SECTION 2

SITE CHARACTERISTICS

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SECTION 2

SITE CHARACTERISTICS

2.1 GEOGRAPHY AND DEMOGRAPHY

2.1.1 Site Location

The Salem site is located on the southern part of Artificial Island on the east bank of the Delaware River in Lower Alloways Creek Township, Salem County, New Jersey. The point of intersection of the centerlines of the two Containment Buildings and the Auxiliary Building is located at Latitude 39° 27 min 46 sec north and Longitude 75° 32 min 08 sec west. The Universal Transverse Mercator coordinates of the reactor site are 4,368,100 m north and 454,070 m east, Zone 18. While called Artificial Island, the site is actually connected to the mainland of New Jersey by a strip of tideland formed by hydraulic fill from dredging operations on the Delaware River by the U. S. Army Corps of Engineers. The site is 15 miles south of the Delaware Memorial Bridge, 18 miles south of Wilmington, Delaware, 30 miles southwest of Philadelphia, Pennsylvania, and 7-1/2 miles southwest of Salem, New Jersey. The location of the site with respect to major cities in the northeast is shown on Figures 2.1-1 and 2.1-2.

Salem Generating Station (SGS) is located on a 700-acre site which is owned by Public Service Electric & Gas (PSE&G). Access to the site is achieved by a road (constructed by PSE&G) that connects with Alloways Creek Neck Road, about 2-1/2 miles east of the site. The location of the site with respect to the surrounding area is shown on Figure 2.1-3, a U. S. Geological Survey map. An aerial photograph is presented on Figure 2.1-4.

2.1.2 Site Description

The location of the site boundary and significant plant features is shown on Figure 2.1-5.

The site exclusion area is defined as follows:

Land

The land exclusion area is defined as that area bounded by the property line as shown on Figure 2.1-5. This land is owned by and under the control of PSE&G. The minimum distance between the reactors and the exclusion area boundary (property line) is 1270 meters.

Water

The water portion of the exclusion area is defined as that area bounded by the locus of points 1270 meters from the Containment Buildings of either Units 1 or 2 and also falling within the Delaware River. The 1270 meters is consistent with the minimum land exclusion area distance.

Discussion of the exclusion of people, property, and river traffic from that portion of the exclusion area which extends over the river is included as part of the detailed Emergency Plan, Section 13.3.

2.1.2.1 Exclusion Area Control

PSE&G owns and has control of the 700-acre land area that comprises the exclusion area. Control of the water portion of the exclusion area is described in Section 13.3, Emergency Plan.

2.1.2.2 Boundaries for Establishing Effluent Release Limits

The land boundary on which technical specification limits on release of gaseous radioactive effluents is based on the property line defining land owned by PSE&G. Figure 2.1-5 is a scale drawing showing the property line in relation to the reactor units. Distances from both the Units 1 and 2 vents to the property line in any direction may be scaled from this drawing. The minimum distance from the vents to the property line is nominally 1270 meters.

2.1.3 Population Distribution

The sources used for the 1970 distribution of population were the U. S. Bureau of the Census counts for 1970 (1), census and topographic maps (2,3), aerial photos (4), and field check surveys.

The Bureau of the Census published various levels of population data: county, minor civil division (MCD), census tract, and block. In 1970, the study area (within 50 miles of the Salem site), included portions of 4 states, 24 counties, 338 MCDs, hundreds of tracts, and thousands of census blocks.

Population distribution about SGS is provided in the sector format required. Concentric circles with the required radii for distances to 10 miles and 10 to 50 miles are provided. The circles are then divided into 22.5 degree segments, each centered on one of the 16 cardinal compass points (e.g., north, north-northeast, etc.). Projections on 10-year intervals to the year 2020 are provided on the above described sector format. Population projections are based on 1970 census data. Projections based on current census data will be provided after the validity of the current projection assumption and calculational techniques have been analyzed.

2.1.3.1 Population Within 10 Miles

For the 96 sectors within 10 miles of the site, the following method of distribution was used. It was felt, and subsequently proven, that the "area" method for distribution, successfully used beyond 10 miles depends on large sector area. Within 10 miles, the sector size is significantly smaller. For example, an average size MCD beyond 10 miles falls into two sectors. Within 10 miles, a similar-sized MCD would include over 5 sectors. The assumption of evenly distributed population within a MCD is only valid beyond 10 miles. This is clearly seen in the area within 5 miles of the site which is mostly marsh. An even distribution of people throughout a sector would place residents in uninhabitable areas. Beyond 10 miles, this factor is not of great concern since habitable land is also included in the larger sectors.

To arrive at an accurate portrayal of the 1970 population distribution within 10 miles, a house count was made from topographic maps. The count was field checked within 5 miles. The total house count for a MCD or census tract was divided into the 1970 census population resulting in persons per household factor of 2.99 to 3.36 as shown in Table 2.1-1. The factors were then applied to the houses in their respective MCDs. By totaling the population in each sector, the 1970 distribution was derived. The results are shown on Figures 2.1-6 through 2.1-10. One problem encountered was the lack of updated maps in some sectors. A review of township population growth showed that in the areas not covered by the 1970 photo-revised topographic maps (concurrent with the census data), the township growth was minimal. Any growth was in areas already populated and beyond 5 miles of the site. The field check proved this to be true. The house count method assumed that growth to 1970 is proportional to development already mapped.

To be consistent, house counts were made for all MCDs which were partially within 10 miles but which extended beyond 10 miles. This dot-map distribution method is more precise than the area

distribution method which assumes equal population density throughout the MCD. However, as noted above, house counts were only necessary within 10 miles where the sector sizes required greater precision.

The great amount of swampy and marshy areas found around the site is not populated. The proximity of the Delaware River is also responsible for the low density within 5 and 10 miles. The population densities for land area only were 29 people per square mile and 109 people per square mile within 5 and 10 miles respectively, in 1970. The nearest residence is approximately 3.4 miles west-northwest of the site in Bay View Beach, Delaware. Other nearby residences are located 3.5 miles east-northeast, and 3.7 miles northwest of the site.

2.1.3.1.1 Population Projections for 0 to 10 Mile Area

The methodology for population projection is described in Section 2.1.3.7. The allocation of 1970 population to the rose within 10 miles was based on house distribution. Projected population distribution is assumed to be similar. Within 5 miles, a land survey field check was made. The area is marsh and meadowland, not suitable in its present form for residential development. Thus, the areas presently developed are assumed to be the focal points of further development. Figures 2.1-6 through 2.1-10 show the estimated future population distributions.

2.1.3.1.2 Population Update Within 10 Miles

Updated population is provided for the most current estimate of population within 10 miles. The updated population is provided in Tables 2.1-2 and 2.1-3.

The population estimates are essentially current (March 1980), although they are based on U.S. Bureau of Census figures of July 1, 1977 and Dresdner Associates' surveys (5) conducted in September 1979 and March 1980. There has been little population

change by sector since July 1, 1977. Changes that have occurred tend to emphasize the conservative (high) nature of the population estimate, including decreased family size, out-migration in older communities, and decline in new housing starts. The methodology of allocating and reporting population is consistent with that already described.

Distribution of Population, 0 to 5 Miles, New Jersey

The distribution of population in New Jersey within 0 to 5 miles of the SGS is based on a comprehensive land use survey of dwelling units factored by an estimated average household size.

1. The 0 to 5 mile area from the SGS was divided into 35 sector/zones based on the standard Nuclear Regulatory Commission (NRC) designators for population distribution maps. The sectors located in New Jersey are north, north-northeast, northeast, east-northeast, east, east-southeast, and southeast in the 0 to 5 mile area.

2. A survey of land uses within the 0 to 5 mile area identified all residential units by zone and sector in New Jersey. The reasonableness of this survey was confirmed by sample counts from aerial photos, the USGS maps, and municipal master plans.

3. Based on the 1970 average household size by community, the population of each sector was determined by multiplying the number of dwelling units in the sector by the average household size of the community in the sector. Where more than one community was within a sector, the average household size of the community with the largest population was assumed to be reasonable. The resultant figure is considered conservative (a high estimate) because all literature indicates that average household size has decreased since 1970.

Distribution of Population, 0 to 5 Miles, Delaware

The distribution of population within 0 to 5 miles in Delaware of the SGS is based on small area (sub-municipal) population estimates made by the Wilmington Metropolitan Area Planning Council (WILMAPCO).

1. The 0 to 5 mile area from the SGS was divided into 45 sector/zones based on standard NRC designators for population distribution maps. The sectors located in Delaware are south-southeast, south, south-southwest, southwest, west-southwest, west, west-northwest, northwest, and north-northwest.

2. The entire portion of the 0 to 5 mile area in Delaware is included in the WILMAPCO Parcel Land Use System (PLUS). This program presented small area, sub-municipal (cells) population data for the year 1976, and estimated current for 1980.

3. Each small area, or cell, was assigned to a zone/sector. Where a cell was located in more than one zone/sector, its proportional area was allocated to each cell.

4. The population of each cell was then proportionately distributed to each zone/sector in the 0 to 5 mile ring in Delaware. This proportional distribution was based on the assumption that population is generally evenly distributed throughout the cell. This distribution was validated by a "windshield" survey, examination of aerial photos, and review of USGS maps. On the basis of this validation, transfers of population from one sector/zone to another (but within the same cell) were undertaken to account for grossly unequal distributions of population within a cell. A typical example would be where the wetlands portion of a cell was located in one zone/sector, and the built up portion located in an

adjacent zone/sector. In such a case, it was assumed that population was concentrated in the developable section of the cell.

Distribution of Population, 5 to 10 Miles, New Jersey

The allocation of population within 5 to 10 miles of the SGS was based on a count of dwelling units except for the City of Salem, New Jersey, where the population was based on a Census update.

1. The 5 to 10 mile area from the SGS was divided into 35 sector/zones based on the standard NRC designators for population distribution maps. The sectors located in New Jersey are north, north-northeast, northeast, east-northeast, east, east-southeast, and southeast in the 5 to 10 mile area, with zones at one mile intervals.

2. A survey of land uses within the 5 to 10 mile area identified all residential units (outside of boroughs and cities) by zone and sector, except for the City of Salem.

3. The population of the City of Salem was taken from the Census update (see Sources) and allocated to the appropriate sector based on its aerial distribution.

4. Based on the 1970 average household size by community, the population of each sector was determined by multiplying the number of dwelling units in the sector by the average household size of the community in the sector. Where more than one community was within the sector, then the average household size of the community with the largest population was assumed to be reasonable. The resultant figure was considered conservative (a high estimate) because all literature indicates that average household size has decreased since 1970.

Distribution of Population, 5 to 10 Miles, Delaware

The distribution of population in Delaware within 5 to 10 miles of SGS is based on small area, sub-municipal population estimates made by WILMAPCO.

1. The 5 to 10 mile area from the SGS was divided into 45 sector/zones based on standard NRC designators for population distribution maps. The sectors located in Delaware are south-southeast, south, south-southwest, southwest, west-southwest, west, west-northwest, northwest, and north-northwest.

2. The entire portion of the 5 to 10 mile area in Delaware is included in WILMAPCO's PLUS program, except for a small section of Kent County. This program presented small area, sub-municipal (cells) population data for the year 1976 and estimated current for 1980.

3. Each small area, or cell, was assigned to a zone/sector. Where a cell was located in more than one zone/sector, its proportional area was allocated to each cell.

4. The population of each cell was then proportionately distributed to each zone/sector in the 5 to 10 mile ring in Delaware. This proportional distribution was based on the assumption that population is generally evenly distributed throughout the cell. This distribution was validated by a "windshield" survey, examination of aerial photos, and review of USGS maps. On the basis of this validation, transfer of population from one sector/zone to another (but within the same cell) were undertaken to account for grossly unequal distributions of population within a cell. A typical example would be where the wetlands portion of a cell was located in one zone/sector, and the built up portion located in an adjacent zone/sector. In such a case, it was assumed

that population was concentrated in the developable section of the cell.

2.1.3.2 Population Between 10 and 50 Miles

This area from 10 to 50 miles is divided into 64 sectors ranging in size from 59 square miles to 177 miles. The great majority of MCDs are divided between two sectors. For this reason, the MCD was chosen as the unit to be studied from 10 to 50 miles. Only in Philadelphia County, which is one MCD, were census tracts used. This was due to the size of Philadelphia which falls within four sectors and partially beyond the 50 mile radius circle. Census tracts more accurately portray the 1970 distribution in urban areas as they are smaller in size than MCDs. However, for most areas beyond 10 miles, they were not available. In many of the rural areas, census tracts are contiguous with MCDs.

The 1970 population data on the MCD level was allocated to the sectors assuming equal distribution throughout the sector. This percentage of each MCD within a sector was calculated. This percentage was multiplied by the MCD population to obtain the population in the sector. The procedure was repeated for all land areas within a sector. The sum of these computations for each sector yielded its 1970 population. The results are shown on Figures 2.1-11 through 2.1-15.

2.1.3.2.1 Population Projections for 10 to 50 Mile Area

The population derived from the MCDs, as discussed above, were allocated to the rose in the same manner as the 1970 populations. The results are shown on Figures 2.1-11 through 2.1-15. The methodology for these projections is described in Section 2.1.3.7.

2.1.3.2.2 Population Update 10 to 50 Miles

Updated population is provided for the most current estimate of population for the area 10 to 50 miles from SGS. This population

distribution is tabulated in Table 2.1-4. The population estimates are essentially current (March 1980), although they are based on U.S. Bureau of Census figures of July 1, 1977 and Dresdner Associates' surveys (5) conducted in September 1979 and March 1980.

There has been little population change by sector since July 1, 1977. Changes that have occurred tend to emphasize the conservative (high) nature of the population estimate, including decreased family size, out-migration in older communities and decline in new housing starts. The methodology of allocating and reporting population is consistent with that already described.

Distribution of Population, 10 to 50 Miles, New Jersey

The distribution of population within 10 to 50 miles in New Jersey of SNGS is based on updated Bureau of Census reports.

1. The 10 to 50 mile area from SGS in New Jersey was divided into 46 sector/zones. The sectors located in New Jersey are north, north-northeast, northeast, east-northeast, east, east-southeast, and southeast.

2. The population for the entire portion of the 10 to 50 mile area in New Jersey is included in the Bureau of Census, P-25 series, Report No. 843. This report, entitled "Population Estimates and Projections," contains current estimates of the July 1977 population for all counties, incorporated places, and active MCDs.

3. Each municipality was assigned a zone/sector. Where a municipality was located in more than one sector, a proportional area was allocated to each one.

4. The population of each sector/zone was based on the percentage of aerial distribution, assuming equal distribution of population through the municipality.

5. Equal distribution of population throughout the municipality was assumed excluding wildlife refuges, state parks, coastal wetlands, and marshlands.

6. Total population distribution by sector.

Distribution of Population, 10 to 50 Miles, Pennsylvania

The distribution of population from 10 to 50 miles from SGS in Pennsylvania was determined by Census Bureau update reports.

1. The 10 to 50 mile area from SGS in Pennsylvania was divided into 30 sector/zones. The sectors in Pennsylvania are north, north-northeast, northeast, west-northwest, northwest, and north-northwest, and fall into the 20 to 50 mile zones.

2. The population for the entire portion of the 20 to 50 mile area in Pennsylvania is included in the Bureau of Census, P-25 series, Report No. 851. This report, entitled "Population Estimates and Projections," contains current estimates of July 1977 populations for all counties, incorporated places, and active minor civil divisions.

3. Each municipality was assigned a zone/sector. Where a municipality was located in more than one sector or zone, a proportional area was allocated to each.

4. The population of each zone/sector was based on the percentage of aerial distribution, assuming equal population throughout the municipality.

5. Equal distribution of the population throughout the municipality was assumed excluding wildlife refuges, state parks, coastal wetlands, and marshlands.

6. Total population distribution by sector.

Distribution of Population, 10 to 50 Miles, Delaware

The distribution of population with 10 to 50 miles in Delaware of SGS is based on updated Bureau of Census reports.

1. The 10 to 50 mile area from SGS in Delaware was divided into 43 sector/zones. The sectors are north, north-northwest, northwest, west-northwest, west, west-southwest, southwest, and south-southwest.

2. The population estimates for this area are available from the Bureau of the Census, P-25 series, Report No. 821. This report, entitled "Population Estimates and Projections," contains current estimates of the July 1977 population for all counties, incorporated areas, and active MCDs. Much of the Delaware and Maryland populations remain unincorporated, meaning that this portion of the populace is represented in the county total only.

To determine the number of unincorporated people per county, the total incorporated population was subtracted from the county total. This portion of the population was then equally allocated, based on a percentage of developed land area for each sector/zone.

1. Each governmental unit was assigned a sector/zone. Where a governmental unit was located in more than one, a proportional area was allocated to each sector or zone.

2. The population of each sector/zone was based on the percentage of aerial distribution for incorporated and unincorporated areas. Equal population distribution was assumed for each.

Distribution of Population, 10 to 50 Miles, Maryland

The distribution of population within 10 to 50 miles in Maryland of SGS is based on updated Bureau of Census reports.

1. The 10 to 50 mile area from SGS in Maryland was divided into 41 sector/zones. The sectors are northwest, west-northwest, west, west-southwest, southwest, and south-southwest.

2. The population estimates for this area are available from the Bureau of Census, P-25 Series, Report No. 833. This report contains current population estimates for July 1977 for all counties, incorporated areas, and active MCDs. Much of the Maryland population remains unincorporated and, therefore, is represented only in the county totals.

To determine the number of unincorporated people per county, the total incorporated population was subtracted from the county total. This portion of the population was then equally allocated, based on a percentage of developed land area for each sector/zone.

1. Each governmental unit was assigned a sector/zone. Where a governmental unit was located in more than one, a proportional area was allocated to each sector or zone.

2. The population of each sector/zone was based on the percentage of aerial distribution for incorporated and unincorporated areas. Equal population distribution was assumed for each.

2.1.3.3 Low Population Zone

The radius of the low population zone (defined in 10CFR100) is 5 miles. This distance is based on plant design and protective

action considerations. The update population (1980) for the area within the 5 mile low population zone is 1298 persons.

2.1.3.4 Transient Population

Within 5 miles of the site, there are no major seasonal or daily additions to the population with the exception of the Salem Station and Hope Creek Station construction and outage support crews and onsite visitor's center. The center has a seating capacity of 140 persons. The area is marsh and meadowland which attracts only limited numbers of hunters and trappers.

A list of the transient population attracted by the recreational facilities around the site is provided in Table 2.1-5. Pleasure craft are used on the Delaware River and Alloways Creek. Prime usage occurs on weekends and holidays. The boats range from 14 feet to 35 feet in length and might accommodate an average maximum of 120 passengers.

The only other major source of transients in the vicinity is the Delaware River traffic. Annual passenger traffic according to the U.S. Corp of Engineers is over four million people (6). This number seems high and might include double counting at the various ports north of the site. It should be stressed that river traffic does not remain within 5 miles of the site vicinity longer than the time required to traverse the river, normally less than 1 hour.

2.1.3.5 Population Center

The nearest population center of about 25,000 (as defined in 10CFR100) is Wilmington, Delaware, 18 miles north of the site. The 1970 population of Wilmington is listed in the U.S. Census report as 80,386, a decrease of 16 percent from the 1960 U.S. Census report population of 95,287. Bridgeton, New Jersey, 15.5 miles east of the site, is listed in the U.S. Census report as

having a 1970 population of 20,453, a decrease of 2.5 percent from the 1960 U.S. Census report.

Wilmington is the center of a Standard Metropolitan Statistical Area (SMSA). The Wilmington SMSA has a population in excess of 300,000. Philadelphia, Pennsylvania, and Camden, New Jersey, are part of the SMSA with a population in excess of 3.5 million, beginning about 30 miles north-northeast of the site. Baltimore, Maryland, with a population of less than 1 million is located 50 miles west of the site.

The City of Salem, located 8 miles north-northeast of the site, had a 1970 population of 7648.

2.1.3.6 Public Facilities and Institutions

An area of approximately 10 miles radius (slightly larger and irregular) has been defined as the Emergency Planning Area (EPZ) for the Salem site. The EPZ area, as defined in NUREG-0654, Rev. 1, dated November 1980, obtains the irregular shape by virtue of being defined by political and physical boundaries. This area is slightly larger than a 10-mile radius, a description of which is provided on Figure 2.1-16. All information related to special facilities, including public facilities and institutions, are those facilities which reside in this area. Additional information with respect to the facilities and related transient population is provided in the Salem Generating Station Emergency Plan and in references contained in Reference 28 of this plan. Total transient population and special facilities population is provided on Figures 2.1-17 and 2.1-18.

2.1.3.6.1 Schools

There are a total of 24 schools in this area. The schools located closest to the site are Lower Alloways Creek Township School, located 6.5 miles east with a total population (students and instructors) of 285, and the Corbit School (185 persons) located

6.5 miles west in Odessa, Delaware. A listing of the schools is provided in Table 2.1-6 and identified on Figure 2.1-16.

2.1.3.6.2 Hospitals and Nursing Homes

There are two hospitals and one nursing home located within the 10 mile EPZ. The Salem County Memorial Hospital is a public facility located in Salem, New Jersey, 10 miles north-northeast of the site. It has a bed capacity of 168. There is also a daytime facility (Association of Retarded Citizens in New Jersey) with an attendance of 80 persons.

The Governor Bacon Health Center is located near Delaware City, Delaware and is 8.5 miles north-northwest of the Salem site. It is operated by the State Division of Mental Health and Retardation primarily for emotionally and mentally ill children. Present capacity is 222 patients with a daytime staff of 66.

Salem Nursing Center, 8 miles north-northeast of the site, has a capacity of 110 patients.

Table 2.1-7 lists the hospital and nursing homes with current patient and staff population.

2.1.3.6.3 Correctional Institutions

There are two correctional institutions within or very near 10 miles of the site. The nearest institution is the Salem County Jail located 8 miles north-northeast of the site with a capacity of 115 inmates and an average of 75 inmates.

The Delaware State Correctional Institution has a total capacity of 775 inmates. Inmate average population as of the beginning of 1981 was 900 inmates. The institution is located in Smyrna, Delaware, 12 miles south-southwest of the Salem Site. Table 2.1-11 lists the correctional institutions.

2.1.3.6.4 Recreational Facilities

Recreational facilities which include State Parks, wildlife refuge areas and boating access areas are tabulated in Table 2.1-5. The major recreational facilities with the largest transient populations are Fort Delaware, 9 miles north-northwest, with a peak summer day attendance of 1200 persons, and Fort Mott State Park, 9.5 miles north, with an annual attendance for the same period of 500 persons. The boating access areas are Augustine Beach and Woodland Beach, located 5 miles west-northwest and 9.8 miles south-southeast, respectively. Both of these access areas are heavily used between April 1 and September 30; however no attendance statistics are available.

Five wildlife refuges are within 10 miles of the site. Artificial Island Wildlife Area is the closest, as it adjoins the site. The northern part of the island and the marshes connecting the island to the mainland are owned by the U.S. Government. Some of this area is leased to hunting and fishing clubs. Adjacent property extending for 3 miles south on the New Jersey Coast is owned by the State of New Jersey and operated as a fish and game preserve for limited use by sportsmen. The closest attraction, although not strictly a recreational facility, is the site Visitor's Center with a seating capacity of 140 persons.

2.1.3.7 Population Projection Methodology

This section describes the procedures used to project the population of the year 2020 and to allocate it to the rose format. It also describes exceptions and their impact. The basis for population projection shown on Figures 2.1-6 through 2.1-15 is a form of cohort-survival analysis. Utilizing data projected on a national level, projections are based on proportions or shares at the MCD level. This step-down method is a systematic approach (7) relying on three assumptions. These are that historic trends of birth, death, and migration will continue.

The Bureau of Census (8,9) formulates projections for the nation to 2020 and for the states to 1990. They project for a range of fertility rates: 3.35 (A) through 2.11 (E); and a choice of migration patterns: the same as presently observed (I), no migration (III) and a mixture (II). The A and B fertility rates have been declared unrealistically high and as of 1972, only C, D, and E rates are used in Federal projections.

The migration patterns projected are I and III. For consistent conservatism, the projections for Salem reflect a C fertility rate, or 2.78 children per woman, and both I and III migration rates. The numbers shown on Figures 2.1-6 through 2.1-10 reflect the IC and IIIC projections.

In the step down method, the change in proportion is all important. Thus, the state projections were extended from 1990 to 2020 by calculating the change in share of state to nation from 1940 to 1990. The change from 1980 to 1990 was considered characteristic and was reapplied to determine the state population in 2000, 2010, and 2020. An example is shown in Table 2.1-8.

The proportion method was carried down to the county level using projections from state or regional planning commissions (10-14). Although the numbers were discarded, the ratio of county to state population was retained. The change in proportion was applied to the federally projected percentage for the state to yield a projected county population. It was felt that the state or regional planning staffs were cognizant of the areas of growth within their region, but that the absolute number might not be reliable.

Thus the total county population of 24 counties was derived from the IC and IIIC Federal/state populations. In the same manner, the MCD populations were calculated. This time, however, the data was only partially complete. Many rural planning boards have not made projections for their counties.

Other commissions have made only limited or short range projections. Although this last is the most realistic and sensible approach, the projections had to be extended to 2020. Accordingly, the county data was reviewed and categorized based on type of projection available. Table 2.1-9 lists the counties and the categories. The basis for classification is discussed below:

1. Near-complete projections - The Delaware Valley Regional Planning Commission (DVRPC) has jurisdiction over seven of the counties in this study. Its projections at the MCD level are by decade to 2000 (10). York and Salem Counties have planning commissions that project MCD populations by decade to 2010 (15,16). These near-complete projections were used to determine projections to 2020.

   As with the step down from state to county, this study utilized the proportions but not the absolute numbers projected. Again it was felt that local agencies have a grasp of where growth will occur within their regions, but the local policies of boosterism or isolationism will bias the numbers.

   Thus, using the proportions of growth for an MCD, and the projected county population, the absolute MCD population, by decade to 2020, was calculated.

2. Limited projections - Six counties involved were placed in this category because planning boards had made one or possibly two projections for the next 45 years (17-22).

   These were not by decade, rather at 15 or 20 year intervals. To utilize these projections, a ratio was made to determine the proportion of the county represented by an MCD at each 10 year interval. This ratio was then extended to 2020.

3. No reliable projections - Nine counties were placed in this division. As shown in Table 2.1-9, four of the counties could be projected on the basis of historic trends. Changes in proportions of MCDs to the county for 10 year periods since 1940 were averaged for each MCD. The result was applied to the 1970 MCD proportion to arrive at the 1980 proportion, and so on to the year 2020. Using the county absolute projections, the MCD future populations were derived.

   The MCD populations in the other five counties where no reliable projections were available were calculated assuming future population distribution similar to the 1970 distribution. They include Philadelphia City/County which is partially within four sectors and is one MCD. Using census tract data for the city (23), the 1970 population was derived for each sector. The same proportion of census tract to MCD/County was used for future populations. This means that city-wide growth over the next 50 years is assumed to occur in proportions similar to the present population. To determine a more reliable projection would require a detailed study of the area. However, the 2020 city population total would be the same; only the distribution within the city would alter. Philadelphia is beyond 30 miles of the site and any distribution effect on the sector totals is minimal.

   Other areas where the 1970 proportions were used throughout the 50 years also fall at the outer edges of the study area and are not divided into many sectors. Sussex County, Delaware, has been restricted since the 1960 census; thus historic trends could not be utilized. Projections for Baltimore County were made to 1985, but were based on 1960 census data and are not reliable. Cecil and Queen Anne's Counties, Maryland, are rural in

nature, and the planning boards have not made projections.

2.1.4 Use of Adjacent Land

The site is located in the southern region of the Delaware River Valley, which is defined as the area immediately adjacent to the Delaware River and extending from Trenton to Cape May Point, New Jersey on the eastern side; and from Morrisville, Pennsylvania, to Lewes, Delaware, on the western side. The northern region is one of the major commercial, industrial, and residential centers of the nation. Much of the land area is highly industrialized or residential.

The southern region is characterized by extensive tidal marshlands and low-lying meadowlands. The major portion of the land in this area is undeveloped. The site, located 15 miles south of the Delaware Memorial Bridge, is isolated from the industrial and population centers of Philadelphia, Wilmington, Camden, and the New York-Washington corridor in general. The Chamber Works, at Deepwater, New Jersey, and at the Carneys Point Works, at Penns Grove, New Jersey, of E. I. DuPont deNemours Company are the southern-most major industrial activities from the Delaware Memorial Bridge, with the exception of the Getty Oil Company refinery across the river near Delaware City, Delaware, about 9 miles north-northwest of the site.

The area within a 25 mile radius of the site encompasses the major portion of 5 counties: Cecil in Maryland, New Castle and Kent in Delaware, and Salem and Cumberland in New Jersey. A summary of land use in these counties is presented in Table 2.1-10. As shown in the table, developed urban land constitutes only a small fraction of the available land - about 10 perent on the average for the 5 counties. The remaining 90 percent is used for agriculture (44 percent) or is undeveloped (46 percent). Agriculture statistics are summarized in Table 2.1-12. Crops primarily consist of fruit (apples and peaches), vegetables (snap

beans, sweet corn, peppers, and tomatoes), and animal feed products.

The Hope Creek Generating Station is located north-northwest of Salem Units 1 and 2. The Hope Creek Generating Station construction area is contiguous to the Salem site (Figure 2.1-5). The remainder is covered with marsh grasses. A strip of land about 1 mile wide to the east of the site extending from Alloways Creek to Hope Creek is owned by the United States Government, and consists entirely of tidal marshes. Most of the diked meadow areas have reverted to tidelands and are not in use. Beyond 3 miles, the land is sufficiently elevated to permit farming and grazing. The Delaware side of the river is similar to the New Jersey site, except that the tidelands and marshes are not as extensive. A great deal of land adjacent to the river on both sides is public land (Federal and state owned), or land planned for future open space projects. In addition, industrial, commercial, or residential growth is limited by recent wetlands and New Jersey Coastal Area Facilities Review Act legislation.

Industrial water supplies are obtained directly from the river above the site. Another source of process water is derived from high capacity wells drilled into the excellent aquifers located close to the river which are subsequently recharged by the Delaware River. No industrial installations are located along the river below the site. Because of salt water intrusions, industrial use of the river water below Marcus Hook, some 25 miles upstream of the site, is limited to cooling water applications. Thus radioactive wastes discharged to the river will remain well downstream of any industrial or domestic usage of river water.

Potable water supplies in Salem County, New Jersey, are obtained primarily from ground water with some inland areas utilizing surface water sources. All municipalities near the site use deep wells with the exception of the city of Salem, New Jersey, which

obtains about two-thirds of its water from surface water supplies from Quinton which is on Alloways Creek about 8 miles northeast of the site. This water supply is a dammed fresh water stream approximately 9 miles upstream of the Delaware River - Alloways Creek confluence. The closest domestic well is a shallow well located about 3 miles from the site.

The Delaware Estuary is being studied by a group of Marine Ecologists (Ichthyological Associates). Over 74,000 specimens of 45 species of fish that with environmental were taken in 1,094 trawl hauls. The most prevalent fish species that account for 98.7 percent of the total trawl catch are the bay anchovy, weakfish, white perch, hog choker, alewife, spot, striped bass, blueback herring, and the silver perch. The drifted gill nets revealed that the anadromous American shad tend to migrate to the area west of Reedy Island Dike. During May and June, the greatest catches were in the eastern section of the estuary, and, in September and October, the western section of the estuary was predominant. The largest quantities of specimens and species from both day and night collections were collected in August. It was noted in July 1970 that a large fish kill had occurred somewhere up river. Many thousands of dead fish drifted into the study area after a period of heavy rain and resultant flooding in the watershed area. In most instances, death was attributed to a dissolved oxygen content below the minimum required to sustain fish life. This was caused by dilution of the river with the ground runoff from heavy rainfall.

Fishing in the Delaware River Estuary has been reduced markedly since 1900 due to river pollution with only 554,000 pounds (valued at $65,000) landed in 1966. Landings in the Delaware River estuary were comprised of shad, striped bass, white perch, sturgeon, and crab with the latter accounting for 75 percent of the total poundage. In the Delaware Bay at the mouth of the estuary, 2.2 million pounds were landed in 1966 valued at $875,000. Oysters accounted for about one-third of that total with the remaining species including weakfish, shad, striped bass,

white perch, and crab. No increase in these values is expected until such time as major water pollution problems are brought under control. The nearest oyster beds are located approximately 4 miles downstream of the Salem site on the New Jersey side of the river.

A comparison of current trends (circa 1972) can be made with respect to the 1966 figures from information for landings in Delaware and New Jersey from the Delaware Bay and the Estuary. The total fish catch was 585,600 pounds valued at $99,387; hard crabs landed were 1,245,700 pounds valued at $201,975; and oysters were 814,300 pounds with a value of $588,234 for an overall total of 2,245,600 pounds and a value of $889,596. This compares with the 1966 figures totaled at 2,754,000 pounds with a total value of $940,000, and represents no significant difference.

2.1.4.1 Recreational Land Use

A description of parks and recreational land use is provided in Section 2.1.3.6.4. The recreational facilities within the 10 mile area around the site are listed in Table 2.1-5. This table lists the recreation areas, populations, and relative position with respect to the site. The location is indicated by compass heading and average distance in miles.

2.1.5 References for Section 2.1

1. U.S. Bureau of Census, 1971, U.S. Census of Population, 1970, "Number of Inhabitants" Final Report: PC (1) A9 Delaware; PC (2) A23 Maryland; PC (1) A32 New Jersey; PC (1) A40 Pennsylvania.

2. U.S. Bureau of Census, 1970, Civil Division Maps for: Delaware, Maryland, New Jersey, and Pennsylvania

3. U.S. Department of the Interior, Geological Survey Topographic Maps. 7.5-Minute Series: Ben Davis Point,

N.J.-Del., 1956; Bennetts Pier, Del., 1956; Bombay Hook, Del.-N.J., 1956; Bridgeton Quad, N.J., 1953; Canton, N.J.-Del., 1948; Cecilton, Del-Md., 1958; Cecilton, Del.-Md., 1944; Claiborne, Md., 1942; Clayton, Del., 1955; Delaware City, Del.-N.J. 1948, 1970; Langford Creek, Md., 1954; Little Creek, Del. (Kent County), 1956; Middletown, Md., 1953; Middletown, Del., 1953; Newark East, Del., 1953, 1970; Saint Georges, Del., 1953; Salem, N.J., (Salem County), 1948, 1970; Smyrna, Del., 1956; Taylors Bridge, Del.-N.J., 1948; and Wilmington South, Del.-N.J., 1967

4. U.S. Department of Agriculture, Aerial photo coverage for area within 5 miles of Salem site, scale of 1 inch to 660 feet, New Jersey portion flown 9/70 and Delaware portion, 5/68.

5. Dresdner Associates, "Distribution of Population within 50 Miles of the Salem Nuclear Generating Station," 1980.

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7. Communication, Dames & Moore and Michael R. Greenberg, PhD. and Donald A. Drueckeberg, PhD., Associate Professors, Department of Urban Planning and Policy Development, Rutgers University, New Brunswick, N.J.

8. U.S. Bureau of Census, Current Population Reports, Series P-25, No. 470, "Projections of the Population of the United States, by Age and Sex: 1970 to 2020," U.S. Government Printing Office, 1971.

9. U.S. Bureau of Census, Current Population Reports, Series P-25, No. 477, "Preliminary Projections of the Population of States: 1975-1990," U.S. Government Printing Office, 1972.

10. Delaware Valley Regional Planning Commission, "Preliminary Population Forecasts to the Year 2000," Philadelphia, Pa, 1971.

11. State Planning Board, "Preliminary Employment and Population," Harrisburg, Pa. 1971.

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13. Maryland Department of State Planning, "Preliminary Maryland Population Projections," 1980-2000, Baltimore, Md., 1971.

14. Delaware State Planning Office, "Final Population Projections," Dover, Del., 1972.

15. York County Planning Commission, "Population York County," York, Pa., 1971.

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17. Kent County Regional Planning Commission, "The Comprehensive Plan," Dover, Del., 1971.

18. New Castle County Department of Planning, Population Estimates, Wilmington, Del., 1971.

19. Communication, Dames & Moore and David Cartes, County Administrator, Caroline Co., Md.

20. Harford County Planning and Zoning Commission, "The Comprehensive Plan," Bel Air, Md., 1969.

21. Planning Commission, "The Comprehensive Plan," Kent County, Md., 1968.

22. Lancaster County Planning Commission, "Sketch Plan," Vol. 1, Lancaster, Pa., 1970.

23. Philadelphia City Planning Commission, "Population and Housing Statistics for Philadelphia Census Tracts, 1970 Census," Philadelphia, Pa., 1971.

24. Parsons; Brinckerhoff, Quade and Douglas, Inc., "Evacuation Time Estimates for the Areas Near the Site of Salem and Hope Creek Generating Stations," 1981.

TABLE 2.1-1

NEW JERSEY POPULATION PROJECTIONS TO 2020

Year	U.S. Population	NJ Population	NJ as Proportion of U.S.	Change in Proportion
1910	92,228	2,537	0.0275	--
1920	106,022	3,156	0.0298	+0.0023
1930	123,203	4,041	0.0328	+0.0030
1940	132,165	4,160	0.0315	-0.0013
1950	151,326	4,835	0.0320	+0.0005
1960	179,323	6,067	0.0338	+0.0018
1970	204,800	7,168	0.0350	+0.0012
		IC Projections		
1980	233,798	8,518	0.0364	+0.0014
1990	269,673	10,152	0.0376	+0.0012
2000	305,111	11,838	0.0388	+0.0012
2010	349,746	13,990	0.0400	+0.0012
2020	397,164	16,363	0.0412	+0.0012
		IIIC Projections		
1980	233,798	8,144	0.0348	-0.0002
1990	269,673	9,281	0.0344	-0.0004
2000	305,111	10,374	0.0340	-0.0004
2010	349,746	11,751	0.0336	-0.0004
2020	397,164	13,186	0.0332	-0.0004

NOTE: 1) Populations shown in 1000's

2) Area under dashed lines represents projections made by continuing the change in proportion in 1990 to 2020 and working left to calculate the state population.

SOURCES: U.S. Bureau of Census, 1971, "Current Population Reports," Series P-25, No. 470.

U.S. Bureau of Census, 1972, "Current Population Reports," Series P-25, No. 477

TABLE 2.1-2

POPULATION PROJECTIONS AVAILABLE FOR MCD'S OF COUNTIES
WITHIN 50 MILES OF SALEM

State/County	New Complete Projections(1)	Limited Projections(2)	No Reliable Projections Historic(3)	No Reliable Projections 1970(4)
Delaware				
Kent		1990		
New Castle		1985		
Sussex				*
Maryland				*
Baltimore County				
Caroline		2015		
Cecil				*
Harford		1985		
Kent		1985		
Queen Anne's			*	
Talbot				*
New Jersey			*	
Atlantic				
Burlington	2000			
Camden	2000			
Cape May	2000		*	
Cumberland				
Gloucester	2000			
Salem	2010			
Pennsylvania			*	
Berks	2000			
Chester	2000			
Delaware	2000			
Lancaster		1985,2010		
Montgomery	2000			*
Philadelphia				
York	2010			

NOTES:
(1) Projections by decade to date listed
(2) Projections only for date listed
(3) Historic trends used
(4) 1970 proportions of MCDs to Counties used due to redistricting, lack of data, or rural nature of county.

TABLE 2.1-3

PERSONS PER HOUSEHOLD FACTORS

State/County	Persons Per Household
County Subdivisions	
Delaware	
Kent	
Smyrna East	3.16
New Castle	
Middletown - Odessa	3.32
Red Lion	3.27
New Jersey	
Cumberland	
Greenwich	3.16
Stow Creek	3.27
Salem	
Elsinboro	2.85
Lower Alloways Creek	3.28
Mannington	3.18
Pennsville	3.18
Quinton	3.36
Salem	2.99 (1)

(1) 1970 Salem population is within one sector.

TABLE 2.1-4

POPULATION ESTIMATES OF CITIES AND TOWN
WITHIN 10 MILES OF THE SITE

Town	Population 1970	Distance and Location from Site
Delaware		
Bay View Beach	168	3.4 WNW
Delaware City	2024	7.5 NNW
Middletown	2644	9.5 W
Odessa	547	6.5 W
Port Penn	369	4.2 NNW
St. Georges	358	9.0 NW
Townsend	505	9.5 WSW
Woodland Beach	100	9.7 SSE
New Jersey (1)		
Canton	350	6.5 E
Hancock's Bridge	358	5.0 NE
Oakwood Beach	295	6.0 N
Quinton	750	8.5 NE

(1) 1972 Estimates

TABLE 2.1-4 (Cont)

Nearest Major City	Population Projections to 2020						Distance and Location from Site (Miles)
	1970	1980	1990	2000	2010	2020	
Salem City	7648	8266	8280	8271	8706	8564	8.0 NNE

TABLE 2.1-5

RESIDENT POPULATION DISTRIBUTION BY ZONE AND SECTOR, 0 TO 10 MILES FROM SGS

Sector		0-1 (1)	1-2 (2)	2-3 (3)	3-4 (4)	4-5 (5)	5-6 (6)	6-7 (7)	7-8 (8)	8-9 (9)	9-10 (10)
N	(A)	0	0	0	0	0	201	200	0	0	44
NNE	(B)	0	0	0	0	33	120	120	1,609	5,832	161
NE	(C)	0	0	0	9	295	252	285	316	459	366
ENE	(D)	0	0	0	35	96	233	255	204	173	153
E	(E)	0	0	0	0	0	135	385	153	117	108
ESE	(F)	0	0	0	0	0	0	90	42	48	348
SE	(G)	0	0	0	0	0	0	0	0	16	50
SSE	(H)	0	0	0	0	0	0	0	0	0	82
S	(J)	0	0	0	0	16	24	35	16	45	42
SSW	(K)	0	0	0	16	11	37	63	74	86	111
SW	(L)	0	0	0	0	15	97	104	193	222	291
WSW	(M)	0	0	0	0	31	228	259	305	350	381
W	(N)	0	0	0	22	54	46	599	61	70	2,721
WNW	(P)	0	0	0	113	68	51	102	87	118	154
NW	(Q)	0	0	0	108	104	65	101	74	446	110
NNW	(R)	0	0	0	10	262	31	35	1,079	1,084	0
TOTAL		0	0	0	313	985	1,520	2,633	4,213	9,066	5,122
CUM. TOTAL				1,298						22,524	

TABLE 2.1-6

RESIDENT POPULATION DISTRIBUTION BY ZONE AND SECTOR, 10 TO 50 MILES FROM SGS

Sector	10-15 (15)	15-20 (20)	20-25 (25)	25-30 (30)	30-35 (35)	35-40 (40)	40-45 (45)	45-50 (50)
N (A)	14,022	67,373	62,976	24,054	43,830	62,400	52,158	69,424
NNE (B)	5,061	11,357	11,972	114,952	422,449	466,085	627,404	431,323
NE (C)	2,013	5,810	3,105	42,450	110,894	350,663	297,887	206,137
ENE (D)	1,776	4,566	4,797	21,646	23,348	21,342	20,832	8,545
E (E)	2,773	19,416	8,943	48,006	22,550	7,172	4,081	13,546
ESE (F)	2,799	9,683	5,014	7,366	11,053	1,417	7,469	12,266
SE (G)	42	17	94	0	0	0	2,356	24,237
SSE (H)	0	40	28	446	374	582	1,470	3,011
S (J)	2,137	7,740	23,781	5,792	9,086	16,173	8,602	9,278
SSW (K)	13,881	3,723	5,276	5,455	5,419	6,998	8,940	5,798
SW (L)	15,072	4,933	3,098	3,820	4,015	4,060	3,877	1,855
WSW (M)	14,232	2,156	2,084	2,797	6,030	1,700	4,018	7,062
W (N)	11,566	4,100	3,284	1,500	26,751	14,448	33,440	75,132
WNW (P)	11,689	4,237	10,492	8,114	16,266	14,454	15,636	16,028
NW (Q)	16,443	23,502	11,736	6,428	12,007	5,460	9,141	17,028
NNW (R)	15,620	27,787	32,941	19,202	9,151	44,094	14,758	13,581
TOTAL	129,084	196,423	189,621	312,028	723,223	1,017,048	1,112,069	914,419
CUM. TOTAL	325,507		501,649		1,740,271		2,026,488	

TABLE 2.1-7

LAND USE IN FIVE SURROUNDING COUNTIES

New Jersey

	Salem County(1)		Cumberland County(2)	
	Acres	%	Acres	%
Developed, urban	16,200	7.4	30,000	9.3
Agriculture	122,000	55.5	80,000	24.9
Undeveloped	81,400	37.1	211,500	65.8
Total	219,600	100.0	321,500	100.0

Delaware

	New Castle County(3)		Kent County(3)	
	Acres	%	Acres	%
Developed, urban	52,300	18.8	20,500	5.4
Agriculture	94,650	34.0	170,600	45.0
Undeveloped	131,385	47.2	188,100	49.6
Total	278,335	100.0	379,200	100.0

Maryland

	Cecil County(4)	
	Acres	%
Developed, urban	16,200	7.1
Agriculture	137,000	60.3
Undeveloped	73,840	32.6
Total	227,040	100.0

Source: (1) Salem County Land Use, 1967, Salem County Planning Board.

(2) Land Use - 1964, Cumberland County Planning Board.

(3) Delaware State Development Department - 1964
Delaware State Agriculture Department - 1964

(4) Cecil County Economic Inventory, Maryland Department of Economic Development - 1964.

TABLE 2.1-8

AGRICULTURAL STATISTICS (1)

County	Salem	Cumberland	New Castle	Kent	Cecil
State	N.J.	N.J.	Del.	Del.	Md.
Total Farm Acreage	122,000	80,000	94,650	170,600	137,000
Percent of County in Farms	55.5	24.9	34.0	45.0	60.3
Number of Farms	796	1035	564	1219	659
Average Farm Size (acres)	139	90	215	190	194
Average Value of Farms	$39,000	$37,000	$116,000	$56,000	$84,000
Farm Population	2529	3564	2155	4551	2431
Major Farm Products	Dairy Products Vegetables Poultry	Poultry Vegetables	Dairy Products Field Crops	Field Crops Dairy Products Poultry	Dairy Products Field Crops
Value of Farm Products Sold (millions of dollars)					
Crops	8.7	17.0	6.0	10.0	2.4
Livestock and Livestock Products	7.3	8.0	4.0	7.0	5.5
Total	16.0	25.0	10.0	17.0	7.9

(1) Statistics taken from "County and City Data Book," 1967; U. S. Department of Commerce, and Rand McNally "Commercial Atlas and Marketing Guide," 1967.

