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1.0 STANDARD CONDITIONS AND SPECIAL AUTHORIZATIONS

1.1 Corporate & Financial Information

This application for license renewal is filed by the Wilmington Manufacturing Department of the General Electric Company, a New York corporation with a principal place of business at One River Road, Schenectady, New York.

1.2 Location & General Description of Wilmington Plant

The General Electric Company, Wilmington Manufacturing Department (WMD) operates a nuclear fuel fabrication plant in Wilmington, North Carolina. At this site, WMD occupies buildings for administrative, laboratory and manufacturing activities. The full address is as follows: General Electric Company, Wilmington Manufacturing Plant, (name of person and mail code), P.O. Box 780, Wilmington, NC 28402.

The arrangement of principal buildings is indicated in Figure 1.1. The site location is identified in Figure 1.2. It is located approximately 6 miles north of Wilmington, North Carolina, on Highway US-117.

1.3 License Number

The Wilmington Manufacturing Department of General Electric Company currently operates the nuclear fuel manufacturing plant in Wilmington, North Carolina, as authorized by the U.S. Nuclear Regulatory Commission by License Number SNM-1097, Docket #70-1113 issued January 1_, 1969 and renewed on May 24, 1976.

FIGURE 1.1

GE-WMD PRINCIPAL BUILDINGS ARRANGEMENT

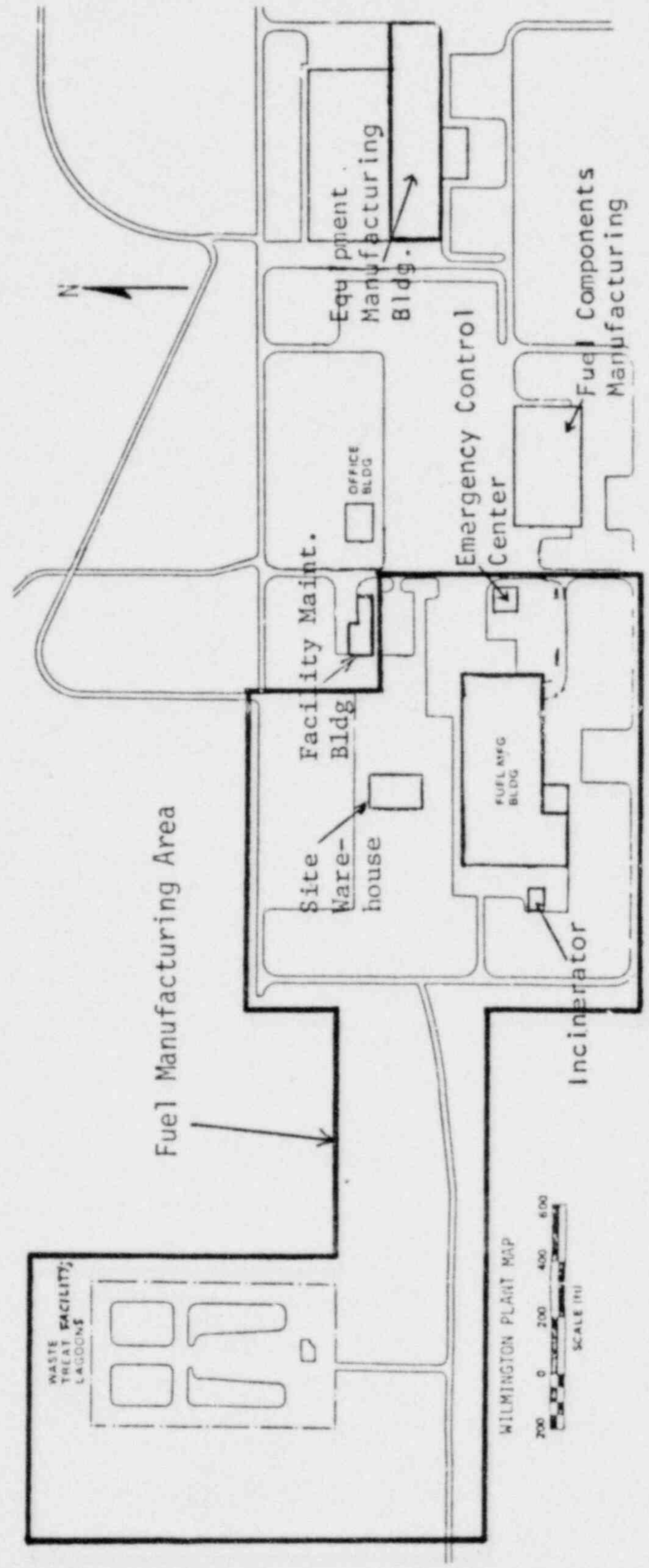


FIGURE 1.2

GE-WMD SITE LOCATION

1.4 Possession Limits

The following types, quantities, and forms of special nuclear materials are authorized:

1.4.1 Uranium 235, 50,000 kgs total

In any form, contained in uranium to a maximum nominal equivalent of 4%.

In the form of loaded fuel rods for use in fabricating fuel assemblies, contained in uranium to a maximum nominal enrichment of 4.5%.

In the form of UO2 powder, for use in quantities of safe batches, in powder blending and in preparation of laboratory standards to be used in laboratory operations, contained in uranium to a maximum nominal enrichment of 6.0%.

1.4.2 Uranium 235, 350 grams total

In any form contained in uranium at any enrichment, for use in measurement, detection, research or development, without regard to conditions of Chapter 4.

1.4.3 Uranium, 500 kgs Total

In any form, contained in uranium at a maximum nominal enrichment of 15% for use in process technology development operations.

1.4.4 Plutonium

1 milligram and not more than 1.5 millicuries in samples for analytical purposes

1 milligram and not more than 65 millicuries of plutonium-239, as standards for checking the response of radiation detection to alpha radiation

7 grams as sealed neutron sources

In nuclear fuel rods containing not more than 10^{-6} grams of plutonium per gram of U-235.

1.5 Material Use Locations

Uranium normally will be used at the Wilmington site in the fuel manufacturing areas only (see Figure 1.1). Occasionally, but infrequently, small quantities (i.e., less than one safe batch of uranium in a completely encapsulated form) may be used for special tests in other buildings or site locations. In such cases, special preparations are made to prevent release of radioactive material to unrestricted areas. For purposes of general orientation, the principal Wilmington Manufacturing Department buildings are described below.

1.5.1 Equipment Manufacturing Facility

The Equipment Manufacturing Facility is a large steel, concrete and transite structure in which non-nuclear reactor components are manufactured.

Only rarely are activities involving special nuclear material conducted in this building, and if so, the material would be encapsulated to prevent release to unrestricted areas.

1.5.2 Fuels Components Facility

The Fuels Components Facility, a large building of similar construction to all other Wilmington facilities, is used to manufacture non-nuclear components for reactor fuels. Only at very rare intervals will activities be conducted in this building involving nuclear materials, and if so, the material would be encapsulated to prevent release to unrestricted areas.

1.5.3 <u>Facility Maintenance Building</u>

This building is similar in construction to other buildings on the site and houses a centralized shop area utilized for maintenance, central stores, and related functions, none of which involve radioactive materials.

1.5.4 <u>Fuels Manufacturing Facility</u>

This building is a structure fabricated of concrete block and insulated metal siding over a steel framework with a concrete floor. A built-up roof consists of a metal deck and insulation which is topped with asphalt and gravel.

Connected to the south side of the Fuels Manufacturing Building, a chemical/metallurgical laboratory is separated by a 10-ft wide enclosed corridor. The laboratory is constructed of tilt-up concrete slab siding with the same roof construction as that on the main building.

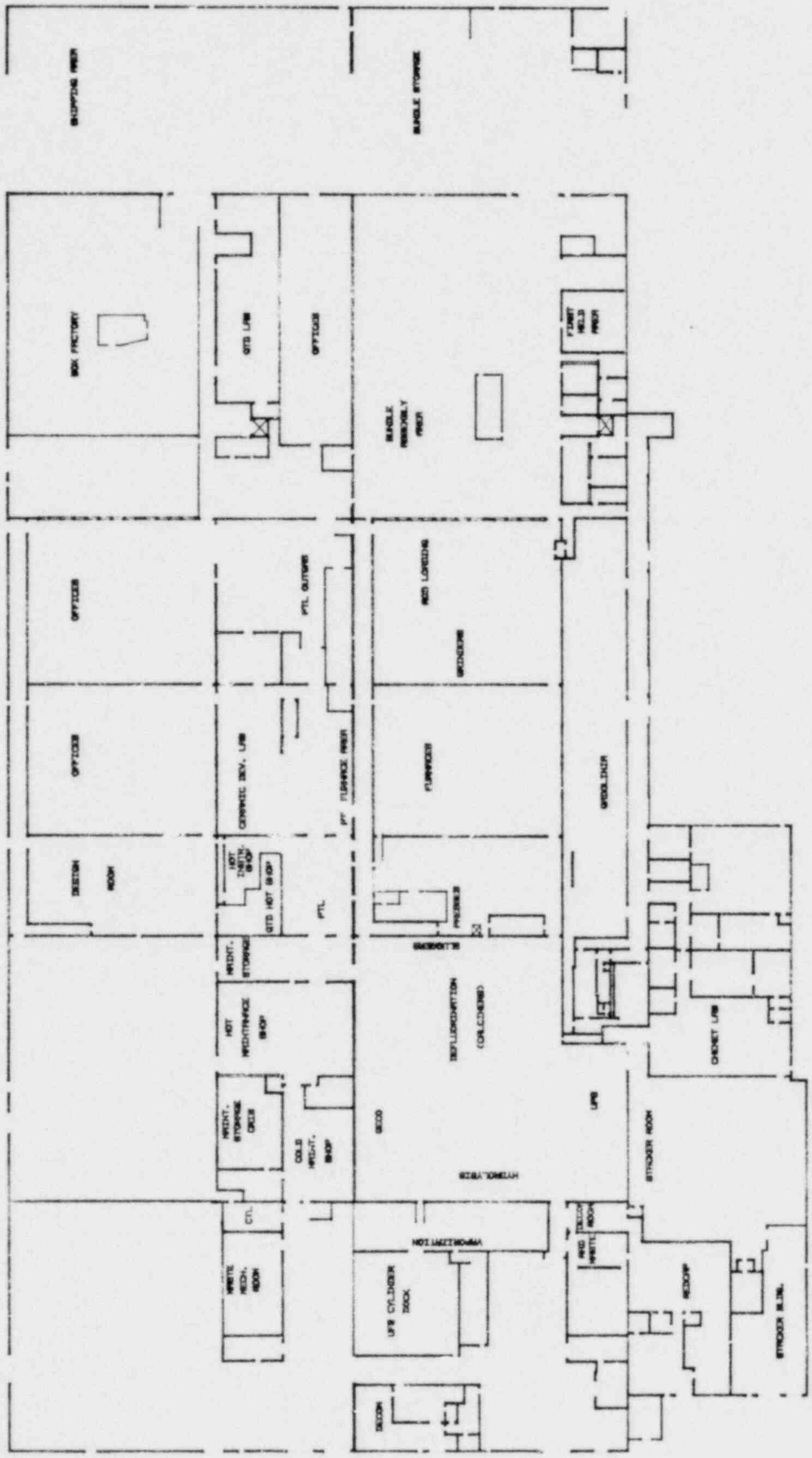
The Fuels Manufacturing Building and associated laboratory provide an integrated facility for the processing of uranium compounds for the manufacture of nuclear reactor fuels as more fully described in later chapters of this application. A general layout of the Fuels Manufacturing Building is shown in Figure 1.3. Details of the mezzanine floor of this building are shown in Figure 1.4.

1.5.5 <u>Warehouse Building</u>

A warehouse building was constructed in August 1980, located north of the Fuels Manufacturing Building. This building is used to store various nuclear fuel shipping containers - empty or full - as well as to

FIGURE 1.3

MAIN FLOOR - FUELS MANUFACTURING BUILDING



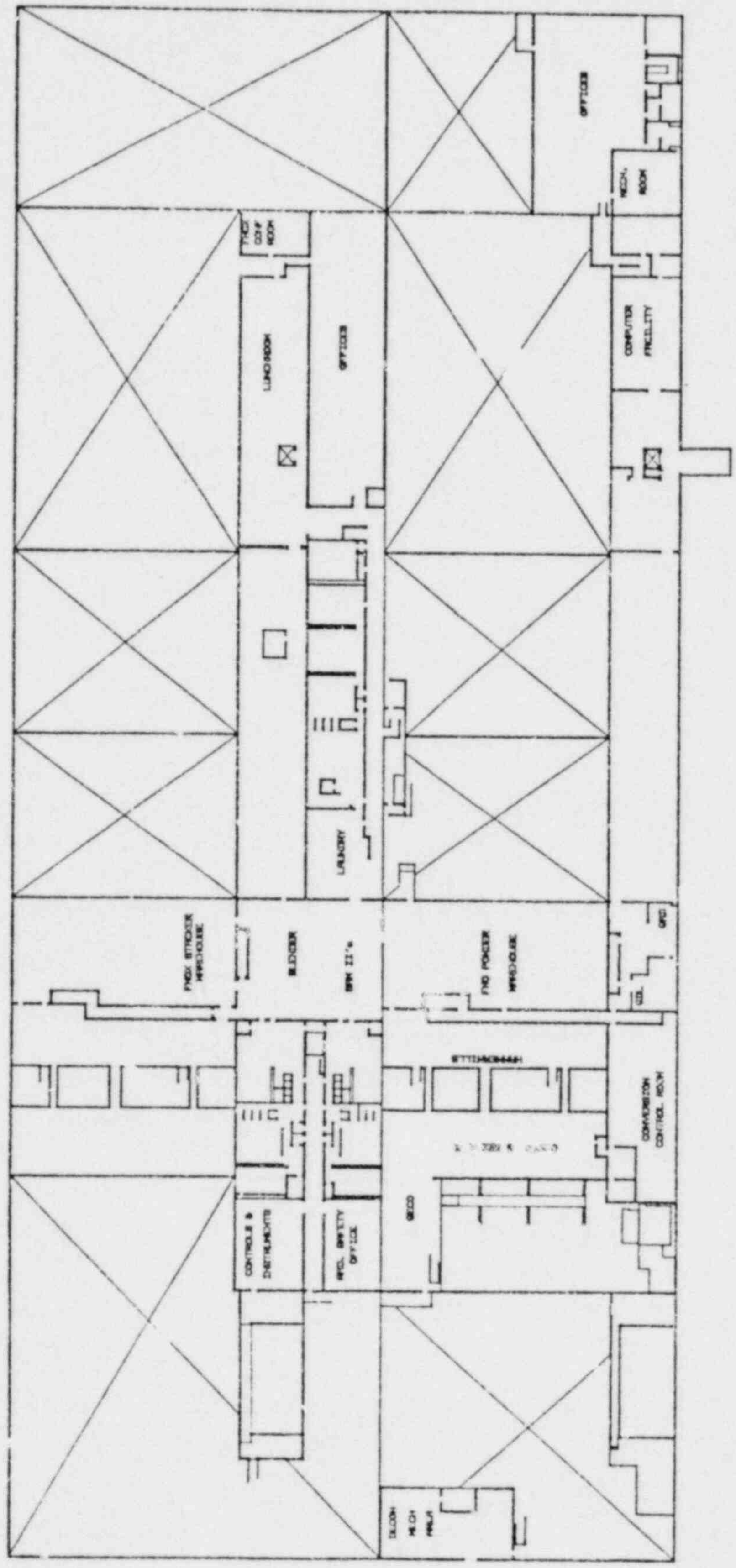


FIGURE 1.4

MEZZANINE - FUELS MANUFACTURING BUILDING store various non-nuclear items (industrial supplies, etc.). It is a pre-engineered structure with sheet metal siding, steel frame, and a poured concrete slab.

1.6 Definitions

Definitions as used in the license conditions are set forth below.

1.6.1 Area Manager - The manager designated by the Department General Manager who is responsible for implementation of nuclear safety requirements in the area assigned. The general title "Area Manager" does not necessarily refer to the title of any specific position in the General Electric's system of organization and position nomeclature.

1.6.2 Array - means two or more interacting accumulations of fissile material.

1.6.3 Criticality Control - means the administrative and technical requirements established to minimize the possibility of achieving inadvertent criticality in the environment analyzed.

1.6.4 Full Reflection - means that degree of reflection equivalent to a tight fitting shell of greater than 3 inches of water.

1.6.5 Minimal Reflection - means that degree of reflection equivalent to a close-fitting shell of water, steel, aluminum, nickle or copper not greater than 1/8 inch in thickness.

1.6.6 Safe Batch - means an accumulation of special nuclear material which is 45% of the critical accumulation for U-235 enrichments less than or equal to 6% and 33 1/3% of the critical accumulation f r U-235 enrichments greater than 6%, considering enrichment, full reflection, and optimum water moderation consistent with the form of the material.

1.6.7 Minimum Critical Dimension - means the smallest dimension which constitutes a critical system for a given geometry under conditions of full reflection and optimum moderation.

1.7 Authorized Activities

1.7.1 Product Processing Operations

1.7.1.1 UF_6 Conversion - Conversion of uranium hexafluoride to uranium oxide powder.

1.7.1.2 Fuel Manufacture - Manufacture of nuclear reactor fuel rods using uranium oxide pellets fabricated from the uranium oxide powder and other non-uranium bearing components.

1.7.1.3 Scrap Recovery - Reprocessing of scrap from WMD and from other sources with nuclear safety characteristics identical to WMD in-process materials, provided that the enrichment surveillance requirements of Chapter 4.2.2 are met.

1.7.2 Process Technology Operations

1.7.2.1 Conversion and fabrication of reactor fuel, fuel elements and fuel assesmblies in small amounts or of advanced design.

1.7.2.2 Development of scrap recovery processs

1.7.2.3 Determination of interaction between fuel additives and fuel materials.

1.7.2.4 Chemical analysis and material testing, including physical and chemical testing and analysis, metallurgical examination and radiography of uranium compounds, alloys and mixtures.

1.7.2.5 Instrument research and calibration, including development, calibration and functional testing of nuclear instrumentation and measuring devices using sealed plutonium-alpha-activated neutron sources.

1.7.2.6 Other process technology development activities related to, but not limited by, the above.

1.7.3 Laboratory Operations

Chemical, physical or metallurgical analysis and testing of uranium compounds and mixtures, including but not limited to, preparation of laboratory standards.

1.7.4 General Services Operations

1.7.4.1 Storage of unirradiated fuel assemblies, uranium compounds and mixtures in areas arranged specifically for maintenance of criticality and radiological safety.

1.7.4.2 Design, fabrication and testing of uranium prototype processing equipment.

1.7.4.3 Maintenance and repair of uranium processing equipment and auxiliary systems.

1.7.4.4 Storage and nondestructive testing of fuel rods containing small amounts of plutonium.

1.7.5 Waste Treatment and Disposal

1.7.5.1 Treatment, disposal and/or shipment of liquid waste whose discharges are regulated.

1.7.5.2 Decontamination of non-combustible contaminated wastes to reduce uranium contamination levels, and subsequent shipment of such low-level radioactive wastes to licensed burial sites for disposal.

1.7.5.3 Treatment or disposal of combustible waste and scrap material by incineration (authorization required pursuant to 10 CFR 20.302(a) and 10 CFR 20.305).

1.7.6 Offsite Activities

Non-destructive modification, testing, demonstration and storage of materials and devices containing unirradiated uranium, provided that such materials and devices shall be in General Electric's control at all times.

1.8 Exemptions & Special Authorizations

1.8.1 Requirements for Prior Authorization of Activities by License Amendment

Prior authorization by license amendment shall be required for the following activities:

1.8.1.1 Major changes or additions to existing processes which may involve a significant increase in potential or actual environmental impact resulting from utilizing such changes or additions.

1.8.1.2 Major process changes or additions which involve a new process technology for which a criticality safety demonstration has not been previously submitted to the Commission. In determining whether a new process technology requires such prior authorization by license amendment, the following factors will be considered: (1) type of equipment utilized, (2) chemical reactions involved and (3) potential and/or actual environmental impact.

1.8.1.3 Proposed activities for which specific application and prior approval are required by Commission regulations.

1.8.2 <u>Contamination-Free Articles</u>

Authorization for disposal of articles removed from a controlled area for transfer of such articles to persons not licensed to possess radioactive materials when each of the following conditions are satisfied:

A reasonable effort to eliminate residual contamination has been made.

All surfaces are accessible for survey or, it is reasonable to assume from the design and usage that no radioactive materials could have contaminated inaccessible surfaces without having contaminated the outer surfaces as well.

Survey of accessible surfaces by the radiation protection function has verified that contamination release limits have been met.

No fixed alpha contamination in excess of 15,000 dpm per 100 cm^2 with an average not in excess of 5,000 dpm per 100 cm^2.

No removable alpha contamination in excess of 1,000 dpm per 100 cm^2.

No beta-gamma radiation in excess of 1 millirad per hour with an average not in excess of 0.2 millirad per hour, as measured one centimeter from the surface with an open window Geiger-Mueller (GM) instrument having a window thickness not in excess of thirty milligrams per square centimeter (or equivalent instrument with appropriation conversion factor for measured radiation level).

1.8.3 Disposal of Contamination-Free Liquids

1.8.3.1 Hydrogen Fluoride Solutions

Authorization, pursuant to 10 CFR 70.42(b)(3), to transfer to persons not possessing an appropriate NRC or Agreement State license for special nuclear material, liquid hydrogen fluoride solutions, provided that the uranium concentration does not exceed three parts per million by weight of the liquid and the enrichment does not exceed 4 weight percent U-235, as evidenced by the process-average enrichment factor.

1.8.3.2 Nitrate-Bearing Liquids

Authorization, pursuant to 10 CFR 20.302(a), to dispose of nitrate-bearing liquids by transport to an offsite liquid treatment system in which decomposition of the nitrates will occur and from which the denitrified liquids will be discharged in the effluent from the system, provided that the uranium concentration does not exceed a 30-day average of 5 parts per million by weight of the liquids, provided that the enrichment does not exceed 4 weight percent U-235, as evidenced by the process-average enrichment factor.

1.8.4 Use of Materials at Off-Site Locations

1.8.4.1 Authorization to use up to 15 grams of U-235 at other sites within the limits of the United States, except where the material is subject to licensing by an Agreement State as defined in 10 CFR 150.

1.8.4.2 Authorization to store uranium fully packaged as for transport in any Fissile Class I package, in accordance with the conditions of a license authorizing delivery of such containers to a carrier for Fissile Class I transport, at locations in the United States providing such locations are controlled by the General Electric Company, with provision of measures to minimize the severity of potential accident conditions to be no greater than those in the design bases for the containers during transportation. Storage at nuclear reactor sites is subject to the financial protection and indemnity provision of 10 CFR 140 and is limited to possession for purposes of delivery to a carrier for transport. The requirements of 10 CFR 70.24 are waived insofar as this section applies to the materials contained in Fissile Class I packages.

1.8.4.3 Authorization to store arrays of finished reactor fuel rods and/or assemblies in any of the inner metal containers of the RA-series shipping package described in Chapters 2.0, 3.0 and 4.0 of the application for renewal of package certificate USA/4986/B()F dated 12/5/80, at locations in the United States providing such locations are controlled by the General Electric Company with provision of measures to minimize the severity of potential accident conditions to be no greater than those in the design bases for the containers during transportation. Arrays can be constructed without limit to the number of containers so stored, except that each array shall be stacked to a height of no more than 4 containers high with each container separated by nominal 2 inch wooden studs, and with the width and length for each array and separation between arrays determined only by container handling requirements. Storage at nuclear reactor sites is subject to the financial protection and indemnity provision of 10 CFR 140 and is limited to possession for purposes of delivery to a carrier for transport. The requirements of 10 CFR 70.24 are waived insofar as this section applies to the materials contained in any of the inner metal containers of the RA-series shipping package.

1.8.4.4 Authorization to process and use unirradiated reactor fuel of General Electric Company manufacture at nuclear reactor sites, for purposes of inspection, fuel bundle disassembly and assembly, including fuel rod replacement, provided that the following conditions are met.

1.8.4.4.1 A valid NRC license has been issued to the reactor licensee, which authorizes receipt, possession and storage of the fuel at the reactor site, and that General Electric Company possesses the fuel only within the indemnified location.

1.8.4.4.2 Not more than one fuel bundle and 30 unassembled fuel rods of the types described in Sections (b)(1)(i) through (v) of NRC Certificate of Compliance USA/4986/B()F, Revision 10 (see Appendix 1), are possessed by General Electric Company at any one reactor site at any one time, except when the fuel has been packaged for transport.

1.8.4.4.3 All operations involving the fuel are conducted by or under the direct supervision of a member of General Electric's staff who shall be responsible for all work on the fuel element assembly. The person shall be knowledgeable concerning all applicable terms and conditions of the licenses in effect at the reactor site and the appropriate actions that are to be taken in the event of emergencies at the site.

1.8.4.4.4 All operations involving the fuel are conducted in locations that have been selected to preclude mechanical damage and flooding.

1.8.4.4.5 Loose rods are stored only in RA-series inner metal containers.

1.8.4.4.6 Fuel is handled in accordance with pertinent provisions of the reactor license and in accordance with written and approved General Electric Company procedures. The procedures shall define the radiation and contamination surveys that are to be performed and the frequency of the surveys.

1.8.4.4.7 Written administrative procedures are jointly prepared and approved by General Electric and the reactor licensee, to provide for the nuclear and radiation safety of the operations to be performed. Records of the operation, including evaluations, procedures used, audits performed, and performance reports are maintained at the Wilmington, North Carolina, plant.

1.8.4.4.8 This authorization (Chapter 1.8.4.4) does not exempt General Electric from the requirements of Section 70.24 of 10 CFR 70, except when the materials are packaged in Model RA-series containers for delivery to a carrier for transport or when the materials are stored in RA-series metal inner containers as described in the application for renewal of package certificate, USA/4986/B()F, dated 12/ /80.

1.8.5 Respiratory Protection

Authorization, pursuant to 10 CFR 20.103(c), to make allowance for the use of respiratory protective equipment in determining whether individuals in controlled areas at the Wilmington plant are exposed to concentrations in excess of the limits specified in Appendix B, Table I, Column 1, 10 CFR 20, subject to the following specifications:

In circumstances in which adequate limitation of the inhalation of radioactive materials by use of process of other engineering controls is impracticable, the licensee may permit an individual in a controlled area to be exposed to average concentrations of airborne radioactive materials in excess of the limits specified in Appendix B, Table I, Column I, or 10 CFR 20 provided:

The individual uses respiratory or other appropriate protective equipment such that the total intake, in any period of seven consecutive days by inhalation, ingestion or absorption, would not exceed that intake which would result from breathing the concentrations specified in Appendix B, Table I, Column I, of 10 CFR 20, for a period of 40 hours.

The licensee shall advise each respirator user that he may leave the area for relief from respirator use in case of equipment malfunction, physical or psychological discomfort, or any other condition might cause reduction in the protection afforded the wearer.

The licensee maintains a respiratory protective program adequate to assure that the objective of Item (a) above is met. Such program shall comply with the requirements of NRC Regulatory Guide 8.15, "Acceptable Programs for Respiratory Protection."

1.8.6 <u>Possession of Special Nuclear Material in Private Carriage</u>

Authorization to possess special nuclear material in packages approved pursuant to the Commission's 1.8.7

regulations 10 CFR 71 in private carriage, in all forms authorized within the Appendix A, and pursuant to applicable rules and regulations of the Commission and the Department of Transportation.

1.8.7 Definition of Airborne Effluents

Authorization to utilize a dilution factor to the measured stack discharges for the purpose of evaluating the airborne radioactivity at the closest site boundary, provided by stack discharges from the uranium processing facilities. For control purposes, this dilution factor shall be no greater than 100.

1.8.8 Monitor System Exemption

Authorization for exemption from the requirements of Section 70.24, 10 CFR 70, for each area in which there is not more than:

One shipment of packages containing special nuclear material licensed pursuant to 10 CFR 71 packaged for transport outside the confines of the Wilmington site, providing all special arrangements necessary in the case of Fissile Class III shipments are observed, or,

one "safe batch" (as defined in Chapter 1.6.10) of finished reactor fuel rods or assemblies, under conditions which protect against rearrangement of fuel-bearing portions into more reactive configuration, or

the number and type of finished reactor fuel rods and/or assemblies authorized for delivery to a carrier for transport as a Fissile Class I shipment in the model RA-series shipping package described in Chapters 2.0, 3.0 and 4.0 of the application for renewal of package certificate USA/4986/B()F dated 12/5/80, without limit on the number of such stored containers, provided the storage locations preclude mechanical damage and flooding, or

the quantity of uranium authorized for delivery to a carrier for transport as a Fissile Class I package when fully packaged as for transport according to a valid NRC authorization for such packages without limit on the number of such packages, provided storage locations preclude mechanical damage and flooding, or

arrays of finished reactor fuel rods and/or assemblies in any of the inner metal containers of the RA-series shipping package described in Sections 2.0, 3.0, and 4.0 of the application for renewal of package certificate USA/4986/B()F dated 12/5/80, under storage conditions described in Chapter 1.8.5(3).

1.8.9 Incinerator Operation

Authorization, pursuant to 10 CFR 20.302( ) and 10 CFR 10.305, to treat or dispose of waste and scrap material containing special nuclear material by incineration.

2.0 GENERAL ORGANIZATIONAL & ADMINISTRATIVE REQUIREMENTS

2.1 Policy

It is the policy of the General Electric Company to maintain a safe work place for its employees and to require the compliance of operations with terms and conditions of special nuclear materials licenses and applicable NRC regulations.

In particular, General Electric has established the principle of keeping radiation exposures to employees and the general public as low as reasonably achievable (ALARA).

2.2 Organizational Responsibility & Authority

2.2.1 Key Positions with Safety Related Responsibilities

2.2.1.1 Area Manager

The area manager is the designated individual in management who is responsible for all safety activities within a specific area of the plant in which uranium materials are processed, handled or stored. The responsibility for safe operation and control of activities in the area and for the safety of the environs as influenced by the activities conducted therein shall be vested in the area manager who shall establish written operating procedures incorporating radiation and criticality safety controls and limits commensurate with the particular operations involved.

2.2.1.2 Criticality Safety Function

The criticality safety function is administratively independent of production responsibilities. The criticality safety function is defined as that function of WMD with designated responsibility for providing authoritative professional advice and counsel to area managers on matters of control against accidental criticality, including at least the following:

Analysis and approval of proposed changes in process conditions and processing equipment involving criticality safety.

Establishment of criticality safety control criteria.

Measurement of the effectiveness of the criticality control program.

2.2.1.3 Radiation Safety Function

The radiation safety function is administratively independent of production responsibilities. The radiation safety function is defined as that function of WMD with designated responsibility to provide authoritative professional advice and counsel to area managers on matters of radiation safety and to measure the effectiveness of the radiation safety program. The radiation safety function shall be responsible to establish and maintain the radiation safety program to ensure the protection of employees at WMD and the community. The radiation safety program shall include at least the following:

Establishment of the radiation protection and radiation monitoring program.

Establishment of radiation protection criteria, procedures and training programs to control contamination and exposure to individuals.

Evaluation of these controls.

Evaluation of radiation exposures of employees and visitors and maintenance of related records.

Emergency planning.

Evaluation of the integrity and reliability of radiation detection instruments.

Establishment of special conditions for the use of laboratory samples containing plutonium and the maintenance of appropriate records.

Analysis of proposed changes in process conditions and processing equipment involving radiological safety.

2.2.1.4 Radiation Protection Function

The radiation protection function is administratively independent of production responsibilities. The radiation protection function is defined as that function of WMD designated with the responsibility to obtain data relative to radiation exposures of employees and visitors, and to provide operational support to department functions requiring radiation monitoring services. Radiation protection responsibilities shall include at least the following:

Conduct of radiation monitoring program.

Administration of radiation work permit (RWP) nuclear safety requirements.

Measurements of airborne uranium concentration, contamination levels and external radiation levels.
Evaluation of the operational integrity and reliability of radiation detection instruments.

2.2.1.5 Environmental Protection Function

The environmental protection function is administratively independent of production responsibilities. It is defined as that function of WMD with designated responsibility to provide authoritative professional advice and counsel to area managers on environmental protection matters, including at least the following:

Specification of environmental monitoring program
Review and interpretation of environmental monitoring measurements.
Evaluation of release of radioactive effluents, materials and wastes from the site.

2.2.1.6 Industrial Safety Function

The industrial safety function is administratively independent of production responsibilities. It is responsible for determining all of the safety requirements associated with the fuel manufacturing operations other than nuclear safety (criticality safety, radiological safety, radiation protection) or environmental protection considerations.

2.3 Safety Review Committee

The functions of the safety review committee shall include responsibility for the following:

Review of ALARA programs and projects.
Review of nuclear and industrial safety practices applied to major changes made or proposed in authorized plant activities.
Professional advice and counsel on criticality and radiation safety issues.

The committee shall consist of at least five senior members of WMD's technical staff, appointed by the Department General Manager and shall include competence in the scientific and engineering disciplines. Senior members of management shall also serve on the committee upon the request of the Department General Manager.

The committee is responsible to the Department General Manager. Its proceedings shall be reported in writing to the section level managers responsible for operations which have been reviewed by the committee. Such reports shall be retained for at least two years.

The committee shall hold at least four meetings each calendar year with not more than a 120-day interval between any such meeting.

2.4 Approval Authority for Personnel Selections

The assignment of individuals to area manager, criticality safety and radiation safety functional positions identified in Section 2.2 shall be approved by the manager at the second organizational level above the position to be staffed.

Assignments to all other safety-related staff positions shall be made within the normal administrative practices of WMD.

2.5 Personnel Education & Experience Requirements

2.5.1 Area Manager

The minimum qualifications of an area manager shall be a BS degree from a college or university in a technical field with two years experience in nuclear plants and laboratories or a high school diploma with ten years nuclear industry experience.

Each area manager shall have demonstrated proficiency in the application of criticality control procedures and be knowledgeable in the procedures applicable to the ar under his management.

Each area manager shall have demonstrated proficiency in the application of a radiation safety program as it relates to limitations and radiological controls for the kind of activities in his assigned radiation or radioactive materials area.

2.5.2 Criticality Safety Function

A criticality safety function manager shall hold a BS degree in science or engineering, and shall have at least five years of experience in a responsible position in a nuclear field such as engineering, physics or chemistry, at least three years of which shall have been in an activity which would develop an understanding of criticality problems.

The criticality safety function shall include not less than two technically trained persons, at least one of whom (a senior member) holds a bachelor's degree in science or engineering with no less than three years of experience in a responsible reactor engineering or physics position and not less than one year of experience in criticality safety.

At least one other member of the criticality safety function shall have demonstrated proficiency in the analysis of criticality safety of the fuels manufacturing process and equipment through one year of such experience. This person shall either hold a bachelor's degree in a technical field or have not less than four years of experience in a function related to criticality safety.

At least one of these two persons shall be physically located at WMD.

2.5.3 Radiation Safety Function

The minimum qualifications of the manager of the radiation safety function will be a BS degree in science or engineering with five years of experience in assignments involving radiation safety.

Qualifications for radiation safety engineers or specialists assigned to the radiation safety function shall vary depending upon position assignments and delegated responsibilities. Such position assignments shall be made and/or approved by the manager of the radiation safety function and his manager.

2.5.4 Radiation Protection Function

2.5.4.1 Radiation Protection Technician - Trainee

A minimum of a high school education with twenty-four months monitoring experience or equivalent experience working with radioactive materials; or two years college training with science major and a minimum of four months monitoring experience; or at least five years of equivalent experience working with radioactive materials.

2.5.4.2 Radiation Protection Technician

Qualifications of a radiation protection technician - Trainee, plus at least six months experience in the nuclear safety field prior to being certified as a radiation protection technician, and successful completion of a General Electric training program which includes both oral and written examinations covering radiological and criticality control procedures.

2.5.4.3 Radiation Protection Supervisor

Qualifications of a radiation protection technician, plus certification as a radiation protection technician and two years of experience as a radiation protection technician, or at least five years of equivalent experience in the field of radiation protection.

2.5.5 Environmental Protection Function

At least one individual assigned responsibilities related to the environmental protection function shall have a BS degree in a technical field with two years of related experience in nuclear plants and/or laboratories, or a high school diploma and ten years nuclear industry experience which includes two years of related experience.

2.5.6 Industrial Safety Function

At least one individual assigned responsibilities related to the industrial safety function shall have a BS degree in a technical field with two years of related experience in nuclear plants and/or laboratories, or a high school diploma and ten years of experience which includes two years of related experience.

2.6 Training

Training programs are established for the various types of working positions, such as production operator, radiation protection technician, contractor personnel, etc., commensurate with criticality safety and/or radiation safety responsibilities associated with each such position. Visitors to the controlled areas shall be trained or shall be escorted by trained personnel.

2.6.1 Area managers assure that initial instruction of employees in criticality safety, radiation safety, radiation protection, and plant operating and emergency procedures takes place prior to such employees' working with special nuclear material.

2.6.2 A training program covering radiation safety, radiation protection and emergency procedures is maintained and includes training in the requirements of 10 CFR 20, license requirements, written procedures, methods of controlling radiation exposure, protective methods, basics of radiation effects, and practices designed to keep radiation exposures as low as reasonably achievable. Periodic safety meetings including radiation safety topics shall be attended by persons who work in radiation areas.

2.6.3 Details of the training program may vary, depending upon the positions of individuals being trained (radiation safety technicians, the managers and engineers of fuel manufacturing operations, and the workers in the uranium processing areas).

2.6.4 Training of radiation protection technicians features details of radiation effects on humans, radiation protection instrumentation, techniques for minimizing the radiation exposure of workers handling radiation materials (i.e., radiation protection) and criticality safety.

2.6.5 To the degree commensurate with their involvement in uranium processing, managers and engineers in fuel manufacturing operations are instructed in radiation effects on humans, techniques for radiation protection, and requirements for criticality safety.

2.6.6 Workers in the uranium processing area are trained in methods of protecting themselves from exposure to radiation and in requirements for criticality safety.

2.6.7 All individuals receiving the training must pass an examination before being permitted access to criticality areas, radiation areas, or radioactive material areas. Such examinations are also utilized by the criticality safety and radiation safety functions to evaluate the effectiveness of the training.

2.6.8 Retraining of all individuals who continually need access to the uranium processing areas is accomplished on an annual basis. Individuals with leave of absence from a uranium processing area extending over more than a year shall receive the initial training program for new individuals.

2.6.9 In addition to the specific training programs all aspects of safety in plant operations are discussed and reviewed on an ongoing basis at frequent roundtable safety meetings held by foremen or supervisors with their workers, and at unit or other component meetings held by managers with their employees.

2.6.10 The effectiveness of the training program is evaluated by means of internal audits.

2.7 Operating Procedures - Administrative Controls

Fissile material processing is conducted in accordance with properly issued procedures or instructions.

2.7.1 Adopting & Issuing Procedures

Area managers shall assure that written nuclear safety control procedures incorporating limitations established by the criticality and radiation safety functions are developed and maintained; they shall assure that these procedures are made readily available to foremen, operators and other concerned personnel through posting of limits, training programs and other appropriate written notifications.

The radiation protection program is designed to establish and maintain a comprehensive set of written instructions for radiation health and safety practices so as to maintain occupational radiation exposures at levels as low as reasonable achievable. Such instructions are reviewed by the radiation safety function prior to issuance by appropriate managers and generally annually thereafter.

Criticality safety control and radiation protection procedures for workers in uranium processing areas are incorporated into the appropriate operating, maintenance and test procedures in place for uranium processing operations.

2.7.2 Changes in Safety-Related Procedures

Activities which do not involve a change in license conditions but which require procedures, facilities or equipment substantially different from those previously used are initiated only after the applicable conditions stated below are met:

Changes which involve radiation hazards considerations are reviewed and evaluated, and approved in writing by the radiation safety function

Changes which involve a change in the parameters on which criticality safety was established are analyzed and approved in writing by the criticality safety function and documented by a written criticality analysis.

2.7.3 Procedures for New or Changed Activities

A request for nuclear safety (criticality and radiation safety) analysis is prepared in writing by, or at the direction of, an area manager for any proposed new activity or change in activity which may require a proposed change in criticality safety or radiological safety controls.

The changed activity will not be initiated until the nuclear safety analysis demonstrating safety of the activity has been completed, a preoperational inspection has been conducted to verify that the installation is in accordance with the nuclear safety analysis, and appropriate procedures and/or instructions are in place.

The results of these analyses are documented in nuclear safety reviews and maintained in an active file while still applicable.

2.7.4 Procedure Review & Update

Document	Review Frequency
Operational (Process Requirement & Operator Documents)	As required
Maintenance/Test (Job Hazard Analysis)	As required
Nuclear Safety (Practices & Procedures)	Biennial
Radiation Protection (Nuclear Safety Instructions)	Annual
Temporary Operating Instructions	Quarterly

These procedures are subject to change at any time when a modification to process operations or safety practices so indicates.

2.8 Audits & Inspections

Assurance of compliance with internal procedures is monitored by regular audits and inspections.

2.8.1 Criticality Safety

2.8.1.1 Radiation Protection Function

The radiation protection function generally inspects the manufacturing operations daily to assure conformance with area criticality control procedures and special procedures established by the criticality safety function. The radiation protection function receives a copy of the criticality safety requirements for each area from the criticality safety function as an aid for its inspections.

Inspections are conducted using these criticality safety requirements as a basis. Inspection results are reported to the area manager and to the criticality safety function. The area manager shall take appropriate corrective action.

2.8.1.2 Criticality Safety Function

Audits shall be performed by the criticality safety function on a quarterly basis for those areas which have not been subject to review in detail or other purposes (e.g., facility changes, comprehensive in-depth review of each major area, etc.). Such audits shall be performed to determine that actual operations confo[illegible] to the physical situations on which the criticality limitations have been based.

Audit reports are furnished to area managers. When a nonconformance is identified, the area manager shall promptly advise the criticality safety function of corrective action.

2.8.1.3 Independent Reviews

The methods of calculation used in establishing criticality control limits shall be independently reviewed when new calculative methods are adopted or when major changes are made to previously used methods. These reviews are performed by recognized authorities in criticality safety.

2.8.1.4 External Reviews

The in-house criticality safety program is audited periodically by an appropriate function outside of the WMD organization. Audit results are reported to the criticality safety function and the area managers. The criticality safety function and the area manager take appropriate response actions.

2.8.2 Radiation Safety

2.8.2.1 Radiation Protection Function

In order to maintain day-to-day cognizance of radiation safety conditions in the uranium processing areas, personnel of the radiation protection function inspec these areas on a routine basis. They also review routine reports of airborne uranium exposures of personnel to assure that no unreasonable or unexplainable increases in personnel exposures have occurred.

Unusual incidents, conditions, or airborne exposures observed by radiation protection personnel, which could lead to radiation health and safety problems, are documented and reported to the appropriate area manager and to engineering personnel of the radiation safety function for their review, analysis and timely correction.

Engineering personnel of the radiation safety function receive routine inspection and unusual condition reports and provide the necessary review and followup to such reports.

Surveys of contamination levels in each of the uranium processing areas are made at least weekly. If established action levels for contamination in areas are exceeded, corrective action is taken including investigation of causes producing the excessive levels.

2.8.2.2 Radiation Safety Function

Engineers of the radiation safety function engage in activities designed to lower the airborne concentrations of uranium in work areas in which activities involving special nuclear material are conducted and to lower the exposures of personnel working in such areas to airborne concentrations of uranium. These activities include the following:

Audit, on a quarterly basis, areas which have not been subject to review in detail for other purposes (e.g., facility changes, comprehensive in-depth reviews of each major area, etc.). Audit results are documented and submitted to area managers.

Review of day-to-day reports on radiation safety conditions from radiation protection personnel.

Review and analysis of data concerning personnel exposures to airborne concentrations of uranium.

Preparation of periodic reports to appropriate area manager outlining conditions in the work area which may lead to radiation health and safety problems, and recommending corrective actions to eliminate or alleviate such conditions.

2.8.2.3 External Reviews

The in-house radiation safety program is audited periodically by an appropriate function outside of WMD. Audit results are reported to the radiation safety function and the area managers. The radiation safety function and the area manager take appropriate response actions.

2.8.3 Environmental Protection

Quarterly audits are conducted by the environmental protection function. These audits include verification of compliance with administrative procedures and operational instructions. Periodic reviews shall be conducted of environmental sampling results to assure compliance with regulatory requirements for liquid and gaseous effluents and to assess trends related to such data.

Action levels have been established and appropriate responses have been specified to be taken when uranium concentration limits exceed these levels, including investigation of causes producing the excessive levels.

2.9 Investigation and Reporting of Off-Normal Occurrences

2.9.1 Incident Classification

All unusual events which potentially threaten or lessen the effectiveness of health, safety or environmental protection are identified by the area manager and reported to the quality assurance section. Each incident is considered in terms of its severity and classified as indicated in Table 2.1. This classification establishes the appropriate response action including notification to federal and state agencies.

2.9.2 Investigation of Unusual Incidents

Each reported unusual incident is evaluated to determine the level of investigation required. The depth of the the investigation depends upon the severity of the incident in terms of the levels of uranium released and/or the degree of potential for exposure of workers or the public. The sequence of events which are followed in investigations and the activities assigned to each function are shown schematically in Figure 2.1. A summary of these assigned responsibilities is as follows:

2.9.2.1 The quality assurance manager is responsible to establish, maintain and coordinate the program for investigation of nuclear safety and environmental incidents. He also performs the duties of investigation team captain when required.

2.9.2.2 The operations manager is responsible for protecting the workers, initiating actions to bring the incident under control, assuring that any injuries are treated,

TABLE 2.1

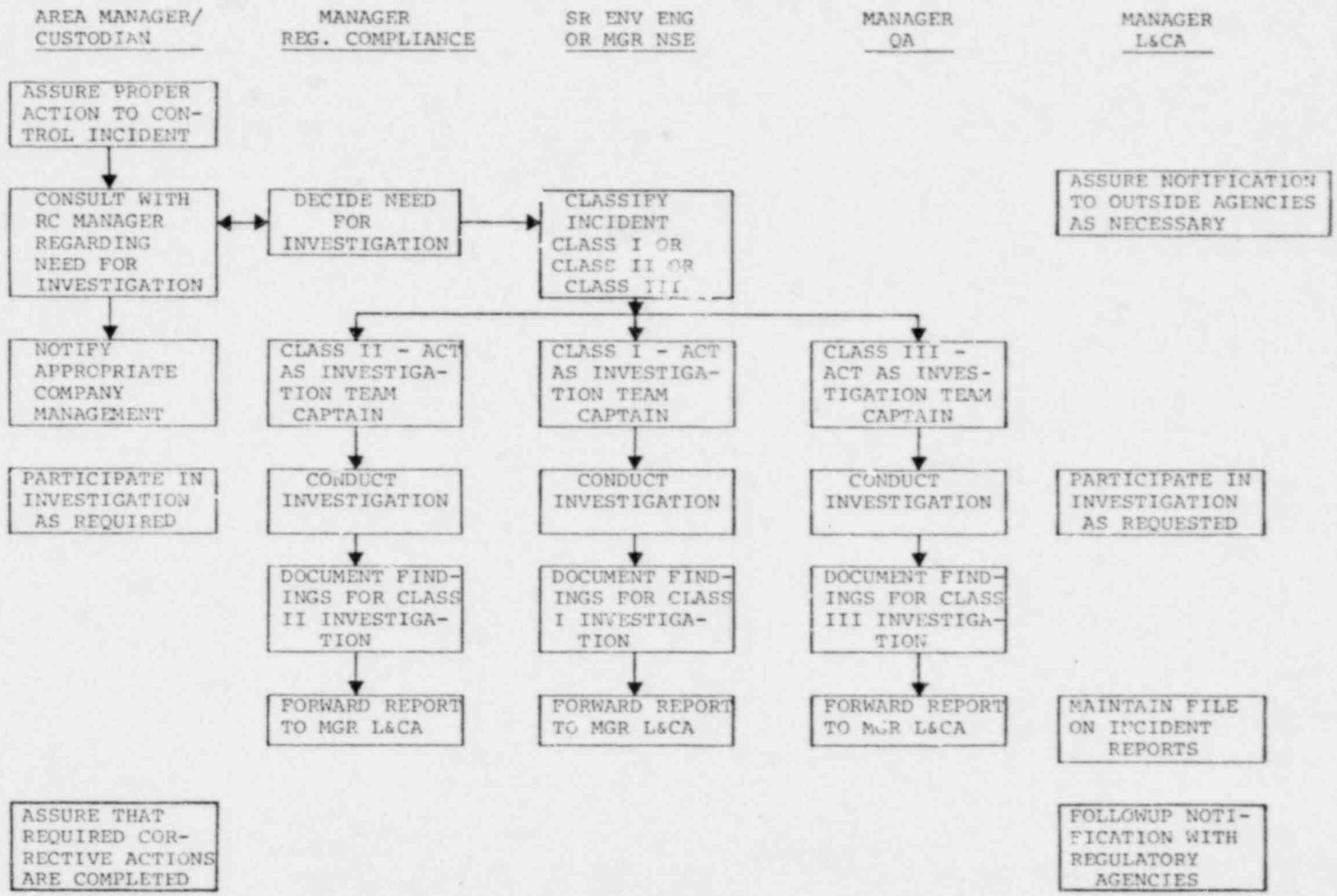
INCIDENT CLASSIFICATIONS

Category	Class 1	Class 2	Class 3
ONSITE PERSONNEL INJURY OR EXPOSURE	o Evidence of apparent exposure less than one times the regulatory limit but greater than or equal to the administrative guides (internal or external).	o Evidence of apparent exposure less than five times the regulatory limit but greater than one times the regulatory limit (internal or external).	o Death or disabling injury as defined under appropriate OSHA regulations. o Evidence of apparent exposure in excess of or equal to five times the regulatory limit (internal or external).
PROPERTY DAMAGE		o Damage or loss less than $200,000 but greater than or equal $50,000.	o Damage or loss greater than or equal to $200,000.

Table 2.1 (Continued)

Category	Class 1	Class 2	Class 3
VIOLATIONS OF LICENSE OR PERMIT CONDITIONS			
o Effluent concentration limit; liquid, airborne, o In-plant airborne, o Contamination release both inside and outside of controlled area	Uranium concentration less than permit criteria but greater than or equal to administrative guide	Uranium concentration less than 10 times permit criteria but greater than or equal to permit criteria for all three categories.	Uranium concentration greater than or equal to 10 times permit criteria for all three categories.
SHIPPING & RECEIVING	o Damage to container in excess of administrative guides with no loss of container integrity.	o Shipment received externally contaminated in excess of license or regulatory limits.	o Breach of container in transit offsite (loss of integrity of container).

FIGURE 2.1


AREA MANAGER/ CUSTODIAN
MANAGER REG. COMPLIANCE
SR ENV ENG OR MGR NSE
MANAGER QA
MANAGER L&CA
ASSURE PROPER ACTION TO CONTROL INCIDENT
CONSULT WITH RC MANAGER REGARDING NEED FOR INVESTIGATION
DECIDE NEED FOR INVESTIGATION
CLASSIFY INCIDENT CLASS I OR CLASS II OR CLASS III
ASSURE NOTIFICATION TO OUTSIDE AGENCIES AS NECESSARY
NOTIFY APPROPRIATE COMPANY MANAGEMENT
CLASS II - ACT AS INVESTIGATION TEAM CAPTAIN
CLASS I - ACT AS INVESTIGATION TEAM CAPTAIN
CLASS III - ACT AS INVESTIGATION TEAM CAPTAIN
PARTICIPATE IN INVESTIGATION AS REQUIRED
CONDUCT INVESTIGATION
CONDUCT INVESTIGATION
CONDUCT INVESTIGATION
PARTICIPATE IN INVESTIGATION AS REQUESTED
DOCUMENT FINDINGS FOR CLASS II INVESTIGATION
DOCUMENT FINDINGS FOR CLASS I INVESTIGATION
DOCUMENT FINDINGS FOR CLASS III INVESTIGATION
FORWARD REPORT TO MGR L&CA
FORWARD REPORT TO MGR L&CA
FORWARD REPORT TO MGR L&CA
MAINTAIN FILE ON INCIDENT REPORTS
ASSURE THAT REQUIRED CORRECTIVE ACTIONS ARE COMPLETED
FOLLOWUP NOTIFICATION WITH REGULATORY AGENCIES

notifying appropriate management, performing an initial documentation of the incident, and participating in the formal investigation as required.

2.9.2.3 For incidents involving nuclear safety the manager of the nuclear safety function has the responsibility for classifying the incident as to its severity, performing the duties of investigation team captain when required and preparing a dossier of all incidents identified by this procedure and ensuring it is accurate and complete.

2.9.2.4 In the event of an environmental incident, the senior engineer-environmental protection is responsible for classifying the incident as to its severity, performing the duties of investigation team captain when required, and preparing a dossier of all incidents identified by this procedure and ensuring it is accurate and complete.

2.9.2.5 The manager of the regulatory compliance function is responsible for deciding the need for classifying/investigating an incident and performing the duties of a team captain when required.

2.9.2.6 The investigation team captain is responsible for assembling the appropriate investigation team and directing and coordinating the activities of the team members and seeing that the investigation report is generated within 30 working days after the incident occurred.

2.9.2.7 The manager of the licensing function is responsible for maintaining an appropriate list of agencies to be notified, determining if a report to the appropriate agencies is required and notifying the appropriate agencies when required, participating in the formal investigation if necessary, distributing the final report, and maintaining the WMD incident investigation files.

2.10 Records

Records appropriate to criticality and radiation safety activities, occupational exposure of personnel to radiation, releases of radioactive materials to the environment, and other pertinent activities, are maintained in such a manner as to demonstrate compliance with Commission license conditions and regulations.

Records of criticality safety analyses are maintained in sufficient detail and form to permit independent review and audit of the method of calculation and results. Such records are retained during the conduct of the activity and for six months following cessation of such activities to which they apply.

All records associated with the radiation protection activities are generated and retained in such a manner as to comply with the relevant requirements of 10 CFR 20 and the Commission license SNM-1097.

All records associated with the environmental protection activities described in Section 5 of this license renewal application are generated and retained in such a manner as to comply with the relevant requirements of 10 CFR 20 and this license.

3.0 RADIATION PROTECTION

3.1 Administrative Requirements

3.1.1 Radiation Work Permit (RWP) Procedures

Routine production and repetitive maintenance work performed in radiation controlled areas is controlled by documented procedures. Nonroutine activities performed by nonemployees (e.g., contractor personnel), which generally are not covered by documented procedures, are controlled and monitored by the RWP system. This includes construction, maintenance, and service work (e.g., equipment relocation, floor tile replacement, ventilation duct removal, etc.) which presents potential for exposure of personnel to wholebody radiation and/or airborne contamination.

The manager responsible for performance of the non routine work is responsible for obtaining the RWP from the radiation protection function and for obtaining RWP approvals by the supervisor of the radiation protection function, the area manager or his delegate and by the requestor. He is also responsible for assuring that only personnel who have completed radiation safety training are assigned to perform work under a RWP.

A copy of the RWP listing any specific radiation safety precautions i posted in a conspicuous location throughout the duration of the activity, and work is monitored by the radiation protection function, as required.

Upon completion of the work under the RWP, the manager responsible for the work is responsible to assure that the RWP is terminated and that the work area is returned to normal conditions.

Responsibilities and elements of the RWP system are documented in the Department Practices and Procedures (P/P) system.

3.1.2 ALARA Program

WMD has established a radiation protection program designed to ensure that occupational radiation exposures are maintained at levels as low as reasonably achievable. The approach consists of (1) a strong management commitment, (2) development and implementation of improved detection/measurement capabilities, (3) development of advanced exposure-related management information systems, and (4) provision of facilities for exposure reduction via implementation of well engineered systems.

3.1.2.1 Management Commitment

The WMD management commitment to the ALARA concept is emphasized in departmental level P/Ps and is evidenced in continued support of long range development programs and near-term improvement projects. In addition, implementing instructions to the operating and engineering personnel stress the importance of continuous effective exposure control.

3.1.2.2 Improved Detection and Measurement Systems

Development of state-of-the-art health physics detection and measurement systems provides improved capability to determine airborne concentrations, internal exposures, extremity exposures, external exposures, water concentrations and criticality detection.

3.1.2.3 Improved Information Systems

A major program is underway to develop an advanced computer based management system to calculate, monitor and record personnel radiological exposures. Relevant data, automatically and manually entered into the system, are integrated to provide near real-time information on employee exposures, medical status, and training. When completed, this program (REMTRAC) will provide employee data to management at all levels for their information and action. Data analysis capability being built into the system will provide accurate information for management planning of the continued employee exposure reductions.

3.1.2.4 Improved Facilities and Equipment

Management attention is continually addressed to identifying operating conditions which require modification for reduced personnel exposure. Major facility changes and equipment process development programs meet stringent criteria directed towards exposure reduction and/or improved shop conditions. Project safety reviews are held to assure ALARA has been effectively addressed in proposed project designs.

Current shop conditions are continually monitored to identify needed near-term upgrades in process equipment, equipment accessories and operating systems which, when implemented, will result in reduced potential for occupational radiation exposures.

3.2 Technical Requirements

3.2.1 Access Control

Controlled areas in the fuel manufacturing building are identified in Figure 3.1. Access points to controlled areas are established through change rooms. Each change room includes a "hot" side and a "cold" side, with a step-off area provided between the hot and cold sides.

The personal clothing and other worker belongings are stored on the cold side in the change rooms. Clean protective clothing (described in Chapter 3.2.4.4) is made available on the cold side to personnel entering a controlled area. Used protective clothing is stored on the hot side and collected there for processing through the laundry facility. (In the case of the gadolinia shop, disposable protective clothing is used to prevent contamination of the UO_2 shop with the gadolinia nuclear poison.

Entry points to controlled areas are posted in accordance with 10 CFR 20.203. Instructions controlling entry and exit from controlled areas are posted at the entry points and address such topics as: reporting time in the controlled areas, personnel dosimetry badges, protective clothing, personnel surveys and emergency evacuation.

FIGURE 3.1

CONTROLLED/NONCONTROLLED AREAS

MAIN FLOOR - FUEL MANUFACTURING BUILDING

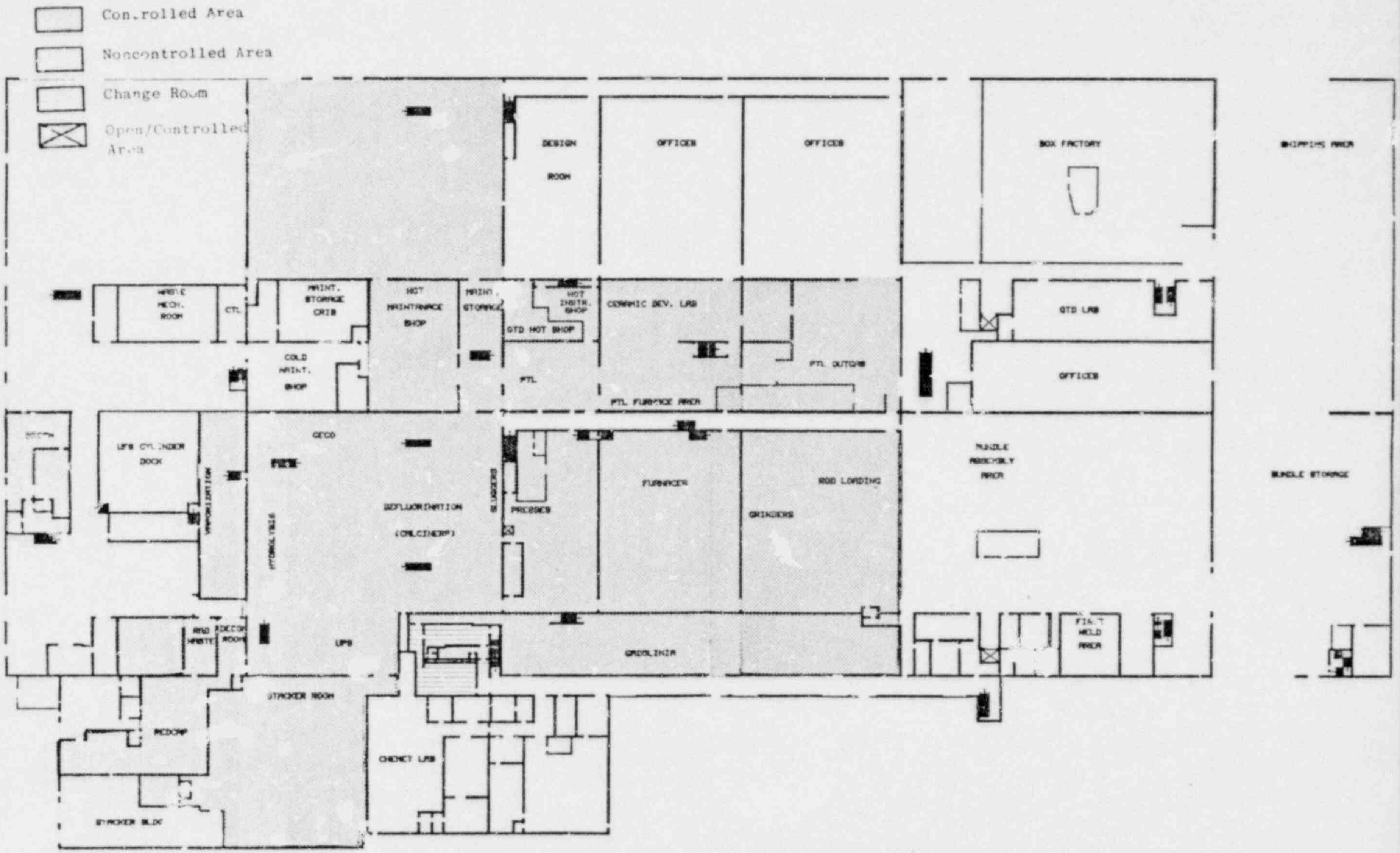
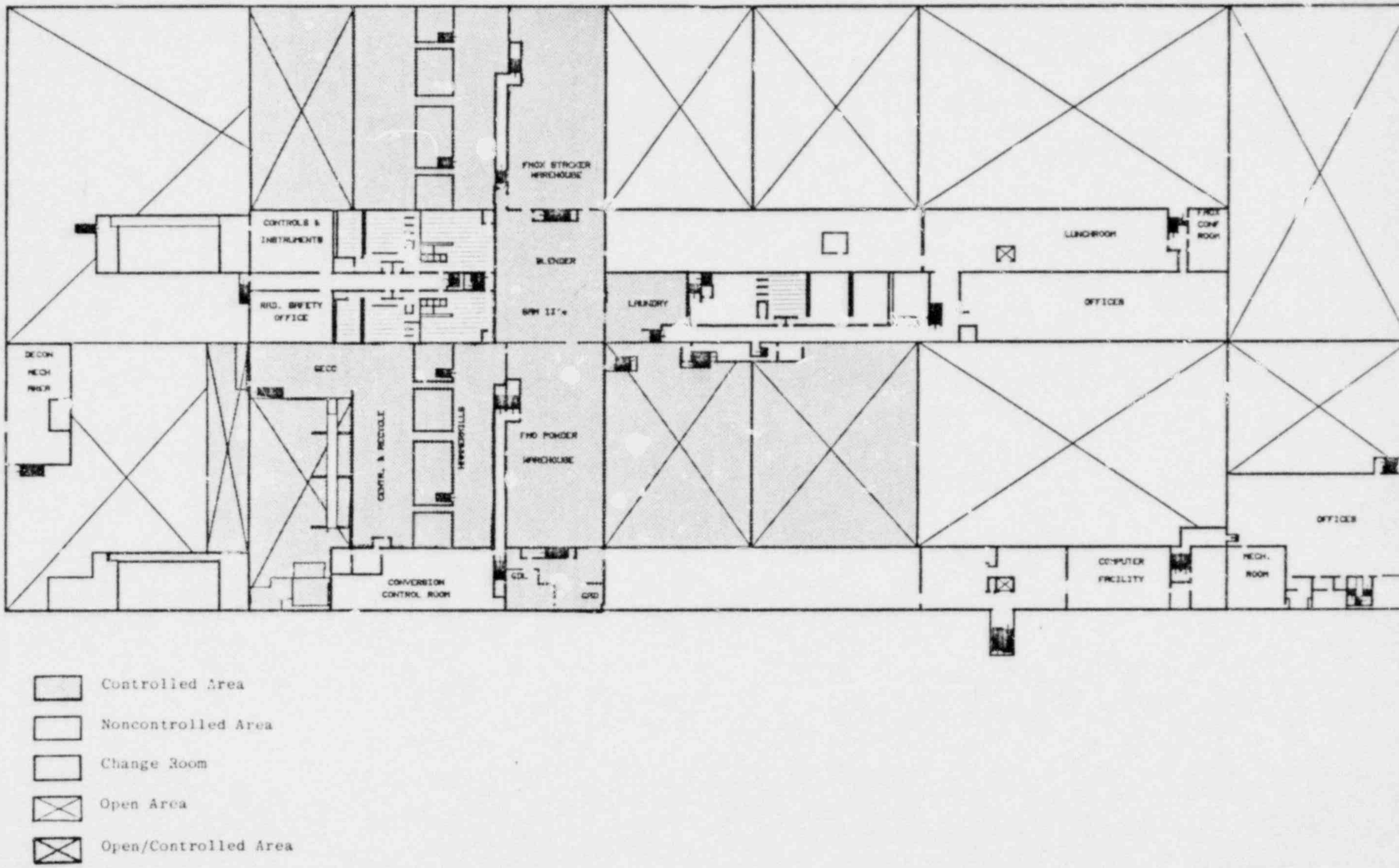


FIGURE 3.1 (CONTINUED)

CONTROLLED/NONCONTROLLED AREAS
MEZZANINE - FUEL MANUFACTURING BUILDING



Personnel survey meters are provided in the step-off area of each change room for use by personnel leaving the controlled areas. Posted instructions address the use of the survey meters and appropriate decontamination or radiation protection function notification instructions should the instrument alarm during the exit survey.

Change room attendants are provided in the main change rooms to assist in monitoring of access controls and radiation safety requirements.

Personnel are authorized to enter controlled areas by virtue of management approval based on their work requirements and after completing the required radiation protection training.

Personnel authorized to enter controlled areas are issued a coded badge which denotes entry authorization. Badges are monitored at random by the change room attendants. Other personnel must be escorted by an authorized person when entering the controlled areas.

3.2.2 Ventilation Requirements

3.2.2.1 Inter-area Air Flow Design

Ventilation equipment is designed to provide air flow from areas of lesser contamination to areas of higher contamination. Specific facilities and capabilities of ventilation systems are detailed in Table 3.1.

TABLE 3.1

SPECIFIC FACILITIES & CAPABILITIES OF VENTILATION SYSTEMS

Facility	Alarms, Interlocks & Safety Features	Purpose
Hoods	Air flow designed ≥80 lineal feet per minute.	Prevents carryout or blowout of radioactive materials.
	Fire extinguishers in work area.	Provides fire prevention.
	Effluent air filtered with absolute filters.	Prevents release of radioactive materials to environs.
Glove Boxes	$\geq 0.1''\ H_2O\ \Delta P$	Prevents blowback or spread to working areas.
	Effluent air filtered through absolute filters.	Prevents release of contaminants to working areas or environs.
	Fire extinguishers in work area and boxes where flammables are handled.	Provides fire prevention.
	Smooth internal surfaces.	Facilitates cleanup.
	Fire-resistant construction.	Prevents fire damage to maintain containment.
High Velocity Local Exhaust	Air flow designated to maintain an average of 200 lineal feet per minute.	Prevents spread of radioactive materials from work area to immediate room area.
	Effluent air filtered with absolute filters.	Prevents release of radioactive materials in environs.
Sintering Furnaces	Automatic hydrogen shutoff and switch over to nitrogen with alarm signal.	Protects against hydrogen explosion and resultant spread of contamination as well as physical injury to room occupants.

Table 3.1 (continued)

Facility	Alarms, Interlocks & Safety Features	Purpose
Recirculating Air Systems	Air flow designed ≥125 lineal feet per minute.	Provides cle nup of contaminated air within rooms.
	Air filtered in potentially contaminated zones with absolute filters or water scrubbers.	Removes essentially all contaminants from room and exhaust to environs.
	Pressure drop indicator set to alarm at ≤4" $H_2O\Delta P$ across final filter.	Maintains adequate circulation for removal of dust and contaminants from the room air.
UF_6 Vaporization Chambers	Temperature controller and alarm.	Controls temperature to not exceed 300° F, which is 40° F below the temperature at which unsafe cylinder pressure might be generated.
	Ventilation enclosure	Provides containment in event of cylinder rupture or abnormal leakage.
	Electricall interlocked solenoid valves between the cold traps and the hydrolysis tanks.	Prevents transfer of material to the UF_6 cylinder from the hydrolysis tank during operation of the cold trap systems.

3.2.2.2 Enclosures

Containment designs for fuel manufacturing areas include glove boxes, hoods, and other special enclosures as applicable to contain airborne uranium and thereby minimize personnel exposures.

Other equipment in which processing operations generate airborne uranium is designed with filtered enclosures, hoods, dust capturing exhaust ports and other devices which maintain air concentrations of radioactivity in work areas below 10 CFR 20 limits under normal and foreseeable abnormal operating conditions.

Air flow through openings in these containment devices is measured periodically to assure adequate system performance as necessary for protection of personnel. The survey is done at least monthly. When air flows through the openings do not meet minimum requirements of 80 LFPM at any point, action is instituted to correct the problem and restore containment to the minimum operating conditions. Additionally, the differential pressure indicators across exhaust system filters are routinely checked to assure system performance. When a differential pressure is observed to have reached four inches of water, the effectiveness of the filter is investigated and if necessary the filter is replaced to maintain the required air flow through openings and containment enclosures.

3.2.2.3 Effluent Air Duct Design

Effluent air ducts and air flow velocities are designed to minimize radioactive dust accumulations.

3.2.2.4 Exhaust System

Exhaust systems in potentially contaminated airborne effluents are equipped with filter media which are selected to maintain its integrity when subjected to chemicals, solvents and abnormal operations of the processes. These filters are at least 99.97% efficient for removal of 0.3 micron particles. At least one filter in each effluent air stream is equipped with a device for measuring differential pressure.

Filter effectiveness is investigated when the pressure differential across the filter exceeds four inches of water. A filter is replaced following evidence of damage to the filter or inability of the filter or the exhaust system to perform its function properly.

Water scrubbers are provided where necessary to treat effluents before filtration. Such scrubbers are installed so that effectiveness of filters is maintained.

3.2.2.5 Air Recirculation

Room air may be recirculated within the uranium processing areas after being filtered and sampled.

3.2.3 Instrumentation

3.2.3.1 General

Appropriate radiation detection instruments are available to ensure adequate radiation surveillance can be accomplished. Selection criteria of portable and laboratory counting equipment is based on the types of radiations detected, maintenance requirements, ruggedness, interchangeability and upper and lower limits of detection capabilities. The radiation safety function annually reviews the types of instruments being used for each monitoring function and makes appropriate recommendations.

3.2.3.2 Equipment Description

Shown below are examples of the types and uses of available instrumentation.

Type	Typical Range	Routine Use
Dose Rate Meters		
GM Low Range	0.01mR-2000mR	Area Dose Rate Survey
GM High Range	0.05mR-1000R	Emergency Monitoring
Ion Chamber		
Low Range	0.1mR-10R	Area Dose Rate Surveys Shipment Survey
High Range	1mR-1000R	Emergency Monitoring
Alpha Survey	50cpm- $2x10^6$cpm	Direct Personnel & Equip. Surveys

Type	Typical Range	Routine Use
Neutron Meters	0.5Rem-5Rem	Special Dose Rate Surveys
Laboratory Instrumentation		
Multichannel Analyzer	N/A	Lab Analysis
Automatic Air Sample Counter	N/A	Lab Analysis
Windowless gas-flow Proportional Counter	N/A	Lab Analysis
Fixed geometry Geiger-Mueller Counter	N/A	Lab Analysis
Sodium iodide well Counter	N/A	Lab Analysis
Phoswich Detectors	N/A	Lab Analysis
Beta Surface Barrier Detectors	N/A	Lab Analysis
Scintillation Counter (PC-6-1) with Detector (RD-14)	N/A	Lab Analysis
In Vivo Lung Counter	N/A	Lung Disposition Measurements

3.2.3.3 Calibration

Monitoring instruments utilized for radiation safety purposes are calibrated upon initial acquisition, after major maintenance, and on a routine basis at least annually. Such calibration consists of (but is not limited to) a performance check on each range scale of the instrument with a radioactive source of known activity.

Background and efficiency of laboratory counting instruments are determined on a daily basis during facility operation. Efficiency is determined using radioactive sources of known activity.

Operability checks are made on monitoring and laboratory counting instruments utilized for radiation safety purposes, prior to each use of such instruments.

Background and quality control checks are made frequently on the in vivo lung counter.

3.2.3.4 Criticality Detection & Evacuation Alarm System

The criticality detection system consists of a series of remotely located detectors which are continually polled for information by a group of microprocessors. All microprocessors continually relay alarm status and detector information to the two control terminals located in the radiation protection function office and the emergency control center.

A predetermined alarm point not to exceed 50 mr/hr above background is programmed for each detector. The evacuation alarm logic is satisfied when two or more detectors in the same microprocessor exceed the high alarm set point or if one detector is in the fail status and another in the same microprocessor exceeds the high alarm set point. The system conforms to the requirements of 10 CFR 70.24.

The sensors and their associated electronics are fail-safe and are designed to initiate the prescribed alarm logic when subject to intense radiation fields.

After initiation of the evacuation alarm, the audio/visual alarms will continue until acknowledged even though the radiation level falls below the alarm point.

The evacuation alarm system meets the guidance established in ANSI 8.3-1979 "Criticality Accident Alarm System".

3.2.4 Internal & External Exposure

3.2.4.1 Ventilation and Containment

The internal radiation exposure of workers is controlled primarily by the ventilation systems and the containment of uranium within process equipment. Within work areas uranium liquids or powders are handled by workers in such a manner that reduces the potential for airborne contamination.

The ventilation system for the fuel manufacturing areas is designed to maintain a conditioned air supply to all areas of the building and to exhaust potentially contaminated air through appropriate filtering or washing devices. Under design process conditions, personnel will not require respiratory protective equipment.

The following design considerations are implemented at WMD to reduce internal radiation exposures for controlled area personnel with regards to the ventilation and containment systems:

> The process is the primary barrier of containment for the radioactive material and for other potentially dangerous substances during normal or abnormal operations.
>
> The primary process containment shall be supplemented with glove boxes, hoods, transfer boxes, or other similar devices to control airborne contamination if the process fails to contain the material.
>
> These containment devices shall be designed to minimize the need for direct contact of contaminated radioactive materials by the operator.
>
> The design philosopy of primary and secondary containment systems shall be to prevent the release of uranium contamination to work areas during planned operation and to minimize it during anticipated accident conditions.

The process area atmospheric pressure shall be negative to the outside.

The exhaust equipment is designed to provide air flow from other areas of lesser contamination to areas of higher contamination, to confine and contain air streams containing radioactive constituents and to minimize the potential accumulation of contamination within the air handling ductwork.

3.2.4.2 Air Sampling & Analysis

3.2.4.2.1 Internal Routine Air Sampling

The airborne radioactivity areas established in accordance with 10 CFR 20.203(d) are continously monitored for airborne radioactivity when there is work being conducted in the area. These areas are equipped with a permanent air sampling system with sample points located at strategic locations for representative sampling of the worker's airborne exposure. The filters from these sample points are normally changed each shift and processed through the laboratory counting equipment for radioactive material count.

This routine radiation survey program is supplemented with backup portable air sample surveys as required to evaluate operational trends or to evaluate breaches in containment.

The routine survey data and individual personnel exposure assignments are monitored by the radiation safety function to evaluate the effectiveness of the radiation controls of personnel exposure.

3.2.4.2.2 Special Air Sampling

For routine maintenance operations, air sampling is provided by the permanently installed air sampling system. Lapel air or other portable samplers may be utilized during times when the air sampling system is not representative of the airborne concentration.

A special survey of airborne concentrations and surface contamination is conducted for nonroutine maintenance and, based on these special surveys, the radiation protection requirements for the particular operation are prescribed. Typical of these special operations are burning, welding, and cutting operations which may result in increased airborne concentrations. Specific radiation protection measures prescribed for these nonroutine maintenance operations may include further decontamination, special clothing, respiratory protection, etc.

3.2.4.3 Internal Exposure Measurements

3.2.4.3.1 Bioassay Program

Routine urine sampling frequencies are established for operators and maintenance personnel assigned to work areas where soluble uranium compounds are processed. These personnel are requested to submit urine samples based upon the activities performed.

After review of unusual incidents which resulted in positive bioassay results, the radiation safety function may request additional urine sampling.

The bioassay sampling frequency is based upon the guidance of Regulatory Guide 8.11.

3.2.4.3.2 In-Vivo Lung Counting

The internal exposure of workers from inhaled or ingested uranium is evaluated by means of in-vivo counting. A stationary counting system is operated by an independent contractor at WMD. The minimum detectable level of the equipment is about 75 ug U-235.

Individual workers are counted on the following frequency based upon assigned airborne concentration exposure:

Derived Airborne Concentration	In-Vivo Counting Frequency
< 10%	Not Required
> 10% < 25%	Annual
> 25% < 50%	Quarterly
> 50% < 100%	Monthly

3.2.4.4 Protective Clothing

Protective clothing is provided to all per[illegible] who are required to enter radiation controlled ar[illegible] where personnel contamination potential exists as [illegible]ermined by the radiation safety function. The amount and type of protective clothing required for a specific area or operation is determined by operational experience and the contamination potential. Available clothing includes caps, hoods, laboratory coats, coveralls, safety glasses, boots, overshoes, shoe covers, rubber and cloth gloves, safety shoes, and respiratory protection equipment. NIOSH approved air supplied hoods are also available, for certain operations.

The minimum clothing requirement for controlled area entry is as follows:

Controlled Area Workers	Visitors
Shoe covers or controlled area work shoes	Shoe covers
Coveralls	Laboratory coats
Head covers	Head covers
Rubber gloves	Rubber gloves (as appropriate)
Safety Glasses	Safety Glasses

The protective clothing is removed upon exit in the controlled area change rooms.

3.2.4.5 Respiratory Protection Program

3.2.4.5.1 Respiratory Protection Equipment

Only respiratory protection equipment specifically approved by the National Institute of Safety and Health (NIOSH) are employed. Two types of respirators are commonly available - half masks and full face masks.

Half mask respirators equipped with particulate filters are employed as a precautionary measure during routine operations which may generate uranium dusts. No protection factor is taken for half mask usage, unless masks are fitted in accordance with Regulatory Guide 8.15.

Full face mask respirators equipped with a combination GMR canister are employed as precautionary measures in routine and for emergency actions which may require additional protection capabilities when there exists a potential for releases of soluble uranium gases. A protection factor of 50 is taken for this type of respirator usage. If quantitative testing is employed, the actual protection factor for that employee may be used.

Self-contained breathing devices are also available for certain emergency situations.

3.2.4.5.2 Employee Qualifications

Employee managers specify and review annually those individuals for whom respiratory protection devices may be required. Each designated employee's medical status is determined and reviewed periodically by the medical function to determine if there are medical restrictions which may prohibit an individual from using a respirator. If the individual has no restrictions, the radiation protection function then proceeds with the respirator training and fitting. Additional training on the use and limitations of self-contained breathing devices is provided by an outside service contractor to designated respirator users.

An adequate mask fit is determined using qualitative (irritant smoke) methods which are reevaluated annually or quantitative (DOP test chamber) methods which are reevaluated every two years. (Quantitative results may be substituted for qualitative.) Respirator qualification records are maintained on each individual as a part of the employee's personnel exposure file.

Appropriate reports showing the status of qualified individuals are routinely sent to the appropriate managers for review.

3.2.4.5.3 Testing and Cleaning of Equipment

Each respirator is processed for cleaning, inspection, and replacement of parts as necessary. Air purifying cartridges and canisters are DOP penetration and pressure differential tested against parameters according to internal procedures. The respirator and canister assembly is DOP penetration and pressure tested prior to reuse. On a quality control basis new respirators and canisters are similarly tested.

Self-contained breathing devices are inspected for operational capability and are cleaned and re-inspected after each use by an outside service contractor.

3.2.4.6 Surface Contamination Monitoring

Routine contamination survey monitoring is performed for all uranium process and manuacturing areas including non controlled areas such as hallways and lunch rooms immediately adjacent to controlled areas. The type of monitoring includes direct and removable contamination measurements based on the potential for contamination in these areas and operational experience.

Survey frequencies are determined by the radiation safety function.

The minimum survey frequencies are as follows:

Area	Minimum Survey Frequency
Controlled Areas	Weekly
Receiving, Storage & Shipping	Weekly
Eating Areas Used Primarily by Controlled Area Personnel	Weekly
Uncontrolled Areas	Monthly

Survey results are compared to action guide values as specified in internal procedures and appropriate responses are taken.

Personnel contamination surveys for external contamination on clothing and body are required by all personnel when leaving the controlled area. Personnel are instructed to recognize that contamination is indicated by a noticeable increase in the audible count rate or when the survey meter reaches a predetermined alarm set point, as determined by the radiation protection function.

3.2.4.7 Decontamination

Personnel monitor themselves upon exit from the controlled areas (see Chapter 3.2.1). If contamination is found in excess of published levels, they attempt to decontaminate themselves at facilities provided in the change rooms. Assistance from the radiation protection function is provided in event the first attempt to decontaminate is not successful.

Personnel contamination accompanied by potential chemical injury is treated by the site medical department. The radiation safety function reviews the contamination levels with medical and makes determination for bioassay or in-vivo counting to further assess potential internal exposures.

3.2.4.8 Emergency Evacuation

All personnel working in the fuel manufacturing operations are instructed to immediately evacuate the area in the event the criticality warning system alarm is activated. Personnel are instructed to leave their work stations and proceed as rapidly as possible along predetermined routes to the designated staging areas. Emergency evacuation drills demonstrate that the evacuation plan is effective. Personnel from controlled areas, who may be contaminated, are segregated from non-contaminated personnel upon arrival at the staging area.

3.2.4.9 Personnel Monitoring - External Radiation

Whole body or partial whole body exposure from external sources of radiation are determined by individually assigned dosimeters. In event of accidents or evaluation of unusual exposure conditions, whole body or partial whole body exposures may be calculated by the radiation protection function on the basis of data obtained by investigation.

Extremity exposure shall be determined by TLD measurements. When TLD measurements are not practical, then extremity exposures may be determined and assigned on the basis of engineering evaluations.

4.0 NUCLEAR CRITICALITY SAFETY

4.1 Administrative Requirements

4.1.1 Process/Facility Design Philosophy

Process designs shall incorporate sufficient factors of safety to require at least two unlikely, independent, and concurrent changes in process conditions before a criticality accident is possible.

The preferred method for assuring nuclear criticality safety is by the use of geometry control.

The use of fixed neutron absorbers is considered to be a form of geometry control and is preferred over the use of administrative controls.

The use of administrative controls for nuclear criticality safety will be restricted to those cases in which geometry control is not practical.

4.1.2 Requests for Nuclear Criticality Analyses

All changes, modifications, or additions to the process system are conducted with the cognizance of the area manager. If the area manager determines that the changes, modifications, or additions are related to criticality control, such changes shall be reviewed by the criticality safety function prior to implementation.

If review by the criticality safety function is required, a request for a nuclear criticality analysis shall be prepared in writing by, or at the direction of, the area manager for the new activity or change in activity. The change shall not be placed into operation until the criticality safety analysis is complete and the concomitant nuclear criticality safety requirements and approval for operation are received from the criticality safety function.

Nuclear criticality analyses of major projects will be reviewed by the safety committee.

4.1.3 Criticality Control Procedures

Each area manager shall assure that criticality control procedures incorporating limitations established by the criticality safety function are developed and maintained and shall assure that foremen, operators and other concerned personnel are made aware of these procedures through posting, training programs or other appropriate written notifications.

4.1.4 Posting of Nuclear Criticality Safety Limits

Nuclear criticality safety requirements which are received from the criticality safety function for each process system shall be available to each work station either in the form of operating procedures or as clear, visible signs or notices.

Posted nuclear criticality safety requirements shall be defined by the criticality safety function and may include: limits on material types and forms; allowable quantities by weight or number; allowable enrichments; required spacings between units; control limits, when applicable, on quantities such as moderation, and density or the presence of additives.

4.1.5 Labeling of Containers of Fissile Material

Containers of fissile material, not including fuel rods, shipping containers, samples and the like, shall be labelled such that the material type and form, U-235 enrichment and gross and net weights can be clearly identified.

4.1.6 Role of the Criticality Safety Function

Personnel of the criticality safety function determine safe batches, safe geometries, safe concentrations, and safe spacing of special nuclear materials; they shall determine limitations of other nuclear parameters utilizing information set forth in the request for criticality analysis; and they assess and verify the normal and potential environmental conditions of significance to criticality control.

4.2 Technical Requirements

4.2.1 Nuclear Criticality Safety Methodology

4.2.1.1 Nuclear criticality analyses shall utilize experimental data or validated analytical methods that produce results which compare favorably and in an established manner with experimental data for similar systems.

4.2.1.2 Each nuclear criticality analysis shall be verified by an independent and qualified member of the criticality safety function.

4.2.1.3 When analytical methods are used in nuclear criticality analyses to determine system neutron multiplication factors, it is required that at the 99 percent confidence level the neutron multiplication factor for normal operations be no greater than 0.90 and the neutron multiplication factor for all conditions required to be critically safe by the double-contingency policy be no greater than 0.97.

The calculated neutron multiplication factors shall be corrected for analytical biases determined from representative benchmark and validation studies.

4.2.1.4 Criticality safety analyses shall take the following into consideration:

Maximum credible degrees of moderation and reflection

Potential heterogeneous effects due to particle sizes, neutron absorbers, material densities, or the separation of fissile material and moderator

The possibility of buildups of fissile material in inaccessible or unplanned locations

Interaction between individual pieces of equipment in the facility including optimum or maximum credible interspersed moderation between units

Neutron absorption capability of the materials of construction.

4.2.1.5 Calculational methods used in nuclear criticality safety analyses shall include: Monte Carlo Neutron Transport Codes, Neutron Transport (Sn) Codes, Diffusion Theory Codes, Keff calculations using the Reactivity Formula, Solid Angle Code, and Monte Carlo Interaction Codes.

4.2.2 <u>Nuclear Criticality Safety Design Considerations for Geometry Control</u>

4.2.2.1 Equipment used to process or store fissile material which is designed to be critically safe by geometry control shall comply with the requirements of 4.1.1 for the following conditions:

Optimum moderation by water or by other materials actually present which may be a more effective moderator than water

Optimum credible density of the fissile material taking into account the presence of the water moderator

The presence of the fissile material with water moderator in all areas in which it is not physically excluded

Full reflection by a layer of water at least 12 inches thick at the closest boundary to the equipment unless a greater degree of reflection is provided by materials (such as concrete) actually present

The optimum degree of heterogeneity credible to the system

The maximum enrichment of fissile material present in the system

4.2.2.2 Equipment used to process or store uranium compounds is geometrically safe if it is designed to retain the process material within any one of the dimensional limitations of Tables 4.1 through 4.3 under normal and foreseeable abnormal process or environmental conditions and provided that it is separated by at least 12 inches from concrete walls or other significant reflectors.

4.2.2.3 When cylinders and slabs are not infinite in extent, the dimensional limitations of Tables 4.1, 4.2 or 4.3 may be increased by means of standard buckling conversion methods or reactivity formula calculations which incorporate validated K-infinites, Migration Areas (M^2) and Extrapolation Distances.

4.2.2.4 Whenever criticality control is directly dependent on the integrity of a structure used to retain the geometric form of a fissile material accumulation or the spacing within a storage array, the structure shall be designed with an adequate strength factor to assure against failure under foreseeable loads or accident conditions. Materials of construction shall be fire resistant. The degree to which any corrosive environment might affect nuclear safety shall be considered and corrosion-resistant materials or coatings applied as necessary. Such designs shall be reviewed by a qualified civil or structural engineer.

TABLE 4.1

SAFE GEOMETRY VALUES

FOR HOMOGENEOUS UO_2-H_2O MIXTURES

Weight Percent U-235[1]	Infinite Cylinders Diameter, Inches	Infinite Slabs Thickness, Inches	Spheres Volume, Liters
2.00	16.7	8.9	105
2.25	14.9	7.9	75.5
2.50	13.75	7.2	61
2.75	12.9	6.65	51
3.00	12.35	6.25	44
3[illegible]	11.7	5.9	38.5
3.50	11.2	5.6	34
3.75	10.8	5.3	31
4.00	10.5	5.1	29
5.00	9.5	4.45	24
6.00	8.95	4.00	18.5
7.00	8.45	3.75	17.0

---

[1] For enrichment not specified in this table, smooth curve interpolation may be used.

TABLE 4.2

SAFE GEOMETRY VALUES

FOR HOMOGENEOUS AQUEOUS SOLUTIONS

W/O U-235[1]	Infinite Slabs Thickness, Inches	Spheres Volume, Liters
2.00	9.3	106.4
2.25	8.4	80.5
2.50	7.8	66.8
2.75	7.3	56.2
3.00	7.0	49.7
3.25	6.7	44.8
3.50	6.5	41.0
3.75	6.3	38.0
4.00	6.0	34.9
5.00	4.8	26.0
6.00	4.4	22.5
7.00	4.1	19.5

[1] For enrichments not specified in this table, smooth curve interpolation of values may be used.

TABLE 4.3

SAFE GEOMETRY VALUES

FOR HETEROGENEOUS MIXTURES OR COMPOUNDS

Weight Percent U-235[1]	Infinite Cylinders Diameter Inches	Infinite Slabs Thickness, Inches	Spheres Volume, Liters
2.00	11.1	5.6	35.7
2.25	10.5	5.1	30.7
2.50	10.1	4.8	27.3
2.75	9.7	4.6	24.7
3.00	9.4	4.4	22.6
3.25	9.2	4.3	20.9
3.50	9.0	4.2	19.2
3.75	8.9	4.1	18.2
4.00	8.8	4.0	16.9
5.00	8.3	3.6	13.0
6.00	7.9	3.5	11.0
7.00	7.4	-	7.6

---

(1)For enrichment not specified in this table, smooth curve interpolation of values may be used.

4.2.2.5 The use of fixed neutron absorber systems as geometric controls shall require that:

The effectiveness of the neutron absorber system is demonstrated utilizing validated calculational methods

The fixed neutron absorber system must be non-combustible

The integrity o˝ .he fi˟ed neutron absorber system must be verified on a periodic schedule compatible with the rates of corrosion and deterioration credible to the process system

The fixed neutron absorber system must be designed to withstand all credible industrial accidents and natural events (such as hurricanes, earthquakes, etc.)

4.2.2.6 Whenever criticality control is directly dependent on the integrity of physical barriers or neutron absorbers, the structure shall be designed to assure against loss of integrity through foreseeable accident conditions such as fire, impact, melting, corrosion or leakage of materials

4.2.3 Nuclear Criticality Safety Considerations for Administrative Control of Mass

4.2.3.1 Where geometric control is not practical and criticality safety control is based upon U-235 mass limits, process operations shall be limited such that the mass of any single accumulation does not exceed 75 percent of the minimum critical mass. However, if double batching is credible, the mass of any single accumulation shall not exceed a safe batch, which is defined to be 45 percent of the minimum critical mass taking into consideration the geometry of the vessel containing the material. Table 4.4 lists safe batch limits for homogeneous mixtures of UO_2 and water as a function of U-235 enrichment over the range of 1.1% to 15.0% for uncontrolled geometric configurations.

4.2.3.2 The safe batch sizes for UO_2 of specific enrichments set forth in Table 4.4 shall be adjusted when applied to other compounds by the formula:

kgs UO_2 x 88% = kg X x f, where f = %U in Compound X

4.2.4 <u>Nuclear Criticality Safety Considerations for Administrative Control of Moderation</u>

4.2.4.1 When geometry controls are not practicable, criticality safety of vessels, structures or processes may be based on control of moderation provided that the following conditions are satisfied:

Validated calculational methods are used to demonstrate the criticality safety of the systems.

Overmoderated fissile material accumulations shall be assayed and periodically inspected or sampled to assure that either the maximum fissile material concentration does not exceed one half of the minimum critical concentration for the given enrichment or that the H/U-235 atomic radio is not less than 5200.

TABLE 4.4

SAFE BATCH LIMITS FOR UO_2 AND WATER

(Kgs UO_2)

Weight Percent U-235	UO_2 Powder (homo-geneous mixtures)	UO_2 Pellets (hetero-geneous mixtures)	Weight Percent U-235	UO_2 Powder (homo-geneous mixtures)	UO_2 Pellets (hetero-geneous mixtures)
1.1	2629	510	3.4	34.6	31.0
1.2	1391	341	3.6	31.1	28.5
1.3	833	246	3.8	28.3	26.4
1.4	583	193	4.0	25.7	24.7
1.5	404	158	4.2	23.7	22.9
1.6	293.3	135	4.4	21.9	21.4
1.7	225.0	116	4.6	20.2	20.0
1.8	183.0	102	4.8	19.1	18.8
1.9	150.6	90.5	5.0	18.1	18.1
2.0	127.5	81.6	5.5	15.4	15.4
2.1	109.2	73.1	6.0	13.8	13.8
2.2	96.8	66.4	7.0	8.3	8.3
2.3	84.3	61.0	8.0	6.9	6.9
2.4	74.7	56.1	9.0	5.9	5.9
2.5	68.9	52.1	10	5.1	5.1
2.6	60.5	48.8	11	4.4	4.4
2.7	56.6	45.4	12	3.9	3.9
2.8	52.2	42.9	13	3.5	3.5
2.9	47.6	40.1	14	3.3	3.3
3.0	44.5	38.1	15	3.0	3.0
3.2	38.9	34.1			

NOTE: For enrichments not specified above, smooth curve interpolation of safe batch values may be used.

4.2.4.2 When control is based upon undermoderated material accumulations:

Sources of moderation internal and external to the process shall be identified and appropriate controls established for each source.

Process equipment shall provide an effective water barrier to all potential forms of external water flooding in the area.

Support equipment associated with the control of processing of moderating materials shall be designed so that they are either geometrically safe or designed to prevent backflow of fissile materials and flood the fissile materials.

Controls shall be established to assure segregation of fissile materials to areas which are compatible in degree of enrichment and in moderation controlled parameters.

4.2.5 <u>Criteria for Fire Protection in Areas Containing Fissile Material</u>

4.2.5.1 Fire protection shall be provided for equipment, processes, and facilities containing fissile material and shall be selected on the basis of minimum impact on area nuclear criticality safety.

4.2.5.2 The use of water in fire protection in moderation control areas shall be minimized and tightly controlled.

4.2.5.3 Fire protection instructions shall be posted in the manufacturing facility to communicate necessary or permissible methods or techniques.

4.2.6 Nuclear Isolation of Facilities and Equipment

Equipment and facilities may be considered to be nuclearly isolated if they are separated from all other accumulations of fissile material by distances which are equivalent to the isolation provided by an eight inch thick slab of water or the larger of: 12 feet or the greatest distance across an orthographic projection of the largest of the fissile accumulations on a plane perpendicular to the line joining their centers.

5.0 ENVIRONMENTAL PROTECTION

Radiological releases from the Wilmington Site can occur via three effluent pathways: airborne, liquid or solid. The control systems for each of these pathways are addressed in the following sections.

5.1 Effluent Control Systems

5.1.1 Airborne Effluents

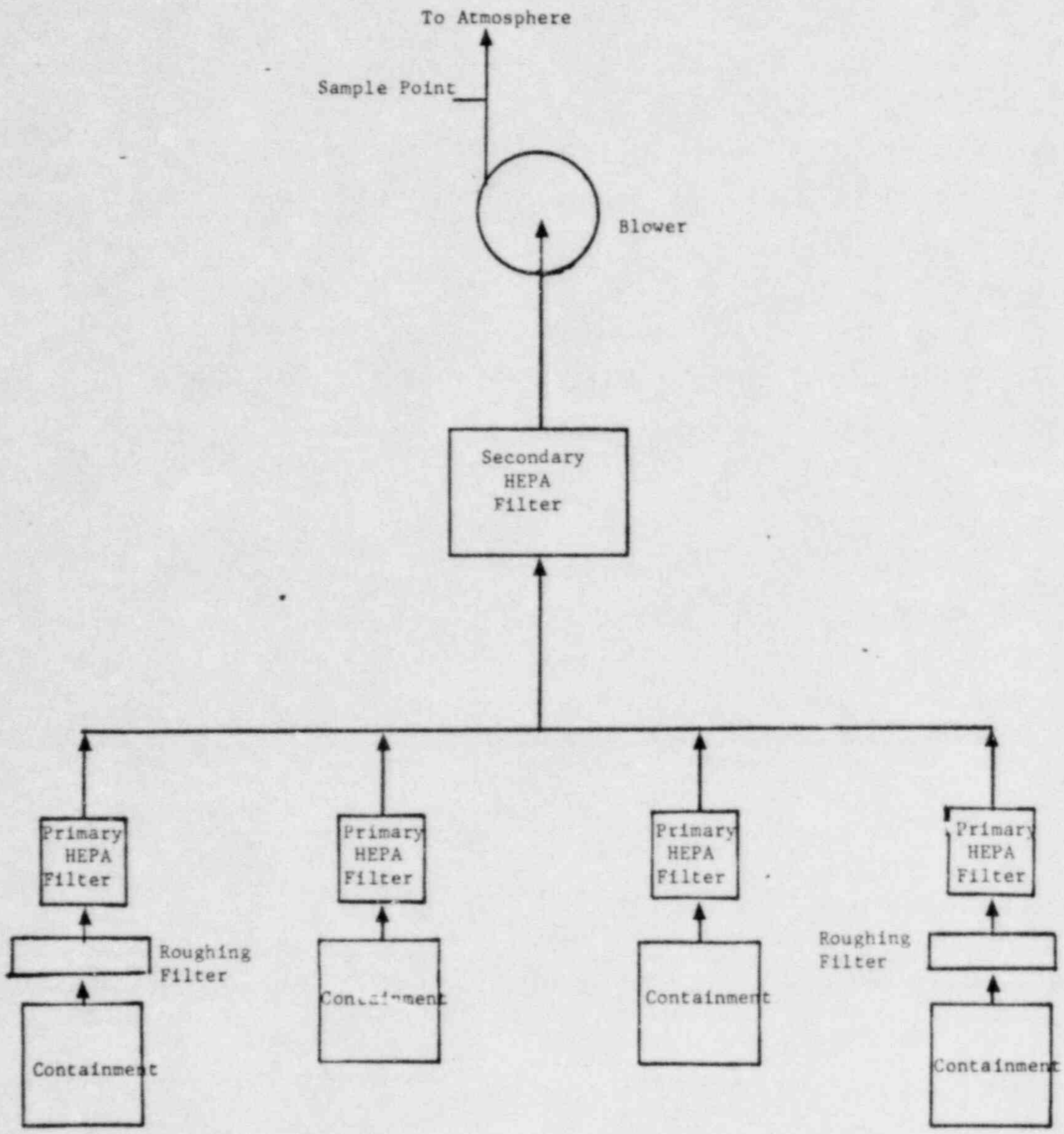
The exhaust systems from uranium processing areas in the fuel manufacturing building are designed to maintain a negative pressure in those areas relative to the outside environment. This assures that air leakage is inward into the uranium processing areas. The negative pressure differential is maintained by regulating the volume of fresh air taken by the ventilation system into the uranium processing areas.

All exhaust systems from the uranium processing areas are discharged through high efficiency particulate air (HEPA) filter assemblies. Each exhaust system contains one final stage of HEPA filtration preceded by other air cleaning devices specifically suited to the process steps served by the exhaust systems. Some of these other air cleaning devices include prefilters, primary HEPA filters, and wet scrubbers.

Each of the exhaust system stacks, except for the wet chemical process area and the incinerator, are serviced by an air cleaning system such as that shown in Figure 5.1. Feed points to these stacks include process areas in which pellet pressing, pellet sintering, pellet

FIGURE 5.1

TYPICAL EXHAUST AIR CLEANING SYSTEM FOR URANIUM PROCESSING AREAS
(EXCEPT FOR WET CHEMICAL PROCESSING AREAS)



grinding, rod loading, scrap sorting, and decontamination as well as other operations.

The exhaust systems from the chemical processing area which includes the process steps of vaporization, conversion, defluorination, and uranium scrap recovery, are serviced by an air cleaning system which is depicted in Figure 5.2.

