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Vol. 20

Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities 1998

Thirty-First Annual Report

U.S. Nuclear Regulatory Commission
Office Nuclear Regulatory Research
Washington, DC 20555-0001

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Thirty-First Annual Report

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PREVIOUS REPORTS IN SERIES

WASH-1311 A Compilation of Occupational Radiation Exposure from Light Water Cooled Nuclear Power Plants, 1969-1973, U.S. Atomic Energy Commission, May 1974.

NUREG-75/032 Occupational Radiation Exposure at Light Water Cooled Power Reactors, 1969-1974, U.S. Nuclear Regulatory Commission, June 1975.

NUREG-0109 Occupational Radiation Exposure at Light Water Cooled Power Reactors, 1969-1975, U.S. Nuclear Regulatory Commission, August 1976.

NUREG-0323 Occupational Radiation Exposure at Light Water Cooled Power Reactors, 1969-1976, U.S. Nuclear Regulatory Commission, March 1978.

NUREG-0482 Occupational Radiation Exposure at Light Water Cooled Power Reactors, 1977, U.S. Nuclear Regulatory Commission, May 1979.

NUREG-0594 Occupational Radiation Exposure at Commercial Nuclear Power Reactors, 1978, U.S. Nuclear Regulatory Commission, November 1979.

NUREG-0713 Occupational Radiation Exposure at Commercial Nuclear Power Reactors 1979, Vol. 1, U.S. Nuclear Regulatory Commission, March 1981.

NUREG-0713 Occupational Radiation Exposure at Commercial Nuclear Power Reactors 1980, Vol. 2, U.S. Nuclear Regulatory Commission, December 1981.

NUREG-0713 Occupational Radiation Exposure at Commercial Nuclear Power Reactors 1981, Vol. 3, U.S. Nuclear Regulatory Commission, November 1982.

NUREG-0713 Occupational Radiation Exposure at Commercial Nuclear Power Reactors 1982, Vol. 4, U.S. Nuclear Regulatory Commission, December 1983.

NUREG-0713 Occupational Radiation Exposure at Commercial Nuclear Power Reactors 1983, Vol. 5, U.S. Nuclear Regulatory Commission, March 1985.

NUREG-0713 Occupational Radiation Exposure At Commercial Nuclear Power Reactors and Other Facilities 1984, Vol. 6, U.S. Nuclear Regulatory Commission, October 1986.

NUREG-0713 Occupational Radiation Exposure At Commercial Nuclear Power Reactors and Other Facilities 1985, Vol. 7, U.S. Nuclear Regulatory Commission, April 1988.

NUREG-0713 Occupational Radiation Exposure At Commercial Nuclear Power Reactors and Other Facilities 1986, Vol. 8, U.S. Nuclear Regulatory Commission, August 1989.

NUREG-0713 Occupational Radiation Exposure At Commercial Nuclear Power Reactors and Other Facilities 1987, Vol. 9, U.S. Nuclear Regulatory Commission, November 1990.

NUREG-0713 Occupational Radiation Exposure At Commercial Nuclear Power Reactors and Other Facilities 1988, Vol. 10, U.S. Nuclear Regulatory Commission, July 1991.

NUREG-0713 Occupational Radiation Exposure At Commercial Nuclear Power Reactors and Other Facilities 1989, Vol. 11, U.S. Nuclear Regulatory Commission, April 1992.

NUREG-0713 Occupational Radiation Exposure At Commercial Nuclear Power Reactors and Other Facilities 1990, Vol. 12, U.S. Nuclear Regulatory Commission, January 1993.

NUREG-0713 Occupational Radiation Exposure At Commercial Nuclear Power Reactors and Other Facilities 1991, Vol. 13, U.S. Nuclear Regulatory Commission, July 1993.

NUREG-0713 Occupational Radiation Exposure At Commercial Nuclear Power Reactors and Other Facilities 1992, Vol. 14, U.S. Nuclear Regulatory Commission, December 1993.

NUREG-0713 Occupational Radiation Exposure At Commercial Nuclear Power Reactors and Other Facilities 1993, Vol. 15, U.S. Nuclear Regulatory Commission, January 1995.

NUREG-0713 Occupational Radiation Exposure At Commercial Nuclear Power Reactors and Other Facilities 1994, Vol. 16, U.S. Nuclear Regulatory Commission, January 1996.

NUREG-0713 Occupational Radiation Exposure At Commercial Nuclear Power Reactors and Other Facilities 1995, Vol. 17, U.S. Nuclear Regulatory Commission, January 1997.

NUREG-0713 Occupational Radiation Exposure At Commercial Nuclear Power Reactors and Other Facilities 1996, Vol. 18, U.S. Nuclear Regulatory Commission, February 1998.

NUREG-0713 Occupational Radiation Exposure At Commercial Nuclear Power Reactors and Other Facilities 1997, Vol. 19, U.S. Nuclear Regulatory Commission, November 1998.

Previous reports in the NUREG-0714 series, which are now combined with NUREG-0713, are as follows:

WASH-1350-R1 through WASH-1350-R6 First through Sixth Annual Reports of the Operation of the U.S. AEC's Centralized Ionizing Radiation Exposure Records and Reporting System, U.S. Atomic Energy Commission.

NUREG-75/108 Seventh Annual Occupational Radiation Exposure Report for Certain NRC Licensees - 1974, U.S. Nuclear Regulatory Commission, October 1975.

NUREG-0119 Eighth Annual Occupational Radiation Exposure Report for 1975, U.S. Nuclear Regulatory Commission, October 1976.

NUREG-0322 Ninth Annual Occupational Radiation Exposure Report for 1976, U.S. Nuclear Regulatory Commission, October 1977.

NUREG-0463 Tenth Annual Occupational Radiation Exposure Report for 1977, U.S. Nuclear Regulatory Commission, October 1978.

NUREG-0593 Eleventh Annual Occupational Radiation Exposure Report for 1978, U.S. Nuclear Regulatory Commission, January 1981.

NUREG-0714 Twelfth Annual Occupational Radiation Exposure Report for 1979, Vol. 1, U.S. Nuclear Regulatory Commission, August 1982.

NUREG-0714 Occupational Radiation Exposure, Thirteenth and Fourteenth Annual Reports, 1980 and 1981, Vols. 2 and 3, U.S. Nuclear Regulatory Commission, October 1983.

NUREG-0714 Occupational Radiation Exposure, Fifteenth and Sixteenth Annual Reports, 1982 and 1983, Vols. 4 and 5, U.S. Nuclear Regulatory Commission, October 1985.

ABSTRACT

This report summarizes the occupational exposure data that are maintained in the U.S. Nuclear Regulatory Commission's (NRC) Radiation Exposure Information and Reporting System (REIRS). The bulk of the information contained in the report was compiled from the 1998 annual reports submitted by six of the seven categories[1] of NRC licensees subject to the reporting requirements of 10 CFR 20.2206. Because there are no geologic repositories for high-level waste currently licensed, only six categories will be considered in this report.

Annual reports for 1998 were received from a total of **288** NRC licensees, of which **105** were operators of nuclear power reactors in commercial operation. Compilations of the reports submitted by the 288 licensees indicated that **132,032** individuals were monitored, **65,070** of whom received a measurable dose (Table 3.1). The collective dose incurred by these individuals was **16,383** person-rem which represents a **17% decrease** from the 1997 value. The number of workers receiving a measurable dose also decreased, resulting in the average measurable dose of **0.25** rem for 1998. The average measurable dose is defined to be the total collective dose (TEDE) divided by the number of workers receiving a measurable dose.[2] These figures have been adjusted to account for transient reactor workers.

In 1998, the annual collective dose per reactor for light water reactor (LWRs) licensees was **125** person-rem. This represents a 26% decrease from the value reported for 1997. The annual collective dose per reactor for boiling water reactors (BWRs) was **190** person-rem and, for pressurized water reactors (PWRs), it was **92** person-rem.

Analyses of transient worker data indicate that **23,061** individuals completed work assignments at two or more licensees during the monitoring year. The dose distributions are adjusted each year to account for the duplicate reporting of transient workers by multiple licensees. In 1998, the average measurable dose calculated from reported data was **0.21** rem. The corrected dose distribution resulted in an average measurable dose of **0.25** rem.

[1] Commercial nuclear power reactors; industrial radiographers; fuel processors (including uranium enrichment), fabricators, and reprocessors; manufacturers and distributors of byproduct material; independent spent fuel storage installations; facilities for land disposal of low-level waste; and geologic repositories for high-level waste.

[2] The number of workers with measurable dose includes any individual with a dose greater than zero rem and does not include doses reported as "not detectable".

EDITOR'S NOTE

The NRC currently has a 5-year contract with Science Applications International Corporation (SAIC) to assist the NRC Staff in the preparation of the NUREG-0713 series. Mr. Charles Hinson (NRR) assisted in the preparation of this NUREG, serving as the NRC Technical reviewer. SAIC will be suggesting changes in the presentation of certain data in these reports. Readers should be alert to these changes, and the NRC welcomes responses, especially where these changes can be improved upon.

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TABLE OF CONTENTS

Page

PREVIOUS REPORTS IN SERIES ii

ABSTRACT iii

EDITOR'S NOTE iv

TABLE OF CONTENTS v

PREFACE xi

FOREWORD xiii

1 INTRODUCTION 1-1

1.1 Background 1-1
1.2 Radiation Exposure Information on the Internet 1-3

2 LIMITATIONS OF THE DATA 2-1

3 ANNUAL PERSONNEL MONITORING REPORTS - 10 CFR 20.2206 3-1

3.1 Definition of Terms and Sources of Data 3-1
3.1.1 Statistical Summary Reports 3-1
3.1.2 Number of Monitored Workers 3-1
3.1.3 Number of Workers with Measurable Dose 3-1
3.1.4 Collective Dose 3-1
3.1.5 Average Individual Dose 3-2
3.1.6 Average Measurable Dose 3-2
3.1.7 Number of Licensees Reporting 3-2
3.1.8 Collective TEDE Distribution by Dose Range 3-2

3.2 Annual TEDE Dose Distributions 3-4

3.3 Summary of Occupational Exposure Data By License Category 3-7
3.3.1 Industrial Radiography Licenses, Single and Multiple Locations 3-7
3.3.2 Manufacturing and Distribution Licenses, Type "A" Broad and Limited 3-8
3.3.3 Low-Level Waste Disposal Licenses 3-11
3.3.4 Independent Spent Fuel Storage Installation Licenses 3-15
3.3.5 Fuel Cycle Licenses 3-18
3.3.6 Light-Water-Cooled Power Reactor (LWR) Licenses 3-21

3.4 Summary of Intake Data by License Category 3-22

TABLE OF CONTENTS (Continued)

Page

4 COMMERCIAL LIGHT WATER REACTORS - FURTHER ANALYSIS 4-1

4.1 Introduction 4-1

4.2 Definition of Terms and Sources of Data 4-1

4.2.1 Number of Reactors 4-1

4.2.2 Electric Energy Generated 4-1

4.2.3 Collective Dose per Megawatt-Year 4-5

4.2.4 Average Maximum Dependable Capacity 4-5

4.2.5 Percent of Maximum Dependable Capacity Achieved 4-6

4.3 Annual TEDE Distributions 4-6

4.4 Average Annual TEDE Doses 4-8

4.5 Three-Year Average Collective TEDE Per Reactor 4-12

4.6 Graphical Representation of Dose Trends in Appendix D 4-17

5 TRANSIENT WORKERS AND CAREER DOSES AT NRC LICENSED FACILITIES 5-1

5.1 Termination Reports 5-1

5.2 Transient Workers at NRC Facilities 5-1

5.3 Career Dose Statistics 1977-1998 5-5

5.3.1 Compilation of the Data 5-5

5.3.2 Limitations of the Data 5-6

5.4 Career Dose Distributions by Dose and Career Length 5-7

5.5 Career Dose Distributions by Age and Sex 5-9

5.6 Patterns of Accumulation of Career Doses at Reactor Facilities 5-14

6 EXPOSURES TO PERSONNEL IN EXCESS OF REGULATORY LIMITS 6-1

6.1 Control Levels 6-1

6.2 Limitations of the Data 6-2

6.3 Summary of Exposures in Excess of Regulatory Limits 6-3

6.4 Maximum Exposures Below the NRC Limits 6-7

7 REFERENCES 7-1

TABLE OF CONTENTS (Continued)

Page

APPENDIX A - ANNUAL TEDE FOR NON-REACTOR NRC LICENSEES, 1998 ..... A-1

APPENDIX B - ANNUAL WHOLE BODY DOSES AT LICENSED NUCLEAR POWER FACILITIES, 1998 ..... B-1

APPENDIX C - PERSONNEL, DOSE, AND POWER GENERATION SUMMARY, 1969-1998 ..... C-1

APPENDIX D - DOSE PERFORMANCE INDICATORS BY REACTOR SITE D-1

LIST OF FIGURES

Page

Figure 3.1 Average Annual Values at Industrial Radiography Facilities 1973-1998 3-9

Figure 3.2 Collective TEDE Distribution by Dose Range, Industrial Radiographer – Single Location Licensees 1994-1998 3-10

Figure 3.3 Collective TEDE Distribution by Dose Range, Industrial Radiographer – Multiple Location Licensees 1994-1998 3-10

Figure 3.4 Average Annual Values at Manufacturing and Distribution Facilities 1973-1998 3-12

Figure 3.5 Collective TEDE Distribution by Dose Range, Type “A” Broad Manufacturing and Distribution Licensees 1994-1998 3-13

Figure 3.6 Collective TEDE Distribution by Dose Range, Limited Manufacturing and Distribution Licensees 1994-1998 3-13

Figure 3.7 Average Annual Values at Low-Level Waste Disposal Facilities 1982-1998 3-14

Figure 3.8 Collective TEDE Distribution by Dose Range, Low-Level Waste Disposal Licensees 1994-1998 3-15

Figure 3.9 Average Annual Values at Independent Spent Fuel Storage Facilities 1982-1998 3-16

Figure 3.10 Collective TEDE Distribution by Dose Range, Independent Spent Fuel Storage Licensees 1994-1998 3-17

Figure 3.11 Average Annual Values at Fuel Cycle Licenses 1973-1998 3-19

Figure 3.12 Collective TEDE Distribution by Dose Range, Fuel Cycle Licensees 1994-1998 3-20

Figure 3.13 Collective TEDE Distribution by Dose Range, Reactor Licensees 1994-1998 3-20

Figure 4.1 Average Collective Dose and Number of Workers per Reactor 1973-1998 4-9

Figure 4.2 Number of Operating Reactors and Gross Electricity Generated 1973-1998 4-10

LIST OF FIGURES (Continued)

Page

Figure 4.3 Average Measurable Dose per Worker and Collective Dose per Megawatt-Year 1973-1998 4-11

Figure 4.4 Average, Median, and Extreme Values of the Collective Dose per Reactor 1973-1986 4-13

Figure 4.5 Average, Median, and Extreme Values of the Collective Dose per Reactor 1987-1998 4-14

Figure 5.1 Mean Annual Dose to Workers with Measurable Dose at Reactor Licensees by Age Group 1986-1998 5-15

Figure 5.2 Average Age of Workers with Measurable Dose at Reactor Licensees From 1969-1998 with Projections to 2020 5-17

LIST OF TABLES

Table 3.1 Annual Exposure Data for Certain Categories of Licensees 1989-1998 3-3

Table 3.2 Distribution of Annual Collective TEDE by License Category 1998 3-5

Table 3.3 Summary of Annual Dose Distributions for Certain NRC Licensees 1968-1998 3-6

Table 3.4 Annual Exposure Information for Industrial Radiographers 1996-1998 3-7

Table 3.5 Annual Exposure Information for Manufacturers and Distributors 1996-1998 3-8

Table 3.6 Annual Exposure Information for Fuel Cycle Licenses 1996-1998 3-18

Table 3.7 Intakes by Licensee Type and Radionuclide Mode of Intake - Ingestion and Other 1998 3-22

Table 3.8 Intakes by Licensee Type and Radionuclide Mode of Intake - Inhalation 1998 3-23

LIST OF TABLES (Continued)

Table 3.9 Collective and Average CEDE by Licensee 1998 3-25

Table 3.10 Internal Dose (CEDE) Distribution, 1994 - 1998 3-26

Table 4.1 Summary of Information Reported by Commercial Boiling Water Reactors 1973-1998 4-2

Table 4.2 Summary of Information Reported by Commercial Pressurized Water Reactors 1973-1998 4-3

Table 4.3 Summary of Information Reported by Commercial Light Water Reactors 1973-1998 4-4

Table 4.4 Summary Distribution of Annual Whole Body Doses at Commercial Light Water Reactors 1977-1998 4-7

Table 4.5 Three-Year Totals and Averages Listed in Ascending Order of Collective TEDE per BWR 1996-1998 4-15

Table 4.6 Three-Year Totals and Averages Listed in Ascending Order of Collective TEDE per PWR 1996-1998 4-16

Table 5.1 Effects of Transient Workers on Annual Statistical Compilations, 1998 5-2

Table 5.2 Career Dose Distributions by Dose and Career Length at Reactor Facilities, 1977-1998 5-8

Table 5.3 Average Career Lengths and Doses by Career Length, 1977-1998 5-9

Table 5.4(a) Career Dose Distributions by Age and Year of Termination For Personnel with Measurable Dose, 1977-1998 5-10

Table 5.4(b) Career Dose Distributions by Age and Year of Termination For Personnel with Measurable Dose, 1977-1998 5-11

Table 5.5 Average Career Values by Sex and Year of Termination For Personnel of Known Age with Measurable Dose, 1977-1998 5-13

Table 6.1 Occupational Exposures in Excess of Regulatory Limits, 1994-1998 6-4

Table 6.2 Occupational Exposures in Excess of Regulatory Limits, 1985-1993 6-5

Table 6.3 Maximum Occupational Exposures for Each Exposure Category 1998 6-8

PREFACE

A number of NRC licensees have inquired as to how the occupational radiation exposure data that are compiled from the individual exposure reports required by § 20.2206 and the annual dose data reported by work function in accordance with Subsection 6.9.1.5 of the standard technical specifications for nuclear power plants are used by the NRC staff. This is a very appropriate inquiry that may be of importance to many affected licensees. In combination with other sources of information, the principal uses of the data are to provide facts regarding routine occupational exposures to radiation and radioactive material that occur in connection with certain NRC-licensed activities. These facts are used by the NRC staff as indicated below:

1. The data permit evaluation, from the viewpoint of trends, of the effectiveness of the overall NRC/licensee radiation protection and as low as reasonably achievable (ALARA) efforts by certain licensees. They also provide for the identification (and subsequent correction) of unfavorable trends.

2. The external dose data assist in the evaluation of the radiological risk associated with certain categories of NRC-licensed activities and are used for comparative analyses of radiation protection performance: US/foreign, BWRs/PWRs, civilian/military, facility/facility, nuclear industry/other industries, etc.

3. The data provide for the monitoring of transient workers who may affect dose distribution statistics through multiple counting.

4. The data help provide facts for evaluating the adequacy of the current risk limitation system (e.g., are individual lifetime dose limits, worker population collective dose limits, and requirements for optimization needed?).

5. The data permit comparisons of occupational radiation risks with potential public risks when action for additional protection of the public involves worker exposures.

6. The data are used in the establishment of priorities for the utilization of NRC health physics resources: research, standards development, and regulatory program development.

7. The data provide facts for answering Congressional and Administration inquiries and for responding to questions raised by the public.

8. The data provide information that may be used in the planning of epidemiological studies.

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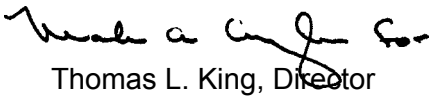
FOREWORD

NUREG-0713, Volume 20, summarizes the 1998 occupational radiation exposure data maintained in the U.S. Nuclear Regulatory Commission's Radiation Exposures Information Reporting System (REIRS). Certain classes of licensees are required to annually report individual exposures in accordance with 10 CFR 20.2206.

This volume also contains an updated analysis of the career dose distribution from the 1989 NUREG-0713, Volume 11. This analysis is in sections 5.3, 5.4, 5.5, and 5.6, and now includes those individuals who had terminated their employment before 1994, those individuals for whom individual exposure reports were submitted after 1994, and individuals for whom historical data were submitted as a result of voluntary generic letter 94-04.

With the publication of this volume information on collective dose and number of personnel by work function and employee type will no longer be included. In addition, the analysis of high dose plants or plant rankings by collective dose per reactor will no longer be included. These decisions were made after publication of the 1996 report in order to produce a more timely and efficient document. These data are available from Nuclear Energy Agency's (NEA) Information System on Occupational Exposure by plant and are included by country in NEA's annual report, "Occupational Exposure at Nuclear Power Plants."



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Section 1
INTRODUCTION

1.1 BACKGROUND

One of the basic purposes of the Atomic Energy Act and the implementing regulations in Title 10, Code of Federal Regulations, Chapter I, Part 20, is to protect the health and safety of the public, including the employees of the licensees conducting operations under those regulations. Among the regulations designed to ensure that the standards for protection against radiation set out in 10 CFR 20 are met is a requirement that licensees provide individuals likely to be exposed to radiation with devices to monitor their exposure. Each licensee is also required to maintain indefinitely records of the results of such monitoring. However, there was no initial provision that these records or any summary of them be transmitted to a central location where the data could be retrieved and analyzed.

On November 4, 1968, the U.S. Atomic Energy Commission (AEC) published an amendment to 10 CFR 20 requiring the reporting of certain occupational radiation exposure information to a central repository at AEC Headquarters. This information was required of the four categories[3] of AEC licensees that were considered to involve the greatest potential for significant occupational doses and of AEC facilities and contractors exempt from licensing. A procedure was established whereby the appropriate occupational exposure data were extracted from these reports and entered into the Commission's Radiation Exposure Information Reporting System (REIRS), a computer system that was maintained at the Oak Ridge National Laboratory Computer Technology Center in Oak Ridge, Tennessee, until May 1990. At that time, the data were transferred to a database management system at Science Applications International Corporation (SAIC) at Oak Ridge, Tennessee. The computerization of these data ensures that they are kept indefinitely and facilitates their retrieval and analysis. The data maintained in REIRS have been summarized and published in a report every year since 1969. Annual reports for each of the years 1969 through 1973 presented the data reported by both AEC licensees and contractors and were published in six documents designated as WASH-1350-R1 through WASH-1350-R6.

In January 1975, with the separation of the AEC into the Energy Research and Development Administration (ERDA) and the U.S. Nuclear Regulatory Commission (NRC), each agency assumed responsibility for collecting and maintaining occupational radiation exposure information reported by the facilities under its jurisdiction. The annual reports published by the NRC on occupational exposure for calendar year 1974 and subsequent years do not contain information pertaining to ERDA facilities or contractors. Comparable information for facilities and contractors under ERDA, now the Department

[3] Commercial nuclear power reactors; industrial radiographers; fuel processors (including uranium enrichment as of 1997), fabricators, and reprocessors; manufacturers and distributors of specified quantities of byproduct material.

of Energy (DOE), is collected and published by DOE's Office of Health, a division of Environment, Safety and Health, in Germantown, Maryland.

In 1982 and 1983, paragraph 20.408(a) of Title 10 of the Code of Federal Regulations was amended to require three additional categories of NRC licensees to submit annual statistical exposure reports and individual termination exposure reports. The new categories are (1) geologic repositories for high-level radioactive waste, (2) independent spent fuel storage installations, and (3) facilities for the land disposal of low-level radioactive waste. Therefore, this document presents the exposure information that was reported by NRC licensees representing two of these new categories. (There are no geologic repositories for high-level waste currently licensed.)

This report and each of the predecessors summarizes information reported for both the current year and for previous years. More licensee-specific data for previous years, such as the annual reports submitted by each commercial power reactor pursuant to 10 CFR 20.407 and their technical specifications, may be found in those documents listed on the inside of the front cover of this report for the specific year desired. Additional operating data and statistics for each power reactor for the years 1973 through 1982 may be found in a series of reports, "Nuclear Power Plant Operating Experience" [Refs. 1-9]. These documents are available for viewing at all NRC public document rooms, or they may be purchased from the National Technical Information Service, as shown in the Reference section.

In May of 1991, the revised 10 CFR 20 "Standards for Protection Against Radiation; Final Rule" was published in the Federal Register. The revision redefined the radiation monitoring and reporting requirements of NRC licensees. Instead of summary annual reports (§ 20.407) and termination reports (§ 20.408), licensees are now required to submit an annual report of the dose received by each monitored worker (§ 20.2206). Licensees were required to implement the new requirements on or before January of 1994. This report is the fifth compilation of radiation exposure information collected under the revised 10 CFR 20. Certain sections of the report have been modified to account for the change in the reporting of exposure information. Readers are encouraged to comment on these changes. Recommendations for further analysis or for different presentation of information are welcome.

1.2 RADIATION EXPOSURE INFORMATION ON THE INTERNET

In May of 1995, the NRC began pursuing the dissemination of radiation exposure information via a World Wide Web site on the Internet. This allows interested parties with the appropriate equipment to access the data electronically rather than through the published NUREG-0713 document. A web site was created for radiation exposure and linked into the main NRC web page. The web site contains up-to-date information on radiation exposure, as well as information and guidance on reporting radiation exposure information to the NRC. Interested parties may read the documents on-line or download information to their systems for further analysis. Software, such as REMIT, is also available for downloading via the web site. There are also links to other web sites dealing with the topics of radiation and health physics. The NRC intends to continue pursuing the dissemination of radiation exposure information via the World Wide Web and will focus more resources on the electronic distribution of information rather than the published hard copy reports.

The main web URL address for the NRC is:

http://www.nrc.gov

The NRC radiation exposure information web URL address is:

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Comments on this report or the NRC's web page should be directed to:

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Section 2
LIMITATIONS OF THE DATA

All of the figures compiled in this report relating to exposures and doses are based on the results and interpretations of the readings of various types of personnel monitoring devices employed by each licensee. This information, obtained from routine personnel monitoring programs, is sufficient to characterize the radiation environment in which individuals work and is used in evaluating the radiation protection program.

Monitoring requirements are specified in 10 CFR § 20.1502, which requires licensees to monitor individuals who receive or are likely to receive a dose in a year in excess of 10% of the applicable limits. For most adults, the annual limit for the whole body is 5 rem, so 0.5 rem per year is the level above which monitoring is required. Separate dose limits have been established for minors and pregnant workers. Monitoring is required for any individual entering a high or very high radiation area. Depending on the administrative policy of each licensee, persons such as visitors and clerical workers may also be provided with monitoring devices, although the probability of their being exposed to measurable levels of radiation is extremely small. Licensees must report the dose records of those individuals for whom monitoring is required. Many licensees elect to report the doses for every individual for whom they provided monitoring. This practice tends to increase the number of individuals that one could consider to be radiation workers. In an effort to account for this, the number of individuals reported as having "no measurable exposure"* has been subtracted from the total number of individuals monitored in order to calculate an average dose per individual receiving a measurable dose, as well as the average dose per monitored individual (for example, see Table 3.1).

The average dose per individual, as well as the dose distributions shown for groups of licensees, also can be affected by the multiple reporting of individuals who were monitored by two or more licensees during the year. Licensees are only required to report the doses received by individuals at their licensed facility. A dose distribution for a single licensee does not consider that some of the individuals may have received doses at other facilities. When the data are summed to determine the total number of individuals monitored by a group of licensees, individuals may be counted more than once. This can also affect the distribution of doses because individuals may be counted multiple times in the lower dose ranges rather than one time in the higher range corresponding to the actual accumulated dose for the year (the sum of the individual's dose accrued at all facilities). This source of error has the greatest potential impact on the data reported by power reactor facilities since they employ many short-term workers. Section 5 contains an analysis that corrects for individuals being counted more than once.

Another fact that should be kept in mind when examining the annual statistical data is that all of the personnel included in the report may not have been monitored throughout the entire year. Many licensees, such as radiography

* The number of workers with measurable dose includes any individual with a TEDE greater than zero rem. Workers reported with zero dose, or no detectable dose, are included in the number of workers with no measurable exposure.

firms and nuclear power facilities, may monitor numerous individuals for periods much less than a year. The average doses calculated from these data, therefore, are less than the average dose that an individual would receive if involved in that activity for the full year.

Considerable attention should also be given when referencing the collective totals presented in this report. The differences between the totals presented for all licensees that reported versus only those licensees that are required to report should be noted. Likewise, one should distinguish between the doses attributed to the pressurized water reactors (PWRs), and boiling water reactors (BWRs). The totals may be inclusive or exclusive of those licensees that were in commercial operation for less than one full year. These parameters vary throughout the tables and appendices of this report in order to provide the most comprehensive analysis of all the data available. The apparent discrepancies among the various tables are a necessary side-effect of this endeavor.

Also, it should again be pointed out that this report contains information reported by NRC licensees only. Since the NRC licenses all commercial nuclear power reactors, fuel processors and fabricators, and independent spent fuel storage facilities, information shown for these categories reflects the U.S. experience. This is not the case, however, for the remaining categories of industrial radiography, manufacturing and distribution of specified quantities of by-product material, and low-level waste disposal. Companies that conduct these types of activities in Agreement States[4] are licensed by the state and are not required to submit occupational exposure reports to the NRC. Approximately twice as many facilities are licensed to Agreement States than the number licensed by the NRC. In addition, this report does not include non-occupational exposure such as exposure due to medical x-rays, fluoroscopy, and accelerators received as a patient.

All dose equivalent values in this report are given in units of rem in accordance with the general provisions for records, 10 CFR 20.2101(a). In order to convert rem into the SI unit of sieverts (Sv), one should divide the value in rem by 100. Therefore 1 rem = 0.01 Sv. In order to convert rem into millisieverts (mSv), multiply the value in rem by 10. Therefore 1 rem = 10 mSv.

[4] States that have entered into an agreement with the NRC that allows each state to license organizations using radioactive materials for certain purposes. As of 12/31/98, there are 30 Agreement States.

Section 3

ANNUAL PERSONNEL MONITORING REPORTS - 10 CFR 20.2206

3.1 DEFINITION OF TERMS AND SOURCES OF DATA

3.1.1 Statistical Summary Reports

The individual's total effective dose equivalent (TEDE, as defined in § 20.1003) is reported, so that the dose distributions may be determined directly from the individual's exposure. The TEDE is summed per individual and tabulated into the appropriate dose range to generate the dose distribution for each licensee. The total collective dose is more accurate using this method, since the licensee reported the dose to each individual and the total collective dose was calculated from the sum of these doses and not statistically derived from the distribution (see Section 3.1.4). The TEDE includes the dose contribution from the committed effective dose equivalent (CEDE) for those workers who had intakes that required monitoring and reporting of internal dose.

3.1.2 Number of Monitored Workers

The number of monitored workers refers to the total number of workers that the NRC licenses, who are covered by 10 CFR 20.1502, reported as being monitored for exposure to external and internal radiation during the year. This number includes all workers for whom monitoring is required, and may include visitors, service representatives, contract workers, clerical workers, and any other workers for whom the licensee feels that monitoring devices should be provided.

For licensees submitting under the revised 10 CFR 20.2206, the total number of workers was determined from the number of unique personal identification numbers submitted per licensee. Uniqueness is defined by the combination of identification number and identification type. [Ref. 10]

3.1.3 Number of Workers with Measurable Dose

The number of workers with measurable dose includes any individual with a TEDE greater than zero rem. This does not include workers with a TEDE reported as zero, not detectable (ND), or not required to be reported (NR). [Ref. 10]

3.1.4 Collective Dose

The concept of collective dose is used in this report to denote the summation of the TEDE received by all monitored workers and has the units person-rem. The revised 10 CFR 20.2206 requires that the TEDE be reported, so the collective dose is calculated by summing the TEDE for all monitored workers. The phrase "collective dose" is used throughout this report to mean the collective TEDE, unless otherwise specified.

It should be noted that prior to the implementation of the revised dose reporting requirements of 10 CFR 20.2206 in 1994, the collective dose was, in some cases, calculated from the dose distributions by summing the products obtained from multiplying the number of workers reported in

each of the dose ranges by the midpoint of the corresponding dose range. This assumes that the midpoint of the range is equal to the arithmetic mean of the individual doses in the range. Past experience has shown that the actual mean dose of workers reported in each dose range is less than the midpoint of the range, and therefore the resultant calculated collective doses shown in this report for these licensees may be about 10% higher than the sum of the actual individual doses. Care should be taken when comparing the actual collective dose calculated for 1998 with the collective dose for years prior to 1994 because of this change in methodology. In addition, prior to 1994, doses only included the external whole body dose. Although the contribution of internal dose to the TEDE is minimal for most licensees, it should be taken into consideration when comparing the 1998 collective dose with the collective dose for prior years. One noted exception is for fuel fabrication licensees where the CEDE in some cases contributes the majority of the TEDE (see Section 3.3.5.).

3.1.5 Average Individual Dose

The average individual dose is obtained by dividing the collective dose by the total number of workers reported as being monitored. This figure is usually less than the average measurable dose because it includes the number of those workers who received zero or less than measurable doses.

3.1.6 Average Measurable Dose

The average measurable dose is obtained by dividing the collective TEDE by the number of workers who received a measurable dose. This is the average most commonly used in this and other reports when examining trends and comparing doses received by workers in various segments of the nuclear industry because it deletes those workers receiving zero or no detectable dose, many of whom were monitored for convenience or identification purposes.

3.1.7 Number of Licensees Reporting

The number of licensees refers to the NRC licenses issued to use radioactive material for certain activities that would place them in one of the six categories that are required to report pursuant to 10 CFR 20.2206. The third column in Table 3.1 shows the number of licensees that have filed such reports during the last 10 years. Agreement State licensees do not submit such reports to the NRC and are not included in this report.

3.1.8 Collective TEDE Distribution by Dose Range

The United Nations Scientific Committee on the Effects of Atomic Radiation's (UNSCEAR) 1993 report entitled "Sources and Effects of Ionizing Radiation" [Ref. 11] recommends the calculation of a parameter "SR" (previously referred to as CR or MR) to aid in the examination of the distribution of radiation exposure among workers. SR is defined to be the ratio of the annual collective dose incurred by workers whose annual doses exceed a certain dose level to the total annual collective dose. UNSCEAR uses a subscript to denote the specific dose level in millisieverts. Therefore, SR_{15} is the notation for the annual

TABLE 3.1
Average Annual Exposure Data for Certain Categories of NRC Licensees
1989 - 1998

NRC License Category* and Program Code	Calendar Year	Number of Licensees Reporting	Number of Monitored Individuals	Number of Workers With Measurable TEDE	Collective TEDE (person-rem)	Average TEDE (rem)	Average Measurable TEDE per Worker (rem)
Industrial Radiography	1989	276	6,745	4,352	2,067	0.31	0.47
	1990	258	6,523	4,458	2,120	0.33	0.48
	1991	248	6,820	4,649	2,160	0.32	0.46
03310	1992	246	6,703	4,265	1,864	0.28	0.44
03320	1993	176	4,721	3,007	1,596	0.34	0.53
	1994	139	2,886	2,007	1,415	0.49	0.71
	1995	139	3,530	2,465	1,338	0.38	0.54
	1996	144	3,631	2,537	1,385	0.38	0.55
	1997	143	3,436	2,454	1,291	0.38	0.53
	1998	141	4,940	3,439	1,859	0.38	0.54
Manufacturing and Distribution	1989	48	4,554	2,345	770	0.17	0.33
	1990	58	4,203	2,279	693	0.16	0.30
	1991	59	4,930	1,952	722	0.15	0.37
	1992	67	5,210	2,250	784	0.15	0.35
02500	1993	58	4,913	2,254	680	0.14	0.30
03211	1994	44	2,941	1,251	580	0.20	0.46
03212	1995	36	2,666	1,222	595	0.22	0.49
03214	1996	36	2,628	1,239	556	0.21	0.45
	1997	31	1,151	665	397	0.34	0.60
	1998	30	1,963	645	401	0.20	0.62
Low-Level Waste Disposal	1989	2	925	119	35	0.04	0.29
	1990	2	784	115	26	0.03	0.23
	1991	2	905	147	39	0.04	0.27
	1992	2	467	82	37	0.08	0.45
03231	1993	2	432	76	21	0.05	0.27
	1994	2	202	83	22	0.11	0.27
	1995	2	212	56	8	0.04	0.15
	1996	2	165	67	8	0.05	0.12
	1997	2	185	50	5	0.03	0.11
	1998	1	27	13	1	0.05	0.10
Independent Spent Fuel Storage	1989	2	190	102	33	0.17	0.32
	1990	2	56	22	6	0.11	0.27
	1991	2	41	24	4	0.10	0.17
	1992	2	290	85	11	0.04	0.13
23100	1993	2	135	52	14	0.10	0.26
	1994	1	158	89	42	0.27	0.47
	1995	1	104	49	51	0.49	1.04
	1996	1	97	53	54	0.56	1.02
	1997	1	55	24	6	0.11	0.24
	1998	1	53	21	3	0.05	0.12
Fuel Cycle Licenses - Fabrication Processing and Uranium Enrich.	1989	8	11,583	2,992	243	0.02	0.08
	1990	11	14,505	3,871	422	0.03	0.11
	1991	11	11,702	3,929	378	0.03	0.10
	1992	11	8,439	5,061	545	0.06	0.11
	1993	8	9,649	2,611	339	0.04	0.13
	1994	8	3,596	2,847	1,147	0.00	0.40
	1995	8	4,106	2,959	1,217	0.30	0.41
21210	1996	8	4,369	3,061	878	0.20	0.29
21200	1997	10	11,214	3,910	1,006	0.09	0.26
	1998	10	10,684	3,613	950	0.09	0.26
Commercial Light Water Reactors**	1989	113	188,477	100,080	35,930	0.19	0.36
	1990	116	187,081	98,802	36,607	0.20	0.37
	1991	115	179,043	91,085	28,528	0.16	0.31
	1992	114	183,900	94,317	29,298	0.16	0.31
41111	1993	114	169,862	86,187	26,365	0.16	0.31
	1994	109	138,595	69,668	21,695	0.16	0.31
	1995	109	133,066	70,986	21,674	0.16	0.31
	1996	109	127,420	68,182	18,874	0.15	0.28
	1997	109	126,689	68,188	17,136	0.14	0.25
	1998	105	114,365	57,339	13,169	0.12	0.23
Grand Totals and Averages	1989	449	212,474	109,990	39,078	0.18	0.36
	1990	447	213,152	109,547	39,874	0.19	0.36
	1991	437	203,441	101,786	31,831	0.16	0.31
	1992	442	205,009	106,060	32,538	0.16	0.31
	1993	360	189,712	94,187	29,014	0.15	0.31
	1994	303	148,378	75,945	24,901	0.17	0.33
	1995	295	143,684	77,737	24,884	0.17	0.32
	1996	300	138,310	75,139	21,755	0.16	0.29
	1997	296	142,730	75,291	19,841	0.14	0.26
	1998	288	132,032	65,070	16,383	0.12	0.25

* These categories consist only of NRC licensees. Agreement State licensed organizations do not report occupational exposure data to the NRC.

** Includes all LWRs in commercial operation, although some of them may not have been in operation for a full year. 1994 - 1998 data are only for reactors that completed a full year of operation during the year. Reactor data have been corrected to account for the multiple counting of transient reactor workers. (see Section 5).

collective dose above 1.5 rem divided by the total annual collective dose. The UNSCEAR 1993 report notes that the 1.5 rem dose level may not be useful where doses are consistently lower than this level and they recommend that research organizations report SR values lower than 1.5 rem where appropriate. For this reason, the NRC has adopted the policy of calculating and tracking the collective TEDE distribution by dose range at dose levels of 0.100 rem, 0.250 rem, 0.500 rem, 1.0 rem, and 2.0 rem. The collective TEDE distribution by dose range values in this report were calculated by summing the TEDE to each individual that received a TEDE greater than or equal to the specified dose range divided by the total collective TEDE. In addition, the distribution is presented as a percentage rather than a decimal fraction.

The collective TEDE distribution by dose range in Figures 3.2, 3.3, 3.5, 3.6, 3.8, 3.10, 3.12, and 3.13 in Section 3 show the collective TEDE distribution by dose range calculated in terms of percentages of the collective dose delivered above the specified dose levels for each of the categories of NRC licensee. There are two properties of these graphs that help to qualify the distribution of dose and dose trends at NRC licensees. The first is that the percentage of dose in the higher dose ranges (above 0.500 rem) should be relatively small. This would indicate that fewer workers are exposed at these higher levels of individual risk. The second property is the ability to track the shift in dose over time. For a given dose level, a reduction in the percentage from one year to the next indicates that less dose is being received by workers above this level. Therefore, these graphs can be useful in qualifying the dose received in a given year, and the trend in doses from year to year.

3.2 ANNUAL TEDE DOSE DISTRIBUTIONS

Table 3.2 is a statistical compilation of the exposure reports submitted by six categories of licensees (see Section 3.3 for a description of each licensee category). The dose distributions are generated by summing the TEDE for each individual and counting the number of individuals in each dose range. In nearly every category a large number of workers receive doses that are less than measurable, and very few doses exceed 4 or 5 rem. About 90% of the reported workers continue to be monitored by nuclear power facilities where they received approximately 80% of the total collective dose in 1998.

Under the regulatory limits of the revised 10 CFR 20.1201, annual TEDE in excess of 5 rem for occupationally exposed adults is, by definition, an exposure in excess of regulatory limits (see Section 6).

Table 3.3 gives a summary of the annual exposures reported to the Commission by certain categories of NRC licensees as required by 10 CFR 20.2206. Table 3.3 shows that ~ 95% of the exposures consistently remained <2 rem between 1968 and 1984. For the past 13 years the percentage of workers with <2 rem has been ≥98%. The number of workers receiving an annual exposure in excess of 5 rem had been <0.01% since 1985. 1998 is the first year in the last 10 years where an individual received a TEDE or whole body dose in excess of 12 rem. This incident occurred at a multi-site radiographer licensee and is discussed in Section 6.

TABLE 3.2
Distribution of Annual Collective TEDE by License Category
1998

License Category (Number of sites reporting)	*Number of Individuals with TEDE in the Ranges (rem)													Total Number Monitored	Number with Meas. Dose	Total Collective Dose (TEDE) (person-rem)
	No Meas.	Meas. <0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	2.00-3.00	3.00-4.00	4.00-5.00	5.00-6.00	6.00-7.00	>12			
INDUSTRIAL RADIOGRAPHY																
Single Location (26)	285	64	10	8	1		1							369	84	8
Multiple Location (115)	1,216	1,037	560	584	329	236	435	118	36	14	4	1	1	4,571	3,355	1,851
Total (141)	1,501	1,101	570	592	330	236	436	118	36	14	4	1	1	4,940	3,439	1,859
MANUFACTURING AND DISTRIBUTION																
"A" - Broad (5)	797	111	39	46	24	28	53	47	32					1,177	380	367
Limited (25)	521	166	54	30	10	5								786	265	34
Total (30)	1,318	277	93	76	34	33	53	47	32					1,963	645	401
LOW-LEVEL WASTE DISPOSAL																
Total (1)	14	5	8											27	13	1
INDEPENDENT SPENT FUEL STORAGE																
Total (1)	32	9	10	2										53	21	3
FUEL CYCLE LICENSES**																
Total (10)	7,071	1,937	601	444	225	170	204	28	4					10,684	3,613	950
COMMERCIAL POWER REACTORS***																
Boiling Water (36)	28,719	16,077	7,623	5,321	2,209	921	700	13						61,583	32,864	6,822
Pressurized Water (69)	48,361	20,962	9,566	5,146	1,720	640	427	19						86,841	38,480	6,347
Total (105)	77,080	37,039	17,189	10,467	3,929	1,561	1,127	32						148,424	71,344	13,169
GRAND TOTALS	**87,016**	**40,368**	**18,471**	**11,581**	**4,518**	**2,000**	**1,820**	**225**	**72**	**14**	**4**	**1**	**1**	**166,091**	**79,075**	**16,383**

* Dose values exactly equal to the values separating ranges are reported in the next higher range.

** Includes fabrication, processing and uranium enrichment plants (see Section 3.3.5).

*** Includes all reactors in commercial operation for a full year during 1998.
These values have not been adjusted for the multiple counting of transient reactor workers (see Section 5).

TABLE 3.3
Summary of Annual Dose Distributions for Certain* NRC Licensees
1968 - 1998

Year	Total Number of Monitored Persons		Percent of Individuals With Doses < 2 rem**	Percent of Individuals With Doses < 5 rem**	Number of Individuals With Doses >12 rem**
	Reported Number	Corrected Number			
1968	36,836		97.2%	99.5%	3
1969	31,176		96.5%	99.5%	7
1970	36,164		96.1%	99.4%	0
1971	36,311		96.3%	99.3%	1
1972	44,690		95.7%	99.5%	8
1973	67,862		95.0%	99.5%	1
1974	85,097		96.4%	99.7%	1
1975	78,713		94.8%	99.5%	1
1976	92,773		95.0%	99.6%	3
1977	98,212	93,438	93.8%	99.6%	1
1978	105,893	100,818	94.6%	99.8%	3
1979	131,027	125,316	95.2%	99.8%	1
1980	159,177	150,675	94.6%	99.7%	0
1981	157,874	149,314	94.6%	99.8%	1
1982	162,456	154,117	94.9%	99.9%	0
1983	172,927	164,239	94.6%	99.9%	0
1984	181,627	168,899	95.1%	99.9%	0
1985	212,217	201,339	97.5%	>99.99% (15)	2
1986	225,582	213,017	98.0%	>99.99% (8)	0
1987	243,562	227,997	98.7%	>99.99% (4)	1
1988	231,234	215,662	98.6%	>99.99% (8)	0
1989	229,353	212,474	98.9%	>99.99% (7)	1
1990	234,045	214,781	98.9%	>99.99% (3)	0
1991	219,229	206,732	99.4%	>99.99% (2)	0
1992	222,728	205,009	99.4%	>99.99% (1)	0
1993	209,386	189,711	99.5%	>99.99% (2)	0
1994	179,803	152,834	99.5%	>99.99% (1)	0
1995	179,176	143,684	99.5%	>99.99% (1)	0
1996	173,536	137,968	99.5%	>99.99% (1)	0
1997	180,677	128,466	99.5%	100% (0)	0
1998	166,091	130,852	99.6%	>99.99% (6)	1

* Licensees required to submit radiation exposure reports to the NRC under 10 CFR 20.2206.

** Data for 1977-1998 are based on the distribution of individual doses after adjusting for the multiple counting of transient reactor workers (see Section 5). The number of people exceeding 5 rem is shown in parentheses from 1985-1998.

3.3 SUMMARY OF OCCUPATIONAL EXPOSURE DATA BY LICENSE CATEGORY

3.3.1 Industrial Radiography Licenses, Single and Multiple Locations

Industrial Radiography licenses are issued to allow the use of sealed radioactive materials, usually in exposure devices or "cameras," that primarily emit gamma rays for nondestructive testing of pipeline weld joints, steel structures, boilers, aircraft and ship parts, and other high-stress alloy parts. Some firms are licensed to conduct such activities in one location, usually in a permanent facility that was designed and shielded for radiography, and others perform radiography at multiple, temporary sites in the field. The radioisotopes most commonly used are cobalt-60 and iridium-192. As shown in Table 3.1, annual reports were received for 141 radiography licensees in 1998. Table 3.4 summarizes the reported data for the two types of radiography licenses for 1998 and for the previous 2 years for comparison purposes.

The average measurable dose for workers performing radiography at a single location ranged from 15 to 30% of the average measurable dose of workers at multiple location facilities over the past 3 years. This is because it is more difficult for workers to avoid exposure to radiation in the field, where conditions are not optimal and may change daily. To see the contribution that each radiography licensee made to the total collective dose, a summary of the information reported by each of these licensees in 1998 is presented in Appendix A.

High exposures in radiography can be directly attributable to the type and location of the radiography field work. For example, locations such as oil drilling platforms and aerial tanks offer the radiographer little available shielding. In these situations, there may not be an opportunity to use distance as a means of minimizing exposure and achieving ALARA. Although these licensed activities usually result in average measurable doses that are higher than other licensees, they involve a relatively small number of exposed workers.

TABLE 3.4
Annual Exposure Information for Industrial Radiographers
1996 - 1998

Year	Type of License	Number of Licensees	Number of Monitored Individuals	Workers With Measurable Dose	Collective Dose (person-rem)	Average Measurable Dose (rem)
1996	Single Location	27	291	60	10	0.17
	Multiple Locations	117	3,340	2,477	1,375	0.56
	Total	**144**	**3,631**	**2,537**	**1,385**	**0.55**
1997	Single Location	27	296	84	10	0.12
	Multiple Locations	116	3,140	2,370	1,281	0.54
	Total	**143**	**3,436**	**2,454**	**1,291**	**0.53**
1998	Single Location	26	369	84	8	0.09
	Multiple Locations	115	4,571	3,355	1,851	0.55
	Total	**141**	**4,940**	**3,439**	**1,859**	**0.54**

Figure 3.1 shows the number of workers with measurable dose per licensee, the total collective dose per licensee, and the average measurable dose per worker for both types of Industrial Radiography facilities from 1973 through 1998. Both the collective TEDE and the number of workers with measurable TEDE increased from 1997 to 1998, resulting in only a small increase in the average measurable TEDE. Figures 3.2 and 3.3 show the collective dose distribution by dose range (see Section 3.1.8) for single location and multiple location radiography licensees. These graphs demonstrate that multiple location licensees consistently have individuals receiving dose in the higher dose ranges and routinely have up to 30% of the collective dose delivered to individuals above 2 rem.

3.3.2 Manufacturing and Distribution Licenses, Type "A" Broad and Limited

Manufacturing and Distribution licenses are issued to allow the manufacture and distribution of radionuclides in various forms for a number of diverse purposes. The products are usually distributed to persons specifically licensed by the NRC or an Agreement State. Type "A" Broad licenses are issued to larger organizations that may use many different radionuclides in many different ways and that have a comprehensive radiation protection program. The Limited licenses are usually issued to smaller firms requiring a more restrictive license. Some firms are medical suppliers that process, package, or distribute such products as diagnostic test kits, radioactive surgical implants, and tagged radiochemicals for use in medical research, diagnosis, and therapy. Limited firms are suppliers of industrial radionuclides and are involved in the processing, encapsulation, packaging, and distribution of the radionuclides that they have purchased in bulk quantities from production reactors and cyclotrons. Major products include gamma radiography sources, cobalt irradiation sources, well-logging sources, sealed sources for gauges and smoke detectors, and radiochemicals for nonmedical research. However, only those NRC licensees that possess or use at any one time specified quantities of the nuclides listed in paragraph 20.2206(a)(7) are required to submit reports to the NRC.

Table 3.5 presents the annual data that were reported by the two types of licensees for 1998 and the previous 2 years. Looking at the

TABLE 3.5
Annual Exposure Information for Manufacturers and Distributors
1996 - 1998

Year	Type of License	Number of Licensees	Number of Monitored Individuals	Workers With Measurable Dose	Collective Dose (person-rem)	Average Measurable Dose (rem)
1996	M & D - "A" - Broad	7	2,018	987	522	0.53
	M & D - Limited	29	610	252	34	0.13
	Total	**36**	**2,628**	**1,239**	**556**	**0.45**
1997	M & D - "A" - Broad	5	496	386	364	0.94
	M & D - Limited	26	655	279	33	0.12
	Total	**31**	**1,151**	**665**	**397**	**0.60**
1998	M & D - "A" - Broad	5	1,177	380	367	0.97
	M & D - Limited	25	786	265	34	0.13
	Total	**30**	**1,963**	**645**	**401**	**0.62**

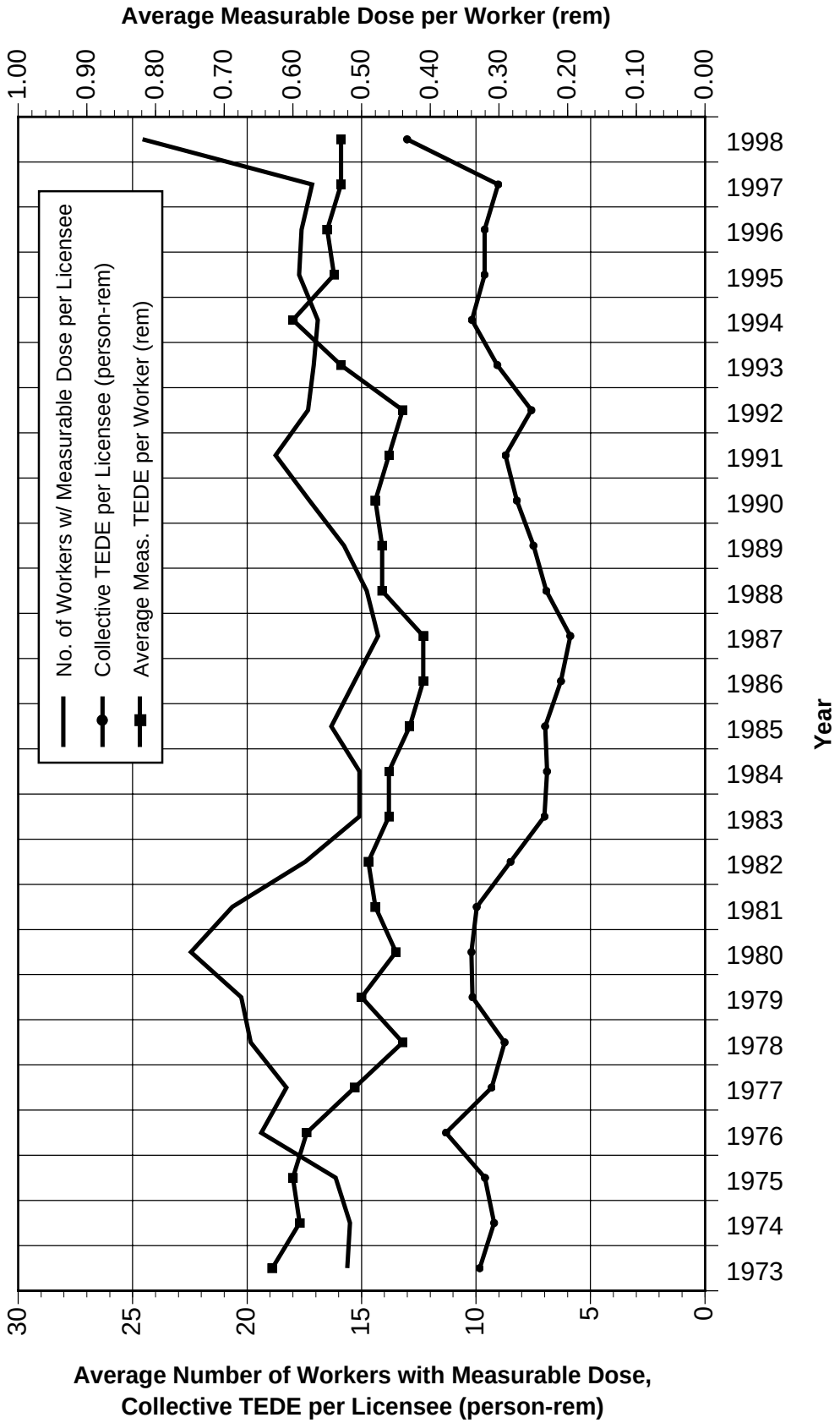


FIGURE 3.1. Average Annual Values at Industrial Radiography Facilities 1973 - 1998

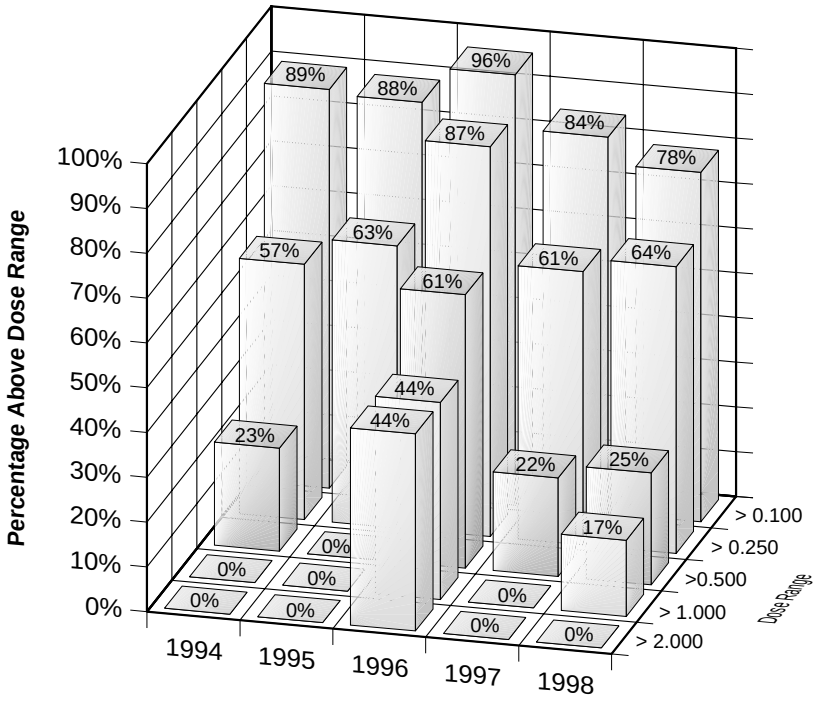


FIGURE 3.2. Collective TEDE Distribution by Dose Range
Industrial Radiographer – Single Location Licensees

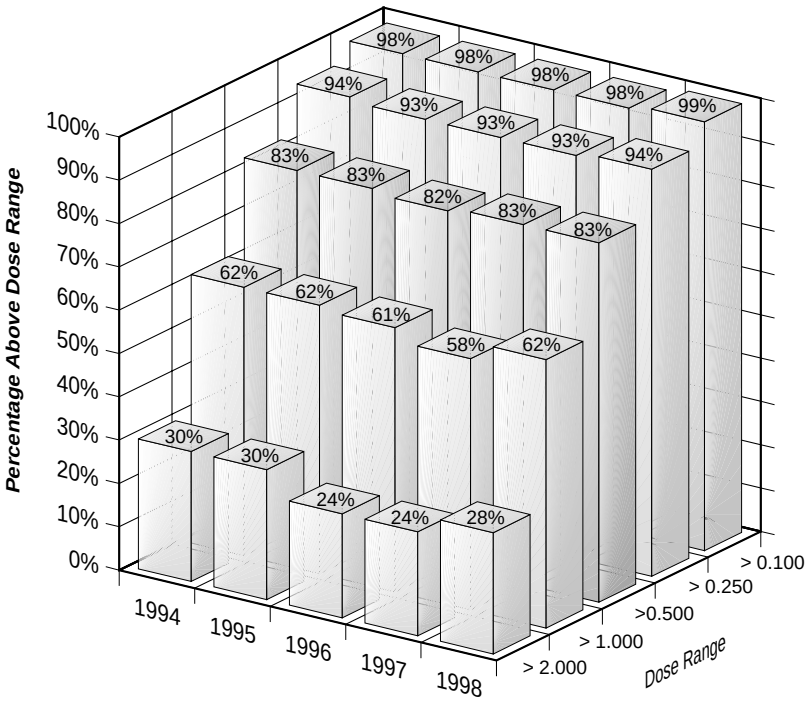


FIGURE 3.3. Collective TEDE Distribution by Dose Range
Industrial Radiographer – Multiple Location Licensees

information shown separately for the Type "A" Broad and Limited licensees, it can be seen that the values of all of the parameters remain higher for the Broad licensees. However, when attempting to examine trends in the data presented for this category of licensees, it should be noted that the types and quantities of radionuclides may fluctuate from year to year, and even during the year, so that some licensees may report dose data one year and not the next and may be included as a Broad licensee one year and a Limited licensee at other times. Because the number of reporting licensees is quite small, these fluctuations may have a significant impact on the values of the parameters.

Figure 3.4 shows the number of workers with measurable dose per licensee, the total collective dose per licensee, and the average measurable dose per worker for both Type "A" Broad and Limited Manufacturing and Distribution facilities. The figures for Type "A" Broad licensees are primarily attributed to Mallinckrodt Medical, Inc., which accounted for 98% of the collective dose for this category of licensee in 1998. Several of the Type "A" Broad licensees that have reported significant dose in prior years, have been transferred to Agreement State licensees. Figures 3.5 and 3.6 show the collective dose distribution by dose range (see Section 3.1.8) for Type "A" Broad and Limited Manufacturing and Distribution licensees. These graphs clearly show that the Type "A" Broad licensees consistently have individuals receiving dose in the higher dose ranges. For 1997 and 1998, over 60% of the collective dose was received by individuals above 2 rem. Limited licensees exhibit a distribution of the collective dose where individuals below 0.500 rem receive most of the collective dose.

For the contribution that each of these licensees made toward the total values of the number of workers monitored, number of workers, and collective dose, see Appendix A, which lists the values of these parameters for each licensee for 1998.

3.3.3 Low-Level Waste Disposal Licenses

Low-Level Waste Disposal licenses are issued to allow the receipt, possession, and disposal of low-level radioactive wastes at a land disposal facility. The licensee has the appropriate facilities to receive wastes from such places as hospitals and laboratories, store them for a short time, and dispose of them in a properly prepared burial ground. The licensees in this category are located in and licensed by Agreement States which have primary regulatory authority over its activity. However, these licensees also have an NRC license that covers certain special nuclear material they might receive. The annual dose reports submitted by these licensees include all doses received during the year regardless of whether they were the result of NRC or Agreement State licensed material.

The requirement for this category of NRC licensee to file annual reports became effective in January 1983. There was only one licensee in this category in 1982 and 1983 and two licensees in this category from 1984 to 1997. In 1998, only one licensee reported in this category since Chem Nuclear is now an Agreement State licensee. Table 3.1 summarizes the data reported for 1989 through 1998. Appendix A summarizes the exposure information reported by this licensee in 1998.

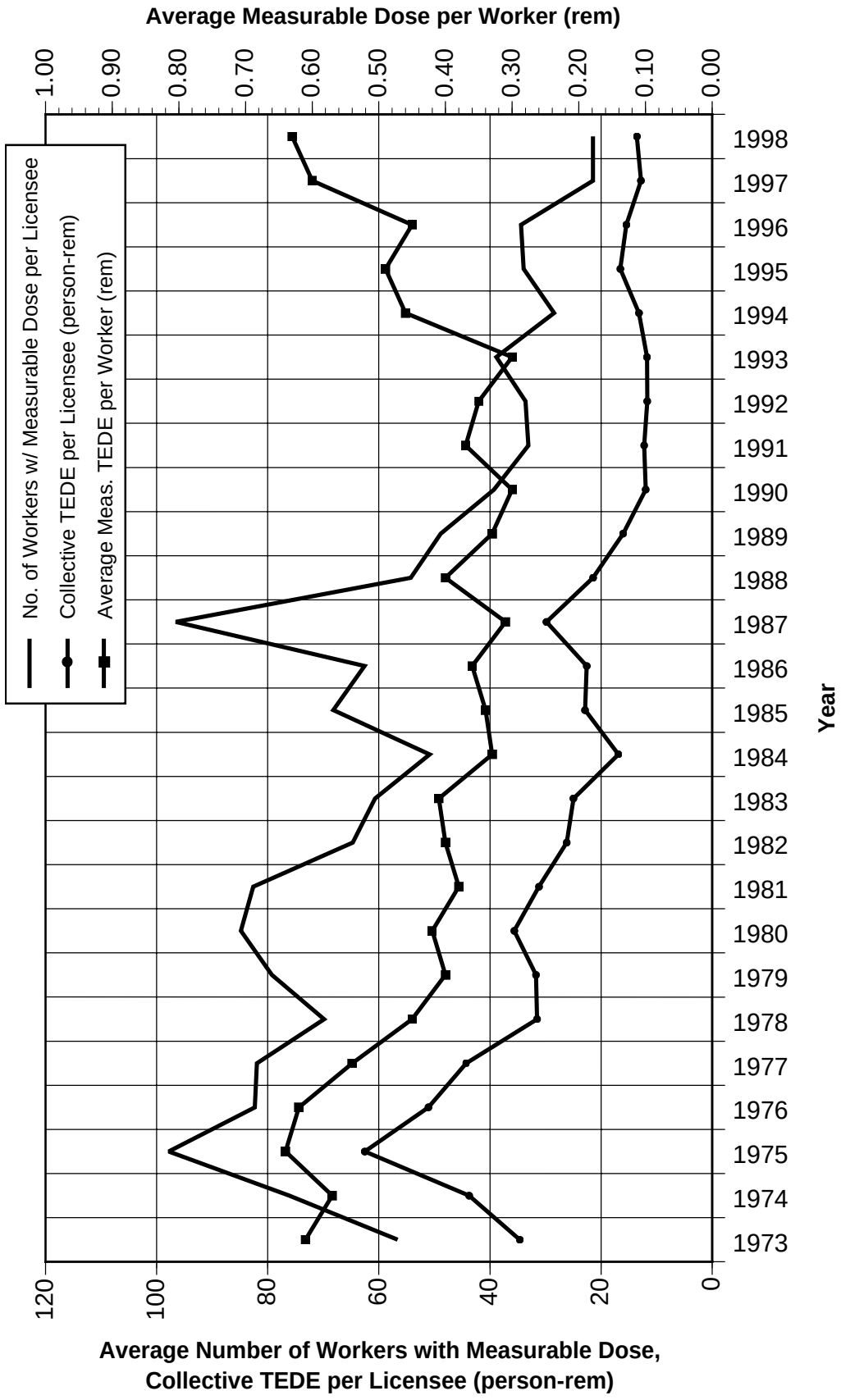


FIGURE 3.4. Average Annual Values at Manufacturing and Distribution Facilities 1973 - 1998

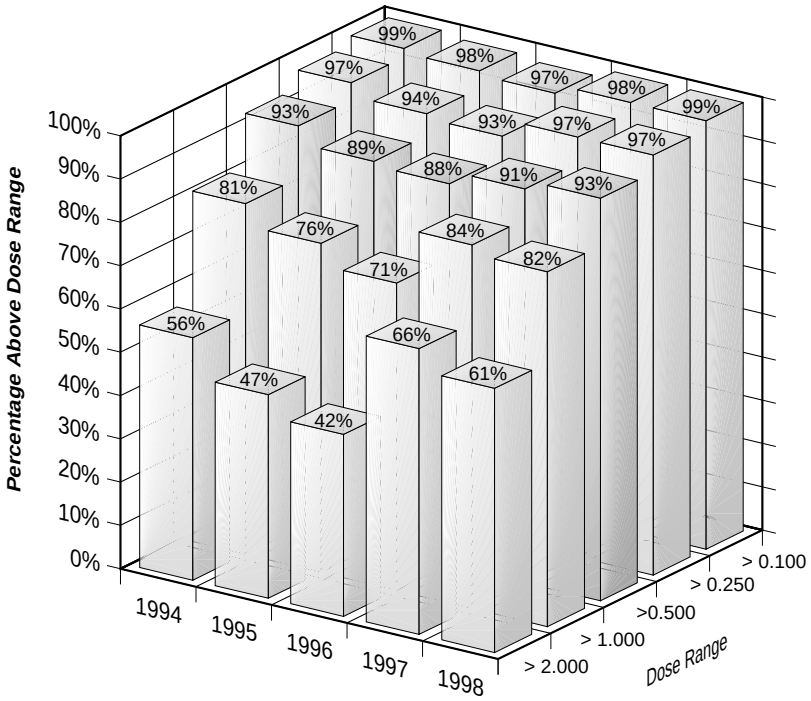


FIGURE 3.5. Collective TEDE Distribution by Dose Range
Type "A" Broad Manufacturing and Distribution Licenses

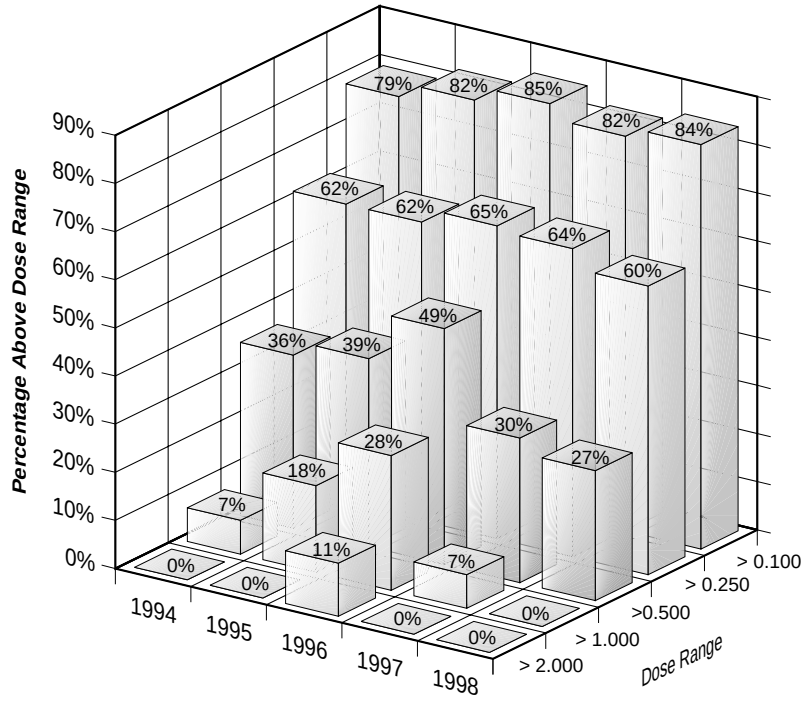


FIGURE 3.6. Collective TEDE Distribution by Dose Range
Limited Manufacturing and Distribution Licensees

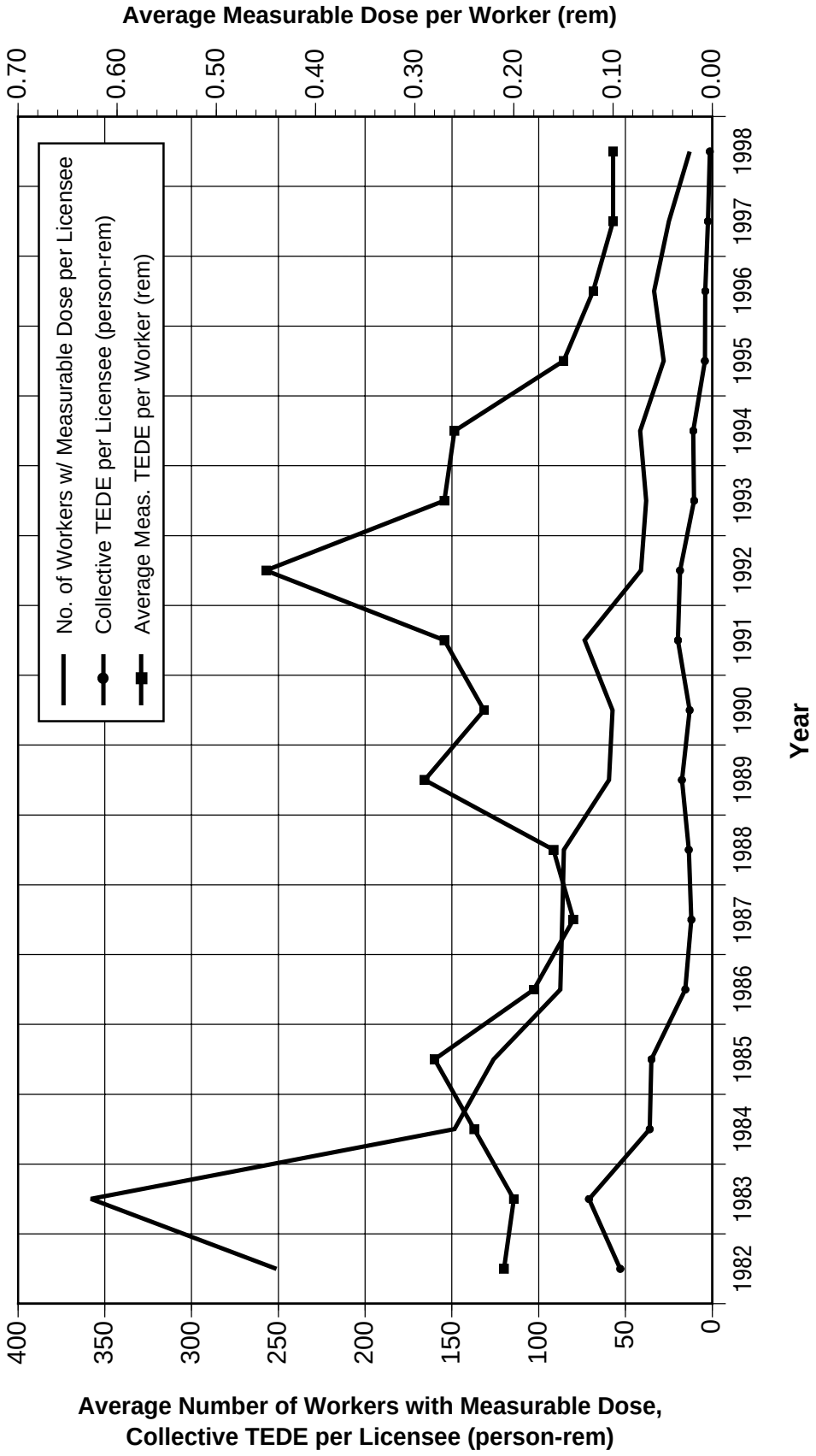


FIGURE 3.7. Average Annual Values at Low-Level Waste Disposal Facilities 1982 - 1998

Figure 3.7 shows the number of workers with measurable dose per licensee, the total collective dose per licensee, and the average measurable dose per worker for Low-Level Waste Disposal facilities from 1982 through 1998. Because only two licensees have been involved in this activity over the past 10 years, the numbers have remained fairly stable from 1984 through 1998 with the exception of the average measurable TEDE, which peaked in 1992 and has decreased by 75% since then. Figure 3.8 shows the collective dose distribution by dose range (see Section 3.1.8) for Low-Level Waste Disposal licensees. This graph shows that relatively small percentages of the collective dose are delivered in the higher dose ranges, and that the percentages above 0.100 rem have been decreasing in every dose range since 1994.

3.3.4 Independent Spent Fuel Storage Installation Licenses

Independent Spent Fuel Storage Installation (ISFSI) licenses are issued to allow the possession of power reactor spent fuel and other associated radioactive materials for the purpose of storage of such fuel in an ISFSI. Here, the spent fuel, which has undergone at least 1 year of decay since being used as a source of energy in a power reactor, is provided interim storage, protection, and safeguarding for a limited time pending its ultimate disposal.

Eighteen licenses have been issued for these activities. Eleven are at nuclear power plants, allowing on-site temporary storage of fuel. These licensees report the dose from fuel

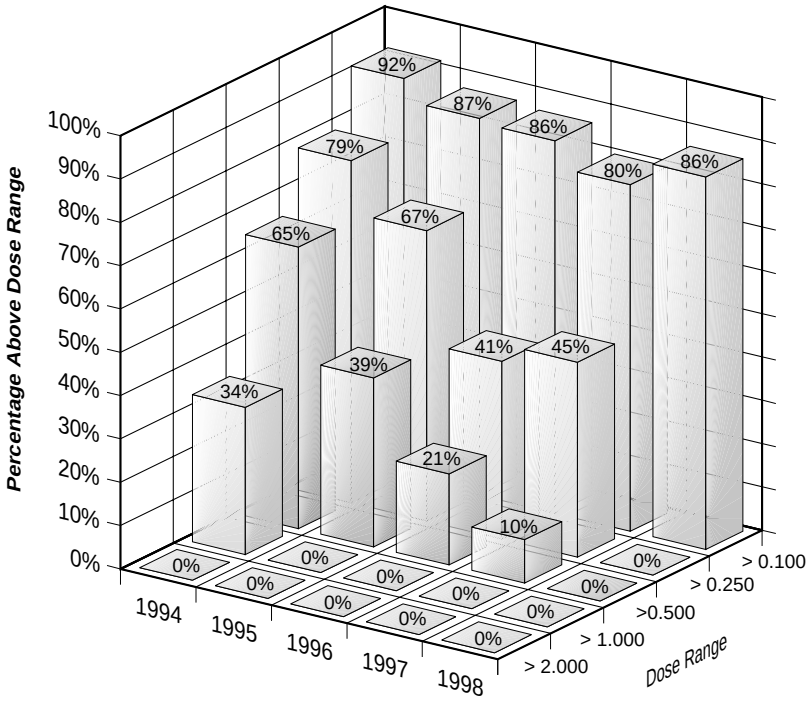


FIGURE 3.8. Collective TEDE Distribution by Dose Range Low-Level Waste Disposal Licensees

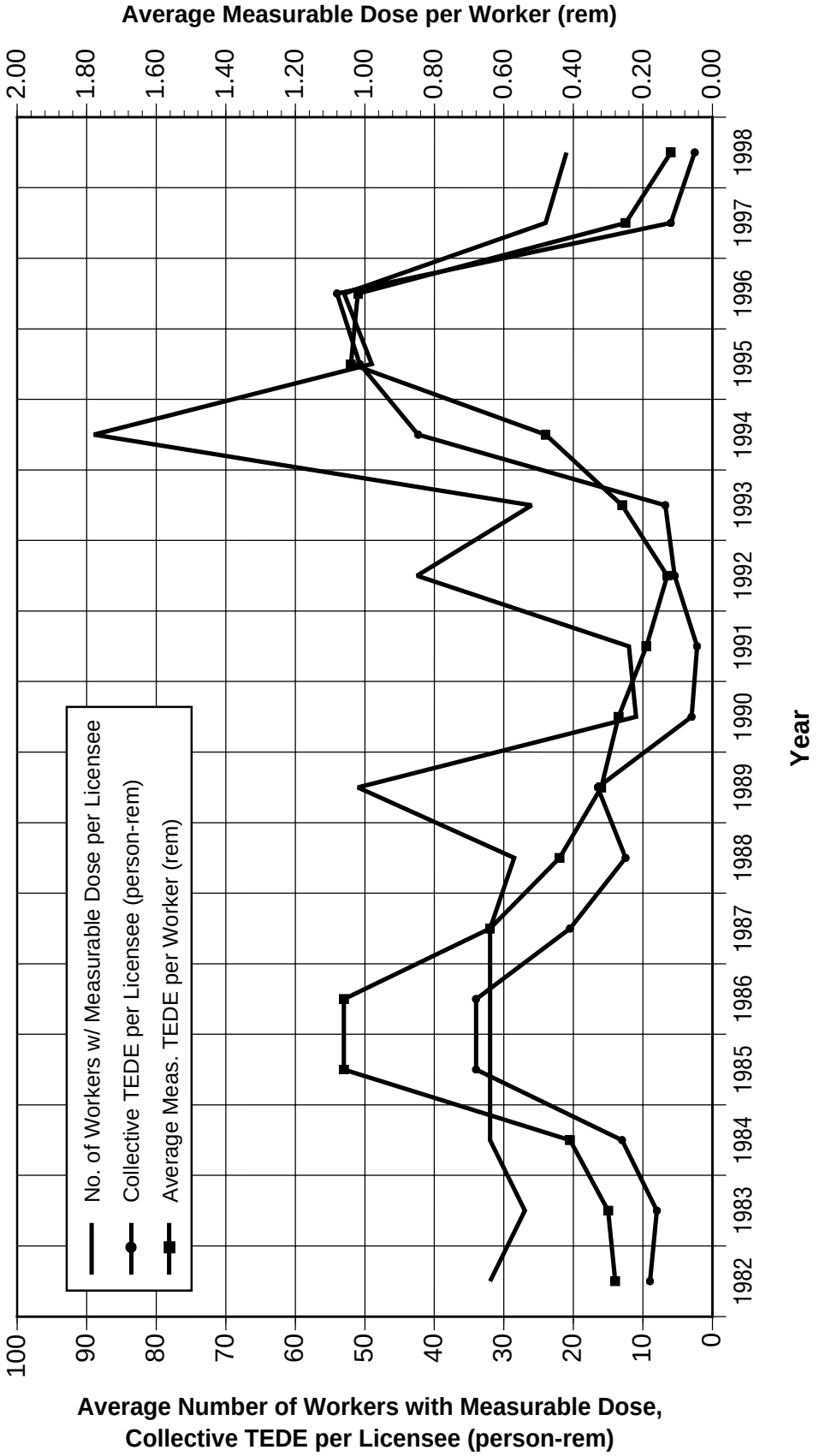


FIGURE 3.9. Average Annual Values at Independent Spent Fuel Storage Facilities 1982 - 1998

storage activities along with the dose from reactor operations at these sites. Out of the seven remaining licenses, only one is active and is located at a facility that is independent of a reactor site. Only this licensee is included in this analysis of ISFSI facilities for 1998. Appendix A summarizes the exposure information reported by this installation.

