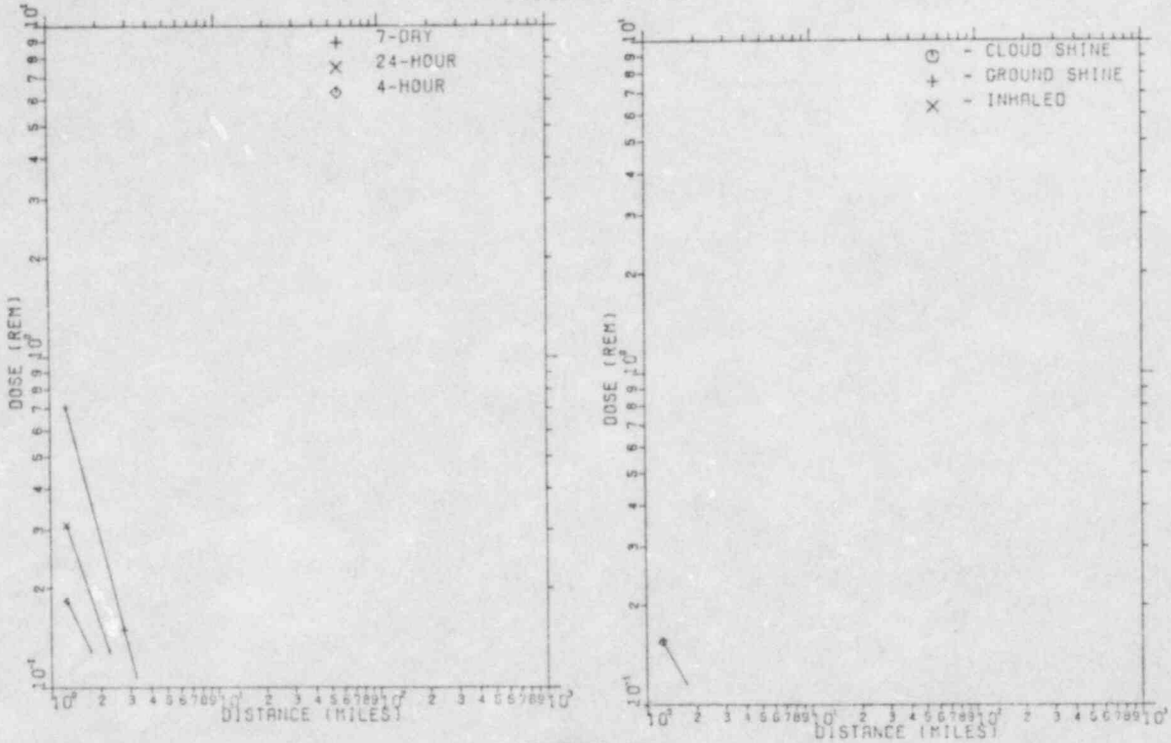
Figure 6-13

PWR #7
CASE 13

Stability Class: E
Windspeed: 2 mph

Rain: yes
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

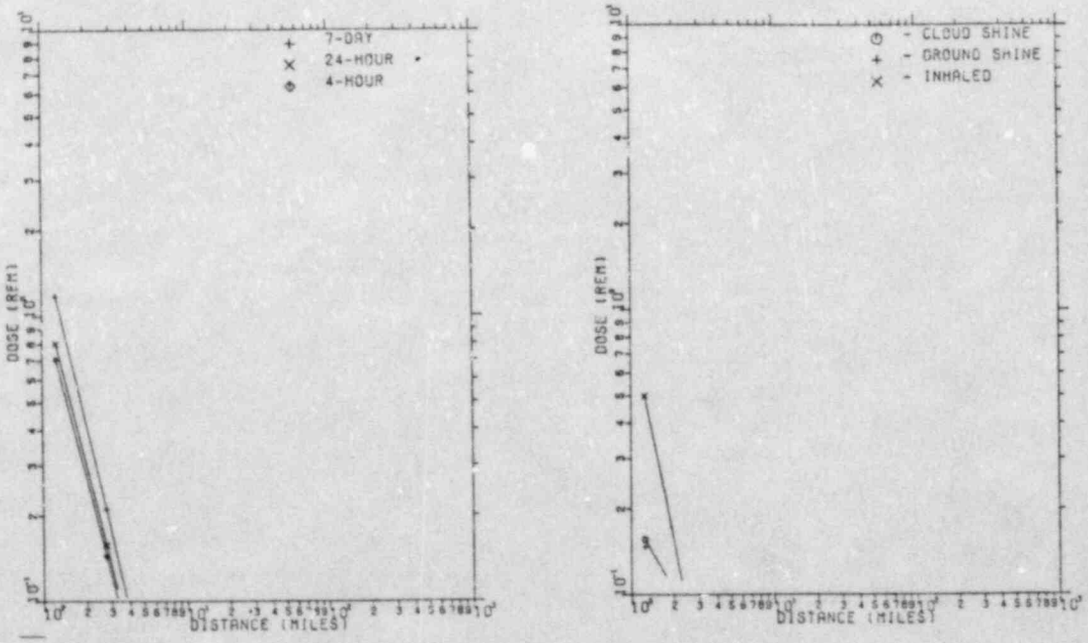


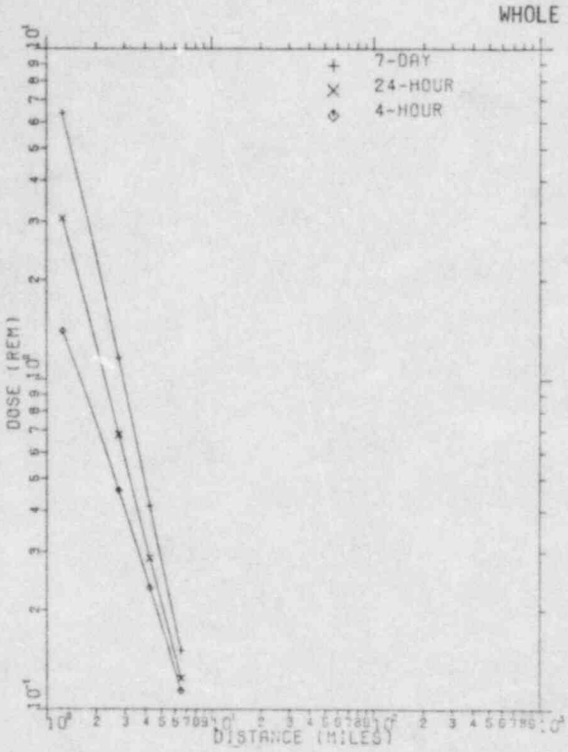
Figure 7-13

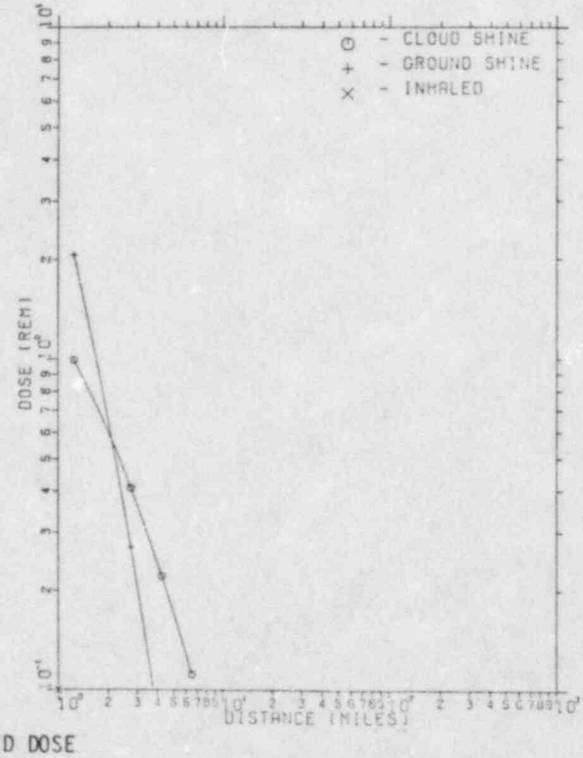
PWR #8
CASE 13

Stability Class: E
Windspeed: 2 mph

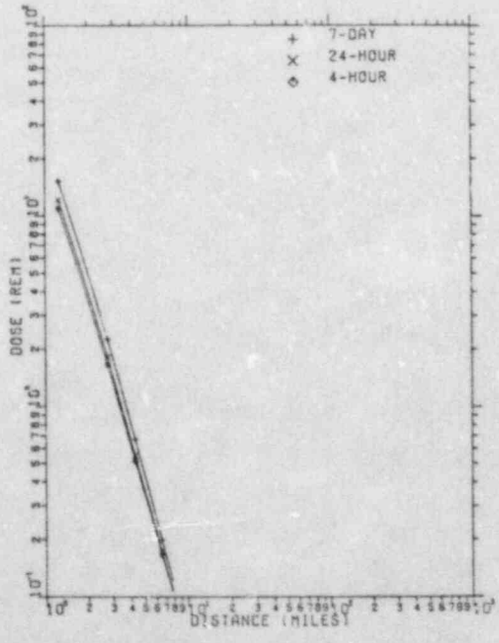
Rain: yes
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



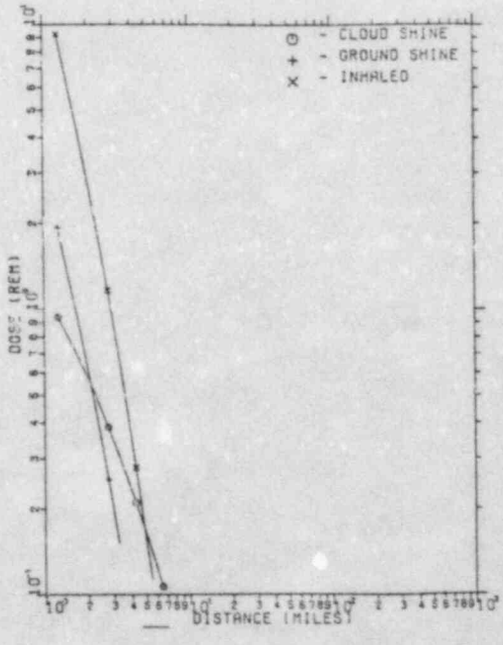


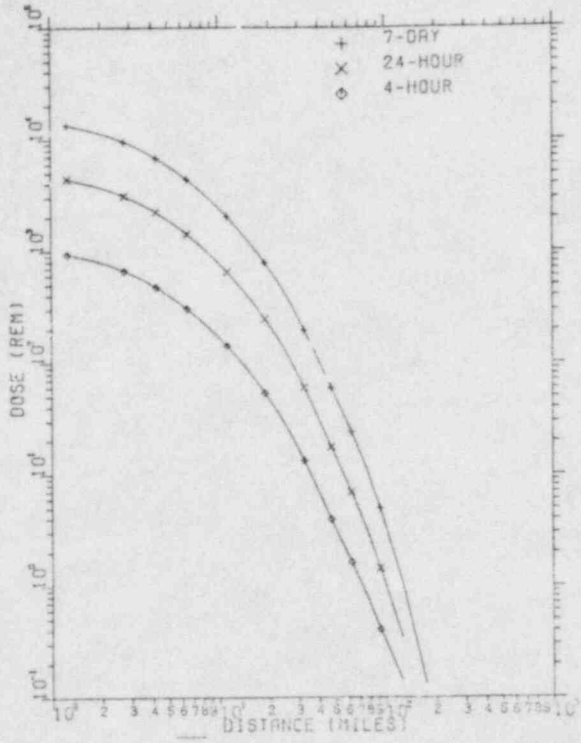
Figure 8-13

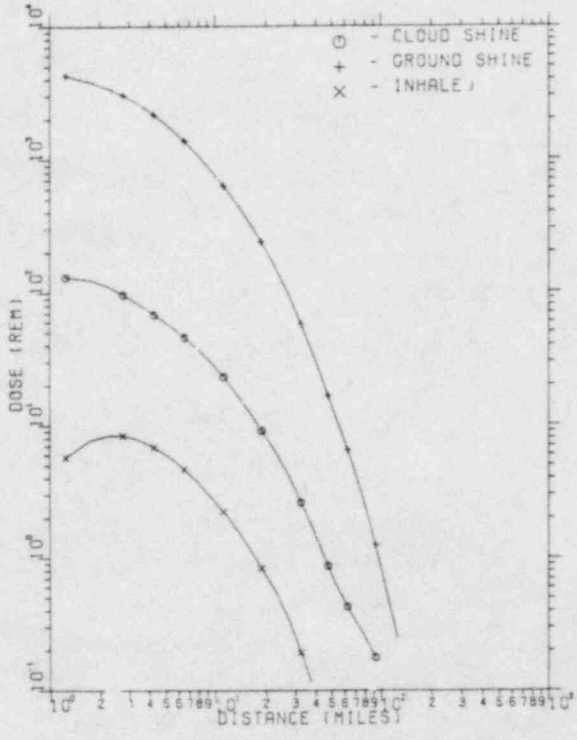
PWR #1A
CASE 14

Stability Class: E
Windspeed: 9 mph

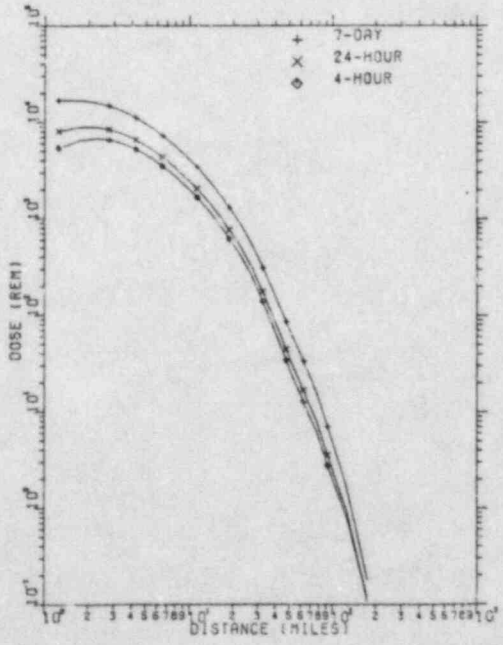
Rain: yes
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



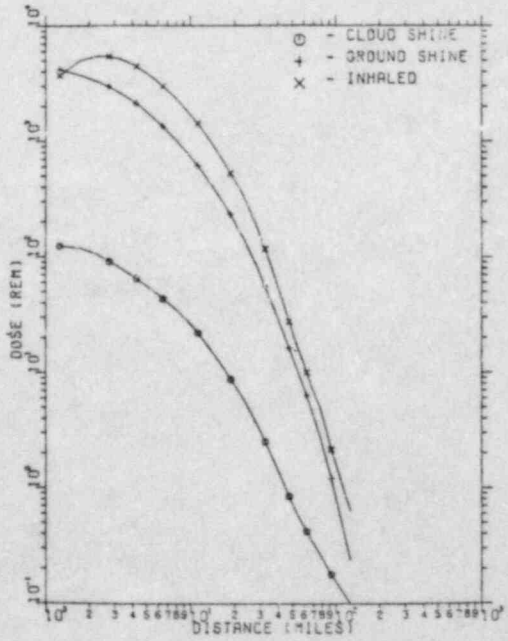


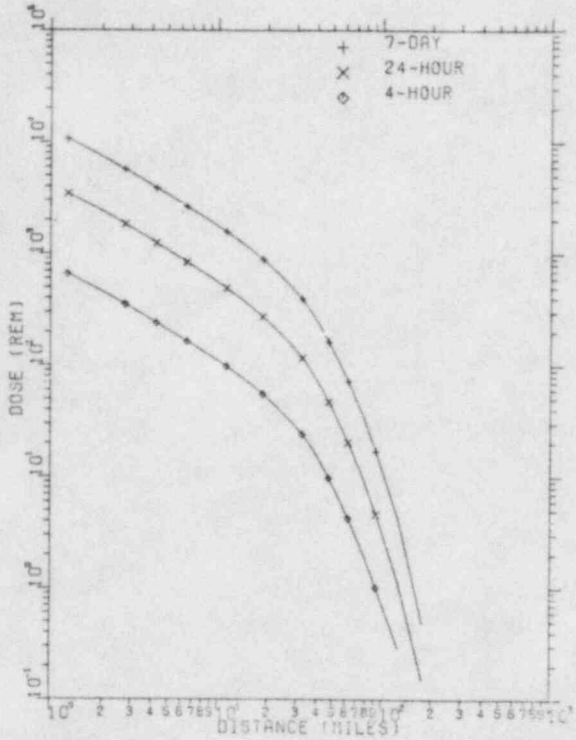
Figure 1A-14

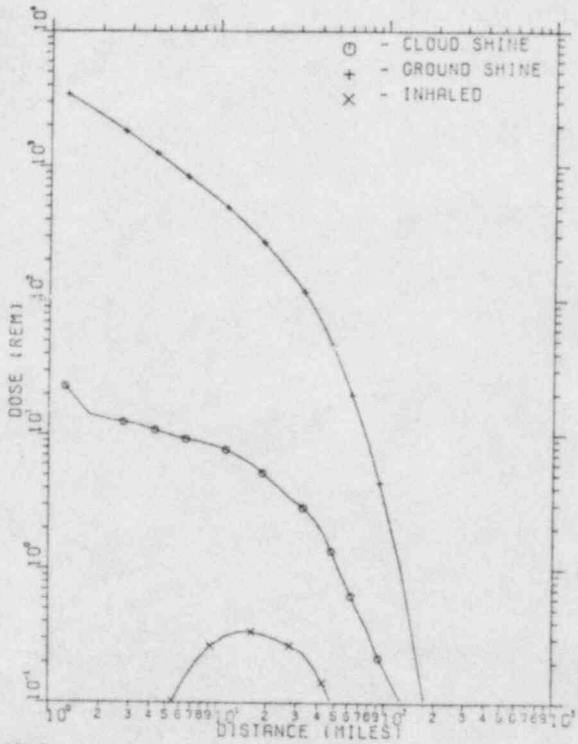
PWR #1B
CASE 14

Stability Class: E
Windspeed: 9 mph

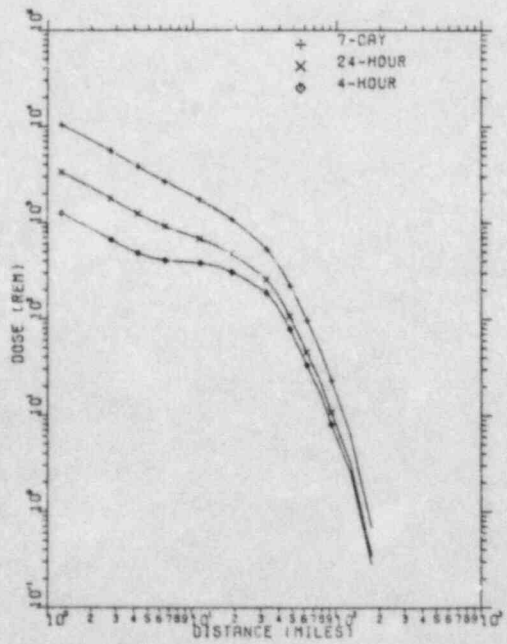
Rain: yes
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



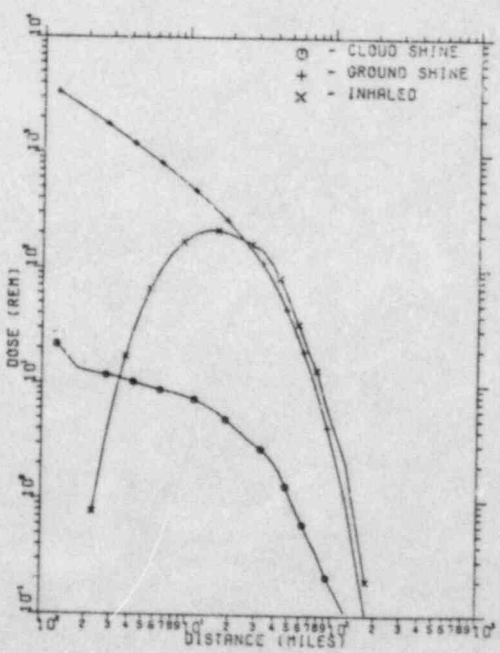


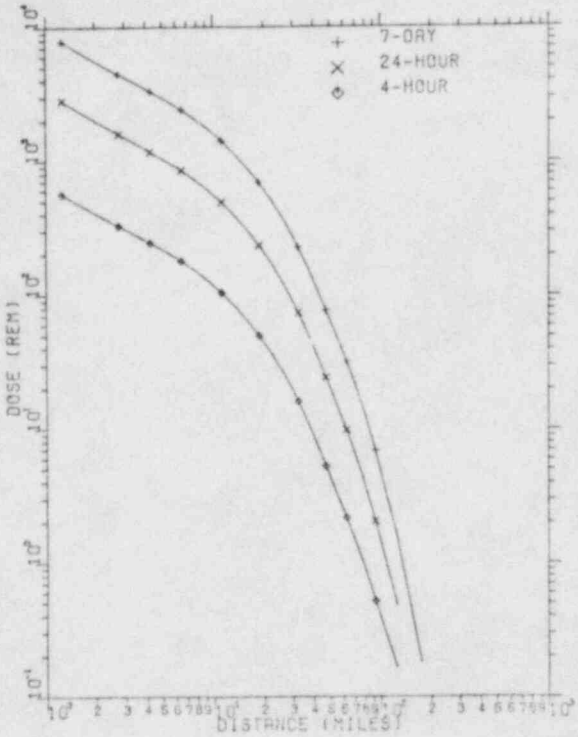
Figure 1B-14

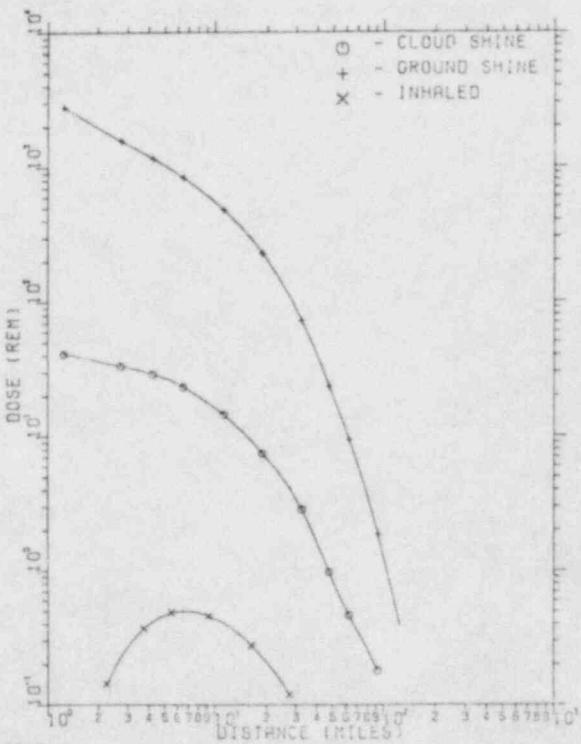
PWR #2
CASE 14

Stability Class: E
Windspeed: 9 mph

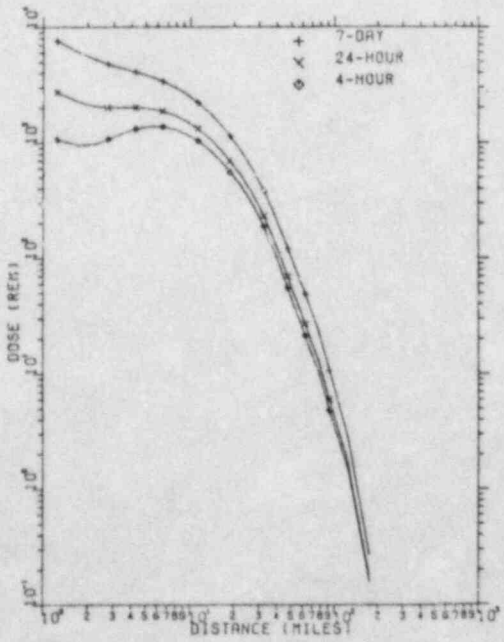
Rain: yes
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



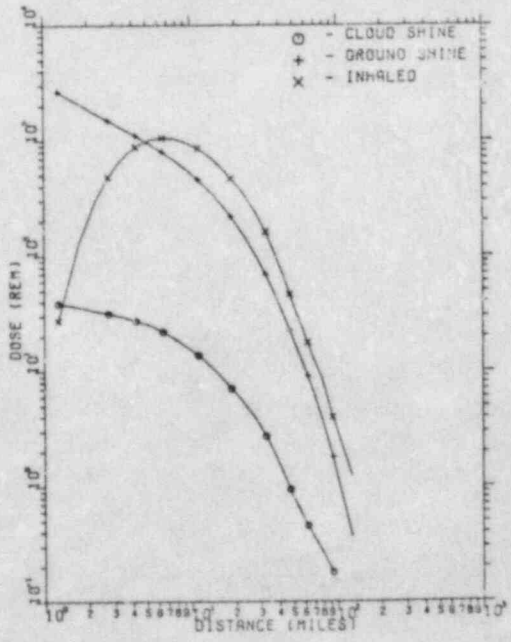


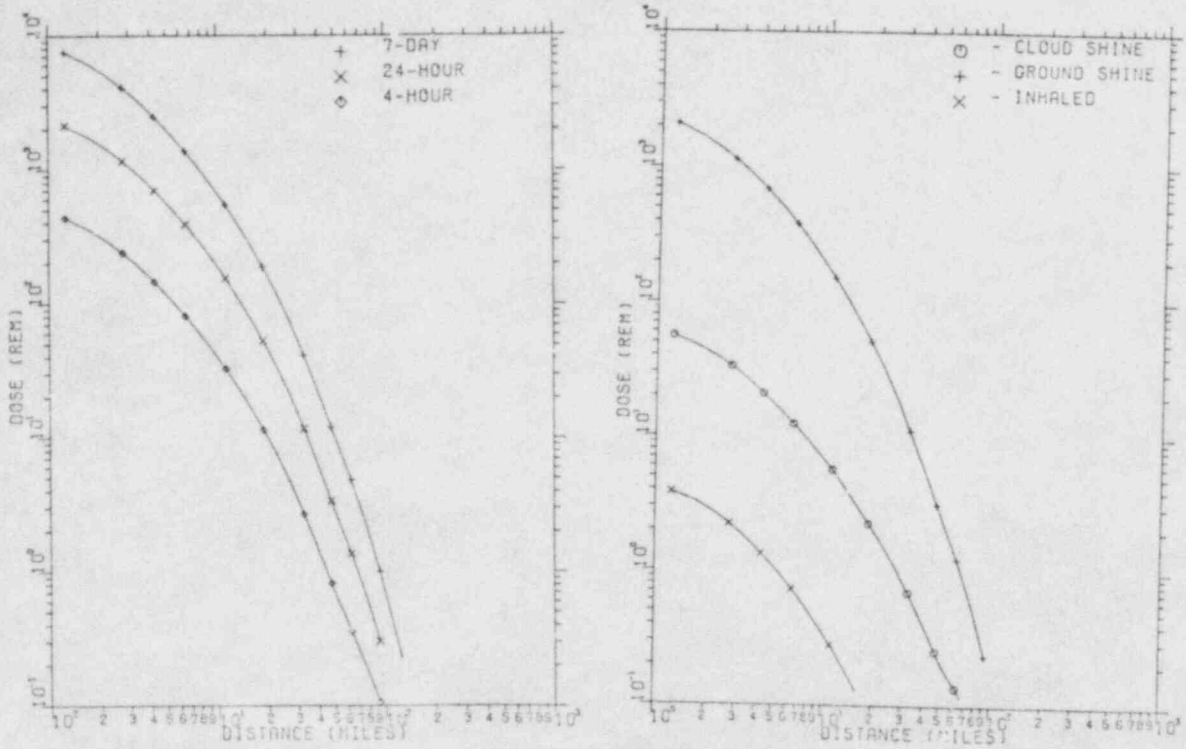
Figure 2-14

PWR # 3
CASE 14

Stability Class: E
Windspeed: 9 mph

Rain: yes
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

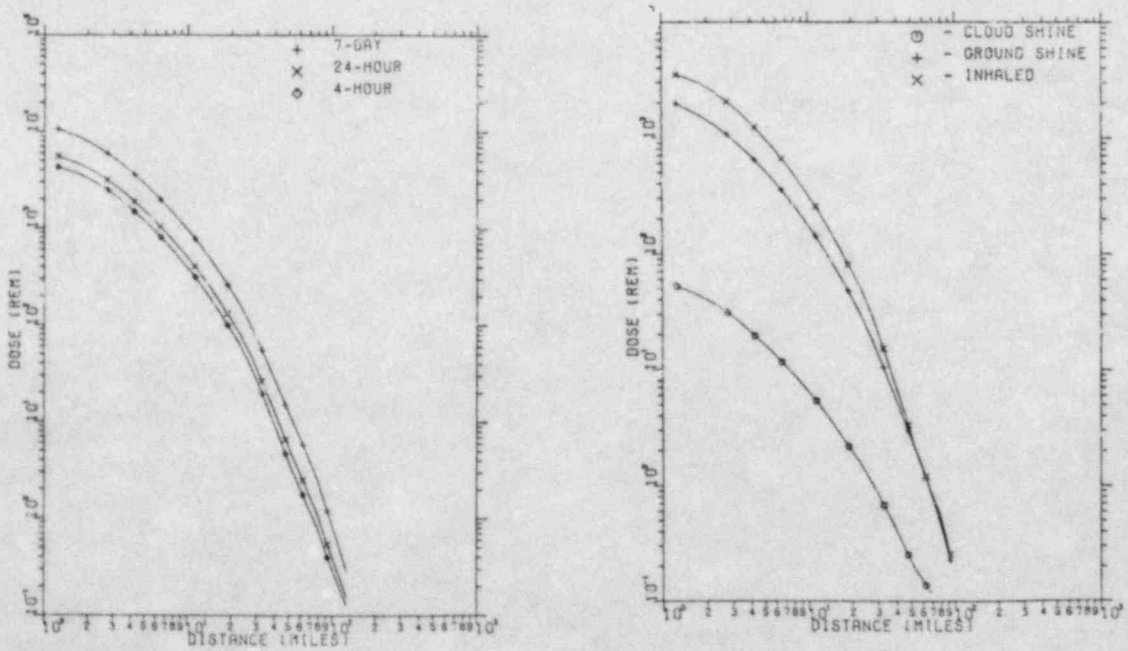


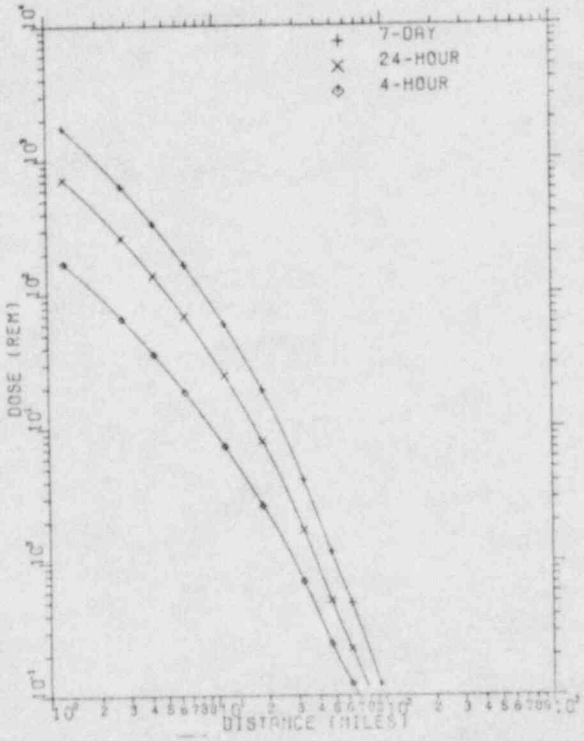
Figure 3-14

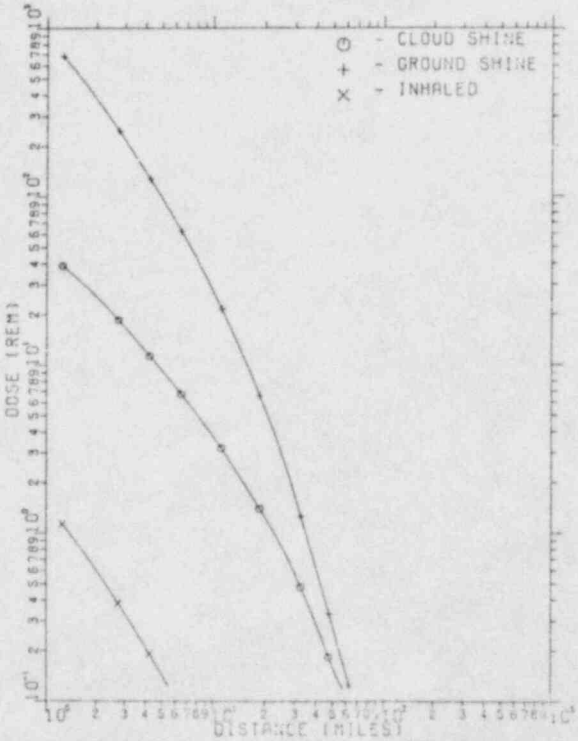
PWR # 4
CASE 14

Stability Class: E
Windspeed: 9 mph

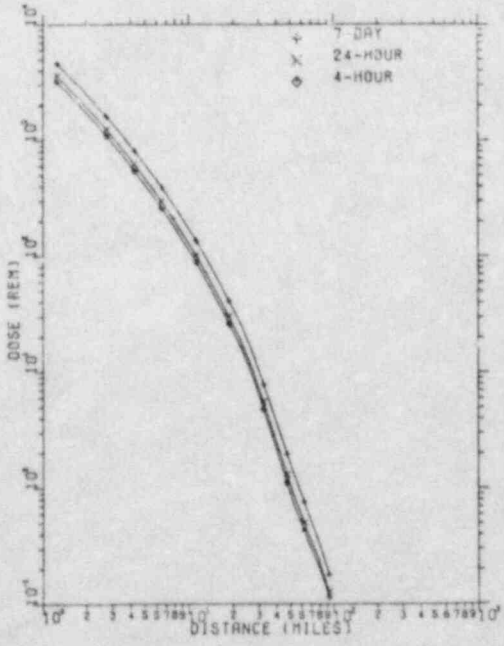
Rain: yes
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



