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AIRBORNE RELEASES FROM BWR'S FOR ENVIRONMENTAL IMPACT EVALUATIONS

AMENDMENT 2 (IODINE-131)

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GENERAL ELECTRIC

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

Page

APPENDICES

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

ABSTRACT

Airborne iodine-131 releases from BWRs are decreasing based on an evaluation of 31 reactor-years of operating plant data. An independent analysis of extensive I-131 measurements sponsored by the Electric Power Research Institute indicate an annual normalized release of elemental iodine (I_2) to be 25 millicuries per reactor. The basis for normalization is a calendar year consisting of 300 days of power operations and one refueling maintenance shutdown period, a concentration of I-131 in reactor water of 1 μCi/kg, a carryover of I-131 from reactor water to reactor steam of 1%, and full-flow condensate treatment. Adjustment factors would be applied to plants with parameters varying from this normalization basis to determine the annual I-131 airborne release rate for future BWR environmental impact assessments.

Actual measurements of I-131 activity in milk produced on farms near BWRs indicate that if an infant consumed this milk at a rate of 300 liters per year, conservative assumptions, then the thyroid dose due to I-131 ingestion would amount to much less than one millirem. This dose estimate is a decade less than the United States Nuclear Regulatory Commission dose objective. Iodine-131 airborne releases from operating BWRs have not been significant causes of dose via the plant airborne release-grass-cow-milk-infant pathway, nor are they anticipated to be in the foreseeable future.

1. INTRODUCTION

This amendment to NEDO-21159, March 1976, "Airborne Releases from BWR's for Environmental Impact Evaluations," updates the original report with new information on iodine-131 (I-131) releases from ventilation systems. New information includes I-131 release measurements from July 1975 to about December 1976, I 131 reactor water concentrations in domestic BWRs and improved-fuel exposures to December 1977, plus an evaluation of I-131 release measurements that allows for the projection of current results to future BWRs.

No new information is included in this amendment about noble radiogas or particulate releases.

For environmental impact assessments of BWRs results are summarized in Section 2. These results for I-131 airborne releases are presented on a "normalized" basis. The reader may recall that the original version of NEDO-21159 (March 1976) treated the release data on an "as is" basis. In NEDO-21159 a limited evaluation indicated that the I-131 releases could be correlated to I-131 reactor water concentrations. This amendment includes the results of a more extensive evaluation of I-131 release data normalized to reactor water concentration and other plant performance parameters. The normalization basis is defined as follows:

1. *a calendar year* consists of 300 days of power operations and one refueling/maintenance shutdown period,

2. *a concentration* of I-131 in reactor water of 1 μCi/kg,

3. *a carryover* of I-131 from reactor water to reactor steam of 1%, and

4. *full-flow condensate treatment.*

For a plant with parameters varying from any of these values adjustment factors would be applied to the normalized release rates to determine the I-131 airborne releases from BWRs. Furthermore, for proper environmental impact evaluations the I-131 releases must include percentages of each species of I-131 from BWR reactor, turbine and radwaste building ventilation exhausts and the gland seal steam/mechanical vacuum pump discharges. The results for I-131 are based on measurements in ventilation exhausts without charcoal treatment.

The results reported in Section 2 establish a quantitative relationship between I-131 airborne releases to the environs of BWRs and plant parameters, including I-131 reactor water concentration. In addition Section 2 presents the results of a significant analysis that indicates a general downward trend in actual I-131 release rates at four BWR plants.

The airborne I-131 releases from currently designed BWR process off-gas treatment systems have been estimated to be essentially zero (Reference 1-1).

In NEDO-21159 (March, 1976) reference was made to 10CFR50 Appendix I in order to establish realistic estimates of off-site doses from nuclear power plant airborne effluents. In this amendment, Appendix 2A presents selected quotations from the Nuclear Regulatory Commissioner's opinion on Appendix I, for the reader's convenience (Reference 1-2). The quotations from the Commissioner's are included in this amendment to re-emphasize the importance of realistic dose assessments and the end to reductions in already conservative dose objectives. The dose *objectives* stipulated in 10CFR50 Appendix I are understood to be firm values which are not expected to be reduced in the future due to superior performance by BWRs (Reference 1-3).

Section 3 of this amendment presents I-131 release measurements on an "as is" basis. These measurements include routine operating plant data for about 31 reactor-years, data for about 3.8 reactor-years from special measurements sponsored by the Electric Power Research Institute (EPRI), and other short-term measurements by the Nuclear Regulatory Commission (NRC) and the General Electric Company (GE). The measurements of I-131 species--particulates, elemental iodine, hypoiodous acid and organic iodine-- are presented in Section 4. The following section presents data for the I-131 concentrations in milk produced on farms near BWRs; this is new information that was not included in NEDO 21159 (March, 1976). An empirical correlation has been developed between I-131 concentrations in milk and distance from the plant.

Section 6 presents background information relative to I-131 carryover from reactor water to steam, I-131 concentrations in reactor water, and data on improved fuel performance. The final part of Section 6 presents the EPRI measurements on a normalized basis including statistical and trend analysis

The results for I-131 airborne measurements are presented in Section 7. These results include average values for the I-131 species, summaries of the utility and EPRI data. In addition an empirical relationship is shown that indicates the overall effect of improved fuel performance on I-131 reactor water concentrations in BWRs. The results of this study for the generic determination of annual I-131 releases from BWRs are verified by test against an independent data set, 3 reactor years of measurements from the Browns Ferry site during 1977. The results of this verification are presented in Section 7.

1.1 REFERENCES

1-1 Gutierrez, R. J. and C. W. Miller, February 1977, "NGG SJAE Off-Gas Treatment System," *General Electric Company, Licensing Topical Report, Class 1*, NEDO-21056, Section 6.6.

1-2 United States Nuclear Regulatory Commission, April 30, 1975, "Opinion of the Commission, In the Matter of Rulemaking Hearing, Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low As Practicable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," Docket No. RM-50-2

1-3 Kahan, R. S., and Y. Feige, 1977, "The Wide Margin of Implicit Built-in Safety Factors in Current Radiation Protection Standards," Health Physics 32, 509.

2. SUMMARY OF RESULTS

This section summarizes the results for normalized iodine-131 release rates as well as a trend analysis of actual airborne I-131 release rates. The data base and methods used to develop these results are described in the following sections of this report. With regard to the concentration levels of I-131 in milk produced in BWR environs all the information is presented in Section 5.

On the basis of extensive special studies of iodine-131 (I-131) airborne releases the normalized annual airborne release of I-131 in elemental form is 25 millicuries per year per reactor, see Tables 2-1 and 2-2. Relative to elemental I-131, the results indicate that about 75% of the iodine is released from the turbine building with the reactor building being the next largest source, 15%. The other sources of elemental I-131 release are nominal, see Table 2-1. Elemental I-131 is the primary form of iodine for environmental impact evaluations of agricultural pathways because its relatively high deposition velocity compared to other identified species in BWR airborne releases.

Airborne release results for non-elemental I-131 species are presented in Tables 2-3 and 2-4.

Iodine-131 normalized releases presented in this amendment are based on measurements sponsored by the Electric Power Research Institute, and conducted by Nuclear Environmental Services at three BWRs, namely, Vermont Yankee, Monticello, and Oyster Creek. There are about 4 reactor years of special measurements at these different types of BWR's. Oyster Creek is the oldest plant, commissioned in 1969 and Vermont Yankee, which began commercial power generation in 1972, is the newest of the three.

The cumulative calendar quarterly I-131 releases were correlated by least-squares regression analysis. This analysis considers reactors for which I-131 ventilation release data are available for at least 2 years. For correlation purposes data from the first year, or so, of reactor operations were eliminated to discount any start-up effects that would have biased the results downwards. The correlation is of the form

where $y = a x^b$

y = cumulative I-131 release, millicuries

x = cumulative plant operating time, months

a, b = constants determined by regression analysis

For the evaluation of trends in I-131 release rates, the important term is the exponent, *b*, because the exponent is an index of whether releases are increasing ($b > 1$), decreasing ($b < 1$), or constant ($b = 1$). The correlation results are summarized in Table 2-5. The *b* results listed in the right-hand column of Table 2-5 indicate that the I-131 ventilation releases from BWR's are on the decrease.

Trend analysis results are also graphically summarized in Figure 2-1. The ordinate of Figure 2-1 is a "normalized" index of I-131 releases useful to monitor trends. The ordinate is the ratio of the calculated deviation between the observed and correlated values at each period to the standard error of estimate* of the correlation. Negative deviations indicate decreasing I-131 release rates, and conversely. This parameter is analogous to the number of standard deviations that a sample point is from the sample mean. In Figure 2-1 the tail-ends of the curves are below the mean by more than two "standard deviations" for three of the four BWR plants; namely, Pilgrim 1, Monticello and Quad Cities 1/2. There has been only a slight decrease in release rates from Dresden 2/3 over the last few years; its I-131 releases have been relatively small.

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*The standard error of estimate, S_E is defined as follows,[1]

$$S_E^2 = \sum_{i=1}^{n} (Y_i - \hat{Y}_i)^2 / (n-2),$$

where n = number of sample poi[illegible]

Y_i = observed value of dependent variable,

$\hat{Y}_i$ = estimated value of Y_i by regression equation.

[1] Ostle, B., and R. W. Mesing, 1975, *Statistics in Research*, 3rd ed., Ames The Iowa State University Press, p. 170

2.1 REFERENCES

2-1 American Nuclear Society Standards Committee Working Group ANS-18.1, "American National Standard Source Term Specification," American Nuclear Society, ANS-18.1, ANSI N237-1976 (Approved May 11, 1976), Table 5.

2-2 Lin, C. C. and H. L. Kenitzer, July 1977, "Fission Product Transport Measurements at Brunswick-2," General Electric Company, Internal Document (Draft), Figure 5.

Table 2-1
NORMALIZED[a] ANNUAL AIRBORNE RELEASES OF ELEMENTAL IODINE-131 FOR ENVIRONMENTAL IMPACT EVALUATIONS OF BWR's

Source Building or Exhaust	Elemental I-131 Release[b,c] Millicuries Per Year Per Reactor	Percent
Reactor[d]	3.8	15
Turbine[e,f,g]	19.0	76
Radwaste	1.3	5
Gland Seal Steam and Mechanical Vacuum Pump[e,f,g]	1.1	4
Total[h]	25.0 millicuries	100%

Notes

(a) Results are normalized to the following conditions (1) a calendar year consisting of 300 days of power operations and one refueling/maintenance shutdown period (2) a concentration of I-131 in reactor water of 1 µCi/kg (3) a carryover of I-131 from reactor water to reactor steam of 1% and (4) full flow condensate treatment

(b) The elemental iodine (I_2) form of I-131 is identified as that portion of the airborne release trapped by cadmium iodide adsorbent in the iodine species sampler, see Section 4

(c) Normalized releases are based on an I-131 reactor water concentration of 1.0 µCi/kg. For BWR's with other than this concentration, adjust releases in direct proportion to the expected I-131 reactor water concentration. On the basis of selected measurements in 1972 at several BWR's an I-131 reactor water concentration of 5 µCi/kg has been used for environmental impact assessments (Reference 2-1). On the basis of this evaluations analysis of 1975 and 1976 operating data from 15 domestic BWR's the expected I-131 reactor water concentration for future BWR's with 100% improved fuel and full flow condensate treatment is 0.5 µCi/kg. However, this concentration should still be conservative because it is based in part on the performance of old-type fuel (see Section 7)

(d) Reactor building releases are based on BWR Mark I containments. For BWR Mark III containments use 50% of the Mark I reactor building result for to the auxiliary and fuel buildings and 50% for the Mark III containment building

(e) For BWRs with deep-bed condensate treatment systems or powdex plants with stainless steel condenser tubing multiply above results by 1.5 and for plants with powdex systems multiply results by 0.4 (see Table F-1)

(f) For BWRs with forward pumped flow multiply above results by 0.25, increase reactor and radwaste building releases by 1.75 (Reference 2-2)

(g) Gland seal steam release is based on BWR's without the use of an auxiliary boiler for clean steam; for BWR's with a separate steam supply, the gland seal release should be divided by 1000

(h) Normalized releases assume one refueling/maintenance outage per year and 300 days of power generation operations; for BWR's with longer fuel cycles the annual releases should be adjusted to the cycle period, see Table 2-2

Table 2-2
NORMALIZED ANNUAL AIRBORNE RELEASES OF ELEMENTAL IODINE-131 ACCORDING TO PLANT OPERATING MODE FOR ENVIRONMENTAL IMPACT EVALUATIONS OF BWR's[a]

Source	Elemental I-131 Release Millicuries per Year per Reactor	
	Plant Operating Mode	
Building or Exhaust	Power Generation	Refueling/Maintenance
Reactor Building	3.4	0.40
Turbine Building	18.0	0.97
Radwaste Building	1.3	0.039
Gland Seal Steam	1.1	--
Mechanical Vacuum Pump	--	0.006
Total	23.8	1.42

Notes (a) See Notes listed in Table 2-1

Table 2-3
NORMALIZED ANNUAL AIRBORNE RELEASES OF NON-ELEMENTAL IODINE-131 SPECIES FOR POWER GENERATION OPERATIONS (300 DAYS), FOR ENVIRONMENTAL IMPACT EVALUATIONS OF BWR's[a,b,c]

Source Building or Exhaust	Species I-131 Release, Millicuries per Year per Reactor Particulate	 HOI	 CH_3I
Reactor Building	1.0	1.5	3.2
Turbine Building	6.4	4.9	3.0
Radwaste Building	0.18	0.48	3.4
Gland Seal Steam and Mechanical Vacuum Pump	0.88	3.9	13.1
Totals	8.5	10.8	22.7

Notes: (a) See Notes listed in Table 2-1

(b) I-131 species are discussed in Section 4; particulates correspond to I-131 trapped on sampler filter paper. HOI means hypoiodous acid and trapped on p-iodophenol adsorbent, and CH_3I means methyl iodide or I-131 species which penetrates the following adsorbents: filter paper, cadmium iodide and p-iodophenol. The CH_3I is trapped by charcoal impregnated with TEDA (or silver zeolite). Actual chemical analyses may indicate relatively small amounts of other organic compounds.

(c) Iodine-131 species are summarized on a percentage basis for the various sources and plant operating modes in Table 4-8.

Table 2-4
NORMALIZED ANNUAL AIRBORNE RELEASES OF NON-ELEMENTAL IODINE-131 SPECIES FOR A REFUELING/MAINTENANCE OUTAGE FOR ENVIRONMENTAL IMPACT EVALUATIONS OF BWR's[a, b]

Source	Species I-131 Release, Millicuries per Year per Reactor		
	Species		
Building or Exhaust	Particulate	HOI	CH_3I
Reactor Building	0.079	0.65	0.46
Turbine Building	0.17	1.4	0.99
Radwaste Building	0.005	0.066	0.69
Mechanical Vacuum Pump	0.012	0.006	6.0
Totals	0.266	2.122	8 14

Notes (a) See Notes listed in Table 2-1

(b) Iodine 131 species are summarized on a percentage basis for the various sources and plant operating modes in Table 4 8

Table 2-5
CORRELATION OF LONG-TERM TRENDS IN ACTUAL I-131 AIRBORNE RELEASES FROM BWR VENTILATION EXHAUSTS

Plant	Exhaust	Operation Period Month/Year	Elapsed Time Months	Correlation Exponent, b Operational Period Overall	Recent
Dresden 2/3	Reactor Bldg.	startup [a] (7/71 and 11/71) to 12/72	12	not calculated	
Dresden 2/3	Reactor Bldg	1/73 to 12/76	48	1.15	—
Dresden 2/3	Reactor Bldg	1/75 to 12/76	24	—	0.95
Quad Cities 1/2	Reactor Bldg	startup [a] (8/72) to 6/73	10	not calculated	
Quad Cities 1/2	Reactor Bldg	7/73 to 6/77	48	1.19	—
Quad Cities 1/2	Reactor Bldg	1/76 to 6/77	18	—	0.71
Monticello	Reactor, Turbine and Radwaste Bldgs	startup [a] (7/71) to 12/73	30	not calculated	
Monticello	Reactor, Turbine and Radwaste Bldgs.	1/74 to 12/76	36	1.00	—
Monticello	Reactor, Turbine and Radwaste Bldgs	1/76 to 12/76	12	—	0.04
Pilgrim 1	Reactor, Turbine and Radwaste Bldgs	startup [a] (12/72) to 9/74	22	not calculated	
Pilgrim 1	Reactor, Turbine and Radwaste Bldgs.	10/74 to 6/76	21	1.29	—
Pilgrim 1	Reactor, Turbine and Radwaste Bldgs	7/75 to 6/76	12	—	0.44

Notes: (a) Startup is defined here as first month of commercial service.

(b) Correlation is of form $y = ax^b$ where b is called the correlation exponent, y is the cumulative I-131 release, and x is the cumulative time.

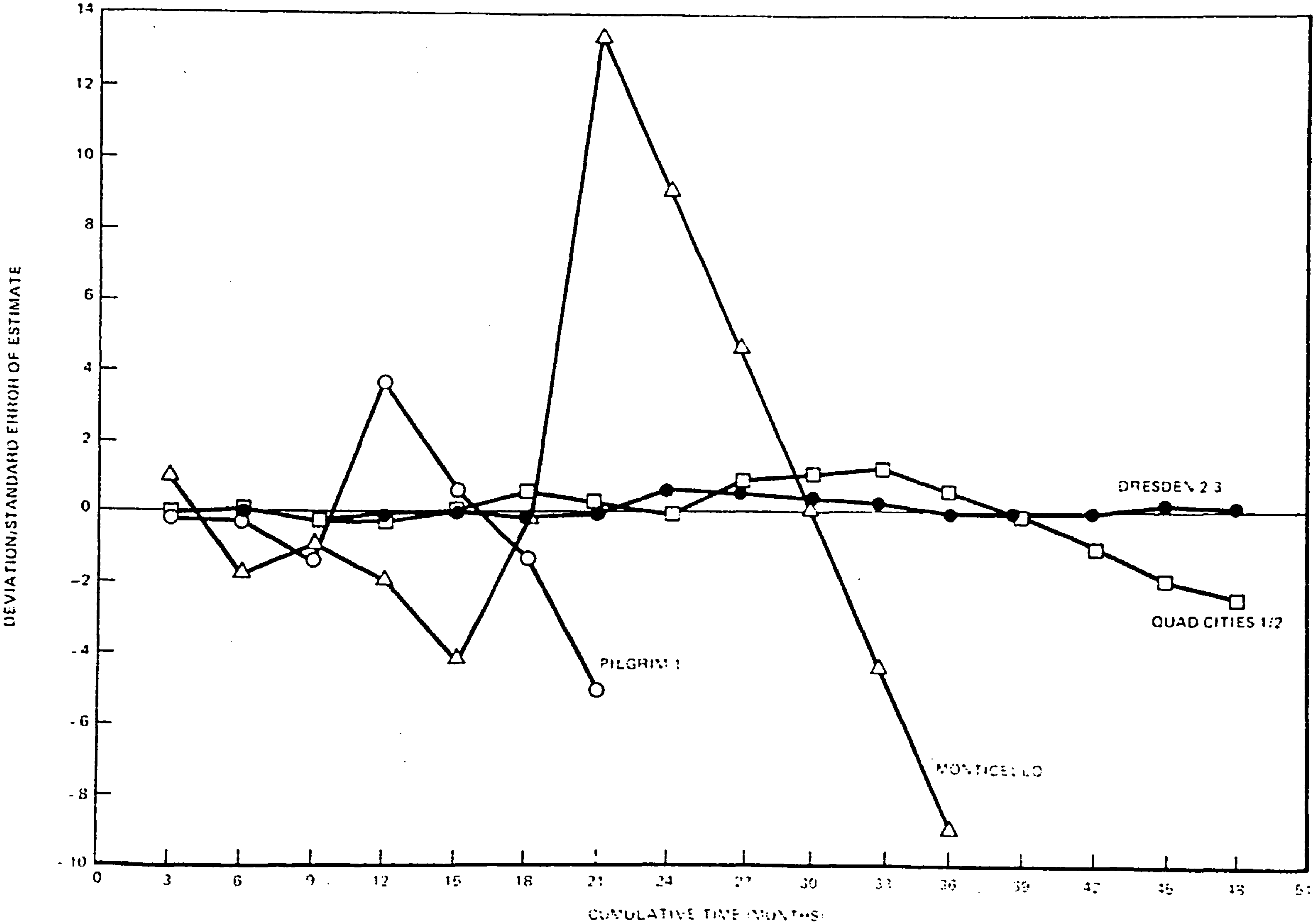

Figure 2-1. Long-Term Trend Analysis of Cumulative Iodine 131 Airborne Releases from BWR Ventilation Exhausts

3. AIRBORNE IODINE-131 RELEASE DATA

This section presents airborne I-131 release data from measurements routinely performed at operating BWR plants and from special studies. The special measurements have been sponsored primarily by the Electric Power Research Institute and conducted by Nuclear Environmental Services, a division of Science Applications, Inc.

A few special measurements have been performed by the General Electric Company and the Atomic Energy Commission (now the Nuclear Regulatory Commission). These results were previously reported in the original version of NEDO-21159 (March 1976), but are included here for completeness.

3.1 MEASUREMENTS BY UTILITIES

The following data were reported in semi-annual operating reports by several utilities, and in some instances, data were obtained from plant records. These data are obtained by routine procedures of health physics/chemistry personnel. The results provide long-term histories of actual BWR airborne releases of iodine-131 via ventilation exhausts.

3.1.1 Boston Edison Company (Pilgrim 1)

For Pilgrim 1 data are available for total plant ventilation exhaust releases from January 1973 to June 1976 (References 3-1 to 3-7). These data are presented in Figure 3-1 and listed in Table 3-1.

Figure 3-2 presents the distribution of quarterly releases of I-131 for the total plant ventilation release, including the total of the reactor, turbine and radwaste building exhausts. The plant operational period is from October 1974 to December 1976, inclusive. This period discounts the data during the first 22 months of commercial operations.

3.1.2 Commonwealth Edison Company (Dresden 2/3, Quad Cities 1/2)

3.1.2.1 Dresden 2/3

For the Dresden 2/3 reactors data are available for the reactor building ventilation release up to December 1976 (References 3-8 to 3-22). Figure 3-3 illustrates the chronology of I-131 ventilation releases from the Dresden 2/3 reactors from 1972 to 1976, inclusive. Table 3-2 lists the data.

The reactor building ventilation releases of I-131 are normally distributed as shown by Figure 3-4. For all the data, 16 calendar quarters the arithmetic mean is 0.026 curies/quarter per 2 reactors, and the standard deviation is large at 0.013 Ci/quarter. The large variance is partially due to one outlier because of an unusually high I-131 release that occurred during the fourth quarter of 1974, as shown by Figure 3-3. Rejection of this value, leads to a slightly lower mean, 0.023 Ci/quarter with a standard deviation of 0.0076. This corresponds to a coefficient of variation of 33% instead of 50% when the outlier is included. The coefficient of variation is defined as the ratio of the sample standard deviation to the sample mean, expressed in percent. This release is about one-half the reactor building release recommended in the original version of NEDO-21159 (March 1976).

During 1975 and 1976 the I-131 reactor water concentrations at Dresden 2 and Dresden 3 ranged from about 0.2 to 5 μCi/kg. Dresden 3 had consistently higher I-131 concentrations than Dresden 2.

3.1.2.2 Quad Cities 1/2

For the Quad Cities 1/2 plants data are presented from July 1972 to December 1977 (References 3-23 to 3-35). Figure 3-5 illustrates the chronology of I-131 releases from the Quad Cities 1/2 reactors, and Table 3-3 lists the data on a quarterly basis.

The Quad Cities 1/2 reactor building ventilation releases of I-131 are normally distributed, as at Dresden 2/3, see Figure 3-6. For the last 8 reactor-years of operations the mean I-131 release is 0.0394 curies per quarter for 2 reactors. The standard deviation is 0.015 Ci/quarter which yields a 36% coefficient of variation. This degree of variation is almost the same as for Dresden 2/3.

The average annual I-131 release for the reactor building ventilation release is 79 millicuries/reactor. This value is about 10% less than the reactor building release recommended in the original version of NEDO-21159 (March 1976).

During 1975 and 1976 the I-131 reactor water concentrations at Quad Cities 1 and Quad Cities 2 range from about 0.3 to 40 μCi/kg. During 1975 the I-131 concentrations were greater at Quad Cities 2, however, during the latter-half of 1976 both reactors were operating with I-131 concentrations of about 2 to 3 μCi/kg. This is a general decrease in concentration with time which is reflected in lower I-131 reactor building ventilation releases, see Figure 3-5.

3.1.3 Northern States Power Company (Monticello)

Iodine-131 ventilation release data are presented from January 1974 to December 1977 for the Monticello plant (References 3-36 to 3-42). Figure 3-7 presents the chronology of total plant ventilation releases; plant ventilation releases are the sum of the reactor, turbine and radwaste building exhausts. These data are listed in Table 3-4.

The Monticello total plant I-131 releases are lognormally distributed prior to 1976; data for 1976 are normally distributed, see Figure 3-8. Note Figure 3-8 plots the 1976 data on lognormal probability paper for convenience only. The change in distribution type occurred after the refueling/maintenance outage in late 1975. After this outage the fuel was primarily of the improved type (GE fuel type, "8x8") and variations in I-131 reactor water concentrations were small. Prior to 1976 I-131 reactor water concentrations ranged from about 10 to 200 μCi/kg, in 1976 concentrations were generally between 4 and 10 μCi/kg with a decreasing trend.

The actual average (geometric mean since data are lognormally distributed) I-131 release from the reactor, turbine and radwaste buildings at Monticello is 0.31 Ci/quarter with a geometric standard deviation of 2.9. This release extends over 2 reactor-years of operation. For the one reactor-year of operation (1976) after complete incorporation of improved fuel, the total plant ventilation I-131 release is an average of 0.015 Ci/quarter wit[illegible]efficient of variation of 24%.

The change from old-type fuel to improved fuel has decreased the average I-131 plant ventilation release by approximately a factor of 20. Further decrease in plant I-131 release would be expected as residual tramp uranium in the reactor vessel is "burned up."

3.1.4 Philadelphia Electric Company (Peach Bottom 2/3)

There is a limited amount of data for I-131 releases via a total plant ventilation exhaust at Peach Bottom 2/3 (Reference 3-43). For these two reactors, the I-131 release data are available for the first 9 months of 1976, see Tables 3-5 and 3-6. Since the data base is only for 1.5 reactor years it is of limited use in establishing long term trends. However, it is presented here because the data are useful when combined with the analysis of I-131 in milk produced on farms in the environs of the plant (see Section 5).

3.2 MEASUREMENTS BY ELECTRIC POWER RESEARCH INSTITUTE

The Electric Power Research Institute sponsored Nuclear Environmental Services (NES) to perform measurements of airborne releases at three BWR's. This report summarizes I-131 release data available in the various studies in the period of June 1974 through December 1976 for Oyster Creek, Monticello and Vermont Yankee (References 3-44 to 3-47). The first phase of studies at Vermont Yankee were sponsored by the Yankee Atomic Electric Company (Reference 3-48).

In this section the data are simply tabulated. In Section 6.4 graphs are presented of the I-131 releases as a function of time. These graphs present the I-131 release information on a normalized basis, that is, the actual I-131 releases for each sample period are divided by the actual average I-131 reactor water concentration during the same period. Normalized releases allow a comparison of I-131 airborne releases from each building ventilation exhaust at each BWR studied on a common basis. Tables 3-7 to 3-19 tabulate the EPRI sponsored data; Tables 3-7 to 3-9 are for Vermont Yankee, Tables 3-10 to 3-12 are for Monticello, and Tables 3-13 to 3-16 are for Oyster Creek. For each plant these tables present information in the following sequence: average I-131 release rate (μCi/s), total I-131 release (millicuries), and average I-131 reactor water concentration (μCi/kg) and power level (% of rated). The results are in chronological order by plant. Table 3-17 presents some miscellaneous data obtained at Oyster Creek. The total I-131 releases are summarized for each plant in Tables 3-18 and 3-19. However, for practical purposes these latter results are not directly useful because of differences in sample time, plant operation and fuel performance. These variables are accounted for in Section 6.4 Thus the results presented in Tables 3-18 and 3-19 are listed only for possible information needs of the reader and the results are *not* applicable as I-131 "source terms" for environmental impact evaluations of BWR's.

3.3 MEASUREMENTS BY NUCLEAR REGULATORY COMMISSION

Table 3-20 is a summary of NRC measurements conducted during 1972 and 1973 (References 3-49 and 3-50) This table appeared as Table 3-28 in the original version of NEDO-21159 (March 1976). References 3-51 and 3-52 contain information by the AEC that confirms the measurements at Dresden by Commonwealth Edison personnel

3.4 MEASUREMENTS BY GENERAL ELECTRIC

Table 3-21 is a summary of GE measurements conducted during 1971 to 1974 (References 3-53 to 3-60) This table appeared as Table 3-29 in the original version of NEDO-21159 (March 1976). One data point has been added, namely for a mechanical vacuum pump I-131 release at Millstone Point 1 during a brief shutdown on September 1, 1972

3.5 REFERENCES

3-1 Pilgrim Nuclear Power Station, January through June 1973, "Semiannual Operating and Maintenance Report," Docket 50-293-151

3-2 Pilgrim Nuclear Power Station, July through December 1973, "Semiannual Operating and Maintenance Report," Docket 50-293-663.

3-3 Pilgrim Nuclear Power Station, January through June 1974, "Semiannual Operating and Maintenance Report," Docket 50-293-334.

3-4 Pilgrim Nuclear Power Station, July through December 1974, "Semiannual Report No. 5, Environmental Radiation Monitoring Program, Supplement," Docket 50-293-411.

3-5 Pilgrim Nuclear Power Station, January 1, to June 30, 1975, "Semiannual Operating and Maintenance Report."

3-6 Pilgrim Nuclear Power Station, July through December 1975, "Radioactive Effluent Release Report."

3-7 Pilgrim Nuclear Power Station, "Radioactive Effluent Release Report, April - June 1976," (Boston Edison Company, Mass.), 30 August 1976, Docket 50-293-717 and

3-7a Pilgrim Nuclear Power Station, "Radioactive Effluent Release Report," July through December, 1976, Docket 50-293-826, February 28, 1977.

3-8 Dresden Nuclear Power Station, January 1 - June 30, 1972, "Radioactive Waste and Environmental Monitoring Semiannual Report Docket," 50-101-119.

3-9 Dresden Nuclear Power Station, July 1, 1972, "Semiannual Report Section IV: Radioactive Waste and Environmental Monitoring," Dockets 50-010-135, 50-237-299, 50-249-190.

3-10 Dresden Nuclear Power Station, January through June 1973, "Radioactive Waste and Environmental Monitoring, Semiannual Report."

3-11 Dresden Nuclear Power Station, July through December 1973, "Radioactive Waste and Environmental Monitoring, Semiannual Report," Docket 50-010-221.

3-12 Appendix A to Operating License DPR-25, "Technical Specifications and Basis for Dresden Nuclear Power Station Unit 3," Grundy County, Illinois, Commonwealth Edison Company Docket 50-249, July 16, 1974, section 3.8, p. 134B (Note: The Dresden Unit 2 has the same values.)

3-13 Dresden Nuclear Power Station, January through June 1974, "Radioactive Waste and Environmental Monitoring, Semiannual Report."

3-14 Dresden Nuclear Power Station, July through December 1974, "Radioactive Waste and Environmental Monitoring Semiannual Report."

3-15 Dresden Nuclear Power Station, January through April 1975, "Units 2 and 3 Vent Stack Release."

3-16 Dresden Nuclear Power Station, July through December 1973, "Unit 2 Rx Vent (CAM)."

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3-29 Quad Cities, Plant Startup through June 1975, "Rx Vent Iodine Release."

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3-33 Quad Cities Nuclear Power Station, January through June 1976, "Radioactive Effluent Discharges, Environmental Monitoring, Solid Radioactive Waste, and Personnel Exposures."

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3-37 Monticello Nuclear Power Station, July 1, 1974, to June 30, 1975, "Chemistry Report-Reactor Building Vent and Stack Releases, Weekly Average Values."

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Table 3-1
IODINE-131 AIRBORNE RELEASE
PLANT — PILGRIM 1
BUILDINGS — REACTOR, TURBINE, AND RADWASTE

Year	Quarter	Iodine-131 Release curies/quarter
1973	1st	0 00429
	2nd	0 05952
	3rd	0 01606
	4th	0 01024
1974	1st	0 00283
	2nd	ND[a]
	3rd	0 00831
	4th	0 1449
1975	1st	0 2306
	2nd	0 4020
	3rd	0 492
	4th	0 0735
1976[b]	1st	0.189
	2nd	0.0609
	3rd	0 0325
	4th	0 0507

arithmetic mean[c] = 0 14 Ci/quarter (October 1974 to December 1976)
standard deviation = 0 16 Ci/quarter

Notes (a) Non-Detectable Activity
(b) Data for latter-half 1976 not available
(c) Discounts initial period of commercial power generation operations

Table 3-2
IODINE-131 AIRBORNE RELEASE
PLANTS — DRESDEN 2/3
BUILDING — REACTOR

Year	Quarter	I-131 Release curies per calendar quarter
1972	1st	0.019
	2nd	0.011
	3rd	0.013
	4th	0.006
1973	1st	0.0230
	2nd	0.0100
	3rd	0.0124
	4th	0.0320
1974	1st	0.0259
	2nd	0.0189
	3rd	0.0317
	4th	0.0664
1975	1st	0.0200
	2nd	0.0196
	3rd	0.0170
	4th	0.0181
1976	1st	0.0257
	2nd	0.0288
	3rd	0.0371
	4th	0.0271

Arithmetic mean release (1973 to 1976)[a] 0.024 Ci/quarter

Standard Deviation 0.013 Ci/quarter

Note (a) This period eliminates release data during first year (approximately) of commercial operation

Table 3-3
IODINE-131 AIRBORNE RELEASE
PLANTS — QUAD CITIES 1/2
BUILDING — REACTOR

Year	Quarter	I-131 Total curies released per calendar quarter
1972	3rd	0.00620
	4th	0.00303
1973	1st	0.0015
	2nd	0.0135
	3rd	0.0253
	4th	0.0370
1974	1st	0.0257
	2nd	0.0389
	3rd	0.0498
	4th	0.0586
1975	1st	0.0327
	2nd	0.0376
	3rd	0.0737
	4th	0.0534
1976	1st	0.0498
	2nd	0.0302
	3rd	0.0307
	4th	0.0243
1977	1st	0.028
	2nd	0.037
	3rd	0.042
	4th	0.053

Arithmetic mean[a] 0.040 = I-131 curies/quarter
Standard deviation = 0.013 Ci/quarter

Note (a) Average calculated for period of 1973 3rd quarter to 1977 4th quarter, inclusive (the last 4½ years). average release excludes data during first year (approximately) of commercial operation

Table 3-4
IODINE-131 AIRBORNE RELEASE
PLANT — MONTICELLO
BUILDINGS — REACTOR, TURBINE, AND RADWASTE

Year	Quarter	Iodine-131 Release curies/quarter	
1974	1st	0.4658	
	2nd	0.1531	
	3rd	0.4638	
	4th	0.2931	geometric mean 0.312 Ci quarter
1975	1st	0.2049	geometric standard deviation 2.93
	2nd	0.7052	
	3rd	1.5005	
	4th	0.0426	
1976	1st	0.0193	Arithmetic mean 0.015 Ci quarter
	2nd	0.0126	
	3rd	0.0116	standard deviation 0.004 Ci quarter
	4th	0.0170	
1977	1st	0.00731	
	2nd	0.00563	
	3rd	0.00421	
	4th	0.00135	

Note The dramatic decrease (See Figure 3-8) in I-131 release which occurred in the 4th quarter of 1975 and thereafter is primarily due to a change in fuel The entire core has been almost completely changed to improved type General Electric fuel

Table 3-5
IODINE-131 AIRBORNE RELEASE
PLANT — PEACH BOTTOM 2
BUILDINGS — REACTOR, TURBINE AND RADWASTE

Year	Quarter	I-131 Release, curies/quarter gaseous	particulate
1976	1st	0.06	0.0072
	2nd	0.13	0.00365
	3rd	0.17	0.0098

Table 3-6
IODINE-131 AIRBORNE RELEASE
PLANT — PEACH BOTTOM 3
BUILDINGS — REACTOR, TURBINE AND RECOMBINER

Year	Quarter	I-131 Release, curies/quarter gaseous	particulate
1976	1st	0.00239	0.00187
	2nd	0.232	0.00496
	3rd	0.080	0.014

Table 3-7
AVERAGE I-131 VENTILATION RELEASE RATES
PLANT — VERMONT YANKEE
DATA SOURCE* — EPRI/NES
Average I-131 Release Rate, μCi/s

Nominal Sample Period Month/Day/Year	Reactor (0.001)	Turbine (0.001)	Radwaste (0.001)	Gland Seal and MVP (0.001)	Stack (0.001)
6/20–7/2/74	3.5[2]	1.4	1.5	0.5	NS[1]
7/2–7/9/74	24.0	2.2	4.0	50.0	NS
7/9–7/23/74	4.2	1.1	2.4	0.37	NS
7/23–7/30/74	2.6	1.5	1.7	0.49	NS
7/30–8/13/74	1.9	1.5	1.1	0.44	NS
8/13–8/27/74	1.8	1.6	1.4	0.40	NS
8/27–9/12/74	4.2	2.6	1.5	0.32	NS
9/14–9/27/74	3.9	1.5	3.0	NS	9.2
9/27–10/10/74	1.1	0.75	1.4	0.36	5.5
10/11–10/13/74[3]	18.0		NS	42.0	NS
10/13–10/14/74	23.0	4.7	NS	110.0	NS
10/14–10/31/74	45.0		8.2	NS	160
10/31–11/1/74	16.0	5.6	1.6	13.0	NS
11/1–11/18/74	17.0	0.86	0.65	0.62	NS
11/18–12/2/74	12.0	0.032	0.38	0.17	NS
12/2–12/6/74	1.2	0.040	0.27	0.18	NS
12/6–12/27/74	0.064	0.023	NS	NS	NS
12/27–1/28/75	0.016	0.025	0.016	0.030[a]	NS
1/28–2/14/75	0.009	0.016	0.012	0.020	NS
2/14–3/5/75	0.064	0.018	0.014	0.037	NS
3/5–3/8/75	0.005	0.008	0.030	0.021	NS
3/8–3/26/75	0.34	0.032	0.035	0.087	NS
3/26–4/10/75	0.034	0.047	0.012	0.025	NS
4/10–4/26/75	0.034	0.027	0.0088	0.0190	NS
4/26–5/8/75	0.029	0.060	0.017	0.0131	NS
5/8–5/29/75	0.020	0.075	0.016	0.0696	NS
5/29–6/13/75	0.042	0.0142	0.0086	0.00736	NS
6/13–6/26/75	0.0223	0.037	0.021	0.0155	NS
6/26–7/10/75	0.048	0.057	0.028	0.0306	NS
7/10–7/29/75	0.026	0.031	0.042	0.0258	0.130[b]
7/29–8/13/75	0.19	0.030	0.010	0.017	0.37
8/13–8/28/75	0.10	0.0077	0.0020	0.020	0.13
8/28–9/19/75	0.021	0.039	0.0060	NS	0.068
9/19–10/7/75	0.031	0.032	0.014	0.050	0.094
10/7–10/21/75	0.069	0.024	0.039	0.014	0.25
10/21–11/7/75	0.072	0.0081	0.050	0.024	0.77

Notes (1) NS means no sample taken
(2) Notation example Reactor Building release rate 6/20–7/2/74 is 0.0035μ Ci/s
(3) Refueling maintenance outage transpired 10/11 to 12/13/74
a Collected 1/7 to 1/28/75
b Collected 6/26 to 7/29/75
*Measurements from 6/20/74 to 7/30/74 were sponsored by Yankee Atomic Electric Company

Table 3-8

ACTUAL I-131 VENTILATION RELEASES
PLANT—VERMONT YANKEE
DATA SOURCE — EPRI/NES

Nominal Sample Period Month/Day/Year	Sample Period Days	Total I-131 Release, millicuries: Reactor	Turbine	Radwaste	Gland Seal & MVP
6/20-7/2/74	12	3.629	1.452	1.555	0.518
7/2-7/9/74	7	14.515	1.331	2.419	30.240
7/9-7/23/74	14	5.080	1.331	2.903	0.448
7/23-7/30/74	7	1.572	0.907	1.028	0.296
7/30-8/13/74	14	2.298	1.814	1.331	0.532
8/13-8/27/74	14	2.177	1.935	1.693	0.484
8/27-9/12/74	16	5.806	3.594	2.074	0.442
9/14-9/27/74	13	1.123	4.380	3.370	NS[1]
9/27-10/10/74	13	1.236	0.842	1.572	0.404
10/11-10/13/74	2	3.110	}	NS	NS
10/13-10/14/74	1	1.987	} 6.903	NS	9.504
10/14-10/31/74	17	66.10	}	12.04	7.258
10/31-11/1/74	1	1.382	0.493	0.138	1.123
11/1-11/18/74	17	24.970	1.263	8.955	0.911
11/18-12/2/74	14	14.515	0.039	0.460	0.206
12/2-12/6/74	4	0.415	0.014	0.093	0.062
12/6-12/27/74	21	0.116	0.042	NS	NS
12/27-1/28/75	32	0.044	0.069	0.044	0.054
1/28-2/14/75	17	0.013	0.024	0.018	0.029
2/14-3/5/75	19	0.105	0.030	0.023	0.061
3/5-3/8/75	3	0.0013	0.0021	0.0078	0.0054
3/8-3/26/75	18	0.5288	0.049	0.0544	0.1353
3/26-4/10/75	15	0.0441	0.0609	0.0156	0.0324
4/10-4/26/75	16	0.0470	0.0373	0.0122	0.0263
4/26-5/8/75	12	0.0301	0.0622	0.0176	0.0136
5/8-5/29/75	21	0.0363	0.1361	0.0290	0.1263
5/29-6/13/75	15	0.0544	0.0184	0.0115	0.0954
6/13-6/26/75	13	0.0250	0.0416	0.0236	0.0174
6/26-7/10/75	14	0.0581	0.0689	0.0339	0.0370
7/10-7/29/75	19	0.0427	0.0509	0.0689	0.0424
7/29-8/13/75	15	0.2462	0.0389	0.0130	0.0220
8/13-8/28/75	15	0.1296	0.0100	0.0026	0.0259
8/28-9/19/75	22	0.0399	0.0741	0.0114	NS
9/19-10/17/75	18	0.0482	0.0498	0.0218	0.0778
10/7-10/21/75	14	0.0835	0.0290	0.0472	0.0169
10/21-11/7/75	17	0.0323	0.0119	0.0734	0.0353
Total I-131 Release, millicuries		151.641	27.205	32.160	53.281
Total sample time, days		502	502	478	418

Notes (1) NS means no sample taken
(2) Release rates reported as less than (·) Table 3-7, were treated as equal to (·)
(3) Sample period for gland seal & MVP release was taken to be 21 days corresponding to collection period of 1/7 to 1/28/75
(4) Stack release not tabulated because release includes process off gas
(5) Actual I-131 Release Data are summarized in Tables 3-18 and 3-19

Table 3-10
AVERAGE I-131 VENTILATION RELEASE RATES
PLANT—MONTICELLO
DATA SOURCE — EPRI/NES

Nominal Sample Period Month/Day/Year	Average Release Rate, μCi/s Reactor (0.001)	Turbine (0.001)	Radwaste (0.001)	Roof-Vent (0.001)
11/15-11/17/74	21.0	3.7	5.3	30
11/20-12/3/74	22	19	2.6	44
12/5-12/18/74	16	9.4	1.4	27
12/18-1/6/75	9.1	7.0	1.8	18
1/8-1/9/75	6.1	4.1	1.2	11
1/13-1/15/75	27	34.	1.4	65
1/9-1/13 and 1/15-1/22/75	18	39	0.64	58
1/22-2/7/75	6.8	6.8	0.28	14
2/7-2/22/75	3.1	28.	0.45	31.
2/22-3/10/75	8.1	18	0.26	26
3/10-3/25/75	22	20	NS	42
3/25-4/7/75	14	44.	1.1	59
4/7-4/21/75	21	37.	0.84	59
4/21-5/5/75	NS	51.	1	NS
5/5-5/17/75	77	52	1.4[a]	130
5/19-6/5/75	36	41.	3.5	81
6/5-6/23/75	58	29	5.3	93.
6/23-7/8/75	77	34	7.5	120
7/8-7/22/75	210	54.	9.6	250
7/11-7/30/75	54.	41.	8.5	93
8/5-8/21/75	83	56.	3.7	140.
8/21-9/3/75	100	110	6.4	210
9/3-9/11/75	53	57.	3.3	110
9/11-9/25/75	48.	5.3	2.9	56
9/25-10/15/75	NS	1.4	0.25	NS
10/15-10/27/75	2.0	0.2	0.029	2.2
10/27-11/14/75	0.18	0.065	0.0096	0.25
11/14-11/17/75	0.0149	0.0188[b]	NS	NS
11/17-11/18/75	0.0425	0.0538	0.0107	NS
11/18-11/18/75	NS	0.1076	0.0213	NS
11/18-11/19/75	0.1296	0.0807	0.0160	NS
11/19-11/19/75	0.0141	0.0829	0.0160	NS
11/19-11/20/75	0.1508	0.0798	0.0304	NS
11/20-11/21/75	0.3398	0.1067	0.0533	NS
11/21-11/21/75	0.3611	0.1573	0.0693	NS
11/21-11/22/75	0.4248	0.4490	0.0405	NS
11/22-11/22/75	0.4885	0.2634	0.0533	NS
11/22-11/23/75	0.4248	0.3725	0.0587	NS
11/23-11/23/75	0.4885	0.3488	0.0491	NS
11/23-11/24/75	0.7646	0.3634	NS	NS

Notes a Sampling period 5/5-5/12/75
b This data point and subsequent turbine building rates excludes MVP equipment compartment exhaust because no samples were taken
(1) Refueling maintenance outages transpired 1/8-2/7/75 and 9/11-11/17/75
(2) NS means no sample taken.

Table 3-9
IODINE-131 REACTOR WATER CONCENTRATIONS AND POWER LEVELS AT VERMONT YANKEE
DATA SOURCE—EPRI/NES

Nominal Sample Period Month/Day/Year	Average I-131 Reactor Water Concentration µCi/kg	Thermal Power % of Rated
6/20-7/2/74	25.0	79
7/2-7/9/74	25.0	35
7/9-7/23/74	25.0	79
7/23-7/30/74	25.0	79
7/30-8/13/74	30.0	79
8/13-8/27/74	35.0	79
8/27-9/12/74	38.0	79
9/14-9/27/74	37.0	73
9/27-10/10/74	35.0	79
10/11-10/13/74	a	0
10/13-10/14/74	a	0
10/14-10/31/74	a	0
10/31-11/1/74	a	0
11/1-11/18/74	a	0
11/18-12/2/74	a	0
12/2-12/6/74	a	0
12/6-12/27/74	1.0	41
12/27-1/28/75	0.81	91
1/28-2/14/75	0.78	99
2/14-3/5/75	0.89	55
3/5-3/8/75	—	—
3/8-3/26/75	0.80	78
3/26-4/10/75	0.63	93
4/10-4/26/75	0.90	99
4/26-5/8/75	0.61	99
5/8-5/29/75	0.71	84
5/29-6/13/75	0.53	36
6/13-6/26/75	0.62	67
6/26-7/10/75	0.62	82
7/10-7/29/75	0.61	82
7/29-8/13/75	0.67	45
8/13-8/28/75	0.64	0
8/28-9/19/75	0.61	79
9/19-10/17/75	0.85	96
10/7-10/21/75	0.77	97
10/21-11/7/75	0.89	99

a Plant down for refueling maintenance 10/11 to 12/13/74. I-131 reactor water concentration data are not available.

Table 3-11
ACTUAL I-131 VENTILATION RELEASES
PLANT—MONTICELLO
DATA SOURCE—EPRI/NES

Nominal Sample Period Month/Day/Year	Nominal Sample Time Days	Total I-131 Release, millicuries Reactor	Turbine	Radwaste	Roof-Vent
11 15-11 17 74	2	3.629	0.639	0.916	5.184
11 20-12 5 74	15	28.51	24.62	3.370	57.02
12 5-12 18 74	13	17.97	10.56	1.572	30.33
12 18-1 6 75	19	14.94	11.49	2.955	29.55
1 8-1 9 75	1	0.527	0.354	0.101	0.950
1 13-1 15 75	2	4.666	5.875	0.242	11.23
1 9-1 13 75 and 1 15-1 22 75	11	17.11	37.07	0.608	55.12
1 22-2 7 75	16	9.400	9.400	0.387	19.35
2 7-2 22 75	15	4.018	36.29	0.583	40.18
2 22-3 10 75	16	11.20	24.88	0.359	35.94
3 10-3 25 75	15	28.51	25.92	NS	54.43
3 25-4 7 75	13	15.72	49.42	1.236	66.27
4 7-4 21 75	14	25.40	44.76	1.016	71.37
4 21-5 5 75	14	NS	61.69	1.210	NS
5 5-5 17 75	12	79.83	53.91	0.847	134.8
5 19-6 5 75	17	52.88	60.22	5.141	119.0
6 5-6 23 75	18	90.20	45.10	8.243	144.6
6 23-7 8 75	15	99.79	44.06	9.720	155.5
7 8-7 22 75	14	254.0	65.32	11.61	302.4
7 11-7 30 75	8	37.32	28.34	5.875	64.28
8 5-8 21 75	16	114.7	77.41	5.115	193.5
8 21-9 3 75	13	112.3	123.6	7.188	235.9
9 3-9 11 75	8	36.63	39.40	2.281	76.03
9 11-9 25 75	14	58.06	6.411	3.508	67.74
9 25-10 15 75	20	NS	2.419	0.432	NS
10 15-10 27 75	12	2.074	0.207	0.030	2.281
10 27-11 14 75	18	0.280	0.101	0.015	0.389
11 14-11 17 75	2.90	0.00	0.005	NS	NS
11 17-11 18 75	1.01	0.002	0.005	0.009	NS
11 18-11 18 75	0.43	NS	0.004	0.008	NS
11 18-11 19 75	0.52	0.006	0.004	0.007	NS
11 19-11 19 75	0.49	0.004	0.004	0.007	NS
11 19-11 20 75	0.68	0.009	0.005	0.002	NS
11 20-11 21 75	0.47	0.0014	0.004	0.002	NS
11 21-11 21 75	0.68	0.02	0.009	0.004	NS
11 21-11 22 75	0.65	0.24	0.025	0.002	NS
11 22-11 22 75	0.43	0.18	0.010	0.002	NS
11 22-11 23 75	0.63	0.23	0.020	0.003	NS
11 23-11 23 75	0.38	0.016	0.011	0.002	NS
11 23-11 24 75	0.61	0.040	0.019	NS	NS
Totals	360.88	1119.847	889.591	74.583	1973.344
sample time, days		326.5	360.9	337.4	317.0

Notes a Sample period is 7 days
(1) Actual I-131 release data are summarized in Tables 3-18 and 3-19
(2) NS means no sample taken

Table 3-12
IODINE-131 REACTOR WATER CONCENTRATIONS AND POWER LEVELS AT MONTICELLO
DATA SOURCE-EPRI/NES

Nominal Sample Period Month/Day/Year	Average I-131 Reactor Water Concentration μCi/kg	Thermal Power % of Rated
11/15-11/17/74	-	-
11/20-12/5/74	72.	80
12/5-12/18/74	83	78
12/18-1/6/75	67.	75
1/8-1/9/75	55	63
1/13-1/15/75	a	0
1/9-1/13 and 1/15-1/22/75	a	0
1/22-2/7/75	a	0
2/7-2/22/75	10.	0-100
2/22-3/10/75	34.	100
3/10-3/25/75	35.	100
3/25-4/7/75	39	100
4/7-4/21/75	52.	100
4/21-5/5/75	67.	100
5/5-5/15/75	73	97
5/19-6/5/75	160.	87
6/5-6/23/75	140.	87
6/23-7/8/75	150.	82
7/8-7/22/75	240.	77
7/22-7/30/75	230.	69
8/5-8/21/75	150.	64
8/21-9/3/75	210.	60
9/3-9/11/75	170.	56
9/11-9/25/75	b	0
9/25-10/15/75	b	0
10/15-10/27/75	b	0
10/27-11/14/75	b	0
11/14-11/17/75	b	0
11/17-11/18/75	0.013	Critical
11/18-11/18/75	0.029	Critical
11/18-11/19/75	0.0783	1.2
11/19-11/19/75	0.433	15.0
11/19-11/20/75	1.43	21.1
11/20-11/21/75	1.83	51.4
11/21-11/21/75	2.09	49.4
11/21-11/22/75	2.83	58.0
11/22-11/22/75	3.56	61.0
11/22-11/23/75	2.75	63.0
11/23-11/23/75	2.72	64.0
11/23-11/24/75	3.21	66.0

Notes a Refueling/maintenance outage transpired 1/9 to 2/7/75.
b Refueling/maintenance outage transpired 9/11 to 11/17/75.

Table 3-12a
IODINE-131 REACTOR WATER CONCENTRATIONS AT MONTICELLO DURING REFUELING/MAINTENANCE OUTAGES
DATA SOURCE — EPRI/NES

Sample Date Month/Day	Average I-131 Reactor Water Concentration μCi/Kg
	Outage of January/February 1975
1/9	54.
1/13	42.
1/15	5.1
1/16	4.2
1/17	3.3
2/5	0.57
2/6	1.2
2/7	4.0
	Outage of September/November 1975
9/11	190
9/15	14.
9/18	5.5
9/22	0.64
9/25	2.1

Table 3-13
AVERAGE I-131 VENTILATION RELEASE RATES
PLANT — OYSTER CREEK (2/75–2/76)
DATA SOURCE — EPRI/NES

Average I-131 Release Rate, μCi/s

Nominal Sample Period Month/Day/Year	Reactor (0.001)	Turbine (0.001)	Radwaste (0.001)	Gland Seal and MVP (0.001)	Total Vent (0.001)
2 22–2 26 75	0.75	25.	0.46	NS	26
2 26–3 12 75	0.53	28.	0.68	NS	29
3 12–3 28 75	2.2	28.	0.49	NS	31.
3 29–4 15 75	5 3	80.	NS	NS	91.
4 15–5 1 75	1.3	53.	3.4	NS	58.
5 1–5 15 75	0.50	4.6	NS	NS	5 1
5 15–5 29 75	0 20	0.42	0.048	NS	0.67
5 29–6 16 75	0 75	2.9	0.16	NS	3.9
6 16–6 30 75	1.1	4.6	0.15	1 4	5.9
6 30–7 17 75	1.1	2.7	0.46	1.22	4 3
7 17–8 5 75	0 42	5.6	1.01	6 6	7.1
8 5–8 21 75	0.33	7.5	0.72	2.2	8 6
8 21–9 8 75	0 10	3.3	1.9	5.5	5 5
9 8–9 29 75	0 18	4.7	1.9	NS	6 8
9 29–10 14 75	0.19	0.95	1.1	NS	2.2
10 14–10 31 75	0 086	NS	0.56	NS	-
10 31–11 14 75	0 096	7.7	0.24	0.55	8 0
11 14–12 4 75	0 94	4.3	1.0	5.6	6 3
12 4–12 18 75	0.19	7.0	0.19	2.0	7.5
12 18–1 5 76	1 2	4.5	NS	8.2	-
1 5–1 22 76	0.18	10.5	0.109	0.18	10 8
1 22–2 9 76	0 031	1.4	0.081	0.0052	1.5

Notes (1) Refueling maintenance outage transpired 3/29 to 5/29/75
(2) Refueling maintenance outage transpired 1/5/76 to 2 9/76 and continued to 3 14/76
(3) NS means no sample taken

Table 3-13a
AVERAGE I-131 VENTILATION RELEASE RATES
PLANT — OYSTER CREEK (6/76–11/76)
DATA SOURCE — EPRI/NES

Average I-131 Release Rate, μCi/s

Nominal Sample Period Month/Day/Year	Reactor (0.001)	Turbine (0.001)	Radwaste (0.001)	Gland Seal and MVP (0.001)	Feedwater Pump/ Condensate Pump Room Exhaust (0.001)	Reheater Protection System Exhaust (0.001)
6/16–6/23/76	0.2388	11.49	0.4632	NS	NS	NS
6/23–6/30/76	0.2095	11.80	0.2714	0.4321	0.1425	NS
6/30–7/7/76	0.2168	21.79	0.5554	0.4887		NS
7/7–7/13/76	0.1049	14.19	0.6074	0.3397	0.1196	NS
7/13–7/20/76	0.1595	12.89	0.1463	0.6198		NS
7/20–7/27/76	0.1875	13.99	0.0930	0.4440	0.09894	0.691
7/27–8/3/76	8.258	6.464	1.0918	27.803		
8/3–8/10/76	0.9990	13.71	0.5491	0.5602	0.2884	1.053
8/10–8/17/76	0.8125	21.20	0.2003	0.1118		
8/17–8/24/76	0.7093	19.19	1.0176	0.6616		1.683
8/24–8/30/76	1.029	11.22	0.9084	1.9281	0.09512	
8/30–9/7/76	0.3363	11.46	0.4060	1.3619		1.690
9/7–9/16/76	0.3563	9.063	0.7462	1.6420	0.1776	
9/16–9/23/76	0.4762	16.72	1.3462	1.9936		0.9508
9/23–9/30/76	0.0406	13.10	4.4096	2.4436		
9/30–10/7/76	0.2831	14.43	0.9657	1.5496		1.006
10/7–10/14/76	0.2801	14.33	0.5554	1.5794	0.1438	
10/14–10/21/76	0.2641	13.51	0.4357	1.4095		0.6566
10/21–10/28/76	0.2298	12.00	1.1554	1.2844	0.1158	
10/28–11/4/76	0.2165	12.83	0.6646	1.2754		0.7524
11/4–11/11/76	0.2244	12.11	0.5194	1.3470	0.2292	
11/11–11/18/76	0.2288	11.39	0.7538	0.9476		NS
11/18–11/30/76	0.1765	10.53	0.6169	1.2278	0.2178	0.3783

Note: Plant shutdown for five days between 7/26 and 8/1/76

Table 3-14
ACTUAL I-131 VENTILATION RELEASES
PLANT — OYSTER CREEK (2/75-2/76)
DATA SOURCE — EPRI/NES

Nominal Sample Period Month/Day/Year	Nominal Sample Time Days	Total I-131 Release, millicuries: Reactor	Turbine	Radwaste	Gland Seal & MVP	Total Vent
2 22-2 26 75	4	0 259	8 640	0 159	NS	8 986
2 26-3 12 75	14	0 641	33.87	0 823	NS	35 08
3 12-3 28 75	16	3 041	38.71	0 677	NS	42 85
3 29-4 15 75	17	7.785	117.5	NS	NS	133 7
4 15-5 1 75	16	1.797	73 27	4.700	NS	80 18
5 1-5 15 75	14	0.605	5 564	NS	NS	6 169
5 15 5 29 75	14	0 242	0.508	0.058	NS	0 810
5 19-6 16	18	1 166	4.510	0 249	NS	6.065
6 16-6 30 75	14	1.331	5 564	0.181	1 693	7.137
6 30-7 17 75	17	1 616	3 966	0 676	1.792	6 316
7 17-8 5 75	19	0 689	9.193	1.658	10.83	11.66
8 5-8 21 75	16	0 456	10.37	0.995	3.041	11 89
8 21-9 8 75	18	0 156	5.132	2.955	8.554	8 554
9 8 9 29 75	21	0 327	8.528	3.447	NS	12.34
9 29-10 14 75	15	0 246	1.231	1.426	NS	2 851
10 14-10 31 75	17	0 126	NS	1.823	NS	-
10 31 11 14 75	14	0 116	9 314	0.290	0.665	9.677
11 14 12 4 75	20	1 624	7.430	1.728	9 677	10 89
12 4-12 18 75	14	0 230	8.467	0.230	2.419	9 072
12 18-1 5 76	18	1 866	6.998	NS	12.75	-
1 5-1 22 76	17	0.264	15.42	0.160	0.264	15 86
1 22-2 9 76	18	0 048	2.177	0.126	0.008	2.333
Total I-131 Release millicuries		24.631	376.362	21.361	51.693	422.420
Total sample time, days		351	334	302	185	316

Notes (1) Refueling maintenance outage transpired 3 29 to 5 29 75
(2) Refueling maintenance outage transpired 1 5 to 2 9 76 and continued to 3 14 76
(3) NS means no sample taken

Table 3-14a
ACTUAL I-131 VENTILATION RELEASES
PLANT — OYSTER CREEK (6/76–11/76)
DATA SOURCE — EPRI/NES

Total I-131 Release, millicuries

Nominal Sample Period Month/Day/Year	Sample Period Days	Reactor	Turbine	Radwaste	Gland Seal & MVP	Feedwater Pump Condensate Pump Room Exhaust	Reheater Protection System Exhaust
6 16-6 23 76	7	0.1444	6.950	0.2802	NS	NS	NS
6 23-6 30 76	7	0.1267	7.136	0.1641	0.2613	0.1724	NS
6 30-7 7 76	7	0.1311	13.176	0.3359	0.2956		NS
7 7-7 13 76	6	0.05438	7.358	0.3149	0.1761	0.1343	NS
7 13-7 20 76	7	0.09647	7.798	0.08847	0.3749		NS
7 20-7 27 76	7	0.1134	8.460	0.05622	0.2685	0.1197	0.8356
7 27-8 3 76	7	4.9947	3.909	0.6603	16.815		
8 3-8 10 76	7	0.6042	8.294	0.3321	0.3388	0.5233	1.274
8 10-8 17 76	7	0.4914	12.824	0.1212	0.06759		
8 17-8 24 76	7	0.4290	11.604	0.6154	0.4001		1.890
8 24-8 30 76	6	0.5334	5.615	0.4709	0.9995	0.1151	
8 30-9 7 76	8	0.2325	7.919	0.2806	0.9413		2.482
9 7-9 16 76	9	0.2771	7.047	0.5803	1.2768	0.4604	
9 16-9 23 76	7	0.2880	10.115	0.8142	1.2057		1.150
9 23-9 30 76	7	0.02457	7.922	2.6669	1.4779		
9 30-10 7 76	7	0.1712	8.729	0.5840	0.9372		1.216
10 7-10 14 76	7	0.1694	8.667	0.3359	0.9552	0.1740	
10 14-10 21 76	7	0.1597	8.170	0.2635	0.8525		0.7943
10 21-10 28 76	7	0.1390	7.260	0.6988	0.7768	0.1400	
10 28-11 4 76	7	0.1309	7.757	0.4020	0.7714		0.9101
11 4-11 11 76	7	0.1357	7.322	0.3141	0.8146	0.2722	
11 11-11 18 76	7	0.1384	6.888	0.4558	0.5731		NS
11 18-11 30 76	12	0.1830	10.921	0.6396	1.2729	0.2258	0.3922
Total I-131 Release (millicuries)		9.7685	192.041	11.4574	31.8535	2.3421	10.9440
Total sample time (days)		167	167	167	167	160	126

Notes (1) Plant shutdown for five days between 7 26 and 8 3 76
(2) NS means no sample taken

Summary of all Data:

	Reactor	Turbine	Radwaste	Gland Seal & MVP	Feedwater Pump Condensate Pump Room Exhaust	Reheater Protection System Exhaust
Total I-131 Release (millicuries)	34.4	568	32.8	83.5	2.34	10.9
Total sample time (days)	518	501	469	352	160	126

Table 3-15
IODINE-131 REACTOR WATER CONCENTRATIONS AND POWER LEVELS AT OYSTER CREEK (2/75–2/76)
DATA SOURCE — EPRI/NES

Nominal Sample Period Month/Day/Year	Average I-131 Reactor Water Concentration μCi/kg	Thermal Power % of Rated
2/22–2/26/75	6.5	88
2/26–3/12/75	6.5	94
3/12–3/28/75	6.5	95
3/29–4/15/75	a	0
4/15–5/1/75	a	0
5/1–5/15/75	a	0
5/15–5/29/75	a	0
5/29–6/16/75	1.7	62
6/16–6/30/75	3.0	80
6/30–7/17/75	1.7	80
7/17–8/5/75	1.8	75
8/5–8/21/75	1.6	82
8/21–9/8/75	1.4	37
9/8–9/29/75	1.3	60
9/29–10/14/75	1.0	27
10/14–10/31/75	1.6	47
10/31–11/14/75	1.7	76
11/14–12/4/75	1.4	47
12/4–12/18/75	1.7	76
12/18–1/5/76	1.6	26
1/5–1/22/76	b	0
1/22–2/9/76	b	0

Notes: a. Refueling maintenance outage transpired 3/29 to 5/29/75
b. Refueling maintenance outage transpired 1/5 to 2/9/76, outage continued to 3/14/76

Table 3-15a
IODINE-131 REACTOR WATER CONCENTRATIONS AND POWER LEVELS AT OYSTER CREEK (6/76–11/76)
DATA SOURCE — EPRI/NES

Nominal Sample Period Month/Day/Year	Average I-131 Reactor Water Concentration µCi/kg	Thermal Power % of Rated
6 16-6 23 76	1 43	90 3
6 23-6 30 76	1.47	91 3
6 30-7 7 76	1.29	89 8
7 7-7 13 76	1 36	92 2
7 13-7 20 76	1 49	91 4
7 20-7 27 76	1 52	80 6
7 27-8 3 76	0 45	33 0
8 3-8 10 76	1 53	91 9
8 10-8 17 76	1 71	95 9
8 17-8 24 76	2.17	96 3
8 24-8 30 76	1 47	96 7
8 30-9 7 76	1 35	95 8
9 7-9 23 76	1 14	83 4
9 23-9 30 76	1.19	97 0
9 30-10 7 76	1.93	93 3
10 7-10 14 76	1 81	96 4
10 14-10 21 76	2 18	94.4
10 21-10 28 76	2.05	99 4
10 28-11 4 76	3 10	96 7
11 4-11 11 76	2 36	99 8
11 11-11 18 76	2.36	97.5
11 18-11 30 76	2.05	95.6

Table 3-15b
IODINE-131 REACTOR WATER CONCENTRATIONS AT OYSTER CREEK
DURING REFUELING/MAINTENANCE OUTAGES
DATA SOURCE — EPRI/NES

Nominal Sample Period Month/Day	Average I-131 Reactor Water Concentration μCi/Kg
	Outage of March/May 1975
4/2 -4/8	3.9
4/9 -4/15	0.70
4/16-4/22	0.44
4/23-4/29	0.053
4/30-5/6	0.016
5/7 -5/13	0.020
5/14-5/20	0.022
5/21-5/27	0.64
	Outage of January/March 1976
12/29-1/5	0.13*
1/5 -1/12	0.11
1/12-1/19	0.095
1/19-1/26	0.080

*Plant down for refueling and condenser maintenance 12/26/75; thermal power (percent of rated) was 26% during period from 12/18/75 to 1/5/76.

Table 3-16
IODINE-131 REACTOR WATER CONCENTRATION, POWER LEVELS AND STEAM FLOW RATES DURING STARTUP (AFTER 75 DAY SHUTDOWN) AT OYSTER CREEK STATION
DATA SOURCE—EPRI/NES

Date Month/Day/Hour 1976		I-131 Concentration in Reactor Water, µCi/Kg	Power Level % of Rated	Steam Flow LB/hr x 10 [illegible]
3 14	0254	—	41 9	2 89
	0820	0 81	—	—
	1054	—	41 8	2 89
	1314	—	45 0	3 13
	1404	—	46 2	3 21
	1755	0 85	—	—
	1959	—	45.2	3 14
3 15	0115	0 86	—	—
	1259	—	44.5	3 09
	1020	0 83	—	—
	1059	—	45 9	3 16
	1559	—	47 7	3 28
	1714	—	45 8	3.19
	1732	0.78	—	—
	1914	—	45 8	3 18
3 16	0127	0 77	—	—
	0214	—	45 0	3 12
	0714	—	46 4	3.20
	0835	0.82	—	—
	1544	—	45 0	3.13
	1604	—	49 4	3 40
	1713	0 88	—	—
	2004	—	49 1	3 39

Table 3-16 (Continued)
IODINE-131 REACTOR WATER CONCENTRATION, POWER LEVELS AND STEAM FLOW RATES DURING STARTUP (AFTER 75 DAY SHUTDOWN) AT OYSTER CREEK STATION
DATA SOURCE—EPRI/NES

Date Month/Day/Hour 1976		I-131 Concentration in Reactor Water, μCi/Kg	Power Level % of Rated	Steam Flow LB/hr x 10^6
3/17	0112	0.84	—	—
	0304	—	49.1	3.39
	0830	0.86	—	—
	1204	—	49.1	3.39
	1304	—	50.5	3.54
	1404	—	54.6	3.86
	1504	—	57.2	4.06
	2004	—	57.2	4.06
3/18	0304	—	58.3	4.14
	1000	0.92	—	—
	1104	—	57.7	4.10
	1910	0.96	—	—
	2024	—	56.1	3.97
3/19	0324	—	56.0	3.97
	0820	0.95	—	—
	1049	—	55.9	3.96
	1909	—	55.8	3.96
3/20	0309	—	55.8	3.96
	1109	—	55.8	3.95
	2009	—	55.8	3.94
3/21	0309	—	56.1	3.94
	1109	—	55.6	3.94
	2009	—	55.4	3.92
	2209	—	55.6	3.94
	2309	—	70.3	5.08

Table 3-16 (Continued)
IODINE-131 REACTOR WATER CONCENTRATION, POWER LEVELS AND STEAM FLOW RATES DURING STARTUP (AFTER 75 DAY SHUTDOWN) AT OYSTER CREEK STATION
DATA SOURCE—EPRI/NES

Date Month/Day/Hour 1976		I-131 Concentration in Reactor Water, μCi/KG	Power Level % of Rated	Steam Flow LB/hr x 10 ⁶
3 22	0009	—	71 2	5 15
	0109	—	72.1	5 22
	0959	—	70 3	5 08
	1959	—	68 7	4 95
3 23	0259	—	68 6	4 95
	1059	—	68 6	4 94
	1909	—	68 6	4 94
3 24	0309	—	67 4	4 85
	0829	1 5	—	—
	1209	--	67.7	4 87

Table 3-17
IODINE-131 AIRBORNE CONCENTRATIONS IN BUILDING EXHAUSTS AND GLAND SEAL STEAM EXHAUST DURING STARTUP (AFTER 75 DAY SHUTDOWN) AT OYSTER CREEK
DATA SOURCE—EPRI/NES

I-131 CONCENTRATION, μCi/cc

Sample Time Month/Day/Hour 1976		Reactor	Turbine	Radwaste	Gland Seal Steam
3 15	0030	—	8.8 (−12)	—	—
	0823	—	—	—	2 6 (10)
	1624	—	7.7 (12)	—	—
3 16	0027	—	4.2 (·12)	—	—
	0043	—	—	3.2 (12)	—
	0852	—	3.2 (12)	—	—
	0910	—	—	—	4.6 (10)
	1700	—	1.6 (11)	—	4.9 (10)
3 17	0100	—	1.4 (11)	4 4 (12)	4 2 (10)
	0900	—	1.2 (· 11)	—	4 3 (10)
	1110	—	—	5 4 (12)	—
	1745	—	—	—	6.3 (10)
	1750	—	6.5 (11)	—	—
	1800	3 0 (· 12)	—	—	—
	1819	—	—	4.8 (· 12)	—
3 18	0029	—	—	—	5.4 (10)
	0041	—	7.8 (· 11)	—	—
	0047	· 2 (12)	—	—	—
	0056	—	—	5 2 (12)	—
	0900	—	1.2 (−10)	—	6.7 (10)
	0930	· 2 (12)	—	—	—
	1645	—	—	—	6.8 (10)
	1650	—	1.5 (10)	—	—
	1700	· 2 (12)	—	—	—
	1800	—	—	4.0 (· 12)	—
3 19	0940	—	—	—	6.9 (10)
	0941	—	1.4 (−10)	—	—
	0948	3.5 (12)	—	—	—
	0956	—	—	3.6 (· 12)	—
3 24	1326	—	—	—	7.8 (10)
	1345	—	3.0 (−10)	—	—
	1355	3 5 (12)	—	—	—
	1425	—	—	1.0 (−11)	—
	2003	—	—	—	1.2 (·9)
	2100	—	2.7 (−10)	—	—
	2200	—	—	1.2 (· 11)	—

cbm

Table 3-18
SUMMARY OF ACTUAL I-131 VENTILATION MEASUREMENTS BY EPRI/NES AT VERMONT YANKEE, MONTICELLO AND OYSTER CREEK

	PLANT					
	Vermont Yankee		Monticello		Oyster Creek	
	Total[a] I-131 Release, millicuries (sample time, days)					
	Power Generation Operations					
Release From:						
Reactor Building	39.	(446)	1028.3	(253.5)	13.89 9.77	(255) (167)
Turbine Building	18.	(446)	828.0	(267.0)	161.9[b] 192.0[c]	(238) (167)
Radwaste Building	18.	(425)	69.4	(264.4)	16.32 11.5	(237) (167)
Gland Seal Steam Exhaust	34.	(379)	No Data		31.9	(167)
	Refueling/Maintenance Outage					
Reactor Building	113.	(56)	31.2 60.4	(29) (44)	10.43 0.312	(61) (35)
Turbine Building	9.	(56)	52.3 9.1	(29) (64)	196.8 17.6	(61) (35)
Radwaste Building	14.	(53)	1.24 3.99	(29) (64)	4.76 0.286	(30) (35)
Mechanical Vacuum Pump	19.	(39)	No Data		No Data 0.272	 (35)

Notes a Total includes all chemical species of I-131

b Excludes I-131 releases from feedwater pump/condensate pump room exhaust and reheater protection system exhaust because no samples were taken.

c Excludes I-131 releases from feedwater pump/condensate pump room exhaust and reheater protection system exhaust, these releases are small, namely 2.34 mCi (160 days) and 10.9 mCi (126 days), respectively

Table 3-19
SUMMARY OF ACTUAL I-131 VENTILATION MEASUREMENTS BY EPRI/NES AT VERMONT YANKEE, MONTICELLO AND OYSTER CREEK ADJUSTED TO 300 DAYS OF POWER OPERATIONS AND 1% I-131 CARRYOVER

	PLANT		
	Vermont Yankee	Monticello	Oyster Creek
	Total[a] I-131 Release, millicuries		
Release From	**Power Generation Operations**		
Reactor	26 3	1217	16 8
Turbine	31 1	2061	127 0[b]
Radwaste	13 0	78 7	20 6
Gland Seal Steam	27 1	No Data	78 8
Sub-total	97 5	3357	243 2
	Refueling Maintenance Outages		
Reactor	112 5	49 5	5 37
Turbine	21 8	68 3	46 6
Radwaste	14 3	2 6	13 4
Mechanical Vacuum Pump	215	No Data	0 12
Sub-total	364	120	65 5
Total[c] Annual Release	462.	3477	309

a Total includes all chemical forms of I-131

b Includes releases from reheater protection system and feedwater condensate pump equipment compartment

c Annual includes 300 days of power operations plus one R M outage

Table 3-20
SUMMARY OF NRC MEASUREMENTS OF I-131 RELEASES AT SIX BWR'S

I-131 Release Rate, μCi/s

Plant	Operating Mode	Reactor	Turbine	Radwaste	Sample Time (Days)
Oyster Creek	Normal	0.0016	0.018	0.00067	14
	Normal	0.0014	0.043	0.00053	14
	Normal	0.0025	NM	NM	14
	Normal	0.0081	0.007	0.0019	14
	Containment Purge	0.14	0.087	0.0011	2
	Refueling	0.011	0.080	0.0025[a]	45
Monticello	Normal[b]	0.0070	0.0050	0.0064	29 hours
	Normal		0.0017[c]		42[d]
Dresden 2	Normal[b]	0.0019	NM	NM	24 hours
	Normal	NM	0.00028	NM	15
	Normal	NM	0.00027	NM	14
Dresden 3	Normal[b]	0.0061	NM	NM	24 hours
	Normal	NM	0.00065	NM	13
	Normal	NM	0.0008	NM	14
Dresden 2 & 3	Normal	NM	0.0006	NM	42[d]
Quad Cities 1	Normal	0.0038	NM	NM	1
	Normal	NM	0.00047	—	14
Quad Cities 2	Normal	0.00023	NM	NM	1

Notes:
a First 31 days only
b In conjunction with iodine species measurement, assume normal operations
c Includes all buildings
d Approximate value (NEDO 21159, March 1976, Figure 3-20)
(1) Measurements made during 1972, except for Quad Cities 1, 2 plants which were investigated in 1973
(2) NM means no measurement

Table 3-21
SUMMARY OF AIRBORNE I-131 RELEASES; MEASUREMENTS BY GENERAL ELECTRIC COMPANY

I-131 RELEASE RATE, μCi/s

Plant	Mode of Operation	Reactor	Turbine	Radwaste	Gland Seal Exhaust	Sample Period (hrs)	Sample Time Month Year	I-131 Coolant Concentration (μCi/cc)
Dresden 2	Normal	0.005	—	—	NM	2	Jan 1971	0.0023
	Normal	NM	0.006		NM	15	Feb 1971	0.0023
Nine Mile Point 1	Normal	NM	0.0016	NM	NM	NA	Dec 1971	0.0017
	Normal	5.57 E-4	5.57 E-3	1.00 E-3[b]		a	March-April 74	0.002
		(29.7)	(42.4)	(50.9)				
	Normal	6.64 E-4	7.3 E-3	4.04 E-4		a		
		(44.9)	(6.7)	(44.1)				
	Normal	4.6 E-4	4.54 E-3	4.2 E-5		a		
		(66.2)	(64.2)	(48.5)				
	Normal	7.97 E-4	7.02 E-3	1.0 E-5		a		
		(5.3)	(65.3)	(43.2)				
	Normal	7.1 E-4	—	—		a		
		(15.8)						
	Shutdown	4.48 E-3	1.38 E-3	5.2 E-5				
		(126.3)	(47.7)	(75.1)		a		
	Shutdown	1.79 E-3	7.81 E-3	1.6 E-4				
		(16.2)	(71.8)	(43.2)				
Oyster Creek	Normal	0.00144	0.0009	<0.00030	<0.006	1	April 1972	0.0075
			0.0029			1		
Millstone Point 1	Normal	0.00165	NM	0.00105	0.000192	1	July 1972	0.0034
	Normal	0.00146	NM	—	—	1		
	Normal	—	0.0026	—	—	9		
	Normal	0.00323		NM	—	1		
	Normal	0.0058		NM	—	1		
	Shutdown				c		Sept 1972	0.030 to 0.232

Notes a Sample period (hrs) in parenthesis
b Concentrator steam leak at about this time
c Approximately 2.1 millicuries of I-131 released during 70 minutes of mechanical vacuum pump operation on September 1 1972. the plant was shut down on August 29. 1972
(1) NM - Not Measured
(2) NA - Not Available

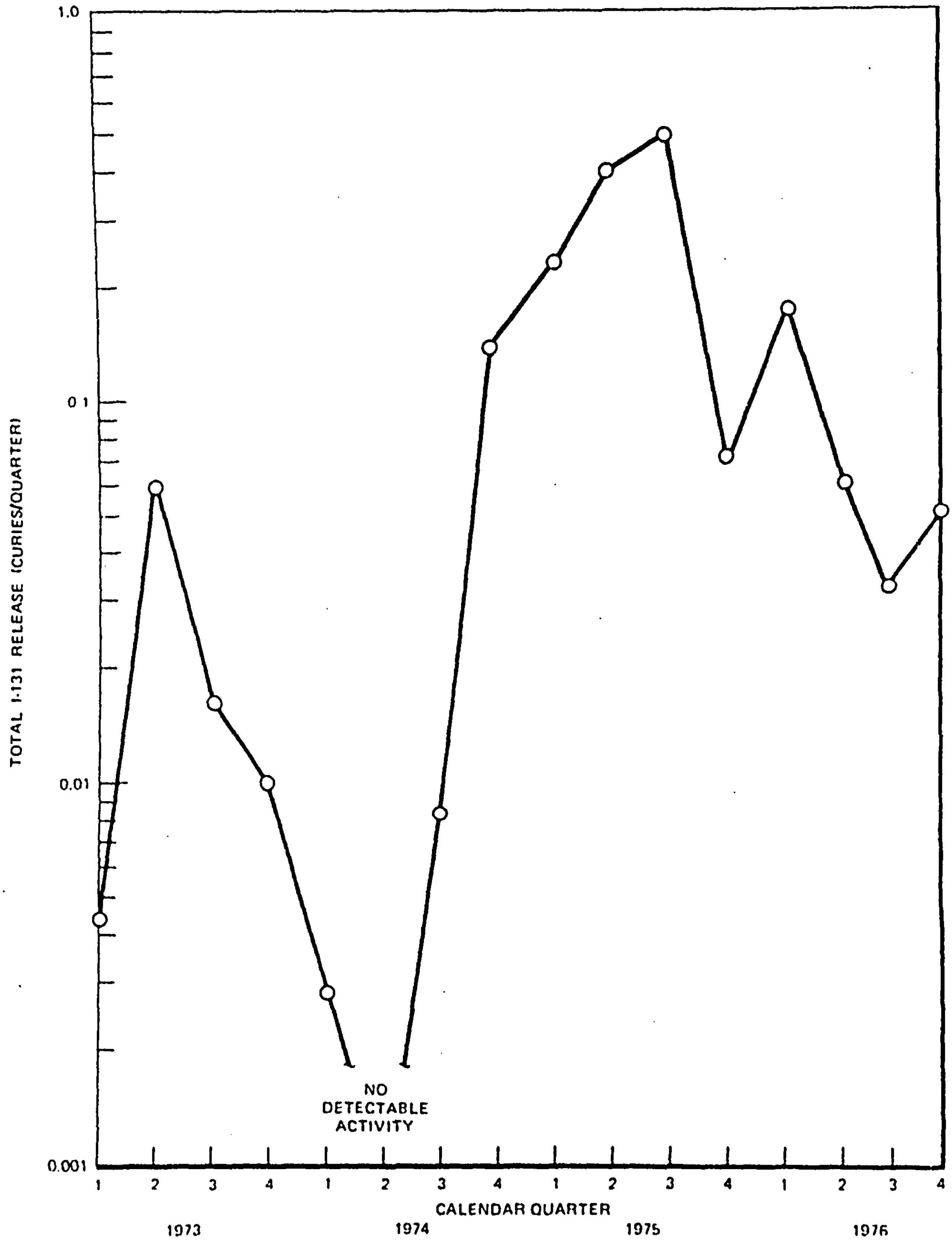

Figure 3-1. Calendar Quarterly Total Plant Ventilation Releases of I-131 versus Time, Pilgrim 1 (Reactor, Turbine and Radwaste Buildings)

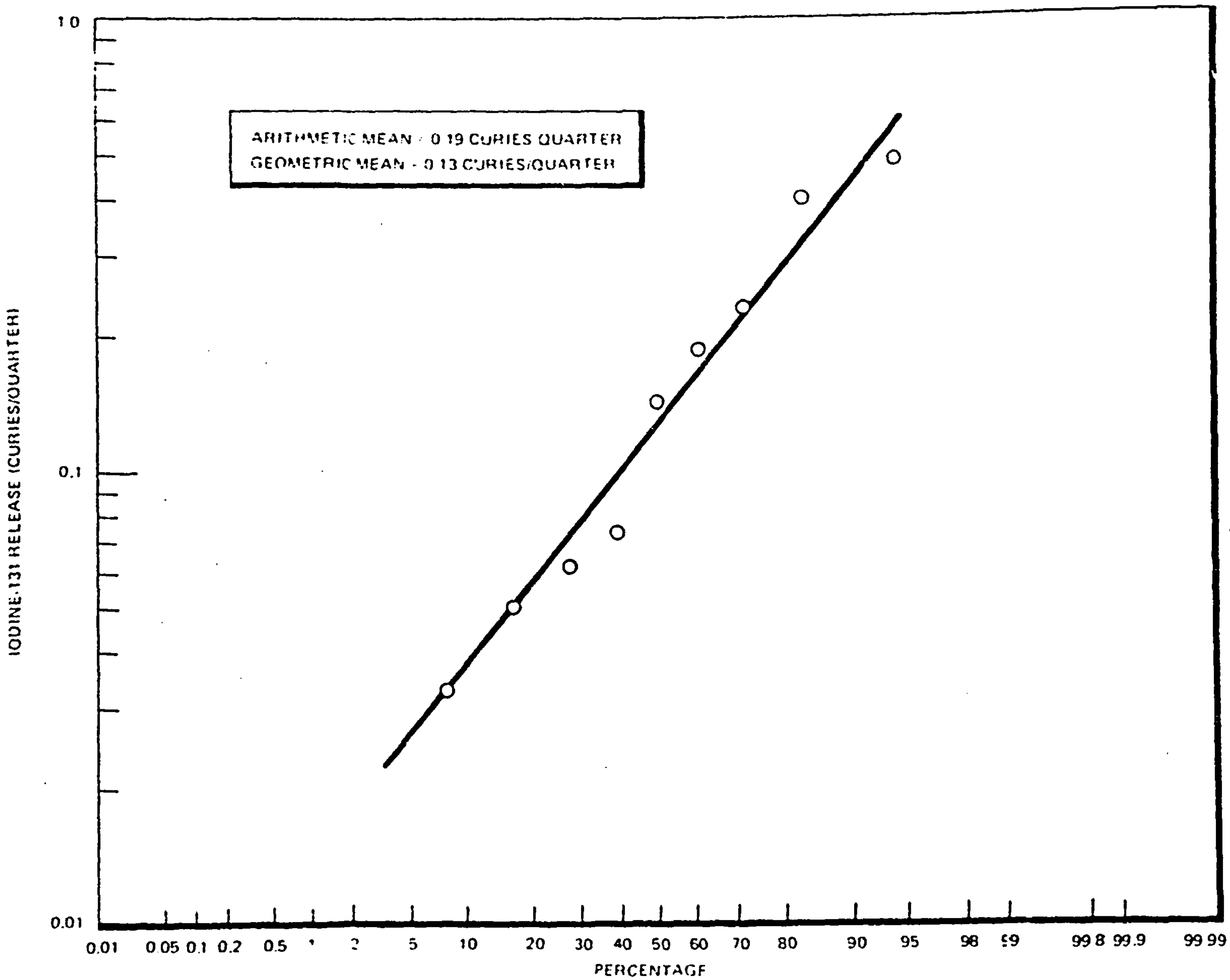

Figure 3-2 Accumulative Probability Distribution of Calendar Quarter I-131 Ventilation Releases, Pilgrim 1 (Reactor, Turbine and Radwaste Buildings, October 1974 to December 1976)