Figure 3.9 shows the number of workers with measurable dose per licensee, the total collective dose per licensee, and the average measurable dose per worker for Independent Spent Fuel Storage facilities. The large increase in the collective dose per licensee and number of workers per licensee in 1994 was mainly because only one licensee reported separately for 1994 through 1998, rather than the two licensees that reported in prior years. All parameters have decreased significantly from 1996 to 1998. Figure 3.10 shows the collective dose distribution by dose range (see Section 3.1.8) for ISFSI licensees from 1994 to 1998. The percentages for each dose range have decreased significantly since 1996.

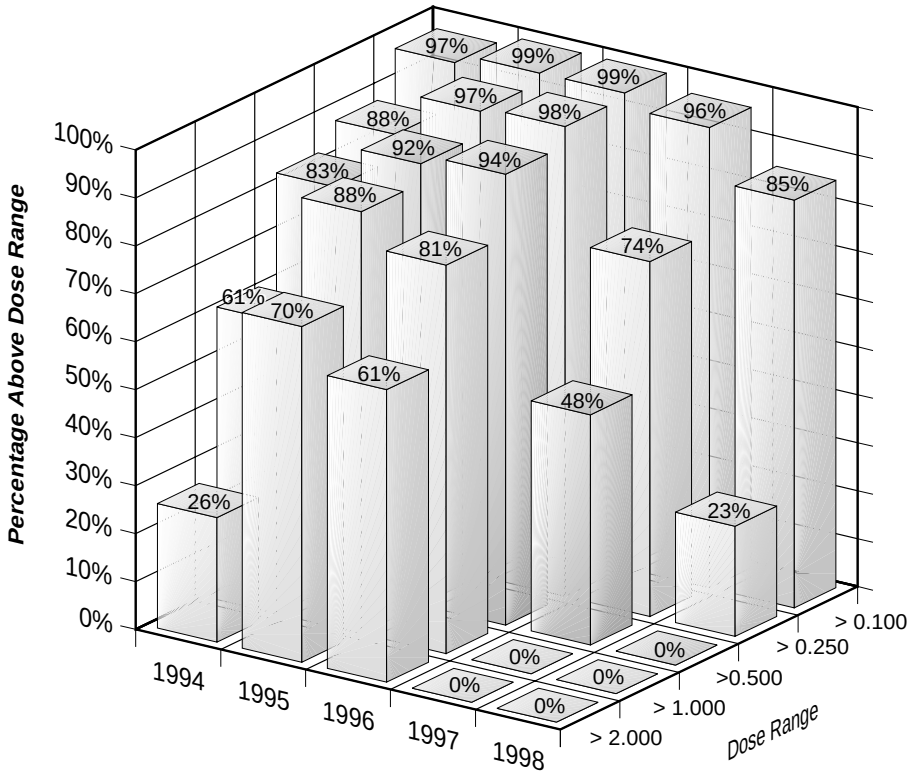


FIGURE 3.10. Collective TEDE Distribution by Dose Range Independent Spent Fuel Storage Licensees

3.3.5 Fuel Cycle Licenses

Fuel cycle licenses are issued to allow the processing, enrichment, and fabrication of reactor fuels. In most uranium facilities where light water reactor (LWR) fuels are fabricated enriched uranium hexafluoride is converted to solid uranium dioxide pellets and inserted into zirconium alloy tubes. The tubes are fabricated into fuel assemblies that are shipped to nuclear power plants. Some facilities also perform chemical operations to recover the uranium from scrap and other off-specification materials prior to disposal of these materials. For 1997 and 1998, this category also includes the two uranium enrichment facilities at Portsmouth, Ohio, and Paducah, Kentucky. The regulatory oversight for these facilities was transferred from the DOE to the NRC in 1997.

Figure 3.11 shows the number of workers with measurable dose per licensee, the total collective dose per licensee, and the average measurable dose per worker for Fuel Cycle licensees. In addition to the TEDE collective and average measurable dose, the Deep Dose Equivalent (DDE) collective dose and DDE average measurable dose are shown. Both doses are shown since the CEDE is a significant contribution to the TEDE for Fuel Fabrication facilities. Figure 3.12 shows the collective dose distribution by dose range (see Section 3.1.8) for Fuel Cycle licensees from 1994 to 1998. The distribution of collective dose has been fairly constant with a decreasing trend in the percentage in almost every dose range over the past 5 years. Appendix A lists each of the licensees reporting in 1998, with the number of workers monitored, the number of workers receiving measurable external doses, and the collective dose for each licensee. Table 3.6 shows that there were 10 licensed Fuel Cycle (Fabrication and Enrichment) facilities in 1998.

TABLE 3.6
Annual Exposure Information for Fuel Cycle Licenses
1996 - 1998

Year	Type of License	Number of Licensees	Number of Monitored Individuals	Workers With Meas. TEDE	Collective TEDE (person-rem)	Average Meas. TEDE (rem)	Workers With Meas. DDE	Collective DDE (person-rem)	Average Meas. DDE (rem)	Workers With Meas. CEDE	Collective CEDE (person-rem)	Average Meas. CEDE (rem)
1996	Fuel Cycle	8	4,369	3,061	878	0.29	1,907	161	0.08	2,260	711	0.32
1997	Fuel Cycle	10	11,214	3,910	1,006	0.26	2,545	197	0.08	2,684	800	0.30
1998	Fuel Cycle	10	10,684	3,613	950	0.26	2,412	204	0.08	2,520	742	0.29

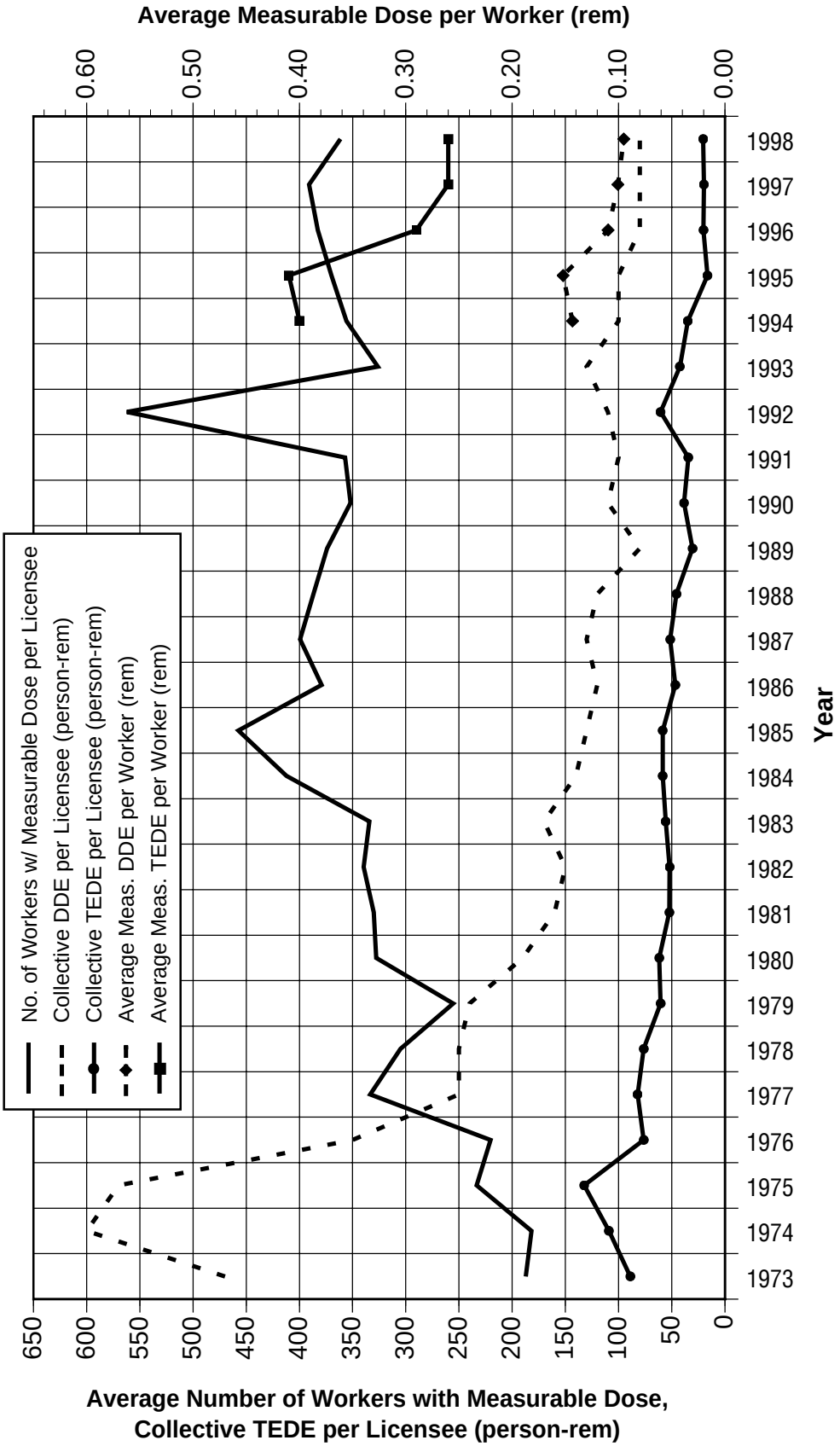


FIGURE 3.11. Average Annual Values at Fuel Cycle Licensees 1973 - 1998

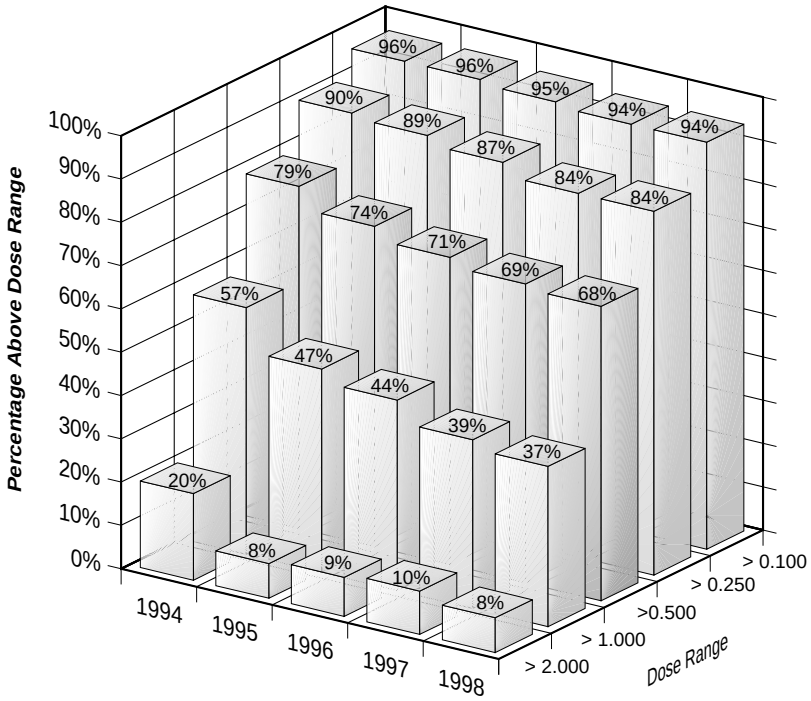


FIGURE 3.12. Collective TEDE Distribution by Dose Range
Fuel Cycle Licensees

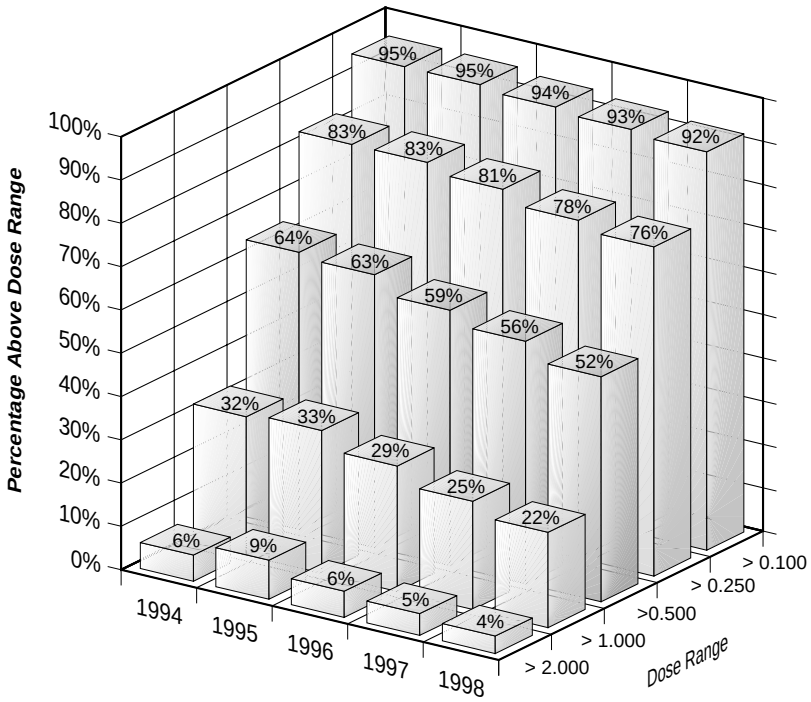


FIGURE 3.13. Collective TEDE Distribution by Dose Range
Reactor Licensees

3.3.6 Light-Water-Cooled Power Reactor Licenses

LWR licenses are issued to utilities to allow them to use special nuclear material in a reactor that produces heat to generate electricity to be sold to consumers. There are two major types of commercial LWRs in the United States - PWRs and BWRs - each of which uses water as the primary coolant.

Table 3.1 shows the number of licensees, total number of monitored workers, the number of workers with measurable dose, the total collective dose, and average dose per worker for all reports received from reactor facilities that were in commercial operation for the years 1989 through 1998. This table includes reactors that may not have been in commercial operation for a full year. Data for 1989 through 1998 do not include reactors that have been shut down. These figures have been adjusted for the multiple counting of transient workers (see Section 5). The reported dose distribution of workers monitored at each plant site is presented in alphabetical order by site name in Appendix B.

Figure 3.13 shows the collective dose distribution by dose range (see Section 3.1.8) for Reactor licensees from 1994 to 1998. The distribution of collective dose has been fairly constant with a decreasing trend in the percentage in almost every dose range over the past 5 years.

More detailed presentations and analyses of the annual exposure information reported by nuclear power facilities can be found in Sections 4 and 5.

3.4 SUMMARY OF INTAKE DATA BY LICENSE CATEGORY

With the revision of 10 CFR 20 in 1994, licensees were required to report additional data to the NRC concerning intakes of radioactive material. Licensees were required to list for each intake the radionuclide that was taken into the body, the pulmonary clearance class, intake mode, and amount of the intake in microcuries. An NRC Form 5 report containing this information is required to be completed and submitted to the NRC under 10 CFR 20.2206.

Tables 3.7 and 3.8 summarize the intake data reported to the NRC during 1998. The data are categorized by licensee type and are listed in order of radionuclide and pulmonary clearance class. Table 3.7 lists the intakes

TABLE 3.7
Intake by Licensee Type and Radionuclide Mode of Intake – *Ingestion and Other*
1998

Mode	Licensee Type	Program Code	Radionuclide	Number of Intake Records*	Collective Intake in Microcuries	Collective Intake in Microcuries (sci. notification)
Injection	Power Reactors	41111	Co-60	1	0.449	4.49E-01
Ingestion	Manufacturer and Distributor	03211	Mo-99	1	4.080	4.08E+00
	Fuel Cycle Licensees	21200	U-234	2	0.006	6.00E-03
		21210	U-234	1	0.003	3.03E-03
		21210	U-235	1	0.000	1.18E-04
		21200	U-238	1	0.000	4.25E-04
	Power Reactors	41111	Alpha	4	0.002	1.90E-03
		41111	Am-241	2	0.000	3.73E-04
		41111	Ce-141	1	0.004	3.68E-03
		41111	Cm-242	2	0.000	2.74E-06
		41111	Cm-243/242	2	0.000	1.29E-04
		41111	Co-57	2	0.000	3.70E-05
		41111	Co-58	8	1.071	1.07E+00
		41111	Co-60	25	352.000	3.52E+02
		41111	Cr-51	2	851.000	8.51E+02
		41111	Cs-137	3	0.090	9.00E-02
		41111	Fe-55	1	0.014	1.41E-02
		41111	Fe-59	1	1.000	1.00E+00
		41111	Mn-54	10	127.067	1.27E+02
		41111	Nb-95	1	0.063	6.30E-02
		41111	Pu-238	2	0.000	2.67E-04
		41111	Pu-239/240	2	0.000	9.36E-05
		41111	Pu-241	2	0.005	5.43E-03
		41111	Ru-106	1	0.780	7.80E-01
		41111	Zn-65	1	1.600	1.60E+00
		41111	Zr-95	1	0.048	4.80E-02

* An intake event may involve multiple nuclides, and individuals may incur multiple intakes during the year. The number of intake records given here indicates the number of separate intake reports that were submitted on NRC Form 5 reports under 10 CFR 20.2206.

TABLE 3.8
Intake by Licensee Type and Radionuclide Mode of Intake – *Inhalation*
1998

Licensee Type	Program Code	Radionuclide	Pulmonary Clearance Class	Number of Intake Records*	Collective Intake in Microcuries	Collective Intake in Microcuries (sci. notification)
Nuclear Pharmacies	02500	I-131	D	44	5.653	5.65E+00
Manufacturing and Distribution	03211	I-125	D	1	0.238	2.38E-01
	03211	I-131	D	8	4.141	4.14E+00
Uranium Enrichment	21200	Th-230	W	46	0.000	2.86E-04
	21200	U-234	D	97	0.055	5.45E-02
	21200	U-234	Y	1	0.000	7.03E-06
Fuel Fabrication	21210	Am-241	W	94	0.000	6.37E-05
	21210	Co-60	Y	502	0.486	4.86E-01
	21210	Cs-137	D	3	0.000	2.45E-06
	21210	Eu-152	W	35	0.000	1.48E-04
	21210	Np-237	W	1	0.000	2.74E-08
	21210	Pa-234	W	1	0.000	5.78E-07
	21210	Pu-234	W	1	0.000	1.42E-07
	21210	Pu-238	W	94	0.000	1.46E-05
	21210	Pu-239	W	160	0.000	2.62E-04
	21210	Pu-239	Y	1	0.000	1.42E-04
	21210	Pu-240	W	94	0.000	4.39E-05
	21210	Ra-224	W	94	0.001	5.03E-04
	21210	Sr-90	D	2	0.000	1.21E-05
	21210	Sr-90	Y	164	0.000	1.73E-04
	21210	Tc-99	D	1	0.000	2.27E-06
	21210	Tc-99	W	2	0.000	1.20E-04
	21210	Th-228	W	1	0.000	2.64E-09
	21210	Th-228	Y	156	0.001	5.11E-04
	21210	Th-230	W	1	0.000	1.16E-07
	21210	Th-230	Y	156	0.000	2.43E-04
	21210	Th-232	W	1	0.000	5.28E-09
	21210	Th-232	Y	181	0.001	9.88E-04
	21210	Th-234	Y	1	0.000	2.28E-07
	21210	U-234	D	548	0.828	8.28E-01
	21210	U-234	W	445	0.104	1.04E-01
	21210	U-234	Y	2564	6.100	6.10E+00
	21210	U-235	D	10	0.001	8.85E-04
	21210	U-235	Y	1035	0.140	1.40E-01
	21210	U-236	Y	226	0.003	3.06E-03
	21210	U-238	D	141	0.047	4.67E-02
	21210	U-238	W	80	0.156	1.56E-01
	21210	U-238	Y	1799	0.542	5.42E-01

TABLE 3.8 (continued)
Intake by Licensee Type and Radionuclide Mode of Intake – *Inhalation*
1998

Licensee Type	Program Code	Radionuclide	Pulmonary Clearance Class	Number of Intake Records*	Collective Intake in Microcuries	Collective Intake in Microcuries (sci. notification)
Power Reactors	41111	Ag-110m	Y	3	0.062	6.20E-02
	41111	Alpha	Y	3	0.001	1.47E-03
	41111	Am-241	W	43	0.139	1.39E-01
	41111	Ba-140	D	1	0.023	2.30E-02
	41111	Ce-141	W	2	0.030	3.03E-02
	41111	Ce-141	Y	1	0.288	2.88E-01
	41111	Cm-242	W	35	0.057	5.67E-02
	41111	Cm-243	W	35	0.310	3.10E-01
	41111	Cm-243/244	W	8	0.000	2.03E-04
	41111	Co-57	Y	2	0.000	4.11E-06
	41111	Co-58	Y	97	2,128.836	2.13E+03
	41111	Co-60	D	1	0.065	6.50E-02
	41111	Co-60	O	1	0.027	2.70E-02
	41111	Co-60	Y	281	26,983.911	2.70E+04
	41111	Cr-51	W	2	0.523	5.23E-01
	41111	Cr-51	Y	4	1.037	1.04E+00
	41111	Cs-134	D	10	0.125	1.25E-01
	41111	Cs-137	D	69	70.353	7.04E+01
	41111	Cs-137	Y	19	0.362	3.62E-01
	41111	Fe-55	D	2	0.243	2.43E-01
	41111	Fe-59	W	2	0.134	1.34E-01
	41111	I-131	D	88	1,488.324	1.49E+03
	41111	I-133	D	2	0.085	8.50E-02
	41111	La-140	W	1	0.028	2.80E-02
	41111	Mn-54	W	26	61.118	6.11E+01
	41111	Mn-54	Y	5	10,120.060	1.01E+04
	41111	Nb-95	W	2	0.165	1.65E-01
	41111	Nb-95	Y	18	134.959	1.35E+02
	41111	Np-237	W	22	0.000	3.80E-04
	41111	Pu-238	W	6	0.000	4.28E-05
	41111	Pu-238	Y	37	0.359	3.59E-01
	41111	Pu-239	W	4	0.000	3.66E-05
	41111	Pu-239	Y	7	0.000	1.27E-04
	41111	Pu-239/240	W	2	0.000	1.04E-05
	41111	Pu-240	Y	22	0.067	6.70E-02
	41111	Pu-241	W	6	0.003	2.50E-03
	41111	Pu-241	Y	29	16.308	1.63E+01
	41111	Pu-242	W	1	0.000	2.00E-08
	41111	Sr-90	D	6	0.001	1.09E-03
	41111	TOTAL	D	2	0.000	6.10E-05
	41111	Zn-65	Y	11	0.423	4.23E-01
	41111	Zr-95	D	3	1.063	1.06E+00
	41111	Zr-95	W	6	32.559	3.26E+01
	41111	Zr-95	Y	14	0.624	6.24E-01

* An intake event may involve multiple nuclides, and individuals may incur multiple intakes during the year. The number of intake records given here indicates the number of separate intake reports that were submitted on NRC Form 5 reports under 10 CFR 20.2206.

TABLE 3.9
Collective and Average CEDE by Licensee
1998

Licensee Type	Licensee Name	License Number	Number with Meas. CEDE	Collective CEDE (person-rem)	Average Meas. CEDE (rem)
Nuclear Pharmacies	EASTERN ISOTOPES, MD	MD-03-068-01*	6	0.010	0.002
02500	NORTHERN VIRGINIA ISOTOPES, INC.	45-25221-01MD	7	0.008	0.001
	SYNCOR INTERNATIONAL CORPORATION	04-26507-01MD	13	0.296	0.023
		Total	**26**	**0.314**	**0.012**
Manufacturing and Distribution	MALLINCKRODT MEDICAL INC.	24-04206-01	8	0.164	0.021
03211		**Total**	**8**	**0.164**	**0.021**
Uranium Enrichment	USEC - PADUCAH	GDP-1	28	0.040	0.001
21200	USEC - PORTSMOUTH	GDP-2	30	0.202	0.007
		Total	**58**	**0.242**	**0.004**
Fuel Fabrication	FRAMATOME COGEMA FUEL	SNM-1168	107	8.433	0.079
21210	BWX TECHNOLOGIES, INC.	SNM-0042	237	163.865	0.691
	COMBUSTION ENGINEERING INC.	SNM-0033	164	121.155	0.739
	GE NUCLEAR ENERGY	SNM-1097	810	148.546	0.183
	NUCLEAR FUEL SERVICES, INC.	SNM-0124	483	56.751	0.117
	SIEMENS POWER CORP. NUCLEAR DIVISION	SNM-1227	366	90.994	0.249
	WESTINGHOUSE ELECTRIC COMPANY	SNM-1107	295	152.009	0.515
		Total	**2,462**	**741.753**	**0.301**
Independent Spent Fuel Storage Installation	GENERAL ELECTRIC CO.	SNM-2500	1	0.001	0.001
23100		**Total**	**1**	**0.001**	**0.001**
Reactors	ARKANSAS	DPR-51	5	0.222	0.044
41111	BIG ROCK POINT	DPR-06	2	0.024	0.012
	BROWNS FERRY	DPR-33	12	0.761	0.063
	BRUNSWICK	DPR-62	80	0.387	0.005
	CALLAWAY	NPF-30	40	0.589	0.015
	CALVERT CLIFFS	DPR-53	8	0.537	0.067
	CATAWBA	NPF-35	6	0.085	0.014
	COMANCHE PEAK	NPF-87	1	0.023	0.023
	COOPER STATION	DPR-46	19	0.053	0.003
	DAVIS-BESSE	NPF-03	19	0.300	0.016
	DRESDEN	DPR-19	2	0.193	0.097
	DUANE ARNOLD	DPR-49	1	0.011	0.011
	FARLEY	NPF-02	6	0.077	0.013
	FERMI	NPF-43	1	0.015	0.015
	FT. CALHOUN	DPR-40	1	0.023	0.023
	HADDAM NECK	DPR-61	2	0.046	0.023
	HARRIS	NPF-63	9	0.083	0.009
	HATCH	DPR-57	3	0.058	0.019
	INDIAN POINT	DPR-26	1	0.030	0.030
	LIMERICK	NPF-39	4	0.220	0.055
	MAINE YANKEE	DPR-36	31	0.375	0.012
	MILLSTONE POINT 1	DPR-21	3	0.030	0.010
	MONTICELLO	DPR-22	5	0.101	0.020
	NINE MILE POINT	DPR-63	37	0.641	0.017
	NORTH ANNA	NPF-07	3	0.047	0.016
	OCONEE	DPR-38	8	0.121	0.015
	OYSTER CREEK	DPR-16	126	0.650	0.005
	PALISADES	DPR-20	55	1.851	0.034
	PEACH BOTTOM	DPR-44	1	0.010	0.010
	PILGRIM	DPR-35	1	0.001	0.001
	POINT BEACH	DPR-24	3	0.053	0.018
	RIVER BEND	NPF-47	3	0.037	0.012
	ROBINSON	DPR-23	1	0.002	0.002
	SAN ONOFRE	DPR-13	14	0.182	0.013
	SEQUOYAH	DPR-77	95	8.676	0.091
	SOUTH TEXAS	NPF-76	1	0.017	0.017
	ST. LUCIE	DPR-67	7	0.073	0.010
	SURRY	DPR-32	4	0.128	0.032
	SUSQUEHANNA	NPF-14	105	0.435	0.004
	THREE MILE ISLAND 1	DPR-50	126	0.798	0.006
	TURKEY POINT	DPR-31	3	0.084	0.028
	VERMONT YANKEE	DPR-28	65	0.482	0.007
	VOGTLE	NPF-68	10	0.227	0.023
	WASHINGTON NUCLEAR 2	NPF-21	9	0.110	0.012
	WOLF CREEK	NPF-42	5	0.024	0.005
		Total	**943**	**18.892**	**0.020**
Grand Totals			**3,498**	**761.366**	**0.218**

* This license is also an Agreement State license.

where the mode of intake into the body was recorded as ingestion. In 1998, one record was reported as an 'injection' of cobalt-60 and is included in Table 3.7. Table 3.8 lists the intakes where the mode of intake was inhalation from ambient airborne radioactive material in the workplace. The pulmonary clearance class is recorded as D, W, or Y corresponding to its clearance half-time in the order of **d**ays, **w**eeks, or **y**ears from the pulmonary region of the lung into the blood and gastrointestinal tract. The amount of material taken into the body is given in microcuries, a unit of measure of the quantity of radioactive material. For each category of licensee, the maximum number of intake records and the maximum intake is highlighted in the table in bold for ease of reference.

Table 3.9 lists the number of individuals with measurable CEDE, the collective CEDE and the average measurable CEDE for each licensee category. Fuel fabrication facilities have the majority of internal dose (97%) and the highest average CEDE per individual. This is due to the worker's exposure to uranium during the processing and fabrication of the uranium fuel.

Table 3.10 shows the distribution of internal dose (CEDE) from 1994 to 1998 for licensees required to report under 10 CFR 20.2206. For the purposes of this table, the definition of a 'measurable CEDE' is any reported value greater than zero. As noted above, the vast majority of the internal doses are received by individuals working at fuel fabrication facilities.

In 1998, the highest CEDE was 3.402 rem, received by an individual at Combustion Engineering, Inc., a fuel fabrication facility. The individual received an intake of uranium U-234, U-235, and U-238. The highest CDE was 28.345 rem to this same individual.

TABLE 3.10
Internal Dose (CEDE) Distribution
1994 - 1998

Year	Number of Individuals with CEDE in the Ranges (rem)										Total with Meas. CEDE	Collective CEDE (person-rem)	Average Meas. CEDE (rem)
	Meas. 0.020	0.020 - 0.100	0.100 - 0.250	0.250 - 0.500	0.500 - 0.750	0.750 - 1.000	1 - 2	2 - 3	3 - 4	4 - 5			
1994	1,379	528	288	353	197	140	294	69	2	-	3,250	1,029.515	0.317
1995	1,417	473	295	315	180	112	192	18	-	-	3,002	709.566	0.236
1996	1,345	567	306	317	190	121	185	22	2	-	3,055	723.208	0.237
1997	1,611	694	381	366	242	148	169	30	-	-	3,641	811.912	0.223
1998	1,507	663	427	355	230	140	153	21	2	-	3,498	761.366	0.218

Section 4

COMMERCIAL LIGHT WATER REACTORS – FURTHER ANALYSIS

4.1 INTRODUCTION

General trends in occupational radiation exposures at nuclear power reactors are best evaluated within the context of other pertinent information. In this chapter, some of the tables and appendices that summarize exposure data also show the type, capacity, amount of electricity generated, and age of the reactor. Exposure data are then presented as a function of these data.

4.2 DEFINITION OF TERMS AND SOURCES OF DATA

4.2.1 Number of Reactors

The *number of reactors* shown in Tables 4.1, 4.2, and 4.3 is the number of BWRs, PWRs, and LWRs, respectively, that had been in commercial operation for at least 1 full year as of December 31 of each of the indicated years. This is the number of reactors on which the *average number of workers with measurable dose* and *average collective dose per reactor* is based. Excluded are those reactors that had been in commercial operation for less than 12 months during the first year and reactors that have been permanently defueled. This yields conservative values for many of the averages shown in the tables. The date that each reactor was declared to be in commercial operation was taken from Reference 12.

Three Mile Island (TMI) 2 had been included in the compilation of data for commercially operating reactors through 1988 even though the reactor was shut down following the 1979 accident and has been in the process of defueling and decommissioning since that time. TMI 2 has not been included in the data analysis since 1988. Data for this reactor, however, will be listed in Appendix B for reference purposes. The dose data presented in Appendix D for Three Mile Island includes the dose data for Unit 2 prior to 1986.

In 1998, Big Rock Point (a BWR) was removed from the count of operating reactors. Zion 1 and 2 (two PWRs) and Maine Yankee (a PWR) were also removed from the count of operating reactors. This brings the count of operating BWRs in 1998 to 36, and the count of operating PWRs to 69. This is the first reduction in the number of operating BWRs in 9 years, and the first reduction in the number of operating PWRs in 5 years. The dose information for these reactors and others that are no longer in commercial operation are listed at the end of Appendix B.

4.2.2 Electric Energy Generated

The electric energy generated in megawatt-years (MW-yr) each year by each reactor is graphically represented in Appendix C. This number was obtained by dividing the megawatt-hours of electricity

TABLE 4.1
Summary of Information Reported by Commercial Boiling Water Reactors
1973 - 1998

Year	Number of Reactors Included*	Annual Collective Dose (person-rem)	No. of Workers With Measurable Dose**	Electricity Generated*** (MW-yrs)	Average Measurable Dose Per Worker (rem)**	Average Collective Dose Per Reactor (person-rem)	Average No. Personnel With Measurable Doses Per Reactor**	Average Collective Dose per MW-yr (person-rem /MW-yr)	Average Electricity Generated Per Reactor (MW-yr)	Average Maximum Dependable capacity Net (MWe)	Percent of Maximum Dependable Capacity Achieved
1973	12	4,564	5,340	3,393.9	0.85	380	445	1.34	283	438	65%
1974	14	7,095	8,769	4,060.2	0.81	507	626	1.75	290	485	60%
1975	18	12,611	14,607	5,786.4	0.86	701	812	2.18	321	595	54%
1976	22	12,300	16,604	8,137.9	0.74	559	755	1.51	370	630	59%
1977	23	19,041	21,388	9,102.5	0.89	828	930	2.09	396	637	62%
1978	25	15,273	20,278	11,856.0	0.75	611	811	1.29	474	660	72%
1979	25	18,325	25,245	11,671.0	0.73	733	1,010	1.57	467	660	71%
1980	26	29,530	34,094	10,868.2	0.87	1,136	1,311	2.72	418	663	63%
1981	26	25,472	34,755	10,899.2	0.73	980	1,337	2.34	419	663	63%
1982	26	24,437	32,235	10,614.6	0.76	940	1,240	2.30	408	663	62%
1983	26	27,455	33,473	9,730.1	0.82	1,056	1,287	2.82	374	663	56%
1984	27	27,097	41,105	10,019.2	0.66	1,004	1,522	2.70	371	754	49%
1985	29	20,573	38,237	12,284.0	0.54	709	1,319	1.67	424	775	55%
1986	30	19,349	37,928	12,102.1	0.51	645	1,264	1.60	403	786	51%
1987	32	16,717	41,737	15,109.0	0.40	522	1,304	1.11	472	832	57%
1988	34	17,983	40,305	16,665.4	0.45	529	1,185	1.08	490	845	58%
1989	36	15,549	44,360	17,543.5	0.35	432	1,232	0.89	487	857	57%
1990	37	15,780	41,577	21,336.1	0.38	426	1,124	0.74	577	862	67%
1991	37	12,005	38,492	21,505.8	0.31	324	1,040	0.56	581	860	68%
1992	37	13,309	42,095	20,592.2	0.32	360	1,138	0.65	557	859	65%
1993	37	12,221	39,352	21,995.6	0.31	330	1,064	0.56	594	798	74%
1994	37	12,092	39,108	22,139.0	0.31	327	1,057	0.55	598	801	75%
1995	37	9,467	35,659	24,737.0	0.27	256	964	0.38	669	835	80%
1996	37	9,461	37,637	24,322.2	0.25	256	1,017	0.39	657	838	78%
1997	37	7,597	33,845	22,866.1	0.22	205	915	0.33	618	845	73%
1998	36	6,823	32,864	23,781.2	0.21	190	913	0.29	661	874	76%

* Includes only those reactors that had been in commercial operation for at least one full year as of December 31 of each of the indicated years.
** Figures are not adjusted for the multiple reporting of transient individuals. See Section 5.
*** Electricity generated reflects the gross electricity generated for the years 1973-1996. Beginning in 1997, it reflects the net electricity generated.

TABLE 4.2
Summary of Information Reported by Commercial Pressurized Water Reactors
1973 - 1998

Year	Number of Reactors Included*	Annual Collective Dose (person-rem)	No. of Workers With Measurable Dose**	Electricity Generated*** (MW-yrs)	Average Measurable Dose Per Worker (rem)**	Average Collective Dose Per Reactor (person-rem)	Average No. Personnel With Measurable Doses Per Reactor**	Average Collective Dose per MW-yr (person-rem /MW-yr)	Average Electricity Generated Per Reactor (MW-yr)	Average Maximum Dependable capacity Net (MWe)	Percent of Maximum Dependable Capacity Achieved
1973	12	9,398	9,440	3,770.2	1.00	783	787	2.49	314	544	58%
1974	19	6,555	9,370	6,530.7	0.70	345	493	1.00	344	591	58%
1975	26	8,268	10,884	11,982.5	0.76	318	419	0.69	461	647	71%
1976	30	13,807	17,588	13,325.0	0.79	460	586	1.04	444	701	63%
1977	34	13,467	20,878	17,345.8	0.65	396	614	0.78	510	688	74%
1978	39	16,528	25,700	19,840.5	0.64	424	659	0.83	509	706	72%
1979	42	21,657	38,828	18,255.0	0.56	516	924	1.19	435	746	58%
1980	42	24,267	46,237	18,289.3	0.52	578	1,101	1.33	435	746	58%
1981	44	28,673	47,351	20,553.7	0.61	652	1,076	1.40	467	752	62%
1982	48	27,754	52,146	22,140.6	0.53	578	1,086	1.25	461	777	59%
1983	49	29,017	52,173	23,195.5	0.56	592	1,065	1.25	473	785	60%
1984	51	28,138	56,994	26,478.4	0.49	552	1,118	1.06	519	809	64%
1985	53	22,469	54,633	29,470.7	0.41	424	1,031	0.76	556	820	68%
1986	60	23,032	62,995	33,593.0	0.37	3841,050		0.69	560	878	64%
1987	6423,684		62,597	37,007.3	0.38	370	978	0.64	578	900	64%
1988	68	22,786	62,921	42,929.7	0.36	335	925	0.53	631	885	71%
1989	71	20,381	63,894	44,679.5	0.32	287	900	0.46	629	897	70%
1990	73	20,812	67,081	46,955.6	0.31	285	919	0.44	643	907	71%
1991	7416,510		60,269	51,942.6	0.27	223	814	0.32	702	913	77%
1992	73	15,985	61,048	53,419.8	0.26	219	836	0.30	732	923	79%
1993	71	14,142	56,588	50,480.6	0.25	199	797	0.28	711	945	75%
1994	72	9,603	44,766	54,618.3	0.21	133	622	0.18	759	932	81%
1995	72	12,207	51,867	55,825.1	0.24170		720	0.22	775	933	83%
1996	72	9,413	46,812	55,337.8	0.20	131	650	0.17	769	935	82%
1997	72	9,539	50,628	48,985.3	0.19	132	703	0.19	680	943	72%
1998	69	6,347	38,480	53,288.7	0.16	92	558	0.12	772	942	82%

* Includes only those reactors that had been in commercial operation for at least one full year as of December 31 of each of the indicated years.
** Figures are not adjusted for the multiple reporting of transient individuals. See Section 5.
*** Electricity Generated reflects the gross electricity generated for the years 1973 - 1996. Beginning in 1997, it reflects the net electricity generated.

TABLE 4.3
Summary of Information Reported by Commercial Light Water Reactors
1973 - 1998

Year	Number of Reactors Included*	Annual Collective Dose (person-rem)	No. of Workers With Measurable Dose**	Electricity Generated*** (MW-yrs)	Average Measurable Dose Per Worker (rem)**	Average Collective Dose Per Reactor (person-rem)	Average No. Personnel With Measurable Doses Per Reactor**	Average Collective Dose per MW-yr (person-rem /MW-yr)	Average Electricity Generated Per Reactor (MW-yr)	Average Maximum Dependable capacity Net (MWe)	Percent of Maximum Dependable Capacity Achieved
1973	24	13,962	14,780	7,164.1	0.94	582	616	1.95	299	491	61%
1974	33	13,650	18,139	10,590.9	0.75	414	550	1.29	321	546	59%
1975	44	20,879	25,491	17,768.9	0.82	475	579	1.18	404	626	65%
1976	52	26,107	34,192	21,462.9	0.76	502	658	1.22	413	671	62%
1977	57	32,508	42,266	26,448.3	0.77	570	742	1.23	464	667	70%
1978	64	31,801	45,978	31,696.5	0.69	497	718	1.00	495	688	72%
1979	67	39,982	64,073	29,926.0	0.62	597	956	1.34	447	714	63%
1980	68	53,797	80,331	29,157.5	0.67	791	1,181	1.85	429	714	60%
1981	70	54,145	82,106	31,452.9	0.66	774	1,173	1.72	449	719	63%
1982	74	52,191	84,381	32,755.2	0.62	705	1,140	1.59	443	737	60%
1983	75	56,472	85,646	32,925.6	0.66	753	1,142	1.72	439	743	59%
1984	78	55,235	98,099	36,497.6	0.56	708	1,258	1.51	468	790	59%
1985	82	43,042	92,870	41,754.7	0.46	525	1,133	1.03	509	804	63%
1986	90	42,381	100,923	45,695.1	0.42	471	1,121	0.93	508	847	60%
1987	96	40,401	104,334	52,116.3	0.39	421	1,087	0.78	543	877	62%
1988	102	40,769	103,226	59,595.1	0.39	400	1,012	0.68	584	871	67%
1989	107	35,930	108,25462,223.0		0.33	336	1,012	0.58	582	883	66%
1990	110	36,592	108,658	68,291.7	0.34333		988	0.54	621	892	70%
1991	111	28,515	98,761	73,448.4	0.29	257	890	0.39	662	895	74%
1992	110	29,294	103,143	74,012.0	0.28	266	938	0.40	673	901	75%
1993	108	26,363	95,940	72,476.2	0.27	244	888	0.36	671	895	75%
1994109		21,695	83,874	76,757.3	0.26	199	769	0.28	704	888	79%
1995	109	21,67487,526		80,562.1	0.25	199	803	0.27	739	900	82%
1996	109	18,874	84,449	79,660.0	0.22	173	775	0.24	731	902	81%
1997	109	17,136	84,473	71,851.4	0.20	157	775	0.24	659	910	72%
1998	105	13,169	71.344	77,069.9	0.18	125	679	0.17	734	918	80%

* Includes only those reactors that had been in commercial operation for at least one full year as of December 31 of each of the indicated years.
** Figures are not adjusted for the multiple reporting of transient individuals. See Section 5.
*** Electricity Generated reflects the gross electricity generated for the years 1973 - 1996. Beginning in 1997, it reflects the net electricity generated.

annually produced by each facility by 8,760, the number of hours in the year, except for leap years when the number is 8,784 hours. For the years 1973 to 1996, the electricity generated is the gross electricity output of the reactor. For 1997 and 1998, the number reflects the net electricity produced which is the gross electricity minus the amount the plant uses for operations. This change is the result of a change in the NRC power generation reporting requirements. The electricity generated (in megawatt-years) that is presented in Tables 4.1, 4.2, and 4.3 is the summation of electricity generated by the number of reactors included in each year. These sums are divided by the number of operating reactors included in each year to yield the average amount of electric energy generated per reactor, which is also shown in Tables 4.1, 4.2, and 4.3. The number of megawatt-hours of electricity produced each year was obtained from Reference 12.

As shown in Table 4.3, there was a 7% increase in the net electricity generated at LWRs in 1998. BWRs increased by 4% in net electricity generated, despite the fact that Clinton produced no power due to refueling, and Millstone Point 1 produced no power due to regulatory restriction. PWRs increased net electric output by 9%, despite the fact that Cook 1, 2 produced no power due to design basis concerns, and there were significant reductions at Beaver Valley 1, 2 and Millstone Point 2, 3. Crystal River generated power in 1998 after being off-line in 1997 and Salem 1, 2 also significantly increased power output from 1997.

4.2.3 Collective Dose per Megawatt-Year

The number of megawatt-years of electricity generated was used in determining the ratio of the average value of the annual collective dose (TEDE) to the number of megawatt-years of electricity generated. The ratio was calculated by dividing the total collective dose in person-rem by the electric energy generated in megawatt-years and is a measure of the dose incurred by workers at power plants in relation to the electric energy produced. For the years 1973 to 1996, the electricity generated is the gross electricity output of the reactor. In 1997, the number reflects the net electricity produced. This ratio was also calculated for each reactor site and is presented in Tables 4.1, 4.2, and 4.3. The average collective dose per MW-year for LWRs decreased by 29% in 1998 to a value of 0.17, which is an all-time low and is ten times less than the value in 1983.

4.2.4 Average Maximum Dependable Capacity

Average maximum dependable capacity, shown in Tables 4.1, 4.2, and 4.3, was found by dividing the sum of the net maximum dependable capacities of the reactors in megawatts (net MWe) by the number of reactors included each year. The net maximum dependable capacity is defined as the gross electrical output as measured at the output terminals of the turbine generator during the most restrictive seasonal conditions, less the normal station service loads. This “capacity” of each plant was found in Reference 12.

4.2.5 Percent of Maximum Dependable Capacity Achieved

The *percent of maximum dependable capacity achieved* is shown for all LWRs in Table 4.3. This parameter gives an indication of the overall power generation performance of LWRs as compared to the maximum capacity that could be obtained in a given year. It is calculated by dividing the average electricity generated per reactor by the average maximum dependable capacity for each year.

From 1973 to 1978 this indicator exhibited an increasing trend as a number of new reactors began producing power at higher efficiencies. Following the accident at Three Mile Island, reactor operations personnel concentrated on improving safety systems and complying with the new regulations for these systems. During this time period, from 1979 to 1987, the percent of maximum dependable capacity remained around 61%. Following the completion of most of these mandated repairs, reactors have increased the percent of maximum dependable capacity from 62% in 1987 to 81% in 1996, a gain of nearly 20% in 10 years. The number increased to 80% in 1998 from 72% in 1997. One reason for the drop in maximum dependable capacity in 1997 was due to the change from measuring the gross electricity generated to the net electricity generated.

4.3 ANNUAL TEDE DISTRIBUTIONS

Table 4.4 summarizes the distribution of the annual TEDE doses received by workers at all commercial LWRs during each of the years 1977 through 1998. This distribution is the sum of the annual dose distributions reported by each licensed LWR each year. As previously noted, the distribution reported by each LWR site for 1998 is shown in Appendix B. Table 4.4 shows the reported dose distributions corrected for the number of transient workers that were reported by more than one site (see Section 5). The total collective dose decreased by 23% to a value of 13,169 person-rem in 1998.

TABLE 4.4
Summary Distribution of Annual Whole Body Doses at Commercial Light Water Reactors*
1977 - 1998

Year	No Measurable Exposure	Measurable <0.10	Number of Individuals with Whole Body Doses in the Ranges (rem)														Total Number Monitored	Number with Measurable Exposure	Collective Dose** (person-rem)
			0.10-0.25	0.25-0.5	0.50-0.75	0.75-1.0	1.0-2.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-6.0	6.0-7.0	7.0-8.0	8.0-9.0	9.0-10.0	10.0-12.0	>12			
1977	23,562	12,395	6,030	4,518	2,890	2,220	5,649	2,856	1,288	661	186	89	47	23	6			62,420	38,858	32,508
1978	28,372	15,101	6,342	4,998	3,088	2,247	5,995	3,034	1,197	514	109	37	9	0	1	0	2	71,046	42,674	31,801
1979	43,330	22,508	8,985	7,469	4,797	3,259	7,572	3,404	1,400	545	117	42	17	3	1			103,449	60,119	39,982
1980	50,873	26,903	10,676	8,904	5,570	4,134	10,671	4,607	1,816	831	235	119	29	7	1			125,376	74,503	53,795
1981	39,265	26,836	11,226	9,330	6,042	4,497	11,170	4,811	1,999	533	103	93	9	3	1	0	1	115,919	76,654	54,144
1982	41,713	29,225	11,713	9,903	6,229	4,420	10,220	4,716	2,066	596	97	31	5	0	1	1		120,936	79,223	52,190
1983	47,048	29,107	11,195	9,344	5,851	4,276	11,345	5,332	2,269	716	121	38	8	2				126,652	79,604	56,472
1984	54,670	36,296	13,427	10,275	6,336	4,804	11,283	5,206	2,122	487	52	22						144,980	90,310	55,235
1985	59,634	36,831	13,008	11,041	6,627	4,547	10,040	3,575	1,001	157	1							146,462	86,828	43,042
1986	67,701	41,467	14,570	11,842	7,016	4,693	10,241	3,062	868	146								161,606	93,905	42,381
1987	85,181	41,222	15,834	12,839	7,586	5,332	10,611	2,192	477	69								181,343	96,162	40,401
1988	87,254	40,225	15,913	13,153	7,903	5,461	10,310	2,442	511	26		1						183,199	95,945	40,769
1989	83,947	45,282	17,267	13,777	7,945	5,137	8,634	1,614	370	34								184,007	100,060	35,930
1990	83,873	42,607	17,529	14,192	8,226	5,260	8,594	1,794	335	21								182,431	98,558	36,592
1991	87,250	42,587	16,764	13,184	7,187	4,194	5,975	938	219	17								178,315	91,065	28,527
1992	87,717	41,934	17,822	14,777	8,134	4,520	6,076	808	85	4								181,877	94,160	29,294
1993	83,069	37,331	17,235	13,733	7,562	4,289	5,322	638	76	5								169,260	86,191	26,363
1994	68,927	31,100	15,750	12,386	6,362	3,655	4,092	415	20									142,707	73,780	21,695
1995	62,080	29,681	15,152	12,083	6,146	3,306	3,905	590	121	2								133,066	70,986	21,674
1996	59,238	30,432	14,626	11,248	5,389	2,823	3,186	409	69									127,420	68,182	18,874
1997	58,501	31,832	14,875	10,910	5,246	2,407	2,575	299	44									126,689	68,188	17,136
1998	57,026	27,912	12,832	8,808	3,929	1,838	1,825	179	15	1								114,365	57,339	13,169

* Summary of reports submitted in accordance with 10 CFR 20.407 or 20.2206 (since 1994) by only those plants that had been in commercial operation for at least 1 full year as of December 31 of each of the indicated years. Figures shown have been adjusted for the multiple reporting of transient individuals (see Section 5).

** The collective dose, when not reported by the licensee, was calculated by the NRC staff using methods described in Section 3.1.4.

4.4 AVERAGE ANNUAL TEDE DOSES

Some of the data presented in Tables 4.1, 4.2, and 4.3 are graphically displayed in Figure 4.1, where it can be seen that the average collective dose and average number of workers per BWR have been higher than those for PWRs since 1974 and that the values of both parameters, in general, continued to rise at both types of facilities until 1983. Between 1983 and 1998, the average collective dose per reactor dropped by 83%. In 1998, the collective dose per reactor for PWRs decreased by 30% to 92 person-rem. The collective dose per reactor for BWRs decreased by 7% to 190 person-rem in 1998. The overall collective dose per reactor for LWRs decreased by 20% to 125 person-rem in 1998. The number of workers with measurable dose per reactor decreased to 913 for BWRs and decreased to 558 for PWRs in 1998. The overall decreasing trend in average reactor collective doses since 1983 indicates that licensees are continuing to successfully implement ALARA dose reduction features at their facilities.

Figures 4.2 and 4.3 are plots of most of the other information that is given in Tables 4.1, 4.2, and 4.3. The value for the total collective dose for all LWRs decreased by 23% from a value of 17,136 person-rem in 1997 to 13,169 person-rem in 1998. Together with the decrease in the number of workers with measurable dose, this resulted in the average measurable dose per worker decreasing to 0.18 rem in 1998. Figure 4.2 shows that in 1998 the net electricity generated was 77,070 MW-yr.

The fluctuations in the parameters for the years following the accident at the TMI plant in 1979 may reflect some of the impact that this incident had on the nuclear power industry. The decrease seen in dose trends since 1983 may be attributable to several factors. Utilities have completed most of the tasks initiated as a result of the lessons learned from the Three Mile Island accident, and they are increasing efforts to avoid and reduce exposure. The importance of exposure control and the concept of keeping exposures to ALARA levels is continually being stressed, and most utilities have established programs to collect and share information relative to tasks, techniques, and exposures.

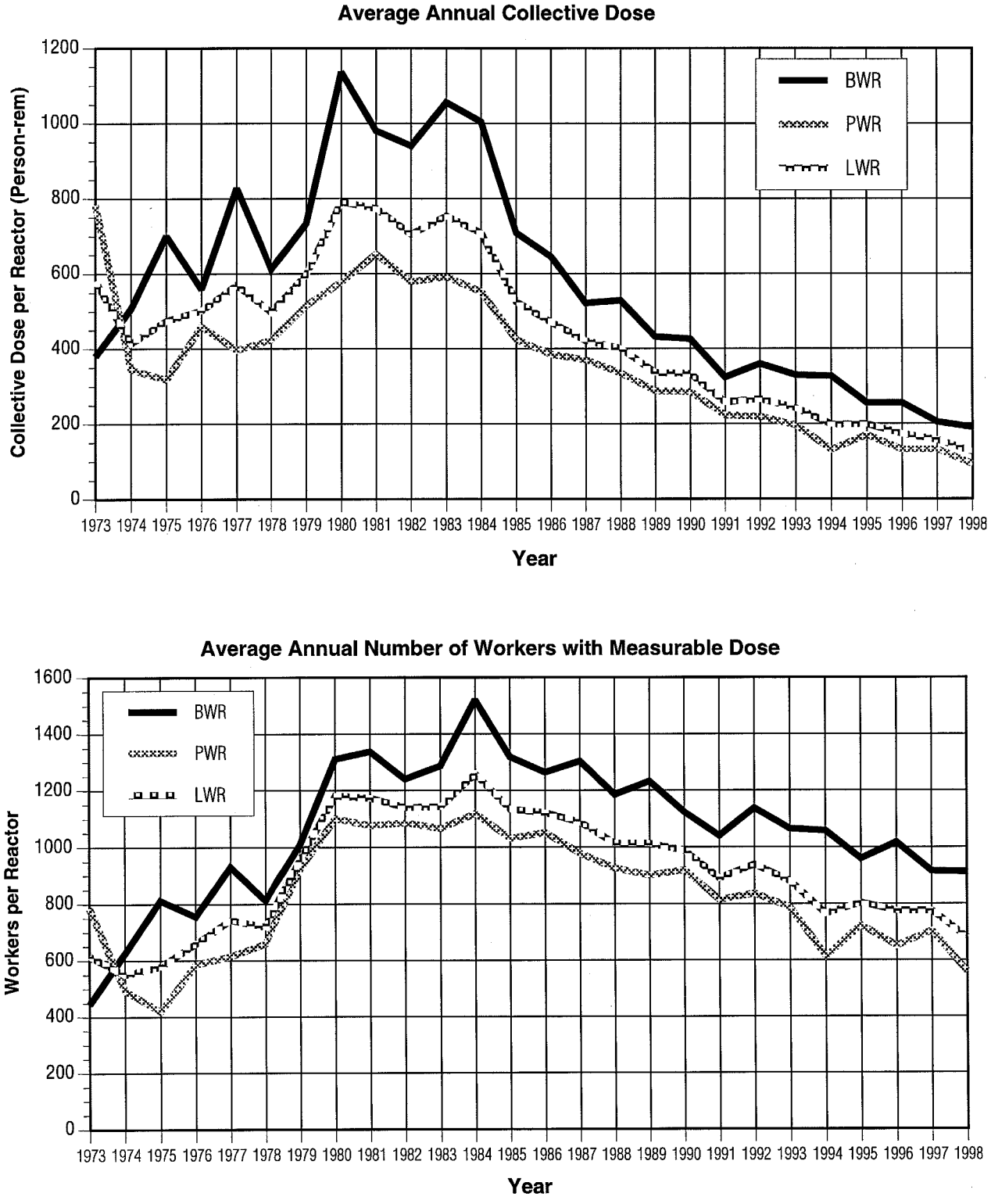
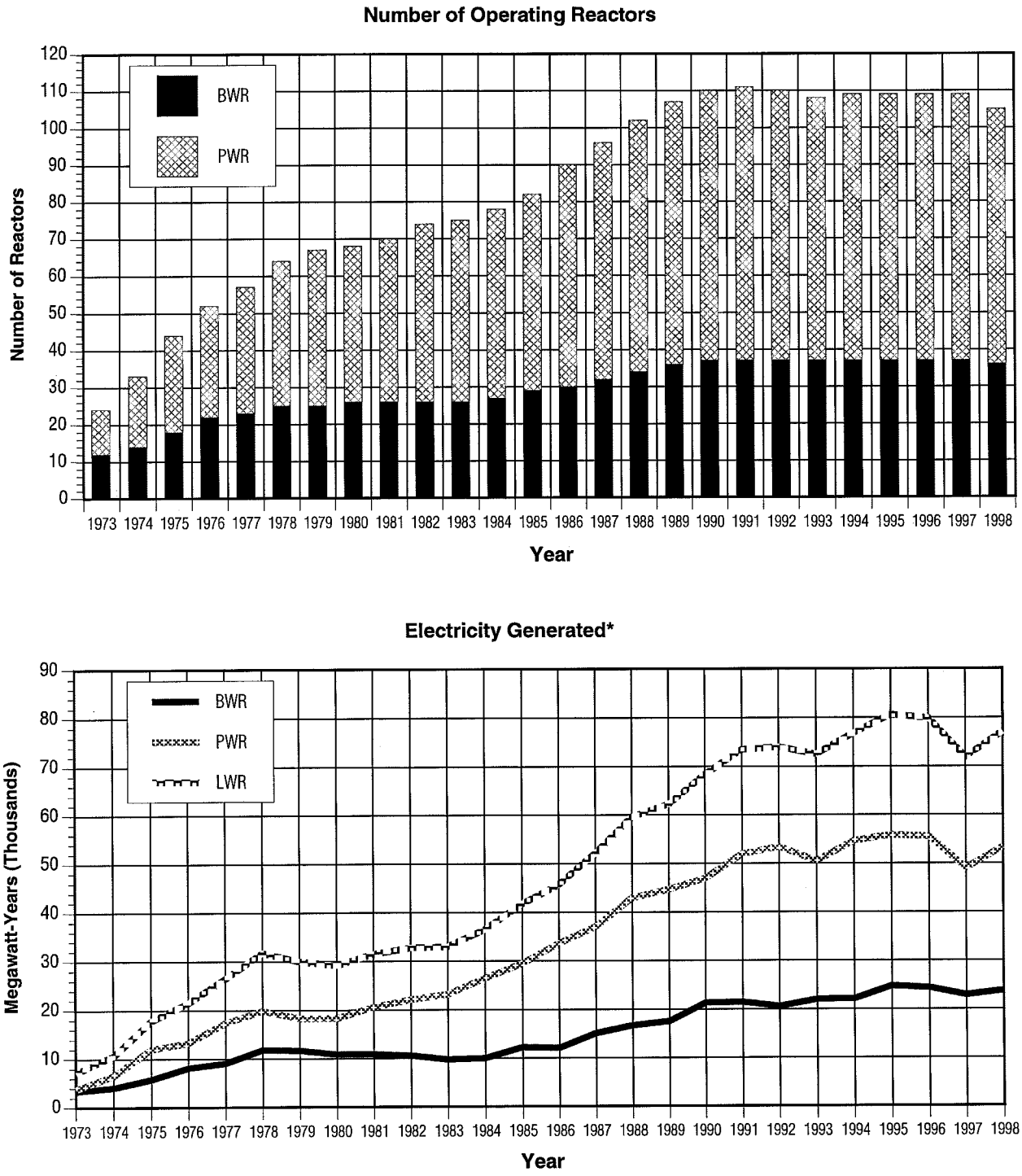
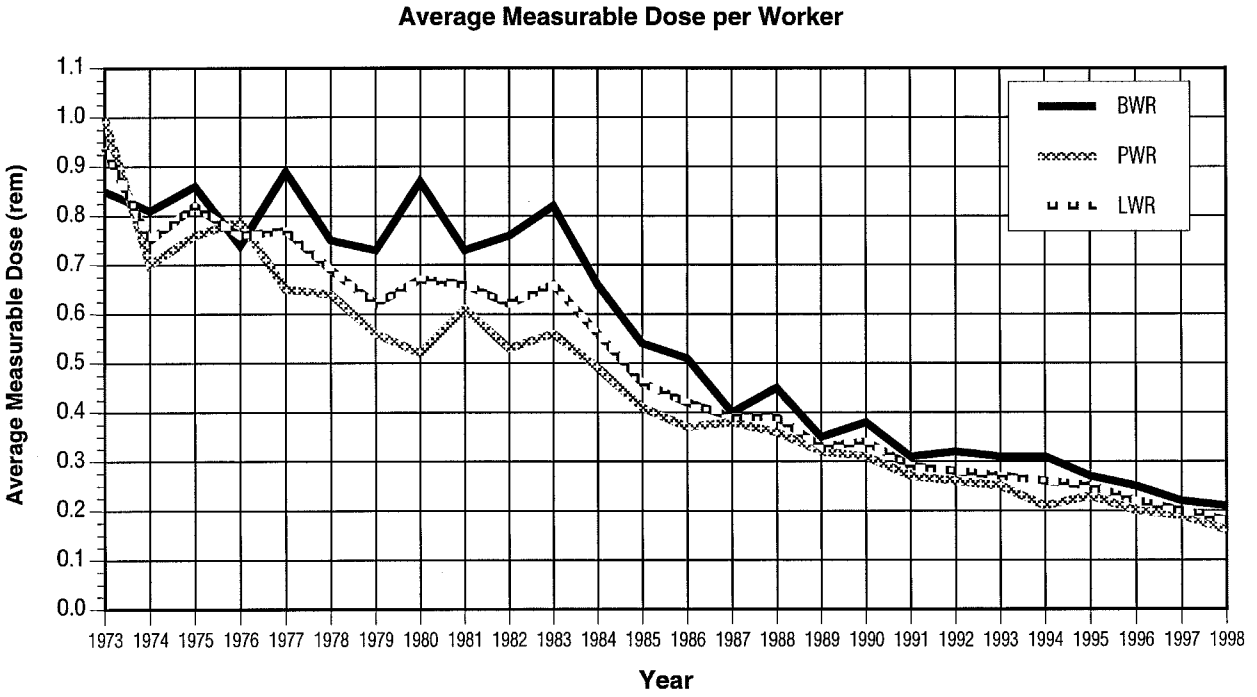


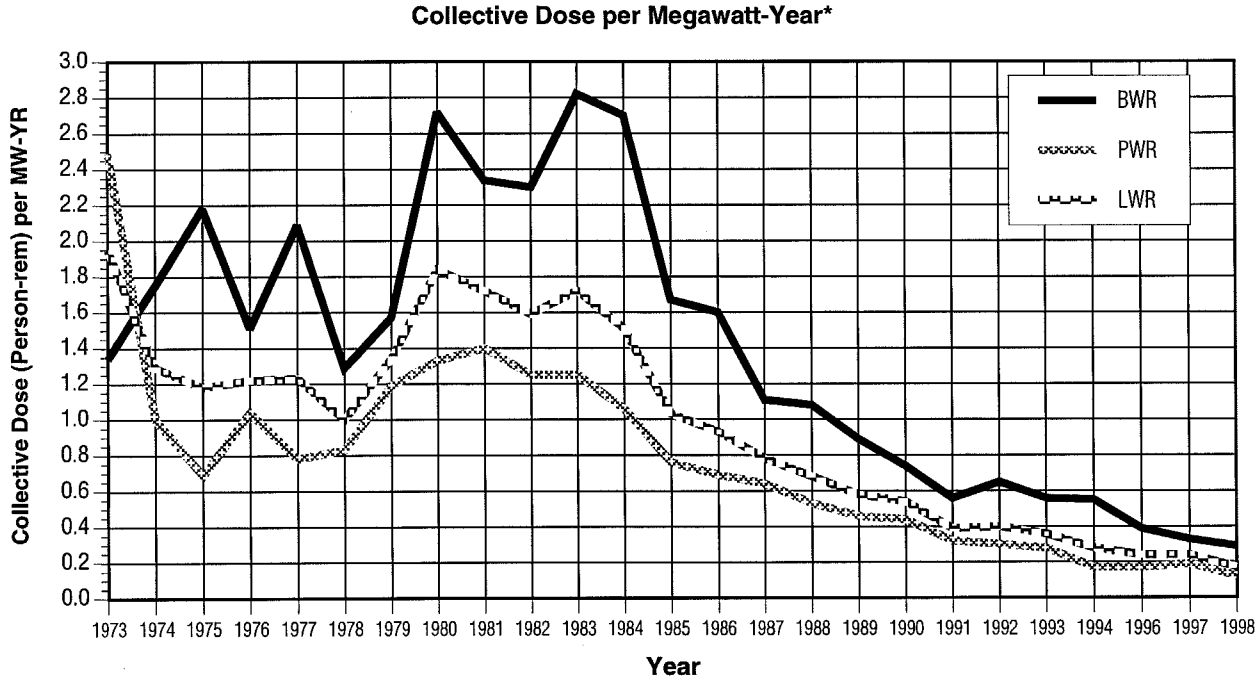
FIGURE 4.1. Average Collective Dose and Number of Workers per Reactor 1973 - 1998



* Gross electricity 1973-1996, net electricity for 1997-1998.

FIGURE 4.2. Number of Operating Reactors and Gross Electricity Generated 1973 - 1998





* Gross electricity 1973-1996, net electricity for 1997-1998.

FIGURE 4.3. Average Measurable Dose per Worker and Collective Dose per Megawatt-Year 1973 - 1998

To further assist in the identification of any trends that might exist, Figures 4.4 and 4.5 display the average and median[5] values of the collective dose per reactor for BWRs and for PWRs for the years 1973 through 1998. The ranges of the values reported each year are shown by the vertical lines with a small bar at each end marking the two extreme values. The rectangles indicate the range of values of the collective dose exhibited by those plants ranked in the twenty-fifth through the seventy-fifth percentiles. Since the median values usually are not as greatly affected by the extreme values of the collective doses, they do not normally fluctuate as much from year to year as do the average values. The median collective dose for PWRs experienced a decrease from 121 person-rem in 1997 to 85 person-rem in 1998. At BWRs, the median fluctuates more from year to year, and in 1998 the median collective dose decreased to 189 person-rem. Figure 4.5 also shows that, in 1998, 50% of the PWRs reported collective doses between 59 and 122 person-rem while 50% of the BWRs reported collective doses between 160 and 214 person-rem. Nearly every year, the median collective dose is less than the average, which indicates that the collective dose for most plants is less than the average collective dose per reactor (the value that is widely quoted).

4.5 THREE-YEAR AVERAGE COLLECTIVE TEDE PER REACTOR

Tables 4.5 and 4.6 list the sites that had been in commercial operation for at least 3 years as of December 31, 1998, and show the values of several parameters for each of the sites. They also give averages for the two types of reactors. Based on the 108 reactor-years of operation accumulated by the 36 BWRs listed, the average 3-year collective TEDE per reactor was found to be 219 person-rem, the average measurable TEDE per worker was 0.23 rem, and the average collective TEDE per megawatt-year was 0.33.

Based on the 204 reactor-years of operation at the 68 PWRs listed, the average annual collective TEDE per reactor, average measurable TEDE per worker, and average collective TEDE per megawatt-year were found to be 119 person-rem, 0.19 rem, and 0.16 person-rem per MW-yr, respectively.

All of the dose values at both types of reactors were lower than for the previous 3-year period. The average 3-year collective TEDE per BWR for 1996 -1998 is 8% less than the average for 1995 -1997. The average 3-year collective TEDE per PWR for 1996 - 1998 is 17% less than the average for 1995 - 1997. The average megawatt-year per reactor for BWRs and PWRs was greater than the previous 3-year average.

[5] The value at which 50% of the reactors reported greater collective doses and the other 50% reported smaller collective doses.

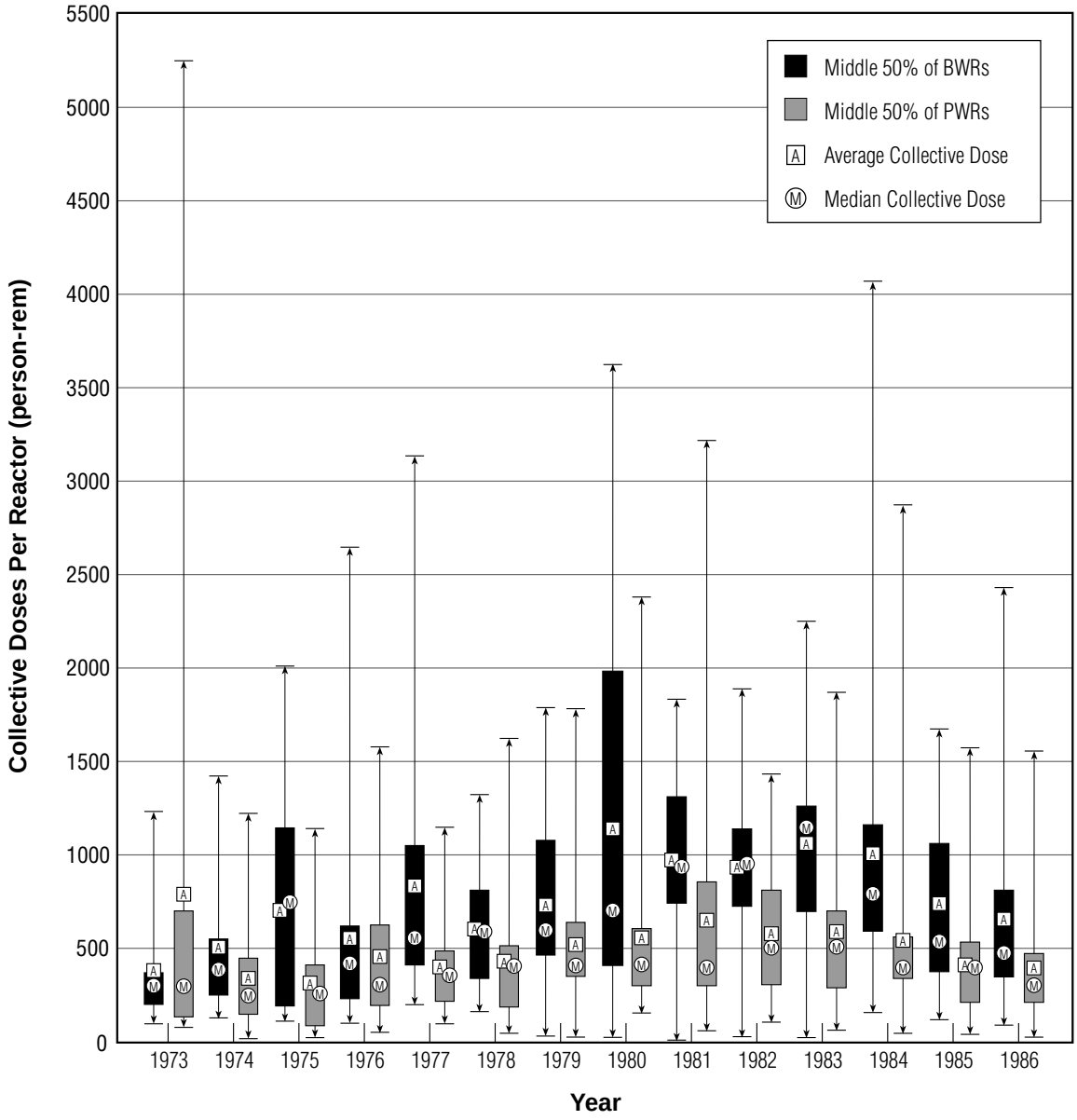


FIGURE 4.4. Average, Median, and Extreme Values of the Collective Dose per Reactor 1973 - 1986

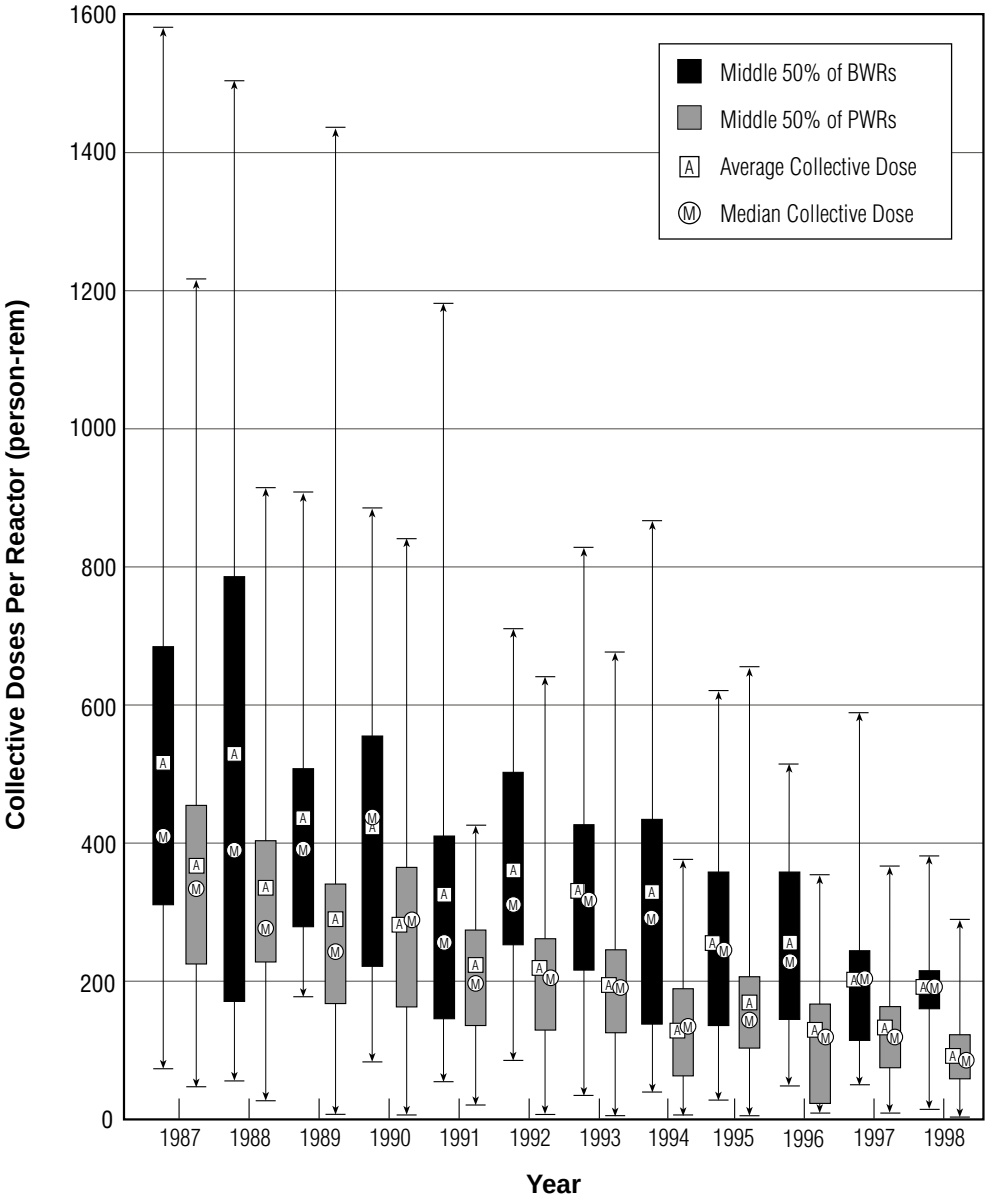


FIGURE 4.5. Average, Median, and Extreme Values of the Collective Dose per Reactor 1987 - 1998

TABLE 4.5

Three-Year Totals and Averages Listed in Ascending Order of Collective TEDE per BWR 1996 - 1998

Site Name*	Reactor Years	Collective TEDE per Reactor	Collective TEDE per Site	Number of Workers with Measurable TEDE	Average TEDE per Worker	Total MW-Years	Average TEDE per MW-Year
COOPER STATION	3	135	404	2,570	0.16	1,918.7	0.21
FERMI 2	3	138	414	3,387	0.12	2,028.7	0.20
LIMERICK 1, 2	6	138	825	4,971	0.17	5,929.6	0.14
BROWNS FERRY 1, 2, 3	9	140	1,261	5,418	0.23	5,858.1	0.22
VERMONT YANKEE	3	162	487	2,155	0.23	1,322.0	0.37
SUSQUEHANNA 1, 2	6	181	1,083	4,651	0.23	5,791.7	0.19
NINE MILE POINT 1, 2	6	183	1,097	4,765	0.23	4,303.1	0.25
MONTICELLO	3	185	555	1,830	0.30	1,347.9	0.41
HOPE CREEK 1	3	188	563	3,436	0.16	2,529.7	0.22
DUANE ARNOLD	3	190	570	2,464	0.23	1,388.2	0.41
PEACH BOTTOM 2, 3	6	190	1,138	5,432	0.21	5,844.4	0.19
PERRY	3	207	621	3,531	0.18	2,986.9	0.21
MILLSTONE POINT 1	3	213	639	2,147	0.30	-	---
CLINTON	3	222	666	2,758	0.24	632.9	1.05
DRESDEN 2, 3	6	225	1,350	6,846	0.20	3,061.8	0.44
HATCH 1, 2	6	247	1,483	5,050	0.29	4,348.5	0.34
BRUNSWICK 1, 2	6	254	1,523	7,001	0.22	4,252.6	0.36
GRAND GULF	3	255	766	3,488	0.22	3,377.3	0.23
PILGRIM	3	258	775	2,702	0.29	1,772.2	0.44
LASALLE 1, 2	6	260	1,557	6,542	0.24	1,431.8	1.09
FITZPATRICK	3	269	806	3,827	0.21	1,940.6	0.42
OYSTER CREEK	3	269	807	3,750	0.22	1,583.5	0.51
RIVER BEND 1	3	293	878	4,230	0.21	2,506.8	0.35
WASHINGTON NUCLEAR 2	3	303	910	3,891	0.23	2,147.6	0.42
QUAD CITIES 1, 2	6	407	2,440	6,899	0.35	2,604.3	0.94
Grand Totals and Averages	**108**		**23,618**	**103,741**	**0.23**	**70,908.9**	**0.33**
Averages Per Reactor-Year			**219**	**961**		**656.6**	

* Sites where not all reactors had completed 3 full years of commercial operation as of 12/31/98 are not included.