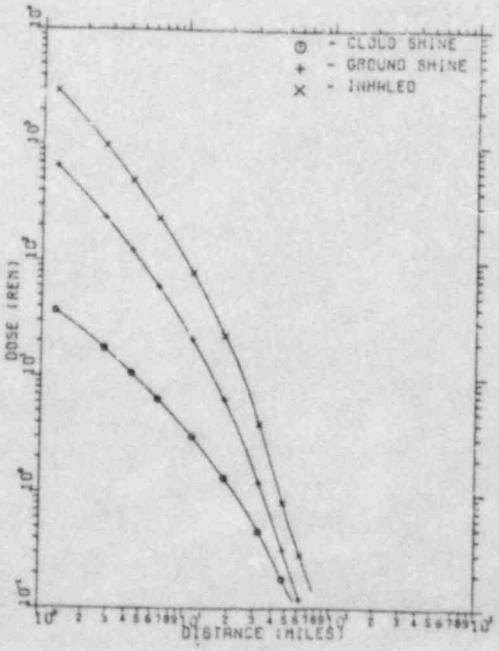


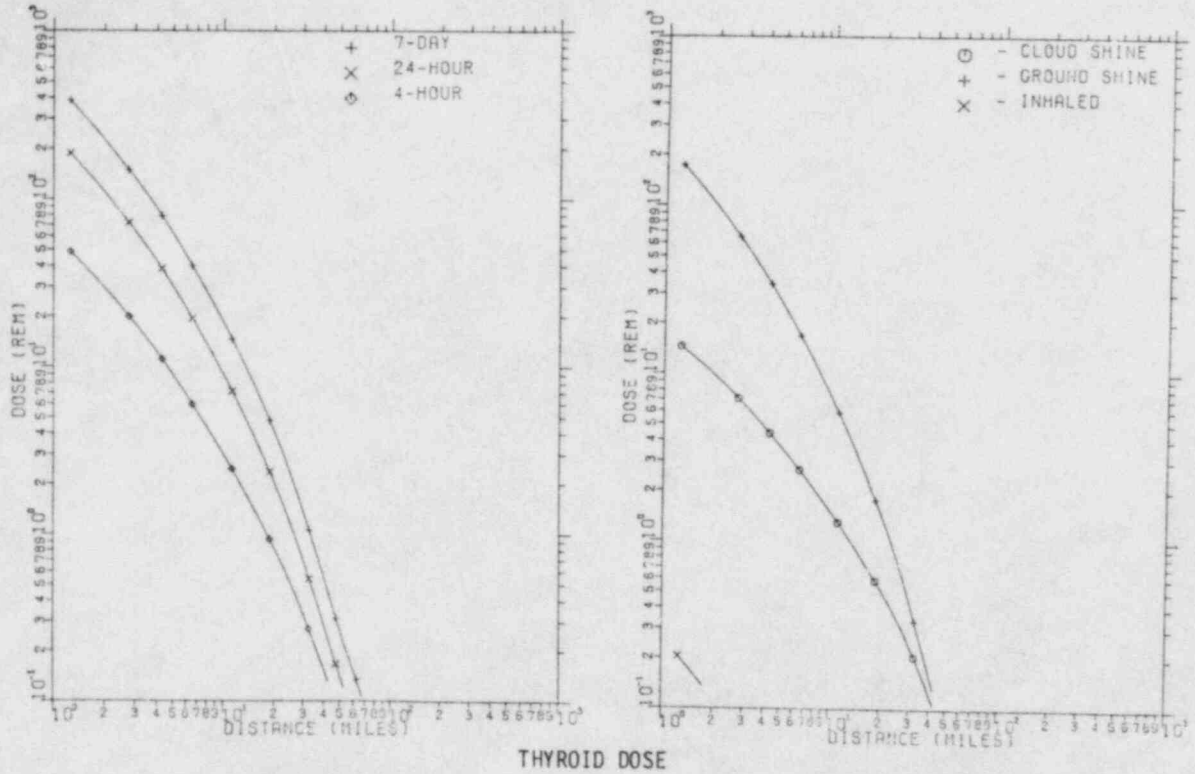
Figure 4-14

PWR #5
CASE T4

Stability Class: E
Windspeed: 9 mph

Rain: yes
Sheltering: None

WHOLE BODY DOSE



THYROID DOSE

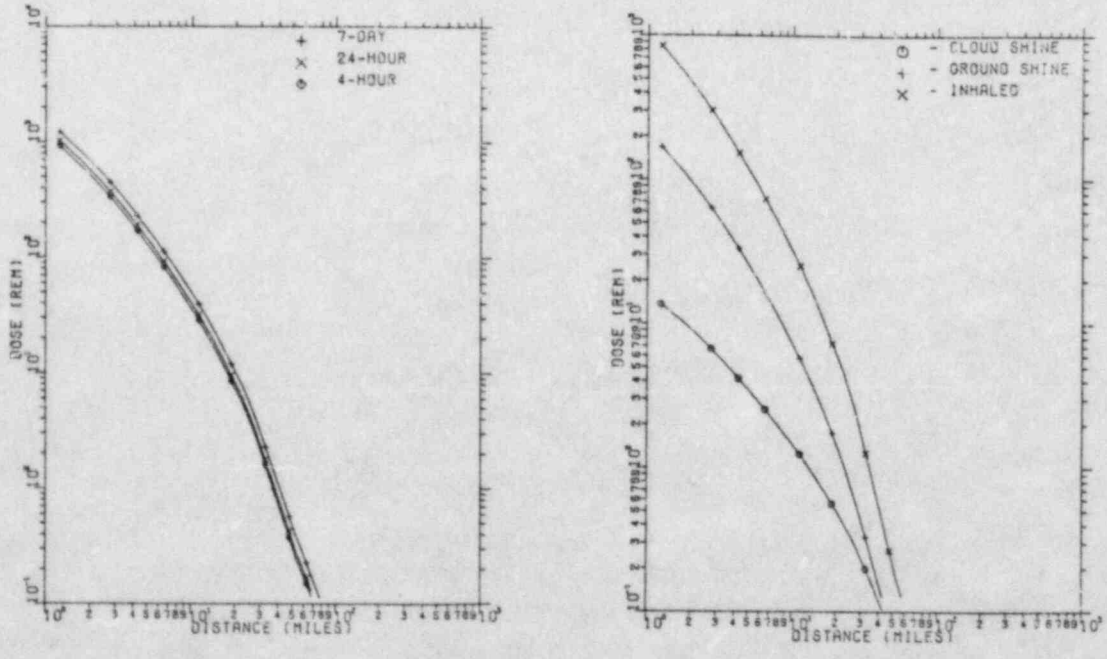


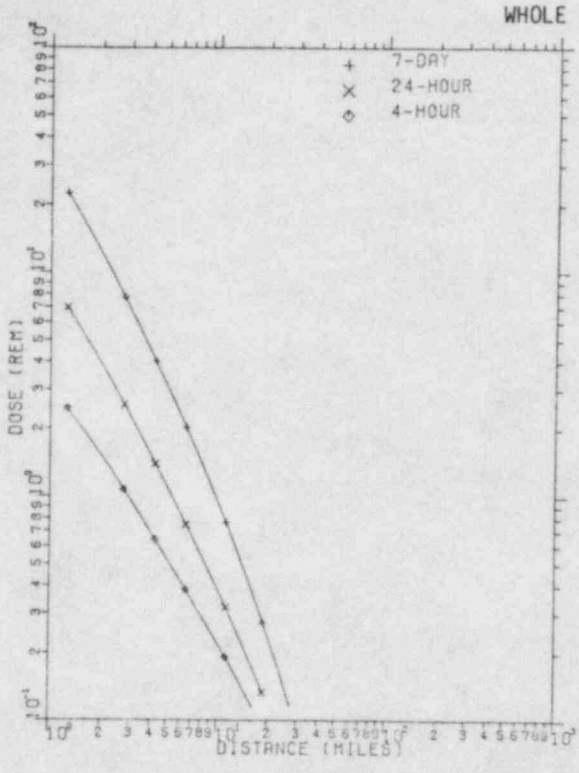
Figure 5-14

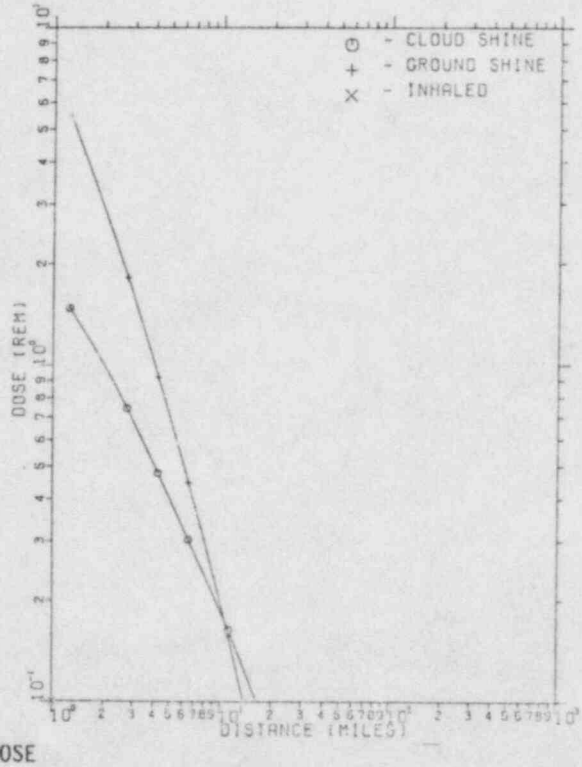
PWR #6
CASE 14

Stability Class: E
Windspeed: 9 mph

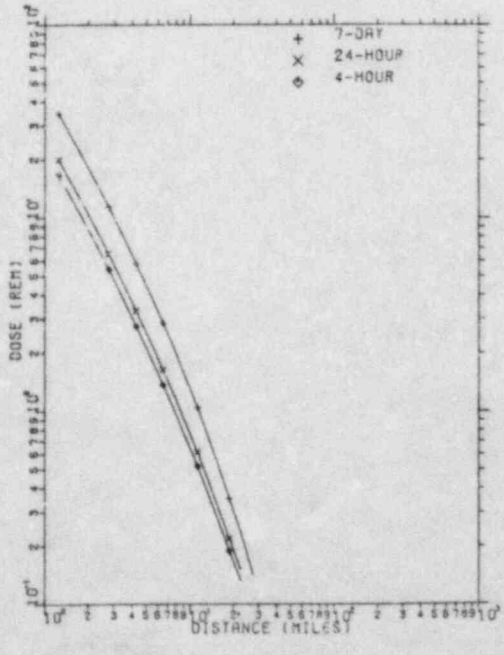
Rain: yes
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



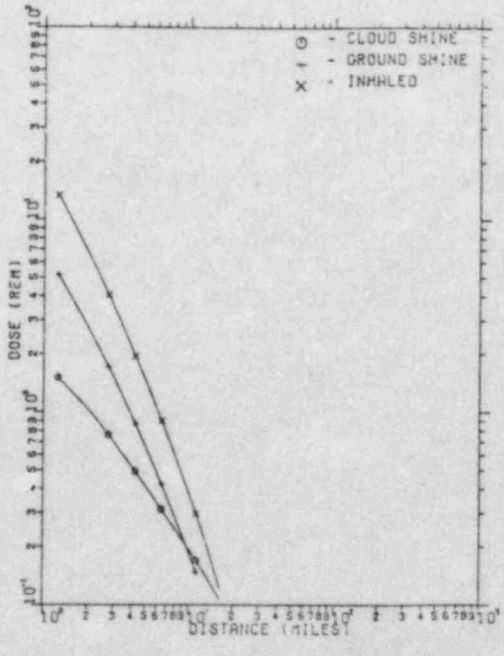


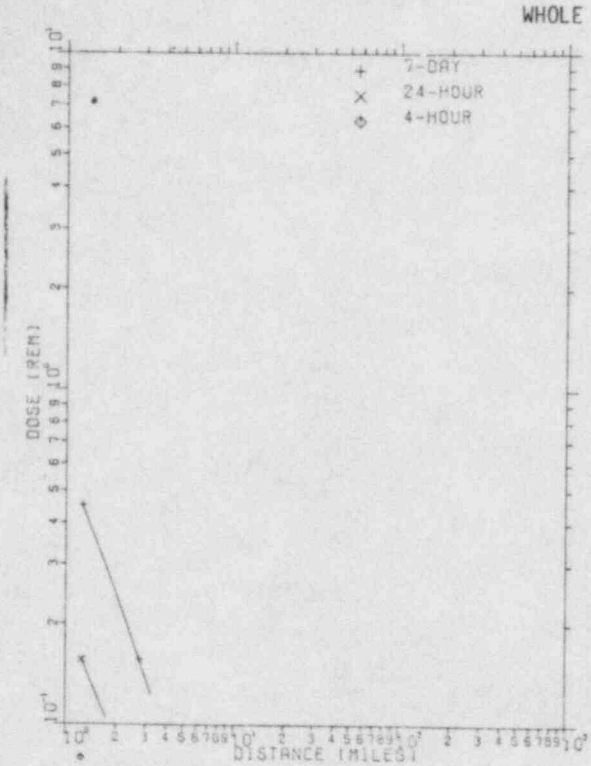
Figure 6-14

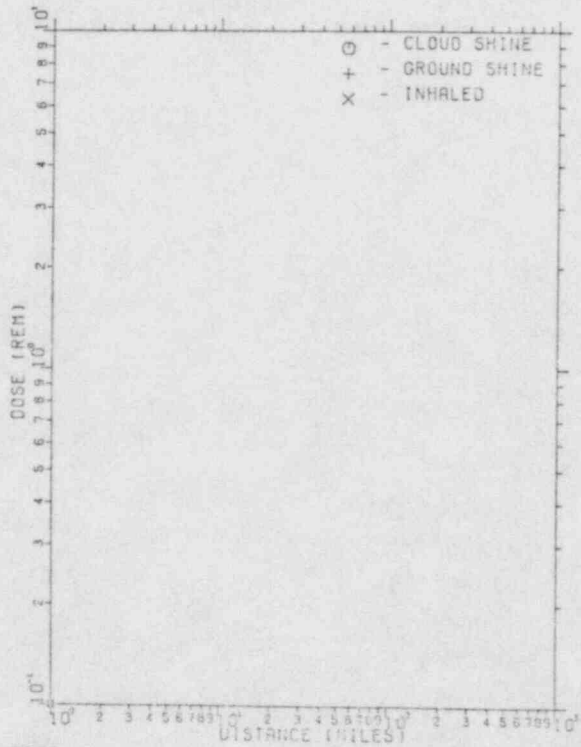
PWR #7
CASE 14

Stability Class: E
Windspeed: 9 mph

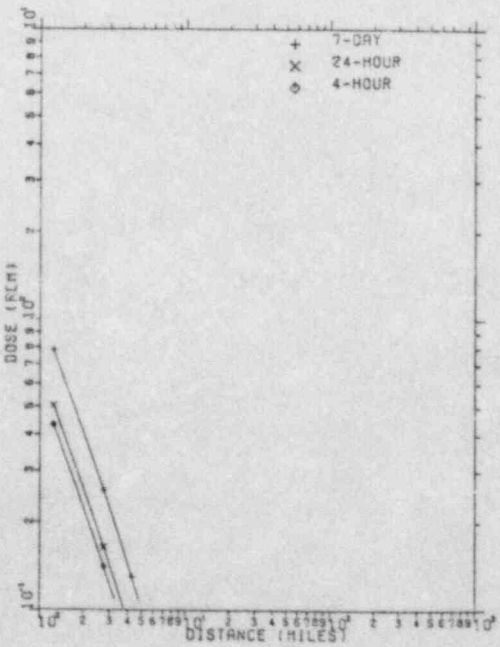
Rain: yes
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