5.1.1.1 Source Point Monitoring of Airborne Effluents

Each exhaust system stack from the uranium processing areas is sampled continuously at a point prior to discharge and after the final HEPA filter in the system. The stack air sampler continuously pulls a sample of air from the air stream in the stack through a filter. The filter on each sampler is changed and evaluated for gross alpha activity. The measurement of gross alpha activity from each stack air sampler filter is utilized to determine uranium concentration in the air and total uranium discharged from the stack.

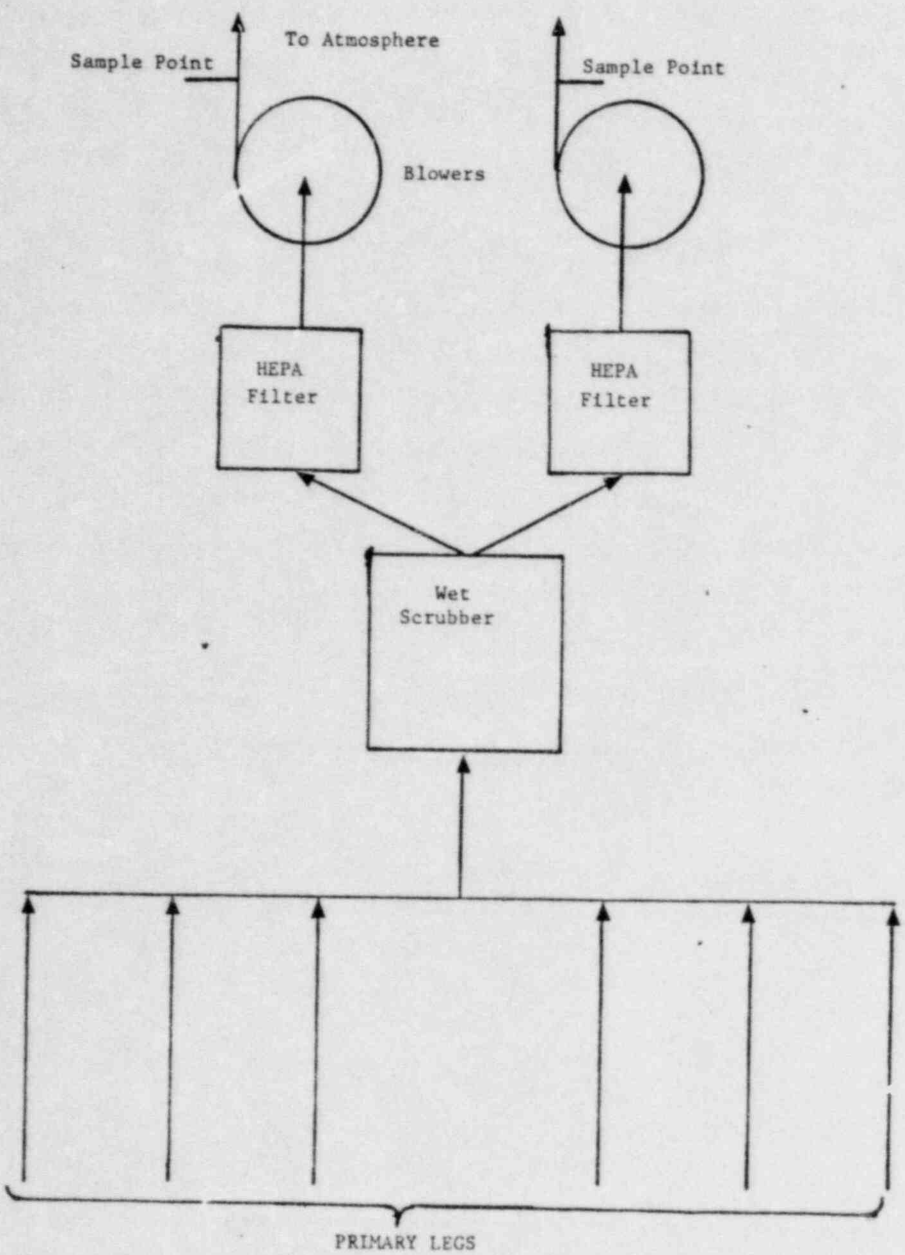
The majority of the sample filters are changed on a weekly basis. The sample filters on the stacks contributing the larger portion of the total activity released are changed on a daily basis.

5.1.1.2 Action Level for Airborne Effluents

Data from the air sampling measurements are entered into a computer program and are analyzed for comparison with the concentrations established as an internal action guide. The occurrence of an individual stack value exceeding the internal action guide will initiate review action.

FIGURE 5.2

EXHAUST AIR CLEANING SYSTEM FOR WET CHEMICAL PROCESSING AREAS



Personnel responsible for operating the exhaust system are notified if any daily or weekly stack result exceeds 3 X 10^{-12} uCi/cc. In the event one of these values exceeds 10 X 10^{-12} uCi/cc nuclea. safety and environmental protection personnel are lso notified. An investigation may be undertaken, de nding on the severity of the event, in accordance with administrative routines described in Chapter 2.9.

5.1.1.3 Reporting Method

Uranium activity releases in the airborne effluents are summarized in a weekly stack program report. This report includes pertinent information for each stack and for the total site. Year-to-date summaries and data for the current week are included in the report.

In the event an action guide is exceeded, additional notification as described in Chapter 5.1.1.2 is initiated.

The activity release data are also accumulated and reported on a semi-annual basis to the Nuclear Regulatory Commission.

5.1.1.4 Lower Limits of Detection, Calibration and Standardization of Measurements

A gas flow proportional counter is currently used to determine the activity on the stack sample filters. The system is calibrated monthly for gross alpha using a standard traceable to the National Bureau of Standards. Background and efficiency checks are performed each operating shift. The lower limit of detection for this method is 50 disintegrations per minute.

5.1.2 Liquid Effluents

The liquid waste streams containing uranium from the fuel manufacturing operations are kept segregated as nitrate wastes, fluoride wastes and radiation waste. This separation makes it possible to utilize final individual treatment processes most compatible with the specific streams.

Each of these separated streams is processed through a quarantine tank system before it is released from the fuel manufacturing operation. The quarantine tank control system assures that internal guidelines for uranium concentrations are met before the liquids are released from the building to the final treatment processes.

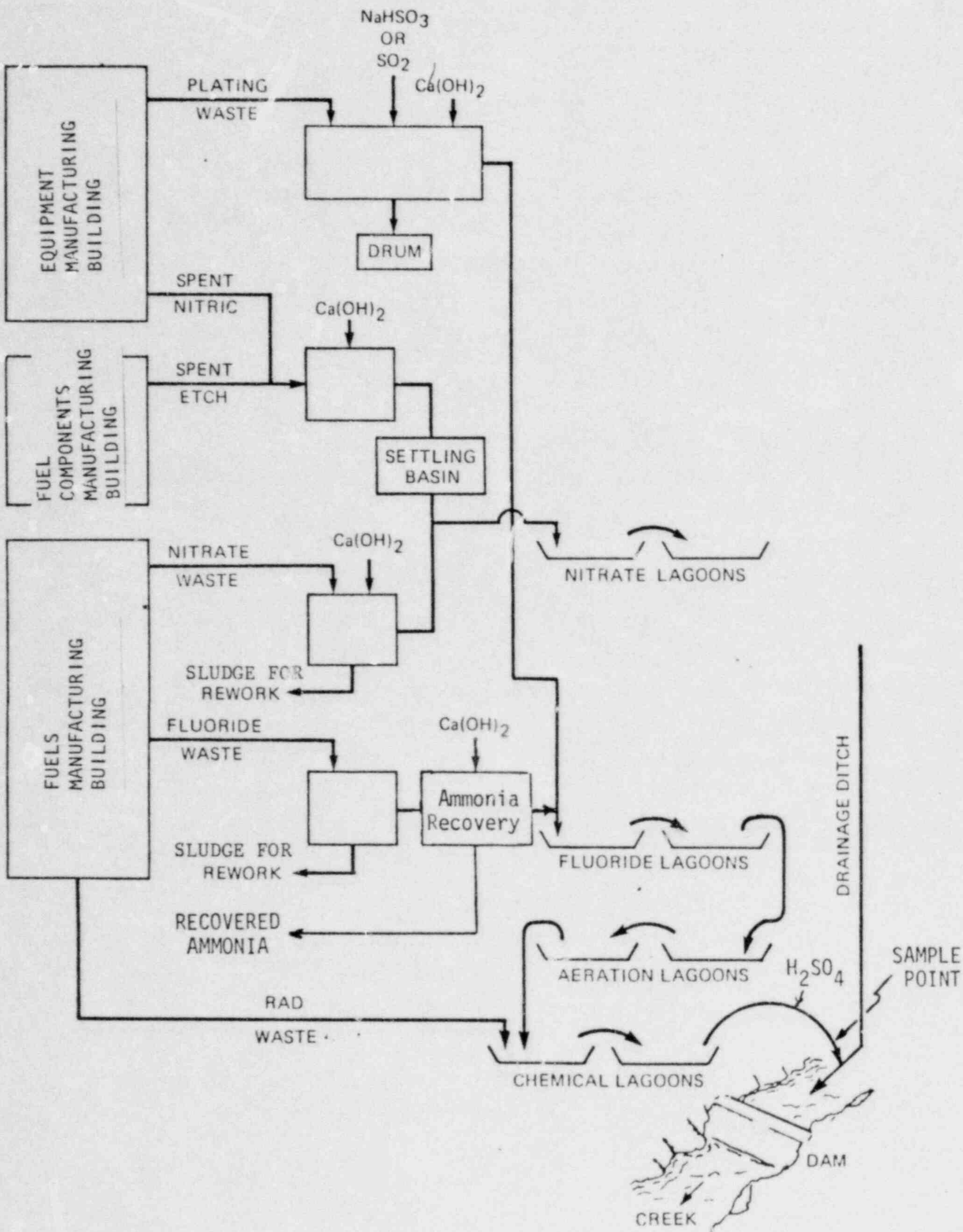
Figure 5.3 shows schematically how each of the waste streams is treated before impoundment or release.

5.1.2.1 Source Point Monitoring of Liquid Effluents (Water)

All process waste liquids are collected, treated and (with the exception of nitrate wastes) discharged to the Northeast Cape Fear River via the discharge canal. Figure 5.3 details the treated process effluent flows from the site. This figure also shows the final discharge measurement points.

The outfalls of each of the two chemical lagoons are sampled by collecting a composite sample on a basis proportionate to flow. The sampling device extracts a 30-ml sample for every 1,000 gallons of discharge. This

FIGURE 5.3 - PROCESS LIQUID WASTE TREATMENT



approximates one sample added to the composite every two or three minutes in that the total volume discharged is about one-half million gallons per day
The volume measurement used to activate the sampler and generate the total flow signal is based upon an impulse generated by the water level in a stilling well in the weir box above a 90-degree vee notch weir. The volume flow is recorded, and an integrated value is generated by the recording instrument.

The composite samples are collected daily and chemically analyzed for uranium concentration. A weekly composite of the daily samples is analyzed for gross alpha and gross beta activity.

5.1.2.2 Action Level for Liquid Effluents

The site liquid effluent is controlled to stay within the 3×10^{-5} uCi/ml annual limit specified in 10 CFR 20 for release to unrestricted areas. For reference, this would equate to approximately 20 ppm at a typical enrichment.

5.1.2.3 Reporting Method

Uranium chemical analyses are available daily via the generation of a laboratory chemical analysis report on the discharge sample data. These data are summarized on a monthly basis. Daily and monthly values are reviewed against the internal action guide.

The activity release data are reported on a semiannual basis to the Nuclear Regulatory Commission.

5.1.2.4 Analysis, Lower Limits of Detection, Calibration and Standardization of Measurements

5.1.2.4.1 Chemical Analysis of Uranium

The lower limit of detection for uranium analysis on environmental samples approximates 0.01 parts per million.

The test method is calibrated using standard solutions made from National Bureau of Standards 950b standard U_3O_8. The method is verified with each group of samples run by use of a verification standard sample.

5.1.2.4.2 Activity Analysis for Liquid Environmental Samples

Gross alpha and gross beta are currently determined by standardized laboratory counting techniques. Lower limits of detection are typically 3×10^{-8} uCi/ml for gross alpha (if no absorption) and 5×10^{-8} uCi/ml for gross beta. The alpha calibration is accomplished using a standard calibrated by the National Bureau of Standards. The detector is checked daily using a source of known value.

5.1.3 Solid Wastes

Solid wastes generated in the fuel manufacturing operation are packaged in boxes. These boxes are assigned to controlled access queuing areas where they await processing through a decontamination facility. The decontamination operation performs a number of functions including recovery of uranium for recycle, separation of wastes into combustible and noncombustible categories, as well as decontamination of material for reuse where feasible.

After separation in the decontamination facility, the combustible wastes are designated for burning in an incinerator designed for processing uranium contaminated wastes. Wastes which cannot be incinerated or reused are shipped to a licensed recipient for disposal.

5.1.3.1 Source Point Monitoring Of Solid Wastes

Each box is assayed for uranium content to assure that it meets storage, shipment and burial requirements.

5.1.3.2 Lower Limits of Detection, Calibration, and Standardization of Measurements

The assay of solid waste boxes for uranium is done by a nondestructive method which employs passive and/or active scanning.

5.1.3.3 Action Level

Boxes which exceed a U-235 content, established by criticality safety analysis and/or burial site requirement are returned to the decontamination facility for further removal of contamination.

5.1.3.4 Reporting Method

The activity data on each shipment is summarized on the shipping papers. The activity data summary is reported on a semiannual basis to the Nuclear Regulatory Commission.

5.1.4 Contamination Free Liquid

Two liquid streams generated as a result of the conversion operation are transferred to unlicensed recipients and are not regarded as radioactive waste because of their low activity level.

5.1.4.1 Hydrofluoric Acid

In the dry process for converting UF_6 to UO_2, a product stream of hydrogen fluoride dissolved in water is generated. This acid contains less than 3 parts per million of uranium by weight of the liquid.

This product is transferred to persons whose uses of the material are such that incorporation of uranium from the liquid is not likely to occur into any food, beverage, cosmetic, drug or other commodity designed for ingestion or inhalation by, or application to, a human being such that the uranium concentration in such items would exceed that which naturally exists.

The acid is collected in a bulk storage tank to await shipment. Material containing more than 3 parts per million uranium is not released for shipment. The total volume produced will vary based on manufacturing requirements.

5.1.4.2 Ammonium Nitrate

A water solution of ammonium nitrate is produced as a result of treating spent etch solutions and nitrate wastes. This solution is impounded in the nitrate lagoons shown in Figure 5.3.

This ammonium nitrate solution is utilized as part of the nutrient system for the biological waste treatment facility owned by Federal Paper Board Company and located in Columbus County, North Carolina. The solution is transferred to the biological waste treatment facility by tank truck.

A grab sample is collected from each truck and analyzed for uranium concentration before release from the site. In addition, a composite of the grab samples taken in one day is collected for subsequent uranium analysis.

Action levels on these transfers are as follows:

Uranium Concentration	Action
At 3 ppm U, averaged over a 30-day period	Investigate the cause for rise in U concentration.
At 5 ppm U, averaged over a 30-day period	Stop shipments to Federal Paper after due notification and within one month.
Above 25 ppm U, for a single truckload	Investigate the cause for higher U concentration Stop shipments to Federal Paper after notification and within one week
Above 50 ppm U, for a single truckload	Stop shipment of the loaded transport vehicle.

5.1.5 Effluent Control Responsibilities

Airborne and Solid Effluents	Monitoring
Responsible Area Manager	Manager, Regulatory Compliance
Liquid Effluents	**Monitoring**
Manager - Facilities	Manager, Regulatory Compliance

5.2 Environmental Monitoring

The environmental monitoring program is based upon the concept of placing primary emphasis on monitoring at the source points. It has been found that data obtained at offsite sampling points fluctuate at background levels. Therefore, data collected at sample points remote from the sources are utilized as a secondary method of identifying any unsuspected impact from plant operations.

5.2.1 Radiological

5.2.1.1 Receiving Stream

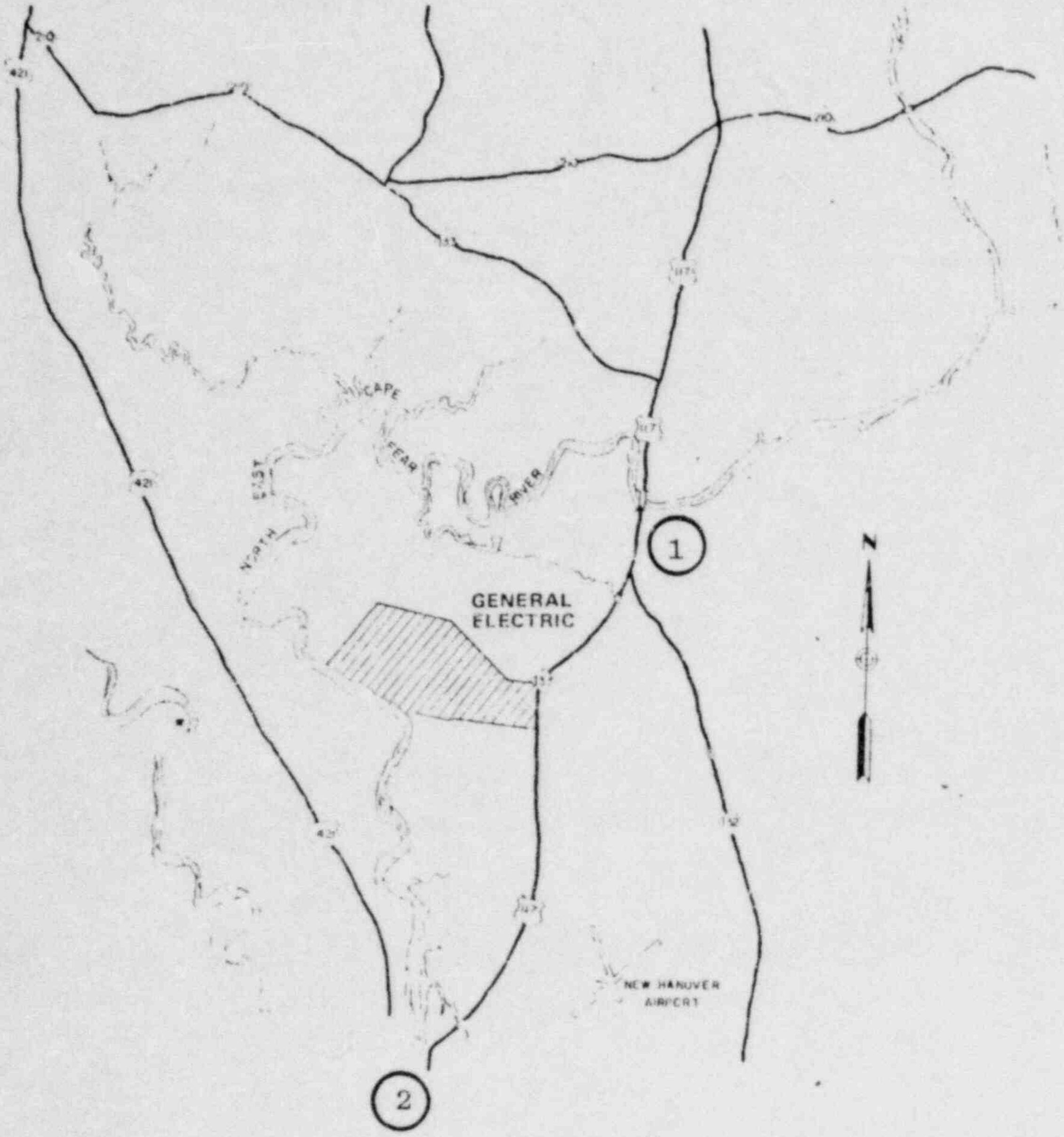
The Northeast Cape Fear River is the receiving stream for treated liquid waste waters discharged from the facilty. The river is routinely monitored to establish chemical uranium concentrations in the river upstream and downstream from the site.

The sampling location, type of sample taken at each location and frequency of sampling are detailed in Figure 5.4.

The data from the monitoring program are evaluated against an internal action level. The uranium concentrations are typically less than 0.01 parts per million. The action level utilized in this program is three successive values greater than 0.2 parts per million.

The upstream and downstream monthly results are reported to the State of North Carolina.

FIGURE 5.4
RIVER WATER SAMPLING LOCATIONS (OPERATIONAL)



		Location	Sample Type	Frequency
①	Upstream	Public boat dock	Grab	Monthly
②	Downstream	Seaboard Coastline Railroad Bridge	Grab	Monthly

5.2.1.2 Soil

Soil samples are collected and analyzed for uranium concentration to monitor for long term buildup of uranium concentrations attributable to plant operations. The locations of these stations are concentrated along the predominent wind directions.

Figure 5.5 details the sample locations.

The samples are collected on a quarterly basis and analyzed for uranium concentration. The results are recorded and evaluated against an internal action guide of 0.7 parts per million.

The plant supply water is sampled on a monthly basis. A grab sample is collected before and after treatment. Samples are analyzed for uranium concentration and the results are reviewed and recorded.

5.2.2 Non-Radiological

5.2.2.1 Airborne

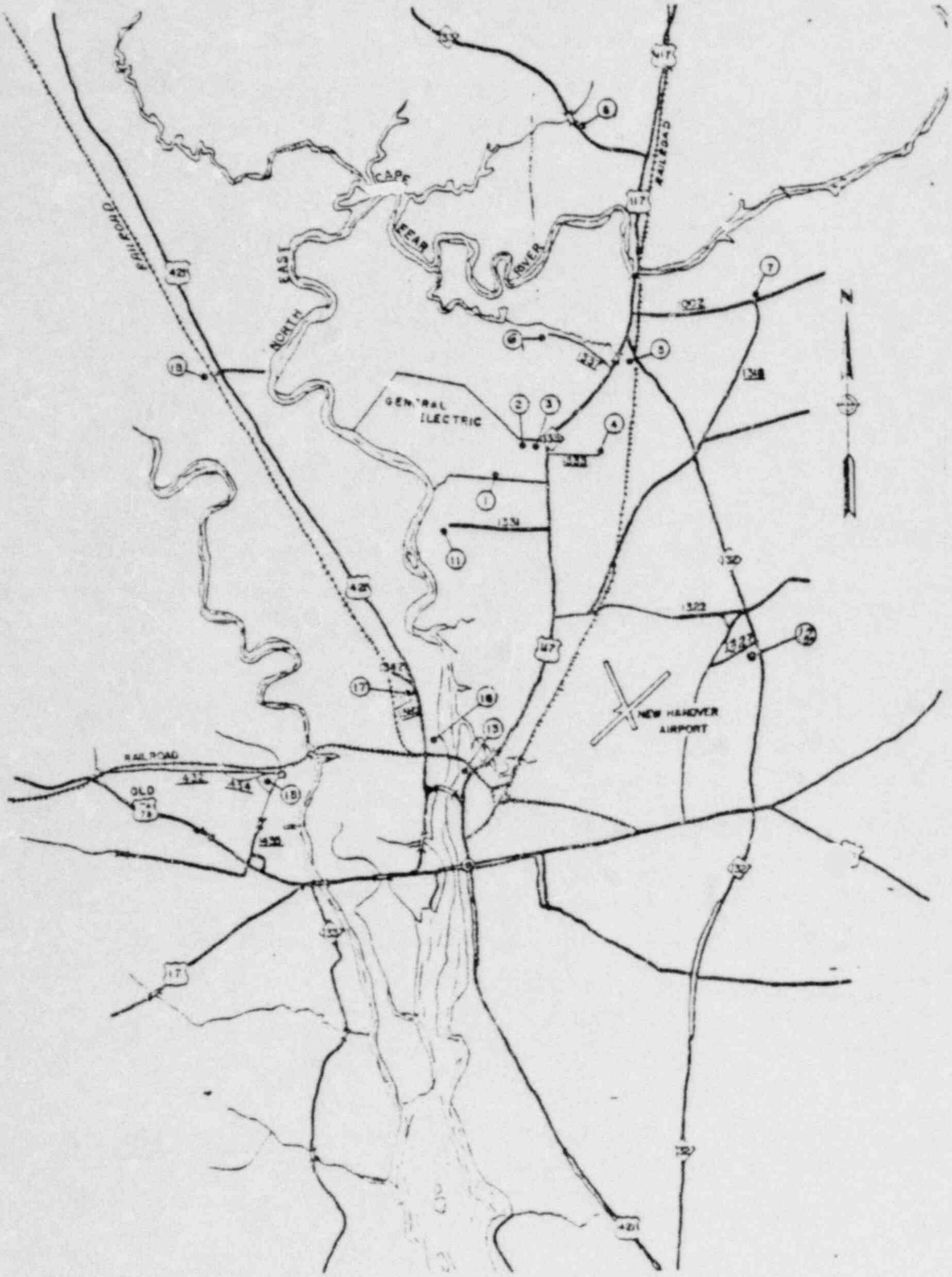
An offsite monitoring program is not conducted for chemical airborne pollutants. Selected stack emissions are sampled on a continuous basis for fluoride emissions. These samples are collected weekly and analyzed for fluoride content. The results are recorded and evaluated. Stack gases are not sampled for other chemical constituents.

5.2.2.2 Receiving Stream

As described in 5.2.1, the North East Cape Fear River is the receiving stream for treated liquid wastes discharged from the site. This river is routinely monitored for temperature, dissolved oxygen, pH and

FIGURE 5.5

ENVIRONMENTAL SOIL SAMPLING LOCATIONS



concentrations of fluoride, nitrogen combined as nitrate or ammonia, biochemical oxygen demand, and fecal coliform bacteria. The sample results from this monitoring program are reported monthly to the State of North Carolina.

The sample sites designated as No. 1 upstream, and No. 2 downstream, in Figure 5.4, are used for this program. Grab samples are collected at these locations three times a week during June, July, August and September and once a week during the balance of the year.

5.2.2.3 Ground Water

The plant supply water is obtained from wells located on site. The water produced from the well system is sampled and analyzed for ammonia, nitrate and chloride. These analyses are conducted on a grab sample collected monthly. The analytical results are evaluated and recorded.

6.0 SPECIAL PROCESS COMMITMENTS

There are no unique processes or operations for which descriptions and appropriate safety analyses have not been included in Chapter 16.

7.0 DECOMMISSIONING PLAN - HISTORY

On January 11, 1978, in connection with a WMD application for extending authorization of disposal of nitrate-bearing liquids to an offsite liquid treatment system and in connection with Amendment 3 to the license granting that request, the NRC added Condition 17 to the license requiring that within six months of issuance of the amendment, WMD submit a plan for future decontamination of the site. See Exhibit 7.1.

On July 14, 1978, WMD submitted an abbreviated decommissioning plan and requested that the requirement for submittal of a detailed decommissioning plan be delayed until the Battelle Pacific Northwest Laboratories completed their model decommissioning plan for a large, low enriched uranium fuel fabrication plant, for which WMD was supplying them information. It was stated that WMD planned to adapt appropriate sections of that model plan to apply to the Wilmington site when Battelle completed their study. See Exhibit 7.2.

Subsequently, on May 14, 1979, a statement from a GE official describing the financial provisions for decommissioning was mailed to the NRC. See Exhibit 7.3.

On June 4, 1979, the NRC amended the WMD license (Amendment 9) by adding Condition 19, which required General Electric to provide further details on our anticipated methods of decontamination, etc., by July 1, 1980. The specification of that date was based upon the expected publication by Battelle of the results of their study by December, 1979. Because of delays in publishing the Battelle study, at WMD request, the NRC on June 24, 1980, granted that the decommissioning plan be submitted 90 days after publication of the Battelle report. See Exhibit 7.4.

Coincidentally, the Environmental Protection Agency (EPA) response to the Resources Conservation and Recovery Act required WMD to prepare a site closure plan involving plans for disposal of materials classified as hazardous by the Act. WMD is preparing a single document to address the decommissioning plan required by the NRC and the site closure plan required by the EPA. Because of the new EPA closure requirement, WMD has received verbal permission to submit the detailed site decommissioning plan to the NRC by July 31, 1981. It is anticipated that this schedule will be met.

In the interim until the detailed decommissioning plan is accepted by the NRC, the abbreviated Wilmington site plan submitted July 14, 1978, is the official site closure document.

EXHIBIT 7.1

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

RECEIVED BY
JAN 17 1978
A. L. KAPLAN

JAN 11 1978

FCPF:EYS
70-1113
SNM-1097, Amendment No. 3

General Electric Company
ATTN: Mr. A. L. Kaplan
Consulting Engineer
Licensing
P. O. Box 780
Wilmington, North Carolina 28401

Gentlemen:

Pursuant to Title 10, Code of Federal Regulations, Part 70, and your application dated December 20, 1977, Item No. 16 of Special Nuclear Material License No. SNM-1097 is hereby amended to extend the expiration date of your authorization to dispose of nitrate-bearing liquids by transportation to an off-site liquid treatment system for test purposes to December 31, 1978.

We have noted that in your license you have not discussed the future decontamination of your facility and the ultimate disposition of the site. Accordingly, we have added Condition 17 to your license.

Condition 17. Within 6 months of the issuance of this amendment, the licensee shall submit a plan for the future decontamination of the places of use and sites authorized by this license so that they can be released for unrestricted use. This submittal shall identify and discuss the factors that were considered in the design of the plan in sufficient detail to enable an independent review. The plan shall include an estimate of the costs involved and the financial arrangements that have been or will be made to insure that adequate funds will be available to cover these costs at the time of decommissioning. In considering alternatives for these financial arrangements, the licensee shall specifically include the posting of a bond as a means of assuring availability of adequate funds.

All other conditions of this license shall remain the same.

Exhibit 7.1 (continued)

2 JAN 1 1 1978

The above condition had been discussed and agreed upon between your Mr. Kaplan and Mr. W. T. Crow of my staff.

Please note that your application dated December 20, 1977, to extend the ex[illegible]ration date for this disposal program for the duration of SNM-10[illegible] itself and to increase the maximum allowable limits of uranium in the nitrate-bearing liquids thus disposed of is still being reviewed by NRC staff.

FOR THE NUCLEAR REGULATORY COMMISSION

Leland C. Rouse

Leland C. Rouse, Chief
Fuel Processing & Fabrication Branch
Division of Fuel Cycle and
Material Safety

EXHIBIT 7.2

GENERAL ELECTRIC

NUCLEAR ENERGY PRODUCTS DIVISION

CASTLE HAYNE ROAD • P. O. BOX 780 • WILMINGTON, N. C. 28401 • (919) 343-5000

WILMINGTON MANUFACTURING DEPARTMENT

July 14, 1978

Director
Office of Nuclear Material Safety and Safeguards
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

ATTN: Mr. Leland C. Rouse, Chief
Fuel Processing & Fabrication Branch
Division of Fuel Cycle and Material Safety

Ref: 1. Amendment No. 3 to SNM-1097, Dated January 11, 1978
2. NRC License SNM-1097, Docket #70-1-13

Dear Mr. Rouse:

General Electric Company hereby submits the information required by Amendment 3 to SNM-1097 (reference 1) related to future decontamination of the places of use and sites authorized by SNM-1097 (reference 2) for the fuel fabrication plant in Wilmington, North Carolina.

We are currently participating in a study being performed by Battelle Pacific Northwest Laboratory to develop a decommissioning plan for a model of a large low-enriched uranium fuel fabrication plant. It is our intention to adapt appropriatesections of this plan to apply to our Wilmington Plant when the study is completed.

General Electric personnel would be pleased to discuss this matter with you and your staff as you may deem necessary.

Very truly yours,

GENERAL ELECTRIC COMPANY

Arthur L. Kaplan
Manager
Licensing and Compliance
Audits

cc. Mr. John B. Kahle
U. S. Nuclear Regulatory Commission
Region II - Suite 1217
230 Peachtree Street NW
Atlanta, Georgia 30303

ATTACHMENT TO LETTER TO MR. LELAND C. ROUSE DATED JULY 14, 1978

CONSIDERATIONS REGARDING PLAN FOR FUTURE DECONTAMINATION OF PLACES OF USE AND SITES AUTHORIZED BY NRC LICENSE SNM-1097

1. INTRODUCTION

General Electric Company is required by Amendment No. 3 to SNM-1097 to provide a plan for future decontamination of the places of use and sites authorized by SNM-1097 for the manufacture of nuclear fuel.

The plan includes a brief description of the fuel fabrication plant, assumptions made in developing the plan, an estimate of the costs involved for such decontamination, and consideration of financial arrangements to insure that adequate funds will be available to cover these costs at the time of decommissioning.

2. PLANT DESCRIPTION

The Wilmington Manufacturing Department of the General Electric Company occupies approximately 1,000,000 square feet of administrative, laboratory, and manufacturing space at the 1650 acre site in Wilmington, North Carolina. Manufacturing activities are carried out in buildings housing equipment for fabrication and assembling of nuclear fuel, nonnuclear parts for the reactor core, and other reactor components.

The arrangement of principal buildings is shown in Figure 1. Fabrication of nuclear fuel bundles utilizing low-enriched uranium is conducted in the Fuel Manufacturing Operation Building. Uranium is normally handled only in this building. Occasionally, but infrequently, small quantities of uranium in a completely encapsulated form may be used for special tests in other buildings or site locations as authorized by SNM-1097. In such cases, special preparations are made to prevent release of uranium to unrestricted areas.

For purposes of general orientation, the functions of principal Wilmington buildings are described below:

(1) Equipment Manufacturing Facility - Building A

The Equipment Manufacturing Building is a large steel, concrete and transite structure east of Buildings B and D used in the manufacture of nonnuclear reactor components.

(2) Fuel Components Building - Building B

The Fuel Components Building is a large structure of similar construction to Building A, located between Buildings A and D. It is used to manufacture the nonnuclear components of reactor fuel bundles.

(3) Facility Maintenance Building - Building C

This building houses a centralized maintenance shop area utilized for maintenance work, shipping, receiving, and related functions, all not involving the fabrication of nuclear fuel bundles.

(4) Fuel Manufacturing Building - Building D

This building is a 700 ft. x 270 ft. structure built of concrete block and insulated metal siding over a steel framework with a concrete floor. A built-up roof consists of a metal deck and insulation which is topped with asphalt and gravel.

3. ASSUMPTIONS

The following assumptions were made in preparing this plan:

(1) Present radiological limits and decontamination technology will apply to decommissioning our plant.

(2) By the time that decommissioning of this plant would take place, the Commission will have established by regulation de minimus quantities of special nuclear material (low-enriched uranium, specifically) for transfer to recipients not specifically licensed by the Commission.

(3) Any materials with special nuclear material exceeding de minimus quantities will be appropriately packaged and sent to a licensed location for disposal.

(4) Packaging, transportation, and disposal charges are determined from costs associated with disposal at the Chem-Nuclear Systems, Inc. facility in Barnwell, South Carolina.

(5) The decommissioning work will be carried out by an independent contractor, and the operation costs are estimated at rates appropriate for such contractor.

(6) Costs are expressed in current (1978) dollars.

(7) Experience from decommissioning a smaller low-enriched uranium fuel fabrication plant in 1969 at our San Jose, California site was utilized in determining the extent of decontamination required, contaminated waste generated, and contractor effort expended in accomplishing the required decommissioning activities. This structure was subsequently released for unrestricted use.

Exhibit 7.2 (continued)

4. PLAN AND COST ESTIMATE

Based on the assumptions outlined above, estimates were made of the equipment likely to be released for unrestricted use by being either uncontaminated or capable of being decontaminated to levels below that required for unrestricted release. The remainder would be prepared and transported for disposal to a licensed offsite burial location. Estimates were also made of the area of walls, floor, etc. requiring decontamination to levels below that required for unrestricted release of the structure.

The total costs associated with these activities, based on realistic current rates for labor, contaminated waste disposal at licensed locations, etc., were estimated by General Electric to be approximately $11,500,000.

5. FINANCIAL ARRANGEMENTS

The decommissioning costs for General Electric's fuel fabrication plant in Wilmington, North Carolina, estimated to be $11,500,000, are small compared to the total assets of the General Electric Company. Therefore, we believe that there is no credible likelihood that General Electric would be unable to meet the financial commitments generally associated with the decommissioning activities as outlined and estimated above.

At some future time, after General Electric has developed a more detailed decommissioning plan and associated cost estimate, based upon the study underway by Battelle Pacific Northwest Laboratory, an appropriate corporate officer of the General Electric Company will certify to the Commission that, at the time of any required decommissioning for the General Electric Fuel Fabrication Plant in Wilmington, North Carolina, General Electric will fully comply with all applicable laws, rules and regulations.

EXHIBIT 7.3

GENERAL ELECTRIC
GENERAL ELECTRIC COMPANY
175 CURTNER AVENUE
SAN JOSE, CALIFORNIA 95125

RECEIVED BY
17 1979
A. L. KAPLAN

ROY H. BEATON
VICE PRESIDENT AND GROUP EXECUTIVE
NUCLEAR ENERGY GROUP

May 14, 1979

Mr. W. T. Crow
Fuel Processing & Fabrication Branch
Division of Fuel Cycle & Material Safety
Office of Nuclear Material Safety & Safeguards
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Reference: NRC License SNM-1097, Docket #70-1113

Dear Mr. Crow:

This letter is to inform you that General Electric Company will have available at the time of decommissioning, the resources deemed necessary to satisfy its obligation to decommission its nuclear fuel manufacturing plant in Wilmington, North Carolina.

Sincerely,

R H Beaton

R. H. Beaton

EXHIBIT 7.4

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

JUN 24 1980

FCUP:RLS
70-1113
SNM-1097, Amendment No. 13

RECEIVED BY
JUL 30 1980
A. L. KAPLAN

General Electric Company
ATTN: Mr. A. L. Kaplan, Manager
Licensing & Compliance Audits,
M/CJ26
P.O. Box 780
Wilmington, North Carolina 28401

Gentlemen:

In accordance with your application dated May 29, 1980, and pursuant to Title 10, Code of Federal Regulations, Part 70, Condition 19 of Special Nuclear Material License No. SNM-1097 is hereby amended to revise the date for the submittal of additional details of the decommissioning plan, including methods of decontamination, areas to be cleaned and volumes to be buried at a licensed burial facility. Instead of the July 1, 1980, date for providing those details, the details shall be provided within 90 days after publication of the final Battelle report on a model decommissioning plan for a reference UO_2 fuel fabrication plant.

All other conditions of this license shall remain the same.

FOR THE NUCLEAR REGULATORY COMMISSION

R G Page

R. G. Page, Acting Chief
Uranium Fuel Licensing Branch
Division of Fuel Cycle and
Material Safety

8.0 EMERGENCY PLAN

On February 27, 1978. WMD was requested to provide a Wilmington Site Emergency Plan. See Exhibit 8.1. This plan was submitted February 27, 1979, and is the currently approved Emergency Plan in effect at this time. On February 11, 1981, General Electric received a new NRC directive requiring preparation of radiological contingency plan information. See Exhibit 8.2. It is apparent that the required radiological contingency planning information is available in the Emergency Plan or in this license renewal. However, the Emergency Plan is being modified to include the radiological contingency planning information. The modified plan will be available shortly.

EXHIBIT 8.1

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

RECEIVED [illegible]
[illegible] 1978
A. L. KAPLAN

Docket No. 70-1113
SNM-1097

FEB 27 1978

General Electric Company
ATTN: Mr. Arthur L. Kaplan
Consulting Engineer Licensing
Castle Hayne Road
P. O. Box 780
Wilmington, North Carolina 28401

Gentlemen:

On March 31, 1977, 10 CFR Part 70, Special Nuclear Material, was amended to require applicants for licenses to possess and use special nuclear material for processing and fuel fabrication, scrap recovery or conversion of uranium hexafluoride to include, in their applications, plans for coping with emergencies. The same amendment for 10 CFR Part 70 requires, as a condition for the approval of applications for the specified licenses, that the Nuclear Regulatory Commission determine that the applicants' proposed emergency plans are adequate. These requirements replaced a prior procedure which required, by license conditions, that selected licensees have emergency plans.

Since the effective date of the change to 10 CFR Part 70, licensees have been submitting their emergency plans as part of their applications for license renewal; and we have been reviewing the plans as part of our effort leading to decisions on the renewal applications. Certain licenses, however, are not due for renewal in the near future; and in these cases, we are requesting that the licensees submit their emergency plans prior to the submittal of their requests for license renewal.

Special Nuclear Material License No. SNM-1097 does not expire until 1981. We are, therefore, requesting that your emergency plan be submitted to us for review by August 1, 1978. For your information and use in preparing your submittal, we are enclosing a copy of

Exhibit 8.1 (continued)

FEB 27 1978

Regulatory Guide 3.42, Emergency Planning for Fuel Cycle Facilities and Plants Licensed Under 10 CFR Parts 50 and 70. Please note the Regulatory Position in Part C of the guide which states that if you determine that any portion of the guide is, in your case, not necessary, you should justify the reason for that determination.

We are also enclosing a copy of Appendix E of 10 CFR Part 50. Section IV of Appendix E lists the elements that shall be contained in emergency plans for fuel cycle facilities and plants.

Sincerely,

John B. Martin, Assistant Director
Fuel Cycle Safety and Licensing
Division of Fuel Cycle and
Material Safety

Enclosures:
1. Regulatory Guide 3.42
2. Appendix E, 10 CFR Part 50

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

FEB 11 1981

General Electric Company
ATTN: J. A. Long, General Manager
Wilmington Manufacturing Department
P.O. Box 780
Wilmington, NC 28401

Gentlemen:

Enclosed is an Order pertaining to License No. SNM-1097 that requires you to prepare and submit radiological contingency planning information to NRC for review.

If you have any questions concerning provisions of the Order, please contact Mr. R. G. Page (301-427-4309) or Dr. F. D. Fisher (301-427-4135) of my staff.

Sincerely,

Richard E. Cunningham, Director
Division of Fuel Cycle and
Material Safety

9.0 OVERVIEW OF OPERATION

9.1 CORPORATE INFORMATION

9.1.1 General

This application is filed by the Wilmington Manufacturing Department (WMD) of the General Electric Company, a New York corporation with a principal place of business at 1 River Road, Schenectady, NY. The General Electric Company is a publically held corporation whose stock is traded on the principal security exchanges.

The Wilmington Manufacturing Department is a function within the Nuclear Energy Business Group with headquarters in San Jose, CA. The Nuclear Energy Business Group is a function of the Power Systems Sector, with headquarters in Fairfield, CT.

The Wilmington plant is located in the State of North Carolina, New Hanover County.

Corporate Financial Qualification

9.2 In order to demonstrate the General Electric Company's financial capabilities for operating and decommissioning the Wilmington plant site, a copy of the Company annual report for 1980 is included as the Appendix of this Chapter.

Summary of Operating Objective and Process

9.3 The WMD facility consists of three manufacturing operations: stainless steel machining, fuel components fabrication, and nuclear fuel production. Each activity is conducted in a separate building or group of buildings. In particular, the uranium processing activities are all conducted within a controlled access area.

The fuel plant capacity for converting UF_6 to UO_2 is presently about 1500 metric tons UO_2 per year and will be increased later in 1981 to about 1800 metric tons UO_2 per year with the planned addition of the GECO (dry process described in Section 16) conversion capacity. In the uranium process, UF_6 is converted to UO_2 powder by either of two processes - ADU (wet) or GECO (dry), both of which are described in Chapter 16.

The UO_2 powder is treated (e.g. hammermilling, slugging, granulating, blending) to prepare it for subsequent processing. Some UO_2 powder may be shipped offsite to customers for their use in manufacturing nuclear fuel. Most of the UO_2 powder is used to manufacture fuel at the Wilmington site. Pressed UO_2 pellets are sintered, ground, and either loaded into fuel rods or shipped offsite to customers for their use in manufacturing nuclear fuel. Fuel rods are assembled into fuel bundles, and the bundles are shipped. Certain activities related to fuel manufacturing, such as laboratory analyses, fuel process development instrumentation development and waste treatment are also conducted at WMD.

9.4 Site Description

General Electric's plant at Wilmington, North Carolina, is situated on a 1664-acre site in New Hanover County. (Refer to maps, Figures 9.1 through 9.3.) New Hanover

FIGURE 9.1

STATE & COUNTY LOCATIONS

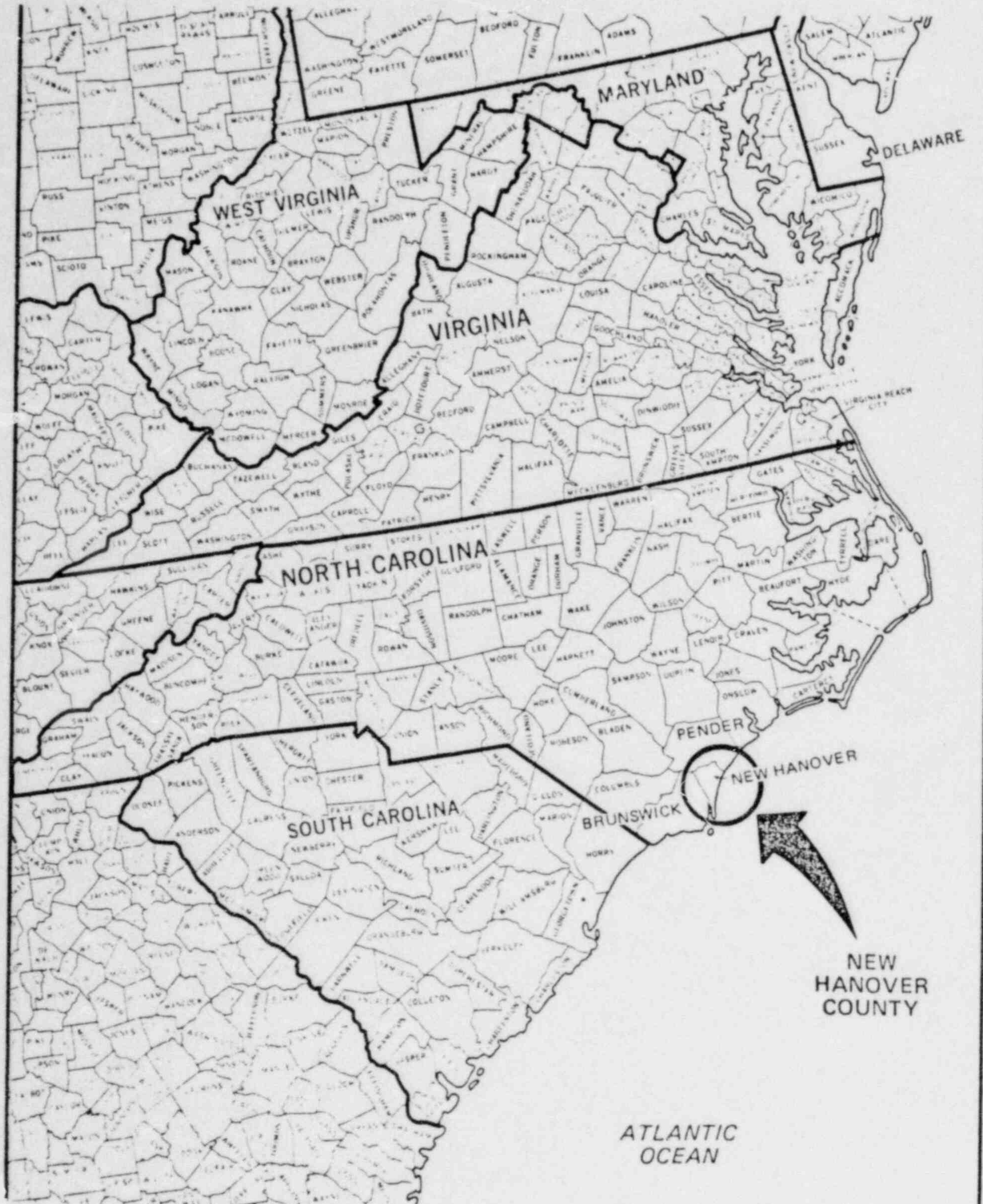


FIGURE 9.2

NEW HANOVER COUNTY & ADJACENT COUNTIES

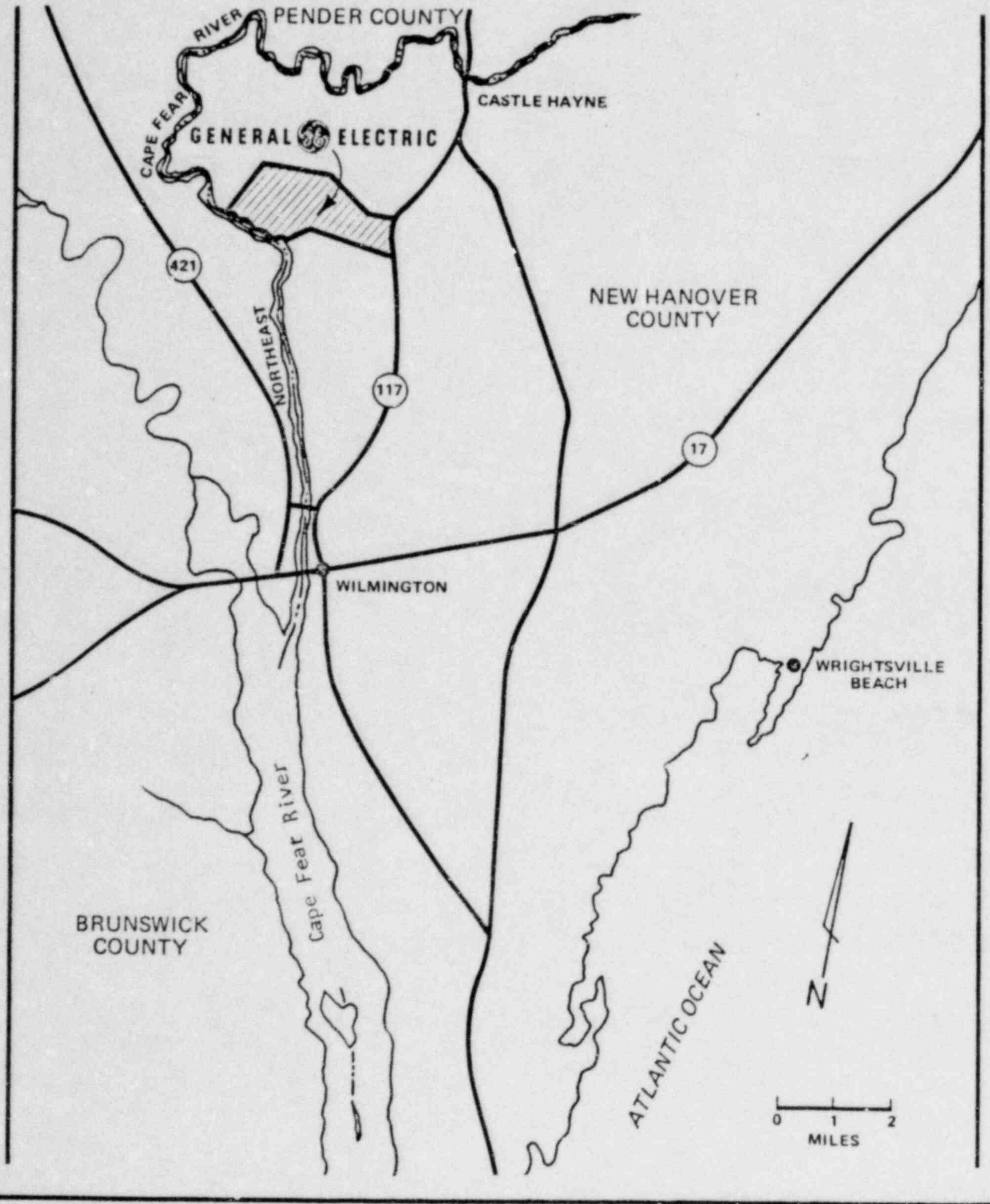
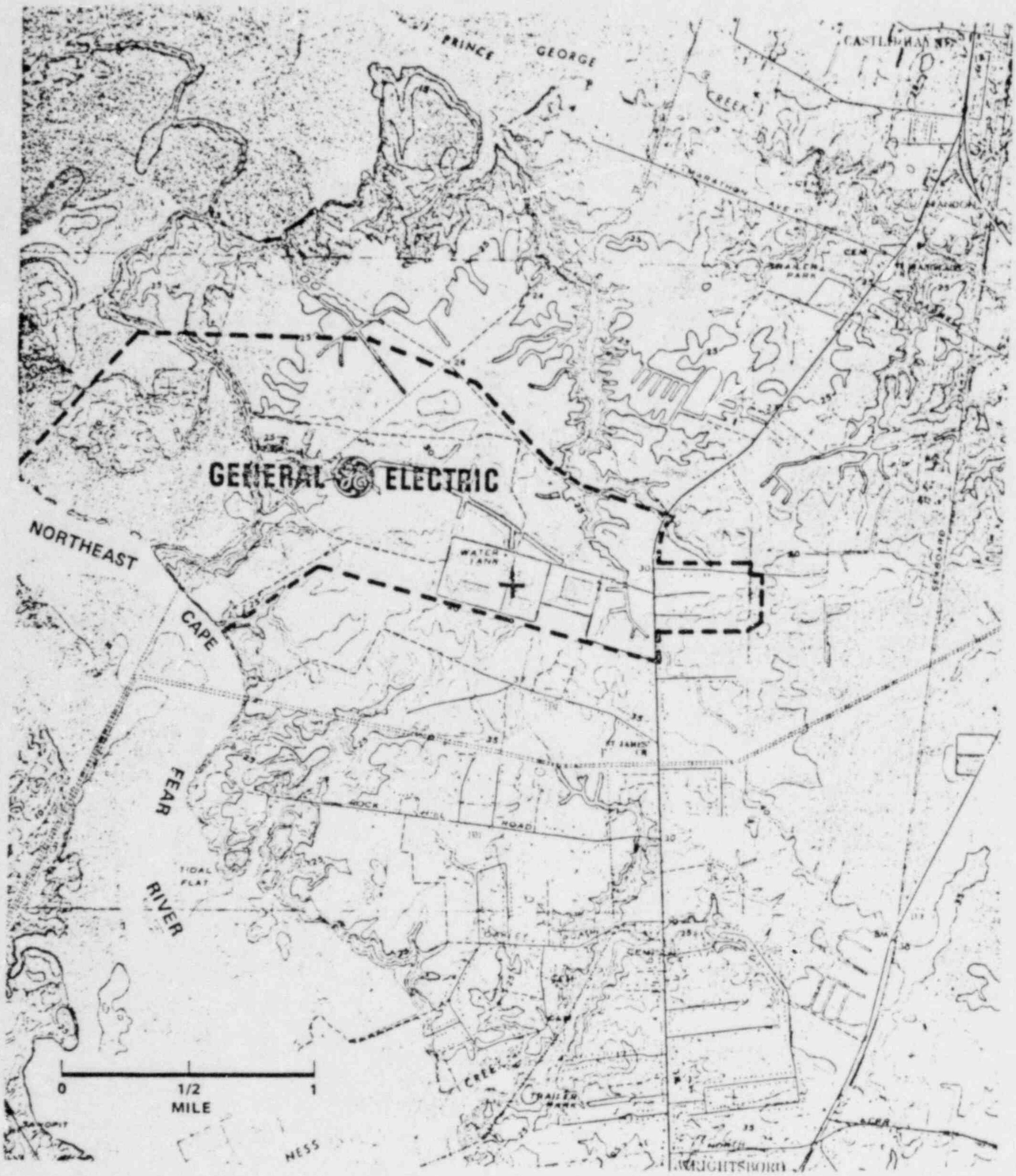


FIGURE 9.3

PLANT SITE (HEAVY OUTLINE) & ENVIRONS



County is located in the southeastern corner of the state, in the coastal plains region. The county is bounded by the Atlantic Ocean and by Pender and Brunswick counties. The region around the site is sparsely settled, and the land is characterized by heavily timbered tracts occasionally penetrated by short roads. Farms, single-family dwellings, and light commercial activities are located chiefly along the highway. The major portion of the site (1650 acres) is bordered on the east by U.S. Highway 117 and on the west by the Northeast Cape Fear River. Fourteen additional acres lie to the east of U.S. 117 and are partially developed including water wells, an employee park and truck parking. The northern and southern boundaries, marked by fences, are surveyed lines through undeveloped forest and marsh lands.[1]

Of the total 1664 acres, only 150 acres (about 10 percent) have been developed. The developed portion is used as shown in Table 9.1.

Table 9.1

USES OF DEVELOPED AREAS OF THE PLANT SITE

Developed Area	Area Size (acres)
Manufacturing Buildings	16.9
Other Buildings	7.8
Waste Treatment Facilities	26.3
Power Supply Line*	31.7
Paved Roadways, Outside Storage and Parking	30.7
Unpaved Roadways and Parking	12.5
Landscaped Areas	24.1

*Easement to Carolina Power and Light

9.4.1 Population Distribution

The five-county area surrounding the plant site is essentially rural with a low population density. The population characteristics of the five-county area are listed in Table 9.2.

TABLE 9.2

POPULATION CHARACTERISTICS

COUNTY	1980 POPULATION	PERCENT URBAN	POPULATION DENSITY PERSONS/MI^2
Bladen	30,069	0	34.1
Brunswick	35,349	0	41.3
Columbus	51,015	8.9	54.0
New Hanover	103,304	69.5	558.4
Pender	22,107	0	25.3

As shown in Table 9.3, this portion of the North Carolina coastal plains has very few large population centers. The closest metropolitan area is the City of Wilmington with a 1980 population of 44,100.

TABLE 9.3

TWENTY-MILE RADIUS POPULATION CHARACTERISTICS

Population Center	1980 Population	Location from Plant Site
Burgaw	2100	16 miles north
Carolina Beach	1791	20 miles south
Castle Hayne	1500	3 miles north
Wilmington	44100	6miles south
Wrightsville Beach	2781	11 miles southeast

Located 45 miles to the northeast are Jacksonville, North Carolina, with a 1980 population of approximately 22,500, and nearby Camp LeJeune (U.S. Marine Corps), which had a 1980 population of 35,149.

Most of the land within a five mile radius of the plant site is wooded and largely undeveloped. The developed areas are used for industrial, commerical, agricultural, residential, public, and recreation purposes. Three manufacturing plants are located within a six mile radius of the plant site: the W. R. Grace & Co. (ammonium nitrate fertilizer plant), Hercofina, Inc.(manufacturers of chemical intermediates for the textile industry) and De Poortere Corporation's (pile fabrics plant).[3] Employment levels at these plants are approximately 200, 200, and 1000 persons, respectively. A small shopping center is located approximately three miles south of the plant site along U.S. 117. Within a five mile radius, several small commercial establishments are located along the area roadways.

With the exception of Castle Hayne (population 1500) to the north, residential development in the five mile area has been primarily in the form of single-family homes located intermittently along the area roads. Some small developments have started with a typical size range of 5 to 20 homes. There are a few churches, one public school, two private schools, and one county prison facility.

The property immediately north of the site is primarily wooded, with limited residential development. The property immediately south of the site is a lightly settled residential area with the majority of the area being wooded or agricultural. A North Carolina Horticultural Crops Research Station is located directly across U.S. 117 from the plant site.

9.4.2 Water Use

Since no municipal water system is available, water supplies for the plant are provided by individual wells on the property, as is the practice of other industrial, residential, commercial, and agricultural establishments that are beyond the Wilmington water district. Calculations based on a study by Hittman Associates[5] indicate that the available supply on the plant site is 10 million gallons per day. Based on a planned growth rate, projected requirements through the year 2000 indicate that only a portion of this supply will be used (Table 9.4).

TABLE 9.4

PROJECTED WATER USAGE

Year	Usage in Millions gal/day
1975	1.0
1980	1.8
1990	4.5
2000	5.0

Drawdown (the difference in the static water level and the pumping level) of observation wells on the site indicate that the level of aquifer (a water-bearing earth stratum) has been stable since the start of plant operation. The fluctuations that do occur are what might be expected from variations in seasonal rainfall.

The Wilmington water district serves the City of Wilmington and obtains supply water from the Cape Fear River. The supply point for the district is King's Bluff, which is about 20 miles above the confluence of the Cape Fear and the Northeast Cape Fear rivers. The supply point is also above the dam and navigational Lock 1. Therefore, the Wilmington water supply is independent of the General Electric plant discharges. Before 1944, the water district obtained its supply from the Northeast Cape Fear River but discontinued this practice because of salt water that intrudes during low river-flow periods.

The Northeast Cape Fear River is the receiving tributary for the treated plant effluents. Its primary recreational usage is for boating and fishing; no features near the plant attract users disproportionately. It is also used to transport material by barge to plants upstream.

9.4.3 Geology

The entire coastal region of southeastern North Carolina consists of relatively flat table land with salt marshes, tidal flats, and shallow sounds near the ocean. New Hanover County elevation averages 30 to 40 feet above sea level, with a maximum elevation of 80 feet[6]. The plant site is very flat, averaging 30 to 35 feet above sea level.

The major subsurface strata in New Hanover County are Peedee sandstone and Castle Hayne limestone. The Peedee formation underlies the plant site and is about 35 feet thick. It slopes from approximately sea-level elevation at the plant site down to about 190 feet below sea level at the Atlantic Ocean, about 12 miles east of the site.[7] The Castle Hayne formation is less extensive and is present at the plant site only to a limited extent. It is of irregular thickness and occurs about 30 feet below the surface. These characteristics are ideal for a plant-site location. The ground is stable (not subject to earth slides or flash flooding) and is sufficiently above sea level to prevent tidal flooding. The surface soils on the plant site consist of sands and clay. In some of the lower swampy areas the sands are mixed with humic materials.

Earthquakes are rare in North Carolina. The western part of the state is in Zone 2 of the Uniform Building Code, and the only two damaging earthquakes in the state have occurred in this area. These earthquakes reached a maximum intensity of VII to VIII on the Modified Mercalli (MM) scale. These intensities imply negligible to slight damage in structures specifically designed for this earthquake zone.

Eastern North Carolina, the area in which the plant site is located, is classified as a Zone 1 area, an area of even lesser earthquake intensity. On the MM scale this zone corresponds to an intensity of V to VI. These intensities imply building damage only to the extent of fallen plaster and damaged chimneys. The only recorded earthquake in the plant-site area was a localized disturbance in Wilmington in 1884. This earthquake had an intensity of V to VI, but the only effect was that some homes rocked and some crockery fell from shelves. The plant structures are specifically designed to withstand earthquakes of Zone 1 intensity without structural damage to buildings.

9.4.4 Hydrology

New Hanover County, on the North Carolina coastal plain, drains either into the river or directly into the ocean. The coastal plain represents part of a Pleistocene sea floor exposed by withdrawal of the sea. Waters that could be affected by operation of the plant or that could influence plant operation are limited to the Northeast Cape Fear River and the groundwaters of the site and immediate environs.

9.4.4.1 Rivers

The Northeast Cape Fear River, at the westernmost boundary of the plant site, is the sole receiver of all surface storm water and treated waste drainage from the plant site. The Northeast Cape Fear River originates in Wayne County, about 100 miles north of the plant site. The total drainage area of the river is 1740 square miles.[7] The river flows southward through Duplin, Pender, and New Hanover counties to its confluence with the Cape Fear River, 6.4 miles south of the plant site. From this point, the Cape Fear widens into an estuary and discharges to the Atlantic Ocean about twenty miles further south. The tributaries of the Northeast Cape Fear consist of a series of small creeks. Prince George Creek, approximately five miles to the north, is one of the largest of these tributaries with a drainage area of 2.4 square miles.

The flow characteristics of the Northeast Cape Fear River are complex because of its estuarine characteristics. Dilution and transit times are a function of both tidal influence and fresh-water inflow. A special study was conducted by the U.S. Geological Survey [8] at the request of and in cooperation with the North Carolina Department of Water and Air Resources to determine the dispersive and assimilative characteristics of this type of flow system. The study was conducted during October, 1969, on the Northeast Cape Fear River in the lower reaches from 2.9 miles above the plant site to 1.4 miles above the confluence with the Cape Fear River. The General Electric Company made a financial contribution to the North Carolina Department of Water and Air Resources to aid in offsetting the study expenses and also furnished a pier for use as a gaging station for the study.

The study determined that the volume of water passing the site during particular ebb and flood tidal cycles was 220 million cubic feet and 310 million cubic feet, respectively, whereas the fresh water inflow was estimated at only 11 million cubic feet during the same period. This study, based on data obtained by fluorescent dye tracing, showed that the Northeast Cape Fear River quickly disperses a solute both vertically and horizontally. This rapid dispersion is caused primarily by the large flow that results from tidal effects rather than from fresh water inflow.

Extrapolation of the study shows that, at the estimated 10-year, 7-day low-flow volume, the daily maximum concentration 1000 feet downstream from the point of discharge of a solute would average about 130g for each 100 pounds of solute added.

While a minimum transit time between point of discharge to point of use is not applicable, extrapolation of the study does show that at the maximum fresh water inflow for the period of record (20,400 cubic feet per second on July 6, 1962),[8] the transit time from the plant site to the confluence with the Cape Fear River would be about 12 hours. A more normal transit time based on the water year, October, 1969, to September, 1970, would be 10 days. This relatively slow time is because of the tidal effects, which overwhelm the effect of fresh water flow.

At the plant site, the tidal range is 3.4 feet, and the water becomes brackish during periods of low fresh water inflow. Although fresh water inflow rates at the site averge more than 1000 cubic feet per second, the 10-year, 7-day low-flow value is about 15 cubic feet per second. Changes in fresh water infow are seasonal and generally follow the region's rainfall pattern.

9.4.4.2 Flood Study

The U.S. Army Corps of Engineers conducted a flood study of the Northeast Cape Fear River, but discontinued the study at Wallace, North Carolina, about 40 miles upstream from the plant site. The study was discontinued because downstream of this point high water was more significantly affected by wind and tide rather than by stream flow.

9.4.4.3 Related Classification of Receiving Streams

The pH of the river water is generally acid, although values as high as 9 have been measured. Fluorides are present in concentrations of nearly 1 ppm and are thought to be of natural origin from fluoride-bearing minerals.

Nitrates, ammonia, and other ions are also present in varying but low concentrations. The color of the river is dark brown, indicative of the contributions from swamps in the drainage area.

The river is classified as "SC" at the site by the North Carolina Office of Water and Air Resources. This classification means that the best use of the water in this classification is designated as "fishing, and any other usage except bathing or shellfishing for market purposes."

9.4.4.4 Groundwater

Three significant aquifers contain potable water in New Hanover County: the shallow surface sands, the Peedee formation, and the Castle Hayne formation. Deeper strata contain saline water. The Peedee formation is separated from the saline aquifers by 100 to 150 feet of impervious clay sediments. The major recharging sources of new-surface ground waters is rainfall.

Residential, industrial, and commercial facilities outside the Wilmington water district draw their water from individual wells. The plant site water is supplied by a series of wells placed strategically on the site to provide optimum drawdown characteristics. Current withdrawal of water from aquifers on the site is a very small portion of the available supply. It has been estimated[5] that approximately 10 million gpd can be supplied from strategically spaced wells on the plant site alone without adversely affecting the water table.

The quality of the groundwater obtained for plant use is characteristic of the aquifer utilized. It contains considerable quantities of CO_2, resulting in a low pH with iron concentrations averaging 1 to 2 ppm. Chloride concentrations are low, typically 30 to 40 ppm, indicating salt water intrusion is not affecting water quality.

9.4.5 Meteorology

Because of its maritime location, the Wilmington area enjoys a relatively mild year-round climate. Summers are warm and humid, moderated by northeast sea breezes which begin in early afternoon, and most winters are short and mild. Occasional hurricanes may produce high winds, tides, and rains. The area receives about two-thirds of the sunshine possible at its latitude[9]. The detailed meteorological data presented in this report are derived primarily from U.S. Department of Commerce measurements recorded at the New Hanover County Airport (latitude 34°, 16' N, longitude 77° 55' W, el. 28 ft.). The airport is about 5 miles southeast of the site. Because the flat, featureless terrain at the airport is similar to the site terrain, this datum is considered representative of conditions at the site.

9.4.5.1 Temperature

Between 1932 and 1971 the annual averge temperature was 63.4°F with the highest averge monthly temperature of 79.6°F occurring in July and the lowest average monthly temperature of 47.3°F occurring in January. The highest and lowest temperatures ever recorded in the Wilmington area were 104°F in June, 1952, and 5°F in February, 1899, respectively.

9.4.5.2 Precipitation

Summer rainfall is usually heavy, occurring as unevenly distributed thundershowers of short duration, while winter rains are generally slow, steady, and evenly distributed lasting 1 or 2 days. Thunderstorms occur on an averge of 46 days per year. Snow is infrequent and is usually not measurable as ground accumulation. Hail occurs less than once a year. From 1932 to 1971, the average annual rainfall was 50.51 inches, with the highest average monthly total of 7.43 inches in July and the lowest average monthly total of 2.48 inches in November. The maximum and minimum figures recorded for any single month were 21.12 inches in July, 1886, and 0.02 in. in October, 1943, respectively.

9.4.5.3 Wind Condition

The mean hourly wind speed in the vicinity of the site is 9.3 mph with a mean monthly range between 11.0 in April and 8.0 in August (1971 data).

These data conform to other data recorded in recent years. Table 9.5 lists normal hourly wind speed and prevailing direction for the Wilmington area.

TABLE 9.5

MONTHLY WIND SPEEDS AND DIRECTIONS

Month	Mean Hourly Speed (mph)	Prevailing Direction
January	10.3	N
February	11.4	NW
March	11.6	SSW
April	12.0	SSW
May	10.5	SSW
June	9.6	SSW
July	9.1	SW
August	8.8	N
September	9.5	N
October	9.2	N
November	9.2	N
December	9.3	N
Annual	10.0	SSW

9.4.5.4 Atmospheric Stability

In New Hanover County atmospheric temperature inversions occur an averge of 36 percent of the time. The seasonal distribution of these temperature inversions is shown in Table 9.6.

TABLE 9.6

OCCURRENCE OF ATMOSPHERIC TEMPERATURE INVERSION

Season	Inversion Frequency (%)
Summer	30
Fall	35
Winter	44
Spring	34

Stagnation conditions, defined as an inversion lasting for 4 or more days, occur for an average of 9 days per year. These inversion frequencies are typical of the country as a whole and do not represent unusual local conditions.

9.4.5.5 Hurricanes

Because of its eastern maritime location, the Wilmington area is subject to occasional hurricanes. These hurricanes are less frequent and less damaging than those further south in the tropical storm areas.

Hurricanes affect the North Carolina coastal area an average of one to three times per year, resulting in strong winds, high tides, and heavy precipitation. The strongest wind recorded in the Wilmington area was in September, 1958, during Hurricane Helene. Wind speeds averaged 88 mph, with some gusts to 135 mph. The plant buildings are designed to withstand sustained winds of 125 mph, with substantial margins of safety. The highest tide recorded in the Wilmington area was caused by Hurricane Ione in September, 1955. The tides were as much as 10 feet above normal. The plant facilities are located 30 to 35 feet above mean high tide and, thus, would not be subject to flooding by a tide equivalent to the historical high tide. This fact is sustained by a Corps of Engineers study.

9.4.5.6 Tornadoes

North Carolina experienced an averge of 7.3 tornadoes per year from 1953 to 1970. The average number of tornadoes from 1916 to 1958 was less than 4 per year. New Hanover County, with an area of 185 square miles has historically experienced an average of only 0.1 tornado per year. This statistic is consistent with the published probability of a tornado occurring once per year in the 1° square (4000 square miles) containing New Hanover County.

9.5 Location of Buildings on Site

Location of buildings on the plant site is shown and discussed in Chapter 10 - Facility Description.

9.6 Location of the Plant Site

Figures 9.1, 9.2, and 9.3 show the location of the WMD plant site in the State, in the County and in the general environs respectively.

9.7 License History

9.7.1 License Amendments

Amendment Number	Subject	Effective Date
License Renewal	--	5/24/76
1	Liquid Nitrate Disposal - Extension of Expiration Date for Authorization	12/29/76
2	Authorization for Continuation of On-site Incineration	5/25/77
3	Liquid Nitrate Disposal - Extension of Expiration Date for Authorization	1/11/78
3	Requirement Placed by NRC Upon GE to Submit Decommissioning Plan	1/11/78
---	Requirement Placed by NRC Upon GE to Submit Emergency Plan	2/27/78
4	Addition of Small U-233 Unsealed Alpha Source to Possession Authorization	4/27/78
5	Storage of Unirradiated Return Heel at Storage Locations or Nuclear Reactor Sites in RA Inner Containers	6/6/78

License Amendments

Amendment Number	Subject	Effective Date
6	Liquid Nitrate Disposal - Extension of Expiration Date for Authorization to Coincide with License Renewal Date	7/3/78
7	Change in Description of Nuclear Safety Training Program	10/27/78
8	Submittal of Revised Emergency Plan	4/23/79
9	Decommissioning Plan and Financial Commitment	6/4/79
10	Change in Description of Radiation Safety Training Program	11/6/79
11	Order from NRC to Install and Operate Samples of Airborne Uranium	1/28/80
12	Additional Small Quantity of U_3O_8 Enriched to 93% in U-235 to Possession Authorization	3/5/80
13	Revision in Date for Submittal of Decommissioning Plan	6/24/80

License Amendments

Amendment Number	Subject	Effective Date
14	Revision to Conditions 3,4, and 5 of Amendment 11 (Off-site Sampling of Airborne Uranium)	7/23/80
15	Addition of New On-site Storage Building as an Authorized Place of Use	9/11/80
16	Deletion of Requirement that Sample Processing be Limited to Scrap from GE Owned or Controlled Plants	2/4/81
17	Revision to Description of the Wilmington Technological Safety Council	2/17/81

9.7.1 Significant Changes in Corporate Structure

There have been no changes in General Electric's Corporate structure which impact significantly the production of nuclear fuel at the Wilmington plant or which affect significantly the Wilmington Manufacturing Department.

9.8 Changes in Procedures, Facilities, and Equipment

Administrative controls to ensure that an independent safety review of the proposed activity is performed and documented, prior to the start of any new or changed activity involving licensed material, are described in Chapters 12 and 15.

REFERENCES FOR CHAPTER 9

[1]"Bio-physical Setting of the General Electric Company Lands, New Hanover County, North Carolina," Coastal Zone Resources Corp., 1973.

[2]U.S. Bureau of the Census, "Final Report PC(1)-A-35," North Carolina.

[3]"Industrial Directory," Research Department, Greater Wilmington Chamber of Commerce, Wilmington, N.C.

[4]"North Carolina Agricultural Statistics," North Carolina Departmnet of Agriculture (1971 Issue).

[5]"Preliminary Study of Water Quality Control and Water Supply Development for the General Electric Facility at Wilmington, North Carolina," Hittman Associates, Columbia, Md. (May 1970).

[6]"Geology and Ground-Water Resources of New Hanover County, North Carolina," Ground Water Bulletin 17, North carolina Department of Water and Air Resources (April 1970).

[7]LeGrand, Harry E., "Geology and Ground-Water Resources of Wilmington - New Bern Area," North Carolina Department of Water Resources (1960).

[8]Hubbard, E. F. and W. G. Stamper, "Movement and Dispersion of Soluble Pollutants in the Northeast Cape Fear Estuary, North Carolina," Geology Survey Water-Supply Paper 1873-E.

[9]"Local Climatological Data," Wilmington, N.C., U.S. Department of Commerce, 1971.

[10]Environmental Data Service, National Oceanic and Atmospheric Administration," U.S. Department of Commerce.

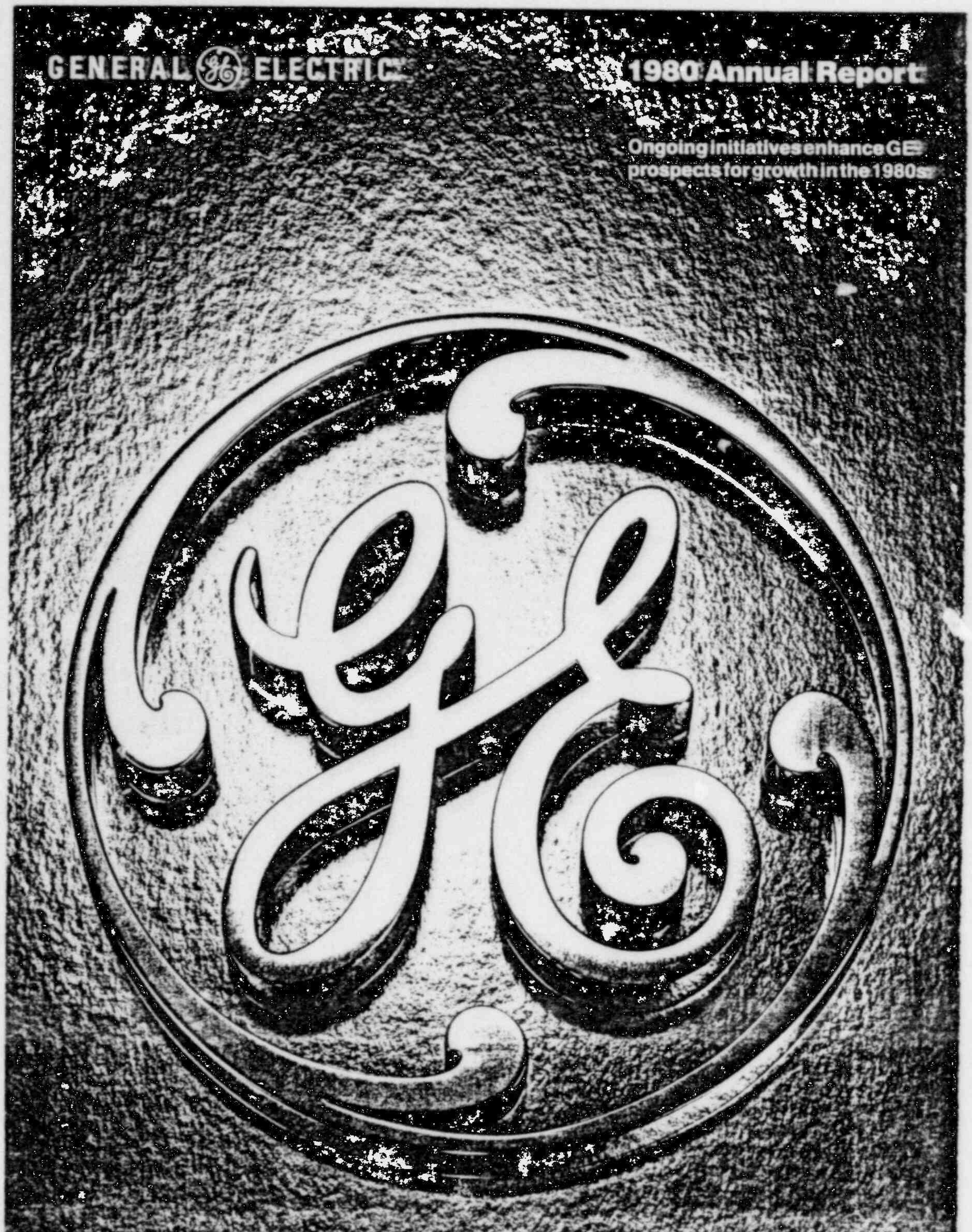
[11]"Preliminary Report on Wind Tide Flooding in N. Hanover County, North Carolina," U.S. Army Corps of Engineers, Wilmington, N.C. District (December, 1969)

[12]"Tornado Occurrences in the United States," U.S. Department of Commerce Technical Paper 20.

[13]"U.S. Department of Commerce NVAA Tornado Central USA," Vol. 22, No. 1.

[14]Bayless, J.D., "Survey and Classification of the Northeast Cape Fear River and Tributaries," North Carolina Wildlife Resources Commission, Raleigh, N.C., 1963.

EXHIBIT 9.1


GENERAL ELECTRIC
1980 Annual Report
Ongoing initiatives enhance GE
prospects for growth in the 1980s

GENERAL ELECTRIC

INVESTOR

Annual Report Issue

General Electric Company
Fairfield, Connecticut 06431

Research and Development

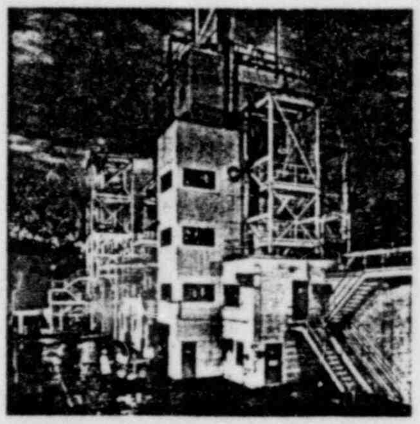
GE R&D expanded in 1980: Continuing to base its sales and earnings growth in large part on innovative technologies, General Electric spent a record $1,598 million on research and development activities in 1980. This included an increase of 19% from 1979 to $760 million in expenditures of the Company's own funds. The balance of $838 million was done under contract, primarily for the U.S. government.

At the corporate Research and Development Center, scientists are playing a key role in the "electronics revolution," producing smaller, faster microcircuits for everything from "intelligent" home appliances to jam-resistant military communications systems. During 1980, they tested an advanced ultrasonic cardiac scanner that can provide moving pictures of the human heart via sound waves.

Higher manufacturing productivity will result from computer and robot technologies in the "factory of the future." The year saw the first tests of a computer-designed injection mold for plastic parts, and a developmental GE robot showed its ability to assemble scores of different types of electric motors. New techniques — some using lasers — were tested for machining tough materials at higher speeds than ever before.

In energy, the Company's R&D efforts focus on clean methods for converting coal into electricity, and on ways to reduce energy consumption. Examples of the latter include new fuel-conserving turbofan aircraft engines; energy-efficient lamps; ac adjustable-speed drives; and energy-saving appliances.

R&D activities pictured below include a unique research facility (left) to study gasified coal-fueled power generation, and studies using interactive graphics to boost productivity by computer-aided design.



GE 1980 Annual Report

Contents

Cover: New luster for the familiar General Electric symbol, the GE monogram, is sought through the wide diversity of growth businesses presented in this Annual Report. Having maintained its earnings momentum through the U.S. recessionary period of 1980, General Electric anticipates a new surge of growth, with the revival of the U.S. and world economies.

Note: Unless otherwise indicated by the context, the terms "GE," "General Electric" and "Company" are used on the basis of consolidation described on page 37. Unless otherwise indicated by the context, the terms "Utah" and "Utah International" mean Utah International Inc., as well as all of its "affiliates" and "associated companies" as those terms are used on page 37.

The 1980 Annual Report is an issue of *The General Electric Investor*, published regularly to inform share owners and investors about activities of the General Electric Company. Others may receive the *Investor* on request.

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Financial highlights

(Dollar amounts in millions; per-share amounts in dollars)		1980	1979	Percent increase
For the year	Sales of products and services to customers	$24,959	$22,461	11%
	Other income	564	519	9
	Total revenues	25,523	22,980	11
	Net earnings applicable to common stock	1,514	1,409	7
At year end	Total capital invested	$10,447	$ 9[illegible]	12%
	Share owners' equity	8,200	7,362	11
	Short- and long-term borrowings	2,093	1,818	15
Per share	Net earnings	$ 6.65	$ 6.20	7%
	Dividends declared	2.95	2.75	7
	Share owners' equity — year end	36.00	32.31	11
Measurements	Operating margin as a percentage of sales	9.0%	9.5%	
	Effective income tax rate	38.4	39.9	
	Earnings as a percentage of sales	6.1	6.3	
	Percent earned on average total capital invested	17.3	17.6	
	Percent earned on average share owners' equity	19.5	20.2	
	Borrowings as a percentage of total capital invested	20.0	19.5	

Comments from the Chairman and the Chairman-elect

"Innovation and self-renewal: these are themes that characterize General Electric as we enter a new era."

The joint signing of these comments signals the approaching change of executive leadership at General Electric. On the retirement of Reginald H. Jones (right) on April 1, 1981, John F. Welch, Jr., will become Chairman and Chief Executive Officer of your Company. He will be the eighth person to hold that office since the founding of GE in the nineteenth century.

John F. Burlingame (middle left) and Edward E. Hood, Jr., continue as Vice Chairmen and Executive Officers with expanded responsibilities for realigned staff and operations.

General Electric's diversity and financial strengths enabled it to turn in a solid performance in 1980 despite adverse economic conditions in the U.S. and many foreign markets. Sales of $24.96 billion represented an 11% increase over 1979. Earnings of $1.5 billion, or $6.65 per share, were 7% above 1979 levels.

The significance of these sales and earnings is not merely that they set new levels in a year when profits for industry generally declined. More importantly, they were achieved in a year when your Company sharply increased investments in new plant and equipment, new technology, new product development and new business ventures.

U.S. business today finds itself challenged by aggressive overseas competitors. National productivity has been declining and, in industry after industry, product leadership is moving to other nations. Companies that refuse to renew themselves, that fail to cast off the old and embrace new technologies, could well find themselves in serious decline in the 1980s.

We are determined that this shall not happen to General Electric.

Self-renewal. Your Company is engaged in a process of internal change that will transform the ways we design, manufacture and distribute our products and services in the 1980s. We are encouraging our people to probe constantly for new markets, new techniques and new business opportunities.

This stress on innovation has been gathering momentum and is perhaps best illustrated by the change in our sources of earnings, as emphasized in last year's Annual Report. As the 1970s began, 80% of your Company's earnings came from its traditional businesses in the manufacture of electrical and electronic equipment. These businesses remain healthy and growing, although they now provide less than half of our earnings. The majority of our earnings are presently derived from growth businesses in man-made materials, natural resources, aerospace and transportation equipment, services and other new lines of opportunity. And 42% of our earnings now come from international activities, compared with only 16% a decade ago.

The status of our current businesses is detailed in the pages of this Annual Report, but to give our share owners a "feel" for the present mood of self-renewal at General Electric, let us comment on the Company's response to several fundamental challenges of the 1980s.

Electronics. There is wide agreement that the new electronics will be the dominant technological force of the 1980s. And so we have been engaged in a Companywide effort to apply the new microelectronics and the related information-based technologies to every possible product, service and process in GE.

The corporate commitment is embodied in hundred-million-dollar investments in the construction and acquisition of new electronics laboratories and manufacturing centers. We have established an Industrial Electronics Group and an Information and Communications Systems Group. GE training programs are under way to bring the thinking of our managers and technical people up to the state of the art in the new electronics, and we are vigorously recruiting more electronic engineers.

The proposed purchase of Calma Company, a leading producer of interactive graphics equipment, and the acquisition of Intersil, a maker of advanced microelectronic chips, are consistent with our intention to be at the leading edge of new technology.

Your management is determined to be a leader in the electronics revolution.

Productivity. After a decade of slow productivity growth, U.S. industry is poised for a major surge of investment in new equipment — the so-called "re-industrialization of America." For GE the process has already begun.

Your Company has invested almost $6 billion over the past five years, including nearly $2 billion in 1980, to upgrade its productive capabilities. Interactive graphics for computer-assisted design, manufacture and test; robotics; programmable electronic controls; energy-efficient drives: these are among the advanced technologies that are transforming our factories into some of the most productive, quality-controlled operations in the world.

And what we develop for our own factories we will then sell to our industrial customers — a productivity-improvement market that is growing well over 20% per annum. With our own factories as a worldwide laboratory for the development of advanced manufacturing systems, and a customer base that urgently feels the need for productivity breakthroughs, GE expects to be a leader in equipping the automated factories of the future.

Energy. From its beginnings, General Electric has been a producer of energy-conversion equipment for electric utilities. But that is now just a modest proportion of our total involvement in the rapidly growing energy field.

Through Utah International's coal mines and Ladd Petroleum's oil and gas wells, as well as our nuclear fuel operations, we are suppliers of basic fuel. Our equipment powers machinery in the mines and drilling fields, our diesel-electric locomotives haul the coal, and our gas turbines power the pipelines.

And as the world strives to reduce its excessive dependence on one energy source — petroleum — GE's research activities seek commercial breakthroughs in significant new energy technologies such as systems to convert coal into clean synthetic fuel gas.

Another profitable facet of the energy market is the redesign of our products to conserve energy — from energy-efficient lamps, appliances and motors to fuel-saving jet engines.

Innovation. Perhaps your Company's commitment to broad-based innovation is best expressed by its rising investment in research and development. Since 1977, we have increased GE-funded R & D expenditures 85% to $760 million. Total R & D expenditures, with external funding, reached $1.6 billion in 1980.

General Electric is not merely in the electrical business, or any other particular business. This Company has moved forward to a new dimension of industrial capability that investors are only beginning to recognize. *We are in the business of creating businesses* to anticipate and serve the needs of a changing world.

This is, at least in scale, something rare. And it can make a constructive contribution to a world that is striving desperately for accelerated economic and social development.

John F. Welch, Jr.
Chairman-elect

Reginald H. Jones, Chairman
and Chief Executive Officer

February 20, 1981

Consumer Products and Services

Earnings are sustained during recessionary period

Paul W. Van Orden
E...utive Vice President and
...r Executive—Consumer
Pro...cts and Services Sector

(In millions)	1980	1979	1978	1977	1976
Revenues*	$5,714	$5,448	$4,865	$4,21[illegible]	$3,510
Net earnings*	407	401	377	323	261
*Includes net earnings of General Electric Credit Corporation	115	90	77	67	57

Consumer Products and Services Sector revenues and earnings were slightly ahead of 1979, despite operating in an environment characterized by a sharp decline in appliance shipments and extremely volatile interest rates. Earnings were led by the strong performance of General Electric Credit Corporation (GECC), the Company's wholly owned nonconsolidated finance affiliate. Sector results reflect effective management actions to control costs, strong consumer acceptance of new products, and an improved balance between product and services businesses.

While sustaining earnings, the Sector continued to fund programs for the development of new products and services to meet consumers' changing lifestyles and the evolving needs of business customers. These programs, designed for future growth, are maintaining a strong emphasis on innovation, quality and productivity improvement.

GECC earnings grew 28% in 1980. As for the product businesses, sustained cost improvement actions and continued emphasis on new and improved products enabled them to outperform the industry and limit their earnings drop to 6%.

In 1980, Sector operations accounted for 22% of GE revenues and 27% of earnings.

General Electric Credit Corporation earned $115 million in 1980, up from $90 million in 1979, and provided 28% of Sector earnings. Growth in earning assets of more than $1.0 billion as well as improved operating efficiencies contributed to the excellent results (see page 40 for condensed GECC financial statements).

With total assets of $9.3 billion, GECC ranks as the largest U.S. diversified financial company. It is the largest nonmanufacturing company in equipment financing and leasing, handling leasing activities ranging from computers to supertankers. Leasing is GECC's fastest-growing business. It pioneered leveraged leasing and is a world leader in that business, with over $5.1 billion of industrial- and transportation-equipment leveraged leases in its portfolio.

GECC also is a leading lender in home products retailing, home equity financing and a wide array of commercial and industrial equipment industries.

Major appliance businesses, serving retail and builder markets with a complete line of GE® and Hotpoint® kitchen and laundry equipment, had lower earnings in 1980 on about the same level of sales as in 1979. The recession, credit restrictions and a weakness in housing severely affected the U.S. major appliance industry, causing 11% lower unit shipments, excluding microwave ovens. General Electric moderated the earnings impact with new productivity programs and strong sales of innovative products. These improvements position these businesses to remain a major contributor to Sector earnings as the Company continues to respond to consumers' changing wants and needs.

Industry unit sales of the microwave oven were up 32% for the year. In this growing business, GE has captured a leadership position with product improvements and customer acceptance of the Spacemaker® unit.

The positive momentum of the dishwasher line was enhanced by strong customer acceptance of the top-of-the-line Model 1200.

To serve customers better, GE placed increased emphasis on product service. In-

Time- and energy-saving products such as those shown above are featured in the Company's ongoing "We Bring Good Things To Life" consumer advertising campaign — which is designed to help make GE an even more visible and valued brand.

home service for more than 100 million GE and Hotpoint major appliances is provided through a network of 135 factory service locations and over 10,000 franchised servicers.

Air conditioning products, affected by the recession, reported lower earnings and sales. Although late-season sales improved sharply in response to hot weather, gains were not sufficient to offset the impact of recession-driven decline in demand and sustained high inflation. However, the market for air conditioning products is expected to improve during the 1980s, led by electric heat pumps which are today's most efficient method of electric heating and cooling.

In 1980, GE introduced a new Executive II two-speed-compressor Weathertron* heat pump with a microprocessor control for automatic adjustments in response to ambient temperature changes.

Lighting operations had slightly lower earnings on somewhat higher sales. Strong performance in most lines did not completely offset substantial declines in markets for photoflash lamps and lamps for automotive uses.

The continuing introduction of innovative and energy-efficient products found excellent reception in both consumer and industrial markets.

GE reinforced its "convert-to-conserve" theme in 1980, emphasizing the energy savings realized by using Lucalox* lighting

New Multi-Vapor® II lamps, illuminating this recently opened department store in Fairfax, Va., deliver lighting at 35% lower energy costs because of their improved efficiency. The new metal halide lamps combine high light output per watt with warm incandescent-like color.

Purchase and renovation of this 24-story high-rise building in Tulsa, Okla., was financed by GECC's real estate financial services operations. The former apartment house has been converted into a 204-unit condominium.

systems. New products included Remote Energy Management (REM™) control for industrial Lucalox® luminaires which uses radio signals to command the luminaires to change wattage settings.

The electronic Halarc™ metal halide lamp is targeted for introduction in 1981. It is the first of a family of long-life lamps that use about one-third as much electricity to generate the same amount of light as the incandescent bulbs they replace.

Additionally, several operations continue to grow outside the lighting industry. General Electric is a major supplier of tungsten and tungsten-carbide powder used in manufacturing cutting tools for metal fabrication, oil drilling and mining. And the Company has become a leading supplier of quartz tubing, rods, boules and crucibles for the semiconductor industry.

Housewares and audio operations increased sales and maintained earnings in a highly competitive industry that experienced significant cost pressures in 1980. Capitalizing on its strong brand-name recognition, GE introduced new products that offer quality with value, including the powerful Food Processor Supreme with a side discharge chute for continuous slicing and shredding, and programmable AM/FM clock radios and ultra-slim portable cassette recorders featuring advanced electronics at affordable prices.

Television receiver operations reported increased sales in 1980 with earnings about the same as the previous year.

Sales of television sets manufactured by General Electric increased for the fifth year in a row. The Widescreen 3000 Home Television Theater, the Company's new projection TV set, played a major role in the surge of interest in projection TV. Sales of video cassette recorders also are on the upswing. In 1980, GE formed joint ventures with three companies to support the U.S. introduction of the VHD video disc system. The home video disc system is expected to be the next major product innovation in consumer electronics.

Broadcasting and cablevision businesses in 1980 set new records in sales and earnings. General Electric operates three VHF television stations and three AM and five FM radio stations. In cablevision, where GE operates 13 systems encompassing 66 franchised communities, customers were added at a 22% annual rate in 1980. GE ended the year with about 260,000 basic-service and 122,000 premium-service customers.

The outlook: With a gradual economic upturn forecast for 1981, and favorable demographics in the '80s, the Sector's product businesses look forward to healthy markets and sustained growth resulting from product innovation and emphasis on quality.

The Sector also sees good opportunities to expand its business participation throughout the decade in the rapidly growing finance and services markets.

Industrial Products and Components

Continued growth for most major businesses

James A. Baker
Executive Vice President and Sector Executive—Industrial Products and Components Sector

(In millions)	1980	1979	1978	1977	1976
Revenues	$5,157	$4,803	$4,124	$3,698	$3,270
Net earnings	315	272	223	191	160

Industrial Products and Components Sector boosted its earnings 16% during 1980 on revenues 7% ahead of 1979. The improved earnings were paced by operations serving transportation, contractor equipment and industrial motor markets, with most major Sector businesses contributing to the growth. Sector operations include motors, industrial electronics, contractor equipment, transportation systems, apparatus service, and supply services for electrical and related products.

During the 1980s, industry's need for new products and services to improve productivity and increase energy supplies will provide favorable opportunities in markets to which the Sector expects to bring continued product leadership and innovation. The industrial electronics field should be a particularly important area for Sector growth.

In 1980, Industrial Products and Components Sector accounted for 19% of total GE revenues and 21% of the year's earnings.

Contractor equipment operations experienced an excellent year, with increased sales and earnings. Strength in commercial construction markets offset the depressed levels of residential construction. Industrial plant and equipment spending remained strong, and international operations showed improvement over the previous year's level.

General Electric manufactures a wide variety of products associated with electrical control, distribution and circuit protection. These GE product lines include low-voltage circuit breakers, motor controls, wiring devices, programmable lighting control, and wire and cable. New products introduced by the Company in 1980 included a line of low-voltage switchgear that provides increased operator safety and improved reliability.

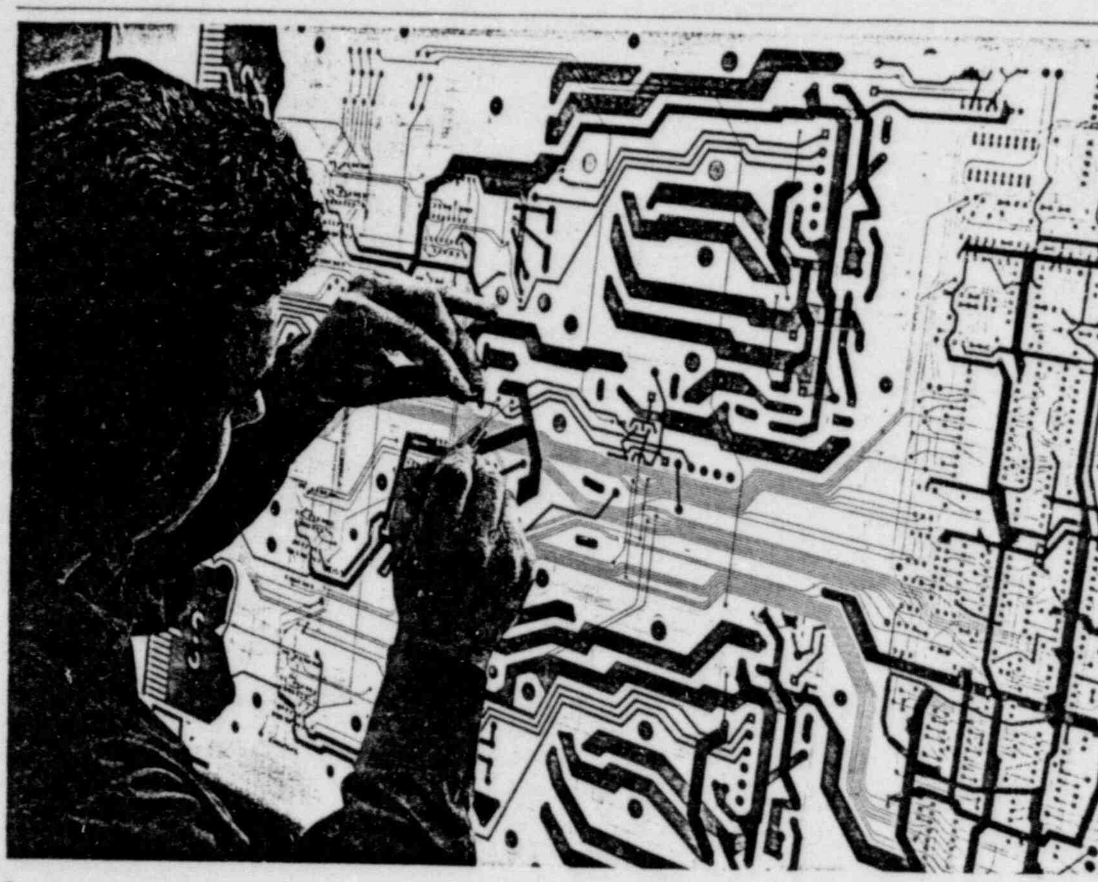
Transportation systems businesses continued to grow as quality suppliers of diesel-electric locomotives, motorized wheels for off-highway vehicles and transit propulsion equipment as well as drilling drives. Earnings improved considerably on slightly higher sales.

International locomotive orders increased in 1980, and the largest contract for locomotives in the Company's history was negotiated with National Railways of Mexico. The ten-year agreement calls for delivery of 60 to 100 locomotives or their component sets each year.

The locomotive line was expanded to include the new B36-7 model which features further improvements in fuel efficiency and pulling power. This 3,600-hp unit uses GE's highly reliable and advanced railroad-type diesel engine. Although the U.S. locomotive market was relatively weak in 1980, over the next few years it is forecast to strengthen. Railroad haulage is expected to increase as a result of both the fuel efficiency advantage of railroads over trucks and increased coal transport.

High levels of mining produced brisk demand for General Electric motorized wheel drives used on haulage trucks. Also, extensive oil-well drilling in 1980 stimulated a sharp increase in demand for the Company's drilling drive systems.