TABLE 4.6

Three-Year Totals and Averages Listed in Ascending Order of Collective TEDE per PWR
1996 - 1998

Site Name*	Reactor Years	Collective TEDE per Reactor	Collective TEDE per Site	Number of Workers with Measurable TEDE	Average TEDE per Worker	Total MW-Years	Average TEDE per MW-Year
WATERFORD 3	3	66	199	1,810	0.11	2,813.2	0.07
PRAIRIE ISLAND 1, 2	6	67	403	1,893	0.21	2,667.3	0.15
SEABROOK	3	72	215	2,336	0.09	3,030.0	0.07
THREE MILE ISLAND 1	3	79	237	1,596	0.15	2,336.6	0.10
ARKANSAS 1, 2	6	82	489	3,885	0.13	4,708.1	0.10
MILLSTONE POINT 2, 3	6	82	492	3,598	0.14	782.5	0.63
PALO VERDE 1, 2, 3	9	82	740	4,712	0.16	10,296.8	0.07
SALEM 1, 2	6	86	516	2,973	0.17	1,908.6	0.27
GINNA	3	88	2641,670		0.16	1,283.4	0.21
INDIAN POINT 3	3	90	271	2,110	0.13	2,062.5	0.13
KEWAUNEE	3	90	270	1,136	0.241,072.2		0.25
POINT BEACH 1, 2	6	90	537	2,580	0.21	1,665.8	0.32
SUMMER 1	3	91	2741,806		0.15	2,612.6	0.10
OCONEE 1, 2, 3	9	94	846	4,553	0.19	5,395.6	0.16
DIABLO CANYON 1, 2	6	95	568	4,106	0.14	5,901.9	0.10
SOUTH TEXAS 1, 2	6	99	5943,899		0.15	7,104.0	0.08
HARRIS	3	100	299	2,506	0.12	2,298.1	0.13
CALVERT CLIFFS 1, 2	6	109	655	3,300	0.20	4,457.3	0.15
NORTH ANNA 1, 2	6	110	660	3,260	0.20	4,909.6	0.13
COMANCHE PEAK 1, 2	6	111	666	3,299	0.20	5,840.0	0.11
DAVIS-BESSE	3	111	332	2,142	0.15	2,293.5	0.14
SAN ONOFRE 2, 3	6	111	666	4,015	0.17	5,613.9	0.12
ROBINSON 2	3	117	350	2,313	0.15	1,989.0	0.18
SURRY 1, 2	6	120	718	3,483	0.21	4,415.1	0.16
CATAWBA 1, 2	6	122	730	4,272	0.17	5,908.6	0.12
TURKEY POINT 3, 46		126	757	3,783	0.20	3,848.2	0.20
VOGTLE 1, 2	6	129	772	3,383	0.23	6,296.2	0.12
BEAVER VALLEY 1, 2	6	136	8143,779		0.22	2,948.0	0.28
COOK 1, 2	6	145	869	4,133	0.21	3,123.3	0.28
MCGUIRE 1, 2	6	145	872	4,860	0.18	5,574.7	0.16
WOLF CREEK 1	3	149	446	2,159	0.21	3,129.5	0.14
BRAIDWOOD 1, 2	6	152	9144	,918	0.19	5,685.0	0.16
CALLAWAY 1	3	1544	61	2,157	0.21	3,057.5	0.15
SEQUOYAH 1, 2	6	156	9344	,776	0.20	6,085.3	0.15
FARLEY 1, 2	6	157	942	3,635	0.26	4,308.6	0.22
BYRON 1, 2	6	162	971	4,965	0.20	5,480.1	0.18
FORT CALHOUN	3	164	491	1,786	0.27	1,197.5	0.41
CRYSTAL RIVER 3	3	184551		2,478	0.22	1,030.0	0.53
PALISADES	3	194	583	2,342	0.25	1,914.3	0.30
ST. LUCIE 1, 2	6	194	1,165	4,917	0.24	4,436.5	0.26
INDIAN POINT 2	3	237	711	2,882	0.25	1,568.6	0.45
Grand Totals and Averages	**204**		**24,244**	**130,206**	**0.19**	**153,049.5**	**0.16**
Averages Per Reactor-Year			**119**	**638**		**750.2**	

* Sites where not all reactors had completed 3 full years of commercial operation as of 12/31/98 are not included.

4.6 GRAPHICAL REPRESENTATION OF DOSE TRENDS IN APPENDIX D

Each page of Appendix D presents a graph of selected dose-performance indicators from 1973 through 1998. The dose and performance indicators illustrate the history of the collective dose per reactor for the site, the rolling 3-year average collective dose per reactor, and the electricity generated at the site. These data are plotted, beginning with the plant's first full year of commercial operation, and continuing through 1998. Data for years when the plant was not in commercial operation have been included when available. However, any data reported prior to 1973 are not included. The 3-year average collective dose per reactor data is included because it provides a better overall indication of the plant's general trend in collective dose. This average is determined by summing the collective dose for the current year and the previous 2 years and then dividing this sum by the number of reactors reporting during those years. Depicting dose trends using a 3-year average reduces the sporadic effects on annual doses of refueling operations (usually a 2- to 3-year cycle) and occasional high-dose maintenance activities, and gives a better idea of collective dose trends over the life of the plant. The annual average collective dose per reactor for all reactors of the same type is also shown on the graph.

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Section 5

TRANSIENT WORKERS AND CAREER DOSES AT NRC-LICENSED FACILITIES

5.1 TERMINATION REPORTS

Under the revised 10 CFR 20, licensees are required to submit NRC Form 5s to the Commission for each individual who is required to be monitored at the end of the monitoring year or upon the individual's termination of employment at the facility. The "termination reports" submitted in accordance with the old § 20.408, listing the individual's complete dose history during employment at the facility, are no longer required.

However, the Form 5s submitted to the NRC upon an individual's termination of employment serve the same function as the previous requirements with regard to the analysis of transient workers at NRC-licensed facilities. The following analysis examines the workers who had more than one Form 5 dose record at more than one NRC-licensed facility during the monitoring year. These workers are defined to be transient in that they worked at more than one facility during the monitoring year.

The term "monitoring year" is used here in accordance with the definition of a year given in § 20.1003, which defines a year as "the period of time beginning in January used to determine compliance with the provisions of this part. The licensee may change the start date of the monitoring year used to determine compliance provided that the change is made at the beginning of the monitoring/calendar year and that no day is omitted or duplicated in consecutive years".

5.2 TRANSIENT WORKERS AT NRC FACILITIES

Examination of the data reported for workers who began and terminated two or more periods of employment with two or more different facilities within one monitoring year is useful in many ways. For example, the number and average dose for these "annual transients" can be determined from examining these data.

Additionally, the distribution of the doses received by transient workers can be useful in determining the impact that the inclusion of these individuals in each of two or more licensees' annual reports has on the annual summary (as reported in Appendix B) for all nuclear power facilities, and all NRC licensees combined (one of the problems mentioned in Section 2). Table 5.1 shows the "actual distribution" of transient worker doses as determined from the above-mentioned Form 5 termination reports and compares it with the "reported distribution" of the doses of these workers as they would have appeared in a summation of the annual reports submitted by each of the licensees.

TABLE 5.1
Effects of Transient Workers on Annual Statistical Compilations
1998

License Category	Number of Individuals with TEDE in the Ranges (rem)												Total Number Monitored	Number with Measurable Exposure	Collective TEDE (person-rem)	Average TEDE (rem)	Average Meas. TEDE (rem)
	No Measurable Exposure	Measurable <0.10	0.10 - 0.25	0.25 - 0.50	0.50 - 0.75	0.75 - 1.0	1.0 - 2.0	2.0 - 3.0	3.0 - 4.0	4.0 - 5.0	5.0 - 6.0	>6					
POWER REACTORS																	
1) Form 5 Summation	77,080	37,039	17,189	10,467	3,929	1,561	1,127	32					148,424	71,344	13,169	0.09	0.18
2) Transients - As Reported	26,496	14,598	7,798	4,777	1,761	744	495	11					56,680	30,184	6,154	0.11	0.20
3) Transients - Actual	6,442	5,471	3,441	3,118	1,761	1,021	1,193	158	15	1			22,621	16,179	6,154	0.27	0.38
Corrected Distribution (1-(2-3))	**57,026**	**27,912**	**12,832**	**8,808**	**3,929**	**1,838**	**1,825**	**179**	**15**	**1**			**114,365**	**57,339**	**13,169**	**0.12**	**0.23**
ALL LICENSEES																	
1) Form 5 Summation	87,016	40,368	18,471	11,581	4,518	2,000	1,820	225	72	14	4	2	166,091	79,075	16,383	0.10	0.21
2) Transients - As Reported	27,283	14,920	7,977	4,941	1,831	787	541	20					58,300	31,017	8,722	0.15	0.28
3) Transients - Actual	6,539	5,522	3,468	3,190	1,826	1,057	1,267	172	18	2			23,061	16,522	8,722	0.38	0.53
Corrected Distribution (1-(2-3))	**66,272**	**30,970**	**13,962**	**9,830**	**4,513**	**2,270**	**2,546**	**377**	**90**	**16**	**4**	**2**	**130,852**	**64,580**	**16,383**	**0.13**	**0.25**

Because >95% of these transients are reported by nuclear power facilities, these data were considered separately. Table 5.1 shows that the power reactor transient data constitute the vast majority of the transient worker exposure. The nonreactor licensees account for only 2% of the transient workforce.

Table 5.1 illustrates the impact that the multiple reporting of these transient individuals had on the summation of the exposure reports for 1998. Because each licensee reports the doses received by workers while monitored by the particular licensee during the year, one would expect that a summation of these reports would result in individuals being counted several times in dose ranges lower

The following definitions apply to Table 5.1:

Form 5 Summation	The summation of the TEDE from each of the Form 5s submitted for the monitoring year. This is the summation of each dose record grouped by licensee and individual. This distribution takes into account multiple Form 5s for an individual at one NRC-licensed facility but not multiple exposures at multiple licensees.
Transients - As Reported	This distribution represents the population of transient workers as they were reported by each licensee. This distribution is the subset of all Form 5s where individuals were monitored at more than one licensee during the monitoring year. This is the summation of dose records grouped by individual and by licensee, so the distribution represents how the transient worker population would appear within the total distribution of all workers. This distribution takes into account multiple Form 5s for an individual at one NRC-licensed facility but not multiple exposures at multiple licensees.
Transients - Actual	This is the actual distribution for transient workers summed per individual. This represents the true number of individuals and places each individual in the correct dose range. This distribution accounts for multiple records per individual and multiple licensees.
Corrected Distribution	This distribution represents the correction of the reported distribution by subtracting the difference in the reported and actual distribution for transient workers. This represents the most accurate dose distribution for the licensee category and accounts for the multiple reporting of individuals.

than the range in which their total accumulated dose (the sum of the personnel monitoring results incurred at each facility during the year) would actually place them. Thus, while the total collective dose would remain the same, the number of workers, their dose distribution, and average dose would be affected by this multiple reporting. This was found to be true because too few workers were reported in the higher dose ranges. For example, in 1998, Table 5.1 shows that the summation of annual reports for reactor licensees indicated that 32 individuals received doses greater than 2 rem. After accounting for those individuals who were reported more than once, the corrected distribution indicated that there were really 195 workers who received doses greater than 2 rem. Correcting for the multiple counting of individuals also has a significant effect on the average measurable dose for these workers. The corrected average measurable dose for transient workers is twice as high as the value calculated by the summation of licensee records. The transient workers represent 26% of the workforce that receives measurable dose and increases the average measurable dose for all licensees by 19% from 0.21 rem to 0.25 rem. It should be noted that this analysis of transient workers does not include workers who may have been exposed at facilities that are not required to report to the NRC REIRS database (see Section 1), such as Agreement State licensees, or DOE facilities.

One purpose of the REIRS database, which tracks occupational radiation exposures at NRC-licensed facilities, is to identify individuals who may have exceeded the occupational radiation exposure limits because of multiple exposures at different facilities throughout the year. The REIRS database stores the radiation exposure information for an individual by their unique identification number and identification type [Ref. 10, Section 1.5] and sums the exposure for all facilities during the monitoring year. An individual exceeding the TEDE 5 rem per year regulatory limit would be identified in Table 5.1 in one of the dose ranges >5 rem. In 1998, no individual was discovered to have exceeded the limit as a result of the correction for transient workers. Since 1985, there have been no additional transient workers identified as having received a dose of >5 rem that have not appeared in the annual reports received by the Commission. This reflects the industry's continuing concerted efforts to keep the total annual doses of all workers under 5 rem and shows that such reductions can be accomplished without increasing the collective dose because the collective dose has decreased during this same time period.

5.3 CAREER DOSE STATISTICS 1977 - 1998

An analysis of career doses was presented in the 1989 annual NUREG-0713. This analysis applied only to those individuals who had terminated their employment from licensees. This analysis has been updated and now includes those individuals who had terminated their employment before 1994, those individuals for whom individual exposure reports were submitted after 1994, and those individuals for whom we have historical data that were submitted as a result of voluntary generic letter 94-04. The reporting requirements and their effective dates are given in the table below.

5.3.1 Compilation of the Data

The data were compiled from reports submitted by licensees for each individual in the REIRS database. The first recorded date of exposure monitoring was used as the "start" date for that individual. Likewise, the last recorded date of exposure monitoring was used for the individual's "end" or termination date. All whole body doses attributed to licensees for an individual were summed during this "career" time period. Whole body dose was used before 1994, and the TEDE was used from 1994 to 1998. For most of the data presented, only workers who received measurable dose were included in the statistics. This eliminates the majority of visitors or individuals who were simply monitored for administrative purposes. Information on the individual's sex and age was also compiled from reports where such information was available.

NRC Document	Requirement or Request	Effective Dates
10 CFR § 20.408	Required licensees to report the doses received by individuals upon termination from NRC-licensed facilities.	1968 – 1994
10 CFR § 20.2206	Requires the reporting of annual monitoring records.	1994 – current
Generic Letter 94-04	Requested reactor licensees to report radiation exposure records for individuals who had not been reported previously under 10 CFR § 20.408 and who remained employed and monitored as of 1/1/94.	1994

The total numbers and percentages of workers in each category reflect the level of completeness of data presented in these analyses. The total number of individuals included in the career dose analysis was 825,021; out of this total, 495,945 (60%) of the individuals received measurable dose. For this analysis, measurable dose is considered to be any recorded dose greater than zero. The birthdate, and therefore the age at termination, was known for 84% of the individuals with measurable dose. The sex was recorded for 93% of the individuals with measurable dose. The age and sex were known for 78% of the total number of workers with measurable dose.

5.3.2 Limitations of the Data

When analyzing and drawing conclusions from these data, it is important to note several limitations of the data. When possible, attempts have been made to minimize these limitations.

A large number of the individuals reported in 1998 have not completed their careers. Many of these individuals will most likely continue employment in 1999. Therefore, these data do not accurately reflect true career length and career dose.

Before 1994, the sex of the individual was often assumed from the first name or "Sir" title in the submittal's letterhead or salutation. Where the first name was not indicative of the sex of the individual, a null value was recorded and it was treated as "unknown". In 1994, the revised Part 20 required the reporting of the sex of the monitored individual. This new requirement resulted in updated personnel records for most of the individuals in the REIRS database and allows for a more complete analysis of the dose based on the sex of the individual.

Another problem has been the licensee's practice of reporting incremental periods of exposure and then reporting all or part of the individual's exposure when the individual actually terminates employment, or as a correction to a previous report. This practice may allow an overlap for some periods of exposure and double the dose recorded for that individual at that facility during the overlapping time period. Considerable effort has gone into eliminating this problem from the data. New data entering the system were run through extensive verification procedures to identify data that overlap or were otherwise inconsistent with data already in the system. However, such procedures were not applied in the past and it has proven difficult to identify and correct for overlapping exposure records. While this only affects a small percentage of the records, it is an additional source of error for any conclusions drawn from the career data.

5.4 CAREER DOSE DISTRIBUTIONS BY DOSE AND CAREER LENGTH

Table 5.2 presents the career dose distribution data based on dose and length of career for individuals who terminated from reactor facilities from 1977 to 1998. The first table shows the number of individuals who accumulated a career dose for each of the dose ranges indicated. An individual whose career dose exactly equals one of the end-points of a range is included in the higher dose range. The column on the far left of the table indicates the "career length" or period of time the individual was monitored during his or her career. The second table (lower half) shows the total collective dose received by individuals in each dose range.

Table 5.2 shows data for more than 825,000 individuals monitored during the period 1977 - 1998. The number of these workers with measurable dose was 495,945. Of the total monitored workforce, 95% received career doses less than 5 rem, while 88% of this group received career doses less than 2 rem. Measurable doses less than 5 rem were received by 91% of workers, whereas 79% of workers received doses less than 2 rem; the vast majority for both categories of workers. It is important to note that this dose is received during the entire career of the worker, and can be compared favorably to the current 5 rem per year regulatory limit. As anticipated, Table 5.2 shows that the longer the career, the higher the career dose for most workers.

TABLE 5.2
Career Dose Distributions by Dose and Career Length at Reactor Facilities
1997 - 1998

Career Length	Number of Personnel in Each Dose Range (remS)															Number with Measurable Dose	Total Monitored
	No Meas.	.001 - 0.1	0.1 - 0.5	0.5 - 1.0	1.0 - 2.0	2.0 - 3.0	3.0 - 4.0	4.0 - 5.0	5.0 - 10.0	10.0 - 15.0	15.0 - 20.0	20.0 - 25.0	25.0 - 30.0	30.0 - 50.0	>50.0		
<=30 days	135,694	24,042	8,071	2,749	3,390	1,185	66	9	8	1	1			1	1	39,524	175,218
31 days - 6 mo.	69,887	39,758	25,534	9,349	7,566	2,673	1,249	323	58	6	3	2	2	1		86,524	156,411
6 mo. - 1 yr.	30,077	17,032	9,964	3,653	3,104	1,418	747	339	273	5	1	1	1			36,538	66,615
1 - 2 yrs.	29,669	19,014	12,671	5,536	4,814	2,107	1,176	684	844	39	4	2	1			46,892	76,561
2 - 3 yrs.	13,012	11,051	7,938	3,699	3,646	1,870	1,005	639	1,051	116	12	1		1		31,029	44,041
3 - 4 yrs.	8,978	8,142	6,336	3,199	3,279	1,707	944	562	1,120	193	38	6	3	1		25,530	34,508
4 - 5 yrs.	7,200	7,313	5,947	3,132	3,329	1,903	1,136	719	1,312	256	45	23	3	2	2	25,122	32,322
5 - 10 yrs.	18,250	20,150	16,642	9,150	10,363	6,204	4,043	2,711	5,869	1,557	522	181	66	30	7	77,495	95,745
10 - 15 yrs.	11,497	13,788	12,356	6,588	7,985	4,997	3,444	2,761	7,148	2,560	967	407	189	127	11	63,328	74,825
15 - 20 yrs.	3,901	6,598	7,582	4,084	4,839	3,326	2,505	2,018	6,139	3,062	1,563	847	463	421	34	43,481	47,382
20 - 25 yrs.	528	1,526	2,264	1,388	1,621	1,082	893	760	2,297	1,307	806	577	308	413	54	15,296	15,824
25 - 30 yrs.	141	428	340	213	250	163	126	103	333	171	136	97	60	106	30	2,556	2,697
30 - 35 yrs.	86	304	182	82	98	70	56	36	119	50	35	30	24	34	9	1,229	1,215
>35 yrs.	156	538	283	129	110	85	51	42	123	62	38	16	9	14	1	1,501	1,657
Totals	**329,076**	**169,684**	**116,110**	**52,951**	**54,394**	**28,790**	**17,441**	**11,706**	**26,694**	**9,385**	**4,171**	**2,190**	**1,129**	**1,151**	**149**	**495,945**	**825,021**

Career Length	Collective Dose of Personnel in each Dose Range (rems)															Collective Dose	Average Career Dose
	No Meas.	.001 - 0.1	0.1 - 0.5	0.5 - 1.0	1.0 - 2.0	2.0 - 3.0	3.0 - 4.0	4.0 - 5.0	5.0 - 10.0	10.0 - 15.0	15.0 - 20.0	20.0 - 25.0	25.0 - 30.0	30.0 - 50.0	>50.0		
<=30 days	0	658	1,901	1,959	5,115	2,645	229	39	47	12	16			43	220	12,884	0.326
31 days - 6 mo.	0	1,411	6,249	6,634	10,819	6,394	4,288	1,406	358	76	50	46	50	31		37,812	0.437
6 mo. - 1 yr.	0	572	2,412	2,605	4,401	3,449	2,584	1,485	1,641	57	15	22	29			19,272	0.527
1 - 2 yrs.	0	649	3,141	3,971	6,818	5,114	4,059	3,054	5,384	445	69	46	26			32,776	0.699
2 - 3 yrs.	0	383	1,997	2,678	5,212	4,564	3,455	2,856	7,107	1,342	196	23		34		29,847	0.962
3 - 4 yrs.	0	289	1,605	2,309	4,738	4,163	3,272	2,514	7,544	2,226	638	134	79	33		29,544	1.157
4 - 5 yrs.	0	265	1,499	2,266	4,859	4,670	3,932	3,197	8,909	3,055	761	507	83	68	110	34,181	1.361
5 - 10 yrs.	0	728	4,275	6,644	15,057	15,259	14,019	12,113	40,536	18,752	8,895	4,019	1,781	1,068	2,045	145,191	1.874
10 - 15 yrs.	0	523	3,180	4,792	11,601	12,313	11,953	12,367	50,445	31,018	16,600	8,998	5,140	4,447	791	174,168	2.750
15 - 20 yrs.	0	272	1,963	2,981	7,044	8,226	8,721	9,032	44,171	37,515	27,049	18,838	12,653	14,959	2,166	195,590	4.498
20 - 25 yrs.	0	66	597	1,014	2,364	2,687	3,083	3,410	16,585	16,148	13,906	12,928	8,438	14,945	3,353	99,524	6.507
25 - 30 yrs.	0	16	85	155	369	404	443	457	2,395	2,144	2,362	2,163	1,638	3,980	1,929	18,540	7.254
30 - 35 yrs.	0	11	42	61	143	172	198	162	875	597	593	671	670	1,276	663	6,134	5.433
>35 yrs.	0	20	65	96	162	207	179	190	886	763	669	359	237	503	59	4,395	2.928
Totals	-	**5,863**	**29,011**	**38,165**	**78,702**	**70,267**	**60,415**	**52,282**	**186,883**	**114,150**	**71,819**	**48,754**	**30,824**	**41,387**	**11,336**	**839,858**	**1.693**

Table 5.3 shows the average career doses, average annual dose, and average career lengths for all monitored individuals and those monitored individuals with measurable dose by career length. The highest average career doses were accumulated by individuals who worked between 25 and 30 years. The average annual dose was calculated from the total collective dose of individuals in each career length range divided by the total collective career length (in years) for these individuals. This resulted in an overall (1977 - 1998) average annual dose for workers with measurable dose of 0.264 rem.

5.5 CAREER DOSE DISTRIBUTIONS BY AGE AND SEX

Table 5.4 presents the data for the 84% of workers with measurable dose for which the age of the worker is known. The analysis is based on age and year of termination for all workers with measurable dose from 1977 through 1998. The average values for age at termination, career length, and career dose are included to examine the trends over time for these workers. The analysis indicates an aging population of workers with the average

TABLE 5.3
Average Career Lengths and Doses by Career Length
1977 - 1998

Career Length	Average Career Dose		Average Annual Dose		Average Career Length	
	Total Monitored (rems)	Number with Measurable Dose (rems)	Total Monitored (rems)	Number with Measurable Dose (rems)	Total Monitored (rems)	Number with Measurable Dose (rems)
<=30 days	0.074	0.326	-	-	0.025	0.043
31 days-6 mo.	0.242	0.437	-	-	0.235	0.233
6 mo. - 1 yr.	0.289	0.527	0.379	0.698	0.762	0.756
1-2 yrs.	0.428	0.699	0.286	0.470	1.495	1.487
2-3 yrs.	0.678	0.962	0.274	0.389	2.476	2.475
3-4 yrs.	0.856	1.157	0.245	0.331	3.499	3.492
4-5 yrs.	1.058	1.361	0.231	0.297	4.580	4.581
5-10 yrs.	1.516	1.874	0.208	0.255	7.306	7.336
10-15 yrs.	2.328	2.750	0.187	0.221	12.458	12.461
15-20 yrs.	4.128	4.498	0.240	0.261	17.195	17.242
20-25 yrs.	6.289	6.507	0.290	0.300	21.677	21.684
25-30 yrs.	6.874	7.253	0.253	0.267	27.215	27.202
30-35 yrs.	5.049	5.433	0.155	0.167	32.573	32.560
>35 yrs.	2.653	2.928	0.065	0.072	40.834	40.680
Overall Average	**1.018**	**1.693**	**0.225**	**0.264**	**4.308**	**6.062**

TABLE 5.4(a)

Career Dose Distributions by Age and Year of Termination for Personnel with Measurable Dose
1977 - 1998

Year	Total Number of Personnel in Each Age Range										Total	Average Age at Term (yrs.)	Average Career Length (yrs.)
	18 - 20	20 - 25	25 - 30	30 - 35	35 - 40	40 - 45	45 - 50	50 - 55	55 - 60	>60			
1977	238	1,620	1,526	1,195	809	595	567	600	638	503	8,291	36.6	2.4
1978	179	1,524	1,478	1,198	821	611	499	525	653	467	7,955	36.7	2.5
1979	238	1,791	1,857	1,563	1,039	700	600	618	666	498	9,570	36.0	2.4
1980	241	2,052	2,104	1,899	1,353	975	776	808	907	645	11,760	36.9	2.4
1981	239	2,635	2,760	2,294	1,608	1,059	947	845	781	658	13,826	35.8	1.8
1982	184	1,607	2,020	1,830	1,487	1,074	835	728	689	665	11,119	37.4	2.1
1983	180	1,709	2,244	1,971	1,686	1,200	837	741	665	650	11,883	37.0	2.3
1984	194	1,940	2,534	2,191	1,868	1,284	1,035	768	786	690	13,290	36.9	2.6
1985	171	1,643	2,526	2,272	1,946	1,423	1,030	841	785	777	13,414	37.6	3.1
1986	189	1,640	2,645	2,381	2,203	1,541	1,051	890	838	865	14,243	37.8	3.6
1987	231	1,807	2,781	2,807	2,435	1,883	1,361	948	965	886	16,104	37.9	3.8
1988	208	1,529	2,216	2,320	2,041	1,672	1,134	810	828	759	13,517	38.0	4.3
1989	239	1,519	2,158	2,437	2,228	1,873	1,353	970	843	820	14,440	38.5	4.5
1990	193	1,402	2,047	2,472	2,332	1,937	1,314	1,017	855	858	14,427	38.9	4.7
1991	149	1,220	1,639	2,113	2,011	1,813	1,276	962	832	867	12,882	39.6	5.4
1992	139	1,357	1,847	2,442	2,482	2,241	1,886	1,323	1,107	976	15,800	40.3	6.1
1993	145	1,406	2,080	3,208	3,954	3,838	3,236	2,295	1,812	2,068	24,042	42.4	7.8
1994	177	1,406	2,150	2,812	2,993	2,691	2,299	1,700	1,418	1,060	18,706	41.0	6.6
1995	174	1,419	2,151	2,712	3,015	2,839	2,414	1,964	1,338	1,015	19,041	40.9	6.8
1996	188	1,259	1,916	2,508	3,018	2,970	2,722	1,951	1,441	925	18,898	41.2	7.2
1997	211	1,390	2,201	2,776	3,678	3,943	3,592	3,002	1,911	1,164	23,868	42.0	8.0
1998	297	2,565	5,444	9,999	19,117	23,440	20,534	14,906	7,754	3,351	107,407	43.5	11.8
Total	**4,404**	**36,440**	**50,324**	**57,400**	**64,124**	**61,602**	**51,298**	**39,212**	**28,512**	**21,167**	**414,483**	**40.2**	**6.6**

TABLE 5.4(b)

Career Dose Distributions by Age and Year of Termination for Personnel with Measurable Dose
1977 - 1998

Year	Total Collective Dose of Personnel in Each Age Range (rems)										Total Dose	Average Career Dose
	18 - 20	20 - 25	25 - 30	30 - 35	35 - 40	40 - 45	45 - 50	50 - 55	55 - 60	>60		
1977	125	1,402	1,400	1,393	895	601	663	837	1,198	703	9,217	1.112
1978	74	1,376	1,709	1,354	955	624	686	760	901	904	9,344	1.175
1979	99	1,410	1,674	1,571	1,133	634	756	727	1,099	755	9,857	1.030
1980	112	1,878	2,173	2,105	1,429	1,009	807	900	1,565	1,069	13,046	1.109
1981	88	2,979	3,332	2,674	1,955	1,233	1,096	1,023	1,074	913	16,366	1.184
1982	78	1,322	2,084	2,254	1,871	1,463	1,005	891	1,069	1,244	13,281	1.194
1983	69	1,706	2,620	2,641	2,269	1,354	1,188	852	840	990	14,528	1.223
1984	69	1,977	3,553	3,146	2,355	2,080	1,295	897	1,166	1,506	18,043	1.358
1985	28	1,317	3,091	3,292	2,830	1,574	1,381	1,834	1,149	1,014	17,508	1.305
1986	28	1,076	2,900	3,428	3,118	2,550	1,559	1,309	1,338	1,661	18,968	1.332
1987	56	822	3,033	3,819	3,077	2,485	1,823	1,342	1,618	1,300	19,375	1.203
1988	33	760	2,347	3,437	2,871	2,211	1,355	1,130	1,344	1,421	16,909	1.251
1989	64	734	2,262	3,520	3,382	2,649	1,741	1,281	1,293	1,425	18,350	1.271
1990	41	637	1,899	3,404	3,808	2,928	1,828	1,485	1,716	1,673	19,420	1.346
1991	33	542	1,374	2,962	3,355	2,645	1,888	1,564	1,530	1,835	17,729	1.376
1992	30	551	1,339	3,124	3,882	3,608	3,027	2,064	2,343	2,213	22,182	1.404
1993	30	665	1,548	4,313	6,394	6,688	5,278	3,807	3,523	3,576	35,823	1.490
1994	37	588	1,762	3,649	5,361	5,026	4,806	3,277	3,830	2,211	30,547	1.633
1995	23	560	1,669	3,468	5,404	5,829	4,651	4,622	3,398	2,425	32,046	1.683
1996	38	528	1,605	3,028	5,149	6,574	5,752	4,588	3,516	2,159	32,937	1.743
1997	34	592	1,762	3,691	6,941	8,731	8,580	7,421	4,857	2,697	45,306	1.898
1998	62	1,337	6,474	19,029	54,434	82,313	73,908	52,277	25,026	9,863	324,723	3.023
Total	**1,251**	**24,759**	**51,610**	**81,302**	**122,868**	**144,809**	**125,073**	**94,888**	**65,393**	**43,557**	**755,505**	**1.832**

career length increasing from about 2 years in 1977 to 8 years in 1997. During this period, the average career doses also increased, but at a slower rate, from 1.112 rem in 1977 to 1.898 rems in 1997. From 1977 to1997, the average career length increased by 233% while the average career dose has increased by 71%. Apart from the 1998 data, the average career dose remained less than 2 rem for each year. The average age at termination increased by 15% from 36.6 years in 1977 to 42.0 years in 1997.

Table 5.5 presents the averages of age at termination, career length, and career dose broken down by sex and year of termination for all workers receiving measurable dose from 1977 through 1998. The sex of the workers was assumed as discussed in Section 5.3.2, and the sex and age were known for 78% of the workers with measurable dose. The table shows that female workers were, on average, 8 years younger than male workers in 1977. This average age difference decreased to about 5 years from 1977 to 1998. The career doses of females averaged about one-third of the male career doses, while career lengths for women averaged about three-fourths of the career lengths for males. Females increased from about 2% of the total in 1977 to 8% in 1998. The average age of females increased 28% from 1977 to 1997 while the average age for males increased by 15%.

The data for workers of known age and unknown sex are included in Table 5.5 to indicate the values for workers not included in the analysis by age and sex. The average age at termination was between that for the male and female workers. The average career length and career dose for this group were usually lower than that for males or females, indicating that this group may have more short-term workers with less complete personnel files. The number of individuals of unknown sex in 1994 decreased significantly as licensees were required to begin reporting the sex of the individual under the revised Part 20.

TABLE 5.5

Average Career Values by Sex and Year of Termination for Personnel of Known Age with Measurable Dose
1977 - 1998

Year	Females of Known Age				Males of Known Age				Known Age, Sex Unknown				Total Personnel			
	Number with Meas.	Average Age at Term. (yrs.)	Average Career Length (yrs.)	Average Career Dose (rem)	Number with Meas.	Average Age at Term. (yrs.)	Average Career Length (yrs.)	Average Career Dose (rem)	Number with Meas.	Average Age at Term. (yrs.)	Average Career Length (yrs.)	Average Career Dose (rem)	Number with Meas.	Average Age at Term. (yrs.)	Average Career Length (yrs.)	Average Career Dose (rem)
1977	154	28.70	1.46	0.705	5,824	36.84	2.79	1.292	3,334	37.06	1.34	0.475	8,291	36.55	2.43	1.112
1978	193	29.81	1.21	0.498	5,888	37.23	2.74	1.262	3,378	36.25	1.28	0.539	7,955	36.67	2.51	1.175
1979	268	30.65	1.49	0.576	7,204	36.30	2.68	1.119	3,381	36.07	1.10	0.486	9,570	36.04	2.39	1.030
1980	457	30.56	1.60	0.458	9,637	37.53	2.54	1.199	2,880	34.69	1.04	0.446	11,760	36.91	2.35	1.109
1981	645	31.27	1.53	0.428	11,391	36.06	1.79	1.310	3,197	35.32	1.23	0.366	13,826	35.78	1.78	1.184
1982	576	31.63	1.79	0.294	8,851	38.02	2.07	1.334	2,781	36.04	1.62	0.468	11,119	37.35	2.08	1.194
1983	595	31.43	2.25	0.339	9,630	37.47	2.35	1.364	3,208	36.88	1.31	0.370	11,883	36.98	2.28	1.223
1984	848	31.40	2.08	0.452	11,428	37.29	2.60	1.469	2,049	37.26	1.74	0.425	13,290	36.93	2.58	1.358
1985	824	31.39	2.47	0.347	10,976	38.32	3.10	1.445	3,150	35.84	1.84	0.431	13,414	37.57	3.05	1.305
1986	938	32.04	2.81	0.323	11,745	38.41	3.70	1.442	3,120	36.56	2.06	0.553	14,243	37.79	3.60	1.332
1987	1,038	32.11	2.99	0.344	13,156	38.55	3.98	1.324	3,849	36.87	1.86	0.415	16,104	37.88	3.80	1.203
1988	906	33.08	3.11	0.385	11,074	38.57	4.43	1.393	3,333	36.63	2.28	0.338	13,517	38.02	4.25	1.251
1989	970	33.52	3.31	0.459	12,208	38.98	4.63	1.361	2,362	36.50	2.89	0.549	14,440	38.46	4.52	1.271
1990	1,016	33.86	3.68	0.429	12,005	39.46	4.92	1.469	2,537	37.31	2.72	0.533	14,427	38.85	4.74	1.346
1991	996	35.09	4.43	0.465	10,487	40.19	5.58	1.509	2,851	38.23	2.69	0.507	12,882	39.61	5.37	1.376
1992	1,203	35.45	5.08	0.459	13,484	40.77	6.27	1.527	2,651	38.80	2.82	0.394	15,800	40.26	6.10	1.404
1993	1,373	37.16	6.62	0.622	20,796	42.80	7.97	1.605	3,673	42.51	6.09	0.434	24,042	42.41	7.81	1.490
1994	958	36.75	5.83	0.572	17,093	41.18	6.57	1.708	873	41.39	6.81	0.927	18,706	40.97	6.56	1.633
1995	95	34.86	6.01	0.838	18,912	40.95	6.84	1.688	35	39.05	7.42	1.416	19,041	40.92	6.83	1.683
1996	1,564	36.88	5.52	0.542	17,257	41.63	7.34	1.856	14	29.99	1.42	0.224	18,898	41.21	7.18	1.743
1997	1,824	36.82	5.67	0.626	22,038	42.47	8.22	2.004	6	33.88	2.17	0.563	23,868	42.04	8.02	1.898
1998	8,461	40.20	8.97	1.099	98,902	43.75	12.06	3.189	45	42.09	8.83	1.231	107,407	43.47	11.82	3.023

5.6 PATTERNS OF ACCUMULATION OF CAREER DOSES AT REACTOR FACILITIES

UNSCEAR reports on ionizing radiation for 1982 and 1993 identify the need for information and analysis of information concerning the accumulation of dose over the career of an individual. While organizations regularly monitor radiation exposure among their workers and report this information on an annual basis, little information is published on how those exposures accumulate over an individual's career. It has been suggested that workers accumulate the majority of their lifetime dose early in their careers, and gradually reduce their exposure as they age. Statistical analysis of more than 30 years of exposure data at commercial reactor licensees supports this view.

Figure 5.1 shows the mean annual dose by age group among commercial nuclear power plant workers aged 18 to 69 from 1986 through 1998. As the graph shows, workers aged 20-29 obtained the highest mean doses at just under 0.05 rem, while mean exposure declined for each age group thereafter. With two exceptions, all the differences between age group means were significant at the 95 percent confidence level, and the pattern remained consistent for each of the years analyzed. The two exceptions were 1) the difference between 20-24 and 25-29 year olds, and 2) the difference between 50-54 and 55-59 year olds. The pattern may reflect the fact that many workers move into supervisory or administrative positions as they get older, and perform less of the hands-on work that results in radiation exposure.

The analysis considered 218,754 individuals who worked at commercial nuclear power plants between 1986 and 1998 and had received some measurable radiation exposure during their careers (1,030,353 person-years). Since dose values do not fit a statistically normal distribution, the calculations presented here used log-transformed data, which were approximately normal. For the years in which an individual had a zero dose, the records were assigned a value of 0.0005 rem (half of the smallest value in the data) in order to obtain a usable logarithmic value. This is a common technique that may slightly overestimate the average exposure, but provides a more accurate result than omitting zero values entirely.[6] The analysis considered only the years after 1985 in order to accurately reflect current conditions. Industry-wide exposure levels were much higher in many of the years from 1979 to 1985, reflecting cleanup activities at Three Mile Island and retrofits required by changes in regulations.

[6] A similar analysis that omitted zero values showed the same pattern, but with much higher mean values, from 0.23 rem for those aged 20-29 to 0.09 rem for those aged 65-69.

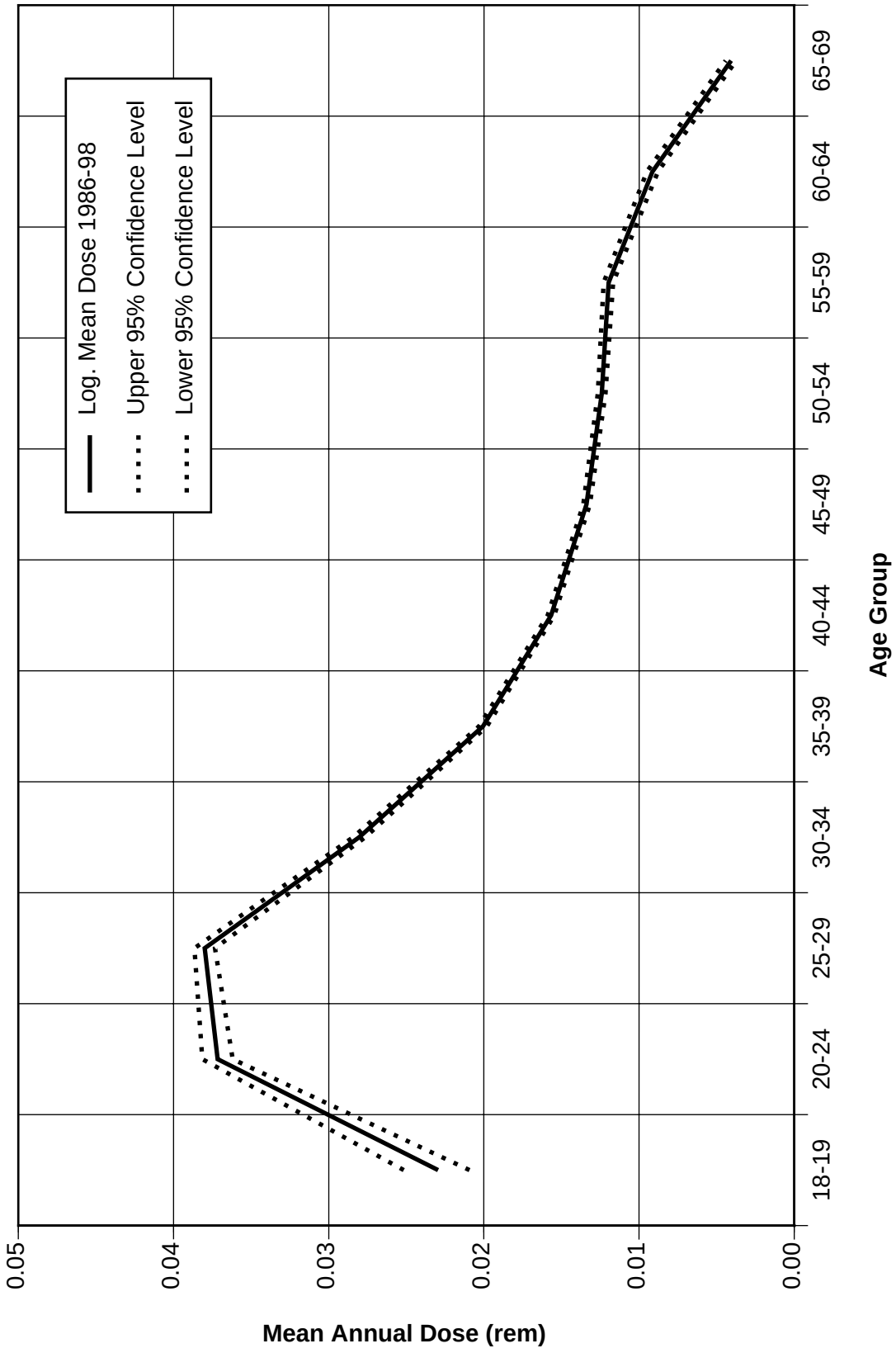

FIGURE 5.1. Mean Annual Dose to Workers with Measurable Dose at Reactor Licensees by Age Group 1986 - 1998

If these aggregate patterns accurately reflect individual exposure patterns, individuals with high exposure levels in one year should have similarly high exposure levels in later years; those with low early exposure levels should show a similar pattern. The decline in exposure with age should also remain significant, even when the data are adjusted for initial high or low exposure rates. A multiple regression analysis suggests that both conditions are true[7]. Current dosage is positively related to dosage for the past 3 years – in fact it is the best predictor of the next year's exposure. Age is still a significant factor, even after adjusting for a 3-year exposure history and variation in site characteristics. The regression equation explained 54% of the variation in annual dose rates – a relatively high percentage for labor market analyses, in which the differences among individuals are often large compared to the effects of other factors.

The regression also examined the influence of site characteristics, including site age (average age of reactors at a site), type of reactor (PWR or BWR), reactor size, total site capacity, and power produced during the year (megawatt-years). All factors except megawatt-years were significant at the 95 percent confidence level. Current dosage is negatively related to site age, site capacity, and reactor size larger than 1000 megawatts. After adjusting for the other factors, dosage is also lower at PWR than BWR sites. The results parallel findings from an earlier study that estimated collective doses at commercial reactor sites based on these characteristics[8].

Figure 5.2 shows the average age of workers who received measurable career doses by monitoring year for 1969 – 1998, and projections for 1999 - 2020[9]. While the average age of the workers in commercial power plants remained between 34 and 36 years from 1969 to 1985, in the years since 1985 this population has been aging steadily. The average age in 1998 was 43.0. If present trends continue, the average age will rise to 49.5 by 2010, and to 55.1 by 2020. This suggests that a limited number of new people are entering the industry, and raises questions about whether the industry will soon have a shortage of workers who are able and willing to perform routine refueling and maintenance functions. Any decommissioning tasks expected over the next 2 decades would further compound such a shortage.

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7 Due to incomplete data, the regression analysis could include only a subset of the full study group – 102,987 individuals, and 476,391 person-years.

8 Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities – 1995, USNRC NUREG-0713, Vol. 17, Section 4.10, "Estimation of Future Occupational Radiation Exposure at Commercial Reactor Sites," January 1997.

9 The projections are based on a simple regression of average age by calendar year for 1986 – 1998. The equation captures 99% of the variation in age for this period.

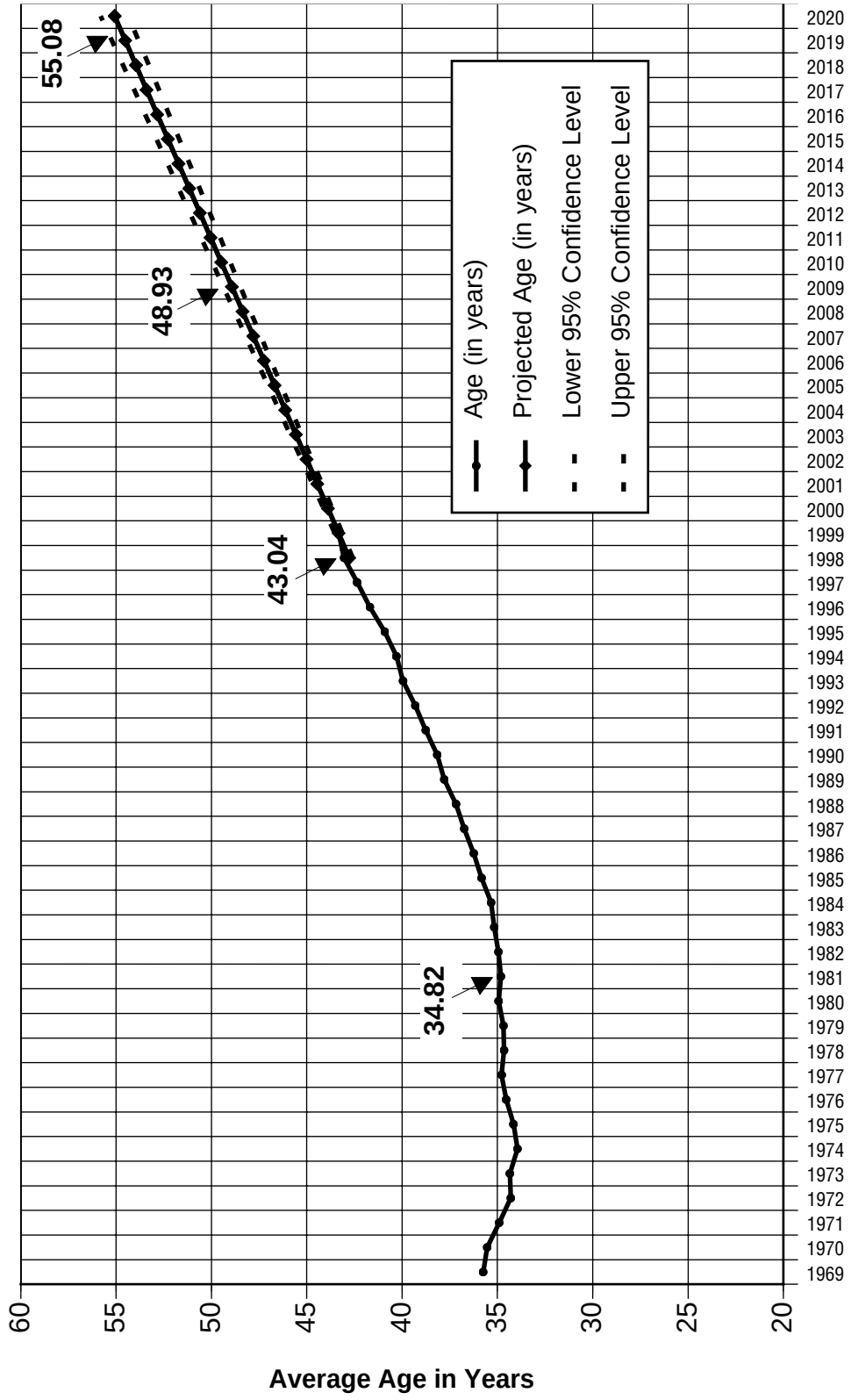

FIGURE 5.2. Average Age of Workers with Measurable Dose at Reactor Licensees from 1969-1998 with Projections to 2020

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Section 6

EXPOSURES TO PERSONNEL IN EXCESS OF REGULATORY LIMITS

6.1 CONTROL LEVELS

Exposures in excess of regulatory limits are sometimes referred to as "overexposures." The phrase "exposures in excess of regulatory limits" is preferred to "overexposures" because the latter suggests that a worker has been subjected to an unacceptable biological risk, which may, or may not, be the case.

The implementation date for the revised 10 CFR 20 was January 1, 1994. The revised 10 CFR 20 includes requirements for summing internal and external dose equivalents to yield TEDE and to implement a similar limitation system for organs and tissues (such as the gonads, red bone marrow, bone surfaces, lung, thyroid, and breast). The revised 10 CFR 20.1201 limits the TEDE of workers to ionizing radiation from licensed material and other sources of radiation within the licensee's control. The revised 10 CFR 20 no longer contains quarterly exposure limits but has reporting requirements for planned special exposures (PSEs)[10]. The annual TEDE limit for adult workers is 5 rem.

The revised 10 CFR 20.2202 and 10 CFR 20.2203 require that all persons licensed by the NRC submit reports of all occurrences involving personnel radiation exposures that exceed certain control levels, thus providing for investigations and corrective actions as necessary. Based on the magnitude of the exposure, the occurrence may be placed into one of three categories:

(1) Category A

10 CFR 20.2202(a)(1) - a TEDE to any individual of 25 rem or more; an eye dose equivalent of 75 rem or more; or a shallow-dose equivalent to the skin or extremities of 250 rad or more. The Commission must be notified immediately of these events.

(2) Category B

10 CFR 20.2202(b)(1) - a TEDE to any individual of 5 rem or more; an eye dose equivalent of 15 rem or more; or a shallow-dose equivalent to the skin or extremities of 50 rem or more in a 24-hour period. The Commission must be notified within 24 hours of these events.

[10] See 10 CFR 20.1206, 20.2204 and Regulatory Guide 8.35 for more information on PSEs and their reporting requirements.

(3) Category C

10 CFR 20.2203 - In addition to the notification required by 20.2202 (category A and B occurrences), each licensee must submit a written report within 30 days after learning of any of the following occurrences: (1) Any incident for which notification is required by 20.2202; or (2) Doses that exceed the limits in 20.1201, 20.1207, 20.1208, 20.1301 (for adults, minors, the embryo/ fetus of a declared pregnant worker, and the public, respectively), or any applicable limit in the license; or (3) Levels of radiation or concentrations of radioactive material that exceed any applicable license limit for restricted areas or that, for unrestricted areas, are in excess of 10 times any applicable limit set forth in this part or in the license (whether or not involving exposure of any individual in excess of the limits in 20.1301); or (4) For licensees subject to the provisions of the Environmental Protection Agency's generally applicable environmental radiation standards in 40 CFR 190, levels of radiation or releases of radioactive material in excess of those standards, or of license conditions related to those standards.

6.2 LIMITATIONS OF THE DATA

It is important to note that this summary of events includes ***only***:

- Occupational radiation exposures in excess of regulatory limits
- Events at NRC-licensed facilities
- Final dose of record assigned to an individual

It ***does not*** include:

- Medical misadministrations to medical patients
- Exposures in excess of regulatory limits to the general public
- Agreement State-licensed activities or DOE facilities
- Other radiation-related violations, such as high dose rate areas or effluent limits
- Exposures to dosimeters that, upon evaluation, have been determined to be high dosimeter readings only and are not assigned to an individual as the dose of record by the NRC

Care should be taken when comparing the summary information presented here with other reports and analyses published by the NRC or other agencies. Various reports may include other types of "overexposure" events; therefore, the distinctions should be noted.

The analysis and summary of incidents presented here involving exposures in excess of regulatory limits represent the status of events as of the publication of this report. Exposure events of this type typically undergo a long review and evaluation process by the licensee, the NRC inspector for the regional office, and NRC headquarters. Preliminary dose estimates submitted by licensees are often conservatively high and do not represent the final (record) dose assigned for the event. It is therefore not uncommon for an "overexposure" event to be reassessed and the final assigned dose to be categorized as not having been in excess of the regulatory limits. In other cases, the exposure may not be identified until a later date, such as during the next scheduled audit or inspection of the licensee's exposure records.

For these reasons, an attempt is made to keep current the exposure events summary presented here. An event that has been reassessed and determined not to be an exposure in excess of the limits is not included in this report. In addition, events that occurred in prior years are added to the summary in the appropriate year of occurrence. The reader should note that the summary presented here represents a "snapshot" of the status of events as of the publication date of this report. Previous or future reports may not correlate in the exact number of events because of the review cycle and reassessment of the events.

6.3 SUMMARY OF EXPOSURES IN EXCESS OF REGULATORY LIMITS

Table 6.1 summarizes the occupational exposures in excess of regulatory limits as reported by Commission licensees pursuant to 10 CFR 20.2202 and 10 CFR 20.2203 from 1994 to 1998. Table 6.2 shows the data reported under 10 CFR 20.403 and 10 CFR 20.405 for the period 1985-1993. Note that the categorization criteria changed effective with the revised 10 CFR 20. The dose reporting thresholds have been revised – the skin of the whole body and the extremities now have the same dose limits, and a new set of dose limits has been added for the lens of the eye.

For the period 1990-1993, Table 6.2 shows the number of individuals who exceeded various limits while employed by one of several types of licensees. For the period 1985-1989, only the exposures in excess of regulatory limits reported by licensed industrial radiography firms are shown separately. Most of the occurrences included in the "Others" category come from research facilities, universities, and measuring and well-logging activities.

TABLE 6.1
Occupational Exposures in Excess of Regulatory Limits
1994 - 1998

Year	LICENSE CATEGORY	PERSONS AND DOSES (REM)	Types Of Exposures And Doses								
			TEDE (rem)			Lens of the Eye (rem)			Skin/Extremity (rem)		
			<5	5 - 25	>25	<15	15 - 75	>75	<50	50 - 250	>250 rad
1998	INDUSTRIAL RADIOGRAPHY	NO. OF PERSONS		4[a]						1	
		SUM OF DOSES		34.8						50-200	
	POWER REACTORS	NO. OF PERSONS									
		SUM OF DOSES									
	MEDICAL FACILITIES	NO. OF PERSONS									
		SUM OF DOSES									
	MARKETING & MANUFACT.	NO. OF PERSONS									
		SUM OF DOSES									
	OTHER	NO. OF PERSONS									
		SUM OF DOSES									
1997	INDUSTRIAL RADIOGRAPHY	NO.OF PERSONS									
		SUM OF DOSES									
	POWER REACTORS	NO.OF PERSONS								1[b]	
		SUM OF DOSES								51.1	
	MEDICAL FACILITIES	NO. OF PERSONS									
		SUM OF DOSES									
	MARKETING & MANUFACT.	NO.OF PERSONS									1
		SUM OF DOSES									533.9
	OTHER	NO.OF PERSONS									
		SUM OF DOSES									
1996	INDUSTRIAL RADIOGRAPHY	NO. OF PERSONS		1							
		SUM OF DOSES		8.3							
	POWER REACTORS	NO. OF PERSONS								1[c]	
		SUM OF DOSES								70.6	
	MEDICAL FACILITIES	NO. OF PERSONS									
		SUM OF DOSES									
	MARKETING & MANUFACT.	NO.OFPERSONS									
		SUM OF DOSES									
	OTHER	NO. OF PERSONS									
		SUM OF DOSES									
1995	INDUSTRIAL RADIOGRAPHY	NO.OF PERSONS		1							
		SUM OF DOSES		5.1							
	POWER REACTORS	NO. OF PERSONS									
		SUM OF DOSES									
	MEDICAL FACILITIES	NO. OF PERSONS									
		SUM OF DOSES									
	MARKETING & MANUFACT.	NO. OF PERSONS								2[d]	
		SUM OF DOSES								572	
	OTHER	NO. OF PERSONS									
		SUM OF DOSES									
1994	INDUSTRIAL RADIOGRAPHY	NO.OF PERSONS		2							
		SUM OF DOSES		12.2							
	OTHER	NO. OF PERSONS							1	1[e]	
		SUM OF DOSES							34	180	

[a] One of these individuals also received the extremity exposure as shown.
[b] This exposure was from a hot particle to a localized area of the skin.
[c] This exposure was from a hot particle to a localized area of the skin.
[d] These two exposures (230 rem and 342 rem) were the result of hot particles.
[e] This exposure was from a hot particle to a localized area of the skin.

TABLE 6.2
Occupational Exposures in Excess of Regulatory Limits
1985 - 1993

Year	License Category	Persons and Doses (rem)	Types Of Exposures And Doses								
			Whole Body (rem)			Skin (rem)			Extremity (rem)		
			<5	5 - 25	>25	<7.5<30	30-50	>150	>18.75>75	75 - 375	>375
1993	INDUSTRIAL RADIOGRAPHY	NO. OF PERSONS		1							
		SUM OF DOSES		6							
	POWER REACTORS	NO. OF PERSONS									
		SUM OF DOSES									
	MEDICAL FACILITIES	NO. OF PERSONS	1							3[f]	
		SUM OF DOSES	1.3							187.3	
	MARKETING & MANUFACT.	NO. OF PERSONS	5								
		SUM OF DOSES	10.6								
	OTHER	NO. OF PERSONS	2[a]	1[a]						1	
		SUM OF DOSES	4.0	5.4						275	
1992	INDUSTRIAL RADIOGRAPHY	NO. OF PERSONS									1
		SUM OF DOSES									300-1000
	POWER REACTORS	NO. OF PERSONS	1			4					
		SUM OF DOSES	1.9			57.7					
	MEDICAL FACILITIES	NO. OF PERSONS							4	1	
		SUM OF DOSES							143.6	272	
	MARKETING & MANUFACT.	NO. OF PERSONS									
		SUM OF DOSES									
	OTHER	NO. OF PERSONS	1[b]			1			1		
		SUM OF DOSES	1.9			24.1			40.5		
1991	INDUSTRIAL RADIOGRAPHY	NO. OF PERSONS	2								
		SUM OF DOSES	5.6								
	POWER REACTORS	NO. OF PERSONS									
		SUM OF DOSES									
	MEDICAL FACILITIES	NO. OF PERSONS	2								
		SUM OF DOSES	3.8								
	MARKETING & MANUFACT.	NO. OF PERSONS							1		
		SUM OF DOSES							22.3		
	OTHER	NO. OF PERSONS	1								
		SUM OF DOSES	2.4								
1990	INDUSTRIAL RADIOGRAPHY	NO. OF PERSONS	3	3[c, d]				1[c]		1	2[d]
		SUM OF DOSES	7.2	49.9				6000		111	3962
	POWER REACTORS	NO. OF PERSONS							1		
		SUM OF DOSES							48.8		
	MEDICAL FACILITIES	NO. OF PERSONS	3[e]								
		SUM OF DOSES	8.9								
	MARKETING & MANUFACT.	NO. OF PERSONS									
		SUM OF DOSES									
	OTHER	NO. OF PERSONS	1								
		SUM OF DOSES	2.3								
1989	INDUSTRIAL RADIOGRAPHY	NO. OF PERSONS	3		1				1		
		SUM OF DOSES	8.1		93				72		
	ALL OTHER	NO. OF PERSONS	4			1			2	1	
		SUM OF DOSES	6.6			9.2			105	178	
1988	INDUSTRIAL RADIOGRAPHY	NO. OF PERSONS	3	1						1	
		SUM OF DOSES	8.1	6.1						118	
	ALL OTHER	NO. OF PERSONS	7			4	1	1	1	1	
		SUM OF DOSES	19.34			66.8	61	278	58	127	
1987	INDUSTRIAL RADIOGRAPHY	NO. OF PERSONS	1							1	
		SUM OF DOSES	3.1							180	
	ALL OTHER	NO. OF PERSONS	2	1		5			3		1
		SUM OF DOSES	2.8	7.5		128.4			72.0		650
1986	INDUSTRIAL RADIOGRAPHY	NO. OF PERSONS	2								
		SUM OF DOSES	4.4								
	ALL OTHER	NO. OF PERSONS	3						1	1	2
		SUM OF DOSES	9.6						41.2	115	930
1985	INDUSTRIAL RADIOGRAPHY	NO. OF PERSONS	6	3	1					1	
		SUM OF DOSES	16.7	32.6	27.0					288	
	ALL OTHER	NO. OF PERSONS	7						3	1	
		SUM OF DOSES	11.8						60.2	93	

[a] Same individual exceeded 1.25 rem/qtr limit twice during 1993.
[b] This 1992 exposure was reported in 1994.
[c] This individual received a whole-body dose of 24 rem in addition to a 6000 rem skin dose.
[d] One of these individuals received a 9 rem whole-body dose in addition to a 1070 rem extremity dose.
[e] One of those individuals exceeded the quarterly whole-body dose limits three times in one calendar year.
[f] An additional 1993 exposure was reported in 1994.

In 1998, six radiography workers received doses that exceeded the 5 rem TEDE regulatory limit. Five of the exposures were "Category B" occurrences, and one was a "Category C" occurrence. There were no occurrences in which individuals received a "Category A" exposure.

In November of 1998, a multi-location radiographer in Montana reported that one individual received a deep dose of 12.916 rem and another received a dose of 5.830 rem. The two radiographers were involved in the same incident. While setting up for a radiography shot, it was noticed that the slider on the camera had not engaged properly from the previous shot, leaving the source unshielded. The individuals were able to turn the crank handle another one half turn, and it went in to the locked position. It was noted that the individual's dosimeters were off scale. The individuals involved estimated that the slider was not locked back for a duration of approximately 3 minutes, but subsequent calculations based on film badge results indicated the duration of the event was approximately 6 minutes. The licensee has removed both individuals from activities involving radioactive materials, and has attributed the occurrence to a failure to follow procedures in verifying that the source was not locked in the shielded position.

Also in November of 1998, a multi-location radiographer in Oklahoma reported an exposure of an individual in excess of the 5 rem TEDE limit. A radiographer and an assistant radiographer were performing radiography on a large diameter pipe. The setup required that the camera and source guide tube be positioned inside the pipe to get a panoramic radiograph of the welds. While the radiographer was absent, the assistant repositioned the radiography equipment to complete the next set of radiographs. The assistant failed to perform a survey of the camera and source guide tube to confirm that the source was returned to its shielded position. In addition, the assistant was not wearing an alarming ratemeter. The source was found to be in the unshielded position during these adjustments. The assistant's pocket dosimeter had fallen off and was subsequently found to be off-scale. A preliminary reading of the TLD indicated a deep dose of 10.8 rem. The licensee sent the assistant radiographer to a physician for a blood sample, and the individual's white cell count was found to be slightly above normal. A subsequent NRC inspection determined that the assistant received a deep dose equivalent between 6.4 rem and 14 rem and an extremity dose to the right hand between 50 rem and 200 rem. The final reported deep dose equivalent was 11.439 rem. The licensee's corrective actions included: 1) the immediate suspension and eventual termination of both the radiographer and the assistant, 2) the performance of an emergency radiation safety meeting with all staff to review the event, 3) a plan to conduct field audits of all personnel and, 4) a review of the incident during orientation of new personnel.

In August of 1998, a multi-location radiographer in Oklahoma reported that an individual had received a year-to-date deep dose equivalent of 5.64 rem. The dosimetry

processor notified the licensee that an individual's film badge indicated a 1-month dose of 2.95 rem, bringing his annual total to 5.64 rem. Subsequent investigation revealed that a dosimeter and rate alarm the individual was wearing did not indicate an exposure of this magnitude and that these devices were within calibration requirements and were operating properly during this period. However, the dose of 5.64 rem could not be disproved and therefore the dose was assigned to the radiographer.

In January of 1999, two individuals at a multi-location radiography licensee in Texas were determined to have exceeded the 5 rem TEDE limit for 1998. In one instance, the individual received a dose of 4.56 rem during the December 1998 monitoring period, bringing the total TEDE for the year to 5.50 rem. In the other instance at this licensee, the individual reported a lost dosimeter during three separate monitoring periods. The licensee assigned an administrative dose of 0.416 rem for each of these periods, bringing the individual's annual TEDE to 5.18 rem. An investigation determined that poor work practices caused the exposure, and the licensee counseled the radiographer. Although the licensee reported these exposures under an NRC license number, they were designated as events that occurred in an Agreement State (Texas) and were therefore investigated by the Texas Department of Health.

6.4 MAXIMUM EXPOSURES BELOW THE NRC LIMITS

Because few exposures exceed the NRC occupational exposure limits, certain researchers have expressed an interest in a listing of the maximum exposures received at NRC licensees that do not exceed the limits. This would allow an examination of exposures that approach, but do not exceed the limits. Table 6.3 shows the maximum exposures for each dose category required to be reported to the NRC. In addition, the number of exposures in certain dose ranges is shown to reflect the number of exposures that approach the NRC limits.

As can be seen from Table 6.3, few exposures exceed half of the NRC occupational annual limits. In 1998, four individuals came within 5% of the TEDE limit in addition to the four individuals who exceeded the limit. One individual was reported to have exceeded the extremity limit in addition to having exceeded the TEDE limit. This individual is not shown in Table 6.3 because the exposure is still under evaluation and has not yet been reported to REIRS.

TABLE 6.3
Maximum Occupational Exposures for Each Exposure Category
1998

Exposure Category	Annual Dose Limit 10CFR20*	Maximum Exposure Reported (rem)	Max Dose Percent of the Limit	Number of Individuals with Measurable Dose	Number of Individuals ≥ 25% of the Limit	Number of Individuals ≥ 50% of the Limit	Number of Individuals ≥ 75% of the Limit	Number of Individuals ≥ 95% of the Limit
SDE-ME	50 rem	41.560	83%	53,558	98	17	3	0
SDE-WB	50 rem	12.705	25%	65,730	1	0	0	0
LDE15	rem	12.926	86%	64,731	12	1	1	0
CEDE		3.402		3,907				
CDE28.34				2,898				
DDE12.91				66,183				
TEDE	5 rem	12.916	> limit	67,221	1,834	209	17	8 (4>limit)
TODE50	rem	28.555	57%	56,310	88	2	0	0

* Shaded boxes represent dose categories that do not have specific dose limits defined in 10 CFR 20.

Section 7
REFERENCES

1. U.S. Atomic Energy Commission, *Nuclear Power Plant Operating Experience During 1973*, USAEC Report 00E-ES-004, December 1974.*

2. U.S. Nuclear Regulatory Commission, *Nuclear Power Plant Operating Experience 1974-1975*, USNRC Report NUREG-0227, April 1977.*

3. U.S. Nuclear Regulatory Commission, *Nuclear Power Plant Operating Experience 1976*, USNRC Report NUREG-0366, December 1977.*

4. M.R. Beebe, *Nuclear Power Plant Operating Experience - 1977*, USNRC Report NUREG-0483, February 1979.*

5. *Nuclear Power Plant Operating Experience - 1978*, USNRC Report NUREG-0618, December 1979.*

6. *Nuclear Power Plant Operating Experience - 1979*, USNRC Report NUREG/CR-1496, May 1981.*

7. *Nuclear Power Plant Operating Experience - 1980*, USNRC Report NUREG/CR-2378, ORNL/NSIC-191, October 1982.*

8. *Nuclear Power Plant Operating Experience - 1981*, USNRC Report NUREG/CR-3430, ORNL/NSIC-215, Vol. 1, December 1983.*

9. *Nuclear Power Plant Operating Experience - 1982*, USNRC Report NUREG/CR-3430, ORNL/NSIC-215, Vol. 2, January 1985.*

10. *Instructions for Recording and Reporting Occupational Radiation Exposure Data*, USNRC Regulatory Guide 8.7, Rev. 1, June 1992.

11. United Nations, *Report of the Scientific Committee on the Effects of Atomic Radiation*, General Assembly of Official Records, United Nations, New York, 1993.

12. *Licensed Operating Reactors, Status Summary Report,* USNRC Report NUREG-0020, Vol. 20, No. 1. Data for 1995 provided on diskette by D. Hartfield, USNRC Office of Information Resources Management, Systems Development Branch.

* Report is available for purchase from the National Technical Information Service, Springfield, Virginia, 22161, and/or the Superintendent of Documents, U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402-9328.

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Appendix A

ANNUAL TEDE FOR NON-REACTOR NRC LICENSEES

1998

APPENDIX A

Annual TEDE for Non-Reactor NRC Licensees
CY 1998

PROGRAM CODE - LICENSEE NAME	LICENSE#	Number of Individuals with Whole Body Doses in the Ranges (rems)													Total Number Monitored	Number With Meas. Dose	Total Collective TEDE (Person-Rem)	Average Meas. TEDE (Rems)
		No Meas. Exposure	Meas. <0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	2.00-3.00	3.00-4.00	4.00-5.00	5.00-6.00	6.00-12.00	>12.0				
NUCLEAR PHARMACIES - 02500																		
CAPITAL PHARMACY INC.	21-26597-01MD	7	5	-	1	-	-	-	-	-	-	-	-	-	13	6	0.530	0.088
EASTERN ISOTOPES	45-25221-01MD	12	10	2	5	1	-	-	-	-	-	-	-	-	30	18	2.621	0.146
MALLINCKRODT MEDICAL, INC.	24-04206-01MD	4	7	-	2	1	-	-	-	-	-	-	-	-	14	10	1.540	0.154
MALLINCKRODT MEDICAL, INC.	24-17450-02MD	10	9	2	1	-	-	-	-	-	-	-	-	-	22	12	0.820	0.068
MALLINCKRODT, INC.	24-04206-08MD	5	8	3	-	-	-	-	-	-	-	-	-	-	16	11	0.670	0.061
MALLINCKRODT, INC.	24-04206-12MD	-	5	4	3	-	1	-	-	-	-	-	-	-	13	13	2.840	0.218
MALLINCKRODT MEDICAL INC.	24-04206-14MD	3	8	8	4	-	-	-	-	-	-	-	-	-	23	20	2.970	0.149
MALLINCKRODT MEDICAL, INC.	24-04206-17MD	-	-	3	-	-	-	-	-	-	-	-	-	-	3	3	0.440	0.147
MALLINCKRODT MEDICAL, INC.	24-04206-19MD	-	5	2	7	1	1	-	-	-	-	-	-	-	16	16	**4.180**	0.261
MID-AMERICA ISOTOPES, INC.	24-26241-01	20	4	-	-	-	-	-	-	-	-	-	-	-	24	4	0.190	0.048
OKLAHOMA, UNIVERSITY OF	35-03176-04MD	17	7	4	-	-	-	-	-	-	-	-	-	-	28	11	0.810	0.074
SPECTRUM PHARMACY INC.	13-26367-01	32	5	1	-	1	2	-	-	-	-	-	-	-	41	9	2.860	**0.318**
SYNCOR INTERNATIONAL CORP.	04-26507-01MD	146	40	6	1	1	-	-	-	-	-	-	-	-	**194**	**48**	2.796	0.058
Total	**13**	**256**	**113**	**35**	**24**	**5**	**4**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**437**	**181**	**23.267**	**0.129**
MANUFACTURING AND DISTRIBUTION - TYPE A BROAD - 03211																		
ABB INDUSTRIAL SYSTEMS INC.	34-00255-03	1	2	-	-	-	-	-	-	-	-	-	-	-	3	2	0.080	0.040
ADVANCED MEDICAL SYS., INC.	34-19089-01	1	1	-	-	-	-	-	-	-	-	-	-	-	2	1	0.050	0.050
BRISTOL-MEYER SQ	29-00139-02	752	31	5	1	3	4	-	-	-	-	-	-	-	**796**	44	7.170	0.163
MALLINCKRODT MEDICAL INC.	24-04206-01	31	58	34	45	21	24	53	47	32	-	-	-	-	345	**314**	**359.829**	**1.146**
NUCLEAR RESEARCH CORP.	29-04236-01	12	19	-	-	-	-	-	-	-	-	-	-	-	31	19	0.234	0.012
Total	**5**	**797**	**111**	**39**	**46**	**24**	**28**	**53**	**47**	**32**	**-**	**-**	**-**	**-**	**1,177**	**380**	**367.363**	**0.967**
MANUFACTURING AND DISTRIBUTION - TYPE B BROAD - 03212																		
BEST INDUSTRIES	45-19757-01	48	11	5	3	3	1	-	-	-	-	-	-	-	71	23	5.146	0.224
OHMART CORP.	34-00639-01	53	25	6	2	2	-	-	-	-	-	-	-	-	**88**	**35**	**3.540**	**0.101**
Total	**1**	**101**	**36**	**11**	**5**	**5**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**159**	**58**	**8.686**	**0.150**

NOTE: The data values shown bolded and in boxes represent the highest value in each category.

APPENDIX A

Annual TEDE for Non-Reactor NRC Licensees
CY 1998

PROGRAM CODE - LICENSEE NAME	LICENSE#	Number of Individuals with Whole Body Doses in the Ranges (rems)													Total Number Monitored	Number With Meas. Dose	Total Collective TEDE (Person-Rem)	Average Meas. TEDE (Rems)
		No Meas. Exposure	Meas. <0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	2.00-3.00	3.00-4.00	4.00-5.00	5.00-6.00	6.00-12.00	>12.0				
MANUFACTURING AND DISTRIBUTION - OTHER - 03214																		
ADVANZ MEASUREMENT & CONTROL	34-26683-01	9	1	-	-	-	-	-	-	-	-	-	-	-	10	1	0.010	0.018
BICRON: SAINT-GOBAIN/NORTON	34-06558-05	48	5	1	-	-	-	-	-	-	-	-	-	-	**54**	**6**	0.260	0.043
DIAGNOSTECH INT'L., INC.	48-26355-01	2	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-
DU PONT MERCK PHARMACEUTICAL CO.	20-00320-19	-	1	4	1	-	-	-	-	-	-	-	-	-	6	**6**	**0.940**	**0.157**
HALLIBURTON CO.	35-00502-03	-	1	2	-	-	-	-	-	-	-	-	-	-	3	3	0.370	0.123
HARRIS SEMICONDUCTORS	37-24841-02	31	-	-	-	-	-	-	-	-	-	-	-	-	31	-	-	-
INTERGRATED INDUSTRIAL SYS., INC.	06-21253-01	39	-	-	-	-	-	-	-	-	-	-	-	-	39	-	-	-
NUCLEAR RESEARCH CORPORATION	37-02401-01	23	6	-	-	-	-	-	-	-	-	-	-	-	29	**6**	0.170	0.028
SEIMENS BUILDING TECHNOLOGIES, INC.	29-08864-03	2	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-
THERATRONICS INTERNATIONAL LTD.	54-28315-01	10	3	1	-	-	-	-	-	-	-	-	-	-	14	4	0.300	0.075
Total	**10**	**164**	**17**	**8**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**190**	**26**	**2.050**	**0.079**
LOW LEVEL WASTE DISPOSAL FACILITIES - 03231																		
U.S. ECOLOGY	WN-I019-2	14	5	8	-	-	-	-	-	-	-	-	-	-	**27**	**13**	**1.355**	**0.104**
Total	**1**	**14**	**5**	**8**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**27**	**13**	**1.355**	**0.104**

NOTE: The data values shown bolded and in boxes represent the highest value in each category.