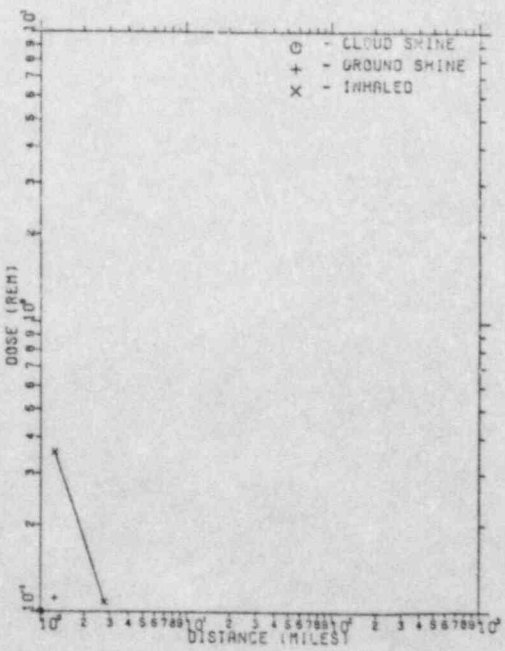


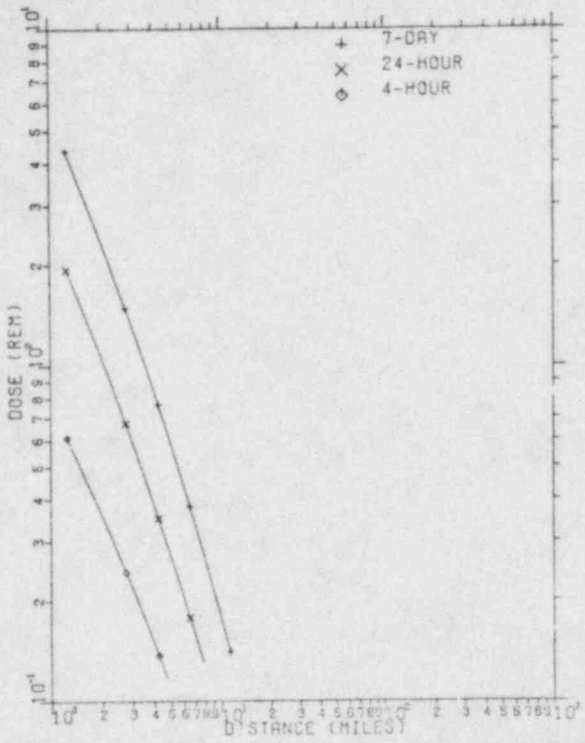
Figure 7-14

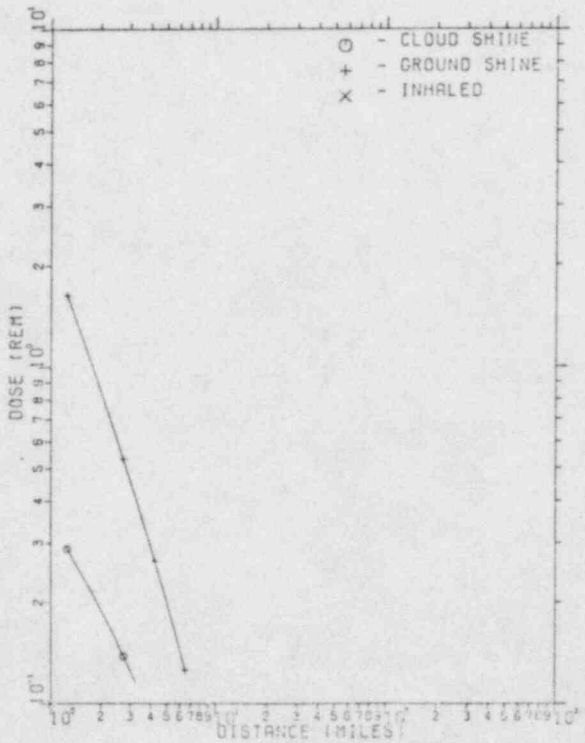
PWR #8
CASE 14

Stability Class: E
Windspeed: 9 mph

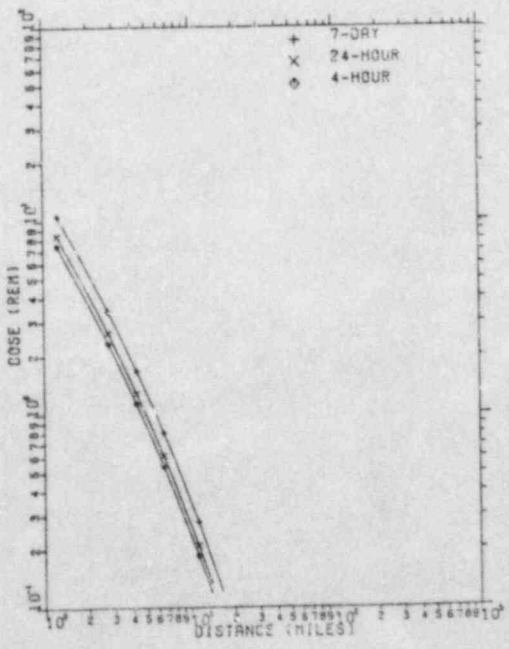
Rain: yes
Sheltering: None

WHOLE BODY DOSE





THYROID DOSE



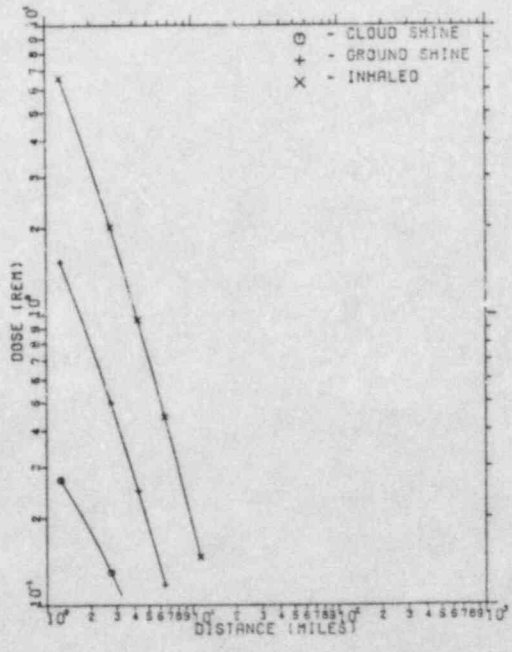


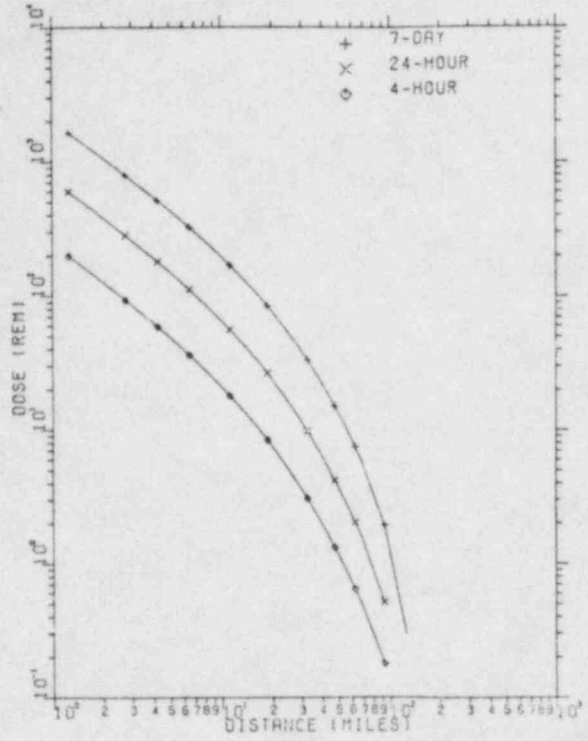
Figure 8-14

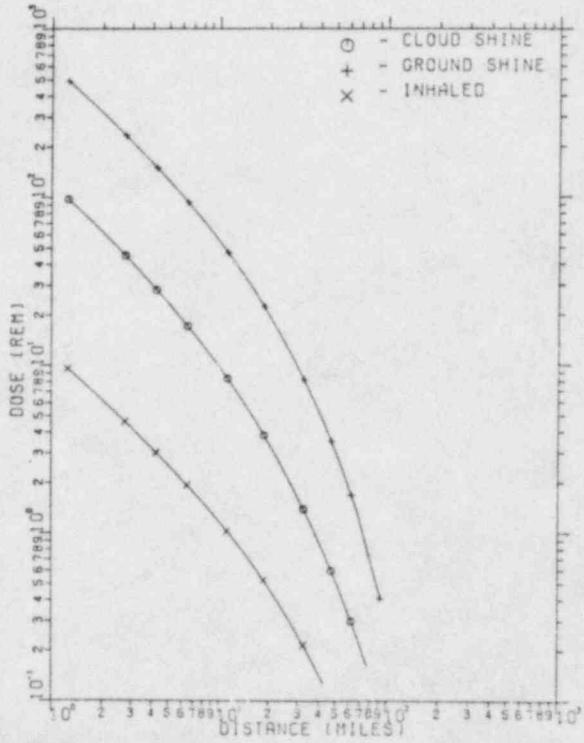
PWR #1A
CASE 15

Stability Class: A
Windspeed: 3 mph

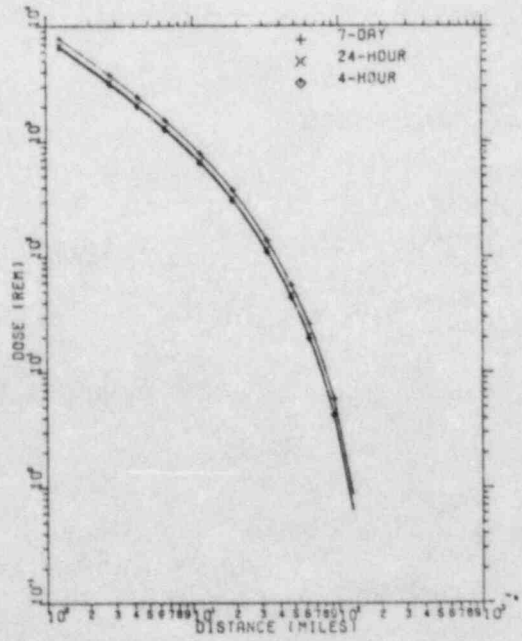
Rain: No
Sheltering: Yes

WHOLE BODY DOSE





THYROID DOSE



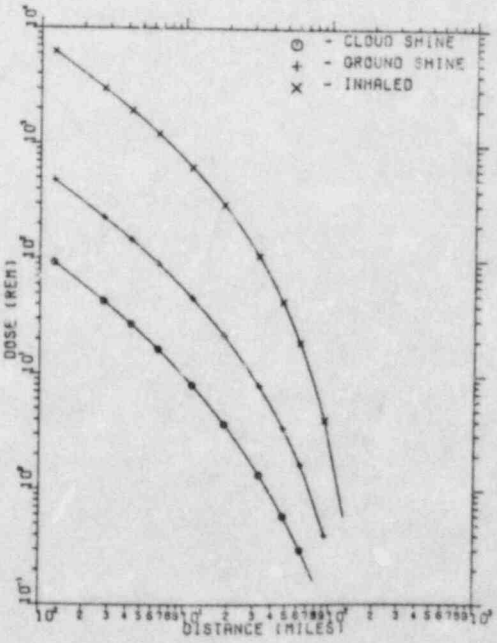


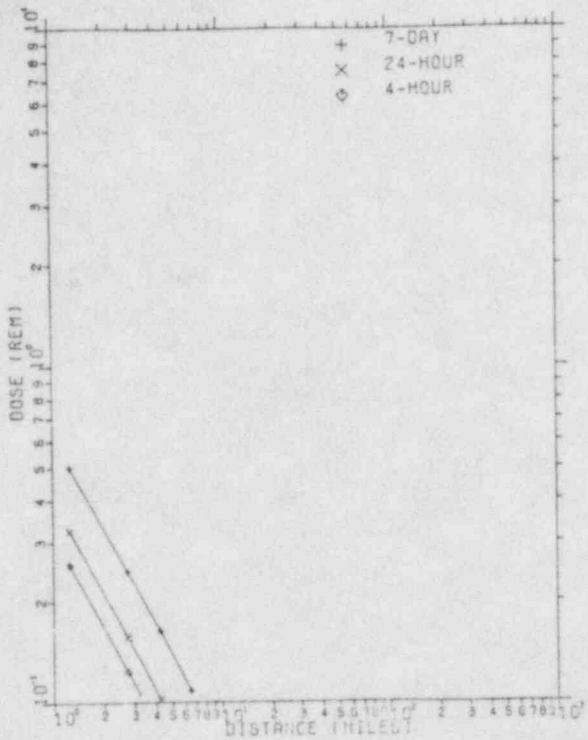
Figure 1A-15

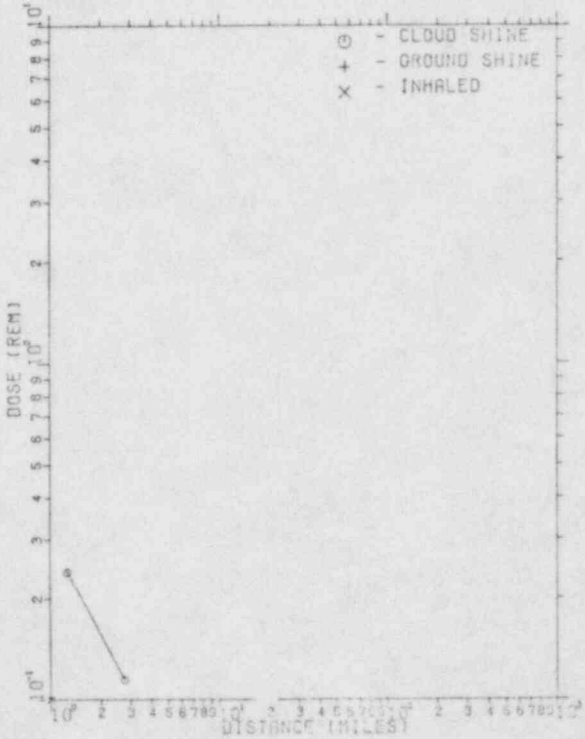
PWR #1B
CASE 15

Stability Class: A
Windspeed: 3 mph

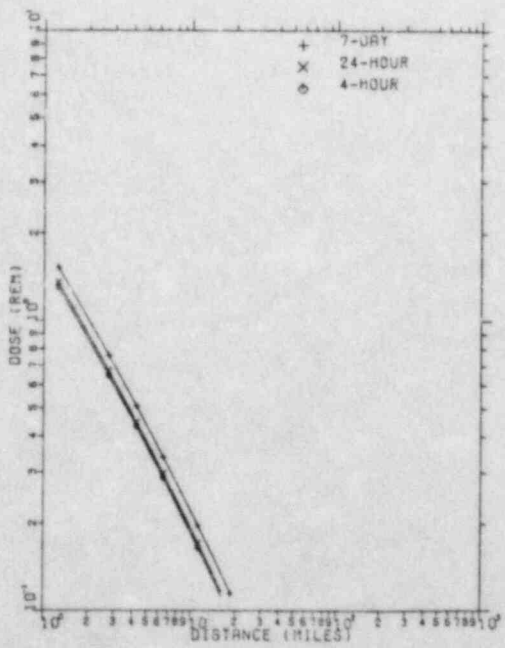
Rain: No
Sheltering: Yes

WHOLE BODY DOSE





THYROID DOSE



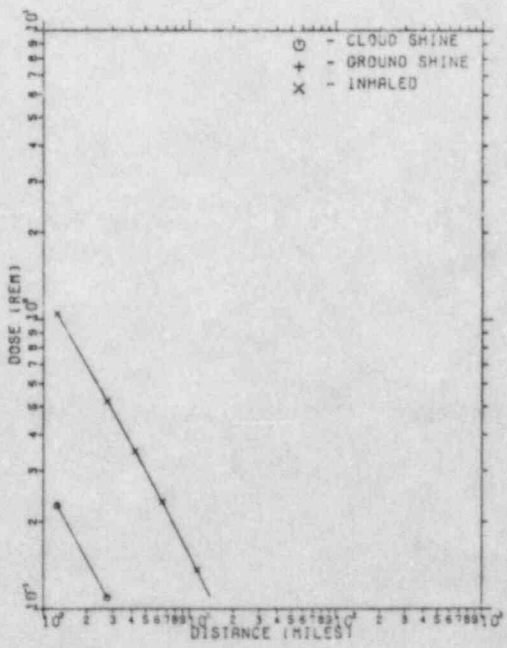


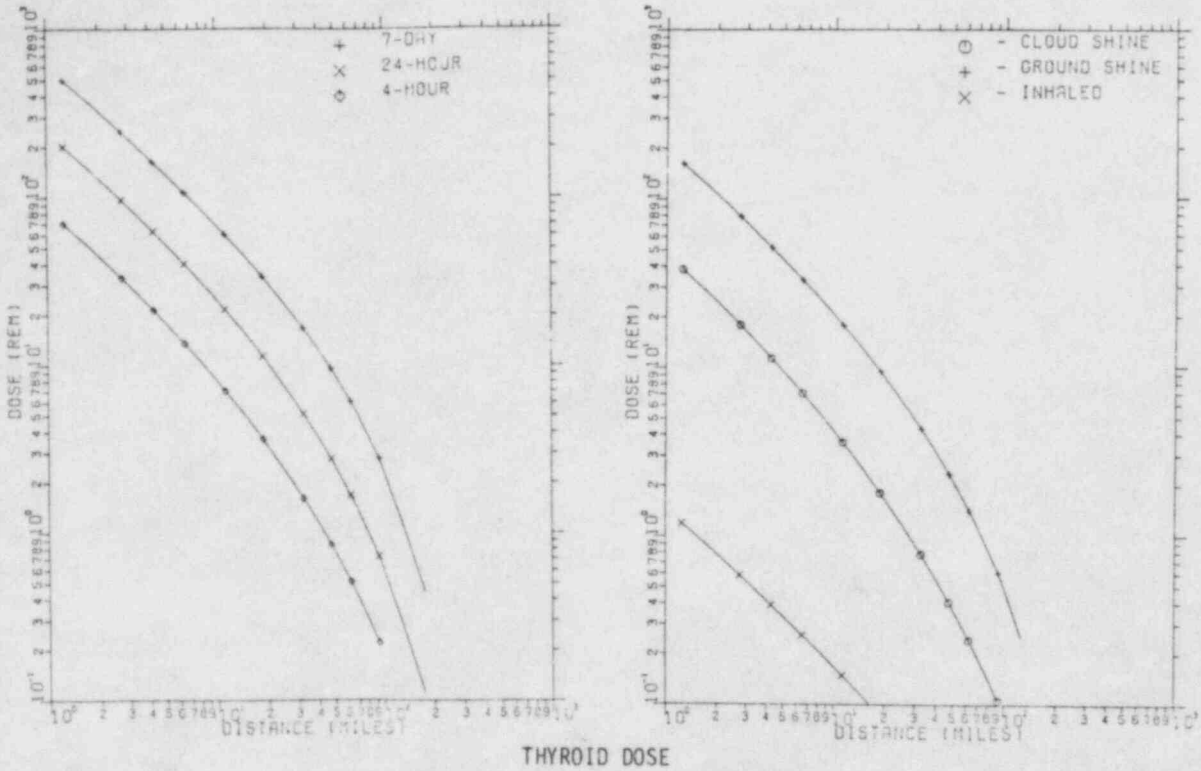
Figure 1B-15

PWR #2
CASE 15

Stability Class: A
Windspeed: 3 mph

Rain: No
Sheltering: Yes

WHOLE BODY DOSE



THYROID DOSE

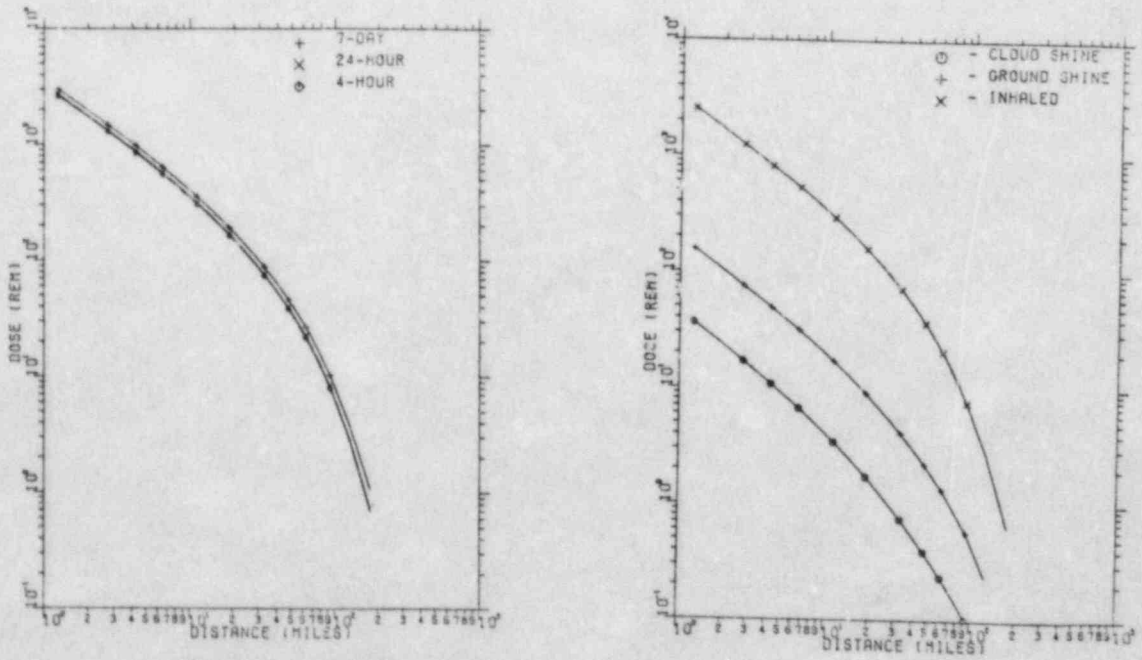


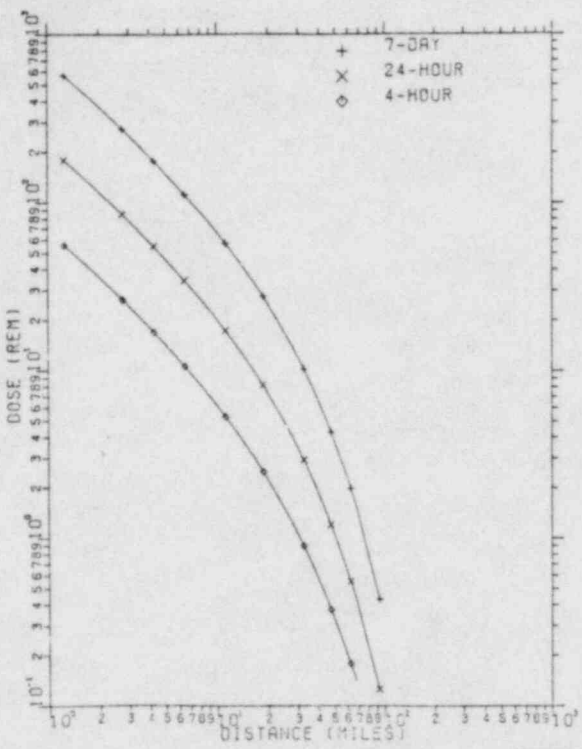
Figure 2-15

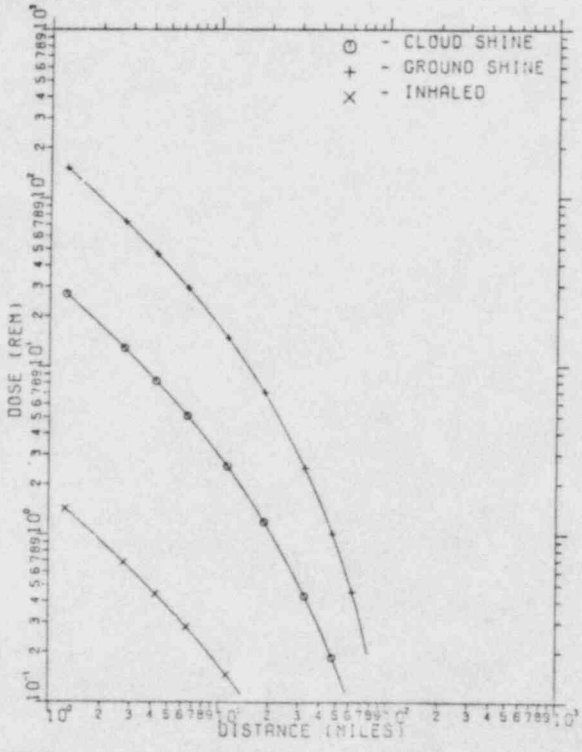
PWR #3
CASE 15

Stability Class: A
Windspeed: 3 mph

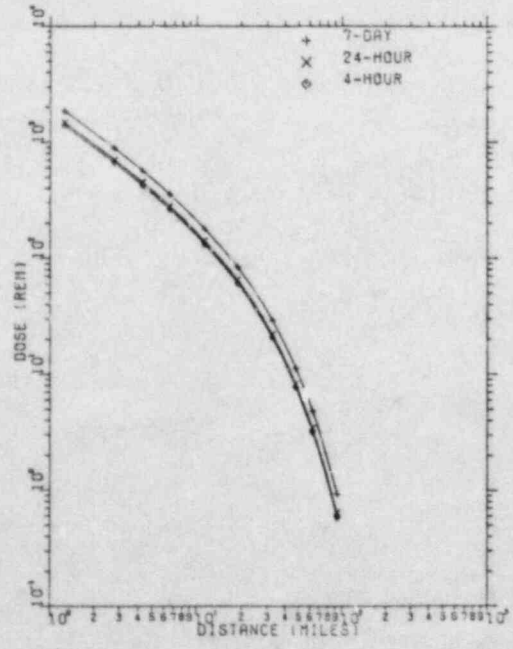
Rain: No
Sheltering: Yes

WHOLE BODY DOSE





THYROID DOSE



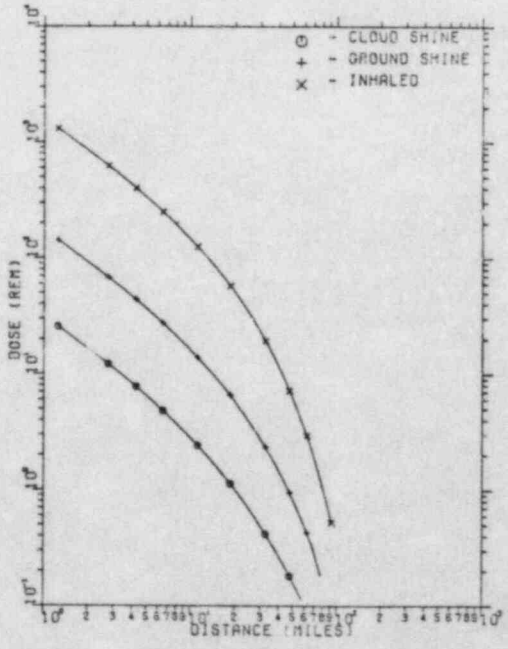


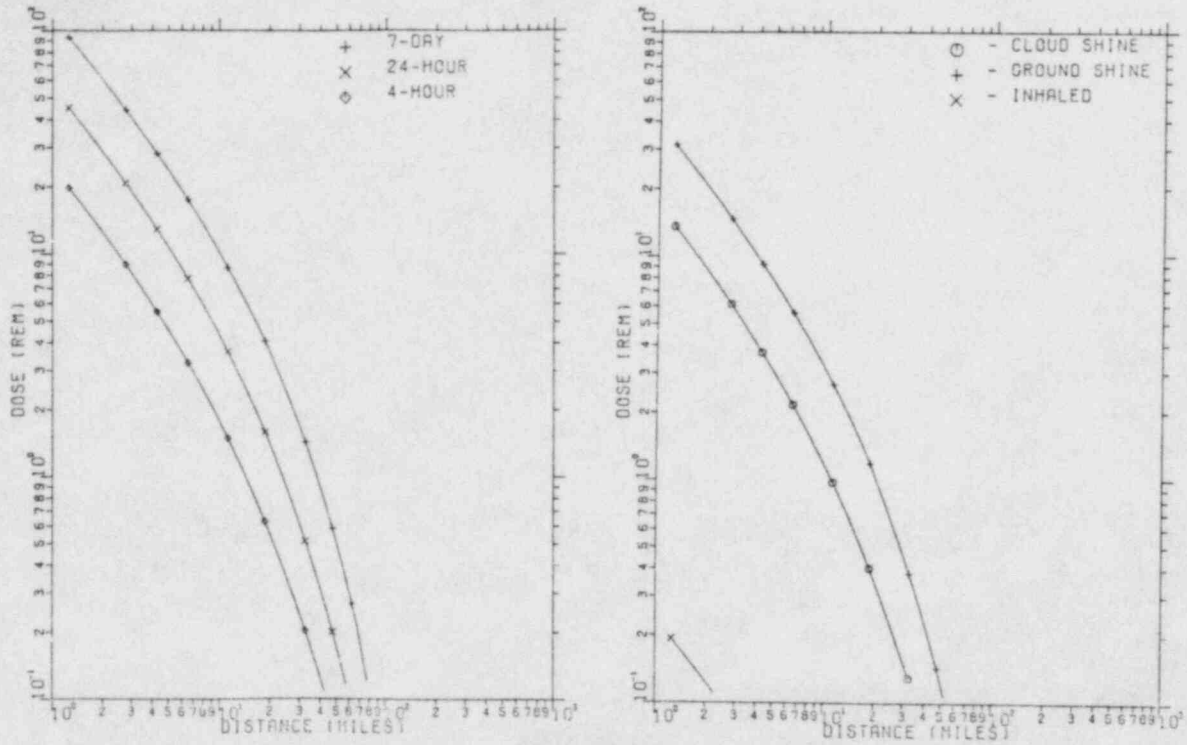
Figure 3-15

PWR #4
CASE T5

Stability Class: A
Windspeed: 3 mph

Rain: No
Sheltering: Yes

WHOLE BODY DOSE



THYROID DOSE

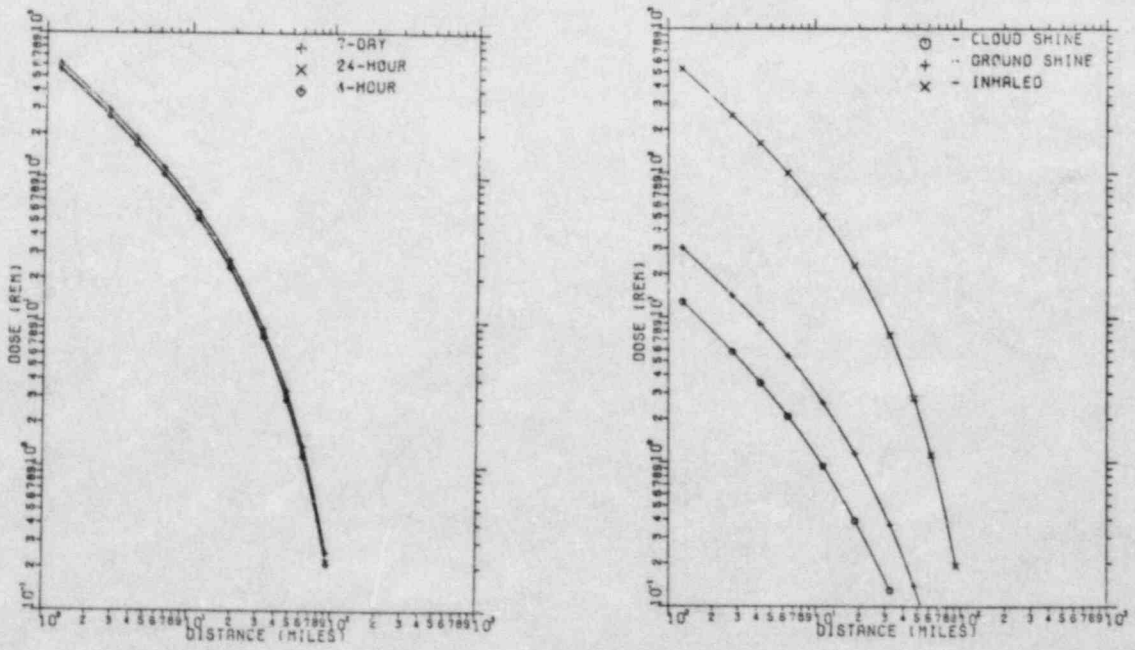


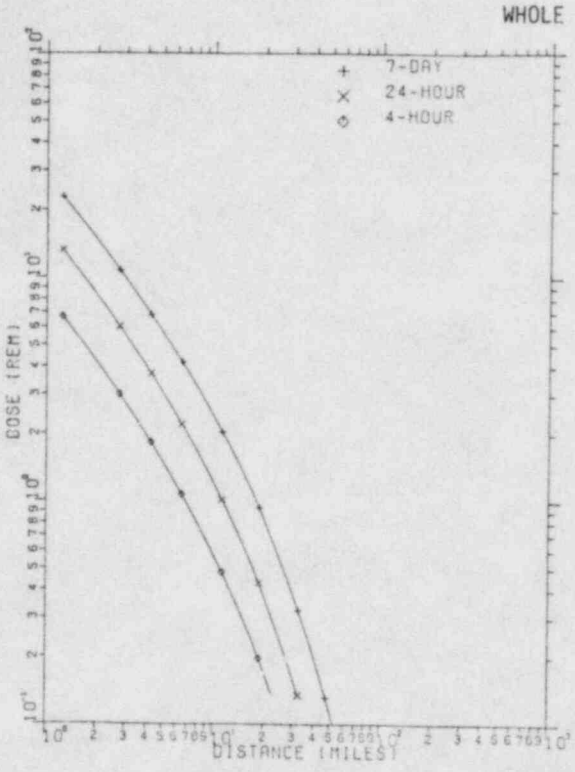
Figure 4-15

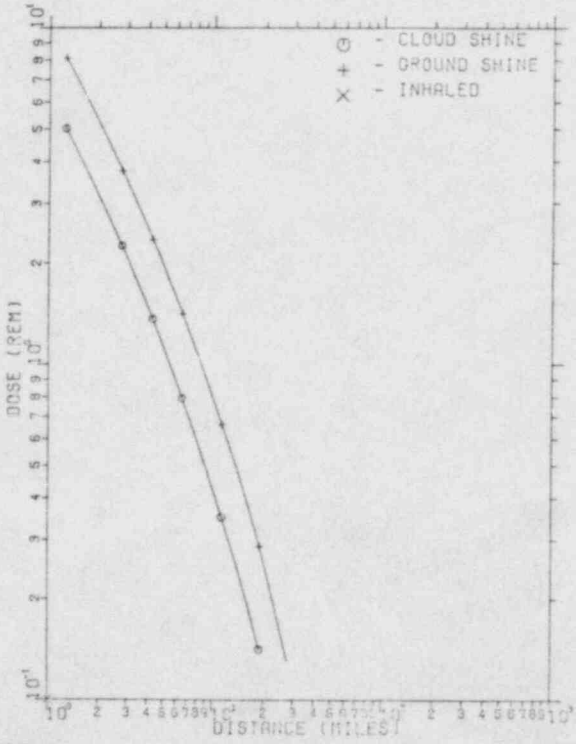
PWR # 5
CASE 15

Stability Class: A
Windspeed: 3 mph

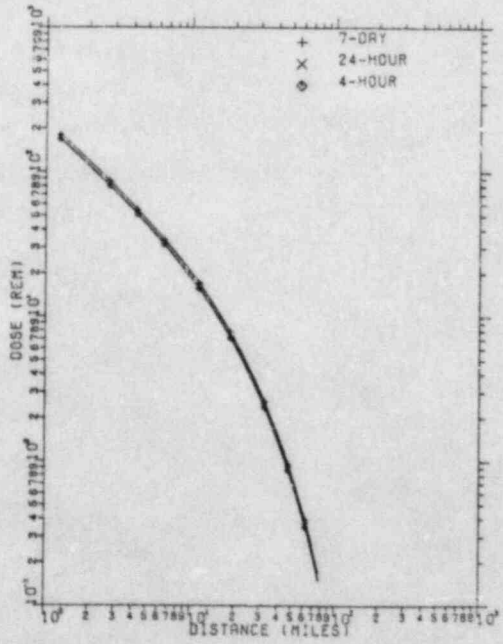
Rain: No
Sheltering: Yes

WHOLE BODY DOSE





THYROID DOSE



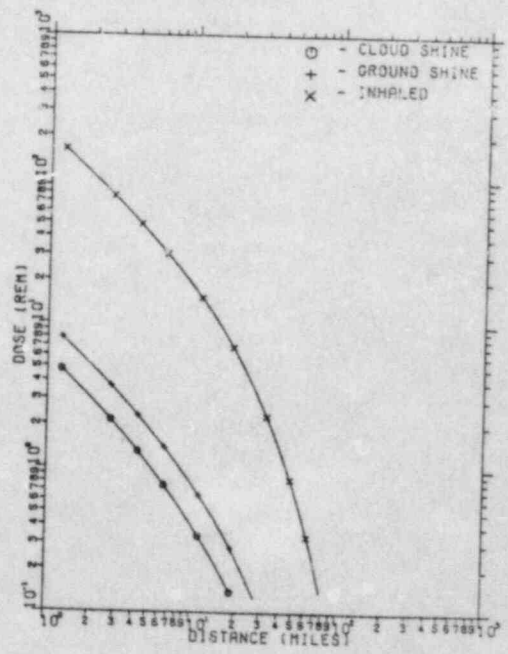


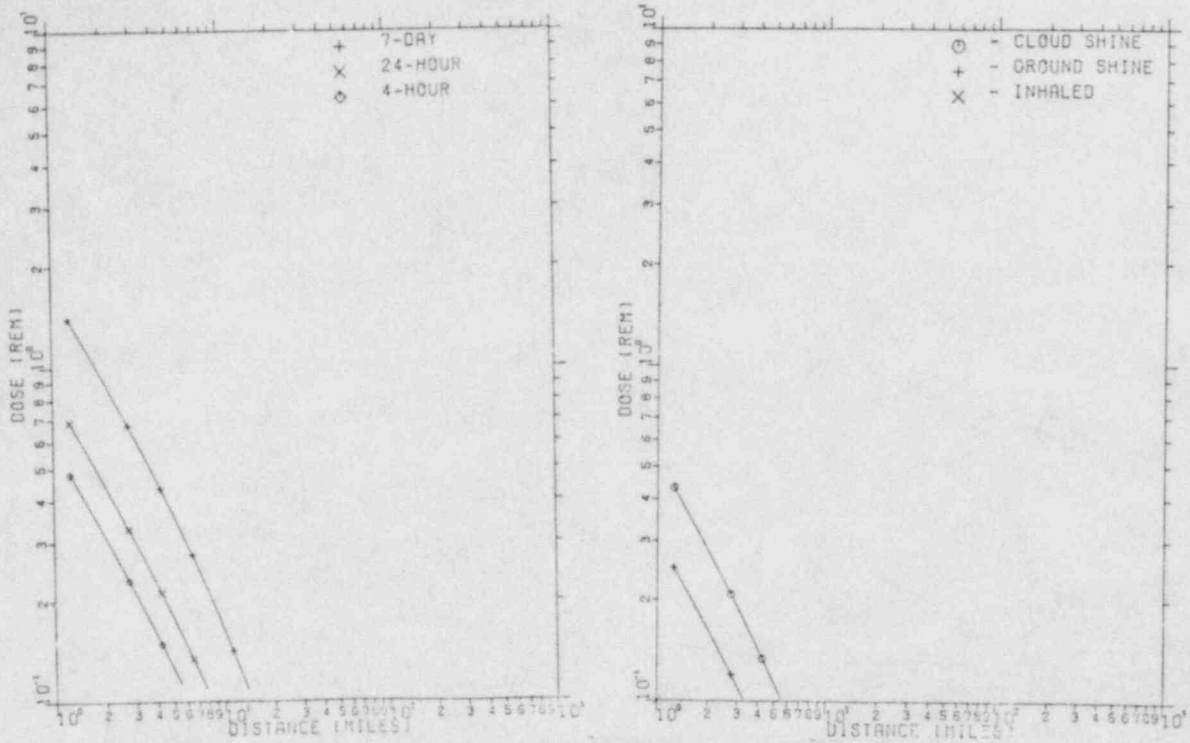
Figure 5-15

PWR #6
CASE T5

Stability Class: A
Windspeed: 3 mph

Rain: No
Sheltering: Yes

WHOLE BODY DOSE



THYROID DOSE

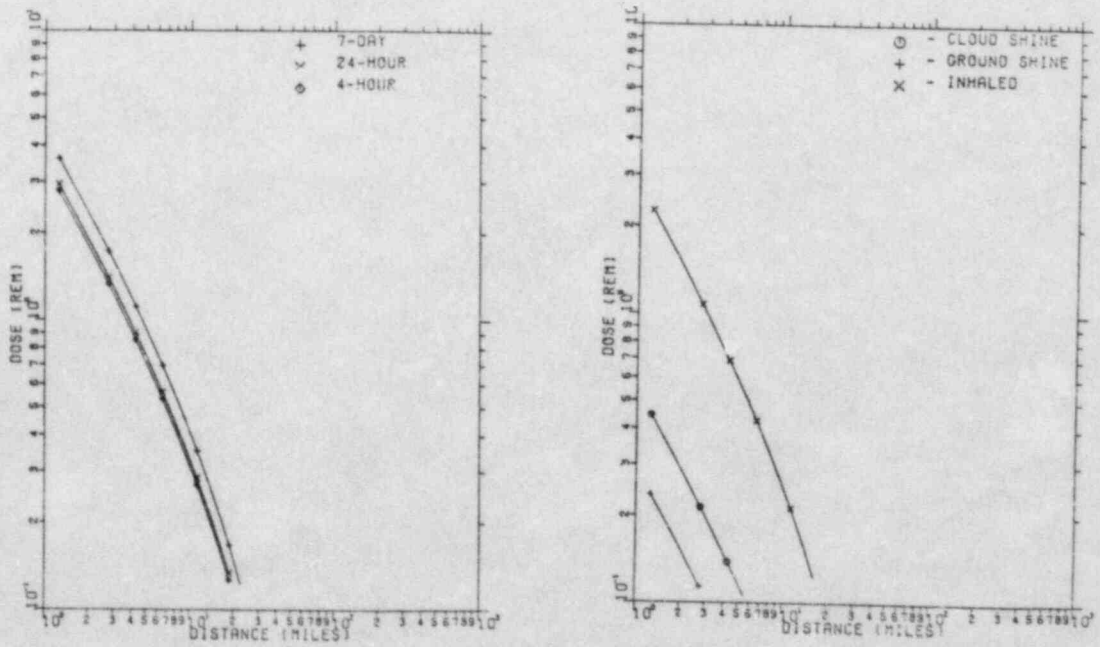


Figure 6-15

PWR # 7
CASE T5

Stability Class: A
Windspeed: 3 mph

Rain: No
Sheltering: Yes

WHOLE BODY DOSE

THYROID DOSE

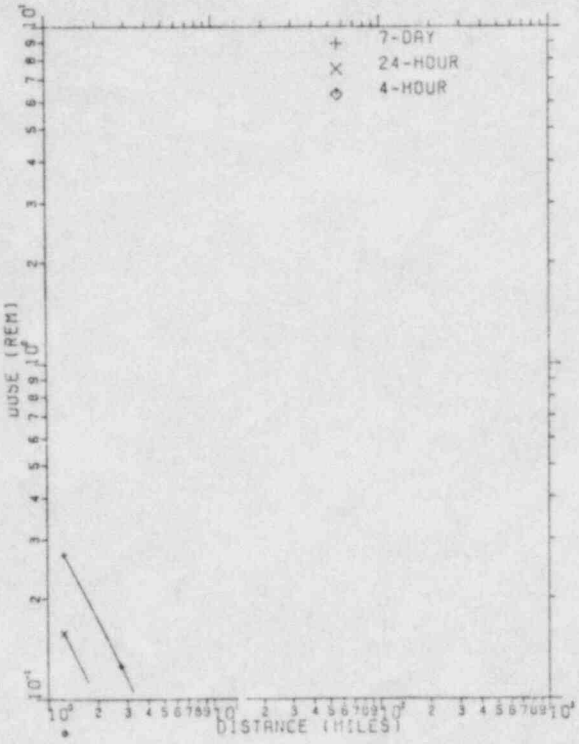
Figure 7-15

PWR #8
CASE 15

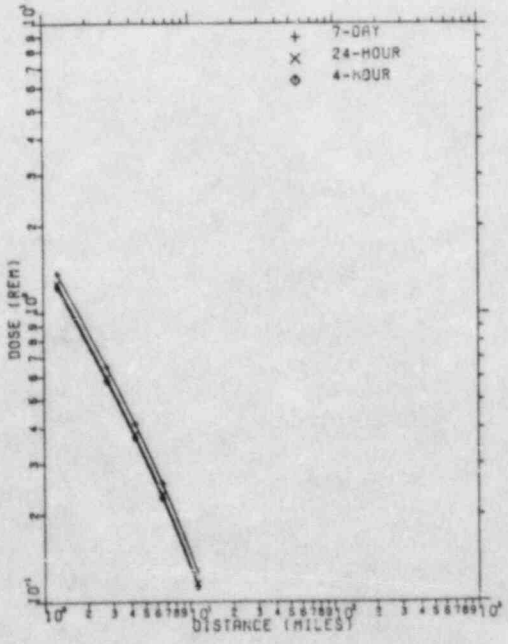
Stability Class: A