TABLE 2.1-9

SCHOOLS LOCATED IN EPZ BY EMERGENCY PLANNING AREA (1)

Name/ Location	Enrollment	Facility & Staff	School & District
Lower Alloways Creek School Lower Alloways Creek, N.J.	255	30	Salem County, SD
Morris Goodwin School Greenwich, N.J.	120	29	Cumberland County, SD
Woodland County Day School Stow Creek, N.J.	125	25	
Stow Creek School Stow Creek, N.J.	196	27	Cumberland County, SD
John Fenwick School Salem City, N.J.	590	35	Salem County, SD
Elsinboro School Elsinboro, N.J.	121	10	Salem County, SD
Dunnington School Dunnington, N.J.	195	21	Salem County, SD
Quinton School Quinton, N.J.	358	26	Salem County, SD
Salem Day Care Center Salem County, N.J.	20	8	

(1) Reference 24

TABLE 2.1-9 (Cont)

Name/ Location	Enrollment	Facility & Staff	School & District
St. Mary's School Salem City, N.J.	237	11	Non-public
Votech Center Complex Mannington, N.J.	203	9	Salem County, SD
Salem Middle School Salem City, N.J.	424	40	Salem County, SD
Salem High School Salem City, N.J.	995	68	Salem County, SD
Townsend Elementary School Townsend, Delaware	224	29	Appoquinimink, SD
St. Andrew's School Middletown, Delaware	230 (residential)	140	Non-public
Silver Lake Elementary School Middletown, Delaware	661	56	Appoquinimink, SD
Redding Middle School Middletown, Delaware	529	66	Appoquinimink, SD
Broadmeadow School Middletown, Delaware	200	40	Non-public
Corbit School Odessa, Delaware	142	13	Appoquinimink, SD

TABLE 2.1-9 (Cont)

Name/ Location	Enrollment	Facility & Staff	School & District
Middletown High School Middletown, Delaware	797	79	Appoquinimink, SD
Au Clair School St. Georges, Delaware	32 (residential)	29	Non-public School for Autistic Children
Commodore McDonough School St. Georges, Delaware	210	17	New Castle County, SD-Area 4
Gunning Bedford Middle School St. Georges, Delaware	1020	99	New Castle County, SD-Area 4
Delaware City School Delaware City, Delaware	169	18	New Castle County, SD-Area 4

TABLE 2.1-10

RECREATIONAL FACILITIES IN SNGS LOCAL AREA

Name and Address	Peak Season	Visitors Peak Day Peak Seasons	Visitors Normal Day Peak Season	Area Segment
Artificial Island Delaware, New Jersey	Waterfowl Season	10-15	10	N 3
Mad Horse Tract Lower Alloways Creek, NJ	Waterfowl Season	200-250	200	NNE 2,3 NE 2,3,4 ENE 2,3 E 2-7 ESE 2-8 SE 6,7,8
Maskell's Mill Pond Lower Alloways Creek, NJ	Summer	12	10	ENE 8
Killcohook National Wildlife Refuge Pennsville, NJ	Fall	25		Outside
Woodland Beach Wildlife Refuge, Delaware (including the area north along the shore)	Fall Summer	100 Hunters 200-300 Fishermen	 200 Fishermen	SSE 8, 9, 10 S 3-7 SW 3 WSW 3
Woodland Beach, Delaware	Summer	500		SSE 8, 9, 10
Augustine Creek Wildlife Refuge, Delaware	Fall	100		WNW 4, 5, 6 NW 4, 5, 6

TABLE 2.1-10 (Cont)

Name and Address	Peak Season	Visitors Peak Day Peak Seasons	Visitors Normal Day Peak Season	Area Segment
Augustine Beach	Summer	75 Fishermen in boats		NW 4 NNW 4,5
Chesapeake & Delaware Canal, Delaware	Fall	400		NNW 7, 8 NW 8, 9, 10
Appoquinimink Wildlife Refuge, Delaware	Fall	6		WSW 3, 4
Fort Mott State Park Pennsville, NJ	Summer Weekend	500	44	N 10
Fort Delaware Pea Patch Island, Delaware	Summer	1200	310	N 9 NNW 9
Marlboro Marina Salem City NJ	Summer	100 marina 100 in boats		NNE 9
Cohansey Marina & Casino Greenwich, N.J	Spring/ Summer	100 marina 250 casino	35	Outside
Hancock Harbor Greenwich, NJ	Summer Weekend	200 in boats 300 in restaurant		Outside
Delaware City Marina Delaware City, Delaware	Summer	100	25	NNW 9

TABLE 2.1-10 (Cont)

Name and Address	Peak Season	Visitors Peak Day Peak Seasons	Visitors Normal Day Peak Season	Area Segment
Meadow View Acres Campground, NJ	Summer	80		E 8, 9
Visitor's Center Salem NGS		200		Center
Holly Mountain Ski Area	Winter Weekend	225	100	E 9, 10

TABLE 2.1-11

HEALTH CARE FACILITIES(1)

Name/Location	Residents/ Patients	Ambulatory	Wheel Chair	Stretcher	Staff Day	Staff Evening	Staff Night
Salem Memorial Hospital Mannington, N.J.	142	60	35	47	255	49	29
Salem Nursing and Convalescent Center Mannington, N.J.	110	20	85	5	40	17	7
Association of Retarded Citizens of Salem County Mannington, N.J.	80 (daily)				15		
Governor Bacon Health Delaware City, Delaware	222	161	46	15	194	66	40

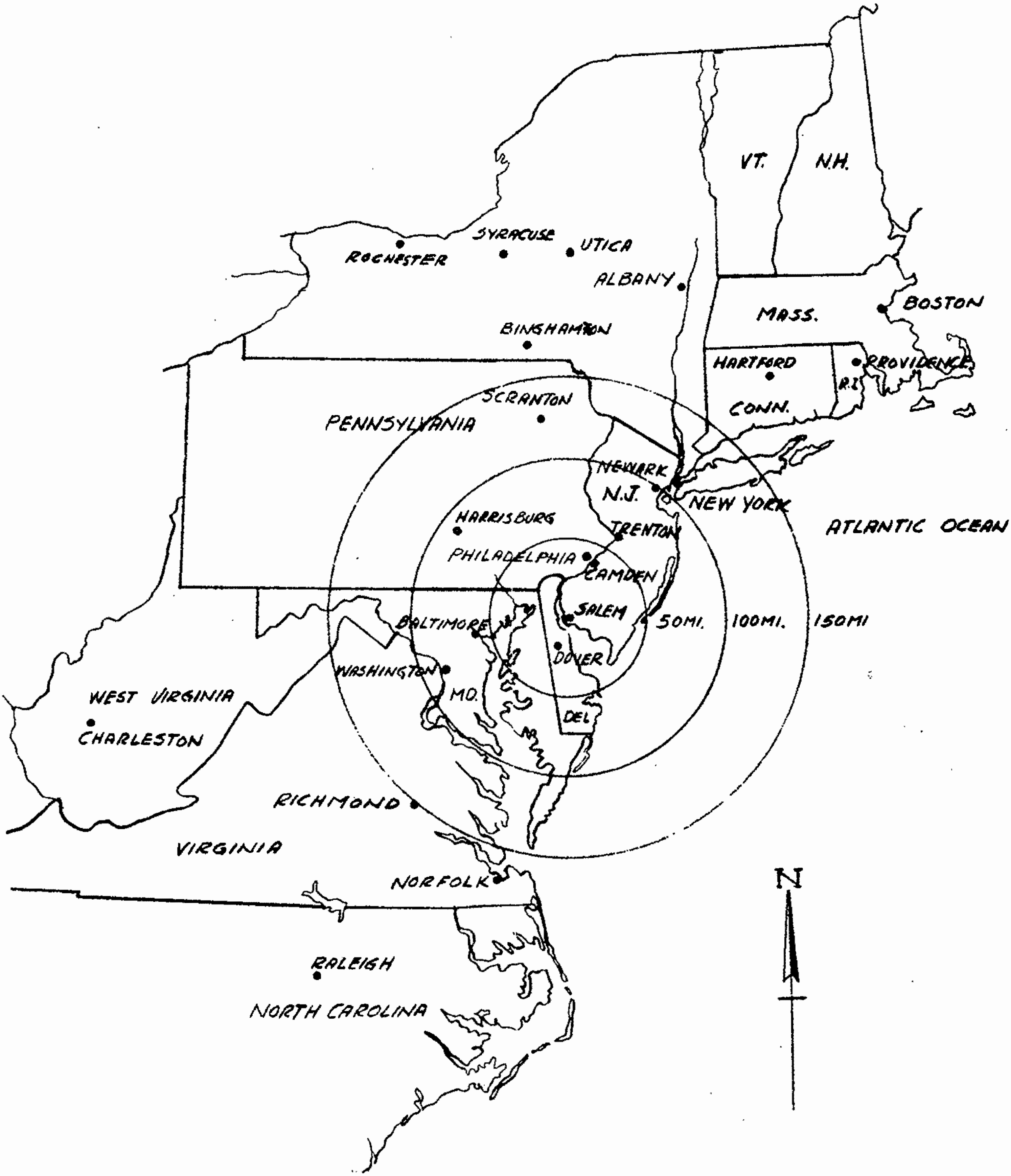
(1) Reference 24

TABLE 2.1-12

CORRECTIONAL FACILITIES/JAILS (1)

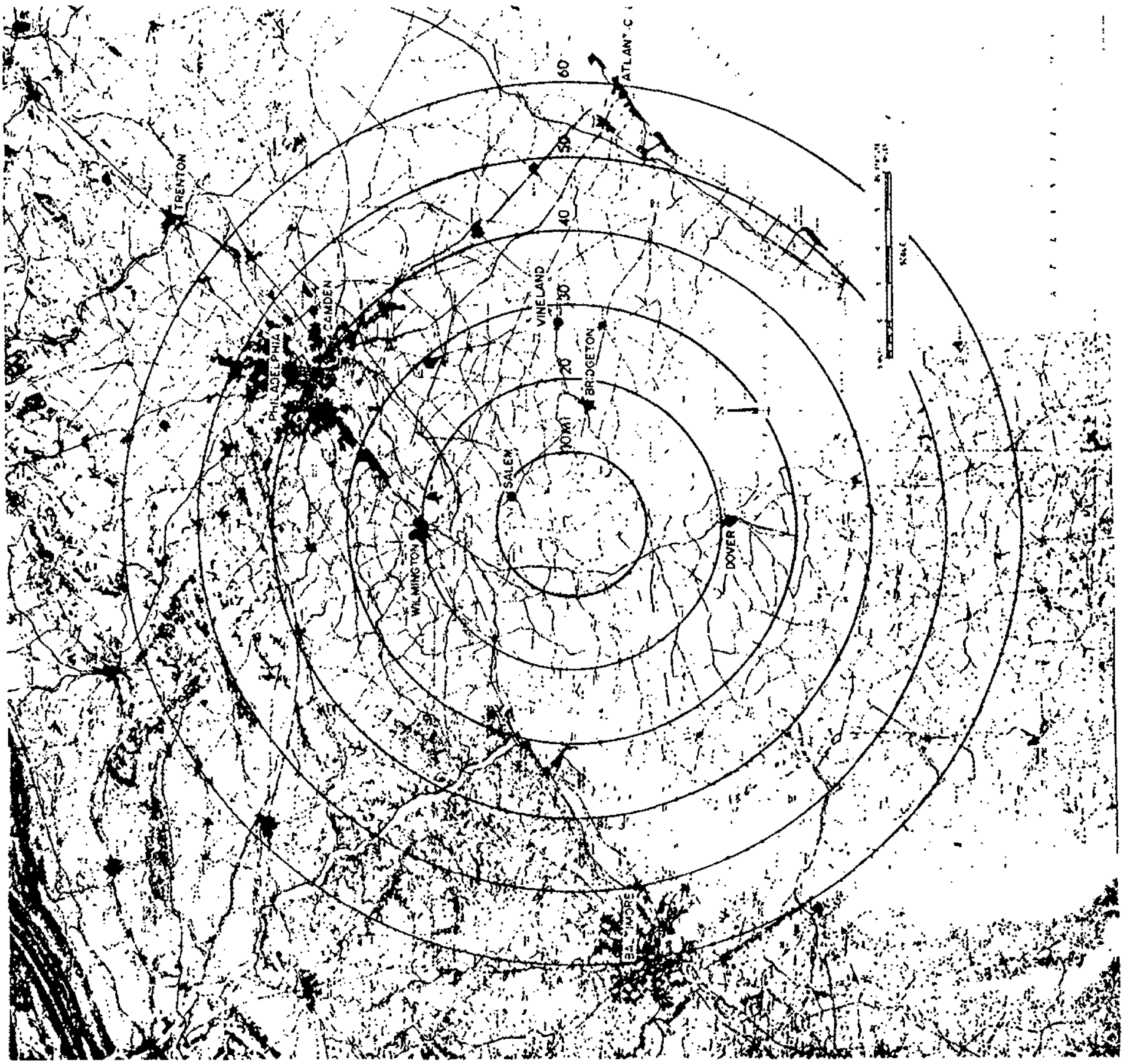
Name/Location	Inmates		Staff		
	Capacity	Average	Day	Evening	Night
Salem County Jail Salem City, New Jersey	115	75		NA	
Delaware Correctional Center, New Castle County Delaware	775	900	175	40	30

(1) Reference 24



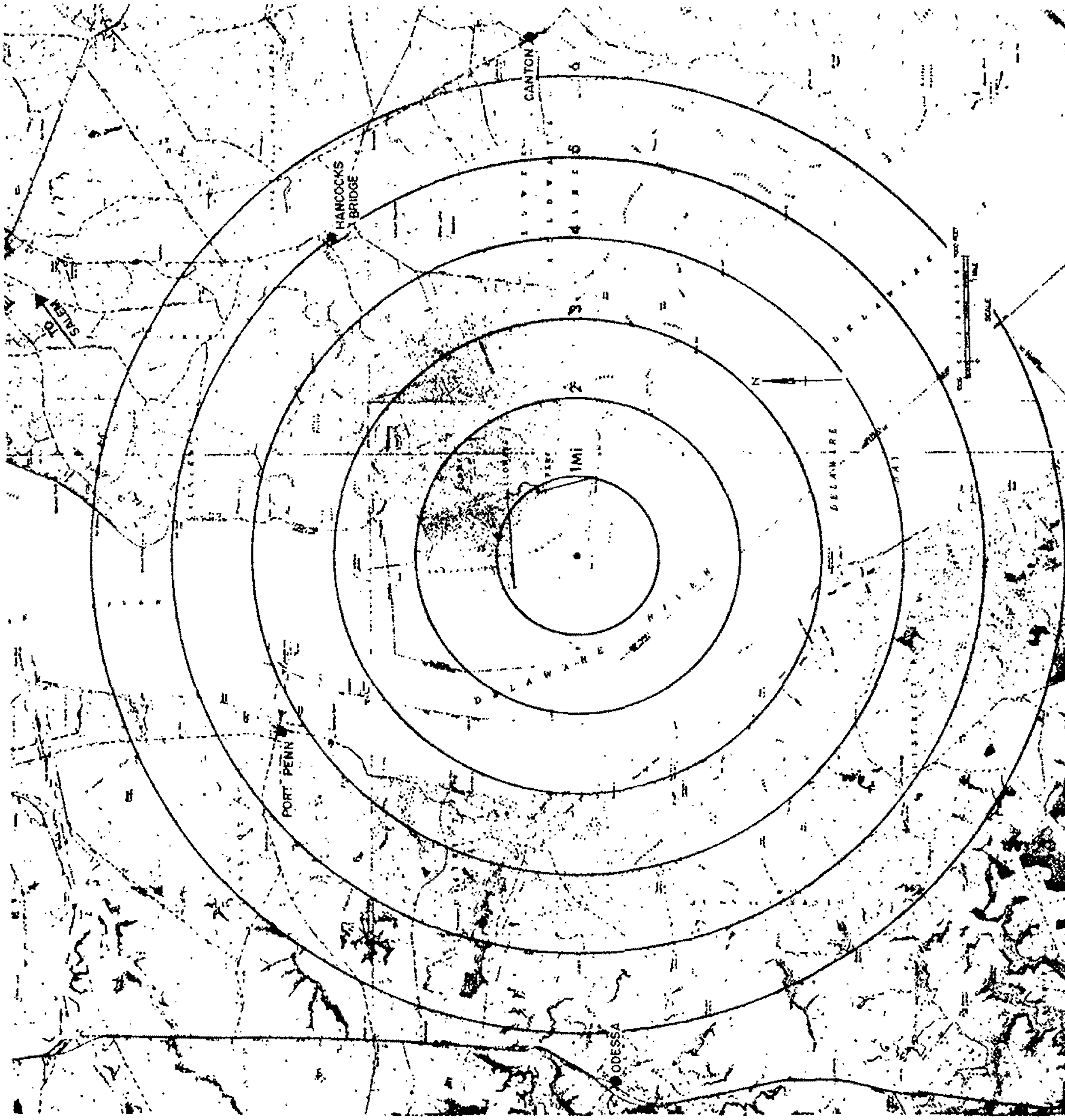
REVISION 6
FEBRUARY 15, 1987

PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	General Site Location	
	Updated FSAR	Figure 2.1-1



REVISION 6
FEBRUARY 15, 1987

PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	General Site Location 0-60 Miles
	Updated FSAR — Figure 2.1-2

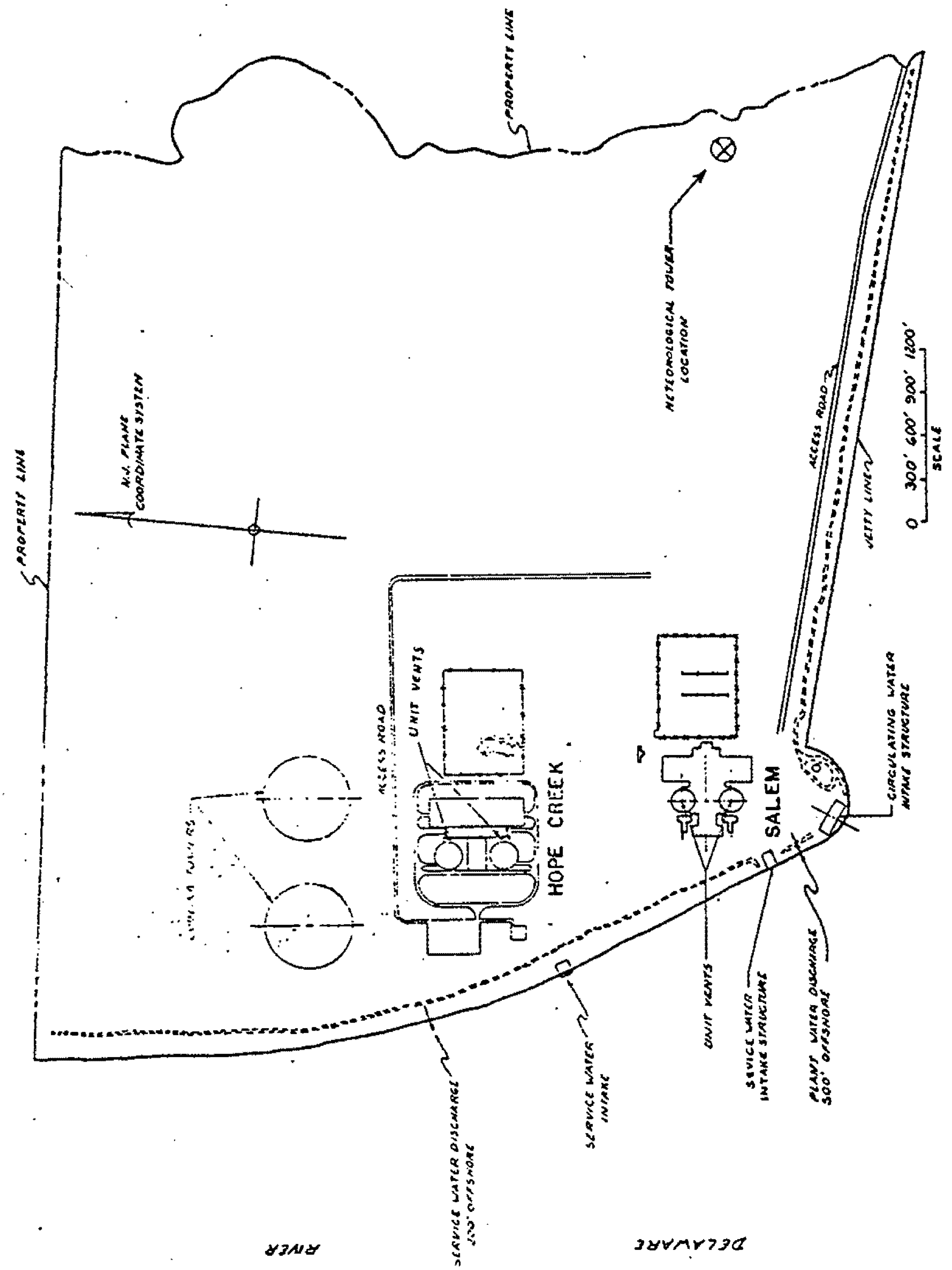


REVISION 6
FEBRUARY 15, 1987

PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Site Environs Detail	
	Updated FSAR	Figure 2.1-3

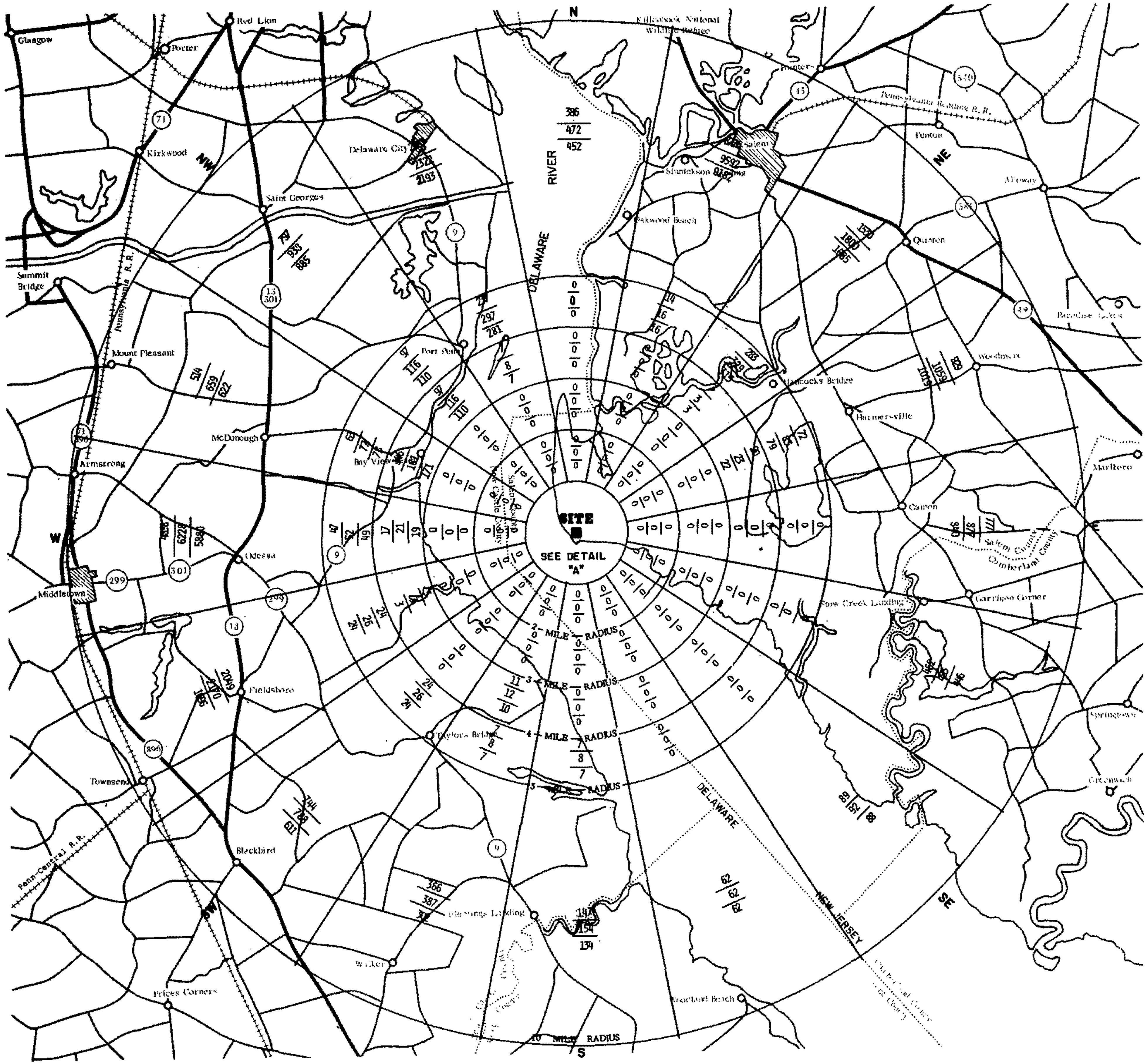
REVISION 6
FEBRUARY 15, 1987

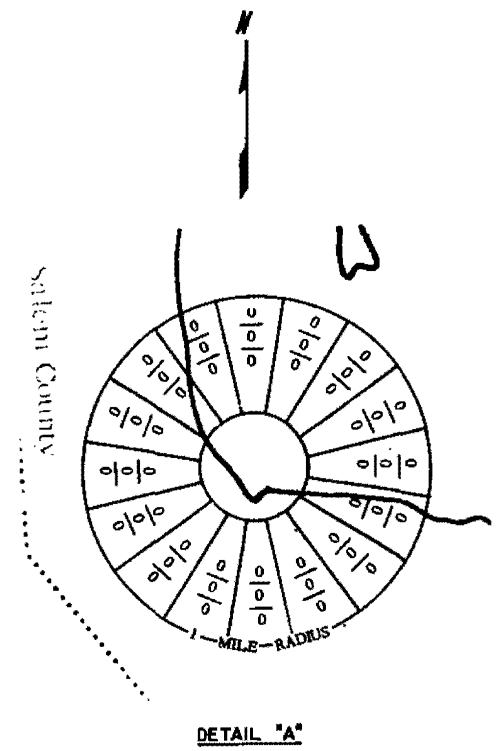
PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Aerial Photograph of Site	
	Updated FSAR	Figure 2.1-4



REVISION 6
FEBRUARY 15, 1987

PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Area Plot Plan of Site	
	Updated FSAR	Figure 2.1-5





STATUTE MILE

KEY:

1,729	1970 RESIDENT POPULATION
2,328	1980 IC RESIDENT POPULATION
1,947	1980 IIIC RESIDENT POPULATION

RADIUS IN MILES	YEAR	0 - 1	0 - 2	0 - 3
ACCUMULATED POPULATION	1970	0	0	0
	1980 - IC	0	0	0
	1980 - IIIC	0	0	0

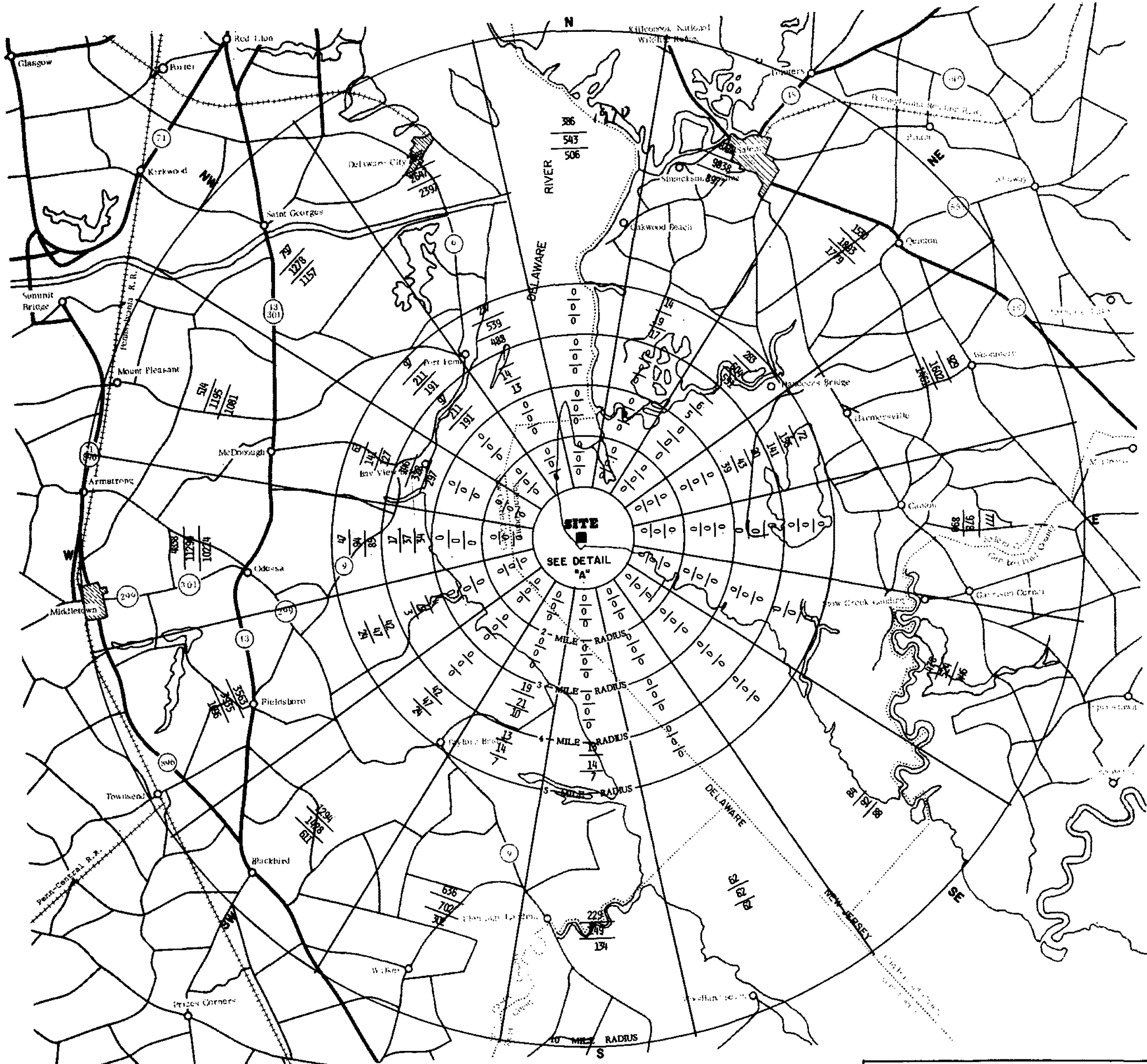
RADIUS IN MILES	YEAR	0 - 4	0 - 5	0 - 10
ACCUMULATED POPULATION	1970	303	1177	25144
	1980 - IC	367	1405	29488
	1980 - IIIC	346	1331	28008

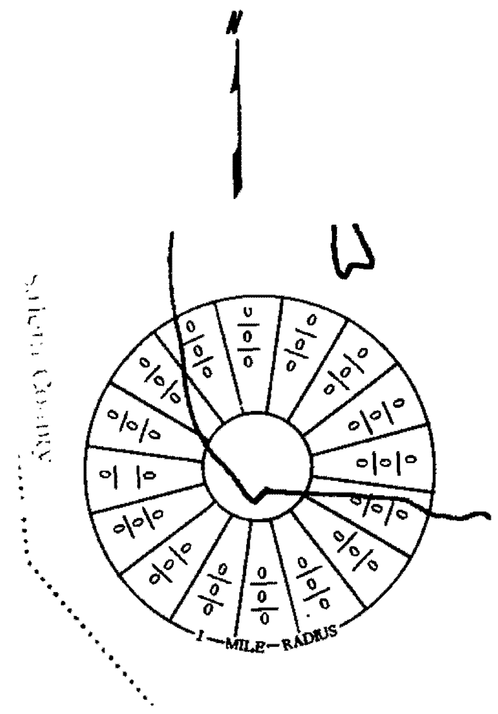
REFERENCE:

THIS MAP WAS PREPARED FROM A PORTION OF THE FOLLOWING U.S.G.S. MAP: WILMINGTON, DELAWARE, 1966.

REVISION 6
FEBRUARY 15, 1987

PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	**Resident Population Distribution 0-10 Miles 1970 and 1980**
	Updated FSAR — Figure 2.1-6





STATUTE MILE

KEY:

1,729 = 1970 RESIDENT POPULATION
1,947 = 1990 IC RESIDENT POPULATION
2,328 = 1990 IIIC RESIDENT POPULATION

RADIUS IN MILES	YEAR	0 - 1	0 - 2	0 - 3
ACCUMULATED POPULATION	1970	0	0	0
	1990-IC	0	0	0
	1990-IIIC	0	0	0

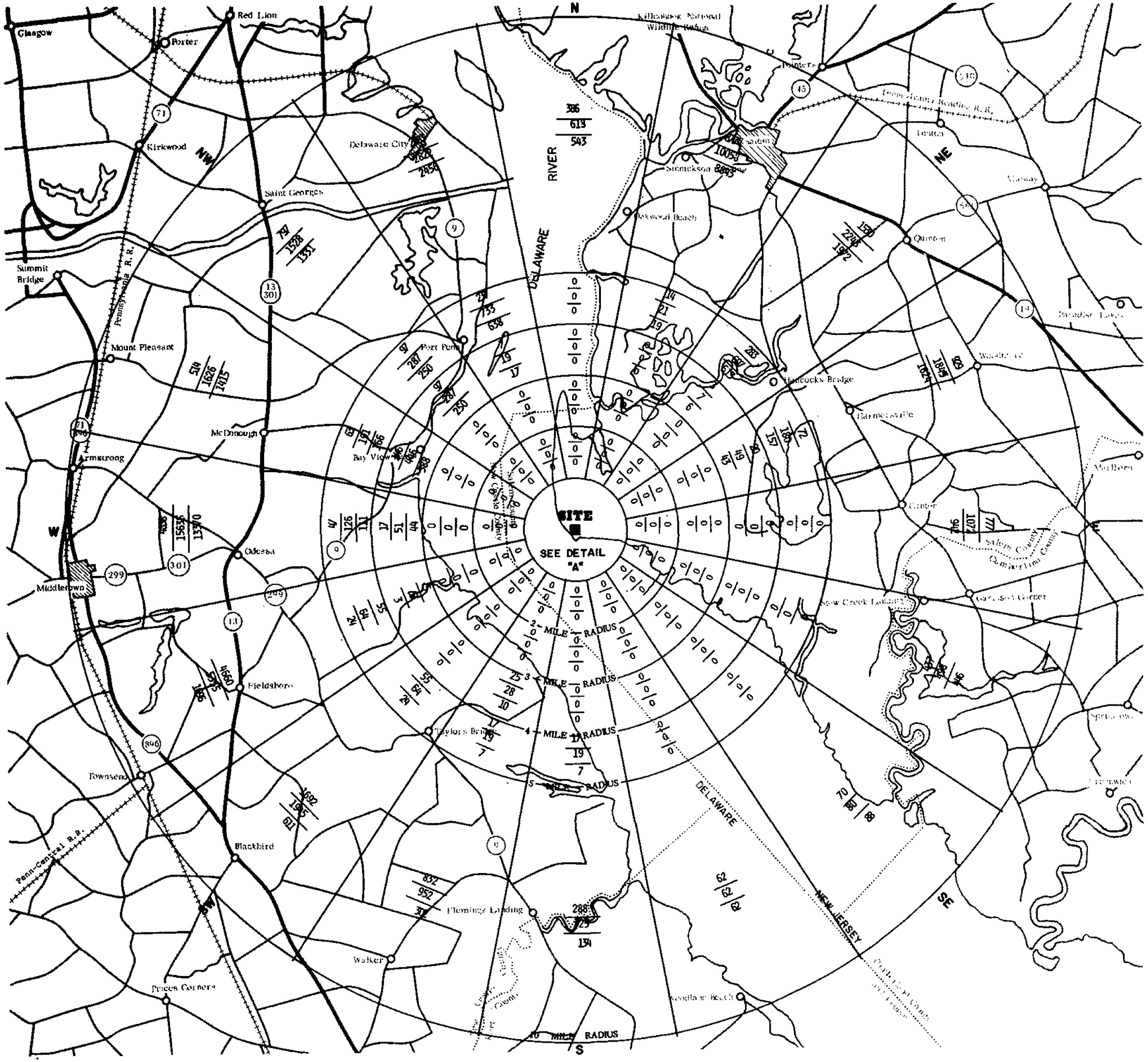
RADIUS IN MILES	YEAR	0 - 4	0 - 5	0 - 10
ACCUMULATED POPULATION	1970	303	1177	25144
	1990-IC	665	2551	40807
	1990-IIIC	602	2312	37130

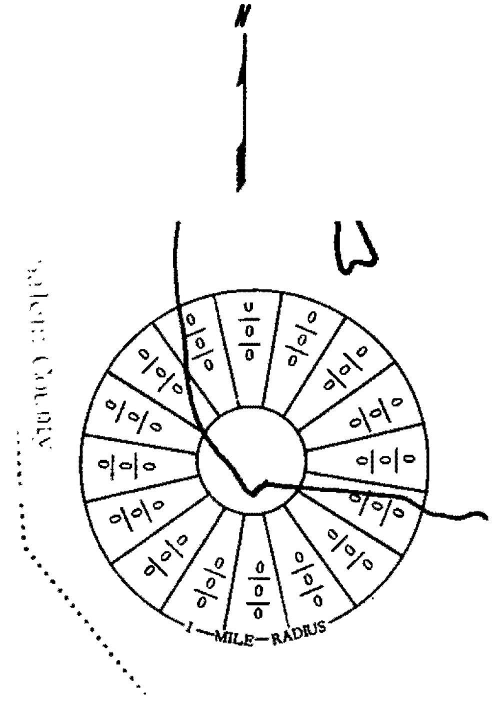
REFERENCE:

THIS MAP WAS PREPARED FROM A PORTION OF THE FOLLOWING U.S.G.S. MAP: WILMINGTON, DELAWARE, 1966.

REVISION 6
FEBRUARY 15, 1987

PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Resident Population Distribution 0-10 Miles 1970 and 1990
	Updated FSAR — Figure 2.1-7





DETAIL "A"

DAMES & MOORE

STATUTE MILE

1 0 1 2 3

KEY:

1,729	=	1970 RESIDENT POPULATION
2,328	=	2000 IC RESIDENT POPULATION
1,947	=	2000 IIIC RESIDENT POPULATION

RADIUS IN MILES	YEAR	0 - 1	0 - 2	0 - 3
ACCUMULATED POPULATION	1970	0	0	0
	2000-IC	0	0	0
	2000-IIIC	0	0	0

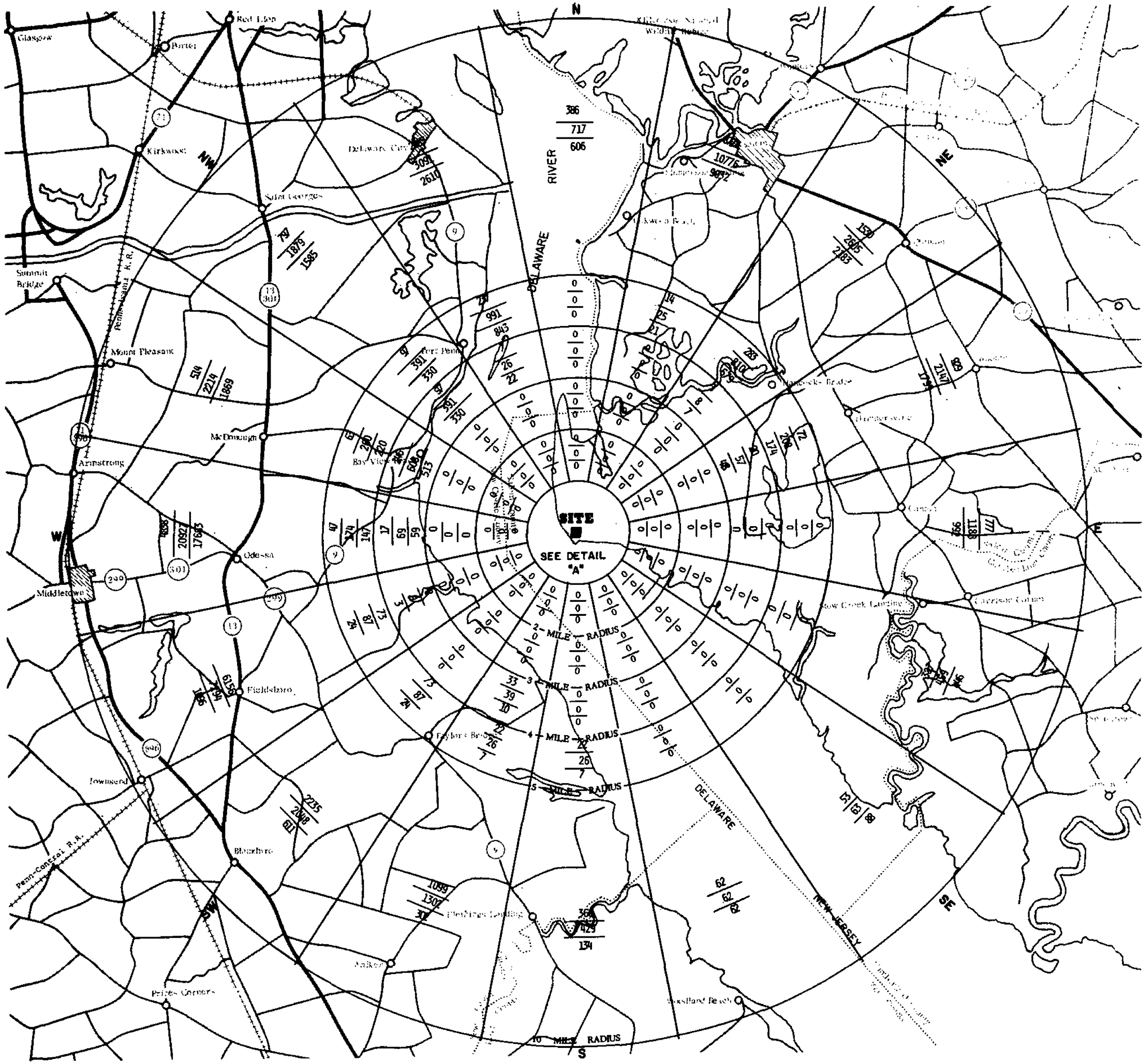
RADIUS IN MILES	YEAR	0 - 4	0 - 5	0 - 10
ACCUMULATED POPULATION	1970	303	1177	25144
	2000-IC	893	3294	49962
	2000-IIIC	778	2876	43413

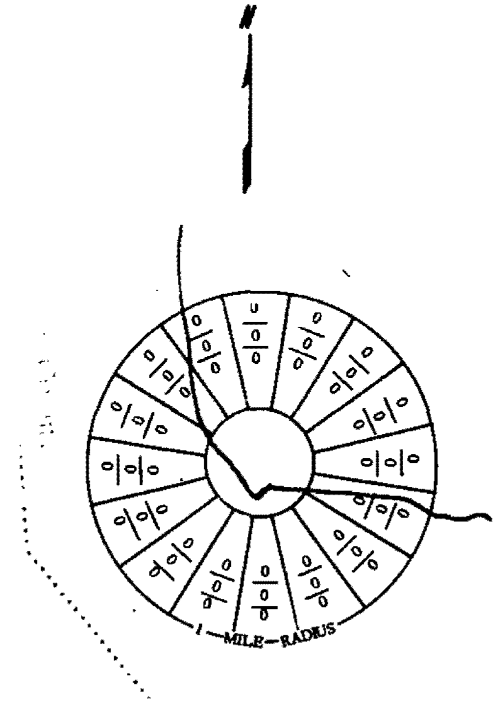
REFERENCE:

THIS MAP WAS PREPARED FROM A PORTION OF THE FOLLOWING U.S.G.S. MAP: WILMINGTON, DELAWARE, 1966.

REVISION 6
FEBRUARY 15, 1987

PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Resident Population Distribution 0-10 Miles 1970 and 2000
	Updated FSAR — Figure 2.1-8





DETAIL "A"

KEY:

1,729	=	1970 RESIDENT POPULATION
2,328	=	2010 IC RESIDENT POPULATION
1,947	=	2010 IIIC RESIDENT POPULATION

RADIUS IN MILES	YEAR	0 - 1	0 - 2	0 - 3
ACCUMULATED POPULATION	1970	0	0	0
	2010-IC	0	0	0
	2010-IIIC	0	0	0

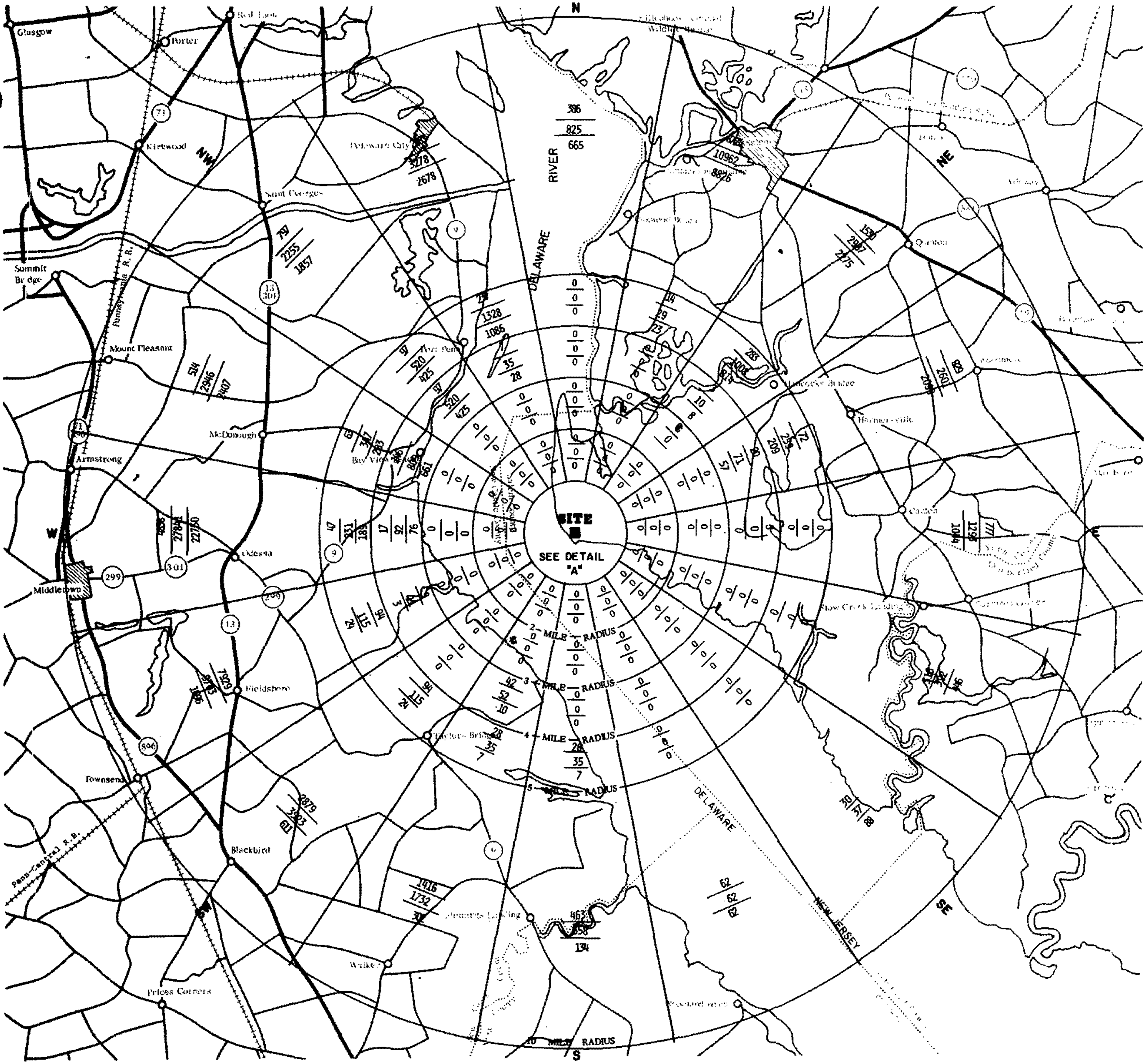
RADIUS IN MILES	YEAR	0 - 4	0 - 5	0 - 10
ACCUMULATED POPULATION	1970	303	1177	25144
	2010-IC	1207	4300	62101
	2010-IIIC	1020	3624	52323

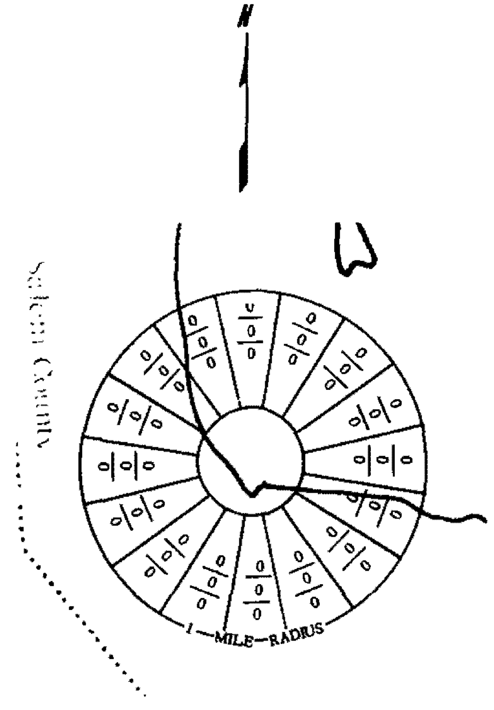
REFERENCE:

THIS MAP WAS PREPARED FROM A PORTION OF THE FOLLOWING U.S.G.S. MAP: WILMINGTON, DELAWARE, 1966.

REVISION 6
FEBRUARY 15, 1987

PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	**Resident Population Distribution** **0-10 Miles** **1970 and 2010**
	Updated FSAR **Figure 2.1-9**





DETAIL "A"

DAMES & MOORE

STATUTE MILE

1 0 1 2 3

KEY:

1,729 = 1970 RESIDENT POPULATION
2,328 = 2020 IC RESIDENT POPULATION
1,947 = 2020 IIIC RESIDENT POPULATION

RADIUS IN MILES	YEAR	0 - 1	0 - 2	0 - 3
ACCUMULATED POPULATION	1970	0	0	0
	2020-IC	0	0	0
	2020-IIIC	0	0	0

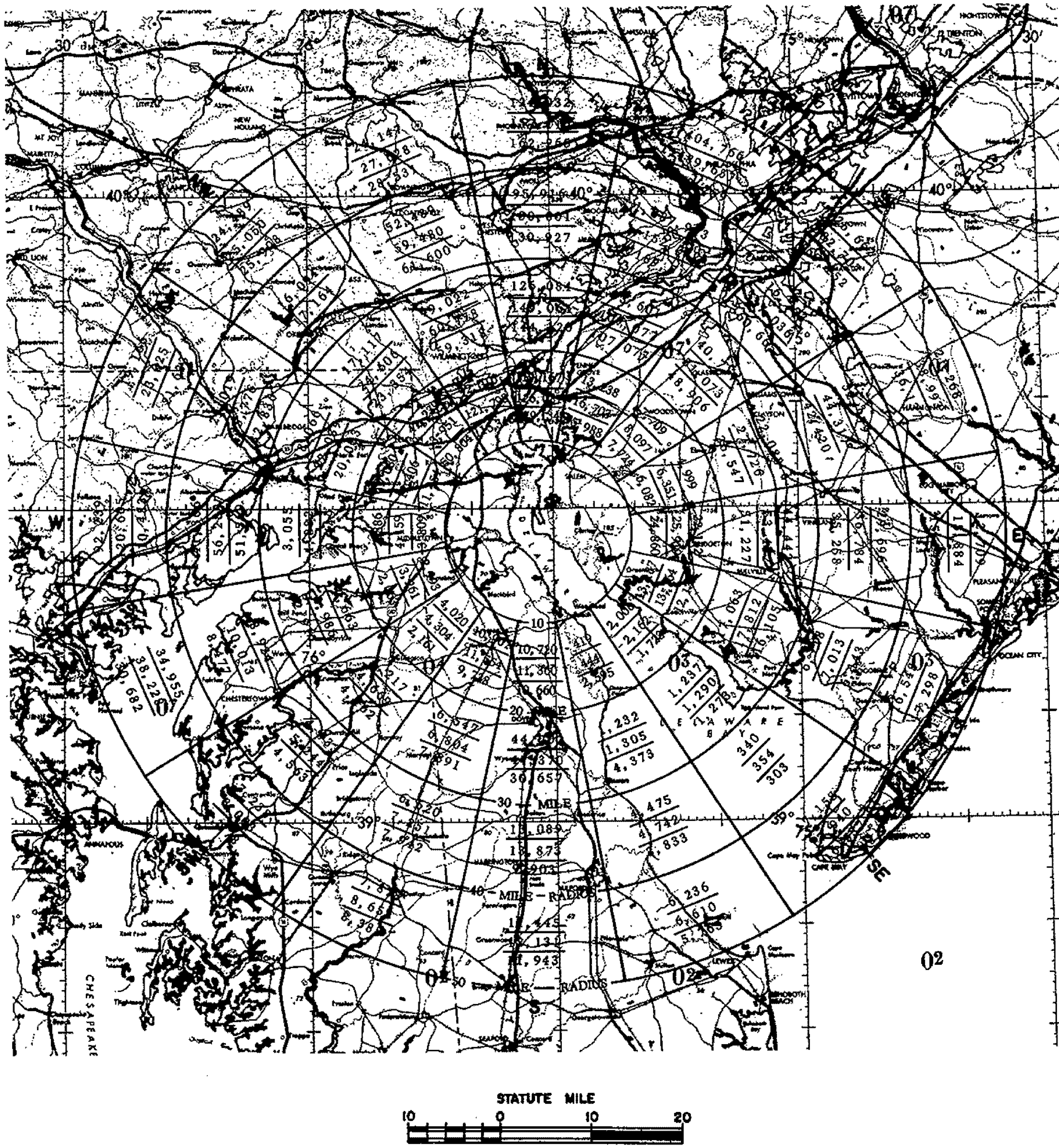
RADIUS IN MILES	YEAR	0 - 4	0 - 5	0 - 10
ACCUMULATED POPULATION	1970	303	1177	25144
	2020-IC	1600	5622	76617
	2020-IIIC	1306	4579	62275

REFERENCE:

THIS MAP WAS PREPARED FROM A PORTION OF THE FOLLOWING U.S.G.S. MAP: WILMINGTON, DELAWARE, 1966.

REVISION 6
FEBRUARY 15, 1987

PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Resident Population Distribution 0-10 Miles 1970 and 2020
	Updated FSAR — Figure 2.1-10



KEY:

1,630	=	1970 RESIDENT POPULATION
2,960	=	1980 IC RESIDENT POPULATION
2,140	=	1980 IIIC RESIDENT POPULATION

REFERENCE:

THIS MAP WAS PREPARED FROM PORTIONS OF THE FOLLOWING SECTIONAL AERONAUTICAL CHART: NEW YORK.

RADIUS IN MILES	YEAR	0 - 20	0 - 30	0 - 40	0 - 50
ACCUMULATED POPULATION	1970	378,589	860,159	2,603,598	4,744,551
	1980 - IC	475,169	1,058,119	2,976,478	5,366,006
	1980 - IIIC	449,887	1,012,549	2,979,952	5,389,121

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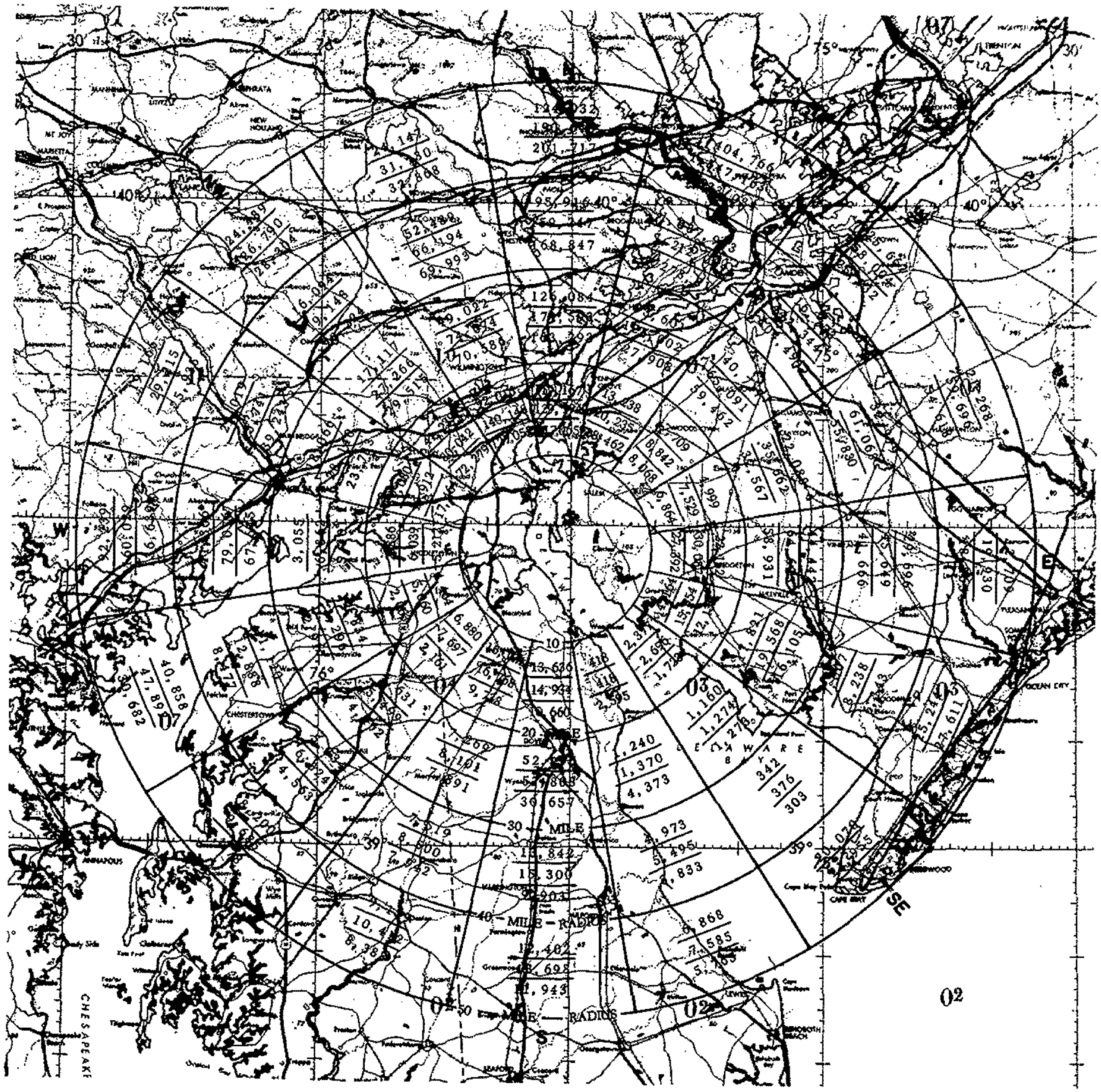
PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Regional Resident Population Distribution 10-50 Miles 1970 and 1980
	Updated FSAR — Figure 2.1-11



STATUTE MILE

10 0 10 20

KEY:

1,630	=	1970 RESIDENT POPULATION
2,960	=	1990 IC RESIDENT POPULATION
2,140	=	1990 IIIC RESIDENT POPULATION

REFERENCE:

THIS MAP WAS PREPARED FROM PORTIONS OF THE FOLLOWING SECTIONAL AERONAUTICAL CHART: NEW YORK.

