SURRY INDEPENDENT SPENT FUEL STORAGE INSTALLATION SAFETY ANALYSIS REPORT AMENDMENT 15 INSTRUCTIONS

These instructions apply for implementing Amendment 15 of the Surry ISFSI Safety Analysis Report (SAR). The SAR update package consists of:

(1) Instruction Sheet

(1) Set, Volume 1 Replacement Pages with Tabs

UPDATE INSTRUCTIONS

1. In Volume 1, remove and set aside the pages behind the *Amendment Record* tab.
2. In Volume 1, remove and discard the remaining contents of Volume 1 *in its entirety*, including all previously issued tabs, table of contents, text pages, table pages, figure pages, appendices, and list of effective pages.
3. Insert the new pages and tabs into Volume 1.
4. In Volume 1, remove the generic "SURRY ISFSI SAFETY ANALYSIS REPORT RECORD OF CHANGES" place holder page and replace it with the pages that were set aside in step 1.
5. Date and initial the Record of Changes entry for Amendment 15 on the "SURRY ISFSI SAFETY ANALYSIS REPORT RECORD OF CHANGES" page inserted in step 4.

[*end*]

SAFETY ANALYSIS REPORT

SURRY POWER STATION

DRY CASK INDEPENDENT SPENT FUEL STORAGE INSTALLATION

VOLUME 1

Amendment Record

SURRY ISFSI SAFETY ANALYSIS REPORT
RECORD OF CHANGES

	DATE	INITIAL		DATE	INITIAL
AMENDMENT 1	XX	XX	AMENDMENT 25		
AMENDMENT 2	XX	XX	AMENDMENT 26		
AMENDMENT 3	XX	XX	AMENDMENT 27		
AMENDMENT 4	XX	XX	AMENDMENT 28		
AMENDMENT 5	XX	XX	AMENDMENT 29		
AMENDMENT 6	XX	XX	AMENDMENT 30		
AMENDMENT 7	XX	XX	AMENDMENT 31		
AMENDMENT 8	XX	XX	AMENDMENT 32		
AMENDMENT 9	XX	XX	AMENDMENT 33		
AMENDMENT 10	XX	XX	AMENDMENT 34		
AMENDMENT 11	XX	XX	AMENDMENT 35		
AMENDMENT 12	XX	XX	AMENDMENT 36		
AMENDMENT 13	XX	XX	AMENDMENT 37		
AMENDMENT 14	XX	XX	AMENDMENT 38		
AMENDMENT 15	XX	XX	AMENDMENT 39		
AMENDMENT 16			AMENDMENT 40		
AMENDMENT 17			AMENDMENT 41		
AMENDMENT 18			AMENDMENT 42		
AMENDMENT 19			AMENDMENT 43		
AMENDMENT 20			AMENDMENT 44		
AMENDMENT 21			AMENDMENT 45		
AMENDMENT 22			AMENDMENT 46		
AMENDMENT 23			AMENDMENT 47		
AMENDMENT 24			AMENDMENT 48		

REVISION SUMMARY

Amendment 15—06/02

Chapter/Section	Changes Made under the provisions of 10 CFR 72.48 except where indicated in brackets.
2.2, 2.2.3.2.1, Table 2.2-5	Transferred the description of chemical products and hazardous substances from a table to text. Augmented the discussion of fuel oil stored at the Gravel Neck Combustion Turbine site.
3.1.1, 3.1.1.1.1.1, 3.1.1.1.1.2, 3.1.1.1.1.3, Table 3.1-1, 3.3.4.1, 3.3.4.2, 3.3.4.3, 3.3.5.2, 4.2.3.3, 5.1.3.1, 7.2.1, 7.3.2.1, 7.3.2.2, 7.3.4, 7.3.5, Tables 7.3-1, 7.3-2, 7.3-3, 7.3-4, & 7.3-5, Figures 7.3-2, 7.3-3, 7.3-4, 7.3-5, & 7.3-6, 7.4.1, 7.4.2, 7.4.3, Tables 7.4-1, 7.4-2, 7.4-3, & 7.4-4, 7.6, 7.6.2, 8.2.9, A.1/7.3.2.1, A.1/7.3.2.2, Tables A.1/7.3-2, A.1/7.3-3, & A.1/7.3-4, Figures A.1/7.3-2, A.1/7.3-3a, A.1/7.3-3b, A.1/7.3-4a, A.1/7.3-4b, A.1/7.3-5a, A.1/7.3-5b, A.1/7.3-6, A.1/7.3-7a, A.1/7.3-7b, A.1/7.3-8a, A.1/7.3-8b, A.1/7.3-9a, A.1/7.3-9b, & A.1/7.3-10, A.2/7.3.2.1, A.2/7.3.2.2, Figure A.2/7.3-6, A.3/7.3.2.1, A.3/7.3.2.2, Figure A.3/7.3-6, A.4/7.3.2.1, A.4/7.3.2.2, Figure A.4/7.3-6, A.5/3.1.2, A.5/3.3.4, A.5/3.3.4.1, A.5/4.2.3.3, Table A.5/4.2-1, A.5/7.3.2.1.1, A.5/7.3.2.2, A.5/7.3.5, Table A.5/7.3-2, Figures A.5/7.3-2, A.5/7.3-3, A.5/7.3-4, A.5/7.3-5, A.5/7.3-6, & A.5/7.3-7, A.5/8.2.9	Updated the shielding, criticality, thermal, and accident evaluations used to support the revised fuel limits for the TN-32 cask. [10 CFR 72.56 License Amendment]
10.2.1.1	Changed the fuel record requirement from date of manufacture to delivery date.

Amendment 15—06/02

Chapter/Section	Changes Made under the provisions of 10 CFR 72.48 except where indicated in brackets.
10.8.1	Updated management titles for those positions responsible for safe operation of the ISFSI.
A.1/3.1.1, A.1/7.3.5, A.2/3.1.1, A.2/7.3.5, A.3/3.1.1, A.3/7.3.5	Included more information on the storage of burnable poison rod assemblies or thimble plug devices with the fuel assemblies placed in the CASTOR V/21, MC-10, and NAC I/28 storage casks. [10 CFR 72.56 License Amendment]
Appendix A.5, Appendix A.5 Attachment 1	Added provisions for the use of TN-32 casks fabricated to the requirements of the TN-32 FSAR, Revision 0.
A.5, A.5 Attachment 1	Incorporated the modified TN-32 cask lid bolt analysis.
A.5, A.5 Attachment 3	Modified the TN-32 cask protective cover and overpressure system.
A.5/7.3.2.1	Added guidance on the calculation of separate gamma and neutron average side surface dose rates for TN-32 storage casks.
A.5 Attachment 3	Reconfigured the TN-32 overpressure system tubing.

Amendment 14

Chapter/Section	Changes Made under the provisions of 10 CFR 72.48 except where indicated in brackets.
A.5	Revised the description of the weld in the neutron shield outer shell of TN-32 casks.
A.5	Clarified the location of borated aluminum plates in the fuel basket of TN-32 casks.
A.5, A.5 Attachment 2	Incorporated structural analyses for missile impacts on TN-32 casks.
A.5/3.1.1, A.5/7.3.5 Refs	Added information on the storage of burnable poison rod assemblies and thimble plug devices in TN-32 casks. [10 CFR 72.56 License Amendment]

Amendment 13

Chapter/Section	Changes
1.2, 1.3, 1.4, Table 1.1-2, Table 1.1-3, Figure 1.2-1, 3.1.2, 3.2.1.1, 3.3.1, 3.3.2.1, 3.3.4, 3.3.5.1, Table 3.3-1, 4.1.2.4, 4.2.3.3, Table 4.2-1, 4.3.2.1, 4.3.8, 4.3.12, 5.1.1, 5.1.4, Table 5.1-1, 5.2.1, 5.2.2, 5.3.1.1, 5.3.1.3, 5.3.2, 6.3.1, 6.4.2, 7.1.1, 7.1.2, 7.1.3, Table 7.1-1, Table 7.1-2, 7.2.1, 7.3.1, 7.3.3, 7.5, 7.5.1, 7.5.2, 7.5.3, Table 7.5-1, Table 7.5-2, Table 7.5-3, Table 7.5-4, Table 7.5-5, Table 7.5-6, Figure 7.5-1, 7.6, 7.6.1.4, Table 7.6-1, Table 7.6-2, Table 7.6-3, Figure 7.6-1, Figure 7.6-2, Figure 7.6-3, Figure 7.6-4, 8.2.5, 8.2.10, 9.2.3, 9.4.1.2, 9.4.2, 10.1, 10.2.1.2, 10.2.2.3, 10.3, A.2/3.1.1, A.2/7.3.2.1, A.2/7.3.2.2, A.2/7.3.5, A.2/8.2.8, & A.3/7.3.2.2	Incorporated technical and editorial corrections and clarifications resulting from the Integrated Configuration Management Project compliance review of the Surry ISFSI facility. The proposed changes include conversion of the entire SAR document to electronic media to facilitate publishing and availability to end-users on the MIND system.

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SURRY ISFSI SAR

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1. Introduction and General Description of Installation

Chapter 1
INTRODUCTION AND GENERAL DESCRIPTION OF INSTALLATION

1.1 INTRODUCTION

The spent fuel pool at the Surry Power Station, like those at most other nuclear power plants in this country, was designed only for short-term storage with the expectation that fuel reprocessing would be available. Fuel reprocessing, however, has not become available, nor is it expected to become available in the near future. Interim storage at away-from-reactor (AFR) fuel storage facilities, and storage at permanent repositories have also yet to become viable alternatives. The independent spent fuel storage installation (ISFSI) at the Surry site is designed to store all the anticipated spent fuel resulting from the operation of the Surry Power Station Units 1 and 2 in excess of that which can be stored in the spent fuel pool.

The Surry ISFSI is located within the site boundary of the Surry Power Station and is owned and operated by Virginia Electric and Power Company (Virginia Power). The fuel is stored in dry sealed surface storage casks (SSSCs) which ensure the confinement of the radioactive fission products and provide shielding. The casks are cooled by natural convection.

The Surry Power Station spent fuel pool has a capacity of 1,044 fuel assemblies, and according to the current refueling schedule (60 assemblies discharged per unit every 18 months) would be totally filled by 1987. However, the capability to discharge an entire core (157 assemblies) would be lost in 1986. Structural limitations preclude adding additional capacity to the spent fuel pool through the use of, for example, higher density spent fuel storage racks. The Surry ISFSI began operation in 1986 in order to avoid the loss of the full core discharge capability, and will continue to operate throughout the life of the power plant or until other arrangements are made to dispose of the spent fuel.

Bechtel Associates Professional Corporation (Virginia), hereafter referred to as Bechtel, is the Architect/Engineer. Casks to be used in the Surry ISFSI are designed and manufactured by other organizations and will be purchased or leased by Virginia Power.

Detailed information describing the SSSCs is provided in SSSC topical reports referenced in Appendix A of this Safety Analysis Report (SAR). General references to the SSSC topical reports are made in sections of this SAR, as needed, to supplement information contained in the SAR. Each cask type is described in a subappendix of Appendix A. Also, the subappendices provides cask-specific information not contained in the SSSC topical reports. The combination of this SAR, including appendices, and any one of the reports describing the SSSCs (one per type of cask or manufacturer) provides all the information described in the U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 3.48, *Standard Format and Content for the Safety Analysis Report for an Independent Spent Fuel Storage Installation (Dry Storage).* The Surry ISFSI

utilizes only those casks described in these reports and meeting the design criteria specified in Chapter 3 of this SAR.

This SAR is primarily directed towards analyzing the safety aspects of cask handling and storage once the casks have left the Surry Power Station decontamination building, and how the safety requirements in 10 CFR Part 72 are satisfied. Handling of the casks inside the fuel and decontamination buildings is addressed as part of the license for the Surry Power Station under 10 CFR Part 50. A summary of SAR sections addressing the technical requirements in 10 CFR Part 72 is presented in Tables 1.1-1 and 1.1-2.

Table 1.1-1
COMPLIANCE WITH TECHNICAL REQUIREMENTS IN 10 CFR PART 72

Section in 10 CFR Part 72	Topic	SAR Section Where Addressed
Subpart E		
72.90 to 72.102	Site characteristics and definition of design basis external events	Chapters 2 and 3 (1)
72.104	Radiological consequences	Chapters 7 and 8
72.106	Controlled area	Section 4.1.2 and Chapter 8
72.32	Emergency planning	Sections 4.1.2.3 and 9.5 (2)
Subpart F		
72.122 (a)	Quality standards	Sections 3.1.2, 3.4, 9.4.1.8, and Chapter 11 (3)
(b)	Protection against environmental conditions	Sections 3.2, 4.2.3, 8.2.2, and 8.2.3
(c)	Fires and explosions	Sections 3.3.6, 4.3.8, 8.2.4, and 8.2.5
(d)	Sharing of structures	Section 5.1.1
(e)	Proximity of sites	Sections 3.3.7.1 and 7.6.2 (1)
(f)	Testing and maintenance	Table 3.3-1, Sections 4.3.9, 4.5, 9.2, and 9.4.1.4, and Chapter 5
(g)	Emergency capability	Section 9.5
(h)	Confinement barriers	Sections 3.3.2, 4.2.2.3, 4.2.3, 4.3.1, 7.3.3, 8.2.9, and 8.2.11
(i)	Instrumentation and controls	Sections 3.3.3.2, 4.3.7, 5.4.1, 7.3.4, and 10.9
(j)	Control areas	Section 5.5 (4)
(k)	Utility services	Sections 4.3 and 8.1
72.124	Criticality	Sections 3.3.4, 4.2.3, and 5.1.3.1
72.126 (a)	Radiation exposure control	Chapter 7 and Sections 5.1.3.5, 9.4.1.3, and 9.4.1.4
(b)	Radiological alarm systems	Sections 3.3.3.2, 3.3.5.3, 4.3.7, 5.1.3.4, 5.4.1, and 10.9
(c)	Effluent and direct radiation monitoring	Sections 7.3.4 and 7.6.1

Table 1.1-1 (continued)
COMPLIANCE WITH TECHNICAL REQUIREMENTS IN 10 CFR PART 72

Section in 10 CFR Part 72	Topic	SAR Section Where Addressed
72.126 (d)	Effluent control	Sections 7.3.1, 7.6, and 8.2.11
72.128 (a)	Criteria for spent fuel storage and handling systems	Chapter 3
(b)	Criteria for waste treatment	Section 3.3.7
72.130	Decommissioning	Sections 3.5 and 9.6 (5)
Subpart G		
72.140	Quality assurance	Chapter 11 and Sections 3.3.2.1 and 9.4.1.8 (3)
Subpart H		
72.182	Physical protection	(4)
Subpart I		
72.190	Operator requirements	Chapter 9
72.192	Operator training and certification	(6)
72.194	Physical requirements	Chapter 9

Notes:

(1) Also addressed in Environmental Report

(2) Also addressed in Emergency Plan

(3) Also addressed in Quality Assurance Program

(4) Also addressed in Physical Security Plan, Design for Physical Security, and Safeguards Contingency Plan

(5) Also addressed in Decommissioning Plan

(6) Also addressed in Training Program

Table 1.1-2
INDEX OF MAJOR TECHNICAL TOPICS

	SAR Sections Where Criteria are Set	SAR Sections Where Addressed	Sections in 10 CFR Part 72 Where Requirements are Placed
Site			
Site Descriptions		2.1.1, 2.1.2, 2.1.4, 4.1	72.90
Meteorology	3.2.4	2.3, 8.3	72.122(b)
Hydrology		2.4, 2.5	72.90, 72.122(b)
Population		2.1.3	72.98, 72.100
Seismology/Geology	3.2.3	2.6, 8.2.1	72.102, 72.122(b)
Natural Hazards	3.2.1, 3.2.2	4.2.3, 8.2.2, 8.2.3	72.90, 72.92, 72.102, 72.122(b)
Man-Made Hazards	3.3.6	2.2, 4.2.3, 4.3.8, 8.2.4, 8.2.5	72.94, 72.98, 72.122(c)
Casks			
Design	3.2.5	3.2.1.2, 4.2.3	
Confinement Capabilities	3.3.2	4.2.2.3, 4.2.3, 8.2.9, 8.2.11	72.122(h), 72.128(a)
Thermal Analyses	3.1.1, 3.1.2	4.2.3	72.128(a)
Criticality Control	3.3.4	4.2.3, 5.1.3.1	72.124
Handling	3.1.2, 3.3.1, 3.3.7.1, 3.3.8	5.1.1, 5.1.2, 5.2.1, 5.2.2	
Instrumentation	3.3.3.2, 3.3.5.3	4.3.7, 5.1.3.4, 5.3.2, 5.4, 5.5, 7.3.4, 7.6.1.4, 9.2, 9.4.1.2, 10.9	72.122(i), 72.126(c), 72.128(a)
Fuel	3.1.1, 3.1.2, 3.3.7.1		

Table 1.1-2 (continued)
INDEX OF MAJOR TECHNICAL TOPICS

	SAR Sections Where Criteria are Set	SAR Sections Where Addressed	Sections in 10 CFR Part 72 Where Requirements are Placed
ISFSI			
Concrete Slabs		4.1.1, 4.2.1	
Access Control	3.3.5.1	9.4.1.1, 9.4.1.3	72.180, 72.182, 72.184, 72.186
Radiological Control			
Onsite Doses		7.3.2.2, 7.4, 9.4.1.3	72.126
Offsite Doses		7.6, 8.2.11	72.104, 72.106
ALARA	3.3.5.2	7.1, 7.3.1, 7.5	72.104(b), 72.126(c)
Shielding	3.3.5.2	7.2.1, 7.3.2	72.128(a)
Decontamination		4.4, 5.6, 6.1, 6.3.2.1, 6.3.3	
Interaction with Power Plant	3.1.2, 3.3.7.1	5.1.1, 5.1.2, 6.1, 7.4, 8.2.6, 8.2.10, 9.1, 9.2	72.122(d) and (e)
Emergency Planning		4.1.2.3, 9.5	72.32, 72.122(g)
Technical Specifications		Chapter 10	
Quality Assurance	3.1.2, 3.4	9.4.1.8, Chapter 11	72.122(a), 72.140
Accident Analyses	3.3.2	Chapter 8	72.122(b)
Maintenance	3.3.3.2	4.3.9, 4.5, 5.1.3.5, 9.4.1.4	72.122(f)
Waste Handling	3.3.7	6.3, 6.4, 6.5	72.128
Decommissioning	3.5	9.6	72.130

1.2 GENERAL DESCRIPTION OF INSTALLATION

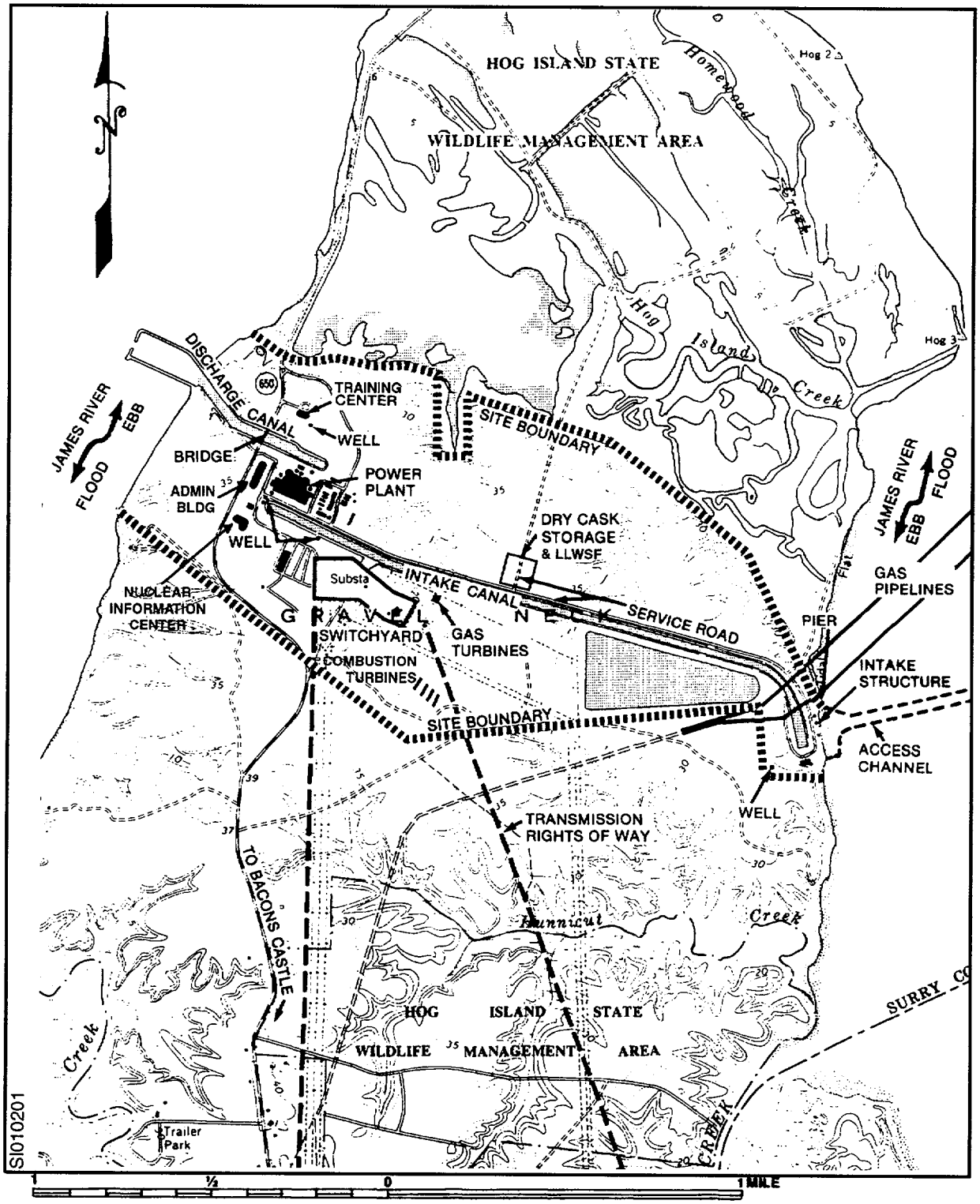
The Surry site comprises about 840 acres in Surry County, Virginia. The ISFSI is located near the center of the site, about 3300 feet east of the Surry Power Station. Figure 1.2-1 shows a general layout of the site.

The Surry Power Station consists of two closed-cycle pressurized water reactors (PWR) provided by Westinghouse. Operating licenses were issued by the Atomic Energy Commission (AEC) in May 1972 and January 1973 for Units 1 and 2, respectively. Unit 1 started commercial operation in December 1972 and Unit 2 in May 1973. A complete description of the power station is provided in the Final Safety Analysis Report (FSAR), AEC/NRC dockets 050-280/281.

An application for a Construction Permit (CP) for two additional units at the Surry site was filed with the AEC in April 1973, and a CP was issued in December 1974. These plants have subsequently been cancelled, but the Preliminary Safety Analysis Report (PSAR) for Units 3 and 4 is referenced in this SAR as a source of more recent information describing the Surry site. The Units 3 and 4 application was filed under AEC/NRC dockets 050-434/435.

The Surry ISFSI consists of three concrete slabs on which the loaded storage casks are placed. The slabs will be built in sequence, as needed, and in an order which minimizes radiation exposures. Each slab is surrounded by an inner security fence which in turn is surrounded by an outer fence (hereinafter referred to as the ISFSI fence). The ISFSI fence also surrounds the nearby Low Level Waste Storage Facility (LLWSF). The only support systems required are those necessary for transferring the loaded and sealed casks from the Surry Power Station to the ISFSI. The SSSCs are the only components with a safety function. The other components, e.g., monitors, alarms, power supplies, lights, etc., do not perform safety functions.

Figure 1.2-1
GENERAL SITE LAYOUT



1.3 GENERAL SYSTEMS DESCRIPTION

The Surry ISFSI uses sealed storage casks to store fuel irradiated at the Surry Power Station. Typically the casks are large cylindrical vessels capable of storing 24 unconsolidated PWR fuel assemblies. The casks are carbon steel, stainless steel, or cast iron with stainless steel cladding, about 16 feet long and 8 feet in diameter, with walls several inches thick and weighing 100 to 125 tons fully loaded. The fuel is stored in a dry atmosphere, possibly inerted, and held in place by a basket or rack.