Windspeed: 3 mph

Rain: No
Sheltering: Yes

WHOLE BODY DOSE



THYROID DOSE



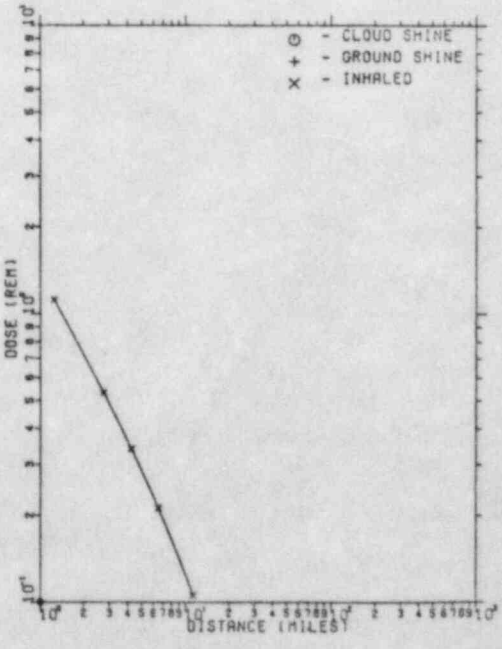


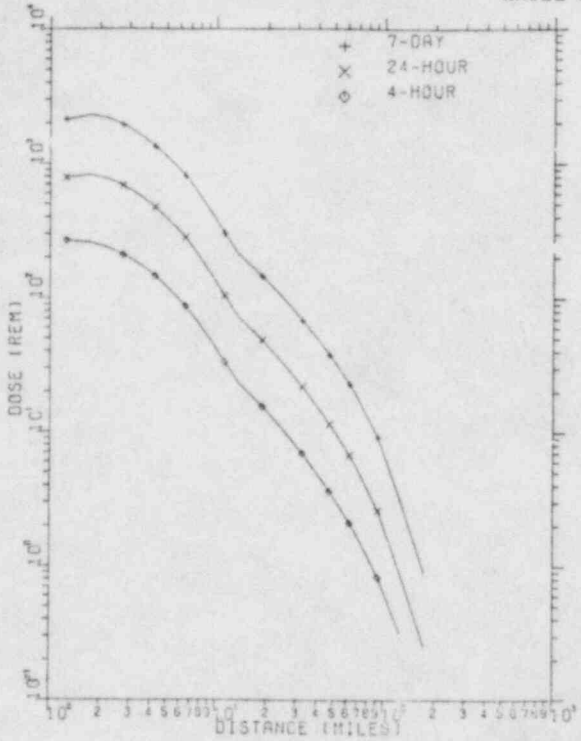
Figure 8-15

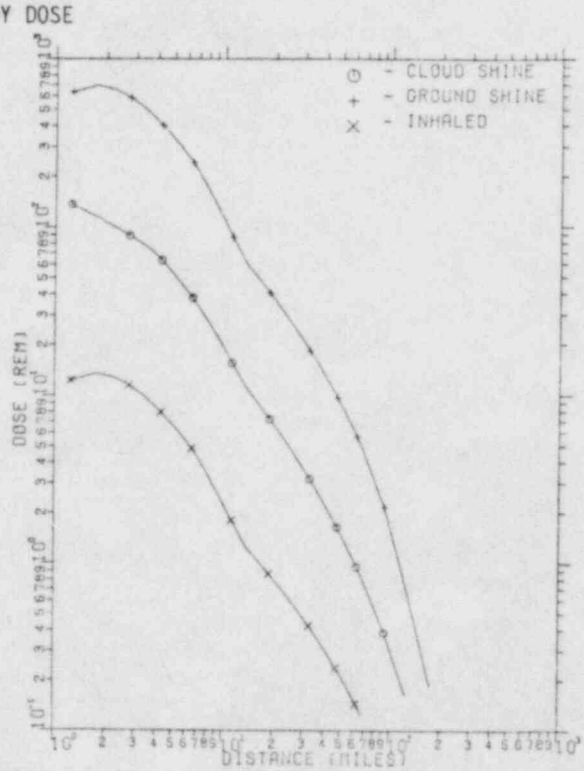
PWR #1A
CASE 16

Stability Class: D
Windspeed: 6 mph

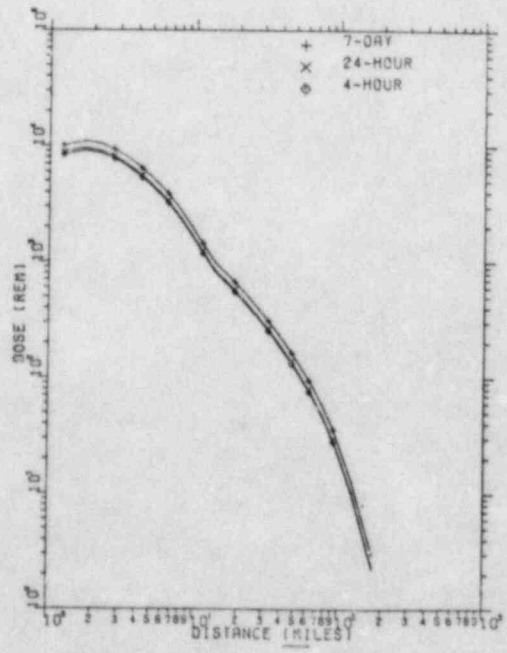
Rain: No
Sheltering: Yes

WHOLE BODY DOSE





THYROID DOSE



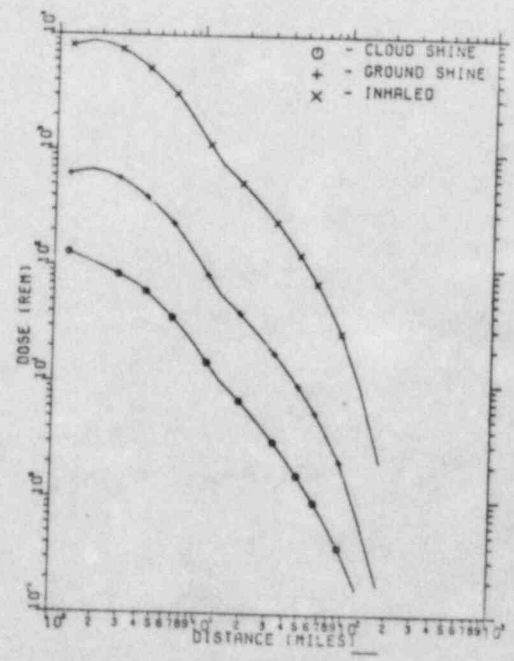


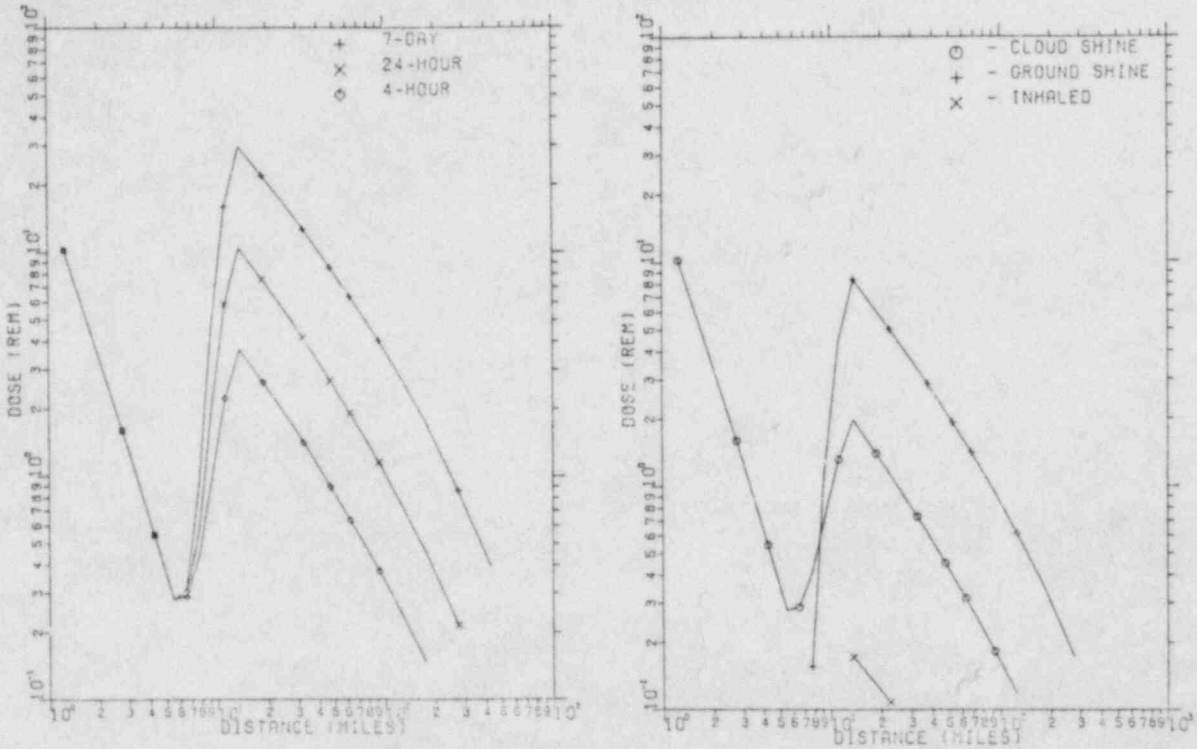
Figure 1A-16

PWR #1B
CASE 16

Stability Class: D
Windspeed: 6 mph

Rain: No
Sheltering: Yes

WHOLE BODY DOSE



THYROID DOSE

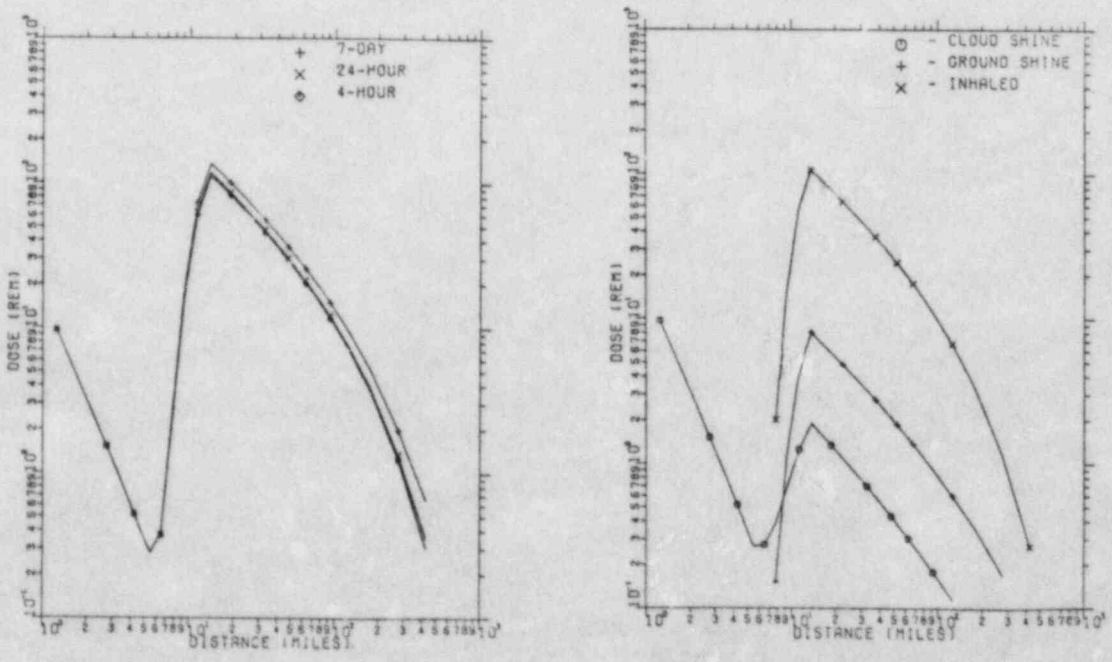


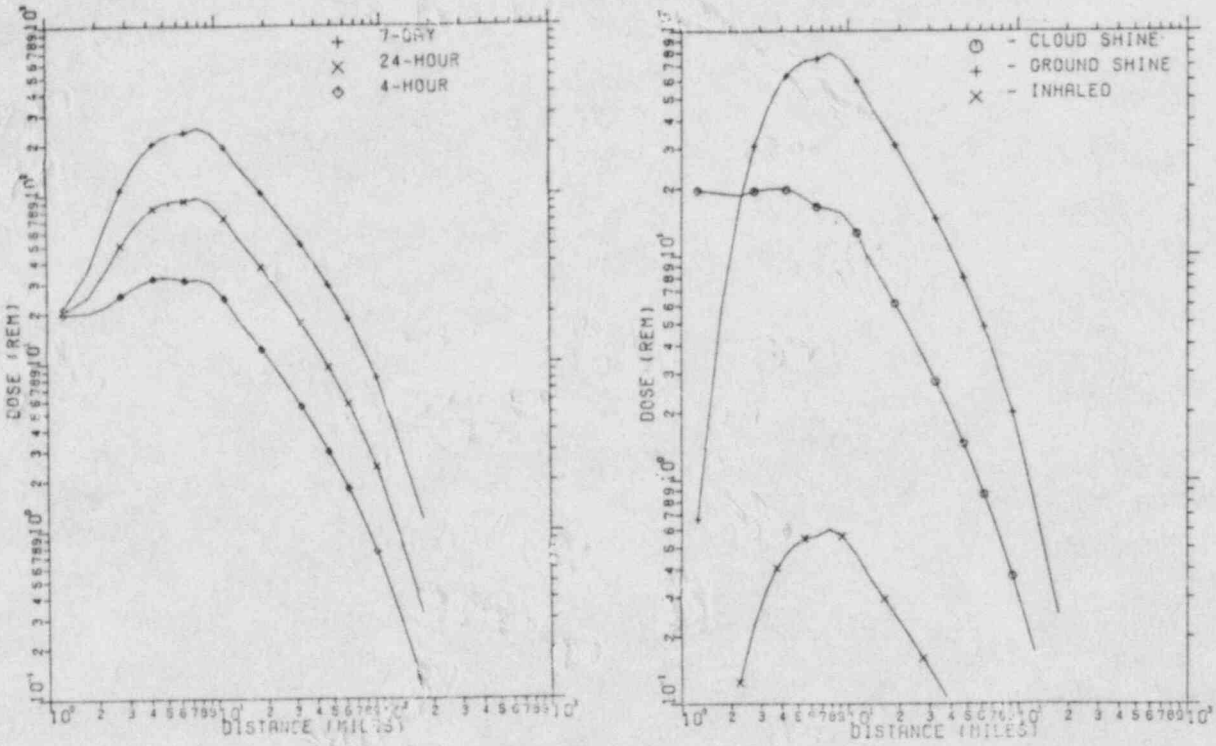
Figure 1B-16

PWR #2
CASE T6

Stability Class: D
Windspeed: 6 mph

Rain: No
Sheltering: Yes

WHOLE BODY DOSE



THYROID DOSE

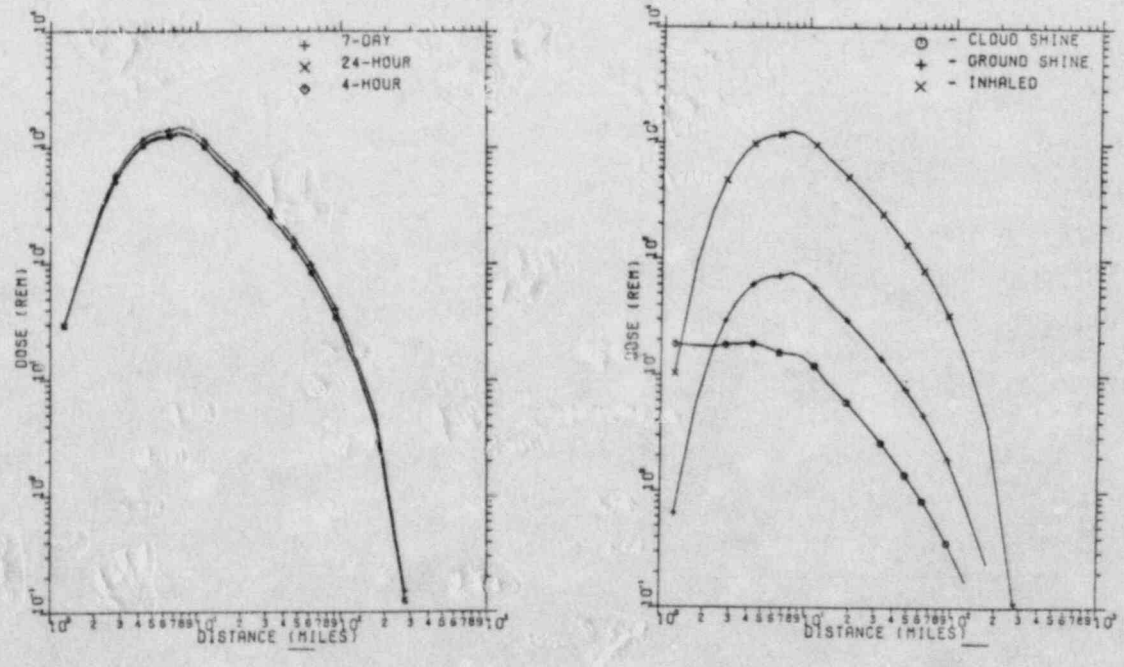


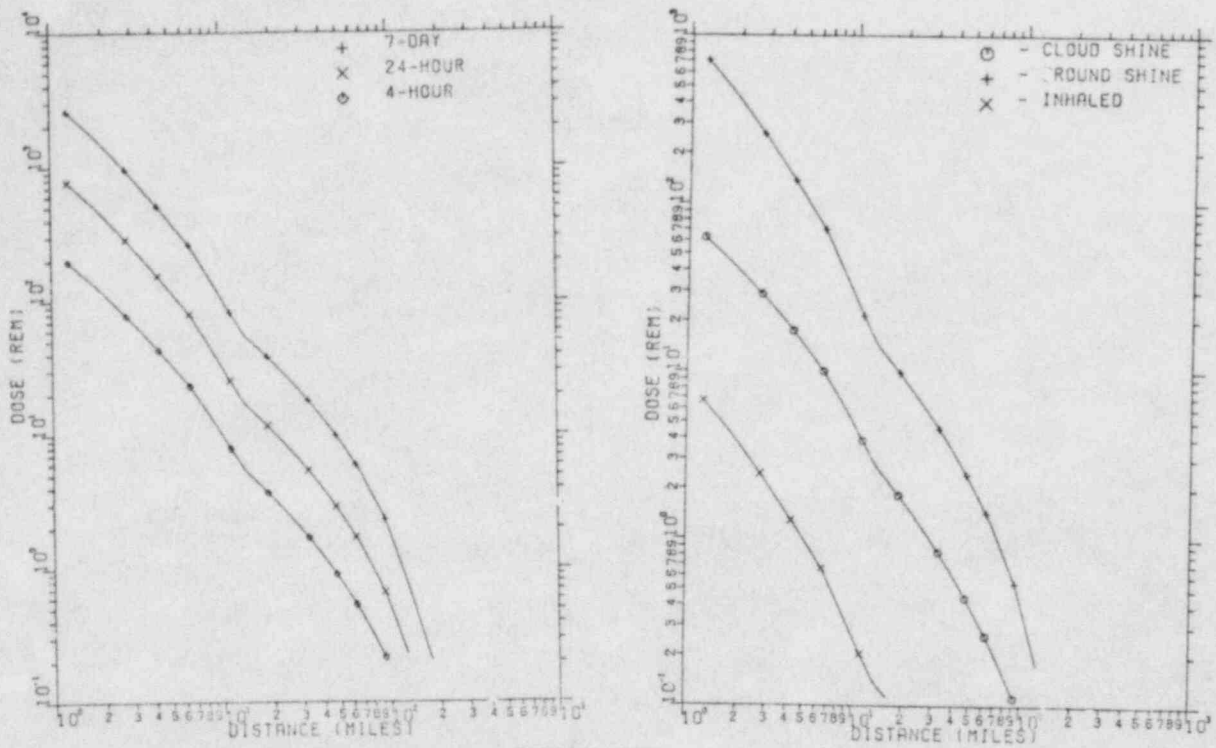
Figure 2-16

PWR #3
CASE 16

Stability Class: D
Windspeed: 6 mph

Rain: No
Sheltering: Yes

WHOLE BODY DOSE



THYROID DOSE

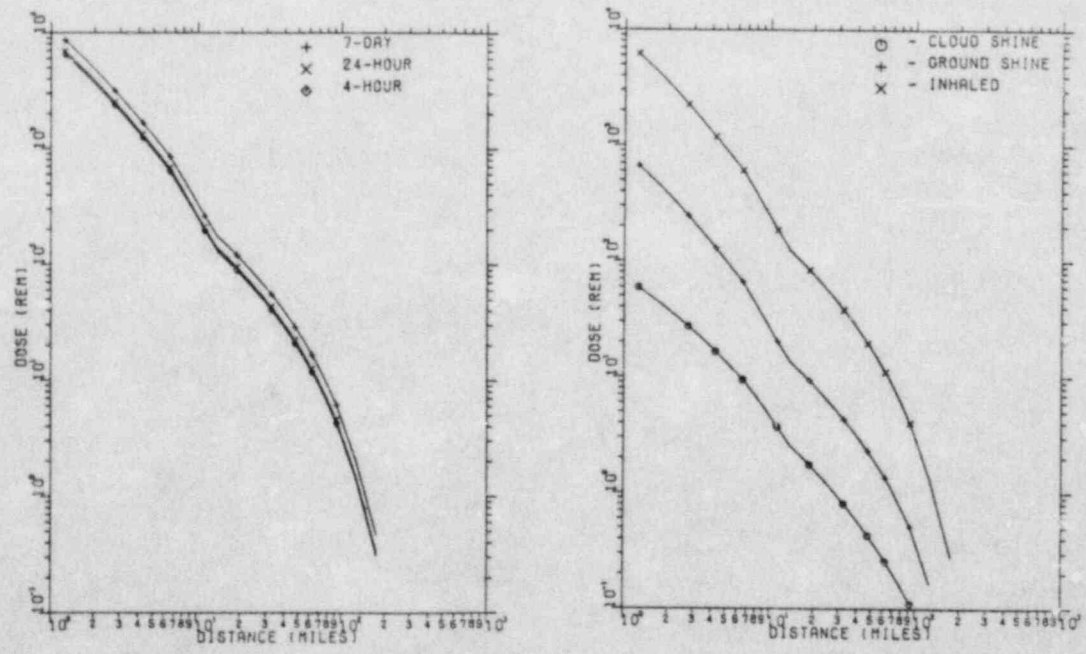


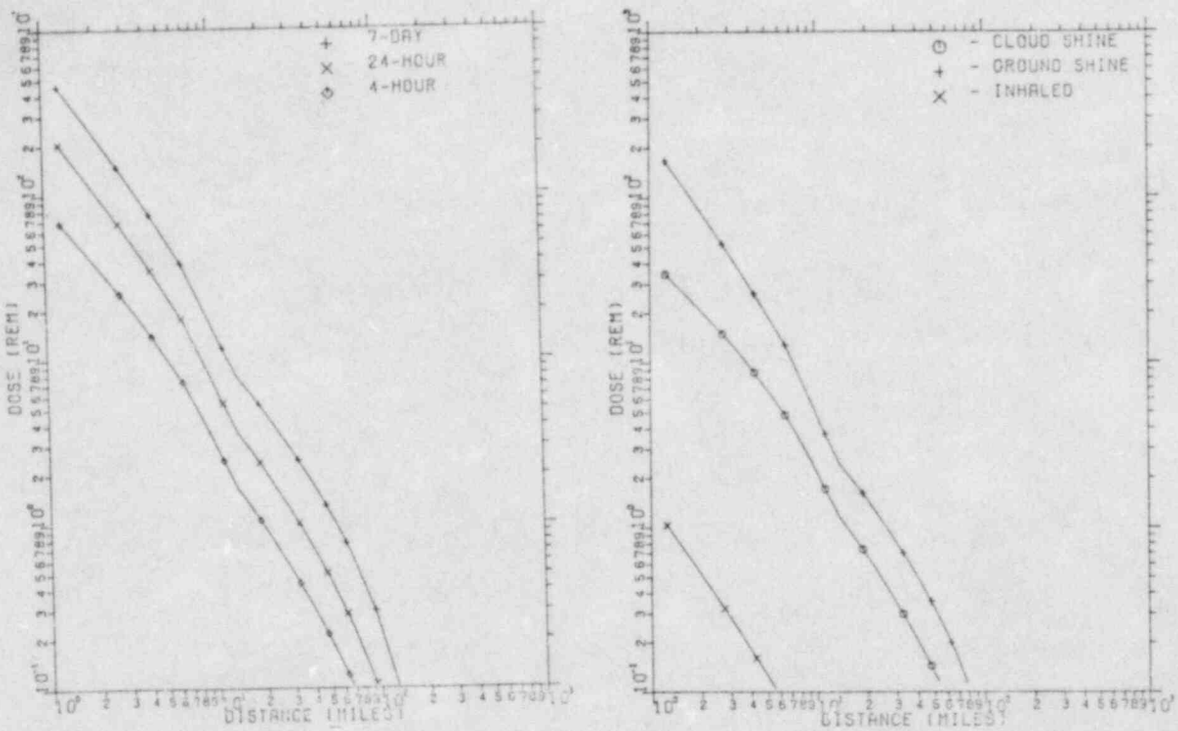
Figure 3-16

PWR # 4
CASE T6

Stability Class: D
Windspeed: 6 mph

Rain: No
Sheltering: Yes

WHOLE BODY DOSE



THYROID DOSE

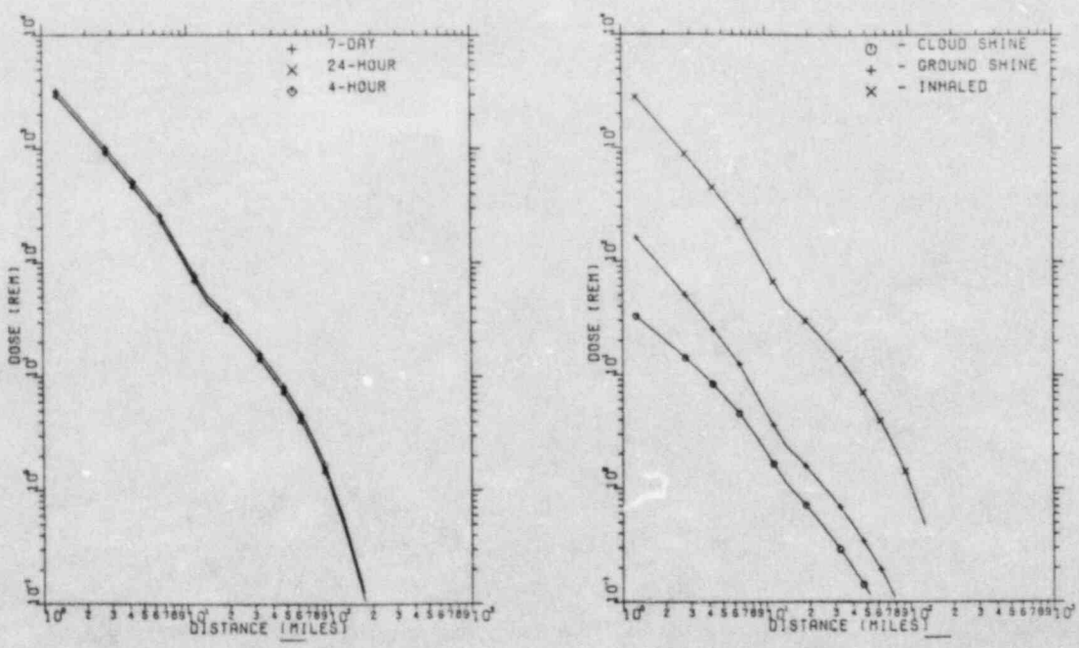


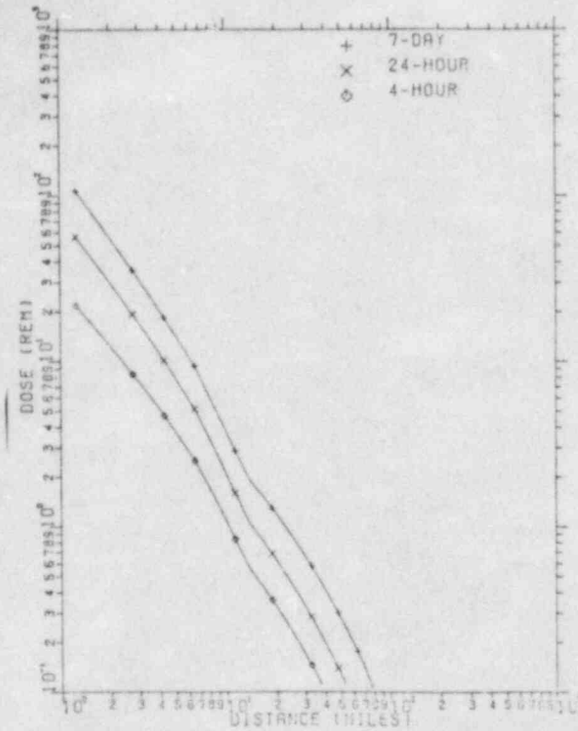
Figure 4-16

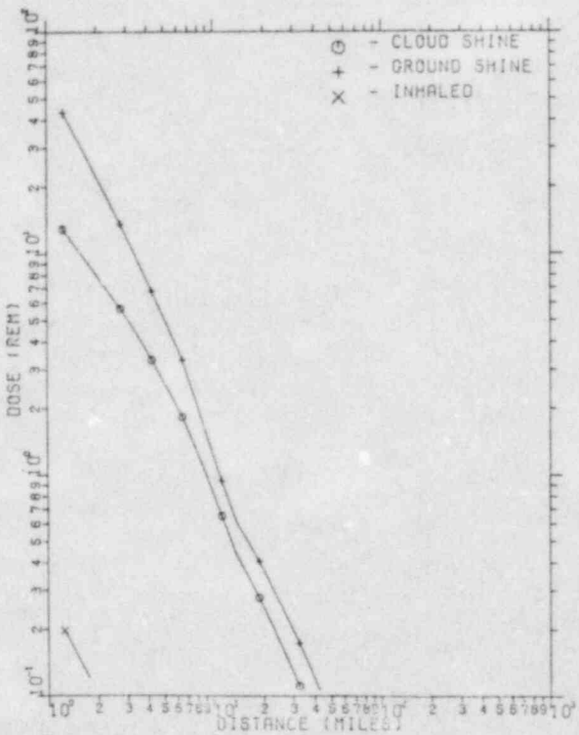
PWR # 5
CASE 16

Stability Class: D
Windspeed: 6 mph

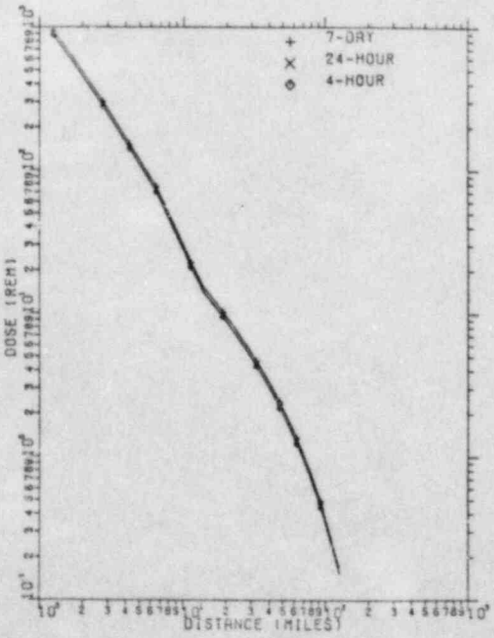
Rain: No
Sheltering: Yes

WHOLE BODY DOSE





THYROID DOSE



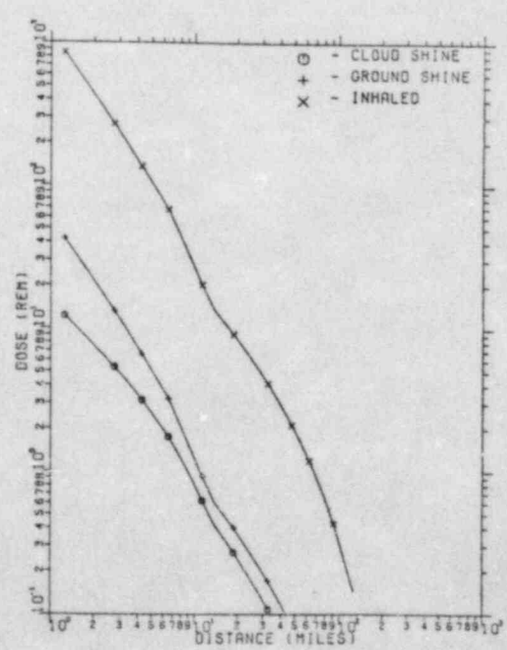


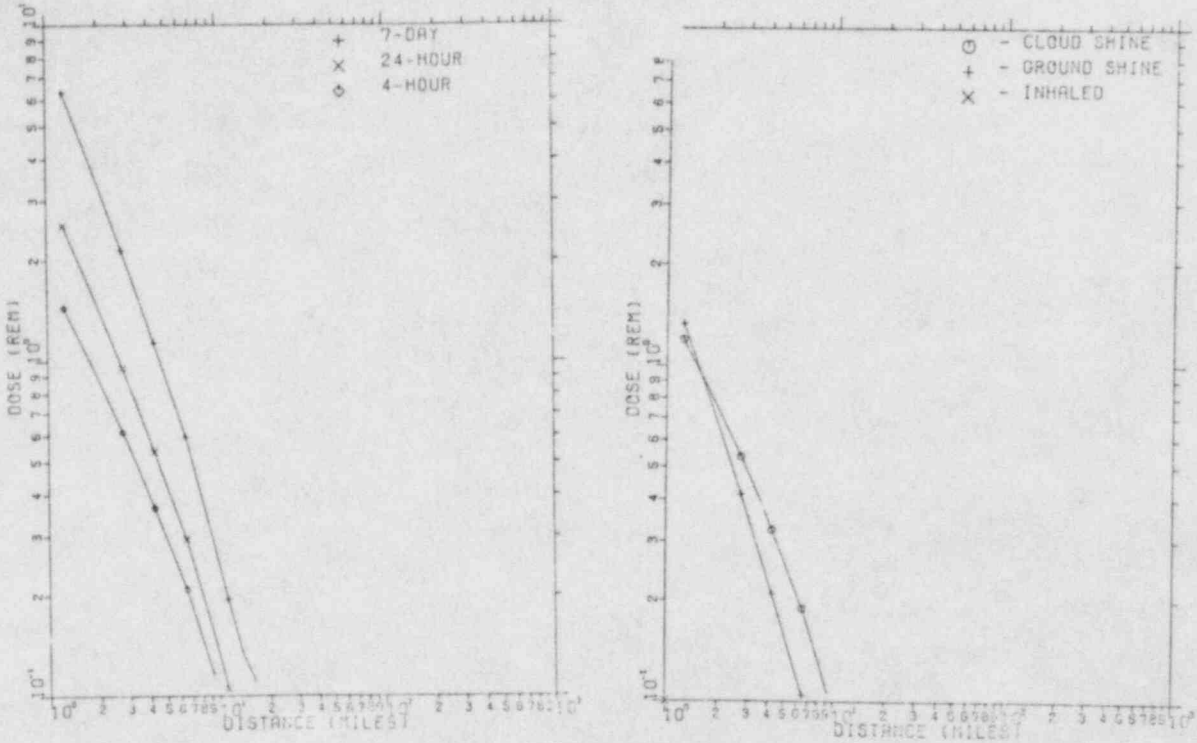
Figure 5-16

PWR # 6
CASE 16

Stability Class: D
Windspeed: 6 mph

Rain: No
Sheltering: Yes

WHOLE BODY DOSE



THYROID DOSE

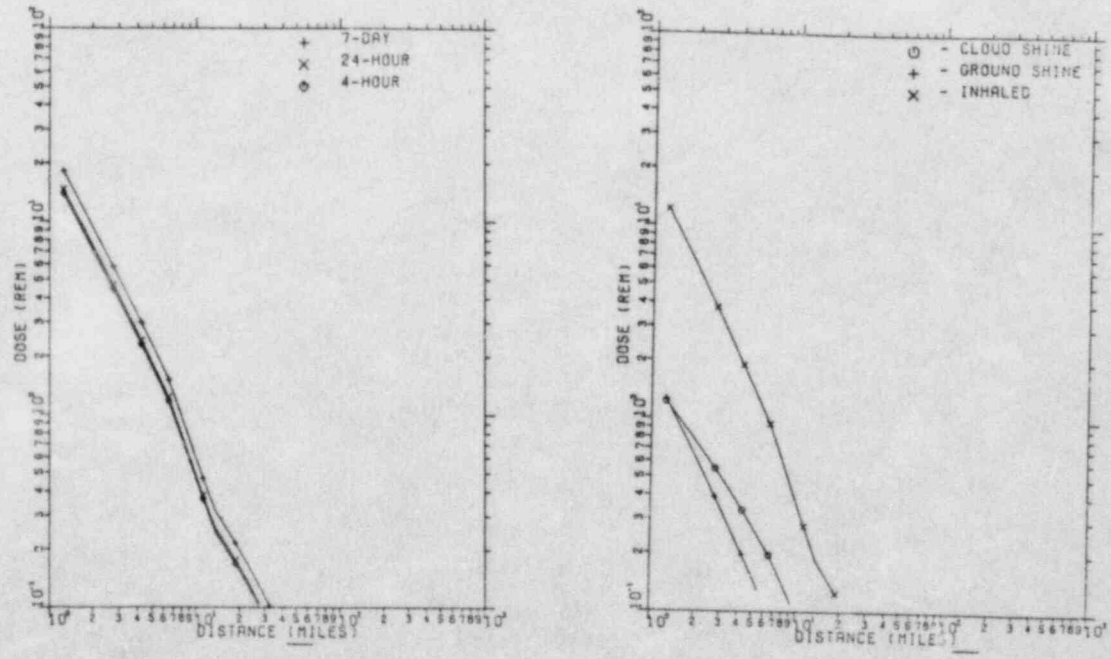


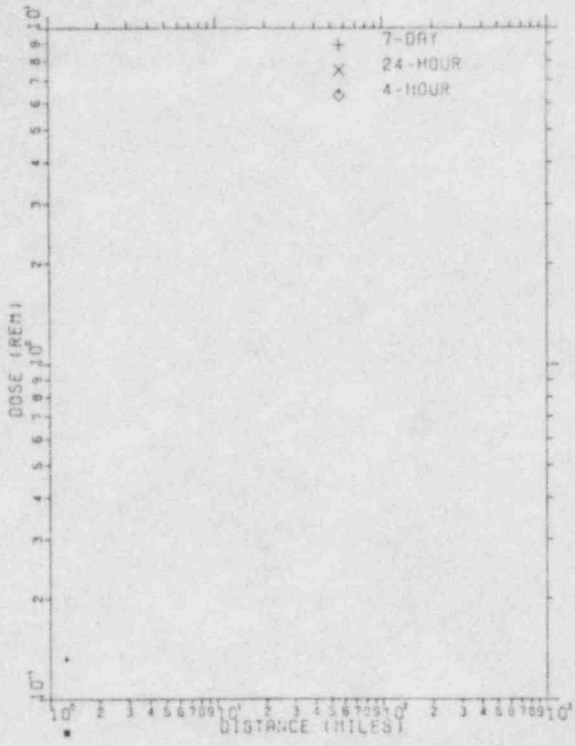
Figure 6-16

PWR #7
CASE 16

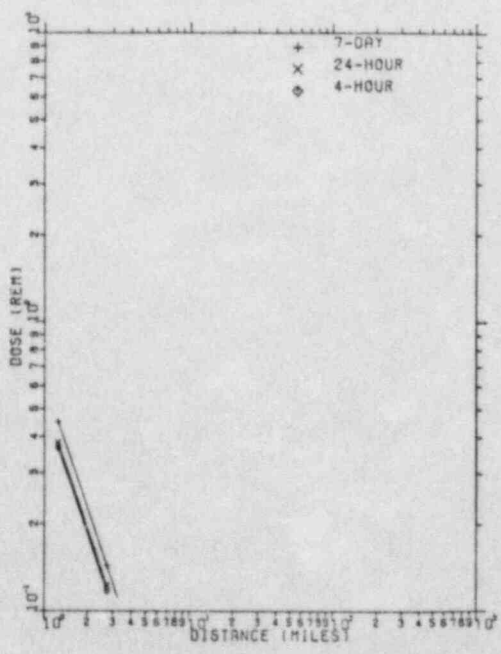
Stability Class: D
Windspeed: 6 mph

Rain: No
Sheltering: Yes

WHOLE BODY DOSE



THYROID DOSE



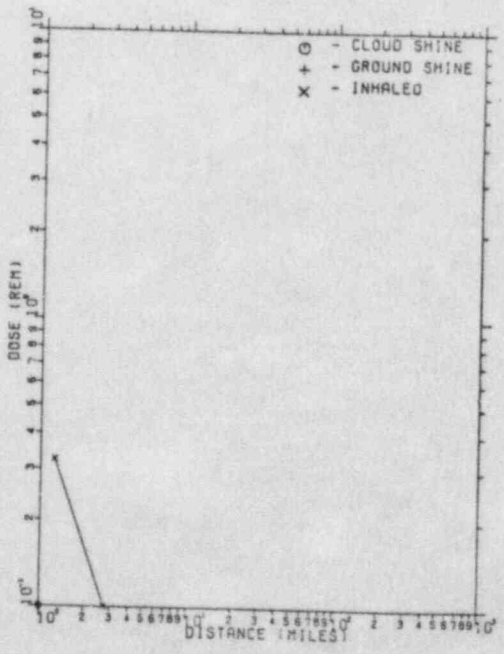


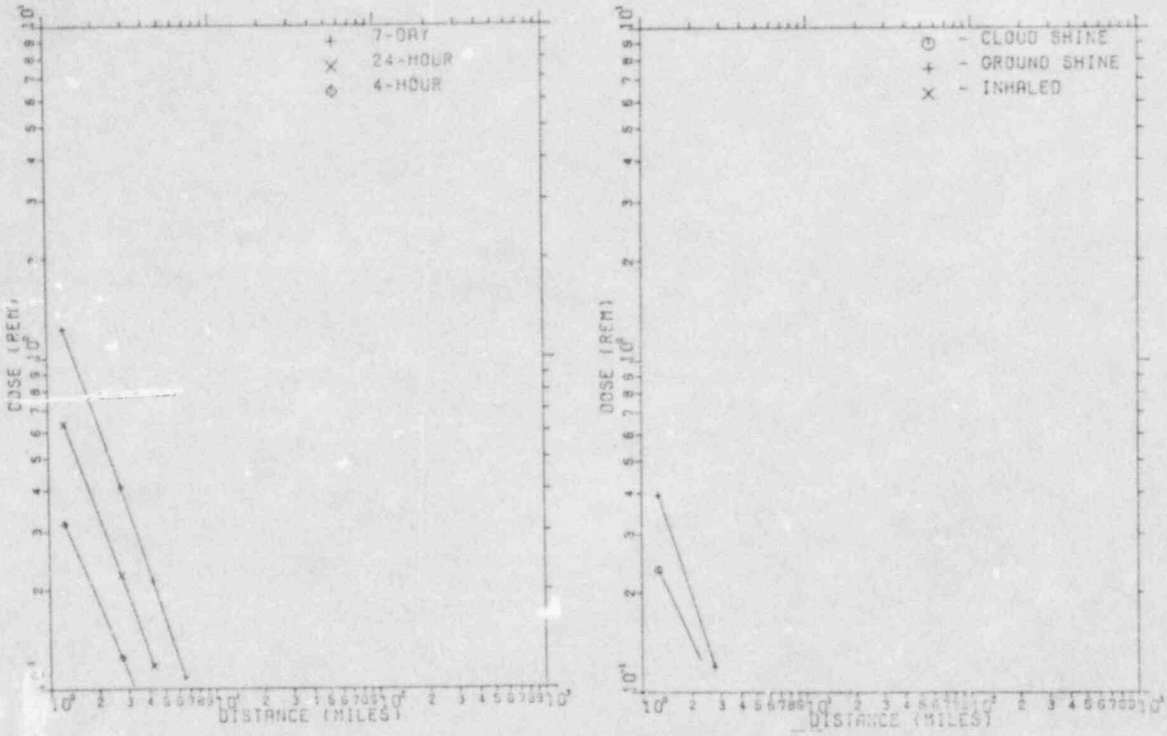
Figure 7-16

PWR # 8
CASE T6

Stability Class: D
Windspeed: 6 mph

Rain: No
Sheltering: Yes

WHOLE BODY DOSE



THYROID DOSE

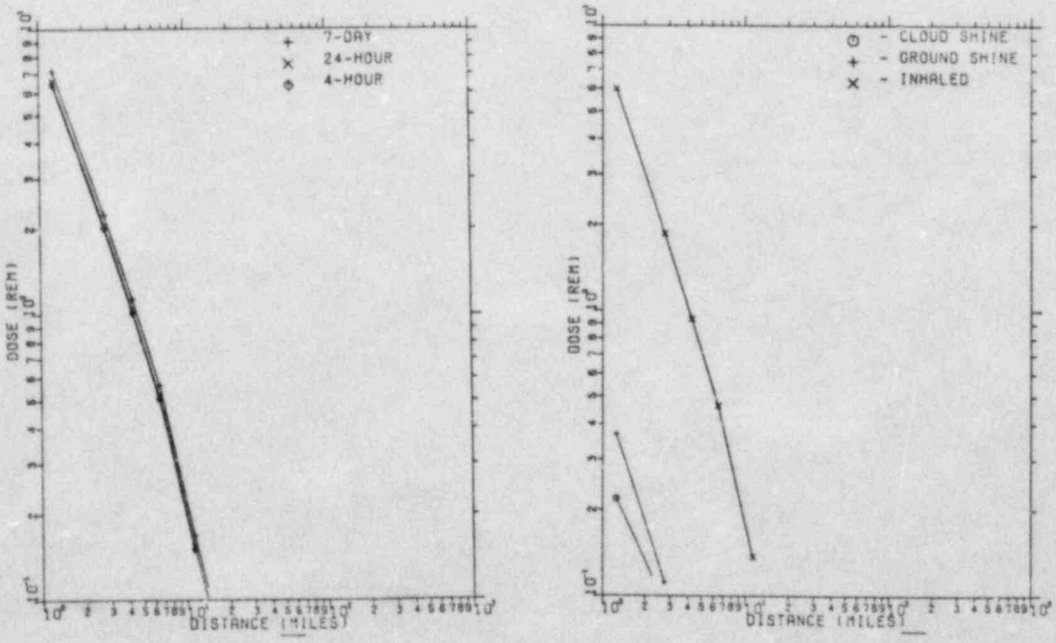


Figure 8-16

PWR # 9
CASE 16

Stability Class: D
Windspeed: 6 mph

Rain: No
Sheltering: Yes

WHOLE BODY DOSE

Doses less than 0.1 Rem.

THYROID DOSE

Doses less then 0.1 Rem.

