Millstone Power Station Unit 3
Safety Analysis Report

Chapter 2: Site Characteristics

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CHAPTER 2 - SITE CHARACTERISTICS

This section contains information on the geological, seismological, hydrological, meteorological, and demographic characteristics of the Millstone site and vicinity to show the adequacy of the site from the safety viewpoint.

2.1 GEOGRAPHY AND DEMOGRAPHY

2.1.1 SITE LOCATION AND DESCRIPTION

2.1.1.1 Specification of Location

The Millstone site is located in the Town of Waterford, New London County, Connecticut, on the north shore of Long Island Sound. The 524-acre site occupies the tip of Millstone Point between Niantic Bay on the west and Jordan Cove on the east and is situated 3.2 miles west-southwest of New London and 40 miles southeast of Hartford.

The Millstone 3 containment structure is located immediately north of Millstone 1 and 2. The geographical coordinates of the centerline of each reactor are as follows:

Unit	Latitude and Longitude	Northing and Easting
Millstone 3	N 41° 18'41"	N 174, 710
	W 72° 10'06"	E 759, 770
Millstone 2	N 41° 18'35"	N 174, 090
	W 72° 10'06"	E 759, 825
Millstone 1	N 41° 18'32"	N 173, 800
	W 72° 10'04"	E 759, 965

2.1.1.2 Site Area

The site is owned by two tenants in common: Connecticut Light & Power Company and Western Massachusetts Electric Company, except for that portion of land designated for the Millstone Nuclear Power Station, Unit 3 site which is owned by its participants in ownership. Figures 2.1–1 through 2.1–4 identify the site.

2.1.1.3 Boundaries for Establishing Effluent Release Limits

Millstone Point was thoroughly investigated for acceptability as a nuclear power plant site and found to be suitable by the Atomic Energy Commission before the Millstone 1 Construction Permit was issued in 1966, before the Millstone 1 Operating License DPR-21 was granted in 1970, prior to the issuance of the Millstone 2 Construction Permit in December 1970, and prior to the Millstone 2 Operating License DPR-65 in August 1976.

Studies and reviews in the areas of marine biology, meteorology, hydrology, and environmental radiation monitoring have been conducted since 1966.

The exclusion area, as described in Section 2.1.2, is considered the restricted area. The restricted area has been conspicuously posted and administrative procedures, including periodic patrolling, have been imposed to control access to the area. For the purpose of radiological dose assessment of accidents, the exclusion area boundary (EAB) was considered the actual site boundary for overland sectors, except in the Fox Island/discharge channel area on the south end of the site. For all water sectors, the nearest land site boundary distance was used.

The EAB boundary shown in Figure 2.1–3 is an example for a Millstone 3 containment release. The actual EAB distance varies as a function of the release point. The actual distances used for each sector for each release point are given inTable 2.3–34.

Any significant normal releases from Millstone 3 are discharged to the atmosphere via the Millstone stack or through various Millstone 3 vents. The distance from the Millstone stack to the nearest residential property boundary in the Millstone Point Colony development (Point A on Figure 2.1–3) is approximately 2,415 feet. This development, adjacent to the eastern site boundary, consists of single family homes on 104 half-acre lots. It was developed from 1951 to the present.

The Colony development has its own beach and boat docking facility, shown as Recreation Area on Figure 2.1–3, extending westward along Jordan Cove. The land is owned by Mr. H. Gardiner, Jr., who permits residents to use it for a fee of $1.00 per year.

The land of the Colony development, the private beach, and the Millstone site were all originally owned by Mr. Gardiner. One of the conditions of the sale of the site to the Hartford Electric Light Company and the Connecticut Light and Power Company was that permanent dwellings would never be permitted in the beach area. Because of this restriction, normal release doses are calculated at Point A rather than at the nearest point on the site boundary. The distance from the Millstone 3 turbine building to Point A is approximately 2,750 feet. Point A is northeast of both the Millstone 3 turbine building and the Millstone stack. The distance to the nearest land for each sector for each release point used in dose calculations for normal effluents is given in Section 2.3.4.2.

2.1.2 EXCLUSION AREA AUTHORITY AND CONTROL

2.1.2.1 Authority

The Millstone Nuclear Power Station site is owned by Dominion Nuclear Connecticut, Inc. (DNC). Figures 2.1–1 through 2.1–4 identify the site.

The exclusion area is equivalent to the area within the site boundary which is identified on Figure 2.1–3. DNC, the operating company for all three units at the Millstone site, has the controlling authority for the exclusion area. Accordingly, DNC has the authority to determine all activities within the exclusion area.

2.1.2.2 Control of Activities Unrelated to Plant Operation

The exclusion area is wholly owned as indicated above; DNC as the operating company has complete control of activities within the exclusion area, except for the passage of trains along the Providence & Worcester (P&W)/Amtrak Railroad track which runs east-west through the site.

To ensure the safety of people within the exclusion area during an emergency, an emergency plan (Section 13.3) for the site has been prepared. The plan includes provisions for alarms both inside and outside buildings and delineates the evacuation routes and assembly areas to be used. The safety of people living or working adjacent to the exclusion area is protected during emergencies according to the procedures outlined in the emergency plan. The State of Connecticut Emergency Plan also provides for the control of activities in that portion of the exclusion area extending offshore through a written agreement between the Applicants and the U.S. Coast Guard at their station in New London, Connecticut.

The owners have encouraged public use of portions of the site. Ownership rights have not, however, been relinquished, and the owners can, and have provision to, fulfill their obligations with respect to 10 CFR 20, “Standards for Protection Against Radiation”.

A portion of the exclusion area is leased to the Town of Waterford for public recreation and is used primarily for soccer and baseball games. Figure 2.1–3 shows the general location of these activities. No attempt is made to restrict the number of persons using these facilities. Estimates of maximum attendance indicate that about 2,000 visitors could be within the exclusion area at any one time at the soccer and baseball fields. The Emergency Plan provides for removal of the visitors on site. The number and configuration of roads and highways assure ready egress from the areas described above (Figures 2.1–2, 2.1–3 and 2.1–4).

2.1.2.3 Arrangements for Traffic Control

Should the need ever arise, provisions to enforce traffic control have been made through the Connecticut State Police, as described in the Millstone Nuclear Power Station Emergency Plan (Section 13.3).

2.1.2.4 Abandonment or Relocation of Roads

On August 30, 1965, a town meeting was called to close and discontinue roads to Millstone Point.

On April 30, 1966, when the 8-month time for public appeal had passed, discontinuance of Millstone Road became effective.

On May 31, 1966, the Connecticut Public Utility Commission gave approval to construct a new limited access highway with a new bridge being built to highway specification 20-44 over the present ConRail/Amtrak rail line approximately 305 meters (1,000 feet) east of Old Millstone Road Bridge No. 45.07.

On December 2, 1966, entrances to Millstone Point from the east via Gardners Wood Road and Jordan Road and from the west via Jordan Cove Road were closed. All access to Millstone Point was shifted to the new limited access highway, which is shown as New Millstone Road on Figure 2.1–3.

No further road closing is necessary.

2.1.2.5 Independent Spent Fuel Storage Installation (ISFSI)

Located on the east side of the site is an area that has been developed for an Independent Spent Fuel Storage Installation (ISFSI). The licensing basis of the ISFSI includes the Transnuclear Safety Analysis Report (SAR), Certificate of Conformance (C of C) No. 1004, Safety Evaluation Report (SER), and the 10 CFR 72.212 report which details compliance of the Millstone site with the requirements of the SAR, C of C and SER. The general location of the area is south of the switchyard, west of the Millstone access road between the switchyard and the crossing of the main rail spur, north of the Main Stack. The approximate location is shown in Figures 2.1–3 and 2.1–4. This area consists of reinforced concrete storage pads and approach aprons.

A heavy haul road is defined between the Unit 3 Railroad Canopy and the ISFSI area. This haul path has been evaluated to adequately support the loads imparted by the ISFSI equipment.

2.1.3 POPULATION DISTRIBUTION

2.1.3.1 Population Distribution within 10 miles

The total 1990 population within 10 miles of the station was estimated to be 120,443. This population is expected to increase to about 129,846 people by the year 2000 and to a total of approximately 142,277 people by the year 2030 (New York State Department of Economic Development, 1989 (Reference 2.1-1); State of Connecticut Office of Policy and Management, 1991 (Reference 2.1-2); US Department of Commerce, Bureau of the Census, 1990 Census of Population (Reference 2.1-3). The 10 mile area includes portions of, or all of, New London and Middlesex Counties in Connecticut and a small portion of Suffolk County on Fishers Island which is part of the town of Southold, New York. Figure 2.1–5 shows counties and towns within the 10 mile area. Town populations and population densities are provided in Table 2.1-1.

The Town of Waterford, in which Millstone 3 is located, contained a total population of 17,930 people in 1990 at an average density of 547 people per square mile (US Department of Commerce Bureau of the Census 1991) (Reference 2.1-3). The population growth of Waterford was small with the 1990 total representing only a 0.5 percent increase over its 1980 population. Compared to towns immediately surrounding it, with the exception of New London, Waterford had the lowest increase in population between 1980 and 1990 (US Department of Commerce Bureau of the Census, 1991 (Reference 2.1-3)).

Waterford's growth has been consistently slowing down over the past 30 years, as shown in Table 2.1-2. This slow growth is projected by state demographers to continue at a low rate through the year 2000, at which time the population is expected to reach 18,480. After that, it is projected to decrease in population. By the year 2010 (the last year of projections), the town's population is projected to be 18,080 (Connecticut Office of Policy and Management, Interim Population Projections, 1991 (Reference 2.1-2)). Population distribution by sector for the area within 20 Km of Millstone 3 for 1985 (the expected first year of operation) is shown in Table 2.1-3 and Figure 2.1–6 (Office of Policy and Management, State of Connecticut, Population Projections to the Year 2000, February 1980 (Reference 2.1-4)). Population distribution by sector for the area within 10 miles of Millstone 3 is shown for the years 1990, 2000, 2010, 2020 and 2030 in Tables 2.1-4 through 2.1-8, which are keyed to the population sectors identified in Figure 2.1–7.

Population distribution within 10 miles is based on 1990 US Census data by Census Block (Reference 2.1-3). The population within a Census Block was assumed to be distributed evenly over its land area, unless USGS 7.5 minute quadrangle maps indicated the population to be concentrated in only one portion of the Block. The proportion of each Block area in each grid sector was determined and applied to the Block total population, yielding the population in each grid sector. Population projections, by municipality, supplied by Connecticut's Office of Policy and Management provided growth factors for projection of populations (State of Connecticut Office of Policy and Management, Interim Population Projections, 1991 (Reference 2.1-2)).

2.1.3.2 Population Distribution within 50 Miles

The area within 50 miles of Millstone 3 includes portions, or all, of eight counties in Connecticut, four counties in Rhode Island and one county in New York. Figure 2.1–8 shows counties and towns within the 50 mile area. In 1990, the 50-mile area contained approximately 2,835,159 people (U.S. Department of Commerce), 1990 Census of Population and Housing (Reference 2.1-5)). This population is projected to increase to about 3,223,654 by the year 2030 (Connecticut Office of Policy and Management, 1991 (Reference 2.1-2); New York State Department of Economic Development, 1989 (Reference 2.1-1); Rhode Island Department of Administration, 1989 (Reference 2.1-6); US Department of Commerce, 1990 Census of Population and Housing, 1991 (Reference 2.1-5). Population distribution by sector for the area within 80 Km of Millstone 3 for 1985 (the expected first year of operation) is shown in Table 2.1-9 and Figure 2.1–9 (Office of Policy and Management, State of Connecticut, Population Projections to the Year 2000, February 1980 (Reference 2.1-4); Economic Development Board, State of New York, Population Projections, 1978 (Reference 2.1-7); Rhode Island Statewide Planning Program, Population Projections, Technical Paper No. 83, Revised April 1979 (Reference 2.1-8)). Population distribution by sector for the area within 50 miles of Millstone 3 is shown for the years 1990, 2000, 2010, 2020 and 2030 in Tables 2.1-10 through 2.1-14, which are keyed to the population sectors identified in Figure 2.1–10.

Population distribution and projections within the 50 mile region surrounding Millstone 3 were calculated based on population by municipalities and were assigned to sectors based on land area allocation. Projections for the 50 mile area were based on country-wide projections.

2.1.3.3 Transient Population

Seasonal population increases resulting from an influx of summer residents total approximately 10,500. However, many of the beaches and recreation facilities in the area are used by residents, and therefore, do not represent any increase in population but instead a slight shift in population. There are, however, a number of schools, industries, and recreation facilities which create daily and seasonal variations in sector populations. Tables 2.1-15 through 2.1-17 show annular sector population variations resulting from school enrollments, industrial employment, and recreation facilities (with documented attendance).

2.1.3.4 Low Population Zone

The low population zone (LPZ) surrounding Millstone 3 encompasses an area within a radial distance of about 2.4 miles. The distance was chosen based on the requirements of 10 CFR 100.11. Figure 2.1–11 shows topographical features, transportation routes, facilities, and institutions within the LPZ.

The LPZ contained approximately 9,846 people in 1990, with an average density of 545 people per square mile. By the year 2030, the LPZ population is projected to increase to about 11,629, or an average density of 643 people per square mile (US Department of Commerce, Bureau of the Census, 1991 (Reference 2.1-3); Connecticut Office of Policy and Management, 1991 (Reference 2.1-2); US Geological Survey (Reference 2.1-9)). The LPZ population distribution for 1990 and 2030 is shown in Table 2.1-18. Table 2.1-19 shows the 1991-1992 school and employment distribution within the LPZ. Both tables are keyed to Figure 2.1–12.

Daily and seasonal variations due to transient population are minimal within the LPZ. Several beaches are located within the area; however, they are predominantly used by local residents and generally have no facilities for parking or accommodation of large groups. Three schools, Great Neck Elementary and Southwest Elementary in Waterford, and Niantic Elementary in East Lyme, are located within the LPZ. Major employment consists of the Connecticut National Guard facility and Hendel Petroleum. The New London Country Club is also located within the LPZ.

2.1.3.5 Population Center

The closest population center to Millstone 3 (as defined by 10 CFR 100 to contain > 25,000 residents) is the City of New London which contained a 1990 population of 28,540 people at an average population density of 5,189 people per square mile (US Department of Commerce Bureau of the Census 1991). The distance between Millstone 3 and the city's closest corporate boundary is about 3.3 miles to the northeast, just beyond the minimum distance requirement set by 10 CFR 100.

The city of New London is part of the New London - Norwich Metropolitan Statistical Area (MSA) which contained an estimated 266,819 people in 1990 (US Department of Commerce Bureau of the Census, 1991 (Reference 2.1-3). An MSA is an area, defined by the US Census Bureau, that always contains a city or cities of specified population, with contiguous cities or towns where the economic and social relationships meet the specified criteria of metropolitan character and integration.

The region within 50 miles of Millstone 3 includes portions, or all, of 11 MSAs. The populations of these areas are shown in Table 2.1-20.

There were 38 population centers within 50 miles of Millstone 3, containing 25,000 or more people in 1990. They are listed in Table 2.1-21 with the populations indicated.

2.1.3.6 Population Density

The population of the area within 50 miles of Millstone was approximately 2,835,159 in 1990, with an average density of 361 people per square mile. This density is lower than the NRC comparison figure of 500 people per square mile (NRC Regulatory Guide 1.70, Revision 3). Within 30 miles of Millstone, the population density is considerably less, at an average of 189 people per square mile. By 2030, the 50-mile population is projected to increase to 3,223,654 or an average population density of about 410 people per square mile, considerably lower than the NRC comparison figure for end-year plant life of 1,000 people per square mile. Within 30 miles, the average density will be 223 persons per square miles by the year 2030. Population densities by sector for the areas within 20 km and 80 km of Millstone 3 for 1985 (the expected first year of operation) are shown in Table 2.1-22 and 2.1-23, respectively. Population densities by sector for 1990 and 2030 are shown for within 10 miles of Millstone in Tables 2.1-24 and 2.1-25 respectively, which are keyed to Figure 2.1–7, and for within 50 miles of Millstone in Tables 2.1-6and 2.1-27, respectively, which are keyed to Figure 2.1–10. Cumulative population densities for the areas within 80 km of Millstone 3 for 1985 (the expected first year of operation) are shown in Table 2.1-28. Cumulative population densities 1990 and 2030 are shown in Tables2.1-29 and 2.1-30 respectively.

2.1.4 REFERENCES FOR SECTION 2.1

2.1-1 New York State Department of Economic Development, Interim County, MSA and Region Projections, 1980-2010, 1989.

2.1-2 Connecticut Office of Policy Management, Interim Population Projections Series 91.1, 1991.

2.1-3 US Department of Commerce, Bureau of the Census, 1990 Census of Population, P.L. 94-171 Counts by Census Block, 1991.

2.1-4 Office of Policy and Management, Comprehensive Planning Division, State of Connecticut, Population Projections for Connecticut Municipalities and Regions to the year 2000, February, 1980.

2.1-5 US Department of Commerce, Bureau of the Census, 1990 Census of Population and Housing - Connecticut, 1990 CPH-1-8, 1991.

2.1-6 Rhode Island Department of Administration, Projections by County, 1990-2020, 1989.

2.1-7 Economic Development Board, State of New York, Official Population Projections for New York State Counties, 1978.

2.1-8 Rhode Island Statewide Planning Program, Rhode Island Population Projections by County, City and Town, Technical Paper No. 83, Revised April 1979.

2.1-9 U.S. Geological Survey, 7.5-Minute Quadrangle maps.

2.1-10 US Nuclear Regulatory Commission, Regulatory Guide 1.70, Revision 3.

SUPPORTING REFERENCES

Massachusetts Institute for Social and Economic Research, Revised Projections of the Population of Massachusetts Cities and Towns to the Year 2000, 1991.

US Department of Commerce, Bureau of the Census, State and Metropolitan Area Book 1991, a Statistical Abstract Supplement, 1991.

US Department of Commerce, Bureau of the Census, 1990 Census P.L. 94-171 Counts by municipality - New York, 1991.

US Department of Commerce, Bureau of the Census, 1990 Census P.L. 94-171 Counts by municipality - Rhode Island, 1991.

US Department of Commerce, Bureau of the Census, Number of Inhabitants: Connecticut, PC(1)-A8, 1971; PC80-1-A8, 1981.

TABLE 2.1-1 1990 POPULATION AND POPULATION DENSITIES CITIES AND TOWNS WITHIN 10 MILES OF MILLSTONE

MUNICIPALITY	1990 POPULATION TOTAL	1990 POPULATION DENSITY (People/Square Mile)	1980 - 1990 CHANGE (%)
East Lyme	15,340	451	10.6
Groton (including City)	45,144	1,442	9.9
Ledyard	14,913	391	8.6
Lyme	1,949	61	7.0
Montville	16,673	397	1.3
New London	28,540	5,189	-1.0
Old Lyme	6,535	283	6.1
Old Saybrook	9,552	637	2.9
Waterford	17,930	547	0.5
Southold, New York (Fishers Island)	19,836	394	3.5

NOTES:

Based on 1990 US Census of Population and Housing.

Includes total 1990 population of all municipalities totally or partially within 10 miles of the site.

TABLE 2.1-2 POPULATION GROWTH 1960-1990

	TOTAL POPULATION				% CHANGE		
MUNICIPALITY	1960	1970	1980	1990	1960-1970	1970-1980	1980-1990
East Lyme	6,782	11,399	13,870	15,340	68.1	21.7	10.6
Groton	29,937	38,523	41,062	45,144	28.7	6.6	9.9
Ledyard	5,395	14,558	13,735	14,913	169.8	-5.7	8.6
Lyme	1,183	1,484	1,822	1,949	25.4	22.8	7.0
Montville	7,759	15,662	16,455	16,673	101.9	5.1	1.3
New London	34,182	31,630	28,842	28,540	-7.5	-8.8	-1.0
Old Lyme	3,068	4,964	6,159	6,535	61.8	24.1	6.1
Old Saybrook	5,274	8,468	9,287	9,552	60.6	9.7	2.9
Waterford	15,391	17,227	17,843	17,930	11.9	3.6	0.5

SOURCES:

1980 Census of Population, Number of Inhabitants, Connecticut, PC80-1-A8, 12/81.

1970 Census of Population, Number of Inhabitants, Connecticut, PC(1)-A8, 4/71.

1980 Final Population and Housing Counts, Connecticut, PHC80-V-8, 3/81.

1990 Census of Population and Housing, Connecticut, CPH-1-8, 7/91.

TABLE 2.1-3 POPULATION DISTRIBUTION 1985 (0-20 km)

Distance (km)

Direction	0-2	2-4	4-6	6-8	8-10	10-20	Total
N	152	1,306	1,341	136	585	9,463	12,983
NNE	12	1,186	1,958	584	2,819	9,676	16,235
NE	326	1,250	763	15,113	8,239	13,641	39,332
ENE	267	513	3,063	3,559	8,491	19,484	35,377
E	366	896	1,169	976	534	4,816	8,757
ESE	0	127	0	0	0	1,184	1,311
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	340	340
SW	0	25	81	0	0	0	106
WSW	0	1,183	193	757	1,960	2,309	6,402
W	0	727	1,102	411	428	8,463	11,131
WNW	0	1,298	1,266	90	140	3,430	6,224
NW	0	852	799	426	418	3,758	6,253
NNW	311	694	902	795	503	6,321	9,526
Total	1,434	10,057	12,637	22,847	24,117	82,884	153,976

TABLE 2.1-4 POPULATION DISTRIBUTION WITHIN 10 MILES OF MILLSTONE - 1990 CENSUS

Distance to Plant

Sector	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	TOTAL
N	16	722	866	784	116	213	542	209	536	1,717	5,721
NNE	13	359	1,146	1,978	1,861	1,622	1,666	2,242	2,192	3,142	16,221
NE	165	455	839	3,888	10,584	7,752	8,164	8,129	911	1,961	42,848
ENE	22	455	292	4,963	971	7,186	3,748	3,047	1,008	2,662	24,354
E	0	636	413	1,804	193	552	0	63	1,434	904	5,999
ESE	0	143	36	0	0	0	0	0	115	214	508
SE	0	0	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0	0	0	0	0
SW	0	0	14	0	0	0	0	0	0	0	14
WSW	0	0	489	91	86	312	472	158	0	74	1,682
W	0	178	1,061	1,014	440	763	475	562	881	408	5,782
WNW	0	476	1,165	1,964	346	239	211	1,654	509	417	6,981
NW	0	634	873	1,192	1,140	644	599	101	209	81	5,473
NNW	148	314	892	522	646	918	221	429	456	314	4,860
Total	364	4,372	8,086	18,200	16,383	20,201	16,098	16,594	8,251	11,894	120,443

TABLE 2.1-5 POPULATION DISTRIBUTION WITHIN 10 MILES OF MILLSTONE - 2000 PROJECTED

Distance to Plant

Sector	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	TOTAL
N	18	778	932	845	126	230	582	225	578	1,852	6,166
NNE	14	387	1,234	2,131	2,006	1,749	1,796	2,415	2,366	3,389	17,487
NE	179	489	905	4,191	11,415	8,359	8,802	8,765	983	2,115	46,203
ENE	24	492	314	5,352	1,045	7,746	4,041	3,285	1,087	2,870	26,256
E	0	685	444	1,944	208	597	0	68	1,546	975	6,467
ESE	0	154	39	0	0	0	0	0	125	233	551
SE	0	0	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0	0	0	0	0
SW	0	0	14	0	0	0	0	0	0	0	14
WSW	0	0	528	98	92	336	509	169	0	78	1,810
W	0	192	1,144	1,093	473	821	513	606	950	436	6,228
WNW	0	514	1,255	2,118	373	258	227	1,783	548	448	7,524
NW	0	684	940	1,285	1,229	695	646	108	226	88	5,901
Total	393	4,715	8,710	19,621	17,663	21,781	17,354	17,886	8,900	12,823	129,846

TABLE 2.1-6 POPULATION DISTRIBUTION WITHIN 10 MILES OF MILLSTONE - 2010 PROJECTED

Distance to Plant

Sector	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	TOTAL
N	18	803	961	871	129	237	600	230	595	1,908	6,352
NNE	14	399	1,272	2,197	2,068	1,804	1,853	2,492	2,437	3,495	18,031
NE	184	504	930	4,321	11,767	8,617	9,074	9,036	1,013	2,180	47,626
ENE	25	507	324	5,518	1,078	7,988	4,166	3,387	1,119	2,960	27,072
E	0	707	458	2,005	215	616	0	70	1,593	1,005	6,669
ESE	0	159	41	0	0	0	0	0	138	255	593
SE	0	0	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0	0	0	0	0
SW	0	0	15	0	0	0	0	0	0	0	15
WSW	0	0	545	102	95	346	525	175	0	79	1,867
W	0	198	1,179	1,126	488	847	530	625	981	443	6,417
WNW	0	529	1,294	2,184	385	266	234	1,838	566	461	7,757
NW	0	705	969	1,325	1,267	716	666	111	232	90	6,081
NNW	163	350	992	582	718	1,021	245	476	506	350	5,403
Total	404	4,861	8,980	20,231	18,210	22,458	17,893	18,440	9,180	13,226	133,883

TABLE 2.1-7 POPULATION DISTRIBUTION WITHIN 10 MILES OF MILLSTONE - 2020 PROJECTED

Distance to Plant

Sector	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	TOTAL
N	19	828	990	899	133	243	620	236	613	1,968	6,549
NNE	14	411	1,310	2,264	2,132	1,860	1,909	2,569	2,513	3,602	18,584
NE	188	519	960	4,455	12,134	8,885	9,355	9,318	1,044	2,247	49,105
ENE	25	523	333	5,689	1,110	8,236	4,296	3,492	1,151	3,052	27,907
E	0	728	472	2,067	222	635	0	72	1,642	1,036	6,874
ESE	0	162	41	0	0	0	0	0	144	268	615
SE	0	0	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0	0	0	0	0
SW	0	0	15	0	0	0	0	0	0	0	15
WSW	0	0	562	105	98	356	541	180	0	80	1,922
W	0	205	1,216	1,161	504	874	546	644	1,011	450	6,611
WNW	0	544	1,336	2,252	398	274	242	1,895	583	476	8,000
NW	0	727	998	1,365	1,308	738	687	114	239	93	6,269
NNW	168	361	1,023	600	738	1,053	253	491	523	362	5,572
Total	414	5,008	9,256	20,857	18,777	23,154	18,449	19,011	9,463	13,634	138,023

TABLE 2.1-8 POPULATION DISTRIBUTION WITHIN 10 MILES OF MILLSTONE - 2030 PROJECTED

Distance to Plant

Sector	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	TOTAL
N	19	855	1,021	927	136	250	638	242	631	2,027	6,746
NNE	14	425	1,351	2,334	2,196	1,916	1,968	2,650	2,590	3,712	19,156
NE	193	535	990	4,592	12,510	9,160	9,644	9,606	1,075	2,315	50,620
ENE	26	539	343	5,866	1,145	8,492	4,428	3,598	1,188	3,147	28,772
E	0	751	487	2,132	229	655	0	73	1,692	1,068	7,087
ESE	0	167	43	0	0	0	0	0	151	281	642
SE	0	0	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0	0	0	0	0
SW	0	0	15	0	0	0	0	0	0	0	15
WSW	0	0	580	108	101	366	558	185	0	81	1,979
W	0	212	1,254	1,197	520	901	561	663	1,043	458	6,809
WNW	0	560	1,377	2,323	409	281	249	1,956	602	490	8,247
NW	0	748	1,029	1,407	1,349	761	708	116	246	95	6,459
NNW	174	371	1,055	618	761	1,085	261	507	539	374	5,745
Total	426	5,163	9,545	21,504	19,356	23,867	19,015	19,596	9,757	14,048	142,277

TABLE 2.1-9 POPULATION DISTRIBUTION 1985 (0-80 km)

Distance (km)

Direction	0-20	20-40	40-60	60-80	Total
N	12,983	24,346	48,558	22,966	108,853
NNE	16,235	48,297	28,695	42,400	135,627
NE	39,332	13,723	24,719	224,759	302,533
ENE	35,377	27,604	33,732	117,868	214,581
E	8,757	14,326	8,982	122	32,187
ESE	1,311	0	674	0	1,985
SE	0	2,038	0	0	2,038
SSE	0	4,457	0	0	4,457
S	0	8,906	2,657	0	11,563
SSW	340	8,979	21,915	2,602	33,836
SW	106	5,869	20,269	210,804	237,048
WSW	6,402	554	0	20,268	27,224
W	11,131	33,197	98,419	361,418	504,165
WNW	6,224	16,353	124,272	276,965	423,814
NW	6,253	12,395	102,235	483,164	604,047
NNW	9,526	13,152	55,071	129,100	206,849
Total	153,977	234,196	570,198	1,892,436	2,850,807

TABLE 2.1-10 POPULATION DISTRIBUTION WITHIN 50 MILES OF MILLSTONE - 1990 CENSUS

Distance to Plant

Sector	0-10	10-20	20-30	30-40	40-50	Total
N	5,721	22,283	26,357	32,610	18,658	105,629
NNE	16,221	34,824	23,730	27,465	35,598	137,838
NE	42,848	9,444	11,334	29,987	199,334	292,947
ENE	24,354	23,914	16,498	43,001	99,721	207,488
E	5,999	10,712	7,992	10,920	0	35,623
ESE	508	0	0	836	0	1,344
SE	0	0	807	0	0	807
SSE	0	0	2,420	0	0	2,420
S	0	1,614	13,541	0	0	15,155
SSW	0	2,443	12,569	14,807	4,498	34,317
SW	14	938	22,042	8,252	143,933	175,179
WSW	1,682	2,471	0	0	20,389	24,542
W	5,782	27,956	34,384	184,723	267,465	520,310
WNW	6,981	12,474	27,895	148,259	259,824	455,433
NW	5,473	6,215	31,331	191,767	365,578	600,364
NNW	4,860	8,809	17,850	115,424	78,820	225,763
Total	120,443	164,097	248,750	808,051	1,493,818	2,835,159

TABLE 2.1-11 POPULATION DISTRIBUTION WITHIN 50 MILES OF MILLSTONE - 2000 PROJECTED

Distance to Plant

Sector	0-10	10-20	20-30	30-40	40-50	Total
N	6,166	24,028	28,707	35,404	20,273	114,578
NNE	17,487	37,551	25,721	29,926	38,135	148,820
NE	46,203	10,183	12,196	31,611	206,940	307,133
ENE	26,256	25,744	17,663	45,998	105,848	221,509
E	6,467	11,497	8,553	11,687	0	38,204
ESE	551	0	0	895	0	1,446
SE	0	0	878	0	0	878
SSE	0	0	2,635	0	0	2,635
S	0	1,759	14,742	0	0	16,501
SSW	0	2,660	13,688	16,122	4,897	37,367
SW	14	1,022	24,000	8,985	156,725	190,746
WSW	1,810	2,641	0	0	22,201	26,652
W	6,228	29,887	36,343	195,006	281,709	549,173
WNW	7,524	13,340	29,762	156,623	273,153	480,402
NW	5,901	6,660	33,435	200,205	380,339	626,540
NNW	5,239	9,492	19,194	121,620	83,732	239,277
Total	129,846	176,464	267,517	854,082	1,573,952	3,001,861

TABLE 2.1-12 POPULATION DISTRIBUTION WITHIN 50 MILES OF MILLSTONE - 2010 PROJECTED

Distance to Plant

Sector	0-10	10-20	20-30	30-40	40-50	Total
N	6,352	24,773	30,056	36,785	21,101	119,067
NNE	18,031	38,716	26,730	31,421	39,720	154,618
NE	47,626	10,499	12,626	32,221	210,368	313,340
ENE	27,072	26,652	18,530	48,258	109,494	230,006
E	6,669	11,986	8,981	12,272	0	39,908
ESE	593	0	0	940	0	1,533
SE	0	0	920	0	0	920
SSE	0	0	2,761	0	0	2,761
S	0	1,847	15,445	0	0	17,292
SSW	0	2,788	14,344	16,896	5,132	39,160
SW	15	1,073	25,151	9,416	164,248	199,903
WSW	1,867	2,689	0	0	23,267	27,823
W	6,417	30,426	37,096	199,100	286,889	559,928
WNW	7,757	13,590	30,311	159,776	278,156	489,590
NW	6,081	6,807	34,052	202,762	384,902	634,604
NNW	5,403	9,778	19,778	123,964	85,735	244,658
Total	133,883	181,624	276,781	873,811	1,609,012	3,075,111

TABLE 2.1-13 POPULATION DISTRIBUTION WITHIN 50 MILES OF MILLSTONE - 2020 PROJECTED

Distance to Plant

Sector	0-10	10-20	20-30	30-40	40-50	Total
N	6,549	25,541	31,470	38,219	21,963	123,742
NNE	18,584	39,916	27,784	32,989	41,349	160,622
NE	49,105	10,825	13,051	32,748	213,221	318,950
ENE	27,907	27,557	19,336	50,343	112,285	234,428
E	6,874	12,452	9,376	12,811	0	41,513
ESE	615	0	0	981	0	1,596
SE	0	0	965	0	0	965
SSE	0	0	2,894	0	0	2,894
S	0	1,939	16,184	0	0	18,123
SSW	0	2,922	15,033	17,707	5,379	41,041
SW	15	1,127	26,355	9,869	172,131	209,497
WSW	1,922	2,737	0	0	24,383	29,042
W	6,611	30,974	37,863	203,283	292,190	570,921
WNW	8,000	13,844	30,871	162,992	283,254	498,961
NW	6,269	6,957	34,678	205,354	389,518	642,776
NNW	5,572	10,070	20,382	126,369	87,794	250,187
Total	138,023	186,861	286,242	893,665	1,643,467	3,148,258

TABLE 2.1-14 POPULATION DISTRIBUTION WITHIN 50 MILES OF MILLSTONE - 2030 PROJECTED

Distance to Plant

Sector	0-10	10-20	20-30	30-40	40-50	Total
N	6,746	26,332	32,953	39,716	22,860	128,607
NNE	19,156	41,155	28,879	34,637	43,058	166,885
NE	50,620	11,159	13,494	33,286	216,112	324,671
ENE	28,772	28,495	20,176	52,519	115,158	245,120
E	7,087	12,937	9,789	13,375	0	43,188
ESE	642	0	0	1,024	0	1,666
SE	0	0	1,011	0	0	1,011
SSE	0	0	3,033	0	0	3,033
S	0	2,036	16,957	0	0	18,993
SSW	0	3,062	15,755	18,558	5,637	43,012
SW	15	1,183	27,619	10,342	180,394	219,553
WSW	1,979	2,787	0	0	25,554	30,320
W	6,809	31,532	38,647	207,551	297,607	582,146
WNW	8,247	14,102	31,441	166,276	288,449	508,515
NW	6,459	7,110	35,317	207,981	394,192	651,059
NNW	5,745	10,373	21,003	128,835	89,919	255,875
Total	142,277	192,263	296,074	914,100	1,678,940	3,223,654

TABLE 2.1-15 TRANSIENT POPULATION WITHIN 10 MILES OF MILLSTONE - 1991-1992 SCHOOL ENROLLMENT

Sector	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Total
N	0	310	0	0	0	0	0	74	0	413	797
NNE	0	0	0	374	897	2,073	174	0	0	444	3,962
NE	0	0	636	210	697	1,352	1,542	534	0	0	4,971
ENE	0	0	0	2,501	0	888	0	1,043	1,609	266	6,307
E	0	292	0	0	0	1,330	0	0	183	0	1,805
ESE	0	0	0	0	0	0	0	0	0	68	68
SE	0	0	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0	0	0	0	0
W	0	0	0	0	0	0	263	0	864	0	1,127
WNW	0	0	345	0	0	0	0	0	0	0	345
NW	0	0	0	843	0	0	0	0	0	0	843
NNW	0	0	0	298	1,250	0	0	0	0	0	1,548
TOTAL	0	602	981	4,226	2,844	5,643	1,979	1,651	2,656	1,191	21,773

Note: Includes student enrollment only.

Sources: Connecticut Department of Education listing of schools; Telephone survey conducted in March 1992.

TABLE 2.1-16 TRANSIENT POPULATION WITHIN 10 MILES OF MILLSTONE (EMPLOYMENT)

Sector	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Total
N	0	0	0	300	0	0	0	0	0	200	500
NNE	0	0	0	0	0	0	375	375	107	277	1,134
NE	0	0	375	80	831	0	375	375	0	0	2,036
ENE	0	0	0	0	8,800	5,500	820	0	0	0	15,120
E	0	0	0	0	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	256	0	256
SSW	0	0	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	125	125	0	0	250
NW	0	500	0	0	0	0	125	125	0	0	750
NNW	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	500	375	380	9,631	5,500	1,820	1,000	363	477	20,046

Note: Firms with 50 employees or more. Excludes plant employee population.

Sources: Telephone survey conducted in March 1992.

TABLE 2.1-17 TRANSIENT POPULATION WITHIN 10 MILES OF MILLSTONE STATE PARKS AND FORESTS (WITH DOCUMENTED ATTENDANCE)

FACILITY	LOCATION	TOTAL ANNUAL ATTENDANCE	SUMMER DAILY ATTENDANCE
State Parks:			
Bluff Point	ENE/E 6-8	97,641	490 *
Fort Griswold	ENE 5-6	58,965	200 *
Haley Farm	ENE/E 7-9	11,675	60 *
Harkness Memorial	E 2-3	157,962	790 *
Rocky Neck	W 3-5	412,495	2,360 **
State Forests:			
Nehantic	WNW/NNW 7-10	81,146	400 *

NOTES:

* Daily summer attendance based on 90% of yearly attendance from April through September.

** Includes campers from April 15 to September 15.

Source:

State of Connecticut DEP - Office of Parks and Forests, 1990 Park Attendance.

TABLE 2.1-18 LOW POPULATION ZONE PERMANENT POPULATION DISTRIBUTIONS

DIRECTION	1990 CENSUS	2030 PROJECTED
N	1,298	1,536
NNE	903	1,065
NE	1,144	1,351
ENE	768	909
E	760	899
ESE	179	212
SE	0	0
SSE	0	0
S	0	0
SSW	0	0
SW	3	3
WSW	429	506
W	1,025	1,211
WNW	1,046	1,233
NW	1,167	1,377
NNW	1,124	1,327
TOTAL LPZ	9,846	11,629

Sources:

1990 Census of Population and Housing.

Connecticut Office of Policy and Management, Interim Population Projections Series 91.1, 4/91.

TABLE 2.1-19 LOW POPULATION ZONE SCHOOL ENROLLMENT AND EMPLOYMENT

DIRECTION	SCHOOL	EMPLOYMENT
N	310	0
NNE	0	0
NE	0	75
ENE	0	0
E	292	0
ESE	0	0
SE	0	0
SSE	0	0
S	0	0
SSW	0	0
SW	0	0
WSW	0	0
W	0	0
WNW	345	0
NW	0	500
NNW	0	0
TOTAL	947	575

NOTES:

1991-1992 Student Enrollment.
Firms with 50 employees or more.

Source:

Telephone survey conducted in March 1992; Connecticut Department of Education school listing.

TABLE 2.1-20 METROPOLITAN AREAS WITHIN 50 MILES OF MILLSTONE 1990 CENSUS POPULATION

AREA	1990 POPULATION
Bridgeport - Milford, CT PMSA	443,722
Bristol, CT PMSA	79,488
Fall River, MA-RI PMSA	157,272
Hartford, CT PMSA	767,899
New Haven - Meriden, CT MSA	530,240
Nassau - Suffolk, NY PMSA	2,609,212
New Britain, CT PMSA	148,188
New London - Norwich, CT-RI MSA	266,819
Providence, RI PMSA	654,869
Waterbury, CT MSA	221,629
Middletown, CT PMSA	90,320

NOTES:

PMSA - Primary Metropolitan Statistical Area.
MSA - Metropolitan Statistical Area.
Total population of metropolitan areas completely or only partially within 50 miles of the site.

Source:

1990 Census of Population

TABLE 2.1-21 POPULATION CENTERS WITHIN 50 MILES OF MILLSTONE

STATE	MUNICIPALITY	1990 POPULATION
Connecticut	Branford	27,603
	Bristol	60,640
	Cheshire	25,684
	East Hartford	50,452
	East Haven	26,144
	Enfield	45,532
	Glastonbury	27,901
	Groton	45,144
	Hamden	52,434
	Hartford	139,739
	Manchester	51,618
	Meriden	59,479
	Middletown	42,762
	Milford	49,938
	Naugatuck	30,625
	New Britain	75,491
	New Haven	130,474
	New London	28,540
	Newington	29,208
	Norwich	37,371
	Shelton	35,418
	Southington	38,518
	Stratford	49,389
	Vernon	29,841
	Wallingford	40,822
	Waterbury	108,961
	West Hartford	60,110
	West Haven	54,021
	Wethersfield	25,651
	Windsor	27,817

TABLE 2.1-21 POPULATION CENTERS WITHIN 50 MILES OF MILLSTONE

STATE	MUNICIPALITY	1990 POPULATION
Rhode Island	Coventry	31,083
	Cranston	76,060
	Johnston	26,542
	Newport	28,227
	Warwick	85,427
	West Warwick	29,268
New York	Brookhaven	407,779
	Southampton	44,976

NOTES:

Municipalities with 25,000 people or more.

Municipalities completely or only partially within 50 miles.

Source: 1990 U.S. Census of Population and Housing.

TABLE 2.1-22 POPULATION DENSITY* 1985 (0-20 km)

Distance (km)

Direction	0-2	2-4	4-6	6-8	8-10	10-20	Average 0-20
N	194	575	345	25	83	161	166
NNE	15	522	504	106	405	169	212
NE	566	557	194	2,970	1,759	234	525
ENE	1,214	218	786	1,990	1,255	334	482
E	1,538	386	403	1,903	482	305	383
ESE	0	279	0	0	0	142	147
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	126	126
SW	0	305	686	0	0	0	520
WSW	0	1,153	270	1,187	980	178	369
W	0	545	308	80	61	171	167
WNW	0	727	324	17	20	60	83
NW	0	550	217	78	63	64	82
NNW	492	969	286	154	71	107	126
Average	409	546	375	570	428	166	236

NOTES:

* People per square kilometer.

