TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

2.0 SITE CHARACTERISTICS

This chapter presents studies and analyses of the site and environment for the Perry Nuclear Power Plant. The studies conducted include geography, demography, effects of nearby facilities, meteorology, hydrology, geology, and seismology. The site characteristics presented provide the basis for selection of design standards for the plant and determine the adequacy of concepts for controlling routine and accidental release of radioactive effluents to the environment.

2.1 GEOGRAPHY AND DEMOGRAPHY

2.1.1 SITE LOCATION AND DESCRIPTION

2.1.1.1 Specification of Location

Located in a rural area of Lake County, Ohio, the site is approximately seven miles northeast of Painesville, the county seat, and 35 miles northeast of Cleveland, the nearest large principal city. The eastern two thirds of the site is within the boundaries of North Perry Village while the western third is within Perry Township. Lake Erie borders the site to the north. <Figure 2.1-1> and <Figure 2.1-2> show the location of the plant site with respect to the lake, nearby roads, highways, communities, cities, and other topographic features.

The centerline of the reactor for Unit 1 is located at north latitude 41° 48′ 04.2″ and west longitude 81° 08′ 36.6″, and under the Universal Transverse Mercator (UTM) grid is located in Zone 17 at coordinates 4,627,498 meters N and 488,079 meters E. The centerline of the Unit 2 reactor is located at north latitude 41° 48′ 02.3″ and west longitude 81° 08′ 35.6″, and under the UTM grid is at coordinates 4,627,437 meters N and 488,100 meters E.

2.1.1.2 Site Area Maps

The plant site is located along the southeastern shoreline of Lake Erie on an ancient lake plain approximately 50 feet above lake low water datum. It is approximately 1,030 acres in size and relatively flat. The land has a very gentle slope toward the lake and is incised by small streams which drain into the lake. About 45 percent of its area is covered with light to heavy woodland with the remainder consisting mostly of farmland and nursery stock.

<Figure 2.1-3> shows the topographic features of the plant site in relation to the approximate location of the plant facilities. <Figure 2.1-4> is an aerial photograph of the site showing the site boundaries, exclusion area, location of the plant, and the general character of the immediate surroundings.

All land within the site boundary, as shown in <Figure 2.1-4>, is plant property owned by CEI except for the right-of-ways for public township and village roads which traverse the area just outside the exclusion area boundary. A right-of-way easement was granted to the East Ohio Gas Company for rerouting their gas line through the site as shown in <Figure 2.1-3>.

2.1.1.3 Boundaries for Establishing Effluent Release Limits

CEI purchased all land within the site boundary except for the right-of-ways of public township and village roads outside the exclusion area boundary. Additionally, the mineral rights of one parcel outside the site boundary in Lake Erie is controlled by CEI. This parcel <Figure 2.1-5> encompasses the cooling water tunnel facilities that project into Lake Erie. CEI entered into a contract with the State of Ohio for this area, delineated as "Limits of Mineral Rights" in <Figure 2.1-5>, wherein the State of Ohio agreed not to exercise their right to lease for salt mining the offshore area within the "Limit of Mineral Rights" for the life of the plant (46 years). No domestic residences exist within the site boundaries; however, certain areas of farmland and nursery within the site may continue to be used after the plant is constructed.

The exclusion area is established as that area which is situated inside 2,900-foot radii centered on the Unit 1 and Unit 2 reactors. Except for Lake Erie, the exclusion area is completely within site boundaries. The minimum distances from the plant effluent release points to the exclusion area boundary are shown in <Figure 2.1-4>. CEI controls the

mineral rights, both within the exclusion boundary on land and within 1,800 feet of all safety-related structures in Lake Erie, to preclude subsidence as a detrimental effect on safety structures.

Those portions of Center Road and Lockwood Road within the exclusion area have been withdrawn from public use, and gates have been installed across these roads to discourage public access to the area. No public road traverses the exclusion area.

The unrestricted area is considered to be the area beyond the site boundary. Access to the unrestricted area is not controlled by FENOC for the purpose of protection of individuals from exposure to radiation and radioactive materials <Figure 2.1-3>. Radioactive effluent releases to unrestricted areas shall be made in accordance with <10 CFR 20.105> and <10 CFR 50, Appendix I>.

2.1.2 EXCLUSION AREA AUTHORITY AND CONTROL

2.1.2.1 Authority

The exclusion area radius is 2,900 feet from the centerline of each reactor. All land within the exclusion boundary is jointly owned by the FirstEnergy Corporation. Companies, and control of the exclusion area, including the mineral rights for oil, gas and salt, is maintained by FENOC <Table 2.1-9>.

Authority to control all activities in the Lake Erie portion of the exclusion area is provided by the United States Coast Guard.

No easements or public roads traverse the exclusion area. The Fairport, Painesville and Eastern Railroad Company serves the plant overland on tracks owned by CEI. The railroad spur is 3.2 miles in length, heading in an east-northeasterly direction from the railroad company

right-of-way to the plant site. Only railroad cars consigned to the Perry Nuclear Power Plant are brought into the plant site over this spur.

2.1.2.2 Control of Activities Unrelated to Plant Operation

Since the exclusion boundary encompasses a portion of Lake Erie <Figure 2.1-4>, activity within the exclusion area that is unrelated to plant operation can be expected from fishing boats and other pleasure craft on Lake Erie. A public address system has been installed for plant communication to individuals in areas within the exclusion boundary including the beach and Lake Erie (Section 7.2.1 of the Emergency Plan). The number and volume of speakers used will be sufficient to immediately warn individuals on the lake within the exclusion boundary in an emergency <Section 9.5.2>.

The Emergency Plan addresses evacuation of personnel (Section 6.4.1 and Section 6.4.2 of the Emergency Plan) and specifically requires written procedures be developed to facilitate evacuation. The basis of the present emergency planning criteria is that early detection of a possible incident will ensure evacuation prior to any personnel receiving an appreciable dose.

2.1.2.3 Arrangements for Traffic Control

Portions of Center Road and Lockwood Road which fall within the exclusion area have been abandoned to the public. There are therefore, no public roads which traverse the exclusion area.

The Fairport, Painesville and Eastern Railroad Company serves the plant over-land and tracks owned by CEI. About 0.5 mile of track is within the exclusion area. Only railroad cars consigned to the PNPP are brought into the plant site over these tracks.

2.1.2.4 Abandonment or Relocation of Roads

No public roads traverse the exclusion area.

2.1.3 POPULATION DISTRIBUTION

This section primarily describes the population distribution around the Perry Nuclear Power Plant.

In the past, minor changes to the information in this section have been made. While updates were not required, these changes have not been removed. Therefore, some parts of this chapter reflect more recent information.

The information in this section is for historical purposes only. For current population estimates and their effect on evacuation capabilities, refer to Development of Evacuation Time Estimates For The Perry Nuclear Power Plant which is part of the emergency preparedness plan.

2.1.3.1 Population Within Ten Miles

<Figure 2.1-6> shows the locations of nearby cities and towns within a ten-mile radius of the Perry Nuclear Power Plant. <Table 2.1-1> presents these population groupings and their associated 2000 population estimates (Reference 20) according to distance and direction from the plant site.

The 1978 estimated population within ten miles of the station is 73,134 persons; within five miles the estimate is 16,875 people. As shown in <Figure 2.1-6>, the following municipalities are located either totally or partially within ten miles of the plant.

Municipality	2000 Census Population	Approximate Distance (Miles) and Direction from Plant to Center of Incorporated Areas
North Perry	838	1.5 – SW
Perry Village	1,195	3.0 – S
Perry Township	8,240	3.0 - S

Municipality	2000 Census Population	Approximate Distance (Miles) and Direction from Plant to Center of Incorporated Areas
Madison Village	2,921	5.5 - ESE
Madison Township	18,428	5.5 - ESE
Painesville City	17,503	7.0 - SW
Painesville Township	18,562	7.0 - SW
Fairport Harbor	3,180	7.0 - WSW
Grand River	345	8.0 - WSW
Geneva	6,595	10.0 - E
Geneva-On-The-Lake	1,545	10.0 - ENE
Mentor City	50,278	15.0 - SW
Mentor-On-The-Lake	8,127	15.0 - SW

The zero- to five-mile population distribution was determined from the 2000 census (Reference 20). Estimates of population for the years 1983, 1984, 1985, 1986, and 2020 were calculated by applying the Lake County growth rates (Reference 3) to the 1978 population. <Table 2.1-1> lists the actual population figures from the 2000 census results.

Population distributions between five and ten miles of the Perry Plant were based on the 1970 census data. Numerical centroids (population totals at concentration centers) were assigned to geographical areas

across the continental United States by the U.S. Census Bureau. Population totals per segment were calculated based on the location of the centroids relative to the reactor location. Population estimates to the year 2020 were projected by applying the decennial growth rates of pertinent counties in Ohio (Reference 3) to the 1970 population distribution results. Decennial growth rates past the year 2000 were assumed to be equivalent to those of 1990 to 2000. <Figure 2.1-7>, <Figure 2.1-8>, <Figure 2.1-9>, <Figure 2.1-10>, <Figure 2.1-11>, <Figure 2.1-12>, <Figure 2.1-13>, <Figure 2.1-14>, <Figure 2.1-15>, and <Figure 2.1-16> show the projected populations from the year 1978 through 2020.

The population estimates for the first year of operation are reflected in <Figure 2.1-10>. In the event of construction delays, population estimates for 1985 and 1986 are included in <Figure 2.1-10>, <Figure 2.1-11>, and <Figure 2.1-12>.

2.1.3.2 Population Between Ten and Fifty Miles

<Figure 2.1-17> shows the locations of cities and towns within a fifty-mile radius of the Perry Nuclear Power Plant. The population distribution estimates for the area between ten and fifty miles were calculated by using methodologies similar to those used to estimate the five- to ten-mile population. As in Ohio, pertinent Pennsylvania county growth rates (Reference 5) were factored into calculations where appropriate.

Canadian influence to population totals within fifty miles of the Perry Plant is minimal. The town of Erieau in Harwich Township, Kent County, is located in the northwestern sector between forty and fifty miles from the nuclear unit. The population estimates for 1978, 1980, 1983, 1984, 1985, and 1986 were calculated utilizing the 1971 and 1976 population figures for Erieau (Reference 6). It was assumed that the decennial growth rates of Kent County were applicable to Erieau. Since population

predictions for Kent County were available only to the year 2000, (Reference 7) decennial growth rates to the year 2020 were based on that from 1990 to 2000.

<Figure 2.1-7>, <Figure 2.1-8>, <Figure 2.1-9>, <Figure 2.1-10>, <Figure 2.1-11>, <Figure 2.1-12>, <Figure 2.1-13>, <Figure 2.1-14>, <Figure 2.1-15>, and <Figure 2.1-16> show the projected population distribution for the years 1978 to 2020 for the areas between ten and fifty miles of the Perry Power Plant.

2.1.3.3 Transient Population

Transient populations within ten miles of the plant are primarily a result of local, seasonal fluctuations of people at various parks and camps. Large recreational areas, such as Township Park, near Madison, and Headlands State Park, 7.5 miles WSW of the plant, offer a variety of facilities which also attract visitors from outside the ten-mile radius. <Table 2.1-2> denotes the seasonal attendance figures for significant parks and camps near Perry (Reference 8).

Summer cottages in both Lake and Ashtabula Counties have predominately been converted to permanent residences (Reference 9) (Reference 10). Lake County has approximately 275 vacant and seasonal cottages, 189 of which are located west of Perry (Reference 9). There are no figures available with regard to cottages and transient populations of Geneva-On-The-Lake in Ashtabula County (Reference 10) (Reference 11).

One manufacturing facility, with a total work force exceeding 100 people that is located in close proximity of the Perry Plant, is the Neff-Perkins Company. Neff-Perkins, located 3,000 feet WSW of the Perry site, has a work force of 175 persons (Reference 12). The average time at work is 45 hours per week. This includes a 40-hour work week, (Reference 14) and approximately five hours per week for lunch and miscellaneous time at the work site.

2.1.3.4 Low Population Zone

The Low Population Zone (LPZ) has been defined as a 2-1/2-mile radius from the plant center, which is midway between the Unit 1 and Unit 2 reactor buildings, as established in accordance with <10 CFR 100>. <Figure 2.1-18> illustrates topographical features characteristic of the LPZ. <Table 2.1-3> denotes the 1978 population distribution of the LPZ, which was determined using the methodology described in <Section 2.1.3.1>. The estimated transient population distribution is provided in <Table 2.1-10>, along with the peak daily and seasonal transient values (Reference 18) (Reference 19). To assist in the formation of emergency planning, the following discussion of activities and facilities is not limited to the LPZ.

Listed below are the schools located within five miles of PNPP and their associated 1998-99 enrollment figures.

Institution	Enrollment as of 1998-99 School Year	Proximity to NPP (miles)
Perry Elementary	643	2-3
Perry Middle	605	2-3
Perry High	677	2-3
New Life Christian Academy	40	2-3
Redbird Elementary	483	3-4
Hale Road Elementary	310	3-4
Homer Nash Kimball Elementary	428	4-5

Institution	Enrollment as of 1998-99 School Year	Proximity to NPP (miles)
North Madison Elementary	534	4-5
Madison Middle	869	4-5
Madison High	1,079	4-5

There are no hospitals located within five miles of the Perry site. Lake East Hospital, located in Painesville approximately eight miles southwest of the Perry site, has 208 beds. A staff consisting of approximately 1,039 people is shared between Lake East and Lake West, located in Willoughby (Reference 16).

The Lake County Jail in Painesville, located seven miles southwest of PNPP, has a capacity of 369 prisoners and is 1 of 2 prisons within 10 miles of the plant with facilities suitable for more than just overnight detention. It is under the auspices of the County Sheriff and is used as the major holding and detention facility for Lake County; this jail also houses federal prisoners on request from Federal agencies. Lake County Sheriff's Department Minimum Security Facility is located approximately 4 miles southwest of the Perry Plant and holds 79 prisoners. The City Jail of Mentor has a capacity of 12 prisoners (Reference 17).

As shown in <Table 2.1-2>, the major camp within five miles of PNPP is Camp Roosevelt.

The Neff-Perkins Company, located 3,000 feet WSW of the Perry site, employing 175 persons, (Reference 12) is the only significant contributor to transient population within the LPZ.

2.1.3.5 Population Center

The 1975 estimated population of Painesville was 17,407 people (Reference 1). This figure approaches the definition of population center described in <10 CFR 100>. By applying the decennial growth rates of Lake County (Reference 3) to Painesville's 1975 population, it can be demonstrated that, through the year 2020, the population will remain below the guidelines set forth in <10 CFR 100>. However, the population within Painesville and its contiguous surroundings is estimated to exceed 25,000 persons by 2010, (e.g., as shown by the estimated population in the SW sector, five to ten miles, on <Figure 2.1-15>. On this basis, the population center is determined to be Painesville. Painesville's closest corporate boundary is located six miles southwest of Perry, which is 2.4 times the radius of the low population zone.

2.1.3.6 Population Density

<Table 2.1-4>, <Table 2.1-5>, <Table 2.1-6>, and <Table 2.1-7> describe the cumulative population and density to a distance of fifty miles from the reactor for the years 1983 through 1986, respectively. For comparison purposes, figures are provided for population resulting from a uniform density of 500 people/square mile to a distance of fifty miles.

Similarly, <Table 2.1-8> provides population and density data for the year 2020. These figures are compared with a cumulative population resulting from a uniform population density of 1,000 people/square mile.

2.1.4 REFERENCES FOR SECTION 2.1

1. U.S. Bureau of the Census, Population Estimates and Projections, U.S. Department of Commerce, Series P-25, No. 683 (Ohio), No. 686 (Pennsylvania), May 1977.

2. (Deleted)

3. Ohio Department of Health, Final Report on Demographic and Economic Projections for the State of Ohio, 1970-2000, Part III-C, HSAG-10, Battelle Columbus Laboratories, Columbus, Ohio, July 15, 1977.

4. (Deleted)

5. State Economic and Social Research Data Center, Pennsylvania Projection Series, Summary Report, Report No. 78-PPS-1, Office of State Planning and Development, June 1978.

6. Personal communication, C. Tappenden, Social and Economic Data Central Statistical Services, Ministry of Treasury, Economics and Intergovernmental Affairs, Toronto, Canada, and R. Smyth (NUS), August 9, 1978.

7. Personal communication, C. Tappenden, Social and Economic Data Central Statistical Services, Ministry of Treasury, Economics and Intergovernmental Affairs, Toronto, Canada, and R. Schlegel (NUS), March 28, 1978.

8. Personal communication, J. Eland, Lake County Planning Commission, and R. Smyth (NUS), August 7, 1978.

9. Personal communication, J. Eland, Lake County Planning Commission, and R. Smyth (NUS), September 14, 1978.

10. Personal communication, H. Thomas, Ashtabula County Planning Commission, and R. Smyth (NUS), September 12, 1978.

11. Personal communication, L. Carter, Village Clerk, Geneva-On-The-Lake, and R. Smyth (NUS), September 13, 1978.

12. Personal communication, R. Elly, Vice President, Neff-Perkins Corporation, and M. Hosford (NUS), ESD-78-256 (EP&CD), August 21, 1978.

13. (Deleted)

14. Personal communication, R. Elly, Vice President, Neff-Perkins Corporation, and R. Uleck (NUS), November 16, 1979.

15. (Deleted)

16. Personal communication, D. Moase, Health Planning Commission, Painesville, Ohio, and D. Myers (NUS), July 1978.

17. Personal communication, E. Cunningham, Sheriff, Lake County, Ohio, and R. Uleck (NUS), November 16, 1979.

18. Personal communication between Webster, Lake County Planning Commission, and R. C. Smyth, NUS Corporation, Rockville, MD, February 25, 1981.

19. Personal communication between Helen Huffacker, Perry, OH, Board of Education, and R. C. Smyth, NUS Corporation, Rockville, MD, February 26, 1981.

20. United States Census, 2000.

TABLE 2.1-1

TOWNS AND CITIES WITHIN FIFTY MILES OF THE PERRY PLANT SITE

Town/City (Ohio)	2000 Population	Distance (miles) From Plant Site	Direction From Plant Site
0-5 MILES FROM PNPP			
North Perry	838	1	E
Perry Village	1,195	3	S
Perry Township	8,240	3	S
5-10 MILES FROM PNPP			
Madison Village	2,921	6	ESE
Madison Township	18,428	6	ESE
Painesville City	17,503	7	SW
Painesville Township	18,562	7	SW
Fairport Harbor	3,180	8	WSW
Grand River	345	9	WSW
10-20 MILES FROM PNPP			
Geneva-on-the-Lake	1,545	11	ENE
Geneva	6,595	11	E
Mentor-on-Lake	8,127	14	WSW
Kirtland Hills	597	15	SW
Mentor	50,278	15	SW
Chardon	5,156	16	SSW
Aquilla	372	18	S
Ashtabula City	20,962	18	ENE
Rock Creek	587	18	SE
Willoughby City	22,621	18	SW
Waite Hill	446	18	SW
Eastlake	20,255	19	SW

TABLE 2.1-1 (Continued)

Town/City (Ohio)	2000 Population	Distance (miles) From Plant Site	Direction From Plant Site
Lakeline	165	19	WSW
Timberlake	775	19	WSW
20-30 MILES FROM PNPP			
Jefferson	3,572	20	ESE
Willowick City	14,361	21	SW
Willoughby Hills	8,595	22	SW
Burton	1,450	23	S
Kirtland	6,670	23	SW
Wickliffe	13,484	23	SW
Gates Mills	2,493	24	SW
Kingsville Township	1,921	24	ENE
Middlefield	2,233	24	S
Orwell	1,519	24	SE
20-30 MILES FROM PNPP			
Euclid City	52,717	25	SW
Highland Heights	8,082	25	SW
Richmond Heights City	10,944	25	SW
Mayfield	3,435	26	SW
North Kingsville	2,658	26	ENE
Hunting Valley	735	27	SSW
Chagrin Falls City	4,024	28	SSW
Lyndhurst	15,279	28	SW
Moreland Hills	3,298	28	SSW
Pepper Pike	6,040	28	SW
South Euclid	23,537	28	SW
South Russell	4,022	28	SSW

TABLE 2.1-1 (Continued)

Town/City (Ohio)	2000 Population	Distance (miles) From Plant Site	Direction From Plant Site
Beachwood City	12,168	29	SW
Bratenahl	1,337	29	SW
East Cleveland City	27,217	29	SW
University Heights	14,146	29	SW
Woodmere	828	29	SW
30-40 MILES FROM PNPP			
Bentleyville	947	31	SSW
Cleveland Heights	49,958	31	SW
Shaker Heights	29,405	31	SW
West Farmington	519	31	SSE
Andover	1,269	33	ESE
Cleveland	478,403	33	SW
North Randall	906	33	SW
Warrensville Heights	15,109	33	SW
Bedford Heights	11,375	34	SW
Hiram	1,242	34	S
Solon City	21,802	34	SSW
Bedford City	14,214	36	SW
Glenwillow	449	36	SSW
Maple Heights	26,156	36	SW
Reminderville	2,347	36	SSW
30-40 MILES FROM PNPP			
Garfield Heights	30,734	37	SW
Garrettsville	2,262	37	S
Newburgh Heights	2,389	37	SW
Oakwood	3,667	37	SSW

TABLE 2.1-1 (Continued)

Town/City (Ohio)	2000 Population	Distance (miles) From Plant Site	Direction From Plant Site
Cuyahoga Heights	599	38	SW
Macedonia	9,224	38	SSW
Mantua	1,046	38	S
Twinsburg	17,006	38	SSW
Walton Hills	2,400	38	SW
Valley View	2,179	38	SW
Brooklyn Heights	1,558	39	SW
Cortland	6,830	39	SE
Independence	7,109	39	SW
Windham	2,806	39	S
30-40 MILES FROM PNPP			
Linesville	1,155	39	ESE
40-50 MILES FROM PNPP			
Streetsboro	12,311	41	SSW
Seven Hills	12,080	41	SW
Linndale	117	41	SW
Brooklyn	11,586	42	SW
40-50 MILES FROM PNPP			
Lakewood	56,646	42	WSW
Warren	46,832	43	SSE
Boston Heights	1,186	43	SSW
Brecksville	13,382	43	SW
Newton Falls	5,002	44	SSE
Sugar Bush Knolls	227	44	SSW

TABLE 2.1-1 (Continued)

Town/City (Ohio)	2000 Population	Distance (miles) From Plant Site	Direction From Plant Site
Hudson	22,439	44	SSW
Broadview Heights	15,967	44	SW
Parma	85,655	44	SW
Parma Heights	21,659	44	SW
Rocky River	20,735	44	WSW
Orangeville	189	46	SE
Ravenna	11,771	46	S
Brady Lake	513	46	SSW
Peninsula	602	46	SSW
North Royalton	28,448	47	SW
Fairview Park	17,572	47	WSW
Niles City	20,932	48	SSE
Craig Beach	1,254	48	S
Silver Lake	3,019	48	SSW
Richfield	3,286	48	SW
Middleburg Heights	15,542	48	SW
Brook Park	21,218	48	SW
Westlake	31,719	48	WSW
North Olmsted	34,113	48	WSW
Bay Village	16,087	48	WSW
Yankee Lake	99	49	SE
Munroe Falls	5,314	49	SSW
Berea City	18,970	49	SW
McDonald	3,481	50	SSE
Strongsville	43,858	50	SW
Avon Lake	18,145	50	WSW

TABLE 2.1-1 (Continued)

Town/City (Pa.)	2000 Population	Distance (miles) From Plant Site	Direction From Plant Site
40-50 MILES FROM PNPP			
Springboro	491	41	E
Conneautville	848	41	E
Albion	1,607	42	E
Cranesville	600	43	E
Jamestown	636	43	ESE
Platea	474	44	ENE
Lake City	2,811	45	ENE

TABLE 2.1-2

MAJOR CAMPS AND PARKS WITHIN TEN MILES OF THE PERRY PLANT SITE[1]

Park/Camp	Annual Attendance	Distance & Direction From Perry
Camp Roosevelt	300	1.4 miles SW
Township Park	60,000[2]	6.0 miles ENE
Headlands State Park	704,383 (1977)	7.5 miles WSW

NOTES:

(1) Refer to (Reference 8) <Section 2.1.4>.

(2) Estimated.

TABLE 2.1-3

POPULATION DISTRIBUTION WITHIN THE
LOW POPULATION ZONE 1978[1]

Direction	Distance 0-1 Mile	1-2 Miles	2-2.5 Miles
N	0	0	0
NNE	0	0	0
NE	37	40	0
ENE	11	224	248
E	0	70	115
ESE	0	236	1,302
SE	0	162	129
SSE	7	541	177
S	18	265	162
SSW	26	70	221
SW	0	44	52
WSW	4	63	0
W	0	0	0
WNW	0	0	0
NW	0	0	0
NNW	0	0	0

NOTE:

(1) Excludes the Neff-Perkins Company work force.

TABLE 2.1-4

POPULATION AND DENSITY WITHIN FIFTY MILES OF PERRY NUCLEAR POWER PLANT (1983)

Radius (Miles)	Cumulative Population	Density (People/Square Mile)	Population Assuming 500 People/Square Mile
0-1	103	32.8	1,571
0-2	1,818	144.7	6,283
0-3	5,725	202.5	14,137
0-4	10,648	211.8	25,133
0-5	16,885	215.0	39,270
0-10	74,085	235.8	157,080
0-20	256,360	204.0	628,319
0-30	693,440	245.3	1,413,717
0-40	1,591,272	316.6	2,513,274
0-50	2,435,526	310.1	3,926,991

TABLE 2.1-5

POPULATION AND DENSITY WITHIN FIFTY MILES OF
PERRY NUCLEAR POWER PLANT (1984)

Radius (Miles)	Cumulative Population	Density (People/Square Mile)	Population Assuming 500 People/Square Mile
0-1	103	32.8	1,571
0-2	1,824	145.1	6,283
0-3	5,743	203.1	14,137
0-4	10,680	212.5	25,133
0-5	16,934	215.6	39,270
0-10	74,397	236.8	157,080
0-20	257,925	205.2	628,319
0-30	694,178	245.5	1,413,717
0-40	1,587,775	315.9	2,513,274
0-50	2,430,200	309.4	3,926,991

TABLE 2.1-6

POPULATION AND DENSITY WITHIN FIFTY MILES OF PERRY NUCLEAR POWER PLANT (1985)

Radius (Miles)	Cumulative Population	Density (People/Square Mile)	Population Assuming 500 People/Square Mile
0-1	103	32.8	1,571
0-2	1,826	145.3	6,283
0-3	5,756	203.6	14,137
0-4	10,707	213.0	25,133
0-5	16,977	216.2	39,270
0-10	74,707	237.8	157,080
0-20	259,500	206.5	628,319
0-30	694,948	245.8	1,413,717
0-40	1,584,337	315.2	2,513,274
0-50	2,425,320	308.8	3,926,991

TABLE 2.1-7

POPULATION AND DENSITY WITHIN FIFTY MILES OF PERRY NUCLEAR POWER PLANT (1986)

Radius (Miles)	Cumulative Population	Density (People/Square Mile)	Population Assuming 500 People/Square Mile
0-1	103	32.8	1,571
0-2	1,835	146.0	6,283
0-3	5,777	204.3	14,137
0-4	10,744	213.7	25,133
0-5	17,037	216.9	39,270
0-10	75,035	238.8	157,080
0-20	261,108	207.8	628,319
0-30	695,773	246.1	1,413,717
0-40	1,580,987	314.5	2,513,274
0-50	2,420,377	308.2	3,926,991

TABLE 2.1-8

POPULATION AND DENSITY WITHIN FIFTY MILES OF
PERRY NUCLEAR POWER PLANT (2020)

Radius (Miles)	Cumulative Population	Density (People/Square Mile)	Population Assuming 500 People/Square Mile
0-1	115	36.6	3,142
0-2	2,043	162.6	12,566
0-3	6,431	227.4	28,274
0-4	11,958	237.9	50,265
0-5	18,959	241.4	78,540
0-10	86,443	275.2	314,159
0-20	314,080	249.9	1,256,637
0-30	756,259	267.5	2,827,433
0-40	1,590,496	316.4	5,026,548
0-50	2,413,435	307.3	7,853,982

TABLE 2.1-9

ACQUISITION OF LAND AND MINERAL RIGHTS
PERRY NUCLEAR POWER PLANT 1 & 2

Land Acquisition

Parcel No.[1]	Owner	Status
1	Bradler	Acquired 8/14/78
2	West & Siegal	Acquired 1/28/74
3	Fairchild	Acquired 11/26/73
43	Mihalik	Acquired 1/21/74
21	Evert	Acquired 10/22/74
22	Schuster	Acquired 2/4/74
47	Torch	Acquired 12/10/74
48	Wakkila	Acquired 10/17/74

Mineral Rights

Parcel No.	Owner	Status
44,45	CEI - Lone Star Producing Co.	Acquired land and mineral rights in 1972 Acquired oil and gas rights 10/25/76
	Lake Erie Parcel State of Ohio	Acquired mineral rights by lease for a 46-year period 5/14/1976 - 5/14/2022, dated 6/8/76

The portion of Center Road north of its intersection with Parmly Road to its terminus at Lockwood Road, and Lockwood Road from its westerly origin to the point at which it crosses the site boundary were vacated by a resolution adopted by the Board of Lake County Commissioners on June 16, 1975.

NOTE:

(1) Refer to <Figure 2.1-5>

TABLE 2.1-10

TRANSIENT POPULATIONS WITHIN THE LOW POPULATION ZONE

Facilities and Institutions	Approximate Peak Transient Population (1999)		Approximate Proximity to PNPP (miles/direction)
SCHOOLS			
Perry Elementary	683	school year[4]	2.2, SSE
Perry Middle	645	school year[4]	2.2, SSE
Perry High	687	school year[4]	2.2, SSE
New Life Christian Academy	43	school year[4]	2.5, SSE
HOSPITALS			
None	-		-
PRISONS			
None	-		-
BEACHES & PARKS			
North Perry Park		summer[1]	1, ENE
Perry Township Park		summer[1]	1, WSW
Parmly Park		summer[1]	1, WSW
Camp Roosevelt	150	summer[2]	1.4, WSW
Lake Shore Park		summer[1]	2, ENE
INDUSTRY			
Neff-Perkins Company	175	daily	0.6, WSW
TOTAL PEAK	1,575	daily during school year	

NOTES:

[1] Small parks for which no attendance records are kept; a summer weekend peak population of 50 was assumed for estimating the total peak.

[2] Estimated 150 per 4-week camping period during summer.

[3] (Deleted)

[4] Includes staff.

2.2 NEARBY INDUSTRIAL, TRANSPORTATION AND MILITARY FACILITIES

2.2.1 LOCATIONS AND ROUTES

2.2.1.1 Industrial Facilities

At present, a number of industrial facilities are located within five miles of the plant center with many firms within a 10-mile radius (the term "plant center," unless otherwise stated, is used in <Section 2.2.1> and <Section 2.2.2> to indicate a point midway between Unit 1 and Unit 2 on the reactor building centerlines). Those which may be significant to the plant are discussed in <Section 2.2.2> and are listed in <Table 2.2-1>; their locations are depicted in <Figure 2.2-1>.

2.2.1.2 Extractive Industries

Extractive activities within five miles of the plant center include oil and gas extraction. These are discussed in <Section 2.2.2.3>.

2.2.1.3 Transportation

a. Roads

<Table 2.2-2> lists the major roads within five miles of the plant center. <Figure 2.2-2> shows the locations of these highways.

b. Railroads

The railroad lines closest to the plant center are the Chessie Seaboard and others (CSX); and the Norfolk Southern (NS) lines which converge in a major railroad corridor approximately three miles south of the plant center. These two railroads serve the area which extends from Painesville to Ashtabula. The Fairport, Painesville and Eastern line (FP&E), a previously independent local

enterprise serving the Painesville-Fairport Harbor vicinity, was taken over by NS in July 1984. Consequently all of the FP&E lines are now run by NS (Reference 1).

A rail spur, owned by CEI and operated by NS has been extended into the plant site from the west for the use of FENOC. This extension to the site originates at the NS branch line (formerly FP&E) which terminates in northeast Painesville Township at the site of the now closed IRC Fiber Company plant. Locations of railroad lines are depicted on <Figure 2.2-2>.

c. Airports

No airports are located within 5 miles of the plant center. However, the Woodworth Airstrip, which is sod and without facilities, is located approximately 4.5 miles east-southeast of the plant center. Three airports are located in Lake County with facilities and hard-surfaced runways which are longer than 1,500 feet: Lost Nation, Concord and Casement Airports. The closest is Casement, approximately six miles southwest of the plant center; Concord Airport is about 10 miles south-southwest. Lost Nation, located in the Willoughby area, is approximately 15 miles to the southwest. FENOC has an onsite private heliport located approximately 2,000 feet southwest of the reactor building complex and 170 feet south of the TEC building (Reference 60). This heliport is intended to be used for emergency and emergency drill cases only.

d. Water

The nearest shipping channel in Lake Erie extends parallel to the shoreline and is located approximately two miles from the plant center.

The nearest dock and anchorage is located at Fairport Harbor, and is approximately seven miles west-southwest of the plant center (Reference 2).

2.2.1.4 Military Facilities

No military bases or missile sites are located within five miles of the plant center (Reference 3) (Reference 4) (Reference 5).

2.2.1.5 Gas Pipelines

The closest gas pipeline is a 4-inch diameter line along Parmly Road which operates at 35 psi. It is approximately 3,000 feet southwest of the reactors at its point of closest approach. The largest gas pipeline within five miles is a 20-inch diameter line which operates at about 150 psi and is approximately 3,200 feet southeast of reactor buildings at its point of closest approach (Reference 6).

<Figure 2.2-3> depicts the location of gas pipelines within the immediate environs of the plant center and <Table 2.2-3> presents information on each pipeline. No oil pipelines are located within 5 miles of the site (Reference 7).

2.2.1.6 Nuclear Power Generating Facilities

The nearest nuclear power plant is Beaver Valley (Units 1 and 2); it is located 25 miles northwest of Pittsburgh, Pennsylvania, approximately 90 miles southeast of the plant center (Reference 8).

2.2.2 DESCRIPTIONS

2.2.2.1 Descriptions of Facilities

A concise description and location of each industrial facility including manufacturing and storage facilities within the vicinity of the plant is provided in <Table 2.2-1> and depicted in <Figure 2.2-1>. Major transportation routes are listed in <Table 2.2-2> and depicted in <Figure 2.2-2>.

2.2.2.2 Description of Products and Materials

a. Industrial

Hazardous materials used, transported, processed, and/or stored in the vicinity of the plant are listed on <Table 2.2-4a>, <Table 2.2-4b>, <Table 2.2-5a>, and <Table 2.2-5b> along with information on maximum quantities, method of storage, frequency, and the particular industry involved with the materials. <Figure 2.2-1> shows the locations of these industries relative to the plant. <Table 2.2-1> also gives information about the location as well as the work force and the products associated with each industry.

The industrial facility closest to the PNPP is the Neff Perkins Corporation which manufactures rubber and steel custom molded products. Materials are brought into this plant by truck. Most shipments contain small quantities and are infrequent. Routes used include US 20, Perry Park Road and Parmly Road in the nearby vicinity. Shipments come from the east, south and west. No change is anticipated for the future in reference to the use, transport, storage, and production of hazardous materials (Reference 9).

Sivon Manufacturing, a firm that manufactures small machinery for the rubber production industry, is located approximately 1 mile southwest of the PNPP center. With the exception of small quantities of gasoline and industrial solvents and paints there are no hazardous materials handled by this facility (Reference 10).

Bentley Excavating is located approximately 3 miles south-southwest of the plant center. They are excavation and building contractors and do not handle any hazardous materials (Reference 11).

Mackenzie Nursery Supply, located 3.5 miles south-southwest of the PNPP center, markets materials and equipment used by the local nursery industry. While they do market small amounts of fertilizer, packaged in small paper or plastic containers, they do not handle any pesticides, herbicides, fungicides, or any other toxic or flammable materials (Reference 12).

The Perry Coal and Feed Company, located approximately three miles south of the plant center, manufactures small amounts of feed. It markets a complete line of herbicides, insecticides and fungicides in the region. These are handled in small containers (usually bags, boxes and gallon jugs). Perry Coal usually has a small amount of ammonium nitrite and similar substances on hand.

Shipments of goods are made once a week during the spring, summer and fall. Trucks using local roads (Route 2, US 20, Narrows Road, and Route 84) ship the materials in all directions. No changes are anticipated for the future relative to the use, transport and storage of hazardous materials (Reference 14).

Located approximately 3.5 miles south of the plant center, are the firms of Thermatool Mill Systems Corporation and Midwest Materials, Inc.

Thermatool Mill Systems, with a staff of 60, manufactures structural I beams. Kerosene is stored on the premises in 250 gallon above ground tanks. No other hazardous materials are produced, stored or transported by the firm (Reference 15).

Midwest Materials Inc. is not a manufacturing firm. They are distributors of finished and semi-finished steel products (Reference 16).

There is an industrial area approximately six miles west-southwest of the plant center located to the east of Fairport Harbor and north of Painesville. Lonza Inc. and Nova Chemicals are the major firms in this area. Also operating in the area is the firm Aluminum Smelting and Refining Company, Inc (Reference 82).

The Aluminum Smelting and Refining Company manufactures aluminum products and additives used for steel purification (oxidizing, degassing) by the steel industry. Approximately 45 people are employed at the company's Painesville facility.

Removed in Accordance with RIS 2015-17

Lonza, Inc. employs 85 to 100 people. It is a manufacturer of distilled fatty acids, glycerine and gylcerides.

Removed in Accordance with RIS 2015-17

Nova Chemicals has undergone extensive expansion over the last five years. It currently employs 60-75 people and manufactures expandable polystyrene at its plant in Painesville. It handles the following hazardous materials: styrene monomer, pentane, caustic, concentrated sulphuric acid, and No. 2 fuel oil.