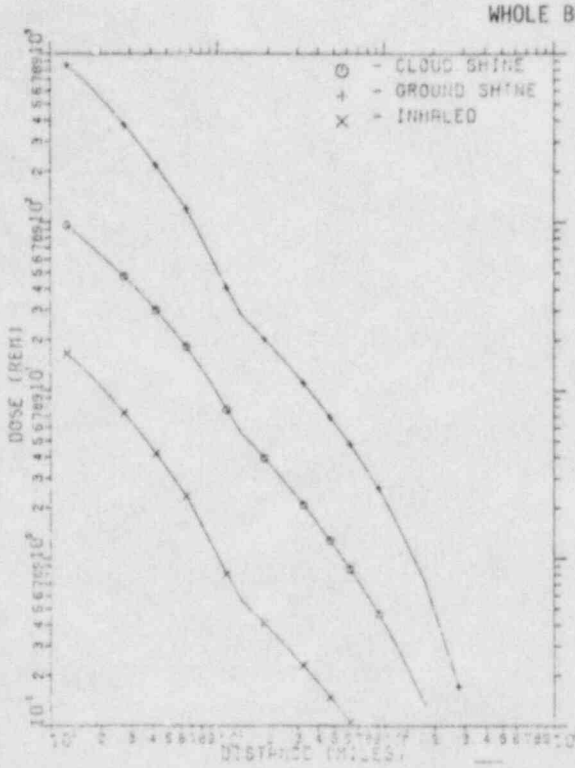
Figure 9-16

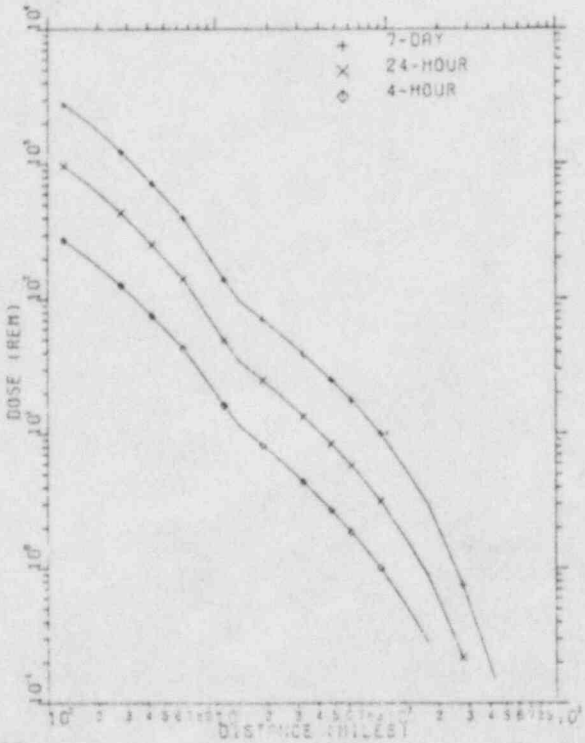
PWR # 1A
CASE 17

Stability Class: D
Windspeed: 16 mph

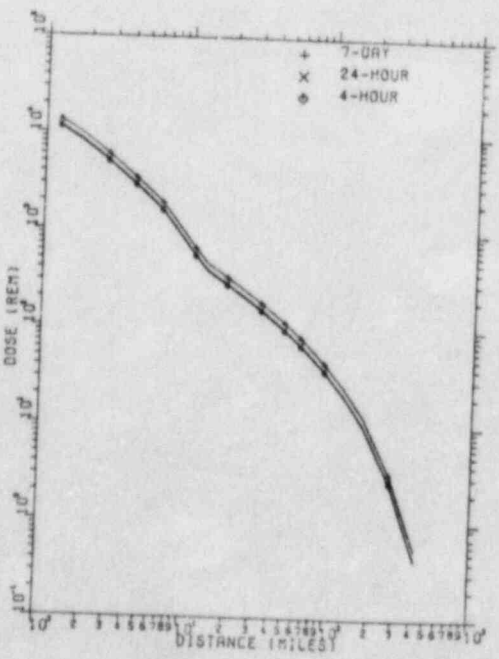
Rain: No
Sheltering: Yes

WHOLE BODY DOSE





THYROID DOSE



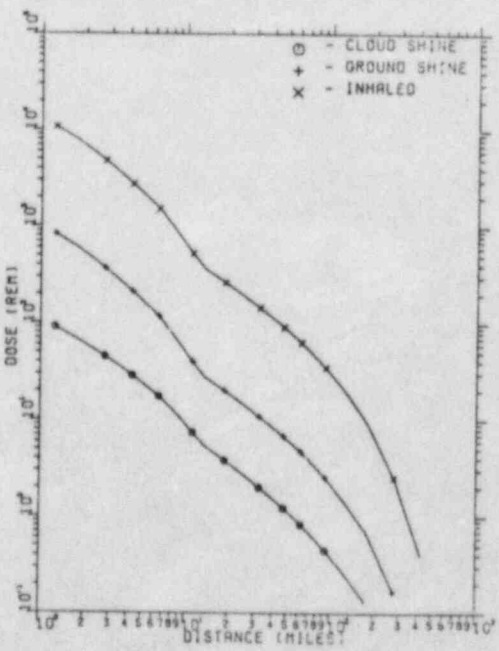


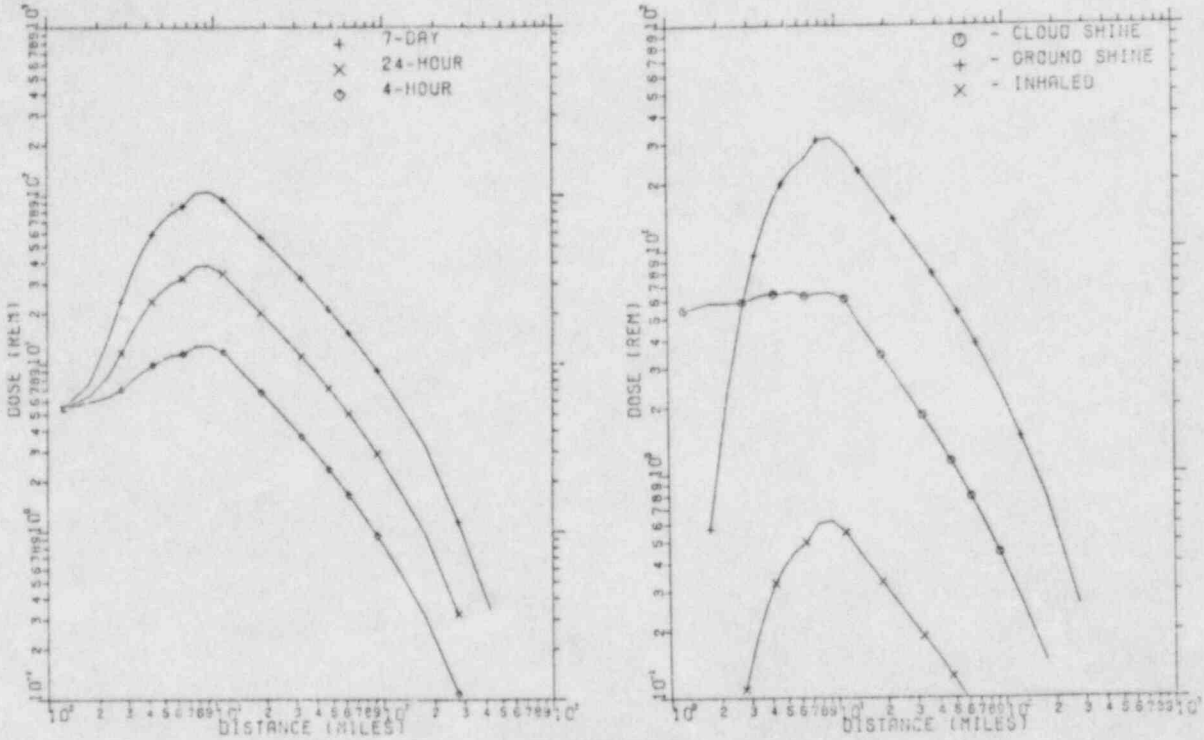
Figure 1A-17

PWR #1B
CASE 17

Stability Class: D
Windspeed: 16 mph

Rain: No
Sheltering: Yes

WHOLE BODY DOSE



THYROID DOSE

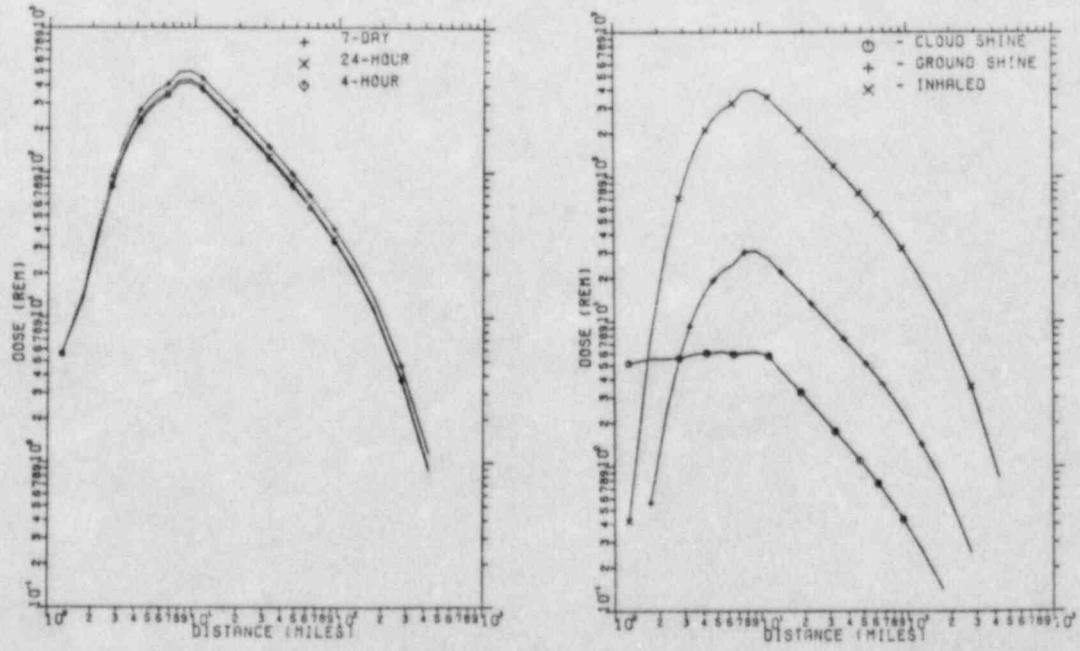


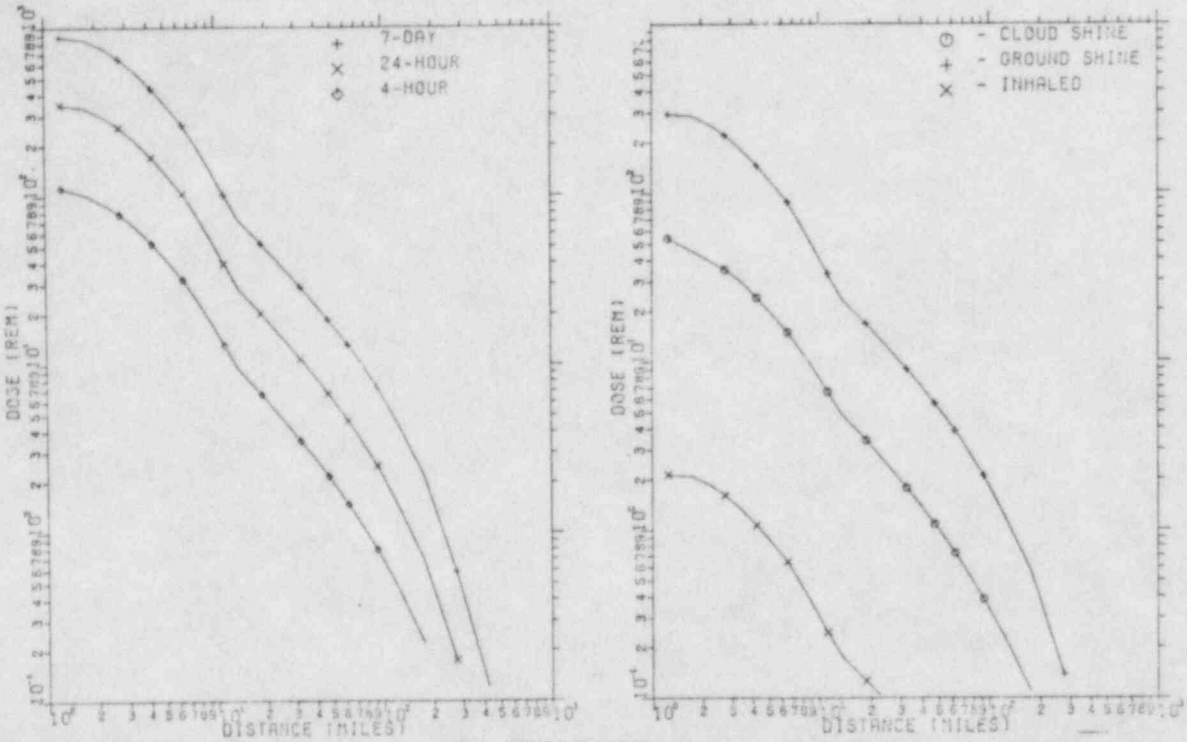
Figure 1B-17

PWR # 2
CASE 17

Stability Class: D
Windspeed: 16 mph

Rain: No
Sheltering: Yes

WHOLE BODY DOSE



THYROID DOSE

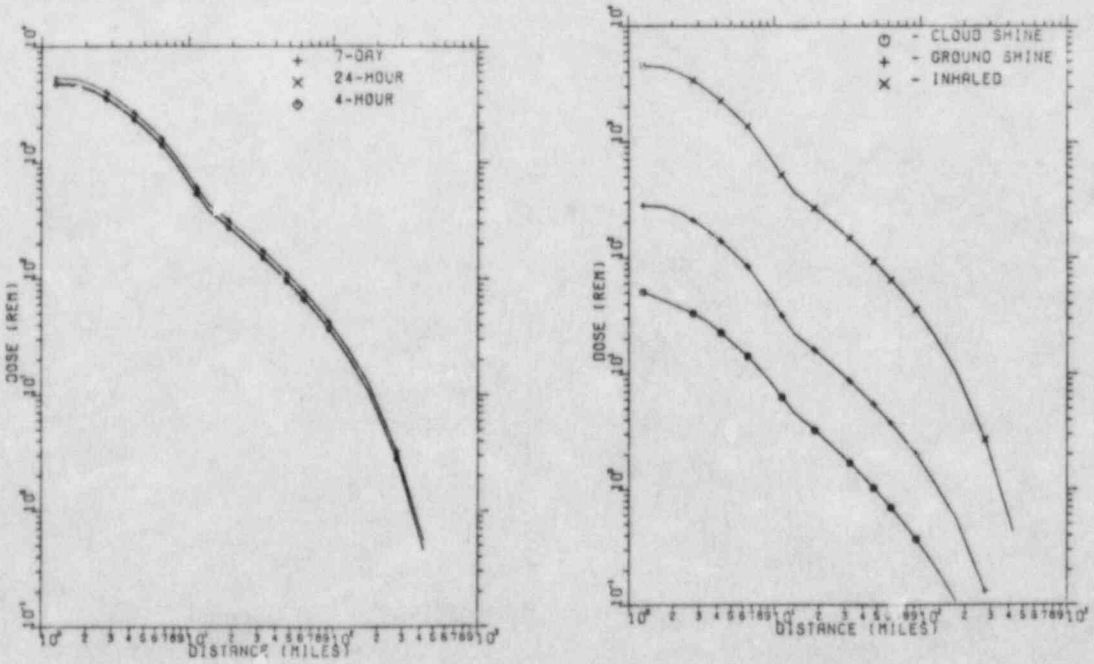


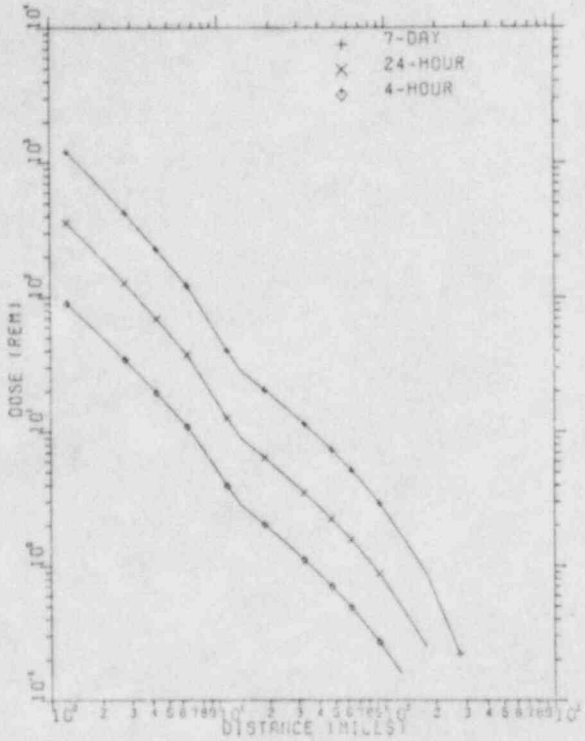
Figure 2-17

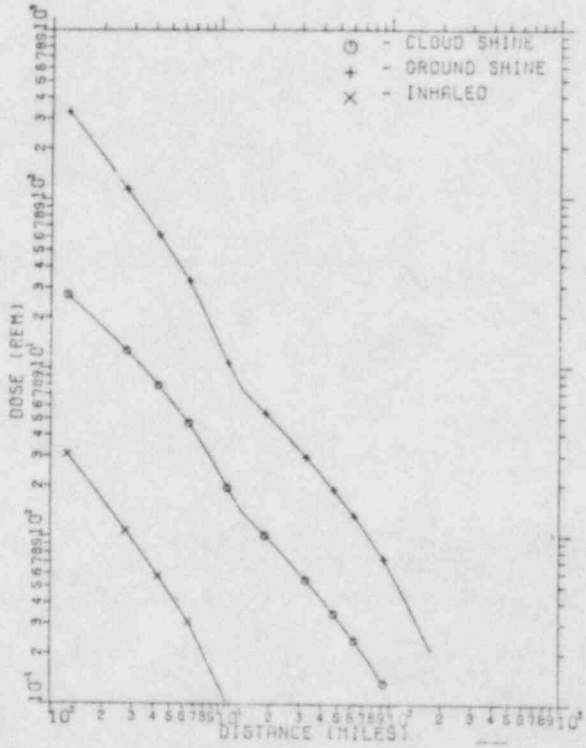
PWR #3
CASE 17

Stability Class: D
Windspeed: 16 mph

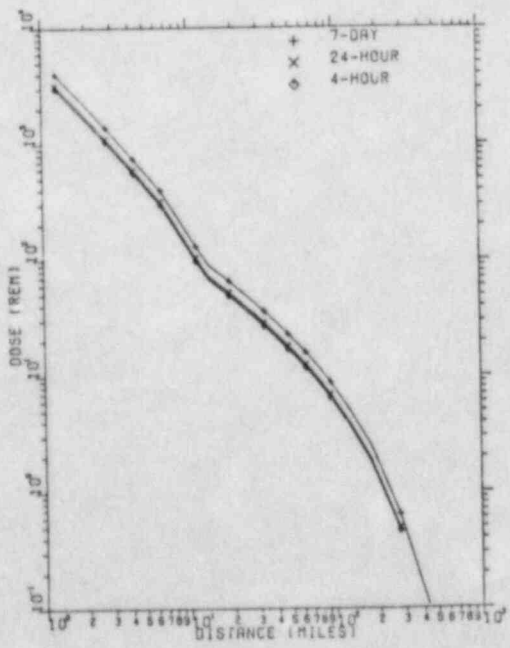
Rain: No
Sheltering: Yes

WHOLE BODY DOSE





THYROID DOSE



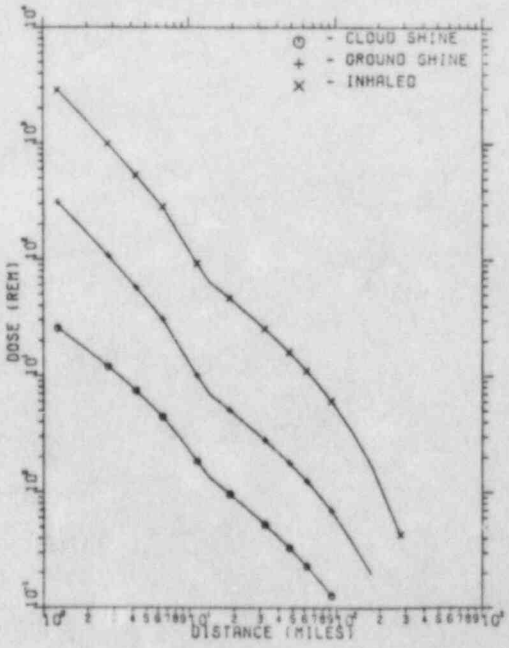


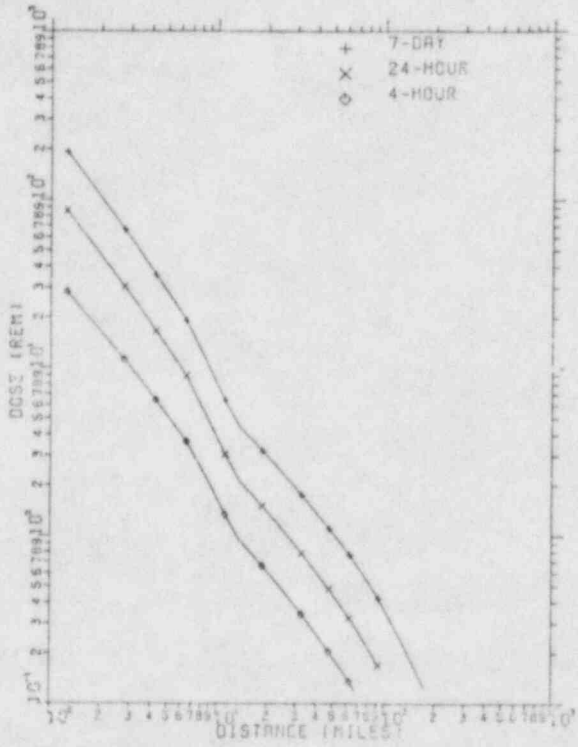
Figure 3-17

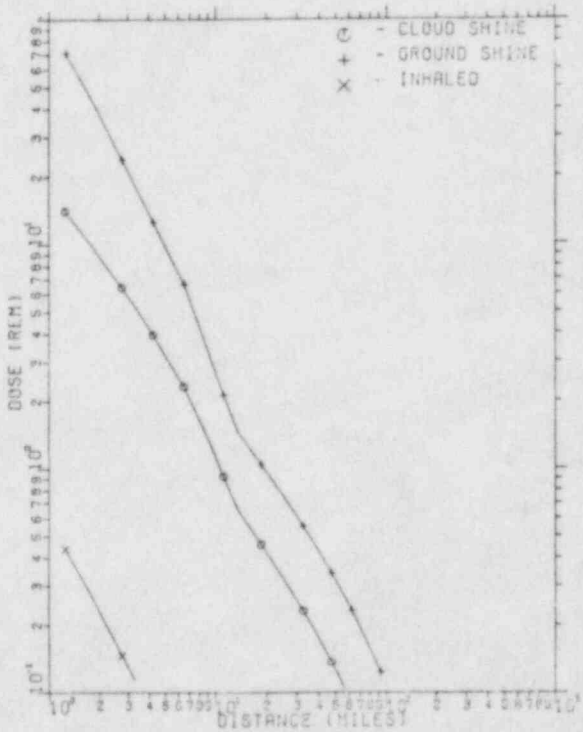
PWR #4
CASE T7

Stability Class: D
Windspeed: 16 mph

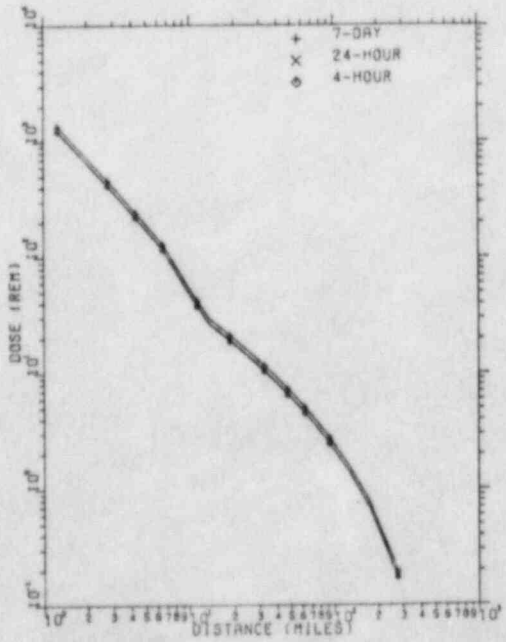
Rain: No
Sheltering: Yes

WHOLE BODY DOSE





THYROID DOSE



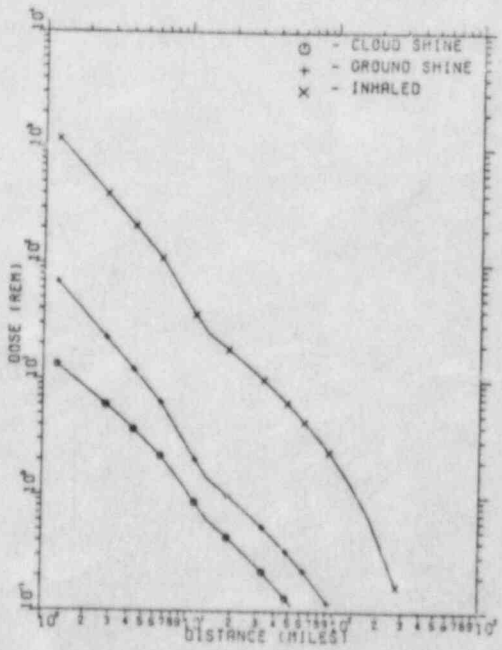


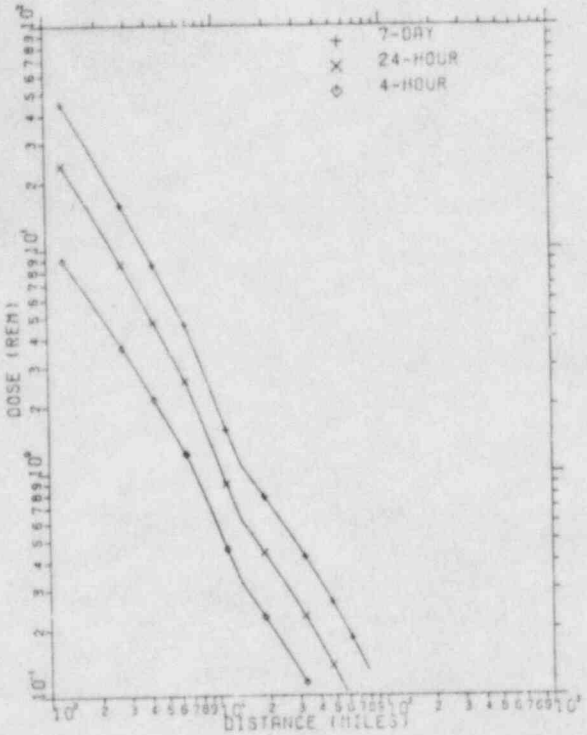
Figure 4-17

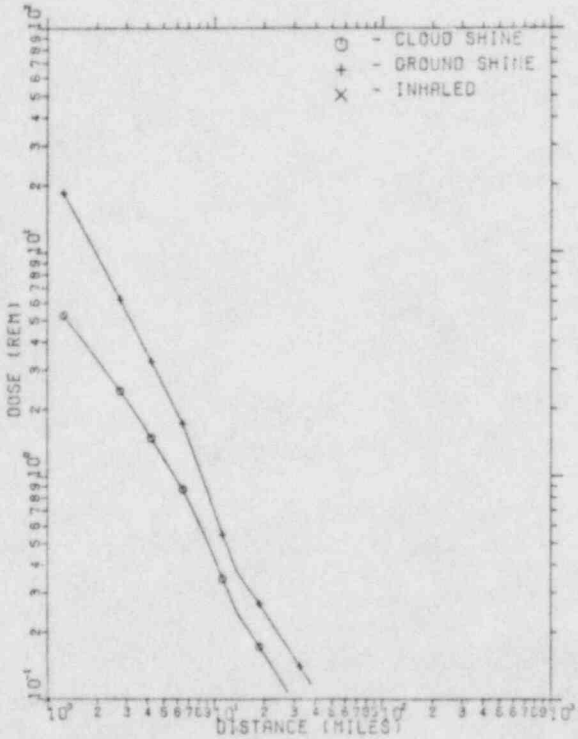
PWR # 5
CASE 17

Stability Class: D
Windspeed: 16 mph

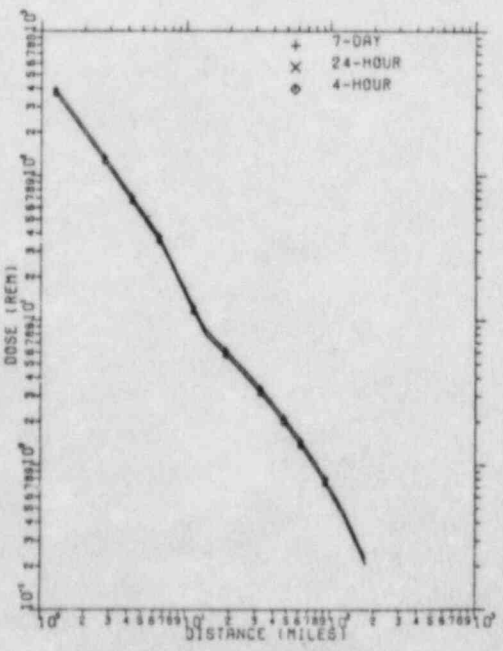
Rain: No
Sheltering: Yes

WHOLE BODY DOSE





THYROID DOSE



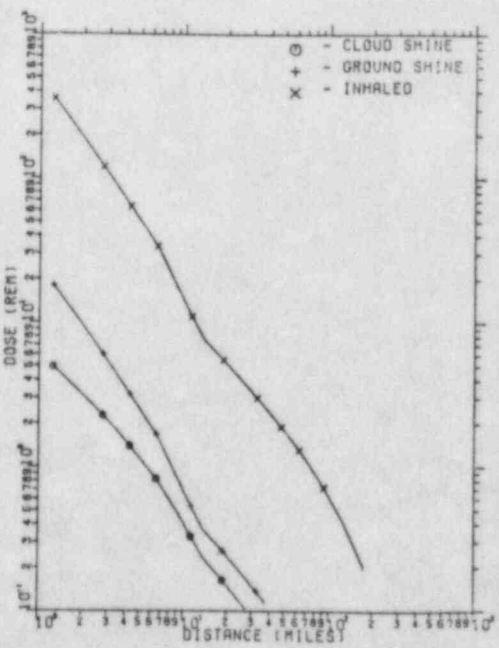


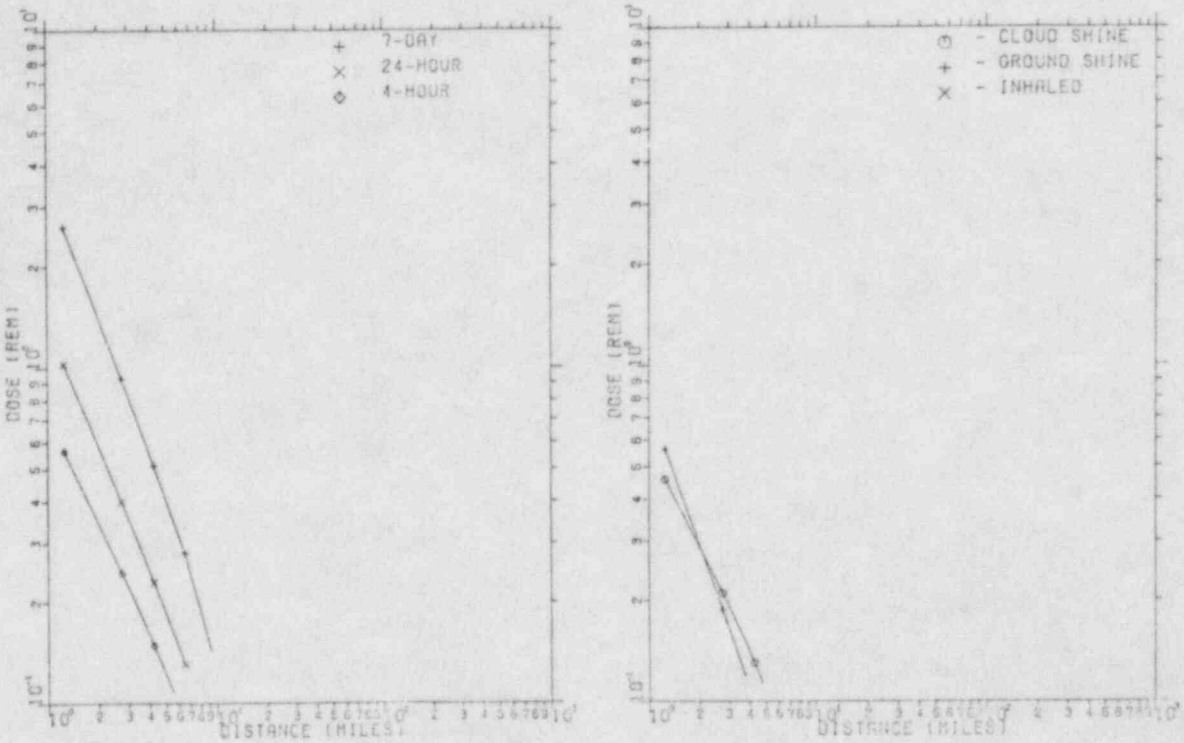
Figure 5-17

PWR # 6
CASE 17

Stability Class: D
Windspeed: 16 mph

Rain: No
Sheltering: Yes

WHOLE BODY DOSE



THYROID DOSE

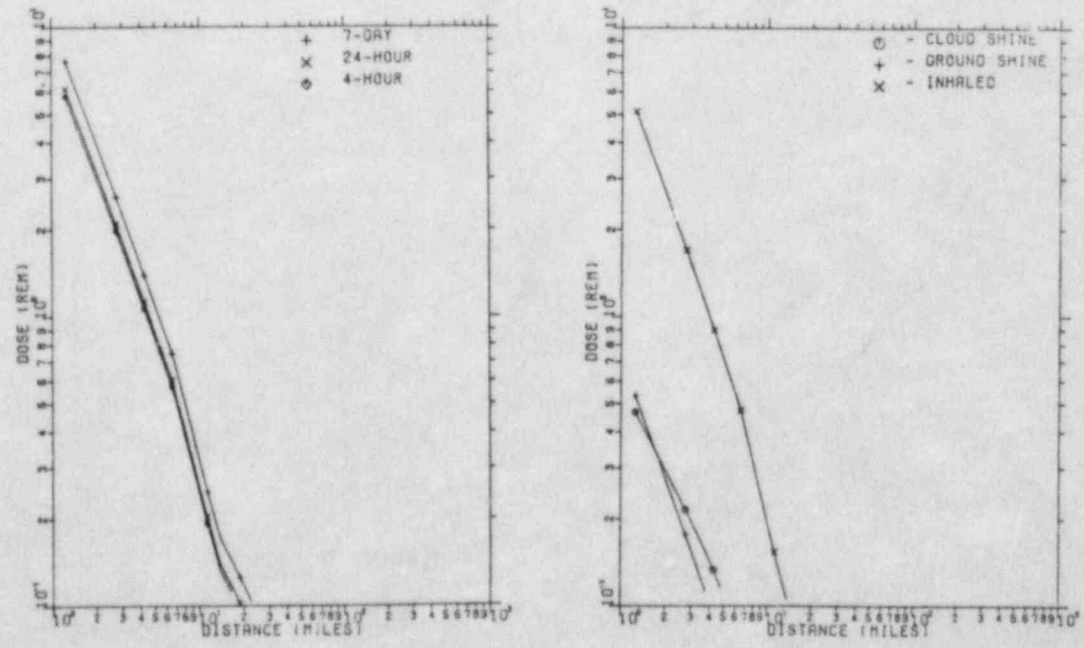


Figure 6-17

PWR #7
CASE 17

Stability Class: D
Windspeed: 16 mph

Rain: No
Sheltering: Yes

WHOLE BODY DOSE

THYROID DOSE

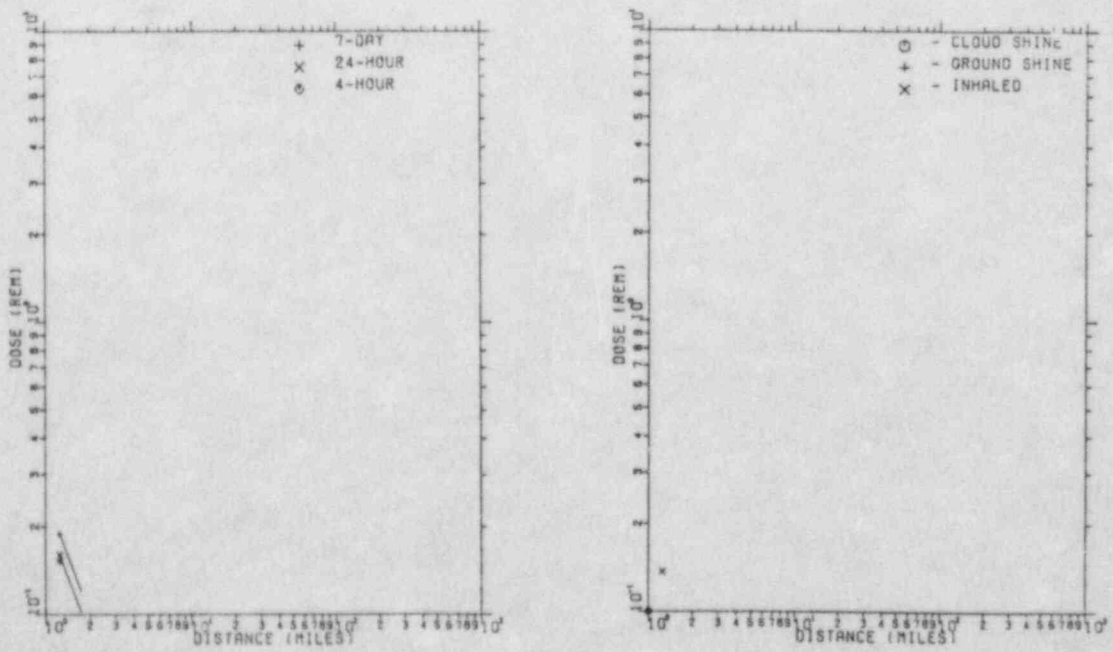


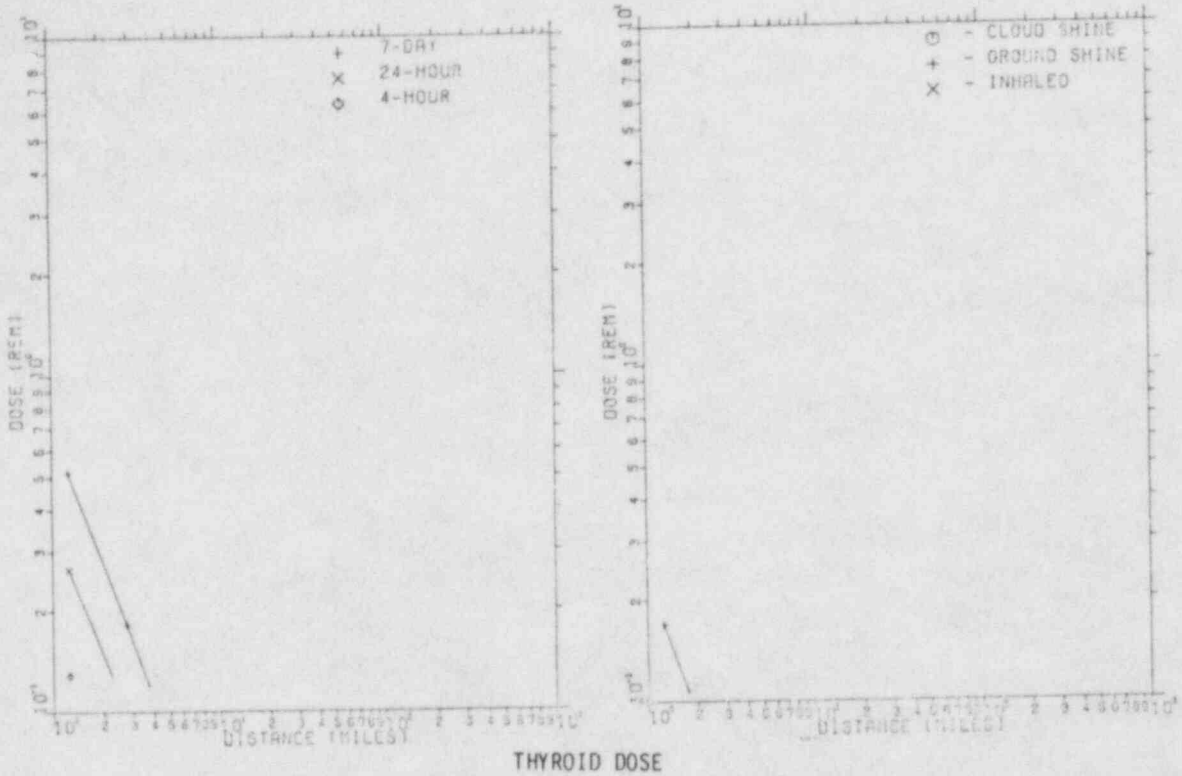
Figure 7-17

PWR #8
CASE 17

Stability Class: D
Windspeed: 16 mph

Rain: No
Sheltering: Yes

WHOLE BODY DOSE