RADIUS IN MILES	YEAR	0 - 20	0 - 30	0 - 40	0 - 50
ACCUMULATED POPULATION	1970	378,589	860,159	2,603,598	4,744,551
	1990 - IC	595,272	1,290,071	3,477,743	6,139,181
	1990 - IIIC	538,736	1,197,383	3,394,807	6,074,100

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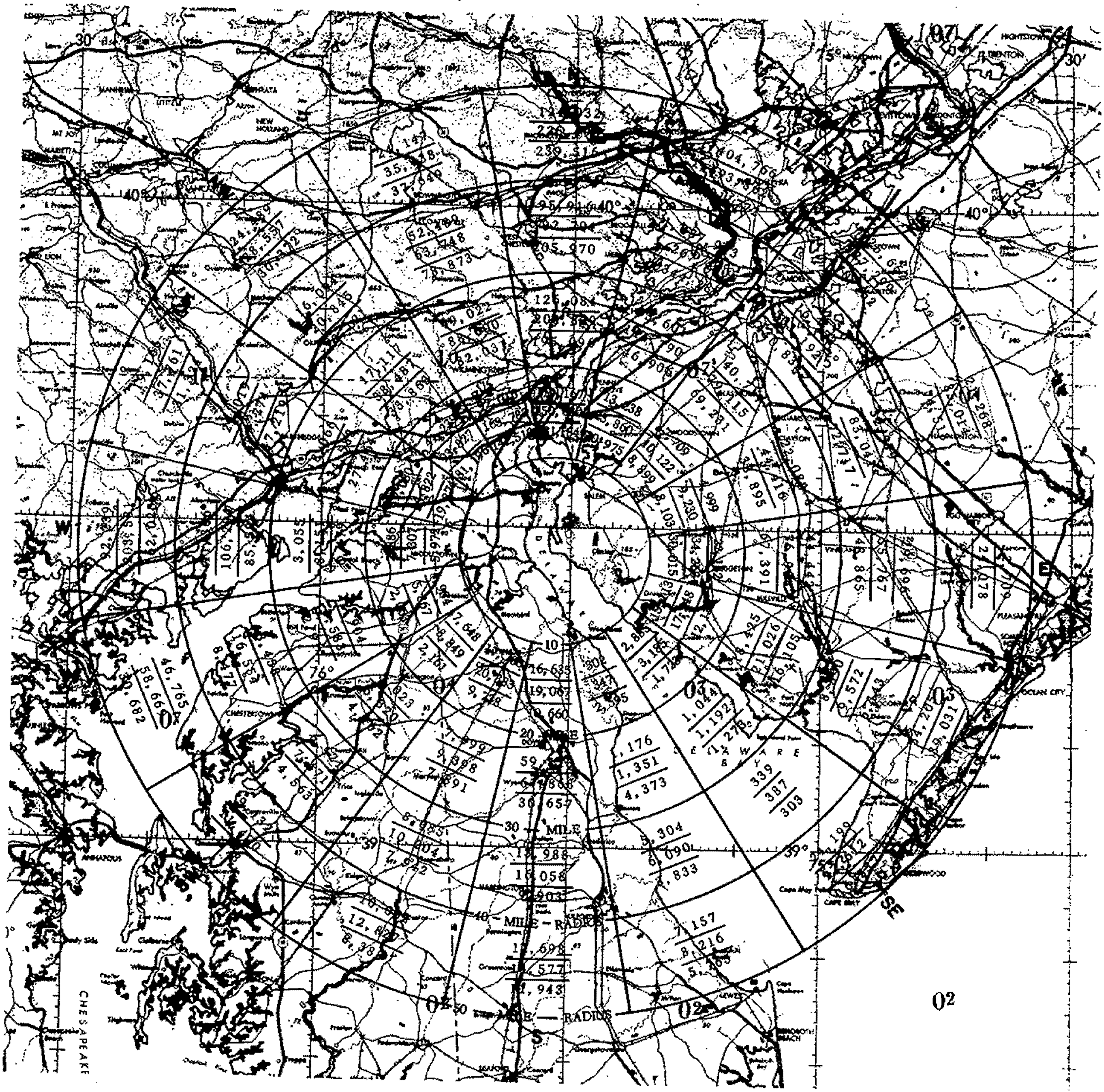
PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Regional Resident Population Distribution 10-50 Miles 1970 and 1990
	Updated FSAR Figure 2.1-12



STATUTE MILE

10 0 10 20

KEY:

1,630	=	1970 RESIDENT POPULATION
2,960	=	2000 IC RESIDENT POPULATION
2,140	=	2000 IIIC RESIDENT POPULATION

REFERENCE:

THIS MAP WAS PREPARED FROM PORTIONS OF THE FOLLOWING SECTIONAL AERONAUTICAL CHART: NEW YORK.

RADIUS IN MILES	YEAR	0 - 20	0 - 30	0 - 40	0 - 50
ACCUMULATED	1970	378,589	860,159	2,603,598	4,744,551
	2000 - IC	695,463	1,572,220	3,990,381	6,923,869
POPULATION	2000 - IIIC	604,449	1,367,489	3,769,655	6,673,401

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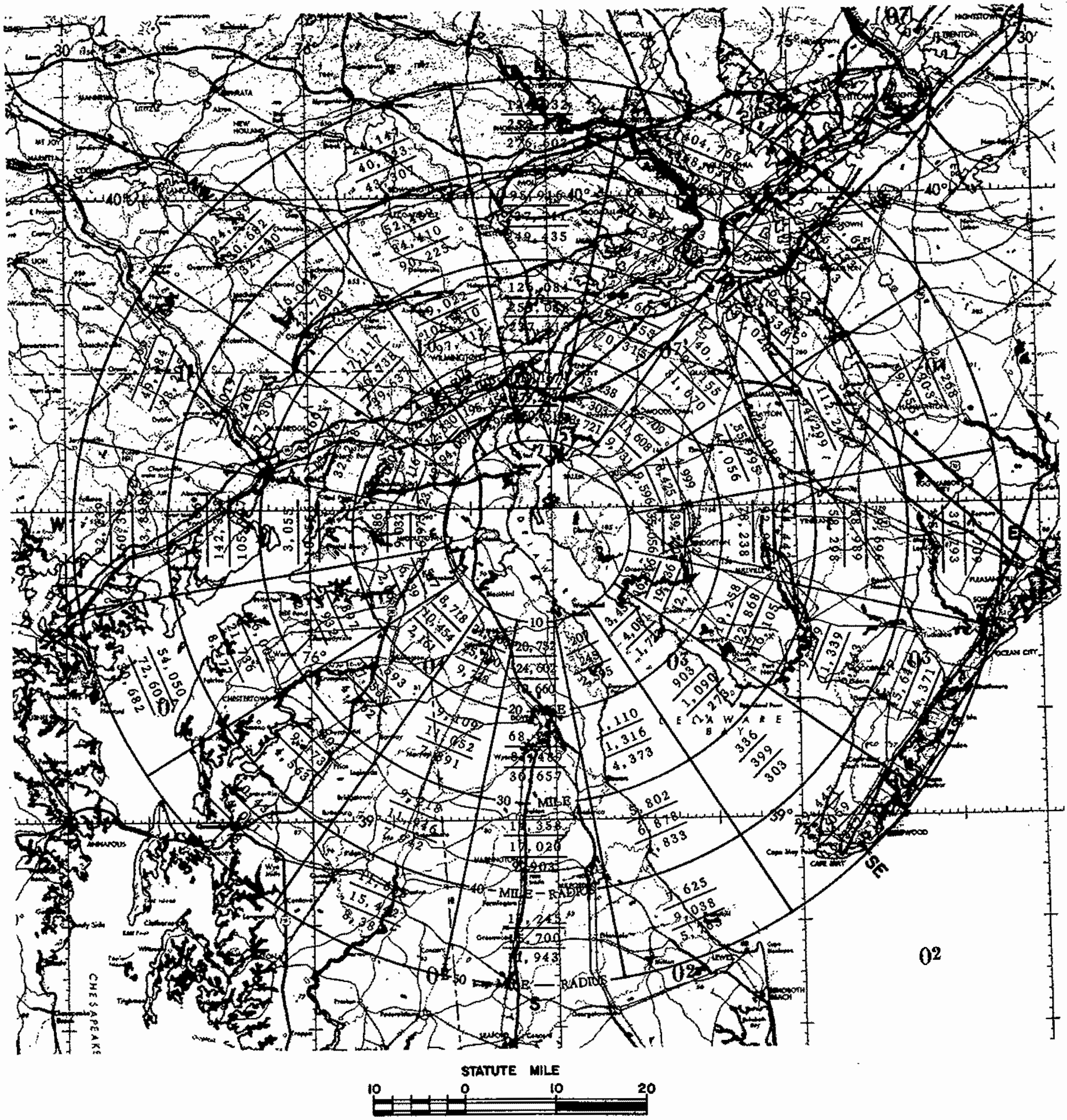
PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Regional Resident Population Distribution 10-50 Miles 1970 and 2000
	Updated FSAR — Figure 2.1-13



KEY:

1,630	=	1970 RESIDENT POPULATION
2,960	=	2010 IC RESIDENT POPULATION
2,140	=	2010 IIIC RESIDENT POPULATION

REFERENCE:

THIS MAP WAS PREPARED FROM PORTIONS OF THE FOLLOWING SECTIONAL AERONAUTICAL CHART: NEW YORK.

RADIUS IN MILES	YEAR	0 - 20	0 - 30	0 - 40	0 - 50
ACCUMULATED	1970	378,589	860,159	2,603,598	4,744,551
	2010-IC	825,722	1,834,465	4,573,681	7,864,519
POPULATION	2010-IIIC	697,225	1,569,536	4,249,811	7,442,726

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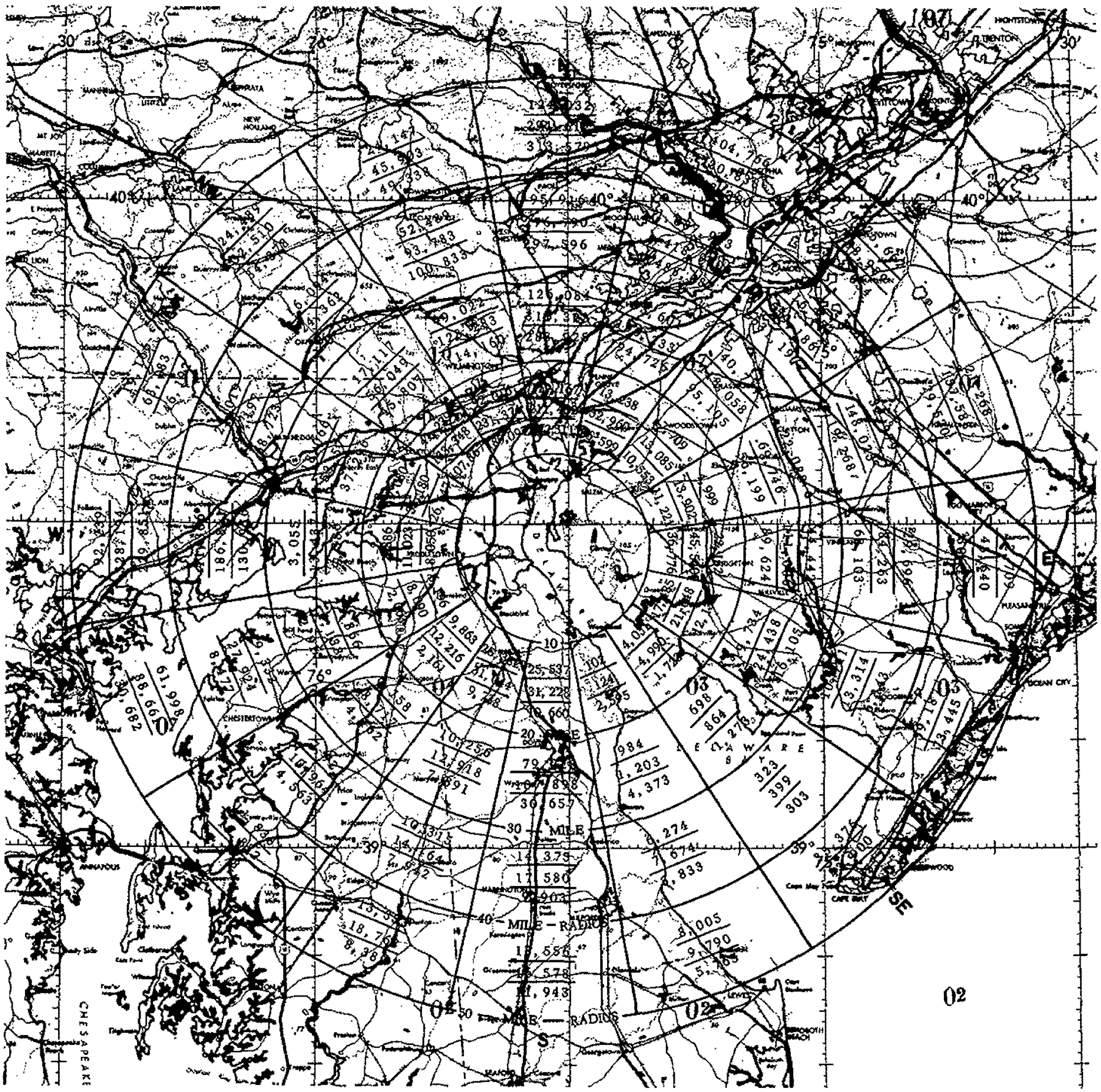
PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Regional Resident Population Distribution 10-50 Miles 1970 and 2010
	Updated FSAR — Figure 2.1-14



STATUTE MILE
10 0 10 20

KEY:

1,630	=	1970 RESIDENT POPULATION
2,960	=	2020 IC RESIDENT POPULATION
2,140	=	2020 IIIC RESIDENT POPULATION

REFERENCE:

THIS MAP WAS PREPARED FROM PORTIONS OF THE FOLLOWING SECTIONAL AERONAUTICAL CHART: NEW YORK.

RADIUS IN MILES	YEAR	0 - 20	0 - 30	0 - 40	0 - 50
ACCUMULATED	1970	378,589	860,159	2,603,598	4,744,551
	2020 - IC	962,447	2,180,329	5,261,695	8,924,121
POPULATION	2020 - IIIC	793,595	1,839,747	4,739,673	8,209,288

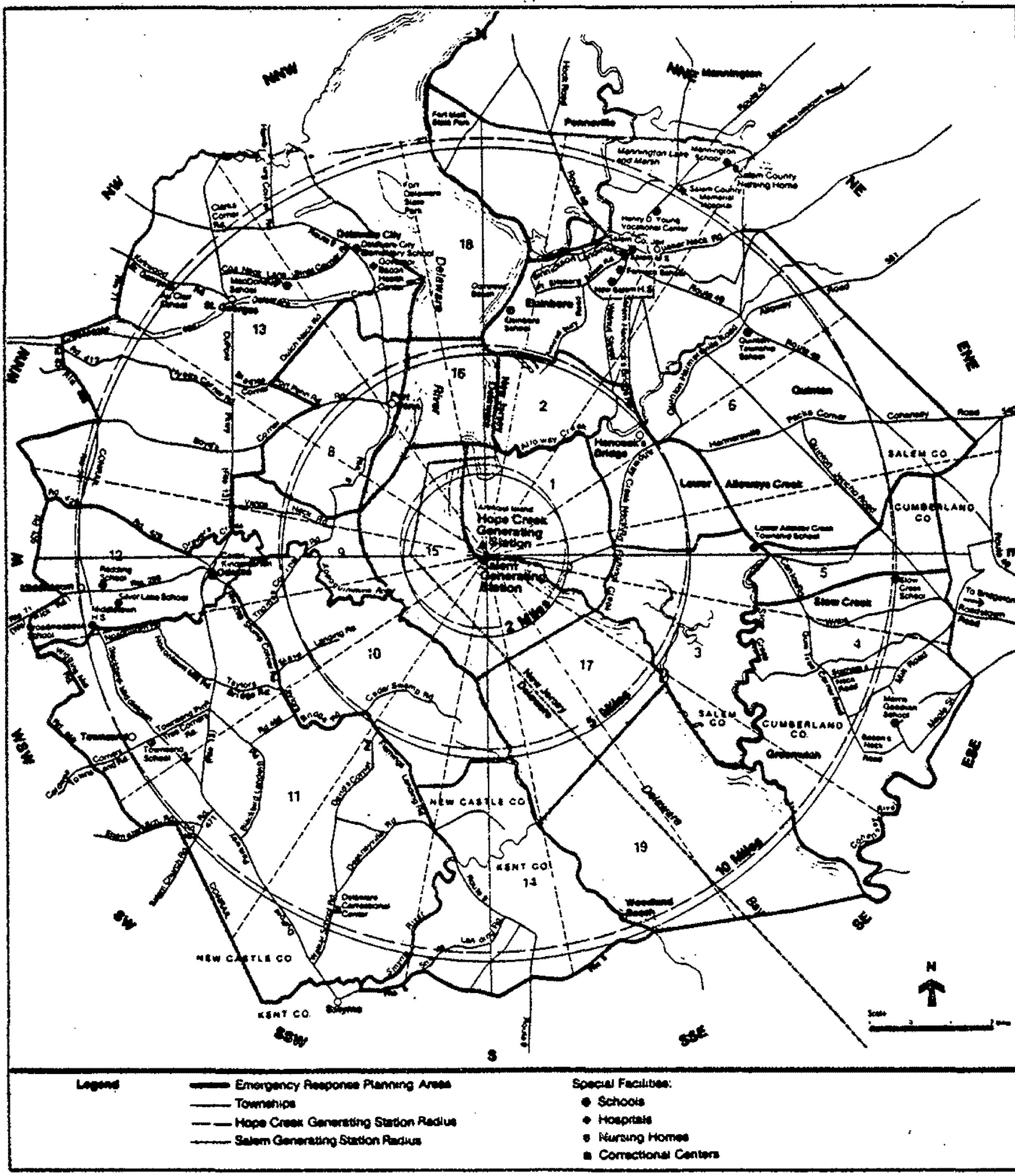
REVISION 6
FEBRUARY 15, 1987

PUBLIC SERVICE ELECTRIC AND GAS COMPANY
SALEM NUCLEAR GENERATING STATION

Regional Resident Population Distribution
10-50 Miles
1970 and 2020

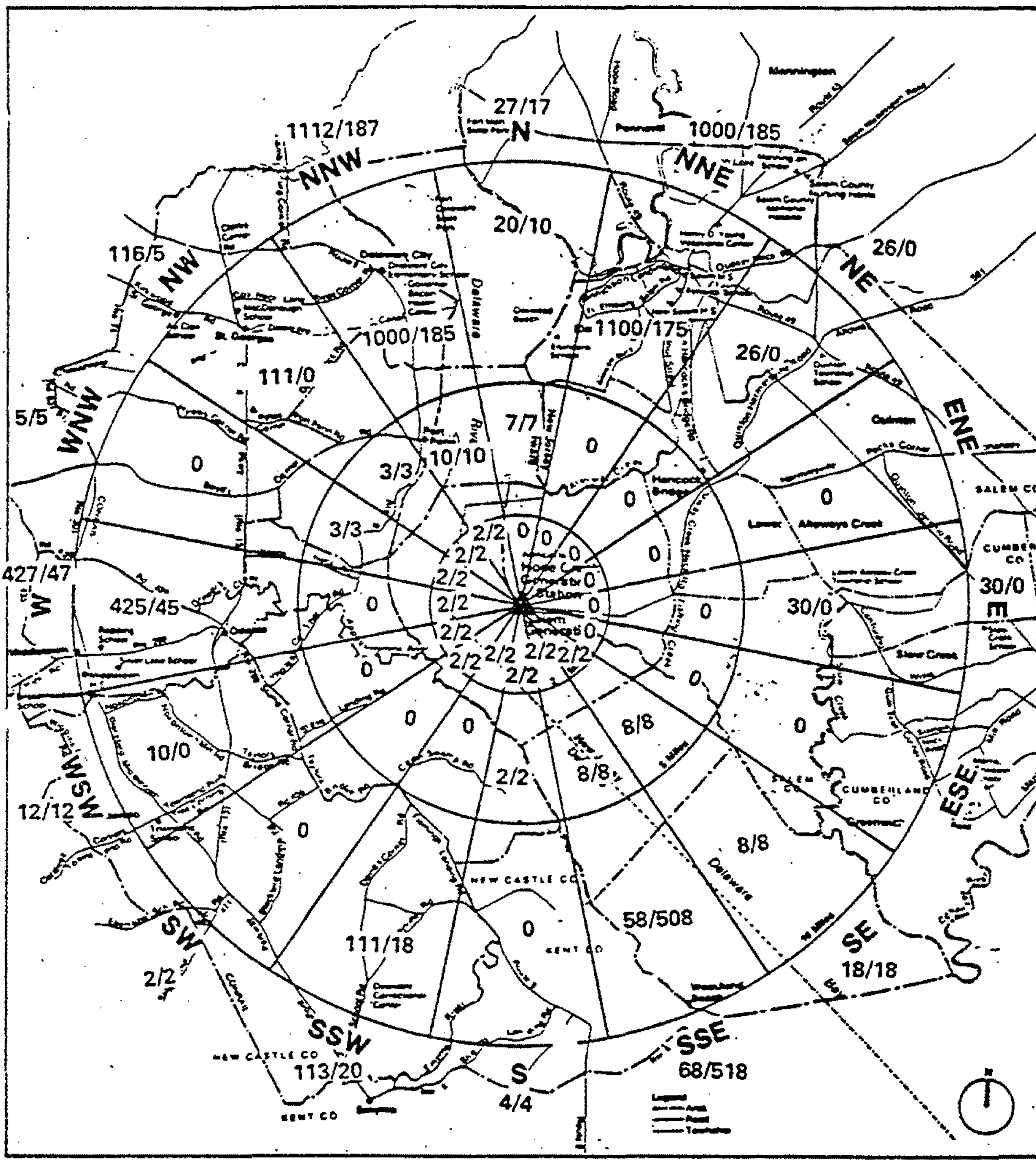
Updated FSAR

Figure 2.1-15



REVISION 6
FEBRUARY 15, 1987

PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	10 Mile EPZ Boundary	
	Updated FSAR	Figure 2.1-16



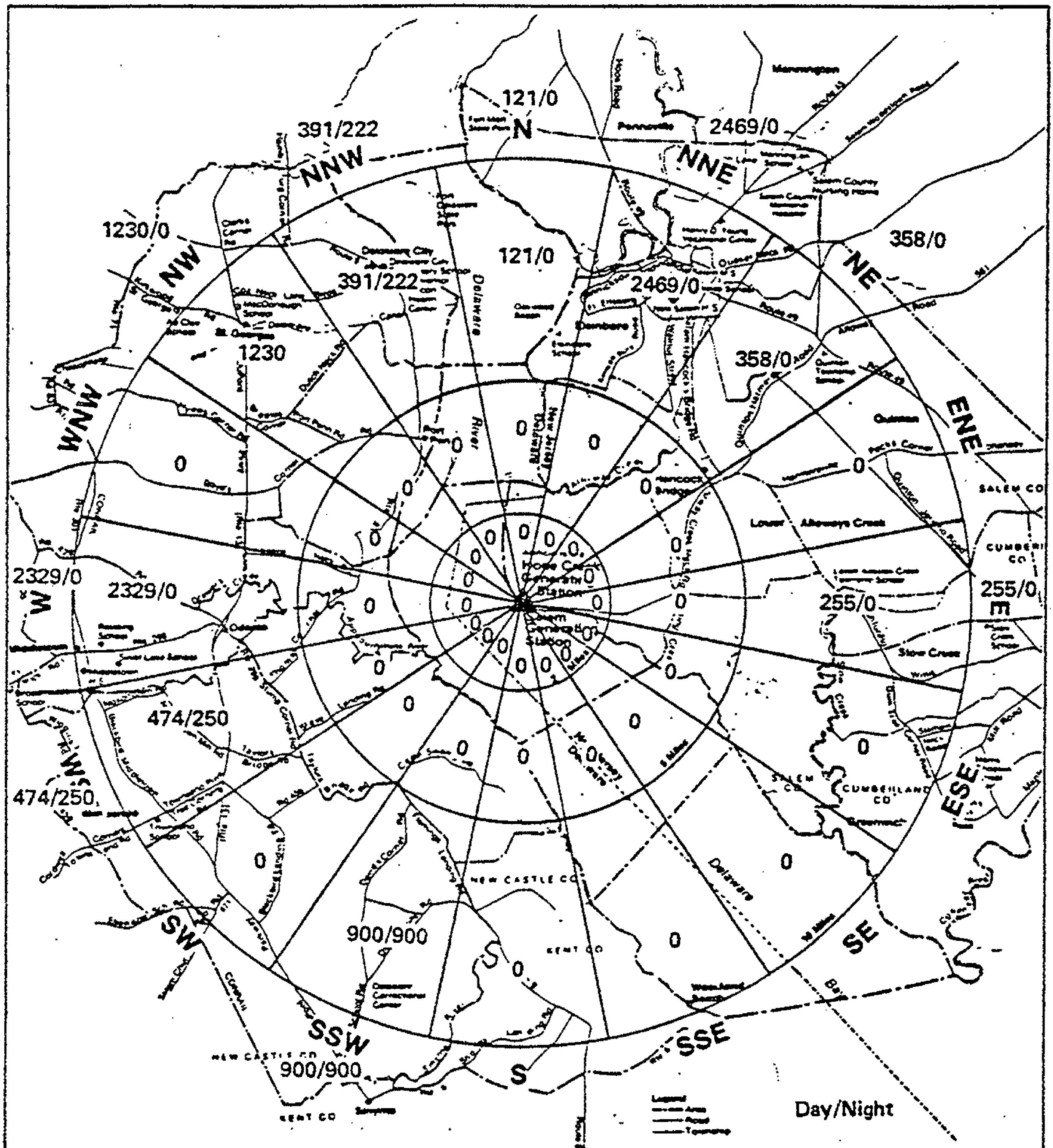
Population Summary

Transient Population

Note: 3385/729 at
Salem and Hope Creek
Generating Stations

REVISION 6
FEBRUARY 15, 1987

PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Evacuation Time Estimates	
	Updated FSAR	Figure 2.1-17



Population Summary

REVISION 6
FEBRUARY 15, 1987

PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Evacuation Time Estimates
	Updated FSAR — Figure 2.1-18

2.2 NEARBY INDUSTRIAL, TRANSPORTATION, AND MILITARY FACILITIES

The Salem site is located in a rural area consisting of marshes, abandoned meadowland, and some farmland. There are no major manufacturing or chemical plants within 5 miles of the site. All such facilities are beyond 8 miles and would not interfere with the normal operation of the Salem Generating Station (SGS).

Due to the lack of plants within 5 miles, our study was extended to 10 miles in order to present an accurate description of the site vicinity.

The Delaware River, a major transportation route, represents the only possible hazard to the Salem Station due to the Intracoastal Waterway which passes through the River 1.5 miles west of the site. The freight traffic on the river is described in Section 2.2.3. All features described in this section are shown on Figure 2.1-16.

2.2.1 Location and Routes

The location of manufacturing plants, chemical plants, storage facilities, and transportation routes (land and water) and pipe lines are provided on Figure 2.2-1 and listed in Table 2.2-1.

2.2.2 Descriptions

2.2.2.1 Missile Bases or Missile Sites

There are no military bases or missile sites within 10 miles of the site. The nearest such facility is the Dover Air Force Base, 20 miles south-southwest, which is capable of handling the C-5A jumbo jet transport plane. The base has a population of 8,200, which is expected to increase to 10,000 persons when in full operation (1). Greater Wilmington Airport, 21 miles north-northwest, serves as a station for a combat helicopter squadron and for a C-130 heavy transport wing (2).

2.2.2.2 Manufacturing Plants

There are no manufacturing plants within 5 miles of the site. There are 11 manufacturing plants within 10 miles of the site producing a variety of goods from canned corn to felt base floor coverings (3,4). The nearest company, Gioia Speciality Foods, Inc., employs less than 25 people and produces canned beans. It is located 6.5 miles west (5). For detailed information about manufacturing plants see Table 2.2-1 and Figure 2.2-1.

2.2.2.3 Chemical Plants and Storage Facilities

There are eight chemical companies in a cluster located 10.0 to 10.5 miles north-northwest. The nearest large operation is the Getty Oil Company Refinery. For more details see Table 2.2-1 and Figure 2.2-1.

2.2.2.4 Oil and Gas Pipelines and Tank Farms

There are two pipelines within 10.5 miles of the site, the nearest of which is the Getty Oil Company pipeline which runs within 9 miles of the site. The pipeline serves a large tank farm of approximately 50 tanks. The tank farm is located 10 miles north-northwest of the site. A second pipeline runs from the Pioneer Chloromane plant 2000 feet into the Delaware River at a point 10.4 miles from the site. These pipelines are shown on Figure 2.2-1.

2.2.2.5 Transportation Complexes (Harbors, Railway Yards, Airports)

There are no major harbors, railway yards, or airports within 10 miles of the site. The only "harbor facility" of any significance is the Getty Oil Company pipeline terminal in Delaware City, 9 miles north-northwest, used by moderate-size tankers (15 to 30,000 tons).

Although there are no harbors located within 10 miles of the site, small craft fishing and pleasure boating is popular in the area. There are two boating access areas within 10 miles, the nearest being Augustine Beach access area, 3.7 miles northwest. Woodland Beach is located 10 miles south-southeast. Although no boating figures are readily available, it was observed that both areas are used heavily for fishing and pleasure boating during the warmer months and probably for hunting during fall.

A list of the Marinas is included in the list of Recreational Facilities in Table 2.1-10.

There are no railroads within 5 miles of the site. However, there is a single track serving the chemical complex 10 miles north-northwest. Forty railroad cars were counted within the complex using aerial photos taken in 1968.

There are three turf airstrips within 10.5 miles of the site, the nearest of which is Salem Airport, 8 miles north-northeast.

2.2.2.6 Transportation Routes (Highways, Railway, and Waterways)

All transportation routes within 10 miles of the site are shown on Figure 2.2-1. The only major route within 5 miles of the site is the Intracoastal Waterway, 1.5 miles west of the island.

The Waterway is the main route for barge and freighter traffic from the Atlantic to the Philadelphia Area ports. In 1970, at least 4,700 vessel trips were made past Artificial Island.*

---

*Total traffic (9,858 trips) on the Chesapeake and Delaware Canal, 8 miles north-northwest was subtracted from the total traffic on the Delaware River (14,565 trips) to determine how many vessels passed Artificial Island (6).

According to U.S. Corps of Engineer Statistics (6) over 4.5 million passengers traveled from Philadelphia to the sea in 1970. This does not include the 25,000 who traversed the Chesapeake and Delaware Canal. The 4.5 million seems unrealistic and may result from double counting passengers on vessels that made several stops above Salem. The method used in compiling the statistics does not allow for double counting errors.

The Delaware River Hydrographic Chart delineates an anchorage zone northwest of Artificial Island. This zone is only for anchorage of vessels carrying explosives. According to Mr. Charles Ide and Lt. Edward Kangeter of the Safety Division, Coast Guard Station at Gloucester City, New Jersey, only one vessel since 1970 has carried explosives up-river past the site. The port of Philadelphia does not accept explosive cargo; all such cargoes, in limited quantities only, must be unloaded at Wilmington, Delaware. It was Lt. Kangeter's opinion that very few vessels with explosive cargoes have passed, or will pass, Artificial Island. He added that, with construction of the Salem Station, the Coast Guard is petitioning for a relocation of the anchorage area. This might increase anchorage by non-hazardous vessels, but Mr. Ide believes this is unlikely due to the distance to port.

U.S. Highway 13, 6.5 miles west, is traveled by an average total of 14,560 vehicles daily (7). Trailways Bus Service runs nine routes daily on this road, and one bus daily through Middletown, 10 miles west on Route 896. Six buses per day run to Salem, New Jersey, 8 miles north-northeast along Route 49 (8).

There are no figures for rail traffic within 10 miles of the site, but rail lines in both Delaware and New Jersey handle mainly freight traffic. No commuter train traffic exists in the site vicinity.

An in depth analysis of the highway network including local roads is provided in Attachment II-1 of the Salem Generating Station

Emergency Plan. Included in this attachment is the analysis of evacuation times as required by NUREG-0654, FEMA-REP-1: Rev. 1.

2.2.2.7 Petroleum Wells, Mines, or Quarries

There are no petroleum wells, mines, or hardrock quarries within 10 miles of the site. The nearest quarrying of any kind is sand and gravel pit activity along Route 49 in Quinton, New Jersey, 9 miles northeast to 10 miles east of the site.

2.2.3 Evaluations

2.2.3.1 Barge Transportation

There is no known movement of high explosives in the vicinity of Artificial Island*, the site of SGS. There is barge movement of flammable materials, such as jet fuel and gasoline, but these movements are not likely to pose much of a hazard to the station, since the probability of a runaway barge carrying flammable material striking the intake structure is very remote (i.e., around 1.0^{-7} per year).

A quantitative probabilistic analysis indicates that the risk of a runaway barge containing flammable material hitting the intake at Salem and igniting is 5.0×10^{-9} occurrences per year. Details of the analysis are given below.

---

*This fact has been verified by searching the records kept by the U.S. Army Corps of Engineers and the Bureau of Customs. In addition, the U.S. Coast Guard Offices in Philadelphia and New York also confirmed this fact. Finally, there are no known industrial or military activities in that region which would warrant shipment of high explosives.

According to the U.S. Corps of Engineers (9), compilation of traffic between Philadelphia and the sea, there are approximately 550 barge movements of loaded barges past the Salem site per year (1972 data). In addition, some 850 non-seagoing barge movements are needed for lightering purposes (10) and also move past Salem each year. Of this grand total of 1,400 loaded barge movements per year, 850 carry crude oil (essentially non-flammable), 160 carry sulfuric acid, 180 carry jet fuel, and the rest carry "clean" petroleum products such as fuel oil and gasoline (9). Since sulfuric acid and crude oil are not flammable, only 390 barges (1400-850-160) move by Salem each year carrying a flammable cargo. Therefore, the total traffic of concern to this analysis is 390 barge movements per year. Note that these 390 barges all have drafts of less than 16 feet and all can potentially approach the intake and hit it.

Based on accident statistics for the years 1968 to 1973 collected by the U. S. Coast Guard (11), the national average accident frequency involving all barges where damage was in excess of $1,500 has been found to be 0.42 accidents per million miles (12). The frequency of all types of barge accidents is therefore 0.42×10^{-6} per mile. Runaway barge accidents form a small subset of all accidents since most barge accidents are caused by impact with bridges, weirs, spillways, piers, other barges, etc., but not due to runaways. A very conservative estimate of number of runaways per total number of accidents is estimated at 0.1 (13).

We calculate the frequency of runaway barge occurrences per year per mile of the Delaware River in the vicinity of Salem, designated by f as:

$$f = \frac{\text{number of barge runaways}}{\text{year-mile}} \quad \text{Delaware} = 390 \times 0.42 \times 10^{-6} \times 0.1$$

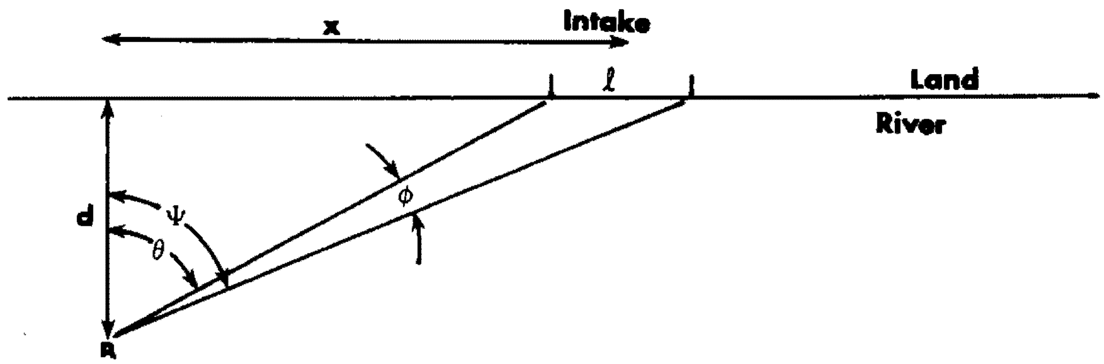
$$= 1.6 \times 10^{-5}/\text{year-mile}$$

We now address the question of how many of these runaways will strike the Salem intake. As shown below, if a barge can run away

in any direction with equal probability and does not change direction once it has run away, the probability of it striking a target (water intake) of length ℓ is given by f

$$\frac{\ell}{2}$$

Consider the collision geometry shown below:



A barge (assumed a point) B runs away in a random direction at a projected distance x from the center of target (water intakes) of length ℓ. Once the barge has run away, it is assumed that it does not change directions. In order to hit ℓ, the barge must be within the section given by angle $\emptyset$.

Since all angles of a runaway are equally likely, the probability of runaway within an angle $\emptyset$ is $\emptyset/2\pi$.

The total probability of a barge runaway at any distance x causing a strike at ℓ is

$$\int_a^b f \frac{\emptyset\ (x)}{2\pi}\, dx$$

where a and b represent the two end-points of the barge movements. Since the integrand decreases rapidly with distance away from the intake, the limits can be replaced with $\pm\infty$.

$$\int_{-\infty}^{\infty} f \frac{\emptyset(x)}{2\pi} dx = \frac{f}{\pi} \int_{0}^{\infty} [\tan^{-1} \frac{x+\ell/2}{d} - \tan^{-1} \frac{x-\ell/2}{d}] \quad dx$$

$$= \frac{f}{\pi} \int_{0}^{\infty} \tan^{-1} \frac{\ell/d}{1 + \frac{x^2 - (\ell/2)^2}{d^2}} \quad dx$$

$= \frac{f}{2}$ for the case when $d >> \ell/2$
This is true for the Delaware
where d = 5000', ℓ = 100'

The above expression represents the probability of a runaway barge (originating anywhere in the river) striking the target ℓ.

Note that the presence of a stream current in real rivers will prevent straight trajectories for runaway barges. However, the effect of slightly curved trajectories is expected to have little effect on the end result.

Since the length of the water intake is 110 feet, or 0.02 mile, the probability of a runaway barge striking the intake is:

$$1.6 \times 10^{-5} \times \frac{0.02}{2} = 1.6 \times 10^{-7} \frac{\text{strikes}}{\text{year}}$$

Not every strike will involve spillage of chemical. On a national average basis, only 45 percent of the barge accidents result in the involvement or release of contents (12) and about 7 percent of the releases result in fire (14). Carrying these frequencies to runaways, the probability of a barge running away, hitting the intake, releasing some of the flammable content and igniting is:

$$1.6\text{x}10^{-7} \times 0.45 \times 0.07 = 5.0\text{x}10^{-9} \text{ occurrences/year}$$

This represents an extremely remote event.

2.2.3.2 Hazardous Chemicals - Onsite

Regulatory Guide 1.78, Paragraph C.2 states that hazardous chemicals such as those indicated in Table C-1 of the Guide, must be included in the analysis if they are frequently shipped within a 5 mile radius of the plant. The Guide also defines frequent shipments as being 50 or more trips per year for barge traffic, 10 or more trips per year for truck traffic, and specifies in Paragraph C.1, that chemicals stored or situated at distances greater than 5 miles from the facility need not be considered.

Following is the analysis of control room habitability during a postulated hazardous chemical release occurring either on the site or within a 5 mile radius of the plant. As indicated in Section 2.2, the Salem site is located in a rural area with no major manufacturing or chemical plants located within 5 miles of the site. The only major transportation route within 5 miles of the plant is the Delaware River, with the Intracoastal Waterway passing 1 mile west of the site.

The SGS uses a sodium hypochlorite biocide system, thus eliminating an onsite chlorine hazard. The control room is equipped with smoke and combustible detectors located in the air conditioning unit ducts. These detectors provide alarms in the control room in the event of smoke or combustible hazards present. The control room is equipped with radiation detectors which provide annunciation, automatically isolate the control room, and initiate emergency ventilation in the pressurized mode. The site was reviewed to identify potentially hazardous chemicals which may impact control room habitability during a postulated release. The site includes the SGS, HCGS, and deliveries to and near the site. Hazardous chemicals which may impact control room habitability are identified as sulfuric acid, nitrogen, ammonium hydroxide, hydrazine, ethanolamine, sodium hydroxide, and helium. Fire fighting agents such as carbon dioxide and halon are discussed later in this section. The basis for identification was the chemical's physical properties, toxicity and/or asphyxiant threshold levels, and storage quantities and locations.

Table 2.2-2 presents the chemicals stored onsite or shipped by the site on the Delaware River which are identified in Regulatory Guide 1.78, Table C-1. Table 6.4-3 in Section 6.4 provides information on the control room ventilation system, as required by Regulatory Guide 1.78, Paragraph C.7. As can be seen from Table 2.2-2, the hazardous chemicals stored onsite are sulfuric acid, nitrogen, ammonium hydroxide, hydrazine, ethanolamine, sodium hydroxide, and helium.

As previously mentioned, several chemicals are stored onsite that are considered hazardous. Sulfuric acid is stored in 4,000 and 2,250 gallon tanks in the SGS Turbine Buildings and it is stored in 16,000 gallon tanks at the HCGS. Calculations indicated that the toxicity limit found in Regulatory Guide 1.78 will not be exceeded in the control rooms during a postulated release at any of the sources.

Liquid nitrogen and nitrogen stored as a compressed gas is stored at various locations onsite. According to the criteria contained in Regulatory Guide 1.78, the largest single source should be evaluated for its impact on control room habitability. The sources evaluated at the SGS are the portable nitrogen tube trailers located in various areas throughout the SGS yard area and the (2) liquid nitrogen tanks located behind Unit No. 1 & 2 Auxiliary Buildings which can contain up to 7500 gallons of liquid nitrogen. In addition to these sources, liquid nitrogen is also stored in 9,000 gallon tanks at the HCGS. Calculations indicated that the oxygen depletion is negligible in the control rooms during a postulated release at any of the significant sources.

Chemicals used as fire-fighting agents were evaluated. Carbon dioxide is stored on the 84 foot elevation of each of the Auxiliary Buildings. It is also stored at the HCGS. Calculations indicated that the toxicity limit established in Regulatory Guide 1.78 as well as asphyxiation levels would not be exceeded during postulated releases at the significant sources. The Halon storage vessels are relatively small and do not contain the volume of Halon required to cause asphyxiation in the control rooms; therefore, a postulated release will not pose a danger to the control rooms.

Ammonium hydroxide is stored in two 350 gallon vessel totes that are connected in series in the SGS Unit No. 1 and SGS Unit No. 2 Turbine Buildings. Evaluations concluded that the control rooms would remain habitable during a postulated release at either of the storage tank locations. The shipments to the site are considered "frequent" and are discussed in Section 2.2.3.3.

Hydrazine is stored in a 300 gallon vessel also in the Unit No. 1 side of the SGS Turbine Building. The calculations indicated that the control room concentrations will not exceed toxicity limits established in 29CFR Part 1910.1000, Subpart Z during a postulated release.

Ethanolamine is stored in two 350 gallon totes that are connected in series in the SGS Unit 2. The effective volume is 700 gallons. Evaluations concluded that the control rooms would remain habitable during a postulated release at the storage totes. The shipments to the site are considered "frequent" and are discussed in Section 2.2.3.3.

Aqueous sodium hydroxide is stored in various quantities and vessels at both the SGS and HCGS. Upon a release, sodium hydroxide vapors may form locally at the spill, but the physical properties of this chemical preclude the formation of a plume that will travel to the control room air intakes. The vapor pressure of aqueous sodium hydroxide is very low, especially as the concentration is increased. During a postulated release, mostly water will evaporate from the liquid pool, leaving the solid sodium hydroxide behind. The solid form of sodium hydroxide poses no danger to the control room due to its physical properties.

Helium is stored in 150 lb cylinders at both the SGS and HCGS. It is much lighter than air and upon a postulated failure of one of the cylinders, the helium would disperse rapidly into the atmosphere and not form a continuing plume.

Our analysis of the control room habitability requirements demonstrates that the control room personnel are adequately protected against the effects of accidental release of onsite

hazardous chemicals and radioactive gases, and shows that the plant can be safely operated or shut down under design basis accident conditions. Due to the use of sodium hypochlorite, there is no chlorine hazard.

2.2.3.3 Hazardous Chemicals - Offsite

Table 2.2-4 provides a tabulation of estimated frequencies of hazardous chemicals shipped past Artificial Island, some of which are listed in Table C-1 of Regulatory Guide 1.78. Regulatory Guide 1.78 requires a control room habitability evaluation for shipments of hazardous chemicals that are considered "frequent" shipments. The frequent criterion for river barges is 50 per year. As seen from Table 2.2-4, none of the hazardous chemicals shipped past the site exceed this criteria, therefore, a control room habitability evaluation is not required.

Hazardous chemicals are also delivered to the SGS and the HCGS. Table 2.2-4 lists the deliveries of hazardous chemicals to the Generating Stations. A review of the shipment deliveries were compared to the "frequent" shipment criteria as stated in Regulatory Guide 1.78. Aqueous sodium hydroxide, sodium hypochlorite, ammonium bisulfite, and ethanolamine shipments are considered "frequent". As mentioned previously, a release of either sodium hydroxide or sodium hypochlorite will not impact the control rooms due to the physical properties of these chemicals. Ammonium bisulfite is also characterized a a chemical that will not readily evaporate and form a plume during a release due to its very low volatility. Therefore, a catastrophic failure of the tankers delivering these hazardous chemicals onsite will not impact control room habitability.

Ethanolamine (ETA) is shipped frequently to the site in 350 gallon stainless steel totes. ETA is characterized as a chemical that will not readily evaporate and form a plume during a release. Therefore, a catastrophic failure of the truck delivering the totes onsite will not impact control room habitability.

Ammonium hydroxide, compressed nitrogen and sulfuric acid shipments delivered onsite also require an evaluation of their impact on control room habitability since their delivery schedule exceeds the criteria in Regulatory Guide 1.78. Calculations conclude that a release of ammonium hydroxide directly from a delivery tanker while onsite may exceed the toxicity limit contained in Regulatory Guide 1.78; however, administrative controls are in place to prevent the control rooms from exceeding the toxicity limit. Normal deliveries of ammonium hydroxide will consist of 350 gallon totes constructed of stainless steel. The catastrophic rupture of this vessel was modeled and shown to be within allowable limits specified in Regulatory Guide 1.78. Calculations regarding the portable nitrogen tube trailers and sulfuric acid tankers conclude that the control rooms will not be impacted during a catastrophic release.

The station control rooms have separate and independent ventilation air supplies which are automatically isolable (see Section 9.4.1).

The ventilation system uses charcoal filters for the iodine removal in the event of a radiological release. The charcoal provides absorption capability for most of the hazardous chemicals. Protection is further provided through individual emergency breathing apparatus located in or near the control room and by protective clothing which is available in other areas of the plant.

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Public Service Electric & Gas (PSE&G) has performed detailed studies of the potential hazards of ship transportation of the materials listed in Table 2.2-4, as well as liquified petroleum gas (LPG) and liquified natural gas (LNG). The report, entitled "Analysis of Potential Effects of Waterborne Traffic on the Safety of the Control Room and Water Intakes at Hope Creek Generating Station," was submitted on October 2, 1974, on the Hope Creek docket (Docket Nos. 50-354 and 50-355). The report provides analyses that support the conclusion that the probability of flammable vapor cloud reaching the nuclear facilities at Artificial Island is sufficiently low such that accidents occurring from the waterborne transportation of hazardous materials need not be considered in the design basis of the nuclear facilities at Artificial Island.

PSE&G is required as a condition of the Hope Creek Construction Permit to submit a yearly report updating factors that affect the probability of a flammable vapor cloud reaching Artificial Island. In addition, any significant changes that alter the probability calculations must be reported in a more prompt manner. A condition of the Salem Unit No. 2 Operating License requires that any significant information affecting probabilities reported on the Hope Creek docket must also be reported on the Salem docket.

The ability to isolate the ventilation system and recirculate the air, along with the protective breathing equipment, provides sufficient time to bring the plant to a safe shutdown condition from the control room in the event of hazardous chemical release from waterborne traffic.

2.2.4 References for Section 2.2

1. Robert W. O'Brian, Director, "The Comprehensive Plan," Kent County Regional Planning Commission, Dover, Del. 1971

2. Communication, Dames and Moore and Greater Wilmington Airport Information Office, Wilmington, Del.

3. Directory of Commerce and Industry, Delaware State Chamber of Commerce, Inc., Wilmington, Del., 1970.

4. Industrial Directory, State of New Jersey, Industrial Directories, Inc., New York, N.Y., 1971.

5. Written Communication, Dames and Moore survey from letter to pertinent industries.

6. Waterborne Commerce of the United States: 1970, Part I, Atlantic Coast, U.S. Army Corps of Engineers, 1971.

7. Communication, Dames and Moore and Rollin Neeman, Bureau of Planning, State of Delaware, Dover, Del.

8. Communication, Dames and Moore and Clerk, Bus Depot, State Road, Del.

9. U.S. Army Corps of Engineers, Waterborne Commerce of the United States, Delaware River, Philadelphia Harbor, 1972.

10. Personal Communications, Mr. Howard Lynch Interstate Oil Transport, Penn Central Plaza, Philadelphia, Pa.

11. U. S. Coast Guard Headquarters, Computer File on all Accidents Involving Damage in Excess of $1,500. Washington, D.C., 1974.

12. U. S. Department of Commerce, A Model Economic and Safety Analysis of the Transportation of Hazardous Materials in Bulk, Report to Office of Domestic Shipping by Arthur D. Little, Inc., Cambridge, Mass., July 1974.

13. U. S. Coast Guard, "Statistical Summary of Casualties to Commercial Vessels on Western Rivers, "November 1973. In this report, runaway barges are classified as being due to material failure (e.g., a broken tow line) and are found to represent 4 percent of all barge accidents. For the Delaware, a conservative estimate of 10 percent is used.