The motor businesses of GE produce a large assortment of motors for residential and industrial applications. In 1980, they had somewhat higher earnings on slightly lower sales. The industrial motor market was strong, reflecting industry's emphasis on productivity and customers' needs for energy-saving motors. The market for high-efficiency industrial motors is growing at more than 60% per year. The component motor market was weak as a result of depressed appliance markets.



Creating new integrated circuits is among the exciting technology programs of Intersil, Inc., a newly acquired affiliate of General Electric that is also a leading producer of microelectronic products.

Because of increased energy exploration worldwide, sales of motors and generators for mining and oil drilling were high. Also, exports of smaller component motors grew dramatically during the year.

Industrial electronics operations had higher sales although earnings were down, reflecting, in part, the impact of new investment programs oriented toward products for factory automation.

General Electric continued its role as a leading supplier of electrical and electronic components and systems to power industry worldwide. New technological developments included a high-efficiency, static, adjustable-speed drive system incorporating the latest microprocessor-based digital control. The system prolongs motor life, and can reduce by up to one-half the amount of power normally consumed by the application of a constant-speed motor.

Among other new GE products offered was the Series Six family of programmable controls, designed to increase productivity and lower costs.

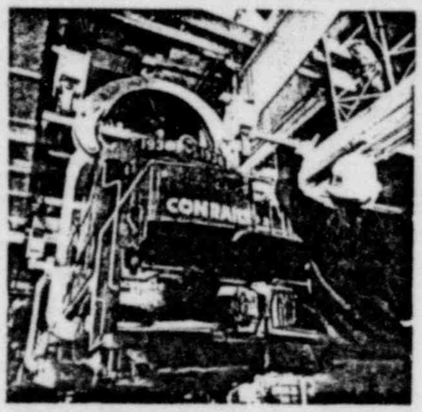
As part of GE's new thrusts in high technology, two electronics-related acquisitions recently were announced. In February 1981, General Electric acquired Intersil, Inc., a leading supplier of advanced integrated circuits and data acquisition and memory products, for $235 million. Intersil will continue as a major supplier to the merchant market as well as a

Increased productivity is the aim of new GE Series Six programmable controls. Equipped with microprocessors, the units guide complex industrial operations such as material handling and process control.

source of integrated circuits for GE's diversified product lines. Also, in December 1980, the Company agreed to acquire Calma Company, a subsidiary of United Telecommunications Inc., for up to $170 million. Calma is a supplier of interactive graphic systems, which include technologies used for computer-aided design and manufacturing.

In addition, a $30 million investment in new electronics capability at Charlottesville, Va., was approved in 1980. Construction will include manufacturing space for industrial controls and a new laboratory to help bolster GE's role in the industrial electronics revolution.

Service and distribution businesses conducted by the Sector include:



...comotive repair and overhaul at the Company's Hornell, N.Y., service shop are part of the offerings of the GE worldwide network of apparatus service shops and affiliates in 19 countries.

- General Electric Supply Company, which reported improved sales for the year. This national network of supply centers provides products of General Electric and other companies to customers in the contractor, industrial, commercial and utility markets.
- Apparatus service shops, sales of which were up, although earnings were lower.

With continued emphasis on expenditures aimed at longer-term growth as well as broadened service offerings, the service shop network was expanded to 197 locations worldwide. The shops provide inspection, maintenance, repair and rebuilding services for industrial equipment manufactured by General Electric and other companies. Forty repair facilities in this international network are concentrating on the fast-growth electronics service market.

The outlook in the 1980s for markets served by Industrial Products and Components Sector is favorable, based on the nation's need for production- and energy-related products.

The Sector has strengthened its competitive position by developing leading-edge products and services, and continues to expand its marketing presence abroad. While some operations may be affected by lingering economic uncertainties, most anticipate improved market conditions. Residential construction markets are forecast to improve, although commercial and industrial construction markets are expected to decline in 1981.

- The U.S. locomotive market is forecast to improve in the early 1980s. International markets, primarily in developing countries with transportation infrastructure needs, should remain strong.
- Continued high levels of mining and oil drilling are expected to sustain demand for motorized wheels, drives and motors.
- Emphasis on energy conservation and productivity should stimulate demand for GE's electronic components and systems.
- Industry's quest for more efficient machine tools and sophisticated production equipment is expected to produce significant GE sales opportunities.
- Growth in worldwide maintenance and repair markets served by General Electric's apparatus service shops is predicted to continue throughout the 1980s.

Power Systems

Earnings growth continues despite slow markets

Herman R. Hill
Executive Vice President and Sector Executive—Power Systems Sector

(In millions)	1980	1979	1978	1977	1976
Revenues	$4,023	$3,564	$3,486	$3,218	$2,998
Net earnings	141	114	93	75	61

General Electric's Power Systems Sector, a world leader in serving markets for electrical generation and power delivery apparatus, increased its 1980 earnings by 24% on a 13% rise in revenues. Good earnings in steam turbine-generator operations and the expanding installation and service engineering business more than offset declines in gas turbine and power delivery operations.

The improved Sector results reflected continued emphasis on productivity gains, increased penetration of international markets, and expansion of equipment maintenance services. Selling price increases only partially offset inflation-driven cost increases.

The Sector's strategy for earnings growth is based on strengthening its leadership in a broad range of energy technologies, and diversifying into new energy technologies such as those related to synthetic fuels and advanced cogeneration.

Power Systems businesses contributed 15% of total GE revenues in 1980 and 9% of net earnings. Presently, high reserve margins of utilities and uncertain national energy policies continue to slow demand for power generation and delivery equipment.

The backlog of unfilled orders was $11.0 billion at the end of 1980, compared with $12.1 billion at the previous year end. The decrease from the 1979 year-end backlog was attributable primarily to elimination of orders for steam turbine-generators no longer expected to go into production, and also to Sector sales that exceeded new orders.

Steam turbine-generator earnings were well up from 1979 on approximately the same level of sales.

As expected, the sluggish demand for large steam turbine-generators caused the level of new orders for these larger units to be lower than in 1979. Notable progress, though, was made in winning domestic industrial cogeneration orders for smaller-size steam turbine-generators.

The orders backlog for steam turbine-generators was $2.7 billion at year-end 1980, of which $1.3 billion is scheduled for shipment after 1985. The comparable backlog for 1979 was $3.9 billion, of which $2.0 billion was scheduled for shipment after 1984.

Mechanical drive turbines showed higher earnings on higher sales compared to 1979. General Electric foresees major long-term growth for this business in international applications such as petrochemical plants and emerging energy technologies involving coal liquefaction and synthetic fuels.

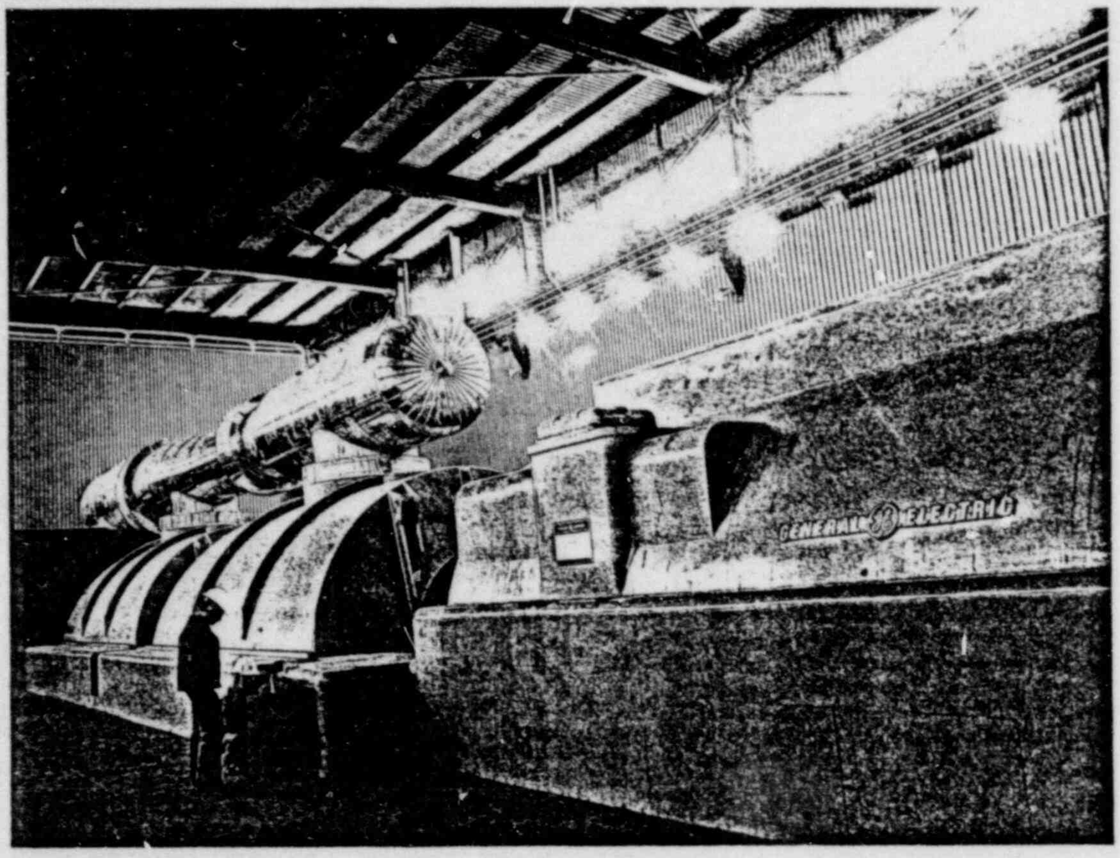
The Sector's marine propulsion business consisted primarily of U.S. Navy projects.

Gas turbine sales were higher but earnings were down, due principally to tighter margins caused by stiff foreign competition. GE gas turbines continued to maintain their world leadership, being used for electric utility peaking and mid-range power, and for industrial applications such as natural-gas pipeline pumping and powering offshore oil platforms.

The Company's highly efficient STAG® (steam and gas) combined-cycle turbine plants continued to be attractive offerings, particularly for foreign customers.

In 1980, the Sector delivered the first of a line of large gas turbines to serve the international electric utility market. This advanced 105-mw heavy-duty gas turbine, the largest such unit ever built by the Company, is now part of a combined-cycle power system operating near Kirchlengern, West Germany.

General Electric announced in 1980 that it



Export orders of GE steam turbine-generators have included two 550-mw units for Spain's Castellón power plant, a coal-fired installation located on the eastern Mediterranean coast.

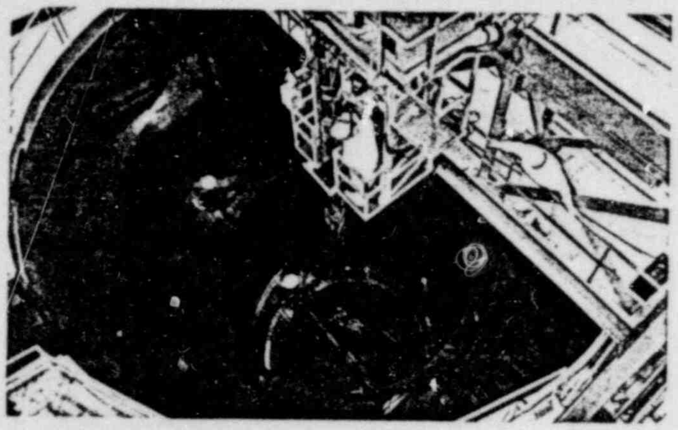
is participating in a $300 million coal gasification/combined-cycle demonstration plant. Planned for completion in 1983, this 100-mw facility is designed to convert coal to synthetic gas, then clean and burn it to provide economical electricity. GE also is supplying the gas and steam turbine-generators for this electric power plant.

Nuclear operations continued to incur a modest loss. As stated in previous Annual Reports, GE is making substantial expenditures on engineering and development in support of nuclear projects in the backlog. These expenditures, added to the effects of deferments of shipments and cancellations of nuclear orders, are expected to result in continuing losses for this business.

Nevertheless, the nuclear fuel fabrication and services segments of the business are profitable, and the nuclear fuel and services needs of U.S. and foreign utilities offer ongoing opportunities. Additional large orders for fuel were received in 1980, and Power Systems' installation and service engineering business, in cooperation with the nuclear business, has expanded GE's nuclear services offerings.

The backlog of orders, including nuclear reactors, fuel assemblies and plant services, totaled $5.5 billion at year-end 1980, of which $1.9 billion is scheduled for shipment after 1985. The comparable backlog for 1979 was $5.3 billion, of which $2.5 billion was

Synthetic-fuels development at GE includes work on an ultra-high-temperature, water-cooled gas turbine which would be installed in advanced synfuels plants. Plans call for this highly efficient "Super-turbine" to be ready by the late 1980s.



To provide GE nuclear field engineers and utility personnel with hands-on training in various aspects of reactor refueling and maintenance, GE in 1980 built a reactor services training center in San Jose, Calif.

scheduled for shipment after 1984. Some fuel orders include reprocessing, plutonium fabrication and waste disposal services. In view of current U.S. government policies, it is highly uncertain whether such services can be provided.

In the U.S., cancellations of nuclear plants have substantially outnumbered new orders during the last six years. General Electric's management believes that resumption of nuclear orders will depend not only on renewed demand for electric generating equipment, but also on government action. Such action is needed to reform the nuclear licensing process and resolve existing uncertainties regarding such issues as radioactive waste storage as well as nuclear export policy.

Installation and service engineering businesses reported record orders, sales and earnings in 1980. This continued growth was achieved by expanded offerings of field engineering and project management services in major domestic and international markets.

Highlights during 1980 included increased participation in domestic nuclear and fossil plant installations as well as in maintenance and refueling; success in developing a market to upgrade older electrical and electronic equipment; and penetration of offshore equipment-maintenance opportunities.

Power delivery businesses, producing transformers, power circuit breakers, switchgear and meters, continued to be depressed, with inadequate recovery of cost increases resulting in lower earnings. To overcome problems of utility overcapacity, a slowdown in residential construction, and inflationary costs which are not completely recoverable through price increases, these GE operations are working to improve their margins by stressing productivity programs to reduce costs and improve efficiency.

Utility load management, an attractive means of energy conservation, represents a growth opportunity, and the Company is positioned to take advantage of this market. By year-end 1980, 18 utilities had purchased GE's newest time-of-use meter, and the Company continued the commercial introduction of its Automatic Meter Reading and Control (AMRAC™) load management system.

The outlook. Power Systems Sector earnings are sensitive to electrical load growth. To offset the relatively low load growth forecast and achieve satisfactory results, the Sector has embarked on major programs to improve productivity and develop new businesses.

General Electric intends to play a major role in whatever forms of energy-related equipment and services are required in the 1980s and '90s.

Over the long term, significant growth opportunities are foreseen as the nation comes to grips with its imported-oil problem. GE is a leader in many energy technologies, and is aggressively pursuing a wide range of advanced energy development activities.

Technical Systems and Materials

Most businesses grow; investments for future continue

Christopher T. Kastner
Executive Vice President and Sector Executive—Technical Systems and Materials Sector

(In millions)	1980	1979	1978	1977	1976
Revenues	$7,128	$6,061	$4,745	$4,145	$3,688
Net earnings	373	356	278	248	202

The high-technology businesses constituting the Technical Systems and Materials Sector had an 18% increase in revenues during 1980. Earnings were 5% ahead of the 1979 level as strong performances in aircraft engines and information and communications systems offset weakness in markets for engineered materials.

During 1980, the Sector continued to make heavy investments in advanced technologies, including microelectronics and engineered materials, which are expected to be important factors in General Electric's future growth.

The Sector accounted for 27% of total GE revenues and 24% of earnings in 1980.

Aircraft engine businesses serving the highly competitive commercial, military, marine and industrial markets produced strong sales and earnings increases.

High fuel costs and intensified competition among airlines stimulated demand for new aircraft with engines of improved efficiencies. GE commercial engines for this market include the CF6-80, which was selected by several airlines to power their Boeing 767 and Airbus Industrie A310 jetliners. Overall, 75 customers have now selected the CF6 or CFM56 for their high-bypass-engine-powered aircraft.

Seven airlines and the French Air Force have placed orders to re-engine their DC-8 aircraft with CFM56 engines jointly developed by the Company and SNECMA, the French engine manufacturer. A smaller fan version of this engine, the CFM56-3, has been offered to power new and derivative twin-engine aircraft.

In 1980, significant milestones in small commercial engines also were reached. The CT7 turboprop engine was chosen to power its first commuter-sized aircraft, the SAAB-Fairchild 34C, and initial orders were received for CT7 turboshaft engines to power the Bell Textron 214ST helicopter. Production go-ahead was announced on the Canadair Ltd. Challenger E executive jet powered by CF34 turbofans.

In military markets, production continued on the F404 turbofan engine for the U.S. Navy's F/A-18, and Canada became the first non-U.S. customer to select this new fighter aircraft. The F404 and F101 DFE advanced fighter engines completed unprecedented durability tests. Both the F101 DFE and a new model of the J79 turbojet flew for the first time in U.S. Air Force F-16s. Flight testing also began on the U.S. Air Force KC-10 tanker powered by the CF6-50, and the CFM56 engine was selected for a program aimed at re-engining KC-135 tankers.

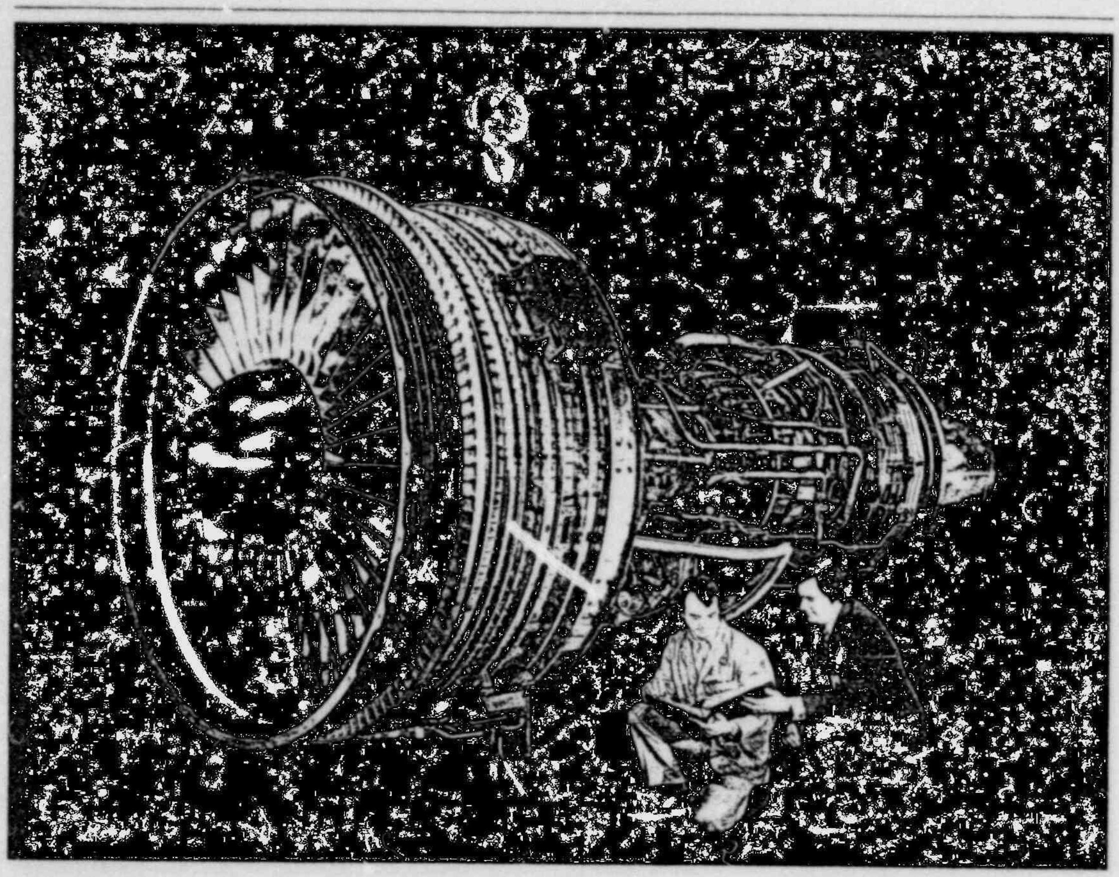
Sales of aircraft engine derivatives continued on the upswing. The U.S. Navy received its 30th Spruance Class destroyer powered by four LM2500 engines, while initial LM2500 deliveries were made for the Aegis cruiser. In industrial markets, large orders were received from Mexico and India for the LM2500 engine.

Aerospace operations increased their sales and earnings in 1980. Technologies of this business, which principally involve U.S. government contracts, span the space sciences, electronics and microelectronics, avionics, computer software and control systems.

In 1980, GE installed its first solid-state, three-dimensional radar system in Belgium as part of NATO's air defense network, and continued work on units for the U.S. Air Force, U.S. Marine Corps and the United Kingdom.

In space technology, GE is the prime contractor for developing Landsat D, a NASA earth-resources satellite, and DSCS III, an advanced defense communications satellite.

In avionics, including aircraft instruments



New CF6-80A turbofan engine under development by the Company is designed to provide takeoff thrust of 48,000 pounds for the Boeing 767 and Airbus Industrie A310 transports.

and controls, digital systems are being tested for the Boeing 767 and 757 aircraft and the Navy F/A-18 jet fighter.

Information and communications systems operations continued their strong increase in sales and earnings during the year.

General Electric Information Services Company (GEISCO) increased its business applications in anticipation of ongoing changes in the computer industry and in customer needs. It broadened its market by expanding into manufacturing resource planning and by introducing an electronic purchase ordering system linking major retailers with large suppliers.

GEISCO strengthened its position as a supplier of total data processing services through new moves into the software and services segment of the industry. Continued internal developments were complemented by external acquisitions which provide entry into new areas of systems design, advanced software and services.

The GE mobile communication products business produced strong gains in both sales and earnings. Demand for this equipment continued in both domestic and foreign markets.

Engineered materials increased sales in 1980. Although earnings were down due to inflation-driven cost increases and lower volume in depressed consumer-related markets, these businesses contributed a major share to

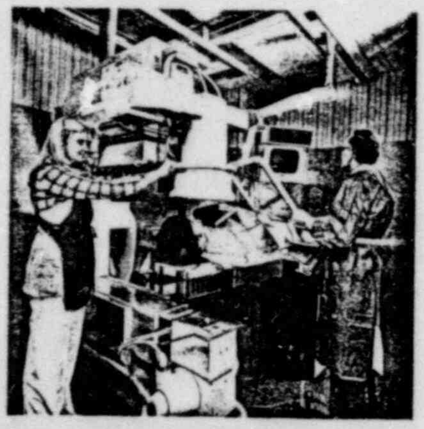
Sector earnings. General Electric high-performance materials encompass engineered plastics, silicone chemicals, tungsten-carbide metals, Man-Made® diamonds, Borazon® abrasives and electro-materials such as laminates and rechargeable batteries.

The Company continued to be a world leader in supplying high-technology engineered plastics. While slow auto sales affected plastics volume, this was partially offset by strong international demand and higher penetration of new markets.

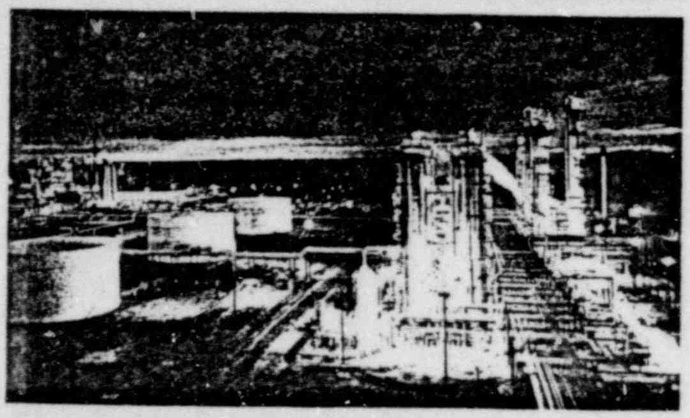
Among significant facility additions was a new phenol plant at Mt. Vernon, Ind., that began operation in late 1980. Production of phenol, a key raw material required for several GE plastics, will help assure supply while improving costs and maintaining high quality.

Emphasis on increased productivity in metal-working industries continued to bring opportunities for the Company's line of tungsten-carbide metals and Man-Made industrial diamonds for metal-cutting tools. Record oil-drilling activity stimulated strong demand for Stratapax® diamond drill blanks.

GE's new L/U-Angio diagnostic x-ray system helps doctors examine the circulatory system of the head and body with a high degree of ease and accuracy. Another version h[illegible]s diagnose coronary artery disease.



A new phenol plant at Mt. Vernon, Ind., will help provide both GE's supply of vital feedstocks and timely customer delivery of many GE plastics.



Medical systems businesses, supplying diagnostic imaging and patient monitoring equipment and services, had higher sales and earnings in 1980. International operations are expected to be aided by the acquisition of significant portions of the Thorn-EMI Medical sales and service operations outside the U.S. This acquisition reinforces the Company's ability to market and support its high-technology medical products in international markets.

Orders for General Electric's computed tomography (CT/T®) scanners increased markedly during the year, with significant contributions from many major world markets.

In ultrasound diagnostics, the Datason B® scanner received an enthusiastic reception.

A GE Microelectronics Center was authorized in 1980 and is being constructed at Research Triangle Park, N.C. The $55 million facility will develop and produce advanced microelectr[illegible] components for GE products, and is desig[illegible]d to strengthen the Company's capabilities in custom integrated circuits.

The outlook for the variety of markets served by Technical Systems and Materials Sector is favorable over the long term. While sales of engineered materials were affected by the short-term decline in U.S. markets during the year, some improvement is expected in 1981.

While the airline industry is undergoing financial difficulties, prospects for new engine sales remain good because of the need for improving fuel economy.

Government markets for defense-related technology, services, and research and development should continue to expand.

Information services and communication equipment markets are expected to maintain their steady growth curves.

Emphasis on improved medical diagnostic procedures should sustain demand for high-technology medical systems.

Natural Resources

Record results from energy and mineral operations

Alexander M. Wilson
Chairman of the Board
and Chief Executive Officer—
Utah International Inc.

(In millions)	1980	1979	1978	1977	1976
Revenues	$1,374	$1,260	$1,032	$965	$1,003
Net earnings	224	208	180	196	181

General Electric's natural resources operations, chiefly Utah International Inc., in 1980 set records for both revenues and earnings. Earnings were up 8% on 9% higher revenues. These operations provided 5% of total GE revenues and 15% of earnings for 1980.

Earnings improvements were paced by oil and natural gas, iron ore, copper, domestic coal and ocean shipping operations — more than offsetting lower earnings for coking coal and uranium.

Continued growth is expected in the 1980s due to Utah's established position as a leading low-cost producer of energy and mineral resources, and because of vigorous ongoing exploration and development programs.

At year-end 1980, the sales backlog for minerals, including uranium, was $6.8 billion, of which $5.7 billion was scheduled for shipment after 1981. All contracts making up this backlog are payable in U.S. dollars.

Approximately 80% of 1980 natural resources revenues and 73% of net earnings originated from operations outside the U.S.

For additional information about certain of Utah's natural resources, see page 31.

Australian coking coal activities, although realizing somewhat lower earnings in 1980, continued to be Utah's major earnings source. Utah owns 89% of Blackwater Mine and 68% of four other Utah-operated open-cut coking coal mines, including Norwich Park Mine which had its first full year of production in 1980. In addition, the company owns 68% of the comparatively small underground Harrow Creek Mine.

A two-year labor agreement reached in July 1980 between management and the mining unions reflects an improved industrial climate at Utah's operations. Production, though, was interrupted for 10 weeks during the third quarter when employees protested a government-proposed tax on subsidized housing.

Utah seeks expansion of its coking coal activities and is investigating the feasibility of developing other mine sites near present operations. Utah-operated coking coal mines now have total annual production capacity, including partners' shares, of about 23 million metric tons.

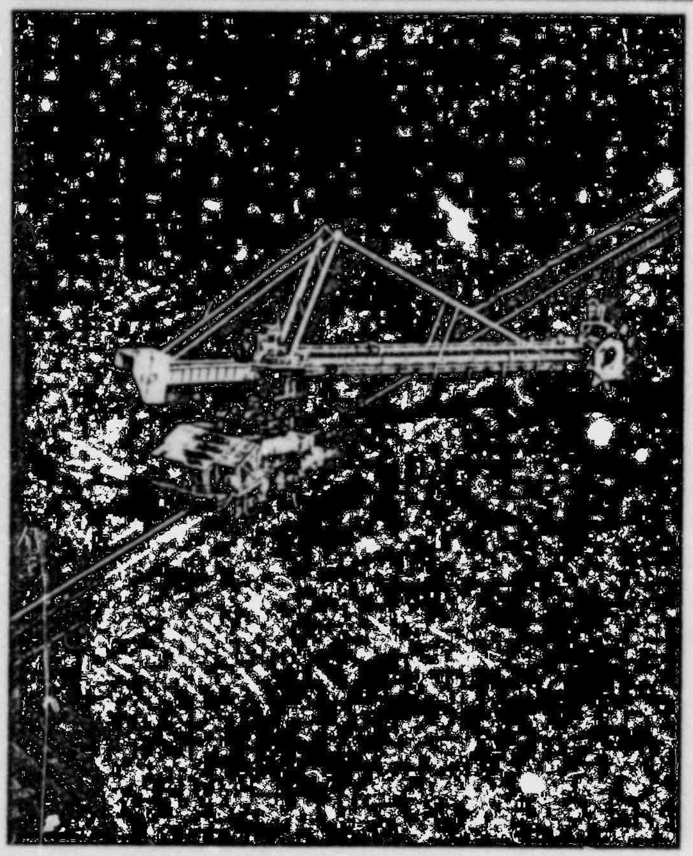
Oil and natural gas operations of Ladd Petroleum, Utah's oil and gas affiliate, produced record revenues and earnings for the year. Higher prices for petroleum products was the primary reason for improved results. Ladd's activities are located in 16 states and three Canadian provinces, and Ladd is a participant in four foreign exploration joint ventures. Drilling and acquisition programs during 1980 expanded its property and reserve positions.

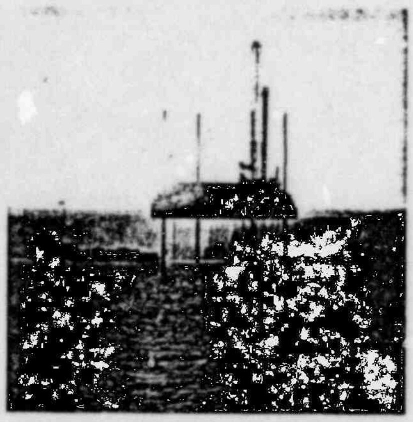
Iron ore activities made a small contribution to earnings in 1980. The largest operation is the Brazil-based Samarco, in which Utah owns 49% of the voting stock and provides debt guarantees. It operated at a break-even level in 1980 compared with a loss in 1979.

Domestic coal mining operations also contributed to the 1980 earnings gain, principally due to increased steam coal shipments from the Navajo and San Juan Mines located in the Four Corners area of New Mexico.

In 1980, Utah acquired the coal leases at San Juan, where previously it had operated under a mining contract, and it completed its purchase from National Steel Corporation of coal reserves in Kentucky and West Virginia.

Copper mining operations at Island Copper Mine in British Columbia, Canada, reported rec-





Clockwise from upper left: at Hay Point port in Australia, coal blended and recovered from large stockpiles by rail-mounted stackers/reclaimers is fed to shipping berths via conveyer belts. In the Gulf of Mexico near Galveston, Texas, and in other locations, Ladd Petroleum is stepping up exploration and development efforts. At Brazil's Point Ubu, Samarco iron ore pellets are loaded aboard large bulk carriers.

ord earnings in 1980. Earnings gains were due primarily to good price realizations for copper early in the year and higher prices for one of the mine's by-products, gold.

Uranium mining operations are conducted in Wyoming by Pathfinder Mines Corporation, a wholly owned nonconsolidated subsidiary, all of whose common stock is held by independent trustees (see note 12 to financial statements). Pathfinder's increased loss during 1980 reflected sharply higher operating costs combined with the low prices received as final deliveries were made under contracts signed in the early 1970s. In 1981, Pathfinder is expected to begin making deliveries on higher-priced sales contracts. Longer-term prospects are clouded by current market weakness, and future improvement is uncertain.

In other activities, ocean transportation operations, carried out in support of Utah's product marketing, realized improved results in 1980. Land development activities were less profitable than the previous year.

The outlook for Utah International's businesses is enhanced by expected long-term growth in world demand for its products. Recognizing this opportunity, Utah is intent upon expanding its current operations. Substantial increases in 1980 exploration and development expenditures reflect management's optimism about future market prospects.

International

U.S. export sales show strong rise; international business increases

Robert R. Frederick
Executive Vice President and Sector Executive—International Sector

Foreign multi-industry operations (in millions)	1980	1979	1978	1977	1976
Revenues	$3.234	$2,901	$2.767	$2.562	$2.334
Net earnings	68	65	78	71	75
Total international operations — all Sectors					
Revenues outside the U.S.	$9.597	$7,840	$7.014	$6.138	$5.567
Net earnings	639	526	486	415	445

General Electric's total international business from its six Sectors in 1980, which is summarized above, reported a 21% earnings rise on a 22% increase in revenues. International operations accounted for 38% of GE revenues and 42% of earnings.

Demand for a wide range of sophisticated products and services needed by the world's economies is expected to continue to make international business a major contributor to General Electric earnings.

The Company's international business is composed of four broad categories of activities: foreign multi-industry operations; U.S. exports of General Electric products and services; operations of nondiversified foreign affiliates including the foreign operations of Utah International; and technology licensing revenues.

A summary of international revenues appears below. Revenues from U.S. exports, operations of nondiversified foreign affiliates and technology licensing also are included in the amounts reported by the appropriate product Sectors elsewhere in this Report.

International revenues

(In millions)	1980	1979
Foreign operations and licensing	$5.816	$5.068
U.S. exports to:		
Unaffiliated customers	$3.781	$2.772
Affiliated companies	484	467
	$4.265	$3.239

Foreign multi-industry operations had generally good results in 1980 despite difficult economic conditions in many of the countries served. These operations are the direct responsibility of the International Sector and consist primarily of affiliates producing varied lines of products for local and export markets. They also include international construction operations.

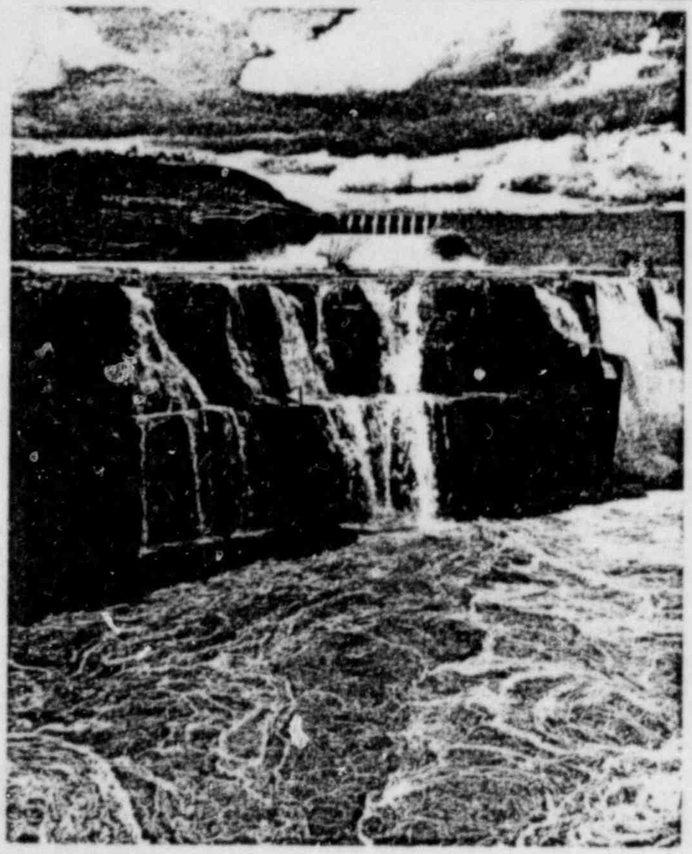
Canadian General Electric Company Ltd., largest of the multi-industry affiliates, reported 1980 earnings significantly higher than those of 1979 on modestly higher sales. Improvements in electrical apparatus and construction products were partially offset by declines in consumer operations.

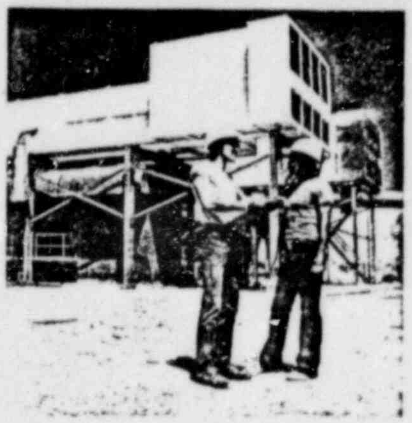
Latin American affiliate earnings were ahead of 1979, primarily because of strong consumer and industrial markets in Mexico and Venezuela.

Elsewhere, operating profit of restructured Italian operations improved. The Spanish affiliate continued in a loss position, largely as a result of depressed local economic conditions. Operations in Africa, the Middle East and Far East generally improved and continued to provide significant assistance in "pulling through" more orders for U.S. exports.

International construction opera[illegible] had increased sales in 1980 with earning[illegible] about the same as the prior year.

Export sales to external customers by General Electric's domestic business operations, assisted by marketing and financial services provided by the International Sector, were up $1.0 billion in 1980, 36% more than in the previous year. This sharp increase was led by high-technology products including





Clockwise from upper left: Brazil's hydroelectric power station, Salto Santiago, under construction on the Iguaçu River, includes turbines designed and built by Canadian GE and GE do Brasil. In Kimberly, Wis., high-quality paper products are manufactured using papermaking drives, motors and gears from Canadian GE. Helping carry out Mexico's electrification plan, GE recently sold six gas turbines to the national utility, including these advanced design 27-mw units in Ciudad Juárez.

aircraft engines and gas turbines.

As one of the nation's leading exporters, General Electric had total exports of $4.3 billion in 1980, which exceeded its direct imports by approximately $3.3 billion, thereby helping offset the unfavorable U.S. trade balance.

The backlog of Company orders from unaffiliated customers for exports from the U.S. again increased, from $4.6 billion in 1979 to $5.1 billion for 1980.

The outlook. Prospects for continued growth of General Electric's international business in 1981 are partly attributable to the Company's wide geographic diversity. After some slowdown in early 1981, economies of major foreign industrial countries and of some of the newly industrializing nations are expected to strengthen in the latter half of the year. This should provide an advantageous economic environment for General Electric operations in those countries, and is expected to stimulate demand for GE's exports from the U.S.

GE operations expect to continue their growth by expanding from their strong bases into countries with high levels of GNP growth — principally the oil-rich nations and several industrializing countries. In addition, International Sector has made notable progress in strengthening its affiliates, by selectively allocating resources to emerging markets which offer maximum potential.

Board of Directors

General Electric's Board of Directors conducted 11 meetings in 1980. The October meeting took place in Houston, Texas, where Board members also attended the 1980 share owners' Information Meeting.

Specific Board attention was directed to proposed programs relating to the Company's strategies for strengthening its electronics capability — an increasingly important factor in today's competitive business environment.

In May, the quarterly dividend was increased by the Board, from 70 to 75 cents per share.

The seven Committees of the Board, listed at lower right, are designed to help the full Board keep pace with the growing scope and complexity of its responsibilities by concentrating on specific areas of interest:

- The Audit Committee, made up entirely of Directors from outside the Company, met four times. Its reviews included those of activities of both the Independent Public Accountants and the Corporate Audit Staff. At a joint meeting with the Finance and Operations Committees, the 1979 Annual Report and the 1980 Proxy Statement were approved.
- The Finance Committee, meeting four times, reviewed the Company's financial position, its investments, and the operations of the General Electric Credit Corporation.
- The Management Development and Compensation Committee held ten meetings and reviewed and approved changes in GE's


John E. Lawrence


Walter B. Wriston


Ralph Lazarus


Gilbert H. Scribner, Jr.


Edmund W. Littlefield


J. Paul Austin


Reginald H. Jones


James G. Boswell II


Charles D. Dickey, Jr.


Henry L. Hillman

John E. Lawrence, President, James Lawrence & Co., Inc., cotton merchants, Boston, Mass. (1957)

Walter B. Wriston, Chairman of the Board and Director, Citicorp and Citibank, N.A., New York, N.Y. (1962)

Ralph Lazarus, Chairman of the Board and Director, Federated Department Stores, Inc., Cincinnati, Ohio (1962)

Gilbert H. Scribner, Jr., Chairman of the Board and Director, Scribner & Co., real estate and insurance, Chicago, Ill. (1962)

Edmund W. Littlefield, Chairman of the Executive Committee and Director, Utah International Inc., San Francisco, Calif. (1964)

J. Paul Austin, Chairman of the Board and Director, The Coca-Cola Company, Atlanta, Ga. (1964)

Reginald H. Jones, Chairman of the Board, Chief Executive Officer and Director, General Electric Company, Fairfield, Conn. (1971)

James G. Boswell II, Chairman of the Board, Chief Executive Officer and Director, J. G. Boswell Company, farming and related businesses, Los Angeles, Calif. (1971)

Charles D. Dickey, Jr., Chairman of the Board, Chief Executive Officer and Director, Scott Paper Company, Philadelphia, Pa. (1972)

Henry L. Hillman, President and Director, The Hillman Company, diversified operations and investments, Pittsburgh, Pa. (1972)

Henry H. Henley, Jr., Chairman of the Board, Chief Executive Officer and Director, Cluett, Peabody & Co., Inc., manufacturing and retailing of apparel, New York, N.Y. (1972)

Silas S. Cathcart, Chairman of the Board and Director, Illinois Tool Works Inc., diversified products, Chicago, Ill. (1972)

Samuel R. Pierce, Jr., Partner, Battle, Fowler, Jaffin, Pierce and Kheel, law firm, New York, N.Y. (1974)

Gertrude G. Michelson, Senior Vice President, External Affairs, R. H. Macy & Co., Inc., retailers, New York, N.Y. (1976)

Lewis T. Preston, Chairman of the Board and Director, J. P. Morgan & Co. Incorporated and Morgan Guaranty Trust Company, New York, N.Y. (1976)

George M. Low, President, Rensselaer Polytechnic Institute, Troy, N.Y. (1977)

Richard T. Baker, Consultant to Ernst & Whinney, public accountants, Cleveland, Ohio (1977) executive compensation and management.

• The Nominating Committee met three times. It assessed candidates for directorships and the memberships of other Board Committees.

• The Operations Committee met five times. At one session, a joint meeting with the Technology and Science Committee at the Company's Plastics Business Operations facility in Mt. Vernon, Ind., it conducted a business review of the Engineered Materials Group, including perspectives on the Group's anticipated financial performance through 1985.

• The Public Responsibilities Committee held two meetings and reviewed key public issues affecting the Company and the current status of the evolving national energy policy.

• The Technology and Science Committee met twice, concentrating on those areas of technological development promising the most significant progress for the Company.

The Board is made up primarily of Directors from outside GE. The 1980 Board members are listed at lower left in order of their Board seniority, with the year in which they were elected shown in parentheses. Besides Mr. Jones, three other directors are not candidates for re-election. Messrs. Lawrence and Austin are retiring from the Board after 23 and 16 years of service, respectively. Mr. Pierce has resigned to become U.S. Secretary of Housing and Urban Development.


Henry H. Henley, Jr.


Silas S. Cathcart


Samuel R. Pierce, Jr.


Gertrude G. Michelson


Lewis T. Preston


George M. Low


Richard T. Baker


John F. Burlingame


Edward E. Hood, Jr.


John F. Welch, Jr.

John F. Burlingame, Vice Chairman of the Board, Executive Officer and Director, General Electric Company, Fairfield, Conn. (1980)

Edward E. Hood, Jr., Vice Chairman of the Board, Executive Officer and Director, General Electric Company, Fairfield, Conn. (1980)

John F. Welch, Jr., Chairman-elect and Director, General Electric Company, Fairfield, Conn. (1980)

Committees of the Board

Audit Committee
Richard T. Baker, *Chairman*, John E. Lawrence, George M. Low, Samuel R. Pierce, Jr., Lewis T. Preston

Finance Committee
Edmund W. Littlefield, *Chairman*, Reginald H. Jones, *Vice Chairman*, Charles D. Dickey, Jr., Henry H. Henley, Jr., Gilbert H. Scribner, Jr., Walter B. Wriston

Management Development and Compensation Committee
Ralph Lazarus, *Chairman*, J. Paul Austin, Silas S. Cathcart, John E. Lawrence, Walter B. Wriston

Nominating Committee
Charles D. Dickey, Jr., *Chairman*, J. Paul Austin, Henry H. Henley, Jr., Ralph Lazarus, Edmund W. Littlefield, George M. Low, Gertrude G. Michelson

Operations Committee
Henry L. Hillman, *Chairman*, John F. Welch, Jr., *Vice Chairman*, James G. Boswell II, Silas S. Cathcart, Gertrude G. Michelson, Samuel R. Pierce, Jr., Lewis T. Preston, Gilbert H. Scribner, Jr.

Public Responsibilities Committee
Henry H. Henley, Jr., *Chairman*, John F. Burlingame, *Vice Chairman*, Richard T. Baker, Henry L. Hillman, Ralph Lazarus, Gertrude G. Michelson, Samuel R. Pierce, Jr.

Technology and Science Committee
George M. Low, *Chairman*, Edward E. Hood, Jr., *Vice Chairman*, James G. Boswell II, Charles D. Dickey, Jr., Henry L. Hillman, Edmund W. Littlefield

GE people

Company domestic employment, including consolidated affiliates, averaged 285,000 during 1980, about the same as 1979.

An analysis of domestic GE and General Electric Credit Corporation employment for the year ended September 30 demonstrates the Company's active support of U.S. progress toward improved career opportunities for women and minorities. The number of women managers increased from 1,288 to 1,478 — up 15%. The number of minority managers increased 8%, from 1,332 to 1,432. The total of women professionals went up from 4,690 to 5,349, an increase of 14%, while the number of minority professionals climbed from 3,348 to 3,663 — up 9%. More than 19,000 women and 9,000 minorities were promoted in 1980. Overall, women account for 28% of General Electric employees, and minorities 12%.

Wages and benefits for GE employees continue to provide a competitive total compensation package. In 1980, the new Dental Assistance Plan was introduced as an additional benefit for employees and their dependents.

Adjustments in the pensions of retired employees were approved by the Board of Directors. Effective February 1, 1981, a maximum increase of 10% was applied to the pensions of those who retired on or before May 1, 1979, and smaller increases were applicable to employees who retired after May 1, 1979, and before the February 1, 1981, effective date. This marks the third pension increase for GE retired employees in the last four years.

Medical care for the Company's retirees was also enhanced with the introduction of a new prescription drug plan and improved medical insurance provisions.

At plant locations such as the GE computer center in Bridgeport, Conn., employees show minority students the opportunities for careers in science and engineering.

GE's occupational safety and health record and experience compare favorably with those for companies in similar businesses. In 1980, General Electric continued to emphasize people-oriented safety programs and health-hazard education.

Contributions to philanthropic organizations by the Company and the General Electric Foundation totaled $13 million. The GE Foundation's annual report will be available in April upon request. Included in the Foundation's contributions were $1,050,000 for minority engineering programs, a major part of an effort to improve career education.

A Companywide survey identified 80 programs in 48 GE plant communities where GE business operations are contributing to local minority engineering activities and scholarships. These efforts helped lead to steady progress in the national effort, which in 1980 resulted in B.S. degrees in engineering for 2,383 minority students — a 90% increase since the program began in 1973.

Strengthening the technical work force of General Electric is a key ongoing objective. Efforts to recruit, retain and retrain the professional and managerial people needed for the changing GE of the 1980s are aggressively under way. During the year, the Company's new two-year Edison Engineering Program — designed to provide entry-level training opportunities for engineers — saw its first graduates.

Management

Marking a carefully planned succession of executive leadership, the Board of Directors in December named John F. Welch, Jr., as Chairman, effective April 1, 1981. He will succeed Reginald H. Jones as Chairman and Chief Executive Officer on that date, when Mr. Jones retires after 41 years of outstandingly effective service with General Electric.

John F. Burlingame and Edward E. Hood, Jr., continue as Vice Chairmen of the Board and Executive Officers reporting to the Chairman-elect, with realigned and increased responsibilities. Reporting to Mr. Burlingame are the International Sector, Power Systems Sector, Utah International Inc., Corporate Planning and Development Staff, and Corporate Relations Staff. Reporting to Mr. Hood are the Consumer Products and Services Sector, Industrial Products and Components Sector, Technical Systems and Materials Sector, Corporate Production and Operating Services, and Corporate Technology Staff.

These executives head the team of 141 managers on this and the following two pages.

Integration of the programs of these senior managers is aided by two management groups: the Corporate Policy Board made up of the Chairman, Chairman-elect, Vice Chairmen and the six Senior Vice Presidents pictured at right; and the Corporate Executive Council which includes these same ten officers plus the six Executive Vice Presidents and Sector Executives pictured earlier in this Annual Report with their Sector reviews.

The 12 other Senior Vice Presidents, pictured on pages 26 and 27 along with the President of GECC, provide management for groups of General Electric businesses.

The continued availability of broadly experienced leadership for General Electric in the future is being achieved through a diverse program of learning opportunities provided by the Company worldwide.

Corporate Policy Board

Reginald H. Jones
Chairman of the Board and Chief Executive Officer

John F. Welch, Jr.
Chairman-elect

John F. Burlingame
Vice Chairman of the Board and Executive Officer

Edward E. Hood, Jr.
Vice Chairman of the Board and Executive Officer

Arthur M. Bueche
Senior Vice President Corporate Technology

Daniel J. Fink
Senior Vice President Corporate Planning and Development

Robert B. Kurtz
Senior Vice President Corporate Production and Operating Services

Leonard C. Maier, Jr.
Senior Vice President Corporate Relations

Walter A. Schlotterbeck
Senior Vice President General Counsel and Secretary

Thomas O. Thorsen
Senior Vice President Finance


Arthur M. Bueche


Daniel J. Fink

Corporate Staff Officers

Thomas R. Casey, M.D.
VP & Company Medical Director

James J. Costello
VP & Comptroller

James R. Donnalley, Jr.
VP – Corporate Environmental Issues Project

Frank P. Doyle
VP – Corporate Employee Relations

Dale F. Frey
VP & Treasurer

Fred W. Garry
VP – Corporate Engineering

Marion S. Kellogg
VP – Corporate Consulting Services

Raymond F. Letts
VP – Corporate Operating Services

Theodore P. LeVino
VP – Executive Manpower

Edward H. Malone
VP – Trust Investments Operation

Terence E. McClary
VP – Corporate Financial Administration

John B. McKitterick
VP – Corporate Development

Phillips S. Peter
VP – Corporate Government Relations Operation

Roland W. Schmitt
VP – Corporate Research and Development


Robert B. Kurtz

R. Howard Annin, Jr.
VP – Northeastern Regional Relations

Kristian H. Christiansen
VP – Southeastern Regional Relations

William B. Frogue
VP – Southwestern Regional Relations

Harry M. Lawson
VP – Western Regional Relations

William C. Lester
VP – East Central Regional Relations

Iver J. Petersen
VP – Central Regional Relations

Donald D. Scarff
VP – Atlantic Regional Relations

Cecil S. Semple
VP – Corporate Customer Relations


Leonard C. Maier, Jr.


Walter A. Schlotterbeck


Thomas O. Thorsen

Management – operations

James A. Baker
Executive Vice President
and Sector Executive
Industrial Products and Components Sector

James P. Curley
Senior VP & Group
Executive – Contractor
Equipment Group

William Longstreet
VP & General Manager
Distribution Equipment
Division

James M. McDonald
VP & General Manager
Apparatus Distribution
Sales Division

Donald K. Grierson
Senior VP & Group
Executive – Industrial
Electronics Group

Erwin M. Koeritz
VP & General Manager
Electronic Components
Division

James R. Olin
VP & General Manager
Industrial Electronics
Systems Division

Van W. Williams
Senior VP & Group
Executive – Motor
Group

George B. Farnsworth
VP & General Manager
Component Motor
Division

Eugene J. Kovarik
VP & General Manager
Industrial Motor
Division

Ralph B. Glotzbach
VP – Industrial Products
and Components
Customer and Industry
Relations Operation

Kertis P. Kuhlman
VP & General Manager
General Electric Supply
Company Division

Donald E. Perry
VP & General Manager
Industrial Sales Division

Bruce O. Roberts
VP & General Manager
Apparatus Service
Division

Carl J. Schlemmer
VP & General Manager
Transportation Systems
Division


James P. Curley


Donald K. Grierson


Van W. Williams

Robert R. Frederick
Executive Vice President
and Sector Executive
International Sector

Willis E. Forsyth
VP & General Manager
Latin American Operations

Rodger E. Farrell
General Manager
Andean Countries
Division

J. Richard Stonesifer
Chairman of the Board and
Chief Executive Officer
General Electric do Brasil
S.A., Latin American
Operations

Paolo Fresco
VP & General Manager
Europe and Africa Operations

Edward C. Bavaria
VP & General Manager
Middle East/Africa
Business Development
Division

George J. Stathakis
VP & General Manager
International Trading
and Construction Operations

Arthur V. Puccini
VP & General Manager
Export Sales and
Trading Division

Edward F. Roache
VP & General Manager
International
Construction Division

Vittorio Orsi
Managing Director
SADE SADELMI
Construction Operations
International Construction
Division

Frank D. Kittredge
VP & General Manager
Far East Area Division

Alton S. Cartwright
Chairman of the Board &
Chief Executive Officer
Canadian General Electric
Company Limited (CGE)
(a General Electric affiliate)

William R. C. Blundell
President and Chief
Executive Officer, Canadian
Appliance Manufacturing
Company Ltd. (a CGE
affiliate)

Robert T. E. Gillespie
Vice President
Consumer and Construction
Products Division, CGE

D. Forrest Rankine
Vice President
Apparatus and Heavy
Machinery Division, CGE

Herman R. Hill
Executive Vice President
and Sector Executive
Power Systems Sector

Roy H. Beaton
Senior VP & Group
Executive – Nuclear
Energy Group

A. Philip Bray
VP & General Manager
Nuclear Power Systems
Division

Warren H. Bruggeman
VP & General Manager
Nuclear Products
Division

Henry E. Stone
VP & General Manager
Nuclear Engineering
Division

Bertram Wolfe
VP & General Manager
Nuclear Fuel and
Services Division

George B. Cox
Senior VP & Group
Executive – Turbine Group

Robert H. Goldsmith
VP & General Manager
Gas Turbine Division

Richard W. Kinnard
VP & General Manager
Large Steam Turbine-
Generator Division

George H. Schofield
VP & General Manager
Industrial and Marine
Steam Turbine Division

John A. Urquhart
Senior VP & Group
Executive – Power
Delivery Group

Nicholas Boraski
VP & General Manager
Large Transformer
Division

Donald C. Berkey
VP & General Manager
Energy Systems and
Technology Division

Robert T. Bruce
VP & General Manager
Installation and
Service Engineering
Division

Edward W. Springer
VP & General Manager
Electric Utility Sales
Division


Roy H. Beaton


George B. Cox


John A. Urquhart

Christopher T. Kastner
Executive Vice President
and Sector Executive
Technical Systems and Materials Sector

Donald S. Bates
Senior VP & Group
Executive – Information
and Communications
Systems Group

Gregory J. Liemandt
VP & General Manager
Information Services
Division

Donald J. Meyers
VP & General Manager
Mobile Communications
Division

Charles R. Carson
Senior VP & Group
Executive – Engineered
Materials Group

Alastair C. Gowan
VP – Engineered Materials
Technical Operation

Glen H. Hiner
VP & General Manager
Plastics Operations

Eugene F. Apple
General Manager
Specialty Plastics Division

D. Rex Blanchard
Managing Director
General Electric Plastics
B.V.

John D. Opie
VP & General Manager
Lexan Products Division

Thomas H. Fitzgerald
VP & General Manager
Silicone Products Division

Robert J. Gerardi
General Manager
Metallurgical Division


Donald S. Bates


Charles R. Carson


Brian H. Rowe

Brian H. Rowe
Senior VP & Group
Executive – Aircraft
Engine Group

James N. Krebs
VP & General Manager
Military Engine Operations

Orville R. Bonner
VP & General Manager
Marine and Industrial
Engine Projects Division

William J. Crawford III
VP & General Manager
Military Engine
Projects Division

W. George Krall
General Manager
Aircraft Engine
Manufacturing Division

Frank E. Pickering
VP & General Manager
Aircraft Engine
Engineering Division

James E. Worsham
VP & General Manager
Commercial Engine
Operations

Neil Burgess
VP & General Manager
Airline Programs Division

Harry C. Stonecipher
VP & General Manager
Commercial Engine
Projects Division

Louis V. Tomasetti
Senior VP & Group Executive
Aerospace Group

William A. Anders
VP & General Manager
Aircraft Equipment Division

Lee L. Farnham
VP – DSCS Program

Thomas I. Paganelli
VP & General Manager
Electronic Systems Division

Allan J. Rosenberg
VP & General Manager
Space Systems Division

Ladislaus W. Warzecha
VP & General Manager
Re-entry Systems Division

Donald S. Beilman
VP & General Manager
Advanced Microelectronics
Operations

James E. Dykes
General Manager
Microelectronics Center

Walter L. Robb
VP & General Manager
Medical Systems Division


Louis V. Tomasetti

Paul W. Van Orden
Executive Vice President
and Sector Executive
Consumer Products and Services Sector

Richard O. Donegan
Senior VP & Group
Executive – Major
Appliance Group

Robert E. Fowler, Jr.
VP & General Manager
Major Appliance
Manufacturing Division

Richard T. Gralton
VP & General Manager
Major Appliance
Marketing Operations

Philip J. Drieci
VP & General
Manager – Major
Appliance Retail
Sales Division

William L. Grim
VP & General Manager
Major Appliance
Contract Sales
Division

James F. West
VP & General Manager
Major Appliance
Marketing Division

John C. Truscott
VP & General Manager
Major Appliance
Applied Research and
Engineering Division

Ralph D. Ketchum
Senior VP & Group
Executive – Lighting
Group

Paul L. Dawson
VP & General Manager
Lamp Components
Division

David O. Gifford
VP & General Manager
International Lighting
Division

Henry J. Singer
VP & General Manager
Lamp Products
Division


Richard O. Donegan


Ralph D. Ketchum

James R. Birle
VP & General Manager
Air Conditioning Division

Fred R. Wellner
General Manager
Television Division

William R. Webber
President
General Electric Video, Inc.

Walter W. Williams
VP & General Manager
Housewares and Audio
Division

John W. Stanger
President &
Chief Executive Officer
General Electric Credit
Corporation (GECC)
(an affiliate of General
Electric)

Lawrence A. Bossidy
Executive VP & Chief
Operating Officer
General Electric Credit
Corporation

Norman P. Blake
VP & General
Manager – GECC
Commercial and
Industrial Financing
Division

Bernard P. Long
VP & General
Manager – GECC
Consumer Financing
Division


John W. Stanger

Alexander M. Wilson
Chairman of the Board and
Chief Executive Officer
Utah International Inc.

James T. Curry
Financial VP

Stephen K. Brimhall
VP & Treasurer

Melvin H. Kennedy
Vice President

Ronald K. Lamson
Controller

Ralph J. Long
Senior VP & Manager
Mineral Exploration and
Development Division

Donn K. Furgerson
VP & Manager
Marine Transportation

Robert O. Wheaton
VP & Manager – Business
Development

Charles K. McArthur
Senior VP & Manager
Mining Division

John T. Atkins
VP & Manager – Western
Coal Operations

Robert N. Hickman
VP & Manager – Mining
Technical Services

Boyd C. Paulson
Vice President

George W. Tarleton
VP & Manager – Mineral
Products Marketing

John H. Moore
President – Ladd
Petroleum Corporation
(a subsidiary of Utah)

Keith G. Wallace
Senior VP & Manager
Australasia Division

Timothy R. Winterer
VP & General Manager
Utah Development
Company (a subsidiary
of Utah)

Bruce T. Mitchell
Secretary

J. Gilbert Selway
General Counsel

Financial review

This financial review supplements the detailed information presented in the audited financial statements which begin on page 34. In addition, reference should be made to the ten-year summary of historical information on pages 46 and 47, which provides a longer-term perspective.

Sales and net earnings were up 11% and 7%, respectively, in 1980 from 1979. This performance, despite a period of adverse economic conditions in the United States as well as in a number of the world's industrialized economies, emphasizes the strength achieved through the diversity and changing mix of General Electric operations. Information about industry and geographic segments is on pages 44 and 45.

In some of the shorter-cycle businesses, particularly those related to consumer and residential construction markets, physical volume was lower in 1980 due to the domestic economic slowdown. In other businesses, particularly where order-to-shipment cycles are longer, as well as where exports from the U.S. are important, 1980 physical volume was higher. Overall, it is estimated that additional volume of shipments accounted for about one-fourth of the increased sales dollars in 1980. During 1979, higher volume had accounted for somewhat more than one-half of the 14% increase in sales dollars from 1978.

Operating margin dollars, as shown in the Statement of Earnings on page 34, were higher in 1980 and 1979 than in each of the previous years. Details of operating costs are shown in note 2 to the financial statements. Operating margin as a percent to sales has declined somewhat since the high in 1978. Despite continued emphasis on productivity improvements, which tend to have longer-term impact, costs of compensation and benefits and purchased materials, supplies and services have been escalating more rapidly than the Company has been able to recover the increases through selling prices. Also, the Company has substantially increased expenditures in recent years to benefit future growth. Research and development expenditures from the Company's own funds were $760 million in 1980. This was 19% more than in 1979, when expenditures were 23% more than in 1978.

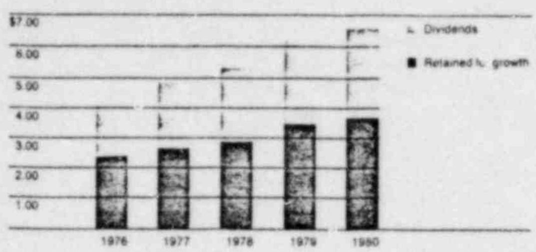
General Electric derives income from a variety of operating and nonoperating sources in addition to amounts realized from sales of products and services. These other sources of Company income have been substantial in recent years, including steady increases in earnings from our nonconsolidated finance affiliate, General Electric Credit Corporation. GECC's earnings rose 28% in 1980 to $115 million from the 1979 amount of $90 million, which was 17% more than 1978 earnings. More detail of other income for 1978-1980 is included in note 4 to the financial statements.

Interest expense and other financial charges were $314 million in 1980, compared with $258 million in 1979 and $224 million in 1978. The 1980 increase from 1979 reflected higher worldwide interest rates as well as a somewhat greater level of borrowing by affiliates. Interest expense in 1979 was more than in 1978 principally due to higher rates.

Provision for income taxes was $958 million in 1980 ($953 million and $894 million in 1979 and 1978, respectively). Note 6 to the financial statements provides details about income tax provisions and GE's effective tax rate.

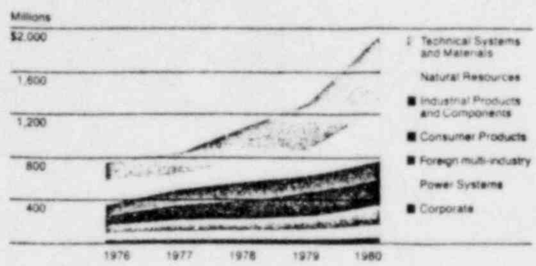
Dividends declared were $2.95 per share in 1980, the fifth consecutive year in which the rate increased, and 74% more than in 1976. Earnings per share of $6.65 in 1980 were 61% more than in 1976. During the years shown below, dividends have been equivalent to just under half of the Company's earnings, with the remainder retained to maintain the Company's productive capacity and support future business growth.

Earnings per Share



Capital expenditures reached a record $1.9 billion in 1980, up 54% from 1979 and more than two-and-a-half times greater than in 1976. Identification of needs for capital expenditures and selective allocation of funds to promising growth businesses, as well as to productivity and technological improvements, are among the most important aspects of the Company's strategic planning system. Expenditures for property, plant and equipment for each of the Company's Sectors for the past five years are depicted below.

Capital Expenditures



In addition to programs aimed at improving productivity, expenditures have been made for increased capacity or to provide adequate sources of key raw materials, such as plastics feedstocks in the Technical Systems and Materials Sector. Still other expenditures are aimed at completely new resources for GE, such as the purchase by Utah International of coal properties in the Eastern United States. Several Sectors and the corporate Research and Development Center are making substantial investments oriented to expanding and improving the Company's integrated capabilities in advanced electronics.

Estimated property, plant and equipment expenditures in future periods to complete projects already approved aggregated $1.0 billion as of year-end 1980.

Cash and marketable securities at year-end 1980 totaled $2.2 billion, some $375 million less than a year earlier. Short-term borrowings increased $2?2 million during 1980 to a total of $1.1 billion at year end. As a result of these changes, a total of $597 million of the Company's net liquid assets were utilized during 1980, primarily to fund current period and long-term growth programs. Net liquid assets stood at $1.1 billion at December 31, 1980.

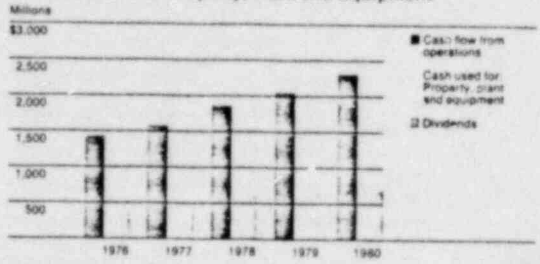
The decrease in cash and marketables was concentrated in the U.S. and reflected significantly higher expenditures for additions to domestic-based property, plant and equipment. The borrowings increase related mainly to foreign affiliate operations where GE's general practice is to utilize local financing for most funding needs.

Working capital, excluding net liquid assets mentioned above, increased $376 million and consisted principally of higher customer receivables (up $548 million) and inventories (up $182 million), partially offset by additions to accounts payable for materials and services, and similar short-term amounts owed to others. The Company's total working capital was $2.3 billion at year-end 1980. With respect to receivables, double-digit interest rates, continuing high inflation, an uncertain economy, and tightening in the availability of bank credit created an environment which necessitated stronger than usual collection efforts in 1980. However, the overall condition of receivables remains good. Inventory levels in the various product businesses were managed throughout the year in response to actual and anticipated customer demand, and year-end balances were at levels consistent with the needs of the business.

Over the last five years, the Company's total working capital has increased by $704 million, led by additions totaling $1.3 billion of cash and marketables. Most of the latter increase came from internally generated funds. Since 1975, net liquid assets have increased by $915 million, after reducing long-term borrowings by $239 million. This strengthening of the Company's liquidity position has been accomplished by strong emphasis on improving the turnover of those elements of working capital, such as customer receivables, which are closely associated with growth in sales volume. This emphasis will continue.

Significant amounts of funds are generated from Company operations, principally through net earnings and non-cash charges against earnings for depreciation, depletion and amortization. The most substantial recurring applications of funds occur in the form of increasing dividends and expenditures for property, plant and equipment. As illustrated in the chart, funds provided from operations have been more than adequate during the five-year period shown to cover those commitments. During 1980, dividends and expenditures for new plant exceeded funds generated from operations by $279 million. This difference was met with amounts available from prior years.

Comparison of Cash Flow from Operations with Cash used for Dividends and Property, Plant and Equipment

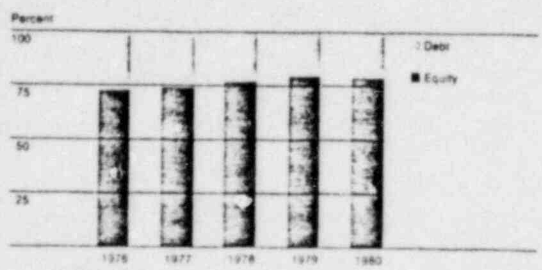


	1976-80
Total cash flow from operations	$9,267
Total cash used for dividends and property, plant and equipment	8,530

The Statement of Changes in Financial Position on page 36 presents further information about sources and applications of funds.

Maintaining a sound capital structure is a key element in meeting the Company's financial objective of achieving sustained earnings growth and a good return on investment. GE's financial planning involves considerable attention to anticipating needs and maintaining a sound relationship between share owners' equity and funds borrowed from others, both long- and short-term. As shown in the chart below, the ratio of equity to total capital has been increased from 73.5% at the end of 1976 to 80.0% at the end of 1980.

Total Capital Invested

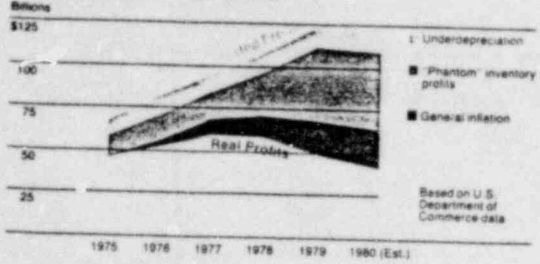


During recent years the Company has been able to maintain and grow its business from internally generated funds. As profitable opportunities are developed, it is likely that additional sources of funds will be needed. GE's strong capital structure and credit ratings should ensure availability of adequate financial resources for continued growth.

Inflation in the U.S. continued at a high level during 1980, and most economists currently forecast double-digit rates again in 1981. Your management has stressed repeatedly the distortion that inflation has on the traditional methods of financial reporting. This distortion affects individuals, companies, and aggregate financial data on which national policy decisions are based.

The chart below highlights this distortion by comparing reported after-tax earnings with *real* after-tax earnings for all U.S. nonfinancial corporations for the years 1975 through 1980. Three inflation-related factors account for the difference between reported earnings and real earnings: underdepreciation, reflecting the shortfall from writing off facilities using acquired rather than replacement costs; "phantom" profits which occur when lower than current costs of inventory output are charged against revenues; and the loss by more than one-third in the general purchasing power of a dollar since 1975.

Reported and Real Profits of U.S. Nonfinancial Corporations



As reported, the aggregate after-tax earnings of all U.S. nonfinancial corporations grew each year except for a small decrease in 1980. The average annual growth rate as reported since 1975 was about 13%.

However, after adjustment for inflation, real earnings in 1980 were lower than any other year during the period, and actually have declined since 1975 at an average rate of about 2% per year.

These data indicate that corporations, just like individuals, are suffering from the pernicious effects of inflation. It is of vital importance to all Americans that intelligent and forceful action be taken to begin the long and arduous task of removing the main controllable causes of inflation — growth of the public sector at the expense of the private sector accompanied by burgeoning federal deficits and nonproductive regulation.

Your Company's financial results are not immune to the distorting effects of inflation. Financial data elsewhere in this Annual Report, including the audited financial statements, are presented using the traditional basis of financial reporting which does not fully identify the effects of inflation. The table at upper right presents information which supplements the traditional financial statements in order to gauge the effect of changing prices on results for 1980.

Supplementary Information
Effect of Changing Prices

(In millions, except per-share amounts)	For the year ended December 31, 1980 As reported	Adjusted for (a) general inflation	Adjusted for (a) current costs
Sales of products and services to customers	$24,959	$24,959	$24,959
Cost of goods sold	17,751	17,904	17,892
Selling, general and administrative expense	4,258	4,258	4,258
Depreciation, depletion and amortization	707	1,052	1,092
Operating costs	22,716	23,214	23,242
Operating margin	2,243	1,745	1,717
Other income	564	564	564
Interest and other financial charges	(314)	(314)	(314)
Earnings before income taxes	2,493	1,995	1,967
Provision for income taxes	(958)	(958)	(958)
Minority interest	(21)	(8)	(8)
Net earnings	$ 1,514	$ 1,029	$ 1,001
Earnings per share	$ 6.65	$ 4.52	$ 4.40
Effective tax rate	38.4%	48.0%	48.7%
Share owners' equity at Dec. 31	$ 8,200	$12,377	$12,913

(a) In dollars of average 1980 purchasing power.

This table shows two different ways of attempting to remove inflationary impacts from financial results as traditionally reported. In both "adjusted for" columns, restatements are made to (1) cost of goods sold for the current cost of replacing inventories, and (2) depreciation for the current cost of plant and equipment. The column headed "general inflation" uses only a broad index to calculate the restatement, while the column headed "current costs" uses data more specifically applicable to GE.

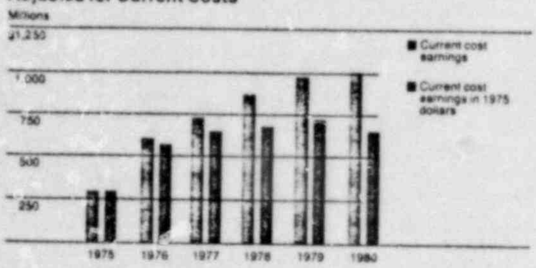
The restatements to cost of goods sold are relatively small for GE because extensive use of last-in, first-out inventory accounting already largely reflects current costs in the traditional earnings statement. However, restatements to depreciation, which allocates plant and equipment costs to expenses over time, are relatively large because of the high rate of inflation, particularly in the last three years. This is because traditional reporting of depreciation based on original cost does not adequately reflect higher prices for replacement of productive capacity of fixed assets which were purchased a number of years ago. Both of these methods of adjusting for inflation result in lower earnings than traditionally reported.

Significantly, because inflation adjustments are not allowable for tax purposes, the "real" tax rate was about 10 points higher than in traditional statements.

Your management believes the "current cost" method is more representative of GE's results, but emphasizes the considerable subjectivity involved in the calculations. These types of adjusted data are likely to be more useful in reviewing trends over a period of time, rather than in making comparisons of restatements for any one period or in specific analyses of one period compared with another. GE's after-tax earnings on the traditional basis of accounting have been higher each year from 1976 through

19[illegible] Since 1975, a recession year like 1980, the average annual growth rate for earnings as reported was about 16%. Using the "current cost" method of removing the effects of inflation, earnings were as depicted on the green bars in the chart below. This shows a pattern similar to earnings as reported on the traditional basis, with an average annual growth rate since 1975 of about 24%.

After-Tax Earnings of General Electric Adjusted for Current Costs



However, the purchasing power of a dollar in 1980 had diminished by more than one-third since 1975. To reflect this deterioration of the dollar's purchasing power, the blue bars in the chart express current-cost earnings for the years since 1975 in dollars of 1975 purchasing power. Even on this basis, the data indicate a real average annual growth rate in earnings since 1975 of about 14%.

General Electric's real annual growth rate of 14% in earnings since 1975 contrasts with the trend in real earnings for the aggregate of all U.S. nonfinancial corporations. As shown on page 30, aggregate earnings for all U.S. nonfinancial corporations declined during the 1975-1980 period at an average rate of about 2% per year.

Dealing with inflation as it affects your Company requires identifying the distorting effects of inflation, understanding them, recognizing them in business planning, and managing assets and operations so as to overcome the effects of inflation.

The Company is conducting an internal program titled Effectively Coping with Inflation. This program helps participants to understand chronic high inflation, realize how it distorts financial data, and learn how to minimize the impact. More than 3,000 key managers and professionals participated in this program through 1980.

Effective asset management through differentiated capital resource allocation is especially important in coping with inflation. Investment in modern plant and equipment provides a direct effect on operations by improving productivity in the face of escalating costs. The Company's commitment to improving productivity is demonstrated by substantial increases in expenditures for new plant and equipment during recent years. In addition, strategic emphasis is placed on those business opportunities having inflation-protection characteristics. As one example, General Electric Credit Corporation owns over $5 billion of assets leased to others. Many of these assets offer significant potential gains on residual values after expiration of the leases.

Another important hedge against inflation over the long term is represented by the mineral resource assets of the Company. Neither traditional nor inflation-adjusted methods of measuring financial results can adequately portray the value of unique, non-reproducible mineral resource assets. Some measure of the significance of these assets is conveyed by statistical data of General Electric's wholly owned, consolidated affiliate, Utah International.

Coking coal is mined by a Utah affiliate, Utah Development Company (UDC). UDC mines and exports coking coal from five mines under long-term renewable Special Coal Mining Leases granted by the state of Queensland, Australia. At December 31, 1980, UDC's share of present export entitlements under these leases amounted to 414.7 million metric tons of coking coal. Total proved reserve quantities of the leased areas exceed current export entitlements. Certain conditions exist under which export entitlements may be increased. The degree to which additional reserves could be mined would depend on commercial feasibility and obtaining additional export entitlements. Fourteen percent of the amount presently available is committed under long-term sales contracts.

Utah has steam coal reserves at several locations in the United States. In the West, Utah has steam coal reserves at three principal locations: the Navajo Mine, held under long-term lease from the Navajo Indian Tribe in New Mexico; the Trapper Mine in Colorado; and the San Juan Mine in New Mexico. For a number of years, Utah had mined coal at the San Juan Mine on a contract basis but acquired the coal leases in December 1980. Total proved and probable reserves at these locations aggregated 1,464 million tons at year-end 1980. Twenty-two percent of these reserves are currently committed under long-term sales contracts.

In 1980 Utah acquired properties in Kentucky and West Virginia which contain 360 million tons of proved and probable reserves, primarily steam coal. These reserves are under development and commercial production is expected to begin on a limited basis during 1981.

Coal	Year ended December 31		
(Quantities in millions)	1980	1979	1978
Coking coal (UDC share in metric tons)			
Shipped (a)	13.1	13.8	13.0
Average price/metric ton (b)	$51.09	$48.39	$47.78
Steam coal (tons) (c)			
Shipped (a)	10.5	8.8	7.1
Average price/ton	$ 7.82	$ 7.09	$ 6.03

(a) Quantities shipped about the same as 1978-80 production.
(b) Represents average prices published by an agency of the Australian government since July 1973 for Queensland production, including Utah-operated mines.
(c) Excludes San Juan Mine prior to Utah's acquiring the coal leases in December 1980.

GE's principal copper resource is the wholly owned Island Copper Mine in British Columbia, Canada. Estimated reserves at the end of 1980 contain approximately 183 million tons of ore with a grade of approximately 0.48% copper. This mine also produces gold.

silver, molybdenum, and rhenium as by-products. Fifteen percent of the copper ore reserves are presently committed under long-term sales contracts. These contracts call for sales based on London Metal Exchange prices.

Island Copper Mine (Quantities in thousands)	Year ended December 31 1980	1979	1978
Ore milled (tons)	15,192	14,705	15,653
Average percent recovery	85.2%	87.5%	86.6%
Pounds of copper – sold (a)	110,305	110,309	111,672
Average price per pound of copper			
– copper	$ 0.98	$ 0.93	$ 0.64
– by-products	0.65	0.43	0.20

(a) Quantities sold about the same as 1978-80 production.

Technical notes The effect of changing prices on General Electric as set forth on page 30 has been prepared in accordance with Financial Accounting Standards Board (FASB) requirements. Information in the following table presents additional data in accordance with FASB requirements.

Current cost information in average dollars of 1980 purchasing power(a)

(In millions except per-share amounts)

	Sales	Net earnings (b)	Share owners' equity Dec. 31 (b)	Per common share: Earnings (b)	Dividends	Market price Dec. 31	Purchasing power gain (loss) (c)
1980	$24,959	$1,001	$12,913	$4.40	$2.95	$59	$(198)
1979	25,493	1,119	12,659	4.93	3.12	54	(237)
1978	24,819	1,092	12,508	4.79	3.16	57	(145)
1977	23,817	1,001	12,095	4.40	2.86	66	(69)
1976	22,717	885	11,947	3.92	2.46	79	(23)
1975	21,590	479	11,414	2.13	2.45	68	22

(a) Average 1980 dollars, using the U.S. Consumer Price Index (1967 = 100): 1975–161.2; 1976–170.5; 1977–181.5; 1978–195.4; 1979–217.4; and 1980–246.8.

(b) Current cost basis.

(c) On net monetary items.

Proper use of supplementary information concerning the effect of changing prices requires an understanding of certain basic concepts and definitions.

In the table on page 30, "as reported" refers to information drawn directly from the financial statements and notes on pages 34 to 45. This information is prepared using generally accepted accounting principles which render an accounting based on the number of actual dollars involved in transactions, with no recognition given to the fact that the value of the dollar changes over time.

"Adjusted for general inflation" refers to information prepared using a different approach to transactions involving inventory and property, plant and equipment assets. Under this procedure, the number of dollars involved in transactions at different dates are all restated to equivalent amounts in terms of the general purchasing power of the dollar as it is measured by the Consumer Price Index for all Urban Consumers (CPI-U). For example, $1,000 invested in a building in 1967 would be restated to its 1980 dollar purchasing power equivalent of $2,468 to value the asset and calculate depreciation charges. Similarly, the 1979 purchases of non-LIFO inventory sold in 1980 would be accounted for at their equivalent in terms of 1980 dollars, rather than in terms of the actual number of dollars spent. Using this method, earnings for 1979 in 1980 dollars were $1,208 million ($5.31 per share) and share owners' equity at December 31, 1979, was $11,845 million.

"Adjusted for current costs" refers to information prepared using a third approach to inventory and property, plant and equipment transactions. In this case, rather than restating to dollars of the same general purchasing power, estimates of specific current costs of the assets are used. Principal types of information used to adjust for changes in specific prices (current costs) are: for inventory costs, GE-generated indices of price changes for specific goods and services; and for property, plant and equipment, externally generated indices of price changes for major classes of assets. Data for mineral resource assets have been adjusted by applying internally generated indices to reflect current costs. Adjustments for oil and gas properties are based on industry indices.

At December 31, 1980, the current cost of inventory was $5,701 million, and of property, plant and equipment was $8,797 million ($5,251 million and $7,004 million, respectively, at December 31, 1979). In dollars of average 1980 purchasing power, estimated current costs applicable to such assets increased during 1980, or during the part of the year the assets were held, by approximately $1,356 million, which was $196 million less than the $1,552 million increase which could be expected because of general inflation. The comparable increase for 1979 in dollars of average 1980 purchasing power was approximately $1,261 million, which was $373 million less than the $1,634 million increase which could be expected because of general inflation.

In presenting results of either of the supplementary accounting methods for more than one year, real trends are more evident when results for all years are expressed in terms of the general purchasing power of the dollar for a designated period. Results of such restatements are generally called "constant dollar" presentations. In the six-year presentations shown at left, dollar results for earlier periods have been restated to their equivalent number of constant dollars of 1980 general purchasing power (CPI-U basis).

Because none of these restatements is allowable for tax purposes under existing laws, income tax amounts are the same as in the traditional statements (but expressed in constant dollars).

All average annual growth rates in this Report use the "least squares" method of calculation.

There are a number of other terms and concepts which may be of interest in assessing the significance of the supplementary information shown. However, it is management's opinion that the basic concepts discussed above are the most significant for the reader to have in mind while reviewing this information.

Report of management

To the Share Owners of General Electric Company

The financial statements of General Electric Company and consolidated affiliates are presented on pages 34 through 45 of this Annual Report. These statements have been prepared by management and are in conformity with generally accepted accounting principles appropriate in the circumstances. The statements include amounts that are based on our best estimates and judgments. Financial information elsewhere in this Annual Report is consistent with that in the financial statements.

General Electric maintains a strong system of internal financial controls and procedures, supported by a staff of corporate auditors and supplemented by resident auditors located around the world. This system is designed to provide reasonable assurance, at appropriate cost, that assets are safeguarded and that transactions are executed in accordance with management's authorization and recorded and reported properly. The system is time-tested, innovative and responsive to change. Perhaps the most important safeguard in this system is the fact that the Company has long emphasized the selection, training and development of professional financial managers to implement and oversee the proper application of its internal controls and the reporting of management's stewardship of corporate assets and maintenance of accounts in conformity with generally accepted accounting principles.

The independent public accountants provide an objective, independent review as to management's discharge of its responsibilities insofar as they relate to the fairness of reported operating results and financial condition. They obtain and maintain an understanding of GE's accounting and financial controls, and conduct such tests and related procedures as they deem necessary to arrive at an opinion on the fairness of financial statements.

The Audit Committee of the Board of Directors, which is composed solely of Directors from outside the Company, maintains an ongoing appraisal of the effectiveness of audits and the independence of the public accountants. The Committee meets periodically with the public accountants, management and internal auditors to review the work of each. The public accountants have free access to the Committee, without management present, to discuss the results of their audit work and their opinions on the adequacy of internal financial controls and the quality of financial reporting. The Committee also reviews the Company's accounting policies, internal accounting controls, and the Annual Report and proxy material.

The Company has long recognized its obligation to conduct its affairs in an ethical and socially responsible manner. Its commitment to these objectives is reflected in key Company policy statements covering, among other things, potentially conflicting outside business interests of Company employees, compliance with antitrust laws and proper conduct of domestic and international business practices. It is not always possible to ensure that all employees fully understand the importance of comp[illegible] with the specific intent and spirit of these policies. When deviations are detected or otherwise reported, the Company will continue to act in a responsible manner with respect to appropriate disclosure and reporting. Additionally, your management will continue efforts to create a strong compliance environment for the ethical conduct of domestic and international business activities.

T. O. Thorsen — Senior Vice President Finance

Reginald H. Jones — Chairman of the Board and Chief Executive Officer

February 20, 1981

Report of independent certified public accountants

To Share Owners and Board of Directors of General Electric Company

We have examined the statement of financial position of General Electric Company and consolidated affiliates as of December 31, 1980 and 1979, and the related statements of earnings, retained earnings and changes in financial position for each of the three years in the period ended December 31, 1980. Our examinations were made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the aforementioned financial statements present fairly the financial position of General Electric Company and consolidated affiliates at December 31, 1980 and 1979, and the results of their operations and the changes in their financial position for each of the three years in the period ended December 31, 1980, in conformity with generally accepted accounting principles applied on a consistent basis.

Peat, Marwick, Mitchell & Co.

Peat, Marwick, Mitchell & Co.
345 Park Avenue, New York, N.Y. 10154 — February 20, 1981

Statement of earnings

General Electric Company and consolidated affiliates

For the years ended December 31 (In millions)		1980	1979	1978
Sales	Sales of products and services to customers (note 1)	$24,959	$22,461	$19,654
Operating costs	Cost of goods sold	17,751	15,991	13,915
	Selling, general and administrative expense	4,258	3,716	3,205
	Depreciation, depletion and amortization	707	624	576
	Operating costs (notes 2 and 3)	22,716	20,331	17,696
	Operating margin	2,243	2,130	1,958
	Other income (note 4)	564	519	419
	Interest and other financial charges (note 5)	(314)	(258)	(224)
Earnings	Earnings before income taxes and minority interest	2,493	2,391	2,153
	Provision for income taxes (note 6)	(958)	(953)	(894)
	Minority interest in earnings of consolidated affiliates	(21)	(29)	(29)
	Net earnings applicable to common stock	$ 1,514	$ 1,409	$ 1,230
	Earnings per common share (in dollars) (note 7)	$6.65	$6.20	$5.39
	Dividends declared per common share (in dollars)	$2.95	$2.75	$2.50
	Operating margin as a percentage of sales	9.0%	9.5%	10.0%
	Net earnings as a percentage of sales	6.1%	6.3%	6.3%

Statement of retained earnings

General Electric Company and consolidated affiliates

For the years ended December 31 (In millions)		1980	1979	1978
Retained earnings	Balance January 1	$6,307	$5,522	$4,862
	Net earnings	1,514	1,409	1,230
	Dividends declared on common stock	(670)	(624)	(570)
	Balance December 31	$7,151	$6,307	$5,522

The information on pages 33 and 37-45 is an integral part of these statements.

Statement of financial position

General Electric Company and consolidated affiliates

At December 31 (in millions)		1980	1979
Assets	Cash (note 8)	$ 1,601	$ 1,904
	Marketable securities (note 8)	600	672
	Current receivables (note 9)	4,339	3,647
	Inventories (note 10)	3,343	3,161
	Current assets	9,883	9,384
	Property, plant and equipment – net (note 11)	5,780	4,613
	Investments (note 12)	1,820	1,691
	Other assets (note 13)	1,028	956
	Total assets	$18,511	$16,644
Liabilities and equity	Short-term borrowings (note 14)	$ 1,093	$ 871
	Accounts payable (note 15)	1,671	1,477
	Progress collections and price adjustments accrued	2,084	1,957
	Dividends payable	170	159
	Taxes accrued	628	655
	Other costs and expenses accrued (note 16)	1,946	1,753
	Current liabilities	7,592	6,872
	Long-term borrowings (note 17)	1,000	947
	Other liabilities	1,565	1,311
	Total liabilities	10,157	9,130
	Minority interest in equity of consolidated affiliates	154	152
	Preferred stock ($1 par value; 2,000,000 shares authorized; none issued)	—	—
	Common stock ($2.50 par value; 251,500,000 shares authorized; 231,463,949 shares issued 1980 and 1979)	579	579
	Amounts received for stock in excess of par value	659	656
	Retained earnings	7,151	6,307
		8,389	7,542
	Deduct common stock held in treasury	(189)	(180)
	Total share owners' equity (notes 18, 19, and 20)	8,200	7,362
	Total liabilities and equity	$18,511	$16,644
	Commitments and contingent liabilities (note 21)		

The information on pages 33 and 37-45 is an integral part of this statement.

Statement of changes in financial position

General Electric Company and consolidated affiliates

For the years ended December 31 (In millions)		1980	1979	1978
Source of funds	From operations			
	Net earnings	$1,514	$1,409	$1,230
	Depreciation, depletion and amortization	707	624	576
	Investment tax credit deferred — net	56	45	25
	Income tax timing differences	63	(37)	32
	Earnings retained by nonconsolidated finance affiliates	(22)	(17)	(16)
	Minority interest in earnings of consolidated affiliates	21	29	29
		2,339	2,053	1,876
	Increase in long-term borrowings	122	50	96
	Newly issued common stock	—	—	3
	Disposition of treasury shares	136	148	190
	Increase in current payables other than short-term borrowings	498	786	570
	Decrease in investments	—	—	24
	Other — net	143	101	150
	Total source of funds	3,238	3,138	2,909
Application of funds	Additions to property, plant and equipment	1,948	1,262	1,055
	Dividends declared on common stock	670	624	570
	Increase in investments	129	281	—
	Reduction in long-term borrowings	69	97	386
	Purchase of treasury shares	145	156	196
	Increase in current receivables	692	358	306
	Increase in inventories	182	158	399
	Total application of funds	3,835	2,936	2,912
Net change	Net change in cash, marketable securities and short-term borrowings	$ (597)	$ 202	$ (3)
Analysis of net change	Increase (decrease) in cash and marketable securities	$ (375)	$ 113	$ 185
	Decrease (increase) in short-term borrowings	(222)	89	(188)
	Increase (decrease) in net liquid assets	$ (597)	$ 202	$ (3)

The information on pages 33 and 37-45 is an integral part of this statement.

Summary of significant accounting policies

Basis of consolidation
The financial statements consolidate the accounts of the parent General Electric Company and those of all majority-owned and controlled companies ("affiliated companies"), except finance companies whose operations are not similar to those of the consolidated group. All significant items relating to transactions among the parent and affiliated companies are eliminated from the consolidated statements.

The nonconsolidated finance companies are included in the statement of financial position under investments and are valued at equity plus advances. In addition, companies in which GE and/or its consolidated affiliates own 20% to 50% of the voting stock ("associated companies") are included under investments, valued at the appropriate share of equity plus advances. After-tax earnings of nonconsolidated finance companies and associated companies are included in the statement of earnings under other income.

A nonconsolidated uranium mining company (see note 12) is also included under investments and is valued at lower of cost or equity, plus advances.

Sales
The Company and its consolidated affiliates record a transaction as a sale only when title to products passes to the customer or when services are performed in accordance with contract terms.

Vacation expense
Most employees earn credits during the current year for vacations to be taken in the following year. The expense for this liability is accrued during the year vacations are earned rather than in the year vacations are taken.

Pensions
Investments of the General Electric Pension Trust, which funds the obligations of the General Electric Pension Plan, are carried at amortized cost plus programmed appreciation in the common stock portfolio. The funding program and Company cost determination for the Pension Plan use 6% as the estimated rate of future Trust income. Trust income includes recognition of appreciation in the common stock portfolio on a systematic basis which does not give undue weight to short-term market fluctuations. Programmed appreciation will not be recognized if average carrying value exceeds average market value, calculated on a moving basis over a multiyear period.

Changes in prior service liabilities of the Plan are amortized over 20 years. Net actuarial gains and losses are amortized over 15 years.

Costs of a separate, supplementary pension plan, primarily affecting long-service professional and managerial employees, are not funded. Current service costs and amortization of prior service liabilities over a period of 20 years are being charged to operating expenses currently.

Investment tax credit
The investment tax credit is recorded by the "deferral method" and is amortized as a reduction of the provision for taxes over the lives of the facilities to which the credit applies, rather than being "flowed through" to income in the year the asset is acquired.

Inventories
Substantially all manufacturing inventories located in the U.S. are valued on a last-in first-out, or LIFO, basis. Manufacturing inventories outside the U.S. are generally valued on a first-in first-out, or FIFO, basis. Valuations are based on the cost of material, direct labor and manufacturing overhead, and do not exceed net realizable values. Certain indirect manufacturing expenses are charged directly to operating costs during the period incurred, rather than being inventoried.

Mining inventories, which include principally mined ore and coal, metal concentrates and mining supplies, are stated at the lower of average cost or market. The cost of mining inventories includes both direct and indirect costs consisting of labor, purchased supplies and services, and depreciation, depletion and amortization of property, plant and equipment.

Property, plant and equipment
Manufacturing plant and equipment includes the original cost of land, buildings and equipment less depreciation, which is the estimated cost consumed by wear and obsolescence. An accelerated depreciation method, based principally on a sum-of-the-years digits formula, is used to record depreciation of the original cost of manufacturing plant and equipment purchased and installed in the U.S. subsequent to 1960. Most manufacturing plant and equipment located outside the U.S. is depreciated on a straight-line basis. If manufacturing plant and equipment is subject to abnormal economic conditions or obsolescence, additional depreciation is provided. Expenditures for maintenance and repairs of manufacturing plant and equipment are charged to operations as incurred.

The cost of mining properties includes initial expenditures and cost of major rebuilding projects which substantially increase the useful lives of existing assets. The cost of mining properties is depreciated, depleted or amortized over the useful lives of the related assets by use of unit-of-production, straight-line or declining-balance methods.

Mining exploration costs are expensed until it is determined that the development of a mineral deposit is likely to be economically feasible. After this determination is made, all costs related to further development are capitalized. Amortization of such costs begins upon commencement of production and is over ten years or the productive life of the property, whichever is less.

Oil and gas properties are accounted for by use of the full-cost method.

Notes to financial statements

1. Sales

Approximately one-eighth of sales were to agencies of the U.S. government, which is the Company's largest single customer. The principal source of these sales was the Technical Systems and Materials segment of the Company's business.

2. Operating costs

Operating costs by major expense categories are shown below:

(In millions)	1980	1979	1978
Employee compensation, including benefits	$ 9,196	$ 8,286	$ 7,401
Materials, supplies, services and other costs	12,696	11,320	9,867
Depreciation, depletion and amortization	707	624	576
Taxes, except Social Security and those on income	299	259	251
Increase in inventories during the year	(182)	(158)	(399)
	$22,716	$20,331	$17,696

Supplemental details are as follows:

(In millions)	1980	1979	1978
Maintenance and repairs	$784	$775	$672
Company-funded research and development	760	640	521
Social Security taxes	484	471	397
Advertising	315	282	247
Mineral royalties and export duties	80	82	79

Foreign currency translation gains, after recognizing related income tax effects and minority interest share, were $40 million in 1980 and $12 million in 1979 and 1978.

3. Pensions

Total pension costs of General Electric and consolidated affiliates were $478 million in 1980, $413 million in 1979, and $381 million in 1978. General Electric and its affiliates have a number of pension plans. The most significant of these plans is the General Electric Pension Plan (the "Plan"), in which substantially all employees in the U.S. are participating. Approximately 80,800 persons were receiving benefits at year-end 1980 (75,700 and 72,100 at year-end 1979 and 1978, respectively).

Pension benefits under the Plan are funded through the General Electric Pension Trust. Earnings of the Trust, including the programmed recognition of common stock appreciation, as a percentage of the carrying value of the portfolio, were 8.4% for 1980 and 1979, and 7.8% for 1978. The limitation on recognition of programmed appreciation of common stock was not exceeded in any year.

Condensed information for the General Electric Pension Trust appears below. Prior-year as well as current-year data are presented in accordance with new standards issued in 1980 by the Financial Accounting Standards Board (FASB).

General Electric Pension Trust

Change in net assets at current value

(In millions) For the year	1980	1979	1978
Net assets at January 1	$4,968	$4,202	$3,734
Company contributions	404	341	317
Employee contributions	86	94	83
Investment income	435	383	312
Pensions paid	(254)	(225)	(201)
Unrecognized portion of change in current value	779	173	(43)
Net assets at December 31	$6,418	$4,968	$4,202

Net assets at current value

(In millions) December 31	1980	1979	1978
U.S. government obligations and guarantees	$ 44	$ 118	$ 93
Corporate bonds and notes	727	496	340
Real estate and mortgages	825	713	725
Common stocks and other equity securities	4,181	3,193	2,726
	5,777	4,520	3,884
Cash and short-term investments	553	371	240
Other assets — net	88	77	78
Current value of net assets	$6,418	$4,968	$4,202
Carrying value of net assets	$5,593	$4,922	$4,329

The actuarial present value of accumulated plan benefits for the General Electric Pension Plan and the supplementary pension plan together represent over 90% of accumulated pension plan benefits for General Electric and its consolidated affiliates. These present values have been calculated using a 6% interest rate assumption as of December 31 for each of the years in the table below. The table also sets forth the total of the current value of Pension Trust assets and the relevant accruals in the Company's accounts.

General Electric Pension Plan and Supplementary Pension Plan

(In millions) December 31	1980	1979	1978
Estimated actuarial present value of accumulated plan benefits:			
Vested benefits	$6,027	$5,426	$4,732
Non-vested benefits	415	382	331
Total benefits	$6,442	$5,808	$5,063
Current value of trust assets plus accruals	$6,580	$5,075	$4,273

For pension plans not included above, there was no significant difference between accumulated benefits and the relevant fund assets plus accruals.

The foregoing amounts are based on new FASB standards which differ from those used by the Company for funding and cost determination purposes. Based on the actuarial method used by the Company, and with assets at carrying value, unfunded and unamortized liabilities for the two principal pension plans totaled $964 million, $1,082 million and $882 million at year-end 1980, 1979 and 1978, respectively.

An increase in pensions of retired employees effective February 1, 1981, will increase the actuarial present value of accumulated vested benefits by an estimated $196 million.

4. Other income

(In millions)	1980	1979	1978
Net earnings of GE Credit Corporation	$115	$ 90	$ 77
Income from:			
Marketable securities and bank deposits	229	229	140
Customer financing	72	70	49
Royalty and technical agreements	52	50	44
Associated companies and non-consolidated uranium mining affiliate	22	11	34
Other investments:			
Interest	21	20	19
Dividends	13	11	10
Other sundry items	40	38	46
	$564	$519	$419

5. Interest and other financial charges

Interest capitalized on major property, plant and equipment projects in 1980 was $21 million.

6. Provision for income taxes

(In millions)	1980	1979	1978
U.S. federal income taxes:			
Estimated amount payable	$574	$599	$590
Effect of timing differences	14	(31)	(13)
Investment credit deferred — net	56	45	25
	644	613	602
Foreign income taxes:			
Estimated amount payable	238	323	221
Effect of timing differences	39	(6)	45
	277	317	266
Other (principally state and local income taxes)	37	23	26
	$958	$953	$894

All General Electric consolidated U.S. federal income tax returns have been closed through 1972.

Provision has been made for federal income taxes to be paid on that portion of the undistributed earnings of affiliates and associated companies expected to be remitted to the parent company. Undistributed earnings intended to be reinvested indefinitely in affiliates and associated companies totaled $1,111 million at the end of 1980, $944 million at the end of 1979, and $815 million at the end of 1978.

Changes in estimated foreign income taxes payable and in the effect of timing differences result principally from fluctuations in foreign earnings and tax rates, and from recognizing in the current year for tax payment purposes the results of transactions in Australia recorded for financial reporting purposes in other years.

Investment credit amounted to $92 million in 1980, compared with $76 million in 1979 and $51 million in 1978. In 1980, $36 million were included in net earnings, compared with $31 million in 1979 and $26 million in 1978. At the end of 1980, the amount still deferred and to be included in net earnings in future years was $262 million.