THYROID DOSE

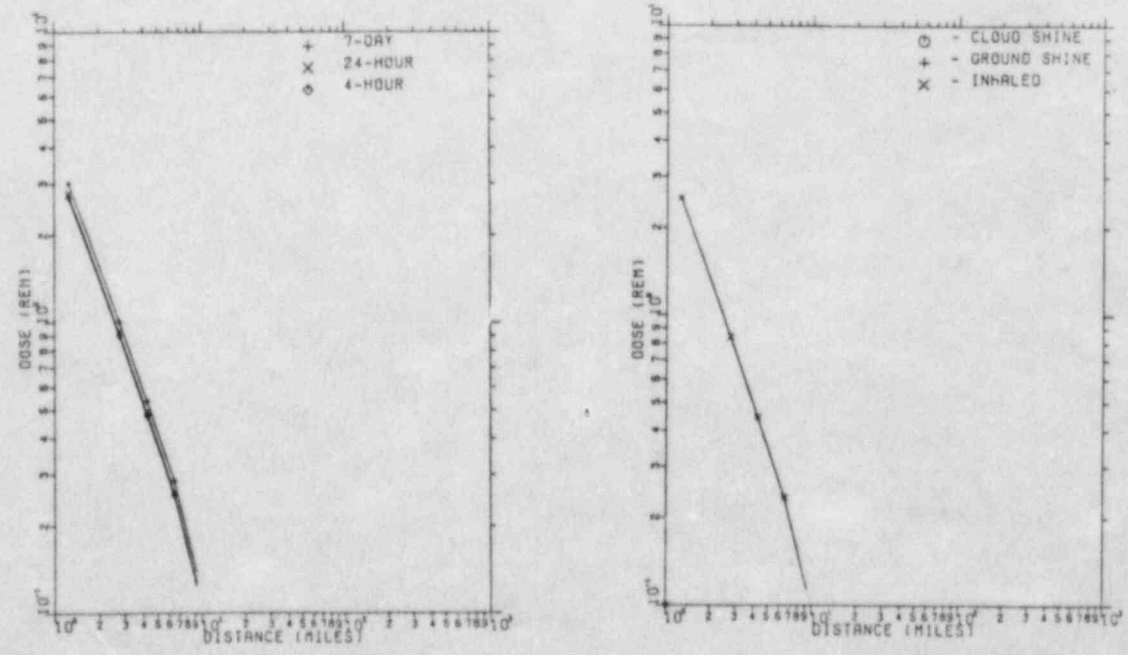


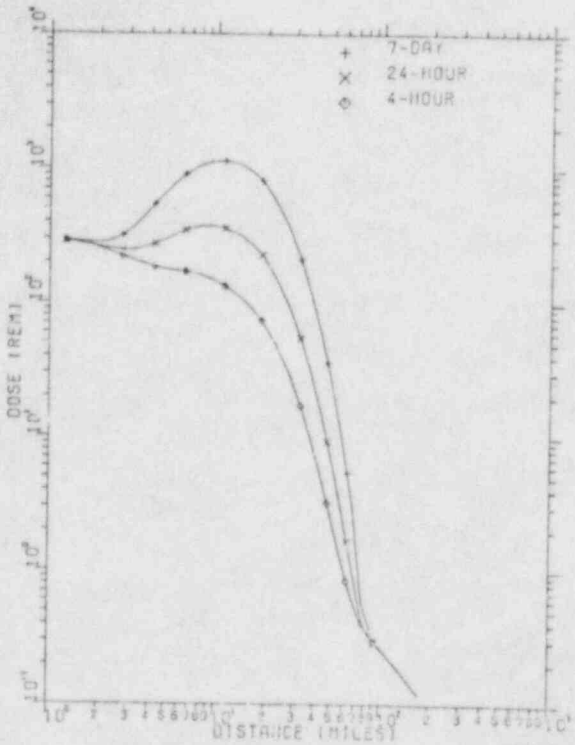
Figure 8-17

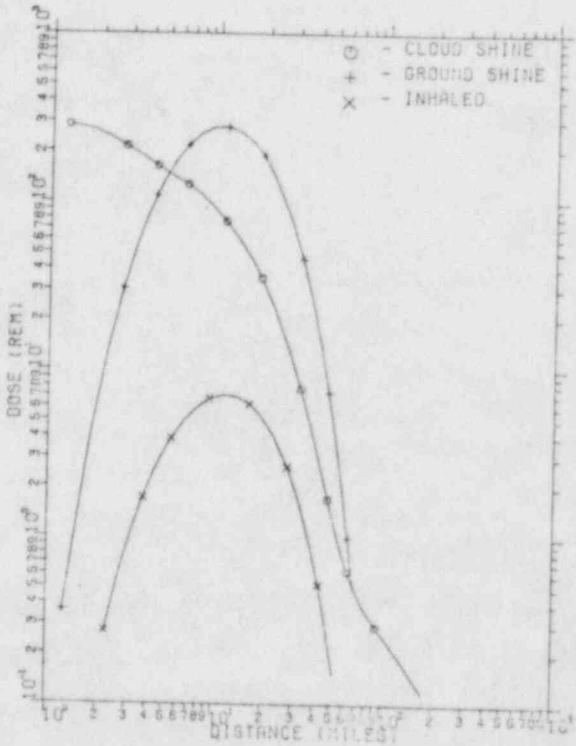
PWR # 1A
CASE 18

Stability Class: F
Windspeed: 1 mph

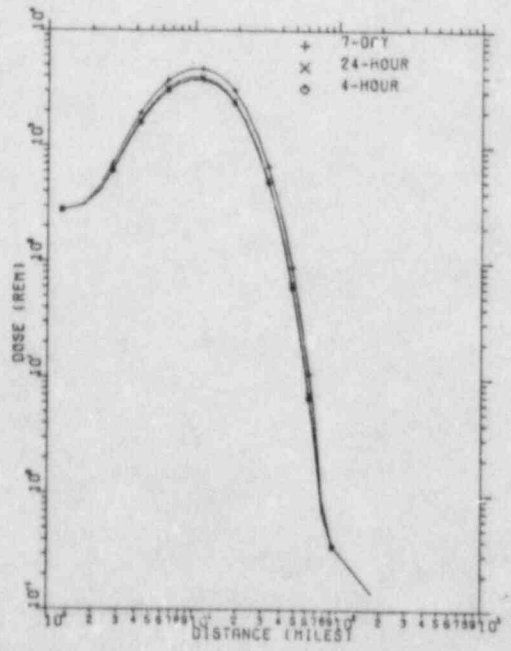
Rain: No
Sheltering: Yes

WHOLE BODY DOSE





THYROID DOSE



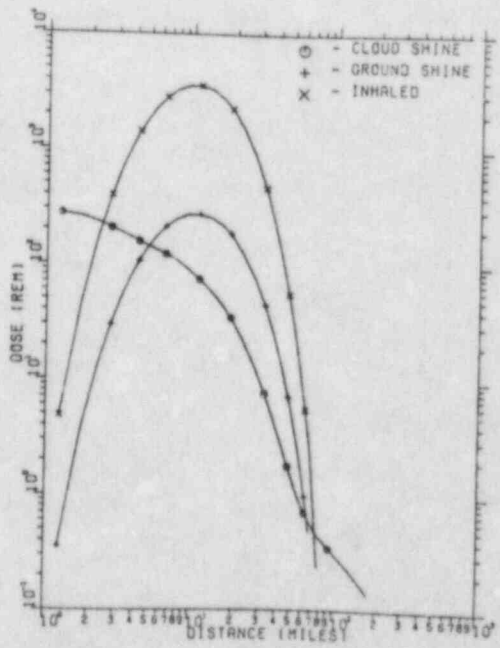


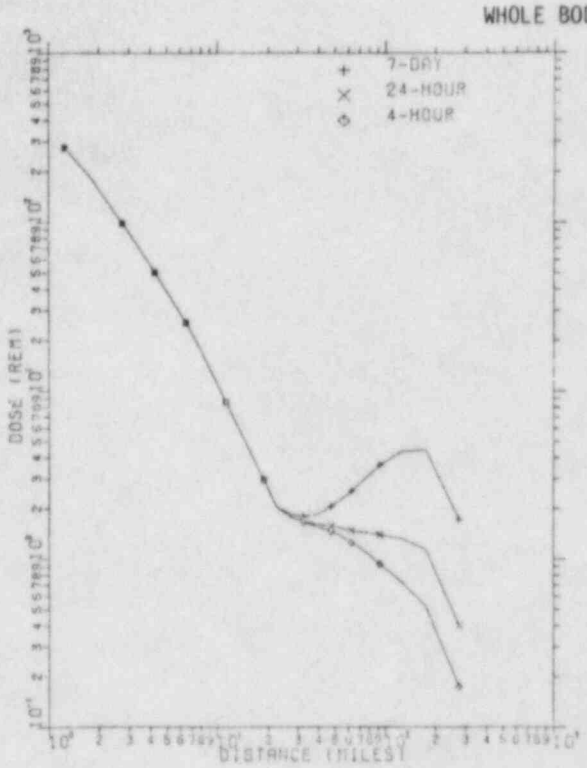
Figure 1A-18

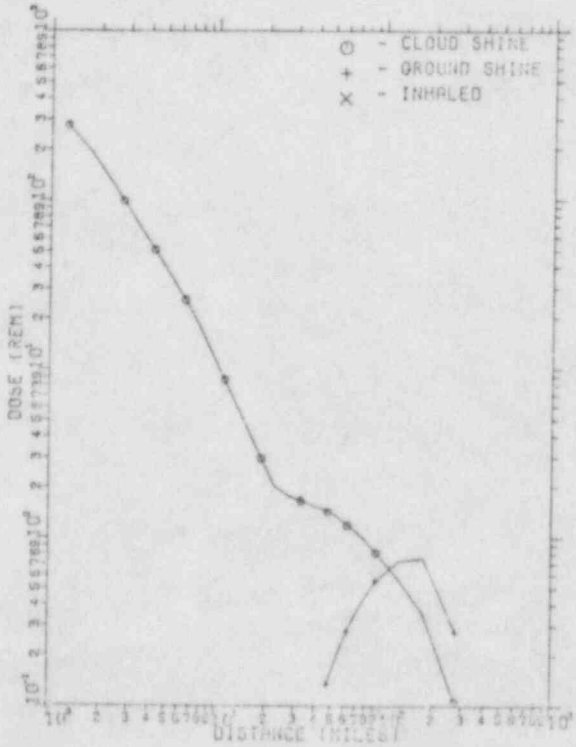
PWR # 1B
CASE 18

Stability Class: F
Windspeed: 1 mph

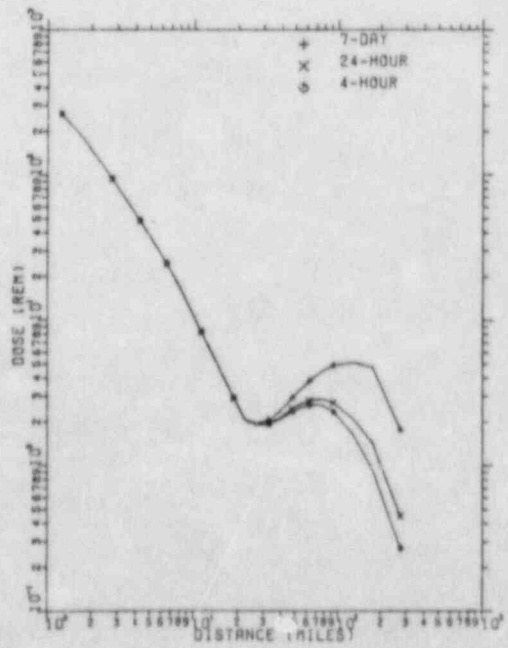
Rain: No
Sheltering: Yes

WHOLE BODY DOSE





THYROID DOSE



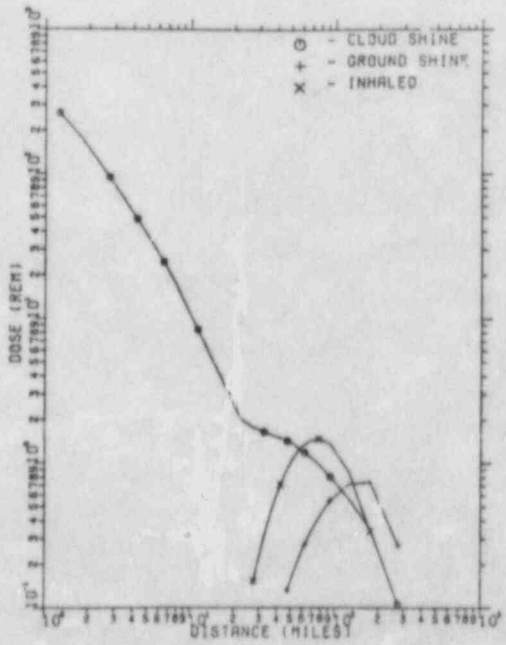


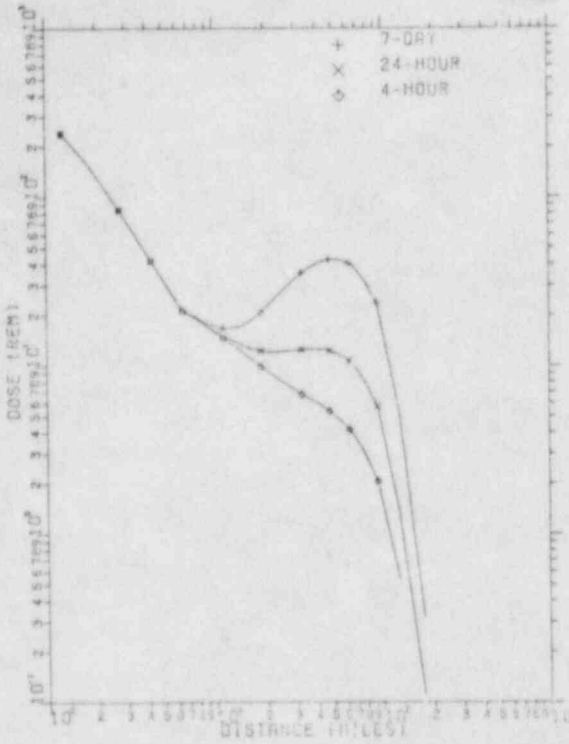
Figure 18-18

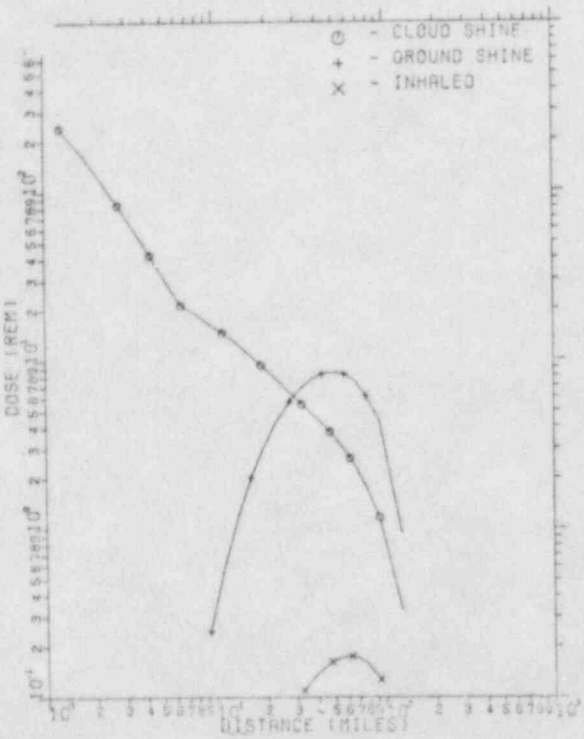
PWR #2
CASE 18

Stability Class: F
Windspeed: 1 mph

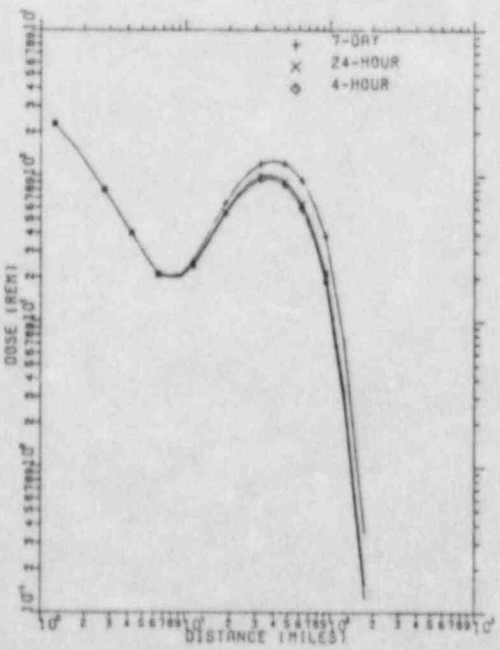
Rain: No
Sheltering: Yes

WHOLE BODY DOSE





THYROID DOSE



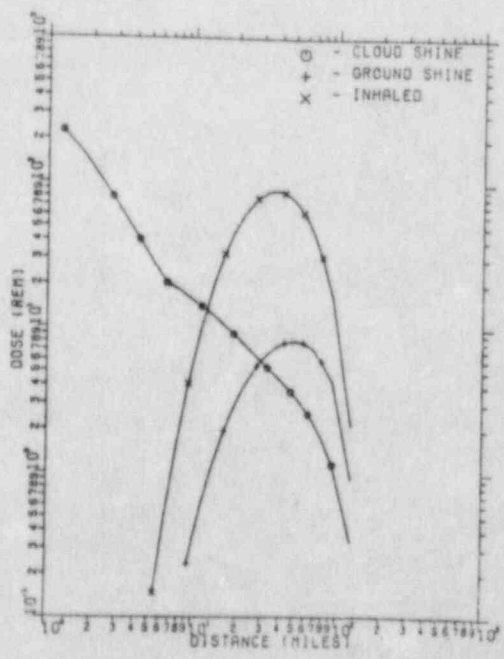


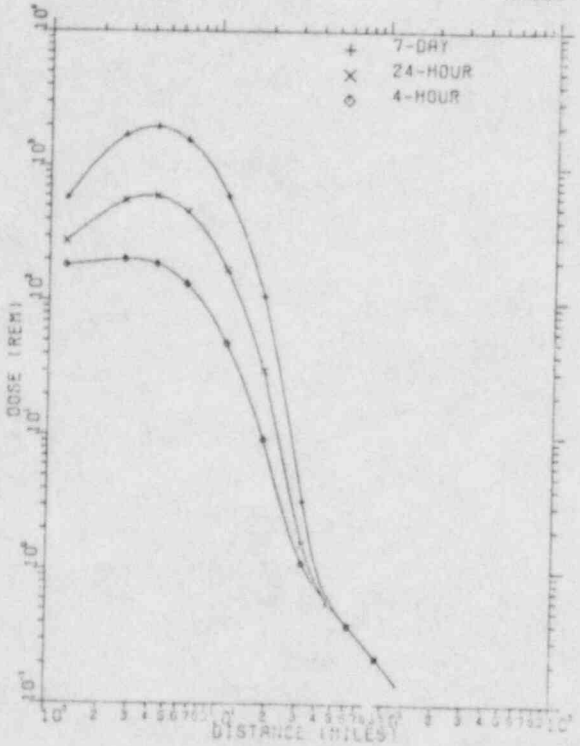
Figure 2-18

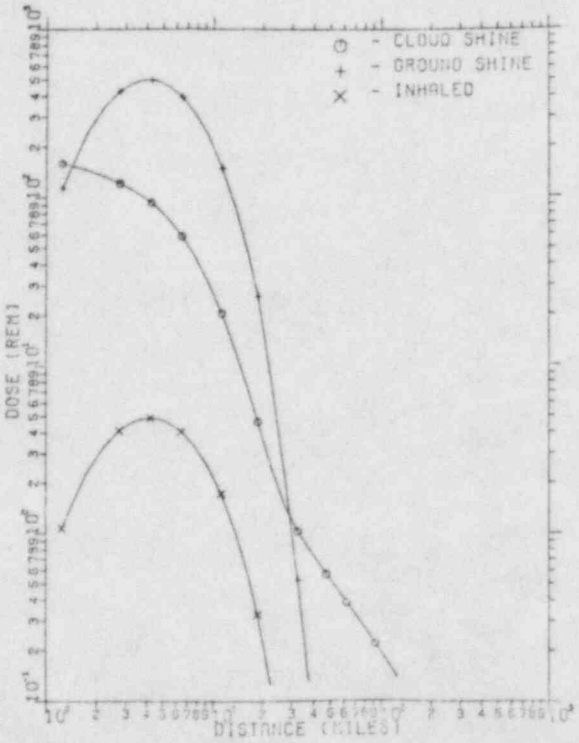
PWR #3
CASE 18

Stability Class: F
Windspeed: 1 mph

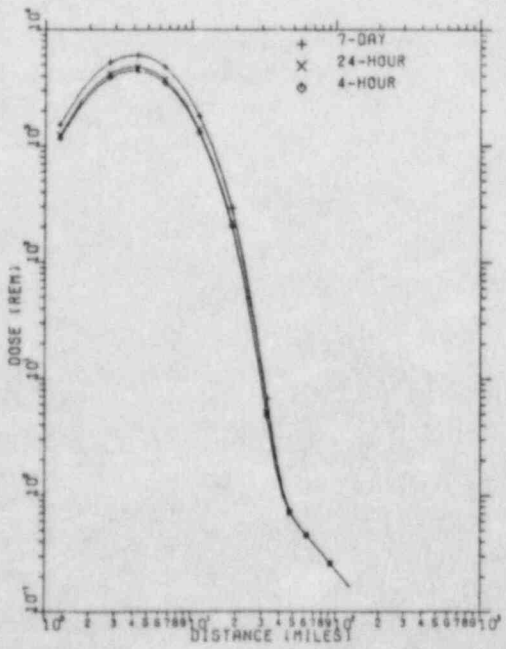
Rain: No
Sheltering: Yes

WHOLE BODY DOSE





THYROID DOSE



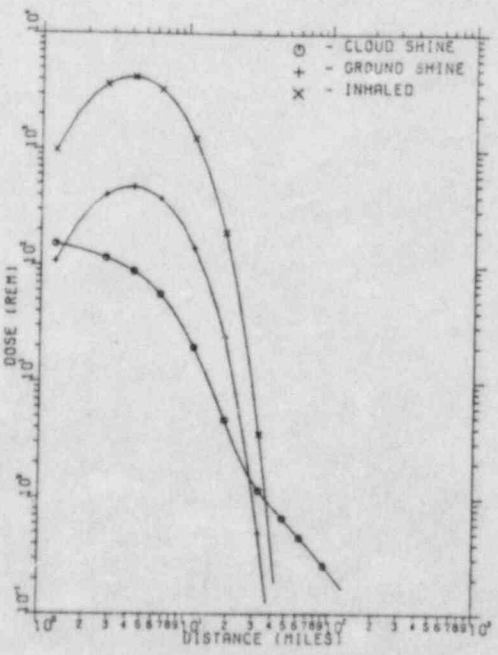


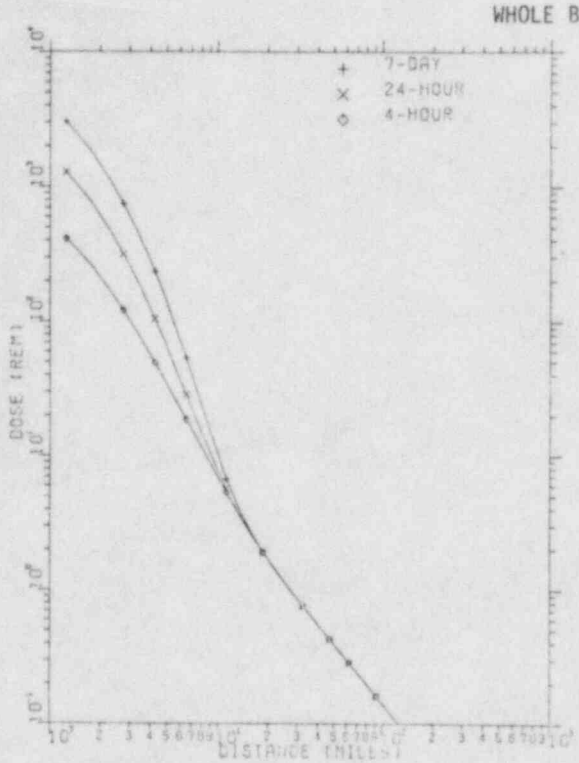
Figure 3-18

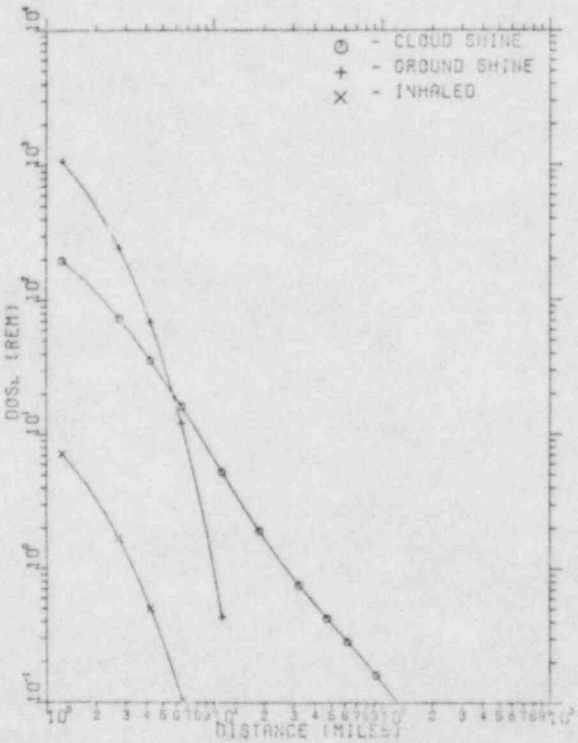
PWR #4
CASE T8

Stability Class: F
Windspeed: 1 mph

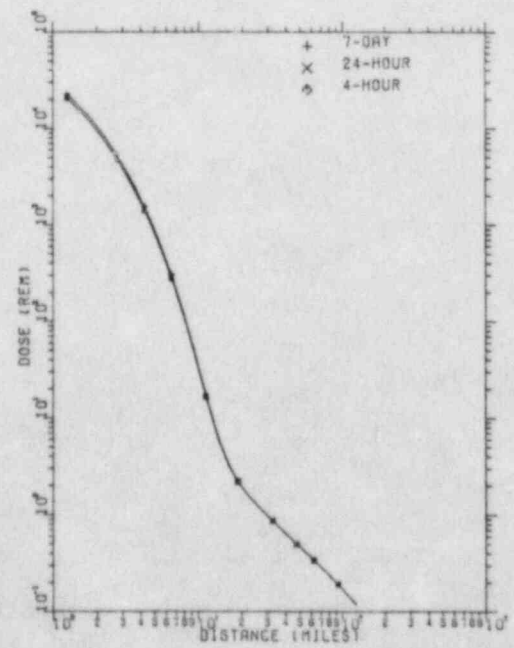
Rain: No
Sheltering: Yes

WHOLE BODY DOSE





THYROID DOSE



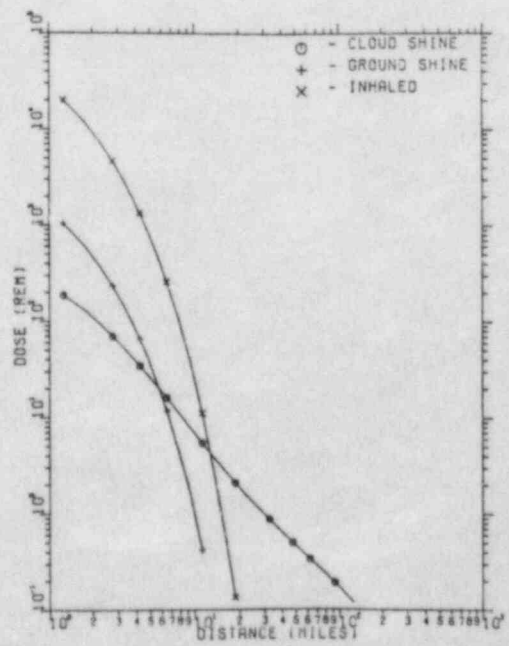


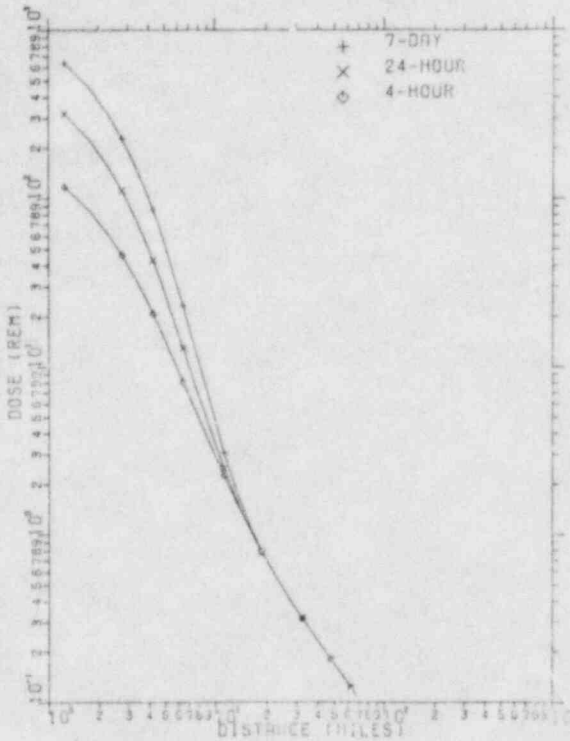
Figure 4-18

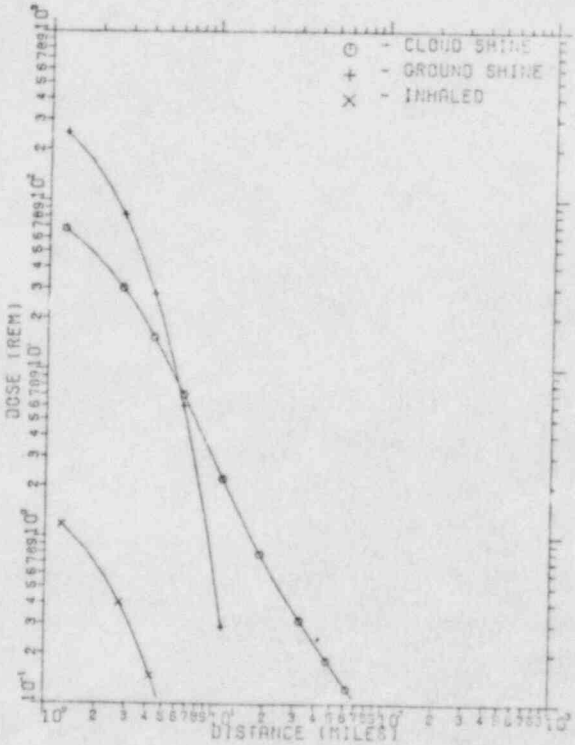
PWR # 5
CASE 18

Stability Class: F
Windspeed: 1 mph

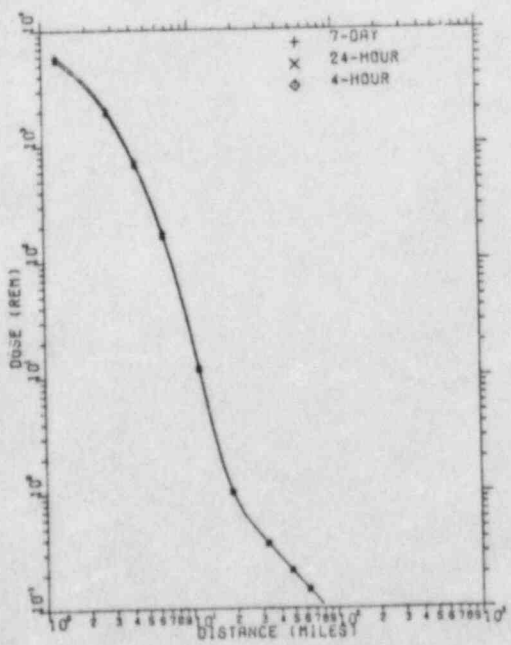
Rain: No
Sheltering: Yes

WHOLE BODY DOSE





THYROID DOSE



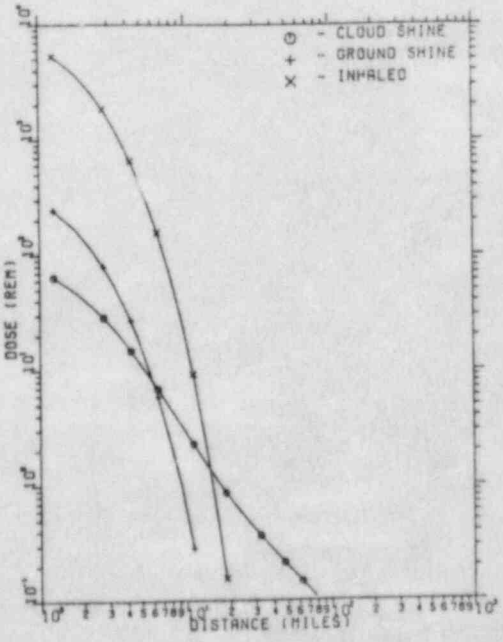


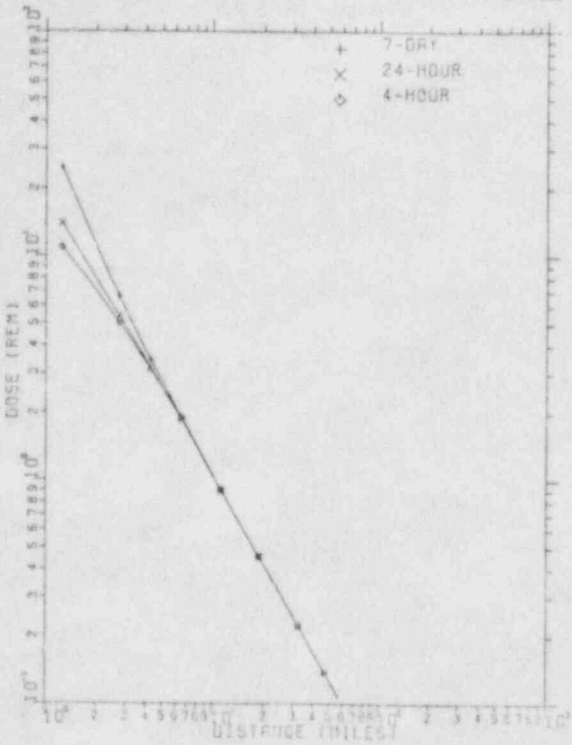
Figure 5-18

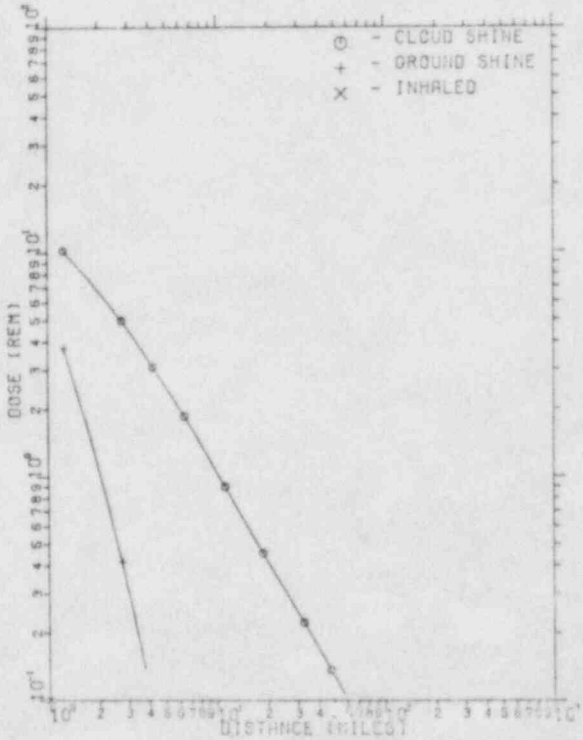
PWR # 6
CASE 18

Stability Class: F
Windspeed: 1 mph

Rain: No
Sheltering: Yes

WHOLE BODY DOSE





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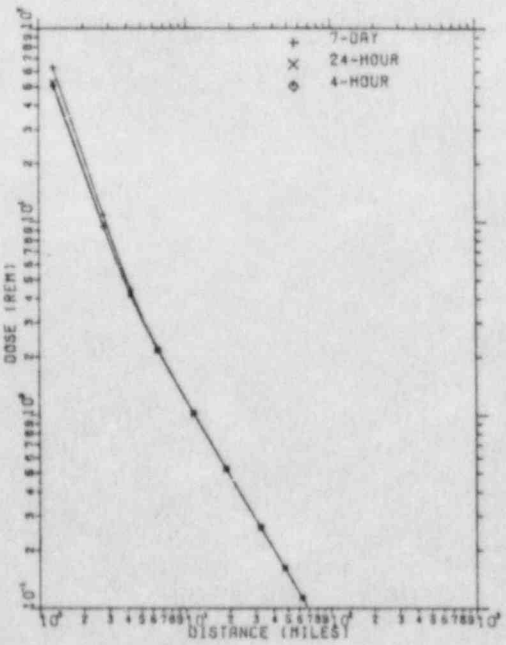