Removed in Accordance with RIS 2015-17

R. W. Sidley, Inc., which manufactures ready mix cement and excavates and processes sand for the construction industry, is located approximately 6.5 miles southwest of the plant center. It has a staff of 35-50 workers. The facility may store up to 100 tons of cement and several thousand tons of limestone, silica sand and large particle aggregates.

Removed in Accordance with RIS 2015-17

Numerous industrial firms operate in the city of Painesville, southwest of the PNPP center. Of them, The Lubrizol Corporation and Fasson, Division of Avery International, maintain facilities that handle various hazardous materials.

The Lubrizol Corporation facility in Painesville manufactures additives for commercial lubricants. The facility is located approximately 7.5 miles from the PNPP center and employs 600 people. A generic list of the types of hazardous materials handled by Lubrizol includes: polybutenyl nitrogen and ester-containing compounds; metal sulfonates, carboxylates and phenates; antioxidants (metal-dithiophosphates); dithiophosphates and sulfur-containing olefins; and carboxylic acids (Reference 24). Detailed information on specific compounds has been made available to the Painesville Township Fire Department and Lake County Emergency Management Agency.

Fasson, Division of Avery International, operates two plants, side by side, on its Painesville campus and a storage facility at a separate location within Painesville Township. There are approximately 700 workers employed at these facilities. The Fasson facilities in Painesville which are 6.0 to 6.5 miles from PNPP, manufacture and test various adhesive compounds used to produce pressure sensitive adhesives for paper, foil and film tapes. Fasson handles the following hazardous materials at its manufacturing and storage facilities: toluene, heptane, ethyl acetate, methanol, hisol-10, and methylethyl ketone (MEK).

Removed in Accordance with RIS 2015-17

Removed in Accordance with RIS 2015-17

Morton Salt, which presently employs 250 workers, mines and processes salt at its facility on Lake Erie in Painesville Township. The facility is approximately 8 miles from the PNPP center.

Removed in Accordance with RIS 2015-17

Hubbell Industrial Controls, The Perfection Corporation and Leeco Refractory Coatings are three major firms operating in the city of Madison, approximately 5.5 miles east-southeast of the plant center.

Hubbell Industrial Controls, with a staff of 137, manufactures customized controls for construction industry machinery. They may have small amounts of acetylene and commercial paint solvents on hand, but handle no other hazardous materials (Reference 27).

The Perfection Corporation, with a staff of 100, manufactures pipe nipples.

Removed in Accordance with RIS 2015-17

Leeco Refractory Coating, a division of Acme Resin Corporation, manufactures paints and washcoatings used by steel foundaries. They use and store isopropyl alcohol and trichloroethylene.

Removed in Accordance with RIS 2015-17

These firms do not anticipate any future changes in reference to the use, transport, storage, or production of hazardous materials (Reference 27) (Reference 28).

The Chesapeake Packaging Company is a small firm which manufactures corrugated cardboard shipping containers. It is located approximately 6.5 miles east of the plant center. The facility does not handle any hazardous materials (Reference 29).

Several industrial facilities previously sited as operating in the Perry Nuclear Power Plant vicinity have since ceased operations. They include the IRC Fiber Company, Sundstrand Service Corporation and Arthur A. Covell's, all in Perry Township, and Erie Coke and Chemical in the Village of Painesville.

b. Transportation

1. Roads

Nearby major roads are listed in <Table 2.2-2>. They are State Highways 84, 528 and 2, U.S. Route 20, and Interstate 90. The closest point on each to the plant, and the annual average daily traffic volume (AADT) for sections of each within a 5-mile radius of the plant are given in <Table 2.2-2>. <Figure 2.2-2> depicts all roads in the vicinity of the plant.

No nuclear power plants are located within 50 miles of the Perry Nuclear Power Plant (Reference 8). The only operating commercial low-level nuclear waste repository east of the Mississippi River is located at Barnwell, South Carolina. Additionally, no nearby institutions or military operations exist which may use or transport radioactive materials. However, Interstate 90 is approved by the NRC as a route that can be used for nuclear shipments. It is estimated that each year approximately 15 truck shipments of radioactive material pass through Lake County on I-90 (Reference 58). It may be assumed that shipments of hazardous materials occur on the various highways within the five mile area around the plant center. Specific hazardous materials shipped on these highways are described in <Table 2.2-4b>.

Refer to Item 2, below, and <Table 2.2-5a> and <Table 2.2-5b> for descriptions, quantities frequency of shipment of hazardous materials transported by rail.

2. Railroads

The nearest railroad line to the plant center is a spur into the plant from a branch line of the NS Railroad (formerly FP&E branch line) originating at the now closed IRC Fiber Company approximately 3.5 miles west-southwest. The spur (owned by CEI, operated by NS) is presently used solely by CEI.

A segment of a major railroad corridor, which transverses northern Ohio, is located within the nearby vicinity. At its closest point, it is three miles south of the plant center. CSX and NS operate rail lines in the area.

The CSX system regularly transports hundreds of hazardous materials in varying amounts. Virtually all materials may be legally transported by rail. <49 CFR 100-199> lists over 1,600 hazardous materials, and their compliance limitations that may be transported by rail or highway.

<Table 2.2-5a> presents a list of the major hazardous materials transported by CSX within the vicinity of the Perry Plant in 2005 (Reference 85).

The NS transports materials in the local area between Painesville and Perry on branch lines formerly operated by FP&E. These lines, taken over by NS in July 1984, service the industrial area located approximately six miles west-southwest of the plant center.

The NS Railroad was unable to readily supply a complete list of hazardous materials transported on the main line between Painesville and Ashtabula, Ohio. This main line does carry all commodities classified as hazardous by the Hazardous Commodity Series 49 of the Standard Transportation Commodity Code (Tariff Number 1-F) (Reference 1) (Reference 31). <Table 2.2-5b> presents a list of the major hazardous materials transported by NS Railroad within the vicinity of the Perry Plant in 2005 (Reference 85).

3. Military Facilities

No military ammunition loading or storage facilities are located within 25 miles and hence no large munitions shipments (Reference 5).

2.2.2.3 Natural Gas Pipelines

Natural gas lines within the immediate environs of the plant are depicted in <Figure 2.2-3> and listed and briefly described in <Table 2.2-3>. The nearest is a 4-inch diameter line which operates at 35 psi and is approximately 3,000 feet southwest of the reactors at its point of closest approach. The largest gas pipeline in the vicinity of the plant is a 20-inch diameter line which operates at about 150 psi and is approximately 3,200 feet southeast of the reactors at its point of closest approach (Reference 6).

No oil pipelines or tank farms are located in the immediate environs of the plant site other than those which are part of the PNPP itself.

The closest extractive industries include a producing gas well one mile northeast of the plant center, two producing gas wells one mile east of the plant center, and two producing gas and oil wells 1.5 miles from the plant. One is located east-southeast, the other west-southwest

(Reference 32). Seventy-three wells were completed in 1983 which were producers of natural gas or natural gas and oil. Exploration for gas and oil may continue in those parts of Lake County that are not developed (Reference 34).

<Figure 2.2-4> depicts locations of gas and oil wells within five miles of the site. No commercial extraction of gravel or sand exists within five miles of the site (Reference 35).

2.2.2.4 Waterways

<Section 2.2.1.3>, Item d, contains information on channels, docks and anchorages within five miles of the plant center. <Figure 2.2-2> shows shipping lanes in the vicinity of Perry. <Table 2.2-6> and <Table 2.2-7> contain information on types and amounts of cargo transported on the Great Lakes in 1982 and the 1982 combined traffic by type of vessel, respectively. The trips and draft of vessels operating in Lake Erie shipping lanes near Perry are presented in <Table 2.2-8>.

The intake structures for PNPP are located approximately 2,600 feet offshore perpendicular from the shoreline. The discharge structure is approximately 1,650 feet offshore. These are located in 20 to 23 feet of water, where the structures have been constructed a minimum of 12 feet below the lake low water datum.

The closest water intake structure on Lake Erie is located at the now inoperative IRC Fiber plant, about 3.5 miles west-southwest of the plant center.

The closest shipping channel is approximately two miles from the plant center at Perry with a depth of approximately 40 feet. It parallels the Ohio coastline between the ports of Fairport Harbor and Ashtabula (Reference 4) (Reference 36).

2.2.2.5 Airports and Airways

a. Airports

No airports are located within five miles of the plant center. One small private sod airstrip (Woodworth) is located 4.5 miles east-southeast of the plant. The airstrip has one 2,300-foot sod runway with 90° -270° orientation and is not attended. Two single-engined prop planes are based at Woodworth. Average annual operations are estimated at six flights per year. The approach pattern for this airport is approximately 3.5 miles east of the plant center (Reference 37) (Reference 83).

Within 10 miles of Perry Nuclear Power Plant, Casement and Concord are the only airports with major facilities and paved runways. (Refer to <Figure 2.2-5> and <Table 2.2-9> for location of these facilities.) Lost Nation is 15 miles southwest. Hopkins International, located in Cleveland, is the nearest regional facility. It is approximately 45 miles southwest of Perry.

The closest airport is Casement which is located approximately six miles south-southwest of the station site. It has one 3,800-foot runway oriented 120° -300°. Approaching and departing aircraft use a standard pattern from either end of the runway depending on wind direction. The Casement facility serves from 10-12 flights per week, year round, is irregularly attended, has runway lighting for night operations, and has neither radio nor air nor ground control. Casement Airport has about 30 planes based at the field. All of these are propeller-driven planes. There were two incidents in 1977, and a minor one in 1983 involving only minimal property damage. Casement Airport has been in operation about 15 years and presently has no plans for expansion. The approach pattern to Casement Airport is approximately 5 miles west of the site (Reference 38).

Concord Air Park is located in Concord Township, approximately 10 miles south-southwest of the plant. One 2,400-foot paved runway exists. It is oriented 20° -200°. A second strip (sod) was converted to farmland in 1983. Flight patterns associated with the facility are standard approach and departure patterns, using either end of the runway depending upon wind direction.

Concord Air Park is a private airport which serves as a training facility and is often used by a number of students. It is attended on an irregular basis, has UNICOM but no radio, ground or air control. The runway is lighted for base fliers on request. Currently, 25 planes are at the Concord Air Park (single and multi-engine craft). Most of the traffic at the airport results from planes that are based there and from training activity. No fatal accidents have occurred since the airport was established in 1957, although one incident was recorded in October 1978. No plans presently exist for expansion of the facility or of operations. The approaches to the Concord Airport are not within 5 miles of the site (Reference 39).

Lost Nation Airport is located approximately 15 miles southwest of the plant site. It has a relatively high level of traffic, mainly business planes. Two 5,000-foot paved runways exist: one oriented 50° -230° and the other 90° -270°. Both have night lighting and can be activated 24 hours a day. Standard flight patterns are used from both ends of the runway depending on wind direction (Reference 84).

No daily breakdown of operations currently exists at Lost Nation Airport; however, a yearly figure of 78,000 was estimated. Of the 185 planes based at the airport, eighteen percent involve operations of jet aircraft with an average seating capacity of eight persons. Thirty percent of the operations are twin engine, propeller craft with an average capacity of six persons. The

remainder of the operations (52 percent) involve single engine propeller craft carrying an average of four passengers. The approach to the Lost Nation Airport is more than 5 miles from the site (Reference 40).

In 38 years of operations, three fatal accidents have occurred, two on airport property and one approximately 500 feet off the end of the runway. Also during this 38-year period, a number of incidents (most unconsequential and occurring on airport property) have occurred. No incidents have occurred recently, however. No definite growth plans are anticipated at present, although the airport management would like to continue to expand operations at Lost Nation (Reference 40).

b. Airways (distances measured from airway centerline)

Airways V-188 and V-188-10 are low altitude airways with a minimum altitude of 1,200 feet above the ground surface <Figure 2.2-6>. These airways connect the Detroit, Michigan area with Ashtabula, Ohio and have a peak daily traffic of 13 flights each. Airway V-188-10 passes about 3.5 miles north-northwest of the plant and V-188 about 1.5 miles west-northwest (Reference 41) (Reference 42).

Airway V-10 is another low altitude airway that passes approximately 1.5 miles southwest of the plant. It begins in Youngstown and joins V-188 about 3.5 miles west-northwest of the plant. Peak daily traffic on V-10 is 15 flights (Reference 41) (Reference 42).

A fourth low altitude airway, V-14-W, passes approximately 6.5 miles north of the plant and had a peak daily traffic of 35 flights (Reference 41) (Reference 42).

These low level airways are four miles wide; therefore, planes from both V-10 and V-188 may pass directly over the plant. Any type of aircraft can use a low level airway (Reference 43). No statistics on specific types are kept. The airways have VOR radio beacons located at either end of each segment and are monitored with radar by Air Route Traffic Control Centers. (Refer to <Figure 2.2-6> for location of airways in relation to plant site.)

Two high altitude airways (minimum altitude 18,000 feet) also pass within the vicinity of the plant. J29-82 connects the Cleveland region with points to the northeast. At the closest point, this airway is approximately 9.5 miles south-southeast of the Perry Plant. It had a peak 1976 traffic volume of 71 flights per day (Reference 42) (Reference 44).

Airway J584 passes approximately four miles north-northeast of the plant site, carrying a maximum peak daily traffic of 94 flights per day (Reference 44). (Refer to <Figure 2.2-6> for location of high altitude airways.)

J584 and J29-82 have a minimum altitude of 18,000 feet. Any type of aircraft can use a high altitude airway but most serve jet and prop-jet aircraft with pressurized cabins.

One holding pattern exists near the plant site. It is associated with Airway J584 and is located approximately 12.5 miles east-northeast of the plant over the shore of Lake Erie (Reference 44).

The preceding describes the facilities that exist within five miles of the facility and facilities of greater distances which are of significance. The following land uses or activities are not located within five miles of the site: airports, military bases,

missile sites, bombing ranges, oil pipelines, nuclear power plants, or commercial gravel and sand operations.

2.2.2.6 Projections of Industrial Growth

The industrial area east of Fairport Harbor, located from 6 miles west-southwest of the plant has undergone significant change in the past few years and is expected to continue to change over the next few.

The Diamond Shamrock industrial facility has been closed and the company has ceased all manufacturing activities in Painesville. The major portion of the main plant facilities now belongs to the Standard Machine and Equipment Company of Uniontown, Pennsylvania. It is anticipated that more industry will be attracted to the Diamond Shamrock facilities. The nature of their future operations is uncertain; however, it is possible that inorganic chemical operations (sodium chlorine, lime) will constitute some of the future manufacturing (Reference 62).

Lonza Chemicals, Inc. is planning growth for the future, but type of activities is unknown (Reference 66).

Nova Chemicals management has not reopened the old Robin-Tech (and earlier Allied) plant which employed around 120 persons in the early 1970's. They have no definite plans or a target date for opening the facility. Feasibility studies are still being done (Reference 67).

2.2.3 EVALUATION OF POTENTIAL ACCIDENTS

On the basis of information provided in <Section 2.2.1> and <Section 2.2.2>, the potential accidents considered as design basis events have been identified and the potential effects on the plant are evaluated in terms of design parameters (e.g., overpressure) or physical phenomena (e.g., concentration of flammable or toxic clouds outside building structures).

2.2.3.1 Determination of Design Basis Events

2.2.3.1.1 Explosions and Flammable Vapor Clouds (Delayed Ignition)

2.2.3.1.1.1 Nearby Transportation Facilities

As shown on <Table 2.2-2> the nearest major highway to the site is U.S. Route 20. <Regulatory Guide 1.91> indicates that the maximum probable

hazardous solid cargo for a simple highway truck is approximately 50,000 pounds. Assuming a TNT equivalency ratio of 1, the safe distance from the explosion as defined in (Reference 73) (i.e., peak incident pressure on the plant structures of 1 psi or less) and as calculated using Equation 1 of <Regulatory Guide 1.91> is approximately 1,660 feet. Since the closest point of Route 20 to the site is one mile, there will not be any adverse effects on the plant from potential explosions. The actual overpressure on the plant is calculated to be approximately 0.22 psi using <Figure 2.2-7>.

The railroad line closest to Perry is a major railroad corridor located approximately 3 miles south of plant center. <Regulatory Guide 1.91> states that the maximum explosive cargo in a single railroad box car is 132,000 pounds. Using the same methods and assumptions as above, the safe distance and the plant overpressure are calculated to be 2,300 feet and 0.07 psi, respectively.

<Table 2.2-5a> and <Table 2.2-5b> list the major hazardous materials shipped by rail on the lines in the area of the site. A conservative evaluation of a worst case hypothetical explosion is given as follows:

a. Cargo - Propane

b. Quantity - 70.4 tons per car

c. TNT Mass Equivalence - 240%

d. Heat of Combustion - 21,670 Btu/lb

Using the above assumptions and the methods presented in <Regulatory Guide 1.91>, the calculated safe distance is approximately 3,130 feet and the plant overpressure is given as 0.11 psi.

Based on the above, it can safely be concluded that the plant will not be affected by any potential explosions at the railroad corridor.

The nearest shipping channel in Lake Erie to the site is one that extends parallel to the shoreline located approximately 2.0 miles (10,560 feet) from the site center. The closest safety-related structure to the shoreline is the emergency service water pumphouse located approximately 410 feet inland. <Regulatory Guide 1.91> lists the maximum probable quantity of explosive material transported by ship as 10,000,000 pounds. Assuming this quantity of material exploded, the safe distance and plant overpressure are given as 9,695 feet and 0.90 psi, respectively. Since the actual distance is approximately 9,820 feet, there will be no adverse effects on plant operation.

2.2.3.1.1.2 Gas Lines

Potential accidents involving the release of natural gas from the existing pipelines, discussed in <Section 2.2.2.3>, do not pose a hazard to the plant. As will be shown, if an accident occurs, the concentration of gas at all plant air intakes is well below the lower flammable limit. Also, detonation of an unconfined natural gas-air mixture is not considered to be a credible event (Reference 69) (Reference 70) (Reference 71) (Reference 72).

Each of the existing pipelines was analyzed to determine the limiting potential accident condition. The results of this analysis indicated that the most limiting release of natural gas involves a break in the closest 4-inch natural gas pipeline. The analysis was performed using the following conservative assumptions:

a. A break in the pipeline occurs at the point of nearest approach to the plant (3,200 feet for 20-inch pipe and 2,000 feet for 4-inch pipe).

b. Gas is released by a constant enthalpy process yielding a gas temperature for dispersion calculations of 24°F for a 40°F initial gas temperature due to the Joule-Thompson effect.

c. The flow rate out the break is ranged from the maximum transient flow rate to a minimum flow rate of 1 m^3/sec.

d. Atmospheric dispersion is for Class G stability using <Regulatory Guide 1.78> dispersion parameters and a virtual source distance correction to account for initial finite source size.

e. A range of wind speeds from 0.1 m/sec. to 9 m/sec. are used, which covers the range in G stability.

f. Plume rise is in accordance with Briggs equation for stable (Class G) atmospheric conditions (Reference 73) and an air temperature of 68°F.

A perfect gas prior to its escape from the broken pipe will expand and accelerate toward the break. As the gas expands, it will tend to cooldown from its original equilibrium temperature. In doing so, a temperature gradient between the pipe and the flowing gas will be established. In addition, friction between the pipe wall and the flowing gas will tend to heat the gas slightly above the temperature it would possess in a frictionless expansion. In the first instance, small amounts of heat will flow from the pipe wall into the expanding gas; in the second instance, energy already possessed by the gas is simply transformed into heat and causes the gas temperature to rise slightly more. Thus, the gas gains a small amount of energy from the pipe wall during this process.

In the second part of the blowdown process, the gas expands through the break at sonic velocity and, if still above atmospheric pressure, continues to expand until it reaches atmospheric pressure. During this

phase, the process is essentially adiabatic. No work is performed either during the expansion or the slowing down period. Consequently, the net energy possessed by the gas just prior to reaching the break, and after it slows down in the atmosphere, remains unchanged.

Since (1) no work has been performed by the escaping natural gas, (2) small quantities of heat have been transferred from the pipe to the gas, and (3) a transformation of energy has occurred by virtue of the fact that the gas is at a substantially lower pressure at the end of the blowdown, the energy gain from (2), above, and the energy transformation indicated in (1), above, must be present in the form of heat. Therefore, the slowed down natural gas in the atmosphere would be at a slightly higher temperature than the original temperature. Therefore the blowdown is essentially a throttling or isenthalpic process. Since natural gas is a real and not a perfect gas, the Joule-Thompson effect will cause the natural gas to be about 16°F below that expected for a perfect gas after blowdown.

The above description process indicates that there is a tendency for a perfect gas to be at a slightly higher temperature than the original temperature after the blowdown and mixing phase. However, with real gases, this temperature increase is lessened or, perhaps, reversed slightly. Therefore, extra conservatism is introduced into the plume rise analysis by assuming that the natural gas does not mix thermally with air and is cooled isenthalpically 16°F below the temperature it possessed prior to the break.

The plume rise calculations conservatively assumed the gas is released with zero momentum flux at the point of the break. In reality, because the pipe is below grade, the gas would be expected to have a significant vertical velocity component. This would tend to carry the plume higher than calculated.

Class G stability results in the smallest plume rise and the largest centerline concentration. These combine to give the highest concentration at the air intake and the smallest distance from the air intake to the lower flammable limit. Using Class G stability is, therefore, conservative.

A range of flow rates from 1 m^3/sec. to 1,800 m^3/sec., which covers up to the maximum break flow from the 20-inch pipe, were studied. While the larger flow rate results in a higher centerline concentration in the plume, it also yields a higher plume rise. The net effect is that the concentration at the air intake decreases as the flow rate increases.

The maximum concentration at the highest air intake is 0.27 percent and results from the break of the closest pipe (4-inch in diameter). The minimum distance between the intake structure and the lower flammable limit (5 percent) is 167 feet. For the largest pipe (20-inch), which is 1,200 feet farther, the analysis gives a maximum concentration of 0.15 percent at the intake, and a minimum clearance of 248 feet. The highest concentration at the air intake corresponds to the case where the break flow yields a plume rise sufficient to carry the plume just over the highest air intake. At this point the centerline concentration is well below the flammable limit.

The preceding discussion shows that the potential accidents involving the nearby natural gas pipelines result in gas concentrations at the plant air intakes that is well below the lower flammable limit. Therefore, these accidents are not considered design basis events.

2.2.3.1.1.3 Underground Gas Storage

No underground gas or petroleum storage facilities currently exist or are planned within five miles of the Perry Plant.

The design and construction of any future underground storage facilities would be done in accordance with local, state and federal regulations in existence at that time.

Salt solution storage of LPG has been in existence since 1951. It has grown until in recent years it exceeds 84 million barrels in the United States (Reference 74) (Reference 75). To store liquid under pressure requires a minimum depth. Depths of 500 feet or more are to be preferred with the range of 1,000 to 2,000 feet as ideal for LP gas storage.

Fresh water is pumped into the well for dissolving the salt to create the cavity. After the cavity is developed, gas is injected into it by pumping out brine. The pressure required on the gas which is being injected into an underground salt cavity is equal to that required to raise brine from the cavity to the surface, plus the pressure required to overcome resistance to flow of gas in the casing and of brine in the tubing. Gas is recovered by forcing brine into the salt cavities.

The use of liquid-to-liquid displacement as the transfer method ensures that the cavity will always be liquid filled with an extremely limited vapor phase resulting from irregular roof surfaces. Air could only get into the cavity under normal operation by being entrained in the brine. Therefore, it could not be present in significant quantities in the vapor spaces. In addition, an ignition source will not be present within the cavity. Thus, an explosion could not occur in the very limited cavity vapor space. The only potential explosion hazard associated with the cavities, as such facilities are currently operated, would be that occurring from an above ground release with delayed ignition (Reference 76) (Reference 77). The chance of a massive leak occurring at the well head with a delayed ignition is extremely remote. However, if it would occur, the result would be a flash fire or atmospheric explosion. The magnitude of such an unlikely explosion would be dependent upon the stoichiometry of the gas air mixture, its

volume, and atmospheric conditions including wind conditions. The worst conceivable delayed combustion event would involve a slight wind toward the plant to achieve proper mixing.

The case postulated for the above ground release assumed the complete shearing of the well head in a manner that allowed the maximum discharge rate from the cavity. The analysis included establishing the maximum assumed gas cloud and its TNT equivalent. A Gaussian plume model for diffusion was used in the analysis to consider the maximum steady-state gas release rate.

The method used is the same as the one used to analyze the natural gas line in <Section 2.2.3.1.1.2>. A conservative assumption of Pasquill Type F atmospheric conditions with a wind speed of 0.75 meters/second is used in the analysis.

The casing size is the controlling factor with respect to the maximum release rate to be used in the Gaussian plume equation. The cavity volume has little effect on the above ground explosion size because the casing determines the release rate. Its only effect would be associated with the period of time that the cloud could exist.

Failure of a propane well head from an underground storage cavern at 750 psig and 72°F will yield a sonic flow condition at the break (Reference 78). Because of the large storage capacity compared to flow rate, the propane will flow steadily at 1,330 ft^3/sec. through the annulus of the 4-1/2 x 8-5/8 inch casing. The flow will consist of 99.3 volume percent propane vapor and 0.7 volume percent liquid.

Assuming the propane ignited immediately, a flame jet 50.3 feet long will issue from the break. The flame will be stabilized at the point in the propane jet where the turbulent flow becomes laminar or about 5.4 feet from the well head break. This flame jet will continue until the propane flow from the underground storage cavern is stopped. A

detonable propane-air mixture will not form because the fuel is burned as it leaves the break. An explosion will not occur in the underground storage cavern because the required air cannot enter the cavern which is under a positive pressure of propane. In the event that the propane is exhausted, air will not leak back into the cavern since the propane will continue to flow at a slow rate as the remaining propane gas warms to the underground ambient temperature.

For the case of a well head failure with delayed ignition a detonable propane-air mixture can be postulated to form. The resulting cloud is calculated to drift approximately 2,400 feet from the release point and yield a detonation with a force equivalent to 372,000 lbs of TNT. Using <Figure 2.2-7>, the calculated peak overpressure at the plant is 1.1 psi which is below the 1.2 psi design value. Based on the above, a separation distance of one mile will be maintained between potential underground propane storage release points and the nearest safety-related structure on the Perry site. CEI has acquired all the propane storage rights within at least one mile of the plant.

2.2.3.1.1.4 Nearby Industrial and Military Facilities

The hazardous materials associated with the industrial facilities in the vicinity of the Perry site are listed in <Table 2.2-4a>. Based on the distances from the facility and the maximum quantities listed, there are no identifiable potential explosions which could adversely affect normal operations of the plant.

As indicated in <Section 2.2.1.4>, there are no military bases or missile sites in the vicinity of the plant.

2.2.3.1.1.5 Unit 1 Fuel Storage Depot

Potential accidents involving the Unit 1 Fuel Storage Depot do not pose a hazard to the plant. The Fuel Depot consists of two-300 gallon

capacity storage tanks containing unleaded gasoline fuel. The installation and maintenance of these fuel storage tanks are in accordance with NFPA 30. In the unlikely event these tanks were to explode, they are located sufficiently away from the Unit 1 safety-related plant buildings to ensure that the peak positive incident overpressurization is below 1.0 psi in accordance with <Regulatory Guide 1.91>. The fuel depot storage tanks are to be refilled via tank trucks driven to the site. The detonation of these tank trucks in the vicinity of the plant is not considered to be a credible event when evaluated in accordance with <Regulatory Guide 1.91>.

2.2.3.1.1.6 HWC Hydrogen and Oxygen Storage Area

Potential accidents involving the on-site storage of liquid hydrogen, gaseous hydrogen, and liquid oxygen to support operation of the Hydrogen Water Chemistry (HWC) System do not pose a hazard to the plant. The Hydrogen and Oxygen Storage Area consists of a 9,000 gallon capacity cryogenic liquid hydrogen storage tank, six 8,350 scf (at 2,400 psi) gaseous hydrogen tanks, and a 6,000 gallon capacity cryogenic liquid oxygen storage tank. The installation and maintenance of these cryogenic storage tanks are in accordance with NFPA 50A (gaseous hydrogen), NFPA 50B (liquid hydrogen), and NFPA 50 (oxygen). The potential impact from an explosion of the liquid hydrogen storage tank has been evaluated in accordance with the requirements of EPRI NP-5283-SR-A, Guidelines for Permanent BWR Hydrogen Water Chemistry Installations-1987 Revision, as part of the design and installation of the HWC System. In the unlikely event the hydrogen tank were to explode or an explosion were to occur resulting from a hydrogen pipe break, sufficient distance exists away from the Unit 1 safety-related plant buildings to prevent any resultant adverse affects on the safety-related structures.

Since the yield from the liquid hydrogen storage is much greater than that from the gaseous hydrogen storage, the liquid hydrogen evaluation above is bounding for the gaseous hydrogen tanks.

The potential impact on safety related air intakes from a failure of the hydrogen or oxygen storage facilities has been evaluated in accordance with the requirements of EPRI NP-5283-SR-A, Guidelines for Permanent BWR Hydrogen Water Chemistry Installations-1987 Revision, as part of the design and installation of the HWC System. The separation distances between the hydrogen and oxygen storage facilities and safety related air intakes is such that the safety related air intakes will not be subject to a dangerous concentration of hydrogen due to a postulated liquid or gaseous hydrogen leak. The separation distances between the hydrogen and oxygen storage facilities and safety related air intakes is such that the safety related air intakes will not be subject to excessive ingestion of oxygen rich air due to failure of the liquid oxygen storage tank.

No serious blast hazard is presented by the 6,000 gallon capacity cryogenic liquid oxygen storage tank. Oxygen is stable in both the gas and liquid phases. The potential threat from a liquid oxygen spill is the contact of oxygen-enriched air with combustible materials or the ingestion of the oxygen-enriched air into safety-related air intakes. Separation of the hydrogen and oxygen tanks is addressed in <Section 2.2.3.1.3.4>.

The liquid hydrogen and liquid oxygen storage tanks are to be refilled via tank trucks driven to the site. The detonation of these tank trucks in the vicinity of the plant is not considered to be a credible event when evaluated in accordance with <Regulatory Guide 1.91>.

2.2.3.1.2 Toxic Chemicals

2.2.3.1.2.1 Nearby Transportation Facilities

Based on the information presented in <Section 2.2.2.2>, an aggregate probability analysis was performed for those chemicals having the potential, per <Regulatory Guide 1.78>, to affect control room operations. This probability analysis is in accordance with <NUREG-0800>, Standard Review Plan Section 2.2.3 "Evaluation of Potential Accidents," dated July 1981, and follows the methodology outlined in <NUREG/CR-2650> "Allowable Shipment Frequencies for the Transport of Toxic Gases Near Nuclear Power Plants," dated October 1982.

$$P_{100} = P_{100/OI} \times P_I \times P_R \times P_{AK} \times L \times F_S$$

where P_{100} = Probability of exceeding Part 100 exposure guidelines per year.

$P_{100/OI}$ = Probability of exceeding Part 100 exposure guidelines given incapacitation of control room operators.

P_I = Probability that control room operators will be incapacitated given that a large release occurs along a specified distance exposed to the plant ($P_{OI/release}$).

P_R = Probability that a large release of toxic gas will occur from a given accident (release/accident).

P_{AK} = Probability of accident per distance traveled (accident/distance).

L = Travel distance exposed to plant per shipment (distance/shipment).

F_S = Frequency of Shipment (shipments/year).

The resultant aggregate probability of all materials transported in the vicinity of the Perry Plant, P_{100}, is estimated to be less than the 10^{-6} Design Basis Event probability stated in <NUREG-0800>, SRP Section 2.2.3. As a result, no protective design features are considered necessary for this event.

2.2.3.1.2.2 Onsite Storage

Toxic gas analyses are performed on potentially hazardous chemicals stored on the plant site in quantities greater than the criteria outlined in <Regulatory Guide 1.78>. A partial list of the chemicals for which evaluations have been performed, including quantity and location, is presented in <Table 2.2-10>. Potential hazardous chemicals other than those listed in <Table 2.2-10> may be stored on the plant site in quantities greater than the 100 lb. criteria of <Regulatory Guide 1.78> only if the accident analyses for the largest container stored on site show control room concentrations will be maintained within acceptable values.

For each chemical identified as potentially hazardous, administrative controls are placed on the size of onsite chemical containers. Conservative estimates of the control room concentrations of the chemicals have been made for postulated failures in accordance with <Regulatory Guide 1.78>. Significant sources of significant airborne contamination include the CO_2 storage tanks, the high pressure hydrogen and nitrogen cylinders, bromine and dichlorodifluoromethane (R-12). The estimated maximum control room concentrations for gross failures of the hydrogen and nitrogen cylinders are conservatively calculated to be less than 0.1 percent and 1.0 percent, respectively. The estimated maximum control room concentrations for gross failures of the liquid and gaseous hydrogen storage tanks is less than 4%, as determined based on separation distance requirements within EPRI NP-5283-SR-A, "Guidelines for Permanent BWR Hydrogen Water Chemistry Installations-1987 Revision". These control room concentrations are below the acceptable values for both hydrogen and nitrogen, which are classified as asphyxiates. The estimated maximum control room concentrations for failure of a bromine or dichlorodifluoromethane (R-12) container is shown by analysis to be within acceptable limits. The control room is equipped with a continuous monitoring system which will alarm prior to reaching unacceptable concentrations. Emergency self-contained breathing apparatus is provided in the control room and the operators are trained in its proper use.

Liquid biocide, rather than chlorine, is used for the service water system. Therefore, no chlorine is stored on the site.

2.2.3.1.2.3 Nearby Industrial and Military Facilities

A discussion of the hazardous materials associated with the nearby industrial facilities is presented in <Section 2.2.2.2>. Considering the materials listed in <Table 2.2-4a>, which are stored in appreciable quantities and are within five miles of the site, only chlorine which

is a liquid at normal conditions, has the potential to affect site operations. Checking the maximum anticipated amount of chlorine stored at the Lake County Water Facility (4 miles southwest of the plant) against the requirements of <Regulatory Guide 1.78>, Table C-2, indicates that the amount is exempt from further

consideration for all types of control room designs listed in the Regulatory Guide including the Type C control room.

Since there are no military facilities in the vicinity of the plant, there are no military related toxic chemicals requiring evaluation.

Based on the above, it can safely be concluded that there are no potential hazards to the Perry control room from toxic chemicals associated with nearby industrial and military facilities.

2.2.3.1.3 Fires

External fires and explosions are extremely unlikely. Exposures to the plant buildings include a 500,000 gallon fuel oil storage tank located approximately 250 feet from the plant in a diked area, two 300-gallon storage tanks of unleaded gasoline fuel located approximately 930 feet from the Unit 1 plant, a 9,000 gallon capacity cryogenic liquid hydrogen storage tank located approximately 1,240 feet from the Unit 1 plant, six 8,350 scf (at 2,400 psi) gaseous hydrogen tanks located approximately 1,240 feet from the Unit 1 plant, a 6,000 gallon capacity cryogenic liquid oxygen storage tank located approximately 1,100 feet from the Unit 1 plant, infrequent existence of tank trucks unloading gasoline fuel, diesel fuel, fuel oil, liquid hydrogen, or liquid oxygen to the site, a 20-inch gas line located more than 3,000 feet from the plant buildings and a wooded area located 350 feet from the plant at the closest point. Refer to <Section 2.2.3.1.1.5> for an evaluation of the gasoline fuel.

2.2.3.1.3.1 Oil Storage Tank

No serious fire exposure hazard is presented by the 500,000 gallon fuel oil storage tank to onsite buildings because of its separation. It is located 250 feet northeast of the Unit 1 turbine building as shown on <Figure 1.2-2> and is located within a dike. The fuel oil is used for firing the plant auxiliary boilers.

The fuel oil storage tank is 50 feet in diameter and is located 250 feet from the plant structure at its closest point. NFPA Flammable Liquid Code No. 30, OSHA Flammable Liquid Storage Requirements and The Ohio State Fire Marshalls Flammable Liquid Storage Code allow such tanks to

be located within 1/3 the tank diameter of important buildings. The storage tank is located 5 tank diameters away. All exposed buildings are of noncombustible or fire-resistive construction. The heat radiation rate from a total fire involvement of the tank would be less than 80 $Btu/hr/ft^2$ of building surface area assuming still air. With a 50 mph wind directed toward the plant, the heat radiation rate would only increase to approximately 110 $Btu/hr/ft^2$. The above rates are very safe for the noncombustible and fire-resistive construction involved since they are less than sun heat radiation.

A flammable vapor air mixture will not exist in the tank vapor space under design atmospheric conditions. The minimum lower flammable limit of fuel oil is 100°F. This temperature must be reached before sufficient vapor will be present in the tank vapor space to support combustion. On a hot sunny day, isolated lean flammable mixtures could exist due to the vaporization of liquid from the wetted shell or the vaporization of liquid condensed on the tank roof. These flammable pockets of vapor have an extremely low probability of being ignited because of the lack of an ignition source. The main volume of liquid will never exceed 90°F as reported in (Reference 79). In the very unlikely event that ignition would occur, any resulting explosion would be weak because of the limited flammable volume, lean mixture and lack of proper mixing. It would not result in any building damage. The tank is designed in accordance with API 650 so the roof would break at the weak roof to cylindrical shell seam and relieve the explosion.

The yard fire hydrant system will provide a ready supply of cooling water, as well as water for generation of foam to extinguish any fuel oil fires. A foam connection, foam proportioning equipment, and a supply of foam will be provided for use during the extinguishing operation. Extinguishment should occur in less than one hour.

Dense smoke will not affect the control room habitability because the air intakes are located approximately 680 feet from the tank on the west

side of the control complex. The air conditioning system is designed to completely isolate the control room during periods when the atmosphere is contaminated using <Section 6.4> redundant leak tight dampers. Oil smoke has a diameter range of 0.03 to 1 microns (0.50 microns average). The roughing filters have an efficiency of 85-90 percent on NBS atmospheric dust (.01 to 10 microns) and the HEPA filters have an efficiency of 99.97 percent on particles 0.3 micron and larger.