Effect of timing differences on U.S. federal income taxes

(In millions) Increase (decrease) in provision for income taxes	1980	1979	1978
Tax over book depreciation	$ 48	$ 23	$ 26
Undistributed earnings of affiliates and associated companies	29	(2)	8
Margin on installment sales	1	(10)	(10)
Provision for warranties	(46)	(36)	(31)
Other — net	(18)	(6)	(6)
	$ 14	$(31)	$(13)

The cumulative net effect of timing differences has resulted in a deferred-tax asset which is shown under other assets.

Reconciliation from statutory to effective income tax rates

	1980	1979	1978
U.S. federal statutory rate	46.0%	46.0%	48.0%
Reduction in taxes resulting from:			
Varying tax rates of consolidated affiliates (including DISC)	(4.7)	(3.3)	(3.4)
Inclusion of earnings of the Credit Corporation in before-tax income on an after-tax basis	(2.1)	(1.7)	(1.7)
Investment credit	(1.5)	(1.3)	(1.2)
Income tax at capital gains rate	(0.1)	—	(0.6)
Other — net	0.8	0.2	0.4
Effective tax rate	38.4%	39.9%	41.5%

Based on the location of the component furnishing goods or services, domestic income before taxes was $1,854 million in 1980 ($1,706 million in 1979 and $1,592 million in 1978). The corresponding amounts for foreign-based operations were $639 million, $685 million and $561 million in each of the last three years, respectively. Provision for income taxes is determined on the basis of the jurisdiction imposing the tax liability. Therefore, U.S. and foreign taxes shown at the left do not compare directly with these segregations.

7. Earnings per common share

Earnings per share are based on the average number of shares outstanding. Any dilution which would result from the potential exercise or conversion of such items as stock options or convertible debt outstanding is insignificant (less than 1% in 1980, 1979 and 1978).

8. Cash and marketable securities

Deposits restricted as to usage and withdrawal or used as partial compensation for short-term borrowing arrangements were not material.

Marketable securities (none of which are equity securities) are carried at the lower of amortized cost or market value. Carrying value was substantially the same as market value at year-end 1980 and 1979.

9. Current receivables

(In millions) December 31	1980	1979
Customers' accounts and notes	$ 3,816	$3,254
Associated companies	25	36
Nonconsolidated affiliates	17	7
Other	584	439
	4,442	3,736
Less allowance for losses	(103)	(89)
	$ 4,339	$3,647

10. Inventories

(In millions) December 31	1980	1979
Raw materials and work in process	$ 2,082	$1,943
Finished goods	961	966
Unbilled shipments	300	252
	$ 3,343	$3,161

About 84% of total inventories are valued using the LIFO method of inventory accounting.

If the FIFO method of inventory accounting had been used to value all inventories, they would have been $2,240 million higher than reported at December 31, 1980 ($1,950 million higher at year-end 1979).

11. Property, plant and equipment

(In millions)	1980	1979
Major classes at December 31:		
Manufacturing plant and equipment		
Land and improvements	$ 139	$ 125
Buildings, structures and related equipment	2,329	2,098
Machinery and equipment	6,197	5,314
Leasehold costs and manufacturing plant under construction	453	372
Mineral property, plant and equipment	1,917	1,456
	$11,035	$9,365
Cost at January 1	$ 9,365	$8,328
Additions	1,948	1,262
Dispositions	(278)	(225)
Cost at December 31	$11,035	$9,365
Accumulated depreciation, depletion and amortization		
Balance at January 1	$ 4,752	$4,305
Current-year provision	707	624
Dispositions	(214)	(188)
Other changes	10	11
Balance at December 31	$ 5,255	$4,752
Property, plant and equipment less depreciation, depletion and amortization at December 31	$ 5,780	$4,613

12. Investments

(In millions) December 31	1980	1979
Nonconsolidated finance affiliates	$ 938	$ 824
Nonconsolidated uranium mining affiliate	188	157
Miscellaneous investments (at cost):		
Government and government-guaranteed securities	187	233
Other	136	148
	323	381
Marketable equity securities	44	44
Associated companies	342	301
Less allowance for losses	(15)	(16)
	$1,820	$1,691

Condensed consolidated financial statements for the principal nonconsolidated finance affiliate, General Electric Credit Corporation (GECC), follow. During the normal course of business, GECC has transactions with the parent General Electric Company and certain of its consolidated affiliates, and GECC results are included in General Electric's consolidated U.S. federal income tax return. However, virtually all products financed by GECC are manufactured by companies other than General Electric. More detailed information is available in GECC's 1980 Annual Report, copies of which may be obtained by writing to: General Electric Credit Corporation, P.O. Box 8300, Stamford, Connecticut 06904.

General Electric Credit Corporation
Financial position

(In millions) December 31	1980	1979
Cash and marketable securities	$ 531	$ 374
Receivables:		
Time sales and loans	8,159	7,480
Deferred income	(1,380)	(1,124)
	6,779	6,356
Investment in leases	1,643	1,207
Sundry receivables	197	141
Total receivables	8,619	7,704
Allowance for losses	(249)	(231)
Net receivables	8,370	7,473
Other assets	443	321
Total assets	$9,344	$8,168
Notes payable:		
Due within one year	$4,425	$3,921
Long-term — senior	1,984	1,743
— subordinated	400	325
Other liabilities	707	631
Total liabilities	7,516	6,620
Deferred income taxes	876	718
Deferred investment tax credit	21	13
Capital stock	658	566
Additional paid-in capital	12	12
Retained earnings	261	239
Equity	931	817
Total liabilities, deferred tax items and equity	$9,344	$8,168

General Electric Credit Corporation
Current and retained earnings

(In millions) For the year	1980	1979	1978
Earned income	$1,389	$1,102	$ 813
Expenses:			
Interest and discount	719	528	337
Operating and administrative	451	396	315
Provision for losses			
— receivables	75	69	56
— other assets	3	(2)	8
Provision for income taxes	26	21	20
	1,274	1,012	736
Net earnings	115	90	77
Less dividends	(93)	(72)	(62)
Retained earnings at January 1	239	221	206
Retained earnings at December 31	$ 261	$ 239	$ 221

Investment in the nonconsolidated uranium mining affiliate consists of investment in a wholly owned affiliate (established in the course of obtaining a U.S. Department of Justice Business Advisory Clearance Procedure Letter in connection with the 1976 Utah merger) to which all of the then existing uranium business of Utah has been transferred. All common stock of this affiliate has been placed in a voting trust controlled by independent voting trustees. Prior to the year 2000, General Electric and its affiliates may not withdraw the common stock from the voting trust except for sale to unaffiliated third parties. Directors and officers of the affiliate may not be directors, officers, or employees of General Electric, Utah or of any of their affiliates. Uranium may not be sold by this affiliate, in any state or form, to, or at the direction of, General Electric or its affiliates.

All outstanding shares of preferred stock of the uranium affiliate are retained by Utah as an affiliate of General Electric. Payment of cumulative quarterly dividends out of legally available funds on this preferred stock is mandatory in amounts equal to 85% of the affiliate's net after-tax income for the previous quarter (without taking account of any deduction for exploration expense as defined). Utah, as holder of the preferred stock, must make loans with up to ten-year maturities when requested by the affiliate, although the aggregate amount of such loans need not at any time exceed preferred dividend payments for the immediately preceding two calendar years.

The estimated realizable value of miscellaneous investments was $287 million at December 31, 1980 ($350 million at December 31, 1979).

Marketable equity securities are valued at the lower of cost or market. Aggregate market value of marketable equity securities was $242 million and $181 million at year-end 1980 and 1979, respectively. At December 31, 1980, gross unrealized gains on marketable equity securities were $198 million.

Investments in nonconsolidated affiliates and associated companies included advances of $180 million at December 31, 1980 ($123 million at December 31, 1979).

13. Other assets

(In millions) December 31	1980	1979
Long-term receivables	$340	$307
Deferred charges	198	145
Real estate development projects	132	81
Recoverable engineering costs on government contracts	113	121
Customer financing	103	107
Licenses and other intangibles — net	75	52
Deferred income taxes	21	98
Other	46	45
	$1,028	$956

Licenses and other intangibles acquired after October 1970 are being amortized over appropriate periods of time.

14. Short-term borrowings

The average balance of short-term borrowings, excluding the current portion of long-term borrowings, was $822 million during 1980 (calculated by averaging all month-end balances for the year) compared with an average balance of $705 million in 1979. The maximum balance included in these calculations was $962 million and $727 million at the end of October 1980 and March 1979, respectively. The average effective interest rate for the year 1980 was 18.9%, and for 1979 was 17.6%. These average rates represent total short-term interest incurred divided by the average balance outstanding. A summary of short-term borrowings and the applicable interest rates is shown below.

Short-term borrowings

(In millions) December 31	1980		1979	
	Amount	Average rate at Dec. 31	Amount	Average rate at Dec. 31
Parent notes with trust departments	$353	15.05%	$290	12.62%
Consolidated affiliate bank borrowings	539	30.83	389	27.10
Other, including current portion of long-term borrowings	201		192	
	$1,093		$871	

Parent borrowings are from U.S. sources. Borrowings of consolidated affiliated companies are primarily from foreign sources. Other borrowings include amounts from nonconsolidated affiliates of $95 million in 1980 ($65 million in 1979).

Although the total unused credit available to the Company through banks and commercial credit markets is not readily quantifiable, informal credit lines in excess of $1 billion had been extended by approximately 100 U.S. banks at year end.

15. Accounts payable

(In millions) December 31	1980	1979
Trade accounts	$1,402	$1,259
Collected for the account of others	203	172
Nonconsolidated affiliates	66	46
	$1,671	$1,477

16. Other costs and expenses accrued

The balances at year-end 1980 and 1979 included compensation and benefit costs accrued of $703 million and $641 million, respectively.

17. Long-term borrowings

(In millions) Outstanding December 31	1980	1979	Due date	Sinking fund/ prepayment period
General Electric Company:				
5¾% Notes	$ 62	$ 69	1991	1972-90
5.30% Debentures	70	80	1992	1973-91
7½% Debentures	135	149	1996	1977-95
8½% Debentures	288	295	2004	1985-03
Utah International Inc.:				
Notes with banks	37	5	1993	1981-93
8% Guaranteed Sinking Fund Debentures	15	17	1987	1977-87
7.6% Notes	28	32	1988	1974-88
Other	32	25		
General Electric Overseas Capital Corporation:				
4¼% Bonds	23	24	1985	1976-84
4¼% Debentures	50	50	1987	None
5½% Sterling/ Dollar Guaranteed Loan Stock	9	8	1993	None
Other	34	37		
All other	217	156		
	$1,000	$947		

The amounts shown above are after deduction of the face value of securities held in treasury as shown below.

Face value of long-term borrowings in treasury

(In millions) December 31	1980	1979
General Electric Company:		
5.30% Debentures	$50	$50
7½% Debentures	35	29
8½% Debentures	12	5
General Electric Overseas Capital Corporation:		
4¼% Bonds	6	7

Utah International Inc. notes with banks were subject to average interest rates at year-end 1980 and 1979 of 11.3% and 7.9%, respectively.

Borrowings of General Electric Overseas Capital Corporation are unconditionally guaranteed by General Electric as to payment of principal, premium if any, and interest. This Corporation primarily assists in financing capital requirements of foreign companies in which General Electric has an equity interest, as well as financing certain customer purchases.

Borrowings include 4¼% Guaranteed Debentures due in 1987, which are convertible into General Electric common stock at $80.75 a share, and 5½% Sterling/Dollar Guaranteed Loan Stock due in 1993 in the amount of £3.6 million ($9 million), convertible into GE common stock at $73.50 a share. During 1980 and 1979, General Electric Overseas Capital Corporation 4¼% Guaranteed Bonds having a face value and a reacquired cost of $2 million were retired in accordance with sinking fund provisions.

All other long-term borrowings were largely by foreign and real estate development affiliates with various interest rates and maturities and included amounts due to nonconsolidated affiliates of $7 million in 1980 and 1979.

Long-term borrowing maturities during the next five years, including the portion classified as current, are $91 million in 1981, $130 million in 1982, $62 million in 1983, $42 million in 1984 and $68 million in 1985. These amounts are after deducting reacquired debentures held in treasury for sinking fund requirements.

18. Common stock

	1980	1979	1980	1979
	(In millions)		(Thousands of shares)	
Common stock issued				
Balance January 1 and December 31	$ 579	$ 579	231,464	231,464
Amounts received for stock in excess of par value				
Balance January 1	$ 656	$ 658		
Gain (loss) on disposition of treasury stock	3	(2)		
Balance December 31	$ 659	$ 656		
Common stock held in treasury				
Balance January 1	$ 180	$ 172	3,625	3,428
Purchases	145	156	2,684	3,155
Dispositions:				
Employee savings plans	(99)	(124)	(1,879)	(2,492)
Employee stock ownership plan	(16)	(11)	(296)	(213)
Incentive compensation plans	(7)	(8)	(158)	(152)
Stock options and appreciation rights	(14)	(5)	(275)	(101)
Conversion of Overseas Capital Corporation loan stock	—	—	(2)	—
Balance December 31	$ 189	$ 180	3,699	3,625

At December 31, 1980, and December 31, 1979, respectively, 227,765,000 and 227,839,000 common shares were outstanding. Common stock held in treasury at December 31, 1980, included 1,921,706 shares for the deferred compensation provisions of incentive compensation plans (1,785,656 shares at December 31, 1979). These shares are carried at market value at the time of allotment, which amounted to $96 million and $88 million at December 31, 1980 and 1979, respectively. The liability is recorded under other liabilities.

Other common stock in treasury, which is carried at cost, aggregated 1,777,382 and 1,839,762 shares at December 31, 1980 and 1979, respectively. These shares are held for future corporate requirements, including distributions under employee savings plans, incentive compensation awards and possible conversion of General Electric Overseas Capital Corporation convertible indebtedness. The maximum number of shares required for conversions was 736,079 at December 31, 1980 (737,725 at December 31, 1979). Corporate requirements of shares for benefit plans and conversions may be met either from unissued shares or from shares in treasury.

During 1978, the balance in common stock issued did not change, amounts received for common stock in excess of par value decreased by $10 million, and the balance of common stock held in treasury increased by $6 million.

19. Retained earnings

Retained earnings at year-end 1980 included approximately $251 million ($246 million at December 31, 1979) representing the excess of earnings of nonconsolidated affiliates over dividends received since their formation. In addition, retained earnings have been increased by $10 million ($5 million reduction at December 31, 1979), which represents the change in equity in associated companies since acquisition.

20. Stock option information

Stock option plans, appreciation rights and performance units are described in the Company's current Proxy Statement. A summary of stock option transactions during the last two years is shown below:

Stock options

	Shares subject to option	Average per share: Option price	Average per share: Market price
Balance at January 1, 1979	4,088,853	$51.37	$47.13
Options granted	1,023,122	46.25	46.25
Options exercised	(98,145)	40.63	50.14
Options surrendered on exercise of appreciation rights	(68,834)	40.52	49.17
Options terminated	(186,068)	50.77	—
Balance at December 31, 1979	4,758,928	50.67	50.63
Options granted	98,100	61.50	61.50
Options exercised	(273,193)	44.13	56.16
Options surrendered on exercise of appreciation rights	(123,350)	41.93	54.92
Options terminated	(157,163)	51.02	—
Balance at December 31, 1980	4,303,322	51.56	61.25

The number of shares available for granting additional options at the end of 1980 was 1,862,758 (1,831,456 at the end of 1979).

21. Commitments and contingent liabilities

Lease commitments and contingent liabilities, consisting of guarantees, pending litigation, taxes and other claims, in the opinion of management, are not considered to be material in relation to the Company's financial position.

Industry segment information

Revenues
For the years ended December 31

(In millions)	Total revenues			Intersegment sales			External sales and other income		
	1980	1979	1978	1980	1979	1978	1980	1979	1978
Consumer products and services	$ 5,599	$ 5,358	$ 4,788	$ 201	$ 199	$ 188	$ 5,398	$ 5,159	$ 4,600
Net earnings of GE Credit Corp.	115	90	77	—	—	—	115	90	77
Total consumer products and services	5,714	5,449	4,865	201	199	188	5,513	5,249	4,677
Industrial products and components	5,157	4,80[illegible]	4,124	565	508	468	4,592	4,295	3,656
Power systems	4,023	3,564	3,486	175	210	174	3,848	3,354	3,312
Technical systems and materials	7,128	6,061	4,745	258	255	190	6,870	5,806	4,555
Natural resources	1,374	1,260	1,032	—	—	—	1,374	1,260	1,032
Foreign multi-industry operations	3,234	2,901	2,767	75	64	55	3,159	2,837	2,712
Corporate items and eliminations	(1,107)	(1,057)	(946)	(1,274)	(1,236)	(1,075)	167	179	129
Total	$25,523	$22,980	$20,073	$ —	$ —	$ —	$25,523	$22,980	$20,073

Operating profit For the years ended December 31 / **Net earnings** For the years ended December 31

	Operating profit			Net earnings		
	1980	1979	1978	1980	1979	1978
Consumer products and services	$ 558	$ 568	$ 574	$ 292	$ 311	$ 300
Net earnings of GE Credit Corp.	115	90	77	115	90	77
Total consumer products and services	673	658	651	407	401	377
Industrial products and components	568	485	426	315	272	223
Power systems	194	174	196	141	114	93
Technical systems and materials	774	672	545	373	356	278
Natural resources	404	431	372	224	208	180
Foreign multi-industry operations	285	241	245	68	65	76
Total segment operating profit	2,898	2,661	2,435			
Interest and other financial charges	(314)	(258)	(224)			
Corporate items and eliminations	(91)	(12)	(58)	(14)	(7)	3
Total	$ 2,493	$ 2,391	$ 2,153	$ 1,514	$ 1,409	$ 1,230

Assets At December 31 / **Property, plant and equipment** For the years ended December 31

	Assets			Additions			Depreciation, depletion and amortization		
	1980	1979	1978	1980	1979	1978	1980	1979	1978
Consumer products and services	$ 2,325	$ 2,157	$ 2,018	$ 238	$ 208	$ 169	$ 133	$ 115	$ 104
Investment in GE Credit Corp.	931	817	677	—	—	—	—	—	—
Total consumer products and services	3,256	2,974	2,695	238	208	169	133	115	104
Industrial products and components	2,595	2,329	2,125	224	176	166	109	106	91
Power systems	2,289	2,135	2,105	129	101	84	91	84	79
Technical systems and materials	4,475	3,422	2,683	693	444	289	200	163	150
Natural resources	2,109	1,679	1,489	446	201	212	94	83	77
Foreign multi-industry operations	2,564	2,259	2,100	161	109	119	66	61	64
Corporate items and eliminations	1,223	1,846	1,839	57	23	16	14	12	11
Total	$18,511	$16,644	$15,036	$ 1,948	$ 1,262	$ 1,035	$ 707	$ 624	$ 576

Consumer Products and Services consists of major appliances, air conditioning equipment, lighting products, housewares and audio products, television receivers, and broadcasting and cablevision services. It also includes service operations for major appliances, air conditioners, TV receivers, and housewares and audio products.

General Electric Credit Corporation, a wholly owned nonconsolidated finance affiliate, engages primarily in consumer, commercial and industrial financing, principally in the U.S. It also participates, to a lesser degree, in life insurance and fire and casualty insurance activities. Products of companies other than GE constitute virtually all products financed by GECC.

Industrial Products and Components includes components (appliance controls, small motors and electronic components); industrial capital equipment (construction, automation and transportation); maintenance, inspection, repair and rebuilding of electric, electronic and mechanical apparatus; and a network of supply houses offering products of General Electric and other manufacturers.

Power Systems includes steam turbine-generators, gas turbines, nuclear power reactors and nuclear fuel assemblies, transformers, switchgear, meters, and installation and maintenance engineering services.

Technical Systems and Materials consists of jet engines for aircraft, industrial and marine applications; electronic and other high-technology products and services primarily for aerospace applications and defense; materials (engineered plastics, silicones, industrial cutting materials, laminated and insulating materials, and batteries); medical and communications equipment; and time sharing, computing, and remote data processing.

Natural Resources includes the mining of coking coal (principally in Australia), uranium, steam coal, iron and copper. In addition, it includes oil and natural gas production, ocean shipping (primarily in support of mining operations) and land acquisition and development.

Foreign Multi-industry Operations consists principally of foreign affiliates which manufacture products primarily for sale in their respective home markets.

Net earnings for industry segments include allocation of corporate interest income, expense and other financial charges to parent company components based on change in individual component average nonfixed investment. Interest and other financial charges of affiliated companies recognize that such companies generally service their own debt.

General corporate expenses are allocated principally on the basis of cost of operations, with certain exceptions and reductions which recognize the varying degrees to which affiliated companies maintain their own corporate structures.

In addition, provision for income taxes ($958 million in 1980, $953 million in 1979, and $894 million in 1978) is allocated based on the total corporate effective tax rate, except for GECC and Natural Resources, whose income taxes are calculated separately.

Minority interest ($21 million in 1980 and $29 million in both 1979 and 1978) is allocated to operating components having responsibility for investments in consolidated affiliates.

In general, it is GE's policy to price internal sales as nearly as practicable to equivalent commercial selling prices.

Geographic segment information

Revenues
For the years ended December 31

(In millions)	Total revenues			Intersegment sales			External sales and other income		
	1980	1979	1978	1980	1979	1978	1980	1979	1978
United States	$20,750	$18,859	$16,443	$ 484	$ 467	$ 362	$20,266	$18,392	$16,081
Far East including Australia	1,277	1,183	1,109	355	280	242	922	903	867
Other areas of the world	4,459	3,814	3,270	124	129	145	4,335	3,685	3,125
Elimination of intracompany transactions	(963)	(876)	(749)	(963)	(876)	(749)	—	—	—
Total	$25,523	$22,980	$20,073	$ —	$ —	$ —	$25,523	$22,980	$20,073

	Net Earnings (For the years ended December 31)			Assets (At December 31)		
	1980	1979	1978	1980	1979	1978
United States	$ 1,175	$ 1,120	$ 961	$13,732	$12,693	$11,410
Far East including Australia	169	174	170	1,090	842	889
Other areas of the world	181	120	104	3,808	3,207	2,827
Elimination of intracompany transactions	(11)	(5)	(5)	(119)	(98)	(90)
Total	$ 1,514	$ 1,409	$ 1,230	$18,511	$16,644	$15,036

Geographic segment information (including allocation of income taxes and minority interest in earnings of consolidated affiliates) is based on the location of the operation furnishing goods or services. Included in United States revenues were export sales to unaffiliated customers of $3,781 million in 1980, $2,772 million in 1979, and $2,571 million in 1978. Of such sales, $2,089 million in 1980 ($1,581 million in 1979 and $1,662 million in 1978) were to customers in Europe, Africa and the Middle East; and $926 million in 1980 ($741 million in 1979 and $498 million in 1978) were to customers in the Far East including Australia.

U.S. revenues also include royalty and licensing income from unaffiliated foreign sources.

Revenues, net earnings and assets associated with foreign operations are shown in the tabulations above. At December 31, 1980, foreign operation liabilities, minority interest in equity and GE interest in equity were $2,562 million, $141 million and $2,195 million, respectively. On a comparable basis, the amounts were $2,101 million, $139 million and $1,809 million, respectively, at December 31, 1979; and $1,910 million, $150 million and $1,656 million, respectively, at December 31, 1978.

Ten-year summary (a)

Selected financial data

(Dollar amounts in millions; per-share amounts in dollars)	1980	1979	1978	1977	1976
Summary of operations					
Sales of products and services to customers	$24,959	$22,461	$19,654	$17,519	$15,697
Cost of goods sold	17,751	15,991	13,915	12,288	11,048
Selling, general and administrative expense	4,258	3,716	3,205	3,011	2,635
Depreciation, depletion and amortization	707	624	576	522	486
Operating costs	22,716	20,331	17,696	15,821	14,169
Operating margin	2,243	2,130	1,958	1,698	1,528
Other income	564	519	419	390	274
Interest and other financial charges	(314)	(258)	(224)	(199)	(175)
Earnings before income taxes and minority interest	2,493	2,391	2,153	1,889	1,627
Provision for income taxes	(958)	(953)	(894)	(773)	(668)
Minority interest	(21)	(29)	(29)	(28)	(28)
Net earnings	$ 1,514	$ 1,409	$ 1,230	$ 1,088	$ 931
Earnings per common share (b)	$ 6.65	$ 6.20	$ 5.39	$ 4.79	$ 4.12
Dividends declared per common share (c)	$ 2.95	$ 2.75	$ 2.50	$ 2.10	$ 1.70
Earnings as a percentage of sales	6.1%	6.3%	6.3%	6.2%	5.9%
Earned on average share owners' equity	19.5%	20.2%	19.6%	19.4%	18.9%
Dividends–General Electric	$ 670	$ 624	$ 570	$ 477	$ 333
Dividends–Utah International Inc. (d)	—	—	—	—	$ 28
Shares outstanding–average (in thousands) (e)	227,541	227,173	227,985	227,154	225,791
Share owner accounts–average	524,000	540,000	552,000	553,000	566,000
Market price range per share (c) (f)	63-44	55⅛-45	57⅜-43⅝	57¼-47⅜	59¼-46
Price/earnings ratio range (c)	9-7	9-7	11-8	12-10	14-11
Current assets	$ 9,883	$ 9,384	$ 8,755	$ 7,865	$ 6,685
Current liabilities	7,592	6,872	6,175	5,417	4,605
Working capital	$ 2,291	$ 2,512	$ 2,580	$ 2,448	$ 2,080
Short-term borrowings	$ 1,093	$ 871	$ 960	$ 772	$ 611
Long-term borrowings	1,000	947	994	1,284	1,322
Minority interest in equity of consolidated affiliates	154	152	151	132	119
Share owners' equity	8,200	7,362	6,587	5,943	5,253
Total capital invested	$10,447	$ 9,332	$ 8,692	$ 8,131	$ 7,305
Earned on average total capital invested	17.3%	17.6%	16.3%	15.8%	15.1%
Share owners' equity per common share–year end (b)	$ 36.00	$ 32.31	$ 28.88	$ 26.05	$ 23.18
Total assets	$18,511	$16,644	$15,036	$13,697	$12,050
Property, plant and equipment additions	$ 1,948	$ 1,262	$ 1,055	$ 823	$ 740
Employees–average worldwide	402,000	405,000	401,000	384,000	380,000

(a) Unless specifically noted, all years are adjusted to include Utah International Inc., which became a wholly owned affiliate of General Electric on December 20, 1976, through the exchange of 41,002,034 shares of General Electric common stock for all of the outstanding shares of Utah.

(b) Computed using outstanding shares as described in note (e).

(c) For General Electric common stock as reported in the years shown.

(d) Reflects transactions prior to merger date.

(e) Includes General Electric outstanding average shares or year-end shares as appropriate, plus, in 1976 and prior years, outstanding shares previously reported by Utah multiplied by 1.3. Adjustments have been made for the two-for-one Utah stock split effected in the form of stock dividends in 1973.

(f) Represents high and low market prices as reported on New York Stock Exchange through January 23, 1976, and as reported on the Consolidated Tape thereafter.

1975	1974	1973	1972	1971
$14,105	$13,918	$11,945	$10,474	$9,557
10,210	10,092	8,445	7,381	6,809
2,238	2,240	2,058	1,872	1,686
470	415	372	344	290
12,918	12,747	10,875	9,597	8,785
1,187	1,171	1,070	877	772
174	207	203	207	177
(187)	(197)	(143)	(121)	(102)
1,174	1,181	1,130	963	847
(460)	(458)	(457)	(385)	(333)
(26)	(18)	(12)	(5)	(4)
$ 688	$ 705	$ 661	$ 573	$ 510
$ 3.07	$ 3.16	$ 2.97	$ 2.57	$ 2.30
$ 1.60	$ 1.60	$ 1.50	$ 1.40	$ 1.38
4.9%	5.1%	5.5%	5.5%	5.3%
15.7%	17.8%	18.4%	17.5%	17.2%
$ 293	$ 291	$ 273	$ 25[illegible]	$ 250
$ 33	$ 24	$ 14	$ 1[illegible]	$ 11
224,262	222,921	222,631	222,503	221,591
582,000	566,000	543,000	542,000	529,000
52¼-32¾	65-30	75⅞-55	73-58¼	66½-46½
17-10	19-9	24-17	25-20	26-18
$ 5,750	$ 5,334	$ 4,597	$ 4,057	$3,700
4,163	4,032	3,588	2,921	2,894
$ 1,587	$ 1,302	$ 1,009	$ 1,136	$ 806
$ 667	$ 656	$ 676	$ 453	$ 582
1,239	1,403	1,[illegible]66	1,191	1,016
105	86	63	54	50
4,617	4,172	3,774	3,420	3,106
$ 6,628	$ 6,317	$ 5,679	$ 5,118	$4,754
12.5%	13.4%	13.7%	12.7%	12.3%
$ 20.49	$ 18.65	$ 16.[illegible]	$ 15.35	$13.96
$10,741	$10,220	$ 9,089	$ 8,051	$7,472
$ 588	$ 813	$ 735	$ 501	$ 711
380,000	409,000	392,000	373,000	366,000

Other information

Quarterly dividend and stock market information

	Dividends declared		Common stock market price range	
	1980	1979	1980	1979
First quarter	70¢	65¢	$57½-$44	$50¾-$45½
Second quarter	75	70	52 - 44½	51⅝- 46⅞
Third quarter	75	70	58⅛- 51⅛	55⅛- 49⅛
Fourth quarter	75	70	63 - 51½	52¼- 45

The New York Stock Exchange is the principal market on which GE common stock is traded and, as of December 8, 1980, there were approximately 512,282 share owners of record.

Operations by quarter for 1980 and 1979

(Dollar amounts in millions; per-share amounts in dollars)	First quarter	Second quarter	Third quarter	Fourth quarter
1980:				
Sales of products and services to customers	$5,881	$6,197	$5,963	$6,918
Operating margin	527	556	513	647
[illegible] earnings	34[illegible]	403	358	411
[illegible] earnings per common share	1.50	1.77	1.58	1.80
1979:				
Sales of products and services to customers	$5,082	$5,642	$5,609	$6,128
Operating margin	470	598	511	551
Net earnings	303	382	341	383
Net earnings per common share	1.33	1.69	1.50	1.68

Dividend Reinvestment Plan

GE share owners whose Company stock is registered in their own names and whose addresses of record are in the United States or its territories or possessions are eligible to participate in the GE Dividend Reinvestment Plan. For information on the plan, write to: Share Owner Records, General Electric Company, P.O. Box 206, Schenectady, N.Y. 12301.

Form 10-K and other supplemental information

The financial information in this Report, in the opinion of management, substantially conforms with or exceeds the information required in the "10-K Report" submitted to the Securities and Exchange Commission. Certain supplemental information, considered nonsubstantive, is included in that report, however, and copies will be available without charge, on or about May 1, from: **Investor Relations, General Electric Company, Fairfield, Connecticut 06431.**

Copies of the General Electric Pension Plan, the Summary Annual Reports for GE employee benefit plans subject to the Employee Retirement Income Security Act of 1974, and other GE employee benefit plan documents and information are available by writing to Investor Relatio[illegible]s and specifying the information desired.

Transfer Agents

General Electric Company
Securities Transfer Operation
570 Lexington Avenue
New York, New York 10022

The First National Bank of Boston
Shareholder Services Division
P.O. Box 644
Boston, Massachusetts 02102

10.0 FACILITIES DESCRIPTION

10.1 Plant Layout

The Wilmington Manufacturing Department (WMD) is located approximately six miles north of Wilmington, NC on U.S. Highway 117. Figure 10.1 shows the plant layout of all major facilities. Figure 10.2 shows that portion of the plant area associated with the fuel manufacturing operations and included in the nuclear risk insurance pool. Figure 10.3 is a layout of the prime fuel manufacturing operations showing principal unit operations.

10.2 Utilities

10.2.1 Electrical

Electric power is supplied from the Carolina Power & Light Company, three-phase (3Ø), 115,000-volt transmission line, originating at the Sutton generating plant approximately four miles southwest of the WMD plant.

Supply power is reduced to 3Ø, 13,000 V at the WMD main substation and distributed throughout the plant on an overhead electrical transmission bridge. Each production building has rooftop penthouses containing transformers and switchgear to reduce the voltage from 3Ø, 13,000 V to 3Ø, 440/277 V.

FIGURE 10.1

GE-WMD PLANT LAYOUT OF MAJOR FACILITIES

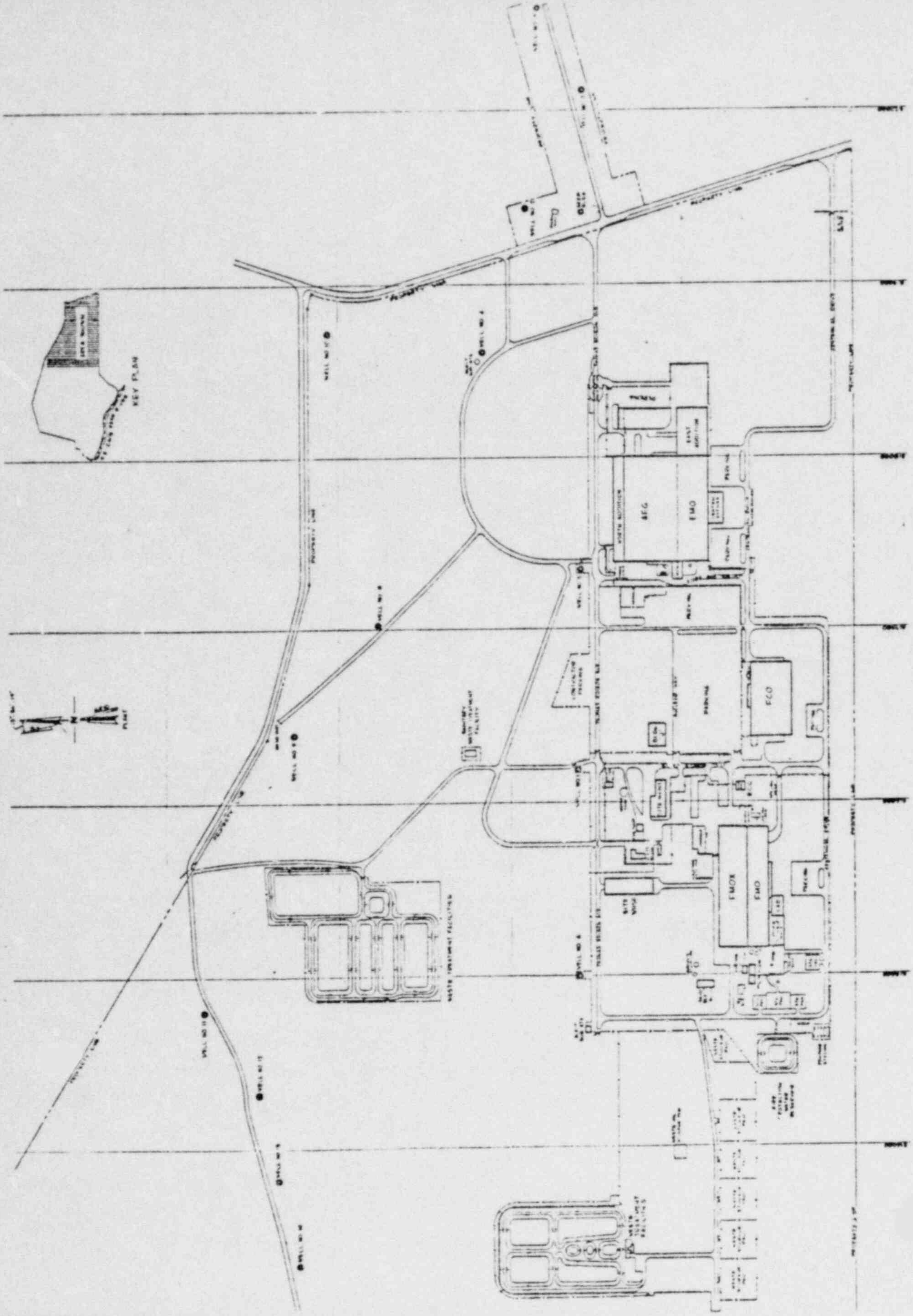
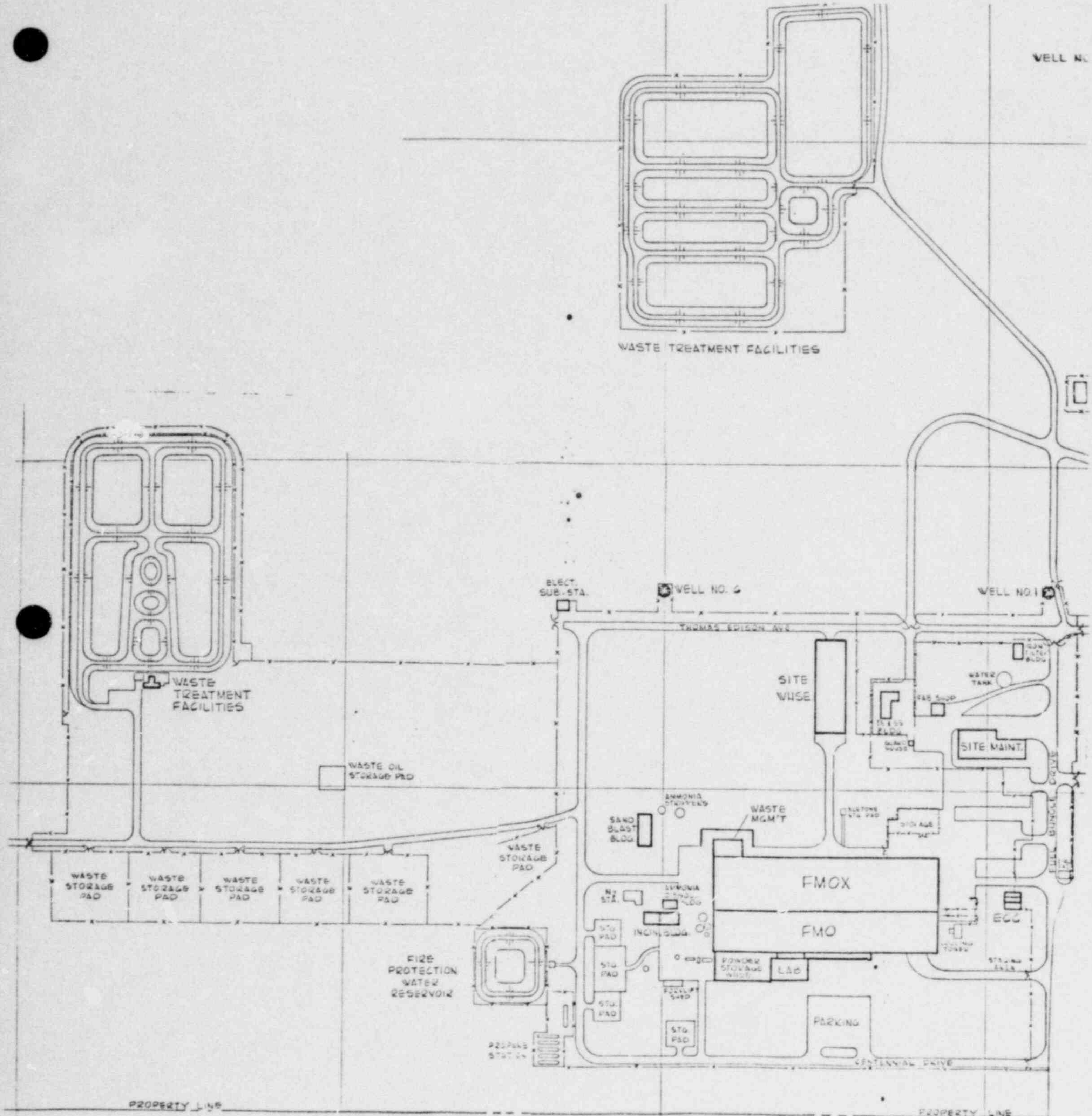


FIGURE 10.2

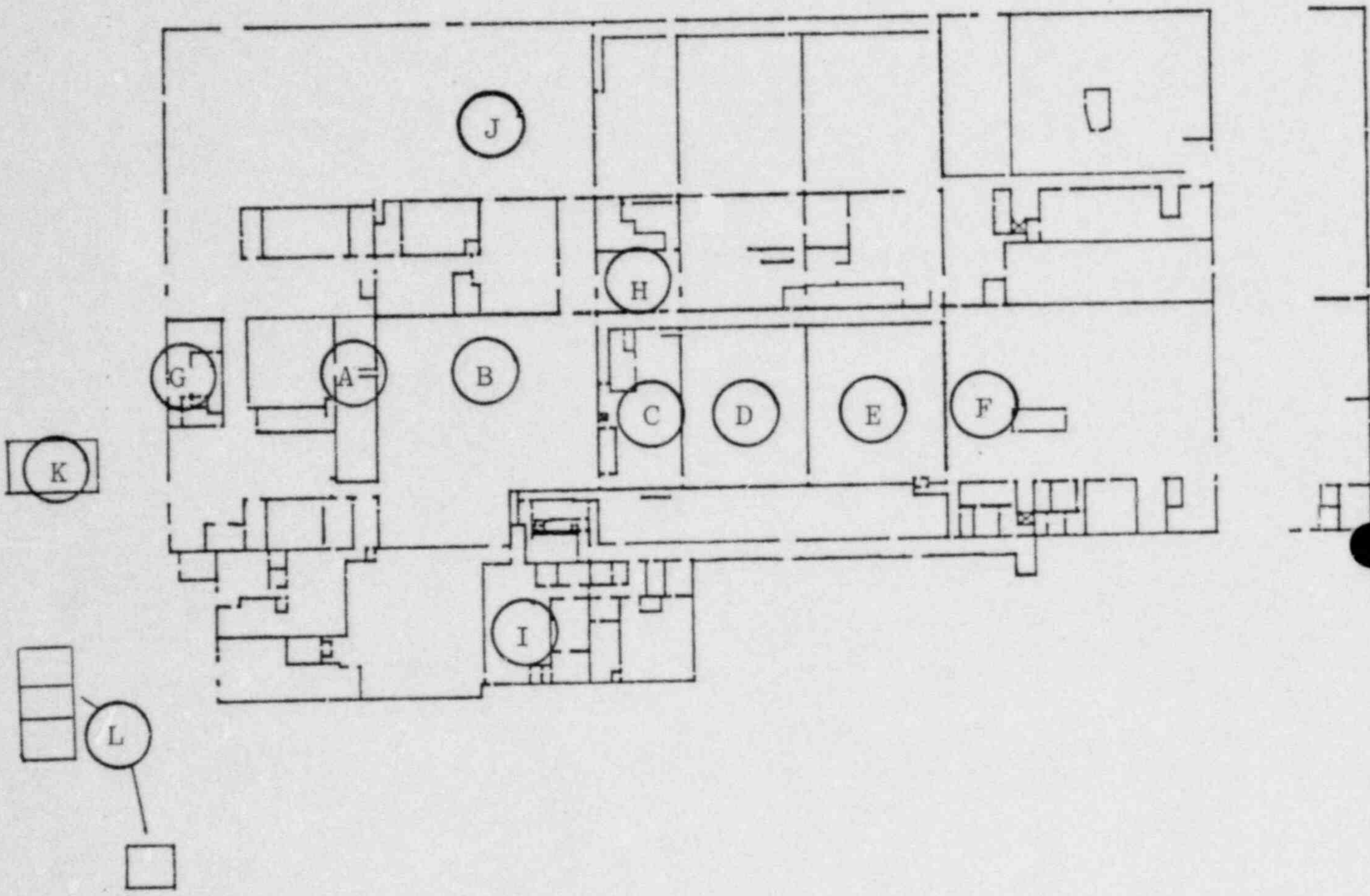
SECTION OF GE-WMD INCLUDED IN NUCLEAR RISK INSURANCE POOL



FUEL MANUFACTURING COMPLEX

FIGURE 10.3

GE-WMD PRIME FUEL MANUFACTURING OPERATIONS



A - Vaporization
B - UF_6-UO_2 Conversion
C - Pelletizing
D - Sintering
F - Segmentizing
F - Bundle Assembly

G - Waste Treatment
H - Powder Storage
I - Chemet Laboratory
J - GECO
K - Incinerator
L - Outside Powder Storage

There are two main feeders from the main substation to each major production facility. The building electrical loads are divided between the two feeders. Manual switching is provided, and capacity is available for either feeder to carry the entire building electric load.

10.2.2 Emergency Power

Process equipment design provides for fail-safe conditions should electrical service be interrupted. Emergency power is provided for water supply, supervised alarm system, and essential equipment cooling. The following are emergency power applications:

10.2.2.1 Emergency Lighting - Individual Units in Area

Battery operated emergency lighting to provide safe egress from all interior building locations - 4-8 hour duration.

10.2.2.2 Emergency Power - Autocall System - Main Guard Shelter

Provides automatic switch over of autocall system to batteries to maintain surveillance of supervised alarm system throughout the plant. Duration 4-8 hours.

10.2.2.3 Emergency Power - Criticality System - Emergency Control Center

Provides automatic switch over to battery system to provide continuous criticality surveillance until system is automatically transferred to the emergency generator.

10.2.2.4 Emergency Power - FMO - Critical System

A 175-HP diesel-operated generator, located outside the east end of the fuel manufacturing building, provides an automatic startup of the emergency generator and a switch over to the emergency system in the event of a power failure. Emergency power is provided for the criticality alarm system, the controlled area air sampling system, and the sintering furnace cooling system.

10.2.2.5 Emergency Power - Standby 13V System

A 13,000 V system from a 22 KVA distribution system is provided for limited emergency power. Normally this system provides power to the water supply system and the waste treatment facility. In an event of a power outage on the main supply there is limited power available by manually switching to provide power to selected operations. The utilization of the standby 13,000 V system for other than the water supply would not be considered unless the electrical outage on the main substation was estimated to be in excess of eight hours. In this case manual switching of all circuits would be initiated to limit emergency power to emergency lighting and selected heating, ventilation, and air conditioning (HVAC) equipment in the fuels manufacturing operation necessary for airborne containment in the controlled areas.

10.2.2.6 Re-establishment of Normal Electric Service

Battery operated emergency systems, used for emergency lighting, autocall system and criticality system, are automatically transferred to the main electric supply when power is returned and recharging capability to the batteries is provided.

Re-establishment of electric load to the sintering furnace cooling system is performed manually by switching individual pump systems and air sampling systems back to normal power. The emergency generator is shutdown and placed in the emergency stand-by mode.

Lighting and air conditioning are automatically restored when electric service is resumed. Process equipment is manually restarted in the same sequence as from a normal shutdown mode.

10.2.3 <u>Compressed Air</u>

There are six air compressors in the fuel manufacturing operation providing a total capacity of 3900 cfm of compressed air at 100 psi. All air compressors discharge to common surge tanks from which the air supply is directed to plant air systems or instrument air systems. The air compressor system provides for prefiltering prior to compression, secondary filtering, and refrigeration drying to remove oil and water. Air destined for instrumentation and for heating apparatuses is further filtered and dried in a descicant filter. Only high quality instrument air is used for breathing purposes in the waste decontamination facility. The air compressors and auxiliaries are located in the west end of the fuel manufacturing building and piped throughout the building area.The plant air and instrument air systems are looped to provide constant air pressure and volume at remote locations. The air compressors are interchanged in pairs with one compressor under load and the second unit idling on line. When air-supply demands reduce the pressure in the surge tank by a predetermined amount, the second unit is automatically placed on line, and remains on the line until the air-supply demand returns to normal.

10.2.4 Water Supply

Plant water is supplied from fifteen deep wells with a combined capacity of 1125 gpm. There is no alternate site water supply. A 300,000 gallon elevated storage tank provides 150,000 gallons of water for plant use in the event of a short interruption of electrical power and maintains a constant pressure in the water system.

Figure 10.4 shows a schematic of the water supply system for the WMD plant. Well water is treated for removal of sand and iron, and is chlorinated prior to entering the distribution system.

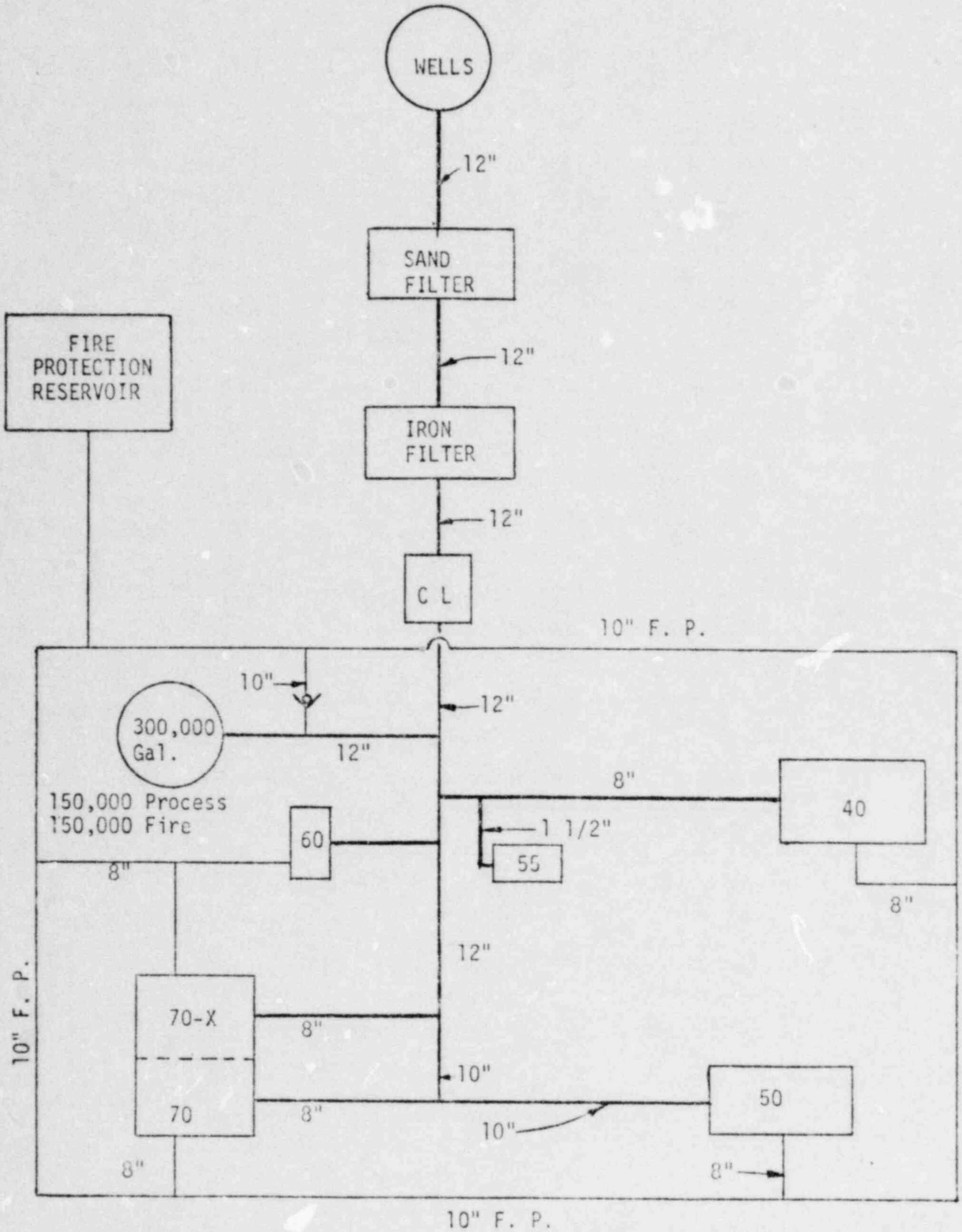
At its entrance to each building the water supply is separated into two systems, potable water and plant water. Potable water is restricted to drinking, sanitary needs, safety showers and eye washers: plant water supplies process and facility needs. The plant water system has reduced pressure backflow preventers to preclude backflow of plant process water into the potable water system under any condition.

Under normal conditions, the average daily water consumption would be 557,000 gallons used for plant industrial use. Abnormally high usage would only occur during activation of the fire protection system at which time water consumption could reach 1125 gpm.

The following is a failure analysis of the water supply system. Note that normally the electricity for the water system is supplied by the 13.8-KV standby system from a 22-KV distribution system.

FIGURE 10.4

GE-WMD WATER SYSTEM



10.2.4.1 Loss of System Power

Action: Open disconnects at standby substation and then transfer system to main substation.

Time: Approximately 15-20 minutes

System Effect: None. Elevated storage tank will normally handle plant loads for 4-6 hours.

10.2.4.2 Loss of Power to Well

System Effect: None. Presently less than 50% of system capacity is being utilized. Elevated storage tank will normally handle plant loads for 4-6 hours.

10.2.4.3 Break in Supply Main

Action: In-line valves installed to allow sectionalizing of system to isolate break point.

Time: 15-30 minutes

System Effect: None. Elevated storage tank will normally handle plant load for 4-6 hours.

10.2.4.4 Break in Distribution System

Action: Close branch header to building

Time: 15-30 minutes

System Effect: Building supply line cut off. Production down time only. As long as electric power is available in the building affected by the water curtailment, the recirculating cooling water system will allow essential equipment to be safely cooled down.

10.3 Heating, Ventilation, and Air Conditioning (HVAC)

10.3.1 General

The heating, ventilation, and air conditioning systems are designed to maintain a clean and conditioned air supply to all areas of the building and to exhaust air through appropriate filtering or washing devices from equipment and areas where significant quantities of radioactive materials are handled. Under normal and most anticipated abnormal process conditions, personnel will not require respiratory protective equipment.

The exhaust equipment is designed to provide air flow from areas of lesser contamination to areas of higher contamination, to confine and contain air streams containing radioactive constituents, and to minimize the potential accumulation of contamination within the air handling ductwork.

Each of the separate area air handling systems appropriately combine fans, dampers, ducts, filters, signals, and pneumatic and electrical control devices to provide ventilation consistent with the specific requirements of that area.

Final filters, greater than 99.97% efficient for 0.3 micron-diameter particles, are equipped with pressure drop measuring devices to detect filter loading; pressure drop of greater than 4.0" of water across a filter will signal a condition requiring special investigation of filter effectiveness. When the airborne radioactivity in the air downstream from a final filter approaches the maximum acceptable release limit as determined by air sample results, the filter is replaced. Detailed information on the various ventilation systems is set forth below. All rates are nominal.

10.3.2 Vaporization Area - Area A

Volume	71,000 cu. ft.
Exhaust	6,000 CFM
Recirculation	9,000 CFM
Air Changes/Hour	11.7

Total air supply to the vaporization area is 15,000 CFM with 6,000 CFM coming from outside air. Another 9,000 CFM is supplied from the recirculating system which is equipped with a high efficiency particulate air (HEPA) filter. Both supply systems are equipped with cooling and heating coils for room temperature conditioning as required.

Room air is exhausted to the conversion area discharge at a rate of 6,000 CFM. The exhaust via this route is discharged through the scrubber and HEPA filter system previously described. Signals, actuated by duct sail switches and differential-pressure gauges, warn of malfunction of either primary or recirculation systems. No gases are discharged directly from this area to the atmosphere.

10.3.3 UF_6-UO_2 Conversion Area - Area B

Volume	473,000 cu. ft.
Roof Scrubber Exhaust	30,000 CFM
Slugger/Granulator Exhaust	16,000 CFM
#5 Mill Exhaust	2,000 CFM
Baghouse Exhaust	2,000 CFM
Recirculation	90,000 CFM
Air Changes/Hr	17.7

Supply air consists of 27,000 CFM into the area and, in lesser rates, from the changerooms and the machine shop. Duct-mounted switches signal loss of air supply at a control panel.

Two large exhaust fans are installed in parallel and are alternately operable by manual switching at the operator control panel. Each fan is independently filtered and capable of maintaining 3.8 air changes per hour. The slugger/granulator exhaust is capable of maintaining 2.0 air changes per hour while the #5 mill and baghouse exhaust provides 0.5 air change per hour. The recirculation system provides an additional 11.4 air changes per hour.

Air intake to the exhaust system moves through polyvinyl chloride ducts to a water scrubber in which a recirculating water stream removes contaminants, returning them, in a portion of the scrub solution, to the process. After scrubbing, the air is heated by steam heaters, passed through an HEPA filter and the exhaust fan, sampled and discharged.

10.3.4 Pelletizing Area - Area C

Volume	66,200 cu. ft.
Exhaust	8,400 CFM
Recirculation	11,000 CFM
Air Changes/Hour	17.6

The room exhaust of 8,400 CFM is primarily taken from the pellet press area. Sail switches signal deficiencies in the exhaust or supply streams at the control panel in the mezzanine equipment room. Room pressure is controlled with a manual damper in the air supply duct. HEPA filtration and sampling is provided before the air is exhausted to the atmosphere, and HEPA filters are installed in the recirculation system.

10.3.5 Sintering Area - Area D

Volume	150,000 cu. ft.
Exhaust	12,000 CFM
Recirculation	60,000 CFM
Air Changes/Hour	27

Four fans recirculate sintering-room air at a rate of 15,000 CFM each through cooling or heating coils, fan and duct to room discharge. The system performance is monitored by sail switches and differential pressure gauges. Alarms for system malfunction are provided at operator control panels.

The above four fans also supply make-up air to the sintering area recirculation system to replace the 8,000 CFM which is exhausted from the furnace hood. That exhaust stream is discharged through HEPA filters to a roof stack. The air stream is sampled prior to its release to the atmosphere. Room pressure can be controlled by adjusting the input damper on outside air.

10.3.6 Segmentizing Area - Area E

Volume	160,000 cu. ft.
Exhaust	11,700 CFM
Recirculation	16,000 CFM
Air Changes/Hour	10.4

Outside air is supplied to the recirculating system duct where it is conditioned and passed on with the recirculated air stream to the room. The recirculating volume is 16,000 CFM, and the outside air supply adds 11,700 CFM.

Exhaust is accomplished with a flow rate of 11,700 CFM from the grinder area and the rod loading stations. Air is routed through the duct to the HEPA filter, fan, and monitored exhaust stack.

10.3.7 Noncontrolled Areas - Area F

Air handling in the noncontrolled area is accomplished by recirculation and fresh air make-up necessary to maintain design temperature and humidity conditions. Controls are provided in the noncontrolled areas so that more pressure can be maintained at a positive level with respect to control zones.

10.3.8 Waste Treatment - Area G

Volume	62,500 cu. ft.
Exhaust	8,600 CFM
Fresh Air Make-up	5,000 CFM
Air Changes/Hour	8.3

Exhaust from the waste treatment tanks and the decontamination hoods is directed to the conversion area vent system. Combined exhaust from those two sources add 8,600 CFM to the vent header.

Outside air is supplied to the waste treatment room at a rate of 5,000 CFM from a 100% outside air make-up unit.

Manual dampers control the amount of air exhausting to the roof scrubbers. Stack gases are sampled prior to release to the atmosphere at the stack termination point.

10.3.9 UO_2 Powder Storage - Area H

Volume	78,500 cu. ft.
Exhaust	6,000 CFM
Recirculation	7,000 CFM
Air Changes/Hour	9.2

All gaseous exhaust from the UO_2 powder storage area is through hoods at the powder transfer hoppers. Total exhaust rate from the room is 9,000 CFM through HEPA filters with 3,000 CFM discharging to a recirculation system.

Outside air is supplied to this system at a rate of 5,000 CFM. It is mixed with 4,000 CFM of recirculating air and is thermally conditioned prior to discharge into the room by the recirculation fan. Pneumatic-electrical instruments monitor the system operation and signal loss of air flow.

10.3.10 Chemet Laboratory - Area I

The chemical and metallurgical laboratory ventilation system where laboratory work is done that products dust is independent of the fuels manufacturing area and is designed to exhaust all laboratory air through the hoods in the controlled rooms. Each hood is equipped with a roughing filter and a HEPA filter. An additional HEPA filter is installed in the main duct upstream from the exhaust fan.

Occasionally, although infrequently, samples of uranium containing trace amounts of plutonium may be received from external sources for purposes of verifying analytical methods and equipment. When such samples are received, special preparation is made to isolate the activity including lining the hood with absorbent paper, additional protective clothing, special step-off pads and frequent monitoring.

10.3.11 GECO Subareas - Area J

	Vaporization	HF Room	Chemical Area
Volume	82,800 cu ft	9,974 cu ft	153,900 cu ft
Exhaust	3,000 CFM	2,000 CFM	14,900 CFM
Recirculation	12,100 CFM	0	31,000 CFM
Air Changes/Hr	10.9/hr	12.3/hr	13.8/hr

The GECO area is divided into three main areas - vaporization, HF room, and a chemical area. The vaporization area and the chemical area HVAC systems provide for outside fresh air make-up, recirculation, and exhaust. The HF room is supplied from the chemical area and only has exhaust capabilities. The exhaust from all three major systems is passed through a wet scrubber in which a recirculating water stream removes contaminants returning them in a portion of the scrubber solution to the waste recovery process stream. After scrubbing, the air is heated by steam heaters, passed through HEPA filters, sampled and discharged. In the event of a power failure all systems are designed for the fail safe mode.

10.3.12 Incinerator - Area K

A contaminated waste incinerator is being constructed on the WMD site west of the fuels manufacturing building. The building will have a volume of 92,400 cu. ft. The HVAC system will provide for fresh air intake, recirculation, and exhaust. Design criteria will be in accordance with latest standard for the control of HVAC systems associated with the handling of radioactive materials and the exhaust from such facilities. Exhaust monitoring capabilities will be provided.

10.4 Waste Handling

10.4.1 Liquid Waste

There are three process liquid waste streams discharged from the fuel manufacturing operation. These waste streams are designated as fluoride wastes, nitrate wastes, and rad waste. The streams are shown schematically on Figure 10.5.

10.4.1.1 Design Concepts

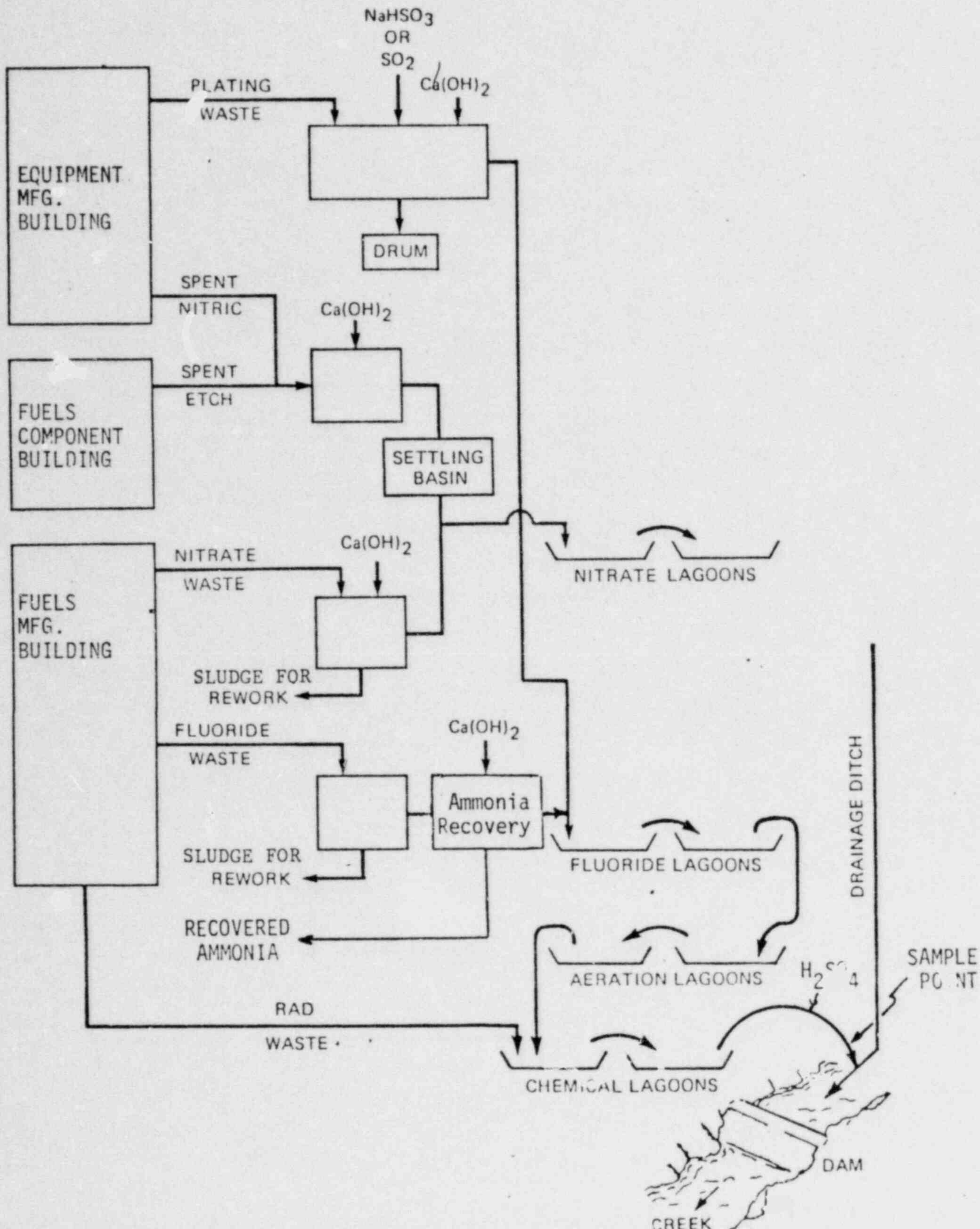
The waste streams are separated into the three chemically compatible groups mentioned above. This segregation facilitates subsequent treatment steps.

Necessary interim storage is provided by use of surge tanks and lagoons. There is no permanent liquid storage on site.

Dikes and curbs are used to either contain spills or direct them to the final lagoon system. The developed areas of the site are graded to direct storm water runoff to a central ditch which is also used to conduct treated process and sanitary wastes to the river. A

FIGURE 10.5

PROCESS LIQUID WASTE TREATMENT



dam installed in this ditch can be utilized to contain the runoff from the developed areas. These details are shown in Figure 10.5.

10.4.1.2 Fluoride Waste Stream

Chemical wastes from the conversion process are collected in slab tanks. The wastes in the tanks are sampled and analyzed for uranium content. If the uranium content meets internal action guides, they are released to a 65,000 gallon storage tank; otherwise they are recycled for additional processing. The liquid in the 65,000 gallon storage tank is circulated constantly to keep the solids in suspension and thus prevent settling in the bottom of the tank. This tank bottom is V-shaped and is checked on a regular basis for accumulation of solid material.

The fluoride waste is transferred via a pipeline from the 65,000 gallon storage tank to a 100,000 gallon settling tank. At the waste treatment facility the solid material is recovered from this settling tank by centrifugation and is collected and stored in five gallon pails. The supernate from this tank is treated to remove ammonia and fluoride.

The recovered ammonia is reused in the manufacturing process. The treated waste water is pumped into storage lagoons in which the precipitated CaF_2 is allowed to settle. The liquid in the storage lagoons is then pumped to aeration lagoons where if necessary it can be sprayed to remove entrained ammonia. The liquid is then discharged through a line in which it is sampled for uranium, nitrate, and ammonia content. It is then fed into the plant industrial waste drain. This drain directs liquid to the final lagoons from which liquid is released into a drainage ditch and then offsite to the river. As the liquid leaves the final lagoons it is sampled for uranium and other chemical contents.

10.4.1.3 Nitrate Waste Stream

The liquid wastes resulting from the uranium purification system are processed through a slab quarantine tank system. As long as the uranium concentration is less than internal action guides the liquids are pumped into a 20,000 gallon accumulation tank. This liquid is then circulated in the accumulation tank until it is pumped to a second 20,000 gallon treatment tank in which it is treated with a lime slurry for raising its pH and for precipitating any uranium remaining in solution. After a period of time to permit settling of solids at the bottom of the tank, the clear supernatant is pumped to nitrate storage lagoons. These treated materials are utilized beneficially as described in Chapter 5.1.4.2. The solids collected in the bottom of the 20,000 gallon treatment tank are recycled through a centrifuge with the solid-free liquid being returned to this tank.

10.4.1.4 Radioactive (RAD) Waste Stream

Waste water from sources such as laboratory sinks, protective clothing laundering machines and floor drains is routed to the RAD waste system. Concentrations of uranium in water from these points normally is quite low. The system consists of collection tanks, centrifuges and uranium monitoring equipment. Waste water is collected and transferred to a slab-shaped accumulator tank.

From the accumulator tank, the water is centrifuged to remove suspended uranium compounds. The clarified water flows into a quarantine tank, is sampled and, as long as the uranium concentration is less than internal action guides, is pumped to the final lagoon system. Higher-than-limits waste is returned to the system for rework. A composite of the RAD waste effluent is collected on a basis proportioned to flow. This sample is analyzed daily for uranium concentration.

This is a contained wet system thus presenting no significant radiation safety hazards. Solids removed from centrifuges are put into pails and lidded while the material is still wet.

10.4.1.5 Sanitary Waste Stream

Sanitary waste is collected and transferred in a dedicated sanitary drain system to an extended aeration sanitary waste treatment facility. The treated effluent enters the site drainage ditch where it combines with other industrial liquid waste for discharge to the Northeast Cape Fear River.

Final Effluent

As shown in Figure 10.5, the treated fluoride waste and rad waste streams flow into chemical lagoons. The effluent from these lagoons is pH adjusted prior to discharge via a ditch to the Northeast Cape Fear River. Internal action guides established for uranium concentration are: (1) a one day value of 5 parts per million, and (2) a calendar month average of 2 parts per million.

10.4.2 Solid Waste

Two types of solid waste are generated at the WMD operation. One is normal industrial waste such as wood crating, packaging material, office paper, rags, cans, barrels, etc. This waste is collected in large containers and transported to the county landfill where it is buried.

Solid process waste can be classified in two categories; contaminated/noncontaminated and combustible/noncombustible. Contaminated combustible solid process waste is burned in a dedicated contamination incinerator; the ash is shipped offsite to an approved facility for recovery of uranium. Contaminated noncombustible waste is cleaned, packaged, and shipped to a licensed low radioactive material burial ground. Some solid waste is generated by chemical precipitation from the liquid solutions and is stored in lagoons. Calcium fluoride sludge is also stored in large holding ground storage areas. Zirconium sludges are fixed by a chemical fixation process and stored in earthen dike storage areas on site. Normal noncontaminated solid process waste is disposed of at the local county landfill.

Other solid wastes are stored in a secured area until processes are developed to recover the material; included in this category is zirconium scrap turnings and grinding dust.

In compliance with the Resource Conservation and Recovery Act, all hazardous waste generated at WMD has been identified and reviewed; provisions have been made to identify, control, store, and dispose of it in approved methods.

10.5 Chemical Systems

Major components of nonradiological chemical operations are discussed in this section. The potential hazards and associated information are presented in Chapter 17.

In addition to nuclear fuel manufacturing, other production operations conducted by General Electric at the Wilmington site include the manufacture of stainless steel reactor equipment, the fabrication of zirconium components for fuel assemblies and the manufacture of aircraft engine components. These activities are typical of conventional metalworking plants and are carried out in facilities physically separate from the fuel building.

Although these facilities operate on a multishift basis (the number of days worked per week and the number of shifts per day will vary with production requirements) the manufacturing chemical processes operate on a batch basis. The chemicals used in the batch processes are drawn from either bulk or small package storage areas adjacent to the facilities. The waste streams are either treated at the generating facility or transported to the site waste treatment facility.

All process areas and chemical storage areas are curbed, diked, sloped to process drains or otherwise contained to control unplanned releases.

10.5.1 Reactor Equipment and Aircraft Engine Components

Surface Cleaning - Metal parts are immersed in tanks containing either water solutions or alkaline cleaners or dilute nitric acid as appropriate. Some components are processed through a vapor degreaser operation.

Inspection - These operations require the use of dye penetrant systems to assure product quality. Small quantities of these materials are handled in water borne systems.

Plating - Copper plating and subsequent stripping, and chromium plating is done on a small portion of the parts manufactured.

Nitriding - Dissociated ammonia is utilized in a nitriding furnace for surface treatment of stainless steel.

Etching - Chemical etching of titanium alloys, Inconel and Rene' will be conducted on a batch basis. The acids used in these operations are nitric, hydrochloric and hydrofluoric.

10.5.2 Zirconium Fuel Assembly Components

Surface Cleaning and Inspection - These operations are similar to those described in Chapter 10.5.1.

Etching - Chemical etching of zircalloy components is conducted on a batch basis. The acids for this operation are nitric and hydrofluoric.

10.5.3 Final Lagoon System

Sulfuric acid is added to the final process lagoon effluent to adjust the pH to the required range of between 6 - 9. This is a continuous operation.

10.5.4 Major Chemical List

Major chemicals involved in the nonradioactive chemical operations are listed below. The U.S. Environmental Protection Agency codifications used in 40 CFR 261 for hazardous wastes are used to denote the type of hazards involved. (40 CFR 261 Designation: C - Corrosive, T - Toxic, R - Reactive).

TABLE 10.

Chemical	40 CFR 261 Code
Ammonia	None
Hydrochloric Acid	C
Nitric Acid	C
Sodium Hydroxide	C
Hydrofluoric Acid	C, T
Sulfuric Acid	C
1, 1, 1 Trichloroethane	T
Spent Plating Solution - Nickel Chloride	R, T
Spent Plating Solution - Copper Sulfate	R, T
Spent Plating Solution - Chromic Acid	R, T

10.6 Fire Protection

10.6.1 Building Design - Nuclear Fuel Manufacturing

Design of the WMD facility was performed by J.E. Sirrine Co., Greenville, N.C. in accordance with existing local, state, federal and national codes, standards and/or regulations. The building and appurtances used to process and store hazardous materials were designed to provide for containment of such materials under extreme uncontrollable environmental conditions such as temperature, fire, wind, flooding, and earthquake.

The building is fabricated of concrete block and insulated metal siding over a steel framework with a concrete floor. A built-up roof consists of a metal deck and insulation which is topped with asphalt and gravel. The insulated steel deck and roof construction meets Factory Mutual requirements for minimum fire hazard and wind resistance. It is designed for 40-psi live-load in addition to the dead-load factor. Earthquake loadings and design criteria are based on the applicable portion of Volume I, "Uniform Building Code", latest edition. The building is complete sprinklered except for the UO_2 powder storage area and the chemical process control room, and is equipped with hose connections. Water is supplied from onsite wells which feed a 300,000 gallon elevated water storage tank and a grade level reservoir of the same capacity. The facility and processes have been insured for nuclear liability and property coverage by the American Nuclear Insurer (ANI). Routine audits of all facilities included in the nuclear risk insurance pool, Figure 10.2, are performed by the insurer.

10.6.2 Design Criteria

Project leader for J.E. Sirrine & Co. for the design of the fire protection system was J.H. Bringhirst Jr., PE #2064, in the State of North Carolina. Design criteria included normal fire protection standards of the National Fire Protection Association and consideration on interaction of water with process materials. All design of the fire protection system, materials, and equipment was reviewed and approved by Factory Mutual Engineering (FM) prior to installation. Initial system inspection for conformance and testing was performed by FM who continues routine inspection and testing for the insurer.

10.6.3 System Components

The fire protection system is designed in accordance with the National Fire Protection Association standards. Prime components of the fire protection system (Figure 10.6) are:

300,000 gal elevated tank capable of supplying 150,000 gals of dedicated water to the fire protection system.

300,000 gal ground level water retention basin.

1,000 gpm diesel pump with automatic startup capabilities for supplying the fire protection loop from the retention basin with water at 125 psi.

Electric jockey pump to maintain a 90 lb. pressure at all times on the fire protection system.

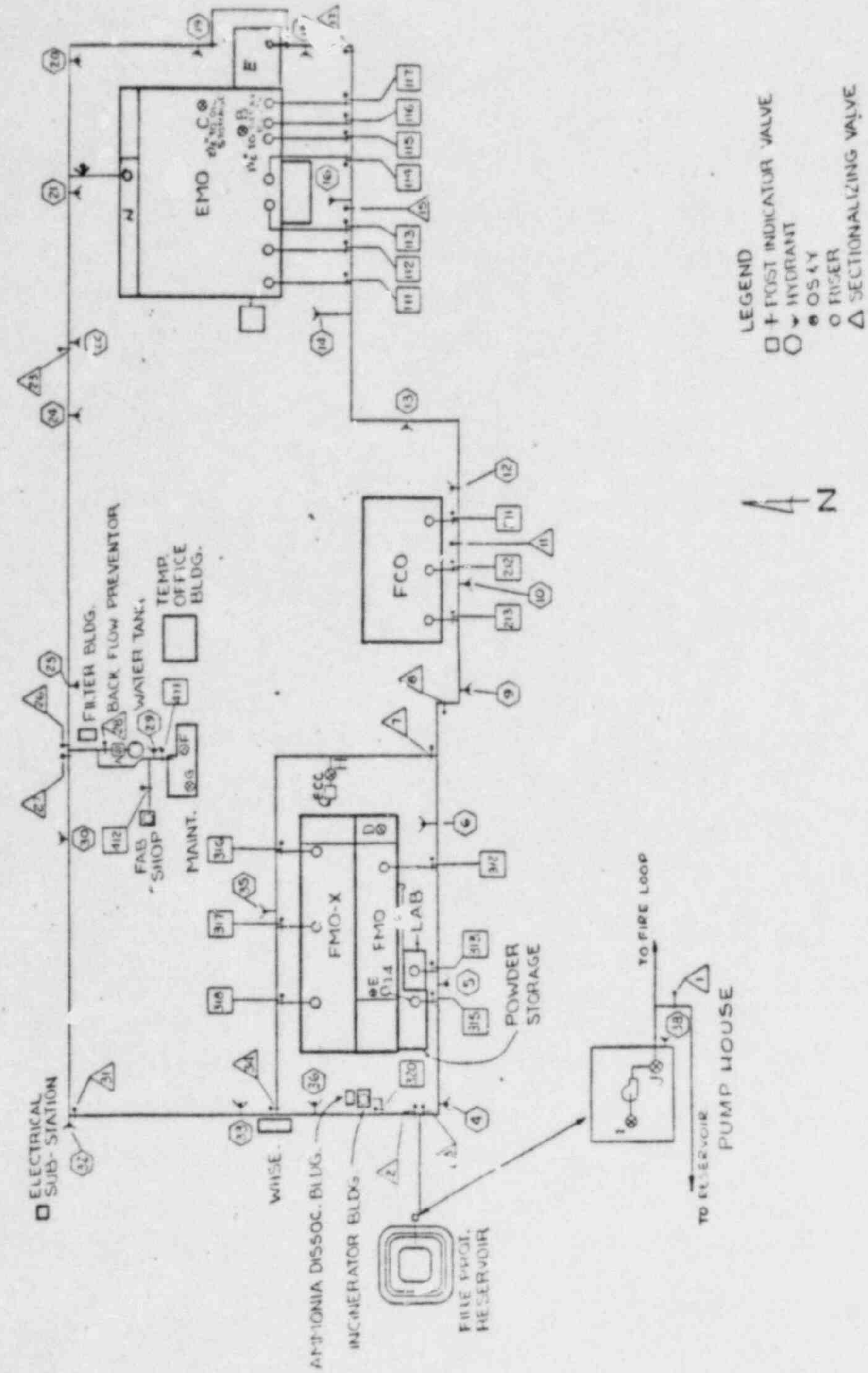
A 10" cast iron underground fire main loop around the prime production facilities.

A series of underground branch headers - normally 8" - from the 10" main loop supplying fire protection water to sectionalized sprinkler systems in each production building.

A supervised alarm and warning system (autocall) providing 24 hour coverage of prime fire protection safety auxilaries such as sprinkler system supply valve closing, water flow in sprinkler system, fire pump operations, smoke detector operation, etc.

FIGURE 10.6

GE-WMD PLANT FIRE PROTECTION SYSTEM



Fire extinguishers designed for specific fire control utilization and strategically located for primary fire containment.

Fire hose on reels connected to the primary fire protection system.

Halon systems for primary fire control in computer facilities.

Hose test and certification facility.

Smoke detectors in essential exhaust systems.

An emergency vehicle with extra hose, protective clothing, self-contained breathing apparatus and miscellaneous tools and equipment.

The fire protection system is supplied by the fifteen site deep wells having a system capacity of approximately 1,125 gpm.

10.6.4 Fire Protection Program

The fire protection program was developed through the combined talents of the General Electric Corporate fire protection specialist, Factory Mutual Engineering, the Wilmington, N.C. City fire department and plant fire protection specialists. This expertise developed the management responsibility for all phases of the program, organization and training plans and for the inspection, testing, and auditing of the program. Details of organization, responsibility, and training are included in the WMD Emergency Plan and Safety Manual. Factory Mutual Engineering conducts an annual fire protection audit which is reviewed with top management.

Routine inspection and testing of the fire protection system is conducted by security personnel under the direction of the manager of the industrial safety function. Maintenance and operation of the fire protection system and equipment is the responsibility of the manager of the installation engineering and the site services function.

10.6.5 Fire Safety Considerations in Waste Procedures

Generally combustible, uncontaminated waste that was generated in normal industrial operations where no toxic or radioactive contaminated material are involved is accumulated in large containers and directly shipped offsite to the county waste disposal facilities.

Combustible contaminated wastes are boxed and stored outdoors in secured storage pads pending incineration and recovery of the uranium. Location of these boxes outdoors and their physical separation for criticality safety minimizes their significance as a fire hazard.

11.0 ORGANIZATION AND PERSONNEL

11.1 UNIT FUNCTIONS

The Wilmington Manufacturing Department (WMD) is a function within the General Electric Company, Nuclear Energy Bu_iness Group (NEBG), headquartered in San Jose, California. NEBG designs nuclear powered reactors and produces nuclear reactor components. WMD manufactures nuclear fuel and special equipment for reactors.

The main functions of WMD are Shop Operations, Quality Assurance, Technical Support, Technology Development, Major Project Administration and Materials (i.e., procurement, production, scheduling and traffic). The functions of these organizational units are as follows:

11.1.1 Shop Operations (e.g. Fuel Manufacturing) manufactures product in accordance with methods prescribed by support units. It manages essentially all of the hourly work force.

11.1.2 Quality Assurance assures outgoing product quality via prescribed inspection techniques, product specifications and operating procedures. Nuclear safety functions including criticality and radiation safety engineering, radiation protection, and environmental protection are subunits within Quality Assurance. They are responsible for establishing and maintaining all nuclear safety programs within WMD.

11.1.3 Technical Support provides technical support for manufacturing operations including process definition, equipment availability, and operating instructions. These functions also provide maintenance support for manufacturing.

11.1.4 Technology Development develops special processes, equipment and instrumentation needed for production of nuclear fuel.

11.1.5 Major Projects provides overall management of major technical programs such as facility modifications, new process introduction and product design changeovers.

11.1.6 Materials schedules of production operations to assure delivery of products as required; procures raw material; and operates traffic operations (receiving and shipping).

11.2 ORGANIZATION CHARTS

Figures 11.1 and 11.2 show current NEBG and WMD organization charts. Functions of Finance and Employee Relations (including Industrial Safety and Health) are located in Wilmington, but are managed from the San Jose, California headquarters.

11.3 ORGANIZATIONAL PROCEDURES

NEBG has established policy for protection of employees, the public and the environs from potential industrial, radiation and nuclear hazards which could occur because of activities conducted at NEBG plants. NEBG policies are documented in Organization and Policy Guides. Responsibility for adherence to these policies at Wilmington rests with the General Manager - WMD. WMD instructions to implement the policies are called Practices and Procedures (P/P's), which clearly define functional responsibilities and authorities. They also contain specific instructions to assure compliance to NEBG and WMD managerial guidelines. P/P's require General Manager approval prior to issue or change. Sections within WMD may prepare Section Administrative Routines (SAR's) to

FIGURE 11.1

General Electric Company Nuclear Energy Business Group Organization

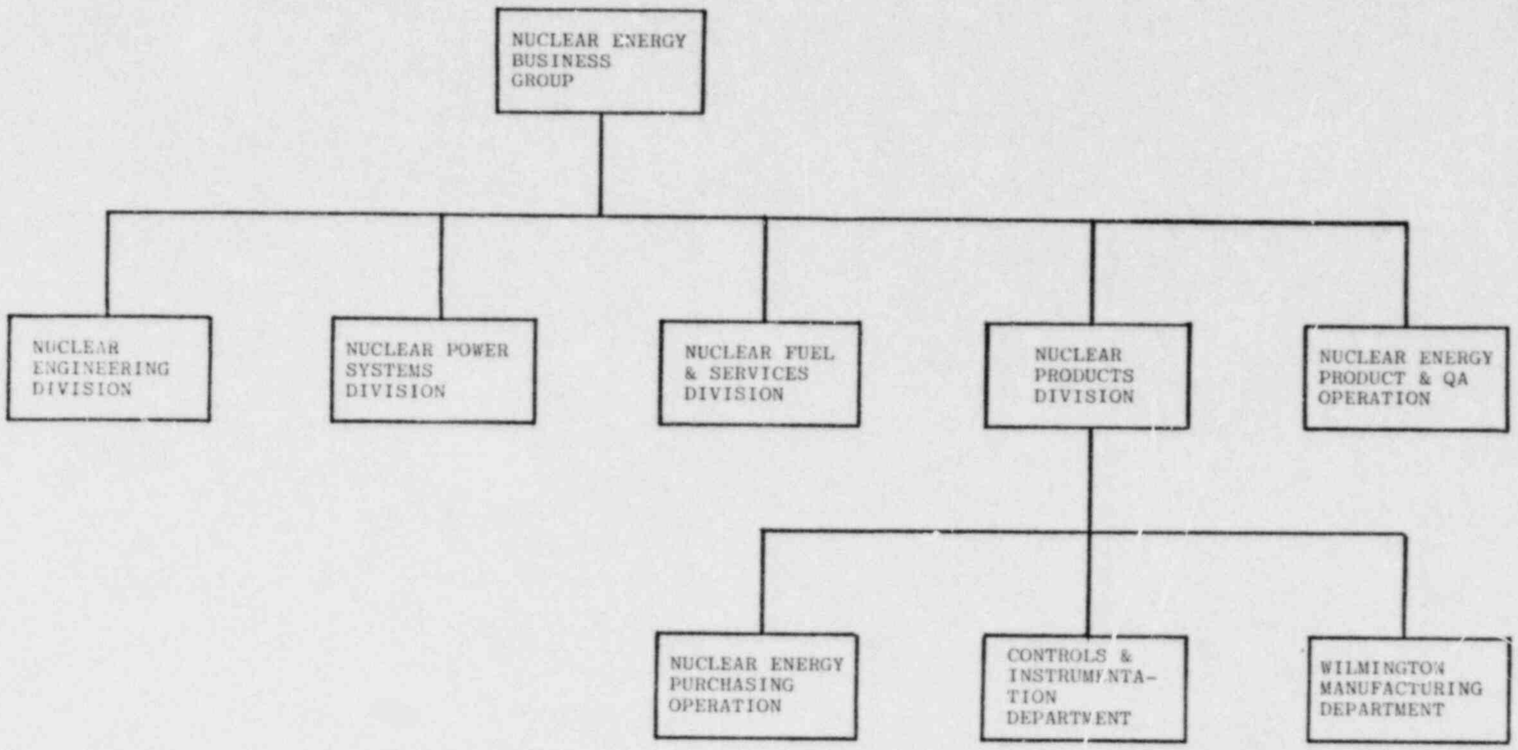
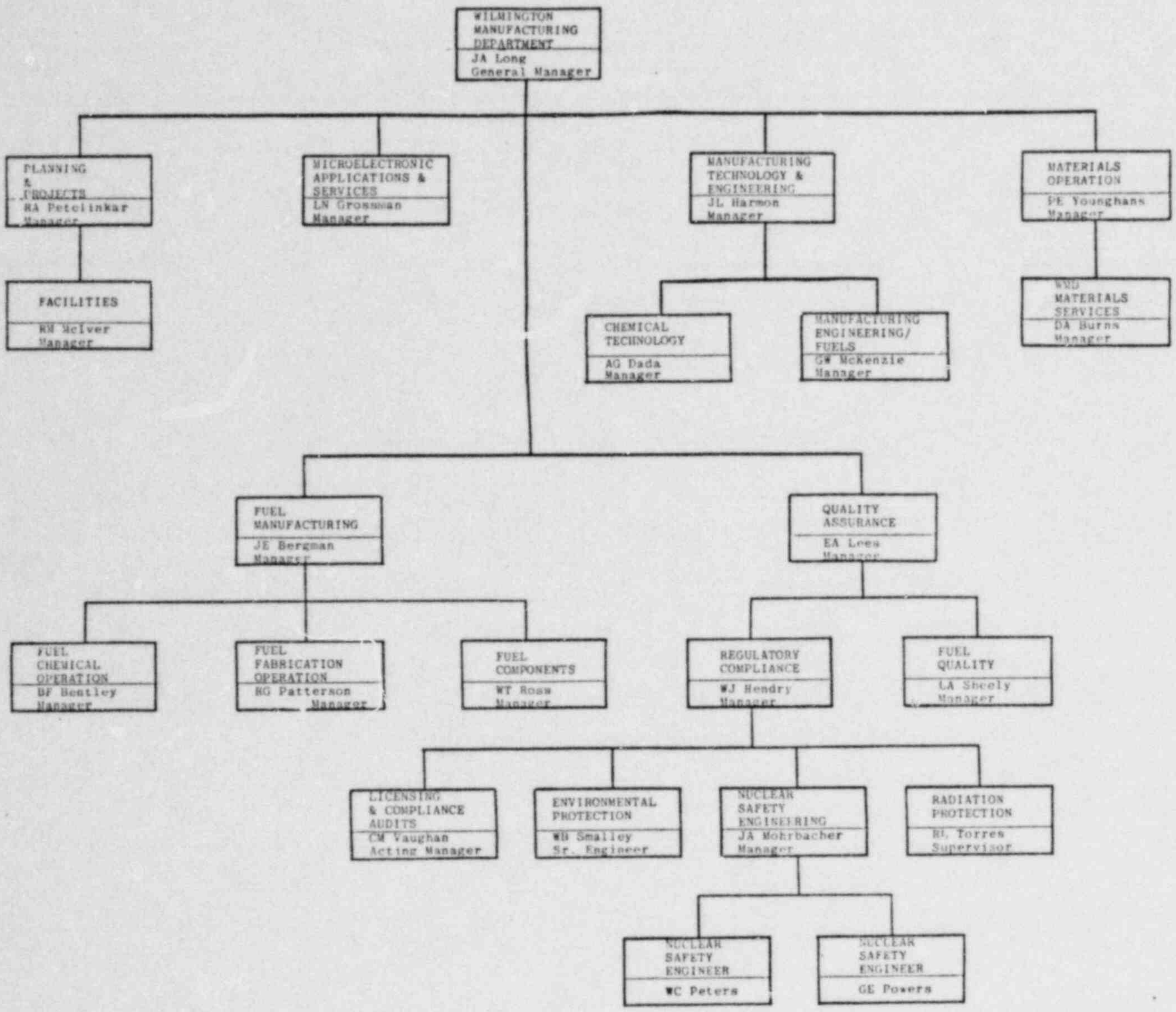


FIGURE 11.2

GE-WMD Organization



govern the conduct of their personnel in accordance with higher level documentation. SAR's require Section Manager approval prior to issue.

11.3.1 Operating Level Instructions

Process Requirements and Operating Documents (PROD's) are prepared by process engineering and Nuclear Safety Engineering personnel to provide on-the-floor instructions to Shop Operating personnel. PROD's require approval of the area manager prior to issue.

11.3.2 Internal Audits

Nuclear safety audits are conducted daily by the radiation protection function in accordance with the instructions issued by Nuclear Safety Engineering (NSE). Additional safety audits are periodically conducted by others including NSE and Licensing and Compliance Audits (L&CA).

11.3.3 External Audits

In-depth nuclear safety audits are conducted periodically by personnel from the NEBG Product and Quality Assurance Operation (P&QAO), a Division-level organization with responsibility of operational over-views of nuclear safety and product quality.

11.4 KEY FUNCTIONS

The following is a description of key functions of Wilmington manufacturing operations. Each has an individual specifically identified as its manager. Normal plant routines require identification of a delegate when managers are unavailable to perform their duties. The Emergency Plan, discussed in Chapter 8, delineates responsible managers and lines of succession for handling site emergency situations.

11.4.1 Functions Relating To Safety Of Operations In The Plant

The following in-house functions are provided in support of fuel manufacturing operations. These are conducted by individual positions or by groups of individuals (i.e., organization components) depending on the size and complexity of the function.

11.4.1.1. Nuclear Safety Engineering

11.4.1.1.1. Criticality Safety

Perform criticality analyses to establish safe batches, geometries, concentrations, and spacing of special nuclear materials and equipment. Provide authoritative professional advice and counsel to area managers on matters of control against accidental criticality. Measure the effectiveness of the criticality control program by reviewing the application of methods and data to actual plant situations. Conduct educational programs in criticality matters. Conduct preoperational audits of new facilities.

11.4.1.1.2. Radiological Safety

Establish a radiological safety program, which includes formulation of radiation protection criteria, definition of a bioassay program, analyses of existing systems, equipment and operations and recommendations for improvements therein. Conduct educational programs in radiological safety matters. Establish personnel exposure records system.

11.4.1.2 Radiation Protection

Administer the radiological safety program, which includes audits for conformance of plant operations to criticality safety and radiation protection criteria. Provide and implement a radiation monitoring program.

Provide assistance in employee training in the methods for minimizing radiation exposure through proper work habits, use of radiation detection instruments, protective clothing, and respiratory protection devices. Maintain all radioactive exposure records required by regulatory agencies.

11.4.1.3 Environmental Protection

Establish and administer an environmental protection program, including monitoring of liquid and gaseous effluents from the plant, periodic sampling of the environment to evaluate the environmental effects of plant operations, and provision of authoritative professional advice and counsel to area managers on matters of minimizing the environmental effects of plant operations.

11.4.1.4 Licensing and Compliance Audits

Represent the Wilmington component in legislative activities concerning radiation protection and licensing. Procure and administer NRC and Agreement State licenses. Interpret and determine application of NRC, State and local government regulations. Provide advice and counsel to Wilmington components and their customers on regulatory matters, and audit WMD activities for compliance with license and regulatory requirements.

11.4.1.5 Industrial Health and Safety

Develop programs to protect employees from industrial hazards, including operation of medical and safety education programs.

11.5 EDUCATION AND EXPERIENCE OF KEY PERSONNEL

11.5.1 General Manager - Wilmington Manufacturing Department

J. A. Long

B.S. - Mechanical Engineering

Mr. Long graduated from the Georgia Institute of Technology in Atlanta, Georgia, in 1957. He worked for three years as a research engineer in high-temperature materials at the Southern Research Institute, Birmingham, Alabama.

In 1960, Mr. Long joined the National Aeronautics and Space Administration where he was a propulsion engineer and manager on the Apollo launch vehicles.

From 1967 to 1971, Mr. Long was Staff Assistant to the administrator of NASA in Washington, D. C.

Mr. Long came to Wilmington in 1974 from the Strategic Planning Operations of the General Electric Power Generation Group, which he joined in New York City in 1971. In 1977, he became Manager, Equipment Manufacturing, in charge of production operations for the mechanical hardware in the General Electric boiling water reactors.

He became General Manager of the Wilmington Manufacturing Department in 1980.

11.5.2 Manager, Fuel Manufacturing

J. E. Bergman

B.S. - Chemical Engineering

Mr. Bergman joined General Electric at the Hanford Atomic Products Operation (HAPO) in 1951 as a member of the Technical Training Program. He later held positions at HAPO in quality control, shop operations, and engineering associated with the manufacture of nuclear fuel.

In 1960, he was appointed Manager, Quality Control for Nuclear Fuel Manufacturing at General Electric's San Jose operation where he was responsible for the quality activities for rod and plate-type fuel for commercial power reactors and research reactors.

In 1962, Mr. Bergman was appointed Project Engineer for the Capacitor Department with responsibility for the design, procurement, installation and startup of the new nickel/cadmium battery plate manufacturing facility in Gainesville, Florida.

In 1964, he was appointed Manager of Manufacturing Engineering for the Battery Operation with responsibility for Facilities, Advanced Manufacturing Engineering, Process Engineering and Method and Work Measurement.

Mr. Bergman joined the Corporate Consulting Operation in New York in 1966, with consulting assignments in the areas of manufacturing operation and organization, and advanced quality techniques development and application.

In 1962, he joined the Wilmington Manufacturing Department as Manager, Fuel Quality Assurance, with responsibility for the direction of quality activities associated with the manufacture of nuclear fuel for commercial power reactors.

In 1977, Mr. Bergman was appointed to his present position of Manager, Fuel Manufacturing, where he is responsible for all fuel and fuel component manufacturing operations performed at Wilmington.

11.5.3 Manager, Fuel Chemical Operation

B. F. Bentley

B.S. - Ceramic Engineering

Mr. Bentley joined General Electric in June 1965 as a member of the Manufacturing Management Program, after graduating from Alfred University with a B.S. in Ceramic Engineering. During the three year program, he held positions in Manufacturing Engineering, Quality Control, Materials and Shop Operations in the Semi-Conductor Diamonds Operations, Metallurgical Products and Neutron Devices Departments.

In 1968, Mr. Bentley was appointed a Methods & Work Measurements Specialist at Neutron Devices Department (NDD) with responsibility for standards introduction into a plant that had not previously had standards. In 1970, he was appointed Manufacturing Engineer at NDD with responsibility for assembly, brazing, chemical cleaning and etching.

In 1962, he was appointed Manufacturing Engineer for the Nuclear Fuel Department with responsbilities for the Gadolinia Shop. In 1973, he was appointed shift Process Control Engineer for the Fuel Manufacturing Operation. This was followed by a Senior Process Control Engineer and Supervisor - Certification and Release.

In 1976, he was appointed Manager, Powder Production Unit with unit shop operation functional responsibilities for uranium powder production. In 1978, he was appointed Manager, Fuel Chemical Operation with operations responsibilities for powder production and waste treatment facilities.

11.5.4 Manager, Fuel Fabrication Operation

R. G. Patterson

B.S. - Industrial Engineering

Mr. Patterson joined General Electric in 1967 as a member of the Manufacturing Management Program. Program assignments included activities at Evandale, Ohio, and Decatur, Illinois. He joined the Wilmington Manufacturing Department in 1971 as a Process Control Engineer in the nuclear fuel operation. Subsequently, he was promoted to positions of Manager - Certification & Release, Manager - Quality Data, Manager - JMC Quality Liaison for foreign fuel manufacturing, and Manager-Uranium Fuel Fabrication Operation. He was assigned to his present position in 1980.

11.5.5 Manager, Fuel Components Operation

W. T. Ross

B.S. - Metallurgical Engineering

Mr. Ross joined General Electric in 1957 at the Hanford Atomic Products Operation in Richland, Washington, as a participant in the Hanford Technical Graduate Program. After one year, he accepted a permanent assignment as a metallurgist in the Plutonium Fuels Development branch of the operation.

In 1962, he transferred to San Jose, California, as Materials Engineer in the Fuel Design Engineering Unit, Atomic Power Equipment Department.

In 1971, Mr. Ross because Manager of the Wilmington Engineering Unit reporting to Design Engineering in San Jose.

Mr. Ross accepted his present position in 1976 and is responsible for the manufacture of zircaloy fuel components including tubing, spacers, end plugs, water rods and fuel channels.

11.5.6 Manager, Quality Assurance

E. A. Lees

A.A. - Engineering

B.S. - Metallurgical Engineering

M. S. - Materials Science

Mr. Lees joined the General Electric Company in 1958 as a member of the Engineering Training Program. During the next two years, he participated in nuclear fuel development programs at the Vallecitos Nuclear Center, Hanford Atomic Laboratories and the Atomic Power Equipment Department in San Jose, California.

From 1960 to 1964, Mr. Lees held a variety of assignments all associated with process development for nuclear fuels, burnable poisons and control rods.

Mr. Lees was appointed Manager, Fuels Development Laboratory in 1964, responsible for all the fabrication facilities devoted to fuel and materials development programs.

In 1966, Mr. Lees was assigned to project responsibility for the AEC sponsored High Performance UO_2 Program.

In 1968, Mr. Lees was assigned to the position of Manager, Oyster Creek Pressure Vessel Repair Program. In this position he was responsible for the rework of the Reactor Pressure Vessel at the Oyster Creek Site.

In 1969, in the position of Manager of Engineering, Japan Nuclear Fuel Company, Mr. Lees was responsible for the design, construction and start up of a nuclear fuel joint venture company near Yokohama, Japan. In 1971, he was appointed Manager, Department of Engineering, Japan Nuclear Fuel Company, with responsibility for JNF manufacturing, engineering, construction, and nuclear safety and licensing.

In 1972, Mr. Lees was assigned to the position Manager, Fuel Manufacturing Plant Engineering, in Wilmington, N.C. In this position he was responsible for providing technical assistance to the manufacturing operation.