Several steps are necessary for the loading and preparation of the casks, which take place within the fuel and decontamination buildings of the existing Surry Power Station. The casks are loaded under water in the spent fuel pool where the primary lid is positioned prior to lifting the casks out of the water. The water in the casks is pumped to the Spent Fuel Pool. The casks are then moved to the Decon Building where they are vacuum dried, backfilled with helium, and leak tested. Following decontamination of the outer surface, the casks are placed on a transporter outside the fuel building. The casks are then transferred to the ISFSI, where they are emplaced on one of the three concrete slabs.

The SSSCs are totally passive systems, with natural convection cooling sufficient to maintain safe fuel clad temperatures. The cask walls provide adequate shielding, and no radioactive products are released under any credible conditions.

1.4 QUALIFICATIONS OF AGENTS AND CONTRACTORS

Bechtel has been contracted for the engineering design of the Surry ISFSI, excluding the casks, and for the preparation of the license application.

The cask manufacturers are responsible for cask fabrication, testing, delivery to the site, and delineation of specific cask requirements, if any. Information related to the qualifications of the cask manufacturers is contained in the topical reports referenced in Section 1.5.1.

Site preparation and necessary construction will be performed by Vepco's construction department, using specialty subcontractors, as required.

1.5 MATERIAL INCORPORATED BY REFERENCE

1.5.1 Topical Reports

The Topical Reports issued by SSSC suppliers, which are referenced in this SAR and Appendix A, are listed in Appendix A, Table A/1.5-1.

1.5.2 Other Reports

The following documents related to the licensing of the Surry Power Station Units 1 and 2, and 3 and 4, which are already on file with the NRC, are reference throughout this SAR:

1. Surry Power Station Units 1 and 2 Final Safety Analysis Report, 1971.

2. Surry Power Station Units 3 and 4 Preliminary Safety Analysis Report, 1973.
3. Surry Power Station Environmental Report for Units 3 and 4, 1973.
4. Surry Power Station Emergency Plan.
5. Virginia Electric and Power Company Operational Quality Assurance Program Topical Report, VEP-1-5A, (updated).

Chapter 2
THE SITE CHARACTERISTICS

2.1 GEOGRAPHY AND DEMOGRAPHY

2.1.1 Site Location

The location of the Independent Spent Fuel Storage Installation (ISFSI) is approximately 3300 feet southeast of the Surry Power Station Units 1 and 2 reactor buildings and within the boundaries of the Surry site (see Figure 2.1-1). The facility occupies approximately 15 acres.

The Surry site is located in Surry County, Virginia, on the south shore of the James River, on a point of land called Gravel Neck. The site is at the end of Route 650, 12 miles from Surry, 44 miles southeast of Richmond, 38 miles east of Petersburg, 7 miles south of Colonial Williamsburg, and 4-1/2 miles west-northwest of Fort Eustis.

Approximate coordinates of the ISFSI are:

LATITUDE-LONGITUDE	UNIVERSAL TRANSVERSE MERCATOR
37° 9.8' N - 76° 41.65' W	4,113,800 mN 349,700 mE Zone 18

2.1.2 Site Description

The Surry site is located on a point of land which projects into the James River from the south giving the appearance of a peninsula. The tip of this peninsula, known as Hog Island, is very marshy and almost severed from the rest of Gravel Neck by many streams and creeks. The site area is mostly wooded to the south. Route 650, a state secondary road, provides the only land access to the Surry site and the Hog Island State Waterfowl Refuge.

Locations of public facilities and institutions, e.g., parks, recreational areas, and schools, in the site area are described in Section 2.1.3.5.

The site plan for the Surry ISFSI and its relative location to the Surry Power Station are presented on Figure 2.1-1. Consistent with the Surry Power Station Units 1 and 2 Updated FSAR, the restricted area for the ISFSI is the Surry site boundary. The controlled area boundary is also the site boundary. As shown on Figure 2.1-1, the minimum distance to the controlled area boundary is approximately 1500 feet and occurs in the northwest sector relative to the ISFSI.

2.1.2.1 Other Activities Within The Site Boundary

Since the controlled area for the Surry ISFSI is wholly within the property lines for the Surry site, Vepco has full authority to determine all activities including the exclusion and the removal of personnel and property.

No activities unrelated to operation of the Surry Power Station or the ISFSI are permitted within the controlled area.

2.1.2.2 **Boundaries for Establishing Effluent Release Limits**

There are no radioactive effluent releases associated with the Surry ISFSI. The boundary line corresponds to the property lines for the site. The nearest real individual is approximately 1.5 miles from the ISFSI.

2.1.3 Population Distribution and Trends

2.1.3.1 **Population Within 10 Miles**

Figure 2.1-2 shows the general locations of the ISFSI and the municipalities and other cultural features within 10 miles of the site.

In the Virginia Radiological Emergency Response Plan, June 1983 (Reference 1), the distribution within 10 miles of the site was reported as shown in Figure 2.1-3. According to this report, the estimated 1980 permanent resident population within 10 miles of Surry Power Station was 84,574 persons. The permanent resident population is a subset of the total population shown in Figures 2.1-3 to 2.1-7, which includes permanent residents and transient and institutional populations. The area within 10 miles of the plant site is predominantly rural and is characterized by coastal lowland farms interspersed with marshy areas near the James River. There are populated areas in the northern and eastern sectors. As indicated on Figure 2.1-2, the municipalities which are wholly or partly within 10 miles of the site are:

	1980 Population (Reference 2)	Distance (Miles) from Surry Site	Direction from Surry Site
Newport News	144,903	4.5 (closest point)	ESE
Williamsburg	9870	7	N
Surry	237	8	WSW

The population projections for the areas within 10 miles for the years 1990, 2000, 2010, and 2020, as shown in Figures 2.1-4 through 2.1-7, were based on Virginia County projections found in the Virginia Population Projections 2000 (Reference 3) and supplemental information provided by the Virginia Department of Planning and Budget Research Section (Reference 4). The specific procedure used to calculate the population involved first dividing each sector along county boundaries so that each applicable county comprises a specific percentage of the individual sector area. Uniform population density throughout each county is assumed. The counties are then assumed to contribute a fraction of their population to the sector which is directly proportional to the fraction of area they contribute to the sector. Consequently, the sector populations are a summation of the area-weighted fraction, by sector, of the projected population contributed by the counties which comprise the sector.

2.1.3.2 **Population Between 10 and 50 Miles**

Towns and cities within 50 miles of the site are shown on Figure 2.1-8. These centers of population are listed in Table 2.1-1 along with their 1980 resident population and their distance and direction from the site. Estimates of the 1980 resident population from 10 to 50 miles are based on data compiled by the Commonwealth of Virginia utilizing the 1980 census figures. Figure 2.1-3 shows the estimated 1980 population distribution.

The population projections for the areas between 10 and 50 miles for the years 1990, 2000, 2010, and 2020, as shown in Figures 2.1-4 through 2.1-7, were based on Virginia County projections found in the Virginia Population Projections 2000 (Reference 3) and supplemental information provided by the Virginia Department of Planning and Budget Research Section (Reference 4). The procedure used to calculate the population by sector from this data was identical to that used for the 0- to 10-mile sector population projections discussed in Section 2.1.3.1.

2.1.3.3 **Transient and Institutionalized Population**

Listings of the nearby transient and institutionalized population, based on the Virginia Radiological Emergency Plan (Reference 1), are provided in Tables 2.1-4 and 2.1-5, respectively.

2.1.3.4 **Population Center**

The nearest population center is the City of Newport News, which had a 1980 population of 144,903 (Reference 3) and whose closest point is 4-1/2 miles east-southeast of the site

2.1.3.5 **Public Facilities and Institutions**

Schools

Schools within 10 miles of the site are listed in Table 2.1-2 and indicated on Figure 2.1-9.

Parks and Recreational Areas

Recreational areas within 10 miles of the site are listed in Table 2.1-3 and indicated on Figure 2.1-10. The recreational facility closest to the site is the Chippokes State Park, 2.5 miles southwest, which had a maximum 2-day attendance of 70,000 during 1981. Busch Gardens at the Anheuser Busch Brewery, 6 miles north of the site, opened in 1975. The combined annual attendance for the brewery and the gardens reached 2,160,000 (estimated) in 1980. The Hog Island State Waterfowl Refuge, 1 mile north-northeast of the site, maintained by the State of Virginia, harbors wild geese, ducks, deer and cranes, as well as other species of wildlife. This area is used by an estimated 25,000 people annually (estimated by refuge manager). The Williamsburg-Jamestown area, 6 miles north, is a popular historical attraction. About a million people per year visit the historical sites in this region.

2.1.4 Uses of Adjacent Lands and Waters

The Surry site is located on a peninsula projecting into the James River. The area within 10 miles of the site covers parts of Surry, Isle of Wight, York, and James City counties, and part of the City of Newport News. Immediate environs of the plant site are shown on Figure 2.1-2. Surry and Isle of Wight Counties are predominantly rural and characterized by farmland, wood tracts of land, and marshy wet lands. York and James City counties and Newport News City are more urban and are characterized by recreational areas and growing population centers. The tip of the peninsula, north of the site, is very marshy and almost severed by many streams and creeks. The Hog Island State Waterfowl Refuge is located on this tip of land.

About half of the total area in Surry and Isle of Wight Counties is used for agricultural purposes. The principal agricultural activity is crop farming. Forest products are also of great importance in the site region. The dominant species are loblolly pine, oak-pine, and oak-hickory. Public and private water supplies for nearby towns and dwellings, recreational facilities, and fishing facilities are described in Section 2.1.3 of the ER.

The discovery of kepone contamination in the James River was made in 1975 and has been responsible for extended periods of fishing restrictions which have varied from a total ban on fishing to selective closure by species, river section, or purpose (commercial or sport). Generally, these restrictions have reduced commercial and sport catches with the exception of channel catfish. Fishing for this species is now open to sport and commercial fisherman.

2.1.5 References

1. The Commonwealth of Virginia Radiological Emergency Response Plan (COVRERP) Annex I-V to Volume II, The Commonwealth of Virginia, Emergency Operations Plan Peacetime Disasters, Revised 1983.

2. Bureau of the Census, U. S. Department of Commerce 1980 Census of Population, Number of Inhabitants, PC (l)-A48, Virginia, February 1982.

3. Virginia Population Projections 2000, Virginia Department of Planning and Budget, Research Section, January 1983.

4. Supplemental Population Projections 2010 and 2020, Virginia Department of Planning and Budget, Research Section, January 1983.

Table 2.1-1 (SHEET 1 OF 2)
TOWNS AND CITIES WITHIN 50 MILES OF PLANT SITE

Town/City	1980 Population	Distance from Surry Site (miles)	Direction from Surry Site
0-10 Miles			
Newport News (closest point)	144,903	4.5	ESE
Williamsburg	9870	7	N
Surry	237	8	WSW
10-20 Miles			
Smithfield	3718	13	SSE
Dendron	307	15	WSW
Hampton (closest point)	122,617	15	ESE
Claremont	380	16	WNW
Poquoson	8726	17	E
20-30 Miles			
Ivor	403	21	SSW
Wakefield	1355	21	SW
Norfolk (closest point)	266,979	24	SE
Portsmouth (closest point)	104,577	24	SE
Waverly	2284	24	WSW
Windsor	985	24	S
Chesapeakes (closest point)	106,426	26	SSE
West Point	4236	27	NNW
30-40 Miles			
Saratoga Place			
Suffolk	35,533	31	S
Urbanna	518	33	N
Virginia Beach (closest point)	257,269	33	SE
Hopewell	23,507	35	WNW
Irvington	567	36	NNE
White Stone	409	36	NNE
Franklin	7308	36	SSW
Ft. Lee	9784	37	W
Courtland	976	37	SW
Cape Charles	1512	38	E
Petersburg	41,055	38	W
Colonial Heights	16,509	39	W

Table 2.1-1 (SHEET 2 OF 2)
TOWNS AND CITIES WITHIN 50 MILES OF PLANT SITE

Town/City	1980 Population	Distance from Surry Site (miles)	Direction from Surry Site
40-50 Miles			
Kilmarnock	869	40	NNE
Cheriton	695	41	ENE
Capron	238	42	SW
Stony Creek	329	42	WSW
Eastville	238	43	ENE
Highland	10,911	43	NW
Chester	11,728	44	WNW
Newsome	368	44	SSW
Richmond (closest point)	219,214	44	WNW
Mechanicsville	9269	48	NW
Boykins	791	49	SW
Jarrat	614	49	WSW
Nassawadox	630	50	ENE

Table 2.1-2 (SHEET 1 OF 2)
SCHOOL ENROLLMENT WITHIN 10 MILES OF THE PLANT SITE
BY MUNICIPAL JURISDICTION

	Subzone	Fall 1979 Enrollment	Total
Counties			
James City			
Berkeley School	10A	485	
Lafayette H.S.	10A	1727	
Rawlsbyrd School	5A	494	
			2706
Surry			
Lebanon School	10F	180	
Surry Elementary	10F	157	
Surry H.S.	10F	545	
			882
York			
Bruton High School	10B	729	
Magruder Elementary	10B	559	
Queens Lake Intermediate	10B	321	
Yorktown Intermediate	10C	590	
Waller Mill Elementary	10B	448	
			2647
Cities			
Newport News			
Lee Hall Elementary	10D	662	
B.C. Charles Elementary	10D	504	
Denbigh Elementary	10D	324	
Denbigh H.S.	10D	1635	
Dozier Intermediate	10D	1144	
Dutrow Elementary	10D	579	
Horace Hepes Elementary	10D	548	
Jenkins Elementary	10D	566	
McIntosh Elementary	10D	689	
Menchville H.S.	10D	2030	
R.O. Nelson Elementary	10D	602	
Reservoir Elementary	10D	823	
Richneck Elementary	10D	821	
Sanford Elementary	10D	702	
			11,629

Table 2.1-2 (SHEET 2 OF 2)
SCHOOL ENROLLMENT WITHIN 10 MILES OF THE PLANT SITE
BY MUNICIPAL JURISDICTION

	Subzone	Fall 1979 Enrollment	Total
Williamsburg			
Blair Middle School	10B	782	
Bruton Heights School	10B	671	
Walsingham Academy	10B	549	
William & Mary College	10B	6000	
			8560
	TOTAL		26,424

Table 2.1-3
RECREATIONAL AREAS WITHIN 10 MILES OF SURRY SITE

Park/Recreational Area	Distance and Direction From Site	Total Annual Attendance
Chippokes State Park	2.5 mi. SW	70,000 (peak two day attendance 1981)
Jamestown Island National Historical Park	4 mi. NW	471,107 (1971)
Jamestown Festival Park	5 mi. NW	449,317 (1971)
Anheuser-Busch Brewery and Busch Gardens	6 mi. N	2,160,000 (1980)
Colonial Williamsburg	7 mi. N	1.5-2 million yearly
Yorktown National Historical Park	10 mi. ENE	201,116 (1971)

Table 2.1-4
TRANSIENT POPULATION WITHIN 10 MILES OF THE PLANT SITE

Transient Population Centers	Maximum Daily Attendance [a]
Jamestown Colonial National Historical Park	2500
College of William and Mary	8300
Colonial Williamsburg Foundation	15,400
Busch Gardens	35,000
Yorktown Colonial National Historical Park	2500
Chippokes State Park	55
TOTAL	63,755

a. The transient population figures above represent the maximum daily attendance at the facilities during the peak season.

Table 2.1-5
INSTITUTIONALIZED POPULATION WITHIN
10 MILES OF THE PLANT SITE

Institutionalized Population Centers	Daily Attendance
Walsingham Academy	600
Eastern State Hospital	1500
Williamsburg Community Hospital	400
Pines Convalescent Center	290
Camp Peary	300
Naval Supply Depot - Cheatham Annex	200
Ball Corporation	400
Yorktown Naval Mine Depot	2400
Badische Corporation	550
Fort Eustis	8500
City Farm Penal Facility	150
TOTAL	15,290

Figure 2.1-1
GENERAL SITE LAYOUT

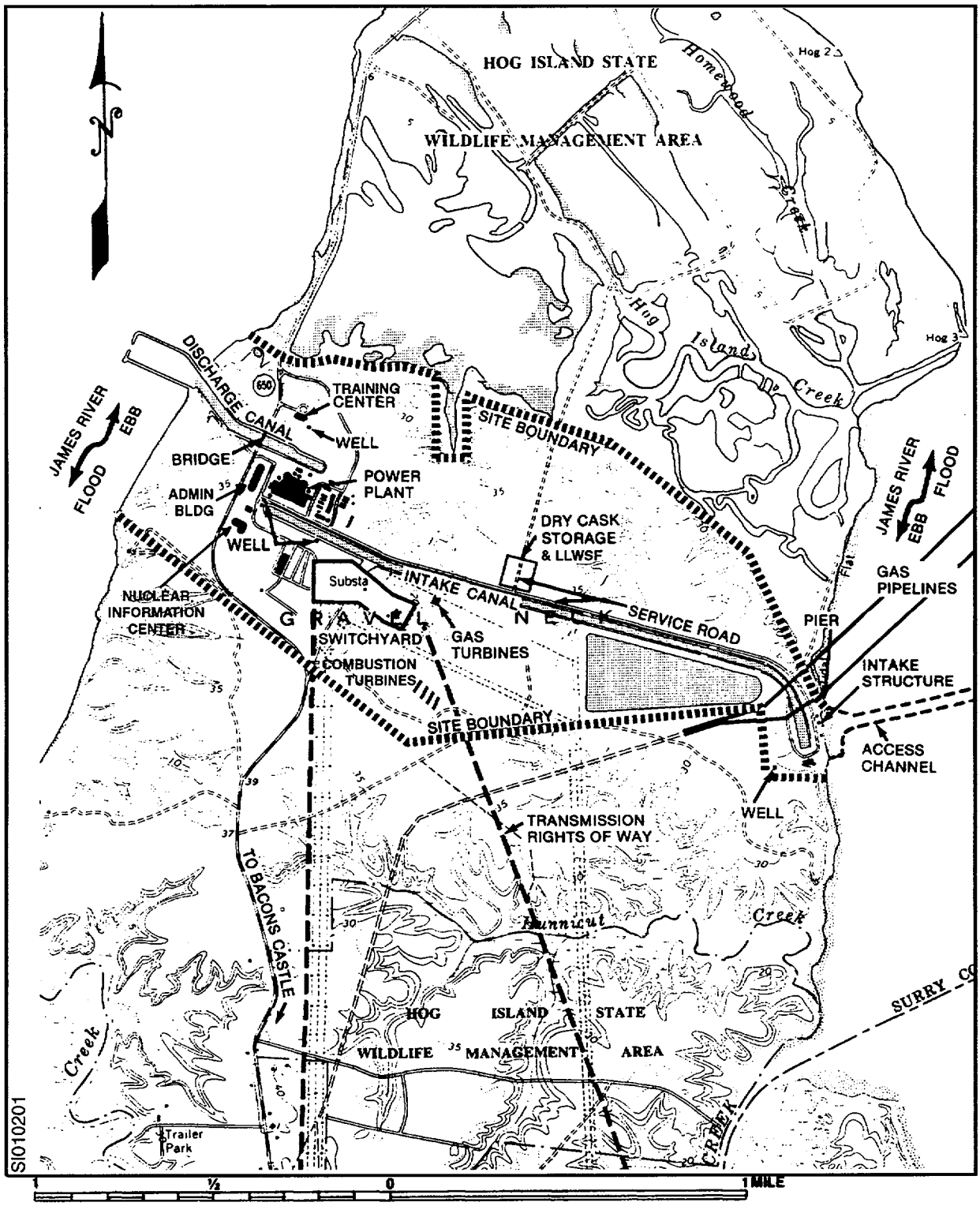


Figure 2.1-2
IMMEDIATE ENVIRONS OF PLANT SITE; SURRY POWER STATION

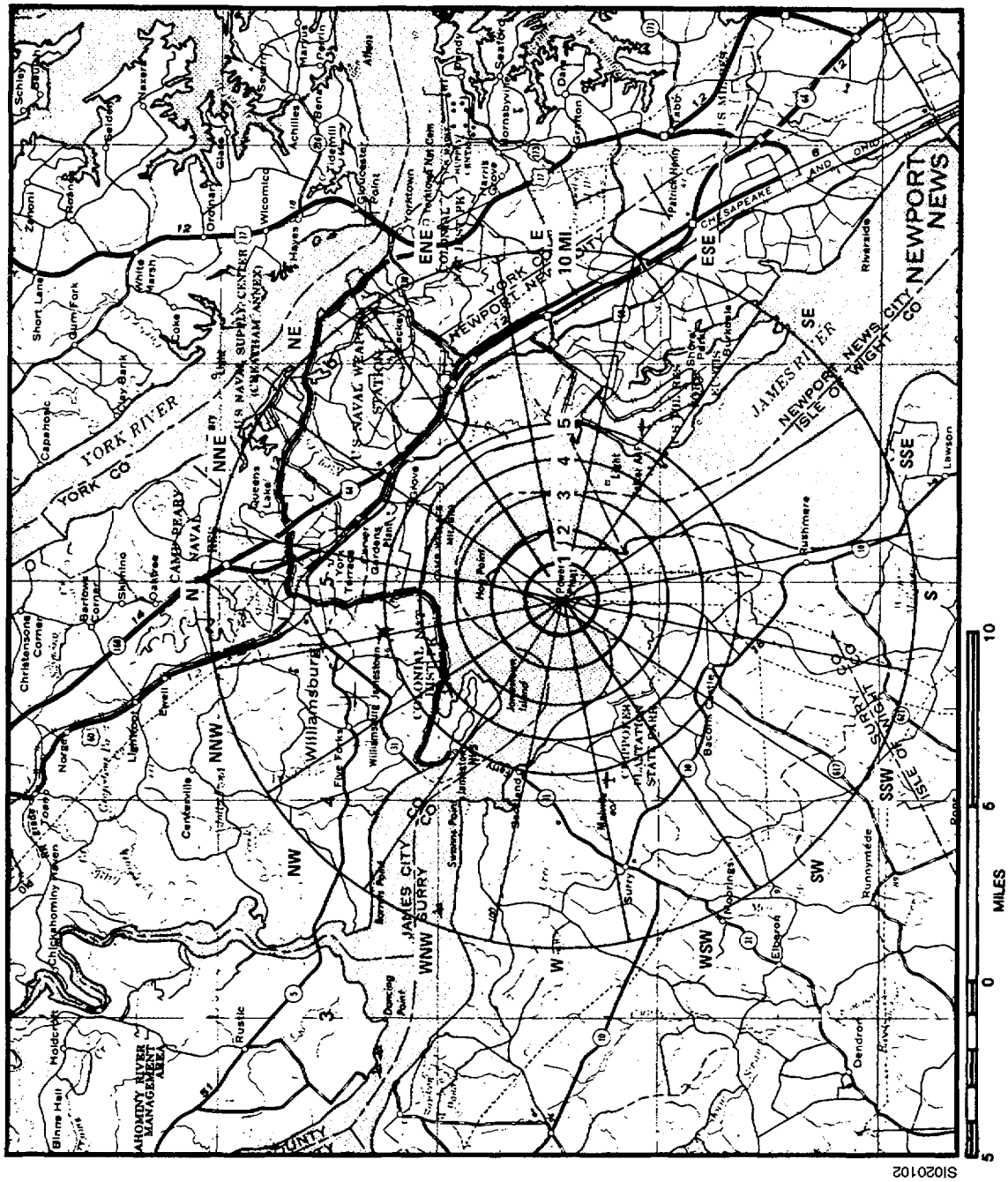


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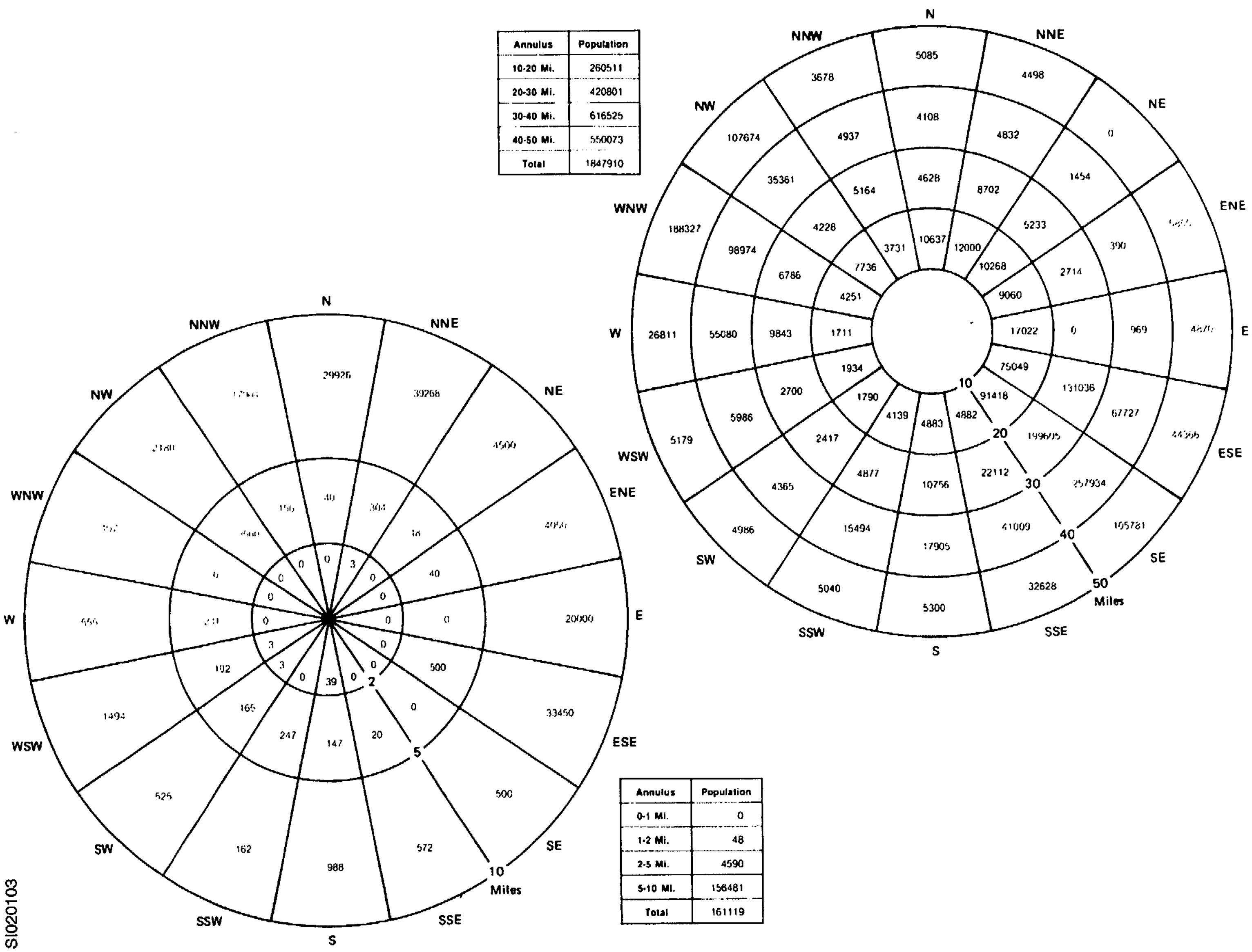
Figure 2.1-3
POPULATION DISTRIBUTION; 0-10 AND 10-50 MILES; SURRY POWER STATION; 1980