APPENDIX A

Annual TEDE for Non-Reactor NRC Licensees
CY 1998

PROGRAM CODE - LICENSEE NAME	LICENSE#	Number of Individuals with Whole Body Doses in the Ranges (rems)													Total Number Monitored	Number With Meas. Dose	Total Collective TEDE (Person-Rem)	Average Meas. TEDE (Rems)
		No Meas. Exposure	Meas. <0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	2.00-3.00	3.00-4.00	4.00-5.00	5.00-6.00	6.00-12.00	>12.0				
INDUSTRIAL RADIOGRAPHY - SINGLE LOCATION - 03310																		
AMERICAN FOUNDRY GROUP, INC.	35-26893-01	2	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-
ARMY, DEPARTMENT OF THE	13-18235-01	43	5	-	-	-	-	-	-	-	-	-	-	-	48	5	0.042	0.008
ARMY, DEPARTMENT OF THE	29-00047-06	-	1	-	-	-	-	-	-	-	-	-	-	-	1	1	0.018	0.018
ARROW TANK & ENGINEERING CO.	22-13253-01	2	1	-	1	1	-	-	-	-	-	-	-	-	5	3	1.120	0.373
BUCKEYE STEEL CASTINGS	34-06627-01	1	1	-	-	-	-	-	-	-	-	-	-	-	2	1	0.010	0.010
BWX TECHNOLOGIES, INC.	34-02160-03	10	8	-	-	-	-	-	-	-	-	-	-	-	18	8	0.110	0.014
CARONDELET FOUNDRY COMPANY	24-26136-01	6	8	-	-	-	-	-	-	-	-	-	-	-	14	8	0.293	0.037
CONNEX PIPE SYSTEMS INC.	45-26591-01	2	2	-	-	-	-	-	-	-	-	-	-	-	4	2	0.014	0.007
DURALOY	37-02279-02	1	1	1	1	-	-	-	-	-	-	-	-	-	4	3	0.600	0.200
GENERAL MOTORS CORP.	21-08678-05	4	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-
GENERAL MOTORS CORP. - DEFIANCE	34-15315-02	3	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-
GREDE-PRYOR, INC.	35-18099-01	1	1	-	-	-	-	-	-	-	-	-	-	-	2	1	0.010	0.010
HARRISON STEEL CASTINGS CO.	13-02141-01	3	4	-	-	-	-	-	-	-	-	-	-	-	7	4	0.182	0.046
HIGH STEEL STRUCTURES, INC.	37-17534-01	3	10	-	1	-	-	-	-	-	-	-	-	-	14	**11**	0.580	0.053
INTERMET CORPORATION	45-17464-01	7	1	-	-	-	-	-	-	-	-	-	-	-	8	1	0.010	0.010
IRONTON IRON, INC.	34-24800-02	1	3	-	-	-	-	-	-	-	-	-	-	-	4	3	0.060	0.020
MANOIR - ELECTRO ALLOYS, INC.	34-24346-01	7	3	3	-	-	-	-	-	-	-	-	-	-	13	6	0.540	0.090
MINNESOTA VALLEY ENGINEERING	22-24393-01	-	6	3	-	-	-	-	-	-	-	-	-	-	9	9	0.490	0.054
MISSOURI STEEL CASTINGS	24-15152-01	5	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-
NILES STEEL TANK CO.	21-04741-01	2	2	-	-	-	-	-	-	-	-	-	-	-	4	2	0.040	0.020
PELTON CASTEEL, INC.	48-02669-02	3	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-
RIDGEWATER COLLEGE	22-15554-01	93	3	1	-	-	-	-	-	-	-	-	-	-	**97**	4	0.190	0.048
THE FLOWSERVE CORPORATION	34-06398-01	2	2	-	-	-	-	-	-	-	-	-	-	-	4	2	0.107	0.054
TRANS WORLD AIRLINES, INC.	24-05151-05	81	-	-	-	-	-	-	-	-	-	-	-	-	81	-	-	-
WAUKESHA FOUNDRY DIVISION	48-13776-01	2	2	-	-	-	-	-	-	-	-	-	-	-	4	2	0.090	0.045
WISCONSIN CENTRIFUGAL, INC.	48-11641-01	1	-	2	5	-	-	1	-	-	-	-	-	-	9	8	**3.349**	**0.419**
Total	**26**	**285**	**64**	**10**	**8**	**1**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**369**	**84**	**7.855**	**0.094**

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APPENDIX A

Annual TEDE for Non-Reactor NRC Licensees
CY 1998

PROGRAM CODE - LICENSEE NAME	LICENSE#	Number of Individuals with Whole Body Doses in the Ranges (rems)													Total Number Monitored	Number With Meas. Dose	Total Collective TEDE (Person-Rem)	Average Meas. TEDE (Rems)
		No Meas. Exposure	Meas. <0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	2.00-3.00	3.00-4.00	4.00-5.00	5.00-6.00	6.00-12.00	>12.0				
INDUSTRIAL RADIOGRAPHY - MULTIPLE LOCATION - 03320																		
ACCURATE TECHNOLOGIES, INC.	29-28358-01	1	2	4	-	2	4	3	4	-	-	-	-	-	20	19	18.785	0.989
ADAMS INDUSTRIAL SERVICES, INC.	45-25355-01	-	2	3	-	1	-	-	-	-	-	-	-	-	6	6	1.054	0.176
ADVANCED INSPECTION TECH	35-27588-01	-	1	-	1	-	3	3	-	-	-	-	-	-	8	8	7.002	0.875
AKRON INDUSTRIAL SERVICES, INC.	34-24673-01	-	-	-	-	1	-	1	-	-	-	-	-	-	2	2	1.730	0.865
ALASKA INDUSTRIAL X-RAY, INC.	50-16084-01	-	1	4	4	1	1	2	1	1	2	-	-	-	17	17	22.150	1.303
ALLEGHENY LABORATORIES	37-20734-01	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
ALLIED INSPECTION SERV., INC.	21-18428-01	-	1	1	-	2	1	-	-	-	-	-	-	-	5	5	2.280	0.456
ALONSO & CARUS IRON WORKS, INC.	52-21350-01	2	3	1	-	-	1	-	-	-	-	-	-	-	7	5	1.088	0.218
AMERICAN AIRLINES, INC.	35-13964-01	33	4	1	-	-	-	-	-	-	-	-	-	-	38	5	0.180	0.036
AMERICAN ENGINEERING TESTING	22-20271-02	2	1	-	3	1	-	1	-	-	-	-	-	-	8	6	3.440	0.573
ANVIL CORPORATION	46-23236-03	10	14	25	15	6	2	13	-	-	-	1	-	1	87	77	50.378	0.654
ARMY, DEPARTMENT OF THE	30-02405-05	-	2	-	-	-	-	-	-	-	-	-	-	-	2	2	0.049	0.025
ASCG INSPECTION SERVICES	50-29015-01	38	14	22	38	12	16	14	4	-	-	-	-	-	158	120	66.913	0.558
BARNETT INDUSTRIAL X-RAY	35-26953-01	5	3	2	2	2	1	5	-	-	-	-	-	-	20	15	11.450	0.763
BIG STATE X-RAY, INC.	35-21144-01	-	6	4	4	3	4	10	1	-	-	-	-	-	32	32	23.312	0.729
BILL MILLER, INC.	35-19048-01	6	-	8	12	11	5	2	-	-	-	-	-	-	44	38	19.088	0.502
BRANCH RADIOGRAPHIC LABS., INC.	29-03405-02	8	4	2	7	2	-	-	-	-	-	-	-	-	23	15	4.638	0.309
BRAUN INTERTEC CORPORATION	22-16537-02	3	4	5	5	1	2	4	-	-	-	-	-	-	24	21	10.091	0.481
CALUMET TESTING SERV., INC.	13-16347-01	11	2	-	1	1	1	2	3	3	1	-	-	-	25	14	27.163	**1.940**
CAPITAL X-RAY SERV., INC.	35-11114-01	1	3	4	12	2	2	8	6	2	-	-	-	-	40	39	39.110	1.003
CENTURY INSPECTION, INC.	42-08456-02	11	20	22	14	11	8	7	1	-	-	-	-	-	94	83	35.667	0.430
CHICAGO BRIDGE AND IRON CO.	42-13553-02	7	13	4	4	-	1	1	-	-	-	-	-	-	30	23	4.170	0.181
COLBY & THIELMEIER TESTING CO.	24-13737-01	-	-	1	4	-	1	4	-	-	-	-	-	-	10	10	8.609	0.861
COMO TECH INSPECTION	15-26978-01	-	2	2	1	-	2	3	-	-	-	-	-	-	10	10	6.180	0.618
CONAM INSPECTION	12-16559-01	51	58	45	53	24	10	11	3	2	-	-	-	-	257	206	81.125	0.394
CONNELL LIMITED PARTNERSHIP	35-13735-01	2	-	-	1	-	-	-	-	-	-	-	-	-	3	1	0.250	0.250
CONSOLIDATED NDE	29-21452-01	19	7	20	20	20	13	18	-	-	-	-	-	-	117	98	58.328	0.595
CONSTRUCTION ENGINEERING CONS.	37-18456-01	9	18	6	1	-	-	-	-	-	-	-	-	-	34	25	1.609	0.064
CONSUMERS ENERGY CO./NON-DEST TE	21-08606-03	5	5	4	5	2	-	-	-	-	-	-	-	-	21	16	3.675	0.230
CRAMER & LINDELL ENGINEERS, INC.	06-20794-01	12	11	11	1	-	-	-	-	-	-	-	-	-	35	23	2.530	0.110
CTI ALASKA, INC.	50-19202-01	7	5	3	1	1	-	-	-	-	-	-	-	-	17	10	1.725	0.173

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CY 1998

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		No Meas. Exposure	Meas. <0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	2.00-3.00	3.00-4.00	4.00-5.00	5.00-6.00	6.00-12.00	>12.0				
INDUSTRIAL RADIOGRAPHY - MULTIPLE LOCATION - 03320 Continued																		
CTL - ASTROTECH DIVISION	37-09928-01	5	4	3	1	-	-	-	-	-	-	-	-	-	13	8	0.988	0.124
DEPARTMENT OF THE NAVY	45-23645-01NA	186	145	10	3	-	-	-	-	-	-	-	-	-	344	158	4.317	0.027
DIAMOND H TESTING COMPANY	11-27316-01	1	10	2	4	2	-	3	-	-	-	-	-	-	22	21	7.506	0.357
EASTERN TESTING & INSPECTION, INC.	29-09814-01	1	3	2	1	1	-	-	-	-	-	-	-	-	8	7	1.510	0.216
EDWARDS PIPELINE TESTING, INC.	35-23193-01	4	22	38	62	38	15	29	1	-	-	-	-	-	209	205	**105.692**	0.516
EG&G FLORIDA, INC.	FL-1219-1	8	25	-	-	-	-	-	-	-	-	-	-	-	33	25	0.069	0.003
ELECTRIC BOAT CORPORATION	06-01781-08	-	18	11	4	-	-	-	-	-	-	-	-	-	33	33	3.728	0.113
ELITE INSPECTION, INC.	13-26712-01	-	3	3	3	-	1	9	1	-	-	-	-	-	20	20	17.410	0.871
FROEHLING & ROBERTSON, INC.	45-08890-01	6	8	2	-	-	-	-	-	-	-	-	-	-	16	10	0.671	0.067
G.E. INSPECTION SERVICES, INC.	39-24888-01	2	7	4	7	3	3	4	1	-	-	-	-	-	31	29	16.290	0.562
GENERAL TESTING & INSP. CO.	34-09037-01	-	1	2	1	1	-	1	-	-	-	-	-	-	6	6	2.970	0.495
GLITSCH FIELD SERVICES/NDE,INC.	34-14071-01	11	12	6	9	-	-	2	-	-	-	-	-		40	29	7.210	0.249
GLOBE X-RAY SERVICES INC.	35-15194-01	2	5	7	12	7	2	15	3	-	-	-	-	-	53	51	39.822	0.781
GREAT LAKES TESTING, INC.	48-26484-01	1	5	2	4	-	3	2	-	-	-	-	-	-	17	16	7.333	0.458
GRINNELL CORPORATION	38-28750-01	2	3	1	-	-	-	-	-	-	-	-	-	-	6	4	0.280	0.070
H&G INSPECTION CO., INC.	42-26838-01	-	1	2	1	1	2	3	-	-	-	-	-	-	10	10	7.650	0.765
H. R. INSPECTION SERVICES INC.	15-06209-01	-	-	2	-	-	1	4	-	-	-	-	-	-	7	7	7.230	1.033
HIGH MOUNTAIN INSPECTION SERVICES	49-26808-02	5	2	3	3	4	6	16	4	-	-	-	-	-	43	38	41.064	1.081
HUNTINGTON TESTING & TECH.	47-23076-01	-	5	5	6	3	-	6	3	1	-	-	-	-	29	29	25.170	0.868
INDUSTRIAL NDT SERVICES DIVISION	13-06147-04	9	7	-	-	1	-	-	-	-	-	-	-	-	17	8	0.914	0.114
INSPECTION MANAGEMENT CORP.	35-26824-01	-	1	2	5	-	2	4	2	1	1	-	-	-	18	18	22.390	1.244
INSPECTION TECH/PSI	24-26628-01	2	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-
INTERMOUNTAIN TESTING CO.	05-07872-01	1	2	1	-	4	3	6	2	1	-	-	-	-	20	19	22.406	1.179
INTERNATIONAL RADIOGRAPHY & INSP.	35-30246-01	1	6	5	5	3	2	7	4	3	2	-	1	-	39	38	56.634	1.490
JAN X-RAY SERVICES, INC.	21-16560-01	2	13	14	11	15	9	14	1	1	-	-	-	-	80	78	47.400	0.608
LAW ENG. & ENV. SVCS./SAM-SON INSP. & TE	34-25898-01	3	6	3	1	1	1	1	1	-	-	-	-	-	17	14	5.600	0.400
LONGVIEW INSPECTION, INC.	45-25279-01	-	6	3	2	-	-	5	-	-	-	-	-	-	16	16	6.390	0.587
LONGVIEW INSPECTION, INC.	45-27593-01	8	12	10	17	10	7	14	4	-	-	-	-	-	82	74	48.275	0.652
LUCIUS PITKIN	29-27816-01	8	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-
MARYLAND QC LABORATORIES	19-28683-01	6	8	4	5	1	-	-	-	-	-	-	-	-	24	18	3.330	0.185
MASSACHUSETTS MATERIALS RES.	07-01173-03	1	-	-	2	-	-	1	-	-	-		-	-	4	3	2.040	0.680

NOTE: The data values shown bolded and in boxes represent the highest value in each category.

APPENDIX A

Annual TEDE for Non-Reactor NRC Licensees
CY 1998

PROGRAM CODE - LICENSEE NAME	LICENSE#	Number of Individuals with Whole Body Doses in the Ranges (rems)													Total Number Monitored	Number With Meas. Dose	Total Collective TEDE (Person-Rem)	Average Meas. TEDE (Rems)
		No Meas. Exposure	Meas. <0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	2.00-3.00	3.00-4.00	4.00-5.00	5.00-6.00	6.00-12.00	>12.0				
INDUSTRIAL RADIOGRAPHY - MULTIPLE LOCATION - 03320 Continued																		
MATERIAL TESTING LABS, INC.	45-17151-01	3	3	1	-	-	-	-	-	-	-	-	-	-	7	4	0.350	0.088
MATTINGLY TESTING SERVICES, INC.	25-21479-01	1	3	1	-	4	3	2	-	-	-	-	-	-	14	13	7.843	0.603
MAXIM TECHNOLOGIES, INC.	22-01376-02	2	8	6	6	3	4	7	-	-	-	-	-	-	36	34	18.370	0.540
MET-CHEM TESTING LABS., INC.	43-27362-01	1	10	1	4	-	2	2	-	-	-	-	-	-	20	19	6.457	0.340
MID AMERICAN INSPECTION SERV, INC	21-26060-01	2	3	3	6	3	5	4	1	-	-	-	-	-	27	25	16.780	0.671
MIDWEST INDUSTRIAL X-RAY, INC.	33-27427-01	-	3	2	-	3	2	4	1	-	1	-	-	-	16	16	17.220	1.076
MIDWEST INSPECTION SERVICES	35-27005-01	2	4	5	3	4	8	14	10	5	3	-	-	-	58	56	85.326	1.524
MONTANA X-RAY, INC.	25-21134-01	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
MQS INSPECTION, INC.	12-00622-07	144	76	48	45	30	14	23	4	-	-	-	-	-	**384**	**240**	94.980	0.396
NAVY, DEPARTMENT OF THE*	45-23645-01	186	145	10	3	-	-	-	4	-	-	-	-	-	344	158	4.317	0.027
NDT SERVICES, INC.	52-19438-01	6	1	1	-	-	-	-	-	-	-	-	-	-	8	2	0.240	0.120
NDT SPECIALISTS, INC.	48-25917-01	1	1	-	1	3	-	2	-	-	-	-	-	-	8	7	5.430	0.776
NEWPORT NEWS SHIPBUILDING	45-09428-02	-	19	9	7	-	-	-	-	-	-	-	-	-	35	35	4.277	0.122
NOOTER CORP.	24-03783-01	7	10	1	1	-	-	-	-	-	-	-	-	-	19	12	0.890	0.074
NORFOLK SHIPBUILDING CO.	45-12042-01	2	8	2	-	-	-	-	-	-	-	-	-		12	10	0.417	0.042
NORTHWEST INSP. & TESTING SERV. INC.	11-27394-01	-	-	1	1	-	-	-	-	-	-	-	-	-	2	2	0.579	0.290
NOVA DATA TESTING LABS, INC.	45-24872-01	-	3	5	1	2	-	-	-	-	-	-	-	-	11	11	2.450	0.223
PITT-DES MOINES, INC.	37-27878-01	12	5	2	2	1	-	-	-	-	-	-	-	-	22	10	1.930	0.193
PRECISION COMPONENTS CORP.	37-16280-01	29	12	1	4	-	-	-	-	-	-	-	-	-	46	17	1.864	0.110
PRIME NDT SERVICES, INC.	37-23370-01	-	3	4	5	1	2	8	1	-	-	-	-	-	24	24	18.840	0.785
PROFESSIONAL SERVICE INDUSTRIES	12-16941-03	6	5	7	7	7	5	3	2	-	-	-	-	-	42	36	22.000	0.611
PROFESSIONAL WELDING ASSOC., INC.	48-25806-01	4	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-
PROGRESS SERV., INC.	34-19592-01	6	2	1	1	-	-	-	-	-	-	-	-	-	10	4	0.580	0.145
PSI ENERGY, INC.	13-15544-06	4	-	1	-	-	-	-	-	-	-	-	-	-	5	1	0.110	0.110
Q. C. LABORATORIES, INC.	09-11579-03	4	7	4	3	2	-	-	-	-	-	-	-	-	20	16	3.210	0.201
QSL INSPECTION, INC.	37-28085-01	3	6	6	7	6	5	13	4	2	-	-	-	-	52	49	45.605	0.931
QUALITY ENERGY SERV. & TESTS CORP.	35-26815-01	3	2	-	2	2	6	3	6	-	-	-	-	-	24	21	26.636	1.268
QUALITY INSPECTION & TESTING	50-29038-01	-	-	3	2	1	-	-	2	-	-	-	-	-	8	8	6.530	0.816
RAYTHEON ENGINEERS & CONST.	42-30336-01	3	5	1	1	1	-	-	-	-	-	-	-	-	11	8	1.110	0.139
RIVEST TESTING	35-27438-01	1	5	-	-	1	1	-	-	-	-	-	-	-	8	7	1.595	0.228

* Reported under program code 03613 as a multi-site, multi-regional R&D broad scope licensee.

NOTE: The data values shown bolded and in boxes represent the highest value in each category.

APPENDIX A

Annual TEDE for Non-Reactor NRC Licensees
CY 1998

PROGRAM CODE - LICENSEE NAME	LICENSE#	Number of Individuals with Whole Body Doses in the Ranges (rems)													Total Number Monitored	Number With Meas. Dose	Total Collective TEDE (Person-Rem)	Average Meas. TEDE (Rems)
		No Meas. Exposure	Meas. <0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	2.00-3.00	3.00-4.00	4.00-5.00	5.00-6.00	6.00-12.00	>12.0				
INDUSTRIAL RADIOGRAPHY - MULTIPLE LOCATION - 03320 Continued																		
SGS INDUSTRIAL SERVICES	04-29067-02	15	10	6	8	4	4	2	-	-	-	-	-	-	49	34	13.695	0.403
S.K. MCBRYDE, INC.	32-25137-01	2	2	1	1	-	-	-	-	-	-	-	-	-	6	4	0.640	0.160
SOUTHWEST X-RAY CORPORATION	49-27434-01	3	2	4	5	5	2	7	1	1	-	-	-	-	30	27	23.890	0.885
SPEC CONSULTANTS, INC.	37-27891-01	6	13	2	2	3	1	-	-	-	-	-	-	-	27	21	4.520	0.215
ST. LOUIS TESTING LABS., INC.	24-00188-02	3	3	1	1	2	2	1	-	-	-	-	-	-	13	10	4.846	0.485
TECHNICAL WELDING LAB, INC.	42-25214-01	6	6	8	9	6	7	17	11	10	4	2	-	-	86	80	123.840	1.548
TEI ANALYTICAL SERVICES, INC.	37-28004-01	4	7	7	10	6	3	5	3	1	-	-	-	-	46	42	30.080	0.716
TENNESSEE VALLEY AUTHORITY	41-06832-06	7	4	3	5	-	-	-	-	-	-	-	-	-	19	12	2.457	0.250
TESTING INST. OF ALASKA, INC.	50-17446-01	1	5	2	-	-	-	2	-	1	-	-	-	-	11	10	6.750	0.675
TESTING TECHNOLOGIES, INC.	45-25007-01	10	6	3	7	3	3	3	-	-	-	-	-	-	35	25	11.389	0.456
TESTMASTER INSPECTION CO.,INC.	34-24872-01	-	1	1	1	2	1	2	-	-	-	-	-	-	8	8	5.585	0.698
THERMAL ENGINEERING, INT'L.	24-19500-01	5	-	-	-	1	-	-	-	-	-	-	-	-	5	-	-	-
TRI STATE INSPECTION	37-19640-01	5	4	3	2	1	1	1	-	-	-	-	-	-	17	12	4.695	0.391
TULSA GAMMA RAY, INC.	35-17178-01	2	13	12	17	6	6	20	12	1	-	1	-	-	90	88	82.340	0.936
TWIN PORTS TESTING, INC.	48-23476-01	10	1	3	3	1	2	1	-	-	-	-	-	-	21	11	5.515	0.501
U.S. INSPECTIONS SERVICES	34-06943-01	8	15	7	7	6	6	2	1	-	-	-	-	-	52	44	18.998	0.432
VALLEY INDUSTRIAL X-RAY	04-29076-01	5	-	10	11	4	6	14	4	-	-	-	-	-	54	49	44.700	0.912
VALLEY INSPECTION SERVICE, INC.	37-28385-01	-	1	-	-	2	-	2	2	-	-	-	-	-	7	7	8.780	1.254
VOITH HYDRO, INC.	37-16280-03	7	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-
WESTERN X-RAY COMPANY	35-19993-01	-	2	4	2	2	-	11	2	-	-	-	-	-	23	23	22.880	0.995
WESTINGHOUSE ELECTRIC CORP.	37-05809-02	50	22	-	-	-	-	-	-	-	-	-	-	-	72	22	0.569	0.026
WOS TESTING COMPANY, INC.	48-26385-01	1	3	1	2	-	-	-	1	-	-	-	-	-	8	7	3.092	0.442
X-R-I TESTING	21-05472-01	114	22	5	1	1	-	2	-	-	-	-	-	-	145	31	6.665	0.215
Total	**115**	**1,216**	**1,037**	**560**	**584**	**329**	**236**	**435**	**118**	**36**	**14**	**4**	**1**	**1**	**4,571**	**3,355**	**1,850.920**	**0.552**

NOTE: The data values shown bolded and in boxes represent the highest value in each category.

APPENDIX A

Annual TEDE for Non-Reactor NRC Licensees
CY 1998

PROGRAM CODE - LICENSEE NAME	LICENSE#	Number of Individuals with Whole Body Doses in the Ranges (rems)													Total Number Monitored	Number With Meas. Dose	Total Collective TEDE (Person-Rem)	Average Meas. TEDE (Rems)
		No Meas. Exposure	Meas. <0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	2.00-3.00	3.00-4.00	4.00-5.00	5.00-6.00	6.00-12.00	>12.0				
FUEL FABRICATION FACILITIES - 21210																		
BWX TECHNOLOGIES, INC.	SNM-0042	14	42	41	58	58	25	53	7	-	-	-	-	-	298	284	175.195	0.617
COMBUSTION ENGINEERING INC.	SNM-0033	44	56	18	27	12	14	40	15	4	-	-	-	-	230	186	139.059	**0.748**
FRAMATOME COGEMA FUELS	SNM-1168	260	200	27	19	3	5	2	-	-	-	-	-	-	516	256	25.273	0.099
GE NUCLEAR ENERGY	SNM-1097	215	440	176	141	68	35	11	-	-	-	-	-	-	**1,086**	**871**	174.185	0.200
GENERAL ATOMICS	SNM-0696	482	46	13	1	-	-	-	-	-	-	-	-	-	542	60	3.582	0.060
NUCLEAR FUEL SERVICES, INC.	SNM-0124	126	387	66	45	16	13	7	-	-	-	-	-	-	660	534	64.951	0.122
SIEMENS POWER CORP. NUCLEAR DIV.	SNM-1227	171	276	104	75	33	34	23	-	-	-	-	-	-	716	545	131.711	0.242
WESTINGHOUSE ELECTRIC COMPANY	SNM-1107	46	135	82	70	35	44	68	6	-	-	-	-	-	486	440	**212.288**	0.482
Total	**8**	**1,358**	**1,582**	**527**	**436**	**225**	**170**	**204**	**28**	**4**	**-**	**-**	**-**	**-**	**4,534**	**3,176**	**926.244**	**0.292**
URANIUM ENRICHMENT PLANTS - 21200																		
USEC - Paducah	GDP-1	2,832	179	35	7	-	-	-	-	-	-	-	-	-	3,053	**221**	**13.462**	**0.061**
USEC - Portsmouth	GDP-2	2,881	176	39	1	-	-	-	-	-	-	-	-	-	**3,097**	216	10.159	0.047
Total	**2**	**5,713**	**355**	**74**	**8**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**6,150**	**437**	**23.621**	**0.054**
INDEPENDENT SPENT FUEL STORAGE INSTALLATION - 23200																		
GENERAL ELECTRIC - MORRIS OPS	SNM-2500	32	9	10	2	-	-	-	-	-	-	-	-	-	**53**	**21**	**2.561**	**0.122**
Total	**1**	**32**	**9**	**10**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**53**	**21**	**2.561**	**0.122**

NOTE: The data values shown bolded and in boxes represent the highest value in each category.

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Appendix B

ANNUAL WHOLE BODY DOSES AT LICENSED NUCLEAR POWER FACILITIES

1998

APPENDIX B

Annual Whole Body Doses at Licensed Nuclear Power Facilities
CY 1998

PLANT NAME	TYPE	Number of Individuals with Whole Body Doses in the Ranges (rems)														Total Number Monitored	Number With Meas. Dose	Total Collective TEDE (Person-Rem)
		No Meas. Exposure	Meas. <0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	2.00-3.00	3.00-4.00	4.00-5.00	5.00-6.00	6.00-7.00	7.00-12.00	>12.0			
ARKANSAS 1,2	PWR	1,527	750	310	137	31	14	7	-	-	-	-	-	-	-	2,776	1,249	166.599
BEAVER VALLEY 1,2	PWR	1,131	490	183	21	4	-	2	-	-	-	-	-	-	-	1,831	700	59.311
BRAIDWOOD 1,2	PWR	1,633	991	564	264	41	8	1	-	-	-	-	-	-	-	3,502	1,869	259.236
BROWNS FERRY 1,2,3	BWR	1,404	691	361	330	119	42	32	2	-	-	-	-	-	-	2,981	1,577	360.676
BRUNSWICK 1,2	BWR	1,136	1,048	461	269	118	59	50	-	-	-	-	-	-	-	3,141	2,005	395.526
BYRON 1,2	PWR	1,655	943	489	300	62	10	5	-	-	-	-	-	-	-	3,464	1,809	275.221
CALLAWAY 1	PWR	727	354	290	182	68	28	7	-	-	-	-	-	-	-	1,656	929	200.729
CALVERT CLIFFS 1,2	PWR	1,588	521	268	159	58	25	11	-	-	-	-	-	-	-	2,630	1,042	186.887
CATAWBA 1,2	PWR	1,742	557	365	158	35	8	-	-	-	-	-	-	-	-	2,865	1,123	161.703
CLINTON	BWR	1,867	418	240	156	37	12	3	-	-	-	-	-	-	-	2,733	866	144.140
COMANCHE PEAK 1,2	PWR	1,233	453	224	143	62	49	35	1	-	-	-	-	-	-	2,200	967	232.026
COOK 1,2	PWR	1,925	876	179	63	33	3	1	-	-	-	-	-	-	-	3,080	1,155	104.638
COOPER STATION	BWR	926	521	213	144	56	26	17	-	-	-	-	-	-	-	1,903	977	181.858
CRYSTAL RIVER 3	PWR	1,155	253	53	7	-	-	-	-	-	-	-	-	-	-	1,468	313	19.298
DAVIS-BESSE	PWR	664	489	273	168	37	10	3	-	-	-	-	-	-	-	1,644	980	155.269
DIABLO CANYON 1,2	PWR	1,464	778	344	129	43	12	7	-	-	-	-	-	-	-	2,777	1,313	173.238
DRESDEN 2,3	BWR	1,459	1,178	543	348	170	64	8	-	-	-	-	-	-	-	3,770	2,311	426.918
DUANE ARNOLD	BWR	753	433	234	212	90	31	19	-	-	-	-	-	-	-	1,772	1,019	236.693
FARLEY 1,2	PWR	857	476	322	289	146	77	61	9	-	-	-	-	-	-	2,237	1,380	431.821
FERMI 2	BWR	1,354	739	344	194	80	5	-	-	-	-	-	-	-	-	2,716	1,362	207.593
FITZPATRICK	BWR	989	881	390	298	135	56	21	-	-	-	-	-	-	-	2,770	1,781	357.826
FORT CALHOUN	PWR	542	291	179	144	109	45	20	-	-	-	-	-	-	-	1,330	788	223.847
GINNA	PWR	734	113	34	12	1	1	-	-	-	-	-	-	-	-	895	161	14.892
GRAND GULF	BWR	1,036	669	345	216	111	38	31	-	-	-	-	-	-	-	2,446	1,410	303.695
HARRIS	PWR	941	519	246	115	47	3	1	-	-	-	-	-	-	-	1,872	931	133.497
HATCH 1,2	BWR	950	778	385	275	124	30	17	1	-	-	-	-	-	-	2,560	1,610	320.469
HOPE CREEK 1	BWR	1,340	431	125	57	7	-	-	-	-	-	-	-	-	-	1,960	620	54.816
INDIAN POINT 2	PWR	774	544	276	152	75	44	61	2	-	-	-	-	-	-	1,928	1,154	289.600
INDIAN POINT 3	PWR	1,036	166	36	11	-	-	-	-	-	-	-	-	-	-	1,249	213	14.774
KEWAUNEE	PWR	313	169	82	86	27	8	12	-	-	-	-	-	-	-	697	384	88.205
LASALLE 1,2	BWR	2,285	1,047	444	377	131	65	35	-	-	-	-	-	-	-	4,384	2,099	422.249
LIMERICK 1,2	BWR	2,121	1,022	365	282	98	40	44	3	-	-	-	-	-	-	3,975	1,854	357.139
MCGUIRE 1,2	PWR	1,581	578	310	113	34	9	1	-	-	-	-	-	-	-	2,626	1,045	142.245
MILLSTONE POINT 1	BWR	488	256	65	23	3	-	-	-	-	-	-	-	-	-	835	347	12.741
MILLSTONE POINT 2,3	PWR	1,659	868	219	79	11	2	-	-	-	-	-	-	-	-	2,838	1,179	112.543
MONTICELLO	BWR	516	258	120	134	83	46	33	-	-	-	-	-	-	-	1,190	674	209.137
NINE MILE POINT 1,2	BWR	1,332	768	448	338	104	50	36	-	-	-	-	-	-	-	3,076	1,744	378.484
NORTH ANNA 1,2	PWR	1,362	553	313	202	69	26	31	7	-	-	-	-	-	-	2,563	1,201	265.922

APPENDIX B

Annual Whole Body Doses at Licensed Nuclear Power Facilities
CY 1998

PLANT NAME	TYPE	Number of Individuals with Whole Body Doses in the Ranges (rems)														Total Number Monitored	Number With Meas. Dose	Total Collective TEDE (Person-Rem)
		No Meas. Exposure	Meas. <0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	2.00-3.00	3.00-4.00	4.00-5.00	5.00-6.00	6.00-7.00	7.00-12.00	>12.0			
OCONEE 1, 2, 3	PWR	2,045	723	502	283	94	48	45	-	-	-	-	-	-	-	3,740	1,695	366.028
OYSTER CREEK	BWR	547	695	295	222	115	48	33	-	-	-	-	-	-	-	1,955	1,408	308.323
PALISADES	PWR	657	372	235	173	51	31	33	-	-	-	-	-	-	-	1,552	895	216.563
PALO VERDE 1, 2, 3	PWR	1,268	865	296	163	64	18	4	-	-	-	-	-	-	-	2,678	1,410	192.425
PEACH BOTTOM 2, 3	BWR	1,464	973	473	261	95	64	36	1	-	-	-	-	-	-	3,367	1,903	366.040
PERRY	BWR	799	210	142	33	-	-	-	-	-	-	-	-	-	-	1,184	385	41.945
PILGRIM	BWR	358	309	117	95	8	-	1	-	-	-	-	-	-	-	888	530	71.446
POINT BEACH 1, 2	PWR	828	463	187	128	63	29	11	-	-	-	-	-	-	-	1,709	881	169.253
PRAIRIE ISLAND 1, 2	PWR	493	273	144	105	33	17	10	-	-	-	-	-	-	-	1,075	582	116.649
QUAD CITIES 1, 2	BWR	1,089	955	394	279	169	133	241	6	-	-	-	-	-	-	3,266	2,177	760.596
RIVER BEND 1	BWR	765	283	113	56	11	3	-	-	-	-	-	-	-	-	1,231	466	57.749
ROBINSON 2	PWR	687	444	293	186	39	13	3	-	-	-	-	-	-	-	1,665	978	170.476
SALEM 1, 2	PWR	886	285	82	37	4	-	-	-	-	-	-	-	-	-	1,294	408	41.100
SAN ONOFRE 2, 3	PWR	3,090	587	246	148	71	26	13	-	-	-	-	-	-	-	4,181	1,091	195.600
SEABROOK	PWR	718	518	32	9	-	-	-	-	-	-	-	-	-	-	1,277	559	18.509
SEQUOYAH 1, 2	PWR	1,217	720	357	245	99	16	3	-	-	-	-	-	-	-	2,657	1,440	255.295
SOUTH TEXAS 1, 2	PWR	1,446	662	273	154	50	19	13	-	-	-	-	-	-	-	2,617	1,171	183.977
ST. LUCIE 1, 2	PWR	1,358	754	290	96	10	11	9	-	-	-	-	-	-	-	2,528	1,170	134.459
SUMMER 1	PWR	697	254	26	5	-	-	-	-	-	-	-	-	-	-	982	285	13.513
SURRY 1, 2	PWR	1,260	638	269	183	48	13	14	-	-	-	-	-	-	-	2,425	1,165	188.959
SUSQUEHANNA 1, 2	BWR	1,658	691	380	277	136	66	25	-	-	-	-	-	-	-	3,233	1,575	360.778
THREE MILE ISLAND 1	PWR	483	247	27	6	-	-	-	-	-	-	-	-	-	-	763	280	16.722
TURKEY POINT 3, 4	PWR	1,057	517	345	134	37	9	3	-	-	-	-	-	-	-	2,102	1,045	156.415
VERMONT YANKEE	BWR	1,068	299	370	189	69	14	3	-	-	-	-	-	-	-	2,012	944	199.399
VOGTLE 1,2	PWR	946	487	297	141	62	7	-	-	-	-	-	-	-	-	1,940	994	162.210
WASHINGTON NUCLEAR 2	BWR	1,015	524	256	256	140	29	15	-	-	-	-	-	-	-	2,235	1,220	286.020
WATERFORD 3	PWR	896	190	77	13	1	1	-	-	-	-	-	-	-	-	1,178	282	24.032
WATTS BAR 1	PWR	1,254	76	4	-	-	-	-	-	-	-	-	-	-	-	1,334	80	3.042
WOLF CREEK 1	PWR	832	155	25	3	1	-	-	-	-	-	-	-	-	-	1,016	184	10.382
TOTALS: 36 BWRs		**28,719**	**16,077**	**7,623**	**5,321**	**2,209**	**921**	**700**	**13**	**-**	**-**	**-**	**-**	**-**	**-**	**61,583**	**32,864**	**6,822.256**
TOTALS: 69 PWRs		**48,361**	**20,962**	**9,566**	**5,146**	**1,721**	**641**	**429**	**22**	**-**	**-**	**-**	**-**	**-**	**-**	**86,849**	**38,487**	**6,347.110**
TOTALS: 105 LWRs		**77,080**	**37,039**	**17,189**	**10,467**	**3,930**	**1,562**	**1,129**	**35**	**-**	**-**	**-**	**-**	**-**	**-**	**148,424**	**71,344**	**13,169.366**

APPENDIX B

Annual Whole Body Doses at Licensed Nuclear Power Facilities
CY 1998

PLANT NAME	TYPE	Number of Individuals with Whole Body Doses in the Ranges (rems)														Total Number Monitored	Number With Meas. Dose	Total Collective TEDE (Person-Rem)
		No Meas. Exposure	Meas. <0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	2.00-3.00	3.00-4.00	4.00-5.00	5.00-6.00	6.00-7.00	7.00-12.00	>12.0			
REACTORS NOT YET IN COMMERCIAL OPERATION																		
WATTS BAR 2	PWR	Reported with Watts Bar 1																
REACTORS NO LONGER IN COMMERCIAL OPERATION																		
BIG ROCK POINT	BWR	213	225	75	54	43	16	19	-	-	-	-	-	-	-	645	432	104.130
HADDAM NECK	PWR	741	227	91	45	18	19	23	-	-	-	-	-	-	-	1,164	423	93.743
HUMBOLDT BAY	BWR	254	37	1	-	-	-	-	-	-	-	-	-	-	-	292	38	0.929
LACROSSE	BWR	41	23	4	-	-	-	-	-	-	-	-	-	-	-	68	27	1.530
MAINE YANKEE	PWR	654	223	62	55	28	15	36	17	2	-	-	-	-	-	1,092	438	163.008
RANCHO SECO	PWR	270	55	4	2	-	-	-	-	-	-	-	-	-	-	331	61	2.661
THREE MILE ISLAND 2	PWR	182	93	10	2	-	-	-	-	-	-	-	-	-	-	287	105	0.697
TROJAN	PWR	333	137	77	51	18	-	-	-	-	-	-	-	-	-	616	283	46.417
YANKEE-ROWE	PWR	681	117	8	-	-	-	-	-	-	-	-	-	-	-	806	125	4.603
ZION 1, 2	PWR	955	206	36	4	-	-	-	-	-	-	-	-	-	-	1,201	246	12.417
REACTORS NO LONGER IN COMMERCIAL OPERATION, REPORTED WITH OTHER UNITS																		
BROWNS FERRY 1	BWR	Reported with Browns Ferry 2, 3 and still included in the count of operating reactors, although Unit 1 has been on Administrative Hold since June, 1985.																
DRESDEN 1	BWR	Reported with Dresden 2, 3																
INDIAN POINT 1	PWR	Reported with Indian Point 2																
SAN ONOFRE 1	PWR	Reported with San Onofre 2, 3																
TOTAL REPORTING: 11		**4,324**	**1,343**	**368**	**213**	**107**	**50**	**78**	**17**	**2**	**-**	**-**	**-**	**-**	**-**	**6,502**	**2,178**	**430.135**

Appendix C*

DOSE PERFORMANCE INDICATORS BY REACTOR SITE

1969 - 1998

* A discussion of the methods used to collect and calculate the information contained in this Appendix is given in Section 2.1.

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
ARKANSAS 1, 2	1975	588.0	76.5	147	21	0.14	0.0
Docket 50-313, 50-368;	1976	464.6	56.6	476	289	0.61	0.6
DPR-51; NPF-6	1977	610.3	76.8	601	256	0.43	0.4
1st commercial	1978	627.2	77.5	722	189	0.26	0.3
operation 12/74, 3/80	1979	397.0	55.3	1,321	369	0.28	0.9
Type - PWRs	1980	452.8	63.7	1,233	342	0.28	0.8
Capacity - 836, 858 MWe	1981	1,104.7	68.3	2,225	1,102	0.50	1.0
	1982	905.4	58.61,6	08	803	0.50	0.9
	1983	915.0	54.7	2,109	1,397	0.66	1.5
	1984	1,289.1	77.4	1,742	8060.46		0.6
	1985	1,192.3	73.61,26	2	286	0.23	0.2
	1986	1,070.3	66.9	2,135	1,141	0.53	1.1
	1987	1,366.1	88.9	1,123	382	0.34	0.3
	1988	1,070.3	69.4	2,421	1,387	0.57	1.3
	1989	1,066.3	72.0	2,063	711	0.34	0.7
	1990	1,351.9	84.2	2,493	762	0.31	0.6
	1991	1,515.8	88.4	2,064	351	0.17	0.2
	1992	1,352.1	77.4	3,114	8760.28		0.6
	1993	1,606.0	91.3	1,981	268	0.14	0.2
	1994	1,662.8	93.6	1,361	172	0.13	0.1
	1995	1,397.0	82.7	2,259	3860.17		0.3
	19961,596	.0	89.5	1,441	203	0.14	0.1
	1997	1,621.9	95.9	1,195	119	0.10	0.07
	1998	1,494.688.1		1,249	167	0.13	0.11
BEAVER VALLEY 1, 2	1977	355.657.0		331	878	0.26	0.2
Docket 50-334, 50-412;	1978	304.2	40.8	646	190	0.29	0.6
DPR-66, NPF-73	1979	221.0	40.0	704	132	0.19	0.6
1st commercial operation	1980	39.8	6.8	1,817	553	0.30	13.9
10/76, 11/87	1981	573.4	73.61,237		229	0.19	0.4
Type - PWRs	1982	326.7	41.6	1,755	599	0.34	1.8
Capacity - 810, 820	1983	561.2	68.2	1,485	772	0.52	1.4
	1984	576.7	71.8	1,393	504	0.36	0.9
	1985	717.7	91.9	619	60	0.10	0.1
	1986581.3		70.7	1,575	627	0.40	1.1
	1987	684.1	83.8	1,282	210	0.16	0.3
	1988	1,386.1	87.4	1,764	530	0.30	0.4
	1989	1,017.4	69.6	2,349	1,378	0.59	1.4
	1990	1,271.0	85.3	1,675	348	0.21	0.3
	1991	1,267.5	78.6	1,689	495	0.29	0.4
	1992	1,441.9	89.1	1,414	289	0.20	0.2
	1993	1,157.9	73.1	2,087	621	0.30	0.5
	1994	1,514.688.6		487	44	0.09	0.0
	1995	1,389.2	83.1	1,536453		0.29	0.3
	19961,26	9.0	76.5	1,688	449	0.27	0.4
	1997	1,159.3	72.1	1,391	3060.22		0.26
	1998	523.1	33.5	700	59	0.08	0.11
BIG ROCK POINT[1]	1969	48.1		165	136	0.82	2.8
Docket 50-155; DPR-6	1970	43.5		290	194	0.67	4.5
1st commercial operation 3/63	1971	44.4		260	184	0.71	4.1
Type - BWR	1972	43.5		195	181	0.93	4.2
Capacity - 67 MWe	1973	50.9		241	285	1.18	5.6
	1974	40.7	70.3	281	2760.98		6.8
	1975	35.1	59.8	300	180	0.60	5.1
	197629.5		50.1	488	289	0.59	9.8
	1977	43.673.4		465	334	0.72	7.7
	1978	48.5	77.9	285	175	0.61	3.6

[1] Big Rock Point was shut down in 9/97 and is no longer included in the count of commercial reactors.

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
BIG ROCK POINT	1979	13.0	23.5	623	455	0.73	35.0
(continued)	1980	48.9	79.0	599	354	0.59	7.2
	1981	56.9	90.6	479	160	0.33	2.8
	1982	43.670.8		521	328	0.63	7.5
	1983	42.3	71.0	493	263	0.53	6.2
	1984	50.3	78.6297		155	0.52	3.1
	1985	43.8	73.5	435	291	0.67	6.6
	19866	1.0	95.5	202	84	0.42	1.4
	1987	45.3	71.0	251	222	0.88	4.9
	1988	46.1	72.8	303	170	0.56	3.7
	1989	50.2	79.0	418	177	0.42	3.5
	1990	51.3	77.2	351	232	0.66	4.5
	1991	59.1	85.2	435	2260.52		3.8
	1992	32.7	54.5	496277		0.56	8.5
	1993	51.2	79.4	419	152	0.363.0	
	1994	49.5	75.3	310	119	0.38	2.4
	1995	62.2	95.0	205	54	0.26	0.9
	1997	22.4	54.1	258	55	0.21	2.46
	1998	0.0	0.0	866	144	0.17	---
BRAIDWOOD 1, 2	1989	1,381.8	75.4	1,460	296	0.20	0.2
Docket 50-456, 50-457;	1990	1,740.2	84.1	1,081	1860.17		0.1
NPF-72, NPF-77	1991	1,377.2	68.9	1,641	550	0.34	0.4
1st commercial operation	1992	1,885.9	89.0	1,059	228	0.22	0.1
7/88, 10/88	1993	1,899.3	86.9	1,043	273	0.26	0.1
Type - PWRs	1994	1,666.1	77.2	1,237	298	0.24	0.1
Capacity - 1100, 1100 MWe	1995	1,914.7	85.4	1,134	2360.21		0.1
	19961,854.9		82.1	1,356	334	0.25	0.2
	1997	1,863.3	85.4	1,693	321	0.19	0.17
	1998	1,971.9	88.9	1,869	259	0.14	0.13
BROWNS FERRY 1[2], 2, 3	1975	161.7	17.8	2,380	325	0.14	2.0
Docket 50-259, 50-260,	1976337.6		26.9	2,207	234	0.11	0.7
50-296	1977	1,327.5	73.7	1,858	863	0.46	0.7
DPR - 33, - 52, - 68	1978	1,992.1	73.5	2,3761,792		0.75	0.9
1st commercial operation	1979	2,393.0	79.1	2,689	1,667	0.62	0.7
8/74, 3/75, 3/77	1980	2,182.1	73.62,712		1,826	0.67	0.8
Type - BWRs	1981	2,132.9	69.5	3,379	2,380	0.70	1.1
Capacity - 0, 1065, 1118 MWe	1982	2,025.4	67.6	3,277	2,220	0.68	1.1
	1983	1,641.0	54.3	3,302	3,363	1.02	2.0
	1984	1,431.9	54.2	2,962	1,940	0.65	1.4
	1985	368.2	11.9	2,755	1,159	0.42	3.1
	19860.0		0.0	3,003	1,050	0.35	---
	1987	0.0	0.0	3,115	1,181	0.38	---
	1988	0.0	0.0	3,324	1,155	0.35	---
	1989	0.0	0.0	2,683	656	0.24	---
	1990	0.0	0.0	2,717	1,310	0.48	---
	1991	445.0	17.7	1,815	354	0.20	0.8
	1992	979.9	32.2	2,658	516	0.19	0.5
	1993	675.1	66.8	3,594	870	0.24	1.3
	1994	860.2	83.4	3,299	855	0.26	0.9
	1995	1,165.8	98.6	2,540	409	0.16	0.4
	19961,972.8		93.0	1,749	384	0.22	0.2
	1997	1,928.8	90.2	2,092	5160.25		0.27
	1998	1,961.9	87.7	1,577	361	0.23	0.18

[2] Browns Ferry 1 remains in the count of operating reactors, but was placed on Administrative Hold in June of 1985.

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
BRUNSWICK 1,2	1976	297.2	56.0	1,265	326	0.26	1.1
Docket 50-324, 50-325;	1977	291.1	55.7	1,512	1,120	0.74	3.8
DPR-62, -71	1978	1,173.1	83.7	1,458	1,004	0.69	0.9
1st commercial operation	1979	810.0	60.1	2,891	2,602	0.90	3.2
3/77, 11/75	1980	687.2	52.2	3,788	3,870	1.02	5.6
Type - BWRs	1981	925.2	56.9	3,854	2,638	0.68	2.9
Capacity - 820, 811 MWe	1982	540.3	50.3	4,957	3,792	0.767.0	
	1983	636.7	44.3	5,602	3,475	0.62	5.5
	1984	761.3	51.5	5,046	3,260	0.65	4.3
	1985	822.2	58.4	4,057	2,804	0.69	3.4
	1986	1,051.3	69.1	3,370	1,909	0.57	1.8
	1987	1,152.4	80.6	3,052	1,419	0.46	1.2
	1988	990.8	70.1	2,648	1,747	0.66	1.8
	1989	990.9	65.8	3,844	1,786	0.46	1.8
	1990	991.66	7.8	3,182	1,548	0.49	1.6
	1991	952.8	64.5	2,586	778	0.30	0.8
	1992	375.9	27.9	2,690	623	0.23	1.7
	1993	470.0	33.8	2,921	872	0.30	1.9
	1994	1,268.4	83.0	3,049	999	0.70	
	1995	1,411.7	92.9	2,657	683	0.26	0.5
	1996	1,26 1.1	85.9	2,784	716	0.26	0.6
	1997	1,474.0	94.1	2,212	411	0.19	0.28
	1998	1,521.0	94.3	2,005	3960.20		0.26
BYRON 1, 2	1986	894.5	88.6	1,081	76	0.07	0.1
Docket 50-454, 50-455;	1987	650.9	70.9	1,826	769	0.42	1.2
NPF-37, NPF-66	1988	1,534.7	86.3	1,222	459	0.38	0.3
1st commercial operation	1989	1,812.6	90.2	1,109	172	0.16	0.1
9/85, 8/87	1990	1,567.3	78.8	1,396	434	0.31	0.3
Type - PWRS	1991	1,816.3	89.9	1,077	268	0.25	0.1
Capacity - 1105, 1105 MWe	1992	1,888.4	90.1	1,021	199	0.19	0.1
	1993	1,785.6	83.5	1,370	432	0.32	0.2
	1994	1,953.3	90.7	962	280	0.29	0.1
	1995	1,900.6	85.5	1,107	306	0.28	0.2
	1996	1,758.4	79.3	1,610	455	0.28	0.3
	1997	1,856.7	86.6	1,546	241	0.16	0.13
	1998	1,869.8	85.9	1,809	275	0.15	0.15
CALLAWAY 1	1985	967.4	90.0	964	36	0.04	0.0
Docket 50-483; NPF-30	1986	86 5.2	81.3	1,052	225	0.21	0.3
1st commercial operation 12/84	1987	759.0	71.1	1,082	393	0.360.5	
Type - PWR	1988	1,069.2	93.4	353	27	0.08	0.0
Capacity - 1125 MWe	1989	1,000.3	85.4	1,055	283	0.27	0.3
	1990	960.7	84.1	1,134	442	0.39	0.5
	1991	1,193.1	99.7	280	21	0.07	0.0
	1992	967.5	83.0	1,133	336	0.30	0.3
	1993	1,002.9	86.4	1,126	225	0.20	0.2
	1994	1,196.4	100.0	191	14	0.07	0.0
	1995	989.6	84.7	1,062	187	0.18	0.2
	1996	1,066.0	90.5	980	248	0.25	0.2
	1997	1,022.2	100.0	248	12	0.05	0.01
	1998	972.2	91.3	929	201	0.22	0.21
CALVERT CLIFFS 1, 2	1976	753.4	95.2	507	74	0.15	0.1
Docket 50-317, 50-318;	1977	583.0	72.1	2,265	547	0.24	0.9
DPR-53, -69	1978	1,188.5	75.8	1,391	500	0.360.4	
1st commercial operation	1979	1,161.0	74.0	1,428	805	0.56	0.7
5/75, 4/77	1980	1,309.9	84.1	1,4966	77	0.45	0.5
Type - PWRs	1981	1,379.7	83.1	1,555	607	0.39	0.4
Capacity - 835, 840 MWe	1982	1,238.3	73.7	1,805	1,057	0.59	0.9
	1983	1,397.2	81.6	1,915	668	0.35	0.5
	1984	1,389.4	79.3	1,369	479	0.35	0.3

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
CALVERT CLIFFS 1, 2	1985	1,189.8	68.4	1,598	694	0.43	0.6
(continued)	19861,530.0		87.2	1,296	347	0.27	0.2
	1987	1,207.3	71.8	1,384	412	0.30	0.3
	1988	1,397.7	81.0	1,296291		0.22	0.2
	1989	333.620.1		1,786346		0.19	1.0
	1990	161.1	11.0	2,019	304	0.15	1.9
	1991	1,085.0	64.7	1,974	132	0.07	0.1
	1992	1,271.2	73.9	1,979	330	0.17	0.3
	1993	1,462.1	83.9	1,462	405	0.28	0.3
	1994	1,342.1	79.4	1,482	454	0.31	0.3
	1995	1,542.8	89.9	1,203	235	0.20	0.2
	19961,438.5		82.4	1,167	239	0.20	0.2
	1997	1,499.689.1		1,091	229	0.21	0.15
	1998	1,523.1	89.3	1,042	187	0.18	0.12
CATAWBA 1, 2	19866	38.9	49.9	1,724	286	0.17	0.4
Docket 50-413, 50-414;	1987	1,651.2	75.9	1,865	449	0.24	0.3
NPF-35, NPF-52	1988	1,675.2	77.2	2,009	556	0.28	0.3
1st commercial operation	1989	1,733.6	79.5	1,660	334	0.20	0.2
6/85, 8/86	1990	1,616.3	70.8	2,174	809	0.37	0.5
Type - PWR	1991	1,691.5	74.6	1,871	462	0.25	0.3
Capacity - 1129, 1129 MWe	1992	1,962.8	83.9	1,515	414	0.27	0.2
	1993	1,896.1	81.5	1,564	396	0.25	0.2
	1994	2,105.2	90.2	1,268	207	0.16	0.1
	1995	2,011.9	85.3	1,892	462	0.24	0.2
	19961,879.1		80.5	1,588	302	0.19	0.2
	1997	2,028.2	89.3	1,561	266	0.17	0.13
	1998	2,006.4	89.6	1,123	162	0.14	0.08
CLINTON	1988	701.3	84.2	769	130	0.17	0.2
Docket 50-461; NPF-62	1989	348.3	48.5	1,196372		0.31	1.1
1st commercial operation 11/87	1990	435.8	55.1	1,390	553	0.40	1.3
Type - BWR	1991	722.7	80.8	1,010	233	0.23	0.3
Capacity - 930 MWe	1992	589.7	68.6	1,195	431	0.36	0.7
	1993	701.5	79.61,253		498	0.40	0.7
	1994	883.3	94.8	409	63	0.15	0.0
	1995	731.1	83.0	1,182	3160.27		0.4
	1996	634.7	66.7	1,154	350	0.30	0.6
	1997	0.0	0.0	738	172	0.23	---
	1998	0.0	0.0	866	144	0.17	---
COMANCHE PEAK 1, 2	1991	644.4	82.2	985	148	0.15	0.2
Docket 50-445; NPF-87	1992	830.8	84.0	1,128	188	0.17	0.2
1st commercial operation	1993	853.8	81.2	945	109	0.12	0.1
8/90, 8/93	1994	1,750.0	93.7	970	90	0.09	0.1
Type - PWR	1995	2,022.692.5		951	179	0.19	0.1
Capacity - 1150, 1150 MWe	19961,804.8		81.4	1,462	288	0.20	0.2
	1997	2,002.4	93.4	870	1460.17		0.07
	1998	2,037.8	94.9	967	232	0.24	0.11
COOK 1, 2	1976807.4		83.1	395	116	0.29	0.1
Docket 5-315; DPR-58, -74	1977	573.0	76.1	802	300	0.37	0.5
1st commercial operation	1978	744.8	73.6778		336	0.43	0.5
8/75, 7/78	1979	1,373.0	65.3	1,445	718	0.50	0.5
Type - PWRs	1980	1,552.4	74.1	1,345	493	0.37	0.3
Capacity - 1000, 1060 MWe	1981	1,557.3	73.4	1,341	656	0.49	0.4
	1982	1,461.6	69.8	1,527	699	0.46	0.5
	1983	1,456.5	71.2	1,418	658	0.46	0.5
	1984	1,526.0	75.3	1,559	762	0.49	0.5
	1985	925.4	47.61,984		945	0.48	1.0
	19861,307.1		73.4	1,774	745	0.42	0.6
	1987	1,199.5	70.2	1,696	666	0.39	0.6

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
COOK 1, 2 (continued)	1988	1,160.4	63.5	2,266	867	0.38	0.7
	1989	1,433.1	72.8	1,575	493	0.31	0.3
	1990	1,318.5	67.9	1,851	580	0.31	0.4
	1991	1,837.4	90.2	815	69	0.08	0.0
	1992	760.9	50.8	1,954	492	0.25	0.6
	1993	1,927.7	98.5	587	44	0.07	0.0
	1994	1,105.2	65.2	1,748	479	0.27	0.4
	1995	1,656.0	82.1	1,310	203	0.15	0.1
	1996	1,938.9	92.7	1,114	214	0.19	0.1
	1997	1,189.7	59.7	1,864	550	0.30	0.46
	1998	0.0	0.0	1,155	105	0.09	---
COOPER STATION	1975	456.4	83.6	579	117	0.20	0.3
Docket 50-298; DPR-46	1976	433.3	75.5	763	350	0.46	0.8
1st commercial operation	1977	538.2	86.2	315	198	0.63	0.4
7/74	1978	576.0	91.0	297	158	0.53	0.3
Type - BWR	1979	591.0	87.6	426	221	0.52	0.4
Capacity - 764 MWe	1980	448.3	71.2	785	859	1.09	1.9
	1981	457.1	71.2	935	579	0.62	1.3
	1982	622.3	84.6	743	542	0.73	0.9
	1983	396.6	63.3	1,383	1,293	0.93	3.3
	1984	411.9	67.2	1,598	799	0.50	1.9
	1985	127.3	21.5	1,980	1,333	0.67	10.5
	1986	480.0	74.7	895	320	0.36	0.7
	1987	652.3	96.2	549	103	0.19	0.2
	1988	493.4	67.9	942	251	0.27	0.5
	1989	564.3	76.2	1,202	343	0.29	0.6
	1990	602.0	79.4	1,174	379	0.32	0.6
	1991	566.3	78.8	1,099	405	0.37	0.7
	1992	731.0	96.4	463	84	0.18	0.1
	1993	436.1	58.8	1,130	391	0.35	0.9
	1994	262.2	35.1	333	79	0.24	0.3
	1995	486.5	66.8	1,095	228	0.21	0.5
	1996	742.1	97.9	468	48	0.10	0.1
	1997	622.8	84.4	1,125	174	0.16	0.28
	1998	555.9	75.9	977	182	0.19	0.33
CRYSTAL RIVER 3	1978	311.5	41.4	643	321	0.50	1.0
Docket 50-302; DPR-72	1979	453.0	58.9	1,150	495	0.43	1.1
1st commercial operation 3/77	1980	404.1	53.2	1,053	625	0.59	1.5
Type - PWR	1981	490.4	62.2	1,120	408	0.36	0.8
Capacity - 818 MWe	1982	589.8	76.0	780	177	0.23	0.3
	1983	452.1	58.8	1,720	552	0.32	1.2
	1984	774.2	94.5	549	49	0.09	0.1
	1985	344.2	47.6	1,976	689	0.35	2.0
	1986	319.5	41.8	1,057	472	0.45	1.5
	1987	436.0	60.9	1,384	488	0.35	1.1
	1988	690.2	84.0	569	64	0.11	0.1
	1989	352.8	48.8	880	234	0.27	0.7
	1990	497.8	63.8	1,441	476	0.33	1.0
	1991	654.6	82.0	821	116	0.14	0.2
	1992	632.1	76.1	1,403	424	0.30	0.7
	1993	722.4	85.0	683	60	0.09	0.1
	1994	711.9	84.3	1,079	228	0.21	0.3
	1995	866.3	100.0	209	8	0.04	0.0
	1996	290.8	37.7	1,192	353	0.30	1.2
	1997	0.0	0.0	973	179	0.18	---
	1998	739.9	90.3	313	19	0.06	0.03

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
DAVIS-BESSE 1	1978	326.4	48.7	421	48	0.11	0.1
Docket 50-346; NPF-3	1979	381.0	67.0	304	30	0.10	0.1
1st commercial operation 7/78	1980	256.4	36.2	1,283	154	0.12	0.6
Type - PWR	1981	531.4	67.4	578	58	0.10	0.1
Capacity - 873 MWe	1982	390.8	51.5	1,350	164	0.12	0.4
	1983	592.1	73.0	718	80	0.11	0.1
	1984	518.5	62.5	1,088	177	0.16	0.3
	1985	238.3	31.2	718	71	0.10	0.3
	19863.3		1.3	981	124	0.13	37.6
	1987	618.0	89.6	625	47	0.08	0.1
	1988	144.1	27.1	1,183	307	0.262.1	
	1989	880.0	98.6404		38	0.09	0.0
	1990	500.0	56.7	1,377	489	0.36	1.0
	1991	703.681.8		1,000	216	0.22	0.3
	1992	915.2	100.0	287	19	0.07	0.0
	1993	729.5	83.4	1,244	348	0.28	0.5
	1994	768.4	88.0	861	144	0.17	0.2
	1995	920.4	100.0	2567		0.03	0.0
	1996775.8		85.3	949	167	0.18	0.2
	1997	820.0	94.0	213	10	0.05	0.01
	1998	699.8	83.2	980	155	0.16	0.22
DIABLO CANYON 1, 2	1986	641.5	80.6	1,260	304	0.24	0.5
Docket 50-275, 50-323;	1987	1,688.6	83.0	1,170	336	0.29	0.2
DPR-80, DPR-82	1988	1,386.1	67.6	1,826	877	0.48	0.6
1st commercial operation	1989	1,899.0	87.5	1,646	465	0.28	0.2
5/85, 3/86	1990	1,952.691.0		1,441	323	0.22	0.2
Type - PWRs	1991	1,809.683.8		2,040	546	0.27	0.3
Capacity - 1073, 1087 MWe	1992	1,995.7	90.9	1,850	459	0.25	0.2
	1993	2,008.691.4		1,508	281	0.19	0.1
	1994	1,832.683.3		2,317	590	0.26	0.3
	1995	1,950.3	90.0	1,615	286	0.18	0.1
	19962,003.6		90.7	1,462	176	0.12	0.1
	1997	1,948.7	92.7	1,331	219	0.17	0.09
	1998	1,955.1	92.8	1,313	173	0.13	0.09
DRESDEN 1[3] , 2, 3	1969	99.7			286		2.9
Docket 50-010, 50-237, 50-249;	1970	163.1			143		0.9
DPR-2, -19, -25	1971	394.5			715		1.8
1st commercial operation 7/60,	1972	1,243.7			728		0.6
6/70, 11/71	1973	1,112.2		1,341	939	0.70	0.8
Type - BWRs	1974	842.5	54.9	1,594	1,662	1.04	2.0
Capacity - 197, 772, 773 MWe	1975	708.1	54.62,310		3,423	1.48	4.8
	19761,127.2		80.8	1,746	1,680	0.96	1.5
	1977	1,132.9	77.0	1,862	1,694	0.91	1.5
	1978	1,242.2	79.5	1,9461,529		0.79	1.2
	1979	1,013.0	74.7	2,407	1,800	0.75	1.8
	1980	1,074.4	55.0	2,717	2,105	0.77	2.0
	1981	1,035.7	51.5	2,331	2,802	1.20	2.7
	1982	1,085.3	77.9	2,572	2,923	1.14	2.7
	1983	913.66	5.6	2,854	3,582	1.26	3.9
	1984	789.8	55.3	2,261	1,774	0.78	2.2
	1985	903.0	64.5	2,817	1,686	0.60	1.9
	1986	740.5	52.6	3,111	2,668	0.86	3.6
	1987	933.9	74.0	2,052	1,145	0.561.2	
	1988	1,014.7	75.8	2,414	1,409	0.58	1.4
	1989	1,184.2	83.1	2,259	1,131	0.50	1.0
	1990	1,107.8	76.6	2,235	1,400	0.63	1.3

[3] Dresden 1 has been shut down since 1978, and in 1985 it was decided that it would not be put in commercial operation again. Therefore, it is no longer included in the count of commercial reactors.

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
DRESDEN	1991	675.2	60.7	2,044	1,005	0.49	1.5
(continued)	1992	872.4	75.4	1,812	619	0.34	0.7
	1993	960.1	68.5	2,751	1,655	0.60	1.7
	1994	690.2	51.7	2,336	833	0.36	1.2
	1995	643.1	49.8	2,482	875	0.35	1.4
	19966	12.6	47.7	1,788	456	0.26	0.7
	1997	1,096.2	79.5	2,747	467	0.17	0.43
	1998	1,354.7	90.62,31	1	427	0.18	0.32
DUANE ARNOLD	1976305.2		78.0	350	105	0.30	0.3
Docket 50-331; DPR-49	1977	353.678.9		538	299	0.56	0.8
1st commercial operation 2/75	1978	149.2	33.2	1,112	974	0.88	6.5
Type - BWR	1979	352.0	78.0	757	275	0.360.8	
Capacity - 520 MWe	1980	339.1	73.3	1,108	671	0.61	2.0
	1981	277.7	69.8	1,286	790	0.61	2.8
	1982	278.5	74.7	524	229	0.44	0.8
	1983	283.0	62.9	1,468	1,135	0.77	4.0
	1984	329.4	72.9	611	189	0.31	0.6
	1985	236.2	53.8	1,414	1,112	0.79	4.7
	198636	5.5	82.0	476	187	0.39	0.5
	1987	308.4	64.7	1,094	667	0.61	2.2
	1988	386.5	75.2	1,136	614	0.54	1.6
	1989	388.5	79.0	425	194	0.460.5	
	1990	367.4	75.8	1,460	861	0.59	2.3
	1991	503.7	94.5	336202		0.60	0.4
	1992	416.5	81.9	1,043	502	0.48	1.2
	1993	393.4	79.5	1,043	407	0.39	1.0
	1994	498.694.0		493	120	0.24	0.2
	1995	452.5	83.8	1,129	357	0.32	0.8
	1996476	.8	90.7	1,093	270	0.25	0.6
	1997	474.4	94.4	352	63	0.18	0.13
	1998	438.3	86.6	1,019	237	0.23	0.54
FARLEY 1, 2	1978	713.8	86.5	527	108	0.20	0.2
Docket 50-348, 50-364;	1979	211.0	28.61,227		643	0.52	3.0
NPF-2, -8	1980	557.3	69.3	1,330	435	0.33	0.8
1st commercial operation	1981	310.2	41.4	1,331	512	0.38	1.7
12/77, 7/81	1982	1,271.5	79.2	1,453	484	0.33	0.4
Type - PWR	1983	1,356.5	83.0	1,938	1,021	0.53	0.8
Capacity - 822, 852 MWe	1984	1,447.0	86.6	2,046	902	0.44	0.6
	1985	1,368.2	81.1	2,551	799	0.31	0.6
	19861,409.4		83.8	2,314	858	0.37	0.6
	1987	1,369.7	84.7	1,871	598	0.32	0.4
	1988	1,567.7	92.3	1,840	552	0.30	0.4
	1989	1,402.9	84.62,206		749	0.34	0.5
	1990	1,464.0	86.7	1,700	457	0.27	0.3
	1991	1,464.0	88.1	1,645	648	0.39	0.4
	1992	1,331.7	81.8	2,018	805	0.40	0.6
	1993	1,455.5	88.3	1,284	333	0.260.2	
	1994	1,587.2	93.0	1,035	250	0.24	0.2
	1995	1,311.2	83.8	1,574	460	0.29	0.4
	19961,549.2		90.9	1,150	232	0.20	0.1
	1997	1,449.7	89.0	1,105	278	0.25	0.19
	1998	1,313.9	80.9	1,380	432	0.31	0.33
FERMI 2	1989	624.0	68.5	1,270	255	0.20	0.4
Docket 50-341; NPF-43	1990	848.2	84.7	462	83	0.18	0.1
1st commercial operation 1/88	1991	739.0	77.0	1,223	228	0.19	0.3
Type - BWR	1992	874.3	81.3	1,213	245	0.20	0.3
Capacity - 1098 MWe	1993	984.3	92.9	360	35	0.10	0.0
	1994	0.0	2.2	1,130	213	0.19	---
	1995	618.3	86.9	390	28	0.07	0.0

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
FERMI	1996577.5		69.1	1,402	157	0.11	0.3
(continued)	1997	637.0	66.6	623	49	0.08	0.08
	1998	815.8	79.9	1,362	208	0.15	0.25
FITZPATRICK	1976489.0		71.6	600	202	0.34	0.4
Docket 50-333; DPR-59	1977	460.5	68.4	1,380	1,080	0.78	2.3
1st commercial operation 7/75	1978	497.0	72.1	904	909	1.01	1.8
Type - BWR	1979	349.0	50.8	850	859	1.01	2.5
Capacity - 785 MWe	1980	509.5	70.3	2,0562,040		0.99	4.0
	1981	562.9	74.7	2,490	1,425	0.57	2.5
	1982	583.675.0		2,322	1,190	0.51	2.0
	1983	546.2	70.6	1,715	1,090	0.64	2.0
	1984	576.2	76.8	1,610	971	0.60	1.7
	1985	492.3	63.7	1,845	1,051	0.57	2.1
	198671	1.2	90.6	1,185	411	0.35	0.6
	1987	496.2	70.3	1,578	940	0.60	1.9
	1988	514.0	69.0	1,553	786	0.51	1.5
	1989	727.5	92.3	1,027	377	0.37	0.5
	1990	543.8	72.61,536		884	0.58	1.6
	1991	399.7	53.4	1,269	333	0.26	0.8
	1992	0.0	0.0	2,374	674	0.28	---
	1993	559.681.7		1,427	232	0.16	0.4
	1994	588.4	83.2	1,595	322	0.20	0.5
	1995	569.8	74.5	1,249	327	0.26	0.6
	19966	23.3	83.1	1,384	357	0.26	0.6
	1997	756.2	95.9	662	91	0.14	0.12
	1998	562.8	78.0	1,781	358	0.20	0.64
FORT CALHOUN	1975	252.3	67.4	469	294	0.63	1.2
Docket 50-285; DPR-40	1976	265.9	69.5	516	313	0.61	1.2
1st commercial operation 6/74	1977	351.8	79.4	535	297	0.560.8	
Type - PWR	1978	342.3	75.1	596410		0.69	1.2
Capacity - 478 MWe	1979	440.0	95.7	451	1260.28		0.3
	1980	242.3	60.4	891	668	0.75	2.8
	1981	260.9	72.3	822	458	0.56	1.8
	1982	418.0	89.7	604	217	0.36	0.5
	1983	330.4	73.1	860	433	0.50	1.3
	1984	279.2	59.9	913	563	0.62	2.0
	1985	367.0	73.7	982	373	0.38	1.0
	1986431.8		94.3	756	74	0.10	0.2
	1987	366.0	75.4	1,247	388	0.31	1.1
	1988	315.5	74.1	1,594	272	0.17	0.9
	1989	395.7	89.2	1,210	93	0.08	0.2
	1990	290.0	64.2	760	290	0.38	1.0
	1991	391.1	91.7	284	57	0.20	0.1
	1992	303.4	65.9	802	272	0.34	0.9
	1993	369.7	80.8	713	157	0.22	0.4
	1994	492.8	99.621	1	23	0.11	0.0
	1995	402.8	83.2	627	139	0.22	0.3
	1996374.9		79.5	740	226	0.31	0.6
	1997	435.9	93.6258		41	0.16	0.09
	1998	387.7	82.5	788	224	0.28	0.58
GINNA	1971	327.8		340	430	1.261.3	
Docket 50-244; DPR-18	1972	293.66		77	1,032	1.52	3.5
1st commercial operation 7/70	1973	409.5		319	224	0.70	0.5
Type - PWR	1974	253.7	62.4	884	1,225	1.39	4.8
Capacity - 480 MWe	1975	365.2	76.7	685	538	0.79	1.5
	1976248.8		58.2	758	636	0.84	2.6
	1977	365.6	85.5	530	401	0.76	1.1
	1978	386.5	80.6	657	450	0.68	1.2
	1979	355.0	72.8	878	592	0.67	1.7

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
GINNA (continued)	1980	370.5	76.0	1,073	708	0.66	1.9
	1981	399.0	82.1	925	655	0.71	1.6
	1982	289.0	58.8	1,117	1,140	1.02	3.9
	1983	365.0	74.6	969	855	0.88	2.3
	1984	378.1	77.2	713	395	0.55	1.0
	1985	436.7	87.9	845	426	0.50	1.0
	1986	433.3	87.4	901	357	0.40	0.8
	1987	459.0	91.5	773	344	0.45	0.7
	1988	423.1	87.4	897	295	0.33	0.7
	1989	369.2	75.9	1,254	605	0.48	1.6
	1990	414.3	84.4	991	347	0.35	0.8
	1991	418.686	.7	947	328	0.35	0.8
	1992	417.686	.9	832	261	0.31	0.6
	1993	419.686	.3	856	193	0.23	0.5
	1994	405.3	83.2	679	138	0.20	0.3
	1995	437.0	89.6738		136	0.18	0.3
	1996	347.9	71.1	976	168	0.17	0.5
	1997	444.691.8		533	81	0.15	0.18
	1998	491.8	100.0	161	15	0.09	0.03
GRAND GULF	1986	494.7	60.9	1,486	436	0.29	0.9
Docket 50-416; NPF-29	1987	920.7	82.2	1,358	420	0.31	0.5
1st commercial operation 7/85	1988	1,136.6	96.7	692	147	0.21	0.1
Type - BWR	1989	932.680.0		1,972	498	0.25	0.5
Capacity - 1204 MWe	1990	883.5	78.9	1,765	482	0.27	0.5
	1991	1,085.2	94.0	699	94	0.13	0.1
	1992	969.0	83.7	2,032	484	0.24	0.5
	1993	936.4	81.5	1,807	332	0.18	0.4
	1994	1,143.2	96.6	455	56	0.12	0.0
	1995	952.9	80.4	1,589	342	0.22	0.4
	1996	1,096	.2	88.7	1,564	357	0.23	0.3
	1997	1,234.9	100.0	514	105	0.20	0.09
	1998	1,049.2	88.9	1,410	304	0.22	0.29
HADDAM NECK[4]	1969	438.5		138	106	0.77	0.2
Docket 50-213; DPR-61	1970	424.7		734	689	0.94	1.6
1st commercial operation 1/68	1971	502.2		289	342	1.18	0.7
Type - PWR	1972	515.6355			325	0.91	0.6
Capacity - 560 MWe	1973	293.1		951	697	0.73	2.4
	1974	521.4	91.2	550	201	0.37	0.4
	1975	494.3	89.9	795	703	0.88	1.4
	1976	482.9	82.5	644	449	0.70	0.9
	1977	480.7	83.9	894	641	0.72	1.3
	1978	563.4	98.6	216	117	0.54	0.2
	1979	493.0	87.5	1,226	1,16	2	0.95	2.4
	1980	426.8	75.0	1,860	1,353	0.73	3.2
	1981	487.5	84.3	1,554	1,036	0.6	7	2.1
	1982	543.9	93.4	559	1260.23		0.2
	1983	453.7	77.8	1,645	1,384	0.84	3.1
	1984	404.0	71.7	1,430	1,216	0.85	3.0
	1985	556.1	98.4	384	101	0.26	0.2
	1986	294.8	53.6	1,945	1,567	0.81	5.3
	1987	304.6	54.0	1,763	750	0.43	2.5
	1988	397.4	70.3	735	237	0.32	0.6
	1989	356.4	67.2	1,455	596	0.41	1.7
	1990	142.7	32.2	979	421	0.43	3.0
	1991	444.4	76.4	1,168	590	0.51	1.3
	1992	465.2	80.1	797	202	0.25	0.4

[4] Haddam Neck was shutdown 12/4/96 and is no longer in the count of operating reactors.