Therefore, in the remote event of smoke inleakage from a fuel oil fire, the series of roughing filter and HEPA filter banks in the supply unit and recirculation unit of the control room HVAC system will effectively reduce the density of any smoke in the control room to a level that will not affect the control room habitability. Self-contained fresh air breathing apparatus will be provided for use by operators until the control room air can be filtered. Smoke detectors will monitor the air entering the control room.

The auxiliary boiler will be used during various plant operations. Minimum demand occurs during normal plant operation. Approximate weekly demand is 450 gallons of fuel oil. Other greater auxiliary boiler demands will occur throughout the year during hot standby, cold startup or shutdown mode.

It is conservatively estimated that approximately ninety 7,300 gallon tank truck deliveries per year will be required as a maximum. The frequency of delivery of fuel oil to the 500,000 gallon storage tank will be limited to a cycle corresponding to the boiler operation. Delivery of fuel oil will be by truck, using Center Road for access to

the plant site. The unloading area is located on the north side of the storage tank.

The truck unloading area is located such that all drainage from the unloading area drains into the diked area, and the diked area is designed to be capable of containing the complete volume of the tank and the delivery truck, with a one foot freeboard.

The area around the fuel oil tank dike is contoured to ensure that drainage from the area is away from the plant proper and toward the diverted creek east of the plant. Normally, any leakage from the tank will be contained within the dike whose base is one foot below grade level. The only common mode failure that would cause rupture of both the tank and the reinforced concrete dike is the postulated seismic event. The slopes around the dike are such that the spillage resulting from the postulated simultaneous breaks would be directed away from the plant, as shown on <Figure 2.1-3>.

2.2.3.1.3.2 Gas Line

A 20-inch buried natural gas line runs adjacent to the Perry site as shown on <Figure 2.2-3>. It is unlikely that this line will rupture. If such a massive leak with immediate ignition did occur, the fire would continue to burn until the line is isolated and the methane gas in the isolated section of pipe is consumed. Sufficient heat radiation could be given off from such a fire to start a forest fire in the adjacent wooded area during dry seasons. However, the heat radiation at the plant buildings would be less than 200 Btu per hour per square foot which would not be sufficient to affect the plant safety. The forest fire is discussed in <Section 2.2.3.1.3.3>.

2.2.3.1.3.3 Forest Fires

The presence of 350 feet of clear space around the plant reduces the potential hazard of forest fire to a minimum (the presence of trees and bushes in landscaped areas does not affect this evaluation). Plant construction is fire resistive with building roof construction of either reinforced concrete or metal deck. The metal decks meet the requirements of Factory Mutual Class I roof decks. Therefore, the hazard from any flying brands is minimized. The yard fire protection system will provide a ready source of water to attack such a forest fire and to apply cooling water to buildings and other structures.

2.2.3.1.3.4 HWC Hydrogen and Oxygen Storage Area

No serious fire exposure hazard is presented by the 9,000 gallon capacity cryogenic liquid hydrogen storage tank or the six 8,350 scf (at 2,400 psi) gaseous hydrogen storage tanks to onsite buildings because of their separation. The hydrogen storage tanks are located approximately 1,240 feet southeast of the fuel handling building, the nearest safety-related plant structure. The cryogenic liquid hydrogen storage tank and gaseous hydrogen storage tanks supply hydrogen for operation of the Hydrogen Water Chemistry (HWC) System.

The location of the hydrogen storage facility complies with the separation distance outline in EPRI NP-5283-SR-A, “Guidelines for Permanent BWR Hydrogen Water Chemistry Installations-1987 Revision”, NFPA 50A (gaseous hydrogen systems at consumer sites) and NFPA 50B (liquefied hydrogen systems at consumer sites), as well as OSHA Standards 29 CFR 1910.103 (hydrogen). This separation distance ensures that the thermal flux from a potential hydrogen gas fireball or the blast overpressure from a potential hydrogen blast will not cause failure of any safety-related structures. The routing and delivery schedule for the hydrogen delivery truck meets the requirements of <Regulatory Guide 1.91> as specified in EPRI NP-5283-SR-A. Delivery of

liquid hydrogen will be by truck, using Center Road for access to the plant site. The unloading area is located on the east side of the storage tank. The detonation of these tank trucks in the vicinity of the plant is not considered to be a credible event when evaluated in accordance with <Regulatory Guide 1.91>.

No serious fire exposure hazard is presented by the 6,000 gallon capacity cryogenic liquid oxygen storage tank to onsite buildings because of their separation. The oxygen storage tanks are located approximately 1,100 feet southeast of the fuel handling building (the nearest safety-related plant structure), with separation distances being greater to safety-related plant air intakes. The cryogenic liquid oxygen storage tank supplies oxygen for operation of the Hydrogen Water Chemistry (HWC) System. Oxygen is stable in both the gas and liquid phases. The potential threat from a liquid oxygen spill is the contact of oxygen-enriched air with combustible materials or the ingestion of oxygen-enriched air into safety-related air intakes. The location of the oxygen storage facility complies with the separation distance outlined in EPRI NP-5283-SR-A, "Guidelines for Permanent BWR Hydrogen Water Chemistry Installations-1987 Revision", NFPA 50 (bulk oxygen systems at consumer sites), as well as OSHA Standards 29 CFR 1910.104 (oxygen).

The area around the storage area is contoured to ensure that a liquid spill from either the hydrogen or oxygen storage tanks will not flow toward, pond or accumulate within 75 ft. of the other.

2.2.3.1.4 Collisions with Intake Structure

The location and design of the main intake structure and the discharge structure, (which also serves as the alternate emergency service water intake structure) are shown in <Figure 2.1-3>, <Figure 3.8-65>, <Figure 3.8-66>, and <Figure 3.8-67>. Consideration of possible loss-of-function of the intake systems due to ice or a water borne

transportation accident is discussed in <Section 2.4.7> and <Section 2.4.11>. The structures are about 1.8 statute miles from chartered shipping lanes.

With the tops of these structures submerged a minimum of 12 feet below the LWD they will not be frozen in fast ice or be an obstruction to floating ice packs. Further, the intake structure is protected against dynamic loads (produced when floating ice islands crush against it) by means of 10 vertical caissons, each six or seven feet in diameter, placed in a 70 foot diameter circle around each of the two intake heads. The discharge nozzle is encased in a 17 foot diameter concrete caisson to protect it from similar dynamic ice loads. The intake structure is designed so that each intake head (located 141 feet apart) can supply the maximum emergency service water flow requirement. Also, the main intake (two heads) and the alternate intake (discharge nozzle) are

separated horizontally by more than one-third of a mile. For these reasons, the likelihood that both the main intakes and the alternate intake would be blocked by ice or a transportation accident, to the extent that it would affect the safety-related flow capacity, is extremely remote.

2.2.3.1.5 Liquid Spills

The accidental release of oils or liquids which may be corrosive, cryogenic or coagulant is not considered in the design of the facility since there is no potential for such liquids to be drawn into the plant's intake structure and circulating water system. Oil spills will have no effect due to the submergence of the intake structures. The effect of accidental releases of other liquids into Lake Erie will be greatly minimized due to the tremendous dilution capability of the lake and the redundancy, separation and submergence of the intakes.

2.2.3.2 Effects of Design Basis Events

The design basis accidents are described in <Section 2.2.3.1>. As indicated in that section, there are no potential adverse effects on the safe operation of the Perry facility from any of these events.

2.2.4 REFERENCES FOR SECTION 2.2

1. Personal communication, Robert Jones, Agent, Norfolk and Western Railroad, Painesville, Ohio, November 26, 1984.

2. Personal communication, Chief Moser, U.S. Coast Guard, Fairport Harbor, Ohio, March 5, 1985.

3. Personal communication, Captain Hunt, Office of Chief of Naval Operations, Washington, D. C., March 28, 1979.

4. Personal communication, Col. Albert W. Schumann, Department of the Air Force Office of Information, Washington, D. C., March 19, 1979.

5. Personal communication, Major Lee DeFormi, Department of the Army, Washington, D. C., March 20, 1979.

6. Personal communication, L. W. Steward, The East Ohio Gas Company, Ashtabula, Ohio, November 20, 1984.

7. Oil and Gas Pipelines in Ohio (Map) Scale 1:500,000. Harold J. Flint, Ohio Department of Natural Resources, Division of Geological Survey, 1973.

8. Commercial Nuclear Power Stations in the United States - Operable, Under Construction or Ordered - August 1, 1984 (Map). Nuclear News, 555 North Kensington Avenue, La Grange Park, Illinois 60525.

9. Personal communication, Richard Pohl, Plant Manager, Neff Perkins Corporation, Perry, Ohio, November 15, 1984.

10. Personal communication, Charlotte Kieffir, Office Manager, Sivon Manufacturing, Perry, Ohio, December 19, 1984.

11. Personal communication, M. Ellis, Operations Assistant, Bentley Excavating, Perry, Ohio, December 19, 1984.

12. Personal communication, W. Mackenzie, Owner, Mackenzie Nursery Supply, Perry, Ohio, December 19, 1984.

13. Personal communication, William Toth, Plant Manager, Calhio Chemicals, Inc., Perry, Ohio, November 15, 1984.

14. Personal communication, A. F. Warren, President, Perry Coal and Feed Co., Perry, Ohio, November 15, 1984.

15. Personal communication, Larry Lamphier, President, Welded Beam/Thermatool Corporation, Perry, Ohio, November 16, 1984.

16. Personal communication, Ted Pode, Vice-President, Midwest Materials, Inc., Perry, Ohio, November 16, 1984.

17. (Deleted)

18. Personal communication, Don Lewis, Environmental Engineer, Aluminum Smelting and Refining Company, Inc., Painesville, Ohio, December 19, 1984.

19. (Deleted)

20. Personal communication, Walter Bubley, Plant Manager, Glyco Chemicals, Inc., Painesville, Ohio, November 16, 1984.

21. Personal communication, Neil Seyler, Plant Manager, Georgia Pacific Plastics, Inc., Painesville, Ohio, November 20, 1984.

22. Personal communication, M. Gertz, Assistant to the President. R. W. Sidley, Inc., Painesville, Ohio, November 21, 1984.

23. (Deleted)

24. Personal communication, R. L. McMillen, Division Head, Health, Environmental Safety and QA, Lubrizol Corporation, Painesville, Ohio, December 21, 1984.

25. Personal communication, Irv Will, Acting Plant Manager, Fasson, Division of Avery International, Painesville, Ohio, December 20, 1984.

26. Personal communication, Mike Fletcher, Manufacturing Manager, Morton Salt-Division of Morton Thiokol, INC., Painesville, Ohio, December 21, 1984.

27. Personal communication, E. Zammer, Industrial Relations, Harvey Hubbell Inc., Madison, Ohio, November 20, 1984.

28. Personal communication, Mac Darnell, Vice-President of Manufacturing, Perfection Corporation, Madison, Ohio, November 20, 1984.

29. Personal communication, Ron Marchewka, Production Manager, Lawless Container Corporation, Madison, Ohio, November 20, 1984.

30. (Deleted)

31. Personal communication, Ralph E. Kaiser, Norfolk and Western Railroad, Roanoke, Virginia, March 16, 1979.

32. Spotted Township Maps (Perry, Painesville and Madison) showing well locations as on file at the Division of Oil and Gas, Department of Natural Resources, Columbus, Ohio, December 20, 1984.

33. Personal communication, Lowell Chocola, Technical Manager, Leeco Refractory Coatings Division/Acme Resin Corporation, Madison, Ohio, February 11, 1985.

34. Debrosse, T. A., Summary of Ohio Oil and Gas Developments in 1983, Figure 2, Division of Oil and Gas, Department of Natural Resources, Columbus, Ohio, March 1984.

35. Personal communication, James Bardrock, Staff Planner, Lake County Planning Commission, Painesville, Ohio, March 26, 1979.

36. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, United States-Great Lakes-Lake Erie-Ohio Ashtabula to Chagrin River. (Map), Washington, D. C., 1974.

37. Personal communication, Mark Woodworth, Owner, Woodworth Airstrip, Madison, Ohio, November 21, 1984.

38. Personal communication, Christine Fryer, Office Manager, Casement Airport, Painesville, Ohio, November 20, 1984.

39. Personal communication, Mrs. A. Luhta, Concord Airport, Concord, Ohio, November 20, 1984.

40. Personal communication, Bill McNeely, Manager, Lost Nation Airport, Painesville, Ohio, November 21, 1984.

41. Detroit Sectional Aeronautical Chart, 17th Edition, November 18, 1978, U.S. Department of Commerce, Washington, D. C.

42. Enroute IFR Peak Day Charts, FY1976, U.S. Department of Transportation, Washington, D. C.

43. Personal communication, J. O. Larson, Federal Aviation Administration, Washington, D. C., March 20, 1979.

44. Enroute High Altitude - U.S., September 1978, U.S. Department of Commerce, Washington, D. C.

45. 1984 Ohio Traffic Survey Report, Ohio Department of Transportation, Columbus, Ohio.

46. Occupational Safety and Health Reporter, Title 29, Sec. 1910.1000, Table Z-1, 1978, Occupational Safety and Health Administration, U.S. Department of Labor, Washington, D. C.

47. Code of Federal Regulations, Title 49 - Transportation Parts 100-199, October 1, 1977, Office of the Federal Register, National Archives and Records Service, General Services Administration, Washington, D. C.

48. Waterborne Commerce of the United States, Part 3, Waterways and Harbors - Great Lakes, Calendar Year 1982, Department of the Army Corps of Engineers, New Orleans, Louisiana.

49. Personal communication, Mr. Debevec/Owner, Chalet Dubonne, Madison, Ohio, February 13, 1985.

50. Personal communication, Dick Schmidt/Owner, Perry Sheet Metal, Perry, Ohio, February 12, 1985.

51. Personal communication, Roger Phillips/Owner, Phillips Welding, Madison, Ohio, February 13, 1985.

52. Personal communication, Kevin Hershey/Technical Services, Safety Clean Corporation, Cleveland, Ohio, February 12, 1985.

53. Personal communication, Wayne Harvey/Manager, Safety Clean Corporation, Painesville, Ohio, February 12, 1985.

54. Personal communication, Bob Mendelsohn/Manager, Universal Oil/Lake Co. Oil Branch, Painesville, Ohio, February 12, 1985.

55. Personal communication, Roy Frank/Owner-Manager, Gyro Fuel Company, Madison, Ohio, February 13, 1985.

56. Personal communication, Lorna Velardi/Staff, Matlack Chemicals, Chicago, Ohio, February 13, 1985.

57. Personal communication, Jeff Wells/Manager, Wells Inc./National Ammonia and Chemical Co., Painesville, Ohio, February 27, 1985.

58. "Courts Make Nuke Shipments Difficult to Stop," Geoff Haynes, The Lake County Telegraph, Painesville, Ohio, June 1, 1984.

59. Suggested Criterion for Selection of Compounds of Interest for the Perry Route 20 Shipping Survey, J. Fulford, NUS Corporation, January 15, 1985.

60. (Deleted)

61. Personal communication, J. W. Heptinstall, Plant Manager, Calhio Chemicals, Inc., Perry, Ohio, June 27, 1978, July 20, 1978, and November 16, 1979.

62. Personal communication, Ralph Parsons, Diamond Shamrock Corporation, Painesville, Ohio, July 21, 1978 and August 9, 1978.

63. (Deleted)

64. (Deleted)

65. (Deleted)

66. Personal communication, Richard T. Morawski, Assistant Plant Manager, Glyco Chemicals, Inc., Painesville, Ohio, July 2, 1978.

67. Personal communication, Harry Zimmerman, Plant Manager, Georgia-Pacific, Plaquemine, Louisiana, March 20, 1979.

68. “Explosion Problems in the Chemical Industry,” American Chemical Society, by Robert W. VanDolah, David S. Burgess, 1970.

69. Foster, J. C., Jr., et. al., “Detonatability of Some Natural Gas-Air Mixture,” Air Force Armament Laboratory, AFATE-TR-74-80, November 1970.

70. Kogarko, S. M., et. al., “An Investigation of Spherical Detonations of Gas Mixture,” International Chemical Engineering, Vol. 6, No. 3, July 1966.

71. Loesch, F. C., “Thermal Radiation and Overpressure from Instantaneous LNG Release into the Atmosphere,” TRW Report No. TRW-08072-4, April 26, 1968.

72. “Safety Evaluation Report, Tennessee Valley Authority, Hartsville Nuclear Plants A and B,” U.S. Nuclear Regulatory Commission, <NUREG-0014>, April 8, 1976.

73. Briggs, G. A., “Plume Rise,” TID 25075, Equations 4.19c, 4.32 and 5.7, November 1969.

74. Underground Storage of Fluids, D. L. Katz and K. H. Coats, Ulrich’s Books, Inc., Ann Arbor, Michigan, 1968.

75. Pipeline and Gas Journal, “Underground Storage Capacity,” December 1979, p. 37.

76. Letter from Dr. R. T. Gallagher, P.E., Consulting Mining Engineer to D. A. Decker, Gilbert Associates, Inc., dated February 11, 1974.

77. Explosive Effects Analysis of Propane Leakage, Steven Tunkel, P.E., Hazard Research Corporation, Denville, New Jersey, dated February 21, 1974.

78. Engineering Division, Crane Company, “Flow of Fluids,” Technical Paper No. 410, Crane Company, Chicago, Illinois, 1957.

79. J. J. Duggan, C. H. Gilman, P. F. Fisher, “The Requirements for Relief of Overpressure in Vessels Exposed to Fire,” presented at ASME Meeting, June 1943.

80. (Deleted)

81. (Deleted)

82. Personal communication, Robert Archer, Lake County Emergency Management Agency. Confirmation of Uniroyal and Pressure Vessel Service of Ohio ceased operations in Lake County, Ohio, May 15, 2001.

83. Personal communication, Richard Woodworth, Owner, Woodworth Airstrip, Madison, Ohio, May 15, 2001.

84. Personal communication, Bill Pfarr, Manager, Lost Nation Airport, Willoughby, Ohio, May 15, 2001.

85. Calculation 5.6.4, Rev. 3, 5-16-06.

86. Calculation 5.6.2, Rev. 2, 5-17-06.

87. Calculation 5.6.1, Rev. 4, 5-15-06.

TABLE 2.2-1

MANUFACTURING AND STORAGE FACILITIES WITHIN FIVE MILES OF THE PLANT[1]

Name of Company	Location	Distance (mi) and Direction from PNPP Center	Products	Primary Function	Total Work Force
Neff Perkins Co.	Perry	3,000 ft WSW	Rubber and steel custom molded products	Manufacturing	175
Sivon Mfg.	Perry	1 mi SW	Rubber production machinery	Manufacturing	5-10
Perry Coal & Feed	Perry	3 mi S	Feed	Marketing	3
Bentley Excavating	Perry	3 mi SSW	None	Contractor	30-60
Mackenzie Nursery Supply	Perry	3.5 mi SSW	Nursery equipment and supplies	Marketing	14
Lake County Water	Painesville	4 mi WSW	Water Treatment	Water Treatment	--
Thermatool Mill Systems	Perry	3.5 mi S	Structural I beams	Manufacturing	60
Pet Processors	Painesville	3.6 mi WSW	Plastics	Manufacturing	--
Midwest Materials	Perry	3.5 mi S	Finished and semi-finished steel products	Manufacturing	110

NOTE: [1] See (Reference 9), (Reference 10), (Reference 11), (Reference 12), (Reference 14), (Reference 15), (Reference 16) and (Reference 86) <Section 2.2.4>

TABLE 2.2-2

MAJOR HIGHWAYS WITHIN FIVE MILES OF STATION CENTER[1]

Road Name/No.	County	Approx Distance (mi) And Direction From Plant Center	Sector Miles	Sector Description	Annual Average Daily Traffic Volume (AADT) Total Vehicles	Vehicles/Day[2] Trailer Trucks	Passenger and Panel Truck
U.S. Route 20	Lake	1 mi SSE	.18	Bowhall Rd. to Half Rd.	9,300	4,600	8,840
			.47	Half Rd. to Rte. 2	5,320	260	5,060
			.62	Rte. 2 to Narrows Rd.	20,900	840	20,060
			2.58	Narrows Rd. to Center Rd.	19,500	750	18,750
			2.39	Center Rd. to Townline Road	17,400	530	16,870
			3.03	Townline Road to Rte. 528	15,340	340	15,000
State Route 84	Lake	3.5 mi SSE	1.98	River Rd. to Shepard Rd.	2,900	100	2,800
			4.36	Shepard Rd. to Madison W. Corp.	3,600	160	3,440
			1.16	Madison W. Corp. to Rte. 528 (River Rd.)	4,800	160	4,640
			.14	River St. to Lake St.	8,000	300	7,700
			.90	Lake St. to Bates Rd.	4,380	100	4,280
State Route 2	Lake	4 mi WSW	1.34	Rte. 535 to East Terminus (U.S. 20)	14,000	580	14,580
Interstate 90	Lake	5 mi SSE	7.66	Vrooman Rd. to Rte. 528	19,040	5,170	13,870
State Route 528	Lake	5 mi E	2.14	Rte. 84 to U.S. 20	9,040	240	8,800

NOTES:

(1) See (Reference 45) <Section 2.2.4>.

(2) AADT provided for segments of each major road within five miles of PNPP.

TABLE 2.2-3

GAS PIPELINES WITHIN THE IMMEDIATE ENVIRONS OF THE PLANT[1]

Pipeline Number[2]	Size (in.)	Operating Pressure (psi)	Maximum Potential Operating Pressure	Year Constructed	Depth Buried
1	2.0	35	60	1950	30
2	2.0	35	60	1977	30
3	3.0	35	60	1977	30
4	4.0	35	60	1960	30
5	20.0	150	250	1975	42
6	16.0	150	250	1975	42
7	20.0	150	250	1975	42
8	4.0	35	60	1975	36
9	2.0	35	60	1940	36
10	1.25	35	60	1940	36
11	1.25	35	60	1940	36
12	1.25	35	60	1940	36
13	10.0	35	60	1930	36

NOTES:

[1] See (Reference 6) <Section 2.2.4>.

[2] See <Figure 2.2-3>.

TABLE 2.2-4a

HAZARDOUS MATERIALS USED, PROCESSED AND/OR STORED WITHIN FIVE MILES OF THE PLANT

Hazardous Material	Threshold Limit Value[(5)] (mg/m^3)	Maximum Quantity	Method Stored	Location
Methyelthyl Ketone (MEK)	590	50 gal.	50 gal. drum	Neff Perkins
Cleaning solvents and cutting oils	See Note[(2)]	300 gal.	50 gal. drums	Neff Perkins

TABLE 2.2-4a (Continued)

Hazardous Material	Threshold Limit Value[5] (mg/m^3)	Maximum Quantity	Method Stored	Location
Kerosene	See Note[2]	250 gal.	above ground tank	Thermatool Mill Systems
Toluene	375	165 gal.	55 gal.	SIVON Mfg.
Herbicides, insecticides, fungicides	See Note[4]	small amounts	shelved bags, boxes and gallon jugs	Perry Coal and Feed
Ammonium nitrite	See Note[6]	small amounts	shelved bags and boxes	Perry Coal and Feed
Chlorine	3	8000 lbs	2000 lb. cylinders stored in block building	Lake County Water

NOTES:

(1) Future storage (March 1985).
(2) Flammable material.
(3) Corrosive material.
(4) Toxic (no value given).
(5) N. Irving Sax, "Dangerous Properties of Industrial Materials," 6th Edition.
(6) Explosive material.

TABLE 2.2-4b

HAZARDOUS MATERIALS TRANSPORTED BY HIGHWAY OR RAILROAD WITHIN FIVE MILES OF THE PLANT

Hazardous Material	Threshold Limit Value[(6)] (mg/m^3)	Shipment Size[(1)]	Shipment Frequency (per/yr.)	Method of Transportation
Toluene	See Note[(3)]	55 gal.	2	Highway
Carbon dioxide, compressed	1,840	60 lb	12	Highway
Nitrogen, compressed	See Note[(7)]	60 lb	12	Highway
Oxygen, compressed	See Note[(2)]	1,320 cu ft	12	Highway
Acetylene, compressed	See Note[(3)]	330 cu ft	28	Highway
Isopropyl alcohol	See Note[(3)]	8,000 gal.	12	Highway
Trichloroethylene	537	8,000 gal.	12	Highway
Paints	See Note[(5)]	1,375 gal.	250	Highway
Maleic anyhydride	1	6,000 gal.	12	Highway
Methylethyl Ketone (MEK)	590	30 gal.	12	Highway
Cleaning liquid, corrosive (DOT NA1760)	See Note[(4)]	120 gal.	50	Highway
Perchloroethylene	678	120 gal.	50	Highway
Petroleum naptha (DOT UN1255)	See Note[(3)]	120 gal.	50	Highway
No. 1 fuel (K1 fuel, kerosene)	See Note[(3)]	8,500 gal.	385	Highway
No. 2 fuel	See Note[(3)]	8,500 gal.	720	Highway
Diesel fuel	See Note[(3)]	8,500 gal.	2,100	Highway
Gasoline	See Note[(3)]	9,500 gal.	3,120	Highway
Lubricants, motor oil, grease	See Note[(3)]	330 gal.	130	Highway
Propane, bulk	See Note[(2)]	2,000 gal.	78	Highway
Propane, canister	See Note[(2)]	3,000 lb	156	Highway
Ammonium hydroxide	See Note[(3)]	6,000 gal.	100	Highway
Liquid hydrogen	See Note[(2)]	17,000 gal.	12	Highway
Liquid oxygen	See Note[(2)]	17,000 gal.	12	Highway

TABLE 2.2-4b (Continued)

Hazardous Material[10]	Threshold[8] Limit Value (mg/m^3)	Shipment Size[1]	Shipment Frequency (per/yr.)	Method of Transportation
Liquid sodium hydroxide	2			Rail
Vinyl chloride	See Note[9]			Rail
Chlorine	3	N/A[11]	N/A[11]	Rail
Liquified Petroleum Gas	1800			Rail
Sulfuric acid	1			Rail
Benzene	160			Rail
Carbon Dioxide	See Note[6]			Rail
Motor anti-knock compound	0.075			Rail
Hydrochloric acid	7			Rail
1.1.1 Trichloroethane	2460			Rail

NOTES:

(1) (Deleted)
(2) Explosive material.
(3) Flammable material.
(4) Corrosive material.
(5) Toxic (no value given).
(6) N. Irving Sax, "Dangerous Properties of Industrial Materials", 6th Edition.
(7) Asphyxiant.
(8) Values from OSHA.
(9) Deleted from OSHA Sec. 1910.1000 (Reference 46).
(10) (Deleted)
(11) Refer to <Table 2.2-5a> and <Table 2.2-5b>.

TABLE 2.2-5a

2005 CSX HAZARDOUS MATERIALS TRAFFIC[(1)(2)]

Commodity	Carloads	Hazard Class[(3)]
Sodium Hydroxide Solution	6,822	8
Chlorine	4,877	2.3
Vinyl Chloride	3,111	2.1
Liquified Petroleum Gas	1,582	2.1
Potassium Hydroxide Solution	1,509	8
Denatured Alcohol	1,261	3
Carbon Dioxide, Liquid	1,249	2.2
Sulfuric Acid	966	8
Petroleum Distillates, NOS[(4)]	626	Combustible
Styrene Monomer	536	3
Vinyl Acetate	521	3
Calcium Carbide	521	4.3
Elevated Temperature Liquid	494	9
Sodium Chlorate	496	5.1
Benzene	489	3
Environmentally Hazardous Liquid, NOS[(4)]	406	9
Molten Phenol	351	6.1
Hydrochloric Acid Solution	340	8
1,1,1-Trichloroethane	335	6.1
Fuming Sulfuric Acid	253	8
Waste Polychlorinated Biphenyls (PCB)	248	9
Butane	243	2.1
Diisobutylene Isomeric Compounds	235	3
Other Regulated Liquid NOS[(4)]	208	9

NOTES:

(1) See (Reference 85) <Section 2.2.4>.

(2) Major Hazardous Materials transported by CSX in the vicinity of the Perry Plant.

(3) Refer to DOT's Hazardous Material table for explanation of classification.

(4) NOS - Not Otherwise Specified.

TABLE 2.2-5a (Continued)

(Deleted)

TABLE 2.2-5a (Continued)

(Deleted)

TABLE 2.2-5a (Continued)

(Deleted)

TABLE 2.2-5a (Continued)

(Deleted)

TABLE 2.2-5a (Continued)

(Deleted)

TABLE 2.2-5b

2005 NORFOLK AND SOUTHERN HAZARDOUS MATERIAL TRAFFIC[(1)(2)]

Commodity	Carloads	Hazard Class[(3)]
Sulfuric Acid	278	8
Anhydrous Ammonia	177	2.2
Phosphorus Pentasulphide	29	4.3
Corrosive Liquids	36	8
Ammonium	13	8
Flammable Liquids, NOS[(4)]	5	3

NOTES:

(1) See (Reference 85) <Section 2.2.4>.

(2) Major Hazardous Materials transported by Norfolk Southern in the vicinity of the Perry Plant.

(3) Refer to DOT's Hazardous Material table for explanation of classification.

(4) NOS – Not Otherwise Specified.

TABLE 2.2-6

TYPES AND AMOUNTS OF CARGO TRANSPORTED IN THE GREAT LAKES IN 1982
CLEVELAND, FAIRPORT, ASHTABULA, CONNEAUT AND ERIE HARBORS[(1)]
(Short Tons)

	Harbors				
Cargo	Cleveland	Fairport	Ashtabula	Conneaut	Erie
Barley and Rye	3,179	-	-	-	-
Wheat	72,674	-	-	-	-
Tobacco, Leaf	30	-	-	-	-
Field Crops (nec)	-	-	-	-	29
Fresh Fish, except Shellfish	248	162	14	298	268
Iron Ore and Concentrates	5,380,815	50,958	1,435,184	413,267	-
Aluminum Ores, Concentrates	10,723	-	-	-	-
Nonferrous Ores and Concentrates	6,053	-	32,384	-	-
Coal and Lignite	-	-	5,008,218	10,128,139	33,196
Limestone	1,340,568	860,161	241,324	413,869	356,150
Sand, Gravel, Crushed Rock	541,685	103,354	-	-	109,081
Clay	3	-	9,026	-	-
Nonmetallic Minerals (nec)	730,874	612,342	-	12,700	51,318
Tallow, Animal Fats and Oils	1,460	-	-	-	-
Vegetables and Preparations of,	41	-	-	-	-
Wheat Flour and Semolina	6,793	-	-	-	-
Alcoholic Beverages	826	-	-	-	-
Miscellaneous Food Products	41	-	-	-	-
Basic Textile Products	57	-	-	-	-
Logs	-	-	-	-	1,863
Lumber	120	-	-	-	1,920
Veneer, Plywood, Worked Wood	-	-	946	-	-
Furniture and Fixtures	21	-	-	-	19
Paper and Paperboard	583	-	-	-	-

TABLE 2.2-6 (Continued)

Cargo	Cleveland	Fairport	Ashtabula	Conneaut	Erie
			Harbors		
Pulp and Paper Products	10	-	-	-	83
Basic Chemicals and Products	3,329	-	-	-	-
Plastic Materials	3	-	-	-	-
Drugs	-	-	-	-	19
Soap	-	-	-	-	19
Paints and Allied Products	69	-	-	-	-
Phosphatic Chemical Fertilizers	-	-	19,997	-	-
Insecticides, Disinfectants	6	-	-	-	-
Miscellaneous Chemical Products	210	-	-	-	-
Residual Fuel Oil	126,598	-	-	-	-
Lubricating Oils and Greases	1	-	-	-	-
Asphalt, Tar and Pitches	39,061	-	-	-	-
Coke, Petroleum Coke	30,500	-	-	-	-
Rubber and Misc. Plastic Products	28	-	-	-	-
Building Cement	232,072	-	-	-	-
Structural Clay Products	59	-	-	-	-
Cut Stone and Stone Products	19	-	-	-	32
Misc. Nonmetallic Mineral Products	21	-	-	-	-
Slag	45,000	-	-	-	-
Iron and Steel Primary Forms	15,796	-	1,599	-	-
Iron, Steel Shapes (except Sheet)	286,942	-	10,938	-	-
Iron and Steel Plates and Sheets	1,071	-	-	-	-
Iron and Steel Pipes and Tubes	3,092	-	-	-	20
Ferroalloys	22,176	-	23,482	-	17,810
Iron, Steel Products (not classified)	292	-	-	-	-
Nonferrous Metals	72	-	86	-	-
Copper Alloys, unworked	57	-	-	-	-
Lead and Zinc, unworked	3,145	-	-	-	-

TABLE 2.2-6 (Continued)

Cargo	Cleveland	Fairport	Harbors Ashtabula	Conneaut	Erie
Aluminum and Alloys, unworked	461	-	-	-	121
Fabricated Metal Products	513	-	2	-	417
Machinery, except electrical	3,047	-	-	-	23
Electrical Machinery and Equipment	313	-	-	-	598
Motor Vehicles, Parts, Equipment	2,235	-	-	-	300
Misc. Transportation Equipment	-	-	-	-	
Ships and Boats	12	-	-	-	-
Misc. Manufactured Products	1	-	-	-	-
Iron and Steel Scrap	28,094	-	-	-	46,484
Nonferrous Metal Scrap	81	-	49,137	-	-
Commodities (not elsewhere clsfd)	44	-	-	-	1
Department of Defense & Sci.	8	-	-	-	-

NOTE:

[1] See (Reference 48) <Section 2.2.4>.

TABLE 2.2-7

1982 COMBINED TRAFFIC BY TYPE OF VESSEL BETWEEN CLEVELAND, OHIO AND ERIE, PENNSYLVANIA[1]

Direction and Vessel Type[2]	Number of Transits per year
a. Upbound[3]	
Passenger and Dry Cargo	6,735
Tug and Barge	32
Tanker	61
Dry Cargo	14
Upbound total	6,842
b. Downbound[4]	
Passenger and Dry Cargo	6,735
Tug and Barge	40
Tanker	51
Dry Cargo	15
Downbound total	6,841

NOTES:

(1) See (Reference 48) <Section 2.2.4>.

(2) See <Figure 2.2-2> for location of shipping lanes.

(3) Inland from Atlantic Ocean.

(4) Outbound from the Great Lakes to the Atlantic Ocean.

TABLE 2.2-8

TRIPS AND DRAFTS OF VESSELS - CLEVELAND, FAIRPORT HARBOR, ASHTABULA, CONNEAUT AND ERIE HARBOR[1]

Draft Vessels (feet)	Total Trips of Vessels Inbound	Total Trips of Vessels Outbound	Total Number of Trips
30	0	4	4
29	4	81	85
28	17	129	146
27	114	116	230
26	138	159	297
25	89	17	106
24	191	42	233
23	351	111	462
22	191	117	308
21	120	116	236
20	125	168	293
19	112	145	257
18	78	91	169
17	61	123	184
16	48	68	116
15	27	100	127
14	94	127	221
13	5	9	14
12 or less	5,077	5,108	10,185

NOTE:

(1) See (Reference 47) and (Reference 48) <Section 2.2.4>.

TABLE 2.2-9

AIRPORTS AND AIRSTRIPS IN THE VICINITY OF THE PLANT[1]

Airport[2]	Location	Distance (mi) and Direction from Station Center	Number of Based Aircraft	Runways No.	Runways Direction	Runways Length(ft)	Runways Composition	Hours Attended	Operations Per Month
1. Woodworth Airstrip	Madison	4.5 ESE	3-5	1	EW	2300	Sod	None	4
2. Casement Airport	Paines-ville	6-7 SSW	28	1	NW-SE	3800	Paved	Irregular	40-50
3. Concord Airport	Paines-ville	10 SSW	35	1	NNE-SSW	2400	Paved	Irregular	See Note[3]

NOTES:

(1) See (Reference 37), (Reference 38), (Reference 39), and (Reference 40) <Section 2.2.4>.
(2) See <Figure 2.2-3> and <Figure 2.2-4> for airport locations.
(3) No operations records kept.

TABLE 2.2-10

CHEMICALS STORED ONSITE[(1)]

Chemicals	Quantity	Location
Sulfuric Acid (93%)	7,000 gal.	Water Treating Building
Caustic Soda Solution (50%)	7,000 gal.	Water Treating Building
Sodium Hypochlorite Solution	1,050 gal.	Service Water Pumphouse
Sodium Hypochlorite Solution (0.8%)	1,500 gal.	Water Treating Building
Nitrogen	10,600 ft^3 (one cylinder)	Auxiliary Building
Nitrogen	102,646 ft^3	Yard
Hydrogen	7,387 ft^3 (one cylinder)	Yard
Liquid hydrogen	9,000 gal	Yard
Liquid oxygen	6,000 gal	Yard
CO_2	4 tons	Yard
CO_2	2-3/4 tons (three tanks)	Yard
Nitrogen Generator	~ 5 SCFM	Chemistry Lab - Control Complex Elev. 599
	~ 5 SCFM	Heater Bay - Elev. 620
Aqueous Sodium Hypochlorite/ Sodium Bromide Biocide	3,000 gal.	Circulating Water Pump House
Dichlorodifluoromethane (R-12)	2,234 lb	P47B001 A/B/C Chiller
Dichlorodifluoromethane (R-12)	2,300 lb	P50B001 A/B/C Chiller
Dichlorodifluoromethane (R-12)	2,997 lb	P46B001 A/B Chiller

TABLE 2.2-10 (Continued)

Chemicals	Quantity	Location
Difluoromethane/ Pentafluoroethane (50%/50%) (R-410A)	90 lb	M52B004 A/B Condensing Unit
Chlorodifluoromethane/ Chloropentafluoroethane (R-205)(R-22-48.8%R-115-51.2%)	125 lb	N64B0113B Chiller
Chlorodifluoromethane (R-22)	220 lb	M53B0031 A/B Chiller

NOTE:

(1) Not a complete list. Chemicals stored and used on site are evaluated for control room habitability in accordance with site procedures.

2.3 METEOROLOGY

This section provides a description of the meteorology of the Perry Nuclear Power Plant (PNPP) site and surrounding areas. The Perry site is located in northeast Ohio on the south shore of Lake Erie, approximately midway between Cleveland, Ohio and Erie, Pennsylvania. See the map in <Figure 2.3-1> for the location of PNPP and other meteorological data monitoring sources.