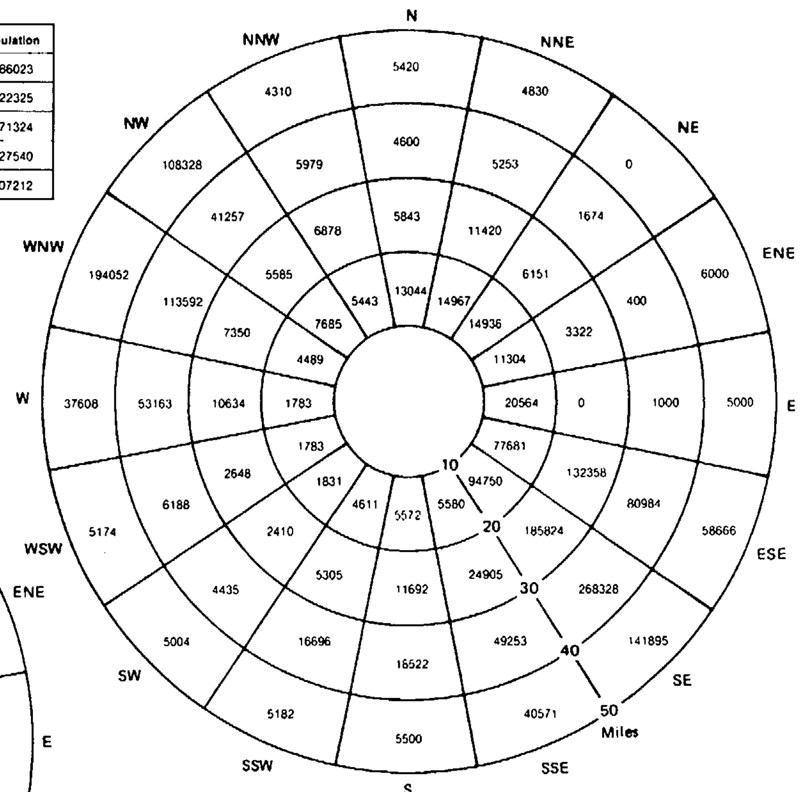
Annulus	Population
10-20 Mi.	260511
20-30 Mi.	420801
30-40 Mi.	616525
40-50 Mi.	550073
Total	1847910

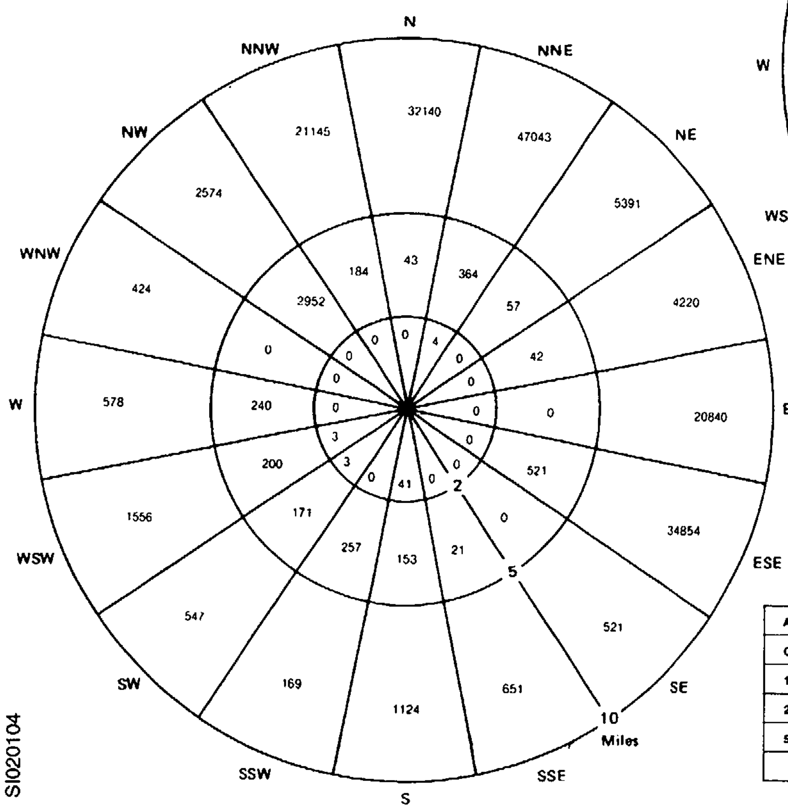
Annulus	Population
0-1 Mi.	0
1-2 Mi.	48
2-5 Mi.	4590
5-10 Mi.	156481
Total	161119

SI020103

Figure 2.1-4
POPULATION DISTRIBUTION; 0-10 AND 10-50 MILES; SURRY POWER STATION - UNITS 3 AND 4; 1990

Annulus	Population
10-20 Mi.	286023
20-30 Mi.	422325
30-40 Mi.	671324
40-50 Mi.	627540
Total	2007212



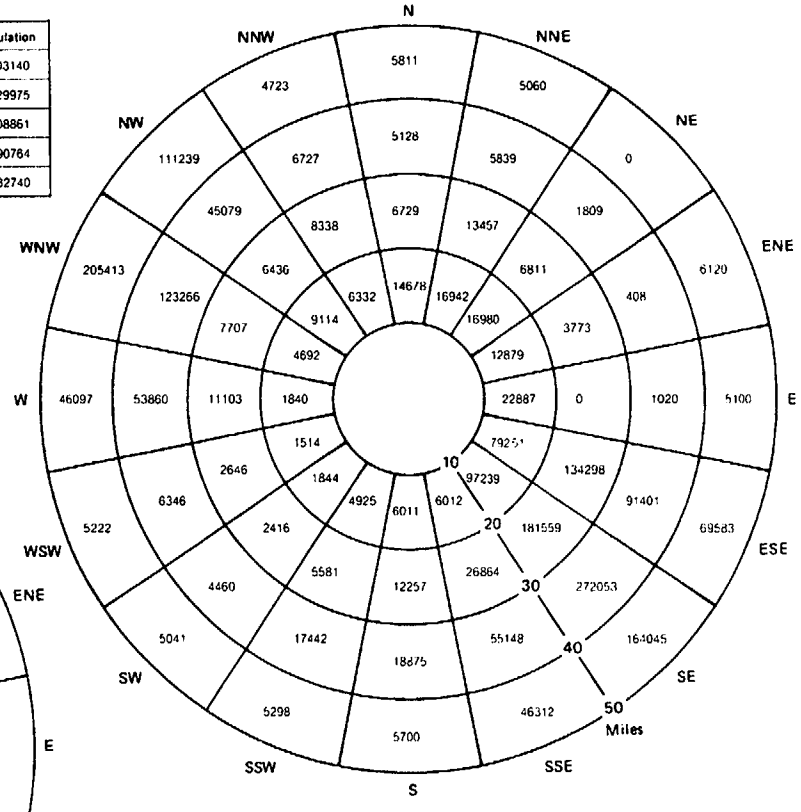


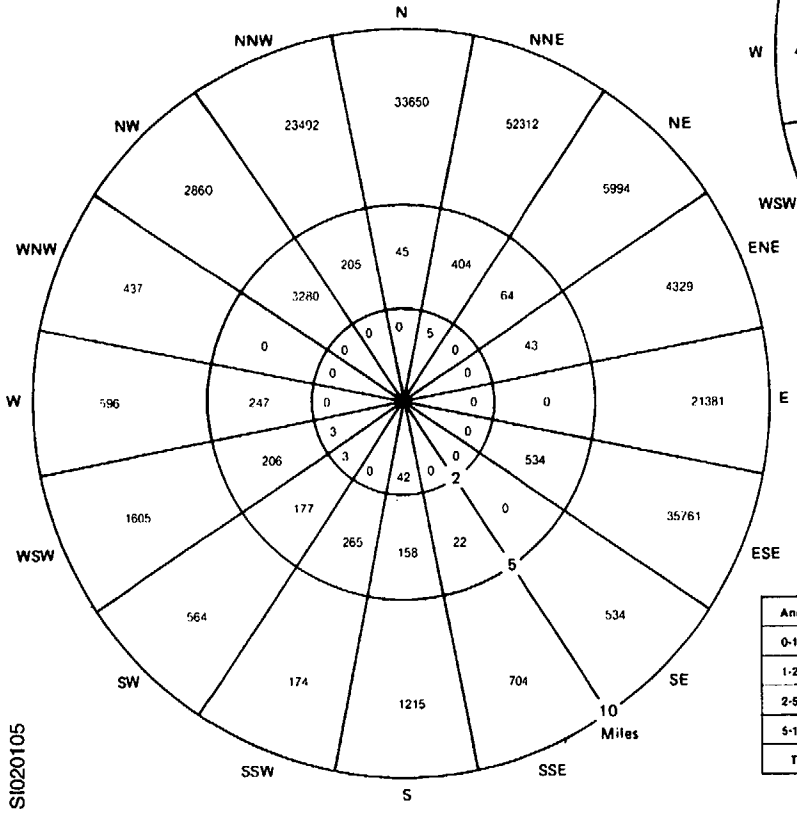
Annulus	Population
0-1 Mi.	0
1-2 Mi.	51
2-5 Mi.	5205
5-10 Mi.	173777
Total	179033

SI020104

Figure 2.1-5
POPULATION DISTRIBUTION; 0-10 AND 10-50 MILES; SURRY POWER STATION - UNITS 3 AND 4; 2000

Annulus	Population
10-20 Mi.	303140
20-30 Mi.	429975
30-40 Mi.	708861
40-50 Mi.	690764
Total	2132740



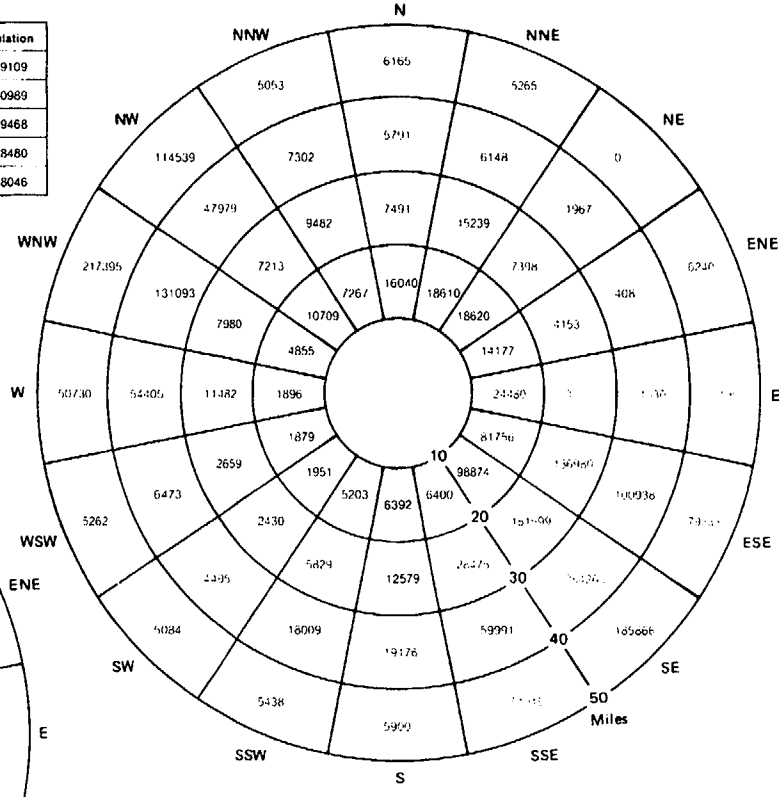


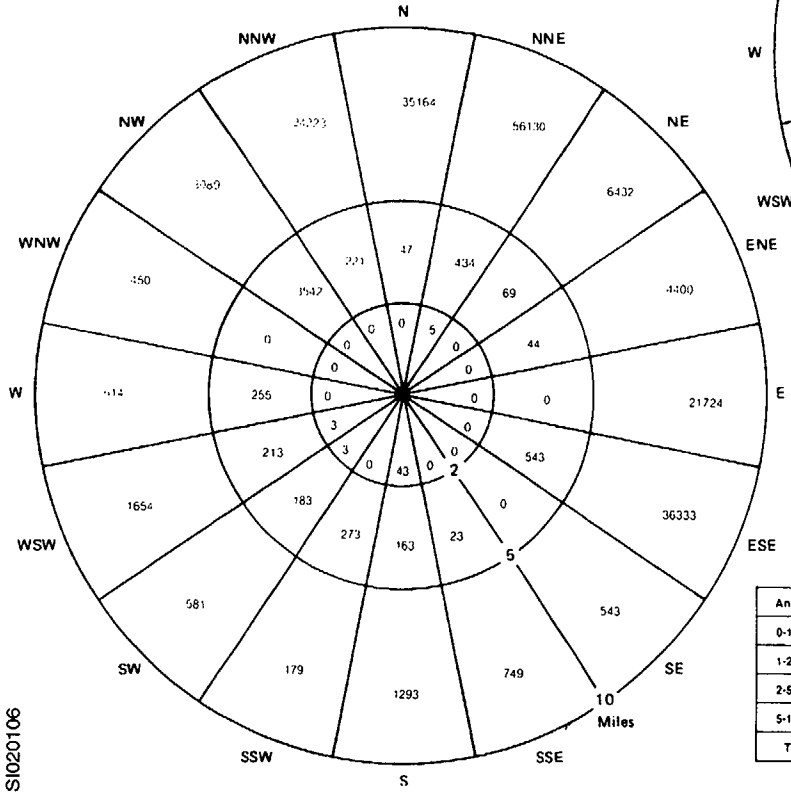
Annulus	Population
0-1 Mi.	0
1-2 Mi.	53
2-5 Mi.	5650
5-10 Mi.	185608
Total	191311

SI020105

Figure 2.1-6
POPULATION DISTRIBUTION; 0-10 AND 10-50 MILES; SURRY POWER STATION - UNITS 3 AND 4; 2010

Annulus	Population
10-20 Mi.	319109
20-30 Mi.	440989
30-40 Mi.	749468
40-50 Mi.	748480
Total	2258046





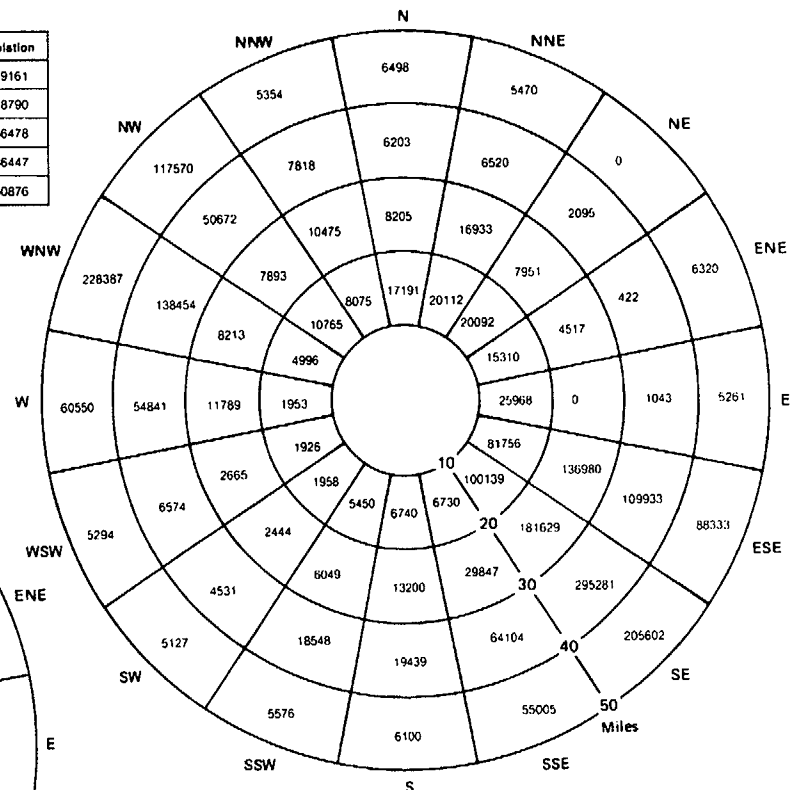
Annulus	Population
0-1 Mi.	0
1-2 Mi.	54
2-5 Mi.	6010
5-10 Mi.	193558
Total	199622

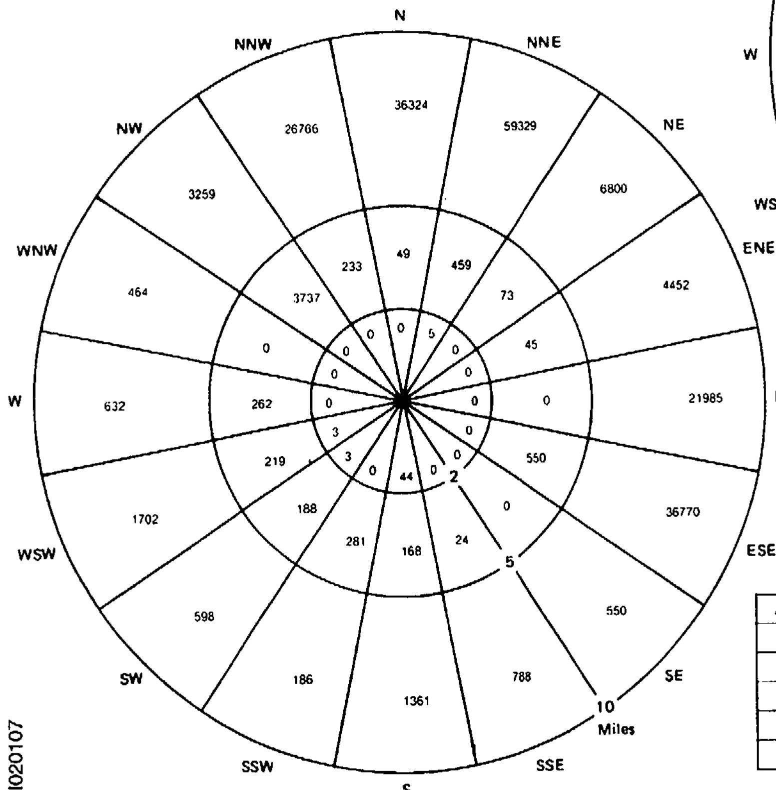
SI020106

Figure 2.1-7

POPULATION DISTRIBUTION; 0-10 AND 10-50 MILES; SURRY POWER STATION - UNITS 3 AND 4; 2020

Annulus	Population
10-20 Mi.	329161
20-30 Mi.	448790
30-40 Mi.	786478
40-50 Mi.	886447
Total	2450876





Annulus	Population
0-1 Mi.	0
1-2 Mi.	55
2-5 Mi.	6288
5-10 Mi.	201966
Total	208309

SI020107

Figure 2.1-8
REGION SURROUNDING PLANT SITE

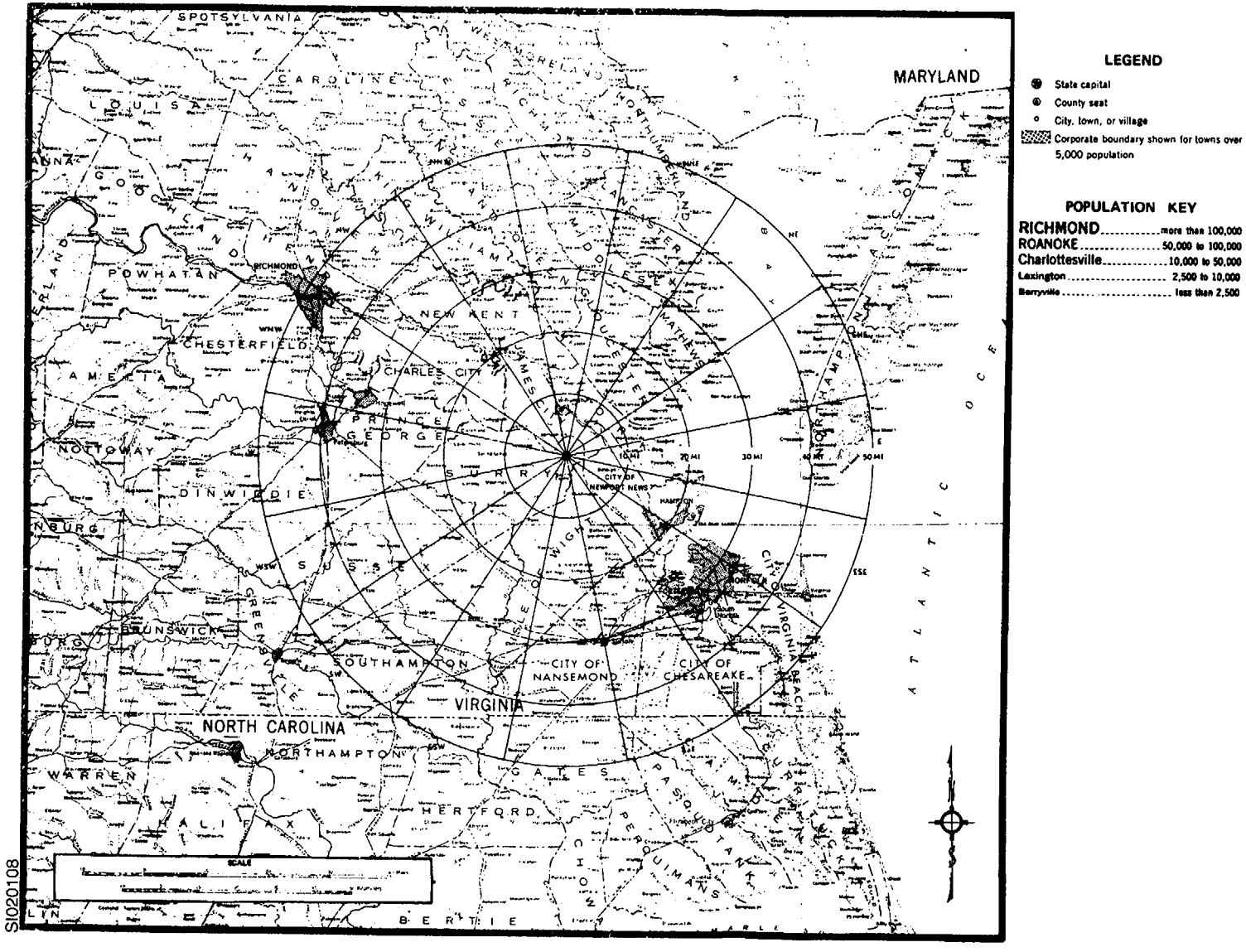


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Figure 2.1-9
SCHOOLS WITHIN 10 MILES OF THE SITE; SURRY POWER STATION