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
HADDAM NECK	1993	448.681.6		1,004	408	0.41	0.9
(continued)	1994	455.677.7		463	135	0.29	0.3
	1995	439.4	77.7	1,006442		0.44	1.0
	1996331.8		55.7	673	175	0.26	0.5
	1997	-1.3	0.0	219	11	0.05	-8.46
	1998	0.0	0.0	1,249	167	0.13	---
HARRIS 1	1988	652.9	75.0	721	169	0.23	0.3
Docket 50-400; NPF-63	1989	690.6	79.5	929	156	0.17	0.2
1st commercial operation 5/87	1990	776.4	89.6	453	85	0.19	0.1
Type - PWR	1991	724.8	81.5	872	2260.26		0.3
Capacity - 860 MWe	1992	661.8	74.9	930	213	0.23	0.3
	1993	913.0	99.7	327	31	0.09	0.0
	1994	740.8	82.7	1,089	222	0.20	0.3
	1995	731.1	83.8	1,068	174	0.16	0.2
	199686	0.6	95.4	444	17	0.04	0.0
	1997	673.6	80.4	1,131	149	0.13	0.22
	1998	766.2	90.4	931	133	0.14	0.17
HATCH 1, 2	1976496	.3	83.8	630	134	0.21	0.3
Docket 50-321, 50-366;	1977	446.8	66.3	1,303	465	0.36	1.0
DPR-57; NPF-05	1978	513.0	72.8	1,304	248	0.19	0.5
1st commercial operation	1979	401.0	54.62,131		582	0.27	1.5
12/75, 9/79	1980	1,008.7	70.9	1,930	449	0.23	0.4
Type - BWRs	1981	870.9	64.3	2,899	1,337	0.46	1.5
Capacity - 800, 855 MWe	1982	768.0	56.6	3,418	1,460	0.43	1.9
	1983	934.7	68.6	3,428	1,299	0.38	1.4
	1984	658.6	47.3	4,110	2,218	0.54	3.4
	1985	1,211.0	79.62,841		818	0.29	0.7
	1986872.0		64.8	3,486	1,497	0.43	1.7
	1987	1,295.4	89.7	2,202	8160.37		0.6
	1988	1,001.4	70.4	2,509	1,401	0.561.4	
	1989	1,271.1	87.1	1,350	5560.41		0.4
	1990	1,268.0	83.5	2,902	1,455	0.50	1.1
	1991	1,152.4	77.4	2,508	1,161	0.46	1.0
	1992	1,293.8	88.61,6	15	550	0.34	0.4
	1993	1,189.685.5		1,733	669	0.39	0.6
	1994	1,289.0	87.1	2,243	864	0.39	0.7
	1995	1,376.3	90.6	1,458	488	0.33	0.4
	19961,519.6		94.0	1,495	441	0.29	0.3
	1997	1,374.7	88.1	1,945	722	0.37	0.53
	1998	1,458.4	91.7	1,610	320	0.20	0.22
HOPE CREEK 1	1987	869.2	86.4	589	117	0.20	0.1
Docket 50-354; NPF-57	1988	832.7	80.7	1,734	287	0.17	0.3
1st commercial operation 12/86	1989	791.1	77.8	1,873	465	0.25	0.6
Type - BWR	1990	966.4	91.6	1,394	196	0.14	0.2
Capacity - 1031 MWe	1991	882.5	84.2	1,700	373	0.22	0.4
	1992	841.9	80.8	1,694	436	0.26	0.5
	1993	1,049.2	97.8	688	98	0.14	0.1
	1994	852.0	81.2	1,779	3260.18		0.3
	1995	844.5	79.8	1,571	1960.12		0.2
	1996	806.9	77.4	1,069	158	0.15	0.2
	1997	731.8	77.8	1,747	350	0.20	0.06
	1998	993.2	98.0	620	55	0.09	0.06

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
HUMBOLDT BAY[5]	1969	44.6		125	164	1.31	3.7
Docket 50-133; DPR-7	1970	49.3		115	209	1.82	4.2
1st commercial operation 8/63	1971	39.6140			292	2.09	7.4
Type - BWR	1972	43.1		127	253	1.99	5.9
Capacity - 63 MWe	1973	50.1		210	266	1.27	5.3
	1974	43.4	83.8	296318		1.07	7.3
	1975	45.3	83.9	265	339	1.28	7.5
	197623.5		46.4	523	683	1.31	29.1
	1977	0.0	0.0	1,063	1,905	1.79	---
	1978	0.0	0.0	320	335	1.05	---
	1979	0.0	0.0	135	31	0.23	---
	1980	0.0	0.0	142	22	0.15	---
	1981	0.0	0.0	75	9	0.12	---
	1982	0.0	0.0	71	19	0.27	---
	1983	0.0	0.0	84	17	0.20	---
	1993	0.0	0.0	24	1	0.04	---
	1994	0.0	0.0	21	1	0.05	---
	1995	0.0	0.0	42	2	0.05	---
	19960.0		0.0	66	5	0.08	---
	1997	0.0	0.0	105	160.15		---
	1998	0.0	0.0	929	201	0.22	---
INDIAN POINT 1[6]**, 2, 3**[7]	1969	206.2			298		1.4
Docket 50-3, 50-247, 50-286;	1970	43.3			1,639		37.8
DPR-5, -26, -64	1971	154.0			768		5.0
1st commercial operation 10/62,	1972	142.3			967		6.8
8/74, 8/76	1973	0.0		2,998	5,262	1.76	---
Type - PWR	1974	556.1	59.4	1,019	910	0.89	1.6
Capacity - 0, 951, 965 MWe	1975	584.4	74.8	891	705	0.79	1.2
	1976273.9		34.8	1,590	1,950	1.23	7.1
	1977	1,278.3	75.3	1,391	1,070	0.77	0.8
	1978	1,172.3	67.8	1,909	2,006	1.05	1.7
INDIAN POINT 1[6]**, 2**	1979	574.0	71.4	1,349	1,279	0.95	2.2
	1980	510.8	64.8	1,577	971	0.62	1.9
	1982	532.4	65.4	2,144	1,635	0.76	3.1
	1983	702.684.0		1,057	486	0.46	0.7
INDIAN POINT 2	1984	416.7	51.9	2,919	2,644	0.91	6.3
Docket 50-247; DPR-26	1985	791.4	95.7	708	192	0.27	0.2
1st commercial operation 8/74	1986	457.5	56.2	1,926	1,250	0.65	2.7
Type - PWR	1987	611.4	73.4	1,980	1,217	0.61	2.0
Capacity - 951 MWe	1988	719.3	86.9	890	235	0.26	0.3
	1989	532.5	64.6	2,093	1,436	0.69	2.7
	1990	618.0	66.6	1,061	608	0.57	1.0
	1991	461.2	55.7	1,810	1,468	0.81	3.2
	1992	930.9	99.1	489	97	0.20	0.1
	1993	702.1	75.7	1,514	675	0.45	1.0
	1994	903.8	100.0	381	48	0.13	0.1
	1995	582.4	70.8	1,690	548	0.32	0.9
	1996927.8		94.8	388	54	0.14	0.1
	1997	360.6	45.1	1,340	367	0.27	1.02
	1998	282.8	31.5	1,154	290	0.25	1.03

[5] Humboldt Bay had been shutdown since 1976, and in 1984 it was decided that it would not be placed in operation again. Therefore, it is no longer included in the count of commercial reactors.

[6] Indian Point 1 was defueled in 1975, and in 1984 it was decided that it would not be placed in operation again. Therefore, it is no longer included in the count of commercial reactors.

[7] Indian Point 3 was purchased by a different utility and now reports separately.

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
INDIAN POINT 3[7]	1979	574.0	66.5	808	636	0.79	1.1
Docket 50-286; DPR-64	1980	367.3	53.2	977	308	0.32	0.8
1st commercial operation 8/76	1981	367.5	59.8	677	364	0.54	1.0
Type - PWR	1982	171.5	22.5	1,477	1,2260.83		7.1
Capacity - 965 MWe	1983	7.8	2.6941		607	0.65	77.8
	1984	714.4	76.3	658	230	0.35	0.3
	1985	566.5	66.0	1,093	570	0.52	1.0
	19866	55.3	73.4	588	202	0.34	0.3
	1987	574.66	2.7	1,308	500	0.38	0.9
	1988	792.5	83.3	451	93	0.21	0.1
	1989	587.8	61.1	1,800	876	0.49	1.5
	1990	595.3	62.9	1,066	358	0.34	0.6
	1991	862.8	87.5	299	40	0.13	0.0
	1992	561.7	61.4	1,003	212	0.21	0.4
	1993	140.5	14.9	478	60	0.13	0.4
	1994	0.0	0.0	529	58	0.11	---
	1995	174.8	21.4	638	67	0.11	0.4
	19966	95.3	74.8	289	22	0.08	0.0
	1997	495.1	54.9	1,608	234	0.15	0.47
	1998	874.0	95.3	213	15	0.07	0.02
KEWAUNEE	1975	401.9	88.2	104	28	0.27	0.1
Docket 50-305; DPR-43	1976405.9		78.9	381	270	0.71	0.7
1st commercial operation 6/74	1977	425.0	79.9	312	140	0.45	0.3
Type - PWR	1978	466.6	89.5	335	154	0.46	0.3
Capacity - 511 MWe	1979	412.0	79.0	343	127	0.37	0.3
	1980	433.8	82.1	401	165	0.41	0.4
	1981	451.8	86.7	383	141	0.37	0.3
	1982	458.4	87.6353		101	0.29	0.2
	1983	444.1	83.7	445	165	0.37	0.4
	1984	455.3	85.7	482	139	0.29	0.3
	1985	443.1	82.4	519	1760.34		0.4
	198646	1.7	85.8	502	169	0.34	0.4
	1987	480.0	89.7	755	2260.30		0.5
	1988	467.5	88.3	705	210	0.30	0.4
	1989	449.1	84.9	570	239	0.42	0.5
	1990	468.8	87.9	490	145	0.30	0.3
	1991	441.8	83.4	495	221	0.45	0.5
	1992	471.4	88.0	450	122	0.27	0.3
	1993	457.1	86.8	436	106	0.24	0.2
	1994	475.688.8		364	72	0.20	0.2
	1995	455.687.8		415	109	0.26	0.2
	1996380.4		71.8	474	126	0.27	0.3
	1997	269.8	56.0	278	56	0.20	0.21
	1998	423.0	87.2	384	88	0.23	0.21
LACROSSE[8]	1970	15.3			111		7.2
Docket 50-409; DPR-45	1971	323.1		218	158	0.72	4.8
1st commercial operation 11/69	1972	29.2			151	1.14	5.9
Type - BWR	1973	24.4			157	1.41	9.1
Capacity - 48 MWe	1974	37.9	81.0	115	139	1.21	3.7
	1975	32.0	69.6	165	234	1.42	7.3
	197621.2		47.6	118	110	0.93	5.2
	1977	11.3	33.7	141	225	1.60	19.9
	1978	21.66	2.0	182	164	0.90	7.6
	1979	24.0	71.8	153	1861.22		7.8

[7] Indian Point 3 was purchased by a different utility and now reports separately.

[8] LaCrosse ended commercial operation in 1987 and will not be put in commercial operation again. Therefore, it is no longer included in the count of commercial reactors.

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
LACROSSE	1980	26.4	68.5	124	218	1.76	8.3
(continued)	1981	29.6	76.0	187	123	0.66	4.2
	1982	17.2	44.6148		205	1.39	11.9
	1983	24.8	59.7	160	313	1.96	12.6
	1984	38.5	80.5	288	252	0.88	6.5
	1985	39.2	86.7	373	173	0.46	4.4
	198619.6		46.1	260	290	1.12	14.8
	1987	0.0	0.0	127	68	0.54	---
	1993	0.0	0.0	48	8	0.17	---
	1994	0.0	0.0	65	8	0.12	---
	1995	0.0	0.0	31	3	0.10	---
	19960.0		0.0	25	4	0.15	---
	1997	0.0	0.0	23	2	0.09	---
	1998	0.0	0.0	1,155	105	0.09	---
LASALLE 1, 2	1984	677.8	77.8	1,245	252	0.20	0.4
Docket 50-373, -374;	1985	987.9	53.0	1,635	685	0.42	0.7
NPF-11, -18	1986929.5		50.6	1,614	898	0.56	1.0
1st commercial operation	1987	1,030.0	59.3	1,744	1,3960.80		1.4
1/84, 6/84	1988	1,317.671.6		2,737	2,471	0.90	1.9
Type - BWR	1989	1,503.5	73.1	2,475	1,3860.56		0.9
Capacity - 1036, 1036 MWe	1990	1,754.3	84.61,830		948	0.52	0.5
	1991	1,837.0	86.7	1,985	806	0.41	0.4
	1992	1,447.4	72.0	2,418	1,167	0.48	0.8
	1993	1,542.0	76.0	1,701	854	0.50	0.6
	1994	1,580.0	77.61,812		726	0.40	0.5
	1995	1,696.6	82.1	1,623	512	0.32	0.3
	19961,053.8		54.3	2,782	819	0.29	0.8
	1997	0.0	0.0	1,661	316	0.19	---
	1998	380.9	19.3	2,099	422	0.20	1.11
LIMERICK 1, 2	1987	636.1	70.2	2,156	174	0.08	0.3
Docket 50-352, 50-353;	1988	794.9	96.5	950	52	0.05	0.1
NPF-39,-85	1989	628.4	66.0	1,818	266	0.15	0.4
1st commercial operation	1990	1,527.7	78.2	1,422	175	0.12	0.1
2/86, 1/90	1991	1,810.9	86.8	1,151	106	0.09	0.1
Type - BWRs	1992	1,741.4	84.8	1,559	330	0.21	0.2
Capacity - 1134, 1115 MWe	1993	1,913.2	91.61,287		217	0.17	0.1
	1994	1,944.4	94.9	1,543	275	0.18	0.1
	1995	1,957.1	93.0	1,581	260	0.16	0.1
	19962,026	.2	93.3	1,654	234	0.14	0.1
	1997	2,001.7	95.8	1,463	234	0.16	0.12
	1998	1,907.2	89.5	1,854	357	0.19	0.19
MAINE YANKEE[9]	1973	408.7		782	117	0.15	0.3
Docket 50-309; DPR-36	1974	432.6	68.7	619	420	0.68	1.0
1st commercial operation 12/72	1975	542.9	79.9	440	319	0.72	0.6
Type - PWR	1976712.2		95.0	244	85	0.35	0.1
Capacity - 860 MWe	1977	617.6	82.2	508	245	0.48	0.4
	1978	642.7	84.1	638	420	0.66	0.7
	1979	537.0	68.4	393	154	0.39	0.3
	1980	527.0	72.2	735	462	0.63	0.9
	1981	624.2	78.2	868	424	0.49	0.7
	1982	542.5	69.1	1,295	619	0.48	1.1
	1983	677.1	83.6	592	165	0.28	0.2
	1984	605.7	74.4	1,262	884	0.70	1.5
	1985	635.4	79.2	1,009	700	0.69	1.1
	1986737.6		87.8	495	100	0.20	0.1
	1987	478.1	65.3	1,100	722	0.66	1.5

[9] Maine Yankee was shut down in 8/97 and is no longer included in the count of commercial reactors.

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
MAINE YANKEE	1988	591.9	79.1	1,058	725	0.69	1.2
(continued)	1989	819.2	93.7	375	99	0.260.1	
	1990	573.0	71.0	1,359	682	0.50	1.2
	1991	738.1	86.6	426	105	0.25	0.1
	1992	631.7	79.1	1,189	461	0.39	0.7
	1993	674.8	79.8	1,016	377	0.37	0.6
	1994	782.8	90.9	297	84	0.28	0.1
	1995	23.63.7		1,167	653	0.56	27.7
	19966	02.9	78.1	408	56	0.14	0.1
	1997	0.0	0.0	991	153	0.15	---
	1998	0.0	0.0	1,313	173	0.13	---
MCGUIRE 1, 2	1982	524.9	80.4	1,560	169	0.11	0.3
Docket 50-369, -370;	1983	558.3	55.4	1,751	521	0.30	0.9
NPF-9, -17	1984	764.1	68.5	1,663	507	0.30	0.7
1st commercial operation	1985	808.4	77.0	2,217	771	0.35	1.0
12/81, 3/84	19861,36	0.0	60.1	2,326	1,015	0.44	0.7
Type - PWRS	1987	1,774.7	79.2	2,865	1,043	0.36	0.6
Capacity - 1100, 1100 MWe	1988	1,830.7	80.2	2,808	1,104	0.39	0.6
	1989	1,810.2	80.8	1,994	620	0.31	0.3
	1990	1,340.3	61.3	2,289	727	0.32	0.5
	1991	1,945.1	85.0	1,723	361	0.21	0.2
	1992	1,696.8	74.4	1,619	418	0.26	0.2
	1993	1,470.4	66.2	1,685	463	0.27	0.3
	1994	1,848.0	80.2	1,637	397	0.24	0.2
	1995	2,132.3	92.9	1,259	138	0.11	0.1
	19961,881.8		82.8	1,622	238	0.15	0.1
	1997	1,558.2	73.0	2,193	492	0.22	0.32
	1998	2,139.8	95.1	1,045	142	0.14	0.07
MILLSTONE POINT 1	1972	377.66		12	596	0.97	1.6
Docket 50-245; DPR-21	1973	225.1		1,184	663	0.56	2.9
1st commercial operation 3/71	1974	430.3	79.1	2,477	1,430	0.58	3.3
Type - BWR	1975	465.4	75.6	2,587	2,022	0.78	4.3
Capacity - 641 MWe	1976449.8		76.1	1,387	1,194	0.86	2.7
	1977	575.7	89.61,075		394	0.37	0.7
	1978	556.6	87.6	1,391	1,416	1.02	2.5
	1979	505.0	77.3	2,001	1,795	0.90	3.6
	1980	405.8	69.0	3,024	2,157	0.71	5.3
	1981	304.3	51.62,506		1,496	0.60	4.9
	1982	490.2	79.9	1,370	929	0.68	1.9
	1983	640.1	95.6	309	244	0.79	0.4
	1984	516.1	78.8	1,992	836	0.42	1.6
	1985	548.5	83.6732		608	0.83	1.1
	1986	626.8	95.4	389	150	0.39	0.2
	1987	523.4	79.61,588		684	0.43	1.3
	1988	658.8	98.6	327	144	0.44	0.2
	1989	554.684.2		852	462	0.54	0.8
	1990	608.3	91.6	365	131	0.36	0.2
	1991	213.1	35.4	1,154	409	0.35	1.9
	1992	431.8	68.1	348	99	0.28	0.2
	1993	627.9	96.8	305	81	0.27	0.1
	1994	394.0	63.6	1,321	391	0.30	1.0
	1995	520.680.0		910	620	0.68	1.2
	19960.0		0.0	747	431	0.58	---
	1997	-2.9	0.0	1,053	195	0.19	-67.24
	1998	-2.7	0.0	347	13	0.04	-4.81

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
MILLSTONE POINT 2, 3	1976	545.7	78.7	620	168	0.27	0.3
Docket 50-336, 50-423;	1977	518.7	65.7	667	242	0.36	0.5
DPR-65, NPF-49	1978	536.6	67.3	1,420	1,444	1.02	2.7
1st commercial operation	1979	520.0	62.8	525	471	0.90	0.9
12/75, 4/86	1980	579.3	69.2	893	637	0.71	1.1
Type - PWR	1981	722.4	82.6890		531	0.60	0.7
Capacity - 871, 1137 MWe	1982	595.9	70.62,083		1,413	0.68	2.4
	1983	294.0	34.2	2,383	1,881	0.79	6.4
	1984	782.7	93.5	285	120	0.42	0.2
	1985	417.8	49.4	1,905	1,581	0.83	3.8
	19861,313.8		80.4	2,393	993	0.41	0.8
	1987	1,624.5	84.1	1,441	505	0.35	0.3
	1988	1,594.8	83.2	1,827	804	0.44	0.5
	1989	1,428.3	72.9	1,984	1,079	0.54	0.8
	1990	1,614.9	87.1	1,652	593	0.36	0.4
	1991	819.5	69.7	1,084	381	0.35	0.5
	1992	1,115.1	59.9	3,190	1,280	0.40	1.1
	1993	1,525.2	79.7	2,064	557	0.27	0.4
	1994	1,556.6	73.1	1,249	188	0.15	0.1
	1995	1,278.1	60.5	1,691	416	0.25	0.3
	1996418.1		19.3	983	126	0.13	0.3
	1997	0.0	0.0	1,435	253	0.18	---
	1998	374.9	20.9	1,179	113	0.10	0.30
MONTICELLO	1972	424.4		99	61	0.62	0.1
Docket 50-263; DPR-22	1973	389.5		401	1760.44		0.5
1st commercial operation 6/71	1974	349.3	74.9	842	349	0.41	1.0
Type - BWR	1975	344.8	72.2	1,353	1,353	1.00	3.9
Capacity - 578 MWe	1976476	.4	91.5	325	263	0.81	0.6
	1977	425.679.9		860	1,000	1.16	2.3
	1978	459.4	87.2	679	375	0.55	0.8
	1979	522.0	97.6372		157	0.42	0.3
	1980	411.8	78.2	1,114	531	0.48	1.3
	1981	389.3	72.61,446		1,004	0.69	2.6
	1982	291.1	63.3	1,307	993	0.76	3.4
	1983	494.696	.3	416	121	0.29	0.2
	1984	33.7	9.2	1,872	2,462	1.32	73.1
	1985	509.8	91.7	586327		0.56	0.6
	1986402.7		79.1	895	596	0.67	1.5
	1987	422.5	81.9	941	568	0.60	1.3
	1988	542.5	99.8	375	110	0.29	0.2
	1989	318.2	76.2	1,102	507	0.46	1.6
	1990	536.0	96.9	336	94	0.28	0.2
	1991	429.4	80.8	964	465	0.48	1.1
	1992	528.3	97.5	454	114	0.25	0.2
	1993	458.1	84.4	954	494	0.52	1.1
	1994	471.3	87.0	788	395	0.50	0.8
	1995	564.7	100.0	200	44	0.22	0.1
	199646	1.6	86.9	757	240	0.32	0.5
	1997	417.4	75.9	399	1060.27		0.25
	1998	470.2	88.1	674	209	0.31	0.44
NINE MILE POINT 1, 2	1970	227.0		821	44	0.05	0.2
Docket 50-220, 50-410;	1971	346.5		1,006	195	0.19	0.6
DPR-63, NPF-69	1972	381.8		735	285	0.39	0.7
1st commercial operation	1973	411.0		550	567	1.03	1.4
12/69, 4/88	1974	385.9	70.5	740	824	1.11	2.1
Type - BWR	1975	359.0	72.1	649	681	1.05	1.9
Capacity - 565, 1105 MWe	1976484.6		88.2	392	428	1.09	0.9
	1977	347.4	59.2	1,093	1,383	1.27	4.0
	1978	527.7	95.1	561	314	0.56	0.6
	1979	354.0	66.1	1,326	1,497	1.13	4.2

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
NINE MILE POINT 1, 2	1980	533.9	92.3	1,174	591	0.50	1.1
(continued)	1981	385.2	66.0	2,029	1,592	0.78	4.1
	1982	133.5	21.4	1,352	1,264	0.93	9.5
	1983	329.8	56.2	1,405	860	0.61	2.6
	1984	426.8	71.9	1,530	890	0.58	2.1
	1985	580.9	96.4	1,007	265	0.26	0.5
	1986	371.0	65.3	1,878	1,275	0.68	3.4
	1987	542.693.3		1,190	141	0.12	0.3
	1988	0.0	0.0	2,626	854	0.33	---
	1989	527.5	29.7	2,737	564	0.21	1.1
	1990	656.2	46.6	2,405	699	0.29	1.1
	1991	1,250.8	79.7	1,543	292	0.19	0.2
	1992	965.9	61.8	1,800	563	0.31	0.6
	1993	1,380.2	84.62,352		633	0.27	0.5
	1994	1,589.695.9		800	149	0.19	0.1
	1995	1,382.2	82.5	2,304	759	0.33	0.5
	19961,598.6		91.6	1,596	290	0.18	0.2
	1997	1,321.5	74.8	1,425	429	0.30	0.32
	1998	1,387.3	87.0	1,744	378	0.22	0.27
NORTH ANNA 1, 2	1979	507.0	61.7	2,025	449	0.22	0.9
Docket 50-338; NPF-04, -09	1980	681.8	86.5	2,086	218	0.10	0.3
1st commercial operation	1981	1,241.9	71.5	2,4166	80	0.28	0.5
6/78, 12/80	1982	777.7	45.8	2,872	1,915	0.67	2.5
Type - PWRs	1983	1,338.4	76.1	2,228	665	0.30	0.5
Capacity - 893, 897 MWe	1984	1,021.3	58.8	3,062	1,945	0.64	1.9
	1985	1,516.9	86.1	2,436	838	0.34	0.6
	19861,484.5		83.0	2,831	722	0.26	0.5
	1987	1,112.66	7.8	2,624	1,521	0.58	1.4
	1988	1,772.7	96.7	992	112	0.11	0.1
	1989	1,226.8	72.5	2,861	1,471	0.51	1.2
	1990	1,590.4	90.5	2,161	590	0.27	0.4
	1991	1,597.5	88.62,085		629	0.30	0.4
	1992	1,403.2	84.1	2,159	5760.27		0.4
	1993	1,428.4	80.1	2,768	908	0.33	0.6
	1994	1,717.1	95.9	1,036193		0.19	0.1
	1995	1,666.4	90.8	1,551	367	0.24	0.2
	19961,56	9.6	89.1	1,203	291	0.24	0.2
	1997	1,711.5	96.2	856	103	0.12	0.06
	1998	1,632.8	92.7	1,201	266	0.22	0.16
OCONEE 1, 2, 3	1974	650.6	60.1	844	517	0.61	0.8
Docket 50-269, 50-270,	1975	1,838.3	75.5	829	497	0.60	0.3
50-287;	19761,56	1.4	63.0	1,215	1,026	0.84	0.7
DPR-38, -47, -55	1977	1,566.4	65.9	1,595	1,329	0.83	0.8
1st commercial operation 7/73,	1978	1,909.0	75.8	1,636	1,393	0.85	0.7
9/74, 12/74	1979	1,708.0	67.7	2,100	1,001	0.48	0.6
Type - PWRs	1980	1,703.7	70.1	2,124	1,055	0.50	0.6
Capacity - 846, 846, 846 MWe	1981	1,661.5	66.8	2,445	1,211	0.50	0.7
	1982	1,293.1	52.5	2,445	1,792	0.73	1.4
	1983	2,141.5	82.2	1,902	1,207	0.63	0.6
	1984	2,242.9	85.7	2,085	1,1060.53		0.5
	1985	2,036.3	80.5	2,729	1,304	0.48	0.6
	19861,995.6		79.0	2,499	949	0.38	0.5
	1987	1,962.6	82.4	2,672	1,142	0.43	0.6
	1988	2,228.9	87.2	2,672	871	0.33	0.4
	1989	2,188.685.4		2,205	684	0.31	0.3
	1990	2,405.2	91.4	1,948	404	0.21	0.2
	1991	2,275.0	86.7	1,966	551	0.28	0.2
	1992	2,110.7	82.0	1,954	612	0.31	0.3
	1993	2,399.2	91.3	1,499	237	0.160.1	
	1994	2,144.3	82.2	1,923	537	0.28	0.2

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
OCONEE 1, 2, 3	1995	2,366.1	89.5	1,586	304	0.19	0.1
(continued)	19961,847.9		70.3	1,479	257	0.17	0.1
	1997	1,563.7	67.7	1,379	223	0.16	0.14
	1998	1,989.1	81.3	1,695	366	0.22	0.18
OYSTER CREEK	1970	413.695			63	0.66	0.1
Docket 50-219; DPR-16	1971	448.9		249	240	0.960.5	
1st commercial operation 12/69	1972	515.0		339	582	1.72	1.1
Type - BWR	1973	424.6782			1,236	1.58	2.9
Capacity - 619 MWe	1974	434.5	70.4	935	984	1.05	2.3
	1975	373.673.3		1,210	1,140	0.94	3.1
	1976456	.5	79.3	1,582	1,078	0.68	2.4
	1977	385.7	70.1	1,673	1,614	0.96	4.2
	1978	431.8	74.3	1,411	1,279	0.91	3.0
	1979	541.0	85.9	842	467	0.55	0.9
	1980	232.9	41.4	1,966	1,733	0.88	7.4
	1981	314.8	59.8	1,689	917	0.54	2.9
	1982	242.7	62.5	1,270	865	0.68	3.6
	1983	27.9	11.5	2,303	2,257	0.98	80.9
	1984	37.1	9.62,36	9	2,054	0.87	55.4
	1985	446.1	89.4	2,342	748	0.32	1.7
	1986157.3		31.5	3,740	2,436	0.65	15.5
	1987	371.0	64.2	1,932	522	0.27	1.4
	1988	419.66	5.9	2,875	1,504	0.52	3.6
	1989	287.5	57.3	2,395	910	0.38	3.2
	1990	511.8	89.1	1,941	310	0.160.6	
	1991	351.66	0.5	3,089	1,185	0.38	3.4
	1992	536.3	85.9	2,771	657	0.24	1.2
	1993	551.9	87.8	2,560	416	0.16	0.8
	1994	431.7	70.8	2,382	844	0.35	2.0
	1995	615.4	97.4	761	90	0.12	0.1
	1996515.0		82.6	1,833	449	0.24	0.9
	1997	579.1	94.3	509	50	0.10	0.63
	1998	490.8	82.4	1,408	308	0.22	0.63
PALISADES	1972	216.8			78		0.4
Docket 50-255; DPR-20	1973	286.8		975	1,133	1.16	4.0
1st commercial operation 12/71	1974	10.7	5.5	774	627	0.81	58.6
Type - PWR	1975	302.0	64.5	495	306	0.62	1.0
Capacity - 730 MWe	1976346	.9	55.2	742	696	0.94	2.0
	1977	616.6	91.4	332	100	0.30	0.2
	1978	320.2	49.7	849	764	0.90	2.4
	1979	415.0	59.9	1,599	854	0.53	2.1
	1980	288.3	42.9	1,307	424	0.32	1.5
	1981	418.2	57.2	2,151	902	0.42	2.2
	1982	404.3	54.7	1,554	330	0.21	0.8
	1983	454.4	60.3	2,167	977	0.45	2.2
	1984	98.7	15.2	1,344	573	0.43	5.8
	1985	639.2	83.8	1,355	507	0.37	0.8
	1986102.3		15.1	1,438	672	0.47	6.6
	1987	319.2	48.2	1,122	4560.41		1.4
	1988	413.4	56.8	1,472	730	0.50	1.8
	1989	442.8	69.1	1,026	314	0.31	0.7
	1990	366.7	58.7	2,414	766	0.32	2.1
	1991	587.0	78.1	1,315	211	0.160.4	
	1992	581.9	76.1	1,267	295	0.23	0.5
	1993	424.4	53.7	908	289	0.32	0.7
	1994	541.8	67.0	397	60	0.15	0.1
	1995	583.5	75.8	1,230	462	0.38	0.8
	19966	38.2	81.4	1,109	318	0.29	0.5
	1997	662.5	89.9	338	48	0.14	0.07
	1998	615.4	83.5	895	217	0.24	0.35

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
PALO VERDE 1, 2, 3	1987	1,638.1	66.1	1,792	669	0.37	0.4
Docket 50-528, 50-529; 50-530;	1988	1,700.9	65.5	2,173	688	0.32	0.4
NPF-41, NPF-51, NPF-74	1989	965.3	26.5	2,615	720	0.28	0.7
1st commercial operation	1990	2,500.9	67.5	2,236	499	0.22	0.2
1/86,9/86,1/88	1991	3,043.9	78.9	2,242	605	0.27	0.2
Type - PWRs	1992	3,102.3	82.0	1,981	541	0.27	0.2
Capacity - 1243, 1243, 1247	1993	2,677.1	74.3	2,124	592	0.28	0.2
MWe	1994	2,827.679.1		2,048	462	0.23	0.2
	1995	3,265.2	85.6	1,875	482	0.26	0.1
	19963,482.7		90.0	1,717	302	0.18	0.1
	1997	3,369.2	92.2	1,585	246	0.16	0.07
	1998	3,454.4	93.2	1,410	192	0.14	0.06
PEACH BOTTOM 2, 3	1975	1,234.3	80.9	971	228	0.23	0.2
Docket 50-277, 50-278;	19761,379.2		73.0	2,136	840	0.39	0.6
DPR-44, -56	1977	1,052.4	58.7	2,827	2,0360.72		1.9
1st commercial operation	1978	1,636.3	84.0	2,244	1,317	0.59	0.8
7/74, 12/74	1979	1,740.0	84.5	2,2761,388		0.61	0.8
Type - BWR	1980	1,374.2	66.3	2,774	2,302	0.83	1.7
Capacity - 1093, 1093 MWe	1981	1,161.8	58.0	2,857	2,506	0.88	2.2
	1982	1,583.3	76.9	2,734	1,977	0.72	1.2
	1983	824.7	41.0	3,107	2,963	0.95	3.6
	1984	1,165.8	57.5	3,313	2,450	0.74	2.1
	1985	682.7	37.5	4,209	3,354	0.80	4.9
	19861,395.0		71.7	2,454	1,080	0.44	0.8
	1987	365.7	20.3	4,363	2,195	0.50	6.0
	1988	0.0	0.0	4,204	2,327	0.55	---
	1989	491.0	35.0	2,301	728	0.32	1.5
	1990	1,684.0	85.7	1,585	377	0.24	0.2
	1991	1,210.9	62.3	2,702	934	0.35	0.8
	1992	1,516.6	78.7	1,911	502	0.26	0.3
	1993	1,654.0	81.9	1,757	552	0.31	0.3
	1994	1,927.4	93.8	2,133	579	0.27	0.3
	1995	1,955.9	95.1	1,940	398	0.21	0.2
	19962,012.4		96.9	1,657	282	0.17	0.1
	1997	1,956.3	95.0	1,872	490	0.26	0.25
	1998	1,881.2	93.2	1,903	366	0.19	0.19
PERRY	1988	869.3	79.0	782	105	0.13	0.1
Docket 50-440; NPF-58	1989	642.2	57.0	1,883	767	0.41	1.2
1st commercial operation 11/87	1990	792.7	67.1	1,537	638	0.42	0.8
Type - BWR	1991	1,074.2	91.9	600	146	0.24	0.1
Capacity - 1160 MWe	1992	856.2	75.5	1,487	571	0.38	0.7
	1993	479.2	48.2	1,235	278	0.23	0.6
	1994	550.8	50.2	2,098	691	0.33	1.3
	1995	1,090.9	95.6587		64	0.11	0.1
	1996895.6		77.2	1,622	307	0.19	0.3
	1997	930.684.7		1,524	272	0.18	0.29
	1998	1,163.1	99.3	385	42	0.11	0.04
PILGRIM 1	1973	484.0		230	1260.55		0.3
Docket 50-293; DPR-35	1974	234.1	39.2	454	415	0.91	1.8
1st commercial operation 12/72	1975	308.1	71.3	473	798	1.69	2.6
Type - BWR	1976287.8		60.7	1,317	2,648	2.01	9.2
Capacity - 670 MWe	1977	316.6	61.4	1,875	3,142	1.68	9.9
	1978	519.5	83.1	1,667	1,327	0.80	2.6
	1979	574.0	89.4	2,458	1,015	0.41	1.8
	1980	360.3	56.2	3,549	3,626	1.02	10.1
	1981	408.9	65.9	2,803	1,836	0.66	4.5
	1982	389.9	63.9	2,854	1,539	0.54	3.9
	1983	559.5	87.2	2,3261,16	2	0.50	2.1
	1984	1.4	0.4	4,542	4,082	0.90	15.7

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
PILGRIM 1	1985	587.3	91.5	2,209	893	0.40	1.5
(continued)	1986121.9		18.8	2,635	874	0.33	7.2
	1987	0.0	0.0	4,710	1,579	0.34	---
	1988	0.0	0.0	2,073	392	0.19	---
	1989	204.66	4.1	1,797	207	0.12	1.0
	1990	503.5	82.1	1,898	225	0.12	0.4
	1991	406.3	65.8	2,836	605	0.21	1.5
	1992	561.0	85.4	1,332	281	0.21	0.5
	1993	513.7	80.9	1,328	435	0.33	0.8
	1994	453.671.4		758	200	0.26	0.4
	1995	531.7	80.7	1,294	482	0.37	0.9
	19966	31.3	95.4	517	116	0.22	0.2
	1997	492.1	80.7	1,655	588	0.36	1.19
	1998	650.5	100.0	530	71	0.13	0.11
POINT BEACH 1, 2	1971	393.4			164		0.4
Docket 50-266, 50-301;	1972	378.3			580		1.5
DPR-24, -27	1973	693.7		501	588	1.17	0.8
1st commercial operation	1974	760.2	81.3	400	295	0.74	0.4
12/70, 10/72	1975	801.2	82.9	339	459	1.35	0.6
Type - PWRs	1976857.3		86.7	313	370	1.18	0.4
Capacity - 485, 485 MWe	1977	873.9	87.3	417	430	1.03	0.5
	1978	914.4	90.9	336320		0.95	0.3
	1979	808.0	80.8	610	644	1.06	0.8
	1980	727.2	82.5	561	598	1.07	0.8
	1981	760.4	83.6	773	596	0.77	0.8
	1982	757.2	84.3	767	609	0.79	0.8
	1983	648.2	72.7	1,702	1,403	0.82	2.2
	1984	788.9	78.61,372		789	0.58	1.0
	1985	831.3	82.5	671	482	0.72	0.6
	1986858.9		85.7	664	402	0.61	0.5
	1987	857.5	85.5	720	554	0.77	0.6
	1988	899.3	88.6734		410	0.56	0.5
	1989	847.8	85.5	736504		0.68	0.6
	1990	875.5	86.5	617	378	0.61	0.4
	1991	874.8	87.1	724	265	0.37	0.3
	1992	866.7	85.8	617	256	0.41	0.3
	1993	911.0	90.0	559	1860.33		0.2
	1994	914.5	91.2	548	170	0.31	0.2
	1995	858.4	86.1	548	190	0.35	0.2
	1996831.6		84.7	1,029	276	0.27	0.3
	1997	186.8	21.8	670	92	0.14	0.49
	1998	649.7	69.7	881	169	0.19	0.26
PRAIRIE ISLAND 1, 2	1974	181.9	43.9	150	18	0.12	0.1
Docket 50-282, 50-306;	1975	836.0	83.3	477	123	0.26	0.1
DPR-42, -60	1976725.2		76.6	818	447	0.55	0.6
1st commercial operation 12/73,	1977	922.9	87.2	718	300	0.42	0.3
12/74	1978	941.1	92.2	546221		0.40	0.2
Type - PWRs	1979	865.0	86.0	594	180	0.30	0.2
Capacity - 526, 512 MWe	1980	800.7	79.9	983	353	0.360.4	
	1981	844.9	80.5	836329		0.39	0.4
	1982	944.9	90.4	645	229	0.36	0.2
	1983	921.1	86.8	654	233	0.36	0.3
	1984	972.4	91.7	546147		0.27	0.2
	1985	882.684.0		1,082	416	0.38	0.5
	1986930.6		90.3	818	255	0.31	0.3
	1987	969.6	91.6	593	135	0.23	0.1
	1988	932.0	89.1	732	199	0.27	0.2
	1989	1,001.8	94.7	47699		0.21	0.1
	1990	925.4	89.2	737	188	0.260.2	

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
PRAIRIE ISLAND 1, 2	1991	1,023.3	95.6586		98	0.17	0.1
(continued)	1992	811.676	.2	845	211	0.25	0.3
	1993	978.3	90.7	532	1060.20		0.1
	1994	996.9	91.5	478	109	0.10	
	1995	1,023.2	93.9	499	107	0.21	0.1
	1996992.1		91.4	558	112	0.20	0.1
	1997	817.681.4		753	174	0.23	0.21
	1998	860.3	83.4	582	117	0.20	0.14
QUAD CITIES 1, 2	1974	958.1	72.3	678	482	0.71	0.5
Docket 50-254, 50-265;	1975	833.66	8.4	1,083	1,618	1.49	1.9
DPR-29, -30	1976951.2		73.1	1,225	1,651	1.35	1.7
1st commercial operation 2/73,	1977	970.1	84.0	907	1,031	1.14	1.1
3/73	1978	1,124.5	88.61,207		1,618	1.34	1.4
Type - BWRs	1979	1,075.0	84.61,6	88	2,158	1.28	2.0
Capacity - 769, 769 MWe	1980	866.9	64.4	3,089	4,838	1.57	5.6
	1981	1,156.9	81.1	2,246	3,146	1.40	2.7
	1982	1,018.7	76.0	2,314	3,757	1.62	3.7
	1983	1,088.5	79.2	1,802	2,491	1.38	2.3
	1984	994.66	5.7	1,678	1,579	0.94	1.6
	1985	1,268.0	82.7	1,184	990	0.84	0.8
	19861,093.2		71.0	1,451	950	0.65	0.9
	1987	1,126.6	75.3	1,429	720	0.50	0.6
	1988	1,173.7	84.1	1,486827		0.56	0.7
	1989	1,196.3	85.9	1,721	900	0.52	0.8
	1990	1,148.9	77.8	2,1861,028		0.47	0.9
	1991	1,044.5	73.2	1,722	509	0.30	0.5
	1992	960.8	68.0	2,413	1,157	0.48	1.2
	1993	974.9	67.0	2,150	849	0.39	0.9
	1994	681.5	48.7	2,163	1,128	0.52	1.7
	1995	1,002.5	70.4	2,041	7360.36		0.7
	1996876	.6	60.1	2,248	1,025	0.46	1.2
	1997	935.3	66.5	2,474	654	0.26	0.70
	1998	794.8	55.1	2,177	761	0.35	0.96
RANCHO SECO[10]	197626	8.1	30.4	297	58	0.20	0.2
Docket 50-312; DPR-54	1977	706.4	77.1	515	391	0.76	0.6
1st commercial operation 4/75	1978	607.7	80.5	508	323	0.64	0.5
Type - PWR	1979	687.0	91.1	287	126	0.44	0.2
Capacity - 873 MWe	1980	530.9	60.4	890	412	0.46	0.8
	1981	321.2	40.2	772	402	0.52	1.3
	1982	409.5	53.3	766	337	0.44	0.8
	1983	347.9	46.8	1,338	787	0.59	2.3
	1984	460.0	58.3	802	222	0.28	0.5
	1985	238.7	30.8	1,764	756	0.43	3.2
	19860.0		0.0	1,513	402	0.27	---
	1987	0.0	0.0	1,533	300	0.20	---
	1988	355.8	63.1	693	78	0.11	0.2
	1989	179.9	54.7	603	81	0.13	0.5
	1990	0.0	0.0	111	13	0.12	---
	1991	0.0	0.0	101	9	0.09	---
	1992	0.0	0.0	70	7	0.10	---
	1993	0.0	0.0	35	4	0.11	---
	1994	0.0	0.0	18	1	0.06---	
	1995	0.0	0.0	161		0.06	---
	19960.0		0.0	16	1	0.04	---
	1997	0.0	0.0	160		0.00	---
	1998	0.0	0.0	408	41	0.10	---

[10] Rancho Seco has been permanently shutdown.

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
	1987	605.2	68.4	1,268	378	0.30	0.6
RIVER BEND 1	1988	880.7	94.3	513	107	0.21	0.1
Docket 50-458; NPF-47	1989	584.5	69.1	1,566	558	0.36	1.0
1st commercial operation 6/86	1990	682.2	78.0	1,616	489	0.30	0.7
Type - BWR	1991	814.7	87.2	780	144	0.18	0.2
Capacity - 936 MWe	1992	336.1	39.7	2,022	710	0.35	2.1
	1993	640.0	71.6	847	180	0.21	0.3
	1994	595.7	64.9	2,209	519	0.24	0.9
	1995	967.1	99.6	667	85	0.13	0.1
	1996836	.1	85.3	2,093	473	0.23	0.6
	1997	778.8	86.3	1,671	347	0.21	0.45
	1998	894.2	96.2	466	58	0.12	0.06
	1972	580.0		245	215	0.88	0.4
ROBINSON 2	1973	455.1		831	695	0.84	1.5
Docket 50-261; DPR-23	1974	578.1	83.3	853	672	0.79	1.2
1st commercial operation 3/71	1975	501.8	72.7	849	1,142	1.35	2.3
Type - PWR	1976585.5		84.7	597	715	1.20	1.2
Capacity - 683 MWe	1977	511.5	85.2	634	455	0.72	0.9
	1978	480.5	72.0	943	963	1.02	2.0
	1979	482.0	70.8	1,454	1,188	0.82	2.5
	1980	387.3	62.2	2,009	1,852	0.92	4.8
	1981	426.6	73.0	1,462	733	0.50	1.7
	1982	277.5	48.9	2,011	1,4260.71		5.1
	1983	409.8	75.5	2,244	923	0.41	2.3
	1984	28.0	7.0	4,127	2,880	0.70	102.9
	1985	629.5	87.9	1,378	311	0.23	0.5
	1986577.1		80.3	1,571	539	0.34	0.9
	1987	510.1	72.5	1,379	499	0.361.0	
	1988	385.0	65.9	1,351	564	0.42	1.5
	1989	336.6	48.7	1,098	195	0.18	0.6
	1990	400.3	64.8	1,626	437	0.27	1.1
	1991	575.1	81.4	885	193	0.22	0.3
	1992	487.2	66.8	1,267	352	0.28	0.7
	1993	502.7	70.7	1,221	337	0.28	0.7
	1994	560.3	79.5	420	63	0.15	0.1
	1995	618.7	84.7	1,058	215	0.20	0.3
	19966	54.8	88.6	1,031	167	0.16	0.3
	1997	707.5	99.0	304	13	0.04	0.02
	1998	628.5	88.9	978	170	0.17	0.27
	1978	546.4	55.6	574	122	0.21	0.2
SALEM 1, 2	1979	250.0	25.5	1,488	584	0.39	2.3
Docket 50-272, -311;	1980	680.6	69.2	1,704	449	0.26	0.7
DPR-70, -75	1981	743.0	78.1	1,652	254	0.15	0.3
1st commercial operation 6/77,	1982	1,440.4	72.63,228		1,203	0.37	0.8
10/81	1983	742.0	30.5	2,383	581	0.24	0.8
Type - PWRs	1984	650.1	31.8	1,395	681	0.49	1.0
Capacity - 1106, 1106 MWe	1985	1,657.7	75.8	1,112	204	0.18	0.1
	19861,484.3		70.4	3,554	599	0.17	0.4
	1987	1,478.2	73.3	2,543	600	0.24	0.4
	1988	1,591.673.6		1,609	503	0.31	0.3
	1989	1,675.4	79.5	2,944	338	0.11	0.2
	1990	1,362.6	65.1	3,636	272	0.07	0.2
	1991	1,726.4	79.3	4,201	458	0.11	0.3
	1992	1,200.9	61.1	4,376	431	0.10	0.4
	1993	1,366.3	65.4	3,559	408	0.11	0.3
	1994	1,367.4	73.8	950	188	0.20	0.1
	1995	558.1	29.3	1,195	218	0.18	0.4
	19960.0		0.0	1,671	300	0.18	---
	1997	279.3	17.8	894	175	0.20	0.63
	1998	1,629.3	79.1	408	41	0.10	0.03

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
	1969	314.1		123	42	0.34	0.1
SAN ONOFRE 1[11], 2, 3	1970	365.9		251	155	0.62	0.4
Docket 50-206, -361, -362;	1971	362.1		121	50	0.41	0.1
DPR-13, NPF-10, NPF-15	1972	338.5		326256		0.79	0.8
1st commercial operation 1/68,	1973	273.7		570	353	0.62	1.3
8/83,4/84	1974	377.8	86.1	219	71	0.32	0.2
Type - PWR	1975	389.0	87.4	424	292	0.69	0.8
Capacity - 436, 1070, 1080	1976297.9		70.2	1,330	880	0.66	3.0
MWe	1977	281.2	63.7	985	847	0.86	3.0
	1978	323.2	80.2	764	401	0.52	1.2
	1979	401.0	90.2	521	139	0.27	0.3
	1980	97.3	22.3	3,063	2,386	0.78	24.5
	1981	95.9	26.7	2,902	3,223	1.11	33.6
	1982	61.6	15.7	3,055	832	0.27	13.5
	1983	0.0	0.0	1,701	155	0.09	---
	1984	670.4	68.3	7,514	986	0.27	1.5
	1985	1,381.8	132.9	5,742	722	0.24	15.5
	19861,6	98.2	61.1	3,594	824	0.24	1.1
	1987	1,983.0	78.8	2,138	696	0.33	0.4
	1988	1,982.3	68.4	2,324	781	0.34	0.4
	1989	1,840.8	64.9	2,237	567	0.25	0.3
	1990	1,980.5	69.1	2,224	885	0.40	0.4
	1991	1,987.675.3		1,814	412	0.23	0.2
	1992	2,228.687.1		1,651	324	0.20	0.1
	1993	1,771.3	79.9	2,193	767	0.35	0.4
	1994	2,220.7	100.0	528	32	0.060.0	
	1995	1,686.9	79.1	1,914	455	0.24	0.3
	19962,089.3		93.2	1,272	129	0.10	0.1
	1997	1,533.9	72.9	1,652	341	0.21	0.22
	1998	1,996.4	92.0	1,091	196	0.18	0.10
	1991	810.4	75.9	699	92	0.13	0.1
SEABROOK	1992	932.4	81.3	806147		0.18	0.2
Docket 50-443; NPF-86	1993	1,071.5	93.61	10	6	0.05	0.0
1st commercial operation 8/90	1994	736.4	63.5	852	113	0.13	0.2
Type - PWR	1995	995.5	87.5	800	102	0.13	0.1
Capacity - 1158 Mwe	19961,16	8.6	99.6	206	10	0.05	0.0
	1997	907.0	79.8	1,571	1860.12		0.21
	1998	957.684.5		559	19	0.03	0.02
	1982	583.5	52.8	1,965	570	0.29	1.0
SEQUOYAH 1, 2	1983	1,663.7	75.1	1,772	491	0.28	0.3
Docket 50-327, -328;	1984	1,481.9	69.0	2,373	1,117	0.47	0.8
DPR-77, -79	1985	1,151.3	51.3	1,854	1,071	0.58	0.9
1st commercial operation 7/81,	19860.0		0.0	1,735	526	0.30	---
6/82	1987	0.0	0.0	2,080	420	0.20	---
Type - PWR	1988	490.8	31.8	2,439	678	0.28	1.4
Capacity - 1122, 1117 MWe	1989	1,851.7	85.7	2,007	657	0.33	0.4
	1990	1,662.6	77.2	2,934	1,678	0.57	1.0
	1991	1,965.4	88.0	1,928	698	0.36	0.4
	1992	1,849.0	85.4	1,714	465	0.27	0.3
	1993	405.7	21.8	1,629	372	0.23	0.9
	1994	1,418.7	66.3	1,657	292	0.18	0.2
	1995	1,864.2	86.1	1,618	358	0.22	0.2
	19962,009.4		87.9	1,404	265	0.19	0.1
	1997	1,946.1	89.0	1,932	414	0.21	0.21
	1998	2,135.3	95.3	1,440	255	0.18	0.12

[11] San Onofre 1 was shut down 11/92 and is no longer in the count of commercial reactors.

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
	1989	769.3	65.6	989	161	0.16	0.2
SOUTH TEXAS 1, 2	1990	1,504.1	65.9	1,136	206	0.18	0.1
Docket 50-498, 50-499;	1991	1,741.5	72.4	1,144	257	0.22	0.1
NPF -76,-80	1992	2,096.0	83.8	923	147	0.16	0.1
1st commercial operation	1993	163.1	8.3	1,138	251	0.22	1.5
8/88, 6/89	1994	1,700.2	70.66	61	47	0.07	0.0
Type - PWRs	1995	2,294.2	89.9	1,485	291	0.20	0.1
Capacity - 1251, 1251 MWe	19962,46	5.9	95.0	1,145	137	0.12	0.1
	1997	2,265.5	93.6	1,583	273	0.17	0.12
	1998	2,379.4	96.9	1,171	184	0.16	0.08
	1977	649.1	84.7	445	152	0.34	0.2
ST. LUCIE 1, 2	1978	606.4	76.5	797	337	0.42	0.6
Docket 50-335, -389; DPR-67;	1979	592.0	74.0	907	438	0.48	0.7
NPF-16	1980	627.9	77.5	1,074	532	0.50	0.8
1st commercial operation	1981	599.1	72.7	1,473	929	0.63	1.6
12/76, 8/83	1982	816.8	94.0	1,045	272	0.26	0.3
Type - PWRs	1983	290.3	15.4	2,211	1,204	0.54	4.1
Capacity - 839, 839 MWe	1984	1,183.0	69.6	2,090	1,263	0.60	1.1
	1985	1,445.8	82.5	1,971	1,344	0.68	0.9
	19861,588.6		89.1	1,279	491	0.38	0.3
	1987	1,407.9	81.9	2,012	951	0.47	0.7
	1988	1,639.7	93.0	1,448	611	0.42	0.4
	1989	1,493.1	85.1	1,414	495	0.35	0.3
	1990	1,188.4	70.0	1,876777		0.41	0.7
	1991	1,592.8	90.8	1,282	479	0.37	0.3
	1992	1,511.9	87.3	1,251	264	0.21	0.2
	1993	1,227.677.7		1,462	492	0.34	0.4
	1994	1,424.8	85.0	1,896505		0.27	0.4
	1995	1,306.6	76.0	1,498	413	0.28	0.3
	19961,473.4		86.5	1,433	385	0.27	0.3
	1997	1,394.683.6		2,314	646	0.28	0.46
	1998	1,572.5	94.2	1,170	134	0.11	0.09
	1984	504.66	1.1	1,120	295	0.26	0.6
SUMMER 1	1985	627.7	71.6	1,201	379	0.32	0.6
Docket 50-395; NPF-12	1986853.7		95.3	392	23	0.06	0.0
1st commercial operation 1/84	1987	618.7	71.0	1,075	560	0.52	0.9
Type - PWR	1988	605.3	69.1	1,127	511	0.45	0.8
Capacity - 945 MWe	1989	652.4	83.1	374	52	0.14	0.1
	1990	730.0	83.9	1,090	3760.34		0.5
	1991	642.5	82.9	984	291	0.30	0.5
	1992	892.697.4		249	27	0.11	0.0
	1993	728.3	84.0	1,121	297	0.260.4	
	1994	536.7	69.5	1,549	374	0.24	0.7
	1995	899.8	97.2	257	13	0.05	0.0
	1996850.4		90.3	701	97	0.14	0.1
	1997	829.7	89.8	820	163	0.20	0.20
	1998	934.8	98.8	285	14	0.05	0.01
	1973	420.6936			152	0.16	0.4
SURRY 1, 2	1974	717.4	49.8	1,715	884	0.52	1.2
Docket 50-280, 50-281;	1975	1,079.0	70.8	1,948	1,649	0.85	1.5
DPR-32, -37	1976930.7		60.4	2,753	3,165	1.15	3.4
1st commercial operation	1977	1,139.0	72.2	1,860	2,307	1.24	2.0
12/72, 5/73	1978	1,210.677.2		2,203	1,837	0.83	1.5
Type - PWRs	1979	343.0	42.3	5,065	3,584	0.71	10.4
Capacity - 801, 801 MWe	1980	568.2	40.3	5,317	3,836	0.72	6.8
	1981	907.659.3		3,753	4,244	1.13	4.7
	1982	1,323.3	88.5	1,878	1,490	0.79	1.1
	1983	916.2	61.3	2,754	3,220	1.17	3.5

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
	1984	1,026.7	71.0	3,198	2,247	0.70	2.2
SURRY 1, 2	1985	1,166.4	78.2	3,206	1,815	0.57	1.6
(continued)	1986	1,080.5	69.0	3,763	2,356	0.63	2.2
	1987	1,132.7	72.7	2,675	712	0.27	0.6
	1988	750.4	50.0	3,184	1,542	0.48	2.1
	1989	489.3	33.0	3,100	8360.27		1.7
	1990	1,276.4	83.9	1,947	575	0.30	0.5
	1991	1,271.9	84.5	1,547	510	0.33	0.4
	1992	1,396.3	88.9	1,660	539	0.32	0.4
	1993	1,283.1	84.61,402		383	0.27	0.3
	1994	1,320.9	85.2	1,530	378	0.25	0.3
	1995	1,333.0	84.2	1,883	4060.22		0.3
	19961,56	2.9	93.1	983	209	0.21	0.1
	1997	1,380.3	87.1	1,335	320	0.24	0.23
	1998	1,476.2	91.6	1,165	189	0.16	0.13
	1984	719.9	72.62,827		308	0.11	0.4
SUSQUEHANNA 1, 2	1985	1,452.2	76.4	3,669	1,106	0.30	0.8
Docket 50-387, 50-388;	19861,344.8		67.0	2,996	828	0.28	0.6
NPF-14; NPF-22	1987	1,749.5	85.3	2,548	621	0.24	0.4
1st commercial operation	1988	1,691.0	83.5	1,904	516	0.27	0.3
6/83, 2/85	1989	1,572.5	77.1	2,063	704	0.34	0.4
Type - BWR	1990	1,746.9	85.4	1,691	440	0.26	0.3
Capacity - 1090, 1094 MWe	1991	1,878.0	89.8	1,844	507	0.27	0.3
	1992	1,604.2	79.7	1,885	724	0.38	0.5
	1993	1,602.1	77.3	1,488	335	0.23	0.2
	1994	1,814.4	85.4	1,580	442	0.28	0.2
	1995	1,850.8	85.3	1,773	4760.27		0.3
	19961,998.7		90.7	1,430	289	0.20	0.1
	1997	1,918.9	89.61,6	46	433	0.26	0.23
	1998	1,879.688.3		1,575	361	0.23	0.19
	1975	675.9	82.2	131	73	0.56	0.1
THREE MILE ISLAND 1, 2	1976530.0		65.4	819	286	0.35	0.5
Docket 50-289, -320;	1977	664.5	80.9	1,122	360	0.32	0.5
DPR-50, -73	1978	690.0	85.1	1,929	504	0.26	0.7
1st commercial operation 9/74,	1979	266.0	21.9	3,975	1,392	0.35	5.2
12/78	1980	0.0	0.0	2,328	394	0.17	---
Type - PWRs	1981	0.0	0.0	2,103	3760.18		---
Capacity - 786, 880 MWe	1982	0.0	0.0	2,123	1,004	0.47	---
	1983	0.0	0.0	1,592	1,159	0.73	---
	1984	0.0	0.0	1,079	688	0.64	---
	1985	103.610.6		1,890	857	0.45	8.3
	1986585.2		70.9	1,360	213	0.16	0.4
THREE MILE ISLAND 1[12]	1987	610.7	73.6	1,259	149	0.12	0.2
Docket 50-289; DPR-50	1988	661.0	77.8	1,012	210	0.21	0.3
1st commercial operation 9/74	1989	871.3	100.0	670	54	0.08	0.1
Type - PWR	1990	645.5	84.6	1,319	264	0.20	0.4
Capacity - 786 MWe	1991	688.7	86.4	1,542	198	0.13	0.3
	1992	836.8	100.0	558	34	0.06	0.0
	1993	722.0	88.5	1,835	2060.1	1	0.3
	1994	798.7	95.5	434	40	0.09	0.1
	1995	772.9	90.8	1,220	213	0.17	0.3
	1996857.4		100.0	267	16	0.06	0.0
	1997	675.7	84.3	1,049	204	0.19	0.30
	1998	805.8	100.0	280	17	0.060.02	

[12] Three Mile Island 1 resumed commercial power generation 10/85 after being under regulatory restraint since 1979.

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
	19860.0		0.0	1,497	915	0.61	---
THREE MILE ISLAND 2[13]	1987	0.0	0.0	1,378	977	0.71	---
Docket 50-320; DPR-73	1988	0.0	0.0	1,247	917	0.74	---
1st commercial operation 12/78	1989	0.0	0.0	1,014	639	0.63	---
Type - PWR	1990	0.0	0.0	484	1360.28		---
Capacity - 880 MWe	1991	0.0	0.0	153	37	0.24	---
	1992	0.0	0.0	315	157	0.50	---
	1993	0.0	0.0	167	33	0.20	---
	1994	0.0	0.0	259	7	0.03	---
	1995	0.0	0.0	191	2	0.01	---
	19960.0		0.0	122	2	0.02	---
	1997	0.0	0.0	232	1	0.00	---
	1998	0.0	0.0	184	10	0.05	---
	1977	792.0	92.6591		174	0.29	0.2
TROJAN[14]	1978	205.5	20.671	1	319	0.45	1.6
Docket 50-344; NPF-1	1979	631.0	58.1	736	258	0.35	0.4
1st commercial operation 5/76	1980	727.5	72.5	1,159	421	0.360.6	
Type - PWR	1981	775.674.1		1,311	609	0.46	0.8
Capacity - 1095 MWe	1982	579.5	60.8	977	419	0.43	0.7
	1983	494.2	62.4	969	307	0.32	0.6
	1984	567.0	54.4	1,042	433	0.42	0.8
	1985	829.1	76.7	852	363	0.43	0.4
	1986852.4		79.7	1,321	381	0.29	0.4
	1987	525.5	54.0	1,209	363	0.30	0.7
	1988	758.66	7.5	1,408	401	0.28	0.5
	1989	666.8	61.9	1,360	421	0.31	0.6
	1990	732.4	66.3	1,169	258	0.22	0.4
	1991	181.616	.1	1,496	567	0.38	3.1
	1992	553.9	68.4	567	84	0.15	0.2
	1993	0.0	68.4	54	21	0.39	---
	1994	0.0	0.0	51	9	0.18	---
	1995	0.0	0.0	141	44	0.31	---
	19960.0		0.0	112	41	0.37	---
	1997	0.0	0.0	227	41	0.18	---
	1998	0.0	0.0	24612		0.05	---
	1973	401.9		444	78	0.18	0.2
TURKEY POINT 3, 4	1974	953.6794			454	0.57	0.5
Docket 50-250, 50-251;	1975	1,003.7	74.9	1,176876		0.74	0.9
DPR-31, -41	1976974.2		71.2	1,647	1,184	0.72	1.2
1st commercial operation	1977	979.5	72.1	1,319	1,0360.79		1.1
12/72, 9/73	1978	1,000.2	78.8	1,3361,032		0.77	1.0
Type - PWRs	1979	811.0	62.4	2,002	1,680	0.84	2.1
Capacity - 693, 693 MWe	1980	990.673.6		1,803	1,651	0.92	1.7
	1981	654.0	46.8	2,932	2,251	0.77	3.4
	1982	915.7	65.2	2,956	2,119	0.72	2.3
	1983	878.4	62.8	2,930	2,681	0.92	3.1
	1984	946.7	68.5	2,010	1,255	0.62	1.3
	1985	1,034.9	74.7	1,905	1,253	0.66	1.2
	1986754.1		54.9	1,808	946	0.52	1.3
	1987	431.3	36.6	1,980	1,371	0.69	3.2
	1988	809.8	59.5	1,841	738	0.40	0.9
	1989	689.9	56.8	1,625	433	0.27	0.6
	1990	933.1	69.0	2,099	730	0.35	0.8

[13] Three Mile Island 2 has been shut down since the 1979 accident, but was still included in the count of reactors through 1988 since dose was still being accumulated to defuel and docontaminate the unit during this time period.

[14] Trojan ended commercial operation as of 1/93, and will not be put in commercial operation again. It is no longer in the count of commercial reactors.

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
	1991	258.2	21.0	2,087	939	0.45	3.6
TURKEY POINT 3, 4	1992	968.9	75.5	1,374	325	0.24	0.3
(continued)	1993	1,244.8	91.0	1,271	275	0.22	0.2
	1994	1,172.9	87.2	1,489	4760.32		0.4
	1995	1,320.3	94.61,142		215	0.19	0.2
	19961,307.8		94.0	1,157	187	0.16	0.1
	1997	1,220.9	88.61,581		414	0.26	0.34
	1998	1,323.0	94.5	1,045	1560.15		0.12
	1973	222.1		244	85	0.35	0.4
VERMONT YANKEE	1974	303.5		357	2160.6	1	0.7
Docket 50-271; DPR-28	1975	429.0	87.8	282	153	0.54	0.4
1st commercial operation 11/72	1976389.6		77.1	815	411	0.50	1.1
Type - BWR	1977	423.5	85.1	641	258	0.40	0.6
Capacity - 510 MWe	1978	387.5	75.9	934	339	0.360.9	
	1979	414.0	82.1	1,220	1,170	0.962.8	
	1980	357.8	71.5	1,443	1,338	0.93	3.7
	1981	429.1	84.61,26	4	731	0.58	1.7
	1982	501.0	96.0	481	205	0.43	0.4
	1983	346.1	69.3	1,316	1,527	1.16	4.4
	1984	398.1	79.0	954	626	0.66	1.6
	1985	361.4	71.8	1,392	1,051	0.76	2.9
	1986248.1		48.9	1,389	1,188	0.86	4.8
	1987	423.684.2		827	303	0.37	0.7
	1988	492.1	95.7	379	124	0.33	0.3
	1989	432.8	84.7	832	288	0.35	0.7
	1990	433.1	85.9	849	307	0.360.7	
	1991	492.3	94.3	310	118	0.38	0.2
	1992	446.8	88.1	921	381	0.41	0.9
	1993	402.3	80.1	833	217	0.260.5	
	1994	515.8	98.7	220	38	0.17	0.1
	1995	462.1	87.0	737	182	0.25	0.4
	1996452.7		85.2	951	231	0.24	0.5
	1997	487.1	96.0	260	57	0.22	0.1
	1998	383.4	77.9	944	199	0.21	0.52
	1988	820.4	77.7	1,108	138	0.12	0.2
VOGTLE 1, 2	1989	1,045.8	96.0	427	32	0.07	0.0
Docket 50-424; 50-425;	1990	1,710.9	82.7	1,602	466	0.29	0.3
NPF-68, -81	1991	1,966.5	89.2	1,357	362	0.27	0.2
1st commercial operation	1992	2,047.9	90.0	1,262	426	0.34	0.2
6/87, 5/89	1993	2,060.4	88.3	1,338	367	0.27	0.2
Type - PWRs	1994	2,170.1	91.3	1,048	217	0.21	0.1
Capacity - 1162, 1167 MWe	1995	2,285.4	95.2	953	199	0.21	0.1
	19962,056	.8	86.5	1,395	452	0.32	0.2
	1997	2,121.1	91.4	994	158	0.160.07	
	1998	2,123.9	92.3	994	162	0.16	0.08
	1985	616.0	87.6	755	119	0.16	0.2
WASHINGTON NUCLEAR 2	1986	616.0	74.4	1,013	222	0.22	0.4
Docket 50-397; NPF-21	1987	639.0	70.8	1,201	406	0.34	0.6
1st commercial operation 12/84	1988	707.7	71.8	1,050	353	0.34	0.5
Type - BWR	1989	727.2	78.3	1,299	492	0.38	0.7
Capacity - 1107 MWe	1990	684.7	67.5	1,348	536	0.40	0.8
	1991	508.5	50.3	1,088	387	0.360.8	
	1992	682.3	65.6	1,489	612	0.41	0.9
	1993	849.679.5		1,385	469	0.34	0.6
	1994	803.8	75.2	1,870	866	0.46	1.1
	1995	824.7	83.8	1,694	456	0.27	0.6
	1996	662.9	82.2	1,453	373	0.26	0.6
	1997	697.0	72.7	1,218	251	0.21	0.36
	1998	789.5	75.3	1,220	2860.23		0.36

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
	1986875.7		79.1	1,244	223	0.18	0.3
WATERFORD	1987	891.8	82.5	959	1560.16		0.2
Docket 50-382; NPF-38	1988	784.3	75.4	1,246259		0.21	0.3
1st commercial operation 9/85	1989	909.8	82.61,306		265	0.20	0.3
Type - PWR	1990	1,027.9	92.8	432	47	0.11	0.0
Capacity - 1075 MWe	1991	870.679.8		1,301	364	0.28	0.4
	1992	909.683.2		1,213	226	0.19	0.2
	1993	1,088.3	99.4	195	15	0.08	0.0
	1994	949.1	87.0	1,167	191	0.16	0.2
	1995	927.4	83.4	1,092	153	0.14	0.2
	19961,06	4.8	94.2	342	27	0.08	0.0
	1997	767.2	71.2	1,186	148	0.13	0.19
	1998	984.1	91.9	282	24	0.09	0.02
	1997	867.6	83.8	1,071	112	0.11	0.13
WATTS BAR 1	1998	1,105.1	99.1	80	3	0.04	0.00
Docket 50-390							
1st commercial operation 5/96							
Type - PWR							
Capacity - 1118 MWe							
	1986832.8		73.3	682	143	0.21	0.2
WOLF CREEK 1	1987	778.8	71.1	675	138	0.20	0.2
Docket 50-482; NPF-42	1988	794.7	70.7	1,010	297	0.29	0.4
1st commercial operation 9/85	1989	1,108.4	99.5	18618		0.10	0.0
Type - PWR	1990	940.2	81.0	798	195	0.24	0.2
Capacity - 1163 MWe	1991	707.671.9		1,010	331	0.33	0.5
	1992	1,010.8	86.7	446	78	0.17	0.1
	1993	940.5	80.6975		183	0.19	0.2
	1994	1,017.2	86.8	1,082	235	0.22	0.2
	1995	1,198.0	98.7	242	14	0.060.0	
	1996980.6		81.2	986	171	0.17	0.2
	1997	964.3	83.8	989	265	0.27	0.27
	1998	1,187.3	100.0	184	10	0.05	0.01
	1969	138.3		193	215	1.11	1.6
YANKEE ROWE[15]	1970	146.1		355	255	0.72	1.7
Docket 50-29; DPR-3	1971	173.5		155	90	0.58	0.5
1st commercial operation 7/61	1972	78.7		282	255	0.90	3.2
Type - PWR	1973	127.1		133	99	0.74	0.8
Capacity - 167 MWe	1974	111.3		243	205	0.84	1.8
	1975	145.1	82.4	249	1160.47		0.8
	1976152.2		89.8	152	59	0.39	0.4
	1977	124.673.9		725	356	0.49	2.9
	1978	145.0	81.0	565	282	0.50	1.9
	1979	149.0	81.6441		127	0.29	0.9
	1980	35.622.0		502	213	0.42	6.0
	1981	109.0	74.4	515	302	0.59	2.8
	1982	108.673.4		814	474	0.58	4.4
	1983	163.5	91.4	395	68	0.17	0.4
	1984	124.8	71.4	654	348	0.53	2.8
	1985	144.3	85.3	653	211	0.32	1.5
	198616	9.7	95.0	384	45	0.12	0.3
	1987	138.7	82.7	593	217	0.37	1.6
	1988	136.4	85.2	738	227	0.31	1.7
	1989	159.4	92.9	4966	2	0.12	0.4
	1990	101.1	61.5	702	246	0.35	2.4
	1991	121.2	72.3	162	40	0.25	0.3
	1992	0.0	0.0	324	94	0.29	---

[15] Yankee Rowe ended commercial operation as of 10/91, and will not be put in commercial operation again. It is no longer in the count of commercial reactors.

Reporting Organization	Year	Megawatt Years MW-YR	Unit Availability Factor	Total Personnel with Measurable Doses	Collective Dose	Average Measurable Dose (rems)	Collective Dose MW-yr
	1993	0.0	0.0	313	163	0.52	---
YANKEE ROWE	1994	0.0	0.0	222	1560.70		---
(continued)	1995	0.0	0.0	191	78	0.41	---
	19960.0		0.0	239	95	0.40	---
	1997	0.0	0.0	323	65	0.20	---
	1998	0.0	0.0	283	460.16		---
	1974	425.3	71.1	30656		0.18	0.1
ZION 1, 2[16]	1975	1,181.5	74.9	436127		0.29	0.1
Docket 50-295; 50-304;	19761,134.9		61.9	774	571	0.74	0.5
DPR-39, -48	1977	1,358.675.0		784	1,003	1.28	0.7
1st commercial operation	1978	1,613.5	80.2	1,104	1,017	0.92	0.6
12/73, 9/74	1979	1,238.0	67.6	1,472	1,274	0.87	1.0
Type - PWRS	1980	1,411.2	74.1	1,363	920	0.67	0.7
Capacity - 1040, 1040 MWe	1981	1,366.9	72.3	1,754	1,720	0.98	1.3
	1982	1,186.4	64.3	1,575	2,103	1.34	1.8
	1983	1,222.3	69.4	1,285	1,311	1.02	1.1
	1984	1,389.9	69.6	1,110	786	0.71	0.6
	1985	1,187.9	62.9	1,498	1,166	0.78	1.0
	19861,46	2.0	73.2	967	474	0.49	0.3
	1987	1,337.0	71.0	1,0466	53	0.62	0.5
	1988	1,549.1	78.3	1,9261,26	0	0.65	0.8
	1989	1,514.1	77.61,282		624	0.49	0.4
	1990	860.4	46.9	1,385	696	0.50	0.8
	1991	1,125.7	58.2	902	173	0.19	0.2
	1992	1,128.8	59.0	1,732	1,043	0.60	0.9
	1993	1,458.2	70.9	1,772	643	0.36	0.4
	1994	1,224.9	59.9	1,176306		0.26	0.2
	1995	1,471.672.4		1,807	797	0.44	0.5
	19961,538.4		75.8	1,567	437	0.28	0.3
	1997	123.2	7.1	924	119	0.13	0.97
	1998	0.0	0.0	24612		0.05	---

[16] Zion 1, 2 was shut down 12/97 and is no longer included in the count of commercial reactors.

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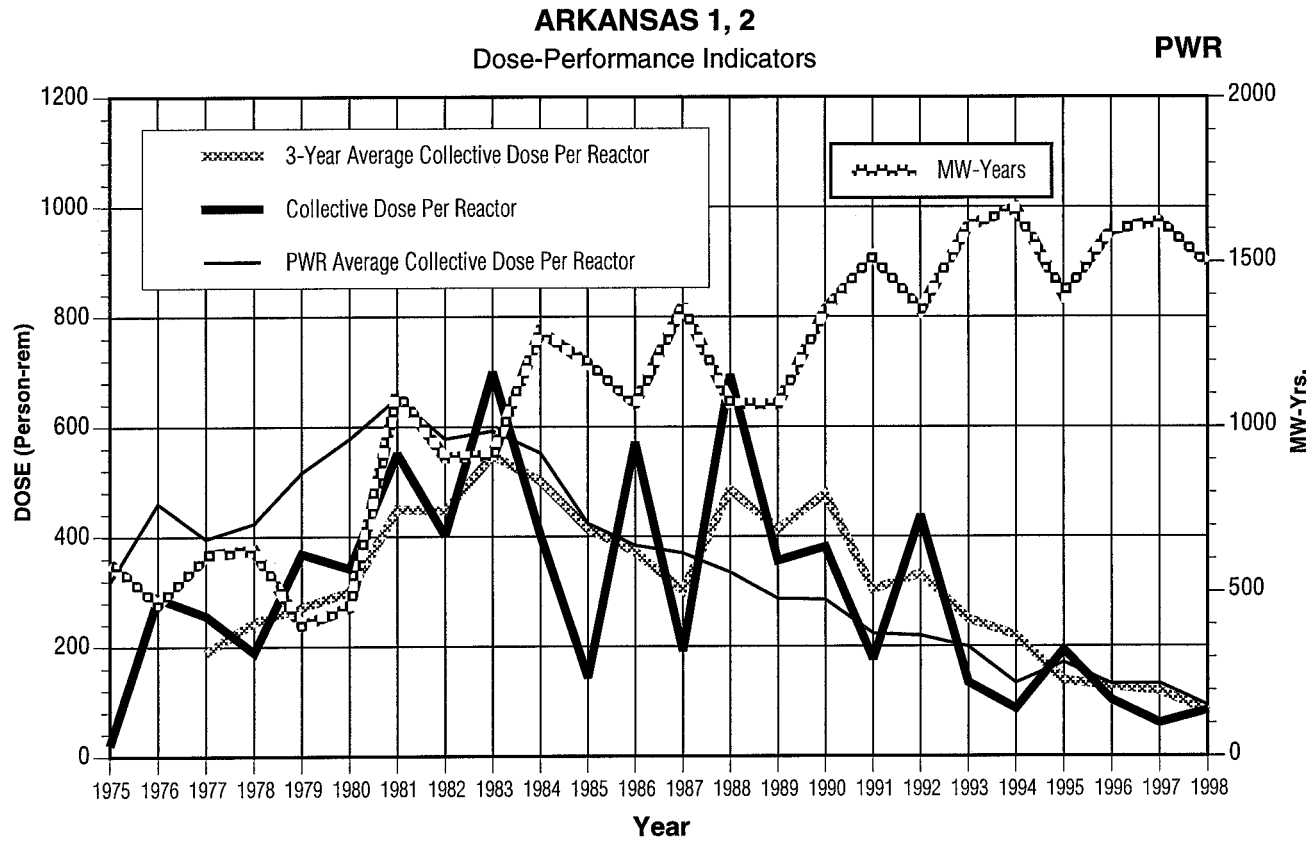
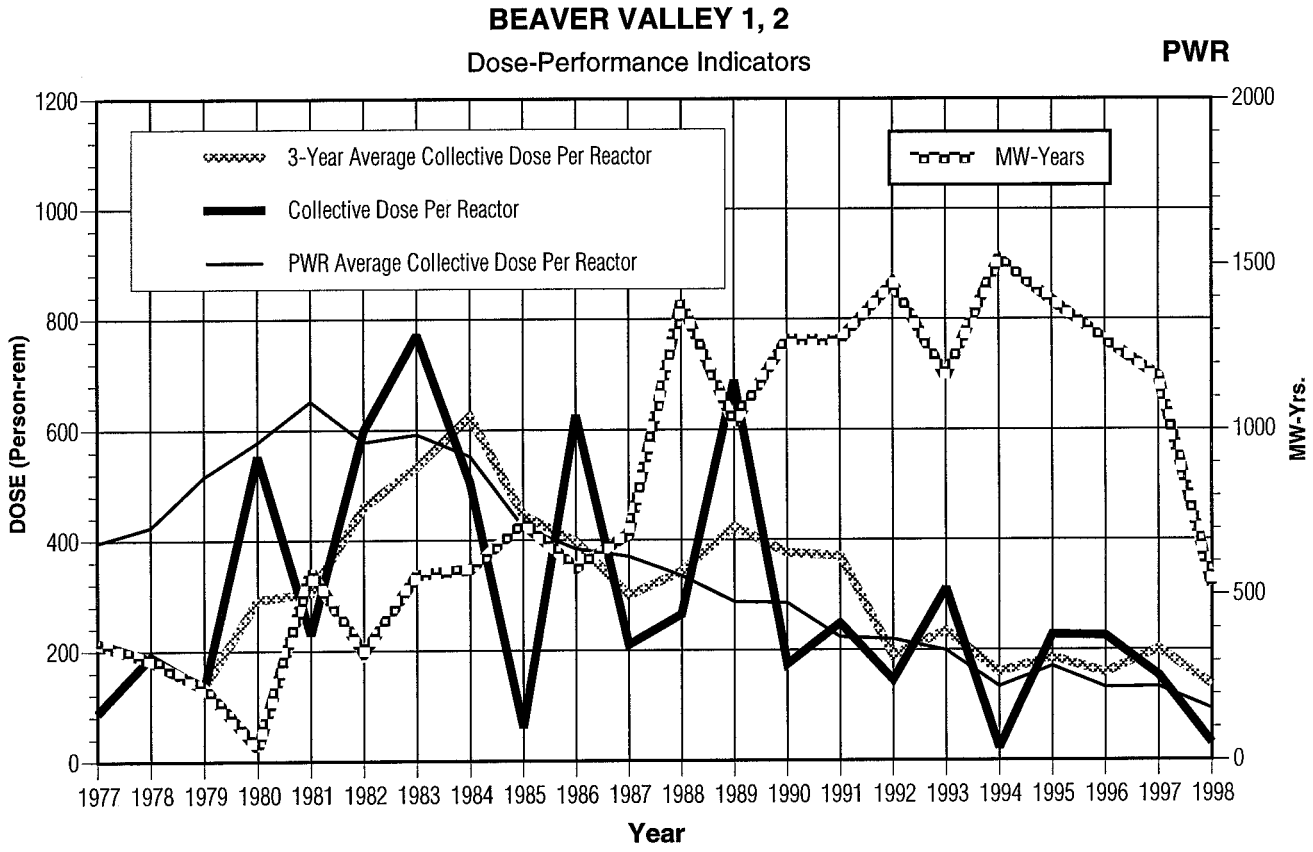
Appendix D

DOSE PERFORMANCE INDICATORS BY REACTOR SITE

1973 - 1998

NOTE: Appendix D contains data on operating plants as well as plants which are no longer in commercial operation.