2.3.1 REGIONAL CLIMATOLOGY

2.3.1.1 General Climate

The climate in the region of the PNPP site is continental in character, moderated somewhat due to the proximity of Lake Erie. West through northerly surface winds from Lake Erie have a moderating effect on surface temperatures tending to lower daily maximum temperatures in the summer and increase temperatures and cloudiness during the winter. The presence of the lake has little effect on local conditions when winds are from other than these directions (Reference 1).

2.3.1.1.1 Air Mass Types and Synoptic Features

Characteristic of the continental interior, the climate of the PNPP region is dominated by a more-or-less steady progression of relatively cold dry arctic air masses from Canada and warm moist maritime air from the Gulf of Mexico. Invasions of arctic air from Canada are more frequent during the winter months, typically occurring on the order of every five to seven days. During the summer months, the region experiences a general southerly flow of warm moist air from the Gulf of Mexico, a situation that can persist for several days as the semipermanent Bermuda High persists off the Atlantic coast (Reference 2).

Occasionally, cool and moist Pacific air finds its way into the PNPP region, but this air is greatly modified by its passage over the Rocky Mountains and the plains states to the west of Perry.

The general eastward movement of these air masses is associated with migrating high and low pressure systems. Movement of the systems is more rapid and development more intense during the winter months than during the summer (Reference 2).

Warm and cold fronts of varying intensities mark the boundaries of these different air masses and generally move according to the circulation and movement of the low pressure centers.

2.3.1.1.2 Airflow Patterns

Surface airflow patterns in the PNPP site region show a fairly high degree of variability, reflecting the fairly steady movement of high and low pressure systems through the area. The annual mean wind speed at Cleveland-Hopkins International Airport for the period 1941 to 1976 was 10.8 mph. The prevailing direction was from the south. Winds are strongest on the average during the winter months, nearly 50 percent faster than in July and August (Reference 3).

2.3.1.1.3 Temperature and Humidity

Typical of the continental climate of the interior, the PNPP region is moderately warm and humid in the summer and cold and cloudy during the winter. As mentioned earlier, Lake Erie does have an influence on temperatures, tending to moderate the extremes. An important mechanism by which the lake influences lakeshore temperatures is the occurrence of land and lake breeze circulations. Lake breezes (surface wind blowing from lake to land) form when the water temperatures are colder than the land temperatures--during spring and summer on a seasonal scale and late morning to later afternoon on a diurnal scale. Land breezes are the

converse of lake breezes and occur when the water is warmer than the land, such as during the fall and winter or during the night in the summer. The lake breeze is generally stronger and occurs more frequently than the land breeze. The lake breeze can lower surface temperatures for several miles inland by advecting lake-cooled air onshore. This phenomenon becomes most pronounced when synoptic scale motions are weak, such as when a large high pressure system is centered in the region.

When synoptic scale motions are strong due to larger horizontal pressure gradients, the land/lake breeze circulation is effectively masked, but lake-influenced temperature variations can still occur as a result of the air temperature being modified by its contact with the water and being advected onshore by the large scale winds.

At Cleveland-Hopkins Airport, located 5 miles from the lakeshore, maximum temperatures average 2-4°F higher than the lakeshore in summer while nighttime low temperatures average 2-4°F lower than the lakefront throughout the year (Reference 3). Normal temperatures representative of this region are taken from Cleveland, Ohio, to the west and Erie, Pennsylvania, to the east of the PNPP. Each of these National Weather Service reporting stations is within about five miles of the lakeshore and is approximately 50 miles from the Perry site. Based on the period 1941 to 1970, the normal maximum and minimum temperatures at Cleveland are 33.4°F and 20.3°F in January and 81.6°F and 61.2°F in July. Normal maximum and minimum temperatures for Erie are 31.7°F and 18.5°F for January and 77.4°F and 60.0°F for July. The annual normal temperature is 47.1°F at Erie and 49.7°F at Cleveland. The mean number of days per year with maximum temperatures 90°F and above is eight for Cleveland and only one for Erie. The mean number of days with minimum temperatures 0°F and below is six days for Cleveland and five for Erie (Reference 3) (Reference 4). This and other information is summarized in <Table 2.3-1> for Cleveland and <Table 2.3-2> for Erie taken from the 1977 issue of the Local Climatological Data Annual Summary for each NWS

station. For additional comparisons, <Table 2.3-3> shows means and extremes for two other climatological reporting stations: Painesville, Ohio, about seven miles southwest of PNPP and Geneva, Ohio, located ten miles east of the site (Reference 1) (Reference 5). The Painesville station is within about a mile of Lake Erie and Geneva is about five miles from the shoreline. Extreme values of temperature for these four stations are given in <Table 2.3-4>.

Relative humidity is generally highest in the early morning hours of the summer months and lowest on early summer and mid-spring afternoons. Mean values are about 80 to 90 percent on summer mornings and 60 to 65 percent on spring and summer afternoons (Reference 3) (Reference 4) (Reference 6).

2.3.1.1.4 Precipitation

Precipitation in the PNPP site region is well distributed throughout the year, although significant monthly and yearly variance is common. Normal precipitation totals for the year are about 35.0 inches for Cleveland and 38.2 inches for Erie based on the period 1941 to 1970 (Reference 2) (Reference 3) (Reference 4). The driest months are December and February with a wet season beginning about April and continuing into November along the southeast shore of Lake Erie (Reference 1) (Reference 2) (Reference 4) (Reference 5). See <Table 2.3-1>, <Table 2.3-2>, and <Table 2.3-3>.

Most of the precipitation during the growing season comes in the form of showers or thundershowers (Reference 3), whereas lake-influenced squalls and snow flurries are significant sources from November through March (Reference 4). <Table 2.3-1>, <Table 2.3-2>, and <Table 2.3-3> show normal monthly distributions of precipitation at four stations. Regional extremes are summarized in <Table 2.3-4>.

Snowfall amounts also vary considerably from year to year and are influenced strongly by regional orographic effects (Reference 7). <Figure 2.3-2> shows the location of the PNPP site in relation to Ohio's "snow belt." As moisture-laden air from the lake moves inland, it encounters an abrupt change in elevation. A ridge running parallel to the lakeshore at a distance of about 5 miles has an elevation approximately 275 feet above lake level. Within 10 to 12 miles of the shoreline, the land becomes hilly with elevations up to 700 feet above lake level. As the air from the lake is forced to rise, it experiences cooling and the excess moisture falls out in the form of snow. As a consequence of these topographic features, the mean annual snowfall amounts in northeastern Ohio exhibit a very high gradient. At Painesville (600 ft, MSL), the annual mean for the period 1950 to 1965 was 56.8 inches (Reference 1), and at Geneva (860 ft, MSL), the annual mean for the same period was 72.3 inches (Reference 5) <Table 2.3-3>. Just 10 miles south of Painesville is Chardon (1,210 ft, MSL) receiving an average of 106.1 inches of snow annually (Reference 7). The mean number of days with snowfall greater than or equal to 1 inch is 21.43 at Painesville, 26.70 at Geneva and 35.11 at Chardon (Reference 7). Maximum monthly snowfall for regional locations is summarized in <Table 2.3-4>. From these examples, it is evident that there is a very wide range of mean snowfall amounts within 15 miles of the Perry site.

It is expected that Painesville would be most representative of the plant site due to greater similarity in elevation and distance from the lakeshore.

2.3.1.1.5 Relationships Between Synoptic and Local Meteorological Conditions

The PNPP site is in a region that experiences moderation in temperature extremes due to a lake effect. It borders on a region that experiences greatly enhanced seasonal snowfall amounts due to a combination of lake

effect and orographic lifting. Further inland from PNPP, valley areas experience extended periods of atmospheric stagnation (Reference 5).

The mechanism of the lake breeze circulation is discussed in some detail in <Section 2.3.2.3.2>. Briefly, the land/lake breeze phenomenon can result in locally modified wind speed and direction in the PNPP site region. This effect becomes more pronounced when the synoptic scale motions are weak. The lake breeze is generally strongest on spring afternoons and when the region is dominated by high pressure. The latter is associated with light to calm surface winds and sunny skies, both of which act to enhance the lake breeze effect.

2.3.1.2 Regional Meteorological Conditions for Design and Operating Bases

2.3.1.2.1 Hurricanes

Hurricanes or low pressure systems with a tropical origin seldom affect northeast Ohio since this area is far inland and these storms lose force rapidly when cut off from their source of moisture. A notable exception of recent record was the remnants of hurricane Agnes, which brought heavy rains and high winds to the Atlantic coastal states from Florida to New York from June 18 to 25, 1972. Heaviest hit by Agnes was Pennsylvania, with damage estimates ranging from $1.2 billion (Reference 2) to $2.1 billion (Reference 8), mostly from devastating floods. Damage estimates for Ohio ranged from just over $2 million (Reference 8) to $4 million (Reference 9), mostly along the southern shore of Lake Erie as strong northeasterly winds caused waves over 15 feet high and the lake level rose 3.5 feet (Reference 10). Rains in the PNPP region occurred on June 21 to 25 with approximately 4.8 inches falling in Cleveland during this period (Reference 10) and approximately 2.3 inches falling at the Perry site. Heaviest rains occurred on June 23. The average wind speed recorded at the Perry site for the

three-day period, June 22 to 24, was 16.3 mph at the 35-foot level and 23.3 mph at the 200-foot level. Maximum hourly wind speeds (15-minute average) recorded at the Perry site were 28.0 mph at 35-foot level and 39.5 mph at the 200-foot level, both on June 23.

Investigation of hurricane data from 1871 through 1975 indicates that 10 hurricanes or remnants of hurricanes passed through Ohio or western Pennsylvania. Of these, one was still in the hurricane stage (winds >74 mph) and occurred in 1896. Of the remaining nine, six were in the extratropical storm stage and three were in the dissipation stage as they passed through Ohio (Reference 8) (Reference 11).

2.3.1.2.2 Tornadoes and Waterspouts

In the period of January 1950, through December 1977, a total of 48 tornadoes were reported within a 50-nautical mile (58 miles) radius of the Perry site (Reference 12). This averages out to 1.71 tornadoes per year within this radius.

The statistical probability of a tornado striking a point within a given area may be conservatively estimated as follows: (Reference 13)

$$P_s = \overline{n}\left(a/A\right) \qquad (2.3\text{-}1)$$

where

- P_s = tornado strike probability per year
- $\overline{n}$ = average number of tornadoes per year
- a = mean individual tornado path area
- A = total area in which the tornado frequency has been determined.

From data obtained from the National Severe Storms Forecast Center (NSSFC) in Kansas City, Missouri, the mean path area of

individual tornadoes was obtained from 28 of the 48 cases between 1950 and 1977 for which both path length and path width data were available. It was found that a = 0.695 nautical square miles (0.921 square miles). Since waterspouts over Lake Erie and the Canadian portion of the 50 nautical miles (58 square miles) area were excluded from the compilation, the land area was estimated at A = 3,820 nautical square miles (5,066 square miles), a little less than half of the circular area. Equation (2.3-1) then yields a probability of 3.11 x 10^{-4} yr^{-1} or a recurrence interval of 3,216 years (Reference 12). See <Section 3.5.1.4.2.1> for the annual probability of tornado strike used in the "TORMIS" analysis.

The representativeness of the recurrence interval has been confirmed with a new study and method described in (Reference 13). This method used a new data base (1954 to 1983) and yielded strike probabilities for one-degree square boxes across the United States. The recurrence interval for the box including Perry was 6,061 years, which is within a factor of two and less frequent than the values already calculated for Perry.

In the PNPP region, tornadoes can occur during any month of the year and any hour of the day, but most tornadoes occur during the spring and summer months (approximately 85 percent in April to September) and from afternoon to early evening hours (approximately 70 percent between 2:00 and 10:00 PM) (Reference 12).

The tornado reported closest to the Perry site occurred on July 4, 1969, approximately five nautical miles (six miles) west of the plant. It had a reported path length of six nautical miles (seven miles) and a reported path width of 300 feet (Reference 12). This tornado moved toward the east-southeast. The only other tornado reported during this period within 10 nautical miles (12 miles) of PNPP occurred on April 19, 1963. This tornado touched down six nautical miles (seven miles) east of Perry, but no path length or width information was available for this

tornado (Reference 12). Each of these tornadoes was assigned a Fujita F-scale classification of F-2 indicating maximum 1/4-mile wind speeds in the range 113 to 157 mph (Reference 12) (Reference 14). The former caused 40 injuries and no deaths, and the latter resulted in no reported injuries or deaths (Reference 12). The most devastating tornado to hit within 50 nautical miles (58 miles) of Perry during the 1950 to 1977 period occurred on June 8, 1953. This tornado touched down 46 nautical miles (53 miles) southwest of Perry and followed a 13 nautical mile (15 miles) path to the northeast into Cleveland, causing six deaths and 300 injuries (Reference 12). This was the sixth touchdown segment of a single tornado and was classified as F-4 on the Fujita scale indicating fastest 1/4-mile wind speeds in the range of 207 to 260 mph (Reference 12) (Reference 15).

<Regulatory Guide 1.76> has designated three tornado intensity regions in the continental United States and has promulgated a design-basis tornado (DBT) for each region based on WASH-1300 (Reference 13). The PNPP site is located in Region I, a large area covering the entire country east of the Rocky Mountain range (Reference 16). Within this region there is large variation in observed tornado frequencies and intensities. The Perry Plant is on the eastern edge of the regional maxima, which occur in the southern plains to the midwest. The DBT characteristics for Region I applying to PNPP are listed in <Table 2.3-5>. The NSSFC tornado occurrence data for the PNPP area suggest that the Region I DBT characteristics are conservative.

For the period of January 1951, through May 1978, there were nine waterspout sightings reported within 43 nautical miles (50 miles) of the site (Reference 8) (Reference 16). At Fairport, Ohio, during an August 11, 1971, sighting and at Cleveland on a September 7, 1973, sighting numerous waterspouts were reported.

Waterspouts can be formed in two ways, either by building downward from heavy clouds, a tornado over water or by building upward from the water

surface, the equivalent of a dust devil over water. The latter of these two, known as a common waterspout, is much less intense than a tornado, as the energy available for its formation and maintenance is small. Tornadic waterspouts spawned from clouds are much more intense and can have tornadic intensities, although on the average they are weaker than tornadoes (Reference 9).

There are no pertinent data available concerning the intensity of Lake Erie waterspouts. However, these waterspouts could have tornadic strength if associated with a severe thunderstorm (most commonly accompanying a cold front or squall line). For the reported waterspouts in the Perry site area, there are no damage reports nor are there any reports of waterspouts coming onshore (Reference 8) (Reference 16). Since the waterspout intensity will not exceed the design-basis tornado, there will not be catastrophic damage to safety class surface structures. The water surface below the waterspout can be raised or lowered dependent on which force has the greatest effect, the atmospheric pressure reduction or the wind force. The waterspout does not lift a significant amount of water (i.e., the depth of penetration is relatively small) (Reference 9). Therefore, waterspouts will not have a significant effect on the plant's intake structure, which is located a minimum of 12 feet below the mean low water datum.

2.3.1.2.3 Extreme Winds

The extreme mile wind speed is defined as the one-mile passage of wind with the fastest speed and includes all meteorological phenomena except tornadoes. Annual fastest mile wind data at Cleveland for the 30-year period from 1948 to 1977 (Reference 3) were used to determine predicted extreme wind speeds for the PNPP site for recurrence intervals of 50 and

100 years. Values were calculated using the following equation based on the method of Brooks and Carruthers: (Reference 17)

$$U_n = \overline{U} + \frac{\left(U_k - \overline{U}\right)\log_{10} n}{\log_{10} K} \qquad (2.3\text{-}2)$$

where

U_n = extreme mile wind speed (mph)

n = recurrence interval in years

$\overline{U}$ = mean maximum wind speed (based on maximum each year) during the period of record (mph)

U_k = the maximum wind speed reported during the period of record (mph)

K = length of data record in years

The wind data was first adjusted to a standard level of 30 feet using the 1/7 power law to describe the vertical wind profile. The values for the 50- and 100-year recurrence maximum wind speeds for the Perry region are 70 mph and 74 mph, respectively. These values are consistent with those published in recent studies by the U.S. Department of Commerce (Reference 18) and the National Oceanic and Atmospheric Administration (Reference 19). Based on a gustiness factor of 1.3 after Huss (Reference 20), the highest instantaneous gust expected once in 100 years is 96 mph.

The fastest mile wind recorded at Cleveland after adjustment to 30-foot equivalent was 68 mph from the west in March 1948 (Reference 3), based on the 1942 to 1977 period of record. Based on the 1958 to 1977 period of record, the fastest mile wind recorded at Erie was 55 mph from the southeast in March 1960 (Reference 4). On January 26, 1978, both Cleveland and Erie reported all-time record low sea-level pressures as a severe blizzard paralyzed much of the midwest (Reference 3) (Reference 4). On that day, each station recorded fastest mile wind

speeds of 53 mph, this being within 2 mph of the record at Erie (Reference 3) (Reference 4). The NWS station at Cleveland reported a peak wind gust of 82 mph, measured at 20 ft (Reference 21), while gusts in excess of 100 mph were reported in other areas of the state (Reference 16). A peak gust of 102 mph was reported over the lake at a height of 60 to 70 ft near Cleveland (Reference 21), but gusts at 30 feet over land were lower due to frictional drag effects. The maximum hourly wind speed (15-minute average) recorded at Perry on January 26 was 36 mph at 10 meters and 47 mph at 60 meters, compared to a maximum hourly wind for Cleveland (6-meter anemometer height) of 46 mph. These observations are consistent with the expected extreme winds presented above.

A possible Venturi effect between the natural draft cooling towers at the PNPP, potentially yielding a subsequent increase in wind speeds and consequently increasing the wind load on plant structures, was analyzed and discussed in <Section 2.3.2.2>. An evaluation of the effects of these winds relative to building design is presented in <Section 3.3>.

2.3.1.2.4 Thunderstorms and Lightning

Thunderstorms can occur at any time of the year but are more frequent in summer than any other season. The mean annual number of days with thunderstorms is 36 for Cleveland, Ohio, and 38 for Erie, Pennsylvania, based on a 36-year and 22-year period of record respectively (Reference 3) (Reference 4). The monthly distribution of mean number of days is shown in <Table 2.3-1> for Cleveland and <Table 2.3-2> for Erie.

Estimates of seasonal and annual frequencies of cloud-to-ground lightning are calculated by using the following equation, based on the technique described by Golde: (Reference 22)

$$N_E = (0.1 + 0.35 \sin \lambda)(0.40 \pm 0.20) \qquad (2.3\text{-}3)$$

where

N_E = number of flashes to earth per square kilometer per thunderstorm day

λ = geographical latitude (for Perry, Ohio, λ = 41° 45').

For the PNPP site region, N_E = 0.20 flashes per square kilometer per thunderstorm day. By multiplying the number of thunderstorms per month in <Table 2.3-1>, <Table 2.3-2>, and <Table 2.3-3> by this value of N_E, one could obtain monthly and seasonal frequencies for cloud-to-ground lightning. For Cleveland, the maximum occurs in June and July indicating 1.4 flashes per square kilometer for each month based on this method. A structure with the approximate dimensions of the PNPP containment buildings (approximately 0.03 square kilometers) will average approximately one strike every five years.

2.3.1.2.5 Frozen Precipitation

<Table 2.3-4> lists extremes of precipitation and other meteorological parameters for Cleveland, Erie, Painesville, and Geneva. The maximum monthly snowfall measured in the region was 71.0 inches at Geneva in December 1962 (Reference 5). The maximum 24-hour snowfall observed was 26.5 inches, which occurred at Erie in December 1944 (Reference 23)

The maximum postulated snowload was determined to be the sum of the weights of the 100-year recurrence maximum snow pack plus the probable maximum winter precipitation (PMWP) (Reference 24). The 100-year recurrence maximum snow pack for the PNPP region is 20 psf

(Reference 25). The PMWP is taken to be the probable maximum 48-hour precipitation during the winter months of December, January and February in the PNPP region. This is based on the assumption that conditions could exist during these months for all of the PMWP to remain on the ground as a live load either as additional snowfall or as liquid precipitation absorbed by the snowpack. For the Perry region, the PMWP is 12 inches (Reference 26), which corresponds to 62.4 psf at 5.2 psf per inch of precipitable water. These calculations yield a conservative design basis snowload value (ground-level equivalent) for Category I structures of 82.4 psf.

Hail can occasionally occur at the Perry site (associated with well-developed thunderstorms) and at times may be intense. A review of data for the 16-year period, 1962 to 1977, indicates that there were 20 reported cases of hail in Lake County (where the Perry site is located) and in the immediately surrounding counties of Ashtabula, Cuyahoga, Geauga, and Trumbull (Reference 16). Nine of the cases occurred in the Cleveland area. Of the reported cases, the largest hailstones reported were of "tennis ball" size in the Hirmal-Garretsville area approximately 35 miles south of the Perry site. Of the 20 reported cases of hail, eleven recorded hailstones >3/4 inches in diameter (seven cases did not report any hailstone size). Usually during a hailstorm, there is a spectrum of hailstone sizes and there is a tendency to report the largest sizes. The average number of hail days per year in northeast Ohio is approximately two at any one site (Reference 27).

An examination of the 16-year period, 1962 to 1977, indicates that there were nine documented cases of ice storms in Lake County and the immediately surrounding counties (Reference 16). Two of these storms affected the entire state of Ohio while the rest were widespread over northern and northeastern Ohio. All cases were associated with a number of traffic accidents, downed power lines and downed tree limbs.

2.3.1.2.6 High Air Pollution Potential

Hosler (Reference 28) estimates the frequency of occurrence of low-level inversions or isothermal layers based at or below a 500-foot elevation in the site region to be 20 percent of the total hours on an annual basis. Seasonally, the greatest frequency of inversions, based on percent of total hours, occurs during the fall and is 28 percent. Winter has the lowest inversion frequency, occurring only 18 percent of the time. The majority of these inversions are nocturnal in nature.

The mean maximum mixing depth (MMMD) is a restriction to atmospheric dilution. The mixing depth is the thickness of the atmospheric layer, measured from the surface upward, in which convective overturning is taking place caused by the daytime heating of the surface. The mixing depth is usually its shallowest in the early morning hours just after sunrise when the nocturnal inversion is being modified by solar heating at the surface. It is at its greatest depth during the latter part of the day, at 3:00 PM to 4:00 PM, when the maximum surface temperature of the day is reached. The approximate annual afternoon MMMD for the site region according to Holzworth (Reference 29) is 4,000 feet. Approximate seasonal afternoon MMMD values are 2,800 feet (winter), 4,900 feet (spring), 5,200 feet (summer), and 3,900 feet (fall) (Reference 29).

Periods of high air pollution potential are usually related to stagnating anticyclones with low average wind speeds, no precipitation and a shallow mixing depth (Reference 30). The greatest air pollution potential in the site region is during the fall and winter seasons, when the tendency is greatest for a quasi-stationary anticyclone to develop. According to Korshover (Reference 31), 24 anticyclone stagnation cases of 4 days or more were reported in the site region during the period of 1936 to 1965. This compares with a maximum of over 80 cases reported in northern Georgia during the same period, with the distribution suggesting a strong influence of the Bermuda High on the eastern United States (Reference 31).

2.3.1.2.7 Droughts

When evaporation greatly exceeds precipitation for prolonged periods, a drought may occur. Between 1929 and 1967, periods of moderate to extreme drought based on the Palmer Drought Severity Index have affected northeast Ohio during the 1930 to 1936, 1953, 1954, 1962, and 1963 growing seasons. The longest continuous period of moderate to extreme drought in the area was 32 months (July 1930, to February 1933) (Reference 1).

2.3.1.2.8 Heavy Fog

The mean annual number of days with heavy fog (visibility 1/4 mile or less) that can be expected in the region is 13 based on 36 years of data at Cleveland (Reference 3). Highest frequency of heavy fog at Cleveland is for the months of January through March. Erie, Pennsylvania, averages 14 days of heavy fog per year with maximum frequency for the months of March through May (Reference 4) <Table 2.3-1> and <Table 2.3-2>.

2.3.1.2.9 Ultimate Heat Sink

The ultimate heat sink for the Perry plant is Lake Erie, which is considered an infinite heat sink. There is an extremely low probability of losing the capability of the single source. No meteorological data have been considered in the design of the heat sink. The design basis temperatures of safety-related equipment are based on the maximum historical lake water temperatures.

2.3.2 LOCAL METEOROLOGY

2.3.2.1 Normal and Extreme Values of Meteorological Parameters

<Figure 2.3-1> indicates the location of the PNPP site and other meteorological data monitoring sources. Offsite data reported in this section were derived from surface observations supplied by the National Climatic Center on magnetic tape (Reference 32) (Reference 33), in addition to the Local Climatological Data (Reference 3) (Reference 4) and Climatological Summaries (Reference 1) (Reference 5).

A variety of data periods were used dependent upon the availability of data and the application. In general, a three-year period of onsite and offsite data (May 1, 1972, to April 30, 1974; September 1, 1977, to August 31, 1978) were used to study concurrent relationships.

A seven site year data set (May 1, 1972, to April 30, 1974; September 1, 1977, to August 31, 1982) was used to represent long term conditions onsite at Perry. Various five or ten-year periods and longer were used to represent long term conditions offsite (Reference 54).

2.3.2.1.1 Wind Direction and Speed

Monthly and annual wind roses for the 10-meter and 60-meter levels are presented in <Figure 2.3-3>, <Figure 2.3-4>, <Figure 2.3-5>, and <Figure 2.3-6> for the seven PNPP site years (May 1, 1972, to April 30, 1974; September 1, 1977, to August 31, 1982). The prevailing winds at both levels usually blow from the southeast through northwest directions. In general, higher speeds are associated with winds from the southwest through northwest directions.

As shown in <Figure 2.3-6>, the annual wind roses for the individual and combined years exhibit the tendency for prevailing wind to occur in the south through west sector. The wind roses for Cleveland and Erie

<Figure 2.3-7> exhibit similar patterns for the three concurrent years (May 1, 1972, through April 30, 1974; September 2, 1977, through August 31, 1978). In comparison to the seven site years, the ten-year wind roses (September 1, 1968, through August 31, 1978) for these two stations are not very different. Therefore, it is concluded that for the PNPP, seven site years are representative of the long term.

Monthly and annual average wind speeds are presented in <Table 2.3-6> and <Table 2.3-7> for both onsite and offsite comparative data. The average wind speed at the 10-meter level for PNPP was 8.2 mi/hr for the three concurrent years and 8.4 for the seven site years. The 60-meter level wind speeds were higher as expected. The Erie and Cleveland long term averages were generally in good agreement with the seven site year averages. Therefore, the PNPP wind speeds for the seven site years are representative of the long term.

The frequency of calm winds is reported in the wind rose <Figure 2.3-6> and <Figure 2.3-7>. Both the three concurrent years and the seven site year composites for PNPP indicated 0.4 percent and 0.1 percent calms at 10 meters and 60 meters, respectively. For the same three-year period, Cleveland and Erie reported a higher frequency of calms than for the ten-year period. The difference in frequency of calms between PNPP and Erie and Cleveland is attributed primarily to differences in speed sensor thresholds and exposure.

Wind direction persistence is defined as the number of hours of continuous air flow within a 22-1/2-degree sector. For computational purposes, calms were considered a direction category, too. The probability of occurrence of wind flow persistence for various durations is presented in <Figure 2.3-8> for PNPP, Erie and Cleveland. Based on the seven site years at PNPP, there is only a 5 percent probability that the persistence will be greater than about eight hours at 10 meters and about nine hours at 60 meters. As depicted in <Figure 2.3-8>, the probabilities for PNPP, Erie and Cleveland are similar.

Maximum wind direction persistence occurrences by direction are presented in <Figure 2.3-9>. Persistence periods at PNPP are fairly well distributed across the direction sectors, being somewhat more frequent for winds from the southwest quadrant. The maximum wind direction persistence event at the 10-meter level for PNPP during the period of record was 36 hours for a wind from the southeast. The maximum 60-meter wind persistence event was 42 hours for a wind from the southwest. The maximum event for Erie during the February 1959, to January 1964, period was 41 hours from the northeast, and the maximum event for Cleveland during the same period was 50 hours from the south.

Persistence of calms at the 10-meter level at PNPP have been limited to five hours or less in duration for the seven site years.

<Appendix 2A>, <Appendix 2B>, and <Appendix 2C> include additional information in the form of joint frequency distributions by atmospheric stability. Offsite data are presented in <Appendix 2A>, while <Appendix 2B> and <Appendix 2C> include onsite data for 10-meter and 60-meter winds, respectively.

2.3.2.1.2 Ambient Temperature

Monthly and annual means and extremes of temperature are presented in <Table 2.3-8> for PNPP, Erie and Cleveland for the three concurrent years (May 1, 1972, to April 30, 1974; September 1, 1977, to August 31, 1978). The monthly PNPP temperatures agree well with the concurrent offsite values. <Table 2.3-9> presents long term annual means and extremes of temperature for PNPP and area stations. The similarity of the long term means to the seven site year means indicates that the seven site years are representative of the long term.

The highest mean monthly maximum temperature at PNPP occurred in July and August (76°F for the three concurrent years). The lowest mean monthly minimum temperature at PNPP occurred in February (16°F for the

three concurrent years). This three-year mean monthly minimum may be somewhat lower than the long term's since February 1978, was one of the coldest Februarys on record for much of the eastern United States (Reference 34), averaging about 11°F below normal in the site region (Reference 3) (Reference 4) (Reference 34).

The diurnal pattern of temperature at PNPP for the seven site years is described in <Table 2.3-10> on an annual average basis. It indicates that the warmest part of the day usually occurs between 2:00 PM and 5:00 PM, EST.; the coolest at about 6:00 AM, EST. The highest hourly 10-meter temperature recorded at PNPP during the period was 92°F and the lowest, -14°F <Table 2.3-9>.

2.3.2.1.3 Atmospheric Water Vapor

Monthly and annual means of humidity and dewpoint for PNPP, Erie and Cleveland are presented in <Table 2.3-11> for the three concurrent years (May 1, 1972, to April 30, 1974; September 1, 1977, to August 31, 1978). The PNPP data are similar to those of the offsite locations.

<Table 2.3-12> describes the long term monthly means and extremes of humidity and dewpoint for Erie and Cleveland based on a ten-year data period and for PNPP for the seven site years. The long term annual means for Erie and Cleveland are similar to the PNPP seven site year values. Therefore, the seven site years are considered representative of the long term.

The annual average diurnal variation of humidity and dewpoint at PNPP is presented in <Table 2.3-10>. It indicates that the highest relative humidities occurred between 5:00 AM and 7:00 AM, EST, during the cool part of the day, and that the highest absolute humidities occurred generally during the warm part of the day. Note that the period of

record for the 60-meter dewpoint is limited to the three concurrent years. More information concerning the 10-meter and 60-meter dewpoint is contained in (Reference 35).

2.3.2.1.4 Precipitation

Monthly and annual greatest precipitation by time interval are presented in <Table 2.3-13> for PNPP for the seven site years (May 1, 1972, to April 30, 1974; September 1, 1977, to August 31, 1982). It indicates that for the seven site years, the greatest 1-hour precipitation was 1.00 inch and occurred in both July and August. The greatest 24-hour precipitation was 2.44 inches and occurred in September.

<Table 2.3-14> contains the percent frequency occurrence of precipitation by amount for any 1-, 6-, 12-, 18-, or 24-hour period during the seven site years. The table indicates that 35.41 percent of the time precipitation of at least 0.01 inch fell during any 24-hour period.

In <Table 2.3-15>, the greatest 24-hour precipitation for PNPP is compared to the offsite locations of Erie, Cleveland, Painesville, and Geneva. The PNPP values are closest to Painesville, most likely because of proximity and the similar position relative to the lake.

In <Table 2.3-16>, the monthly and annual average total precipitation for the three concurrent years and the same sites are compared. The PNPP totals are generally less than the offsite locations. This can be attributed to lower data recovery for PNPP, differences in collection gauges, catch efficiency, and local terrain effects.

The long term total precipitation values are presented in <Table 2.3-17>. The agreement of the long term totals with the seven site year totals indicates that the seven site years are representative of the long term.

Monthly and annual precipitation wind roses are presented in <Figure 2.3-10>, <Figure 2.3-11>, <Figure 2.3-12>, and <Figure 2.3-13> for the seven site years combined. These show the average speed by direction of winds during precipitation events and the percentage of total hours that precipitation occurs with each wind direction. Seasonal variations are apparent. On an annual basis, precipitation frequences are fairly evenly distributed for winds from the northeast through south to west, and are less frequent for winds out of the west-northwest through north-northeast.

Snowfall is not directly measured onsite: All PNPP precipitation values described so far in this section were for melted precipitation since the rain gauge is equipped with a heater. Snowfall in the region is discussed in <Section 2.3.1.1.4> and <Section 2.3.1.2.5>.

2.3.2.1.5 Fog

The PNPP site is located in a region in which heavy fog occurs about 13 days per year. Additional discussion may be found in <Section 2.3.1.2.8>.

2.3.2.1.6 Atmospheric Stability

Monthly and annual stability class distribution based on ΔT (60-10 meters) are presented in <Table 2.3-18> for the seven site years (May 1, 1972, to April 30, 1974; September 1, 1977, to August 31, 1982).

<Table 2.3-19> presents annual stability class distribution based on National Weather Service data with an applied Pasquill-Turner (Reference 36) classification method for Erie and Cleveland, as well as the PNPP distributions based on ΔT. The differences shown in <Table 2.3-19> between the seven site year PNPP period and the ten-year National Weather Service periods can be attributed to the differences in

methodology for stability classifications. However, the distributions are similar, indicating that the seven site years are representative of the long term.

The onsite PNPP data in <Table 2.3-18> indicates that very unstable (A) conditions are most frequent during the summer months of maximum solar heating. Neutral (D) and slightly stable (E) conditions predominate throughout the year. The annual average stability distributions by hour of the day for the seven site years <Table 2.3-20> demonstrate that stable conditions are commonly associated with the nighttime and unstable conditions with the daytime.

<Table 2.3-21> presents for each stability class the number of occurrences of stability class persistence for a given time period for the seven site years. The longest persistence during the seven site years occurred for D conditions for 148 hours. The longest persistence period for stable (E, F and G) conditions was 54 hours.

<Appendix 2A>, <Appendix 2B>, and <Appendix 2C> include additional stability distribution information in the form of joint frequency distributions. Offsite data are presented in <Appendix 2A>, while <Appendix 2B> and <Appendix 2C> include onsite data for 10-meter and 60-meter winds, respectively.

2.3.2.1.7 Station Pressure

Measurement of station pressure at PNPP began on September 1, 1977. The annual average PNPP station pressure is 29.35 inches Hg, and has ranged from 28.00 inches Hg to 30.33 inches Hg. The historical onsite record covers the five-year period from September 1, 1977, to August 31, 1982. The average station pressure for Cleveland for the long term period (1973 to 1983) was 29.18 inches Hg (Reference 3). Differences in average pressure between PNPP and Cleveland are accounted for primarily

by the difference in station elevation between the two sites, 645 feet above mean sea level (MSL) at PNPP and 805 feet above MSL at Cleveland.

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

2.3.2.2.1 Influence of Plant Physical Structures on Airflow and Dispersion

The physical structure of the station, especially the large natural draft cooling towers, are expected to locally increase atmospheric turbulence. This mechanical turbulence will enhance slightly the dispersion capability of the atmosphere downwind of the plant. Analysis (Reference 37) has shown that a cooling tower has a turbulent wake extending two or three tower diameters downwind for winds greater than 5 to 8 mph. The depth of the wake would be at least 1.5 times the tower height.

The leveling of terrain, removal of associated vegetation and replacement with plant structures will have altered the surface thermal characteristics. This may result in the formation of a localized heat island over the plant, which raises slightly the air temperature in relation to the surroundings. This effect at night will tend to locally make the atmosphere less stable so that dispersion is somewhat enhanced. These effects, however, are expected to be minimal.

It can be postulated that the presence of the cooling tower structures may interact with the wind flow under some conditions such that the wind velocity between and just downwind of the towers is enhanced. To establish an upper bound to the velocity increase, a simplistic model was analyzed. In this model, each tower was represented by a trapezoid, as shown in <Figure 2.3-14>. Each tower was 450 feet high with a width that varied from 475 feet at the base to 275 feet at the exit nozzle. The base separation was 275 feet. It was assumed further that the wind

flow was perpendicular to the plane of the towers and that the flow impinging on the towers was diverted, with no loss of energy or momentum around and over the towers. Half of the flow diverted by the towers was merged with the air flowing between the towers and with the air flowing over and within 100 feet of the towers.

A ratio of the flow area approaching the towers (412,500 square feet) to the flow area passing the towers (243,750 square feet) indicates a limiting velocity increase of less than 70 percent over the approach velocity. Thus, for example, for an approach velocity of 90 mph, the maximum corresponding velocity between and downwind of the towers would be less than 153 mph.

This analysis has assumed conservation of mass flow and a constant approach velocity. All the air approaching the cross-hatched area of the towers <Figure 2.3-14> is assumed to flow between and over the towers without loss of energy or change of direction.

In reality, the velocity of the wind approaching the tower is expected to vary in proportion to the 1/7 power of the height above ground. Thus, the mass flow will be greater at higher elevations (i.e., near the top of the tower). Since most of the air mass diverted by the towers is near the ground and thus of lower velocity, the assumption of uniform velocity of the air mass over-estimates the mass of air diverted and the associated wind velocity between the towers.

Recognizing, however, that wind speed tends to increase with height above ground, we may conservatively apply the 1/7 power law to the wind

flowing between the towers. For a 90-mph approach velocity at 10 meters above the ground, the corresponding velocities between the towers would be:

33 ft (10 meters)	153 mph
50 ft	162 mph
100 ft	179 mph
150 ft	190 mph
200 ft (60 meters)	198 mph

An evaluation of the effects of these winds relative to building design is presented in <Section 3.3>.