14. Atomic Energy Commission, "The Probability of Transportation Accidents, "by William A. Brobst. Presented at the 14th Annual Explosives Safety Seminar, New Orleans, Louisiana, November 1972.

15. Waterborne Commerce of the United States, U. S. Army Corps of Engineers.

16. Commodity traffic data for imports and exports collected by the Philadelphia Maritime Exchange.

17. Foreign trade cargo movements collected by the Delaware River Port Authority.

18. U. S. Department of Commerce, Census Bureau (handling foreign trade data for custom purposes.

19. Interstate Oil Transport, Inc. (which handles most of the barge operations on the Delaware River).

20. U. S. Coast Guard, Captain of the Port, Philadelphia (who is cognizant of all hazardous materials shipments in the Delaware River).

21. U.S. Coast Guard, Vessel Chemical Traffic Report, "Hazardous Traffic Passing Salem and Hope Creek Stations," Dated July 15, 1993.

TABLE 2.2-1

INDUSTRIES WITHIN TEN MILES OF THE SITE

Company	Location	Estimated No. of Employees	Product
MANUFACTURING PLANTS			
1. Gayner Glass	8 miles (NE)	266[a]	Glass Containers
2. Anchor Hocking Co.	8 miles (NE)	1323[a]	Glass Containers
3. Mannington Mills, Inc.	8 miles (NE)	567[a]	Felt Base Floor and Wall Coverings
4. H. J. Heinz Co.	8 miles (NE)	200[a]	Pickled Fruits, Vegetables, Sauces
5. Blue Ridge-Winkler Textiles	9.5 miles (W)	26-50[c]	Garments
6. Evergreen Acres, Inc.	9.5 miles (W)	80[b]	Ornamental Evergreens
7. Gioia Specialty Food Inc.	6.5 miles (W)	0-25[c]	Canned Beans
8. St. Georges Canning Co.	8.8 miles (NW)	51-100[c]	Canned Vegetables
9. Tyson F. Sartin, Inc.	8.8 miles (NW)	20[b]	Septic Tanks, Well Rings
10. Globe Union, Inc.	9.5 miles (W)	300[b]	Lead Acid Auto Storage Batteries
11. Delmarva Power & Light Co. Fossil Fuel Plant	10.2 miles (NNW)	NA	Electric Power
CHEMICAL PLANTS AND STORAGE FACILITIES			
12. Getty Oil Co.	10 miles (NNW)	501-1000[c]	Petroleum and Petrochemicals
13. Stauffer Chemical Co.	10 miles (NNW)	51-100[c]	Chemicals, Inorganic Resin

TABLE 2.2-1 (Cont)

Company	Location	Estimated No. of Employees	Product
MANUFACTURING PLANTS			
14. Keysor Chemical Co.	10 miles (NNW)	NA	Petrochemicals
15. Air Products and Chemicals, Inc.	10.5 miles (NNW)	26-50[c]	Hydrogen and Industrial Gases
16. Standard Chlorine of Delaware, Inc.	10.5 miles (NNW)	26-50[c]	Chlorine, HCL
17. Pioneer Chloromane	10.4 miles (NNW)	28[b]	Chlorine
18. Diamond Shamrock Chemical Co.	10.3 miles (NNW)	201-300[c]	Chlorine, Caustic Soda, Hydrogen
19. Stauffer Hoechst Polymer Corporation	10.2 miles (NNW)	151-200[c]	Film

NA - Not available
a - Source: N.J. Industrial Directory, 1971.
b - Source: Questionnaire sent to all Delaware Firms
c - Source: Delaware Directory of Commerce and Industry, 1970. (A range in number of employees is given.)

Note: Locations shown on Figure 2.5-1.

TABLE 2.2-2

HAZARDOUS CHEMICALS STORED ONSITE

Name of Chemical	Sulfuric Acid	Nitrogen	Ammonium Hydroxide	Hydrazine	Ethanolamine	Sodium Hydroxide	Helium	Carbon Dioxide	Halon	Sodium Hypochlorite
Type of Source	Onsite	Onsite	Onsite	Onsite	Onsite	Onsite	Onsite	Onsite	Onsite	Onsite
Human Detection Threshold (mg/m^3)	1.0	N/A	3.5	3.5		N/A	N/A	N/A	N/A	N/A
Maximum Allowable 2-minute Limit (mg/m^3)	2.0	Asphyxi-ant	70.0	0.04		2.0	Asphyxi-ant	Asphyxi-ant	Asphyxi-ant	N/A
Largest Single Container of Chemical (gallons)	1) 4000 (Unit 1) 2) 2250 (Unit 2)	1) 9000 (Hope Creek) 2) 7500 Salem	1) 3000	1) 300	1) 700	1) 4000 (Unit 1) 2) 2250 (Unit 2)	1) 150 lbs	2) 10 tons (Salem) 1) 17 tons (Hope Creek)	1) 310 lbs	1) 88,000
Maximum Continuous Release Rate (g/s)	Approx. zero	Instant-aneous	450	0.53		Approx zero	Instant-aneous	Instant-aneous	Instant-aneous	Approx. zero
Vapor Pressure (mmHg)	Approx. zero	N/A	450@ 115°F	35@ 115°F	0.3-0.4@ 68F	Approx zero	N/A	N/A	N/A	Approx. zero
Fraction of Chemical Flashed/ Rate of Boiloff when Spilling occurs	0%	100%	0%	0%		0%	100%	55%	100%	0%
Closest Distance between Source and control room (ft)	1) 290 2) 280	1) 200 (portable tube trailer)	1) 275 (Unit 1)	1) 375	1) 267	1) 300	1) 325	1) 140	1) <100	1) 575 (Unit 1)

TABLE 2.2-3

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TABLE 2.2-4

ESTIMATES OF HAZARDOUS CHEMICAL TRAFFIC

Chemical	No. of Vessel Trips/Year[1]
Acetone[2]	2
Ammonia[2] (incl. anhydrous ammonia)	14
Ammonium Bisulfite	2
Ammonium Hydroxide[3]	30
Asphalt	2
Benzene[2]	5
Butane	1
Caustic Soda	26
Cresylic Caustic	1
Cumene	11
Cyclohexane	3
Ethanol	1
Ethanolamine [6]	>10
Heptane	1
Heptene	1
Lube Oil	1
Methyl Alcohol[2] (methanol)	9
Methyl tertiary butyl ether (MTBE)	32
Napthalene	4
Nitrogen (compressed gas) [2,5]	>10
Nonene	8
Paraffin	1
Propane[2]	2
Propylene	1

Chemical	No. of Vessel Trips/Year[1]
Sodium Hydroxide[4] (mercury cell grade)	6
Sodium Hydroxide[4] (diaphragm grade)	26
Sodium Hydroxide[3,4]	104
Sulfuric Acid[3,4]	110
Toluene	2
VGO	1
Xylene	9

Notes:

(1) Delivery frequencies were provided per Reference 21 except where noted.

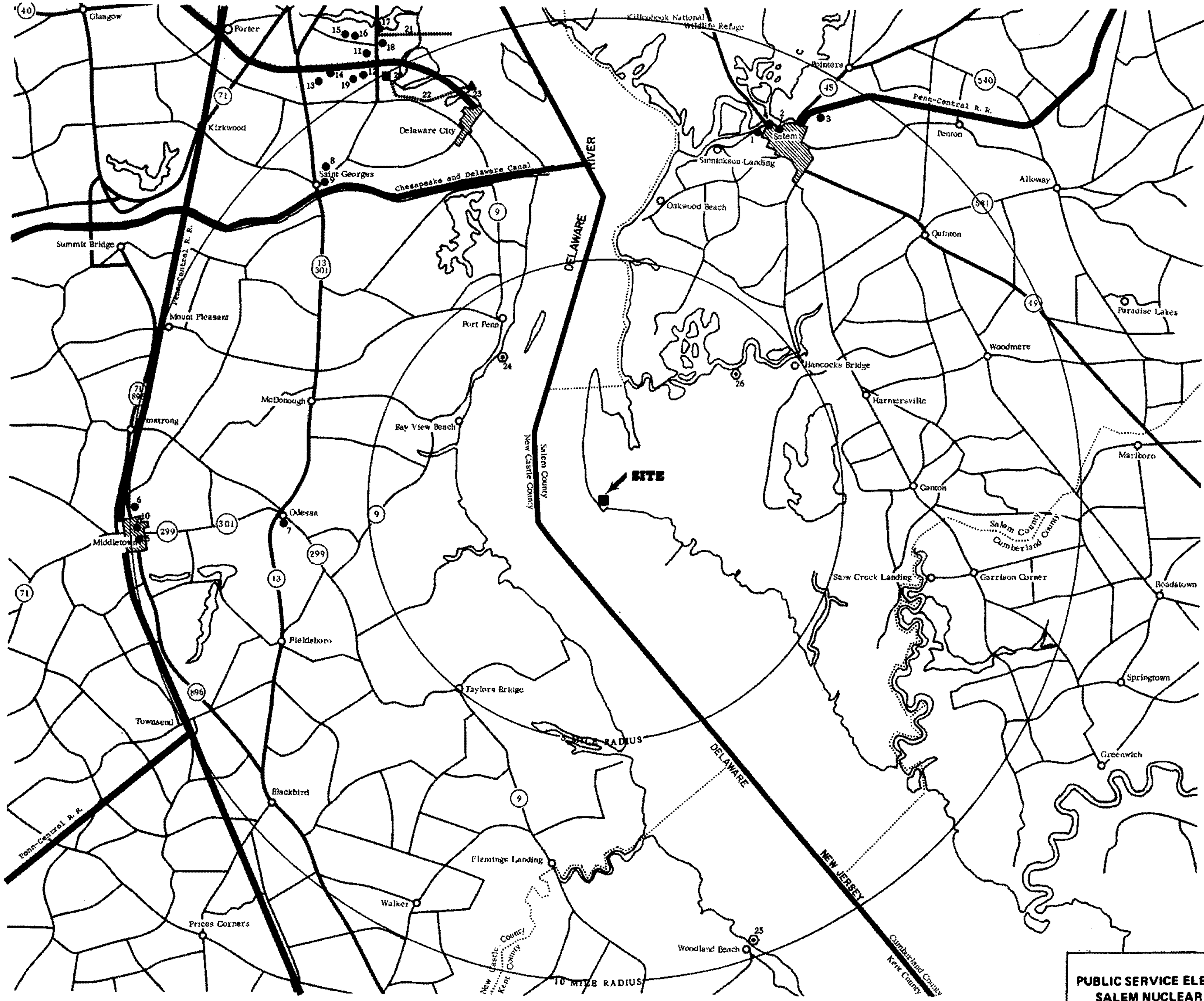
(2) Chemical is contained in Table C-1 of Regulatory Guide 1.78, or its references.

(3) Delivery frequency is based on Salem chemical delivery ordering logs and reflects number of tote deliveries.

(4) Delivery frequency is based on Hope Creek bulk chemical delivery ordering logs and reflects tanker truck delivery.

(5) Delivery frequencies are based on Salem bulk chemical delivery ordering logs and reflect portable tube trailer delivery.

(6) Delivery frequency reflects portable tote truck delivery.



KEY:

MANUFACTURING PLANTS

1. GAYNER GLASS
2. ANCHOR HOCKING CO.
3. MANNINGTON MILLS, INC.
4. HEINZ, H. J. CO.
5. BLUE RIDGE-WINKLER TEXTILES
6. EVERGREEN ACRES, INC.
7. GIOIA SPECIALTY FOOD, INC.
8. ST. GEORGES CANNING CO.
9. TYSON F. SARTIN, INC.
10. GLOBE UNION, INC.
11. DELMARVA POWER AND LIGHT CO. FOSSIL FUEL PLANT

CHEMICAL PLANTS

12. GETTY OIL CO.
13. STAUFFER CHEMICAL CO.
14. KEYSOR CHEMICAL CO.
15. AIR PRODUCTS AND CHEMICALS, INC.
16. STANDARD CHLORINE OF DELAWARE, INC.
17. PIONEER CHLOROMANE
18. DIAMOND SHAMROCK CO.
19. STAUFFER HOECHST POLYMER CORP.

TANK FARM

20. GETTY OIL CO.

PIPELINES

21. PIONEER CHLOROMANE
22. GETTY OIL CO.

TANKER DOCK

23. GETTY OIL CO.

BOATING ACCESS AREAS

24. AUGUSTINE BEACH
25. WOODLAND BEACH
26. ALPHA YACHT CLUB

INTRACOASTAL WATERWAY

REFERENCE:

REVISION 6
FEBRUARY 15, 1987

PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Site Vicinity Map Showing Major Facilities
	Updated FSAR — Figure 2.2-1

2.3 METEOROLOGY

2.3.1 Regional Climatology

2.3.1.1 Data Sources

Data sources are listed in the references provided at the end of this section.

2.3.1.2 General Climate

Based on the Koeppen climatic classification system, the region intersects two climatic zones. They are humid continental and humid sub-tropical. Both zones have characteristics of warm summers and mild winters (1). Summer maximum average temperatures are near 80 degrees Fahrenheit, and the coldest month is January having an average daily temperature of approximately 32 degrees Fahrenheit. Examining a 30 year mean of precipitation amounts for Wilmington, Delaware, National Weather Service (NWS) station shows that the most rainfall occurs in the summer months, followed by spring, fall, and winter (2).

The area of southern New Jersey is frequented by Polar Canadian air masses in the fall and winter and occasionally invaded by Arctic Canadian air late in winter. During the spring and summer, the dominant air mass is Maritime Tropical (1).

2.3.1.2.1 Precipitation

The frequency of precipitation events such as rain, snow, ice storms, thunderstorms, and hail are tabulated in Tables 2.3-1, 2.3-2, and 2.3-3. The data in Table 2.3-1 were obtained from the Revised Uniform Summary of Surface Weather Observations, Dover (Delaware) Air Force Base, 1942-1965. The data presented in Tables 2.3-2 and 2.3-3 were obtained from Philadelphia International Airport and Trenton Airport, respectively.

2.3.1.2.2 Humidity, Winds

Humidity annually averages 70 percent (3). Prevailing winds on a monthly average during the winter (December to March) are from a northwest direction with a range of speeds from 9 to 13 mph. Average monthly winds for the spring and summer months (April to August) are from a southerly to southwesterly direction at speeds ranging from 7 to 10 mph. Winds during the fall are predominantly from the west-southwest veering to a west-northwest direction by December. The average wind speeds increase as the season progresses (4).

2.3.1.3 Severe Weather

The terrain is open and extremely flat which favors a vigorous wind flow. While the area is almost certain to experience hurricane force winds frequently, there is no reason to anticipate fastest mile velocity, reaching 100 miles per hour, more than once in 100 years. Table 2.3-4 lists the distribution of peak winds for Philadelphia International Airport based on a 25-year record. The tornado frequency in this area is reassuringly low; a few small funnels have been observed in southeastern Pennsylvania and southern New Jersey, but it is unlikely that any tornado would affect the site itself more than once in 4300 years.

2.3.2 Local Meteorology

Figure 2.3-1 shows the different stations that collect meteorological records. Figures 2.3-2 and 2.3-3 are 2-year wind roses derived from Artificial Island wind data using all hours and only hours with a stable stability, respectively. The wind direction is randomly distributed when stable atmospheric conditions occur, whereas using all hours of data shows a northwest wind direction peak.

2.3.3 Onsite Meteorological Measurements Program

Meteorological Data Collection Program

In order to arrive at atmospheric dispersion factors for use in calculating radiological exposures from both low level normal releases and accidental releases, an extensive data collection program was undertaken at the site. This data collection program is described in detail in the following paragraphs. The present meteorological monitoring program is in conformance with the recommendations of Regulatory Guide 1.23.

2.3.3.1 Preoperational Data Collection Program

Data became available from the 300 feet meteorological tower located on Artificial Island in June of 1969. The official preoperational data collection program was terminated at the end of May 1971. The tower was positioned just north of the actual plant site and is shown on Figure 2.3-1. The actual location was 2700 feet north of Unit 2 at a Latitude of 39 degrees 28 minutes 13 seconds north, and a Longitude of 75 degrees, 32 minutes 12 seconds west.

A detailed representation of the meteorological facility is not necessary because of the simplicity of the terrain. The tower data used in this study is primarily that from the 33 and 300-foot levels, although some data were obtained at the intermediate 150-foot elevation. The wind instrumentation consisted of Aerovanes, and the temperature-difference measurements were obtained from aspirated resistance thermometers. The usual precipitation, humidity, and solar radiation are on record if they are ever needed for general environmental applications.

2.3.3.1.1 Data Summaries and Turbulence Classifications

The record of temperature and all other data extends from June 1969. Data are being obtained continuously. A monthly temperature distribution is presented in Table 2.3-5.

Table 2.3-6 shows monthly summaries of precipitation in inches for June 1969 through November 1970. Included with this summary is a range of maximum hourly rates.

Table 2.3-7 lists the monthly percentages of hours with fog in 3-hour intervals. October through March have the largest percentage of fog during the hours of 0600 to 0800. During April through September, the largest percentage occurred between the hours of 0300 to 0500.

Stability

Alternative techniques of estimating the turbulence usually involve one of two methods: approximating it from a combination of lapse rate and wind speed measurements, or from the fluctuations of a standard wind instrument such as an Aerovane. We believe the latter to be more representative of the typical problems, and accordingly this presentation is largely based on wind direction range and gustiness data. The lapse rate classification has been used, however, and some of the data are summarized in the report. In this instance, the two techniques are in good agreement.

Turbulence Classifications

The system used for defining the turbulence is that developed originally by Singer and Smith(5) and widely applied in both nuclear and fossil power plant evaluations. The classification is depicted on Figure 2.3-4, where Classes I and II represent unstable conditions.

Class III is the overcast stormy situation, and Class IV is the stable, inversion flow pattern.

In the Preliminary Safety Analysis Report the distribution of turbulence classifications obtained from the Delaware City site 10 miles north-northwest of Salem, was presented as probably typical of the dispersion regimes. In Table 2.3-8 the new Salem data (300-foot level) are compared with the earlier summary from Delaware City, and the agreement is very good despite the fact that the information was obtained in different years. The only notable difference is that Salem showed a more marked tendency toward the neutral Class III turbulence than did Delaware City. This aberration may be real, but it is more likely that the water tower on which the Delaware City instrument was located produced somewhat broader and more turbulent direction traces than the clean installation at Salem. In any case, the difference has no great significance in the dispersion evaluation.

At both sites, the distributions seem quite normal for open, mid-latitude locations. The Class II turbulence dominates the distributions, accounting for approximately 60 percent of all hours, and the stable cases are found in roughly 25 percent of the remainder. We had anticipated a noticeable increase in the frequency of Class IV conditions during the late spring and early summer at Salem, because it is directly exposed to over-water flow which might be stable, but apparently the combination of infrequent winds from the 130- to 160-degree sector and the relatively mild bay temperatures did not produce the expected increase.

Lapse Rates

In Table 2.3-9, the distribution of lapse rates over the year is shown. These data agree well within the indications of the turbulence classification, in that 24 percent of the hours appear to be stable, 14 percent neutral, and the remainder unstable.

Another indication that the water influence is fairly small at this site is that the diurnal variation of the lapse rate in June (Figure 2.3-5) does not show any tendency toward stability in the afternoon hours, and, in fact, is quite similar to the December (Figure 2.3-6) pattern.

Relation Between Lapse Rates and Turbulence Classes

As a final comparison between turbulence classes and the lapse rate data, Table 2.3-10 is presented which clearly shows that the two methods of estimating turbulence are compatible at this site. The vast majority of Class I and Class II turbulence hours are associated with unstable lapse rates, and the Class IV hours are primarily inversion periods as they ought to be.

The distributions of lapse rates, winds, and turbulence classes already presented are adequate to define the diffusion meteorology of this site as quite normal and uncomplicated, but it is important to translate the data as accurately as possible into the dispersion parameters actually used in numerical evaluations. Since the experience with the bi-directional wind vane was typically unsuccessful, the measurement of hourly wind direction range was evaluated and used for estimates of $\sigma\theta$. These data, separated according to turbulence class, are given for the entire period of observation in Table 2.3-11, and it is apparent that the wind fluctuations at this site are very nearly identical to those at Brookhaven National Laboratory (6) where the turbulence classification was originally developed. It therefore is reasonable to utilize the diffusion parameters developed at that site (7) in this study.

One further point is important, and that is to be sure that diffusion with south-southeast winds from the open waters of Delaware Bay is not significantly different from that occurring with other wind directions. Table 2.3-12 is a replica of Table 2.3-11, except that only south-southeast winds are represented. Obviously there is no difference.

Hour-by-hour stability frequency tables are presented in Tables 2.3-9 and 2.3-10.

Wind Patterns

The distribution of wind speeds at the 33- and 300-foot levels as a function of turbulence class are presented in Table 2.3-13, where the most notable feature is the very low frequency of calms. Normally, with an Aerovane as a sensing instrument, calms at the 33-foot elevation are prominent, but the very flat terrain and the air-sea interaction at Salem obviously favor a vigorous wind flow. Also, the percentage of hours having relatively high speeds, reflected in both Tables 2.3-13 and 2.3-14, is quite large, as one would anticipate in this locality.

Data recovery percentages for the June 1969 to May 1970, 33-foot and 300-foot wind data, are shown in Table 2.3-15.

2.3.3.2 Operational Data Collection Program

The digital Meteorological Data Acquisition Systems provide increased data recovery over traditional systems. The digital Meteorological Data Acquisition systems were designed to meet the intent of Regulatory Guide 1.23.

The Salem and Hope Creek Safety Parameter Display System (SPDS), provides an Artificial Island wide source of 15-minute average meteorological monitoring system parameters, which are read from the two digital data acquisition systems. The parameters available for display are 33-ft wind speed, direction, sigma theta, and horizontal stability class; 150-ft wind speed, direction, sigma theta, and horizontal stability class; 300-ft wind speed, direction, sigma theta, and horizontal stability class; delta temperature between 300 and 33-ft; delta temperature between 150 and 33-ft; vertical stability class for each delta temperature; precipitation; barometric pressure; solar radiation; and ambient and dew point temperatures.

Atmospheric transport and diffusion is calculated by the Meteorological Information and Dose Assessment System (MIDAS) computers installed in both Salem and Hope Creek. A method for determining atmospheric transport and diffusion throughout the plume exposure emergency planning zone during emergency conditions has been developed.

The system became operational in April 1976.

The location of the 300-foot guy wire supported tower is Latitude 39 degrees, 27 minutes, 48.9 seconds, North and Longitude 75 degrees, 31 minutes, 11.76 seconds, West.

The data collection program also includes an additional tower, identified as a backup meteorological tower, consisting of a 10-meter telephone pole. The backup tower is located approximately 500 feet south of the primary meteorological monitoring tower. Backup meteorological data provides wind speed, wind direction, and a computed sigma theta.

Wind speed and direction instruments are located at 300-foot, 150-foot, and 33-foot elevations on the primary tower and at the 33-foot elevation on the backup tower. Temperature measurement includes ambient temperature taken at the 33 foot elevation and temperature differences taken between $T_{300} - T_{33}$ and $T_{150} - T_{33}$ levels. Temperature sensors consist of thermistors in a motor aspirated solar radiation shield. The dew-point is measured at the 33-foot level. Rainfall and barometric pressure are measured at approximately 3 and 6 feet, respectively. Figure 2.3-7 depicts the heights of these instruments on the tower.

All meteorological parameters are electronically recorded in the Meteorological Instrument Building at the base of the tower.

The data acquisition system includes capabilities for remote interrogation in addition to data acquisition. The data acquisition systems consist of primary and backup data acquisition systems (DAS) located at the Meteorological Instrument Building. A diagram of the system configuration is provided on Figure 2.3-8. The rain gauge uses a tipping bucket.

The primary and backup DAS are configured with identical hardware. Each DAS is provided with communication ports, including one as a link to the Salem and Hope Creek SPDS, and one for direct dialup capability. Each DAS provides storage for at least 7 days of 15-minute averages.

The primary DAS collects wind speed and direction from the primary tower. The backup DAS collects wind speed and direction from the backup meteorological tower. Each DAS calculates a sigma theta for its respective meteorological tower (each of the three level wind directions on the primary tower, one level on the backup tower). The host computers acquire the meteorological data collected by the data loggers.

The calculations of the sigma thetas use samples of horizontal wind direction at each elevation/location.

Data interrogation is possible through dial-up connection to the digital data acquisition systems, which also provide data to the Salem and Hope Creek SPDS. The SPDS supports display units in the EOF, the Hope Creek Control Point, the Salem and Hope Creek TSCs, the Hope Creek OSC, and the Salem Ops Ready Room.

Additional sources of meteorological data to provide a description of airflow trajectories from the site out to a distance of 50 miles include Wilmington and Philadelphia National Weather Service (NWS) stations.

Hourly wind, temperature, and cloud cover data are readily available from these NWS stations.

2.3.4 Short-Term Diffusion Estimate

2.3.4.1 Objective

The objective is to provide conservative and realistic short term estimates of relative concentration (X/Q), at both the site boundary and the outer boundary of the low population zone (LPZ) following a hypothetical release of radioactivity from SGS Units 1 or 2. The assessment is based on the results of atmospheric diffusion modeling and onsite meteorological data.

A ground-level accidental radionuclide release from SGS is analyzed at various distances. Conservative and realistic X/Q values at the exclusion area boundary (EAB) are derived for the 0- to 2-hour period following a postulated accident. Conservative and realistic estimates of the X/Q value at the outer boundary of the LPZ are computed for 2, 8, 16, 72, and 624 hours following a postulated accident. For this modeling assessment, the EAB is a distance of 1270 meters in all sectors except the Northeast and East, which were 1391 meters. The LPZ boundary is 5.0 miles (8,047 meters), all sectors.

2.3.4.2 Accident Assessment

The short-term, 0- to 2-hour X/Q values for ground-level releases are calculated with the sector dependent model described in Regulatory Guide 1.145, Reference 8. Annual accident X/Q values are also required to derive the intermediate time period X/Q values. These annual accident X/Q values are derived using the long-term diffusion model described in Regulatory Guide 1.111, Revision 1, Reference 9.

2.3.4.2.1 Methodology

The procedures used to estimate the X/Q values for the appropriate time periods following a postulated accident are described in Regulatory Guide 1.145. The diffusion model generates a cumulative frequency distribution of X/Q values for each sector-distance combination representing the first 2 hours after the postulated accident. These 2-hour X/Q values are based on 1-hour averaged data, but are assumed to apply for 2 hours. The frequency distributions are plotted on a log-probability scale for each sector-distance combination, and are then enveloped in accordance with the methodology described by Markee and Levine in Reference 11.

The X/Q value that is equaled or exceeded 0.5% of the time at each sector-distance combination is then determined from the intersection of the envelope and the 0.5% probability level. The highest sector dependent X/Q value is then compared with the "overall" 5% accident X/Q value. The highest value represents the conservative 2-hour accident X/Q. The realistic 2-hour accident X/Q is evaluated at the overall 50% probability level.

The overall 5% and 50% X/Q values are determined by summing the sixteen sector dependent X/Q distributions for each distance into a cumulative frequency distribution representing all sectors and again enveloping the data points. The 5% and 50% values are determined by the intersection of the envelope with the 5% and 50% probability levels, respectively.

The conservative accident X/Q values for time periods of up to 30 days following an accident are derived by logarithmic interpolation between the 2-hour 0.5% and the annual accident X/Q value at each sector-distance combination. The intermediate time periods for the overall 5% and 50% X/Q values are determined by logarithmic interpolation between the overall 2-hour 5% and 50% X/Q values and the maximum annual X/Q. The maximum conservative X/Q value for a given distance is the maximum sector 0.5% X/Q, or the overall 5% X/Q, whichever is higher, for the conservative assessment. The realistic assessment is based upon the overall X/Q and the overall 50% X/Q. The higher X/Q value is chosen again.

2.3.4.2.2 Meteorological Data

2.3.4.2.2.1 Representativeness

The Artificial Island meteorological tower data from January 1988 through December 1994 are employed in the accident assessment. The data collected at the tower are representative of the meteorological conditions under which effluents are released, since both are located on the Delaware River shoreline. Furthermore, the proximity of the 300-foot tower to SGS ensures that the data are representative of the conditions used in an accident evaluation.

2.3.4.2.2.2 Joint Frequency Distributions

Joint frequency distributions of wind speed and direction by atmospheric stability class are used as input to the diffusion calculations. Wind speed and direction data from the 33-foot level are used in the assessment of diffusion for the ground-level releases.

Atmospheric stability is determined for the 33-foot distributions by the vertical temperature difference between the 300- and 33-foot levels. Joint frequency distributions of wind speed and direction by atmospheric stability class are computed for 22.5° sector using the wind speed groups and atmospheric stability classes suggested in Regulatory Guide 1.23. The 7-year frequency distributions are used in the analysis.

With the exception of the calm and 25+ mph wind speed groups, the highest wind speed in each group is used to represent that group in the diffusion calculations. For conservatism, a wind speed of 0.5 mph is used to represent calms at the 33-foot level. This value represents a conservative threshold wind speed for the 33-foot wind instrumentation. Due to the high wind speeds associated with this site, a wind speed of 30 mph is used to represent the 25+ mph wind speed group.

2.3.4.3 Atmospheric Diffusion Model

The reactor building vent is treated as a ground-level source for both short-term and long-term calculations. This implies that no plume rise is calculated and no terrain corrections are applied. A building wake correction factor is used, in accordance with the methodology discussed in Regulatory Guide 1.145 for vent releases. The building wake correction factor takes into account the initial mixing of the plume within the building cavity.

The vent release X/Q values are calculated with the following equations from Regulatory Guide 1.145:

$$X/Q = \frac{1}{U_{10}\ (\pi S_y S_z + A/2)} \qquad (2.3\text{-}2)$$

$$X/Q = \frac{1}{U_{10}\ (3\pi S_y\ S_z)} \qquad (2.3\text{-}3)$$

$$X/Q = \frac{1}{U_{10}\ (\pi \Sigma_y\ S_z)} \qquad (2.3\text{-}4)$$

where:

X/Q = relative concentration, s/m^3

U_{10} = wind speed at the 10 m level, m/s

S_y = lateral plume speed, m

Σ_y = lateral plume spread with meander and building wake effects, m

S_z = vertical plume spread, m

A = smallest vertical-plane cross-sectional area of the reactor building, and adjacent structures, m^2.

A building wake correction factor of 2430 m^2 is used for calculations of the short-term X/Q.

For neutral or stable conditions combined with wind speeds less than 6.0 m/s, calculations of the X/Q values are made using Equations 2.3-2 through 2.3-4. For all other meteorological conditions, X/Q values are calculated using Equations 2.3-2 and 2.3-3 only.

The values computed from Equations 2.3-2 and 2.3-3 are compared, and the higher value is selected. For neutral and stable conditions with a wind speed less than 6 m/s, the value from Equation 2.3-4 is compared with the value chosen from Equations 2.3-2 and 2.3-3, and the lower value is chosen to represent these conditions.

2.3.4.4 Diffusion Estimates

2.3.4.4.1 Exclusion Area Boundary

The maximum conservative 2-hour X/Q at the EAB, 0.79 miles, is 1.30 x 10^{-4} s/m^3. This is the maximum overall 0.5% sector dependent value at this distance. This value is larger than the overall 5% X/Q value. The maximum realistic (50%) 2-hour X/Q at the EAB is 3.0 x 10^{-5} s/m^3. This is the overall 50% X/Q value. Conservative and realistic X/Q values for the EAB (0.79 miles) for all the time periods following the accident are given in Table 2.3-21.

2.3.4.4.2 Low Population Zone

The maximum conservative and realistic X/Q values, 0.5% and 50%, respectively, given in Table 2.3-21 represent the maximum X/Q values (sector value used if greater than the overall value) at the LPZ boundary, 5 miles.

2.3.5 Long-Term Diffusion Estimate

2.3.5.1 Objective

The objective is to provide realistic estimates of annual average offsite atmospheric dilution factors based on site meteorological data.

2.3.5.2 Calculations

Annual X/Q values for sixteen - 22.5 -degree arcs at sixty distances are presented in Tables 2.3-17 through 2.3-20. The meteorological input data used was the 2-year period, June 1969

through May 1971. X/Q estimates are based on the procedures presented in Regulatory Guide 1.111. These values were submitted in July 1976 as part of the Appendix I, 10CFR50 submittal to the NRC.

2.3.6 References for Section 2.3

1. Chritchfield, Howard J. "General Climatology," Englewood Cliffs, N.J. (Prentice Hall Inc.) pp. 148-151, 1966.

2. Wilmington, Delaware Local Climatological Data, U.S. Department of Commerce, 1980 ed.

3. U.S. Department of Commerce. "Weather Atlas of the United States," pp. 170-175, June 1968.

4. U.S. Department of Commerce. "Weather Atlas of the United States," pp. 228-234, June 1968.

5. DELETED

6. DELETED

7. DELETED

8. U.S. NRC "Atmospheric Dispersion Models For Consequence Assessments at Nuclear Power Plants," Regulatory Guide 1.145, Rev 1, Nov. 1982

9. U.S. NRC "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors," Regulatory Guide 1.111, Rev 1, July 1977

10. Meteorological Evaluation Services Co., Inc., "Accident X/Q Values at the Salem Generating Station Control Room Fresh Air Intakes, Exclusion Area Boundary and Low Population Zone," April 1996

11. Markee, E.H. and J.R. Levine, 1977, "Probabilistic Evaluations of Atmospheric Diffusion Conditions for Nuclear Facility Design and Siting," in proceedings of the American Meteorological Society Conference on Probability and Statistics in Atmospheric Sciences, Las Vegas, Nevada, pp. 146-150

TABLE 2.3-1

PERCENTAGE OF DAYS WITH VARIOUS HYDROMETERS
DOVER DELAWARE AIR FORCE BASE
1942-1965

Month	Fog	Snow and/or Sleet	Hail	Thunderstorms
Jan	43.7	4.1	0.4	0.6
Feb	45.0	3.4	0.2	0.9
Mar	48.4	2.7	-	3.7
Apr	44.4	0.3	0.2	8.9
May	49.0		0.9	16.6
Jun	55.3		0.4	17.1
Jul	54.3		0.2	19.6
Aug	66.3		-	17.4
Sept	59.0		-	6.8
Oct	53.8		0.2	3.0
Nov	47.6	0.6	0.2	1.2
Dec	44.5	2.5	0.2	0.5
Annual	51.2	1.2	0.3	8.2

TABLE 2.3-2

SNOWFALL
(inches)

PHILADELPHIA INTERNATIONAL AIRPORT

Month	Mean	Monthly Maximum
Jan	5.7	19.7
Feb	6.1	18.4
Mar	4.1	13.4
Apr	0.3	4.3
May	T	T
Jun		
Jul		
Aug		
Sept		
Oct	T	T
Nov	0.8	8.8
Dec	4.6	18.8
Annual	21.6	
Length of Record (yr)	28	

(T = Trace of precipitation)

TABLE 2.3-3

SNOWFALL
(inches)

TRENTON AIRPORT

Month	Mean	Monthly Maximum	24-Hour Maximum
Jan	5.8	16.1	10.1
Feb	6.7	23.1	13.0
Mar	4.4	21.5	14.3
Apr	0.4	4.2	4.2
May	T	T	T
Jun			
Jul			
Aug			
Sept			
Oct	0.1	1.6	1.6
Nov	1.0	13.0	7.7
Dec	4.9	21.5	16.6
Annual	23.3		

Length of Record (yr) 34

(T = Trace of precipitation)

TABLE 2.3-4

DISTRIBUTION OF PEAK WINDS

PHILADELPHIA INTERNATIONAL AIRPORT
(25-year record)

Month	Fastest Mile	
	Speed (mph)	Direction
Jan	61	NE
Feb	59	NW
Mar	56	NW
Apr	59	SW
May	56	SW
June	73	W
July	67	E
Sept	49	NE
Oct	66	SW
Nov	60	SW
Dec	47	NW

Fastest Mile Observed in Area: 88 mph, north, July 1931

Estimated Peak Hourly Value: 70 mph

TABLE 2.3-5

DISTRIBUTION OF HOURLY TEMPERATURES
(percent)
Temperature Classes
(°F)

Month	< -20	-20 to -10	-10 to 0	0 to +10	+10 to +20	+20 to +30	+30 to +40	+40 to +50	+50 to +60	+60 to +70	+70 to +80	+80 to +90	+90 to +100
Jan				6	19	44	25	6	<1				
Feb					6	31	42	17	4				
Mar						9	52	35	4	<1			
Apr							9	35	38	15	3	<1	
May								8	36	34	14	6	2
*Jun									9	48	36	7	<1
*Jul									1	28	54	16	1
*Aug									<1	18	54	24	
*Sep								2	15	30	43	8	2
*Oct						<1	6	19	33	34	8	<1	
*Nov					<1	5	20	42	29	4			
Dec					1	25	59	14	1				
Annual					<1	1	10	18	15	14	17	18	5

*2 months of data

TABLE 2.3-6

PRECIPITATION

(in water)

Month	1969	1970	Range of Maximum Hourly Rate
Jan		0.65	0.01 to 0.10
Feb		1.70	0.11 to 0.20
Mar		3.03	0.21 to 0.30
Apr		4.54	0.51 to 0.60
May		1.39	0.21 to 0.30
Jun	1.87	3.89	0.51 to 0.60
Jul	7.18	2.82	1.00 Plus
Aug	3.75	1.29	0.71 to 0.80
Sept	2.02	1.47	0.41 to 0.50
Oct	2.92	2.13	0.61 to 0.70
Nov	1.64	5.46	0.51 to 0.60
Dec	6.92		0.51 to 0.60

TABLE 2.3-7

PERCENTAGE OF HOURS WITH FOG

Month / Hour	00-02	03-05	06-08	09-11	12-14	15-17	18-20	21-23	Mean
Jan	19.8	22.3	23.8	19.2	13.5	13.8	15.7	17.3	18.2
Feb	21.4	23.3	25.1	18.0	14.2	13.9	16.5	18.2	18.8
Mar	20.3	23.3	24.9	15.8	12.2	12.2	14.9	17.4	17.6
Apr	18.4	24.2	23.2	12.8	8.8	10.1	12.3	14.18	15.6
May	22.7	27.9	22.2	10.1	6.0	5.4	8.6	14.7	14.7
Jun	21.4	37.2	22.9	7.9	4.6	4.0	6.5	11.0	14.4
Jul	22.7	35.8	23.8	5.1	3.6	3.1	4.8	11.7	13.8
Aug	27.6	42.5	31.8	6.8	3.7	3.1	6.3	14.2	17.0
Sept	25.9	37.6	33.9	9.4	5.0	4.8	8.6	16.2	17.7
Oct	23.6	33.5	35.0	11.2	6.6	6.5	9.6	15.0	17.6
Nov	19.4	22.9	27.6	14.9	8.0	8.6	12.3	15.8	16.2
Dec	20.4	21.4	25.5	19.9	14.7	14.9	17.1	18.0	19.0

TABLE 2.3-8

PERCENTAGE FREQUENCY
OF
TURBULENCE CLASSES

Salem and Delaware City

Turbulence Class

Month	I		II		III		IV	
Jan	6	(2)	62	(65)	13	(2)	19	(31)
Feb	4	(3)	57	(64)	16	(5)	23	(28)
Mar	7	(3)	59	(66)	12	(6)	22	(25)
Apr	6	(2)	60	(72)	15	(9)	19	(17)
May	12	(11)	59	(63)	6	(1)	23	(25)
*Jun	13	(12)	57	(58)	10	(1)	20	(29)
*Jul	12	(4)	58	(64)	10	(0)	20	(32)
*Aug	12	(3)	53	(65)	10	(0)	25	(32)
*Sep	14	(4)	50	(62)	12	(7)	24	(27)
*Oct	8	(6)	52	(62)	14	(5)	26	(27)
*Nov	6	(7)	56	(64)	13	(15)	25	(14)
Dec	4	(8)	72	(51)	12	(12)	12	(29)
Annual	8	(6)	58	(62)	12	(5)	22	(27)

*2 months of data

( ) data for Delaware City

TABLE 2.3-9

PERCENTAGE FREQUENCY

OF

LAPSE RATES

Lapse Rate Group ($^{t}300 - {}^{t}33$°F)

Month	≤ -1.7	-1.6 to -0.5	-0.4 to +0.5	+0.6 to +1.5	-1.6 to +2.5	+2.6 to +3.5	+3.6 to +4.5	≥ +4.6
Jan	18	46	11	8	5	5	2	5
Feb	18	37	14	10	6	6	3	6
Mar	20	47	14	6	4	3	2	4
Apr	19	45	12	7	5	6	0	6
May	30	27	10	8	6	7	5	7
*Jun	32	40	12	6	4	3	1	2
*Jul	25	45	13	7	5	3	1	1
*Aug	30	32	14	8	9	4	2	1
*Sep	24	32	18	9	7	5	3	2
*Oct	19	33	20	10	7	4	2	5
*Nov	13	43	20	8	6	3	3	4
Dec	18	57	15	5	3	1	<1	1
Annual	22	40	14	8	6	4	2	4

*2 months of data

TABLE 2.3-10

RELATION BETWEEN LAPSE RATES
AND
TURBULENCE CLASSES
(percent)

Turbulence Class	Temperature Difference, T300-T33 Ft (°F)							
	≤-1.7	-1.6 to -0.5	-0.4 to -0.5	0.6 to 1.5	1.6 to 2.5	2.6 to 3.5	3.6 to 4.5	≥4.6
I	5.6	3.2	0.5	0.1	0.1	0.1	0.1	0.1
II	15.4	26.4	7.3	3.1	1.6	0.9	0.4	0.6
III	0.7	5.9	2.8	1.0	0.6	0.4	0.1	0.2
IV	1.0	3.7	4.5	3.8	3.6	2.7	1.5	2.4

TABLE 2.3-11

AVERAGE HORIZONTAL RANGE

(Degrees)

Month	I	II	III	IV	All
Jan	60	30	20	<10	25
Feb	60	30	20	<10	30
Mar	70	30	20	<10	25
Apr	60	30	20	<10	30
May	70	25	20	<10	25
*Jun	55	25	20	10	25
*Jul	65	25	15	10	20
*Aug	65	20	20	10	20
*Sept	60	25	20	10	25
*Oct	60	30	20	<10	25
*Nov	55	30	20	<10	30
Dec	50	30	20	<10	30
Annual	60	30	20	<10	
sigma	12	6	3-4	< 2	

*2 months of data

TABLE 2.3-12

AVERAGE HORIZONTAL RANGE (DEGREE) FOR
WIND DIRECTIONS BETWEEN 130 AND 160 DEGREES

Turbulence Class

Month	I	II	III	IV	All
Jan	90	40	20	<10	10
Feb	80	30	20	<10	10
Mar	60	30	30	<10	10
Apr	50	40	20	<10	40
May	70	30	20	<10	30
*Jun	70	30	20	10	30
*Jul	60	30	20	10	20
*Aug	70	30	30	<10	30
*Sept	70	30	30	<10	30
Oct	60	30	20	<10	20
Nov	60	30	30	<10	30
Dec	60	30	30	-	30
Annual	70	30	20-30	10	

*2 months of data

TABLE 2.3-13

PERCENTAGE FREQUENCY OF WIND SPEED CLASSES

33ft Wind Speed

Turbulence Class	Calm	2-3	4-7	8-12	13-18	19+	All
I	0.6	2.5	4.4	1.7	0.3	0.0	9.5
II	0.7	4.1	20.9	20.0	8.6	1.8	56.1
III	0.0	0.3	2.6	5.3	2.6	0.7	11.4
IV	1.4	4.2	11.3	5.0	0.9	0.1	22.9
All	2.8	11.1	39.2	32.0	12.3	2.6	100.0

300-ft Wind Speed (mph)

Turbulence Class	Calm	2-3	4-7	8-12	13-18	19+	All
I	0.7	1.9	4.1	2.1	0.6	0.2	9.6
II	0.2	1.1	7.2	18.0	18.6	11.4	56.5
III	0.0	0.0	0.1	0.9	4.8	6.0	11.8
IV	0.4	1.0	3.8	7.1	6.8	3.1	22.2
All	1.3	4.0	15.2	28.1	30.8	20.8	100.0

TABLE 2.3-14

MEAN ANNUAL WIND SPEEDS
AT
VARIOUS LEVELS
(mph)

Turbulence Class	33 ft	300 ft
I	5.0	6.0
II	8.0	13.0
III	10.0	19.0
IV	5.0	12.0
All Hours	7.0	13.0

TABLE 2.3-15
WIND DATA RECOVERY
JUNE 1969 - MAY 1970
(percent)

Month	33-ft Level	300-ft Level
Jun 1969	85	85
Jul	67	67
Aug	92	85
Sep	64	65
Oct	96	97
Nov	86	96
Dec	93	94
Jan 1970	89	99
Feb	86	86
Mar	78	78
Apr	90	23
May	98	84
Annual	86	81

TABLE 2.3-16

METEOROLOGICAL INSTRUMENTATION

Height Above Tower Base (feet)	Sensed Parameter	Recorded Parameter
300	Wind Speed	Wind Speed
	Wind Direction	Wind Direction
	Temperature (a)	Temperature Difference

TABLE 2.3-16 (Cont.)

Height Above Tower Base (feet)	Sensed Parameter	Recorded Parameter
150	Wind Speed	Same
	Wind Direction	As
	Temperature (b)	Above
33	Wind Speed	Same
	Wind Direction	As
		Above
	Temperature Differential $T_{300} - T_{33}$(a) $T_{150} - T_{33}$(b)	
	Dew Point	Dew Point
	Temperature Ambient	Temperature

TABLE 2.3-16 (Cont.)