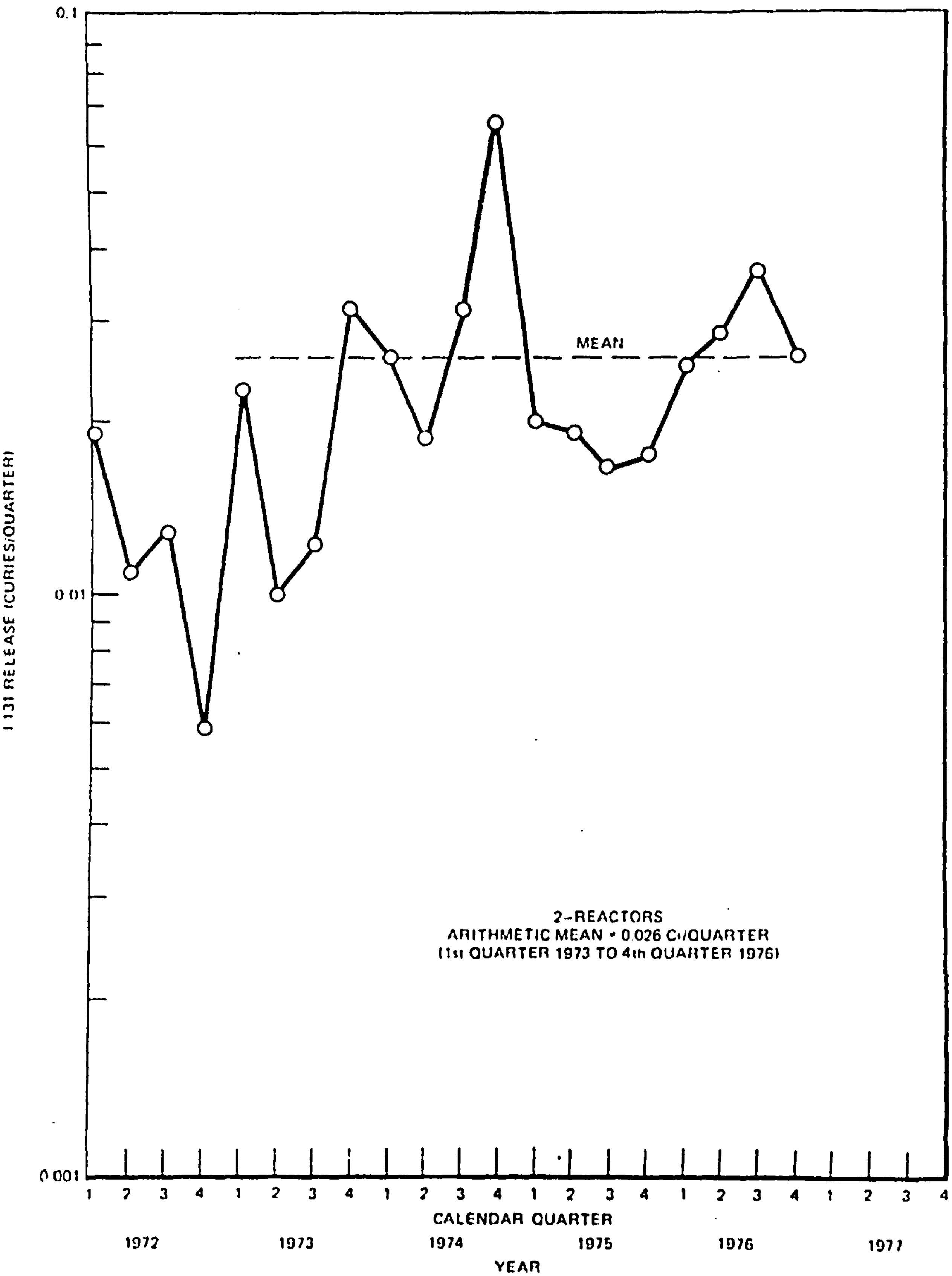

Figure 3-3. Calendar Quarter Reactor Building Ventilation Release of I-131 Versus Time, Dresden 2/3

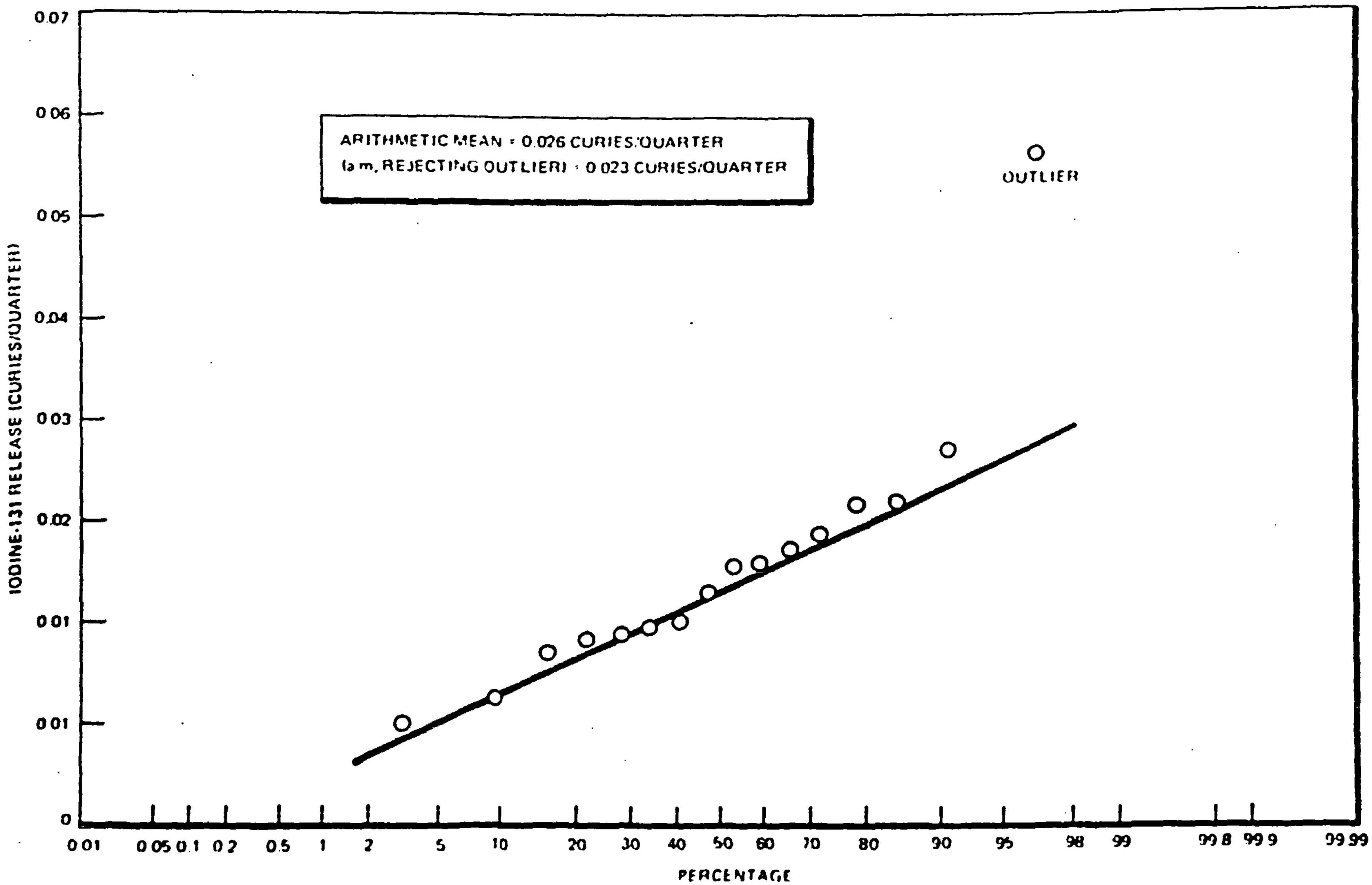

Figure 3-4. Accumulative Normal Probability Distribution of Calendar Quarter Reactor Building Ventilation Releases of I-131 Dresden 2/3 (January 1973 to December 1976)

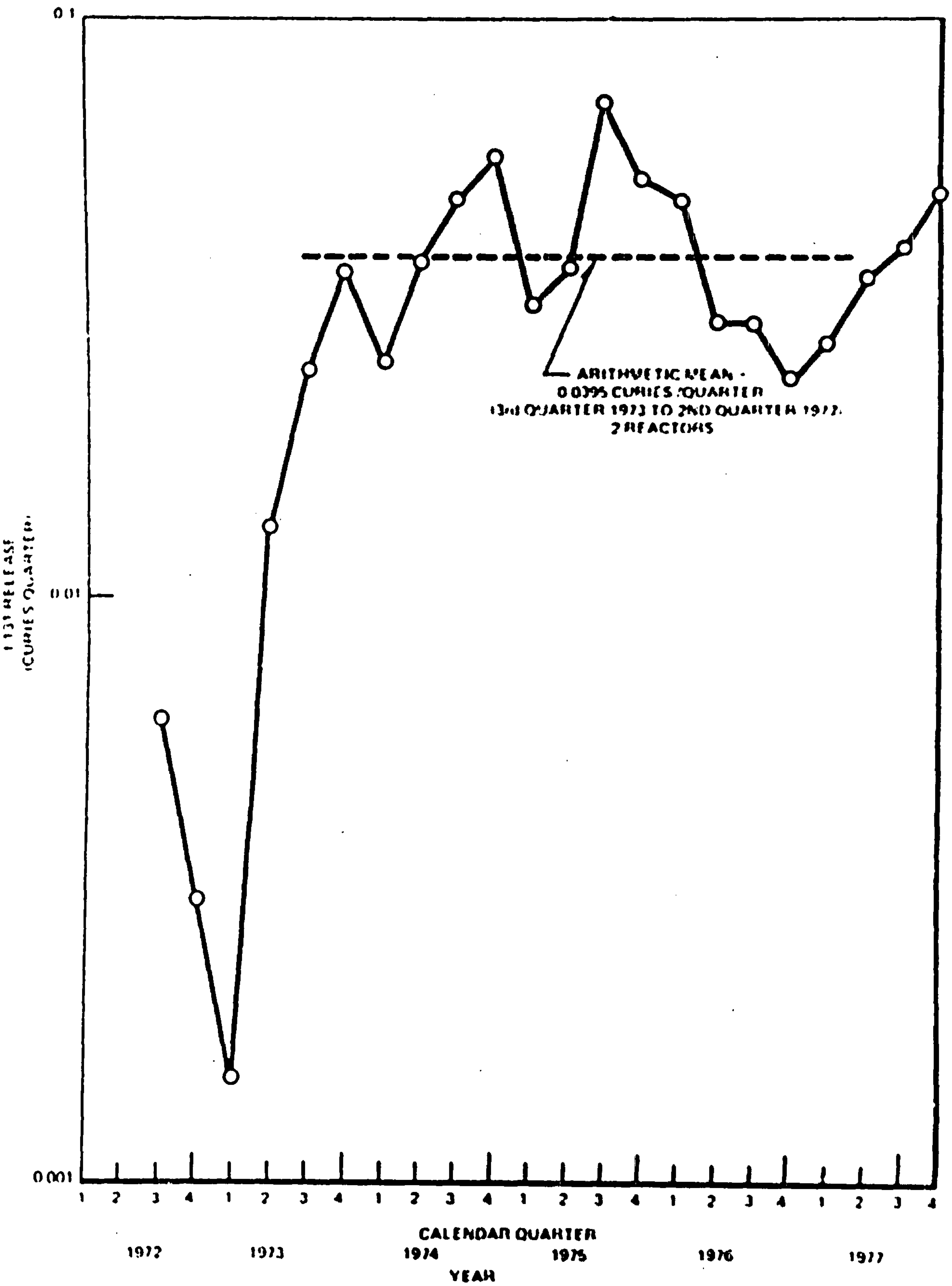

Figure 3.5 Calendar Quarter Reactor Building Ventilation Release of I-131 versus Time, Quad Cities 1-2

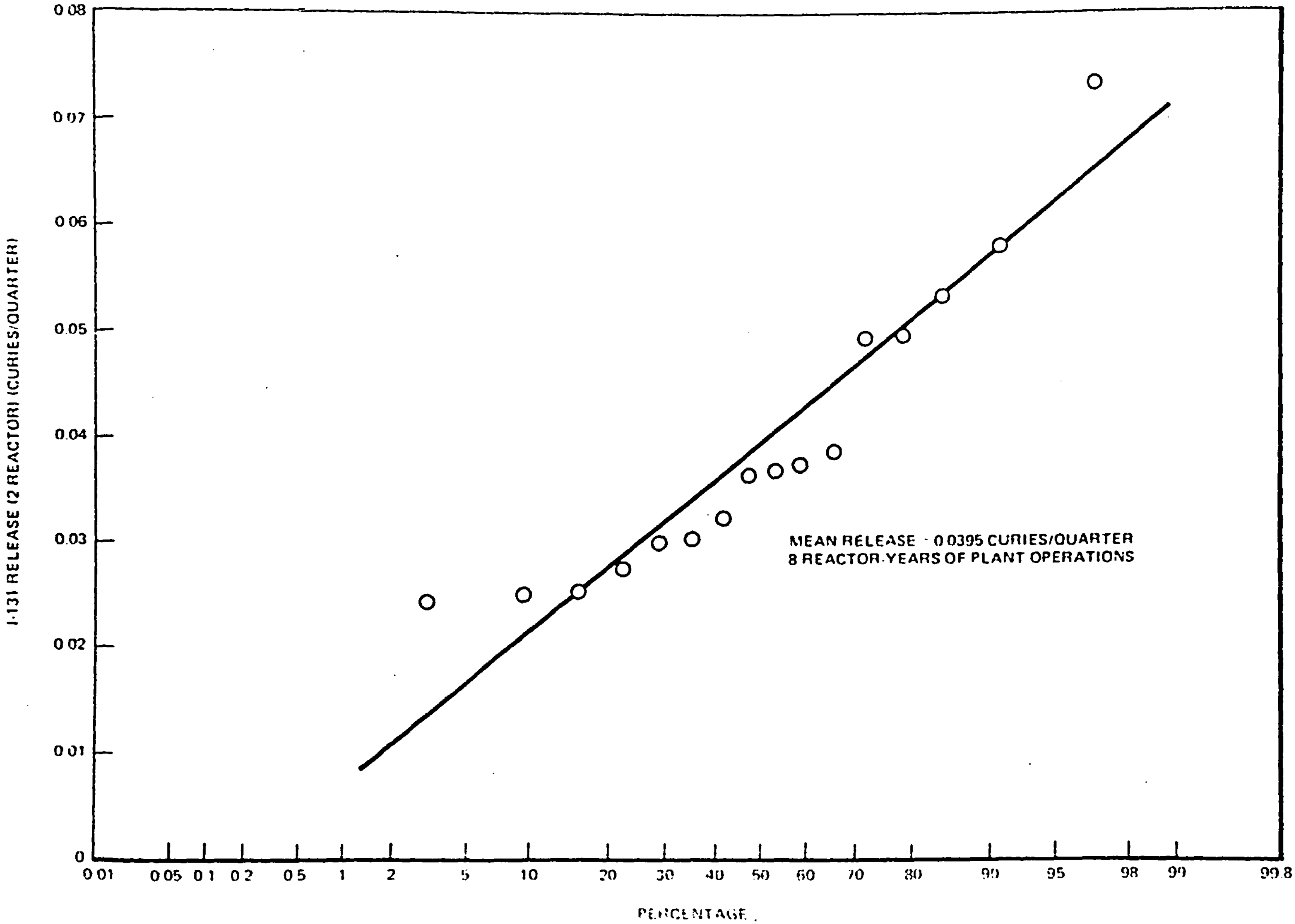

Figure 3-6. Accumulative Normal Probability Distribution of Calendar Quarter Reactor Ventilation Releases of I-131, Quad Cities 1-2 (July 1973 to June 1977)

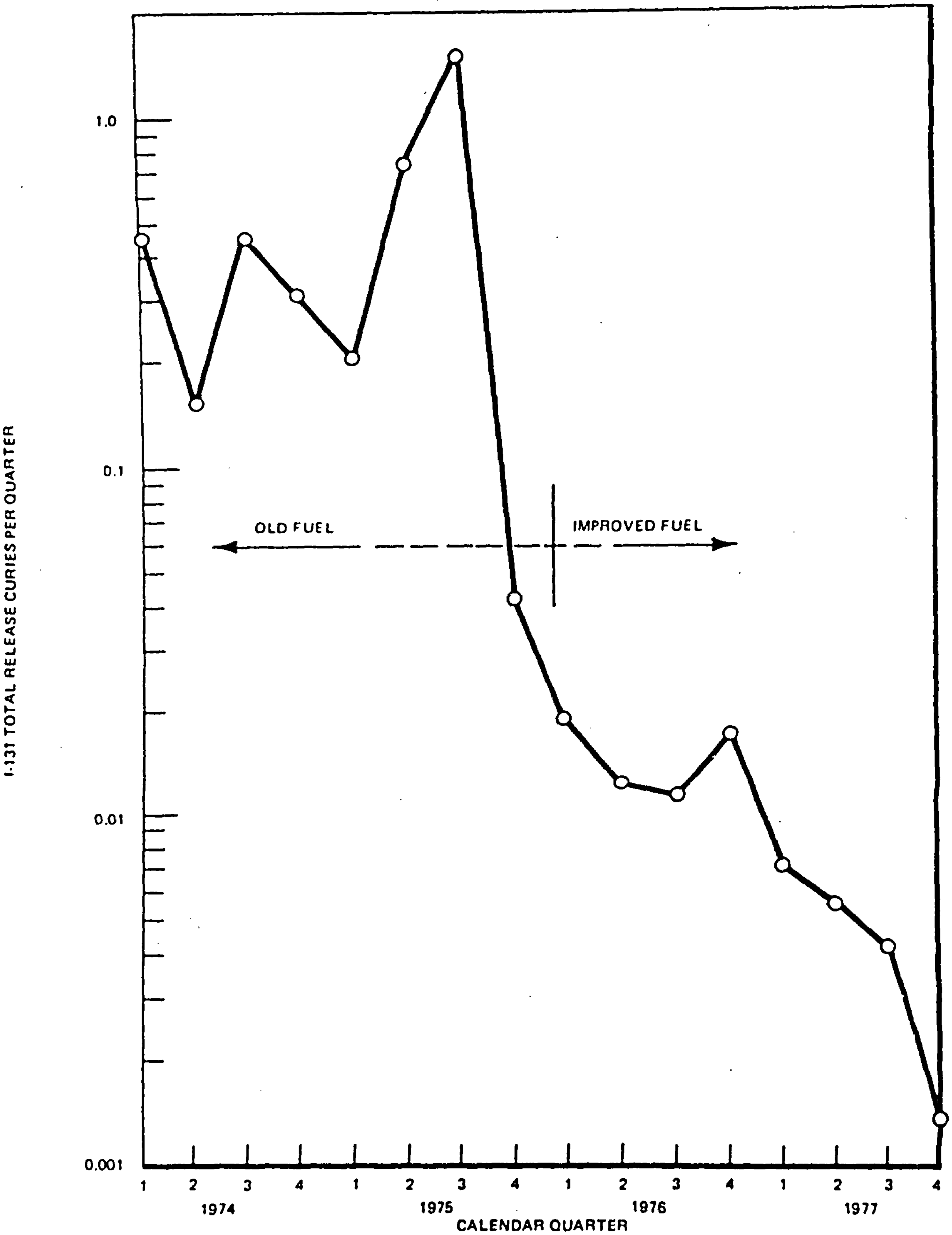

Figure 3-7. Calendar Quarter Total Plant Ventilation Release of I-131 versus Time, Monticello (Reactor, Turbine and Radwaste Buildings)

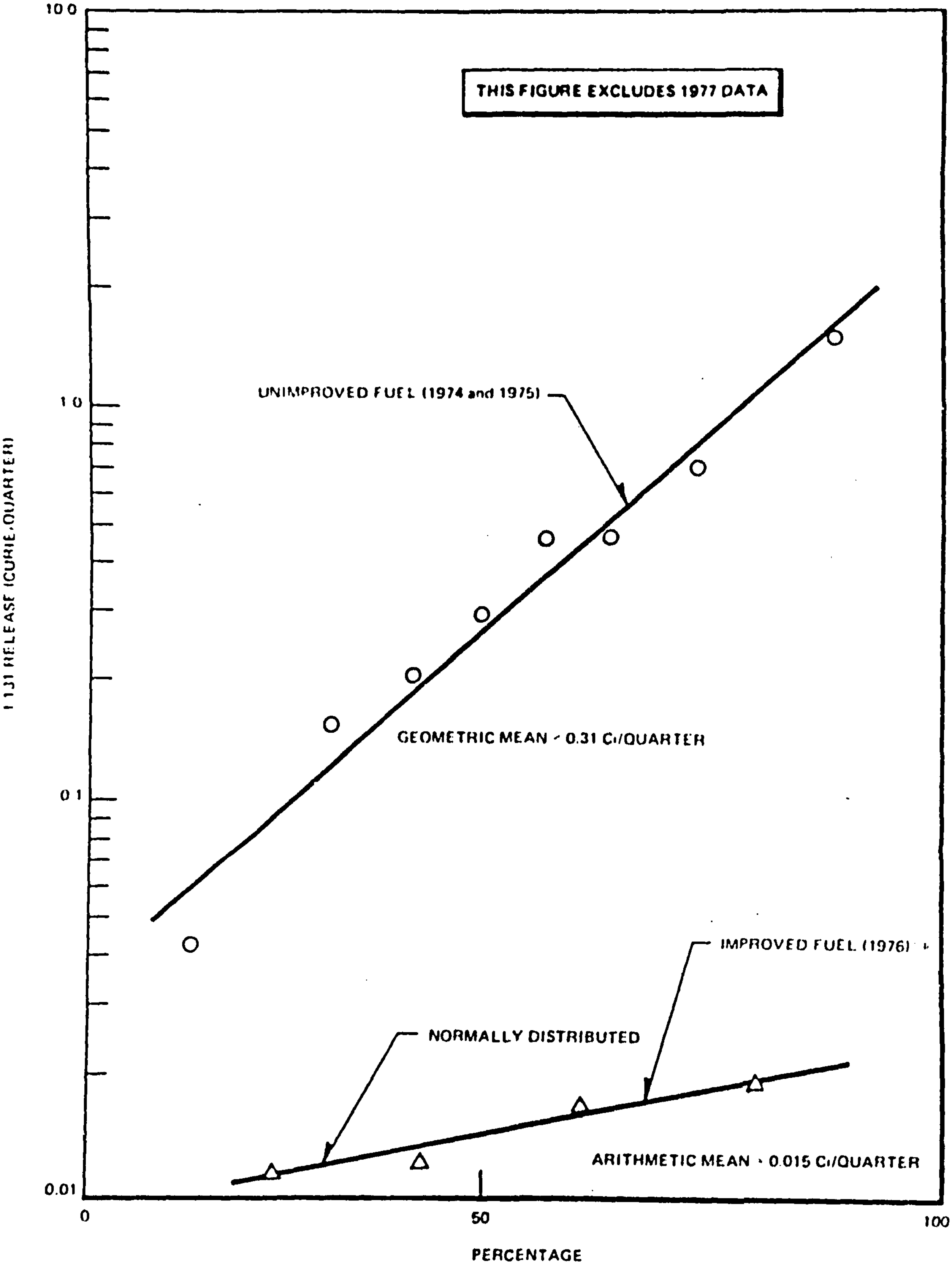

Figure 3-8. Accumulative Lognormal Probability Distribution of Calendar Quarter I-131 Total Plant Ventilation Releases, Monticello (Reactor, Turbine and Radwaste Buildings, January 1974 to December 1976)

4. CHEMICAL FORM OF IODINE-131 RELEASES

The following material on iodine-131 chemical form updates data previously reported in NEDO-21159, March 1976, Chapter 4.

The chemical form of radioiodine releases is an important factor in a realistic and proper environs dose impact assessment. The specification of I-131 species is in accord with Appendix I of 10CFR50 which requires realistic dose evaluations (see Appendix 2A). From BWR operating plant experience, I-131 exists in several forms, both inorganic and organic. Inorganic iodine forms of interest are particulate, elemental (I_2), and hypoiodous acid (HOI). For ingestion dose evaluations, the amount of elemental I-131 release is needed (Reference 4-1). Organic iodine (methyl iodide) is not a significant contributor to the milk pathway dose. However, CH_3I would contribute to an inhalation dose. Methyl iodide is known to have a much smaller deposition velocity than elemental iodine, thus it does not readily deposit on vegetation which could be eaten by cows and found in milk (References 4-2, 4-3, 4-4, and 4-5). The deposition velocity for I_2 is more than 1000 times greater than for CH_3I, and more than 10 times greater than for iodine in particulate form. The deposition velocity for HOI is unknown.

The importance of iodine chemical form in BWR releases has been recognized by the NRC. In 1972, the NRC (then AEC) conducted measurements of BWR releases which included measurements of radioiodine species. Similar species measurements with improved techniques were conducted in 1973. In addition to the NRC measurements, GE has independently conducted species measurements at a few BWR plants. The most extensive measurements of radioiodine species have been sponsored by EPRI. This chapter includes EPRI results through December, 1976.

The chemical forms of iodine-131, or species thereof, are defined on the basis of samplers previously described (References 4-6 through 4-11). All the samplers consist of a series of adsorbents which selectively identify the iodine species in the direction of air flow as follows:

I-131 species	*adsorbent*
particulate	filter paper, Flanders F-700
elemental (I_2)	cadmium iodiode on chromasorb - p
hypoiodous acid (HOI)	4-iodophenol on alumina
organic (CH_3I)	KI or TEDA impregnated charcoal (or silver zeolite)

Thus the iodine species are defined in terms of the adsorbents.

At this time there is some question about the actual presence of HOI. The chemical nature of the HOI has not been positively determined and is so-called on the basis of circumstantial evidence. In this document the iodine species collected on the third adsorbent is called HOI, but with serious reservations as to its existence. Also, in this document CH_3I is used as a synonym for organic iodine. However, organic iodine species other than CH_3I have not been fully determined in operating plant atmospheres.

The chemical form of I-131 varies significantly between BWR operating modes. The relative amounts of elemental and organic iodine change from normal power generation operations to refueling/maintenance outages. Furthermore, the I-131 species concentrations are different for each of the principal building ventilation exhausts and the gland seal/mechanical vacuum pump exhausts. The available measurements on I-131 species are listed in Tables 4-1, 4-2, 4-5, and 4-6 are for the reactor, turbine, radwaste, and gland seal/MVP exhausts, respectively. Tables 4-3 and 4-4 list results, unique to Oyster Creek, for I-131 species of the Feedwater Pump and Condensate Pump room exhaust and the Reheater Protection System and Lube Oil Storage Area exhaust. The total I-131 release from both these exhausts is less than 10% of the turbine building release.

Appendix 2B summarizes I-131 species data for in-plant compartments of the BWR reactor and turbine buildings. In addition I-131 species measurements at the end of the SJAE delay line are listed in Appendix 2B. This appendix contains data for the reader's convenience; the information was not used to calculate I-131 species concentrations in ventilation exhausts.

Table 4-7 summarizes the I-131 chemical form data according to plant. The data for normal power generation operations are separate from data for refueling/maintenance outages.

The concentrations of particulate, elemental, HOI and CH_3I recommended for environmental impact evaluations are listed in Table 4-8.

The species measurements were evaluated to obtain the best single estimate of the I-131 chemical form in each building ventilation exhaust during both power generation operations (including brief plant shutdowns) and refueling/maintenance outages. Inspection of the data indicated that species concentrations were relatively similar for a given plant, but significant differences existed between plants. For example, the average CH_3I concentration during power generation operations in the reactor building ventilation exhaust at Quad Cities 1 is approximately a factor of 1.5 greater than at Quad Cities 2. The assumption was made that the available measurements constitute a random selection of operating BWR's. For each plant, the relative I-131 concentrations (percentages of I-131 released in each ventilation exhaust) were determined by weighting the reported results according to sample time. This assumes that a sample of long-duration yields more characteristic information than a short-time sample (Reference 4-12). The weighting of data according to sample time is analogous to taking samples for a constant sample period but weighting the mean results according to the number of samples. The greater the number of samples (equivalent to longer sample times), the more certain one becomes that the sample mean will be close to the (unknown) population mean. This effect is based on the central limit theorem of statistics (Reference 4-13). After a set of weighted mean concentrations were determined for each plant and exhaust, these results were simply averaged (the arithmetic mean calculated) in order to establish the best single estimate of the average I-131 species concentrations.

The above data reduction procedure gives equal weight to results from each BWR in spite of the number of samples at each BWR. This may be considered a shortcoming to the results reported here. However, the data reduction method favors a best-estimate on the basis of measurements from many different BWR's rather than a large number of measurements from a few BWR plants.

A summary of the number of data points and plants is presented in Table 4-9. There are a total of 14 domestic BWR's that have commenced commercial operations since 1969 (starting with Oyster Creek) and with more than one year of commercial operation, but excluding the Browns Ferry plants. The iodine-131 species measurements have been made at more than half of the domestic BWR reactor buildings, and at about one-fifth of the turbine and radwaste building exhausts.

The I-131 species data were also evaluated to determine the sensitivity of the reported concentrations to the various variables. The I-131 species concentrations were found to be independent of the following variables:

1. total I-131 release rate,
2. total I-131 activity collected on sampler,
3. sample time,
4. sampling by different organizations,
5. sampling at different times after the plant has commenced commercial operation.

Furthermore, a consistent set of ratios between the species for a given plant, ventilation exhaust, operating condition was not apparent. The I-131 species data were found to be relatively consistent for each plant, ventilation exhaust, and plant mode of operation.

It is beyond the scope of this document to present analyses of variance or estimates of confidence intervals for I-131 species.

4.1 REFERENCES

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4-8 Marrero, T. R., 1976, "Airborne Releases from BWR's for Environmental Impact Evaluations," General Electric Company, Licensing Topical Report, NEDO-21159, Appendix A.

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4-12 Healy, J. W., 1970, *Los Alamos Handbook of Radiation Monitoring*, (Los Alamos Scientific Laboratory of the University of California, Los Alamos, New Mexico, LA-4400), pp. 83-86.

4-13 Ostle, B. and R. W. Mensing, 1975, *Statistics in Research*, (The Iowa State University Press, Ames, Iowa), p. 76.

4-14 Voilleque, P., (NES-SAI), 8 April 1977, Speed Message to M. Bell (NRC).

Table 4-1

SUMMARY OF MEASUREMENTS OF IODINE-131 SPECIES IN BWR REACTOR BUILDING VENTILATION EXHAUSTS

Plant	Sample Period Month/Day/Year	Particulate	Species, % of I-131 Release I_2	HOI	CH_3I	Measurements By	Sample Time Days	Reference
Plant Mode: Power Generation Operations								
Nine Mile Point 1	3-24-74	11.0	44.0	3.0	42.0	GE	1.87	3-55
Nine Mile Point 1	3-29-74	25.0	41.0	[illegible]	34.0	GE	0.22	3-55
Oyster Creek	2-22 — 2-27-75	49.0	17.0	<2.0	34.0	EPRI(NES)	5	3-44
Oyster Creek	9-29 — 10-14-75	2.6	9.7	19.4	68.2	EPRI(NES)	15	3-44
Oyster Creek	12-4 — 12-18-75	20.5	26.0	21.9	31.5	EPRI(NES)	14	3-44
Oyster Creek	6-16 — 6-23-76	<1.0	24.0	12.0	64.0	EPRI(NES)	7	3-45
Oyster Creek	6-23 — 6-30-76	10.0	69		21.0	EPRI(NES)	7	3-45
Oyster Creek	6-30 — 7-7-76	17.0	62		21.0	EPRI(NES)	7	3-45
Oyster Creek	7-7 — 7-13-76	<7.0	27.0	40.0	25.0	EPRI(NES)	6	3-45
Oyster Creek	7-13 — 7-20-76	17.0	24.0	35.0	24.0	EPRI(NES)	7	3-45
Oyster Creek	7-20 — 7-27-76	13.0	30.0	33.0	24.0	EPRI(NES)	7	3-45
Oyster Creek	7-27 — 8-3-76	8.0	26.0	35.0	31.0	EPRI(NES)	7	3-45
Oyster Creek	8-3 — 8-10-76	2.0	25.0	46.0	27.0	EPRI(NES)	7	3-45
Oyster Creek	8-10 — 8-17-76	5.0	24.0	39.0	32.0	EPRI(NES)	7	3-45
Oyster Creek	8-17 — 8-24-76	6.0	19.0	38.0	37.0	EPRI(NES)	7	3-45
Oyster Creek	8-24 — 8-30-76	5.0	11.0	17.0	67.0	EPRI(NES)	6	3-45
Oyster Creek	8-30 — 9-7-76	11.0	24.0	41.0	24.0	EPRI(NES)	8	3-45
Oyster Creek	9-7 — 9-16-76	7.0	26.0	46.0	21.0	EPRI(NES)	9	3-45
Oyster Creek	9-16 — 9-23-76	9.0	26.0	39.0	25.0	EPRI(NES)	7	3-45
Oyster Creek	9-23 — 9-30-76	4.0	28.0	37.0	31.0	EPRI(NES)	7	3-45
Oyster Creek	9-30 — 10-7-76	6.0	35.0	34.0	25.0	EPRI(NES)	7	3-45
Oyster Creek	10-7 — 10-14-76	10.0	27.0	41.0	22.0	EPRI(NES)	7	3-45
Oyster Creek	10-14 — 10-21-76	11.0	33.0	29.0	27.0	EPRI(NES)	7	3-45
Oyster Creek	10-21 — 10-28-76	10.0	34.0	31.0	25.0	EPRI(NES)	7	3-45
Oyster Creek	10-28 — 11-4-76	13.0	35.0	27.0	25.0	EPRI(NES)	7	3-45
Oyster Creek	11-4 — 11-11-76	16.0	33.0	26.0	25.0	EPRI(NES)	7	3-45
Oyster Creek	11-11 — 11-18-76	15.0	40.0	21.0	24.0	EPRI(NES)	7	3-45
Oyster Creek	11-18 — 11-30-76	5.0	37.0	30.0	29.0	EPRI(NES)	12	3-45
Dresden 2	1973	8.0	45.0	15.0	32.0	AEC	1	3-49
Dresden 2	1973	24.0	56.0	7.0	13.0	EPA-NRC	NA	3-52

Table 4-1
SUMMARY OF MEASUREMENTS OF IODINE-131 SPECIES IN
BWR REACTOR BUILDING VENTILATION EXHAUSTS (Continued)

Plant	Sample Period Month/Day/Year	Particulate	Species, % of I-131 Release I_2	HOI	CH_3I	Measurements By	Sample Time Days	Reference
Dresden 3	1973	0.0	71.0	18.0	11.0	AEC	1	3-49
Dresden 3	1973	<4.0	54-58	<4.0	38-42	EPA-NRC	NA	3-52
Monticello	1973	10.3	29.3	21.7	38.7	EPA-NRC	NA	3-52
Monticello	11-18 — 11-19-74	27.3	45.1	10.6	17.0	EPRI(NES)	1	3-44
Monticello	1-8 — 1-9-75	25.4	53.6	13.3	7.7	EPRI(NES)	1	3-44
Monticello	7-31 — 8-3-75	22.3	34.4	30.6	11.6	EPRI(NES)	3	3-44
Monticello	9-3 — 9-5-75	27.8	41.5	22.2	8.0	EPRI(NES)	2	3-44
Quad Cities 1	6-27 — 7-9-74	7.8	15.1	19.4	57.7	EPA-NRC	12	4-14
Quad Cities 1	7-9 — 7-17-74	8.6	25.8	15.3	50.4	EPA-NRC	8	4-14
Quad Cities 1	7-17 — 7-25-74	10.1	24.0	19.4	46.6	EPA-NRC	8	4-14
Quad Cities 1	7-25 — 8-6-74	20.0	22.9	15.9	41.1	EPA-NRC	12	4-14
Quad Cities 1	8-6 — 8-20-74	19.0	36.6	26.7	17.7	EPA-NRC	14	4-14
Quad Cities 1	8-28 — 9-12-74	3.6	15.6	25.6	55.2	EPA-NRC	15	4-14
Quad Cities 1	9-12 — 9-19-74	2.6	25.7	25.3	46.3	EPA-NRC	7	4-14
Quad Cities 1	9-19 — 9-26-76	1.4	9.3	9.9	79.4	EPA-NRC	7	4-14
Quad Cities 1	9-26 — 10-1-74	13.4	13.6	14.8	58.2	EPA-NRC	5	4-14
Quad Cities 1	10-1 — 10-10-74	7.0	17.4	18.9	56.7	EPA-NRC	9	4-14
Quad Cities 1	10-10 — 10-17-74	12.9	21.2	18.6	47.4	EPA-NRC	7	4-14
Quad Cities 1	10-17 — 10-24-74	8.0	33.2	17.8	40.9	EPA-NRC	7	4-14
Quad Cities 2	6-27 — 7-9-74	12.6	39.4	16.7	31.2	EPA-NRC	12	4-14
Quad Cities 2	7-9 — 7-17-74	12.9	33.0	21.4	32.7	EPA-NRC	8	4-14
Quad Cities 2	7-17 — 7-25-74	13.4	34.3	21.2	31.1	EPA-NRC	8	4-14
Quad Cities 2	7-25 — 8-6-74	14.8	37.8	24.8	22.7	EPA-NRC	12	4-14
Quad Cities 2	8-6 — 8-20-74	18.0	41.8	26.1	14.1	EPA-NRC	14	4-14
Quad Cities 2	8-28 — 9-12-74	5.5	25.7	31.3	37.5	EPA-NRC	15	4-14
Quad Cities 2	9-12 — 9-19-74	3.7	23.5	28.0	44.8	EPA-NRC	7	4-14
Quad Cities 2	9-19 — 9-26-74	2.0	16.0	20.5	61.6	EPA-NRC	7	4-14
Quad Cities 2	9-26 — 10-1-74	10.1	23.5	22.2	44.2	EPA-NRC	5	4-14
Quad Cities 2	10-1 — 10-10-74	13.4	17.9	18.3	50.4	EPA-NRC	9	4-14
Quad Cities 2	10-10 — 10-17-74	16.5	22.9	16.8	43.8	EPA-NRC	7	4-14
Quad Cities 2	10-17 — 10-24-74	5.7	39.4	20.4	34.4	EPA-NRC	7	4-14
Quad Cities 2	10-24 — 10-31-74	7.7	44.4	25.4	22.6	EPA-NRC	7	4-14
Vermont Yankee	6-19 — 6-22-74	3.7	23.5	14.5	59.4	YAEC(NES)	3	3-44

Table 4-1
SUMMARY OF MEASUREMENTS OF IODINE-131 SPECIES IN
BWR REACTOR BUILDING VENTILATION EXHAUSTS (Continued)

Plant	Sample Period Month/Day/Year	Particulate	Species, % of I-131 Release I_2	HOI	CH_3I	Measurements By	Sample Time Days	Reference
Vermont Yankee	9-12 — 9-13-74	7.4	24.7	17.7	50.0	EPRI(NES)	1	3-44
Vermont Yankee	10-10 — 10-11-74	6.6	6.2	6.8	80.4	EPRI(NES)	1	3-44
Vermont Yankee	9-19 — 9-22-75	4.8	34.6	(18.5)	(42.1)	EPRI(NES)	3	3-44
Vermont Yankee	9-22 — 10-7-75	16.1	26.2	(<5.0)	(57.7)	EPRI(NES)	15	3-44
Vermont Yankee	10-7 — 10-21-75	<15.0	<15.0	(<15.0)	(100.0)	EPRI(NES)	14	3-44
Vermont Yankee	11-7 — 11-8-75	<7.0	25.3	(<8.0)	(74.7)	EPRI(NES)	1	3-44
Plant Mode: Refueling/Maintenance Outage								
Oyster Creek	12-18 — 1-5-76	7.1	11.1	27.3	54.5	EPRI(NES)	18	3-44
Oyster Creek	1-5 — 1-22-76	5.1	13.7	52.7	28.5	EPRI(NES)	17	3-44
Oyster Creek	1-22 — 2-9-76	<6.0	11.8	32.8	55.4	EPRI(NES)	18	3-44
Monticello	1-13 — 1-15-75	6.9	61.0	12.6	19.6	EPRI(NES)	2	3-44
Monticello	9-11 — 9-25-75	6.8	33.8	41.7	17.6	EPRI(NES)	14	3-44
Monticello	10-15 — 10-27	9.7	23.3	(<6.5)	(64.9)	EPRI(NES)	12	3-44
Monticello	10-27 — 11-14	31.2	9.1	(<8.8)	(59.6)	EPRI(NES)	18	3-44
Vermont Yankee	10-31 — 11-1-74	2.0	16.0	59.0	23.0	EPRI(NES)	1	3-44

NOTES (1) NA - Data Not Available

(2) Numbers in parenthesis indicate questionable quality of sample adsorbent media IPH

Table 4-2
SUMMARY OF MEASUREMENTS OF IODINE-131 SPECIES IN
BWR TURBINE BUILDING VENTILATION EXHAUSTS

Plant	Sample Period Month/Day/Year	Particulate	Species, % of I-131 Release I_2	HOI	CH_3I	Measurements By	Sample Time Days	Reference
Plant Mode: Power Generation Operations								
Nine Mile Point 1	3-24-74	18.0	68.0	2.0	12.0	GE	0.28	3-55
Oyster Creek	2-22 — 2-27-75	27.0	47.0	19.0	7.0	EPRI(NES)	5	3-44
Oyster Creek	9-8 — 9-29-75	13.5	46.1	(17.4)	(23.0)	EPRI(NES)	21	3-44
Oyster Creek	9-29 — 10-14-75	11.8	44.1	(14.7)	(29.4)	EPRI(NES)	15	3-44
Oyster Creek	10-31 — 11-14-75	22.5	46.8	(1.2)	(29.5)	EPRI(NES)	14	3-44
Oyster Creek	12-4 — 12-18-75	22.4	45.4	24.4	7.8	EPRI(NES)	14	3-44
Oyster Creek	12-18 — 1-5-76	20.3	39.1	27.3	13.3	EPRI(NES)	18	3-44
Oyster Creek	6-16 — 6-23-76	18.0	49.0	28.0	5.0	EPRI(NES)	7	3-45
Oyster Creek	6-23 — 6-30-76	22.0	49.0	45.0	4.0	EPRI(NES)	7	3-45
Oyster Creek	6-30 — 7-7-76	11.0	— 84	—	5.0	EPRI(NES)	7	3-45
Oyster Creek	7-7 — 7-13-76	20.0	37.0	38.0	5.0	EPRI(NES)	6	3-45
Oyster Creek	7-13 — 7-20-76	23.0	29.0	43.0	5.0	EPRI(NES)	7	3-45
Oyster Creek	7-20 — 7-27-76	21.0	43.0	31.0	5.0	EPRI(NES)	7	3-45
Oyster Creek	7-27 — 8-3-76	18.0	31.0	39.0	13.0	EPRI(NES)	7	3-45
Oyster Creek	8-3 — 8-10-76	25.0	45.0	25.0	5.0	EPRI(NES)	7	3-45
Oyster Creek	8-10 — 8-17-76	25.0	39.0	30.0	6.0	EPRI(NES)	7	3-45
Oyster Creek	8-17 — 8-24-76	22.0	29.0	40.0	9.0	EPRI(NES)	7	3-45
Oyster Creek	8-24 — 8-30-76	9.0	39.0	41.0	11.0	EPRI(NES)	6	3-45
Oyster Creek	8-30 — 9-7-76	12.0	40.0	38.0	10.0	EPRI(NES)	8	3-45
Oyster Creek	9-7 — 9-16-76	15.0	30.0	46.0	9.0	EPRI(NES)	9	3-45
Oyster Creek	9-16 — 9-23-76	21.0	41.0	29.0	9.0	EPRI(NES)	7	3-45
Oyster Creek	9-23 — 9-30-76	18.0	52.0	23.0	7.0	EPRI(NES)	7	3-45
Oyster Creek	9-30 — 10-7-76	15.0	52.0	27.0	6.0	EPRI(NES)	7	3-45
Oyster Creek	10-7 — 10-14-76	18.0	45.0	31.0	6.0	EPRI(NES)	7	3-45
Oyster Creek	10-14 — 10-21-76	16.0	51.0	25.0	8.0	EPRI(NES)	7	3-45
Oyster Creek	10-21 — 10-28-76	12.0	54.0	26.0	8.0	EPRI(NES)	7	3-45
Oyster Creek	10-28 — 11-4-76	22.0	44.0	25.0	9.0	EPRI(NES)	7	3-45
Oyster Creek	11-4 — 11-11-76	3.0	65.0	24.0	8.0	EPRI(NES)	7	3-45
Oyster Creek	11-11 — 11-18-76	14.0	57.0	19.0	10.0	EPRI(NES)	7	3-45
Oyster Creek	11-18 — 11-30-76	6.0	56.0	30.0	8.0	EPRI(NES)	12	3-45
Monticello	11-18 — 11-19-74	15.1	47.9	14.8	22.3	EPRI(NES)	1	3-44

Table 4-2
SUMMARY OF MEASUREMENTS OF IODINE-131 SPECIES IN
BWR TURBINE BUILDING VENTILATION EXHAUSTS (Continued)

Plant	Sample Period Month/Day/Year	Particulate	Species, % of I-131 Release I_2	HOI	CH_3I	Measurements By	Sample Time Days	Reference
Monticello	1-8 — 1-9-75	13 4	64 0	12 3	10 3	EPRI(NES)	1	3-44
Monticello	5-12 — 5-15-75	26 5	51 5	15 4	6 6	EPRI(NES)	3	3-44
Vermont Yankee	6-23 — 6-24-74	24 9	63 8	· 4 0	11 3	EPRI(NES)	1	3-44
Vermont Yankee	9-12 — 9-14-74	17 1	55.0	20 9	7 0	EPRI(NES)	2	3-44
Vermont Yankee	10-10 — 10-11-74	33 7	57 1	9 2	· 3 0	EPRI(NES)	1	3-44
Vermont Yankee	9-22 — 10-7-75	8 0	48 6	(26 4)	(25 0)	EPRI(NES)	15	3-44
Vermont Yankee	10-7 — 10-21-75	21.0	48 6	(·.8 0)	(30 3)	EPRI(NES)	14	3-44
Vermont Yankee	10-21 — 11-6-75	50 0	100 0	(· 50 0)	(· 50 0)	EPRI(NES)	16	3-44
Vermont Yankee	7-5 — 7-8-74	—— 89 5	——	0 0	10 5	EPRI(NES)	3	3-44
Plant Mode: Refueling/Maintenance Outage								
Oyster Creek	3-30 — 3-31-75	12 3	28 6	19.0	40 1	EPRI(NES)	1	3-44
Oyster Creek	3-31 — 4-1-75	2 0	53 7	19.3	27.1	EPRI(NES)	1	3-44
Oyster Creek	1-5 — 1-22-76	5 7	18 4	50 3	25 6	EPRI(NES)	17	3-44
Oyster Creek	1-22 — 2-9	3 2	14 3	56 8	25.7	EPRI(NES)	18	3-44
Monticello	1-13 — 1-15-75	2 4	55 5	16 3	25 8	EPRI(NES)	2	3-44
Monticello	9-11 — 9-25-75	8 1	31 3	40.0	20 6	EPRI(NES)	14	3-44
Monticello	9-25 — 10-15	2 3	9 4	(0 4)	(88 0)	EPRI(NES)	20	3-44
Monticello	10-15 — 10-27	2 4	17 6	(· 3 2)	(82 4)	EPRI(NES)	12	3-44
Monticello	10-27 — 11-14	7 1	11.9	(· 11 9)	(100 0)	EPRI(NES)	17	3-44
Vermont Yankee	10-31 — 11-1-74	2 0	10 0	57 0	31 0	EPRI(NES)	1	3-44

NOTE Numbers in parentheses indicate questionable quality of adsorbent media, IPH

Table 4-3
SUMMARY OF MEASUREMENTS OF IODINE-131 SPECIES IN
BWR FEEDWATER AND CONDENSATE PUMP ROOM EXHAUSTS AT OYSTER CREEK

Plant	Sample Period Month/Day/Year	Particulate	Species, % of I-131 Release I_2	HOI	CH_3I	Measurements By	Sample Time Days	Reference
Plant Mode: Power Generation Operations								
Oyster Creek	6-16 — 6-23-76		No Sample			EPRI(NES)	7	3-45
Oyster Creek	6-23 — 7-7-76	<1	35	62	3	EPRI(NES)	14	3-45
Oyster Creek	7-7 — 7-20-76	5	— 95	—	<1	EPRI(NES)	13	3-45
Oyster Creek	7-20 — 8-3-76	10	— 83	—	7	EPRI(NES)	14	3-45
Oyster Creek	8-3 — 8-24-76	8	— 87	—	4	EPRI(NES)	21	3-45
Oyster Creek	8-24 — 9-7-76	12	44	15	29	EPRI(NES)	14	3-45
Oyster Creek	9-7 — 10-7-76	6	41	49	4	EPRI(NES)	30	3-45
Oyster Creek	10-7 — 10-21-76	6	50	43	1	EPRI(NES)	14	3-45
Oyster Creek	10-21 — 11-4-76	7	82	8	3	EPRI(NES)	14	3-45
Oyster Creek	11-4 — 11-18-76	17	77	6	<1	EPRI(NES)	12	3-45
Oyster Creek	11-18 — 11-30-76	12	69	15	4	EPRI(NES)	12	3-45

Table 4-4

SUMMARY OF MEASUREMENTS OF IODINE-131 SPECIES IN BWR REHEATER PROTECTION SYSTEM AND LUBE OIL STORAGE AREA EXHAUSTS AT OYSTER CREEK

Plant	Sample Period Month/Day/Year	Particulate	Species, % of I-131 Release I_2	HOI	CH_3I	Measurements By	Sample Time Days	Reference
Plant Mode: Power Generation Operations								
Oyster Creek	7-20 — 8-3	3.0	9.0	19.0	69.0	EPRI(NES)	14	3-45
Oyster Creek	8-3 — 8-17	1.0	6.0	7.0	86.0	EPRI(NES)	14	3-45
Oyster Creek	8-17 — 8-30	1.0	2.0	5.0	92.0	EPRI(NES)	13	3-45
Oyster Creek	8-30 — 9-16	6.0	12.0	14.0	68.0	EPRI(NES)	17	3-45
Oyster Creek	9-16 — 9-30	0.3	17.0	12.0	71.0	EPRI(NES)	14	3-45
Oyster Creek	9-30 — 10-14	10.0	28.0	15.0	47.0	EPRI(NES)	14	3-45
Oyster Creek	10-14 — 10-28	9.0	21.0	14.0	56.0	EPRI(NES)	14	3-45
Oyster Creek	10-28 — 11-11	9.0	20.0	13.0	58.0	EPRI(NES)	14	3-45
Oyster Creek	11-18 — 11-30	7.0	20.0	23.0	50.0	EPRI(NES)	12	3-45

NOTE No results available for periods of 6 16 to 7 20 76 and 11 11 to 11 18 76

Table 4-5
SUMMARY OF MEASUREMENTS OF IODINE-131 SPECIES IN
BWR RADWASTE BUILDING VENTILATION EXHAUSTS

Plant	Sample Period Month/Day/Year	Particulate	Species, % of I-131 Release I_2	HOI	CH_3I	Measurements By	Sample Time Days	Reference
Plant Mode: Power Generation Operations								
Nine Mile Point 1	3-24-74	9.0	56.0	1.0	34.0	GE	1.84	3-55
Oyster Creek	2-22 — 2-27-75	< 2.0	20.0	30.0	50.0	EPRI(NES)	5	3-44
Oyster Creek	9-29 — 10-14-75	2.5	18.2	(9.5)	(69.9)	EPRI(NES)	15	3-44
Oyster Creek	10-14 — 10-31-75	< 1.0	15.1	(5.5)	(79.4)	EPRI(NES)	17	3-44
Oyster Creek	10-31 — 11-14-75	< 1.0	12.8	(< 2.3)	(87.0)	EPRI(NES)	14	3-44
Oyster Creek	12-4 — 12-18-75	< 2.0	9.0	28.8	62.2	EPRI(NES)	14	3-44
Oyster Creek	6-16 — 6-23-76	< 0.2	9.0	18.0	73.0	EPRI(NES)	7	3-45
Oyster Creek	6-23 — 6-30	6.0	49		45.0	EPRI(NES)	7	3-45
Oyster Creek	6-30 — 7-7	< 0.2	47		53.0	EPRI(NES)	7	3-45
Oyster Creek	7-7 — 7-13	< 0.1	15.0	28.0	57.0	EPRI(NES)	6	3-45
Oyster Creek	7-13 — 7-20	< 0.5	13.0	26.0	61.0	EPRI(NES)	7	3-45
Oyster Creek	7-20 — 7-27	< 0.7	13.0	20.0	66.0	EPRI(NES)	7	3-45
Oyster Creek	7-27 — 8-3	< 0.1	5.0	17.0	78.0	EPRI(NES)	7	3-45
Oyster Creek	8-3 — 8-10	< 0.2	9.0	14.0	77.0	EPRI(NES)	7	3-45
Oyster Creek	8-10 — 8-17	< 0.3	41.0	43.0	16.0	EPRI(NES)	7	3-45
Oyster Creek	8-17 — 8-24	< 0.1	7.0	21.0	72.0	EPRI(NES)	7	3-45
Oyster Creek	8-24 — 8-30	0.3	8.0	17.0	75.0	EPRI(NES)	6	3-45
Oyster Creek	8-30 — 9-7	< 0.2	14.0	23.0	63.0	EPRI(NES)	8	3-45
Oyster Creek	9-7 — 9-16	< 0.1	9.0	23.0	68.0	EPRI(NES)	9	3-45
Oyster Creek	9-16 — 9-23	< 0.1	10.0	14.0	76.0	EPRI(NES)	7	3-45
Oyster Creek	9-23 — 9-30	< 0.1	2.0	3.0	95.0	EPRI(NES)	7	3-45
Oyster Creek	9-30 — 10-7	0.5	41.0	17.0	41.0	EPRI(NES)	7	3-45
Oyster Creek	10-7 — 10-14	< 0.2	29.0	20.0	51.0	EPRI(NES)	7	3-45
Oyster Creek	10-14 — 10-21	< 0.2	15.0	30.0	55.0	EPRI(NES)	7	3-45
Oyster Creek	10-21 — 10-28	< 0.1	27.0	33.0	40.0	EPRI(NES)	7	3-45
Oyster Creek	10-28 — 11-4	0.6	27.0	18.0	55.0	EPRI(NES)	7	3-45
Oyster Creek	11-4 — 11-11	0.2	17.0	32.0	51.0	EPRI(NES)	7	3-45
Oyster Creek	11-11 — 11-18	< 0.1	8.0	23.0	69.0	EPRI(NES)	7	3-45
Oyster Creek	11-18 — 11-30	< 0.1	19.0	22.0	59.0	EPRI(NES)	12	3-45
Monticello	11-18 — 11-19-74	0.2	1.5	1.6	96.7	EPRI(NES)	1	3-44
Monticello	1-8 — 1-9-75	< 1.0	1.0	< 1.0	100.0	EPRI(NES)	1	3-44

Table 4-5
SUMMARY OF MEASUREMENTS OF IODINE-131 SPECIES IN BWR RADWASTE BUILDING VENTILATION EXHAUSTS (Continued)

Plant	Sample Period Month/Day/Year	Particulate	Species, % of I-131 Release I_2	HOI	CH_3I	Measurements By	Sample Time Days	Reference
Vermont Yankee	6-19 — 6-20-74	<0.6	14.5	10.8	74.9	EPRI(NES)	1	3-44
Vermont Yankee	9-12 — 9-13-74	<0.1	11.7	9.2	79.1	EPRI(NES)	1	3-44
Vermont Yankee	9-26 — 9-27-74	0.5	8.2	8.7	82.4	EPRI(NES)	1	3-44
Vermont Yankee	10-10 — 10-11-74	0.9	16.0	5.4	77.7	EPRI(NES)	1	3-44
Vermont Yankee	3-5 — 3-8-75	<1.0	<1.0	<1.0	100.0	EPRI(NES)	3	3-44
Vermont Yankee	9-22 — 10-7-75	<3.0	25.7	(7.3)	(67.0)	EPRI(NES)	15	3-44
Vermont Yankee	10-7 — 10-21-75	<1.0	35.2	(2.1)	(62.7)	EPRI(NES)	14	3-44
Vermont Yankee	10-21 — 11-8-75	<1.0	37.0	(<2.0)	(63.0)	EPRI(NES)	18	3-44
Plant Mode: Refueling/Maintenance Outage								
Oyster Creek	1-5 — 1-22-76	<6.0	9.7	17.6	72.7	EPRI(NES)	17	3-44
Oyster Creek	1-22 — 2-9-76	<9.0	13.0	27.6	72.4	EPRI(NES)	18	3-44
Monticello	1-13 — 1-15-75	0.3	3.9	3.9	91.9	EPRI(NES)	2	3-44
Monticello	9-11 — 9-25-75	0.2	5.5	14.7	79.6	EPRI(NES)	14	3-44
Monticello	9-25 — 10-15-75	<0.2	6.7	(<0.4)	(93.3)	EPRI(NES)	20	3-44
Monticello	10-15 — 10-27-75	<1.8	11.9	(<3.7)	(88.1)	EPRI(NES)	12	3-44
Monticello	10-27 — 11-14-75	<8.4	33.0	(<11.0)	(67.0)	EPRI(NES)	18	3-44
Vermont Yankee	10-31 — 11-1-74	1.0	5.0	7.0	87.0	EPRI(NES)	1	3-44

NOTE Numbers in parentheses indicate questionable quality of adsorbent media IPH

Table 4-6
SUMMARY OF MEASUREMENTS OF IODINE-131 SPECIES IN
BWR GLAND SEAL STEAM AND MECHANICAL VACUUM PUMP EXHAUSTS

Plant	Sample Period Month/Day/Year	Particulate	Species, % of I-131 Release I_2	HOI	Organic	Measurements By	Sample Time Days	Reference
Plant Mode: Power Generation Operations (Gland Seal Steam Exhaust)								
Oyster Creek	7-16-75	28.0	15.0	8.0	49.0	EPRI(NES)	1	3-44
Oyster Creek	3-24-76	38.0	6.5	7.6	48.0	EPRI(NES)	1	3-44
Oyster Creek	3-24-76	•	(10.4)	(12.2)	(77.4)	EPRI(NES)		3-44
Oyster Creek	6-16 — 6-23-76		No Sample			EPRI(NES)	7	3-45
Oyster Creek	6-23 — 6-30	< 0.1	9.0	12.0	79.0	EPRI(NES)	7	3-45
Oyster Creek	6-30 — 7-7	1.0	18.0	26.0	55.0	EPRI(NES)	7	3-45
Oyster Creek	7-7 — 7-13	1.0	15.0	19.0	65.0	EPRI(NES)	6	3-45
Oyster Creek	7-13 — 7-20	1.0	36		63.0	EPRI(NES)	7	3-45
Oyster Creek	7-20 — 7-27	1.0	7.0	33.0	59.0	EPRI(NES)	7	3-45
Oyster Creek	7-27 — 8-3	<0.1	6.0	15.0	79.0	EPRI(NES)	7	3-45
Oyster Creek	8-3 — 8-10	1.0	22.0	38.0	39.0	EPRI(NES)	7	3-45
Oyster Creek	8-10 — 8-17	1.0	1.0	28.0	70.0	EPRI(NES)	7	3-45
Oyster Creek	8-17 — 8-24	3.0	9.0	42.0	46.0	EPRI(NES)	7	3-45
Oyster Creek	8-24 — 8-30	0.2	8.0	55.0	37.0	EPRI(NES)	6	3-45
Oyster Creek	8-30 — 9-7	0.4	5.0	55.0	40.0	EPRI(NES)	8	3-45
Oyster Creek	9-7 — 9-16	0.3	6.0	57.0	37.0	EPRI(NES)	9	3-45
Oyster Creek	9-16 — 9-23	0.1	8.0	50.0	42.0	EPRI(NES)	7	3-45
Oyster Creek	9-23 — 9-30	0.3	5.0	50.0	44.0	EPRI(NES)	7	3-45
Oyster Creek	9-30 — 10-7	1.0	6.0	43.0	50.0	EPRI(NES)	7	3-45
Oyster Creek	10-7 — 10-14	0.2	7.0	49.0	44.0	EPRI(NES)	7	3-45
Oyster Creek	10-14 — 10-21	0.3	6.0	43.0	51.0	EPRI(NES)	7	3-45
Oyster Creek	10-21 — 10-28	0.4	6.0	47.0	47.0	EPRI(NES)	7	3-45
Oyster Creek	10-28 — 11-4	0.3	5.0	44.0	51.0	EPRI(NES)	7	3-45
Oyster Creek	11-4 — 11-11	1.0	6.0	45.0	48.0	EPRI(NES)	7	3-45
Oyster Creek	11-11 — 11-18	0.4	10.0	6.0	83.0	EPRI(NES)	7	3-45
Oyster Creek	11-18 — 11-30	1.0	6.0	42.0	51.0	EPRI(NES)	12	3-45
Vermont Yankee	6-18 — 6-19-74	6.5	0.4	0.8	92.3	EPRI(NES)	1	3-44
Vermont Yankee	6-20 — 6-21-74	3.6	1.0	3.9	91.5	EPRI(NES)	1	3-44
Vermont Yankee	9-13 — 9-14-74	12.0	1.0	1.6	85.6	EPRI(NES)	1	3-44
Vermont Yankee	10-10 — 10-11-74	1.5	2.9	2.7	93.0	EPRI(NES)	1	3-44
Vermont Yankee	3-5 — 3-8-75	12.0	6.0	4.0	78.0	EPRI(NES)	3	3-44

Table 4-6
SUMMARY OF MEASUREMENTS OF IODINE-131 SPECIES IN
BWR GLAND SEAL STEAM AND MECHANICAL VACUUM PUMP EXHAUSTS (Continued)

Plant	Sample Period Month/Day/Year	Particulate	Species, % of I-131 Release I_2	HOI	Organic	Measurements By	Sample Time Days	Reference
Vermont Yankee	10-7 — 10-21-75	<0.1	5.0	8.8	86.2	EPRI(NES)	14	3-44
Vermont Yankee	11-18-75	<0.3	2.1	(3.0)	(94.8)	EPRI(NES)	0.42	3-44
Plant Mode: Refueling/Maintenance Outage (Mechanical Vacuum Pump Exhaust)								
Monticello[a]	1-9-75	0.4	0.9	1.8	97.0	EPRI(NES)	0.542	3-44
Monticello[a]	1-10-75	0.8	2.8	6.9	98.5	EPRI(NES)	0.583	3-44
Monticello[a]	1-14-75	1.5	9.8	41.0	47.7	EPRI(NES)	0.917	3-44
Vermont Yankee	10-11 — 10-12-74	0.3	0.1	0.1	99.5	EPRI(NES)	0.67	3-44
Vermont Yankee	10-12 — 10-14-74	0.2	0.2	0.2	99.4	EPRI(NES)	1.92	3-44
Vermont Yankee	10-31-74	<1.0	<1.0	<1.0	<99.0	EPRI(NES)	1	3-44

NOTES (a) Monticello MVP results are actually stack releases which may include I-131 releases other than from use of MVP.
(1) Numbers in parentheses indicate questionable quality of adsorbent media. IPH

Table 4-7
SUMMARY OF IODINE-131 SPECIES MEASUREMENTS IN BWR VENTILATION EXHAUSTS

Ventilation Exhaust	Plant	Species, % of I-131 Release: Normal Operations: Particulate	Normal Operations: I_2	Normal Operations: HOI	Normal Operations: CH_3I	Refueling Operations: Paticulate	Refueling Operations: I_2	Refueling Operations: HOI	Refueling Operations: CH_3I
Reactor Building	Nine Mile Point 1	18.0	42.5	1.5	38.0	—	—	—	—
	Oyster Creek	10.3	26.4	30.5	32.3	6 1	12.2	37.6	46.1
	Dresden 2	16 0	50.5	11.0	22.5	—	—	—	—
	Dresden 3	2.0	63 5	11.0	25.5	—	—	—	—
	Monticello	23.2	42.8	17.6	16.2	6.9	47.4	27.2	18.6
	Quad Cities 1	10.0	22.1	19.9	48.1	—	—	—	—
	Quad Cities 2	11 0	31.7	23.1	34.3	—	—	—	—
	Vermont Yankee	5.9	18.1	13.0	63.3	2.0	16.0	59.0	23 0
Turbine Building	Nine Mile Point 1	18 0	68.0	2.0	2.0	—	—	—	—
	Oyster Creek[a]	17.1	44.5	30.7	8.3	6 7	28.7	36.4	29.6
	Monticello	18 3	54.5	14.2	13.1	5.3	43 4	28 2	23.2
	Vermont Yankee	25.2	58.6	11.4	7.1	2.0	10 0	57.0	31.0
Radwaste Building	Nine Mile Point 1	9.0	56 0	1.0	34.0	—	—	—	—
	Oyster Creek	0.80	15.6	22.8	60.5	7.5	11.4	22.6	72.6
	Monticello	2.4	15.2	6.2	73.9	0 3	4.7	9 3	85.8
	Vermont Yankee	0 62	10.3	7.0	82.8	1.0	5.0	7.0	87.0
Gland Seal Steam	Oyster Creek	0.85	8.0	38.2	54.4	—	—	—	—
	Vermont Yankee	7.1	2.3	2.6	88.1	—	—	—	—
Mechanical Vacuum Pump[b]	Vermont Yankee	—	—	—	—	0.2	0.13	0.13	99.3

NOTES: (a) Turbine Building results for Oyster Creek exclude contributions from the feedwater pump and condensate pump compartment exhaust and the reheater protection system and lube oil storage area exhaust

(b) Mechanical Vacuum Pump release reported for Monticello (Table 4-6) are not inluded here because of uncertainties in obtaining a representative sample.

Table 4-8
RECOMMENDED RELATIVE CONCENTRATIONS OF IODINE-131 SPECIES IN BWR VENTILATION EXHAUSTS DURING NORMAL POWER GENERATION OPERATIONS AND REFUELING/MAINTENANCE OUTAGES FOR ENVIRONMENTAL IMPACT EVALUATIONS[a]

I-131 Species	Plant Mode: Power Generation	Plant Mode: Refueling/Maintenance
	Species, % of I-131 Release	
	Reactor Building Exhaust	
Particulate	11.3	5.0
Elemental	37.4	25.2
Hypoiodous Acid	16.6	41.3
Organic	35.0	29.2
	100.3	100.7
	Turbine Building Exhaust	
Particulate	20.0	4.7
Elemental	55.8	27.4
Hypoiodous Acid	15.3	40.5
Organic	9 5	27.9
	100.6	100.5
	Radwaste Building Exhaust	
Particulate	3.3	0.6
Elemental	24.1	4.9
Hypoiodous Acid	9.0	8.2
Organic	64.2	86.4
	100.6	100 1
	Gland Seal Steam and Mechanical Vacuum Pump[b]	
Particulate	4.7	0.2
Elemental	5.7	0.1
Hypoiodous Acid	20.6	0.1
Organic	69.8	99 3
	100.8	99 7

NOTES (a) Data weighted by sample time to obtain a weighted average value for each plant studied, recommended values are the arithmetic means of the sample-time weighted plant averages
(b) Mechanical Vacuum Pump corresponds to refueling/maintenance outages, only

Table 4-9
SUMMARY OF NUMBER OF IODINE-131 SPECIES MEASUREMENTS

	Plant Mode			
	Power Generation Operations		Refueling/Maintenance Outage	
Ventilation Exhaust	**Plants**	**Samples**	**Plants**	**Samples**
Reactor Building	8	69	3	8
Turbine Building	4	40	3	10
Radwaste Building	4	39	3	8
Gland seal steam	2	32	—	—
Mechanical Vacuum Pump	—	—	2	6

5. IODINE-131 IN MILK

The purpose of this section is to update I-131 in milk data previously presented in NEDO-21159 (March 1976). Additional data have been obtained for the Monticello and Peach Bottom 2/3 plants for the 1976 grazing season.

At Monticello the 1976 annual release of I-131 (all species) was 0.12 curies from the stack and the plant ventilation exhaust. Most of the release was from the ventilation exhaust. The amount of I-131 which was observed in the milk at farms as close as 2.4 miles to the plant corresponded to activities less than 0.25 pCi/liter (Reference 5-1). The Monticello data are summarized in Table 5-1.

At the Peach Bottom station with two 1000 MWe reactors operating the I-131 activity in milk was very carefully monitored at farms from about 1. miles from the plant site to 11 miles from the plant site (Reference 5-2). During the grazing season (April 1 to November 30) the I-131 release the environs amounted to 0.78 Ci (all species). At the closest farm the arithmetic mean I-131 activity was 0.7 pCi/liter. The mean I-131 activity in milk decreased with distance from the plant, and the results were correlated by least-squares regression analysis.

The regression analysis considered correlations of both arithmetic and geometric means of the milk sample data. Normally arithmetic means are used for environmental dose assessments. However, in this instance, geometric means yield more conservative results as the milk samples are taken from farms further away from the plant. This effect arises because a majority of the samples taken during the entire sampling period have activities less than or equal to the minimum detection limit. On the other hand, samples from the closest farm result in an arithmetic mean which is 13% greater than the geometric mean. Calculation of geometric mean discounts samples with activities reported as less than the minimum detection limit, and calculation of the arithmetic mean assumes those samples to be at the minimum detection limit, 0.07 pCi/liter. Both of these calculation procedures are conservative. At a distance of 2.4 miles from the plant, the correlated results have a crossover point, that is, for distances less than 2.4 miles the arithmetic mean is greater than the geometric mean, and conversely. For overall correlation purposes an equation based on the geometric means of the data is recommended. This equation is shown in Figure 5-1. The Peach Bottom 2/3 data are summarized in Table 5-2. The Peach Bottom 2/3 I-131 activity levels are consistent with the Monticello data when compared on the basis of similar I-131 airborne releases from the plant, see Figure 5-1.

Iodine-131 concentrations in milk in environs of Quad Cities 1/2 site are listed in Table 5-3. Concentrations were not above background during 1975 and the first-half of 1976. These results have a detection limit of 0.5 pCi/liter.

The observations of I-131 activity in milk at Monticello can be used to estimate a maximum annual ingestion thyroid dose. Assume an infant drinks 300 liters of milk per year, which is a conservative assumption by a factor of about 50% and a dose conversion factor of 0.013 mrem/picocurie ingested (References 5-3, 5-4 and 5-5). During 1976 the I-131 activity was always less than 0.25 picocuries/liter in milk collected at farms as close as 2.3 miles to the plant. (This excludes radioactive fallout effects due to the Chinese weapons test of September 1976.) The maximum dose is 0.25 picocuries/liter x 300 liter x 0.013 mrem/picocurie = < 1.0 mrems. This dose estimate corresponds to an annual I-131 airborne release of 0.12 curies. The calculated dose is more than a decade below the NRC dose objective of 15 mrem stipulated in 10CFR50 Appendix I.

Calculations similar to the above can be made on the basis of the Peach Bottom data. At the farm within 1 mile of the plant the maximum potential dose due to milk ingestion is 2.6 mrems. This is a factor of 6 less than the NRC dose objective. The calculated dose corresponds to a I-131 release during the grazing season of 0.75 curies.

5.1 REFERENCES

5-1 Clark, B. W., March 30, 1977, letter to T. R. Marrero, "Monticello Nuclear Generating Plant Radiation Environmental Monitoring Program. Annual Report - 1976."

5-2 Peach Bottom Atomic Power Station, Radiological Regional Environmental Monitoring Program Report Number 12 (1976), Table XXXI.

5-3 Thompson, J. C., 1976, "Comments on the Paper, 'Radiation Doses from Iodine-129 in the Environment,' by J. K. Soldat," Health Physics *31*, 287.

5-4 Soldat, J. K., 1976, "Reply to J. C. Thompson, Jr.'s Comments on the Paper, ' Radiation Doses from Iodine-129 in the Environment, ' " by J. K. Soldat, Health Physics *31*, 288.

5-5 U. S. Nuclear Regulatory Commission, March 1976, "Calculation of Annual Average Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Implementing Appendix I," Regulatory Guide 1.109, p. 27.

5-6 Commonwealth Edison Company, "Quad Cities Power Station Radioactive Waste, Environmental Monitoring and Occupational Personnel Radiation Exposure," Semi-annual reports for January through June 1975, July through December 1975, January through June 1976.

Table 5-1
IODINE-131 ACTIVITY IN MILK IN ENVIRONS OF MONTICELLO (DURING 1976)

FARM

Peterson 2.3 mi at 111°/ESE	Nelson 2.4 mi at 269°/W	Olson 2.5 mi at 24°/NWE	Shovelain 3.0 mi at 250°/WSW	Kotilinek 5.6 mi at 230°/SW	Hopkins 7.6 mi at 193°/SSW
<0.25(1-13)	<0.25(1-13)	<0.25(1-13)	<0.25(1-13)	<0.25(3-8)	<0.25(3-8)
<0.25(2-9)	<0.25(2-9)	<0.25(2-9)	<0.25(2-9)	<0.25(5-11)	<0.25(5-11)
<0.25(3-8)	<0.25(3-8)	<0.25(3-8)	<0.25(3-8)		
<0.25(4-12)	<0.25(4-12)	<0.25(4-12)	<0.25(4-12)		
<0.25(5-11)	<0.25(5-11)	—	<0.25(5-11)		
<0.25(6-2)	<0.25(6-2)	<0.25(6-2)	<0.25(6-2)		
<0.25(6-8)	<0.25(6-8)	<0.25(6-8)	<0.25(6-8)		
<0.25(6-15)	<0.25(6-15)	<0.25(6-15)	<0.25(6-15)		
<0.25(6-22)	<0.25(6-22)	<0.25(6-22)	<0.25(6-22)		
<0.25(6-29)	<0.25(6-29)	<0.25(6-29)	<0.25(6-29)		
<0.25(7-13)	<0.25(7-13)	<0.25(7-13)	<0.25(7-13)		
<0.25(8-10)	<0.25(8-10)	<0.25(8-25)	<0.25(8-10)		
<0.25(9-8)	<0.25(9-7)	<0.25(9-7)	<0.25(9-7)		
<0.25(10-19)	0.76(10-19)[a]	<0.25(10-19)	0.96(10-19)[a]		
<0.25(11-9)	<0.25(11-9)	<0.25(11-9)	<0.25(11-9)		
<0.25(12-7)	<0.25(12-7)	<0.25(12-7)	<0.25(12-15)		

Holland 8.1 mi at 199°/SSW	Vandergon 8.3 mi at 247°/WSW	Vetsch 9.4 mi at 128°/SE	Becker 10.0 mi at 130°/SE	Kirchenbauer 11.5 mi at 323°/NW	Dwinger 13.0 mi at 335°/NNW
<0.25(3-16)	<0.25(3-8)	<0.25(3-8)	<0.25(3-8)	<0.25(3-8)	<0.25(3-8)
<0.25(5-11)	<0.25(5-11)	<0.25(5-11)	<0.25(5-11)	<0.25(5-11)	<0.25(5-11)
				<0.25(7-13)	
				<0.25(8-25)	
				<0.25(9-7)	
				2.23(10-19)[a]	
				<0.25(11-9)	
				<0.25(12-7)	

NOTES.
a. Higher activity due to fallout from nuclear test conducted by People's Republic of China on September 26, 1976
b. The nominal lower limit of detection based on 3 sigma error for background sample is 0.25 picocuries/liter
c. The milk sample collection date is indicated parenthetically next to the I-131 activity

Table 5-2
IODINE-131 ACTIVITY IN MILK IN ENVIRONS OF PEACH BOTTOM 2/3 (DURING 1976)

I-131 Activity, picocuries/liter

Farm Sector / Distance (miles) / Sample No.	J 0-1 W	G 1-2 SSW	H 1-2 S&SSW	M 2-3 ENE	L 2-3 NE	D 3-4 NE	N 3-4 ESE	A 5-10 WSW	C 5-10 NW	E 5-10 N	B 10-20 S
1	1.9 E-1	5.5 E-1	3.2 E-1	5.7 E-1	5.2 E-1	0.4 E-1	1.5 E-1	1.3 E-1	0.5 E-1	1.5 E-1	0.9 E-1
2	7.4 E-1	3.8 E-1	2.3 E-1	1.2 E-1	1.3 E-1	2.0 E-1	11.0 E-1	10.0 E-1	2.1 E-1	1.9 E-1	0.4 E-1
3	13.0 E-1	3.2 E-1	7.7 E-1	2.1 E-1	0.9 E-1	2.0 E-1	9.2 E-1	3.2 E-1	2.2 E-1	1.1 E-1	1.0 E-1
4	2.4 E-1	0.6 E-1	4.5 E-1	0.5 E-1	1.8 E-1	7.5 E-1	9.0 E-1	1.2 E-1	1.9 E-1	1.0 E-1	2.7 E-1
5	1.5 E-1	7.4 E-1	1.2 E-1	0.9 E-1	4.9 E-1	4.4 E-1	5.1 E-1	0.7 E-1	0.5 E-1	0.9 E-1	0.7 E-1
6	43.0 E-1	22.0 E-1	2.3 E-1	9.2 E-1	1.3 E-1	2.1 E-1	2.2 E-1	0.5 E-1	1.0 E-1	1.4 E-1	0.5 E-1
7	20.0 E-1	32.0 E-1	9.0 E-1	1.0 E-1	1.0 E-1	0.8 E-1	3.3 E-1		0.5 E-1	1.6 E-1	
8	12.0 E-1	17.0 E-1	13.0 E-1	0.7 E-1	1.6 E-1	3.6 E-1	2.6 E-1		4.0 E-1	4.0 E-1	
9	6.1 E-1	10.0 E-1	10.0 E-1	3.2 E-1	0.9 E-1	1.0 E-1	2.0 E-1			4.1 E-1	
10	3.6 E-1	5.2 E-1	2.8 E-1	3.0 E-1	3.9 E-1	4.0 E-1	1.9 E-1			2.3 E-1	
11	2.5 E-1	1.7 E-1	0.7 E-1	0.7 E-1	7.2 E-1	0.8 E-1	10.0 E-1				
12	2.3 E-1	0.7 E-1	3.2 E-1	0.8 E-1	4.4 E-1	2.5 E-1	6.3 E-1				
13	14.0 E-1	1.1 E-1	3.0 E-1		3.4 E-1	1.8 E-1	1.1 E-1				
14	9.0 E-1	1.4 E-1	1.6 E-1		8.2 E-1	1.3 E-1	2.3 E-1				
15	3.7 E-1	12.0 E-1	6.8 E-1			2.4 E-1	4.6 E-1				
16	8.0 E-1	1.1 E-1	4.2 E-1			2.3 E-1	2.0 E-1				
17	4.1 E-1	3.3 E-1	10.0 E-1				1.4 E-1				
18	3.0 E-1	6.0 E-1	1.5 E-1				8.5 E-1				
19	11.0 E-1	2.8 E-1	9.4 E-1				9.0 E-1				
20	4.7 E-1	2.0 E-1	5.3 E-1				7.2 E-1				
21		0.4 E-1	1.6 E-1				3.4 E-1				
22		13.0 E-1	4.0 E-1				2.2 E-1				
							6.0 E-1				
Geometric Mean	0.58	0.37	0.37	0.16	0.25	0.19	0.38	0.16	0.12	0.17	0.084
Arithmetic Mean	0.66	0.58	0.41	0.15	0.20	0.17	0.42	0.12	0.096	0.12	0.077

NOTE: Samples were collected from 3-29-76 to 9-26-76 on a weekly basis. Thus sample numbers are in sequence; however many samples had activity levels less than the lower limit of detection (0.07 pCi/liter) and these results are omitted from this tabulation. Prior to 3-29-76 I-131 concentrations in milk were less than 0.07 pCi/liter. After 9-27-76 the I-131 activities increased significantly due to the nuclear weapons test conducted by the People's Republic of China.

Table 5-3
IODINE-131 ACTIVITY IN MILK IN ENVIRONS OF QUAD CITIES 1/2 (DURING 1975 AND FIRST-HALF OF 1976)

Collection Date Month/Day 1975	Dairy Background[a] I-131 Concentration, pCi/liter	Dairy Indicator[b] I-131 Concentration, pCi/liter
1/4	<4	<4
2/1	<4	<4
3/2	<4	<4
4/5	<0.5	<0.5
4/12	<0.5	<0.5
4/19	<0.5	<0.5
4/26	<0.5	<0.5
5/3	<0.5	<0.5
5/10	<0.5	<0.5
5/18	<0.5	<0.5
5/24	<0.5	<0.5
5/31	<0.5	<0.5
6/7	<0.5	<0.5
6/14	<0.5	<0.5
6/21	<0.5	<0.5
6/28	<0.5	<0.5
7/5	<0.5	<0.5
7/12	<0.5	<0.5
7/19	<0.5	<0.5
7/26	<1.0	<0.5
8/2	<0.5	<0.5
8/9	0.6 ± 0.2	<0.5
8/16	<0.5	<0.5
8/22	<0.5	<0.5
8/30	<0.5	<0.5
9/6	<0.5	<0.5
9/14	<0.5	<0.5
9/20	<0.5	<0.5
9/27	<0.5	<0.5
10/4	<4	<4
11/1	<4	<4
12/7	<4	<4

Table 5-3 (Continued)
IODINE-131 ACTIVITY IN MILK IN ENVIRONS OF QUAD CITIES ½
(DURING 1975 AND FIRST-HALF OF 1976)

Collection Date Month/Day 1976	Dairy Background[a]	Indicator[b]
	I-131 Concentration, pCi/liter	
1/3	<4	<4
2/7	<4	<4
3/6	<4	<4
	<0.5	<0.5
4/10		<0.5
4/17	<0.5	<0.5
4/24	<0.5	<0.5
5/1	<0.5	<0.5
5/8	<0.5	<0.5
5/15	<0.5	<0.5
5/22	<0.5	<0.5
5/26	<0.5	<0.5
6/4	<0.79	0.69
6/11	<0.5	0.5
6/18	<0.5	<0.7
6/25	<0.5	0.5

Notes: Data reported as "<" are at the 99% confidence level
a. Hansen Dairy Farm, about 5.5 miles from site.
b. Saddle Club Dairy, less than 1 mile from site

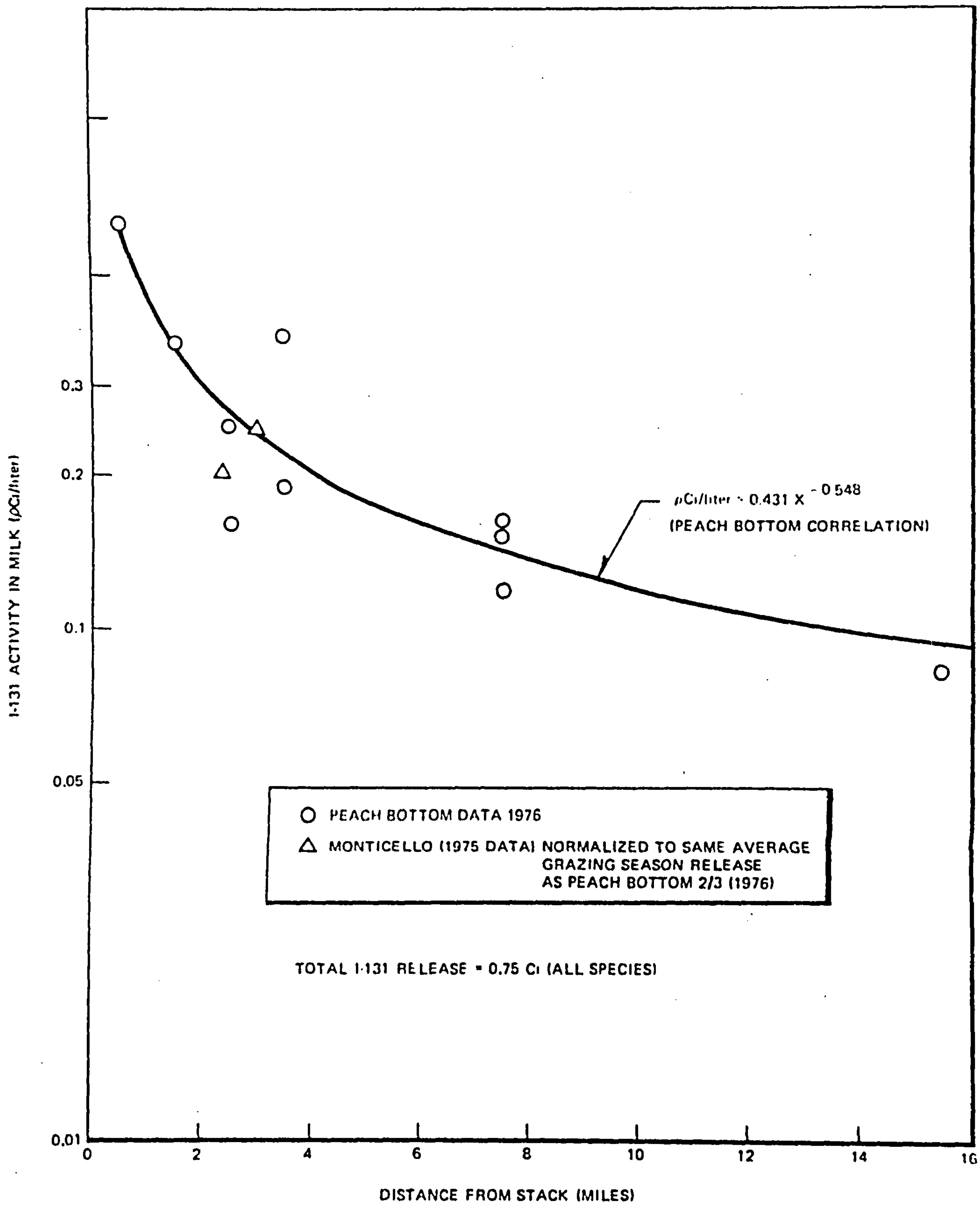

Figure 5-1. Empirical Correlation of I-131 Activity in Milk as Produced in Environs of BWR's

6. NORMALIZATION OF IODINE-131 RELEASES

The following information on iodine-131 updates data previously reported in NEDO-21159, March 1976, Chapter 6. This information is divided into four major subjects; namely,

1. iodine-131 carryover,

2. iodine-131 reactor water concentrations,

3. fuel performance of current B .R's,

4. normalization of iodine-131 ventilation releases to its reactor water concentration.

6.1 IODINE-131 CARRYOVER

Iodine-131 carryover is significant because it affects the amount of I-131 release from the turbine building ventilation exhaust, the gland seal steam exhaust and the mechanical vacuum pump. A first-order approximation is that the higher the carryover the higher will be the I-131 release from the above exhausts. Measurements of I-131 carryover at operating BWR's indicate that carryover may range from 0.2 to 2.5 percent, depending on the plant. Thus in order to compare I-131 releases from the turbine building ventilation exhaust, etc., it is necessary to account for differences in I-131 carryover.

Iodine-131 carryover is defined as the ratio of the I-131 concentration in the condenser hotwell to its concentration in the reactor vessel. This definition is directly applicable to BWR's in which 100% of the steam is condensed in the hotwell. At this time there is only one exception to this flow pattern. The Brunswick plants have forward pumped flow, and for this type of flow the I-131 that is recycled to the reactor without passing through the hotwell must be taken into account in order to estimate I-131 carryover, as defined above. This is an important consideration because many future BWR's will have forward pumped flow and the distribution of I-131 sources within the turbine building will depend on the steam/condensate flow pattern.

A brief outline of the principal methods used to determine I-131 carryover is as follows. The most frequent method is based on sampling I-131 activity in the water of the reactor vessel and the hotwell. Carryover is the simple ratio of I-131 activities per unit volume, hotwell to reactor, and reported as a percentage. Less frequently "no-cleanup" tests are conducted. This method compares the rate-of-loss of iodine from the reactor vessel by all processes with and without the cleanup system in service. These processes include radioactive decay, leakage of primary water, and carryover. A third method, infrequently performed, determines carryover based on anal ;ses of the turbine moisture separator and heater drains. Further information on I-131 carryover measurement methods can be found in References 6-1 and 6-2. Iodine-131 activities are based on analyses of the sample by gamma spectra usually with Ge (Li) detectors. Liquid samples are concentrated by use of ion-exchange membranes.

The I-131 carryover data are summarized in Table 6-1. These results are based on various internal General Electric Company documents, including Chemical and Radiochemical Startup Reports, and personal communications for some unpublished results. The data has been approved for release by the utilities involved. The summary includes data available to this author through January 1977 (References 6-1, 6-3 and 6-4). The carryover results exclude data from BWR's which commenced commercial operations prior to 1969, or plants of pre-Oyster Creek vintage. For some BWR's several I-131 carryover values have been reported, however this summary presents only one value per plant.

A discussion of the effects of power, water level, steam flow, and other variables on I-131 carryover is beyond the scope of this report.

The results in Table 6-1 indicate that I-131 carryover is related to the type of condensate treatment system. This empirical result is illustrated in Figure 6-1. Apparently BWR's with "Powdex" condensate treatment systems have lower carryover values than plants with "Deep Bed" condensate systems. The only exception to this grouping is "Powdex" plants with stainless steel condenser tubing, the other "Powdex" plants have condenser tubing made of a copper bearing alloy. This exception implies circumstantially that the amount of copper in the reactor water has a significant effect on I-131 carryover (see also, Reference 6-5).