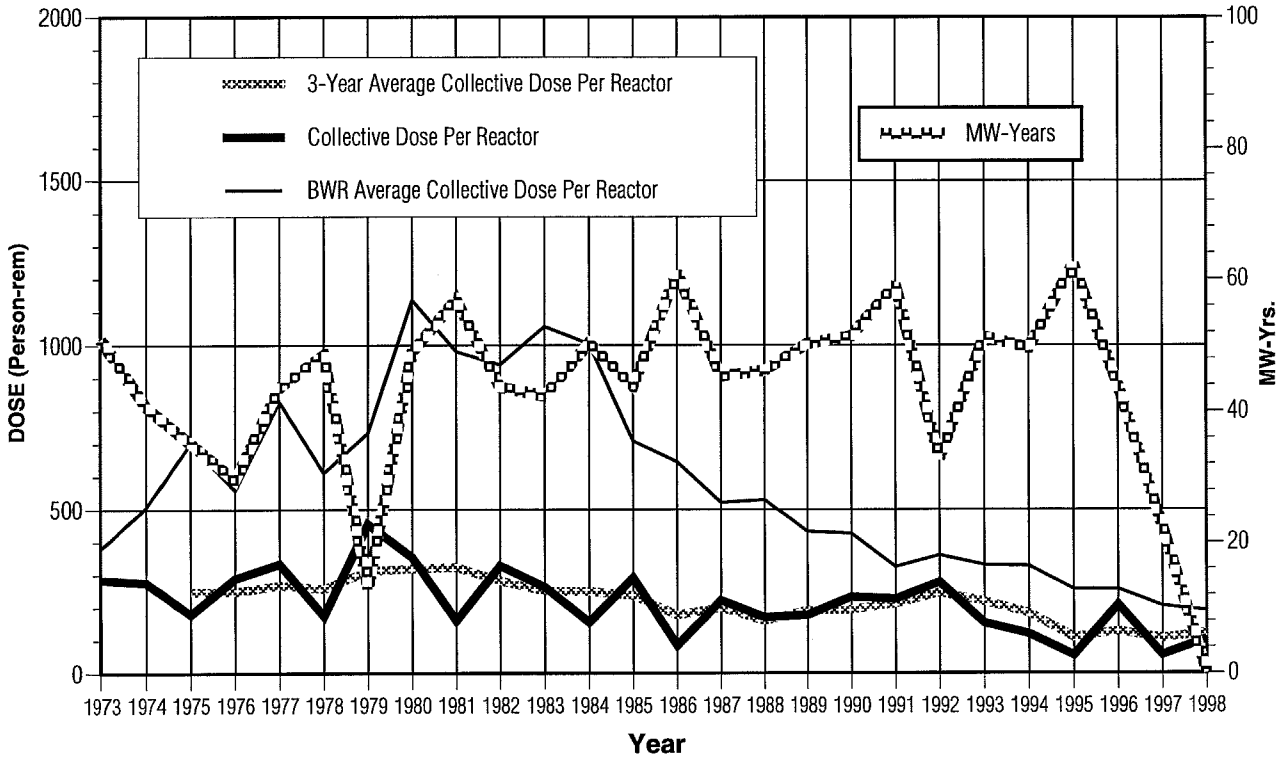

ARKANSAS 1, 2
Dose-Performance Indicators
PWR
3-Year Average Collective Dose Per Reactor
Collective Dose Per Reactor
PWR Average Collective Dose Per Reactor
MW-Years
DOSE (Person-rem)
MW-Yrs.
0
200
400
600
800
1000
1200
500
1000
1500
2000
1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998
Year


BEAVER VALLEY 1, 2
Dose-Performance Indicators
PWR
3-Year Average Collective Dose Per Reactor
Collective Dose Per Reactor
PWR Average Collective Dose Per Reactor
MW-Years
DOSE (Person-rem)
MW-Yrs.
0
200
400
600
800
1000
1200
500
1000
1500
2000
1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998
Year