Height Above Tower Base (feet)	Sensed Parameter	Recorded Parameter
6	Barometric Pressure	Barometric Pressure
3	Rainfall	Rainfall

(a) Temperature taken as part of Temperature Differential Measurement $T_{300} - T_{33}$

(b) Temperature taken as part of Temperature Differential Measurement $T_{150} - T_{33}$

TABLE 2.3-16A

THIS TABLE HAS BEEN DELETED

TABLE 2.3-17

VENT RELEASE - EXIT VELOCITY OF 7.2 M/SECONDS

UNDEPLETED X/Q AT GROUND LEVEL APPLICABLE TO LONG

TERM (ROUTINE) GASEOUS RELEASES

(SECONDS/M^3)

SECTOR ANNUAL X/Q AT GROUND LEVEL

DISTANCE MILES	SECTOR BEARING (DEGREES) 22.5*	45.0	67.5	90.0	112.5	135.0	157.5	180.0
.25	1.492E-06	1.583E-06	1.277E-06	2.114E-06	1.837E-06	2.599E-06	1.811E-06	1.807E-06
.50	8.364E-07	9.285E-07	8.418E-07	1.221E-06	9.332E-07	1.282E-06	8.977E-07	1.028E-06
.75	5.310E-07	6.006E-07	5.664E-07	7.884E-07	5.747E-07	7.853E-07	5.499E-07	6.636E-07
1.00	3.633E-07	4.145E-07	3.976E-07	5.445E-07	3.880E-07	5.293E-07	3.705E-07	4.578E-07
1.10	3.176E-07	3.631E-07	3.498E-07	4.771E-07	3.380E-07	4.610E-07	3.226E-07	4.011E-07
1.20	2.800E-07	3.207E-07	3.100E-07	4.214E-07	2.972E-07	4.052E-07	2.835E-07	3.542E-07
1.30	2.487E-07	2.853E-07	2.766E-07	3.749E-07	2.634E-07	3.591E-07	2.512E-07	3.151E-07
1.40	2.225E-07	2.555E-07	2.483E-07	3.358E-07	2.351E-07	3.205E-07	2.242E-07	2.822E-07
1.50	2.002E-07	2.302E-07	2.242E-07	3.025E-07	2.112E-07	2.880E-07	2.014E-07	2.543E-07
1.60	1.812E-07	2.085E-07	2.034E-07	2.740E-07	1.909E-07	2.602E-07	1.819E-07	2.303E-07
1.70	1.648E-07	1.898E-07	1.855E-07	2.495E-07	1.734E-07	2.364E-07	1.652E-07	2.097E-07
1.80	1.506E-07	1.736E-07	1.698E-07	2.281E-07	1.583E-07	2.157E-07	1.508E-07	1.917E-07
1.90	1.382E-07	1.594E-07	1.561E-07	2.095E-07	1.451E-07	1.978E-07	1.382E-07	1.760E-07
2.00	1.273E-07	1.469E-07	1.441E-07	1.931E-07	1.335E-07	1.820E-07	1.272E-07	1.622E-07
2.10	1.177E-07	1.359E-07	1.334E-07	1.786E-07	1.233E-07	1.681E-07	1.174E-07	1.500E-07
2.20	1.092E-07	1.261E-07	1.239E-07	1.657E-07	1.143E-07	1.558E-07	1.088E-07	1.392E-07
2.30	1.015E-07	1.173E-07	1.154E-07	1.542E-07	1.063E-07	1.448E-07	1.012E-07	1.296E-07
2.40	9.473E-08	1.095E-07	1.077E-07	1.439E-07	9.905E-08	1.350E-07	9.429E-08	1.209E-07
2.50	8.859E-08	1.024E-07	1.009E-07	1.347E-07	9.258E-08	1.262E-07	8.812E-08	1.131E-07
2.60	8.305E-08	9.607E-08	9.464E-08	1.263E-07	8.674E-09	1.182E-07	8.256E-08	1.061E-07
2.70	7.804E-08	9.030E-08	8.901E-08	1.187E-07	8.146E-08	1.110E-07	7.752E-08	9.969E-08
2.80	7.348E-08	8.505E-08	8.388E-08	1.118E-07	7.666E-08	1.045E-07	7.295E-08	9.389E-08
2.90	6.932E-08	8.026E-08	7.919E-08	1.055E-07	7.229E-08	9.852E-08	6.879E-08	8.859E-08
3.00	6.552E-08	7.588E-08	7.490E-08	9.974E-08	6.830E-08	9.308E-08	6.498E-08	8.375E-08
3.10	6.203E-08	7.186E-08	7.097E-08	9.445E-08	6.464E-08	8.809E-08	6.149E-08	7.931E-08
3.20	5.883E-08	6.816E-08	6.735E-08	8.960E-08	6.127E-08	8.351E-08	5.829E-08	7.523E-08
3.30	5.588E-08	6.475E-08	6.401E-08	8.512E-08	5.818E-08	7.928E-08	5.534E-08	7.147E-08
3.40	5.315E-08	6.161E-08	6.092E-08	8.098E-08	5.532E-08	7.539E-08	5.262E-08	6.799E-08
3.50	5.063E-08	5.869E-08	5.806E-08	7.715E-08	5.267E-08	7.178E-08	5.010E-08	6.477E-08
3.60	4.829E-08	5.599E-08	5.540E-08	7.359E-08	5.022E-08	6.844E-08	4.776E-08	6.179E-08

* Compass Direction

TABLE 2.3-18

VENT RELEASE - EXIT VELOCITY OF 7.2 M/SECONDS

UNDEPLETED X/Q AT GROUND LEVEL APPLICABLE TO LONG TERM (ROUTINE) GASEOUS RELEASES

(SECONDS/M^3)

SECTOR ANNUAL X/Q AT GROUND LEVEL

DISTANCE MILES	SECTOR BEARING (DEGREES) 202.5	225.0	247.5	270.0	292.5	315.0	337.5	360.0
.25	1.113E-06	1.196E-06	8.330E-07	1.003E-06	5.579E-07	1.014E-06	1.619E-06	2.300E-06
.50	7.889E-07	7.386E-07	5.207E-07	6.487E-07	4.403E-07	7.496E-07	1.053E-06	1.277E-06
.75	5.407E-07	4.879E-07	3.452E-07	4.342E-07	3.105E-07	5.194E-07	7.043E-07	8.125E-07
1.00	3.824E-07	3.401E-07	2.408E-07	3.042E-07	2.222E-07	3.690E-07	4.931E-07	5.568E-07
1.10	3.370E-07	2.987E-07	2.115E-07	2.676E-07	1.965E-07	3.257E-07	4.336E-07	4.870E-07
1.20	2.991E-07	2.644E-07	1.872E-07	2.371E-07	1.748E-07	2.894E-07	3.841E-07	4.295E-07
1.30	2.672E-07	2.356E-07	1.668E-07	2.115E-07	1.565E-07	2.587E-07	3.425E-07	3.817E-07
1.40	2.401E-07	2.113E-07	1.496E-07	1.898E-07	1.409E-07	2.327E-07	3.074E-07	3.415E-07
1.50	2.170E-07	1.906E-07	1.350E-07	1.714E-07	1.275E-07	2.103E-07	2.774E-07	3.074E-07
1.60	1.970E-07	1.729E-07	1.224E-07	1.555E-07	1.159E-07	1.911E-07	2.517E-07	2.783E-07
1.70	1.797E-07	1.575E-07	1.115E-07	1.417E-07	1.058E-07	1.744E-07	2.294E-07	2.531E-07
1.80	1.647E-07	1.442E-07	1.021E-07	1.298E-07	9.707E-08	1.599E-07	2.100E-07	2.314E-07
1.90	1.515E-07	1.325E-07	9.377E-08	1.193E-07	8.937E-08	1.471E-07	1.931E-07	2.123E-07
2.00	1.398E-07	1.222E-07	8.648E-08	1.101E-07	8.256E-08	1.359E-07	1.781E-07	1.956E-07
2.10	1.295E-07	1.131E-07	8.003E-08	1.019E-07	7.652E-08	1.259E-07	1.649E-07	1.809E-07
2.20	1.203E-07	1.050E-07	7.430E-08	9.464E-08	7.114E-08	1.170E-07	1.531E-07	1.678E-07
2.30	1.121E-07	9.778E-08	6.917E-08	8.815E-08	6.632E-08	1.090E-07	1.426E-07	1.561E-07
2.40	1.047E-07	9.129E-08	6.458E-08	8.232E-08	6.199E-08	1.019E-07	1.332E-07	1.456E-07
2.50	9.806E-08	8.545E-08	6.044E-08	7.707E-08	5.808E-08	9.542E-08	1.247E-07	1.362E-07
2.60	9.204E-08	8.017E-08	5.670E-08	7.232E-08	5.454E-08	8.959E-08	1.170E-07	1.277E-07
2.70	8.658E-08	7.538E-08	5.331E-08	6.801E-08	5.133E-08	8.429E-08	1.100E-07	1.200E-07
2.80	8.161E-08	7.103E-08	5.022E-08	6.409E-08	4.840E-08	7.947E-08	1.036E-07	1.130E-07
2.90	7.707E-08	6.705E-08	4.740E-08	6.052E-08	4.573E-08	7.506E-08	9.785E-08	1.066E-07
3.00	7.291E-08	6.341E-08	4.483E-08	5.724E-08	4.320E-08	7.102E-08	9.255E-08	1.008E-07
3.10	6.909E-08	6.007E-08	4.246E-08	5.423E-08	4.102E-08	6.732E-08	8.768E-08	9.541E-08
3.20	6.558E-08	5.700E-08	4.029E-08	5.146E-08	3.895E-08	6.390E-08	8.320E-08	9.048E-08
3.30	6.233E-08	5.416E-08	3.828E-08	4.891E-08	3.703E-08	6.075E-08	7.907E-08	8.595E-08
3.40	5.934E-08	5.155E-08	3.643E-08	4.655E-08	3.526E-08	5.784E-08	7.526E-08	8.176E-08
3.50	5.656E-08	4.912E-08	3.471E-08	4.437E-08	3.362E-08	5.514E-08	7.172E-08	7.788E-08
3.60	5.398E-08	4.687E-08	3.312E-08	4.234E-08	3.210E-08	5.263E-08	6.844E-08	7.428E-08

TABLE 2.3-19

VENT RELEASE - EXIT VELOCITY OF 7.2 M/SECONDS

UNDEPLETED X/Q AT GROUND LEVEL APPLICABLE TO LONG

TERM (ROUTINE) GASEOUS RELEASES

(SECONDS/M^3)

SECTOR ANNUAL X/Q AT GROUND-LEVEL

DISTANCE	SECTOR BEARING (DEGREES)							
MILES	22.5	45.0	67.5	90.0	112.5	135.0	157.5	180.0
3.70	4.611E-08	5.347E-08	5.293E-08	7.029E-08	4.794E-08	6.534E-08	4.560E-08	9.901E-08
3.80	4.409E-08	5.113E-08	5.063E-08	6.721E-08	4.582E-08	6.245E-08	4.358E-08	5.643E-08
3.90	4.220E-08	4.895E-08	4.848E-08	6.434E-08	4.385E-08	5.975E-08	4.170E-08	5.402E-08
4.00	4.044E-08	4.691E-08	4.648E-08	6.166E-08	4.200E-08	5.724E-08	3.994E-08	5.176E-08
4.10	3.879E-08	4.500E-08	4.460E-08	5.915E-08	4.028E-08	5.489E-08	3.830E-08	4.966E-08
4.20	3.724E-08	4.322E-08	4.284E-08	5.680E-08	3.866E-08	5.268E-08	3.676E-08	4.768E-08
4.30	3.579E-08	4.154E-08	4.118E-08	5.459E-08	3.715E-08	5.062E-08	3.532E-08	4.583E-08
4.40	3.443E-08	3.996E-08	3.963E-08	5.252E-08	3.572E-08	4.867E-08	3.396E-08	4.408E-08
4.50	3.314E-08	3.847E-08	3.817E-08	5.056E-08	3.439E-08	4.685E-08	3.269E-08	4.244E-08
4.60	3.194E-08	3.708E-08	3.679E-08	4.872E-08	3.312E-08	4.513E-08	3.149E-08	4.090E-08
4.70	3.080E-08	3.576E-08	3.549E-08	4.699E-08	3.194E-08	4.351E-08	3.036E-08	3.944E-08
4.80	2.972E-08	3.451E-08	3.426E-08	4.535E-08	3.081E-08	4.197E-08	2.929E-08	3.807E-08
4.90	2.871E-08	3.333E-08	3.309E-08	4.380E-08	2.975E-08	4.053E-08	2.828E-08	3.676E-08
5.00	2.774E-08	3.222E-08	3.199E-08	4.233E-08	2.875E-08	3.916E-08	2.733E-08	3.553E-08
5.10	2.683E-08	3.116E-08	3.095E-08	4.094E-08	2.780E-08	3.786E-08	2.643E-08	3.437E-08
5.20	2.597E-08	3.016E-08	2.996E-08	3.962E-08	2.690E-08	3.663E-08	2.557E-08	3.326E-08
5.30	2.515E-08	2.921E-08	2.902E-08	3.837E-08	2.605E-08	3.546E-08	2.476E-08	3.221E-08
5.40	2.437E-08	2.831E-08	2.813E-08	3.718E-08	2.524E-08	3.436E-08	2.399E-08	3.121E-08
5.50	2.363E-08	2.745E-08	2.728E-08	3.604E-08	2.447E-08	3.330E-08	2.326E-08	3.026E-08
6.00	2.043E-08	2.373E-08	2.360E-08	3.114E-08	2.113E-08	2.874E-08	2.008E-08	2.615E-08
7.50	1.413E-08	1.639E-08	1.634E-08	2.145E-08	1.450E-08	1.975E-08	1.386E-08	1.804E-08
10.00	8.334E-09	1.028E-08	1.027E-08	1.336E-08	9.101E-09	1.229E-08	8.702E-09	1.128E-08
15.00	4.698E-09	5.396E-09	5.404E-09	6.929E-09	4.810E-09	6.367E-09	4.590E-09	5.890E-09
20.00	2.997E-09	3.414E-09	3.424E-09	4.347E-09	3.050E-09	3.995E-09	2.915E-09	3.714E-09
25.00	2.093E-09	2.385E-09	2.395E-09	3.019E-09	2.133E-09	2.774E-09	2.041E-09	2.583E-09
30.00	1.559E-09	1.773E-09	1.782E-09	2.236E-09	1.587E-09	2.054E-09	1.520E-09	1.921E-09
35.00	1.213E-09	1.377E-09	1.385E-09	1.731E-09	1.233E-09	1.590E-09	1.181E-09	1.490E-09
40.00	9.737E-10	1.104E-09	1.111E-09	1.386E-09	9.889E-10	1.272E-09	9.480E-10	1.194E-09
45.00	9.013E-10	9.080E-10	9.142E-10	1.138E-09	8.132E-10	1.044E-09	7.798E-10	9.812E-10
50.00	6.725E-10	7.616E-10	7.671E-10	9.529E-10	6.821E-10	8.743E-10	6.542E-10	8.226E-10

Table 2.3-20

VENT RELEASE - EXIT VELOCITY OF 7.2 M/SECONDS
UNDEPLETED X/Q AT GROUND LEVEL APPLICABLE TO LONG
TERM (ROUTINE) GASEOUS RELEASES
(SECONDS/M^3)
SECTOR ANNUAL X/Q AT GROUND LEVEL

SECTOR BEARING (DEGREES)

DISTANCE MILES	202.5	225.0	247.5	270.0	292.5	315.0	337.5	360.0
3.70	5.158E-08	4.478E-08	3.164E-08	4.048E-08	3.068E-08	5.030E-08	6.538E-08	7.093E-08
3.80	4.934E-08	4.283E-08	3.026E-08	3.870E-08	2.935E-08	4.813E-08	6.254E-08	6.782E-08
3.90	4.725E-08	4.101E-08	2.897E-08	3.706E-08	2.812E-08	4.610E-08	5.989E-08	6.492E-08
4.00	4.531E-08	3.931E-08	2.777E-08	3.553E-08	2.696E-08	4.420E-08	5.741E-08	6.220E-08
4.10	4.348E-08	3.772E-08	2.665E-08	3.409E-08	2.588E-08	4.243E-08	5.508E-08	5.966E-08
4.20	4.177E-08	3.623E-08	2.559E-08	3.275E-08	2.486E-08	4.076E-08	5.291E-08	5.729E-08
4.30	4.016E-08	3.483E-08	2.460E-08	3.148E-08	2.391E-08	3.919E-08	5.086E-08	5.505E-08
4.40	3.865E-08	3.351E-08	2.367E-08	3.030E-08	2.301E-08	3.772E-08	4.894E-08	5.295E-08
4.50	3.723E-08	3.227E-08	2.280E-08	2.918E-08	2.216E-08	3.634E-08	4.713E-08	5.098E-08
4.60	3.588E-08	3.111E-08	2.198E-08	2.813E-08	2.136E-08	3.503E-08	4.542E-08	4.912E-08
4.70	3.462E-08	3.001E-08	2.120E-08	2.714E-08	2.061E-08	3.380E-08	4.382E-08	4.737E-08
4.80	3.342E-08	2.897E-08	2.047E-08	2.620E-08	1.989E-08	3.264E-08	4.230E-08	4.571E-08
4.90	3.229E-08	2.798E-08	1.977E-08	2.531E-08	1.922E-08	3.153E-08	4.086E-08	4.414E-08
5.00	3.122E-08	2.705E-08	1.912E-08	2.447E-08	1.858E-08	3.049E-08	3.950E-08	4.266E-08
5.10	3.021E-08	2.617E-08	1.850E-08	2.368E-08	1.797E-08	2.950E-08	3.821E-08	4.125E-08
5.20	2.924E-08	2.534E-08	1.791E-08	2.292E-08	1.739E-08	2.857E-08	3.698E-08	3.992E-08
5.30	2.833E-08	2.454E-08	1.735E-08	2.221E-08	1.685E-08	2.768E-08	3.582E-08	3.866E-08
5.40	2.746E-08	2.379E-08	1.682E-08	2.153E-08	1.633E-08	2.683E-08	3.472E-08	3.746E-08
5.50	2.663E-08	2.307E-08	1.632E-08	2.088E-08	1.583E-08	2.602E-08	3.367E-08	3.631E-08
6.00	2.305E-08	1.996E-08	1.413E-08	1.808E-08	1.367E-08	2.253E-08	2.911E-08	3.136E-08
7.50	1.597E-08	1.384E-08	9.851E-09	1.256E-08	9.372E-09	1.563E-08	2.010E-08	2.158E-08
10.00	1.005E-08	8.740E-09	6.296E-09	7.964E-09	5.746E-09	9.856E-09	1.257E-08	1.344E-08
15.00	5.303E-09	4.640E-09	3.419E-09	4.256E-09	2.875E-09	5.211E-09	6.550E-09	6.957E-09
20.00	3.366E-09	2.958E-09	2.212E-09	2.726E-09	1.757E-09	3.312E-09	4.123E-09	4.361E-09
25.00	2.356E-09	2.076E-09	1.568E-09	1.919E-09	1.199E-09	2.320E-09	2.870E-09	3.027E-09
30.00	1.754E-09	1.549E-09	1.178E-09	1.435E-09	8.768E-10	1.729E-09	2.129E-09	2.241E-09
35.00	1.364E-09	1.206E-09	9.211E-10	1.119E-09	6.731E-10	1.345E-09	1.651E-09	1.735E-09
40.00	1.095E-09	9.692E-10	7.427E-10	8.999E-10	5.352E-10	1.081E-09	1.323E-09	1.388E-09
45.00	9.012E-10	7.981E-10	6.132E-10	7.417E-10	4.373E-10	8.896E-10	1.087E-09	1.139E-09
50.00	7.564E-10	6.703E-10	5.160E-10	6.233E-10	3.650E-10	7.469E-10	9.110E-10	9.540E-10

TABLE 2.3-21

ACCIDENT X/Q ESTIMATES
(sec/m^3)

EAB (0.79 Miles)	2 Hours	8 Hours	16 Hours	3 Days	26 Days	Annual
Conservative Estimate	1.30E-04	6.07E-05	4.15E-05	1.82E-05	5.55E-06	1.30E-06
Realistic Estimate	3.00E-05	1.79E-05	1.38E-05	7.87E-06	3.51E-06	1.31E-06
LPZ (5.0 Miles)						
Conservative Estimate	1.86E-05	7.76E-06	5.01E-06	1.94E-06	4.96E-07	9.37E-08
Realistic Estimate	2.35E-06	1.38E-06	1.06E-06	5.93E-07	2.59E-07	9.37E-08

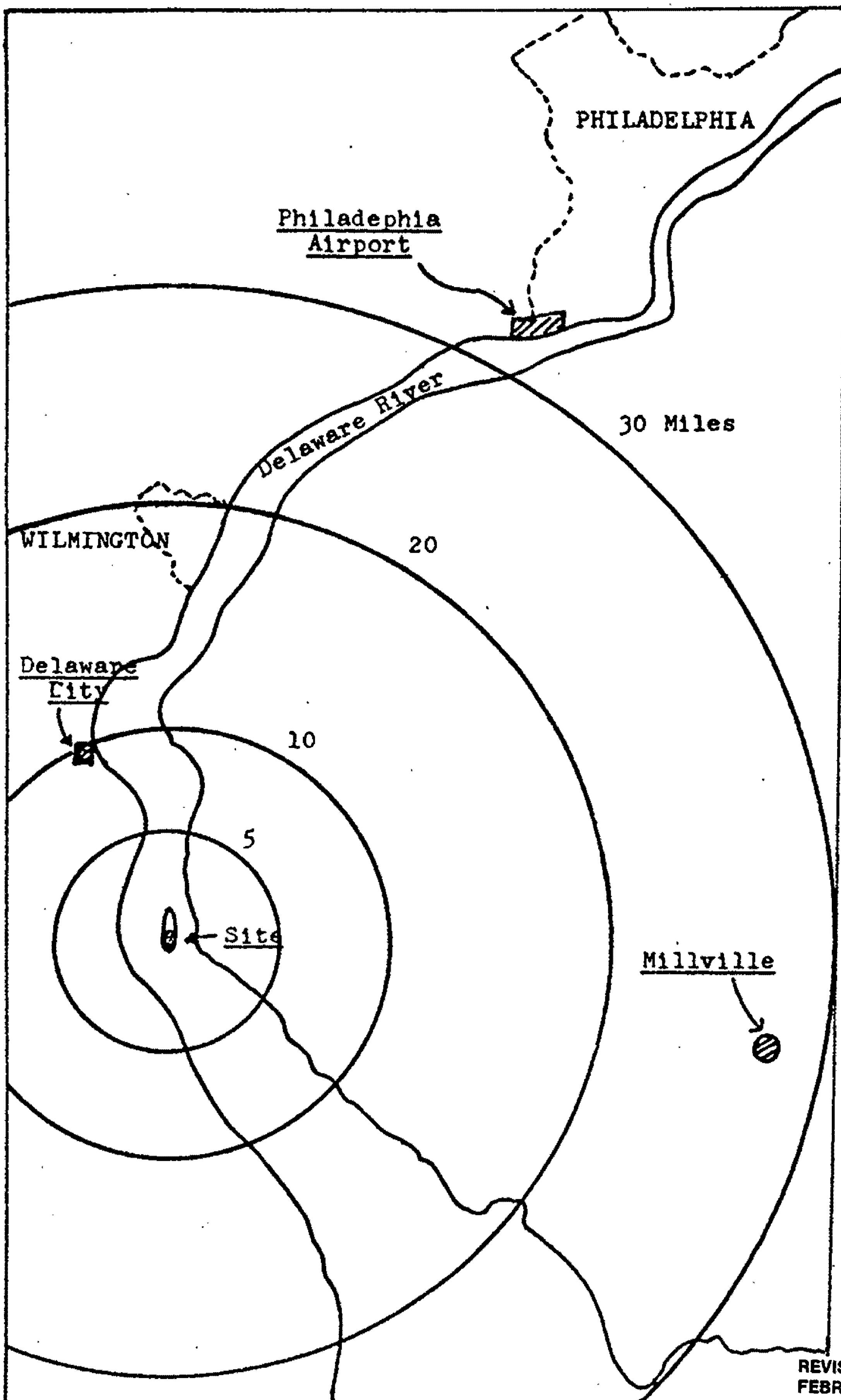
TABLE 2.3-22

ACCIDENT X/Q VALUES AT LPZ BY SECTOR
(sec/m^3)

Sector Bearing	0.5 percent (2) X/Q	Annual X/Q
NNE	8.20E-06	7.26E-08
NE	9.20E-06	7.73E-08
ENE	8.80E-06	6.23E-08
E	7.70E-06	6.04E-08
ESE	7.00E-06	6.11E-08
SE	8.40E-06	8.27E-08
SSE	8.40E-06	7.76E-08
S	1.00E-05	8.02E-08
SSW	1.20E-05	8.93E-08
SW	1.20E-05	8.77E-08
WSW	1.05E-05	6.62E-08
W	9.40E-06	5.42E-08
WNW	9.50E-06	5.10E-08
NW	1.86E-05 (1)	9.37E-08
NNW	1.40E-05	8.59E-08
N	8.50E-06	6.61E-08
Overall 5 percent	1.29E-05	

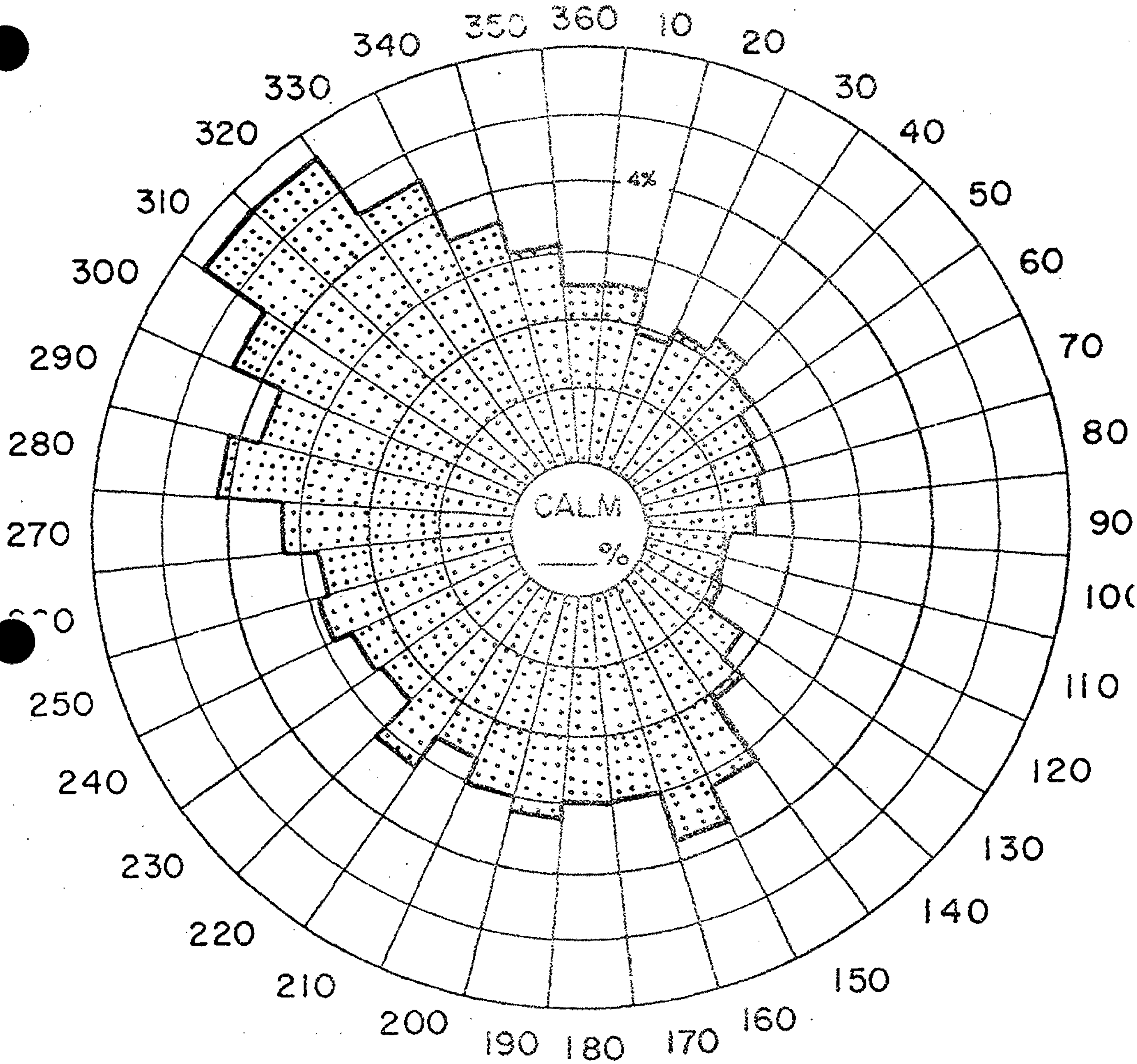
(1) 1.86E-05 is the maximum 0.5 percent X/Q (Conservative at the LPZ)

(2) Two Hour value



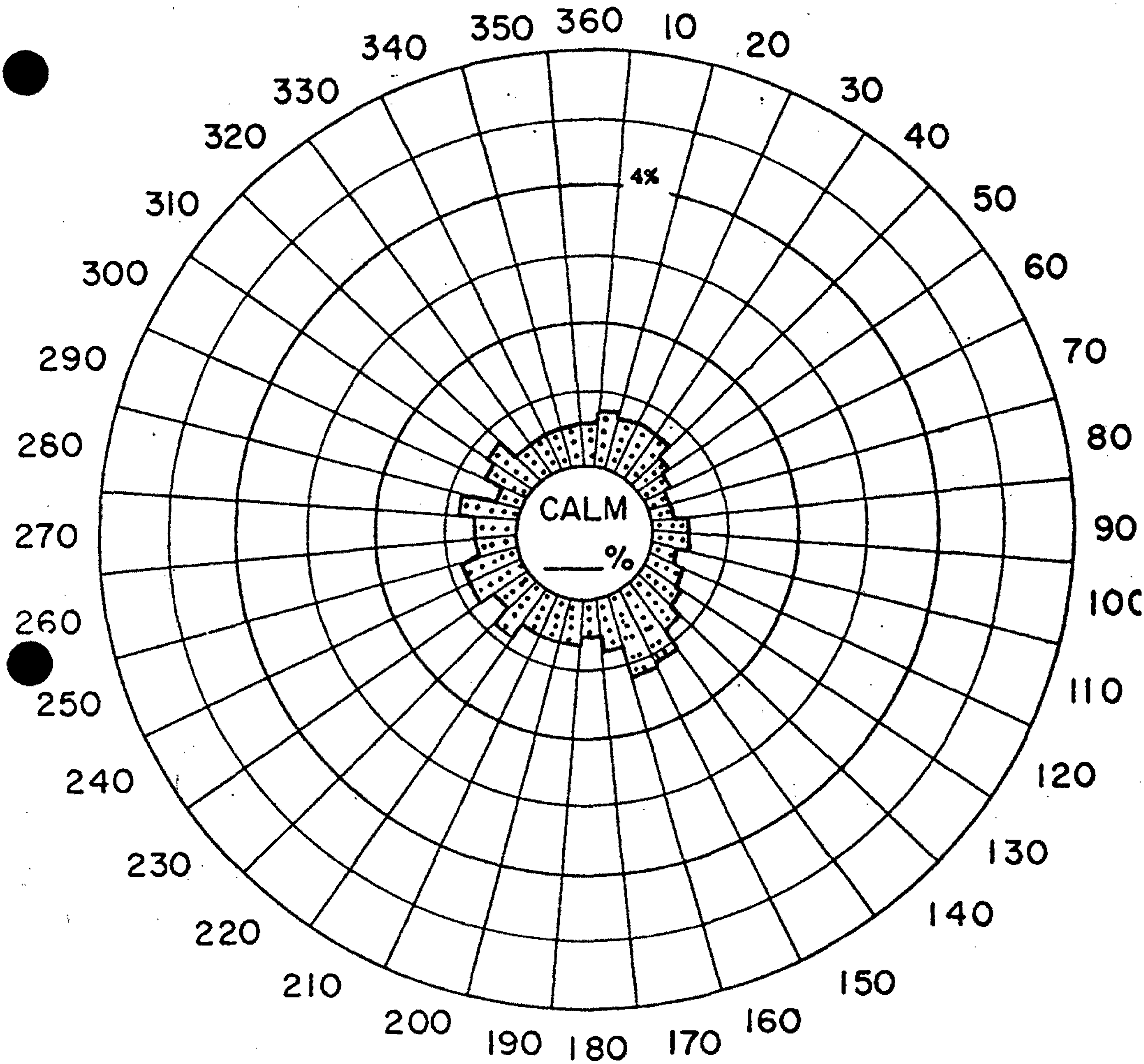
REVISION 6
FEBRUARY 15, 1987

PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Sources of Meteorological Records
	Updated FSAR — Figure 2.3-1



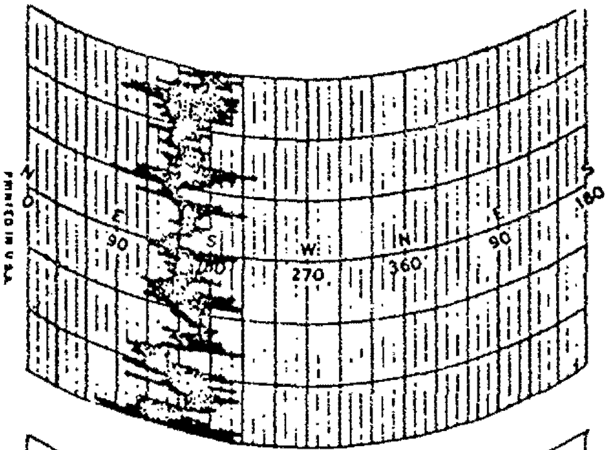
REVISION 6
FEBRUARY 15, 1987

PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Two-Year Wind Rose - All Hours	
	Updated FSAR	Figure 2.3-2



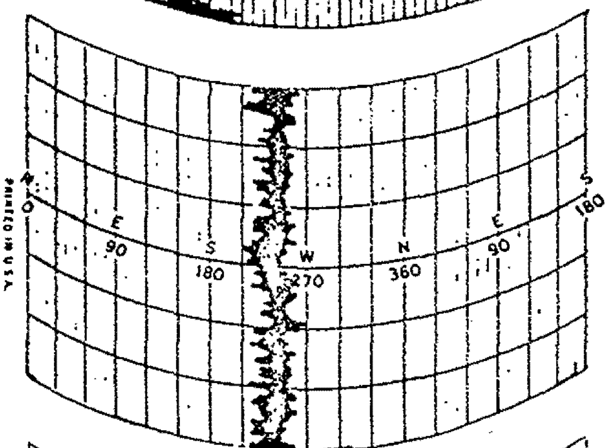
REVISION 6
FEBRUARY 15, 1987

PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Two-Year Wind Rose - Only Hours With a Stabile Stability
	Updated FSAR — Figure 2.3-3



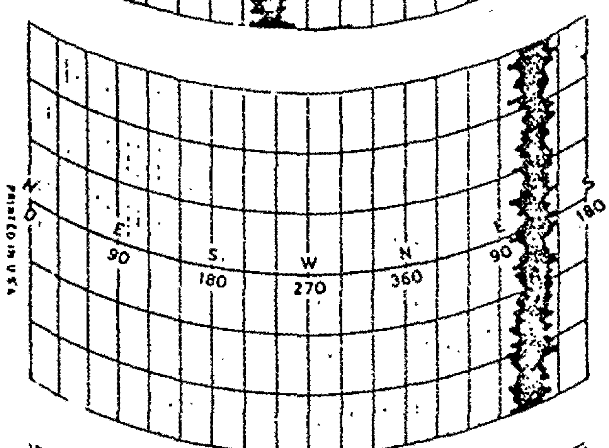
CLASS I

LARGE, LAZY CONVECTIVE EDDIES CAUSED BY HEATING AIR CLOSE TO THE GROUND. MOST FREQUENT ON SUMMER MORNINGS WHEN WIND SPEEDS ARE LIGHT AND LAKE BREEZES ARE NOT PRESENT.



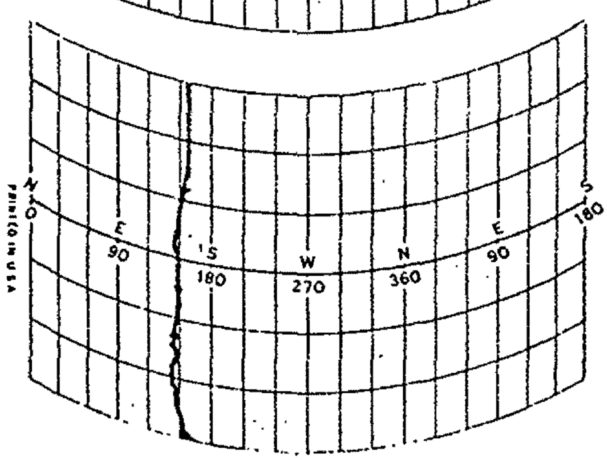
CLASS II

TYPICAL DAYTIME TRACE HAVING A MIXTURE OF CONVECTIVE AND MECHANICAL TURBULENCE. FLUCTUATIONS ARE MORE SUBDUED WITH ONSHORE WINDS THAN OFFSHORE.



CLASS III

TYPICAL TURBULENCE ASSOCIATED WITH OVERCAST, STORMY, OR NOCTURNAL SITUATIONS HAVING RELATIVELY STRONG WINDS. MECHANICAL TURBULENCE PREDOMINATES.

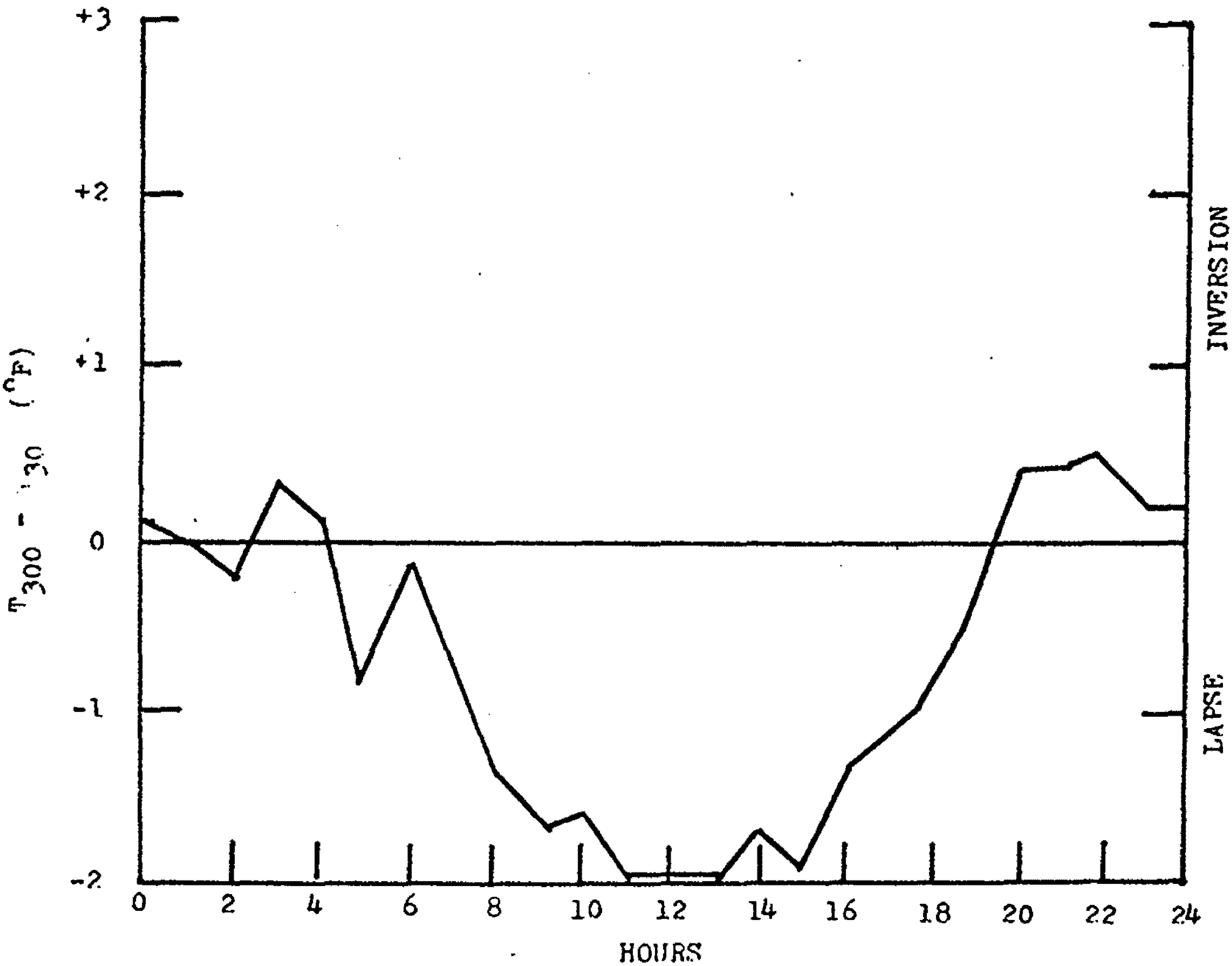


CLASS IV

CLASSIC TEMPERATURE INVERSION CASE WITH ALMOST NO TURBULENCE EITHER NOCTURNAL OR OR ASSOCIATED WITH DAYTIME LAKE BREEZES, ESPECIALLY IN THE SPRING.

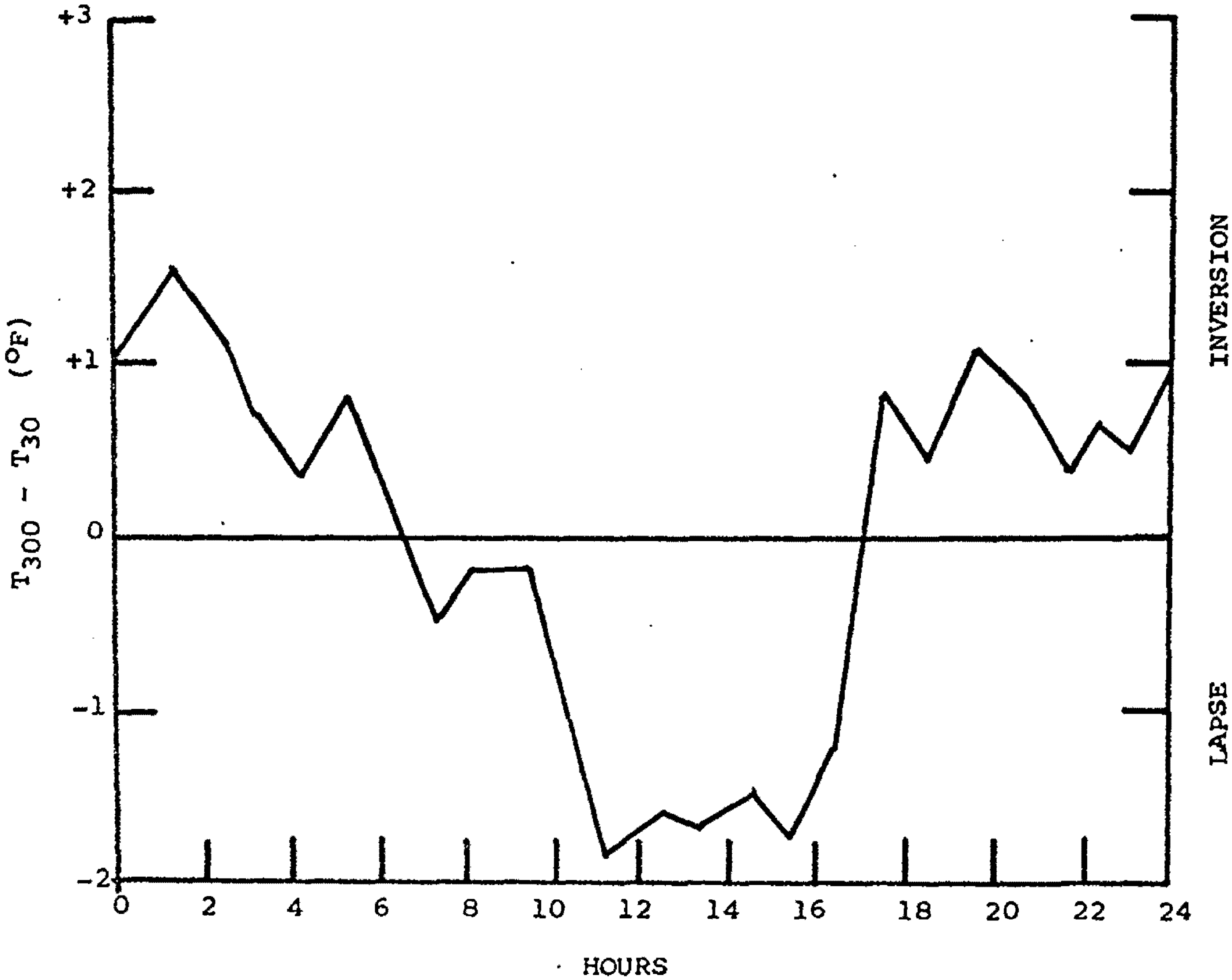
REVISION 6
FEBRUARY 15, 1987

PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Definition of Turbulence Classes	
	Updated FSAR	Figure 2.3-4



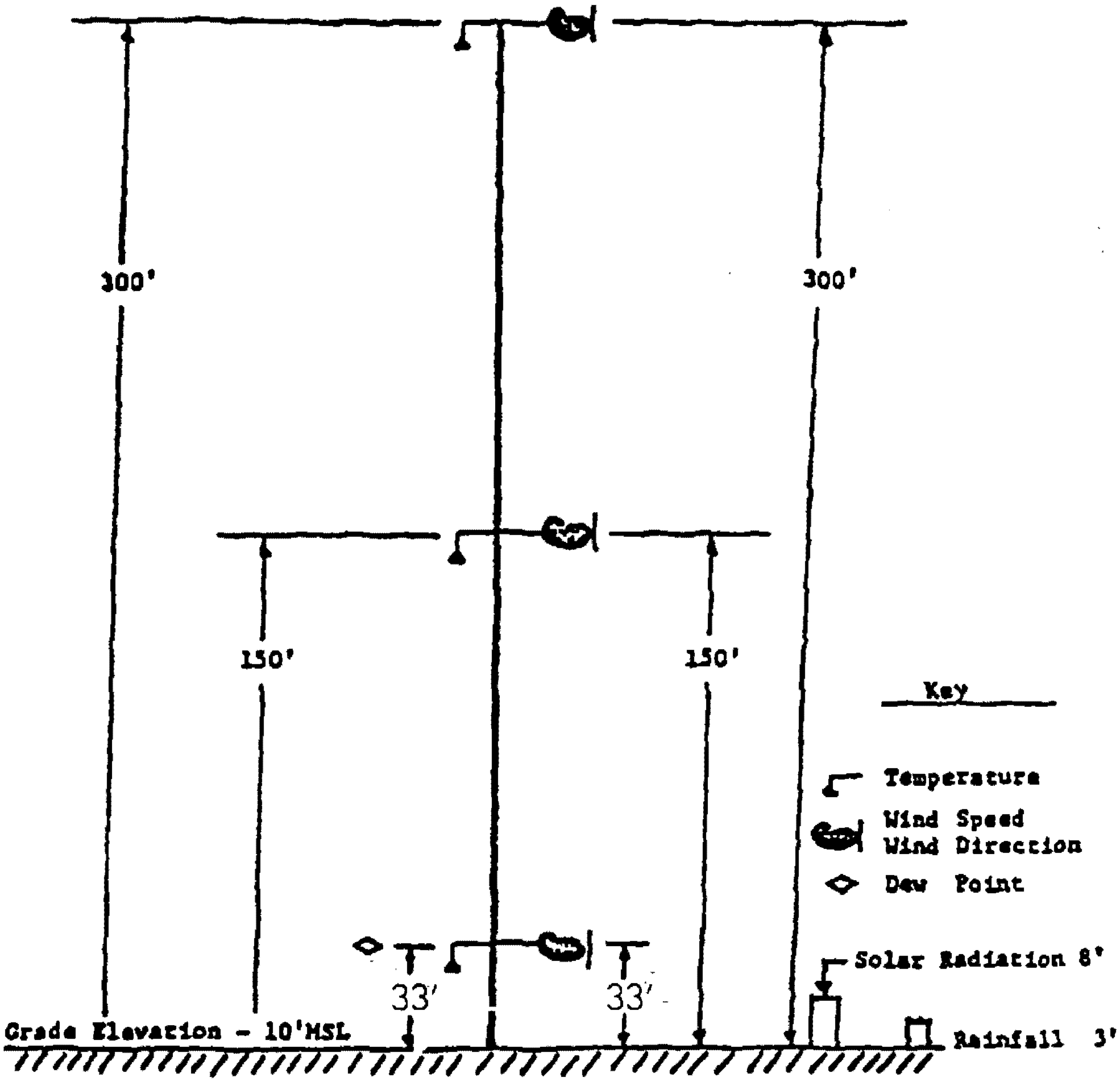
REVISION 6
FEBRUARY 15, 1987

PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Diurnal Variation of Lapse Rate June 1970
	Updated FSAR — Figure 2.3-5



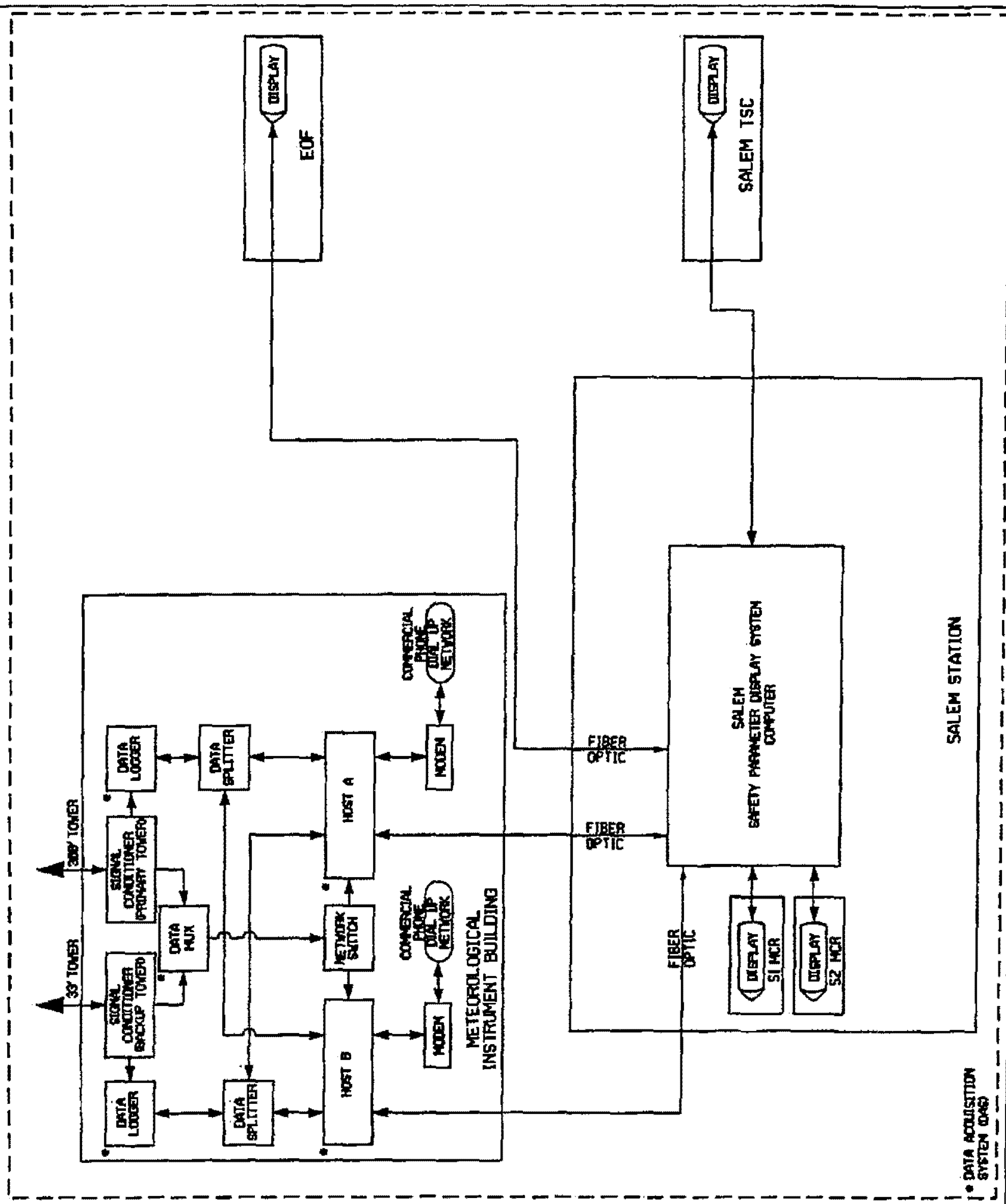
REVISION 6
FEBRUARY 15, 1987

PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Diurnal Variation of Lapse Rate December 1970	
	Updated FSAR	Figure 2.3-6



Revision 18, April 26, 2000

PSEG Nuclear, LLC SALEM NUCLEAR GENERATING STATION	Salem Nuclear Generating Station METEOROLOGICAL TOWER SCHEMATIC Updated FSAR — Figure 2.3-7



Revision 24
May 11, 2009

PSEG Nuclear, LLC SALEM NUCLEAR GENERATING STATION	Salem Nuclear Generating Station METEOROLOGICAL DATA AQUISITION DISPLAY SYSTEM
	Updated FSAR — Figure 2.3-8

APPENDIX 2.3A

THIS APPENDIX INTENTIONALLY DELETED

2.4 HYDROLOGIC ENGINEERING

2.4.1 Hydrologic Description

2.4.1.1 Site and Facilities

The site is located on an irregularly shaped prominence in the Delaware Estuary. It is believed that hydraulic fill, dredged from the Delaware River or Bay was placed on and between two small bars. The preconstruction configuration of the area is shown on Figure 2.4-1, Map of Area.

The area was and is quite flat, previously having an average elevation of about 9 feet above sea level. This was raised slightly in the plant area, to Elevation +10.5 Mean Sea Level (MSL) or 99.5 Public Service Datum (PSD). A levee, about 10 feet high, had been constructed around most of the westerly bar. As subsequently discussed, this levee became the basis for a protective sea wall. The predominant form of vegetation is Phragmites, a rather tall reed-like grass which is characteristically found in low-lying wetlands in the region.

Aside from the access roads and bridges, the only modification to the island and the adjacent river and marsh area is within the station construction area in this area. The site grade has been raised about 1 1/2 feet except for the protective structures at the shoreline. There is a slight gradient toward the Delaware Estuary. The present configuration of the site is shown on Plant Drawing 232091.

There was no established systematic surface-drainage system on the site prior to construction. Precipitation either ran off to the Delaware Estuary in a random pattern or collected in puddles where it infiltrated into the ground or evaporated. All surface drainage at the site flowed directly into the Delaware Estuary.

The island upon which the site is located is separated from the New Jersey mainland by Hope Creek, a tidal stream which connects Alloways Creek with the Delaware Estuary. Hope Creek drains a rather large marsh, and has undergone some channel dredging and straightening. It is a brackish water stream and is used to a small extent for fishing and hunting.

Studies of historical high and low water elevations indicated a maximum high water mark of 8.5 feet MSL datum, Sandy Hook (+97.5 PSD), and minimum water level of -5.9 feet MSL datum (83.1 PSD).

Station structures have been designed to not only withstand extreme recorded water levels, but also postulated extreme conditions, as subsequently discussed. Safety-related structures have been designed as follows:

1. The service water pumps can operate to a low water level of 76 feet PSD.

2. The service water structure is shown on Plant Drawing 211612. The portion of the service water intake enclosing the pumps, motors, and vital switchgear is watertight up to Elevation 126 feet PSD with wave runup protection to elevation 128 feet PSD. The service water intake can also withstand the static and dynamic effects of the storm. Each vertical, turbine type service water pump column bowl and suction bell is installed in an individual chamber which is open to the river. The chamber is isolated from the watertight compartments where the pump discharge heads and motors are located. The pump discharge heads are bolted down to pads at Elevation 92 feet 6 inches. The joint between the pump discharge head and the pad at Elevation 92 feet 6 inches is watertight to prevent leakage of water into the compartments. Provisions have also been made to prevent leakage from the discharge head glands and leakoff connections into the watertight compartments. A sump pump is provided in each

compartment to remove any accumulated water in the event a minor leak should occur.

3. All safety-related structures are watertight.

4. The Containment is, by nature, watertight and can withstand the static and dynamic loads associated with a storm producing a stillwater level of 113.8 feet PSD and the corresponding wave runup to 120.4 feet PSD (See Section 2.4.5 for the design storm water levels.)

5. The Auxiliary Building is watertight up to Elevation 115 feet PSD. All doors in the outer Auxiliary Building walls below Elevation 120.4 feet are watertight. All watertight doors and structural walls can withstand the static and dynamic effects associated with a storm that produces a stillwater level of 113.8 feet PSD with wave runup to Elevation 120.4 feet. Conduit penetrations above Elevation 115 feet and below Elevation 120.4 feet are packed to eliminate gross inleakage during the design storm.

   Each residual heat removal pump room, the lowest point in the Auxiliary Building, contains two sump pumps, each adequate to provide the minimum capacity of 50 gpm.

6. The main steam and feedwater pipe penetration area is watertight below Elevation 120.4 feet. The structural walls and watertight doors are also capable of withstanding the static and dynamic effects of the storm

which produces a stillwater level of 113.8 feet PSD and wave runup to 120.4 feet PSD.

2.4.1.2 Hydrosphere

The station is located on the east shore of the estuarian zone of the Delaware River - Delaware Bay system. Delaware River flow enters the head of Delaware Bay 2 miles downstream of the site. The largest tributaries of the Delaware River are the Schuylkill River in Pennsylvania; the Christina River in Delaware; the Assunpink, Crosswicks, Rancocas, and Salem Rivers; and Big Timbers, Hope, and Alloways Creeks in New Jersey.

The head of the Delaware Estuary is at Trenton, New Jersey, about 83 miles upstream of the site. The Chesapeake and Delaware Canal, which connects the Delaware River with Chesapeake Bay, is located about 7 miles north of the Salem site. Figure 2.4-4 presents the site location in relation to the surrounding area.