2.3.2.2.2 Influence of Cooling Tower Operation

Based upon operating experience, natural draft cooling towers produce insignificant impacts on the atmosphere near ground level. The major potential impact due to the operation of natural draft cooling towers is the occurrence of elevated visible plumes. Due to the high release point from natural draft towers, the plume has never been observed to reach the ground. Spurr (Reference 38), in his paper, states that ". . . experience suggests that in the U.K. the impact of these towers on local climate is too small to be of any consequence, at least up to the present." He also concluded that ". . . the impact of their operation has been found to have a negligible effect on the local climate." Smith and Singer meteorologists (Reference 39) conducted airborne measurements of natural draft cooling tower plume behavior at three American Electric Power Generating Stations (Amos, Muskingum River and Mitchell). It has been observed from their measurements that the visible plumes never reached the ground in any test and low level fog has not been created; also, aerodynamic downwash was not a problem. From the same four-year (1973 through 1976) set of airborne measurements, Kramer et al. (Reference 40) observed and reported tower-induced snow during the winter of 1975 to 1976. Data from the

1973 to 1975 tests indicated no ground level precipitation or fog induced by the cooling towers. They analyzed the data and concluded that in one case the snow first reached the ground at 13 km downwind of the towers and continued to 43 km. The maximum snow accumulation was estimated to be 2.5 cm. They indicated that the key atmospheric conditions for tower-induced snow are temperatures below 15°F and stable conditions. They often observed natural snow occurring before, during or after the observations of tower-induced snow, which reveals that the snow from the cooling towers coincides with that of natural snowfall. They concluded that "with power plants in the size range and area studied, the effects seem likely to be minor. Occasional very small additions to natural snow and slight restrictions of visibility are all that one would anticipate."

Coleman and Crawford (Reference 41) characterized the observations of visible plume heights and lengths from natural draft cooling towers and of several meteorological parameters at the TVA Paradise Steam Plant. Their data show that the visible plumes are 200 meters above tower top, and do not increase the frequency of local ground level fog or influence local meteorology.

Due to the high release of the effluent from the natural draft cooling towers, the ground level concentrations of cooling tower drift are expected to be very low. This conclusion is substantiated by observational data collected around the operating natural draft cooling tower at the Chalk Point site (Reference 42). Particulate matter deposition data were collected before and after the plant commenced operation. Based upon the collected dustfall sodium data, it was concluded that ". . . there appears to be little contribution of cooling tower salts to the area." It should be noted that the cooling water in the Chalk Point cooling tower is brackish, with a mean dissolved solids concentration of 7,800 ppm. By contrast, the dissolved solids concentration in the PNPP cooling tower is approximately 535 ppm.

Based on the above observational studies, it is concluded that natural draft cooling towers at PNPP would not significantly influence the local climate in the vicinity of the site.

Generally, asbestos-cement is used in tower construction for outer walls, piping air-inlet louvers, splash boards, and as fill. Asbestos-cement is selected because of its resistance to chemical leaching and erosion. Research-Cottrell, a supplier of cooling towers using asbestos-cement exclusively as fill material, performed tests on natural draft towers similar to those proposed at PNPP and found that the concentration buildup of asbestos in the circulating water was insignificant. The release of asbestos from the operation of cooling towers at the Perry site is expected to be negligible; therefore, no adverse effects are anticipated.

B. Lewis (Reference 43) made an exhaustive study on "Asbestos in Cooling Tower Waters," and concluded that the asbestos concentrations in effluents from cooling towers using asbestos fill ranged from "none detected" to 10^8 fibers/liter; the literature study did not support conclusively the relationship between human cancers and the presence of asbestos fibers in food, beverages or drinking water. Lewis suggested that the use of asbestos-fill cooling towers be continued, since no evidence of adverse health effects were confirmed.

2.3.2.3 Topographic Description

2.3.2.3.1 General Description

The terrain in the region of the Perry site is gently rolling except for the 20-foot to 50-foot bluff at the lake shoreline. Since the meteorological tower has been 3,700 feet or more inland from the lake, the effects of the bluff on site meteorology are not considered significant. <Figure 2.3-15> illustrates the PNPP site. The exclusion boundary is described by a 2,900-foot radius circle centered on Unit 1

and Unit 2 reactors and the low population zone by a distance of 2.5 miles. A plot of maximum terrain elevation between the plant and a given downwind distance out to five miles is presented in <Figure 2.3-16> for each of 16 direction sectors. <Figure 2.3-17> is a topographic map of the site area within a 5-mile radius and <Figure 2.3-1> is the topographic map of the site area within a 50-mile radius.

2.3.2.3.2 Topographic Influence on Meteorology and Diffusion Estimates

The major local effect on site meteorology is the presence of Lake Erie and the resultant occurrences of lake and land breeze circulations. The fact that water has a higher thermal capacity than the land mass, and therefore responds more slowly to changes in radiation intensity, implies that temperature/density gradients between the water and land will occur with diurnal and seasonal periods. Turbulent mixing within the lake, effecting a downward transport of surface heat through large masses of water, also contributes to the land-lake temperature variation. Lake breezes (surface wind blowing from lake to land) form when the water temperatures are colder than the land temperatures, i.e., during spring and summer on a seasonal scale and late morning to late afternoon on a diurnal scale. The air over the land will be more bouyant than the lake air, and as it rises, a horizontal density gradient will form causing the colder air over the water to flow underneath the warmer air. Land breezes are the converse of lake breezes and occur when the water is warmer than the land, such as during the fall and winter or during the night in the summer. The lake breeze is generally stronger and occurs more frequently than the land breeze because the bouyancy of the warmer air is the driving mechanism, and this is accomplished more effectively by heating the land mass relative to the water, as in summer, than vice versa. This phenomenon becomes most pronounced when synoptic scale motions are weak, such as when a large high pressure system is centered in the region. When synoptic

scale motions are strong due to larger horizontal pressure gradients, the land/lake breeze circulation is effectively masked. A more detailed discussion of the Perry lake breeze phenomenon is discussed in Section 20 of (Reference 44).

During onshore wind flows, such as a lake breeze, cool air flowing off the lake is modified by thermal (surface heating) and by surface roughness effects as the air flows over the land. The air from the lake is modified significantly as it flows over the land, especially during the spring and early summer. The air is heated from below resulting in an unstable vertical temperature gradient and hence enhanced diffusion conditions. Surface roughness effects over the land increase atmospheric turbulence (also resulting in enhanced diffusion conditions), although low-level wind speeds will decrease. The thermal and roughness effects occur at the shoreline and form a “boundary layer,” which increases in depth with distance inland. Within this boundary layer, the air is unstable with more stable air (suppressed diffusion) above the boundary layer (Reference 45).

Offshore wind flows generally result in somewhat suppressed diffusion conditions. The warm air advected from over the land is cooled from below, resulting in a stable vertical temperature gradient (inversion) and less diffusion for the overwater flow than for an overland flow. There is also a decrease in wind turbulence, although wind speeds will increase as the air flows from the relatively rough land surface over the smooth water surface (Reference 45).

In addition to lake-land breeze effects near a shoreline, there are also downwash and upwash effects. The primary cause for a downwash or upwash condition is the difference in surface roughness between the land and the lake (Reference 46). The upwash situation occurs with the winds blowing off the lake. The air flows from the relatively frictionless lake surface over the rough land and a reduction in low-level wind speed occurs. This reduction in wind speed enhances plume rise to the extent

that the plume can more easily escape the dynamic downwash effects of the plant structure. Downwash effects occur primarily with an offshore wind. The increase in wind speed of low-level winds, coming off the relatively rough land over the smooth lake, enhances plume downwash toward the lake surface.

2.3.3 ONSITE METEOROLOGICAL MEASUREMENT PROGRAM

<Section 2.3.3.1>, <Section 2.3.3.2>, and <Section 2.3.3.3> pertain to the preoperational program that was in place for measurements made for the <Section 2.3> analyses. <Section 2.3.3.4> pertains to the current operational program.

2.3.3.1 System Description

The onsite meteorological program at the Perry site began in April 1972. The 60-meter tower was upgraded and moved 3,500 feet to a new location in August 1977 <Figure 2.3-15>. The tower was moved in 1977 in order to minimize any potential effect of the PNPP cooling towers under construction at the time.

The old location of the tower was approximately 3,700 feet south of the Lake Erie shoreline. The new location is approximately 6,000 feet inland and 4,300 feet away from the hyperbolic cooling towers. The terrain in both locations is flat with grasses, small shrubs and small trees. The terrain is similar in the site region. Therefore, the meteorological data collection from the tower is representative of the site region.

Wind and temperature data were collected at the 10-meter (35 feet) and 60-meter (200 feet) levels of the open lattice tower. Wind sensors were mounted on booms that extended to approximately 9 feet to the west of the tower. Temperature and dewpoint (10-meter level) sensors were mounted on booms that extended approximately 7 feet and 6 feet,

respectively, to the west of the tower. The station atmospheric pressure sensor was mounted on the tower at a height of 2 meters. Precipitation was measured at the surface by a rain gauge near the base of the tower.

Analog data recording equipment was located in an environmentally controlled shelter at the base of the tower. Also in the shelter was a minicomputer that provided a digitized record of averaged meteorological data, both directly to a remote onsite location and via telecommunication to a remote offsite location, where the record was examined daily for anomalous meteorological conditions or obvious instrumentation problems.

Instrumentation for the onsite program included the following:

1. Winds--A set of Climet wind speed and wind direction sensors at 10 meters and 60 meters.

2. Temperature--Rosemont resistance temperature breakers at 10 meters and 60 meters housed in Geotech aspirated solar radiation shields; Endevco signal conditioner.

3. Dewpoint--Aspirated EG&G dewpoint measuring unit at 10 meters.

4. Precipitation--At ground level, Belfort heated tipping bucket rain gauge and wind shield.

5. Atmospheric Pressure--Teledyne Geotech unit at 2 meters to provide station pressure.

6. Recorders--Esterline-Angus multipoint for all parameters except wind speed/direction, for which there were Esterline-Angus two-channel strip recorders.

7. Computer--A Digital Equipment Corporation LSI II used subsecond sampling rates to develop 15-minute values, which were combined to yield hourly values.

The specifications of the equipment for the meteorological system, which complied with the intent of the position in <Regulatory Guide 1.23> (Reference 47), are provided in <Table 2.3-22>. The sensor accuracies reflected all the equipment through the signal conditioners, and the overall system accuracy for each meteorological parameter could be calculated from this information.

Accuracies for instantaneous recorded values were calculated using the root sum squares of the accuracies of each component. Time-averaged accuracies were computed by dividing the instantaneous accuracy by the square root of the number of samples taken per hour. The analog strip recorders (wind speed and wind direction) were continuous so the number of samples was essentially infinite. For an hourly average, a sampling rate of ten times per second was assumed. The analog multipoint (temperature, ΔT, dewpoint, and precipitation) sampled each parameter approximately once per minute. The digital system sampled each parameter ten times per second. The time-averaged overall digital system accuracy was within +0.02° for wind direction, +0.01 mph for wind speed, +0.01°C for temperature, +0.01°C for temperature difference, +0.01°C for dewpoint, and +0.01 inch of Hg for station pressure.

The 9-foot high shelter housing the signal conditioning equipment and recorders was located approximately 8 feet east of the base of the tower. It was expected that the shelter would have negligible effect on the representativeness of data collected at the tower.

The automated tipping bucket rain gauge was located approximately 11 feet west of the tower and 30 feet west of the shelter. It was not anticipated that the tower or shelter would affect precipitation measurements. Recorded precipitation values may be in greater error

than stated in <Table 2.3-22>. It was determined that recorded precipitation in the cold months was lower than what actually fell. When the heater came on in cold weather to melt frozen precipitation, it evaporated some of the precipitation captured in the gauge before the precipitation fell through the funnel and was able to fill and to activate the measuring device. For example, during a light fall of dry snow, the recorded precipitation is sometimes zero during an inch or more snow accumulation.

The meteorological system at PNPP was calibrated semiannually. System surveillance included daily checks by a duty observer; checks by dial-up of the computer have been made since April 1978. As soon as a malfunction was detected either by daily system surveillance or by weekly analog chart review, field service personnel were dispatched to correct the problem.

2.3.3.2 Meteorological Data Reduction

Up to November 1978, analog strip charts and multipoint charts were manually reduced for all onsite data. One-hour averages of all parameters except the wind and precipitation were read from the multipoint chart. Precipitation was totaled for the hour period. The reading for each hour was previously centered on the hour, but after the digital system was installed (April 1978) the period was shifted to end on the hour, so as to be compatible with the realtime digital printout. The strip charts for wind records were read for a 15-minute period ending on the hour. All the manually reduced data were transcribed on punch cards, listed and subsequently used as input to data analysis computer programs.

In November 1978, the digital system became the primary data source, so that the analog charts were used only infrequently to improve data recovery. The hourly values output by the digital system normally represent hourly averages (ending on the hour), which were derived from

four 15-minute averages. In those instances when a full hour’s worth of data were not available, the hourly value may have been represented by as few as one 15-minute average. Hourly sigma theta values represent the average of the computed 15-minute values. Hourly precipitation values, however, represent hourly accumulations rather than averages. Measurement of the dewpoint at 60 meters was discontinued in January 1980.

The classification of atmospheric stability was based on the temperature differential, ΔT (60-10 meters), in accordance with <Regulatory Guide 1.23>. <Appendix 2B> and <Appendix 2C> provide joint frequency distributions by stability class.

2.3.3.3 Meteorological Data Recovery

The monthly and annual meteorological data recovery rates, by year and combined, are presented in <Table 2.3-23>.

Onsite data for the seven site years were derived from analog chart records for the period August 1972, through October 1978, and from digital records thereafter. Annual recovery rates generally exceeded 90 percent for the entire period. However, during the first data year 1972 to 1973, a set of charts lost in the mail contributed to a low recovery. Design changes and accumulation of airborne dirt contributed to low dewpoint recoveries. During the first and second year, the lower data recovery for the 60-meter wind speed was due primarily to an instrumentation problem, which necessitated an engineering design change (which was made in December 1973) and to a bearing problem. During the third year, 1977 to 1978, low dewpoint recoveries were associated with design problems in new-model sensors.

Low dewpoint recoveries during May, June and July 1979 were due to problems encountered with the balance/stability of the sensors and with airborne contaminants accumulating on the mirror in the sensors. Data

loss in August 1979 was due to computer down time related to an air conditioner failure. Loss of ΔT (60-10 meters) data in March and April 1979, was due to a tripped relay for the motor status of the 60-meter aspirator.

During data year five, 1979 to 1980, measurement of the 60-meter dewpoint was discontinued, since sufficient data had been collected for preparation of the PNPP ER/OL; measurement at 10 meters has continued.

The low 10-meter dewpoint recovery of 88 percent during this year was attributed to balance/stability problems of the sensors with airborne contaminants accumulating on the mirror and with frost/dew phase problems. The September 1979, joint 10-meter wind and stability recovery of only 88 percent was attributed to some extensive maintenance on the temperature shields and calibration.

The low recovery rate (84 percent) from 10-meter dewpoint measurements for data year six, 1980 to 1981, was primarily due to mirror contamination and to a malfunctioning thermister in the sensor. Sensors were replaced in May and June 1981. The low recovery rate (86 percent) of joint 60-meter winds and ΔT data during the year is primarily attributable to a wind direction transmitter problem in November and December 1980. In two months, during 1980 to 1981, the joint recovery rates for ΔT and 10-meter winds were slightly below 90 percent due to inking problems on the wind recorder and to moisture and aspirator problems with the ΔT sensors.

The monthly recovery rates below 90 percent for data year seven, 1981 to 1982, for joint 10-meter winds and ΔT were attributed to various causes, including an intermittent power supply, calibration, site observer error, maintenance, and a moisture problem.

The unweighted average annual data recovery for the seven site years combined was 94 percent for the joint occurrence of 10-meter wind data

and ΔT (60-10 meters) data, and 90 percent for the joint occurrence of 60-meter wind data and ΔT (60-10 meters) data.

The meteorological data collection program at PNPP was subject to detailed NUS Corporation quality assurance and quality control procedures, which were supplemented with site-specific work plans and procedures.

Scheduled calibration and maintenance of the Perry meteorological system was conducted at three-month intervals according to written procedures. Ad hoc maintenance trips were made as necessary. Daily system surveillance by local personnel using checklists and by dial-up computer were performed in order to achieve maximum data recovery. All data sets were finalized for use after intensive review by a meteorologist. Detailed records of all phases of the program were maintained for future reference.

2.3.3.4 Onsite Meteorological Measurement Program (Operational System)

The tower location (current) remains approximately 6,000 feet inland and 4,300 feet away from the hyerbolic cooling towers. The terrain is similar to the site region. Because of the similarity in terrain, the meteorological data collected on the tower is representative of the site region.

The current tower remains an open lattice structure with sensors located at various predetermined positions. The current operational system was upgraded in 1999 to include two nearly independent meteorological monitoring systems, "A" and "B". Each system has a wind speed and direction sensor at 10 and 60 meters. System "A" sensors are positioned approximately 9 feet from the tower on swing-out booms while System "B" sensors are positioned approximately 11.5 feet from the tower on slide-out booms. In addition, aspirated temperature sensors are mounted

six feet from the tower at each level for both the “A” and “B” Systems. System “A” also includes a dew point temperature sensor mounted at the 10-meter level platform, precipitation sensors located at the surface near the base of the tower, and station pressure sensor mounted inside the shelter. Measurement of these variables meets the intent of the regulatory position in Section C.1 of NRC <Regulatory Guide 1.23>. The meteorological acquisition system meets the system accuracy requirements of <Regulatory Guide 1.97>, (Revision 3) and as listed in <Table 2.3-31>.

<Table 2.3-31> contains a listing of the “A” and “B” System parameters, their subsystems, and system accuracy.

System “A” and “B” each includes a data logger with an internal communications modem, associated signal conditioning equipment and a data acquisition system consisting of an input/output drop (I/O) located in an environmentally controlled shelter near the tower. The meteorological sensors provide analog outputs to their assigned I/O rack. The signals are converted from analog to digital and the meteorological parameters are transmitted to the plant computer via fiber optic cables. This data can be accessed by the Control Room via the Plant Computer System Monitors. Sensor outputs are also connected to the data loggers for access via remote dial-up. Systems “A” and “B” provide multiple methods for communicating data to the plant computer for dispersion modeling and dose assessment as part of the dose assessment software program.

The instrument cables between the meteorological tower and the signal conditioning/data acquisition system are surge protected. The tower, as well as individual systems for each parameter on the tower, is lightning protected, except for the Dew Point System.

In the event that the System “A” or “B”, 10 meter wind speed, wind direction, Sigma Theta, 10 meter ambient temperature, or -60m-10m Delta-T is unavailable or invalid, the equivalent data from the redundant system will be provided for input to the emergency dose assessment computer program. Regional weather data is available for manual input to the emergency dose program from the Cleveland Hopkins National Weather Service (NWS) Office. This data is available 24 hours per day and is representative of the meteorological conditions at the Perry Plant.

The meteorological data collection program at the Perry Plant is subject to detailed quality assurance and quality control procedures which are supplemented with site-specific plans and procedures. A Site Observer performs a weekly inspection to verify proper system operation, routine operations and minor preventive maintenance. Calibrations and routine preventive maintenance are conducted at six (6) month intervals by trained personnel according to set procedures. The system is checked at least daily to determine if repairs requiring emergency maintenance between regularly scheduled calibrations are necessary to meet the action requirements of the Operational Requirements Manual (ORM). Instrument maintenance and servicing schedules meet the regulatory position in Section C.5 of NRC <Regulatory Guide 1.23>.

Information about data reduction and compilation can be found in the annual report of the Meteorological Program at the Perry Nuclear Power Plant.

2.3.4 SHORT TERM (ACCIDENT) DIFFUSION ESTIMATES

2.3.4.1 Objective

Onsite meteorological data from the PNPP facility for seven site years were used to evaluate the accident meteorology for the Perry area. The seven site years include May 1, 1972, to April 30, 1974; and September 1, 1977, to August 31, 1982. Accidents are postulated to characterize upper limit concentrations and dosages that might occur in the event of an inadvertent release. Among the basic inputs to the accident analysis are the meteorological conditions that determine the dilution capacity of the atmosphere.

2.3.4.2 Calculations

Dilution factors (χ/Q) for ground level releases were determined using the methodology presented in Draft <Regulatory Guide 1.145> (Reference 48).

The χ/Q values applicable for releases less than or equal to two hours were calculated at the exclusion area boundary (EAB) and at the outer boundary of the low population zone (LPZ) using the joint frequency distributions of wind speed and wind direction by atmospheric stability class. The EAB and LPZ distances for each unit are 863 meters and 4,002 meters, respectively, defined by circles about each of Units 1 and 2 and measured from the outer edge of the reactor containment building. Winds were determined at the 10-meter level and the stability class was based on the vertical temperature gradient between 10 meters and 60 meters, ΔT (60 meters-10-meters), as indicated in <Regulatory Guide 1.23>. <Appendix 2B> summarizes the wind and stability information in the form of joint frequency distribution.

The χ/Q value was determined as the greater value calculated from either

$$\chi/Q = \frac{1}{\bar{u}\left(\pi \sigma_y \sigma_z + A/2\right)} \qquad (2.3\text{-}4)$$

or

$$\chi/Q = \frac{1}{\bar{u}\, 3\pi \sigma_y \sigma_z} \qquad (2.3\text{-}5)$$

where

χ/Q = the relative concentration at ground level (sec/m^3)

π = 3.14159

$\bar{u}$ = the mean wind speed at 10 meters (m/s)

σ_y = the lateral plume spread, a function of atmospheric stability and distance (m)

σ_z = the vertical plume spread, a function of atmospheric stability and distance (m)

A = 1780 m^2, the smallest vertical plane, cross-sectional area of the building from which the effluent is released

During periods of neutral (D) and stable (E, F and G) conditions, when the wind speed was less than 6 m/s, credit for horizontal plume meander was considered such that

$$\chi/Q = \frac{1}{\bar{u}\, \pi \Sigma_y \sigma_z} \qquad (2.3\text{-}6)$$

where

Σ_y = the lateral plume spread with meander, a function of atmospheric stability, wind speed and downwind distance from release. For distances to 800 meters, $\Sigma_y = M\sigma_y$; M being a function of atmospheric stability and wind speed. For distances greater than 800 meters, $\Sigma_y = (M-1)\sigma_{y800m} = \sigma_y$, (m).

and other symbols are as defined for Equations 2.3-4 and 2.3-5. For these conditions, this χ/Q value (from Equation 2.3-6) was selected when it was less than the greater value calculated above, from Equations 2.3-4 and 2.3-5.

The following methodology was used to determine accident χ/Q values for periods up to two hours. Cumulative probability distributions of χ/Q values were determined for each of the 16 wind sectors in terms of probabilities (relative to total hours in all sectors) of given χ/Q values being exceeded in a given sector. For each distribution, the 0.5 percentile level was selected. Each of the resulting 16 χ/Q values was compared and the highest value selected to represent conservative dilution conditions for the accident assessment.

For periods greater than two hours (i.e., 8 and 16 hours, 3 and 26 days as discussed in Section 2.3.4 of <Regulatory Guide 1.70>) the χ/Q value for each sector and distance was obtained by a logarithmic interpolation between the calculated value that was selected using the above procedure and the annual average value at the distance of interest in the same direction sector. The annual average value was calculated in accordance with the methodology described in <Regulatory Guide 1.111>, which is discussed in <Section 2.3.5>. For each time period of interest, each of the resulting 16 χ/Q values was compared and the highest value selected to represent conservative dilution conditions for the accident assessment.

In accordance with the Interim Branch Technical Position of August 2, 1978 (Reference 49), and additional constraint was placed on the controlling χ/Q values for the accident assessment. An overall 5th percentile χ/Q value was calculated at the EAB and LPZ, and the larger of this χ/Q and the controlling sector χ/Q was used in the accident assessment. The methodology consists of determining the χ/Q values for each of the sectors and distances of interest (either the EAB or LPZ) and ordering these values without regard to the sector. The

5th percentile value (based on total observations) was then selected. For time periods greater than two hours, the χ/Q values were determined by a logarithmic interpolation between this 5th percentile value and the maximum annual average χ/Q value over the 16 sectors. It was found that the 5th percentile χ/Q values were less than the highest sector χ/Q values throughout the accident. Therefore, the maximum sector χ/Q values at the 0.5 percentile were chosen to represent conservative dilution conditions for the accident assessment.

As recommended in <Regulatory Guide 1.70>, realistic χ/Q values were also determined. These were calculated in the same manner as the overall 5th percentile with the exception that the 50th percentile was selected.

<Table 2.3-24> presents the conservative and realistic χ/Q values for the EAB and LPZ distances for the periods of interest. It is noted that the maximum sector χ/Q values (conservative assessment) for the LPZ do not occur in the same sector throughout the course of the accident. In such a case, Section C.3.b of <Regulatory Guide 1.145> prescribes an evaluation of the consequences of the accident for each sector using the χ/Q values in that sector throughout the course of the accident. Then the sector that produces the greatest potential risk is considered to be the controlling sector. <Table 2.3-24> presents the conservative χ/Q values for each of the sectors of interest (NW and WNW) for all periods of the potential accident.

2.3.5 LONG TERM (ROUTINE RELEASE) DIFFUSION ESTIMATES

2.3.5.1 Objective

Onsite meteorological data from the PNPP facility were used to determine the long term diffusion estimates for the Perry area. The atmospheric dilution factors (Chi/Q) and deposition rates (D/Q) were determined for the site boundary and for distances out to 50 miles (mi) (or

80 kilometers (km)) from the containment structures. A set of distances by sector direction from the containment structures was developed by determining the shortest distance to the site boundary from the closest edge of either the containment, turbine building, or offgas building in each sector. These particular buildings were used because the vents are located on or adjacent to these respective buildings (i.e., containment represents the plant vents located on the intermediate building common for Units 1 and 2; the turbine building represents the heater bay vent; and the offgas building represents the offgas vent pipe). A separate set of such distances was developed for Unit 1 and Unit 2. For building height wake effects on dispersion, a height of 40-meter was assumed and releases were assumed to be at ground level. This 40-meter value represents the height of the springline of the containments.

2.3.5.2 Calculations

Dilution factors (χ/Q) and deposition rates (D/Q) were determined using the methodology presented in <Regulatory Guide 1.111> and the NRC computer code XOQDOQ (Reference 50). The calculations were made for the site boundary and at the "population distances" discussed in <Regulatory Guide 1.70>. For conservatism, all releases were assumed to occur at ground level. Winds were determined at the 10-meter level, and the stability class was based on the vertical temperature gradient between 10 meters and 60 meters, ΔT (60-10 meters). In accordance with <Regulatory Guide 1.111>, calms were distributed directionally in proportion to the directional distribution within a stability class of the lowest wind speed group. Calms were assigned a speed one-half the threshold wind speed of the wind vane.

χ/Q values were determined by use of the following:

$$(\chi/Q)_D = \frac{2.032}{x} \sum_{ij} \frac{n_{ij}}{N\Sigma_{zj}\bar{u}_i} \tag{2.3-7}$$

where

$(\chi/Q)_D$ = the average effluent concentration, X, normalized by source strength, Q, at a downwind distance, x, for a given direction, D (sec/m^3)

x = downwind distance (m)

n_{ij} = length of time in hours of valid data for a given wind direction, D, wind speed class, i, and atmospheric stability, j.

N = total number of hours of valid data

Σ_{zj} = effective vertical dispersion parameter for stability class j (m)

$\bar{u}_i$ = mid-point at wind speed class i (m/s)

An effective vertical stability parameter, Σ_{zj}, is calculated to account for building wake effects as follows:

$$\Sigma_{zj} = \left(\sigma_{zj}^{2} + \frac{H^2}{2\ \pi}\right)^{1/2} \tag{2.3-8}$$

with the constraint

$$\Sigma_{jz} \le \sqrt{3}\ \sigma_{zj}$$

where

σ_{jz} = vertical plume spread, a function of atmospheric stability, j, and distance, x (m)

H = maximum adjacent building height (m)

Calculations of average D/Q values were made as follows:

$$\left(\frac{D}{Q}\right)_k = \frac{8}{\pi} \frac{d}{Q} \frac{f_k}{x}$$

where

$\left(\frac{D}{Q}\right)_k$ = relative deposition per unit area for sector k, m^{-2}

x = downwind wind distance, m

$\frac{d}{Q}$ = relative deposition rate per unit downwind distance, m^{-1}

f_k = relative frequency of wind direction into sector k, dimensionless

The values of d/Q are based on the curves of NRC <Regulatory Guide 1.111>, Revision 1.

In accordance with <Regulatory Guide 1.111>, since this model does not directly consider the effects of spatial and temporal variation in airflow due to terrain, appropriate adjustments were made to the calculated χ/Q values. The terrain adjustment factors used are site specific to Perry and were developed previously (Reference 51) (Reference 52) by comparing χ/Q values determined by this straight-line model and by the time-dependent, segmented-plume model NUSPUF (Reference 53). The adjustment factors as a function of sector and distance are presented in <Table 2.3-26>; the value for each sector and distance is the maximum factor within that area. It is thought that this maximum is related to the decline and subsequent decay of the lake breeze in the late afternoon and early evening (Reference 53).

<Table 2.3-27> presents the long term χ/Q diffusion estimates (undepleted and depleted) and D/Q values for Perry for the site boundary. For the population distances, χ/Q values (undepleted and

depleted) and D/Q values are presented in <Table 2.3-28>, <Table 2.3-29>, and <Table 2.3-30>, respectively.

2.3.6 REFERENCES FOR SECTION 2.3

1. ESSA, Climatological Summary, Painesville, Ohio. U.S. Department of Commerce, ESSA, Climatography of the United States No. 20-33-69, 1969.

2. Baldwin, J. L., Climates of the United States, National Oceanic and Atmospheric Administration, Washington, D.C., 1973.

3. National Oceanic and Atmospheric Administration, Local Climatological Data, Cleveland, Ohio, 1948-August 1982, Annual and Monthly Summaries. NOAA, EDS, NCC, Asheville, North Carolina.

4. National Oceanic and Atmospheric Administration, Local Climatological Data, Erie, Pennsylvania, 1972-August 1982, Annual and Monthly Summaries. NOAA, EDS, NCC, Asheville, North Carolina.

5. ESSA, Climatological Summary, Geneva, Ohio. U.S. Department of Commerce, ESSA, Climatography of the United States No. 20-33-63, 1968.

6. National Oceanic and Atmospheric Administration, Comparative Climatic Data Through 1977, NOAA, EDS, NCC, Asheville, North Carolina, 1978.

7. Miller, Marvin E. and C. R. Weaver, Snow in Ohio, Ohio Agricultural Research and Development Center, Wooster, Ohio, 1971.

8. National Oceanic and Atmospheric Administration, Climatological Data, National Summary, 1951-1978, NOAA, EDS, NCC, Asheville, North Carolina.

9. Brooks, Edward M., Tornadoes and Related Phenomena, Compendium of Meteorology, AMS, Boston, Mas., pp. 673-680, 1951.

10. National Oceanic and Atmospheric Administration, Climatological Data, Ohio, 1972-1978, NOAA, EDS, NCC, Asheville, North Carolina.

11. Cry, George W., Tropical Cyclones of the North Atlantic Ocean, Technical Paper No. 55, NOAA, Washington, D.C., 1965.

12. National Severe Storms Forecast Center, "Tornado Summary 1950-1977," Computer printout of occurrences and tornado statistics within 50 nautical miles of Perry, Ohio, 1978.

13. Markee, E. H., Jr., J. G. Beckerly, and K. E. Sanders, Technical Basis for Interim Regional Tornado Criteria, WASH-1300 (UC-11) U.S. Atomic Energy Commission, Washington, D.C., 1974.

14. Ramsdell, J. V., and Andrews, G. L., Tornado Climatology of the Contiguous United States, <NUREG/CR-4461>, PNL-5697, May 1986.

15. Fujita, T. T., "Proposed Characterization of Tornadoes and Hurricanes by Area and Intensity, Satellite and Mesometeorology Research Project," SMRP Research Paper No. 91, Chicago, Illinois, 1971.

16. National Oceanic and Atmospheric Administration, Storm Data 1959-1978. NOAA, EDS, NCC, Asheville, North Carolina.

17. Brooks, C. E. P., and N. Carruthers, Handbook of Statistical Methods in Meteorology, M.O.-538, London, England, Her Majesty's Stationery Office, pp. 131-136, 1953.

18. U.S. Department of Commerce, "Extreme Wind Speeds at 129 Stations in the Contiguous United States," NBS Building Science Series 118, March 1979.

19. Chancery, M. J., Historical Extreme Winds for the United States - Great Lakes and Adjacent Regions, <NUREG/CR-2890>, August 1982.

20. Huss, P. O., Relations Between Gusts and Average Wind Speeds for Housing Load Determination, DGAF 140, Daniel Guggenheim Airship Institute, Cleveland, Ohio, 1946.

21. Personal communication, NWS Duty Observer, Cleveland-Hopkins Airport, February 6, 1978.

22. Golde, R. H., "Protection of Structures Against Lightning," Proceedings, The Institute of Electrical Engineers, Vol. 115, No. 10, pp 1523-1529; October 1968.

23. December 1970: Extremes of Snowfall, Weatherwise. Princeton, New Jersey.

24. U.S. Nuclear Regulatory Commission, Winter Precipitation Loads, Site Analysis Branch Position, March 24, 1975.

25. American National Standards Institute, ANSI A58.1-1972; Building Code Requirements for Minimum Design Loads in Buildings and Other Structures. ANSI, Inc., New York, New York.

26. Riedel, J. T., J. F. Appleby, and R. W. Schloemer, "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas From 10 to 1,000 square Miles and Durations of 6, 12, 24, and 48 Hours," U.S. Weather Bureau, Hydrometeorological Report No. 33, Washington, D.C., 1956.

27. Changnon, S. A., Jr., "The Climatology of Hail in North America," Hail: A Review of Hail Science and Hail Suppression, Foote G. B. and C. A. Knight, (eds.), Meteorological Monographs 16:38, American Meteorological Society, Boston, Massachusetts, December 1977.

28. Hosler, C. R., "Low Level Inversion Frequency in the Contiguous United States," Monthly Weather Review, 89, pp 319-332, 1961.

29. Holzworth, G. C., Mixing Heights, Wind Speeds and Potential for Urban Air Pollution Throughout the Contiguous United States, Environmental Protection Agency, Research Triangle Park, North Carolina, 1972.

30. Stackpole, J. D., "The Air Pollution Potential Forecast Program," Weather Bureau Technical Memo NMC-43, NMC, Suitland, Maryland, 1967.

31. Korshover, J., Climatology of Stagnating Anticyclones East of the Rocky Mountains, 1963-1965, U.S. Department of Health, Education, and Welfare, Cincinnati, Ohio, 1967.

32. National Oceanic and Atmospheric Administration, Surface Observations for Erie, Pennsylvania, February 1959, to January 1964, and September 1968, to August 1978, National Weather Service TDF-14, NOAA, EDS, NCC, Asheville, North Carolina.

33. National Oceanic and Atmospheric Administration, Surface Observations for Cleveland, Ohio, February 1959, to January 1964, and September 1968, to August 1978, National Weather Service TDF-14, NOAA, EDS, NCC, Asheville, North Carolina.

34. National Oceanic and Atmospheric Administration, "Weekly Weather and Crop Bulletin," NOAA, EDS, Asheville, North Carolina, March 7, 1978.

35. Mitchell, A. E., Jr., Relationship of the 60-meter to the 10-meter Dewpoint at the PNPP Meteorological Tower, NUS-3565, NUS Corporation, Gaithersburg, Maryland, 1981.

36. Turner, D. B., "A Diffusion Model for an Urban Area," J. of Appl. Met; 3, February 1964, pp. 83-91, 1964.

37. Smith, T. B. and V. A. Mirabella, "Meteorological Effects of Cooling Towers at SMUD Site," Meteorology Research, Inc., 1971.

38. Spurr, G., "Meteorology and Cooling Tower Operation," Atmospheric Environment, 8, p. 321, 1974.

39. Kramer, M. L., M. E. Smith, M. J. Butler, and D. E. Seymour, "Cooling Towers and the Environment," Journal of the Air Pollution Control Association, 26, No. 6, p. 582, June 1976.

40. Kramer, M. L., D. E. Seymour, and M. E. Smith, "Snowfall Observations from Natural Draft Cooling Tower Plume," Science, 193, p. 1239, January 1976.

41. Coleman, J. H. and T. L. Crawford, "Characterization of Cooling Tower Plumes. A Symposium on Environmental Effects of Cooling Tower Emissions," University of Maryland, May 2-4, 1978, p. II-31, Cooling Tower Environment--1978 Proceedings, May 1978.

42. Mulchi, C. L., D. C. Wolf, and J. A. Armbruster, "Cooling Tower Effects on Crop and Soil," Chalk Point Cooling Tower Project, Postoperational Report No. 3, Final Report, FY78, WRRC Special Report No. 11, July 1978.

43. Lewis, B. G., "Asbestos in Cooling Tower Waters: Final Report," <NUREG/CR-0770>, ANL/ES-71, March 1979.

44. Wilkinson, M. J., A. E. Mitchell, Jr., L. A. Friedman, Description of the Perry Nuclear Power Plant Emergency Offsite Dose Calculations, NUS-4336, Revision 1, NUS Corporation, Gaithersburg, Maryland, April 1983.

45. VanderHoven, Issac, "Atmospheric Transport and Diffusion at Coastal Sites," Nuclear Safety, 8, No. 5, 1967.

46. Olsson, L. E., Lake Effects on Air Pollution Dispersion. Ph.D. Dissertation, University of Michigan, Ann Arbor, Michigan, 1969.

47. U.S. Nuclear Regulatory Commission, <Regulatory Guide 1.23>; Onsite Meteorological Programs, February 1972.

48. U.S. Nuclear Regulatory Commission, Draft <Regulatory Guide 1.145>; Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants, August 1979.

49. U.S. Nuclear Regulatory Commission, Accident Meteorology Model, Interim Branch Technical Position, Hydrology-Meteorology Branch, August 2, 1978.