For "Deep Bed" plants the arithmetic mean I-131 carryover is 1.5% with a sample standard deviation of 0.65%; for "Powdex" plants the mean and standard deviation are 0.40% and 0.1%, respectively.

The above results suggest a mean I-131 carryover value of about 1.0%. A one percent I-131 carryover is used in later sections of this document to normalize BWR I-131 airborne release data from the turbine building ventilation exhaust, gland seal steam exhaust, and mechanical vacuum pump.

6.2 IODINE-131 REACTOR WATER CONCENTRATIONS

Iodine-131 reactor water concentration data are presented in this section. The data have been obtained under Operational Information Exchange Provisions between the General Electric Company and utilities with commercially operating BWR's and are reported here with the concurrence of the utilities. The reported I-131 reactor water concentrations are for 15 domestic BWR's operating during 1975 and 1976. The time period was chosen to provide more recent data, to determine a I-131 concentration trend with time, if any, and for two plants data from 1974 were included to show the effect of improved fuel performance. These numerous data are here provided by a series of graphs, Figures 6-2 to 6-34a. In these figures improved-fuel denotes both General Electric Company fuel types (7x7R) and (8x8).

Table 6-2 lists the maximum monthly value of the available I-131 reactor water concentrations by plant. The medians of the monthly maximum concentrations were plotted on normal probability paper, Figure 6-35. This figure shows that the range of I-131 reactor water concentrations decreased significantly from 1975 to 1976. Figure 6-36 is a trend analysis over the two year period. This figure was developed from the deviations on a monthly basis of the arithmetic mean of the 24 medians of the maximum monthly concentrations. The results indicate a decreasing concentration with time. The above analyses are like "snapshots" of I-131 concentrations for all BWR's sampled.

On a plant basis over the two year period, Table 6-3 summarizes the median maximum monthly I-131 reactor water concentrations. Data are excluded when a plant is undergoing refueling/maintenance outage or there are not data available for a given month. Thus the I-131 concentrations conservatively apply only to plants in the power generation mode of operations. Table 6-3 also indicates the fractional I-131 fuel release resulting from old type fuel defects, namely, from GE type "7x7" fuel. These values are estimates from a survey of 1975 and 1976 fuel performance data and account for the increase in I-131 reactor water concentration from the beginning of a fuel cycle.

An analysis was also performed to determine an empirical relationship between the percentage of improved fuel in the reactors and the I-131 reactor water concentration. The purpose of this analysis was to see if the current BWR fuel performance and plant operations indicate any differences from the previous source-term (Reference 2-1). The data presented in Figures 6-2 to 6-34a were evaluated according to fuel cycle number and fraction of core loading that consisted of improved fuel.

The 15 domestic BWR's studied contain large differences in the amount of improved fuel loaded into the core, and in most cores there is a mixture of old-type fuel and improved fuel. Reactors with a relatively large amount of old-type fuel would not be representative of current fuel design. Thus, the following criteria were selected in an attempt to correlate I-131 reactor water concentration with the percentage of improved-fuel in BWR's:

1. Fuel cycle numbers must be greater than 1.

2. The amount of old-type fuel (7x7) must be less than or equal to 67%.

The first criterion eliminates data from reactors that are still in their first fuel cycle. The fuel exposures would be low relative to the total exposure to be experienced by the fuel. The observed I-131 reactor water concentrations during the first fuel cycle are probably less than in later cycles. The second criterion, eliminates data from reactors that have a preponderance of old-type fuel; core loadings which would be atypical for future BWR's.

On the basis of these criteria, twelve data points were available for consideration. Each point corresponded to the arithmetic mean of the monthly I-131 reactor water concentration data available for a reactor and fuel cycle. These results are summarized in Table 6-4.

The mean I-131 concentrations were then plotted against percent improved fuel, and a definite correlation was apparent. However, there were two outliers, namely Dresden 2 (fuel cycle 5) and Monticello (fuel cycle 5). The Dresden 2 point fell way below the other data points. This is probably due to the fact that in 1972, at the end of cycle 2, almost the entire core loading was changed, which removed the defective fuel and tramp uranium. Thus, subsequent cycles would not be so affected by the previous fuel performance due to the "core flush." The Monticello point was above the other points because of residual tramp uranium. At Monticello, in 1975, with old-type fuel the I-131 reactor water concentration had been up to about 200 μCi/kg. These two outliers were rejected for correlation purposes. Furthermore, the data from Nine Mile Point 1 (cycles 3 and 4) seemed slightly out-of-line. A review of its history indicated that Nine Mile Point 1 has been operating at "stretch power levels," not at design levels. This kind of plant operation essentially increased the number of defects. To adjust the Nine Mile Point 1 data to the same design bases as the other plants the average I-131 reactor water concentrations were multiplied by 0.7.

The 10 data points for I-131 concentration were correlated with percent improved fuel by least squares regression analysis. The correlation was found to be linear,

$$y = a + bx$$

where

y = concentration of I-131 in reactor water, μCi/kg

x = percentage of improved fuel,

a,b = constants determined by regression analysis

The *a* coefficient was found to be 4.46 and the *b* coefficient was −0.0393. The latter indicates that increasing the amount of improved fuel decreases the I-131 concentration in the reactor water, as would be expected. The correlation coefficient was fairly good, equal to 0.86.

Additional analyses were performed of the data at 100% improved fuel conditions. These data are listed in Table 6-5. The results are graphically presented in Section 7.

The data provided in this report are more comprehensive and recent than the input to the currently accepted value for I-131 reactor water concentration. Both the American Nuclear Society 18.1 Standards Committee and the U.S. Nuclear Regulatory Commission, Office of Standards Development, use a value of 5 μCi/kg, I-131 in the reactor water (References 6-6 and 6-7). This value has recently been reduced to 1.7μCi/kg (Reference 6-8).

6.3 FUEL PERFORMANCE

As previously reported (NEDO-21159, March 1976) BWR cores containing all or significant quantities of improved fuel (the 7x7R and/or the 8x8 fuel design) demonstrate much lower iodine reactor water concentrations than BWR cores containing old 7x7 fuel. This is the result of a factor of 100 fewer fuel defects in early life (<5 GWD/T) and a factor of >10 fewer fuel defects in mid-life (5-15 GWD/T) burnups. Additionally, the fuel defects that have been inspected in the 7x7R fuel design show very small tight cracks in the active fuel region with no exposed fuel. In comparison the old 7x7 fuel was frequently exposed directly to the coolant resulting in a rapid increase in the core "recoil" level. Defects in the improved fuel are consequently degrading at a much slower rate and at lower release levels than previously observed (lower by greater than a factor of ten). The net effect is reactor water iodine-131 concentrations of 0.006 to 0.5 (μCi/kg in cores that contain only improved fuel (plants B, C, D & E *in Table 6-6)*. In cores that contain reload improved fuel the old 7x7 effects are still being seen with higher iodine concentrations of

2 to 5 μCi/kg (plants A & K in Table 6-6). The old 7x7 fuel "recoil" is *continually decreasing* due to fissioning during plant operation and core component replacement (fuel, channels, etc.) during refueling. This is dramatically seen at Vermont Yankee end-of-cycle 2 (10/74) and throughout cycles 3 and 4 (Figures 6-32 and 6-33). A similar reduction in iodine concentrations occurred at Monticello end-of-cycle 4 (9/75) (Figures 6-16 and 6-17).

The increased experience with improved fuel and the extremely low offgas and reactor water iodine release rates, a number of reactor operators with improved fuel cores have elected to dispense with leak detection and defective fuel removal at end of fuel cycles. As a result of this practice a number of improved fuel bundles containing defects have seen extensive core residence time with only modest increases in core "recoil", offgas, and reactor water iodine concentrations being observed. The reactor water iodine concentrations remained 1 to 2 decades lower than levels typically observed in old 7x7 cores.

Table 6-7 summarizes information related to fuel loadings, plant capacity, and reactor water cleanup system capacity.

6.4 NORMALIZED RELEASE RATES OF IODINE-131

Measurements of I-131 airborne releases have been made at BWR's operating under different conditions. In order to provide expected annual I-131 releases, the actual release rates (see Section 3) have been normalized. The basis for normalization is a concentration of I-131 in reactor water of 1 μCi/kg, a carryover of I-131 from reactor water to reactor steam of 1%, full-flow condensate treatment, and a calendar year consisting of 300 days of power operations and one refueling/maintenance shutdown period. The next discussion deals with normalization of actual I-131 release data to its reactor water concentration, only.

The I-131 release rate normalized to concentration is the rate of the actual release divided by the average I-131 reactor water concentration in μCi/kg during the same operating period. Thus, the units for normalized I-131 release rates may be expressed as (μCi/s), corresponding to an I-131 reactor water concentration of 1.0 μCi/kg. Similarly, the normalized I-131 release (millicuries) is the product of the normalized release rate times the normal sample time in seconds times 1.0×10^{-3}. The latter factor converts microcuries to millicuries. Normalized I-131 release rates significantly reduce the variations in release rates for both intra-plant and inter-plant results. For a given plant the normalized release rates over about one calendar year of operation will usually vary by less than a factor of 10. Generally, the inter-plant results also have less than a factor of 20 difference on a normalized basis.

A normalized airborne I-131 release is determined for both power generation operations and refueling/maintenances (R/M) outages. For (R/M) outages the average I-131 reactor water concentration for about three to four weeks, equivalent to about 3 half-lives, prior to the shutdown is used for normalization purposes. This assumes that the R/M outage I-131 release is proportional to the previous plant I-131 inventory and allows a reasonable time to account for its radioactive decay. Note that normalized I-131 release rates do not account for its chemical form; normalized rates are based on all I-131 species.

The normalization of I-131 ventilation releases to its reactor water concentration is admittedly a first approximation. Other plant design features or operating conditions will also affect I-131 ventilation releases. However, as previously indicated in NEDO-21159 (March 1976) there appears to be a strong correlation between I-131 release and its reactor water concentration. On the other hand the analysis of I-131 normalized release rates can help determine the effect of plant operations or system conditions. In this report only a very limited discussion is presented of plant operation effects; such as equipment testing, process changes, process leaks that are identified and repaired.

This amendment to NEDO-21159 presents data obtained by the Electric Power Research Institute from mid-1974 through December 1976.

The available results of the EPRI sponsored measurements are presented in Tables 6-8 and 6-9 for Vermont Yankee (BWR/4), Tables 6-10 and 6-11 for Monticello (BWR/3), and Tables 6-12 and 6-13 for Oyster Creek (BWR/2). These results are illustrated in Figures (6-38 to 6-46) for the three plants as a function of time and ventilation release point (building).

The normalized I-131 release results are presented in Tables 6-8 to 6-13. For each plant – Vermont Yankee, Monticello and Oyster Creek normalized I-131 release rates and releases (millicuries) are tabulated. The results for second listing for measurements of June through November, 1976. Table 6-14 is a summary of the normalized I 131 releases for the three BWR's and indicates the release activities for power generation operations and refueling/maintenance outages. For purposes of normalization, the power generation operation period is assumed to be 300 days and the refueling/maintenance outage is assumed to be an annual event.

Table 6-15 compares normalized I-131 releases from the turbine building of all three BWR's (above) at the same I-131 carryover. For normalization purposes a 1.0 percent carryover was assumed.

The tabulated normalized I-131 releases are presented in a series of bar graphs, Figures 6-47 to 6-49, which compare the building releases at the three BWRs for different plant operations. These results are a marked contrast to the results on an "as is " basis, discussed in Section 3.2. For all plant operations, assuming one R/M outage per year, the reactor building normalized I-131 average airborne release for the three BWR's is approximately 10 millicuries/year plus-or-minus 50%. For the turbine building the I-131 annual release ranges from 3 to 70 millicuries. Two of the three BWR's have normalized I-131 annual releases from the radwaste building of only millicurie/year, the third is more than a factor of 10 greater.

Figures 6-50 to 6-53 are frequency polygons of the normalized I-131 airborne release rates. The I-131 release rates that are not normally distributed, but are lognormal. The results were calculated by means of a General Electric Company data analysis program STATPAC (Reference 6-9). These graphs are helpful in determining causes of abnormal I-131 releases. For example, at Vermont Yankee the reactor building normalized I-131 release rates appear to be bimodal. The relatively high values occurred during the refueling/maintenance outage. The low peak occurred after the R/M outage. Presumably some leaks from the power-generation and process equipment were repaired during the outage. The turbine building is distinctly unimodal with a mean of about the same magnitude as the reactor building normalized I-131 release rate after the R/M outage. There are two low outliers and these correspond to the final days of the R/M outage. Apparently all the I-131 is released from the turbine building during the first-phase of a R/M outage at Vermont Yankee. Similar evaluations of frequency polygons are possible for all the other BWR's. However, further detailed discussions are outside the scope of this report.

Figure 6-53 compares the frequencies of turbine building airborne normalized I-131 release rates at the three plants at 1% I-131 carryover. It is readily apparent from Figure 6-53 that the normalized I-131 release rates increase in the order, Vermont Yankee, Monticello and Oyster Creek. On an "as is" basis the frequency of I-131 rates would show greater differences between Oyster Creek and the other two plants because the sample I-131 carryover at Oyster Creek is 2.3%, whereas at Vermont Yankee and Monticello the carryover is 0.40 and 0.45%, respectively.

Figure 6-54 shows that the turbine building, normalized I-131 release rate correlates with plant power level. This effect was not evident at Vermont Yankee and Monticello. Presumably, at Oyster Creek there is relatively large fluid leakage-probably steam. This conclusion is made because turbine steam pressures at intermediate and low-pressure stages are proportional to power level. Estimates were made of turbine intermediate pressures as a function of power from sample BWR heat balances. These results indicate that the normalized I-131 release rate can be correlated to the square root of pressure. It is generally true that fluid leakage from orifices is proportional to the square-root of pressure.

Another evaluation of the normalized I-131 release results was made by integrating the releases as a function of time. These cumulative amounts were plotted on log-log graph paper, Figure 6-55 to 6-66. The slope of these data indicate whether or not leakage is increasing, decreasing or remains the same during plant operations. If the slope is greater than 1 the release rate is increasing, if the slope is 1 then the release rate is constant; and if the slope is less than 1 then the rate is decreasing with time. Since the above graphs plot normalized I-131 release rates the results are estimates of the effective fluid leakage from the nuclear steam supply system and auxiliaries. Only a few comments follow regarding the interpretation of the cumulative I-131 release results. A refueling/maintenance outage causes a sharp rise in *normalized* I-131 release. The system is opened and more fluid leakage is inevitable. However, the actual I-131 releases are off-set by decreasing I-131 inventories due to clean-up and radioactive decay. At Monticello the reactor building leakage increased rapidly during mid-1975, between the R/M outages. This increase may be due to the continued deterioration of the seals on the reactor water cleanup pumps. At Oyster Creek the radwaste building leakage increased significantly with time presumably due to changes in processing methods. At Vermont Yankee leakage was constant or decreasing with time presumably due to the implementation of an effective maintenance program.

Trend analyses were made of actual I-131 airborne emissions from several BWR's on the basis of routine operating plant data. The purpose of these analyses was to determine the long-term trend in airborne release rates. The numerical results have already been presented in Table 2-5. In this section the results are presented in graphical form, Figures 6-67 to 6-70. Trend analysis are based on the cumulative releases as a function of plant operating time. The cumulative I-131 airborne release for Dresden 2/3, Quad Cities 1/2, Monticello and Pilgrim 1 show a decreasing trend. This is apparent from Figures 6-67 to 6-70 which are log-log plots of the data. Increases in rates correspond to slopes greater than one, and decreases in rates correspond to slopes less than 1. For these turned analyses data from the first year, or so, of commercial operations were deleted to eliminate any startup effects. Such effects were apparent for the plants considered, see Figures 3-1, 3-3, and 3-5.

6.5 REFERENCES

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Table 6-1
SUMMARY OF BWR IODINE-131 CARRYOVER VALUES

A. BWRs with Deep Bed Condensate Treatment Systems or Powdex Systems with Stainless Steel Condenser Tubing

Plant	Carryover %
Cooper[a]	1.2
Dresden 2	1.8
Dresden 3	2.0
Fukushima 1[c]	1.1
Fukushima 2	1.4
Fitzpatrick	1.8
Millstone Point 1	1.2
Pilgrim 1	0.82
Quad Cities 1[a]	1.09
Nine Mile Point 1	2.0
Oyster Creek	2.4
Tsuruga	2.5
Nuclenor	0.21

B. BWRs with Powdex Condensate Treatment Systems[b]

Plant	Carryover %
Browns Ferry 1	0.5
Browns Ferry 2	0.23
Browns Ferry 3	0.3
Duane Arnold[d]	0.4
Hatch 1	0.35
KKM	0.6
Monticello	0.4
Peach Bottom 2	0.4
Peach Bottom 3	0.44
Vermont Yankee	0.4

a Powdex with stainless steel condenser tubing

Arithmetic mean 1.5%
STD 0.65%

b Plants have condensers with admiralty brass tubing or other copper bearing material
Arithmetic mean 0.4%
STD 0.10%

c Reported values are sample cases

d Based on measurements of I-132, I-133 and I-135

Table 6-2
ARITHMETIC MEAN OF I-131 REACTOR
WATER CONCENTRATIONS FOR DOMESTIC BWR's DURING 1975

Year — 1975

Plant/Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
					I-131 Concentration, μCi/kg							
Cooper	0.000724	0.00145	0.00177	0.00228	0.00157	0.00188	0.00328	0.0044	0.00206	—	0.0137	0.0352
Dresden 2	—	—	—	—	—	0.22	0.34	0.24	0.23	0.16	0.21	0.27
Dresden 3	4.2	5.7	5.9	5.8	—	—	—	—	1.5	2.8	2.9	2.4
Duane Arnold	0.00172	0.00169	0.00188	0.00163	0.00182	0.00194	0.00195	0.00224	0.00200	0.00220	0.00258	0.00243
Hatch 1	—	—	0.00196	0.00240	0.00181	0.00402	0.00250	0.00425	0.00549	0.00512	0.00280	0.00330
Millstone Point 1	5.05	6.35	9.35	9.88	9.19	8.48	9.15	19.5	14.4	1.61	3.21	2.45
Monticello	56.0	23.5	31.1	49.8	77	138	203.	175	171	—	2.6	7.26
Nine Mile Point 1	1.20	2.54	3.21	4.72	4.71	4.05	4.61	8.33	12.9	—	—	—
Oyster Creek	3.56	4.86	9.96	—	—	1.66	1.96	1.78	1.21	1.30	1.69	1.63
Peach Bottom 2	0.0083	0.0261	0.0200	0.0185	0.0147	—	0.0600	0.0243	0.0215	0.0374	—	0.0277
Peach Bottom 3	0.00292	0.0525	0.0384	0.0826	0.0699	0.0580	0.0202	0.0308	—	0.0294	0.0274	0.0307
Pilgrim 1	14.0	5.70	13.1	15.3	18.0	13.1	18.7	20.9	20.3	—	13.0	17.6
Quad Cities 1	0.041	0.306	0.328	0.921	0.559	0.868	2.48	1.36	0.521	0.650	0.365	0.344
Quad Cities 2	—	—	—	—	2.79	8.25	40.	23.3	9.02	43.	0.982	1.97
Vermont Yankee	0.86	0.663	0.738	0.82	0.75	0.85	0.77	0.66	0.79	0.84	0.843	0.725
Browns Ferry 1	0.121	0.933	0.413	—	—	—	—	—	—	—	—	—
Browns Ferry 2	0.0034	0.0083	0.124	—	—	—	—	—	—	—	—	—
Brunswick 2	—	—	—	—	—	—	—	—	—	0.0059	0.0033	0.012

Table 6-2a
ARITHMETIC MEAN OF I-131 REACTOR WATER CONCENTRATIONS FOR DOMESTIC BWR's DURING 1976

Year — 1976

I-131 Concentration, μCi/kg

Plant/Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Cooper	0.0612	0.0382	0.0756	0.0168	0.279	0.0820	0.0250	0.0361	0.0524	—	Cycle 2 → 0.0103	0.0036
Dresden 2	0.27	0.35	0.28	—	—	0.35	0.21	0.26	0.33	0.26	0.29	0.32
Dresden 3	2.9	2.7	2.5	2.5	4.0	2.6	3.6	3.6	6.8	—	3.5	4.0
Duane Arnold	0.00278	0.00267	—	Cycle 2 → 0.00739	0.00717	0.00501	0.00519	0.0147	0.0480	0.348	0.238	0.0108
Fitzpatrick	—	—	—	—	—	—	—	0.144	0.112	—	0.179	0.195
Hatch 1	0.00619	0.00693	0.0108	0.0111	0.0952	0.0672	0.0296	0.0188	0.0437	0.179	0.297	0.413
Millstone Point 1	2.24	2.10	0.895	1.73	2.34	2.29	2.65	2.70	—	—	—	1.14
Monticello	7.09	7.91	7.42	9.07	8.40	7.91	7.03	4.95	8.20	6.97	6.04	4.69
Nine Mile Point 1	1.46	1.41	1.14	0.857	1.23	1.50	0.835	1.34	1.99	1.41	1.67	5.63
Oyster Creek	—	—	1.12	1.40	1.23	1.55	1.37	1.95	1.95	2.33	2.75	1.90
Peach Bottom 2	8.43	19.9	79.3	—	—	Cycle 2 → 0.253	0.522	4.79	0.809	0.786	0.680	1.12
Peach Bottom 3	—	0.0446	0.504	0.257	0.396	0.221	0.591	0.636	1.91	0.767	0.40	0.556
Pilgrim 1	—	—	—	—	—	11.2	12.4	15.5	35.6	11.4	11.6	18.3
Quad Cities 1	—	—	—	1.37	1.31	1.17	3.77	3.15	2.47	7.94	2.40	1.34
Quad Cities 2	2.53	28.8	6.37	8.30	2.38	2.59	1.59	1.87	1.60	—	1.90	13.1
Vermont Yankee	0.638	0.680	0.700	0.603	0.686	0.470	—	0.410	0.483	0.328	0.487	0.328
Browns Ferry 1	—	—	—	—	—	—	—	—	—	—	0.238	0.781
Browns Ferry 2	—	—	—	—	—	—	—	—	—	—	0.030	0.345
Brunswick 2	—	0.0082	—	—	—	0.0055	0.290	1.00	0.441	—	6.15	0.070

Table 6-2b
ARITHMETIC MEAN OF I-131 REACTOR
WATER CONCENTRATIONS FOR DOMESTIC BWR's DURING 1977

Year — 1977

I-131 Concentration, µCi/kg

Plant/Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Cooper	0.00828	0.00531	0.00437	0.00369	0.00681	0.00802	0.0364	0.278	0.243	0.00416	0.00459	0.00442
Dresden 2	0.530	0.55	0.30	0.643	0.593	0.392	0.345	0.303	R.M	R.M	R.M	0.220
Dresden 3	4.10	4.30	4.90	3.50	2.18	5.14	2.58	2.45	2.90	2.48	7.94	13.6
Duane Arnold	0.770	0.0960	R.M	R.M	0.109	0.00931	0.00919	0.0172	0.0237	0.0244	0.0155	0.0107
Hatch 1	1.20	1.47	12.7	R.M	R.M	Cycle 2 → 0.00968	0.0128	0.0108	0.0832	0.230	0.0170	0.186
Millstone Point 1	1.19	0.936	1.52	2.88	1.78	1.26	2.65	4.05	2.62	5.91	6.29	6.92
Monticello	4.95	5.38	4.45	4.71	5.25	5.23	4.95	4.87	5.45	R.M	3.13	3.10
Nine Mile Point 1	6.38	8.26	R.M	R.M	R.M	R.M	R.M	1.34	1.20	1.44	1.38	1.44
Oyster Creek	1.97	2.33	2.75	1.71	R.M	R.M	R.M	1.77	2.62	2.60	3.59	4.11
Peach Bottom 2	1.58	0.728	0.569	2.33	R.M	R.M	R.M	R.M	R.M	0.210	0.273	0.344
Peach Bottom 3	R/M	R.M	R.M	R/M	Cycle 2 → 0.697	NA	1.54	0.747	0.610	1.17	1.16	NA
Pilgrim 1	9.9	16.6	11.6	28.0	17.2	15.7	17.	16.	R.M	R/M	R/M	0.92
Quad Cities 1	3.41	2.39	2.15	R/M	R.M	<LLD	0.312	0.19	5.55	6.98	NA	1.18
Quad Cities 2	1.95	<LLD	2.61	2.72	7.59	4.49	1.45	7.66	1.72	2.04	<LLD	11.5
Vermont Yankee	0.391	0.431	0.394	0.383	0.333	0.470	0.554	0.318	R.M	0.394	0.246	0.287
Browns Ferry 1 (Cycle 1)	0.483	0.195	0.0911	2.13	1.04	0.728	0.958	1.53	0.131	R.M	R.M	R.M
Browns Ferry 2 (Cycle 1)	0.0369	0.0135	0.0220	0.142	10.0	0.800	0.260	0.334	0.0213	0.0207	M	0.00450
Browns Ferry 3 (Cycle 1)	0.0349	0.0532	0.0605	0.0520	0.165	0.0848	0.787	0.0539	0.0500	0.0450	0.0440	0.0374
Brunswick 1 (Cycle 1)	NA	0.0139	0.00940	0.0258	M	M	0.0514	0.0213	0.0129	0.00954	0.00997	0.0179
Brunswick 2 (Cycle 1)	0.402	10.8	0.442	1.04	0.770	1.67	0.923	1.39	4.16	R.M	R.M	R.M
Fitzpatrick	0.198	0.212	0.152	0.122	0.127	0.150	R.M	R.M	R.M	Cycle 2 0.0104	0.120	0.0555

<LLD = less than lower limit of detection
M = maintenance outage
NA = not available
R.M = refueling/maintenance outage

Table 6-3
SUMMARY OF MEDIANS OF MAXIMUM MONTHLY I-131 REACTOR WATER CONCENTRATION AT 15 DOMESTIC BWR'S[a]

Plant	Concentration I-131 Ci/Kg	Fractional I-131 Release Resulting From Old Fuel Defects
Cooper (from July 1975)	0.039	0.0
Dresden 2	0.27	0.95
Dresden 3	3.5	0.95
Duane Arnold (1975 only)	0.011	0.0
Hatch 1 (1976 only)	0.070	0.0
Millstone Point 1	2.9	0.9
Monticello (from Dec., 1975)	9.0	1.0
Nine Mile Point	2.0	0.8
Oyster Creek	2.0	0.95
Peach Bottom 2	0.88	1.0
Peach Bottom 3	0.76	1.0
Pilgrim 1	19.7	0.95
Quad Cities 1	1.9	0.9
Quad Cities 2	5.4	0.95
Vermont Yankee	0.76	1.0

Notes a Data for 1975 and 1976 unless otherwise specified

Table 6-4
IODINE-131 REACTOR WATER CONCENTRATIONS AT BWR'S WITH HIGH AMOUNTS OF IMPROVED FUEL IN THE REACTORS[a]

Plant	Date Year	Cycle Number	Amount of Improved Fuel %	Mean Monthly I-131 Concentration[b] μCi/kg
Dresden 2	1976	5	44	0.289 ± 0.0487(7)
Dresden 3	1975/76	4	33	3.138 ± 1.269(13)
Duane Arnold	1976	2	100	0.0847 ± 0.1328(8)
Millstone Point 1	1975/76	4	51	2.202 ± 0.620(11)
Monticello	1975/76	5	100	7.149 ± 1.282(13)
Nine Mile Point 1	1975	3	38	5.140 ± 3.505(9)
Nine Mile Point 1	1976	4	76	1.705 ± 1.275(12)
Oyster Creek	1975	5	c	1.597 ± 0.307(7)
Oyster Creek	1976	6	c	1.768 ± 0.542(10)
Peach Bottom 2	1976	2	100	1.281 ± 1.570(7)
Vermont Yankee	1975/76	3	100	0.727 ± 0.102(8)
Vermont Yankee	1976	4	100	0.407 ± 0.078(5)

Notes. (a) Selection of plants excludes reactor in their first fuel cycle
(b) Notation is arithmetic mean ± one standard deviation, months of continuous power generation are listed in parentheses
(c) Old-type fuel (7x7) amounts to 40% for cycle 5, and 30% for cycle 6

Table 6-5
IODINE-131 REACTOR WATER CONCENTRATION DATA FOR BWR's WITH 100% IMPROVED FUEL

Plant (fuel cycle)	sample date month/day/year	I-131 concentration µCi/kg
Duane Arnold (2)	4/27/76	0.00739
	5/4/76	0 00795
	5/11/76	0.00458
	5/18/76	0 00897
	6/8/76	0 0106
	6/15/76	0 00235
	6/22/76	0 00229
	6/29/76	0 00481
	7/6/76	0.00417
	7/13/76	0 00246
	7/27/76	0 00895
	8/3/76	0 0169
	8/10/76	0 0121
	8/17/76	0 0203
	8/24/76	0 00949
	9/7/76	0 0170
	9/14/76	0 114
	9/21/76	0.0147
	9/28/76	0.0461
	10/5/76	0 0317
	10/12/76	0 0292
	10/19/76	0.0128
	10/26/76	1 32
	11/2/76	0 484
	11/9/76	0.0561
	11/18/76	0 105
	11/23/76	0.382
	11/30/76	0.165
	12/7/76	0 0185
	12/14/76	0.00822
	12/28/76	0.00556
Peach Bottom 2 (2)	6/28/76	0.253
	7/6/76	0.231
	7/12/76	0.861
	7/13/76	0.877
	7/14/76	0.86
	7/20/76	0.499
	7/27/76	0.143
	8/3/76	0.257
	8/17/76	9.32
	9/2/76	0.449
	9/7/76	0.551
	9/14/76	0.555
	9/21/76	0.709
	9/30/76	1.78
	10/5/76	0.905
	10/15/76	0.691

Table 6-5 (Cont.)
IODINE-131 REACTOR WATER CONCENTRATION DATA
FOR BWR's WITH 100% IMPROVED FUEL

Plant (fuel cycle)	sample date month/day/year	I-131 concentration μCi/kg
Peach Bottom 2 (2)	10/26/76	0.763
	11/2/76	0.645
	11/9/76	0.715
	12/3/76	1.28
	12/7/76	1.15
	12/16/76	0.944
Vermont Yankee (3)	1/9/75	1.03
	1/21/75	0.77
	1/30/75	0.78
	2/4/75	0.738
	2/25/76	0.588
	3/4/75	0.935
	3/12/75	0.880
	3/18/75	0.400
	4/4/75	0.700
	4/8/75	0.670
	4/15/75	1.10
	4/22/75	1.00
	4/29/75	0.64
	5/8/75	0.58
	5/15/75	0.56
	5/22/75	0.96
	5/29/75	0.88
	6/4/75	0.90
	6/20/75	0.73
	6/26/75	0.93
	7/3/75	0.50
	7/11/75	0.69
	7/15/75	1.10
	7/22/75	0.851
	7/29/75	0.703
	8/6/75	0.66
	9/5/75	0.569
	9/11/75	0.770
	9/18/75	0.809
	9/25/75	1.01
	10/2/75	0.78
	10/8/75	0.798
	10/14/75	0.824
	10/23/75	0.760
	10/30/75	1.00
	11/4/75	0.863
	11/7/75	0.798
	11/18/75	0.934
	11/26/75	0.778
	12/2/75	0.748
	12/8/75	0.744

Table 6-5 (Cont.)
IODINE-131 REACTOR WATER CONCENTRATION DATA
FOR BWR's WITH 100% IMPROVED FUEL

Plant (fuel cycle)	sample date month/day/year	I-131 concentration μCi/kg
Vermont Yankee (3)	12/15/75	0.682
	1/8/76	0.675
	1/13/76	0.670
	1/20/76	0.568
	2/20/76	0.598
	2/24/76	0.761
	3/2/76	0.862
	3/9/76	0.709
	3/30/76	0.519
	4/6/76	0.559
	4/15/76	0.531
	4/20/76	0.588
	4/29/76	0.735
	5/4/76	0.614
	5/11/76	0.832
	5/20/76	0.612
	6/4/76	0.427
	6/8/76	0.524
	6/15/76	0.459
Vermont Yankee (4)	8/19/76	0.475
	8/24/76	0.352
	8/31/76	0.404
	9/7/76	0.559
	9/24/76	0.407
	10/1/76	0.443
	10/8/76	0.271
	10/15/76	0.451
	10/22/76	0.348
	10/28/76	0.128
	11/5/76	0.520
	11/9/76	0.483
	11/16/76	0.458
	12/3/76	0.348
	12/7/76	0.225
	12/14/76	0.411

Note: Data base includes information available from January 1975 to December 1976 excluding experience data for first fuel cycle of BWRs with 100% improved fuel excludes Monticello data for cycle 5 which has 100% improved fuel but relatively high amounts of tramp uranium due to previous defects in unimproved fuel

Table 6-6
COMPARISON OF I-131 REACTOR WATER CONCENTRATIONS AND FUEL BURNUPS.

BWR		I-131 Coolant Concentration and Burnup			
		NEDO-21159[a]		Present[b]	
Plant	Name	Conc. µCi/Kg	Burnup GWD/t	Conc. µCi/Kg	Burnup GWD/t
A	[c]	0.08	6.6	2.1	15
B	[c]	0.2	3.2	0.5	10
C	Cooper	0.005	5.7	0.006	11
D	Duane Arnold	0.005	4.4	0.13	10
E	Vermont Yankee	1.0	5.0	0.43	15
K	[c]	99.	[d]	5.4	10

NOTES a Data as of about 12.31.75. concentration values are maximum values reported during fuel cycle to indicated burnup
b Data as of about 1/26.77. concentration values correspond to this date
c No permission received from utility to identify plant by name
d Unimproved fuel, fuel performance not like improved fuel in other listed plants

Table 6-7
SUMMARY OF BWR FUEL TYPES BY PLANT AND RELATED PARAMETERS.

Plant	Rated Power[a] MWR	Fuel Type[b] % 7x7	7x7R	8x8	Reactor Water Cleanup Flow % of Feedwater Flow
Cooper	801	2	76	22	1
Dresden 2	810	56	4	39	8
Dresden 3	810	47	7	46	8
Duane Arnold	566	—	77	23	1
Fitzpatrick	850	24	76	—	1
Hatch 1	809	—	—	100	1
Millstone Point 1	650	28	26	46	7
Monticello	543	—	4	96	1
Nine Mile Point 1	620	24	20	56	5
Oyster Creek	641	30	—	—	[c]
Peach Bottom 2	1098	—	75	25	1
Peach Bottom 3	1098	—	100	—	1
Pilgrim 1	655	74	—	26	2
Quad Cities 1	810	70	4	27	1
Quad Cities 2	810	57	—	43	1
Vermont Yankee	537	—	11	89	1

Notes a Nominal turbine plate rating
b Date as of 1.1.77
c Nominal capacity is 6% however system always operated at 3% of feedwater flow

Table 6-8
NORMALIZED I-131 AIRBORNE RELEASE RATES AT VERMONT YANKEE [a, b, c]

Nominal Sample Period Month/Day/Year	Normalized I-131 Release Rate, [μCi/s] Reactor (0.001)	Turbine (0.001)	Radwaste (0.001)	GS & MVP (0.001)
6/20-7/2/74	0.1400	0.0560	0.0600	0.0120
7/2-7/9/74	0.9600	0.0880	0.1601	2.0001
7/9-7/23/74	0.1680	0.0440	0.0960	0.0148
7/23-7/30/74	0.1040	0.0600	0.0680	0.0195
7/30-8/13/74	0.0633	0.0500	0.0367	0.0146
8/13-8/27/74	0.0514	0.0457	0.0400	0.0114
8/27-9/12/74	0.1105	0.0684	0.0395	0.0084
9/14-9/27/74	0.0271	0.1054	0.0811	NS
9/27-10/10/74	0.0314	0.0215	0.0400	0.0102
10/11-10/13/74	0.5000		(0.0694)[d]	1.1667
10/13-10/14/74	0.6389	0.1110		3.0556
10/14-10/31/74	1.250		0.0227	(1.16)[d]
10/31-11/1/74	0.444	0.1551	0.0440	0.3611
11/1-11/18/74	0.4722	0.0239	0.0180	0.0172
11/18-12/2/74	0.3333	0.0009	0.0106	0.0047
12/2-12/6/74	0.0333	0.0012	0.0075	0.0049
12/6-12/27/74	0.0639	0.0231	NS	NS
12/27-1/28/75	0.0196	0.0308	0.0196	0.0241
1/28-2/14/75	0.0114	0.0210	0.0157	0.0253
2/14-3/5/75	0.0719	0.0205	0.0157	0.0417
3/5-3/8/75	—	—	—	—
3/8-3/26/75	0.4250	0.0400	0.0437	0.1087
3/26-4/10/75	0.0540	0.0746	0.0191	0.0397
4/10-4/26/75	0.0378	0.0299	0.0098	0.0211
4/26-5/8/75	0.0476	0.0984	0.0279	0.0215
5/8-5/29/75	0.0282	0.1057	0.0225	0.0980
5/29-6/13/75	0.0792	0.0268	0.0167	0.1389
6/13-6/26/75	0.0359	0.0597	0.0339	0.0250
6/26-7/10/75	0.0775	0.0918	0.0452	0.0494
7/10-7/29/75	0.0426	0.0508	0.0688	0.0423
7/29-8/13/75	0.2836	0.0448	0.0150	0.0253
8/13-8/28/75	0.1562	0.0120	0.0032	0.0312
8/28-9/19/75	0.0344	0.0639	0.0098	NS
9/19-10/7/75	0.0365	0.0377	0.0165	0.0588
10/7-10/21/75	0.0896	0.0312	0.0507	0.0181
10/21-11/7/75	0.0247	0.0091	0.0562	0.0270

Notes (a) Normalized I-131 release rates are based on EPRI/NES measurements
(b) Data are normalized to an I-131 Reactor water concentration of 1μCi/Kg
(c) Refueling/maintenance outage transpired 10/11 to 12/13/74.
(d) Numbers in parenthesis are estimated values

Table 6-9
NORMALIZED I-131 AIRBORNE RELEASES AT VERMONT YANKEE[a, b, d, f]

Nominal Sample Period Month/Day/Year	Normalized I-131 Release, millicuries Reactor	Turbine	Radwaste	Gland Seal & MVP
6/20–7/2/74	0.1452	0.0581	0.0622	0.0207
7/2–7/9/74	0.5806	0.0532	0.0968	1.210
7/9–7/23/74	0.2032	0.0532	0.1161	0.0179
7/23–7/30/74	0.0629	0.0363	0.0411	0.0118
7/30–8/13/74	0.0766	0.0605	0.0444	0.0177
8/13–8/27/74	0.0622	0.0553	0.0484	0.0138
8/27–9/12/74	0.1528	0.0946	0.0546	0.0116
9/14–9/27/74	0.0304	0.1184	0.0911	NS
9/27–10/10/74	0.0353	0.0241	0.0449	0.0115
10/11–10/13/74	0.0864	} 0.1918	} (0.018)[d]	0.2016
10/13–10/14/74	0.0552			0.2640
10/14–10/31/74	1.836		0.334	(0.1)[d]
10/31–11/1/74	0.0384	0.0134	0.0038	0.0312
11/1–11/18/74	0.6936	0.0351	0.0265	0.0253
11/18–12/2/74	0.4032	0.0011	0.0128	0.0057
12/2–12/6/74	0.0115	0.0004	0.0026	0.0017
12/6–12/27/74	0.116	0.042	NS	NS
12/27–1/28/75	0.0543	0.0852	0.0543	0.0667
1/28–2/14/75	0.0167	0.0308	0.0231	0.0372
2/14–3/5/75	0.1180	0.0337	0.0258	0.0685
3/5–3/8/75	—	—	—	—
3/8–3/26/75	0.6610	0.0622	0.0680	0.1691
3/26–4/10/75	0.0070	0.0967	0.0248	0.0514
4/10–4/26/75	0.0522	0.0414	0.0136	0.0292
4/26–5/8/75	0.0493	0.1020	0.0289	0.0223
5/8–5/29/75	0.0511	0.1917	0.0408	0.1779
5/29–6/13/75	0.1026	0.0347	0.0217	0.1800
6/13–6/26/75	0.0403	0.0671	0.0381	0.0281
6/26–7/10/75	0.0937	0.1111	0.0547	0.0597
7/10–7/29/75	0.0700	0.0834	0.1130	0.0695
7/29–8/13/75	0.3675	0.0581	0.0194	0.0328
8/13–8/28/75	0.2025	0.0156	0.0041	0.0405
8/28–9/19/75	0.0654	0.1215	0.0187	NS
9/19–10/7/75	0.0567	0.0586	0.0256	0.0915
10/7–10/21/75	0.1084	0.0377	0.0613	0.0219
10/21–11/7/75	0.0363	0.0134	0.0825	0.0397

Notes (a) Normalized I-131 releases are based on EPRI/NES measurements
(b) Data are normalized to an I-131 reactor water concentration of 1.0 μCi/kg for each sample period
(c) Refueling/maintenance outage transpired 10/11 to 12/13/74.
(d) See Table 6-12 for summary of total I-131 releases
(e) Numbers in parentheses are estimated values
(f) Sample I-131 carryover is 0.40%

Table 6-10
NORMALIZED I-131 AIRBORNE RELEASE RATES AT MONTICELLO[a, b, c]

Nominal Sample Period Month/Day/Year	Normalized I-131 Release Rate, (μCi/s) Reactor (0.001)	Turbine (0.001)	Radwaste (0.001)	Roof-Vent (0.001)
11/15–11/17/74	—	—	—	—
11/20–12/5/74	0.3056	0.2639	0.0361	0.6111
12/5–12/18/74	0.1927	0.1133	0.0169	0.3253
12/18–1/6/75	0.1358	0.1045	0.0269	0.2687
1/8–1/9/75	0.1109	0.0745	0.0218	0.2000
1/13–1/15/75	0.4426	0.5574	0.0230	1.0656
1/9–1/13 and 1/15–1/22/75	0.2951	0.6393	0.0105	0.9508
1/22–2/7/75	0.1115	0.1115	0.0046	0.2295
2/7–2/22/75	0.3100	2.8000	0.0450	3.1000
2/22–3/10/75	0.2382	0.5294	0.0076	0.7647
3/10–3/25/75	0.6286	0.5714	NS[d]	1.2000
3/25–4/7/75	0.3589	1.1282	0.0282	1.5128
4/7–4/21/75	0.4038	0.7115	0.0161	1.1346
4/21–5/5/75	NS	0.7611	0.0149	NS[d]
5/5–5/17/75	1.0548	0.7123	0.0191	1.7808
5/19–6/5/75	0.2250	0.2562	0.0218	0.5062
6/5–6/23/75	0.4142	0.2071	0.0378	0.6642
6/23–7/8/75	0.5133	0.2266	0.0500	0.8000
7/8–7/22/75	0.8750	0.2250	0.0400	1.0416
7/11–7/30/75	0.2347	0.1782	0.0369	0.4043
8/5–8/21/75	0.5533	0.3733	0.0246	0.9333
8/21–9/3/75	0.4761	0.5238	0.0304	1.0000
9/3–9/11/75	0.3118	0.3353	0.0194	0.6471
9/11–9/25/75	0.2526	0.0279	0.0153	0.2947
9/25–10/15/75	NS	0.0074	0.0013	NS[d]
10/15–10/27/75	0.0105	0.0011	0.0002	0.0116
10/27–11/14/75	0.0009	0.0003	0.0001	0.0013
11/14–11/17/75	—	—	NS[d]	NS
11/17–11/18/75	3.269	4.14	0.823	NS
11/18–11/18/75	NS	3.71	0.734	NS
11/18–11/19/75	1.655	1.03	0.204	NS
11/19–11/19/75	0.240	0.191	0.037	NS
11/19–11/20/75	0.105	0.056	0.201	NS
11/20–11/21/75	0.186	0.0583	0.0291	NS
11/21–11/21/75	0.173	0.0753	0.0332	NS
11/21–11/22/75	0.150	0.159	0.0143	NS
11/22–11/22/75	0.137	0.0740	0.0150	NS
11/22–11/23/75	0.155	0.136	0.0213	NS
11/23–11/23/75	0.180	0.128	0.0181	NS
11/23–11/24/75	0.238	0.113	NS	NS

Notes (a) Normalized I-131 release rates are based on EPRI-NES measurements
(b) Data are normalized to an I-131 reactor water concentration of 1.0 μCi/kg for each sample period
(c) Refueling maintenance outages transpired 1/9 to 2/7/75 and 9/11 to 11/17/75.
(d) NS indicates that no sample measurement is available

Table 6-11
NORMALIZED I-131 AIRBORNE RELEASES AT MONTICELLO[a, b, c, f]

Nominal Sample Period Month/Day/Year	Normalized I-131 Release, millicuries Reactor	Turbine	Radwaste	Roof-Vent
11/15–11/17/74	—	—	—	—
11/20–12/5/74	0.3960	0.3419	0.0468	0.7919
12/5–12/18/74	0.2165	0.1272	0.0189	0.3654
12/18–1/6/75	0.1715	0.2230	0.0441	0.4410
1/8–1/9/75	0.0096	0.0064	0.0019	0.0173
1/13–1/15/75	0.0765	0.0963	0.0040	0.1841
1/9–1/13 and 1/15–1/22/75	0.2805	0.6077	0.0100	0.9036
1/22–2/7/75	0.1541	0.1541	0.0063	0.3172
2/7–2/22/75	0.0402	3.629	0.0583	4.0180
2/22–3/10/75	0.3294	0.7318	0.0106	1.0571
3/10–3/25/75	0.8145	0.7405	NS[d]	1.5551
3/25–4/7/75	0.4030	1.2671	0.0316	1.6992
4/7–4/21/75	0.4884	0.8607	0.0195	1.3725
4/21–5/5/75	NS	0.9207	0.0181	NS
5/5–5/17/75	1.0935	0.7384	0.0116	1.8465
5/19–6/5/75	0.3305	0.3763	0.0321	0.7437
6/5–6/23/75	0.6442	0.3221	0.0588	1.0328
6/23–7/8/75	0.6652	0.2937	0.0648	1.0366
7/8–7/22/75	1.0583	0.2721	0.0483	1.2600
7/11–7/30/75	0.1622	0.1232	0.0255	0.2794
8/5–8/21/75	0.7646	0.5160	0.0341	1.2900
8/21–9/3/75	0.5347	0.5885	0.0342	1.1230
9/3–9/11/75	0.2155	0.2318	0.0134	0.4472
9/11–9/25/75	0.3056	0.0337	0.0185	0.3565
9/25–10/15/75	NS	0.0127	0.0023	NS
10/15–10/27/75	0.0109	0.0011	0.0002	0.0120
10/27–11/14/75	0.0015	0.0005	0.0001	0.0020
11/14–11/17/75	—	—	NS	NS
11/17–11/18/75	0.2860	0.3620	0.0720	NS
11/18–11/18/75	NS	0.1362	0.0270	NS
11/18–11/19/75	0.0745	0.0464	0.0092	NS
11/19–11/19/75	0.0102	0.0081	0.0016	NS
11/19–11/20/75	0.0062	0.0033	0.0013	NS
11/20–11/21/75	0.0076	0.0024	0.0012	NS
11/21–11/21/75	0.0101	0.0044	0.0019	NS
11/21–11/22/75	0.0085	0.0090	0.0008	NS
11/22–11/22/75	0.0051	0.0028	0.0006	NS
11/22–11/23/75	0.0084	0.0074	0.0012	NS
11/23–11/23/75	0.0059	0.0042	0.0006	NS
11/23–11/24/75	0.0125	0.0060	NS	NS

Notes: (a) Normalized I-131 release rates are based on EPRI-NES measurements.
(b) Data are normalized to an I-131 reactor water concentration of 1.0 μCi/kg for each sample period.
(c) Refueling/maintenance outages transpired 1/9 to 2/7/75 and 9/11 to 11/17/75.
(d) NS indicates that no sample measurement is available.
(e) Sample I-131 carryover of 0.45%.
(f) See Table 6-12 for a summary of total I-131 releases.

Table 6-12
NORMALIZED I-131 AIRBORNE RELEASE RATES AT OYSTER CREEK (1975–1976)

Nominal Sample Period Month/Day/Year	Normalized I-131 Release Rate, (μCi/s) Reactor (0.001)	Turbine (0.001)	Radwaste (0.001)	Gland Seal & MVP (0.001)
2/22–2/26/75	0.1154	3.8462	0.0708	NS
2/26–3/12/75	0.0815	4.3077	0.1046	NS
3/12–3/28/75	0.3385	4.3077	0.0754	NS
3/29–4/15/75	0.8154	12.3077	NS	NS
4/15–5/1/75	0.200	8.1538	0.5231	NS
5/1–5/15/75	0.0769	0.7077	NS	NS
5/15–5/29/75	0.0308	0.0646	0.0074	NS
5/29–6/16/75	0.4412	1.7059	0.0941	NS
6/16–6/30/75	0.3667	1.5333	0.0500	0.4667
6/30–7/17/75	0.6471	1.5882	0.2706	0.7176
7/17–8/5/75	0.2333	3.1111	0.5611	3.6667
8/5–8/21/75	0.2063	4.6875	0.4500	1.3750
8/21–9/8/75	0.0714	2.3571	1.3571	3.9286
9/8–9/29/75	0.1385	3.6154	1.4615	NS
9/29–10/14/75	0.1900	0.9500	1.1000	NS
10/14–10/31/75	0.0538	NS	0.3500	NS
10/31–11/14/75	0.0565	4.5294	0.1412	0.3235
11/14–12/4/75	0.6714	3.0714	0.7143	4.0000
12/4–12/18/75	0.1117	4.1176	0.1118	1.1765
12/18–1/5/76	0.7500	2.8125	NS	5.1250
1/5–1/22/76	0.1125	6.5625	0.0681	0.1125
1/22–2/9/76	0.0194	0.8750	0.0506	0.0033

Note. See end of Table 6-12a

Table 6-12a
NORMALIZED I-131 AIRBORNE RELEASE RATES AT OYSTER CREEK (1976)[a, b, c]

Normalized I-131 Release Rate, (μCi/s)

Nominal Sample Period Month/Day/Year	Reactor (0.001)	Turbine (0.001)	Radwaste (0.001)	Gland Seal & MVP (0.001)	Feedwater Pump/ Condensate Pump Room Exhaust (0.001)	Reheater Protection System Exhaust (0.001)
6/16–6/23/76	0.167	8.04	0.324	NS[d]	NS	NS
6/23–6/30/76	0.142	8.03	0.185	0.294	0 103	NS
6/30–7/7/76	0.168	16.9	0.431	0.379		NS
7/7–7/13/76	0 0771	10.4	0 447	0.250	0.0836	NS
7/13–7/20/76	0.107	8.65	0 982	0.416		NS
7/20–7/27/76	0 123	9 20	0.0612	0 292	0 0846	0 698
7/27–8/3/76	18.4	14 4	2.43	61.8		
8/3–8/10/76	0.653	8 96	0.359	0.366		0.650
8/10–8/17/76	0 475	12.4	0 117	0.0654	0 149	
8/17–8/24/76	0 327	8 84	0.469	0.305		0 924
8/24–8/30/76	0 700	7.63	0.618	1.31	0 0684	
8/30–9/7/76	0.249	8.49	0.301	1.01		1.14
9/7–9/16/76	0.221	5.63	0.464	1.02		
9/16–9/23/76	0 418	14 7	1.18	1.75	0.114	0 813
9/23–9/30/76	0 0341	11.0	3.71	2.05		
9/30–10/7/76	0.147	7.48	0.500	0 803		0 538
10/7–10/14/76	0.155	7.92	0.307	0.873	0.0719	
10/14–10/21/76	0.121	6.20	0.200	0.647		0 310
10/21–10/28/76	0.112	5.86	0.564	0.627	0.449	
10/28–11/4/76	0.0698	4.14	0.214	0.411		0.276
11/4–11/11/76	0.0951	5.13	0.220	0.571	0.0971	
11/11–11/18/76	0.0969	4.83	0.319	0.402		NS
11/18–11/30/76	0.0861	5.14	0.301	0.599	0.106	0.185

Notes (a) Normalized I-131 release rates are based on EPRI NES measurements.
(b) Data are normalized to an I-131 reactor water concentration of 1 0 μCi/kg for each sample period.
(c) Refueling maintenance outages transpired 3/29 to 5 29 75 and 1/5 to 3/14 76.
(d) NS indicates that no sample measurement is available

Table 6-13
NORMALIZED I-131 AIRBORNE RELEASE RATES AT OYSTER CREEK (1975–1976)

Nominal Sample Period Month/Day/Year	Normalized I-131 Release, Millicuries Reactor	Turbine	Radwaste	Gland Seal & MVP
2/22–2/26/75	0.0398	1.3292	0.0245	NS
2/26–3/12/75	0.0986	5.2108	0.1266	NS
3/12–3/28/75	0.4678	5.9954	0.1042	NS
3/29–4/15/75	1.1977	18.0769	NS	NS
4/15–5/1/75	0.2765	11.2723	0.7231	NS
5/1–5/15/75	0.0931	0.8560	NS	NS
5/15–5/29/75	0.0372	0.0782	0.0089	NS
5/29–6/16/75	0.6859	2.6529	0.1465	NS
6/16–6/30/75	0.4437	1.8547	0.0603	0.5643
6/30–7/17/75	0.9506	2.3329	0.3976	1.0541
7/17–8/5/75	0.3828	5.1072	0.9211	6.0167
8/5–8/21/75	0.2850	6.4813	0.6219	1.9006
8/21–9/8/75	0.1114	3.6657	2.1107	6.1100
9/8–9/29/75	0.2515	6.5600	2.6515	NS
9/29–10/14/75	0.2460	1.231	1.4260	NS
10/14–10/31/75	0.0788	NS	0.5144	NS
10/31–11/14/75	0.0682	5.4788	0.1706	0.3912
11/14–12/4/75	1.1600	5.3071	1.2343	6.9121
12/4–12/18/75	0.1353	4.9806	0.1353	1.4229
12/18–1/5/76	1.1663	4.3738	NS	7.9688
1/5–1/22/76	0.1650	9.6375	0.1000	0.1650
1/22–2/9/76	0.0300	1.3606	0.0788	0.0050

Note: See notes at end of Table 6-13a

Table 6-13a
NORMALIZED I-131 AIRBORNE RELEASE RATES AT OYSTER CREEK (1976)[a, b, c, e, f]

Normalized I-131 Release, Millicuries

Nominal Sample Period Month/Day/Year	Reactor	Turbine	Radwaste	Gland Seal & MVP	Feedwater Pump/ Condensate Pump Room Exhaust	Reheater Protection System Exhaust
6/16–6/23/76	0.10098	4.8601	0.1959	NS[d]	NS	NS
6/23–6/30/76	0.08618	4.8544	0.1117	0.1778	0.1249	NS
6/30–7/7/76	0.10164	10.214	0.2604	0.2291		NS
7/7–7/13/76	0.03998	5.4100	0.2315	0.1295	0.0939	NS
7/13–7/20/76	0.06475	5.2335	0.05938	0.2516		NS
7/20–7/27/76	0.07460	5.5657	0.03699	0.1767	0.1023	0.844
7/27–8/3/76	11.099	8.6873	1.4674	37.368		
8/3–8/10/76	0.39490	5.4211	0.2171	0.2215		0.787
8/10–8/17/76	0.28738	7.4995	0.07086	0.0395	0.2697	
8/17–8/24/76	0.19769	5.3474	0.2836	0.1844		1.04
8/24–8/30/76	0.36287	3.9559	0.3204	0.6799	0.0828	
8/30–9/7/76	0.17220	5.8660	0.2079	0.6973		1.68
9/7–9/16/76	0.17209	4.3773	0.3604	0.7931		
9/16–9/23/76	0.25263	8.8724	0.7142	1.0577	0.2951	0.983
9/23–9/30/76	0.02065	6.6572	2.2411	1.2419		
9/30–10/7/76	0.08870	4.5227	0.3026	0.4856		0.650
10/7–10/14/76	0.09358	4.7882	0.1856	0.5278	0.0870	
10/14–10/21/76	0.07326	3.7478	0.1209	0.3911		0.375
10/21–10/28/76	0.06779	3.5415	0.3409	0.3789	0.0543	
10/28–11/4/76	0.04223	2.5021	0.1297	0.2488		0.333
11/4–11/11/76	0.05752	3.1026	0.1331	0.3452	0.1175	
11/11–11/18/76	0.05863	2.9186	0.1931	0.2429		NS
11/18–11/30/76	0.08926	5.3274	0.3120	0.6210	0.1101	0.191

Notes. (a) Normalized I-131 releases are based in EPRI/NES measurements.
(b) Data are normalized to an I-131 reactor water concentration of 1.0 μCi/kg for each sample period.
(c) Refueling/maintenance outages transpired 3/29 to 5/29/75 and 1/5 to 3/14/76
(d) NS indicates that no sample measurement is available
(e) Sample I-131 carryover is 2.3%
(f) See Table 6-12 for a summary of total I-131 releases.

Table 6-14
SUMMARY BY PLANT OF NORMALIZED I-131 RELEASES AT VERMONT YANKEE, MONTICELLO AND OYSTER CREEK FOR POWER GENERATION OPERATIONS (300 DAYS) AND ONE REFUELING/MAINTENANCE OUTAGE[a, b, c]

Building/Plant	Vermont Yankee	Monticello[d]	Oyster Creek
	Power Generation Operations (300 Days)		
	I-131 Release, millicuries		
	I-131 Release, millicuries		
Reactor	2.49 (53)	10.50 (40)	14.62 (9)
Turbine	1.25 (27)	14.72 (57)	137.65 (83)
Radwaste	0.94 (20)	0.80 (3)	14.21 (9)
Total Building Release =	4.68 mCi	26.03 mCi	166.48 mCi
Gland Seal Steam =	2.00 mCi	——	74.60 mCi
	Refueling/Maintenance Outage[e]		
Reactor	3.12 (83)	0.69 (59)	0.90 (4)
Turbine	0.24 (6)	0.45 (39)	20.64 (88)
Radwaste	0.40 (11)	0.03 (3)	1.96 (8)
Total Building Release =	3.76 mCi	1.17 mCi	23.50 mCi
MVP =	2.4 mCi	——	——

Notes (a) Normalized I-131 releases are based on EPRI.NES measurements
(b) Data are normalized to an I-131 reactor water concentration of 1.0 μCi/kg.
(c) Numbers in parentheses are percentages of total building ventilation release per plant per operation
(d) Monticello radwaste release includes input from reactor water cleanup demineralizer which is an input source to reactor building at the other two plants
(e) At plants with two R/M outages, the I-131 releases were determined by the arithmetic mean.

Table 6-15
NORMALIZED I-131 TURBINE BUILDING RELEASE ADJUSTED TO ONE PERCENT I-131 CARRYOVER[a, b]

I-131 RELEASE, MILLICURIES

Power Generation Operations (300 days)	
Vermont Yankee	3.12
Monticello	32.71
Oyster Creek	59.85
Refueling/Maintenance Outage	
Vermont Yankee	0.60
Monticello	1.01
Oyster Creek	8.97

NOTES: (a) At Vermont Yankee gland seal release is 5.0 millicuries and the MVP I-131 release is 6.0 millicuries.
(b) At Oyster Creek gland seal I-131 release is 32.4 millicuries.