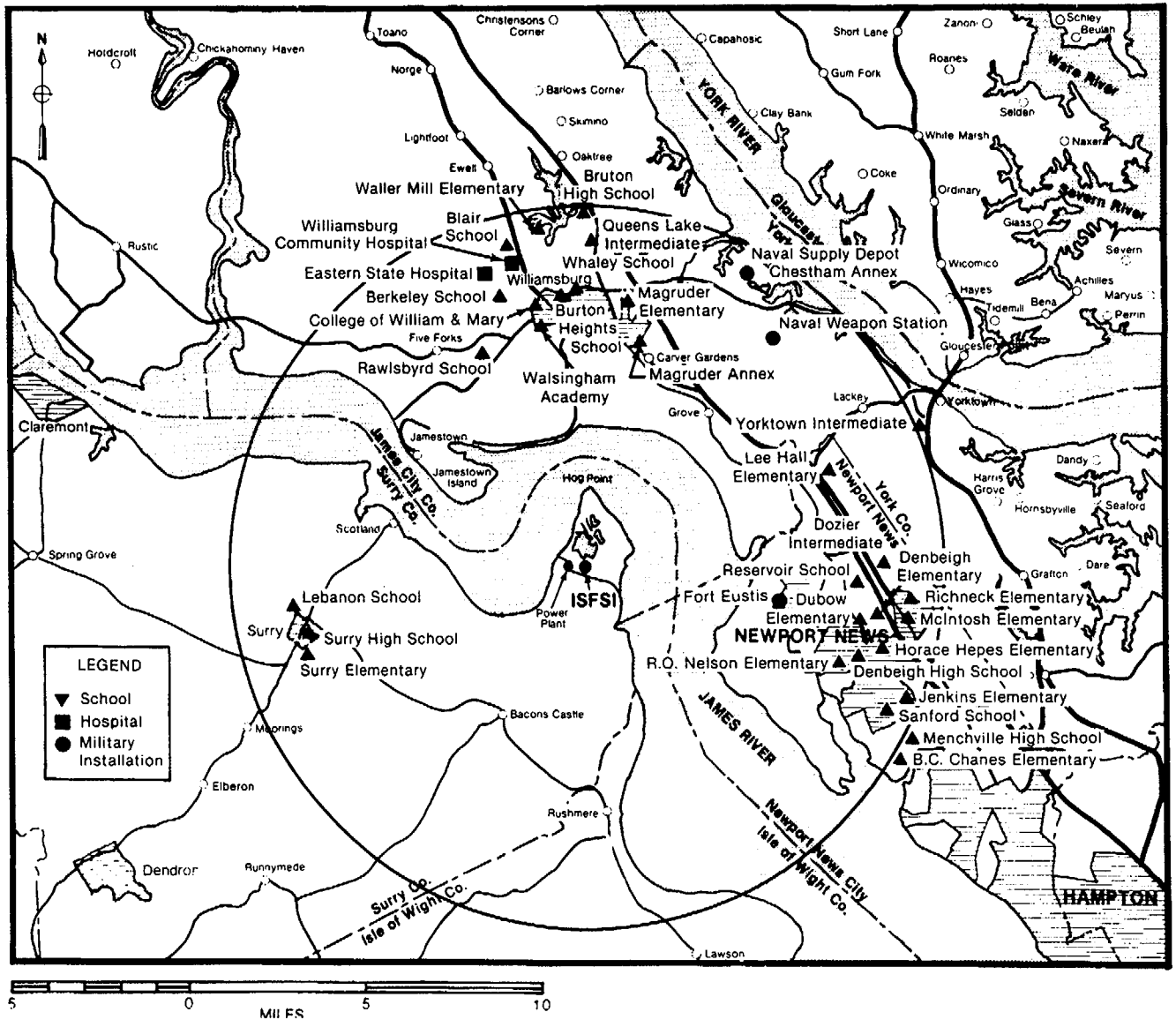
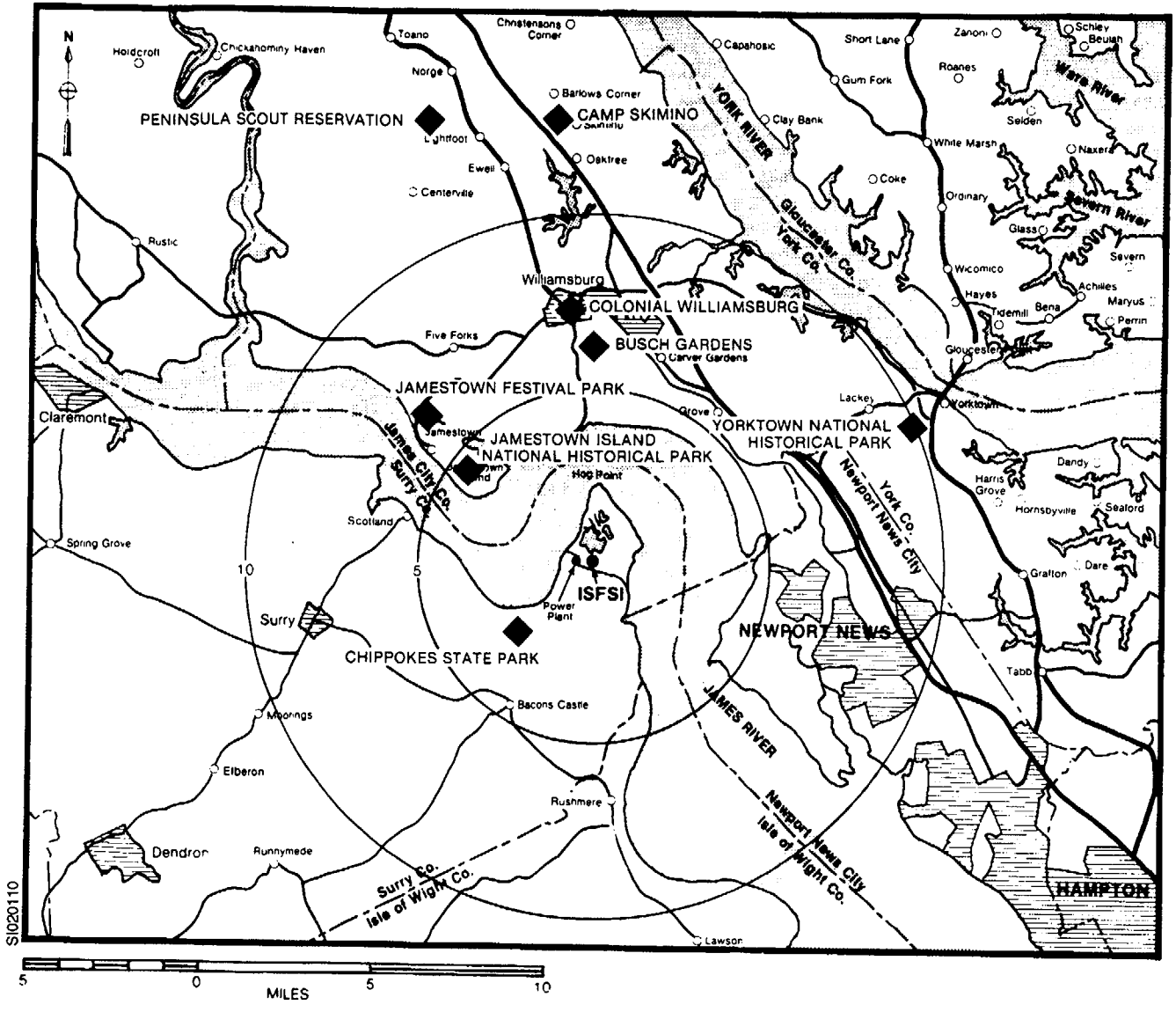


Figure 2.1-10
PARKS AND RECREATIONAL AREAS; SURRY POWER STATION; UNITS 3 & 4



2.2 NEARBY INDUSTRIAL, TRANSPORTATION, AND MILITARY FACILITIES

This section evaluates the effects of potential accidents in the vicinity of the site from industrial, transportation, and military installations and operations to determine whether they present a hazard to the safe operation of the Surry ISFSI.

Potentially hazardous chemicals used and stored onsite were previously quantified in tabular format in this section. The list of chemicals in the table included morpholine, acetone, cyclohexylamine, sulfuric acid, ammonium hydroxide, carbon dioxide, No. 2 fuel oil, chlorine, hydrazine, and dimethylamine. Not all of these chemicals continue to be used and stored onsite. The current requirements, responsibilities, and methodology for control of chemical products and hazardous substances are governed by station administrative procedures. The ongoing chemical control program and spill prevention control and countermeasure plan described in procedures provide details of the quantities of substances and their proper handling and use.

2.2.1 Location and Routes

Route 650, a state secondary road, provides the only land access to the ISFSI. Roads within 10 miles of the site are shown on Figure 2.2-1. Also shown on Figure 2.2-1, the Chesapeake and Ohio Railway passes approximately 6 miles northeast of the ISFSI at its closest approach. The site is bordered on the east and west by the James River and is accessible by water craft at the eastside pier. As discussed in Section 2.2.2.5, there are two airports 5 miles from the Surry site, Williamsburg-Jamestown Airport (5 miles north northwest) and Felker AAF field (5 miles southeast). Airports within 10 miles of the site are illustrated on Figure 2.2-2.

There are no major communities within 5 miles of the Surry site. The closest industrial facilities to the site are Anheuser-Busch, a brewery plant (4.5 miles northeast), and Dow Badische Co., a synthetic fibers factory (4.9 miles north). Other industries within 10 miles of the site are discussed in Section 2.2 of the Surry Power Station Units 3 and 4 PSAR. They are mostly food processing plants or hardware/clothing manufacturers.

The largest and nearest military installation within 5 miles of the site is the U. S. Army Transportation Center at Fort Eustis (5 miles east- southeast).

As shown on Figures 2.2-3 and 2.2-4, both the Commonwealth Natural Gas Corporation and Colonial Pipeline Company own pipelines which cross the southeast corner of the site. The Commonwealth pipeline branches into the combustion turbine building which is located south of the cooling canal to supply natural gas to the Surry station. There are no other pipelines within 5 miles of the facility.

There are no known mine or stone quarries within 5 miles of the site or nuclear facilities other than the Surry Power Station within 50 miles of the Surry ISFSI.

2.2.2 Description

2.2.2.1 Description of Facilities

Table 2.2-1 lists the primary function, major products, and the number of people employed for all the industrial, transportation, and military facilities identified in Section 2.2.1.

2.2.2.2 Description of Products and Materials

A survey (Reference 1) of the Surry site was conducted in 1981 to identify locations of chemical compounds transported, stored, and/or used within 5 miles of the facility. The James River comprises most of the study area, with marsh/swamp land distributed over the peninsula, farmland on the southern boundaries and residential and recreational areas on the northern boundary. The James River and Virginia Highway 10 are the only two transportation routes serving the site area.

Chemical compounds shipped along the James River are listed in Table 2.2-2. Table 2.2-3 provides the list of chemical compounds transported on a regular basis by truck on Virginia Highway 10. This list does not include shipments of small amounts of chemical compounds shipped to and used by the local farmers and merchants in Surry and Isle of Wight counties.

State secondary Route 650 is the only land access to the Surry site. It ends at the Hog Island State Waterfowl Refuge, north of the site. No chemicals or cargo are expected to be transported on this portion of Route 650 unless the chemicals are used by the Surry Power Station.

2.2.2.3 Pipelines

The location and size of the pipelines are shown on Figure 2.2-3 and 2.2-4. No automatic check valves are located in the vicinity of the Surry Power Station. The products carried in each pipeline and their operating pressures are given in Table 2.2-6.

2.2.2.4 Waterways

Since the ISFSI does not involve the use of an intake structure, this section does not apply.

2.2.2.5 Airports

There are three airports within approximately 5 miles of the site. Melville, a private field with a 2900-foot unpaved runway, lies 6 miles west-southwest of the site. Williamsburg-Jamestown Airport, 5 miles north-northwest has a 3200-foot paved runway. Felker AAF field is 5 miles southeast of the site. This facility maintains a control tower and has a 3000-foot paved runway. These and other airports within 25 miles of the site are listed in Table 2.2-7. There are no federal airways within 5 miles of the plant (Reference 2).

2.2.3 Effects of Potential Accidents

2.2.3.1 Explosions and Flammable Vapor Clouds

Based on information presented in Section 2.2.1 and 2.2.2, possible sources of explosion and formation of flammable vapor clouds include the natural gas or petroleum products carried by the pipelines passing near the site or explosive materials/chemicals used by nearby industrial facilities, carried by truck traffic on Virginia Highway 10, or carried by waterborne traffic on the James River.

2.2.3.1.1 Truck Traffic

As shown in Table 2.2-3, the largest explosive load transported on Highway 10 contains 8500 gallons of gasoline. The explosive force of this quantity of gasoline is estimated to be equivalent to 50,700 pounds of TNT using a simple TNT equivalent yield formula (Reference 3).

According to NRC Regulatory Guide 1.91 *Evaluation of Explosives Postulated to Occur on Transportation Routes Near Nuclear Power Plants* (Reference 4), if this amount of gasoline were to explode at the closest point to the site, 4.5 miles, on Highway 10, a peak overpressure of 1 psi would be experienced about 1900 feet away from the point of explosion. The overpressure experienced by the casks 4.5 miles downwind of the explosion would be significantly less than 1 psi.

Flammable vapor clouds formed from a spill of gasoline on the highway, do not present an explosive hazard because gasoline vapor clouds are not known to detonate in unconfined areas (References 5 & 6). The other chemicals listed in Table 2.2-3 are not flammable in nature.

2.2.3.1.2 Waterborne Traffic

Traffic on the James River is confined to a dredged ship channel which is 2.5 miles from the ISFSI at its closest point. As indicated in Table 2.2-2, gasoline carried by barge is the only chemical transported on the river that would present a potential explosion hazard.

Assuming the whole barge is filled with gasoline, 1,300,000 gallons, and is involved in an explosion, the explosive force generated by this quantity of gasoline is estimated (Reference 3) to be equivalent to 7,760,000 pounds of TNT.

Regulatory Guide 1.91 (Reference 4) indicates an overpressure of 1 psi would be experienced about 8000 feet (1.6 miles) downwind of the explosion. Therefore, the overpressure experienced by the casks 2.5 miles away would be much less than 1 psi.

2.2.3.1.3 Industrial Facilities

The nearest industrial facility, as identified in Section 2.2.1, is located 4.5 miles from the site. Chemical compounds used by, and/or stored at the nearby chemical facilities are listed in Table 2.2-4.

As shown in Table 2.2-4, only acrylonitrile and methyl acrylate are explosive. The explosive forces generated by 50,000 gallons of acrylonitrile and 25,000 gallons of methyl acrylate are estimated (Reference 3) to be equivalent to 240,000 and 99,000 pounds of TNT respectively. Assuming an explosion involving one tank of either chemical compound, Regulatory Guide 1.91 (Reference 4) estimates that a peak overpressure of 1 psi would be experienced at a distance less than 3000 feet from explosion of either chemical.

Therefore, the overpressure experienced by the casks 4.5 miles downwind of the explosives would be significantly less than 1 psi.

2.2.3.1.4 Pipelines

The largest and closest natural gas pipeline, 12 inches in diameter, is located 1300 feet southwest of the ISFSI, and a 14-inch petroleum-products pipeline, carrying a number of different fuels (leaded and unleaded gasoline, aviation fuel, kerosene, and No. 2 fuel oil) is located 3600 feet south of the ISFSI.

An explosion of either natural gas or any petroleum products occurring in the pipelines is considered to be impossible due to the absence of oxygen. However, potential explosions may result from ruptured or leaking pipelines. As indicated in Regulatory Guide 1.91 (Reference 4), for an overpressure of about 1 psi to be experienced at about 1300 feet or 3600 feet down-wind, explosions involving the equivalent of 25,000 pounds or 500,000 pounds TNT of explosive material, respectively, would be needed. Based on these findings and the nature of the chemicals, the natural gas pipeline poses the most significant hazard to the safe operation of the ISFSI.

The amount of natural gas, which would produce an explosive force equivalent to 25,000 pounds TNT, corresponds to the contents of a 2.6-mile section of the pipe. In the case of a leaking pipeline, any possible explosion will not involve the whole quantity of the natural gas within the pipeline. This is due to the fact that the natural gas will be dispersed and carried downwind by the ambient wind as soon as it leaks from the pipeline. An unconfined natural gas vapor cloud is not known to explode (References 6, 7 & 8). In the ruptured pipeline case, assuming the whole quantity is involved in an explosion and natural gas is escaping at sonic velocity, it will take more than 12 seconds to empty a 2.6-mile pipe section. The natural gas cloud will eventually occupy a volume of 450,000 ft^3 without wind advection. If the gas cloud is advected by a very low wind, i.e., 1 meter per second, the elongated gas cloud will have a diameter of 135 feet. As discussed in the leaking pipeline case, an unconfined natural gas vapor cloud is not known to explode. There- fore, the assumption of an explosion involving the 2.6-mile section of a natural gas pipeline is a very conservative assumption.

2.2.3.2 **Fires**

The potential sources of fire are: (1) fossil fuels stored on or off the Surry Power Station site; (2) the flammable liquids carried by the truck traffic on Virginia Highway 10; (3) the flammable liquids carried by the waterborne traffic on James River; (4) the flammable

liquids/gases carried by pipelines passing near the site; and (5) security-related equipment (Reference 16).

2.2.3.2.1 Fuel Storage Facility

A 320,000 gallon tank of No. 2 fuel oil, is stored at 1300 feet southwest of the ISFSI. The tank is surrounded by a dike. An open pool of fire, restricted to the area enclosed by the dike, has been assumed for evaluation of heat effects on the casks. Based on the results of a simplified study, it is estimated that the hot buoyant plume will not intercept the 16-foot-high cask under any meteorological conditions using the Briggs' plume rise equation (Reference 9). Therefore, any heat effects on the cask would be from radiation heating. Using a flame temperature of 1800°F (References 10 & 11), the estimated air temperature 1300 feet away from the fire would be 8°F higher than the ambient temperature.

In addition, the fuel storage facility has been enlarged to include two 3 million gallon tanks of No. 2 fuel oil located approximately 2600 feet south of the ISFSI. Each of these tanks is also surrounded by a dike. Radiant heat flux to a target is a function of the inverse of the distance squared. Therefore, the above analysis based on a fire involving the 320,000 gallon tank remains bounding since it is the closest to the ISFSI.

2.2.3.2.2 Flammable Liquid

Flammable vapor clouds resulting from liquid spills on Virginia Highway 10 and James River or pipeline ruptures have the potential to deflagrate. If a delayed ignition takes place within the flammable vapor cloud, it would potentially flash back to the source and burn. Since the separation between any potential fire hazard source and the Surry ISFSI is greater than the separation of the No. 2 fuel oil storage tank and the ISFSI, the heat effects on the casks from any of the potential flammable liquid sources would be less than the heat effect resulting from the No. 2 fuel oil burning.

2.2.3.2.3 Security-Related Equipment

Adequate separation from the storage slabs has been provided for security-related equipment.

2.2.3.3 **Aircraft Accidents**

The probability of an aircraft accident is a direct function of target area, traffic volume of the airfield involved, and the probability of a fatal crash in the area of the target.

An aircraft accident probability analysis has been conducted for Surry Power Station. Results of the analysis are reported in NRC NUREG-75/ 014 (Reference 12), The study concluded that the probability of an aircraft accident due to the flights passing near the Surry site from either of the two airports 5 miles from the site, Felker AAF and Williamsburg-Jamestown Airport, was less than 7×10^{-7} per year. The target area used in the study was 0.005 square mile for small aircraft.

Using the same methodology as the NRC study, the area of the ISFSI is 0.00053 square mile. The ratio between the target area of the Surry Power Station, reactor buildings, and the ISFSI is approximately 10:1. Thus the probability of an aircraft accident at the ISFSI due to operations of the two airports 5 miles from the site is conservatively estimated to be less than 1×10^{-7} per year.

Melville, which lies 6 miles west southwest of the site, is a private field with a 2900-foot unpaved runway. Use of the airfield is limited to a low volume of small aircraft. Any aircraft accident probability due to operation of Melville airfield will be less than the probability due to operation of the two airports analyzed. There are no more airfields within 10 miles of the site.

Patrick Henry, 11 miles east-southeast of the site, is an international airport with 1982 projected movements of 172,000 (Reference 13). Using a probability of 1.2×10^{-9} per square mile per aircraft movement (Reference 12) for a fatal crash for a runway that is more than 10 miles away from the site, the probability of an aircraft accident occurring at the Surry ISFSI is estimated to be 2.7×10^{-8} per year. Airports/airfields further away from the site are not considered to be significant in the aircraft accident probability analysis.

2.2.4 References

1. *Surry Offsite Toxic Chemical Release Analysis,* NUS Corporation, Md., June 1981.
2. NOAA, Washington, Sectional Aeronautical Chart, 29th Edition, March 14, 1981.
3. W. C. Brasie and D. W. Simpson, *Guidelines for Estimating Damage Explosions,* American Institute of Chemical Engineers, Chemical Engineering Process, 1968.
4. NRC Regulatory Guide 1.91, *Evaluations of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants,* Rev. 1, February 1978.
5. Morgan, T., (Bechtel, Gaithersburg Power Division) Personal Communication with Mr. Keller of the National Fire Protection Agency, Boston Mass., June 1982.
6. CHRIS: Hazardous Chemical Data, U. S. Coast Guard, 1978.
7. Marshall, V. C., *Unconfined - Vapor-Cloud Explosions,* Chemical Engineering, June 14, 1982.
8. U.S. Nuclear Regulatory Commission, Safety Evaluation Report, Tennessee Valley Authority, Hartsville Nuclear Plant A and B, NUREG-0014, April 8, 1976.
9. G. A. Briggs, *Plume Rise,* U. S. Atomic Energy Commission, 1969.
10. Morgan, T., (Bechtel, Gaithersburg Power Division) Personal Communication with Mr. Menery of the National Fire Protection Agency, Boston Mass., July 1982.
11. Belason, B., et al., *A Fire Simulation Facility for Materials Response Testing,* Fire Technology, Vol. 6., No. 2, May 1970.

12. *Reactor Safety Study, An Assessment of Accident Risks in U. S. Commercial Nuclear Power Plants,* U. S. NRC, NUREG-75/014, October 1975.

13. U.S. Department of Transportation, Terminal Area Forecasts for Fiscal Years 1981-1982, FHA-APO-80-10, February 1981.

14. Personal Communication, P. C. Carr, Bechtel Associates Professional Corporation (Virginia) to B. Godfrey, Commonwealth Gas Pipeline Corporation, October 10, 1983.

15. Personal Communication, P. C. Carr, Bechtel Associates Professional Corporation (Virginia) to R. Calcupa, Colonial Pipeline Company, October 10, 1983.

16. Security Program, Dry Cask Independent Spent Fuel Storage Installation, Surry Power Station, Virginia Electric and Power Company, July 29, 1983.