50. J. F. Sagendorf and J. T. Goll, XOQDOQ, Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Station, Draft <NUREG-0324>, September 1977.

51. Letter From D. R. Davidson, Vice President, Engineering, Perry Nuclear Power Plant to Director, Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, Subject: Docket Nos. 50-440, 50-441, Terrain-Corrected Atmospheric Dispersion Factors, April 27, 1976.

52. Letter From D. R. Davidson, Vice President, Engineering, Perry Nuclear Power Plant, to Director of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, Subject: Docket Nos. 50-440, 50-441, Terrain-Corrected Atmospheric Dispersion Factors, July 2, 1976.

53. Chandler, M. W., J. R. Fleming, S. L. Shipley, M. S. Tapparo, NUSPUF - A Segmented Plume Dispersion Program for the Calculation of Average Concentrations in a Time-Dependent Meteorological Regime, NUS-TM-260, NUS Corporation, Gaithersburg, Maryland, March 1976.

54. Timbre, K., Mazaika, M., Eighth Annual Report of the Meteorological Programs at the Perry Nuclear Power Plant for the Partial Annual Period May 1, 1983, to December 31, 1983, NUS-4536, NUS Corporation, Gaithersburg, Maryland, March 1985.

TABLE 2.3-1

NORMALS, MEANS, AND EXTREMES FOR CLEVLEAND, OHIO [1]

Month	Temperatures °F Normal Daily maximum	Temperatures °F Normal Daily minimum	Temperatures °F Normal Monthly	Temperatures °F Extremes Record highest	Year	Temperatures °F Extremes Record lowest	Year	Normal Degree days Base 65°F Heating	Normal Degree days Base 65°F Cooling	Precipitation in inches Water equivalent Normal	Water equivalent Maximum monthly	Year	Water equivalent Minimum monthly	Year	Water equivalent Maximum in 24 hrs.	Year	Snow, Ice pellets Maximum monthly	Year	Snow, Ice pellets Maximum in 24 hrs	Year	Relative humidity pct. Hour 01 (Local time)	Hour 07	Hour 13	Hour 19	Wind Mean speed m.p.h.	Wind Prevailing direction	Wind Fastest mile Speed m.p.h.	Fastest mile Direction	Fastest mile Year	Pct. of possible sunshine	Mean sky cover, tenths, sunrise to sunset	Mean number of days Sunrise to sunset Clear	Partly cloudy	Cloudy	Precipitation .01 inch or more	Snow, Ice pellets 1.0 inch or more	Thunderstorms	Heavy fog, visibility ¼ mile or less	Temperatures °F Max. (b) 90° and above	Max. 32° and below	Min. 32° and below	Min. 0° and below	Average Station pressure mb. Elev. 805 feet m.s.l.
(a)				36		36					36		36		36		36		36		17	17	17	17	36	14	36	36		34	36	36	36	36	36	36	36	36	17	17	17	17	5
J	33.4	20.3	26.9	73	1950	-19	1963	1181	0	2.56	7.01	1950	0.36	1961	2.33	1959	21.5	1976	9.3	1952	74	76	69	71	12.5	SW	68	SW	1959	32	8.2	3	5	23	16	4	*	2	0	16	28	4	988.2
F	35.0	20.8	27.9	69	1961	-15	1963	1039	0	2.18	4.64	1950	0.73	1963	2.33	1959	20.7	1942	10.6	1973	74	77	68	71	12.4	S	65	W	1956	37	7.9	3	5	20	15	4	1	2	0	12	25	2	986.9
M	44.1	28.1	36.1	83	1945	-5	1948	896	0	3.05	6.07	1954	0.78	1958	2.76	1948	26.3	1954	14.9	1954	74	77	65	69	12.5	W	74	W	1948	46	7.5	4	7	20	16	3	2	2	0	5	21	0	986.0
A	58.0	38.5	48.3	88	1942	10	1964	501	0	3.49	6.61	1961	1.18	1946	2.24	1961	14.5	1943	7.6	1957	72	75	57	61	11.8	S	65	W	1951	53	6.9	5	8	17	14	1	4	1	0	*	10	0	987.4
M	68.4	48.1	58.3	92	1959	25	1966	244	37	3.49	6.04	1947	1.00	1963	3.73	1955	2.1	1974	2.1	1974	76	77	58	60	10.3	S	68	SW	1957	59	6.5	6	11	14	13	*	5	1	*	0	1	0	985.5
J	78.2	57.5	67.9	101	1944	31	1972	40	127	3.28	9.06	1972	1.17	1967	4.00	1972	0.0		0.0		80	80	59	62	9.4	S	57	SW	1958	65	6.0	7	11	12	11	0	7	1	2	0	*	0	986.2
J	81.6	61.2	71.4	103	1941	41	1968	9	208	3.45	6.47	1969	1.23	1952	2.87	1969	0.0		0.0		82	82	58	62	8.7	S	65	W	1956	68	5.5	9	12	10	10	0	7	1	3	0	0	0	987.6
A	80.4	59.6	70.0	102	1948	41	1965	17	172	3.00	8.96	1975	0.53	1969	3.07	1947	0.0		0.0		84	85	60	66	8.3	S	61	W	1956	64	5.5	9	12	10	9	0	5	1	2	0	0	0	989.5
S	74.2	53.5	63.9	101	1953	32	1942	95	62	2.80	6.37	1945	0.74	1964	2.26	1969	T	1976	T	1976	81	84	61	70	9.1	S	45	S	1953	60	5.8	9	9	12	10	0	3	1	1	0	0	0	989.0
O	63.6	43.9	53.8	90	1946	22	1969	354	7	2.57	9.50	1954	0.61	1952	3.44	1954	8.0	1962	6.7	1962	77	80	60	68	10.0	S	43	W	1946	55	6.0	9	8	14	11	*	2	1	0	0	3	0	990.3
N	48.8	34.4	41.6	82	1950	3	1976	702	0	2.76	6.44	1950	0.80	1976	2.23	1958	22.3	1950	15.0	1950	76	79	67	72	12.1	S	59	W	1948	31	7.9	3	6	21	15	2	1	1	0	1	12	0	988.1
D	36.4	24.1	30.3	69	1971	-11	1976	1076	0	2.36	5.60	1951	0.71	1958	2.06	1974	30.3	1962	12.2	1974	75	77	71	74	12.3	S	49	SW	1971	26	8.3	2	6	23	16	4	*	1	0	11	24	1	987.5
YR	58.5	40.8	49.7	103	JUL 1941	-19	JAN 1963	6154	613	34.99	9.50	OCT 1954	0.36	JAN 1961	4.00	JUN 1972	30.3	DEC 1962	15.0	NOV 1950	77	79	63	67	10.8	S	74	W	MAR 1948	52	6.8	69	100	196	157	18	36	13	8	46	124	6	987.7

Means and extremes above are from existing and comparable exposures. Annual extremes have been exceeded at other sites in the locality as follows: Maximum monthly precipitation 9.77 in June 1902; minimum monthly precipitation 0.17 in August 1881; maximum precipitation in 24 hours 4.97 in September 1901; maximum monthly snowfall 30.5 in February 1908; maximum snowfall in 24 hours 17.4 in November 1913; fastest mile of wind 78 from Southwest in May 1940.

(a) Length of record, years, through the current year unless otherwise noted, based on January data.

(b) 70° and above at Alaskan stations.
* Less than one half.
T Trace

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

Note:

[1] See (Reference 3) <Section 2.3.6>.

TABLE 2.3-2

NORMALS, MEANS, AND EXTREMES FOR ERIE, PENNSYLVANIA [1]

Month	Temperatures °F – Normal – Daily maximum	Temperatures °F – Normal – Daily minimum	Temperatures °F – Normal – Monthly	Temperatures °F – Extremes – Record highest	Year	Record lowest	Year	Normal Degree days Base 65°F – Heating	Cooling	Precipitation in inches – Water equivalent – Normal	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Snow, Ice pellets – Maximum monthly	Year	Maximum in 24 hrs	Year	Relative humidity pct. – Hour 01 (Local time)	Hour 07	Hour 13	Hour 19	Wind – Mean speed m.p.h.	Prevailing direction	Fastest mile – Speed m.p.h.	Direction	Year	Pct. of possible sunshine	Mean sky cover, tenths, sunrise to sunset	Mean number of days – Sunrise to sunset – Clear	Partly cloudy	Cloudy	Precipitation .01 inch or more	Snow, Ice pellets 1.0 inch or more	Thunderstorms	Heavy fog, visibility ¼ mile or less	Temperatures °F – Max. – (b) 90° and above	Max. – 32° and below	Min. – 32° and below	Min. – 0° and below	Average Station pressure mb. Elev. 805 feet m.s.l.
(a)				24		24					24		24		22		23		23		12	12	12	12	24	8	20	20			22	22	22	22	24	22	22	22	12	12	12	12	5
J	31.7	18.5	25.1	64	1967	-15	1963	1237	0	2.47	4.59	1959	0.90	1967	1.51	1959	29.9	1966	10.0	1958	75	76	73	74	13.4	WSW	42	32	1959		8.5	2	4	25	18	7	*	1	0	17	28	2	990.3
F	32.5	17.9	25.2	67	1657	-12	1973	1114	0	2.12	5.01	1976	0.73	1969	2.16	1961	32.1	1972	12.4	1971	76	77	71	75	12.6	WSW	52	29	1972		8.0	2	6	20	15	5	1	1	0	15	26	2	989.3
M	40.4	25.4	32.9	79	1977	-1	1960	995	0	2.75	6.78	1976	0.63	1960	1.87	1965	26.8	1971	12.0	1965	74	77	67	71	12.4	NNE	55	14	1960		7.4	5	7	19	15	3	2	3	0	8	24	*	988.5
A	53.5	36.1	44.8	85	1958	12	1954	606	0	3.55	7.11	1961	1.63	1975	2.53	1977	17.2	1957	10.0	1957	72	75	61	64	11.8	WSW	46	21	1965		6.7	6	8	16	14	1	3	2	0	1	13	0	989.6
M	63.7	45.5	54.6	89	1975	26	1970	336	13	3.63	5.59	1956	1.45	1962	2.23	1969	0.1	1963	0.2	1963	77	78	64	64	10.2	WSW	37	25	1964		6.4	7	10	14	12	0	4	2	0	0	1	0	987.9
J	73.5	55.6	64.6	92	1964	32	1972	80	68	3.50	7.74	1957	0.85	1963	2.80	1957	0.0		0.0		81	82	66	66	9.6	S	37	36	1975		5.8	8	11	11	10	0	6	1	*	0	*	0	988.6
J	77.4	60.0	68.7	94	1968	44	1963	24	139	3.52	7.70	1970	1.11	1974	3.22	1970	0.0		0.0		82	83	65	66	9.1	S	46	32	1959		5.5	9	12	10	10	0	7	1	*	0	0	0	989.8
A	76.0	58.9	67.5	92	1965	41	1971	43	120	3.35	11.06	1977	0.58	1959	3.29	1975	0.0		0.0		85	87	67	71	9.1	S	35	24	1970		5.5	10	10	11	11	0	7	*	*	0	0	0	991.9
S	70.2	52.6	61.4	94	1959	33	1974	141	33	3.56	10.65	1977	1.45	1960	4.84	1959	0.0		0.0		83	86	68	76	10.1	S	45	17	1965		6.3	7	9	14	11	0	4	*	0	0	0	0	991.1
O	60.2	43.0	51.6	88	1963	24	1975	415	0	3.24	9.87	1954	1.13	1963	4.35	1954	4.0	1954	2.3	1974	76	79	66	74	11.4	SSE	39	21	1967		6.5	7	8	16	12	*	3	*	0	0	2	0	992.4
N	46.5	33.7	40.1	80	1961	7	1976	747	0	3.70	6.25	1977	1.95	1954	2.86	1956	36.3	1967	23.0	1956	77	78	72	76	13.2	SSW	39	30	1968		8.5	2	5	23	16	3	2	1	0	2	13	0	989.9
D	34.8	23.3	29.1	68	1966	-2	1976	1113	0	2.81	5.63	1977	1.38	1960	2.31	1977	56.0	1963	12.9	1966	77	78	75	77	13.6	SSW	38	17	1964		9.0	1	4	26	19	7	*	1	0	11	26	*	989.6
YR	55.0	39.2	47.1	94	JULY 1968	-15	JAN 1963	6851	373	38.20	11.06	AUG 1977	0.58	AUG 1959	4.84	SEP 1959	56.0	DEC 1963	23.0	NOV 1956	78	80	68	71	11.4	S	55	14	MAR 1960		7.0	66	94	205	162	27	38	14	1	53	133	5	989.9

Means and extremes above are from existing and comparable exposures. Annual extremes have been exceeded at other sites in the locality as follows: Highest temperature 99 in September 1953; lowest temperature –16 in February 1875; maximum monthly precipitation 13.27 in July 1947; minimum monthly precipitation 0.02 in October 1924; maximum precipitation in 24 hours 10.42 in July 1947; maximum snowfall in 24 hours 26.5 in December 1944.

(a) Length of record, years, through the current year unless otherwise noted, based on January data.

(b) 70° and above at Alaskan stations.

* Less than one half .

T Trace

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

Note:

[1] See (Reference 4) <Section 2.3.6>.

TABLE 2.3-3

CLIMATOLOGICAL SUMMARIES FOR PAINESVILLE AND GENEVA [1,7]

CLIMATOLOGICAL SUMMARY

LATITUDE 41°45' N
LONGITUDE 81°18' W
ELEV. (GROUND) 600 Ft.

STATION: Painesville, Ohio

MEANS AND EXTREMES FOR PERIOD 1950-1965

MONTH	TEMPERATURE (°F) MEANS: DAILY MAXIMUM	MEANS: DAILY MINIMUM	MEANS: MONTHLY	EXTREMES: RECORD HIGHEST	EXTREMES: YEAR	EXTREMES: DAY	EXTREMES: RECORD LOWEST	EXTREMES: YEAR	EXTREMES: DAY	MEAN DEGREE DAYS**	MEAN NUMBER OF DAYS MAX.: 90° AND ABOVE	MAX.: 32° AND BELOW	MIN.: 32° AND BELOW	MIN.: 0° AND BELOW	PRECIPITATION TOTALS (INCHES) MEAN	GREATEST MONTHLY	YEAR	GREATEST DAILY	YEAR	DAY	SNOW, SLEET: MEAN	SNOW, SLEET: MAXIMUM MONTHLY	SNOW, SLEET: YEAR	SNOW, SLEET: GREATEST DAILY	SNOW, SLEET: YEAR	SNOW, SLEET: DAY	MEAN NUMBER OF DAYS: .01 or MORE	.10 or MORE	.50 or MORE	1.00 or MORE	MONTH
JAN	35.3	21.2	28.2	70	50	25	-15	63	24	1135.	0	13	28	0	2.95	6.56	50	1.40	59	21	12.4	31.5	57	10.0	64	13	13	7	1.6	.3	JAN
FEB	36.6	21.5	29.0	69	57	25	-9	63	26	1013.	0	9	25	1	2.41	4.94	50	2.03	50	13	10.4	21.2	64	7.0	51	1	11	6	1.1	.3	FEB
MAR	42.3	27.4	34.8	80	63	29	3	60	9	930.	0	5	23	0	2.90	5.50	50	1.90	50	12	10.2	22.2	54	14.6	54	1	12	7	1.6	.3	MAR
APR	55.9	38.0	46.9	87	57	25	19	54	3	543.	0	0	8	0	3.47	6.49	54	1.48	57	4	1.5	14.0	57	6.0	57	7	13	8	2.0	.4	APR
MAY	67.3	48.2	57.7	92	56	22	25	63	24	255.	0	0	0	0	2.80	6.43	53	2.44	53	22	.0	1.0	63	1.0	63	1	11	6	1.6	.3	MAY
JUNE	76.7	57.4	67.0	96	53	20	39	58	7	60.	1	0	0	0	2.97	7.17	57	2.28	57	28	.0						9	6	2.0	.6	JUNE
JULY	80.5	61.6	71.0	95	56	1	43	63	15	7.	1	0	0	0	3.30	6.65	58	2.20	50	19	.0						9	6	3.0	.8	JULY
AUG	79.2	60.8	70.0	96	51	31	47*	50	22	13.	1	0	0	0	3.16	9.53	56	2.28	56	18	.0						9	5	2.1	.7	AUG
SEPT	74.2	55.2	64.7	96*	59	9	34	57	29	97.	0	0	0	0	2.71	5.61	58	1.70	62	28	.0						8	5	2.0	.4	SEPT
OCT	64.1	45.8	54.9	91	51	4	25	65	29	322.	0	0	0	0	3.17	11.33	54	3.50	54	15	.7	10.0	54	9.0	54	31	9	5	1.8	.7	OCT
NOV	50.9	35.9	43.4	81*	61	3	7	58	29	647.	0	1	10	0	3.46	7.05	50	2.16*	63	13	6.9	39.5	50	21.0	50	24	12	7	2.1	.6	NOV
DEC	38.7	25.7	32.2	68	56	6	-4	60	24	1013.	0	8	23	0	2.38	4.06	53	1.25	57	7	14.7	38.2	62	10.0	58	6	13	7	1.0	.1	DEC
						JUNE			JAN							OCT			OCT			NOV			NOV						
YEAR	58.4	41.5	49.9	96*	53	20	-15	63	24	6035	3	36	117	1	35.68	11.33	54	3.50	54	15	56.8	39.5	50	21.0	50	24	129	75	22.	6.	YEAR

**BASE 65° F *Also on earlier dates, months, or years.

CLIMATOLOGICAL SUMMARY

LATITUDE 41°46' N
LONGITUDE 81°00' W
ELEV. (GROUND) 850 Ft.

STATION: Geneva, Ohio

MEANS AND EXTREMES FOR PERIOD 1950-1965

MONTH	TEMPERATURE (°F) MEANS: DAILY MAXIMUM	MEANS: DAILY MINIMUM	MEANS: MONTHLY	EXTREMES: RECORD HIGHEST	EXTREMES: YEAR	EXTREMES: DAY	EXTREMES: RECORD LOWEST	EXTREMES: YEAR	EXTREMES: DAY	MEAN DEGREE DAYS**	MEAN NUMBER OF DAYS MAX.: 90° AND ABOVE	MAX.: 32° AND BELOW	MIN.: 32° AND BELOW	MIN.: 0° AND BELOW	PRECIPITATION TOTALS (INCHES) MEAN	GREATEST MONTHLY	YEAR	GREATEST DAILY	YEAR	DAY	SNOW, SLEET: MEAN	SNOW, SLEET: MAXIMUM MONTHLY	SNOW, SLEET: YEAR	SNOW, SLEET: GREATEST DAILY	SNOW, SLEET: YEAR	SNOW, SLEET: DAY	MEAN NUMBER OF DAYS: .01 or MORE	.10 or MORE	.50 or MORE	1.00 or MORE	MONTH
JAN	34.6	19.5	27.0	72	50	25	-17	63	24	1171.	0	13	28	1	2.73	5.93	50	1.65	59	21	16.2	32.5	57	9.0*	60	21	11	7	1.4	.1	JAN
FEB	36.3	19.6	27.9	68	54	15	-12	51	3	1044.	0	9	26	1	2.32	4.94	50	1.71	48	12	10.7	21.0	47	7.5	51	1	10	5	1.0	.3	FEB
MAR	44.1	26.5	35.3	80	45	27	-7	60	11	918.	0	5	23	0	3.07	5.23	51	1.98	64	4	10.3	33.3	47	10.0	47	28	11	8	1.7	.2	MAR
APR	57.4	37.2	47.3	85*	62	27	14*	64	1	534.	0	0	10	0	3.91	6.57	61	2.28	59	28	2.3	20.5	57	7.5	57	8	11	8	2.7	.5	APR
MAY	67.7	47.1	57.4	89	62	18	28	45	2	262.	0	0	0	0	3.88	7.27	46	2.34	46	31	.0	1.5	47	1.0	47	6	11	8	2.5	.8	MAY
JUNE	76.3	56.7	66.5	96	52	25	37	50	18	72.	0	0	0	0	3.66	6.69	48	2.60	61	13	.0						9	7	2.5	.8	JUNE
JULY	80.0	61.1	70.5	94*	55	27	44	63	9	13.	1	0	0	0	3.14	7.43	59	2.37	50	20	.0						8	5	2.3	.7	JULY
AUG	78.9	60.4	69.6	96	53	30	42*	65	30	20.	1	0	0	0	3.45	8.30	56	2.56	56	4	.0						8	6	2.5	.8	AUG
SEPT	73.4	54.3	63.8	98	54	5	35*	59	17	115.	0	0	0	0	3.11	7.20	45	3.17	60	11	.0						7	6	1.7	.7	SEPT
OCT	63.7	44.8	54.2	87*	63	7	28*	65	29	343.	0	0	1	0	3.16	10.67	54	4.09	54	15	.8	11.0	54	8.0	54	31	8	6	2.0	.5	OCT
NOV	49.5	34.0	41.7	82	50	1	0	55	29	694.	0	1	13	0	3.73	6.81	50	2.13	63	12	11.0	40.5	50	18.0	56	22	12	9	2.2	.3	NOV
DEC	37.3	23.5	30.4	69	52	9	-4*	62	13	1070.	0	10	26	0	2.91	5.59	62	2.10	65	4	21.0	71.0	62	23.0	62	9	12	8	1.3	.1	DEC
						SEPT			JAN							OCT			OCT			DEC			DEC						
YEAR	58.2	40.3	49.3	98	54	5	-17	63	24	6256.	2	38	127	2	39.07	10.67	54	4.09	54	15	72.3	71.0	62	23.0	62	9	118	83	24.	6.1	YEAR

**BASE 65° F *Also on earlier dates, months, or years.

TABLE 2.3-4

SITE REGION METEOROLOGICAL EXTREMES (DATE OF OCCURRENCE)[1]

	Cleveland (1942-6/78)	Erie (1954-6/78)	Painesville (1950-65)	Geneva (1944-65)
Maximum Temperature, °F	103(7/41)	94(7/68)	96(6/53)	98(9/54)
Minimum Temperature, °F	-19(1/63)	-17[7]	-15(1/63)	-20[7]
Maximum Monthly Precipitation, Inches	9.50(10/54)	11.06(8/77)	11.33(10/54)	10.67(10/54)
Maximum Monthly Snowfall, Inches	42.8(1/78)[2]	62.4(1/78)[3]	39.5(11/50)	71.00(12/62)
Maximum 24-Hour Precipitation, Inches	4.00(6/72)	4.84(9/59)[4]	3.50(10/54)[5]	4.09(10/54)[5]
Maximum 24-Hour Snowfall, Inches	17.4(11/13)[2]	26.5(12/44)[3]	21.0(11/50)[5]	23.0(12.62)[5]
Fastest Mile Wind, mph, and Direction	74W(3/48)	55SE(3/60)[6]	(Not Available)	(Not Available)

NOTES:

(1) See (Reference 1), (Reference 3), (Reference 4), (Reference 5), (Reference 22) <Section 2.3.6>.
(2) Record begins with 1871.
(3) Record begins with 1894.
(4) Record begins with 1956.
(5) Maximum daily precipitation amounts.
(6) Record begins with 1958.
(7) Revised based on 1978-1980 data.

TABLE 2.3-5

DESIGN-BASIS TORNADO CHARACTERISTICS FOR THE PNPP SITE[1]

Characteristic	Value
Region	I
Maximum Wind Speed (mph)	360
Rotational Speed (mph)	290
Translational Maximum Speed (mph)	70
Translational Minimum Speed (mph)	5
Radius of Maximum Rotational Speed (ft)	150
Maximum Pressure Drop (psi)	3.0
Rate of Pressure Drop (psi/s)	2.0

NOTE:

[1] Refer to <Regulatory Guide 1.76>.

TABLE 2.3-6

MONTHLY AND ANNUAL AVERAGE WIND SPEED (MPH)
FOR PNPP REGION SITE YEARS AND LOG TERM

Month	PNPP 3 years[3] 10 m	PNPP 3 years[3] 60 m	PNPP 7 Years[4,5] 10 m	PNPP 7 Years[4,5] 60 m	ERIE 3 years[3] 6.1 m	ERIE Long Term[1,6]	CLEVELAND 3 years[3] 6.1 m	CLEVELAND Long Term[2,7]
January	10.1	13.9	10.5	14.3	13.9	13.4	12.3	12.5
February	8.1	11.1	8.7	12.1	11.2	12.6	10.4	12.4
March	9.5	13.6	9.8	13.9	12.4	12.4	11.6	12.5
April	9.5	12.9	9.5	13.4	12.4	11.8	11.9	11.8
May	7.6	11.3	7.1	10.6	10.3	10.2	9.6	10.3
June	7.0	11.3	7.0	11.0	9.6	9.6	9.0	9.4
July	6.1	9.4	6.0	9.6	8.8	9.1	8.3	8.7
August	5.7	9.7	5.9	10.0	8.6	9.1	7.7	8.3
September	6.8	11.4	6.9	11.4	9.9	10.1	8.6	9.1
October	8.2	13.2	8.7	13.6	11.1	11.4	9.3	10.0

TABLE 2.3-6 (Continued)

Month	PNPP 3 years[3] 10 m	PNPP 3 years[3] 60 m	PNPP 7 Years[4,5] 10 m	PNPP 7 Years[4,5] 60 m	ERIE 3 years[3] 6.1 m	ERIE Long Term[1,6]	CLEVELAND 3 years[3] 6.1 m	CLEVELAND Long Term[2,7]
November	10.0	15.1	9.8	14.5	13.1	13.2	11.0	12.1
December	9.8	14.4	10.4	14.8	13.4	13.6	12.2	12.3
Annual	8.2	12.4	8.4	12.4	11.3	11.4	10.2	10.8

NOTES:

(1) 30 ft for January 1, 1954 - January 31, 1960; 55 ft for February 1, 1960 - September 28, 1965; 20 ft for September 29, 1965 - December 31, 1977.
(2) 56 ft for January 1, 1942 - January 30, 1956; 88 ft for January 30, 1956 - June 25, 1959; 20 ft for June 26, 1959 - December 31, 1977.
(3) Concurrent years: May 1, 1972, to April 30, 1973; May 1, 1973, to April 30, 1974; September 1, 1977, to August 31, 1978.
(4) May 1, 1972, to April 30, 1974; September 1, 1977, to August 31, 1982.
(5) See (Reference 50) <Section 2.3.6>.
(6) See (Reference 4) <Section 2.3.6>.
(7) See (Reference 3) <Section 2.3.6>.

TABLE 2.3-7

ANNUAL AVERAGE WIND SPEEDS (MPH) FOR PNPP REGION

Period	PNPP 10 m	PNPP 60 m	Erie[1] 6.1 m	Cleveland[2] 6.1 m
May 1, 1972 - April 30, 1973	8.0	12.0	11.0	10.1
May 1, 1973 - April 30, 1974	8.4	13.0	11.9	10.2
September 1, 1977 - August 31, 1978	8.3	12.4	10.9	10.2
Combined 3-year Period	8.2	12.5	11.3	10.2
Long term	8.4[3,4]	12.4[3,4]	11.4	10.8

NOTES:

(1) See (Reference 4) <Section 2.3.6>.
(2) See (Reference 3) <Section 2.3.6>.
(3) See (Reference 50) <Section 2.3.6>.
(4) PNPP: May 1, 1972, to April 30, 1974; September 1, 1977, to August 31, 1982.

TABLE 2.3-8

PNPP AREA MONTHLY AND ANNUAL MEANS AND EXTREMES OF TEMPERATURE (°F) FOR THREE CONCURRENT YEARS[(1)]

	PNPP					ERIE					CLEVELAND				
		Maximum		Minimum			Maximum		Minimum			Maximum		Minimum	
	Mean	Mean	Extr	Mean	Extr	Mean	Mean	Extr	Mean	Extr	Mean	Mean	Extr	Mean	Extr
January	27	34	67	22	5	26	32	59	21	4	27	34	62	21	0
February	22	28	57	16	-12	21	27	55	15	-12	24	31	56	18	-1
March	37	44	74	31	2	35	42	74	29	-3	39	47	73	33	0
April	47	55	78	40	26	45	52	75	38	22	49	58	80	42	26
May	56	63	82	50	33	54	61	80	48	29	58	66	86	50	32
June	65	73	87	58	43	63	71	86	56	34	65	76	90	59	33
July	70	76	90	63	47	69	76	89	62	48	71	80	93	64	45
August	70	76	89	63	49	68	76	90	62	45	70	80	93	63	47
September	65	71	88	58	37	62	69	86	55	38	64	73	91	57	40
October	52	59	79	47	28	49	56	73	44	27	51	60	78	46	28
November	42	48	73	38	21	41	46	70	37	22	41	48	75	38	14
December	31	37	63	26	3	30	36	60	26	2	33	38	62	27	1
Annual	49	55	90	42	-12	47	54	90	41	-12	52	58	93	43	-1

TABLE 2.3-8 (Continued)

NOTE:

[(1)] May 1, 1972 to April 30, 1974; September 1, 1977 to August 31, 1978.

TABLE 2.3-9

PNPP AREA LONG TERM ANNUAL MEANS AND EXTREMES OF TEMPERATURE (°F)

	Mean	Mean Maximum	Extreme Maximum (and year)	Mean Minimum	Extreme Minimum (and year)	Period of Record
Erie[1]	47.1	55.0	94(7/68)	39.2	-17[7]	1954-1980
Cleveland[2]	49.7	58.5	103(7/41)	40.8	-19(1/63)	1942-1977
Painesville[3]	49.9	58.4	96(6/53)	41.5	-15(1/63)	1950-1965
Geneva[4]	49.3	58.2	98(9/54)	40.3	-20[7]	1944-1980
PNPP	48.6[5]	54.9[5]	92(7/80)	42.2[5]	-14(1/82)	7 Years[6]

NOTES:

[1] See (Reference 4) <Section 2.3.6>.
[2] See (Reference 3) <Section 2.3.6>.
[3] See (Reference 1) <Section 2.3.6>.
[4] See (Reference 7) <Section 2.3.6>.
[5] See (Reference 50) <Section 2.3.6>.
[6] May 1, 1972, to April 30, 1974; September 1, 1977, to August 31, 1982.
[7] Revised based on 1978-1980 data.

TABLE 2.3-10

ANNUAL PNPP DIURNAL VARIATIONS OF TEMPERATURE, DEW POINT, RELATIVE HUMIDITY, AND ABSOLUTE HUMIDITY FOR PNPP

	10-m LEVEL[1]				60-m LEVEL[2,3]			
Hour	Temp. (°F)	Dew Pt. (°F)	Rel. Hum. (%)	Abs. Hum. (gm/m^3)	Temp. (°F)	Dew Pt. (°F)	Rel. Hum. (%)	Abs. Hum. (gm/m^3)
1	47	39	77	8	48	37	74	7
2	46	39	78	8	47	37	75	7
3	46	38	78	7	47	37	75	7
4	46	38	78	7	47	36	76	7
5	45	38	79	7	46	36	76	7
6	45	38	79	7	46	36	77	7
7	46	38	79	7	46	36	78	7
8	47	39	77	8	46	37	78	7
9	48	39	74	8	47	38	76	7
10	49	39	72	8	48	38	74	7
11	50	39	70	8	49	38	73	7
12	51	40	68	8	50	39	72	7
13	52	40	68	8	50	39	71	7
14	52	40	67	8	51	39	70	8
15	52	40	67	8	51	40	70	8
16	52	40	67	8	51	39	70	7
17	52	40	68	8	51	39	70	7
18	51	40	69	8	50	39	70	7
19	50	40	71	8	50	38	70	7
20	49	40	73	8	50	38	71	7
21	49	40	75	8	49	38	71	7
22	48	40	76	8	49	38	72	7

TABLE 2.3-10 (Continued)

	10-m LEVEL[1]				60-m LEVEL[2,3]			
Hour	Temp. (°F)	Dew Pt. (°F)	Rel. Hum. (%)	Abs. Hum. (gm/m³)	Temp. (°F)	Dew Pt. (°F)	Rel. Hum. (%)	Abs. Hum. (gm/m³)
23	47	39	76	8	48	37	73	7
24	47	39	77	8	48	37	73	7
Mean	49	39	73	8	49	38	73	7

NOTES:

(1) May 1, 1972 to April 30, 1974; September 1, 1977 to August 31, 1982.
(2) May 1, 1972, to April 30, 1974; September 1, 1977, to August 31, 1978.
(3) See (Reference 51) <Section 2.3.6>.

TABLE 2.3-11

MONTHLY AND ANNUAL MEANS OF RELATIVE HUMIDITY, ABSOLUTE HUMIDITY, AND DEW POINT FOR PNPP AREA FOR THREE SITE YEARS[(1)]

	PNPP			ERIE			CLEVELAND		
Month	Relative Humidity (%)	Absolute Humidity (gm/m^3)	Dew Point (°F)	Relative Humidity (%)	Absolute Humidity (gm/m^3)	Dew Point (°F)	Relative Humidity (%)	Absolute Humidity (gm/m^3)	Dew Point (°F)
January	75	3	20	77	3	19	75	3	20
February	76	2	13	75	2	14	72	2	16
March	72	4	24	75	4	27	72	5	30
April	66	5	36	69	5	34	67	6	38
May	74	9	48	75	8	45	72	9	48
June	75	12	58	76	11	55	73	11	56
July	76	14	62	74	13	60	73	14	62
August	79	14	62	76	13	60	75	14	61
September	73	11	55	82	11	56	76	12	56
October	71	7	43	77	7	42	74	7	43
November	73	5	32	77	5	34	77	5	35

TABLE 2.3-11 (Continued)

	PNPP			ERIE			CLEVELAND		
Month	Relative Humidity (%)	Absolute Humidity (gm/m^3)	Dew Point (°F)	Relative Humidity (%)	Absolute Humidity (gm/m^3)	Dew Point (°F)	Relative Humidity (%)	Absolute Humidity (gm/m^3)	Dew Point (°F)
December	78	3	28	80	3	25	78	4	26
Annual	74	7	40	76	7	39	74	8	43

NOTE:

(1) May 1, 1972, to April 30, 1974; September 1, 1977, to August 31, 1978

TABLE 2.3-12

LONG TERM VALUES OF RELATIVE HUMIDITY, ABSOLUTE HUMIDITY AND DEW POINT FOR PNPP AREA

		Mean			MAXIMUM Mean			MAXIMUM Extreme			MINIMUM Mean			MINIMUM Extreme		
		RH (%)	AH (g/m^3)	DP (°F)	RH (%)	AH (g/m^3)	DP (°F)	RH (%)	AH (g/m^3)	DP (°F)	RH (%)	AH (g/m^3)	DP (°F)	RH (%)	AH (g/m^3)	DP (°F)
January	E[1,2]	76	2	16	78	3	17	100	11	54	73	2	15	27	0	-23
	C[1,3]	72	3	16	76	3	19	100	11	55	65	2	15	28	0	-24
	P[4,5]	75	3	17	88	4	24	100	10	53	61	2	12	30	1	-20
February	E	75	3	17	78	3	19	100	11	55	71	2	15	33	0	-22
	C	70	3	18	75	3	20	100	11	55	60	2	15	25	1	-17
	P	75	3	15	88	4	21	100	11	54	60	2	10	18	1	-16
March	E	73	3	25	78	4	26	100	13	59	66	3	23	23	1	-10
	C	67	4	25	75	4	28	100	14	63	57	3	20	21	1	-5
	P	72	4	26	88	5	32	100	12	56	55	3	20	23	1	-10
April	E	67	5	33	75	5	34	100	15	64	59	5	31	20	1	5
	C	64	5	35	75	6	37	100	17	68	53	5	33	19	2	10
	P	68	6	35	85	7	41	100	15	64	51	5	29	19	2	8
May	E	71	8	45	80	8	47	100	19	71	60	7	43	22	2	10
	C	67	8	47	80	9	49	100	19	72	54	7	44	21	3	17
	P	72	9	48	86	11	52	100	23	78	56	7	42	18	2	16
June	E	74	11	55	84	12	57	100	21	75	63	10	53	32	4	28
	C	71	12	56	83	12	58	100	24	79	59	10	52	28	4	27
	P	75	12	56	90	14	61	100	26	81	62	10	52	21	3	23
July	E	74	13	59	84	14	61	100	23	77	63	12	58	32	6	37
	C	71	14	61	85	14	63	100	23	78	57	13	59	30	5	36
	P	76	14	62	92	17	67	100	23	77	59	12	58	35	7	41
August	E	77	13	60	87	14	61	100	22	76	64	12	58	35	5	35
	C	73	13	60	86	14	62	100	24	79	57	12	57	29	6	41
	P	78	14	62	93	16	66	100	22	76	62	12	58	35	5	32
September	E	78	11	54	86	11	55	100	22	75	66	10	52	35	3	24
	C	75	11	54	85	12	56	100	20	73	62	10	53	31	3	24
	P	74	12	55	89	14	60	100	22	76	58	10	50	22	4	30

TABLE 2.3-12 (Continued)

		Mean			MAXIMUM Mean			MAXIMUM Extreme			MINIMUM Mean			MINIMUM Extreme		
		RH (%)	AH (g/m^3)	DP (°F)	RH (%)	AH (g/m^3)	DP (°F)	RH (%)	AH (g/m^3)	DP (°F)	RH (%)	AH (g/m^3)	DP (°F)	RH (%)	AH (g/m^3)	DP (°F)
October	E	74	7	42	79	8	44	100	17	67	66	7	40	26	2	16
	C	72	7	43	81	8	45	100	16	66	61	6	39	26	3	18
	P	71	7	42	87	9	47	100	16	65	55	6	37	30	3	17
November	E	76	5	33	78	5	34	100	15	63	72	5	32	34	2	4
	C	74	5	33	80	5	35	100	15	64	67	5	32	29	1	-2
	P	71	5	33	86	7	38	100	14	63	57	4	27	22	2	8
December	E	74	7	39	80	7	40	100	23	77	66	7	37	20	1	-7
	C	73	3	23	75	3	24	100	12	58	70	3	21	27	1	-17
	P	74	4	24	87	5	30	100	12	56	60	3	18	30	1	-2
Annual	E	74	7	39	80	7	40	100	23	77	66	7	37	20	0	-23
	C	71	7	39	79	8	41	100	24	79	62	7	37	19	0	-24
	P	73	8	39	88	9	45	100	26	81	58	6	34	18	1	-20

NOTES:

(1) Period of record: September 1, 1968, to August 31, 1978.
(2) E = Erie refer to (Reference 30), <Section 2.3.6>.
(3) C = Cleveland refer to (Reference 31), <Section 2.3.6>.
(4) P = PNPP (May 1, 1972, to April 30, 1974; September 1, 1977, to August 31, 1982).
(5) See (Reference 50) <Section 2.3.6>.