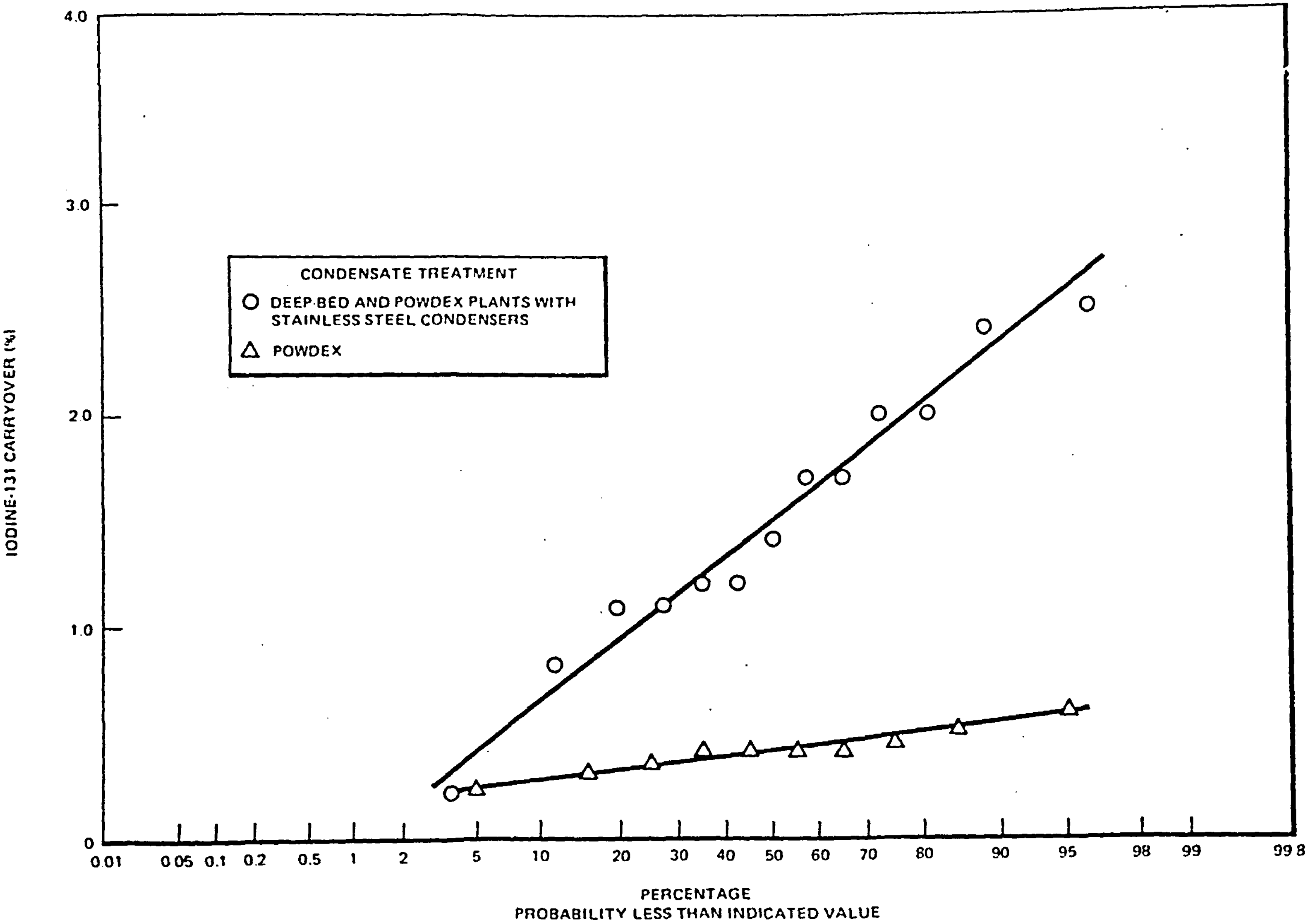


Figure 6-1. Normal Probability Distribution of Iodine-131 Carryover in BWR's

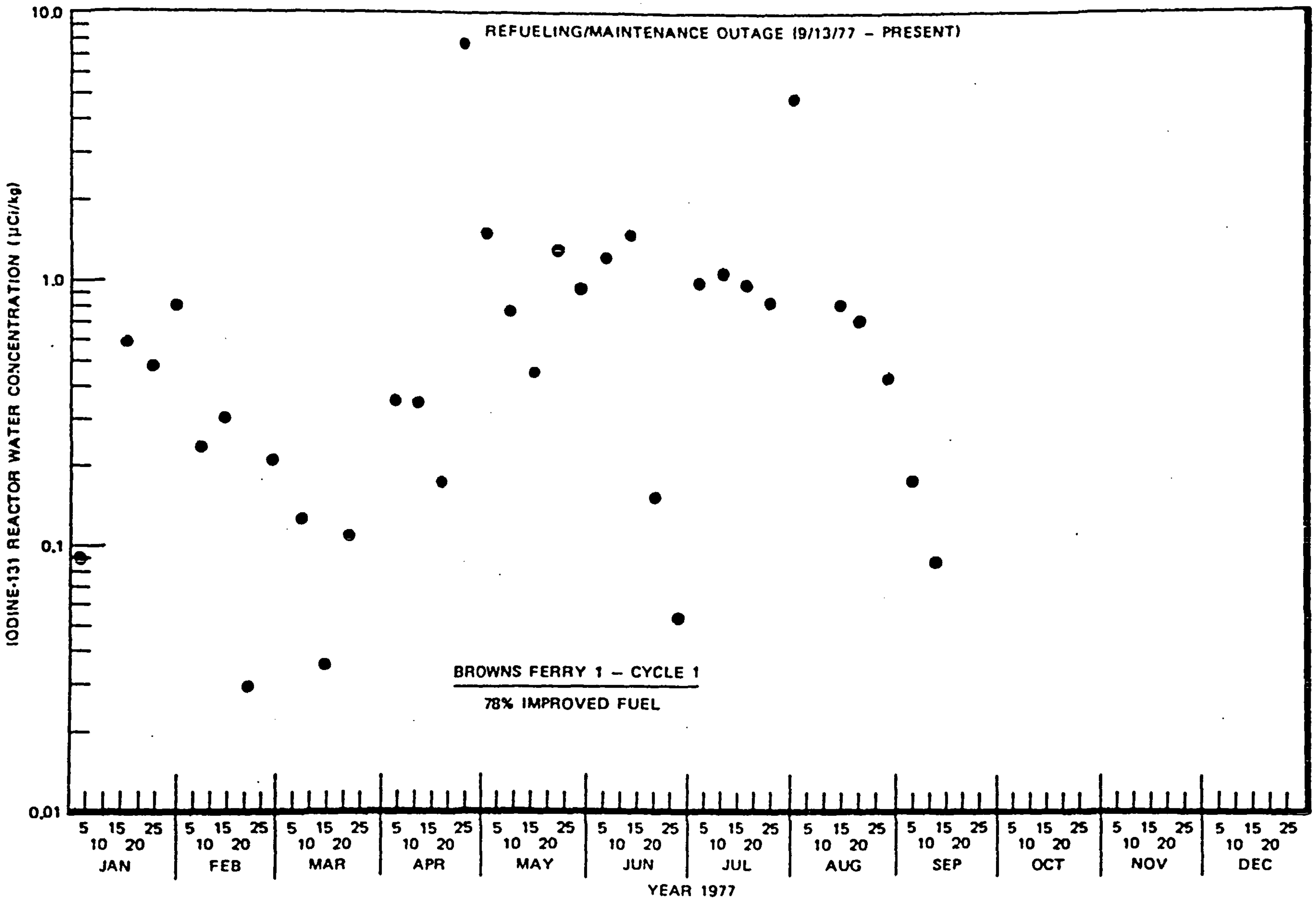


Figure 6-2. Iodine-131 Reactor Water Concentration at Browns Ferry 1, 1977

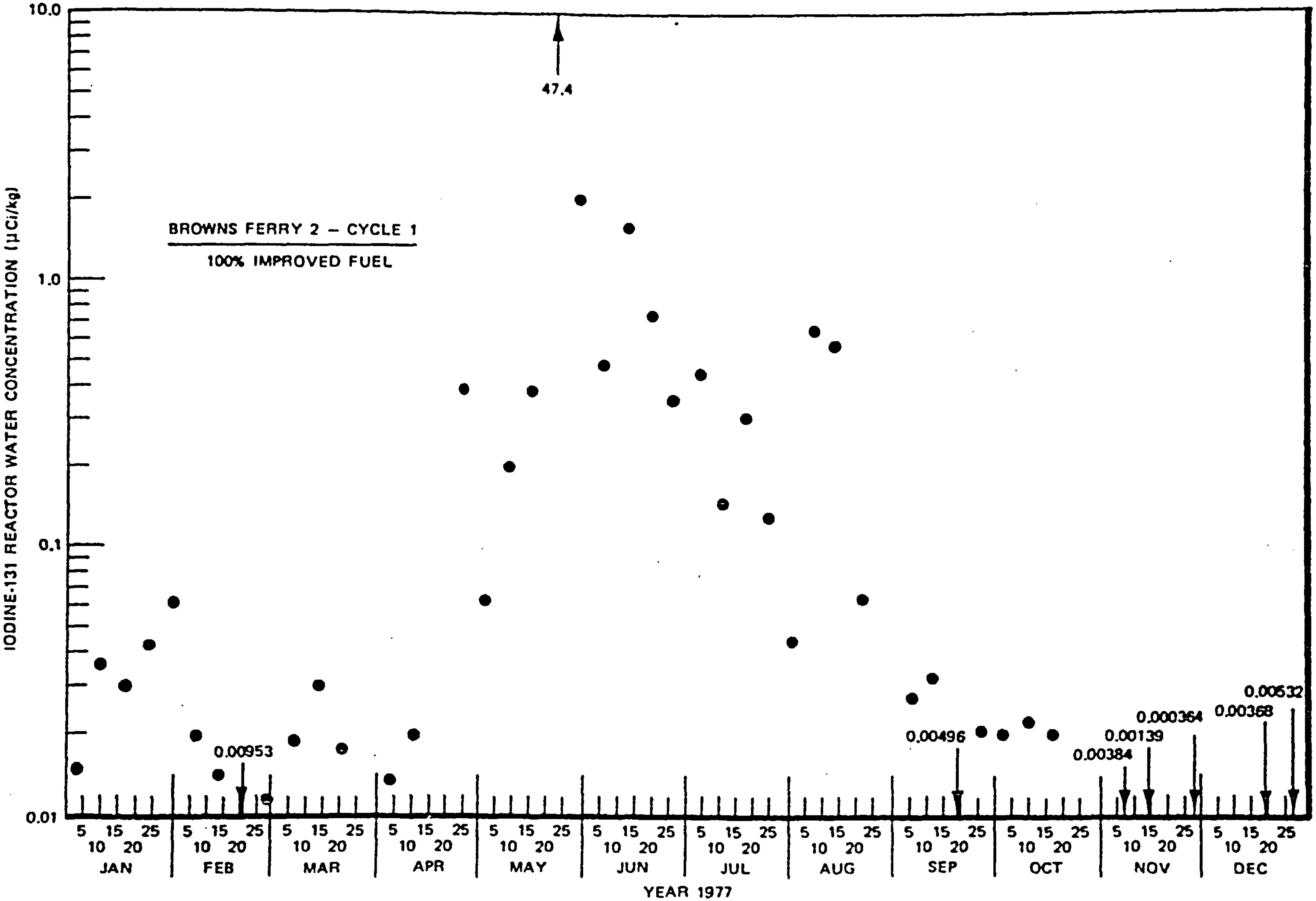


Figure 6-3. Iodine-131 Reactor Water Concentration at Browns Ferry 2, 1977

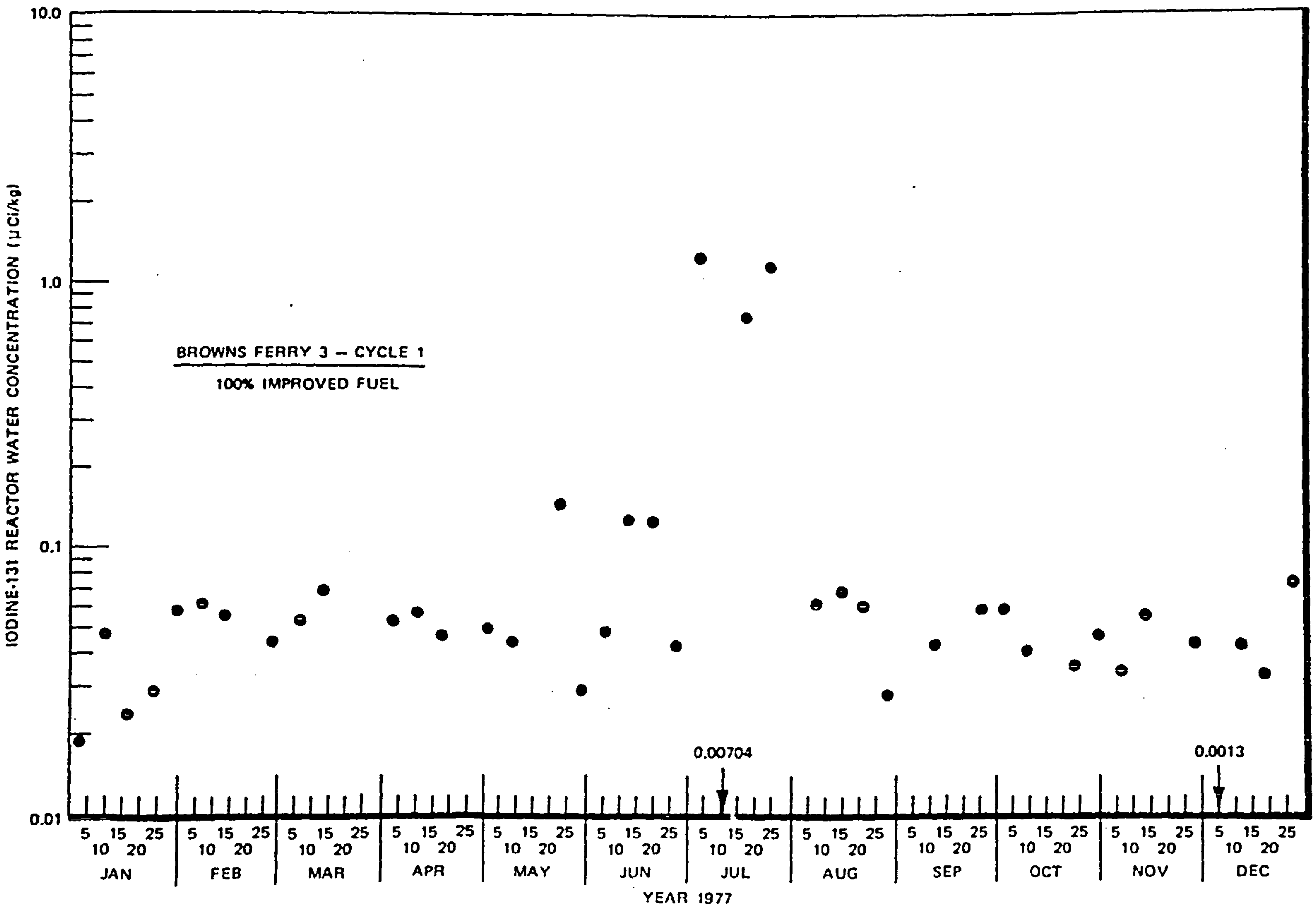


Figure 6-4. Iodine-131 Reactor Water Concentration at Browns Ferry 3, 1977

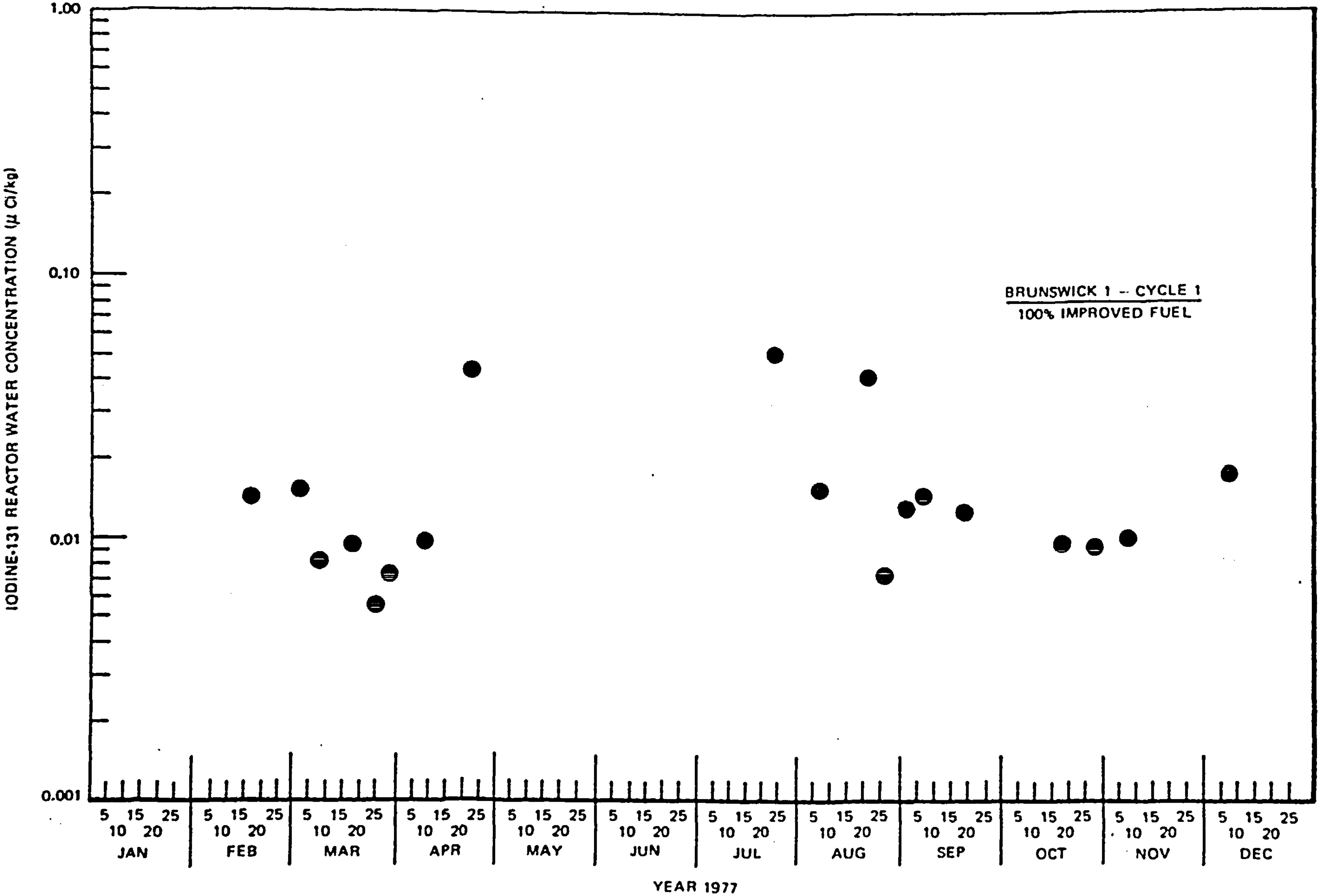


Figure 6-5. Iodine-131 Reactor Water Concentration at Brunswick 1, 1977

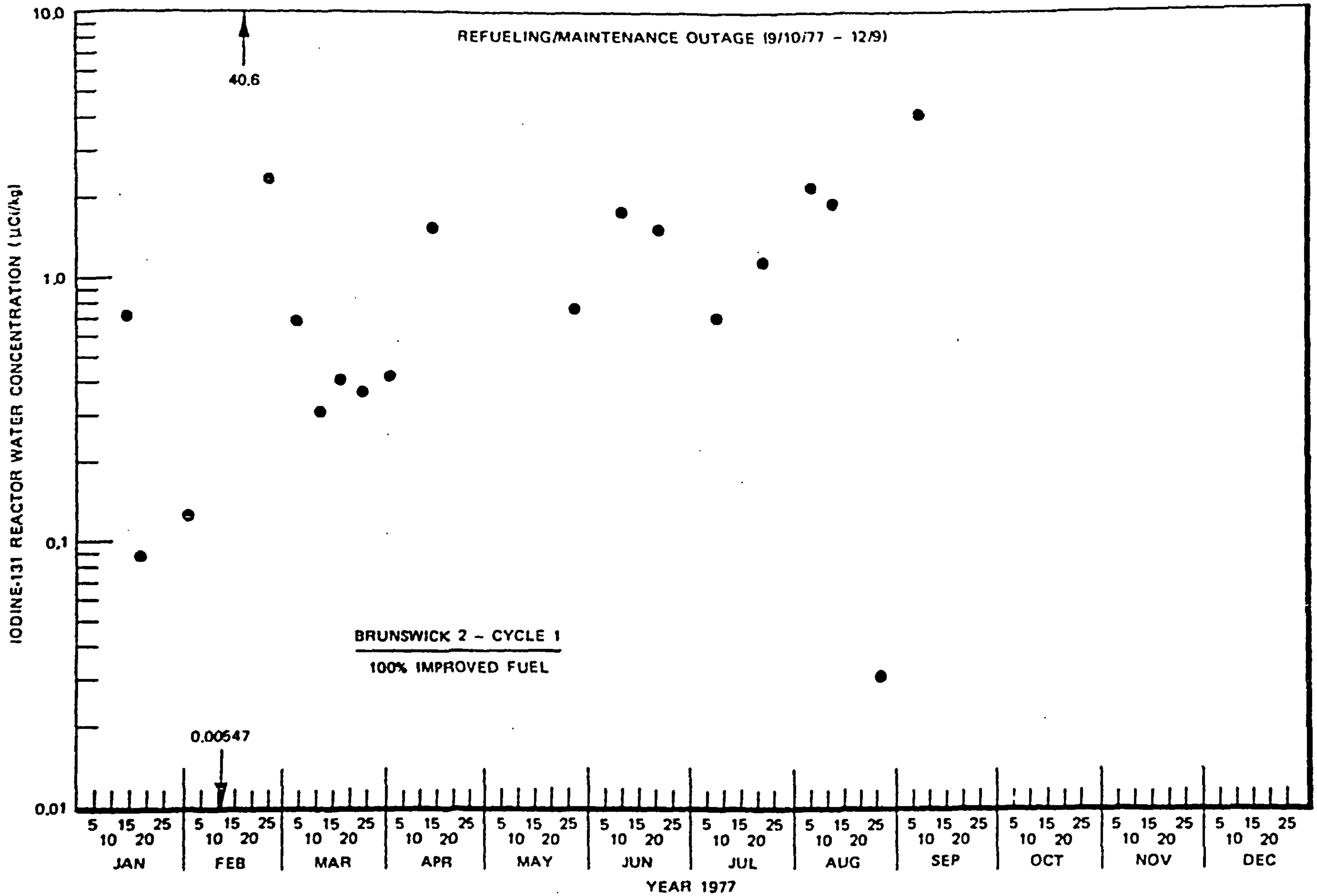


Figure 6-6. Iodine-131 Reactor Water Concentration at Brunswick 2, 1977

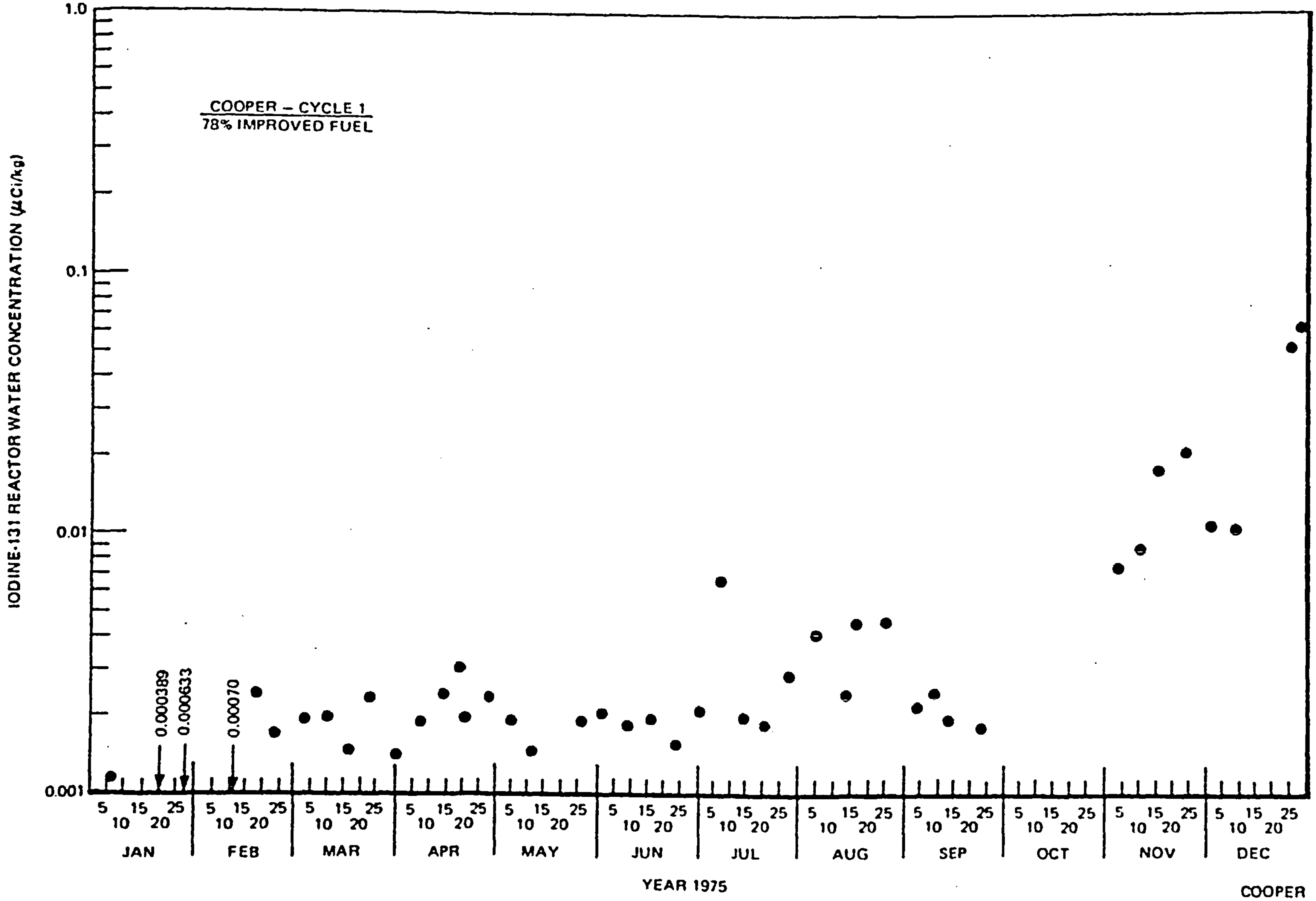


Figure 6-7. Iodine-131 Reactor Water Concentration at Cooper, 1975

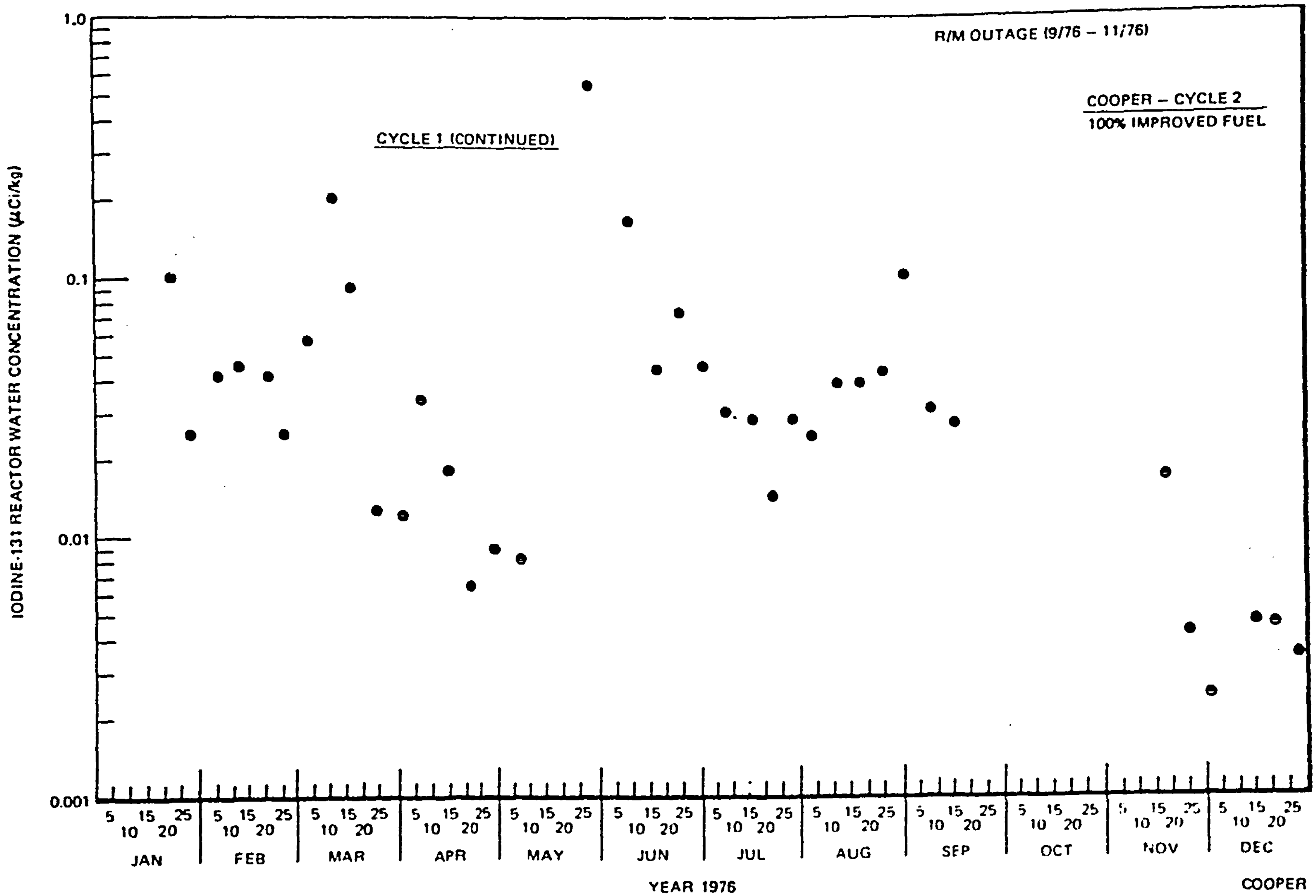


Figure 6-7a. Iodine-131 Reactor Water Concentration at Cooper, 1976

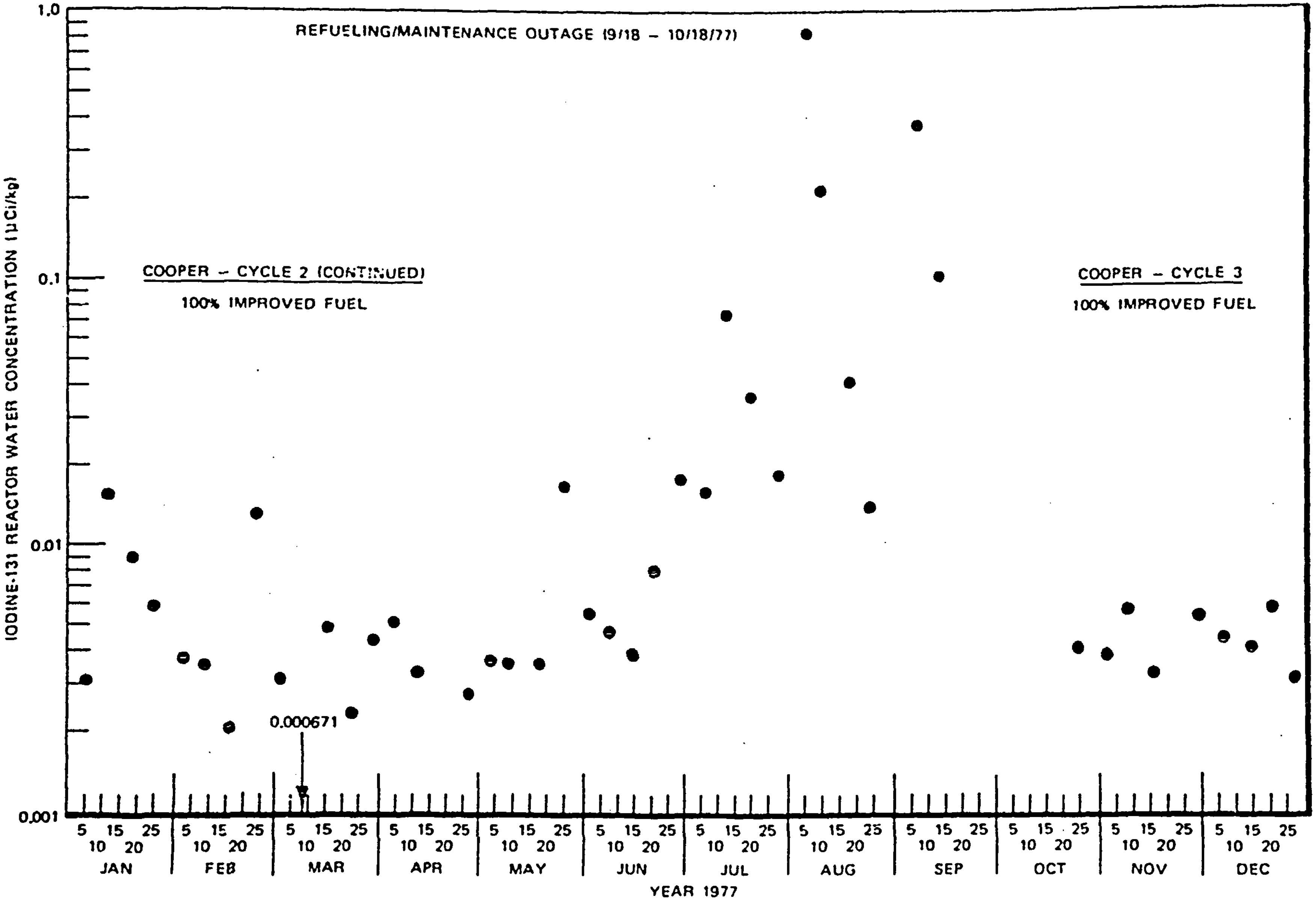


Figure 6-7b. Iodine-131 Reactor Water Concentration at Cooper, 1977

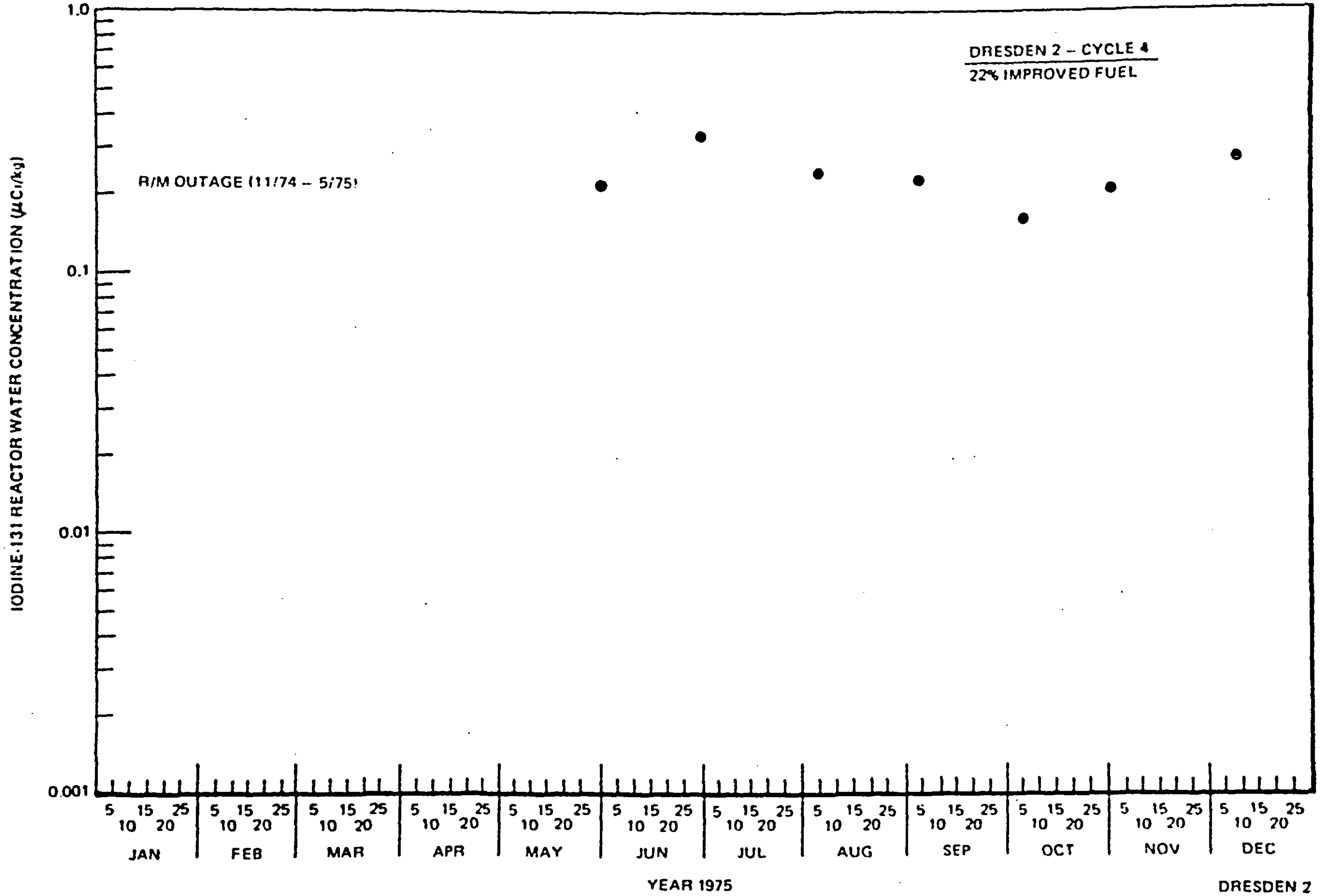


Figure 6-8. Iodine-131 Reactor Water Concentration at Dresden 2, 1975

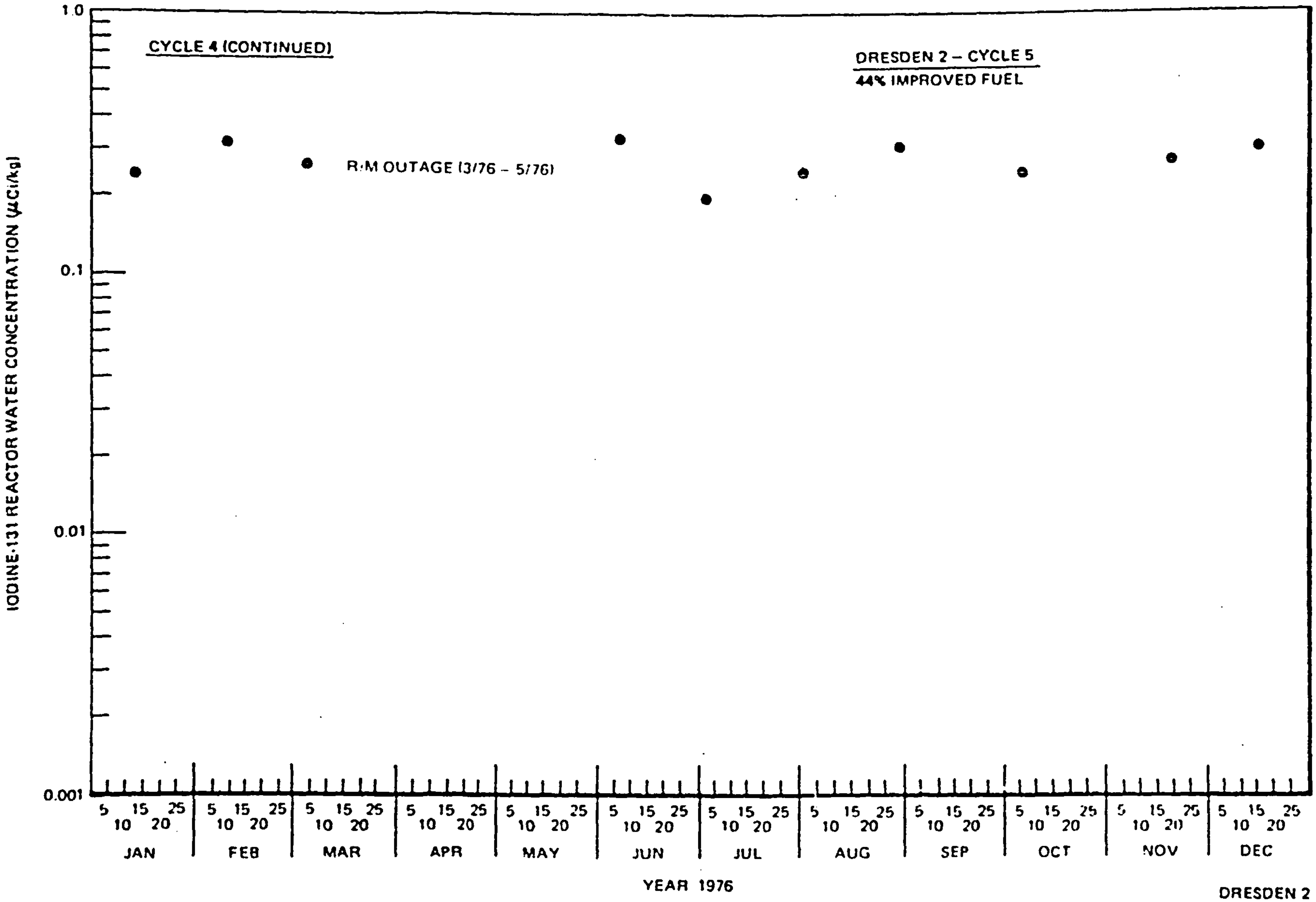


Figure 6-8a. Iodine-131 Reactor Water Concentration at Dresden 2, 1976

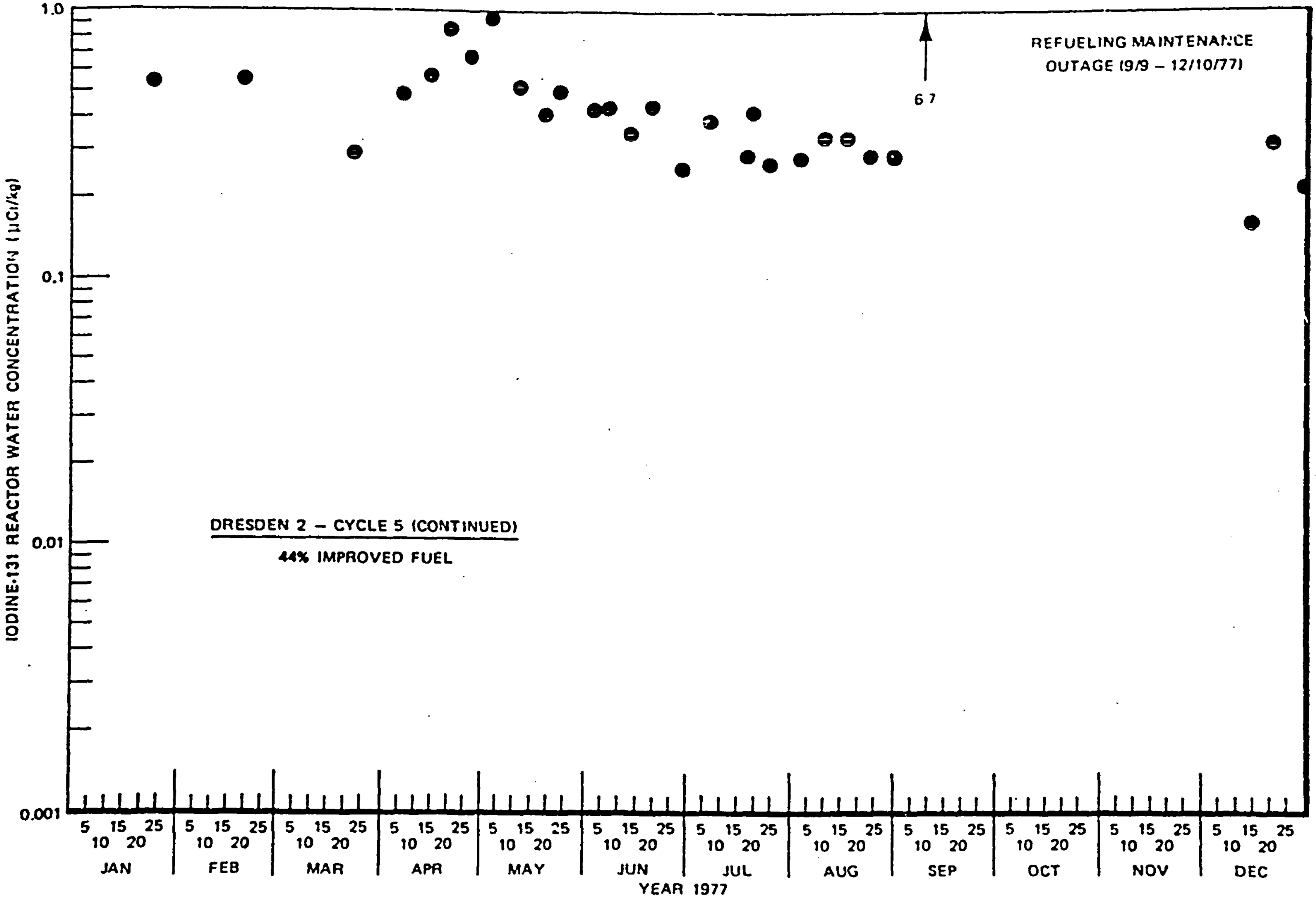


Figure 6-8b. Iodine-131 Reactor Water Concentration at Dresden 2, 1977

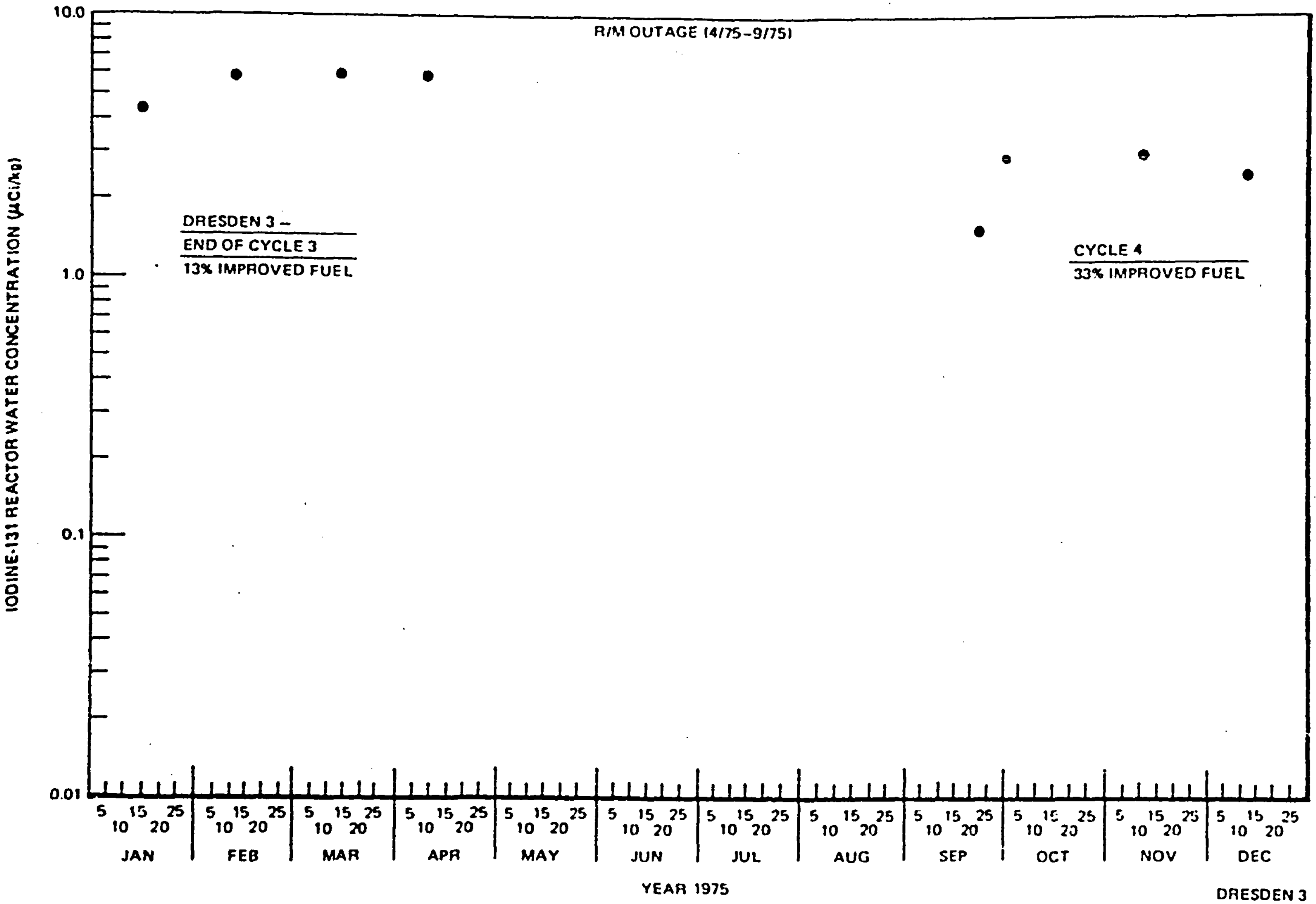


Figure 6-9. Iodine-131 Reactor Water Concentration at Dresden 3, 1975

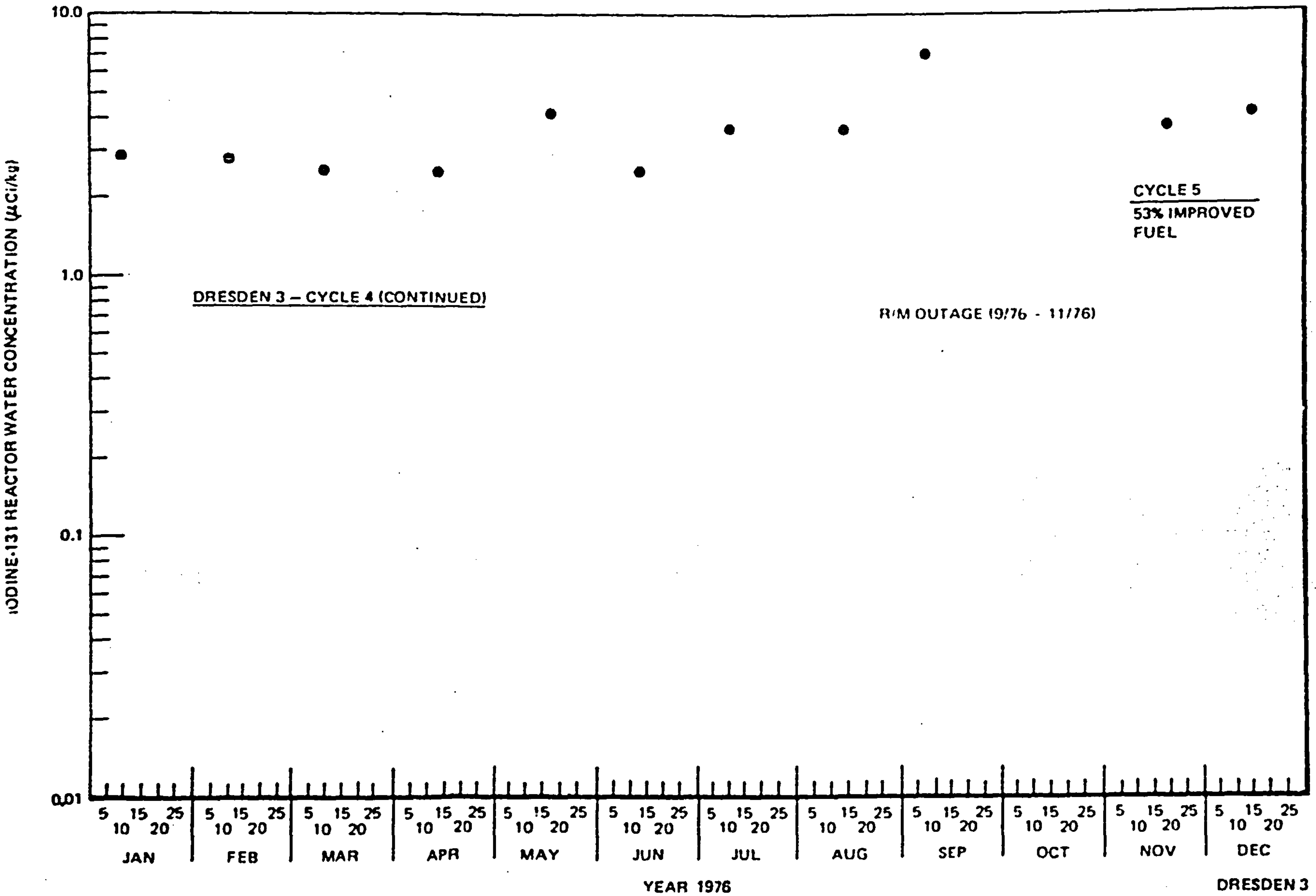


Figure 6-9a. Iodine-131 Reactor Water Concentration at Dresden 3, 1976

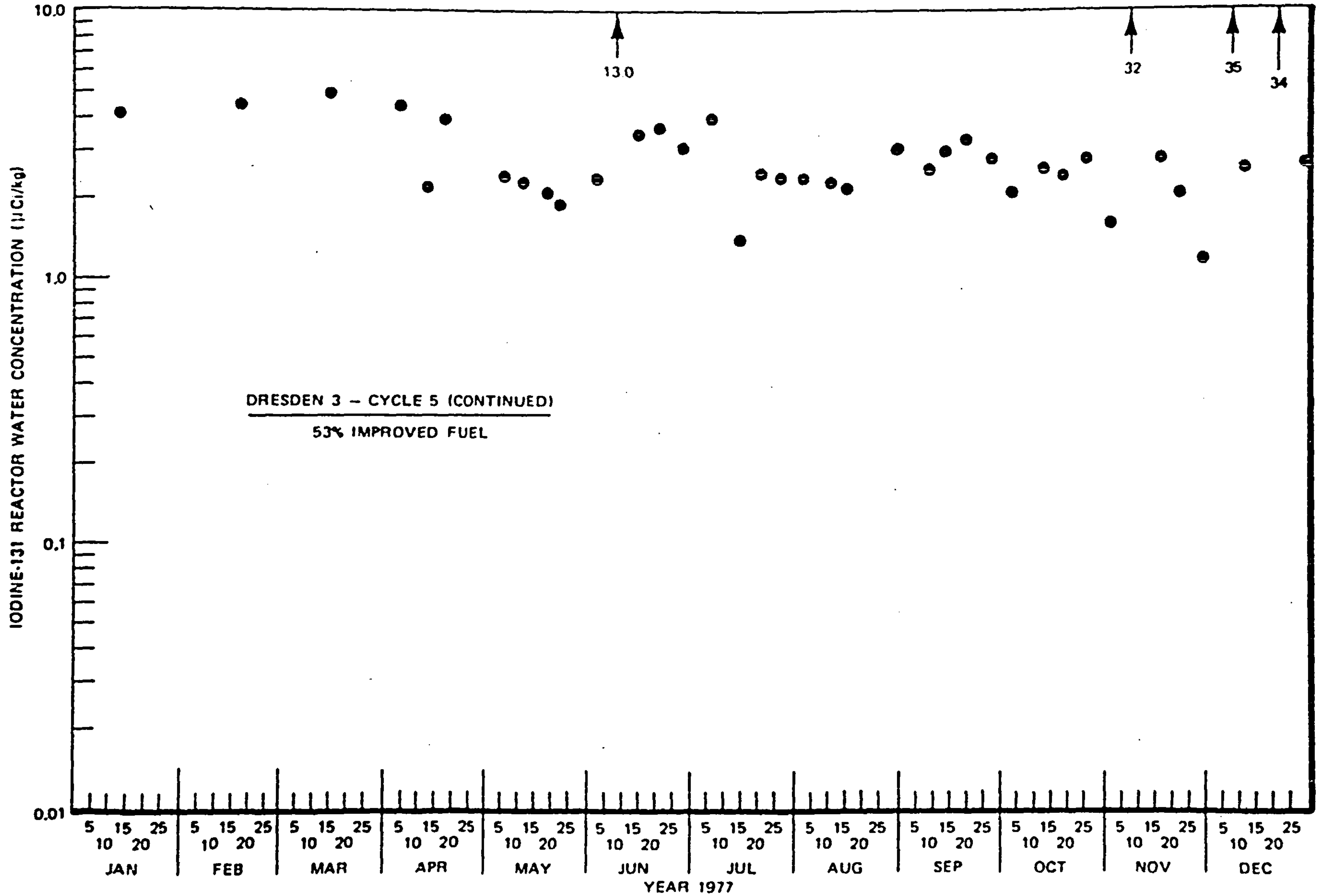


Figure 6-9b. Iodine-131 Reactor Water Concentration at Dresden 3, 1977

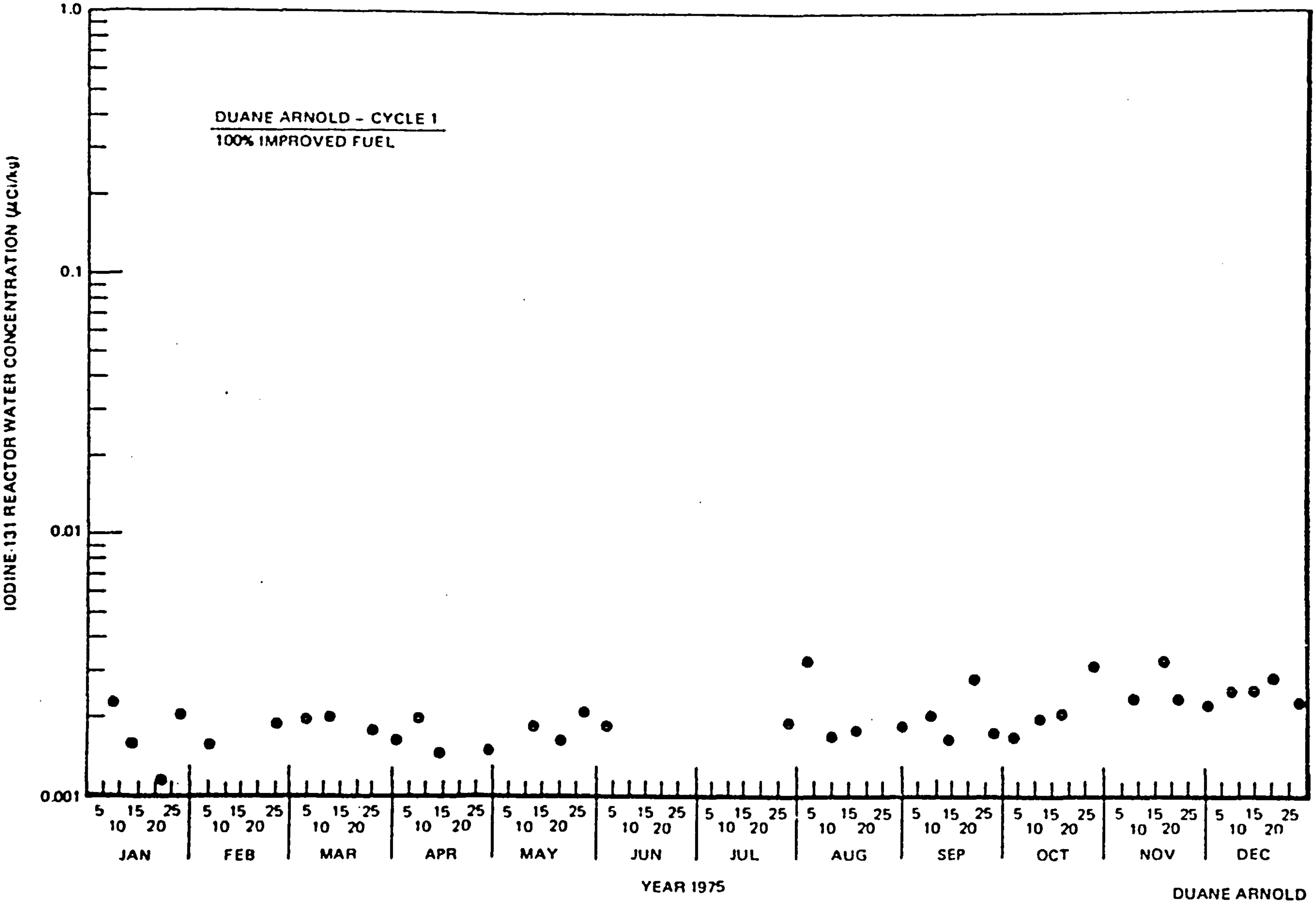


Figure 6-10. Iodine-131 Reactor Water Concentration at Duane Arnold, 1975

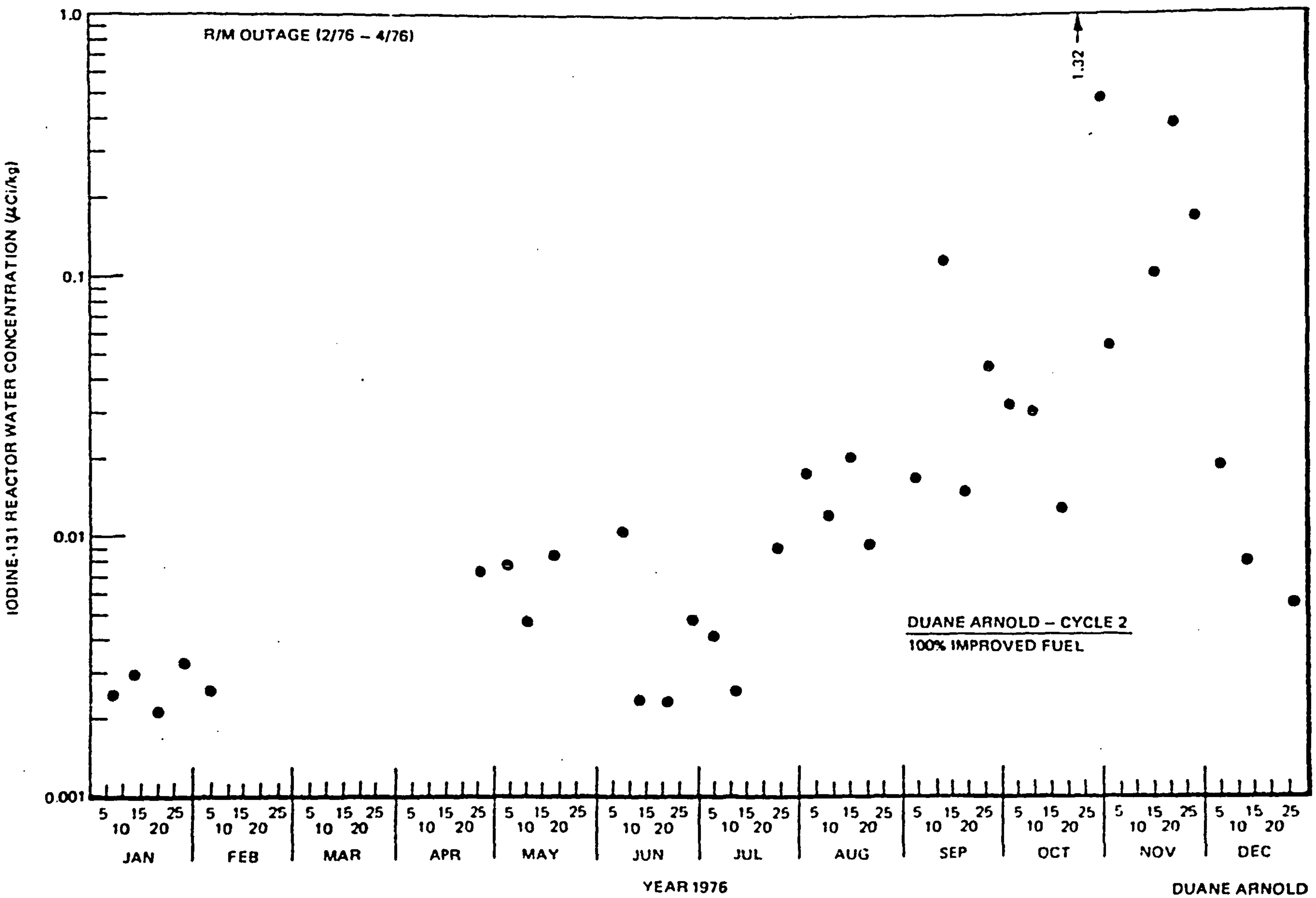


Figure 6-10a. Iodine-131 Reactor Water Concentration at Duane Arnold, 1976

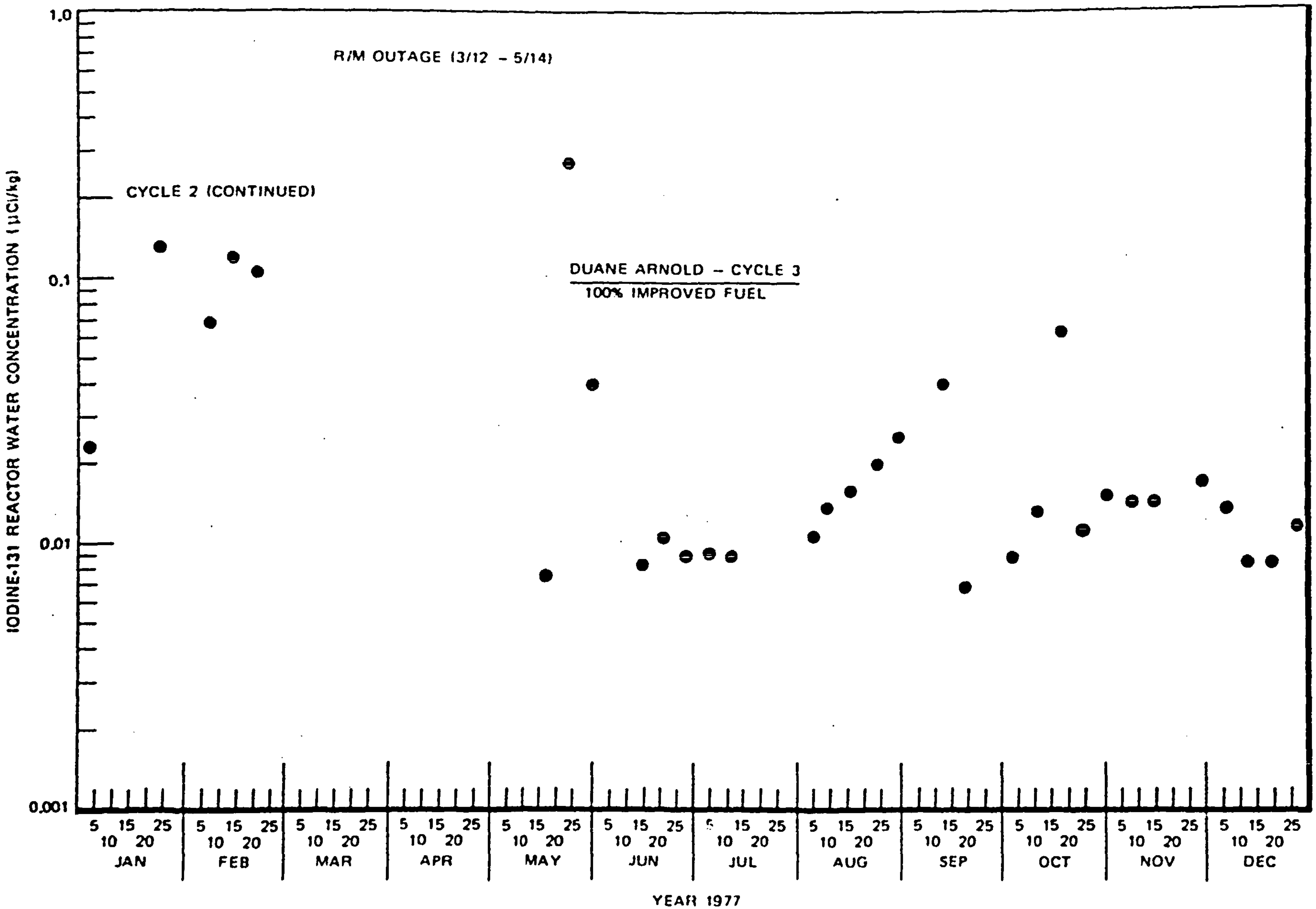


Figure 6-10b. Iodine-131 Reactor Water Concentration at Duane Arnold, 1977

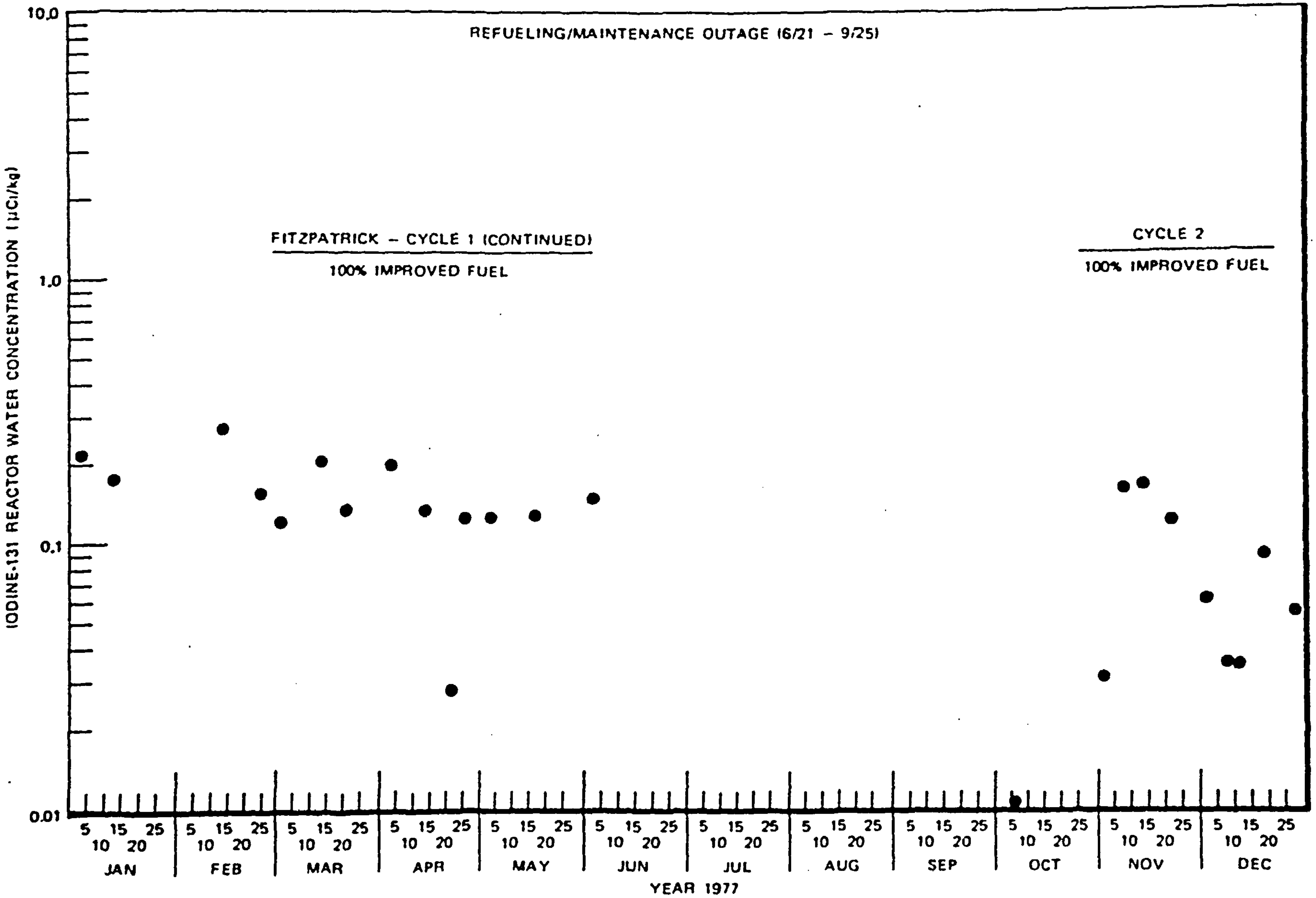


Figure 6-11. Iodine-131 Reactor Water Concentration at Fitzpatrick, 1977

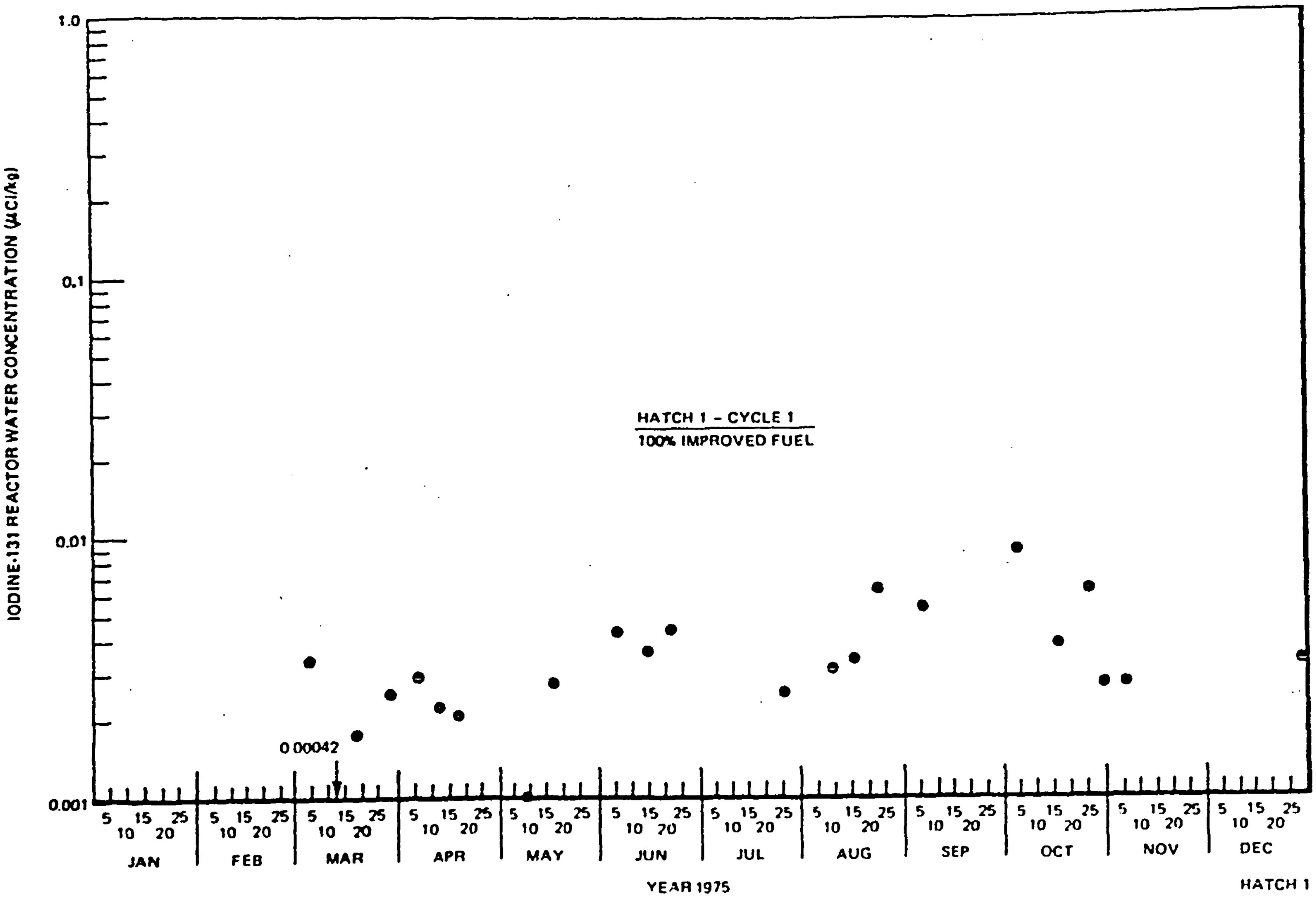


Figure 6-12. Iodine-131 Reactor Water Concentration at Hatch 1, 1975

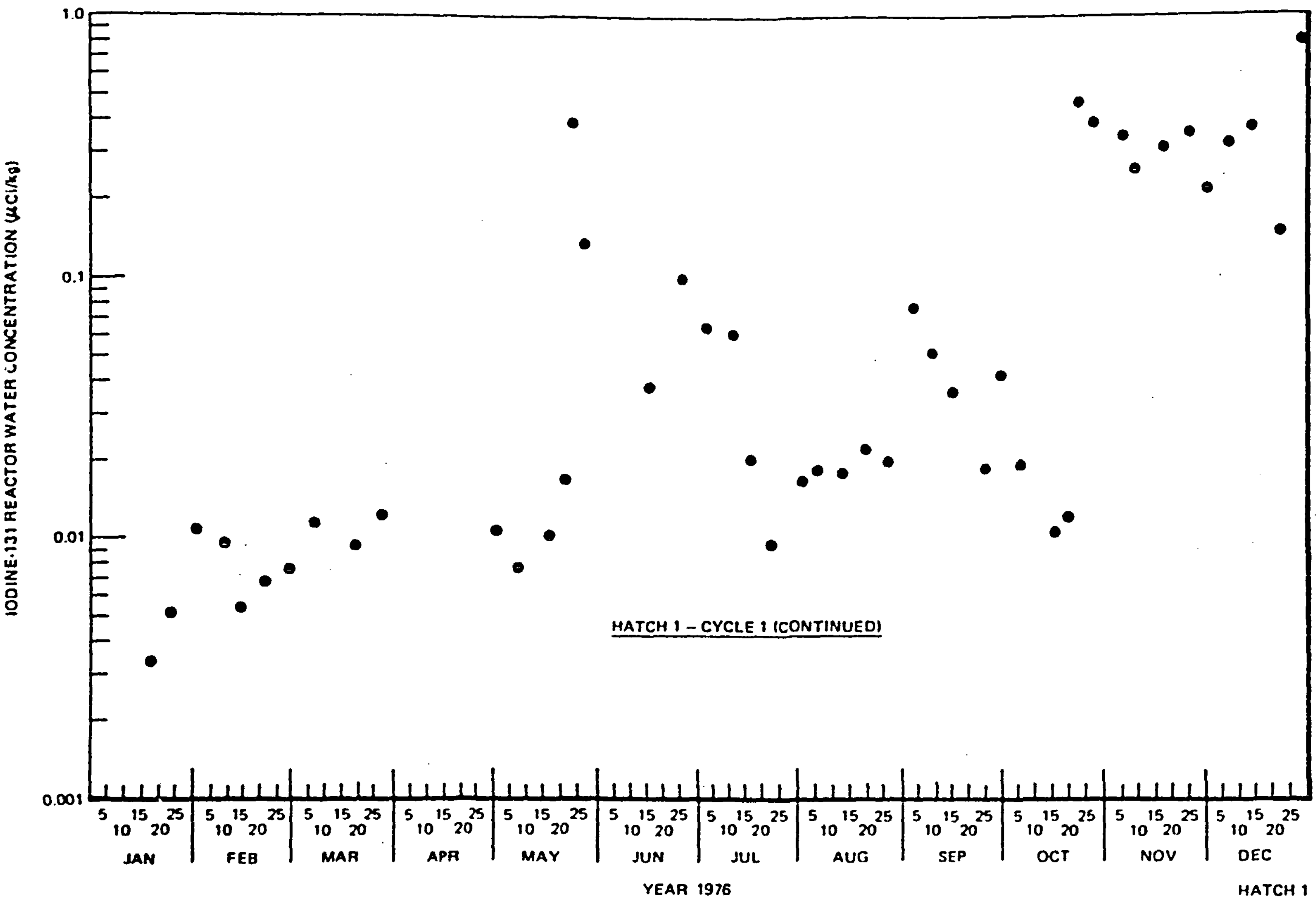


Figure 6-12a. Iodine-131 Reactor Water Concentration at Hatch 1, 1976

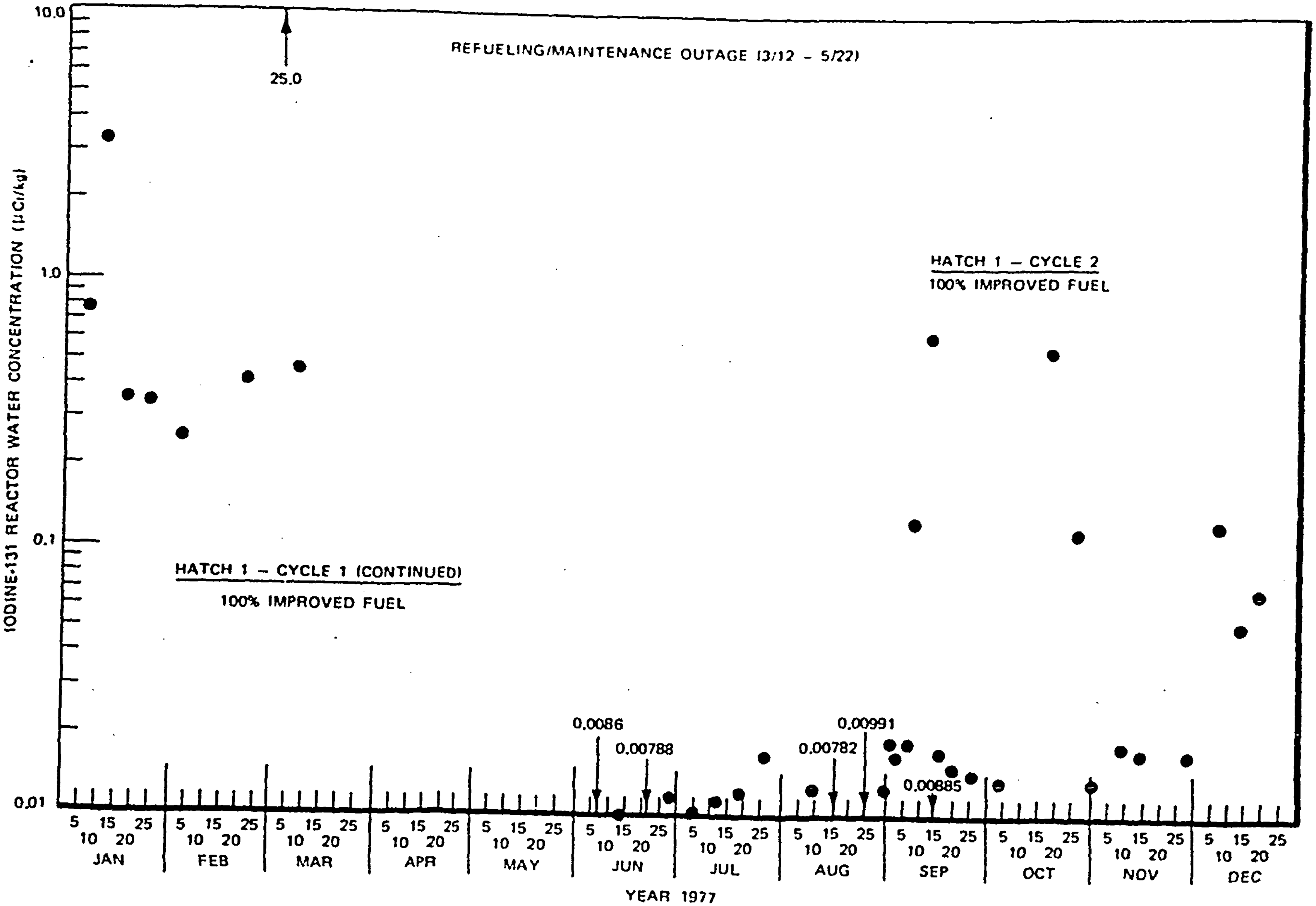


Figure 6-12b. Iodine-131 Reactor Water Concentration at Hatch 1, 1977

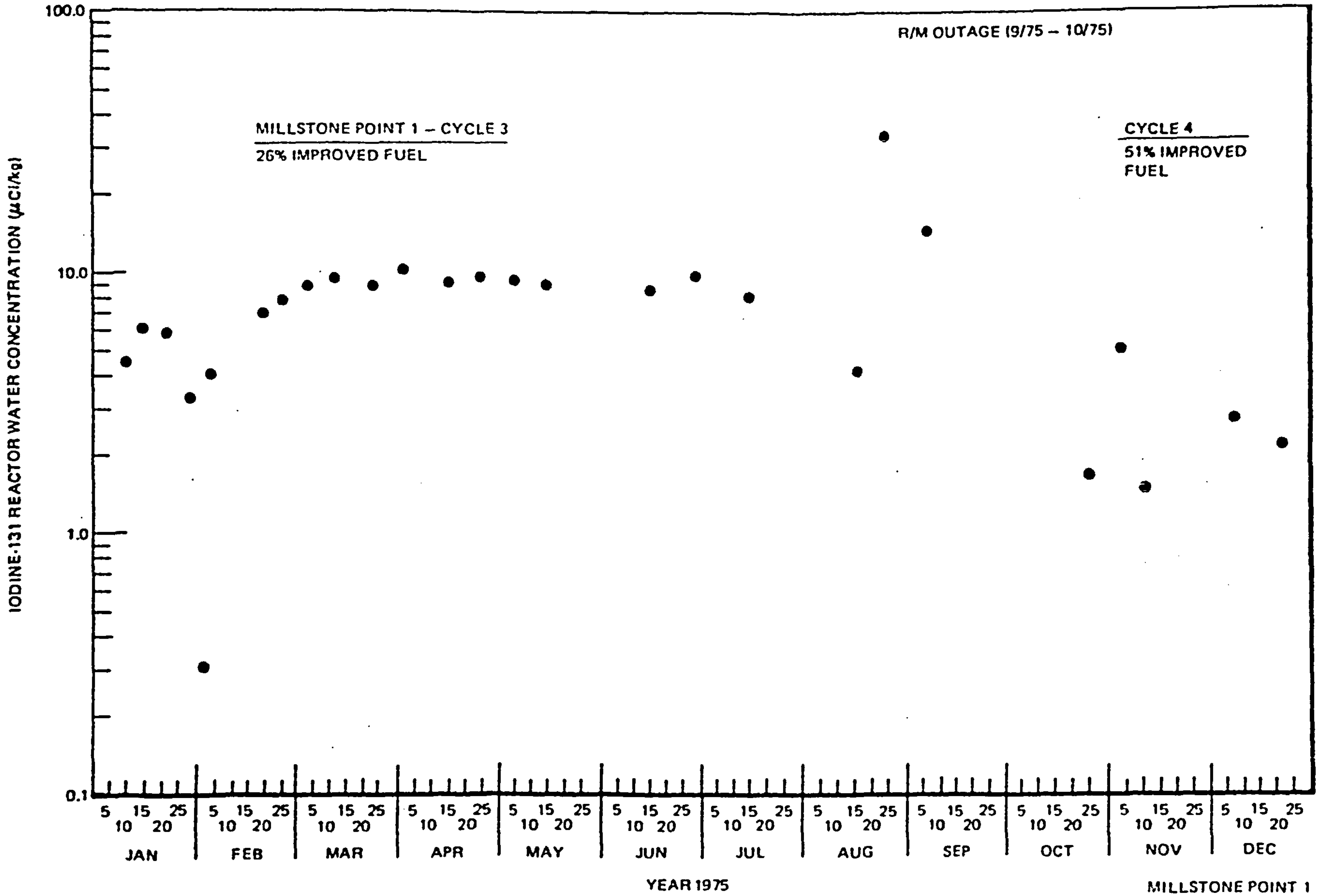


Figure 6-13. Iodine-131 Reactor Water Concentration at Millstone Point 1, 1975

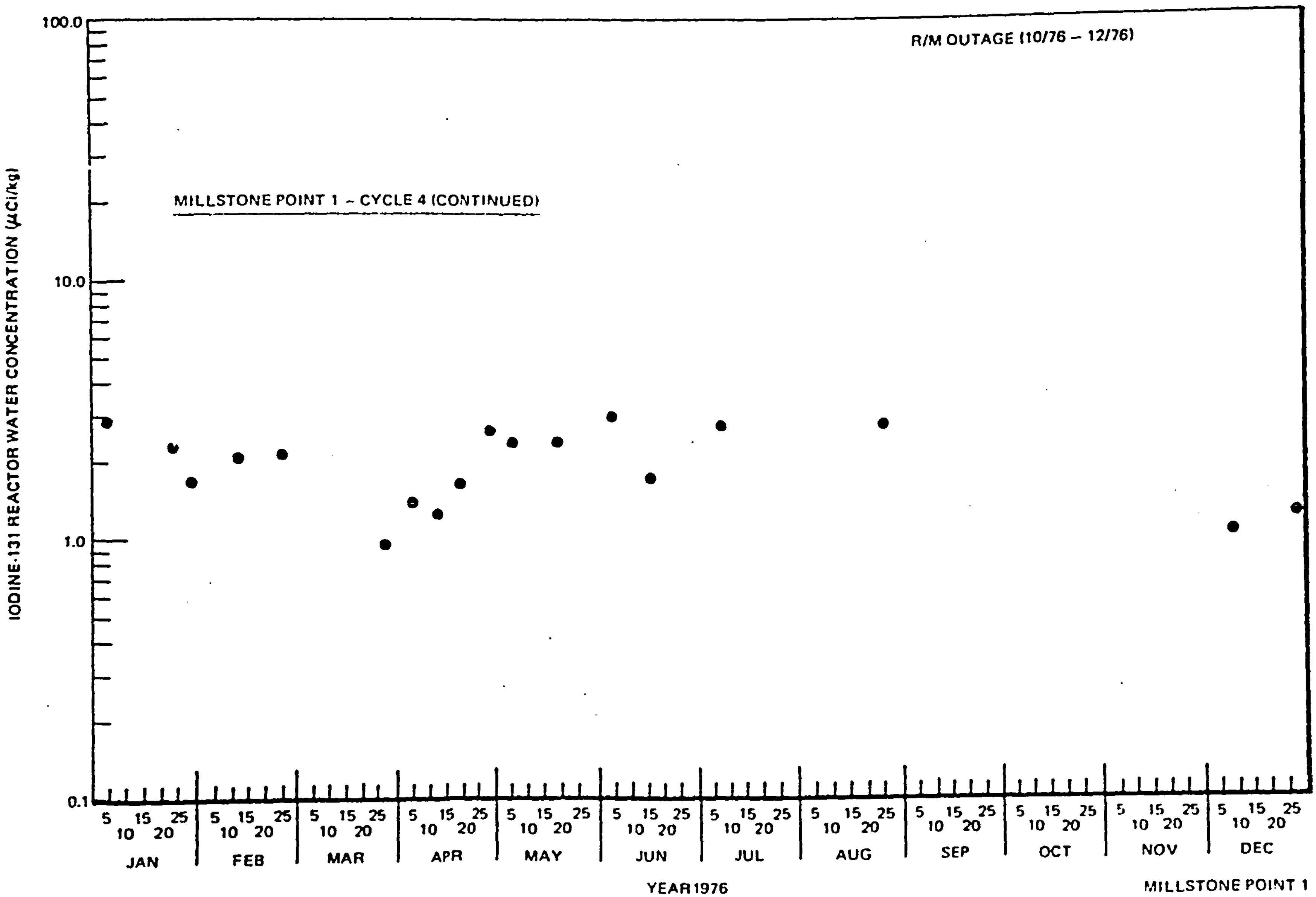


Figure 6-14. Iodine-131 Reactor Water Concentration at Millstone Point 1, 1976

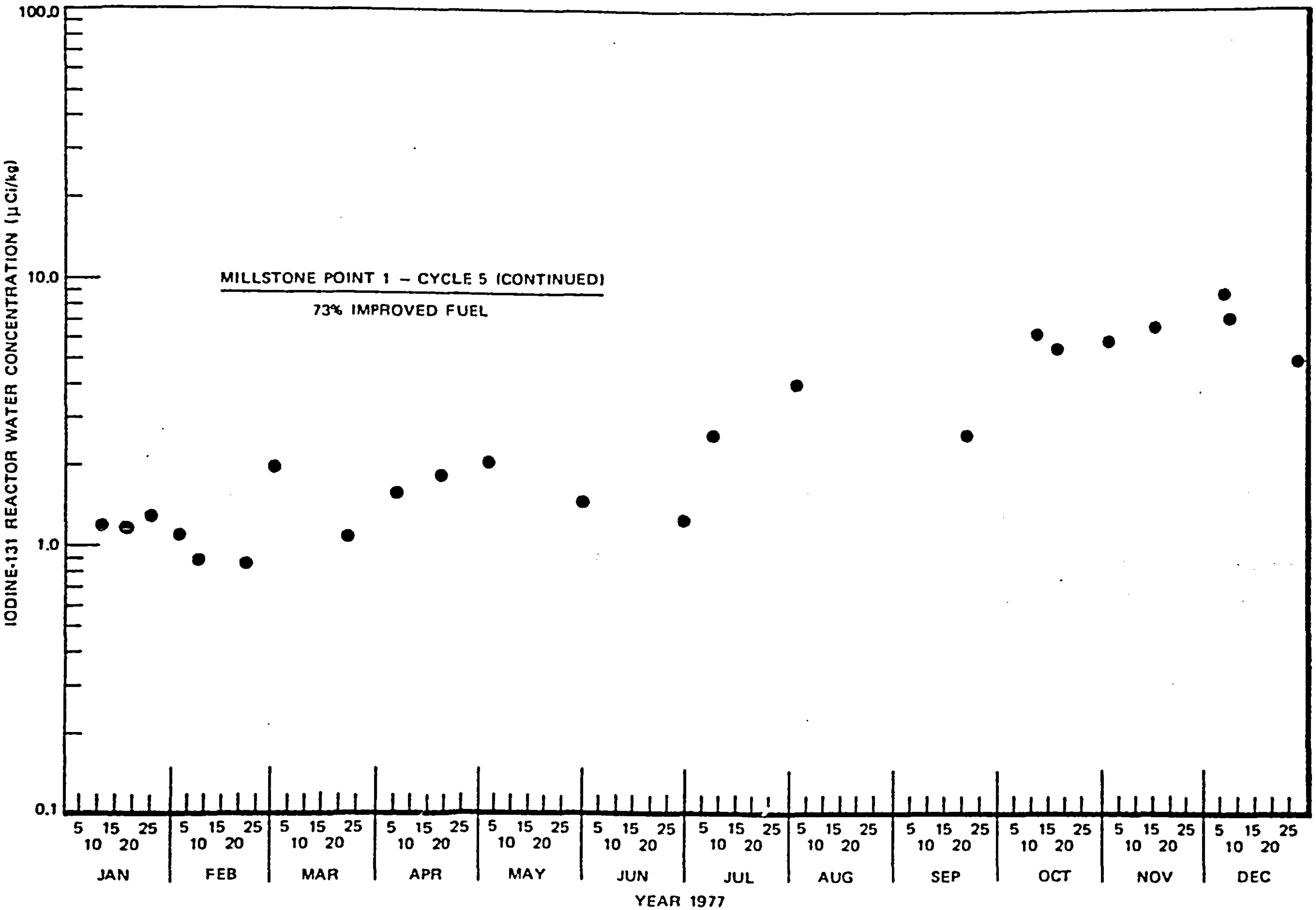


Figure 6-14a. Iodine-131 Reactor Water Concentration at Millstone Point 1, 1977

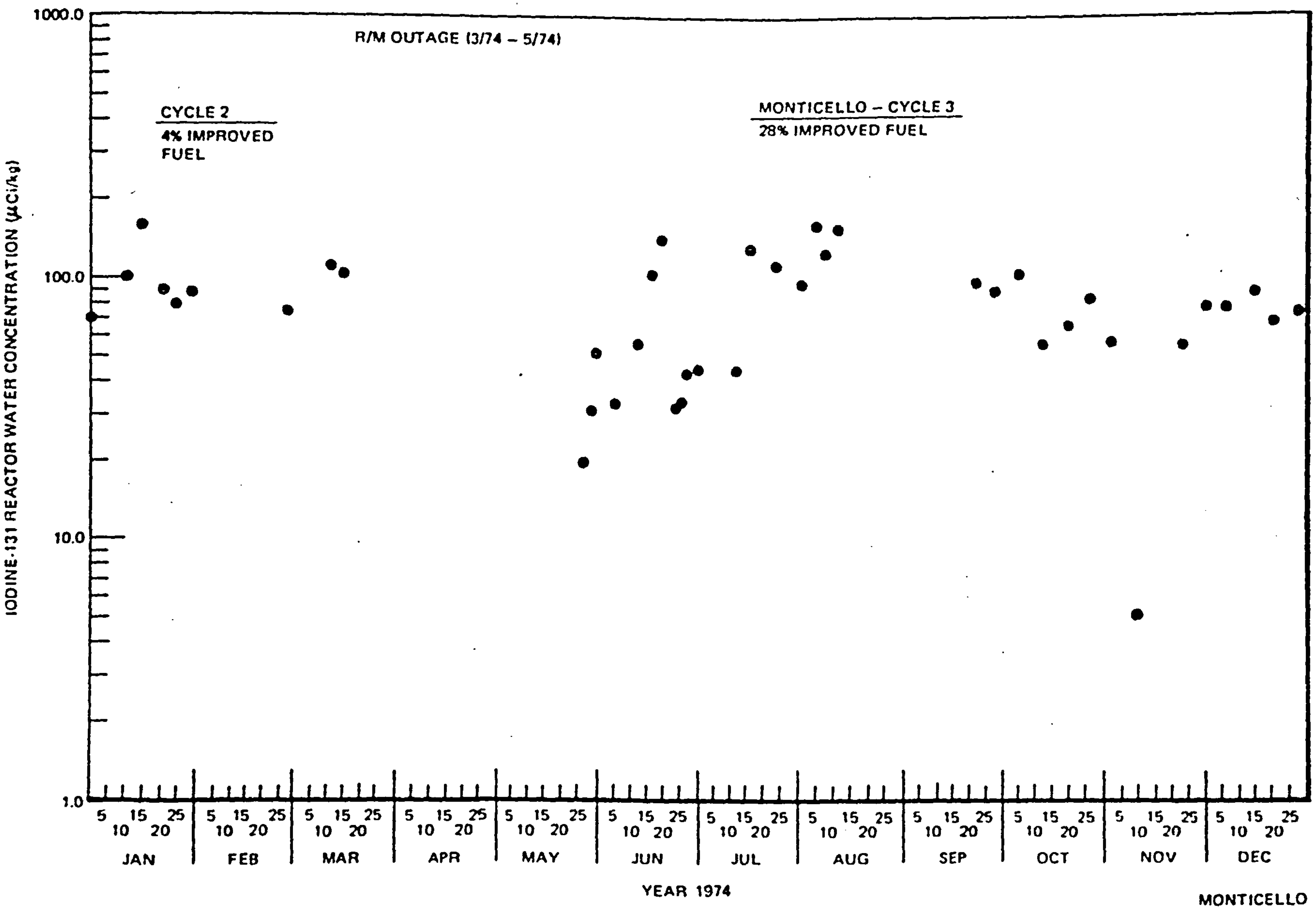


Figure 6-15. Iodine-131 Reactor Water Concentration at Monticello, 1974

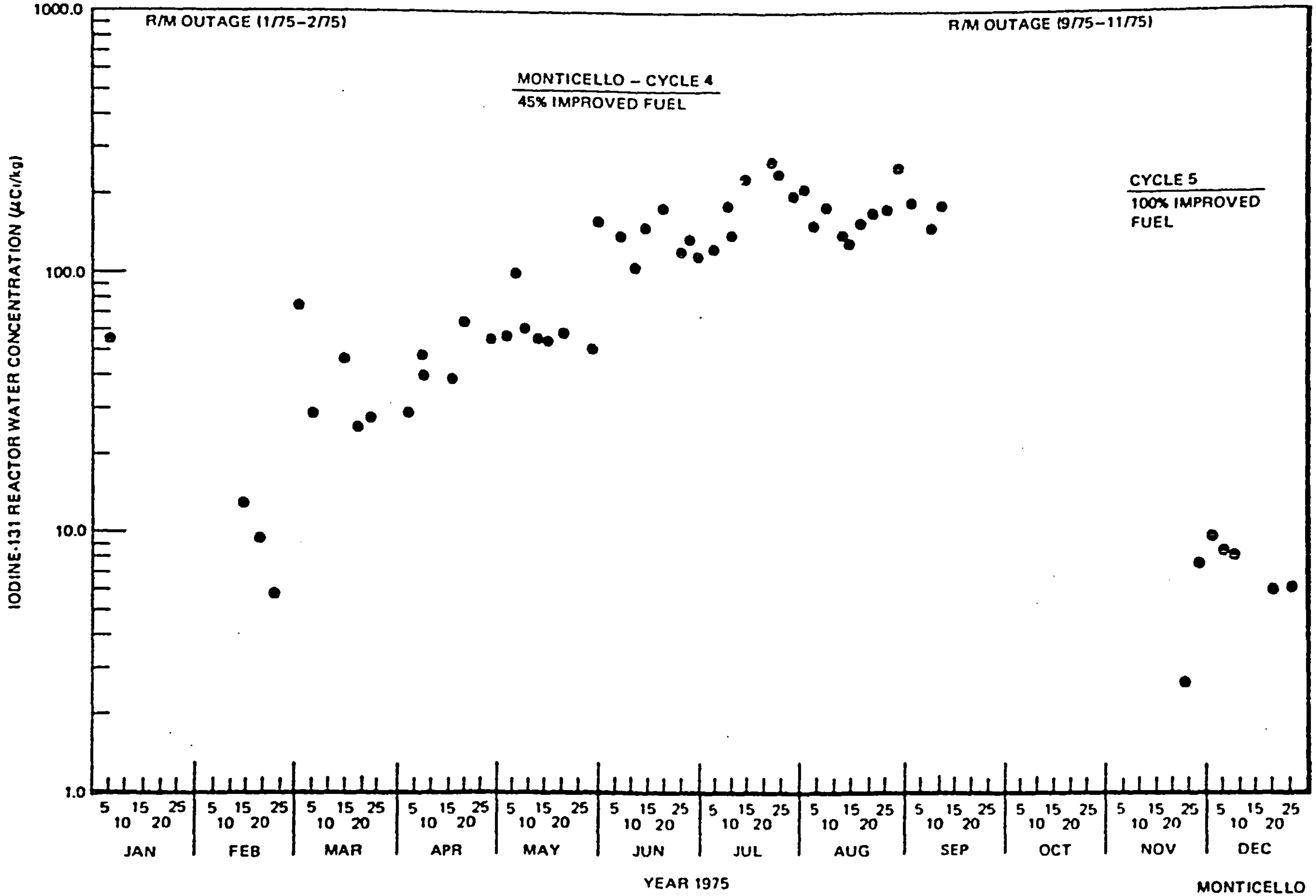


Figure 6-16. Iodine-131 Reactor Water Concentration at Monticello, 1975

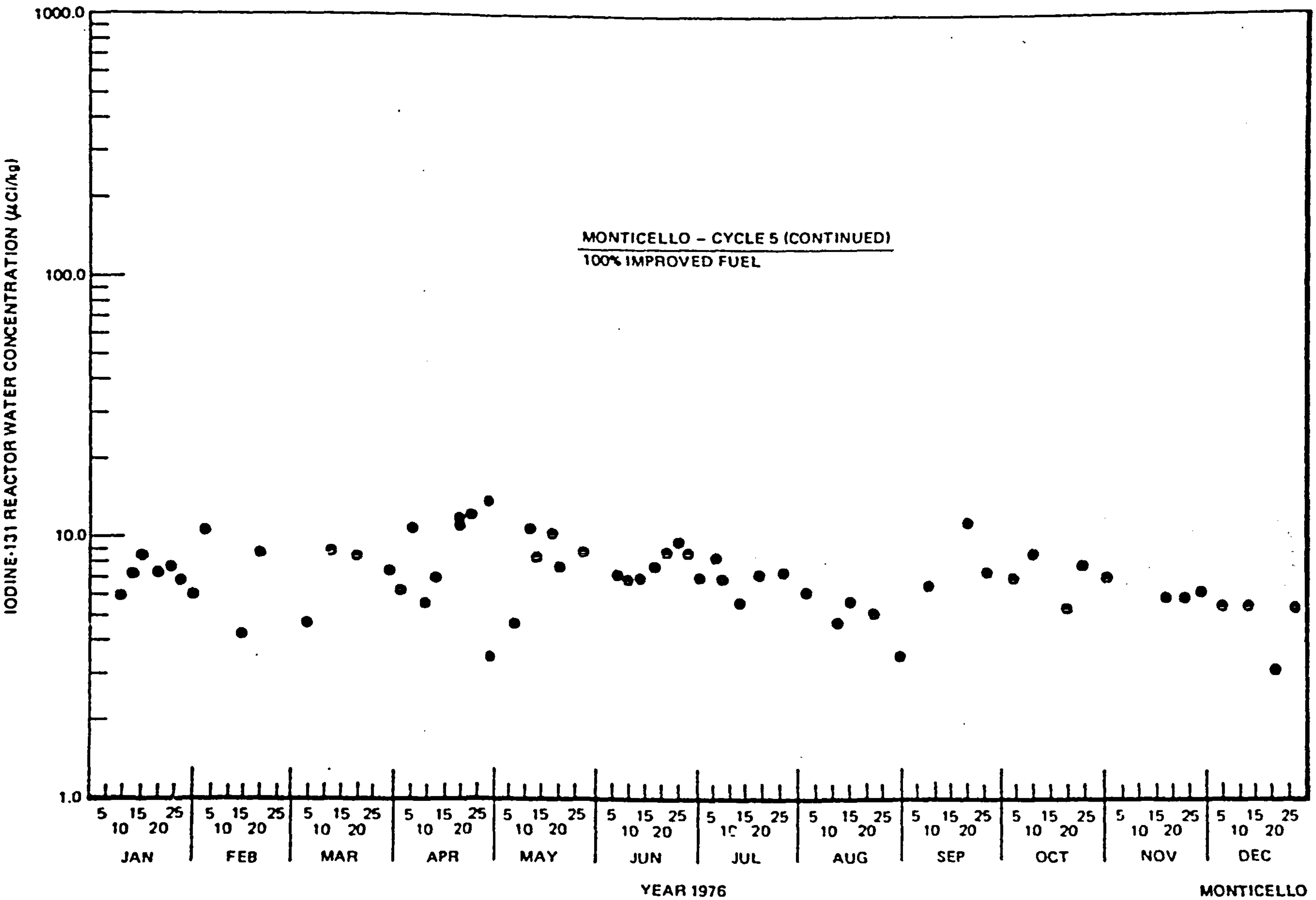


Figure 6-17. Iodine-131 Reactor Water Concentration at Monticello, 1976