The Delaware River has a drainage area of 12,765 square miles and its average freshwater discharge into the head of the estuary at Trenton is about 12,000 cfs (16,000 cfs at the site). The average tidal flow at Wilmington, Delaware, about 20 miles above the site, has measured at 400,000 cfs. Hence the tidal flow, which greatly exceeds the runoff flow, dominates the flow velocity at the site. The normal daily range in the height of the tide at the site is 5.8 feet. Larger fluctuations have been caused by hurricanes which bring heavy precipitation and may cause storm surges and severe wave action, and by strong northerly winds which push the Delaware River water into Delaware Bay. The highest tide ever recorded in the vicinity of the site (+8.5 feet MSL) occurred in November 1950. The lowest tide likely experienced, based on projections of data recorded at Reedy Point, Delaware, would have occurred on January 25, 1939 (-5.9 feet MSL). Hence, the maximum estimated historical tidal range is about 14.4 feet.

The net tidal flow has been estimated at 400,000 cfs, which produces a relatively high current velocity in the station vicinity.

Some small dams are in existence well upstream of the site (in New York State). Currently no major dams are planned for the river. As subsequently discussed (Section 2.4.2) the existence of dams upon the Delaware River does not influence the site safety analysis.

The nearest public water supply is located about 8 miles northeast of the site. It utilizes both surface water and groundwater. There are five other public water supplies in New Jersey within 25 miles of the site and five in Delaware within 15 miles of the site. All are located upgradient from the site.

Private water supplies in the area utilize groundwater as a source of water. The nearest producing well is located more than 2 miles from the site. There are 20 known wells in New Jersey within 4 miles of the site. All are located upgradient from the site. For a more detailed discussion of groundwater supplies, see Section 2.4.13.

2.4.2 Floods

The water body to the west of the site is considered to be a tidally affected estuary by the U. S. Geologic Survey. As such, water levels are recorded by tidal gauges and no "flood record" is kept. The tidal flow in the site area is estimated to be more than an order of magnitude greater than the average fresh water flow in the site vicinity. Thus, maximum and minimum water levels that may be of concern to plant safety were derived through considerations of coastal environmental conditions rather than riverine conditions.

2.4.3 Probable Maximum Flood

Not applicable, see Sections 2.4.2 and 2.4.5.

2.4.3.1 Probable Maximum Precipitation

The maximum probable rainfall is of consideration only in design of yard drainage facilities and as a possible loading on critical structures, not as it may pertain to river flooding.

The Yard Drainage System is designed to pass the drainage associated with a rainfall rate of 4 inches per hour for a period of 20 minutes (based on 90 percent runoff from paved areas and 50 percent runoff from graded areas). This rainfall intensity has a return frequency of 15 years (see Figure 2.4-5) and therefore, an unusually severe storm producing a rainfall rate in excess of 4 inches per hour for time periods of less than 20 minutes can be handled by the system.

In the unlikely event that the Yard Drainage System were to be loaded beyond its capacity, the excess water would accumulate and run off as the storm subsided. All doors and penetrations in the Class I (seismic) buildings are watertight up to Elevation 115 feet (PSD). The interior drains in the Auxiliary and Fuel Handling Buildings are independently piped to the Liquid Waste Disposal System and are not connected to the Yard Drainage System.

Roof drains are designed to dispose of a maximum rainfall rate of 4 inches per hour for a period of 20 minutes through the Yard Drainage System. Roof slabs are watertight to prevent building interiors from being damaged by severe rainstorms. The slabs are designed to withstand a loading equivalent to a depth of water up to the full height of the building's parapet or roof curb. In the unlikely event that some of the roof drains become plugged, the backed up water will spill down the outside of the building. Wall penetrations above Elevation 115 feet (PSD) on Class I

(seismic) buildings are designed to prevent roof spillage or heavy rain from seeping inside the building.

In the event the capacity of the Yard Drainage System were to be exceeded as a result of an unusually severe rainstorm, the excess water would accumulate in puddles in the vicinity of the catch

basins and run off. This water would not enter any safety-related structure, since these structures are watertight up to Elevation 115 feet (PSD). Therefore, safety-related equipment would not be adversely affected as a result of a severe rainstorm.

2.4.4 Potential Dam Failures

Not applicable, see Sections 2.4.2 and 2.4.5.

2.4.5 Probable Maximum Surge and Seiche Flooding

2.4.5.1 Probable Maximum Winds and Associated Meteorological Parameters

Probable Maximum Hurricane (PMH) storm surges have been calculated for the site using the bathystropic storm tide theory described by Marinos and Woodward (1968) (1). The hurricane surge was computed at the mouth of Delaware Bay and routed up the bay in accordance with a method described by Bretschneider (1959) (2).

Components of the stillwater level are 1) the mean low water depth, 2) the astronomical tide, 3) the rise in water level resulting from the hurricane's atmospheric pressure reduction, 4) the wind stress component perpendicular to the bottom contours (onshore wind components), 5) the wind stress component parallel to the bottom contours which produces a longshore flow that is deflected to the right (in the northern hemisphere) by the Coriolis forces, and 6) the initial surge (a slow general rise in sea level existing before the actual hurricane winds arrive).

The PMH is defined by the U. S. Department of Commerce Report HUR 7-97 (3) as: "A hypothetical hurricane having that combination of characteristics which will make it the most severe that can probably occur in the particular region involved. The hurricane should approach the point under study along a critical path and at an optimum rate of movement." Indices used to calculate maximum storm surge are taken in part from HUR 7-97 where values are grouped according to defined coastal zones and by latitude within each zone. The following parameters and characteristics are based on empirical observations, assumptions, and experience. PMH indices and parameters include:

1. CPI (P_o) - The maximum surface pressure in the center of a particular hurricane, in inches of mercury.

2. Asymptotic Pressure (P_n) - The surface pressure at the outer limits of the hurricane, in inches of mercury.

3. Radius of Maximum Winds (R) - The distance from the storm center to the point of maximum wind velocity in nautical miles.

4. Forward Speed (V_t) - Rate of forward movement of the center of the storm, in knots.

5. Maximum Wind Speed (^{U}Max) - The absolute highest surface wind speed in the belt of maximum winds (measured as a maximum average 10-minute wind at a height of 30 feet above the water) calculated using equations from HUR 7-97.

6. PMH Path - The path selected for the PMH's approach is a critical factor, which in combination with other indices will determine the duration and magnitude of the storm winds over the critical fetch and the resulting peak hurricane surge elevation at the site. The path which produces peak hurricane surge will approach the area of

interest normal to the general bottom contours. The hurricane's center will pass to the left (when facing shoreward) of the profile through the bay by a distance that allows the hurricane's maximum winds to pass directly over this profile.

7. Astronomical Tide (Ha) - Data for the predicted high astronomical tides are taken from the National Oceanic and Atmospheric Administration Tide Tables.

8. Initial Surge (Hi) - The initial surge is attributed to a tidal anomaly evaluated on the basis of variations between the observed and predicted tide. Data for initial surge as determined by the Coastal Engineering Research Center (CERC) were used.

9. Bottom Friction Coefficient (k) - The bottom friction coefficient is a function of several variables, among them the slope and width of the Continental Shelf in the area of study.

10. Wind Speed Adjustment Near Shore - The computed overwater wind must be adjusted when moving onshore. The overwater wind field was reduced, from its full value 2 miles offshore to 0.89 of its full value at the shoreline.

11. Wind Stress Factor - The wind stress factor is generally given as a function of wind speed, although other variables enter into its determination. The wind stress factor relationship suggested by CERC was used for the surge computations in this report.

Analyses were undertaken to predict the surge heights at the mouth of Delaware Bay generated by a PMH at latitude 39°N. Maximum surge elevation was calculated by moving the hurricanes across the continental shelf on a track normal to the bathymetric contours.

The track of the postulated hurricane is shown on Figure 2.4-6. Two different forward speeds of translation were used to determine the effect that the rate of forward movement of the hurricane would have on the surge elevation.

The PMH utilized in the analyses was a large radius, moderate forward speed hurricane which generated the maximum surge on the open coast. The quantitative meteorological parameters describing the PMH are:

1. CPI: 27.09 inches Hg

2. Peripheral Pressure: 30.72 inches Hg

3. Radius of Maximum Winds: 39 nautical miles

4. Maximum Wind Speed: 132 miles per hour

5. Forward Speed: 27 knots

A computer program was developed by Dames and Moore using previous work by the Galveston District Corps of Engineers.

The program is described by Marinos and Woodward (1968) (1). Input data to the computer program describing the storm and the bathymetric conditions included the basic parameters of the hurricane, an initial surge of 1 foot, wind friction factor, bottom friction factor (0.008), wind speed at various radial distances and angles of wind direction relative to the translational velocity vector of the hurricane, bathymetric traverse data and astronomical tide (5.6 feet).

Winds which approach the site from a direction off the axis of the bay produce a component which is perpendicular to the axis of the bay. This cross-wind component causes the water surface to be raised on the upwind side of the bay and depressed an equal amount on the downwind side of the bay.

As the PMH is moved along its postulated track, wind speed and direction at the site change because of the effects of friction and filling over land and also because of the position of the storm center with respect to the site. The cross-wind effects were calculated for the six wind directions chosen for analysis. The six wind directions or fetches radiate downbay from the site at 15-degree intervals from the east bank of Delaware Bay.

The calculations consist of determining the corrected wind speed along the fetch, the cross-wind component of the wind speed, and the resulting cross-wind setup or drawdown. A summary of the calculations for each of the fetches is presented in Table 2.4-1.

The wind speed was corrected to include the effect of the fetch distance from the storm center and also for friction and filling overland.

The computer maximum surge elevation at the mouth of Delaware Bay was 21.9 feet above mean low water. This surge included the effects of the astronomical high spring tide.

The maximum surge of 21.9 feet above mean low water at the mouth of Delaware Bay was routed to the site using the procedure of Bretschneider (1959) (2). The model surge hydrographs for Delaware Bay computed by Bretschneider were then used to determine hurricane surge values at the Salem site (which is within Bretschneider's Section 4) as a function of time.

The maximum stillwater elevation at the site is a combination of the storm surge and the crosswind setup or drawdown. Storm surge elevations have been calculated for the six fetches chosen and are presented in Table 2.4-1 with the computed crosswind setup and the maximum stillwater elevation at the site. The six wind fetches radiate downbay from the site at 15-degree intervals from the east bank of the Delaware Bay. Subsequently, site hydrologic design parameters were developed using a maximum surge elevation of

113.8 feet PSD, as recommended by the Nuclear Regulatory Commission consultants.

Table 2.4-2 contains a list of agencies and individuals contacted relative to this section.

2.4.5.2 Surge and Seiche History

A review of local tidal gage history indicates that the maximum recorded water level was +8.5 feet MSL. It was recorded in November 1950. The lowest recorded level reached -5.9 feet MSL on January 25, 1939. The lowest "historic" water levels at the site that could be postulated from projections of data recorded in Philadelphia (December 31, 1962) (4) is -8.0 feet MSL.

2.4.5.3 Surge and Seiche Sources

The most severe storm postulated for the site is the PMH. The PMH indices developed by the U. S. Department of Commerce studies (Memorandum HUR 7-97) (3) and utilized by CERC were described in Section 2.4.5.1.

2.4.5.4 Wave Action

The primary factors influencing the generation of waves will be the maximum wind speed over the water, the effective fetch length, and the average depth of water along the fetch. The values of these parameters used in the computations of wave heights and periods were determined for the fetches analyzed by:

1. Determining the location of the center of the storm required to produce winds along the fetch,

2. Calculating corrected wind speeds to account for friction and filling over the land and distance from the storm center to the fetch center,

3. Calculating the still water elevation at the center of the fetch due to storm surge at the time the storm center is located to produce the maximum wind speed along the pre-selected fetch,

4. Computing the average depth along the fetch.

The basic assumptions used in the analyses were:

1. Storm generated waves from the open sea are dissipated at the mouth of Delaware Bay.

2. Steady state waves are generated along each fetch (these waves are independent of time).

3. Only the area northwest of Ben Davis Point generates significant wave energy at the site.

The PMH was located so as to produce maximum waves. In the vicinity of the site, the PMH winds had a maximum sustained wind velocity of 85 miles per hour from the southeast. With the surge level at 113.8 feet PSD, wave runup elevations on safety-related structures inside the sea wall were calculated to be a maximum of 120.4 feet PSD. Maximum wave run up elevation on the service water intake structure was calculated to be 127.3 feet PSD.

2.4.5.5 Resonance

As a result of the nature of the estuary upon which the site is located, resonance was not a necessary consideration.

2.4.5.6 Runup

As noted in Section 2.4.5.4, maximum wave runup elevation was calculated to be +120.4 feet PSD on critical structures inside the sea wall and 127.3 feet PSD on the service water intake structure. The Sainflou method was used, assuming a minimum sea wall height of Elevation 108 feet PSD in the most critical area. As discussed in Section 2.4.1, all safety-related structures are protected for water levels to equal or greater elevations.

2.4.5.7 Protective Structures

[redacted]

The stability of the dike was checked by Dames and Moore, using a computer program based on the Fellinius method of slices under the effect of the assumed wave forces. Some of the softer soils in the previously existing dike area were replaced with granular fill.

2.4.6 Probable Maximum Tsunami Flooding

The occurrence of tsunamis is infrequent in the Atlantic Ocean. Other than the tidal fluctuation recorded on the New Jersey Coast during the Grand Banks earthquake of 1929, there has been no record of tsunamis on the northeastern United States coast.

The earthquake of November 18, 1929, on the Grand Banks about 170 miles south of Newfoundland, resulted in a tsunami which struck the south end of Newfoundland about 750 miles northeast of the Massachusetts coast. The tsunami occurred at a time of abnormally high tide and resulted in some loss of life and destruction of property. The effect of this tsunami was recorded on tide gages along the United States east coast, as far south as Charleston, South Carolina. A tidal fluctuation of approximately nine-tenths of one foot was noted at Atlantic City, New Jersey and Ocean City, Maryland.

The Lisbon earthquake of November 1, 1755, produced great waves, which contributed heavily to the destruction on the coast of Portugal. These waves were noticeable in the West Indies. It had been reported that the Cape Ann, Massachusetts, earthquake of November 18, 1755, caused a tsunami in Saint Martin's Harbor in the West Indies; however, there is no record of a tsunami occurrence along the east coast of the United States at this time and it has since been determined that the Saint Martin's Harbor report actually refers to the tsunami caused by the Lisbon earthquake, which occurred within three weeks of the Cape Ann shock. Some tsunami activity has occasionally followed earthquakes in the Caribbean, but none of these was reported in the United States.

There is no evidence of surface rupture in East Coast earthquakes and no history of significant tsunami activity in the region. Hence, we do not believe that the plant site would be subjected to any significant tsunami effect. The maximum expected tsunami would result in only minor wave action, and the maximum expected storm wave effect is the critical factor in design.

2.4.7 Ice Flooding

Ice barriers are provided for the service water intake structure. Surface ice jams will not exert direct structural loading. The barrier will also enable the intake components to operate normally without the effect of ice.

2.4.8 Cooling Water Canals and Reservoirs

The Delaware Estuary is the cooling water reservoir for the plant. For discussions of the design parameters intended to provide a secure source of water, see Sections 2.4.1.1, 2.4.2, 2.4.3, 2.4.5, 2.4.10, and 2.4.11.

2.4.9 Channel Diversions

As the source of cooling water is the Delaware Estuary, no channel diversions need be considered.

2.4.10 Flood Protection Requirements

The relationship of hurricane induced surge and wave flooding and the site design parameters are discussed in Sections 2.4.1.1 and 2.4.5. No other possible sources of flooding are as critical; hence, station design was predicated upon the worst possible meteorological event as previously described (Section 2.4.5).

2.4.11 Low Water Considerations

2.4.11.1 Low Flow in Rivers and Streams

Not applicable, see Sections 2.4.2 and 2.4.5.

2.4.11.2 Low Water Resulting from Surges, Seiches, and Tsunamis

The anticipated minimum stillwater elevation for the Delaware River Estuary in the vicinity of the Salem Nuclear Generating Station is -10.6 feet MSL. This extreme water level was developed from critically locating a postulated PMH (HUR 7-97) (3).

The PMH was located in its more severe position as follows:

Latitude of storm center: 39 degrees north.

1. CPI: 27.09 inches Hg

2. Peripheral pressure: 30.72 inches Hg

3. Radius of Maximum Winds: 39 nautical miles

4. Forward Speed: 0 knot

5. Maximum Wind Speed: 124 miles per hour

The location of the storm center was chosen so that the radius of maximum winds from the northwest would coincide with the axis of the bay between the Salem site and the mouth of the bay. The location of the storm is shown on Figure 2.4-8.

The maximum winds associated with the PMH would be from the northwest (N45°W) along the axis of Delaware Bay when the stillwater level is at the postulated minimum. In the vicinity of the site, the maximum wind velocity would be 85 miles per hour. With the stillwater level at -10.6 feet MSL, the winds would generate waves having a significant wave height and period of

5.0 feet and 4.8 seconds, respectively. This would correspond to a maximum wave height of 8.3 feet. The waves would travel along the axis of Delaware Bay in the most critical condition.

Routing these waves to the service water screen well structure, the waves will undergo the effects of refraction, diffraction, and breaking. With the maximum winds of 85 miles per hour from the northwest, local waves trying to refract into this wind would become unstable and break; therefore, the effects of refraction have been ignored.

The offshore topography from the service water screen well indicates that during the PMH low water level, there would be exposed shoreline with a northwest alignment, adjacent and to the northwest of the service water screenwell, projecting about

150 feet into the Delaware River from the entrance to the service water screen well. Waves coming from the northwest would diffract around this exposed point of land in reaching the screen well entrance. The significant wave height would diffract to 1.5 feet in height while the maximum wave height would first be subjected to breaking due to depth restrictions. A maximum nonbreaking wave of 6.5 feet would diffract to a height of 2.0 feet in reaching the screen well.

As the diffracted waves pass the screen well entrance, they will undergo several severe effects causing the wave to become unstable and deformed in shape. Some of these effects are: further diffraction of the waves as they strike the protruding ice barriers and enter the individual service water pump channels, and the reflection of waves in several directions causing a confused sea state at the screen well entrance. To be conservative, the pump channel walls and the ice barriers were treated as a pile array. Using this assumption, the 1.5 feet and 2.0 feet wave heights would be reduced to 1.1 feet and 1.5 feet, respectively, as they entered the individual pump chambers.

These waves then must travel 50 to 60 feet in reaching the service water pumps, passing through a trash rack, curtain wall, stop log guide, ladders, etc. Therefore, there essentially would be no wave action at the pumps, but only a choppy water level. Water level amplification due to resonance is negligible because the fundamental period of the pump channels is approximately 13 to 16 seconds and the only possible wave excitation would come from a high order harmonic, resulting only in ripples.

It is concluded that the highest possible wave at the service water pumps is 0.8 feet to 1.0 feet in height resulting in a water level change of approximately plus or minus 0.5 feet. Therefore, the lowest instantaneous water elevation at the service water pumps is -11.1 feet MSL.

2.4.11.3 Historical Low Water

See Sections 2.4.2 and 2.4.5.

2.4.11.4 Future Control

There are no provisions required for control of the flow in the Delaware Estuary area.

2.4.11.5 Plant Requirements

Plant water requirements are predominantly determined by the need for heat dissipation within the plant. The primary heat removal system is the Circulating Water System. The monthly flow is about 9.6×10^{10} gallons, total for both units. The Service Water System averages approximately 4.3×10^{7} gallons per month (both units). Requirements in a safe shutdown mode are much less. However, even using operating flow as a criterion, the daily average plant requirement is only about one-eighth of the tidal flow.

2.4.11.6 Heat Sink Dependability Requirements

Essentially, the ultimate heat sink is the Atlantic Ocean. The Water Intake System is designed to operate at the lowest postulated water level in the estuary (Elevation -13.1 feet MSL). Also see Sections 2.4.1, 2.4.11.2, and 2.4.11.5.

2.4.12 Environmental Acceptance of Effluents

The significance of onsite release of effluent is also discussed in Section 2.4.13.3. Basically, the Delaware River Estuary will be the final recipient of onsite spills or operating discharge. As the water is brackish, there are no public water supplies affected by estuary flows.

The Delaware Estuary behaves as a mixed estuary. It is essentially homogeneous vertically; salinity averages 10 to 15 ppt with vertical variations at a given point limited generally to less than 1 ppt. Some variation in salinity is observed across the estuary due to Coriolis Forces which tend to concentrate less-than-average salinities on the west (Delaware shoreline and slightly greater than average salinities on the east (New Jersey shoreline). As a well-mixed estuary, the tidal mixing is sufficiently vigorous to keep the vertical salinity stratification to a low value; thus the dynamic and kinematic processes, which govern salinity, act to produce a relatively one-dimensional salinity distribution until a point is reached in the lower Delaware Bay where the tidal velocities are low enough to permit a degree of vertical stratification to develop. In the lower bay, below the Salem Station, there is an extensive amount of nontidal circulation brought about by the combination of salinity gradients and meteorological conditions. However, above the site the classic salinity profile for the vertically homogeneous estuary is prevalent.

The Pritchard-Carpenter Consultants have estimated secondary, or nontidal flow as it can relate to the dispersion of effluent below the Salem Station. Their information indicates that as the observer travels seaward from the upstream freshwater end of the Estuary, there is an increasing amount of nontidal circulation. The relationship of this nontidal circulation to the transport of materials seaward has not been quantitatively established for the Salem Station and is of interest only in a qualitative overview. Based on computations using the vertical salinity measurements taken in conjunction with biological assessments, the net nontidal circulation in the station vicinity due to Coriolis Forces, wind stress, and gravity-induced circulation, produces salinities on the order of one-third of those in the lower bay. Other estimates of nontidal flow as high as six times the net freshwater supply are suggested, but insufficient data are available to assess either the numerical accuracy or the significance of this phenomenon in relation to the dispersion and advection of

effluents from the Salem Station. However, it is clear that surface flow at the site is to the Estuary and the Estuary is a well mixed body of water in direct connection with the Atlantic Ocean.

2.4.13 Groundwater

2.4.13.1 Description and Onsite Use

On a regional basis, the site is located on the Atlantic Coastal Plain about 18 miles south of the Fall Zone. The aquifers of the Coastal Plain are almost entirely unconsolidated sand and gravel, and water is stored in and transmitted through the primary pore spaces between the sand grains. The most productive aquifers in the region are the Cohansey Sand and the Raritan and the Magothy Formations. Other aquifers include all or portions of the Wenonah and Mount Laurel Sands, the Englishtown Formation and the Vincetown Formation. Sands and gravels of Pleistocene and Recent Age are irregularly distributed throughout the Coastal Plain, but are used as aquifers only in a few areas adjacent to the Delaware River.

A summary of the hydrologic characteristics of geologic formations in the regions is presented in Table 2.4-3, Hydrologic Characteristics of Geologic Formations. They are discussed in order of the youngest formation to the oldest. Additional geologic information is given in Section 2.5.1, Geology and Seismology.

A total of six production wells have been drilled at the site. They are screened in Wenonah - Mount Laurel and in the Upper and Middle Raritan Formations. Average flow of the wells is 1000 gallons per minute (gpm) with a maximum anticipated requirement of 1400 gpm. The location of these wells is shown on Figure 2.4-9.

2.4.13.2 Sources

At the time of the preparation of the original Safety Analysis Report (late 1960s), nearly all water used for consumptive purposes within 25 miles of the site was groundwater. With the exception of the highly industrialized Wilmington, Delaware area, the major use of water is for domestic and agricultural purposes. This situation has not changed significantly in recent times.

Public Water Supplies

There are six towns in New Jersey within 25 miles of the proposed site that have public water supplies. There are five public water supplies within 15 miles of the site. Data concerning these public water supplies are shown in Table 2.4-4, Public Water Supplies in the Vicinity of the Site. The locations of these supplies are shown on Figure 2.4-10, Public Water Supplies in the Vicinity of the Site.

Private Wells

Nearly all domestic water supplies in this region are obtained from private wells. Most wells are 2 inches in diameter and greater than 75 feet in depth. The aquifer commonly utilized in the vicinity of the site is the Mount Laurel-Wenonah Formation. Information pertaining to these wells is presented in Table 2.4-5, Private Water Wells in Vicinity of Site. The locations of wells in the vicinity of the site are shown on Figure 2.4-11, Known Water Wells in New Jersey in Vicinity of Site.

There are no known productive water wells within 2 miles of the site other than those installed by Public Service Electric & Gas (PSE&G) (see Section 2.4.13.1). There are three abandoned wells near the site. The wells are reported to be several hundred feet deep. The location of the offsite wells are shown on Figure 2.4-11; the onsite wells are shown on Figure 2.4-9.

The nearest residences to the site are about 3 miles distant. Their water supply is obtained from shallow driven wells, or, in some cases, is carried in along with other provisions.

Most water wells inventoried were located 3 to 4 miles from the site. The nearest wells in Delaware are more than 3 miles from the site and were not canvassed since it is believed that they would not be affected by a change in the groundwater regimen at the site because of the intervening Delaware Estuary.

Site Groundwater

The subsurface soils and groundwater conditions at the site are consistent with the regional picture. The upper soils at the site are dredged fills which were placed there by the United States Army Corps of Engineers around the turn of the century. The fill material apparently came from the channel of the Delaware River. Information obtained from test borings drilled on the site

indicates the thickness of the hydraulic fill is generally less than 10 feet. Dames and Moore's report on Foundation Studies for Hope Creek Generating Station states:

> "At the surface, the hydraulic fill extends to a depth of about 30 feet below the present ground surface. The fill deposit is of man-made origin, having been deposited on the site as a result of channel maintenance in nearby areas..."

We have been calling the 30 foot upper layer as hydraulic fill all through the project work, including the correspondence with Nuclear Regulatory Commission.

Dames and Moore's site subsurface section designated the upper 30 feet as hydraulic fill also. It is is of the same designation in "Engineering Seismology" (page 2-9).

The fill material is composed of a heterogeneous mixture of silt, silty clay, fine sand, and organic material. Four soil percolation tests were conducted on these materials to measure the absorption rate of the surficial soil. These tests were conducted in accordance with the U. S. Army Corps of Engineers' procedures. The absorption rate ranged from 1 to 4 gallons per day per square foot. The average rate was 2.7 gallons per day per square foot. Water levels are approximately at the level of the adjacent estuary waters.

Below the hydraulic fill, a grey sandy and gravelly material, which formally comprised the bed of the Delaware River, was found. This layer varies in thickness from 2 to 5 feet and is composed of fine-to-coarse sand, a little fine-to-coarse gravel, and a trace of silt. The permeability of the sand, based upon particle size analyses, ranges from about 50 to 150 gallons per day per square foot. The clay facies is essentially impermeable. The lateral extent of this sand member is unknown, but it appears to exist in most of the site area. It is hydraulically connected with the Delaware Estuary, and water levels in this formation change in response to tidal variations. Water levels in this formation are essentially horizontal and although changes in response to tides do occur, the horizontal component of groundwater movement is small.

The Kirkwood Formation of Miocene Age underlies the Quaternary soil and extends to about 70 feet in depth. It consists of gray silty clay and is an aquitard. Permeability values are less than 50 gallons per day per square foot.

The Vincetown Formation is about 45 to 75 feet thick and is encountered at a depth of about 70 feet. It consists of a fine-to-medium-grained sand with occasional gravel and is separated from the Quaternary soils by about 35 feet of impermeable silty clay of the Kirkwood Formation. Grain size analyses of this sand indicate a permeability of about 200 gallons

per day per square foot. Water levels in this formation are essentially horizontal with an artesian pressure head just slightly lower than the surficial groundwater table. The horizontal component of groundwater movement in this formation is probably negligible, except for tidal oscillations.

Two piezometers were installed about 75 feet from the Delaware Estuary to determine the tidal efficiency of the Vincetown Formation. Water level measurements were made in the estuary from high to low tide and corresponding measurements were made in the piezometers. Total tidal fluctuation amounted to 6.3 feet, and the maximum variation in the piezometers was 3.9 feet. The time lag between peaks in the estuary and in the piezometers was about 20 minutes.

The Vincetown Formation is underlain by the Hornerstown Sand which, according to published information, and information from the borings at the site, is an aquitard. Underlying the Hornerstown is the Navesink and Wenonah-Mount Laurel Sands.

The Raritan-Magothy Formation is encountered at a depth of approximately 450 feet at the site. It consists of interbedded clays, gravel, and sands. The sand layers are generally 20 to 30 feet thick and the clay layers on the order of 100 feet in thickness. Fresh water was encountered in the sand layers to a depth of 900 feet at the site. At greater depths, the sands probably contain salt water.

Although the site is underlain by sand and gravel formations which are utilized as a source of water supply in the region, these aquifers are separated from the surficial soils by one or more impermeable silty clay beds. Since the hydraulic gradient of these aquifers at the site is too small to measure, it is probable that the only groundwater movement at the site is a result of tidal influences. Except for production wells recently constructed at the site by PSE&G, there are no water wells within

2 miles of the site, and the possiblity of offsite wells being affected by changes in the groundwater regimen at the site is remote.

2.4.13.3 Accident Effects

In summary, the hydrological conditions at the site are well suited for the operation of the proposed power station. Fluid spills at the surface would be contained within the station drainage system or be drained toward the Delaware Estuary. All public water supplies in the Delaware are upstream of the site. Because of salt water intrusions, industrial use of the river water below Marcus Hook, some 25 miles upstream of the site is limited to cooling water applications. Thus radioactive wastes discharged to the river will remain well downstream of any industrial or domestic usage of river water.

Any accidental spills that reached the subsurface would tend to move slowly to the southwest, although short-term reversals occur as a result of tidal fluctuations in the estuary. All water wells in the vicinity of the site are located upgradient. The closest domestic well is a shallow well located about 3 miles from the site.

Movement of groundwater through the site is quite low as a result of the comparatively low coefficients of permeability and the low hydraulic gradients.

Fluid infiltration in the area surrounding the actual construction site is low as many of the strata are relatively impermeable. Even in the station area, where the Pleistocene-aged and Miocene-aged Kirkwood Formation was removed, infiltration of fluids will be quite slow as the plant structures are founded on a lean concrete fill placed upon the Vincetown soils (which also have low permeabilities as a result of their cemented nature).

The Vincetown is a fine to medium-grained calcareous sand, containing variable amounts of cementing material. The groundwater in the Vincetown is artesian and contains chloride concentrations of several thousand parts per million, thus, not suitable for drinking water.

Below the Vincetown are the underlying Hornerstown and Navesink Formations which act as confining beds.

A groundwater protection program was designed and implemented to provide reasonable assurance that a groundwater leak or spill of radioactive materials should be detected early and effectively remediated well before any potential impact to the offsite public health and safety or onsite workers.

2.4.13.4 Monitoring or Safeguard Requirements

Surface and subsurface flow is toward the estuary. In general, infiltration and surface flow are slow. No public water supplies are down-gradient or downstream of the station. Thus, special monitoring or safeguard requirements are not necessary,

2.4.13.5 Technical Specifications and Emergency Operation Requirements

Consistent with Section 2.4.13.4, no technical specifications have been prepared. No emergency plans, other than those presented in Section 13.3 are contemplated.

2.4.14 References for Section 2.4

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3. U.S. Dept. of Commerce, Interim Report Meteorological Characteristics of the Probable Maximum Hurricane, Atlantic and Gulf Coast of the United States: Environmental Science Services Administration, Memorandum HUR 7-97, May 7, 1968.

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2.4.16 Agencies and Individuals Contacted

Agency	Location	Individual
U.S. Geological Survey Water Resources Division	Trenton, New Jersey	Mr. H. Gill Mr. H. Meisler
New Jersey Division of Water Policy and Supply	Trenton, New Jersey	Mr. J. C. Mearill
Coleman Well Drilling Co.	Hancocks Bridge, New Jersey	Mr. P. Coleman
	Vicinity of site	Numerous local residents

TABLE 2.4-1

SUMMARY OF MAXIMUM STILLWATER ELEVATION DETERMINATIONS

Fetch Number	Maximum Wind Speed at Fetch Center) (mph)	Angle of Wind to Bay Axis (degrees)	Crosswind Component (mph)	Average Fetch Depth dt (ft)	Crosswind Setup (ft)	Surge Elevation at the Site (ft)	Maximum Stillwater Elevation at the Site (ft)
1	108.6	-13.0	24.4	39.3	0.00	109.2	109.2
2	113.3	2.0	4.0	39.3	0.00	110.9	110.9
3	112.2	17.0	32.8	38.0	0.00	109.2	109.2
4	108.6	32.0	57.5	37.9	0.08	106.5	106.6
5	106.6	47.0	78.0	35.6	0.25	104.3	104.6
6	106.0	62.0	93.5	37.4	0.34	101.8	102.1

TABLE 2.4-2

AGENCIES AND INDIVIDUALS CONTACTED

Agency	Location	Individual
U.S. Geological Survey Water Resources Division	Trenton, New Jersey	Mr. H. Gill Mr. H. Meisler
New Jersey Division of Water Policy and Supply	Trenton, New Jersey	Mr. J. C. Mearill
Coleman Well Drilling Co.	Hancocks Bridge, New Jersey	Mr. P. Coleman
	Vicinity of site	Numerous local residents

TABLE 2.4-3

HYDROLOGIC CHARACTERISTICS OF GEOLOGIC FORMATIONS
(Youngest to Oldest Formations)

Pleistocene Series: Pleistocene deposits occur in this region as thin discontinuous formations and are not a major source of water. Large capacity wells from these deposits are not feasible; however, infiltration galleries have been used in this formation where hydraulically connected to the Delaware River. Shallow wells draw water from these aquifers for domestic suppliers in some area.

Cohansey Sand: The Cohansey Sand outcrops along a line trending northeast-southwest, about 6 miles east of the site. The formation dips to the southeast and therefore is not present at the site. It is composed predominantly of well-sorted sand and gravel, and is potentially the most productive aquifer in the Coastal Plain area.

Groundwater in the Cohansey Sand is largely unconfined. There is no significant regional pattern of water movement in the formation. The flow pattern is governed largely by local topography.

Kirkwood Formation: The Kirkwood Formation immediately underlies the Pleistocene Soils at the site and dips to the southeast. It is composed of light gray clay with interbedded layers of sand. Domestic and farm water supplies are obtained from wells in the Kirkwood Formation. Yields on the order of 5 to 100 gallons per minute are obtained in the Kirkwood.

A few pumping tests have been made in aquifers within the Kirkwood Formation, although none have been documented in the vicinity of the site. The nearest test on record (about 15

miles to the northeast) indicates a field coefficient of permeability of about 200 gallons per day per square foot.

More often than not, the direction of the hydraulic movement in the Kirkwood Formation does not conform with the direction of dip. The major areas of discharge are probably in the permeable parts of the outcrop area where stream channels, swamps, and marshes provide relatively low-elevation discharge areas. A potentially large natural discharge area occurs where the Kirkwood Formation crops out in the Delaware River. This occurs at the site.

Vincetown Formation: This formation is a minor but relatively important source of water in New Jersey. It crops out in the vicinity of the site and is composed of a semi-consolidated sand.

In the vicinity of Salem, New Jersey, about 8 miles northeast of the site, wells in the Vincetown Formation have been reported to yield as much as 300 gallons per minute. This is in an area where the granular portion of the aquifer is thicker than normal. At the site the Vincetown Formation contains saline water.

Navesink Formation: The Navesink Formation is composed of fine to medium-grained sand with some clay. It is not widely used as a source of water supply in the region.

Hornerstown Sand: This formation is composed of sand and clay. It is not used as a source of water supply due to its impermeable nature. However, it is not a tight aquiclude and some vertical leakage may occur into or out of the underlying aquifer, depending upon the hydraulic gradient. Production wells tested at the site in 1970 confirmed that vertical

leakage occurs in some areas due to changes in hydraulic gradient.

Wenonah - Mt. Laurel Sands: These formations function hydrological as a single unit; the Wenonah sand is composed mainly of fine to coarse-grained sand and is overlain by the Mt. Laurel sand which is characteristically a medium to coarse-grained sand.

This unit is well utilized aquifer, used predominantly for domestic purposes. The aquifer recharges from precipitation and discharges predominantly in low outcrop areas. The aquifer outcrops beneath the Delaware River, a probable discharge area. Since the aquifer is confined and withdrawal volumes are small, it is probably that very little water movement occurs. Operation of onsite production wells in the Mount Laurel-Wenonah Formation will induce groundwater flow towards the wells.

Marshalltown Formation: The Marshalltown Formation is composed of clay, is impermeable, and considered to be an aquiclude.

Englishtown Formation: This sand formation is not utilized as a source of water in the vicinity of the site due to a large amount of clay and silt in the formation. Its permeability increases to the north and east, where it is tapped by wells having yields up to 200 gallons per minute.

Merchantville Clay: This formation is characteristically a clay or sandy clay overlain in many areas by the Woodbury clay, of similar characteristics. In combination with the Woodbury clay, it forms an effective aquiclude.

Magothy Formation: This formation consists of sand with thin beds of silt and organic matter. It is a major aquifer in much of the area, although it is generally not utilized south and east of the site due to the high chloride content of its water.

Aquifer coefficients, based on pump test data, indicate that the Magothy has a permeability value of about 400 gallons per day per square foot. Its porosity is about 45 percent and the specific yield is about 40 percent.

Potomac Group: The Potomac Group consists of an upper aquifer (Raritan Formation) and a lower aquifer (Patuxent Formation) separated by clay with sand lenses. The movement of groundwater through this formation is generally downdip, or southeast. This aquifer is not used in the vicinity of the site due to its depth and proximity to the salt water-fresh water interface believed to occur about 5000 feet east of the site.

Source: Dames and Moore, 1970.

TABLE 2.4-4

PUBLIC WATER SUPPLIES

Town	Population Served	Average Output (mgd)*	Source of Water
Salem, New Jersey	9,000	1.7	About 2/3 of water consumed is surface water, pumped from the Quinton pumping station about 3 miles east of town and 9 miles northeast of the site. Remainder is obtained from four wells, ranging in depth from 80 to 168 feet, located east of Salem.
Pennsville, New Jersey	10,500		Four wells ranging in depth from 105 to 240 feet. The wells are probably completed in the Magothy Formation.
PennsGrove, New Jersey	8,000		Two wells, 292 and 360 feet deep. The water probably comes from the Potomac Group.
Woodstown, New Jersey	3,000		Eight wells; six are about 100 feet deep and the others are about 300 and 350 feet deep.
Elmer, New Jersey		2,500	Three wells; two are 80 feet deep and the third is 500 feet deep. The shallow wells probably tap the Mount Laurel-Wenonah Formation.

TABLE 2.4-4 (Cont)

Town	Population Served	Average Output (mgd)*	Source of Water
Bridgeton, New Jersey	22,000		A total of 12 wells, some of which are no longer in use, range in depth from 75 feet to 129 feet. They are completed in the Cohansey Sand.
Smyrna, Delaware		0.27	Two wells, 20 feet and 95 feet deep supply the town. The shallower well is used for standby purposes.
Clayton, Delaware	825	1.2	One well, 272 feet deep, is the source of water supply.
Middletown, Delaware	2,000	0.2	Three wells, having depths of 100 feet, 200 feet and 500 feet, supply the town.
Delaware City, Delaware	1,500	0.2	Two wells, one 26 feet deep in the Wenonah Formation and the other in the Magothy Formation, supply the town.
New Castle, Delaware			The town obtains water from a shallow infiltration gallery system located in Pleistocene deposits.

* mgd = millions of gallons per day

TABLE 2.4-5

PRIVATE WATER WELLS IN VICINITY OF THE SITE

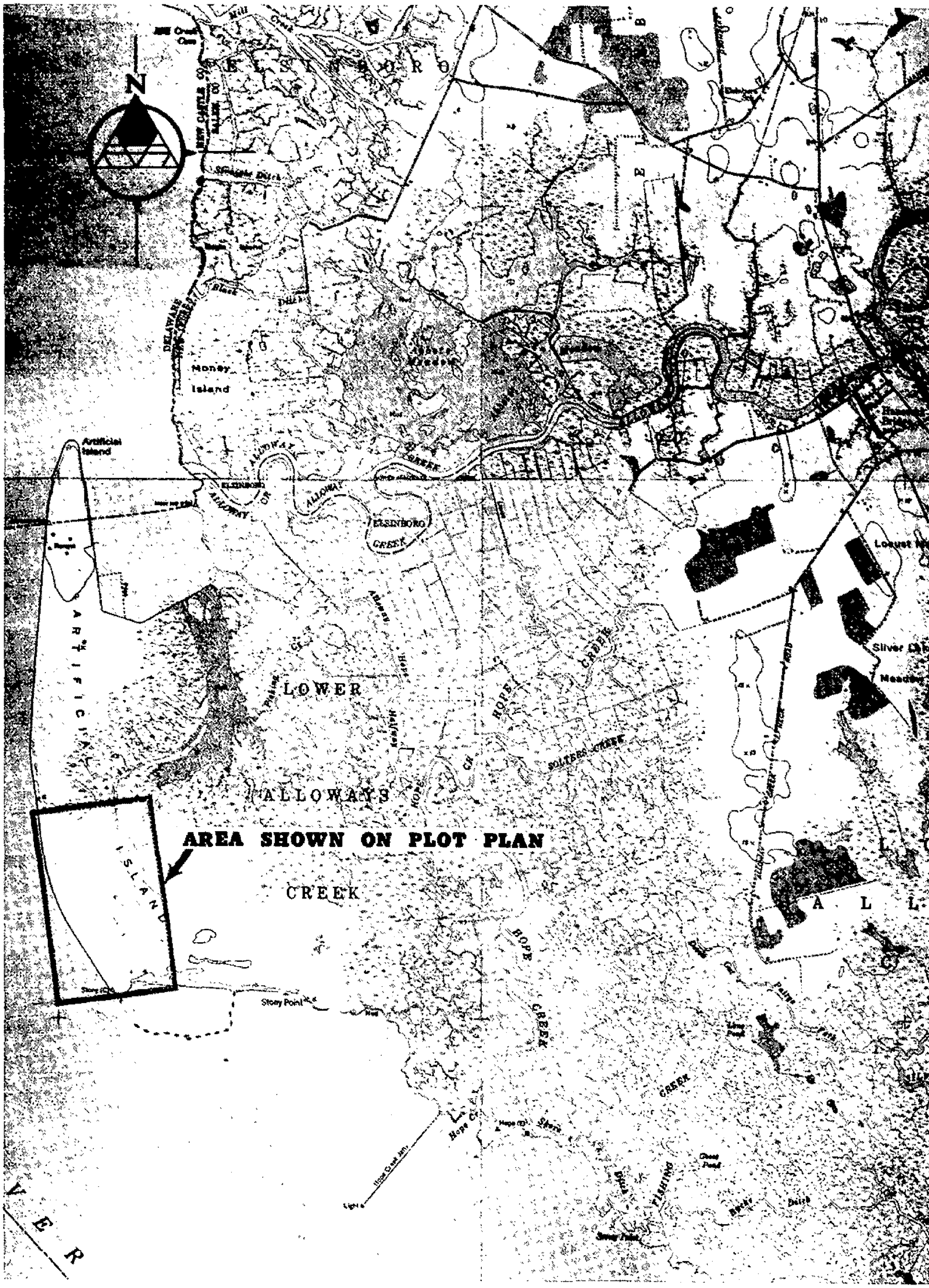
Well No.	Owner's Name	Total Depth (ft)	Diameter (in.)	Casing Length (ft)	Static Water Level (ft)	Yield	Remarks
1	Aloes Marina	252	2	220	3½		
2	Dr. Devlin	252	2	210	5		
3	Dr. Devlin	252	2	230	2½		
4	Dr. Devlin	252	2	212	4		
5	Mr. Henchman	252	2	218	6		
6	G. Harbeson	15	42				Dug well
7	G. Harbeson	15	42				Dug well
8	F. Harris	12	36		8±		Four wells, Deepest is 32 feet.
9	F. Shimp	90		60±	12-13		
10	T. Hilliard	90	6	60±	12-13		
11	Mr. Snideker	10	36		7-8		
12	Mr. Snideker	90	4				
13	W. Ashlock	252	2	231	8		
14	F. Schrier	90	4	60	12-13		
15	B. Hendman	89	2	84	15		
16.	B. Hendman						Well filled in.
17	State of N.J.	89	2	84	12		
18			2				
19	T. Dixon	156	2	147	3		
20							Well abandoned.
21	T. Dixon	90	2		12		Well abandoned.

TABLE 2.4-5 (Cont)

Well No.	Owner's Name	Total Depth (ft)	Diameter (in.)	Casing Length (ft)	Static Water Level (ft)	Yield	Remarks
22	D. Harris	32	2	32		Flowing	Well abandoned.
23	Mr. McCray	17	2	17		Flowing	Water is salty.
24	Mr. McCray	165	2	147	5		
25	J. Pancast	115	2		5-6		
26	J. Pancast	89	2	82	4		
27	R. Davis	14	36		6		Dug well.
28	W. Hancock	90	4	50	10-12		Iron, bad water.
29	Mr. Ingersol	90	4	50	10-12		
30	L. Fonderbank	100	2	86	3		
31	O. Ayrs	199	2	189	7		
32	Stony Point	315±					Well abandoned.
33		400±					
34		900±					
35							
36		165	2	90			
37	Eagle Island Gun Club	110	2	103	6		
38	J. Dilkes		2	131	8		
39	Public Service (Production Well 3)	298	16	243	20	200	Not in use
40	Public Service (Production Well 4)	284	16	210		200	Not in use

TABLE 2.4-5 (Cont)

Well No.	Owner's Name	Total Depth (ft)	Diameter (in.)	Casing Length (ft)	Static Water Level (ft)	Yield	Remarks
41	Public Service (Production Well 1)	300	10	250		200	Intermit Use for Construction
42	Public Service (Production Well 2)	286	16	220	18½	200	Not in use



REVISION 6
FEBRUARY 15, 1987

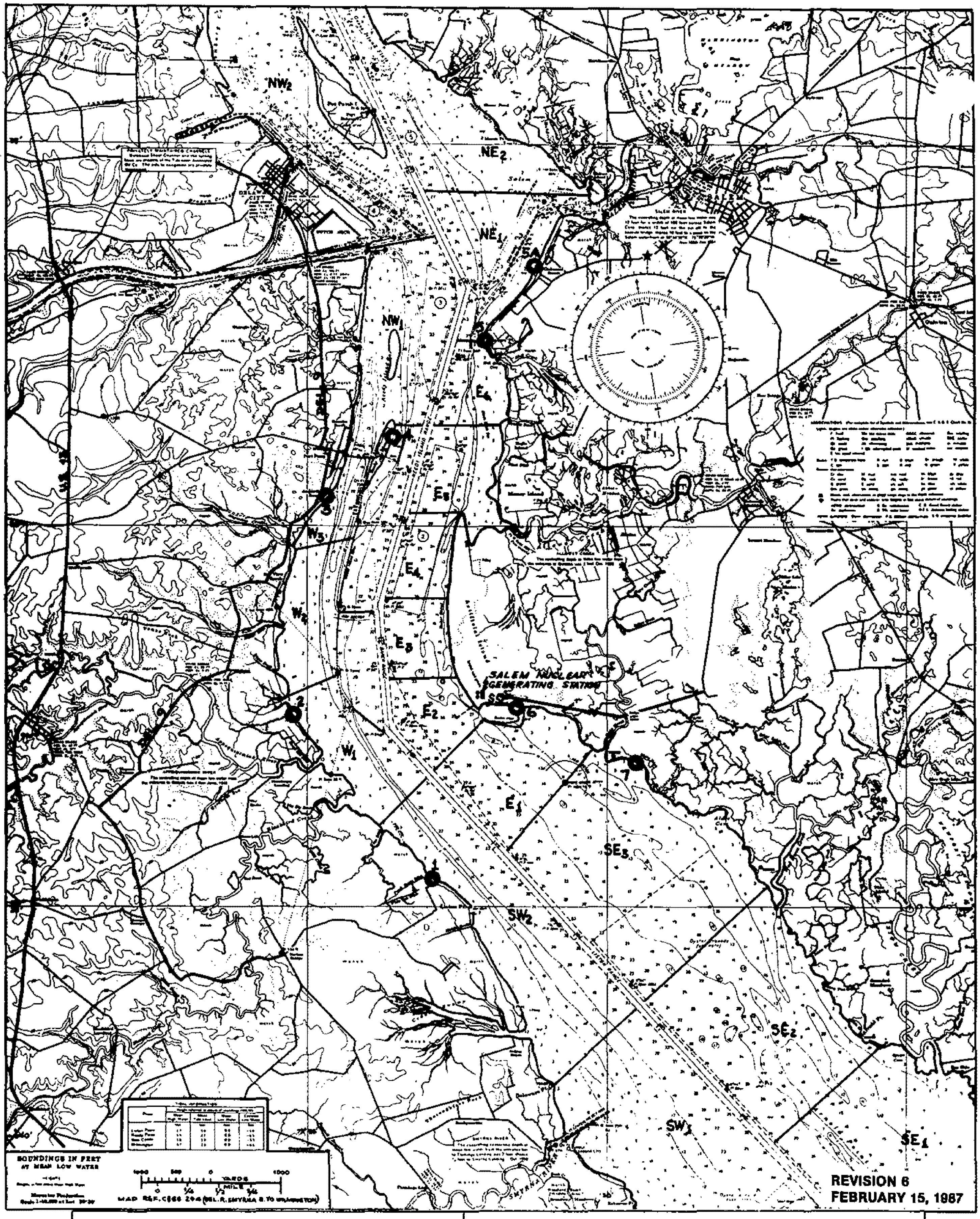
PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Map of Area
	Updated FSAR — Figure 2.4-1

Figure F2.4-2 intentionally deleted.

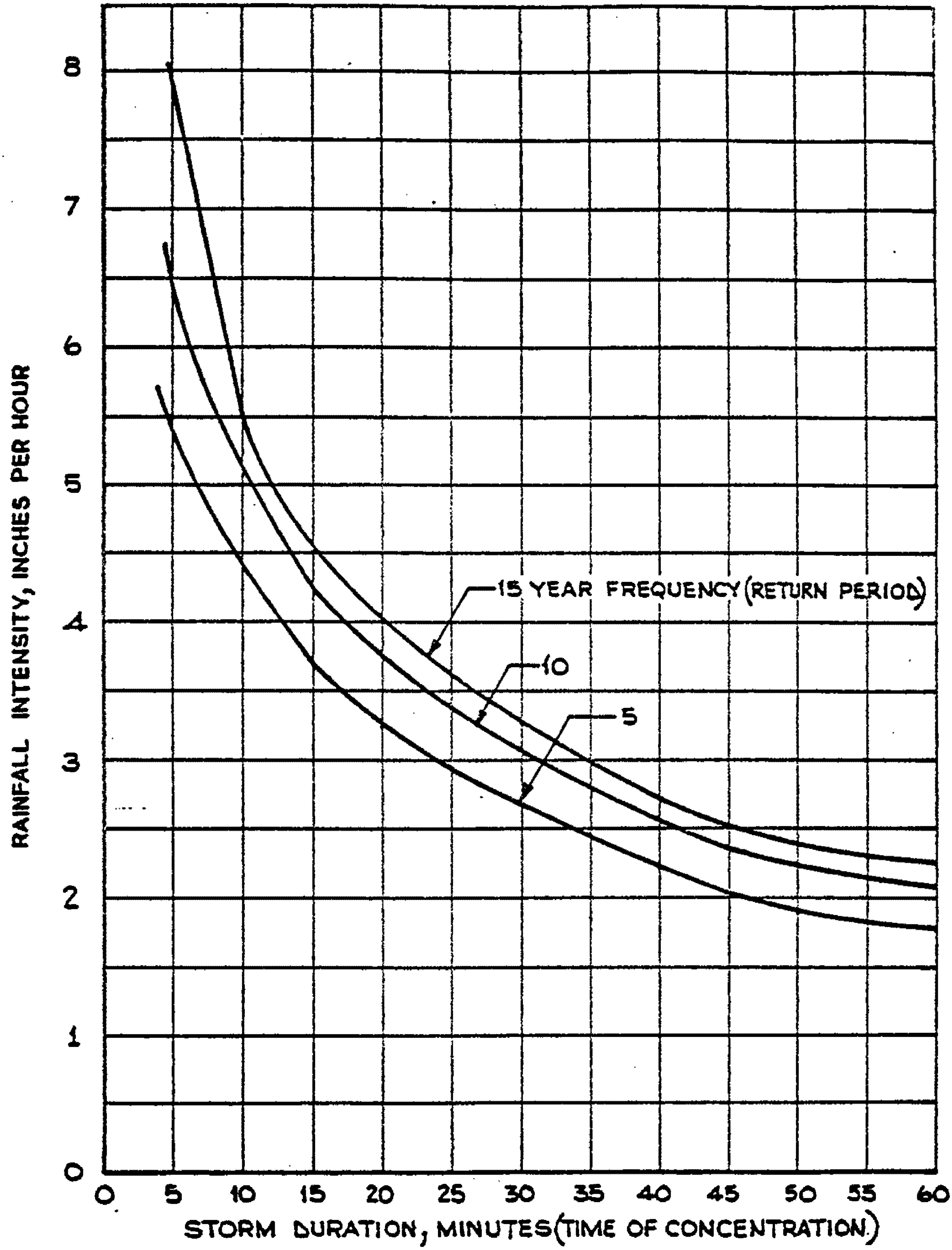
Refer to plant drawing 232091 in DCRMS

Figure F2.4-3 intentionally deleted.