TABLE 2.1-23 POPULATION DENSITY 1985 (0-80 km)

Distance (km)

Direction	0-20	20-40	40-60	60-80
N	166	103	124	42
NNE	212	205	73	77
NE	525	58	63	412
ENE	482	117	86	402
E	383	198	167	364
ESE	147	0	29	0
SE	0	87	0	0
SSE	0	98	0	0
S	0	88	96	0
SSW	126	104	122	112
SW	520	142	134	471
WSW	369	194	0	907
W	167	151	302	781
WNW	83	69	316	504
NW	82	53	260	879
NNW	126	56	140	235
Average	236	104	163	416

TABLE 2.1-24 POPULATION DENSITY WITHIN 10 MILES OF MILLSTONE 1990 (PEOPLE PER SQUARE MILE)

Sector	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Average
N	82	1,226	883	571	66	99	212	71	161	460	292
NNE	66	610	1,168	1,440	1,054	751	653	762	657	843	827
NE	842	772	855	2,830	5,993	3,591	3,200	2,761	273	526	2,183
ENE	112	772	298	3,612	550	3,328	1,469	1,035	302	714	1,241
E	0	1,080	421	1,313	109	256	0	21	430	242	306
ESE	0	243	37	0	0	0	0	0	34	57	26
SE	0	0	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0	0	0	0	0
SW	0	0	14	0	0	0	0	0	0	0	1
WSW	0	0	498	66	49	145	185	54	0	20	86
W	0	302	1,082	738	249	353	186	191	264	109	295
WNW	0	808	1,188	1,429	196	111	83	562	153	112	356
NW	0	1,076	890	868	646	298	235	34	63	22	279
NNW	755	533	909	380	366	425	87	146	137	84	248
AVERAGE	116	464	515	828	580	585	394	352	155	199	384

Source: 1990 Census of Population.

TABLE 2.1-25 POPULATION DENSITY WITHIN 10 MILES OF MILLSTONE 2030 (PEOPLE PER SQUARE MILE)

Sector	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Average
N	97	1,452	1,041	675	77	116	250	82	189	544	344
NNE	71	722	1,377	1,700	1,243	887	771	900	776	995	976
NE	985	908	1,009	3,345	7,084	4,243	3,780	3,263	322	621	2,579
ENE	133	915	350	4,272	648	3,933	1,736	1,222	356	844	1,466
E	0	1,275	496	1,553	130	303	0	25	507	286	361
ESE	0	284	44	0	0	0	0	0	45	75	33
SE	0	0	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0	0	0	0	0
SW	0	0	15	0	0	0	0	0	0	0	1
WSW	0	0	591	79	57	170	219	63	0	22	101
W	0	360	1,278	872	294	417	220	225	313	123	347
WNW	0	951	1,404	1,692	232	130	98	664	180	131	420
NW	0	1,270	1,049	1,025	764	352	278	39	74	25	329
NNW	888	630	1,075	450	431	503	102	172	162	100	293
AVERAGE	136	548	608	979	685	691	466	416	183	235	453

Source: CT Office of Policy and Management, Interim Population Projections Series 91.1, 4/91.

TABLE 2.1-26 POPULATION DENSITY WITHIN 50 MILES OF MILLSTONE 1990 (PEOPLE PER SQUARE MILE)

Sector	0-10	10-20	20-30	30-40	40-50	Average
N	292	378	269	237	106	215
NNE	827	591	242	200	202	281
NE	2,183	160	116	218	1,129	597
ENE	1,241	406	168	313	564	423
E	306	182	81	79	0	73
ESE	26	0	0	6	0	3
SE	0	0	8	0	0	2
SSE	0	0	25	0	0	5
S	0	27	138	0	0	31
SSW	0	41	128	108	25	70
SW	1	16	225	60	815	357
WSW	86	42	0	0	115	50
W	295	475	350	1,345	1,514	1,061
WNW	356	212	284	1,079	1,471	928
NW	279	106	319	1,396	2,070	1,224
NNW	248	150	182	840	446	460
AVERAGE	384	174	158	368	528	361

Source: 1990 Census of Population and Housing.

TABLE 2.1-27 POPULATION DENSITY WITHIN 50 MILES OF MILLSTONE 2030 (PEOPLE PER SQUARE MILE)

Sector	0-10	10-20	20-30	30-40	40-50	Average
N	344	447	336	289	129	262
NNE	976	699	294	252	244	340
NE	2,579	190	138	242	1,224	662
ENE	1,466	484	206	382	652	499
E	361	220	100	97	0	88
ESE	33	0	0	7	0	3
SE	0	0	10	0	0	2
SSE	0	0	31	0	0	6
S	0	35	173	0	0	39
SSW	0	52	161	135	32	88
SW	1	20	281	75	1,021	447
WSW	101	47	0	0	145	62
W	347	536	394	1,511	1,685	1,187
WNW	420	240	320	1,210	1,633	1,036
NW	329	121	360	1,514	2,232	1,327
NNW	293	176	214	938	509	522
AVERAGE	453	204	189	416	594	410

Source: CT Office of Policy and Management, Interim Population Projections, Series 91.1, 4/91.

TABLE 2.1-28 CUMULATIVE POPULATION DENSITY 1985

Distance (km)

Direction	0-20	20-40	40-60	60-80
N	166	119	122	87
NNE	212	207	132	108
NE	525	171	111	242
ENE	482	204	138	216
E	383	242	215	216
ESE	147	147	61	61
SE	0	86	86	86
SSE	0	98	98	98
S	0	86	88	88
SSW	126	105	116	116
SW	520	144	136	370
WSW	369	344	344	640
W	167	155	233	469
WNW	83	73	208	338
NW	82	60	172	482
NNW	126	73	110	165
Average	236	134	150	260

TABLE 2.1-29 CUMULATIVE POPULATION DENSITY WITHIN 50 MILES OF MILLSTONE 1990 (PEOPLE PER SQUARE MILE)

Sector	0-10	0-20	0-30	0-40	0-50
N	292	357	308	277	215
NNE	827	650	423	326	281
NE	2,183	666	360	298	597
ENE	1,241	615	367	343	423
E	306	213	140	113	73
ESE	26	6	3	4	3
SE	0	0	5	3	2
SSE	0	0	14	8	5
S	0	21	86	48	31
SSW	0	31	85	95	70
SW	1	12	130	100	357
W	295	430	386	805	1,061
WNW	356	248	268	623	928
NW	279	149	244	748	1,224
NNW	248	174	178	468	460
Average	384	226	189	267	361

TABLE 2.1-30 CUMULATIVE POPULATION DENSITY WITHIN 50 MILES OF MILLSTONE 2030 (PEOPLE PER SQUARE MILE)

Sector	0-10	0-20	0-30	0-40	0-50
N	344	421	374	337	262
NNE	976	768	505	394	340
NE	2,579	787	426	346	662
ENE	1,466	730	438	414	499
E	361	255	169	138	88
ESE	33	8	4	5	3
SE	0	0	6	3	2
SSE	0	0	17	10	6
S	0	26	108	60	39
SSW	0	39	107	119	88
SW	1	15	163	125	447
WSW	101	61	27	15	62
W	347	488	436	906	1,187
WNW	420	285	305	701	1,036
NW	329	173	277	818	1,327
NNW	293	205	210	529	522
Average	453	266	223	307	410

FIGURE 2.1–1 GENERAL SITE LOCATION

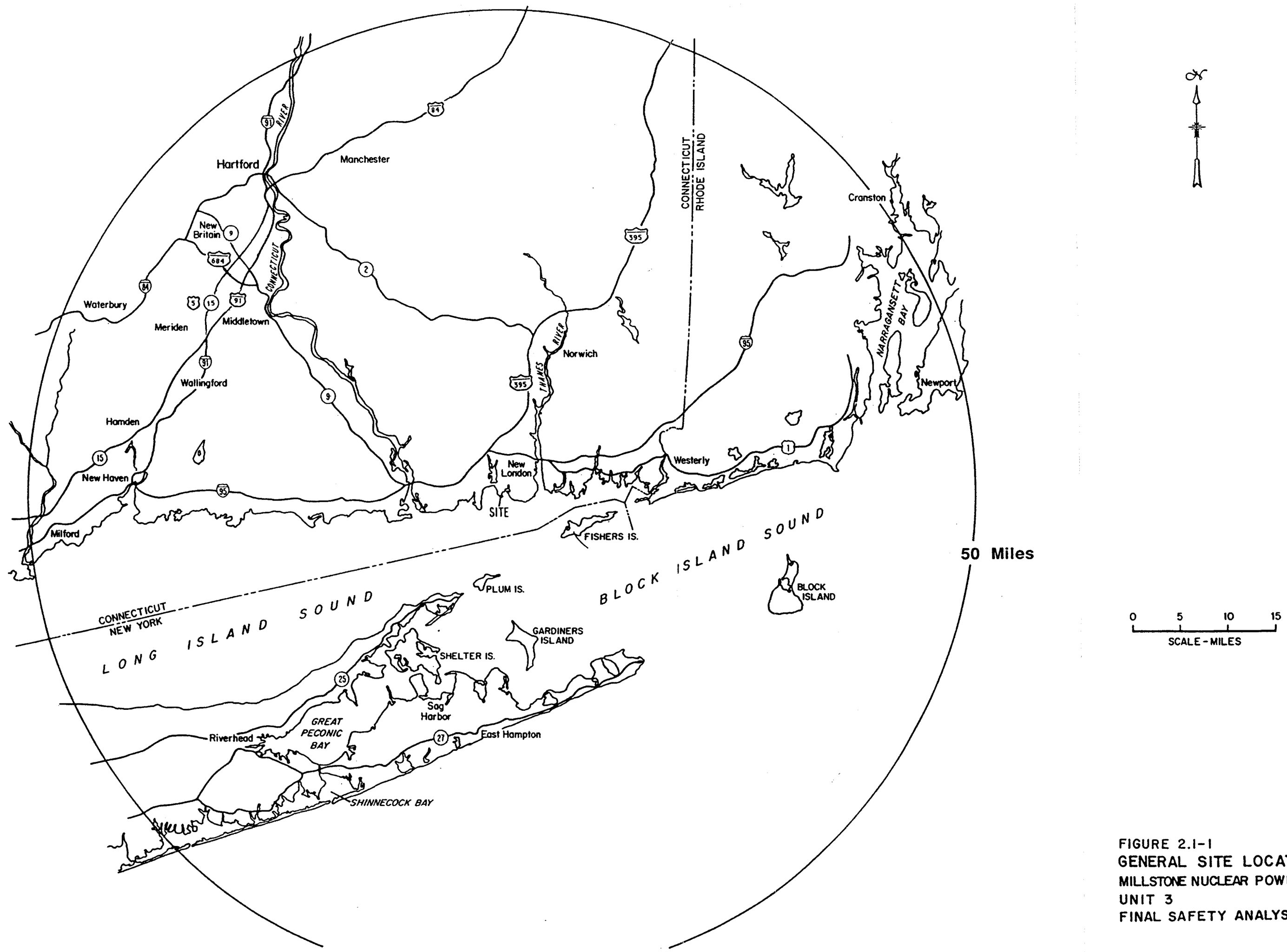


FIGURE 2.1-1
GENERAL SITE LOCATION
MILLSTONE NUCLEAR POWER PLANT
UNIT 3
FINAL SAFETY ANALYSIS REPORT

MAY 1993

FIGURE 2.1–2 GENERAL VICINITY

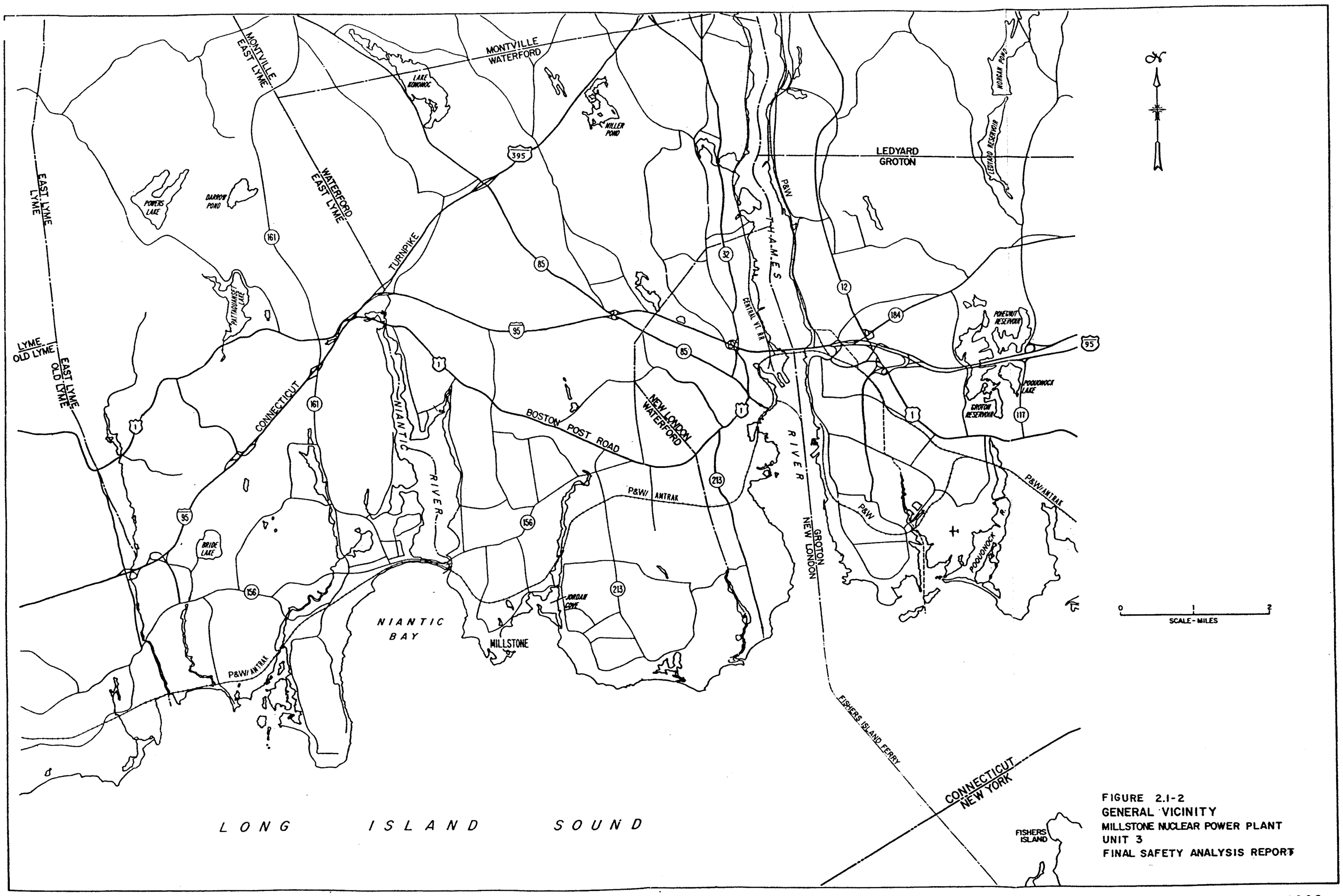


FIGURE 2.1-2
GENERAL VICINITY
MILLSTONE NUCLEAR POWER PLANT
UNIT 3
FINAL SAFETY ANALYSIS REPORT

MAY 1993

FIGURE 2.1–3 SITE LAYOUT

[redacted]

FIGURE 2.1–4 SITE PLAN

[redacted]

FIGURE 2.1–5 TOWNS WITHIN 10 MILES

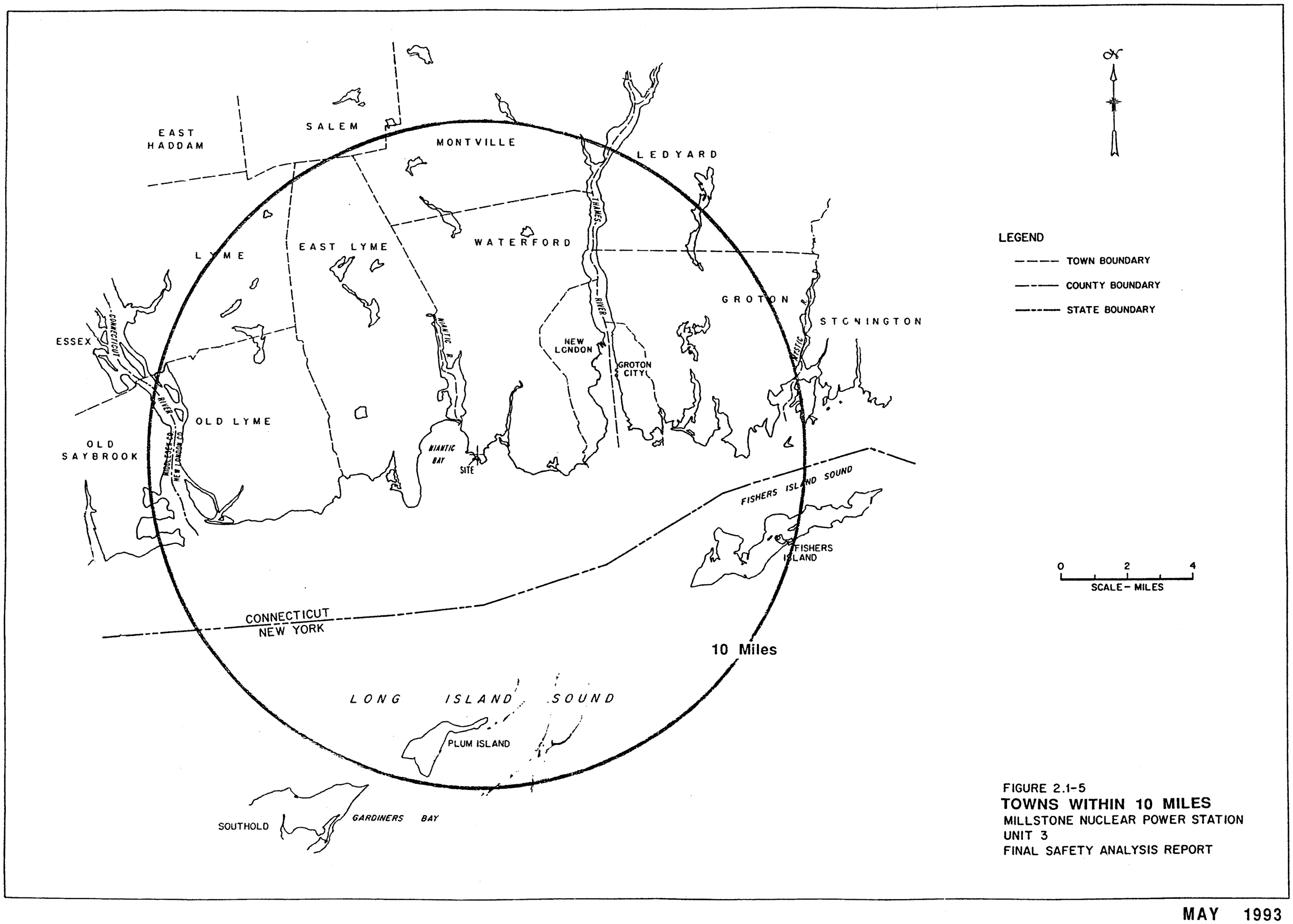


FIGURE 2.1–6 1985 POPULATION DISTRIBUTION 0-20 KM

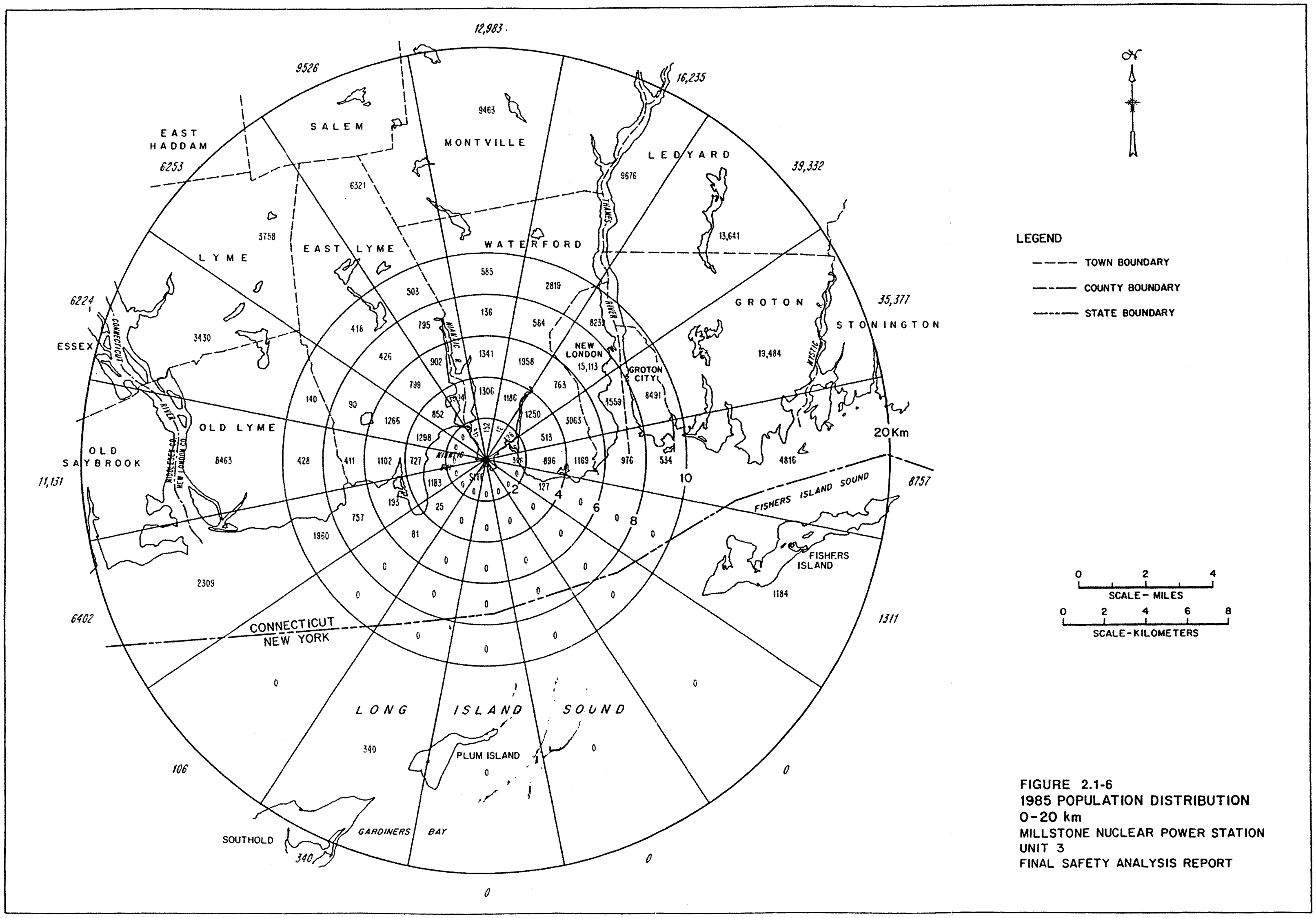


FIGURE 2.1-6
1985 POPULATION DISTRIBUTION
0–20 km
MILLSTONE NUCLEAR POWER STATION
UNIT 3
FINAL SAFETY ANALYSIS REPORT

MAY 1993

FIGURE 2.1–7 POPULATION SECTORS FOR 0-10 MILES

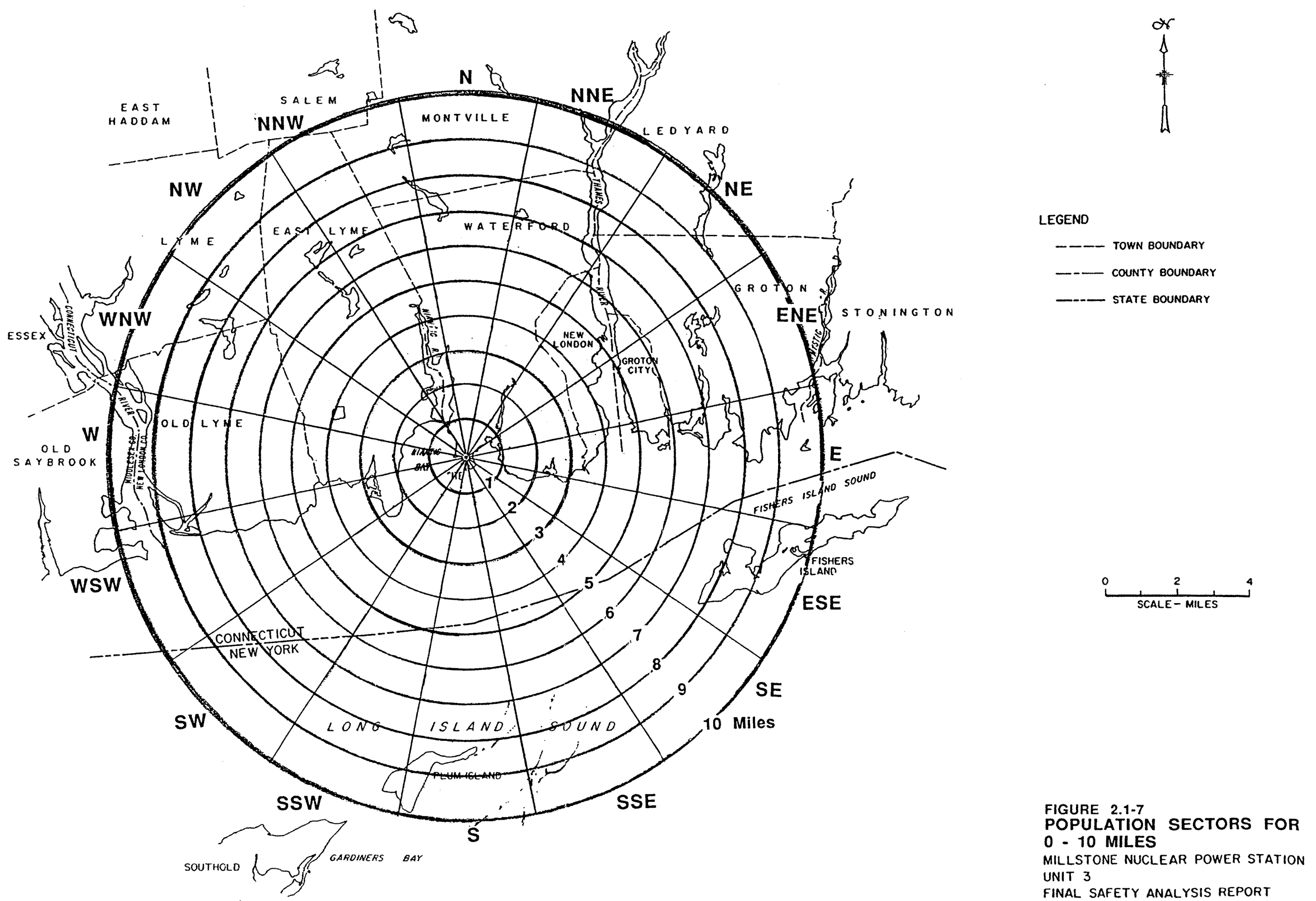


FIGURE 2.1-7
POPULATION SECTORS FOR 0 - 10 MILES
MILLSTONE NUCLEAR POWER STATION
UNIT 3
FINAL SAFETY ANALYSIS REPORT

FIGURE 2.1–8 COUNTIES WITHIN 50 MILES

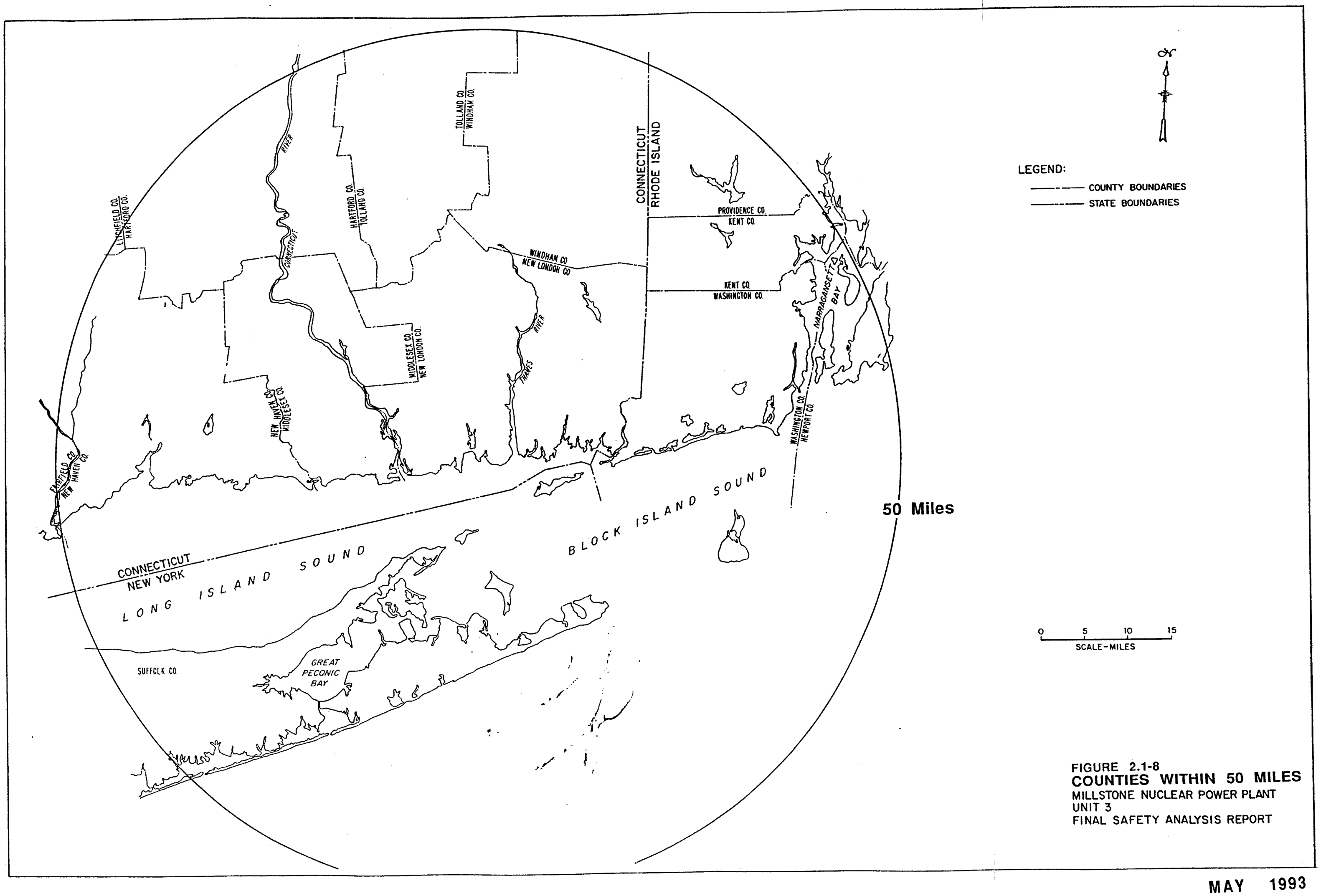


FIGURE 2.1–9 1985 POPULATION DISTRIBUTION 0-80 KM

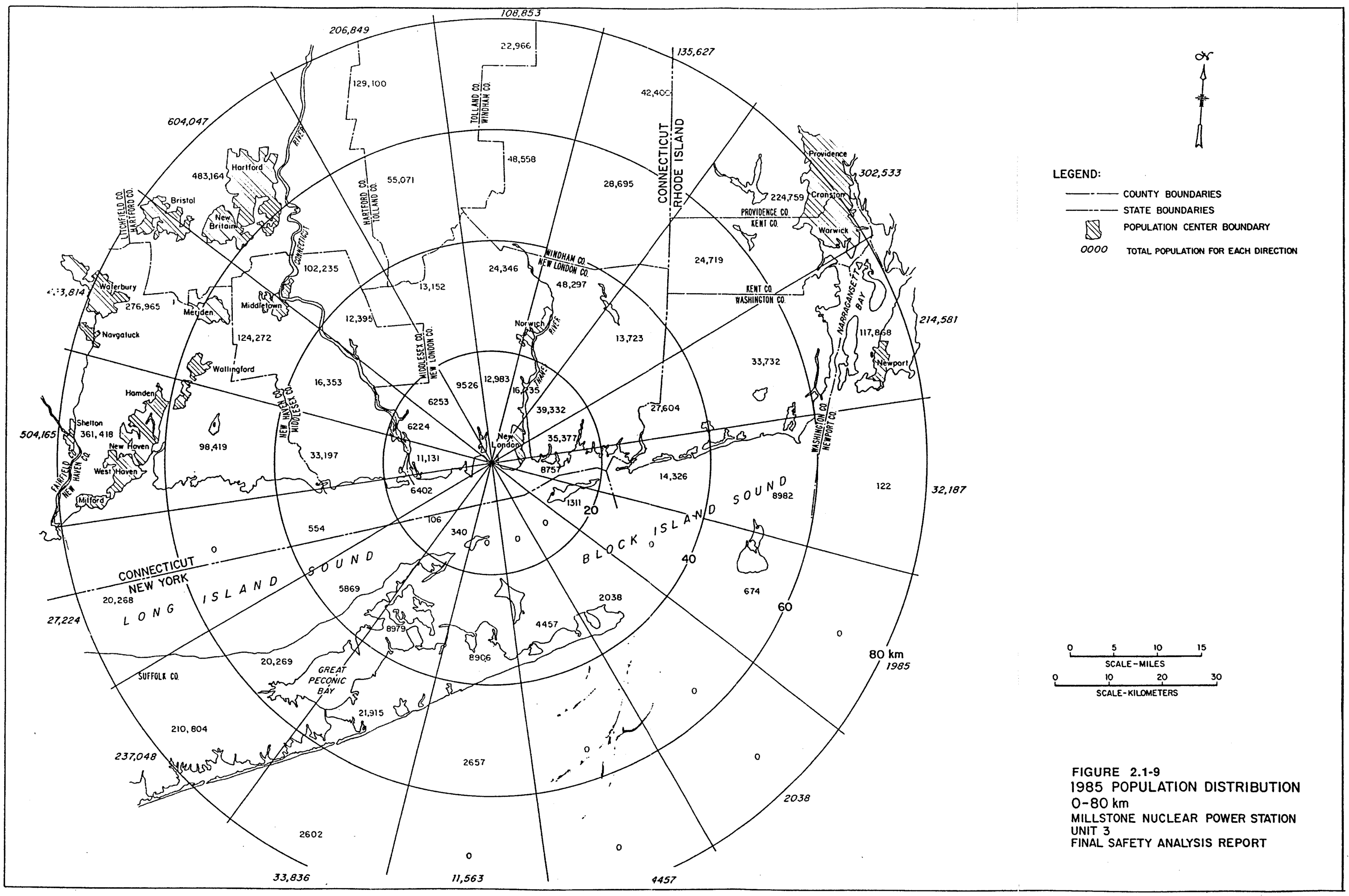


FIGURE 2.1-9
1985 POPULATION DISTRIBUTION
0-80 km
MILLSTONE NUCLEAR POWER STATION
UNIT 3
FINAL SAFETY ANALYSIS REPORT

MAY 1993

FIGURE 2.1–10 POPULATION SECTORS FOR 0-50 MILES

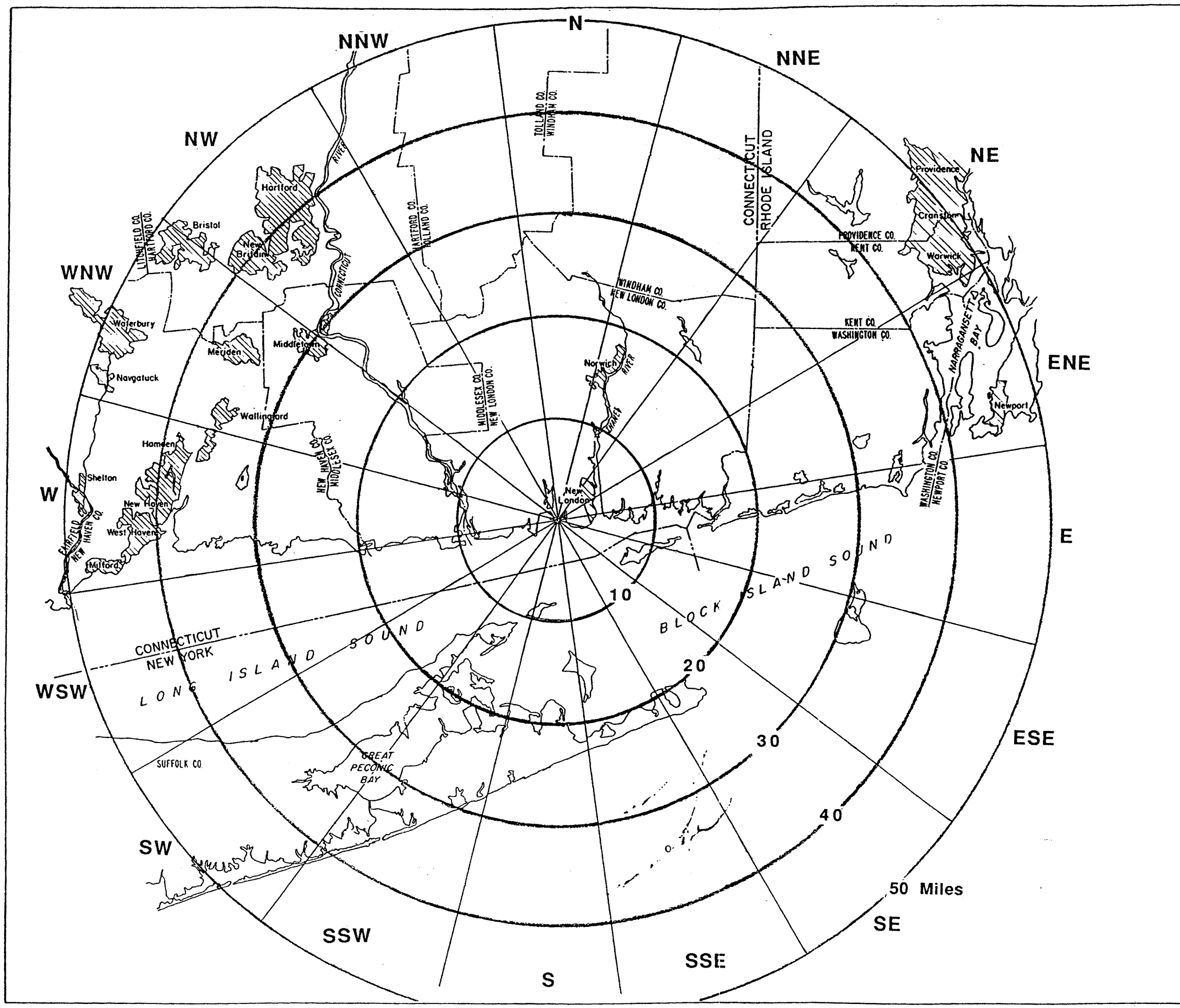


FIGURE 2.1-10
POPULATION SECTORS FOR 0 - 50 MILES
MILLSTONE NUCLEAR POWER STATION UNIT 3
FINAL SAFETY ANALYSIS REPORT

MAY 1993

FIGURE 2.1–11 ROADS AND FACILITIES IN THE LPZ

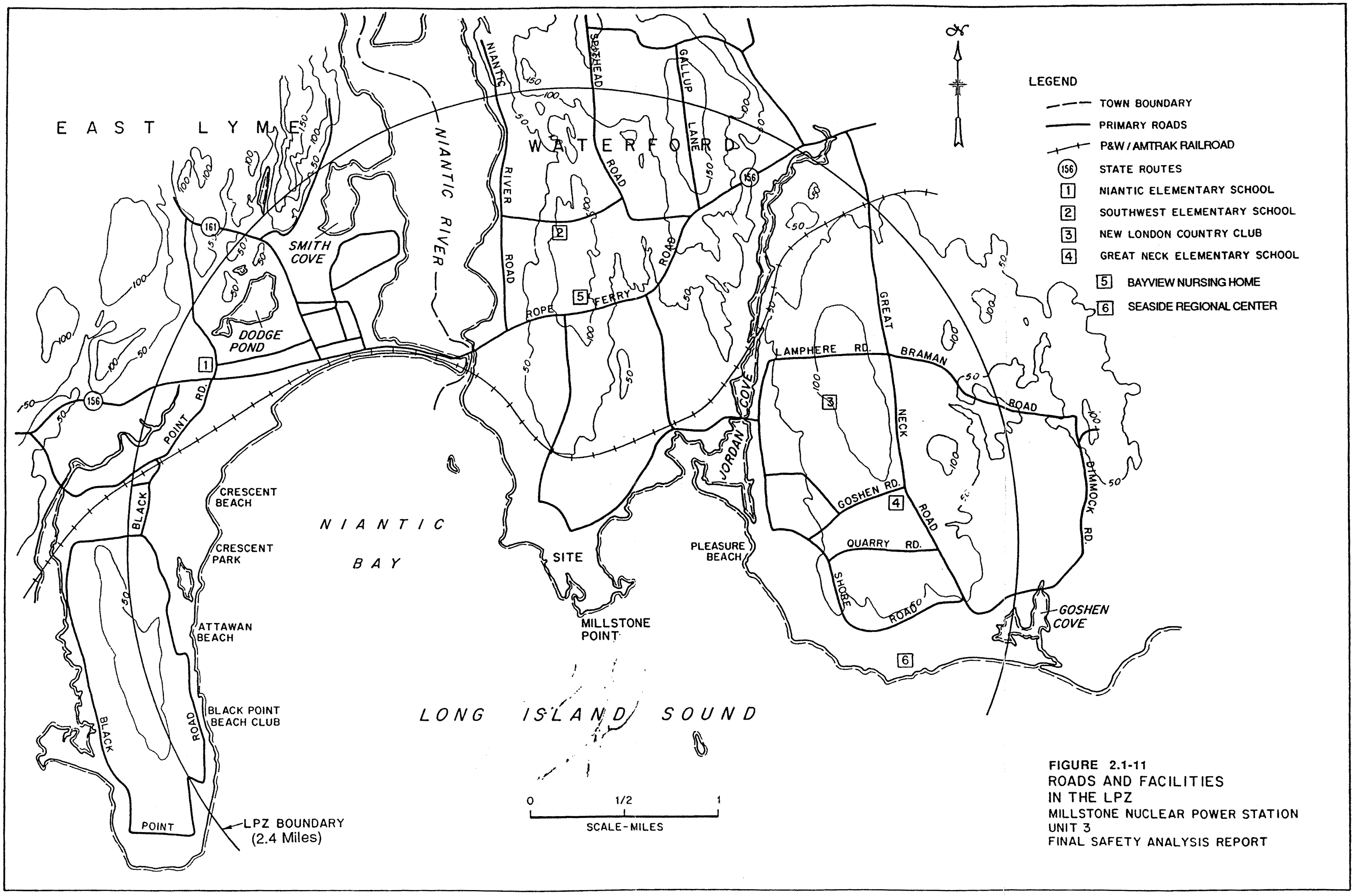
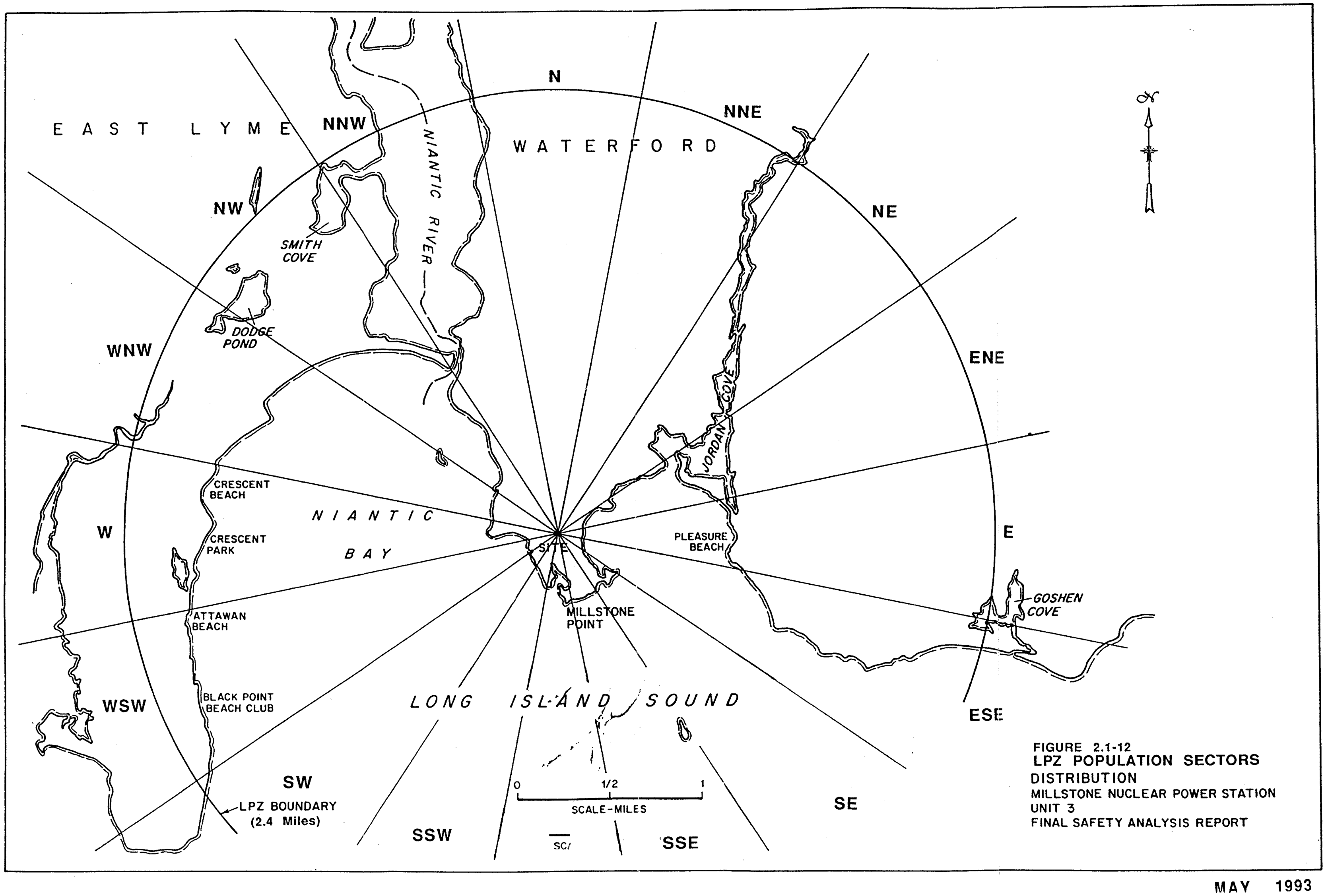


FIGURE 2.1–12 LPZ POPULATION SECTORS DISTRIBUTION



2.2 NEARBY INDUSTRIAL, TRANSPORTATION, AND MILITARY FACILITIES

2.2.1 LOCATIONS AND ROUTES

The area around the Millstone site contains three major industrial facilities (Dow Chemical Corporation, Pfizer Corporation, and Electric Boat Division of General Dynamics Corporation); two transportation facilities (Groton/New London) Airport and the New London Transportation Center; and four military installations (U.S. Navy Submarine Base, U.S. Coast Guard Academy, Camp Rell, and Stone's Ranch Military Reservation).