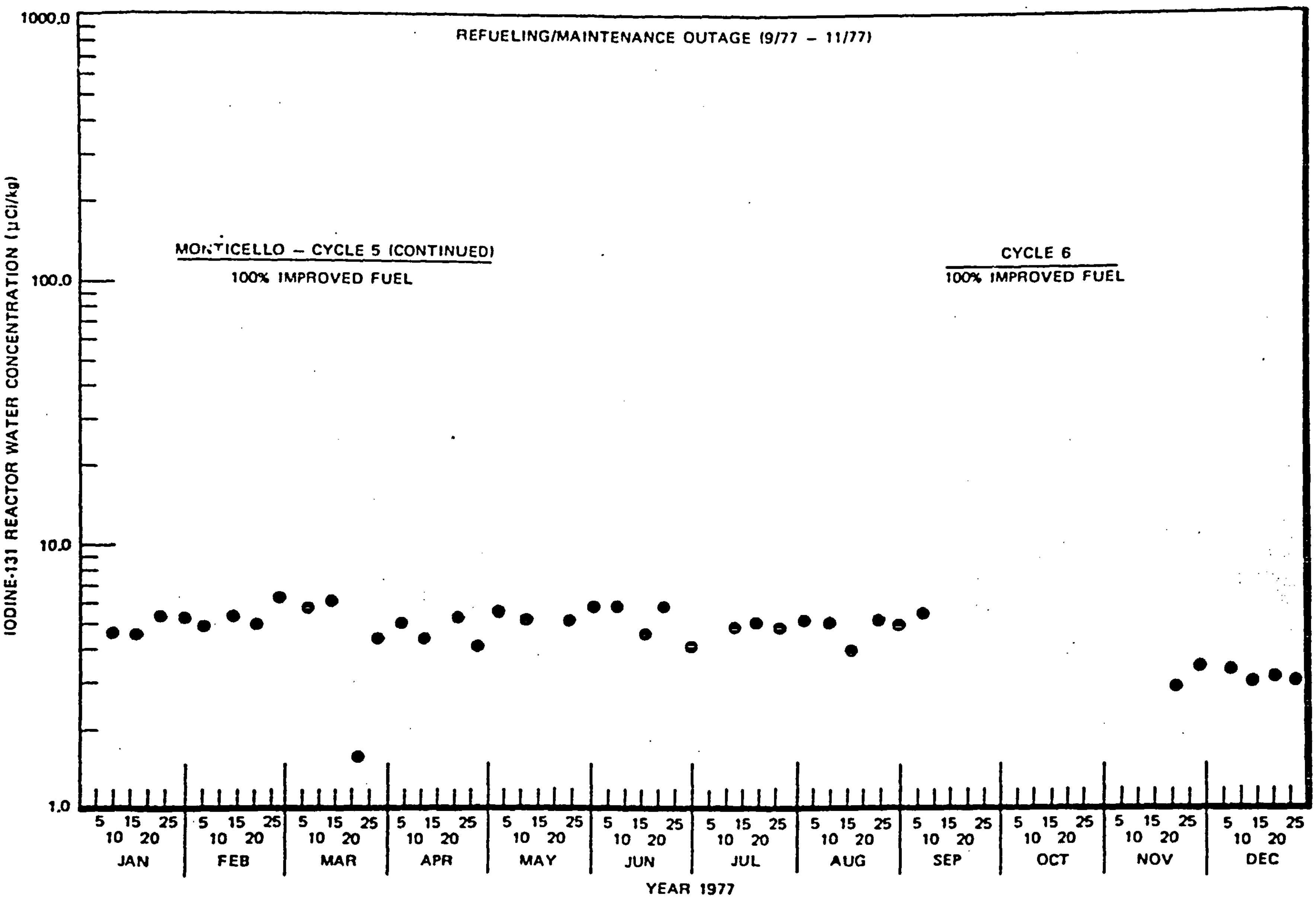


Figure 6-17a. Iodine-131 Reactor Water Concentration at Monticello, 1977

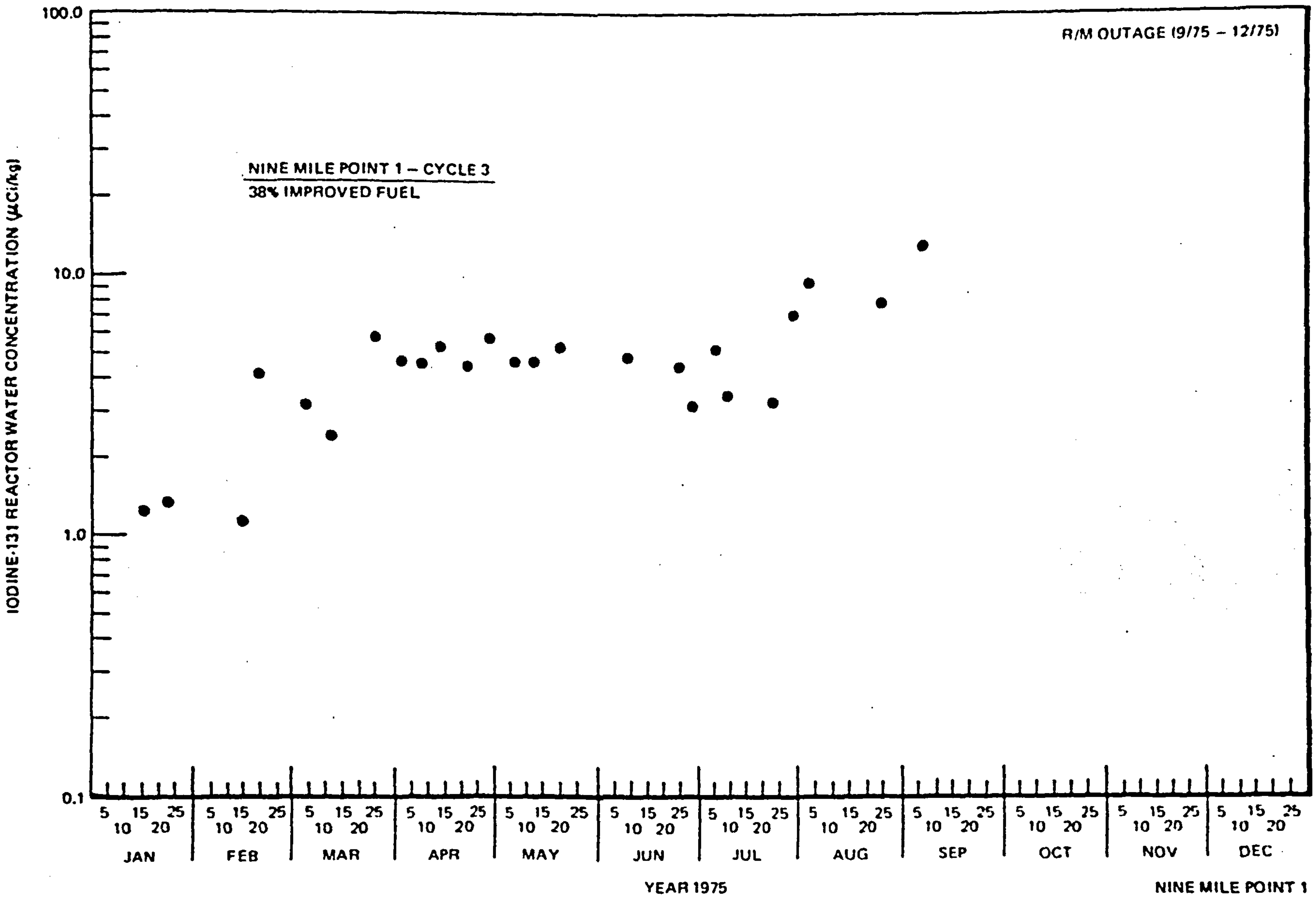


Figure 6-18. Iodine-131 Reactor Water Concentration at Nine Mile Point 1, 1975

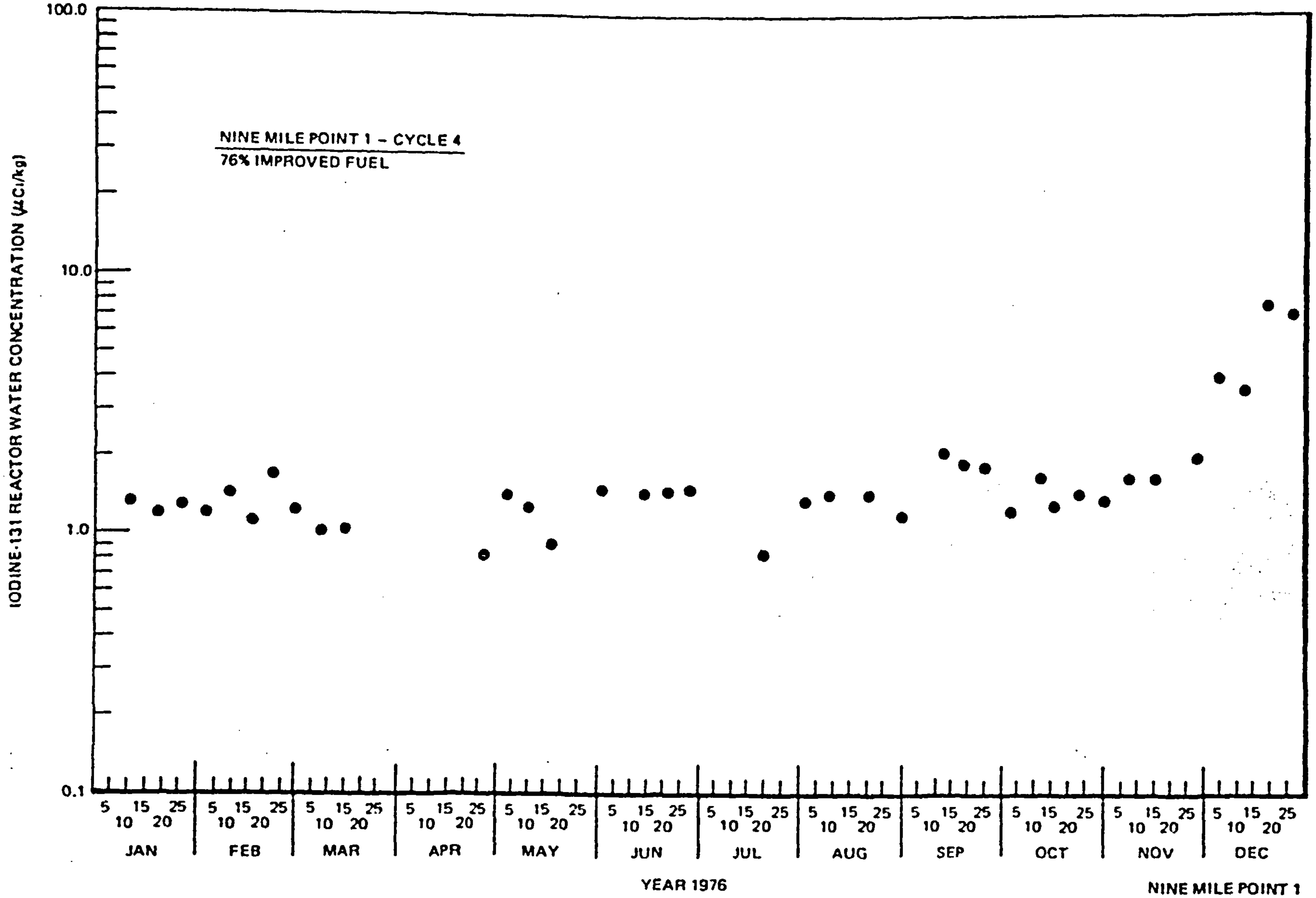


Figure 6-19. Iodine-131 Reactor Water Concentration at Nine Mile Point 1, 1976

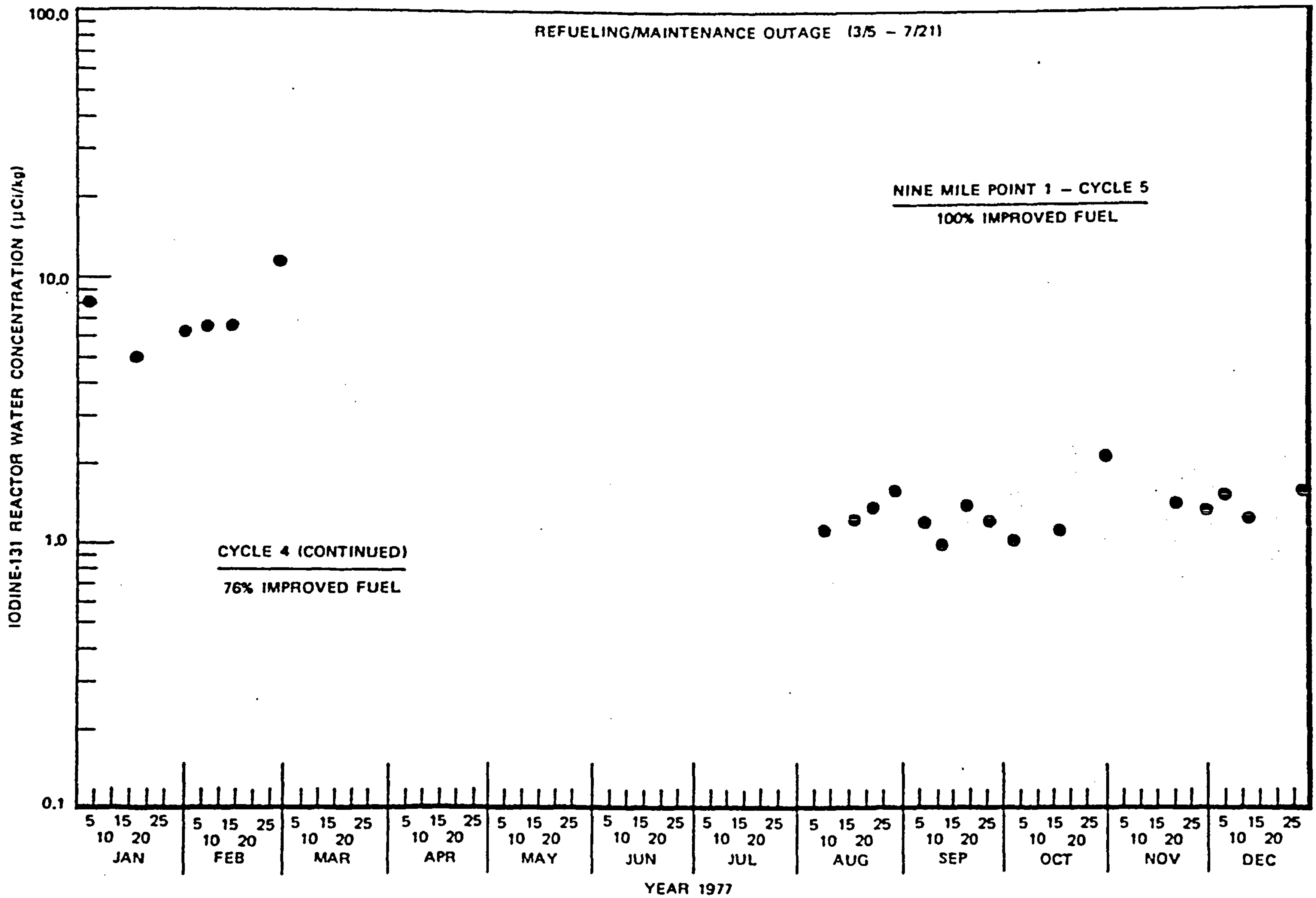


Figure 6-19a. Iodine-131 Reactor Water Concentration at Nine Mile Point 1, 1977

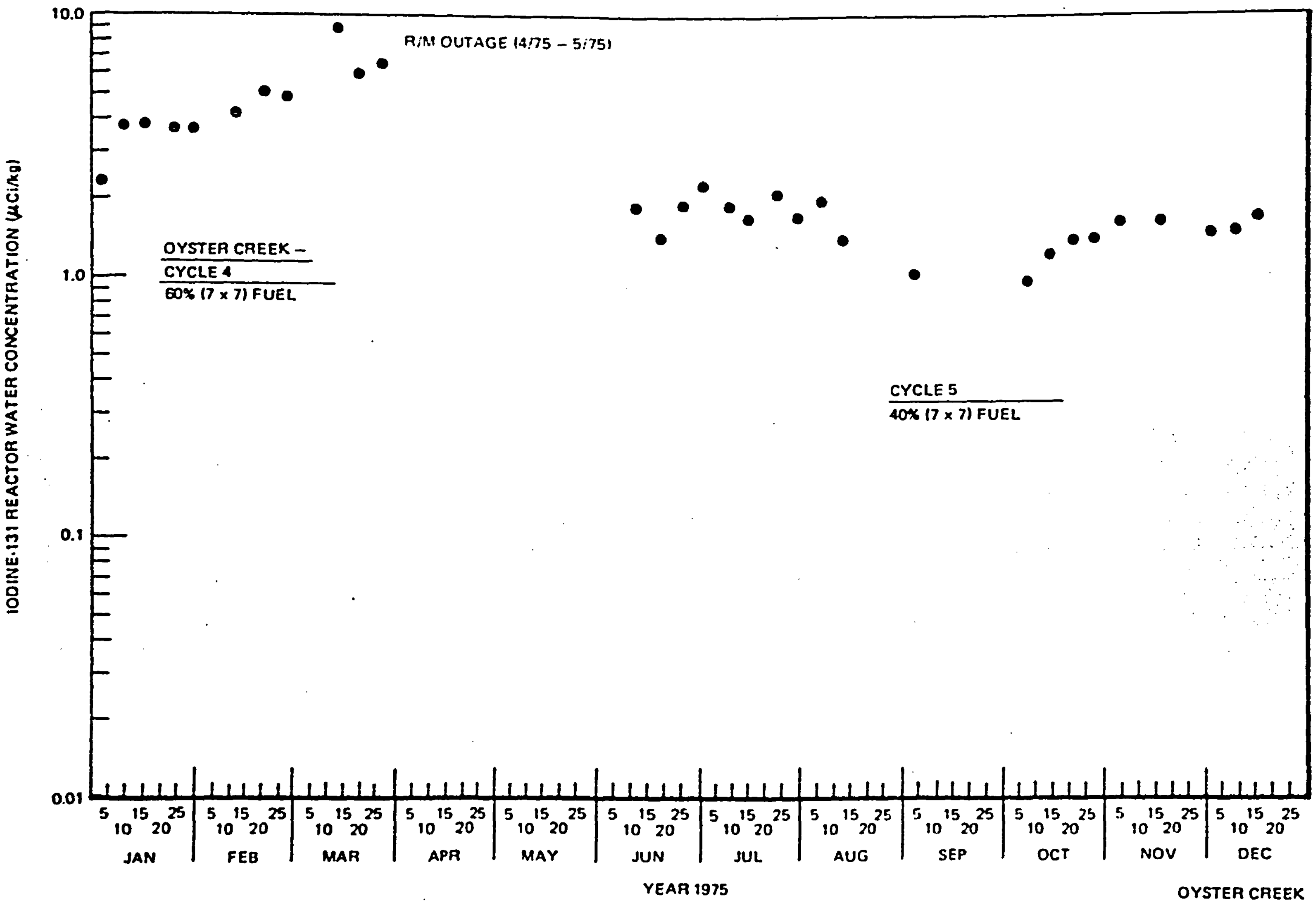


Figure 6-20. Iodine-131 Reactor Water Concentration at Oyster Creek, 1975

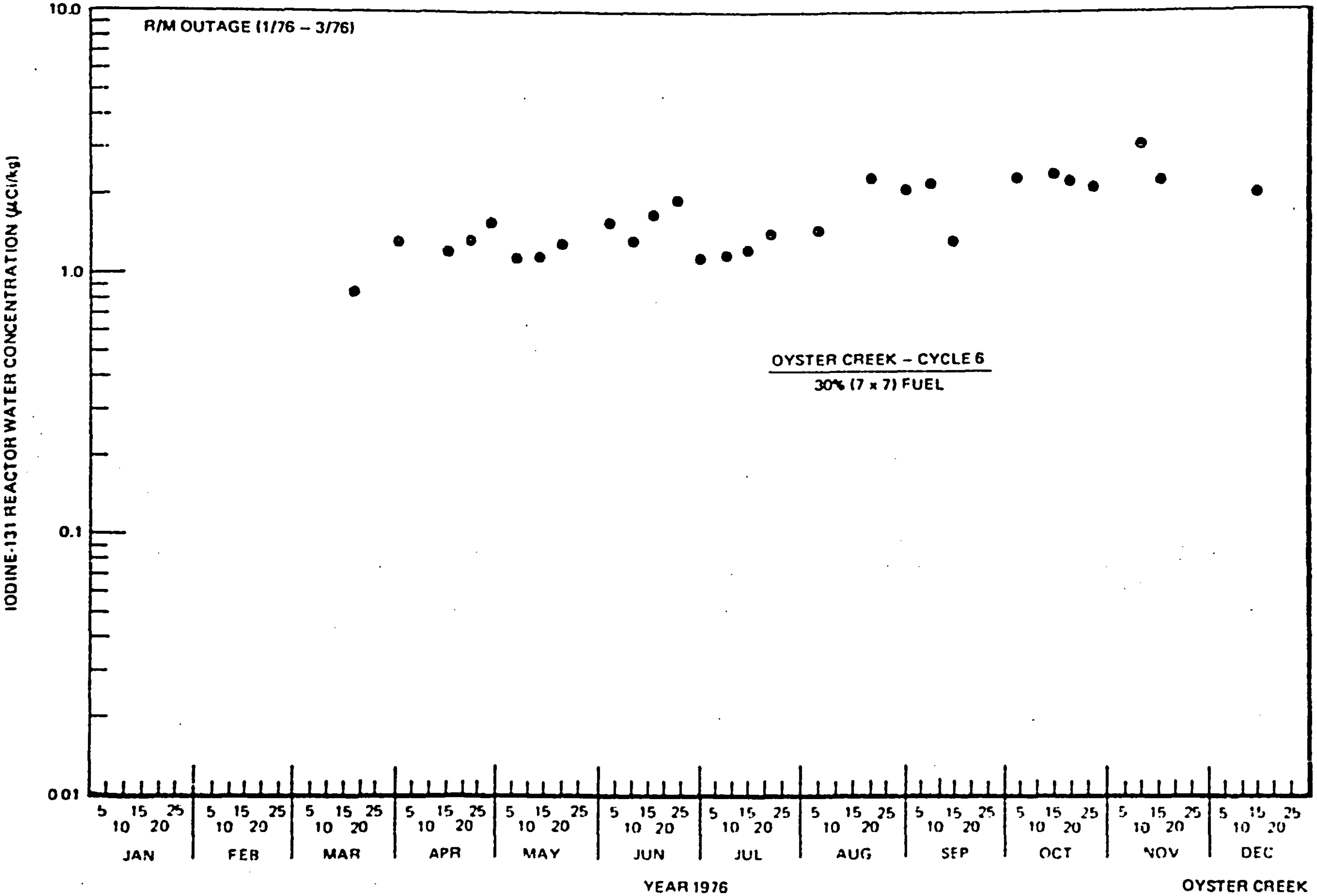


Figure 6-21. Iodine-131 Reactor Water Concentration at Oyster Creek, 1976

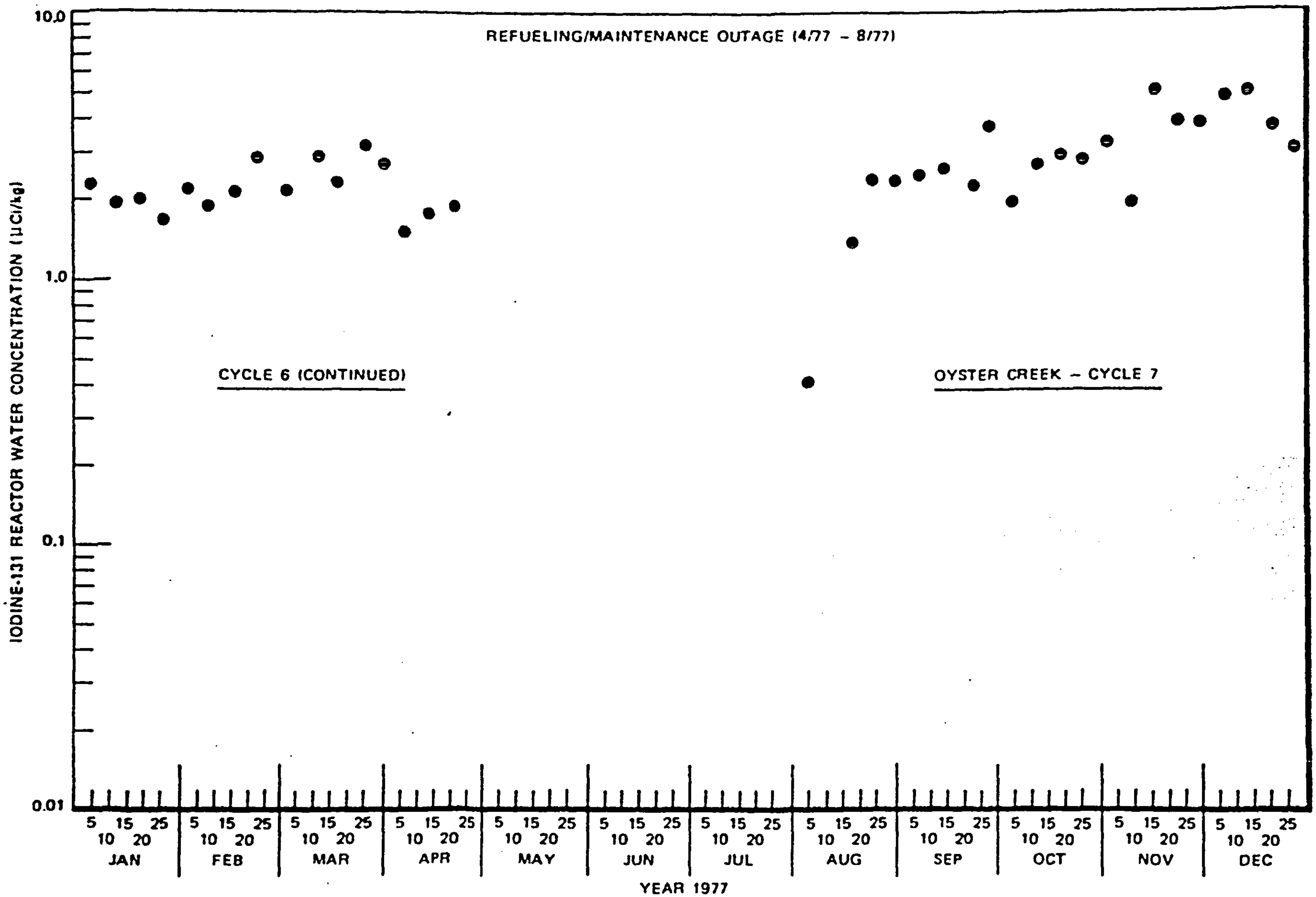


Figure 6-21a. Iodine-131 Reactor Water Concentration at Oyster Creek, 1977

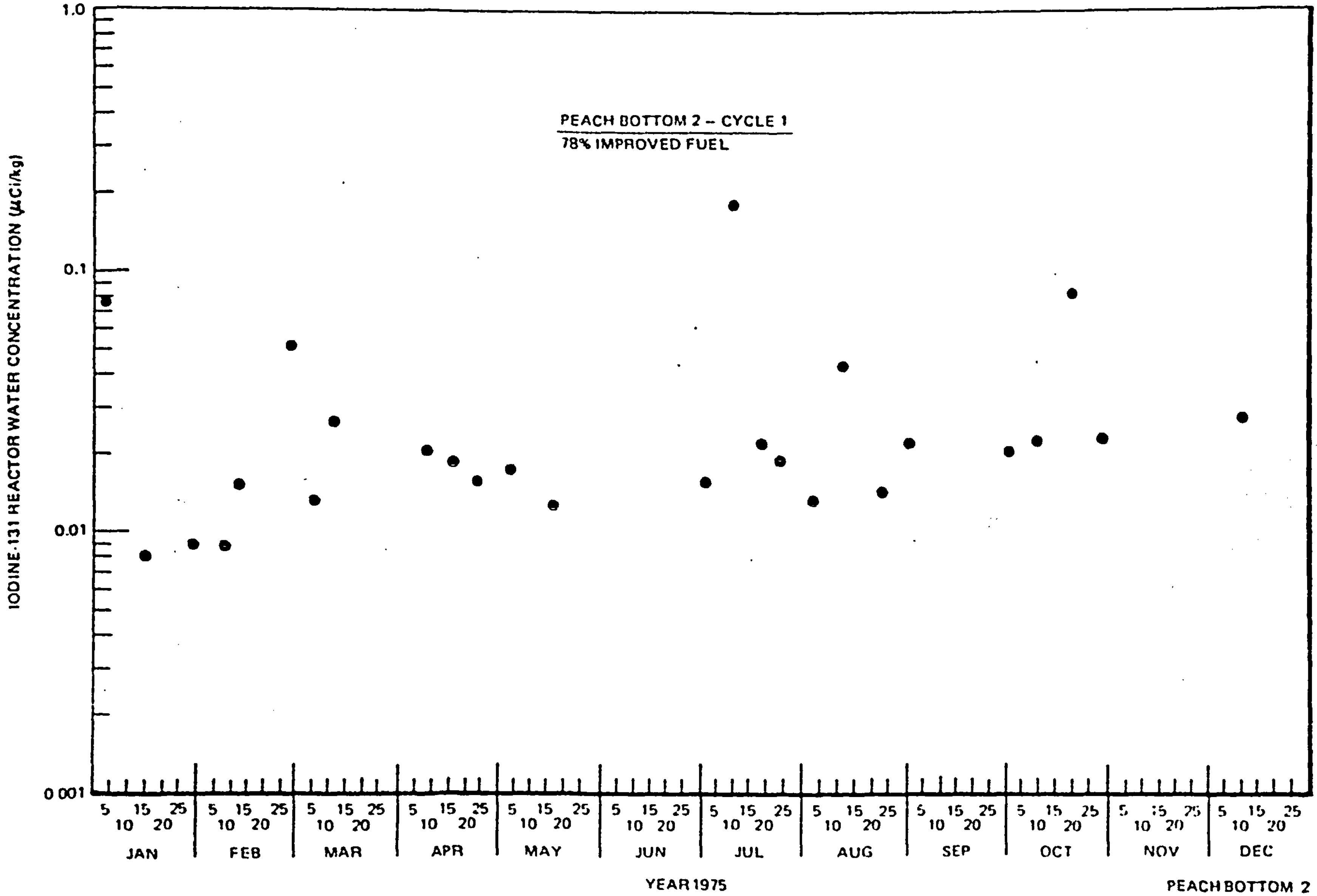


Figure 6-22. Iodine-131 Reactor Water Concentration at Peach Bottom 2, 1975

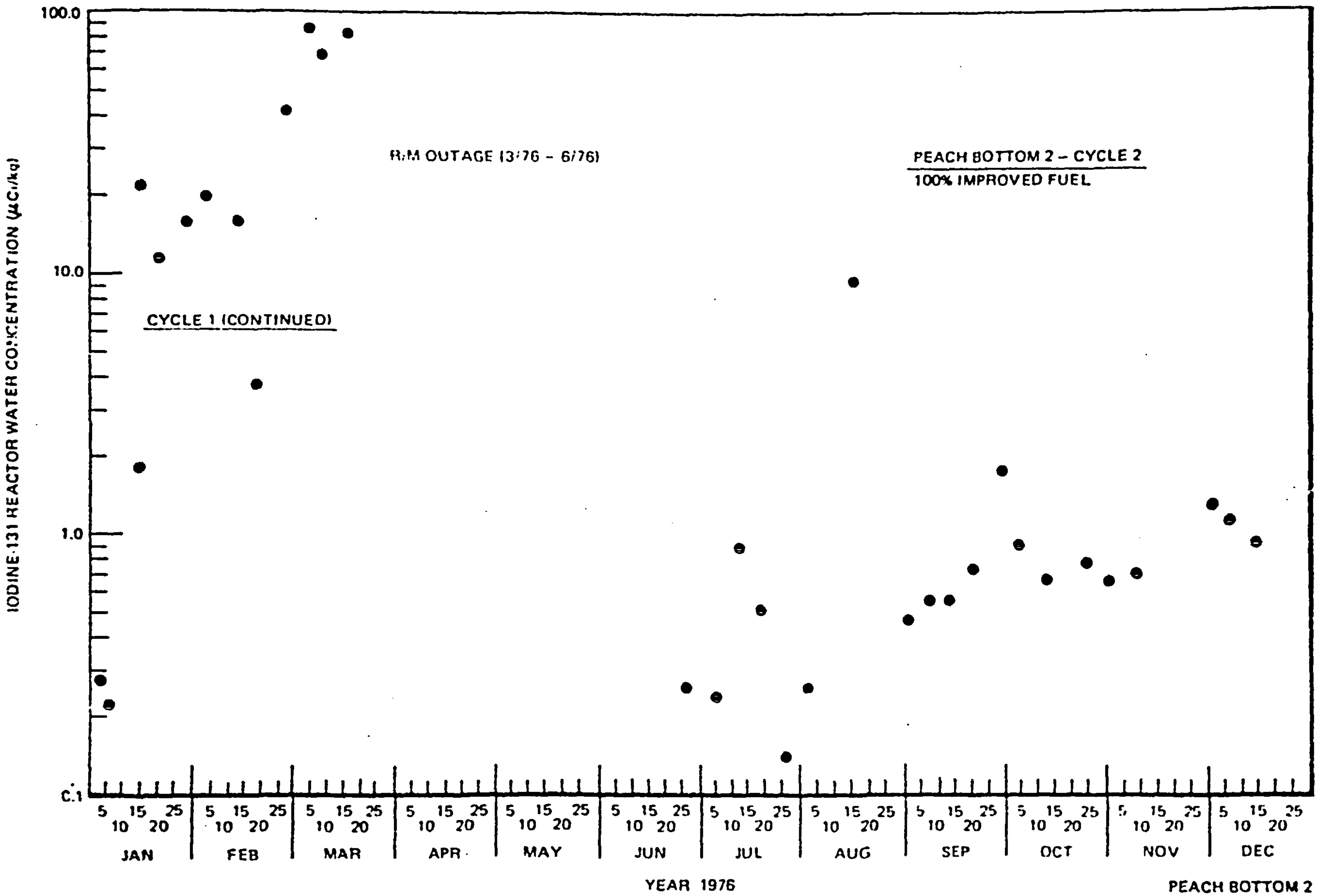


Figure 6-23. Iodine-131 Reactor Water Concentration at Peach Bottom 2, 1976

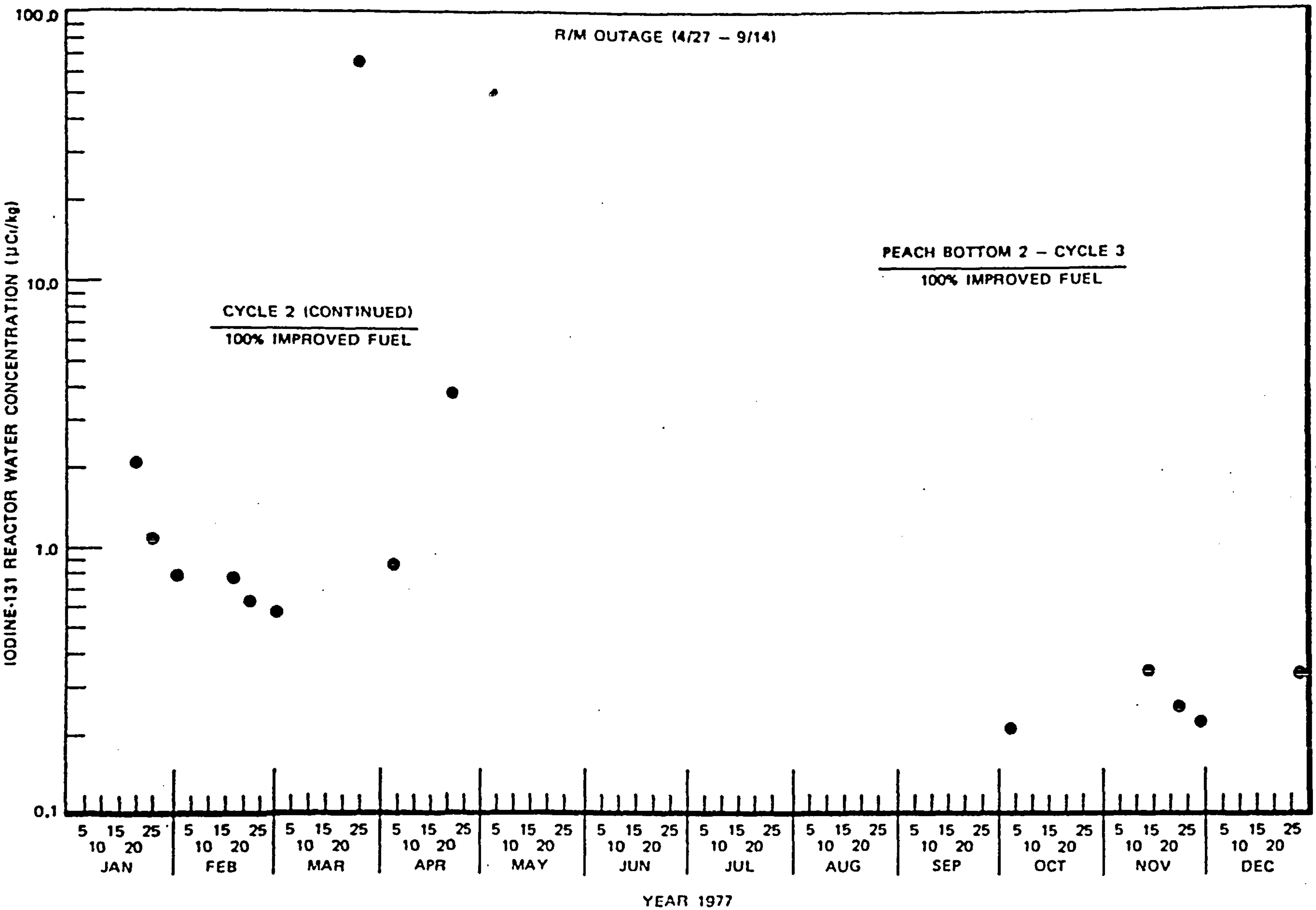


Figure 6-23a. Iodine-131 Reactor Water Concentration at Peach Bottom 2, 1977

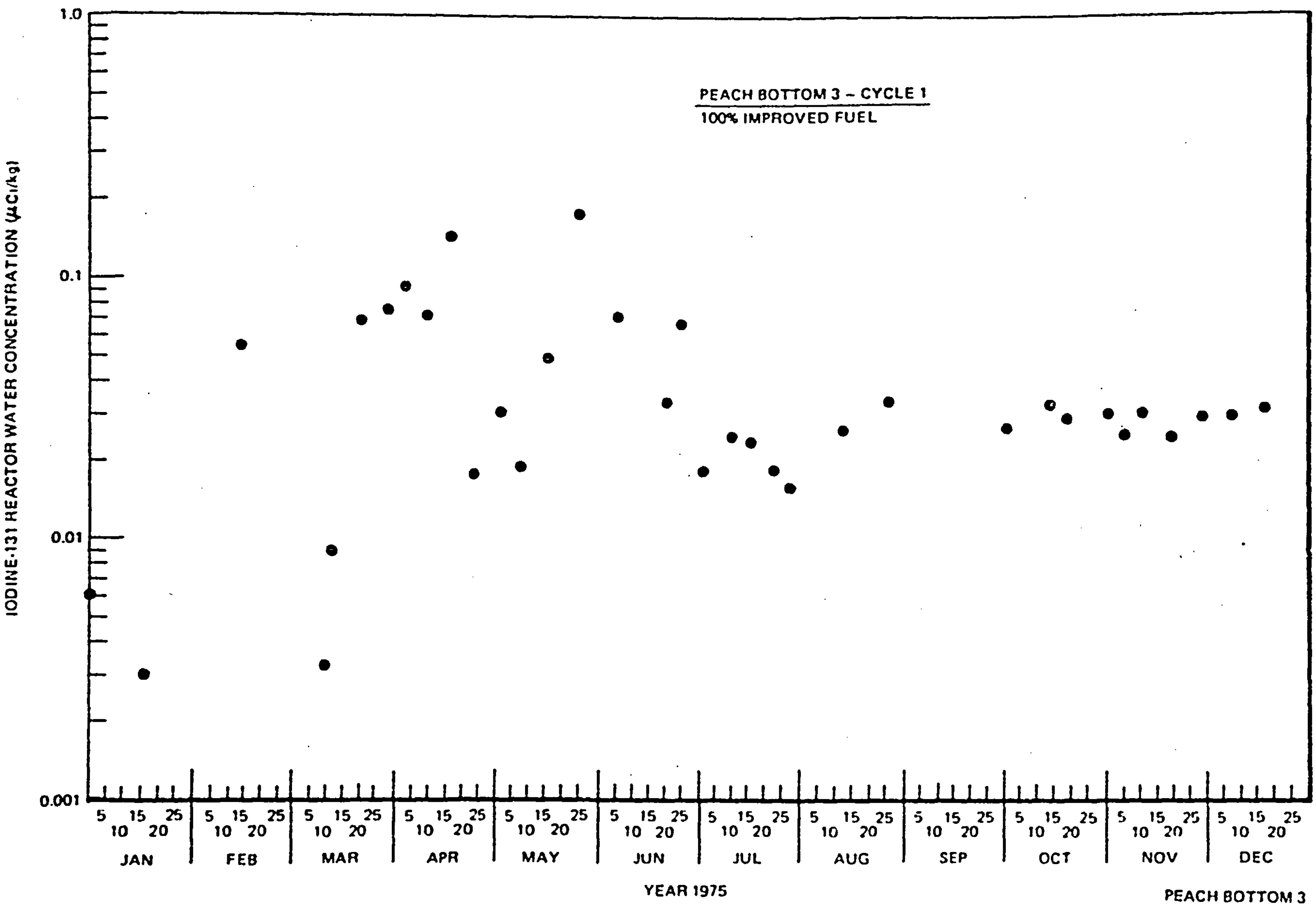


Figure 6-24. Iodine-131 Reactor Water Concentration at Peach Bottom 3, 1975

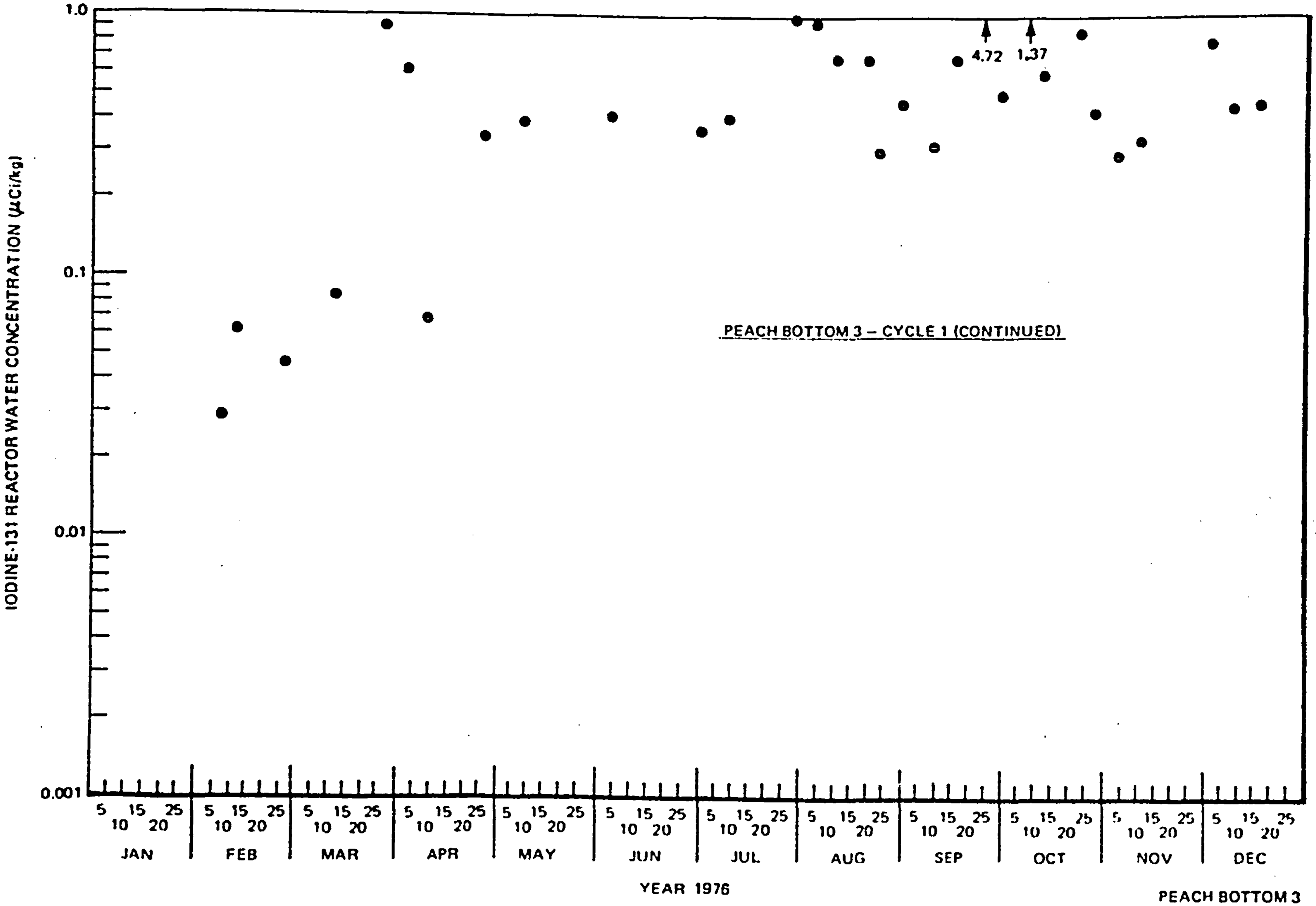


Figure 6-25. Iodine-131 Reactor Water Concentration at Peach Bottom 3, 1976

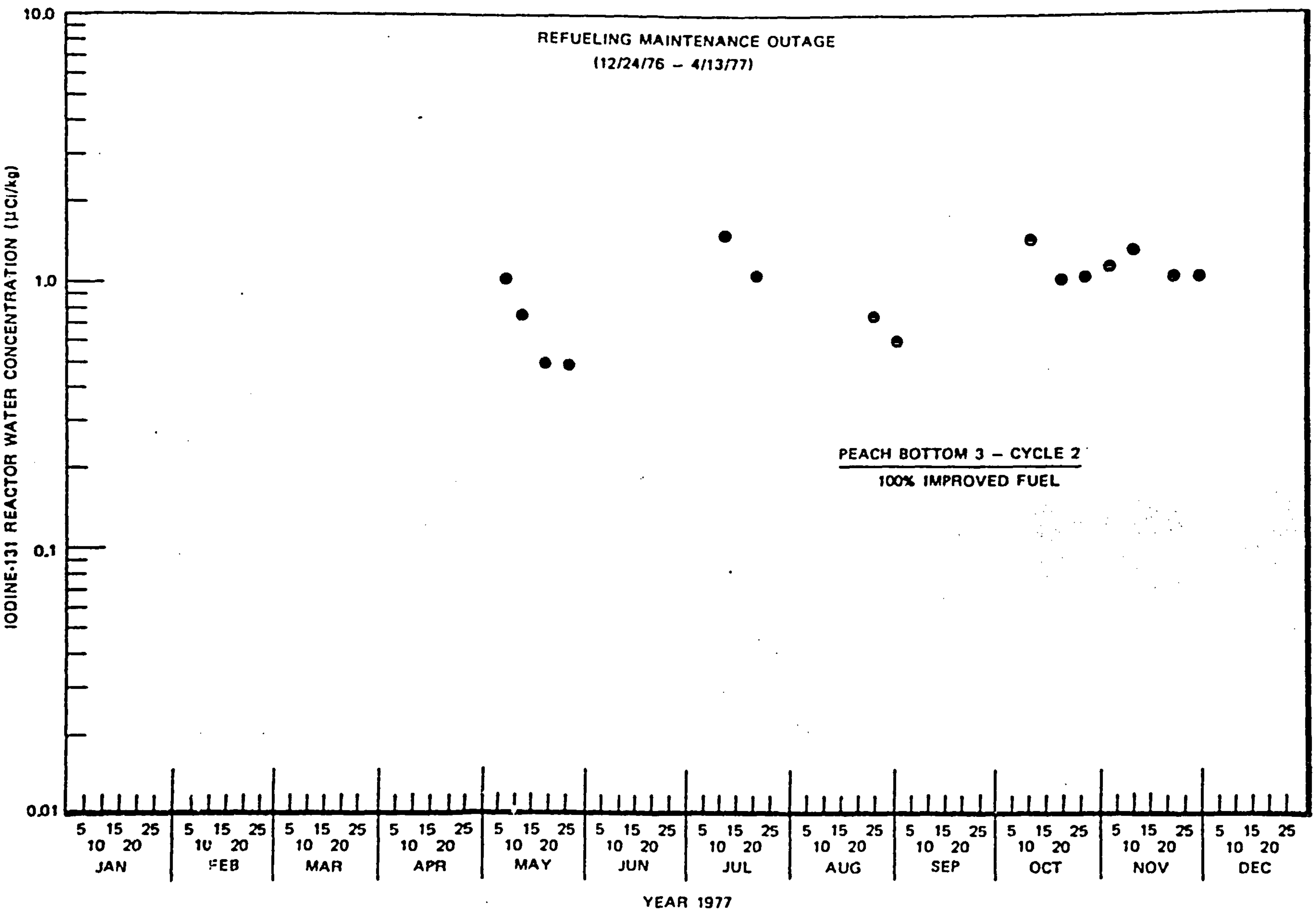


Figure 6-25a. Iodine-131 Reactor Water Concentration at Peach Bottom 3, 1977

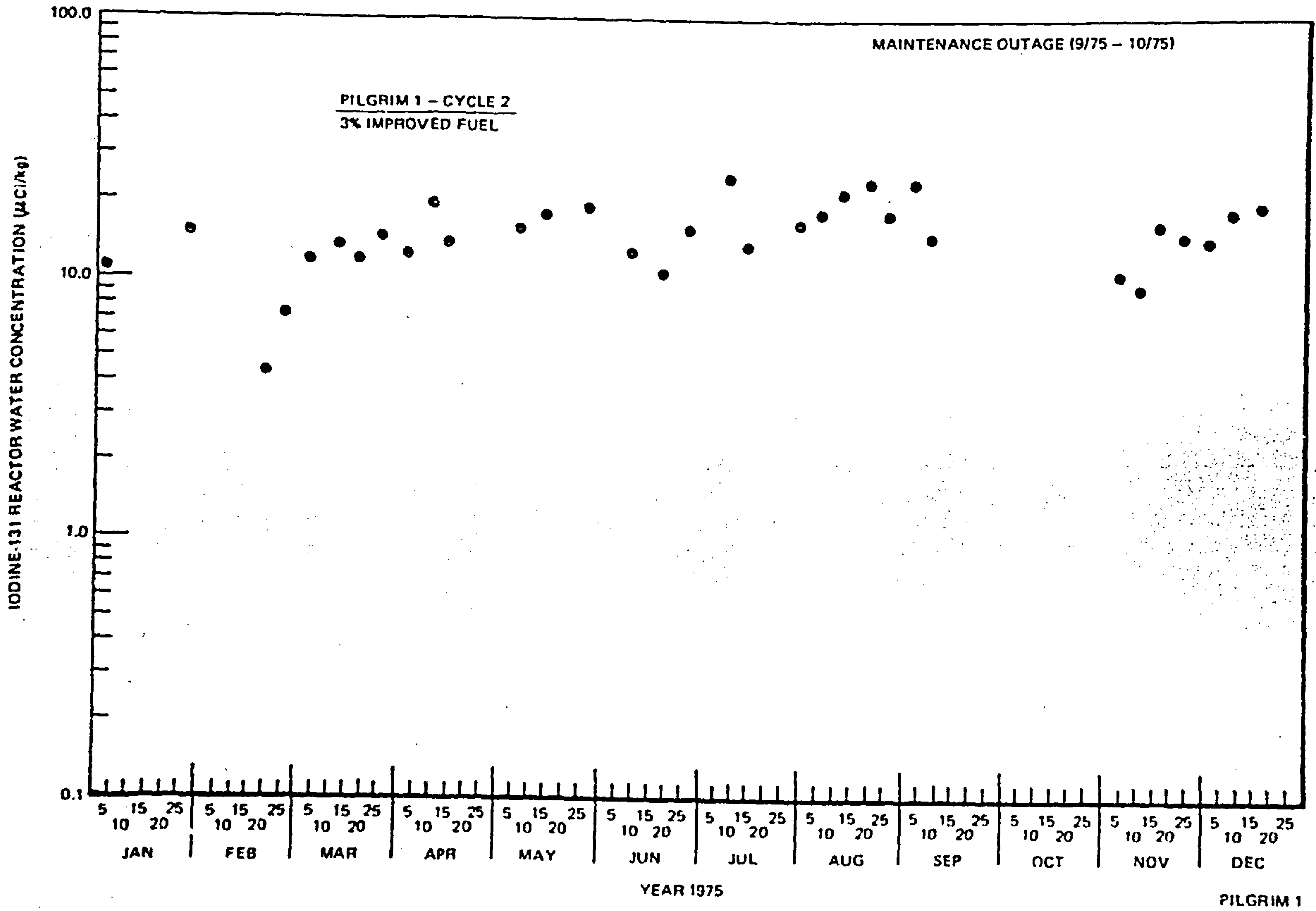


Figure 6-26. Iodine-131 Reactor Water Concentration at Pilgrim 1, 1975

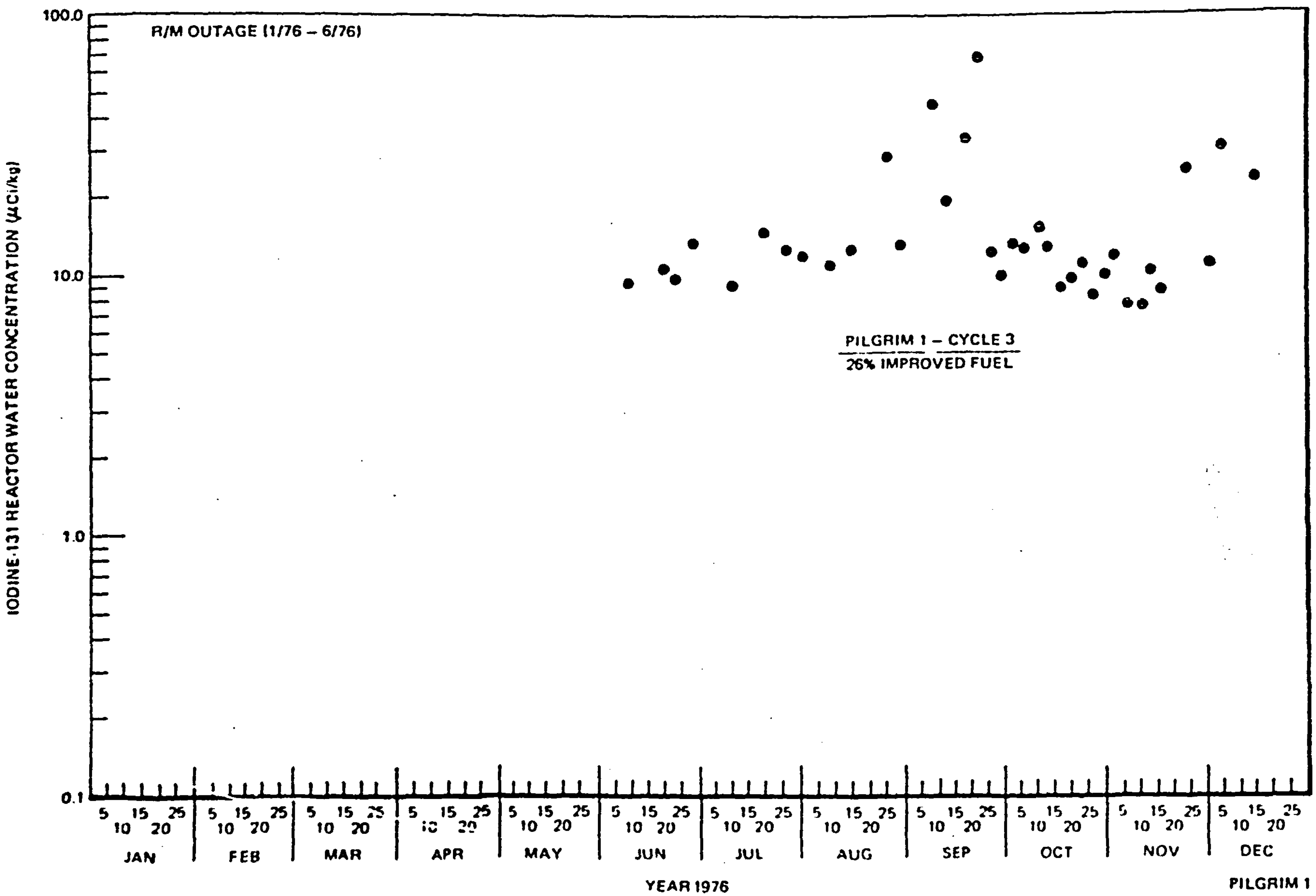


Figure 6-27. Iodine-131 Reactor Water Concentration at Pilgrim 1, 1976

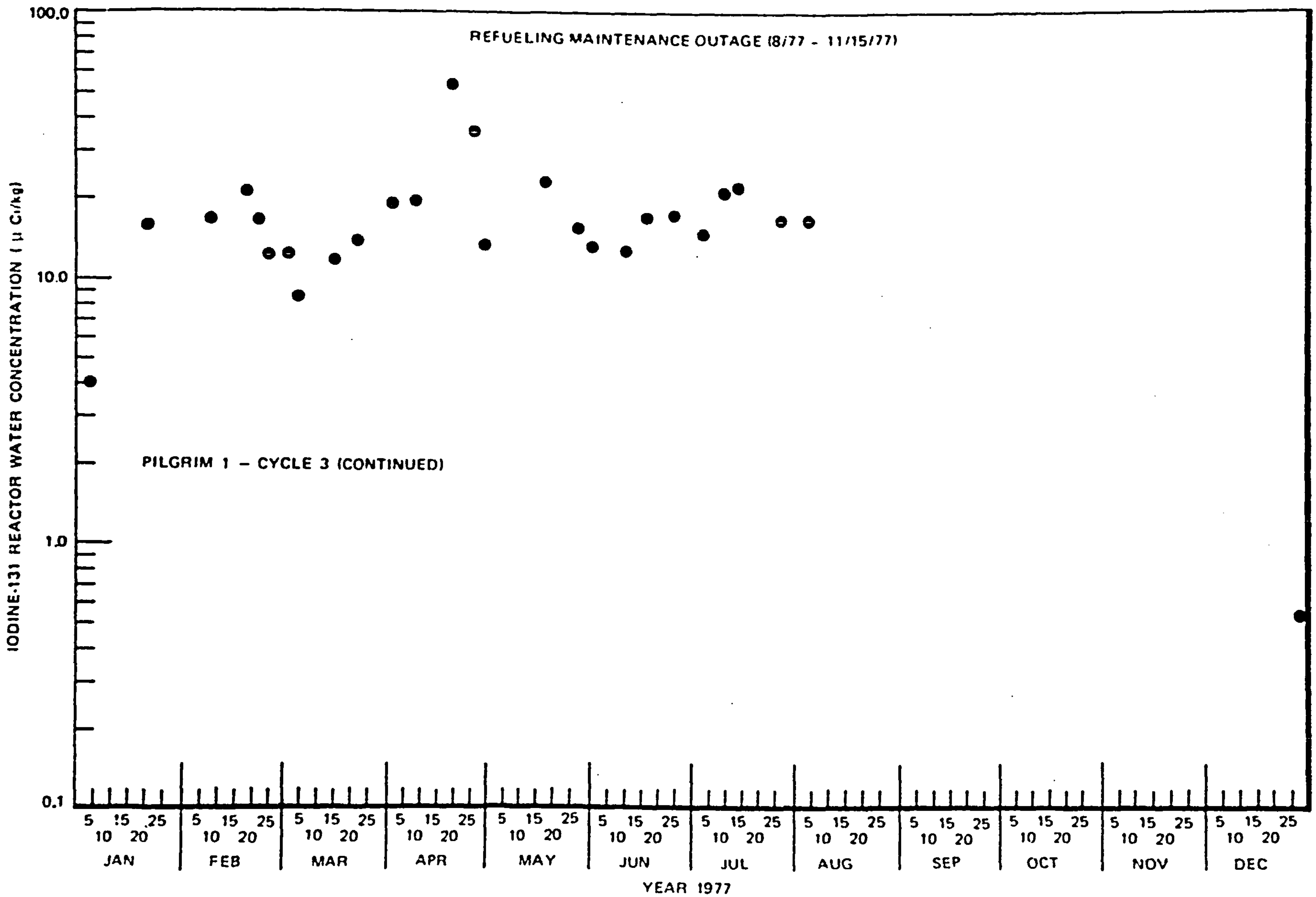


Figure 6-27a. Iodine-131 Reactor Water Concentration at Pilgrim 1, 1977

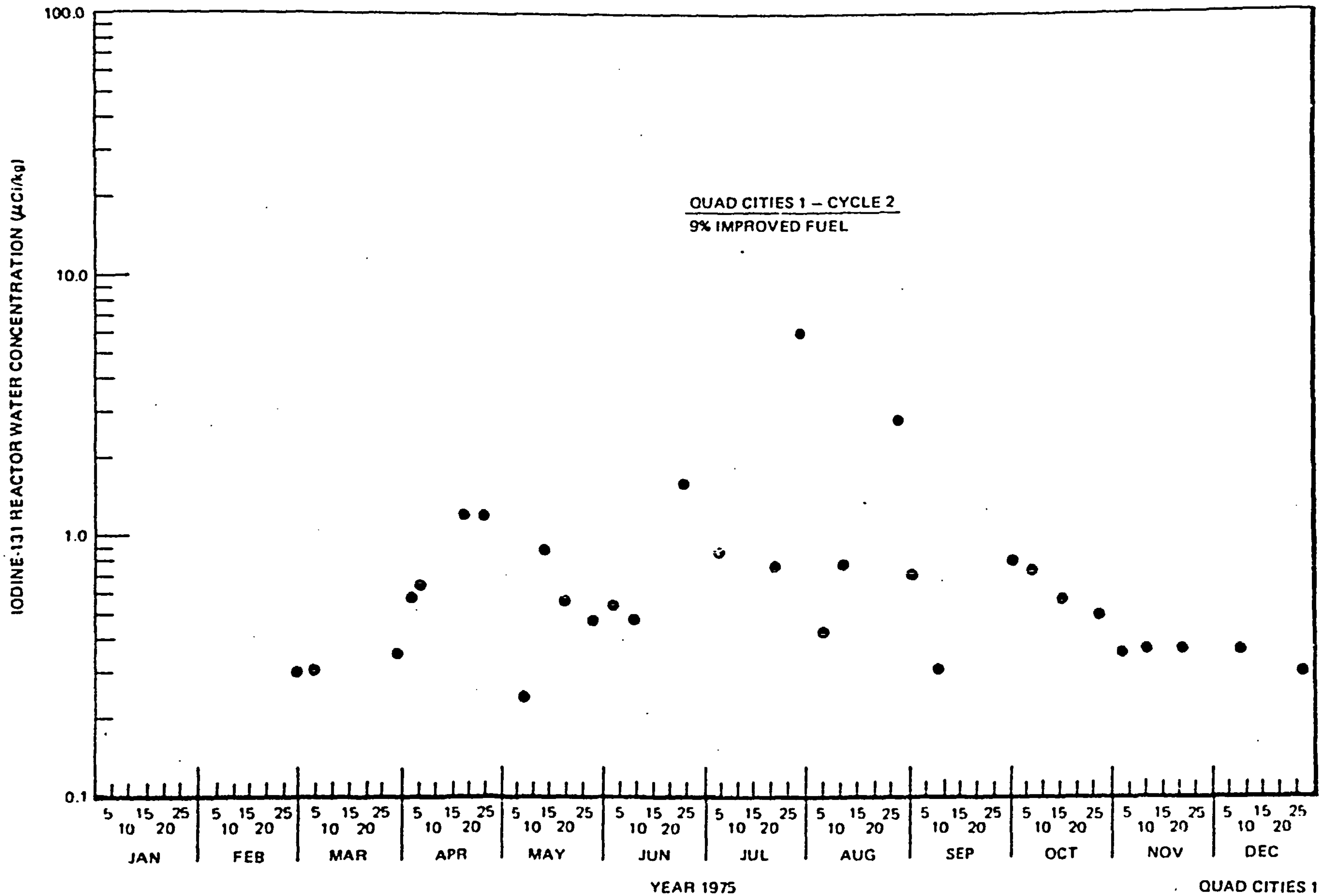


Figure 6-28. Iodine-131 Reactor Water Concentration at Quad Cities 1, 1975

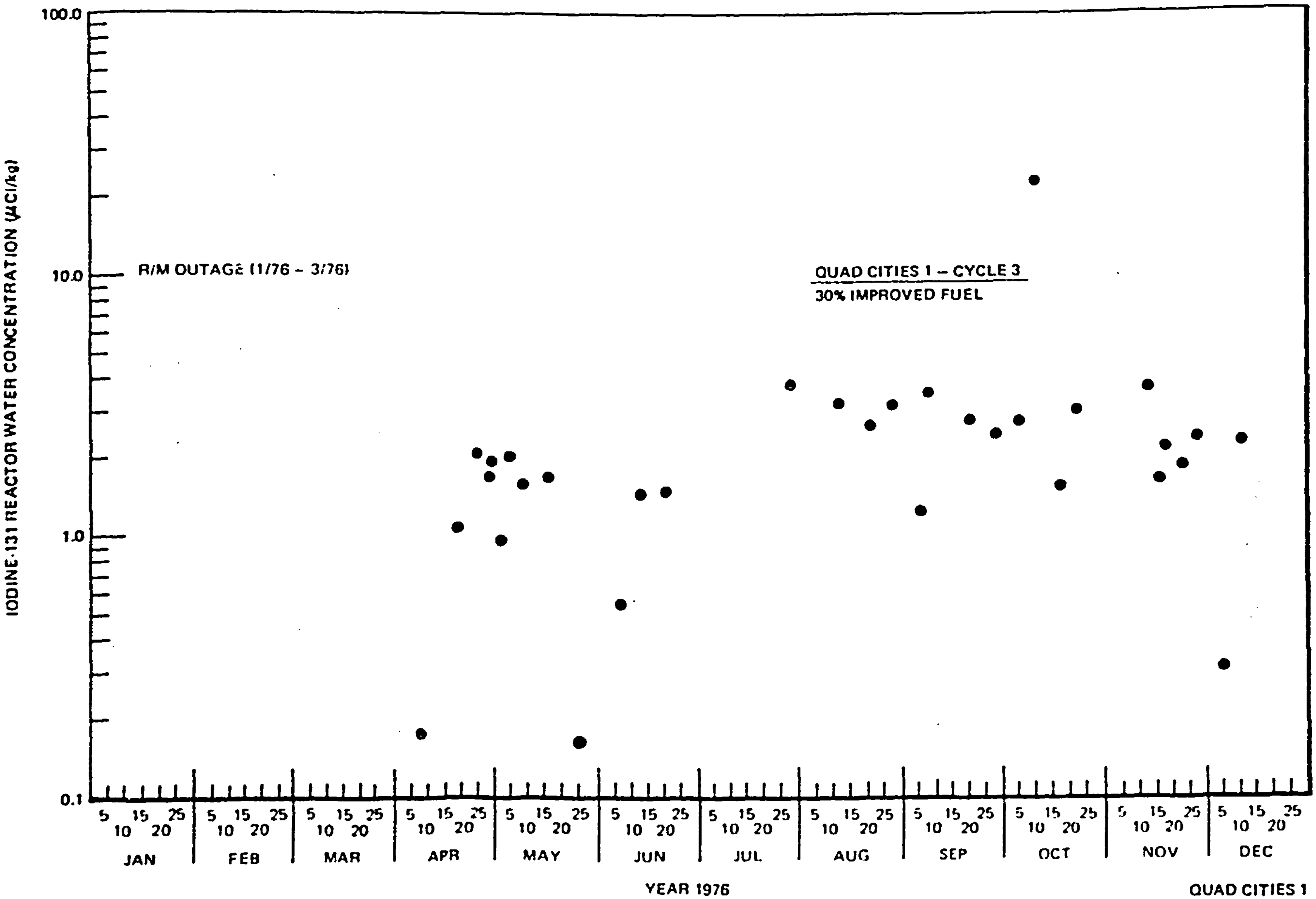


Figure 6-29. Iodine-131 Reactor Water Concentration at Quad Cities 1, 1976

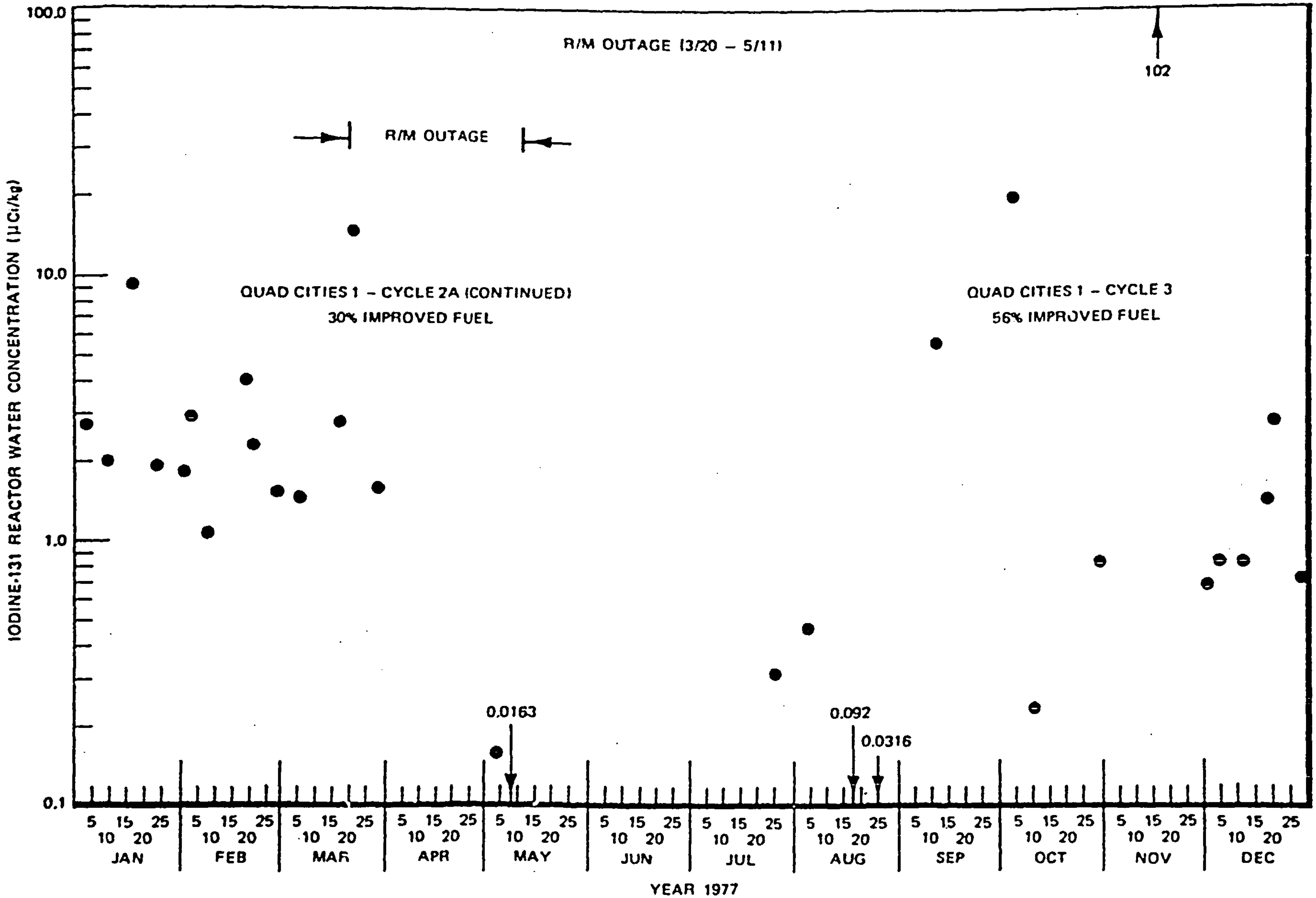


Figure 6-29a. Iodine-131 Reactor Water Concentration at Quad Cities 1, 1977

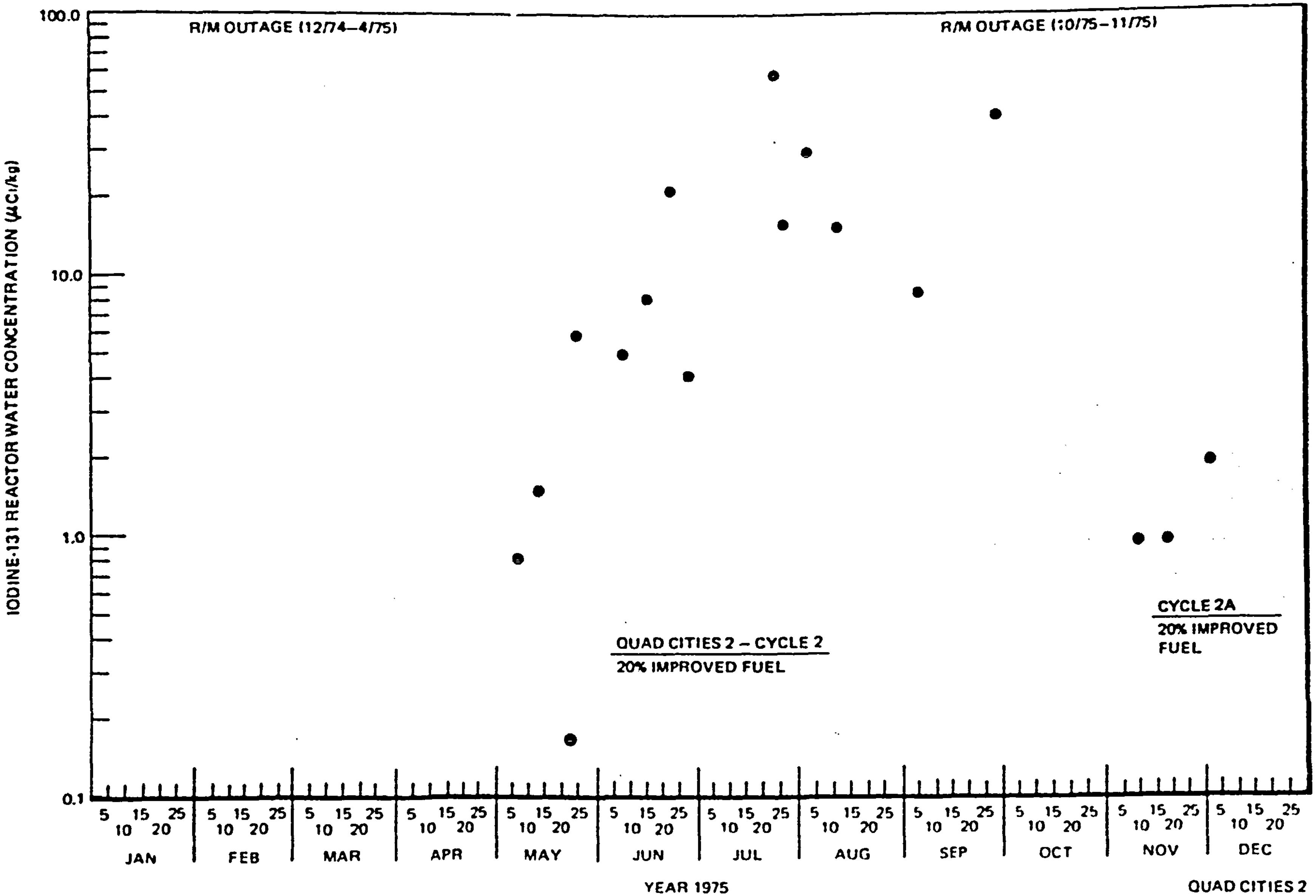


Figure 6-30. Iodine-131 Reactor Water Concentration at Quad Cities 2, 1975

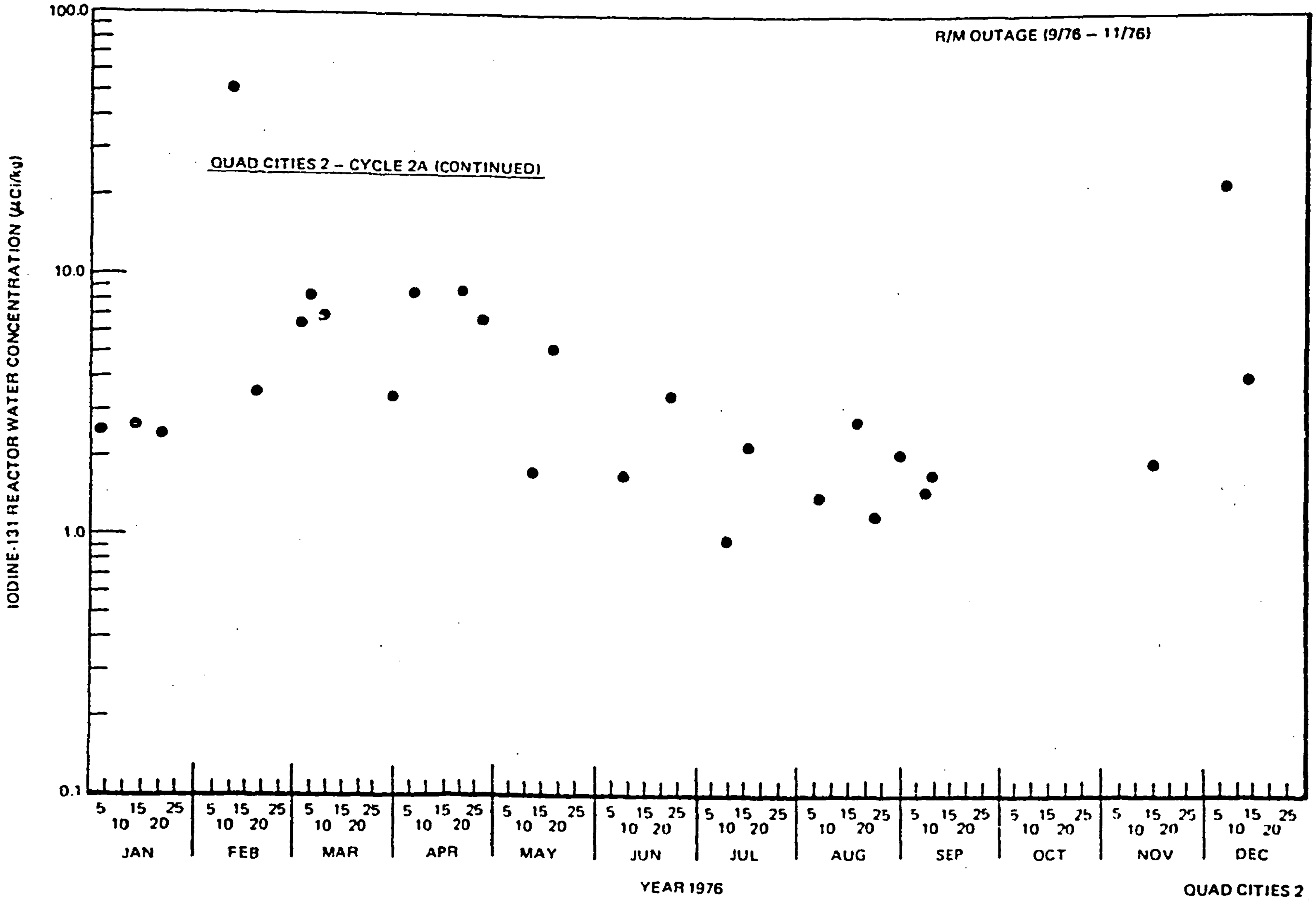


Figure 6-31. Iodine-131 Reactor Water Concentration at Quad Cities 2, 1976

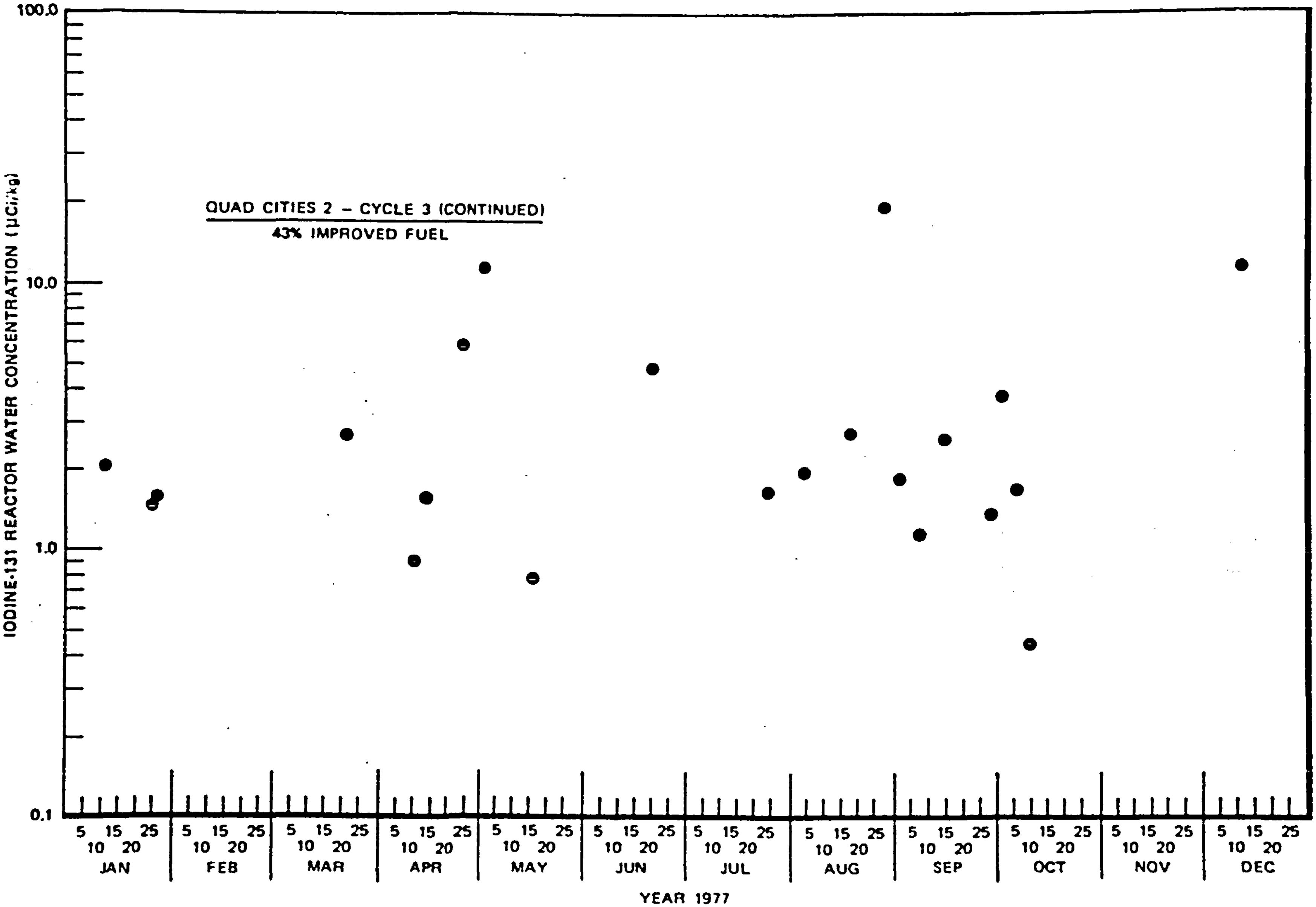


Figure 6-31a. Iodine-131 Reactor Water Concentration at Quad Cities 2, 1977

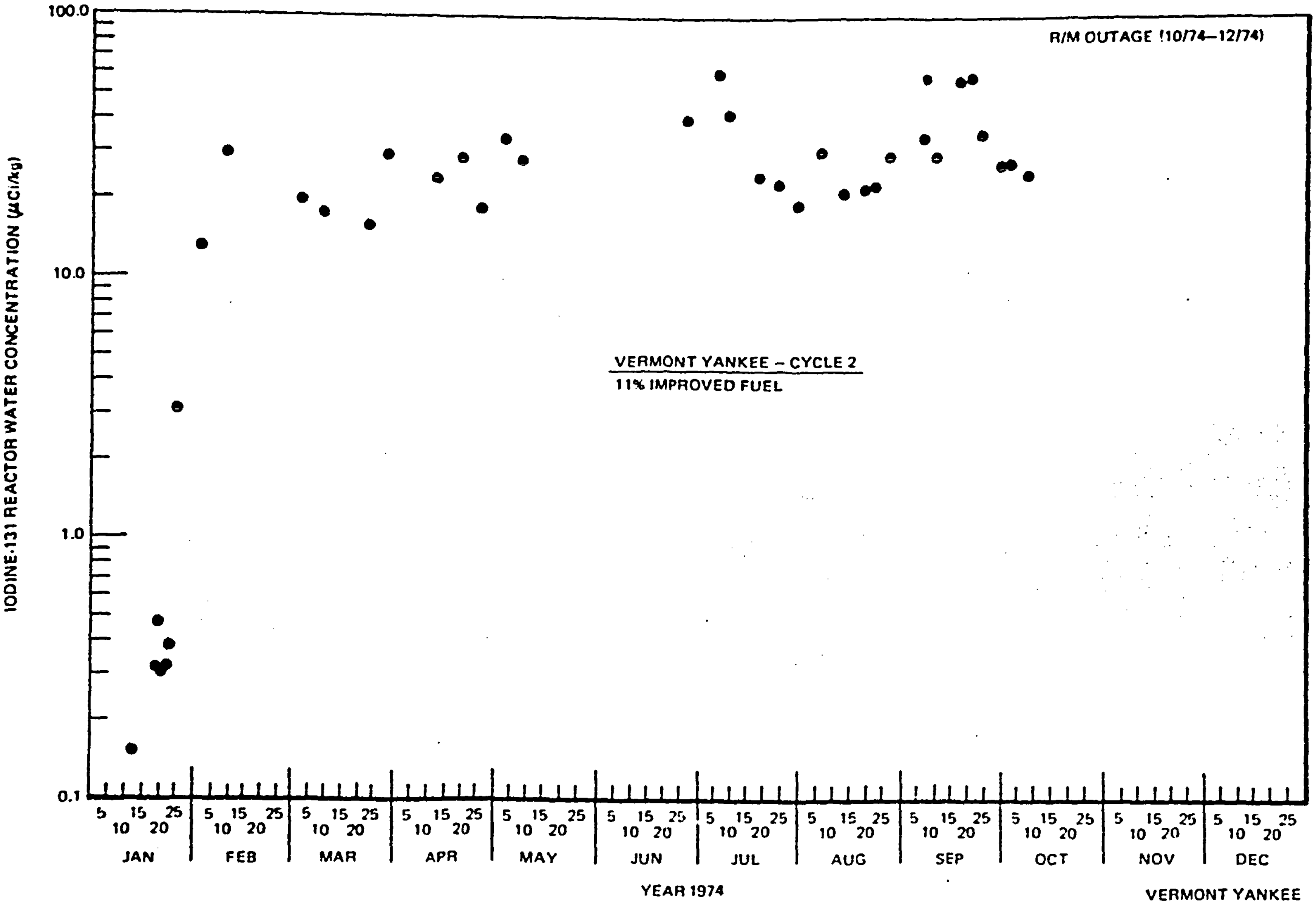


Figure 6-32. Iodine-131 Reactor Water Concentration at Vermont Yankee, 1974

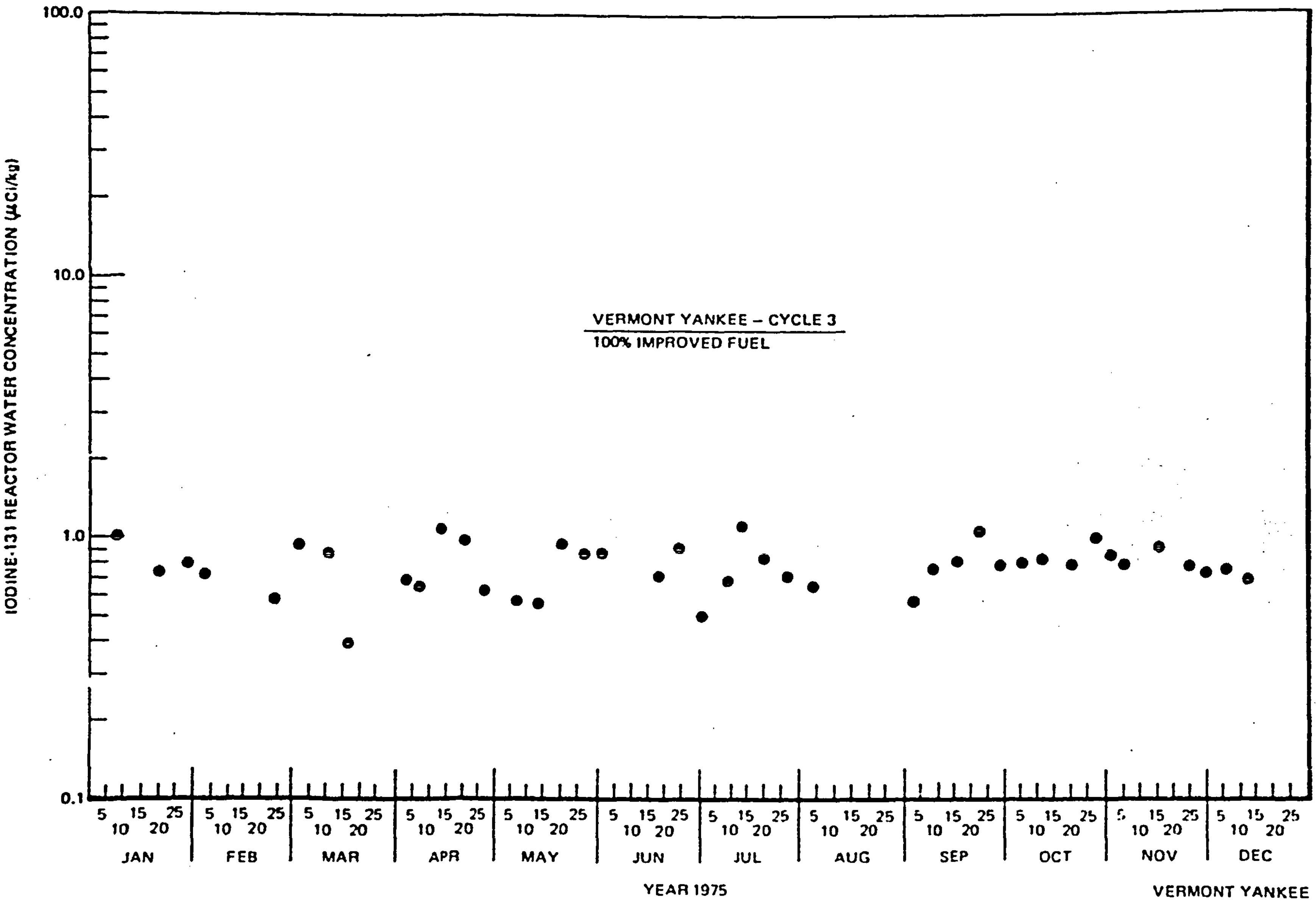


Figure 6-33. Iodine-131 Reactor Water Concentration at Vermont Yankee, 1975

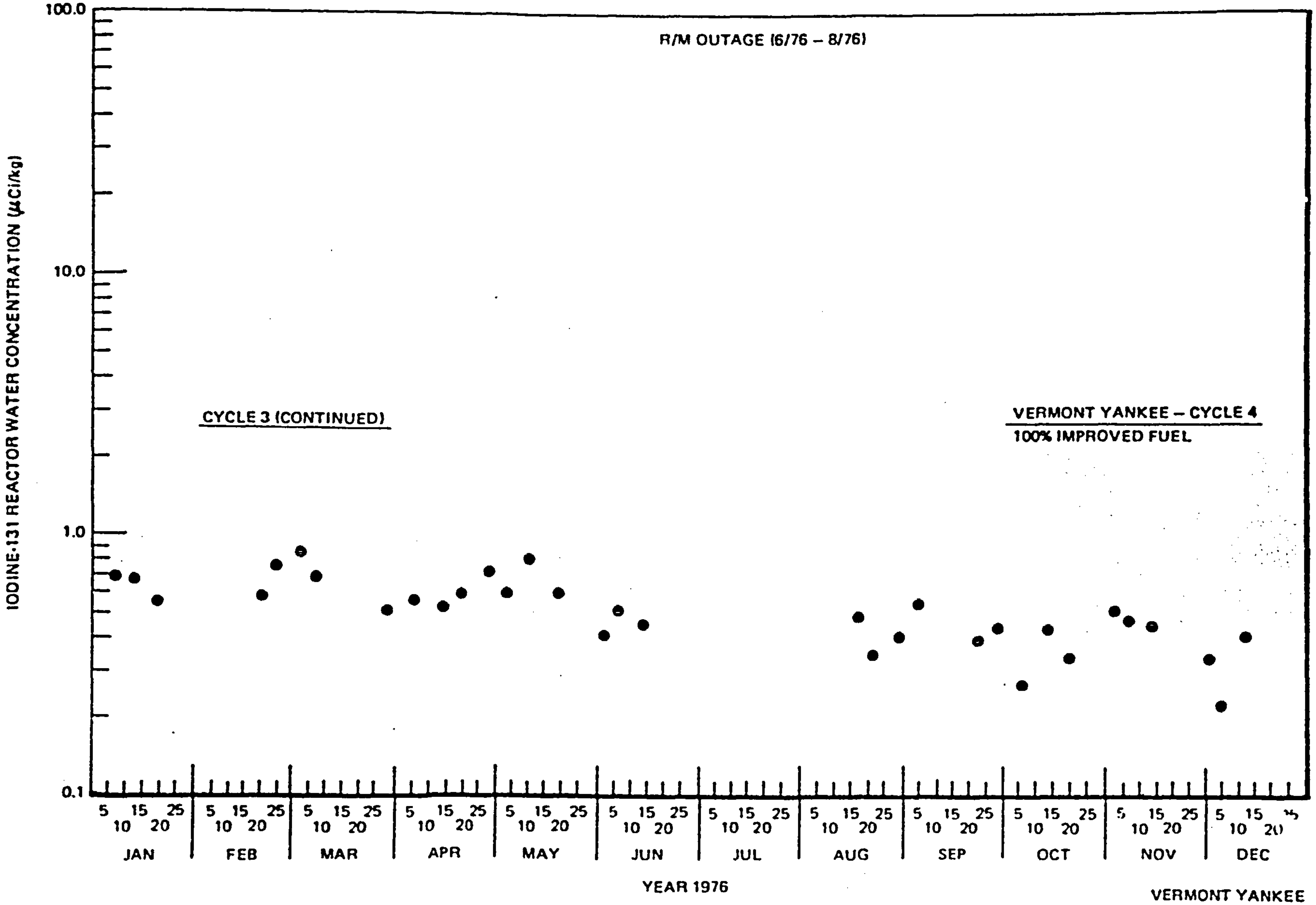


Figure 6-34. Iodine-131 Reactor Water Concentration at Vermont Yankee, 1976

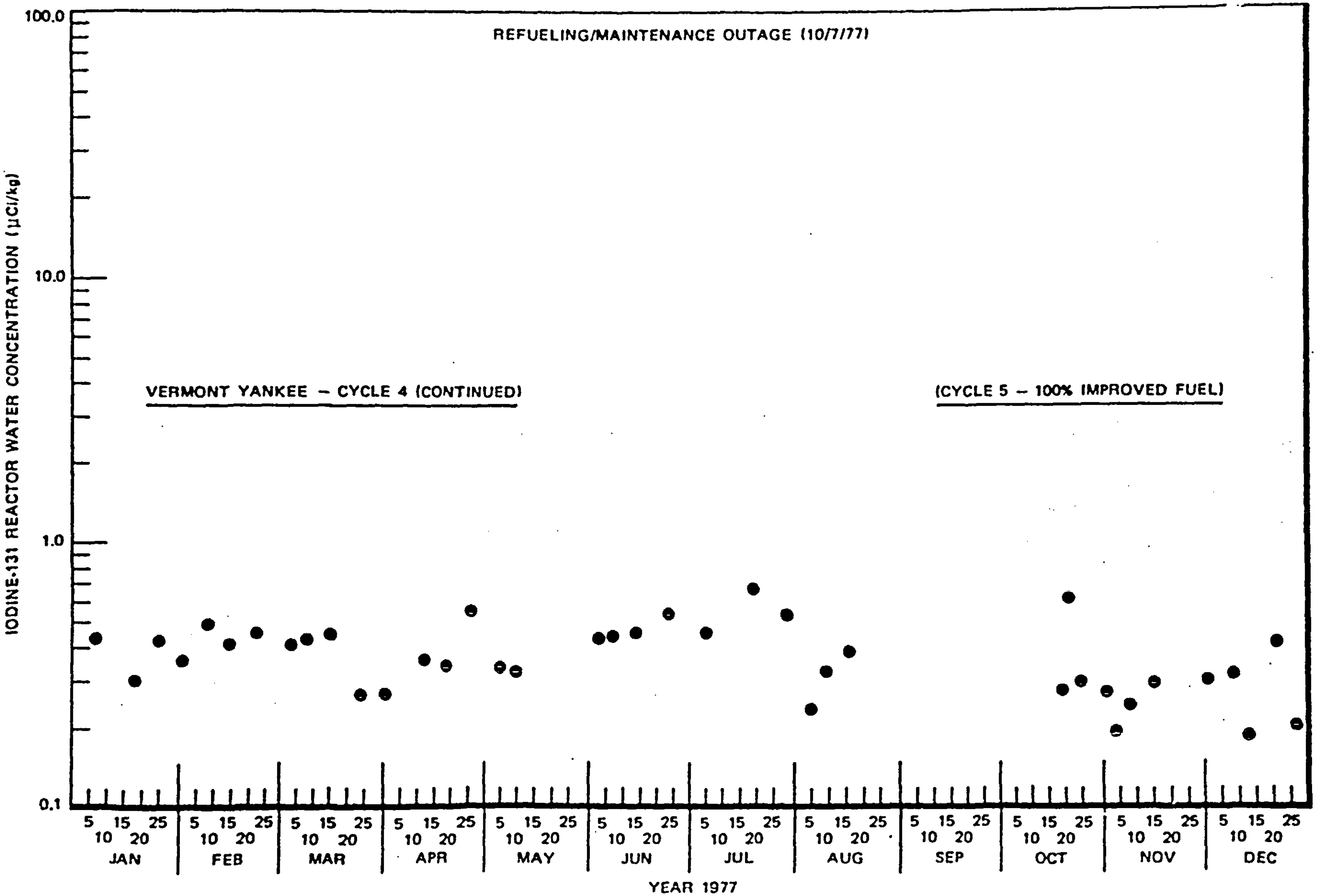


Figure 6-34a. Iodine-131 Reactor Water Concentration at Vermont Yankee, 1977

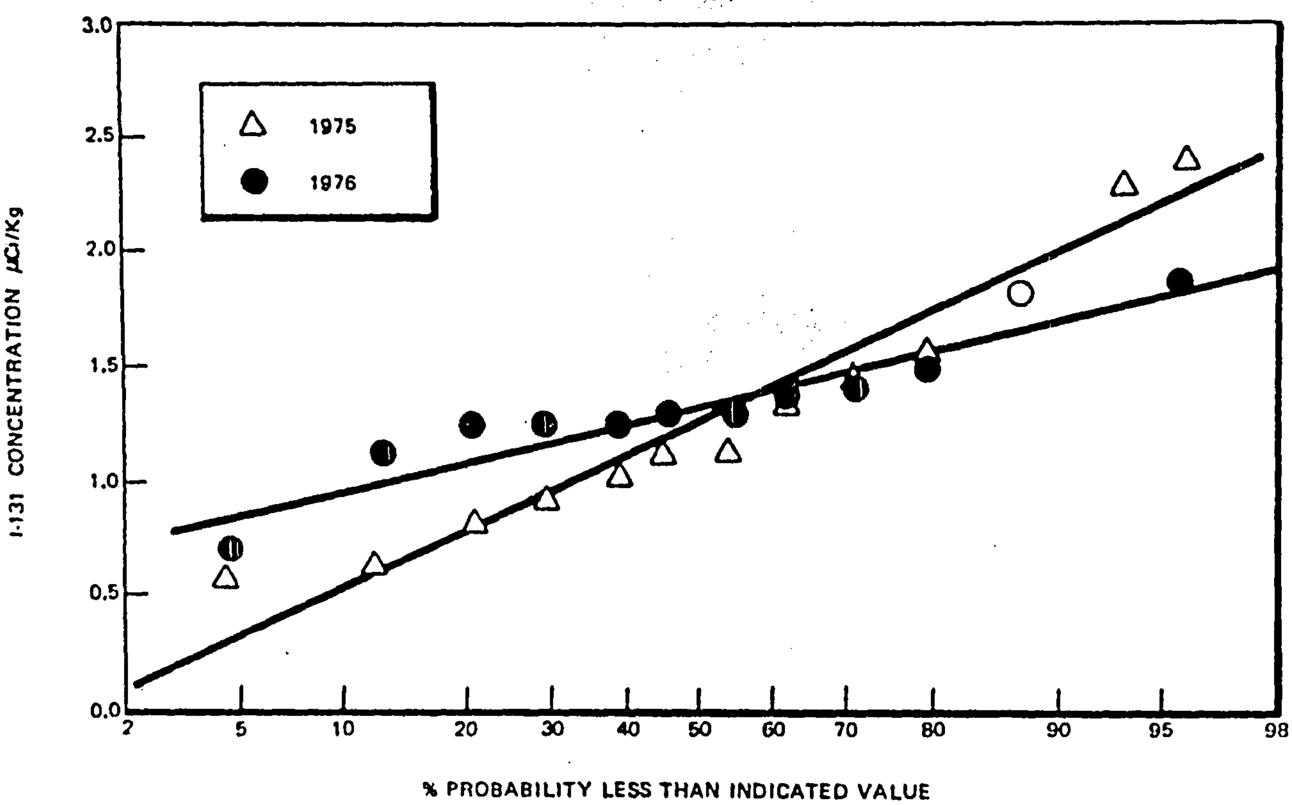


Figure 6-35. Normal Probability Distribution of Medians of Maximum Monthly I-131 Reactor Water Concentrations During 1975 and 1976 for 15 Domestic BWR's