Table 2.2-1
FACILITIES NEAR THE SITE

Facility	Primary Function Products	Number of Employees	Location (from site)
Industry			
Anheuser-Busch, Inc.	Brewery	300	4.5 mi NE
Dow Badische Co.	Synthetic Fibers	500	4.9 mi ENE
Military Base			
Fort Eustis	Army	16,000	5 mi ESE
Supervisory of Ship Building	Navy	435	5 mi ESE
Airport			
Felker AAF	Military		5 mi SE
Williamsburg-Jamestown	Commercial		6 mi NNW
Melville	Private		6 mi WSW

Data Source: Section 2.2 of the PSAR for Surry Power Station Units 3 and 4.

Table 2.2-2 (SHEET 1 OF 2)
CHEMICAL COMPOUNDS SHIPPED ON THE JAMES RIVER

Chemical	Site Container	Quantity Per Unit	Type Container	Distance Miles[a]
Diaminocyclo Hexane Corrosive Liquid	55 gal/barrel 80 to 140	4400 to 7700 gals	Closed Van Ocean Vessel	1 1/2
Ethanol/Inflammable Liquid	55 gal/barrels 80 to 140	4400 to 7700 gals	Closed Van Ocean Vessel	1 1/2
Tiazinetrione Dry Oxidizer	50 lb bags Palletized	40,000 to 60,000 lbs	Closed Van Ocean Vessel	1 1/2
Napthyl Methyl Carbonate - Poison	50 lb bags Palletized	40,000 to 60,000 lbs	Closed Van Ocean Vessel	1 1/2
Ethyl Alcohol Flammable Liquid	55 gal/barrels 80 to 140	4400 to 7700 gals	Closed Van Ocean Vessel	1 1/2
Sodium Meta Periodate - Oxidizer	50 lb bags Palletized	40,000 to 60,000 lbs	Closed Van Ocean Vessel	1 1/2
Nitro Imidayol Poison - Solid	50 lb bags Palletized	40,000 to 60,000 lbs	Closed Van Ocean Vessel	1 1/2
Ethyacloxysilane Corrosive Liquid	55 gal/barrels 80 to 140	4400 to 7700 gals	Closed Van Ocean Vessel	1 1/2
Dinitrochloro Benzene - Poison	50 lb bags Palletized	40,000 to 60,000 lbs	Closed Van Ocean Vessel	1 1/2
Monochloracetic Acid Corrosive	50 lb bags Palletized	40,000 to 60,000 lbs	Closed Van Ocean Vessel	1 1/2
2-Methox 4-2-3 Dyhydro 4-H Inflammable Liquid	55 gal/barrels 80 to 140	4400 to 7700 gals	Closed Van Ocean Vessel	1 1/2
Ortho-Phenylenediamine Poison	50 lb bags Palletized	40,000 to 60,000 lbs	Closed Van Ocean Vessel	1 1/2
Chloro Benzo Tri Floride Inflammable Liquid	55 gal/barrels 80 to 140	4400 to 7700 gals	Closed Van Ocean Vessel	1 1/2
Caustic Alkali Liquid Corrosive	55 gal/barrels 80 to 140	4400 to 7700 gals	Closed Van Ocean Vessel	1 1/2
Thionyl Chloride Corrosive	55 gal/barrels 80 to 140	4400 to 7700 gals	Closed Van Ocean Vessel	1 1/2
Gasoline, No. 6 oil, diesel oil, No. 2 oil	Steel tanks 8 compartments	168,000 gal ea 1,300,000 total	Barge	1 1/2
Phenol	Steel tanks 2 compartments	1325 tons ea 2650 total	Barge	1 1/2
Oleum	Steel tanks 2 compartments	1500 tons ea 3000 total	Barge	1 1/2
Sulfur (Liquid @ 260°F to 275°F)	Steel tanks 2 compartments	10,000 tons ea 20,000 total	Barge	1 1/2

Table 2.2-2 (SHEET 2 OF 2)
CHEMICAL COMPOUNDS SHIPPED ON THE JAMES RIVER

Chemical	Site Container	Quantity Per Unit	Type Container	Distance Miles[a]
Liquid Fertilizer (Uran)	Steel tanks 2 compartments	5000 tons ea 10,000 total	Barge	1 1/2
Ammonium Sulfate	50 lb bags Palletized	1500 to 12,000 tons	Barge	1 1/2
Ammonium Sulfate	50 lb bags Palletized	8000 to 25,000 tons	Closed Van Ocean Vessel	1 1/2

Data Source: Survey by NUS Corporation, Rockville, MD, 1981.

a. Distance refers to minimum separation between the Surry Power Station Control Room and the midpoint of the James River. The ISFSI is approximately 1 mile further away.

Table 2.2-3
CHEMICAL COMPOUNDS TRANSPORTED BY TRUCK ON VIRGINIA HIGHWAY 10

Chemical	Size Container	Quantity Per Unit	Type Container	Distance Miles
Sulfuric Acid	25-Ton Truck Tank	3300 gals	Metal Tank	4 1/2
Nitric Acid	25-Ton Truck Tank	4000 gals	Metal Tank	4 1/2
Muratic Acid	25-Ton Truck Tank	5000 gals	Metal Tank	4 1/2
Petroleums Gasoline, Oil	25-Ton Truck Tank	8500 gals	Metal Tank	4 1/2

Data Source: Survey by NUS Corporation, Rockville, MD, 1981.

Table 2.2-4
CHEMICAL COMPOUNDS USED AND/OR STORED NEAR SURRY

Chemical	Size Container	Quantity Per Unit	Type Container	Distance Miles	Berm
Acrylonitrile	50,000 gal	1	Metal Tank	4.9	50'x30'x4.5'
	(5000 gal)	4 ea			(30'x15'x4.5')
Methyl Acrylate	25,000 gal	1	Metal Tank	4.9	30'x20'x5.5'
	(5000 gal)	1			(30'x15'x4.5')
Sulfuric Acid	5000 gal	3 ea	Metal Tank	4.9	40'x20'x2'
Hydrochloric Acid	5000 gal	3 ea	Metal Tank	4.9	40'x20'x2'

Data Source: Survey by NUS Corporation, Rockville, MD, 1981

Table 2.2-5
[DELETED]

Table 2.2-6
PIPELINE DATA

Company	Product Carried	Number of Lines	Diameter (inch)	Operating Pressure (psi) Max	Operating Pressure (psi) Normal
Commonwealth Natural Gas	Natural Gas	2	8[a]	600	150
		1	10[a]	600	150
		1	12-3/4[a,b]	600	150
		1	12[a,c]	600	150
Colonial Pipeline	Petroleum Products[d]	1	14[e]	1181	500

NOTES:

a. These lines run under the James River bed at a depth of 3 to 4 feet. The pipelines remain buried 30 to 36 inches below grade after emerging from the river (Reference 14).
b. This lines does not cross Surry Power Station property.
c. This line runs from the lo-inch line to the Surry Plant combustion turbine and is used seasonally.
d. These include leaded and unleaded gasoline, aviation fuel, kerosene, and No. 2 fuel oil.
e. This line is buried approximately 20 feet below the river bed while crossing the James River. It remains buried 30 to 36 inches below grade after emerging from the river (Reference 15).

Table 2.2-7
AIRPORTS WITHIN 25 MILES OF THE SITE

Airport	Distance (mi)	Sector	Number of Movements	Type of Airport
Felker AAF	5	SE	81,500 (Reference 11)	F, M (30)
Melville	6	SW	---	E, R (29)
Williamsburg-Jamestown	5	NNW	45,000 (Reference 11)	E, P (32)
Patrick Henry	11	ESE	172,000 (Reference 13)	F, C (80)
Langley AFB	19	ESE	---	F, M (100)
NAS Norfolk	24	SE	---	F, M (37)

F- Aerodromes with facilities (land)
E- Aerodromes with emergency or no facilities (land)
P- Public use
C- Civil
M- Military
R - Restricted
( )- Length of longest runway in hundreds of feet

Data Source: Section 2.2 of the PSAR for Units 3 and 4 of Surry Station.

Figure 2.2-1
ROADS WITHIN 10 MILES OF THE SITE

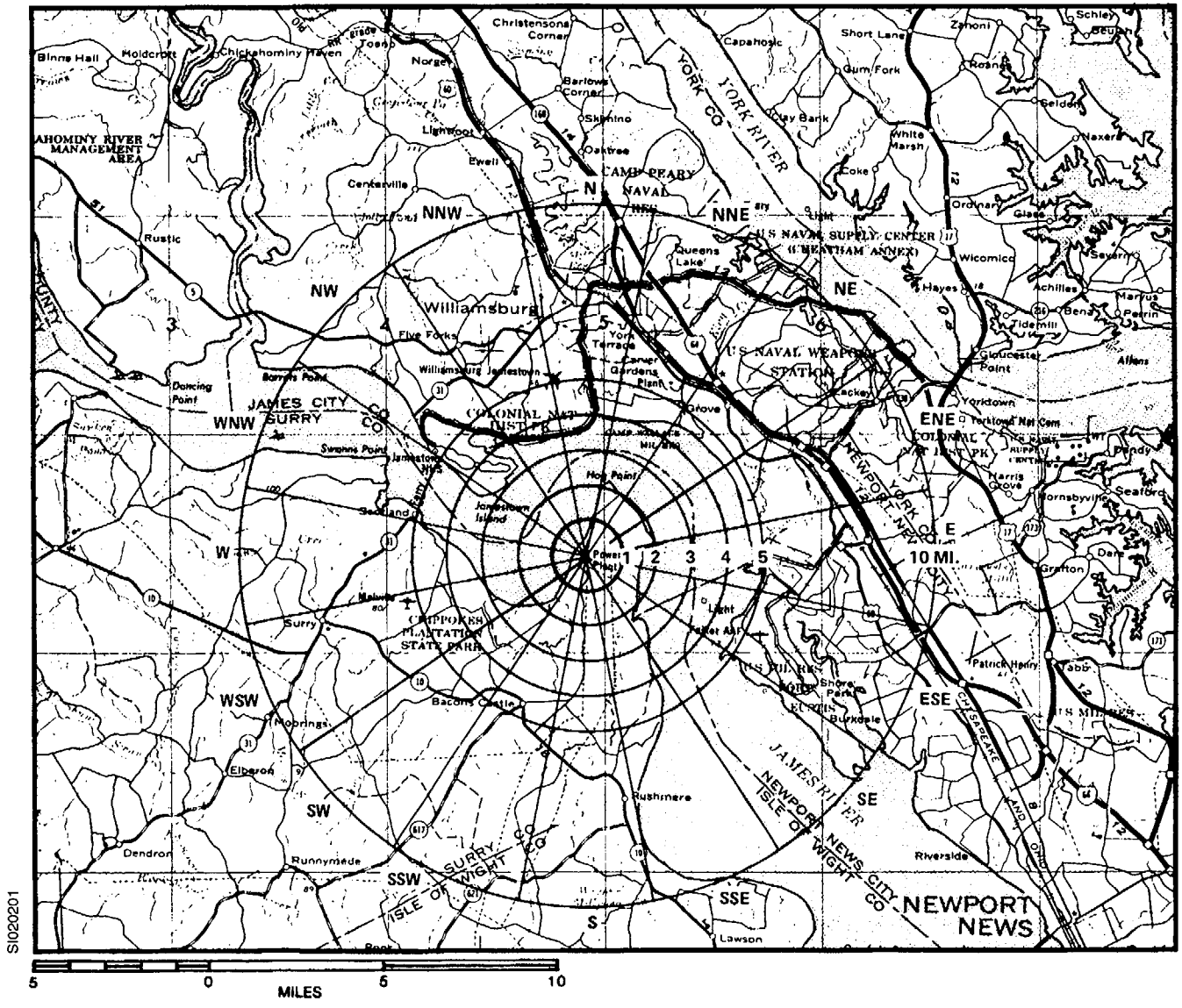
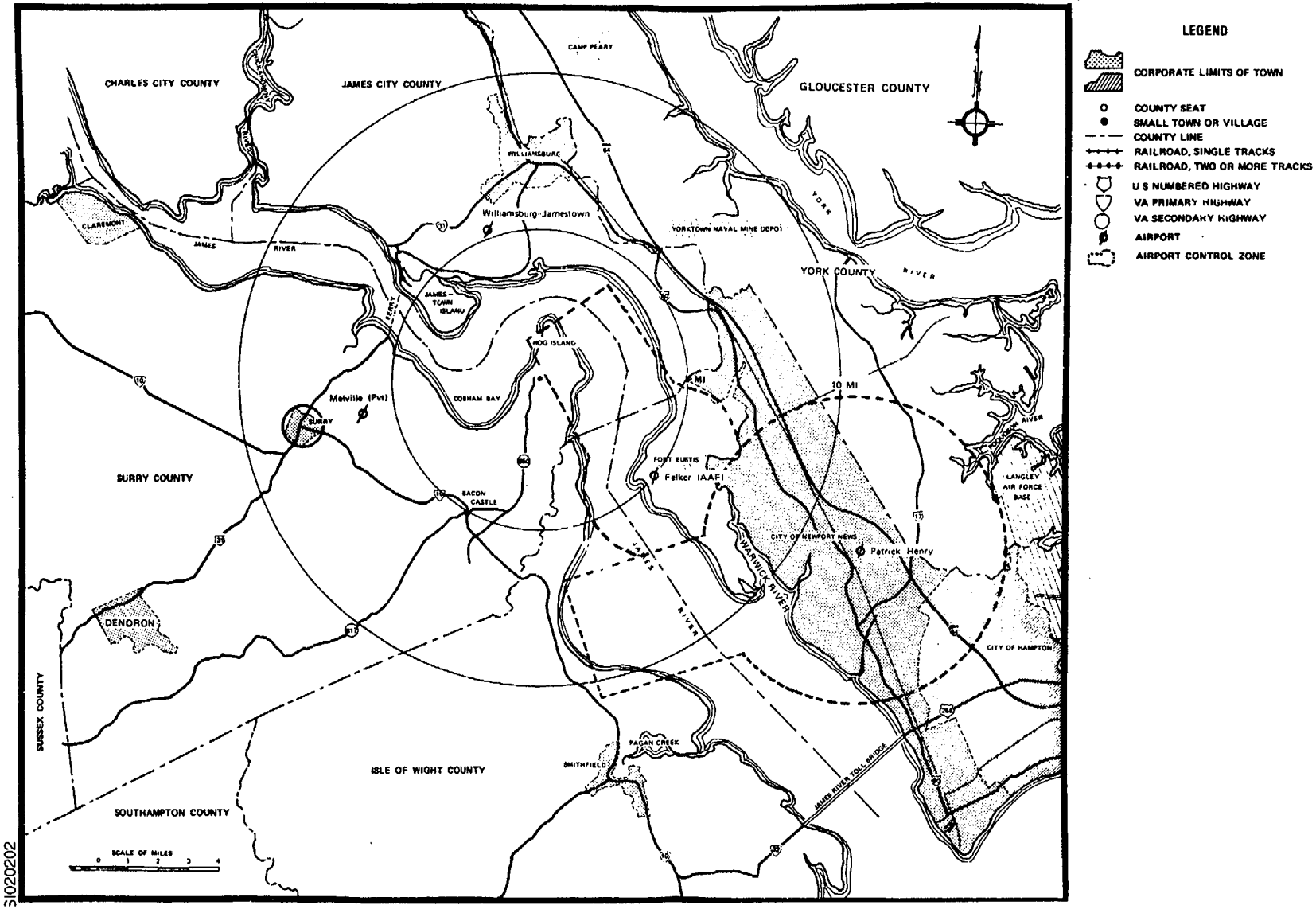


Figure 2.2-2
AIRPORTS WITHIN 10 MILES OF PLANT SITE



G1020202

Figure 2.2-3
NATURAL GAS PIPE LINES WITHIN 10 MILES OF PLANT SITE

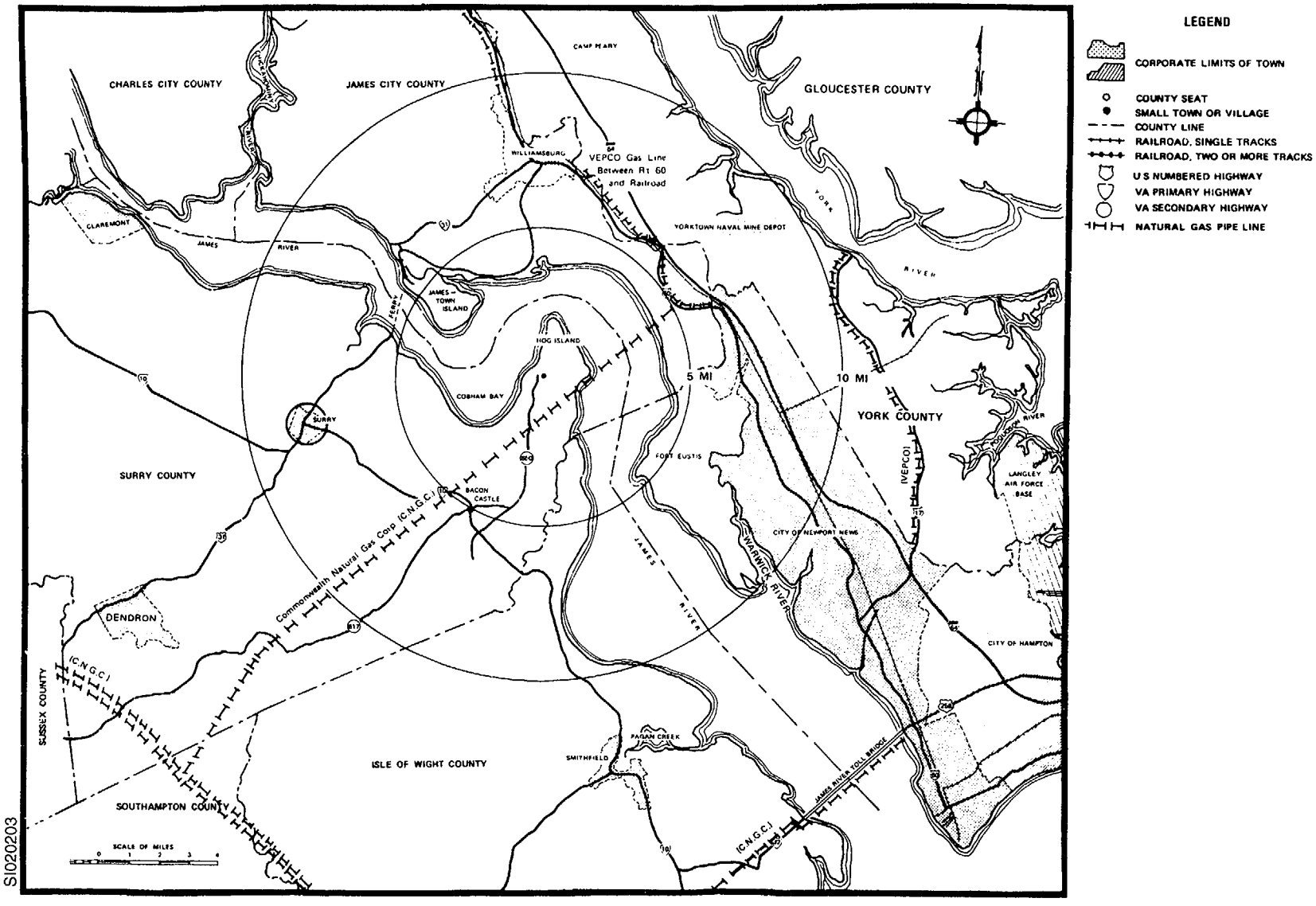
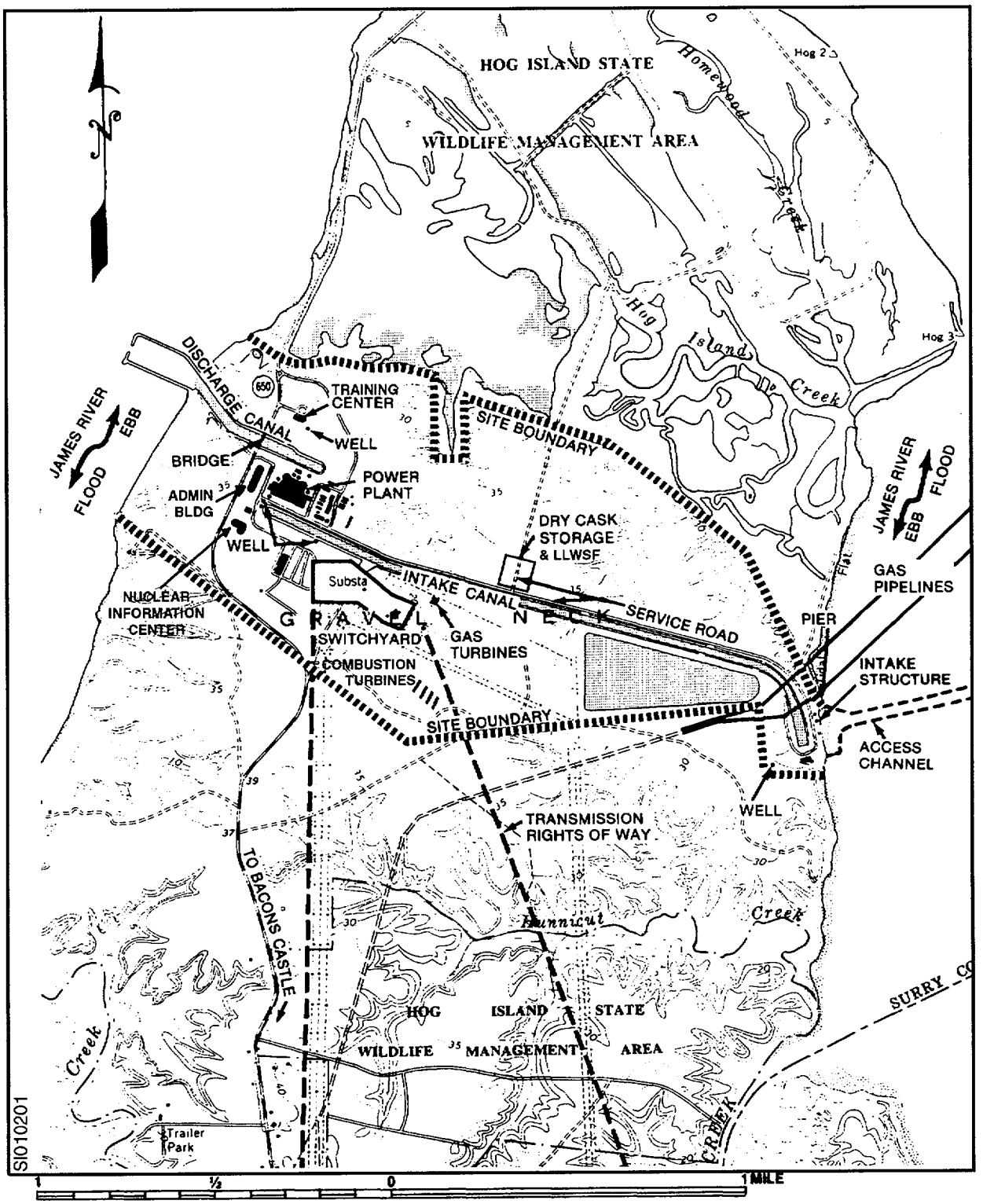


Figure 2.2-4
PIPELINES



2.3 METEOROLOGY

2.3.1 Regional Climatology

2.3.1.1 Data Sources

Data acquired by the National Weather Service (NWS) and summarized by the Environmental Data Service (EDS) were used to determine the regional climatology pertinent to the Surry site. References 1 and 2 were used to determine the climatological characteristics of Richmond and Norfolk, Virginia and Reference 3 for the climatological characteristics of the region.

Extreme wind data were obtained from studies by Thom (Reference 4) and Huss (Reference 5). Severe weather data were obtained from a variety of sources. Severe storm, tornado, and hurricane data were obtained from References 6, 7, 8, 9, and 10.

Data for meteorological extremes were obtained for Richmond and Norfolk from References 1 and 2 and temperature and precipitation extremes for selected meteorological stations in the site region were obtained from References 11, 12, 13, and 14. Monthly storm data (Reference 6) were used to compute the number of occurrences of hail and ice storms. Climatological data for restrictive dilution conditions were obtained from a variety of sources dealing with stagnating conditions in the United States (References 15, 16, 17 & 18).

2.3.1.2 General Climate

The Surry site is situated in a humid subtropical climate which is characterized by warm humid summers and mild winters. During the summer months this region is dominated by tropical maritime air masses while during the winter season this area is in a transitional zone between polar continental and tropical maritime air masses.