In July 1973, Mr. Lees was appointed Manager, Fuel Chemical Operation, where he was responsible for production in the UF_6 to UO_2 conversion operation.

In January 1974, Mr. Lees was appointed to the position of Manager, Fuel Manufacturing, where he was responsible for all fuel manufacturing operations performed at Wilmington.

Mr. Lees was appointed to his current position as Manager, Quality Assurance, in June of 1977, In this position, he is responsible for the direction of quality activities associated with the manufacture of nuclear fuel for commercial power reactors.

11.5.7 Manager, Fuel Quality

L. A. Sheely

B. S. - Electrical Engineering

Mr. Sheely joined General Electric in 1962 in the Capacitor Department, Irmo, S.C. He was selected for the Manufacturing Management Program in early 1965 and completed manufacturing assignments of six months duration in five different GE Departments in four different plant locations.

Upon completion of this program, he came to Wilmington in Janaury 1968 and accepted an assignment as Specialist, Shop Administration in the Reactor Equipment Operation.

In 1969, Mr. Sheely was made Manager of the Tube, Annealing and Cleaning Shop Operations Unit in the Fuel Components Operation.

In 1971, Mr. Sheely was assigned as Manager, Powder Production in the Fuel Chemical Operation, responsible for the chemical operation engaged in the conversion of UF_6 to UO_2 powder and for the operation of the Uranium Purification System (UPS) used to recover discrepant material and convert it to usable powder.

Mr. Sheely was promoted to the position of Manager, Fuel Chemical Operation in 1974, which gave him responsibility for the chemical processes in the Fuel Manufacturing Operation.

In 1977, Mr. Sheely assumed the position of Manager, Fuel Quality. In this position, he is responsible for the definition and implementation of the Quality System for the Fuel Manufacturing Operation.

11.5.8 Manager, Regulatory Complaince

W. J. Hendry

B.S. - Metallurgical Engineering

M.B.A.

Mr. Hendry joined General Electric Company in 1954 in the Aircraft Nuclear Propulsion Department where he served in management positions related to the production of high temperature fuel elements for aircraft and missiles. He also served as a consultant to the Nuclear Material Management Operation concerned with accountability systems for high enriched UO_2 fuel.

In 1961 he left the Aircraft Nuclear Propulsion Department to join the Metallurgical Products Department as Manager of Manufacturing Engineering.

Mr. Hendry joined the General Electric Nuclear Fuel Department in 1968 as the Manufacturing Engineering Manager for nuclear fuel and reactor component production. He provided technical direction for the start-up of the Wilmington, N.C. nuclear fuel facility. He subsequently initiated the development of the fuel Manufacturing Information Control System (MICS).

Mr. Hendry became Manager of Manufacturing Systems in 1972, responsible for the development and implementation of computerized information systems throughout the Department.

Mr. Hendry also performed special business studies and compiled annual long-range forecasts for the business. In addition, in 1975 he assumed responsibility for the implementation of all major facility improvement projects.

In July 1978, Mr. Hendry assumed his present position as Manager of Regulatory Compliance.

11.5.9 Manager, Nuclear Safety Engineering

J. A. Mohrbacher

B. A. - Physics & Mathematics

Certified Health Physicist

In 1952, Mr. Mohrbacher was appointed health physicist at General Dynamics, which conducted nuclear reactor research for the Aircraft Nuclear Propulsion Program. His work area included shielding studies in connection with remote maintenance for the design aircraft.

He next held a position in the Nuclear Engineering group of Lockheed Aircraft Corporation from 1955-64, involved in licensing and health physics in support of plant design and reactor tests.

In 1964, he was appointed Manager, Health Safety for Pan American World Airways providing radiation safety support to reactor test projects at the Nuclear Rocket Development Station until 1969.

He spent the next four years as Manager, Nuclear Safety & Licensing at Gulf General Atomic's fuel reprocessing plant in Barnwell, S.C.

In 1973, Mr. Mohrbacher held a position at Los Alamos Scientific Laboratories.

Mr. Mohrbacher was appointed to his present position as Manager, Nuclear Safety Engineering, in 1974, In this capacity, he is responsible for radiation safety and nuclear safety related to all operations of nuclear fuel manufacturing involving the processing of uranium materials and the utilization of sealed radioactive sources and x-ray machines.

11.5.10 <u>Nuclear Safety Engineer</u>

W. C. Peters

B.S. - Physics and Mathematics

PhD Nuclear Physics

Dr. Peters joined the Wilmington Manufacturing Department in December 1975. Prior to this assignment, he was associated for two years with General Atomic Company in San Diego, California, where he was a staff physicist with the responsbility for criticality safety at the HTAR and TRIGA Fuel Fabrication Facilities. In this capacity, he provided review and final approval of designs and operation of high enriched and low enriched uranium facilities containing significant quantities of fissile materials.

11.5.11 <u>Nuclear Safety Engineer</u>

G. E. Powers

B.S. - Biological Science

M.S. - Health Physics

PhD Radiation Biology

From 1964-68, Dr. Powers taught science, physics and biology at the high school level in Colorado. In 1968 he joined the staff of Colorado State University as a Graduate Research Assistant where he assisted in the development of personal TLD monitoring systems used by uranium miners. He remained with Colorado State until 1976 in the positions of Research Associate and Instructor/Assistant Professor.

Dr. Powers joined General Electric Company at Wilmington in 1976 in the position of Nuclear Safety Engineer. In this position, he is responsible for assisting in the upgrading of present programs, projects and development of a training program in radiological health for WMD.

11.5.12 Supervisor, Radiation Protection

R. L. Torres

A.A. - Applied Sciences

Mr. Torres joined Sandia Corporation in Albuquerque, New Mexico, in 1962 as a Certified Reactor Health Physicist on the Sandia Pulsed Reactory Facility.

From 1963-73, he was employed by Pan American at Jackass Flats, Nevada, in the following positions: Radiation Monitor, Senior Radiation Monitor and Lead Technician. In these positions, he was involved in assembly/disassembly and testing of high enriched test reactors.

Mr. Torres joined Los Alamos Scientific Laboratory in 1973 as Health Physics Surveyor. In this position, he assisted operating crews in the operation, experimental set up, shield design and safety program at the accelerator.

In 1976, Mr. Torres joined General Electric Company in Wilmington, N.C. as a Shift Supervisor. In 1978, he was appointed to his present position as Supervisor, Radiation Protection. In this position, he is responsible for the overall plant radiation protection program administered through crews of salaried, weekly, and hourly personnel.

11.5.13 Senior Engineer, Environmental Protection

W. B. Smalley

B.S. - Chemical Engineering

Registered Professional Engineer - New York, Massachusetts and North Carolina

Mr. Smalley joined the General Electric Chemical Development Department in 1956 as a Process Development Engineer. He was responsible for development and operation of process segments of manufacturing processes for new plastic materials.

He later assumed process and project responsibilities in conjunction with the development and expansion of the Lexan Polycarbonate Resin Commercial Plant.

He was appointed Manager, Manufacturing Engineering Phenolic Products in 1965 and was responsible for process engineering, plant engineering and project engineering activities as well as pilot manufacturing activities.

In 1969, he was appointed Manager, Manufacturing Engineering at Elmira Foundry where he held similar responsibilities.

Mr. Smalley was appointed to his present position as Senior Engineer, Environmental Protection, in 1971.

11.5.14 Acting Manager, Licensing & Compliance Audits

C. M. Vaughan

B. S. - Chemistry

Mr. Vaughan entered the nuclear industry in 1965 when he joined Nuclear Fuel Services as a Chemist with responsibility for operation of the uranium scrap accountability laboratory. He subsequently was active in the development of analyses of plutonium exotic metals and U-233, activities which resulted in his promotion to Manager of the Alpha Containment Laboratory.

He joined General Electric as a Specialist - Nuclear Materials Management at the Wilmington, N.C. nuclear fuel fabrication facility. He was promoted to the position of Manager - Nuclear Materials Management in 1974 and assumed acting responsibilities of his present position in 1981.

11.5.15 Manager, Materials Operation

P. E. Younghans

B. S. - Metallurgical Engineering

Mr. Younghans joined the General Eelctric Company in 1965. He has held positions in Materials/Production Control functions at Transportation Components Department, Transportation Equipment Department, Propulsion Equipment Department, and the Semiconductor Products Department at the General Electric Company. He became associated with General Electric nuclear business in 1975 when he was appointed Manager of Production Control with responsibilities for scheduling production in all fuel operations. Prior to his promotion to Manager of Materials he was the Manager of the Equipment Products Operation where he was responsible for the manufacture of reactor components.

11.5.16 Manager, Material Service

D. A. Burns

Mr. Burns joined General Electric in 1956 in the machining apprentice course in Schenectady, N.Y. Upon completion, he began various assignments in the Light Military Electronic Department, Johnson City, N.Y., in planning, computer task force member, budgets and measurements. He then moved to various department assignments in Advanced Materials and the Business Information Systems, Lynn, Massachusetts, and Phoenix, Arizona.

He came to Wilmington in March 1970 and accepted an assignment as Specialist, Advanced Materials, in the Reactor Equipment Operation.

In 1971, Mr. Burns became Manager of Bundle Assembly and Fuel Finishing Unit in the Fuel Fabrication Operation.

Mr. Burns was promoted to Manager, Production Planning in 1973 and was responsible for master scheduling of the fuel manufacturing operations.

In 1975, he was promoted to Manager, Fuel Fabrication Operation responsible for the manufacturing operations encompassing fabrication of pellets through bundle packing.

In 1978 he moved to Manager Procurement and Material Logistics responsible for purchasing and traffic. The traffic operation involved nuclear material transportation to and from the site and the purchasing, design, and refurbishment of all fuel shipping containers.

In 1980, Mr. Burns moved to Material Service dropping purchasing activities and gaining advanced materials activities.

1[illegible].17 Manager, Manufacturing Technology and Engineering Operations

J. L. Harmon

B. S. - Metallurgical Engineering

Mr. Harmon joined the General Electric Company at the Knolls Atomic Power Laboratory in 1965. He held the positions of Manager - Physical Metallurgy Laboratories, Manager - Core Manufacturing and Specification Analysis, Manager - Core Materials and Systems Test, and Manager - Core Manufacturing Engineering. Mr. Harmon had technical responsibility for product and manufacturing processes for all naval cores for which KAPL had prime contractor responsibility. Management assignments included manufacturing process analysis and the development of manufacturing specifications as well as material and systems testing evaluation.

In 1977, Mr. Harmon was appointed Manager - Manufacturing Engineering, Components and Metals, for the Wilmington Manufacturing Department. In this capacity Mr. Harmon was responsible for all aspects of Manufacturing Engineering in the manufacture of nuclear components and zircaloy metal working. In 1981, he was appointed to his present position as Manager - Manufacturing Technology and Engineering Operations. In this position he is responsible for directing the engineering and development efforts at WMD.

11.5.18 Manager, Microelectronic Applications & Services

L. N. Grossman

A.B. - Physics

M.S. - Engineering

Mr. Grossman joined the General Electric Company as a Metallurgist/Ceramist at the Vallecitos Nuclear Center in 1960. At the Center he subsequently held positions of Senior Research Ceramist, Technical Leader and Manager - Ceramic Development. In 1974 he was appointed to the position of Manager - Quality Technology Development at the Wilmington Manufacturing Department. In this position he was responsible for the development of applications of advanced technology to quality measurement systems. He was appointed to his present position in 1981.

11.5.19 Manager, Manufacturing Engineering-Fuels

G. W. McKenzie

B.S. - Electrical Engineering

Mr. McKenzie joined General Electric in 1954 after graduating from the University of New Hampshire. He was assigned to the Engineering Test Program in Pittsfield, Massachusetts (H. V. Lab). After completing additional assignments in Somersworth, New Hampshire (Meters) and Schenectady, New York (Motors), Mr. McKenzie entered the Army as a lieutenant in Guided Missiles. He rejoined General Electric in 1957 in Mac Motors, Schenectady as a deisgn engineer. In 1959, he transferred to Utica, New York as a Test Equipment Engineer, became manager of QIEE in 1962, and held several other managerial positions in R&QA until 1974 when he transferred to Wilmington as Manager - AME-Automation. In May 1976, he was appointed to his current position.

11.5.20 Manager, Chemical Technology

A. G. Dada

B. S. - Chemical Engineering

Mr. Dada joined General Electric in 1967 after graduating from Oregon State University. After four years at San Jose, he transferred to the Wilmington Manufacturing Department as a Senior Project Engineer. During his fourteen years with the company, he has been responsible for implementing the GECO process. He has been responsible for several patents including the UF_6 to UO_2 Conversion Process. He was appointed to his present position in 1977.

11.5.21 Manager, Planning & Projects

R. A. Petelinkar

B.S. - Chemical Engineering

M.S. - Chemical Engineering

Mr. Petelinkar joined the General Electric Company in 1960 where he held numerous Process Engineering assignments and managerial positions involving production of silicone products. He also held a managerial position in the Strategy Review and Ventures Operation for the Silicone Products Department in Pittsfield, Massachusetts.

He became Manager of Major Projects for the Wilmington Manufacturing Department in 1974 and was assigned his present position in 1980.

11.5.22 Manager, Facilities

R. M. McIver

B. S. - Civil Engineering

In 1964, Mr. McIver joined the U. S. Corps of Engineers as a Civil Engineer. During the following years, he held the positions of Engineering/Maintenance Supervisor at the Kinston, N.C., DuPont plant (1966-70), and Staff Civil Engineer at Consolidated Aluminum in Waverley, Tennessee (1970-72).

Mr. McIver joined General Electric Company at the Wilmington plant in 1972 as a project engineer. In 1975, he was appointed Unit Manager, Installation Engineering and Site Services, and in 1978 he was appointed Manager, Facilities.

In his present position, he is responsible for the general overall management of plant facilities, site services and utilities. This responsibility includes facility engineering and design, alterations, additions, and operation and maintenance.

12.0 RADIATION PROTECTION PROCEDURES AND EQUIPMENT

12.1 Procedures for Radiation Surveys

The system of the WMD procedures and instructions described in Chapter 11.3 outlines the Department commitment to maintaining radiation exposures to ALARA. Implementation of ALARA is further defined with specific requirements and methods specified in lower level procedures which direct the activities of the operating and maintenance personnel. These instructions include Nuclear Safety Instructions (NSI's), Process Requirements and Operating Documents (PROD's), Temporary Operating Instructions (TOI's) and the Job Hazard Analyses (JHA's).

The purpose of the NSI system is to define the implementing procedures and routines to be followed within the radiation safety and radiation protection functions. NSI's are prepared by the radiation safety function and are reviewed annually. In addition to this review, an independent audit of the NSI procedural system is performed annually generally by a function from NEBG headquarters.

The procedures for radiation surveys are contained in NSI's which define the type of survey, the survey instrument, and the frequency of the surveys. Radiation surveys are conducted by trained personnel in the radiation protection function.

12.2 Posting and Labeling

It is the Department practice that all areas where radioactive materials are utilized will be reviewed and posted in accordance with the requirements of 10 CFR Part 20.203. Containers of radioactive materials which are not a standard part of the uranium process operation and licensed sealed source materials are marked with the standard radiation symbol and the words "Caution Radioactive Material". Areas are classified and posted as radiation areas, high radiation areas, or radioactive material areas, as appropriate. In addition, process areas where uranium is handled in dispersable forms where an inhalation potential may exist are designated as controlled areas and are posted as airborne radioactivity areas. Emergency routes and exits are posted according to the WMD Emergency Plan. Determination of the area postings is made by the radiation safety function, and the radiation protection function periodically audits the postings.

Criticality control limits are posted for those operations which are not specifically controlled by the process or designed storage areas. These limits are extracted directly from the PROD's and are available at the appropriate process work stations.

12.3 Personnel Monitoring

12.3.1 External Wholebody Exposures

12.3.1.1 Thermoluminescent Dosimeters (TLD's)

TLD's are the primary dosimetry devices for monitoring external wholebody radiation exposure. The TLD's utilized in WMD are provided, processed, and evaluated by an external vendor.

Two types of TLD's are furnished based upon the radiation safety function evaluation of the individual's potential for exposure. In the absence of neutron exposure potentials, beta-gamma sensitive TLD's are provided for personnel monitoring and are exchanged on a quarterly basis, or sooner if there is indication of an exposure in excess of established action guides. The range of these TLD's is 10 millirem to approximately 10,000 rem. A combination neutron and beta-gamma TLD badge is furnished where there is a potential for both beta-gamma and neutron exposures. These devices are exchanged on a monthly basis. The minimum sensitivity for the neutron dosimeter is 20 millirem for fast neutrons; 10 millirem for thermal neutrons.

Where appropriate, as determined by evaluation of the specific operations, TLD's may be used for monitoring extremity exposure. Where particular operations, such as the inspection of pellets, do not lend themselves to direct extremity monitoring, extremity exposure is administratively assigned to individuals based on the amount of material processed at his work station. This administrative exposure assignment is based on time-and-motion studies and pellet-surface dose rates.

Exposure results are monitored and evaluated by the radiation safety function, and appropriate investigative action is taken if the exposure exceeds predetermined action guides. The circumstances are investigated, and the individual is restricted for further radiation work until the exposure is resolved.

12.3.1.2 Direct Reading Dosimeters

In accordance with internal procedures, pocket dosimeters may be used to supplement the TLD personnel-monitoring device for certain personnel operating radiographic facilities, x-ray generators or using radioactive sources. Such dosimeters are read on a daily basis, and the results are reviewed by the radiation protection function at least weekly. If a pocket dosimeter result indicates an offscale reading or an accumulated exposure of 500 mr in one week, the individual is restricted from further exposure, and his TLD is returned for immediate processing.

12.3.1.3 Criticality Exposure Monitors

Each TLD issued contains an indium activation foil which could be used as quick sort method in the event potential exposure occurs from a criticality accident.

Additionally, indium foils are included as part of the identification badge for all personnel (employees, visitors, and contractors) not requiring TLD dosimeters. The foils are used as a quick sort method in the event of an accidental criticality to determine if an individual was exposed and the relative level of exposure. Procedures for this interpretation are incorporated in the emergency response plan. Dosimetry devices containing criticality activation inserts are also strategically located throughout fuel manufacturing process areas to provide additional assessment capabilities.

12.3.2 Internal Wholebody Exposure Control

Internal exposure for individuals working in airborne radioactivity areas is administratively controlled on the basis of assigned exposure to airborne contamination. This exposure is assigned on the basis of airborne concentrations of airborne activities at the work area and the time that the individual worked at the specific location. Exposure to airborne activity is assessed and assigned on a weekly basis. When an individual's assigned exposure exceeds predetermined levels, he or she is restricted from further work in radioactivity areas for the remainder of the week.

In addition, bioassay techniques are employed which have been established on the basis of Regulatory Guides 8.9 and 8.11. Personnel who work routinely with soluble forms of uranium compounds are routinely monitored by urinalysis methods. Those individuals who work with insoluble compounds of uranium are routinely monitored by in vivo lung counting to evaluate the body burden of these materials. For additional information refer to Chapters 13.3 and 13.4.

12.4 Surveys

A system of structured survey procedures has been developed and implemented through the NSI's. Implementing survey procedures include:

- Control of uranium concentration in final liquid effluent
- Radiation protection instrumentation
- Surface contamination and control
- Stack sampling program
- Containment flow inspections
- X-ray equipment surveys
- Shipment and receipt of radioactive materials
- Site radiation and contamination surveys

Routine survey results are reviewed by the radiation protection function and are examined for trends by the radiation safety function to evaluate the effectiveness of the overall radiation safety program. As appropriate, the information is factored into new equipment designs and modification of operational procedures to further reduce personnel exposures.

12.5 Surveys

12.5.1 Records

Records of individual exposures to radiation, radiation surveys and monitoring results, and the disposal of licensed material are maintained in accordance with 10 CFR 20.401. Additionally, other records are maintained as may be required. These records and the retention periods are as follows:

Type Record	Minimum Retention Period
Individual Radiation Exposure	Until Disposal is Authorized
Contamination Surveys	Two Years
Nuclear Safety Training	Period of Employment plus 3 Years
Instrument Calibration	Two Years
Stack Releases	Until Disposal is Authorized
Liquid Releases	Until Disposal is Authorized
Disposal of Licensed Solid Waste	Until Disposal is Authorized
Routine Maintenance	Six Months
Environmental Surveys	Two Years
External Radiation Surveys	Two Years
Process Changes and Additions	Two Years
Criticality Analysis	Life of Project + Six Months

Type Record	Minimum Retention Period
Radiological Safety Analyses	Life of Project + Six Months
Accident Investigations (involving releases or exposure)	Until Disposal is Authorized
Audits and Inspection Reports	Two Years
Radiological Exposure Trends	Two Years

All radiologically related records are periodically validated and micropacked for permanent storage in separate locations from WMD. The record elements that are maintained in this fashion include: personnel exposure, training, respiratory protection, surveys, instrument calibration, accident investigations, whole body counting, stack releases, liquid releases, extremity exposure, film badge reports, and waste disposal.

12.5.2 Reports

Summary reports of radiation surveys and employee exposure status are made to operating management in accordance with internal established procedures as necessary to keep management fully informed of radiation control status of their individual employees.

Formal reports are made as required by 10CFR19, 10CFR20, 10CFR21, 10CFR70, 10CFR71, and Regulatory Guide 10.1.

12.6 Instrumentation

12.6.1 General

An adequate number of radiation detection instruments is available to ensure the proper radiation surveys can be performed. Selection criteria of portable and laboratory counting equipment are based on the types of radiation detected, maintenance requirements, ruggedness, interchangeability, and the upper and lower limits of detection. The radiation safety function annually reviews the types of instruments being used for each monitoring function and makes appropriate recommendations.

12.6.2 Instrumentation Types

A detailed listing of the types of radiation detection instruments employed at WMD is shown in Table 12.1.

12.6.3 Equipment Storage and Maintenance

Counting equipment is stored and made available for routine use at various plant locations such as the radiation protection offices, designated locations and controlled area change rooms. Emergency equipment is also stored and made available in the radiation protection offices and designated emergency lockers. Additional emergency counting and survey equipment are available in the site emergency control center. Maintenance is provided at specified frequencies by an assigned equipment maintenance function, by the manufacturer's representative, or by contracted service vendors.

TABLE 12.1

TYPES OF RADIATION DETECTION INSTRUMENTS

	Typical Models
Fixed Installation Equipment	
Wholebody counter (Radiation Management Corp.)	RMC-01
Criticality Warning System	Eberline DA16CCG-M
Detectors	Eberline DA16CC
	Eberline DA15CC
Portable Instrumentation	
Beta-gamma Geiger-Mueller counter	Eberline E-120
Beta-gamma Geiger-Mueller counter	Eberline E-520
Alpha survey meter w/AC-3 probe	Eberline PRM-6
Alpha survey meter w/AC-3 probe	Eberline PRM-4B
Beta-gamma survey meter, tissue equivalent	HP-1070
Low-energy beta-gamma survey meter	Victoreen 440
Low-energy beta-gamma survey meter	Victoreen 470A
Neutron REM detector	Eberline PRN-4
Alpha scintillation counter w/AC-3 probe	Eberline PAC-4S
Ionization chamber gamma survey meter	Eberline PIC-6A
Ionization chamber beta-gamma survey meter	Eberline RO-3, 30-3A
Alpha-beta-gamma radiation monitor w/HP-210 probe	Eberline RM-14
Alpha radiation monitor w/AC-3 probe	Eberline RM-15

TABLE 12.1 (Continued)
TYPES OF RADIATION DETECTION INSTRUMENTS

	Typical Models
Portable Instrumentation (Continued)	
Gama dose rate meters	Teletector 6112
High-level gamma detectors w/RD-17A detectors	Eberline RM-16
Laboratory Instrumentation	
Multichannel analyzer w/2"x2" NaI well	
Low background proportional Alpha Counter	Canberra Model 2201
Automatic air sample counter	Harshaw Task 12
Gas-flow proportional counter	Nuclear Chicago
Fixed geometry Geiger-Mueller counter	
Scintillation counter with detector (RD-14)	Eberline MS-3

12.6.4 Criticality Warning System

The WMD criticality warning system complies with the requirements of Regulatory Gu..e 8.12. The criticality warning system can be divided into two systems. The outside system consists of 19 DA1-6CC Geiger-Mueller gamma detectors and four microprocessors (field units). The inside system contains 27 DA1-6CC detectors, one high-level ionization detector (1-1000 R/hr) model DA1-5CC, and six microprocessors (field units). The microprocessors continually poll the detectors for information, calculate dose rates, determine detector status, and maintain various history files. In addition, t' microprocessors determine when the criticality arm logic is satisfied and cause the evacuation alarms to sound.

Each microprocessor is routinely polled by the central control terminals located in the radiation protection function office and the emergency control center ..d these terminals provide the system's current status using printouts and warning lights.

Typical configurations of the criticality warning system showing a component block diagram and inside and outside detector locations are sho-- in Figures 12.1, 12.2, and 12.3. The detector locations and system configuration are subject to modification as may be necessary to demonstrate adequacy of coverage. This determination is made by the radiation safety function.

12.7 Protective Clothing

Protective clothing is provided to all persons who are required to enter radiation controlled areas where personnel contamination potential exists as determined by the radiation safety analysis. The amount and type of protective clothing required for a specific area or operation are determined by the radiation safety function based upon the contamination potential. Available clothing includes caps, hoods, laboratory coats, coveralls, boots, overshoes, shoe covers, gloves, safety shoes, and respiratory protection equipment. National Institute of Safety and Health (NIOSH) approved air supplied hoods are available.

12.8 Administrative Action Guides

Administrative control guidelines are established to assure that the occupational exposure of WMD employees is kept as low as reasonably achievable and within the limits established in 10 CFR 20.101 and 10 CFR 20.103. These guidelines are established and maintained by the radiation safety function and are documented in the Department P/P system. Chapter 13 defines specific action levels for contamination surveys and for shipping/receiving. Administrative guidelines for personnel radiation control are shown in Table 12.2.

12.9 Respiratory Protection

12.9.1 Respiratory Protection Equipemnt

Only respiratory protection equipment specifically approved by NIOSH or by the NRC is employed. Two types of respirators are commonly available, half-mask and full-face mask.

Half-mask respirators, equipped with particulate filters are employed as a precautionary measure during routine operations which may generate uranium dusts. No protection factor is taken for this type of respirator

FIGURE 12.1

GE-WMD Criticality Warning System Block Diagram

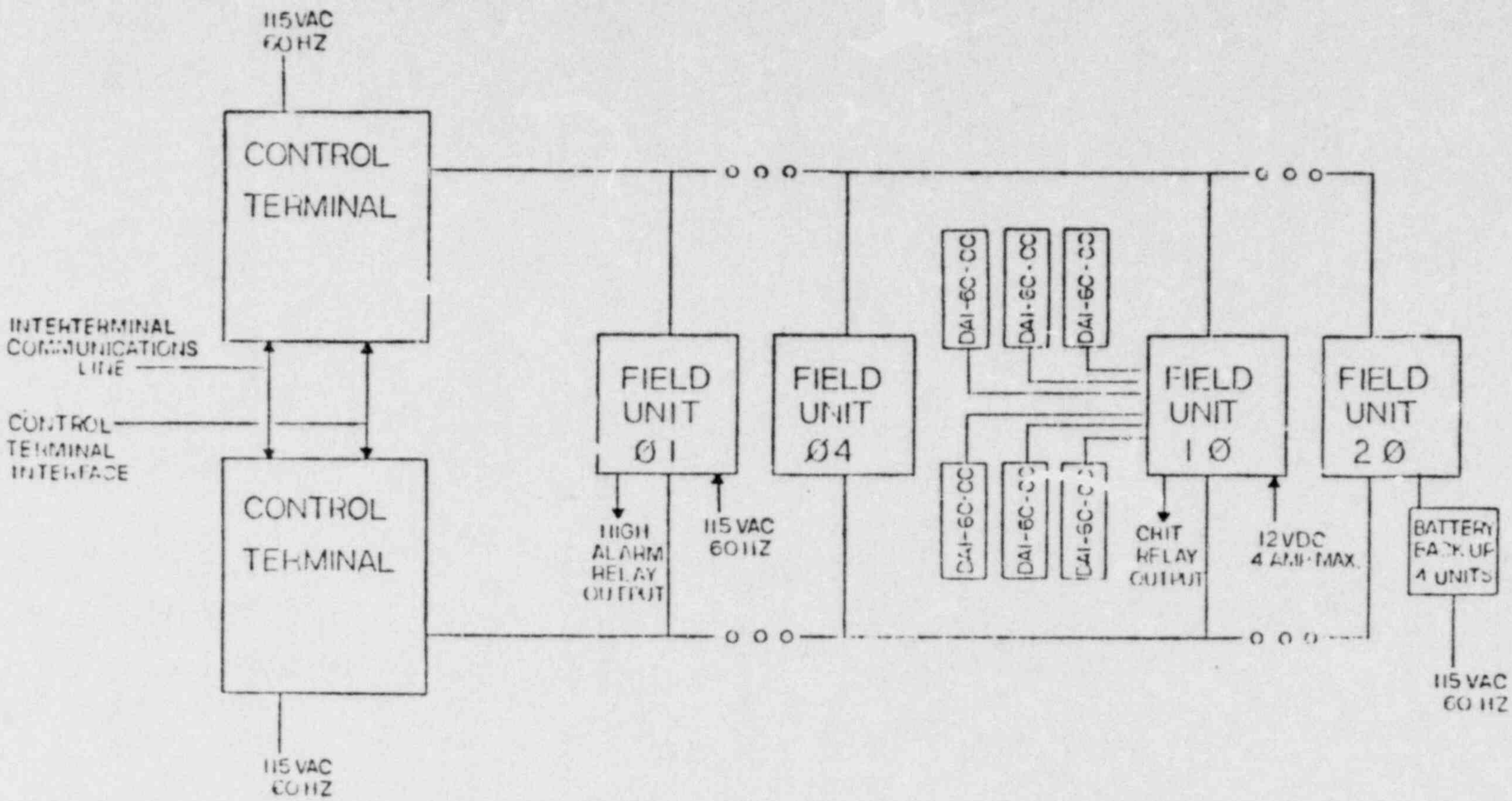
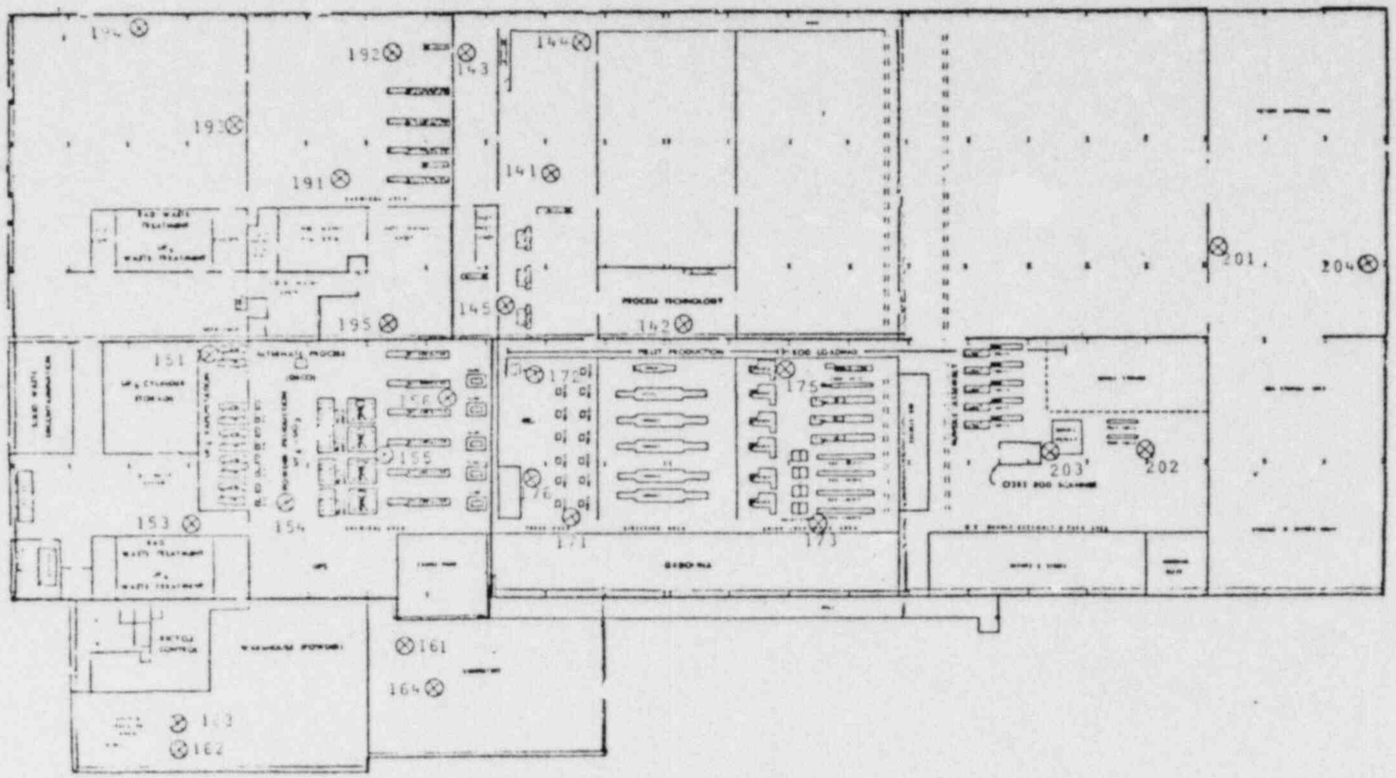


FIGURE 12.2

Criticality Warning System Detector Locations
FMO/FMOX



⊗ Sensor Location

FIGURE 12.3

GE-WMD Site Criticality Warning System
Detector Locations

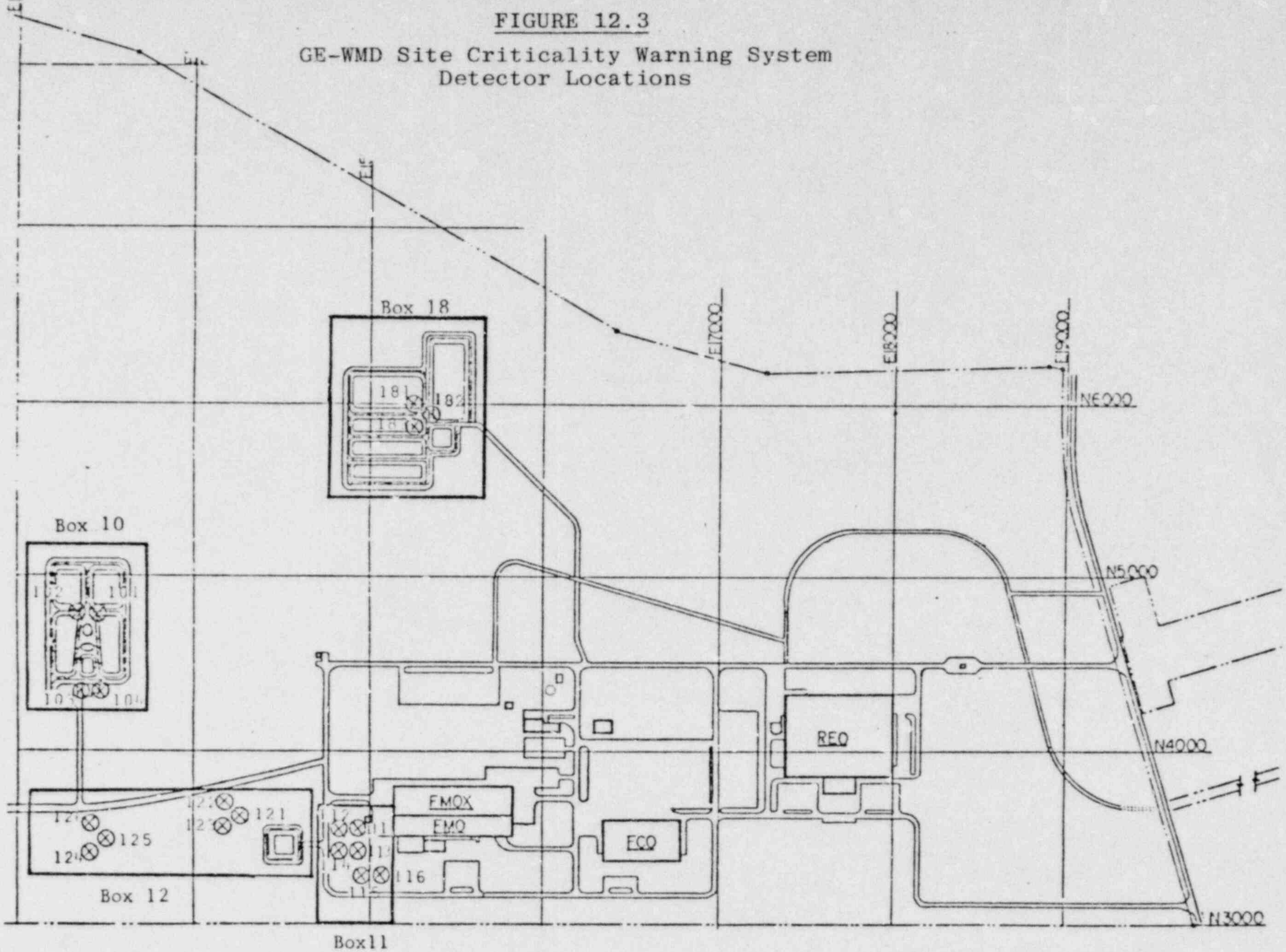


TABLE 12.2

ADMINISTRATIVE ACTION GUIDES - PERSONNEL EXPOSURE CONTROL

		Action
External Exposure		
Wholebody	1 Rem/qtr	Restrict for remainder of quarter
Skin	6 Rem/qtr	Restrict for remainder of quarter
Extremities	15 Rem/qtr	Restrict for remainder of quarter
Internal		
Assigned Airborne	> 300×10^{-11} uCi-hrs/cc	Restrict for remainder of week
In vivo Lung Count	> 250 ug	Restrict until count less than 100 ug
Urinalyses	30 mg/liter	Investigate
Skin Contamination		
Average	> 1000 dpm/cm^2	Notify Radiation Protection
Spot	> Detectable	Wash and resurvey

usage unless field tested in accordance with Regulatory Guide 8.15.

Full-face-mask respirators, equipped with an appropriate canister, are employed as precautionary measures in routine operations and for emergency actions which may require additional protection capabilities. A protection factor of 50 is taken for this type of respirator usage.

Self-contained breathing devices, operated in the pressure demand mode, are also available for certain emergency situations.

Typical respiratory protection equipment used at WMD for protection for internal exposure are summarized in Table 12.3.

12.9.2 Testing and Cleaning of Equipment

Respirator users deposit used respirators in designated receptacles after use. Each respirator is processed for cleaning, inspection and replacement of parts as necessary. Air purifying cartridges and canisters are DOP-penetration and pressure-differential tested according to internal procedures. New respirators and canisters are cleaned and tested in a similar fashion prior to initial usage.

Self-contained breathing devices are inspected for operational capability and are cleaned and re-inspected after each use by an outside service contractor.

TABLE 12.3

TYPICAL RESPIRATORY PROTECTION EQUIPMENT

FACEPIECE	TYPE	FILTER/CANISTER/CARTRIDGE	UNIT PART #	NIOSH APPROVAL #	FOR PROTECTION AGAINST	PROTECTION FACTOR FOR URANIUM
MSA Reg ComfoII (460968)	ON	Type H Ultra Filters (459322/464035)	459439	TC-21C-135	H	10 (2)
MSA Small ComfoII (465825)	ON (1)	Type H Ultra Filters (459322/464035)	459439	TC-21C-135 ext.	H	10 (2)
Welsh/Norton (7500-30)	ON (1)	Filter (7500-8)	7580	TC-21C-152	H	10 (2)
Welsh/Norton (7500-30M)	ON (1)	Filter (7500-8)	7580M	TC-21C-152	H	10 (2)
Willson (AR700)	ON (1)	Filter (R12)	1212	TC-21C-142	H	10 (2)
MSA Clearview (84304)	FF	Ultra Filter Cartridge (88480)	88479	TC-21C-150	H	50
		Cartridge (88182GMR/466221GMR-C)	466225	TC-14G-105	H,Cl,(HF)	50
		Cartridge (448973GMD)	448979	TC-14G-88	NH_3	--
MSA Ultraview (457126)	FF (1)	Ultra Filter Cartridge (88480)	457117	TC-21C-150	H	50
		Cartridge (88182GMR/466221GMR-C)	466226	TC-14G-105	H,Cl,(HF)	50
		Cartridge (448973GMD)	448980	TC-14G-88	NH_3	--
MSA Ultra Twin (460560)	FF (1)	Cartridge (461834/464028GMB-H)	461854	TC-23C-150	H,OV,C ,SO2	50
		Cartridge (460845/464030GMD-H)	461857	TC-23C-152	H,NH_3,MA	50
		Cartridge (460844/464027GMC-H)	461855	TC-23C-153	H,OV,Cl,SO2,HCL	50
Scott Air Pac		Open Circuit Pressure Demand w/30 min. cylinder of air	900014-00	BM-13E-08/TC-13F-40		10,000 (3)
3M White Cap Hood & Vent (5201)	H/H	Regulator (2800AA/9470)		TC-19C-69		500 (4)

(1) Special order respirators for personnel unable to get fit on majority (stocking of spare parts optional)
(2) Applicable protection factor if preirritant smoke test performed
(3) Refer to Reg. Guide 8.15
(4) Refer to IE Bulletin No. 78-07

ABBREVIATIONS USED IN LISTS

ON - Orinasal
FF - Full facepiece
H/H - Hood or Helmet
Cl - Chlorine
NH_3 - Ammonia
OV - Organic Vapor
HCL - Hydrogen Chloride
SO2 - Sulfur Dioxide
MA - Methyl Amine

H - Respirators, with replaceable filters, designed as respiratory protection against dusts, fumes, and mists having an air contamination level less than 0.05 milligram per cubic meter, and against radionuclides.
OPD - Open Circuit Pressure Demand Type

13.0 OCCUPATIONAL RADIATION EXPOSURE

13.1 Occupational Exposure Analysis

13.1.1 External Exposures

In the second quarter of 1980 WMD terminated the use of the film badge as the primary dosimeter device for external exposures and instituted the use of thermal-luminescent dosimeters (TLD). The decision to utilize TLDs was based on their increased sensitivity and compatibility with the WMD working environment. Badge assignments to individuals are based on their work areas. Exposure measurements for individuals are made and recorded quarterly. External dosimetry results prove that exposures at WMD are relatively constant and evenly distributed each quarter.

Figures 13.1, 13.2, and 13.3 depict the annual individual exposures for the years 1978, 1979, and 1980. Over the three year period, an average of 1200 individuals were issued external dosimetry. Approximately 99% of the individual annual exposures were less than 1 Rem. Only 5% of the individuals received exposures greater than 500 mRem per year. Less than 1% of the exposures were greater than 25% of the annual dose limit for which monitoring would be required by 10 CFR 20.

13.1.2 Internal Exposures

13.1.2.1 Bioassay

An average of 3200 bioassay samples are taken per year based upon the criteria defined in Chapter 13.3. Figure 13.4 summarizes the quarterly bioassay results for the years 1979, 1980, and 1981. Internal exposures from

FIGURE 13.1

1978 EXTERNAL WHOLEBODY EXPOSURE SUMMARY
(PERCENT UNDER NORMAL PROBABILITY PLOT)

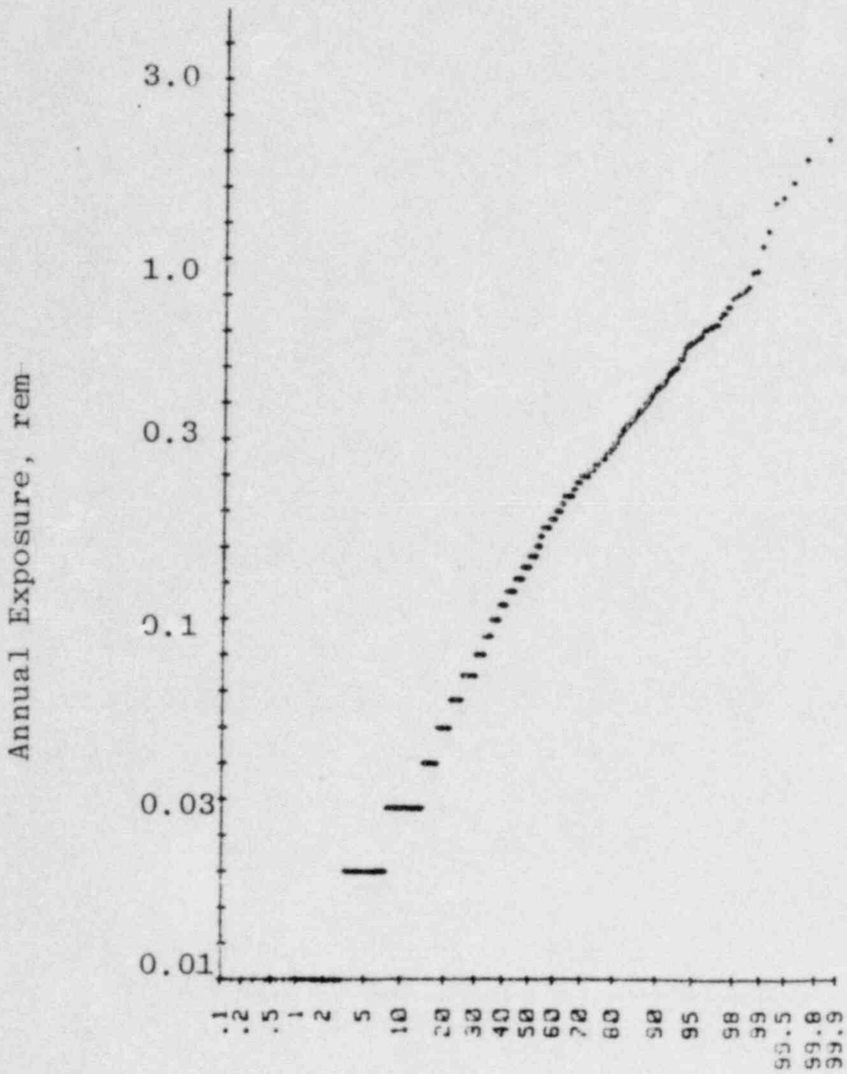
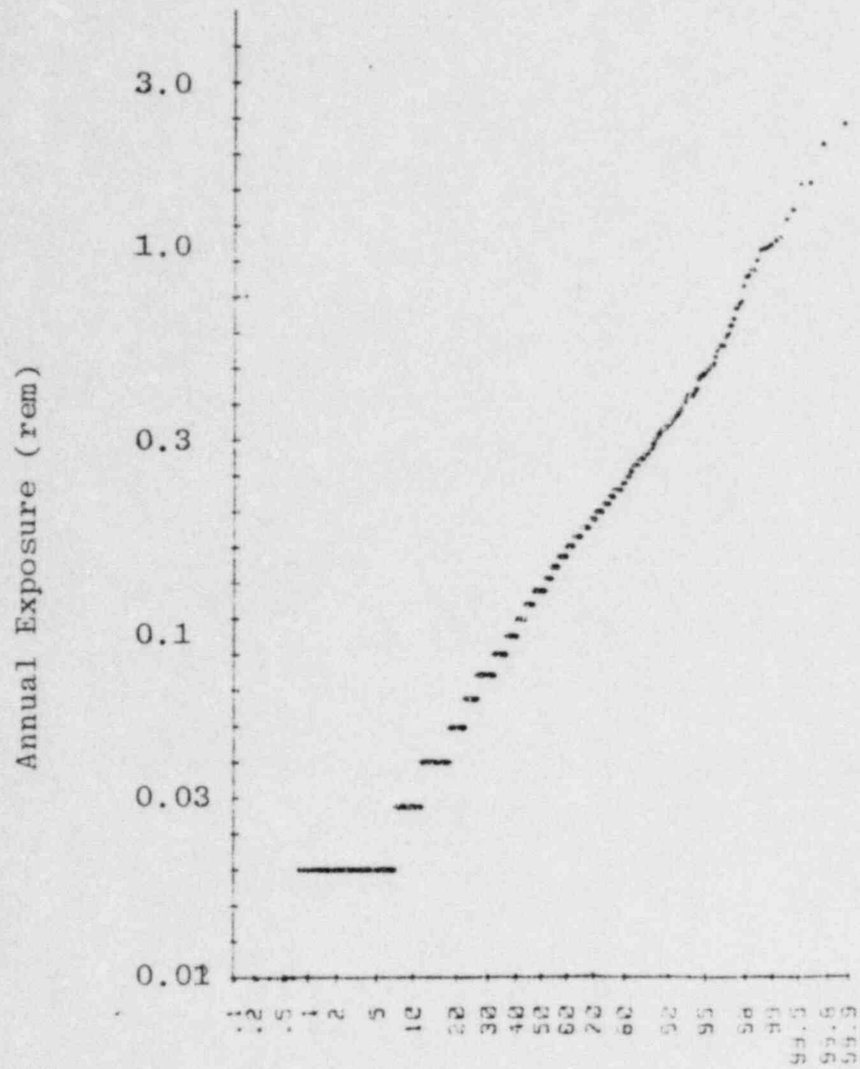


FIGURE 13.2

1979 EXTERNAL WHOLEBODY EXPOSURE SUMMARY
(PERCENT UNDER NORMAL PROBABILITY PLOT)



<u>FIGURE 13.3</u>

1980 EXTERNAL WHOLEBODY EXPOSURE SUMMARY
(PERCENT UNDER NORMAL PROBABILITY PLOT)

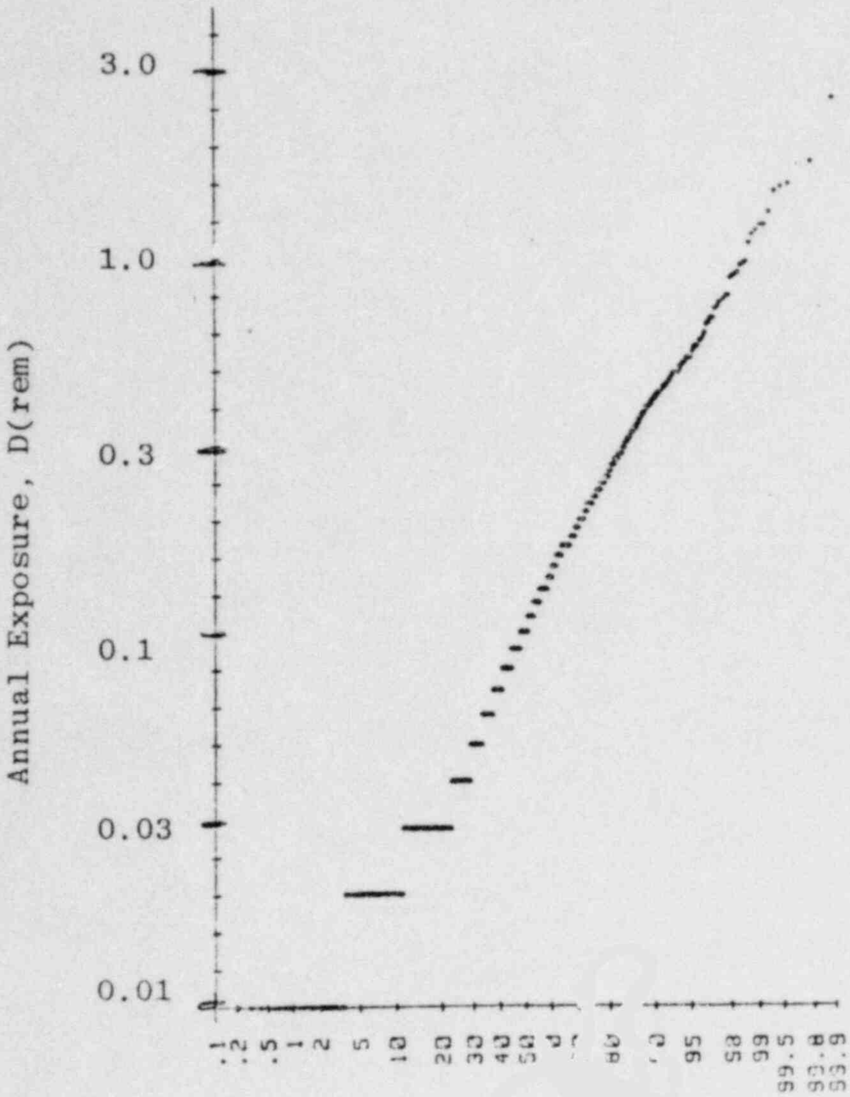
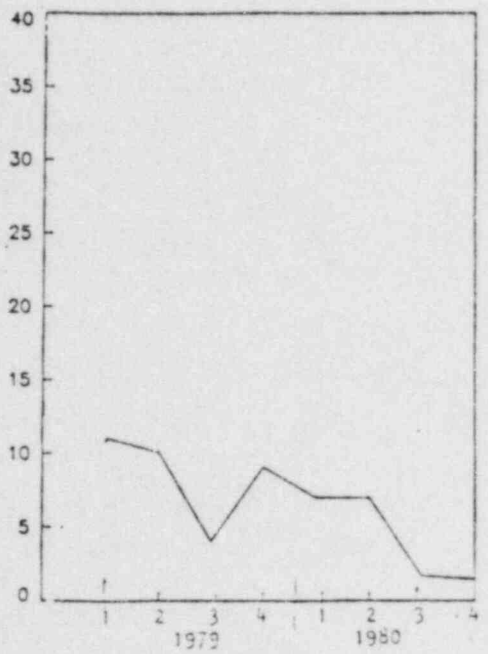
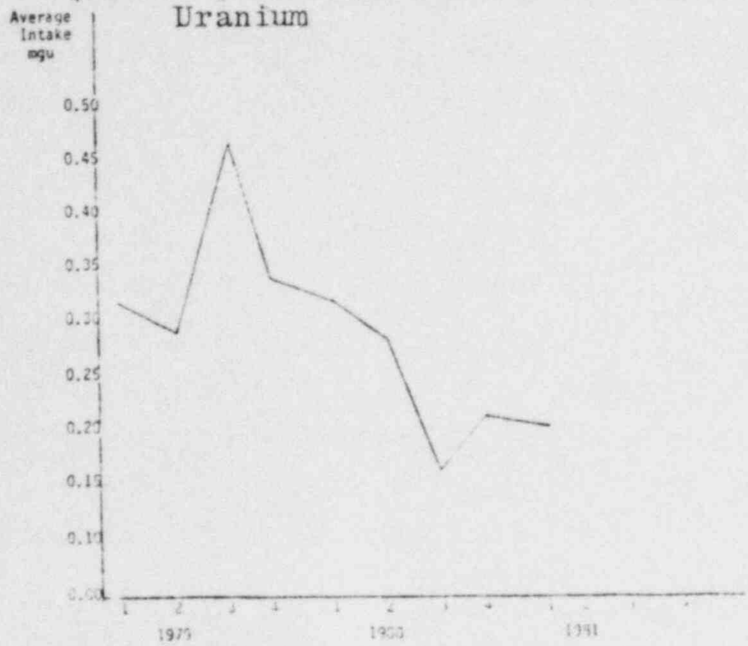


FIGURE 13.4

Per Cent of Total Bioassay Samples with Uranium Content Above Action Guide 1979-1980



Quarterly Average Calculated Intake, Soluble Uranium



soluble uranium compounds are effectively controlled. Quarterly average intake results have decreased from .4 milligrams uranium to .2 milligrams uranium during the period reported. Samples with results greater than 35 ug/liter (Reg Guide 8.11 investigation guideline) have decreased from 11% (of the total samples) during the first quarter 1979 to 2.5% in the third and fourth quarters of 1980.

Fecal sampling is conducted when ingestion of insoluble uranium is known or suspected. For those infrequent occurrences when fecal sampling has been performed (approximately twice per year), analytical results have been negative.

13.1.2.2 <u>In Vivo Lung Counting</u>

The WMD in vivo lung counting facility is operated by Radiation Management Corporation under a contract with General Electric. The equipment and facility have been continually upgraded since first installed in 1976; the counting electronics was upgraded in 1978 and again in 1980. Additional facility and equipment upgrades are planned in 1981.

Lung counting results for 1979 through the first quarter 1981 are summarized in Table 13.1. An abrupt change in counting levels was noted in the third quarter of 1980. It is apparent that these values do not reflect shop conditions and that the new levels were not the result of a long-term trend. Investigation indicates that the shift in levels is probably attributable to electronics and detector problems in the counter. Actions have been taken to resolve the problem, and an improvement (i.e.,

TABLE 13.1

IN-VIVO LUNG COUNTS

Quarter	Total # Persons Counted	% of Counts <75 ugm U-235	% of Counts 76-150 ugm U-235	% of Counts >150 ugm U-235
1Q79	464	85	16	1
2Q79	483	79	19	4
3Q79	410	81	17	2
4Q79	437	80	20	< 1
1Q80	470	84	15	1
2Q80	424	83	16	1
3Q80	429	56	40	4
4Q80	428	58	33	9
1Q81	526	71	17	13

return to prior levels) is apparent from more recent data. In the interim, the apparently overconservative measurements of the lung burden have been treated as being valid. Individual exposures were controlled during this period in accordance with internal procedures. There were no overexposures.

13.1.3 Airborne Concentrations

During the period of 1979 through the first quarter of 1981, the average air concentrations in individual work areas show good trends in the areas where uranium has been historically difficult to contain.

13.1.3.1 Air Sampling System

Details of the WMD air sampling program are described in Chapter 13.4. In 1979, a new air sampling system was installed throughout the fuel plant. The system was designed based upon operational experience, changes to the process operations and recognition of the need for additional data for better analyses. The stationary sampling points were increased from 70 to 120. Since that time, 40 additional points have been added as a result of changes in operation and ongoing data evaluation. The system has significantly improved the quality, traceability and usefullness of factory environment data. It should be noted that in the figures discussed below data for many of the areas were not available until the new system was installed.

13.1.3.2 Chemical Area

In the chemical area, the air concentrations are generally less than 5 x 10^{-10} uCi/cc as compared to the 10 CFR 20 limit of 1 x 10^{-10} uCi/cc for insoluble uranium.

Figures 13.5 through 13.14 indicate average airborne concentrations in individual operations in the chemical area, i.e. calciners, sluggers, hammermills, and the decon operation. Although none of these areas indicate unfavorable trends or levels of airborne concentrations, numerous improvements have been made.

In the calciner area improved hoods have been installed at the powder discharges and the air cleaning system upgraded to control releases from the calciner fron end; the slugger and hammermill containment systems have been replaced; in the decontamination facility engineering improvements which have been implemented reduced air concentrations from 2 x 10^{-10} uCi/cc in the first quarter of 1980 to the current level of approximately 0.8 x 10^{-10} uCi/cc.

Airborne concentrations in the vaporization area from 1979 to 1981 are depicted in Figure 13.15. A marked increase in concentrations during the first half of 1980 was caused by a series of failures in UF_6 piping flanges and automatic shutoff valves. The flanges have been repaired and the automatic valves were installed. These actions, complete with improvements in the UF_6 cylinder hook-up and ventilation system have effectively corrected the problem. During the period, personnel were protected by respiratory protection and administrative control of personnel occupancy time.

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FIGURE 13.5

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

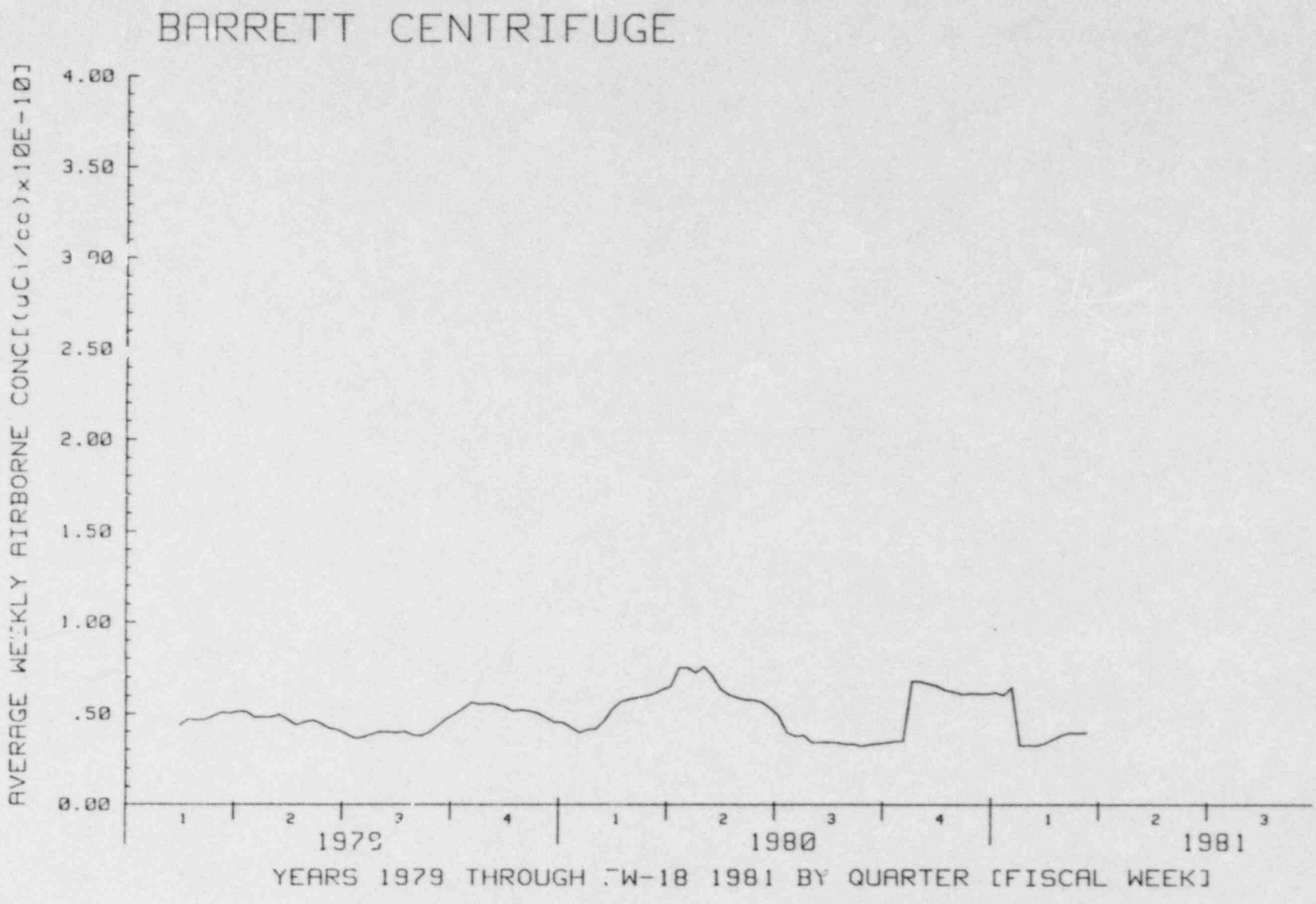

FIGURE 13.6

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

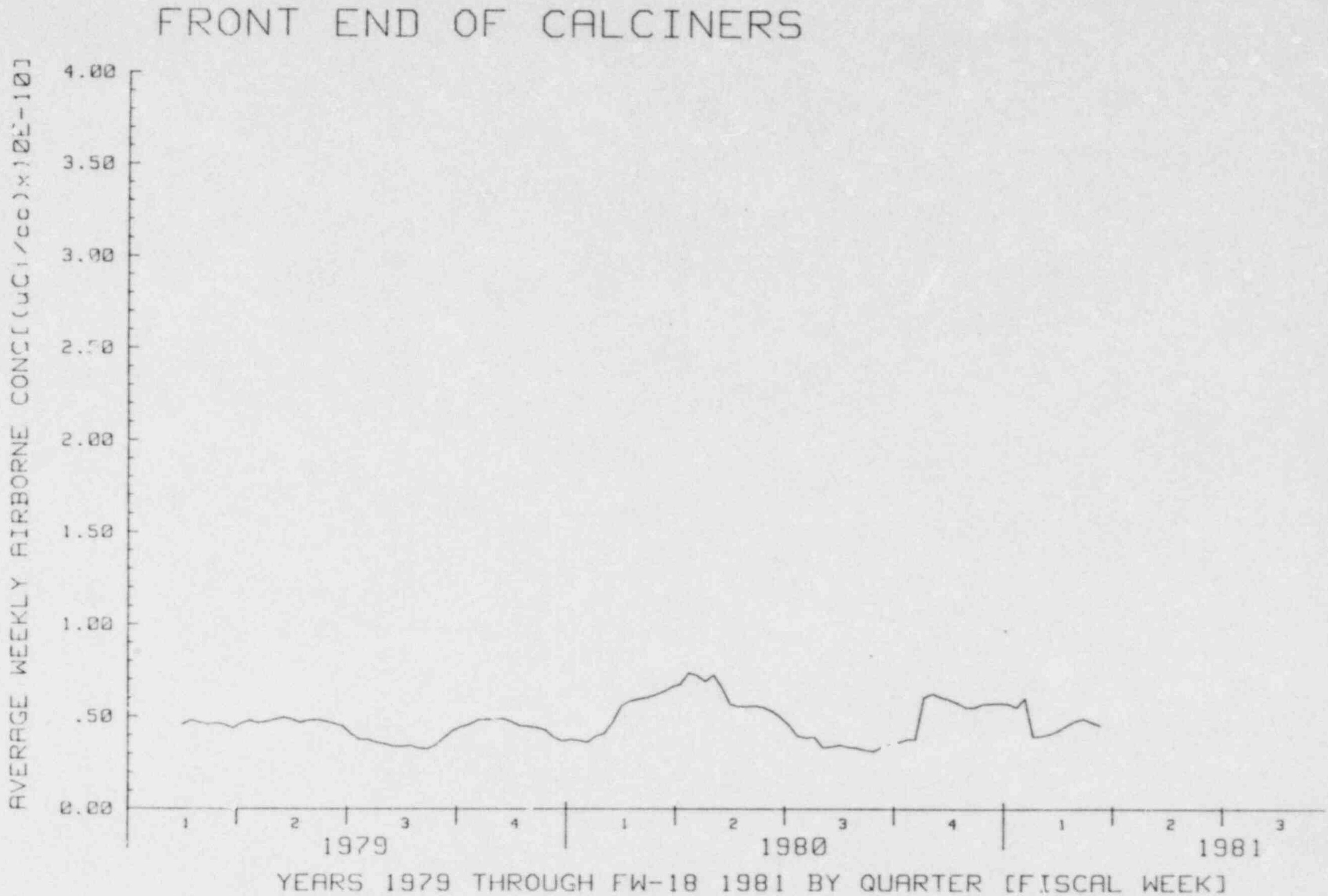

FIGURE 13.7

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

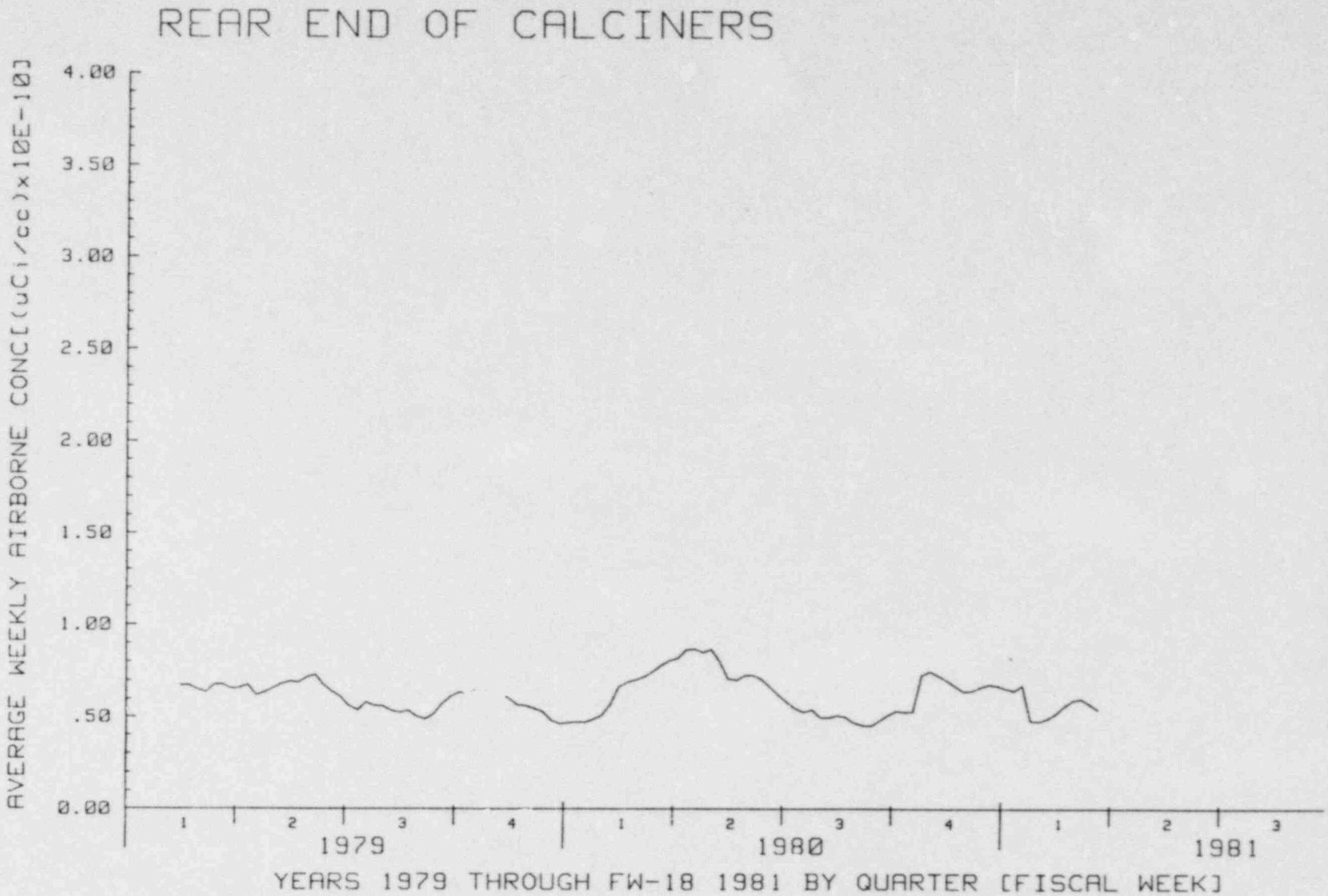

FIGURE 13.8

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

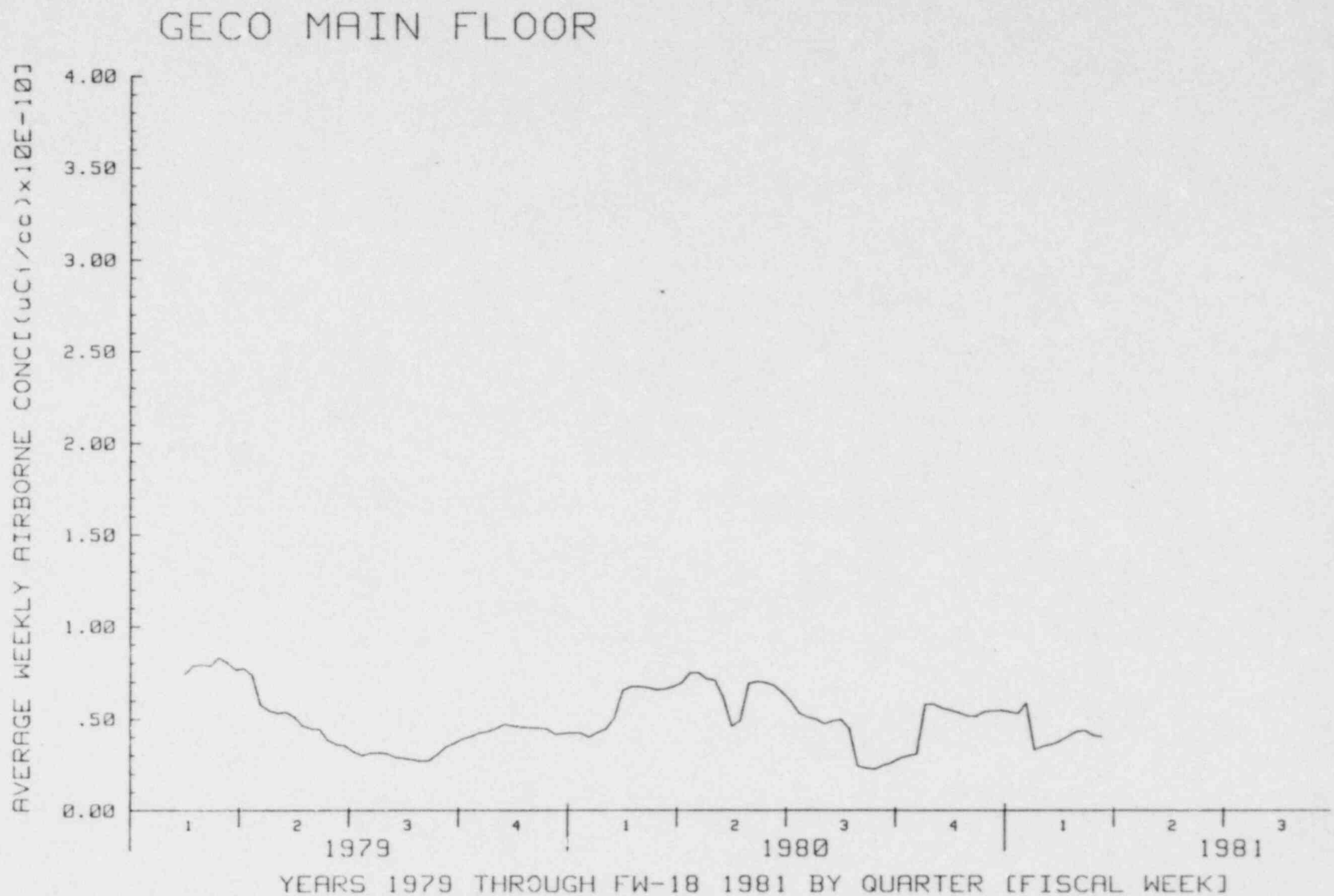

FIGURE 13.9

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

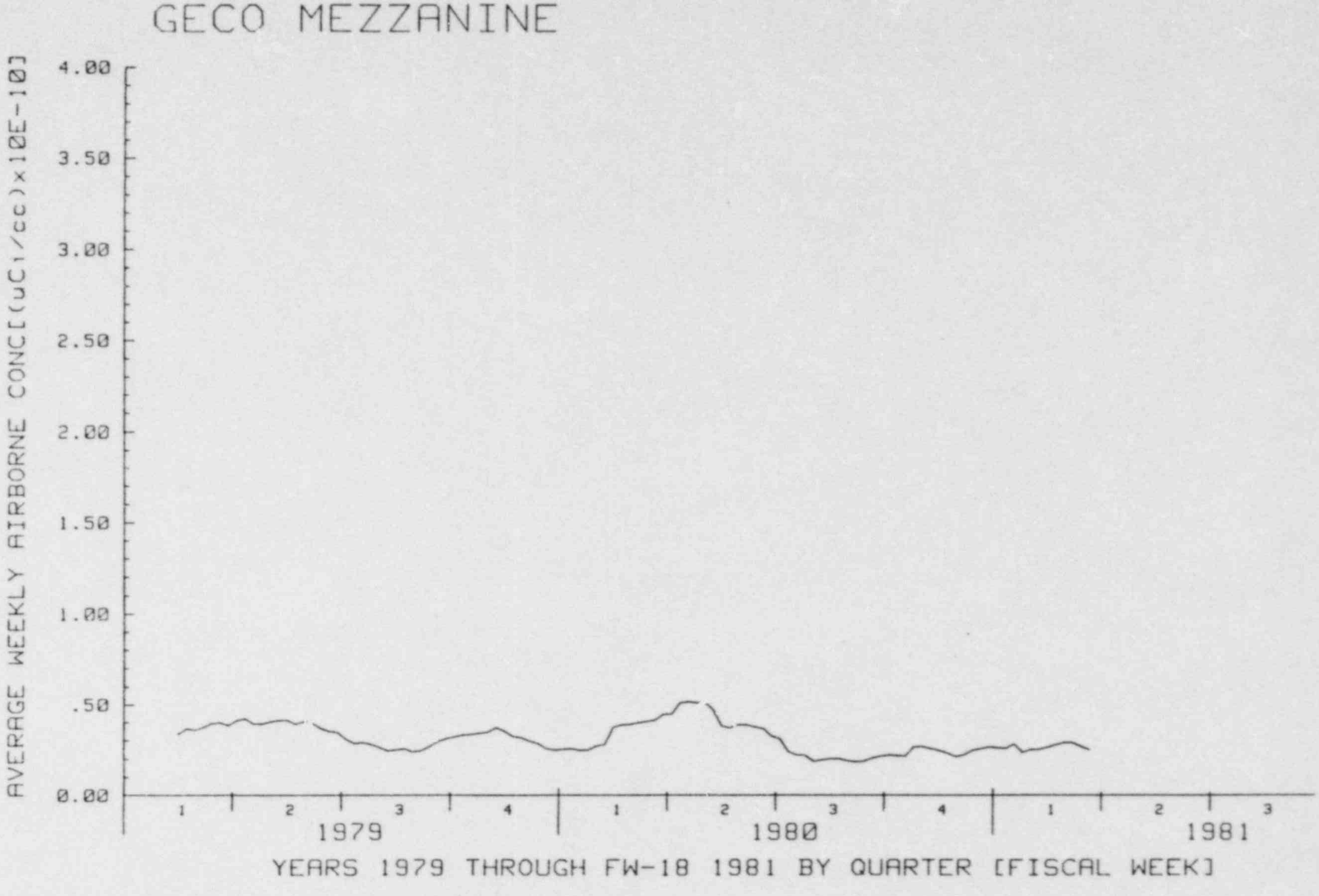

FIGURE 13.10

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

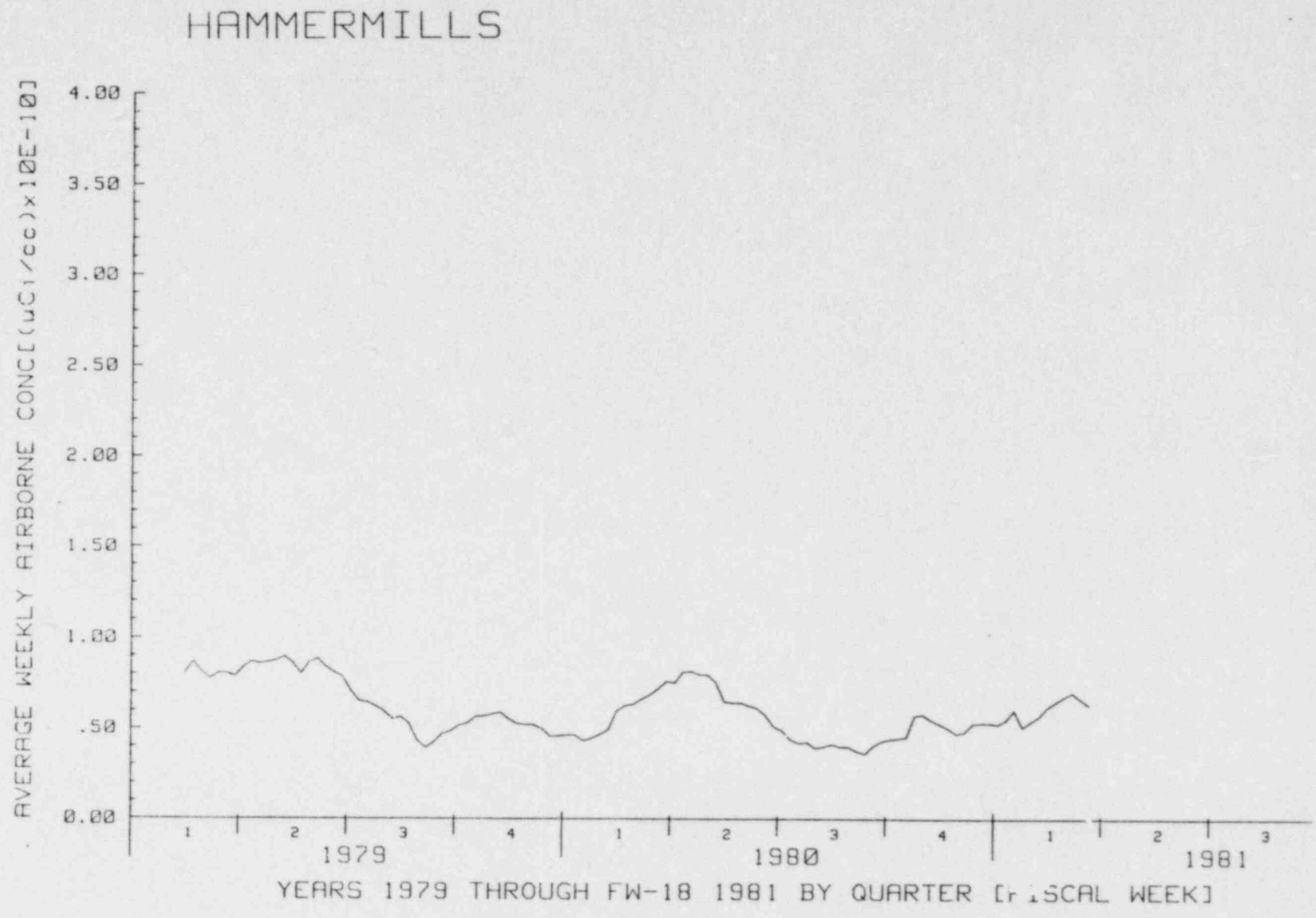

FIGURE 13.11

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

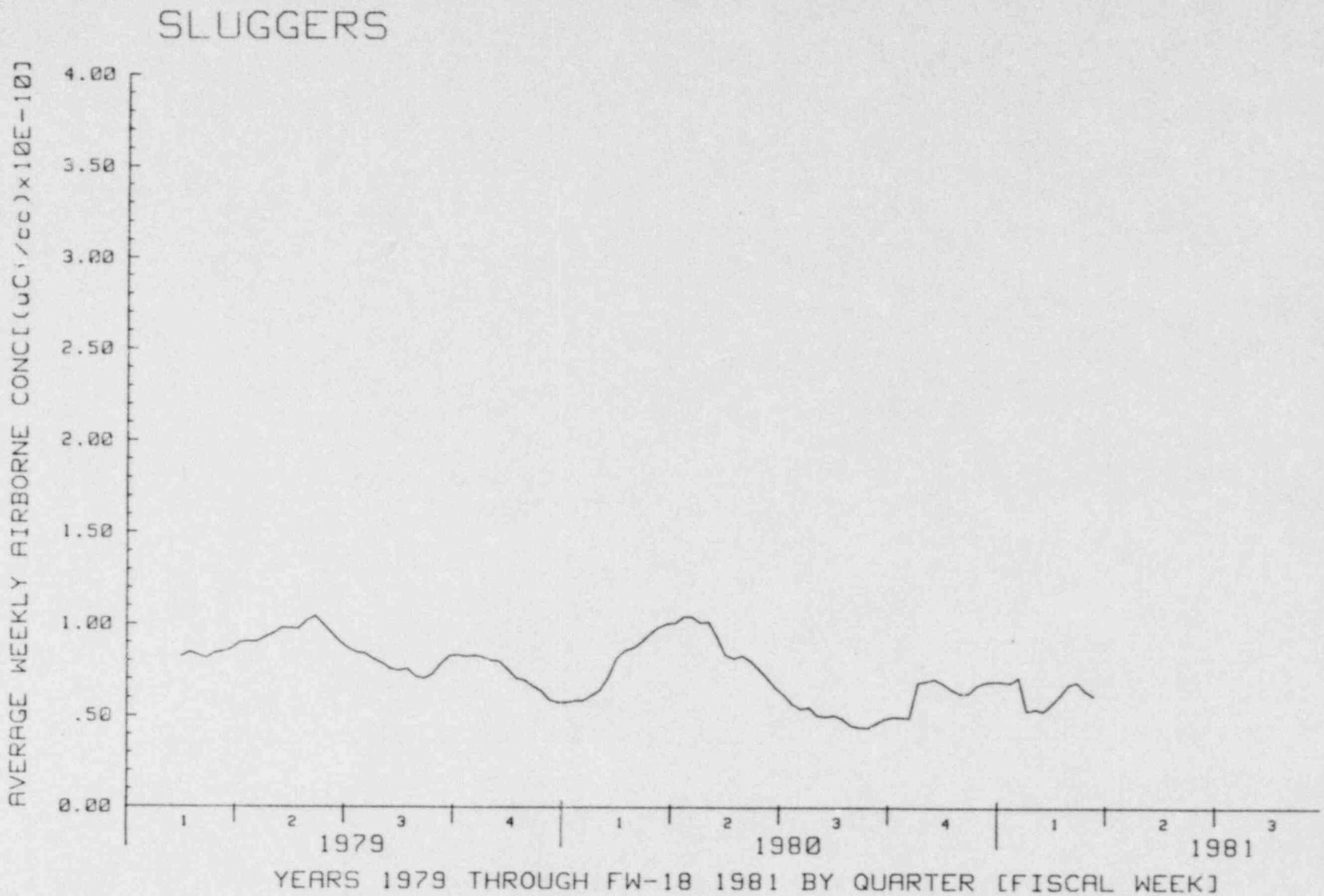

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FIGURE 13.12

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

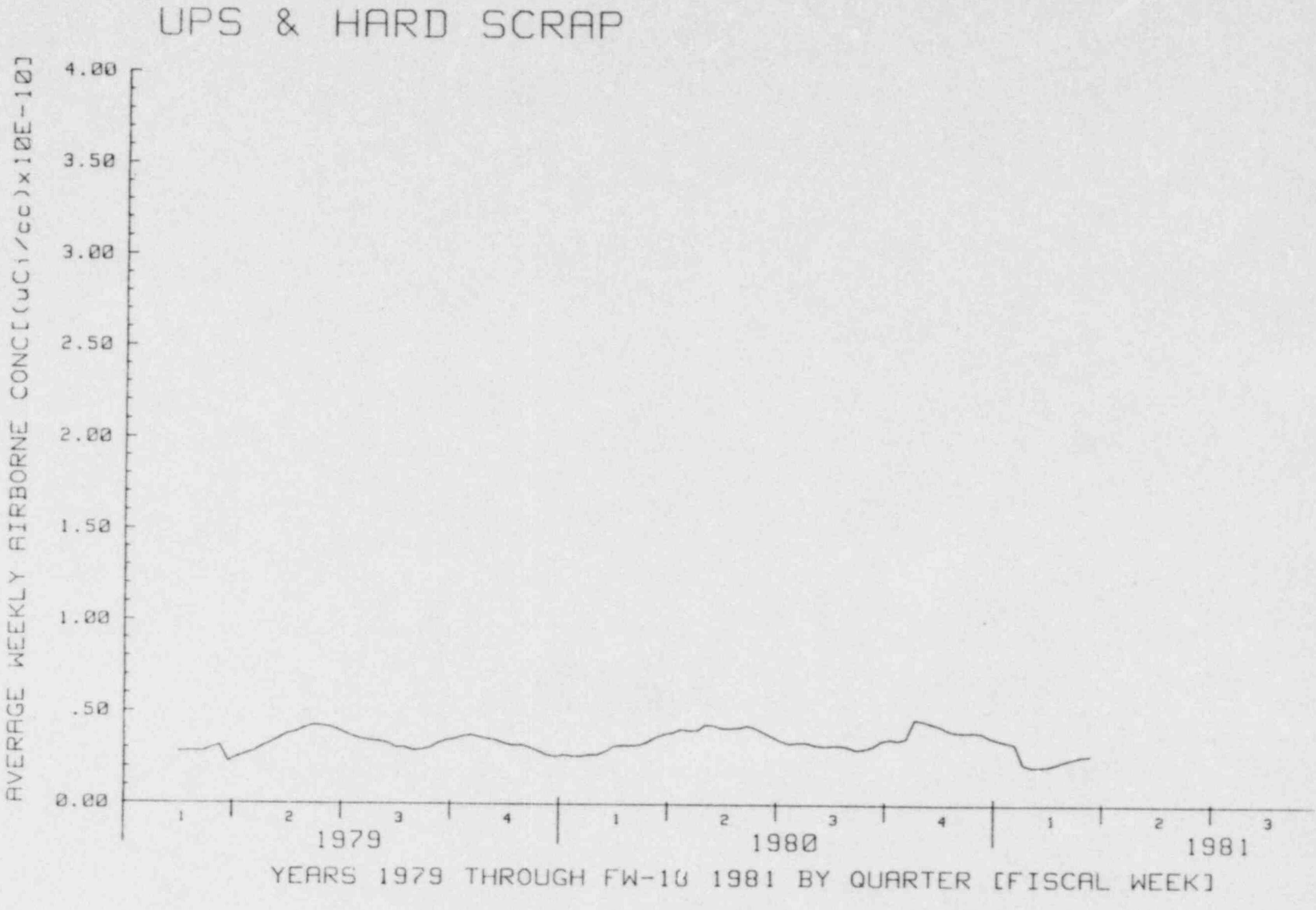


FIGURE 13.13

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

DECON FACILITY-OUTER ROOM

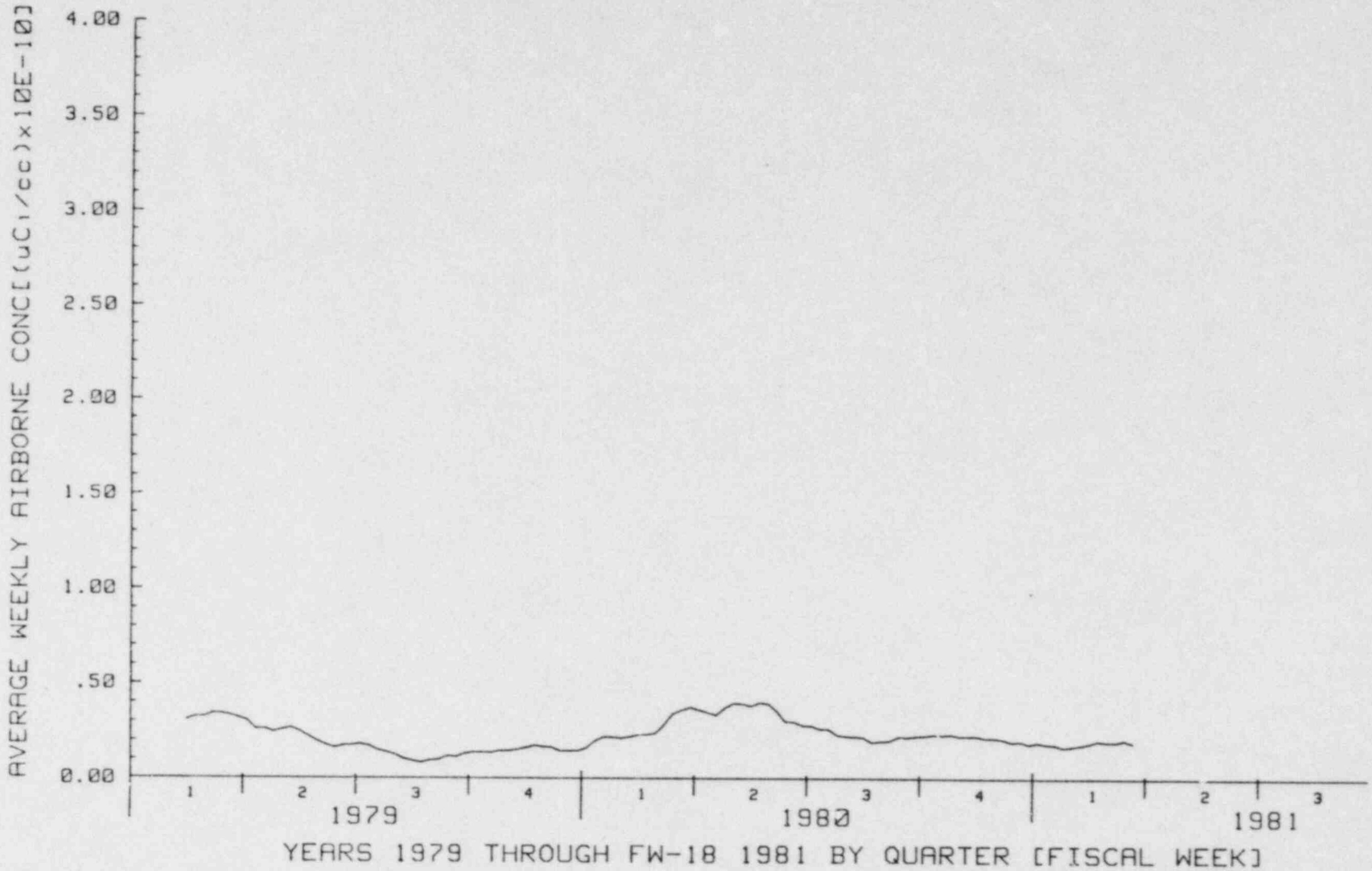


FIGURE 13.14

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

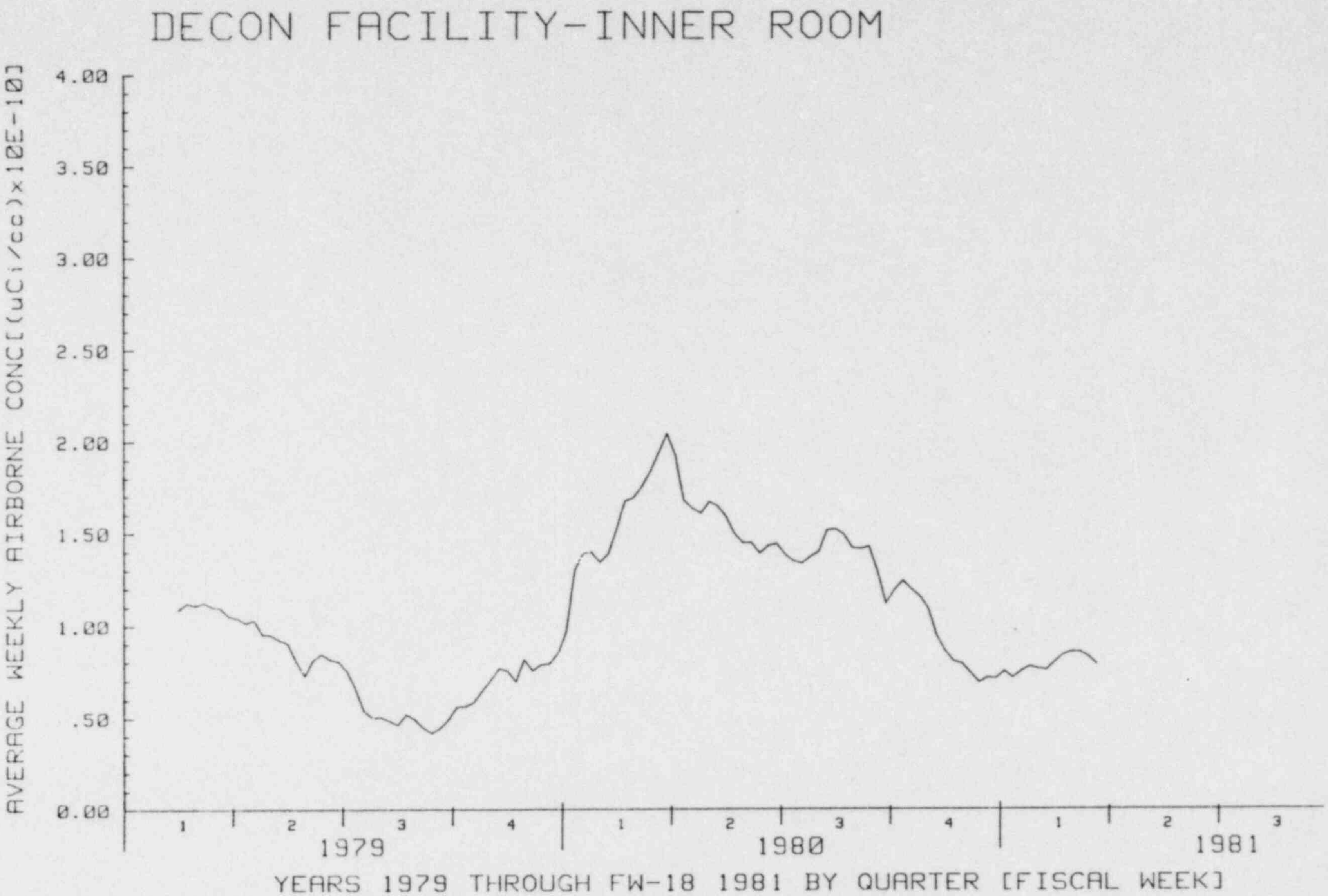
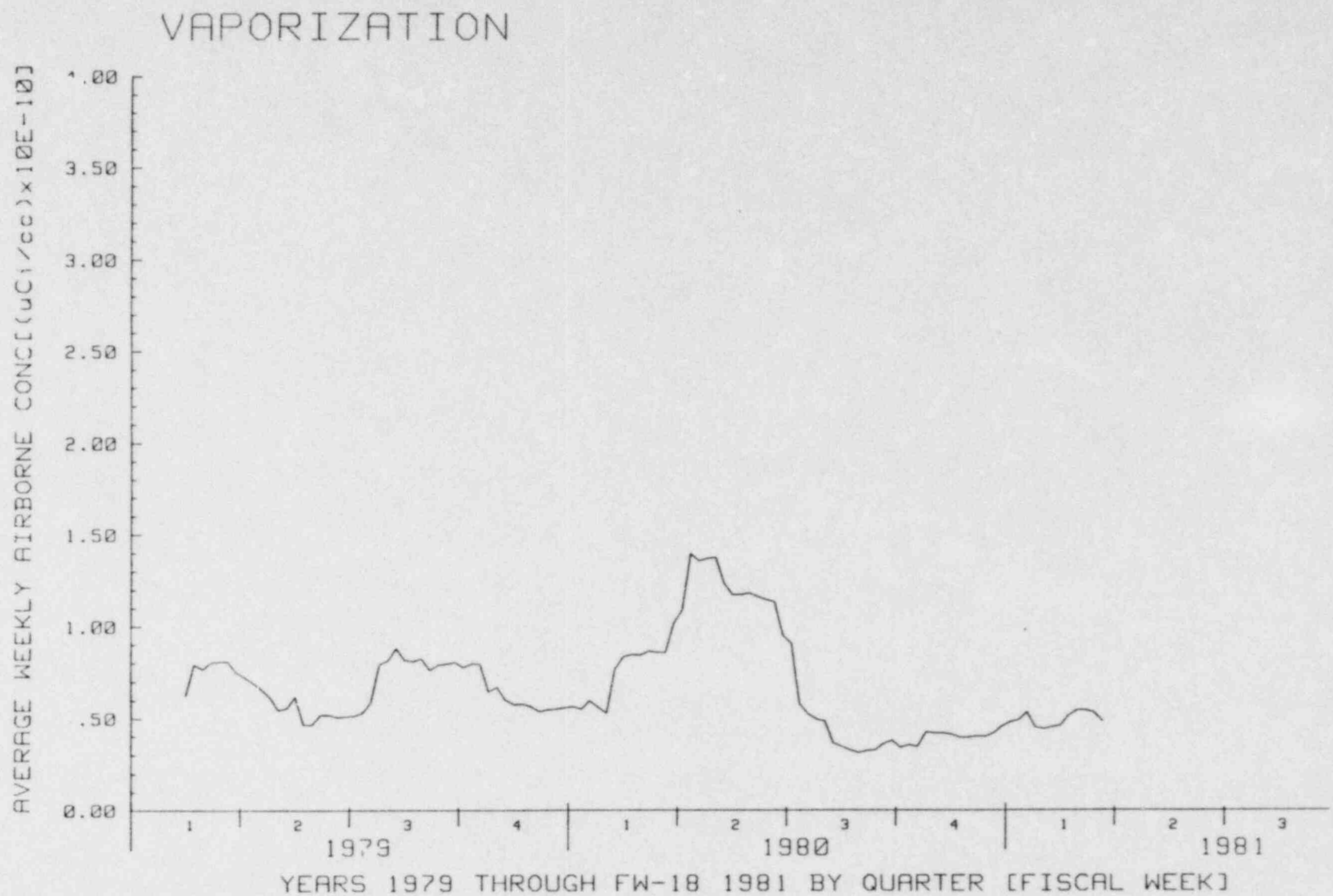


FIGURE 13.15

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS



There were no significant personnel exposures or high bioassay results during this period. (Although the permissible air concentration for soluble uranium at the average plant enrichment of 2.5% is in the order of 27.5 x 10^{-11} uCi/cc as compared to 10 x 10^{-11} uCi/cc for insoluble uranium, the weekly assigned exposures are routinely controlled to an internal action guide of 300 x 10^{-11} uCi - hrs/cc averaged over 40 hours rather than a permissible assigned exposure of 1100 x 10^{-11} uCi - hrs/cc.)