There is also an interstate highway (Interstate 95), passenger and freight railroad lines, gas distribution lines, above ground gas and oil storage facilities and two major waterways (Long Island Sound, Thames River) in the vicinity of the Millstone site.

There are no major gas transmission lines, oil transmission or distribution lines, underground gas storage facilities, drilling or mining operations, or military firing, or bombing ranges near the site.

The locations of the major industrial, transportation and military facilities are shown on Figure 2.2–1. Aircraft patterns and routes are shown on Figures 2.2–2 and 2.2–3. Figure 2.2–4 shows the road and highway system in the area of the Millstone site.

2.2.2 DESCRIPTIONS

2.2.2.1 Description of Facilities

A summary of the significant industrial, transportation, military, and industrial related facilities is shown in Table 2.2-1, as listed below.

1. Dow Chemical Corporation of Allen Point, Ledyard, Connecticut is located on the east bank of the Thames River approximately 10 miles north-northeast of the site. Dow Chemical is a producer of synthetic compounds and employs approximately 115 persons.

2. Pfizer Corporation of Eastern Point Road, Groton, Connecticut is located on the east bank of the Thames River, approximately 4.9 miles east-northeast of the site. Pfizer Corporation is a producer of pharmaceutical and medical supplies, employing approximately 3,000 persons.

3. Electric Boat Division of General Dynamics of Eastern Point Road, Groton, Connecticut is located approximately 5 miles east-northeast of the site. Electric Boat employs approximately 12,000 persons, and is a producer of submarines and oceanographic equipment for commercial industry and the U.S. Navy.

4. Groton/New London Airport, approximately 6 miles east-northeast of the site, handles regularly scheduled commercial passenger flights (Section 2.2.2.5). Approximately 13 persons are employed at Groton/New London Airport on a

full-time basis, excluding airline and car rental employees. The National Guard has an aircraft repair facility at the airport that has approximately 140 full-time employees.

5. The New London Transportation Center, located at City Pier, New London on the west bank of the Thames River, is approximately 4 miles northeast of the site. Approximately 20 persons are employed there on a full time basis.

6. U.S. Navy Submarine Base, Groton, Connecticut is located on the east bank of the Thames River, approximately 7 miles northeast of the site. The base population includes approximately 8,500 military personnel. In addition, there are about 1,800 civilian employees at the base.

7. The U.S. Coast Guard Academy, New London, Connecticut is located on the west bank of the Thames River, approximately 5.6 miles northeast of the site. Approximately 900 cadets attend the academy, while approximately 360 military and civilian personnel are employed here.

8. The Connecticut National Guard facility, located approximately 2 miles northwest of the site, is a training headquarters for the Connecticut Army National Guard. It is owned and operated by the Military Department of the State of Connecticut. On a full-time basis, it employs 16 persons (military and civilian), including the headquarters for the Connecticut Military Academy, Post Operations personnel, and the 745th Signal Company. On a part-time basis, during various weekends, Camp Rowland is occupied by varying numbers of troop units for administrative training maneuvers, billeting, and supply functions for the Connecticut Army National Guard. During the training maneuvers there may be from 300 to 1,200 people at the facility.

9. In addition to the Connecticut National Guard facility, the Military Department of the State of Connecticut also maintains a field training facility known as Stone's Ranch Military Reservation, located approximately 7 miles northwest of the site. Fourteen persons are employed here full-time for two regional motor vehicle and equipment maintenance shops. It is also occupied on a part-time basis by varying numbers of troop units for periods of field training for the Connecticut Army National Guard. During some weekend training sessions there may be up to 500 people at the facility.

10. Hess Oil Corporation of Eastern Point Road, Groton, Connecticut is located on the east bank of the Thames River, approximately 5 miles east-northeast of the site. It is located north of Pfizer Corporation, and south of General Dynamics-Electric Boat Division and services as a fuel storage facility. There are about 14 persons employed there on a full time basis.

11. There is one medium-sized propane storage area in the proximity of the Millstone site. Hendel Petroleum Company, is located in Waterford, approximately 2.5 miles northeast of the site on Great Neck Road, and employs about 75 people.

    On the Millstone site, at the Fire Training Facility located approximately 2,800 feet to the north of the protected area (3,400 feet to Unit 3 Control Room), are two 1,000 gallon propane cylinders. The two cylinders are used to supply propane to the fire simulator.

12. Montville Station is a Fossil Fuel powered electric generating plant operated by Connecticut Light & Power Company in Montville, Connecticut. It is located on the west bank of the Thames River, approximately 9.5 miles north-northeast of the site. Approximately 67 people are employed there.

2.2.2.2 Description of Products and Materials

1. Dow Chemical produces organic compounds, such as Styron, Styrofoam, and a base product of latex paints. All materials are moved to and from the company by truck and/or railroad.

2. Pfizer Corporation produces organic compounds and pharmaceutical materials, such as citric acid, antibiotics, synthetic medicines, vitamins and caffeine. All materials are moved to and from Pfizer Corporation by truck and/or railroad.

3. The nature of products produced at Electric Boat requires that they handle substantial amounts of nuclear material which is licensed under the Naval Reactors Division. All material is moved by truck, railroad, and/or barge to and from the company with the exception of completed ships which leave under their own power.

4. Groton/New London Airport (Section 2.2.2.5)

5. The New London Transportation Center is a large complex in downtown New London in the City Pier area. It encompasses numerous facilities, including a train station, several ferry companies, commercial and private boat slips, an interstate bus terminal, local bus interchangers, and commercial land transportation facilities. It serves as the prime entrance and exit for New London for civilian and commercial travel.

6. The U.S. Navy Submarine Base provides logistics as well as training and operation of the base and its ships (nuclear and non-nuclear). All materials are moved by truck, railroad, barge and/or ship to and from this government installation.

7. The U.S. Coast Guard Academy is headquarters for indoctrination and training of future officers in the Coast Guard. All materials used at the academy are of the software nature and are moved by truck.

8. The Connecticut National Guard facility is an administrative training center for troops of the Connecticut Army National Guard. Because of the solely administrative nature of its occupancy, the camp's operation has no effect on the Station's operation.

9. Stone's Ranch Military Reservation is a military field training facility for the Connecticut Army National Guard. Limited quantities of munitions and explosives are stored in underground bunkers at this facility. These materials are used in quarry operations for the Connecticut Army Corps of Engineers. No live ammunition is used at the facility. All materials are moved to and from Stone's Ranch by truck.

   In addition, a small paved utility landing strip is located at Stone's Ranch. While capable of handling light, fixed-wing aircraft, the strip is not routinely used except for occasional rotary-wing operations. Because of its distance from the site, the limited quantity of materials stored and used, and the type of aircraft operations occurring at the facility, Stone's Ranch Military Reservation does not pose any hazard to the Millstone station.

   No other military operations such as firing ranges, bombing ranges, ordnance depots, or missile sites exist near the Millstone site.

10. Hess Oil Corporation operates a fuel distribution and storage facility for home heating oil and kerosene. There are large above ground tanks capable of storing heating oil, residual fuel oil, and kerosene. The fuel arrives by ships or barges and is distributed by trucks.

11. Hendel Petroleum Company operates a fuel distribution facility for commercial and residential use. There are 5 above ground tanks (3-30,000 gallons and 2-16,000 gallons) which are capable of storing 126,000 gallons total of propane gas. The facility also stores 40,000 gallons of gasoline, and 40,000 gallons of No. 2 fuel oil. The propane for the facility arrives by train and truck, and is distributed by truck.

    The Fire Training Facility was constructed in 1994 for the purpose of training Millstone's fire brigade members. The Training Facility consists of six live burn “mock-ups” which replicate nuclear power plant fire hazards. Propane is used to fuel these “fireplaces.”

    Two 1,000 gallon propane storage cylinders are located at the Training Facility. These two cylinders are positioned such that their ends are pointed away from the Millstone site. Both cylinders are above ground domestic storage cylinders designed per ASME Code for Pressure Vessels, Section VIII Division 1-92.

12. The Montville Station Electric Generating Station is capable of providing 498 mW of electric power. Its generators are powered by fossil fuel. The fuel is stored in

three large above ground tanks, capable of storing approximately 175,000 barrels of fuel each, two medium above ground tanks, capable of storing approximately 12,000 barrels of fuel each, and two small above ground tanks, capable of storing approximately 250 barrels of fuel each. The fuel arrives by barges or trucks.

2.2.2.3 Pipelines

There are no major transmission lines within 5 miles of the site. There are two medium pressure gas distribution lines in the near proximity of the site. The nearest gas distribution line is approximately 2.9 miles from the site, located along Rope Ferry Road in Waterford. This 35 psi gas distribution line is a 6-inch plastic pipeline, buried approximately 3 feet deep. The control valve for this line is located at the intersection of Clark Lane and Boston Post Road in Waterford. The second gas distribution line, in place and pressurized, ends at and serves the shopping center complex, near the intersection of I-95 and Parkway North, approximately 4 miles north of the site. This 35 psi gas distribution line is an 8-inch plastic pipeline buried approximately 3 feet deep. The control valve for this line is located at the complex where it intersects with Parkway North.

There are no oil transmission or distribution lines within 5 miles of the Millstone site.

2.2.2.4 Waterways

Ships that pass by the site in the shipping channels of Long Island Sound are of two types: general cargo freighters, usually partially unloaded, with drafts of 20 to 25 feet, and deep draft tankers with drafts of 35 to 38 feet. Both of these classes of ships must remain at least 2 miles offshore to prevent running aground on Bartlett Reef.

No oil barges pass to the shore side of Bartlett Reef, and since there are no tank farms in Niantic Bay, no oil barges pass within 2 miles of the site. The largest oil barges have a capacity of 60,000 barrels and draw 15 feet 6 inches of water.

Barge traffic in the vicinity of the site has been diminishing over the past several years due to the decrease in the amount of oil used by area facilities. Barge traffic is heaviest during the winter months, and averages only 1 barge per day during these months. On the average of once a month, a barge carrying 15,000 barrels of sulfuric acid is towed past the site outside of Bartlett Reef. Approximately 10 ships per day traverse the Reef in the vicinity, 6 miles of the site.

For these reasons, it is concluded that shipping accidents would not adversely affect Millstone 3 safety related facilities.

2.2.2.5 Airports

There is one airport within 6 miles of the site: The Groton/New London Airport.

Groton/New London Airport, approximately 6 miles east- northeast of the site, handles regularly scheduled commercial passenger flights. It is served by two airlines: Action Airlines, and U.S. Air Express. It has two runways: 5-23, 5,000 feet long; and 15-33, 4,000 feet long; which are both illuminated. There is a control tower at Groton/New London, with ILS (Instrument Landing System) and VOR (Very High Frequency Omni Range). ILS is available on runway 5. As shown on Figure 2.2–2, the landing patterns used do not direct traffic near the Millstone site.

The largest commercial aircraft to use Groton/New London Airport on a regularly scheduled basis are Beachcraft 1900's which carry approximately 19 passengers. The only jets using the airport on a regular basis are two small chartered Cessna Citation which carry 10 passengers.

During fiscal year 1980-1981, an average of 96,000 civilian takeoffs and landings occurred at Groton/New London Airport. Comparatively, during Calendar Year 1995, about 78,700 civilian takeoffs and landings occurred.

The largest military aircraft to use Groton/New London Airport on an occasional basis is C-130's. There are also two C-23's. Additionally, there are several military helicopters stationed at the airport.

In 1995 there were approximately 4,490 military flights, approximately half of which were military helicopters. Millstone station is not in the flight path of these flights, and pilots are briefed to avoid the site.

The largest aircraft to ever use Groton/New London Airport is a Boeing 727. However, the use of this and other large aircraft at Groton/New London is limited and very infrequent.

As shown on Figure 2.2–3, the air lane nearest the site is V58 which is approximately 4 miles northeast of the site. Other adjacent air lanes include V16, which is approximately 6 miles northwest of the site, and V308, which is approximately 8 miles east of the site. The nearest high-altitude jet route, J121-581, passes approximately 9 miles southeast of the site. A second jet route, J55, passes approximately 12 miles northwest of the site.

2.2.2.6 Highways

The area around the Millstone site is served by interstate, state, and local roads. These are shown on Figure 2.2–4.

The nearest major highway which would be used for frequent transportation of hazardous materials is U.S. Interstate 95, which is located 4 miles from the Millstone site.

Other principal highways which pass near the site include U.S. Highway 1 which is located 3 miles from the site, and State Highway 156, located 1.5 miles from the site.

These separation distances exceed the minimum distance criteria given in Regulatory Guide 1.91, Revision 1 and provide assurance that any transportation accidents resulting in explosions or toxic gas releases of truck size shipments of hazardous materials would not have a significant adverse effect on the safe operation or shutdown capability of the unit. See Section 2.2.3 for a more detailed evaluation of potential accidents.

2.2.2.7 Railroads

The site is traversed from east to west by a Providence & Worcester (P&W)/Amtrak railroad right-of-way. The mainline tracks are about 1,795 feet from the Millstone 3 containment structure.

Both P&W and Amtrak trains are currently diesel powered. However, Amtrak, the operator of the passenger train service, plans to electrify its passenger trains, and has embarked on a project to construct overhead electric lines to power the trains. The project is currently scheduled for completion in 1997. These new lines will be 23 feet above the rails and will not affect the site nor the overhead transmission lines leading out of the site which traverse the railroad line above the tracks. Additionally, Amtrak is considering raising the track bed as much as 3 feet at various points along the railroad line, but does not plan to do this where it traverses the Millstone site.

Withheld under 10 CFR 2.390 (d)(1)

[redacted]

2.2.2.8 Projections of Industrial Growth

<u>Pipelines</u>

No expansion of facilities is presently planned in the area for oil distribution within the southeastern region of Connecticut. The gas distribution line along Rope Ferry Road ends at Waterford High School, approximately 2.9 miles from the Millstone site. The gas distribution line at I-95 and Parkway North ends at, and serves the shopping complex approximately 4 miles from the Millstone site.

Waterways

As previously mentioned, ship and barge traffic in the area of the Millstone site has decreased over the past several years. No new ship or barge traffic is anticipated at this time in the Niantic Bay area on Long Island Sound near the location of the intake structures.

Airports

No expansion of facilities at Groton/New London Airport is proposed although some improvements to the facility, such as expansion of the approach lights, and upgrading of the terminal and runways is planned. Southeastern Connecticut Regional Planning Agency (SCRPA) recommends that a master plan be prepared for the airport before any major physical improvements are made. The agency has previously adopted the policy that Groton/New London Airport should remain a small feeder airport providing connection to larger airports and direct service to a limited number of cities within a 500-mile radius.

Highways

Three major highway improvements were made for the area around the Millstone site. The section of Route 85 between I-95 and Route I-395 (Formally Route 52) was widened in 1989 in connection with the new shopping mall built on Route 85, the widening of “Cross Roads” between I-95 and Route 85 in 1990 for another new shopping mall on Cross Roads, and a new bridge between Waterford and East Lyme was completed in 1991 to replace the Niantic River Bridge with a high rise bridge one mile long. This high-level draw bridge replaced the older lower swing bridge, creating a smoother flow of traffic along State Highway 156.

Railroads

In 1982 there was a transfer of the operating rights of freight service over coastal trackage from ConRail to the Providence & Worcester (P&W) railroad. While this involved the trackage near the site, there was no appreciable change in either the amount or the nature of freight traffic.

Evaluation of potential accidents and identification of design basis events are discussed in Section 2.2.3.

2.2.3 EVALUATION OF POTENTIAL ACCIDENTS

The evaluation of potential accidents includes analysis of hazardous materials from both offsite industrial, transportation, and military facilities within a 5-mile radius of the Millstone site, as well as from specified onsite sources. Section 2.2.1 defines industrial, transportation, and military facilities that exist within 10 miles of the Millstone site. All major industrial plants are more than 5 miles from Millstone. Likewise, due to the innocuous nature of operations at nearby military installations, as well as the location of the Groton/New London airport and the nature of traffic and the flight routes into and out of the airport, no potential accidents from military installations or from aircraft have been postulated concerning the safe operation or shutdown capability of the plant.

Ships that pass by the site in the shipping channels of Long Island Sound are of two types: general cargo freighters, which usually are partially unloaded, with drafts of 20 to 25 feet, and deep draft tankers with drafts of 35 to 38 feet (Section 2.2.2.4). Both of these classes of ships must remain at least 2 miles offshore to avoid running aground on Bartlett Reef. Approximately ten ships per day transverse the shipping channels in the vicinity of the site (Section 2.2.2.4).

Since there are no tank farms in Niantic Bay, oil barges do not pass to the shore side of Bartlett Reef or within 2 miles of the site. Barge traffic is heaviest in the winter, averaging only one loaded oil barge daily, the largest having a capacity of 60,000 barrels and a draw of 15 feet-6 inches of water (Section 2.2.2.4). On the average of once a month, a barge carrying 15,000 barrels of sulfuric acid is towed past the site, outside of Bartlett Reef. Total round-trip traffic is less than 10 ships per day.

Section 2.2.2.4 defines the nature of water use relative to commercial shipping and recreational boating. The only safety related structure subject to this evaluation is the circulating and service water pumphouse. Since there is no commercial water traffic in the area of the pumphouse, the only consideration that exists is the remote possibility of a runaway barge colliding with the pumphouse.

The possible damage to the pumphouse by a drifting barge was investigated. The barge can approach the pumphouse only through the intake channel, which is perpendicular to the front of the pumphouse. The relatively shallow bay bottom surrounding the intake channel prevents the barge from hitting the side of the pumphouse. Should a barge hit the pumphouse from the front, damage would be limited to the front wall of the recirculation tempering water gallery, which projects seaward from the pumphouse. The service water pumps, which are the only safety related equipment housed in the pumphouse, are located approximately 50 feet from the front wall. The operation of these pumps would not be impaired and the water intake source would not be blocked, as the water intake source lies between elevations (-) 28 feet 0 inch and (-) 8 feet 0 inch.

For these reasons, it is concluded that shipping accidents would not adversely affect safety related facilities.

The possibility of facility impacts due to explosion or release of hazardous materials from industrial facilities was considered for two facilities listed in Section 2.2.2. Hendel Oil Company and Hess Oil Company were selected for evaluation based on proximity to the site and volume of material stored. Several incident conditions were modeled for each facility using “Automated Resource for Chemical Hazard Incident Evaluation” (ARCHIE) version 1.00 produced by FEMA/USDOT and USEPA. ARCHIE is a software planning tool which provides an integrated method for assessment of vapor dispersion, fire and explosion impacts related to the discharge of hazardous material into the terrestrial environment.

Inputs to the model include physical properties of the hazardous material such as molecular weight, boiling point, and vapor pressure for various temperatures. These were obtained from the Chemical Engineer's Handbook, Fifth Edition, 1973. The type and quantity of hazardous material on-hand at each facility was obtained from the facility managers. Conservative assumptions were made where applicable, the most notable of which was that all the tanks at a facility should be treated as one large tank for the purpose of calculating risks associated with fire or explosion. Non-fire or explosion hazards, such as toxic vapor dispersion were projected using the largest single tank at each facility, since a major fault in more than one storage tank in the absence of an explosion was considered unlikely.

The first event considered was the potential for toxic concentrations of propane to reach the site from a release of propane gas from a commercial facility, other than by explosion. A nearly instantaneous release (1 minute duration) coupled with stability class “F” (most stable) and a low wind velocity (4.5 mph) was chosen to minimize diffusion of the puff of propane. Hendel Oil Company has a 30,000 gallon tank which is located 2.5 miles from the site. The plume is conservatively assumed to be transported by the wind directly towards the Control Room ventilation intakes. The maximum concentration reached at the intakes will be approximately 7,311 ppm 31 minutes after tank rupture. Using the same input parameters and methodology to assess infiltration to the pressurized control room as in FSAR Section 2.2.3.1.4, the concentration inside the control room should reach a maximum value of 13.4 ppm 61 minutes after the tank rupture. Both values are well below the toxic vapor limit of 20,000 ppm. The only scenario in which concentration anywhere on the Millstone site reaches or exceeds the toxic vapor limit would occur in the case of an instantaneous release of the contents of all 5 tanks (126,000 gallons) of propane from Hendel Oil Company without explosion or fire. In this unlikely event, concentrations at the control room intakes could reach 29,146 ppm 31 minutes after the start of the release. Concentrations inside the Control Room would reach 58 ppm (well below the toxic vapor limit), 61 minutes after the release.

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Due to its further distance from the site (5 miles), and the lesser volatility of the kerosene, #2 fuel oil, and residual fuel oil stored there, there is no impact on the Millstone plant from a fire or explosion at the Hess Oil facility. For these reasons, it is concluded that explosion or release of hazardous material from any of these facilities would not adversely affect the safe operation or shutdown capabilities of the plant.

Other land and water uses prevailing in the Millstone Point vicinity are such that the unit's intake of cooling water is not jeopardized by ice blockage and/or damage (the ocean temperatures prohibit significant icing), or release of corrosive chemicals or oil (only remote and distant offshore releases are possible).

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The determination of design basis events therefore provides an analysis and discussion of:

1. missiles generated by offsite events near Unit 3;
2. unconfined vapor cloud explosion hazard;
3. hydrogen storage at the site; and
4. toxic chemicals stored at the site.

2.2.3.1.1 Missiles Generated by Events near the Millstone Site

The guidelines of NUREG-0800 state that the aggregate probability of exceeding plant design criteria associated with all identified external man made hazards be less than 10^{-6}. In particular the total probability of penetrating site proximity missile strikes on safety- related structures should be shown to be less than 10^{-7} per year or the design bases be modified to accommodate them.

The relative importance of potential sources of missiles is derived from two primary factors: (1) the nature of shipment loading, and (2) shipment frequency past the site. Several studies show that shipment of flammable compressed gases are the most likely sources to produce transportation tank fragments in the event of an accident. Depending on the nature of hazardous material and the actual accident scenario the tank fragments may travel sufficient distances and create a potential threat of damage upon impact to a safety related structure at the site.

The following algorithm is used to estimate the aggregate probability of a violent rupture or explosion from a rail shipment of hazardous materials capable of producing large missiles able to reach safety related structures at the site:

$$P_r = (i{=}1)RE\left(\frac{S_i L_i}{T_i}\right) \tag{2.2.3-1}$$

where:

P_r = Aggregate probability of missiles generating ruptures or explosions from rail accidents of significance to safety related structures (events/year)

R = Number of hazardous materials likely to produce violent ruptures or explosions with significant missiles generating capability (dimensionless)

E = Frequency of events which result in explosions or violent ruptures capable of producing significant missiles (events/shipment)

S_i = Shipment frequency of i-th hazardous material past site (shipment/year)

L_i = Track exposure length for the i-th material (miles)

T_i = Average shipment trip length for i-th material (miles)

<u>Number of Hazardous Materials, R</u>

The hazardous materials considered likely to produce significant missiles in terms of size and potential range were selected from the Hazardous Materials Link Report (ConRail, 1980) between New Haven and New London, Connecticut, fr January 1978 through June 1979. These materials were also found to be prevalent in more recent accident/incident data contained in special DOT Research and Special Programs Administration computer outputs of March 26, 1981 (Research and Special Programs Administration, U.S. Dept. of Transportation, March 1981), and April 15, 1981 (Research and Special Programs Administration, U.S. Dept. of Transportation, April 1981) tank car rupture data from the Railroad Tank Car Safety Research and Test Project Report, RA-01-2-7 (Association of American Railroads and Railway Progress Institute, 1972), and several other pertinent railroad accident reports by the National Transportation Safety Board (October 1971 through July 1980).

The materials selected (Table 2.2-2) are flammable compressed gases since they are known to produce a characteristic tank rupture event. The rupture event may range from a single over-pressure followed with fire to a boiling liquid vapor explosion (BLEVE).

<u>Frequency of Events, E</u>

The incidence of significant missile generating events is relatively infrequent in the transport of hazardous materials and the material specific data is unreliable to be useful for the present probabilistic analysis. In addition, specific data supplied by ConRail for the period March 30, 1976, through December 31, 1979, contained no incidents involving explosions. Instead, a comparison was made for propane transport by Battelle Memorial Institute in PNL-3308, Report of March 1980 (Giffen et al., 1980), and the DOT data in accident/incident bulletins for the years 1975-1979. In terms of violent tank car ruptures or explosions per tank car mile, the predicted values were as follows:

PNL-3308	3.1×10^{-9} events/tank car mile
DOT (75-79)	1.5×10^{-9} events/tank car mile

The Battelle report considers non-accident related tank ruptures as well as transportation accidents and it is further stated that about 20 percent of ruptures occur in non-accident situations. We have used Battelle event frequency in the present analysis, even though we recognize it to be demonstrably conservative. The present analysis also accounts for the contribution to the average rate from slightly higher incidence for propane and LPG shipments.

Shipment Frequency, S_i

Shipment frequencies are derived from applicable data in the ConRail link report for the period January 1978 through June 1979 (ConRail, 1980). Tank cars per year and per train for the commodities in question appear in Table 2.2-2.

More recent shipment frequency shipment data was obtained for the time period January 1992 through December 1992. Frequency of shipment of anhydrous ammonia has remained steady at 5 cars per year. Propane shipments have decreased to 35-40 cars per year. This evaluation was conservatively based on the January 1978 through June 1979 shipment data.

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Average Shipment Trip Length, T_i

The average shipment lengths for each hazardous material derived from one percent Waybill Sample of U.S. Tank Car shipments, or Appendix E to the Final Phase O2 Report, Accident Review, AAR-RPI No. RA 02-2-18 (1982).

Aggregate Probability of Missile Generating Ruptures, P_r

The results from the above analysis are summarized in Table 2.2-4. The aggregate probability of tank car violent ruptures or explosions which can produce significant missiles is conservatively estimated to be 5.6 x 10^{-9} per year. This is considerably below the NUREG-0800, Section 3.5.1.5, suggested limit (1 x 10^{-7}) for conservatively estimated explosion probability.

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We have used NASA Report 3023 computer program entitled “THRUST” to calculate the acceleration velocity and displacement distances of fragments propelled by a liquified compressed gas. The NASA analysis assumes that a large portion of the vessel containing a liquid/gas mixture, in equilibrium at greater than atmospheric pressure, separates from the rest of the storage vessel. As the liquid under pressure converts to gas when exposed to atmospheric pressure a thrust is produced causing the fragment to move away from the scene of accident.

The types of tank car fragments are illustrated in Table 2.2-5. In type A, the tank is shown to rupture in two equal halves. In type B, the tank car is assumed to split in 2:1 ratio and the smaller fragment is assumed to move away from the accident scene. Type C and D ruptures are not considered in this analysis because:

1. In type C, the man-way has no significant amount of liquid to provide it with thrust.

2. In type D, the leak is relatively too slow to create a violent change in vapor/liquid equilibrium within the tank.

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Discussion of Results

The Federal Railroad Administration retrofit standards “J”, “S”, and “T”, for pressurized tank car require thermal insulation protection head puncture shields, self-couplers, and upgraded safety relief valve capacities. According to Folden (Personal Communication between S.N. Bajpai, SWEC, and Robert Folden, Federal Railroad Administration, 1982), these retrofits have been installed on existing tank cars. The new compressed gas tank cars also meet these provisions in compliance with Docket HM144 and modified in subsequent notices under Titles 173 and 174. The compliance with retrofit standards is expected to result in substantial reduction in severity of violent ruptures. The Federal Railroad Administration believes that compressed flammable gas tank car head punctures and fire induced violent ruptures are greatly reduced or eliminated in 90 percent of the cases as a result of the improvements.

According to Folden, the “S”, “J”, and “T” retrofit requirements together with self-couplers have reduced the violent ruptures considerably. The ruptures in ammonia tank cars are principally due to material degradation. However, ruptures in ammonia tank are not violent. Folden described one incident involving ammonia in which “the tank just opened up along the seam and the ammonia escaped without any thrusting fragments.”

The present analysis is based on the data from past experience and does not include the safety improvements resulting from DOT required safety retrofits. This analysis also includes the contribution of non-accident ruptures because the Battelle (Giffen et al., 1980) propane risk assessment study has been used as the reference point for the calculation of the probability of catastrophic ruptures of other hazardous materials.

The overall risk to the Millstone plant due to catastrophic ruptures resulting from transport of hazardous materials is subject to additional reducing factors. These factors are included in NUREG-0800, Section 3.5.1.5, and according to the following model:

$$P_t = P_e \times P_{mr} \times P_{sc} \times P_p \times N \qquad \textit{(2.2.3-2)}$$

where:

P_t = Total probability per year of a damaging missile strike

P_e = Probability of an explosion or rupture potentially capable of missile generation

P_{mr} = Probability of a missile reaching the plant (that is, distance to safety related structures)

P_{sc} = Probability of a missile striking a critical area

P_p = Probability of a missile energy exceeding the energy required to penetrate the safety related structures

N = Number of missiles per explosion

Railroad cars carrying hazardous materials and involved in a derailment do not necessarily result in tank car ruptures. Furthermore, not all ruptures result in the generation of missiles. In fact, data in AAR-RPI No. RA-01-2-7 (1972) shows that in approximately one-third of major ruptures, no significant missiles are generated. Therefore, it is reasonable to incorporate a conditional probability (P_m) of missile generation to the model. Thus the conditional probability of missile generation $P_m = 0.67$.

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The tank car fragments (e.g., elliptical head) have different punching-shear characteristics than a “flying telephone pole” moving at 200 mph. Tank car head missiles have been known to demolish brick walls, but tend to bounce off built stonewalls with little damage to the structure (Personal Communication between S.N. Bajpai and Robert Folden 1982).

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2.2.3.1.3

Compressed liquified gases are shipped over the railroad line adjacent to the Millstone site. These gases normally are propane and anhydrous ammonia. In the event of a catastrophic rupture, the liquified gas is released to the atmosphere under pressure, and a fraction of the liquid is vaporized. The remaining liquid, due to the cooling effect, remains as chilled liquid and vaporizes further upon contact with the ground. The rapid loss of lading results in the formation of an unconfined vapor cloud which is at least partially mixed with air.

The probability of a vapor cloud explosion on the railroad line adjacent to the Millstone site is based on the probability of a catastrophic rupture event, the probability of flammable vapor cloud formation, the probability of wind direction from the railroad sector (bounded by the 1 psi over-pressure radius), and the probability of the vapor cloud encountering an ignition source.

The probability of a flammable vapor cloud explosion is thus:

$$P_{ve} = \sum_{i=1}^{R} P_{ri} \, X \, P_{rfi} \, X \, f_w \, X \, P_{ii} \qquad (2.2.3\text{-}3)$$

where:

P_{ve} = Probability per year of vapor cloud explosion

R = Number of hazardous materials likely to produce vapor cloud

P_{ri} = Probability of catastrophic rupture events per year for the i-th hazardous material

P_{vfi} = Probability of forming a flammable vapor cloud

f_w = Frequency of wind speed which promotes transport and mixing with air

P_{ii} = Probability of finding an ignition source given that a flammable vapor cloud is formed by the i-th hazardous material

Number of Hazardous Materials, R

The hazardous materials likely to produce an unconfined vapor cloud explosion due to a catastrophic rupture event on the railroad line adjacent to the Millstone Site are propane and anhydrous ammonia.

Probability of Catastrophic Rupture Events, P_{ri}

The probability of catastrophic rupture events per year involving the i-th hazardous material is estimated using the model described in Section 2.2.3.1.1 of this report. These probabilities are presented in Table 2.2-4.

Probability of Forming a Flammable Vapor Cloud, P_{rfi}

All catastrophic rupture events involving flammable compressed gases do not necessarily result in the formation of vapor clouds. The usual case is that ignition source is available in the immediate vicinity of accident and a fire usually results. Depending on the actual accident scenario, the fire, at worst, would cause the tank car contents to be released and result in the formation of a "fireball." The fireball accident scenario has no incident pressures associated with it to be of concern for the plant structures. However, the formation of a flammable vapor cloud and its subsequent ignition is of potential safety concern. The formation of a flammable vapor cloud also implies that an ignition source was not available in the immediate vicinity of the scene of accident.

Accidental spill data (U.S. Dept. of Transportation, March 1981) was used to estimate the probability of forming a vapor cloud given a catastrophic rupture event. This probability was conservatively estimated as 0.1.

Wind Speed Frequency, f_W

Favorable wind speed would allow optimum transport and mixing of air with the vapor cloud. The probability of favorable wind speed is assumed to be 1.0.

Probability of Encountering an Ignition Source, P_{ii}

In a catastrophic rupture event involving flammable compressed gases, an immediate encounter with an ignition source would typically result in a torching effect. In this case, the released gas is consumed immediately and the flames are confined locally. The torching effect can lead to an enlarged fire or, at worst, the formation of a "fireball." The probability of encountering ignition is 1.0 in the immediate vicinity of the accident and decreases away from it. The probability of ignition for the torching effect, fire, and fireball formation is therefore, nearly 1.0.

The formation of a flammable vapor cloud in or around the scene of an accident implies that an immediate ignition source was not encountered. The probability of an unconfined vapor cloud encountering an ignition source then decreases from nearly one to some value less than 1.0, which is dependent upon the area of the vapor cloud.

The probability of ignition was estimated using Table 9-2 of the Battelle PNL 3308 Report (Giffen et al., 1980). The use of this table requires an estimation of the area of the vapor cloud for a conservatively estimated instantaneous release of the compressed liquid.

The area of the unconfined vapor cloud was estimated by calculating: (1) the weight, i.e., vapor volume, of the liquid which vaporizes upon exit from a tank car and, (2) the depth of the unconfined vapor cloud above the ground.

The weight fraction, which vaporizes upon exit from a tank car, is given by:

$$f = 1 - \exp\left[\frac{C_v}{\lambda}(T_b - T_i)\right] \qquad (2.2.3\text{-}4)$$

where:

C_v = Liquid heat capacity

λ = Heat of vaporization

T_b = Normal boiling point

T_i = Initial temperature of the stored liquid

f = Fraction of the liquid that flash vaporizes.

The fraction vaporized, for both the hazardous materials, was under 0.4. To be on the conservative side, the fraction vaporized was taken to be 0.5. Thus, knowing the weight of tank car lading which was vaporized, the volume of the vapor cloud was estimated. The fraction of air entrained in the vapor cloud was ignored for this purpose.

The thickness of the vapor cloud above ground level was estimated by the following relation given by Kaiser and Griffiths (1982):

$$L = \frac{gh\Delta p}{\rho_a u_*^2} \qquad (2.2.3\text{-}5)$$

where:

L = 2

h = Thickness of the vapor cloud

$\Delta\rho$ = Density differences between cloud vapor and ambient air

ρ_a = Density of air

u_* = The vapor cloud spreading velocity

The spreading velocity was assumed to be equal to the wind velocity.

The estimated ignition probabilities are presented in Table 2.2-7.

The Probability of an Unconfined Vapor Cloud Explosion

The probability of an unconfined vapor cloud explosion at Millstone 3 was calculated using the model discussed above. These probabilities are presented in Table 2.2-8.

The aggregate estimated probability of an unconfined vapor cloud explosion is 2.54×10^{-11}, which is several orders of magnitude lower than the recommended range in Regulatory Guide 1.91. The unconfined vapor cloud and associated explosion pressure, therefore, does not constitute a design basis event for the Millstone 3 plant.

2.2.3.1.4 Hydrogen Storage at the Site

Section 2.2.3.1 describes the generator hydrogen storage facility. Each high pressure storage tube is restrained from movement by its supporting frame and is provided with an approved shutoff valve, bursting disc assembly, and vent. The installation is posted with NO SMOKING signs located no further than a distance of 25 feet away. A fire wall is constructed between the hydrogen storage facility and the east-west access road. Unauthorized entry is prevented by chain link fencing and a locked gate. Since the generator hydrogen facility poses no hazard to safety related structures, systems, or components, no further consideration is therefore required.

2.2.3.1.5 Toxic Chemicals

The assessment of control room habitability following a postulated accidental release of hazardous chemicals includes both onsite and offsite sources. The analysis is based on Regulatory Guide 1.78, "Assumptions for Evaluating the Habitability of a Nuclear Plant Control Room During a Postulated Hazardous Chemical Release." The release of any hazardous chemical stored onsite in a quantity greater than 100 pounds is considered, along with other potential releases from facilities within 5 miles of the control room. Transportation sources of hazardous chemicals frequently passing within 5 miles of the control room are also evaluated. Frequent shipments are defined as exceeding 10 per year for truck shipments, 30 per year for rail shipments, and 50 per year for barge shipments.

For the Millstone 3 site, two potential accidents involving two toxic chemicals were analyzed prior to Licensing Application. Chlorine was stored onsite in two separate 55 ton railroad tank cars. In addition, liquid propane had been transported prior to 1982 by ConRail within 5 miles of the site at a frequency greater than 30 railroad carloads per year. The chlorine tanks were removed in September 1986.

The effect of an accidental release of each of the chemicals on control room habitability was evaluated by calculating vapor concentrations as a function of time both outside and inside the control room. This calculation was performed using methodology outlined in NUREG-0570, Toxic Vapor Concentrations in the Control Room Following a Postulated Accidental Release, and utilizing the assumptions described in Regulatory Guide 1.78. A brief description of the underlying assumptions follows.

In a postulated accident, the entire contents of the largest single storage container are released, resulting in a toxic vapor cloud and/or plume which is conservatively assumed to be transported by the wind directly toward the control room intakes. The formation of the toxic cloud or plume is dependent upon the chemical nature of the release and ambient environmental characteristics. The entire amount of the chemical stored as a gas is treated as a puff or a cloud which has a finite volume determined from the quantity and density of the stored chemical. A toxic substance stored as a liquid with a boiling point below the ambient temperature forms an instantaneous puff, due to flashing (rapid gas formation) of some fraction of the quantity stored. The remaining liquid forms a puddle which quickly spreads into a thin layer on the ground, subsequently vaporizing and forming a ground-level vapor plume. A liquid that has a boiling point above the ambient temperature forms a puddle which evaporates by forced convection, resulting in a ground-level plume with no flashing involved. In all cases, the puff and/or ground-level plume is dispersed by atmospheric turbulence as it is transported by the wind directly toward the control room intakes. The effects of this postulated accident scenario are described in Section 2.2.3.2.

The habitability of the control room is evaluated by comparing the calculated chemical concentrations inside the control room with known human toxicity limits. These limits are determined to be the lowest concentration of a chemical that could interfere with an operator's ability to function properly and are obtained from Regulatory Guide 1.78 and other appropriate references. The control room is considered to be uninhabitable when toxic limits are exceeded by estimates of control room concentration. The input data required for the analysis include the chemical's physical properties, control room parameters, atmospheric stability, wind speed, distance from the spill to the control room air intakes, quantity of chemical released, and toxicity limits. For low boiling point liquids (i.e., chlorine and propane), the boiling point, puff density, heat of vaporization, specific heat, and liquid density are required as input.

For the Millstone 3 toxic chemical evaluation, various atmospheric stability and wind speeds representing a wide range of meteorological conditions along with an ambient dry bulb temperature of 30°C (80°F), were utilized to obtain the condition which would result in a maximum control room concentration.

The control room parameters that were used as input to the propane analysis consisted of the following:

- Air intake height above ground: 65 feet
- Control room volume: 191,940 ft^3
- Normal ventilation flow rate: 1450 cfm

The control room volume used in this analysis is conservative relative to the actual value presented in Table 15.6–12.