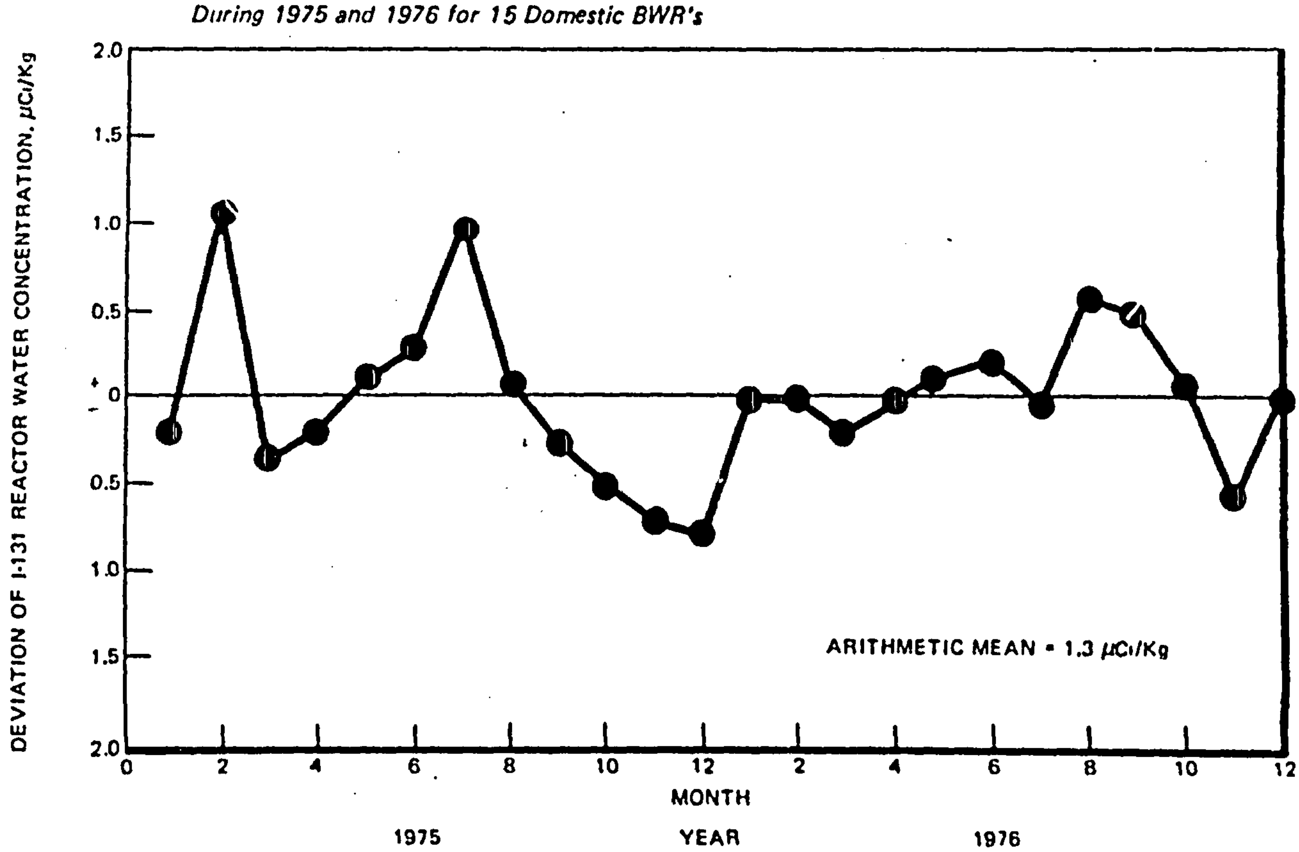
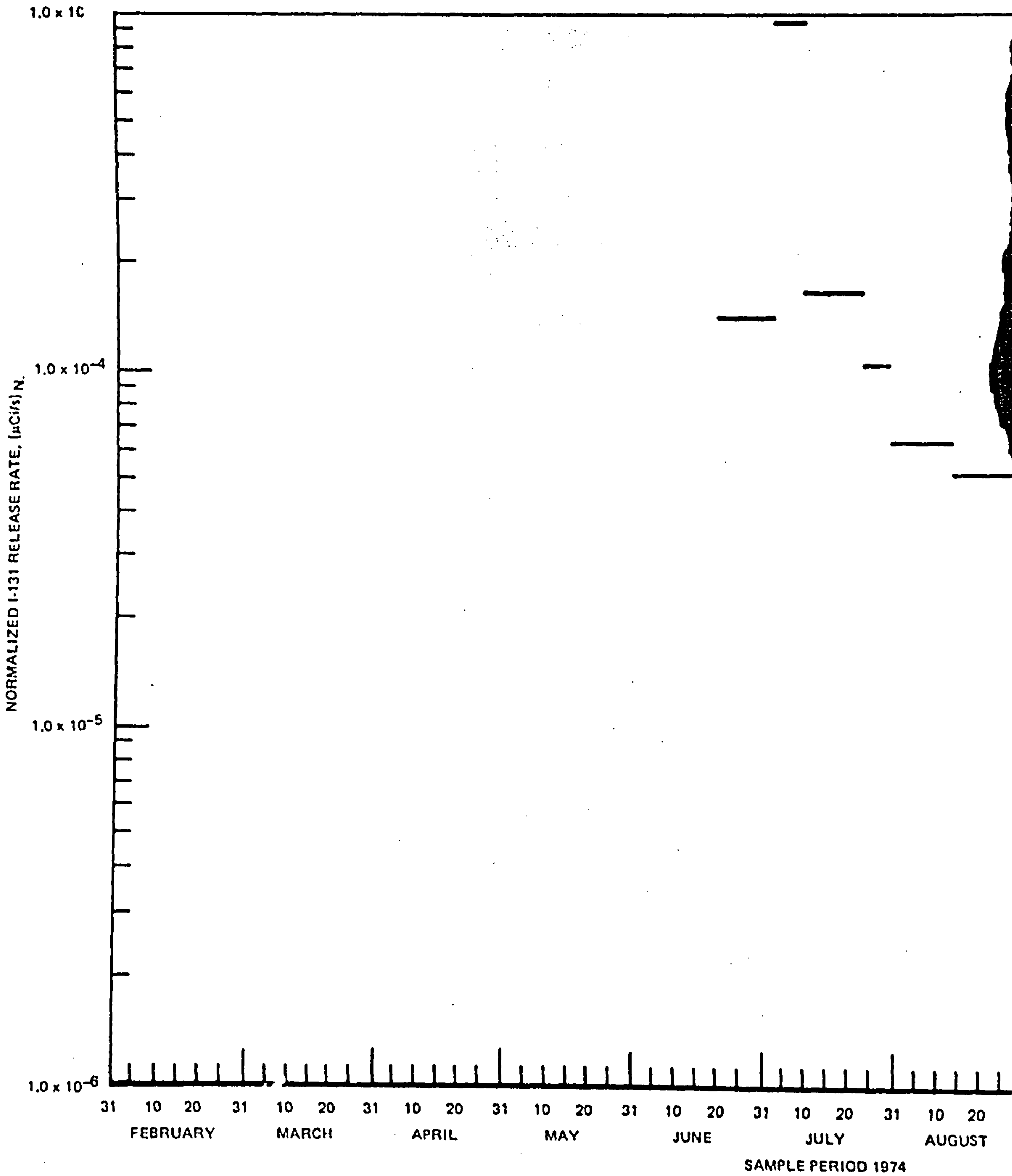


Figure 6-36. Variation of Median I-131 Reactor Water Concentration in Domestic BWR's for 1975 and 1976

Figure 6-37. Deleted



1.0 x 10
1.0 x 10⁻⁴
1.0 x 10⁻⁵
1.0 x 10⁻⁶
NORMALIZED I-131 RELEASE RATE, (μCi/s) N.
31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SAMPLE PERIOD 1974

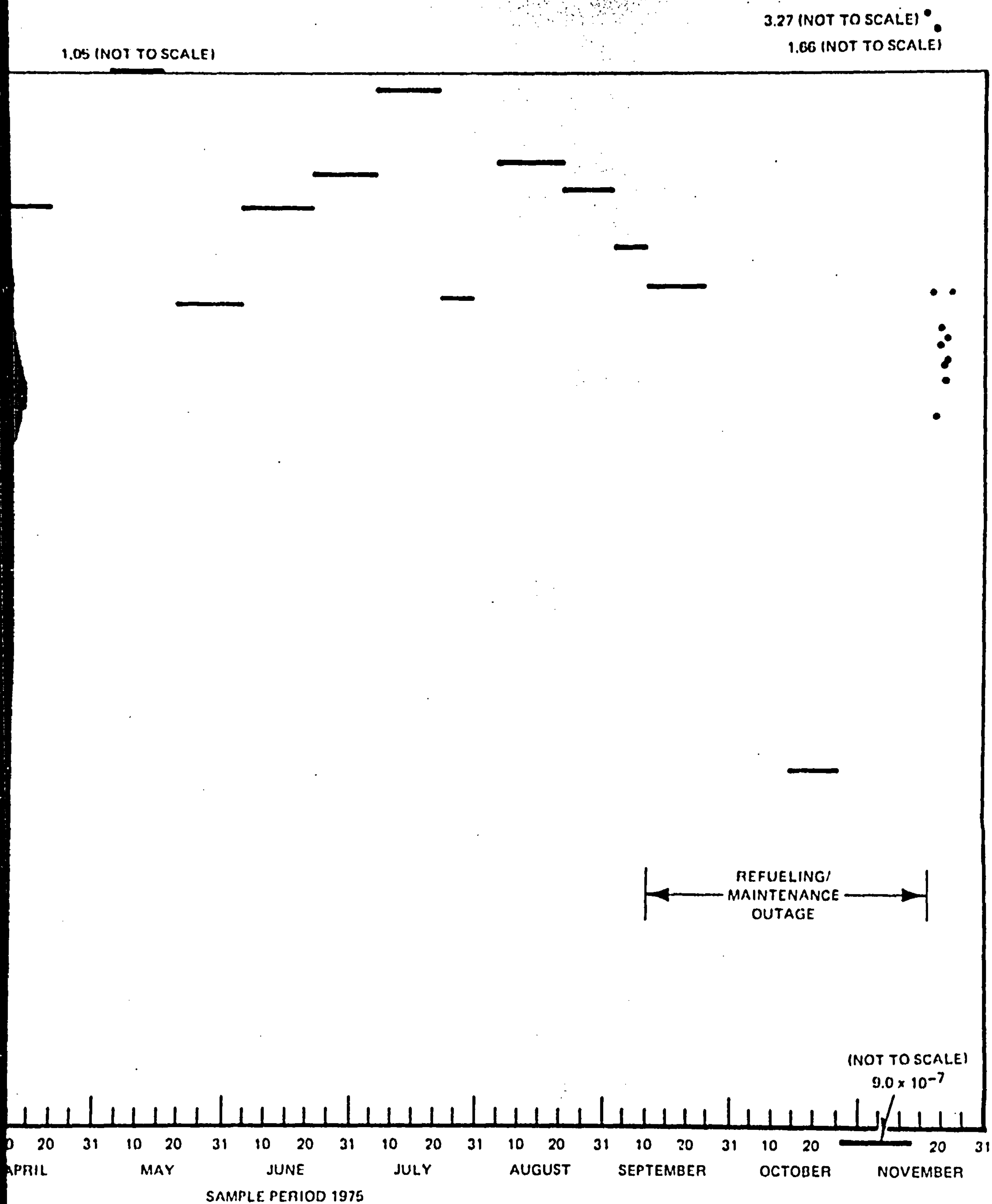
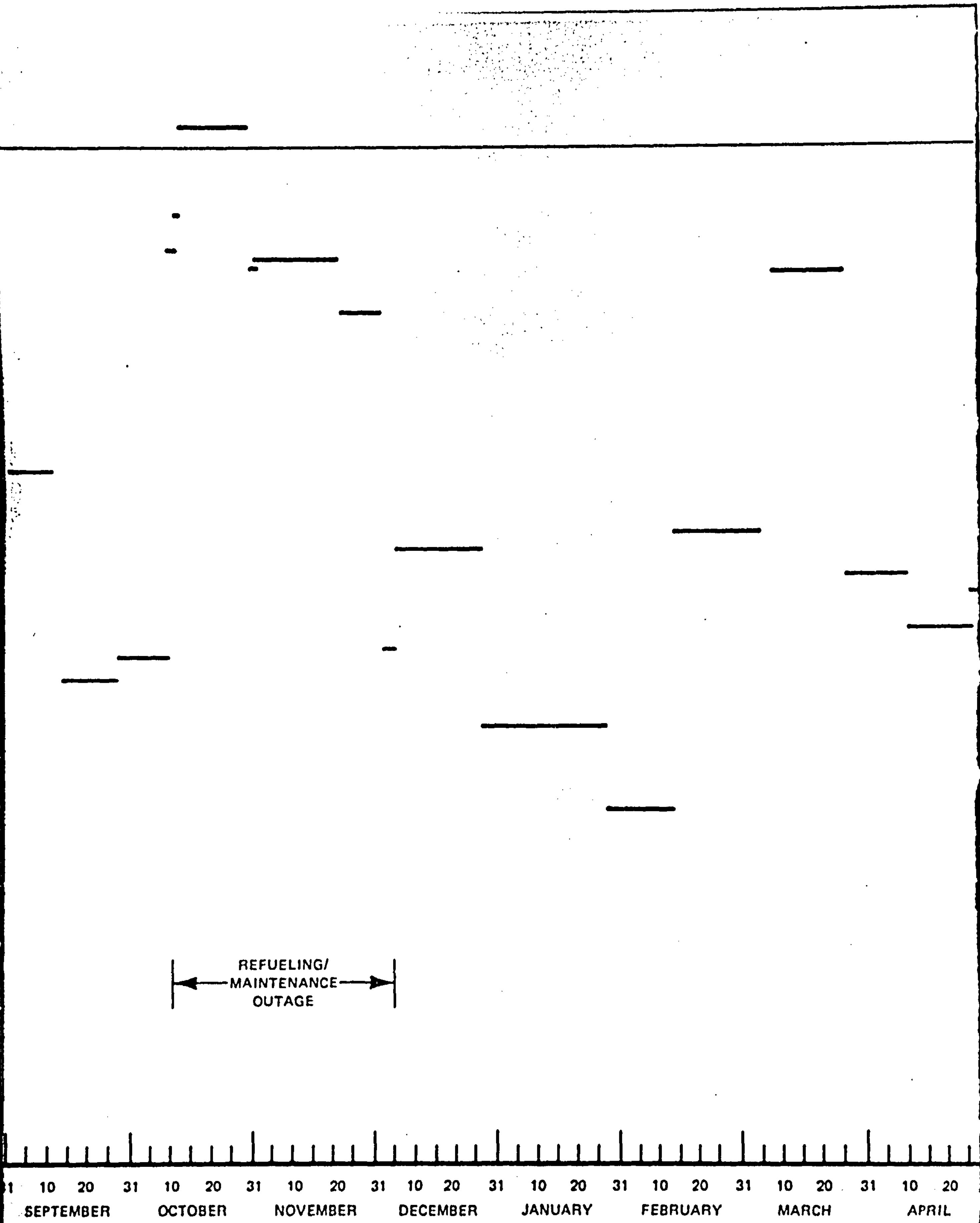
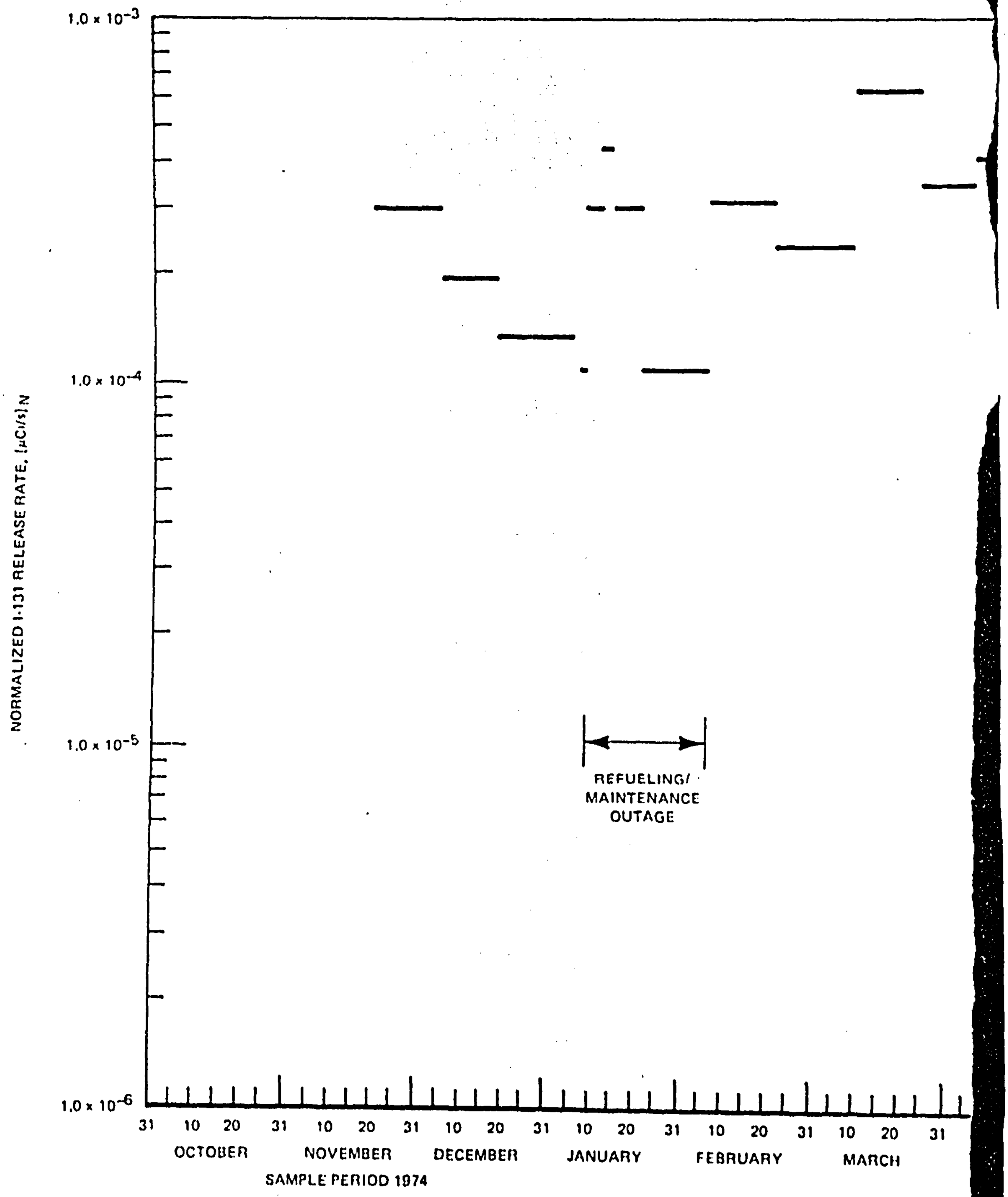


Figure 6-39. Normalized I-131 Release Rates, Reactor Building Ventilation Exhaust at Monticello (1974 and 1975)


REFUELING/
MAINTENANCE
OUTAGE
1 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL


1.0 x 10^-3
1.0 x 10^-4
1.0 x 10^-5
1.0 x 10^-6
NORMALIZED I-131 RELEASE RATE, [μCi/s]N
REFUELING/
MAINTENANCE
OUTAGE
31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
SAMPLE PERIOD 1974

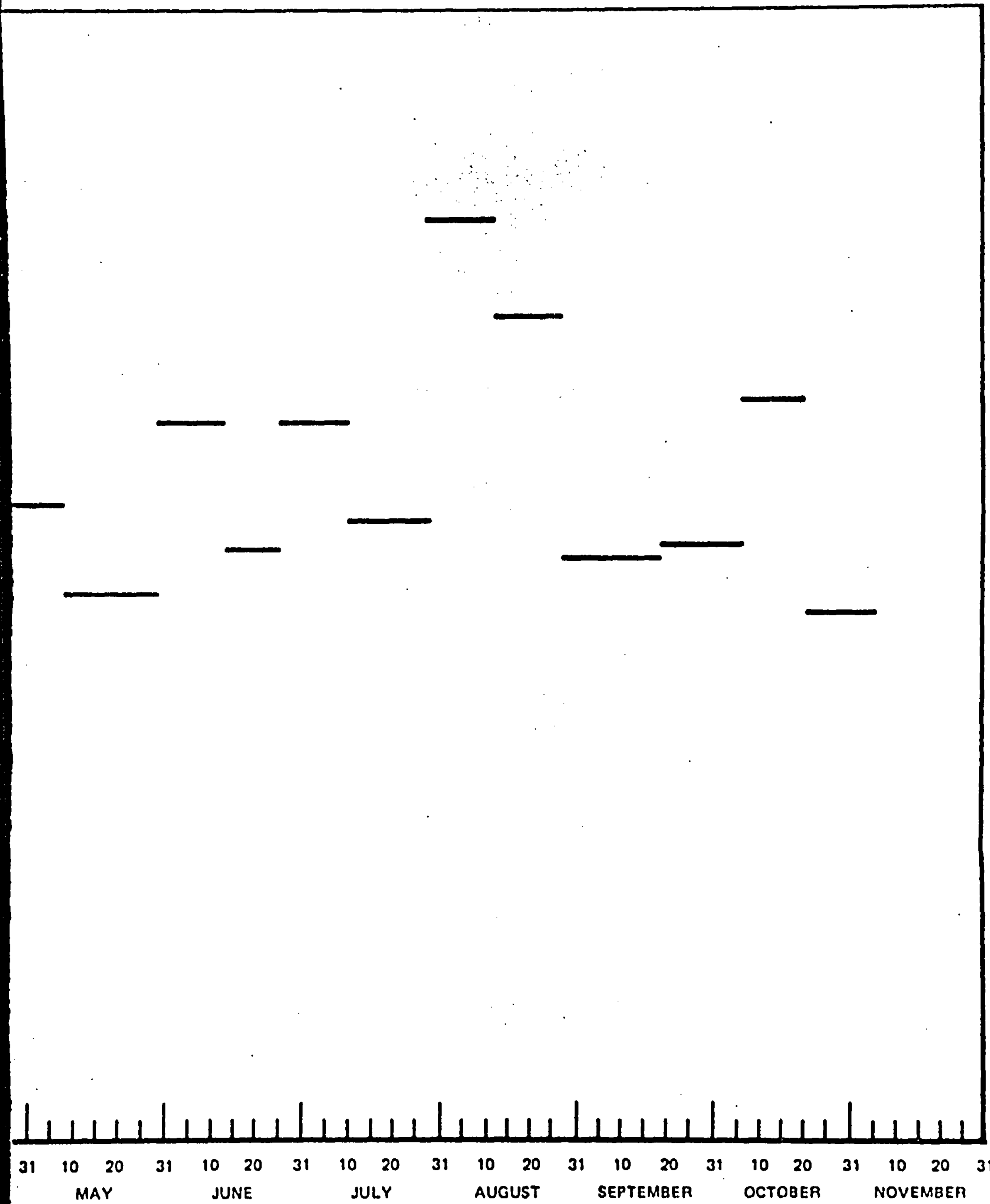
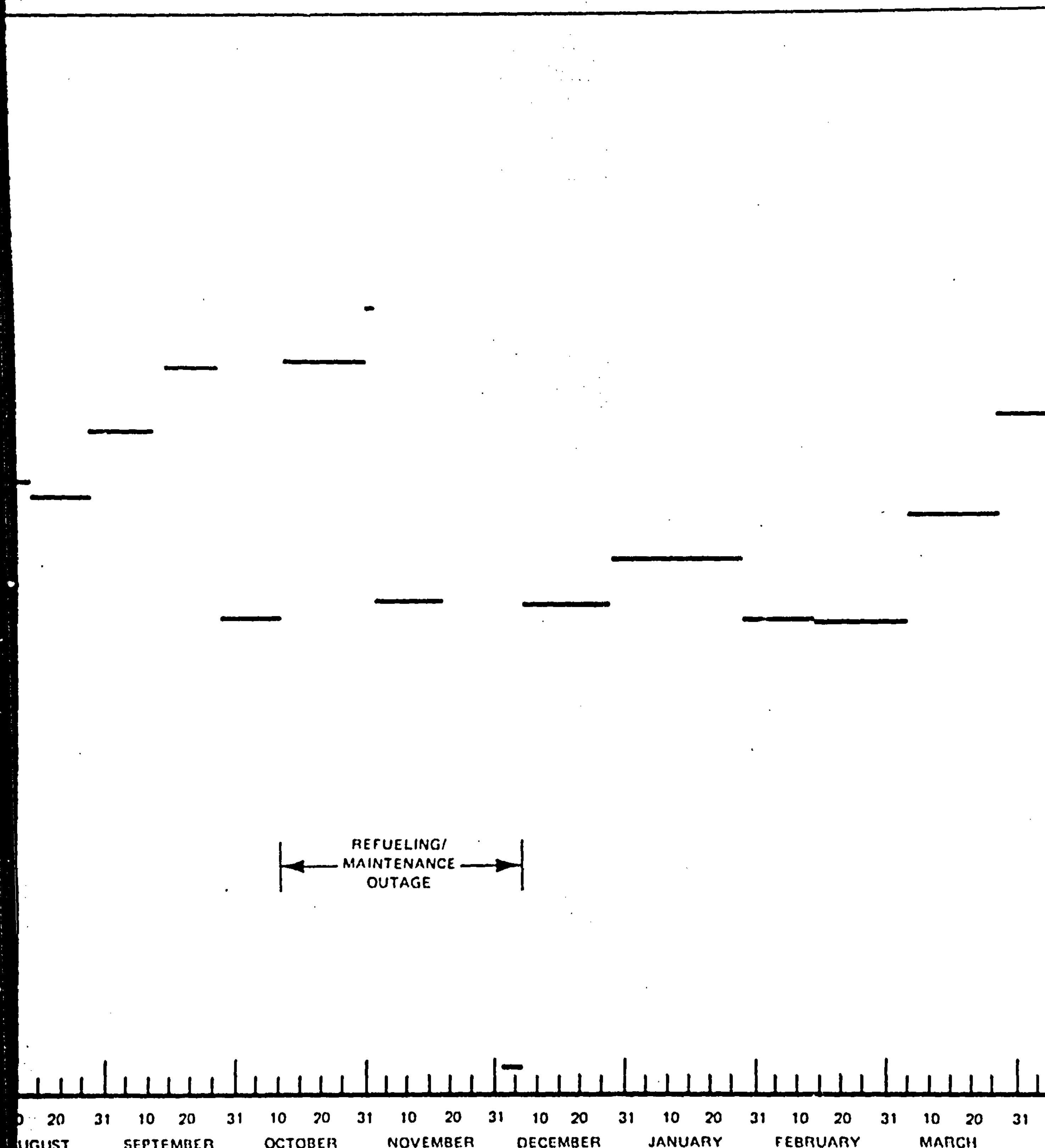


Figure 6-38. Normalized I-131 Release Rates, Reactor Building Ventilation Exhaust at Vermont Yankee (1974 and 1975)


REFUELING/
MAINTENANCE
OUTAGE
20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31
UGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH

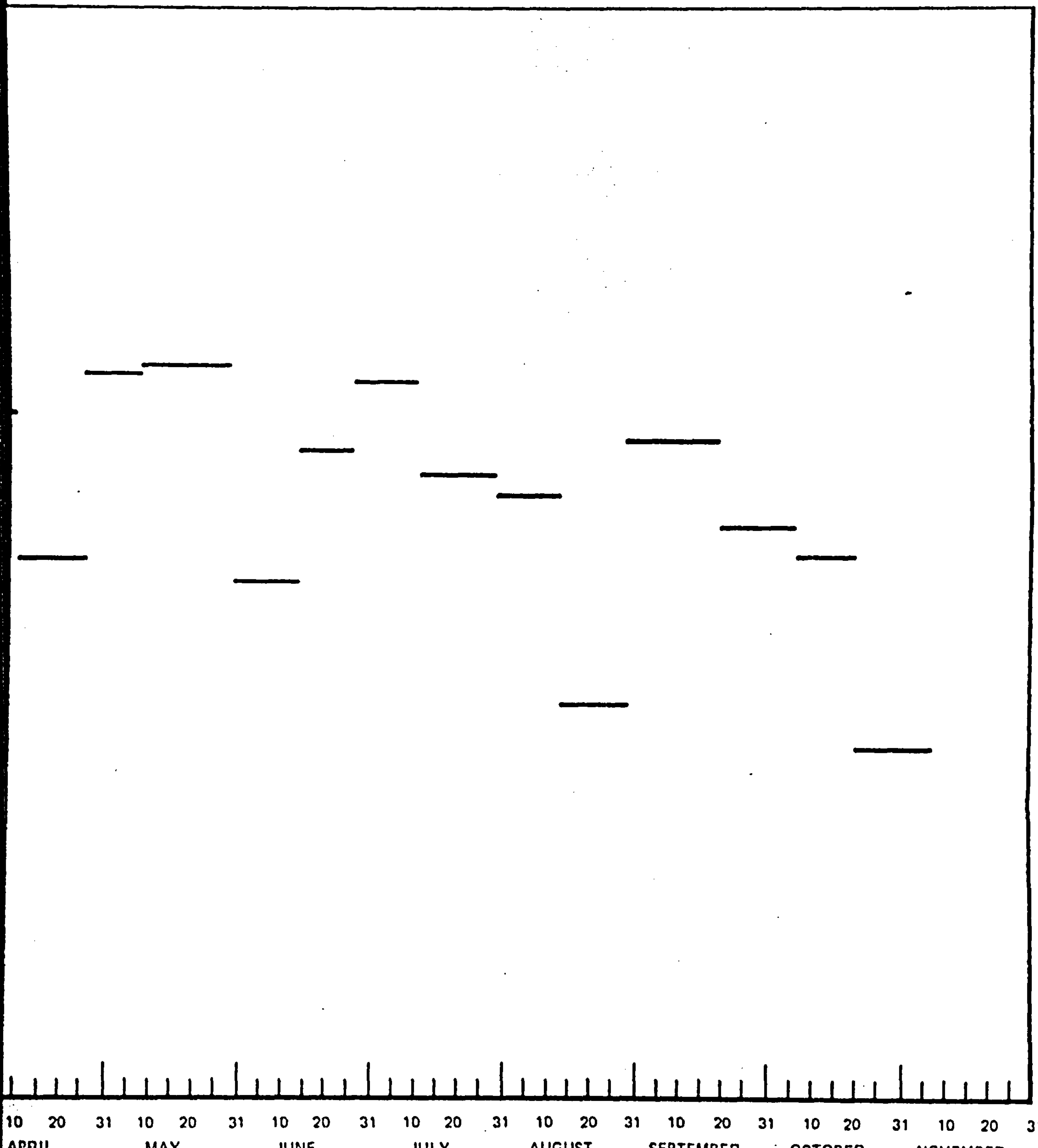
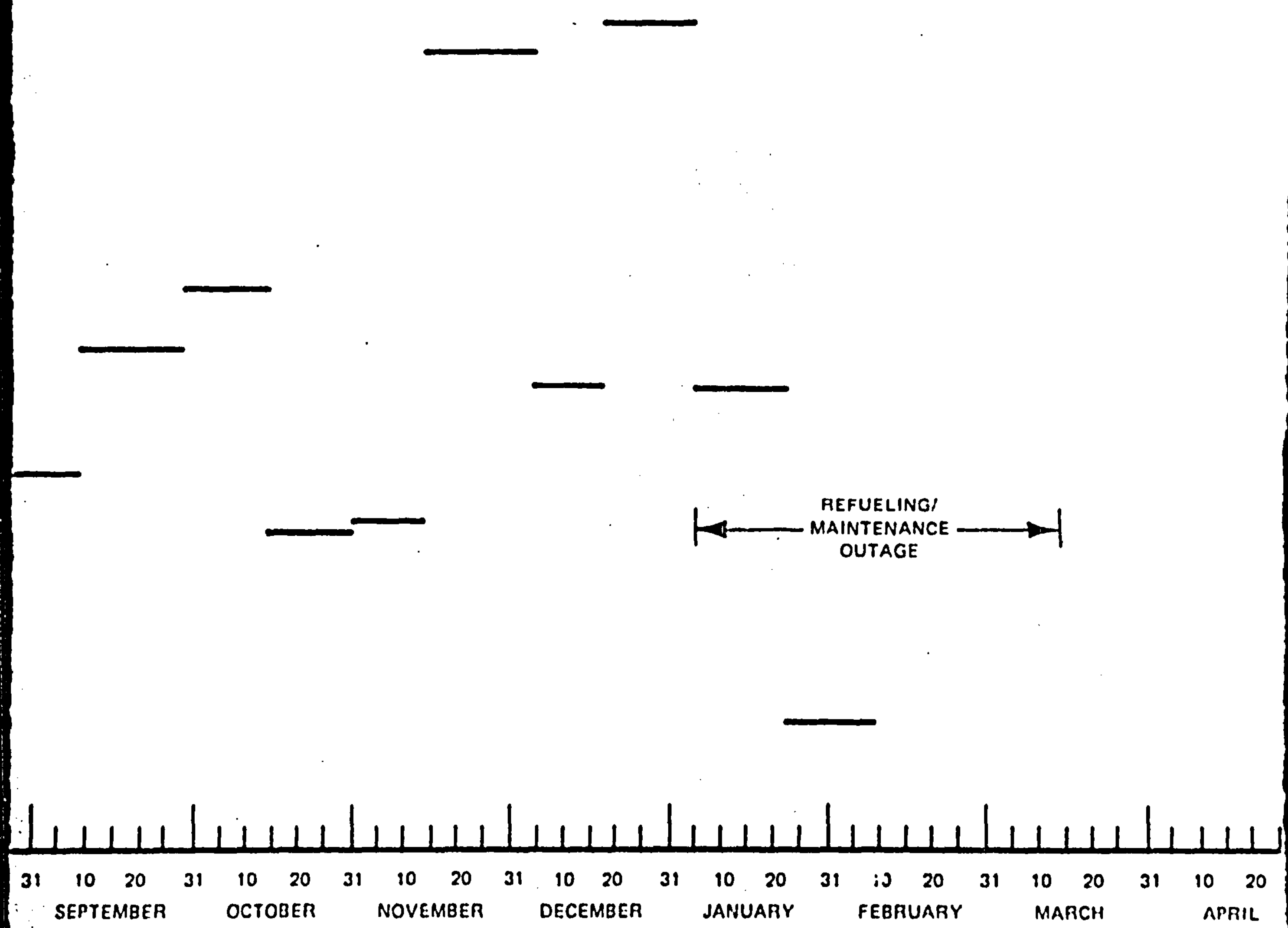
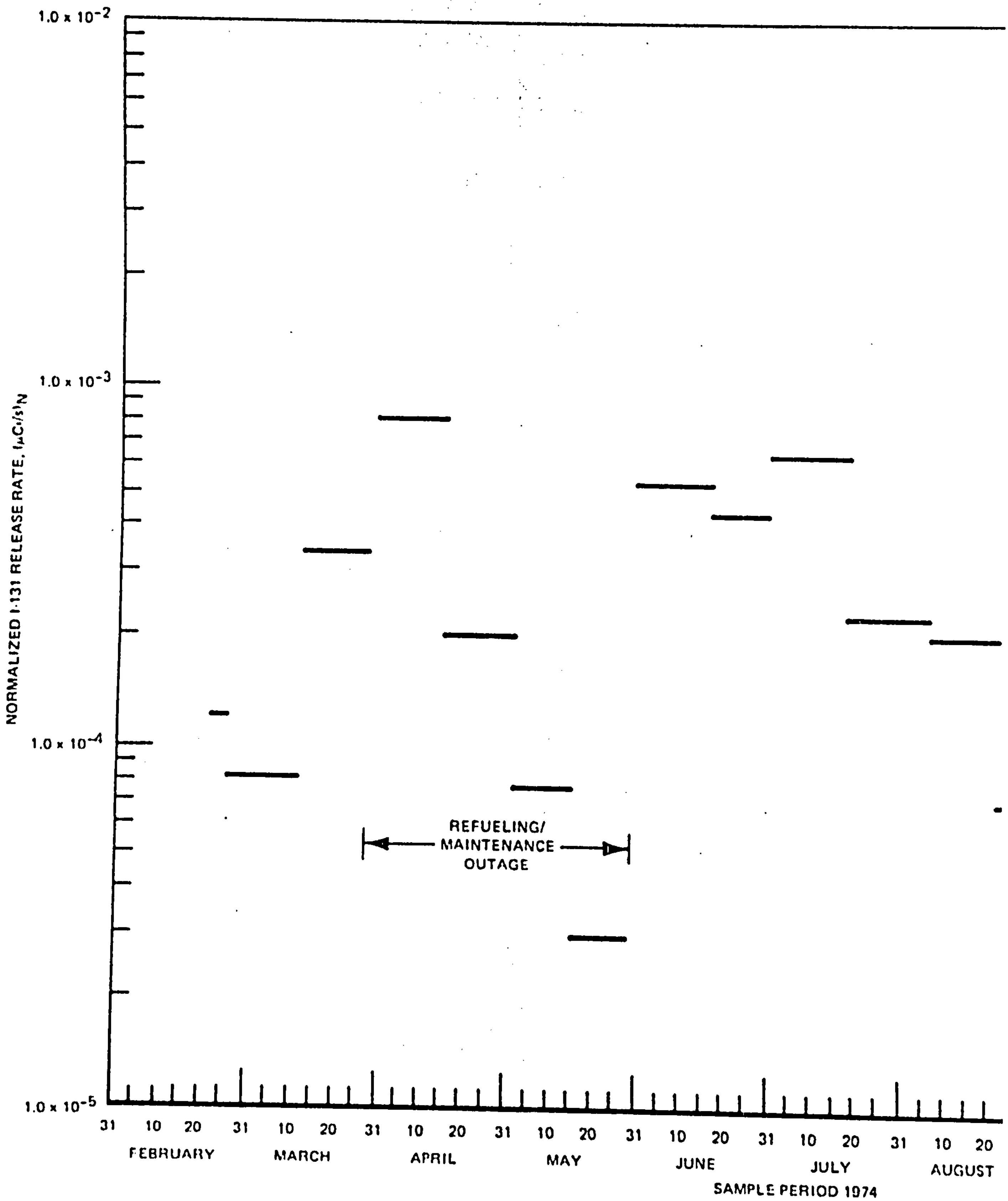


Figure 6-41. Normalized I-131 Release Rates, Turbine Building Ventilation Exhaust at Vermont Yankee (1974 and 1975)


REFUELING/
MAINTENANCE
OUTAGE
31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL



1.0 x 10^-2
1.0 x 10^-3
1.0 x 10^-4
1.0 x 10^-5
NORMALIZED I-131 RELEASE RATE, (μCi/s)N
REFUELING/
MAINTENANCE
OUTAGE
31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SAMPLE PERIOD 1974

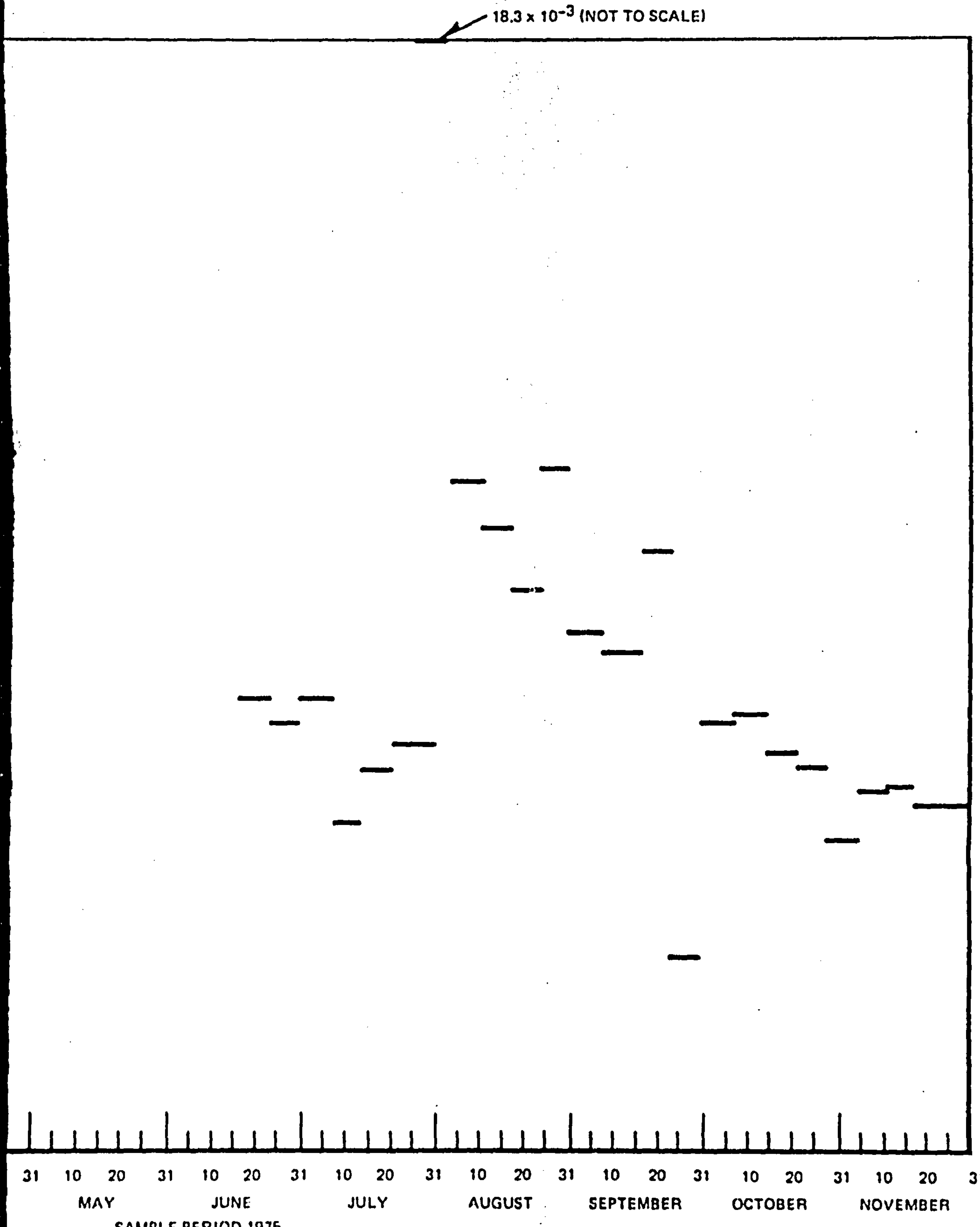
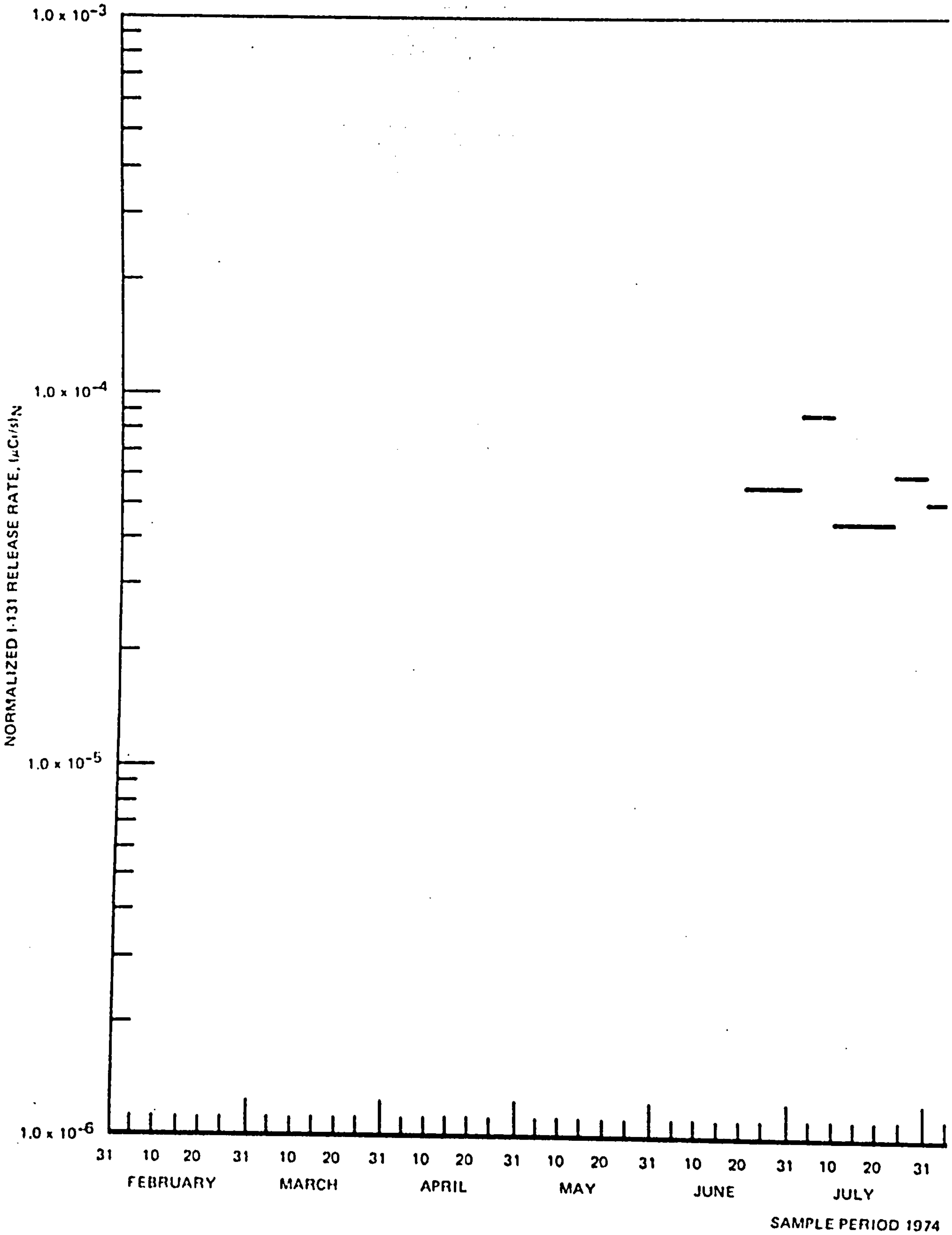
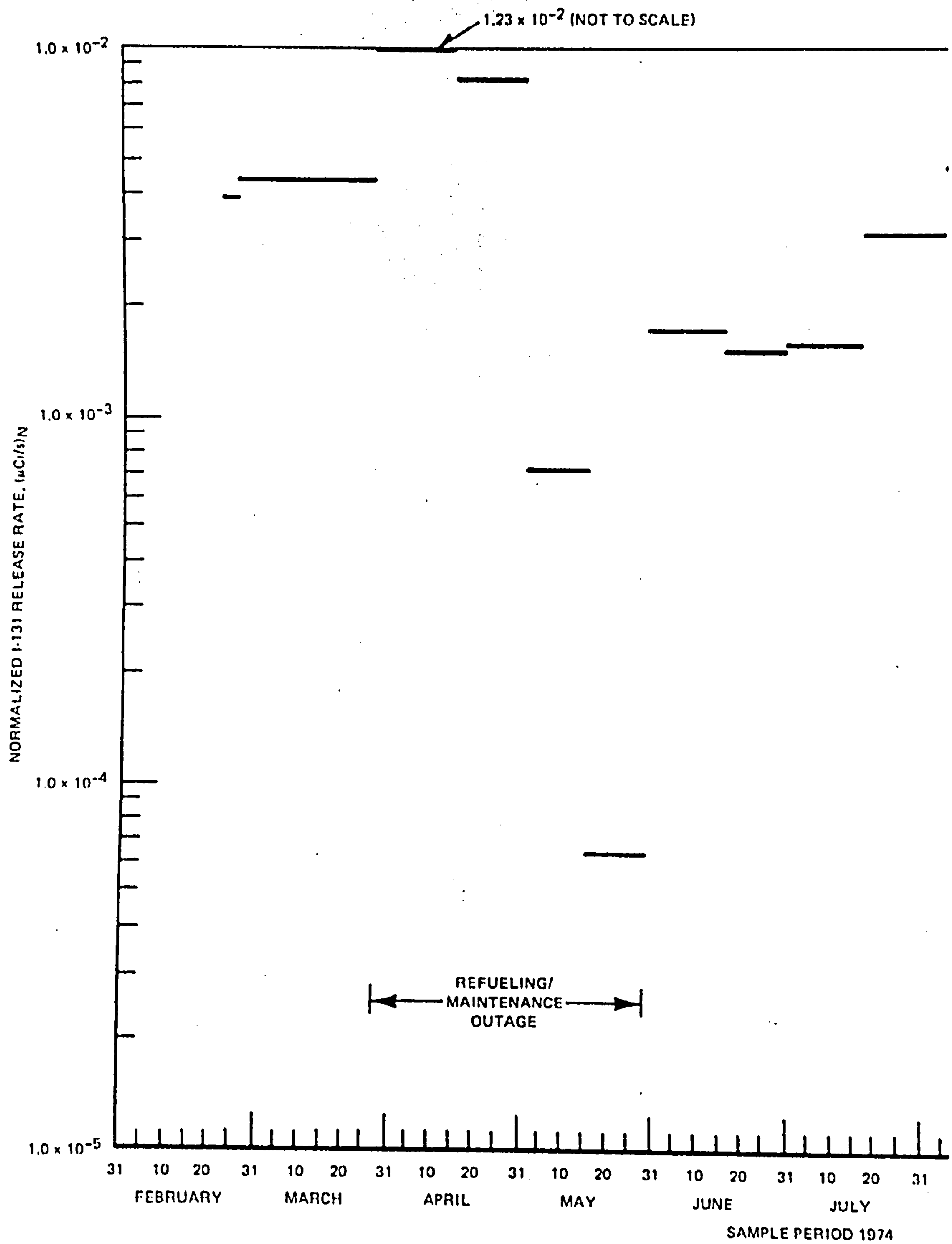


Figure 6-40. Normalized I-131 Release Rates, Reactor Building Ventilation Exhaust at Oyster Creek (1975 and 1976)



1.0 x 10⁻³
1.0 x 10⁻⁴
1.0 x 10⁻⁵
1.0 x 10⁻⁶
NORMALIZED I-131 RELEASE RATE, µCi/s/N
31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
SAMPLE PERIOD 1974



1.23 x 10^-2 (NOT TO SCALE)
1.0 x 10^-2
1.0 x 10^-3
1.0 x 10^-4
1.0 x 10^-5
NORMALIZED I-131 RELEASE RATE, (μCi/s)N
REFUELING/
MAINTENANCE
OUTAGE
31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
SAMPLE PERIOD 1974

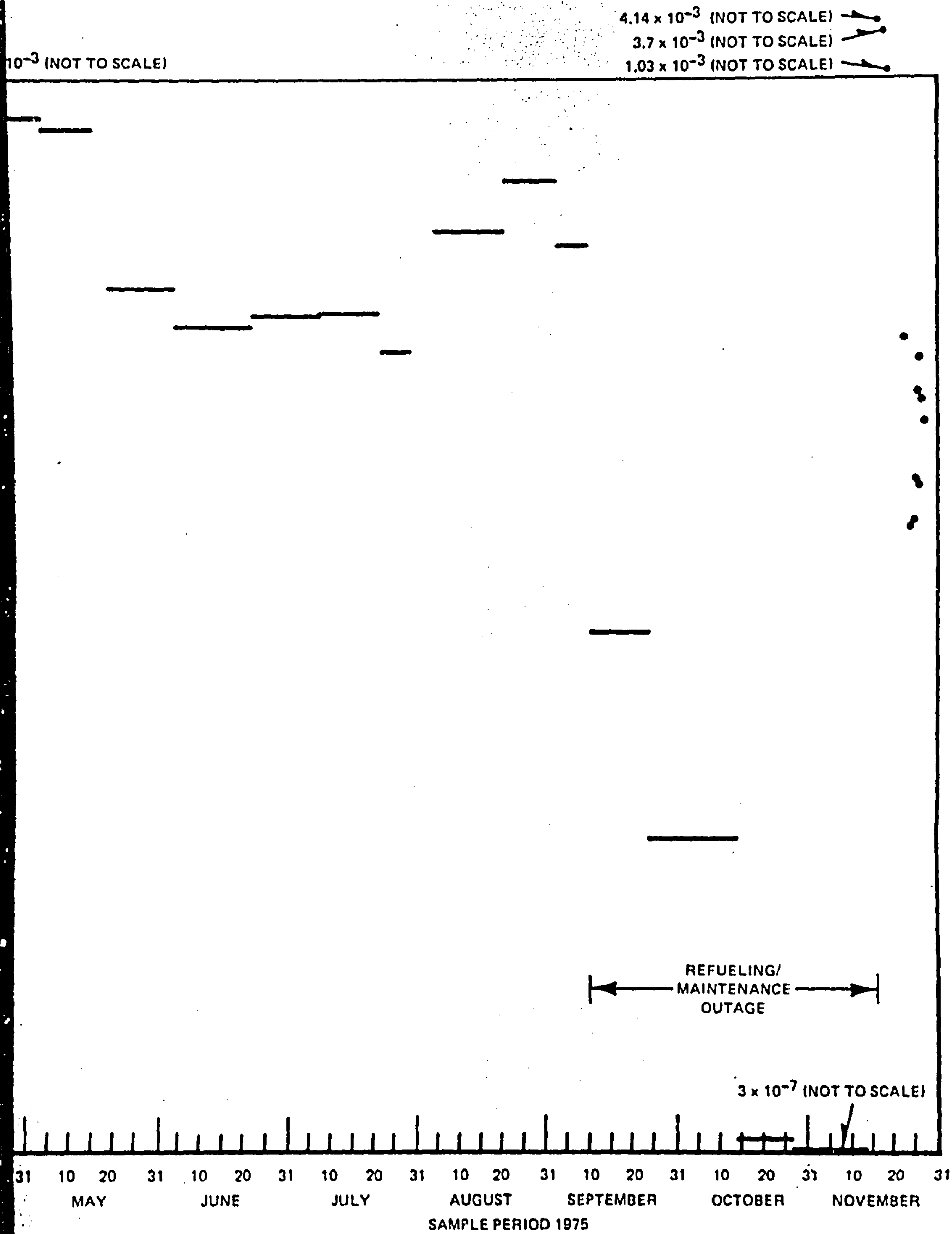
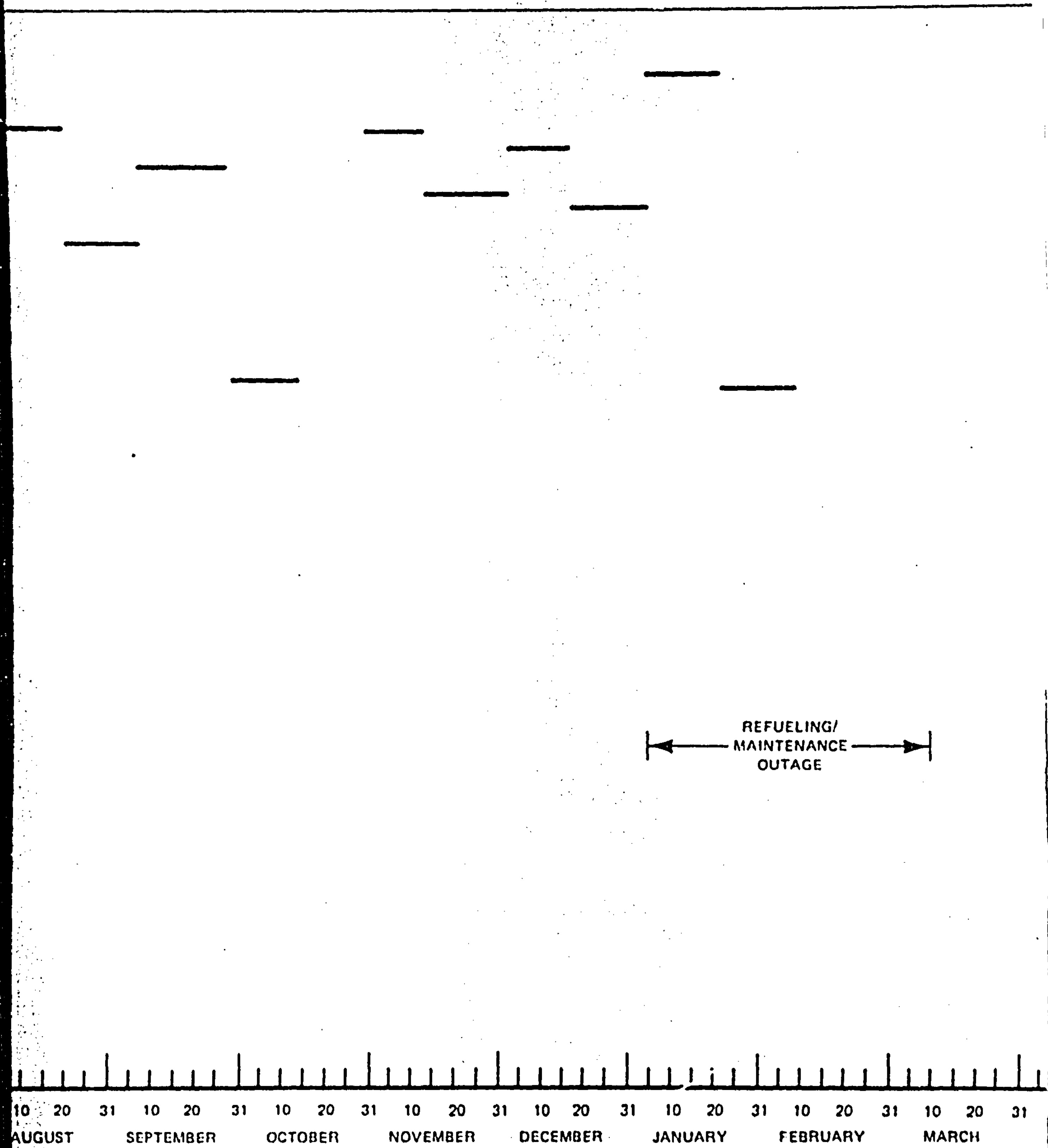
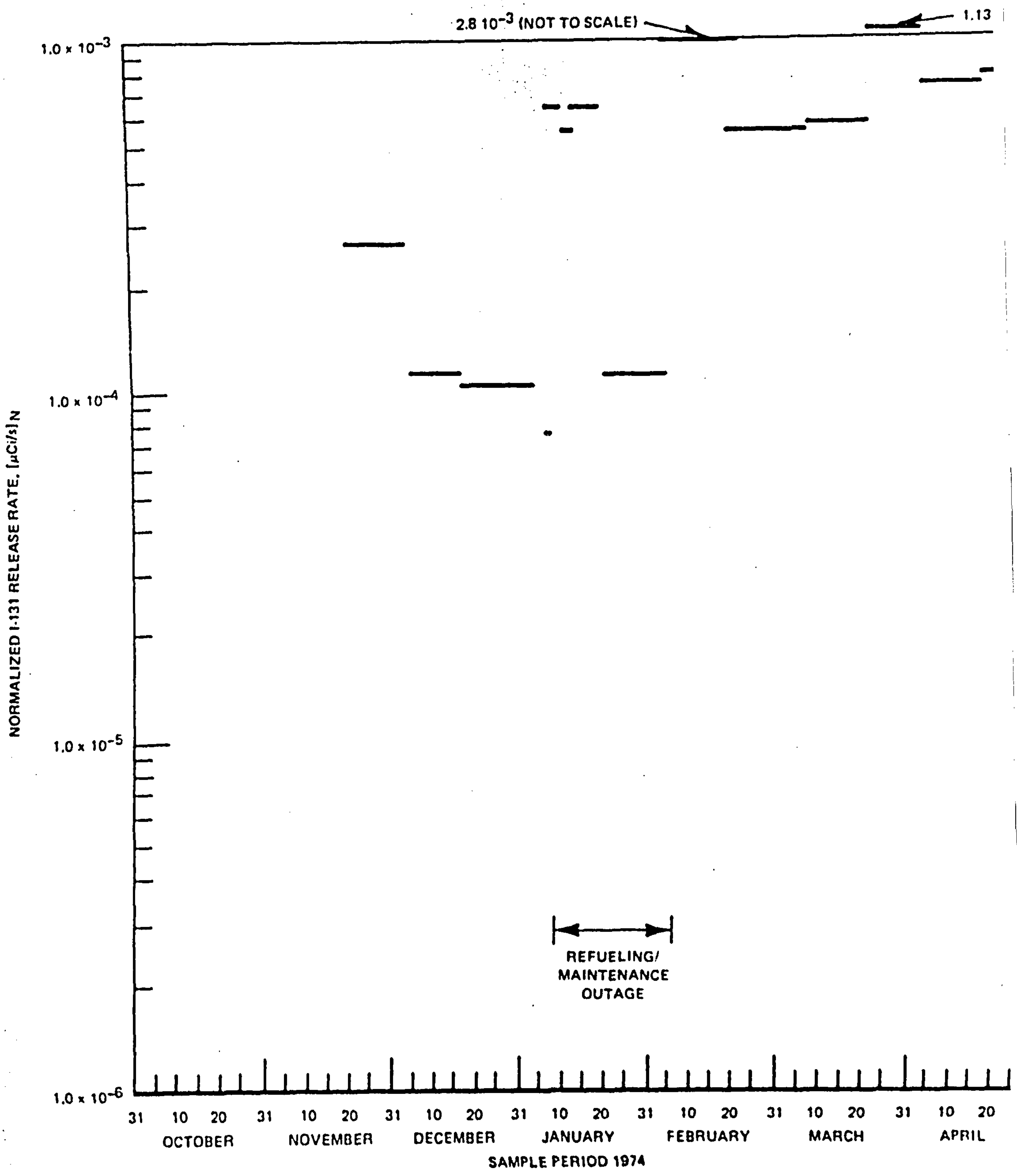


Figure 6-42. Normalized I-131 Release Rates, Turbine Building Ventilation Exhaust at Monticello (1974 and 1975)


REFUELING/
MAINTENANCE
OUTAGE
10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH



2.8 10^{-3} (NOT TO SCALE)
1.13
1.0×10^{-3}
1.0×10^{-4}
1.0×10^{-5}
1.0×10^{-6}
NORMALIZED I-131 RELEASE RATE, [μCi/s]N
REFUELING/
MAINTENANCE
OUTAGE
31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20
OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL
SAMPLE PERIOD 1974

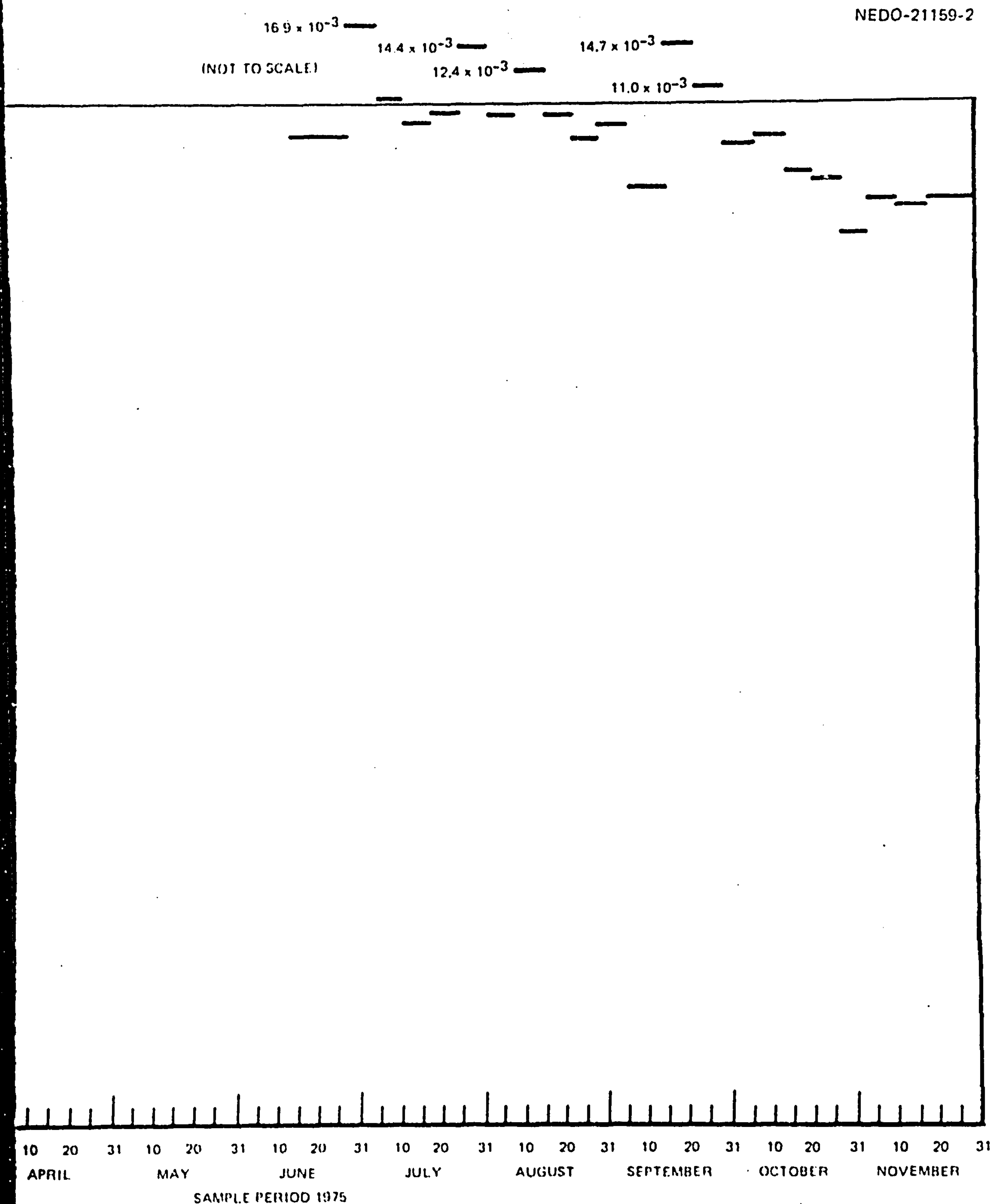
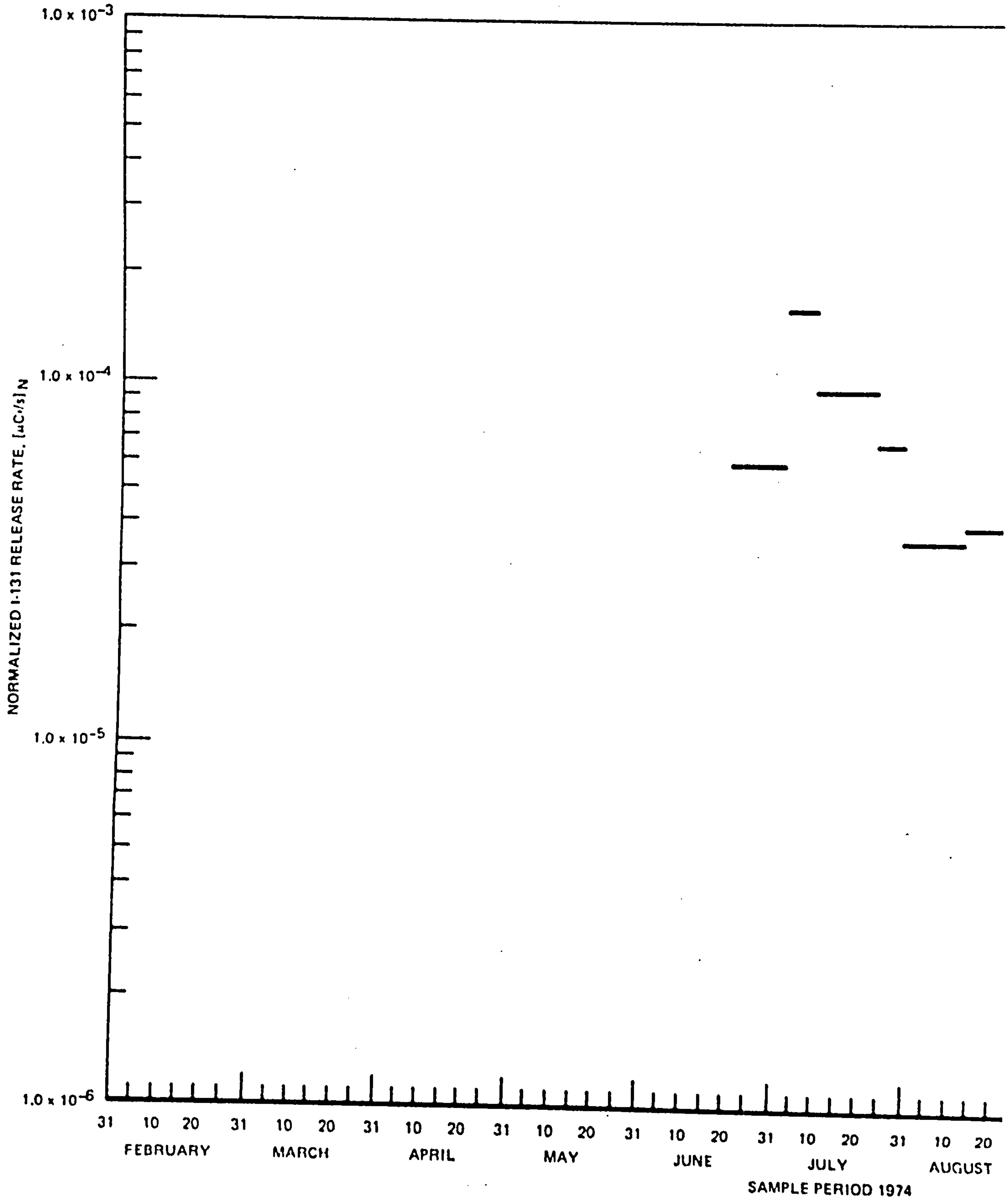


Figure 6-43 Normalized I-131 Release Rates, Turbine Building Ventilation Exhaust at Oyster Creek (1975 and 1976)


1.0 x 10^-3
1.0 x 10^-4
1.0 x 10^-5
1.0 x 10^-6
NORMALIZED I-131 RELEASE RATE, [μCi/s]N
31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SAMPLE PERIOD 1974

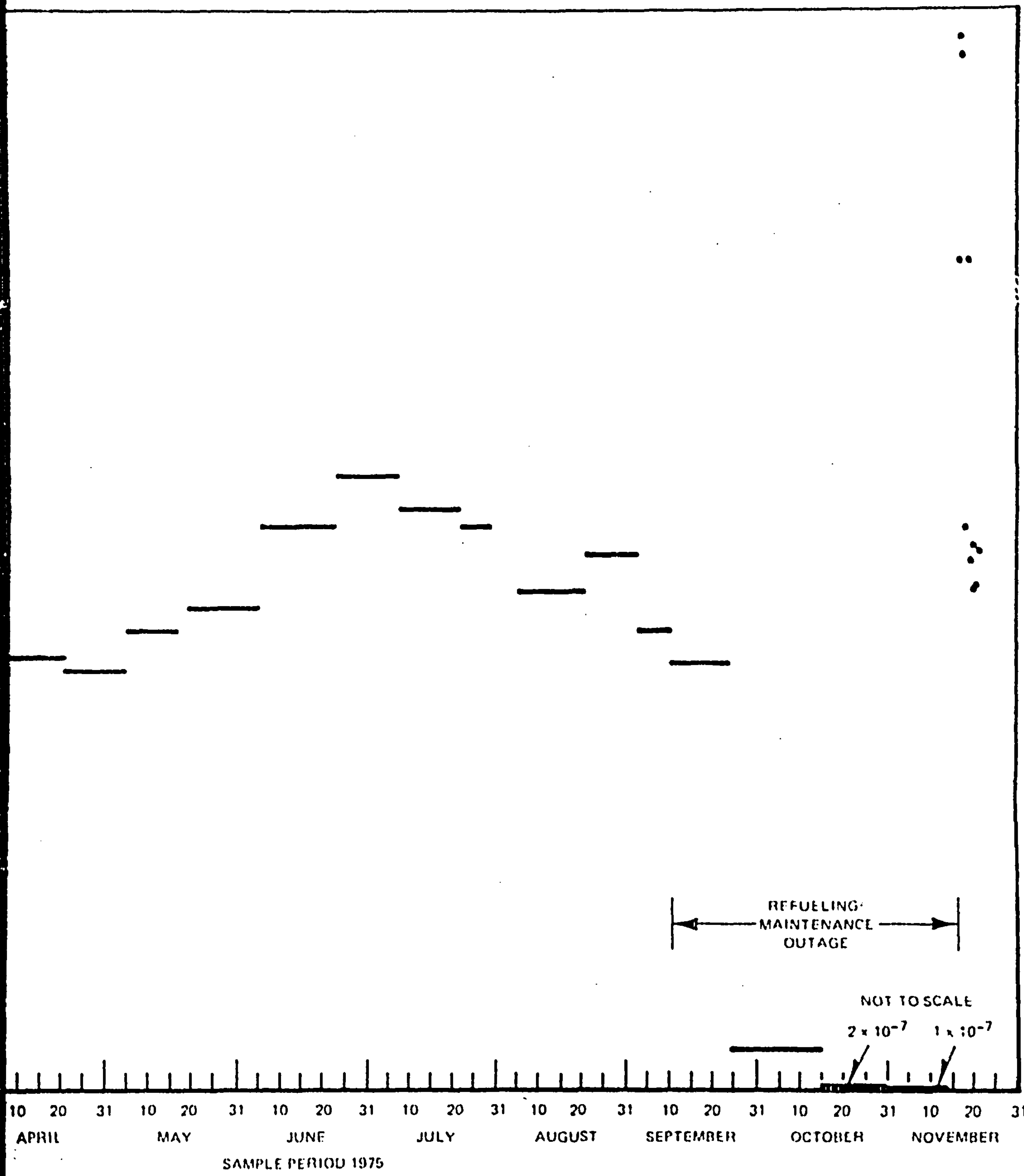
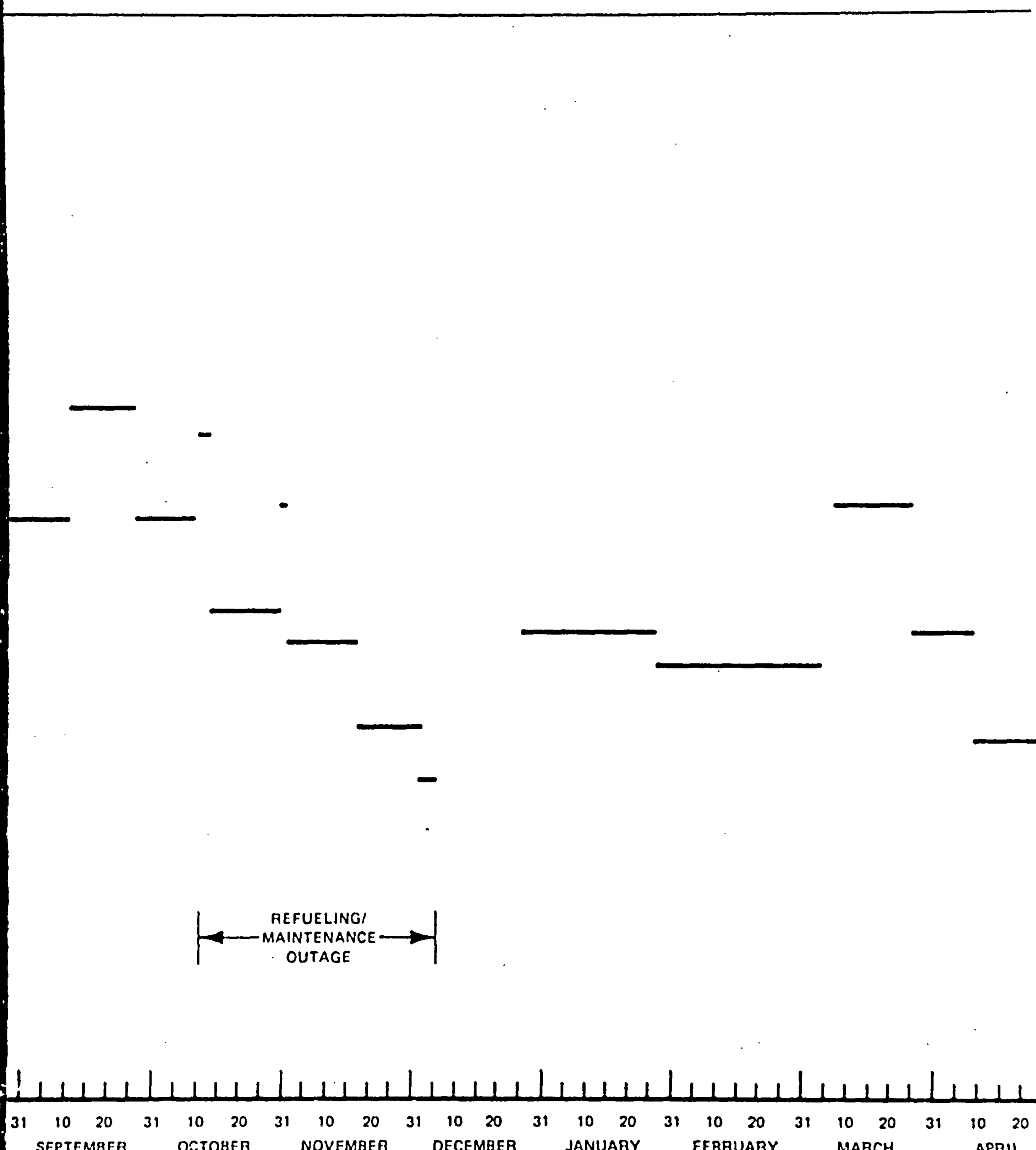


Figure 6-45. Normalized I-131 Release Rates, Radwaste Building Ventilation Exhaust at Monticello (1974 and 1975)



REFUELING/
MAINTENANCE
OUTAGE
31
10
20
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31
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SEPTEMBER
OCTOBER
NOVEMBER
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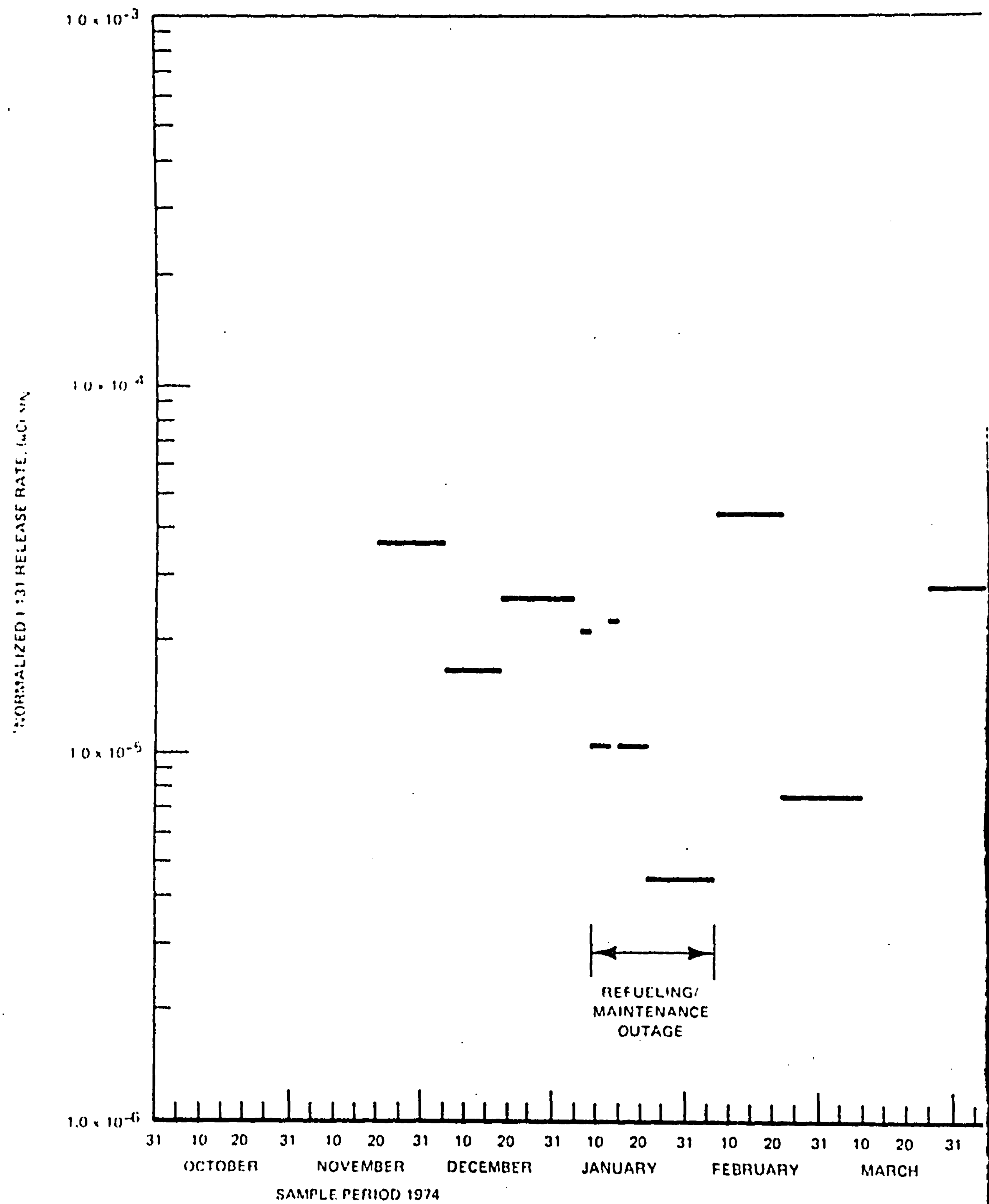
JANUARY
FEBRUARY
MARCH
APRIL



1.0 × 10⁻³
1.0 × 10⁻⁴
1.0 × 10⁻⁵
1.0 × 10⁻⁶
NORMALIZED I-131 RELEASE RATE, μCi/s
REFUELING/
MAINTENANCE
OUTAGE
31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
SAMPLE PERIOD 1974