13.1.3.3 Ceramic Areas

The air concentrations in the ceramic areas (Figures 13.16 through 13.27) are favorably low (less than 0.25 x 10^{-10} uCi/cc) and show a good trend.

13.1.3.4 Other Areas

Airborne concentrations in the process technology laboratory, the maintenance shops, gadolinia operations and other work areas are generally less than 0.1 x 10^{-10} uCi/cc. (See Figures 13.28 to 13.40.)

13.1.3.5 Management Review

It is the practice at WMD to review the performance of air concentration controls. Operating first-line supervision and area managers review the air sample results on a shift basis and take corrective actions. The manager of the fuel manufacturing operation, the fuel manufacturing area managers, the radiation protection function and the nuclear safety functions hold a weekly review of airborne levels in the operation. Problems are identified and evaluated and

FIGURE 13.16

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

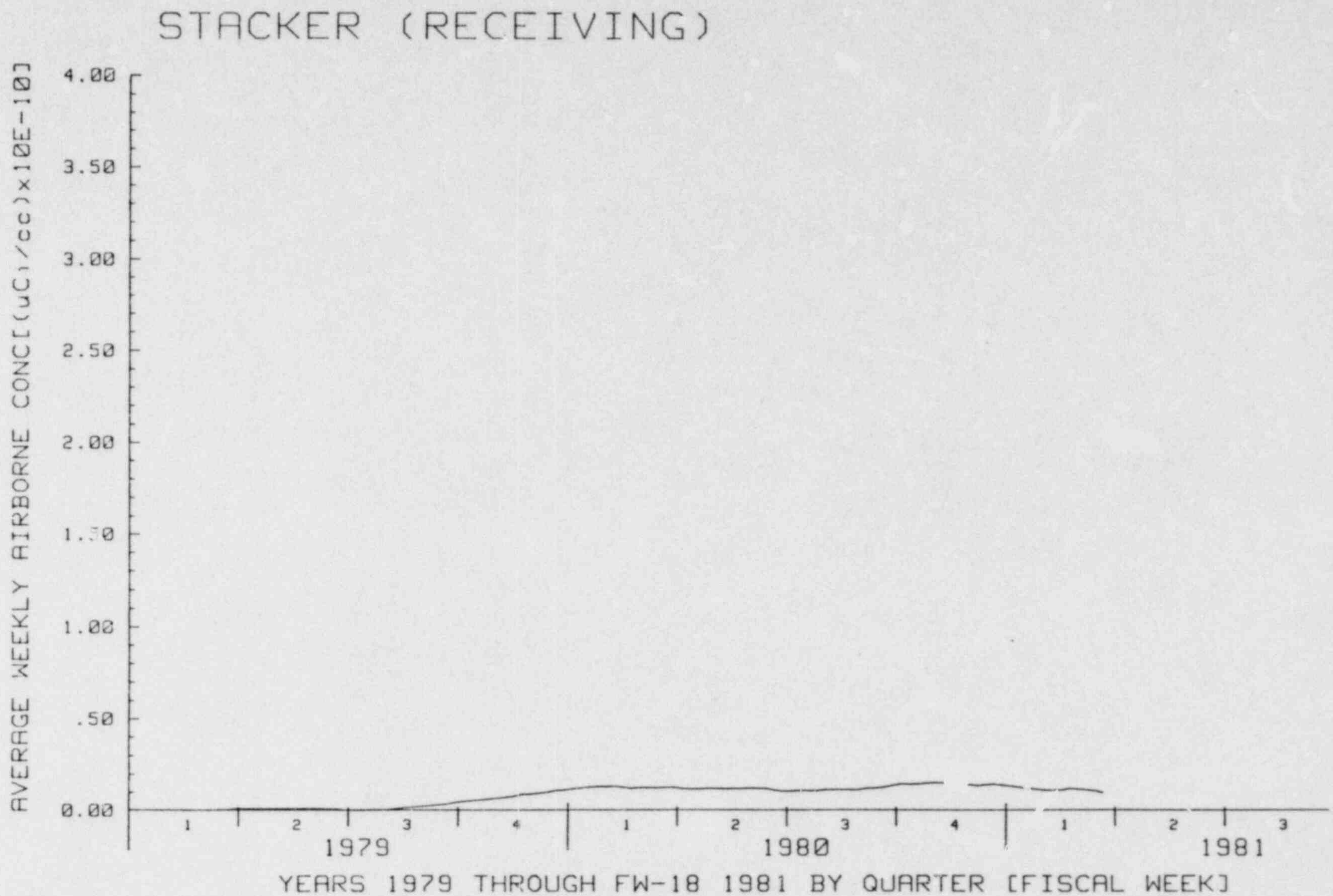


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FIGURE 13.17

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

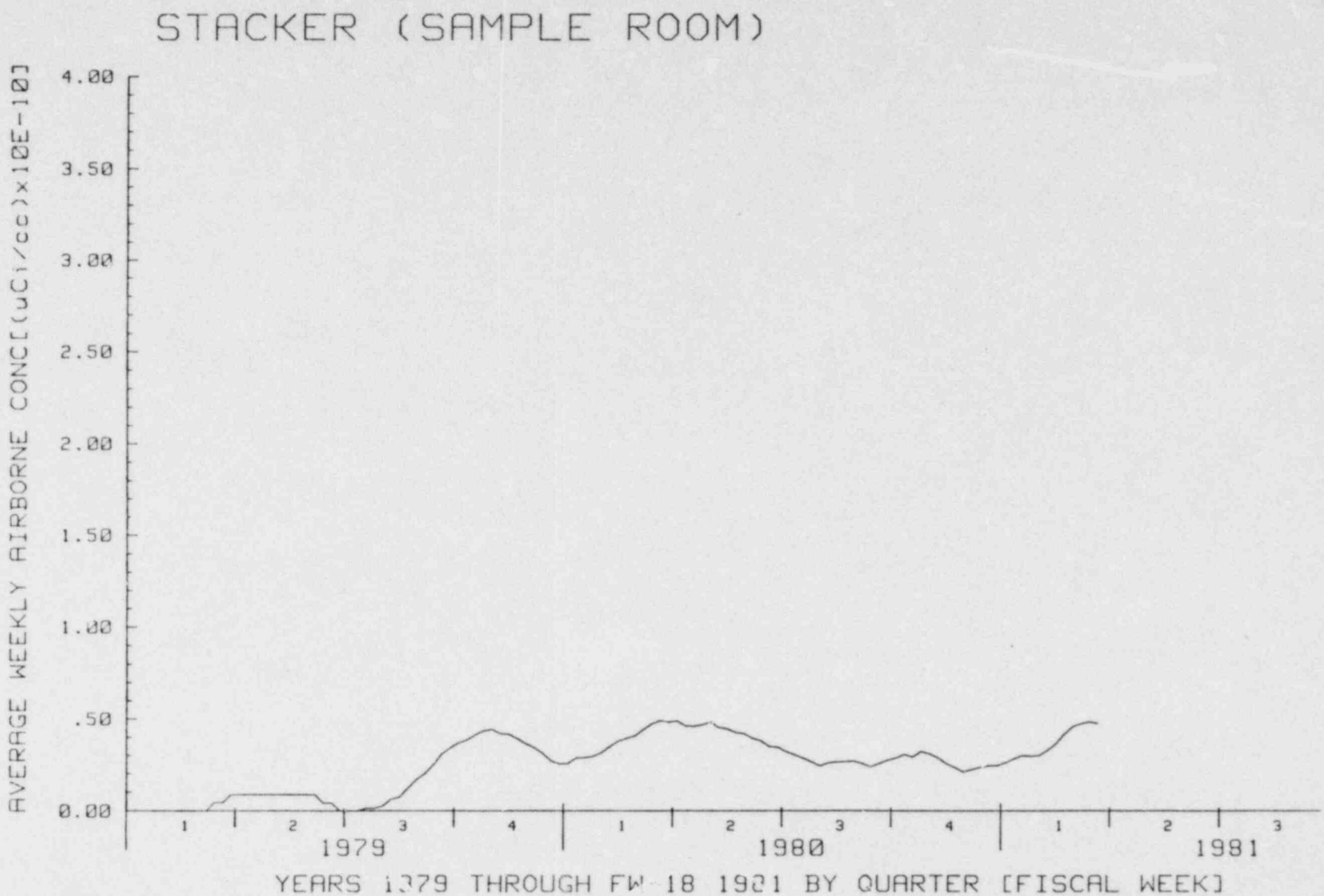

FIGURE 13.18

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

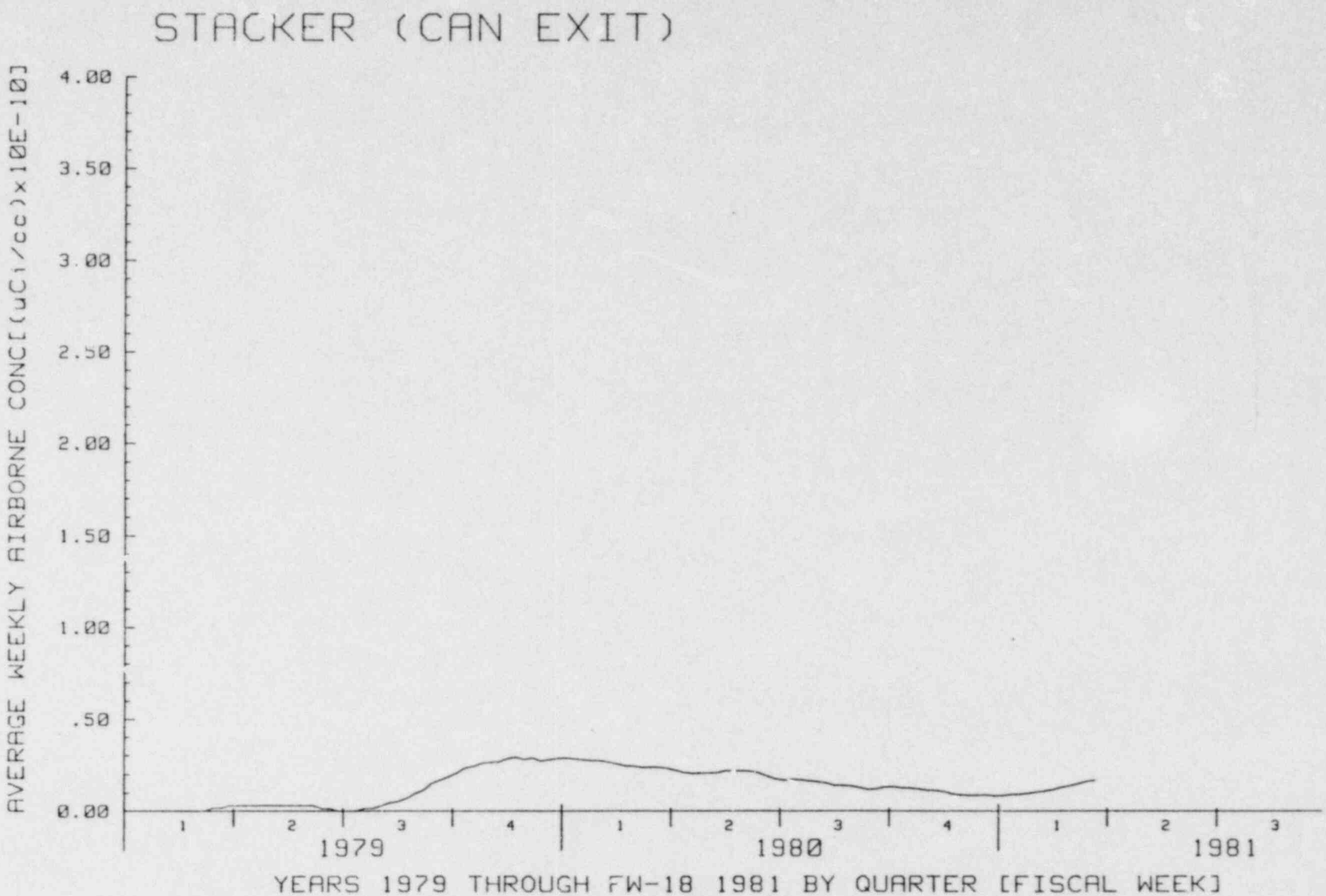

FIGURE 13.19

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

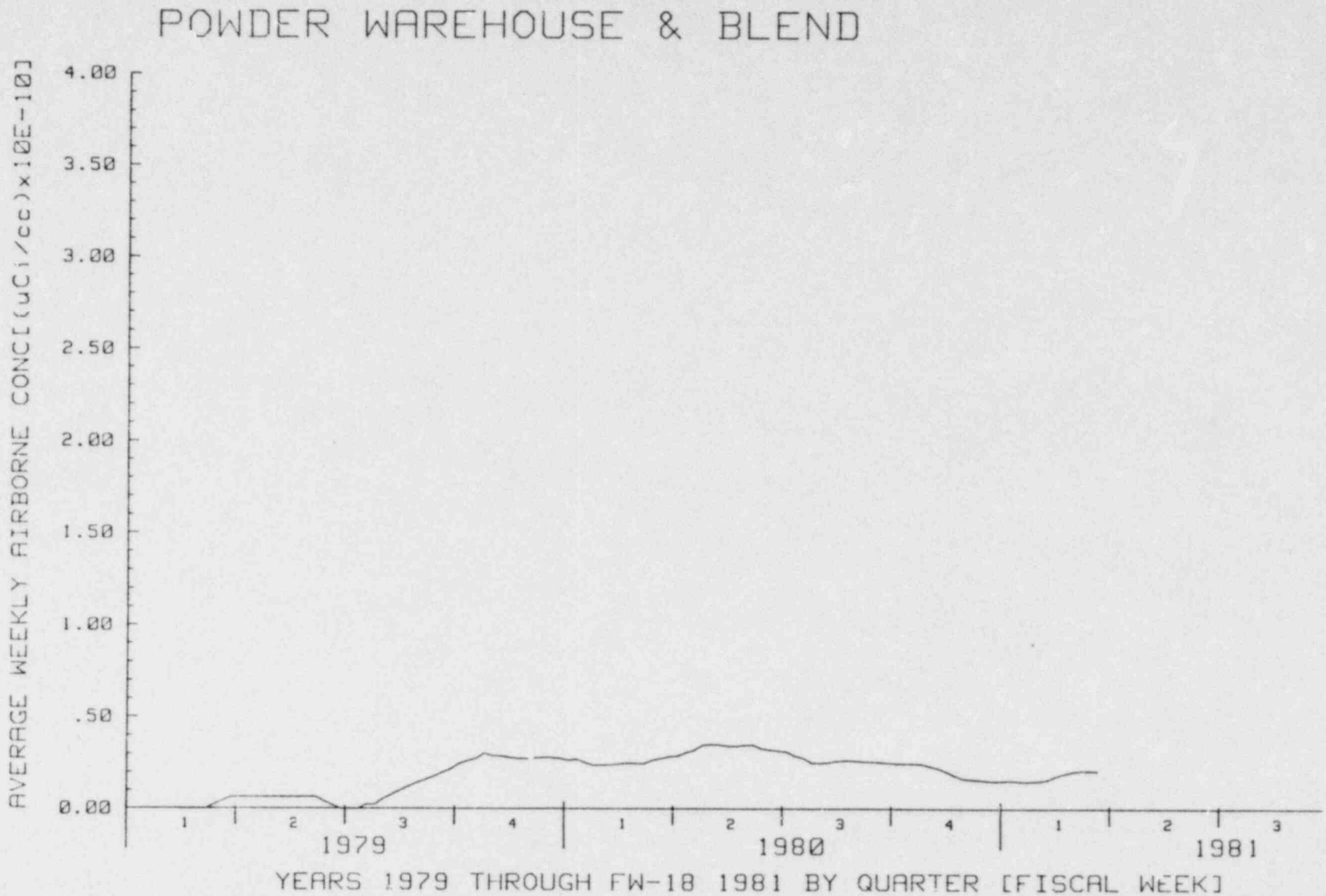

FIGURE 13.20

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

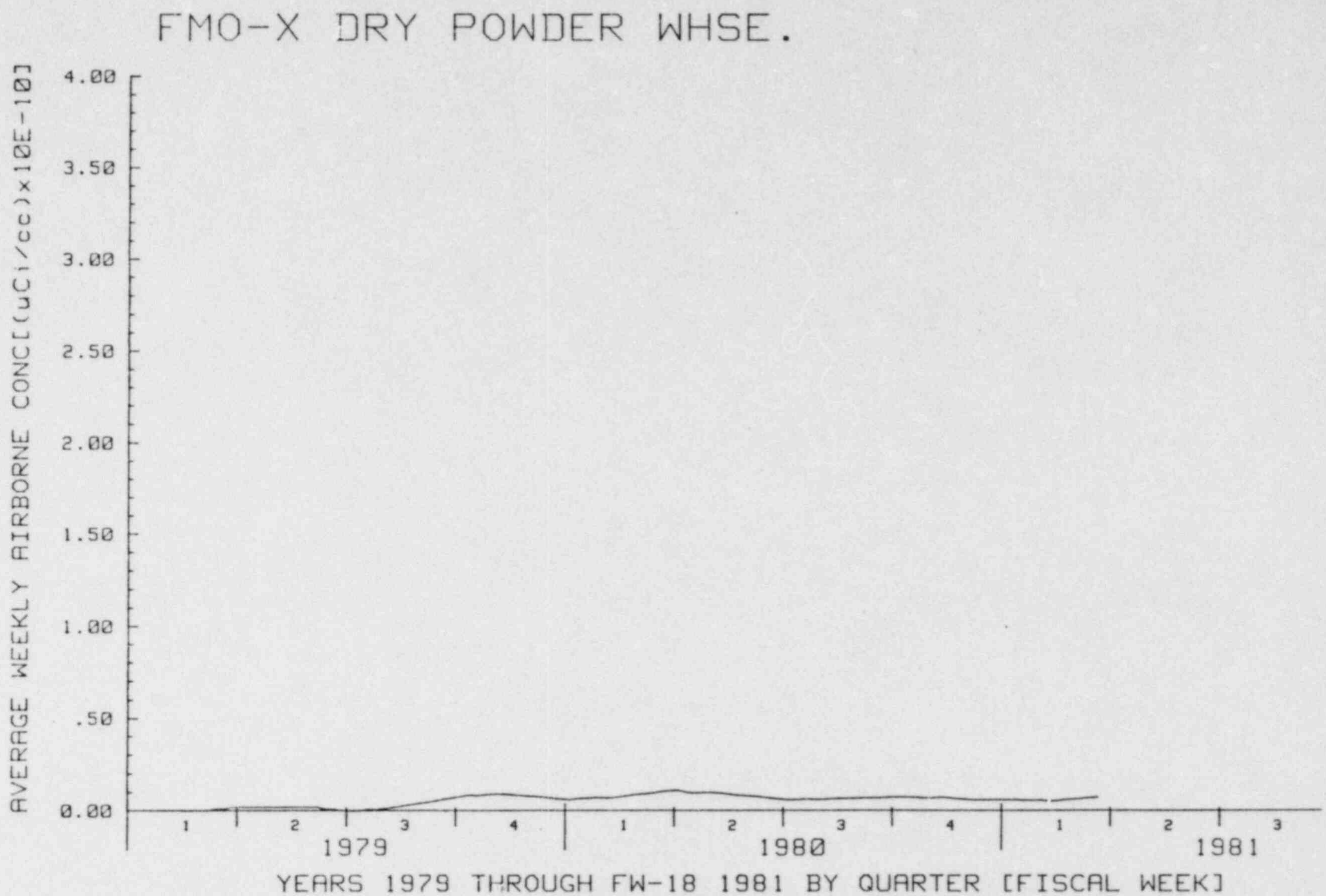

FIGURE 13.21

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

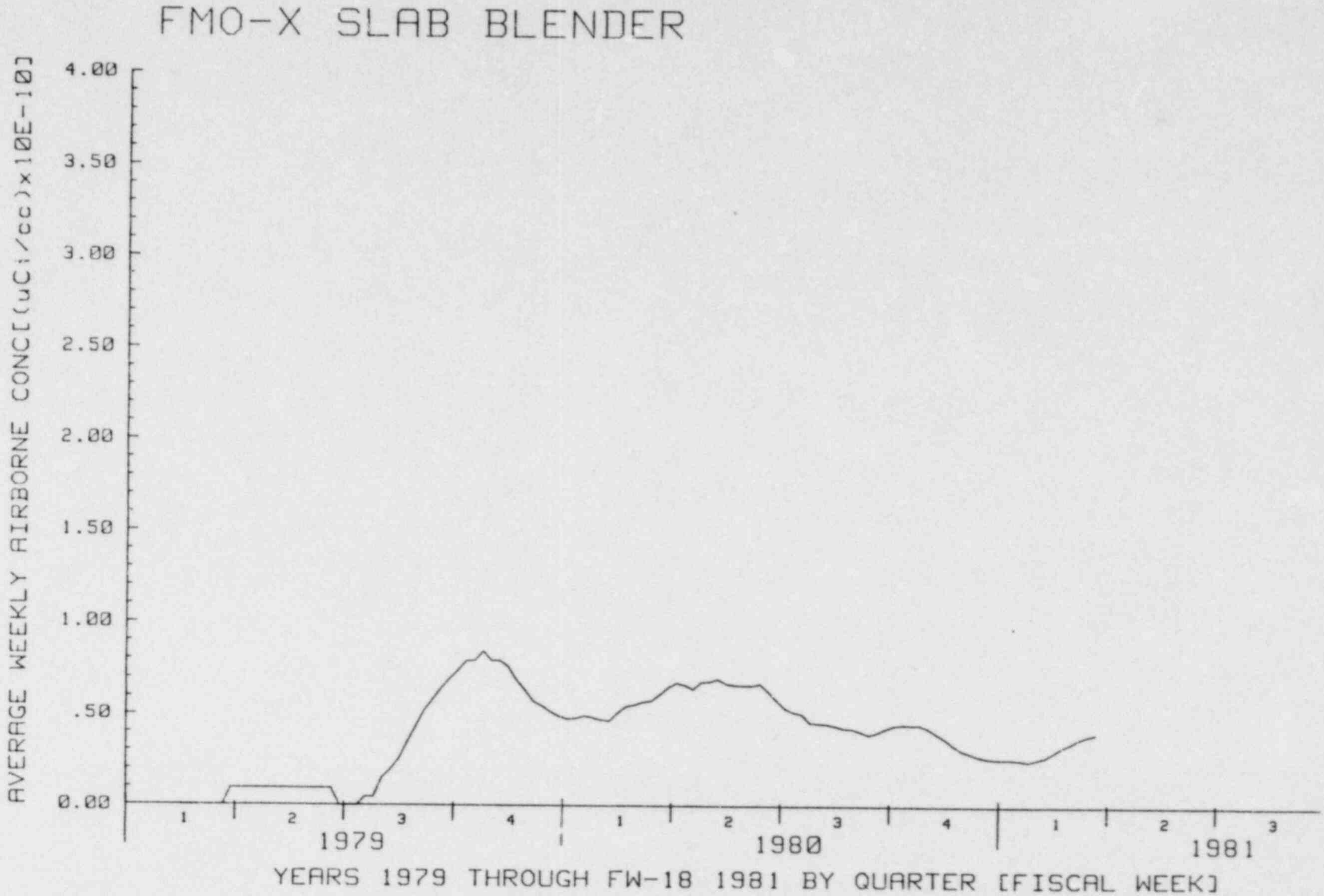

FIGURE 13.22

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

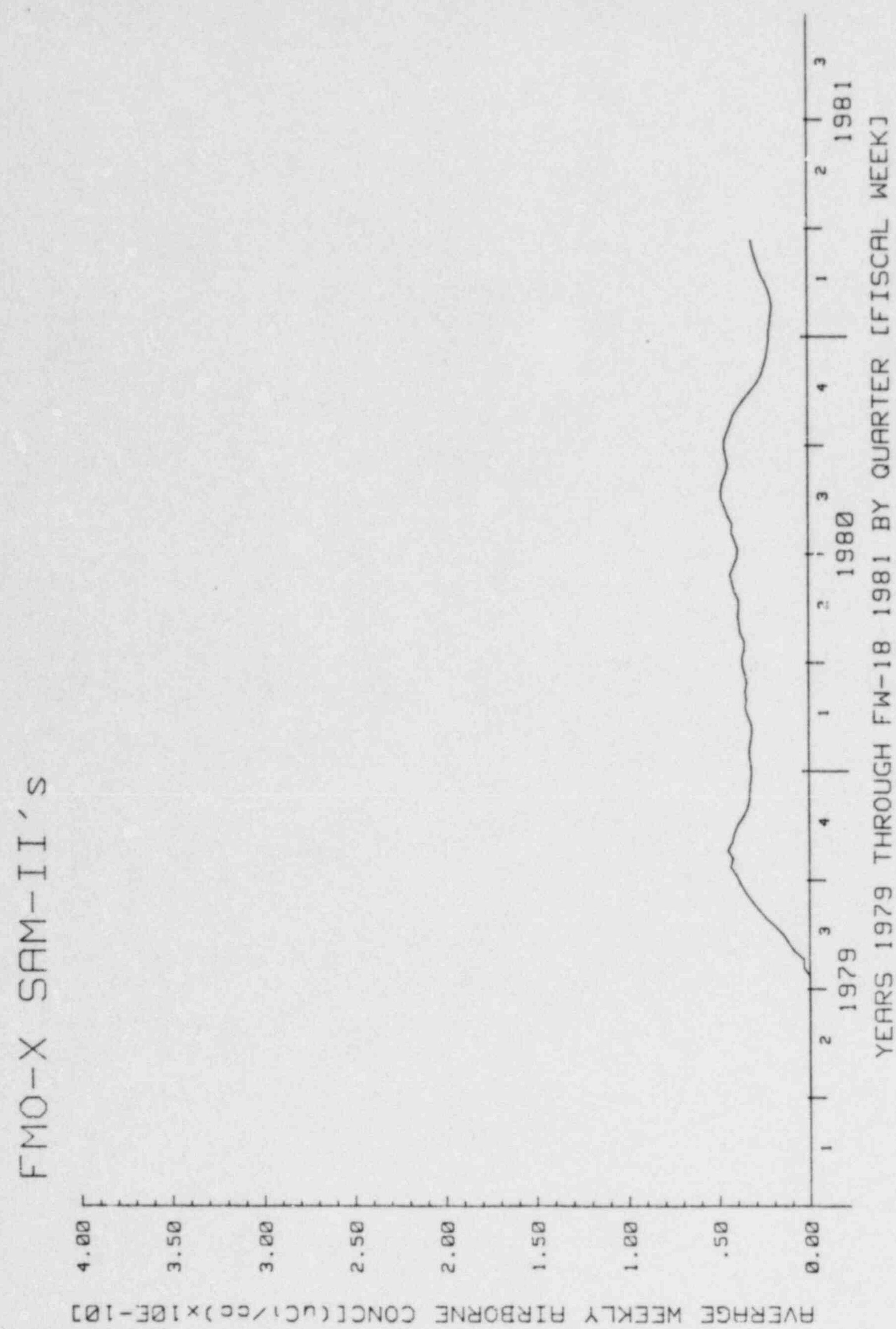

FIGURE 13.23

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

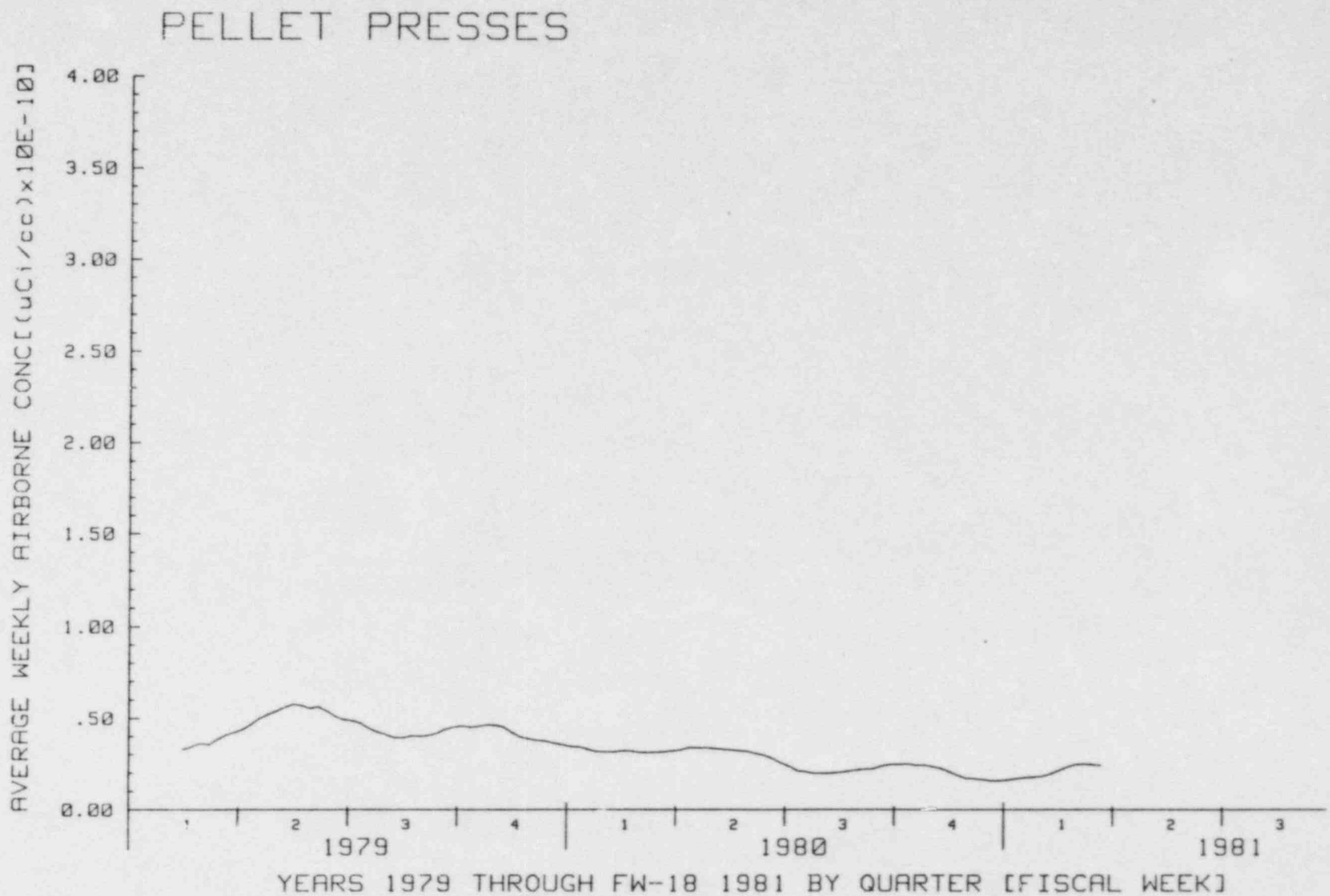

FIGURE 13.24

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

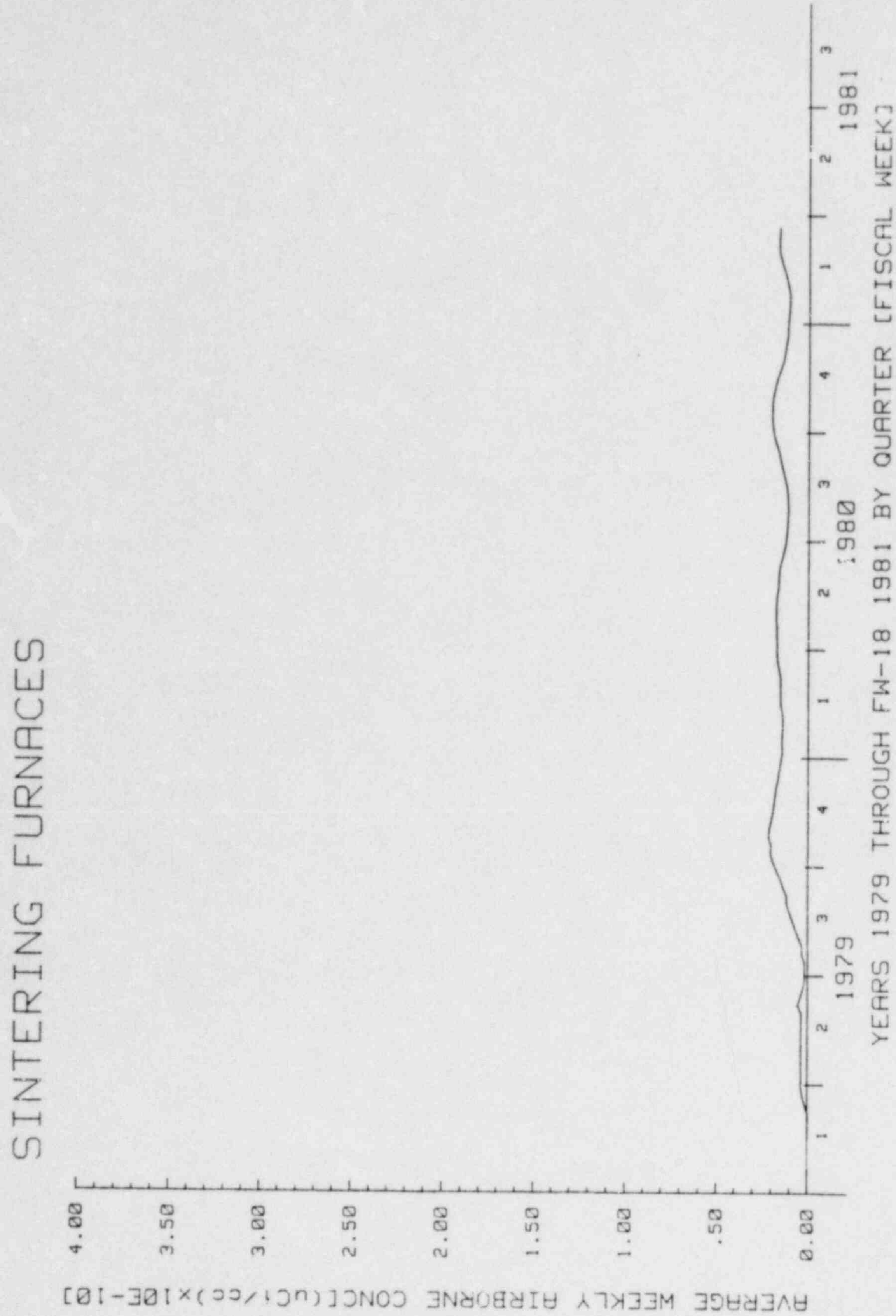

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FIGURE 13 25

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

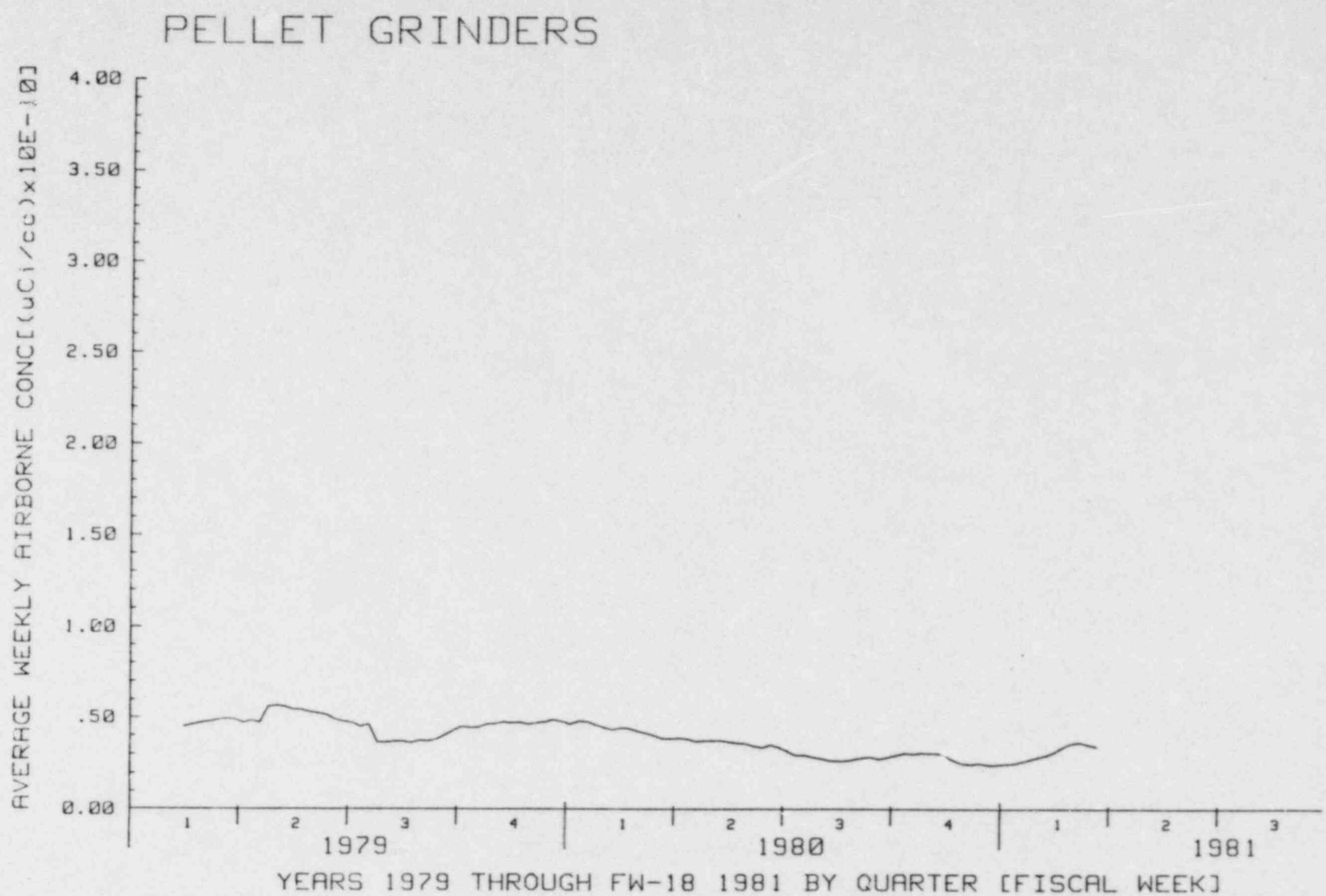

FIGURE 13.26

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

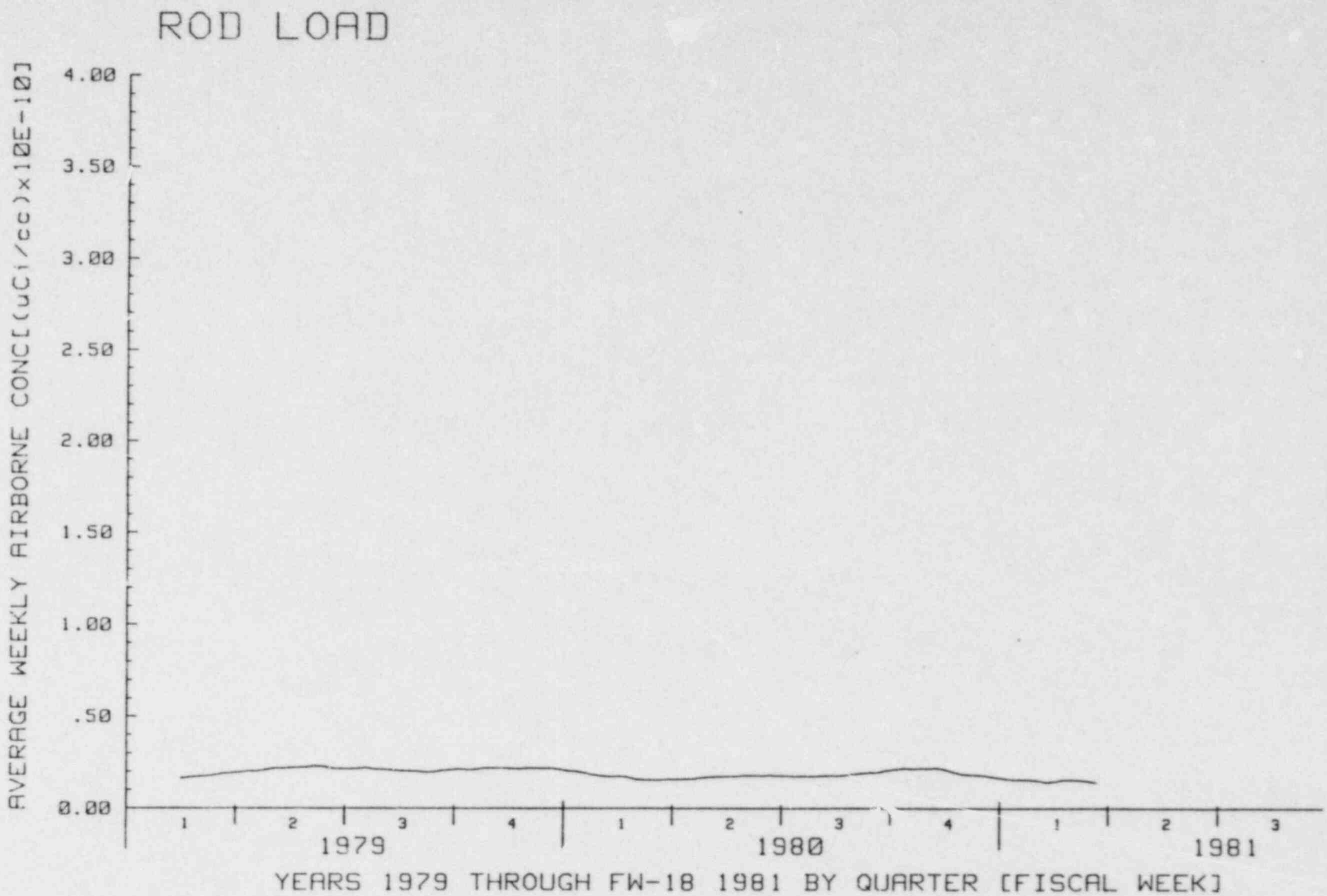

FIGURE 13.27

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

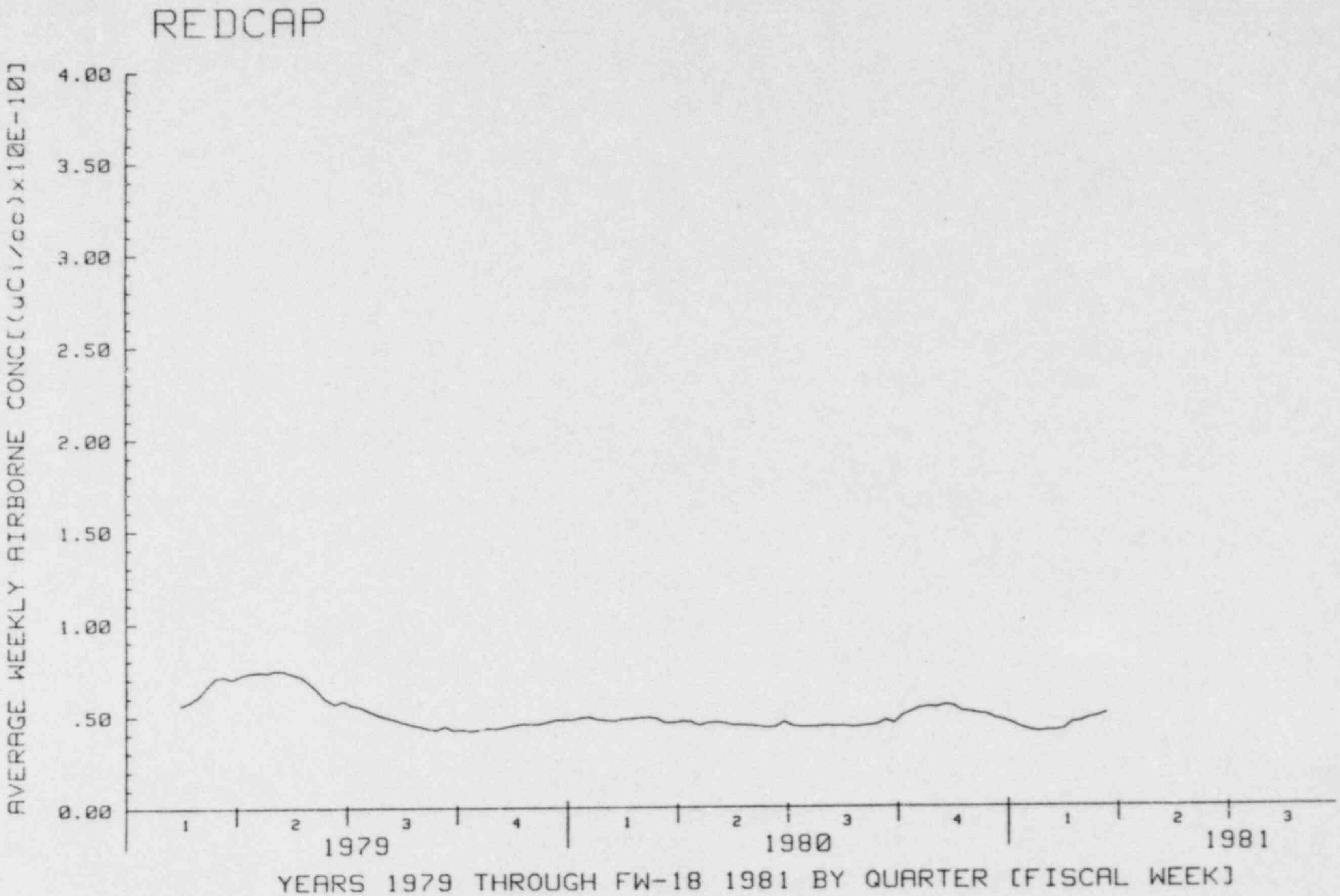

FIGURE 13.28

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

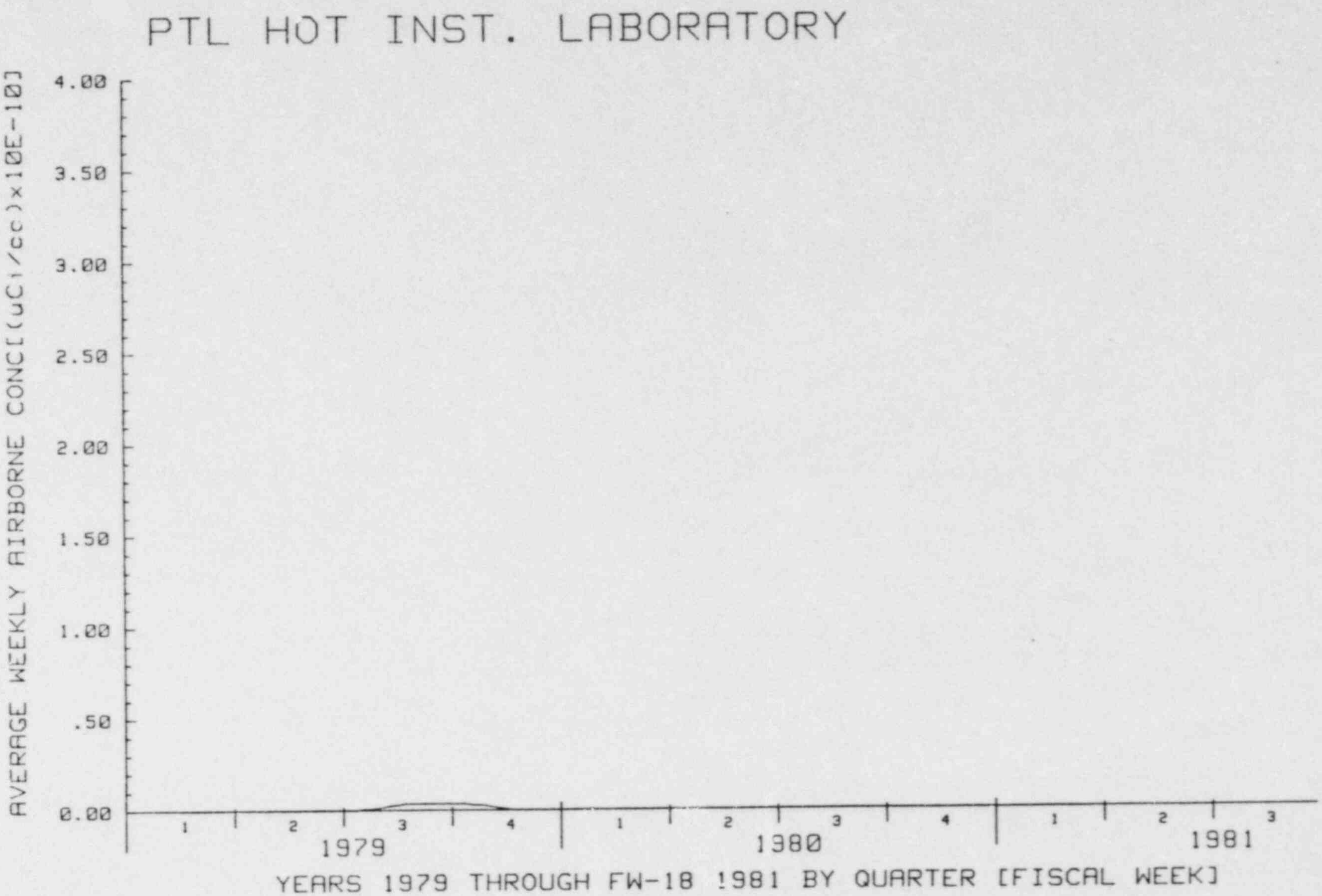

FIGURE 13.29

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

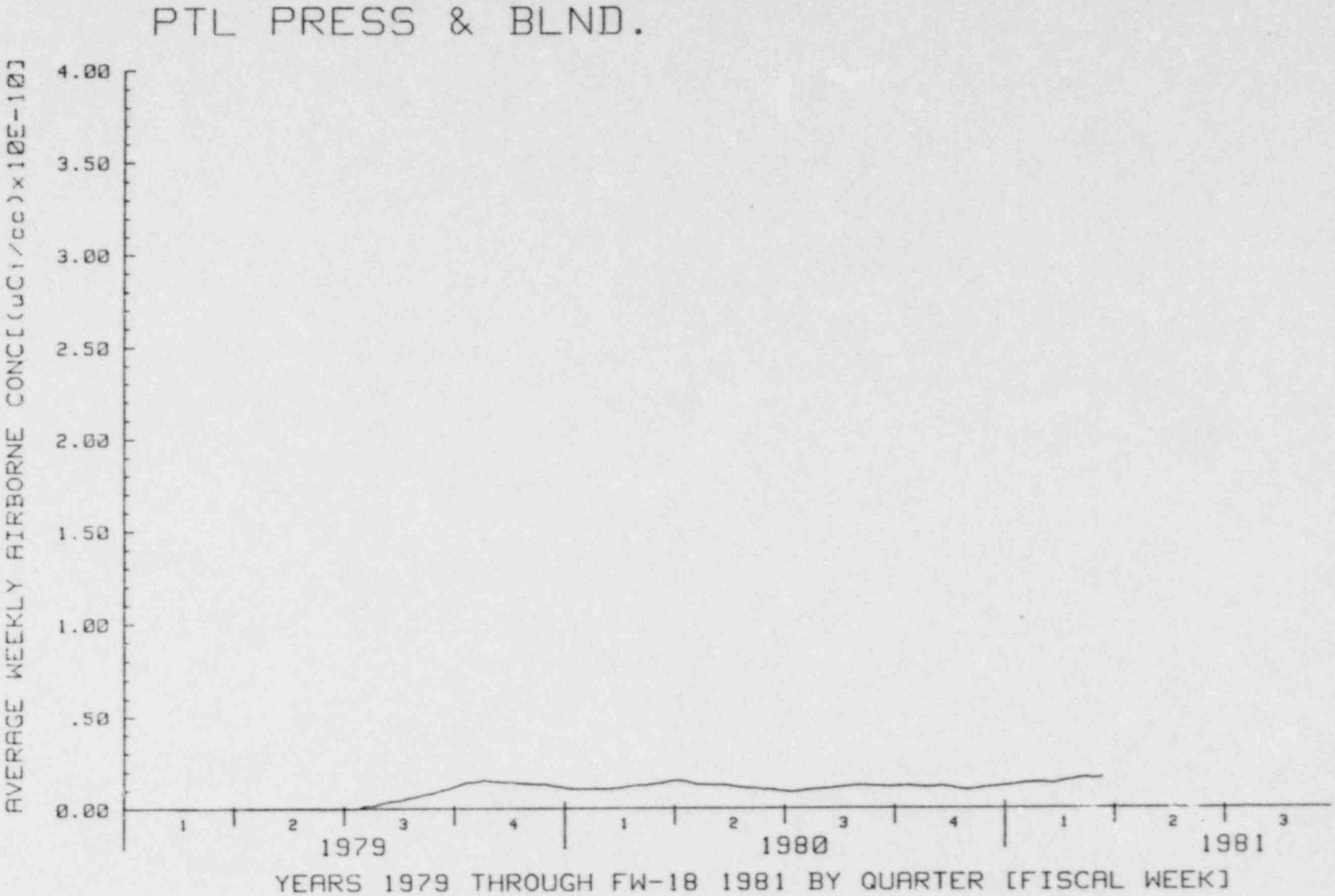

FIGURE 13.30

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

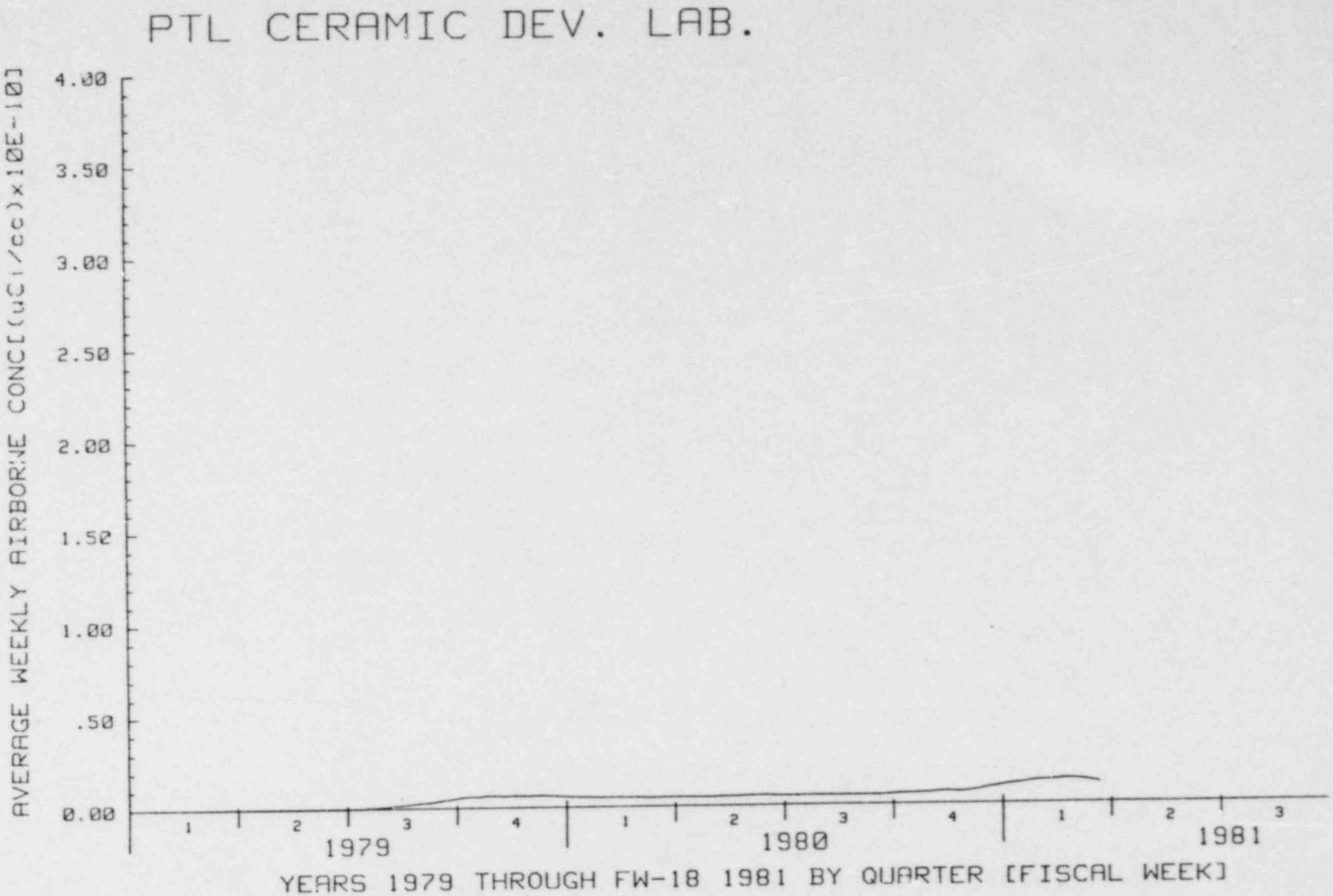

FIGURE 13.31

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

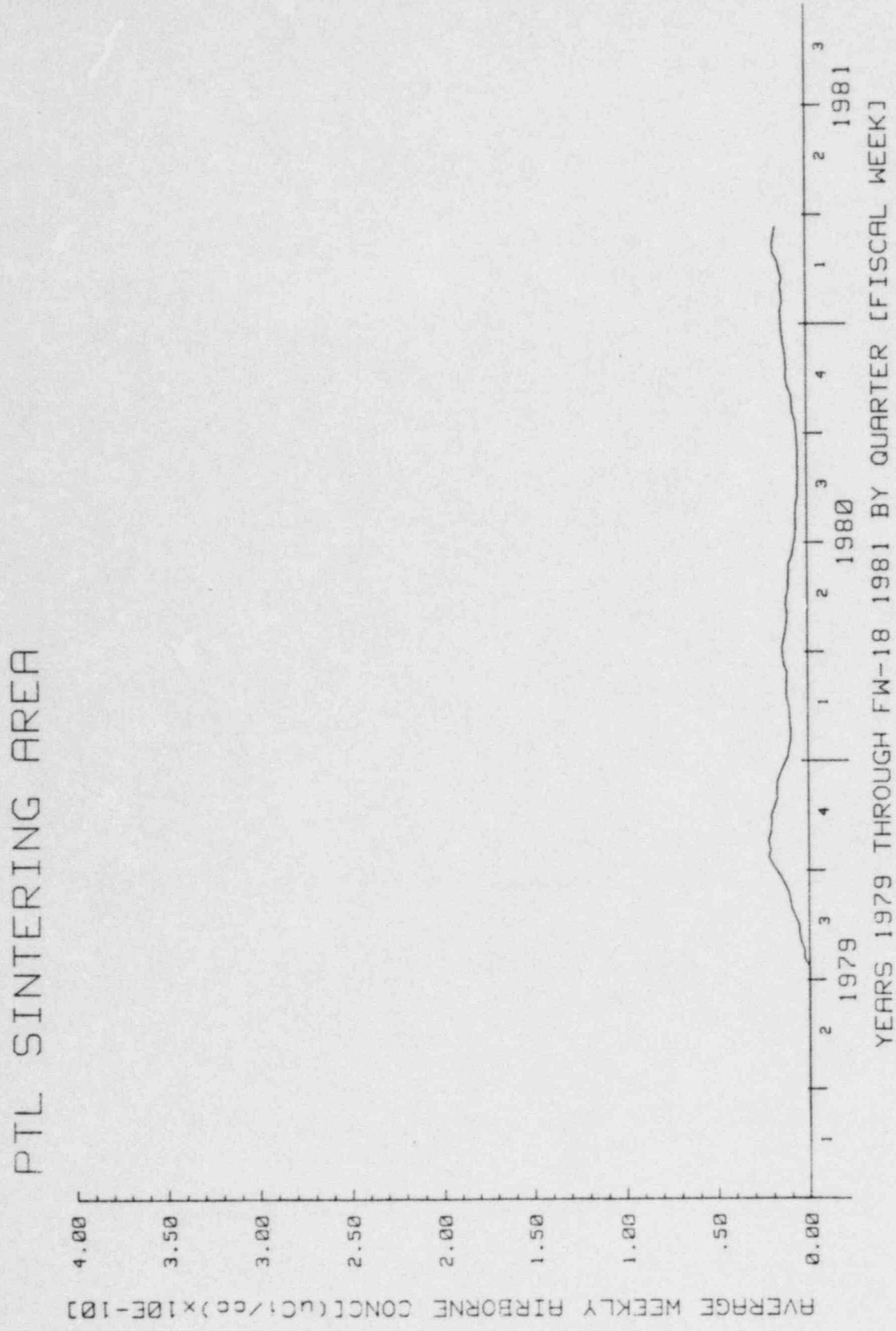

FIGURE 13.32

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

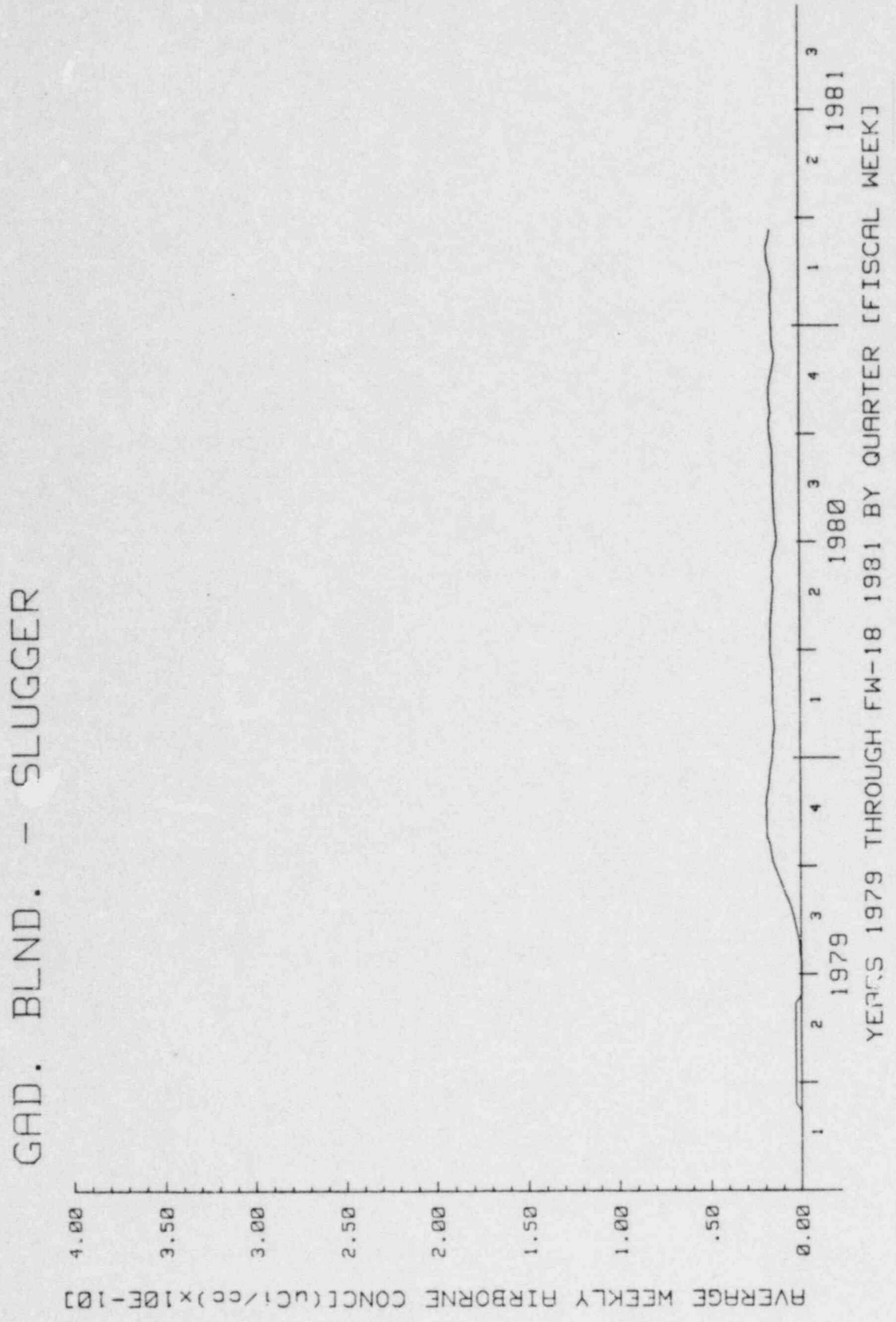

FIGURE 13.33

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

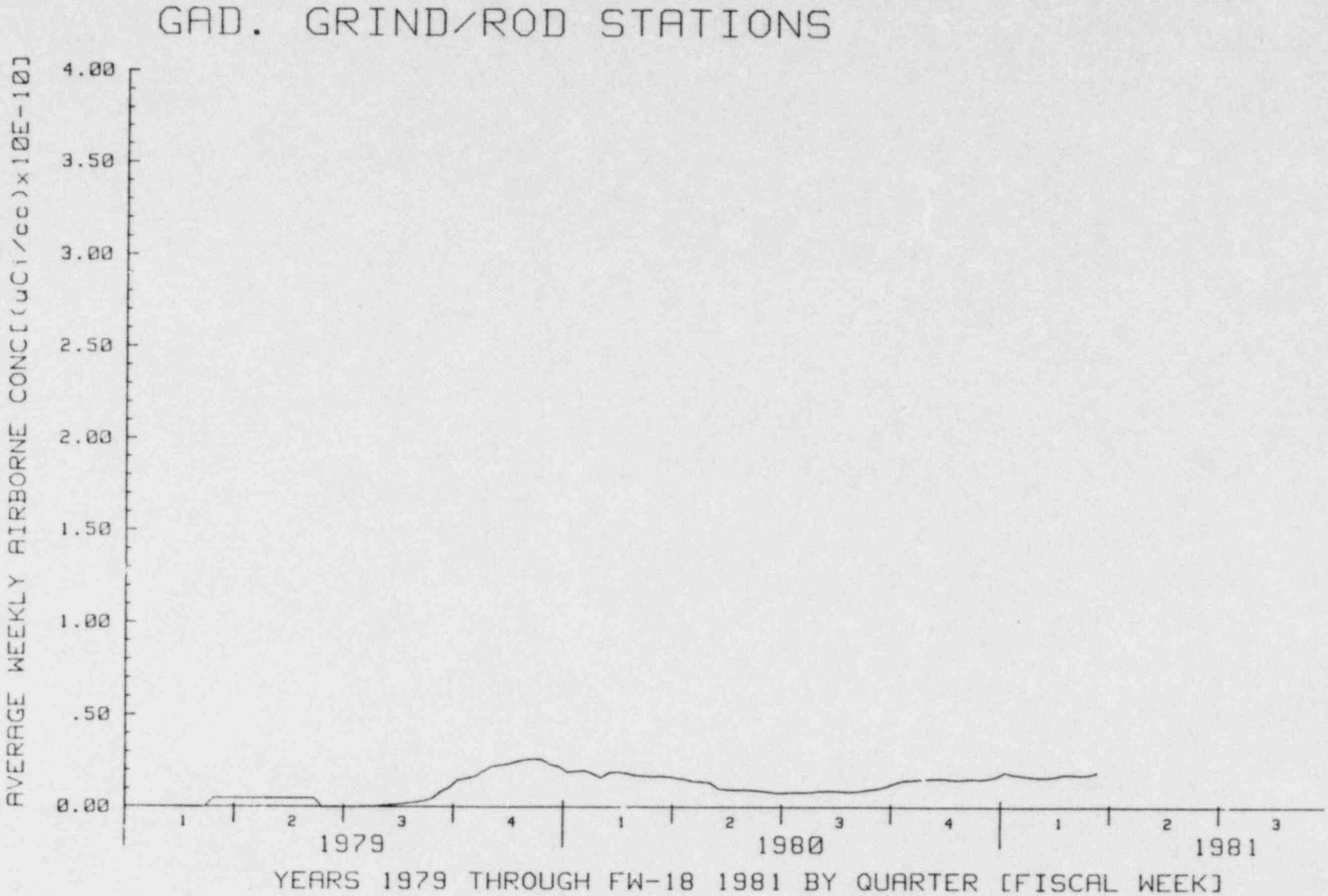

FIGURE 13.34

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

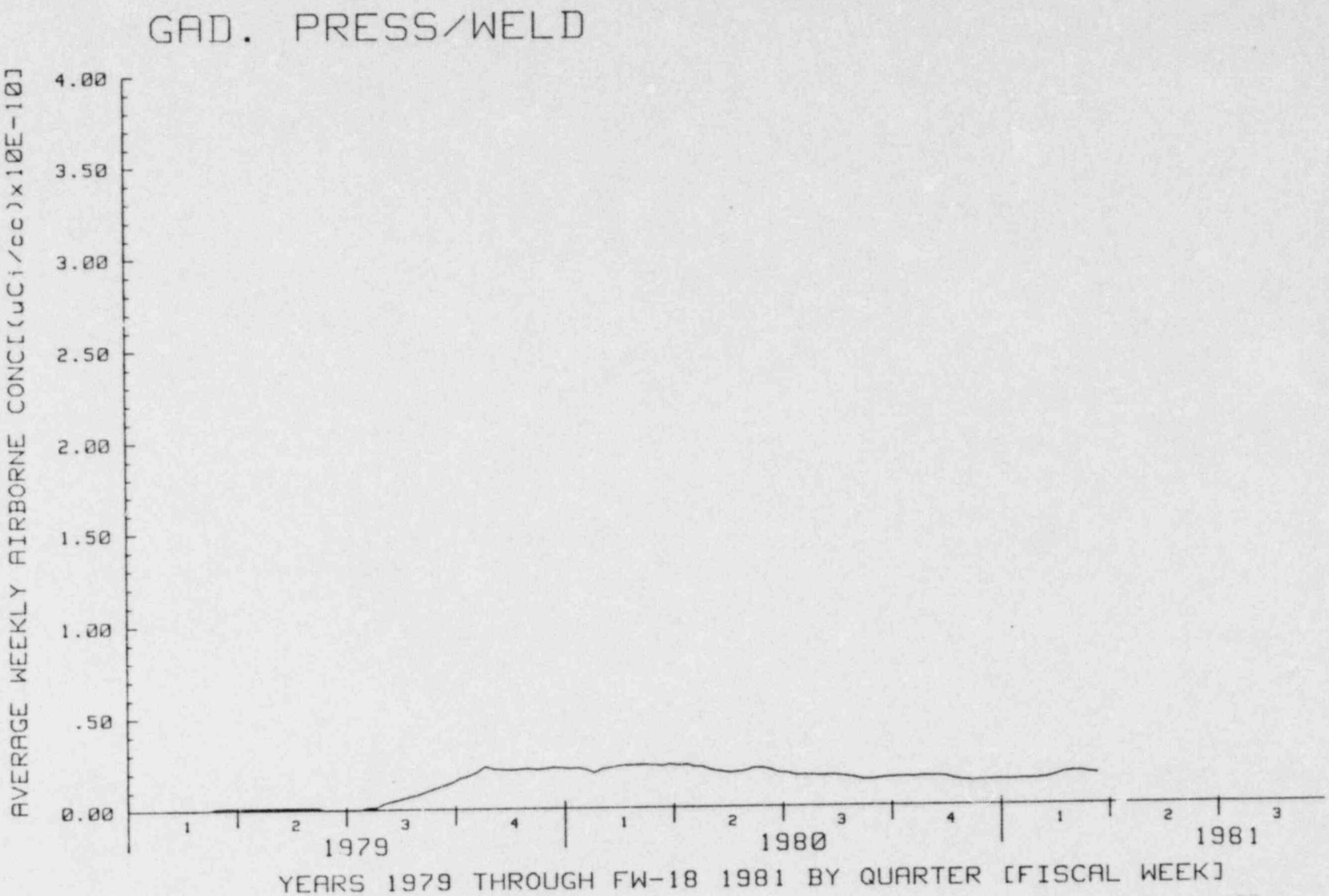

FIGURE 13.35

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

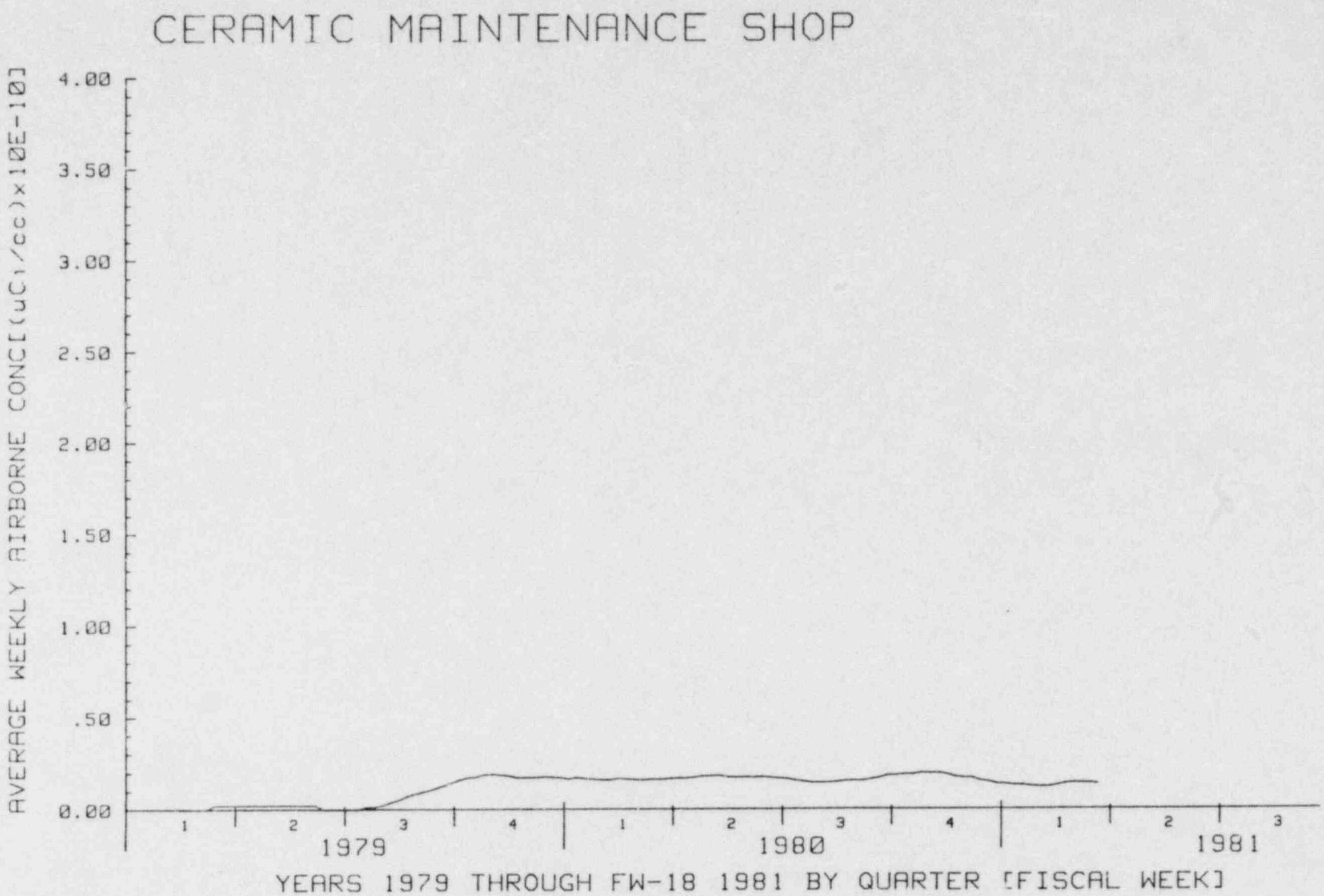

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FIGURE 13.36

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

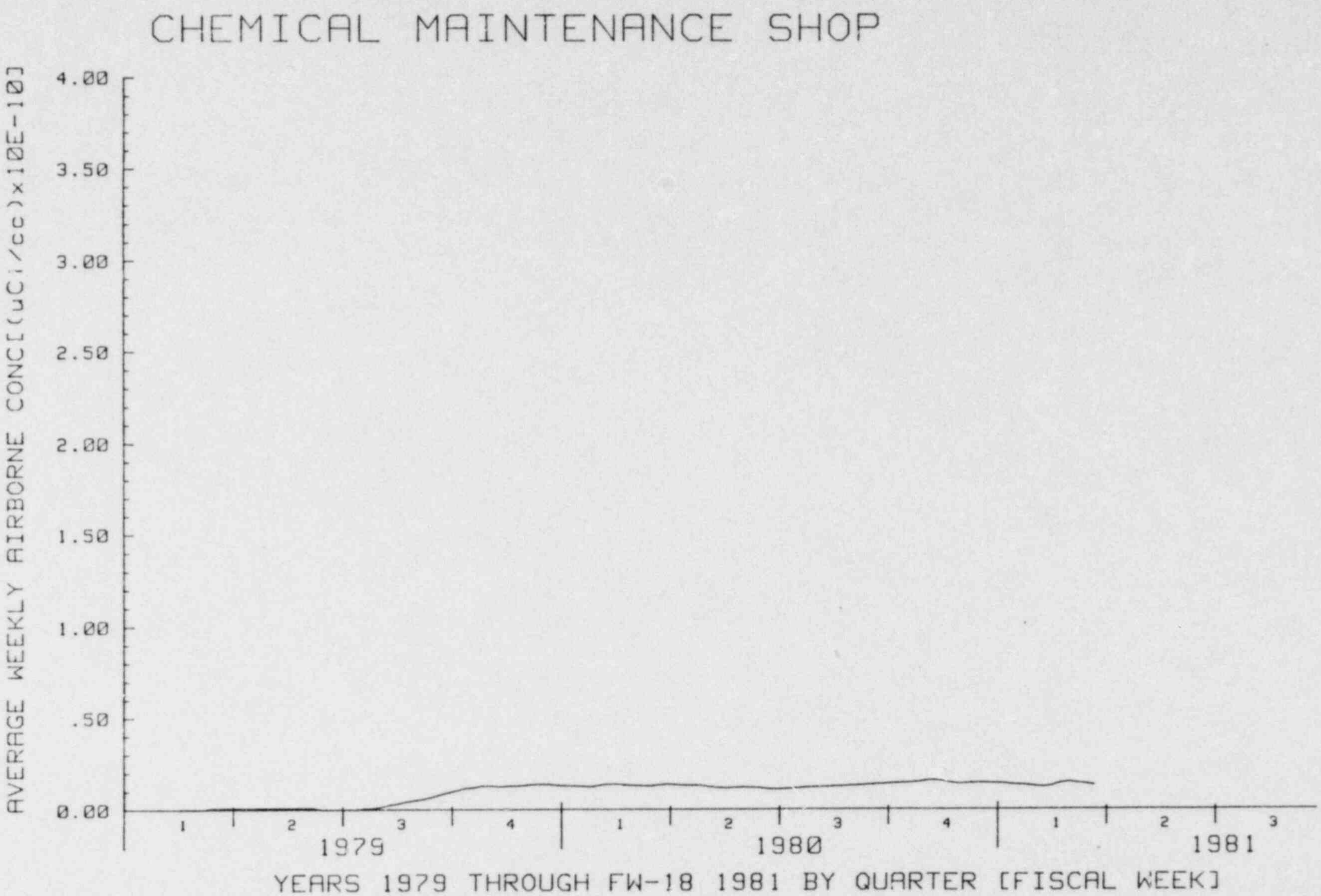

FIGURE 13.37

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

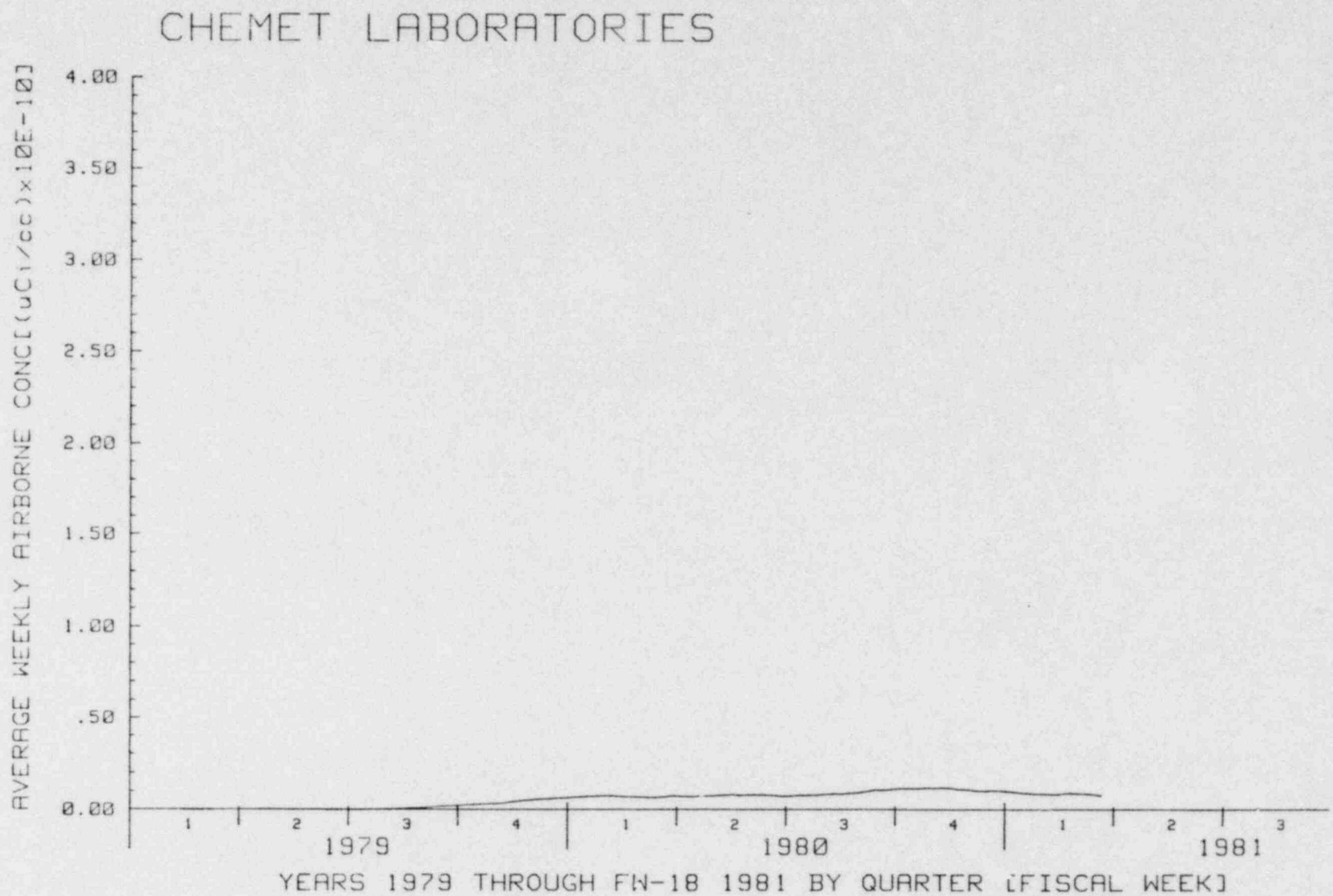

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FIGURE 13.38

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

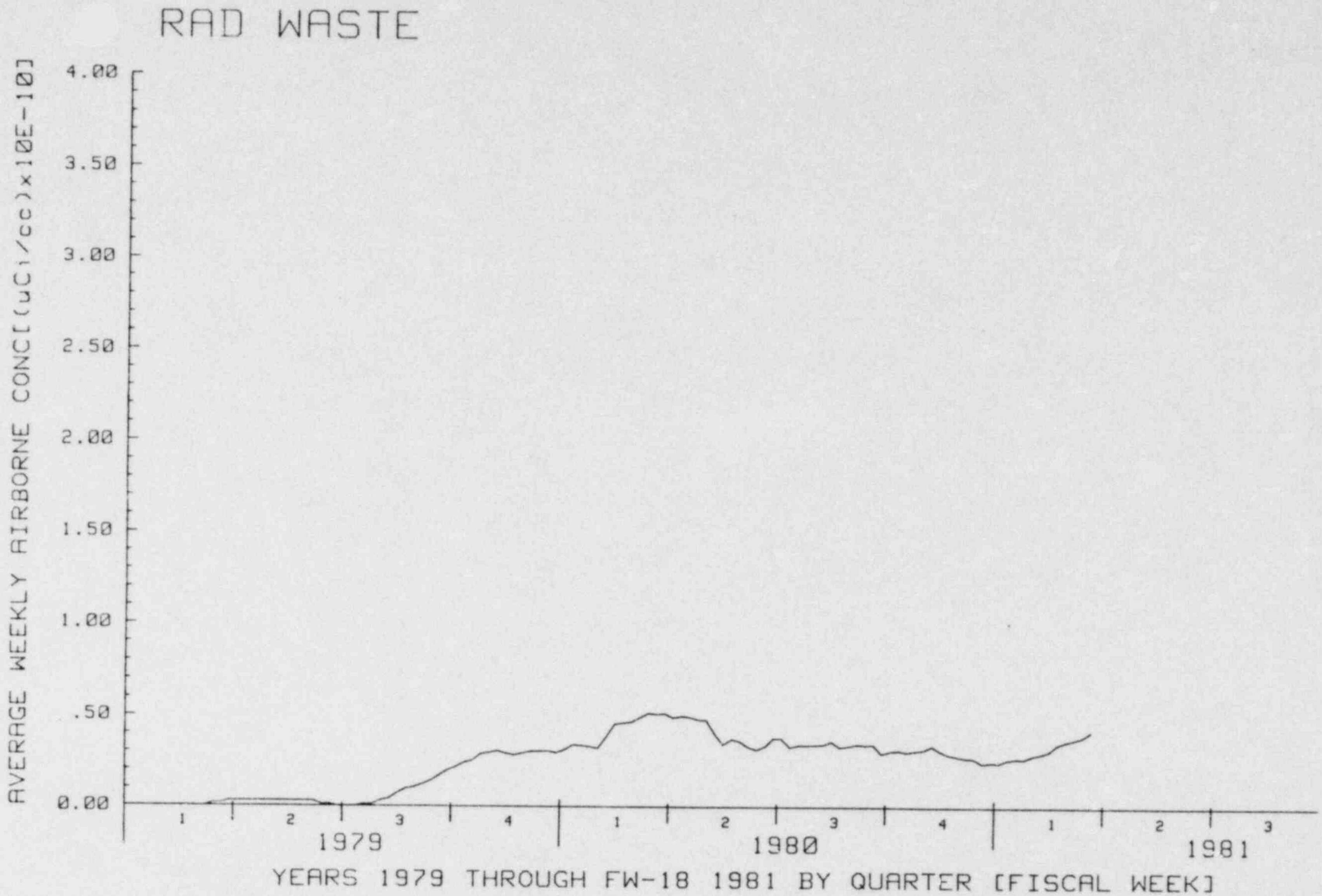
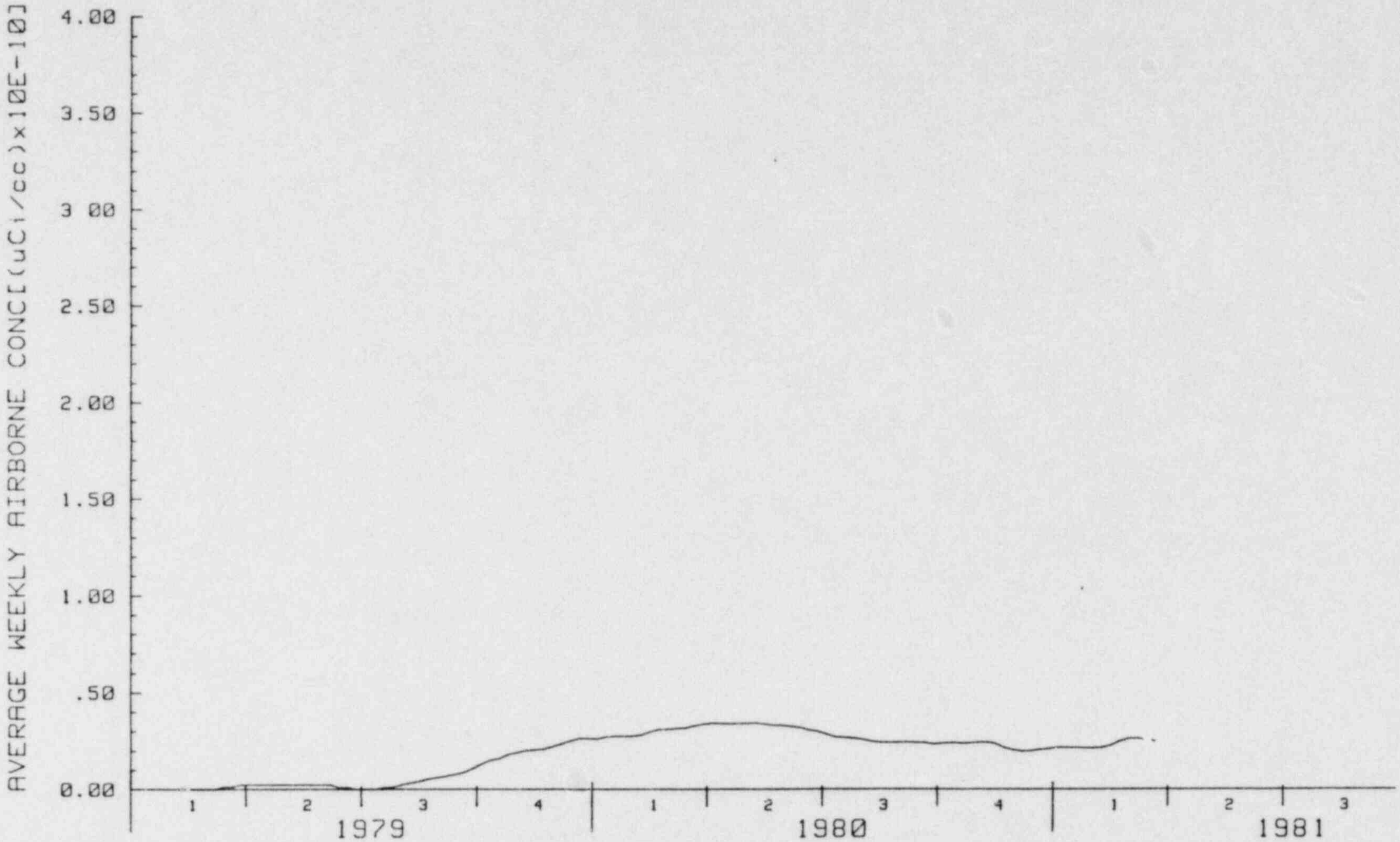


FIGURE 13.39

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS

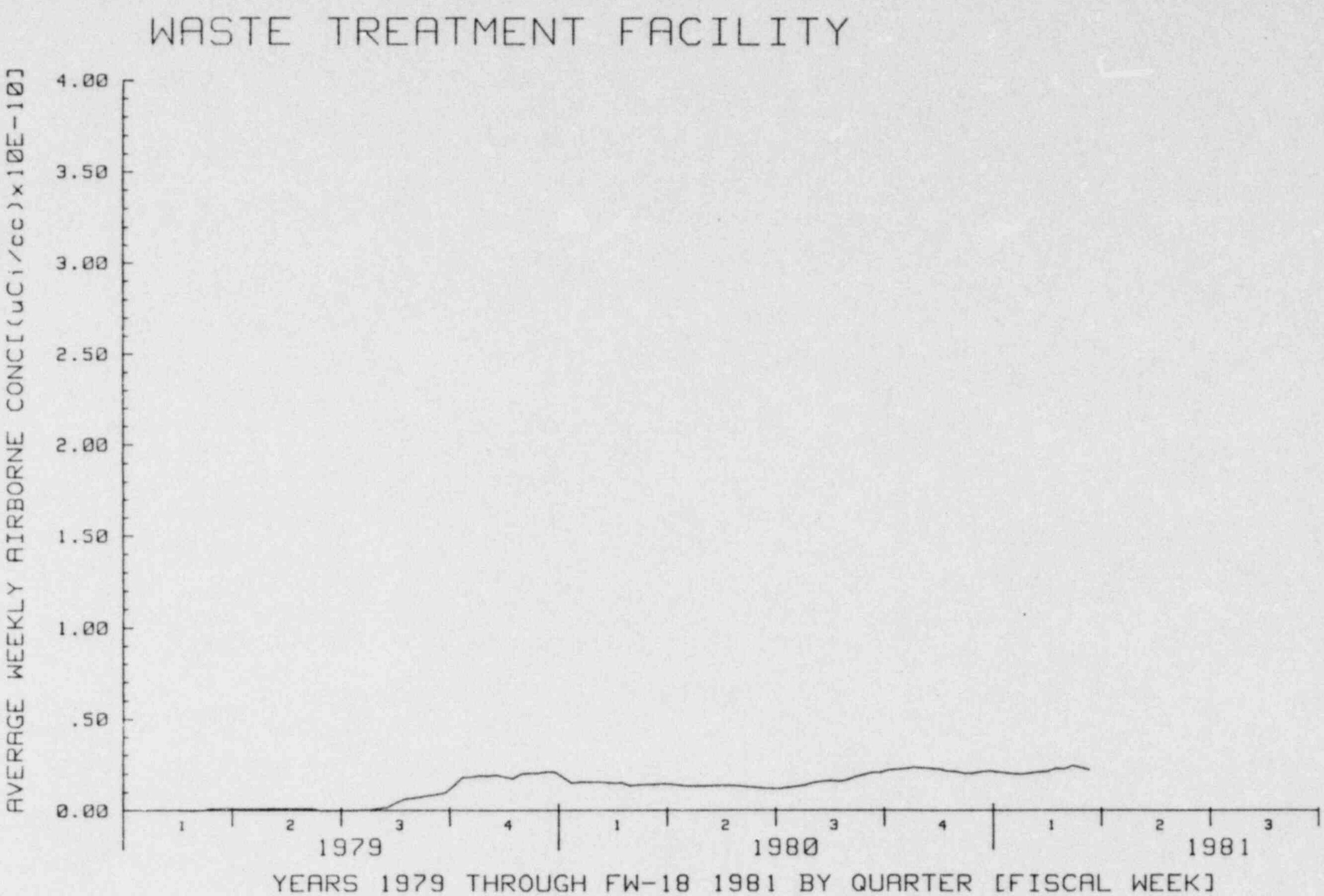
LAUNDRY ROOM



YEARS 1979 THROUGH FW-18 1981 BY QUARTER [FISCAL WEEK]

FIGURE 13.40

QUARTERLY AVERAGE AIRBORNE CONCENTRATIONS



appropriate management action is taken. Figure 13.41 depict charts of typical weekly air concentrations used in these reviews. (It should be noted that these data deliberately are biased 10-15% high for conservatism.)

13.1.4 Respirator Usage

In 1978, WMD implemented the requirements of Regulatory Guide 8.15. Prior to that time, half masks were employed and a factor of 5 protection factor was taken in airborne assignments.

When the protection factor for half masks was removed, WMD did not change its operational mode. These type of masks are still employed as a standard precautionary measure in operations. It should be noted that with this practice assigned individual exposures have a tendency to be biased high.

13.1.5 Abnormal Occurrences

Abnormal occurrences which could adversely impact air concentration control and/or personnel exposure are summarized in Table 13.2. There were five such occurrences since early 1979.

Two UF_6 releases occurred in the vaporization area in the first half of 1980. Preventative action was taken to repair faulty pipe flange gaskets.

The other two UF_6 leaks, one in 1980 and one in 1981, occurred in the hydrolysis area. Improvements in the dip tubes and the containment system have been instituted and the problems have been corrected.

<u>FIGURE 13.41</u>

TYPICAL WEEKLY AIR CONCENTRATIONS
USED IN WEEKLY REVIEWS OF AIRBORNE TRENDS
BY NUCLEAR SAFETY & SHOP MANAGEMENT PERSONNEL

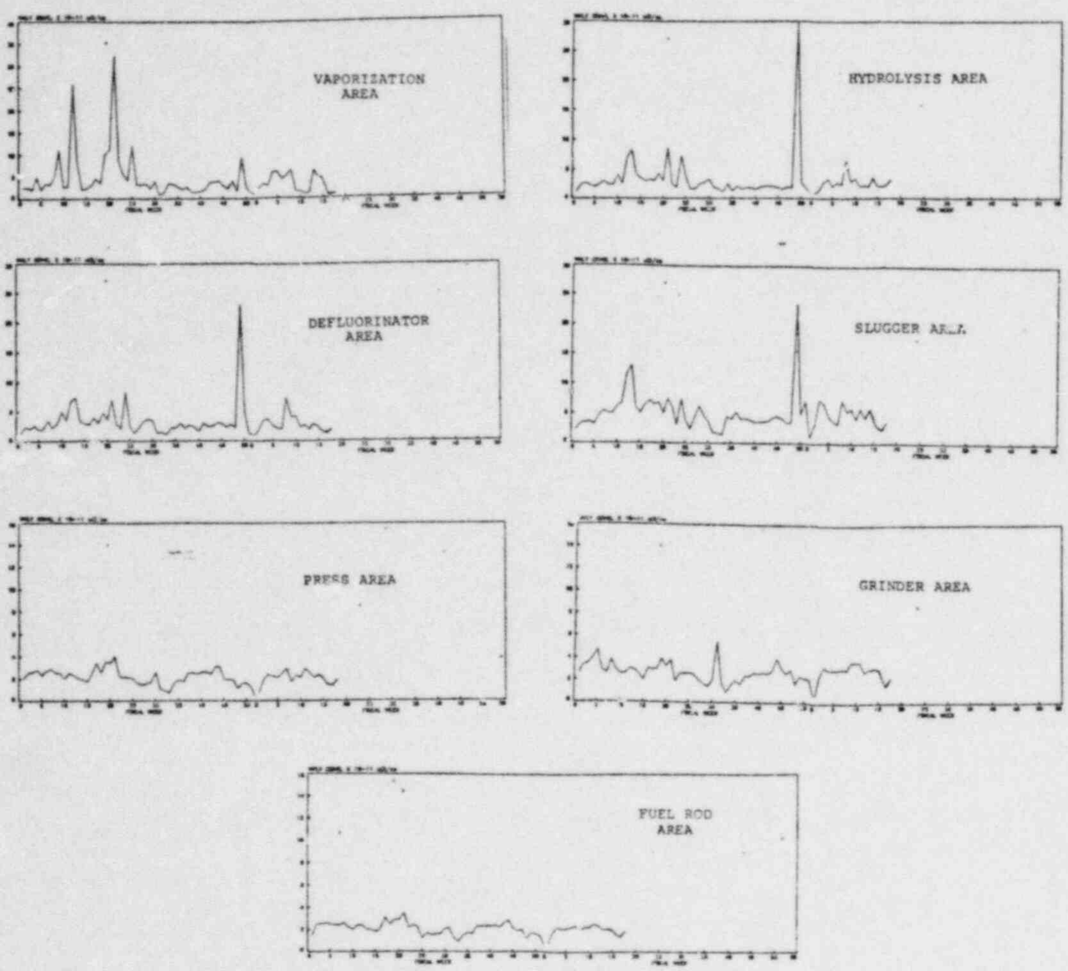


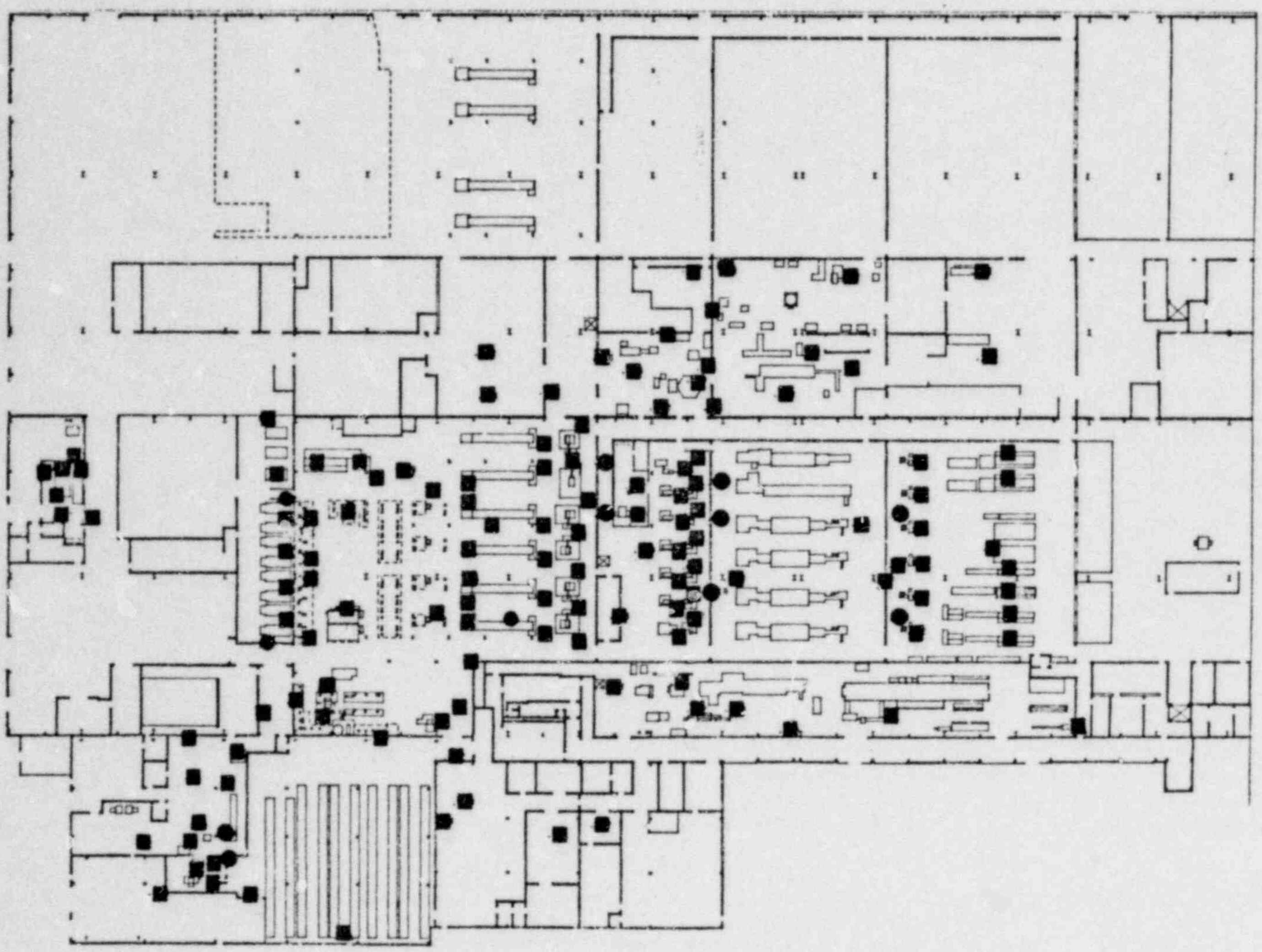
TABLE 13.2

CATEGORIZATION OF ABNORMAL OCCURRENCES

	1979	1980	1981	Total
Fire	0	0	0	0
Explosion	0	0	0	0
UF_6 Gas Release	0	3	1	4
Personnel Injury with Accompanying Contamination	0	0	0	0
Defective HEPA Filter	0	0	0	0
Leaking Sealed Source (AM-241)	1	0	0	1
Release in Excess of 10 CFR 20.45 Reporting Requirements	0	0	0	0

FIGURE 13.42

TYPICAL AIR SAMPLE LOCATIONS



■ Stationary Air Samplers (168)

● Continuous Air Monitors (31)

The leaking sealed source (AM-241) in 1979 was detected and controlled without spread of contamination or personnel exposures.