BIG ROCK POINT

Dose-Performance Indicators

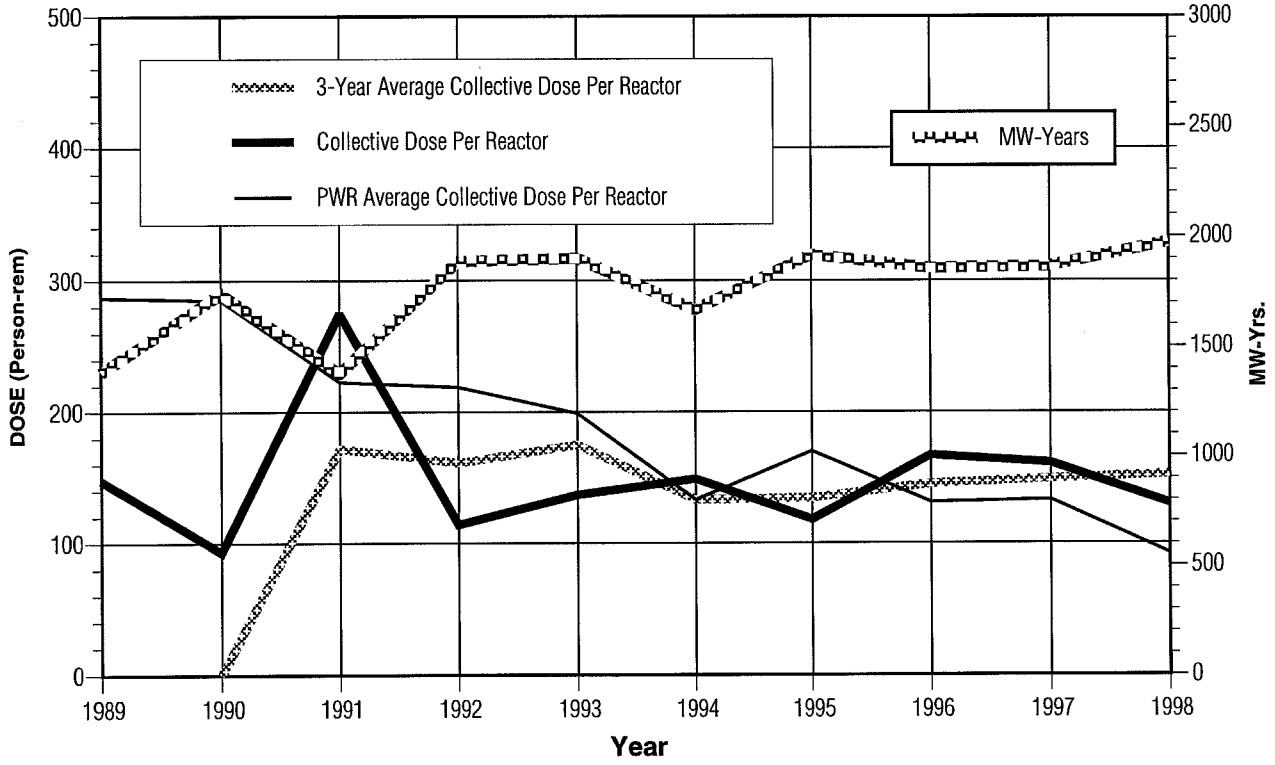
BWR



BRAIDWOOD 1, 2

Dose-Performance Indicators

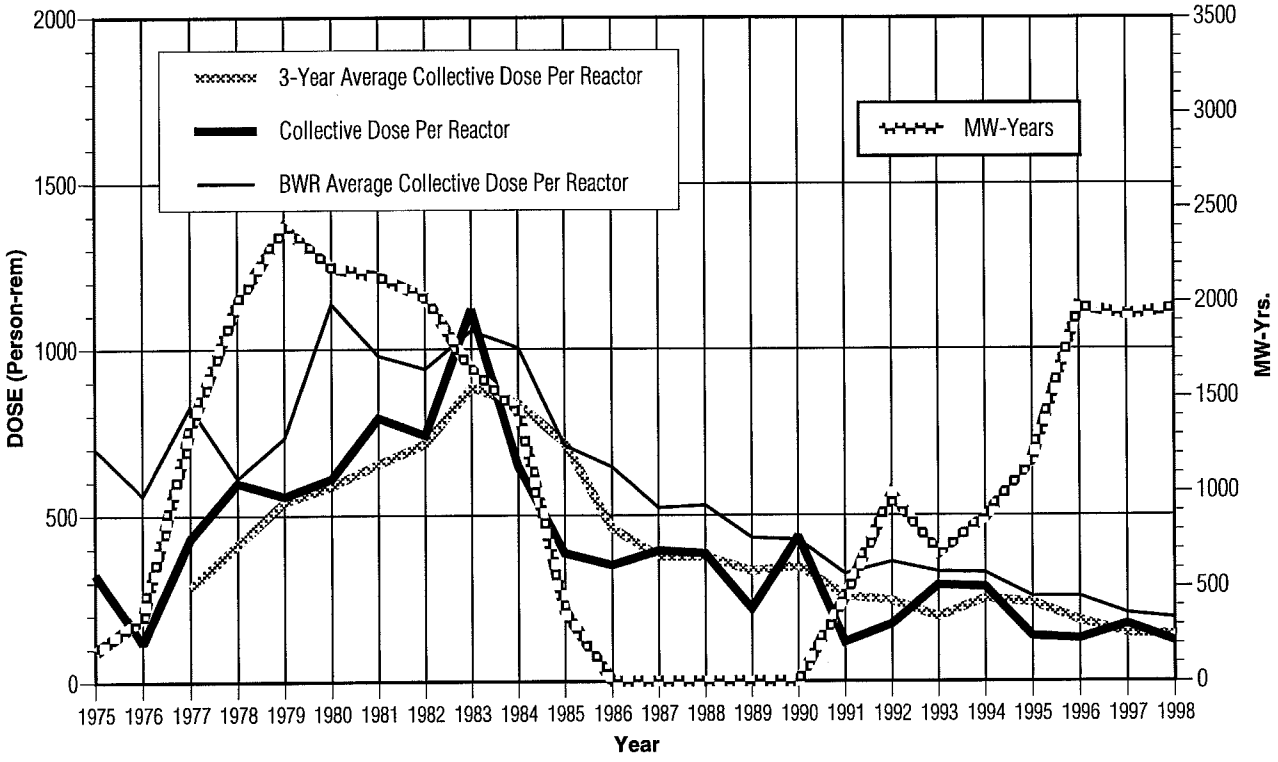
PWR



BROWNS FERRY 1, 2, 3

Dose-Performance Indicators

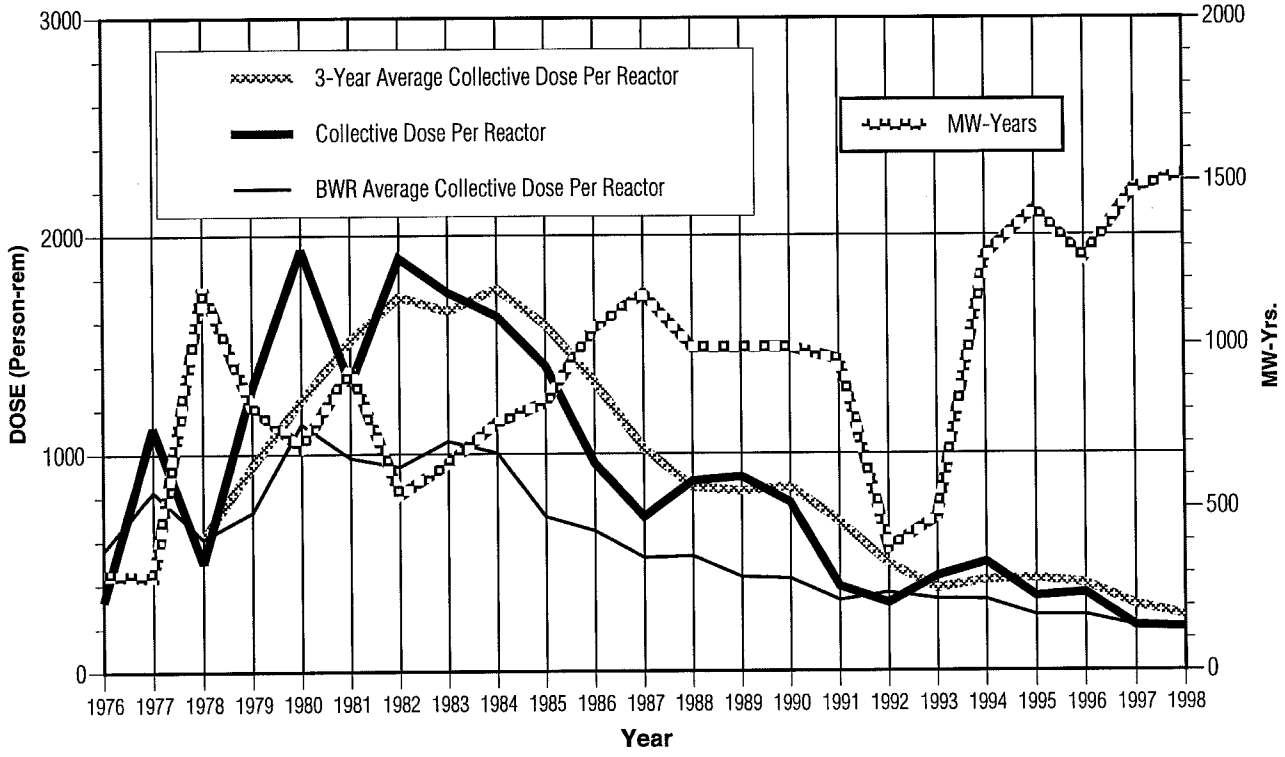
BWR



BRUNSWICK 1, 2

Dose-Performance Indicators

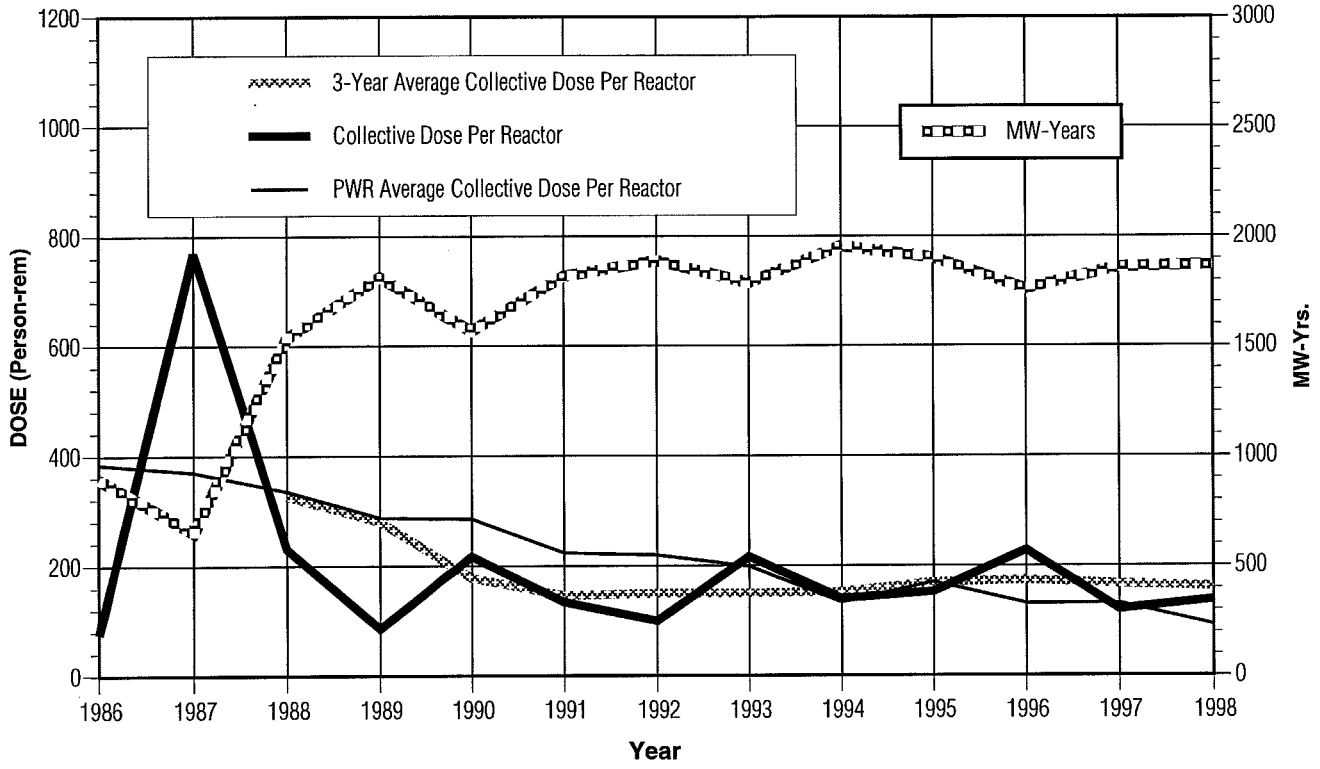
BWR



BYRON 1, 2

Dose-Performance Indicators

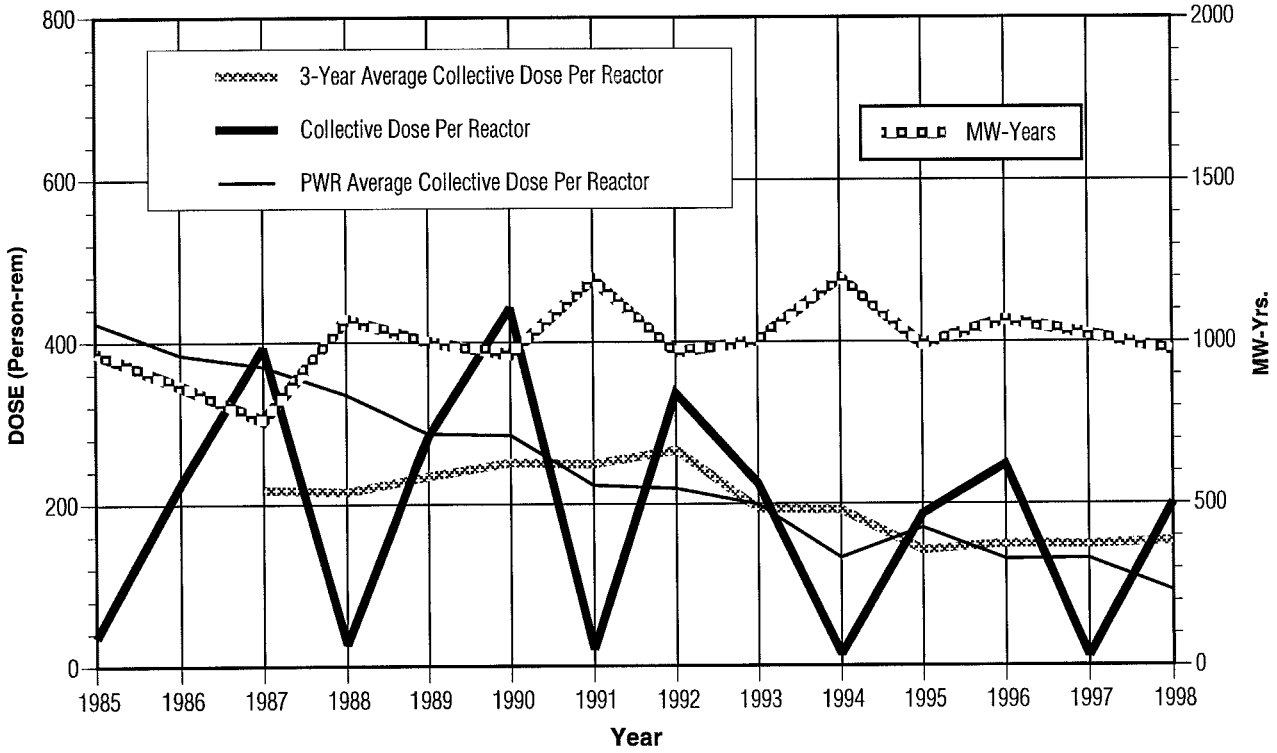
PWR



CALLAWAY 1

Dose-Performance Indicators

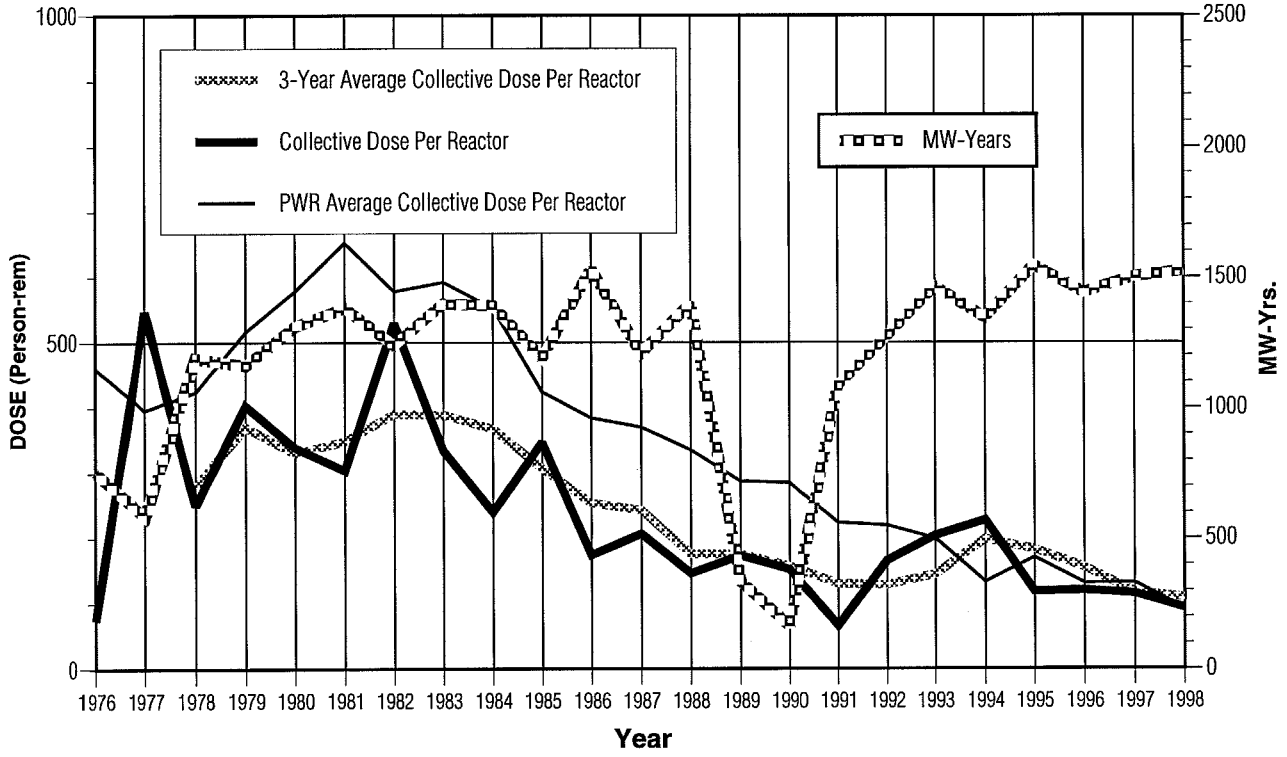
PWR



CALVERT CLIFFS 1, 2

Dose-Performance Indicators

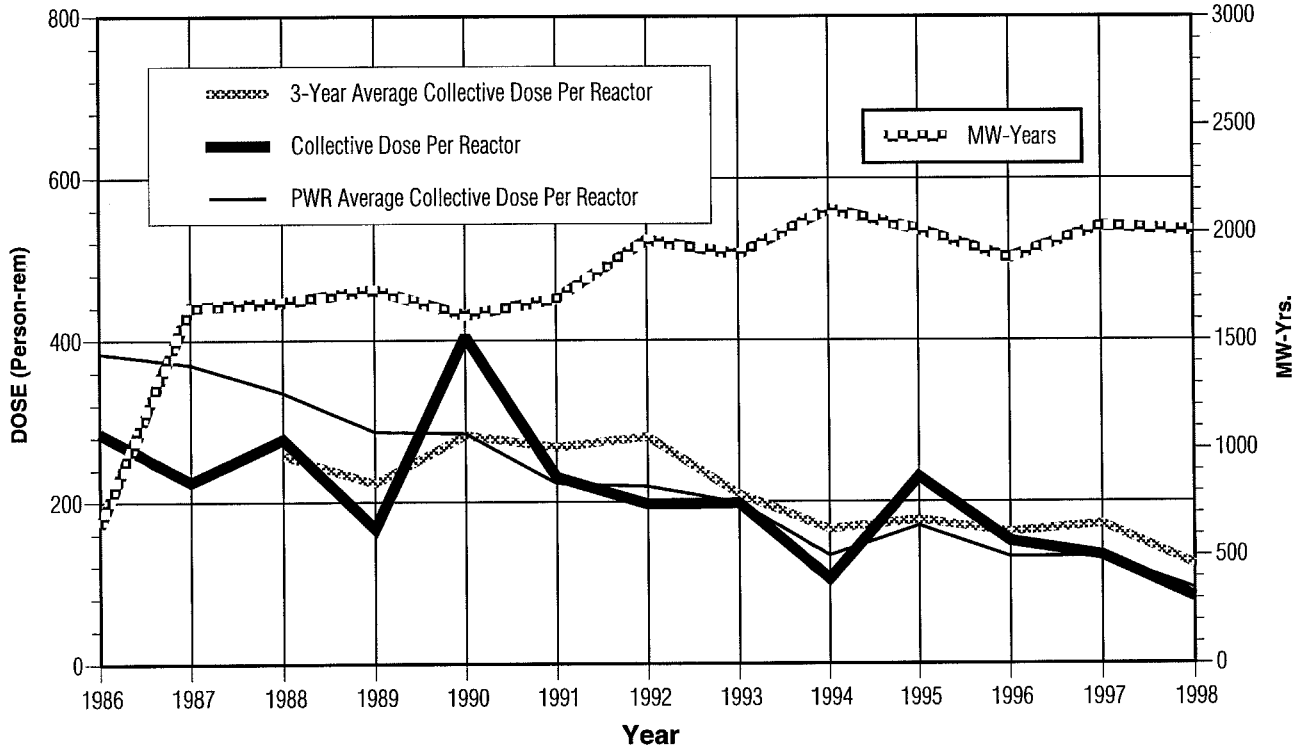
PWR



CATAWBA 1, 2

Dose-Performance Indicators

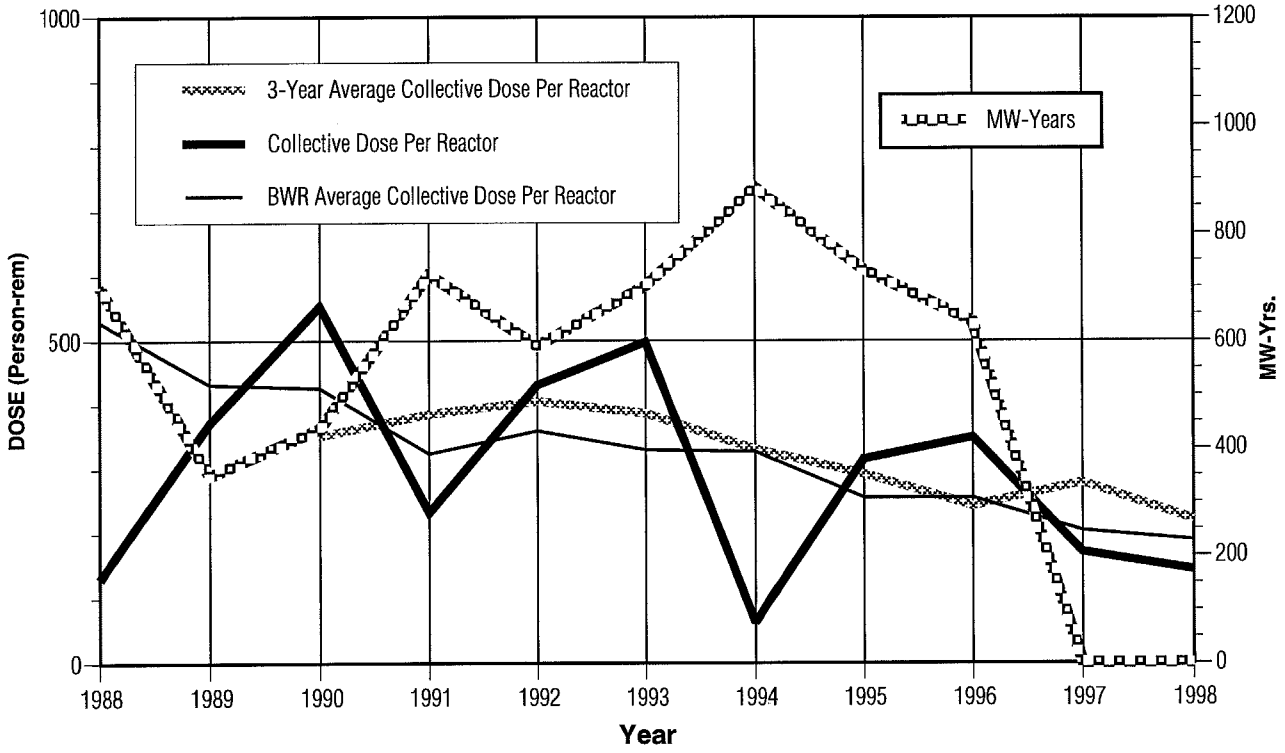
PWR



CLINTON

Dose-Performance Indicators

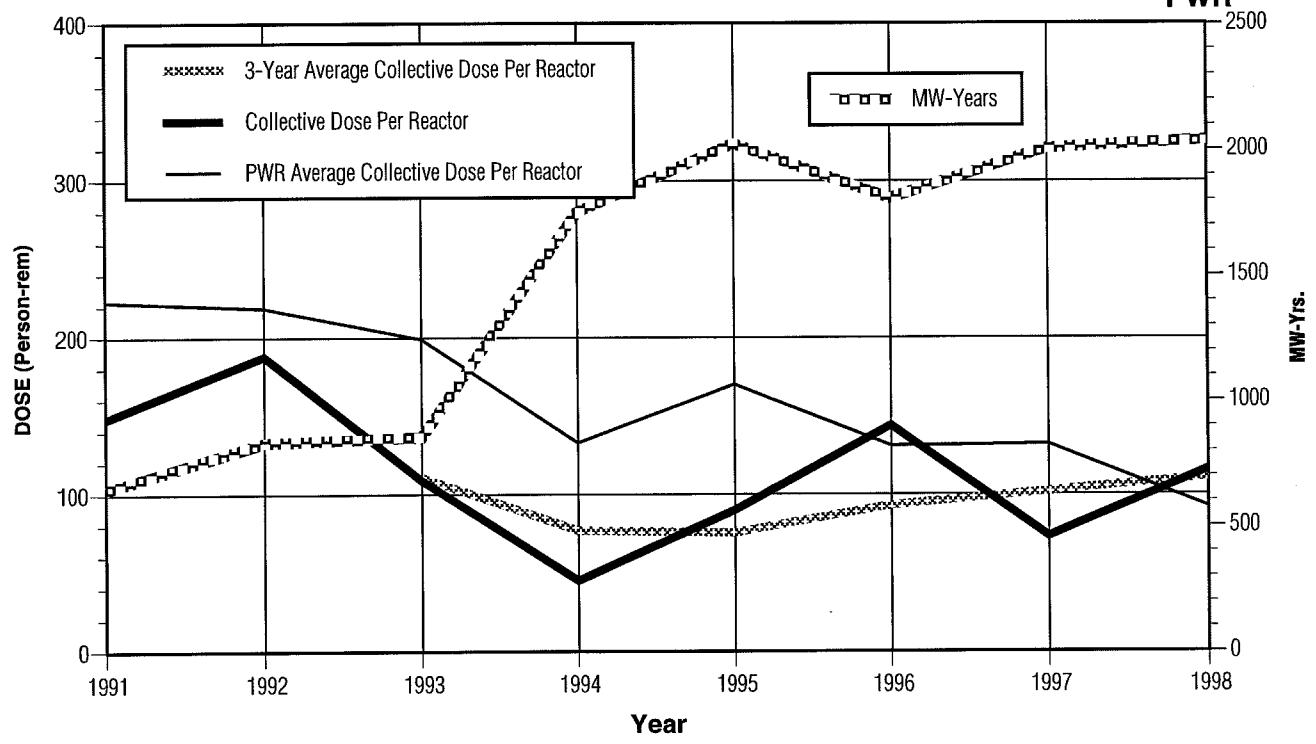
BWR



COMANCHE PEAK 1, 2

Dose-Performance Indicators

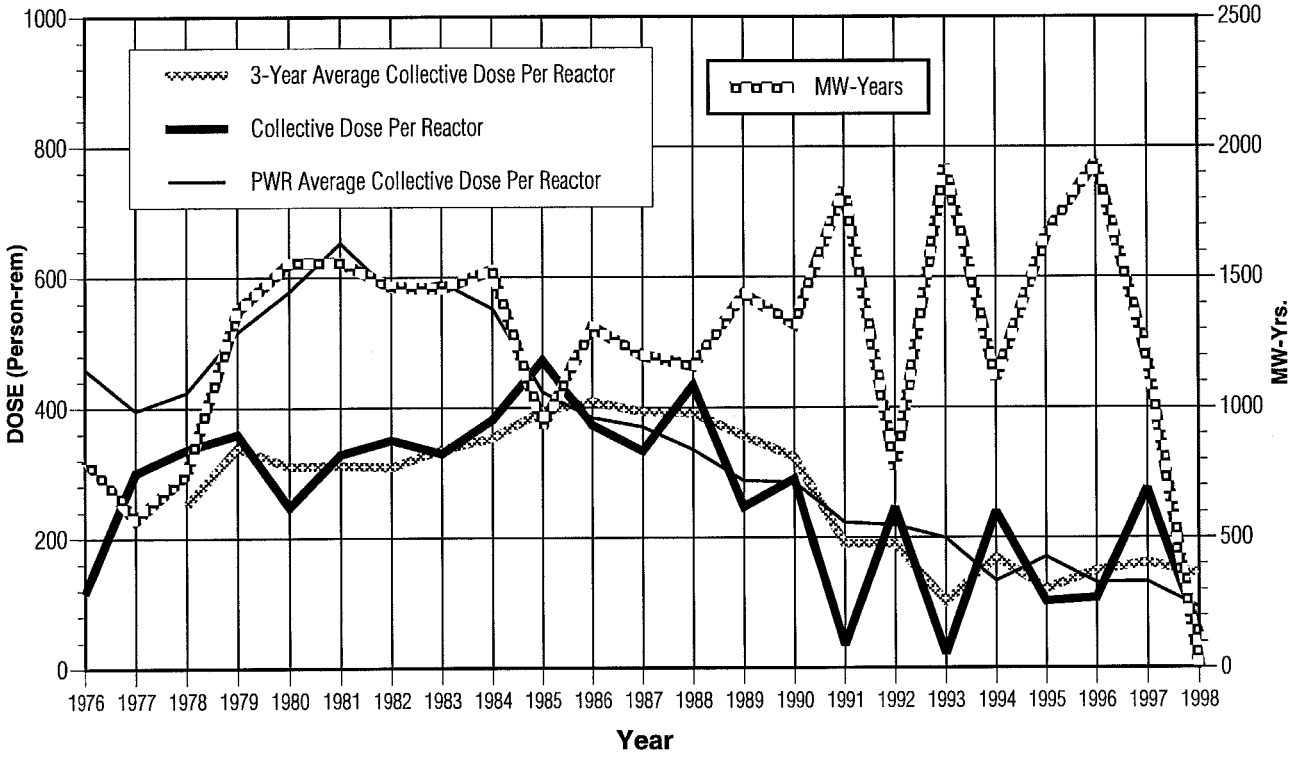
PWR



COOK 1, 2

Dose-Performance Indicators

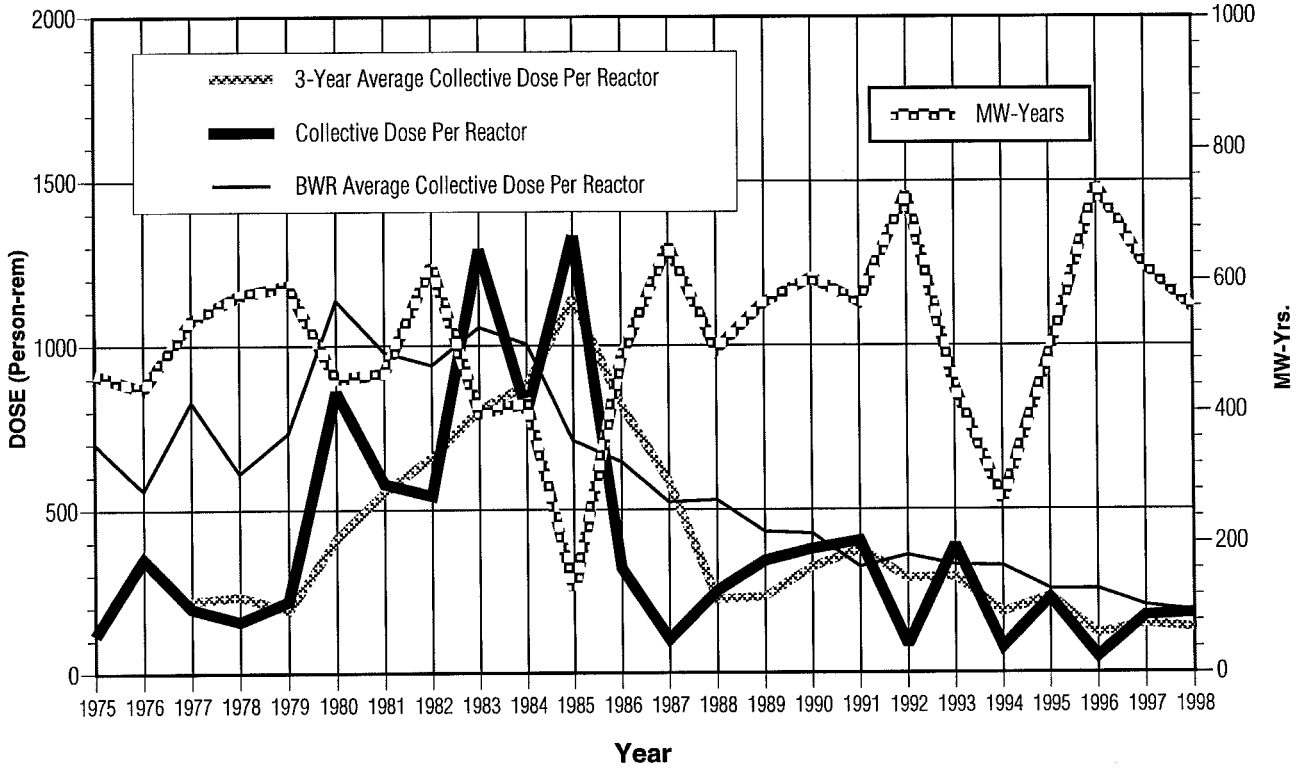
PWR



COOPER STATION

Dose-Performance Indicators

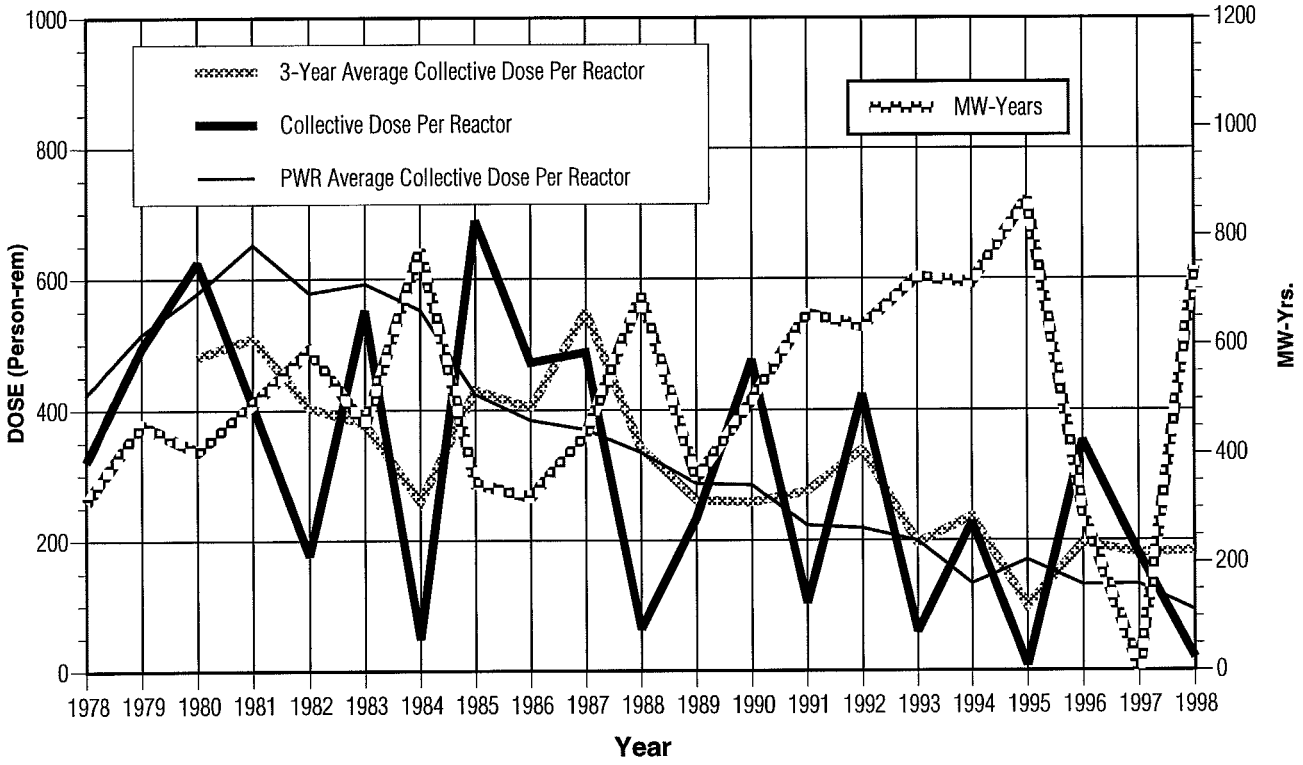
BWR



CRYSTAL RIVER 3

Dose-Performance Indicators

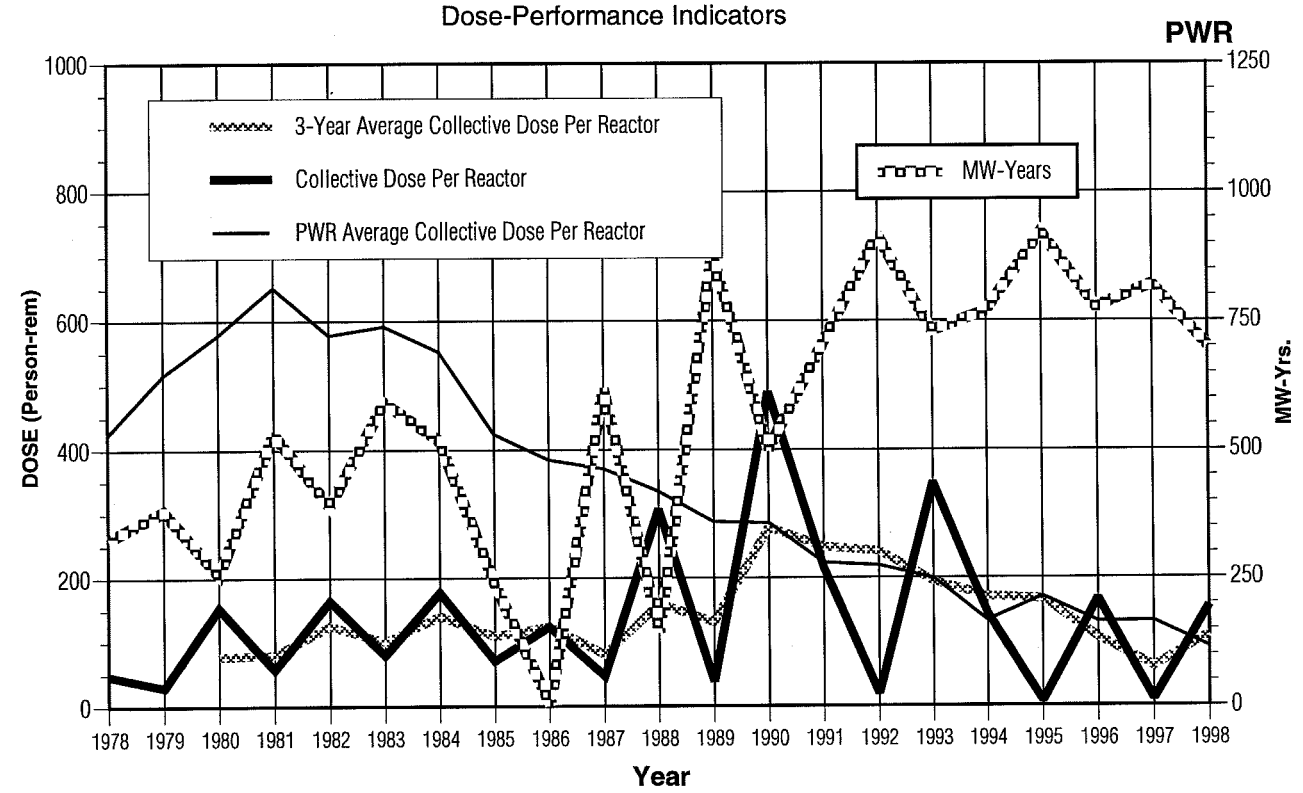
PWR



DAVIS-BESSE

Dose-Performance Indicators

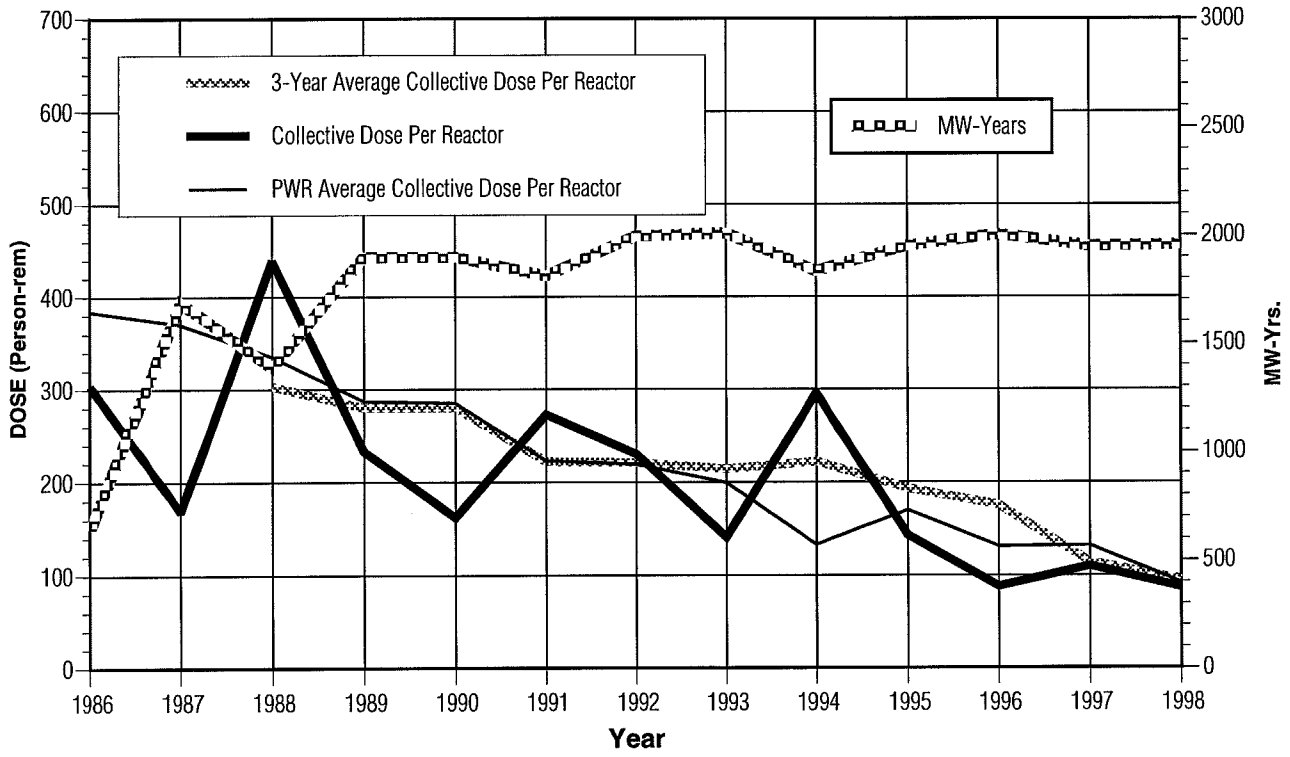
PWR



DIABLO CANYON 1, 2

Dose-Performance Indicators

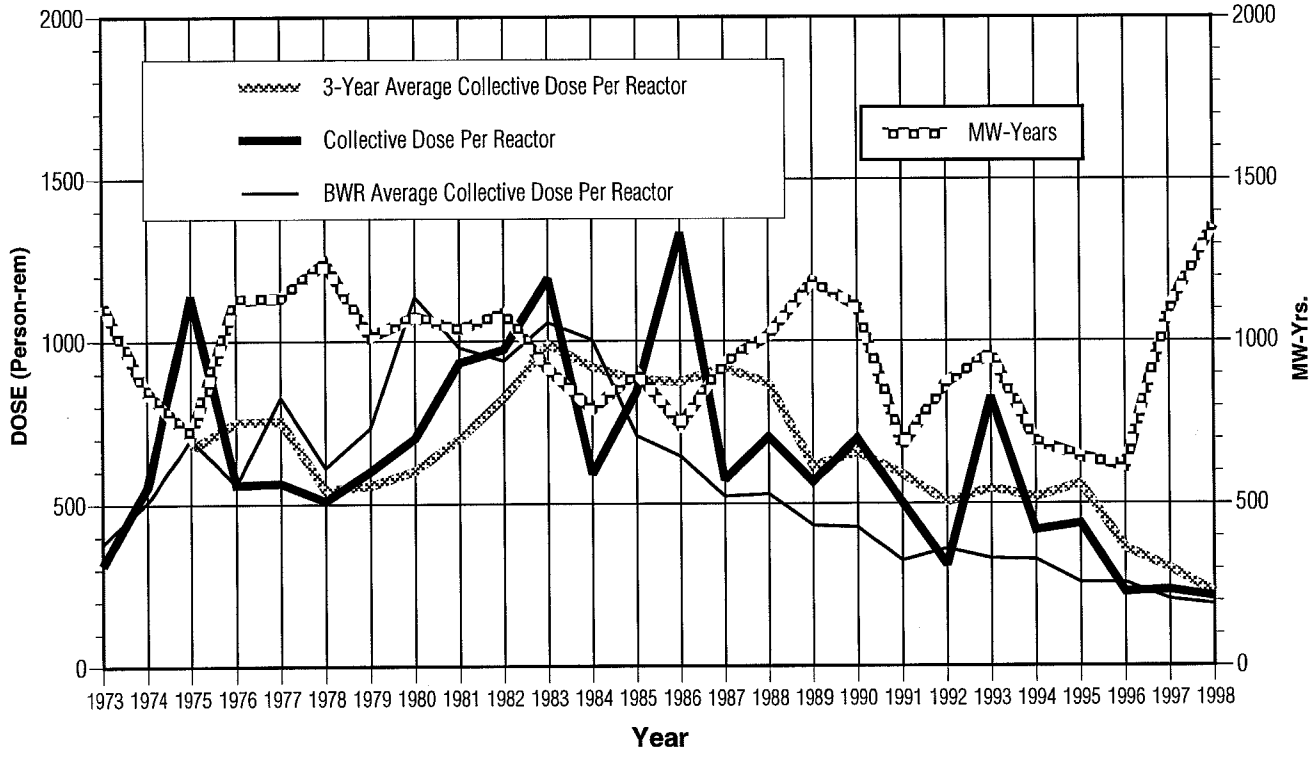
PWR



DRESDEN 2, 3

Dose-Performance Indicators

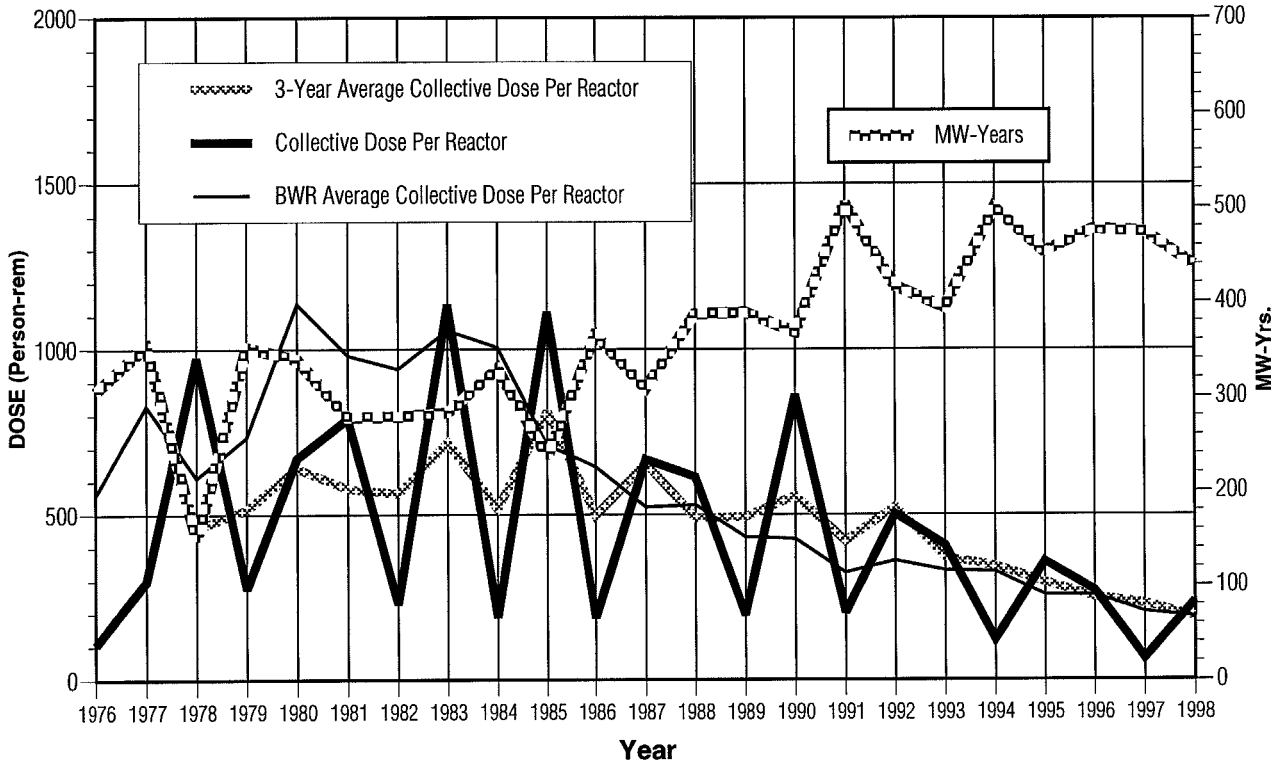
BWR



DUANE ARNOLD

Dose-Performance Indicators

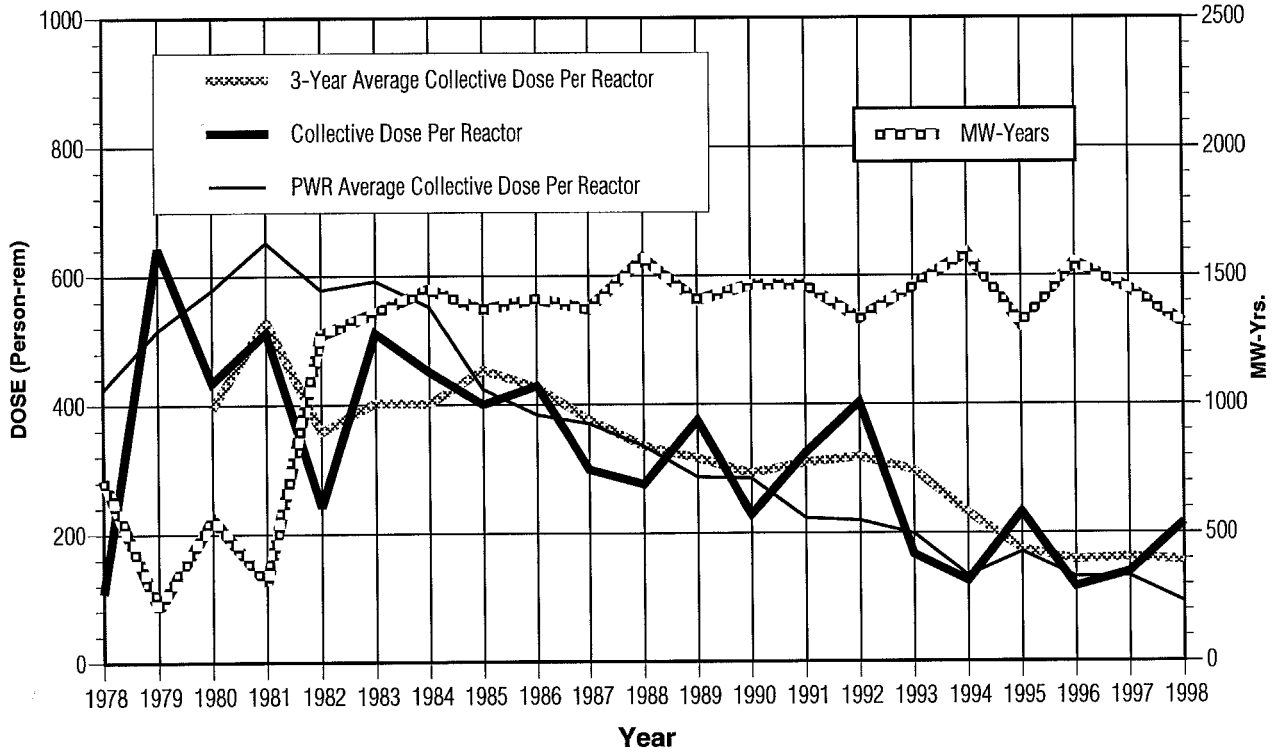
BWR



FARLEY 1, 2

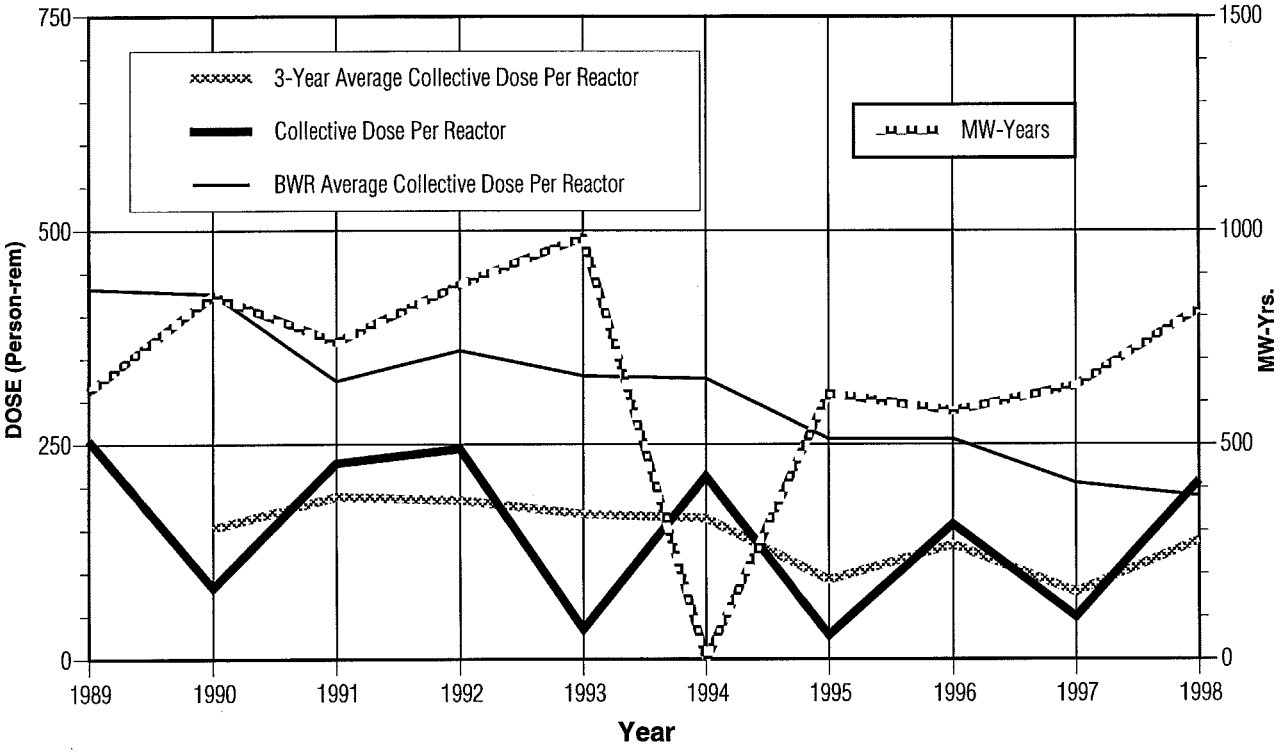
Dose-Performance Indicators

PWR



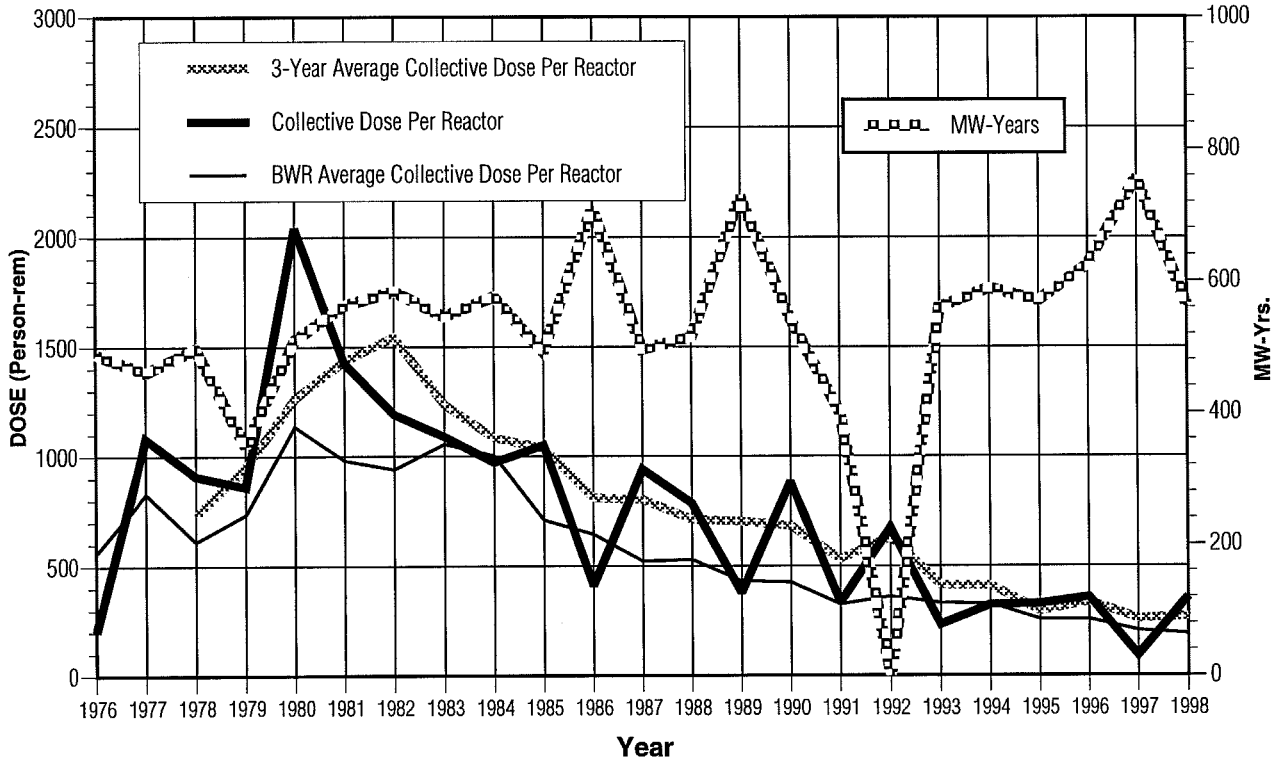
FERMI 2

Dose-Performance Indicators **BWR**



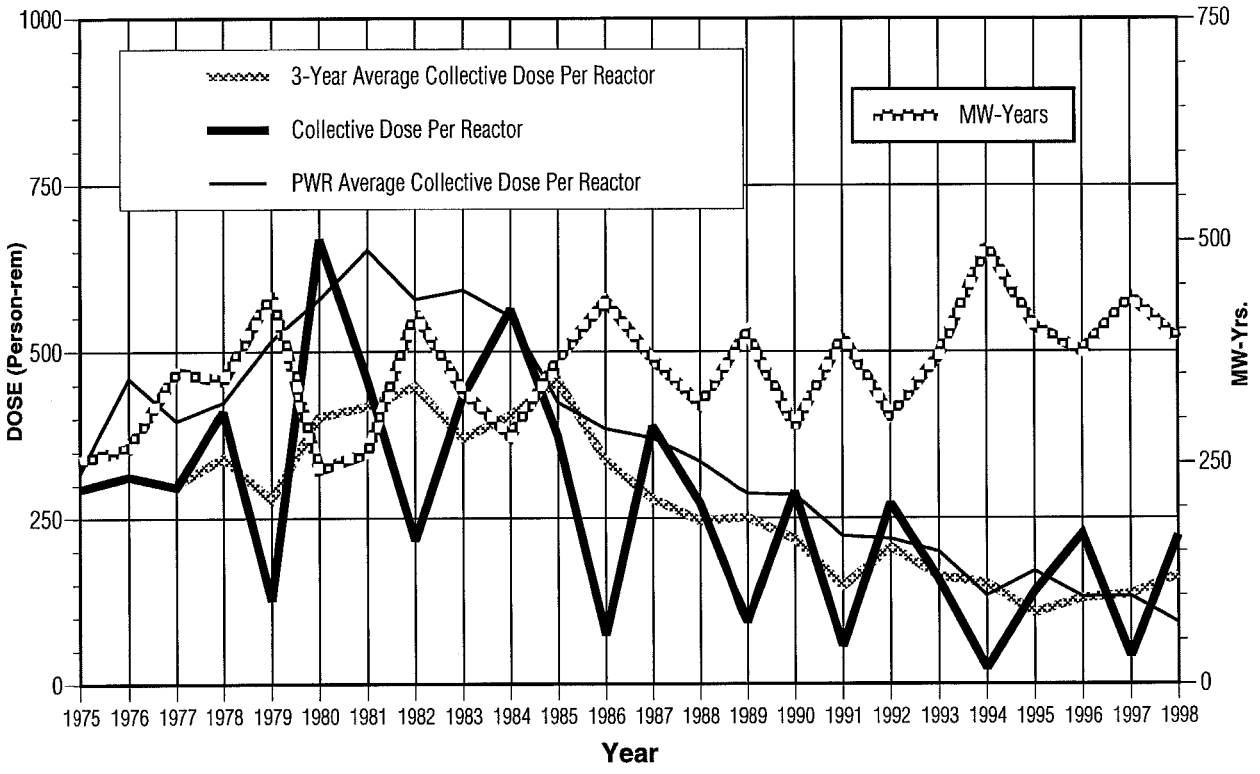
FITZPATRICK

Dose-Performance Indicators **BWR**



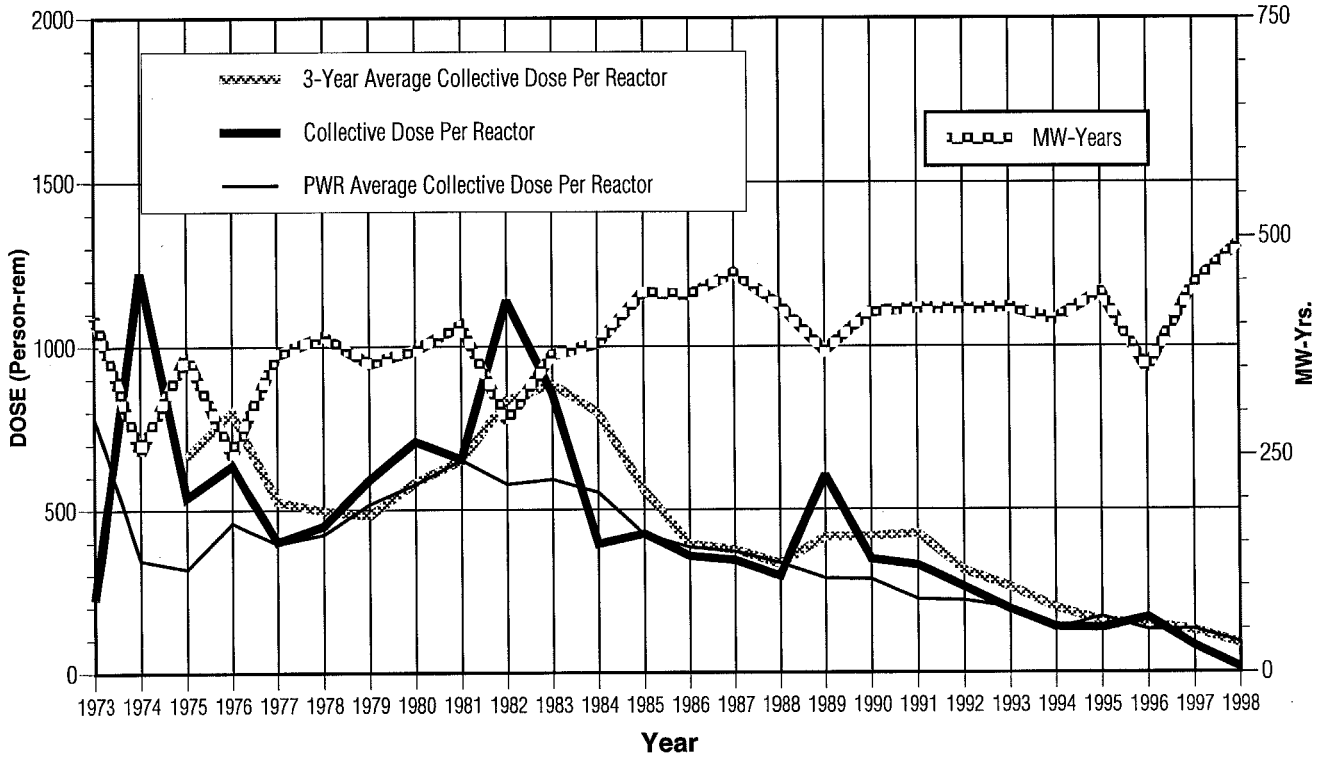
FORT CALHOUN

Dose-Performance Indicators **PWR**



GINNA

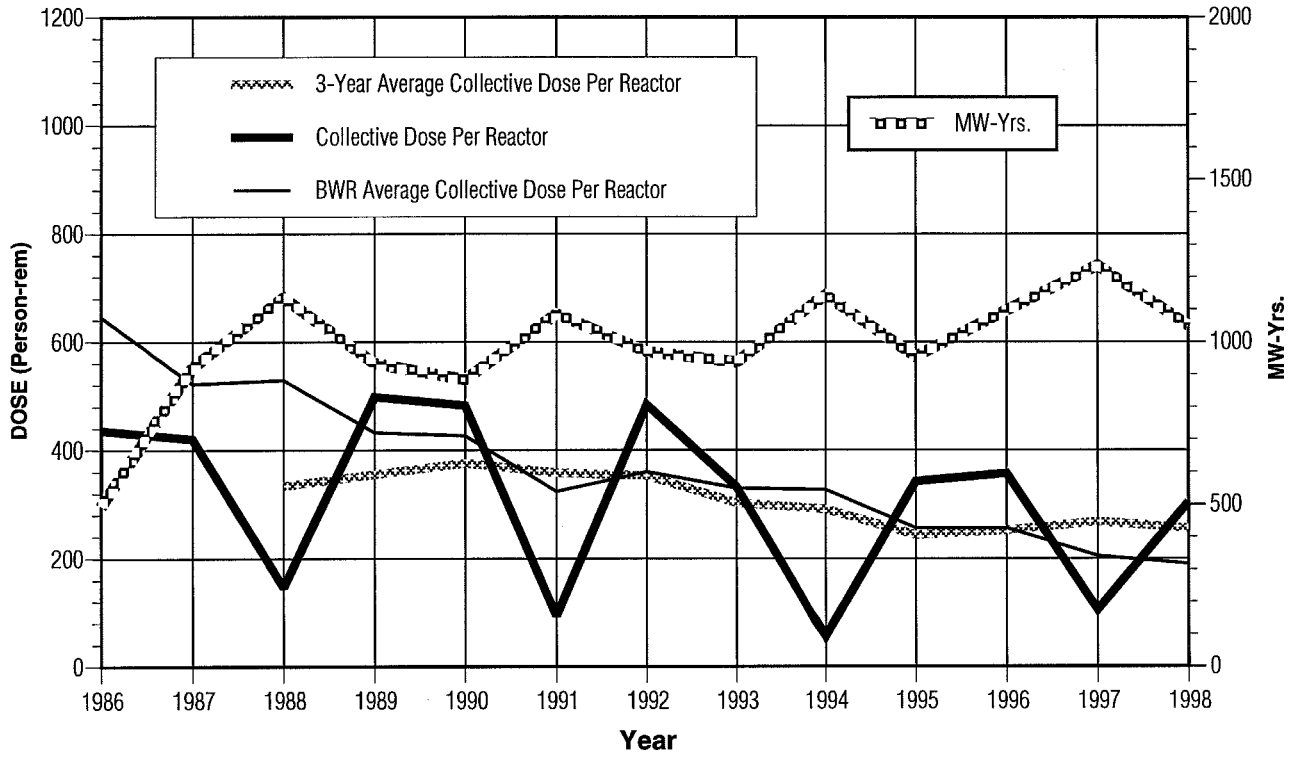
Dose-Performance Indicators **PWR**



GRAND GULF

Dose-Performance Indicators

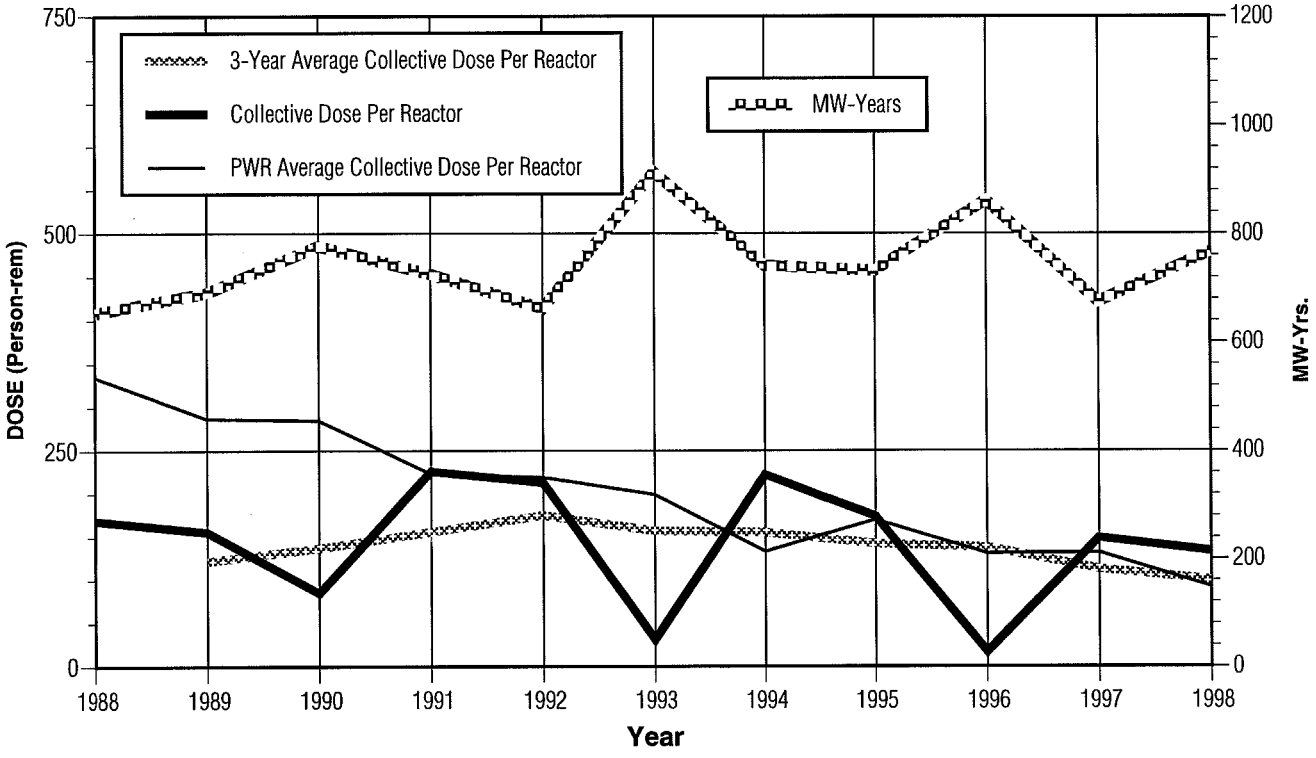
BWR

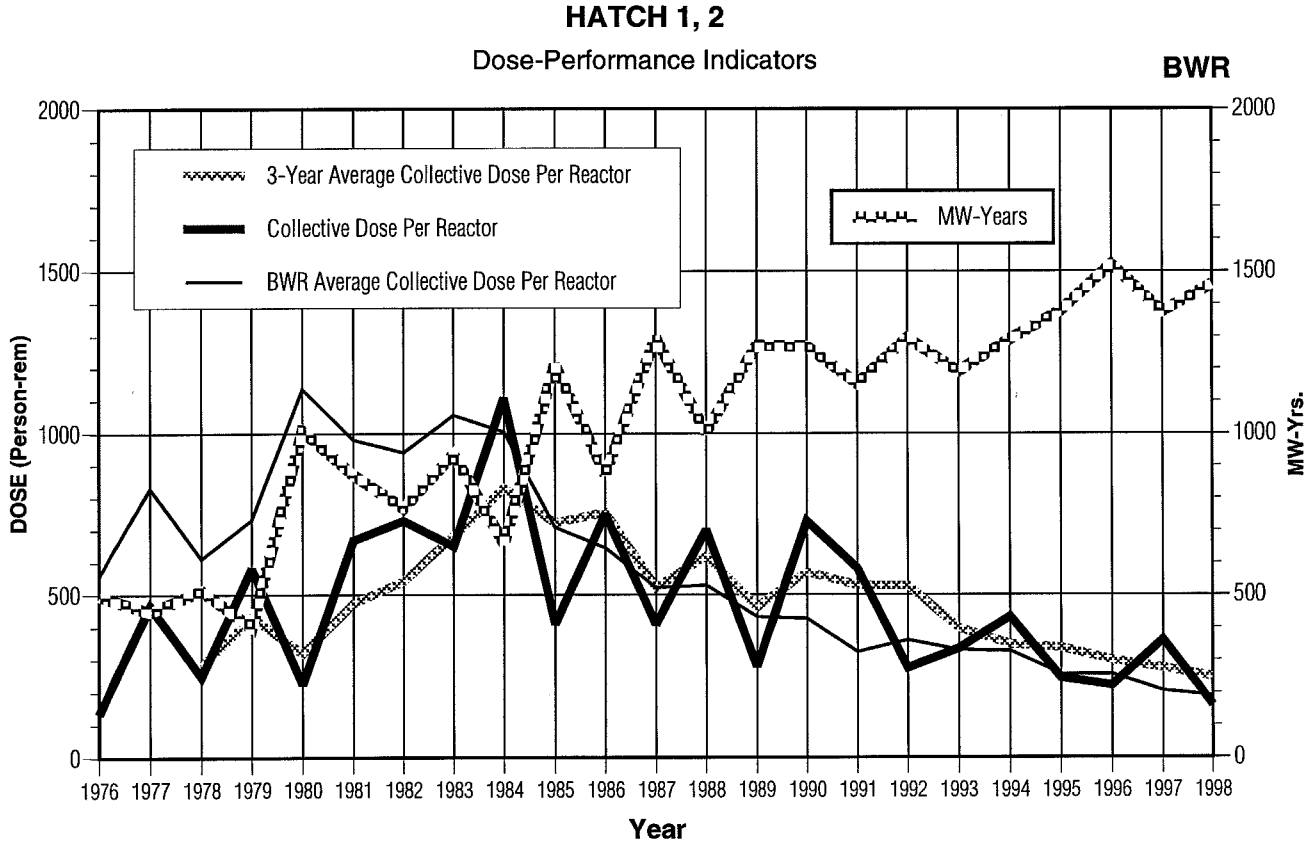


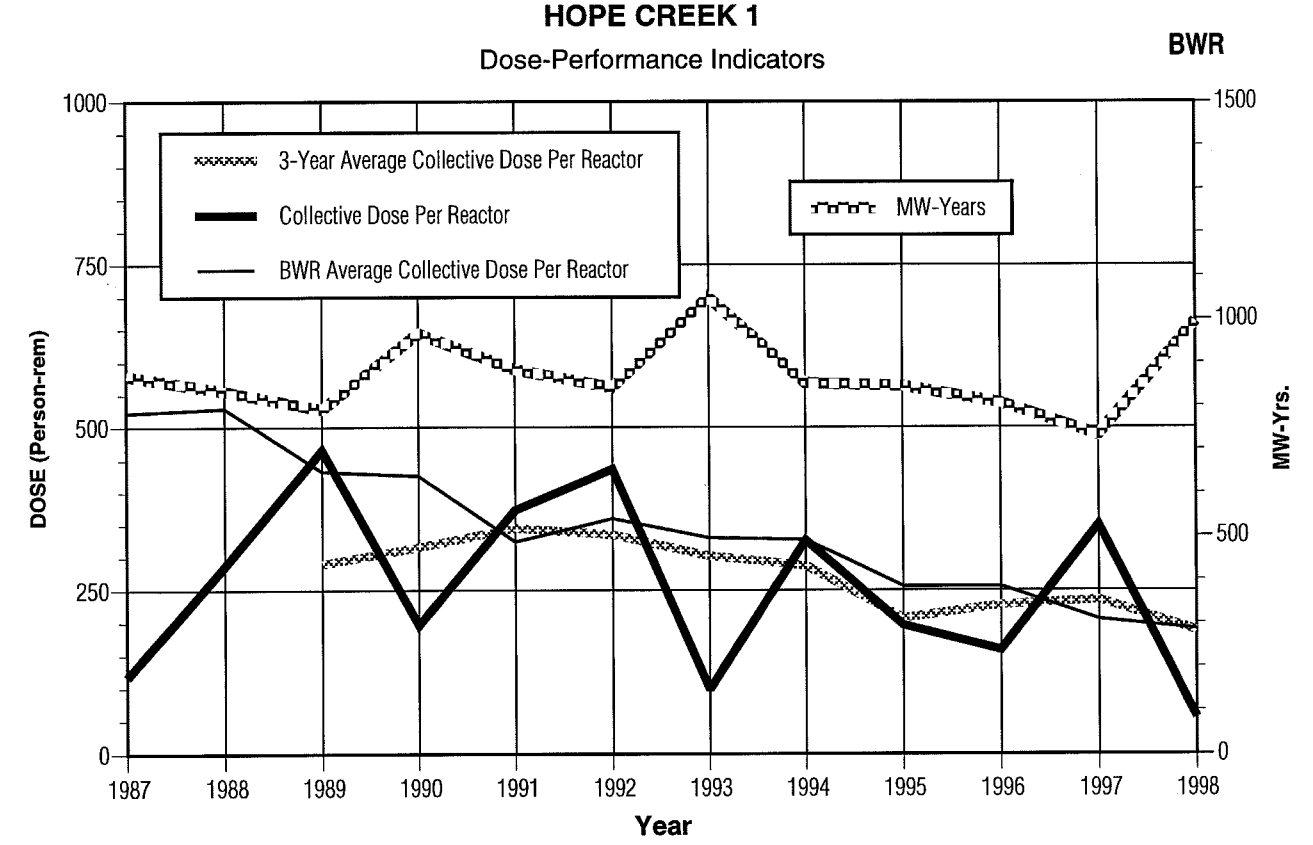
HARRIS

Dose-Performance Indicators

PWR



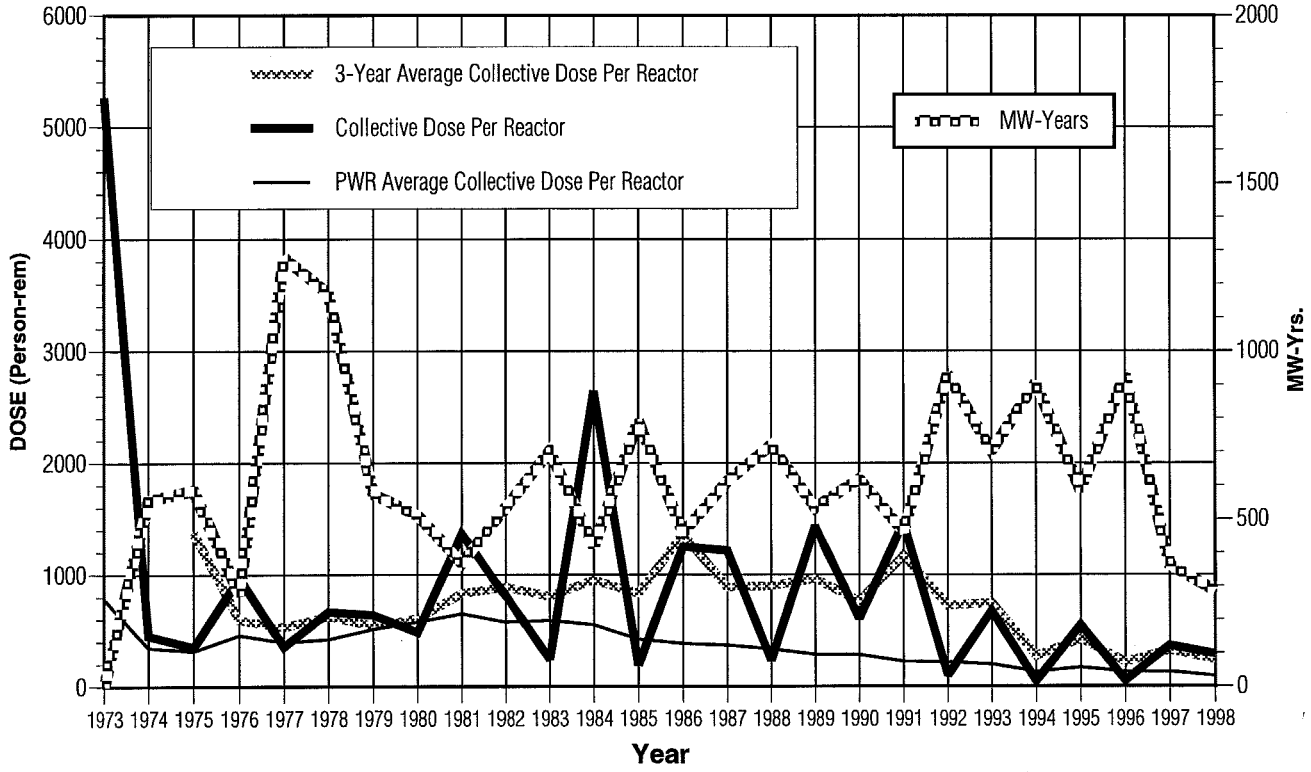

HATCH 1, 2
Dose-Performance Indicators
BWR
3-Year Average Collective Dose Per Reactor
Collective Dose Per Reactor
BWR Average Collective Dose Per Reactor
MW-Years
DOSE (Person-rem)
MW-Yrs.
2000
1500
1000
500
0
1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998
Year


HOPE CREEK 1
Dose-Performance Indicators
BWR
3-Year Average Collective Dose Per Reactor
Collective Dose Per Reactor
BWR Average Collective Dose Per Reactor
MW-Years
DOSE (Person-rem)
MW-Yrs.
1000
750
500
250
0
1500
1000
500
0
1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998
Year

INDIAN POINT 2

Dose-Performance Indicators

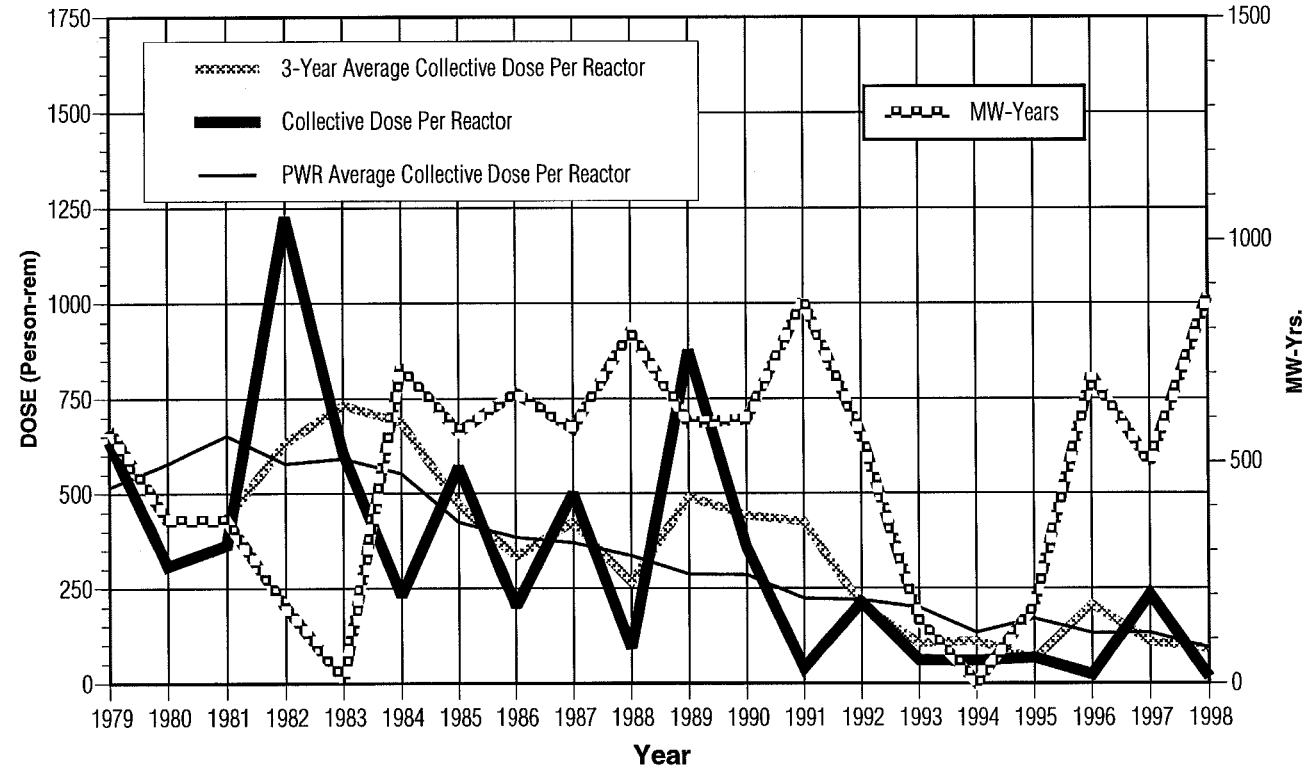
PWR

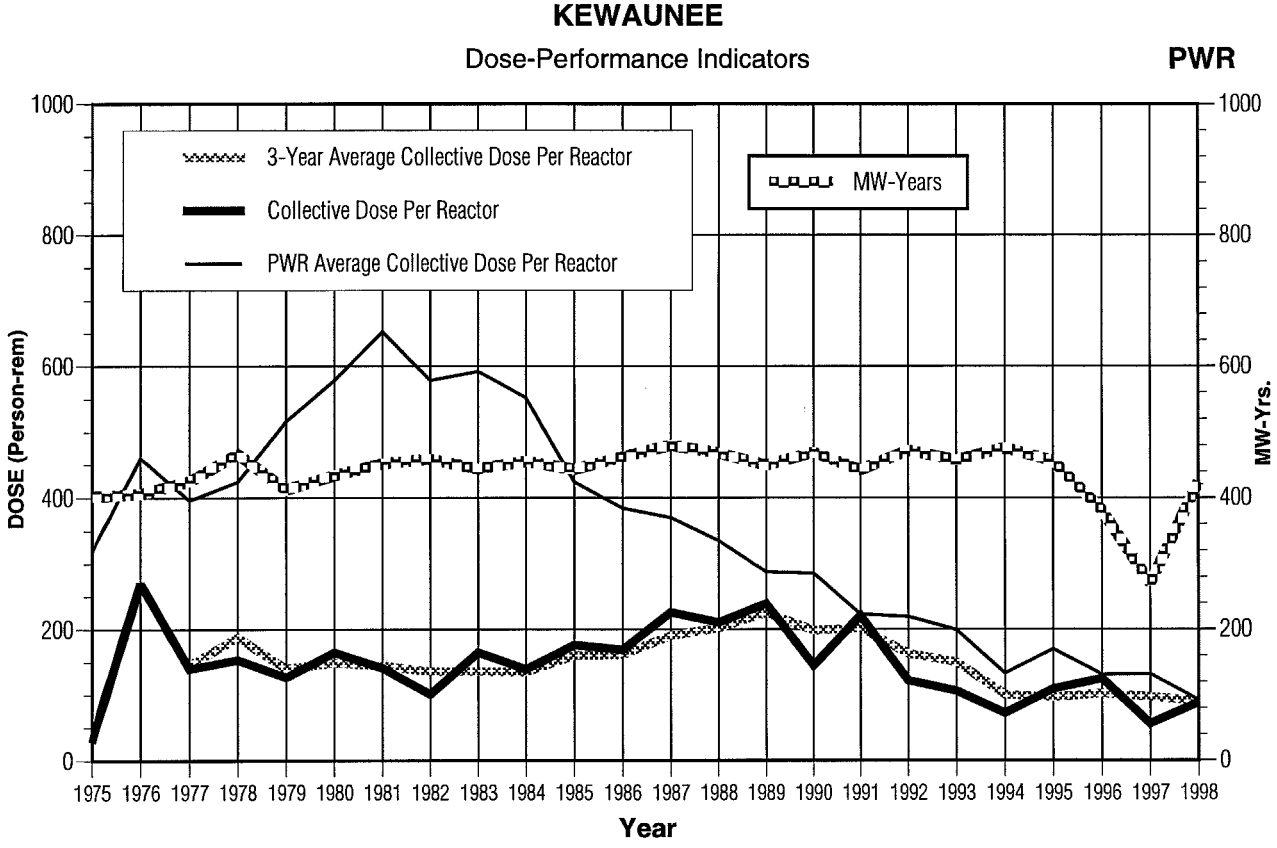


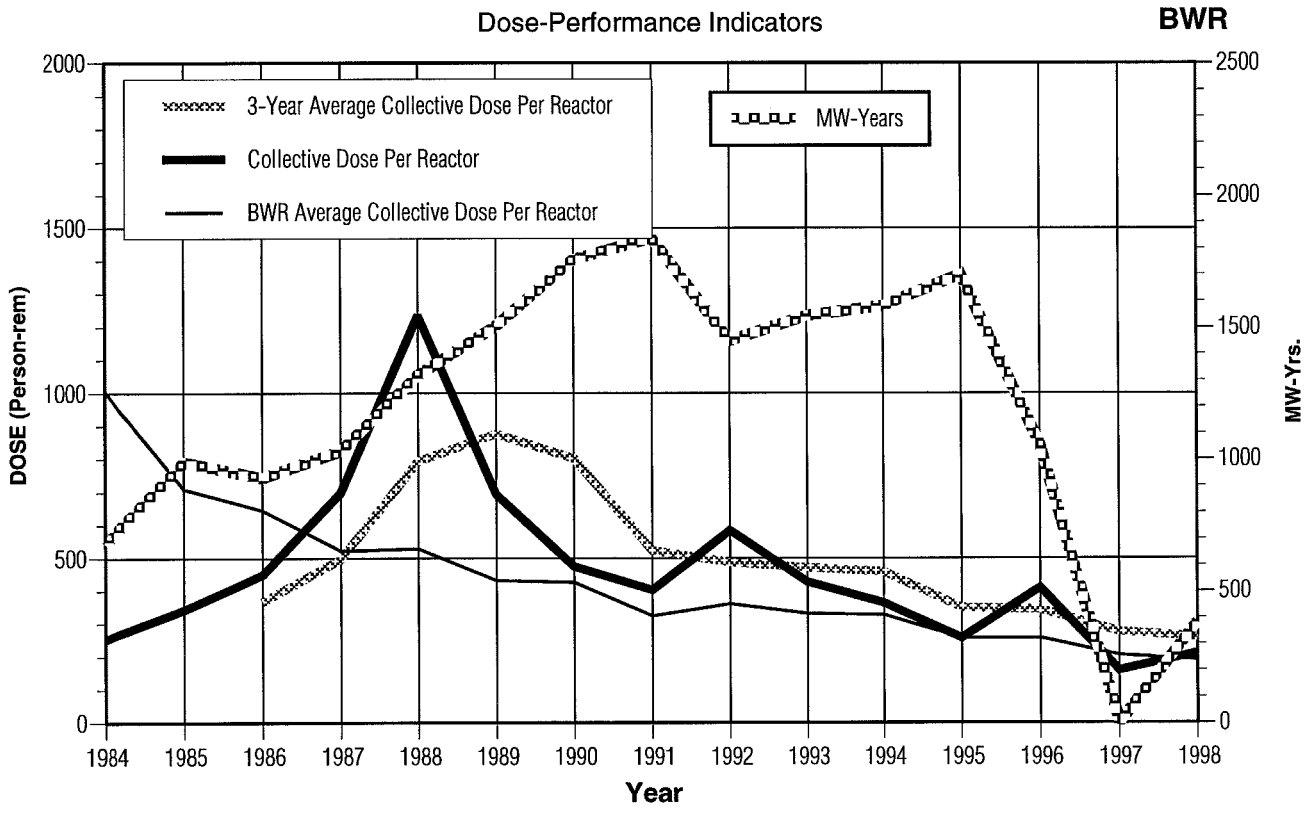
INDIAN POINT 3

Dose-Performance Indicators

PWR



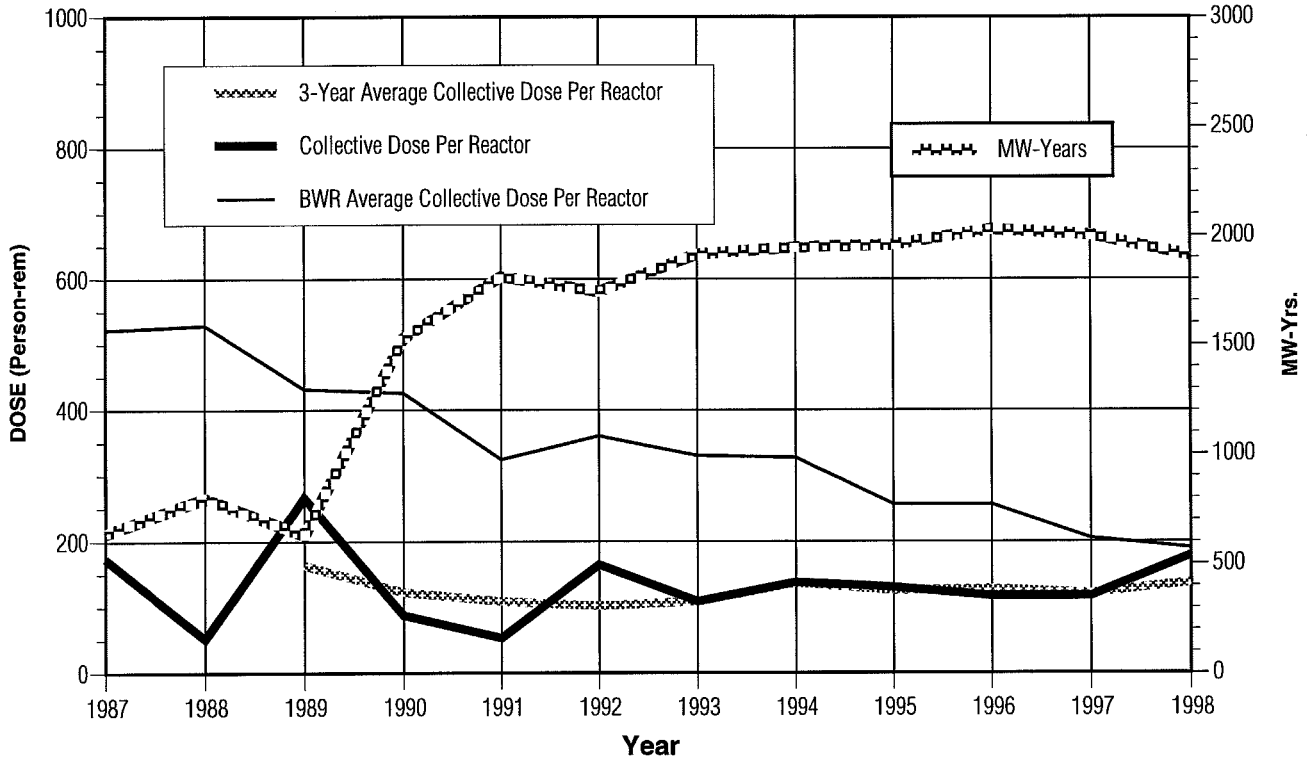

KEWAUNEE
Dose-Performance Indicators
PWR
3-Year Average Collective Dose Per Reactor
Collective Dose Per Reactor
PWR Average Collective Dose Per Reactor
MW-Years
DOSE (Person-rem)
MW-Yrs.
0
200
400
600
800
1000
1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998
Year


LASALLE 1, 2
Dose-Performance Indicators
BWR
3-Year Average Collective Dose Per Reactor
Collective Dose Per Reactor
BWR Average Collective Dose Per Reactor
MW-Years
DOSE (Person-rem)
MW-Yrs.
0
500
1000
1500
2000
2500
1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998
Year

LIMERICK 1, 2

Dose-Performance Indicators

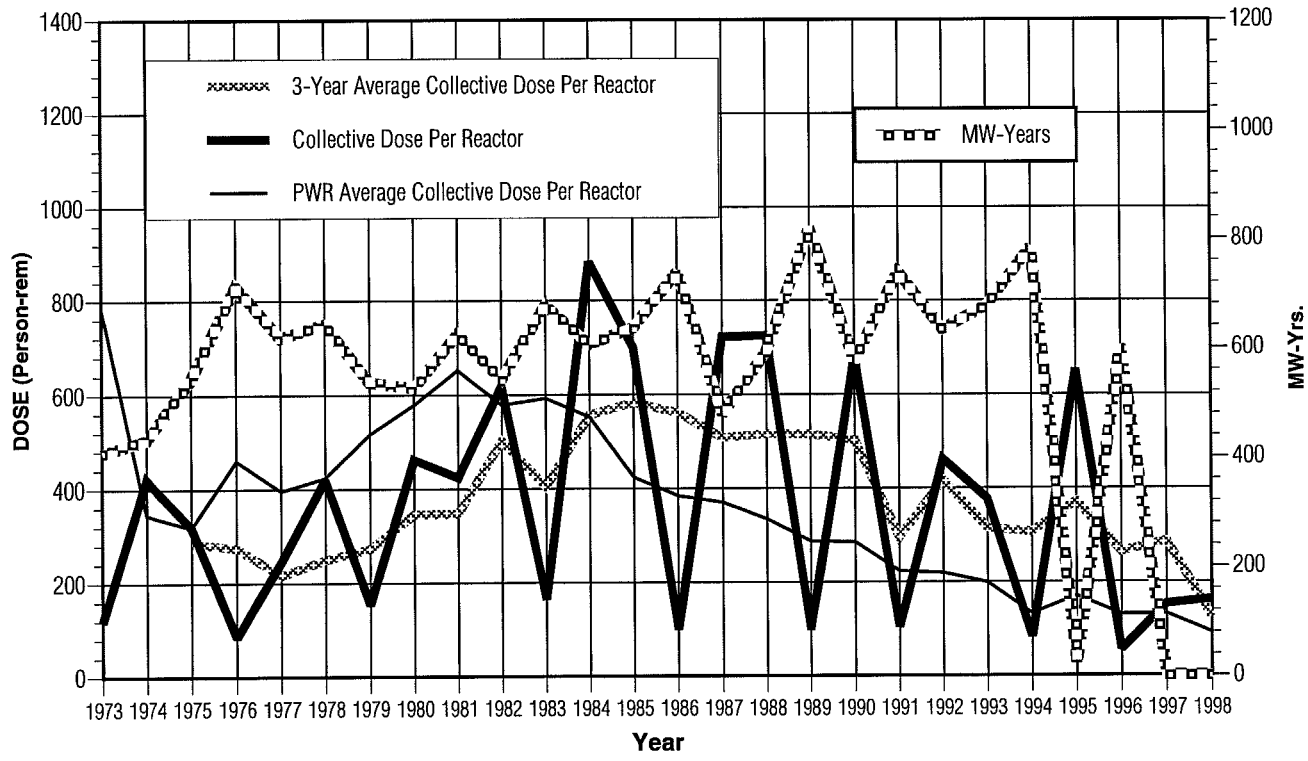
BWR

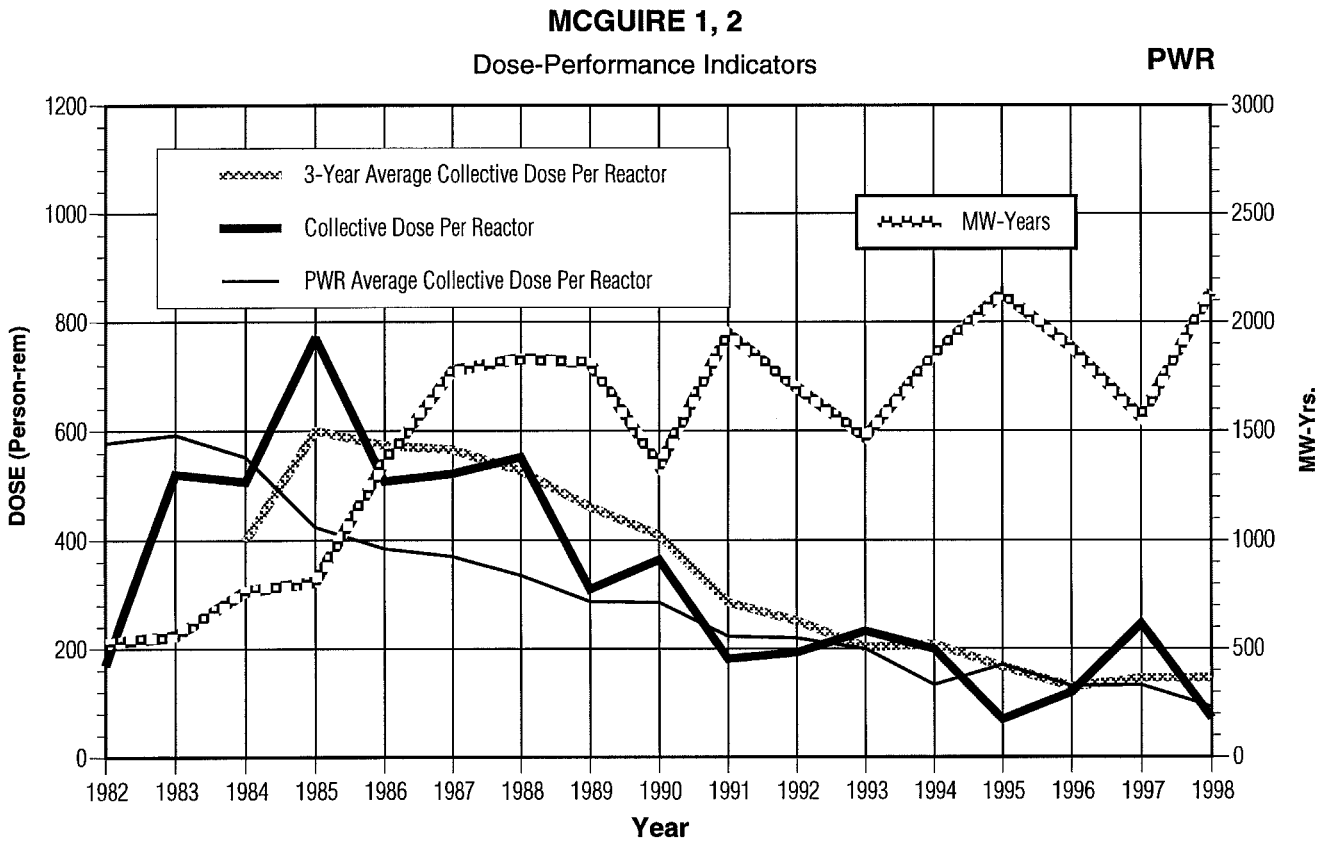


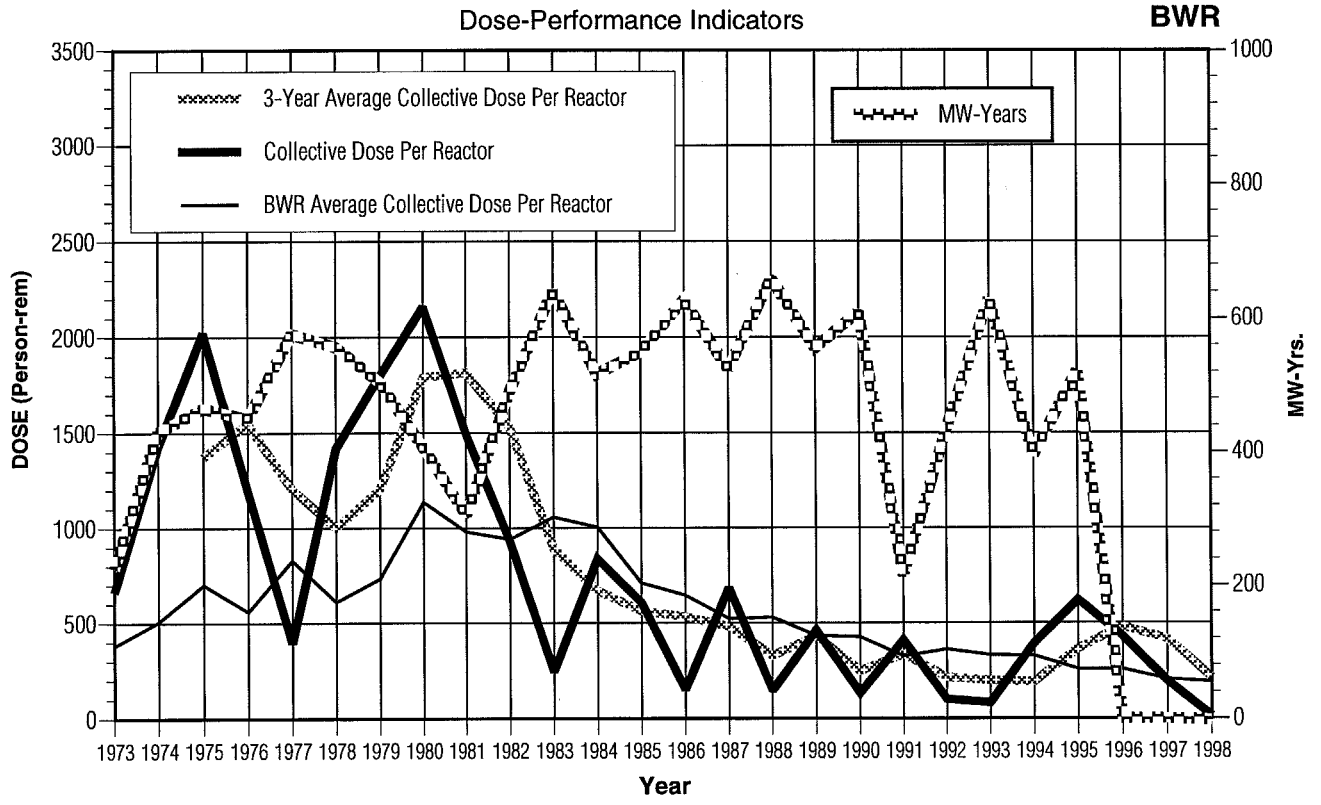
MAINE YANKEE

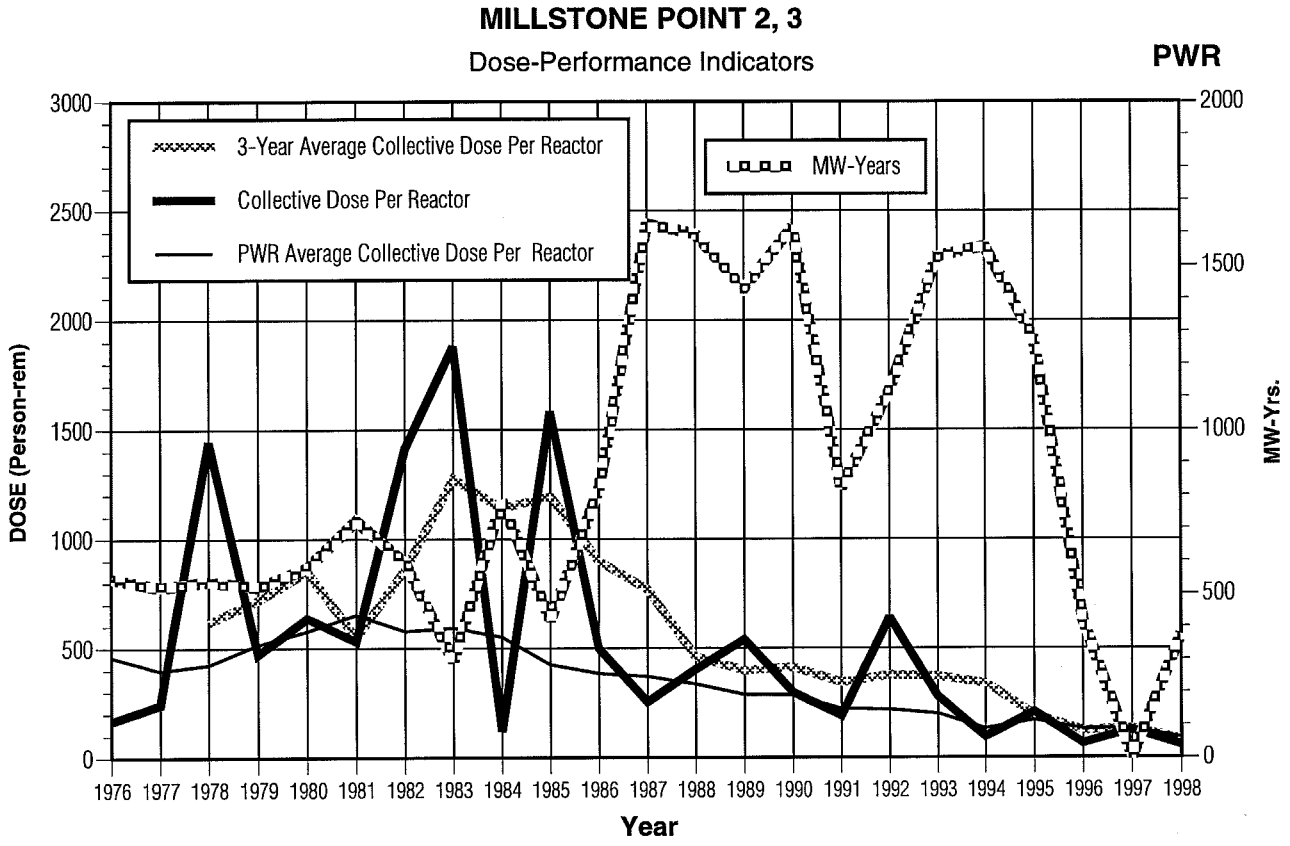
Dose-Performance Indicators

PWR




MCGUIRE 1, 2
Dose-Performance Indicators
PWR
3-Year Average Collective Dose Per Reactor
Collective Dose Per Reactor
PWR Average Collective Dose Per Reactor
MW-Years
DOSE (Person-rem)
MW-Yrs.
Year


MILLSTONE POINT 1
Dose-Performance Indicators
BWR
3-Year Average Collective Dose Per Reactor
Collective Dose Per Reactor
BWR Average Collective Dose Per Reactor
MW-Years
DOSE (Person-rem)
MW-Yrs.
Year


MILLSTONE POINT 2, 3
Dose-Performance Indicators
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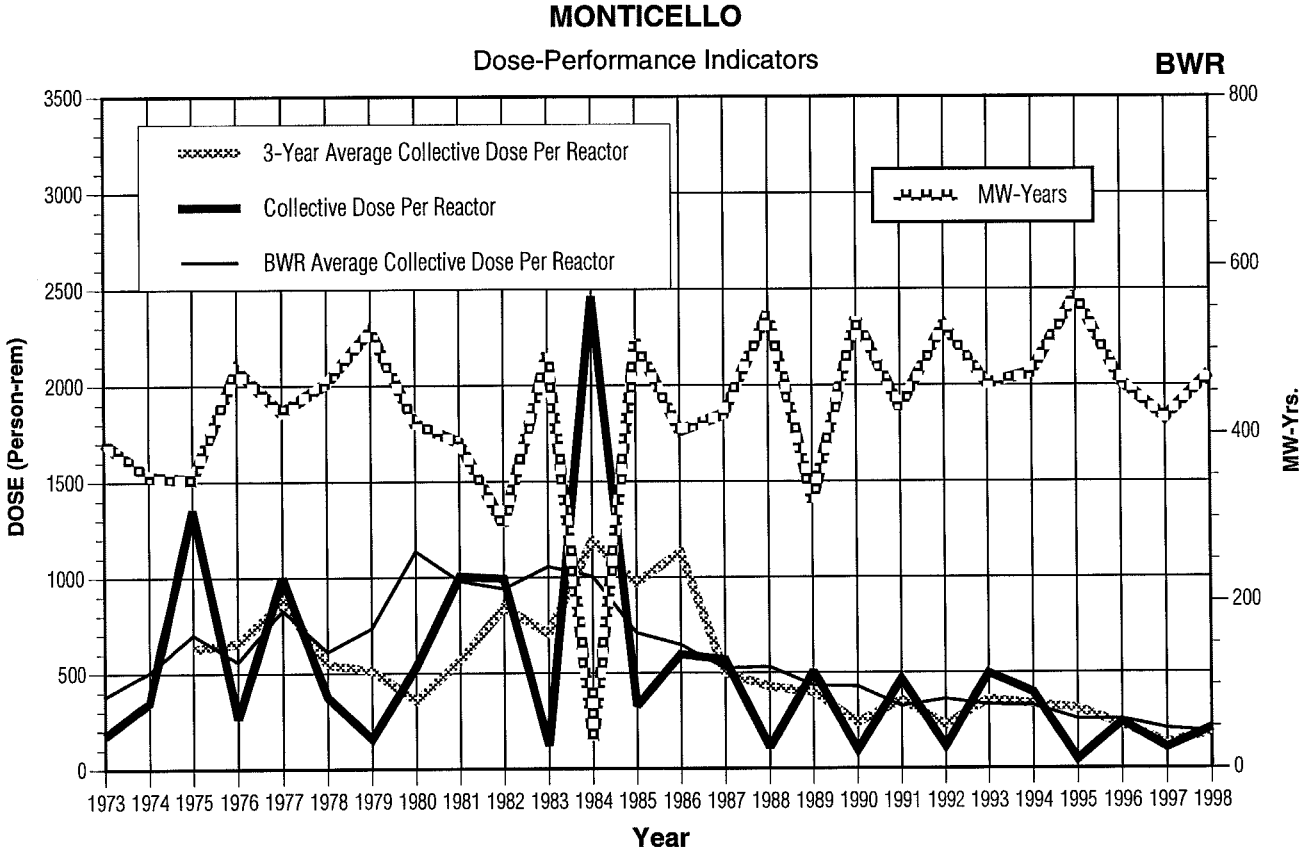
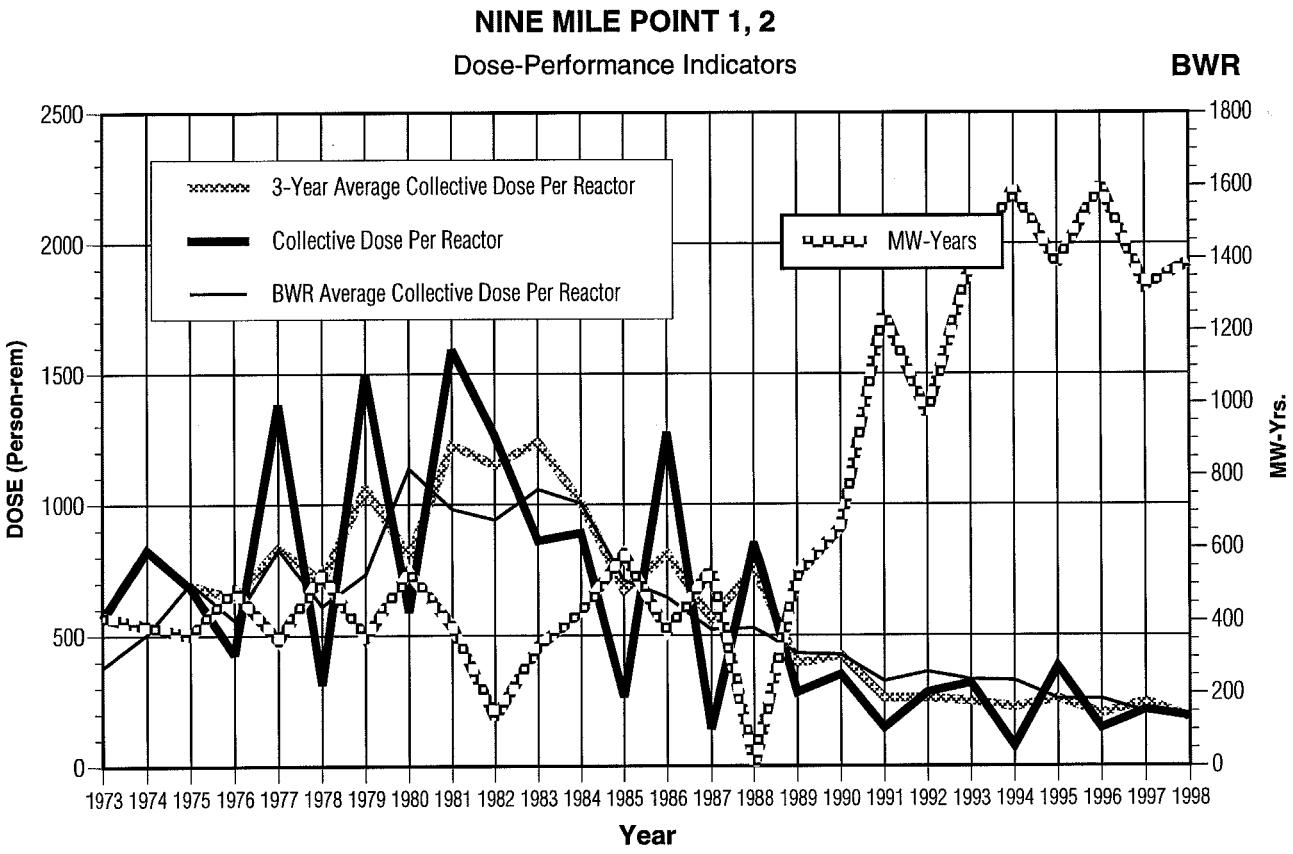
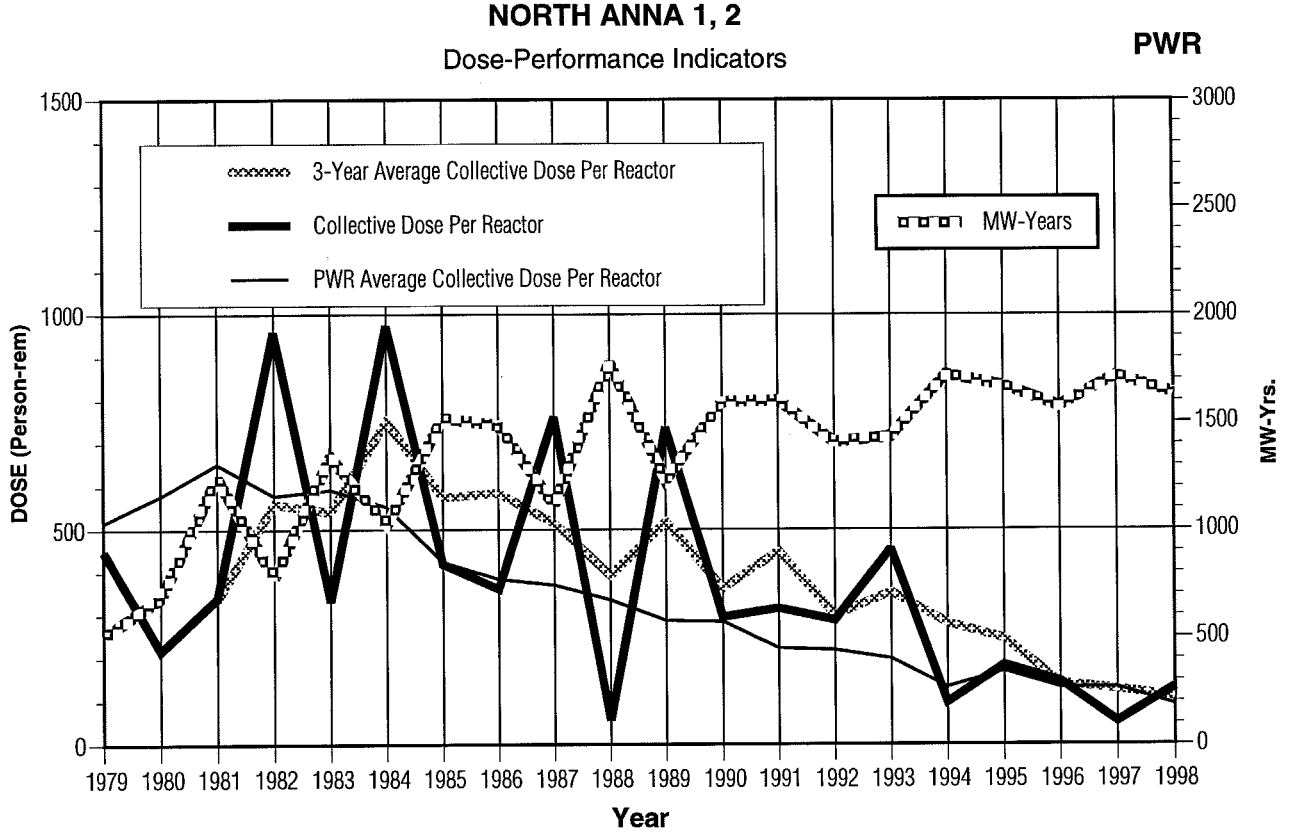
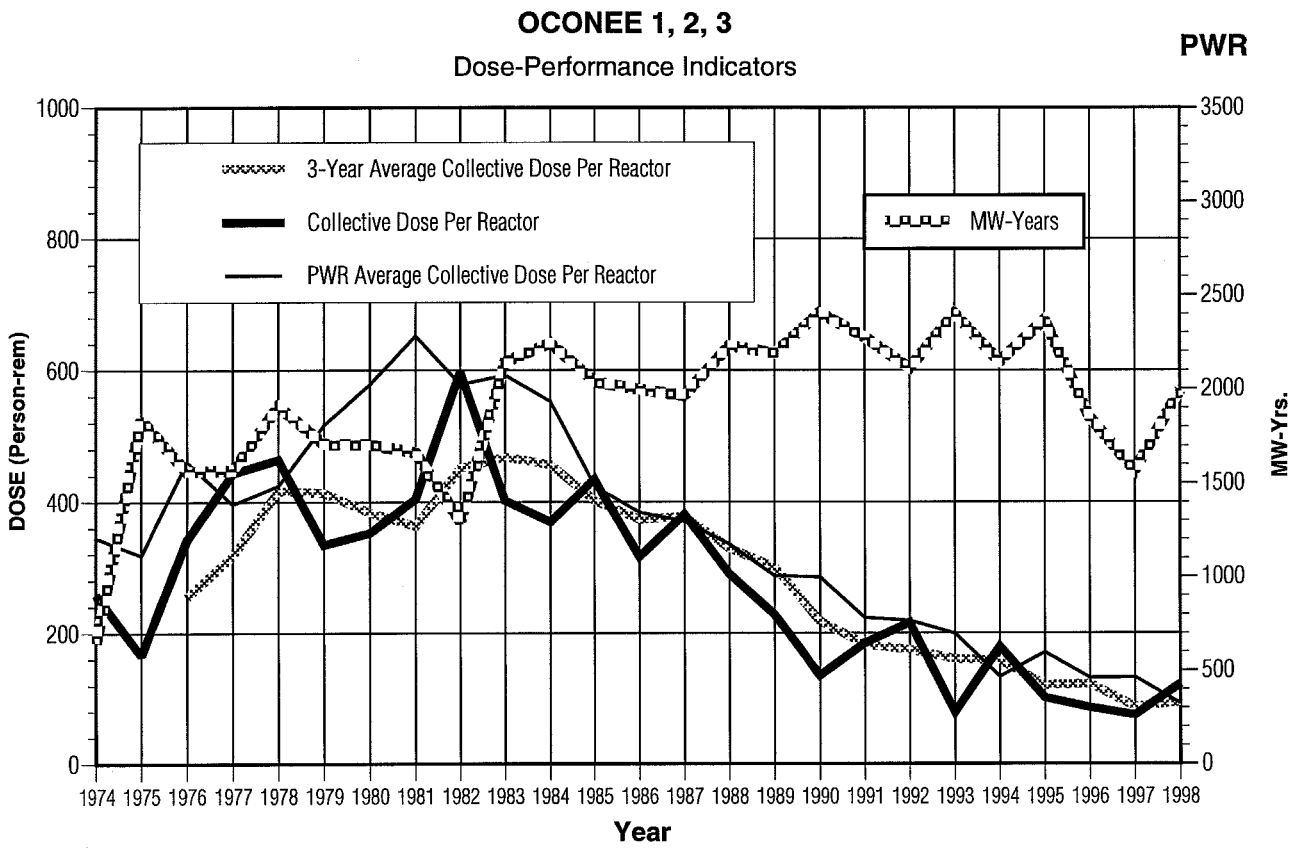
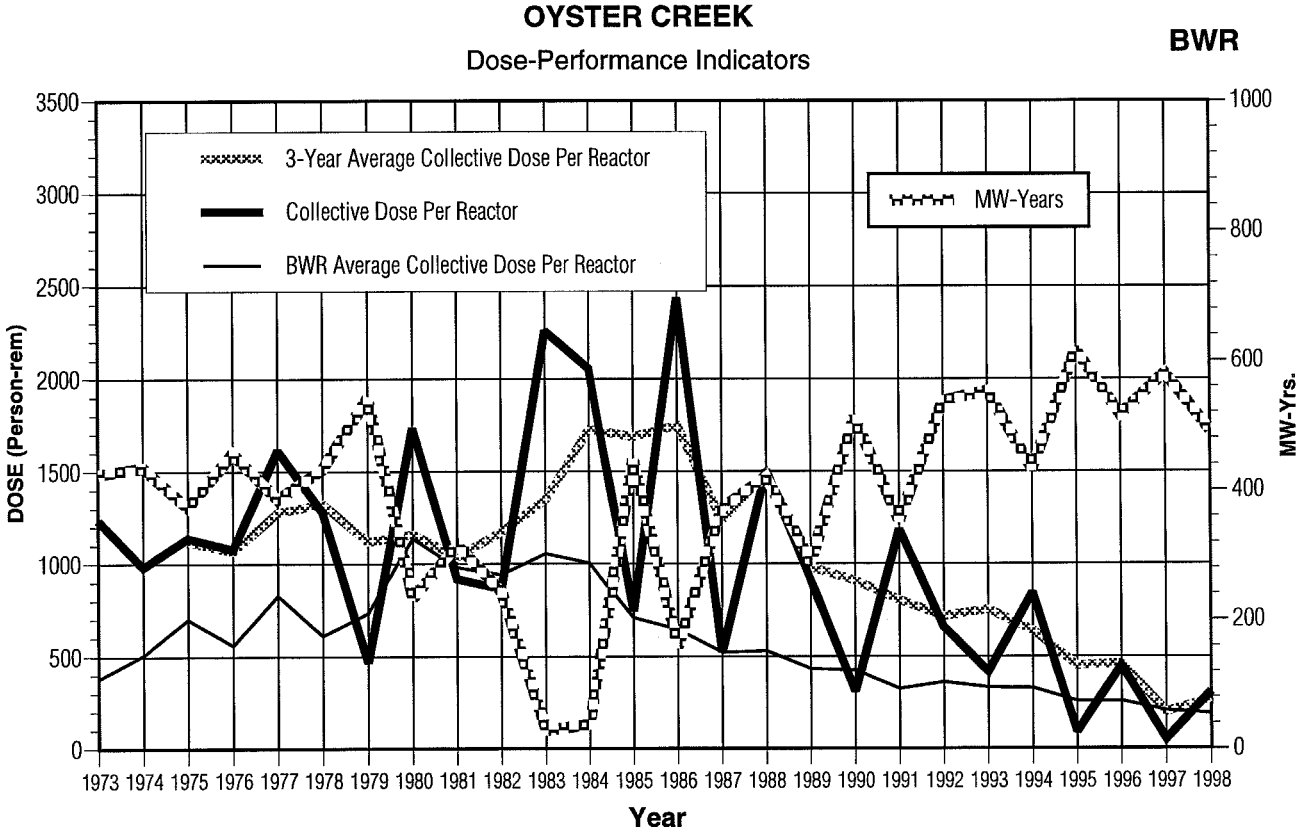
3-Year Average Collective Dose Per Reactor
Collective Dose Per Reactor
PWR Average Collective Dose Per Reactor
MW-Years
DOSE (Person-rem)
MW-Yrs.
Year


MONTICELLO
Dose-Performance Indicators
BWR
3-Year Average Collective Dose Per Reactor
Collective Dose Per Reactor
BWR Average Collective Dose Per Reactor
MW-Years
DOSE (Person-rem)
MW-Yrs.
Year


NINE MILE POINT 1, 2
Dose-Performance Indicators
BWR
3-Year Average Collective Dose Per Reactor
Collective Dose Per Reactor
BWR Average Collective Dose Per Reactor
MW-Years
DOSE (Person-rem)
MW-Yrs.
2500
2000
1500
1000
500
0
1800
1600
1400
1200
1000
800
600
400
200
0
1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998
Year


NORTH ANNA 1, 2
Dose-Performance Indicators
PWR
3-Year Average Collective Dose Per Reactor
Collective Dose Per Reactor
PWR Average Collective Dose Per Reactor
MW-Years
DOSE (Person-rem)
MW-Yrs.
1500
1000
500
0
3000
2500
2000
1500
1000
500
0
1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998
Year

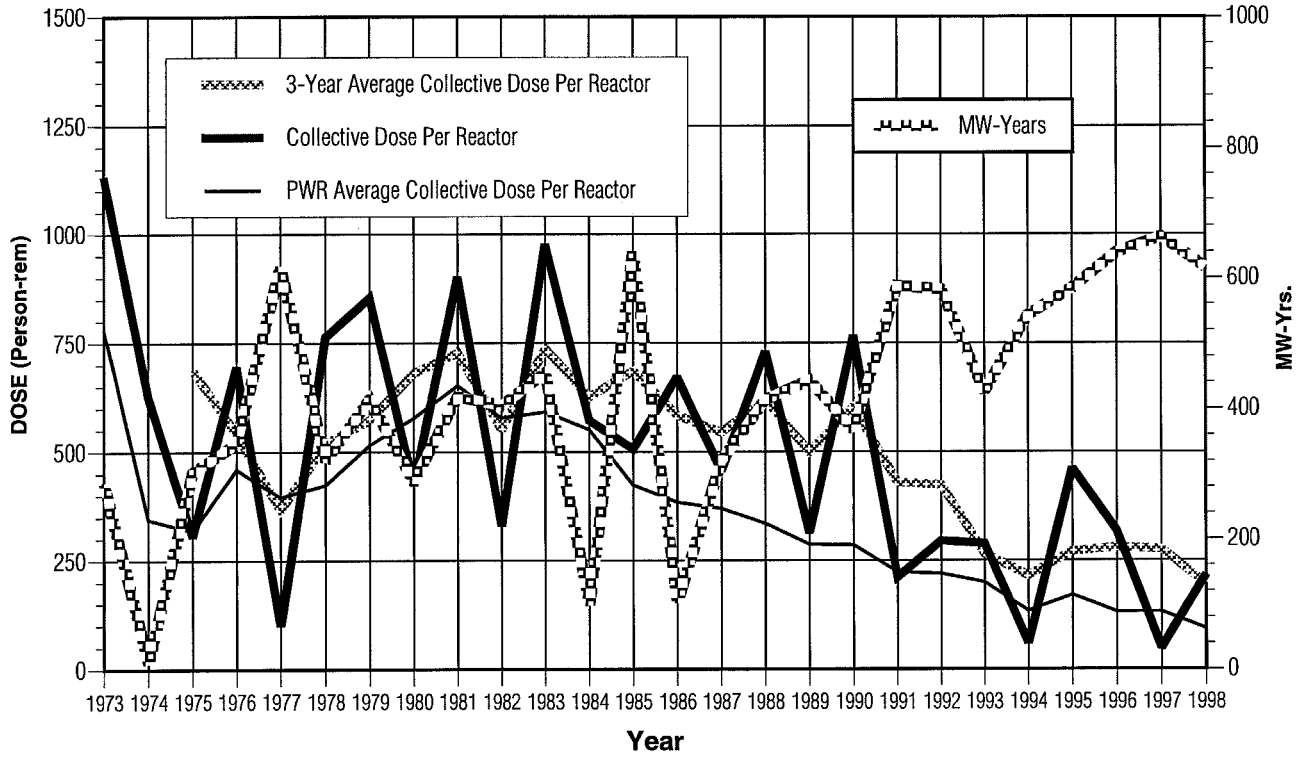

OCONEE 1, 2, 3
Dose-Performance Indicators
PWR
3-Year Average Collective Dose Per Reactor
Collective Dose Per Reactor
PWR Average Collective Dose Per Reactor
MW-Years
DOSE (Person-rem)
MW-Yrs.
1000
800
600
400
200
0
3500
3000
2500
2000
1500
1000
500
0
1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998
Year


OYSTER CREEK
Dose-Performance Indicators
BWR
3-Year Average Collective Dose Per Reactor
Collective Dose Per Reactor
BWR Average Collective Dose Per Reactor
MW-Years
DOSE (Person-rem)
MW-Yrs.
3500
3000
2500
2000
1500
1000
500
0
1000
800
600
400
200
0
1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998
Year