A description of the operation of the control room pressurization system is presented in FSAR Section 9.4.0. For propane chemical sources, the contents of the largest single storage container were used as the amount of chemical released during a postulated accident.

2.2.3.2 Effects of Design Basis Events

The accidents involving transportation of propane and anhydrous ammonia have the potential of forming flammable vapor clouds as well as rail tank car missiles. However, the probability of these events near the Millstone 3 site is lower than the 1.0×10^{-7} per year for consideration of such events as recommended by NUREG-0800 (USNRC 1981a), Section 2.2.3. The transportation accidents on the ConRail rail line near the Millstone 3 site do not form a design basis event. Therefore, probable effects of these accidents are not discussed. The results of the toxic chemical analysis are presented in Figure 2.2–5 for propane.

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TABLE 2.2-1 DESCRIPTION OF FACILITIES

	Facility	Location	Approx. No. Persons Employed or Stationed	Approximate Distance From Site Miles	Sector
Industrial					
1. *	Dow Chemical Corp.	Ledyard	115	10+	NNE
2. **	Pfizer Corporation	Groton	3,000	4.9	ENE
3.**	Electric Boat (Division of General Dynamics	Groton	12,000	5	ENE
Transportation					
4. **	Groton/New London Airport (Trumbull)	Groton	153	6	ENE
5. **	New London Transportation Center	New London	20	4	NE
Military					
6. **	U.S. Navy Submarine Base	Groton	10,300	7	NE
7. **	U.S. Coast Guard Academy	New London	1,260	5.6	NE
8. **	Connecticut National Guard facility	East Lyme	16	2	NW
9. **	Stone's Ranch Military Reservation	East Lyme	14	7	NW
Industrial Related Facilities					
10. **	Hess Oil Corporation	Groton	14	5	ENE
11. **	Hendel Petroleum Co.	Waterford	75	2.5	NE
12. *	Montville Station Electric Generation Plant	Montville	67	10	NNE

NOTES:

* Not shown; located approximately near 10 mile radius, NNE of site.

** Location of facility on Figure 2.2–1.

TABLE 2.2-2 LIST OF HAZARDOUS MATERIALS POTENTIALLY CAPABLE OF PRODUCING SIGNIFICANT MISSILES

[redacted]

TABLE 2.2-3 SUMMARY OF EXPOSURE DISTANCE CALCULATION

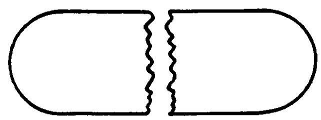
[redacted]

TABLE 2.2-4 AGGREGATE PROBABILITY OF EXPLOSION OR VIOLENT RUPTURE CAPABLE OF MISSILE GENERATION

[redacted]

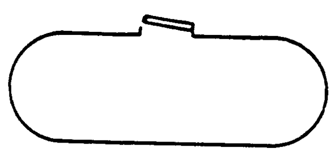
TABLE 2.2-5 TYPES OF TANK CAR MISSILES

A. Tank Splits at Mid-Seam.



B. Tank Splits in 2:1 Ratio with the Smaller Section “Thrusting”.

C. Manway Separates



D. Tank Punctured at Head.

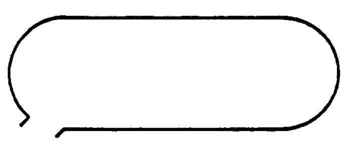


TABLE 2.2-6 TANK CAR FRAGMENT RANGE (FEET) AT 10-DEGREE LAUNCH ANGLE

	Postulated Missile Type (Table A)			
Hazardous Material	**Type A**	**Type B**	**Type C**	**Type D**
1. Propane	142	370	-	-
2. Anhydrous ammonia	264	803	-	-

TABLE 2.2-7 ESTIMATED IGNITION PROBABILITIES

[redacted]

TABLE 2.2-8 PROBABILITY OF AN UNCONFINED VAPOR CLOUD EXPLOSION

[redacted]

FIGURE 2.2–1 MAJOR INDUSTRIAL, TRANSPORTATION AND MILITARY FACILITIES

[redacted]

FIGURE 2.2–2 INSTRUMENT LANDING PATTERNS AT TRUMBULL AIRPORT

[redacted]

FIGURE 2.2–3 AIR LANES ADJACENT TO MILLSTONE POINT

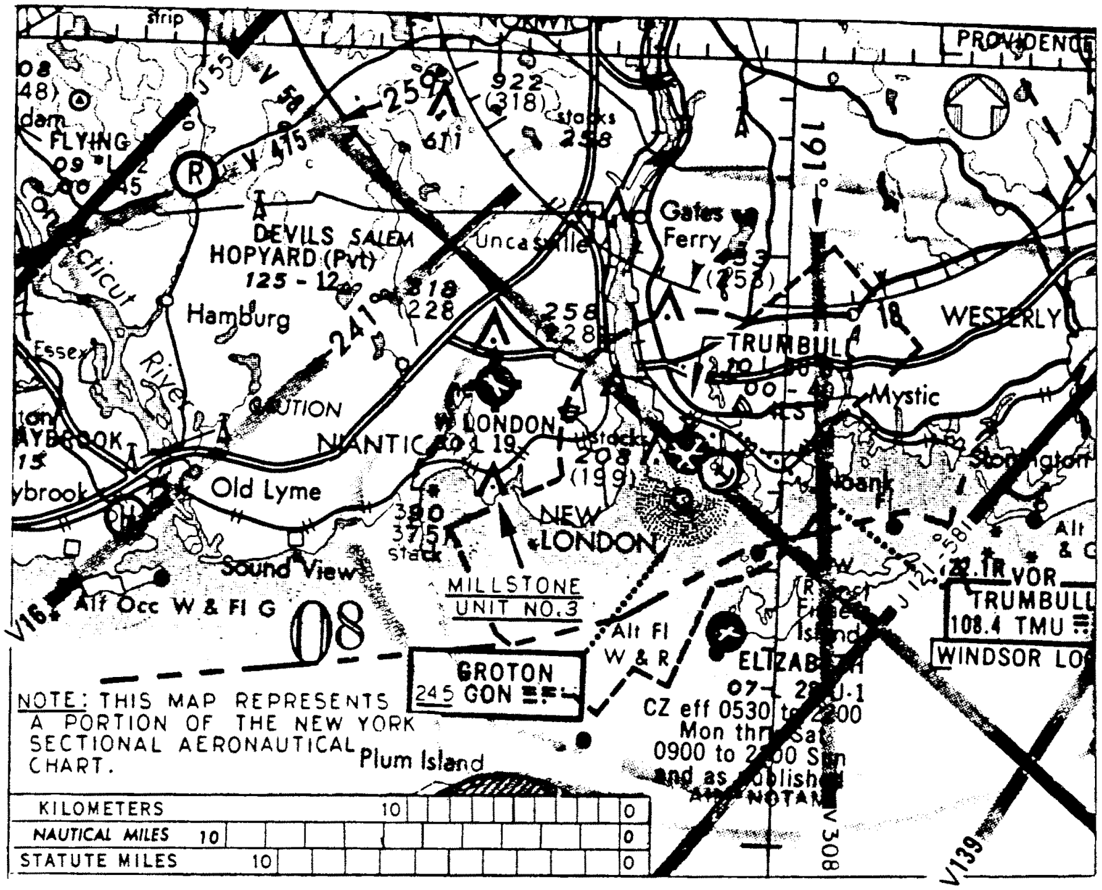


FIGURE 2.2-3
AIR LANES ADJACENT TO
MILLSTONE POINT
MILLSTONE NUCLEAR POWER STATION
UNIT 3
FINAL SAFETY ANALYSIS REPORT

FIGURE 2.2–4 NEW LONDON COUNTY-STATE HIGHWAYS AND TOWN ROADS

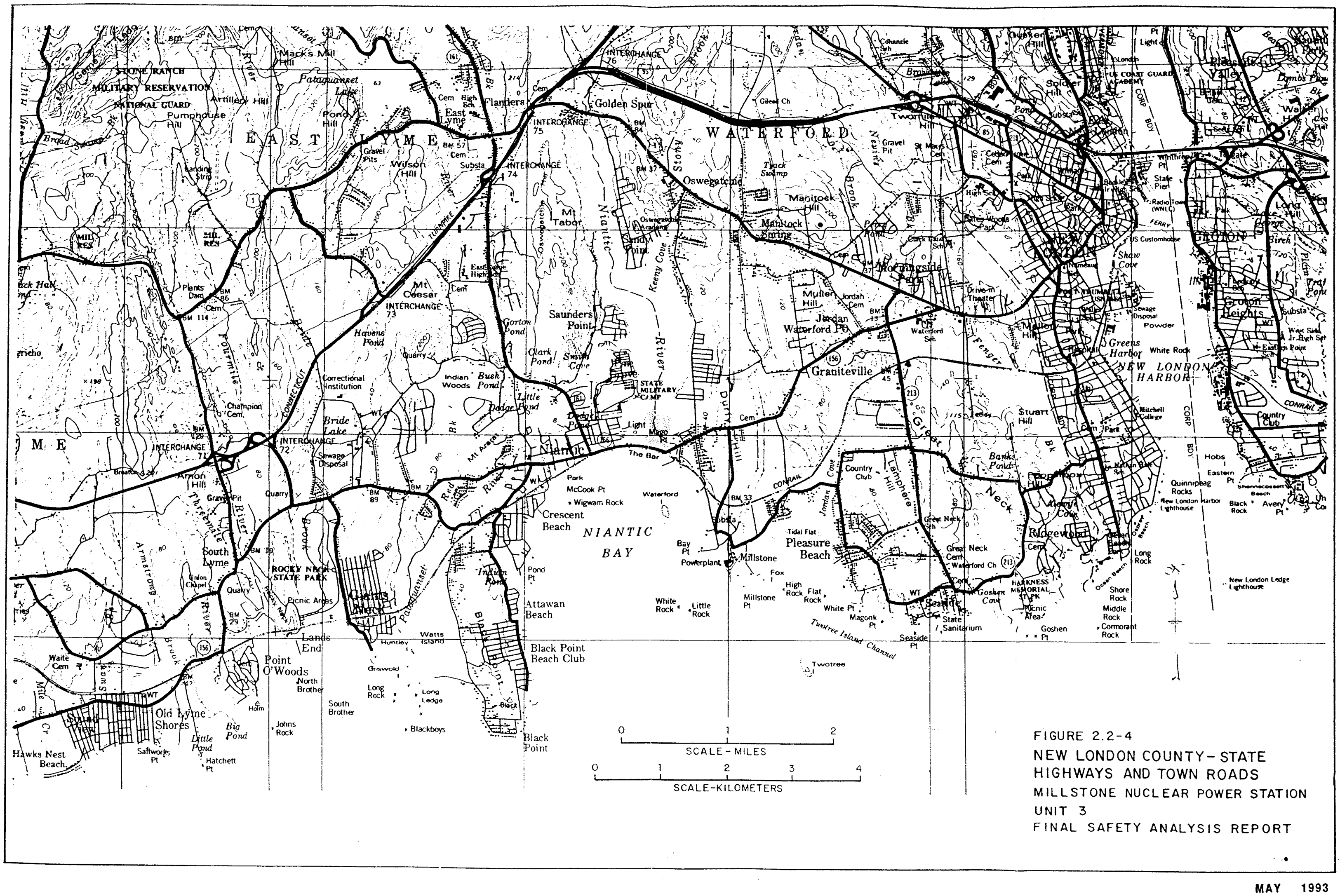
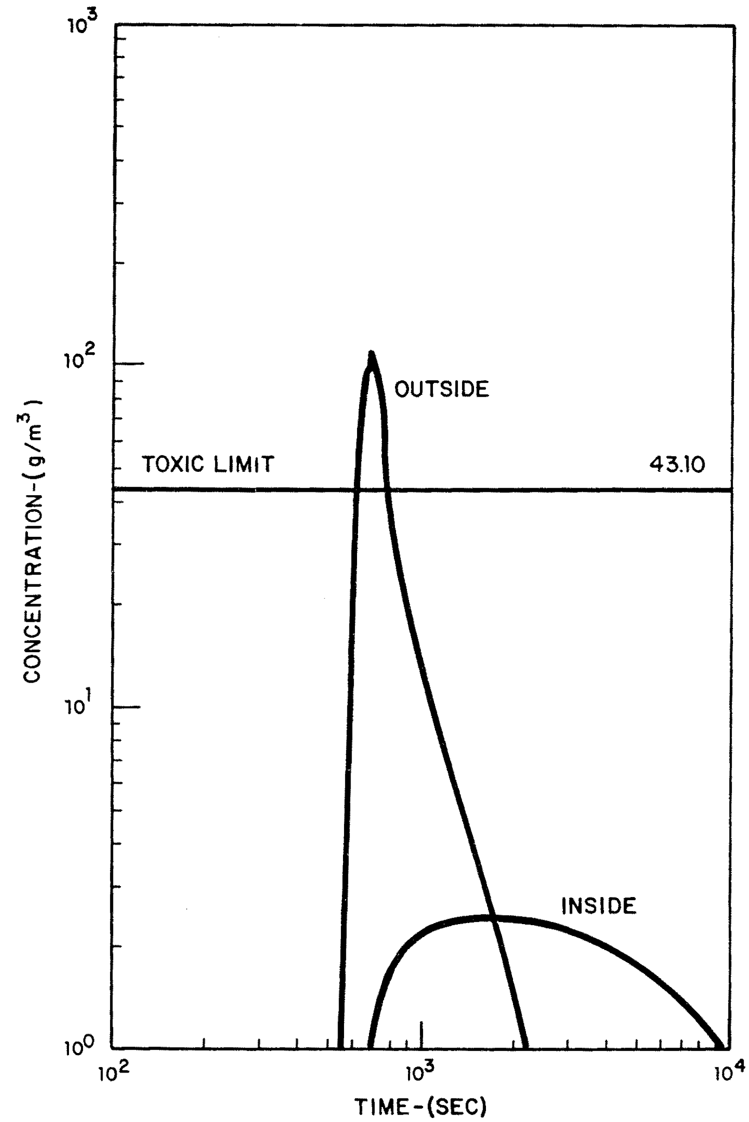


FIGURE 2.2–5 PROPANE CONCENTRATION OUTSIDE AND INSIDE THE CONTROL ROOM



STABILITY CLASS E
WIND SPEED 0.8 m/sec
RECEPTOR 528 m
HEIGHT 20 m
℄ 0 m

FIGURE 2.2-5
PROPANE CONCENTRATION
OUTSIDE AND INSIDE THE
CONTROL ROOM
MILLSTONE NUCLEAR POWER STATION
UNIT 3
FINAL SAFETY ANALYSIS REPORT

AMENDMENT 10 OCTOBER 1984

2.3 METEOROLOGY

This section provides a meteorological description of the site and its surrounding areas. Supporting data are included in accompanying tables. Tables 2.3–1 through 2.3–18, 2.3–20 through 2.3–30 and 2.3–33 provide information about the site climatology and meteorology. They are the historical record for the site and are not updates on a continual basis. Table 2.3–19 also provides meteorological information but the information continues to be of interest and use to station personnel. As such, it will be updated to reflect major changes which affect plant safety or as needed. Tables 2.3–31 and 2.3–32 provide information regarding the ongoing site meteorological monitoring program and will be updated as necessary. Tables 2.3–34 through 2.3-77 provide information regarding atmospheric diffusion estimates. They also provide historical record for the site and are not updated on a continual basis.

2.3.1 REGIONAL CLIMATOLOGY

The climatology of the Millstone site region may be reasonably described by data collected by the National Weather Service at Bridgeport, Connecticut. The National Weather Service Station for Bridgeport is located at the Sikorsky Memorial (Bridgeport Municipal) Airport, approximately 50 miles west-southwest of the site. The airport is located on a peninsula which protrudes into Long Island Sound in a similar manner to the Millstone site peninsula.

The Bridgeport meteorological data are reasonably representative of the climate at the Millstone site since both Bridgeport and the site are influenced by similar synoptic scale and mesoscale meteorological conditions. Temperature data prior to January 1, 1948, and precipitation and snowfall data prior to March 1, 1948, are from cooperative observers in the Bridgeport area. Following these dates, all data were collected at Bridgeport Municipal Airport locations. From May 16, 1953, to February 29, 1960, and June 1, 1981, to June 30, 1982, the Bridgeport weather station was closed between the hours of 11 p.m. and 6 a.m. During these time periods, hourly data were recorded 16 hours per day by the National Weather Service (NOAA 1971, 1990).

2.3.1.1 General Climate

The general climate of the region is described with respect to types of air masses, synoptic features, general airflow patterns, temperature, humidity, precipitation, and relationships between synoptic-scale atmospheric processes and local meteorological conditions.

2.3.1.1.1 Air Masses and Synoptic Features

The Millstone site region has a continental climate, modified by the maritime influence of Long Island Sound and the Atlantic Ocean, immediately to the south and southeast. The general eastward movement of air encircling the globe at middle latitudes transports large air masses into the region. Four types of air masses usually produce the meteorology in the region of the Millstone site: cold, dry continental polar air originating in Canada; warm, moist tropical air originating over the Gulf of Mexico and the Atlantic Ocean; cool, damp maritime air originating over the North Atlantic; and modified maritime air originating over the Pacific Ocean. Constant interaction of these air masses produces a large number of migratory cyclones and accompanying weather fronts, passing near or over the site region throughout the year. These weather systems are strongest during the winter and decrease in intensity during the summer. Infrequently, a storm of tropical origin affects the Millstone site region.

2.3.1.1.2 Temperature, Humidity, and Precipitation

The mean annual temperature is approximately 51°F at Bridgeport, Connecticut. Due to the proximity of Long Island Sound and the Atlantic Ocean, both the heat of summer and the cold of winter are moderated. During the summer months, normal monthly temperatures near the shoreline average 3°F to 5°F cooler than nearby inland stations. Temperatures of 90°F or greater occur an average of seven days per year at Bridgeport, while temperatures of 100°F or greater have occurred only in July and August; with an extreme maximum of 103°F occurring in July 1957. Freezing temperatures have not been recorded during the summer months (NOAA 1990).

Winters are moderately cold, but seldom severe. Minimum daily temperatures during the winter months are usually below freezing, but subzero (°F) readings are observed, on the average, less than one day every two years. Below zero temperatures have been observed in each winter month, with an extreme minimum of -20°F occurring in February 1934 (NOAA 1971, 1990).

Table 2.3–1 presents monthly, seasonal, and annual averages and extremes of temperature at Bridgeport (NOAA 1970, 1975, 1975, 1978, 1981; Weather Bureau 1959; Weather Bureau 1960), while Table 2.3–2 gives the mean number of days with selected temperature conditions (NOAA 1970, 1974, 1975, 1978, 1981).

The normal annual precipitation at Bridgeport is well distributed throughout the year. Migratory low-pressure systems, and their accompanying frontal zones, produce most of the precipitation throughout the year. From late spring through early fall, bands of thunderstorms and convective showers produce considerable rainfall. These storms, often of short duration, frequently yield the heaviest short-term precipitation amounts. During the remainder of the year, the heaviest amounts of rain and snow are produced by storms moving up the Atlantic coast of the eastern United States. Precipitation of 0.01 inch or more occurs approximately 117 days annually (NOAA 1990).

On the average, relative humidity values are lowest during the winter and spring months in the early afternoon. Relative humidity values are at a maximum during the summer and fall months in the early morning hours. On occasions, the humidity is uncomfortably high for periods up to several days during the warmer months. Table 2.3–3 (NOAA 1970, 1974, 1975, 1978, 1981; NOAA 1949-1980) gives the monthly, seasonal, and annual averages and extremes of relative humidity.

2.3.1.1.3 Prevailing Winds

The weather pattern in the region is controlled by the global band of prevailing westerly winds throughout most of the year. These winds act as the steering currents for synoptic scale weather systems which produce day-to-day weather changes.

During the winter months, the predominating northwesterly winds transport cold, dry air from the northern United States and Canada into the region. From April through September, warm and often humid southwesterly winds occur most frequently. Winds from the south through the west-southwest sectors occur nearly 42 percent of the time during the summer months, displaying the increased activity of a sea breeze during these months. Table 2.3–4 presents monthly, seasonal, and annual frequency distributions of wind direction at Bridgeport, while Table 2.3–5 (NOAA 1949-1980) shows directional persistence. Winds were assumed to persist if they remained in the same 22.5-degree sector for at least 5 consecutive hours.

The annual frequency of calm winds (less than 2 mph) is 2.9 percent. The highest frequency of calm and light winds (less than or equal to 3 mph) occurs during the summer season. Higher wind speeds commonly occur from November through April when weather systems of synoptic scale are strongest. Wind speeds greater than 25 mph occur 6.2 percent of the time during the months of December through February. Table 2.3–6 (NOAA 1949-1980) gives the frequency distributions of wind speed at Bridgeport.

2.3.1.1.4 Relationships of Synoptic to Local Conditions

The inland terrain in Connecticut is not pronounced enough to produce any significant local modifications of synoptic conditions at the shoreline. The shoreline areas do, however, experience local modifications of synoptic patterns because of the temperature differences between air over land and air over water. The most pronounced modification is the development of a diurnal sea breeze, commonly experienced in the months of April through October on sunny days. During the daytime on these days, solar heating of land causes relative low pressure over land near ground level and relative high pressure over water offshore. This results in the setup of a mesoscale wind circulation near the shoreline from water to land, with a return flow aloft. This sea breeze is sometimes strong enough to set up in the face of an offshore pressure gradient (i.e., northerly winds) but it most commonly occurs as a reinforcement of the typical summertime southwesterly wind flow associated with an offshore high pressure system.

2.3.1.2 Regional Meteorological Conditions for Design and Operating Bases

Seasonal and annual frequencies of severe weather phenomena are provided in this subsection.

2.3.1.2.1 Strong Winds

Strong winds, usually caused by intense low pressure systems, tropical cyclones, or passages of strong winter frontal zones, occasionally affect the region. For the period from 1961 through 1990, the fastest mile wind speed recorded at Bridgeport was 74 mph occurring with a south wind in September 1985. Table 2.3–7 lists extreme wind speeds on a monthly, seasonal, and annual basis (NOAA 1990).

Fastest-mile wind speeds of 50, 60, 70, 75, and 90 mph are expected to recur at the site in intervals of approximately 2, 10, 25, 50, and 100 years, respectively, according to a study by Thom (1968). Based on observations from Montauk Point (located about 23 miles southeast of Millstone Point on the eastern tip of Long Island), the maximum reported wind speed in the region was associated with the passage of a hurricane during which sustained winds of 115 mph, with short-term gusts up to 140 mph (Dunn and Miller 1960) were observed.

2.3.1.2.2 Thunderstorms and Lightning

Thunderstorms most commonly occur during the late spring and summer months, although they have been observed during all months of the year. Severe thunderstorms with strong winds, heavy rain, intense lightning, and hail have infrequently affected the region. Table 2.3–8 presents the monthly, seasonal, and annual frequency of thunderstorm days at Bridgeport (NOAA 1990).

A study of storm data indicates that intense lightning often accompanies strong thunderstorms in the region. Lightning strikes have injured or killed people and animals, caused numerous power failures, and have damaged or destroyed dwellings by setting them afire (NOAA 1959-1981).

The frequency of lightning strikes during a thunderstorm is dependent upon the storm's intensity and development. A nomograph of the number of lightning strikes per year (normalized for a region with 30 thunderstorm days per year) as a function of isolated object height, indicates about 2 strikes per year for a 450-foot object located on level terrain (Viemeister 1961).

The quantity of charge flowing out of a single stroke is typically 20 coulombs with a range from 10 to 50 coulombs (Tverskoi 1965). The current strength may reach 1.0 to 1.5×10^5 amperes; but for 80 percent of the measured cases, it does not exceed 2.0×10^4 amperes (Tverskoi 1965). A reasonable estimate of 2.0 to 2.5×10^4 amperes (Tverskoi 1965; Neuberger 1965) is common for a fully developed thunderstorm.

2.3.1.2.3 Hurricanes

Storms of tropical origin occasionally affect the region during the summer and fall months. According to a statistical study by Simpson and Lawrence (1971), the 50-mile segment of coastline on which Millstone is located, was crossed by five hurricanes during the 1886 through 1970 period.

2.3.1.2.4 Tornadoes and Waterspouts

From a study of tornado occurrences during the period of 1955 through 1967 (augmented by 1968-1981 storm data reports), the mean tornado frequency in the one-degree (latitude-longitude) square where the Millstone site is located is determined to be approximately 0.704 per year (NOAA 1959-1981; Pautz 1969). Applying Thom's method for determining the probability of a tornado striking a point on the Millstone site, it is conservatively estimated to be 0.00055 per year with a recurrence expected every 1,804 years (Thom 1963). Section 2.3.2.3.1 discusses the design basis tornado.

Waterspouts have been observed over the waters of Long Island Sound (NOAA 1959-1981). Six waterspouts were observed off shore of Connecticut from 1955 through 1967 (Pautz 1969).

2.3.1.2.5 Extremes of Precipitation

The normal annual precipitation at Bridgeport is 43.63 inches. Since 1894, annual totals have ranged from a minimum of 23.03 inches in 1964, to a maximum of 73.93 inches in 1972. Monthly precipitation totals have ranged from 0.07 inch in June 1949 to 18.77 inches in July 1897. Since 1949, the maximum measured 24-hour rainfall has been 6.89 inches occurring in June 1972 (NOAA 1971, 1990).

Table 2.3–9 lists normal precipitation amounts and extreme 24-hour and monthly rainfall values at Bridgeport (NOAA 1970, 1974, 1975, 1978, 1981 and January - June 1982; Weather Bureau 1960). Table 2.3–10 lists estimated extreme short term precipitation quantities (Hershfield 1961).

2.3.1.2.6 Extremes of Snowfall

Measurable snowfall has occurred in the months of November through April, although heavy snowfall occurrences are usually confined to the months of December through March. The mean annual snowfall at the present Bridgeport location is 25.3 inches, with totals since 1932 ranging from 8.2 inches in the 1972-1973 season, to 71.3 inches in the 1933-1934 season. The maximum monthly snowfall, occurring in February 1934, was 47.0 inches. Since 1949, both the maximum measured snowfall in 24 hours (16.7 inches), and the greatest snowfall in one storm (17.7 inches) occurred during the same storm in February 1969. The maximum measured snowfall in 24 hours (16.7 inches) was matched again in January 1978. Snowfalls of 1.0 inch or more occur approximately 7 days annually. Table 2.3–11 gives the monthly, seasonal, and annual snowfall statistics (NOAA 1971, 1990).

The 100-year recurrence maximum snow load is estimated to be 31 lb/sq ft (ANSI 1972). Assuming a snow-to-water ratio of 8.7 to 1 (calculated using data from 10 snowstorms of 0.10-inch precipitation or more during 1974 and 1975 (NOAA 1974-1975), the corresponding 100-year snow depth is estimated to be about 52 inches. The 48-hour probable maximum winter precipitation snow accumulation is about 48 inches (Riedel et al., 1956). When added to a snowpack of 52 inches, the total snow depth is about 100 inches. Snow load data available from a study conducted by the Housing and Home Finance Agency (1952) also suggests that the total weight of the 100-year recurrence maximum snow load when added to the maximum probable single storm accumulation would be about 60 lb/sq ft, or total depth of about 100 inches. (See Section 2.3.2.3.3 for design snow load information.)

2.3.1.2.7 Hailstorms

Large hail, which sometimes accompanies severe thunderstorms, occurs infrequently in the Millstone area. Based on a 1955 through 1967 study (Pautz 1969), hailstones with diameters greater than or equal to 0.75 inch occur at an average of 1.4 times per year in the 1-degree (latitude-longitude) square where the Millstone site is located. During the period of 1959 through 1981, the largest hailstones observed in the 1-degree square containing the site were qualitatively described as “baseball” size, and occurred in Groton, Connecticut (5 miles northeast of the site), on May 29, 1969 (NOAA 1959-1981). Most hail reported in the area is less than 0.5 inches in diameter.

2.3.1.2.8 Freezing Rain, Glaze, and Rime

Freezing rain and drizzle are occasionally observed during the months of December through March, and only rarely observed in November and April. An average of 18.5 hours of freezing rain and 8.5 hours of freezing drizzle occur annually in the region. In the 32-year period, 1949 through 1980, all cases of freezing precipitation were reported as light (less than 0.10 inch per hour), except for 1 hour of moderate (0.10 to 0.30 inch per hour). Table 2.3–12 presents average monthly, seasonal, and annual occurrences of freezing precipitation at Bridgeport (NOAA 1949-1980).

According to a study by Bennett (1959), based on 9 years of data, ice accumulations of greater than 0.25 inch due to freezing precipitation may be expected to occur about one time per year. Ice accumulations greater than 0.50 inch may be expected about once every two years. The maximum ice accumulation is estimated to be 1.68 inches based on Bridgeport observations (NOAA 1949 through 1981), and assuming a conservative average rainfall of 0.07 inch per hour.

2.3.1.2.9 Fog And Ice Fog

The average annual fog frequency (with visibility less than 7 miles) is 13.3 percent at Bridgeport, with the maximum monthly frequency of fog (16.4 percent) occurring in May (NOAA 1949-1980). The average annual ground fog frequency is 2.2 percent, with October having the maximum monthly frequency of 3.4 percent. Only 1 hour of heavy ice fog, a winter phenomenon, has been recorded during the period of 1949 through 1980.

Heavy fog (visibility of 0.25 mile or less) occurs an average of 1.5 percent of the time, on about 29 days annually (NOAA 1970, 1974, 1975, 1978, 1981), and predominantly during the months of December through June. The maximum number of consecutive hours of heavy fog observed during the period 1949 through 1964 was 26. Table 2.3–13 presents monthly, seasonal, and annual frequencies of various fog conditions based on 1949 through 1980 data at Bridgeport, Connecticut (NOAA 1949-1980).

2.3.1.2.10 High Air Pollution Potential

The Millstone site is in an area of relatively infrequent episodes of high air pollution potential. The continuous progression of large scale weather systems across North America frequently changes the air mass in the region and allows only infrequent extended periods of air stagnation. According to Holzworth (1972), high meteorological potential for air pollution occurs an average of about two times per year. A stationary high-pressure system over the eastern United States is generally the cause of these high air pollution potential days.

2.3.1.2.11 Meteorological Effects on Ultimate Heat Sink

A depression of water levels in Long Island Sound may result from an intense storm or hurricane moving up the Atlantic coast. The most conservatively calculated depression (NNECO 1974a) does not exceed the operable depth of safety related service water pumps in the intake structure (Section 2.4).

2.3.2 LOCAL METEOROLOGY

Local meteorology for the Millstone site is described by weather observations taken over a 32-year period (1949 through 1980) at Bridgeport and by data collected during a 8-year period (1974 through 1981) by an instrumented meteorological tower at Millstone. The Bridgeport weather facility at Sikorsky Airport is located southeast of Bridgeport (an urban industrial area) and about 1 mile from Long Island Sound. The Millstone meteorological tower is located on a point of land right at the shore and is surrounded by water on three sides. The water temperatures in the eastern end of Long Island Sound (Millstone area) tend to be somewhat cooler than water temperatures in the western end (Bridgeport) because of water exchange with the Atlantic Ocean. This is particularly true in the summer. In spite of these differences in location, the meteorological conditions are similar. Millstone data for a 8-year period (1974 through 1981) were compared where possible to Bridgeport data for the same period. The comparisons indicated that meteorological conditions at the two locations were similar and thus that the 32-year Bridgeport data base can be used to reasonably represent long-term meteorology at Millstone.

2.3.2.1 Normal and Extreme Values of Meteorological Parameters

2.3.2.1.1 Wind Conditions

Table 2.3–14 shows monthly and annual summaries of wind speed and direction at Bridgeport for 1949 through 1980. Table 2.3–15 shows monthly and annual summaries of wind speed and direction at Millstone for 1974 through 1981, taken from the 10-meter level on the meteorological tower.

Table 2.3–16 compares the frequency of wind directions by quadrant at Millstone and Bridgeport for the comparison period (1974 through 1980, and 1974 through 1981) and relates both to the short-term (8-year) and long-term Bridgeport data base. There is good statistical agreement between the sites. Table 2.3–17 compares the frequency of wind speeds by quadrant in a similar manner. Wind speeds at Bridgeport are somewhat higher; this may be due to the greater elevation of the wind sensor at Bridgeport for a part of the comparison period and most of the long-term period. Nonetheless, there is reasonable agreement between the sites. Table 2.3–18 shows the directional persistence by compass sector of 10-meter winds at Millstone from 1974 through 1981. Table 2.3–5 shows the directional persistence by compass sector of winds at Bridgeport from 1949 through 1965.

2.3.2.1.2 Air Temperature and Water Vapor

Tables 2.3–1 and 2.3–3 give the normal and extreme values of air temperature and humidity for 32 years of Bridgeport data. Table 2.3–19 presents normal and extreme values of air temperature, dewpoint temperature, absolute humidity, and relative humidity for 19 years of Millstone data at the 10-meter level. Tables 2.3–20 and 2.3–21 compare Bridgeport and Millstone data for the same data period. Temperatures at Millstone are slightly cooler than at Bridgeport, probably reflecting cooler water temperatures around Millstone, the presence of an urban heat island affecting Bridgeport, and closer proximity of the Millstone instrumentation to the shoreline. Dewpoint temperatures are about the same at both sites. Relative humidity values are slightly higher at Millstone than at Bridgeport, reflecting the cooler temperatures at Millstone.

2.3.2.1.3 Precipitation

Tables 2.3–9 through 2.3–12 give the normal and extreme values of precipitation based on long term Bridgeport data. No precipitation data are collected at Millstone.

2.3.2.1.4 Fog and Smog

Table 2.3–13 provides a summary of fog conditions based on long term Bridgeport data. Most of the heavy fog in the Millstone area is an advection type caused by the passage of warm moist air over relatively cold water. Since Millstone has greater exposure to the cooler waters of eastern Long Island Sound and the Atlantic Ocean, the frequency of heavy fog there is expected to be somewhat greater than the frequency at Bridgeport. This expectation is borne out in Table 2.3–22, which compares heavy fog occurrence at Bridgeport to that at Block Island (NOAA 1970, 1974, 1975, 1978, 1981). Block Island has greater exposure to cool waters in all directions and experiences a higher frequency of heavy fog than Bridgeport. The frequency of occurrence of heavy fog at Millstone is probably greater than that at Bridgeport but less than that at Block Island. The Millstone meteorological tower at one time had a visibility monitor, and joint frequency summaries of visibility, wind direction, and atmospheric stability are provided for Millstone data in Table 2.3–23. The visibility monitor reflects the occurrence of haze, rain, and snow as well as fog and consequently may not be directly compared to either Bridgeport or Block Island fog occurrence data, which are derived from actual visual observations of fog.

Table 2.3–24 provides monthly frequencies of the duration of poor visibility conditions (less than 1 mile) as measured by the Millstone visibility monitor for a 8-year period. Similar information for Bridgeport is not available.

2.3.2.1.5 Atmospheric Stability

Table 2.3–25 shows the percentage distribution of stability data within the seven classes specified by Regulatory Guide 1.23 (Table 1.8-1) for the period 1949 through 1980 at Bridgeport. The method used to assign a datum to a particular stability class is based on a parameterization of incoming solar radiation and wind speed and is known as the STAR method. This method yields a low percentage of cases in the A stability class (Pasquill classification method) at Bridgeport because a solar angle of at least 60 degrees is required concurrent with relatively clear skies; this requirement is fulfilled only on sunny June and July days for a few hours around solar noon. Also, E, F, and G stabilities are constrained to occur only during nighttime hours by this program, and the Bridgeport data are thus unable to reflect daytime occurrences of stable conditions such as those associated with the shallow inversions of a sea breeze.

Table 2.3–26 shows the percentage distribution of stability data within seven classes for the 1974 through 1981 period at Millstone, based on vertical temperature difference measurement at three levels on the meteorological tower. Table 2.3–27 shows the same information, based on wind direction variance measurements at the four wind instrument levels on the tower.

Table 2.3–28 compares the stability class distribution at Bridgeport for the period 1974 through 1980 to that at Millstone for the period 1974 through 1981. The distributions are not particularly comparable because of the differences in methodology.

Table 2.3–29 shows cumulative frequency distributions of the duration of inversion conditions (E, F, and G stability class) by month for the 1974 through 1981 data at Millstone, based on vertical temperature difference measurements at three levels on the meteorological tower.

2.3.2.1.6 Seasonal and Annual Mixing Heights

Seasonal and annual mixing height data for Millstone are adapted from Holzworth (1972) and shown in Table 2.3–30. No direct measurements of mixing height are made.

2.3.2.2 Potential Influence of the Plant and Its Facilities on Local Meteorology

Millstone 3 uses a once-through cooling water system, discharging its cooling water into an existing quarry, into which Millstone Units 1 and 2 also discharge, and then into Long Island Sound. Thin wisps of steam fog occasionally form over the quarry and less frequently over the discharge plume during the winter months, depending on tidal conditions and temperature differences between air and water. This fog dissipates rapidly as it moves away from the water area. The areal extent of the steam fog is negligible.

2.3.2.3 Local Meteorological Conditions for Design and Operating Bases

2.3.2.3.1 Design Basis Tornado

The design basis tornado for Millstone 3 (used for missile damage estimates) was developed from Regulatory Guide 1.76 (Table 1.8-1). The specifications are as follows:

Maximum wind speed	360 mph
Rotational speed	290 mph
Maximum translational speed	70 mph
Pressure drop	3.0 psi
Rate of pressure drop	2.0 psi/sec

Based on descriptions of Connecticut tornadoes (NOAA 1959-1981; Pautz 1969), a tornado more severe than this has never been recorded in Connecticut.

2.3.2.3.2 Design Basis Hurricane

The design basis hurricane for Millstone (used for flooding and setdown estimates) was developed in the Millstone 3 PSAR (NNECO 1974b). The specifications are:

Central pressure index	27.26 inches
Peripheral pressure	30.56 inches
Radius to maximum winds	55 miles
Angle of maximum wind from direction of travel	115 degrees
Maximum gradient wind	124 mph
Speed of translation	17 mph

This design hurricane is considerably more intense than the worst on record (Hurricane of 1938).

2.3.2.3.3 Snow Load

The design total snow load (Section 2.3.1.2.6) for Millstone (used for Category I building design) is 60 lb/sq ft (depth of 100 inches). This is assumed to consist of a preexisting snowpack of depth 48 inches and a 2-day winter snowstorm delivering another 52 inches. Conditions like this have not been recorded on the Connecticut shoreline. The roofs of safety-related structures are designed for a snow load of 60 lb/sq ft. The roofs of nonsafety-related structures (convention) are designed for a snow load of 40 lb/sq ft which exceeds the ANSI requirement of 30 lb/sq ft.

2.3.2.3.4 Rainfall

The design maximum rainfall rate for Millstone (used in the original site flooding estimate) was 9.4 inches in 1 hour. Roof drainage was originally designed for a rainfall rate of 6.5 inches per hour. Site flooding and roof drainage have since been assessed for a rainfall rate of 17.4 inches in 1 hour. The maximum 24 hour rainfall recorded at Bridgeport was 6.89 inches in June 1972.

2.3.2.3.5 Adverse Diffusion Conditions

The occurrence of adverse diffusion conditions (low winds, high stabilities, sea breeze fumigation, long periods of directional persistence of winds, or long periods of persistence of high stabilities) used for diffusion estimates at Millstone, are considered in the methodology of the diffusion estimates that appear in Sections 2.3.4 and 2.3.5.

2.3.2.4 Topography

The topography around Millstone is marked by low rolling hills rising inland from the shoreline. The maximum height of the surrounding terrain within 5 miles of the site is about 250 feet above mean sea level (msl) at 3.2 miles to the north-northwest. To the south of the site, from east through west, is open water. Figure 2.3–1 shows the general topography of the Millstone area.

Figures 2.3–2 and 2.3–3 show vertical profiles of maximum elevations versus distance from the plant for each of 16 compass sectors to 5 miles. Figures 2.3–4 through 2.3–5 are the vertical profiles to 50 miles.

2.3.3 ON-SITE METEOROLOGICAL MEASUREMENTS PROGRAM

The meteorological monitoring program at the Millstone site began in August 1965 to collect preoperational wind and temperature data for Millstone 1. The program initially consisted of collecting analog data from a 140-foot instrumented tower and manually digitizing these data into hourly values which served as the basis for appropriate joint frequency distributions and atmospheric diffusion analyses for both Millstone 1 and 2. After the publication of Regulatory Guide 1.23 (as Safety Guide 23 in 1972), the on-site meteorological program was found to be deficient with respect to the requirements of this guide regarding both data recovery rates and instrumentation specifications. In late 1973, a new meteorological tower which met the requirements of Regulatory Guide 1.23 was erected and instrumented. Eight full calendar years of data (1974, 1981) from this new tower are used in the climatological summaries presented in this section. The following sections refer only to the new tower and the on-site program after late 1973.

In 1992 a backup meteorological mast was installed near the EOF. The backup mast provides a secondary source of on-site meteorological data in the event data from the primary tower is not available. This mast consists of wind speed and direction instrumentation at the 33 foot level above grade. Atmospheric stability can be estimated using the variance of the wind direction. The backup mast 33 foot wind data can be extrapolated upward to provide estimates of wind at heights which correspond to the primary tower wind measurement elevations.

2.3.3.1 Measurement Locations and Elevations

All primary measurements are made at the meteorological tower. The tower is located on a point of land about 1,200 feet south-southeast of the Millstone 1 turbine building, which is the nearest large structure. The top of this building is at elevation 105 feet, msl. The base of the tower is at approximate elevation 15 feet msl; plant grade for Millstone 1 and 2 is 14 feet msl, and for Millstone 3 is 24 feet msl. The top of the tower is at 465 feet msl; the top of the Millstone stack is 389 feet msl. Figure 1.2-1 shows the tower location with respect to plant layout. The tower measures meteorological parameters at five levels. All measurements are taken on the tower except solar radiation which is taken to the south of the tower in a shadow-free area. Table 2.3–31 lists the measurements and their elevations. All measurements are continuous.

Backup meteorological measurements are made at the backup meteorological mast. The base of the backup mast is at 73 feet (MSL).

2.3.3.2 Meteorological Instrumentation

The instruments used on the tower and mast were selected for conformance with the recommendations of Regulatory Guide 1.23 and are listed in Table 2.3–32. All temperature sensors are mounted in aspirated radiation shields.

All instruments are calibrated quarterly by a trained instrument technician. Wind speed and direction sensors are removed from the tower and mast at least semiannually and replaced with newly calibrated sensors. The removed wind speed sensors are sent to an instrument vendor for replacement of worn components, recalibration to initial specifications, and certification. The removed wind direction sensors are reconditioned by an instrument technician by replacement of worn components, recalibration to initial specifications, and certification. Temperature sensors and temperature difference sensors are calibrated quarterly on the tower by immersion of both in ice baths; the resultant output is compared to 0°C.