The climatic characteristics of the site region are influenced by the Atlantic Ocean and the Appalachian Mountains. The Atlantic Ocean has a moderating effect on the temperature for the Surry region whereas the Appalachians act as a barrier to deflect midwest winter storms to the northeast of the Surry region.

Snow is not common during winter in the Tidewater area of Virginia. (The Tidewater area is defined as the Coastal Plain area of Virginia extending west to the fall line). A snowfall of 10 inches or more a month in the Tidewater area is expected to occur once every 4 years. In general, the total accumulated snow for the Tidewater area is approximately 10 inches per year. Precipitation occurs mostly as rain in the site area. The summer months are usually associated with the greatest amount of precipitation. However, great amounts of rainfall have occurred during the fall season associated with the passages of tropical storms or hurricanes.

The Bermuda high that develops off the coast of the United States during the spring and summer seasons results in a moist southerly flow of air from the Caribbean and South Atlantic to the Surry region. During the fall and winter seasons a semipermanent high-pressure cell develops

over the midwest region of the United States resulting in a prevailing north-westerly flow of air into the Surry region. The mean annual wind speed for the Norfolk area is 10.5 mph (Reference 2). The mean annual wind speed for Richmond is 7.5 mph (Reference 1).

The annual mean number of days with heavy fog is 22 and 29 in the Norfolk and Richmond areas, respectively. Thunderstorms are frequent during the summer months with the greatest occurrence during the month of July (8 for Norfolk and 9 for Richmond). Only a small percentage of these can be classified as severe. Approximately four tornados are reported in Virginia each year, with the majority occurring east of the Blue Ridge Mountains.

An average of two hurricanes each year come close enough to the coast to affect Virginia. These hurricanes usually bring torrential rainfall to the Tidewater area, and high tides result in flood conditions for low lying areas along the coast. However, less than one hurricane (0.6 per year) actually crosses the state. A recent hurricane to affect the Tidewater area was Hurricane Dennis (August 1981) which brought 2.4 inches of rainfall to the Norfolk area and 0.25 inch to the Richmond area.

2.3.1.3 **Severe Weather**

2.3.1.3.1 Extreme Winds

According to Thom (Reference 4), the extreme 1 mile wind speed at 30 feet above the ground for a 100-year recurrence interval for the Surry region is 105 mph. Based on a gustiness factor of 1.3 according to Huss (Reference 5), the highest instantaneous gust expected once in 100 years is 137 mph.

The fastest mile wind recorded at Norfolk based on the 1953 to 1980 period of record was a southerly wind with a speed of 78 mph (Reference 2). The fastest mile wind recorded at Richmond based on the 1951 to 1980 period of record was a southeasterly wind with a speed of 68 mph (Reference 1). Both of these extreme wind speeds occurred during the passage of Hurricane Hazel in October 1954 (References 1, 2 & 3).

2.3.1.3.2 Tornados

During the period of January 1951 through December 1981 a total of 30 tornados on land have been reported within a 50 mile radius of the Surry site for an average of 0.9 tornado per year within this radius.

The probability of a tornado striking a point within a given area may be estimated as follows (Reference 8):

$$P = \frac{\bar{z}\bar{t}}{A}$$

Where:

P = the mean probability per year

$\bar{z}$ = the geometric mean tornado path area

$\dot{t}$ = the mean number of tornados per year observed in the area of concern A

For the region surrounding the Surry site, the computed geometric mean tornado path length was about 1.6 miles and the computed geometric mean path width reported was about 118 yards based on examination of reported tornado statistics (Reference 6). These values yield a $\bar{z}$ of 0.106 square miles based on tornado data for the period of January 1951 through December 1981. Using a 50-mile radius as a basis for A (excluding the Chesapeake Bay) and a value of 0.9 tornado per year for $\dot{t}$ yields a probability of 1.2×10^{-5} per year, or a recurrence interval of about 80,000 years.

2.3.1.3.3 Tropical Storms and Hurricanes

Since 1871 (when more complete weather record keeping began) through 1981, a total of 52 tropical storms or hurricane centers passed within 100 nautical miles of the Surry site (References 6 & 9). After 1885, weather records differentiated between tropical storms (<73 mph) and hurricanes (>73 mph). From 1886 through 1981, there have been 32 passages of tropical storms and 8 hurricanes have passed within 100 nautical miles of the site. The last tropical storm to affect the site was Hurricane Dennis, which occurred from August 19 through August 21, 1981. The center of maximum rainfall during this storm was located in extreme southeastern Virginia. The rainfall amounts were 2.40 inches for Norfolk and 0.25 inch for Richmond.

2.3.1.3.4 Precipitation Extremes

Table 2.3-1 lists some extremes of meteorological measurements for selected National Weather Service stations in the Surry region. The maximum amount of precipitation recorded at Norfolk for a 24-hour period was 11.4 inches which occurred in August of 1964 (Reference 2). The maximum amount of precipitation recorded at Richmond for a 24-hour period was 8.79 in August 1955 (Reference 1). The maximum monthly snowfall measured in the Norfolk area was 18.9 inches in February 1980, and the maximum monthly snowfall measured in Richmond was 28.5 inches in January 1940 (Reference 1). The maximum 24-hour snowfalls observed at Richmond were 21.6 inches in January of 1940 (Reference 1) and 12.4 inches at Norfolk in February 1980 (Reference 2).

2.3.1.3.5 Hail and Ice Storms

Hail can occasionally occur at the Surry site (associated with well developed thunderstorms) and at times may be intense. A review of data for the 30-year period, 1951 to 1981, indicates that there were 15 reported cases of hail in Surry County and the immediate surrounding counties (Reference 6). There was one reported case of hailstones with diameters of 1.75 inches, and one case of hailstones 1.5 inches in diameter.

An examination of the 20-year period, 1962 to 1981, indicates that there were only five documented cases of ice storms in Surry County and the immediate surrounding counties (Reference 6). Of these, only one was reported to have caused major damage.

2.3.1.3.6 Thunderstorms

Norfolk and Richmond both average 37 thunderstorm days a year. The highest frequency of occurrence of thunderstorms, 8 days (Reference 2) for Norfolk and 9 days (Reference 1) for Richmond, is in July.

2.3.1.3.7 Restrictive Dilution Conditions

The frequency of occurrence of low level inversions or isothermal layers based at or below a 500-foot elevation in the site region is approximately 25 percent of the total hours on an annual basis (Reference 15).

Seasonally, the greatest frequencies of inversions occur during the fall (31 percent) and winter (26 percent). The lowest inversion frequencies occur during the spring (24 percent) and summer (25 percent). The majority of these inversions occur nocturnally.

The mean maximum mixing depth (MMMD) is another restriction to atmospheric dilution. By definition, the MMMD is the thickness of the atmospheric layer, measured from the surface upward, in which convective overturning is taking place caused by the daytime heating at the surface (Reference 19). The mixing depth is usually shallowest during the early morning hours just after sunrise when the nocturnal inversion is being modified by solar heating at the surface. The mixing layer is at its greatest depth during the latter part of the afternoon when the maximum surface temperature of the day is reached. The annual afternoon MMMD for the site region according to Holzworth (Reference 16) is approximately 4600 feet. Seasonal afternoon MMMD values are 3000 feet (winter), 5000 feet (spring), 5000 feet (summer), and 4600 feet (fall) (Reference 16).

Periods of high air pollution potential are usually related to a stagnating anticyclone with an average wind speed <9.0 mph (4.0 m/s), no precipitation, and a shallow mixing depth (<1600 feet or 500 meters) (Reference 17).

The greatest air pollution potential in the site region occurs during the fall and winter seasons when the tendency is greatest for a quasi-stationary anticyclone to develop in association with wind speed ≤5 mph and a shallow mixing depth.

There was a total of 227 cases of days when a stagnating high occurred for 4 or more days during the period 1936 to 1965 (Reference 18).

2.3.2 Local Meteorology

2.3.2.1 Data Sources

Data acquired by the National Weather Service and summarized by the Environmental Data Service were utilized to determine the normals, means, and extremes of temperature, precipitation, relative humidity, and fog applicable to the Surry Power Station site region.

The 1980 Richmond and Norfolk LCDs (References 1 & 2) provide detailed climatological data for these first order observation stations. References 11, 12, 13, and 14 provide data for other stations in the area, although not as complete as for Norfolk and Richmond. Site data were obtained from meteorological instrumentation located at the plant site and summarized for the period March 3, 1974 to December 31, 1981.

Data from the Surry Station were taken from a Westinghouse magnetic tape from pulses every 15 minutes for all meteorological parameters. The data were assembled into a data base and quality ensured before being entered on the universal data base (UDB).

In general, for determination of meteorological design basis parameters, long-term climatological data collected at nearby representative weather stations, such as at Norfolk and Richmond, rather than short-term onsite data are used. Meteorological data measured at the Richmond and Norfolk NWS Stations can be considered representative of the region including the Surry site because both NWS Stations as well as the Surry site fall within the same NWS-defined climatic region: Tidewater. The Climate of Virginia publication (Reference 3) defines Tidewater Virginia as a region which extends westward from the Atlantic Coast and west shore of the Chesapeake Bay to the Fall Line. The Fall Line extends from Great Falls in the north, southward through Richmond to Emporia. The region is divided into peninsulas by four principal rivers and by numerous estuaries that open into the Chesapeake Bay. The climate of this flat to gently rolling, at times swampy, Tidewater region is influenced by the ocean and other nearby water bodies. Due to the varying proximities to the moderating ocean, extremes recorded in Richmond, which is a more inland station, are expected to be more pronounced than those recorded at the coastal city, Norfolk. However, due to the small variations in terrain elevation, ranging from 300 feet to sea level, the weather pattern from one side of the region to the other cannot be significantly different.

Land use, terrain, and the proximity of the ocean or other large bodies of water are the dominant factors related to an area's peculiar micro-meteorological conditions. For the ISFSI site to have unique micro-meteorological conditions as compared to the Norfolk and Richmond NWS Stations, the site would have to have decidedly unique land use, terrain, or ocean exposure. The ISFSI site is in a predominantly rural area characterized by coastal lowland farms interspersed with marshy areas near the James River. The site is within 10 miles of an urban area, Newport News. However, the site is not close enough to the urban area to be influenced by the urban heat island effect, i.e., warmer than normal ambient temperatures and the reduced frequency of nocturnal stable conditions. The valley associated with the James River is broad and shallow and,

therefore, will probably not encourage down-valley drainage flows. The James River itself is not large enough to promote "sea breeze circulations" or moderate the temperatures significantly.

Both the Richmond and Norfolk NWS Stations, like the ISFSI site, are located in rural areas outside of the urban centers along the James River Valley. The Norfolk Station more directly borders an urban area and consequently it feels more urban heating effects, i.e., warmer than normal ambient temperatures and the reduced frequency of nocturnal stable conditions than Richmond or the Surry site. However, these heating effects are tempered only slightly by Norfolk's proximity to the Atlantic Ocean and its moderating breezes. The net effect of these competing influences is that the urban heat island effects cannot be considered a significant meteorological phenomenon in Norfolk.

As Richmond, Norfolk, and the ISFSI site all possess similar land use, terrain, and ocean exposure, the ISFSI site is not expected to experience temperatures and other meteorological conditions significantly different from these two stations.

Also, a statistical analysis of temperature records for January and July 1977 from the site and the Norfolk and Richmond NWS Stations has been performed using data from References 20 and 21. In July 1977, a record high temperature, 105°F, was measured at the Richmond Station. In January 1977, a record low, 5°F, was recorded at the Norfolk Station. The analysis shows that there is a strong correlation and similarity between onsite temperatures and temperatures measured at these nearby NWS stations. A summary of the analysis results is given in Table 2.3-9. Furthermore, the three stations' daily maximum and minimum temperatures are in good agreement as indicated in Table 2.3-10. As expected, the Surry site temperatures are bracketed by the two NWS stations with one exception: the Norfolk daily maximum mean temperature for July is 2 degrees higher than the corresponding Surry temperatures.

2.3.2.1.1 Local Climatological Data

Climatological extremes for selected meteorological stations in the region are presented in Table 2.3-1. Normals and extremes of temperature, precipitation, relative humidity, and fog are presented for Richmond and Norfolk in Tables 2.3-2, 2.3-3, and 2.3-4.

The closest available fog data for Surry site are from the National Weather Service observation stations at Byrd Field, Richmond and Regional Airport, Norfolk, Virginia. The Local Climatological Data (1980) for Richmond indicates an average of 29 days per year of heavy fog based on 51 years of records and 22 days per year of heavy fog based on 32 years of Norfolk data. Heavy fog is defined by the National Weather Service as fog which reduces visibility to 1/4 of a mile or less (Reference 1). The frequency of fog conditions reported at Surry is expected to be more similar to the annual average of heavy fog reported at Richmond than to Norfolk (References 1 & 2). Surry is in close proximity to the James River and has a rural environment (i.e., land use characteristics favorable for rapid radiation cooling of the ambient air with high specific humidity due to the close proximity of the river). The occurrence of heavy fog in the

Norfolk area (Reference 2) is less than Richmond (Reference 1) due to the moderating influence of the Atlantic Ocean.

2.3.2.1.2 Wind Direction and Speed

The distribution of wind direction and speed is an important consideration when evaluating transport conditions relevant to site diffusion climatology. There are no significant topographic features that would have any major influence on wind direction distribution.

Seasonal and annual distributions of wind direction recorded at the Surry site meteorological tower are presented on Figures 2.3-1 through 2.3-10. Measurements at 147.4-foot and 30.3-foot levels were made on the tower.

On an annual basis the predominant wind direction at both the upper and lower level is from the southwest and south-southwest direction.

Seasonal variations in average wind speed, are presented in Table 2.3-5. The annual average wind speeds at Surry (5.8 mph) lower level and (9.8 mph) upper level are comparable to average wind speeds of 10.5 mph at Norfolk for the period 1949 to 1980 and of 7.5 mph at Richmond for the period 1949 to 1980.

Calms are defined in this report as winds less than or equal to 0.75 mph, commensurate with data reduction limitations for onsite data. Lower wind speeds and an increased frequency of calms are expected at a lower sampling height.

2.3.2.1.3 Wind Direction Persistence

Wind persistence is extremely important when considering potential effects from any radiological release. Wind persistence is defined as a continuous flow from a given direction or range of directions.

Periods of maximum wind persistence in 22-1/2 degree sectors recorded at the Surry site meteorological tower are presented on Figures 2.3-11 through 2.3-20. The maximum persistence period at the 147.4-foot level was for 28 hours from the south. At the 30.3-foot level the maximum persistence period was for 30 hours from the west-southwest.

2.3.2.1.4 Atmospheric Stability

Atmospheric stability refers to the degree of wind turbulence. Stable conditions are associated with low turbulence and poor diffusion capability. Unstable conditions are associated with a high degree of turbulence and favorable diffusion characteristics. The standard deviation of horizontal wind direction (σ_θ) for a 15 minute sample per hour is used to determine atmospheric stability from onsite data in this report. The classification of σ_θ data utilized is summarized in Table 2.3-6.

The seasonal and annual frequency of σ_θ stability classes and associated wind speeds for the Surry site are presented in Table 2.3-7. These distributions indicate that the 147.4-foot level stability data are more stable than the 30.3-foot level data. Seasonal variations of the stability distribution presented are minor. Stable conditions were recorded 37 percent of the time at the upper level and 9 percent at the lower level and unstable conditions 22 percent and 61 percent, respectively.

2.3.2.1.5 Temperature

For the Surry ISFSI site region, a record high temperature, 105°F, was measured at the Richmond Station and a record low, 5°F, was recorded at the Norfolk Station.

The frequency of hot periods can be described by the annual mean number of days with temperatures at or above 90°F. Norfolk, near the moderating ocean, experiences an average of 31 "plus 90" days (Reference 22). Farther inland, Richmond experiences 42 "plus 90" days. The ISFSI site, located between these two stations, probably experiences between 31 and 42 "plus 90" days annually.

The distribution of temperatures at or above 90°F for these two NWS stations is given in Table 2.3-1. These temperatures represent only 3 percent of the hourly temperature observations per year. As shown from the table, the majority (70 percent or more) of these temperature observations fall within the range of 90°F to 94°F. Temperatures in excess of 100°F represent less than 5 percent of the total. No temperatures higher than 104°F were recorded for the stations during the period in which temperature observations have been made (References 22, 23, 24, & 25).

The recurrence interval of maximum temperatures for southeastern Virginia, which includes the ISFSI site, is as follows (Reference 26):

Return Period (years)	Temperature (°F)
2	98
50	105
100	107

The extreme temperature used as the design criteria for the ISFSI casks, 115°F, was selected because it exceeds the extreme temperatures recorded at the Norfolk and Richmond Stations as well as exceeds the 100-year maximum temperature for southeastern Virginia.

2.3.2.1.6 Lightning

The Surry Power Station (SPS) does not routinely record information concerning onsite lightning strikes. As the newer power stations and accompanying switchyards have become less susceptible to damage from lightning strikes, the importance of maintaining such information has decreased.

No SPS onsite data relating to the frequency of thunderstorms is available. However, the expected annual frequency of thunderstorms at the Surry ISFSI can be expressed in terms of the mean number of thunderstorm days experienced annually at Norfolk (45 miles, SE) and Richmond, Virginia (50 miles, NW). As discussed in Section 2.3.2.1, meteorological data measured at these nearby National Weather Service Stations can be considered representative for the region which includes the ISFSI site.

Both Norfolk and Richmond experience an average of 37 thunderstorm days a year (References 22 & 23). The term thunderstorm day is defined as an observational day during which thunder is heard at the station. Precipitation need not occur (Reference 27).

Information concerning the correlation of frequency and intensity of both single and multiple lightning strikes associated with regional thunderstorms is unavailable. However, a probability distribution of crest currents in lightning strikes has been compiled from measurements made in the United States and Europe. Figure 2.3-28, derived from these measurements, illustrates the relationship between crest currents and frequency of occurrence. (Reference 28).

This figure represents the best available information concerning the correlation of frequency and intensity of lightning strikes. However, there was no differentiation of whether the crest current is from single or multiple lightning strikes.

2.3.2.1.7 Solar Radiation

At the Surry ISFSI site, the normal daily total solar radiation (June 21) is 500 g-cal/cm^2 and the normal daily hours of sunshine during summer is 10 hours (Reference 29). During winter, the sunshine exposure period is shorter and consequently, the daily insolation value is lower. To encompass this, a daily total solar radiation value of 800 g-cal/cm^2 (10-hour exposure) was chosen as the design solar heat burden at the Surry ISFSI site. This maximum insolation value represents about 90 percent of the solar radiation incident at the top of the atmosphere at the ISFSI latitude (Reference 30). The 90 percent assumption refers to a 0.9 transmissivity factor which is representative of a conservative clear sky transmissivity (Reference 31), i.e., the percent of solar radiation at the top of the atmosphere which makes it to the ground after absorption or scattering by atmospheric constituents other than clouds. The length of the exposure period has been provided for information only; it does not enter into the calculation of the daily maximum insolation.

Regulatory Guide 7.8 (Reference 32) describes maximum insolation data as part of the general and initial conditions to be used for both normal and hypothetical accident conditions for shipping casks. The Regulatory Guide defines the maximum insolation for horizontally transported casks as 800 g-cal/cm^2 per day. For stationary and vertically stored casks, which are more representative of the ISFSI casks, the Regulatory Guide defines the design insolation as 400 g-cal/cm^2. Consequently, the ISFSI cask design insolation of 800 g-cal/cm is conservative.

2.3.2.2 Topography

The Surry site is situated in the Tidewater area of Virginia. This area is typical of Coastal Plain topography. Elevations in the site region range from 0 feet mean sea level (msl) at the James River to approximately 200 feet msl at Richmond (fall line). In general, the area is fairly flat with no distinctive relief features within 50 miles of the station.

The ISFSI is located in the flood plain of the James River. Elevations generally range from 0 feet msl at the James River to 35 feet msl further inland. Some channeling of winds associated with cold air drainage that would occur would be very minimal. Figures 2.3-21 through 2.3-24 illustrate the topographic profile of the site region out to 10 miles from the ISFSI site. Figure 2.3-25, presents a general topographic view of the site region for a 5-mile radius and Figure 2.3-26 for a 50-mile radius.

2.3.3 On-Site Meteorological Measurements Program

2.3.3.1 General Program Description

The onsite meteorological measurements program for the Surry Power Station will be used as the onsite meteorological measurements program for the Surry ISFSI. There are two towers installed on the Surry site. Their locations are illustrated on Figure 2.3-27. The primary tower is 147.4 feet high and the backup tower is 30.3 feet high. At the primary site monitoring of wind direction and wind speed at two levels of the tower, ambient air temperature at the lower tower level, differential air temperature between tower levels, horizontal wind direction fluctuation (σ_θ) at both tower levels, dew point temperature at the lower tower level, and rainfall at the base of the tower is performed. At the backup site, wind direction, wind speed, and horizontal wind direction fluctuation (σ_θ) are monitored at an elevation of 30.3 feet.

2.3.3.2 Location, Elevation, and Exposure of Instruments

The location of the meteorological towers is shown on the topographic map, Figure 2.3-27. The nearest structures are 500 feet north-northwest and 150 feet northwest of the primary and backup sites, respectively. At the primary site, the nearest tree is approximately 50 feet south of the tower, as is the nearest continuous tree line. Tree heights are 40 to 50 feet. At the backup site, a 5-foot tree stands 5 feet south-southeast of the tower. The nearest tree line, with trees 10 to 15 feet high, is located approximately 200 feet north-northeast of the tower.

Ground cover at the location is characteristically native grasses. Comparable cover will be maintained at the bases of the towers.

The primary tower is a guyed, triaxial, open-latticed structure (Rohn 90 series). The lower level instrumentation is at 30.3 feet above ground level (agl). The upper instrumentation is at approximately 147.4 feet above the finished plant grade of 26.5 feet. The backup tower is a freestanding, triaxial, open-latticed structure (Rohn 25 series). The instrumentation is at 30.3 feet agl.

The wind sensors are positioned such that the towers do not influence the prevailing south-southwest wind flow detected by the sensors.

On the primary tower, the wind speed, wind direction, and σ_θ sensors are mounted on booms longer than one and one half times the tower face width. The sensor is postmounted on top of the backup tower.

Temperature, differential temperature, and dew point temperature sensors are housed in motor aspirated shields to insulate them from thermal radiation from the tower, and solar and terrestrial radiation. (See Table 2.3-8 for aspirated shield performance characteristics.)

2.3.3.3 **Meteorological Sensors - Type and Performance Specifications**

2.3.3.3.1 General Description

Wind speed, wind direction, and σ_θ are measured by an MRI 1074-22 sensor at the 147.4-foot level of the primary tower, and at the 30.3-foot level of the primary tower and on the backup tower. The MRI 1074-22 is a combined anemometer cup and vane sensor. The wind speed signal is generated by a light emitting diode-photo-Darlington assembly and light chopper mechanically linked to the anemometer cup shaft.

The sensor provides for a dual output of direction signal. The 0° to 540° wind direction for strip chart recording and data transmission is generated by a ganged two section potentiometer. Sine/cosine function potentiometers, mechanically geared along with the 540° pot to the vane shaft, also generate wind direction signals for historical data files. The σ_θ is electronically calculated from the analog voltages produced by the 540° pot and associated circuitry.

Temperature is measured at the 30.3-foot level and differential temperature is measured between the 30.3-foot and 147.4-foot level use Rosemont 104MB 12 ADCA sensors. The Rosemont system consists of one single element high precision platinum resistance temperature sensor located at the 147.4-foot level for measuring part of the differential temperature, and one single element precision platinum resistance sensor located at the 30.3-foot level for measuring ambient temperature and the other part of differential temperature. Compensating resistance loops are used to compensate for the probe signal cable resistance. Endevco 4473.2 Signal Conditioners convert the probe resistances to analog signals.

Dew point temperature, as measured at the 30.3-foot level of the primary tower, uses either an EG&G 110(S)M or Model 220 sensor. The EG&G sensor is a thermoelectric chilled mirror with optical sensing bridge for condensation. The mirror temperature is measured by a platinum resistance temperature sensor tied to a temperature transmitter/control unit.

2.3.3.3.2 Instrument Performance Specifications

Performance specifications for the Met towers' instrumentation are provided in Table 2.3-8.