Refer to plant drawing 211612 in DCRMS



PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Site Location in Relation to the Surrounding Area	
	Updated FSAR	Figure 2.4-4



REVISION 6
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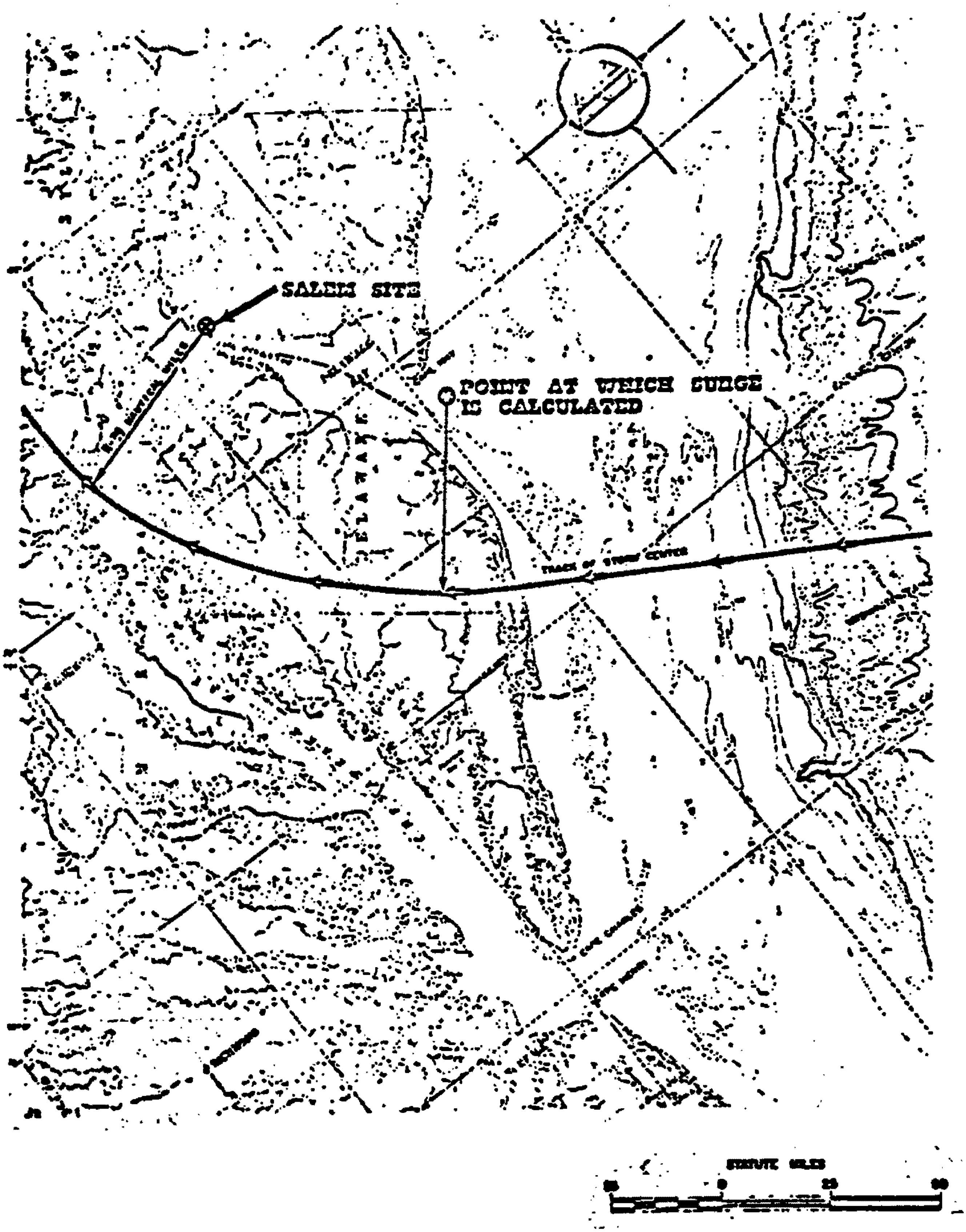
PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Typical Rainfall Intensity - Duration Frequency Curves for New Jersey Area
	Updated FSAR — Figure 2.4-5



REVISION 6
FEBRUARY 15, 1987

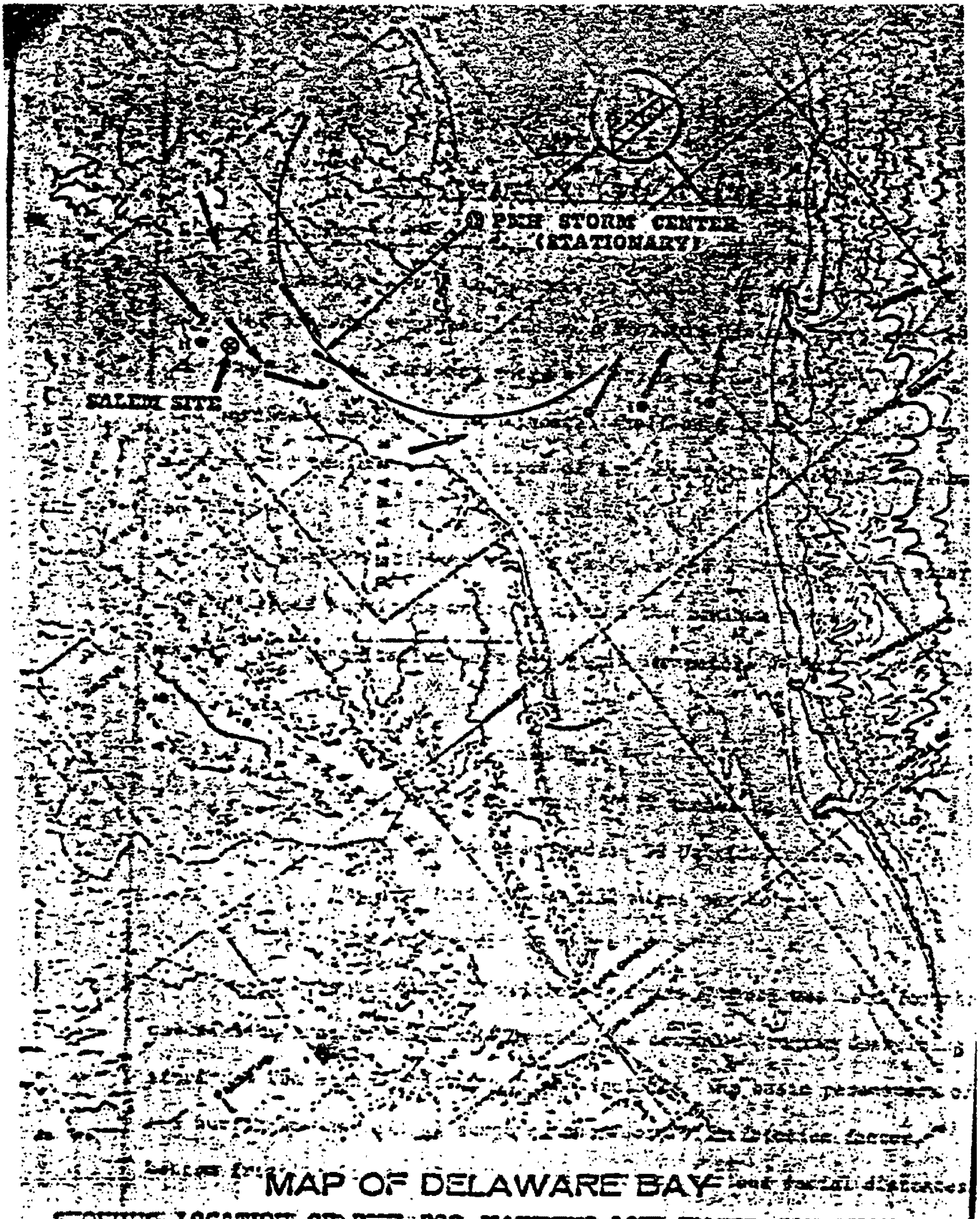
PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Map of Delaware Bay Showing Storm Track and Point of Calculations for Maximum Hurricane Surge
	Updated FSAR Figure 2.4-6

FIGURE 2.4-7 INTENTIONALLY DELETED.

REFER TO FIGURE 3.4-2

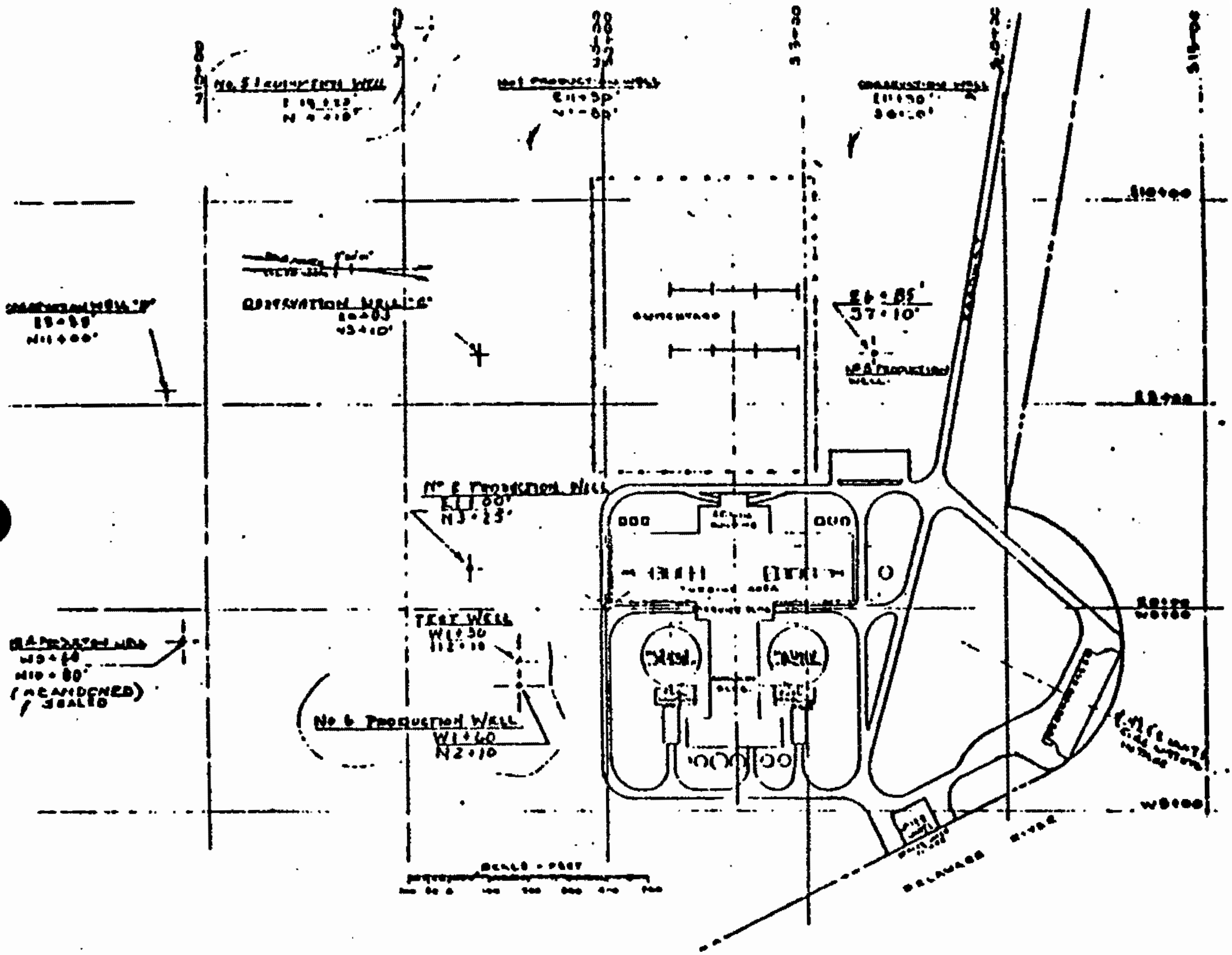
Revision 23, October 17, 2007

PSEG Nuclear, LLC SALEM NUCLEAR GENERATING STATION	Salem Nuclear Generating Station DIKE ELEVATION
	Updated FSAR Figure 2.4-7



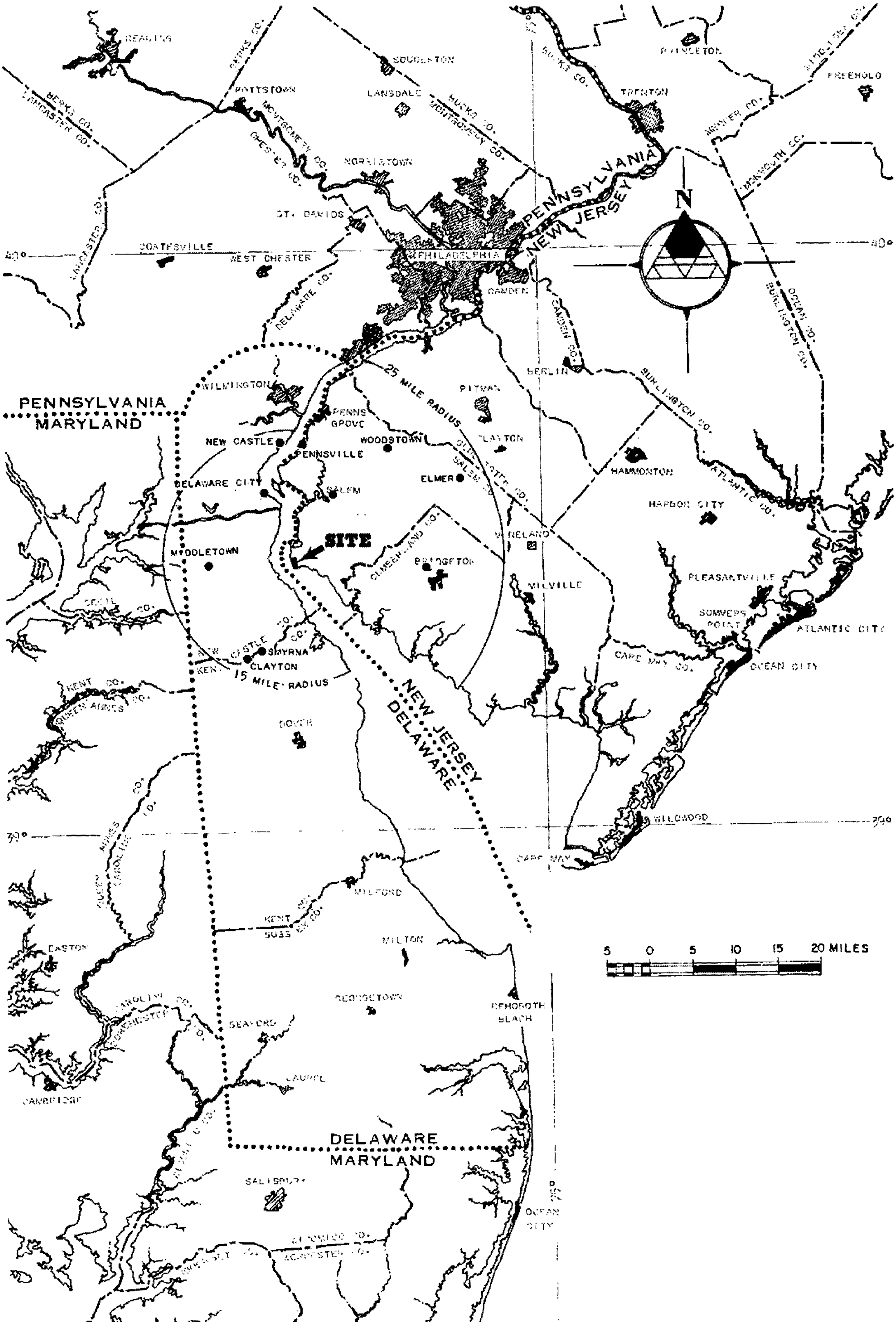
REVISION 6
FEBRUARY 15, 1987

PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Map of Delaware Bay Showing Location of PMH for Maximum Low Water Conditions
	Updated FSAR — Figure 2.4-8



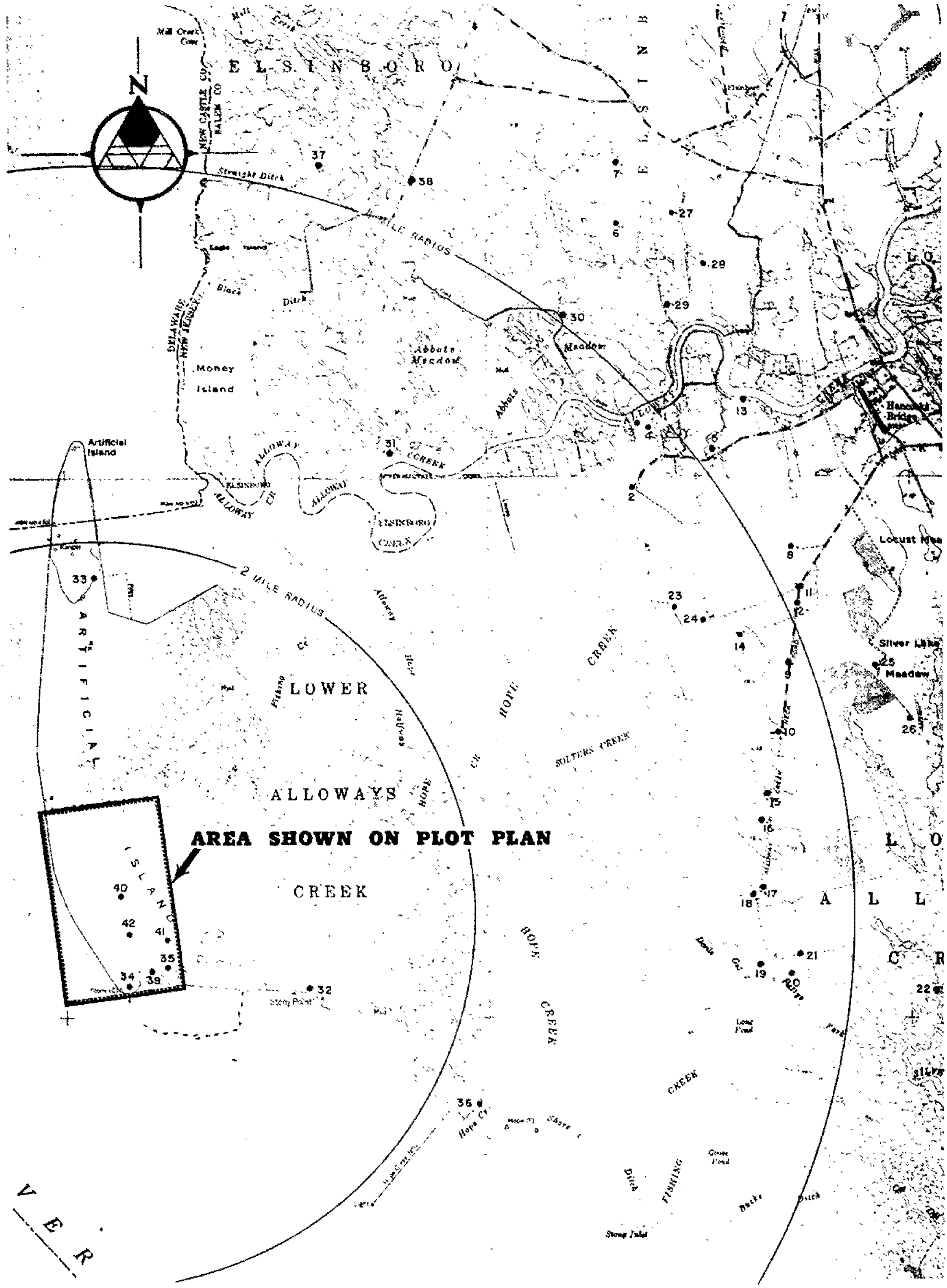
REVISION 6
FEBRUARY 15, 1987

PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Yard-Fresh Water Well Locations
	Updated FSAR Figure 2.4-9



REVISION 6
FEBRUARY 15, 1987

PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Public Water Supplies in Vicinity of Site
	Updated FSAR — Figure 2.4-10



REVISION 6
FEBRUARY 15, 1987

PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Map of Area Known Water Wells on New Jersey in Vicinity of Site
	Updated FSAR — Figure 2.4-11

2.5 GEOLOGY AND SEISMOLOGY

2.5.1 Basic Geologic and Seismic Information

The Salem site is located adjacent to and east of the Delaware River Estuary. It is approximately 19 miles south of Wilmington, Delaware, and 16 miles west of Bridgeton, New Jersey (Figure 2.5-1).

The area investigated for the nuclear generating facilities covers approximately 170 acres. Most of the facilities are located in the southern half of this area.

The scope of the geologic and seismologic phases of the Salem site was quite broad and encompassed the disciplines of geology, engineering, seismology, geophysics, and soil mechanics. The work was performed by Dames & Moore Consultants in coordination with locally knowledgeable individuals.

The research included a review of available pertinent geologic literature and interviews with representatives of state and Federal agencies and individuals possessing local knowledge. A list of the agencies contacted and the publications reviewed to obtain the information contained in this portion of the report is presented in Table 2.5-1 and Section 2.5.6.

Seismologic studies included literature research to compile a record of the seismicity of the area, an evaluation of the geologic structure and tectonic history of the region, and analyses to evaluate the response of the foundation materials to earthquake-type loading. Field geophysical studies were performed to aid in evaluating the in-situ dynamic properties of the foundation materials.

In addition, a geologic reconnaissance of the site and surrounding area was made by engineering geologists. The site was

investigated in detail by drilling test borings and performing geophysical explorations.

Laboratory tests were performed to aid in evaluating both the static and dynamic properties of the subsurface soils.

Physiographically and tectonically, the site lies within the Atlantic Coastal Plain Province. The Coastal Plain has been described as a wedge shaped (thickening to the southeast) series of Cretaceous to Quaternary-aged sediments overlying Precambrian-aged basement rocks (see Figure 2.5-2).

The site structures are founded on the Paleocene-Eocene Vincetown Formation, a competent, cemented, granular soil. Below the Vincetown are some 1800 feet of increasingly older sediments.

The foundation soils will perform well under the anticipated static and dynamic loadings. The dynamic loads are expected to be low (the largest earthquake experienced in the regions surrounding the site is a Modified Mercalli Intensity VII earthquake). However, the plant is designed to withstand free field ground earthquake acceleration levels of 20 percent of gravity horizontal, and 13.3 percent gravity vertical.

2.5.1.1 Regional Geology

2.5.1.1.1 Physiography

The site lies within the Atlantic Coastal Plain Physiographic Province, about 18 miles southeast of the Piedmont Physiographic Province. The Fall Zone marks the contact of the low lying, gently undulating terrain of the Coastal Plain and the higher, more rugged terrain of the Piedmont Province. The relation of the site to these Physiographic Provinces and the Fall Zone is shown on the Regional Physiographic Map (Figure 2.5-1).

The Coastal Plain of New Jersey is a low plain rising from sea level to about Elevation +200 feet at the Fall Zone. Ground surface elevations in areas near the larger streams and in the coastal lowlands are generally less than 50 feet above sea level. The regional slope of the ground surface is to the southeast at approximately 1 1/2 feet per mile. The topography is characterized by a series of broad step-like terraces probably formed during Pleistocene time by a fluctuating sea level resulting in alternate deposition and erosion. The terraces are successively less dissected by steam erosion from the Fall Zone to the shoreline.

The post-glacial sea level rise inundated the former shore of the Coastal Plain and drowned the lower portions of the streams. Delaware Bay and the estuary of the Delaware River, which extends inland as far as Trenton, have been formed by this sea level rise. It is estimated that the sea has risen approximately 300 feet since the retreat of the glaciers.

2.5.1.1.2 History and Tectonics

The record of geologic history of the region starts with the deposition of sediments in Precambrian times. These sediments were metamorphosed subsequently to gneisses and schists. Contemportaneously, granites and other igneous rocks intruded these Precambrian sediments. Subsequently, these intrusives were metamorphosed to gneisses.

In late Precambrian to early Paleozoic time (following the completion of the Grenvillian orogenic cycle) the Proto-Atlantic Ocean began to form. The process caused the separation of the North American and African plates. In this initial rifting phase an eastward thickening wedge of clastic sediments, interbedded with volcanic rocks, were deposited unconformably on the Grenvillian basement in water-filled basins within the ancient continental margins.

As rifting progressed, the Proto-Atlantic Ocean opened and the previous system of isolated rift basins gave way to a long depositional trough underlain by oceanic crust.

The history of the closing of the Proto-Atlantic is reflected in the convergent stage of the Appalachian Orogeny, beginning in Ordovician times. The early phases of this stage are evidenced by a pre-Middle Ordovician unconformity, followed by the influx of detrital sediments over the previous carbonate bank, along the margin of the craton. The close of the Taconic Orogeny marked the destruction of the ancient continental margin and the development of a mature arc-trench-subduction zone.

During Triassic time, a series of elongated troughs were formed by faulting between the mountains uplifted by the Appalachian Orogeny, and the remnants of the old mountains to the west. Subsequently, the mountains were eroded and sediments were deposited in these troughs from both east and west. The long period of erosion and deposition extended into early Cretaceous time and reduced the region to a nearly level plain, exposing igneous and metamorphic Precambrian and early Paleozoic rocks with local areas of sedimentary and igneous rocks of Triassic age.

The Post-Middle Triassic development of the Orogeny initiated the opening of the North Atlantic Ocean. This structural development (the youngest regionally recognizable diatrophism in the northeastern United States) is characterized by vertical movements and related continental and marine sedimentation, transcurrent faulting along pre-existing zones of crustal weakness and extrusive and intrusive igneous activity.

In late Jurassic and early Cretaceous time, the region was downwarped to the east. The downwarping continued intermittently through Cretaceous and Tertiary time resulting in the present-day accumulation of sediments in the Coastal Plain.

During the early Pleistocene period, river sand and gravel were deposited by glacial meltwater over much of southern New Jersey. During the last interglacial stage, higher sea levels resulted in the deposition, in the lowland areas, of marine and estuarine sediments. In the higher areas, streams deposited sand and gravel.

The last continental glacier which extended into northern New Jersey resulted in the deposition of outwash material in streams and river valleys, such as the Delaware River. The post-glacial sea level rise submerged a large portion of the Coastal Plain marginal lands. Measurements indicate that sea level, on the average, has apparently risen approximately 0.3 cm/yr in the last 100 or so years. The surface exposure of these Precambrian to recent materials is presented on Figure 2.5-3, Regional Geologic Map.

2.5.1.1.3 Stratigraphy

The sediments deposited on the downwarped basement in the Coastal Plain range from early Cretaceous to Quaternary in age and consist of inter-bedded silt, clay, sand, and gravel, of both marine and non-marine origin. These strata form a wedge-shaped mass which thickens to the southeast. The strata out crop near the Fall Zone and dip to the southeast as shown on Figure 2.5-2, Geologic Section and Figure 2.5-3, Regional Geologic Map. Generally, each successively younger formation has a more gentle dip than that lying below, resulting in a decrease in slope upward in the sequence, from a crystalline basement dip of approximately 75 feet per mile, to about 10 feet per mile in the upper Tertiary formations. The decrease in dip is accompanied by gradual thickening of the strata to the southeast.

As a result of sea level fluctuations during deposition, the unconsolidated sediments of the Coastal Plain exhibit considerable lateral and vertical variations in lithology and texture. However, since the ocean lay to the east during the accumulation

of the sediments, they generally grade finer-grained to the east. Two periods of extreme sea level fluctuations occurred at the end of the Cretaceous and at the end of the Paleocene time. Both were times of widespread erosion and explain the absence of formations in some areas.

2.5.1.1.4 Structure

The site is located near the edge of the Chesapeake-Delaware Embayment. To the north and west of the site is the highly folded and faulted Piedmont Province. To the north has been postulated the Cornwall-Kelvin Wrench Fault Zone.

The Chesapeake-Delaware Embayment is an area of more extensive downwarping of the Atlantic Coastal Plain. It is marked by the re-entrance of the coastline and a deep accumulation of sediments. The areas of the greatest embayment exist in northern Maryland and in the vicinity of Long Island. Bedrock contours in the vicinity of the site are shown on Figure 2.5-4, Regional Tectonic Map.

The present day area of the Chesapeake and Delaware Bays was affected by the formation of the embayment in early Cretaceous or, possibly in some areas, in late Jurassic. From that time on, this region was generally downwarped and accumulated sediments. Local shallow folding has been recognized in some of these sediments, but no faults have been identified within them. The folding may be related to depositional features rather than post-depositional tectonic activity.

Eighteen miles northwest of the site, rocks of the basement complex crop out and mark the boundary of the Piedmont Physiographic Province. As discussed in Section 2.5.1.1.2, these rocks were subjected to significant tectonic activity in the form of intense folding, faulting, igneous intrusion, and metamorphism. As would be expected from the regional tectonic history, most of these structural features follow a strong northeast-southeast trend.

The basement complex underlying the site is generally similar to the metamorphic and igneous rocks observed in the Piedmont. However, geologic information relative to the basement structure is limited, due to the thick sequence of sediments overlying the basement. Interpretation has been based on geophysical data and the relatively few deep wells penetrating the basement complex in the region. It is probable that there are also faults lying beneath the Coastal Plain sediments, likely following the same regional trend as observed in the Piedmont area. Some minor faulting of this nature was observed in the basement complex underneath approximately 300 feet of sediments in Gibbstown, New Jersey. This is approximately 25 miles north of the site and the closest approach of known faulting to the Salem site.

No faulting has been identified in the Cretaceous sediments above the basement complex in this area. Therefore, it is probable that the faulting in the basement is Pre-Cretaceous (more than 135 million years in age).

One feature of interest, approximately paralleling the New Jersey coastline, is revealed only by geophysical data. This feature is the change in the rate of dip of the basement complex from approximately 75 feet per mile to over 200 feet per mile and more. Though the feature is fairly well documented, no really satisfactory explanation of its origin has been proposed for the New Jersey-Delaware area. Some geologists explain it relative to differential peneplanation, some to gradual flexing of the basement, or some due to faulting. The closest approach of this feature is about 55 miles east of the site (see Figure 2.5-4).

Approximately 50 to 60 miles north of the Salem site, and transverse to the regional structural trend, is the postulated Cornwall-Kelvin Wrench Fault Zone (1). This zone has been mapped on the basis of subsea topography and geophysical surveys and has been inferred to extend through the Triassic Lowlands of southeastern Pennsylvania. It has been suggested that this fault may be part of a major east-west continental fault which extends

from the mid-United States to 300 miles beyond the present Atlantic shoreline. A 94-mile, right lateral offset of sedimentary basins and belts of magnetic anomalies has been determined by oceanographic surveys near the 40th parallel in the ocean basin and onto the continental shelf and slope. However, there is neither geological or geophysical evidence of a continuation at this fault in the continent at the surface, or at depth (2). No disturbance has been observed in the Cretaceous and younger sediments in this zone. Again, it appears that any possible faulting has been Pre-Cretaceous in age.

As previously noted, the site is located in the inner plain of the Coastal Plain Physiographic Province. The Coastal Plain Physiographic Province has also been accepted as a tectonic province in accord with definitions in Appendix A to 10CFR100. This physiographic province is bounded on the east by the Atlantic Ocean and on the west by the Fall Zone and the Piedmont Physiographic (and Tectonic) Province. A generalized representation of the subsurface conditions in the site area is shown on Figure 2.5-5, Geologic Columnar Section - Site Area.

Thus, in summary, numerous ancient faults are likely in the basement rock. However, regional diatrophism ceased at least 85 million years ago and only minor fold-like structures appear in the sediments overlying the ancient basement.

Considering the lack of Post-Cretaceous tectonic activity along the eastern seaboard of the United States, it is likely that the Post-Cretaceous features are the results of differential compaction over basement relief.

2.5.1.1.5 Groundwater

See Section 2.4.13.1 for a discussion of the local hydrologic conditions.

2.5.1.2 Site Geology

The site is located on the southern tip of what was once a natural bar in the Delaware Estuary, adjacent to the western shore of New Jersey. In the past, the bar and the area between the bar and mainland has been used as a disposal area for material dredged from the Delaware Estuary or River. No additional dredged material has been placed for at least the past 25 years.

The subsurface conditions of the site area were investigated by 35 borings to depths of up to 200 feet. The locations of these borings are shown on Figures 2.5-6 and 2.5-7, Boring Plan and Boring Plan - Detail A. Stratigraphy developed from these borings is shown on Section A-A and B-B on Figure 2.5-8, Subsurface Sections.

The deepest formation penetrated in the boring program was the top of the Mount Laurel Sand. The sands of this formation and those of the conformably overlying Navesink Formation mark the end of Cretaceous deposition. The top of the Navesink is an unconformity recording a period of widespread erosion. The Red Bank Sand, present in northern New Jersey, and part of the Navesink, were probably removed from southern New Jersey during late Cretaceous or early Tertiary time.

During the Paleocene, silty glauconitic sands of the Hornerstown Sand and the clays, silts, and sands of the Vincetown Formation were deposited. The top of the Vincetown again marks a period of erosion during Eocene and Oligocene time.

During the Miocene, clays and silts of the Kirkwood Formation were deposited. This formation was encountered in the borings at the site and can be observed in outcrops further north, although it is usually covered by a thin veneer of Quaternary deposits.

At the Salem site, the borings encountered Quaternary deposits to an average depth of about 35 feet. These Quaternary soils consist

of approximately 25 to 30 feet of hydraulic fill and an alluvium of loose organic silts and clays, and about 5 to 10 feet of coarser sands and gravels at the base.

Generalized descriptions of the formations encountered at the Salem site, their physical properties, and their corresponding depths are shown on the Columnar Section - Showing Geophysical Data (Figure 2.5-9). The upper 200 feet of the column are based on the borings at the site, drilled under inspection. The descriptions below 200 feet are based on regional data and deep well information in the vicinity of the site. A 900-foot deep pilot hole, drilled at the site subsequent to the initial investigation, showed generally good correlation with the geologic column. No faulting or folding was observed at the site in a detailed review of all boring data.

The Vincetown Formation was determined to be the closest stratum to the ground surface suitable for foundation support. In the Salem Station area the Vincetown is located some 70 feet below grade. The bottom of the base mats of the major Category I structures are located 22 to 46 feet below grade. A lean concrete fill was placed between the Vincetown and the base of the Category I structures.

Conventional strength and consolidation tests were performed upon the foundation soils. These laboratory tests confirmed the results of field penetration tests and visual examination of undisturbed samples. The strength of the Vincetown was completely adequate to loads.

To evaluate the performance of the Vincetown under dynamic earthquake loadings, a study of its liquefaction potential was undertaken. A comparison was made between the subsurface conditions at Salem and the soil conditions at Niigata, Japan, where on June 16, 1964, an earthquake of greater magnitude than that postulated for the site Safe Shutdown Earthquake occurred, causing areas of liquefaction. The standard penetration

resistances of the Vincetown soils were compared with those recorded in areas of Niigata where liquefaction both did and did not occur. The penetration resistances of the Vincetown soils were found to be even greater than those in the areas of Niigata where no liquefaction occurred.

On the basis of these static and dynamic analyses, the Vincetown was considered to be a suitable foundation medium. All analysis considered the existence of a near surface water table and the artesian head in the Vincetown in accordance with the data presented in Section 2.4.13.

2.5.2 Vibratory Ground Motion

2.5.2.1 Geologic Conditions at Site

As described in Sections 2.5.1.1 and 2.5.1.2, the site is underlain by some 1800 feet of Cretaceous, Tertiary, and Quaternary-aged sediments. Crystalline basement rock outcrops near the Fall Zone, some 18 miles northwest of the site. A graphical representation of the site subsurface conditions is presented on Figures 2.5-5 and 2.5-9, Columnar Sections. Conditions encountered at the site are completely consistent with the known regional picture.

2.5.2.2 Tectonic Conditions

The Coastal Plain sediments effectively mask the crystalline basement rock and no significant faulting has been identified in the area. However, based on regional data, the overlying Cretaceous and Tertiary sediments are undeformed. The absence of folding and faulting in the sedimentary strata indicates that, if unknown faults are present in the basement, any displacements along these faults during the last 135 million or so years have been negligible.

No known faults exist within the basement rock or sedimentary deposits in the vicinity of the site. The closest known faulting to the site is about 25 miles away. Faults, at this distance, are found in the rocks of the Piedmont west of the Fall Zone; however, a minor fault has been identified east of the Fall Zone, near Gibbstown, New Jersey, about 25 miles northeast of the site. This fault is in the crystalline basement, covered by about 300 feet of Coastal Plain sediments, and apparently parallels the general northeast-southeast trend of the Piedmont.

The Piedmont Province consists of igneous and metamorphic rock of Precambrian and early Paleozoic Age, with areas of sedimentary and igneous rocks of Triassic Age. The geologic history of this province is complex (see Section 2.5.1.1.2). Major tectonic activity has occurred in the Piedmont and many zones of major faulting have been identified.

Well north of the site there is an inferred east-west trending fault system known as the Cornwall-Kelvin Wrench Fault Zone (see Figure 2.5-4). Regionally developed information (2) indicates that there is neither geological or geophysical evidence of this fault on the continent or at depth.

The site lies to the north of the central portion of the Chesapeake-Delaware Embayment. This embayment is a zone of regional downwarping in the Coastal Plain, typical of other areas found extending from the Cape Fear Arch to as far north as the Grand Banks of Newfoundland. It is possible that faulting was associated with the formation of the embayment.

2.5.2.3 Behavior During Prior Earthquakes

No major earthquake activity has affected the site area and no record of deleterious behavior of onsite soils (even the poorest surficial materials) is known.

2.5.2.4 Geotechnical Properties

In summary, the significant soil layers in the site vicinity are from the surface downward:

1. Hydraulic fill

2. River bottom sand

3. Clays of the Kirkwood Formation

4. Basal sand of the Kirkwood Formation

5. Vincetown Formation

6. Various sandy formations (Hornerstown and Navesink Formations)

Support of all Category I structures was provided by a lean concrete fill placed upon the Vincetown Formation. Physical properties developed for use in dynamic design are summarized on Figure 2.5-10. These material properties were developed as described in Section 2.5.1.2.

2.5.2.5 Seismicity

The site is situated in a region which has experienced only minor earthquake activity. Only one shock within 50 miles of the site has been large enough to cause even minor structural damage. Since the region has been populated for over 300 years, it is probable that any earthquake of moderate intensity, say VI or

greater on the Modified Mercalli Scale*, would have been reported during this period. It is very likely that all earthquakes within the last 200 years, with intensities greater than V, in the region surrounding the site, have been reported.

The first report of significant earthquake occurrence in the general area of the site dates back to 1871. Since then, only 22** earthquakes with epicentral intensities of V or greater on the Modified Mercalli Scale have been reported within about 100 miles of the site (2). None of these shocks was greater than Intensity VII.

Few were of high enough intensity to cause any structural damage and only two of these shocks can be considered more than minor disturbances. These were Intensity VII shocks near Wilmington, Delaware and Long Branch/Asbury Park, New Jersey, about 15 and 90 miles from the site, respectively. A list of earthquakes of Intensity V or greater with epicenters located within a distance of about 100 miles of the site is presented in Table 2.5-3, Significant Earthquakes Within 100 Miles of Salem, New Jersey. The locations of these and other earthquakes (through 1970) in the region surrounding the site are shown on Figure 2.5-11, Epicentral Location Map.

Most of the reported earthquakes in the region have occurred in the Piedmont Physiographic Province, west of the Fall Zone. The closest approach of the Fall Zone to the site is about 18 miles.

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* All intensity values in this report refer to the Modified Mercalli Scale as abridged in 1956 by Richter. The intensity scale, a copy of which is presented in Table 2.5-2, is a means of indicating the relative size of an earthquake in terms of its perceptible effect.

** Excluding aftershocks of an event.

There have been several large shocks with epicenters in the Coastal Plain, some of which were damaging. The largest are the Charleston, South Carolina, earthquakes of 1886, which are rated as having an epicentral intensity of IX. These two closely spaced (chronologically) earthquakes and other minor earthquakes in the Charleston area are localized in a very limited area.

The largest and closest earthquake in the Coastal Plain to be of significance in the current study occurred near the northern New Jersey coast in 1927, about 90 miles northeast of the Salem site. The epicentral intensity of this earthquake was VII. Three shocks were felt over an area of about 3,000 square miles from Sandy Hook to Toms River. Highest intensities were felt from Asbury Park to Long Branch where chimneys fell, plaster cracked, and articles were thrown from shelves. This shock, which is the largest reported earthquake within 100 miles of the site, has not been related to any known geologic features.

An Intensity VII earthquake occurred near Wilmington, Delaware, in 1871. It is not possible to precisely locate the epicenter of this shock with the limited data available, but it is probable that the shock occurred along the Fall Zone some 15 to 20 miles north of the Salem site. The epicentral intensity of this shock is rated at VII. At Wilmington, chimneys toppled and windows broke. Damage was also reported at Newport and New Castle, Delaware, and Oxford, Pennsylvania. The earthquake was felt over a relatively small area of northern Delaware, southeastern Pennsylvania and southwestern New Jersey. The shock was probably felt at Salem.

Several smaller shocks also have been reported in the Coastal Plain in the region surrounding the site. None of these earthquakes caused any structural damage and they are of interest only in that they indicated the possible presence of unidentified faulting in the basement rock of the Coastal Plain.

Nine earthquakes of Intensity V or greater have been reported within about 50 miles of the proposed station site. The largest

of these was the aforementioned Intensity VII Wilmington earthquake of 1871. Other shocks occurred in 1879, Modified Mercalli Intensity (MMI) IV to V and in 1973 (MMI V) near the epicenter of the 1871 shock. These shocks were also probably felt at Salem. It is likely that these shocks are related to the Fall Zone or faulting in the vicinity of Wilmington, associated with Piedmont-type geologic structure. The epicenters of two shocks with intensities of IV to V in Harford County, Maryland in 1889, are within the Piedmont and can be related to well documented local structure. Four Intensity V earthquakes (1906 near Seaford, Delaware; 1921 near Moorestown, New Jersey; 1939 in Salem County, New Jersey; and east of Hammonton, New Jersey in 1968), originated within the Coastal Plain. These shocks have not been basement structure, generally similar to that exposed in the Piedmont. Available data regarding these shocks are very limited, and it is impossible to accurately estimate the maximum intensities of these shocks, or to precisely locate their epicenters. It is possible that some reports of older shocks may refer to relatively distant earthquakes which were felt in this area. Other shocks may possibly be attributed to causes other than tectonic activity.

2.5.2.6 Correlation of Epicenters with Geologic Structures

In some instances, earthquakes occurring in the eastern United States have been associated with specific geologic structure, or at least some generalized seismogenitic source area. However, earthquakes occurring within about 200 miles of the site have been small (no greater than MMI VII) and any positive identification with specific fault structure is somewhat tenuous. In general, because of the age of the "larger" shocks and the scatter of both the small, well located shocks and the regional fault systems, earthquakes have been assumed to have an equal possibility of occurrence any place within a tectonic (or seismotectonic) province. As a result, the 1871 and 1927 MMI VII shocks in the regions surrounding the site are of prime significance in selecting the "design" earthquakes for the site although neither have been positively associated with specific geologic structures.

As subsequently discussed (Section 2.5.2.9) this lack of specific association requires the conservative use of a "floating" earthquake to define the Safe Shutdown Earthquake for the site.

2.5.2.7 Identification of Active Faults

Small earthquakes in the region have been spatially associated with ancient faulting. However, in most instances, the focal mechanism solution to the shock is not consistent with the stress conditions responsible for the last movements upon the fault in question. In addition, no evidence of surface rupture has been associated with local earthquake activity.

Thus, "active" faulting, as the term is ordinarily used in connection with active plate margins (e.g. California), is non-existent in the region of the site.

2.5.2.8 Description of Active Faults

See Section 2.5.2.7.

2.5.2.9 Maximum Earthquake

The two largest earthquakes nearest the site were the 1871 Wilmington, Delaware and the 1927 Asbury Park, New Jersey shocks (see Table 2.5-3). Both had maximum epicentral intensities of VII. Intensity VII shocks are the largest that have occurred throughout the surrounding regions, and both from a deterministic and probabilistic standpoint, appear to be the largest credible earthquake. Therefore, for purposes of seismic design, an Intensity VII shock has been assumed to occur near the site.

The selection of the Operating Basis Earthquake was based upon the assumption of a shock similar to the following:

1. A shock equivalent to the Intensity VII, 1871 Wilmington earthquake occurring as close to the site as its related geologic structure. It is likely that this earthquake was related to the Fall Zone or to faulting in the Piedmont west of the Fall Zone. However, since it is impossible to precisely locate the epicenter of this shock from the limited available data, and since the earthquake was felt in portions of the Coastal Plain, it has been considered that the epicenter of this shock may have been located somewhat east of the Fall Zone and similar geologic structure could be postulated near the site.

2. A shock equivalent to the Intensity VII northern New Jersey earthquake of 1927 occurring close to the site. This shock occurred in the Coastal Plain and has not been related to any known geologic structure. Therefore, the conservative assumption has been made that it could occur along a hypothetical geologic structure in the basement rock near the site.

Based on the foregoing statements the very conservative assumption has been made that the maximum potential earthquake would be a shock as large as Intensity VII originating in the basement rock close to the site.

2.5.2.10 Safe Shutdown Earthquake

For a safe shutdown of the reactor, the facility has been designed using a seismic factor of 20 percent of gravity at foundation level. This level of horizontal ground acceleration is significantly greater than that which would be expected upon the foundation soils at the site if the safe shutdown earthquake (SSE)

were to occur. The corresponding vertical ground acceleration is taken as 13.3 percent of gravity.

2.5.2.11 Operating Basis Earthquake

On the basis of the seismic history of the area, it does not appear likely that the site will experience any significant earthquake ground motion during the economic life of the proposed facility. However, the proposed nuclear power station has been designed to respond elastically with no loss of function to horizontal earthquake ground accelerations of 10 percent of gravity, and vertical ground accelerations of 6.7 percent of gravity. These values are conservatively greater than the level of ground motion which would be expected at the site during an earthquake similar to any historical event. This ground acceleration is greater than what might be reasonable expected due to an earthquake similar to the 1871 Wilmington shock, Intensity VII, at an epicentral distance of about 15 to 20 miles.

2.5.2.12 Response Spectra

Response spectra used in design are presented on Figures 2.5-12 and 2.5-13, Response Spectra. These spectra conform to the average spectra developed by Dr. G. W. Housner for the frequency range higher than about 0.33 cycle per second. These average spectra were originally presented in TID-7024. The spectra presented considered Dr. Housner's latest revisions. The spectra for frequencies lower than about 0.33 cycle per second were prepared utilizing data suggested by Dr. N. M. Newmark. These data are presented in the Proceedings of the International Atomic Energy Agency Panel on Aseismic Design and Testing of Nuclear Facilities (1967).

The spectra have been normalized to a horizontal ground acceleration of 20 percent of gravity for the SSE and 10 percent of gravity for the Operating Basis Earthquake.

2.5.3 Surface Faulting

See Section 2.5.2.7, Identification of Active Faults.

2.5.4 Stability of Subsurface Materials

The foundation of the Class I station structures are established directly in the Paleocene silty sands of the Vincetown Formation or upon lean concrete fill extending to this Formation.

The Vincetown soils are preconsolidated and/or cemented as a result of its depositional environment and subsequent erosion of younger sediments. Thus, this formation provides excellent foundation support for Salem Generating Station structures. Measurements made throughout plant construction and during initial operation indicated a maximum settlement of only about 0.5 inch.

For a further description of the subsurface conditions at the site see Section 2.5.1.2, Site Geology.

2.5.5 Slope Stability

At the completion of construction, the only slope of significance across the site is at the sea wall. As discussed in Section 2.4.5.7, Protective Structures, the sea wall was investigated by conventional engineering procedures and designed to withstand the site maximum environmental loadings.

2.5.6 References for Section 2.5

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TABLE 2.5-1

LIST OF REFERENCES

Agencies and Individuals Interviewed

Agency	Location	Individual
New Jersey Geological Survey	Trenton, NJ	Mr. F. J. Markewicz
Delaware University, Delaware Geological Survey	Newark, DE	Dr. R. R. Jordan
Maryland Geological Survey	Baltimore, MD	Dr. K. N. Weaver
Maryland Geological Survey	Baltimore, MD	Dr. H. J. Hansen
Johns Hopkins University	Baltimore, MD	Dr. E. Cloos
U.S. Corps of Engineers	Philadelphia, PA	Mr. A. Depman
U.S. Corps of Engineers	Philadelphia, PA	Mr. B. Uibel
U.S. Geological Survey	Trenton, NJ	Mr. H. Meisler
U.S. Geological Survey	Trenton, NJ	Mr. H. Gill
Alpine Geophysics	Norwood, NJ	Dr. C. Frye
Lamont Geological Observatory	Palisades, NY	Dr. C. Drake
University of Massachusetts	Amherst, MA	Dr. R. Bromery

TABLE 2.5-2

MODIFIED MERCALLI INTENSITY (DAMAGE) SCALE OF 1931
(Abridged)

I. Not felt except by a very few under especially favorable circumstances. (I Rossi-Forel Scale.)

II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing. (I to II Rossi-Forel Scale.)

III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibration like passing of truck. Duration estimated. (III Rossi-Forel Scale.)

IV. During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing motorcars rocked noticeably. (IV to V Rossi-Forel Scale.)

V. Felt by nearly everyone, many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop. (V to VI Rossi-Forel Scale.)

VI. Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight. (VI to VII Rossi-Forel Scale.)

VII. Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motorcars. (VIII Rossi-Forel Scale.)

VIII. Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motorcars disturbed. (VIII+ to IX Rossi-Forel Scale.)

IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse.