TABLE 2.3-13

PNPP MONTHLY AND ANNUAL GREATEST PRECIPITATION (INCHES) BY TIME INTERVAL FOR SEVEN SITE YEARS[1,2]

INTERVAL (HOURS)

Month	1	6	12	18	24
January	0.15	0.62	0.66	0.66	0.85
February	0.16	0.53	0.70	0.92	0.92
March	0.40	0.72	0.81	0.83	0.83
April	0.50	0.86	1.34	1.72	1.73
May	0.72	0.77	0.93	1.16	1.38
June	0.98	1.49	2.02	2.05	2.05
July	1.00	1.51	1.51	1.51	1.51
August	1.00	1.16	1.55	1.55	1.60
September	0.85	1.85	2.35	2.44	2.44
October	0.48	1.63	1.77	1.77	1.78
November	0.33	0.95	1.14	1.30	1.31
December	0.29	0.76	1.31	1.59	1.65
Annual	1.00	1.85	2.35	2.44	2.44

NOTES:

(1) May 1, 1972, to April 30, 1974; September 1, 1977, to August 31, 1982.

(2) See (Reference 50) <Section 2.3.6>.

TABLE 2.3-14

PERCENT FREQUENCY OF PRECIPITATION BY AMOUNT AND INTERVAL FOR PNPP FOR SEVEN SITE YEARS

Amount Inches[1]	INTERVAL (HOURS)[2] 1	6	12	18	24
0.01	5.74	14.90	22.76	29.48	35.41
0.02	4.17	12.55	19.84	26.19	31.80
0.03	3.18	10.98	17.87	23.86	29.28
0.04	2.52	9.83	16.36	22.07	27.29
0.05	2.02	8.89	15.15	20.70	25.75
0.07	1.39	7.40	12.96	18.05	22.73
0.10	0.87	5.91	10.92	15.50	19.83
0.15	0.44	4.18	8.27	12.05	15.72
0.20	0.28	3.09	6.43	9.61	12.74
0.25	0.20	2.26	4.87	7.46	10.04
0.30	0.13	1.68	3.86	6.01	8.21
0.35	0.09	1.27	3.11	5.08	7.04
0.40	0.07	1.01	2.56	4.19	5.88
0.45	0.05	0.79	2.07	3.38	4.76
0.50	0.04	0.66	1.76	2.94	4.13
0.60	0.03	0.46	1.23	2.12	3.05
0.70	0.02	0.34	0.95	1.65	2.39
0.80	0.02	0.25	0.72	1.29	1.83
0.90	0.01	0.19	0.55	1.02	1.48
1.00	<0.01	0.15	0.41	0.73	1.12
1.10	0.00	0.10	0.27	0.52	0.83
1.20	0.00	0.05	0.17	0.35	0.60
1.30	0.00	0.04	0.14	0.29	0.49
1.40	0.00	0.03	0.11	0.23	0.38
1.50	0.00	0.02	0.09	0.18	0.30
1.60	0.00	0.01	0.06	0.12	0.20
1.70	0.00	0.01	0.05	0.10	0.17
1.80	0.00	<0.01	0.04	0.08	0.12
1.90	0.00	0.00	0.02	0.05	0.10
2.00	0.00	0.00	0.01	0.05	0.08

NOTES:

[1] Percentages for a given category include precipitation of that category up to the next higher category (i.e., an amount of 0.34 would be included in the 0.30 category).
[2] Hours with missing precipitation data were assumed to be hours with no precipitation.

TABLE 2.3-15

PNPP AREA GREATEST 24-H PRECIPITATION (INCHES)
FOR THREE CONCURRENT YEARS[1]

Month	PNPP	Erie[2]	Cleveland[3]	Painesville[4]	Geneva[4]
January	0.85	1.08	1.10	0.88	0.55
February	0.32	0.70	0.72	0.36	0.46
March	0.83	1.12	1.07	0.80	0.82
April	1.11	1.06	1.53	0.97	1.13
May	0.95	1.72	1.06	0.87	2.01
June	1.30	2.51	4.00	1.69	2.40
July	1.51	1.46	2.00	1.56	1.59
August	1.55	1.91	1.53	1.78	2.80
September	2.39	2.03	1.81	2.26	2.81
October	0.80	1.36	1.16	0.80	0.96
November	1.31	1.12	1.19	1.69	1.13[5]
December	1.18	2.31	1.41	1.62	1.45
Annual	2.39	2.51	4.00	2.26	2.81

NOTES:

[1] May 1, 1972, to April 30, 1973; May 1, 1973, to April 30, 1974; September 1, 1977, to August 31, 1978.
[2] See (Reference 4) <Section 2.3.6>.
[3] See (Reference 3) <Section 2.3.6>.
[4] See (Reference 8) <Section 2.3.6>; values for Painesville and Geneva are for “greatest day of precipitation.”
[5] Only two years of data available, 1972 and 1973.

TABLE 2.3-16

PNPP AREA AVERAGE TOTAL PRECIPITATION FOR THREE CONCURRENT YEARS[1]

Month	PNPP	Erie[2]	Cleveland[3]	Painesville[4]	Geneva[4]
January	1.34	2.59	2.62	2.93	2.18
February	0.40	1.50	1.77	1.20	1.41
March	2.84	3.33	3.18	3.60	3.74
April	2.75	3.35	3.35	3.43	4.25
May	2.61	4.01	3.85	3.69	4.68
June	3.53	5.49	6.36	4.53	4.89
July	1.55	1.70	3.26	2.56	2.97
August	2.62	3.84	4.36	4.52	2.98
September	4.24	6.08	3.37	4.96	5.25
October	2.14	2.88	2.51	2.61	3.01
November	2.51	4.15	3.61	4.11	3.87
December	2.56	4.26	3.43	3.76	3.45
Annual	29.07	43.18	41.67	41.90	42.68

NOTES:

(1) May 1, 1972, to April 30, 1974; September 1, 1977, to August 31, 1978.

(2) See (Reference 4) <Section 2.3.6>.

(3) See (Reference 3) <Section 2.3.6>.

(4) See (Reference 8) <Section 2.3.6>.

TABLE 2.3-17

LONG-TERM TOTAL PRECIPITATION (INCHES) VALUES FOR PNPP AREA

	ERIE[1]			CLEVELAND[2]			PAINESVILLE[3]		PNPP[4]		
Month	Normal	Maximum Monthly	Minimum Monthly	Normal	Maximum Monthly	Minimum Monthly	Normal	Maximum Monthly	Normal	Maximum Monthly	Minimum Monthly
January	2.47	4.59	0.90	2.56	7.01	0.36	2.95	6.56	1.22	2.11	0.29
February	2.12	5.01	0.73	2.18	4.64	0.73	2.41	4.94	0.80	1.91	0.05
March	2.75	6.78	0.63	3.05	6.07	0.73	2.90	5.50	2.24	3.66	0.80
April	3.55	7.11	1.63	3.49	6.61	1.18	3.47	6.49	2.46	3.71	0.56
May	3.63	5.59	1.45	3.49	6.04	1.00	2.80	6.43	2.02	3.19	1.19
June	3.50	7.74	0.85	3.28	9.06	1.17	2.97	7.17	3.45	5.36	1.89
July	3.52	7.70	1.11	3.45	6.47	1.23	3.30	6.65	2.56	5.03	0.80
August	3.35	11.06	0.58	3.00	8.96	0.53	3.16	9.53	2.82	3.93	1.60
September	3.56	10.65	1.45	2.80	6.37	0.74	2.71	5.61	3.87	5.81	1.79
October	3.24	9.87	1.13	2.57	9.50	0.61	3.17	11.33	2.76	4.18	1.51
November	3.70	6.25	1.96	2.76	6.44	0.80	3.46	7.05	1.93	3.22	0.85

TABLE 2.3-17 (Continued)

	ERIE[1]			CLEVELAND[2]			PAINESVILLE[3]		PNPP[4]		
Month	Normal	Maximum Monthly	Minimum Monthly	Normal	Maximum Monthly	Minimum Monthly	Normal	Maximum Monthly	Normal	Maximum Monthly	Minimum Monthly
December	2.81	5.63	1.38	2.36	5.60	0.71	2.38	4.06	2.49	3.86	1.31
Annual	38.20	11.06	0.58	34.99	9.50	0.36	35.68	11.33	28.32	5.81	0.05
Period of Record	1941-70	1954-77	1954-77	1941-70	1942-77	1942-77	1950-65	1950-65	-[5]	-[5]	-[5]

NOTES:

[1] See (Reference 4) <Section 2.3.6>.
[2] See (Reference 3) <Section 2.3.6>.
[3] See (Reference 1) <Section 2.3.6>.
[4] See (Reference 50) <Section 2.3.6>.
[5] May 1, 1972, to April 30, 1974; September 1, 1978, to August 31, 1982.

TABLE 2.3-18

PNPP STABILITY CLASS DISTRIBUTIONS (PERCENT) BY MONTH FOR SEVEN SITE YEARS[1,2]

Stability Class Based on ΔT (60 - 10 m)

	A	B	C	D	E	F	G
January	0.04	0.04	0.57	72.46	21.54	3.05	2.30
February	0.68	0.89	1.35	60.20	25.85	5.76	5.27
March	2.59	2.59	4.63	56.72	22.46	6.20	4.80
April	4.90	4.90	6.37	46.56	23.52	7.17	6.58
May	4.84	4.04	6.57	41.98	21.67	8.92	11.98
June	6.24	5.11	6.10	35.95	24.70	9.29	12.61
July	7.58	4.94	7.11	29.66	25.01	10.20	15.51
August	5.87	5.35	5.75	28.11	26.87	11.42	16.63
September	5.73	3.63	4.44	33.91	30.73	9.49	12.07
October	2.68	3.04	3.93	45.51	31.47	7.21	6.15
November	0.43	1.24	2.48	64.86	22.11	5.12	3.76
December	0.12	0.08	0.53	71.39	24.92	2.22	0.73
Annual	3.49	3.00	4.17	48.90	25.06	7.17	8.21

NOTES:

(1) May 1, 1972, to April 30, 1974; September 1, 1977, to August 31, 1982, and associated with valid 10-m wind data.
(2) See (Reference 54) <Section 2.3.6>.

TABLE 2.3-19

PNPP AREA LONG TERM ANNUAL STABILITY CLASS DISTRIBUTIONS[5]

	A	B	C	D	E	F	G
ERIE[1,2]							
10 years[3]	0.08	3.27	9.04	71.63	7.76	6.66	1.55
CLEVELAND[2,4]							
10 years[3]	0.27	3.47	9.52	66.74	9.74	7.74	2.52
PNPP[7]							
7 years[6,7]	3.49	3.00	4.17	48.90	25.06	7.17	8.21

NOTES:

(1) See (Reference 32) <Section 2.3.6>.
(2) Stability class based on Pasquill-Turner Method.
(3) Based on NWS data: September 1, 1968, to August 31, 1978.
(4) See (Reference 33) <Section 2.3.6>.
(5) Stability class based on Delta-T Method.
(6) May 1, 1972, to April 30, 1974; September 1, 1977, to August 31, 1982.
(7) See (Reference 54) <Section 2.3.6>.

TABLE 2.3-20

PNPP STABILITY DISTRIBUTIONS BY HOUR OF DAY FOR SEVEN SITE YEARS[1,2]
(NUMBER OF OCCURRENCES)

Stability Class

HR. OF DAY	A	B	C	D	E	F	G	TOTAL	FG	EPG
1	1	2	5	851	830	308	455	2,452	763	1,593
2	0	4	2	869	824	324	430	2,453	754	1,578
3	0	1	4	870	858	315	406	2,454	721	1,579
4	3	1	4	843	898	286	421	2,456	707	1,605
5	0	2	1	853	920	271	404	2,451	675	1,595
6	0	1	5	887	899	269	386	2,447	655	1,554
7	0	2	7	1,040	864	260	263	2,436	523	1,387
8	11	15	42	1,461	673	141	83	2,426	224	897
9	49	55	109	1,770	381	34	22	2,420	56	437
10	120	134	253	1,673	210	17	4	2,411	21	231
11	209	218	311	1,492	171	8	3	2,412	11	182
12	322	239	309	1,377	151	13	2	2,413	15	166
13	377	238	272	1,364	139	8	4	2,402	12	151
14	352	245	282	1,372	137	8	4	2,400	12	149
15	274	218	286	1,453	166	9	0	2,406	9	175
16	186	179	232	1,622	175	14	2	2,410	16	191
17	84	115	162	1,698	329	19	4	2,411	23	352
18	38	44	90	1,571	585	64	16	2,408	80	665
19	3	9	32	1,287	908	152	46	2,437	198	1,106
20	2	4	4	897	1,074	321	147	2,449	468	1,542
21	1	3	4	832	894	381	340	2,455	721	1,615
22	1	3	7	813	867	330	433	2,454	763	1,630
23	0	4	4	824	859	309	452	2,452	761	1,620
24	0	3	5	838	848	311	450	2,455	761	1,609
ALL	2,033	1,739	2,432	28,557	14,660	4,172	4,777	58,370	8,949	23,609

NOTES:

(1) May 1, 1972, to April 30, 1974; September 1, 1977, to August 31, 1982.

(2) Stability based on ΔT (60 - 10 m).

TABLE 2.3-21

PNPP STABILITY PERSISTENCE FOR SEVEN SITE YEARS[1,2]
(NUMBER OF OCCURRENCES)

STABILITY CLASS

Persistence Periods (Hours)	A	B	C	D	E	F	G	TOTAL	FG	EFG
1	276	764	1,140	1,196	1,649	1,098	186	6,309	332	631
2	100	231	335	835	742	393	155	2,791	194	349
3	78	82	115	594	434	199	99	1,601	142	203
4	66	38	36	330	286	94	95	945	86	151
5	53	16	19	257	217	74	69	705	90	128
6	36	3	6	169	174	54	50	492	89	116
7	32	2	0	155	112	28	60	389	59	80
8	28	0	0	102	109	19	51	309	73	90
9	13	0	0	116	66	9	38	242	56	69
10	1	0	0	100	76	10	59	246	89	74
11	0	0	0	71	63	5	67	206	136	135
12	0	0	0	72	57	2	20	151	93	266
13	0	0	0	42	46	1	9	98	67	271
14	0	0	0	48	35	0	5	88	24	204
15	0	0	0	32	21	0	2	55	12	142
16	0	0	0	34	17	0	0	51	5	84
17	0	0	0	30	13	0	0	43	0	51
18	0	0	0	28	5	0	0	33	0	27
19	0	0	0	23	3	0	0	26	0	9
20	0	0	0	30	4	0	0	34	0	10
21 - 25	0	0	0	77	10	0	0	87	0	16
26 - 30	0	0	0	39	4	0	0	43	0	5
31 - 35	0	0	0	33	2	0	0	35	0	3
36 - 40	0	0	0	24	1	0	0	25	0	0
41 - 45	0	0	0	17	0	0	0	17	0	4
46 - 50	0	0	0	16	0	0	0	16	0	0
51 - 55	0	0	0	11	0	0	0	11	0	1
56 - 60	0	0	0	13	0	0	0	13	0	0
GT 60	0	0	0	35	0	0	0	35	0	0
TOTAL	683	1,136	1,651	4,529	4,146	1,986	965	15,096	1,547	3,119
MAXIMUM PERSISTENCE DURATION (HOURS)	10	7	6	148	37	13	15	148	16	54

TABLE 2.3-21 (Continued)

NOTES:

(1) May 1, 1972, to April 30, 1974; September 1, 1977, to August 31, 1982.
(2) Stability based on ΔT (60 - 10 m).

TABLE 2.3-22

PNPP METEOROLOGICAL SYSTEM EQUIPMENT SPECIFICATIONS - (APRIL 1972 TO AUGUST 1982)

Instrument	Mfr.	Model	Level	Specifications
Wind Speed-Direction	Climet	Wind Direction WD-012-10	10m, 60m	Threshold 0.75 mph Accuracy ±3°
		Wind Speed WS-011-1		Threshold 0.6 mph Accuracy ±1% of the wind speed reading or 0.15 mph, whichever is greater
		Translator 025-2		
Temperature	Endevco	4470.114 Universal Signal Conditioner	T(10m) ΔT(60-10m)	T (scale -20°F to 100°F) Accuracy ±.12°F
		4473.2 RTB Conditioner		ΔT (scale -4°F to 8°F) Accuracy ±.02°F
	Teledyne Geotech	M327 Aspirators		
	Rosemount	104MB12ADCA four wire RTB		
Precipitation	Belfort	5-405 H Rain Gauge	Ground	Accuracy ±2% (in) for 1 in./h
	Weather Measure	P565 windshield (after 1978)		
Dew Point	Cambridge	110S-S	10m	Accuracy ±0.5°F
	EG&G (after August 1977)	220	10m, 60m[(1)]	Accuracy ±0.4°C
Station Pressure	Teledyne Geotech (after August 1977)	BP-100(28-32)	2m	Accuracy ±0.02 in. of Hg

TABLE 2.3-22 (Continued)

Instrument	Mfr.	Model	Level	Specifications
Multipoint Recorder T(10m), ΔT(60-10m), dewpoints, pressure, precipitation	Esterline-Angus	E1124E	Shelter	Accuracy ±0.25% of full scale
Strip Recorders (2 ea.) ws/wd)	Esterline-Angus	E1102R	Shelter	Accuracy ±1% of full scale
Minicomputer	DEC (after August 1977)	LSI-11 with ADV 11-A converter	Shelter	Accuracy of converter is ±0.10% of full scale

NOTE:

(1) 60-m dew point discontinued in January 1980.

TABLE 2.3-23

METEOROLOGICAL DATA RECOVERY (PERCENT) AT PNPP[1]

	60-m Winds[2]	10-m Winds[2]	Delta T (60-10m)	Joint 10-m Winds & Delta T	Joint 60-m Winds & Delta T	10-m Dew Point	60-m Dew Point	Precip.	Ambient Temp.	10-m Station Pressure
January										
1973	85	99	99	99	85	57	-[3]	99	99	-
1974	96	100	100	100	96	100	-	99	99	-
1978	99	96	99	96	99	45	99	99	99	99
1979	97	97	97	97	97	87	92	97	97	97
1980	99	99	98	98	98	74	45	100	98	99
1981	99	99	95	95	95	96	-	100	95	99
1982	90	89	81	80	81	80	-	99	84	91
February										
1973	85	90	93	83	79	0	-	96	95	-
1974	99	100	99	99	99	98	-	99	99	-
1978	100	100	99	99	99	99	43	99	99	99
1979	94	94	97	94	94	91	86	98	97	97
1980	100	100	99	99	99	94	-	100	99	100
1981	83	90	93	85	81	83	-	100	86	86
1982	94	94	75	72	70	90	-	100	74	94
March										
1973	88	99	99	99	88	45	-	99	99	-
1974	57	98	98	97	55	98	-	98	99	-
1978	90	90	94	88	87	53	41	98	95	97
1979	99	99	86	86	86	97	91	100	98	99
1980	99	99	91	91	91	88	-	99	91	98
1981	95	95	94	94	94	92	-	100	95	95
1982	99	98	98	97	98	85	-	100	99	98

TABLE 2.3-23 (Continued)

	60-m Winds(2)	10-m Winds(2)	Delta T (60-10m)	Joint 10-m Winds & Delta T	Joint 60-m Winds & Delta T	10-m Dew Point	60-m Dew Point	Precip.	Ambient Temp.	10-m Station Pressure
April										
1973	99	100	100	100	99	96	-	100	99	-
1974	38	100	100	100	38	100	-	100	99	-
1978	100	100	85	85	85	60	25	98	96	94
1979	98	98	87	87	87	98	98	98	97	98
1980	99	99	98	98	98	80	-	99	93	99
1981	99	99	95	95	95	92	-	99	99	99
1982	97	97	95	95	95	92	-	100	97	93
May										
1972	97	90	97	88	95	47	-	97	98	-
1973	100	100	100	100	100	56	-	100	99	-
1978	98	98	95	95	95	94	83	99	98	97
1979	99	99	99	99	99	58	40	99	99	99
1980	93	93	92	92	92	80	-	99	92	93
1981	99	99	94	94	94	61	-	100	96	98
1982	94	94	90	89	89	95	-	100	95	94
June										
1972	100	99	99	99	99	43	-	99	98	-
1973	50	99	96	96	50	57	-	99	96	-
1978	98	96	98	98	96	74	74	99	98	99
1979	99	99	98	97	97	39	26	99	97	99
1980	91	91	91	91	91	79	-	99	90	90
1981	86	99	95	95	82	49	-	99	85	87
1982	89	94	91	91	86	94	-	100	93	93

TABLE 2.3-23 (Continued)

	60-m Winds[2]	10-m Winds[2]	Delta T (60-10m)	Joint 10-m Winds & Delta T	Joint 60-m Winds & Delta T	10-m Dew Point	60-m Dew Point	Precip.	Ambient Temp.	10-m Station Pressure
July										
1972	77	74	76	73	76	44	-	67	77	-
1973	24	99	97	97	23	97	-	99	98	-
1978	99	99	99	99	99	83	90	100	99	73
1979	99	99	99	99	99	77	45	100	99	99
1980	99	99	98	98	98	94	-	100	98	98
1981	98	98	91	91	90	89	-	100	95	98
1982	99	99	97	97	97	99	-	99	99	98
August										
1972	100	100	100	100	100	99	-	100	99	-
1973	81	99	96	96	79	94	-	96	96	-
1978	98	97	96	96	96	63	98	90	96	74
1979	87	92	92	92	87	87	80	98	87	87
1980	99	99	90	90	90	95	-	99	90	99
1981	89	98	88	88	79	80	-	100	88	88
1982	99	99	95	95	95	99	-	100	98	98
September										
1972	98	98	93	92	92	66	-	93	92	-
1973	100	100	99	99	99	99	-	99	99	-
1977	99	95	99	95	99	0	0	99	99	53
1978	97	96	94	91	91	63	96	98	95	98
1979	91	99	88	88	80	80	80	98	82	91
1980	95	95	95	95	95	93	-	100	95	95
1981	98	97	90	89	90	86	-	100	93	98

TABLE 2.3-23 (Continued)

	60-m Winds[2]	10-m Winds[2]	Delta T (60-10m)	Joint 10-m Winds & Delta T	Joint 60-m Winds & Delta T	10-m Dew Point	60-m Dew Point	Precip.	Ambient Temp.	10-m Station Pressure
October										
1972	100	100	99	99	99	99	-	99	99	-
1973	99	100	100	100	99	100	-	100	99	-
1977	100	99	95	95	95	86	7	95	96	77
1978	100	100	100	100	100	100	100	100	100	99
1979	99	99	99	99	99	99	65	100	99	99
1980	99	99	92	92	92	98	-	99	98	98
1981	90	89	85	85	85	69	-	100	88	97
November										
1972	100	100	100	100	100	99	-	100	99	-
1973	100	100	99	99	99	99	-	99	99	-
1977	84	91	98	90	83	65	67	99	98	0
1978	95	95	95	95	95	95	77	95	95	95
1979	100	100	99	99	99	99	56	100	99	99
1980	81	95	92	92	77	81	-	100	82	80
1981	99	98	97	96	97	99	-	100	99	99
December										
1972	90	92	100	92	90	97	-	100	99	-
1973	86	96	84	82	75	84	-	99	98	-
1977	100	99	99	99	99	83	99	99	99	33
1978	100	100	97	97	97	91	86	100	97	100
1979	100	100	100	100	100	89	74	100	100	100
1980	61	94	94	94	60	92	-	100	94	93
1981	99	99	94	93	94	91	-	100	99	99

TABLE 2.3-23 (Continued)

	60-m Winds[2]	10-m Winds[2]	Delta T (60-10m)	Joint 10-m Winds & Delta T	Joint 60-m Winds & Delta T	10-m Dew Point	60-m Dew Point	Precip.	Ambient Temp.	10-m Station Pressure
Annual[4]										
1972-1973	93	95	96	94	92	67	-	96	96	-
1973-1974	77	99	97	97	76	90	-	99	98	-
1977-1978	97	97	96	94	94	67	60	98	97	74
1978-1979	97	98	95	95	94	82	76	99	97	98
1979-1980	97	98	95	95	95	88	-	99	94	97
1980-1981	90	97	93	92	86	84	-	99	92	93
1981-1982	96	96	91	90	90	90	-	99	93	96
Combined (Unweighted)	92	97	95	94	90	81	68	98	95	92

NOTES:

(1) Seven year period May 1, 1972, to April 30, 1974; September 1, 1977, to August 31, 1982.
(2) Recoverable wind data defined as the hourly availability of valid wind speed and direction data.
(3) Denotes parameter not monitored at the time.
(4) 1972-1973; May 1, 1972 - April 30, 1973.
1973-1974: May 1, 1973 - April 30, 1974.
1977-1978: September 1, 1977 - August 31, 1978.
1978-1979: September 1, 1978 - August 31, 1979.
1974-1980: September 1, 1979 - August 31, 1980.
1980-1981: September 1, 1980 - August 31, 1981.
1981-1982: September 1, 1981 - August 31, 1982.

TABLE 2.3-24

PNPP SHORT TERM (ACCIDENT) χ/Q VALUES[1]
AT THE EXCLUSION AREA BOUNDARY (EAB)
AND THE LOW POPULATION ZONE (LPZ) BASED ON SEVEN SITE YEARS[2,5]

Accident Period	Distance (m)	Conservative χ/Q Values (sec/m^3)[3] (Receptor Direction)		Realistic χ/Q Values (sec/m^3)[4]
2 hours	863 (EAB)	4.3E-4[6]	(NW)	4.0E-5
8 hours	4,002 (LPZ)	4.8E-5	(WNW)	3.8E-6
16 hours	4,002 (LPZ)	3.3E-5	(WNW)	3.3E-6
72 hours (3 days)	4,002 (LPZ)	1.4E-5	(WNW)	2.4E-6
624 hours (26 days)	4,002 (LPZ)	4.1E-6	(WNW)	1.6E-6

NOTES:

(1) From a ground-level release to a ground-level receptor.
(2) May 1, 1972, to April 30, 1974; September 1, 1977, to August 31, 1982.
(3) Values are the maximum of 16 sectors at 0.5 percentile and the 5th percentile overall for each time period.
(4) Calculated from the 50th percentile overall 2 hour value and the maximum sector annual average by logarithmic interpolation.
(5) See (Reference 50) <Section 2.3.6>.
(6) 4.3E-4 = 4.3×10^{-4}.

<TABLE 2.3-25>

DELETED

TABLE 2.3-26

PNPP TERRAIN ADJUSTMENT FACTORS[(1)]

Standard Population Distances (in miles and meters)

Receptor Direction	0.5 805	1.5 2,414	2.5 4,023	3.5 5,633	4.5 7,242	7.5 12,070	15.0 24,140	25.0 40,234	35.0 56,327	45.0 72,420
N	1.8	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0
NNE	1.6	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0
NE	1.6	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
ENE	1.6	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0
E	1.6	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
ESE	1.6	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
SE	2.0	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0
SSE	4.0	1.6	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0
S	4.5	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
SSW	2.2	1.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
SW	2.0	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0
WSW	1.9	1.1	1.7	1.4	1.2	1.0	1.0	1.0	1.0	1.0

TABLE 2.3-26 (Continued)

Receptor Direction	0.5 805	1.5 2,414	2.5 4,023	3.5 5,633	4.5 7,242	7.5 12,070	15.0 24,140	25.0 40,234	35.0 56,327	45.0 72,420
W	1.8	1.1	1.7	1.6	1.2	1.0	1.0	1.0	1.0	1.0
WNW	1.7	1.1	1.6	1.8	1.4	1.0	1.0	1.0	1.0	1.0
NW	1.7	1.1	1.1	1.2	1.2	1.0	1.0	1.0	1.0	1.0
NNW	1.7	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0

Range of Applicability (in miles and meters)

0.00-1.00	1.01-2.00	2.01-3.00	3.01-4.00	4.01-5.00	5.01-10.00	10.01-20.00	20.01-30.00	30.01-40.00	>40.00
0-1609	1610-3219	3220-4828	4829-6437	6438-8047	8048-16093	16094-32186	32187-48279	48280-64372	>64372

NOTE:

[1] See (Reference 46) <Section 2.3.6>.

TABLE 2.3-27

PNPP ANNUAL AVERAGE SITE BOUNDARY χ/Q AND D/Q VALUES[1]
FOR TEN SITE YEARS[2]

UNIT 1: Maximum χ/Q is to the receptor direction NW

Wind Direction	Receptor Direction	Minimum Distance[3]	Undepleted χ/Q (s/m^3)	Depleted χ/Q (s/m^3)	D/Q (m^2)
NNE	SSW	1,452	1.6E-6[4]	1.4E-6	6.9E-9
NE	SW	1,047	3.6E-6	3.2E-6	1.3E-8
ENE	WSW	900	7.1E-6	6.4E-6	1.6E-8
E	W	430	3.6E-5	3.4E-5	4.6E-8
ESE	WNW	283	6.8E-5	6.5E-5	8.7E-8
SE	NW	273	6.9E-5	6.6E-5	1.0E-7
SSE	NNW	280	5.8E-5	5.5E-5	1.1E-7
S	N	294	5.0E-5	4.8E-5	1.4E-7
SSW	NNE	402	2.4E-5	2.3E-5	9.0E-8
SW	NE	678	7.4E-6	6.8E-6	3.5E-8
WSW	ENE	1,079	2.5E-6	2.3E-6	1.8E-8
W	E	1,104	2.1E-6	1.9E-6	1.5E-8
WNW	ESE	1,130	1.6E-6	1.5E-6	1.1E-8
NW	SE	1,345	1.4E-6	1.2E-6	8.6E-9
NNW	SSE	1,445	2.5E-6	2.2E-6	1.2E-8
N	S	1,420	2.9E-6	2.5E-6	1.4E-8

TABLE 2.3-27 (Continued)

Wind Direction	Receptor Direction	Minimum Distance[3]	Undepleted χ/Q (s/m^3)	Depleted χ/Q (s/m^3)	D/Q (m^2)
UNIT 2: Maximum χ/Q is to the receptor direction NW					
NNE	SSW	1,284	1.9E-6	1.7E-6	8.6E-9
NE	SW	1,563	1.9E-6	1.7E-6	6.4E-9
ENE	WSW	893	7.2E-6	6.5E-6	1.7E-8
E	W	610	2.0E-5	1.8E-5	2.6E-8
ESE	WNW	455	2.9E-5	2.8E-5	4.3E-8
SE	NW	409	3.4E-5	3.2E-5	5.7E-8
SSE	NNW	409	3.0E-5	2.8E-5	6.3E-8
S	N	427	2.6E-5	2.5E-5	8.0E-8
SSW	NNE	495	1.7E-5	1.6E-5	6.6E-8
SW	NE	800	5.7E-6	5.2E-6	2.7E-8
WSW	ENE	1,079	2.5E-6	2.3E-6	1.8E-8
W	E	1,072	2.2E-6	2.0E-6	1.6E-8
WNW	ESE	1,083	1.8E-6	1.6E-6	1.2E-8
NW	SE	1,269	1.5E-6	1.4E-6	9.5E-9
NNW	SSE	1,316	2.8E-6	2.5E-6	1.4E-8
N	S	1,298	3.3E-6	2.9E-6	1.6E-8

NOTES:

(1) From a ground-level release to a ground-level receptor.
(2) 2006-2016
(3) Distance in meters.
(4) 1.6E-6 = 1.6×10^{-6}

TABLE 2.3-28

PNPP ANNUAL AVERAGE χ/Q (s/m^3) VALUES (UNDEPLETED) FOR A GROUND

LEVEL RELEASE FOR TEN YEARS[1]

DISTANCE (METERS)

Receptor Direc-tion	805	2,414	4,023	5,633	7,242	12,070	24,140	40,234	56,327	72,420
N	9.36E-06[2]	1.12E-06	5.58E-07	3.54E-07	2.30E-07	1.17E-07	4.77E-08	2.49E-08	1.63E-08	1.19E-08
NNE	7.93E-06	1.07E-06	5.21E-07	3.28E-07	2.11E-07	1.06E-07	4.25E-08	2.19E-08	1.43E-08	1.04E-08
NE	5.65E-06	7.51E-07	3.28E-07	2.04E-07	1.43E-07	7.09E-08	2.78E-08	1.41E-08	9.08E-09	6.55E-09
ENE	4.02E-06	5.13E-07	2.39E-07	1.46E-07	1.01E-07	4.86E-08	1.83E-08	9.06E-09	5.73E-09	4.08E-09
E	3.49E-06	4.35E-07	1.83E-07	1.11E-07	7.65E-08	3.65E-08	1.36E-08	6.73E-09	4.25E-09	3.03E-09
ESE	2.82E-06	3.48E-07	1.60E-07	8.75E-08	6.02E-08	2.85E-08	1.05E-08	5.17E-09	3.25E-09	2.31E-09
SE	3.13E-06	3.09E-07	1.42E-07	8.54E-08	5.34E-08	2.52E-08	9.29E-09	4.54E-09	2.85E-09	2.02E-09
SSE	6.17E-06	4.55E-07	1.46E-07	8.91E-08	6.18E-08	2.97E-08	1.13E-08	5.60E-09	3.56E-09	2.54E-09
S	7.00E-06	5.73E-07	1.34E-07	8.19E-08	5.69E-08	2.75E-08	1.05E-08	5.23E-09	3.33E-09	2.39E-09
SSW	4.00E-06	4.70E-07	1.60E-07	9.88E-08	6.93E-08	3.41E-08	1.34E-08	6.81E-09	4.39E-09	3.18E-09
SW	5.53E-06	5.77E-07	2.83E-07	1.78E-07	1.26E-07	6.37E-08	2.57E-08	1.33E-08	8.71E-09	6.36E-09
WSW	8.51E-06	9.57E-07	7.39E-07	3.87E-07	2.38E-07	1.22E-07	4.98E-08	2.61E-08	1.72E-08	1.26E-08
W	1.22E-05	1.46E-06	1.15E-06	7.00E-07	3.80E-07	1.98E-07	8.30E-08	4.42E-08	2.93E-08	2.16E-08
WNW	1.10E-05	1.40E-06	1.04E-06	7.59E-07	4.27E-07	2.23E-07	9.38E-08	5.00E-08	3.32E-08	2.45E-08
NW	1.05E-05	1.34E-06	6.83E-07	4.80E-07	3.47E-07	1.81E-07	7.57E-08	4.03E-08	2.67E-08	1.97E-08
NNW	9.51E-06	1.21E-06	6.11E-07	3.91E-07	2.56E-07	1.32E-07	5.46E-08	2.89E-08	1.90E-08	1.40E-08
Distance:	0.5 mi	1.5 mi	2.5 mi	3.5 mi	4.5 mi	7.5 mi	15.0 mi	25.0 mi	35.0 mi	45.0 mi

NOTES:

(1) 2006-2016

(2) 9.36E-6 = 9.36×10^{-6}.