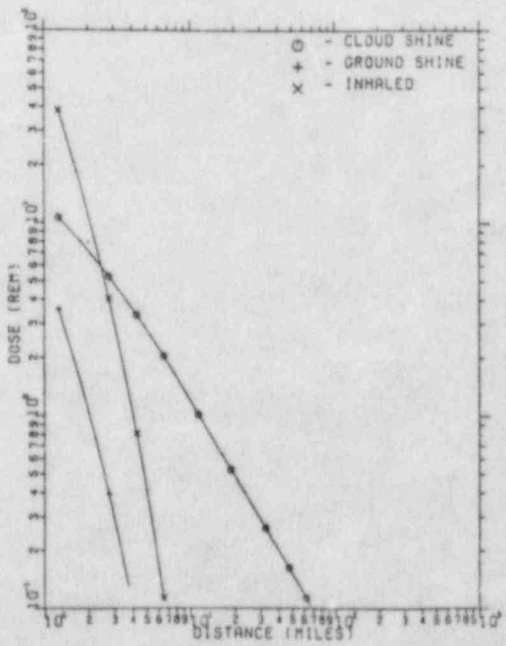


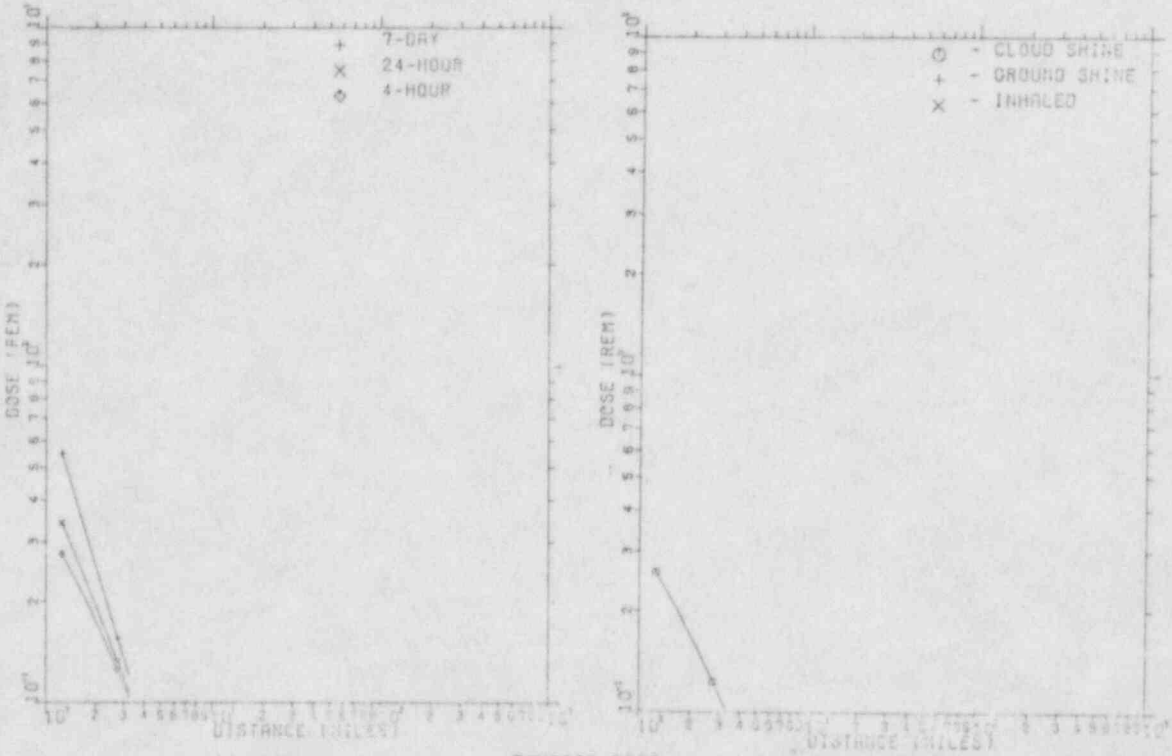
Figure 6-18

PWR # 7
CASE 18

Stability Class: F
Windspeed: 1 mph

Rain: No
Sheltering: Yes

WHOLE BODY DOSE



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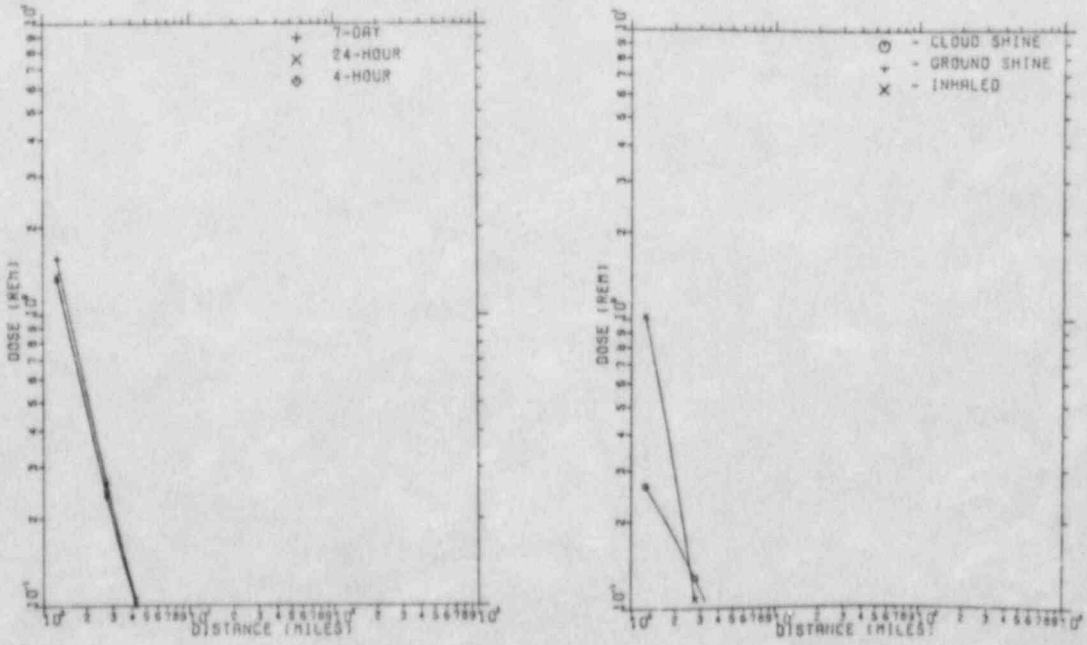


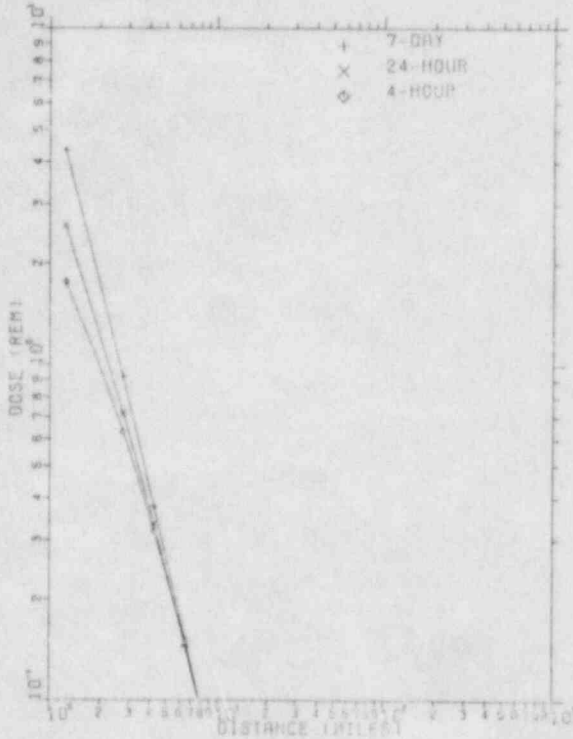
Figure 7-18

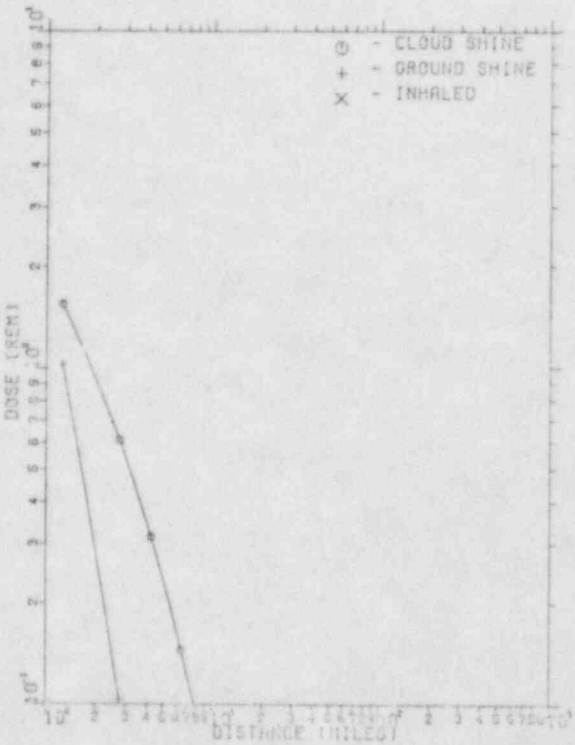
PWR #8
CASE T8

Stability Class: F
Windspeed: 1 mph

Rain: No
Sheltering: Yes

WHOLE BODY DOSE





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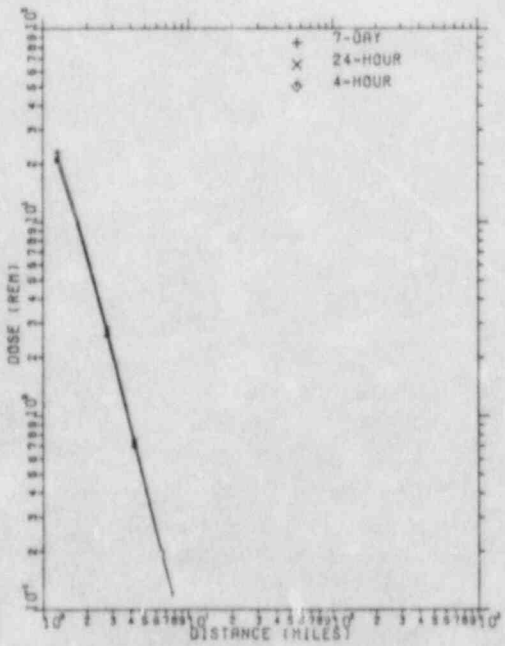


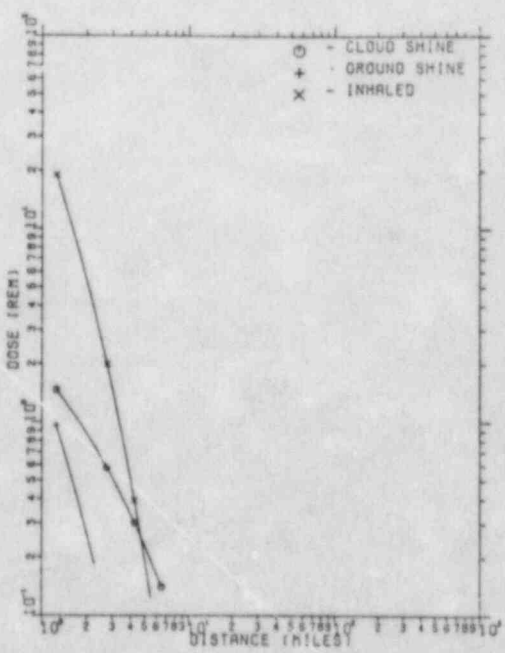


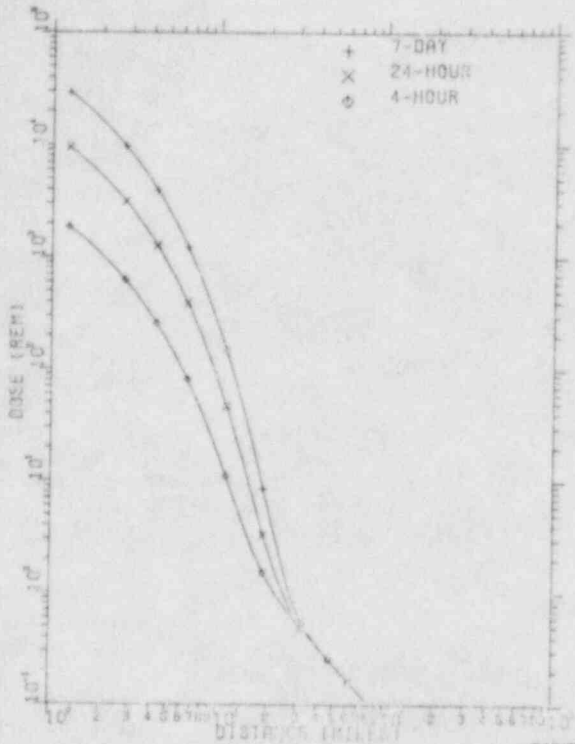
Figure 8-18

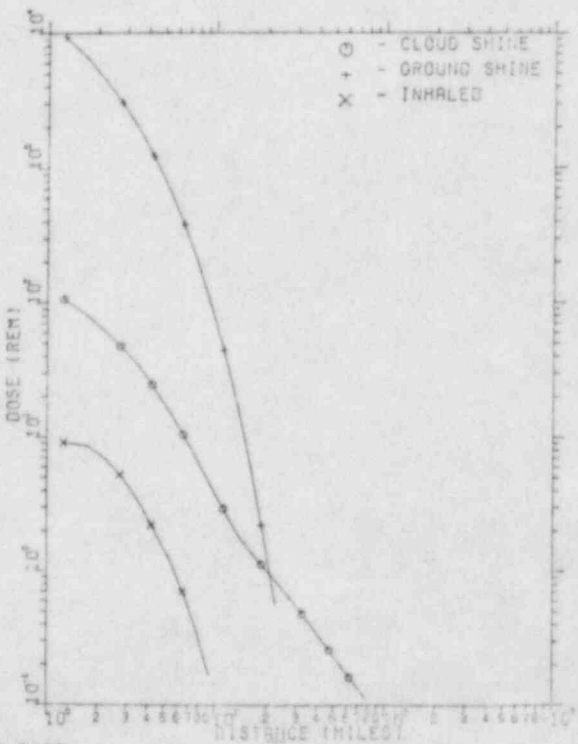
PWR # 1A
CASE 19

Stability Class: D
Windspeed: 6 mph

Rain: Yes
Sheltering: Yes

WHOLE BODY DOSE





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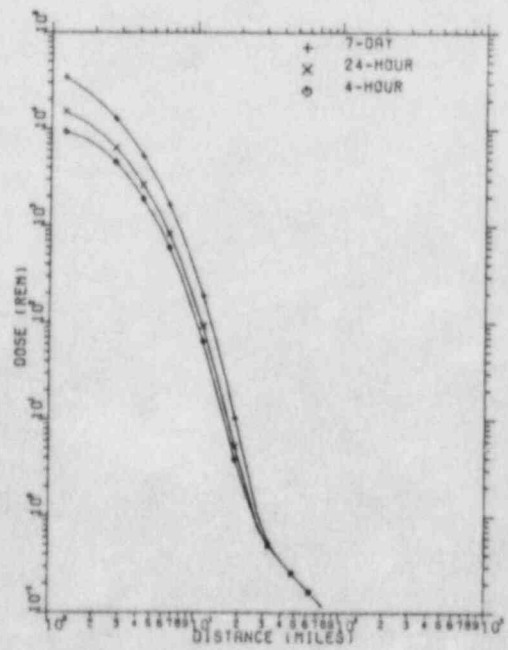


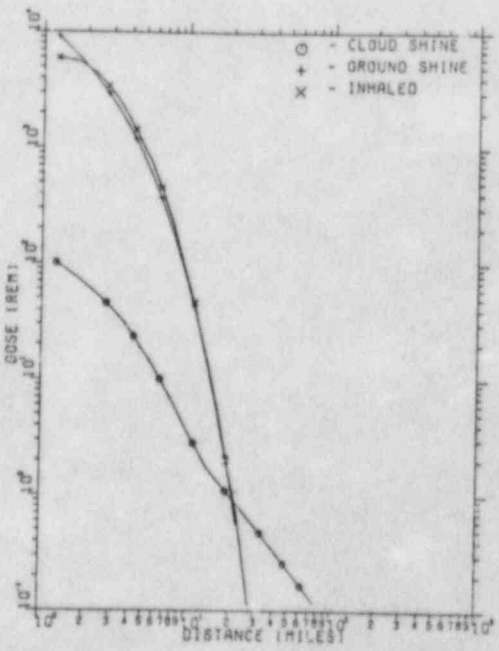


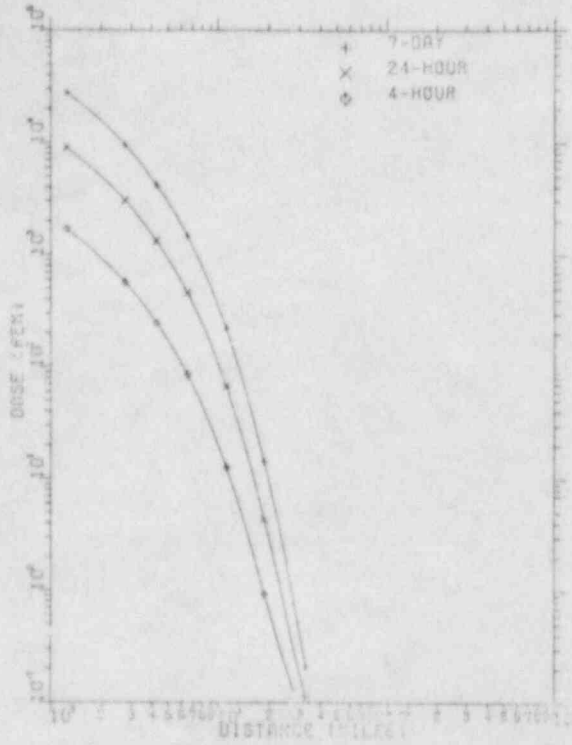
Figure 1A-19

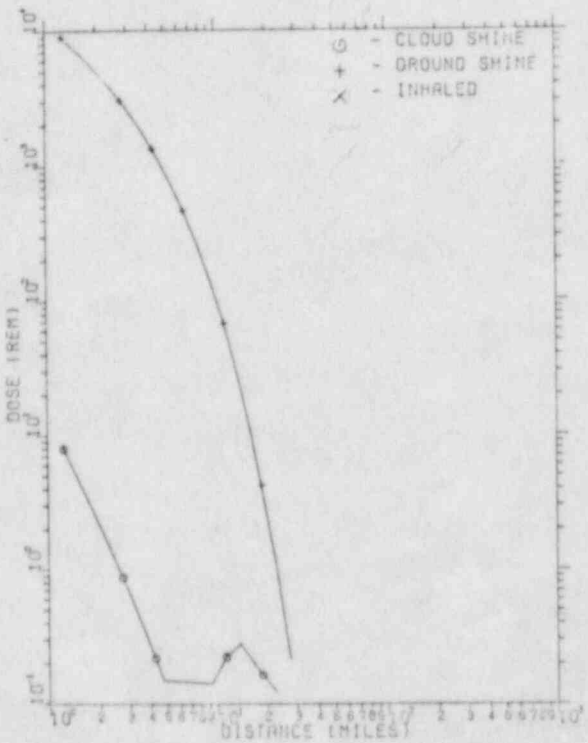
PWR # 1B
CASE 19

Stability Class: D
Windspeed: 6 mph

Rain: Yes
Sheltering: Yes

WHOLE BODY DOSE





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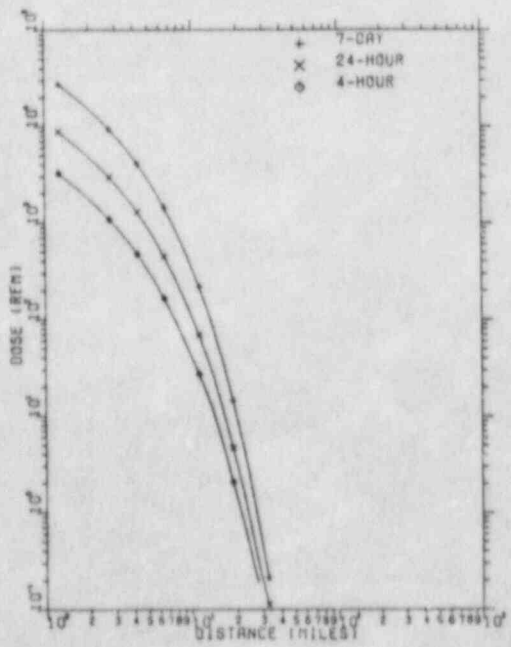


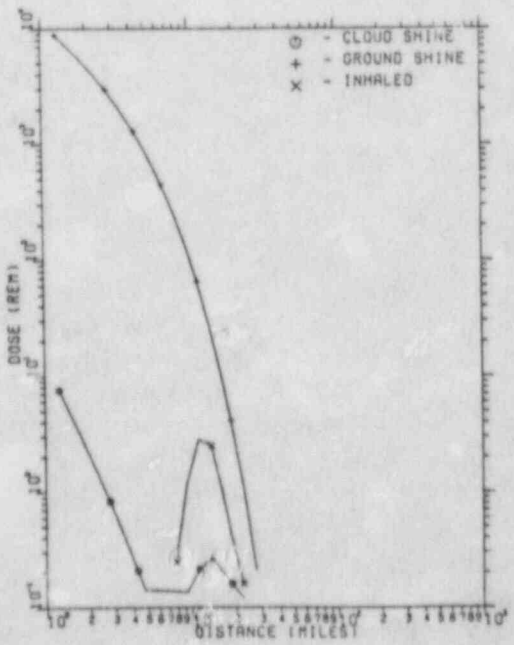


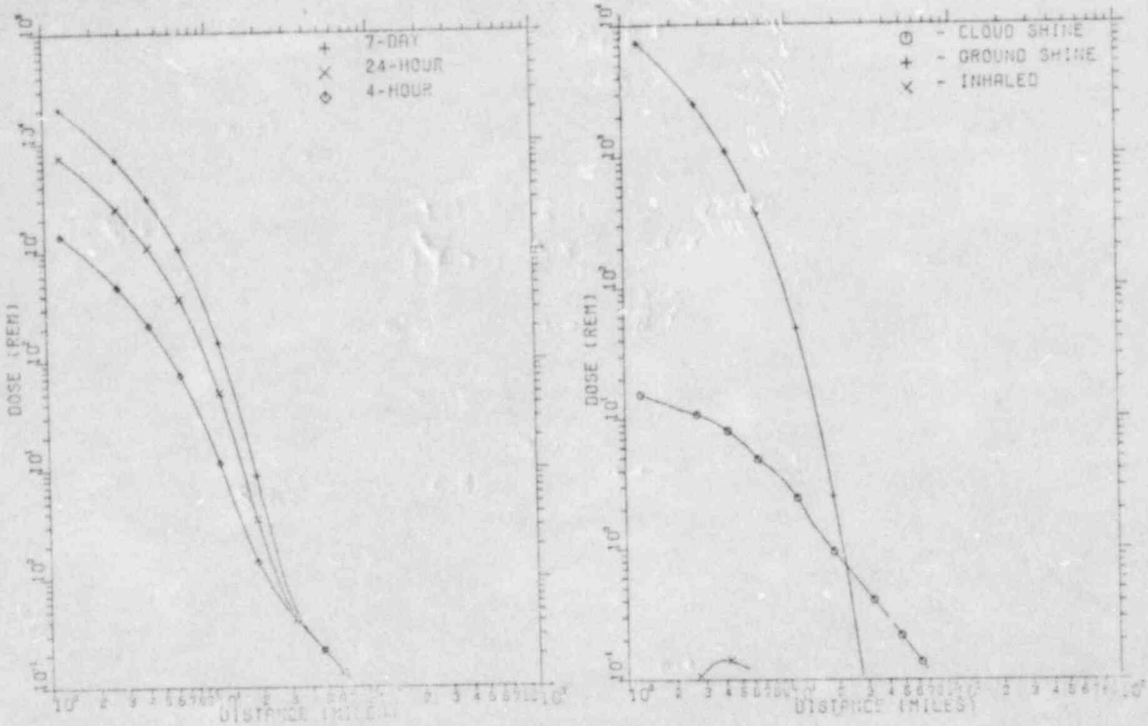
Figure 18-19

PWR # 2
CASE T9

Stability Class: D
Windspeed: 6 mph

Rain: Yes
Sheltering: Yes

WHOLE BODY DOSE



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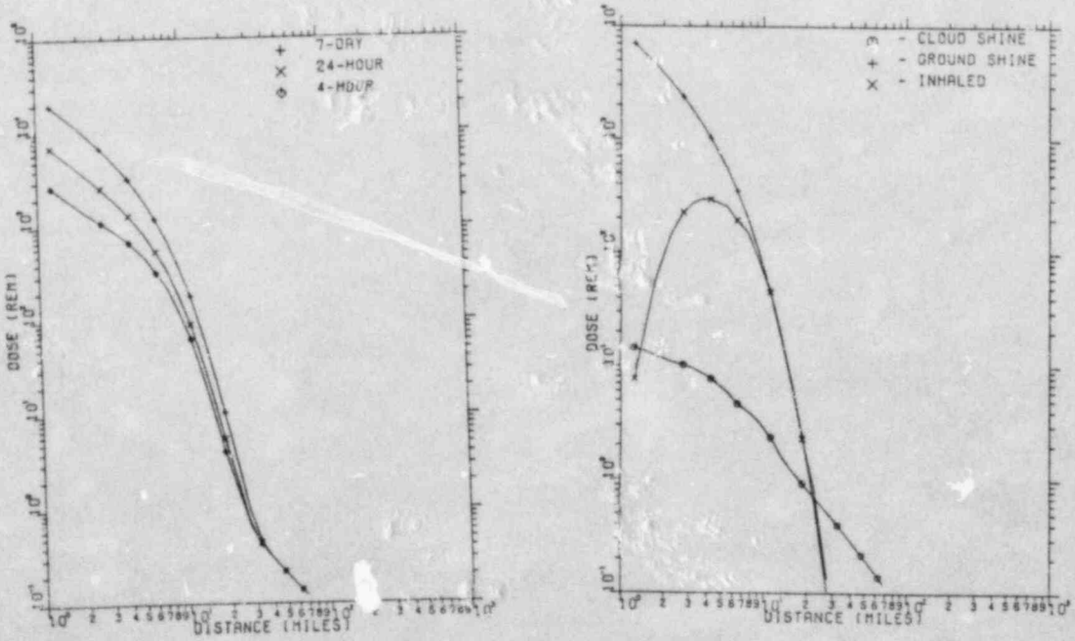


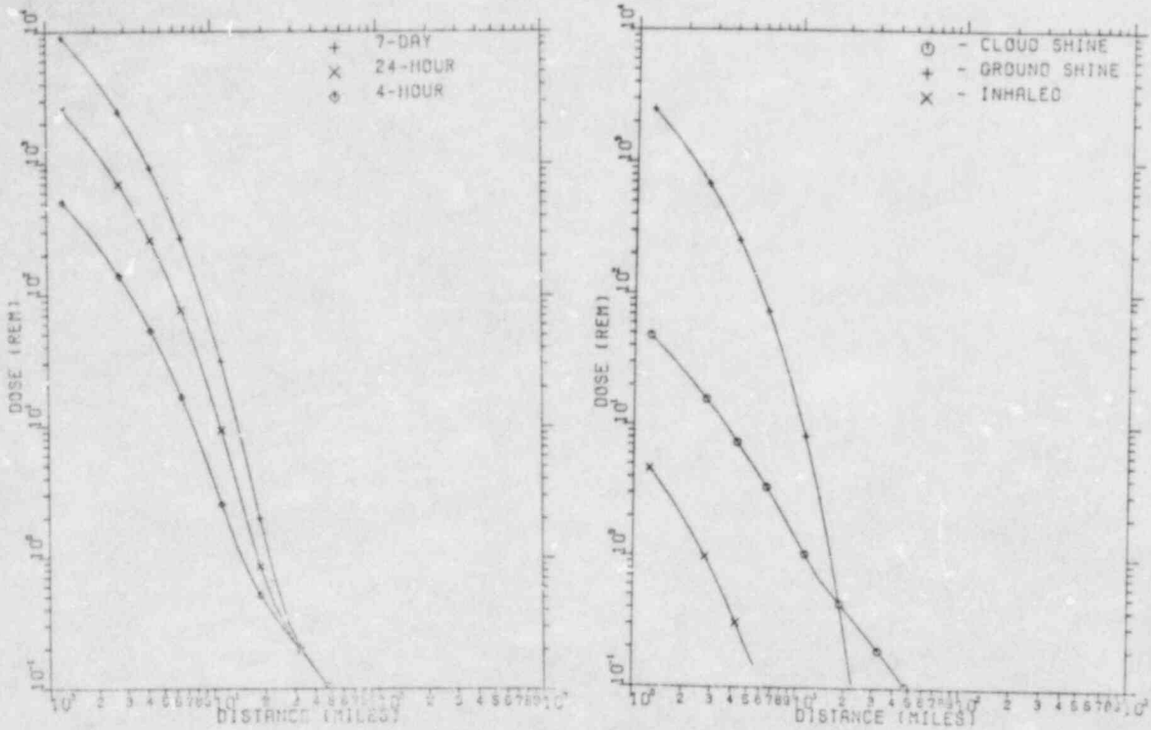
Figure 2-19

PWR # 3
CASE 19

Stability Class: D
Windspeed: 6 mph

Rain: Yes
Sheltering: Yes

WHOLE BODY DOSE



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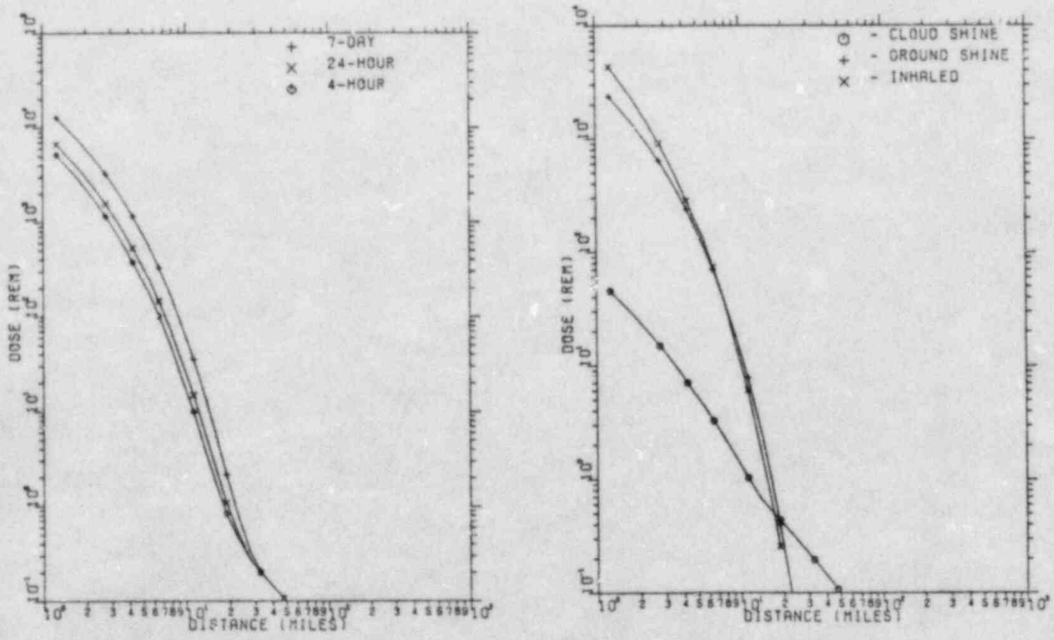