2.3.3.4 **Instrument and Maintenance**

The meteorological monitoring installations are calibrated quarterly. Inspection, service, and maintenance are performed as required to ensure not less than 90 percent data recovery. A body of instrument technicians with the requisite expertise to service and, in the event of a system failure, repair the monitoring equipment is maintained by an environmental services support organization.

An inventory of spare sensors and parts is maintained for replacement of major components in the event of a system outage. Redundant recording systems are incorporated into the program to further minimize data loss due to recorder failure.

2.3.3.5 **Data Recording Systems**

Control Room Systems

Temperature, differential temperature, and wind speed and wind direction from both the 30.3-foot and 147.4-foot primary tower level sensors are displayed on strip chart recorders in the control room, as are wind speed, wind direction, and σ_θ from the 30.3-foot backup tower.

Tower Base Shelter Systems

A nominally 8- by 18- by 8-foot shelter is located at the base of each tower. The shelters have thermostatically controlled heat and air conditioning to maintain an interior temperature within a range appropriate for proper equipment operation. The enclosures are located to minimize any micrometeorological effects on the tower instrumentation.

Equipment and circuitry for two separate data recording systems are housed in instrument racks mounted in the shelters. Esterline Angus Models E1102R and A601R strip chart recorders are utilized as a visual display of the data and as a backup collection medium. The recorders' specifications are listed in Table 2.3-8.

A Westinghouse magnetic tape pulse metering system is the primary method of data acquisition for the offsite historical files. The sensor analog signals are coverted through the system circuitry to pulse trains linearly proportional to the input signal. The pulse trains are recorded continuously with time hacks entered every 15 minutes. The tapes are translated, initially reducing the data to 30-minute average pulse totals. This 30-minute data base is then directly converted to the meteorological units of the parameters.

The Westinghouse pulse recorder tapes have a rated acceptance density of approximately 1500 pulses per 15 minutes period. The applicant has conducted independent evaluations of these systems by applying constant known analog signals to the system circuitry. Maximum three interval average deviation from calculated pulse totals has been found to be less than ±0.5 percent with typical performance at ±1 pulse per interval or ±0.07 percent deviation at full acceptance density.

The instruments and recorders as detailed herein are consistent with the current level of technology for meteorological monitoring and the accuracies of the components are adequate to ensure system accuracy in accordance with Regulatory Guide 1.23, Onsite Meteorological Programs, February 1972.

2.3.3.6 **Impact of ISFSI Operation on Meteorological Instrument Performance**

As illustrated by Figure 2.3-27, distances from the primary and backup site meteorological towers to the ISFSI are approximately 1880 and 820 feet, respectively. Since the casks are a continuous source of heat, the potential heat impact of the casks on meteorological measurements made at the towers has been evaluated. The assumptions, methodology and conclusions of this evaluation are as follows:

1. Assumptions

   Two parallel rows of 14 casks are placed on each of three, 230- by 32-foot concrete pads as shown on Figure 4.1-1. An approximate 8-foot surface-to-surface separation is provided between casks. Each cask is approximately 8 feet in diameter and 16 feet in height. The maximum cask surface temperature is assumed to be a constant 260°F.

   Furthermore, the heat generated by the 28 casks in one pad was conservatively assumed to be equivalent to a heated block with dimensions 216 feet by 24 feet by 16 feet which has a surface temperature of 260°F. This is equivalent to assuming that all the air between casks within the imaginary block is at a temperature of 260°F.

   An ambient temperature of 115°F was used in the calculation. Note that the maximum temperature recorded for the area is 105°F as shown on Table 2.3-1. Therefore, the selected ambient temperature of 115°F is an extremely conservative value.

   Heat loss by the casks to the immediate environment will be from conduction, convection, and radiation. Thermal conductivity for air at 115°F is less than 0.02 Btu/hr-ft-°F, (33) and the heat transfer coefficient for air under free convection is between 1 to 5 Btu/hr-ft^2-°F (Reference 33). Since the closest meteorological tower is 820 feet away, the heat impact from heat conduction and convection from the casks to the tower is judged to be negligible based on the above stated thermal conductivity and free convection heat transfer coefficient for air.

   Emissivity of steel varies from 0.066 for a polished surface at 212°F to 0.80 for a strong, rough, oxidized surface at 75°F (Reference 33). For the casks, a conservative emissivity of 0.8 is assumed. Using the same reference, an emissivity of 0.1 is assumed for the meteorological instruments which are made mostly of aluminum with brush finished surfaces.

2. Methodology

   A simplified heat balance calculation for meteorological instruments on the towers was performed. The methodology used is described below.

At equilibrium, the heat gain by the instrument is equal to the heat loss of the instrument. Heat gain was determined by the casks' radiant heat flux intercepted by the instrument. Heat loss was approximated by the convective heat loss and radiative heat loss of the instrument. Conductive heat loss of the instrument was neglected.

Cask radiant heat flux was calculated using the Stefan-Boltzman Law of thermal radiation. All the radiant energy was assumed to be distributed evenly on the surface of a hemisphere with a radius equal to the specified distance of interest, i.e., 820 feet or 1880 feet. Heat gain by the instrument was calculated by using a heat transfer coefficient, h_c, which is a function of the instrument length (L) and the temperature differential (ΔT) between the equilibrium temperature of the instrument (Tm) and the ambient temperature (Ta), and the driving force T. The expression of the h_c used is:

$$h_c = 0.27\left(\frac{Tm - Ta}{L}\right)^{0.25} \qquad \text{(Reference 33)}$$

The radiative heat loss of the instrument to the environment was calculated by using the Stefan-Boltzman Law of thermal radiation.

Conclusions

The maximum estimated rise in temperature of the meteorological instruments located at 820 feet and 1880 feet away is calculated to be 2.0°F and 0.5°F, respectively. These are conservative estimates based on the conservative assumptions used in the calculation. The separation of the cask and the tower is defined as the distance between the tower and the closest cask pad. The estimated temperature rise caused by casks further away on the other pads will be lower. Furthermore, due to the quantity of fuel which can be stored on the pads, it will be an extended period of time before the second pad is filled. At that time, the cask surface temperature on the first pad will have decayed considerably. Therefore, the final temperature rise due to the existence of casks on three pads (28 by 3 casks) is not expected to be more than twice the estimates for one pad, i.e., no more than 4.0°F and 1.0°F.

Based on instrument performance specifications given in Table 2.3-8 and the above estimated temperature rises, the increase in temperature will not cause the instrument to exceed its design operating range, and no degradation of instrument performance is expected. As described in Section 2.3.3.1, no temperature measurements are made at the backup meteorological tower. The ambient temperature and dew point are measured at the primary tower which is 1880 feet from the facility. The maximum estimated temperature rise of 1.0°F at the primary tower location is comparable with the system accuracy as required by Regulatory Guide 1.23, Onsite Meteorological Programs (Safety Guide 23), for the instrument used on the tower. For the differential air temperature (ΔT) measurements, since the temperature rise at the upper level of the tower is the same as at the lower level, the net difference in ΔT measurement will remain unchanged. Therefore, the operation of the ISFSI will cause no significant measurable impact and will not affect the operation of the Surry Power Station meteorological towers.

2.3.4 Diffusion Estimates

2.3.4.1 General

Atmospheric dilution estimates at the Exclusion Area Boundary (EAB) and population centers out to 50 miles from the Surry ISFSI site are required in Chapter 8 to evaluate the radiological consequences of postulated accident. These atmospheric dilution factors χ/Q values, were calculated using the bivariate normal or Gaussian diffusion model (Regulatory Guide 1.145, Rev. 1) assuming ground level releases.

2.3.4.1.1 Hourly Average χ/Q Estimates

Hourly average χ/Q values for the l-hour (representative of the 0- to 2-hour period) accident period were calculated using equations 1 through 3.

For neutral (D) and stable (E, F, and G) stability conditions, when the wind speed is less than 6 meters per second, χ/Q values were calculated using equation 1.

$$\chi/Q = (\bar{U}_{33}\pi\Sigma_y\sigma_z)^{-1} \quad (1)$$

where:

χ/Q = Relative Concentration (sec/m^2)

$\bar{U}_{33}$ = Wind speed at 33 feet above plant grade (m/sec)

$\pi = 3.14159...$

Σ_y = Lateral plume spread with meander and building effects

$\Sigma_y = M\sigma_y$ for distances up to 800 m

$\Sigma_y = (M\text{-}1)\sigma_y$ 800 m + σ_y for distances beyond 800 m

σ_y, σ_z = Lateral and vertical plume spread (m)

Figure 2.3-29 depicts the functional relationship of M (meander factor) with respect to wind speed and atmospheric stability.

If the χ/Q value calculated in equation 1 is less than the greater χ/Q value of either of the following equations, it is retained; otherwise, the applicable χ/Q value which is the greater of those calculated by equations 2 and 3 becomes limiting.

$$\chi/Q = [\bar{U}_{33}(\pi\sigma_y\sigma_z + A/2)]^{-1} \quad (2)$$

$$\chi/Q = [\bar{U}_{33}(3\pi\sigma_y\sigma_z)]^{-1} \quad (3)$$

where:

A = The smallest vertical plan cross-sectional building area (m). For ISFSI releases, credit due to the effects of building wake were not considered.

For all unstable (A, B, and C) stability conditions and for D, E, F, and G stability conditions when the wind speed is greater than or equal to 6 meters per second, the greater of the two χ/Q values calculated from equations 2 and 3 becomes limiting.

2.3.4.1.2 Annual Average χ/Q Estimates

The calculation of the annual average χ/Q value for each downwind sector centered at the cask was determined using equation 4, which is based on Regulatory Guide 1.111, Revision 1.

$$(\chi/Q)_{k,l} = \sum_{j=1}^{n_l} \frac{2.032\Omega}{N\bar{U}_{33}x(\sigma_{z_k}^2 + ch_b^2/\pi)^{1/2}} \quad (4)$$

where:

n = Number of hours of wind in a particular 22.5 degree sector

l = Index for a particular 22.5 degree sector

k = Index for a particular receptor distance

j = Index for a number of hours

$2.032 = (2/\pi)^{1/2}(2\pi/16)^{-1}$

π = 3.14159 . . .

Ω = Terrain recirculation factor (obtained by using Figure 2 of the Regulatory Guide 1.111, Rev. 0, March 1976)

N = Total number of hours of wind in all sectors for applicable averaging period

$\bar{U}_{33}$ = Average wind speed at 33 feet above plant grade (m/sec)

x = Downwind receptor distance (m)

σ_z = Vertical dispersion coefficient (m)

h_b = Building height (m) (set equal to 0.0)

c = Building shape factor = 0.5

2.3.4.2 **Calculations**

Meteorological input parameters were determined from onsite meteorological data acquired during the January 1, 1976 through December 31, 1982 (7-year) time period. The parameters

included hourly average values (based on 15-minute averages) of wind speed and wind direction at the 30-foot level, and atmospheric stability determined from the temperature differences measured at 30.3- and 147.4-foot levels. Atmospheric stability was classified according to the temperature gradient values for the various Pasquill stability categories (A through G).

Each valid hour of the data period was used for the calculation. An hour of data was considered valid if recovery of the wind speed, wind direction, and temperature difference (ΔT) were simultaneously accomplished. For each valid hour of meteorological data, a χ/Q value was calculated as described in Section 2.3.4.1, where the wind direction determined the applicable downwind sector. The EAB and population midpoint distances were used (along with the stability class), to determine magnitudes of σ_y and σ_z.

For the hours with calm wind speeds, a wind speed of 0.75 miles per hour was assigned. The wind directions during these calm conditions were assigned in proportion to the directional distribution of the noncalm through 3.4-mile-per-hour wind speed condition. Regulatory Guide 1.145 states noncalm wind speeds below 3.4 miles per hour provide a reasonable method for defining the distribution of wind directions during light winds.

For each downwind section, χ/Q values were stored and arranged in descending order and 0.5-percent χ/Q values during the total time period were chosen. These values were compared and the sector with the largest χ/Q value determined the 0.5-percent χ/Q for the 0- to 2-hour time period.

For time periods greater than 2 hours, χ/Q values were determined graphically by techniques outlined in Regulatory Guide 1.145. The 0.5-percent value for the 0- to 2-hour period was plotted at the 2-hour time period on logarithmic versus time coordinates, while the annual average χ/Q value for the same sector was plotted at 8760 hours. Logarithmic interpolation was applied to locate values for the time periods corresponding to 0 to 8 hours, 8 to 24 hours, 1 to 4 days, and 4 to 30 days following an accidental release. For overall site χ/Q calculation, the maximum of the 16 annual average χ/Q values was used along with the 5 percent 2-hour χ/Q value to determine χ/Q values for the intermediate time periods by logarithmic interpolation. The 5 percent overall site χ/Q value was also compared with the maximum sector dependent χ/Q values and the higher set of values was selected.

Resultant accident χ/Q values (sector dependent) at the EAB (503 m) and various population receptors are presented in Tables 2.3-12 through 2.3-24. The maximum 0- to 2-hour χ/Q value at the EAB is 1.07×10^{-3} sec/m^3. As can be shown from these tables, maximum sector χ/Q values occur at the north sector of the ISFSI site. These values, as a function of downwind distance, are summarized in Table 2.3-25.

The following hypothetical accident diffusion meteorology, Pasquill F (stable) stability condition and 1 m/sec wind speed, was used in Chapter 8 to evaluate the radiological consequences of a postulated loss of the confinement barrier. This analysis produced a χ/Q of 1.56×10^{-3} (sec/m^3) at the nearest site boundary to the ISFSI, 629 meters away.

For ground level releases, i.e., the postulated dry cask release and a given meteorological condition, the resulting χ/Q values decrease as the distance from the release point increases. A comparison of the maximum calculated 0- to 2-hour χ/Q value at the EAB (503 m), 1.07×10^{-3} sec/m^3 (using onsite meteorological data), with the χ/Q value at the nearest site boundary (629 m), 1.56×10^{-3} sec/m^3 (using the hypothetical meteorology), shows that the χ/Q value used in Chapter 8 radiological consequences evaluation is conservative.

There are no long-term (routine) airborne releases associated with the operation of the ISFSI facility; therefore, no long-term diffusion estimate is reported.

2.3.5 References

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Table 2.3-1
SELECTED NATIONAL WEATHER SERVICE STATIONS FOR METEOROLOGICAL EXTREMES IN THE SURRY SITE REGION (DATE OF OCCURRENCE)

	Norfolk		Richmond	
Maximum temperature	104°F	(8/80)	105°F	(7/77)
Miminum temperature	5°F	(l/77)	-12°F	(l/40)
Maximum monthly rainfall	13.80 in.	(9/79)	18.87 in.	(7/45)
Maximum monthly snowfall	18.9 in.	(2/80)	28.5 in.	(l/40)
Maximum 24-hour rainfall	11.4 in.	(8/64)	8.79 in.	(8/55)
Maximum 24-hour snowfall	12.4 in.	(2/80)	21.6 in.	(l/40)
Fastest mile wind	78 mph S	(10/54)	68 mph SE	(10/54)

Table 2.3-2
RICHMOND METEOROLOGICAL NORMALS, MEANS, AND EXTREMES (REFERENCE 1)

Month	Temperature °F							Normal Degree days Base 65 °F		Precipitation in Inches										
	Normal			Extremes						Water equivalent							Snow, ice pellets			
	Daily maximum	Daily minimum	Monthly	Record highest	Year	Record lowest	Year	Heating	Cooling	Normal	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Maximum monthly	Year	Maximum in 24 hrs.	Year
(a)				51		51					43		43		43		43		43	
J	47.4	27.6	37.5	80	1950	-12	1940	853	0	2.86	7.97	1978	1.08	1951	3.31	1962	28.5	1940	21.6	1940
F	49.9	28.8	39.4	83	1932	-10	1936	717	0	3.01	5.97	1979	0.48	1978	2.67	1979	19.5	1979	10.9	1979
M	58.2	35.5	46.9	93	1938	11	1960	569	8	3.38	8.04	1975	0.94	1966	2.04	1942	19.7	1960	12.1	1962
A	70.3	45.2	57.8	96	1976	25	1977	226	10	2.77	5.32	1952	0.64	1963	2.60	1978	2.0	1940	2.0	1940
M	78.5	54.5	66.5	100	1941	31	1956	64	111	3.42	8.87	1972	0.87	1965	2.53	1972	0.0		0.0	
J	85.4	62.9	74.2	104	1952	40	1967	0	276	3.52	9.24	1938	0.38	1980	4.61	1963	0.0		0.0	
J	88.2	67.5	77.9	105	1977	51	1965	0	400	5.63	18.87	1945	0.52	1963	5.73	1969	0.0		0.0	
A	86.6	65.9	76.3	102	1953	46	1934	0	350	5.06	14.10	1955	0.52	1943	8.79	1955	0.0		0.0	
S	80.9	59.0	70.0	103	1954	35	1974	21	171	3.58	10.98	1975	0.26	1978	3.82	1955	0.0		0.0	
O	71.2	47.4	59.3	99	1941	21	1962	203	27	2.94	9.39	1971	0.30	1963	6.50	1961	T	1979	T	1979
N	60.6	37.3	49.0	86	1974	10	1933	480	0	3.20	7.64	1959	0.36	1965	4.07	1956	7.3	1953	7.3	1953
D	49.1	28.8	39.0	80	1971	-1	1942	806	0	3.22	7.07	1973	0.40	1980	3.16	1958	12.5	1958	7.5	1966
					JUL		JAN					JUL		SEP		AUG		JAN		JAN
YR	68.8	46.7	57.8	105	1977	-17	1940	3939	1353	42.59	18.87	1945	0.26	1978	8.79	1955	28.5	1940	21.6	1940

Month	Relative humidity pct. (Local time)				Wind					Pct. of possible sunshine	Mean sky cover, tenths, sunrise to sunset	Mean number of days											Average station pressure mb.
							Fastest mile					Sunrise to sunset							Temperature °F Max.		Temperature °F Min.		
	01 Hour	07 Hour	13 Hour	19 Hour	Mean speed mph	Prevailing direction	Speed mph	Direction	Year			Clear	Partly cloudy	Cloudy	Precipitation .01 inch or more	Snow ice pellets 1.0 inch or more	Thunderstorms	Heavy fog, visibility ¼ mile or less	(b) 90° and above	32° and below	32° and below	0° and below	Elev. 177 feet msl
(a)	46	46	46	46	32	15	30	30		30	35	35	35	35	43	43	43	51	51	51	51	51	8
J	77	81	57	69	8.0	S	43	NW	1971	51	6.5	8	7	16	11	1	•	3	0	3	21	•	1012.2
F	74	79	52	62	8.5	NNE	45	SW	1951	57	6.1	9	6	13	9	1	•	2	0	2	19	•	1017.6
M	74	78	49	59	8.9	W	42	SE	1952	59	6.2	8	8	15	11	1	1	2	•	•	10	0	1010.8
A	74	76	45	55	8.8	S	40	NW	1972	64	6.0	8	9	13	9	•	2	2	1	0	2	0	1009.7
M	84	80	51	65	7.7	SSW	45	N	1962	64	6.3	7	11	13	11	0	6	2	3	0	•	0	1008.8
J	87	82	54	68	7.2	S	52	NW	1952	68	6.0	7	12	11	9	0	7	2	9	0	0	0	1015.6
J	89	85	56	71	6.6	SSW	56	NW	1955	66	6.1	7	12	12	11	0	9	2	13	0	0	0	1010.1
A	90	89	57	76	6.3	S	54	W	1964	65	6.0	7	12	12	10	0	7	3	11	0	0	0	1011.6
S	90	90	57	79	6.6	S	45	SE	1952	64	5.8	9	9	12	8	0	3	3	5	0	0	0	1011.7
O	87	90	53	77	6.8	NNE	68	SE	1954	60	5.3	12	7	12	7	0	1	3	•	0	2	0	1012.5
N	80	84	50	70	7.4	S	38	NW	1977	56	5.7	10	8	12	8	•	1	2	0	•	10	0	1013.3
D	78	81	55	70	7.5	SW	40	SW	1968	52	6.1	10	6	15	9	1	•	3	0	2	21	•	1012.9
YR	82	83	53	69	7.5	S	68	SE	OCT 1954	61	6.0	102	107	156	113	4	37	29	42	6	86	1	1011.3

Means and extremes above are from existing and comparable exposures. Annual extremes have been exceeded at other sites in the locality as follows: highest temperature 107 in August 1918; minimum monthly precipitation 0.11 in November 1890 and eariler.

(a) Length of record, years, through the current year unless otherwise noted, based on January data.
(b) 70° and above at Alaskan stations.
• Less than one half.
T Trace.

NORMALS — Based on record for the 1941-1970 periods.
DATE OF AN EXTREME — The most recent in cases of multiple occurrence.
PREVAILING WIND DIRECTION — Record through 1963.
WIND DIRECTION — Numerals indicate tens of degrees clockwise from true north. 00 indicate calm.
FASTEST MILE WIND — Speed is fastest observed 1-minute value when the direction is in tens of degrees.

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Table 2.3-3
NORFOLK METEOROLOGICAL NORMALS, MEANS, AND EXTREMES (REFERENCE 2)

Month	Temperature °F							Normal Degree days Base 65 °F		Precipitation in Inches										
	Normal			Extremes						Water equivalent							Snow, ice pellets			
	Daily maximum	Daily minimum	Monthly	Record highest	Year	Record lowest	Year	Heating	Cooling	Normal	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Maximum monthly	Year	Maximum in 24 hrs.	Year
(a)				32		32					32		32		32		32		32	
J	48.8	32.2	40.5	78	1970	5	1977	760	0	3.35	6.47	1979	1.60	1949	3.80	1967	14.2	1966	9.1	1973
F	50.0	32.7	41.4	81	1976	8	1965	661	0	3.31	5.72	1956	0.86	1950	1.87	1970	18.9	1980	12.4	1980
M	57.3	38.9	48.1	85	1968	18	1980	532	8	3.42	7.80	1978	1.34	1967	3.18	1958	13.7	1980	9.9	1980
A	67.7	47.9	57.8	97	1960	28	1964	226	10	2.71	7.00	1979	0.99	1976	2.76	1979	1.2	1964	1.2	1964
M	76.2	57.2	66.7	97	1956	36	1966	53	106	3.34	10.12	1979	1.48	1965	3.41	1980	0.0		0.0	
J	83.5	65.5	74.5	101	1964	45	1967	0	285	3.62	9.72	1963	0.37	1954	6.85	1963	0.0		0.0	
J	86.6	69.9	78.3	103	1952	54	1979	0	412	5.70	13.73	1975	1.69	1961	5.64	1969	0.0		0.0	
A	84.9	68.9	76.9	104	1980	52	1965	0	369	5.92	11.19	1967	0.74	1975	11.40	1964	0.0		0.0	
S	79.6	63.9	71.8	98	1954	45	1967	0	213	4.20	13.80	1979	0.36	1958	6.79	1959	0.0		0.0	
O	70.1	53.3	61.7	95	1954	27	1976	141	38	3.06	10.12	1971	0.93	1967	4.38	1971	0.0		0.0	
N	60.5	42.6	51.6	86	1974	20	1950	402	0	2.94	7.01	1951	0.49	1965	3.35	1952	0.6	1950	0.6	1950
D	50.6	34.0	42.3	80	1978	14	1980	704	0	3.11	5.83	1973	0.98	1979	2.12	1958	14.7	1958	11.4	1958
YR	68.0	50.6	59.3	104	AUG 1980	5	JAN 1977	3438	1441	44.68	13.80	SEP 1979	0.36	SEP 1958	11.40	AUG 1964	18.9	FEB 1980	12.4	FEB 1980

Month	Relative humidity pct. (Local time)				Wind					Pct. of possible sunshine	Mean sky cover, tenths, sunrise to sunset	Mean number of days											Average station pressure mb.
							Fastest mile †					Sunrise to sunset							Temperature °F Max.		Temperature °F Min.		
	01 Hour	07 Hour	13 Hour	19 Hour	Mean speed mph	Prevailing direction	Speed mph	Direction	Year			Clear	Partly cloudy	Cloudy	Precipitation .01 inch or more	Snow ice pellets 1.0 inch or more	Thunderstorms	Heavy fog, visibility ¼ mile or less	(b) 90° and above	32° and below	32° and below	0° and below	Elev. 30 feet msl
(a)	32	32	32	32	32	15	8	8		21	32	32	32	32	32	32	32	32	32	32	32	32	8
J	73	75	59	68	11.6	SW	39	23	1978	56	6.3	9	6	16	11	1	*	2	0	3	17	0	1017.9
F	72	74	56	65	12.0	NNE	44	36	1973	59	6.1	9	5	14	10	1	1	3	0	1	15	0	1017.6
M	72	74	54	62	12.3	SW	46	22	1973	63	6.1	9	7	15	11	*	2	2	0	*	6	0	1016.5
A	73	73	50	61	11.7	SW	39	06	1978	66	5.8	9	9	12	10	*	3	1	1	0	*	0	1015.4
M	81	78	56	67	10.2	SW	38	02	1979	65	6.1	8	10	13	10	0	5	2	1	0	0	0	1014.4
J	83	79	57	67	9.2	SW	46	30	1977	68	5.8	8	11	11	9	0	6	1	6	0	0	0	1015.6
J	85	82	59	71	8.9	SW	46	34	1973	65	5.9	8	11	12	11	0	8	1	11	0	0	0	1015.6
A	86	84	61	74	8.8	SW	46	35	1979	65	5.7	8	12	11	10	0	7	1	9	0	0	0	1017.2
S	84	84	61	76	9.6	NE	30	06	1979	64	5.7	9	10	11	8	0	3	1	3	0	0	0	1017.0
O	82	83	60	75	10.4	NE	32	23	1980	60	5.3	12	7	12	8	0	1	2	*	0	*	0	1017.9
N	76	79	56	69	10.6	SW	32	21	1973	59	5.3	11	8	11	8	0	1	2	0	0	3	0	1018.8
D	73	75	58	68	11.0	SW	35	35	1980	57	6.0	10	7	14	9	*	*	2	0	1	14	0	1018.4
YR	78	78	57	69	10.5	SW	46	35	AUG 1979	63	5.8	110	103	152	115	2	37	22	31	5	55	0	1016.9

(a) Length of record, years, through the current year unless otherwise noted, based on January data.
(b) 70° and above at Alaskan stations.
* Less than one half.
† 1973 to date.