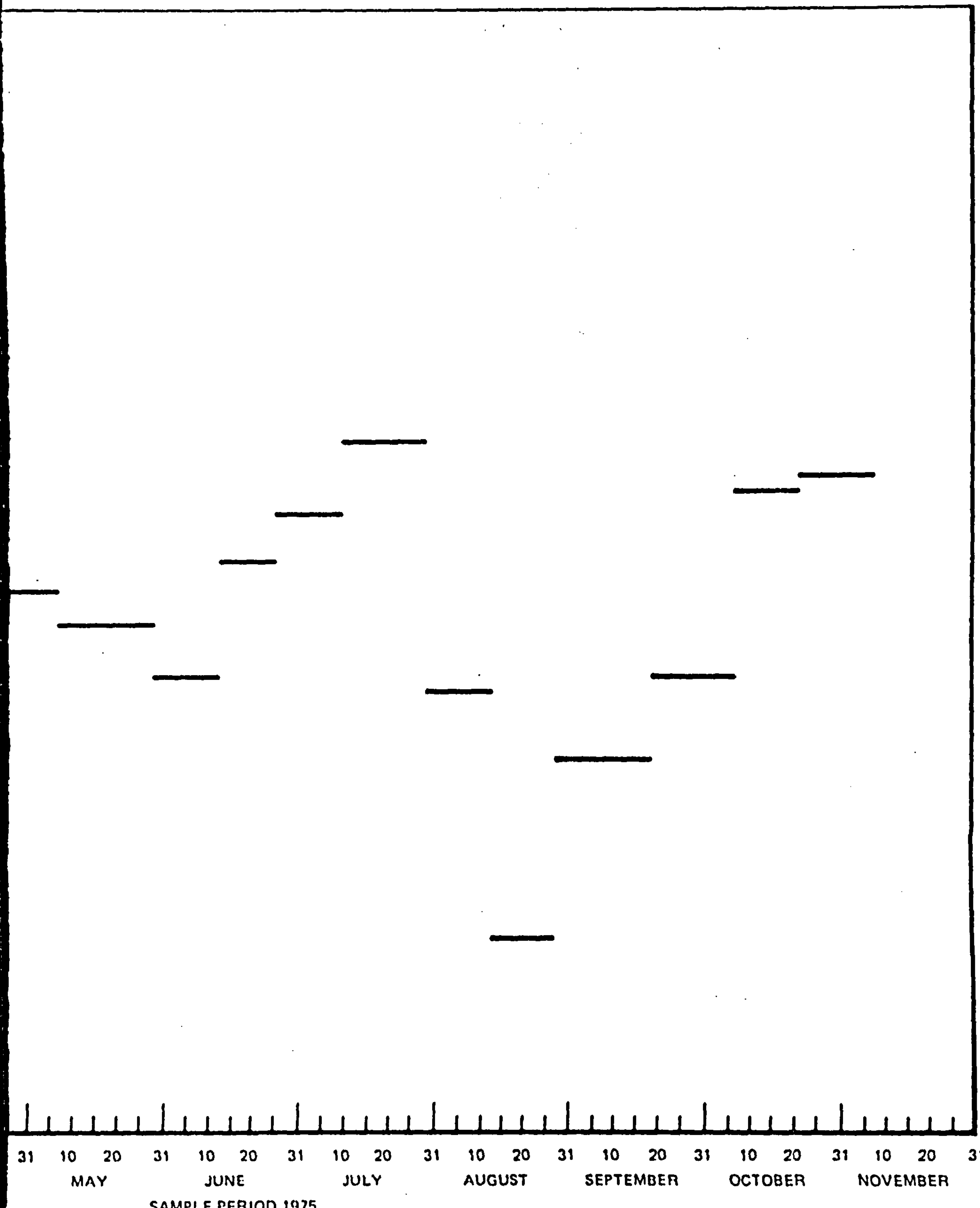
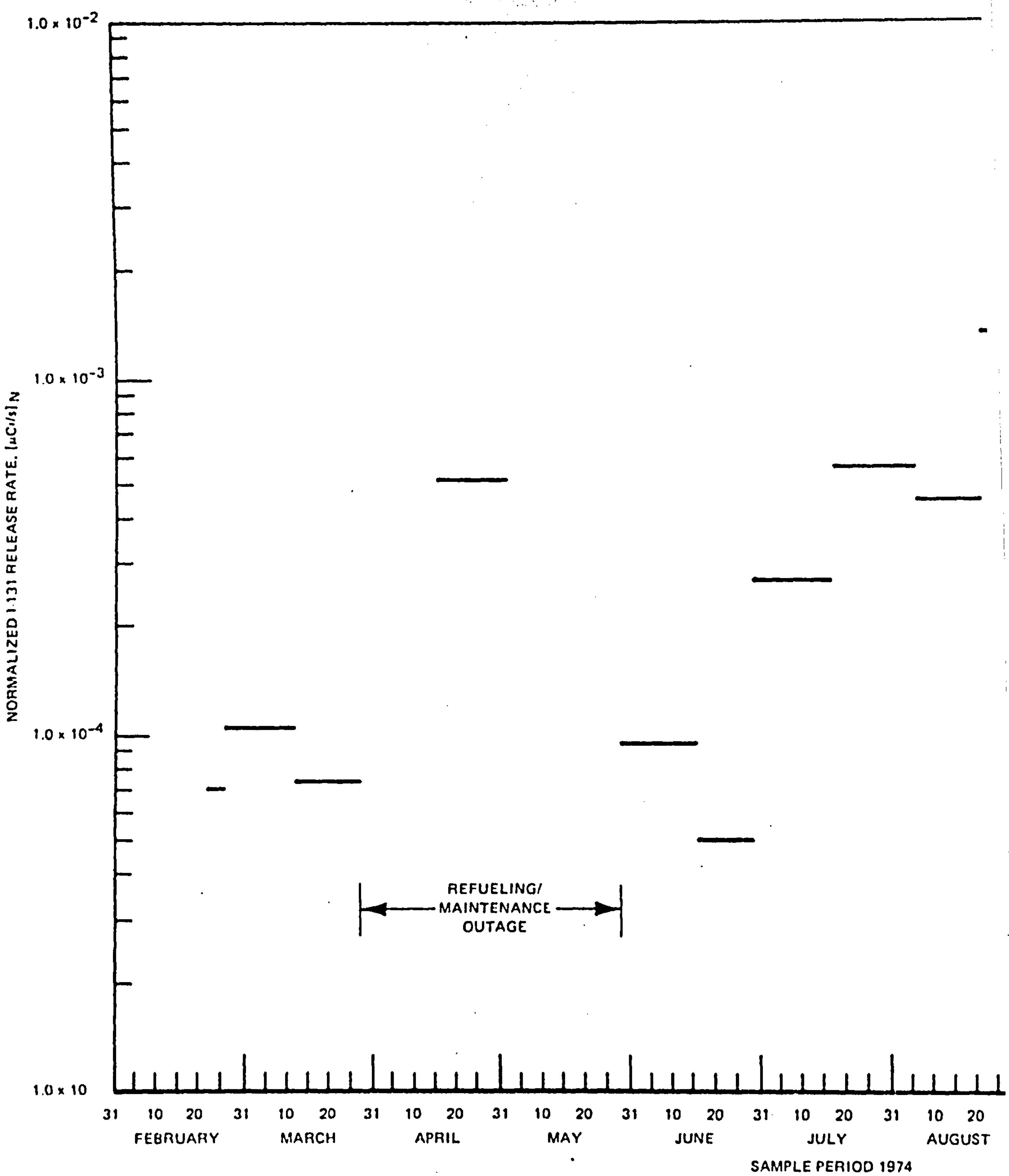
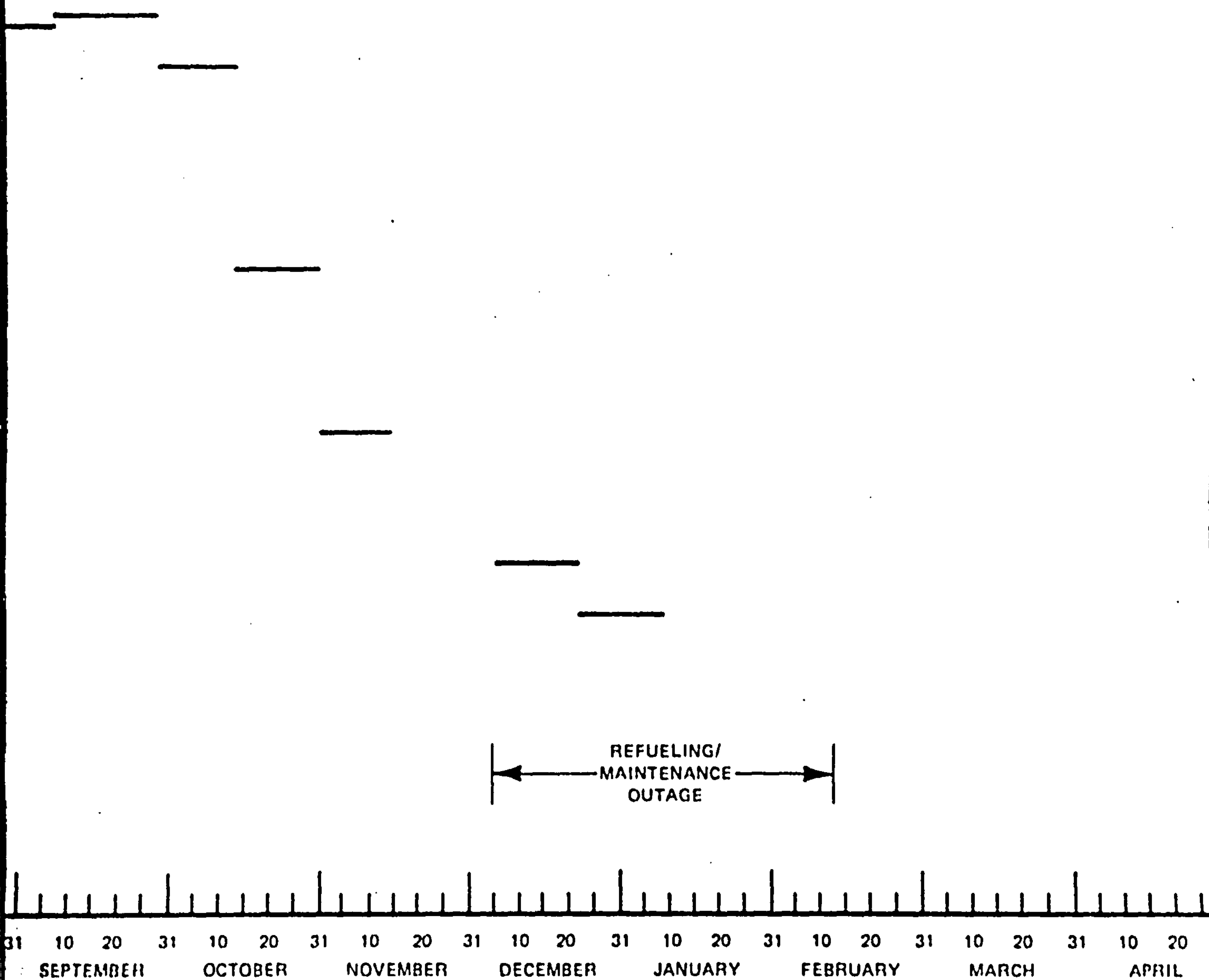


Figure 6-44. Normalized I-131 Release Rates, Radwaste Building Ventilation Exhaust at Vermont Yankee (1974 and 1975)



NORMALIZED I-131 RELEASE RATE, (μCi/s)N
1.0 x 10-2
1.0 x 10-3
1.0 x 10-4
1.0 x 10
REFUELING/
MAINTENANCE
OUTAGE
31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SAMPLE PERIOD 1974


REFUELING/
MAINTENANCE
OUTAGE
31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20 31 10 20
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL

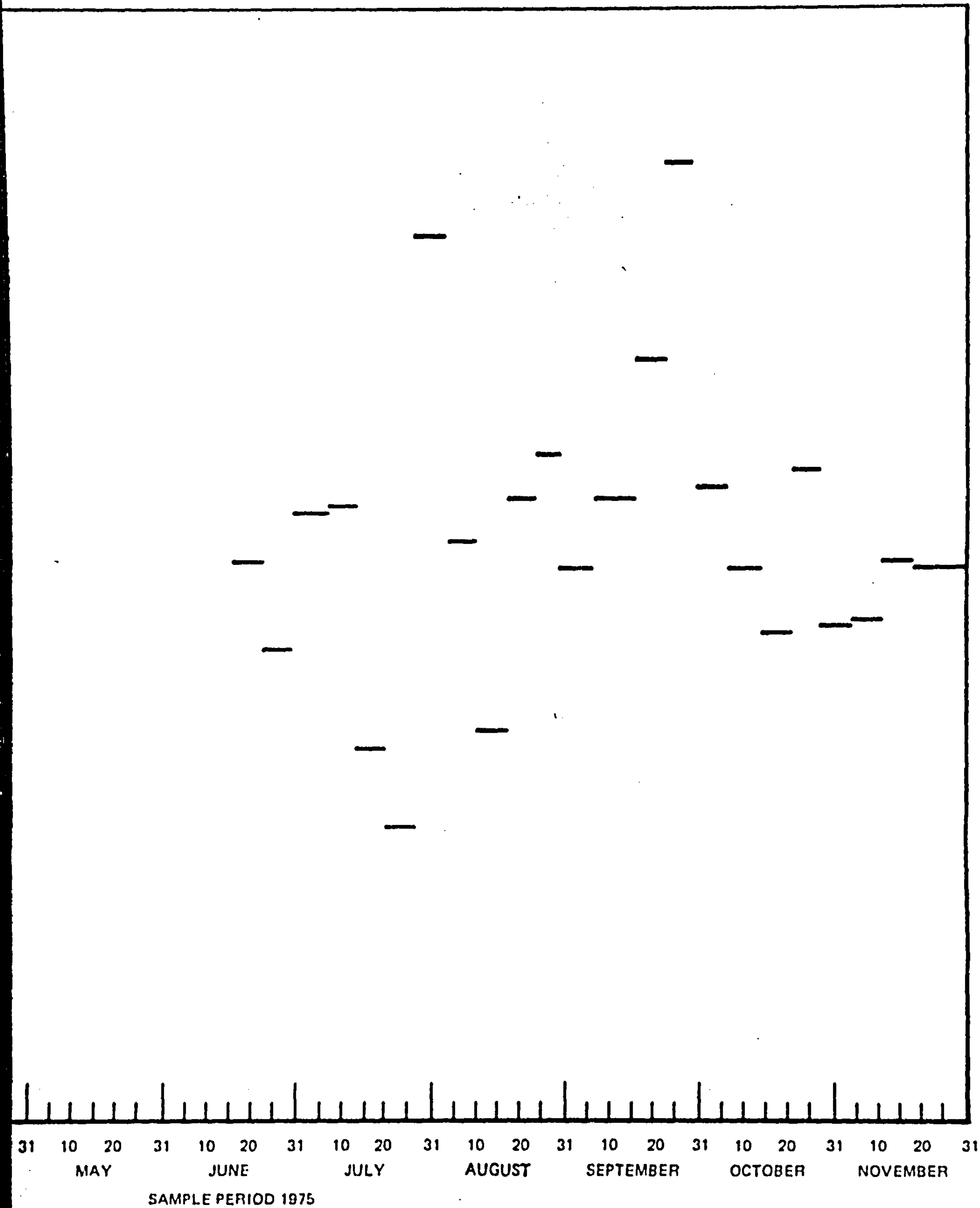


Figure 6-46. Normalized I-131 Release Rates, Radwaste Building Ventilation Exhaust at Oyster Creek (1975 and 1976)

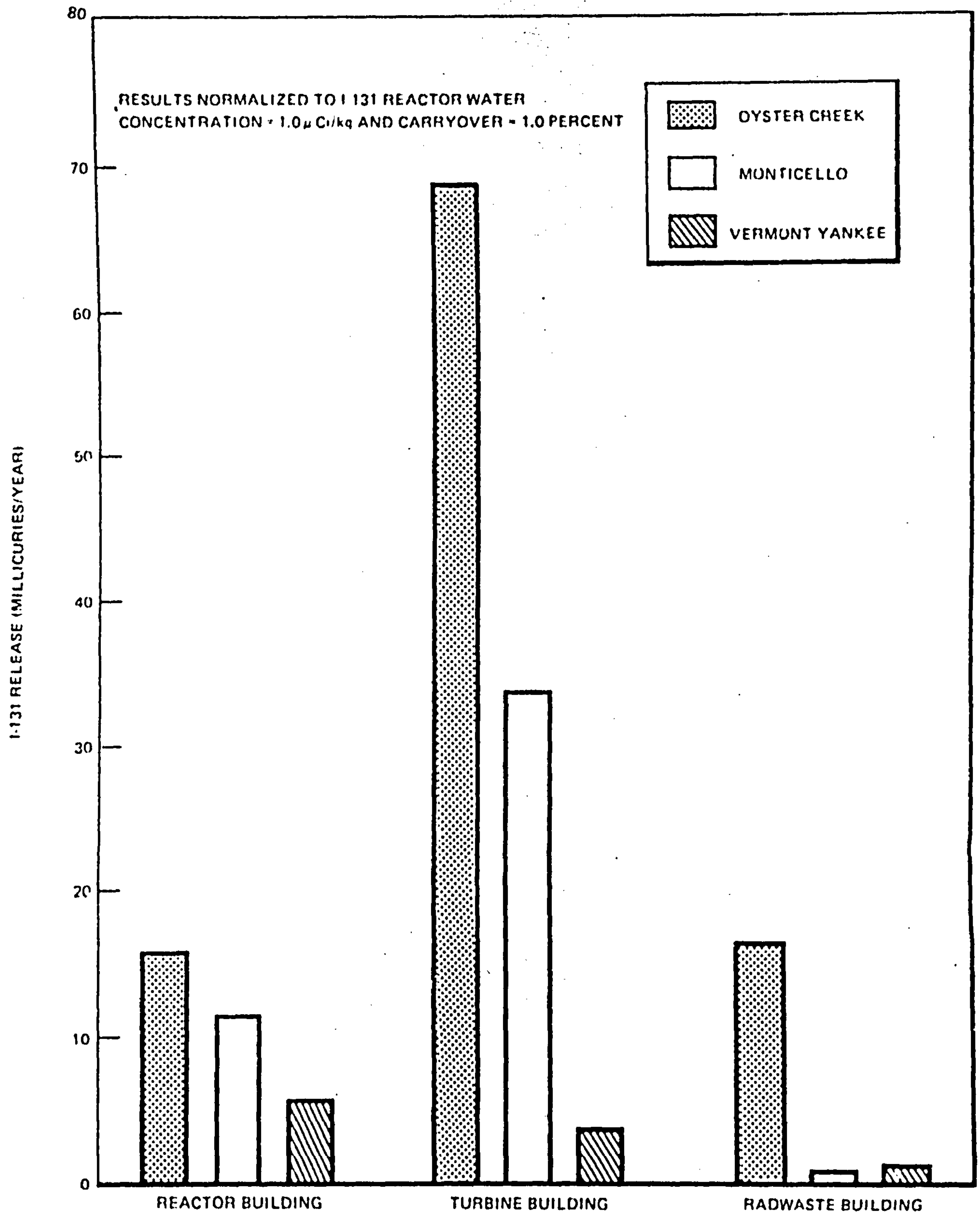


Figure 6-47. Bar Graph of Normalized I-131 Airborne Releases at Three BWRs for All Plant Operations

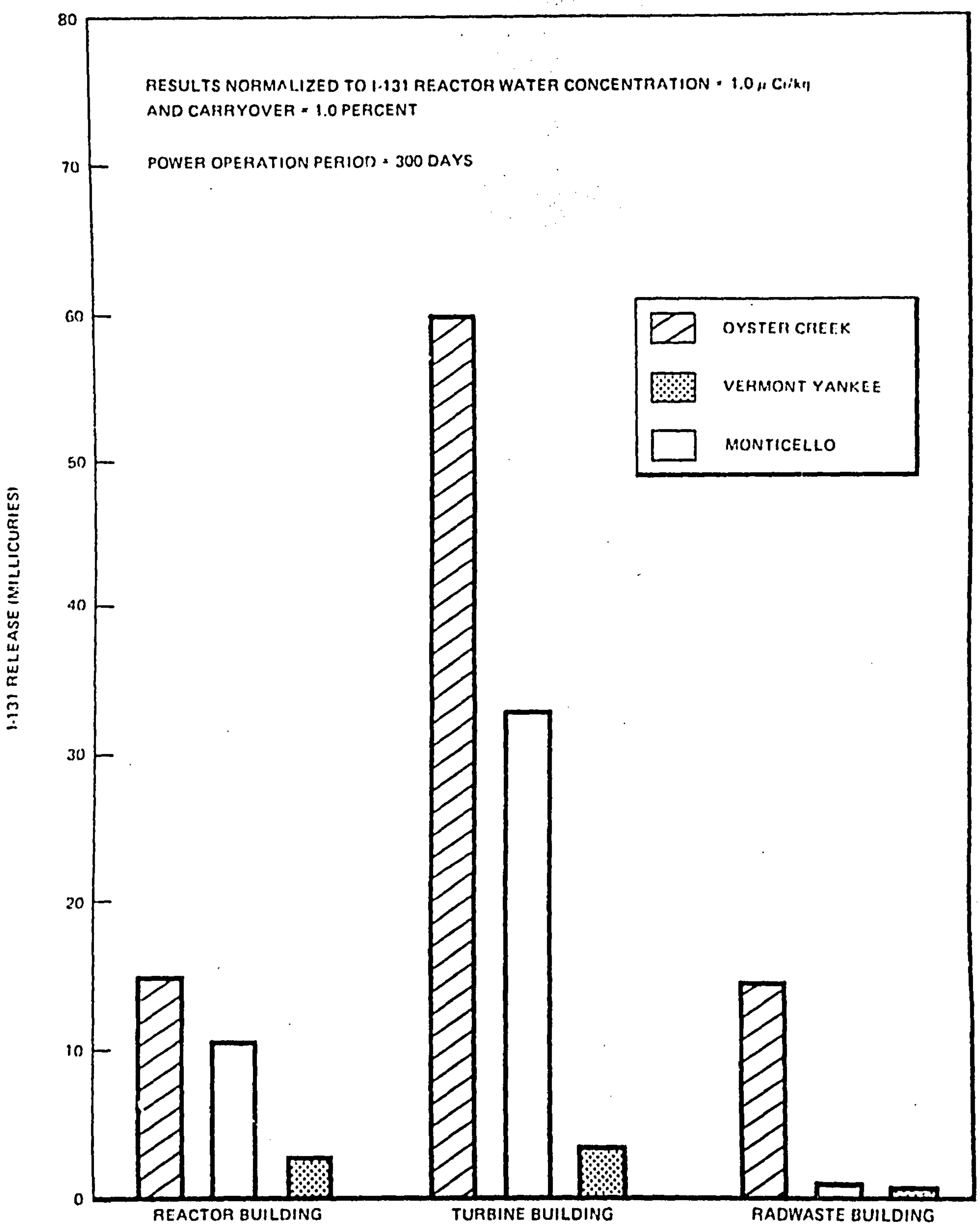


Figure 6-48. Bar Graph of Normalized I-131 Airborne Releases at Three BWRs for Power Generation Operations

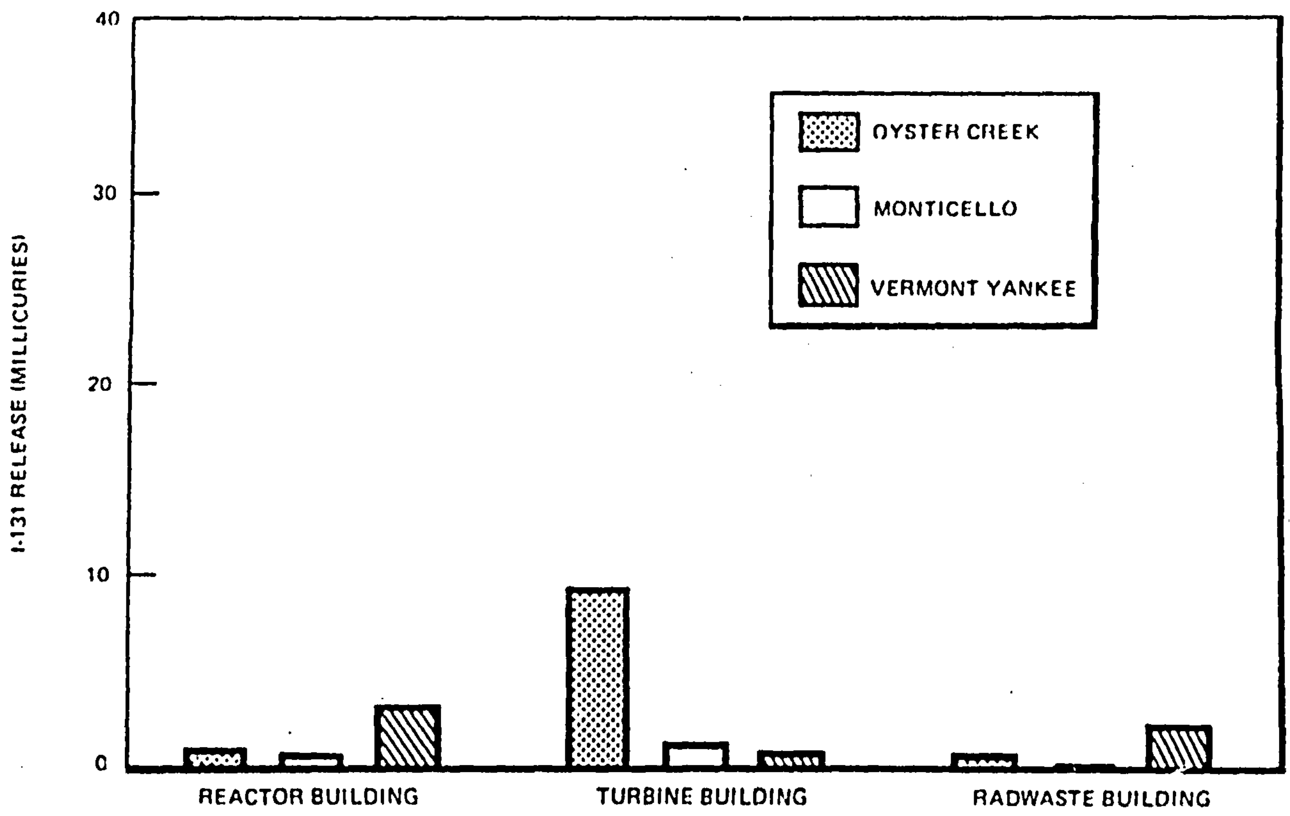


Figure 6-49. Bar Graph of Normalized I-131 Airborne Releases at Three BWRs for One Refueling/Maintenance Outage

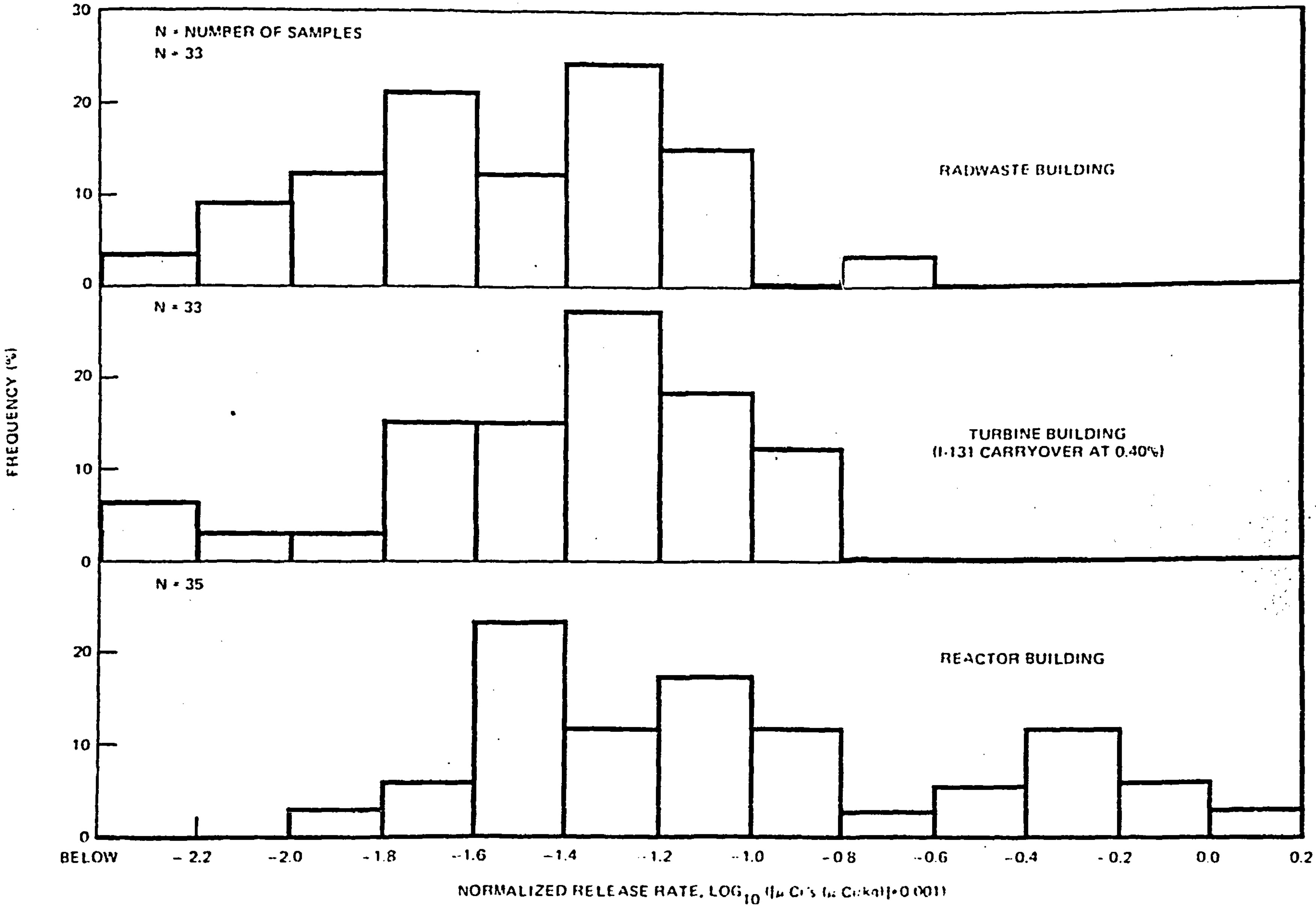


Figure 6-50. Frequency Polygons of Normalized I-131 Airborne Release Rates From Reactor, Turbine and Radwaste Buildings at Vermont Yankee

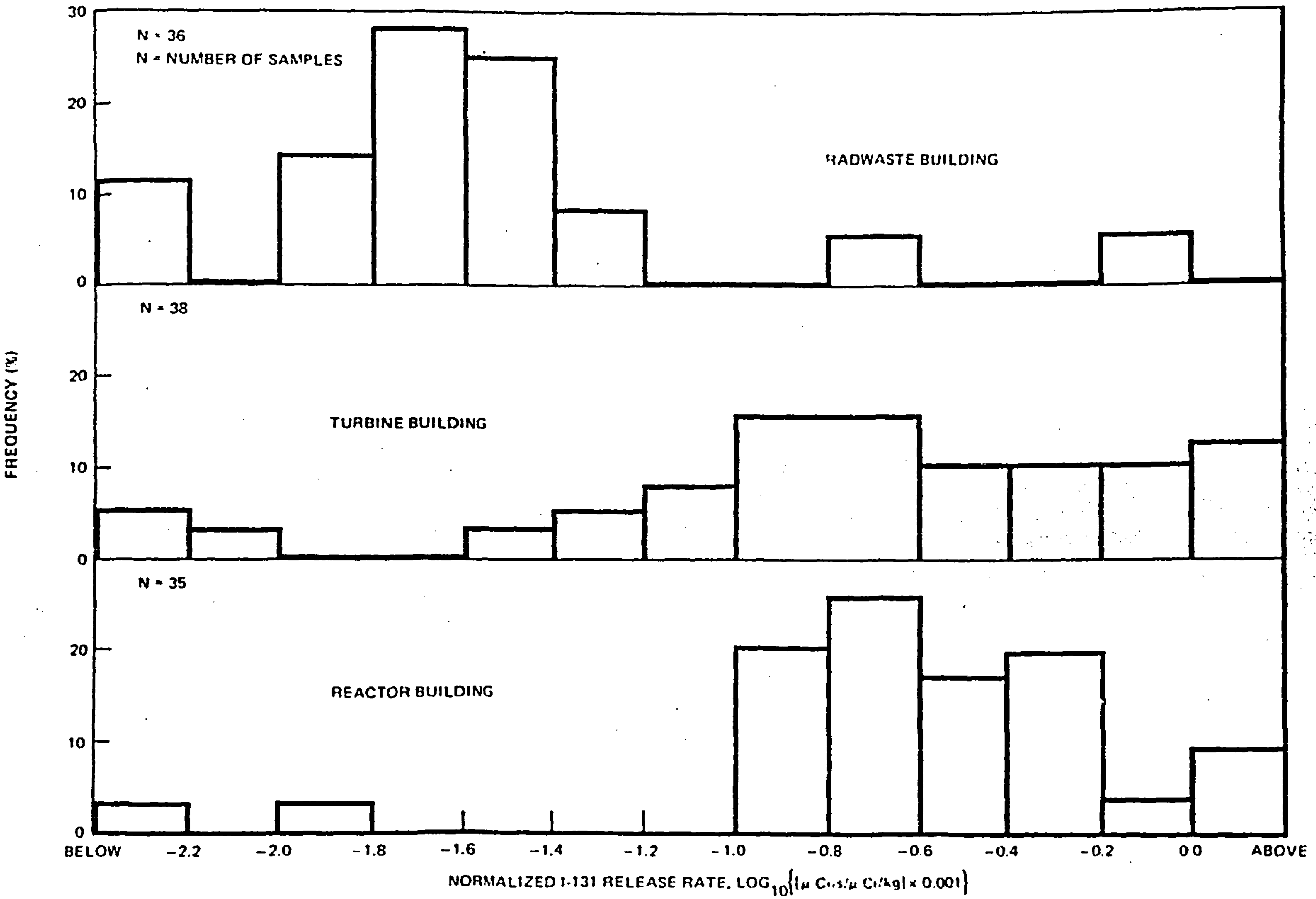


Figure 6-51. Frequency Polygons of Normalized I-131 Airborne Release Rates from Reactor, Turbine and Radwaste Buildings at Monticello

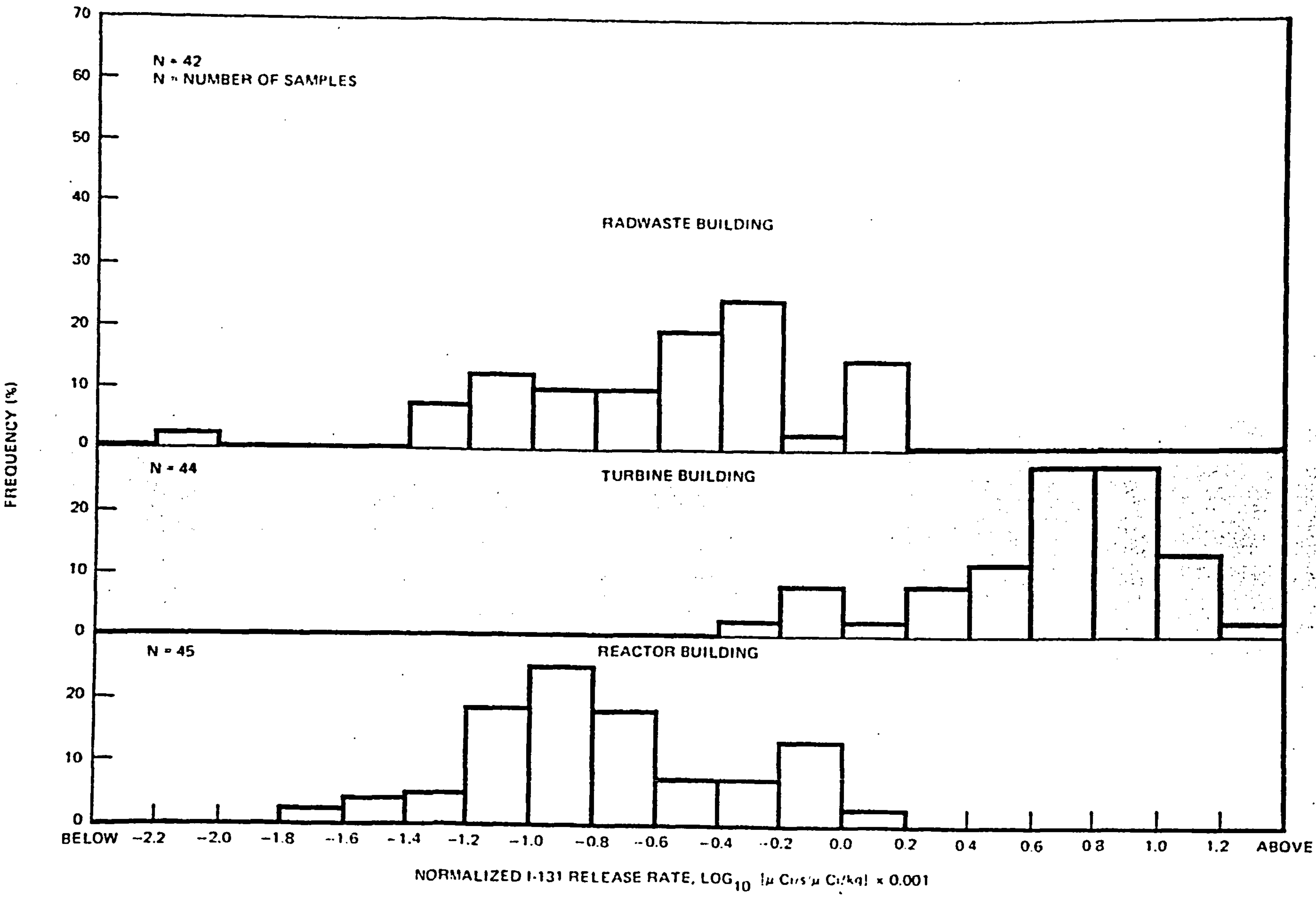


Figure 6-52. Frequency Polygons of Normalized I-131 Airborne Release Rates From Reactor, Turbine and Radwaste Buildings at Oyster Creek

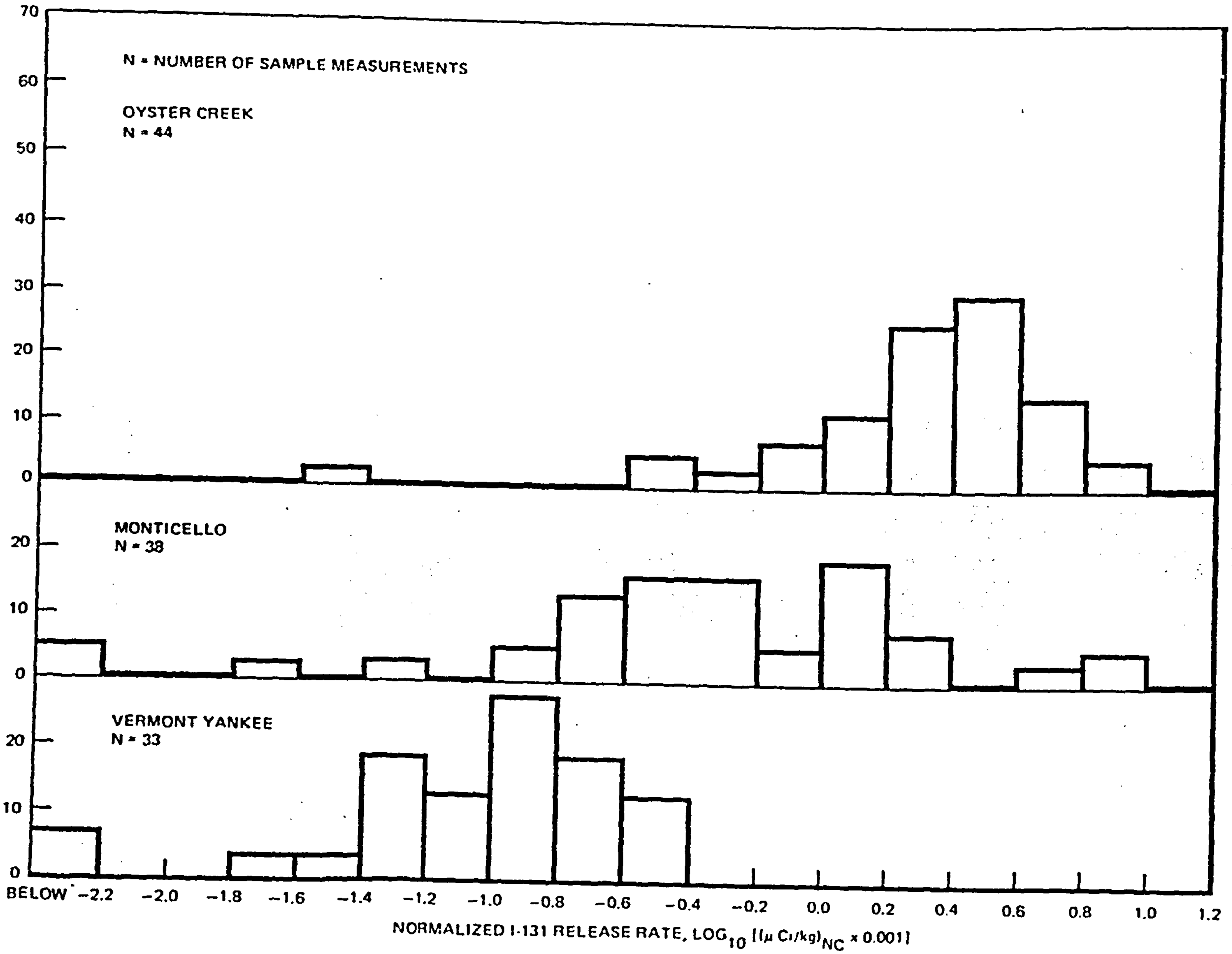


Figure 6-53. Frequency Polygons of Normalized I-131 Turbine Building Airborne Release Rates Adjusted to I-131 Carryover of 1 Percent

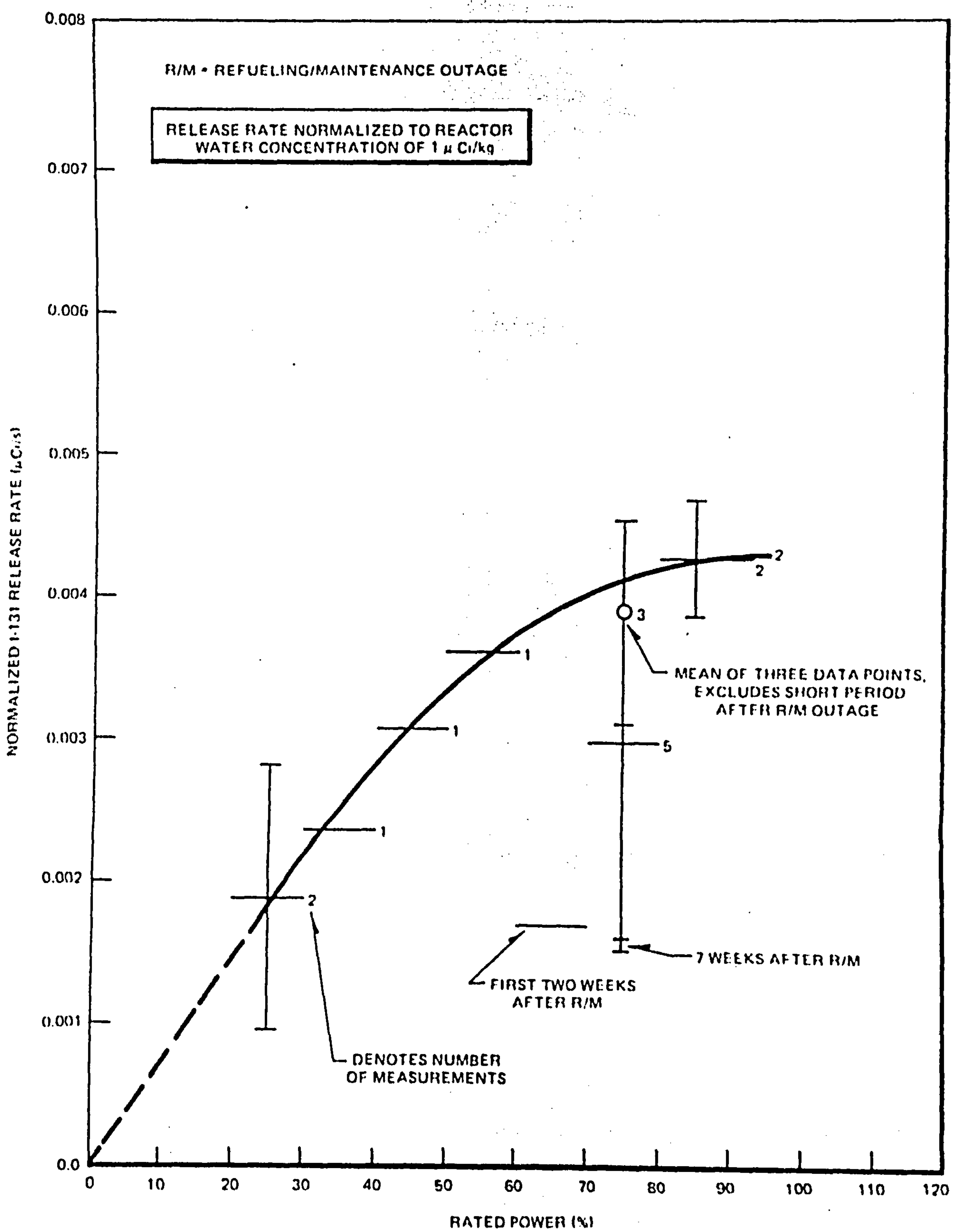


Figure 6-54. Normalized I-131 Turbine Building Airborne Release Rates and Reactor Power at Oyster Creek

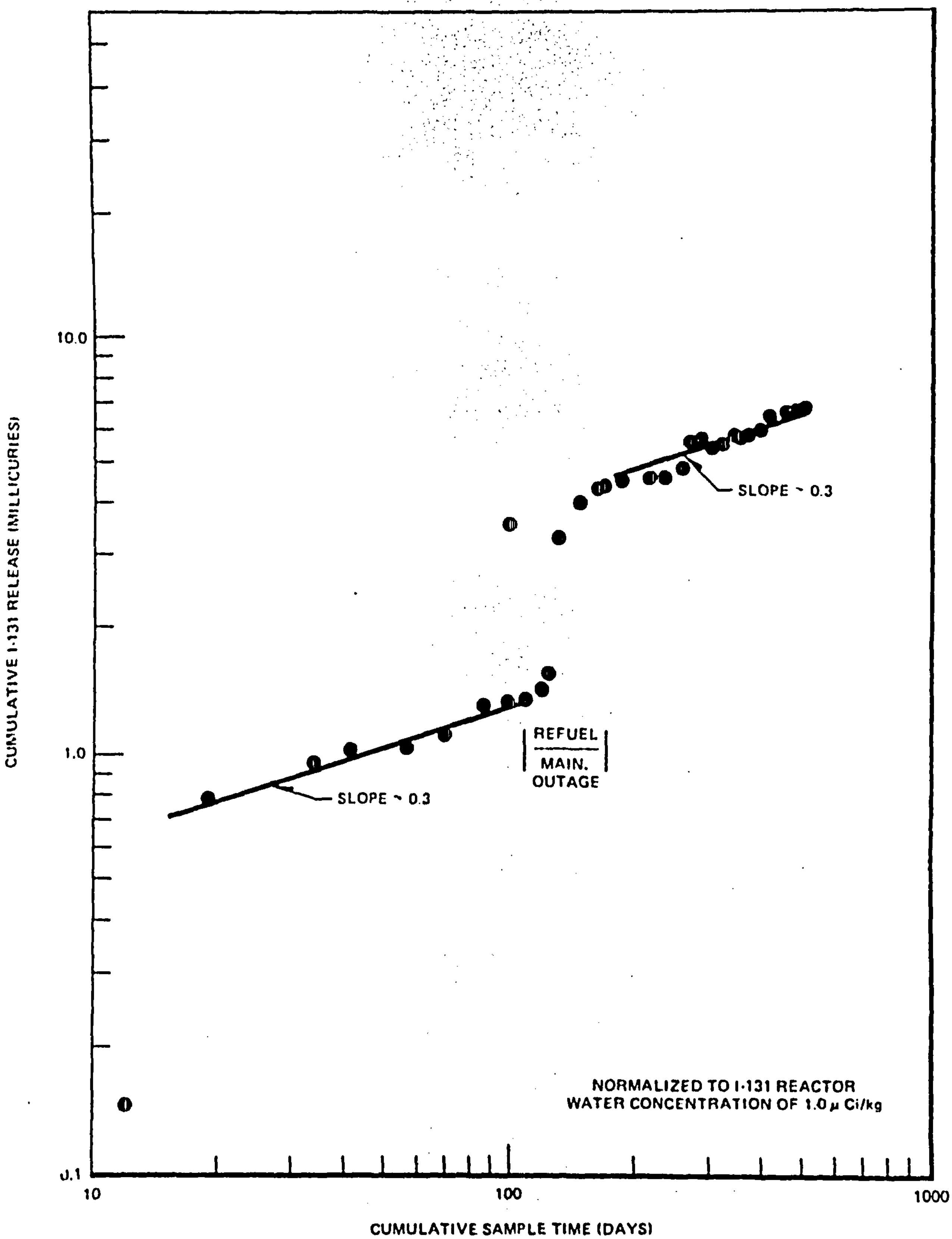


Figure 6-55. Cumulative Normalized I-131 Radwaste Building Airborne Release at Vermont Yankee

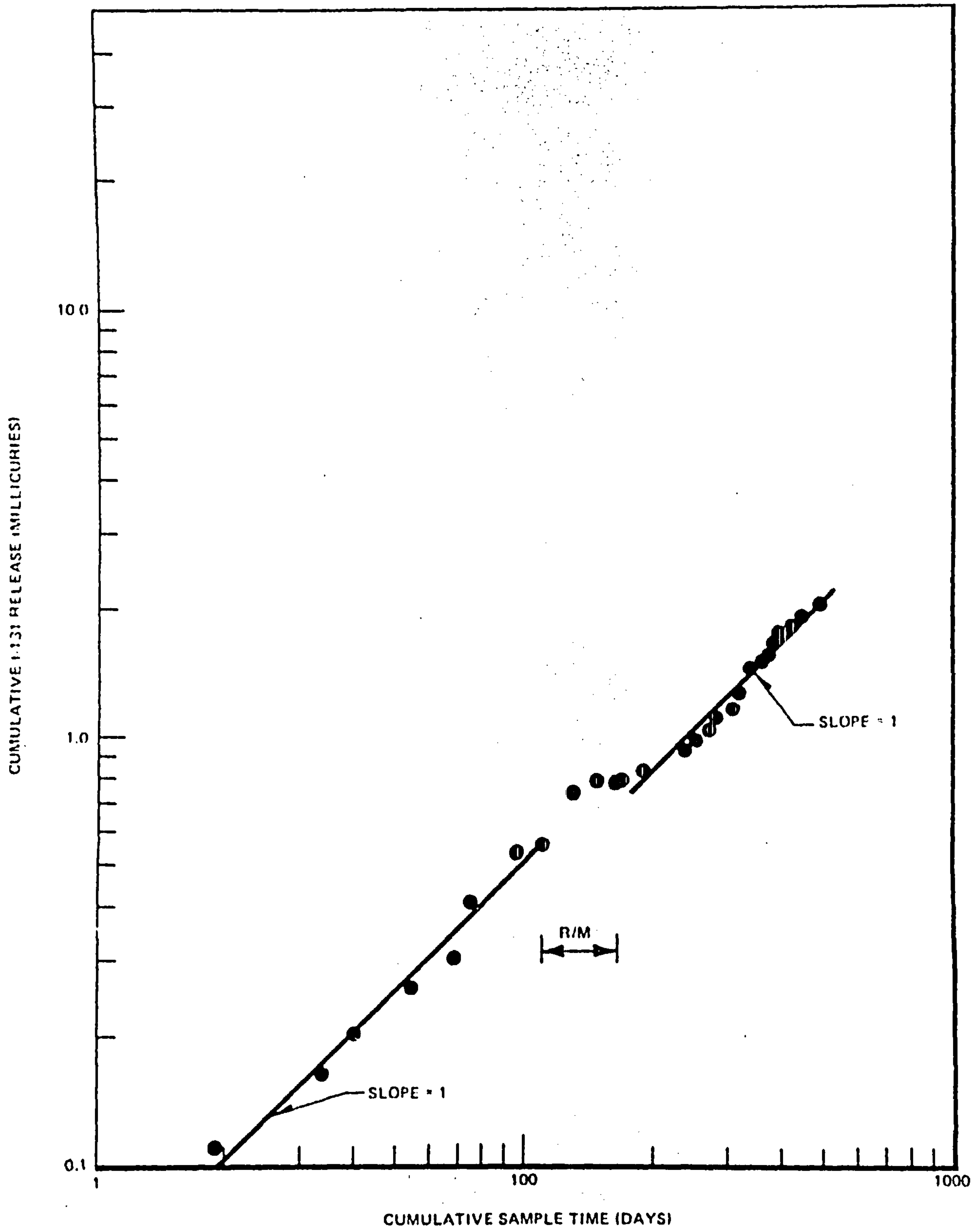


Figure 6-56. Cumulative Normalized I-131 Turbine Building Airborne Release at Vermont Yankee

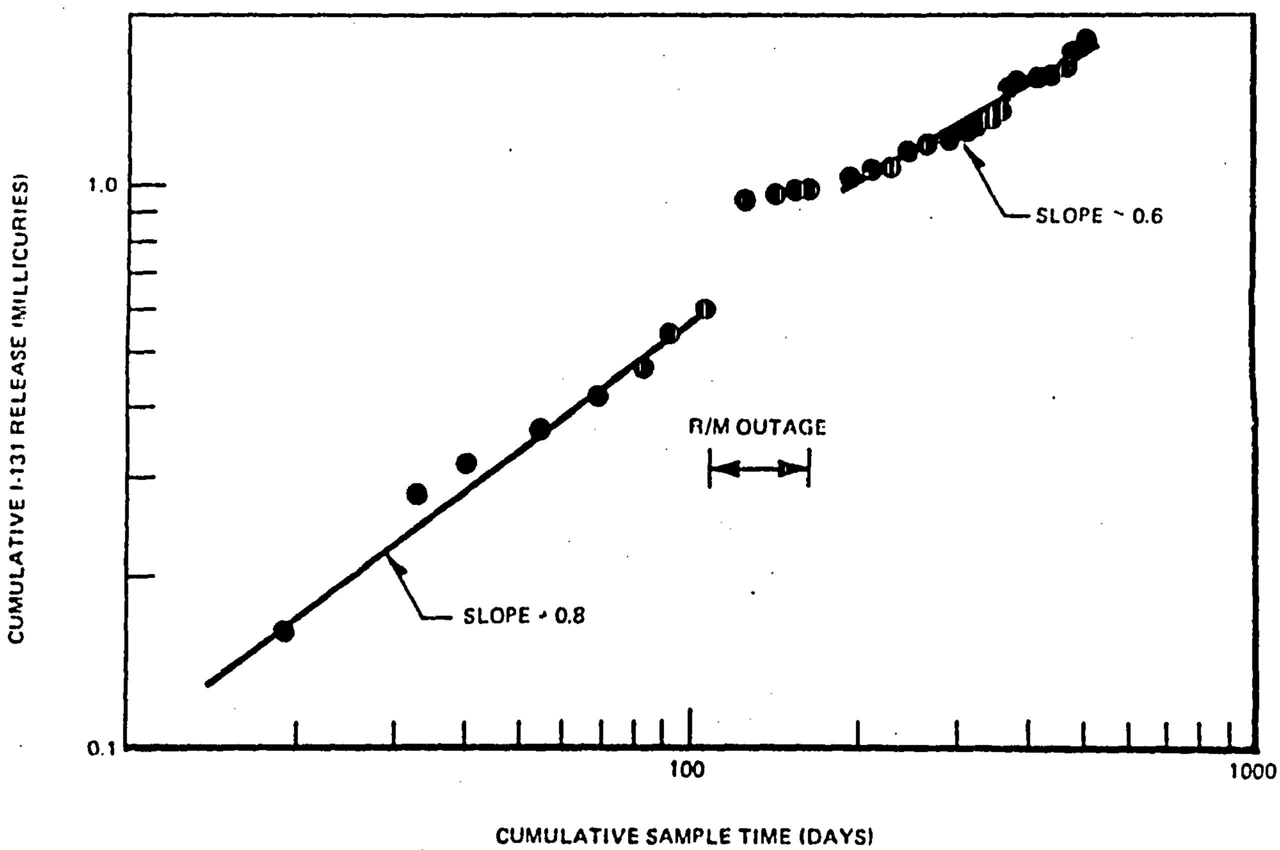


Figure 6-57. Cumulative Normalized I-131 Radwaste Building Airborne Release at Vermont Yankee

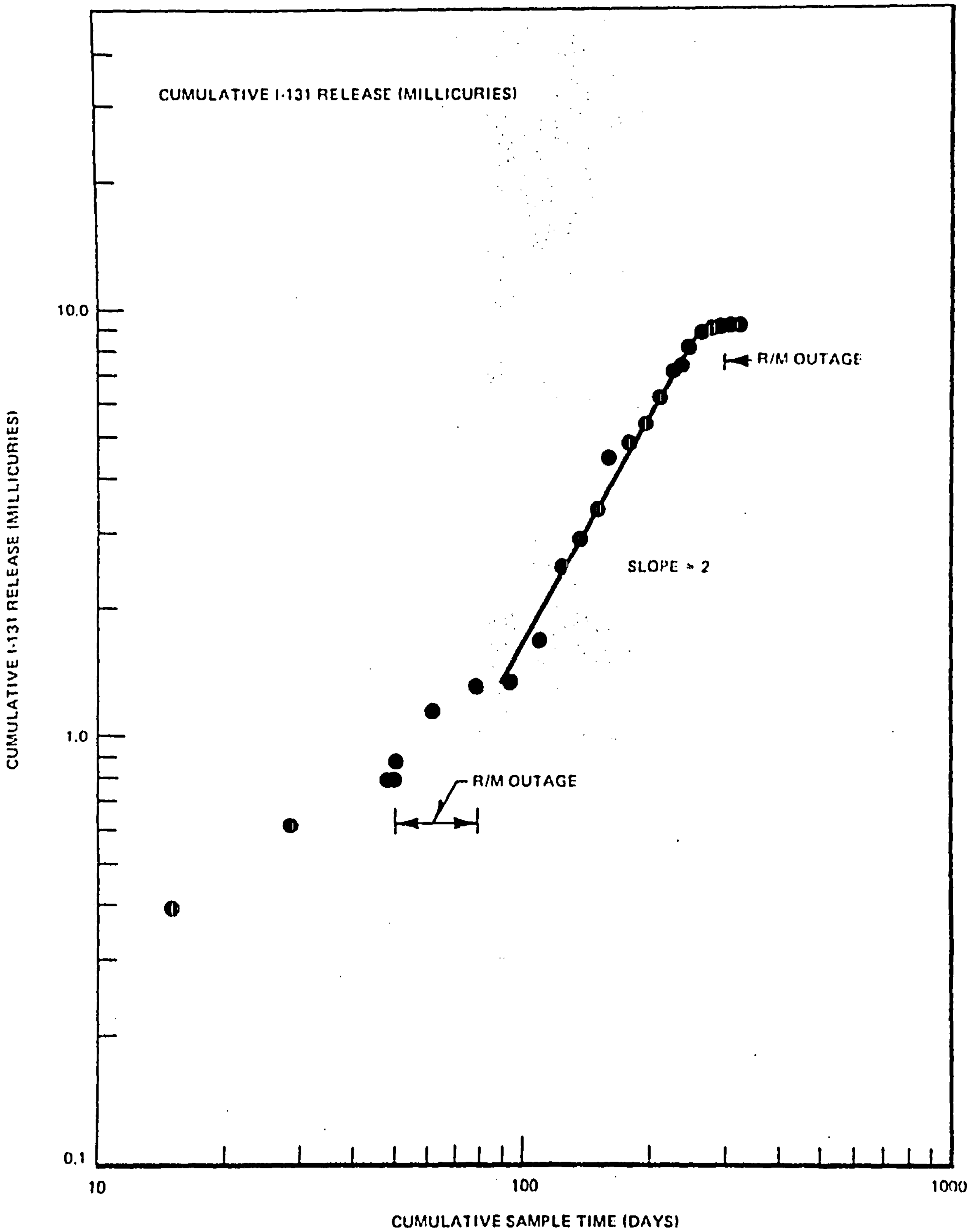


Figure 6-58. Cumulative Normalized I-131 Reactor Building Airborne Release at Monticello

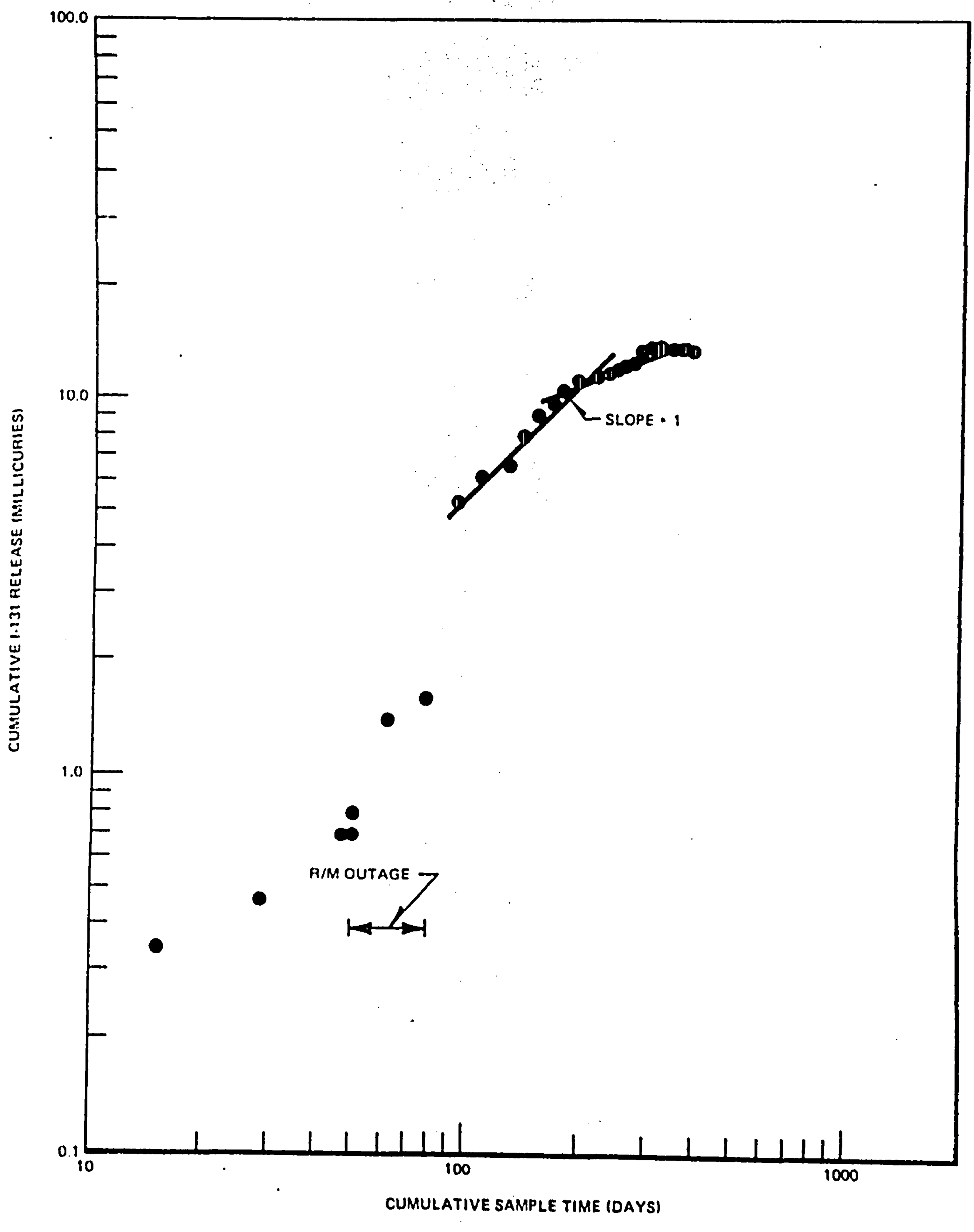


Figure 6-59. Cumulative Normalized I-131 Turbine Building Airborne Release at Monticello

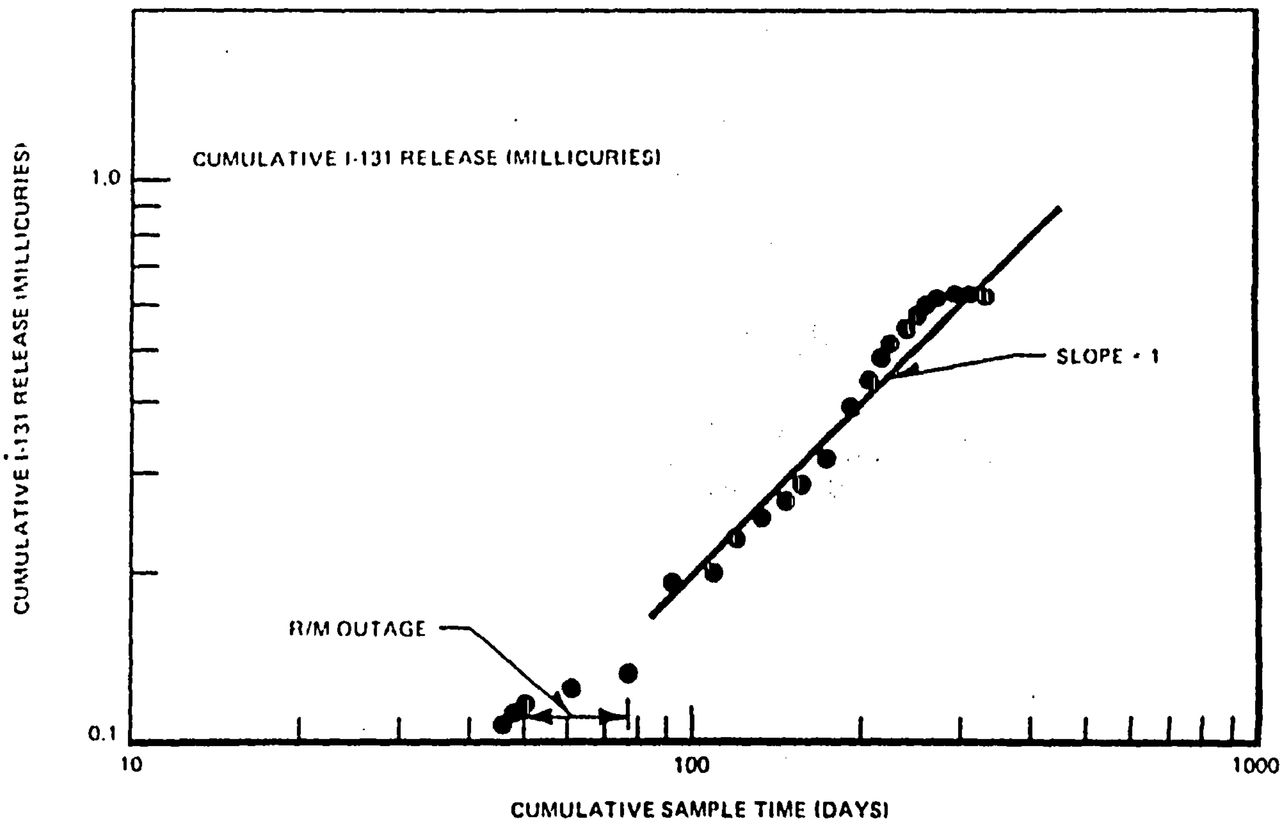


Figure 6-60. Cumulative Normalized I-131 Radwaste Building Airborne Release at Monticello

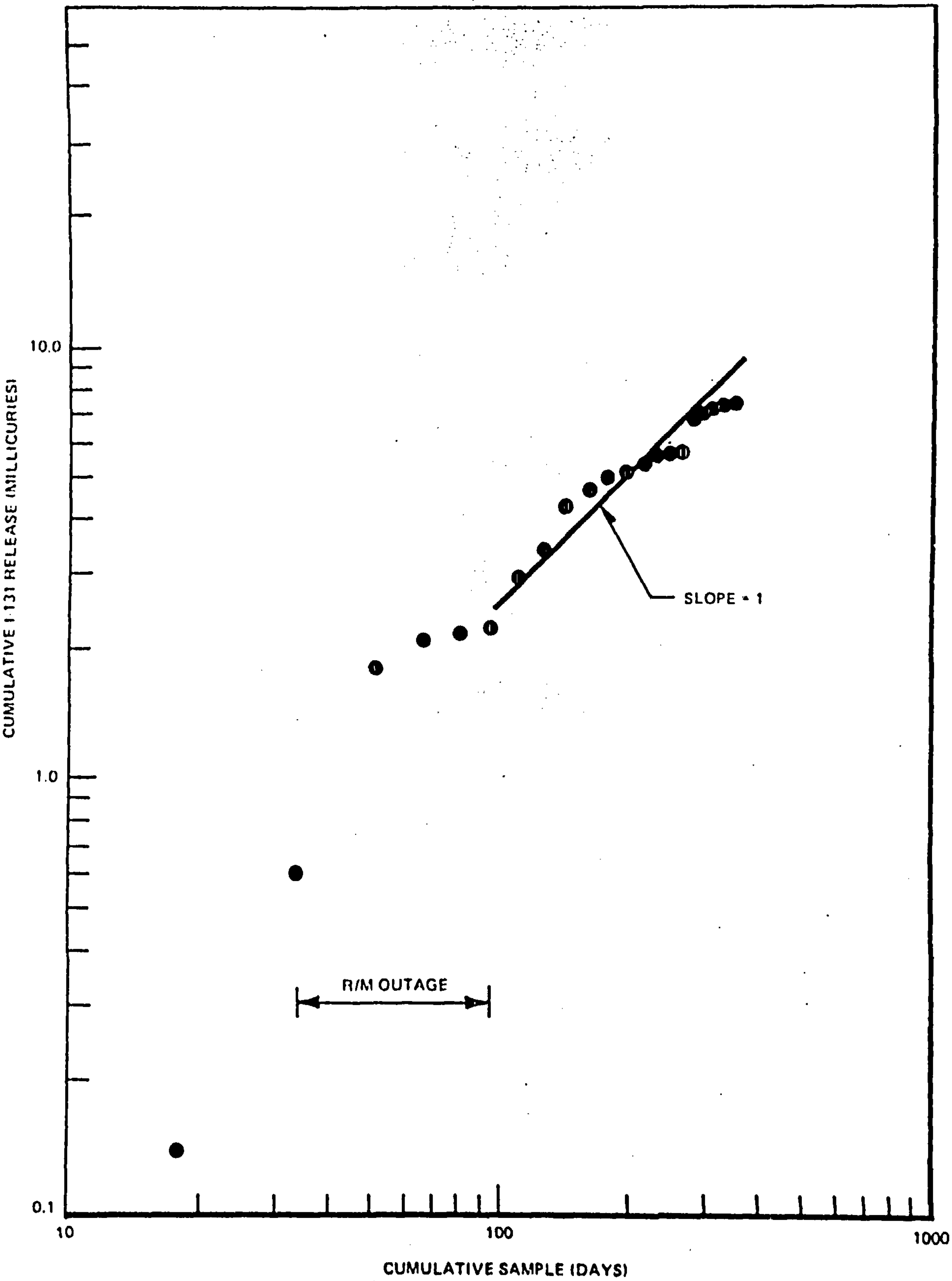


Figure 6-61. Cumulative Normalized I-131 Reactor Building Airborne Release at Oyster Creek (1975 – 1976)

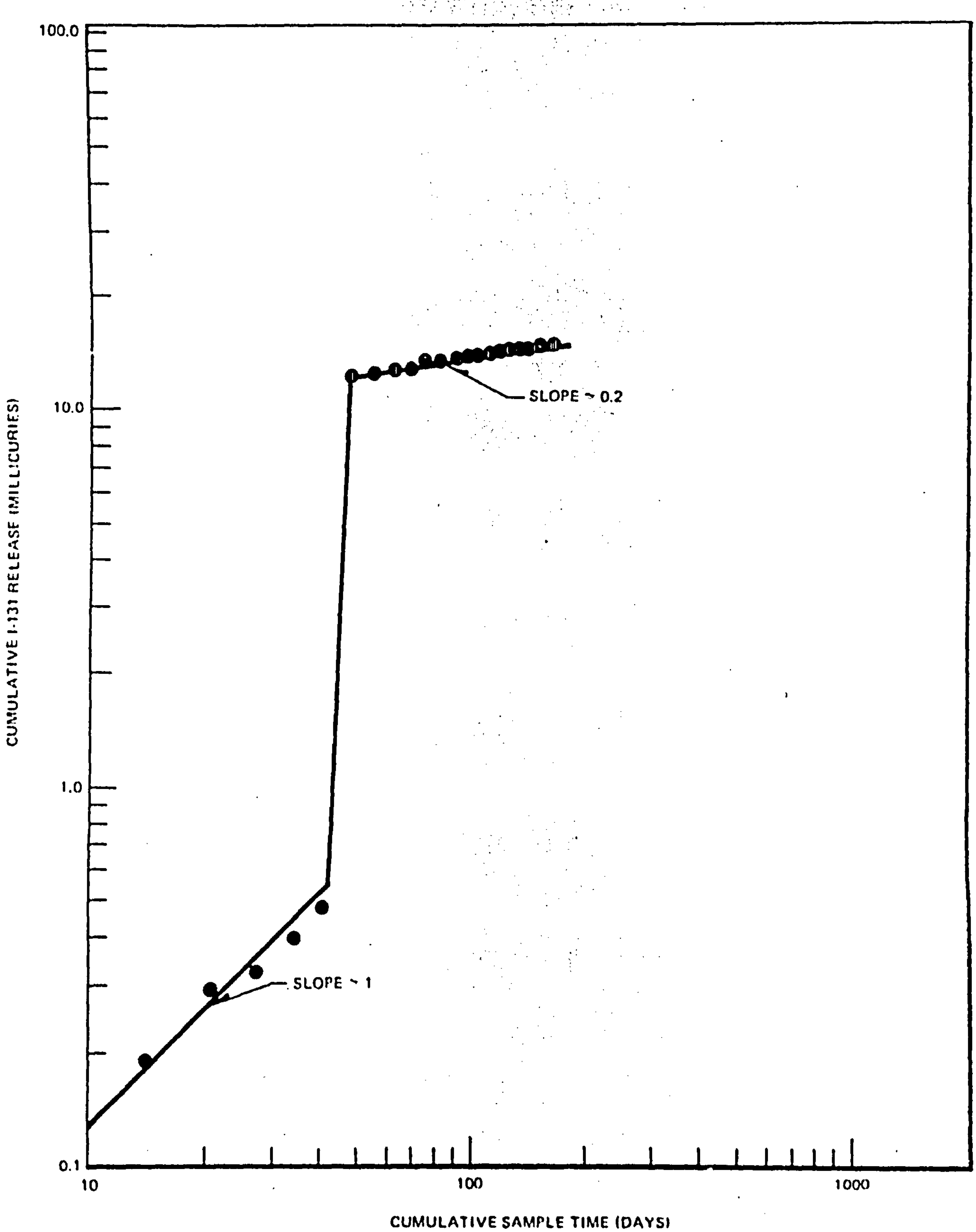


Figure 6-62. Cumulative Normalized I-131 Reactor Building Airborne Release at Oyster Creek (1976)

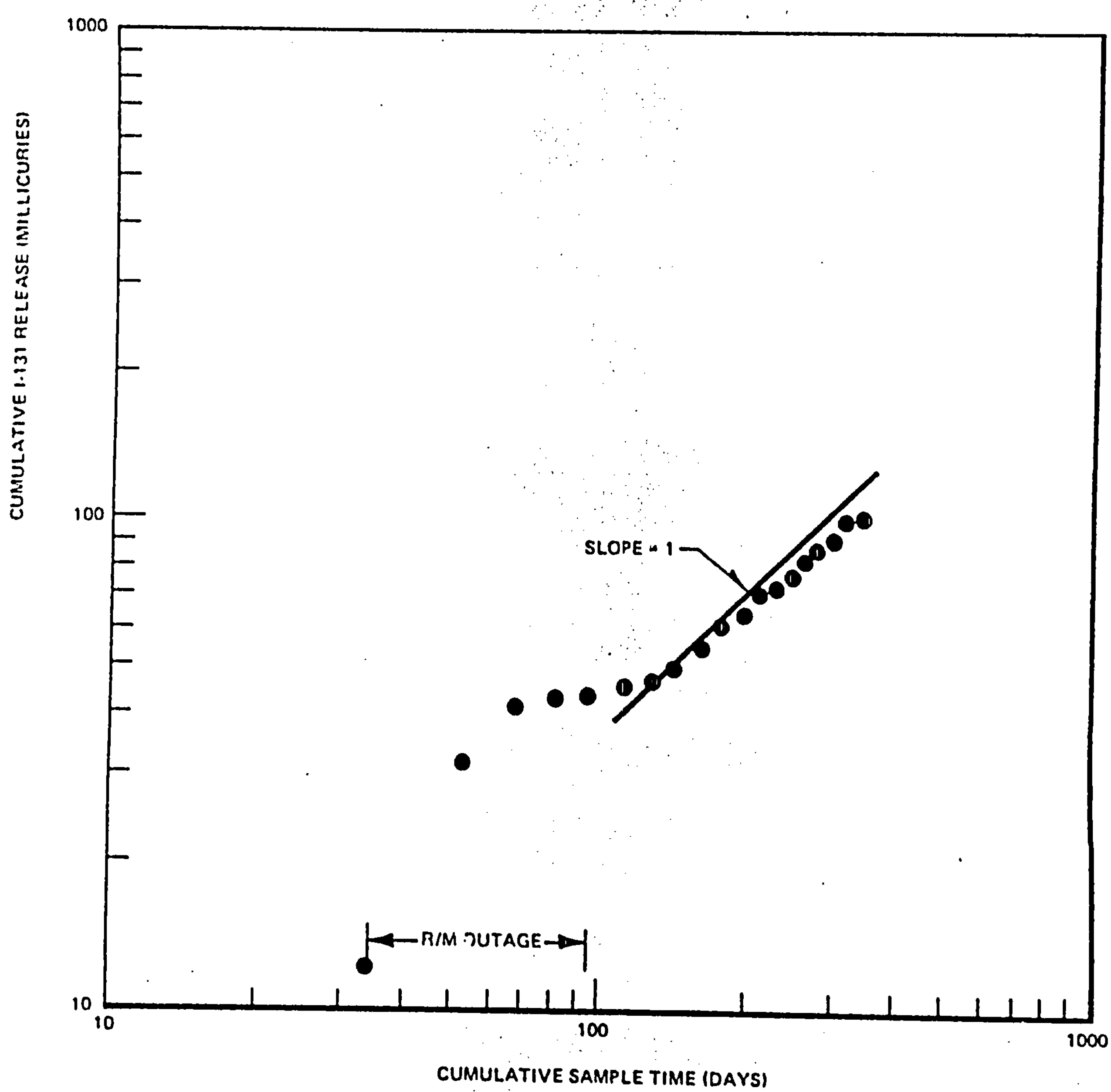


Figure 6-63. Cumulative Normalized I-131 Turbine Building Airborne Release at Oyster Creek (1975 – 1976)

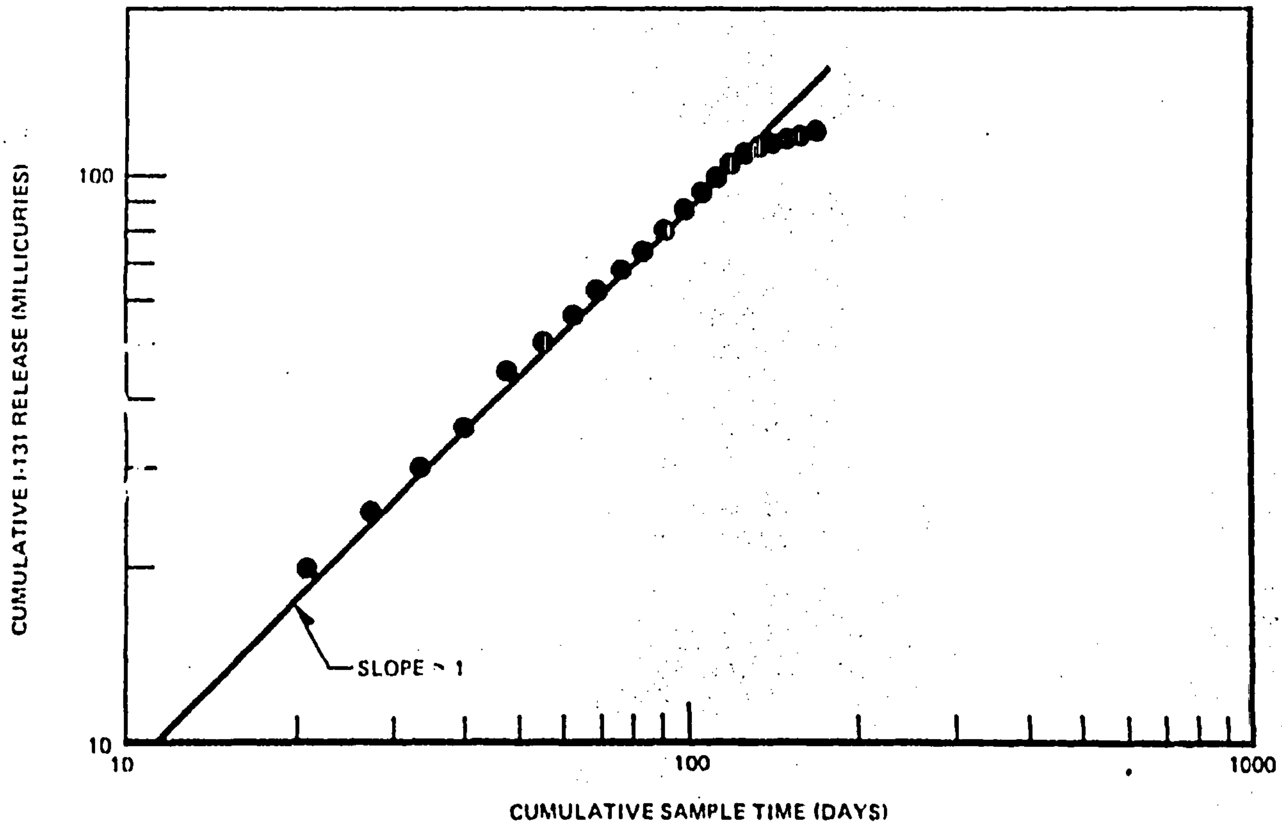


Figure 6-64. Cumulative Normalized I-131 Turbine Building Airborne Release at Oyster Creek (1976)

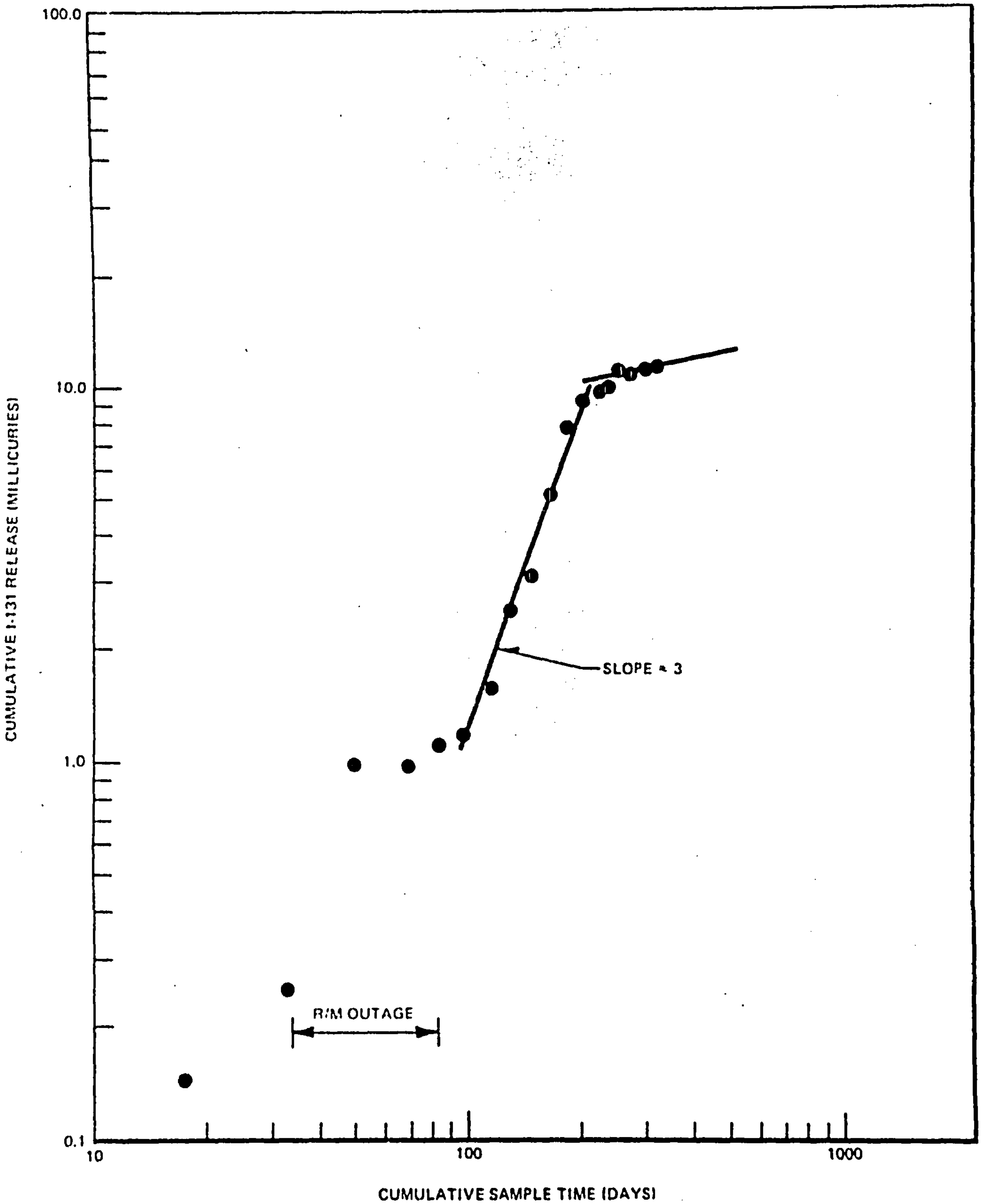


Figure 6-65. Cumulative Normalized I-131 Radwaste Building Airborne Release at Oyster Creek (1975 – 1976)

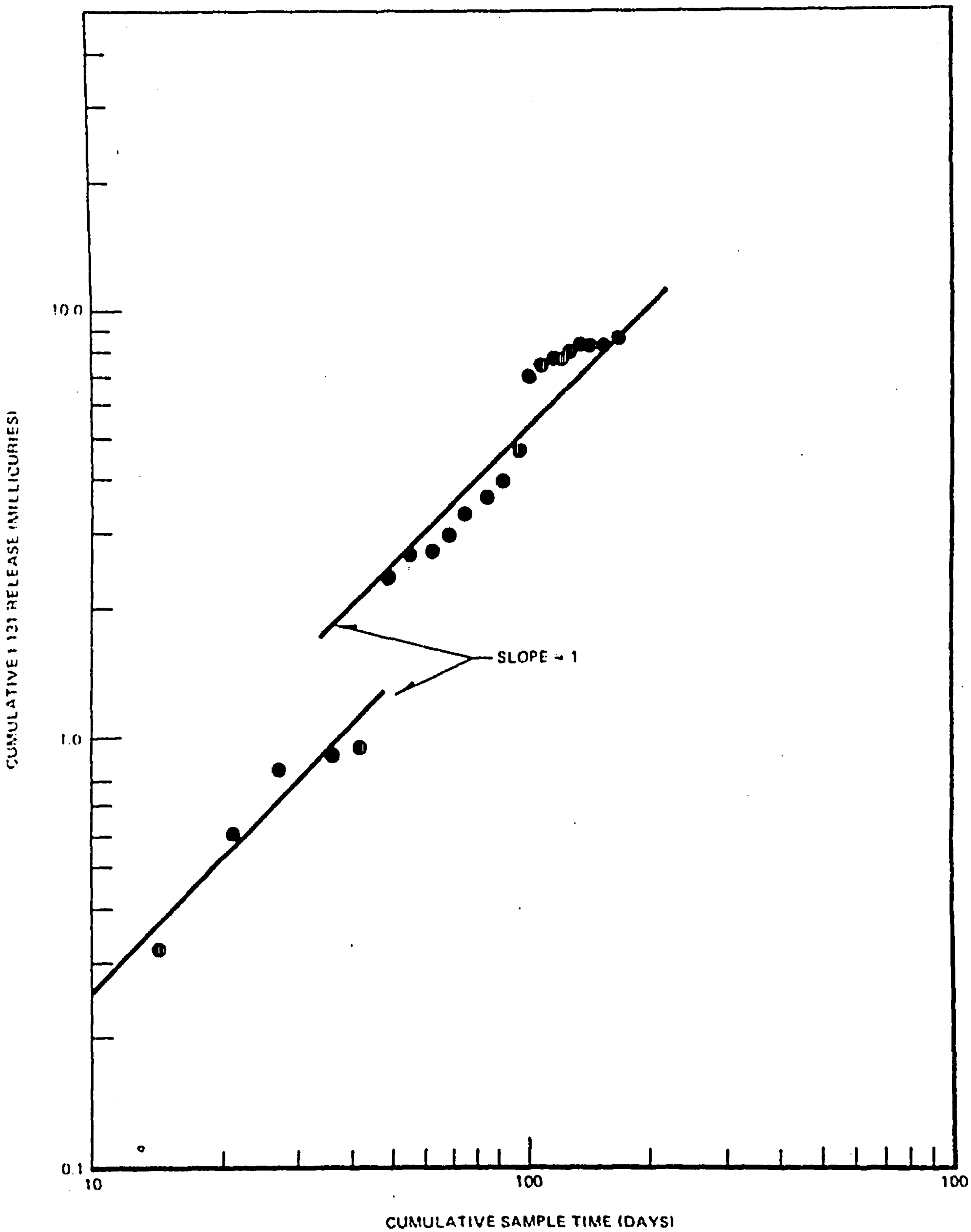


Figure 6-66. Cumulative Normalized I-131 Radwaste Building Airborne Release at Oyster Creek (1976)