Routine inspection visits to the tower and mast are conducted by instrument technicians who execute a checklist designed to identify any instrument problems. Additionally, emergency visits are made when a company meteorologist or other qualified person identifies an instrument problem through daily inspection of telemetered data. These procedures ensure prompt repair of any malfunctioning instrument and a high rate of data recovery.

2.3.3.3 Data Recording Systems and Data Processing

Tower and mast data is digitized and processed by data loggers. One data logger is located within the instrument shelter at the base of the tower and receives tower and solar radiation data and one data logger is located within the instrument shelter adjacent to the Site Training Facility and receives mast data. These data loggers provide digital data to the Unit 2 and Unit 3 plant process computers. The plant process computers relay this data to each of two Environmental Data Acquisition Network (EDAN) field minicomputers, through separate transmission paths. Tower and mast data is available for display at each of these four, redundant digital recording systems.

An EDAN host computer collects and saves data from all EDAN field minicomputers. Once loaded on the host computer, the data are available for inspection, editing, and analysis. Data is saved on a mirrored disk system on the host computer. Periodic database backups are performed to protect against data loss. Additionally, recent data is available on each field computer for restoration to the host, if necessary.

The EDAN field minicomputers are checked for correct operation during scheduled inspections by technicians. Emergency visits are made if inspection of telemetered data indicates the field minicomputer is malfunctioning. Correct operation of the host computer is checked every work day by a computer operator. Transfer of the data between the field and host computers is monitored by both a computer operator and by an automated process for detecting the failure of field computers to report to the host computer. Both field and host minicomputers undergo rigorous preventive maintenance programs. Troubleshooting is accomplished by on-call computer technicians. These procedures assure prompt repair of any malfunctioning component.

2.3.3.4 Quality Assurance for Meteorological System and Data

Figure 2.3–7 is a simplified diagram of the procedures developed to ensure that the entire path from sensor to the final data used for analyses is as free from errors as possible, that the data are of assured quality, that questionable or bad data are corrected or deleted, and that an adequate rate of data recovery is achieved. Table 2.3–33 shows the monthly and annual recovery rates for 8 years

(1974, 1981) of Millstone meteorological data. Records are kept of the data in the form received (raw data) and in the final form (edited data). Records are also kept for the editing operations performed and the basis for these operations, such as calibration adjustments and the deletion of data during periods of instrument malfunction.

2.3.3.5 Data Analysis

The digital data recording system produces 15-minute average data that are directly suitable for input into site climatology or atmospheric diffusion models.

Monthly and annual joint frequency distributions of wind speed, wind direction, and atmospheric stability for each level on the meteorological tower are contained in Tables 2.3–15 and 2.3–18. These analyses are based on Millstone data collected during 1974 through 1981. Section 2.3.2 compares these analyses with the long- term Bridgeport data (1949 through 1980). The data used to prepare these analyses are available in printed form or on magnetic tape and upon request may be obtained from the Environmental Programs Department.

2.3.4 SHORT-TERM (ACCIDENT) DIFFUSION ESTIMATES

2.3.4.1 Objective

Accidents at Millstone 3 are assumed to result in airborne radioactive releases from various release points. For various time periods after an accident, atmospheric diffusion factors (X/Q) were calculated for emissions from Millstone 3 at the exclusion area boundary (EAB) and low population zone (LPZ) for each downwind sector.

The distances from each release point to the EAB in each sector are given in Table 2.3–34. The LPZ is taken to be 3860 meters in all sectors from any release point.

2.3.4.2 Calculation

Accident X/Q's were calculated using the basic methods of Regulatory Guide 1.145. For elevated releases, the X/Q's for the first four hours are calculated using a seabreeze fumigation model adapted from Regulatory Guide 1.3. X/Q values for the control room were calculated using approved methods such as Regulatory Guide 1.194.

2.3.4.3 Results

The calculated X/Q's used in DBA radiological consequence calculations are presented with the list of assumptions used in each calculation.

2.3.5 LONG TERM (ROUTINE) DIFFUSION ESTIMATES

2.3.5.1 Calculation Objective

Low levels of radioactivity are routinely released from the Millstone stack and the MP3 vent. Atmospheric Diffusion Factors (X/Q) based on site meteorological data are calculated for various downwind receptor locations of interest. The meteorological data is used to calculate the dose consequences to the public from routine airborne effluents. The calculated doses are submitted annually to the NRC.

2.3.5.2 Calculations

2.3.5.2.1 Release Points and Receptor Locations

Routine releases occur from both the MP3 vent and the Millstone stack. Releases from the Millstone stack are considered elevated. The distances from each release point to the nearest land and nearest residence in each downwind sector are listed in Table 2.3–34 and used in X/Q calculation.

2.3.5.2.2 Database

Calculations are performed on a quarterly basis using the actual meteorology for that period.

2.3.5.2.3 Models

All X/Q and D/G values are calculated from hourly in-site meteorological data via methods adapted from Regulatory Guide 1.111 using a conventional Gaussian plume model.

2.3.6 REFERENCES FOR SECTION 2.3

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TABLE 2.3–1 MONTHLY, SEASONAL, AND ANNUAL AVERAGES AND EXTREMES OF TEMPERATURE AT BRIDGEPORT, CONN. (1901-1981)

	Temperature °C (°F)						
	Normal	Average Maximum	Absolute Maximum	Highest Average Minimum	Lowest Absolute Minimum	Highest Monthly Average	Lowest Monthly Average
Length of Record	*	*	**	*	**	***	***
December	1.0 (33.8)	4.7 (40.5)	19.4 (67)	-2.7 (27.1)	-24 (-12)	3.8 (38.8)	-3.1 (26.4)
January	-1.0 (30.2)	2.7 (36.9)	20.0 (68)	-4.8 (23.4)	-26 (-14)	3.8 (38.8)	-5.7 (21.8)
February	-0.6 (30.9)	3.3 (37.9)	21.1 (70)	-4.5 (23.9)	-29 (-20)	2.8 (37.1)	-9.1 (15.6)
Winter	-0.2 (31.6)	3.6 (38.4)	21.1 (70)	-4.0 (24.8)	-29 (-20)	-	-
March	3.3 (37.9)	7.2 (45.0)	28.3 (83)	-0.7 (30.8)	-16 (3)	8.0 (46.4)	0.1 (32.1)
April	9.1 (48.4)	13.6 (56.5)	33.9 (93)	4.6 (40.3)	-13 (9)	11.8 (53.3)	6.3 (43.4)
May	14.6 (58.3)	19.3 (66.7)	35.0 (95)	9.9 (49.9)	-2 (28)	17.3 (63.2)	10.6 (51.1)
Spring	9.0 (48.2)	13.4 (56.1)	35.0 (95)	4.6 (40.3)	-16 (3)	-	-
June	19.9 (67.9)	24.4 (76.0)	35.6 (96)	15.4 (59.8)	1 (34)	22.6 (72.6)	17.8 (64.0)
July	23.2 (73.8)	27.5 (81.5)	39.4 (103)	18.9 (66.1)	7 (44)	25.2 (77.4)	21.2 (70.1)
August	22.6 (72.7)	26.9 (80.4)	38.3 (101)	18.3 (64.9)	6 (42)	24.5 (76.1)	20.0 (68.0)
Summer	21.9 (71.5)	26.3 (79.3)	39.4 (103)	17.6 (63.6)	1 (34)	-	-

TABLE 2.3–1 MONTHLY, SEASONAL, AND ANNUAL AVERAGES AND EXTREMES OF TEMPERATURE AT BRIDGEPORT, CONN. (1901-1981) (CONTINUED)

	Temperature °C (°F)						
	Normal	Average Maximum	Absolute Maximum	Highest Average Minimum	Lowest Absolute Minimum	Highest Monthly Average	Lowest Monthly Average
September	19.2 (66.5)	23.6 (74.5)	37.2 (99)	14.7 (58.4)	0 (32)	21.4 (70.5)	16.4 (61.5)
October	13.8 (56.8)	18.4 (65.1)	32.2 (90)	9.2 (48.5)	-7 (20)	15.7 (60.2)	9.7 (49.4)
November	7.8 (46.0)	11.8 (53.3)	25.6 (78)	3.7 (38.7)	-13 (9)	10.3 (50.5)	3.6 (38.4)
Fall	13.6 (56.4)	17.9 (64.3)	37.2 (99)	9.2 (48.5)	-13 (9)	-	-
Annual	11.1 (51.9)	15.3 (59.5)	39.4 (103)	6.8 (44.3)	-29 (-20)	-	-

NOTES:

*1941 through 1970 (30 years) (NOAA 1970, 1974, 1975, 1978, 1981)

**1901 through 1181 (81 years) (NOAA 1954, 1959, 1963, 1970, 1974, 1975, 1978, 1981; Pautz 1969)

***1931 through 1981 (51 years) (NOAA 1970, 1974, 1975, 1978, 1981)

TABLE 2.3–2 MEAN NUMBER OF DAYS WITH SELECTED TEMPERATURE CONDITIONS AT BRIDGEPORT, CONN. (1966-1981)

	Mean Number of Days			
	Maximum Temperature		Minimum Temperature	
	32°C (90°F) and Above	0°C (32°F) and Below	0°C (32°F) and Below	-18°C (0°F) and Below
December	0	5	22	*
January	0	11	26	*
February	0	8	24	*
Winter	0	24	72	*
March	0	1	17	0
April	0	0	4	0
May	*	0	*	0
Spring	*	1	21	0
June	1	0	0	0
July	3	0	0	0
August	2	0	0	0
Summer	6	0	0	0
September	*	0	0	0
October	0	0	1	0
November	0	*	7	0
Fall	*	*	8	0
Annual	6	25	101	0

NOTES:

* Less than 1 day every 2 years

TABLE 2.3–3 MONTHLY, SEASONAL, AND ANNUAL AVERAGES AND EXTREMES OF RELATIVE HUMIDITY AT BRIDGEPORT, CONN. (1949-1981)

	Relative Humidity (%)					
	1 AM (EST)	7 AM (EST)	1 PM (EST)	7 PM (EST)	Absolute Maximum	Absolute Minimum
Length of Record	*	**	**	**	***	***
December	72	73	62	68	100	14
January	69	71	61	64	100	22
February	67	71	59	62	100	9
Winter	69	72	61	65	100	9
March	69	72	58	62	100	11
April	70	69	53	60	100	9
May	79	76	60	67	100	12
Spring	73	72	57	63	100	9
June	83	78	62	70	100	20
July	82	78	60	69	100	24
August	83	79	61	71	100	24
Summer	83	78	61	70	100	20
September	83	82	63	72	100	24
October	77	78	60	69	100	21
November	75	77	61	69	100	20
Fall	78	79	61	70	100	20
Annual	76	75	60	67	100	9

NOTES:

*1968 through 1981 (14 Years) (NOAA 1970, 1974, 1975, 1978, 1981)
**1966 through 1981 (16 Years) (NOAA 1978, 1981)
***1949 through 1980 (26 Years; 1/1/49 through 4/30/53, 5/1/60 through 12/31/80)

TABLE 2.3–4 MONTHLY, SEASONAL, AND ANNUAL FREQUENCY DISTRIBUTIONS OF WIND DIRECTION AT BRIDGEPORT, CONN. (1949-1980)

Frequency Distribution (%) of Wind Direction	December	January	February	WINTER	March	April	May	SPRING
N	8.7	8.2	8.8	8.6	8.6	7.0	5.4	7.0
NNE	5.5	5.2	4.9	5.2	4.9	4.1	4.2	4.4
NE	9.4	9.6	7.9	9.0	6.8	5.5	5.7	6.0
ENE	5.8	5.6	6.2	5.9	6.8	5.6	5.7	6.0
E	2.4	3.2	4.7	3.4	7.6	7.4	10.6	8.5
ESE	1.6	1.4	1.8	1.6	3.7	3.2	5.4	4.1
SE	1.2	1.1	1.6	1.3	2.1	2.3	3.4	2.6
SSE	1.3	0.9	1.1	1.1	1.6	2.2	3.0	2.3
S	1.5	1.6	1.9	1.7	3.0	4.7	5.6	4.5
SSW	1.8	2.0	2.3	2.1	3.5	5.3	6.4	5.1
SW	4.1	4.8	4.9	4.6	6.5	8.2	9.1	7.9
WSW	5.5	7.7	7.5	6.9	5.8	8.8	9.1	7.9
W	12.0	12.7	9.5	11.4	7.2	7.9	6.7	7.2
WNW	14.6	12.6	11.3	12.9	8.5	7.7	5.0	7.1
NW	12.6	12.0	13.5	12.7	11.1	8.9	5.6	8.5
NNW	9.0	8.6	9.2	8.9	9.5	8.5	5.9	8.0
Calm	3.0	2.9	2.9	2.9	2.9	2.7	3.1	2.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total Hours	10,616	11,126	10,140	31,882	10,645	10,304	10,646	31,595

TABLE 2.3–4 MONTHLY, SEASONAL, AND ANNUAL FREQUENCY DISTRIBUTIONS OF WIND DIRECTION AT BRIDGEPORT, CONN. (1949-1980) (CONTINUED)

Frequency Distribution (%) of Wind Direction	June	July	August	SUMMER	Sept.	Oct.	Nov.	FALL	ANNUAL
N	5.4	5.4	7.2	6.0	8.3	9.0	8.8	8.7	7.6
NNE	3.4	3.7	5.3	4.1	7.4	6.4	6.0	6.6	5.1
NE	4.2	4.6	6.5	5.1	11.0	10.9	9.3	10.4	7.6
ENE	3.7	2.8	3.0	3.2	4.8	4.6	4.1	4.5	4.9
E	6.4	4.4	4.1	5.0	4.1	3.4	3.5	3.7	5.2
ESE	4.6	3.5	3.3	3.8	3.7	2.5	1.9	2.7	3.1
SE	3.6	3.3	3.1	3.3	2.9	2.3	1.9	2.4	2.4
SSE	3.2	3.5	3.3	3.3	2.8	2.2	1.9	2.3	2.2
S	7.5	7.8	7.3	7.5	4.6	3.4	2.7	3.5	4.3
SSW	7.6	8.3	8.3	8.1	5.2	3.7	3.0	4.0	4.8
SW	14.0	14.6	13.3	13.9	9.9	8.4	6.1	8.1	8.6
WSW	12.6	13.1	10.4	12.0	7.1	8.2	7.2	7.5	8.6
W	7.4	8.1	6.5	7.3	6.5	9.4	10.0	8.6	8.7
WNW	4.3	4.9	4.7	4.6	5.9	8.4	11.6	8.6	8.3
NW	5.1	4.8	5.6	5.1	7.0	8.1	11.0	8.7	8.8
NNW	4.2	4.3	5.1	4.5	5.9	6.9	8.9	7.2	7.2
Calm	2.8	3.1	3.3	3.1	2.8	2.4	2.4	2.5	2.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total Hours	10,773	11,140	11,140	33,053	10,291	10,645	10,291	31,227	127,757

TABLE 2.3–5 OCCURRENCE OF BRIDGEPORT WIND PERSISTENCE EPISODES WITHIN THE SAME 22.5-DEGREE SECTOR (1949-1965)

	Hours of Persistence													
Direction	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
N	72	42	33	21	10	6	2	3	1	3		2	1	2
NNE	61	30	18	4	1	3	3	4						
NE	107	64	55	37	24	16	16	8	4	9	5	4	4	5
ENE	52	38	19	11	6	8	11	3		1	1	1		1
E	51	29	22	14	10	6	5	4	5	2		1	1	2
ESE	30	22	5	9	5	3		4						
SE	20	10	5	2	1	2			2					1
SSE	18	7	2		3	2			1	1				
S	30	16	9	3	4	3		1						
SSW	48	16	11	5	6	2		1	2	1			1	
SW	124	67	53	28	21	9	7	3	4	1	3	2		1
WSW	115	74	37	18	9	11	5	4	3	3		1	1	1
W	70	45	37	9	13	14		1	3	2	2		2	
WNW	101	59	42	31	19	5	6	4	6		2	3	2	1
NW	96	46	42	25	23	11	13	6	11	5	1	2		
NNW	86	40	32	16	10	5	4	4	1	2	2		1	2
Total Persistence Episodes	1,081	605	422	233	165	106	72	50	43	30	16	16	11	18

TABLE 2.3–5 OCCURRENCE OF BRIDGEPORT WIND PERSISTENCE EPISODES WITHIN THE SAME 22.5-DEGREE SECTOR (1949-1965) (CONTINUED)

	Hours of Persistence														
Direction	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29 thru 33**	**34**	**35 thru 40**	**41 >41**	**Total**
N			1		1										200
NNE															124
NE	2	2	1			1			1					1	366
ENE		1				1						1			155
E	1					1				1					155
ESE															78
SE															43
SSE															34
S															66
SSW															93
SW	1		1												325
WSW	1														283
W									1						199
WNW				1											282
NW	3	1													286
NNW		1	1											1	207
Total Persistence Episodes	8	5	4	1	1	3	0	0	2	1	0	1	0	2	2,896

TABLE 2.3–6 MONTHLY, SEASONAL, AND ANNUAL FREQUENCY DISTRIBUTIONS OF WIND DIRECTION AT BRIDGEPORT, CONN. (1949-1980)

	Frequency Distribution (%) Wind Speed Class km/hr (mph)								
	km/hr (mph) Calm	1.6-4.8 (1-3)	6.4-11.2 (4-7)	12.8-19.2 (8-12)	20.8-28.8 (13-18)	30.4-38.4 (19-24)	>40 (≥25)	Total	Total Hours
December	3.0	6.1	16.2	28.1	29.8	11.2	5.6	100.0	10,616
January	2.9	7.8	15.2	25.6	29.1	13.0	6.5	100.0	11,123
February	2.9	6.7	14.1	25.4	30.1	14.5	6.4	100.0	10,140
Winter	2.9	6.8	15.1	26.4	29.7	12.9	6.2	100.0	31,879
March	2.9	6.7	13.7	26.8	29.8	13.6	6.6	100.0	10,645
April	2.7	6.7	14.9	28.0	29.9	12.3	5.5	100.0	10,304
May	3.1	7.0	18.5	32.1	28.3	9.0	2.1	100.0	10,646
Spring	2.9	6.8	15.7	29.0	29.3	11.6	4.7	100.0	31,595
June	2.8	6.7	23.4	36.9	24.9	4.5	0.8	100.0	10,773
July	3.1	7.6	22.7	40.1	22.9	3.2	0.4	100.0	11,140
August	3.3	8.3	21.9	38.9	23.7	3.6	0.3	100.0	11,140
Summer	3.0	7.5	22.7	38.6	23.9	3.8	0.5	100.0	33,053
September	2.8	6.9	18.5	33.7	29.9	6.9	1.2	100.0	10,291
October	2.4	6.3	18.0	32.6	29.3	9.0	2.06	100.0	10,645
November	2.4	6.4	16.9	29.0	28.9	11.6	4.7	100.0	10,291
Fall	2.5	6.5	17.8	31.7	29.4	9.2	2.8	100.0	31,227
Annual	2.9	6.9	17.78	31.4	28.1	9.4	3.6	100.0	127,754

TABLE 2.3–7 MONTHLY, SEASONAL, AND ANNUAL WIND SPEED EXTREMES AT BRIDGEPORT, CONN. (1961-1990)

	Fastest-Mile Wind Speed km/hr (mph)		Wind Direction* of Fastest-Mile Wind Speed
December	84.8	(53)	WSW
January	107	(67)	NNW
February	104	(65)	NNW
Winter	107	(67)	NNW
March	92.8	(58)	E
April	88	(55)	NW
May	80	(50)	NNW
Spring	92.8	(58)	E
June	60.8	(38)	WNW
July	64	(40)	WNW
August	92.8	(58)	NE
Summer	92.8	(58)	NE
September	121.3	(74)	S
October	92.8	(58)	E
November	92.8	(58)	SE
Fall	121.3	(74)	S
Annual	121.3	(74)	S

NOTE:

*Based on a 16-compass-point system

TABLE 2.3–8 MEAN NUMBER OF DAYS OF THUNDERSTORM OCCURRENCE AT BRIDGEPORT, CONN. (1951-1981)

	Number of Days
December	*
January	*
February	*
Winter	*
March	1
April	2
May	3
Spring	6
June	4
July	5
August	4
Summer	13
September	2
October	1
November	*
Fall	3
Annual	22

NOTES:

* Less than 1 day every 2 years

TABLE 2.3–9 MONTHLY, SEASONAL, AND ANNUAL AVERAGES AND EXTREMES OF PRECIPITATION AT BRIDGEPORT, CONN. (1901-JUNE 1982)

	Precipitation mm (inches)				
	Normal Total	Maximum Monthly	Minimum Monthly	Maximum in 24 Hours	Mean Number of Days with Precipitation 0.25 mm (0.01 Inch) or More
Length of Record	*	**	**	***	***
December	87.4 (3.44)	250 -(9.85)	8.4 - (0.33)	93.7 -(3.69)	11
January	68.8 (2. 71)	284 -(11.20)	10.0 -(0.40)	116.0 -(4.55)	11
February	68.8 (2. 71)	169 -(6.65)	21.6 -(0.85)	58.7 -(2.31)	10
Winter	255.0 (8.86)	-	-	93.7 -(3.69)	32
March	86.6 (3.49)	245 -(9.64)	7.4 - (0.29)	117 - (4.60)	11
April	86.1 (3.39)	239 -(9.41)	17.5 -(0.69)	84.0 -(3.32)	11
May	90.7 (3.57)	258.6 -(10.18)	12.4 -(0.49)	82.0 -(3.23)	11
Spring	265.4 (10.45)	-	-	117 -(4.60)	33
June	65.0 (2.56)	449.6 -(17.70)	1.8 -(0.07)	175 -(6.89)	9
July	87.4 (3.44)	476.8 -(18.77)	11.4 -(0.45)	151 -(5.95)	8
August	96.5 (3.80)	337.6 -(13.29)	5.1 -(0.20)	101 -(3.97)	9
Summer	248.9 (9.80)	-		175 -(6.89)	26
September	73.2 (2.88)	359.4 -(14.15)	2.3 -(0.09)	119 -(4.67)	9
October	70.9 (2.79)	272.3 -(10.72)	7.6 -(0.30)	109 -(4.28)	7
November	97.3 (3.83)	259.6 -(10.22)	9.1 -(0.36)	103 -(4.07)	10
Fall	241.4 (9.50)	-	-	119 -(4.67)	26
Annual	980.7 (38.61)	-	-	175 -(6.89)	117

TABLE 2.3–10 ESTIMATED PRECIPITATION EXTREMES FOR PERIODS UP TO 24 HOURS AND RECURRENCE INTERVALS UP TO 100 YEARS

	Estimated Precipitating Extremes rom (inches) at Different Recurrence Intervals			
Period of Rainfall	**1 Year**	**10 Years**	**50 Years**	**100 Years**
30 minutes	22.9 (0.90)	41.9 (1.65)	53.3 (2.10)	61.0 (2.40)
1 hour	27.9 (1.10)	53.3 (2.10)	67.3 (2.65)	76.2 (3.00)
2 hours	36.8 (1.45)	64.8 (2.55)	83.8 (3.30)	92.7 (3.65)
3 hours	39.4 (1.55)	71.1 (2.S0)	92.7 (3.65)	103 (4.05)
6 hours	47.0 (1.85)	90.2 (3.55)	112 (4.40)	130 (5.10)
12 hours	62.2 (2.45)	107 (4.20)	135 (5.30)	IS5 (6.10)
24 hours	68.6 (2.70)	127 (5.00)	163 (6.40)	180 (7.10)

TABLE 2.3–11 MONTHLY, SEASONAL, AND ANNUAL AVERAGES AND EXTREMES OF SNOWFALL AT BRIDGEPORT, CONN. (1893-JUNE 1990)

	Snow, Ice Pellets			
	Mean Total cm (Inches)	Maximum Monthly cm (Inches)	Maximum in 24 Hours cm (Inches)	Mean Number of Days Vith Occurrence of 2.51 cm (1.0 Inch) or More
Length of Record	*	**	*	*
December	11.8 (4.6)	65.5 (25.8)	19.8 (7.8)	2
January	19.5 (7.6)	77.0 (30.3)	42.4 (16.7)	2
February	19.0 (7.4)	119.4 (47.0)	42.4 (16.7)	2
Winter	50.3 (19.6)			6
March	11.5 (4.5)	92.0 (35.9)	28.2 (11.1)	1
April	1.3 (0.5)	20.5 (8.0)	15.4 (6.0)	+
May	T	T	T	0
Spring	12.8 (5.0)			1
June	0.0	0.0	0.0	0
July	0.0	0.0	0.0	0
August	0.0	0.0	0.0	0
Summer	0.0			0
September	0.0	0.0	0.0	0
October	T	2.5 (1.0)	1.3 (.5)	0
November	1.5 (0.6)	84.5 (32.2)	16.9 (6.6)	+
Fall	1.5 (0.6)			+
Annual	64.6 (25.2)	119.4 (47.0)	42.4 (16.7)	7

NOTES:

T = trace

+Less than 1 day every 2 years

*1949 through 1990 (41 years) (NOAA 1990)

**1893 through 1990 (97 years) (NOAA 1990, Brumbach 1965)

TABLE 2.3–12 MONTHLY, SEASONAL, AND ANNUAL AVERAGES OF FREEZING RAIN AND DRIZZLE AT BRIDGEPORT, CONN. (1949-1980)

	Freezing Rain (hr)		Freezing Drizzle (hr)
	Light*	Moderate**	Light*
December	5.4	0.1	2.9
January	7.7	0.0	2.7
February	3.3	0.0	1.5
Winter	16.4	0.1	7.1
March	2.0	0.0	1.3
April	0.1	0.0	0.0
May	0.0	0.0	0.0
Spring	2.1	0.0	1.3
June	0.0	0.0	0.0
July	0.0	0.0	0.0
August	0.0	0.0	0.0
Summer	0.0	0.0	0.0
September	0.0	0.0	0.0
October	0.0	0.0	0.0
November	0.1	0.0	0.1
Fall	0.1	0.0	0.1
Annual	18.5	0.1	8.5

NOTES:

* Less than 2.54 mm (0.1 inch) per hour

** 2.54 to 7.62 mm (0.1 to 0.3 inch) per hour

TABLE 2.3–13 AVERAGE MONTHLY, SEASONAL, AND ANNUAL HOURS AND FREQUENCIES (PERCENT) OF VARIOUS FOG CONDITIONS (1949-1980) AT BRIDGEPORT, CONNECTICUT

	Fog		Ground Fog		Heavy Fog		
	Average No. of Hours	Freq. (%)	Average No. of Hours	Freq. (%)	Average No. of Hours	Freq. (%)	Total Number of Sample Observations
December	106	14.3	12	1.6	16	2.2	10,664
January	111	14.9	14	1.9	15	2.0	11,160
February	88	13.1	7	1.1	13	1.9	10,163
Winter	305	14.1	32	1.5	43	2.0	31,987
March	107	14.4	11	1.5	16	2.1	10,664
April	95	13.2	8	1.1	12	1.6	10,320
May	122	16..4	13	1.7	24	3.2	10,664
Spring	325	14.7	31	1.4	51	2.3	31,648
June	109	15.1	22	3.0	15	2.1	10,320
July	92	12.4	21	2.8	7	0.9	10,664
August	100	13.5	24	3.2	3	0.4	10,664
Summer	300	13.6	66	3.0	24	1.1	31,648
September	80	11.1	22	3.0	2	0.3	10,320
October	67	9.0	25	3.4	7	0.9	10,664
November	85	11.8	14	2.0	4	0.5	10,320
Fall	232	10.6	61	2.8	13	0.6	31,304
Annual	1,165	13.3	193	2.2	131	1.5	126,587

TABLE 2.3–14 MONTHLY AND ANNUAL WIND DIRECTION AND SPEED DISTRIBUTIONS FOR SURFACE WINDS, AT BRIDGEPORT, CONN. (1949-1980)

A. JANUARY

Wind Direction	km/hr (mph)	1.6-4.8 (1-3)	6.4-11.2 (4-7)	12.8-19.2 (8-12)	20.8-28.8 (13-18)	30.4-38.4 (19-24)	≥40 (25)	All Speeds
	Wind Speed Distribution (%) Within Wind Speed Class							
N		0.76	1.46	2.54	2.46	0.73	0.26	8.22
NNE		0.64	1.12	1.55	1.29	0.43	0.16	5.18
NE		1.45	1.82	2.51	2.21	1.20	0.41	9.60
ENE		0.64	1.07	1.59	1.61	0.40	0.32	5.64
E		0.35	0.58	0.96	0.76	0.38	0.19	3.22
ESE		0.22	0.34	0.43	0.30	0.12	0.04	1.44
SE		0.20	0.26	0.35	0.16	0.07	0.01	1.05
SSE		0.20	0.31	0.19	0.11	0.05	0.03	0.87
S		0.21	0.40	0.38	0.21	0.18	0.23	1.60
SSW		0.19	0.38	0.62	0.47	0.22	0.12	1.99
SW		0.46	0.92	1.37	1.38	0.54	0.14	4.80
WSW		0.33	1.03	1.95	2.40	1.44	0.55	7.69
W		0.58	1.31	3.22	4.67	1.88	0.98	12.65
WNW		0.42	1.31	3.15	4.58	2.11	1.05	12.62
NW		0.78	1.47	2.70	3.90	1.94	1.12	12.00
NNW		0.36	1.41	2.09	2.57	1.35	0.78	8.56
All Sectors		7.78	15.16	25.58	29.08	13.03	6.47	

Calm = 2.89

TABLE 2.3–14 MONTHLY AND ANNUAL WIND DIRECTION AND SPEED DISTRIBUTIONS FOR SURFACE WINDS, AT BRIDGEPORT, CONN. (1949-1980) (CONTINUED)

B. FEBRAURY

Wind Direction	km/hr (mph)	1.6-4.8 (1-3)	6.4-11.2 (4-7)	12.8-19.2 (8-12)	20.8-28.8 (13-18)	30.4-38.4 (19-24)	≥40 (25)	All Speeds
		Wind Speed Distribution (%) Within Wind Speed Class						
N		0.78	1.44	2.46	2.66	0.97	0.50	8.81
NNE		0.57	0.82	1.20	1.52	0.61	0.22	4.94
NE		0.89	1.46	2.29	2.35	0.71	0.22	7.91
ENE		0.39	0.79	1.43	2.10	0.95	0.51	6.16
E		0.30	0.30	0.80	1.22	1.31	0.74	4.68
ESE		0.13	0.48	0.67	0.39	0.16	0.02	1.84
SE		0.25	0.49	0.41	0.32	0.11	0.01	1.59
SSE		0.17	0.27	0.37	0.19	0.07	0.04	1.10
S		0.30	0.27	0.68	0.34	0.16	0.18	1.91
SSW		0.34	0.59	0.59	0.53	0.17	0.09	2.31
SW		0.43	0.97	1.61	1.37	0.33	0.16	4.86
WSW		0.29	1.20	2.23	2.47	1.08	0.26	7.52
W		0.34	1.19	2.94	3.06	1.39	0.61	9.53
WNW		0.41	1.05	2.55	3.89	2.41	1.02	11.32
NW		0.69	1.18	2.41	4.82	3.00	1.42	13.52
NNW		0.40	1.08	2.38	2.83	1.65	0.83	9.16
All Sectors		6.66	14.07	25.43	30.13	14.48	6.38	

Calm = 2.85

TABLE 2.3–14 MONTHLY AND ANNUAL WIND DIRECTION AND SPEED DISTRIBUTIONS FOR SURFACE WINDS, AT BRIDGEPORT, CONN. (1949-1980) (CONTINUED)

C. MARCH

Wind Direction	km/hr (mph)	1.6-4.8 (1-3)	6.4-11.2 (4-7)	12.8-19.2 (8-12)	20.8-28.8 (13-18)	30.4-38.4 (19-24)	≥40 (25)	All Speeds
		Wind Speed Distribution (%) Within Wind Speed Class						
N		0.47	1.10	2.37	3.11	1.18	0.34	8.57
NNE		0.48	1.11	1.70	1.20	0.30	0.15	4.94
NE		0.96	1.43	1.90	1.69	0.57	0.22	6.76
ENE		0.52	0.98	1.78	2.03	0.81	0.65	6.75
E		0.28	0.90	1.92	2.45	1.27	0.79	7.61
ESE		0.25	0.63	1.15	1.14	0.44	0.13	3.74
SE		0.19	0.56	0.80	0.43	0.11	0.00	2.09
SSE		0.18	0.39	0.53	0.32	0.10	0.10	1.62
S		0.42	0.67	0.92	0.58	0.34	0.09	3.03
SSW		0.23	0.49	1.08	1.13	0.46	0.11	3.50
SW		0.55	1.21	2.41	1.75	0.40	0.12	6.45
WSW		0.53	0.83	2.04	1.65	0.55	0.17	5.76
W		0.44	0.95	2.30	2.05	0.94	0.52	7.20
WNW		0.39	0.71	1.67	2.75	1.78	1.17	8.47
NW		0.46	0.80	2.10	4.01	2.48	1.27	11.12
NNW		0.39	0.90	2.12	3.50	1.84	0.76	9.52
All Sectors		6.73	13.65	26.78	29.79	13.57	6.60	

Calm = 2.88

TABLE 2.3–14 MONTHLY AND ANNUAL WIND DIRECTION AND SPEED DISTRIBUTIONS FOR SURFACE WINDS, AT BRIDGEPORT, CONN. (1949-1980) (CONTINUED)

D. APRIL

	Wind Speed Distribution (%) Within Wind Speed Class							
Wind Direction	km/hr (mph)	1.6-4.8 (1-3)	6.4-11.2 (4-7)	12.8-19.2 (8-12)	20.8-28.8 (13-18)	30.4-38.4 (19-24)	≥40 (25)	All Speeds
N		0.57	1.03	2.00	2.59	0.74	0.10	7.03
NNE		0.44	0.79	1.37	1.23	0.15	0.08	4.05
NE		0.64	0.97	1.83	1.47	0.50	0.10	5.49
ENE		0.35	0.96	1.20	1.76	0.87	0.44	5.58
E		0.39	0.86	2.00	2.34	1.13	0.71	7.42
ESE		0.22	0.62	1.04	0.90	0.28	0.11	3.17
SE		0.35	0.63	0.76	0.52	0.08	0.00	2.34
SSE		0.16	0.56	0.97	0.45	0.07	0.03	2.23
S		0.39	0.88	1.75	1.20	0.40	0.11	4.73
SSW		0.37	0.77	1.32	1.84	0.85	0.21	5.34
SW		0.64	1.36	2.50	2.85	0.74	0.11	8.20
WSW		0.51	1.45	3.24	2.66	0.76	0.21	8.82
W		0.38	1.36	2.83	2.16	0.76	0.39	7.87
WNW		0.38	0.82	1.50	2.30	1.63	1.04	7.66
NW		0.52	0.84	1.75	2.90	1.68	1.22	8.91
NNW		0.40	1.04	1.99	2.71	1.72	0.62	8.47
All Sectors		6.67	14.93	28.04	29.88	12.33	5.46	

Calm = 2.69

TABLE 2.3–14 MONTHLY AND ANNUAL WIND DIRECTION AND SPEED DISTRIBUTIONS FOR SURFACE WINDS, AT BRIDGEPORT, CONN. (1949-1980) (CONTINUED)

E. MAY

Wind Direction	km/hr (mph)	1.6-4.8 (1-3)	6.4-11.2 (4-7)	12.8-19.2 (8-12)	20.8-28.8 (13-18)	30.4-38.4 (19-24)	≥40 (25)	All Speeds
		Wind Speed Distribution (%) Within Wind Speed Class						
N		0.51	1.09	1.81	1.55	0.39	0.09	5.44
NNE		0.43	1.01	1.39	1.02	0.27	0.09	4.23
NE		0.63	1.43	1.65	1.44	0.48	0.06	5.68
ENE		0.28	1.15	1.75	2.03	0.36	0.16	5.72
E		0.46	1.42	3.56	3.93	0.91	0.27	10.55
ESE		0.26	1.27	2.00	1.53	0.28	0.09	5.43
SE		0.52	0.89	1.22	0.60	0.12	0.06	3.41
SSE		0.32	0.73	1.16	0.66	0.12	0.01	3.00
S		0.38	1.36	1.93	1.37	0.49	0.11	5.64
SSW		0.37	1.09	2.13	1.99	0.81	0.06	6.44
SW		0.63	1.31	3.49	2.86	0.74	0.06	9.08
WSW		0.40	1.36	3.64	2.85	0.73	0.12	9.09
W		0.48	1.60	2.40	1.59	0.44	0.15	6.65
WNW		0.38	0.86	1.28	1.42	0.79	0.33	5.04
NW		0.59	0.92	1.17	1.64	0.94	0.33	5.60
NNW		0.34	1.01	1.49	1.85	1.14	0.09	5.93
All Sectors		6.96	18.50	32.07	28.32	9.01	2.08	

Calm = 3.07

TABLE 2.3–14 MONTHLY AND ANNUAL WIND DIRECTION AND SPEED DISTRIBUTIONS FOR SURFACE WINDS, AT BRIDGEPORT, CONN. (1949-1980) (CONTINUED)

F. JUNE

	Wind Speed Distribution (%) Within Wind Speed Class							
Wind Direction	**km/hr (mph)**	**1.6-4.8 (1-3)**	**6.4-11.2 (4-7)**	**12.8-19.2 (8-12)**	**20.8-28.8 (13-18)**	**30.4-38.4 (19-24)**	**≥40 (25)**	**All Speeds**
N		0.48	1.51	1.80	1.21	0.33	0.06	5.38
NNE		0.35	1.24	1.02	0.73	0.05	0.01	3.41
NE		0.71	1.04	1.31	0.98	0.17	0.03	4.22
ENE		0.35	0.91	1.23	0.96	0.25	0.05	3.74
E		0.45	1.39	2.27	1.73	0.45	0.10	6.38
ESE		0.30	1.08	2.00	0.88	0.27	0.05	4.57
SE		0.44	1.18	1.32	0.63	0.06	0.00	3.59
SSE		0.29	1.07	1.43	0.38	0.03	0.00	3.19
S		0.60	1.86	2.90	1.83	0.31	0.02	7.51
SSW		0.29	1.45	3.02	.240	0.38	0.07	7.60
SW		0.62	2.89	5.84	4.19	0.39	0.03	13.95
WSW		0.55	2.58	3.84	3.29	0.36	0.03	12.64
W		0.32	2.11	3.21	1.63	0.14	0.01	7.42
WNW		0.26	1.17	1.22	1.13	0.36	0.14	4.28
NW		0.39	0.98	1.24	1.73	0.58	0.18	5.09
NNW		0.33	0.96	1.23	1.24	0.43	0.05	4.23
All Sectors		6.69	23.40	36.85	24.92	4.53	0.81	

Calm = 2.89

TABLE 2.3–14 MONTHLY AND ANNUAL WIND DIRECTION AND SPEED DISTRIBUTIONS FOR SURFACE WINDS, AT BRIDGEPORT, CONN. (1949-1980) (CONTINUED)

G. JULY

Wind Direction	km/hr (mph)	1.6-4.8 (1-3)	6.4-11.2 (4-7)	12.8-19.2 (8-12)	20.8-28.8 (13-18)	30.4-38.4 (19-24)	≥40 (25)	All Speeds
	Wind Speed Distribution (%) Within Wind Speed Class							
N		0.49	1.71	2.02	1.04	0.14	0.02	5.40
NNE		0.69	1.12	1.32	0.49	0.07	0.00	3.69
NE		0.76	1.38	1.51	0.78	0.12	0.00	4.55
ENE		0.33	0.68	0.97	0.70	0.14	0.00	2.83
E		0.39	0.82	1.69	1.12	0.26	0.14	4.42
ESE		0.19	0.75	1.60	0.72	0.23	0.00	3.48
SE		0.28	0.93	1.53	0.51	0.01	0.00	3.26
SSE		0.35	0.98	1.60	0.54	0.01	0.00	3.47
S		0.45	1.68	3.46	1.95	0.25	0.00	7.78
SSW		0.29	1.33	3.25	3.12	0.35	0.00	8.33
SW		0.64	2.58	6.80	4.24	0.34	0.01	14.60
WSW		0.64	2.70	6.30	3.15	0.26	0.03	13.08
W		0.67	2.52	3.62	1.16	0.14	0.02	8.12
WNW		0.46	1.39	1.50	1.15	0.29	0.10	4.88
NW		0.66	1.07	1.49	1.11	0.35	0.07	4.76
NNW		0.33	1.07	1.44	1.17	0.21	0.05	4.26
All Sectors		7.61	22.70	40.07	22.94	3.16	0.43	

Calm = 3.09

TABLE 2.3–14 MONTHLY AND ANNUAL WIND DIRECTION AND SPEED DISTRIBUTIONS FOR SURFACE WINDS, AT BRIDGEPORT, CONN. (1949-1980) (CONTINUED)

H. AUGUST

Wind Direction	km/hr (mph)	1.6-4.8 (1-3)	6.4-11.2 (4-7)	12.8-19.2 (8-12)	20.8-28.8 (13-18)	30.4-38.4 (19-24)	≥40 (25)	All Speeds
		Wind Speed Distribution (%) Within Wind Speed Class						
N		0.93	2.28	2.62	1.12	0.22	0.01	7.17
NNE		0.91	1.45	1.86	0.98	0.05	0.02	5.26
NE		1.28	1.64	1.86	1.52	0.20	0.01	6.51
ENE		0.31	0.78	0.93	0.82	0.15	0.00	2.99
E		0.39	0.76	1.51	1.21	0.26	0.01	4.14
ESE		0.27	0.66	1.28	0.95	0.11	0.03	3.30
SE		0.26	0.91	1.21	0.63	0.04	0.01	3.05
SSE		0.26	0.81	1.63	0.54	0.04	0.01	3.28
S		0.49	1.82	3.30	1.54	0.11	0.01	7.28
SSW		0.40	1.27	3.63	2.62	0.34	0.02	8.27
SW		0.52	2.28	5.83	4.20	0.41	0.02	13.26
WSW		0.40	1.84	4.60	3.05	0.49	0.04	10.41
W		0.37	1.37	3.32	1.14	0.28	0.00	6.48
WNW		0.39	1.15	1.86	1.00	0.28	0.02	4.69
NW		0.70	1.34	1.80	1.27	0.38	0.09	5.57
NNW		0.46	1.52	1.72	1.13	0.24	0.04	5.10
All Sectors		8.32	21.88	38.93	23.72	3.59	0.31	

Calm = 3.25

TABLE 2.3–14 MONTHLY AND ANNUAL WIND DIRECTION AND SPEED DISTRIBUTIONS FOR SURFACE WINDS, AT BRIDGEPORT, CONN. (1949-1980) (CONTINUED)