NORMALS — Based on record for the 1941-1970 periods.
DATE OF AN EXTREME — The most recent in cases of multiple occurrence.
PREVAILING WIND DIRECTION — Record through 1963.
WIND DIRECTION — Numerals indicate tens of degrees clockwise from true north. 00 indicate calm.
FASTEST MILE WIND — Speed is fastest observed 1-minute value when the direction is in tens of degrees.

Means and extremes above are from existing and comparable exposures. Annual extremes have been exceeded at other sites in the locality as follows:

Temperature
Highest: 105 in Aug. 1918
Lowest: 2 in Feb. 1895.

Precipitation
Maximum monthly: 15.61 in Aug. 1942.
Minimum monthly: 0.04 in Oct. 1874.

Fastest Mile Wind
Highest: 80 mph W in Jun. 1925.

Snowfall
Maximum in 24 hours: 17.7 in Dec. 1892.

SI_T002

Table 2.3-4
MONTHLY METEOROLOGICAL MEANS FOR TEMPERATURE AND PRECIPITATION FOR STATIONS IN THE SURRY SITE REGION

Month	Norfolk	Richmond
January		
Temp	41.4°F	37.6°F
Precip	3.32 in.	3.20 in.
February		
Temp	42.1°F	39.1°F
Precip	3.33 in.	2.96 in.
March		
Temp	48.9°F	47.2°F
Precip	3.78 in.	3.52 in.
April		
Temp	57.5°F	57.1°F
Precip	3.20 in.	2.88 in.
May		
Temp	66.7 °F	66.2°F
Precip	3.73 in.	3.68 in.
June		
Temp	74.6°F	73.9°F
Precip	4.01 in.	3.67 in.
July		
Temp	78.6 °F	77.7°F
Precip	5.70 in.	5.57 in.
August		
Temp	77.6°F	76.4°F
Precip	5.33 in.	4.98 in.
September		
Temp	72.5°F	70.2°F
Precip	3.89 in.	3.67 in.
October		
Temp	62.1°F	58.7°F
Precip	3.13 in.	3.42 in.
November		
Temp	52.1°F	48.8°F
Precip	2.62 in.	3.19 in.
December		
Temp	43.6 °F	39.7°F
Precip	3.19 in.	3.17 in.

Table 2.3-5
SURRY SEASONAL AND ANNUAL MEAN WIND SPEED SUMMARY (mph)
(March 3, 1974 - December 31, 1981)

	147.4-foot Level	30.3-foot Level
Spring (Mar, Apr, May)	10.7	6.8
Summer (June, July, Aug)	8.9	5.1
Fall (Sept, Oct, Nov)	9.4	5.3
Winter (Dec, Jan, Feb)	10.3	6.3
Annual	9.8	5.8

Table 2.3-6
σ_θ STABILITY CATEGORIES

Range of Standard Deviation, (Degrees)		Turbulence Type
A = Extremely Unstable	$\sigma_\theta \geq 22.5$	
B = Moderately Unstable	$22.5 > \sigma_\theta \geq 17.5$	High Atmospheric Turbulence
C = Slightly Unstable	$17.5 > \sigma_\theta \geq 12.5$	
D = Neutral	$12.5 > \sigma_\theta \geq 7.5$	Moderate Atmospheric Turbulence
E = Slightly Stable	$7.5 > \sigma_\theta \geq 3.8$	
F = Moderately Stable	$3.8 > \sigma_\theta \geq 2.1$	Low Atmospheric Turbulence
G = Extremely Stable	$\sigma_\theta < 2.1$	

Table 2.3-7
SEASONAL AND ANNUAL STABILITY AND WIND SPEED DISTRIBUTION

	σ_θ						
	A	B	C	D	E	F	G
Spring (Mar, Apr, May)							
147.4 Feet Frequency, %	4.13	4.50	14.17	44.21	27.90	4.26	.82
Wind Speed, mph	(5.3)	(7.0)	(9.2)	(11.66)	(10.8)	(8.9)	(7.4)
30.3 Feet Frequency, %	12.53	16.19	33.09	30.91	6.19	.47	.60
Wind Speed, mph	(4.5)	(6.2)	(7.3)	(7.4)	(4.7)	(2.2)	(1.1)
Summer (June, July, Aug)							
147.4 Feet Frequency, %	5.88	6.45	15.58	36.59	27.88	6.21	1.41
Wind Speed, mph	(5.1)	(6.3)	(8.0)	(9.4)	(8.9)	(8.0)	(6.6)
30.3 Feet Frequency, %	19.10	18.49	26.79	25.90	7.16	.98	1.58
Wind Speed, mph	(4.2)	(5.2)	(5.6)	(5.1)	(3.4)	(2.0)	(1.0)
Fall (Sept, Oct, Nov)							
147.4 Feet Frequency, %	3.37	3.82	13.30	40.56	30.29	7.01	1.64
Wind Speed, mph	(4.8)	(6.1)	(8.5)	(10.3)	(9.3)	(8.5)	(7.5)
30.3 Feet Frequency, %	13.53	17.29	30.74	28.28	7.87	.99	1.31
Wind Speed, mph	(4.3)	(5.5)	(5.9)	(5.6)	(3.6)	(2.4)	(.5)
Winter (Dec, Jan, Feb)							
147.4 Feet Frequency, %	2.77	3.14	9.86	45.65	32.65	5.39	.55
Wind Speed, mph	(4.3)	(5.8)	(8.3)	(11.4)	(10.4)	(8.7)	(7.8)
30.3 Feet Frequency, %	9.95	13.57	32.82	35.64	7.25	.49	.28
Wind Speed, mph	(3.8)	(5.7)	(6.6)	(7.2)	(4.3)	(3.3)	(.8)
Annual							
147.4 Feet Frequency, %	4.02	4.46	13.23	41.69	29.71	5.77	1.13
Wind Speed, mph	(5.0)	(6.3)	(8.5)	(10.7)	(9.9)	(8.5)	(7.2)
30.3 Feet Frequency, %	13.74	16.40	30.88	30.15	7.14	.74	.95
Wind Speed, mph	(4.3)	(5.6)	(6.4)	(6.4)	(4.0)	(2.4)	(.8)

Table 2.3-8 (SHEET 1 OF 2)
INSTRUMENT PERFORMANCE SPECIFICATIONS

MRJ 1074-22		
Wind Speed:		
Starting threshold	-	0.75 mph
Response distance	-	18' (63% recovery)
Flow coefficient	-	7.9'/rev
Accuracy	-	±0.25 mph
Range	-	125 mph maximum
Temperature range	-	40°C to +50°C
Humidity range	-	0% to 100% RH
0°-540° Direction:		
Starting threshold	-	0.75 mph
Delay Distance	-	4' (50% recovery)
Damping ratio	-	0.5 to 0.6
Accuracy	-	±2.5°
Range	-	540° (electrical)
	-	360° (mechanical)
Linearity	-	±0.25% of full scale with 4° open space
Sin/Cos Direction:		
Starting threshold	-	0.75 mph
Delay distance	-	4' (50% recovery)
Damping ratio	-	0.5 to 0.6
Accuracy	-	±3.6°
Range	-	360° (mechanical and electrical)
Linearity-not linear, conformity to function	-	±1% of full scale

Rosemont 104MB 12 ADCS probes and Endevco 4473.2 Signal Conditioner

Accuracy (RSS)	-	±0.18°F (temperature)
	-	±0.13°F (differential temperature)
Range	-	10°F to +110°F (temperature)
	-	-6°F to +6°F (differential temperature)
Linearity	-	±0.1% (typical for resistance sensor)

Table 2.3-8 (SHEET 2 OF 2)
INSTRUMENT PERFORMANCE SPECIFICATIONS

EG&G 110(S)M or 220 with Aspirator Housing		
Range	-	-80°F to +160°F (overall, dependent on ambient temperature)
	-	-100°F to +160°F (for resistance temperature sensor)
	-	-30°F to +120°F (measurement range)
Relative humidity	-	<1% to 100% RH
Response	-	3°F to 5°F/sec (typical)
Sensitivity	-	±0.1°F
Dew point depression		0 to 100°F
Depression slow rate		4°F/sec maximum
System accuracy	-	±0.5°F (typical, accuracy analysis available from EG&G)
Teledyne Geotech 327B		
Motor Aspirated Solar Radiation Shield for Temperature and Differential Temperature Resistance Sensors		
Radiation shield	-	<0.2°F error at maximum solar radiation of 1.6 gm-cal/cm^2/sec
MRl 302		
Tipping bucket rain gage and heater		
Resolution	-	0.01 inches melted precipitation
Accuracy	-	±1% @ 3 inches/hour ±5% @ 10 inches/hour
Esterline Angus E11 and A6 series recorders		
Accuracy (DCV or milliamps)	-	±1% of full scale 0.5 sec. to record 99% of final value at critical damping
Temperature range	-	20°F to 120°F

Table 2.3-9
TEMPERATURE CORRELATION FACTOR

Daily Temperature		Site/Norfolk	Site/Richmond
January	Maximum	0.959	0.961
	Minimum	0.902	0.872
July	Maximum	0.952	0.924
	Minimum	0.861	0.914

Table 2.3-10
MONTHLY MEAN EXTERNAL TEMPERATURES

	Site[a]		Norfolk[b]		Richmond[c]	
Month	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin
January	35.4	22.8	35.9	23.1	36.1	16.2
July	86.7	69.9	88.8	70.5	91.8	66.9

Note: Tmax = monthly mean of daily maximum temperatures (°F)
Tmin = monthly mean of daily minimum temperatures (°F)

a. Data source for onsite information - Meteorological Data Summary 1977 Surry Nuclear Power Station.
b. Source: Reference 20 of Section 2.3.2.1.
c. Source: Reference 21 of Section 2.3.2.1.

Table 2.3-11
DISTRIBUTION OF TEMPERATURES 90°F

Temperature Range (°F)	Richmond[a, b]	Norfolk[b, c]
104/100	12 (5%)	1 (1%)
99/85	59 (25%)	19 (12%)
94/90	163 (70%)	136 (87%)
Totals	234 (100%)	156 (100%)

a. Data period 3/50 - 2/55 (5 years)
b. (%) indicates percent of observation with temperature 90°F and above.
c. Data period 1/51 - 12/60 (10 years)

Table 2.3-12
0.5 PERCENT GROUND LEVEL χ/Q VALUES ($\times 10^{-4}$ SEC/M^3) AT THE 0.313-MILE EXCLUSION AREA BOUNDARY FOR THE 0- TO 720-HOUR PERIOD FOLLOWING AN ACCIDENT AT THE INDEPENDENT SPENT FUEL STORAGE INSTALLATION

Downwind Sector	Distance (m)	0-2 hr	0-8 hr	8-24 hr	1-4 day	4-30 day
N	503	10.7	7.39	6.15	4.12	2.32
NNE	503	10.1	6.93	5.74	3.82	2.13
NE	503	9.56	6.28	5.09	3.22	1.67
ENE	503	7.27	4.68	3.75	2.32	1.17
E	503	4.85	3.19	2.59	1.64	0.856
ESE	503	3.52	2.35	1.92	1.24	0.661
SE	503	3.63	2.43	1.98	1.28	0.682
SSE	503	3.18	2.19	1.82	1.22	0.685
S	503	3.42	2.38	1.98	1.33	0.755
SSW	503	2.76	1.85	1.52	0.985	0.529
SW	503	2.62	1.76	1.45	0.942	0.509
WSW	503	2.35	1.56	1.27	0.814	0.429
W	503	3.03	2.04	1.67	1.09	0.589
WNW	503	4.43	2.96	2.42	1.56	0.834
NW	503	6.73	4.38	3.53	2.21	1.13
NNW	503	8.95	6.03	4.95	3.22	1.74

Five percent direction independent 8.65

Table 2.3-13
0.5 PERCENT GROUND LEVEL χ/Q VALUES ($\times 10^{-5}$ SEC/M^3) AT THE 0.5-MILE EXCLUSION AREA BOUNDARY FOR THE 0- TO 720-HOUR PERIOD FOLLOWING AN ACCIDENT AT THE INDEPENDENT SPENT FUEL STORAGE INSTALLATION

Downwind Sector	Distance (m)	0-2 hr	0-8 hr	8-24 hr	1-4 day	4-30 day
N	805	49.9	34.1	28.2	18.6	10.3
NNE	805	47.2	32.0	26.3	17.3	9.41
NE	805	44.7	28.9	23.3	14.5	7.40
ENE	805	34.0	21.6	17.2	10.5	5.16
E	805	22.2	14.4	11.6	7.31	3.75
ESE	805	15.8	10.5	8.53	5.45	2.86
SE	805	16.3	10.8	8.80	5.62	2.96
SSE	805	14.3	9.78	8.09	5.37	2.98
S	805	15.4	10.6	8.80	5.88	3.29
SSW	805	12.5	8.33	6.79	4.36	2.31
SW	805	11.8	7.86	6.42	4.15	2.21
WSW	805	10.7	7.00	5.66	3.58	1.85
W	805	13.7	9.15	7.47	4.81	2.56
WNW	805	20.1	13.3	10.8	6.92	3.64
NW	805	30.7	19.8	15.9	9.84	4.95
NNW	805	40.4	27.0	22.1	14.3	7.63

Five percent direction independent 40.2

Table 2.3-14
0.5 PERCENT GROUND LEVEL χ/Q VALUES ($\times 10^{-5}$ SEC/M^3) AT THE 1.5-MILE POPULATION RECEPTOR FOR THE 0- TO 720-HOUR PERIOD FOLLOWING AN ACCIDENT AT THE INDEPENDENT SPENT FUEL STORAGE INSTALLATION

Downwind Sector	Distance (m)	0-2 hr	0-8 hr	8-24 hr	1-4 day	4-30 day
N	2414	18.9	10.1	7.42	3.77	1.43
NNE	2414	17.8	9.49	6.92	3.49	1.31
NE	2414	16.9	8.59	6.12	2.94	1.02
ENE	2414	12.4	6.19	4.38	2.07	0.706
E	2414	7.51	3.90	2.81	1.38	0.498
ESE	2414	5.25	2.77	2.02	1.01	0.375
SE	2414	5.09	2.72	1.99	1.01	0.380
SSE	2414	4.46	2.47	1.84	0.967	0.385
S	2414	5.09	2.81	2.09	1.10	0.434
SSW	2414	3.84	2.07	1.52	0.778	0.297
SW	2414	3.34	1.83	1.36	0.706	0.277
WSW	2414	3.07	1.64	1.20	0.610	0.230
W	2414	4.25	2.29	1.68	0.858	0.327
WNW	2414	6.37	3.40	2.49	1.26	0.474
NW	2414	10.8	5.52	3.94	1.90	0.665
NNW	2414	15.3	8.03	5.81	2.89	1.06

Five percent direction independent 14.6

Table 2.3-15
0.5 PERCENT GROUND LEVEL χ/Q VALUES ($\times 10^{-5}$ SEC/M^3) AT THE 2.0-MILE POPULATION RECEPTOR FOR THE 0- TO 720-HOUR PERIOD FOLLOWING AN ACCIDENT AT THE INDEPENDENT SPENT FUEL STORAGE INSTALLATION

Downwind Sector	Distance (m)	0-2 hr	0-8 hr	8-24 hr	1-4 day	4-30 day
N	3218	14.7	7.39	5.24	2.49	0.851
NNE	3218	13.9	6.93	4.89	2.30	0.778
NE	3218	13.2	6.27	4.33	1.93	0.609
ENE	3218	9.31	4.40	3.02	1.34	0.416
E	3218	5.65	2.77	1.94	0.892	0.293
ESE	3218	3.95	1.97	1.39	0.653	0.220
SE	3218	3.83	1.93	1.37	0.651	0.224
SSE	3218	3.34	1.74	1.26	0.622	0.226
S	3218	3.82	1.99	1.43	0.705	0.255
SSW	3218	2.82	1.44	1.03	0.494	0.173
SW	3218	2.40	1.25	0.901	0.443	0.160
WSW	3218	2.24	1.13	0.806	0.386	0.134
W	3218	3.09	1.58	1.13	0.543	0.190
WNW	3218	4.66	2.35	1.67	0.798	0.276
NW	3218	8.15	3.92	2.72	1.23	0.392
NNW	3218	11.90	5.86	4.11	1.90	0.630

Five percent direction independent 11.4

Table 2.3-16
0.5 PERCENT GROUND LEVEL χ/Q VALUES ($\times 10^{-5}$ SEC/M^3) AT THE 2.5-MILE POPULATION RECEPTOR FOR THE 0- TO 720-HOUR PERIOD FOLLOWING AN ACCIDENT AT THE INDEPENDENT SPENT FUEL STORAGE INSTALLATION

Downwind Sector	Distance (m)	0-2 hr	0-8 hr	8-24 hr	1-4 day	4-30 day
N	4023	12.1	5.80	4.02	1.82	0.580
NNE	4023	11.4	5.43	3.75	1.68	0.530
NE	4023	10.8	4.91	3.32	1.41	0.414
ENE	4023	7.60	3.43	2.31	0.974	0.283
E	4023	4.46	2.10	1.44	0.637	0.197
ESE	4023	3.17	1.52	1.05	0.470	0.149
SE	4023	3.08	1.49	1.03	0.469	0.151
SSE	4023	2.68	1.34	0.950	0.448	0.152
S	4023	2.99	1.50	1.06	0.501	0.170
SSW	4023	2.21	1.08	0.758	0.350	0.115
SW	4023	1.87	0.935	0.662	0.313	0.107
WSW	4023	1.69	0.827	0.579	0.267	0.088
W	4023	2.40	1.18	0.827	0.383	0.127
WNW	4023	3.74	1.81	1.26	0.575	0.186
NW	4023	6.54	3.02	2.05	0.005	0.265
NNW	4023	9.77	4.59	3.15	1.39	0.430

Five percent direction independent 9.32

Table 2.3-17
0.5 PERCENT GROUND LEVEL χ/Q VALUES ($\times 10^{-6}$ SEC/M^3) AT THE 3.5-MILE POPULATION RECEPTOR FOR THE 0- TO 720-HOUR PERIOD FOLLOWING AN ACCIDENT AT THE INDEPENDENT SPENT FUEL STORAGE INSTALLATION

Downwind Sector	Distance (m)	0-2 hr	0-8 hr	8-24 hr	1-4 day	4-30 day
N	5633	88.6	40.1	27.0	11.5	3.34
NNE	5633	83.7	37.6	25.2	10.6	3.04
NE	5633	79.2	34.0	22.3	8.89	2.38
ENE	5633	55.8	23.7	15.5	6.13	1.62
E	5633	31.2	14.0	9.34	3.90	1.11
ESE	5633	22.7	10.3	6.90	2.91	0.845
SE	5633	21.4	9.82	6.65	2.86	0.848
SSE	5633	19.2	9.08	6.24	2.77	0.861
S	5633	21.3	10.1	6.94	3.08	0.962
SSW	5633	15.5	7.20	4.91	2.14	0.647
SW	5633	12.6	6.03	4.17	1.87	0.592
WSW	5633	11.4	5.32	3.64	1.60	0.489
W	5633	17.0	7.92	5.40	2.36	0.715
WNW	5633	26.2	12.1	8.17	3.52	1.05
NW	5633	46.8	20.4	13.5	5.49	1.51
NNW	5633	71.7	31.8	21.2	8.77	2.47

Five percent direction independent 68.1

Table 2.3-18
0.5 PERCENT GROUND LEVEL χ/Q VALUES ($\times 10^{-6}$ SEC/M^3) AT THE 4.5-MILE POPULATION RECEPTOR FOR THE 0- TO 720-HOUR PERIOD FOLLOWING AN ACCIDENT AT THE INDEPENDENT SPENT FUEL STORAGE INSTALLATION

Downwind Sector	Distance (m)	0-2 hr	0-8 hr	8-24 hr	1-4 day	4-30 day
N	7242	69.9	30.5	20.2	8.21	2.26
NNE	7242	66.0	28.6	18.8	7.58	2.05
NE	7242	62.6	25.8	16.6	6.36	1.61
ENE	7242	44.0	18.0	11.6	4.39	1.09
E	7242	24.2	10.4	6.86	2.76	0.745
ESE	7242	17.1	7.48	4.96	2.03	0.561
SE	7242	16.6	7.34	4.88	2.02	0.567
SSE	7242	14.9	6.78	4.58	1.98	0.574
S	7242	16.1	7.39	5.00	2.15	0.637
SSW	7242	11.5	5.21	3.50	1.47	0.426
SW	7242	9.33	4.33	2.95	1.28	0.574
WSW	7242	8.47	3.85	2.59	1.10	0.332
W	7242	12.7	5.74	3.86	1.63	0.472
WNW	7242	20.2	8.89	5.93	2.46	0.696
NW	7242	36.3	15.3	9.92	3.88	1.01
NNW	7242	56.6	24.2	15.8	6.28	1.67

Five percent direction independent 52.8

Table 2.3-19
0.5 PERCENT GROUND LEVEL χ/Q VALUES ($\times 10^{-6}$ SEC/M^3) AT THE 7.5-MILE POPULATION RECEPTOR FOR THE 0- TO 720-HOUR PERIOD FOLLOWING AN ACCIDENT AT THE INDEPENDENT SPENT FUEL STORAGE INSTALLATION

Downwind Sector	Distance (m)	0-2 hr	0-8 hr	8-24 hr	1-4 day	4-30 day
N	12070	43.1	17.7	11.4	4.34	1.09
NNE	12070	41.2	16.7	10.7	4.02	0.990
NE	12070	38.3	14.9	9.30	3.34	0.768
ENE	12070	27.4	10.6	6.56	2.33	0.527
E	12070	13.8	5.67	3.64	1.39	0.348
ESE	12070	10.1	4.20	2.71	1.04	0.265
SE	12070	9.57	4.02	2.61	1.02	0.264
SSE	12070	8.61	3.72	2.44	0.983	0.266
S	12070	9.57	4.14	2.72	1.10	0.297
SSW	12070	6.19	2.68	1.76	0.709	0.192
SW	12070	5.04	2.24	1.50	0.621	0.176
WSW	12070	4.54	1.98	1.31	0.531	0.146
W	12070	7.17	3.08	2.02	0.809	0.217
WNW	12070	11.5	4.85	3.15	1.23	0.322
NW	12070	21.5	8.59	5.43	2.00	0.478
NNW	12070	35.3	14.2	8.98	3.34	0.806

Five percent direction independent 32.2