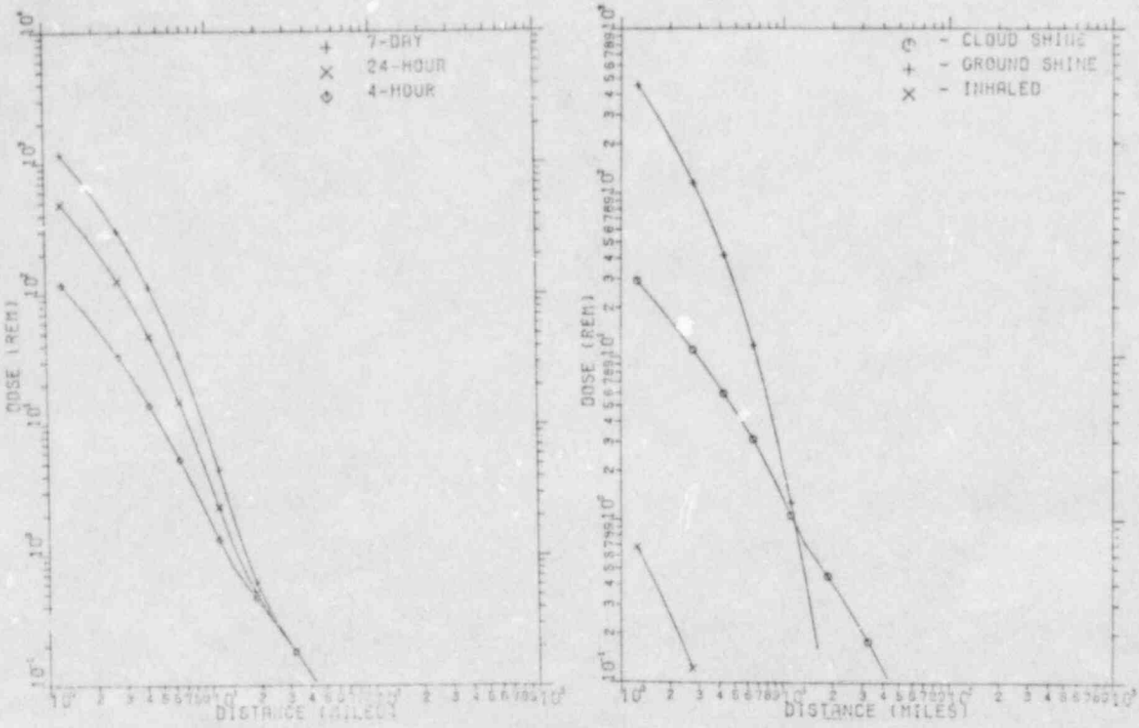
Figure 3-19

PWR #4
CASE 19

Stability Class: D
Windspeed: 6 mph

Rain: Yes
Sheltering: Yes

WHOLE BODY DOSE



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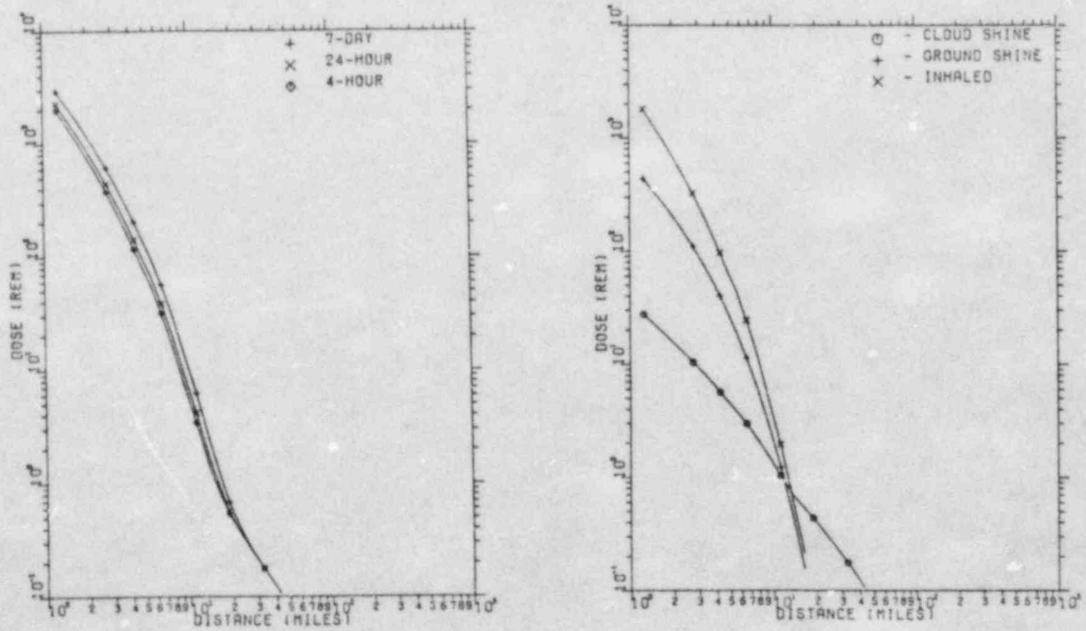


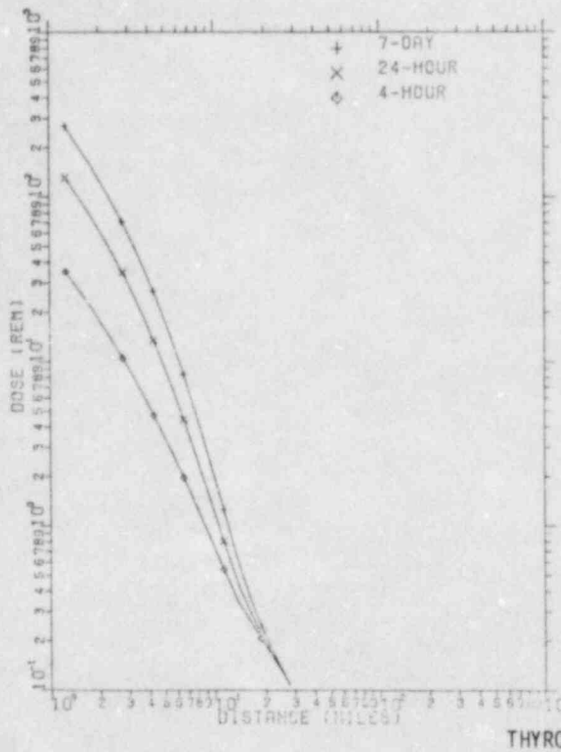
Figure 4-15

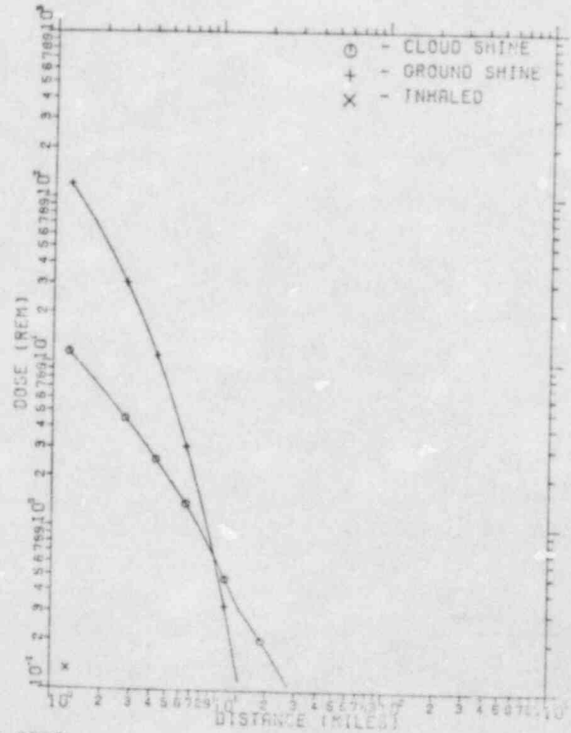
PWR # 5
CASE T9

Stability Class: D
Windspeed: 6 mph

Rain: Yes
Sheltering: Yes

WHOLE BODY DOSE





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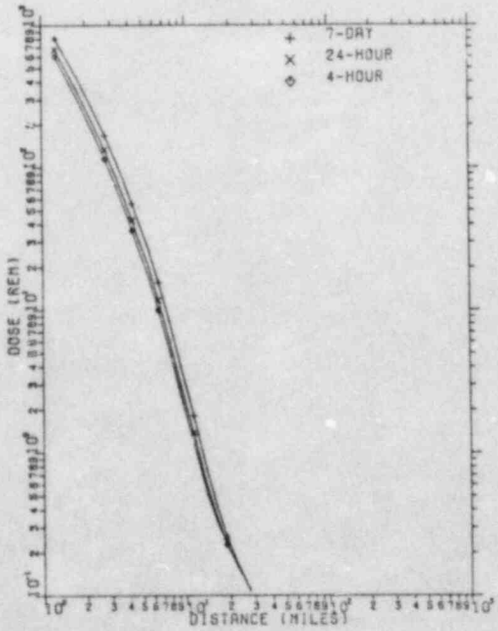


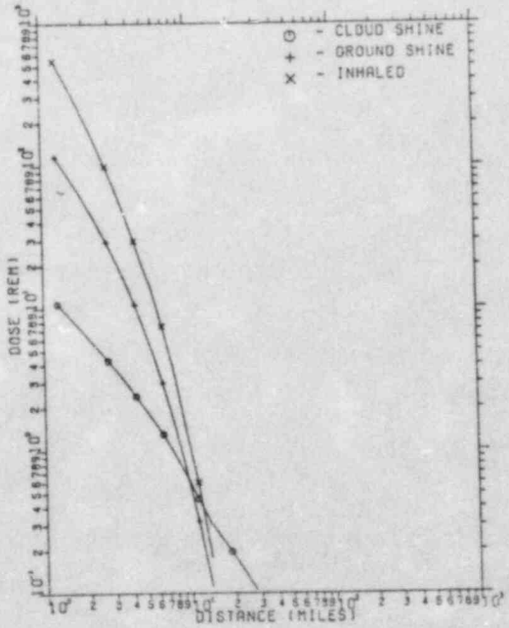


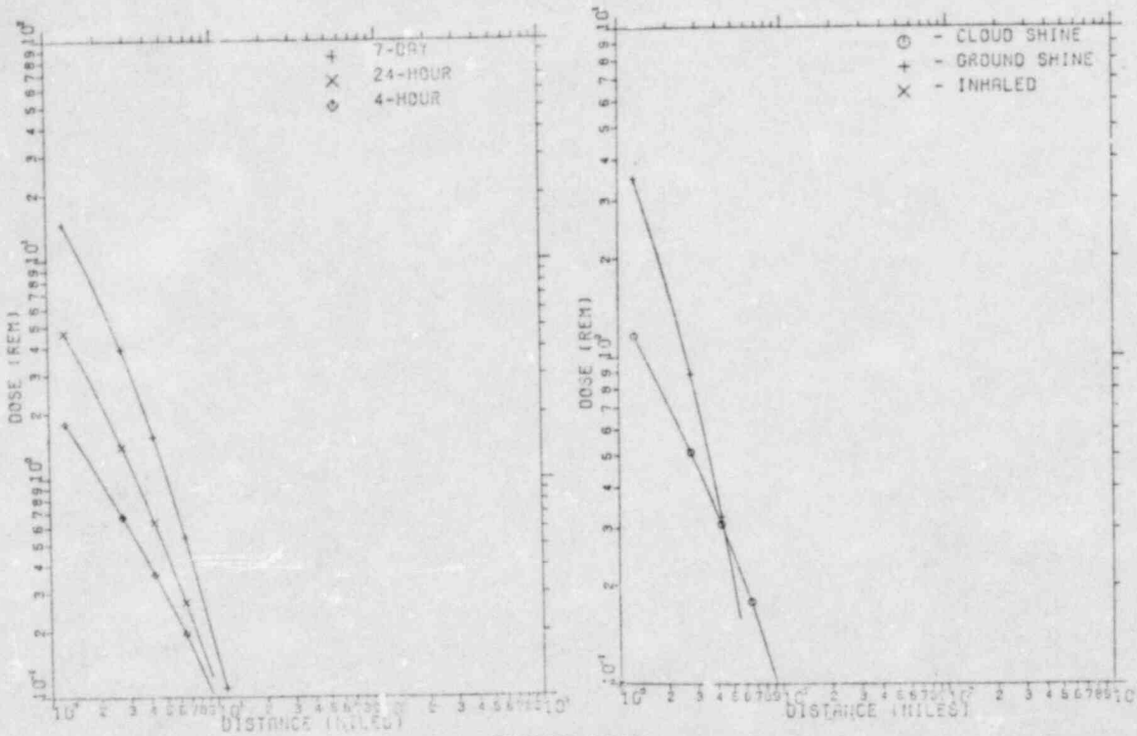
Figure 5-19

PWR # 6
CASE 19

Stability Class: D
Windspeed: 6 mph

Rain: Yes
Sheltering: Yes

WHOLE BODY DOSE



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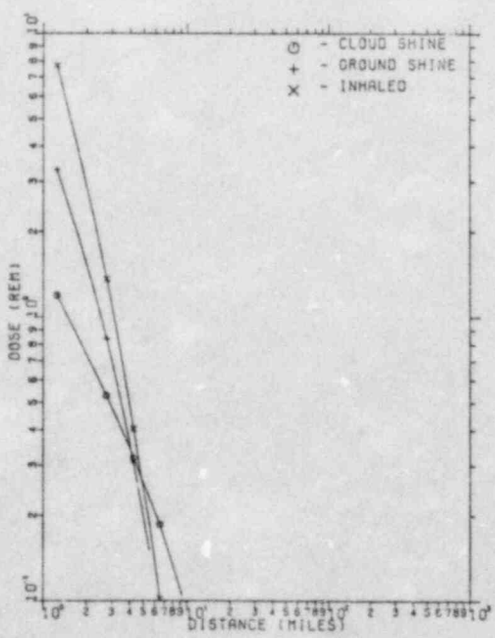


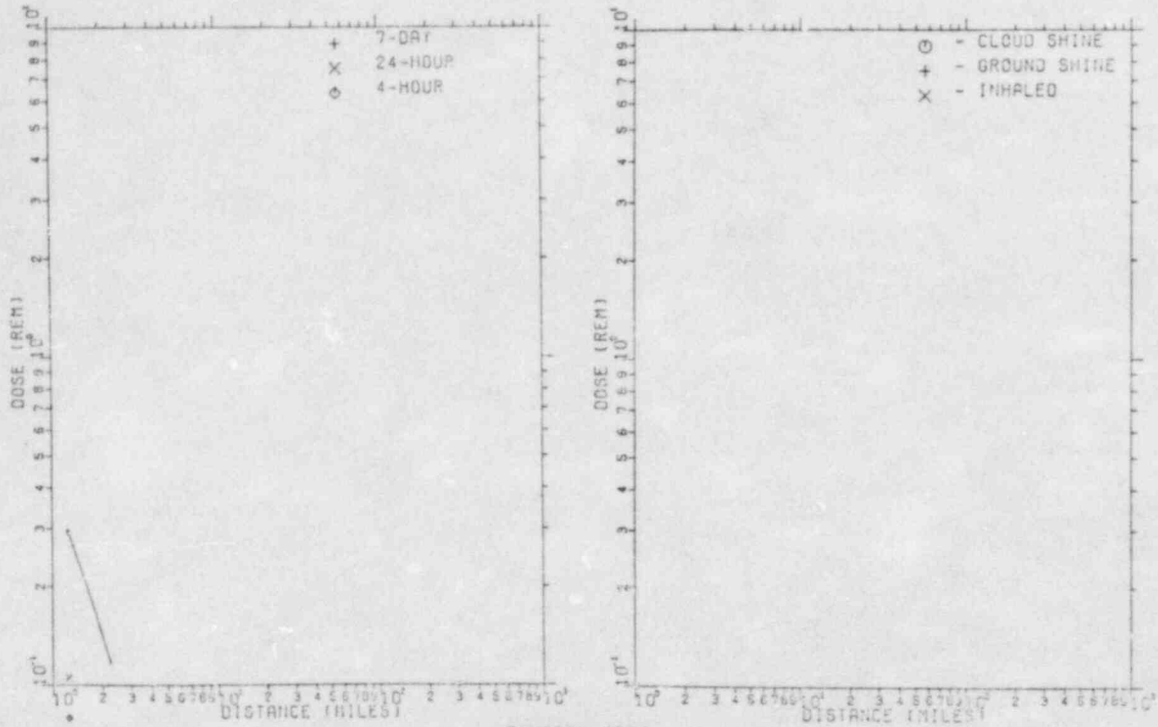
Figure 6-19

PWR # 7
CASE 19

Stability Class: D
Windspeed: 6 mph

Rain: Yes
Sheltering: Yes

WHOLE BODY DOSE



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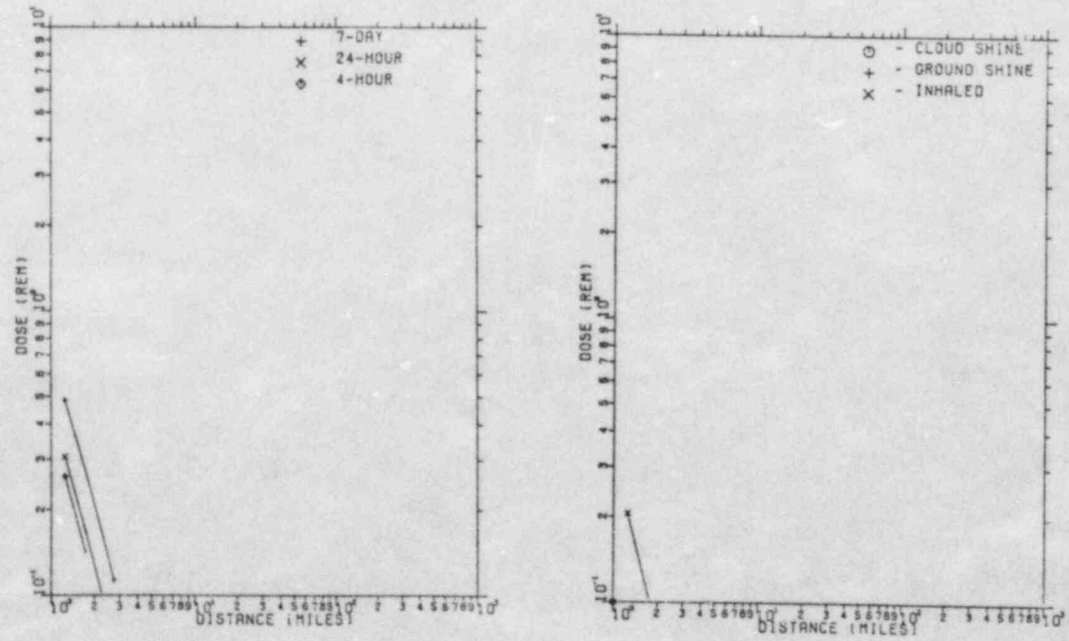


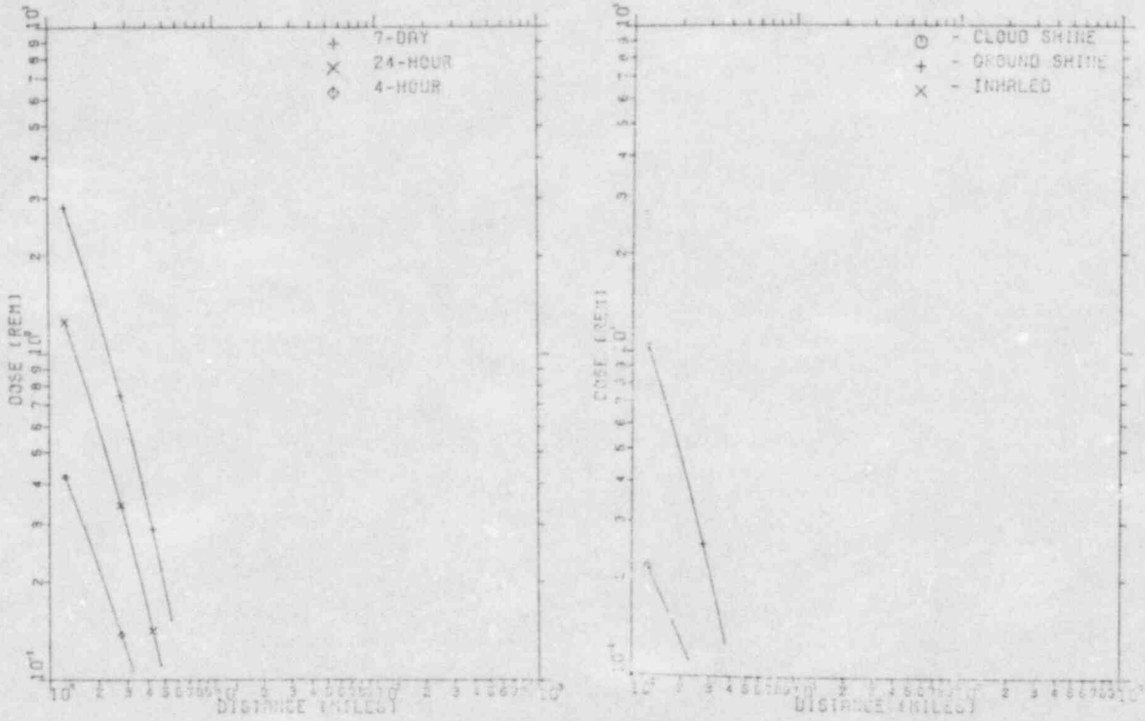
Figure 7-19

PWR # 8
CASE 19

Stability Class: D
Windspeed: 6 mph

Rain: Yes
Sheltering: Yes

WHOLE BODY DOSE



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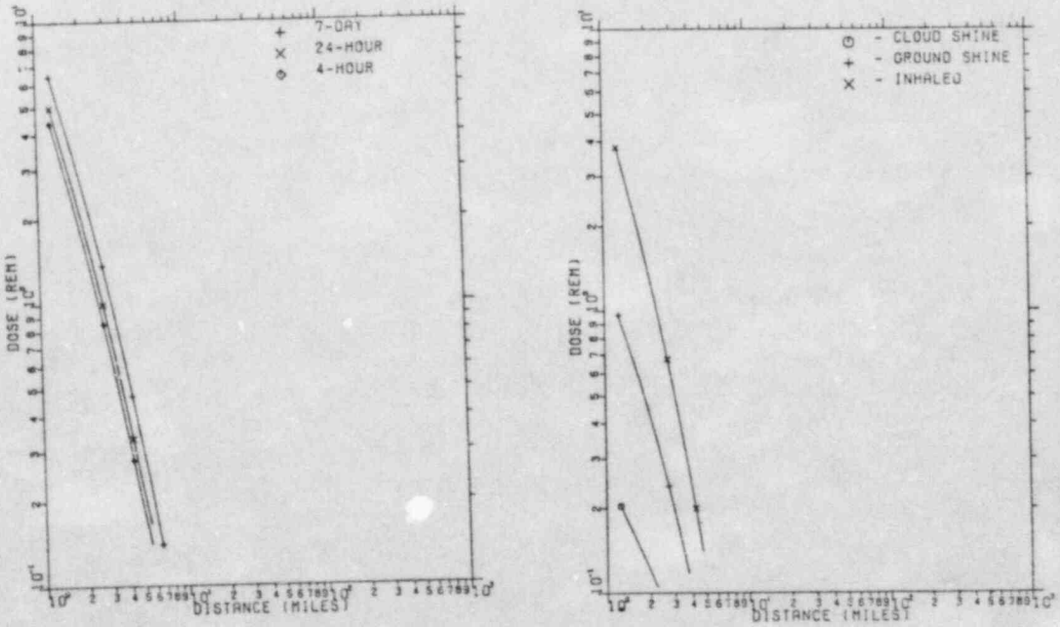


Figure 8-19

Appendix B

LWR Accident Categories and Release Sequences

To help the reader understand the postulated accident sequences, this section presents brief descriptions of the various physical processes that define each release category. For more detailed information on the release categories and the techniques employed to compute the radioactive releases to the atmosphere, the reader is referred to Appendices V, VI, VII, and VIII of the RSS. The dominant event tree sequences in each category are discussed in detail in Section 4.6 of Appendix V of WASH-1400.

In subsequent sections of this Appendix colloquial descriptions of the PWR and BWR severe accident sequences of the Reactor Safety Study will be presented. As an introduction, the information illustrated in Figure B.1 will be discussed. This figure illustrates the various ways in which a major release to the atmosphere can occur. Four paths are shown between an initiating event and a major release to the atmosphere. Each of these four paths would involve a failure of systems that are designed to protect the core and the containment. If the containment does not fail, offsite doses would be very low regardless of the status of a core. This condition is not shown in the figure. If the core is not damaged, doses would be low also, approaching routine operational release limits. This normal conditon is not shown either. The figure pertains to the ways in which a severe accident sequence could evolve, from a big block overview perspective.

Examination of Figure B.1 will show that four core melt/containment failure combinations can occur:

- Core melt followed by containment failure;
- Containment failure followed by core melt;
- Simultaneous failure of all cooling modes, with core melt and containment failure occurring almost simultaneously; and
- Containment bypass scenarios, where releases from the core travel through open plumbing paths to the atmosphere, leaving the containment relatively clear.

For each of these cases, a spectrum of releases and timings of releases can occur.

It will be helpful to keep this overview in mind when perusing the Reactor Safety Study PWR and BWR sequences described below. These descriptions were taken virtually verbatim from the Reactor Safety Study:

PWR 1

This release category can be characterized by a core meltdown followed by a steam explosion on contact of molten fuel with residual water in the reactor vessel. The containment spray and heat removal systems are also assumed to have failed and, therefore, the containment could be at a pressure above ambient at

the time of the steam explosion. It is assumed that the steam explosion* would rupture the upper portion of the reactor vessel and breach the containment barrier, with the result that a substantial amount of radioactivity might be released from the containment in a puff over a period of about 10 minutes. Due to the sweeping action of gases generated during containment-vessel meltthrough, the release of radioactive materials would continue at a relatively low rate thereafter. The total release would contain approximately 70 percent of the iodines and 40 percent of the alkali metals present in the core at the time of release. Because the containment would contain hot pressurized gases at the time of failure, a relatively high release rate of sensible energy from the containment could be associated with this category. This category also includes certain potential accident sequences that would involve the occurrence of core melting and a steam explosion after containment rupture due to overpressure. In these sequences, the rate of energy release would be lower, although still relatively high.

PWR 2

This category is associated with the failure of core-cooling systems and core melting** concurrent with the failure of containment spray and heat-removal systems. Failure of the containment barrier would occur through overpressure, causing a substantial fraction of the containment atmosphere to be released in a puff over a period of about 30 minutes. Due to the sweeping action of gases generated during containment vessel meltthrough, the release of radioactive material would continue at a relatively low rate thereafter. The total release would contain approximately 70 percent of the iodines and 50 percent of the alkali metals present in the core at the time of release. As in PWR release category 1, the high temperature and pressure within containment at the time of containment failure would result in a relatively high release rate of sensible energy from the containment.

PWR 3

This category involves an overpressure failure of the containment due to failure of containment heat removal. Containment failure would occur prior*** to the commencement of core melting. Core melting then would cause radioactive materials to be released through a ruptured containment barrier. Approximately 20 percent of the iodines and 20 percent of the alkali metals present in the core at the time of release would be released to the atmosphere. Most of the release would occur over a period of about 1.5 hours. The release of radioactive material from containment would be caused by the sweeping action of gases generated by the reaction of the molten fuel with concrete. Since these gases would be heated initially by contact with the melt, the rate of sensible energy release to the atmosphere would be moderately high.

*Currently, the massive steam explosion is not considered credible.
**Core melt should be distinguished from fuel melt.
***Emphasis added.

PWR 4

This category involves failure of the core-cooling system and the containment spray injection system after a loss-of-coolant accident, together with a concurrent failure of the containment system to properly isolate. This would result in the release of 9 percent of the iodines and 4 percent of the alkali metals present in the core at the time of release. Most of the release would occur continuously over a period of 2 to 3 hours. Because the containment recirculation spray and heat-removal systems would operate to remove heat from the containment atmosphere during core melting, a relatively low rate of release of sensible energy would be associated with this category.

PWR 5

This category involves failure of the core cooling systems and is similar to PWR release category 4, except that the containment spray injection system would operate to further reduce the quantity of airborne radioactive material and to initially suppress containment temperature and pressure. The containment barrier would have a large leakage rate due to a concurrent failure of the containment system to properly isolate, and most of the radioactive material would be released continuously over a period of several hours. Approximately 3 percent of the iodines and 0.9 percent of the alkali metals present in the core would be released. Because of the operation of the containment heat-removal systems, the energy release rate would be low.

PWR 6

This category involves a core meltdown due to failure in the core cooling systems. The containment sprays would not operate, but the containment barrier would retain its integrity until the molten core proceeded to melt through the concrete containment base mat. The radioactive materials would be released into the ground, with some leakage to the atmosphere occurring upward through the ground. Direct leakage to the atmosphere would also occur at a low rate prior to containment-vessel meltthrough. Most of the release would occur continuously over a period of about 10 hours. The release would include approximately 0.08 percent of the iodines and alkali metals present in the core at the time of release. Because leakage from containment to the atmosphere would be low and gases escaping through the ground would be cooled by contact with the soil, the energy release rate would be very low.

PWR 7

This category is similar to PWR release category 6, except that the containment sprays would operate to reduce the containment temperature and pressure as well as the amount of airborne radioactivity. The release would involve 0.002 percent of the iodines and 0.001 percent of the alkali metals present in the core at the time of release. Most of the release would occur over a period of 10 hours. As in PWR release category 6, the energy release rate would be very low.

PWR 8

This category approximates a PWR design basis accident (large pipe break), except that the containment would fail to isolate properly on demand. The other engineered safeguards are assumed to function properly. The core would not melt. The release would involve approximately 0.01 percent of the iodines and 0.05 percent of the alkali metals. Most of the release would occur in the 0.5-hour period during which containment pressure would be above ambient. Because containment sprays would operate and core melting would not occur, the energy release rate would also be low.

PWR 9

This category approximates a PWR design basis accident (large pipe break), in which only the activity initially contained within the gap between the fuel pellet and cladding would be released into the containment. The core would not melt. It is assumed that the minimum required engineered safeguards would function satisfactorily to remove heat from the core and containment. The release would occur over the 0.5-hour period during which the containment pressure would be above ambient. Approximately 0.00001 percent of the iodines and 0.00006 percent of the alkali metals would be released. As in PWR release category 8, the energy release rate would be very low.

BWR 1

This release category is representative of a core meltdown followed by a steam explosion in the reactor vessel. The latter would cause the release of a substantial quantity of radioactive material to the atmosphere. The total release would contain approximately 40 percent of the iodines and alkali metals present in the core at the time of containment failure. Most of the release would occur over a 1/2 hour period. Because of the energy generated in the steam explosion, this category would be characterized by a relatively high rate of energy release to the atmosphere. This category also includes certain sequences that involve overpressure failure of the containment prior* to the occurrence of core melting and a steam explosion. In these sequences, the rate of energy release would be somewhat smaller than for those discussed above, although it would still be relatively high.

BWR 2

This release category is representative of a core meltdown resulting from a transient event in which decay-heat-removal systems are assumed to fail. Containment overpressure failure would result, and core melting would follow. Most of the release would occur over a period of about 3 hours. The containment failure would be such that radioactivity would be released directly to the atmosphere without significant retention of fission products. This category involves a relatively high rate of energy release due to the sweeping action of the gases generated by the molten mass. Approximately 90 percent of the iodines and 50 percent of the alkali metals present in the core would be released to the atmosphere.

*Emphasis added.

BWR 3

This release category represents a core meltdown caused by a transient event accompanied by a failure to scram or failure to remove decay heat. Containment failure would occur either before core melt or as a result of gases generated during the interaction of the molten fuel with concrete after reactor-vessel melt through. Some fission-product retention would occur either in the suppression pool or the reactor building prior to release to the atmosphere. Most of the release would occur over a period of about 3 hours and would involve 10 percent of the iodines and 10 percent of the alkali metals. For those sequences in which the containment would fail due to overpressure after core melt, the rate of energy release to the atmosphere would be relatively high. For those sequences in which overpressure failure would occur before core melt, the energy release rate would be somewhat smaller, although still moderately high.

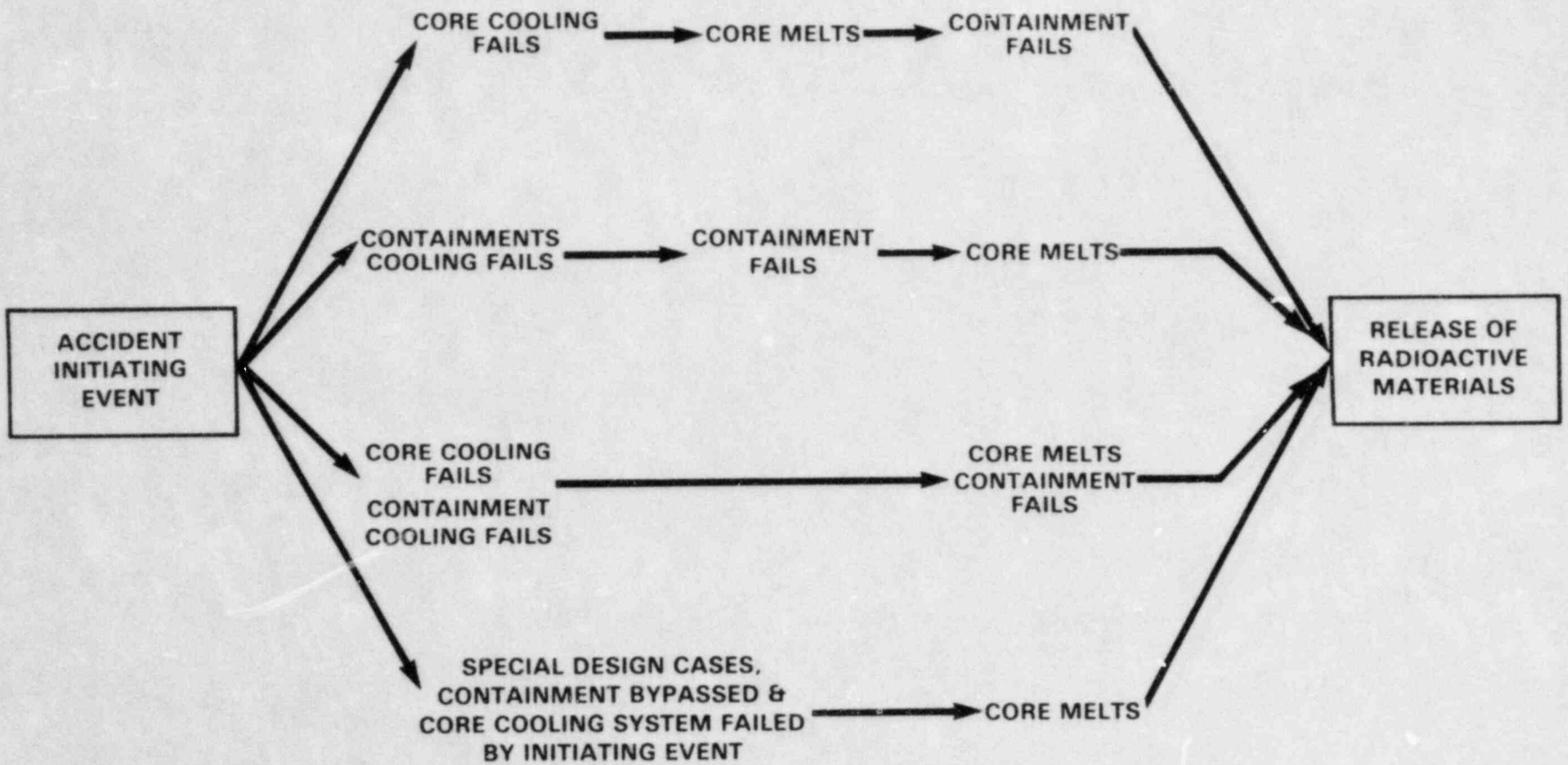
BWR 4

This release category is representative of a core meltdown with enough containment leakage to the reactor building to prevent containment failure by overpressure. The quantity of radioactivity released to the atmosphere would be significantly reduced by normal ventilation paths in the reactor building and potential mitigation by the secondary containment filter systems. Condensation in the containment and the action of the standby gas treatment system on the releases would also lead to a low rate of energy release. The radioactive material would be released from the reactor building or the stack at an elevated level. Most of the release would occur over a 2-hour period and would involve approximately 0.08 percent of the iodines and 0.5 percent of the alkali metals.

BWR 5

This category approximates a BWR design basis accident (large pipe break) in which only the activity initially contained within the gap between the fuel pellet and cladding would be released into containment. The core would not melt, and containment leakage would be small. It is assumed that the minimum required engineered safeguards would function satisfactorily. The release would be filtered and pass through the elevated stack. It would occur over a period of about 5 hours while the containment is pressurized above ambient and would involve approximately 6×10^{-9} percent of the iodines and 4×10^{-7} percent of the alkali metals. Since core melt would not occur and containment heat-removal systems would operate, the release to the atmosphere would involve a negligibly small amount of thermal energy.

POSSIBLE CONTAINMENT FAILURE/CORE MELT ACCIDENT SEQUENCES



[1]E.G., LOCAs, TRANSIENTS

Figure B-1. Core melt/containment failure severe accident sequences.

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U.S. NUCLEAR REGULATORY COMMISSION

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7. AUTHOR(S)
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15. SUPPLEMENTARY NOTES

14. *(Leave blank)*

16. ABSTRACT *(200 words or less)*

This report presents a set of precalculated doses based on a set of postulated accident releases and intended for use in emergency planning and emergency response. Doses were calculated for the PWR (Pressurized Water Reactor) accident categories of the Reactor Safety Study (WASH-1400) using the CRAC (Calculations of Reactor Accident Consequences) code. Whole body and thyroid doses are presented for a selected set of weather cases. For each weather case these calcaluations were performed for various times and distances including three different dose pathways--cloud (plume) shine, ground shine and inhalation. During an emergency this information can be useful since it is immediately available for projecting offsite radiological doses based on reactor accident sequence information in the absence of plant measurements of emission rates (source terms). It can be used for emergency drill scenario development as well.

17. KEY WORDS AND DOCUMENT ANALYSIS

Emergency Response
Emergency Planning
Reactor Risk
Radiological Assessment
Water Reactor Safety
Dose Calculations

17a. DESCRIPTORS

Severe Reactor Accidents
Light Water Reactor (LWR)

17b. IDENTIFIERS/OPEN-ENDED TERMS

18. AVAILABILITY STATEMENT
Unlimited

19. SECURITY CLASS *(This report)*
Unclassified

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