I. SEPTEMBER

	Wind Speed Distribution (%) Within Wind Speed Class						
Wind Direction	**km/hr (mph)** 1.6-4.8 (1-3)	**6.4-11.2 (4-7)**	**12.8-19.2 (8-12)**	**20.8-28.8 (13-18)**	**30.4-38.4 (19-24)**	**≥40 (25)**	**All Speeds**
N	0.83	2.14	2.87	1.96	0.39	0.07	8.25
NNE	0.97	1.94	2.20	1.69	0.49	0.12	7.41
NE	1.11	2.21	3.41	3.43	0.69	0.19	11.03
ENE	0.23	0.65	1.41	1.77	0.63	0.14	4.83
E	0.16	0.64	1.18	1.57	0.44	0.12	4.10
ESE	0.18	0.63	1.23	1.31	0.31	0.05	3.71
SE	0.25	0.66	1.15	0.75	0.08	0.02	2.91
SSE	0.19	0.55	1.28	0.62	0.11	0.02	2.77
S	0.21	1.04	1.95	1.16	0.19	0.02	4.57
SSW	0.22	0.76	1.65	1.77	0.67	0.17	5.24
SW	0.45	1.40	3.47	3.76	0.76	0.07	9.90
WSW	0.15	0.86	2.60	2.95	0.54	0.02	7.12
W	0.24	0.94	3.04	1.87	0.34	0.06	6.49
WNW	0.28	1.11	2.35	1.76	0.36	0.07	5.93
NW	0.82	1.79	1.97	1.89	0.42	0.11	6.99
NNW	0.66	1.21	1.90	1.65	0.51	0.01	5.93
All Sectors	6.94	18.52	33.66	29.91	6.91	1.22	

Calm = 2.84

TABLE 2.3–14 MONTHLY AND ANNUAL WIND DIRECTION AND SPEED DISTRIBUTIONS FOR SURFACE WINDS, AT BRIDGEPORT, CONN. (1949-1980) (CONTINUED)

J. OCTOBER

Wind Direction	km/hr (mph)	1.6-4.8 (1-3)	6.4-11.2 (4-7)	12.8-19.2 (8-12)	20.8-28.8 (13-18)	30.4-38.4 (19-24)	≥40 (25)	All Speeds
	Wind Speed Distribution (%) Within Wind Speed Class							
N		0.68	2.39	2.93	2.30	0.58	0.08	8.95
NNE		0.80	1.69	2.36	1.25	0.27	0.04	6.41
NE		1.03	2.18	3.30	3.44	0.83	0.10	10.88
ENE		0.31	0.65	1.46	1.45	0.52	0.17	4.55
E		0.21	0.66	0.96	0.94	0.46	0.22	3.44
ESE		0.22	0.32	0.85	0.74	0.24	0.14	2.50
SE		0.28	0.55	0.81	0.54	0.14	0.01	2.33
SSE		0.24	0.65	0.81	0.36	0.09	0.05	2.19
S		0.23	0.83	1.43	0.71	0.12	0.04	3.38
SSW		0.22	0.72	1.25	1.15	0.32	0.07	3.72
SW		0.41	1.19	2.72	3.02	0.77	0.24	8.35
WSW		0.28	0.85	2.73	3.11	0.88	0.35	8.20
W		0.24	1.17	3.27	3.46	0.97	0.26	9.37
WNW		0.23	1.34	3.12	2.57	0.86	0.26	8.38
NW		0.48	1.47	2.44	2.42	1.00	0.32	8.13
NNW		0.41	1.35	2.13	1.79	0.95	0.24	6.89
All Sectors		6.26	18.01	32.56	29.26	8.99	2.57	

Calm = 2.35

TABLE 2.3–14 MONTHLY AND ANNUAL WIND DIRECTION AND SPEED DISTRIBUTIONS FOR SURFACE WINDS, AT BRIDGEPORT, CONN. (1949-1980) (CONTINUED)

K. NOVEMBER

	Wind Speed Distribution (%) Within Wind Speed Class							
Wind Direction	**km/hr (mph)**	**1.6-4.8 (1-3)**	**6.4-11.2 (4-7)**	**12.8-19.2 (8-12)**	**20.8-28.8 (13-18)**	**30.4-38.4 (19-24)**	**≥40 (25)**	**All Speeds**
N		0.97	2.15	2.93	1.95	0.56	0.20	8.77
NNE		0.67	1.70	2.00	1.30	0.25	0.06	5.99
NE		1.07	1.95	2.94	2.58	0.54	0.17	9.25
ENE		0.26	0.68	1.04	1.29	0.54	0.24	4.06
E		0.22	0.48	0.75	0.91	0.54	0.56	3.47
ESE		0.13	0.45	0.51	0.40	0.30	0.15	1.92
SE		0.25	0.42	0.57	0.34	0.19	0.12	1.90
SSE		0.15	0.41	0.68	0.53	0.07	0.04	1.88
S		0.20	0.58	1.00	0.65	0.16	0.07	2.66
SSW		0.07	0.39	0.97	1.08	0.35	0.13	2.98
SW		0.32	0.80	1.81	2.22	0.65	0.29	6.08
WSW		0.25	0.85	2.40	2.53	1.11	0.40	7.17
W		0.20	1.14	3.07	3.54	1.59	0.48	10.02
WNW		0.45	1.34	3.63	4.03	1.58	0.54	11.58
NW		0.71	2.03	2.83	2.94	1.85	0.62	10.98
NNW		0.49	1.56	2.22	2.62	1.34	0.63	8.86
All Sectors		6.41	16.92	28.99	28.92	11.64	4.69	

Calm = 2.43

TABLE 2.3–14 MONTHLY AND ANNUAL WIND DIRECTION AND SPEED DISTRIBUTIONS FOR SURFACE WINDS, AT BRIDGEPORT, CONN. (1949-1980) (CONTINUED)

L. DECEMBER

Wind Direction	km/hr (mph)	1.6-4.8 (1-3)	6.4-11.2 (4-7)	12.8-19.2 (8-12)	20.8-28.8 (13-18)	30.4-38.4 (19-24)	≥40 (25)	All Speeds
		Wind Speed Distribution (%) Within Wind Speed Class						
N		0.83	2.04	2.69	2.27	0.66	0.25	8.72
NNE		0.61	1.52	1.66	1.25	0.40	0.03	5.46
NE		0.91	.86	2.57	3.06	0.84	0.14	9.38
ENE		0.35	1.06	1.63	2.04	0.49	0.24	5.81
E		0.17	0.58	0.71	0.56	0.20	0.23	2.43
ESE		0.14	0.38	0.44	0.23	0.17	0.20	1.55
SE		0.24	0.30	0.34	0.26	0.07	0.00	1.21
SSE		0.10	0.38	0.25	0.37	0.19	0.03	1.31
S		0.12	0.49	0.41	0.31	0.14	0.04	1.52
SSW		0.13	0.33	0.56	0.57	0.13	0.12	1.84
SW		0.29	0.63	1.36	1.14	0.54	0.12	4.08
WSW		0.27	0.84	1.64	1.73	0.63	0.34	5.45
W		0.30	1.06	3.67	4.46	1.75	0.77	12.02
WNW		0.36	1.53	4.38	5.07	2.20	1.07	14.61
NW		0.71	1.67	3.19	3.99	1.89	1.12	12.57
NNW		0.55	1.52	2.59	2.52	0.92	0.90	9.00
All Sectors		6.09	16.16	28.08	29.82	11.22	5.59	

Calm = 3.04

TABLE 2.3–14 MONTHLY AND ANNUAL WIND DIRECTION AND SPEED DISTRIBUTIONS FOR SURFACE WINDS, AT BRIDGEPORT, CONN. (1949-1980) (CONTINUED)

M. ANNUAL

		Wind Speed Distribution (%) Within Wind Speed Class						
Wind Direction	**km/hr (mph)**	**1.6-4.8 (1-3)**	**6.4-11.2 (4-7)**	**12.8-19.2 (8-12)**	**20.8-28.8 (13-18)**	**30.4-38.4 (19-24)**	**≥40 (25)**	**All Speeds**
N		0.69	1.69	2.41	2.01	0.57	0.16	7.53
NNE		0.63	1.29	1.63	1.16	0.28	0.08	5.06
NE		0.95	1.61	2.24	2.07	0.57	0.14	7.58
ENE		0.36	0.86	1.36	1.54	0.50	0.24	4.87
E		0.31	0.83	1.56	1.57	0.58	0.30	5.14
ESE		0.21	0.64	1.10	0.79	0.24	0.08	3.06
SE		0.29	0.65	0.88	0.47	0.09	0.02	2.40
SSE		0.22	0.60	0.91	0.42	0.08	0.03	2.25
S		0.34	1.00	1.69	1.00	0.24	0.08	4.33
SSW		0.26	0.80	169	1.57	0.42	0.10	4.83
SW		0.50	1.47	3.30	2.76	0.55	0.11	8.69
WSW		0.38	1.37	3.27	2.66	0.73	0.21	8.62
W		0.38	1.40	3.08	2.57	0.88	035	8.67
WNW		0.37	1.15	2.35	2.63	1.21	0.56	8.27
NW		0.63	1.29	2.09	2.70	1.36	0.66	8.73
NNW		0.42	1.22	1.93	2.12	1.01	0.41	7.12
All Sectors		6.93	17.87	31.51	28.01	9.31	3.52	

Calm = 2.85

TABLE 2.3–15 MONTHLY AND ANNUAL WIND DIRECTION AND SPEED DISTRIBUTIONS FOR 33-FOOT WINDS AT MILLSTONE (1974-1981)

CLICK HERE TO SEE TABLE 2.3-15

TABLE 2.3–16 COMPARISON OF WIND DIRECTION FREQUENCY DISTRIBUTION BY QUADRANT AT BRIDGEPORT, CONN. AND MILLSTONE

			Wind Frequency Percentage by Quadrant				
			Onshore		Offshore		
	Valid Data (Hours)	Data Period	ESE-S	SSW-W	WNW-N	NNE-E	Calm
Millstone*	58,193	1/1/74-12/31/80	15.3	31.9	33.6	17.9	1.3
Millstone*	66,392	1/1/74-12/31/81	15.3	31.4	34.2	17.8	1.2
Bridgeport**	21,882	1/1/74-12/31/80	12.2	34.5	31.3	20.1	1.9
Bridgeport**	127,933	1/1/49-04/30/53 05/01/60-12/31/80	12.0	30.8	31.6	22.7	2.9

NOTES:

* Wind direction measured at the 33-foot tower level

** Observations recorded every third hour beginning March 1, 1965

TABLE 2.3–17 COMPARISON OF AVERAGE WIND SPEED BY QUADRANT AT BRIDGEPORT, CONN. AND MILLSTONE

			Wind Frequency Percentage by Quadrant			
			Onshore		Offshore	
	Valid Data (Hours)	Data Period	ESE-S	SSW-W	WNW-N	NNE-E
Millstone*	58,193	1/1/74- 12/31/80	13.7 (8.5)	18.0 (11.2)	15.0 (9.3)	14.2 (8.8)
Millstone*	66,392	1/1/74- 12/31/81	13.7 (8.5)	17.9 (11.1)	15.1 (9.4)	13.8 (8.6)
Bridgeport**	21,882	1/1/74- 12/31/81	16.1 (10.0)	19.5 (12.1)	21.1 (13.1)	19.3 (12.0)
Bridgeport**	127,933	1/1/49- 04/30/53 05/01/60- 12/31/80	16.3 (10.2)	19.0 (11.9)	20.6 (12.9)	18.7 (11.6)

NOTES:

* Wind direction measured at the 33-foot tower level

** Observation recorded every third hour beginning March 1, 1965

*** Wind speed measured at 48 feet above ground level until 6/19/61, at 84 feet above ground from 6/19/61 to 4/18/74, and 33 feet above ground from 4/18/74 to 12/31/78

TABLE 2.3–18 OCCURRENCE OF WIND PERSISTENCE EPISODES WITHIN THE SAME 22.5-DEGREE SECTOR AT MILLSTONE (1974-1981)

CLICK HERE TO SEE TABLE 2.3-18

TABLE 2.3–19 MILLSTONE CLIMATOLOGICAL SUMMARY (1974-2000)

A. Monthly and Annual Ambient Temperature

	Average Daily Mean		Average Daily Maximum		Average Daily Minimum		Extreme Maximum		Extreme Minimum	
Month	**°C**	**(°F)**	**°C**	**(°F)**	**°C**	**(°F)**	**°C**	**(°F)**	**°C**	**(°F)**
January	-1.0	(30.3)	2.4	(36.4)	-4.5	(23.8)	14.7	(58.5)	-19.4	(-2.9)
February	-0.3	(31.5)	3.0	(37.3)	-3.6	(25.5)	16.9	(62.4)	-19.3	(-2.7)
March	3.1	(37.5)	6.4	(43.5)	-0.1	(31.8)	23.3	(73.9)	-14.0	(6.8)
April	7.7	(45.8)	11.0	(51.8)	4.7	(40.4)	27.3	(81.1)	-5.6	(21.9)
May	12.4	(54.3)	15.8	(60.5)	9.5	(49.0)	29.7	(85.5)	1.0	(33.8)
June	17.1	(62.8)	20.3	(68.6)	14.2	(57.5)	31.8	(89.2)	6.6	(43.9)
July	20.5	(69.0)	23.4	(74.1)	18.0	(64.3)	32.8	(91.0)	10.5	(50.9)
August	20.7	(69.3)	23.4	(74.1)	17.9	(64.3)	32.2	(90.0)	8.9	(48.0)
September	17.7	(63.8)	20.5	(68.9)	14.1	(57.4)	29.6	(85.3)	3.4	(38.1)
October	12.4	(54.3)	15.6	(60.0)	8.5	(47.2)	26.3	(79.3)	-1.8	(28.8)
November	7.5	(45.6)	10.7	(51.2)	4.1	(39.3)	22.7	(72.9	-9.1	(15.6)
December	2.0	(35.6)	5.3	(41.5)	-1.5	(29.4)	20.1	(68.1)	-20.6	(-5.1)
1/1/74 - 12/31/00	10.0	(50.0)	13.1	(55.7)	6.8	(44.2)	32.8	(91.0)	-20.6	(-5.1)

TABLE 2.3–19 MILLSTONE CLIMATOLOGICAL SUMMARY (1974-2000)

B. Monthly and Annual Dew Point

Month	Average Daily Mean °C	Average Daily Mean (°F)	Average Daily Maximum °C	Average Daily Maximum (°F)	Average Daily Minimum °C	Average Daily Minimum (°F)	Extreme Maximum °C	Extreme Maximum (°F)	Extreme Minimum °C	Extreme Minimum (°F)
January	-5.8	(21.5)	-1.7	(28.9)	-9.8	(14.4)	12.6	(54.7)	-29.0	(-20.2)
February	-5.5	(22.0)	-1.8	(28.8)	-9.2	(15.5)	10.1	(50.2)	-24.1	(-11.4)
March	-3.0	(26.7)	0.8	(33.4)	-6.5	(20.3)	13.0	(55.4)	-24.6	(-12.3)
April	1.2	(34.1)	4.4	(40.0)	-2.1	(28.2)	14.5	(58.1)	-17.0	(1.4)
May	6.6	(43.8)	9.5	(49.1)	3.8	(38.8)	19.3	(66.7)	-10.4	(13.4)
June	11.7	(53.1)	14.4	(57.9)	9.2	(48.5)	22.2	(72.0)	-3.3	(26.1)
July	15.1	(59.1)	17.5	(63.5)	12.8	(55.0)	24.7	(76.5)	2.4	(36.3)
August	15.5	(60.0)	17.9	(64.3)	13.1	(55.6)	24.3	(75.7)	0.3	(32.5)
September	12.0	(53.7)	14.9	(58.9)	9.3	(48.7)	24.4	(75.9)	-3.3.	(26.1)
October	6.1	(43.0)	9.5	(49.1)	2.9	(37.2)	20.4	(68.7)	-11.9	(10.6)
November	1.5	(34.7)	5.0	(41.0)	-2.0	(28.3)	16.6	(61.9)	-16.9	(1.6)
December	-3.5	(25.7)	0.5	(32.9)	-7.2	(19.0)	13.6	(56.5)	-29.3	(-20.7)
1/1/74 - 12/31/00	4.3	(39.8)	7.6	(45.6)	1.2	(34.1)	24.7	(76.5)	-29.3	(-20.7)

TABLE 2.3–19 MILLSTONE CLIMATOLOGICAL SUMMARY (1974-2000)

C. Monthly and Annual Absolute Humidity

Month	Average Daily Mean °C	Average Daily Mean (°F)	Average Daily Maximum °C	Average Daily Maximum (°F)	Average Daily Minimum °C	Average Daily Minimum (°F)	Extreme Maximum °C	Extreme Maximum (°F)	Extreme Minimum °C	Extreme Minimum (°F)
January	3.3		4.3		2.4		11.1		0.5	
February	3.3		4.3		2.5		9.5		0.8	
March	4.0		5.1		3.1		11.3		0.7	
April	5.3		6.6		4.2		12.4		1.4	
May	7.6		9.1		6.3		16.6		2.3	
June	10.5		12.4		9.0		19.6		3.8	
July	12.9		15.0		11.2		22.7		5.7	
August	13.3		15.3		11.5		22.1		4.9	
September	10.7		12.8		9.0		22.3		3.8	
October	7.3		9.1		5.9		17.7		2.0	
November	5.4		6.9		4.2		14.1		1.4	
December	3.8		5.1		3.0		11.8		0.5	
1/1/74 - 12/31/00	7.3		8.8		6.0		22.7		0.5	

TABLE 2.3–19 MILLSTONE CLIMATOLOGICAL SUMMARY (1974-2000)

D. Monthly and Annual Relative Humidity

Month	Average Daily Mean		Average Daily Maximum		Average Daily Minimum		Extreme Maximum		Extreme Minimum	
	°C	(°F)	°C	(°F)	°C	(°F)	°C	(°F)	°C	(°F)
January	71.2		85.7		56.4		100.0		18.1	
February	68.9		84.4		53.3		100.0		16.0	
March	67.0		82.9		50.7		100.0		14.8	
April	66.2		82.4		49.3		100.0		14.1	
May	69.8		85.1		53.5		100.0		14.7	
June	72.4		87.1		57.1		100.0		18.3	
July	72.3		86.0		58.4		100.0		23.6	
August	73.6		86.7		60.1		100.0		22.9	
September	71.2		85.3		57.2		100.0		19.9	
October	67.4		82.7		52.6		100.0		17.9	
November	67.0		80.7		53.0		100.0		16.1	
December	68.6		82.6		54.7		100.0		22.8	
1/1/74 - 12/31/00	69.6		84.3		54.7		100.0		14.1	

TABLE 2.3–19 MILLSTONE CLIMATOLOGICAL SUMMARY (1974-2000)

E. Episodes of Ambient Temperature Below 0.0°F:

Date(s)	Time(s)	Minimum (°F)	Duration (hrs)
January 23, 1976	0300-0915	-2.0	6.50
January 18, 1977	0630-0800	-0.2	1.75
February 11, 1979	0315-0915	-2.7	6.25
February 12, 1979	0245-0315	-0.2	0.75
February 12, 1979	0345-0815	-1.5	4.75
February 14, 1979	0330-0830	-2.7	5.25
February 17, 1979	0700	-0.0	0.25
February 18, 1979	0230-0815	-2.0	6.00
December 25, 1980	0700-1400	-5.1	7.25
December 25-26, 1980	1645-0300	-1.8	10.50
January 5, 1981	0230-0300	-0.2	0.75
January 12, 1981	0445-0515	-0.0	0.75
January 12, 1981	0630-0800	-0.6	1.75
January 12, 1982	0800	-0.0	0.25
January 17-18, 1982	2215-0915	-2.9	11.25
January 22, 1984	0645	-0.0	0.25
January 22, 1984	0730	-0.4	0.25
January 16, 1994	0630-0930	-1.5	3.25

TABLE 2.3–19 MILLSTONE CLIMATOLOGICAL SUMMARY (1974-2000)

E. Episodes of Ambient Temperature Below 0.0°F:

Date(s)	Time(s)	Minimum (°F)	Duration (hrs)
January 19, 1994	0545-0815	-0.6	2.75
January 27, 1994	0345-0515	-0.2	1.75
January 16, 1994	0545-0730	-0.6	2.00

TABLE 2.3–19 MILLSTONE CLIMATOLOGICAL SUMMARY (1974-2000)

F. Episodes of Ambient Temperature Above 86.0°F:

Date(s)	Time(s)	Maximum (°F)	Duration (hrs)
July 18, 1977	1515-1800	87.6	3.00
July 7, 1981	1645-1830	88.7	2.00
June 24, 1983	1630-1700	86.9	0.75
July 16, 1983	1500-1615	88.7	1.50
July 16, 1983	1900	86.7	0.25
July 16, 1983	1945	86.5	0.25
August 20, 1983	1645-1845	89.4	2.25
July 12, 1984	1215-1515	91.0	3.25
July 24, 1984	1600-1830	88.2	2.75
August 8, 1984	1030-1230	90.0	2.25
August 17, 1984	1130-1730	88.3	6.25
August 31, 1984	1430-1730	89.6	3.25
August 18, 1987	1045-1245	87.6	2.25
July 23, 1989	1445	86.2	0.25
July 5, 1990	1245-1530	88.2	3.00
June 29, 1991	1145-1330	88.2	2.00
July 21, 1991	1800-1815	88.3	0.50
July 10, 1993	1615-1630	88.2	0.50

TABLE 2.3–19 MILLSTONE CLIMATOLOGICAL SUMMARY (1974-2000)

F. Episodes of Ambient Temperature Above 86.0°F:

Date(s)	Time(s)	Maximum (°F)	Duration (hrs)
July 10, 1993	1715-1745	86.7	0.75
June 19, 1994	1445-1715	89.2	2.75
July 15, 1995	1815-2030	88.5	2.50
July 30, 1995	1600-1745	87.3	2.00
July 22, 1998	1500	86.7	0.25

TABLE 2.3–20 COMPARISON OF MONTHLY AND ANNUAL AVERAGE DRY-BULB AND DEWPOINT TEMPERATURE AVERAGES AT BRIDGEPORT, CONN. AND MILLSTONE

CLICK HERE TO SEE TABLE 2.3-20

TABLE 2.3–21 COMPARISON OF MONTHLY AND ANNUAL AVERAGE RELATIVE HUMIDITY AVERAGES AT BRIDGEPORT AND MILLSTONE

CLICK HERE TO SEE TABLE 2.3-21

TABLE 2.3–22 MEAN NUMBER OF DAYS WITH HEAVY FOG AT BRIDGEPORT, CONN. AND BLOCK ISLAND, RHODE ISLAND (1951-1981)

CLICK HERE TO SEE TABLE 2.3-22

TABLE 2.3–23 WIND DIRECTION/STABILITY CLASS/VISIBILITY JOINT FREQUENCY DISTRIBUTION AT MILLSTONE

CLICK HERE TO SEE TABLE 2.3-23

TABLE 2.3–24 PERSISTENCE OF POOR VISIBILITY (≤ 1 MILE) CONDITIONS AT MILLSTONE (HOURS) (1974-1981)

CLICK HERE TO SEE TABLE 2.3-24

TABLE 2.3–25 BRIDGEPORT PASQUILL STABILITY CLASS DISTRIBUTION (1949-1980)

CLICK HERE TO SEE TABLE 2.3-25

TABLE 2.3–26 MILLSTONE STABILITY CLASS DISTRIBUTION USING DELTA-T FOR STABILITY DETERMINATION

CLICK HERE TO SEE TABLE 2.3-26

TABLE 2.3–27 MILLSTONE STABILITY CLASS DISTRIBUTION USING SIGMA THETA FOR STABILITY DETERMINATION

CLICK HERE TO SEE TABLE 2.3-27

TABLE 2.3–28 COMPARISON OF PASQUILL STABILITY CLASS DISTRIBUTION AT BRIDGEPORT, CONN. AND MILLSTONE

CLICK HERE TO SEE TABLE 2.3-28

TABLE 2.3–29 PERSISTENCE OF STABLE CONDITIONS (E, F, AND G STABILITIES) AT MILLSTONE (1974-1981)

CLICK HERE TO SEE TABLE 2.3-29

TABLE 2.3–30 SEASONAL AND ANNUAL ATMOSPHERIC MIXING DEPTHS AT MILLSTONE

CLICK HERE TO SEE TABLE 2.3-30

TABLE 2.3–31 ON-SITE METEOROLOGICAL TOWER MEASUREMENTS

PRIMARY METEOROLOGICAL TOWER

Elevation (above base) * (ft)	(m)	Measurements
447	136.3	Wind Speed and Variance Wind Direction and Variance Air Temperature Temperature Difference to 10 m Level
374	114.0	Wind Speed and Variance Wind Direction and Variance Temperature Difference to 10 m Level
142	43.3	Wind Speed and Variance Wind Direction and Variance Temperature Difference to 10 m Level
64	19.5	Air Temperature
33	10.0	Wind Speed and Variance Wind Direction and Variance Air Temperature Humidity
5	1.5	Solar Radiation **

BACKUP METEOROLOGICAL MAST

Elevation (above base) *** (ft)	(m)	Measurements
33	10.0	Wind Speed and Variance Wind Direction and Variance

* Base of tower at 15 ft msl
** Mounted on a platform to south of tower
*** Base of mast at 73 ft msl

TABLE 2.3–32 MILLSTONE METEOROLOGICAL TOWER INSTRUMENTATION

Parameter	Sensor	Model
Wind Speed	Climatronics	F460
Wind Direction	Climatronics	F460
Temperature	Climatronics	100093
Temperature Difference	Climatronics	100093
Humidity	Climatronics	100098
Solar Radiation	Eppley	848

TABLE 2.3–33 MONTHLY SUMMARY OF DATA RECOVERY RATES/ METEOROLOGICAL SYSTEM

CLICK HERE TO SEE TABLE 2.3-33

TABLE 2.3–34 DISTANCES FROM RELEASE POINTS TO RECEPTORS

DOWNWIND SECTOR	UNIT 3 CONTAINMENT TO EAB	MILLSTONE STACK TO EAB	UNIT 3 VENT TO NEAREST LAND	UNIT 3 VENT TO NEAREST RESIDENCE	MILLSTONE STACK TO LAND	MILLSTONE STACK TO NEAREST RESIDENCE
SSW	524 (2)	496 (2)	14,500	14,500	14,500	14,500
SW	524 (2)	496 (2)	3380	3380	3660	3820
WSW	524 (2)	496 (2)	3050	3050	3270	3290
W	524 (2)	496 (2)	2700	2700	3050	3070
WNW	524 (2)	649	2310	2310	2700	2760
NW	524 (2)	710	680	680	947	997
NNW	532	1029	690	690	1029	1029
N	782	1677	920	920	1695	1695
NNE	826	813	1550	1550	813	813
NE	548	496 (1)	840	840	496	736
ENE	524 (1)	496 (2)	600	810	1101	1560
E	524 (2)	496 (2)	1300	1300	1410	1480
ESE	524 (2)	496 (2)	1690	1690	1640	1760
SE	524 (2)	496 (2)	31,700	31,700	31,700	31,700
SSE	524 (2)	496 (2)	12,390	12,390	12,390	12,390
S	524 (2)	496 (2)	13,100	13,100	13,100	13,100

(1) Shortest Exclusion Area Boundary Distance in any Landward Sector

(2) Water Sector, SO(1) is used when greater than shoreline distance

FIGURE 2.3–1 TOPOGRAPHY IN THE VICINITY OF MILLSTONE POINT

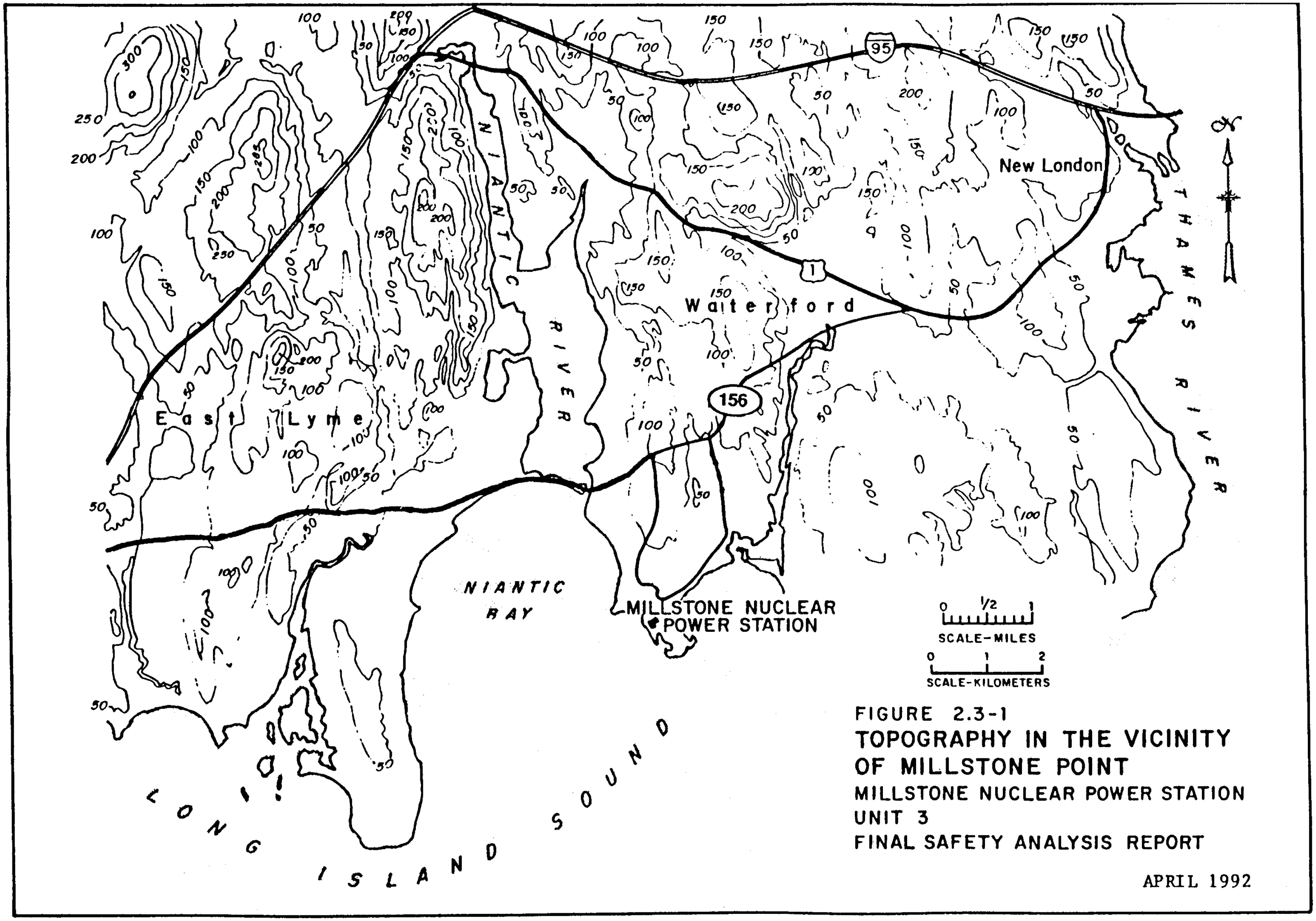

FIGURE 2.3-1
TOPOGRAPHY IN THE VICINITY OF MILLSTONE POINT
MILLSTONE NUCLEAR POWER STATION
UNIT 3
FINAL SAFETY ANALYSIS REPORT

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FIGURE 2.3–2 TOPOGRAPHICAL PROFILES WITHIN 5 MILES OF SITE

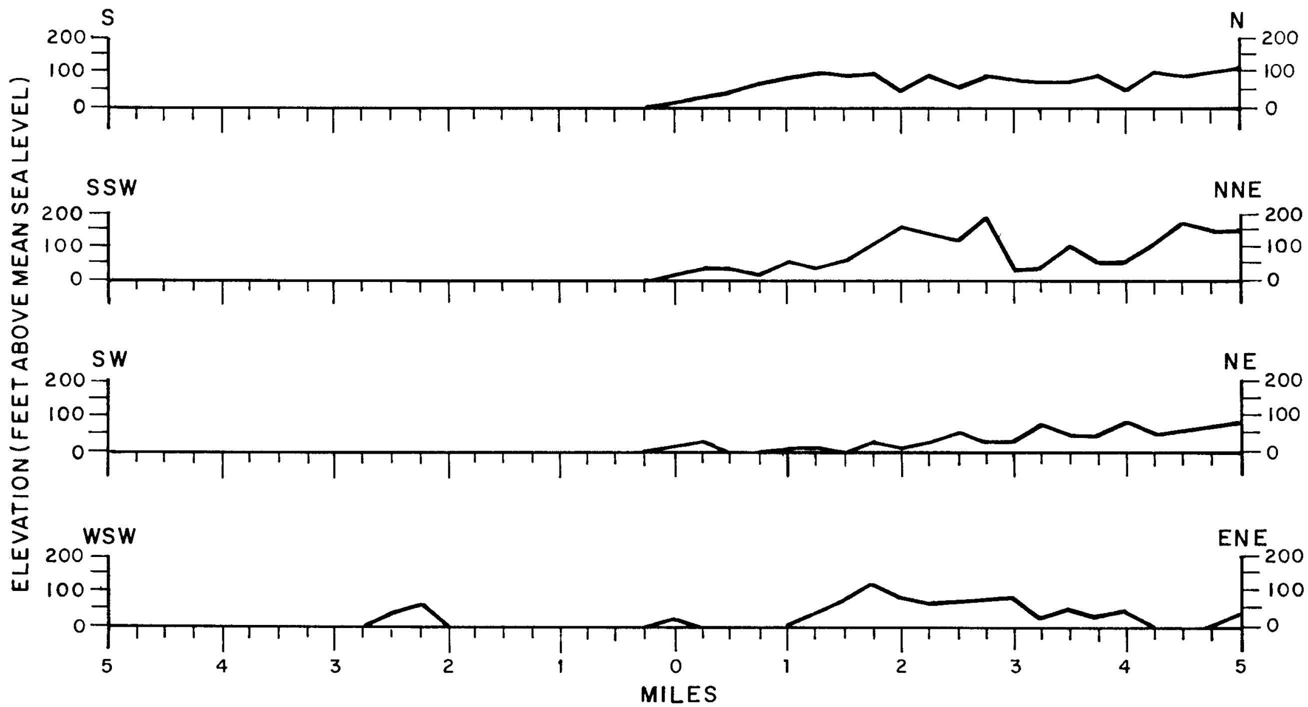


FIGURE 2.3-2
TOPOGRAPHICAL PROFILES
WITHIN 5 MILES OF SITE
MILLSTONE NUCLEAR POWER STATION
UNIT 3
FINAL SAFETY ANALYSIS REPORT

FIGURE 2.3–3 TOPOGRAPHICAL PROFILES WITHIN 5 MILES OF SITE

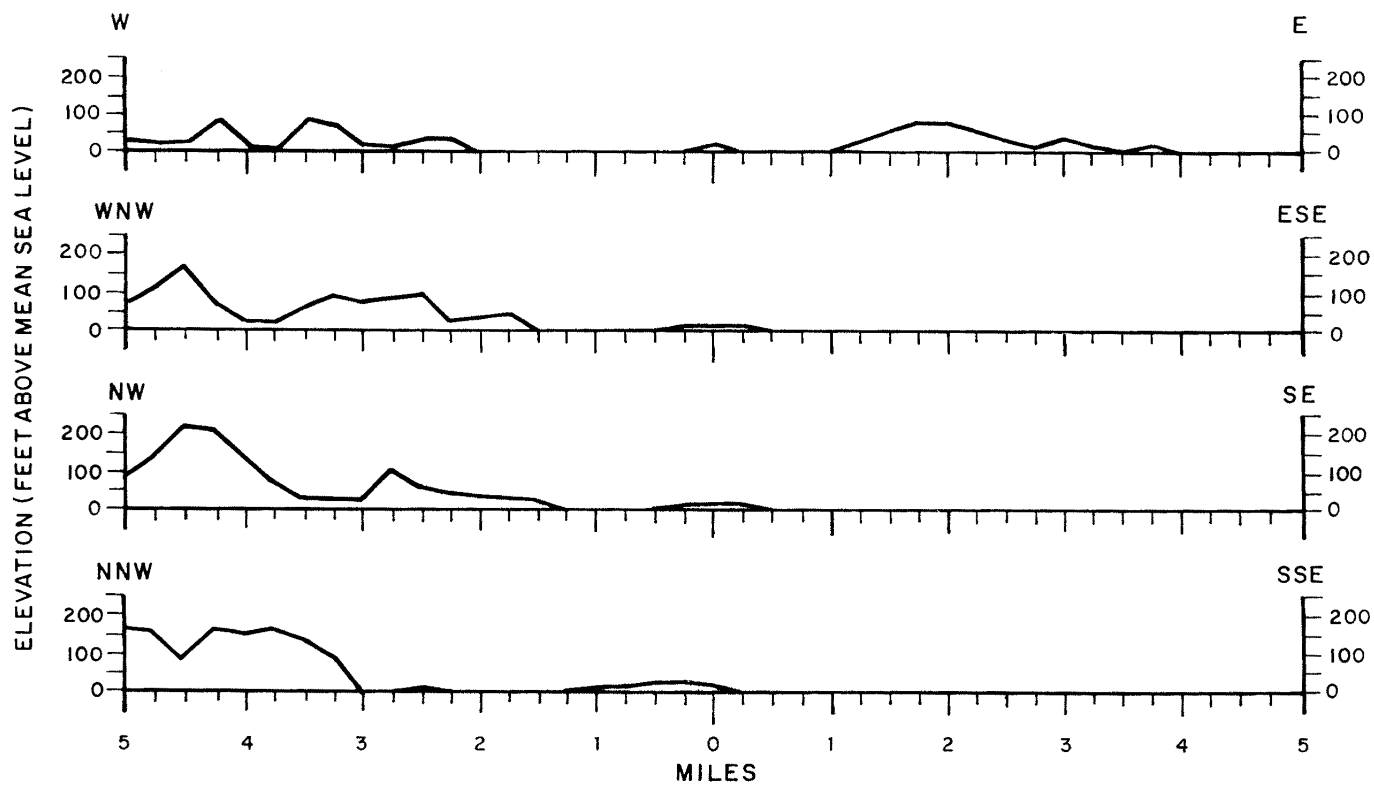
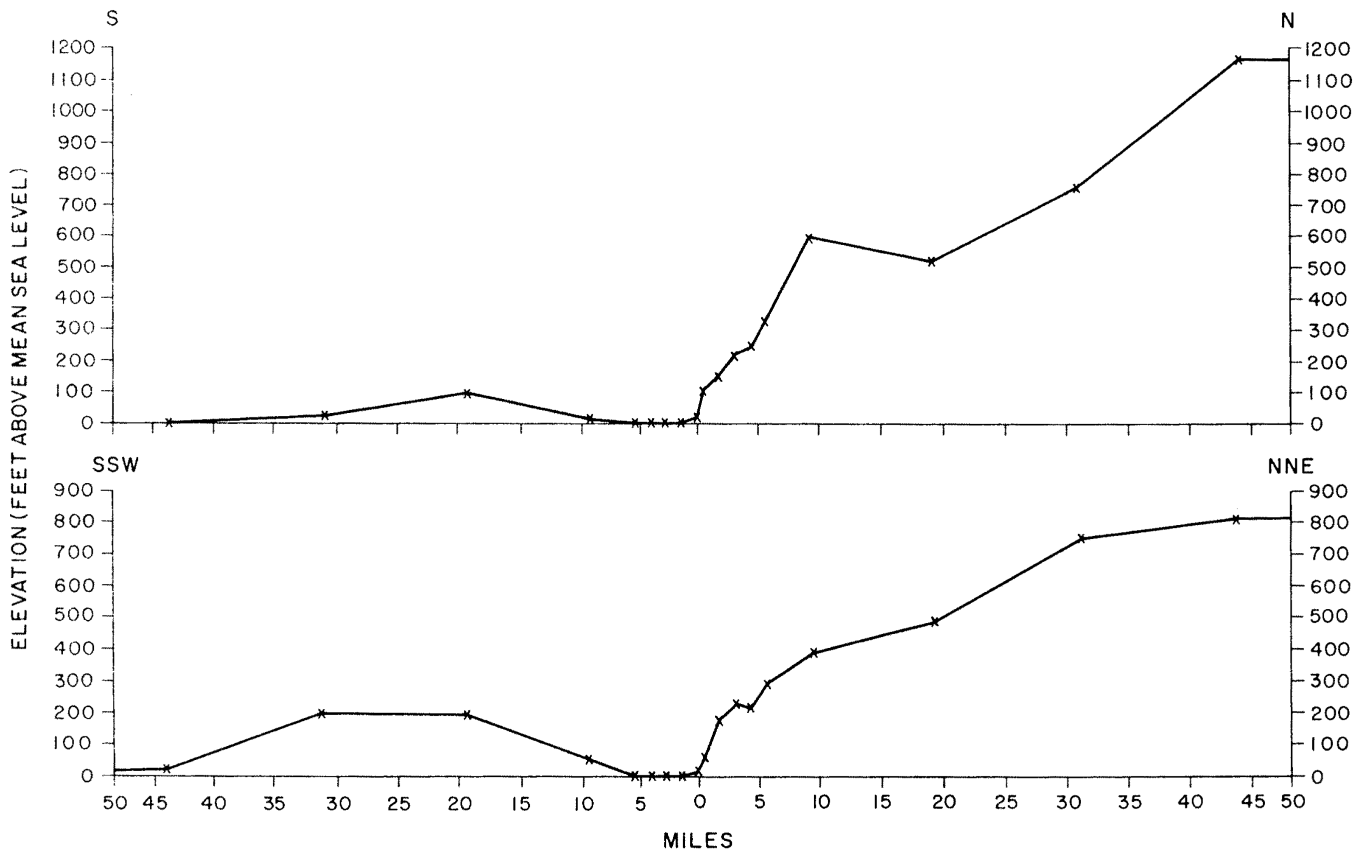


FIGURE 2.3-3
TOPOGRAPHICAL PROFILES
WITHIN 5 MILES OF SITE
MILLSTONE NUCLEAR POWER STATION
UNIT 3
FINAL SAFETY ANALYSIS REPORT