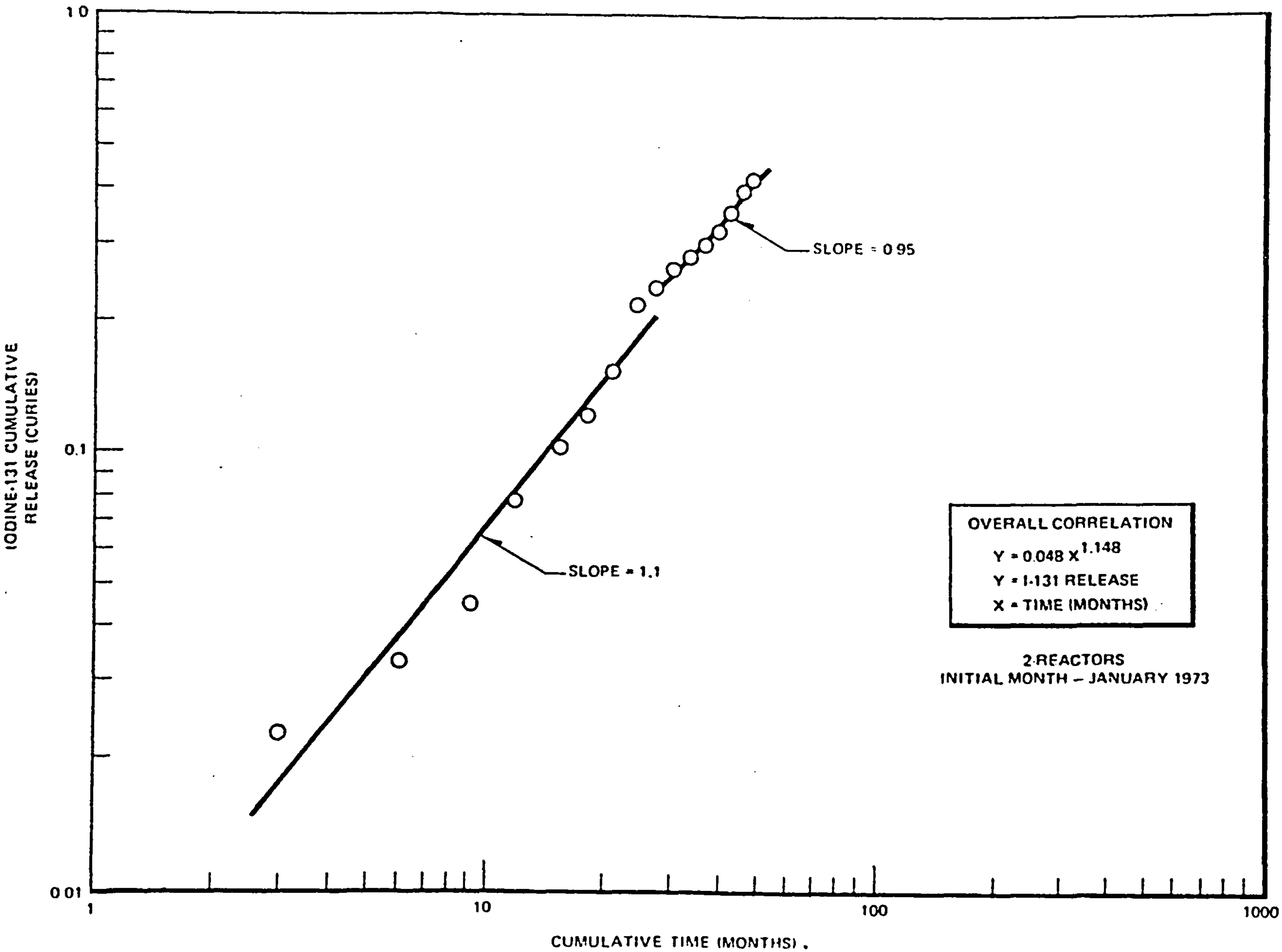


Figure 6-67. Trend Analysis of Dresden 2/3 Iodine-131 Airborne Releases from Reactor Building Ventilation Exhaust

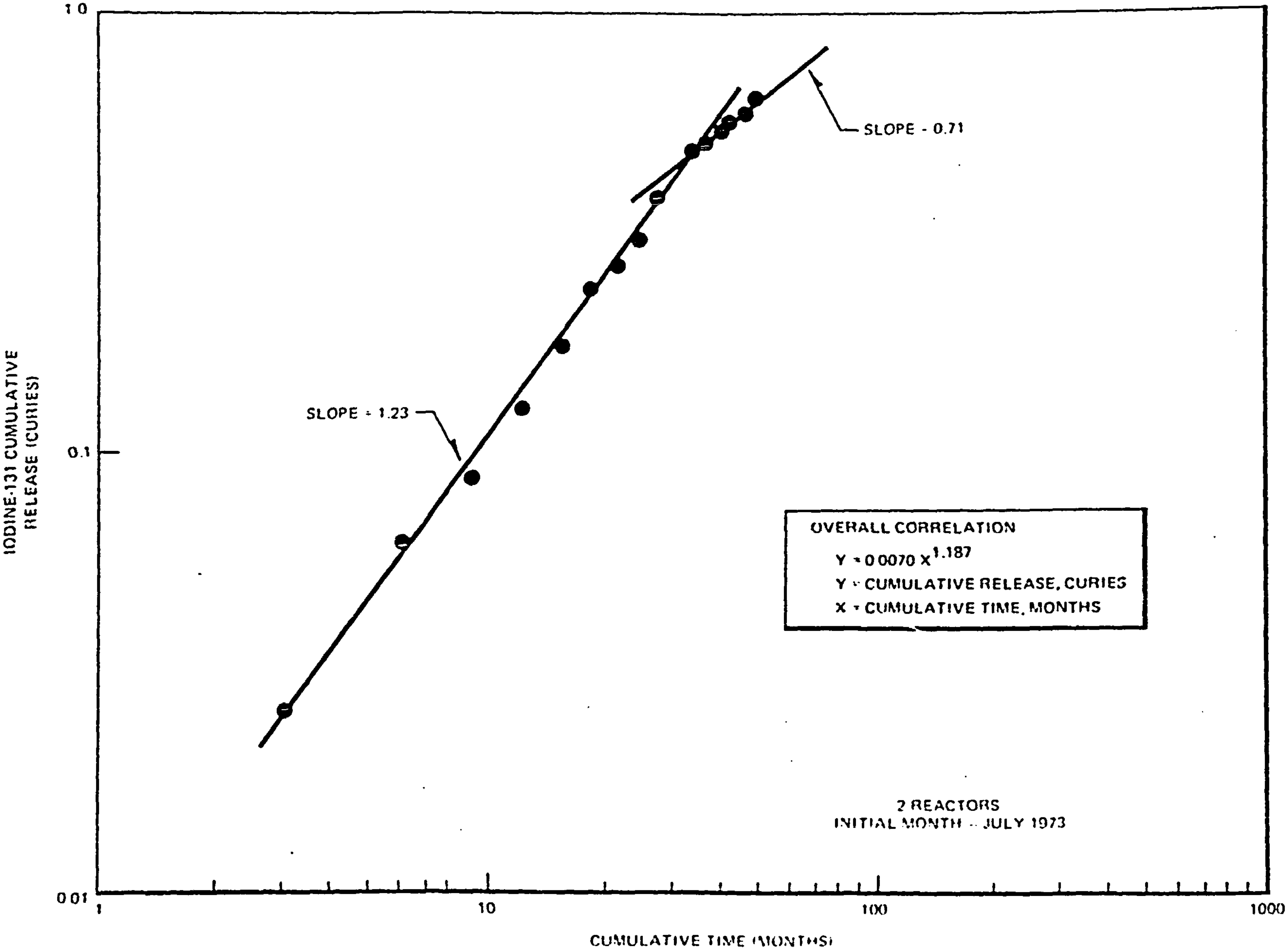


Figure 6-68. Trend Analysis of Quad Cities 1/2 Iodine-131 Airborne Releases of Reactor Building Ventilation Exhaust

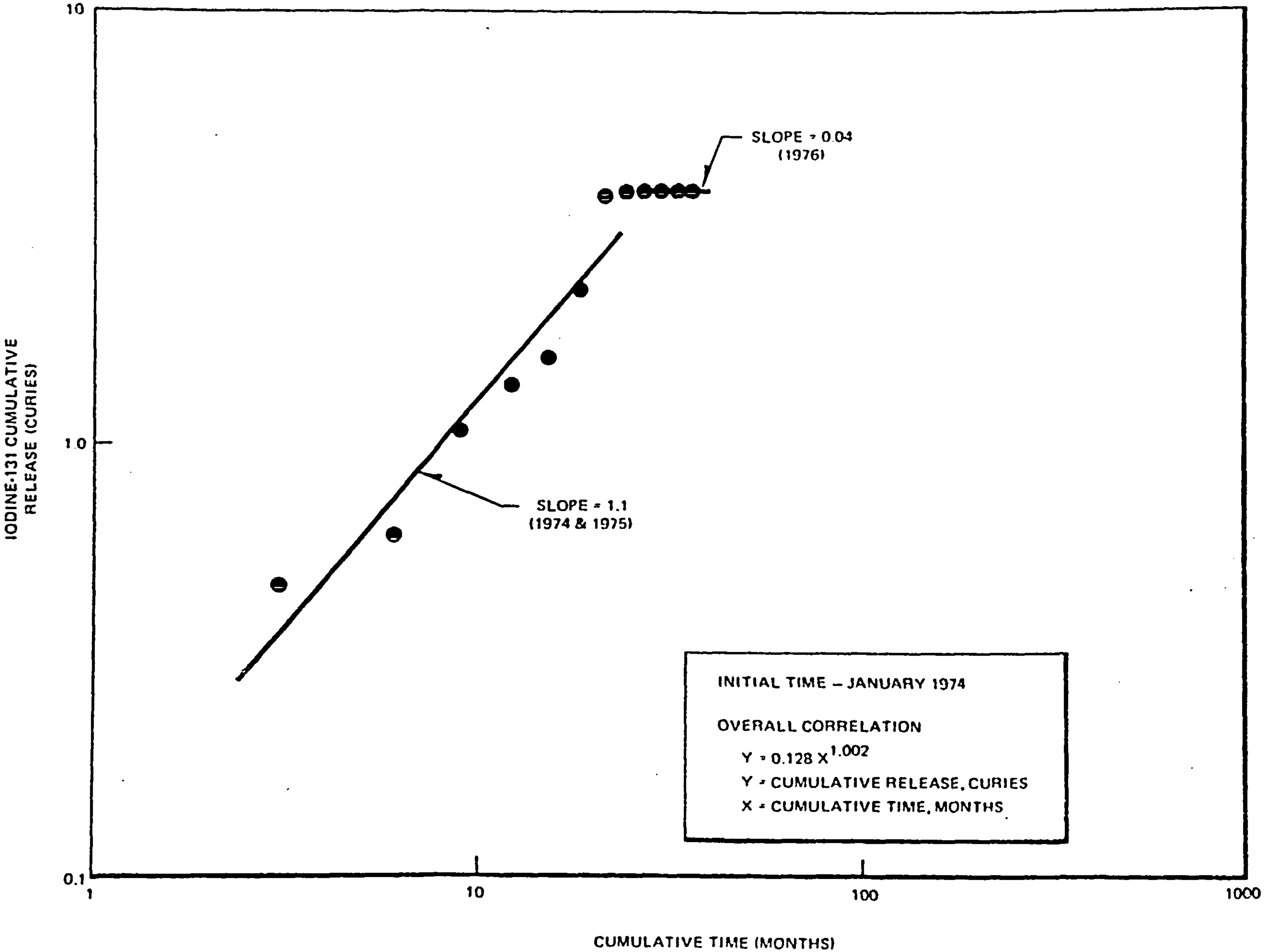


Figure 6-69. Trend Analysis of Monticello Iodine-131 Airborne Releases from Reactor, Turbine and Radwaste Buildings

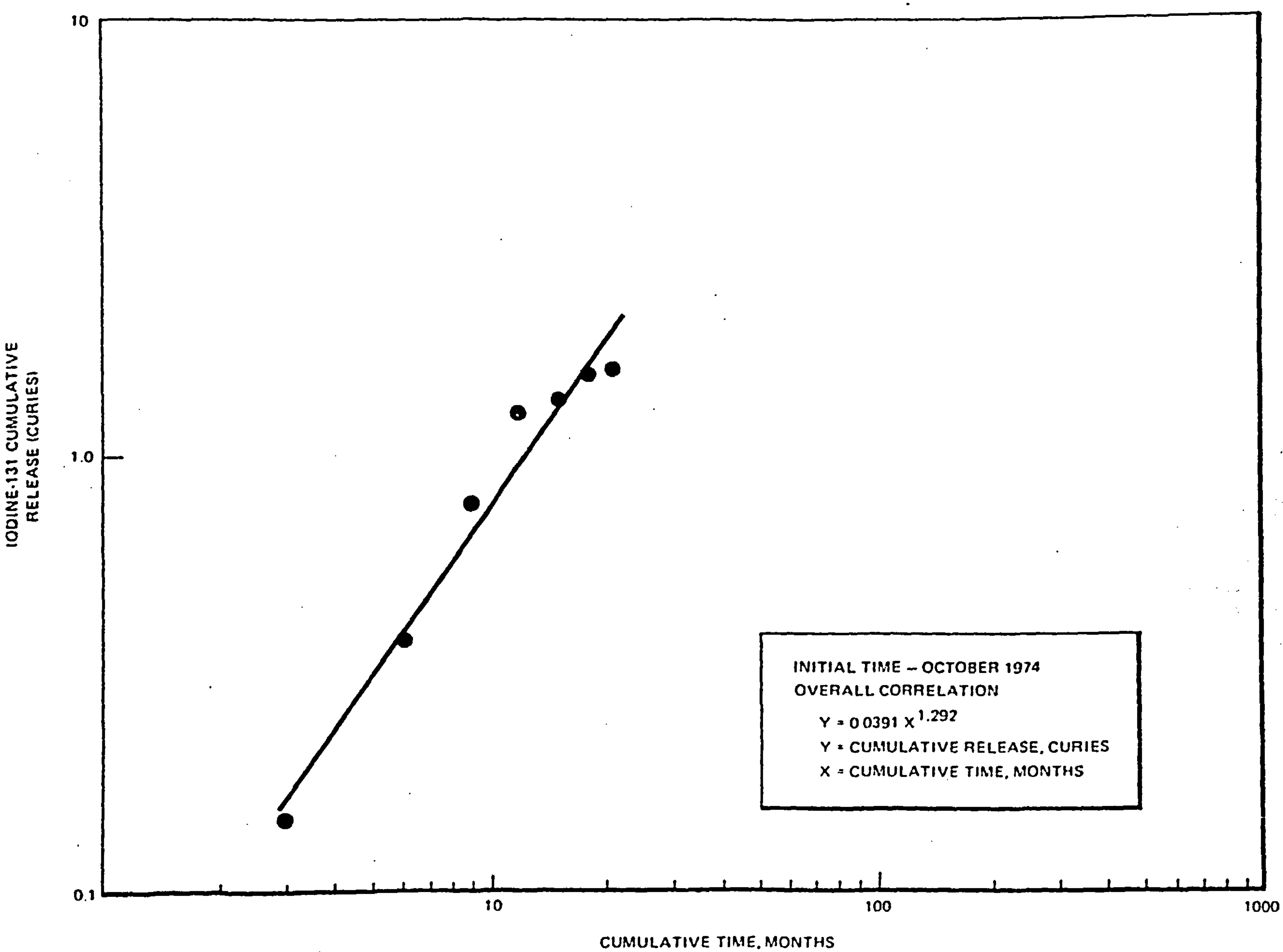


Figure 6-70. Trend Analysis of Pilgrim 1 Iodine-131 Airborne Releases from Reactor, Turbine and Radwaste Buildings

7. RESULTS

The additional measurements of airborne I-131 releases since the issuance of the NEDO-21159, March 1976, provides corroborative evidence regarding I-131 species, fuel performance, building ventilation release rates, and gland seal steam/mechanical vacuum pump exhausts.

The percentages of the various I-131 species released from BWRs are summarized in Table 7-1. Most of the elemental I-131 arises from the turbine building ventilation exhaust. A majority of organic I-131 (methyl iodide) is released from the mechanical vacuum pump (MVP). The I-131 species appears to be dependent on its hold-up time in processes and/or plate-out on building or process equipment surfaces. In areas where the I-131 would be delayed the most the relative amount of organic I-131 increases. Additional summaries of I-131 species have been presented in Tables 4-8 and Tables 2-1 to 2-4.

Table 7 2 summarizes the utility data and includes a rough indication of the I-131 reactor water concentrations. Precise estimates are not available for the 24 reactor years of operation, but if the average total annual I-131 release, as measured by the utility, is divided by the approximate mean reactor water concentration to obtain normalized release rates, it is apparent that the annual normalized releases are in most cases in the 10 to 100 millicurie range. This range is comparable to the results calculated from the extensive EPRI/NES measurements, see Table 7-3.

Table 7-3 is a summary of normalized I-131 airborne releases for the three BWR's according to building and plant. The arithmetic mean building I-131 release is indicated for both power generation operations (on 300 days) and a refueling/maintenance outage. The results are conservative because one of the plants (Oyster Creek) can operate with relatively high I-131 releases and cause no significant environmental impact, because the airborne activity is discharged from a tall stack. Thus by use of the simple arithmetic mean these results are skewed in favor of Oyster Creek.

The EPRI/NES study also included an independent method for the determination of normalized I-131 release rates. The results reported by EPRI/NES are compared to the results of this study in Table 7-4. In many instances the results are the same, differences are generally small. Both analyses have the same magnitude for I-131 releases and this confirms the general validity of the results reported here.

A comparison of the current NRC source-term and the results reported here is presented in Table 7-5. The NRC source term for elemental I-131 based on the earlier 1972-1974 measurements can now be reduced by about an order of magnitude.

With regard to the reactor building releases from Mark I/BWR plants relative to Mark III/BWRs it is difficult to assess the division of releases between the containment and the auxiliary/fuel buildings. The reactor building releases were due primarily to problems with the reactor water cleanup pump at Monticello and the sample hood at Oyster Creek, according to the EPRI/NES study. However other plants have different leakage sources in the reactor building. Thus even though the reactor water cleanup is located in the Mark III auxiliary building the releases from it may not be greater than the containment building. The type of sample hood at Oyster Creek is not used in any new BWR's designs and sample hoods are not expected to be a significant in-plant source of I-131. Thus, it is probably best at this time to assume a 50/50 split for releases between the containment and auxiliary buildings.

Figure 7-1 shows the correlation of I-131 concentration in reactor water with percent improved fuel discussed in Section 6.2. At the reactors with 100% improved fuel each reported concentration was considered, Table 6-5, and plotted to determine a frequency distribution, Figure 7-2. Recall that these data include results from Vermont Yankee which still has some tramp uranium in the reactor from the exposure of old-type fuel. This uranium is slowly "burning-off" as indicated by continuing decreases in the I-131 reactor water concentrations, see Figures 6-32, 6-33, and 6-34. From Figure 7-2 a bimodal frequency distribution is apparent, the low value corresponds to fuel performance at Duane Arnold (fuel cycle 2) and the upper from Peach Bottom 2 (fuel cycle 2) and Vermont Yankee (fuel cycle 3 and 4). These data are conveniently presented in the form of a *cumulative* frequency distribution showing the num of observations less than or equal to a specified value, see Figure 7-3.

A summary of iodine-131 reactor water concentrations in domestic BWRs is presented in Appendix C. This summary includes the experience of 21 plants during 1975, 1976 and 1977. The results are the arithmetic mean of data available. Individual utilities have been contacted to verify the data base appropriate to their plant(s). The majority of the plants have verified or modified the data base as appropriate. The values in this document reflect the verified and modified utility input. The plants with mostly improved type fuel (7x7R and 8x8) are the BWR/4s which have experienced fewer defects than other BWRs; accordingly, these plants have lower levels of I-131 in the reactor water in comparison to the other BWRs which have used old-type (7x7) fuel. Two BWRs (Browns Ferry 3 and Brunswick 1) have had an initial core loading of all 8x8 type fuel, the only type of fuel now manufactured by General Electric. These plants exhibit much lower I-131 concentrations, <0.2 μCi/kg. Although this upper limit value is limited to 1 year of data at each plant, it agrees with the above analysis (see Figure 7-1). Due to this limited operating experience, the 8x8 data from these two plants was not used in the determination of the normalized release rates.

A verification of the normalization method for the determination of I-131 release rates was completed. Release rate data were obtained from three BWRs, not included in any or the original studies. The data are from Browns Ferry 1/2/3 during all of 1977. A comparison of the normalized release values of this report and those from the three Browns Ferry reactors is presented in Table 7-6. The available data are presented in Appendix D. These results show that I-131 airborne effluent rates from the reactor and turbine buildings as calculated by the values listed in Chapter 2 (of this report) are always conservative by factors of 1.3, 4.9 and 1.7, for Browns Ferry 1, Browns Ferry 2, and Browns Ferry 3, respectively. Apparently, Unit 2 has extremely little leakage. For the radwaste building, a factor 2.6 was calculated, again indicating that the results of this report lead to conservative values for I-131 airborne releases. This conservatism is quite reasonable because the reference plants Monticello, Oyster Creek and Vermont Yankee all have tall stacks which allow operations with greater leakage due to more favorable atmospheric diffusion conditions.

The above results are on a normalized basis, namely, the same I-131 reactor water concentration, carryover, and an annual fuel cycle. The actual average total I-131 from the Browns Ferry plants indicates an annual release of ≃10 millicuries per reactor-year (see Appendix D, Table D-1). This total includes all chemical forms of I-131. Thus, the Browns Ferry plants are operating with effluent rates (and no charcoal treatment on the ventilation exhausts) a factor of approximately 10 less than would be calculated by NRC procedures in NUREG 0016, Rev. 1 Draft, June 1978.

Table 7-1
AMOUNTS OF IODINE-131 SPECIES IN AIRBORNE RELEASES OF BWRs.[a,b]
PROPORTION OF PLANT, %

Source	I-131 Species Elemental	Particulate	HOI	CH_3I
Reactor building	15	13	17	12
Turbine building	76	75	49	13
Radwaste building	5	2	4	13
Gland seal steam and MVP	4	10	30	62
Total annual release, millicuries	25.0	8.7	13.0	31.0

Grand total all I-131 species ≈ 78 millicuries

NOTES (a) Source release is taken to be 300 days of power operations and one refueling maintenance outage
(b) The total annual release including all I-131 species for the sources are as follows:
reactor 11 mCi, turbine 36 mCi, radwaste ≈ 6.2 and gland seal and MVP ≈ 15 mCi

Table 7-2
SUMMARY OF UTILITY MEASUREMENTS ON I-131 AIRBORNE RELEASES.

Plant	Sample Period Month/Year	Operating Period Reactor-Years	Approximate Index of I-131 Reactor Water Concentration μCi/Kg	Average Total I-131 Release (all plant operations) Millicuries/Year/Reactor
Reactor Building Release (only)				
Dresden 2/3	1/73–12/76	8	0.3 to 4	46
Quad Cities 1/2	7/73– 6/77	8	2 to 5	80
Reactor, Turbine and Radwaste Buildings				
Monticello	1/74–12/75	2	10–200	1240
	1/76–12/76	1	9	60 (effect of improved fuel)
Pilgrim 1	1/73– 6/76	3.5	20	480
Peach Bottom 2/3	1/76– 9/76	1.5	0.5–100	440

Total Length of Operations ≈ 24. Reactor-Years

Table 7-3
SUMMARY BY BUILDING OF NORMALIZED I-131 RELEASES AT VERMONT YANKEE, MONTICELLO AND OYSTER CREEK FOR POWER GENERATION OPERATIONS (300 DAYS) AND ONE REFUELING/MAINTENANCE OUTAGE.[a, b, c, d]

		Plant Operation		
	Power generation	Refueling/maintenance		Annual total
	I-131 release, millicuries			
Reactor Building				
Vermont Yankee	2.49	3.12	=	5.61
Monticello	10.50	0.69	=	11.19
Oyster Creek	14.62	0.90	=	15.52
Arithmetic mean =	9.20	1.57		
Turbine Building (I-131 Carryover at 1%)				
Vermont Yankee	3.12	0.61	=	3.73
Monticello	32.71	1.01	=	33.72
Oyster Creek	59.85	8.97	=	68.82
Arithmetic mean =	31.89	3.53		
Radwaste Building				
Vermont Yankee	0.94	0.40	=	1.34
Monticello	0.80	0.03	=	0.83
Oyster Creek	14.21	1.96	=	16.17
Arithmetic mean =	5.32	0.80		

NOTES: (1) Data are normalized to an I-131 reactor water concentration of 1.0 μCi/Kg.
(2) Gland seal steam I-131 release (I-131 carryover at 1%) is 5.0 millicuries at Oyster Creek.
(3) Mechanical Vacuum Pump (MVP) I-131 release (I-131 carryover at 1%) is 6.0 millicuries at Vermont Yankee.
(4) At plants with two R/M outages the I-131 releases were determined by the arithmetic mean.

Table 7-4

COMPARISON OF NORMALIZED I-131 RELEASES WITH EPRI/NES RESULTS.[a, b]

Source	Power generation (300 days)		Refueling/maintenance	
	I-131 release, millicuries			
	This report	**EPRI/NES**	**This report**	**EPRI/NES**
Reactor building at:				
Vermont Yankee	2.5	1.5	3.1	3 2
Monticello	11.	11.	0.81	0 93
Oyster Creek	7.7	5.7	1.8	2.5
Turbine building at:				
Vermont Yankee	1.3	2.0	0.24	0 25
Monticello	15.	17.	0 91	0 78
Oyster Creek	79.	98.	41.	48
Radwaste building at.				
Vermont Yankee	0.94	1.0	0 40	0 40
Monticello	0.80	0.73	0 06	0 04
Oyster Creek	13.	13.	2.0	1 4

NOTES (a) EPRI NES results evaluated at 1 μCi Kg
(b) Oyster Creek results exclude June–November 1976 data

Table 7-5

COMPARISON OF NORMALIZED I-131 RELEASES WITH THE CURRENT NRC "SOURCE TERM"[a, b, c]

ALL I-131 SPECIES

Source	(NRC NUREG-0016)	This Report I-131 Reactor Water Concentration at 5 μCi/kg	at 1 μCi/kg
Reactor Building	340	55	11
Turbine Building	190	180	36
Radwaste Building	46	31	6.2
Mechanical Vacuum Pump	30	30	6
	606	296	59

Notes (a) In dose evaluations the NRC assumes 50% of the total I-131 release is in elemental form or 303 millicuries according to this study the recommended results is 25 millicuries/year reactor of I-131 in elemental form
(b) Annual releases were calculated at two I-131 reactor water concentrations to illustrate differences between old (1972) values (5 μCi kg) and expected values concentrations based on data to 1976
(c) NRC "source term" is NUREG-0016 April 1976 "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Boiling Water Reactors (BWR-Gale Code), PP. 1-6 and 2-27.

Table 7-6
SUMMARY OF IODINE-131 VENTILATION RELEASES AT BROWNS FERRY SITE DURING 1977–NORMALIZED RESULTS[a]

	PLANT OPERATION				
Reactor and Turbine Building Releases:	**Power Operations**	**Refuel/ Maint.**	**Power Operations**	**Refuel/ Maint.**	**Power Operations**
Reactor Unit	1		2		3
Vent Location (NO.)	Normalized I-131 Release, mCi/Reactor Year				
Reactor Bldg. & Turbine Equip. Rooms (-250)	12.5	5.53	4.422	0.213	10.38
Turbine Operating Floor (4 vents) (-249)	0.094	0.102	0.087	0.013	1.01
Turbine Operating Floor (5 vents) (-251)	0.265	0.073	0.034	0.013	1.68
Annual Normalized Release	18.6		5.1		13.1
Calculated Normalized Release (This Report)	25.0		25.0		22.0
Release Ratio. (This Report/Browns Ferry Plant)	1.3		4.9		1.7

Radwaste Building Release (Unit 1/2/3 Combined):

Average Normalized Release of the Three Plants	2.41 mCi/reactor-year
Calculated Normalized Release (This Report)	6.16 mCi/reactor-year
Release Ratio. (This Report/Browns Ferry Plants)	2.6

a Normalized results calculated from annual (300 days power operations plus one refueling/maintenance outage) releases presented in Appendix D. Table D-1, divided by the appropriate I-131 reactor water concentration. The average annual I-131 concentrations at each plant were as follows: Browns Ferry 1, 0.889 μCi/kg; Browns Ferry 2, 1.35 μCi/kg, Browns Ferry 3, 0.132 μCi/kg, average of three plants, 0.79 μCi/kg.

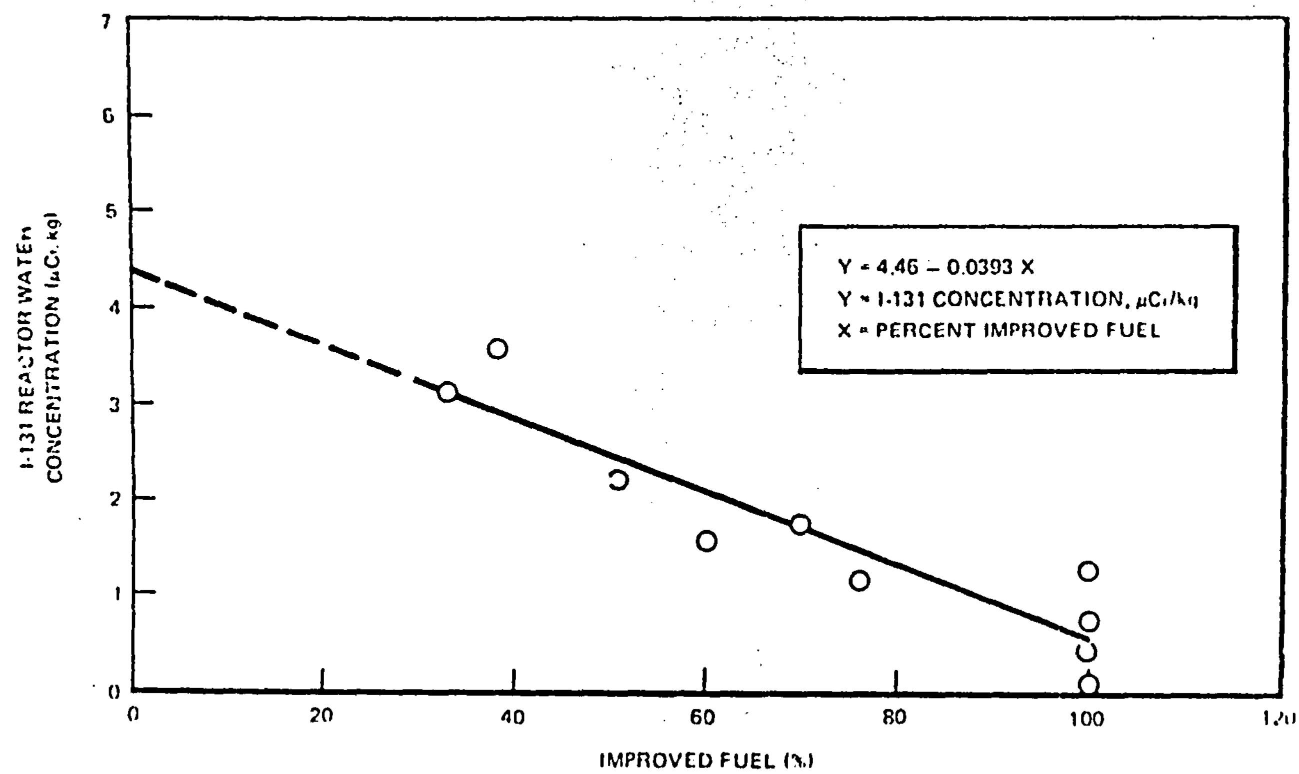


Figure 7-1. Correlation of I-131 Concentration in Reactor Water with Amount of Improved Fuel

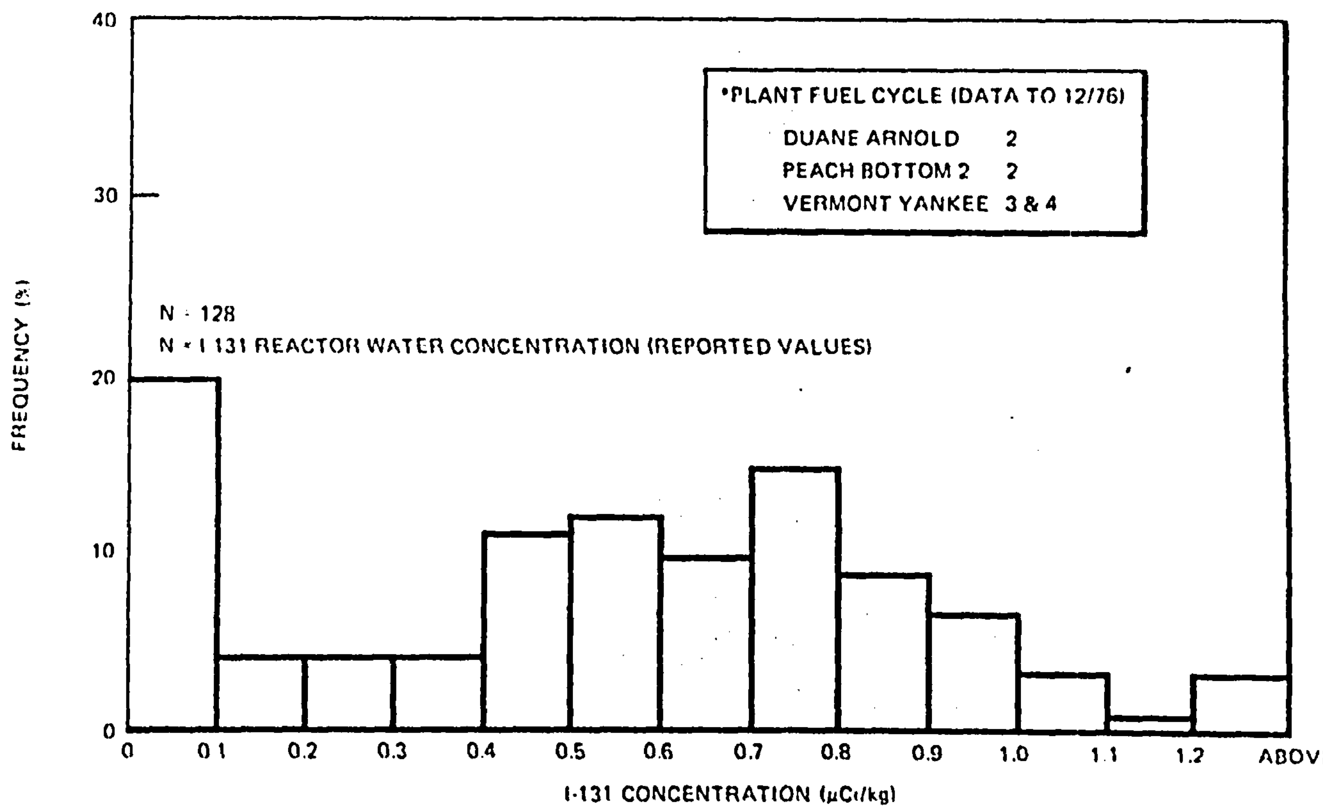


*Figure 7-2. Frequency Polygon of I-131 Reactor Water Concentrations in BWR's with 100% Improved Fuel**

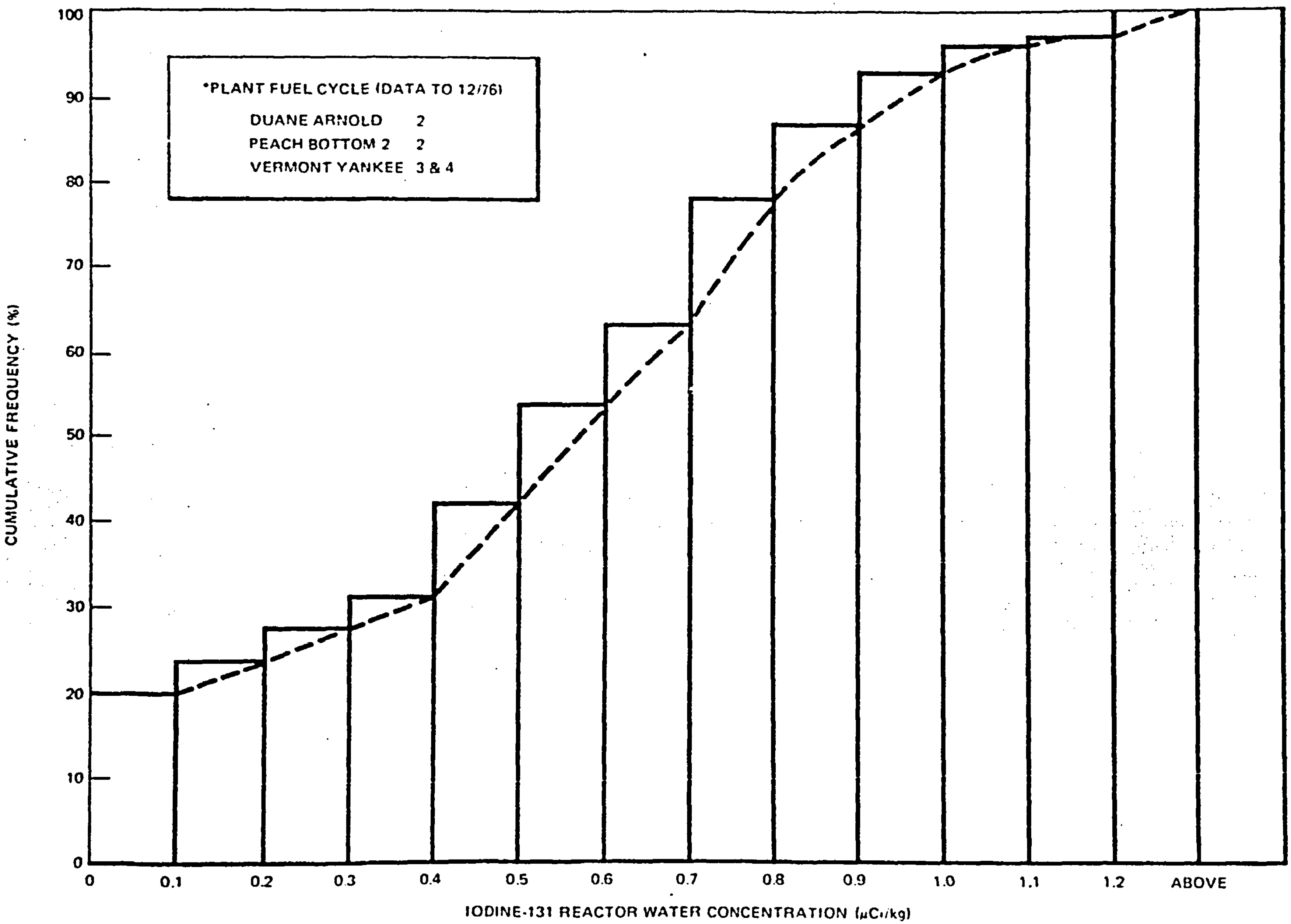


*Figure 7-3. Cumulative Frequency Polygon and Ogive Curve of I-131 Reactor Water Concentrations in BWR's with 100% Improved Fuel**

8. RECOMMENDATIONS

For the purposes of iodine-131 "source terms" for environmental impact evaluations of future BWRs the results of this study are recommended. For each chemical form of I-131, the annual airborne effluent releases are to be determined by the product of normalized release rates from the various release points in a BWR plant and the I-131 reactor water concentration. Iodine-131 reactor water concentrations of 1μCi/kg for full-flow condensate treatment and 2μCi/kg for pumped-forward heater drain plants are realistic, yet conservative, average values for BWRs.

To date, the extensive BWR operating experience indicates that no charcoal treatment is required on any ventilation exhausts to meet Nuclear Regulatory Commission Appendix I dose objectives.

The measurements of I-131 activities in milk are the most reliable index of potential dose. From operating BWRs, which have released more than 10 times as much I-131 to the environs as expected from future plants, the measured I-131 activities in milk were still sufficiently low such that doses (if the milk were continuously ingested) would equal a fraction of the NRC dose objectives. Thus, it is suggested that the costly monitoring of milk, as currently performed by BWR owners, could be reduced in terms of sample frequency and precision requirements. It is recommended that more simple programs for milk monitoring be developed and implemented.

9. ACKNOWLEDGMENTS

The preparation of this amendment required the continued cooperation of many personnel and organizations. The author appreciates the assistance from all who helped make this report possible. Especial thanks are due to Dr. Henry A. Till of the Electric Power Research Institute, who allowed the release of data prior to its formal publication, and to operating-BWR owners who permitted the release of proprietary information on I-131 concentrations in reactor water, I-131 carryover, and I-131 activities in milk. Particularly helpful in the transmittal of utility data were the following personnel: M. Whitemore with the Commonwealth Edison Company, B. Clark with Northern States Power Company, and A. Clements with the Tennessee Valley Authority. Many personnel at the General Electric Company have expended a great deal of effort towards this report, namely, B. J. Dalton, C. G. Ellis, W. J. Michaels, R. H. Thomas and the following Units: Product Services, Reactor Chemistry, Fuel Projects, Safety and Licensing, and Installation and Service Engineering. The author again thanks J. M. Smith for his continuing encouragement and kindly assistance.

APPENDIX 2A

NRC Commissioners' Opinion on 10CFR50 Appendix I (April 30, 1975): Selected Quotations

Quotations From

NRC Commissioners' Opinion on

10CFR50 Appendix I, dated April 30, 1975

The following are quotes from the Commissioners' opinion at the time of issuance of Appendix I for ALARA on reactor effluents, on the question of use of environs monitoring data to improve dose calculational models and to change technical specification. This is of particular practical importance on the relationship between radioiodine emissions and actual dose from milk consumption.

The page numbers indicated are from the original typewritten 149 page issue of April 30, 1975. Other publications of the opinion may have other page numbering systems.

Chapter I: Summary and Statement of Considerations

Background

Page 4-5

' The numerical guides of Appendix I which we announce today are a quantitative expression of the meaning of the requirement that radioactive material in effluents released to unrestricted areas from light-water-cooled nuclear power reactors be kept 'as low as practicable.' "

Page 6

"The commission believes that the record clearly indicates that any biological effects that might occur at the low levels of these standards have such low probability of occurence that they would escape detection by present-day methods of observation and measurement."

Chapter II: Appendix I

Section I. Introduction

Page 25

"Design objectives and limiting conditions for operation conforming to the guidelines of this appendix shall be deemed a conclusive showing of compliance with the 'as low as practicable' requirements of 10 CFR sections 50.34a and 50.36a."

Chapter IV, Guides on Technical Specifications for Limiting Conditions of Operation

A. The Rule

Page 101

"If, for any individual light-water-cooled nuclear power reactor, the quantity of radioactive material actually released in effluents to unrestricted areas during any calendar quarter is such as to cause radiation exposure, calculated on the same basis as the design-objective exposure, which would exceed one-half the annual design-objective exposure, the licensee shall make an investigation to identify the causes of these high release rates."....

Page 102

"The licensee is also required. . . .to provide data on measurable levels of radiation and radioactive materials in the environment so that the relationship between quantities of radioactive materials released and radiation dosages to individuals can be evaluated"....

Page 103

"It is further provided that, if the data developed in the surveillance and monitoring program described above show the relationship betwon quantities of radioactive materials released in effluents and the dose to individuals in unrestricted areas is significantly different from that assumed in the calculations used to determine design-objective limits, the Commission may modify the quantities in the technical specifications defining the limiting conditions for operation in the license that authorized operation of the light-water-cooled nuclear power reactor."

B. Discussion of Section IV of Appendix I

2. Surveillance and Measurement in Operating Plants

Page 106-107

"Quantitative measurement of radioactive materials released in effluents has always been required of persons licensed to operate nuclear power plants."

Page 107-108

"This preference for measured confirmation of estimates was shared by other participants. As discussed in Chapter V, the incentives for improving calculational models, which must necessarily be used in establishing design objectives for each reactor, are strong. Measurements at operating reactors are a means for making improvements. We are in sympathy with those who cite the virtues of designing and operating effluent-control systems with the enlightenment of real experience rather than with arbitrarily conservative calculational models. Measured levels of environmental radioactivity are generally small in comparison with values calculated from known or presumed release rates."

Page 109-110

"The pathway of greatest concern is the radioiodine course from air to grass to cow to milk to child. The Commission and the Environment Protection Agency made a study of this pathway, including a program of independent measurements in the vicinity of three operating light-water-cooled nuclear power plants. This study and further evidence in the record show the practicability of making useful measurements pertaining to the radioiodine pathway in situations in which radioiodine releases are substantial. We have required, by Appendix I, special surveillance measures for such situations and have adopted an implementation policy that should encourage applicants to use the best data available in any case."

Chapter V Implementation

A. Applicability

2. Discussion of Applicability

Page 119

". . . We agree that it would be preferable to base evaluations of design objectives on actual operating experience with the reactor in question in cases where substantial relevant information has been accumulated during plant operations."

B. Implementation of Numerical Guidelines

2. Discussion

Page 126-127

". . . . The necessity of explicit guidance is suggested in the argument that the procedures used by the Regulatory Staff for calculating doses show a predisposition to make unnecessarily conservative assumptions. The draft

Regulatory Guides circulated by the Directorate of Regulatory Standards with the Staff's concluding statement reflect a tendency toward the use of unnecessarily conservative calculational assumptions. The calculational methods described in the Final Environmental Statement and in draft Regulatory Guides are opposed in some particulars; furthermore it was argued that the Staff has, in the course of reactor licensing actions, generally been quite conservative in its quantitative assessment of effluent controls.

Particular areas of controversy shifted as the hearing progressed. It was not clear to participants whether or not models and assumptions used in the Final Environmental Statement were also intended by the Regulatory Staff to be applicable to the analysis of individual applications for licenses in the implementation of Appendix I. Examples of allegedly unnecessarily conservative implementation methods as they have been used in current licensing, include: excessive source-term assumptions with regard to radioiodine emissions; neglect, with regard to such emissions, of their chemical form, actual release points and modes, and expected plume behavior; overestimation of dispostion rates and retention factors for radioiodine on forages, and postulation of nonexistent dairy cows and unrealistic milk-consumption patterns."

Page 130

"....Our resolution strongly favors the suggestions that calculational methods be realistic, which in turn has influenced our adoption of particular numerical guideline values for dose objectives . ."

Page 131-133

"The essence of our conclusions on how calculational procedures should be used in determining design objectives is given in the five following points.

(1) *An applicant should be free to use as realistic a model for characterizing natural phenomena, including plant performance, as he considers useful. An applicant may take into account situations not adequately characterized by such standardized models as may be available with respect to specific features of plant design, proposed modes of plant operation, or local natural environmental features which are not likely to change significantly during the term of plant operation.*

....several effects that should be recognized, and we restate some of them here to illustrate natural phenomena that might be partially or entirely neglected in standard models but could be properly considered:

(a) radioisotopic composition of effluents;

(b) radioactive decay of released nuclides prior to exposure of the receptor;

(c) waterway flow and the associated diffusion and dilution;

(d) removal of radioactive material from solution or suspension in the water by sedimentation or other naturally occurring mechanisms or by water-treatment processes;

(e) exposure modes and occupancy or use factors;

(f) release conditions (to the atmosphere) including elevation of release point, effluent stream buoyancy and momentum, and building geometry;

(g) local meteorological and aerodynamic conditions influencing airborne effluent plume dispersion,

(h) beta and gamma radiation energies for the radioisotopes released and the associated dose effects;

(i) chemical form and physical behavior of the effluent constituents;

(j) plume elevation, size, and depletion;

(k) shielding effects;

(l) partitioning, filtration, and other retention and depletion effects;

(m) deposition rates and velocities for the various chemical forms of released radioiodine on offsite vegetation, ground, and other surfaces, with appropriate apportionment to the vegetation of its capture fraction; and

(n) weathering and other loss factors for radioiodine on grass and other vegetation.

Clearly other natural phenomena must also be adequately taken into account in models used for determining design objectives, but these are sufficiently established in practice that they need not be repeated here."

Page 134

"The models last proposed by the Regulatory Staff are different from the highly criticized versions used in the evaluations presented in the Final Environmental Statement. Testimony of the Staff indicates that the models used by the Staff and described in Regulatory Guides will continue to change. We believe Regulatory Guides to be useful; however, Regulatory Guide models should not be applied as a norm to be abandoned at the peril of the applicant. We believe the testimony of Staff witnesses in this hearing might, by some reasonable persons, indeed be construed as indicating that the Staff has been excessively zealous in applying Regulatory Guide models. We particularly expect all parties to licensing actions to which Appendix I applies to note both the potential utility of Regulatory Guides and their subordinate status relative to Commission regulations and opinions."

Page 135-136

". . We believe that the opportunity to modify models and data as new experimental information comes to light could have substantial advantages over a rigid rule, which is a persuasive argument for permitting this matter to be dealt with by the preparation of Regulatory Guides and be case-by-case evaluations."

Page 138

"The models described in the hearing record and the evidence and arguments advances with regard to numerical estimation of dose lead us to the conclusion that one should try to attain realistic estimates; but, where uncertainties exist, one should choose calculational procedures that are unlikely to produce substantial underestimates. We believe, furthermore, that it is in the best interest of the public to make realistic estimates, even with uncertain data, and to depend upon the programs for improving models and data, particularly programs of in-plant measurements, to determine whether proper case-by-case design decisions were made. . . ."

Page 148

"Furthermore the evidence shows that with additional experience and data from operating plants the most likely result will be that estimates based upon present-day models and assumptions are unrealistically high. . . ."

APPENDIX 2B

Iodine-131 Species Measurements of In-Plant Equipment Compartments and SJAE Delay Pipe Exhaust

Table B-1
I-131 SPECIES — IN-PLANT COMPARTMENTS/REACTOR BUILDING

Plant	Compartment	Sample Date Month/Day/Year	Species, % of I-131 Release: Particulate	I_2	HOI	CH_3I	I-131 Release Rate, μCi/s (0.001)	Plant Operating Condition	Sample Time Days
Monticello	Fuel Pool Skimmer	11-5 — 11-7-74	24.1	22.7	20.8	32.4	0.16	O	2
		1-8 — 1-9-75	40.8	59.2	<27.0	<27.0	0.10	O	1
		1-13 — 1-15-75	2.8	52.6	37.4	7.3	22.0	R	2
		9-11 — 9-25-75	3.5	30.2	37.4	28.9	20.0	R	14
		9-25 — 10-15-75	2.0	20.0	(0.3)	(77.5)	7.8	R	20
		10-15 — 10-27-75	3.4	21.3	(2.6)	(75.6)	1.7	R	12
		10-27 — 11-14	<2.4	31.0	(<2.7)	(69.0)	0.12	R	18
Monticello	Sampling Hood	11-5 — 11-7-74	6.4	19.0	9.3	65.3	0.49	O	2
		1-8 — 1-9-75	16.1	73.5	<4.0	8.5	0.078	O	1
		1-12 — 1-15-75	2.4	44.7	15.1	37.3	0.22	R	2
Monticello	Containment purge to Standby Gas Treatment System	11-17 — 11-18-74	0.3	6.2	16.1	77.4	2.4	O	1
		1-9 — 1-10-75	7.9	8.0	25.4	58.7	1.9	R	1
		1-10 — 1-12-75	0.2	2.9	14.6	82.3	1.1	R	2
		1-12 — 1-14-75	0.3	5.6	28.1	66.0	0.32	R	2
			Inlet						
Monticello	Standby Gas Treatment System	5-16 — 5-17-75 (1700 hrs — 1555 hrs)	2.3	19.2	50.4	28.1	3.6	O	0.96
			Outlet						
			2.8	14.8	17.9	65.5	0.21	O	0.96
Monticello	Clean-up pump room exhaust	0015, 5-19 to 1020, 5-19-75	19.1	45.4	29.1	6.4	36.0	O	0.42
		1920, 7-30 to 0832, 7-31-75	23.0	42.8	26.5	7.7	110.0	O	0.55
		0856, 7-31 to 2007, 7-31-75	26.9	35.9	29.1	8.1	96.0	O	0.47

Table B-1

I-131 SPECIES — IN-PLANT COMPARTMENTS/REACTOR BUILDING (Continued)

Plant	Compartment	Sample Date Month/Day/Year	Species, % of I-131 Release Particulate	I_2	HOI	CH_3I	I-131 Release Rate, μCi/s (0.001)	Plant Operating Condition	Sample Time Days
		2010, 7-31 to 0917, 8-1-75	27 9	34.9	27.9	9 2	95 0	O	0.55
		0920, 8-1 to 2232, 8-1-75	29 9	39 5	22.5	8 1	95 0	O	0.55
		1920, 7-30 to 2232, 8-1-75	23.7	36 2	30 9	9.2	100.0	O	2.1
Nine Mile Point 1	Drywell Purge	3-29-74	21.8	10.9	0.0	67.3	1.47	R	0 11
Nine Mile Point 1	Steam Dome	4-1-74	1.1	35.9	27.5	35.4	NA	R	0.18

NOTE (1) All measurements sponsored by EPRI (conducted by NES) except those at Nine Mile Point 1 which were done by GE
(2) Plant mode notation: O – Power Generation Operations (which may include brief plant shutdowns) R – refueling maintenance outage
(3) I-131 Release rate notation 0.16 (0.001) = 0.00016 microcuries/second

Table B-2
I-131 SPECIES — IN PLANT COMPARTMENTS/TURBINE BUILDING
(ALL MEASUREMENTS SPONSORED BY EPRI, CONDUCTED BY NES)

Plant	Compartment	Sample Date Month/Day/Year	Species, % of I-131 Release: Particulate	I_2	HOI	CH_3I	I-131 Release Rate, μCi/s (0.001)	Plant Operating Condition	Sample Time Days
Monticello	Condenser area	11-15 — 11-17-74	18.4	53.1	12.2	16.3	2.9	D	2
		1-8 — 1-9-75	13.8	68.6	9.2	8.4	3.4	O	1
		1-13 — 1-15-75	1.4	50.7	16.9	32.4	22.0	R	2
		5-12 — 5-15-75	26.5	51.5	15.4	6.6	31.0	O	3
		9-11 — 9-25-75	8.1	31.3	40.0	20.6	4.7	R	14
		9-25 — 10-15	2.3	9.4	(0.4)	(88.0)	1.3	R	20
		10-15 — 10-27	<2.4	17.6	(<3.2)	(82.4)	0.17	R	12
		10-27 — 11-14-75	<7.1	<11.9	(<11.9)	(100.0)	0.058	R	18
Oyster Creek	Condenser area (top)	3-27 — 3-28-75	38.0	48.0	10.0	4.0		O	1
	(bottom)	3-27 — 3-28-75	51.0	40.0	9.0	<1.0		O	1
Vermont Yankee	Condenser area	9-12 — 9-14-74	30.4	60.6	6.7	1.6	4.1	O	2
		10-31 — 11-1-74	1.0	9.0	47.0	43.0	5.6	R	1
Monticello	SJAE Room	11-15 — 11-17-74	3.4	30.4	16.3	50.0	0.5	O	2
		1-8 — 1-9-75	12.6	43.3	28.8	15.3	0.62	O	1
		1-13 — 1-15-75	4.0	71.6	13.8	10.5	2.8	R	2
Monticello	MVP Room	11-18 — 11-19-74	2.2	26.5	37.0	34.0	0.3	O	1
		1-8 — 1-9-75	<6.8	40.8	15.0	44.8	0.1	O	1
		1-13 — 1-15-75	3.0	30.6	24.2	42.2	2.8	R	2
Monticello	Operating floor	1-8 — 1-9-75	12.7	63.3	36.7	<19.0	0.11	O	1
		1-12 — 1-15-75	2.9	26.0	23.0	48.0	7.8	R	2
Oyster Creek	Operating floor	2-22 — 2-27-75	32.0	43.0	21.0	4.0	4.0	O	5

Table B-2
I-131 SPECIES — IN PLANT COMPARTMENTS/TURBINE BUILDING
(ALL MEASUREMENTS SPONSORED BY EPRI, CONDUCTED BY NES) (Continued)

Plant	Compartment	Sample Date Month/Day/Year	Species, % of I-131 Release Particulate	I_2	HOI	CH_3I	I-131 Release Rate, μCi/s (0.001)	Plant Operating Condition	Sample Time Days
Oyster Creek	Heater Bay 1	2-22 — 2-27-75	17.0	60.0	20.0	3.0	NA	O	5
	2	2-22 — 2-27-75	16.0	56.0	23.0	5.0		O	5
	2	3-30 — 3-31-75	6.4	18.2	14.5	60.9		R	1
	3	2-22 — 2-27-75	17.0	55.0	23.0	5.0		O	5
	4	2-22 — 2-27-75	17.0	55.0	23.0	5.0		O	5
	5	2-22 — 2-27-75	27.0	47.0	20.0	6.0		O	5
	5	3-30 — 3-31-75	<2.0	42.9	20.2	36.9		R	1
	6	2-22 — 2-27-75	25.0	50.0	19.0	6.0		O	5
Oyster Creek	Climate	2-22 — 2-27-75	25.0	50.0	20.0	5.0	NA		5
		3-30 — 3-31-75	5.7	33.5	13.6	47.3	NA	R	1
Oyster Creek	Reheater area (top)	3-27 — 3-28-75	17.0	67.0	13.0	3.0	NA	O	1
	(middle)	3-27 — 3-28-75	1.0	79.0	12.0	8.0		O	1
	(bottom)	3-27 — 3-28-75	21.0	68.0	7.0	4.0		O	1
	exhaust	4-1 — 4-2-75	0.2	11.0	58.8	30.0		R	1

NOTES (1) Plant Mode notation: O - Power Generation Operations (which may include brief plant shutdowns), R - refueling-maintenance outages
(2) I-131 Release Rate notation 2.9 (0.001) = 0.0029 microcuries/second
(3) NA = Data not available

Table B-3
SUMMARY OF MEASUREMENTS OF IODINE-131 CHEMICAL FORM IN
BWR STEAM-JET AIR-EJECTOR DELAY LINE

Plant	Sample Period Month/Day/Year	Species, % of I-131 Release Particulate	I_2	HOI	CH_3I	Measurements By	Sample Time Days
Oyster Creek	6-16 — 6-23-76		No Sample			EPRI(NES)	7
Oyster Creek	6-23 — 6-30-76	<0.1	1.0	18.0	81	EPRI(NES)	7
Oyster Creek	6-30 — 7-7-76	<0.1	0.1	19.0	81	EPRI(NES)	7
Oyster Creek	7-7 — 7-13-76		Sample Lost			EPRI(NES)	6
Oyster Creek	7-13 — 7-20-76	0.1	<0.1	18.0	82	EPRI(NES)	7
Oyster Creek	7-20 — 7-27-76	0.1	3.0	16.0	81	EPRI(NES)	7
Oyster Creek	7-27 — 8-3-76	<0.1	1.0	10.0	89	EPRI(NES)	7
Oyster Creek	8-3 — 8-10-76	<0.1	1.0	24.0	75	EPRI(NES)	7
Oyster Creek	8-10 — 8-17-76	<0.1	0.4	19.0	80	EPRI(NES)	7
Oyster Creek	8-17 — 8-24-76	<0.1	1.0	17.0	82	EPRI(NES)	7
Oyster Creek	8-24 — 8-30-76	<0.1	3.0	18.0	79	EPRI(NES)	6
Oyster Creek	8-30 — 9-7-76	<0.1	1.0	25.0	74	EPRI(NES)	8
Oyster Creek	9-7 — 9-16-76	<0.1	0.4	33.0	67	EPRI(NES)	9
Oyster Creek	9-16 — 9-23-76	<0.1	0.4	12.0	88	EPRI(NES)	7
Oyster Creek	9-23 — 9-30-76	<0.1	<0.1	13.0	87	EPRI(NES)	7
Oyster Creek	9-30 — 10-7-76	<0.1	0.2	6.0	94	EPRI(NES)	7
Oyster Creek	10-7 — 10-14-76	<0.1	0.1	<0.1	100	EPRI(NES)	7
Oyster Creek	10-14 — 10-21-76	<0.1	0.2	6.0	94	EPRI(NES)	7
Oyster Creek	10-21 — 10-28-76	<0.1	0.1	3.0	97	EPRI(NES)	7
Oyster Creek	10-28 — 11-4-76	<0.1	<0.1	1.0	99	EPRI(NES)	7
Oyster Creek	11-4 — 11-11-76	<0.1	<0.1	2.0	98	EPRI(NES)	7
Oyster Creek	11-11 — 11-18-76	<0.1	<0.1	1.0	99	EPRI(NES)	7
Oyster Creek	11-18 — 11-30-76	<0.1	<0.1	1.0	99	EPRI(NES)	12

APPENDIX 2C

Summary of Iodine-131 Reactor Water Concentrations in BWRs (1975 to 1977), Average Annual Values

Table C-1
SUMMARY OF IODINE-131 REACTOR WATER CONCENTRATIONS IN BWRs (1975–1977), AVERAGE ANNUAL VALUES

Type	Condensate Treatment	Plant	1975 (Year; I-131 Concentration, μCi/Kg)	1976	1977
2	Full-Flow	Nine Mile Point 1	4.5	1.9	3.0
		Oyster Creek	3.2	1.7	2.7
		Average	3.9	1.8	2.9
3	Full-Flow	Dresden 2	0.24	0.29	0.64
		Dresden 3	3.9	3.5	4.9
		Millstone Point 1	8.0	2.0	3.2
		Monticello	101.	7.3	4.7
		Pilgrim 1	16.	16.	17.
		Quad Cities 1	0.83	2.7	6.5
		Quad Cities 2	16	6.1	3.6
		Average	21	5.4	5.9
4	Full-Flow	Browns Ferry 1	0.46	0.55	0.89
		Browns Ferry 2	0.046	0.17	1.4
		Browns Ferry 3	—	—	0.13
		Cooper	0.0061	0.054	0.044
		Duane Arnold	0.0020	0.082	0.036
		Fitzpatrick	—	0.14	0.12
		Hatch 1	0.0034	0.11	0.89
		Peach Bottom 2	0.028	12.	5.2
		Peach Bottom 3	0.043	0.59	1.0
		Vermont Yankee	0.79	0.52	0.38
		Average	0.17	1.6	1.0
4	Pump-Forward	Brunswick 1	—	—	0.017
		Brunswick 2	0.0070	0.89	3.0
		Average	0.0070	0.89	1.5

APPENDIX 2D

Summary of Data Available for Iodine-131 Ventilation Releases at Browns Ferry During 1977

Table D-1

SUMMARY OF ACTUAL IODINE-131 VENTILATION RELEASES AT BROWNS FERRY DURING 1977

Plant	Vent No.[a]	Vent Flow Rate cc/s	I-131 Conc. (avg.) µCi/cc	I-131 Release Rate (avg.) µCi/s	Sample Period Days: Power Oper.	Sample Period Days: Refuel/Maint.	I-131 Release mCi/Year[b]: Power Oper.	I-131 Release mCi/Year[b]: Refuel/Maint.		Total Plant I-131 Release mCi/Reactor Yr.
Browns Ferry 1	1-250	11.9 E-7[c]	36.2 E-13	43.0 E-5	257	—	11.1	—		
	1-250	11.9 E-7	45.1 E-13	53.7 E-5	—	106	—	4.92		
	1-249	2.98 E-7	3.00 E-13	0.322 E-5	(108 • 00S)[c]	—	0.0834	—		
	1-249	2.98 E-7	12.6 E-13	1.62 E-5	—	(28 • 00S)	—	0.0910		
	1-251	3.27 E-7	7.61 E-13	0.912 E-5	(110 • 00S)	—	0.236			
	1-251	3.27 E-7	4.19 E-13	1.16 E-5	—	(55 - 00S)	—	0.0650		
Totals							11.4	5.07	=	16.5
Browns Ferry 2	2-250	12.6 E-7	18.3 E-13	23.0 E-5	296	—	5.97			
	2-250	12.6 E-7	3.56 E-13	4.49 E-5	—	74	—	0.287		
	2-249	3.03 E-7	4.89 E-13	0.450 E-5	(91 • 00S)	—	0.117	—		
	2-249	3.03 E-7	3.36 E-13	0.313 E-5	—	(20 • 00S)	—	0.0176		
	2-251	3.79 E-7	1.53 E-13	0.176 E-5	(91 - 00S)	—	0.0455	—		
	2-251	3.79 E-7	2.67 E-13	0.312 E-5	—	(20 + 00S)	—	0.0175		
Totals							6.13	0.322	=	6.45
Browns Ferry 3	3-250	12.1 E-7	4.37 E-13	5.29 E-5	365		1.37	No Outage		
	3-249	2.58 E-7	2.86 E-13	0.514 E-5	(209 • 00S)		0.133	During		
	3-251	3.23 E-7	4.55 E-13	0.857 E-5	(175 • 00S)		0.222	Year		
Totals							1.73		=	1.73
Browns Ferry 1/2/3	0-252	1.61 E-7	112. E-13	18.0	365		5.69	(three plants)	=	1.90[d]

NOTES

a Vent-250 releases are from reactor building and certain equipment rooms in turbine building. Vent-249 are releases from four fans over operating floor of turbine building. Vent-251 releases are from 5 fans over operating floor of turbine building.

b Releases adjusted to 300 days of power operation per year plus one R/M outage.

c Notations: 11.9 E-7 = 11.9 × 10⁷; 00S • Out of Service

d Radwaste building processes wastes from all three reactors; annual release taken as total release divided by three.

1 Average I-131 reactor water concentration (µCi/kg) during power operation is as follows: Unit 1: 0.890; Unit 2: 1.35; Unit 3: 0.131

2 Average I-131 release per plant (total of reactor, turbine and radwaste building ventilation releases): (16.5 + 6.45 + 1.73 + 5.69)/3 = 10.1 mCi/reactor year

Table D-2
IODINE-131 VENT MONITOR MEASUREMENTS AT BROWNS FERRY 1 DURING 1977, MONITOR 1-250 (REACTOR BUILDING AND EQUIPMENT ROOMS IN TURBINE BUILDING, FLOW RATE = 11.9 × 10^{4} cc/s).

Sample Period Month/Day	I-131 Concentration (μCi/cc) × 10^{12}	Sample Period Month/Day	I-131 Concentration (μCi/cc) × 10^{12}
12/31–1/7	0.505	5/26–5/27	4.42
1/6–1/7	7.95	5/27–6/4	3.73
1/7–1/15	0.116	6/4–6/11	43.5
1/15–1/21	<0.0161	6/11–6/17	5.17
1/21–1/25	<0.126	6/17–6/20	0.334
1/25–1/26	<0.399	6/20–6/21	1.61
1/26–1/27	1.51	6/21–6/24	2.31
1/27–1/27	<3.50	6/24–7/1	0.590
1/27–1/29	1.00	7/1–7/7	2.31
1/29–2/4	0.352	7/7–7/8	0.880
2/4–2/11	0.152	7/8–7/9	<0.723
2/11–2/13	9.80	7/9–7/11	2.16
2/13–2/13	2.90	7/11–7/11	5.52
2/13–2/14	4.79	7/11–7/15	2.44
2/14–2/16	2.17	7/15–7/21	2.28
2/16–2/17	2.67	7/21–7/22	2.73
2/17–2/18	1.15	7/22–7/27	1.66
2/18–2/21	0.342	7/27–7/28	1.14
2/21–2/22	<0.435	7/28–7/29	5.67
2/22–2/26	0.327	7/29–8/5	12.9
2/26–3/5	0.119	8/5–8/13	3.82
3/5–3/11	0.234	8/13–8/19	2.26
3/11–3/12	<0.834	8/19–8/22	2.30
3/12–3/12	<4.10	8/22–8/23	2.29
3/12–3/13	<0.544	8/23–8/26	1.36
3/13–3/14	<0.480	8/26–8/30	1.18
3/14–3/18	0.391	9/2–9/9	0.691
3/18–3/21	<0.215	9/9–9/16	0.806
3/21–3/22	<0.631	9/16–9/20	12.2
3/22–3/24	0.651	9/20–9/21	12.7
3/24–3/24	0.843	9/21–9/23	4.77
3/24–3/25	<2.17	9/23–9/30	2.50
3/25–3/25	1.37	9/30–10/8	40.4
3/25–4/2	0.864	10/8–10/14	6.85
4/1–4/9	0.447	10/14–10/22	3.86
4/9–4/15	0.490	10/22–10/24	0.335
4/15–4/22	1.49	10/24–10/25	1.25
4/22–4/25	15.7	10/25–10/29	13.6
4/25–4/26	9.15	10/29–11/4	0.512
4/26–4/30	37.3	11/4–11/12	0.563
4/30–5/6	<2.54	11/12–11/19	<0.137
5/6–5/13	2.88	11/19–11/21	<0.318
5/13–5/20	1.32	11/21–11/22	<1.11
5/20–5/23	5.55	11/22–11/26	0.812
5/23–5/23	7.95	11/26–12/3	0.269
5/23–5/23	9.96	12/3–12/9	0.158
5/23–5/24	<5.56	12/9–12/16	<0.162
5/24–5/24	4.51	12/16–12/19	<0.266
5/24–5/26	<2.56	12/19–12/20	<0.629
5/26–5/26	<4.78	12/20–12/23	<0.183
5/26–5/26	4.21	12/23–12/31	<0.115

Table D-3
IODINE-131 VENT MONITOR MEASUREMENTS AT BROWNS FERRY 1 DURING 1977, MONITOR 1-249 (FOUR VENTS OVER OPERATING FLOOR OF TURBINE BUILDING, FLOW RATE = 2.98 × 10^{7} cc/s).

Sample Period Month/Day	I-131 Concentration (μCi/cc) × $10^{[illegible]}$
1/1 -5/27	Out of Service
5/27-5/27	<0.993
5/27-6/4	<0.108
6/4 -6/10	0.657
6/10-6/17	0.332
6/17-6/20	<0.253
6/20-6/21	<0.510
6/21-6/24	0.210
6/24-7/1	0.157
7/1 -7/9	0.135
7/9 -7/10	<0.104
7/15-7/22	<0.0823
7/22-7/27	<0.159
7/27-7/28	<0.456
7/28-7/29	<0.195
7/29-8/5	0.984
8/5 -8/13	0.307
8/13-8/19	0.279
8/19-8/22	0.208
8/22-8/23	<0.417
8/23-8/26	<0.158
8/26-8/30	<0.175
8/30-9/2	<0.153
9/2 -9/9	<0.0824
9/9 -9/16	<0.0855
9/16-9/20	<0.248
9/20-9/21	<0.538
9/21-9/23	1.26
9/23-9/30	1.07
9/30-10/8	3.79
10/8-10/14	<0.672
10/14-12/31	Out of Service

Table D-4
IODINE-131 VENT MONITOR MEASUREMENTS AT BROWNS FERRY 1 DURING 1977, MONITOR 1-251 (FIVE VENTS OVER OPERATING FLOOR OF TURBINE BUILDING, FLOW RATE = 3.72 × 10' cc/s).

Sample Period Month/Day	I-131 Concentration (μCi/cc) × 10''
1/1 -5/27	Out of Service
5/27-5/27	<1.14
5/27-6/4	0.344
6/4 -6/10	0.751
6/10-6/17	0.491
6/17-6/20	<0.299
6/20-6/21	<0.706
6/21-6/24	<0.294
6/24-7/1	<0.184
7/1-7/7	<0.184
7/8-7/9	<0.139
7/15-7/21	0.165
7/21-7/22	<6.57
7/22-7/23	4.03
7/22-7/27	<0.225
7/27-7/28	<0.677
7/28-7/29	<0.289
7/29-8/5	1.26
8/5-8/13	0.250
8/13-8/19	0.360
8/19-8/22	<0.228
8/22-8/23	<0.361
8/23-8/26	<0.182
8/26-8/30	<0.292
8/30-9/2	<0.140
9/2-9/9	<0.116
9/9-9/16	<0.104
9/16-9/20	<0.260
9/20-9/21	<0.441
9/21-9/23	1.31
9/23-9/30	0.374
9/30-10/8	0.551
10/8-10/14	<0.185
10/14-10/22	<0.0502
10/22-10/24	<0.306
10/24-10/25	<0.610
10/25-10/29	<0.208
10/29-11/4	<0.0956
11/4-11/13	<0.179
11/2-12/13	Out of service

Table D-5
IODINE-131 VENT MONITOR MEASUREMENTS AT BROWNS FERRY 2 DURING 1977, MONITOR 2-250 (REACTOR BUILDING AND EQUIPMENT ROOMS IN TURBINE BUILDING, FLOW RATE = 12.6 × 10^{7} cc/s).

Sample Period Month/Day	I-131 Concentration (μCi/cc) × 10^{12}	Sample Period Month/Day	I-131 Concentration (μCi/cc) × 10^{12}
12/31-1/7	0.151	5/20-5/23	3.28
1/7-1/15	0.232	5/23-5/24	0.695
1/15-1/21	0.0902	5/24-5/27	3.73
1/21-1/25	3.30	5/27-6/4	2.55
1/25-1/26	29.9	6/4-6/11	9.87
1/26-1/29	8.17	6/11-6/17	0.573
1/29-2/3	2.35	6/17-6/20	0.419
2/3-2/4	1.47	6/20-6/21	<0.405
2/4-2/11	1.72	6/21-6/24	0.293
2/11-2/18	1.10	6/24-7/1	0.337
2/18-2/19	<1.03	7/1-7/9	0.854
2/19-2/21	<0.279	7/9-7/15	0.673
2/21-2/22	0.699	7/15-7/23	0.537
2/22-2/22	5.75	7/22-7/27	0.218
2/22-2/26	0.481	7/27-7/28	<0.40
2/26-3/5	0.185	7/28-7/29	<0.285
3/5-3/11	<0.0989	7/29-8/5	<0.0833
3/11-3/14	0.408	8/5-8/13	0.331
3/14-3/14	<1.67	8/13-8/20	0.212
3/14-3/18	<0.130	8/20-8/22	<0.189
3/18-3/21	0.263	8/22-8/23	<0.444
3/21-3/22	<0.444	8/23-8/26	<0.133
3/22-3/24	0.850	8/26-9/2	<0.0891
3/24-3/25	<0.757	9/2-9/9	<0.0836
3/25-3/25	<1.83	9/9-9/16	<0.502
3/25-3/25	<3.01	9/16-9/19	12.1
3/25-3/26	<0.693	9/19-9/21	2.71
3/26-3/28	<0.239	9/21-9/23	1.65
3/28-3/28	<7.25	9/23-9/30	0.928
3/28-3/31	<0.174	9/30-10/8	7.53
3/31-4/1	<0.544	10/8-10/14	2.03
4/1-4/1	<0.512	10/14-10/22	2.16
4/1-4/8	<0.0868	10/22-10/24	<0.307
4/8-4/9	<0.937	10/24-10/25	1.05
4/9-4/11	<0.172	10/25-10/29	<0.379
4/11-4/23	<0.638	10/29-11/4	0.385
4/12-4/12	4.28	11/4-11/11	0.420
4/12-4/13	<0.857	11/11-11/18	0.213
4/13-4/15	<0.187	11/18-11/21	<0.252
4/15-4/22	0.823	11/21-11/22	<0.750
4/22-4/25	0.788	11/22-11/26	<0.268
4/25-4/26	0.934	11/26-12/3	<0.237
4/26-4/30	1.30	12/3-12/9	<0.175
4/30-5/6	0.258	12/9-12/16	<0.139
4/5-5/13	0.456	12/16-12/19	<0.213
5/13-5/21	0.264	12/19-12/20	<0.570
		12/20-12/23	<0.220
		12/23-12/31	0.124

Table D-6
IODINE-131 VENT MONITOR MEASUREMENTS AT BROWNS FERRY 2 DURING 1977, MONITOR 2-249 (FOUR VENTS OVER OPERATING FLOOR OF TURBINE BUILDING, FLOW RATE = 3.03×10^7 cc/s).

Sample Period Month/Day	I-131 Concentration (μCi/cc) $\times 10^{12}$
1/1 -7/19	Out of Service
7/19-7/20	<1.83
7/25-7/26	0.130
7/26-7/27	<0.621
7/27-7/29	0.217
7/29-8/5	0.676
8/5-8/6	0.139
8/13-8/19	0.143
8/19-8/22	<0.215
8/22-8/23	<0.623
8/23-8/26	<0.229
8/26-9/2	<0.411
9/2-9/9	<0.110
9/9-9/16	<0.155
9/16-9/19	<0.300
9/19-9/20	<0.716
9/20-9/23	1.42
9/23-9/30	0.552
9/30-10/7	0.466
10/7-10/14	<0.556
10/14-10/21	0.277
10/21-10/24	<0.324
10/24-10/25	<0.796
10/25-10/29	<0.260
10/29-11/5	<0.182
11/5-11/10	<0.117
11/10-12/31	Out of Service

Table D-7
IODINE-131 VENT MONITOR MEASUREMENTS AT BROWNS FERRY 2 DURING 1977, MONITOR 2-251 (FIVE VENTS OVER OPERATING FLOOR OF TURBINE BUILDING, FLOW RATE ≈ 3.79×10^{7} cc/s).

Sample Period Month/Day	I-131 Concentration (μCi/cc) $\times 10^{12}$
1/1 –7/19	Out of Service
7/19–7/20	<0.0710
7/25–7/26	<0.0944
7/26–7/27	<0.194
7/27–7/29	<0.0852
7/29–8/5	0.0685
8/5–8/13	<0.363
8/13–8/19	0.0409
8/19–8/22	<0.0943
8/22–8/23	<0.192
8/23–8/26	<0.0882
8/26–9/2	<0.0546
9/2–9/9	<0.0492
9/9–9/16	<0.044
9/16–9/19	<0.114
9/19–9/20	<0.252
9/20–9/23	1.01
9/23–9/30	0.0869
9/30–10/7	0.0543
10/7–10/14	0.0456
10/14–10/21	<0.0538
10/21–10/24	<0.306
10/24–10/25	<0.194
10/25–10/29	<0.725
10/29–11/5	<0.0741
11/5–11/10	<0.0375
11/10–12/31	Out of Service

Table D-8

IODINE-131 VENT MONITOR MEASUREMENTS AT BROWNS FERRY 3 DURING 1977, MONITOR 3-250 (REACTOR BUILDING AND EQUIPMENT ROOMS IN TURBINE BUILDING, FLOW RATE = 12.1 × 10^{7} cc/s).

Sample Period Month/Day	I-131 Concentration (μCi/cc) × 10^{12}	Sample Period Month/Day	I-131 Concentration (μCi/cc) × 10^{12}
12/31-1/7	1.23	7/1-7/9	<0.0727
1/7-1/15	0.145	7/9-7/15	<0.0814
1/15-1/21	<0.0651	7/15-7/22	<0.0791
1/21-1/25	0.198	7/22-7/27	<0.103
1/25-1/26	<0.396	7/27-7/28	<0.399
1/26-1/29	1.59	7/28-7/29	<0.255
1/29-2/3	0.376	7/29-8/5	<0.0802
2/4-2/11	<0.932	8/5-8/13	<0.0659
2/11-2/18	0.0977	8/13-8/20	<0.0744
2/18-2/19	<0.193	8/20-8/22	<0.18
2/21-2/21	<0.522	8/22-8/23	<0.386
2/22-2/26	<0.169	8/23-8/26	<0.129
2/26-3/5	0.115	8/26-9/2	<0.0841
3/5-3/11	<0.104	9/2-9/9	<0.0848
3/11-3/18	0.103	9/9-9/16	0.346
3/18-3/21	0.206	9/16-9/19	5.33
3/21-3/22	<0.531	9/19-9/21	0.668
3/22-3/25	<0.144	9/21-9/23	0.653
3/25-4/1	<0.858	9/23-9/30	0.499
4/1-4/8	<0.0884	9/30-10/8	2.34
4/9-4/15	<0.107	10/8-10/14	0.450
4/15-4/22	0.274	10/14-10/22	0.323
4/22-4/25	0.338	10/22-10/24	0.715
4/25-4/26	<0.447	10/24-10/25	<0.381
4/26-4/30	0.239	10/25-10/29	<0.194
4/30-5/6	1.33	10/29-11/4	0.228
5/6-5/13	1.45	11/4-11/11	<0.0905
5/13-5/20	<0.0748	11/11-11/18	0.114
5/20-5/23	<0.179	11/18-11/21	<0.215
5/23-5/24	<0.412	11/21-11/22	<0.586
5/24-5/27	<0.133	11/22-11/26	0.339
5/27-6/4	<0.0746	11/26-12/3	<0.132
6/4-6/11	0.120	12/3-12/9	<0.146
6/11-6/17	<0.0837	12/9-12/16	<0.110
6/17-6/20	<0.145	12/16-12/19	<0.227
6/20-6/21	<0.372	12/19-12/20	<0.485
6/21-6/24	<0.123	12/20-12/23	<0.172
6/24-7/1	0.177	12/23-12/31	<0.120

Table D-9
IODINE-131 VENT MONITOR MEASUREMENTS AT BROWNS FERRY 3 DURING 1977, MONITOR 3-249 (FOUR VENTS OVER OPERATING FLOOR OF TURBINE BUILDING, FLOW RATE = 2.58 × 10^{7} cc/s).

Sample Period Month/Day	I-131 Concentration (μCi/cc) × 10^{12}
1/1 –4/18	Out of Service
4/18–4/22	<0.335
4/22–4/24	1.01
4/24–4/26	0.646
4/26–4/27	<0.455
4/27–4/30	2.04
4/30–5/6	0.19
5/6–5/13	<0.0938
5/13–5/21	<0.123
5/21–5/23	0.430
5/23–5/24	0.918
4/25–5/27	0.269
5/27–6/4	<0.180
6/4–6/11	0.300
6/11–6/17	0.194
6/17–6/20	<0.242
6/20–6/21	<0.451
6/21–6/24	<0.136
6/24–7/1	<0.0815
7/1–7/9	<0.0776
7/9–7/15	<0.0825
7/15–7/22	<0.0773
7/22–7/27	<0.125
7/27–7/28	<0.397
7/28–7/29	<0.178
7/29–8/5	0.0939
8/5–8/13	<0.0775
8/13–8/20	<0.149
8/20–8/23	<0.970
8/23–8/26	<0.220
8/26–9/2	<0.118
9/2–9/9	<0.367
9/9–9/15	<0.112
9/15–9/16	<0.312
9/16–9/19	<0.237
9/19–9/21	<0.482
9/21–9/23	<0.198
9/23–9/30	0.104
9/30–10/8	0.0704
10/8–10/14	<0.0390
10/4–10/22	<0.0459
10/22–10/24	<0.0898
10/24–10/25	<0.180
10/25–10/29	<0.655
10/29–11/4	<0.0373
11/4–11/11	<0.0805
11/11–12/31	Out of Service

Table D-11
IODINE-131 VENT MONITOR MEASUREMENTS AT BROWNS FERRY 1, 2, and 3 DURING 1977, MONITOR 0-252 (RADWASTE BUILDING, FLOW RATE = 1.61 × 10^7 cc/s).

Sample Period Month/Day	I-131 Concentration (μCi/cc) × 10^{12}	Sample Period Month/Day	I-131 Concentration (μCi/cc) × 10^{12}
12/31–1/7	23.2	7/9–7/10	0.375
1/7-1/15	22.0	7/10–7/15	0.954
1/15–1/21	3.08	7/15–7/22	0.855
1/21–1/25	118.	7/22–7/27	1.41
1/25–1/26	104.	7/27–7/28	0.316
1/26–1/29	272.	7/28–7/29	0.847
1/29–2/4	<0.215	7/29–8/5	10.4
2/4–2/11	15.3	8/5–8/13	3.33
2/11–2/18	<0.156	8/13–8/19	1.55
2/18–2/21	32.6	8/19–8/22	1.33
2/21–2/21	26.2	8/22–8/23	0.928
2/21–2/22	<2.62	8/23–8/26	0.646
2/22–2/26	9.85	8/26–9/2	0.978
2/26–3/5	13.7	9/2–9/9	0.291
3/5–3/11	4.11	9/9–9/16	0.558
3/11–3/18	1.34	9/16–9/20	13.8
3/18–3/21	0.363	9/20–9/21	4.00
3/21–3/22	0.239	9/21–9/23	1.47
3/22–3/25	0.486	9/23–9/30	0.887
3/25–4/2	1.57	9/30–10/8	17.9
4/1–4/9	0.400	10/8–10/14	4.51
4/9–4/9	<0.446	10/14–10/22	2.09
4/9–4/15	0.336	10/22–10/24	<0.150
4/15–4/22	2.47	10/24–10/25	0.657
4/22–4/25	14.2	10/25–10/29	0.395
4/25–4/26	28.3	10/29–11/5	1.63
4/26–4/30	9.53	11/4–11/23	0.617
4/30–5/6	5.69	11/12–11/19	0.347
5/6–5/13	2.42	11/19–11/21	1.18
5/13–5/20	1.08	11/21–11/22	1.09
5/20–5/23	8.89	11/22–11/26	1.53
5/23–5/24	30.1	11/26–12/3	0.300
5/24–5/27	30.0	12/3–12/9	<0.221
5/27–6/4	1.84	12/9–12/16	<0.102
6/4–6/11	8.32	12/16–12/19	<0.260
6/11–6/17	4.83	12/19–12/20	<0.605
6/17–6/20	1.12	12/20–12/24	<0.183
6/20–6/21	1.83	12/24–12/31	<0.102
6/21–6/24	0.640		
6/24–7/1	1.30		
7/1–7/9	0.976		

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TECHNICAL INFORMATION EXCHANGE

TITLE PAGE

AUTHOR	SUBJECT	TIE NUMBER 77NED140
T. R. Marrero	Reactor Technology	DATE October 1978
TITLE Airborne Releases from BWRs for Environmental Impact Evaluations Amendment 2 (Iodine 131)		GE CLASS I
		GOVERNMENT CLASS
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SUMMARY

Airborne iodine-131 releases from BWRs are decreasing based on an evaluation of 31 reactor-years of operating plant data. An independent analysis of extensive I-131 measurements sponsored by the Electric Power Research Institute indicate an annual normalized release of elemental iodine (I_2) to be 25 millicuries per reactor. The basis for normalization is a calendar year consisting of 300 days of power operations and one refueling/maintenance shutdown period, a concentration of I-131 in reactor water of 1 μCi/kg, a carryover of I-131 from reactor water to reactor steam of 1%, and full-flow condensate treatment. Adjustment factors would be applied to plants with parameters varying from this normalization basis to determine the annual I-131 airborne release rate for future BWR environmental impact assessments.

By cutting out this rectangle and folding in half, the above information can be fitted into a standard card file.

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