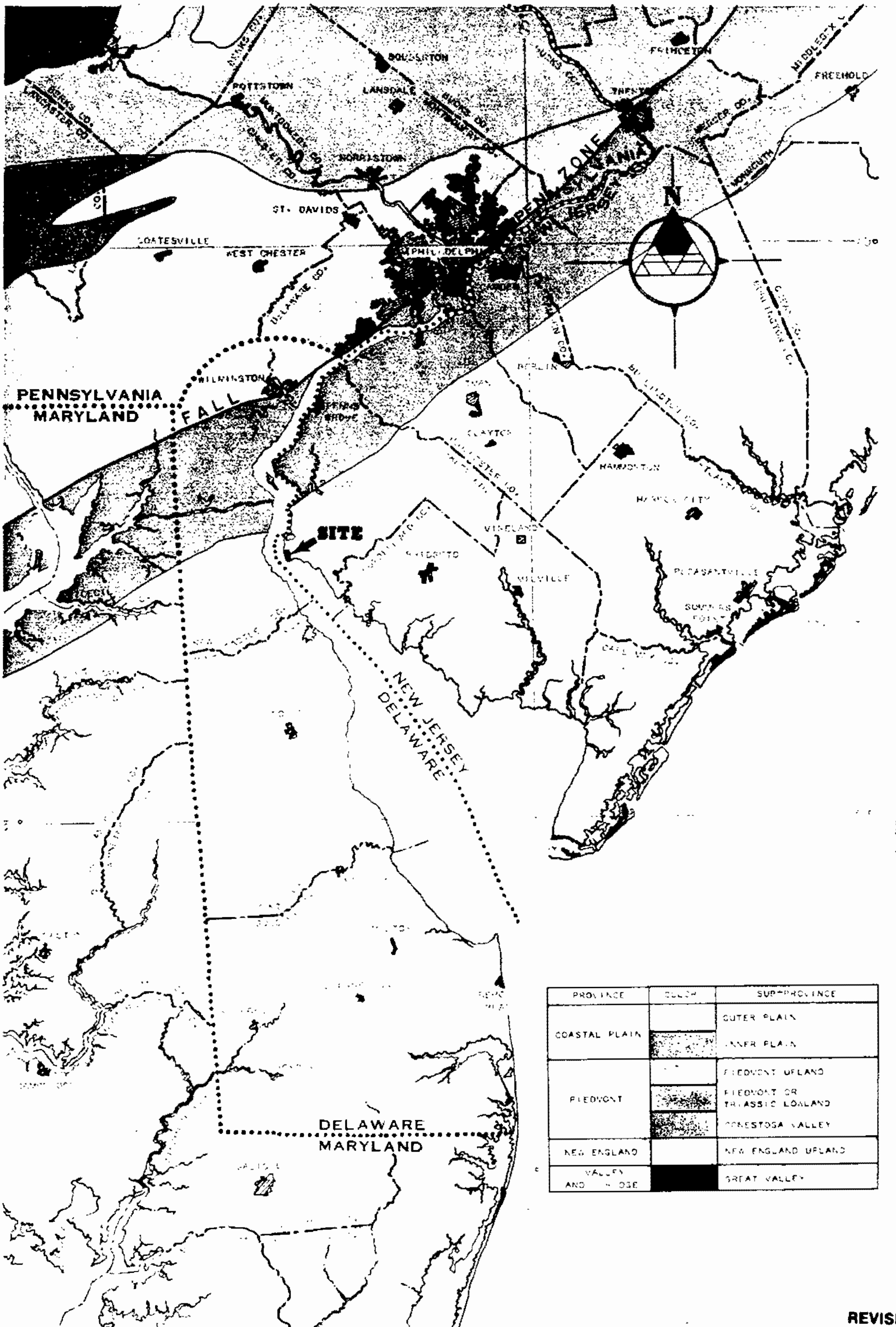
	Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. (IX+ Rossi-Forel Scale.)
X.	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks. (X Rossi-Forel Scale.)
XI.	Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
XII.	Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air.

TABLE 2.5-3

SIGNIFICANT EARTHQUAKES WITHIN 100 MILES OF SALEM, NEW JERSEY
(Intensity V or Greater)

Year	Date	Time	Intensity	Location	N. Lat. (degrees)	W. Long. (degrees)	Area Felt (sq mi)	Distance From Site (mi)
1871	Oct. 9	09:40	VII	Wilmington, DE	39 3/4	75 1/2	- -	15
1877	Sept. 10	09:59	IV-V	Delaware Valley	40.1	74.9	300	60
1879	Mar. 25	19:30	IV-V	Delaware River	39 3/4	75 1/2	600	15
1883	Mar. 11	18:57	IV-V	Harford County, MD	39.5	76.4	Local	50
	Mar. 12	00:00 01:00	IV-V	Harford County, MD	39.5	76.4	Local	50
1884	May 31	- -	V	Allentown, PA	40.6	75.5	Local	80
1889	Mar. 8	18.40	VI	Southeastern, PA	40	76 3/4	4,000	50
1895	Sept. 1	06:09	VI	Near High Bridge, NJ	40.7	74.8	35,000	90
1906	May 8	12:41	V	Seaford, DE	38.7	75.7	400	50
1908	May 31	12:42	VI	Allentown, PA	40.6	75.5	Local	80
1921	Jan. 26	18:40	V	Moorestown, NJ	40.0	75.0	150	45
1927	June 1	07:23 07:31 07:39	VII	New Jersey Coast	40.3	74.0	3,000	90

Year	Date	Time	Intensity	Location	N. Lat. (degrees)	W. Long. (degrees)	Area Felt (sq mi)	Distance From Site (mi)
1933	Jan. 24	21:00	V	Central NJ	40.1	74.5	600	60
1938	Aug. 22 Aug. 23	22:37 00:05 02:03	V	Central NJ	40.1	74.5	5,000	70
1939	Nov. 14	21:54	V	Salem County, NJ	39.6	75.2	6,000	20
1954	Jan. 7	02:25	VI	Sinking Spring, PA	40.3	76.0	- -	60
1957	Mar. 23	14:03	VI	West-Central, NJ	40.6	74.8	- -	90
1961	Sept. 14	21:17	V	Lehigh Valley, PA	40.6	75.4	Local	80
1961	Dec. 27	12:06	V	PA-NJ Border	40.1	74.8	- -	60
1964	May 12	04:45	VI	Cornwall, PA	40.2	76.5	- -	70
1968	Dec. 10	09:12	V	Wharton State Forest	39.7	74.6	- -	50
1973	Feb. 28	03:21	V	Penns Grove, NJ/ Wilmington, DE	39.7	75.4	15,000	20



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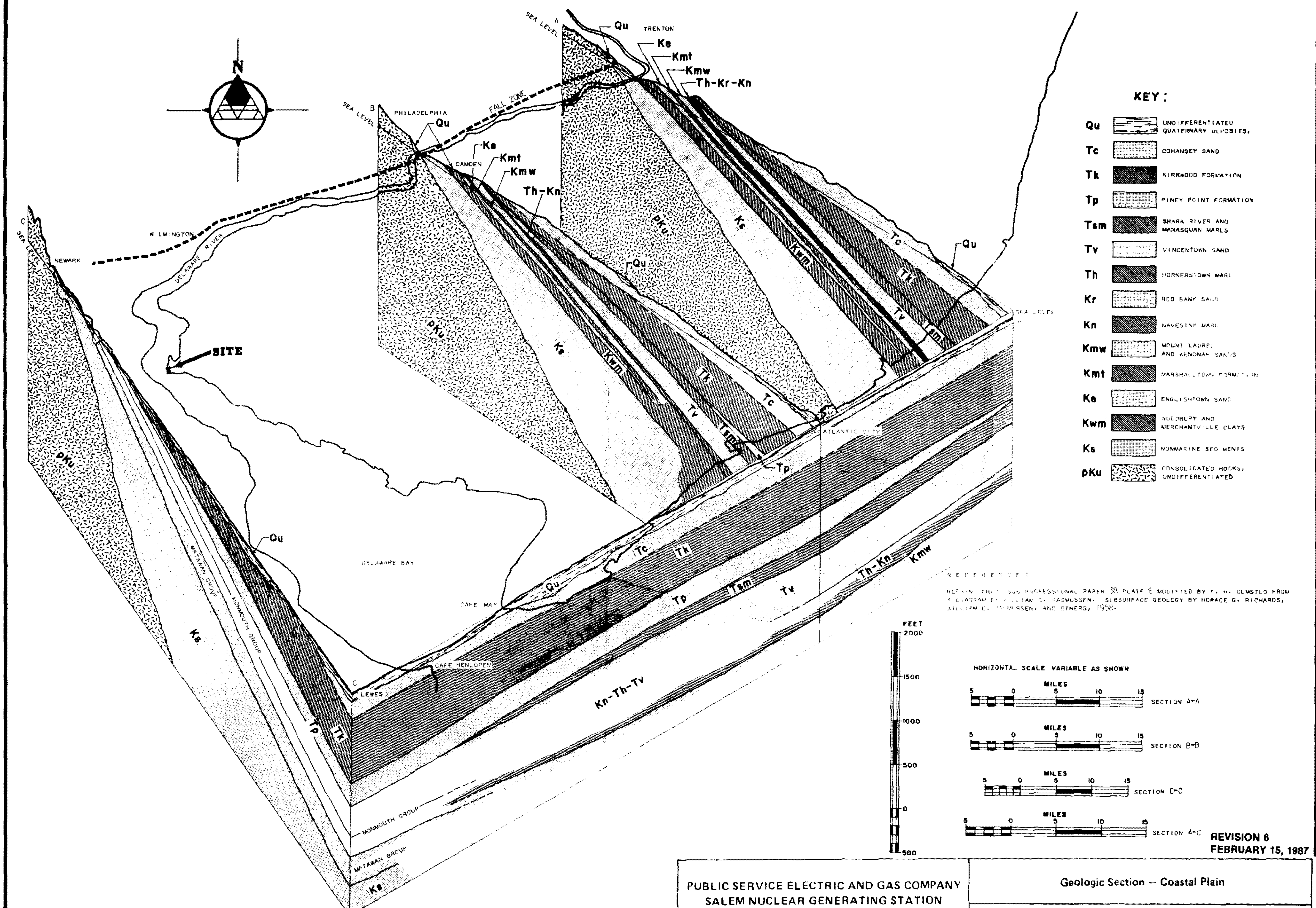
PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Regional Physiographic Map	
	Updated FSAR	Figure 2.5-1



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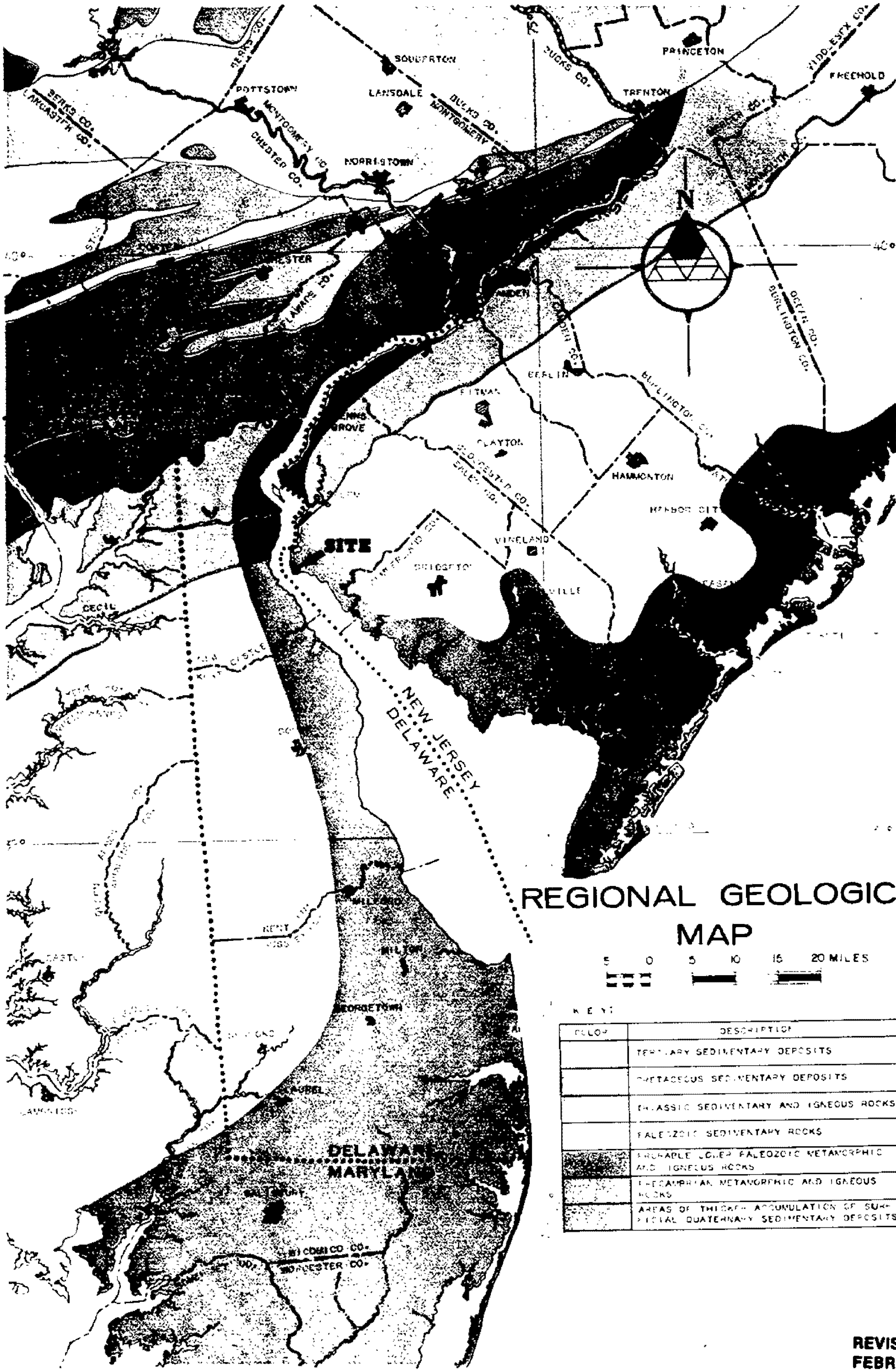
PUBLIC SERVICE ELECTRIC AND GAS COMPANY
SALEM NUCLEAR GENERATING STATION

Geologic Section – Coastal Plain

Updated FSAR

Figure 2.5-2



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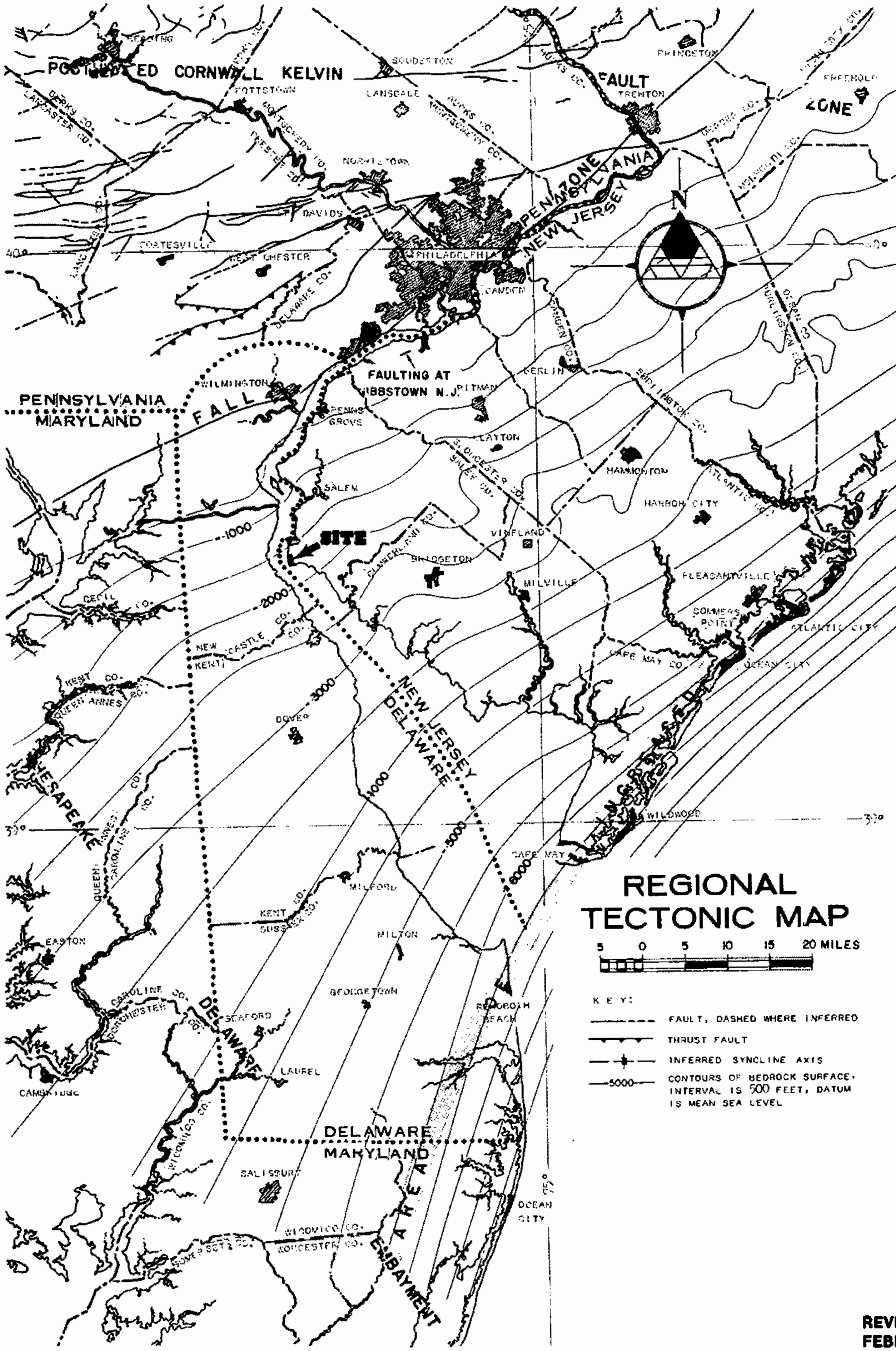
PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Regional Geologic Map	
	Updated FSAR	Figure 2.5-3



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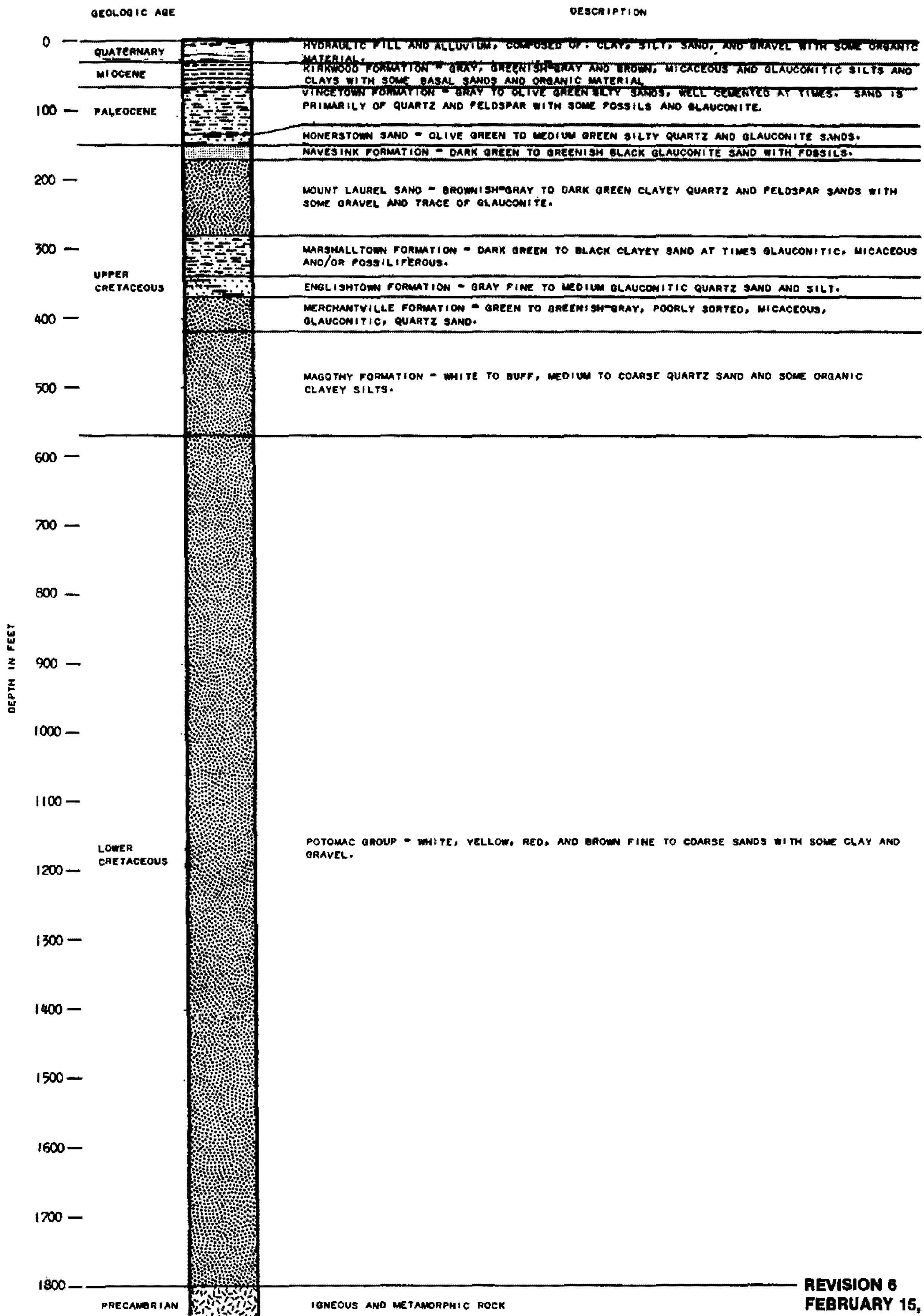
PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Regional Tectonic Map	
	Updated FSAR	Figure 2.5-4



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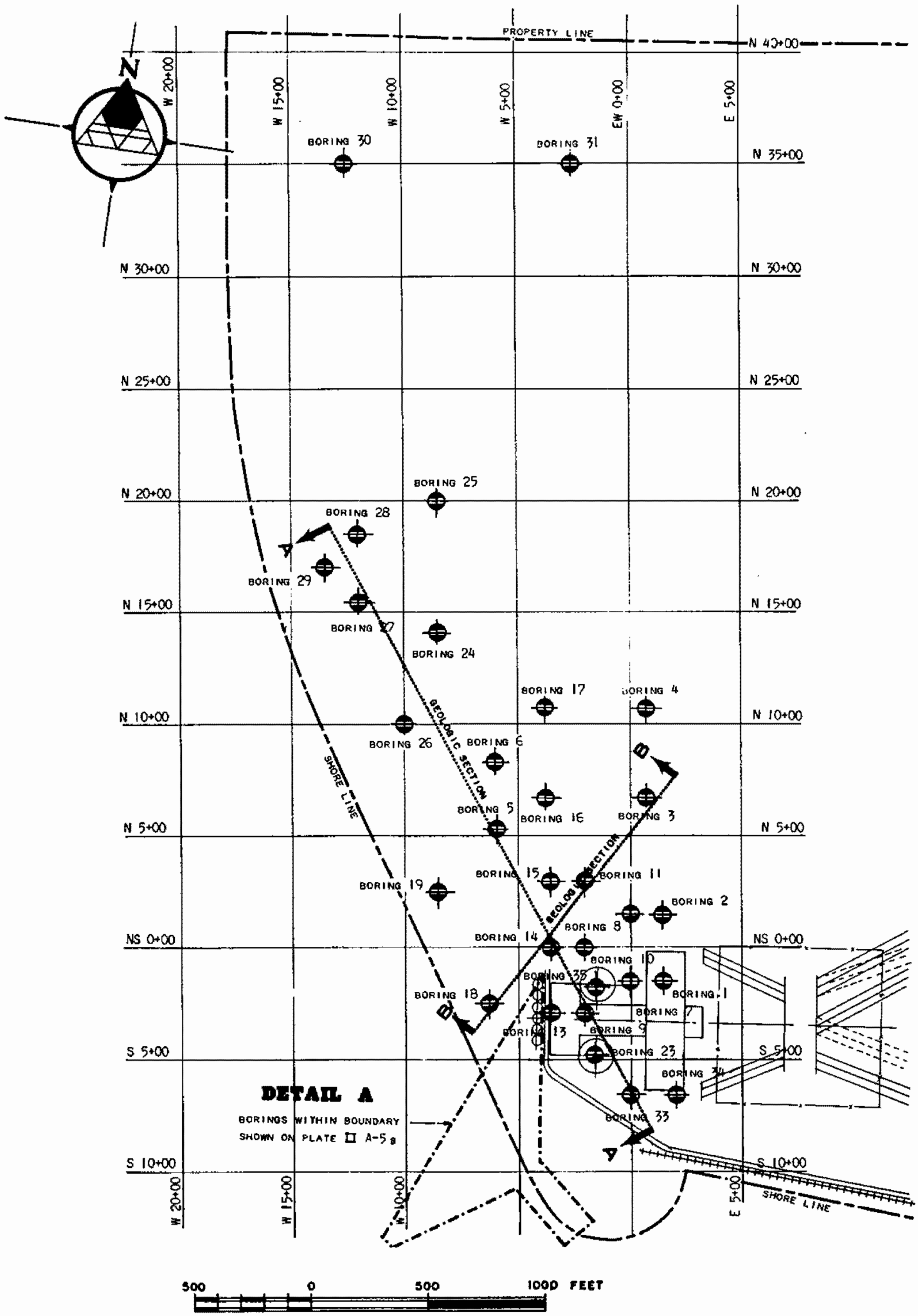
PUBLIC SERVICE ELECTRIC AND GAS COMPANY
SALEM NUCLEAR GENERATING STATION

Geologic Columnar Section – Site Area

Updated FSAR

Figure 2.5-5



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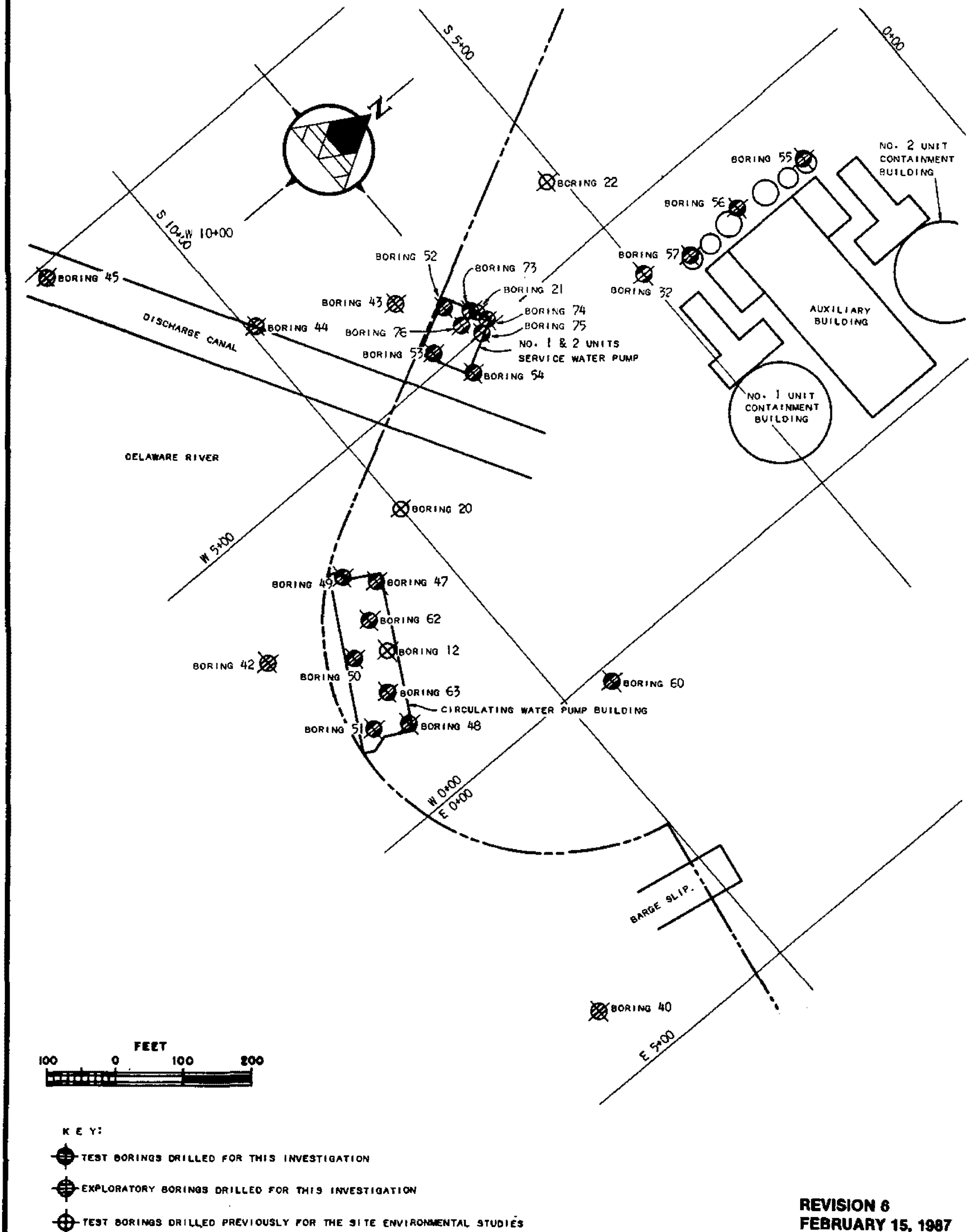
PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	**Boring Plan**
	Updated FSAR — **Figure 2.5-6**



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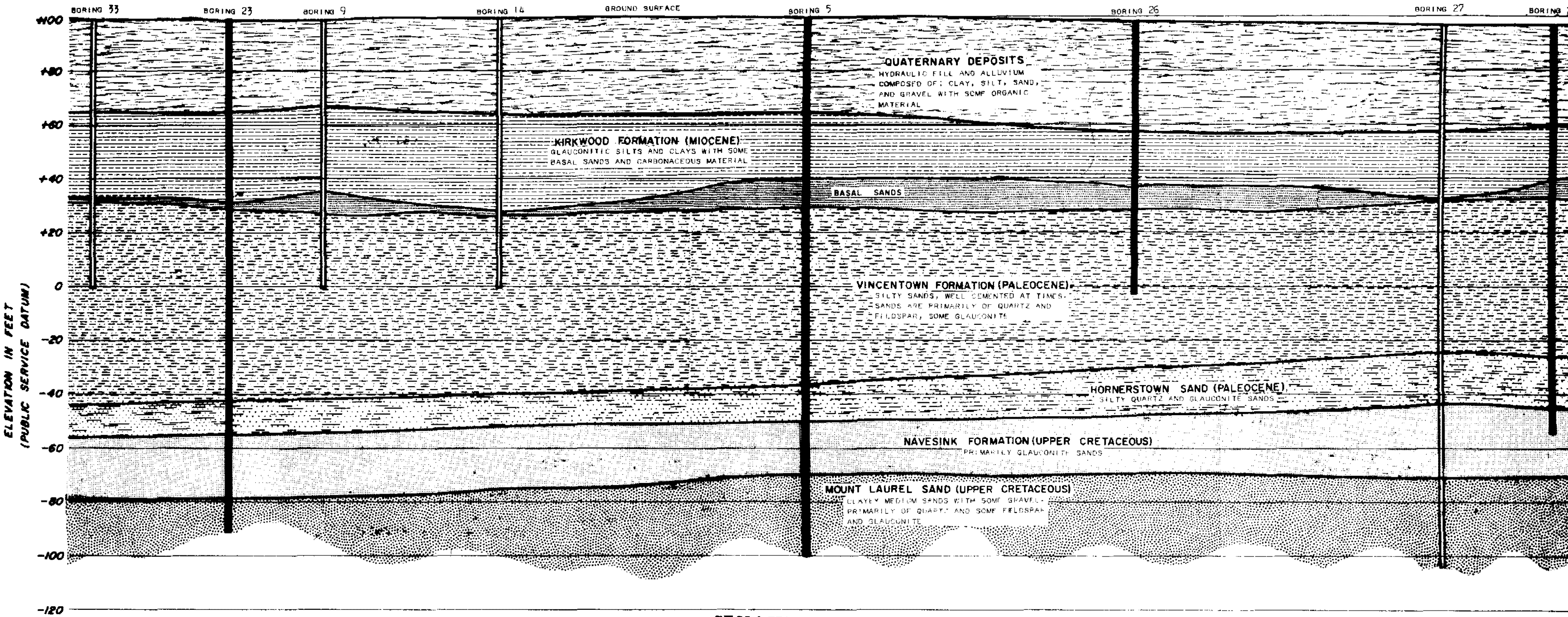
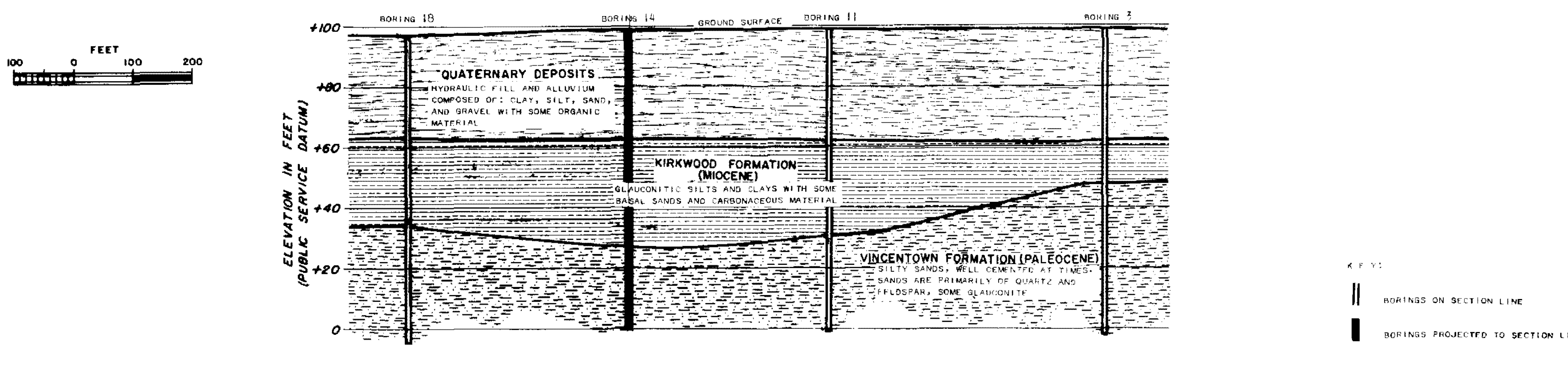
PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Boring Plan Detail A
	Updated FSAR — Figure 2.5-7



GEOLOGIC SECTION A-A



GEOLOGIC SECTION B-B

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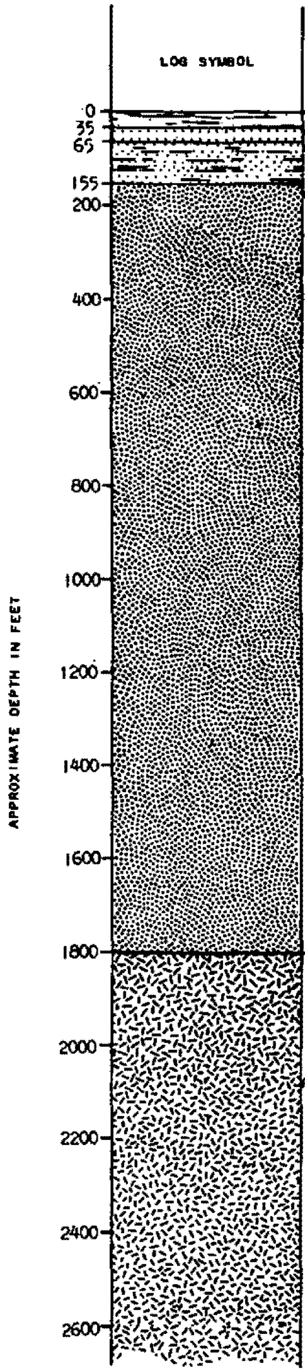
PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Sub-Surface Sections
	Updated FSAR — Figure 2.5-8



DESCRIPTION	COMPRESSIONAL WAVE VELOCITY (FT/SEC) (MEASURED)	POISSON'S RATIO	SHEAR WAVE VELOCITY (FT/SEC)	UNIT WEIGHT (LBS/CU.FT.)
HYDRAULIC FILL AND QUATERNARY ALLUVIUM OF CLAY, SILT AND SOME SAND AND GRAVEL	3150±150	.497 (COMPUTED)	250±10 (MEASURED)	95-105 (MEASURED)
MIOCENE SILT AND CLAY	5650±250	.45 (ESTIMATED)	1700 (COMPUTED)	105 (MEASURED)
PALEOCENE SILT AND SAND				125 (MEASURED)
CRETACEOUS SAND WITH SOME SILT AND CLAY	6500±300	0.30 (ESTIMATED)	3500 (COMPUTED)	130-135 (ESTIMATED)
PRECAMBRIAN IGNEOUS AND METAMORPHIC ROCK	17250±1000	0.15 (ESTIMATED)	11,000 (COMPUTED)	170 (ESTIMATED)

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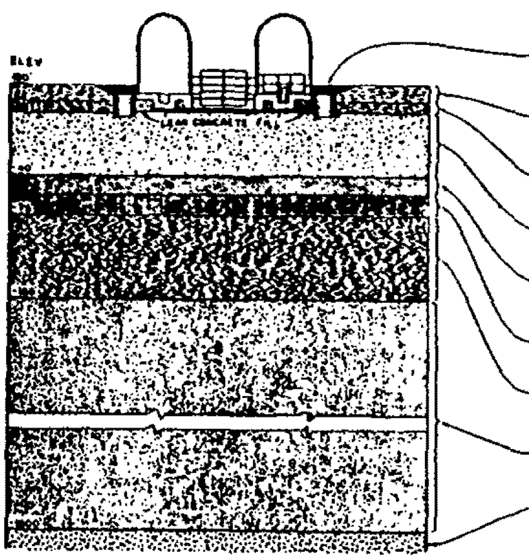
PUBLIC SERVICE ELECTRIC AND GAS COMPANY
SALEM NUCLEAR GENERATING STATION

Columnar Section showing Geophysical Data

Updated FSAR

Figure 2.5-9

SOIL PROFILE



MATERIAL PROPERTIES OF SOIL LAYERS

MATERIAL DESCRIPTION	MODULUS OF ELASTICITY		SHEAR MODULUS		POISSON'S RATIO	SEISMIC VELOCITY		COMPRESSIVE STRENGTH		UNIT WEIGHT pcf
	STATIC psf	DYNAMIC psf	STATIC psf	DYNAMIC psf		COMPRESSIVE fps	SHEAR fps	STATIC psf	DYNAMIC psf	
LEAN CONCRETE FILL	$34{,}000 \times 10^4$	364×10^6	$15{,}000 \times 10^4$	160×10^6	0.18	9000	6000	2500	2500	140
COMPACTED SAND FILL	80×10^4	4.6×10^6	30×10^4	1.7×10^6	0.35	1000.	800	Function of $\phi = 32°$	Confinement $\phi = 35°$	120
QUATERNARY – Hydraulic Fill & Alluvium – Clay, Silt, Sand and Gravel	2.0×10^4	0.2×10^6	0.6×10^4	0.06×10^6	0.487	3100	250	Function of $\phi = 25°$	Confinement $\phi = 28°$	98
KIRKWOOD FORMATION – Gray, Brownish-Gray and Brown Micaceous and Glauconitic Silts and Clays	17×10^4	2.0×10^6	6.0×10^4	0.7×10^6	0.45	5600	1700	3000	6000	105
VINCENTOWN FORMATION – Gray to Olive Green Silty Sands, with cemented at times	100×10^4	8.1×10^6	40×10^4	3.0×10^6	0.35	6800	3100	Function of $\phi = 34°$	Confinement $\phi = 38°$	125
HORNERSTOWN FORMATION – Olive to Medium Green Silty Quartz and Glauconitic Sands	100×10^4	8.1×10^6	40×10^4	3.0×10^6	0.35	6300	3100	Function of $\phi = 34°$	Confinement $\phi = 38°$	125
NAVESINK FORMATION – Dark Green to Greenish Black Glauconitic Sand with Fossils	160×10^4	12×10^6	60×10^4	5.0×10^6	0.30	6500	3300	Function of $\phi = 34°$	Confinement $\phi = 34°$	135
MOUNT LAUREL FORMATION – Brownish Gray to Dark Green Clayey Quartz and Feldspar Sands with some Gravel	200×10^4	18×10^6	80×10^4	7.0×10^6	0.30	6500	3500	Function of $\phi = 34°$	Confinement $\phi = 38°$	135
CRETACEOUS (Undifferentiated) – Fine to Coarse Sands with some Clay and Gravel	200×10^4	18×10^6	80×10^4	7.0×10^6	0.30	6500	3800	Function of $\phi = 34°$	Confinement $\phi = 38°$	135
IGNEOUS AND METAMORPHIC ROCK	$120{,}000 \times 10^4$	1200×10^6	$50{,}000 \times 10^4$	500×10^6	0.15	17,250	10,000			170

NOTE: Dynamic stresses are based on strain levels induced under Design Base Earthquake loading

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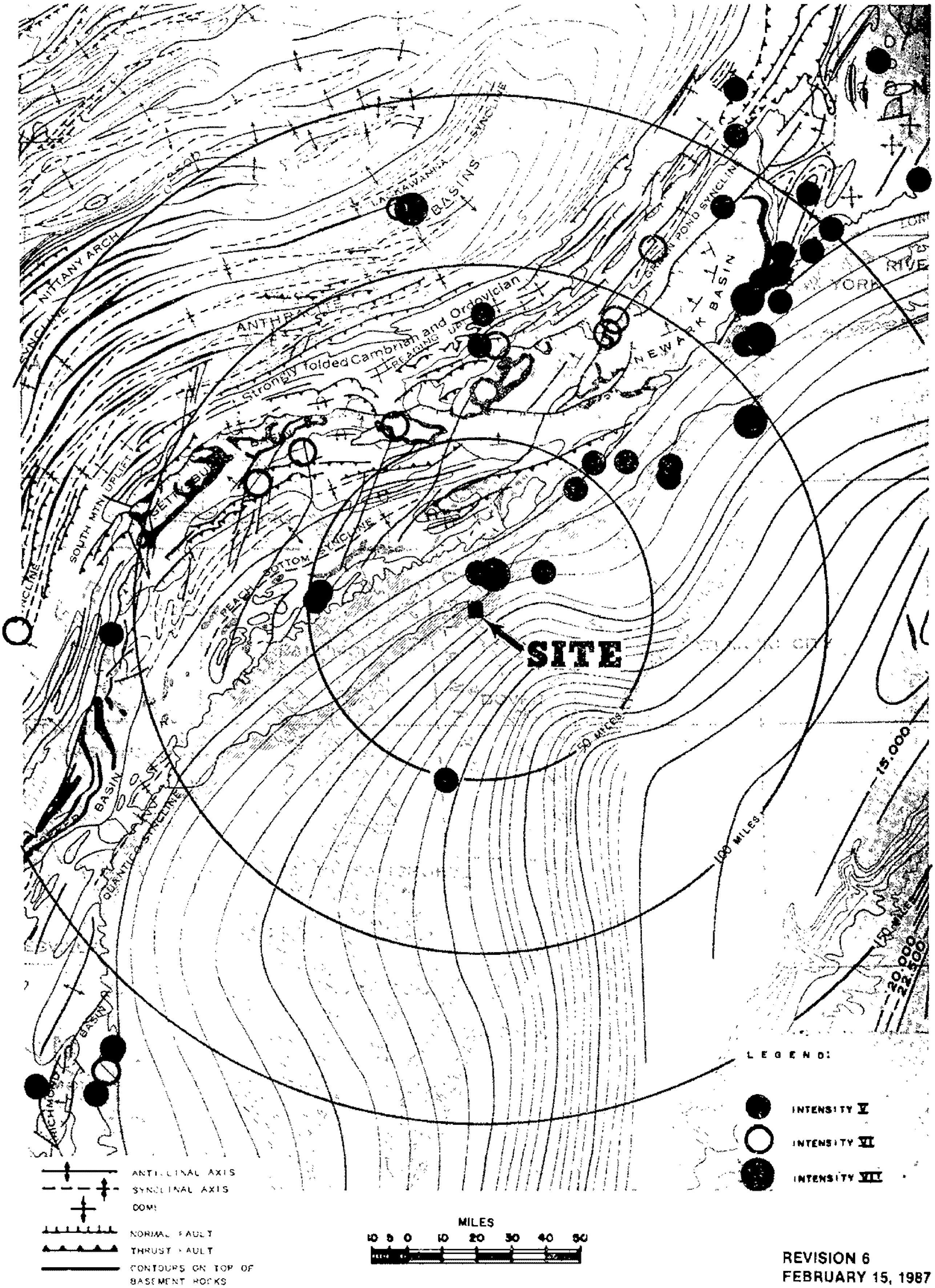
PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Soil Profile and Material Properties at Salem Nuclear Generating Station Site
	Updated FSAR — Figure 2.5-10



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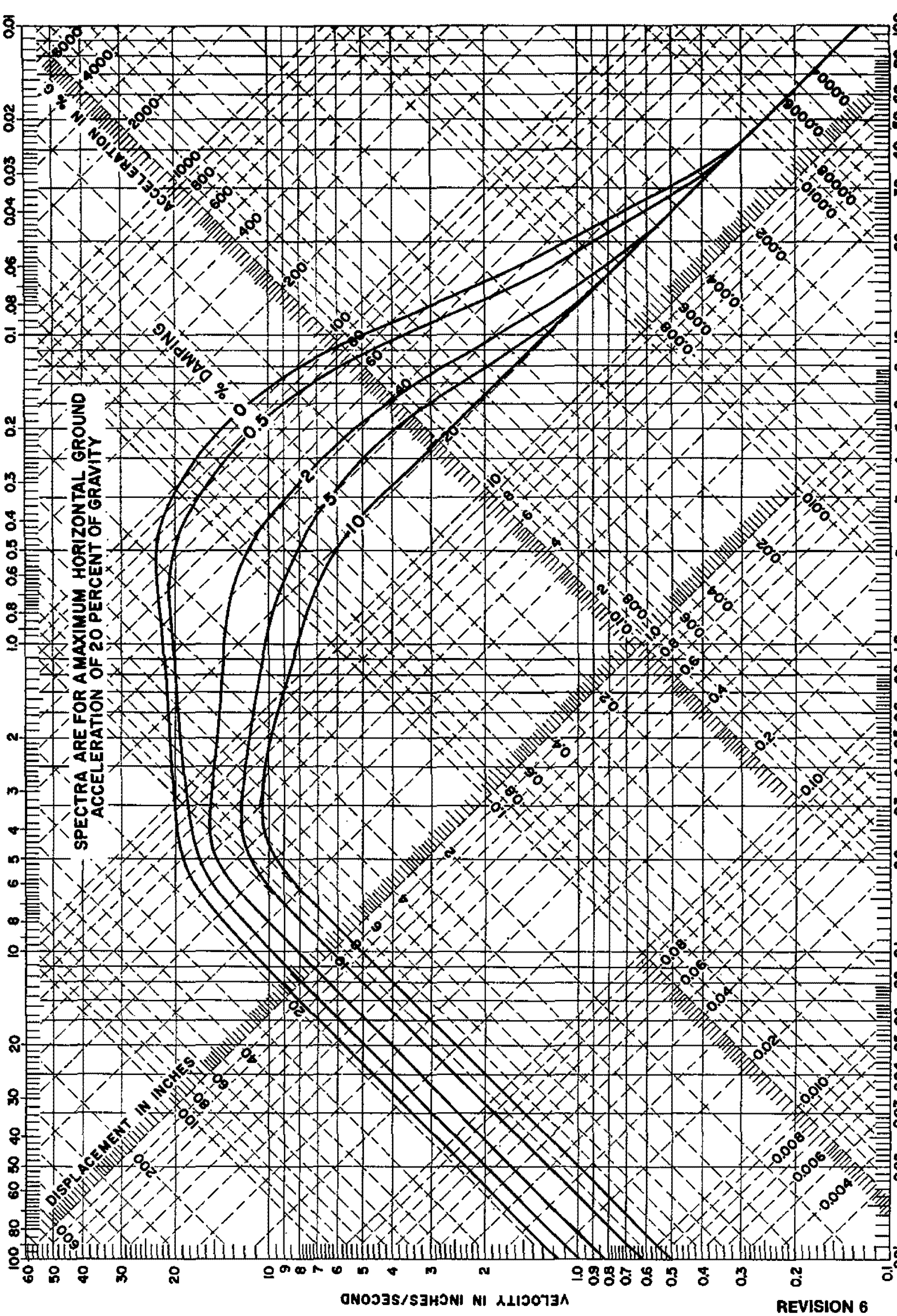
PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Epicentral Location Map Updated FSAR — Figure 2.5-11



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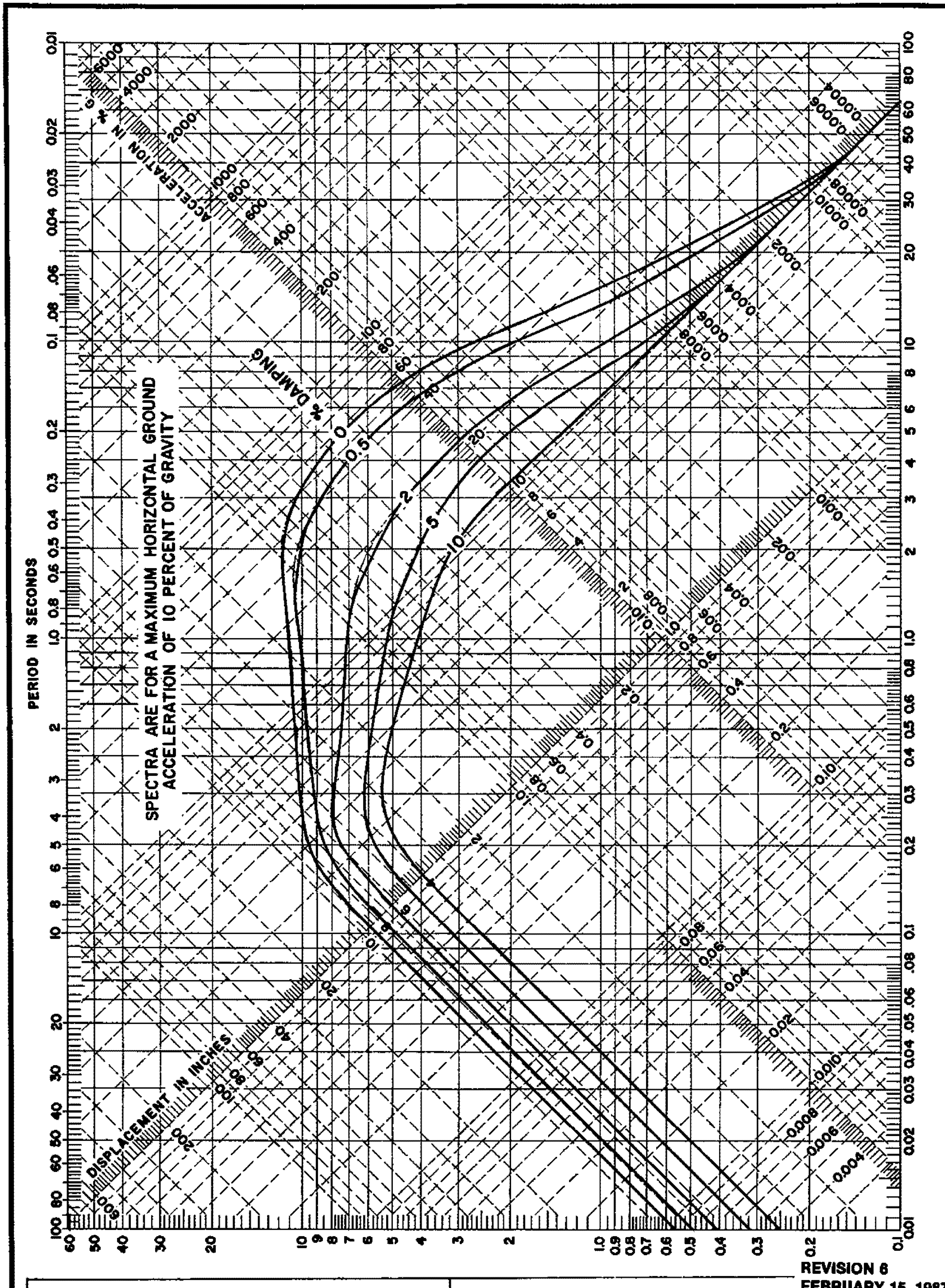
PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Ground Response Spectra Safe Shutdown Earthquake
	Updated FSAR — Figure 2.5-12



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PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM NUCLEAR GENERATING STATION	Ground Response Spectra Operating Basis Earthquake
	Updated FSAR — Figure 2.5-13