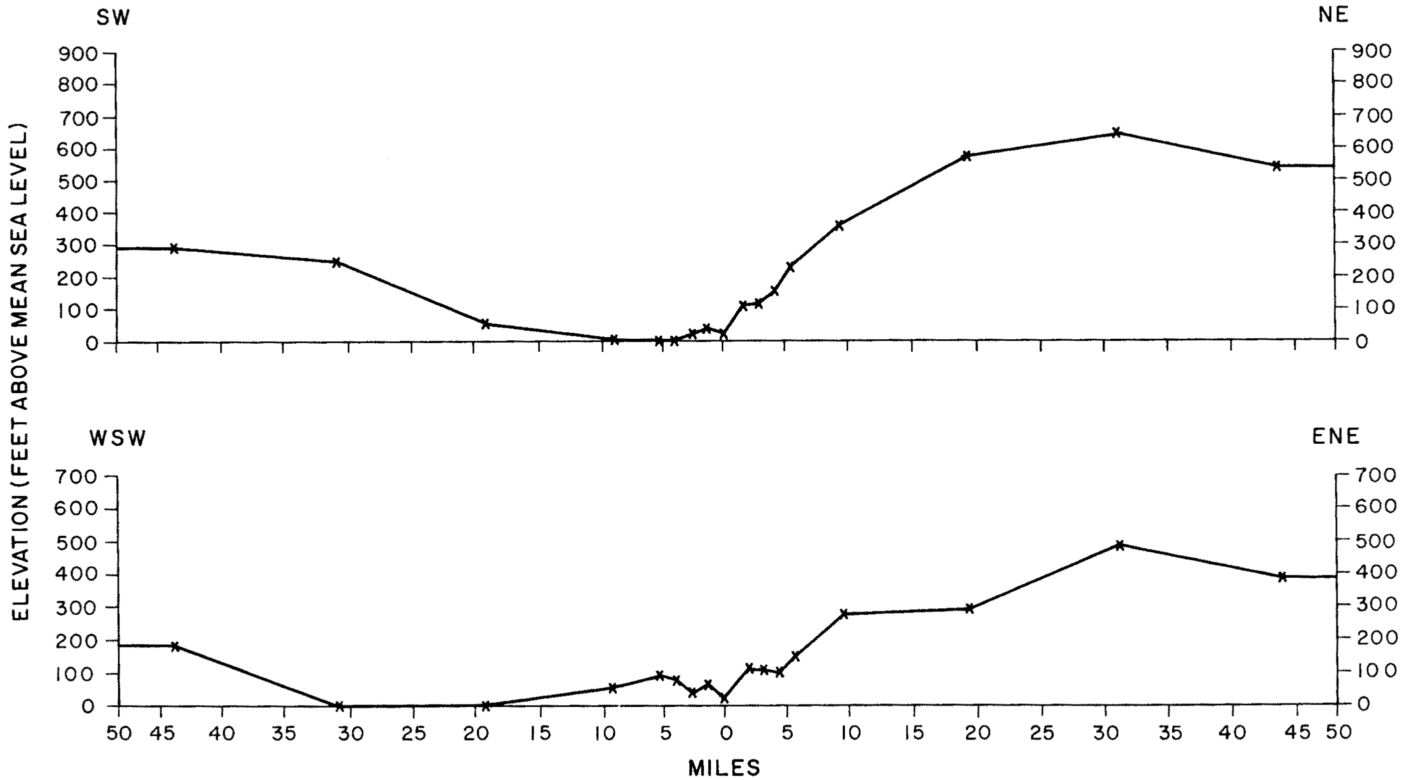
FIGURE 2.3–4 TOPOGRAPHICAL PROFILES WITHIN 50 MILES OF SITE (SHEET 1)



NOTE
X - MAXIMUM HEIGHT ESTIMATED WITHIN POPULATION WHEEL ANNULUS - SECTOR (LOCATION DEFINED BY MIDPOINT OF SECTOR)

FIGURE 2.3-4 (SHEET 1 OF 2)
TOPOGRAPHICAL PROFILES WITHIN 50 MILES OF SITE
MILLSTONE NUCLEAR POWER STATION
UNIT 3
FINAL SAFETY ANALYSIS REPORT

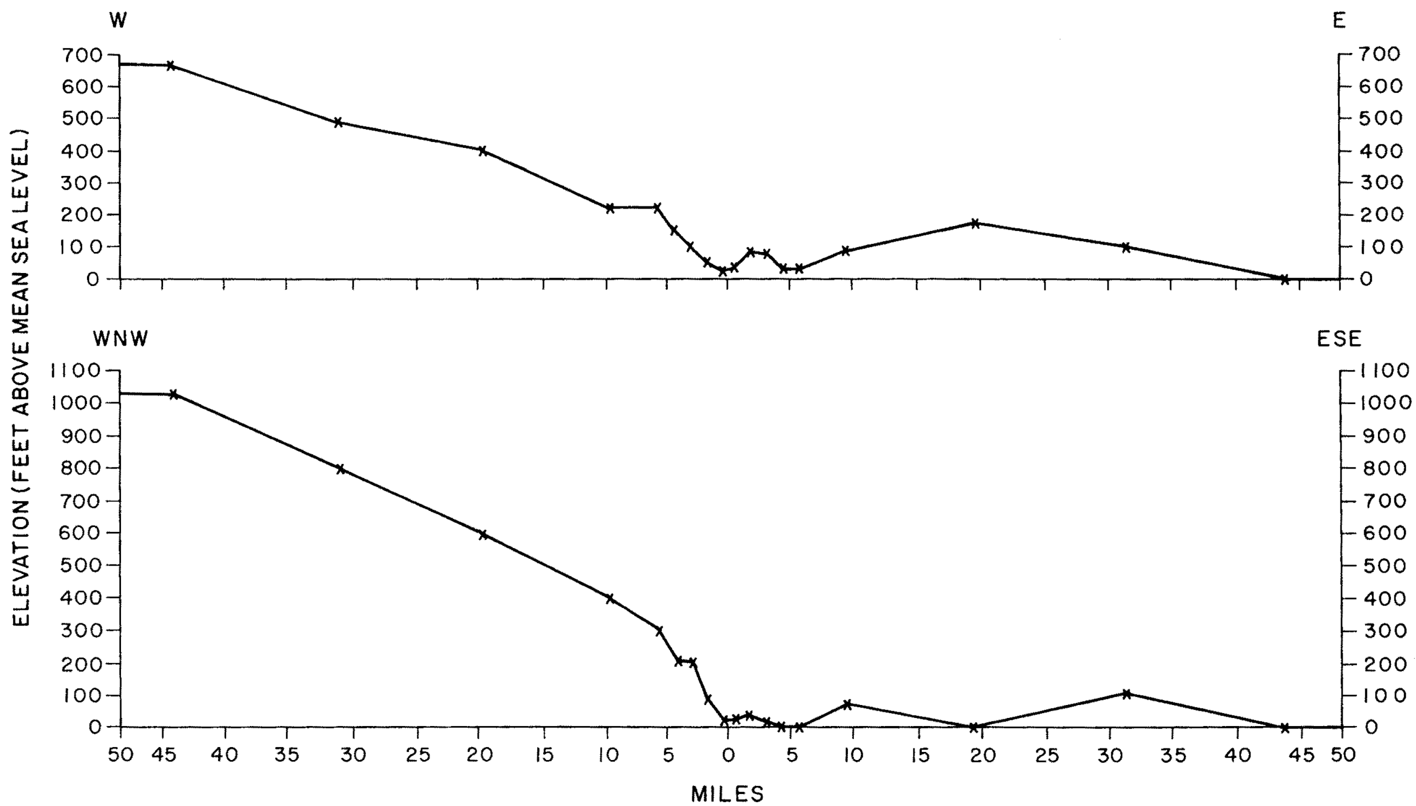
FIGURE 2.3–4 TOPOGRAPHICAL PROFILES WITHIN 50 MILES OF SITE (SHEET 2)



NOTE
X-MAXIMUM HEIGHT ESTIMATED WITHIN POPULATION WHEEL ANNULUS-SECTOR (LOCATION DEFINED BY MIDPOINT OF SECTOR)

FIGURE 2.3-4 (SHEET 2 OF 2)
TOPOGRAPHICAL PROFILES WITHIN 50 MILES OF SITE
MILLSTONE NUCLEAR POWER STATION
UNIT 3
FINAL SAFETY ANALYSIS REPORT

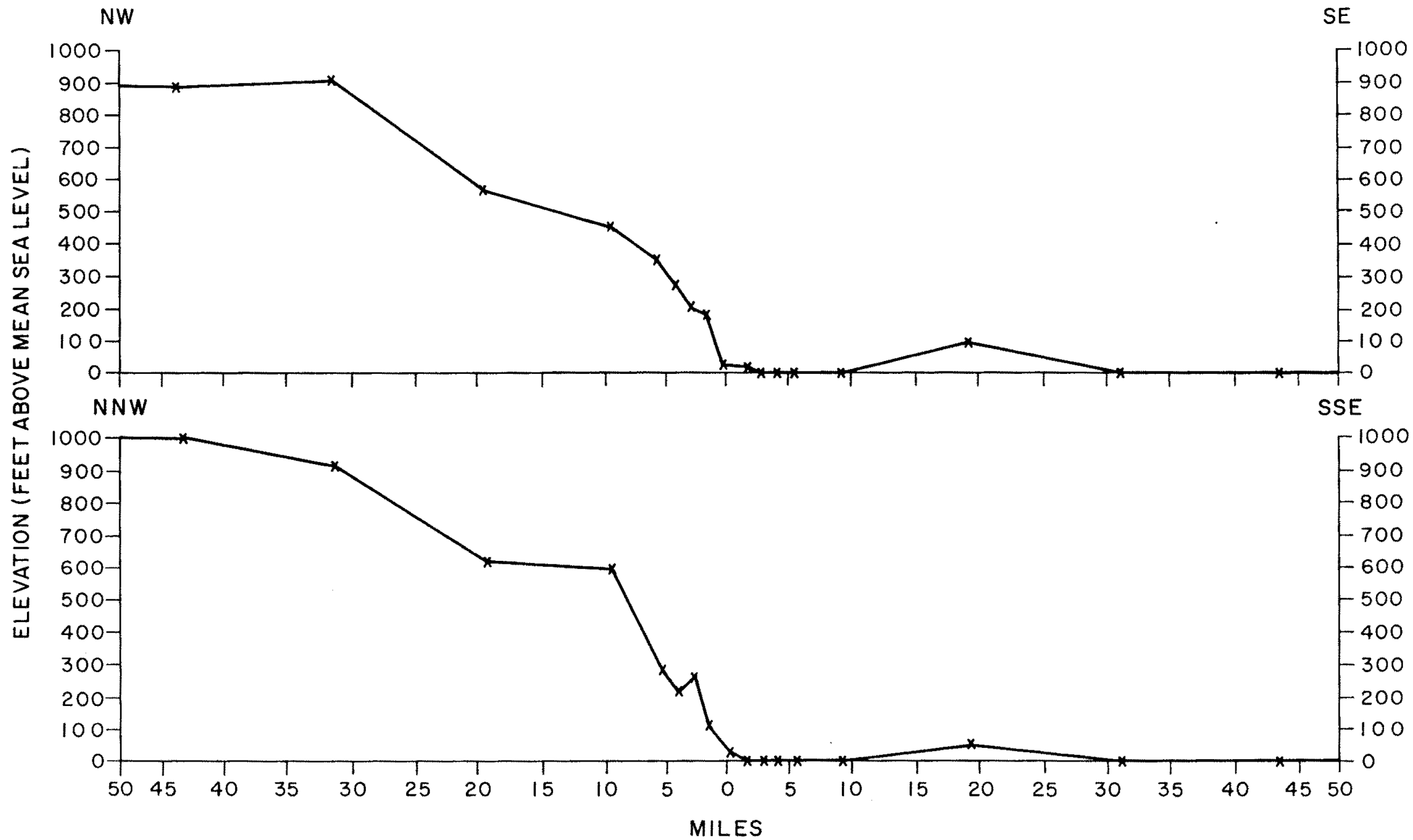
FIGURE 2.3–5 TOPOGRAPHICAL PROFILES WITHIN 50 MILES OF SITE (SHEET 1)



NOTE
X-MAXIMUM HEIGHT ESTIMATED WITHIN POPULATION WHEEL ANNULUS-SECTOR (LOCATION DEFINED BY MIDPOINT OF SECTOR)

FIGURE 2.3-5 (SHEET 1 OF 2)
TOPOGRAPHICAL PROFILES WITHIN 50 MILES OF SITE
MILLSTONE NUCLEAR POWER STATION
UNIT 3
FINAL SAFETY ANALYSIS REPORT

FIGURE 2.3–5 TOPOGRAPHICAL PROFILES WITHIN 50 MILES OF SITE (SHEET 2)



NOTE
X-MAXIMUM HEIGHT ESTIMATED WITHIN POPULATION WHEEL ANNULUS-SECTOR (LOCATION DEFINED BY MIDPOINT OF SECTOR)

FIGURE 2.3-5 (SHEET 2 OF 2)
TOPOGRAPHICAL PROFILES WITHIN 50 MILES OF SITE
MILLSTONE NUCLEAR POWER STATION
UNIT 3
FINAL SAFETY ANALYSIS REPORT

FIGURE 2.3–6 GENERAL TOPOGRAPHY - 50 MILES (SHEET 1)

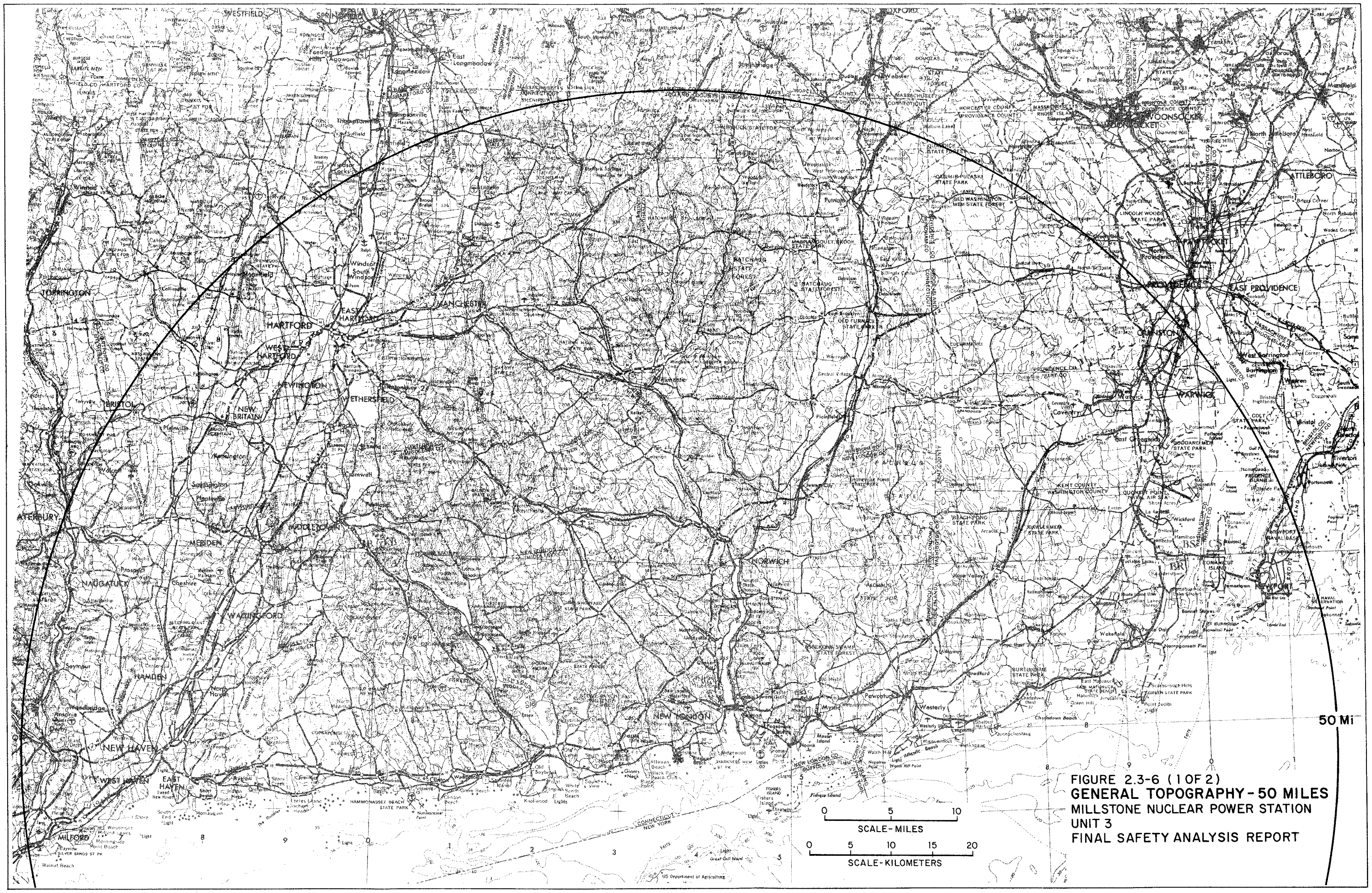


FIGURE 2.3–6 GENERAL TOPOGRAPHY - 50 MILES (SHEET 2)

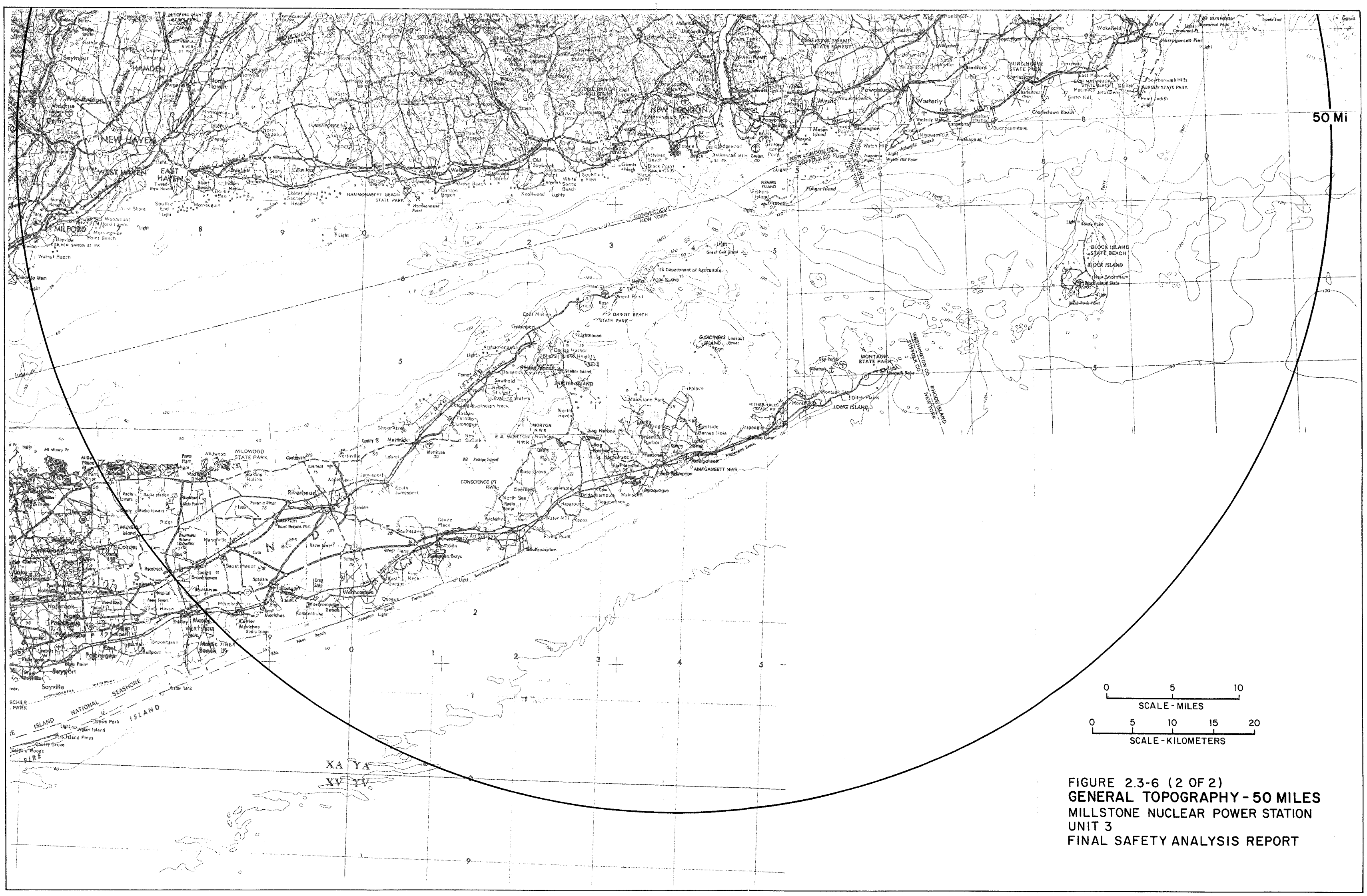


FIGURE 2.3-6 (2 OF 2)
GENERAL TOPOGRAPHY - 50 MILES
MILLSTONE NUCLEAR POWER STATION
UNIT 3
FINAL SAFETY ANALYSIS REPORT

FIGURE 2.3–7 METEOROLOGICAL INSTRUMENT AND DATA QUALITY ASSURANCE FLOW DIAGRAM

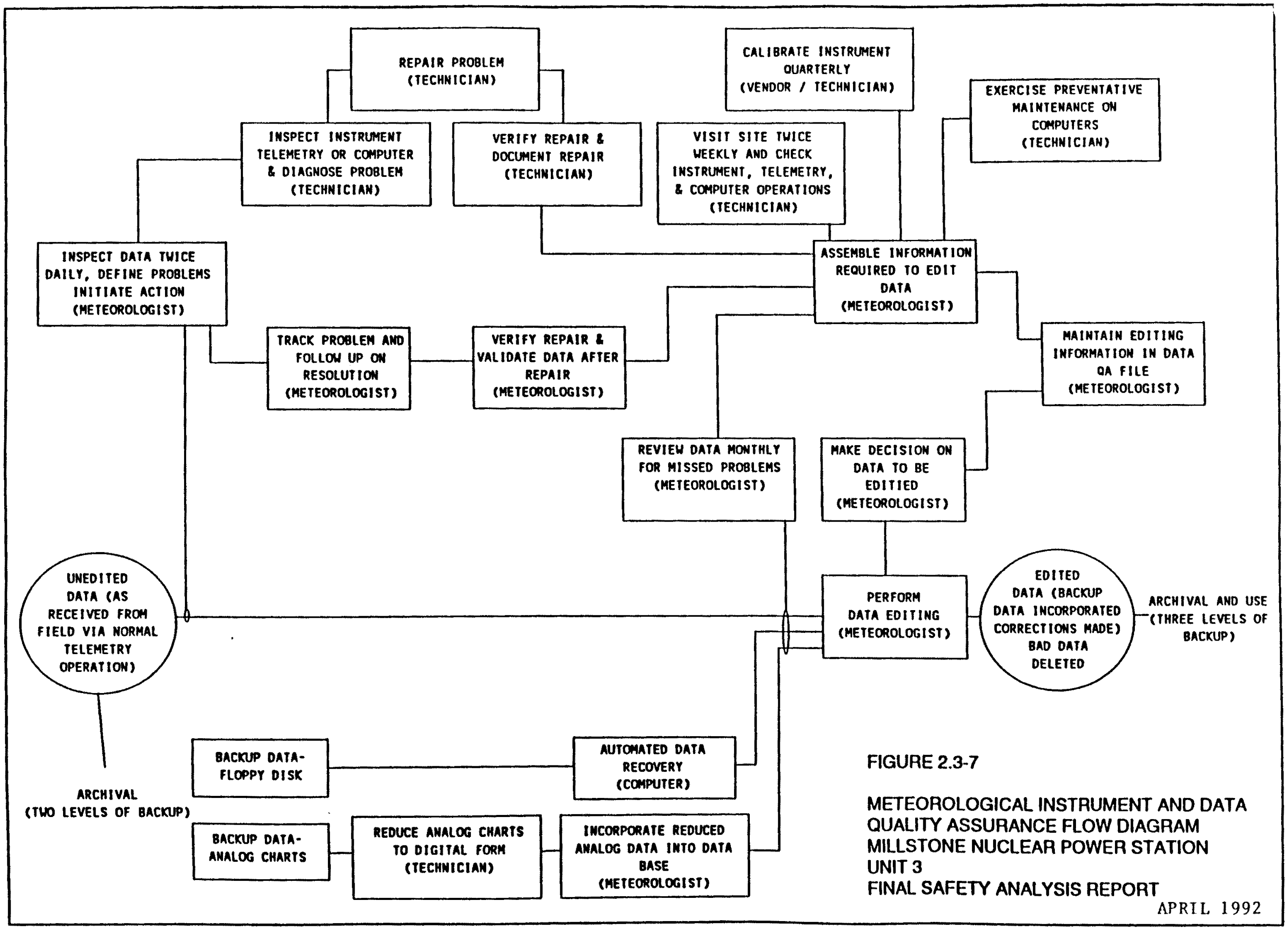


FIGURE 2.3-7

METEOROLOGICAL INSTRUMENT AND DATA QUALITY ASSURANCE FLOW DIAGRAM
MILLSTONE NUCLEAR POWER STATION
UNIT 3
FINAL SAFETY ANALYSIS REPORT
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2.4 HYDROLOGIC ENGINEERING

The information given here is sufficient for making an independent hydrological engineering review of hydrologically related design bases, performance requirements, and bases for operation of structures, systems, and components important to safety. It considers the hydrological phenomena and conditions associated with the site. It also gives the flooding protection requirements and the emergency operation requirements.

2.4.1 HYDROLOGIC DESCRIPTION

This section describes the site and all safety related elevations, structures, exterior accesses, equipment, and systems from the standpoint of hydrologic considerations.

2.4.1.1 Site and Facilities

Millstone Point is located on the north shore of Long Island Sound. To the west of the site is Niantic Bay and to the east is Jordon Cove. Figure 2.4–1 shows the topography of the site, and Figure 2.3–1 shows the general topography of the Millstone area. As discussed in Section 2.4.5, the large radius, slow forward speed of translation, probable maximum hurricane (RL/ST PMH) was used to calculate the maximum still water level, or surge, and the design basis flood level (maximum combination of storm surge and wave runup). All safety related unit structures and equipment, except the circulating and service water pump house, are protected from flooding due to storm surge by the site grade of elevation +24 feet msl. Flood protection of the pump house and other safety related structures and facilities from hydrologically or hydrometeorologically induced flooding is discussed in Section 3.4.1.

2.4.1.2 Hydrosphere

The public water supplies within a 20 mile radius of the site are identified on Figure 2.4–2. The surface and groundwater supplies within a 20 mile radius are identified and their characteristics are listed in Table 2.4–1. This information was furnished by the Water Supplies Section, Bureau of Health Promotion and Disease Prevention of the Connecticut State Health Department. The nearest surface water supply is the New London Water Company's Lake Konomac, 6 miles north-northwest of the site. No surface drainage from the site could affect these reservoirs due to the distance involved, the topography, the expected groundwater gradient between the reservoir areas and the site, and the generally impervious nature of the overburden on and near the site.

The bedrock surface outcrops at the south end of Millstone Point and is generally covered with a layer of dense glacial till towards the north end. Groundwater flows across the site through the pervious outwash sands in a northeast-southwest direction towards Long Island Sound at approximately a 2-percent gradient, as shown on Figure 2.5.4–37. Some surface water collects in depressions in the marshy areas north of the site.

Section 2.4.13 describes the groundwater hydrology in the vicinity of the site.

An abandoned granite quarry is located on the southeast side of Millstone Point. Rock outcrops on the promontories with beach deposits located in the protected areas of the shoreline. Much of the southern portion of Millstone Point is protected from wave action by concrete seawalls adjacent to the intake structures of the three Millstone units.

Normal tides at Millstone Point are semidiurnal with a mean range of 2.7 feet and a spring range of 3.2 feet. Tides in excess of the mean high water occur on an average as follows: in excess of 3 feet about once a year, in excess of 2 feet about 5 times a year, and in excess of 1 foot about 98 times a year. Mean high water (mhw) at Millstone Point is 1.3 feet msl. Mean low water (mlw) is -1.4 feet msl.

Tidal current measurements were made at various locations in the vicinity of Millstone Point, by the Essex Marine Research Laboratory in 1965, and by the U. S. Coast and Geodetic Survey (USC&GS, now NOAA) in August and September of 1965. Figure 2.4–3 shows the location of the survey stations.

The results of the Essex Marine Laboratory tidal current survey (Figure 2.4–4), taken at the index station indicate an asymmetry between the flood and ebb tides, with the flood tide achieving a peak velocity of 1.75 fps and the ebb tide reaching a peak velocity of 1.48 fps. The USC&GS 1965 data are generally consistent with the data collected by the Essex Marine Laboratory.

Bottom profiles (Figure 2.4–5) were run by Essex Marine Laboratory from Station 1 through Station 2 to the shoreline, and from Station 4 to Station 3 to the shoreline, with a continuous recording fathometer. Using a mean velocity of 0.857 fps for the tidal cycle beginning 1 hour before low slack water on September 2, 1965 (obtained from the current survey) calculations show a mean tidal flow of 126,287 cfs in the Twotree Island Channel, and 79,186 cfs across the section running from Station 4 northeast toward the shore.

2.4.2 FLOODS

This section reviews the flood history in the vicinity of Millstone Point, flood design considerations, and the effects of local intense precipitation.

2.4.2.1 Flood History

The only sources of flooding that could affect Millstone 3 are direct rainfall and storm surge. Section 2.3.1 discusses historical rainstorms. Historical hurricanes and the resulting surges are described in this section.

Since Millstone Point is a peninsula projecting into Long Island Sound, it is subjected to tidal flooding from severe storms. The highest such flooding has resulted from the passage of hurricanes. The literature (NOAA 1968, U.S. Army Corps of Engineers 1965, Harris 1963, and Redfield et al., 1957) indicates that twelve severe hurricanes have crossed coastal southern New England since 1635 and that four of these storms occurred in the past 40 years.

These four are listed below along with the location where each storm center entered southern New England and its distance from Millstone Point. The tabulation also gives maximum flood tide levels recorded in the vicinity of Millstone Point.

Storm Center Flood Tide

Date of Hurricane	Inland Crossing	Distance from Millstone Point	Flood Tide Levels (msl in feet)
9/21/38	15 miles east of New Haven	20 miles west	9.7
9/14/44	Between Charlestown, RI, and Pt. Judith, RI	35 miles east	6.2
8/31/54	Vicinity of Millstone Point	Within vicinity	8.9
9/12/60	Vicinity of Millstone Point	Within vicinity	6.0

Figure 2.4–6 is a frequency plot of tidal flooding at New London, Connecticut, about 10 miles east of Millstone Point. This figure was based on information presented in Plate 1-6 of the U.S. Army Corps of Engineers report (1965). The plot is based on 25.5 years of records (July 1938 - December 1963) at a recording tide gage located at the State Pier in New London since July 1938 and 149 year record (1815- 1963) of high water marks. The continuous tide record was used to define the lower end of the frequency curve, and the record of high water marks was used to establish the upper portion of the curve. Because of the proximity of Millstone Point to New London and because of the similar exposure of the two areas to tidal flooding, the frequency plot is representative of Millstone Point tidal flood frequencies. This plot indicates that the 9.7-foot level recorded during the 1938 hurricane would have a recurrence interval of about 335 years and the 8.9-foot level reached in 1954 would have a recurrence interval of about 100 years.

2.4.2.2 Flood Design Considerations

The controlling event for flooding at the Millstone site is a storm surge resulting from the occurrence of a probable maximum hurricane (Section 2.4.5). As discussed in Section 2.4.5, the maximum still water level is +19.7 feet msl, and the associated wave runup elevation is +23.8 feet msl. All safety related unit structures and equipment, except the circulating and service water pumphouse, are protected from flooding due to storm surge by the site grade elevation for Unit 3 of +24.0 feet msl. The service water pumps and motors are located at elevation +14.5 feet msl inside watertight cubicles of the pumphouse. The walls of the cubicles are watertight to elevation +25.5 feet msl, protecting the pump motor control centers and associated electrical equipment from flooding due to wave action and storm surge. The front wall of the intake structure extends to elevation +43.0 feet msl; it is designed to withstand the forces of a standing wave or clapotis with a crest elevation of +41.2 feet msl. Section 3.4.1 gives further flood design considerations on storm surge and wave action.

The design basis flood levels for the Millstone site comply with Regulatory Guide 1.59, Revision 2, as follows:

1. The design basis flood levels comply with Regulatory Guide 1.59, Revision 2, Positions C.1.b, C.1.e, and C.4.

2. Regulatory Guide 1.59, Revision 2, Positions C.1.a, C.1.c, C.1.d, C.2.a, C.2.b, C.2.c, C.2.d, and C.3 are not applicable.

Refer to Section 1.8 for clarification to Position C.1.

No commitments for compliance are made or implied for the “to be issued” appendices.

2.4.2.3 Effect of Local Intense Precipitation

Hydrometeorological Report No. 33 (U.S. Weather Bureau 1956) was used to develop the design basis probable maximum precipitation (PMP) for the site. In addition, the most recent PMP guidance available on rainfall depth-duration relations, Hydrometeorological Reports No. 51 (Schreiner 1978) and No. 52 (Hansen 1982), collectively referred to as HMR-51/52, was used to determined the impact of this ultra- conservative PMP-induced site flooding on plant safety-related structures.

The all season envelope PMP for the site based on HMR-51/52 is tabulated below. PMP values for durations of 5 to 15 minutes for drainage basins of less than 1 square mile are applicable to the Millstone site.

Probable Maximum Precipitation

Duration	Rainfall Depth for 1 mi^2 Area (inches)	Hydromet Report Number
5 min	5.86	52
15 min	9.22	52
30 min	13.2	52
1 hr	17.4	52
6 hr	26.0	51

The storm drains are designed to pass, without flooding, a rainfall intensity of 6.5 iph for an unlimited duration.

A study was performed to determine the impact of the HMR-51/52 PMP intensity on the roof. Roof area and ponding level due to PMP for Category I structures are presented in Table 2.4–12. Results of the study show that roofs of safety related structures are capable of withstanding loads due to accumulation of rainwater (see Table 2.4–9). Scuppers are provided in parapet walls of the control, hydrogen recombiner, and containment enclosure buildings to preclude the possibility of a large depth of standing water remaining on the roof in the unlikely event that the roof drains were plugged. Details of scuppers are provided on Figure 2.4–34. Roof ventilators are weatherproof and are located above the level of maximum ponding on the roofs.

Covers of equipment removal hatches are located on curbs which are higher than the roof parapet walls with the exception of the hydrogen recombiner building, control building, and the circulating and service water pumphouse. The hydrogen recombiner building hatch is flush with the roof slab. The entire roof is covered with a waterproof sheet membrane. The membrane is covered with a 6 inch thick reinforced concrete wearing slab. No leakage is anticipated. The intake pumphouse and control building hatch cover seals remain structurally intact under hydrostatic loading, which is not capable of overcoming the dead weight of the concrete hatch covers acting on the seals. Details for sealing of the hatch covers are provided on Figures 2.4–35, 2.4–36, and 2.4–37.

The overflow lengths of the parapet wall on the roof used in PMP analysis for Category I structures are presented in Table 2.4–13.

It was estimated that the seal of the hatch cover on the control building roof would be under a maximum depth of 3 inches of water for a short duration, during the peak roof ponding due to a PMP event. To make the seal watertight, a continuous 0.5 inch thick by 4 inch neoprene pad is cemented to the sill angle, which is embedded along the perimeter of the hatch cover curb. The 0.5 inch thickness envelopes the permitted tolerance in the construction of the hatch cover and the curb.

Site ground elevation surrounding all buildings is elevation 24.0 feet msl with all safety related building entrances and ground level floors set at elevation 24.5 feet except the Demineralized Water Storage Tank (DWST) Block House and Refueling Water Storage Tank (RWST)/SIL Valve Enclosure. The entrance elevation for the DWST Block House is elevation 24.33 feet with ground level floor set at elevation 24.0 feet msl and the entrance and ground level floor for the RWST/SIL Valve Enclosure are set at elevation 24.33 feet msl. The yard area north of the control building and the waste disposal building is depressed below elevation 24.0 feet to create a swale to drain the PMP flood flow. The site was considered to be rendered impermeable due to saturation prior to the onset of the precipitation of highest intensity.

The site was divided into drainage basins according to the revised topography and plant layout as shown on Figure 2.4–7. Runoff hydrographs were developed using the U.S. Army Corps of Engineers HEC-1 flood hydrograph computer program. The surface area of buildings that were within the drainage basins were included in the runoff calculations. The following two conservative assumptions were made for this analysis: (1) no credit was taken for the site storm drainage system, and (2) zero infiltration rate was assumed for the analysis. Data for the drainage basins, runoff coefficients, and computed flows are presented in Table 2.4–10.

Modifications were made to the grading plan at the site boundary to prevent water in Basins A and B from flowing into Basins C and D where the safety related structures are located.

Flow from three Drainage Basins (C, C′ and D as shown on Figure 2.4–7) on site affects water levels at safety related structures. Basin C consists of the yard area north of the control building and waste disposal building. Basin C′ consists of the yard area north of Basin C as constricted by existing structures. Basin D consists of the yard area south of the containment building. Flood water from basin C flows west past the waste disposal building to the area north of the control building, and then over the roadway to the west of the site. Water from Basin C′ has been conservatively assumed to contribute totally to Basin C flows. Water from Basin D flows east between the containment building and the railroad tracks, through the Unit 2 area and on to the quarry southeast of the site.

The computed flows were then used to determine the water surface profile for each basin by utilizing the latest version of the U.S. Army Corps of Engineers HEC-2 Computer Program (Water Surface Profiles, Computer Program 723-X6-L202A). The swales and depressions that form drainage channels were divided into reaches to construct the model. Cross sections were taken to accurately describe the channel, site topography, and project features such as road crowns and railroad tracks. The locations of the cross sections are shown on Figure 2.4–7. Conservative values for Manning's coefficient were chosen as follows: lawn areas 0.05, paved areas 0.015, combination paved and gravel areas 0.020 and gravel covered areas 0.025. PMP runoff was proportioned into local incremental flows and then introduced at the appropriate cross sections.

The computed water surface elevations at the safety related structures are summarized in Table 2.4–11. In Drainage Basin C, the computed water surface elevation exceeds the door sill elevation of 24.5 feet at the auxiliary building. In Drainage Basin D, the computed water surface elevation exceeds the door sill elevation of 24.5 feet at the main steam valve, auxiliary, engineered safety features, fuel and hydrogen recombiner buildings. A detailed analysis considering the effects of doors A-24-5 and A-24-6 in Drainage Basin D show that the water will not exceed elevation 25 feet inside door A-24-5. A ramp and curb are installed inside auxiliary building door A-24-5. The curb has a top elevation of 25.0 feet to keep runoff from Drainage Basin D from entering the auxiliary building.

Results of a detailed analysis of the hydrogen recombiner and main steam valve buildings showed that the depth of any potential inleakage would be on the order of 0.16 feet which is substantially less than the base of any safety related equipment. Detailed analysis of the engineered safety features building showed that the depth of any potential inleakage would be in the order of 0.44 feet in the worst location which is substantially less than the base of any safety related equipment. Detailed analysis of the auxiliary building in Drainage Basin C and the fuel building in Drainage Basin D showed that any potential inleakage would be insignificant and would not affect any safety related equipment.

In Drainage Basin D, the computed water surface elevation 24.85 feet exceeds the entrance floor elevation of 24.33 feet at the DWST Block House and the RWST/SIL Valve Enclosure. The worst submergence level of 24.85 feet would not affect any safety related equipment in the DWST Block House and RWST/SIL Valve Enclosure.

Service building exterior door may allow a small amount of inleakage into the service building. This water may leak into the auxiliary building or control building. The total inleakage into the auxiliary building or control building would be insignificant and result in submergence levels much less than that used for the environmental design of mechanical and electrical equipment as identified in Section 3.11.

Since the intensity of winter PMP is only about half of the annual PMP (U.S. Weather Bureau 1956) and the snow accumulation on the road is plowed regularly, flooding at the site is not anticipated in the winter.

2.4.3 PROBABLE MAXIMUM FLOOD ON STREAMS AND RIVERS

There are no major rivers or streams in the vicinity of Millstone Point, nor are there any watercourses on the site. A number of small brooks flow into Jordan Cove, east of the site, and into the Niantic River and thence to Niantic Bay, west of the site. Any flooding of these brooks, even as a result of the probable maximum precipitation, would not significantly raise the water levels in Niantic Bay, Jordan Cove, or Long Island Sound in the vicinity of the site. Additionally, in each area, local topography precludes flooding of any portion of the site from the landward side.

2.4.4 POTENTIAL DAM FAILURES, SEISMICALLY INDUCED

Since there are no major rivers or streams in the vicinity of Millstone Point, the effects of potential dam failures, seismically induced, are not applicable.

2.4.5 PROBABLE MAXIMUM SURGE AND SEICHE FLOODING

2.4.5.1 Probable Maximum Winds and Associated Meteorological Parameters

The meteorological characteristics used to calculate the probable maximum storm surge at the Millstone Point site are those associated with the PMH as reported by the U.S. National Oceanic and Atmospheric Administration (NOAA) in their unpublished report HUR 7-97 (NOAA 1968). HUR 7-97 describes the PMH 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. The hurricane characteristics used in establishing the PMH include:

1. Central Pressure Index (CPI) - the minimum surface pressure in the eye of the hurricane

2. Radius of Maximum Wind (R) - the distance from the eye of the hurricane to the locus of maximum wind

3. Forward Speed (T) - the rate of forward movement of the hurricane center (eye)

4. Maximum Gradient Wind (V_{gx}) - the absolute highest wind speed in the belt of maximum winds

5. Peripheral Pressure (P_n) - the surface pressure at the outer limits of the hurricane where hurricane circulation ends

HUR 7-97 presents values for each of those characteristics for each degree of north latitude along the East Coast United States. Single values are presented for CPI and P and three values are given for both R and T. Since V_{gx} is dependent upon P_n, CPI, and R, three values are also given for this parameter. At the Millstone Point latitude (approximately 41 degrees north) the following PMH characteristics are recommended in HUR 7-97 (NOAA 1968).

1. CPI: 27.26 in Hg

2. R for small radius storm (RS): 8 nmi

   R for medium radius storm (RM): 24 nmi
   R for large radius storm (RL): 48 nmi

3. T for slow forward speed (ST): 15 knots

   T for high forward speed (HT): 51 knots
   T for high forward speed (HT): 51 knots

4. V_{gx} for RS: 131 mph (114 knots)

   V_{gx} for RM: 128 mph (111 knots)
   V_{gx} for RL: 124 mph (108 knots)

5. P: 30.56 in Hg

The PMH maximum gradient wind speeds are used for surge analysis only, design wind loads for structures can be found in Section 3.3.1.

2.4.5.2 Surge and Seiche Water Levels

Although frontal storms and squall lines cause tidal flooding in the Millstone Point area, by far the most severe flooding has resulted from hurricanes. For this reason, the PMH as defined in HUR 7-97 (NOAA 1968) was used to compute the design storm surge level at the site. The calculated total surge height or still water level includes the wind setup, the water level rise due to barometric pressure drop, the astronomical tide and forerunner or initial rise.