13.2 Measures Taken To Implement ALARA

13.2.1 Improved Detection and Measurement Capability

State-of-the-art measurement systems are developed and implemented to measure personnel exposure conditions and to provide data for ALARA evaluations. In general, the systems are complex technically and costly. Implementation of a new measurement system is made via procurement of new commercial state-of-the-art equipment or the in-house development programs. Typical examples of these new measurement systems are described in the following sections.

13.2.1.1 Continuous Air Monitoring System

The continuous air monitoring system (CAM) was installed in 1979 to provide early warning of releases of airborne uranium caused by process or containment failures. Sensors have been installed throughout the fuel manufacturing process (typical sensor locations are shown in Figure 13.42). Operating details of the system are presented in Chapter 13.4.5. It is planned to interface the CAM units with the REMTRAC program (Chapter 13.2.2) to provide live time monitoring of personnel exposures via integration of airborne data with personnel location.

13.2.1.2 Central Air Sampling System

The previous system of individual air samplers in the shop was replaced in early 1979 with a central air sample system of broader scope and improved capability. Details of the system are presented in Chapter 13.4.2.

The system provides an increased number of sample points; typical sample locations of the central air sampling system are shown in Figure 13.42.

13.2.1.3 Measurement Instruments

State-of-the-art low level counting equipment has been provided to update the accuracy of air sample counting. These new systems can be interfaced with onsite computers to facilitate data handling and to provide direct counting data to REMTRAC.

The in vivo lung counter was upgraded in late 1980 to provide capability to detect and evaluate very low level surface contamination which could interfere with the in vivo lung counting program. Further improvements; e.g., computer upgrades, new and data handling systems, are planned in 1981.

13.2.2 REMTRAC Program for Radiological Safety

In 1979, simultaneous with the installation of the central air sampling systems, WMD initiated a major systems development program to upgrade data accumulation and analytical routines for the definition, evaluation, comparison and trending of employee occupational exposures and factory airborne concentrations. This program, with the acronym REMTRAC, will result in a disciplined information system structure which integrates all nuclear safety related data for presentation to, and used by, radiation safety personnel, shop operations, and general management.

REMTRAC has been designed to provide improved accuracy, traceability, and flexibility in collecting, analyzing and reporting occupational exposure to radioactive materials. The system will also provide on-line ad hoc inquiries to the correlations of exposures vs personnel vs equipment or job tasks. Timely reports will be generated for management information to assure that they are knowledgeable of potential problems that may jeopardize employee health and safety.

13.2.2.1. Current Status

Essentially all historical employee exposure data has been reviewed in depth, verified or corrected, and entered into the REMTRAC data base. Computer operating systems have been designed. TLD control routines have been implemented. The system reporting capability will come on-line by year end 1981.

13.2.2.2 REMTRAC System Capabilities

13.2.2.2.1 Access Control

The system will provide knowledge of the employees authorized to have access to the nuclear fuel facility based upon having met specific radiological safety program criteria.

13.2.2.2.2 Integrated Record Control

The system will provide the information control mechanisms to assure that all exposure related records (wholebody count, airborne assignment and external dosimetry) are complete and secure, and that schedules of training, bioassay tests, and medical examinations are maintained and evaluated.

13.2.2.2.3 Programmed Exposure Control

The system will assure that airborne exposure assignments are tracked and evaluated on a timely basis. This portion of the program integrates data provided by the continuous air sampling system and employee time/location within a specific factory area. On-line evaluation of these data determines airborne exposure assignments and assures that individuals are properly scheduled for in-vivo counting or urinalysis sampling. If the individual does not satisfy the health physics program requirements, that individual is restricted from further exposure until the program requirements are satisfied.

13.2.2.2.4 Disciplined Methodology

The system will provide a structured and procedurally verifiable methodology to evaluate and report accurate assessment of occupational exposure from varied work conditions using either regulatory exposure modeling or the most recent models developed in the open literature.

13.2.3 Facility and Equipment Improvement

Engineered facility and process improvements to reduce exposures are being made continually. Typical projects recently completed and current projects are shown in Table 13.3.

TABLE 13.3

PROJECT	PURPOSE	STATUS
GECO II	Improved Process and Containment	Complete
Roof Scrubber Housing	Improved Contamination Control	Complete
Hydrolysis Scrubber and Hood	Improved Containment	Complete
Replace Slugger Hoods	Improved Containment	Complete
New Hoods - Decon Room	Improved Containment	Complete
Offgas Scrubbed, Red Cap	Effluent Control Upgrade	Complete
Controlled Ventilation, Old Stacker	Contamination Control Upgrade	Complete
UF_6 Leak Detectors	Improved UF_6 Leak Control	Complete
Slab Blender Accessories	Improved Containment	Complete
Hood Air Flow Controls	Improved Containment	Complete
Upgrade Calciner Scrubber	Reduced Air Concentrations	In Process
Automatic Pellet Inspection	Reduced Extremity Exposure	In Process
Upgrade Press Hoods	Improved Containment	In Process
Grinder Accessories	Improved Containment	In Process

13.2.4 Radiation Safety Committee

An Active Radiation Safety Committee has been assembled to review shop radiological safety conditions and to plan short-term projects for improvement. Members of this committee include the supervisor of the radiation protection function, the manager of the radiation safety function, and key operations managers (shop manufacturing, manufacturing engineering, etc.). The group generally meets biweekly and minutes of the meetings are distributed to higher level management.

The minutes result in identification of specific problems and corrective actions to be completed; progress of improvement projects is monitored continually. Typical projects addressed by the Radiation Safety Committee are shown in Table 13.4.

TABLE 13.4

PROJECT	STATUS
Film Badge Storage and Control	Complete
New Hire Training and Orientation	Complete
Personnel Surveys	Ongoing
Mask Use and Storage	Ongoing
Contamination Control, Assembly Area	Complete
Contamination Control, Clean Areas	Complete
Copntamination Control, Cylinder Dock	Complete
Contamination Control - Powder Pack	Ongoing
Air Concentration Control	
Calciner Hood	Ongoing
Vaporization	Complete
Slugger Containment	Complete
Hydramet Press Containment	Ongoing
Powder Sample Room Containment	Complete
Slab Blender Containment	Complete
Red Cap Blender Containment	Complete
Vacuum Cleaner	Ongoing
Protective Clothing Evaluation	Ongoing
Use of Protective Clothing	Ongoing
Emergency Staging Area Control	Ongoing

13.3 Bioassay Program

13.3.1 General

The WMD bioassay program is necessary and desirable to aid in determining the extent of an individual's internal exposure to concentrations of uranium by analysis of material excreted or removed from the body and by the in-vivo wholebody counting (WBC) program.

From diagnostic standpoint, the capability exists for excreta analyses and in-vivo measurements as necessary to estimate the quantity deposited in the critical body organ of interest, and the rate of elimination if an internal exposure has occurred.

13.3.2 Urinalysis Program

The urinalysis program is designed to permit the determination of soluble uranium intake and to verify the validity of the air sampling program and radiation control program. This is accomplished by establishing routine urine sampling for normal production and maintenance activities and by special sampling for abnormal occurrences.

13.3.2.1 Routine Sampling

13.3.2.1.1 Vaporizatin & Hydrolysis Operators

These operators are required to submit urine samples at the end of their shift every other day and/or on the last day of the scheduled work week in the vaporization and hydrolysis areas, regardless of the time spent in these areas during their work day.

13.3.2.1.2 Maintenance Personnel

Maintenance personnel working in vaporization or hydrolysis submit urine samples daily at the end of their shift when performing duties associated with the duct/vent system; pumps, valves, piping (repair or removal); plugged dip tubes; inside hoods; reworking or removing insulation; scrubbers and their vent lines; chamber valves and piping; removal of UF_6 lines; inside heating chambers; changing UF_6 cylinder valves.

Maintenance personnel working in the uranium purification system (UPS) submit urine samples before entering the controlled area the following scheduled work day, when performing work associated with pump repair or removal; duct or vent system; or work on equipment inside hoods.

13.3.2.1.3 UPS Operators

A minimum of six individuals assigned to the UPS area (two on each shift) are required to submit a urine sample once a week on the last day of their work week. The radiation protection function will designate those individuals, based on their time in the UPS area during the week. Based upon these sample results, the sampling frequency may be modified to require additional sampling.

13.3.2.2 Special Sampling

13.3.2.2.1 UF6 Gad Leak/Release Detected by Air Samplers

When a leak is detected by evaluation of the air sampler results, personnel who worked in the vaporization or hydrolysis areas are requested to submit an additional urine sample before entering the controlled area the following day.

13.3.2.2.2 Gas Leak/Release Detected by Air Monitors

All personnel involved during the leak or release are requested to submit an initial urine sample and subsequent samples, as required.

13.3.2.2.3 UNH Gas Leak/Release

All personnel involved in UNH leaks or releases submit urine samples 24 hours after the incident, or before entering the controlled area the following day.

13.3.2.2.4 Ingestion of Soluble Uranium Compounds

If any personnel in the vaporization, hydrolysis, or UPS area have or suspect that they have ingested soluble uranium compounds, they immediately notify the radiation protection function. Urinalysis frequency will be outlined and reviewed with the personnel involved.

13.3.2.3 Sample Results

The urinalysis sample results are reviewed by the radiation protection function. Results that exceed the equivalent 35 ug uranium per liter for routine vaporization operators and 15 ug uranium per liter for UPS operators are subject to a preliminary investigation by the radiation protection function. This investigation consists of a brief description of the incident, the individual's work performed prior to the time the sample was submitted, and the sample results.

Following the preliminary investigation, the radiation protection function back calculates the urinalysis sample results to determine if the calculated maximum intake exceeds allowable intake of soluble uranium material.

If the urinalysis sample results received by the radiation protection function exceed 100 ug uranium per liter, the radiation safety function is notified.

In the event any urinalysis result exceeds 2,000 ug uranium per liter, the manager of the radiation safety function is immediately notified.

Appropriate investigtions are initiated by the radiation safety function, where necessary, and individuals are notified immediately and restricted from the area based on internal procedures specifying action guide values.

Sample results obtained from special sampling are forwarded to the radiation safety function. This function initiates appropriate investigations and, where necessary, immediately notifies individuals who are required to be restricted from the area based on internal procedures specifying action guide values.

The radiation protection function ensures by review that the appropriate sampling frequencies are met, and on a weekly basis submits a summary of samples and results to the radiation safety function.

Urinalysis sample forms are filed in the individual's personnel exposure history folder and maintained on an indefinite basis.

13.3.3 Wholebody Counter (WBC) Program

The WBC program is designed to determine uranium lung burdens. The program is subcontracted to an outside vendor.

The detectors and associated electronics consist of four 5" diameter phoswich detectors, each equipped with a pulse shape analyzer and HV power supply. Data analysis is performed by a computer-based multi-channel analyzer using alpha-M spectra fit programs. Detector shielding is provided by a four inch thick steel shadow shield.

The system is calibrated using known standards of U-235, uranium-235, cesium-137, thorium-234, and potassium-40, distributed in a lung or Remcal phantom. Typical minimum detectable activities are U-235 - 75 ug; Th-234 - <1 nCi; Cs-137 - 6 nCi; K-40 - 60 nCi.

Typical counting frequencies are as follows:

13.3.3.1 As Soon As Possible

New hires (if the employee has a previous history of working around radioactive materials) or personnel being assigned to the controlled area.

Terminating employees (if a weekly potential exposure exists greater than 25% or if time-in-area (TIA) is greater than 10% for any quarter).

Personnel involved in an incident (assigned daily exposure of greater than 400 x 10^{-11} uCi-hr/ml).

Personnel whose last count was greater than 200 ug uranium-235, if first in a series.

13.3.3.2 Monthly

Personnel whose last count was greater than 150 ug U-235.

13.3.3.3 Quarterly

Personnel whose quarterly potential airborne exposure is greater than 100% (>5200 x 10^{-11} uCi-hrs/ml).

Personnel whose last count was greater than the minimum detectable level (MDL).

Personnel whose quarterly assigned airborne exposure is greater than 10% (>520 x 10^{-11} uCi-hrs/ml).

13.3.3.4 Annual

Personnel whose quarterly TIA is less than 25% but greater than 10% (52-130 hours), or

Personnel whose quarterly assigned airborne exposure is less than 10% (520 x 10^{-11} uCi-hrs/ml), and

Personnel whose weekly potential exposure is greater than 25% (>100 x 10^{-11} uCi-hrs/ml).

13.3.3.5 No Counting

Personnel whose quarterly time in controlled areas is less than 10% (52 hours).

Personnel whose total weekly potential exposure is less than 25% during the quarter (<100 x 10^{-11} uCi-hrs/ml).

13.3.3.6 Counting Procedure

Prior to counting, each individual is requested to shower and wear fresh disposable clothing. They are then instructed to lie in a supine position on a movable pallet. This pallet then moves the individual into position between two sets of phoswich detectors. The upper set of detectors is then positioned on each person so that the upper edge of each detector is in contact with the clavicle and centered between the sternum and outer edge of the body. The lower detectors are then placed directly against the person in the corresponding position of the back. Once positioned, the person is counted for 20 minutes.

13.3.3.7 Counting Results

Preliminary counting results are used as a guideline to determine the need for corrective actions such as area restrictions or re-counting as shown in Table 13.5.

A final report is prepared by the vendor and submitted to the radiation safety function on a monthly basis.

TABLE 13.5

TYPICAL WBC RESTRICTION & RECOUNT GUIDELINES

WBC Result in ug U-235	Action to be Taken
>250	Restrict and reschedule count as soon as possible
>200	Reschedule count within one to two weeks. If second count is greater than 200, restrict and count monthly until the result is less than 100.
>150	Monthly count until less than 100.
>MDL	Schedule for count following quarter.
<MDL	No action required.

13.4 Air Sampling Program

13.4.1 The air sampling system samples airborne concentrations at work stations and the airborne concentrations in the work areas. The designed air flow through the sampling media is a minimum of two (maximum of three) times the breathing rate.

WMD has five categories of operational and back-up units for monitoring airborne concentration levels. These include the stationary air samplers, high volume portable units, low volume portable units, continuous air monitors and the emergency back-up air samplers.

13.4.2 Stationary Air Sampler System (SAS)

There are currently two SAS systems in place in WMD. The first is located in the FMO/FMOX area used in support of the existing ADU/GECO process. The second (new) system is located in FMOX and is used in support of the new GECO expansion process. Each system consists of a primary vacuum unit that supports a series of air sampling units.

The vacuum system has three levels of back-up to minimize the risk of downtime: a reserve vacuum pump for each area (total of four pumps); two separate electrical feeders (one for each active pump) coming from the substation each on a different transformer; and a diesel generator to be used in the event of a total power loss.

Approximately 170 stationary air samplers are used in support of the ADU/GECO process and approximately 36 units will support the new GECO process.

Each sampling unit has a flow meter that controls air volume and a filter holder containing a round glass fiber filter (44 mm) which is changed every shift.

These filter samples are analyzed each shift for the area's alpha activity within approximately four hours following removal from the filter holder. This analysis is performed by placing the filters into individual planchets and loading them into the low background alpha counting systems. The counting time requires approximately one and a half hours.

Sample counting and sample flow results are converted by a computer program to microcuries per cubic centimeter. The program then summarizes the average airborne concentration for specific areas. The program also determines each individuals daily airborne exposure based on airborne concentrations relative to assigned work areas and the workers time in the area.

If an employee's cumulative assigned airborne exposure (based on a seven day work week) exceeds 300 x 10^{-11} uCi-hrs/cc (time related), the individual is restricted from working in an area containing radioactive airborne material for the remainder of that work week.

If the individual's exposure exceeds 400 x 10^{-11} uCi-hr/cc, an investigation is performed and documented by the radiation protection function.

The radiation safety function evaluates the individual assigned airborne exposures on a quarterly basis. Exposures exceeding 520 x 10^{-11} uCi-hrs/cc are scheduled for the wholebody counter.

In the event that airborne concentrations in an area exceed 10 x 10^{-11} uCi/cc, the area and/or equipment is identified and an investigation initiated to determine the cause. The investigation consists of a review of the activity that occurred in the area during the time frame. Additional air concentration level samples will be taken using a high volume portable unit to determine if the problem still exists.

If a problem does exist, employees in the area will either be evacuated or required to wear respiratory protection until the problem is resolved.

13.4.3 High Volume Portable Units

There are approximately eight high volume portable units used at WMD for special spot sampling to determine airborne concentrations as required to evaluate breaches in containment and as back-up units during an emergency.

These units maintain an air flow of about 20 cfm through a four inch ashless filter paper. The average run time is between five and ten minutes. The units are self-contained inasmuch as they produce their own vacuum utilizing a 110 power source.

13.4.4 Low Volume Portable Units

There are approximately six low volume portable units used at WMD for performing long-term airborne studies such as determining airborne trends on new or existing pieces of equipment. These units maintain an air flow of 150 scfh through a 44 mm round glass fiber filter. The units are self-contained inasmuch as they produce their own vacuum utilizing a 110 power source.

13.4.5 Continuous Air Monitor (CAM) System

There are approximately thirty-one CAM units used at WMD to identify airborne problems as they occur. These units are similar to the ones used in the central vacuum system (Chapter 13.4.2) with the additional features of a solid-state detector and a single channel analyzer. The primary function of the CAM system is to provide early warning of loss of containment control.

The CAM's, which are strategically located throughout the controlled areas, provide instant readout capability to the radiation protection function's office and the Emergency Control Center (ECC).

In the event of abnormal air concentrations, the system will produce three levels of alarms.

Trend Alarm - Produced when air concentrations are increased above pre-set percentages (typically 3-5%).

Alert Alarm - Produced when the airborne concentration exceeds a pre-set limit (typically 50% of the high alarm limit).

High Alarm - Produced when the airborne concentration exceeds twice the alert alarm limit. The high level alarm is set at 10×10^{-11} uCi/cc.

In addition, there are individual printouts for each of the CAMs which provide a ten minute average over a past four hour period and a one hour average over a past twenty-four hour period.

13.5 Surface Contamination Control Program

13.5.1 General

The NMD surface contamination control program requires that administrative action guidelines be established to assure that contamination levels and employee exposures are kept as low as reasonably achievable and within the limits established by internal action guides.

In order to comply with these limits, WMD has a program for monitoring area contamination levels, personnel contamintaion, and protective clothing program.

13.5.2 Action Guide Levels

Action guides are established to ensure appropriate corrective actions are taken for contamination control. The guideline levels are designed to be conservative in nature and are not to be regarded as the borderline between "safe" and "unsafe".

If contamination in excess of the guideline limits occurs, the necessary decontamination action that should be taken is based upon knowledge of the particular circumstances and the behavior of the material involved.

Typical action guides values are shown in Table 13.6.

13.5.3 Survey Frequencies

Routine contamination survey frequencies (as shown in Table 13.7) are established for all uranium process and manufacturing areas including those noncontrolled areas such as hallways and lunch rooms immediately adjacent to controlled areas. These frequencies are based on operational experience for effective contamination control.

When detected contamination levels exceed established action guides (as shown in Table 13.6), action is initiated for remedial decontamination. The survey results are trended and evaluated for effectiveness of radiation controlled programs and to identify potential problem areas.

TABLE 13.6

Typical Action Guides Values

Area	Measurement Method	Response Level, alpha	Response
Controlled			
- Operational Equipment	Uniform (smears)	25,000 dpm/100 cm^2	Delayed
- Traffic Areas	-Local (smear)	10,000 dpm/100 cm^2 visible (trackable)	Immediate
	-Uniform (smear)	5,000 dpm/100 cm^2	Delayed
Stacker Warehouse	Local (smear)	5,000 dpm/100 cm^2	Immediate
	Uniform (smear)	2,200 dpm/100 cm^2	Delayed
Uncontrolled	Spot (total)(meter)	>5,000 dpm	Immediate
	Local (smear)	>1,000 dpm/100 cm^2	Immediate
	Spot (total)(meter)	>1,000 dpm	Delayed
	Local (smear)	>220 dpm/100 cm^2	Delayed

Items			
Respirators (Interior surfaces)	Fixed (ratemeter)	ND	Relaunder
	Removable	ND	Relaunder
Protective clothing	Spot (total)	15,000 dpm/100 cm^2	Relaunder
	Uniform (fixed)	10,000 dpm/100 cm^2	Discard
	Uniform (total)	2,200 dpm/100 cm^2	Relaunder
Equipment Removed From Controlled Areas			
- Unconditional Release	Local (smear)	220 dpm/100 cm^2	Restrict and decontaminate
	Local (fixed)	2,200 dpm/100 cm^2	Restrict and decontaminate
	Local (dose rate)	1 mR/hr	Restrict and decontaminate
	Uniform (dose rate)	.2 mR/hr	Restrict and decontaminate

Table 13.6 (continued)

Items	Measurement Method	Response Level alpha	Response
- Conditional Release	Local (smear)	2,200 dpm/100 cm^2	Restrict and decontaminate
	Local (fixed)	5,000 dpm/100 cm^2	Restrict and decontaminate
	Local (dose rate)	1 mR/hr	Restrict and decontaminate
	Uniform (dose rate)	.2 mR/hr	Restrict and decontaminate
Sealed Sources	1st survey - total (smear)	1,110 dpm	Resurvey
	2nd survey - total (smear)	2,200 dpm	Dispose
	2nd survey - total (smear)	1,100 dpm	Restrict 7 days, resurvey
	3rd survey - total (smear)	1,100 dpm	Dispose

TABLE 13.7

Guidelines for Survey Frequencies

Area/Item Surveyed	Minimum Survey Frequency
Controlled Areas	Weekly
Receiving, Storage & Shipping	Weekly
Eating Areas Used Primarily by Controlled Area Personnel	Weekly
Uncontrolled Areas	Monthly
Other Appropriate Areas	Quarterly
- FMO: Office area aisleways, boiler and compressor areas	
- FMOX: Office area aisleways, engineering desks and equipment	
- FCO: General aisleways, rod trays, tool room, and locations where DI water is used	
- EMO: General aisleways, gage lab, and locations where DI water is used (e.g., cleaning room, shipping and receiving)	
- Waste Treatment Facility Boiler Building - General floor areas, pumps in for repair	
- Nonradioactive Material Storage Pads - Random pieces of equipment, but especially items that could have come from FMO or the WTF.	
- Scrap Yard: Same as above	
- Contractor Work Area: Tools and equipment, spare and used parts, includes fenced-in area	
- Site Maintenance Building - General floor area, tools and equipment, used parts	

13.6 Shipping & Receiving Controls

The purpose of the WMD shipping and receiving control program is to provide a uniform method for monitoring the shipment and receipt of radioactive materials according to NRC and DOT regulations.

13.6.1 Packaging

The licensing function designates which licenses, certified or DOT specification packaging can be used routinely for specified radioactive materials and for others in special instances. Licensing obtains the required certificates of compliance and furnishes interpretations of licenses and regulations. Table 13.8 shows a listing of authorized shipping containers currently in use at WMD.

The fuel shipping function routinely refurbishes used packaging and furnishes additional packaging which may be required to meet DOT regulations.

The designated shop operation function packs materials for shipment in authorized containers according to internal instructions.

The designated quality control function inspects packages for required identification, closures and seals, and provides appropriate quality certifications.

Packaging of special or unusual material requiring radiation shielding or containment (e.g., neutron sources) is the responsibility of the component desiring shipment and is subject to traffic and materials review for conformance to NRC and DOT regulations. The regulatory compliance function determines acceptability

TABLE 13.8

SHIPPING PACKAGES AUTHORIZED FOR USE BY GE-WMD

Certificate Number	Package Name	Description	Authorized Contents
0002	UNC 2400 -6M	10 gallon metal drum	SNM powder, etc.
0003	UNC 2400 -6L	55 gallon metal drum	SNM powder, etc.
4904	21PF-1, etc.	Metal cylinder overpacks and inner metal cylinders	UF_6
4986	RA-series	Wooden outer box and metal inner container	Fuel assemblies/rods
5059	UNH trailer	3800 gallon stainless steel tank trailer	UNH
5236	PR-1, etc.	5" steel pipe with end caps in plywood box	Fuel rods
5331	BP-2	3" x 10" steel pipe in 5 gallon pail	SNM powder, etc.
5768	BB-250-2	74" long outer steel drum	SNM powder, etc.
5857	HG	Steel box	Fuel assemblies
5926	GE 100	Steel shipping cask	Irradiated SNM
6273	48A, etc.	48" cylinders	UF_6
6294	UNC 2901	55 gallon steel drum	SNM powder, etc.
6364	RR1	10" x 94" steel pipe	Fuel rods
6458	BU-5	55 gallon steel drum	SNM powder, etc.
9009	FL 10-1	2 - 55 gallon steel drums welded together	SNM powder, etc.
9018	BU-6	10 gallon metal outer container, ½ gallon inner	SNM powder, etc.
9019	BU-7	55 gallon drum	SNM powder, etc.

Table 13.8 (continued)

Certificate Number	Package Name	Description	Authorized Contents
9065	BU-4	55 gallon drum	SNM powder, etc.
9078	GENS	DOT spec 37A-80	SNM sandy powder
9091	30A & 30B	Cylinders	UF_6

for shipment when it becomes necessary in the opinion of the traffic and material distribution function.

13.6.2 Shipping

The traffic and material distribution function prepares the required shipping forms, including the radioactive materials shipping and packaging record for each shipment.

The radiation protection function does the following according to internal instructions: performs radiation and contamination surveys of outgoing shipments to assure that radiation and contamination levels are below acceptable limits and supplies shipment release documentation to the traffic and material distribution function as shown in Table 13.9.

13.6.3 Receiving

Incoming shipments that contain radioactive material are identified using a designated inspection code that alerts the receiving function that the shipment will require timely radiation monitoring.

The traffic and material distribution function performs the following: notifies the radiation protection function when radioactive materials are received at the plant; inspects packaging of received shipments for damage; and reports actual or suspected damage to the appropriate site functions.

The radiation protection function performs surveys on incoming packages containing radioactive materials within three hours of receipt during normal working

TABLE 13.9

Action Guide for Shipping/Receiving Radioactive Materials

Shipping Container Criteria	Maximum permissible contamination level*	Actions to be Taken if Level is Exceeded
Removal contamination averaged over 300 cm^2 of exterior surface of container being shipped or received, with the following types of contents or contamination:		
- Natural or depleted uranium	2200 β-γ/cm^2 - min. 2200 /cm^2 - min.	Decontaminate surface and resurvey before shipping or accepting receipt until contamination levels are below maximum limit
- All other beta-gamma emitting materials	220 - /cm^2 - min.	Same as above
- All other alpha emitting materials	20 /cm^2 - min.	Same as above
Dose rate at external surface of container	<0.5 mRem/hr at any point on external surface	Container must have Radioactive White-I label (except for small quantities of radioactive materials as defined in 49 CFR 173.391).
	Between 0.5 & 10 mRem/hr at any point on external surface & <0.5 mRem/hr at 3-ft from external surface.	Container must have Radioactive Yellow-II label
	In excess of either 10 mRem/hr at any point on external surface or 0.5 mRem/hr at 3-ft from external surface.	Container must have Radioactive Yellow-III label

*For shipments consigned to vehicles as exclusive use, limits shown above may be multiplied by a factor of 10.

Table 13.9 (continued)

Transport Vehicle Criteria	Maximum permissible contamination level	Actions to be Taken if Level is Exceeded
Incoming Shipments, removable contamination - Exclusive use vehicle (natural of depleted U only)	2,200,000 dpm β/300 cm^2 220,000 dpm α/300 cm^2	- Decontaminate surface and resurvey before releasing transport truck - Notify the manager of the radiation safety function
- Exclusive use vehicle (other than natural or depleted uranium), general transport vehicle (containing natural or depleted uranium)	220,000 dpm β/300 cm^2 22,000 dpm α/300 cm^2	Same as above
- General transport vehidle (for other than natural or depleted uranium)	22,000 dpm β/300 cm^2 2,200 dpm α/300 cm^2	Same as above

Outgoing Shipments

- General release contamination values may not exceed the established (at the time of initial incoming survey) contamination levels if the vehicle or containers are in transit.
- Removable contamination levels for release of vehicles and containers generated on plant site will be 10% of the acceptance values. If the contamination levels exceed 10% of the accepted values, the manager of the radiation safety function is contacted for authorization to have the shipment released or to have shipment decontaminated until it is below the release limits.

hours or within 18 hours of receipt if received after normal working hours, pursuant to 10 CFR 20.205. Action guide levels and corrective actions are specified in Table 13.9.

14.0 ENVIRONMENTAL SAFETY

The General Electric environmental monitoring program at Wilmington is based upon the concept of placing primary emphasis on monitoring at the source points. It has been found that data obtained at offsite sampling points fluctuate at background levels and are useful only as a secondary method of identifying any unsuspected impact from plant operations. Therefore, the source point data is used to generate the exposure and offsite concentration information in this section.

14.1 Radiological

14.1.1 Water Pathway

An extensive environs study of the facility was conducted between July 1974 and March 1975* by the Eastern Environmental Radiation Facility of the U.S. Environmental Protection Agency. At that time, the water pathway was judged as not significant since the water in the receiving stream is not potable, is not used for irrigation, and uptake of uranium from the river by plants and animals was not considered a significant pathway to man. There was practically no swimming in the area. The direct radiation pathway was not considered significant.

A determination of exposure via ingestion via the water pathway was made during the study even though the water is not used for potable purposes. The potential dose commitment was determined to be less than 3 millirem per year based on a 0.96 Ci annual discharge to the river.

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*EPA 520/5-77-044

For reference, the releases to the river for the years 1979 and 1980 were 0.61 Ci and 0.61 Ci, respectively. These values indicate a potential dose commitment of less than 2 millirem per year for these years.

14.1.2 Air Pathway

It was determined in the previously referenced EPA study that the airborne uranium activity concentration at the nearest resident would be 0.22 fCi per cubic meter. This concentration was based on an annual facility release of 2 to 3 mCi per year. This concentration results in a 50 year organ dose commitment of less than one millirem to the lung.

The facility activity releases for the year 1979 to 1980 were 1.69 and 1.05 mCi, respectively, and the calculated 50 year dose commitment from uranium activity to the lung would still be less than one millirem.

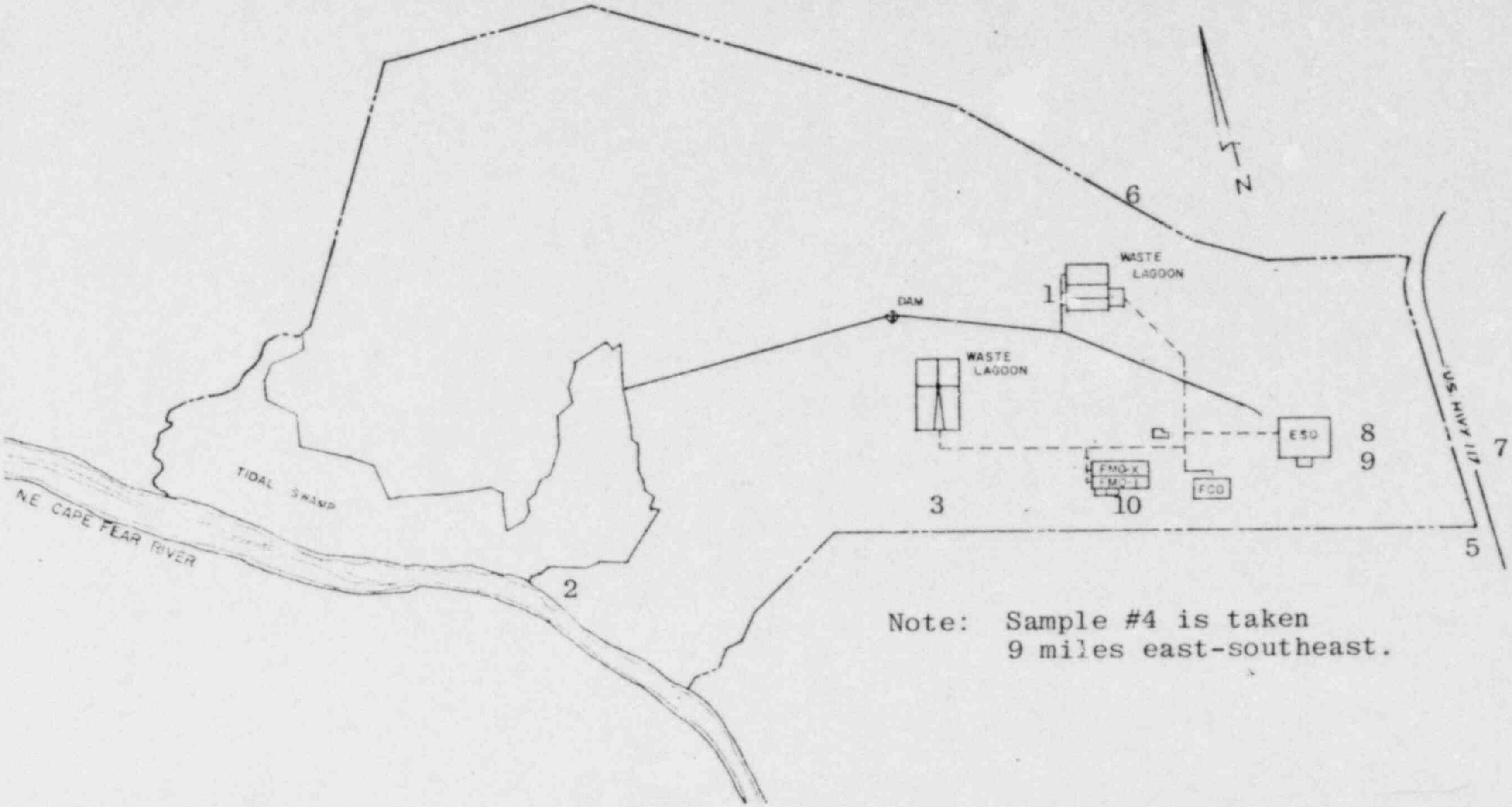
Based upon a 10 quarter study using TLD's conducted between October 1976 and July 1979, (location shown in Figure 14.1) an analysis of variance and a least significant differences test of the data showed that there is no statistically significant difference at the 95% confidence level between background locations (see Figure 14.2). Therefore, there is no discernible whole body dose to the nearest resident.

14.1.2.1 Dilution of Air Effluents

A value of X/Q, which is used to compute the dilution factor for air effluents from the uranium processing areas in the fuel manufacturing building to the nearest site boundary, is determined as shown below:

FIGURE 14.1

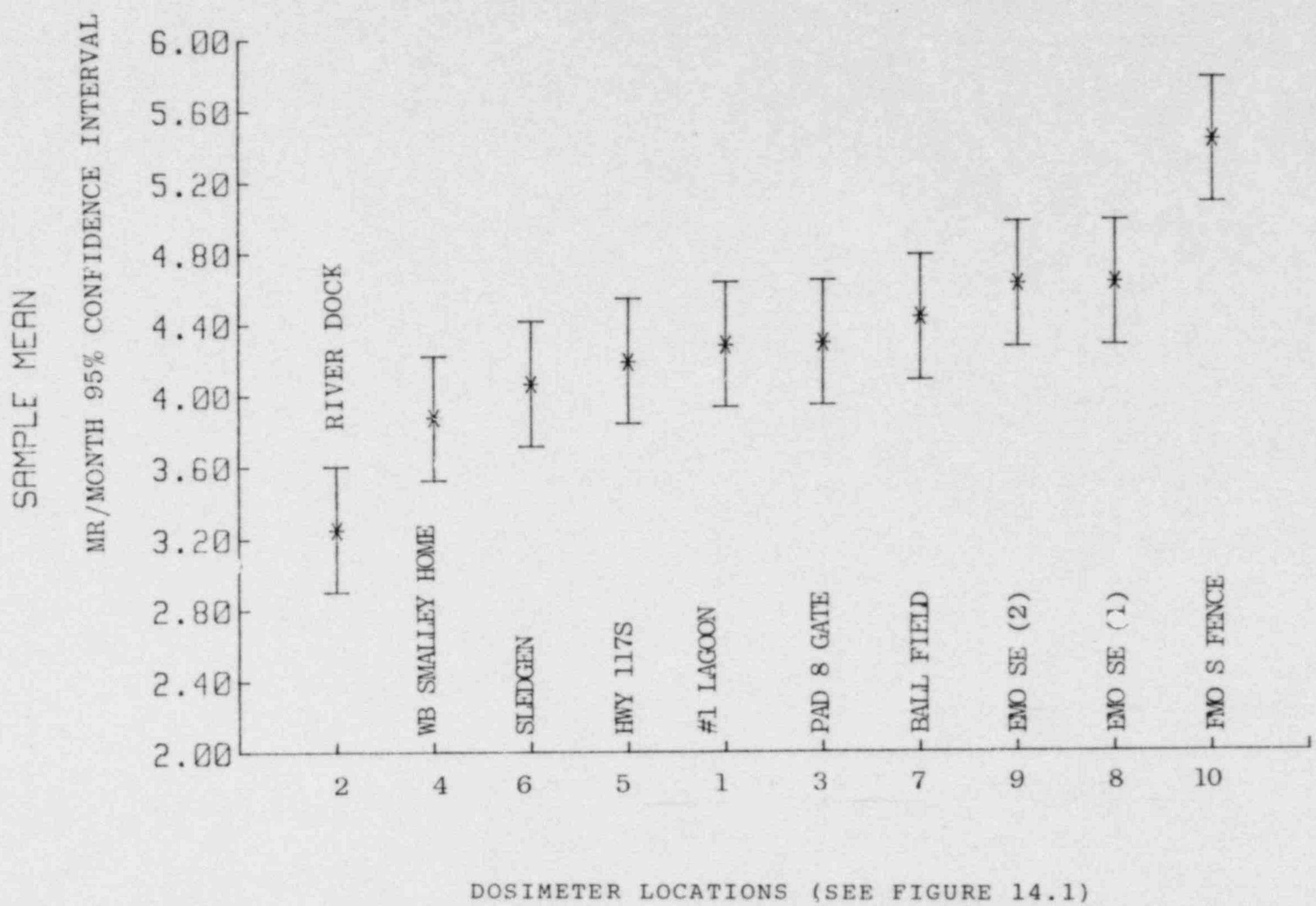
DOSIMETER LOCATIONS



Note: Sample #4 is taken 9 miles east-southeast.

FIGURE 14.2

10 QUARTER EXTERNAL DOSIMETRY EVALUATION
OCTOBER 1976 - JULY 1979



Assumptions made in the calculations are as follows:

The value of the annual average dispersion factor, X/Q, is a maximum in the south-southwest (SSW) sector from the stacks.

The nearest site boundary is a distance X of 137 meters from the stacks.

The average annual wind speed U in the SSW direction is 3.52 meters per second.

The average atmospheric stability class is E.

The average volume of air released from the stacks is 101 cubic meters per second.

The minimum cross-sectional area A for the fuel manufacturing building is 1154 square meters.

The value of the frequency F with which the wind blows toward the SSW sector is 0.0823.

The annual average atmosphere dispersion factor for a building release is calculated from the following equation:

$$\frac{X}{Q} = \frac{2.032}{\Sigma_z \bar{U} \tilde{X}} F$$

where X is the averge annual ground level the sector of interest of the radioactive material released in uCi/m³,

Q is the average annual release rate of the radioactive material released from all stacks in uCi/m³,

$\bar{U}$ is the average annual wind speed for the sector of interest in meters/sec,

$\bar{X}$ is the distance from the point of release to the minimum site boundary in meters and

F is a variable added to account for the frequency with which the wind blows towards the sector of interest.

The vertical dispersion coefficient, σz, has been replaced by Σz to account for the building wake effect, and is equal to the following:

$$\Sigma z = (\sigma z^2 + \frac{CA}{\pi})^{1/2}$$

where σz is the Pasquill-Gifford type vertical dispersion coefficient in meters as defined in Figure 3.11, Metorology and Atomic Energy, 1968[1].

C represents an estimation of the relation of the cross-sectional area of the building to the size of observed pressure wakes = 1/2, and

A equals the minimum cross-sectional area of the building in m^2.

The assumption was made that all airborne effluent sources come from the center of the roof of the fuel manufacturing building. The maximum dispersion factor is chosen from the data combinations of site boundary distance, averge wind speed, and the fraction of the time the wind blows into each sector. In order to determine the value of σz, an average atmospheric stability class for the year is assumed to be E.

Presently, the minimum building cross-sectional area, A, is equal to 1154 m^2, and the minimum site boundary distance is 122 meters in the south sector.

Using the above assumed values for the variables $\overline{U}$, F, C, A, and $\overline{X}$, value for σz of 4.5 as obtained from Figure 3.11 of reference 1, a value of $X/Q = 4.5 \times 10^{-5}$ sec/m^3 is calculated. The dilution factor corresponding to this X/Q is 220. As stated in Chapter 1.6.7 a dilution factor of no greater than 100 shall be used for purposes of controlling concentrations of uranium released in airborne effluents from the uranium processing areas in the fuel manufacturing building.

14.1.3 Solid Waste - Contaminated solid wastes are either held onsite pending rework or transportation to a licensed disposal facility. There is no potential effect to the public from the temporary onsite retention of solid wastes and effect to the public of solid waste is addressed by the disposal site license.

14.2 Nonradiological

14.2.1 Water Pathway

Process wastes and sanitary wastes generated onsite are collected and treated in separate facilities before discharge from the site. The discharge of these treated wastes is regulated by North Carolina under the State administered NPDES permit program.

Discharges of the treated waste waters have been within the NPDES permit parameters during 1979 and 1980. The quantities of contaminants released have been insufficient to change the water quality of the receiving stream.

Data including effluent concentrations and release rates and pertinent monitoring information from the sampling program conducted in the receiving stream are summarized in Tables 14.1 through 14.3.

14.2.2 Gaseous Effluents

Individual effluent streams from the fuel manufacturing operation are treated as appropriate to remove specific contaminants before discharge to the atmosphere. Each process emission point is regulated under a permit issued by the State of North Carolina.

The treatment systems are effective in maintaining contaminant emission levels low enough to avoid impact on the environs.

Pine trees, which are notably susceptible to fluoride damage, flourish immediately adjacent to the conversion

TABLE 14.1

TREATED PROCESS EFFLUENT DATA

1979	Avg. Daily Discharge Volume(1)	pH Min.	pH Max.	F Avg. ppm(2)	F Avg. #/Day	$NH_3(N)$ Avg. ppm	$NO_3(N)$ Avg. ppm	$NO_2(N)$ Avg. ppm	Total Nitrogen #/Day	Cu Avg ppb(3)	Cu Avg. #/Day	Ni Avg. ppb	Ni Avg. #/Day	Cr Avg. ppb	Cr Avg. #/Day	U Avg. ppb
JAN	.650	6.6	8.7	2.1	16	6.1	3.7	.28	73	12	.09	13	.10	10	.07	380
FEB	.694	6.5	8.7	3.6	26	7.5	2.2	.50	71	12	.08	12	.08	10	.07	390
MAR	.610	6.6	8.7	2.4	18	3.2	2.2	.6	47	<10	.06	<10	.07	<10	.06	340
APR	.590	6.5	8.9	3.3	26	4.4	2.7	.37	60	<10	.05	<10	.06	<10	.06	460
MAY	.647	6.0	8.9	3.9	28	4.8	3.9	.55	67	<10	.06	<10	.08	<10	.06	560
JUN	.638	6.5	9.0	3.14	24	2.1	3.3	.89	51	<10	.08	<10	.06	<10	.07	470
JUL	.610	6.6	8.7	3.8	27	3.8	2.8	.62	48	<10	.08	<10	.08	<10	.07	630
AUG	.571	6.5	8.8	2.5	15	1.9	1.7	.4	25	14	.08	13	.10	51	.21	660
SEP	.765	6.6	8.8	4.0	27	4.2	2.2	.2	54	<10	.10	<10	.07	<10	.06	540
OCT	.780	7.0	8.8	3.5	30	2.8	3.1	.42	57	<10	.08	<10	.07	<10	.07	790
NOV	.658	6.8	8.7	3.5	28	5.0	3.4	.42	73	<10	.06	<10	.06	<10	.06	460
DEC	.587	6.6	9.0	6.5	40	4.1	3.4	.43	67	10	.06	13	.07	<10	.06	620
1980																
JAN	.638	6.6	8.3	2.5	19	3.1	3.2	.21	49	10	.07	13	.09	<10	.06	1080
FEB	.592	6.6	7.8	2.9	20	2.65	3.26	.23	44	11	.07	10	.05	<10	.05	1030
MAR	.563	6.4	8.1	4.5	21	3.4	6.3	.51	54	13	.06	16	.06	<10	.07	1120
APR	.464	6.6	9.0	3.1	18	2.2	2.6	.38	31	10	.05	11	.08	11	.06	880
MAY	.498	6.7	7.8	3.5	32	2.2	5.3	1.0	67	10	.06	12	.07	11	.06	860
JUN	.580	6.3	8.6	2.8	20	.89	2.2	.6	26	<10	.05	10	.06	<10	.05	370
JUL	.460	6.5	8.4	3.5	19	1.1	4.1	.88	33	10	.06	13	.07	13	.08	330
AUG	.451	6.6	9.0	3.6	21	2.3	3.8	.6	41	<40	.05	<10	.05	<10	.05	270
SEP	.501	6.2	8.8	4.1	18	2.3	2.8	1.0	39	<10	.05	10	.06	<10	.05	520
OCT	446	6.6	8.9	5.2	19	5.5	4.3	.9	40	10	.04	13	.05	10	.04	460
NOV	.384	7.1	8.9	4.0	15	4.0	6.6	1.4	45	10	.05	12	.04	10	.04	730
DEC	.590	6.6	8.3	5.4	20	5.7	11.3	.6	67	11.5	.05	13.5	.05	15	.06	420

(1) millions of gallons per day

(2) parts per million

(3) parts per billion

TABLE 14.2

SANITARY EFFLUENT DATA

Year	Month	Avg. Daily Discharge, MGD(1)	BOD, ppm(2)	COD, ppm
1979	JAN	0.022	10	64
	FEB	0.022	8	36
	MAR	0.021	11	41
	APR	0.018	9	28
	MAY	0.020	10	20
	JUN	0.019	15	43
	JUL	0.017	16	43
	AUG	0.017	7	48
	SEP	0.024	8	28
	OCT	0.018	14	52
	NOV	0.016	8	40
	DEC	0.014	13	47
1980	JAN	0.017	6	48
	FEB	0.017	7	40
	MAR	0.017	5	40
	APR	0.017	19	59
	MAY	0.019	4	31
	JUN	0.024	3	16
	JUL	0.022	7	48
	AUG	0.020	6	52
	SEP	0.025	19	55
	OCT	0.024	6.0	24
	NOV	0.022	6.5	28
	DEC	0.022	7	16

(1) Millions of Gallons per Day

(2) Parts per Million

TABLE 14.3

NORTHEAST CAPE FEAR RIVER MONITORING DATA*

Year	Month	Monitoring Location - Upstream					Monitoring Location - Downstream				
		F	$NO_3(N)$	$NH_3(N)$	pH	BOD	F	$NO_3(N)$	$NH_3(N)$	pH	BOD
1979	JAN	0.11	0.19	0.58	5.8-8.7	1.8	0.15	0.42	0.59	6.3-6.8	2.1
	FEB	<0.10	0.45	0.50	6.1-6.6	<1.0	0.13	0.41	0.52	6.5-6.9	<1.0
	MAR	0.11	0.27	0.33	5.8-7.1	3.0	0.11	0.37	0.45	6.1-6.5	1.0
	APR	<0.10	0.26	0.68	6.3-6.8	<1.0	<0.10	0.30	0.47	6.4-6.8	<1.0
	MAY	<0.10	0.25	0.67	6.0-6.5	1.2	0.15	0.36	0.46	6.6-6.9	1.4
	JUN	0.10	0.27	0.81	6.0-6.5	-	0.11	0.39	0.62	6.4-6.9	-
	JUL	0.16	0.29	0.60	6.0-6.9	1.4	0.35	0.32	0.54	6.5-7.2	-
	AUG	0.19	0.22	0.69	6.2-6.8	1.8	0.37	0.27	0.45	6.6-7.3	3.6
	SEP	0.13	0.11	1.00	5.5-7.0	-	0.18	0.16	0.60	6.0-7.1	-
	OCT	0.19	0.14	1.06	6.0-6.4	2.6	0.20	0.18	0.63	6.3-7.1	4.6
	NOV	0.25	0.22	0.95	6.6-6.7	-	0.35	0.[illegible]	0.83	6.7-7.2	-
	DEC	0.37	0.29	0.89	6.0-6.5	2.2	0.35	0.32	0.64	6. -7.0	2.7
1980	JAN	0.21	0.74	0.77	6.3-6.7	1.6	0.23	0.37	0.59	6.6-7.0	1.6
	FEB	0.20	0.50	0.79	6.3-6.5	<1.0	0.20	0.47	0.68	6.4-6.8	1.2
	MAR	0.27	0.38	0.88	5.9-6.6	3	0.27	0.38	0.77	6.2-6.7	2.2
	APR	0.26	0.37	0.88	5.9-6.6	-	0.28	0.39	0.71	6.3-6.7	-
	MAY	0.30	0.59	0.67	6.2-6.7	4.2	0.31	0.57	0.48	6.7-6.8	3.4
	JUN	0.26	0.30	0.68	5.7-6.6	-	0.40	0.51	0.69	6.4-7.2	-
	JUL	0.21	0.39	0.63	6.1-6.7	-	0.31	0.56	0.29	6.6-7.1	-
	AUG	0.24	0.32	0.90	6.2-7.1	<1.0	0.43	0.54	0.34	6.6-7.3	1.2
	SEP	0.27	0.32	0.73	7.0-7.0	8.0	0.66	0.47	0.46	6.8-6.8	2.0
	OCT	0.25	0.30	0.78	6.6-7.1	-	0.72	0.49	0.32	7.1-7.4	-
	NOV	0.22	0.44	0.44	6.7-7.0	1.2	0.52	0.50	0.21	7.1-7.2	1.0
	DEC	0.15	0.58	0.23	7.0	<1.0	0.31	0.43	0.20	7.0	1.0

*pH results in units; all other results in parts per million

Note: Upstream and downstream uranium concentrations were <0.01 ppm area and in the plant environs. Calculated concentrations of fluoride at the site boundary are less than 0.01 micrograms per cubic meter.

Monitoring data summarizing fluoride emissions from the chemical operations area are summarized in Table 14.4.

The discharge of nitrogen oxides from the chemical process area is controlled so as to result in a nitrogen dioxide concentration of less than 0.05 ppm on an annual basis at the site boundary.

Routine discharges of ammonia to the atmosphere as a result of process liquid waste treatment were eliminated in 1977 with the addition of an ammonia recovery system.

TABLE 14.4

AIRBORNE FLUORIDE RELEASES
(GRAMS/WEEK)

1979 Wk		1979 Wk		1980 Wk		1980 Wk	
01	119	27	7	01	81	27	140
02	17	28	38	02	84	28	138
03	29	29	54	03	79	29	48
04	40	30	23	04	72	30	135
06	30	31	4	05	109	31	781
06	7	32	23	06	70	32	49
07	20	33	13	07	91	33	50
08	24	34	15	08	121	34	87
09	31	35	8	09	233	35	118
10	27	36	53	10	181	36	138
11	11	37	22	11	157	37	125
12	18	38	1	12	96	38	79
13	29	39	5	13	89	39	--
14	66	40	75	14	84	40	--
15	20	41	54	15	11	41	93
16	181	42	109	16	115	42	257
17	464	43	54	17	125	43	100
18	225	44	42	18	62	44	--
19	--	45	50	19	111	45	--
20	23	46	39	20	82	46	127
21	114	47	28	21	56	47	298
22	435	48	121	22	46	48	183
23	39	49	68	23	1[illegible]3	49	204
24	69	50	68	24	171	50	97
25	34	51	120	25	124	51	--
26	104	52	68	26	87	52	--

15.0 NUCLEAR CRITICALITY SAFETY

This chapter describes the administrative and technical procedures, design approaches, criticality safety methodology and analytical methods which are used by the Wilmington Manufacturing Department to ensure nuclear criticality safety in the fabrication, storage and movement of fissile material.

15.1 Administrative Practices - Area Managers

Responsibility for criticality safety in fuel manufacturing operations is vested in area managers. Area managers are appointed by the Department General Manager, taking into account the Department organizational structure and the qualifications of the appointee.

15.1.1 The current area managers assignments are listed in Table 15.1

15.1.2 Area Manager Responsibilities

15.1.2.1 Full responsibility for operation of his area in a criticality safe manner.

15.1.2.2 Requesting or authorizing the request for a nuclear criticality safety analysis from the criticality safety function for new activities or changes in activities which he determines may require a change in criticality controls or changes in environment of possible consequence to criticality safety.

TABLE 15.1

BUILDING AREAS ASSIGNED TO AREA MANAGERS

Area Manager	Building/Outside Location	Areas of Responsibility, Building/Outside Location
Manager, Fuel Chemical Operation	FMO/FMOX - ground floor	Rad waste treatment & UF_6 waste treatment
	FMO/FMOX - mezzanine	Solid waste decontamination
	Fuel support areas	UF_6 cylinder storage
	Outside Locations	Vaporization
		Powder production & UPS
		REDCAP
		Stacker warehouse
		Waste treatment facility (including lagoons)
		Outside pads
		Changerooms
		Blender
		Laundry
		New stacker
		UF_6 mezzanine
		FMOX rad waste
		FMOX GECO (expansion)
		Powder screen & pack
		Incinerator Building
Manager, Fuel Fabrication Operation	FMO/FMOX - ground floor	Sintering
	FMO/FMOX - mezzanine	Grind, load, weld
		Gadolinia change rooms
		Gadolinia
		Bundle assembly, packing & storage
		Press
		Powder dump stations
Manager, Fuels Manufacturing Engineering	FMO/FMOX - ground floor	Gadolinia laboratory (upstairs)
	FMO/FMOX - mezzanine	Process Technology Laboratory
	FMO/FMOX - roof	FMO maintenance shop, cribs & roof
Manager, Measurement Techniques	FMO/FMOX - ground floor	QTD cold lab
		Automatic pellet inspection

Table 15.1 (continued)

Area Manager	Building/Outside Location	Areas of Responsibility, Building/Outside Location
Manager, Control Instrumentation Support	FMO/FMOX - ground floor Outside location	Instrument laboratory Source storage outside pad
Manager, Analytical Chemistry Development	FMO/FMOX - ground floor	Neutron facility in box factory QTD hot laboratory
Manager, Fuels Quality	FMO/FMOX - ground floor	Chemet laboratory
Manager, Facilities	FMO/FMOX Outside locations	Process lagoons All areas of FMO/FMOX and outside locations not specifically assigned to another Area Manager
Manager, Procurement & Material Logistics	Onsite locations	Pad 12 annex FMOX shipping bay, box factory Pad 12 and north roadway Site warehouse & roadway storage areas
	Offsite location	Greenville, SC, facility
Manager, Equipment Quality	EMO	Equipment Manufacturing Operation Building
Manager, Fuel Components Operation	FCO	Fuel Components Operation Building

15.1.2.3 Assuring that changes for which a criticality safety function review has been requested are not initiated (that is, placed into operation) until authorized by the criticality safety function.

15.1.2.4 Assuring that criticality control procedures are written and maintained which incorporate the criticality safety requirements established by the criticality safety function in its review.

15.1.2.5 Assuring that these written procedures are provided to foremen, operators, and other concerned personnel.

15.1.2.6 Assuring that all personnel who enter his criticality area are properly instructed in the criticality safety requirements applicable to their function and the area.

15.1.3 Area Manager Compliance

15.1.3.1 Responsibility for and control of the nuclear criticality safety of the operation under his management is achieved through the authority delegated to the lower line management (unit managers, foremen, and supervisors). Day to day operation is controlled at this level and necessary instructions relative to this control are communicated in management meetings and round table sessions.

15.1.3.2 Each WMD manager is responsible to the Area Manager for the control of his functional personnel while in the criticality safety area.

15.1.3.3 Each area manager assures that proposed changes to his area are evaluated to determine if a review by the criticality safety function is required. If a review is required or if the area manager is uncertain as to whether one is required or not, a Facility Change Request (FCR) is submitted to the criticality safety function.

15.1.3.4 If a FCR is submitted to the criticality safety function, the change is not permitted to begin operation until the criticality safety function either indicates that a review is not required or gives written approval for the operation.

15.1.3.5 When the criticality safety functon completes a review of a proposed change in operation, it transmits in writing any criticality safety requirements which must be implemented for the operation. These criticality safety requirements are then incorporated into the operating procedures for the system either by attaching the written criticality safety function communication to the procedure or by incorporating the requirements into the procedural instructions. For areas or systems which do not have detailed written operating procedures, the criticality safety function document itself serves as the procedure.

15.1.4 <u>Operating Procedures</u>

15.1.4.1 Major Department-level procedures (called Practices and Procedures - P/Ps) are generated for communication between Department sections.

15.1.4.2 In response to the Department P/Ps, section-level administrative routines may be developed for communication within the section as required.

15.1.4.3 Subsections and units may also develop administrative routines or instruction documents appropriate for their functions.

15.1.4.4 Production Requirements and Operating Documents (PRODs) are prepared for operators of the fuel manufacturing operation.

15.1.4.5 The criticality safety function document (currently called a Nuclear Safety Release/Requirements - NSR/R) giving the criticality safety requirements for each operation, is controlled by the criticality safety function and is binding on all personnel who enter the criticality area.

15.1.4.6 Operating procedures and instructions (including NRSs) are available throughout the criticality control areas.

15.1.5 Typical Training

15.1.5.1 Personnel who are authorized to enter criticality controlled areas receive levels of instructions in the criticality safety requirement applicable to their function.

15.1.5.2 The first level of instruction is the training program conducted or approved by the radiation safety function for new personnel and for periodic retraining of the workforce.

15.1.5.3 Instruction programs are maintained at the subsection and unit level through staff level meetings and roundtable discussions.

15.2 <u>Administrative Practices - Criticality Safety Function</u>

The criticality safety function has the responsibility for providing authoritative professional advice and counsel to area managers on nuclear criticality safety matters; to analyze proposed changes in equipment, processes, and facilities involving nuclear criticality safety; and to measure the effectiveness of the criticality control program through periodic inspection and evaluation of criticality safety related data.

The criticality safety function's analysis of proposed changes in equipment, processes and facilities for nuclear criticality safety is administered through the nuclear safety review system. The key elements of this system are that:

15.2.1 A Facility Change Request (FCR) is received by the criticality safety function on which a proposed change is summarized. Based on this summary, a criticality or nuclear safety engineer in the function determines whether a criticality safety review is required. If no review is required, it is so designated on the FCR and a copy is returned to the requestor. The signed off copy represents the criticality safety function's approval of the proposed change and the requestor is authorized to initiate the change.

FCRs which may not require a criticality safety function review are those which usually fall under one or more of the following guidelines:

The change represents replacement, usually in like kind, of an existing piece of equipment, system or facility.

The change is permissible under the conditions of the existing criticality safety analysis without a new analysis being required

The change does not affect the criticality safety of the area by, for example, not involving fissile material.

The change involves insignificant or negligible amounts of fissile material (as described in Chapter 15.4.4).

15.2.2 If the criticality or nuclear safety engineer determines that a criticality safety review is required, further information as required is obtained from the requestor and a criticality safety analysis is performed using the analytical methodology and assumptions described in Chapter 15.4 and 15.5. The criticality analysis is usually performed by a member of the criticality safety function but occasionally it is contracted to qualified outside organizations. While the criticality safety analysis is being performed, discussions as necessary are held with the requestor to resolve difficulties or revise design considerations so that the design criteria in Chapter 3 are satisfied.

When the criticality safety analysis is completed, it is formally documented and referred to an alternate member of the criticality safety function for review and verification.

Following this, criticality safety requirements for the proposed change are identified and transmitted to the requestor for incorporation into operating procedures or posting in the area. Operating procedures are developed and implemented prior to startup of the operation.

15.2.3 When the proposed change has been installed and is ready to be placed into operation, criticality or nuclear safety personnel from the criticality safety function perform a pre-operational inspection to verify that the installation is in agreement with the criticality safety analysis.

If the pre-operational inspection reveals discrepancies between the criticality safety analysis and the installaton, these are resolved by revising the analysis or the installation.

15.2.4 When the key items in 15.2.1 through 15.2.3 are completed, the criticality safety function transmits in writing formal approval for operation and the identified criticality safety requirements to the cognizant area manager. This approval for operation is designated a NSR/R and is required to be signed by the manager of the criticality safety function.

15.2.5 Records of the FCR, criticality safety analysis and NSR/R are filed in the radiation safety function nuclear safety review files. These files are maintained for as long as the equipment system or facility is in operation and are not deleted for at least six months after the operation is terminated.

15.2.6 On a quarterly basis, criticality or nuclear safety engineers from the criticality safety function perform inspections of the fuel manufacturing operations. These inspections are performed to verify compliance with the criticality safety requirements in the NSR/Rs as well as to identify previously unrecognized potential criticality.

15.3 Equipment and Facility Design Considerations

15.3.1 Designs of new equipment, processes and facilities comply with safety design criteria prepared by nuclear safety engineering.

15.3.1.1 Equipment, processes and facilities must be designed to be critically safe even if single controls or related multiple controls fail.

15.3.1.2 Geometry control is the preferred method for criticality safety.

15.3.1.3 Geometry control is implemented in designs either by restriction of key dimensions to the safe geometry values tabulated in Chapter 4.2.3 (or the equivalent finite dimensions determined from standard buckling relationships) or by demonstration of geometric safety by the methodology described in Chapters 15.4 and 15.5.

15.3.1.4 Because equipment, processes and facilities must be critically safe even when controls (such as geometry) fail, the use of process designs which incorporate optimum or uncontrolled moderation into normal operations is minimized.

15.3.1.5 The use of fixed poisons is identified as a form of geometry control and is encouraged over the use of administrative controls. For example special case of this is the use of borosilicate-glass raschid rings which is used in conformance with ANS-8.5/N16.4.

15.3.1.6 The use of geometry control in equipment design also require that the structural integrity of the equipment be reviewed by a qualified civil or structural engineer. Compliance with this requirement is documented in the form of either drawings properly stamped by the reviewer or a written report from the reviewer.

15.3.1.7 Equipment and process designs must consider and control accumulation of fissile materials in inaccessible or unplanned locations. Periodic inspections are also required to verify the effectiveness of the controls.

15.3.1.8 Non-Geometry Controls

If geometry control is not practicable for assuring criticality safety, the administrative control methods listed below in order of preference are authorized. Implementation of any of these must incorporate in addition to the criteria in Chapter 4.2, the criteria safety factors of at least 2 unless a smaller value is justified. This requirement is interpreted as follows:

15.3.1.8.1 Mass Control

Mass limits must be specified such that if the limit is exceeded by a factor of 2, the unit will be critically safe. Safe batch limits are an example of this for uncontrolled geometries but other limits may be determined (in conjunction, for example, with geometric configurations) using the methodology described in Chapters 15.4 and 15.5.

15.3.1.8.2 Moderation Control

Moderation must be controlled such that if the degree of moderation is changed by a factor of 2, the equipment or system will still be critically safe.

15.3.1.8.3 Density Control

Density controls must incorporate the safety factors specified in Chapter 4.

15.3.1.8.4 Combinations of Controls

It is preferrable to utilize combinations of these types of controls for criticality safety rather than to base safety on a single type. An example of this would be a storage area of containers which are critically safe based upon both mass and moderation controls. By this is meant that in the event the mass control failed, the system would still be critically safe because of the moderation controls and if the moderation control failed, the system would still be critically safe because of the mass control.

15.4 METHODOLOGY IN CRITICALITY SAFETY ANALYSES

The analytical methods and techniques used by the Wilmington Manufacturing Department to demonstrate criticality safety of equipment, processes and facilities are described in Chapter 15.5. The purpose of this section is to describe the methodology and basic assumptions that are the precursors to the use of these methods in WMD applications. These are as follows:

15.4.1 Density Limits

The maximum credible density of fissile material is a key parameter in the analytical evaluation of criticality safety in Wilmington Manufacturing Department operations. Several such density specifications have been established. These include:

15.4.1.1 UO_2 has the maximum uranium density of any uranium compound utilized in the manufacturing operation. It is therefore conservative (but not mandatory) to model any fuel-moderator mixture in Wilmington Manufacturing Operations as UO_2 and water.

15.4.1.2 The maximum theoretical density of UO_2 is 10.96 gm/cc.

15.4.1.3 It has been determined experimentally that the maximum bulk density of UO_2 powder at WMD is less than 4.5 gm/cc.

15.4.1.4 The normal density of UO_2 pellets is approximately 95% of the theoretical density (i.e., 10.41 gm/cc).

15.4.1.5 The maximum theoretical density of U_3O_8 is 8.39 gm/cc and of ADU is 6.40. Densities of other uranium compounds are tabulated in the literature.

15.4.2 <u>Mixture Specifications</u>

Materials such as UO_2 and U_3O_8 are characterized by their very low solubilities in water. Mixtures of these materials with water are therefore easily determined by calculation.

15.4.2.1 For mixtures in which the materials achieve their maximum possible densities - so that the sum of the volume fraction of fuel and the volume fraction of water equals 1.0, the mixture density is

$$\rho_{mix} = \frac{1}{\dfrac{WF_X}{\rho_X^T} + \dfrac{WF_{H_2O}}{\rho_{H_2O}^T}}$$

In this formula, ρ_X^T and $\rho_{H_2O}^T$ are the maximum theoretical densities of the fuel (10.96 for UO_2, 8.39 for U_3O_8, etc.) and water (usually $\rho_{H_2O}^T = 1.00$) and WF_X and WF_{H_2O} are the weight fractions of fuel and

H_2O in the mixture. It follows of course that

$$WF_x + WF_{H_2O} = 1.0$$

and that the densities of the fuel and water in the mixture are

$$\rho_x = WF_x \ \rho_{mix}$$

$$\rho_{H_2O} = WF_{H_2O} \ \rho_{mix}$$

15.4.2.2 In some mixtures, the maximum densities described above may not be achieved. In this event, the fuel-moderator mixture is described by the relationships

$$\rho_x = WF_x \ \rho_{mix}$$

and

$$\rho_{H_2O} = WF_{H_2O} \ \rho_{mix}$$

15.4.2.3 An example of the application of the relationship above occurs for the case of UO_2 powder and water. As described in 15.4.1.4, the maximum density of WMD UO_2 powder is 4.5 gm/cc. This corresponds to a "full density" mixture of 4.5 gm/cc of UO_2 and 0.5894 gm/cc of H_2O*.

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*This can be seen from the relationship

$$\frac{\rho_x}{\rho_x^T} + \frac{\rho_{H_2O}}{\rho_{H_2O}^T} = 1.0$$

Thus if UO_2 powder and water mix such that the density of water in the mixture is less than 0.5894 gm/cc, the mixture will not be full density. For example, if the water content is 5.0 weight percent (50000 ppm), the mixture will be

$$\rho_{UO_2} = 4.5 \text{ gm/cc}$$

$$\rho_{H_2O} = \frac{4.5 \text{ gm/cc}}{(1-0.05)} \times 0.05 = 0.2368 \text{ gm/cc}$$

15.4.3 Basic Assumptions for Geometry Control

15.4.3.1 Geometry control is defined such that criticality safety must be assured over normal and abnormal ranges of fissile material density, enrichment, mass and moderation. The consideration of normal and abnormal ranges of fissile material and moderator leads to the requirement that geometrically safe equipment be critically safe for optimum moderation. Optimum moderation is defined to be the combination of fuel and moderator which results in the maximum neutron multiplication factor.

15.4.3.2 In addition to optimum moderation, it is required that geometry controls assure criticality safety for conditions of full or maximum credible reflection and must take into consideration potential heterogeneous effects in the fuel-moderator and equipment geometry. Full reflection is usually considered to be a 12 inch thick layer of water placed at the immediate boundary of the system unless other more reflective materials such as concrete are present. Concrete reflection is modelled as a 16 in. thick layer at the system boundary.

Heterogeneity of the fuel-moderator mixture is required to be taken into consideration if the fuel particle size exceeds 127 microns. In WMD applications involving UO_2 it is therefore assumed that UO_2 powder (which has a particle size in the 0.2 - 1.2 micron range) mixes homogeneously with water while pellets, rods and chips greater than 127 microns mix heterogeneously.

15.4.4 Neutron Interaction Between Equipment

Critically safe spacings between equipment and systems of fissile material are determined by analyses of the neutron interaction between the individual units. These analyses are required to demonstrate nuclear criticality safety for conditions of optimum interspersed water between the individual units and full reflection by water and/or concrete of the entire system. Individual units are defined to be those which maintain a surface-to-surface spacing of at least 12 inches from all other accumulations of fissile material. Units which do not meet this spacing requirement must be analyzed first in connection with all units closer than 12 inches subject to the requirements of chapter 4 and 15.4 and then included in the overall interaction analysis. Basic to the interaction analyses are the following assumptions:

15.4.4.1 All units in the interaction analysis must individually satisfy the double contingency policy as described in Chapter 4.

15.4.4.2 Negligible quantities or volumes of fissile material can be omitted from the analysis. For this purpose, negligible is defined to be less than 10% of the values listed in Tables 4.1 through 4.4.

15.4.4.3 Individual units of fissile material with a K_∞ 1.0 which meet the 12 inch spacing requirement can be omitted from the interaction analysis if they do not provide more neutron reflection to any other unit than a 12 inch thick blanket of water at the unit's boundary.

15.4.4.4 Units isolated by the distance specification in Chapter 4.2.8 may be omitted from the interaction analysis.

15.4.4.5 Units with natural or depleted uranium may be omitted from the interaction analysis but must be considered as potential reflectors of other units if they do not satisfy the 12 inch spacing requirement.

15.4.4.6 If a unit or horizontal planar array of fissile material is separated from all other units and horizontal planar arrays by a distance at least as great as its height and all units or arrays satisfy the requirements of Chapter 4 and 15.4, then the total interacting system is critically safe.

15.5 ANALYTICAL METHODS

The analytical methods used by WMD's criticality safety function in nuclear criticality safety analyses are standard throughout the industry and reflect the ongoing upgrade and improvement in nuclear analysis technology. These methods are of four types. First and most basic is the use of experimental or published data along with simple hand calculations utilizing well known formulas or relationships. Next are the one and two dimensional multigroup diffusion theory and transport codes. Third are the Monte Carlo codes which, because of their modelling capabilities and wide range of applicability, have become the preferred analysis method in criticality safety analyses. Lastly are the more or less empirical interaction codes which are used to evaluate the criticality safety of complex systems or entire facilities.

15.5.1 Published Data and Hand Calculations

15.5.1.1 The technical literature contains the results of many experiments performed expressly to determine appropriate criticality safety limits for specific processes and operations. These experimental values and interpolations between these values are used extensively to benchmark nuclear analysis codes and to establish critically safe parameters for individual accumulations and arrays of accumulations. The most commonly used and readily available documents from which experimental parameters may be obtained are:

- Karlsruhe Symposium papers, 1961
- AHSB Handbook 1, "Handbook of Criticality Data"
- TID-7028, "Critical Dimensions of Systems Containing U-235, PU-239 & U-233"
- TID-7016, Rev. 1, "Nuclear Safety Guide"
- LAMS-3067, "Los Alamos Critical Mass Data"
- KAMS-2537, "Correlations of Expermental & Theoretical Critical Data"
- Y-1272, "Y-12 Plant Nuclear Safety Handbook"
- RFP-NUREG, "Reference Control Experiments"

15.5.1.2 Also published in the technical literature or available internally within the General Electric Company are compendia of basic nuclear parameters such as infinite neutron multiplication factors, migration areas, extrapolation distances, minimum critical masses and multigroup cross section sets. These parameters can be used with standard analytical methods described in most nuclear engineering text books. Examples of such publications are:

- ARH-600, "Criticality Handbook"
- DP-1014, "Critical and Safe Masses and Dimensions of Lattices of U and UO_2 Rods in Water", Savannah River Laboratory.
- Artigas, R., "Rod Studies Data"

15.5.1.3 A typical analytical method used with experimental or published data is the calculation of effective neutron multiplication factors using the reactivity formula. The reactivity formula is the well-known relationship

$$K_{eff} = \frac{K_\infty}{1 + B^2 M^2}$$

where: K_∞ is the published infinite neutron multiplication factor,
M^2 is the published migration area, and
B^2 is the geometric buckling (itself a function of the material extrapolation distance - which is also obtained from published data).

Functional relationships of buckling factors on geometric dimensions are well known for simple geometries such as cylinders, slabs, and spheres.

15.5.2 Diffusion Theory and Transport (SN) Codes

If accumulations of fissile material are not geometrically simple, it is often necessary to use advanced nuclear analysis methods to evaluate nuclear criticality safety. When the geometries and materials are not too complex, the more traditional methods used have been diffusion theory or transport (SN) codes. These are multidimensional, multigroup codes which solve the standard neutron transport equation in either rectangular, cylindrical or spherical coordinates. Problem input consists of data such as densities, macroscopic cross section sets, fission spectra, geometry specifications and convergence criteria. It is often necessary to compute cross sections using sophisticated preprocessing codes prior to performing the diffusion theory of transport calculations. Examples of these types of computer codes are:

15.5.2.1 HECATE: A one-dimensional, three-group diffusion theory program which solves slab and cylindrical geometry problems and yields the K-infinite or K-effective of the system.

15.5.2.2 PDQ-04: A two-dimensional, multigroup diffusion theory program which solves either x - y or r - z geometry problems for K-effective or K-infinite values.

15.5.2.3 TWOD: A two-dimensional, multigroup diffusion theory program which solves either x - y or r - z geometry problems for K-effective or K-infinite values.

15.5.2.4 ANISN: One-dimensional SN-theory solution of the Boltzmann transport equation for neutrons.

15.5.2.5 XSDRN: One-dimensional SN-theory solution of the Boltzmann transport equation, for calculating reaction rates, eigenvalues and critical dimensions.

15.5.2.6 DOT and TWOTRAN: Two-dimensional SN-theory solution of the Boltzmann transport equation.

15.5.3 Monte Carlo Codes

For complex 3 dimensional geometries or problems requiring a high degree of accuracy or reliability, it is usually necessary to utilize Monte Carlo codes. These codes solve the Boltzmann transport equation by simulating on a statistical basis the propagation of neutrons through the described geometry model.

Monte Carlo codes are especially useful because their geometry capabilities permit more extensive benchmarking against critical experiments. The primary Monte Carlo codes used by the WMD criticality safety function are shown below:

15.5.3.1 MORSE: A multipurpose neutron and gamma-ray transport Monte Carlo code used primarily for shielding and neutron criticality problems.

15.5.3.2 KENO IV and GEKENO: Multigroup Monte Carlo codes specifically designed for neutron criticality calculations of three-dimensional systems with leakage and absorption by region and energy group. These codes stress the Monte Carlo method rather than the treatment of cross sections and require broad group cross sections developed elsewhere as problem input. The standard sources of these cross section sets are the JRK Modified

Hansen-Roach 16 group cross section sets or the 123 group or 216 group cross section sets from the AMPX system (NITAWL and X5DRNPM).

GEKENO is a version of KENO which has expanded geometry and editing capabilities. The major difference between KENO IV and GEKENO is that GEKENO permits arrays of box types to be defined internal to other box types.

15.5.3.3 MERIT: MERIT is a version of the BMC Monte Carlo code which has been developed to provide benchmark calculations for design codes used in BWR design. MERIT has a standard 190 broad group cross section set coupled with resonance parameters to permit a more proper treatment of cross section resonances.

15.5.3.4 GEMER: GEMER is a three-dimensional multigroup Monte Carlo code with the geometry features of GEKENO and the cross section and resonance integral treatment of MERIT. GEMER is the most powerful and most accurate code currently used by the criticality safety function and is as a consequence often used to validate the other codes.

15.5.4 <u>Interaction Codes</u>

The analytical methods used to demonstrate the criticality safety of interacting accumulations of fissile material are as follows:

15.5.4.1 Monte Carlo: In some cases, the three-dimensional modelling capabilities in codes uch as GEKENO and GEMER permit explicit modelling and analysis of interacting systems.

15.5.4.2 Solid Angle Code (SAC): The solid angle method is a widely recognized method for specifying safe parameters of an array of interacting accumulations. With this method, accumulations in an array are spaced so that each accumulation of fissile material is allowed to "see" only a number of other accumulation. The maximum allowable solid angle subtended by surrounding accumulations is inversely related to the effective multiplication factor (K_{eff}). The value of K_{eff} for each accumulation is determined using one of the methods of Chapter 15.5 for the unreflected but optimally moderated unit. The solid angles are determined using the "point-to-plane" or exact formulas given in TID-7016, Rev. 1, or from tabulated values in publications such as TID-14975.

If the array being analyzed consists of identical accumulations, only the most centrally located accumulation need be considered as the center point for a solid angle calculation. In other cases, it is usually necessary to choose more than one "center-point" accumulation to assure that the K_{eff}-solid angle relation is satisfied for all accumulations. In the use of the solid angle method, contributions from accumulations that are so far from a "center-point" accumulation that their solid angle does not exceed 0.005 steradians, are neglected provided that the total amount neglected is less than 50% of the total solid angle. The exact relations between the K_{eff} value of an accumulation, and the maximum allowable solid angle that may be subtended by other accumulations is shown in Figure 15.1. Curve #1 of this figure is well known in the literature and has been used extensively for most types of fissile materials. The analytical expression for this curve is:

FIGURE 15.1

k_{eff} - SOLID ANGLE RELATION

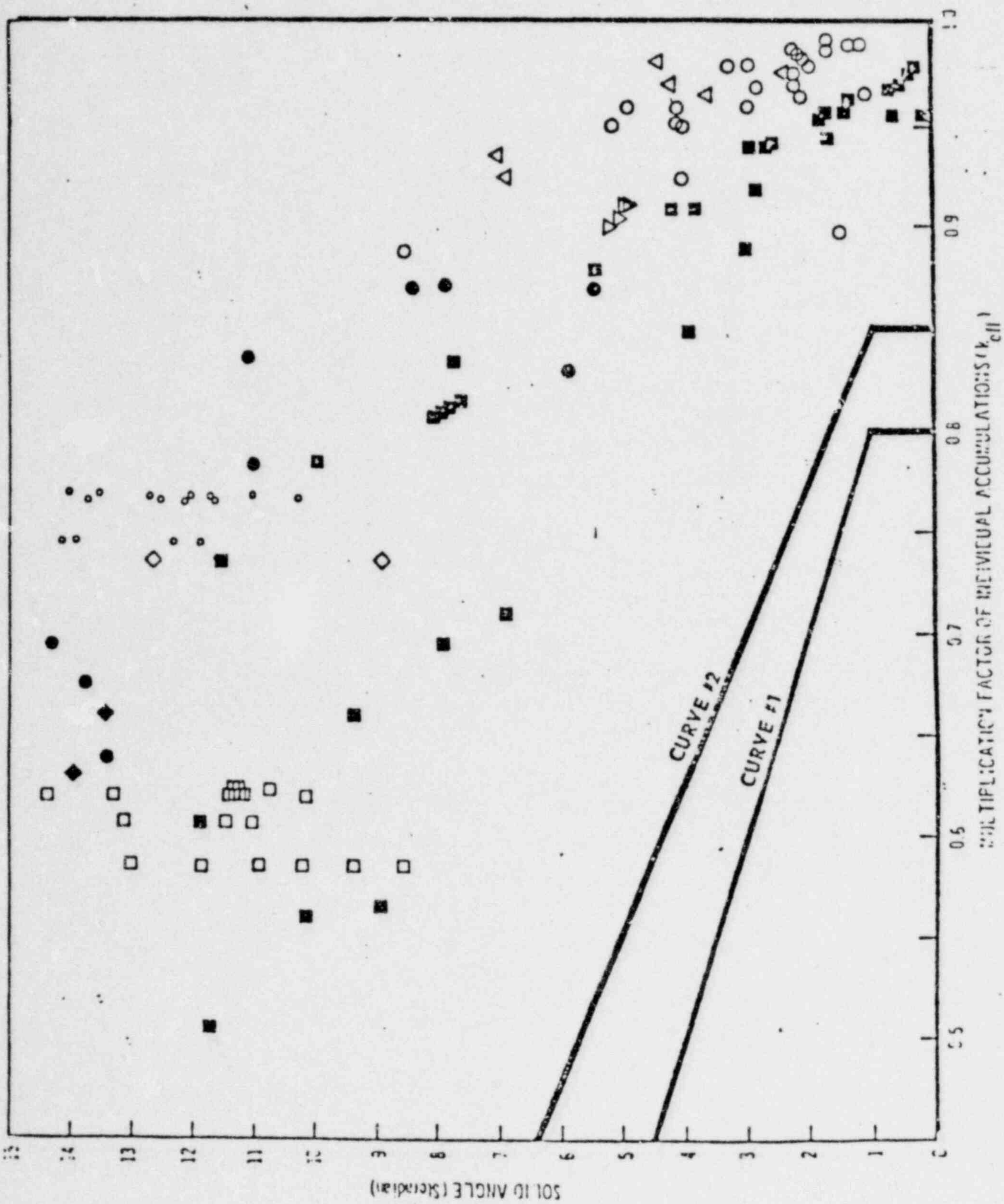


FIGURE 15.1 (continued) KEY TO SYMBOLS

Symbol	Type of Accumulation	Reference
•	H/X 493 4.9% ENRICHMENT CYLINDERS	ORNL-3714, VOL. 1 FIGURE 2.2.1
○	H/X 297 93.2% ENRICHMENT CYLINDERS	Y-1272, FIGURE V 3.3
●	H/X 309 93.2% ENRICHMENT CYLINDERS	Y-1272, FIGURE V 3.4
◆	H/X 50.1 93.2% ENRICHMENT CYLINDERS	Y-1272, FIGURE V 3.5
△	H/X 14.3 93.2% ENRICHMENT CYLINDERS	Y-1272, FIGURE V 3.6
□	H/X 59 92.6% ENRICHMENT CYLINDERS	TID-7028, FIGURE 76
▽	H/X 50 93.2% ENRICHMENT SLABS	Y-1272, FIGURE V 4.1
■	H/X 44 93.2% ENRICHMENT CYLINDERS H/X 169 93.2% ENRICHMENT CYLINDERS H/X 330 93.2% ENRICHMENT SLABS	Y-1272, FIGURE V 1.1
◇	H/X 59 92.6% ENRICHMENT CYLINDERS	TID-7028, TABLE 21

when K_{eff}	ALLOWED SOLID ANGLE (STERADIANS)
<.3	Ω all = 6
.3-.8	Ω all = 9-10 K_{eff}
>.8	Ω all = 0

However, Curve #1 provides an excessive degree of conservatism when applied to many arrays of low enriched UO_2 systems. Therefore, Curve #2 of Figure 15.1 is often used for certain types of arrays. Specifically, Curve #2 may be used for arrays which are only partially reflected (as for example, an array of solution processing vessels in a building that has a thick concrete floor, and thin walls and roof). The limit of array reflection (for using Curve #2) is established as a reflector that is not more effective than a thick water reflector over one-half of the surface of the array.

The analytical expressions for Curve #2 are:

where K_{eff}	SOLID ANGLE (STERADIANS)
<.47	Ω all = 6
.47-.85	Ω all = (12 1/3) - (13 1/3)$\cdot k_{eff}$
>.85	Ω all = 0

Curve #2 is derived in a manner that is analogous to the derivation of Curve #1 which was originally developed by Henry, Newlon and Knight. (K-1317, "Self-Consistent Criteria for Evaluation of Neutron Interaction", December 21, 1956.)

15.5.4.3 ALBALLA/ENANGHAN: These are two Monte Carlo codes that use 16 group Hansen-Roach cross section sets and the KENO/GEKENO anisotropic scattering equations to track neutrons through a medium. ALBALLA estimates the return to a surface of neutrons entering a reflector at a specified energy and angle. ENANGHAN estimates the energy and angular distribution of neutrons that pass through a surface from a source at a specified distance from the surface.

The purpose of these two codes is to compare various reflecting conditions to the reflection provided by a tight blanket of water.

15.6 METHOD VALIDATION

The analytical met [illegible] escribed in the previous sections are validated by comparison with experimental data or benchmark calculations. The recent increase in benchmark critical experiments which is illustrated by work such as that documented in references 11-14 has made possible significant expansion of the application of criticality safety methods and codes. This is especially true of Monte Carlo codes which have the flexibility necessary to take advantage of the technological advances in critical experiments.

15.6.1 In WMD applications, the GEMER and GEKENO Monte Carlo codes are examples of this upgraded technology. These codes were developed not only to take advantage of the new extensions in critical experiment benchmarks but also to permit use of previous validation work; such as the Handley Hopper benchmarks in references 25 and 26 at the end of this chapter or the RSIC Compendium of KENO IV benchmarks.

Tables 15.2 and 15.3 show illustrative benchmark calculations performed with GEKENO and GEMER based on these sources. The examples in the tables are especially applicable to WMD applications because of their ranges of enrichment, moderation and conditions of reflection. The Handley Hopper benchmarks in Table 15.2 are systems with homogeneous fuel-moderator mixtures and the Table 15.3 benchmarks are heterogeneous fuel rod-moderator mixtures. Both sets contain examples of fixed neutron poisons such as boron or cadmium.

Table 15.4 shows the results of an analysis of bias of Tables 15.2 and 15.3. The bias in GEKENO ranges from 0.0035 for homogeneous mixtures to -0.0045 for heterogeneous and that in GEMER ranges from -0.0047 for homogeneous to -0.0092 for heterogeneous. A negative bias indicates that the code underpredicts the experimental value.

15.6.2 Because of the general utility, flexibility, and accuracy of Monte Carlo codes as illustrated by the validation study in the previous section, GEMER and GEKENO calculations are sometimes used as benchmarks for the validation of other analytical methods. An example of this is a comparison study which has been made between GEMER, MERIT, GEKENO and the reactivity formula for homogeneous $U(4.0)O_2$ and water mixtures with typical reflector conditions. Table 15.5 specifies the

TABLE 15.2

VALIDATION OF GEKENO & GEMER FOR HANDLEY-HOPPER BENCHMARKS

Experiment No.	GEKENO K-eff	GEKENO +1 sigma	GEMER K-eff	GEMER +1 sigma
1	1.0047	0.0023	0.9858	0.0025
2	1.0064	0.0023	0.9829	0.0023
3	1.0053	0.0024	0.9864	0.0024
4	1.0014	0.0021	0.9915	0.0023
5	0.9989	0.0025	0.9910	0.0022
6	0.9997	0.0024	0.9944	0.0024
7	1.0128	0.0024	0.9829	0.0026
8	1.0109	0.0022	0.9861	0.0024
9	1.0065	0.0022	0.9891	0.0025
10	0.9957	0.0024	0.9839	0.0023
11	1.0132	0.0029	0.9993	0.0028
11	1.0210	0.0032	1.0000	0.0031
13	0.9996	0.0023	0.9963	0.0028
14	1.0077	0.0028	0.9916	0.0031
15	1.0103	0.0025	0.9937	0.0031
16	1.0049	0.0031	0.9944	0.0030
17	0.9842	0.0027	0.9865	0.0023
18	0.9929	0.0024	0.9879	0.0026
19	1.0050	0.0022	0.9812	0.0019
20	1.0073	0.0023	0.9838	0.0021
21	1.0174	0.0034	1.0144	0.0031
22	1.0155	0.0030	1.0100	0.0035
23	1.0200	0.0032	1.0117	0.0035
24	1.0074	0.0029	0.9974	0.0033
25	1.0106	0.0035	1.0071	0.0032
26	1.0176	0.0033	1.0135	0.0032
27	1.0113	0.0035	1.0105	0.0032
28	1.0127	0.0031	1.0032	0.0041
29	1.0116	0.0036	1.0028	0.0031
30	1.0055	0.0034	1.0081	0.0036
31	0.9998	0.0031	1.0039	0.0033
32	1.0047	0.0034	1.0042	0.0032
33	0.9827	0.0037	0.9907	0.0033
34	0.9793	0.0032	0.9894	0.0034
35	0.9865	0.0033	0.9987	0.0032

Table 15.2 (continued)

Experiment No.	GEKENO K-eff	GEKENO +1 sigma	GEMER K-eff	GEMER +1 sigma
36	0.9920	0.0034	0.9969	0.0033
37	0.9839	0.0036	0.9892	0.0034
38	1.0004	0.0033	0.9966	0.0029
39	0.9938	0.0033	0.9834	0.0033
40	1.0003	0.0034	0.9916	0.0031

TABLE 15.3

VALIDATION OF GEKENO AND GEMER FOR HETEROGENEOUS LOW-ENRICHED URANIUM SYSTEMS

CRITICAL EXPERIMENT REFERENCE	EXPERIMENT NUMBER	GEKENO		GEMER	
		K-EFF	+ SIGMA	K-EFF	+ SIGMA
Bierman (Ref. 11,12 & 14)	12	0.9847	0.0028	0.9832	0.0030
	21	0.9959	0.0030		
	23	0.9988	0.0032	0.9862	0.0032
	26			0.9833	0.0038
	31	0.9983	0.0029	0.9850	0.0031
	32	0.9976	0.0029	0.9914	0.0035
	33	0.9900	0.0031	0.9879	0.0036
	34	0.9911	0.0033	0.9907	0.0035
	35	1.0018	0.0032	0.9895	0.0033
	36	0.9987	0.0031	0.9945	0.0034
	37	0.9955	0.0033	0.9880	0.0033
	38	1.0010	0.0031		
	39	0.9985	0.0034		
	40	0.9890	0.0032		
RSIC (KENO IV Benchmarks	14	1.0377	0.0028	0.9979	0.0029
	15			0.9928	0.0030
	21			0.9959	0.0035
	22			0.9912	0.0029
TRX (REF. 22 and 23)	TRX-1			0.9969	0.0017
	TRX-2			0.9987	0.0020

TABLE 15.4

ANALYTICAL BIASES FOR GEKENO AND GEMER FOR LOW ENRICHED[1] URANIUM SYSTEMS

CASE 1	HOMOGENEOUS MIXTURES	(HANDLEY HOPPER BENCHMARKS)
CODE	Bias[2]	Uncertainty in Bias (1σ)
GEKENO	0.0035	0.00166
GEMER	-0.0047	0.00151

CASE 2	HOMOGENEOUS MIXTURES	(BIERMAN, RSIC, AND TRX)
CODE	Bias[2]	Uncertainty in Bias
GEKENO[3]	-0.0045	0.00143
GEMER	-0.0092	0.00126

[1] Enrichments below 6.0% U-235

[2] A negative value indicates that the experimental value was under predicted

[3] Does not include RSIC Experiment #14

TABLE 15.5

Geometry Parameters for WMD Benchmark Study

	pU (gm/cc)*	Infinite Cylinder Radii, cm		Infinite Slab Thickness, cm	
		Case 1	Case 2	Case 1	Case 2
Over Moderated Mixtures	0.56	27.864	16.105	32.292	16.930
Optimally Moderated Mixture	2.58	14.067	9.593	13.800	7.952
Under Moderated Mixture	6.70	30.761	16.921	33.940	15.860

*4.00% enriched UO_2 and water at full density simple geometries used (infinite cylinders and infinite slabs) and the fuel water mixtures (calculated in accordance with Chapter 15.4 for full density mixtures), and Table 15.6 lists the calculated neutron multiplication factors. These results have been analyzed for biases relative to GEMER and the results are shown in Table 15.7.

15.6.3 The inherent conservatism of the SAC (solid angle code) is illustrated by the comparison of a wide range of critical data points, plotted in Figure 15.1, with the two curves (for half reflected and fully reflected arrays) derived from the solid angle-K_{eff} relationship described in Chapter 15.5. The critical data shown in Figure 15.1 are for arrays that have less than a close fitting full reflector. The exact degree of reflection varies from one experiment to another. It is noted, however, that the data characteristically correspond to reflection due to a floor underneath the experiment and with some reflection from distant walls and a ceiling. Such ref..ction is more effective than no reflection but not as effective as in half reflections.

TABLE 15.6

Comparison of Analytical Methods for WMD Benchmarks

System		Neutron Multiplication Factors (k_∞'s or k-eff ± σ)			
		Reactivity Formula*	GEKENO**	MERIT	GEMER
MATERIAL K_∞'s					
Over Moderated Mixture (ρu = 0.560 gm/cc)		1.150	1.175 ± 0.002	1.144 ± 0.003	1.153 ± 0.001
Optimally Moderated Mixture (ρu = 2.58 gm/cc)		1.390	1.422 ± 0.004	1.351 ± 0.011	1.398 ± 0.003
Under Moderated Mixture (ρu = 6.70 gm/cc)		1.150	1.183 ± 0.003	1.128 ± 0.003	1.134 ± 0.003
UNREFLECTED CYLINDERS					
Over Moderated Mixture	- Case 1	0.967	0.979 ± 0.003	0.971 ± 0.005	0.966 ± 0.004
	- Case 2	0.763	0.756 ± 0.004	0.755 ± 0.004	0.758 ± 0.004
Optimally Moderated Mixture	- Case 1	0.849	0.826 ± 0.005	0.813 ± 0.005	0.831 ± 0.00[illegible]
	- Case 2	0.626	0.545 ± 0.004	0.553 ± 0.005	0.546 ± 0.004
Under Moderated Mixture	- Case 1	0.942	0.948 ± 0.004	0.923 ± 0.005	0.930 ± 0.004
	- Case 2	0.693	0.675 ± 0.004	0.660 ± 0.005	0.659 ± 0.004
UNREFLECTED SLABS					
Over Moderated Mixture	- Case 1	0.946	0.964 ± 0.004	0.959 ± 0.005	0.949 ± 0.004
	- Case 2	0.703	0.680 ± 0.004	0.673 ± 0.004	0.684 ± 0.003
Optimally Moderated Mixture	- Case 1	0.740	0.692 ± 0.005	0.679 ± 0.004	0.689 ± 0.005
	- Case 2	0.474	0.326 ± 0.004	0.333 ± 0.004	0.335 ± 0.003
Under Moderated Mixture	- Case 1	0.898	0.[illegible]07 ± 0.004	0.882 ± 0.004	0.893 ± 0.004
	- Case 2	0.570	0.525 ± 0.003	0.522 ± 0.004	0.528 ± 0.004

*ARH 600 data

**JRK modified Hansen-Roach 16 group cross sections

Table 15.6 (continued)

System		Neutron Multiplication Factors (k-eff ± σ) Reactivity Formula*	GEKENO**	MERIT	GEMER
WATER REFLECTED* CYLINDERS**					
Over Moderated Mixture	- Case 1	1.000	1.021 ± 0.004	1.005 ± 0.005	0.998 ± 0.003
	Case 2	0.850	0.856 ± 0.004	0.845 ± 0.005	0.846 ± 0.004
Optimally Moderated Mixture	- Case 1	1.000	1.008 ± 0.005	0.984 ± 0.005	0.989 ± 0.004
	- Case 2	0.850	0.823 ± 0.005	0.829 ± 0.007	0.817 ± 0.005
Under Moderated Mixture	- Case 1	1.000	1.012 ± 0.004	0.992 ± 0.005	0.990 ± 0.004
	- Case 2	0.850	0.866 ± 0.004	0.835 ± 0.006	0.844 ± 0.005
WATER REFLECTED* SLABS**					
Over Moderated Mixture	- Case 1	1.000	1.016 ± 0.003	1.006 ± 0.004	1.010 ± 0.003
	- Case 2	0.850	0.859 ± 0.005	0.847 ± 0.006	0.846 ± 0.002
Optimally Moderated Mixture	- Case 1	1.000	1.004 ± 0.005	0.997 ± 0.006	0.994 ± 0.005
	- Case 2	0.850	0.835 ± 0.005	0.812 ± 0.005	0.822 ± 0.005
Under Moderated Mixture	- Case 1	1.000	1.021 ± 0.005	0.990 ± 0.004	0.989 ± 0.003
	- Case 2	0.850	0.867 ± 0.004	0.865 ± 0.004	0.850 ± 0.004
CONCRETE REFLECTED** CYLINDERS**					
Over Moderated Mixture	- Case 1	1.011	1.034 ± 0.003		1.021 ± 0.003
	- Case 2	0.878	0.888 ± 0.004		0.884 ± 0.003
Optimally Moderated Mixture	- Case 1	1.052	1.048 ± 0.004		1.040 ± 0.005
	- Case 2	0.928	0.877 ± 0.005		0.870 ± 0.004
Under Moderated Mixture	- Case 1	1.027	1.049 ± 0.004		1.014 ± 0.004
	- Case 2	0.917	0.899 ± 0.004		0.884 ± 0.004

* ARH 600 data
** JRK modified Hansen-Roach 16 group cross sections
*** 30 cm thick close-fitting blanket
**** 40 cm thick Oak Ridge concrete close-fitting blanket

Table 15.6 (continued)

System		Neutron Multiplication Factors (k-eff ± σ) Reactivity Formula*	GEKENO**	MERIT	GEMER
CONCRETE REFLECTED SLABS***					
Over Moderated Mixture	- Case 1	1.016	1.051 ± 0.003	1.031 ± 0.003	1.035 ± 0.003
	Case 2	0.891	0.926 ± 0.004		0.908 ± 0.003
Optimally Moderated Mixture	- Case 1	1.076	1.114 ± 0.004	1.101 ± 0.004	1.100 ± 0.005
	- Case 2	0.964	0.965 ± 0.004	0.954 ± 0.006	0.964 ± 0.004
Under Moderated Mixture	- Case 1	1.038	1.067 ± 0.005		1.031 ± 0.003
	- Case 2	0.945	0.969 ± 0.004		0.934 ± 0.004

* ARH 600 data
** JRK modified Hansen-Roach 16 group cross sections
*** 40 cm thick Oak Ridge concrete close-fitting blanket

TABLE 15.7

BIAS COMPARISONS BETWEEN GEMER REACTIVITY FORMULA, GEKENO, & MERIT

Description	Bias (%) Reactivity Formula	GEKENO	MERIT
REFLECTOR			
Unreflected systems	6.99	0.37	-0.53
Water reflected systems	1.01	1.74	0.11
Concrete reflected systems	0.60	1.72	-0.44
MODERATION			
Over moderated systems	-0.17	1.08	-0.06
Optimally moderated systems	6.71	0.43	-0.38
Under moderated systems	2.06	2.32	-0.25
OVERALL	2.87	1.28	-0.23

REFERENCES TO CHAPTER 15

1. AHSB Handbook 1, "Handbook of Criticality Data"

2. ANS-8.13.1 (draft), "Criteria for Establishing and Applying a Solid Angle Method for Nuclear Criticality Safety," American Nuclear Society.