PALISADES

Dose-Performance Indicators

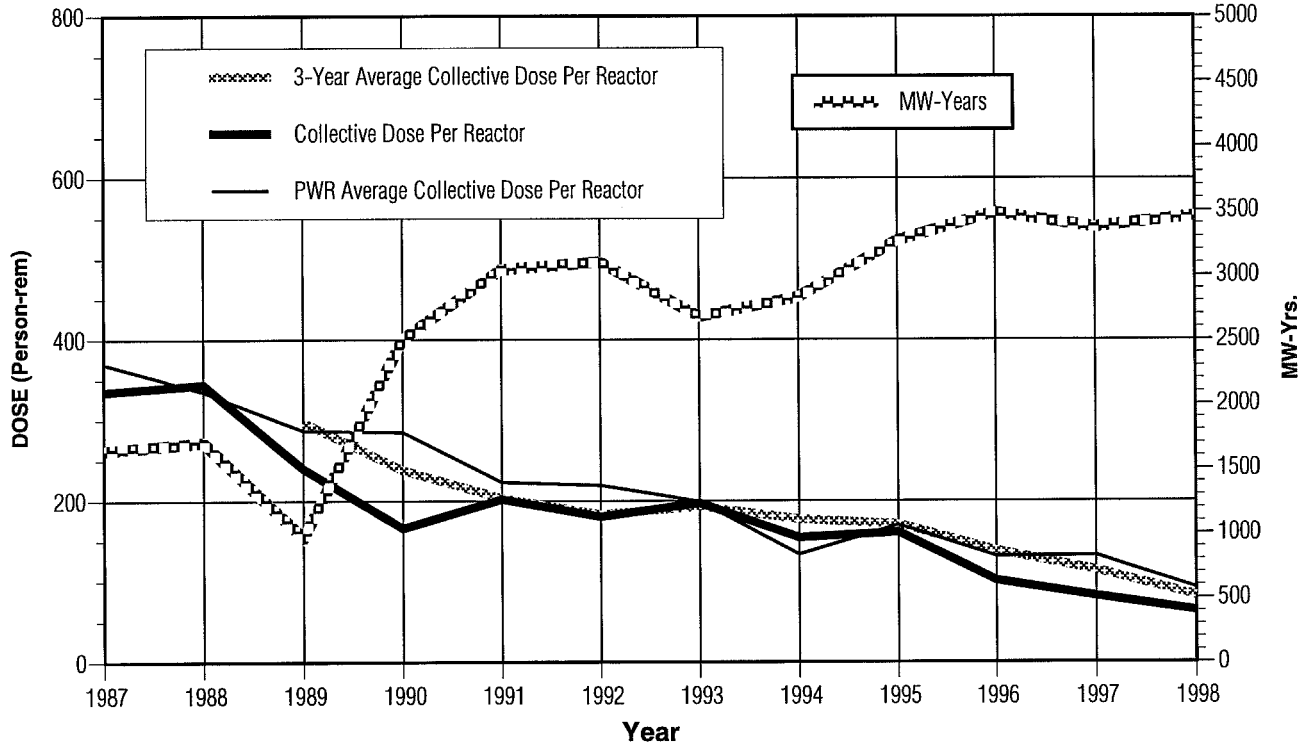
PWR



PALO VERDE 1, 2, 3

Dose-Performance Indicators

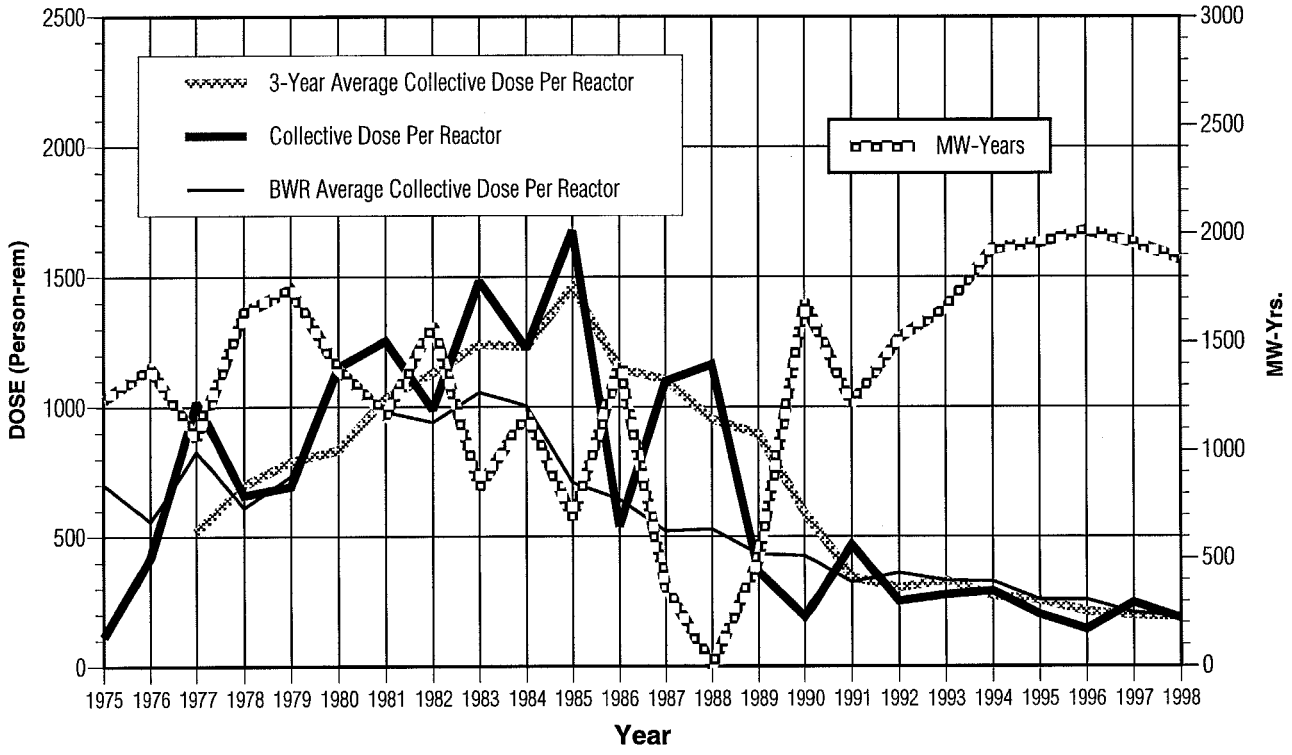
PWR



PEACH BOTTOM 2, 3

Dose-Performance Indicators

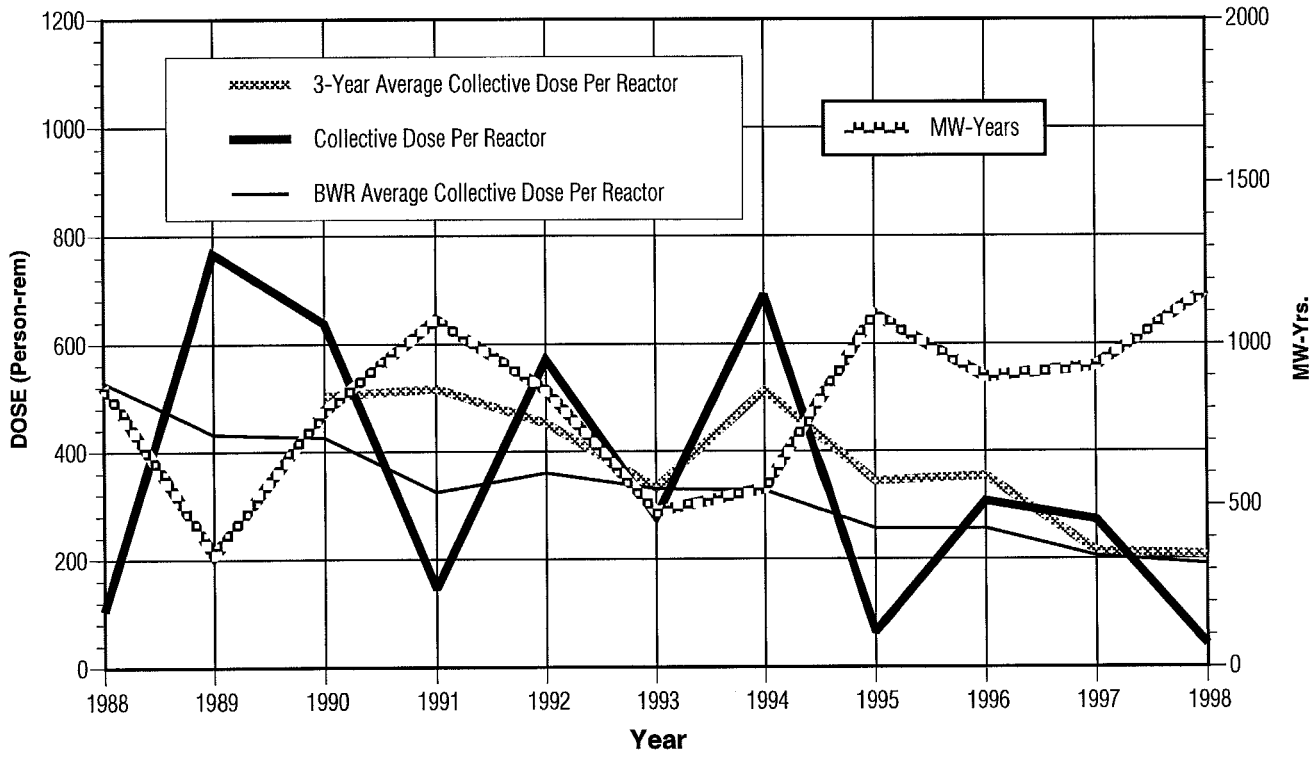
BWR



PERRY

Dose-Performance Indicators

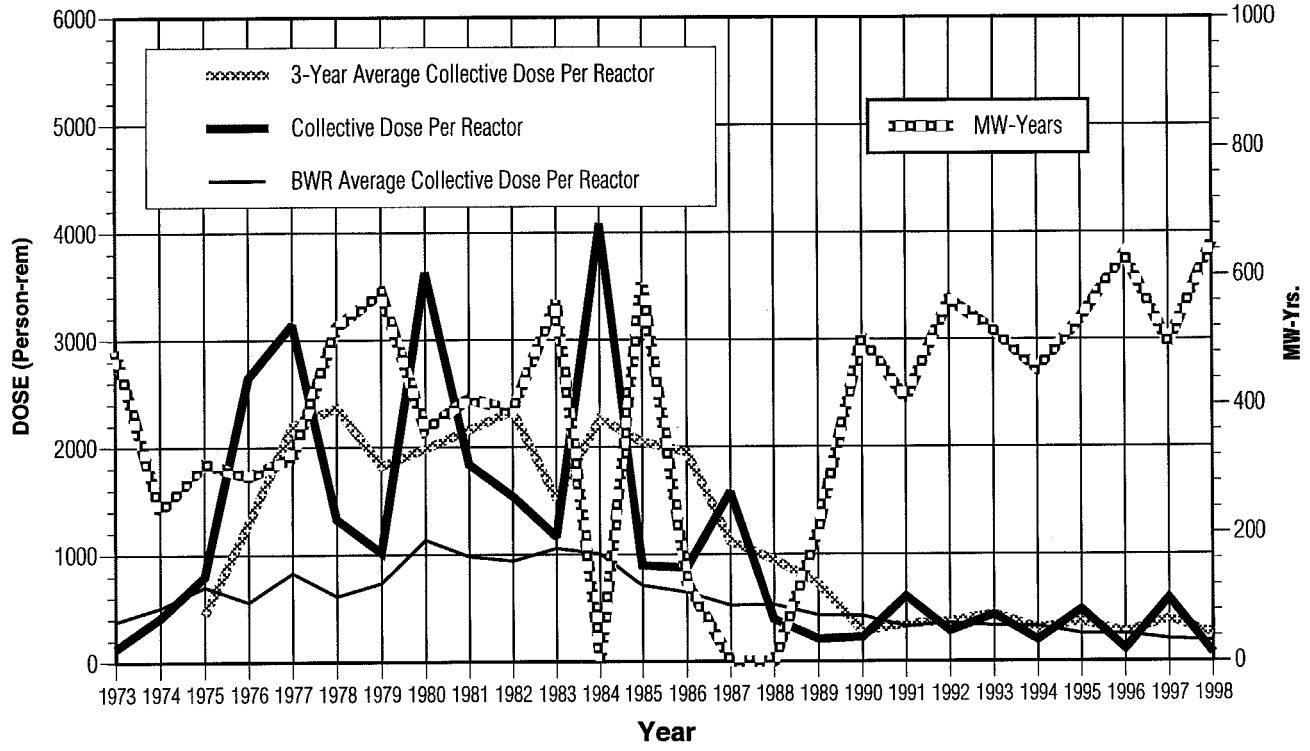
BWR



PILGRIM

Dose-Performance Indicators

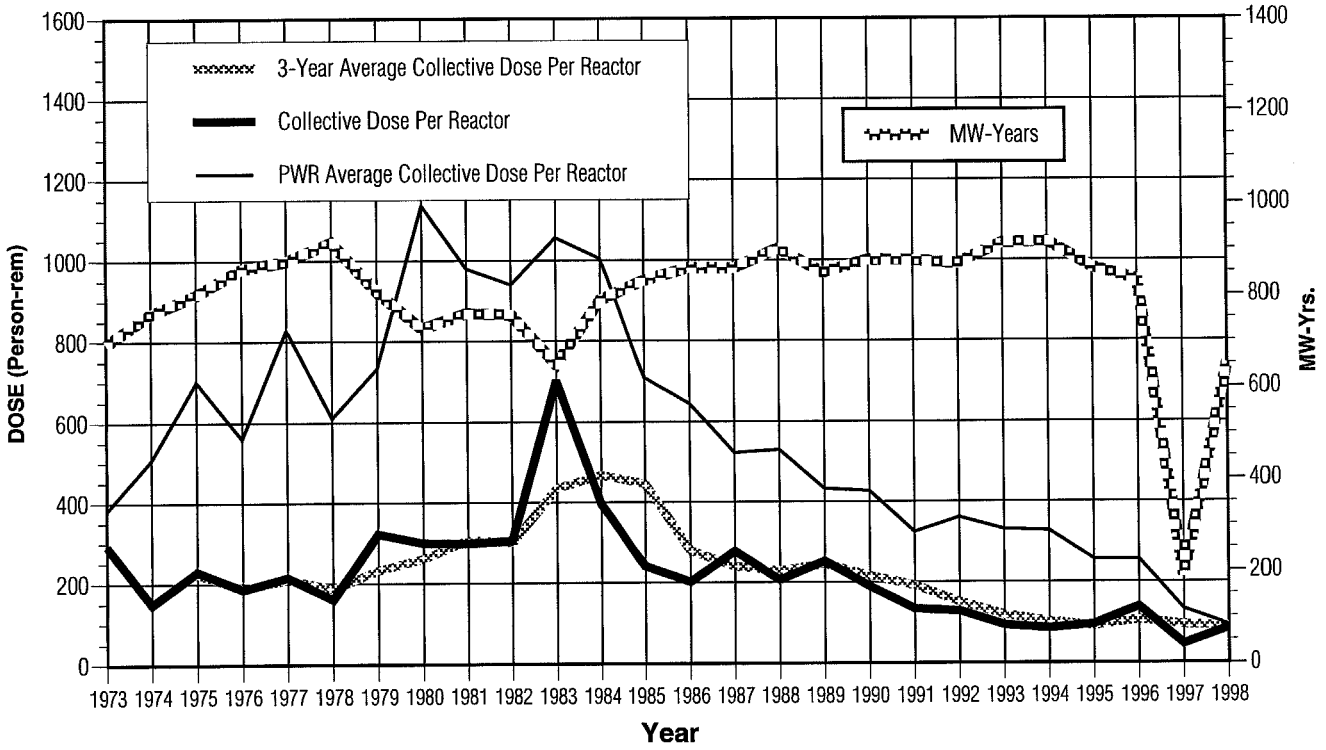
BWR



POINT BEACH 1, 2

Dose-Performance Indicators

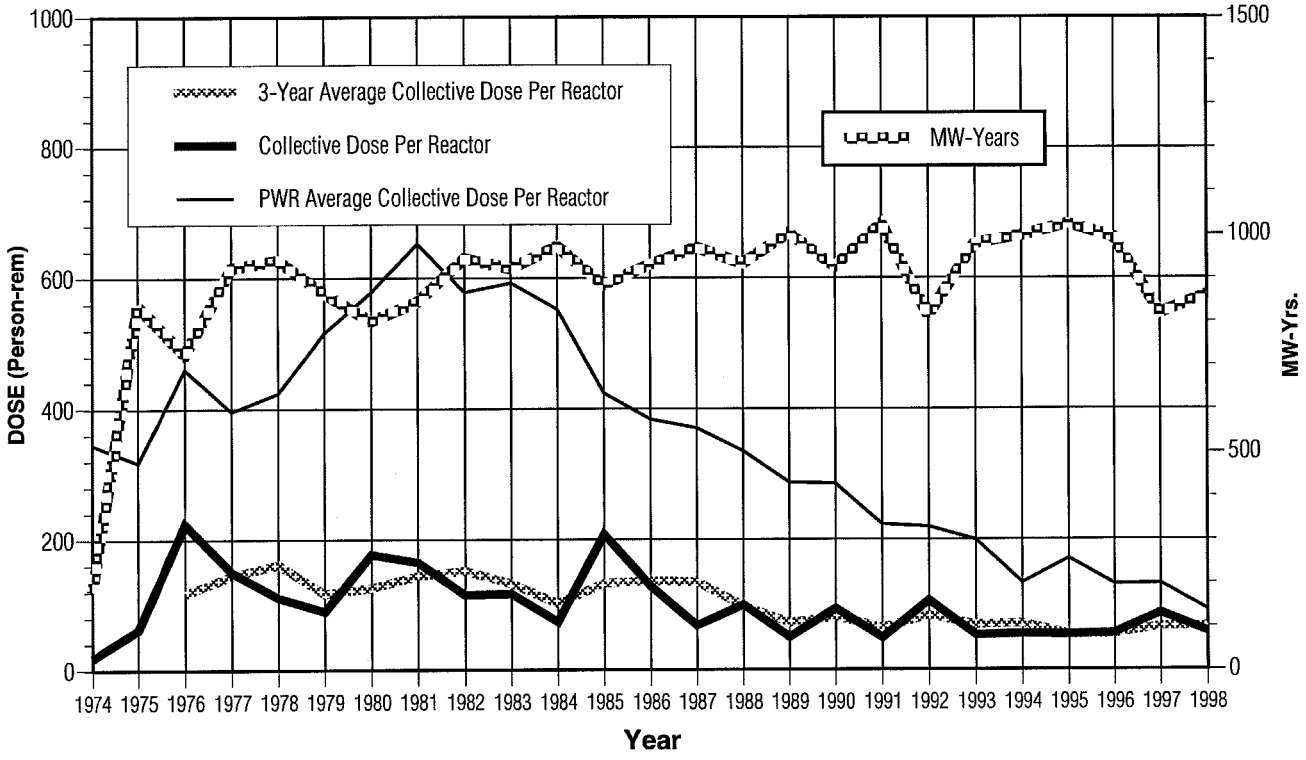
PWR



PRAIRIE ISLAND 1, 2

Dose-Performance Indicators

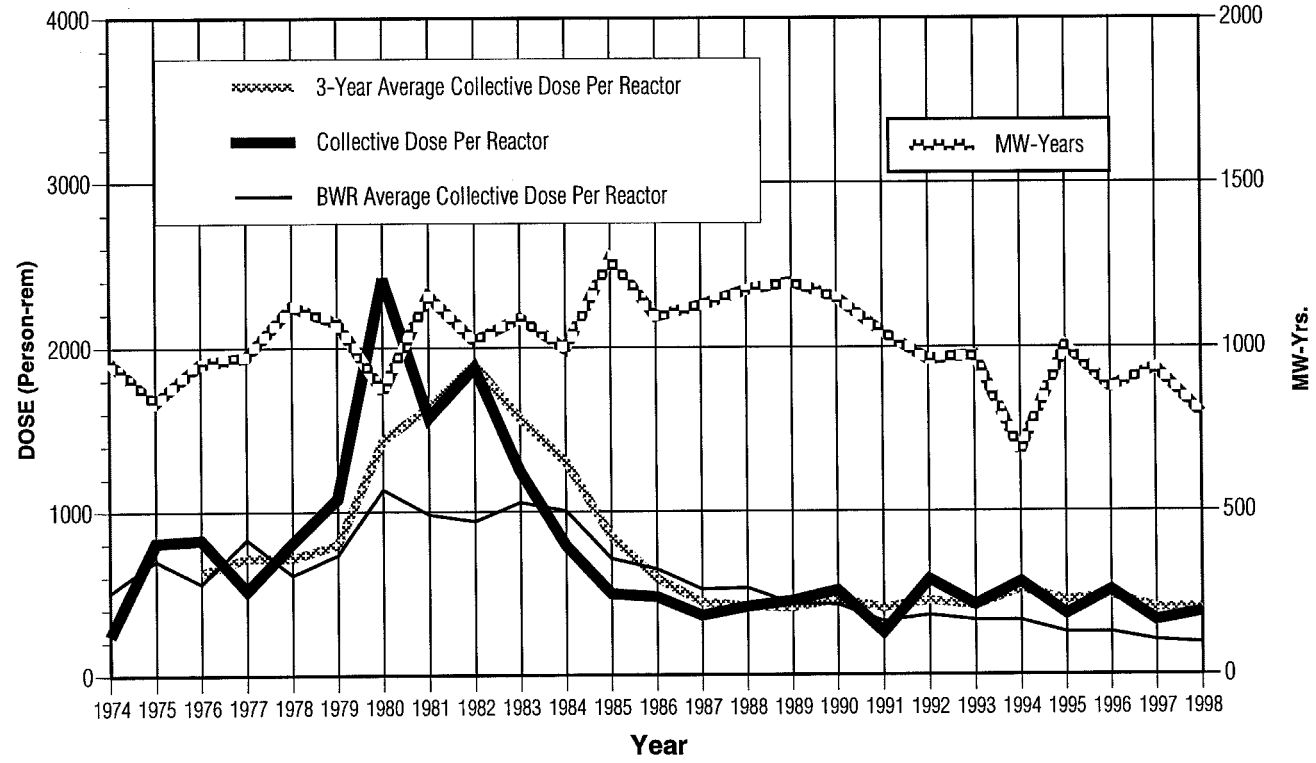
PWR

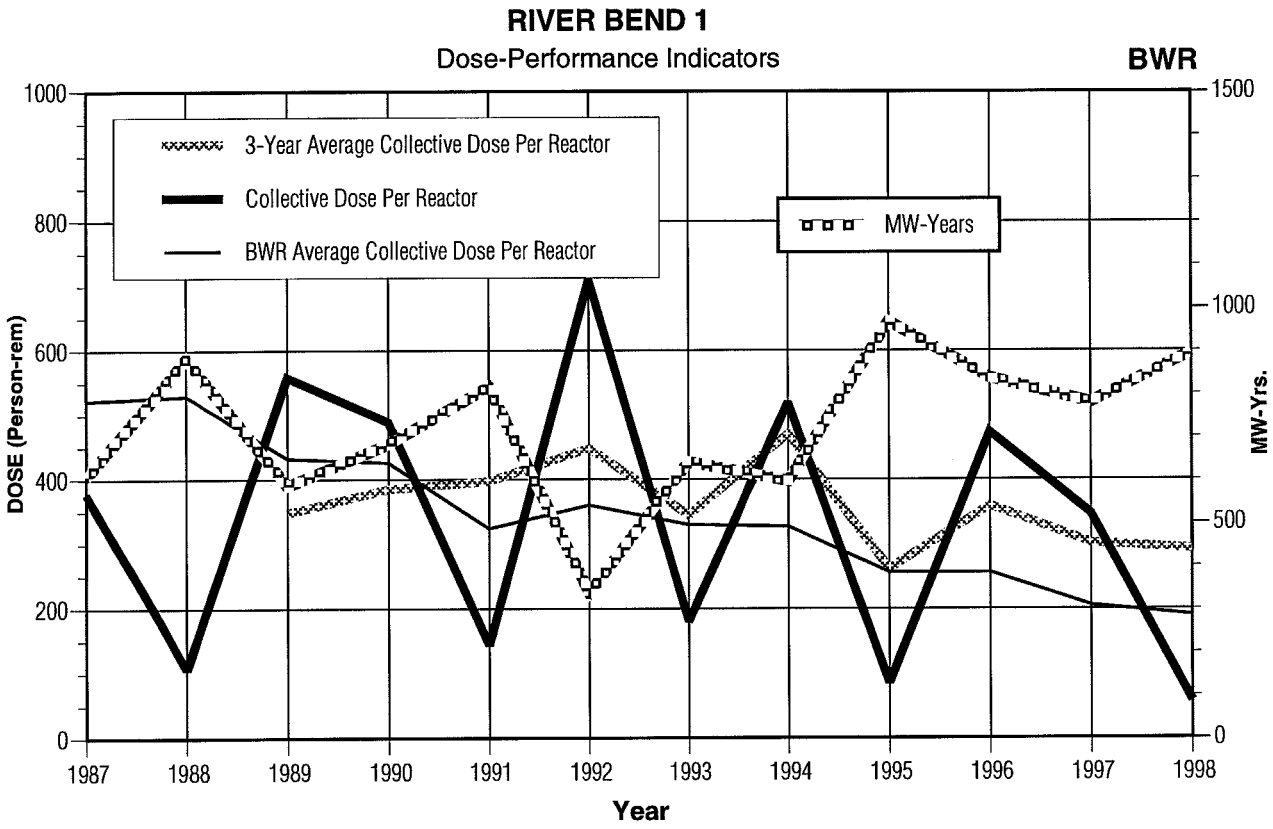


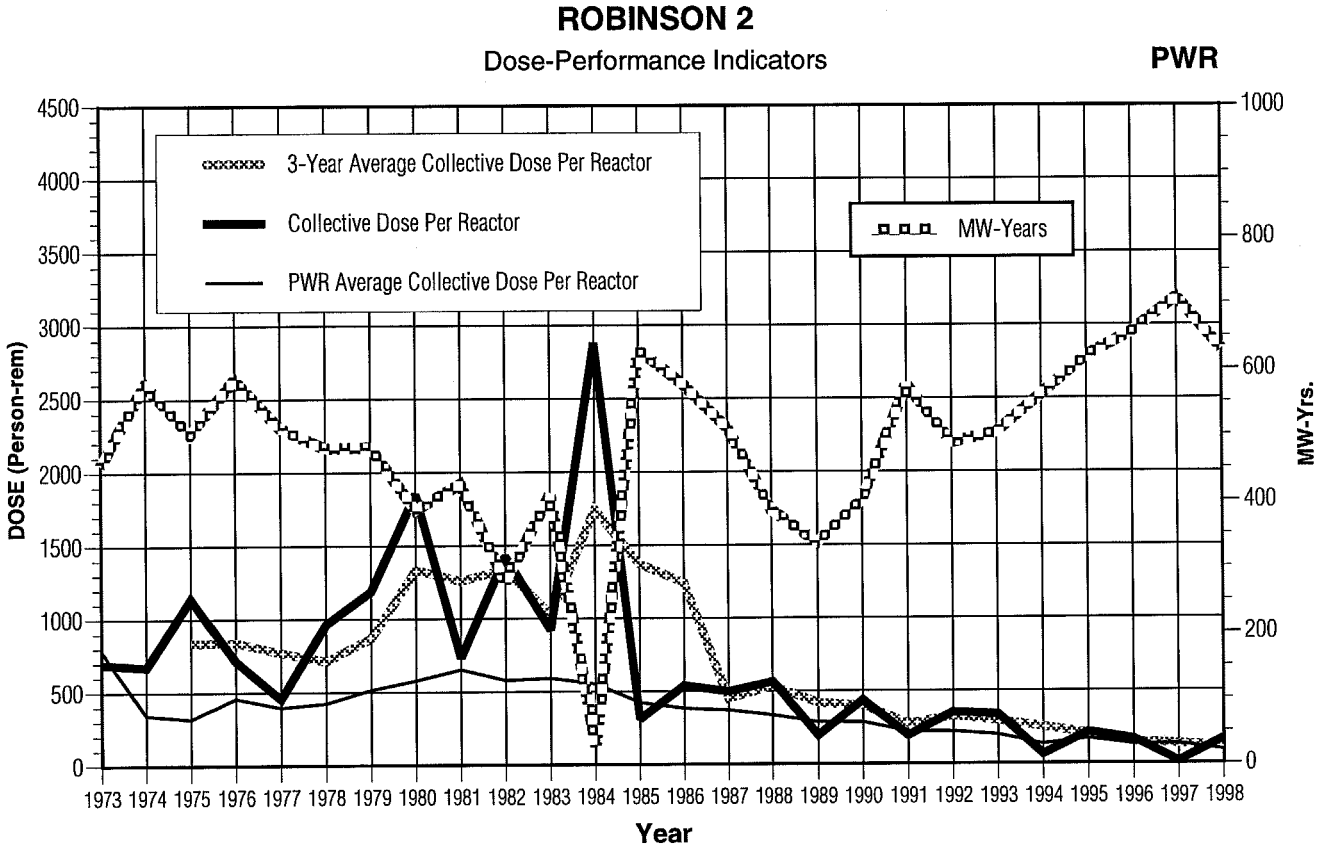
QUAD CITIES 1, 2

Dose-Performance Indicators

BWR



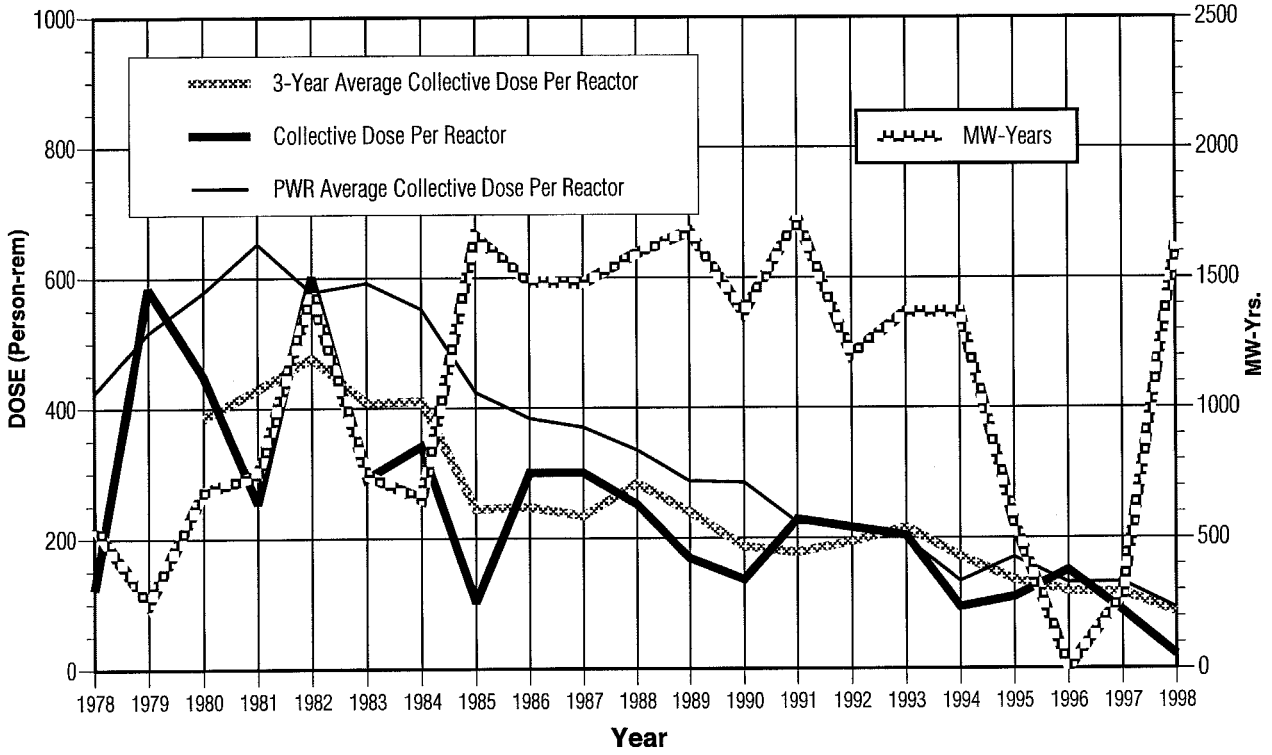

RIVER BEND 1
Dose-Performance Indicators
BWR
3-Year Average Collective Dose Per Reactor
Collective Dose Per Reactor
BWR Average Collective Dose Per Reactor
MW-Years
DOSE (Person-rem)
MW-Yrs.
Year
1000
800
600
400
200
0
1500
1000
500
0
1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998


ROBINSON 2
Dose-Performance Indicators
PWR
3-Year Average Collective Dose Per Reactor
Collective Dose Per Reactor
PWR Average Collective Dose Per Reactor
MW-Years
DOSE (Person-rem)
MW-Yrs.
Year
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1000
800
600
400
200
0
1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998

SALEM 1, 2

Dose-Performance Indicators

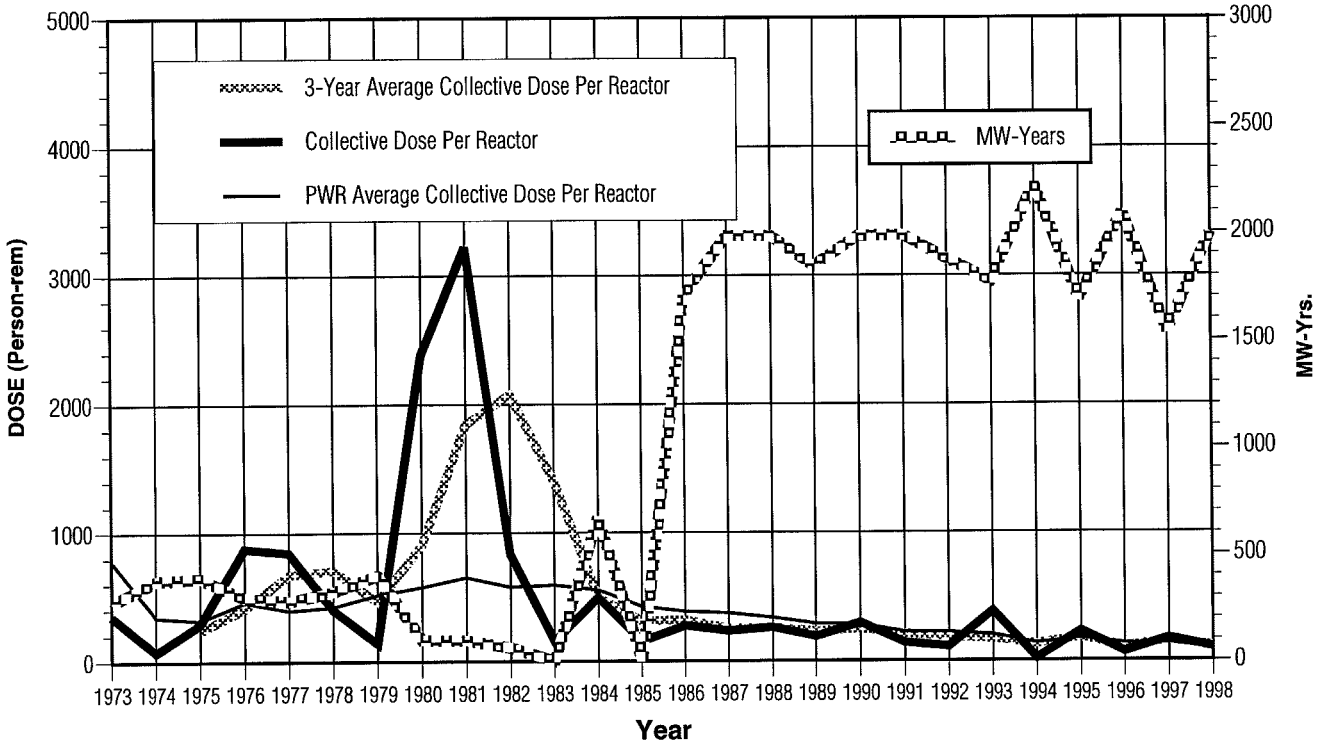
PWR

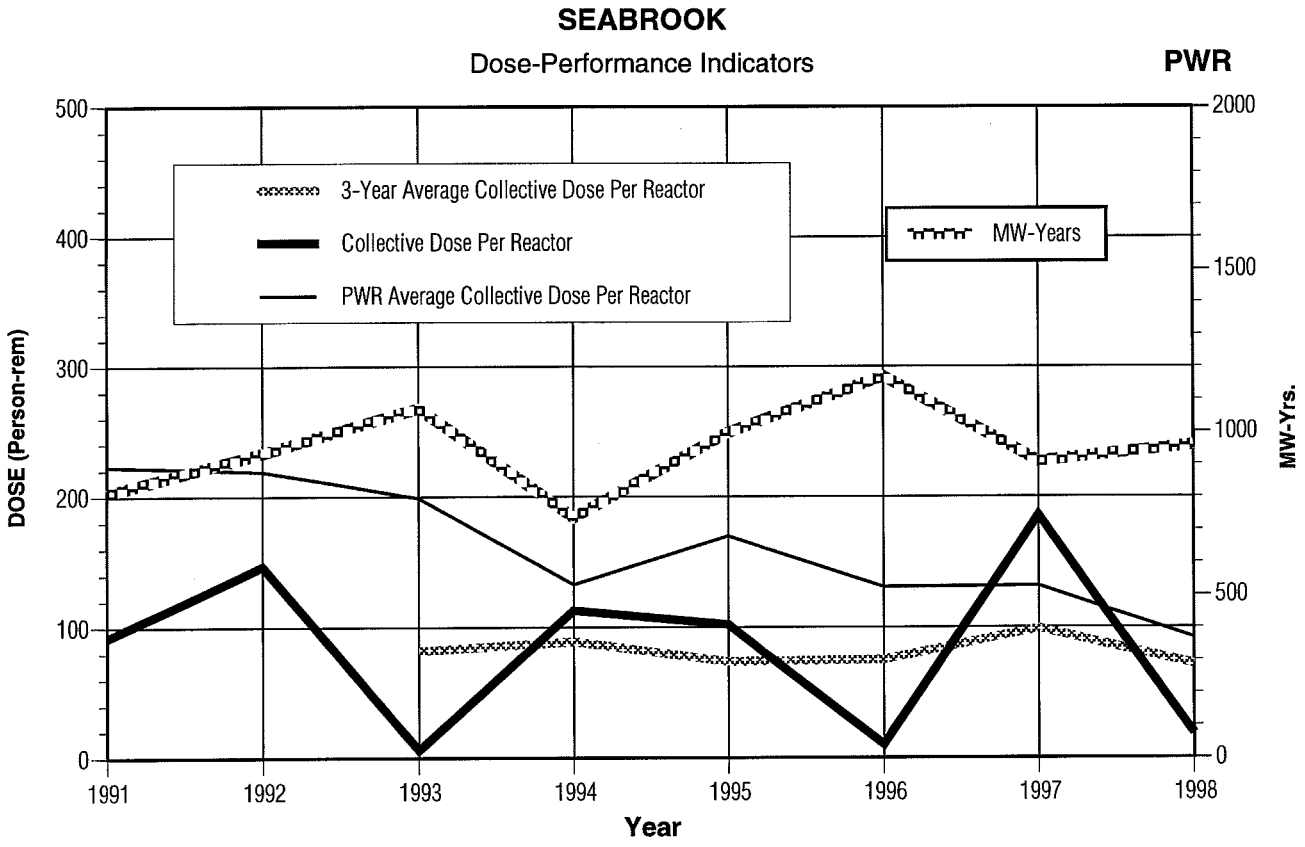


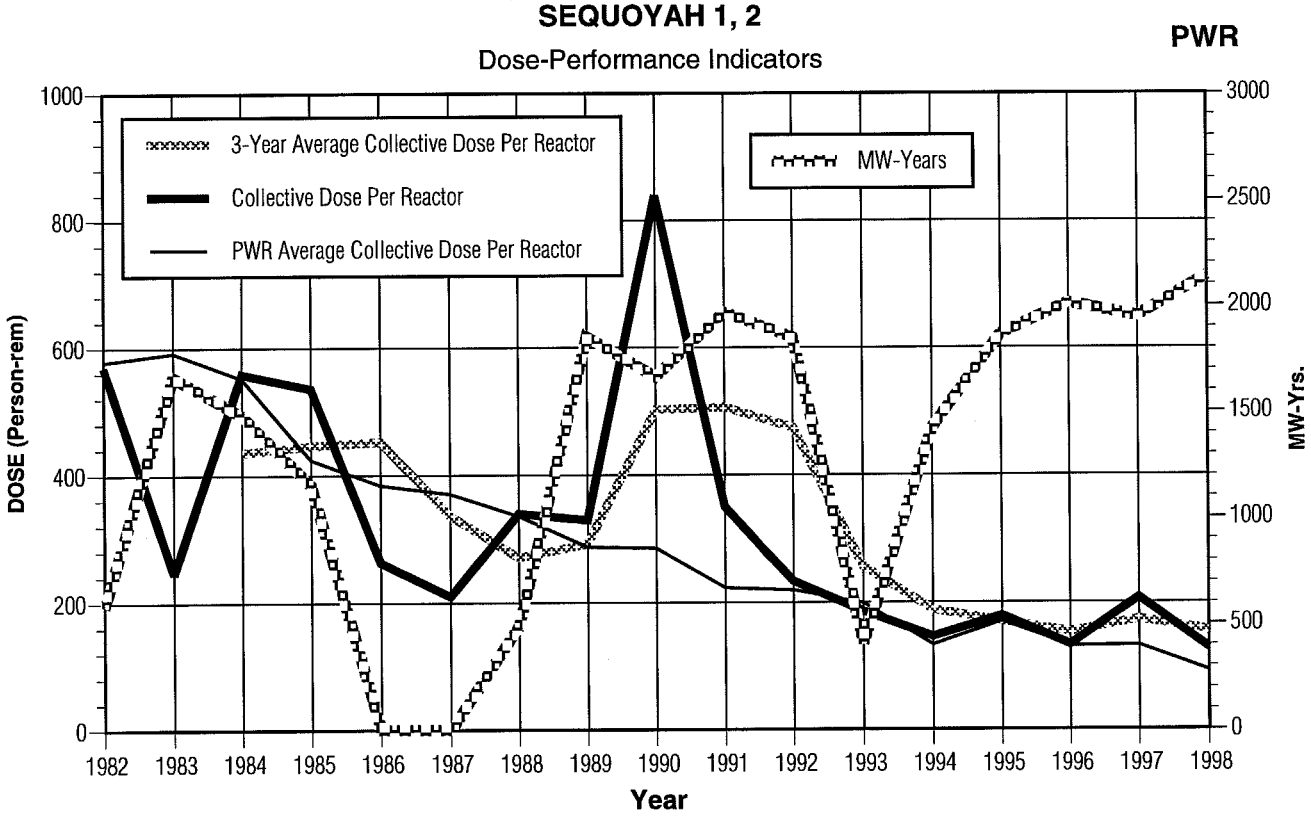
SAN ONOFRE 1, 2, 3

Dose-Performance Indicators

PWR



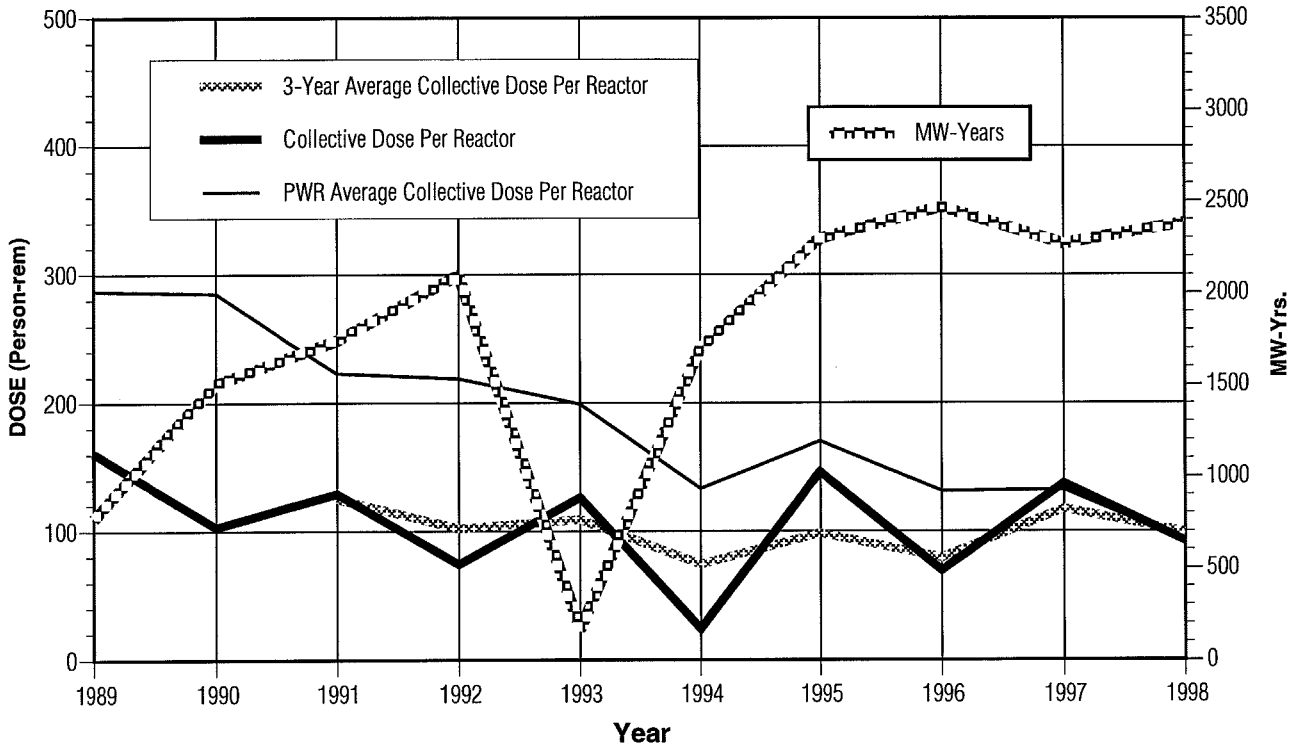

SEABROOK
Dose-Performance Indicators
PWR
3-Year Average Collective Dose Per Reactor
Collective Dose Per Reactor
PWR Average Collective Dose Per Reactor
MW-Years
DOSE (Person-rem)
MW-Yrs.
Year
0
100
200
300
400
500
500
1000
1500
2000
1991
1992
1993
1994
1995
1996
1997
1998


SEQUOYAH 1, 2
Dose-Performance Indicators
PWR
3-Year Average Collective Dose Per Reactor
Collective Dose Per Reactor
PWR Average Collective Dose Per Reactor
MW-Years
DOSE (Person-rem)
MW-Yrs.
Year
0
200
400
600
800
1000
500
1000
1500
2000
2500
3000
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998

SOUTH TEXAS 1, 2

Dose-Performance Indicators

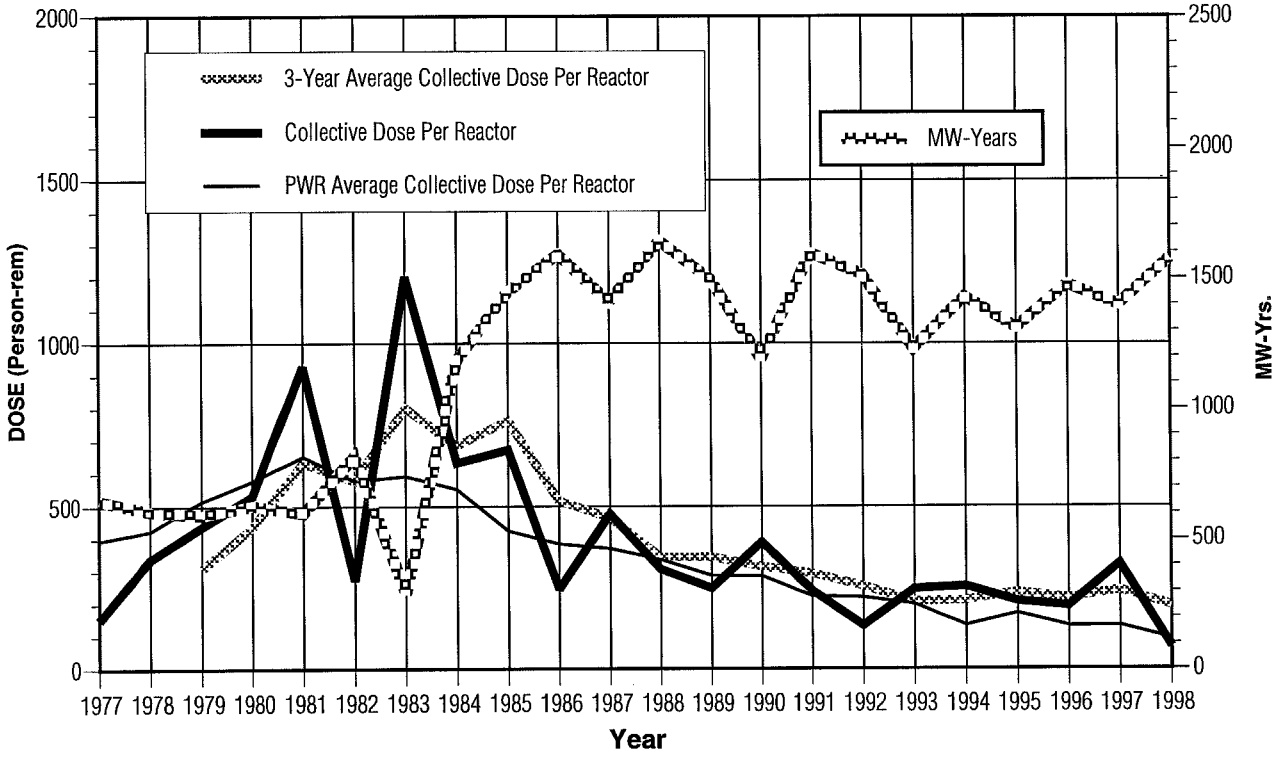
PWR



ST. LUCIE 1, 2

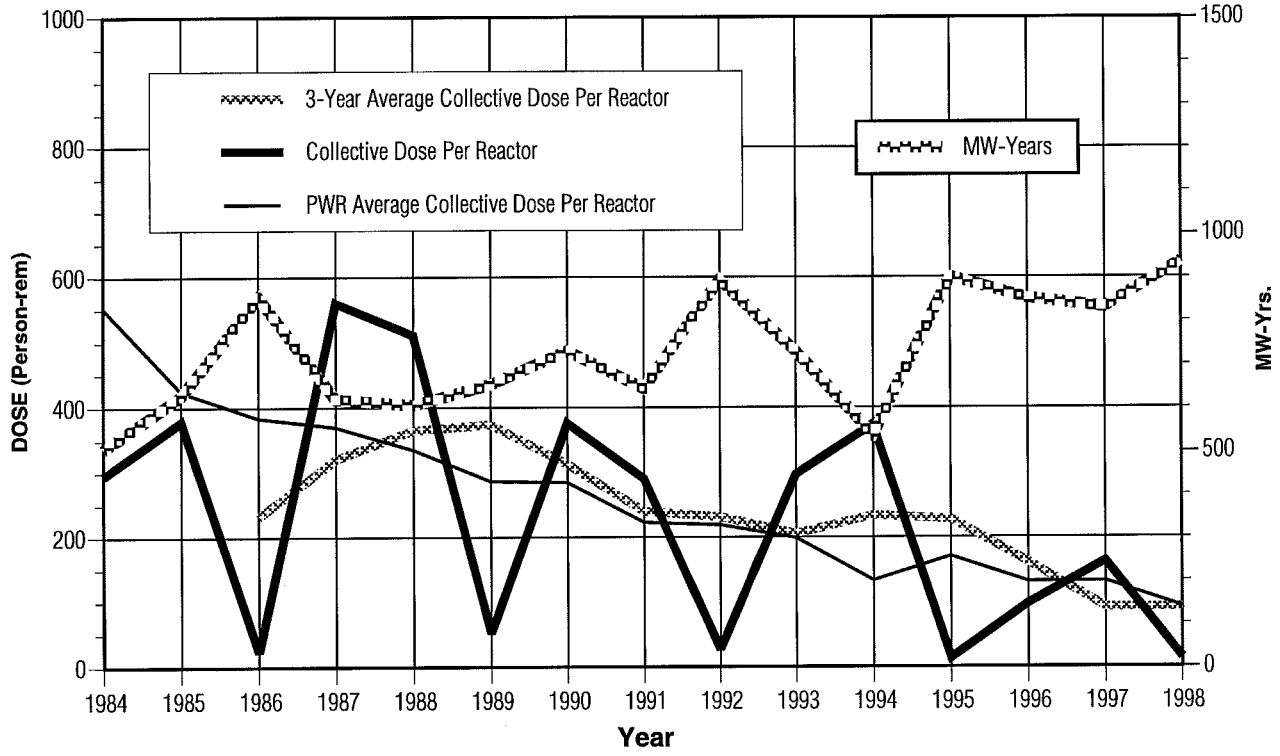
Dose-Performance Indicators

PWR



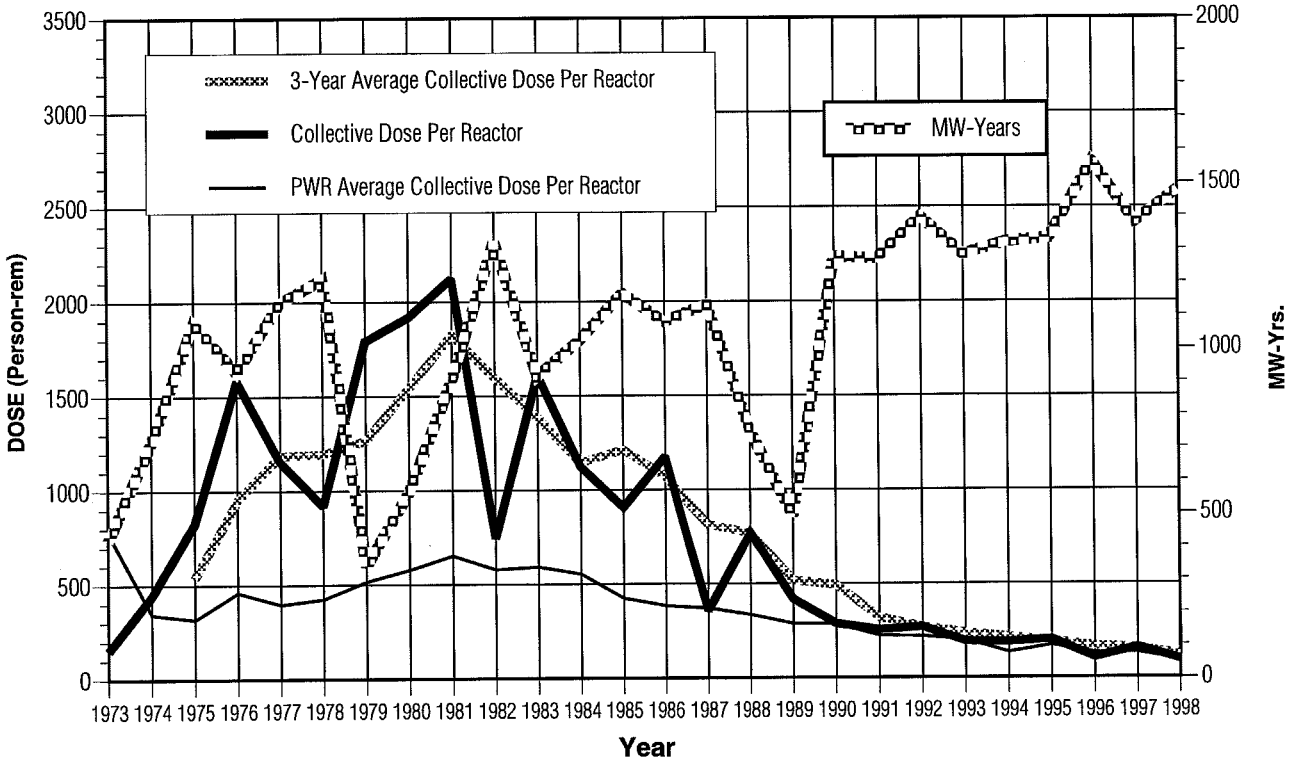
SUMMER 1

Dose-Performance Indicators **PWR**



SURRY 1, 2

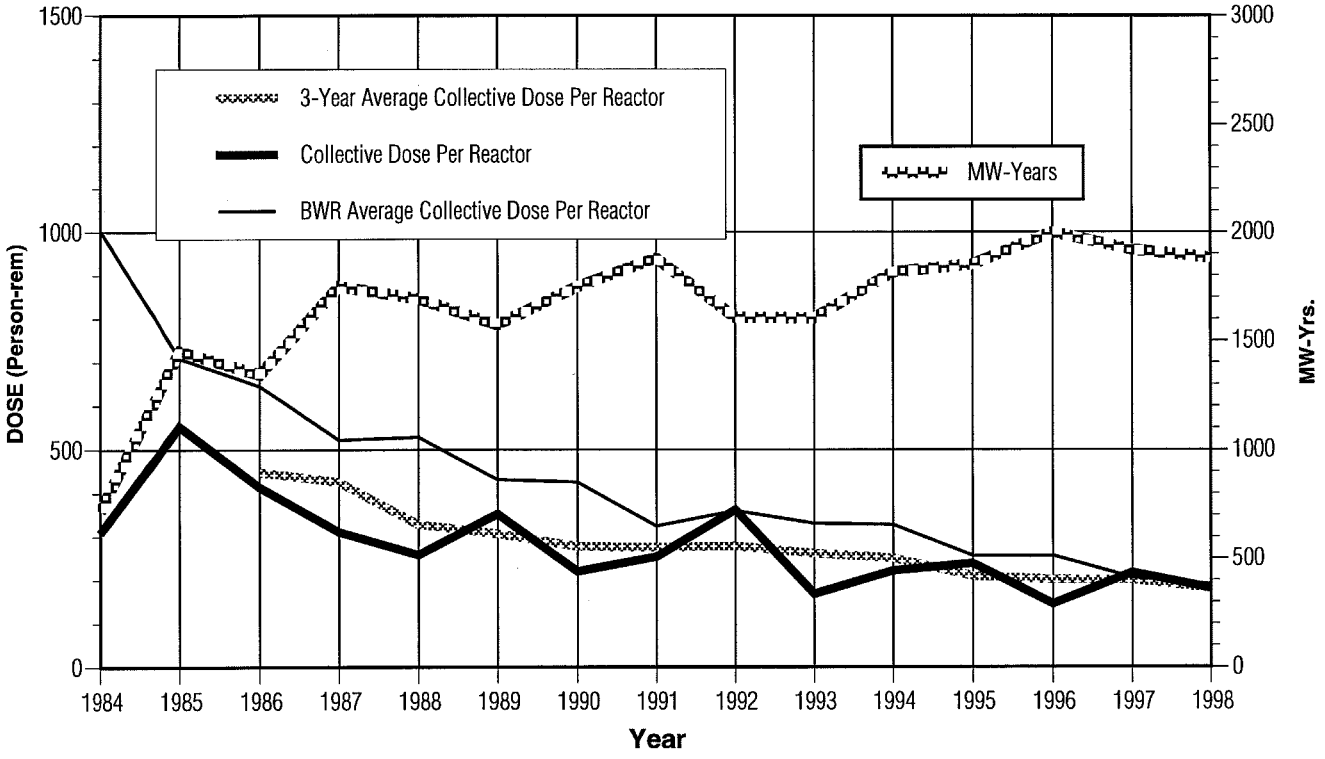
Dose-Performance Indicators **PWR**



SUSQUEHANNA 1, 2

Dose-Performance Indicators

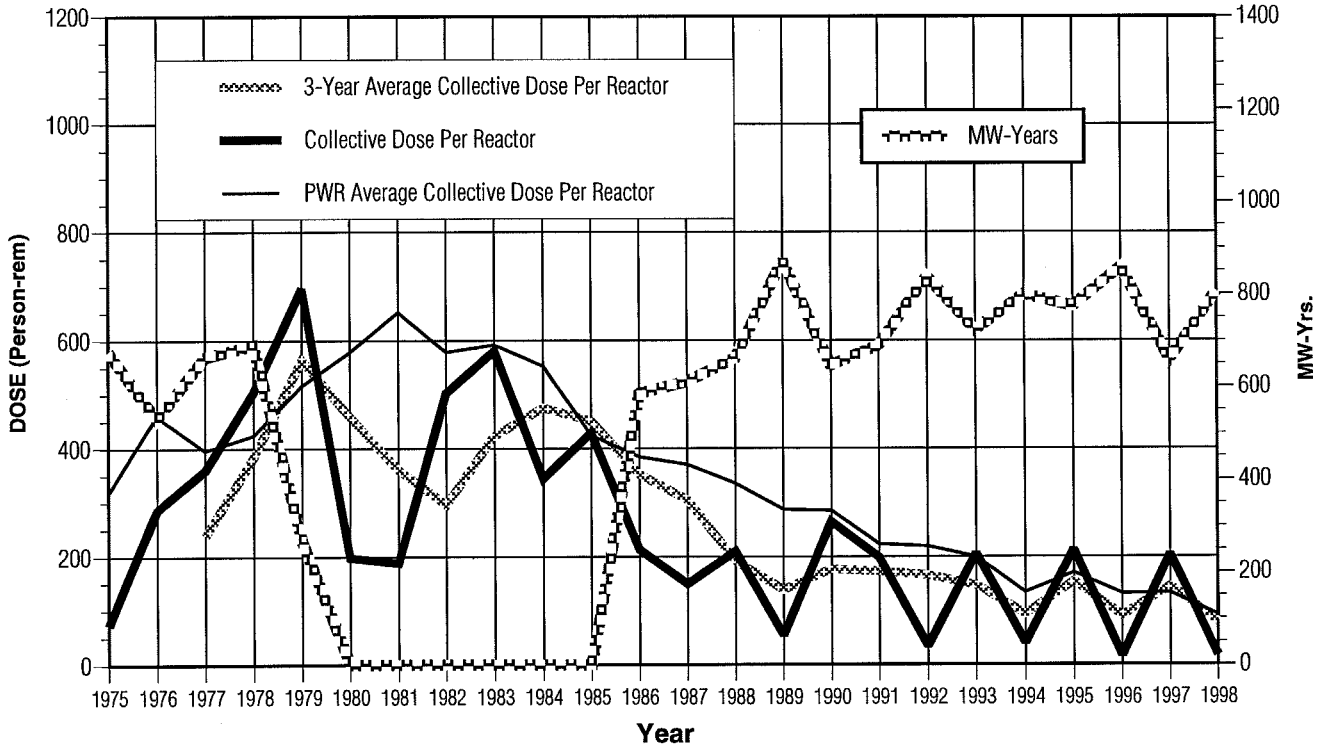
BWR



THREE MILE ISLAND 1

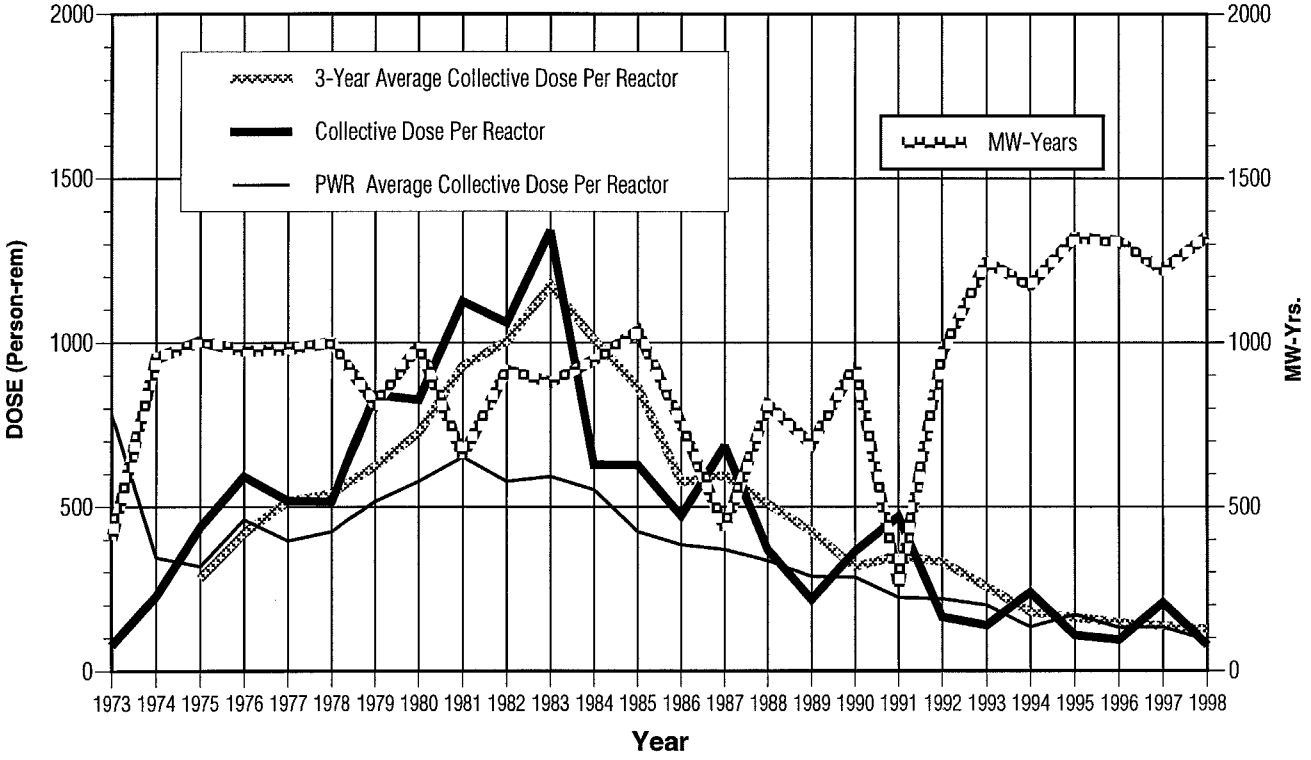
Dose-Performance Indicators

PWR



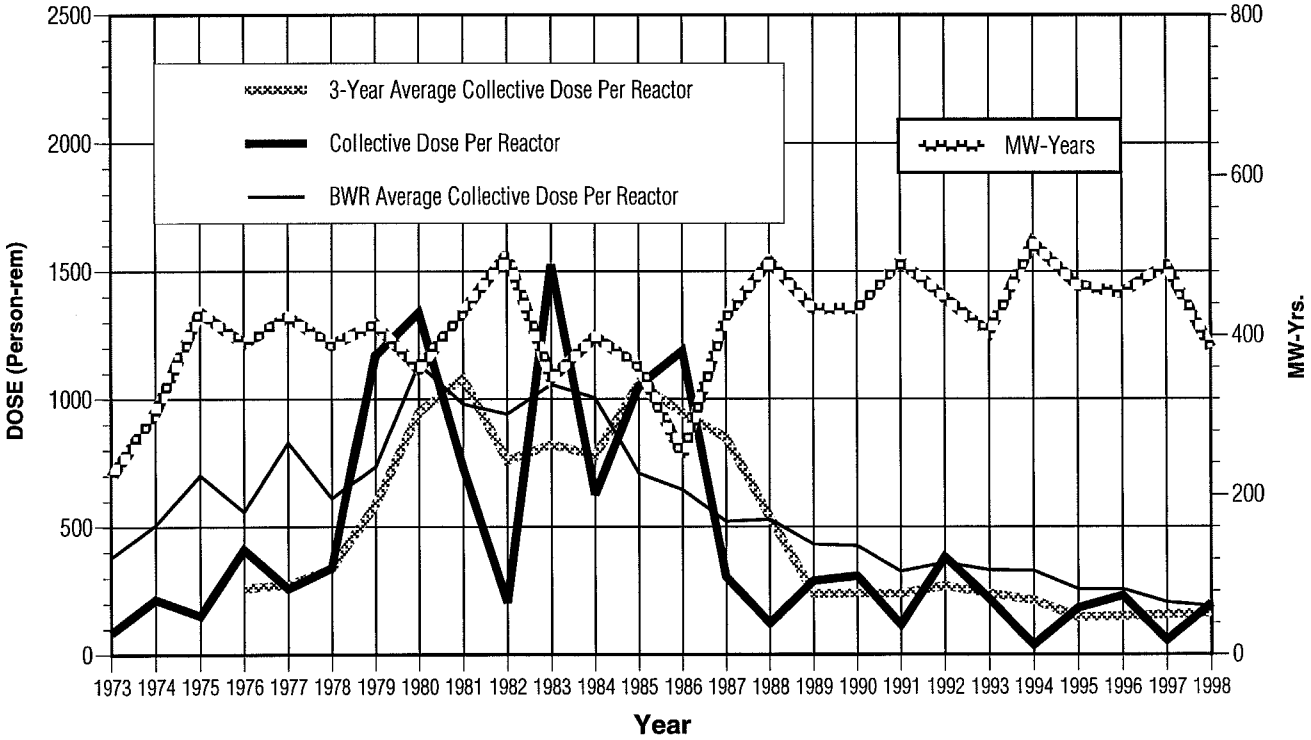
TURKEY POINT 3, 4

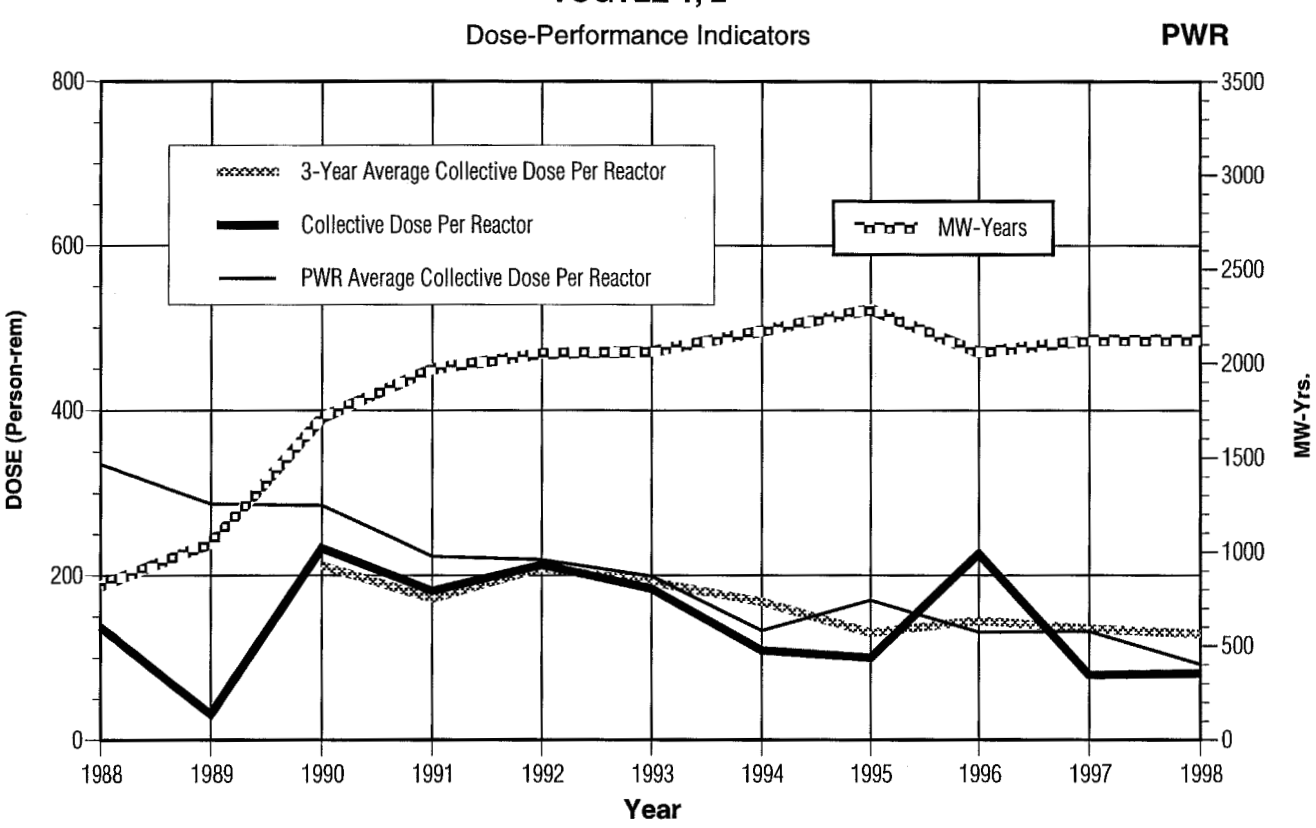
Dose-Performance Indicators **PWR**

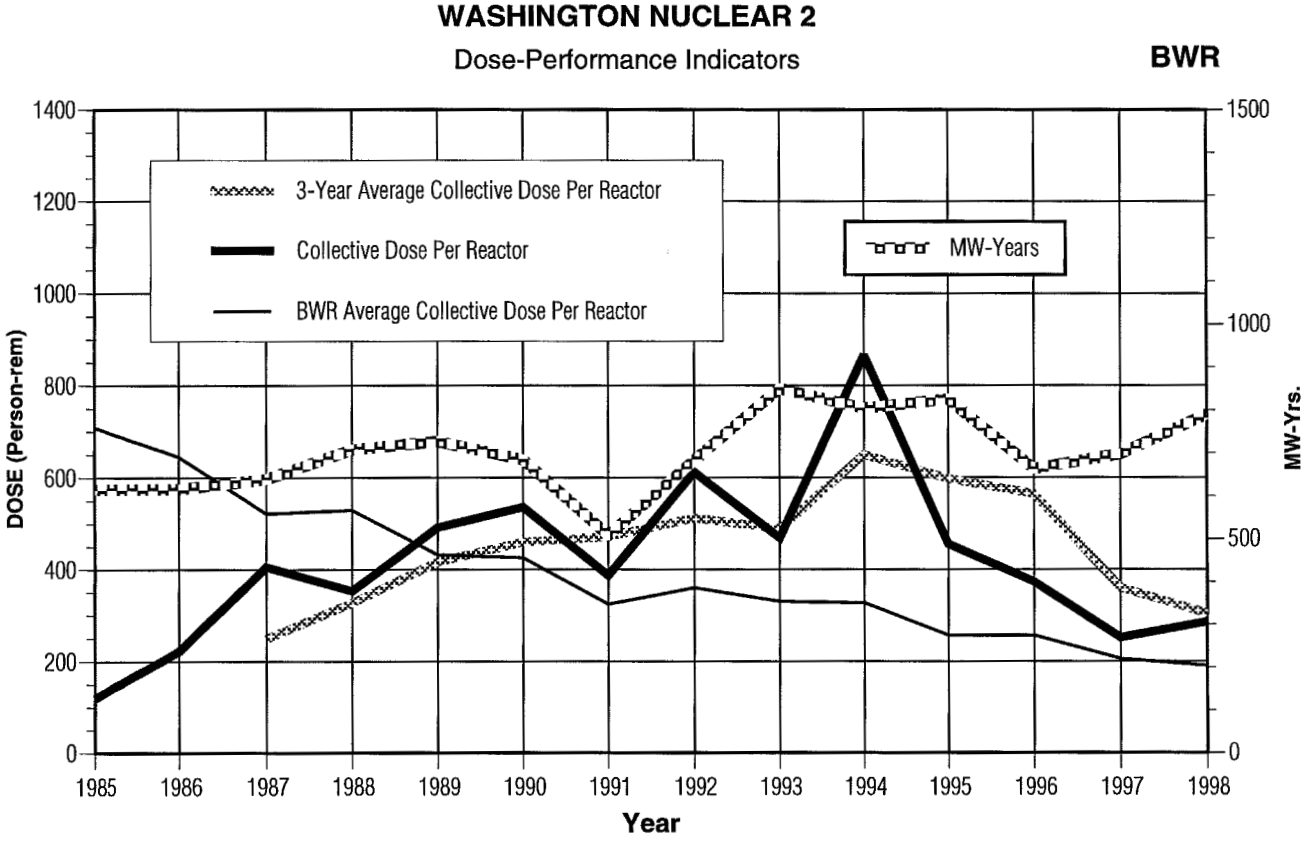


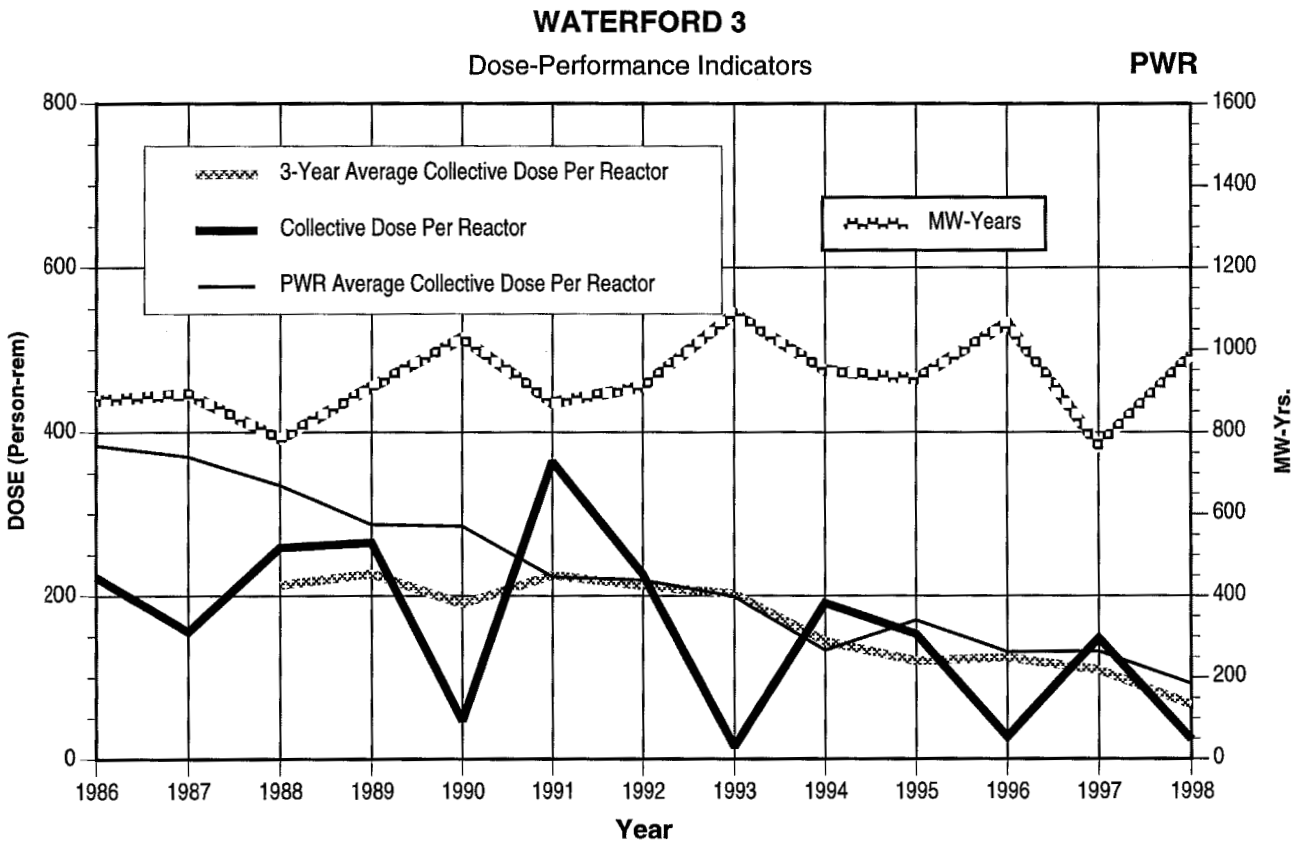
VERMONT YANKEE

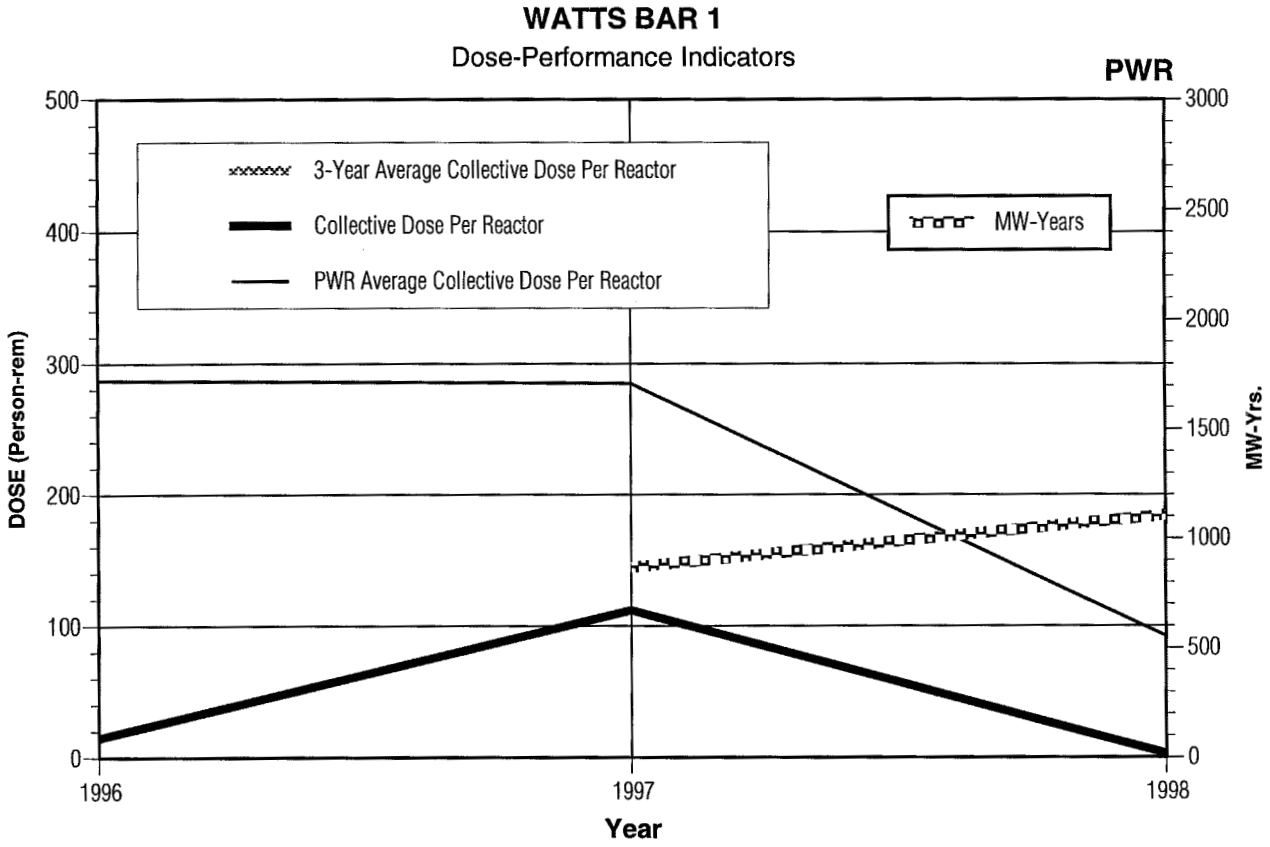
Dose-Performance Indicators **BWR**

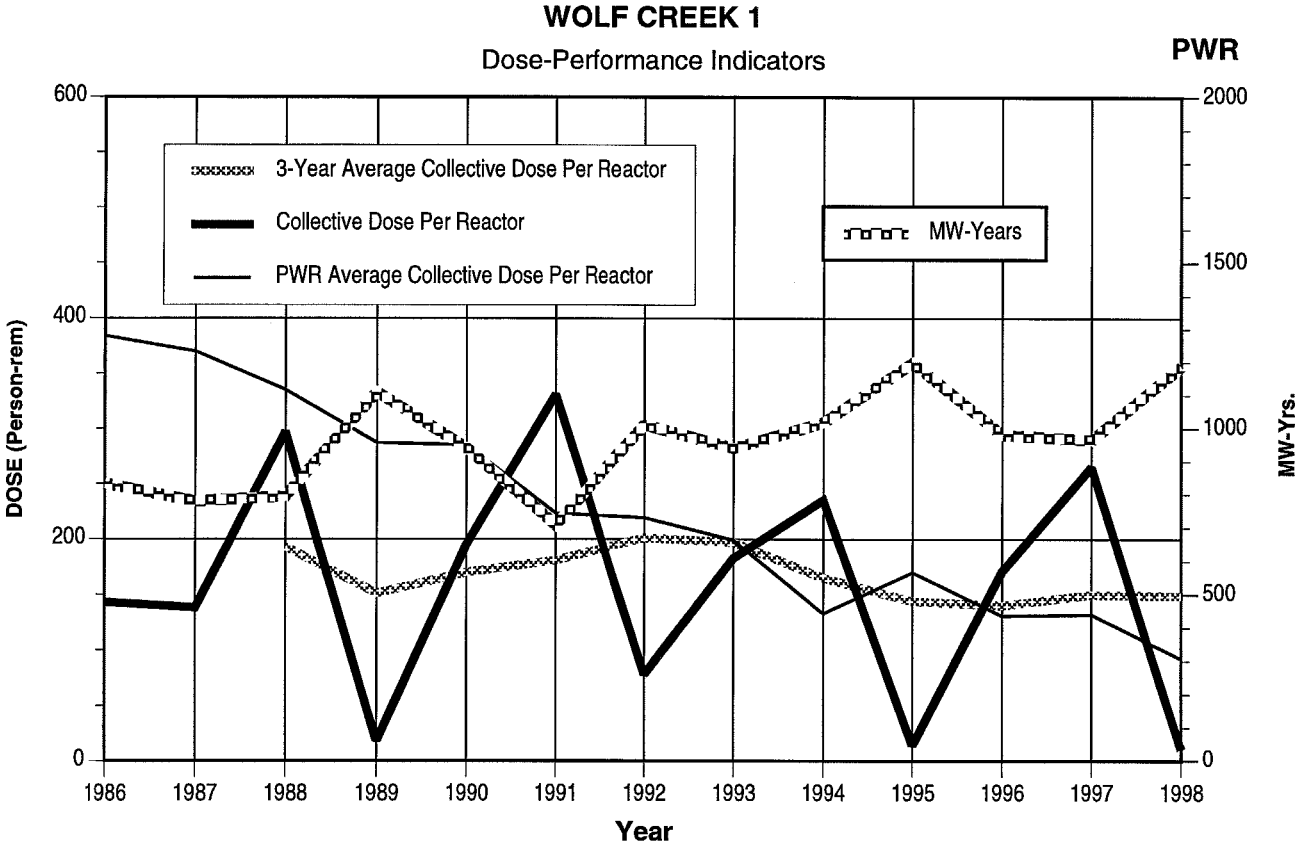


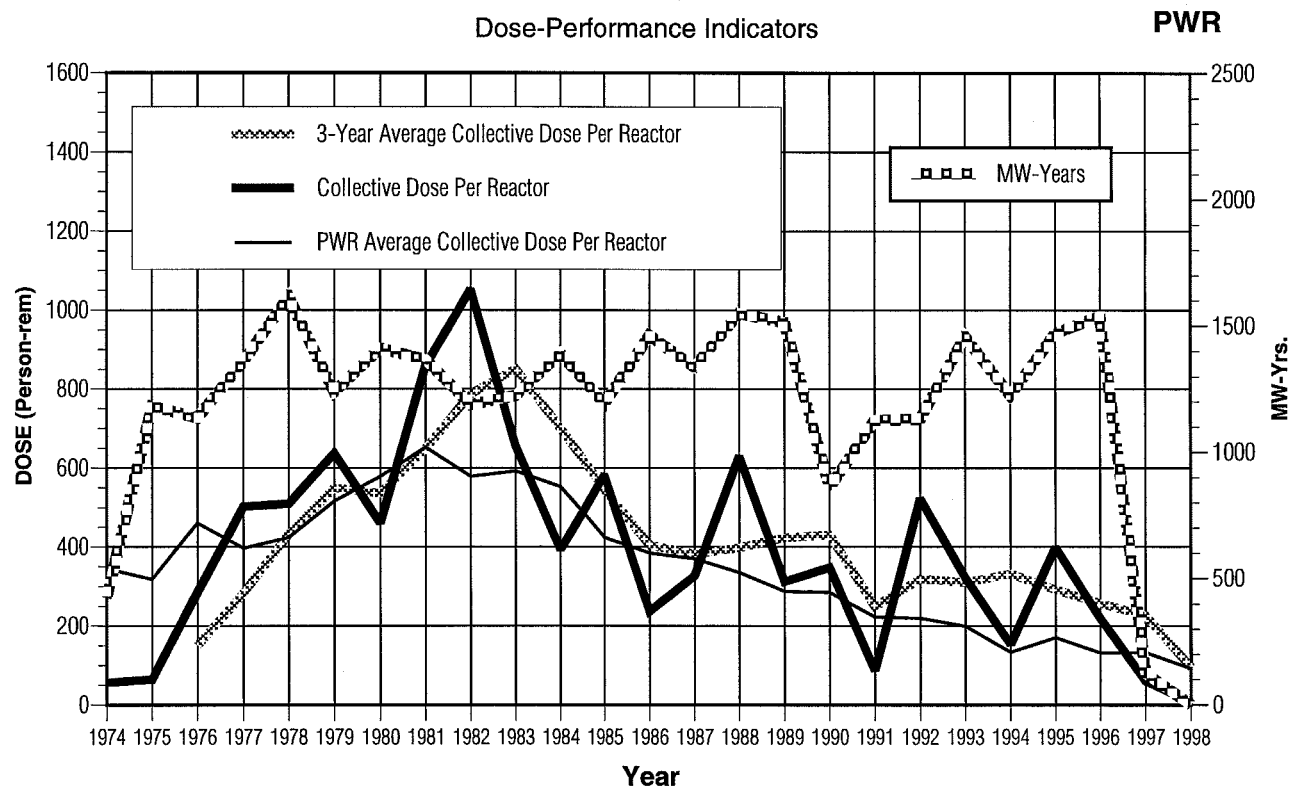

VOGTLE 1, 2
Dose-Performance Indicators
PWR
3-Year Average Collective Dose Per Reactor
Collective Dose Per Reactor
PWR Average Collective Dose Per Reactor
MW-Years
DOSE (Person-rem)
MW-Yrs.
Year
800
600
400
200
0
3500
3000
2500
2000
1500
1000
500
0
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998


WASHINGTON NUCLEAR 2
Dose-Performance Indicators
BWR
3-Year Average Collective Dose Per Reactor
Collective Dose Per Reactor
BWR Average Collective Dose Per Reactor
MW-Years
DOSE (Person-rem)
MW-Yrs.
Year
1400
1200
1000
800
600
400
200
0
1500
1000
500
0
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998


WATERFORD 3
Dose-Performance Indicators
PWR
3-Year Average Collective Dose Per Reactor
Collective Dose Per Reactor
PWR Average Collective Dose Per Reactor
MW-Years
DOSE (Person-rem)
MW-Yrs.
800
600
400
200
0
1600
1400
1200
1000
800
600
400
200
0
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
Year


WATTS BAR 1
Dose-Performance Indicators
PWR
3-Year Average Collective Dose Per Reactor
Collective Dose Per Reactor
PWR Average Collective Dose Per Reactor
MW-Years
DOSE (Person-rem)
MW-Yrs.
500
400
300
200
100
0
3000
2500
2000
1500
1000
500
0
1996
1997
1998
Year


WOLF CREEK 1
Dose-Performance Indicators
PWR
3-Year Average Collective Dose Per Reactor
Collective Dose Per Reactor
PWR Average Collective Dose Per Reactor
MW-Years
DOSE (Person-rem)
MW-Yrs.
600
400
200
0
2000
1500
1000
500
0
1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998
Year


ZION 1, 2
Dose-Performance Indicators
PWR
3-Year Average Collective Dose Per Reactor
Collective Dose Per Reactor
PWR Average Collective Dose Per Reactor
MW-Years
DOSE (Person-rem)
MW-Yrs.
1600
1400
1200
1000
800
600
400
200
0
2500
2000
1500
1000
500
0
1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998
Year