Calculation of the total surge height used a computerized bathystrophic storm surge model, which is based on procedures described in Freeman et al. (1957), Bodine (1971), Bretschneider et al. (1963), and Marinos et al. (1968). This theory was derived from the momentum and continuity equations with basic physical assumptions (Freeman et al., 1957, Bodine 1971). The model has been used to predict hurricane surge with good agreement with observed data (Bretschneider et al., 1963, Marinos et al., 1968). Use of this model requires that the storm be brought ashore from the edge of the continental shelf in a direction perpendicular to the general trend of the bottom contours. The surge is computed along the path of the locus of maximum winds as the storm moves onshore. In determining the maximum surge at Millstone Point, the locus of maximum winds is brought inshore along a track which passes just to the east of the eastern end of Long Island. This track produces the maximum surge heights at the mouth of Long Island Sound and consequently at Millstone Point.

Use of the bathystrophic storm surge program requires the input of several meteorological and physical parameters, including: the central pressure, the peripheral pressure, the maximum wind speed, the radius to maximum wind, the speed of translation, the initial rise, the astronomical tide, the bottom profile along the track of the maximum winds, the bottom friction coefficient, and the shape of the curve describing the relationship between the ratio of wind speed at any point to maximum surface wind speed and the ratio of the radius at any point to the radius to maximum wind. In addition, provision is made to enter a wind stress correction factor.

In general, the maximum surge and maximum wave need not be coincidental. For this reason, surge, wave heights, and corresponding runup at different times were considered. The maximum combination of the surge and runup on various plant structures were considered as the most severe flood level for the site.

Memorandum HUR 7-97 (NOAA 1968) gives three different values for both radius to maximum wind and speed of translation; therefore, it was necessary to compute nine different surge levels using all of the possible combinations of meteorological parameters. These calculations indicated that the large radius (RL) slow speed of translation (ST) storm yields the highest surge level at Millstone Point. The input parameters for this storm are as follows:

Central pressure	27.26 inches Hg
Peripheral pressure	30.56 inches Hg
Maximum gradient wind	124 mph (108 knots)
Radius to maximum wind	48 nmi
Speed of translation	15 knots
Astronomical tide (10 percent exceedance high tide)	2.4 feet above msl
Initial rise (Regulatory Guide 1.59, Table C.1)	1.0 feet
Bottom friction	0.0025
Wind stress coefficient factor	1.10
Bottom profile (Figure 2.4–8)	
Hurricane track (Figure 2.4–12)	

Surge analyses based on different types of hurricanes show that the large radius, slow forward speed hurricane produces the maximum stillwater level at the Millstone site.

The resulting maximum surge stillwater level is +19.7 feet msl. Additional surge data, including surge hydrographs for all three large radius storms, are shown on Figures 2.4–9 through 2.4–11.

2.4.5.3 Wave Action

Wave characteristics are dependent upon wind speed and duration, wind direction, fetch length, and water depth. Millstone Point is sheltered from the direct onslaught of open ocean waves by Long Island. Moreover, the unit itself is located on the western side of the Point and a considerable distance (about 2500 feet) inland from the southernmost tip. Thus, the topography of the Point itself protects the unit area from breaking waves during the period of peak tidal flooding when the winds are from the southeast quadrant.

For maximizing hurricane effects, the hurricane track was bent in order to have the maximum wind attack the site for the maximum possible time. The tracks are shown on Figures 2.4–12 through 2.4–14. Because of the location of the site, two possible methods of generating maximum waves, deep- and shallow-water waves, were considered.

2.4.5.3.1 Deep Water Waves

The first method was to generate deep-water waves offshore of the continental shelf and let them propagate over the shelf to Block Island Sound, finally reaching the Millstone location. Two independent analyses, one graphically by Wilson (1955, 1963) and the other computational by Bretschneider (1972) provide comparison for deep water waves.

Wilson Analysis

Wave forecasting in deep water depends on a number of empirical relationships involving the variables of significant wave height H, significant wave period T, wind velocity U, wind duration t, and length of the fetch F.

These relationships are as follows:

$$\frac{gH}{U^2} = 0.26 \tan h \left[\frac{1}{100}\left(\frac{gx}{U^2}\right)^{1/2}\right] \tag{2.4.1}$$

$$\frac{c}{U} = 1.40 \tan h \left[\frac{4.36}{100}\left(\frac{gx}{U^2}\right)^{1/3}\right] \tag{2.4.2}$$

where:

H = Wave height (ft)

U = Wind velocity (fps)

c = Deep water velocity of significant waves (fps)

x = Finite fetch over deep water (ft)

g = Acceleration due to gravity (ft/sec^2)

By using Equations 2.4.1 and 2.4.2 and the fact that the group velocity of the wave is half of its wave celerity, a H-t-F-T diagram covering the variables H, T, U, t, and F was constructed according to Wilson's graphical method. A transect along the forward direction on the hurricane wind field was then chosen, such that the wind components represent the maximum energy available for the wave generation. At this time, a space-time field of the wave generating wind component was constructed in conjunction with the hurricane forward velocity.

By adjusting the space-time field in the t-F quadrant of the H-t-F-T diagram, different significant wave heights and wave periods can be obtained for specific locations of the hurricane. This method was applied to the RL ST, RL MT, and RL HT probable maximum hurricanes, with the results given in Table 2.4–2. The low speed hurricane exhibited higher deep water waves than the medium or high speed hurricanes.

Special adaptation of the H-t-F-T diagram also gave information regarding time lags between surge levels and wave heights. This was accomplished by determining distances from the hurricane eye to the actual wave and noting that the hurricane travels at its translational velocity and the wave at its group velocity.

Bretschneider Analysis

The analysis by Bretschneider (1972) uses empirical data of 51 typical hurricanes to determine nondimensional, stationary deep water wave field models. The maximum significant wave height due to a stationary hurricane is as follows:

$$H_R = k' \sqrt{R \Delta P} \qquad (2.4.3)$$

where:

k′ is determined from the 51 model hurricanes

H_R = Maximum significant wave height at R, stationary hurricane (ft)

R = Radius to maximum wind (nmi)

ΔP = Central pressure reduction from normal (in Hg)

For a hurricane moving forward at a speed equal to or less than the critical forward speed (V_{CR} = 16.3 exp RΔP/200), it can be shown that:

$$H'_R = \left[1 + \frac{2\Delta U}{U_R} + \left(\frac{\Delta U}{U_R}\right)^2\right] H_R \qquad (2.4.4)$$

$$\Delta U = 1/2\ V \cos\theta \qquad (2.4.5)$$

where:

H'_R = Maximum significant wave height (feet, corrected for forward speed of hurricane)

U_R = Maximum wind speed (knots)

V = Forward speed of hurricane (knots)

θ = Angle position of the radius measured counter-clockwise from its axis (degrees)

It was found that Bretschneider's estimate of hurricane waves produced by slow moving hurricanes was in agreement with the graphical solution of Wilson (Table 2.4–2). Bretschneider also provided formulation for calculating the critical wave speed. The medium and high-speed hurricanes were found to have forward speeds higher than the critical speed computed. Since Bretschneider's method included assumptions applying only to the slow moving storms, no comparison was possible with the waves generated by medium and high speed storms.

2.4.5.3.2 Shallow Water Waves

The second method considers shallow water wave generation. The geographic characteristics of Long Island Sound prevent deep-water waves from propagating through Long Island Sound. However, as hurricanes follow the track, moving over Long Island Sound and turning north-eastward as shown on Figures 2.4–12 through 2.4–14, wind generates waves within the Sound. As a wave grows in height and length, the attenuation of energy by bottom friction begins to hinder its growth. The wave attack on site thus depends on the complex interaction of shoaling, bottom friction, refraction, wind duration, and available fetch.

Energy loss due to bottom friction has been studied by Putnam and Johnson (1949), Bretschneider and Reid (1954), and Bretschneider (1954a). Combining the deep-water wave relationship given by Wilson (1963) and the shoaling and energy dissipation by friction Putnam and Johnson (1949), Bretschneider and Reid (1954), Bretschneider (1954a, b) used a numerical method to study shallow water wave generation.

Bretschneider's method (1954b) is extensively used in this study with a conservative friction coefficient of 0.01 as suggested by the U.S. Army Corps of Engineers, Shore Protection Manual (1977). However, instead of using a constant wind, a variable wind for generating the wave was taken to be the wind component along the specific direction of the hurricane.

Actual bottom topography along the specific direction was also used. The location and bottom topography of the three transects considered for Long Island Sound are shown on Figure 2.4–15. Wave heights generated by the slow, medium, and high speed PMH are shown in Tables 2.4-3 through 2.4-5.

2.4.5.3.3 Wave Shoaling

Changes in deep-water waves occur as they cross the continental shelf into intermediate water depths. The effects which must be included are the combined effects of bottom friction, the continued action of the wind, and the forward speed of the hurricane. All of these effects were taken into account by a computer program following the method developed by Harrison and Wilson (1964).

The above method also makes use of dissipation functions, introduced by Putnam and Johnson (1949), which obtain the reduction factor due to friction for any bottom slope, depth, initial wave height, or wave period. The continued action of the wind was taken into account by using Bretschneider's (1954a) determination of energy added to wind stress. The results of wave height reduction due to shoaling, with dissipation functions included, are shown in Table 2.4–2.

2.4.5.3.4 Wave Refraction

The process of refraction causes water waves to change direction when going from deep water to shallow water, because the inshore portion of the wave front travels at a lower velocity than does the portion in deep water. It is this change in orthogonal directions which causes the wave heights to be either magnified or reduced.

A program by Harrison and Wilson (1964) was adopted for the wave refraction study.

With the depth information on the constructed grid layout and the incident wave period and angle, the program constructed the wave rays inside the grid layout. In each ray construction step, a linear interpolation from wave celerities at four adjacent grid points was used. Wave refraction was considered to be significant for waves traveling through the Block Island Sound grid (along with shoaling) and the Millstone grid (Figure 2.4–16). The actual areas considered, along with refraction diagrams at various angles of approach, are shown on Figures 2.4–17 through 2.4–21. The resulting wave heights after shoaling and refraction are shown in Table 2.4–2.

2.4.5.3.5 Wave Runup

The wave data at three critical transects (Figures 2.4–22 through 2.4–25) was used to compute the elevation of maximum wave runup. Saville's method of composite slopes (U.S. Army Corps of Engineers 1977) was used, which relies on laboratory data to form curves relating the runup to wave steepness, structure type, and the depth at the structure toe. In order to obtain a maximum runup, the method of composite slopes was applied to several wave periods within the permissible range along with several controlling depths. The maximum runup for transects B and C, which occurs during the slow speed PMH, was calculated to be +23.8 feet msl and +21.2 feet msl, respectively.

2.4.5.3.6 Clapotis on Intake Structure

The water depth at the intake structure and the characteristics of the incident waves determine what type of waves would be formed at the intake, i.e., nonbreaking, breaking, or broken waves. Detailed analysis of incident waves showed only nonbreaking and broken waves are possible at the intake of Millstone 3. The bottom profile leading to the intake structure is shown on Figure 2.4–23.

Using the Miche-Rundgren (U. S. Army Corps of Engineers 1977) method, the maximum water level on the intake structure was calculated to be +41.2 feet msl. The maximum high water occurred for the slow speed PMH at the time of the peak surge of +19.7 feet msl and a wave height of 16.2 feet. Using this information, the maximum wave loading on the front of the intake structure was calculated and is shown on Figure 2.4–26.

2.4.5.4 Resonance

Resonance phenomena in a water body excited by incident waves from the open sea are associated with one or more of that body's natural periods. These natural periods vary with the size, shape, and depth of the water body. The extent of amplification at resonant period decreases with an increase in the order of harmonics considered. Therefore, in a resonant study, only the first few lower harmonics are of concern.

For the Millstone Point quarry in particular, neither the storm surge nor the waves associated with a PMH would cause the type of wave oscillations that are common in some harbors. The storm surge is a long wave whose period is far greater than the natural period of the quarry which is estimated to be about 1 minute. The net effect of the surge is to cause the water level in the quarry to vary slowly in accordance with the water level variations in the immediately adjacent areas of Long Island Sound.

During the peak surge period, general flooding of the Millstone Point area causes the quarry to become part of the open sea where resonance is not of concern. At a lower surge level, both before and after the peak surge period, the quarry is connected to Long Island Sound by the discharge channel which would allow waves to be transmitted in the quarry. However, because the incoming wave period would be in the order of 10 seconds, about one-sixth of the estimated natural period along the long axis of the quarry, there would be no significant amplification of the waves transmitted into the quarry. Moreover, the shape of the quarry is irregular and its boundary walls are not vertical resulting in scattering and imperfect reflection of waves and thereby greatly dampening the available wave energy.

Because the quarry is deep (about 100 feet), the wind fetch is short (about 1,400 feet), and there is an outlet from the quarry to the Sound, there would be no natural period seiching in the quarry due to variable hurricane winds.

2.4.5.5 Protective Structures

All safety related structures and equipment, except the circulating and service water pumphouse, are protected from flooding due to storm surge and wave action by the site grade elevation of +24 feet above msl. The effects of wave action on the pumphouse is the only topic discussed in this section, flood protection of the pumphouse is discussed in Sections 2.4.1 and 3.4.1.

The seaward wall of the intake structure is constructed of reinforced concrete designed to withstand the forces of a standing wave, or clapotis, with a maximum crest elevation of +41.2 feet msl. The resultant hydrostatic pressure distribution on the intake wall is shown on Figure 2.4–26.

To determine the maximum uplift pressure on the pumphouse floor, several combinations of surge level and coincident wave height for three different speed PMHs were examined. The maximum uplift pressure on the watertight cubicles within the pumphouse was generated by the maximum surge level of 19.7 feet msl and coincident wave height of 16.2 feet. The maximum net uplift pressure on the pumphouse floor with openings was generated by a surge level at the same level as the bottom of the pumphouse floor (11.5 feet msl) and a coincident wave height of 16.9 feet.

The calculated maximum uplift pressure on the watertight cubicles is 863 psf. The calculated maximum net uplift pressure on the pumphouse floor with openings is 557 psf. The pumphouse floor, including the watertight cubicles, is designed to withstand pressure of more than 863 psf.

The water level fluctuations within the pumphouse, resulting from storm surge and wave action, would be dampened by the energy lost in passage through the restricted openings in the trash racks, traveling screens, and operating deck. Internal water level fluctuations would be further attenuated because water must enter the structure through a submerged opening (elevation -7 to -30 feet) through which the pressure response factor would be less than unity.

Scour protection for the service water lines located behind the pumphouse is provided by a concrete retaining wall extending north from the west wall of the pumphouse.

Shoreline protection in the vicinity of the pumphouse to prevent beach erosion is discussed in Section 2.5.5.1.

2.4.6 PROBABLE MAXIMUM TSUNAMI FLOODING

The areas of the North American continent most susceptible to tsunamis are those bordering the Pacific Ocean and the Gulf of Mexico. Millstone Point is located on the North Atlantic coastline where there is an extremely low probability of tsunamis. Therefore, tsunamis are not considered to be credible natural phenomena which might affect the safety of the Millstone site.

2.4.7 ICE EFFECTS

There is no history of ice in Niantic Bay or ice jam formation in the area of the circulating and service water pumphouse. It is considered highly unlikely that ice would form or collect in a manner or amount sufficient to obstruct the flow to safety related pumps (Section 2.2.3).

A reinforced concrete curtain wall located at the front of the pumphouse and extending to -7.0 feet msl precludes floating or partially submerged ice from entering the pumphouse and damaging or blocking the bar racks.

Frazil ice formation takes place in the presence of supercooling, where turbulence is too great to allow surface ice to form, and can adhere to surfaces with a temperature equal to or less than the freezing point of water. However, at velocities of less than 2 fps, submerged frazil ice rises to the surface and form sheet ice (Bureau of Reclamation 1974). Since the water velocity in the area of the bar racks is approximately 1 fps, the possibility of submerged frazil ice adhering to the bar racks is considered unlikely.

2.4.8 COOLING WATER CANALS AND RESERVOIRS

There are no cooling water canals or reservoirs which would have any effect on safety related equipment.

2.4.9 CHANNEL DIVERSIONS

There are no channel diversions to the cooling water supply which would have any effect on safety related equipment.

2.4.10 FLOODING PROTECTION REQUIREMENTS

Section 3.4.1 discusses the flooding protection of safety related structures, and Section 2.4.2 gives a detailed discussion of the design criteria for site and roof drainage facilities.

Section 2.4.13 states that there is one Technical Requirements Manual item and one plant procedure that describe the requirements for protection of safety related equipment and facilities due to flooding.

2.4.11 LOW WATER CONSIDERATIONS

2.4.11.1 Low Flow in Rivers and Streams

Since Millstone 3 does not depend on either rivers or streams as a source of cooling water, this section is not applicable.

2.4.11.2 Low Water Resulting from Surges, Seiches, or Tsunamis

Probable minimum low water level at the Millstone 3 intake structure resulting from an occurrence of a PMH oriented so as to cause maximum depression of the water surface (setdown) at the site, is calculated to be -5.85 feet msl.

This estimate is based on a one-dimensional model with (U.S. Army Corp of Engineers 1977) with conservative assumptions regarding the hurricane track, wind field orientation, bottom profile, traverse line, and pressure effects. In addition, the model itself is inherently conservative because it does not consider return flow along the sides of the negative surge axis.

The large radius, slow speed of translation (LR/ST) PMH, with characteristics as specified in Section 2.4.5.1, is assumed to be the critical storm since the higher translational velocities of the high and medium speed of translation storms result in lesser offshore wind speeds on the backsides of those storms. The storm is assumed to approach along a track which is normal to the shoreline and which intersects the coast in western Rhode Island (Figure 2.4–27). The isovel pattern of the LR/ST PMH is assumed to be the overwater isovel pattern, (Figure 2.4–28) neglecting friction effects of overland traverse on the offshore part of the storm circulation. The wind field at Millstone results from the advection of this isovel pattern along the specified track and is shown on Figure 2.4–29. For the purpose of computing wind stress and resultant setdown, the offshore wind directions considered to apply are from 315 degrees clockwise through 045 degrees (with respect to true north). For the time period during which the winds are within this offshore direction, the average offshore wind speed is 82 mph. This wind speed is assumed to be applied along the traverse line (axis) of an outward moving surge under steady state conditions where the water surface level is balanced by the wind stress. A constant wind direction parallel to the surge traverse line is also assumed as a steady state condition.

The surge traverse and bottom profile lines assumed for the model (Figure 2.4–27) are conservative assumptions because the effects of Long Island are ignored and the surge is assumed to be directed into the open ocean; that is, a traverse line inside Long Island Sound would not produce as much setdown because the length of available fetch would be much shorter and bottom friction effects more pronounced due to shallower water.

The setdown at Millstone under the above assumptions was calculated for a wind speed of 82 mph. Figure 2.4–30 shows a plot of calculated setdown versus wind speed for a range of wind speeds from zero to 90 mph, added to the suggested 10-percent exceedence spring low tide level of -0.75 feet mlw. At 82 mph the probable minimum low water level is calculated to be -4.45 feet mlw or -5.85 feet msl.

The design low water level of the service water pumps is -8.0 feet msl, compared to a conservatively estimated -5.85 feet msl for probable minimum low water. Therefore, continuous operation of the service water pumps is ensured. The fire water pumps are supplied from two 250,000 gallon storage tanks connected to the public water system of the Town of Waterford. Probable minimum low water has no effect on these pumps.

2.4.11.3 Historical Low Water

Historical low tides at New London, Connecticut, from 1938 to 1974 are given in Table 2.4–6. The minimum tide level recorded at New London was about -4.8 feet msl on December 11, 1943.

2.4.11.4 Future Control

Consideration of future control of the cooling water source is unnecessary since the plant uses water from Niantic Bay. The use of water from the Bay by future users would not affect the cooling water supply because of the abundance of water available.

2.4.11.5 Plant Requirements

The ultimate heat sink consists of a single source of safety related cooling water, Long Island Sound. Long Island Sound contains sufficient volume to provide cooling for extended time periods (greater than 30 days) to permit safe shutdown of the unit. The minimum safety related cooling water flow required during accident conditions is provided in Table 9.2–1. Safety related plant water requirements for all modes of operation are given in Table 9.2–1.

During normal plant operation, cooling water is withdrawn from Long Island Sound and delivered by two of four available 15,000 gpm rated capacity service water pumps, enclosed in a Seismic Category I structure; the circulating and service water pumphouse (CSP). Figure 3.4–1 (sheets 3 and 4) shows the CSP (Section 3.4), configuration and minimum design operating water level. Each service water pump is designed to operate with a minimum submergence requirement of 4 feet.

2.4.11.6 Heat Sink Dependability Requirements

The ultimate heat sink for Millstone 3 is Long Island Sound. Sensible heat removed from both safety and non-safety related cooling systems during normal operation, shutdown, and accident conditions is discharged via the circulating and service water systems, through the quarry, and into Long Island Sound. Both the circulating and service water systems have as their source of water Niantic Bay, which is fed from Long Island Sound. The ultimate heat sink (Section 9.2.5) satisfies the requirements of Regulatory Guide 1.27.

Long Island Sound is capable of dissipating waste heat under all environmental and operating conditions. Table 2.4–7 lists the heat loads rejected under various operating modes.

The design low water level of elevation -8.0 feet msl for the service water pumps includes added conservatism to the calculated extreme low water level of elevation -5.85 feet msl (Section 2.4.11.2). The suction bells of the Millstone 3 circulating and service water pumps are located at elevation -19.5 feet msl and elevation -13.0 feet msl, respectively; well below the low water levels. Therefore, during all operating conditions, sea water is available to the safety related service water pumps. Table 9.2–1 gives the minimum cooling water flow required accident conditions for safety related service water loads. The circulating water system cooling water flow required during normal operating conditions is 912,000 gpm. Circulating water is not required during accident conditions.

The temperature extremes of the water in Niantic Bay and Long Island Sound are 80°F maximum and 33°F minimum (see Section 9.2.1.1). Long Island Sound and Niantic Bay can provide a 30 day supply of service water that does not exceed the design temperature, under any 30 day meteorological conditions that result in maximum evaporation.

The applicants have no knowledge of any history of significant ice formation in Niantic Bay. It is considered highly unlikely that ice would form or collect in a manner or amount sufficient to obstruct the flow to the service water and circulating water pumps (Sections 2.4.7 and 2.2.3). A reinforced concrete curtain wall located at the front of the pumphouse and extending down to elevation - 7.0 feet msl acts as an air seal and also prevents floating or partially submerged debris and ice from entering the pumphouse. Additionally, the flow velocity at the bar racks is low enough to cause frazil ice to rise to the surface and form sheet ice, such that there would not be blockage affecting the service water pumps.

Sedimentation that would affect the safety function of the service water pumps is considered unlikely. The suction bells of the circulating water pumps are at an elevation 6.5 feet lower than the suction bells of the service water pumps. The rated flow capacity of the circulating water pumps is approximately ten times larger than that of the service water pumps. Therefore, any sediment that might settle in the pump bays downstream of the traveling screens would be removed by suction through the circulating water pumps before it could block the inlets to the safety related service water pumps. In the event that significant sedimentation should deposit on the floor of the pumphouse bays, it would be removed by occasional dredging.

2.4.11.7 Dispersion, Dilution, and Travel Times of Accidental Releases of Liquid Effluents in Surface Waters

Dispersion characteristics and dilution capability of Niantic Bay and Long Island Sound for an accidental release through the circulating water discharge tunnel is the only case discussed here. Section 2.4.13 discusses the effects of contamination of groundwater, which subsequently flows into Long Island Sound.

Predictions of the dispersion and dilution of the accidental releases of liquid effluents in surface water are divided into two regions:

1. In the near-field, the dilution is due to momentum induced mixing and turbulence mixing created by the surface discharge jet from the quarry through the quarry cut into Long Island Sound.

2. In the far-field, the dilution is due to ambient tidal current in Niantic Bay and Long Island Sound.

It is assumed that no dilution occurred within the quarry. In the near-field at the edge of mixing zone, the dilution factor was estimated to be 3 (E. E. Adams 1999). In the far-field dilution factors were calculated using the two dimensional, vertically averaged numerical model as discussed in Regulatory Guide 1.113. The velocity field was computed from the following vertically integrated two-dimensional equations of mass and momentum conservation:

Mass:

$$\frac{\partial\eta}{\partial t} + \frac{\partial}{\partial x}[u(h+\eta)] + \frac{\partial}{\partial y}[v(h+\eta)] - \Upsilon = O \qquad (2.4.6)$$

Momentum:

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = -g\frac{\partial n}{\partial x} - \frac{1}{\rho}\frac{\partial P_a}{\partial x} + fv + \frac{1}{\rho(h+\eta)}(\Gamma_{w,x} - \Gamma_{b,x}) \qquad (2.4.7)$$

$$\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} = -g\frac{\partial n}{\partial y} - \frac{1}{\rho}\frac{\partial P_a}{\partial y} + fu + \frac{1}{\rho(h+\eta)}(\Gamma_{w,y} - \Gamma_{b,y}) \qquad (2.4.8)$$

where:

h = The wave height

h = The mean water depth

t = Time coordinate

u and v = Velocity components in the x and y directions, respectively

y = A source term which is defined as the discharge or intake rate per unit area at a specified grid point

g = Gravitational constant

P_a = Atmospheric pressure

f = 2Ω sin ψ = the Coriolis parameter

in which:

Ω = The angular velocity of the earth

ψ = The latitude

Γ_w and Γ_b = Shear stresses at the water surface and the bottom, respectively.

$$\Gamma_{b,x} = \rho g C^{-2} u(u^2 + v^2)1/2 \qquad (2.4.9)$$

$$\Gamma_{b,y} = \rho g C^{-2} v (u^2 + v^2) 1/2 \qquad (2.4.10)$$

where:

C = The Chezy coefficient

Equations 2.4.6 and 2.4.7 represent a two-dimensional transient hydrodynamic mathematical model in a general form. The source term ϒ is included because it would simulate the intake and discharge flow effects on the ambient flow patterns. If the interested area is relatively small, P_a can be assumed to be constant, and if there is no source or sink in the area (ϒ = 0), then Equations 2.4.6 and 2.4.7 are those shown in page 1.113-15 of Regulatory Guide 1.113.

The numerical solution of Equations 2.4-6 through 2.4-8 was developed and a computer program was written. In using the computer program, a collection of square cells, with the height equal to the average water depth, is used to simulate Niantic Bay and the adjacent portion of Long Island Sound. A grid size of 1,000 by 1,000 feet was used. Figure 2.4–31 illustrates the area modeled by 280 cells. The solid line defines the closed boundary which was chosen to closely approximate the shoreline geometry from Black Point to Seaside Point. The dashed line defines the open boundary which extends through the open water of Long Island Sound. The model boundary also includes the Niantic River estuary.

The model used tidal level information from the 1974 hydrographic hydrological survey as input to obtain flow pattern predictions (NUSCo. 1975). Current data from the same survey were used for comparison and calibration. The bottom roughness (Manning's coefficient) was assumed to equal one of three values (0.02, 0.03, or 0.045) depending on the bathymetric conditions and the velocity profiles obtained. A phase lag of 10.5 minutes was used across the model region (east to west). With these inputs and refinements, the model predicted the flow field and tidal heights within the model region. A comparison of the predicted flow field velocities at points where current meter measurements were available was performed (NUSCo. 1975). Reasonably good agreement between current direction and magnitude existed between predicted and observed data.

The output of the model indicates that during the strength of flood the flow pattern shows a general westward circulation with maximum velocities of 2 fps in the Twotree Island Channel. The high slack stage occurs approximately 0.52 hour after high tide. The flow pattern at this stage shows the low velocities and mixed directions characterizing this period of tide reversal. The tidal current stage of the Niantic River estuary lags in time and still shows a moderate flooding current (NUSCo. 1975).

The strength of ebb develops about 4.05 hours after high tide and the flow pattern is from west to east. Finally, low slack water occurs and a general mixed flow pattern precedes a reversal direction. The tidal current stage of the Niantic River still lags the outer bay and shows an ebbing flow.

The general flow patterns are similar to those observed in past field surveys. They also indicate two phenomena recently noted in the summer 1973 survey data (NUSCo. 1975). First, there are no completely slack water conditions between the flood and ebb tides, a characteristic of rotary tidal current. Second, the time of lowest velocity does not always coincide with the high and low tide, as is observed in other bays along open coastlines, but rather exhibits a lag of from 1/2 to 1 hour usually (NUSCo. 1975).

The resulting velocity field then becomes the advective mechanism in the following vertically averaged conservation equation for the dissolved constituent concentration C (from Regulatory Guide 1.113):

$$\begin{aligned}&\frac{\partial}{\partial t}(HC) + \frac{\partial}{\partial x}(uHC) + \frac{\partial}{\partial y}(vHC) = \\ &\frac{\partial}{\partial x}\left(HK_x\frac{\partial C}{\partial x}\right) + \frac{\partial}{\partial y}\left(HK_y\frac{\partial C}{\partial y}\right) - H\lambda C\end{aligned} \tag{2.4.11}$$

where:

H = Depth from water surface to bottom

K_x and K_y = Dispersion coefficients in the x and y directions, respectively

l = Decay coefficient

In the numerical computation, an initial concentration Co is arbitrarily assigned as one of the input data. The computer program computes the concentration, C(x,y), at every grid point in the interested area. The dilution factor, D, is given by:

$$D_f = \frac{C_o}{C(x, y)} \tag{2.4.12}$$

The dispersion coefficients, k_x, k_y, used in the model described above were determined by using the thermal plume survey data obtained in July 1977. In the process of calibrating the model for a two-unit operation, a sensitivity analysis shows that using a dispersion coefficient of 450 sq ft/sec with a limiting depth of 18 feet, the model yields results compatible with those from the dye survey (Liang and Tsai 1979).

Principal users of Niantic Bay or Long Island Sound waters in the vicinity of the plant are recreational users. Table 2.4–8 summarizes areas of recreational water use and their corresponding dilution factors. To be conservative, no travel time from the accidental release point (quarry cut) to users was taken into consideration in calculating the concentrations of liquid contaminants.

The nearest industrial user of Long Island Sound water is the Pfizer Corporation located 5.5 miles east-northeast of Millstone Point. Normal or accidental releases from the site are not expected to affect this plant because of its distance from the site. No potential future users of Niantic Bay or Long Island Sound water are known at this time.

2.4.12 GROUNDWATER

2.4.12.1 Description and Onsite Use

Groundwater is not used as a source of plant water supply.

2.4.12.2 Sources

The Millstone site has several shallow wells near it, the nearest being about one-third of a mile from the station proper. None of these provides domestic drinking water, but one is used to water a nearby baseball field and to supply a drinking fountain at the field.

Three shallow wells (Figure 2.4–32) are located within 1.5 miles of the site; one nearly 1.5 miles to the north-northeast, one approximately 1 mile to the northeast, the third approximately 0.5 mile to the northwest.

Figure 2.4–2 identifies the public water supplies within a 20 mile radius of the site.

Groundwater conditions on Millstone Point have been documented in previous studies for Millstone 1 and 2, and have been observed by water level observations in borings drilled for the Millstone 3 site study in 1972 (Section 2.5.4.6).

Prior to development of the site as a nuclear power facility, there existed a granite quarry located approximately 1,200 feet south- southeast of the Millstone 3 area. Observations of the water levels in the granite quarry show that the water level in the quarry before the existing discharge channel opened it to the ocean, typically lay approximately 17 feet below the level of the adjacent Long Island Sound. It is significant that this quarry was worked for over 100 years (1830-1960) at distances of as little as 200 feet from the waters of Long Island Sound without experiencing notable inflows of water indicating that the permeability of the bedrock is very low.

Pressure tests (Table 2.5.4–16) were conducted in the vicinity of the quarry and in the containment area as part of the Millstone 3 site study. These tests indicate that the bedrock is generally massive with slight to moderate interconnected jointing. Geologic mapping of the site bedrock indicated that the bedrock is fresh, hard crystalline rock with tight, moderately spaced joints. Very little inflow of water was noticed entering the excavations through the bedrock. These observations also suggest that the permeability of the bedrock is very low, and that very little groundwater or seawater seeps through the site bedrock.

Both the basal till and the overlying ablation till are relatively impervious. The ablation till soils are more pervious than the basal tills and occasionally exhibit partial stratification, including sporadic sand lenses; accordingly, the upper portions of the soil transmit water more readily than the underlying dense basal tills. Groundwater levels appear to be subject to considerable seasonal fluctuations. In addition, borings taken prior to the 1972 Millstone 3 observations near the shoreline exhibited tidal fluctuations, suggesting that the occasional sand lenses can be quite permeable (Bechtel 1972).

Water levels measured in borings taken at the site in early 1972 indicate a groundwater piezometric surface with a gradient generally sloping from northeast to southwest (Figure 2.5.4–37).

Localized perched groundwater conditions probably exist because of the irregular distribution of ablation till materials of varying gradation and porosity. It is also likely that shallow, ponded water exists in localized bedrock troughs. The prevalence of bedrock outcrops to the north and northwest of the site indicate that bedrock acts as groundwater divide, isolating the soils of the tip of Millstone Point from soils further inland.

Since there is no plant use of groundwater, and the plant area is isolated from soils further inland, there is no effect on groundwater on the site or surrounding areas.

Groundwater recharge would primarily be due to infiltration of local precipitation, with probable migration to the waters of the immediately-adjacent Long Island Sound. As previously described, little groundwater is present in the crystalline bedrock, and virtually all of the groundwater movement is restricted to the soil overburden. Measurements taken during previous investigations (Goldsmith 1960) showed average influx rates into test pits of about 8 gph and concluded that both the ablation and basal tills are relatively impervious.

2.4.12.3 Accident Effects

Within a 5-mile radius of the Millstone 3 containment structure, public water supplies originate from ground sources, most of which are shallow wells and distant from the site. Three shallow wells shown on Figure 2.4–32 are located within 1.5 miles of the site. There are ridges in between the Millstone 3 location and the wells which are undoubtedly underlaid by rock. They create a drainage divide, the groundwater flowing to the east and west and to the south. Water or chemicals accidentally released during operation or accident conditions to the site surface would not reach these wells. Accidental waste discharges would not affect public groundwater supplies since the Niantic River and Niantic Bay lie west and northwest of the site while accidental spillage in the soil or rock column at the site while the Jordan Cove drainage basin is east of the site. Any accidental spillage in the soil or rock column at the site would be interrupted by these bodies of water and would prevent contamination of distant groundwater sources. Elevations exceeding those of the site and at-surface bedrock ridges preclude migration of contaminated groundwater to the north.

An investigation of possible diffusion in the groundwater was made, in case of an accidental liquid release of waste on the site outside the normal flow paths.

Liquid Release from Boron Recovery Tank

It is estimated that 80 percent of tank volume (120,000 gal) liquid would be discharged into the ground and eventually would reach the groundwater following the assumed tank failure. The location of the boron recovery tank is such that the bedrock and basal till overlaying the rock (both with very low permeability) have higher elevations to the south, east, and west of the location. The rock contours to the northwest of the boron recovery tank indicate a depression considered a channel through which the fluid might flow toward the trench for the circulating and service water pipelines. The granular backfill to be used in this trench is estimated to have a higher permeability than other surrounding soils (tills); hence, the trench offers the most probable path for discharging the boron recovery tank liquid to Niantic Bay. Under these conditions, the length of the possible flow path (Figure 2.4–33) is approximately 1,230 feet.

Once the boron recovery tank liquid reaches the groundwater, it is diluted by the groundwater through diffusion. In addition, the radioactive constituents in the liquid undergo radioactive decay. The filtering action and ion exchange action of the soil on particulates and solubles, respectively, in the discharged liquid are neglected.

The coefficients of permeability for each beach and outwash sand and the structural backfill have been determined using constant head and falling head tests. The permeabilities obtained during testing ranged between 1.2 x 10^{-4} to 2.7 x 10^{-3} cm/sec for the beach and outwash sand and between 1.6 x 10^{-4} to 4.0 x 10^{-4} cm/sec for structural backfill. The coefficients of permeability for the beach and outwash sand and the structural backfill are assumed equal 10^{-3} cm/sec.

Because the normal groundwater level at the location of the boron recovery tank is at elevation +22 feet and Niantic Bay is at Elevation 0 feet, the hydraulic gradient along the flow path is:

$$i = \frac{22}{1230} = 0.0179 \ or \ 1.79\% \tag{2.4.13}$$

The effective porosity, n_e, determined by porosity tests of soil samples from the site, equaled 0.1.

The seepage velocity in the groundwater is given by Darcy's Law:

$$u = \frac{k_i}{n_e} = \frac{3.28x10^{-5} \ x \ 0.0179}{0.1} = 5.87x10^{-6} ft/\text{sec} \tag{2.4.14}$$

The time for the discharged liquid to travel from the boron recovery tank to the point of discharge into Niantic Bay is given by:

$$t = \frac{D}{u} = \frac{1230}{5.87x10^{-6}} = 2.095\ x\ 10^{8}\ \text{sec} = 6.64\ yr \qquad (2.4.15)$$

The dispersion coefficients are related to the flow velocity by the dispersivity (Bredehoeft and Pinder 1973), i.e:

$$K_{x,y} = \alpha_{x,y} u \qquad (2.4.16)$$

where:

$K_{x,y}$ = The horizontal dispersion coefficients; K_x is the component in the direction of the flow, K_y is in the direction perpendicular to the flow

$\alpha_{x,y}$ = The corresponding longitudinal transverse components of the dispersivity

u = Seepage velocity

Values are assigned to, based on a best fit between the results of a mathematical model and the field data for the Snake River Plain aquifer (Robertson 1974). The former is an analytical approach to the three dimensional dispersion problem which simulates the continuous release of a contaminant in a vertical line source. This calibration establishes a value for of 59 feet. Bredehoeft and Pinder (1973) suggest the relation:

$$\alpha_x = \frac{10}{3}\alpha_y \qquad (2.4.17)$$

These results are generalized to other sites by assuming that, all other properties being equal, the property of an aquifer that fixes the dispersivity is the porosity, such that:

$$\alpha_y = \alpha_{ys}\left(\frac{n_{es}}{n_e}\right) \qquad (2.4.18)$$

where:

α_y = Transverse dispersivity for the aquifer of interest

α_{ys} = Transverse dispersivity for Snake River aquifer

n_e = Effective porosity for the aquifer of interest

n_{es} = Effective porosity for Snake River aquifer

Because the local groundwater velocity (Equation 2.4.16) can be used to compute the horizontal dispersion coefficients, it is subsequently assumed that $K_z = k_y$.

As the liquid from the boron recovery tank reaches the groundwater, several factors contribute to its dispersion and dilution. These include advection, hydraulic dispersion, radioactive decay, and ion exchange. If the fluid flow is uniform, steady, and parallel to the x-axis, the hydraulic dispersion coefficients are homogeneous, anisotropic and orders of magnitude greater than the molecular diffusion coefficients, and the radioactive decay and sorption processes are not considered, the equation governing the distribution of contaminant is:

$$\frac{\partial C}{\partial t} + u\frac{\partial C}{\partial x} = K_x\frac{\partial^2 C}{\partial x^2} + K_y\frac{\partial^2 C}{\partial y^2} + K_z\frac{\partial^2 C}{\partial z^2} + \frac{M'}{n_e} \qquad (2.4.19)$$

where:

C = Contaminant concentration

u = Seepage velocity

M' = Rate of release of mass per unit volume of aquifer

The solution of Equation 2.4.19 for an instantaneous volume source in an aquifer of finite depth is:

$$C=\frac{C_o}{4}\left\{erf\,\frac{x-ut+l/_2}{(4K_xt)^{1/2}} - erf\,\frac{x-ut-l/_2}{(4K_xt)^{1/2}}\right\}\cdot\left\{erf\frac{y+b/_2}{(4K_yt)^{1/2}} - erf\frac{y-b/_2}{(4K_yt)^{1/2}}\right\}\cdot$$
$$\left\{\frac{H_2-H_1}{H} + 2\sum_{n=1}^{\infty}\cos\left(\frac{n\pi z}{H}\right)\frac{1}{n\pi}\left(\sin\frac{n\pi H_2}{H} - \sin\frac{n\pi H_1}{H}\right)\cdot\exp\left[-\left(\frac{n\pi}{H}\right)^2 K_zt\right]\right\} \qquad (2.4.20)$$

where:

C_o = Initial contaminant concentration at source location

l, b = Source dimensions in the x and y direction, respectively

H_1, H_2 = Upper and lower surface of the volume source

H = Aquifer thickness

x, y, z = Coordinates in the longitudinal, transverse, and vertical direction, respectively

t = Time from initial release

When input data are substituted in Equation 2.4.9, the minimum dilution factor for the groundwater, C_o/C, equals 73.

The discharged liquid on reaching Niantic Bay is diluted further in that body of water. The method used to calculate the dilution in Niantic Bay and Long Island Sound is the same method as described in Section 2.4.12. The only difference is that the released point is in the intake area instead of the circulating water discharge tunnel. The dilution factor upon entering Niantic Bay at the Intake area is calculated to be 13,052 and at 1,000 feet from the point of discharge into Niantic Bay is calculated to be 32,151. One-thousand feet was chosen arbitrarily as the point to calculate the dilution factor in Niantic Bay so as to show the large dilution factor obtained in the bay.

2.4.12.4 Monitoring or Safeguard Requirements

Since the potential for groundwater contamination is minimal, as discussed in Sections 2.4.13.2 and 2.4.13.3, procedures and safeguards to protect groundwater users are not necessary.

2.4.12.5 Design Bases for Subsurface Hydrostatic Loading

There is no safety related permanent dewatering system for lowering groundwater levels for Millstone 3. Safety related structures are designed for water pressure and buoyancy forces applied from their respective foundation levels to the design piezometric surface levels, as shown in Figure 2.5.4–37 assuming saturated soil conditions to the water surface. Section 2.5.4.6 includes a discussion of groundwater conditions with respect to plant structure design and construction and Section 3.4 includes a discussion of flood design for Seismic Category I structures and components. Section 9.3.3 includes a description of the sump systems installed in the ESF Building for removal of groundwater inleakage collected in the porous concrete groundwater sump.

2.4.13 TECHNICAL SPECIFICATION AND EMERGENCY OPERATION REQUIREMENTS

In order to minimize the water associated impact of adverse hydrologically related events on safety related equipment and facilities, Millstone 3 has no related Technical Specification discussion. However, Technical Requirements Manual 3/4.7.6, Flood Protection, describes the measures required to provide flood protection for the service water pump cubicles.

The service water pumps are designed to operate at a low water level of elevation -8.0 feet msl, which is 3.2 feet lower than the historical low water level (Section 2.4.11.3) and are enclosed in a flood protected portion of the circulating and service water pumphouse (Sections 2.4.1.1 and 3.4.1). Other safety related structures and components are protected from flooding by the site grade of elevation 24.0 feet msl. AOP 3569 addresses safety measures to be taken in the case of severe weather conditions. These measures ensure that all watertight doors are in place and the pump cubicle sump drain lines are isolated and thus all safety-related structures and components are protected from flooding.

Section 2.4.2.3 states that there is no water associated impact in the safety related facilities, resulting from local rainfall as severe as the probable maximum. Therefore, no technical specifications or emergency operating procedures are required, except as discussed above for the pumphouse.

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