3. ANSI N16.1, "Nuclear Criticality Safety Standard for Operations with Fissionable Materials Outside Reactors," American National Standards Institute

4. ANSI N16.5, "American National Standard Guide for Nuclear Criticality Safety in the Storage of Fissile Materials," American National Standards Institute

5. ANSI N16.9, "Validation of Calculational Methods for Nuclear Criticality Safety," American National Standards Institute

6. ARH 6C J, "Criticality Handbook," Atlantic Richfield Handford Company

7. BNWL-2233, "Critique of the Solid Angle Neutron Interaction Method," Battelle Pacific Northwest Laboratory

8. Glasstone, S. and Sesonske, A., "Nuclear Reactor Engineering," Van Nostrand Reinhold Company, New York, 1967

9. K-1317, "Self-Consistent Criteria for Evaluation of Neutron Interaction," 1956

10. LAMS-3067, "Los Alamos Critical Mass Data"

11. NUREG/CR-0073, "Critical Separation Between Subcritical Clusters of 4.29 WT % U-235 Enriched Rods in Water with Fixed Neutron Poisons," Battelle Pacific Northwest Laboratory

12. NUREG/CR-0674, "Benchmark Critical Experiments on Low-Enriched Uranium Oxide Systems with H/U = 0.77," Rockwell International Energy Systems Groups

13. NUREG/CR-0796, "Criticality Experiments with Subcritical Clusters of 2.35 WT % and 4.29 WT % U-235 Enriched UO_2 Rods in Water with Uranium or Lead Reflecting Walls," Battelle Pacific Northwest Laboratory

14. NUREG/CR-1784, "Criticality Experiments with Subcritical Clusters of 2.35 WT % and 4.31 WT % U-235 Enriched UO_2 Rods in Water with Steel Reflecting Walls," Battelle Pacific Northwest Laboratory

15. ORNL-3714, Volume 1, "Neutron Physics Division Annual Progress Report for Period Ending August 1, 1964"

16. ORNL-4938, "KENO IV, An Improved Monte Carlo Criticality Program," Oak Ridge National Laboratory

17. ORNL/TM-3706, "AMPX: A Modular Code System for Generating Coupled Multigroup Neutron-Gamma Libraries from ENDF/B," Oak Ridge National Laboratory

18. Regulatory Guide 3.4.1, "Validation of Calculational Methods for Nuclear Criticality Safety," U. S. Nuclear Regulatory Commission

19. TID 7016, "Nuclear Safety Guide," Revision 2 (1978), Oak Ridge National Laboratory

20. TID 7028, "Critical Dimensions of Systems Containing U-235, Pu-239, and U-233," Los Alamos Scientific Laboratory and Oak Ridge National Laboratory

21. TID-14975, "Tables of Solid Angles," University of North Carolina at Chapel Hill

22. WAPD-176, "Kinetic and Buckling Measurements on Lattices of Slightly Enriched Uranium and UO_2 Rods in Light Water," Bettis Atomic Power Laboratory, 1958

23. WAPD-TM-931, "A Study of Physics Parameters in Several Water-Moderated Lattices of Slightly Enriched and Natural Uranium," Bettis Atomic Power Laboratory, 1970

24. Y-1272, "Y-12 Plant Nuclear Safety Handbook," Oak Ridge National Laboratory

25. Y-1858, "Validation Checks of the 'ANISN' and 'KENO' Codes by Correlation with Experimental Data," Oak Ridge National Laboratory

26. Y-1948, "Validation of the 'KENO' Code for Nuclear Criticality Safety Calculations of Moderated, Low-Enriched Uranium Systems," Oak Ridge National Laboratory

16.0 PROCESS DESCRIPTION AND SAFETY ANALYSES

Included in this chapter are descriptions of each major process step and a discussion of the associated safety features. An overall process flow sheet is shown in Figure 16.1. The part of the overall process flow sheet associated with each major process step is also shown in each section in which the process step is described.

16.1 Receiving and Storing UF_6

16.1.1 Process Description

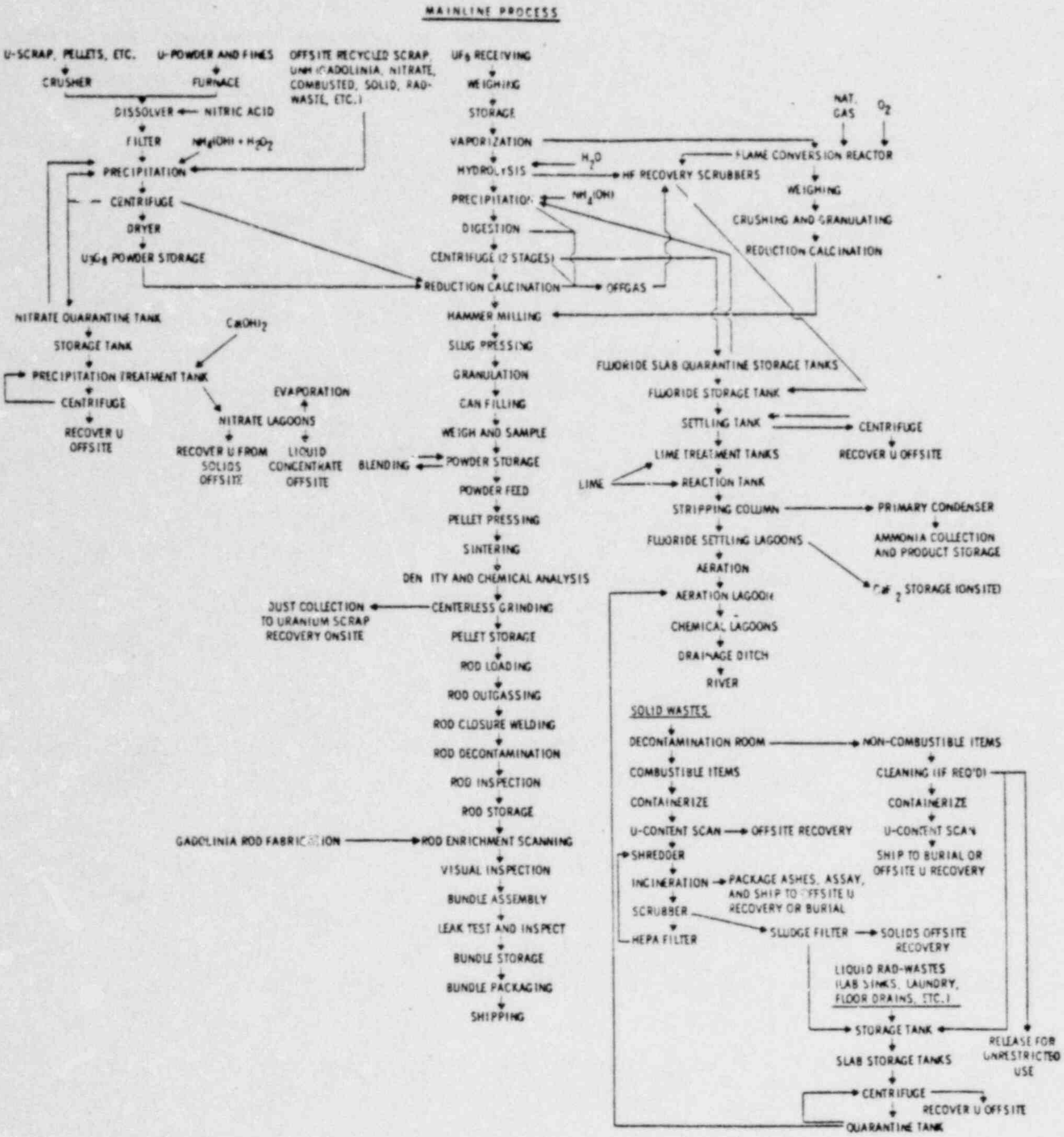
Uranium hexafluoride (UF_6) enriched in U-235 up to 4.0% is received in 2.5 ton, 30" diameter cylinders (Models OR-30A or OR-30B) each contained within a protective shipping overpack (Models 21PF-1 and 21PF-2). Five cylinders are normally received in a single truck shipment. The protective overpack is opened to permit removal of the UF_6 cylinder via an installed bridge crane and transferred to a scale where it is weighed and placed in cylinder storage position on the receiving and storage platform.

Storage space is provided for 35 of the OR-30A or OR-30B cylinders on the elevated concrete platform adjacent to the truck unloading area.

UF_6 enriched in U-235 above 4% for use in the Process Technology Laboratory is received in 55 pound, 5" diameter cylinders (Model OR-5A), each contained within a protective shipping overpack (Model 20PF-1). One or two cylinders are normally received in a single truck shipment. The protective fixture is opened to permit removal of the UF_6 cylinder in the UF_6-to-UO_2 conversion area of the laboratory. The cylinder is

FIGURE 16.1

GE-WMD PROCESS FLOW SHEET



placed on a scale, weighed, and placed in a storage area within the confines of the laboratory.

The one or two OR-5A cylinders are stored in a designated location within the Process Technology Laboratory.

16.1.2 Safety Features

The full UF_6 OR-30A or OR-30B cylinders are received in protective overpacks. These cylinders are stored outside within a fenced storage pad equipped with criticality sensors which tie into the plant criticality warning system. The cylinders are placed on metal "chocks" in an array which maintains a 12" spacing. Those cylinders that are being queued for imminent use are stored on an elevated concrete platform next to the vaporization room which is adjacent to the truck unloading area. These cylinders are also stored on metal "chocks" and maintain a 12" spacing.

16.1.3 Safety Analyses

As reported in K-1686[1], protective shipping packages for UF_6 cylinders are designed to withstand severe accidents without release of radioactive contents. Receiving facilities are designed to minimize the travel distance of bare cylinders from the truck bed to the scale and to the storage areas.

Cylinders containing UF_6 (99.5% pure UF_6) of less than 4.2% enriched uranium have been shown to be nuclearly safe even with interspersed water moderation, and in a close packed ($\leq$ 1.0" edge-to-edge) hexagonal array.

[1] K-1686, Protective Shipping Packages for 30" Diameter UF_6 Cylinders, A. J. Mallet, C. E. Newlon

Although these experiments involved only seven cylinders, it has been shown (K-1686) by calculation that criticality is improbable for any number of containers of this size with ≤ 0.5% impurities and ≤ 4.5% enrichment.

In addition to the K-1686 study, WMD has performed an analysis to show that an infinite two high array of 30A or 30B UF_6 cylinders whose axes are parallel to the ground is critically safe regardless of the arrangement of the cylinders. This analysis was performed with the GEKENO Monte Carlo Code using JRK Modified Hansen-Roach 16 group cross section sets. The results showed that for U-235 enrichments up to 5.00%, the k-effective of the infinite two high array with optimum interspersed water and full reflection by water and concrete was less than 0.93 at the 99% confidence level. The maximum k-effective of a normal one high planar array under the same interspersed moderation and reflection conditions is less than 0.84 at the 99% confidence interval.

Cylinders containing UF_6 (99.5% pure UF_6) of greater than 5% enriched uranium are loaded as limited by the parameter of mass, volume, shape, and moderation.[2] No more than 80% of a critical mass is loaded into each cylinder. Also, outer packaging is used to assure safe spacing.

Internal moderation of the UF_6 cylinders during operations with those cylinders is not credible.

[2]ORO-651, Revision 3, Uranium Hexafluoride Handling Procedures and Container Criteria.

Receipt of the correct number of cylinders is verified by count. Gross weight of each cylinder is compared with shipper documentation and significant differences are reconciled with the shipper. A cylinder travel card is prepared for each cylinder identifying pertinent UF_6 data.

Storage of the OR-30A or OR-30B cylinders on the raised cement platform effectively precludes accidents involving collisions by vehicles. Equipment for handling UF_6 cylinders are limited to the overhead crane, special transfer cart and forklift with special cylinder handling attachment, each sized with ample safety margins to prevent damage to the cylinder during handling operations. The cylinder valve cap is is place whenever the cylinder is in transit with any of the handling equipment. Radiation levels at the surface of fully loaded cylinders seldom exceed seven mr/hr.

In addition, it should be noted that the storage area is covered by a sheet metal roof which serves to preclude interspersed moderation between cylinders. OR-5A cylinders are stored indoors, thus also precluding interspersed moderation between these cylinders.

A sample of UF_6, certified to have been withdrawn from the vessel containing the material subsequently loaded into shipping cylinders for transfer to GE, is shipped to an independent laboratory. This sample is analyzed to verify that the enrichment is not greater than 4.0%, for the OR-30A or OR-30B cylinders, and to verify the enrichment as to what is on the label and shipping papers for the OR-5A cylinders.

16.2 UF_6-to-UO_2 Conversion - ADU Process

16.2.1 Cylinder Connections and Vaporization

16.2.1.1 Process Description

Cylinders are moved one at a time on the transfer cart from the storage platform into the adjacent vaporization room where an installed overhead bridge crane is used to lift cylinder and lower it into one of the vaporization chambers. With the cylinder at ambient temperature, the valve cap is removed and flexible tubing is connected.

The cylinder is heated within its vaporization chamber by means of recirculation of air which is electrically heated within the closed system. Vaporized UF_6 flows through the installed header system and is hydrolyzed to UO_2F_2 + HF in a 10" diameter hydrolysis vessel in the adjacent chemical processing room.

When the flow of gas from the cylinder slows significantly, the residual UF_6 gas is withdrawn into a "cold trap". The cold trap is an externally refrigerated 12" inside-diameter cylinder (OR-12A). The UF_6 is drawn into the cold trap which has previously been evacuated by a vacuum pump which exhausts to the filtered vent system.

16.2.1.2 Safety Features

The ambient temperature in the vaporization chamber is recorded continuously and an overtemperature device de-energizes the electrical heater at a preset temperature well below that which could result in UF_6 system rupture. Power to the heater is also de-energized upon indication of abnormally high line pressure.

In the event of piping or valve rupture, a quick quench carbon dioxide discharge system is activated locally by a process operator or remotely from the process control room to aid in freezing the UF_6 at the point of rupture and in general cooling of the cylinder. A photoelectric device is installed in each vaporization chamber to aid in leak detection.

Full-face filtered respirators are worn by personnel when the cylinder connection is made and during other activities in which a potential UF_6 exposure exists.

Additionally, each vaporization chamber is independently connected to a ventilation duct fan which may be activated from the control panel to exhaust chamber atmosphere in the event of unusual leakage. This system discharges to the water scrubber in the vent system.

It has been demonstrated that water from the hydrolysis receiver (capacity nineteen gallons of water) cannot enter the UF_6 cylinder at times of low UF_6 flow due to the immediate formation of the uranium hydrate which plugs the connecting line and stops all flow. At times of low cylinder flow, the cylinder contains only a residual heel. Normal heel quantities are of the order of ten to twenty pounds of UF_6. The heel must be cold-trapped in order to reduce the heel value.

The cold trap vessel is a 12" cylinder with an external cooling coil in which a refrigerant is circulated. The reflecting properties of the refrigerant are probably less effective than those of water and there is no mechanism for introducing the refrigerant into the cold trap. Even if the cylinder were filled with an optimally moderated UO_2F_2 solution instead of dry UF_6, the system would still be subcritical due to its 12" diameter being less than the 12.5" diameter required for criticality of a 4.0% reflected system.

16.2.1.3 <u>Safety Analysis</u>

Interaction among vessels in the chemical process area has been analyzed by the k-effective solid angle method and shown to be within safe limits. In addition, process ventilation equipment such as scrubbers, bag houses, etc., have been sized to be critically safe and included in the interaction calculations.

Criticality safety of the primary exhaust system scrubber reservoir is based on controls in the manufacturing operation which preclude major releases of uranium to the scrubber and on concentration limits in the basin itself. The geometry of the reservoir is a slab 13 1/2' wide by 15' long by an average of 6" deep. Based on the standard operating conditions and the postulated worst case accident of loss of an entire UF_6 cylinder into the scrubber system, the maximum credible uranium density will not exceed 275 gm U/liter. Adequate mixing is assured by the constant agitation of the scrubber system and at the 275 gm U/liter level, settling of (soluble) UO_2F_2 in water is not credible. Criticality safety is achieved since 275 gm U/liter is below the 350 gm U/liter limit tabulated in ARH-600 for which 4.0% enriched UO_2 and water achieve a $K_\infty < 1.0$.

Minor losses of gaseous UF_6 are expected during cylinder connection and disconnection but normally are less than 1 kilogram of UF_6 or less than 25 grams of U-235 per cylinder. Even under unusual leakage situations, however, essentially all of this material would be recovered in the vent scrubber system and returned to the process. Since the only UF_6 flow path from the cylinder is to the hydrolysis tank or the cold trap, there are no possibilities for accidental losses through valving errors. The net weight of residual material in the empty cylinder is determined by re-weighing prior to cylinder return and is verified at the suppliers plant.

16.2.2 Precipitation

16.2.2.1 Process Description

Vaporized UF_6 is introduced beneath the liquid level in a 10" diameter polypropylene hydrolysis receiver tank where it is contacted with a predetermined quantity of water recirculating by pump through one of two 10" diameter hydrolysis storage tanks. When the proper concentration of uranyl fluoride (UO_2F_2) is formed, as indicated by specific gravity instrumentation, the recirculation (hydrolysis process) is diverted to a second identical hydrolysis storage tank and the contents of the first tank are fed by pump to the 10" precipitation tank.

Ammonium hydroxide is flow-controlled into the precipitation tanks where the ammonium diuranate (ADU) precipitate is formed. Upon completion of precipitation, the suspension is pumped to the 10" diameter digestor tank.

16.2.2.2 Safety Features

The hydrolysis receiver tank is equipped with a hood through which off-gases are collected and in turn withdrawn by the vent system into a water scrubber.

Hydrolysis and precipitation process steps are conducted in closed tanks vented to the process vent system. In the event of leakage, the contents may be pumped to standby tanks to permit prompt repairs.

The hydrolysis storage, precipitation and digest tanks have an inverted "Y" in the vent lines. There are neither pumps nor drainage systems in this area to which process material can flow from leaks or ruptures of the equipment. A gross rupturing of a vessel would flow over the floor of the UF_6 conversion area in a safe slab configuration.

Since all process material is enclosed, there are no mechanisms for significant loss of nuclear material.

16.2.2.3 Safety Analyses

The aqueous solutions in the precipitation and digestion processes are confined to 10" diameter polypropylene tanks. This diameter is 80% of the minimum critical diameter for 4.0% enriched UO_2F_2 if optimum moderation and full water reflection are assumed. The walls of the tanks, which are polypropylene for corrision resistance are at least 1/2" thick and are operated near room temperature and pressure. The tanks are not subject to accidental enlargement; nevertheless, all polypropylene tanks, which are greater than 8.5' in height and the hydrolysis receiver which is about 7' in height are externally reinforced to preclude enlargement to unsafe diameter.

Process material is controlled to prevent its flow to unsafe geometry systems. If the liquid level in the hydrolysis receiver tank rises, despite control instrumentation, the liquid would overflow through a 2" hole in the bottom of the hood. If the normal liquid level increases in the water scrubber basin it would overflow to the floor via the hood at a volume of 20.169 liters (64.5% of the critical volume). Should that overflow line become plugged, it would rise to 37.035 liters (81.8% of the critical volume) and similarly flow to the floor via the hood through the vent line.

16.2.3 Centrifugation

16.2.3.1 Process Description

From the precipitation vessel, the ADU slurry containing about 2% solids is continuously pumped to a horizontal cylindrical dewatering centrifuge. Dewatered ADU "paste", containing about 50% water, discharges downward through a 5" or 6" thick slab-type hopper to a pump feeding the defluorination-reduction unit. Water from this centrifuging step normally retains about 500 parts ADU per million part water and is therefore passed through a second high speed clarification centrifuge of

1.8 gallon capacity where more than 95% of the remaining ADU is removed and pumped back to the precipitation tank. The aqueous stream is pumped to quarantine tanks (addressed in Chapter 16 15.2).

16.2.3.2 Safety Features

The centrifugation step introduces no new or different radiation hazards. The equipment provides a totally enclosed environment for the process streams with provisions for removal of uranium constituents from effluent vapors prior to their release to the environment.

16.2.3.3 Safety Analyses

The ADU dewatering centrifuge has been analyzed under conservative and simplifying assumptions due to its complex geometry. The calculations were done using the KENO IV computer code and JRK modified Hansen-Roach 16 group cross section sets.

The results of the analysis show that under the postulated worse case accident (assuming a maximum credible percent solids of 70%) with full reflection by water and concrete, the system k-effective is less than 0.932 at the 99% confidence level. With the same geometry conditions and optimum moderation the k-effective value is less than 0.97 at the 99% confidence interval. Under normal conditions the centrifuges are geometrically safe since the solids discharge is controlled by the 5" thick discharge hopper.

The only accidental loss mechanism from the centriguge process is through equipment leakage which is readily detectable and would be in the form of a dilute (less than 0.1% ADU) aqueous solution.

16.2.4 Defluorination

16.2.4.1 Process Description

The ADU paste is continuously fed into the 10" inside diameter horizontal chamber of a gas-fired defluorination-reduction furnace where it is dried at about 1200°F and reduced to uranium dioxide (UO_2).

The product chamber rotates about its horizontal axis and is slightly tilted from the absolute horizontal, thus transferring the product by gravity through the heated chamber.

A steam-dissociated ammonia reducing atmosphere is passed through the chamber countercurrent to the product flow. Off-gas from the product chamber is withdrawn by means of a blower, after passing through a 10" diameter baffled water scrub chamber.

16.2.4.2 Safety Features and Analyses

This step of the process is conducted in an enclosed chamber. The process chamber is vented to a scrubber system which removes ammonia and fluorides prior to filtration. The gas-fired heating chamber is designed to meet standard codes.

The defluorinator chamber has a 10" inside diameter and thus is critically safe even if filled with optimumly moderated material since the minimum critical cylinder diameter for UO_2-H_2O systems is 11.3". The 1/2" thick Inconel wall of the chamber prevents loss of the product to a more reactive configuration. The defluorinator may be safely operated at temperatures up to 2100°F.

The only credible loss mechanism for uranium being processed in the defluorination step is that involved with a buildup of material in the expansion bellows at each end. Although no material accountability problems arise due to such buildup, the bellows area are of concern to the criticality safety of the operation since maximum diameter involved is as much as 19.5".

To demonstrate criticality safety under such conditions, an analysis has been performed with the GEKENO Monte Carlo Code using JRK modified Hansen-Roach 16 group cross section sets. The analysis considered 4.0% enriched UO_2 and water with optimum moderation in the 10" defluorinator tube and a buildup in the bellows filling up half the available volume. The result was that for full external reflection of the defluorinator system, the maximum k-effective was less than 0.97 at the 99% confidence interval.

16.3 UF_6-to-UO_2 Conversion - GECO Process

16.3.1 Process Description

Uranium hexafluoride (UF_6) is received in steel cylinders containing ~4800 pounds of solid material. The cylinder is placed in a steam autoclave and heated by the condensing steam. The UF_6 melts at 150°F and the liquid is heated to about 180°F developing a gas pressure of 50-psia. The hot UF_6 gas is fed to the reactor.

The reactor is a vertical, cylindrical chamber. Gaseous UF_6, hydrogen from dissociated ammonia (DA), and oxygen from dry air, are introduced through a nozzle assembly into the top of the reactor. The critical flow rate of each component is measured and controlled within $\pm$ 2% of the component parameter.

The chemical reactors for this process are:

Primary reaction -

$$UF_6 + 6H_2 + 3.2O_2 \rightarrow 1/3\ U_3O_8 + 6HF + 3H_2O + 0.37O_2$$

Secondary reaction -

$$UF_6 + 2H_2 + O_2 \rightarrow UO_2F_2 + 4HF$$

About 80% of the UF_6 is converted to U_3O_8 and the remaining to UO_2F_2. These reactions take place in a flame in which the UF_6 burns in the presence of hydrogen and oxygen.

The hot reaction products, U_3O_8 and UO_2F_2 powder, water vapor (H_2O), hydrogen fluoride (HF), nitrogen (N_2), and oxygen (O_2) are discharged from the bottom of the chamber to the primary filter. The U_3O_8 and UO_2F_2 powder are removed from the gaseous phase. This separation takes place in the primary filter, containing hollow, porous monel filter tubes. The powder is collected on the external surface of the filters and the gas is pulled through the porous metal by a high volume vacuum system. The efficiency of these filters is 99.999%.

Dry powder from the primary filter is fed into the defluorinator and dissociated ammonia and steam are introduced into the discharge end flowing countercurrent to the powder. The defluorinator is a rotating, gas-fired kiln, similar to the ADU defluorinator.

In the defluorinator, the fluoride is removed from the UO_2F_2 and the U_3O_8 powder is reduced to UO_2 at temperatures up to 700°C. The UO_2 powder is discharged from the defluorinator and is collected in 5-gallon cans, weighed, and sent to the powder preparation operation.

The gas stream removed from the front of the defluorinator is cooled and scrubbed with deionized water and discharged to the process ventilation system. Ammonium hydroxide is added to the scrub water to neutralize the hydrogen fluoride, and the water is sent to waste treatment. This is the only potential for systematic loss of uranium from the GECO process.

The gas stream from solids separation contains hydrogen fluoride (HF), water vapor (H_2O), nitrogen (N_2), and oxygen (O_2). This gas passes through an absorption system to recover the HF as an acid solution. This is a standard absorption system commonly used in the chemical industry for recovery of acid gases.

The acid solution contains about 30% HF. It is purified by distillation and stored for sale or disposal. The gas from the absorption system contains mostly nitrogen and oxygen with trace concentrations of HF and water vapor. The gas goes to the vacuum system where it is scrubbed with ammoniated water to remove any HF and discharged to the process ventilation system.

16.3.2 Safety Features and Analyses

Excess air is provided to ensure complete consumption of the hydrogen in the GECO reactor.

Interlocks such as flow, temperature, and flame sensors ensure safe operation of the reactor.

The reactor pressure is controlled to a sub-atmospheric pressure. A special high-volume vacuum scrubber system pulls the gases from the reactor through the filters and HF recovery system.

16.3.2.1 Hydrogen

Safety features have been built into the hydrogen distribution system supplying hydrogen to the GECO reactor to avoid hydrogen fires or explosions in the system, as follows:

16.3.2.1.1 Dissociated Ammonia Production Unit

Dissociated gases are cooled in the unit and pressure regulated to 7-psig (0.5 kg/cm^2 gauge). Pure hydrogen will not explode unless there is oxygen or air present and the hydrogen content of the mixture has to be less than 75%. Air is excluded from the system by design.

16.3.2.1.2 Hydrogen Distribution System

The piping used for the hydrogen distribution system consists of all-welded lines. Air is excluded from the lines by design.

Pressure in the line is limited to 15 psig (1.1 kg/cm^2) gauge by a pressure reducing valve.

Lines are purged with nitrogen and pressure tested at 100 psig prior to each use of the system.

16.3.2.1.3 Reactor Unit

There are provisions to assure that hydrogen will not pass through the reactor even under upset conditions. These are (1) the reactor gases are always maintained in an oxidative environment. (i.e., ratio of H_2 to O_2 is always < 1.9, minimum H_2/O_2 ratio of 2.1 required for detonation, (2) as inlets are automatically shut off and the reactor shut down under "upset conditions" such as loss of vacuum inside the reactor, high hydrogen flow, or no hydrogen flame and (3) after reactor shutdown, a five minute post-operation purge of the system with nitrogen occurs.

16.3.2.2 Other Gases

The small amount (<0.0001%) of U_3O_8 and UO_2F_2 powder that passes through the primary filter is carried into the HF recovery system with the off-gas from the primary filter. There this powder is captured by the exhaust gases that go to the roof scrubber and HEPA filter in the chemical area exhaust stack. This stack is monitored daily for compliance with requirements for uranium and weekly for fluoride content in gaseous effluents to the atmosphere.

There are cases where UF_6 could be carried through the reactor under upset conditions. For example, if both the H_2 and O_2 (air) systems failed at the same time (double failure), some unreacted UF_6 could pass through the system before the inlet valves automatically closed.

Under such conditions, most of the UF_6 will condense out into the pipes as UO_2F_2 and travel into the primary filter, and then be caught in the hydrogen fluoride recovery system. The small remainder will be caught in the offgas system and exhausted to the roof scrubber where it would be converted to UO_2F_2 in liquid form. Thus all such UF_6 would be trapped before reaching the roof exhaust stack.

The gas from the primary filter, which contains HF, water vapor, nitrogen and oxygen, as well as the very small quantities of U_3O_8 and UO_2F_2 (0.0001% of the powder in the gaseous phase before passing through the primary filter), all goes to the HF recovery system. This is a standard absorption system commonly used in the chemical industry for recovery of acid gases. The gas from the absorption system goes to a vacuum system where it is scrubbed with ammoniated water to remove any HF and then discharged to the process ventilation system.

The gas stream removed from the front of the defluorinator is cooled and scrubbed with ammoniated deionized water and discharged to the process ventilation system.

Thus, eventually, the gas stream from the primary filter as well as those from the vacuum system and from the defluorinator, are all discharged into the same process ventilation system.

The criticality safety of the steam autoclaves is assured by controls which limit the amount of water which can come into contact with UF_6 under any credible accident conditions. Under normal conditions the autoclave is critically safe since, as discussed in Chapter 16.1.3, a water refelcted UF_6 cylinder filled with 2000 kg of 5.0% enriched UF_6 is critically safe if no more than 0.5% by weight of the contents are impurities.

The control of water in the system autoclave environment is based upon calculations made with the GEKENO code which show that the minimum amount of water required to result in criticality for a 5.0% enriched UO_2 + H_2O system with tight water reflection is 22 liters. Based on this the steam environment is controlled by temperature and pressure to assure that the total amount of water inside the autoclave (including that in the UF_6 cylinder by virtue of the 0.5% impurity level) is less than 16 kg. In addition to the temperature and pressure controls, the steam autoclave is also designed with controls to monitor the HF content of the autoclave steam and the condensate drain line to assure that condensate water is properly drained. Failure of any of these controls (including temperature and pressure) results in immediate shutdown of the system and shutoff of the steam supply.

The GECO reactor and primary filter systems are critically safe because of geometry control. This has been demonstrated by calculations made with the GEKENO code and JRK modified Hansen Roach 16 group cross sections in which it was shown that for 4.00% enriched

U_3O_8 and water with optimum moderation and full reflection. The results of these calculations were that the k-effective of the reactor was less than 0.945 and the k-effective of the primary filter wsa less than 0.965 at the 99% confidence level.

The HF recovery system is also critically safe because of geometry control. All vessels in the system have cylindrical diameters no greater than the safe geometry limits listed in Table 4.1.

16.4 UO_2 Powder Pre-Treatment

16.4.1 Process Description

Uranium dioxide is discharged from the defluorinator through a 6" diameter double rotary airlock system to 5-gallon cans. Lids are placed on the cans and they are then moved to a station to be transferred to a hammermill. The dry milled product discharges to a slab-shaped hopper which feeds a 2.5" diameter conveyor. This conveyor transfers the material to a 5" thick slab-type powder collector feeding a predensifier press via a 3" diameter base. At the predensifier, the material is compacted in a 3 1/8" diameter, 2" deep die cavity and transferred to a granulator via a 3" slab-type vibrating conveyor. The 16-liter granulator crushes the compacts into material of uniform particle size which is discharged via a 5.9-liter hopper through a 4" diameter hose into a 5-gallon product transfer and storage can. The product transfer and storage can is a standard 5-gallon paint pail having a 11 1/4" inside diameter. Filled cans are moved one at a time to a storage warehouse. Prior to transfer to the storage area, a statistical sample of the powder production is analyzed for moisture and uranium content and each can is weighed and labeled.

16.4.2 Safety Features and Analyses

Equipment used to handle and process UO_2 powder is designed to assure a high degree of containment integrity due to the intrinsic economic value of the material. To prevent loss of powder from the hammermill, a vented enclosure is installed. Additionally, if the mill becomes plugged, it will be detected by loss of vacuum at the inlet air stream to the mill and the milling process can be promptly shut down.

The completely enclosed and controlled process equipment used in the UO_2 pre-treatment has been sized to be critically safe under conditions of optimum moderation and full reflection. Powder controlling enclosures (hoods) would not retain water, however. The highest reactivity occurs in the granulator and granulator hopper complex. The nuclear safety of this complex is based on geometry safety under the specifications given in Table 4.1 or as demonstrated by Monte Carlo Code calculations. The hammermills and granualtors have been analyzed using the KENO IV doe with JRK Modified Hansen Roach 16 group cross-sections for the case of optimum moderation and full reflection. For 4.0% enriched UO_2 powder these results were that the k-effectives were 0.9550 $\pm$ 0.0049 for the granualtor. These are both less than 0.97 at the 99% confidence interval.

The criticality safety of the slab type powder collector and predensifier are based on the 5" safe geometries and volumes in accordance with Table 4.1.

The 5-gallon product can is nuclearly safe based on the 22.45 liter volume which is 51.9% of the minimum critical volume under conditions of full-reflection. Howver, the product containers are sampled on a statistical basis and the UO_2 analyzed for moisture prior to transfer to the dry storage area on the mezzanine.

The weighing of cans of powder represents the first opportunity to perform an in-process inventory measurement since the UF_6 cylinder receiving point. These scales are calibrated according to a set schedule.

16.5 UO_2 Powder Blending

UO_2 powder is blended for purposes of adjusting the uranium enrichment or for assuming homogeneity of physical properties for a batch of UO_2 powder. Two blending methods are currently in use - slab blending and fluidized bed blending.

16.5.1 Slab Blender - Process Description

Powder to be blended is accumulated in 5-gallon pails and transferred to hold areas in the immediate area of the blender. The cans are then transferred, one at a time, to an enclosed and ventilated hood, where the blend is charged to the slab-process vessel.

After the blender has been charged, it is closed and rotated. Upon completion of the blend, the blended material is discharged to 5-gallon containers which are subsequently transferred to the adjacent hold area to await enrichment verification.

16.5.2 Fluidized Bed Blender - Process Description

As an alternate to the slab blender described above, a fluidized bed blender has been designed and built. The blender includes a vertically oriented mixing vessel equipped with a fluidizing grid attached at the bottom. Also attached at the bottom is a valved outlet and a conduit assembly for UO_2 powder discharge into a 5-gallon container. The fluidized bed apparatus is mounted over an enclosed conveyor for moving empty containers under the discharge assembly and for moving full containers out.

Weight of UO_2 discharged into the container is controlled automatically. All powder vessels are designed to be geometrically safe for uranium at U-235 enrichments up to and including 4%. The entire apparatus including the conveyor under the discharge assembly is equipped with containment to preclude release of airborne UO_2 powder.

16.5.3 Safety Features and Analyses

Five-gallon cans in transit and storage are fitted with lids, thus precluding significant radiation safety hazards. The transfer hood is exhausted through absolute filters to insure sufficient face velocity to preclude loss of uranium dusts to the working environs.

The criticality safety of the UO_2 powder blending operations is based on geometry safety. Five-gallon containers are geometrically safe for 4.00% enriched UO_2 by virtue of their 22.45 liters volume. The corresponding safe geometry volume for 4.00% enriched UO_2 is 29.0 liters (Table 4.1).

The slab blender and fluidized bed blender are both geometrically safe by virtue of their 5.0" slab thickness (Ref. Table 4.1).

16.6 Pellet Production

16.6.1 Process Description

The 5-gallon cans containing UO_2 powder are positioned one at a time in each of the hoods which contain hoppers connected to tubes that feed UO_2 powder to the pellet presses on the floor below. Each of these cans has an identity card which is used to input pertinent data to the computer before the powder is transferred to the press.

Pellets formed by the pellet presses are nominally a little more than 1/2" long and 1/2" in diameter and are transferred, as they are formed, into permanently numbered open-top box-shaped containers fabricated of molybdenum metal (referred to as furnace boats). The U-235 enrichment (percent) is impressed deeply into one end of each pellet.

As each furnace boat is being loaded, sample pellets are checked for density. The weight of each filled boat is determined and an accompanying identity card is prepared and data inputed to the computer.

The card remains with the pellets throughout subsequent process steps. Filled boats are stored on a slab type conveyor system in the sintering furnace room.

16.6.2 Safety Features and Analyses

UO_2 powder pails remain closed during storage to protect product quality and thus present no radiation safety hazard. Filtered hoods above the feed hoppers are designed to maintain sufficient face velocity to assure no powder is lost from the feed system as shown by air samples at the work stations. Pellet presses are equipped with filtered vented enclosures and pressed pellets are not subject to significant dusting problems.

The powder hoppers are a maximum of 10" in diameter and are separated by 12' from one another. The hoppers are connected by a vertical 4" diameter feed line to the presses. The 5-gallon cans are fitted with valve cones to facilitate transfer of powder to the hopper. The safety of this operation is based on the absence of moisture in the powder and on the diameter of the hopper and feed line. The pellets, after pressing, are placed in furnace boats which are transferred to a conveyor storage system prior to introduction into the sintering furnaces. The conveyor system is designed as a safe slab limited to 4" high. This is 83% of the minimum critical slab thickness for pellets stacked in furnace boats.

16.7 Sintering

16.7.1 Process Description

Furnace boats are received in the furnace area and two boats are charged in a single line into one of five electrically fired furnaces that are maintained at about 1800°F. As the boats pass through the furnaces in a controlled reducing atmosphere, the pellets are sintered to about 95% of theoretical UO_2 density. Upon discharge from the furnaces, the furnace boats are stored on the slab-roller conveyor system prior to entering the next processing area which is grinding. A computer transfer is made for each boat exiting from the furnaces and the density is determined of each boat of pellets using a gamma densitometer. A statistical sample of pellets is analyzed for uranium and chemical impurities.

16.7.2 Safety Features and Analyses

Although protective clothing is worn in the furnace area, the pelletized form of the material minimizes the generation of dusts. No appreciable radiation exposure is encountered in this room.

The movement and storage of loaded pellet boats in the furnace room and the adjacent grinding area are on the safe slab conveyor system. Physical barriers prevent the stacking of boats above the safe slab thickness. Administrative controls are employed where physical barriers are impractical.

16.8 Pellet Grinding

16.8.1 Process Description

To obtain uniform diameter, all sintered pellets are processed through one of five centerless grinders equipped with a diamond grit work wheel. The grinding is done without liquid coolant. Pellets to be ground are received in furnace boats on the input conveyor adjacent to the grinder feeder bowl. The pellets are transferred from boats to the feeder bowl for automatic grinding. As pellets are ground to the specified diameter, they are inspected for defects and placed in layers on shallow corrugated trays on the output table. Loaded trays of pellets are transferred via a cart to controlled storage cabinets prior to the rod loading operation.

Grinding swarf generated at each grinder is collected in a cyclone separator and electrostatic precipitator operated in series and vented to a bank of HEPA filters. The material accumulated together with off-standard sintered pellets is containerized and stored for subsequent recovery in the uranium purification recovery process.

16.8.2 Safety Features and Analyses

The pellet grinding operation is a batch-controlled process based on material to and from the operation. The transfer cart is an array of six shelves 5" apart.

Optimum moderation of the pellets in the cart in transit is considered to be incredible. However, the maximum value for k-effective under this condition would be less than 0.97 assuming optimum moderation of the pellets, optimum interspersed moderation and full reflection. Physical barriers prevent placement of pellets between the shelves. The k-effective value was determined by a Monte Carlo Code, Merit.

16.9 Fuel Rod Loading

16.9.1 Process Description

Pellet trays are removed from the storage cabinets and located on one of four pellet loading stations. Normally six trays are at a station at any one time. The fuel pellets are placed on fuel rod mock-up channels, weighed and measured to required specifications. The string of pellets is pushed into an empty zircaloy tube previously welded at one end with a prenumbered end plug. The loaded tubes, now called fuel rods, are placed in rod trays and held in temporary storage prior to being transferred to the rod outgas ovens.

Close capture ventilation ports adjacent to the rod mock-up channel provide effective control of the small dusting that may occur as the pellets slide into the fuel tube.

Trays of rods are inserted into one of three horizontal ovens for final complete removal of moisture. The oven is maintained in an inert atmosphere throughout the operation. The rods are heated at a temperature in excess of 500°F for about two hours under less than 50 microns of mercury pressure. After the rods are cooled, a statistical sample of rods is analyzed for moisture. Then the rod trays are transferred to one of three final end plug welders.

Individual rods from the tray rod lot are inserted into a controlled atmosphere weld box. The inside of the rod is evacuated, then backfilled to positive pressure with inert gas. The end plug is then inserted and welded using the tungsten inert gas process. The exterior of each rod is cleaned mechanically to remove trace amounts of UO_2 before trays of rods are released to storage cabinets for subsequent gamma scanning and assembly in bundles.

16.9.2 Safety Features and Analyses

The storage of pellets is based on calculations made with the Merit Monte Carlo Code. The k-effective value for a flooded pellet cabinet is 0.84 assuming a water density of 1.0 gm/cc throughout. Physical barriers prevent placement of pellets between the shelves. The shelves are 5" apart vertically, which gives 4 1/2" spacing between the single layers of pellets on each shelf. The cabinets are noncombustible and the doors are designed to eliminate the probability of inleakage of water due to a fire and the associated water spray. The cabinets are securely anchored to prevent pellet spillage due to tipping. The transfer cart is maintained at a 2 ft. separation distance from the storage cabinets and from loaded rod trays.

The rod loading, welding and storage operations are controlled by geometry. Rod trays are 5" high and deep and are processed and stored at a constant height in the controlled area. Calculations of nuclear safety for the 5" trays are described in Chapter 16.10.2.

16.10 Fuel Bundle Assembly

16.10.1 Process Description

Rod trays are removed from the storage cabinets to a captive fork truck. Every fuel rod is scanned for U-235 content by means of an active scanner employing a neutron source and appropriate gamma radiation detectors. Based on the rod enrichment requirements of the fuel bundle design, the required number of rods are removed from the tray and laid out on one of five assembly tables. Data from the rod lot and the individual rod numbers imprinted on the end plugs are recorded for the specifically numbered fuel bundle. The remainder of the unused rod lot tray is returned to a storage cabinet. This procedure is repeated for each enrichment until the number of rods for the bundle to be assembled is on the bundle makeup table in proper loading order. The rods are visually inspected and are hand cleaned.

The assembly operation begins by positioning the spacer and lower tie plate hardware within the fixtures on one of five horizontal bundle loading tables. Fuel rods suitably identified are inserted into the spacer hardware according to a fixed insertion schedule. When all rods are in place, an upper tie plate is bolted into position and the assembly is raised to the vertical position. The bundle is unlocked from the fixture and removed by means of the overhead crane to the leak test and inspection station.

16.10.. Safety Features and Analyses

Since all radioactive material is completely enclosed in rods that have been cleaned, there are no radiation hazards associated with the assembly operation. This work is conducted in a clean area but periodic surveys are performed to verify that status.

The storage of finished fuel rods is in a noncombustible covered cabinet. The k-effective of this cabinet is 0.89 under conditions of full water moderation of the rods and full density water in the minimum 4 3/8" space between trays. The design of this cabinet is such as to prevent moderation by water spray.

The criticality safety analysis of the fuel rod storage cabinet was performed with the Merit Monte Carlo Code. In this analysis a single cabinet was modeled as two columns of trays with J = 0 on one side reflected by a 10" thick concrete floor on the bottom and by 12" of water on the other sides and top. Each fuel rod storage tray contains a maximum of 99 fuel rods arranged in a square pitch in a stainless steel tray. The fuel was assumed to be uniformly enriched to 4.00% U-235.

The result of the MERIT calculation was that the k-effective of the fuel rod storage cabinet was less than 0.89 at the 99% confidence interval for optimum interspersed water between trays of 0.10 gm/cc.

Movement of rods in this area is in rod trays with a height of 5". Rod processing, inspection and bundle assembly operations are conducted at a constant height and confined to safe geometries. If rods are to be removed from trays, they are removed on a safe batch basis, i.e., 45% of the critical number of rods under conditions of optimum moderation and infinite water reflection in cylindrical shape. The criticality safety of individual fuel rod trays is based upon calculations made with the reactivity formula and tabulated values of K_∞, M^2 and Weight Fraction Ratio (W/F) calculated for UO_2 pellets and water using the CEBLA code. For the case of optimum moderation by water of 4.0% enriched UO_2 pellets, these values are:

W/F Ratio = 3

$K_\infty = 1.49$

$M^2 = 30.07$

reflected = 6.7 cm

unreflected = 3.2 cm

For a rod tray with dimensions of 5" by 6" by 15', the reactivity formula gives values of:

Fully reflected k-effective = 0.828

Unreflected k-effective = 0.608

During bundle assembly, one rod is handled at a time. Assembled bundles and those being assembled are processed on a batch basis.

16.11 Fuel Bundle Leak Test and Final Inspection

16.11.1 Process Description

Assembled bundles are leak tested in a chamber. The chamber is closed and evacuated If there is a leak in the fuel rods, it will be detected by a helium mass spectrograph which is sensitive to 6.4 x 10^{-10}cc helium per second in the exhausted air.

Following leak tests, the bundle is removed from the chamber and placed in a lighted inspection fixture where it is inspected for rod straightness, linearity and similar design requirements.

16.11.2 Safety Features and Analyses

There are no radiation safety problems involved in the leak test and inspection step. Any tubes which are found leaking by the helium leak test method are removed from the assembly for controlled repair or rework.

Bundles are handled on a batch basis. The leak check and inspection stations are spaced at distances greater than that of the bundle storage rack described in the next section.

16.12 Fuel Bundle Storage

16.12.1 Process Description

Following leak test and inspection, each fuel bundle is wrapped, but not sealed, with a plastic dust cover and removed by means of the overhead crane to the bundle storage racks and suspended by the upper tie plate from a hook on the rack. The storage area consists of eight rows of racks which hold 56 bundles vertically on each side of the rack. The racks are rigidly constructed of steel girders on 48" centerlines. The center-to-center spacing is 16 3/4". The center-to-center distance of rows of bundle adjacent to each other and hanging on adjacent racks is 31 1/4".

16.12.2 Safety Features and Analyses

The maximum radiation reading from a fully loaded storage system is seldom greater than seven mr/hr. Work assignments are designed to minimize the time that workers have to spend at locations in the fuel bundle storage rack. If a bundle were to fall from a rack, uranium would not be released in harmful concentrations or in nonrecoverable forms.

Criticality safety of the fuel bundle storage area is maintained by the fixed spacing provided by the storage rack. The fuel rods in the individual assemblies are in fixed positions leaving well-defined air spaces within the assembly which could conceivably be occupied (at least partially) by water from overhead sprinklers. For this reason, optimum interspersed moderation is assumed to be possible within the interstices as well as between the assemblies.

The criticality safety analysis for the fuel bundle storage area was performed with the MERIT Monte Carlo Code. The MERIT calculations employed a three dimensional geometry model which allowed for a discrete bundle definition and for inclusion of storage rack materials of construction. The analysis of the bundle storage area also considered optimum interspersed water at full reflection of the storage array when completely filled with the most reactive type of BWR fuel bundle. The result of the analysis was that the maximum expected k-effective of the fuel bundle storage area is below 0.90.

The bundles are covered by polyethylene bags which are open at the bottom to prevent buildup of water in the bundle.

The fuel assembly storage racks are rigidly constructed steel frameworks which securely hold the bundles in their designated positions. It is physically impossible to load the rack with more than one assembly per storage position.

Interaction of the storage area with special nuclear material accumulations in adjacent areas were analyzed and determined to be within acceptable limits by the solid angle method.

16.13 Packaging of Fuel Bundles for Transport

Finished fuel bundles are removed by means of an overhead crane to the inner metal container of the GE Model RA-Series package. This container is designed to be loaded in the vertical position. When loaded and sealed, the cover and end cap are bolted in place. The container is then lowered into the horizontal position and placed in the outer shipping container. The cover of the outer container is bolted in position.
According to a predetermined schedule and upon release by radiation monitoring and nuclear materials management, the containers are tranferred to the transport vehicle for shipment to an authorized receiver.

There are no radiation safety hazards involved in the packaging operation. Containers are lined with shock absorbent material. Packaging operations are conducted to 10 CFR Part 71. The RA-Series package capacity is limited to two bundles.

Rigid administrative control requires the authorization of several internal functions in order to release packages for shipment.

16.14 Scrap Recovery

Internally-generated uranium as compounds in various physical forms which do not meet quality standards, or which have been mixed with foreign material is reprocessed through scrap recovery equipment. This equipment is located in the UF_6 to UO_2 conversion area. Recovered material is later blended at appropriate points in the process with primary production flow.

16.14.1 Dissolution and Filtration

Material to be reprocessed in scrap recovery equipment is accumulated in batches in 5-gallon pails at the various locations where scrap is generated. A storage area for accumulating pails of scrap is provided.

One product pail containing a dissolver batch is placed in a ventilated cabinet where the lid is removed.

The pail is then transferred into position over the charging chute of a dissolver. Nine 10" diameter vertical stainless steel dissolvers are arranged in three sets of three. The dissolver has been previously charged with nitric acid to which the scrap is slowly added and the contents heated with steam to 180°F and air sparged until dissolution to uranyl nitrate is complete. The uranyl nitrate is then pumped through a 10" diameter stainless steel tank containing a porous filter in order to remove undissolved foreign material.

16.14.2 Precipitation

Filtered uranyl nitrate is pumped from the cooling tank to one of three 10" diameter precipitation tanks. Ammonium hydroxide and hydrogen peroxide are fed to the precipitation tank where the uranium tetroxide (UO_4-H_2O) precipitate is formed. The contents of the precipitation tank are then pumped to the centrifuge.

16.14.3 Centrifugation and Drying

The slurry enters the end of a horizontal dewatering centrifuge. This unit is identical to that used in the previously described UF_6 to UO_2 conversion process. The solids discharge to the 6" thick slab feed chute where they are pumped into a 10" diameter gas-fired rotary dryer operating at about 1200°F for conversion to UO_2.

The aqueous stream from the centrifuge is collected in a 10" diameter tank and pumped to a high speed clarification centrifuge. The underflow slurry from the clarifier is collected in a 10" diameter tank from which it is pumped to the precipitation tank and recycled through the recovery process. The clarified overflow is collected in a 10" diameter tank from which it is pumped to a quarantine tank system for sampling, uranium analysis and release to the 20,000 gallon accumulation tank or reworked as appropriate.

16.14.4 Safety Features and Analysis

The wet chemical method of processing scrap uranium described above, presents no radiation safety hazards of significance, since the equipment is totally enclosed and is designed on the same basis as that in the UF_6 conversion process. Powder handled in product pails at the beginning and end of the process is controlled against becoming airborne by means of the hoods and by the use of rotary airlocks to feed and discharge from the calciners.

Essentially all equipment in the wet chemical scrap recovery system is individually geometrically safe assuming optimum water moderation and full water reflection. An exception is the dewatering centrifuge which has been described in Chapter 16.2.3.

Product pails containing scrap and recovered uranium are labeled, with identifying information for material control.

The liquid in the quarantine tank which results of uranium analysis show can be released are pumped into a 20,000 gallon accumulation tank. This liquid is then circulated in the accumulation tank until it is pumped to a second 20,000 gallon treatment tank in which it is treated with a lime slurry for raising its pH and for precipitating any uranium remaining in solution. After a period of time to permit settling of solids at the bottom of the tank, the clear supernatant is pumped to nitrate storage lagoons in which the contents are quarantined The solids collected in the bottom of the 20,000 gallon treatment tank are recycled through a centrifuge with the solid-free liquid being returned to this tank.

16.15 Waste Treatment and Disposal

16.15.1 Liqui. Radioactive Waste (RADWASTE) System

Waste water from sources such as laboratory sinks, protective clothing laundering machines and area clean-up is routed to the RAD waste system.

Concentration of uranium in water from these points normally is quite low. The system consists of collection tanks, centrifuges and uranium monitoring equipment. Waste water is collected in 10" diameter cylindrical tank in the floor. This tank in effect serves as a head tank for a pump which automatically transfers the water as it is collected to a 5" thick slab-shaped accumulator tank.

From the accumulator tank, the water is pumped to one of two dewatering centrifuges (one serves as an installed spare) where suspended uranium compounds and other solids are removed. The clarified water flows into a quarantine tank, is sampled and, so long as the uranium concentration is less than internal action guides, is pumped by one of two pumps to the process waste disposal system. Higher-than-limits waste is returned to the system for rework.

16.15.1.1 Safety Features and Analysis

This is a contained wet system thus presenting no significant radiation safety hazards. Solids removed from centrifuges are put into pails and lidded while the material is still wet.

All equipment in the RAD waste system with the exception of the slab tanks is individually safe for homogeneous uranium oxide water mixtures assuming optimum water moderation for minimum critical cylinder diameter or volume with full water reflection. The mixtures expected in the slab tanks are dilute mixtures of the order of a few grams per liter. Sources of water for this system are off-line drains which, even under abnormal operating conditions, would not discharge large quantities of uranium into this system. It is anticipated that even if large quantities of UO_2 were to enter the system by way of the off-line drains, it would not make its way to the centrifuges due to the presence of traps in drains and the 10" collection tank which would serve as a trap.

Each quarantine tank is 6" thick, 8' high and 20' long and is separated from the adjacent tank by a 1" wide airtight stainless steel panel containing a polyethylene and cadmium poison sheet and a 10" thick, 140 pounds per cubic foot reinforced concrete slab with 2 1/2" of intervening air space on both sides of the poison panel. When analysis of this material verifies the uranium content meets internal release critera, the water is routed to the rad waste effluent stream.

In order to achieve a solution in the slab tanks with a k-infinite value of 1.0 or more, the uranium concentration of 4.00% enriched UO_2 and water mixture must be at least 380 grams per liter.[1]

The criticality safety of the quarantine tanks is based on the geometry control obtained by the use of the cadmium panels. This has been demonstrated for the worst case (albeit incredible) conditions of optimum moderation and full reflection and for 4.00% enriched UO_2 and water in the tanks. Calculations made with the MERIT and GEMER Monte Carlo Codes show that the worse case k-effective for the quarantine tank system is less than 0.94 at the 99% confidence interval.

In addition to the individual batch sampling a composite of the rad waste effluent is collected on the basis of proportioned flow sampling. This sample is analyzed daily for uranium concentration.

16.15.2 Fluoride Waste Treatment

Chemical wastes from the conversion process are collected in three banks of two 6" thick slab tanks described in Chapter 16.2.3 above. As a tank system is filling, the contents are being recirculated. Thus, the feed material is well mixed with the recirculating stream. When one tank system is filled, the feed is automatically diverted to a second dual tank system. A third dual tank system is installed and serves as a

[1]ARH-600

spare. The filled tank system is sampled and analyzed for uranium content. If the uranium content meets internal action guides, it is released to a 65,000 gallon storage tank; otherwise the material is recycled through the utility system described above. The liquid in the 65,000 gallon storage tank is circulated constantly to keep the solids in suspension and thus prevent settling in the bottom of the tank. This tank bottom is V-shaped and is checked on a regular basis for accumulation of solid material.

The liquid is then pumped from the 65,000 gallon storage tank to a 100,000 gallon settling tank. The solid material is centrifuged from the settling tank and is collected in the centrifuge bowl from which it is cleaned out and stored in five gallon pails. Here the supernate from this tank is decanted and treated with a lime slurry to accomplish recovery of the ammonia and removal of fluorides. (See Chapter 16.15.3 for a description of the ammonia recovery process.)

After recovery of the ammonia, the liquid emerging from the bottom of the ammonia stripping column is pumped into storage lagoons in which solid CaF_2 is allowed to settle. The liquid in the storage lagoons is then pumped to aeration lagoons where, if necessary, it can be sprayed to remove entrained ammonia. The liquid is then discharged through a line in which it is sampled for uranium, nitrate, and ammonia content. It is then fed into the plant industrial waste stream. This stream travels to the chemical lagoon, from which liquid is released into a drainage ditch and then flows off site to a river. All of the liquids as they leave the chemical process lagoons headed for the river are also sampled for uranium and other chemical contents.

16.15.2.1 Safety Features and Analysis

The criticality safety of the fluoride waste treatment system is based upon a combination of safe batch and concentration controls. Under normal operations the allowable concentrations of uranium in the fluoride liquid wastes are such that the 65,000 gallon tank will not contain more than 37 kg of uranium and the 100,000 gallon tank will not contain more than 57 kg of uranium. These values are both less than 45% of the minimum critical mass for credible fluoride sludge densitites. An additional criticality safety control for the 100,000 gallon tank is provided by two sludge density probes placed in a 10" ID leg in the conical bottom of the tank. These controls are set to alarm and air sparge (mix) the tank if the sludge density in the 10" ID leg reaches 1.20 gm/cc. If the sludge is entirely in the form of UO_2 and water, this corresponds to a uranium density of less than 200 gm U/liter. This value is less than the 350 gm U/liter minimum critical density tabulated in ARH-600 for 4.0% enriched UO_2 and water.

16.15.3 Ammonia Recovery

Recovery of ammonia from the fluoride liquid waste stream is accomplished in equipment located next to (east of) the control and process building of the waste treatment facility. In the ammonia recovery process the fluoride waste solution is fed into the top of a stripping column. The solution flows down through the packing. Steam flows upward through the packing, stripping the ammonia from the solution. The ammonia vapors emerge from the top of the stripping column and flow to a condenser where they are condensed as aqueous ammonia. The solution emerging from the bottom of the stripping column is pumped to the existing settling lagoon.

Criticality safety of the ammonia recovery operation and the settling lagoons is based upon concentration control from the 100,000 gallon settling tank. The supernate decanted from the 100,000 gallon tank is limited to no more than 150 ppm U and the resulting lime, CaF_2 and uranium chemistry assumes a uranium concentration of no more than 10,500 ppm U in dry sludge. This value is well below the 350 gm U/cc minimum critical concentration given in ARH-600 for 4.00% enriched UO_2 and water systems and indicates a worst case minimum critical mass for moderated sludge on the order of 10^6 kg of UO_2.

16.15.4 Liquid Waste From the GECO Process

The waste water from the GECO process originates in the defluorinator scrubber and the vacuum system. Both contain ammonium hydroxide and a small amount of fluoride. The water from the defluorinator scrubber is pumped to a high efficiency filtration system (inertial filtration) for recovery of uranium solids. The waste water is sent to waste treatment where the solution is treated with lime to precipitate the fluorides, and the ammonia is recovered. The ammonia as ammonium hydroxide is returned to the process. The residual solution is pumped to a lagoon where the calcium fluoride precipitate is settled.

16.15.5 Solid Wastes

Contaminated articles such as paper, rags, mops, plastic, wood, protective clothing, damaged tools, and equipment and similar contaminated materials which are no longer serviceable are collected in designated containers to prevent the loss of contents and spread of contamination. Containers are located at points in the plant where such wastes may occur. These materials are segregated into noncombustible and combustible categories in the decontamination facility, decontaminated and disposed of as described below.

16.15.5.1 Noncombustible Solid Waste Material

Filled containers are closed, tagged, and moved to the packaged waste storage area awaiting transfer to the Decontamination Facility.

In the decontamination facility, containers of noncombustible waste are emptied onto a cleaning and sorting table. An air velocity of 200 linear feet per minute is maintained across the face of the table to minimize the generation of airborne uranium. A high velocity water steam and a steam-cleaning apparatus are employed to decontaminate the contaminated noncombustible waste materials. These decontaminated materials are then repacked into containers. Noncombustible material may be crushed before containerization. The containers are scanned for U and U-235 content by means of a passive scanner. If the material in a waste container has more uranium than the established limit (which is based on economic as well as nuclear safety consideration) the container will be returned to the decontamination facility for further removal of uranium from the contents prior to shipment. A computer transaction is made for each waste container to keep track of its U and U-235 content for material control and accounting purposes.

Detailed shop procedures for packaging and decontaminating solid wastes are effective in controlling against contamination spread.

These procedures and the design of the manufacturing equipment and processes also provide the control required for criticality safety. Non-geometrically safe vessels and containers used for solid waste are authorized under safe batch controls and are therefore restricted from being used for significant amounts of uranium-bearing materials.

Procedures for reclaiming appreciable quantities of materials preclude the possibility of accumulating more than a few grams of U-235 in a single package. Disposal to burial is confirmed by passive scanning prior to shipment.

16.15.5.2 Disposition of Solid Waste Material

Filled containers are closed and placed in sealed plastic bags or cans and transferred to waste storage boxes. These boxes are scanned to determine uranium content and are then queued on outside storage pads awaiting incineration for combustible wastes or transfer to a licensed site for burial of non-combustible low-level radioactive materials.

16.16 Chemical-Metallurgical Laboratory

The chemical-metallurgical (Chemet) laboratory, located adjacent to the south face of the fuel manufacturing area is operated in support of the fuel fabrication process. Special nuclear materials and source materials are chemically and spectrographically analyzed and/or subject to physical testing, metallurgical examination, and radiography.

The laboratory receives uranium in the following forms:

Metal buttons, turnings, powder sheets, sectons, and mixtures of the preceding;
Powder oxides and mixtures of oxides;
Pellets and various sintered shapes;
Fuel tubes and various configurations of fuel containers.

Special nuclear materials in various enrichments are received and used. Materials are in the form of reference samples, samples in process, standards, waste residue, rechecks, mounted specimens, and test pieces in quantities of a few grams. Laboratory samples for physical testing, metallurgical examination, and radiography are returned after testing to the responsible individual who requested the test. Thus, no accumulation of radioactive material occurs in the laboratory from this source. Containers of liquid waste are routed to the RAD waste system.

The laboratory ventilation system is independent of the fuels manufacturing area and is designed to exhaust all laboratory air through the hoods in the controlled rooms. Each hood is equipped with a roughing filter and an absolute filter. An additional absolute filter is installed in the main duct upstream from the exhaust fan.

Occasionally, although infrequently, samples of uranium containing trace amounts of plutonium may be received from external sources for purposes of verifying analytical methods and equipment. When such samples are received, special preparations are made to isolate the activity including lining the hood with absorbent paper, additional protective clothing, special step-off pads and frequent monitoring.

The wet laboratory area and the spectrograph room are controlled radiation areas. All personnel working in those areas wear the prescribed protective clothing. All laboratory work producing dust or gases is performed in hoods vented through filters. Liquid acid wastes are neutralized before disposal to insure proper treatment in the liquid waste treatment facility.

The criticality safety of the Chemet laboratory is based upon a combination of geometry and safe batch controls. Geometry controls apply to units such as five gallon containers, fuel rod trays and sample storage areas (for example, limited to a 4.0" thick slab). Other areas in which geometry control is not practicable are limited to 22 kg of uranium which is the safe batch limit for 4% enriched heterogeneous mixtures of UO_2 and water. The criticality safety of the interaction of each of the areas with all others is demonstrated by a SAC (Solid Angle Calculation).

Since inventories of special nuclear material are held to a minimum and are logged in and out, it is highly unlikely that a significant unaccountable loss could occur in the laboratory.

16.17 Outside Product Can Storage

Immediately adjacent to the south side of the fuels building are fenced pads utilized for temporary storage of 5-gallon cans of uranium compounds. Each can is separated 12" from adjacent cans in a row by physical barriers with 3' aisleways between adjacent rows. Only closed containers which are free of surface contamination are stored in these outside storage areas.

The criticality safety of the outside can storage areas has been demonstrated by an analysis performed with the KENO IV Monte Carlo Code and using JRK Modified Hansen-Roach 16 group cross section sets. Calculations were performed for an infinite planar array of containers with a minimum separation between containers of 12" with each container limited to 35 kg of 4.00% enriched UO_2, with optimum moderation by water of the UO_2, and with full reflection on the top and bottom of the array by 12" of water. The KENO IV result was a k-effective of less than 0.961 at the 99% confidence level. Stored containers are protected against rearrangement under severe wind conditions.

16.18 Process Technology Laboratory

16.18.1 General Plans and Uses of Materials

The Process Technology Laboratory provides a facility for performing tasks associated with the development of fuel for nuclear power. In addition, facilities are available for the fabrication of fuel or poison rods, irradiated test capsules, the development of fabrication processes and subsequent mock-up to pilot plant scale, and for the fabrication of partial reactor cores. The special nuclear materials which are used consist of uranium compounds. These materials contain U-235 concentrations ranging from depleted to 15% enrichment.

Activities in the laboratory include UO_2 conversion, fabrication of ceramic pellets, fabrication of fuel rods, assembly of fuel rods into fuel bundles, thermal cycling, creep and strain cycle experiments on potential fuel claddings, and evaluation and development of nondestructive testing techniques.

UO_2 powder enriched in U-235 up to 15% is pressed, sintered, and ground by a centerless grinding process. Conventional, as well as developmental, equipment is used for these activities.

Containment for the equipment utilized in the fabrication of ceramic pellets is designed to be similar to that presently in place in the WMD facility. This includes, but is not limited to, hoods over the back end of the pellet presses and over that section of the pellet grinder in which the pellets are actually being ground.

Fabrication of fuel rods is accomplished, including loading of fuel pellets into cladding rods, welding of end plugs, and cleaning and monitoring of finished rods.

16.18.7 Radiation Safety

16.18.7.1 General

The Process Technology laboratory work and processes require that all personnel wear protective clothing. Approved respiratory equipment is provided when required. Since all dust-producing processes in the handling of special nuclear materials are enclosed in vented hoods or are vented to the filtered building exhaust system, these requirements are infrequent. Special glove boxes and/or other appropriate containments are provided in the laboratory for ball milling, screening, blending and pellet pressing operations. Surveys are made and air samples obtained on a routine basis, to assure that personnel in the laboratory are not exposed to excessive airborne concentrations of uranium, and to assure contamination control. Entrance to the laboratory area is controlled, requiring supervisory authorization and the proper use of protective clothing.

16.18.7.2 Ventilation

All operations in the process technology laboratory which potentially produce radioactive dust are hooded and vented through filters. Typical examples of the types of operations which are performed in enclosures are grinding, cutting, powder mixing, pressing, and powder sampling. These enclosures are maintained at negative pressure with respect to room pressure. Additionally, the process technology laboratory is maintained at a negative pressure with respect to the remainder of the fuel manufacturing building to prevent the spread of dust to these parts of the building. Each vented enclosure is equipped with a roughing filter in the lead to the exhaust system. All air exhausted from these enclosures is passed through absolute filters to prevent the spread of radioactive dust to the environs. The outlet air is continuously sampled to verify filter integrity.

Each major piece of equipment in the process technology lab that is not enclosed is equipped with a filtered local trunk line from the ventilation equipment. These lines are placed near the operation to prevent the spread of small chips and small amounts of contaminated dust from the work. For example, lathes, welding fixtures and drill presses are equipped with local ventilation. Exhaust air from these sources is filtered through absolute filters.

Prefilters are used wherever necessary to prevent unsafe buildup of dust in vent system ducts.

In all areas, ventilation has been designed to reduce the uranium air concentration to within allowable amounts. Six air changes per hour are passed through the process technology laboratory from areas of no contamination to the area of highest contamination potential.

The bases for adequacy of ventilation and air flows are the same as those given in Chapter 10 of this application.

16.18.7.3 Protective Features

Special design features for the fuel development laboratory include a smooth floor to facilitate cleanup. Personnel access to the area is through a change room equipped with lockers, showers, and hand counters. As previously mentioned, all work functions that are potential dust-producing operations are hooded or vented, and each new operation is designed to reduce personnel contact with bare radioactive material to a minimum.

16.18.7.4 Waste Disposal

Dry waste containing uranium enriched in U-235 to greater than 5% will be collected in containers on a safe batch basis, stored within the laboratory, and shipped periodically for disposal to a licensed vendor.

Liquid waste containing uranium enriched in U-235 to greater than 4% will be collected, analyzed, and dried on a safe batch basis, and disposed of in the same manner as dry waste.

16.18.8 Criticality Safety

In many cases, the process technology laboratory employs equipment and materials which are identical to those used in the fuel manufacturing operations. Examples of these are pellet presses, grinders, powder hoppers and five gallon containers. When these are used and when the U-235 enrichment of the material being processed is not greater than 4%, the criticality safety analyses and controls are the same as for the fuel manufacturing operation.

On the other hand for operations with fuel enriched to greater than 4% criticality safety is assured by safe batch limits. Each batch is contained in a clearly identified limit area separated from other limit areas by an isolation zone which satisfies the isolation criteria established in Chapter 4.

For operations in which special nuclear material is known to accumulate, as in the pellet grinding operation, a running inventory is maintained by weighing batches before and after the operation.

When two physical forms of special nuclear material are handled in a single limit area on a safe batch basis, e.g., pellets and rods, the smaller batch limit is always used.

All accumulations are identified by cards indicating mass, chemical form and enrichment. Color-coded tape is also used for ease in identifying enrichments. To assist in identifying individual fuel pellets, they are each stamped either with the enrichment itself or with a symbol peculiar to a given enrichment.

Since there are no floor drains in this building, all contaminated waste water is temporarily stored in a critically-safe container. When this storage container is nearly full of waste water, the waste is disposed of as described in Chapter 16.18.7.4.

17.0 ENVIRONMENTAL EFFECTS OF ACCIDENTS

17.1 Introduction

In processing low enriched uranium into fuel for nuclear reactors, the only significant amount of radioactive material present at the fuel fabrication facility is the uranium. Because of the low specific activity of low enriched uranium (2.25 uCi/gm for 4 percent-enriched uranium), the radiological impact on the environment of any type of postulated accident within the fuel fabrication facility or elsewhere on the plant site would be insignificant compared to the nonradiological impacts, e.g., chemical effects.

Therefore, with the exception of a criticality accident, the environmental impact which could result from postulated accidents in a light-water reactor fuel fabrication plant and elsewhere on the plant site should be analyzed primarily from the point of view of chemical effects. This would be the same as for any other manufacturing plant in which large amounts of nonradioactive chemicals are processed and in which large inventories of such chemicals are stored. This is the basis for the discussions in this Chapter.

17.2 Accident Spectrum

The spectrum of possible accidents is arranged to incorporate the design basic accidents (DBAs) of fire, explosion, criticality power failure, and water failure. There DBAs are reviewed on the basis of three categories of verity, described in Table 17.1.

TABLE 17.1

DESIGN BASIC ACCIDENTS - CATEGORIES OF SEVERITY

Severity Category	Typical Accident	Definition
1	Pipe line leak or small spill	Likely to happen during life of plant
2	Breaching of bulk storage tanks	Unlikely to happen during life of plant
3	Incredible	Catastrophic events that have not yet occurred

Floods are not addressed in Severity Category 1 and 2 design basis accidents. A flood study[1] by the U.S. Army Corps of Engineers established that wind and tide effects would control flood water levels at the plant site.

The highest tide recorded from these effects was caused by Hurricane Ione in September 1955. The tides were as much as 10 feet above normal. The plant facilities are located 30 to 35 feet above mean high tide and, thus, would not be subject to flooding by a tide equivalent to the historical high tide.

[1]Preliminary Report on Wind Tide Flooding in N. Hanover County, North Carolina, U.S. Army Corps of Engineers, Wilmington, NC District (December, 1969).

TABLE 17.2
SUMMARY OF SOURCE TERM DATA

	Largest Quantity Stored, lbs[5]	Accident Dispersal Pathway: Air	Accident Dispersal Pathway: Water	Site Boundary Accident Concentrations in Air, ppm	Characteristics of Concern[4]		IDLH, ppm[3]	Ref.
Anhydrous Ammonia	150,000	x	x	<500	ppm_{wt}	NH_3	500	R[1]
Aqueous Ammonia	280,000	x	x	<100	ppm_w	NH_3	500	R[1]
Hydrochloric Acid	67,000	x	x	1	ppm_w	HCl	100	R[1]
Hydrofluoric Acid	150,000	x	x	1	ppm_{wt}	HF	20	R[1]
Nitric Acid	32,000	x	x	1	ppm_w	HNO_3	100	R[1]
Sulfuric Acid	122,600	x	x	1	ppm_w	H_2SO_4	8[2]	R[1]
Sodium Hydroxide	45,000		x	NA	ppm	NaOH	200[2]	R[1]
Uranium Dioxide (insoluble)	1,000,000	NA		NA	ppm_w	UO_2	30[2]	R[1]
Uranium Hexafluoride (soluble)	1,000,000		x	NA	ppm_{wt}	UF_6	20[2]	R[1]
Aqueous Ammonium Nitrate with Uranium in Lagoon	23,000,000		x	NA	ppm_w ppm_w ppm_w	NH_3 F U	NA	R[1] R[1] R[1]
Aqueous Ammonia with Uranium & Fluoride in Lagoon	23,000,000		x	NA	ppm_w ppm_w ppm_w	NH_3 F U	NA	R[1] R[1] R[1]

[1]National Institute for Occupational Safety and Health, "NIOSH/OSHA Pocket Guide to Chemical Hazards," September 1978.

[2]Units are mg/m^3.

[3]IDLH means immediately dangerous to life and health.

[4]Concentration of particular species expressed in parts per million (ppm) by weight.

[5]Includes weight of associated water.

TABLE 17.3
ACCIDENT SPECTRUM

	DBA Mode				
SEVERITY CATEGORY	Fire 1	Explosion 2	Criticality 3	Power Failure 4	Water Failure 5
1. OPERATIONAL INCIDENT					
Outdoor Chemical Storage					
Anhydrous Ammonia	0	0	0	0	0
Aqueous Ammonia	0	0	0	0	0
Hydrofluoric Acid	0	0	0	0	0
Hydrochloric Acid	0	0	0	0	0
Nitric Acid	0	0	0	0	0
Sodium Hydroxide	0	0	0	0	0
Uranium Hexafluoride	0	0	0	0	0
Uranium Dioxide	0	0	0	0	0
Urynal Nitrate	0	0	0	0	0
Sulfuric Acid	0	0	0	0	0
Lagoons Containing Treated Effluents					
Ammonium Nitrate/Uranium	0	0	0	0	0
Calcium Fluoride and Ammonia/Uranium	0	0	0	0	0
Building Containing Processing Activities	0	0	0	0	0
2. UNUSUAL INCIDENT					
Outdoor Chemical Storage					
Anhydrous Ammonia	X	0	0	0	0
Aqueous Ammonia	0	X	0	0	0
Hydrofluoric Acid	0	X	0	0	0
Hydrochloric Acid	0	X	0	0	0
Nitric Acid	0	X	0	0	0
Propane	X	X	0	0	0
Sodium Hydroxide	0	X	0	0	0
Uranium Hexafluoride	X	X	0	0	0
Uranium Dioxide	X	X	0	0	0
Sulfuric Acid	0	X	0	0	0

X – Event which produces significant emission *is possible*

0 – Event which produces significant emission *is not possible*

Table 17.3 (continued)

SEVERITY CATEGORY	Fire 1	DBA Explosion 2	Criticality 3	Power Failure 4	Water Failure 5
	DBA Mode				
Lagoons Containing Treated Effluents					
Ammonium Nitrate/Uranium	0	0	0	0	0
Calcium Fluoride and Ammonia/Uranium	0	0	0	0	0
Building Containing Processing Activities	0	0	0	0	0
3. CATASTROPHIC INCIDENT					
Outdoor Chemical Storage					
Anhydrous Ammonia	X	0	0	0	0
Aqueous Ammonia	0	X	0	0	0
Hydrofluoric Acid	0	X	0	0	0
Hydrochloric Acid	0	X	0	0	0
Nitric Acid	0	X	0	0	0
Sodium Hydroxide	0	X	0	0	0
Uranium Hexafluoride	X	X	X	0	0
Uranium Dioxide	X	X	X	0	0
Sulfuric Acid	0	X	0	0	0
Lagoons Containing Treated Effluents					
Ammonium Nitrate/Uranium	0	X	0	0	0
Calcium Fluoride and Ammonia/Uranium	0	X	0	0	0
Building Containing Processing Activities	X	X	X	0	0

X – Event which produces significant emission *is possible.*

0 – Event which produces significant emission *is not possible.*

The chemicals stored on-site in significant quantities are listed in Table 17.2. For each of these chemicals, the largest quantity stored at any time is given, and other information required to characterize the source-term aspects of each chemical is provided.

The accident spectrum for each of these materials is analyzed in Table 17.3 against the degree of accident severity.

17.3 Nonradiological Accidents

17.3.1 Severity Category 1 Accidents

An accident in this category in the chemical processing area would be typified by a leak in a pipeline resulting in the release of a few gallons of the material in the pipelines. A leak of this type inside the manufacturing buildings would be quickly detected by operators, and corrective action (such as isolation of the leaking line section) would be taken. The spilled liquids along with any necessary water spray utilized to control fumes would be transferred to the appropriate waste treatment system. There would not be a release to the environment through either airborne or liquid pathway.

A leak of this type outside the building would again be located rapidly by operators and corrective action implemented. An off-site environmental impact is not anticipated either from an airborne or waterborne pathway because of material retention provisions and fast response time inherent in the systems and procedures. Released material would be retained for processing in the appropriate waste treatment system.

Another example of this type of accident might be the inadvertent release to the storage lagoons of improperly treated waste. However, before entering the lagoons, all water is pretreated and analyzed on a batch basis, precluding more than one batch from being untreated and, thus, the environmental effects of such an occurrence are negligible.

17.3.2 Severity Category 2 Accidents

Category 2 accidents occurring inside the building could not result in releases that would be of concern to the external environment for the same reasons previously described under Category 1.

Category 2 accidents occurring in the bulk storage areas could result in a complete or partial emptying of the storage tank. Each of the bulk storage tanks is discussed on the basis of appropriate DBAs in the following sections.

17.3.2.1 Anhydrous Ammonia

The DBAs of water failure, power failure, criticality, and explosion will not result in the release of anhydrous ammonia. A release due to a fire could occur. The storage tanks for anhydrous ammonia are constructed of welded steel and are capable of withstanding an internal operating pressure of 265 psi. Pressure-relief valves are installed to prevent overpressure in case of fire.

Exposure of the storage vessel to an intense fire would result in operation of the relief valves, designed to bleed overpressure. The release would cease as the fire is extinguished. Ammonia vapors could reach 50 percent concentrations in the release area.

Utilizing an aeolian dilution factor (X/Q) of 10^{-3} at 100 meters, it is expected that concentrations at the nearest site boundary would be less than IDLH level of 500 ppm referenced in Table 17.2

17.3.2.2 Aqueous Ammonia

The DBAs of water failure, power failure, criticality, and fire are not applicable. The storage tank is an isolated, self-contained tank independent of water supply and electrical power. It is also protected by an earthen dike and would not be affected by fire.

A projectile from an adjacent explosion could puncture the tank resulting in discharge of a portion of the contents into the diked area.

Aqueous ammonia is stored on-site as a 29.4 percent concentration of ammonia. It is anticipated that the airborne concentration in the spill area would be less than 1000 ppm. Using an aeolian dilution factor (X/Q) of 10^{-3} for a ground release at 100 meters, the concentration in air at the site boundary would be less than 1 ppm (substantially less than the IDLH level referenced in Table 17.2). There would not be a loss of liquid solution from the dike area. The released solution would be pumped into tank trucks or other storage as available.

17.3.2.3 Hydrochloric Acid

Hydrochloric acid is stored in an Atlak fiberglas inner tank surrounded by an outer fiberglas emergency tank. The tank is a self-contained storage vessel, and the DBAs of water failure, power failure, and fire do not apply. If a projectile from an explosion penetrated the tank, all or a portion of the contents would be released. The released material would flow into the storm drain system and be impounded behind the site dam. The impounded material would be neutralized and released to the river over a several day period. If it were all released in 1 day during a period of 10-year, 7-day consecutive low flow, the anticipated increase in river chloride concentration 1000 feet downstream would be 16 ppm. River concentrations of several hundred ppm chloride from natural causes are frequently encountered in the Northeast Cape Fear River.

The concentration of hydrochloric acid in air at the site boundary would be less than 1 ppm utilizing the same dilution factor as in previous discussions. This concentration is considerably below the IDLH level (Table 17.2).

17.3.2.4 Nitric Acid

The nitric acid solutions are stored in stainless steel tanks that are self-contained. DBAs of water failure, power failure, and fire will not cause a release. A projectile from an explosion could pierce the tank wall, resulting in release of all or part of the tank's contents. The tank areas are curbed or graded so the released liquid would flow to the chemical discharge lagoons. The material would be neutralized in these lagoons. The site dam and the parallel flow feature of the chemical discharge lagoons would permit gradual release of the nitrate solution. It is calculated that if the release occurred during the low-flow, 10-year, 7-day consecutive period, the nitrate concentration 1000 feet downstream would increase 2 ppm.

17.3.2.5 Sodium Hydroxide

Sodium hydroxide is stored in a self-contained, insulated, heated stainless steel tank. The DBAs of power failure, water failure, and fire do not apply.

In the case of extended power failure at low temperatures, the contents of the tank would solidify but could be liquified by reheating when power service is resumed.

The tank could be pierced by a projectile in the event of an explosion and all or part of the material could be discharged to the chemical discharge lagoons. The material would be neutralized and released over a several day period. No impact on the river is foreseen.

17.3.2.6 Hydrofluoric Acid

Hydrofluoric acid is stored in a self-contained, diked, butyl rubber-lined, steel tank. The DBAs of power failure, water failure, and fire do not apply.

A projectile from an explosion could pierce the tank wall, resulting in a release of part of the tank contents into the diked area. The liquid would be retained and pumped into trailers or available storage.

Vapor concentrations of hydrofluoric acid at the site boundary would be expected to be below 1 ppm using an aeolian dilution factor of 10^{-3} for ground level releases at 100 meters. The IDLH level referenced in Table 17.2 is 20 ppm.

17.3.2.7 Lagoon

An example of the Category 2 accident in the lagoon area is a leak in the lagoon lining. This is very unlikely to occur since the lagoon lining is specifically designed for this application and is not subject to aging by the elements. The lagoons are designed such that flow from a leak is in a lateral direction to the adjacent ditches.

If such a leak were to occur in significant volume, it would be detected by the routine, periodic analysis of water in the perimeter ditches. The only material that would enter the ground water from the lagoon would be a minor amount of the liquid phase. The solids would stay behind either in the lagoon or in the soil immediately adjacent to the lagoon. Thus, the environmental effects of such an accident would be insignificant.

17.3.2.8 Sulfuric Acid

Sulfuric acid is stored in a carbon steel tank. The DBAs of power failure, water failure and fire do not apply. A projectile from an explosion would pierce the tank wall resulting in release of all or part of the tank's contents. The spilled liquid would flow to a diked area.

17.3.3 Severity Category 3 Accident

The Category 3 accident in the chemical storage area would release no more than the contents of a bulk storage tank. This type of release has been discussed under Category 2.

A Category 3 accident in the lagoon area would involve a catastrophic dike failure causing almost total discharge of the contents of a lagoon. It is highly unlikely that this would nappen and no natural disaster of record would cause such an accident.

The largest lagoons are the calcium fluoride lagoons, each containing three million gallons. Ammonia and fluoride must be removed from the liquid in these lagoons before discharge to the environment is acceptable. The average amount of the materials in a calcium fluoride lagoon would be about 160,000 pounds of ammonia and 3,200 pounds of fluoride.

Even the highly unlikely accident of a dike failure would not cause a serious environmental effect. If such a failure occurred, the material would flow to the drainage ditch and to the river. As discussed previously, the drainage ditch flow can be stopped and the material treated or held for a gradual discharge to the river at a discharge rate determined as a function of river flow rate.

Assuming the material would be discharged to the river over a 10-day period, and that one-half of the ammonia would evaporate, the average effect on the river would be an increase in fluoride concentration of 0.08 ppm and an increase in ammonia concentration of 1.8 ppm. These concentrations would not cause any significant damage to aquatic life.

17.4 Radiological Accidents

17.4.1 Severity Category 1 Accidents

Because any accident in this category inside the fuel manufacturing building would be quickly detected, isolated, and contained (as described under paragraph 17.3.1), there would not be a significant release to the environment either through an airborne or a liquid pathway. Therefore, no radiological impact to the environment would result from a Category 1 accident occurring inside the building.

Outside the fuel manufacturing building, a typical accident in this category might be the dropping of a cylinder (see Figure 17.1) of uranium hexafluoride (UF_6). These cylinders arrive by truck in their protective shipping containers (see Figure 17.2). The shipping container is opened, and the cylinder is transferred by a stationary crane to a weighing and staging area, and then moved into the fuel building or into an outdoor storage area. All precautions associated with moving high-pressure cylinders are observed, but it is possible that a cylinder might be dropped.

At no time is a cylinder more than 10 feet from an unyielding surface. Thus, no damage would be expected even if a drop did occur. During testing it took a 30-foot drop to cause even a hairline crack. If such a hairline crack did occur, it would not cause major leakage of UF_6. The UF_6 is a solid at ambient temperature (sublimes at 130°F) and therefore would evaporate out very slowly. Also, UF_6 reacts with

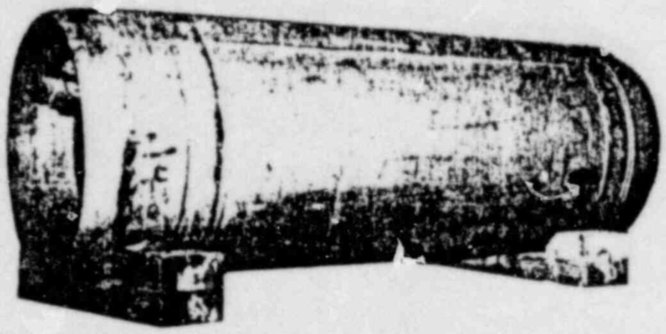


FIGURE 17.1 2-1/2 TON URANIUM SHIPPING CYLINDER

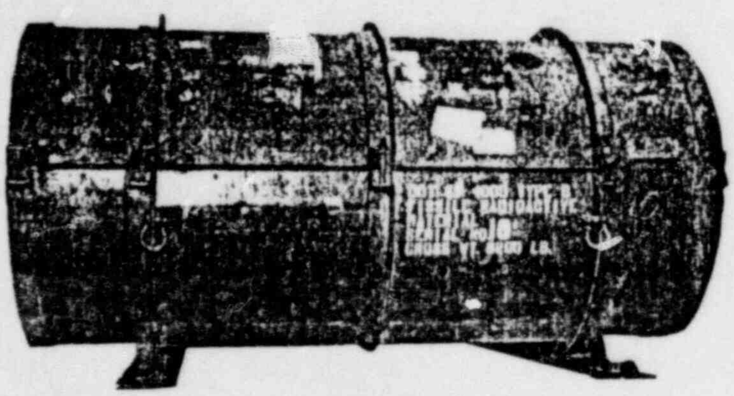


FIGURE 17.2 MODEL OR 30 SHIPPING PACKAGE

(UO_2F_2), a non-volatile solid. Thus, a slow leak is self-sealing.

If a cylinder was dropped, it would be checked for leakage, and corrective action taken immediately. A leaking cylinder would be taken immediately into the fuel building where the fumes would enter the scrubbed ventilation system.

The amount of UF_6 which could enter the environment from such an accident is too small to cause concern.

In any other Category 1 accident outside the building which might involve uranium dioxide, the maximum amount of material which could be released (e.g., 90 kg in a 55-gallon shipping container) is very small. The physical form of the powder is such that the material would not tend to become airborne or go into solution. Under any conceivable circumstances of an accident, no significant off-site environmental impact from either airborne or waterborne pathways would occur.

17.4.2 Severity Category 2 Accidents

As discussed in paragraph 17.3.2, Category 2 type accidents occurring inside the building would result in release of uranium-bearing materials which would be contained and would not be of concern to the external environment.

For example, an explosion in a calciner would cause the release of uranium compounds which would either remain inside the building or, if a filter in the ventilation system failed as a result of the explosion, would be released to the atmosphere in an insoluble form. If one-fifth of the material in the reduction furnace (about 32 kg) were released, the calculated radiation dose to an individual at the site boundary (about 175 meters from the release point) would be less than 0.2 mRem to the lungs.*

For category 2 type accidents occurring outside the building, the worst radiological impact on the environment would result from the release of all the uranium-bearing material from a shipping container stored outside. This situation could only occur in the very unlikely instance of a complete failure of the container, whatever the cause.

In the case of uranium doxide, about 90 kg of material, containing a maximum of 80 kg uranium and a maximum of 3.2 kg of U-235, would be released in an insoluble form and would therefore not produce any off-site environmental impact. For uranium hexafluoride, the entire contents of a cylinder would not be immediately released to the atmosphere in the unlikely event of a massive cylinder failure, even if heating of the cylinder causes or results from the condition causing the cylinder to rupture.

The types of cylinders at the Wilmington site are 72 inches long and 30 inches in diameter, with a capacity of 4800 pounds (about 2200 kgs) of uranium hexafluoride

*Environmental Survey - Nuclear Fuel Cycle, U.S. Atomic Energy Commission

(UF_6). In the case of a massive cylinder failure, the UF_6 would vaporize over a period of time, forming UO_2F_2 and HF upon contact with the moisture in the atmosphere. The uranium released from this reaction would be in soluble form.

The maximum inhalation dose commitments for an individual located at the nearest site boundary (about 574 feet would be typical) which would result from the massive failure of a 30-inch UF_6 cylinder are given in Table 17.4. The following assumptions were made in determining these dose commitments:

An aeolian dilution factor of 10^{-3} was used for the closest site boundary (574 feet from the release point).

The ruptured cylinder contained the maximum amount of UF_6 (4800 pounds).

The entire cylinder contents (4800 pounds of UF_6) were released immediately to the atmosphere.

The dose commitments to the bone and kidney were calculated based upon all of the inhaled uranium.

Although the uranium would be entirely in soluble form, the dose commitments to the other organs (lung, stomach, small intenstine, upper and lower large intestine) were calculated based upon the conservative assumption that the uranium inhaled was in an insoluble form.

TABLE 17.4

MAXIMUM INHALATION DOSE COMMITMENT TO AN INDIVIDUAL AT THE NEAREST SITE BOUNDARY RESULTING FROM ACCIDENTAL RELEASE OF URANIUM HEXAFLUORIDE*

Organ	Dose Commitment (Rem)
Lung	3.16
Bone	1.06
Kidney	0.176
Stomach	2.47×10^{-5}
Small Intestine	3.16×10^{-11}
Upper Large Intestine	1.24×10^{-8}
Lower Large Intestine	9.15×10^{-8}

*Instantaneous release from a 30-inch cylinder containing 4800 pounds of uranium hexafluoride. See paragraph 17.4.2 for other assumptions.

It should be recognized that there is an element of conservatism in these accident calculations because of the nature of the materials involved. The postulated release would be in the form of HF and UO_2F_2, both of which would be expected to be visible as a white cloud. Hydrogen fluoride, in particular, is very irritating to the lungs and mucuous membranes; hence, the natural reaction when exposed to this material is to hold one's breath and run from the cloud. Thus, it is extremely unlikely that an individual would be exposed to the cloud for any length of time. An exposure of the order of a few minutes would be most likely for an individual standing relatively close to the site boundary when the postulated incident occurred. Hence, the actual maximum dose commitments are likely to be a factor of 10 to 100 lower than those calculated.

17.4.3 Severity Category 3 Accident

With the exception of the criticality accident, the results of a Category 3 type accident inside or outside the plant involving uranium dioxide or uranium hexafluoride are no worse than those previously discussed for a Category 2 type accident.

No accident analysis of a nuclear fuel manufacturing plant would be complete without a discussion of a criticality accident. Actually, no criticality accidents have ever occurred in a low enrichment uranium fuel fabrication facility.

At WMD, programs of design, review, procedural control, engineered safeguards, and audits are in place to prevent criticality accidents and consequently the probability of an accident of this type is extremely low. There have been six criticality accidents, however, which have occurred in operations related to fuel fabrication or scrap recovery of highly enriched uranium or plutonium.

It should be noted that much larger quantities of low-enriched uranium would be required for a criticality accident than have been involved in these accidents with highly enriched uranium. Based on this accident experience, it can be stated that significant environmental impact is highly improbable.

17.4.3.1 Criticality Accident Postulation

It is reasonable, based on the past accident experience, to assume that the most-probable maximum-criticality accident will result in a total of 10^{18} fissions. Since there are no significant fission products existing in the mass of uranium prior to the initiation of the accident, the only fission products which could be released are those formed during the accident.

The assumptions used in determining the amount of radioactivity released were as follows:

The release results from 10^{18} fissions in a liquid supercritical system.

Initial fission-product inventory is zero and the accident lasts one second. Radioactive decay begins at this time. Only volatile fission products are considered to be released.

The volatile fission product cloud is released from the liquid system and is drawn into the building ventilation system. The time required for the cloud to exit the stack is based on the rate of room air changes in the UF_6 conversion and is 13 minutes.

The velocity of the cloud once it is released from the conversion area stack is 1 m/sec toward the southern site boundary which is 574 feet from the stack. Time for this travel is three minutes. Therefore, the fission products are 16 minutes old at the time the site boundary is reached. A conservative age of 10 minutes is used in the calculations.

It is assumed that an individual at the site boundary would receive exposure from both internal and external sources of radiation. The doses (Table 17.5) were calculated from the individual's submersion in a semi-infinite cloud of beta and gamma emitters, from inhalation of the fission products, and from the direct radiation associated with the incident.

The dose from prompt fission gamma rays and neutrons was obtained from the reference Y-1272, "Y-12 Plant Nuclear Safety Handbook", J. W. Achter, et al, March 27, 1973, Union Carbide Nuclear Co., Oak Ridge, Tenn.

The whole body dose due to submersion in the fission-product cloud was calculated by the standard semi-infinite cloud assumptions.

The inhalation dose to the thyroid was calculated based upon the resulting short-lived radioactive nuclides contained in the fission products.

A median atmospheric diffusion factor at the nearest site boundary of 10^{-3} was used in these calculations.

TABLE 17.5

DOSES TO AN INDIVIDUAL AT THE NEAREST SITE BOUNDARY RESULTING FROM A CRITICALITY INCIDENT

Direct Dose (prompt neutrons and gamma rays)	2.8 Rem
Submersion Dose	2.1 Rem
Inhalation Dose (thyroid)	0.8 Rem

As can be seen from Table 17.5, the doses to an individual at the nearest site boundary from a criticality accident are smaller than the occupational exposure limits for individuals working with radioactive materials.

Therefore, even in the incredible case of a criticality accident in the fuel fabrication plant in which low-enriched uranium is processed, no significant environmental impact (i.e., radiation dose to an individual at the nearest site boundary) would result.

17.5 Transportation Accidents

17.5.1 Effects on Local Traffic Patterns

The manufacturing activities have had two effects on local patterns. The first of these effects is the increase in personal vehicular traffic due to transportation of personnel to and from their place of employment. The impact of plant personnel vehicles on local traffic patterns is kept to a minimum by the staggered reporting hours associated with a 24-hour a day operation.

The estimated traffic contribution from the WMD site personnel is approximately 2,000 per day.

The second effect on local traffic patterns is caused by the shipping and receiving of product and process materials. All of these activities are conducted by truck.

The only change in local roadways necessitated by this increase in traffic was the installation of a turnoff lane at each of the plant entrances and a traffic actuated stop light at one entrance. A vehicular accident involving a truck carrying either uranium bearing materials or chemical process supplies has a potential low probability of occurrence (10^{-6} per vehicle miles).* This probability decreases rapidly as the anticipated severity postulated for the accident increases (10^{-13} per vehicle mile for extremely severe accidents).** Frequency of truck movements carrying these materials to and from the site is only 0.2 per day.

Specific areas considered in material movement are detailed in the following sections:

17.5.2 UF_6 Shipments to the Site

The shipment of enriched UF_6 to the Wilmington Site invovles transportation of fissile, low specific activity material. The enriched UF_6 is received in 2.5 ton capacity cylinders 30 inches in diameter by 81 inches long (Figure 17.1) containing 2.2 metric tons of UF_6. These cylinders are contained in a Model OR30 protective shipping package (Figure 17.2). This

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*Environmental Survey - Nuclear Fuel Cycle, U.S. Atomic Energy Commission.

**Environmental Survey of Transportation of Radioactive Materials To and From Nuclear Power Plants, U.S. Atomic Energy Commission, December, 1972.

packaging is designed to prevent release or criticality under normal and severe accident conditions. While material could be released in an extremely severe accident the probability of criticality occurring would require an incredible series of events.

17.5.3 Shipment of Finished Fuel Assemblies, Uranium Dioxide Powder, and Uranium Dioxide Pellets

The finished fuel assemblies are shipped from the site in GE RA - series shipping packages (Figure 17.3). These containers meet DCT Specifications* and NRC regulations necessary for shipment of these materials.** Uranium dioxide powder and pellets are also shipped in containers that meet DOT specifications and NRC Regulations necessary for shipment of these materials. Accident frequency and severity would be as in subsection 17.5.1 above.

17.5.3.1 Intermediate Shipments and Receipts of Uranium-Bearing Materials

Fissile low enriched materials are also shipped and received in other forms. These include returned, unirradiated fuel rods, low specific activity uranyl nitrate solutions, and waste materials shipped to licensed vendors for off-site disposal. All of these shipments are made in containers which meet the DOT and NRC regulations. Accident frequency and severity would be as in paragraph 17.5.1.

*40 CFR 173

**10 CFR 71

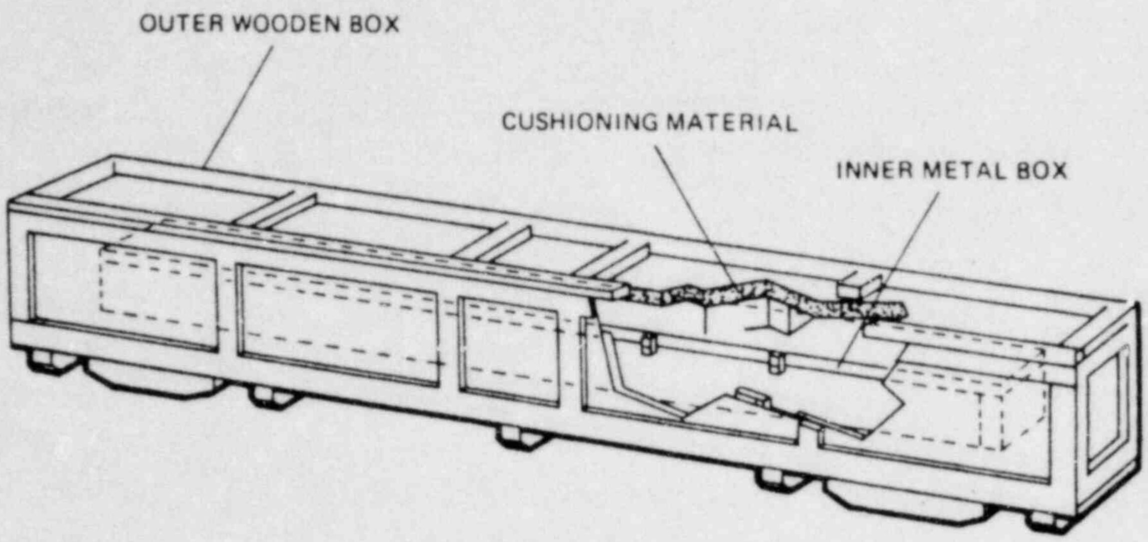

FIGURE 17.3 TYPICAL FUEL ELEMENT SHIPPING CONTAINER

Radiation exposures as a result of the shipments to transportation workers, onlookers, and people along the shipping route are well within established limits. The highest exposure would be obtained by the truck drivers. This exposure is extremely low; i.e., if one driver handled the total year's production, he would receive less than 5 mRem which is less than 5 percent of the background radiation dose.

17.5.3 Bulk Chemicals

Bulk tank truck shipments of anhydrous ammonia, aqueous ammonia, nitric acid, hydrofluoric acid, hydrated lime, and sodium hydroxide solutions are received and utilized on site.

The frequency of these receipts as well as shipments of nitrate solutions, hydrofluoric acid and spent caustic is less than 25 per week. These materials are all shipped in accordance with DOT regulations. The probability of accident frequency is similar to the probability discussed for a truckload shipment of UF_6.