TABLE 2.3-29

PNPP ANNUAL AVERAGE χ/Q (s/m^3) VALUES (DEPLETED) FOR A GROUND LEVEL RELEASE FOR TEN SITE YEARS[1]

Distance in Meters

Receptor Direction	805	2,414	4,023	5,633	7,242	12,070	24,140	40,234	56,327	72,420
N	8.54E-06[2]	9.52E-07	4.50E-07	2.75E-07	1.73E-07	8.15E-08	2.89E-08	1.32E-08	7.71E-09	5.12E-09
NNE	7.23E-06	9.02E-07	4.21E-07	2.54E-07	1.59E-07	7.40E-08	2.58E-08	1.17E-08	6.79E-09	4.49E-09
NE	5.15E-06	6.36E-07	2.65E-07	1.58E-07	1.08E-07	4.95E-08	1.69E-08	7.53E-09	4.35E-09	2.86E-09
ENE	3.67E-06	4.35E-07	1.93E-07	1.13E-07	7.61E-08	3.39E-08	1.12E-08	4.83E-09	2.75E-09	1.78E-09
E	3.19E-06	3.69E-07	1.48E-07	8.60E-08	5.75E-08	2.54E-08	8.30E-09	3.59E-09	2.04E-09	1.32E-09
ESE	2.57E-06	2.95E-07	1.29E-07	6.80E-08	4.52E-08	1.99E-08	6.41E-09	2.75E-09	1.56E-09	1.00E-09
SE	2.86E-06	2.62E-07	1.14E-07	6.63E-08	4.01E-08	1.76E-08	5.63E-09	2.41E-09	1.35E-09	8.71E-10
SSE	5.63E-06	3.85E-07	1.18E-07	6.90E-08	4.63E-08	2.07E-08	6.79E-09	2.94E-09	1.66E-09	1.07E-09
S	6.39E-06	4.86E-07	1.08E-07	6.35E-08	4.27E-08	1.91E-08	6.32E-09	2.75E-09	1.56E-09	1.01E-09
SSW	3.64E-06	3.97E-07	1.29E-07	7.65E-08	5.18E-08	2.36E-08	7.98E-09	3.52E-09	2.01E-09	1.31E-09
SW	5.04E-06	4.88E-07	2.27E-07	1.38E-07	9.44E-08	4.40E-08	1.53E-08	6.85E-09	3.96E-09	2.60E-09
WSW	7.76E-06	8.10E-07	5.95E-07	3.00E-07	1.78E-07	8.41E-08	2.98E-08	1.36E-08	7.93E-09	5.24E-09
W	1.11E-05	1.23E-06	9.27E-07	5.41E-07	2.84E-07	1.37E-07	4.96E-08	2.29E-08	1.35E-08	8.96E-09
WNW	1.00E-05	1.19E-06	8.41E-07	5.88E-07	3.20E-07	1.55E-07	5.63E-08	2.61E-08	1.54E-08	1.03E-08
NW	9.59E-06	1.13E-06	5.50E-07	3.72E-07	2.60E-07	1.25E-07	4.54E-08	2.10E-08	1.24E-08	8.25E-09
NNW	8.68E-06	1.02E-06	4.92E-07	3.03E-07	1.92E-07	9.15E-08	3.29E-08	1.51E-08	8.88E-09	5.90E-09
Distance:	0.5 mi	1.5 mi	2.5 mi	3.5 mi	4.5 mi	7.5 mi	15.0 mi	25.0 mi	35.0 mi	45.0 mi

NOTES:

(1) 2006-2016

(2) 8.54E-6 = 8.54 X 10^{-6}.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE 2.3-30

PNPP ANNUAL AVERAGE Δ/Q (m^{-2}) VALUES FOR
A GROUND LEVEL RELEASE FOR TEN SITE YEARS[1]

Distance in Meters

Receptor Direction	805	2,414	4,023	5,633	7,242	12,070	24,140	40,234	56,327	72,420
N	2.97E-08[2]	2.86E-09	1.17E-09	6.45E-10	3.74E-10	1.52E-10	4.81E-11	1.95E-11	1.05E-11	6.52E-12
NNE	3.04E-08	3.29E-09	1.35E-09	7.43E-10	4.31E-10	1.75E-10	5.54E-11	2.25E-11	1.21E-11	7.51E-12
NE	2.64E-08	2.85E-09	1.06E-09	5.86E-10	3.74E-10	1.52E-10	4.80E-11	1.95E-11	1.05E-11	6.52E-12
ENE	2.86E-08	3.09E-09	1.27E-09	6.97E-10	4.45E-10	1.80E-10	5.72E-11	2.32E-11	1.25E-11	7.75E-12
E	2.52E-08	2.72E-09	1.02E-09	5.59E-10	3.57E-10	1.45E-10	4.58E-11	1.86E-11	1.00E-11	6.22E-12
ESE	1.94E-08	2.10E-09	8.60E-10	4.31E-10	2.75E-10	1.11E-10	3.53E-11	1.43E-11	7.71E-12	4.79E-12
SE	2.01E-08	1.74E-09	7.12E-10	3.92E-10	2.27E-10	9.22E-11	2.92E-11	1.19E-11	6.38E-12	3.97E-12
SSE	3.05E-08	1.92E-09	5.41E-10	2.98E-10	1.90E-10	7.70E-11	2.44E-11	9.92E-12	5.34E-12	3.31E-12
S	3.47E-08	2.42E-09	4.97E-10	2.74E-10	1.75E-10	7.08E-11	2.25E-11	9.11E-12	4.90E-12	3.04E-12
SSW	1.85E-08	1.85E-09	5.42E-10	2.99E-10	1.91E-10	7.72E-11	2.45E-11	9.94E-12	5.35E-12	3.32E-12
SW	1.93E-08	1.67E-09	6.85E-10	3.77E-10	2.41E-10	9.76E-11	3.09E-11	1.26E-11	6.76E-12	4.20E-12
WSW	1.97E-08	1.79E-09	1.14E-09	5.16E-10	2.82E-10	1.14E-10	3.63E-11	1.47E-11	7.91E-12	4.92E-12
W	1.70E-08	1.64E-09	1.04E-09	5.37E-10	2.57E-10	1.04E-10	3.30E-11	1.34E-11	7.21E-12	4.48E-12
WNW	1.74E-08	1.77E-09	1.06E-09	6.56E-10	3.25E-10	1.32E-10	4.18E-11	1.70E-11	9.13E-12	5.67E-12
NW	1.98E-08	2.02E-09	8.27E-10	4.97E-10	3.17E-10	1.28E-10	4.07E-11	1.65E-11	8.89E-12	5.52E-12
NNW	2.18E-08	2.22E-09	9.11E-10	5.02E-10	2.91E-10	1.18E-10	3.74E-11	1.52E-11	8.17E-12	5.07E-12
Distance:	0.5 mi	1.5 mi	2.5 mi	3.5 mi	4.5 mi	7.5 mi	15.0 mi	25.0 mi	35.0 mi	45.0 mi

NOTES:

(1) 2006-2016
(2) 2.97E-8 = 2.97 x 10^{-8}.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE 2.3-31

METEOROLOGICAL DATA COLLECTION SYSTEM

System "A"	System "B"	System Accuracy
10m/60m Wind Speed	10m/60m Wind Speed	±0.5 MPH <5 MPH, 10% of measured value >5 MPH
10m/60m Wind Direction	10m/60m Wind Direction	±5.0° of azimuth
10m Ambient Temperature	10m Ambient Temperature	±0.9°F
Delta Temperature (60m – 10m)	Delta Temperature (60m – 10m)	±0.27°F
10m Dewpoint	N/A	±2.7°F
Precipitation	N/A	N/A
Station Pressure	N/A	N/A
10m Sigma Theta[1]	10m Sigma Theta[1]	N/A
60m Sigma Theta[1]	60m Sigma Theta[1]	N/A

NOTE:

[1] Sigma Theta – horizontal wind direction fluctuations, etc., for preliminary dispersion estimates.

2.4 HYDROLOGIC ENGINEERING

2.4.1 HYDROLOGIC DESCRIPTION

2.4.1.1 Site and Facilities

The Perry Nuclear Power Plant is located in Lake County, Ohio, approximately seven miles northeast of Painesville. The southern plant site boundary line is 3,100 feet from the shoreline of Lake Erie on the west side of the site and 8,000 feet on the east side. Grade elevations in the immediate plant area prior to plant construction varied between 620.0 feet and 623.0 feet based upon the USGS datum. The maximum monthly average level of record for Lake Erie is 575.4 feet (USGS); therefore, no problems of site flooding exists owing to the nature of the site.

The construction of the plant resulted in some minor changes in local drainage patterns, runoff characteristics and in the diversion of one small stream. Final topography is shown in <Figure 2.1-3> and an aerial photograph of the site, prior to plant construction, is shown in <Figure 2.1-4>.

Protection is provided for safety-related structures, exterior systems and access equipment against flooding from Lake Erie, surface runoff and local intense precipitation. This is accomplished by location, arrangement and design of these structures, systems and equipment as discussed in the following sections.

2.4.1.2 Hydrosphere

Lake Erie, the major hydrologic feature of this location, will provide cooling water for the plant. The lake will not influence the surface water characteristics of the site since the mean lake level is in excess of 40 feet below plant grade.

In the vicinity of the site, the coastal watershed is drained by several small streams. These streams have cut deep channels as they approach the lake in the otherwise flat terrain of this region. The width of this coastal watershed in the site area is approximately 4.5 miles with the ground falling away sharply to the south of the ridge into the Grand River Basin.

Topographically, the site lies in the Old Lake-bed Region of northeast Ohio.

Two nameless, parallel streams run close to the plant area. The larger has a drainage basin of 7.16 square miles and runs northwestward within 1,000 feet of the southwest corner of the plant. The smaller stream, which has a drainage area of only 0.76 square mile, borders the plant area to the east and north. The drainage areas are shown in <Figure 2.4-1>. The safety-related structures of the plant are located within the drainage basin of the small stream which was diverted to border the final plant area to the east only.

No recorded data exists for either stream, or any similar stream in the general area of the site. However, estimates made during site visits indicate that the average flow for the larger and smaller streams would be approximately 5 cfs and 1 cfs, respectively. Older local inhabitants living on Lockwood and Center Roads did not recall either stream level overtopping Center Road. High water marks on the headwalls of the preexisting Center Road bridge over the major stream indicated that the maximum depth at this point had been approximately four feet. The smaller stream previously passed through a 4-foot by 5-foot rough stone culvert under Center Road.

There are no users of water from the minor stream. The only user of surface water from the major stream is the Neff Perkins Corporation which intermittently withdraws water from a pond near the downstream end. Use of groundwater is discussed in <Section 2.4.13>. Possible

contamination of groundwater is also discussed in <Section 2.4.13> and the degree of contamination as assessed in that section will also apply to both streams.

Lake Erie has an area of 9,970 square miles and is only slightly larger than Lake Ontario, which has the smallest surface area of any of the Great Lakes. It is the shallowest of the lakes, with a maximum depth of 210 feet and an average depth of 58 feet. Also, Lake Erie has the smallest volume, 110 cubic miles (Reference 1).

The lake is about 241 miles long with a maximum width of 57 miles. The long axis of the lake lies in a general northeast-southwest direction.

The drainage basin of Lake Erie, including Lake St. Clair, is about 29,650 square miles. The mean annual flow from the Detroit River at the western head of the lake is 178,000 cfs which accounts for about 90 percent of the inflow into Lake Erie. The mean annual outflow into Lake Ontario is about 194,000 cfs through the Niagara River and about 8,000 cfs through the Welland Canal (Reference 1).

Lake Erie level records have been maintained by the Lake Survey Center (NOAA) since 1859. As shown in <Figure 2.4-2>, the average level is 572.3 feet above mean sea level, mean tide, New York City, which is the USGS datum. The 1973 monthly levels were exceptionally high, setting a new maximum monthly mean level of 575.4 feet (USGS) in June, 1973. The lowest average monthly recorded level was 569.3 feet (USGS) in February, 1936. Corresponding levels relative to the 1955 International Great Lakes Datum (IGLD) are 1.9 feet less. The Lake Erie Low Water Datum (LWD) is at Elevation 570.5 feet (USGS) and Elevation 568.6 feet (IGLD) (Reference 2).

Minimum lake levels usually occur in February when precipitation throughout the Great Lakes drainage basin is being stored in the form of ice and snow. Maximum levels occur in mid-summer when the full effect of

the runoff from the drainage basin is felt. Fluctuations of several feet, but of short duration, are caused by wind effects. Northerly winds raise lake levels in the plant area, while winds from the south and east tend to lower the lake levels (Reference 3).

2.4.2 FLOODS

2.4.2.1 Flood History

No records of flooding in the plant area of the site exist, either from the two streams draining the coastal watershed, or from Lake Erie. The terrain is relatively flat and gently sloping toward the lake. The soil is relatively permeable and contains sand layers in the upper reaches of the drainage area. The ground surface in much of the catchment area is forested with a heavy mulch ground cover. Due to the flat terrain, permeable upper soil layers and the small catchment areas <Section 2.4.1.2>, it is unlikely that this location has ever been subjected to flooding or is likely to experience severe flooding from surface runoff in the future.

2.4.2.2 Flood Design Considerations

The probability of any flooding in the area of the site is exceptionally low. The storm drainage system for the plant was designed to prevent flooding during the Probable Maximum Flood (PMF). Studies discussed in <Section 2.4.3> have shown that even if a PMF is experienced, the streams will be contained within their natural channels except for the overtopping of the crossings at Lockwood Road and the plant main access road, which would temporarily prevent road access. The presence of a natural, high ridge along the right bank of the major stream will preclude flooding of the site by the PMF, allowing the plant to continue uninterrupted operation.

Flooding from Lake Erie is extremely improbable. Final grade elevations in the immediate plant area vary from 617 to 620 feet (USGS). This is about 45 feet above the maximum monthly mean lake level of 575.4 feet (USGS). Surge flooding is described in <Section 2.4.5>. Runup occurring coincidentally with the probable maximum setup would extend to about Elevation 607.9 feet on the bluff at the lake shore. This runup would still be about 12 feet below the 620 foot (USGS) plant grade elevation.

2.4.2.3 Effects of Local Intense Precipitation

The plant site is drained by three separate storm drainage systems, two draining to the west and the third draining to the east. The entire storm drainage system is as shown by <Figure 2.4-3>. The entire site area is subdivided into discrete subbasins, each having storm water inlets referred to as catch basins.

Peak flows to all catch basins are based on the Rational Formula which does not account for complications in the runoff processes, neglects the advantages of storage, and assumes a steady-state flow condition.

The 6-hour Probable Maximum Precipitation (PMP) of 26.7 inches for the site was distributed into hourly intensities as described in <Section 2.4.3>. The maximum hourly rainfall of 13.1 inches per hour will be occurring during the first hour.

Three values of rainfall intensity were used in the Rational Formula based on this most intense hourly value and the type of area from which the flows originated. The values used are:

a. Rainfall intensity of 4.1 inches/hour for roof downspout systems leading directly into a catch basin; this value was used because the roof systems are structurally designed to hold 9 inches of water, and therefore, the downspouts were sized to discharge 4.1 inches/hour.

b. Rainfall intensity of 9.1 inches/hour for roof areas with scupper overflows along the sides; this value was used since any rainfall intensity greater than the downspout capacity of 4 inches/hour will pass through the scupper overflows.

c. Rainfall intensity of 7.1 inches/hour for all overland flow calculations; this value was used because total depth of 6 inches is allowed to build up over the entire plant site.

In case of complete blockage of roof downspouts, building scuppers have been sized to alleviate water from a PMP event. Water level on the roofs will not exceed the maximum loading limit of 16.25”.

In addition, runoff coefficients of 0.25 for the general site area and 0.90 for roof top areas and pavements are used for the design of the system.

Sizing of storm drainage pipes is based upon basic hydraulic theory employing entrance, exit and friction losses. Tailwater conditions were assumed to exist at each pipe based on the previous downstream pipes headwater calculation. The final outlet of each storm drainage subsystem was assumed to have no downstream tailwater restrictions.

Storm water flows overland for no more than 300 feet before it reaches a catch basin. Subbasin gradients are 0.5 percent or greater.

In case of complete blockage of the storm drainage system, the plant site has been graded so that overland drainage will occur away from the plant site buildings and will not allow the accumulated storm water to exceed Elevation 620’-6”.

The area surrounding the plant site is traversed by an inner perimeter road which, for the most part, is at Elevation 620'-4" (the exceptions are at the northwest plant site corner, where it dips to Elevation 616'-11", and the area directly east of the intermediate building, where it dips to Elevation 619'-6"). The railroad enters the plant buildings at Elevation 620'-6", although it has been lowered to

Elevation 620’-2” (in the vicinities of catch basins W-7 and E-5) so that excess storm water adjacent to the buildings on the east and west sides can be discharged to lower areas.

As a result, overland flow will begin once the ponding has reached an elevation of 620’-4” (based on all centerline roadway elevations being the same). Assuming the worst case (i.e., complete blockage of the site storm drainage system and using peak discharge from the most intense hour of the PMP), the resulting increase in surface elevation of water flowing over the surrounding roads and railroads (acting as weirs) would not exceed one inch. This ponding elevation of 620’-5” will have no adverse affect upon safety class equipment because the floors at plant grade are set at Elevation 620’-6”.

As the water overflows the inner perimeter road and access railroad at Elevation 620’-4”, the storm water will be carried away by several large drainage swales including:

a. The large swale between the two cooling towers carries water away to the east.

b. The swale south of the Unit 2 cooling tower carries water to the southeast.

c. A major portion of the plant site overland flow at the north area will be carried away by the previously mentioned low area at the northwest corner into the barge unloading ramp area.

2.4.3 PROBABLE MAXIMUM FLOOD (PMF) ON STREAMS AND RIVERS

In accordance with Appendix A of <Regulatory Guide 1.59> and the applicable sections of (Reference 55), the procedures and data of the U.S. Army Corps of Engineers (Reference 4) and the U.S. Bureau of Reclamation (Reference 5) were used to calculate effective Probable

Maximum Floods for the two streams mentioned in the preceding sections. The calculated PMF for the major stream was found to be 31,250 cfs, and for the minor stream 7,000 cfs, at their outfalls into Lake Erie. <Figure 2.4-4> and <Figure 2.4-5> show the hydrographs generated for the PMF of both streams.

2.4.3.1 Probable Maximum Precipitation

The Probable Maximum Precipitation (PMP) for areas from 10 to 1,000 square miles east of the 105th Meridian has been derived by the Corps of Engineers and is presented in (Reference 4). For the Perry site, the PMP for the 6-hour, 12-hour, 24-hour and 48-hour storms are 26.7, 28.8, 31.8, and 33.9 inches, respectively.

The following tabulation provides a further breakdown of the 6-hour PMP made according to procedures outlined by the U.S. Bureau of Reclamation (Reference 5) and U.S. Army Corps of Engineers (Reference 6):

	Hour					
	1	2	3	4	5	6
a. U.S. Bureau of Reclamation Procedure (Reference 5)						
Cumulative Percentage of 6-hr rain	49	64	75	84	92	100
Cumulative Rainfall, in.	13.1	17.1	20.0	22.4	24.6	26.7
Incremental Rainfall, in.	13.1	4.0	2.9	2.4	2.2	2.1

b. U.S. Army Corps of Engineers Procedure (Reference 6)

Cumulative Percentage of 6-hr rain	10	22	37	75	89	100
Cumulative Rainfall, in.	2.7	5.9	9.8	20.0	23.8	26.7
Incremental Rainfall, in.	2.7	3.2	3.9	10.2	3.8	2.9

Comparison of the cumulative rainfall values and peak incremental rainfall for the two methods shows that the U.S. Bureau of Reclamation Procedure (item a) to be more conservative for every hour. It was, therefore, used as a basis for the flood calculations.

2.4.3.2 Precipitation Losses

To increase the conservatism of the results, 100 percent antecedent saturation of the basins and no losses were assumed.

2.4.3.3 Runoff and Stream Course Models

Runoff was determined according to curve No. 100 of Figure A-4, Page 542 of (Reference 5). However, for conservatism the PMP was assumed to fall on fully saturated terrain, with 100 percent runoff.

2.4.3.4 Probable Maximum Flood Flow

The probable maximum flood flow hydrograph for the major and minor streams at their outfalls into Lake Erie are presented in <Figure 2.4-4> and <Figure 2.4-5>, respectively. These hydrographs correspond to the incidence of the PMP. Other factors such as surges or upstream dam

failures will not affect the PMF. The PMF's for both streams were calculated with the rain data given in <Section 2.4.3.1> and the procedures outlined in Pages 73 through 82 of (Reference 5).

2.4.3.5 Water Level Determinations

<Figure 2.4-6> and <Figure 2.4-8> show the bed elevation and PMF surface profiles for the major and minor streams, respectively. Surface profiles were determined according to the standard step method utilizing Manning's formula. The Manning coefficient of friction was assumed to be equal to 0.100 for the portions of the existing stream bed and overbanks, and equal to 0.024 for the trapezoidal sections used in the relocated stream bed. At each stream station a cross section was drawn and the area of flow and hydraulic radius were calculated for a range of elevations. The stations and corresponding cross sections are shown on <Figure 2.4-7>, <Figure 2.4-8>, <Figure 2.4-9>, <Figure 2.4-10>, and <Figure 2.4-11>. Commencing at the first station upstream of the lake, trial and error procedures were followed until the hydraulic gradient required to produce the PMF flow was obtained. The elevation determined from the hydraulic gradient described above became the first point of the profile and the whole procedure was then repeated for the next upstream station. Successive repetitions were made until the PMF profile could be drawn <Figure 2.4-6> and <Figure 2.4-8>.

The water surface profiles during the PMF were calculated under the assumption that the plant access road and the sediment control dams placed across the streams remained intact during the event. Furthermore, a discharge coefficient of 3.00 was used for calculating the depth of the PMF passing over the broad crested weirs formed either by the access road or the sedimentation dam crests.

Trial and error procedures were again employed for the weir and culvert flow computations. The water surface elevation upstream of the plant access road for the PMF was found to be 624.0 feet until this surface

met the normal depth of flow in the existing stream. The existing natural ridge along the right bank of the stream is at a maximum elevation of 630’-0” (approximate). This water surface elevation will safely pass beneath the railroad bridge. As no recorded data exists, no correlation is possible between the results obtained and floods on record. For added conservatism, the flow for each reach of both streams was considered to be equal to the corresponding PMF flow at the outfall to Lake Erie.

2.4.3.6 Coincident Wind Wave Activity

Wind wave activity is of no concern with the flood conditions in these small streams as previously discussed.

2.4.4 POTENTIAL DAM FAILURES, SEISMICALLY INDUCED

Presently there are no impoundments upstream of the plant, and since the drainage basins of the two streams passing through the site are small and the terrain is quite flat, it is unlikely there will be any impoundments in the future. Therefore, dam failure is not included as a design condition.

2.4.4.1 Dam Failure Permutations

This section is not applicable to PNPP.

2.4.4.2 Unsteady Flow Analysis of Potential Dam Failures

This section is not applicable to PNPP.

2.4.4.3 Water Level at Plant Site

This section is not applicable to PNPP.

2.4.5 PROBABLE MAXIMUM SURGE FLOODING

2.4.5.1 Probable Maximum Winds and Associated Meteorological Parameters

2.4.5.1.1 Introduction

This section describes the cyclonic type wind storm (Probable Maximum Storm - PMS) that might result from the most extreme pressure gradients that are reasonably possible in the Lake Erie area and which would produce a maximum increase in the lake level (setup) at Perry, Ohio. The approach used was to impose the extreme high and low pressure values (based on meteorological records of the United States) on the high and low pressure centers of a specific meteorological synoptic situation. This specific meteorological situation is such that it would produce maximum probable wind speeds of sufficient duration in a direction normal to the lake shore at Perry, Ohio, to attain maximum lake setup. Winds associated with thunderstorms, tornados, water spouts, and other short duration phenomenon are of little significance in generating lake setups since they do not persist for periods long enough to induce setup.

2.4.5.1.2 Meteorological Synoptic System for Lake Level Setup

Lake level setup is the increase of the lake level caused by the wind moving the surface waters of the lake from one position to another with sufficient speed so that the surface of the lake becomes tilted. Since a body of water tends to remain level, this wind must be of sufficient speed and duration to maintain a steady-state of the lake surface tilt (Reference 7) (Reference 8).

The magnitude of the wind induced surges depends primarily on the wind speed, the distance over the water the wind blows (fetch), and the depth of the lake (Reference 9). For the Perry area, a meteorological

synoptic situation with winds from the NNW, a minimum velocity equal to or greater than the drag coefficient critical velocity (14 knots) (Reference 10), and a duration of at least 10 hours (Reference 11) is needed to generate a setup. A number of meteorological synoptic situations were examined to determine the type of situation that could produce these required conditions. <Figure 2.4-12> is an example of the type of meteorological synoptic situation that meets these requirements.

2.4.5.1.3 Procedure to Develop the Probable Maximum Storm for Lake Level Setup

To develop a meteorological situation that has virtually no chance of being exceeded, the high pressure center was assigned the value of the highest pressure recorded in the United States (1,063.3 millibars (mb) - 31.40 inches Hg, occurring on January 9, 1962 at Helena, Montana) (Reference 12) and the low pressure center was assigned the lowest (non-hurricane) pressure recorded in the United States (954.96 mb - 28.20 inches Hg, occurring during 1913 at Canton, N.Y.) (Reference 12). The use of these extreme values develops an extremely strong pressure gradient (which determines the wind speed) between the pressure centers. This pressure gradient exceeds any observed pressure gradient, excluding hurricanes over the ocean. The postulated, sustained wind speeds for this system have virtually no chance of being exceeded.

The basis for the separation of the pressure centers shown on <Figure 2.4-13> is the result of a procedure to produce strong winds for at least 36 hours. Stronger winds for a shorter period of time could be generated by placing the centers closer together, or weaker winds for a longer period of time could be generated by placing the centers further apart. The presented separation is a trade-off to obtain strong winds for at least 36 hours.

To synthesize the sequence of the movement and the life cycle of the PMS, a series of meteorological charts was developed. The PMS was

assumed to occur over a 72-hour period, during which the winds increased from 20 mph to the maximum speed of approximately 103 mph over the lake and then decreased to less than 35 mph in the Perry area.

The first chart was based on an assumed 1,033-mb high pressure center located approximately at the first 12 hour center position of the high as shown on <Figure 2.4-12>. The low pressure center was assumed to have a pressure of 985 mb and was located approximately at the first 12-hour center position of the low as shown on the same figure. Subsequent approximate 12-hour positions of the high and low centers are also indicated. The high and low pressure centers intensified at the rate of 10 mb per 12 hours, attaining the values of the PMS at 36 hours after the initial chart. The centers then moved northeastward and decreased in intensity at the rate of 10 mb per 12 hours.

2.4.5.1.4 Procedures Used to Generate the Individual Meteorological Charts

The separation and position of the pressure centers were determined to generate strong winds perpendicular to the shoreline in the area of interest. Meteorological theory (Reference 13) (Reference 14) (Reference 15) (Reference 16) (Reference 17) indicates that if the pressure centers were closer together the storm would have stronger winds, but would either move eastward much faster or fill and dissipate. In either case the stronger winds would last a shorter period of time. Conversely, if the pressure centers were further apart, the generated winds would be weaker and the storm would either move slower or intensify. In either case, the storm would last for a longer period of time. The postulated separation is a compromise to obtain the stronger wind speeds for at least 36 hours. The location and direction of movement of the pressure centers were determined to generate winds approximately perpendicular to the shoreline in the Perry area and to maintain the maximum possible lake setup effect during the period of the PMS.

An isobaric pattern (lines of equal pressure) was drawn for consecutive 12 hour time periods using standard synoptic meteorological models (Reference 13) (Reference 14). Wind speeds for specific points within each system were calculated using the following equations (Reference 14) (Reference 15):

a. Cyclonic

$$u = R\,\omega \sin\Phi \left(-1 + \sqrt{1 + \frac{4\left(\frac{\Delta P}{2\,p\,H\omega \sin\Phi}\right)}{2\,R\,\omega \sin\Phi}} \right)$$

b. Anticyclonic

$$u = R\,\omega \sin\Phi \left(+1 - \sqrt{1 + \frac{4\left(\frac{\Delta P}{2\,p\,H\omega \sin\Phi}\right)}{2\,R\,\omega \sin\Phi}} \right)$$

where:

u	=	gradient wind, meters per second
R	=	radius of curvature of the airflow, meters (positive if cyclonic, negative if anticyclonic)
ΔP	=	the pressure difference between two points, centibars
H	=	the distance between two points, meters (same points used to determine ΔP)
p	=	density of air, 1.11×10^{-3}, metric tons per cubic meter
ω	=	angular velocity of the earth, 7.292×10^{-5}, per sec.
Φ	=	latitude angle where P and H are measured, degrees

The gradient wind in meters per second for each specific point was then converted into miles per hour using the following relationship:

$$U_{(mph)} = 2.2364\,u\,(mps)$$

These calculated winds were then plotted on a chart (for each 12-hour period) and an isotach pattern (lines of equal wind speed) was drawn for the gradient wind field.

To account for the surface frictional forces, Petterssen (Reference 18) suggests a ratio of the surface speed to the gradient speed of 2:3 for strong winds over the open sea. Shaw (Reference 19) indicates that the surface wind in the NW quadrant would be 0.6 to 0.72 of the gradient wind over the ocean. Graham and Hudson (Reference 20) indicate that surface winds in hurricanes would be 0.6 to 0.7 of the gradient wind at distances of more than 50 to 60 miles from the storm center. For conservatism, the surface wind of the PMS was reduced to 0.75 of the gradient wind to account for surface friction over water. The resultant isotach patterns are presented in <Figure 2.4-14>, <Figure 2.4-15>, <Figure 2.4-16>, <Figure 2.4-17>, <Figure 2.4-18>, <Figure 2.4-19>, <Figure 2.4-20>, <Figure 2.4-21>, <Figure 2.4-22>, <Figure 2.4-23>, <Figure 2.4-24>, and <Figure 2.4-25>. The intermediate 6-hour isotach patterns (6 hr/18 hr) are the result of graphical interpolation of the 12-hour and 24-hour patterns. Directions, wind speeds and pressures of PMS for various grid points are also tabulated in <Table 2.4-1>. <Figure 2.4-13> is a chart covering a much larger area depicting the synoptic meteorological pattern with the isotachs superimposed. This chart represents the time of maximum wind speeds of the synoptic series.

2.4.5.1.5 Supporting Data for Uniqueness of the PMS

This section presents the information to support the calculated maximum wind speed associated with the PMS.

A probable maximum hurricane, as defined in HUR 7-97 (Reference 21), at the latitude of Lake Erie would produce a maximum wind calculated in the following manner:

Using equation (3) from Page 8 of (Reference 21):

$$V_x = 0.865\, V_{gx} + 0.5T \qquad (2.4\text{-}1)$$

where:

V_x = Maximum wind speed, mph

V_{gx} = Gradient wind speed, mph

T = Forward speed of the storm, mph.

To obtain winds from the NNE through WNW (which are required for lake setup) at a point on the south shore of Lake Erie, the hurricane center would be to the east of the point. For a storm moving north, maximum winds would be east of the storm center, and therefore on the opposite side of the center from the point of interest. The +0.5T in Equation 2.4-1 would then become -0.5T for winds to the west of the storm. To ensure conservatism, T was assumed to be 0, and Equation 2.4-1 becomes:

$$V_x = .865\, V_{gx} \qquad (2.4\text{-}2)$$

Using the V_{gx} value for 42° latitude from Table 1 of (Reference 21), Equation 2.4-2 results in the following wind speed:

$$V_x = .865\,(118) = 102 \text{ mph}$$

This wind speed value is for a hurricane at 42° latitude based on a 1,000-year return period (Reference 21).

By comparison, <Figure 2.4-21> shows an area of winds exceeding 100 mph centered over the northern shore opposite the site area. The tabular data for station 6 (Reference 40) (Reference 21) shows a wind speed of 102 mph on the second day, 24th hour.

Tannehill (Reference 11) and HUR 7-97 (Reference 21) have shown that hurricanes do not penetrate the area while maintaining their strong winds, so that the wind speed calculated for the maximum hurricane would not occur in the site area. Therefore, the winds postulated for the PMS are conservative estimates of the highest sustained wind speeds with virtually no chance of being exceeded in the site area.

2.4.5.2 Surge and Seiche Water Levels

2.4.5.2.1 Surge Sources

The predominant cause of surges at the Perry site is the frontal or cyclonic type wind. As discussed in <Section 2.4.5.1>, hurricanes do not cause significant surges but do possess the capability of raising the lake level by the amount of rainfall within the lake drainage basin.

The PMS discussed in <Section 2.4.5.1> would be the cyclonic type storm which would produce the maximum surge (setup) at the site. The method used to compute the maximum setup and setdown at the site was the one dimensional numerical prediction model described by the U.S. Corps of Engineers in Technical Report No. 4 (Reference 22).

2.4.5.2.2 Brief Description of Numerical Method of Setup Prediction

The wind setup computation was based on a one-dimensional, steady-state approximation of the dynamic response of the lake surface as fully described in (Reference 22). In summary, the method relies on an expression for the slope of the water surface derived by vertically integrating the horizontal momentum equation relative to a fetch axis

aligned with the mean wind direction. The expression for the slope may, in turn, be numerically integrated to yield the setup or setdown at any desired point along the fetch. Computation is initiated at an estimated nodal point where the setup is assumed to be zero and proceeds by increments toward either endpoint at the shoreline. The resulting surface profile should be regarded as a first approximation which may then be refined with an iterative procedure based on the assumption of constant volume. Comparison of the lake volume computed from the inclined profile with that corresponding to the undisturbed surface, yields a correction for the assumed location of the nodal point.

The setup is then re-computed along the fetch in a series of successive approximations until a satisfactory volume balance is achieved.

The relationship used for the numerical integration was taken directly from (Reference 22):

$$\Delta S_i = d_T \left[\sqrt{\frac{2NK\left(UU_x\right)_i \Delta X_i}{gd^2T} + 1} \quad -1 \right]$$

$$d_T = d_i + \sum_{i=1}^{M-1} \Delta Si$$

$$S = \sum_{i=1}^{M} \Delta S_i$$

where:

ΔS_i = Incremental rise or fall in surface elevation over corresponding increment ΔX_i

d_i = Depth in section i, exclusive of setup

d_T = Total water depth excluding ΔS_i for the section under consideration but including the Δs_i's from all preceding sections

S = Total setup (or setdown)

N = Planform factor

U_x = Wind speed component along fetch axis

K = Wind stress constant, equal to 3.3×10^{-6} (Reference 22)

The computation is indexed with reference to an initial section at the nodal point and proceeds over M sections to yield the total setup or setdown depending upon the sign of ΔXi (distance X along the fetch axis is defined as positive in the direction of the prevailing wind). The value of N, the planform factor, is taken as unity with the provision that the length of each fetch increment ΔX_i is small in comparison with the total fetch length. Depths along the fetch were obtained from Great Lakes Chart No. 3 (1971).

The wind data furnished for the computation represented the wind speed and direction for ten stations on the periphery of the lake <Figure 2.4-26> at 6-hour intervals over the entire 3-day storm period. The wind values along the fetch axis for each time increment were determined by means of a linear spatial interpolation.

As emphasized in the discussion given in (Reference 22), it is important to investigate alternative orientations of the fetch axis to arrive at a maximized setup estimate. This was accomplished by varying the direction of the axis slightly from that of the mean wind until a well defined maximum of 4.30 feet was established. The results of this procedure are shown in <Figure 2.4-27>. This value occurs at about 2400 hours on the second day of the storm when maximum winds at the

center of the lake reach 102 mph. The temporal variation in setup height over the remaining storm period is plotted in the hydrograph shown in <Figure 2.4-28>. The spatial profile of the lake surface at maximum deflection is plotted in <Figure 2.4-29>.

It should be noted that these values do not reflect corrections for pressure differences or precipitation. With an antecedent water level of 575.4 feet (USGS), a precipitation value of 0.5 feet, a pressure correction of 0.3 feet, and a wind setup of 4.30 feet, the total maximum stillwater surface level at the plant site was computed to be 580.5 feet (USGS).

Wind velocities for the PMS were generated at three hour intervals for ten stations around the periphery of Lake Erie using the techniques discussed in <Section 2.4.5.1>. <Figure 2.4-26> shows the locations of the ten stations. <Figure 2.4-30> and <Figure 2.4-31> show variations of wind speed and direction for the two stations (20,1) and (40,1) adjacent to the site and the two stations (20,21) and (40,21) north of the site, respectively. <Table 2.4-1> indicates the site setup winds at these stations.

The wind speed for the stations adjacent to the site averages above 70 mph for a period of 18 hours. During the same period the wind speeds for the stations across the lake from the site average 80 mph or above with a maximum of 110 mph being reached at the center of the lake.

2.4.5.3 Wave Action

The wind field used to determine the probable maximum setup was also used to find the concurrent wave action. As discussed in <Section 2.4.5.1>, this wind field was defined at ten stations located around the lake to give complete meteorological coverage of Lake Erie. A study of the critical fetch direction showed that the fetch lengths were approximately the same for winds directed toward the site from

N 70°W to N 25°E. During the PMS, the winds in the central portion of the lake are from the NNW and, therefore, the wind speeds at the station nearest the site and at the station directly north across the lake were used to calculate the wave action.

The average wind speed at these two stations taken at the peak of the storm is 80 mph with a duration of 12 hours. Due to the limited depth of the lake across the 50-mile fetch (average depth of 70 feet), the waves generated by the PMS will be limited in height and period by bottom effects. Deep water waves cannot occur for these high wind speeds. The waves generated by the PMS were determined by the method of forecasting shallow water waves as given in (Reference 22). This gives a significant wave height, H_s (the average height of the highest one third of the waves), of 17 feet with a period of seven seconds, and the "maximum" wave height, H_{max}, of 1.77 H_s, (30 feet).

The design of the cooling water intake and discharge structures is shown on <Figure 3.8-67>. <Section 3.4.2> and <Section 3.8.4> discuss dynamic forces on the structures due to wave action.

2.4.5.4 Resonance

The amplitude of oscillations within the emergency service water pump house caused by wave action in Lake Erie was analyzed by the GAI hydraulic transients computer program WHAM24. This program used the 17-foot waves that accompanied the probable maximum setup and a wave period of seven seconds.

WHAM24 determines transient pressures and velocity in series or branched conduit systems with a water body at one end, and a pump chamber(s) and piping system(s) at the other end(s). The program uses the method of characteristics for the transient conditions within the conduit and applies appropriate boundary conditions at the ends of the system. The

application of the method of characteristics in hydraulic transients has been verified many times with experimental and field data (Reference 23).

The program's boundary condition at the lake end of the system consists of representing the oscillation of the lake surface as a sine wave with the amplitude and period representing the height and period of the waves, respectively. The boundary condition at the plant ends of the conduit combines the continuity equation for the pump chambers, the head-flow (H-Q) curves for the pumps, and lumped representations (system head loss equals $K_{sys}Q^2$) of the onshore circulating water system and emergency service water system. The boundary conditions and the characteristics equations are solved at each time step.

The main intake system consists of submerged offshore intake structures with a 2,857 foot length of 10-foot diameter tunnel leading to a branch. From the branch the 10-foot tunnel continues 100 feet to the service water pumphouse, and a 10-foot tunnel goes 246 feet to the emergency service water pumphouse. With the lake condition acting as the forcing function, the maximum oscillation of the water surface within the emergency service water pumphouse was 0.94 feet. The alternate intake system consists of 2,029 feet of 10-foot diameter discharge tunnel to a branch plus 142-foot length of 10-foot tunnel from the branch to the emergency service water pumphouse. The other arm of the branch consists of 100 feet of 10-foot tunnel to the discharge tunnel entrance structure. The maximum water level variation in the emergency service water pump chamber with the alternate system was 1.19 feet.

The small response of the chamber water level to the lake boundary condition is due primarily to the magnitude of the incremental volume of the pump chamber relative to the change in chamber inflow caused by the waves. The continuation of the 10-foot tunnel at the branch of both systems also dampens the oscillation.

The setup of the lake level causes the pumps to operate at a higher than normal flow rate since the static head is reduced. With these wave induced variations in the pump chamber water level, no problem exists in meeting the flow requirement described in <Section 9.2.1>.

2.4.5.5 Protective Structures

2.4.5.5.1 Shoreline Recession

2.4.5.5.1.1 Summary

Since plant grade is approximately 45 feet above the normal lake level and there are no safety-related structures within 380 feet of the lake shoreline (toe of bluff), damage to the shoreline bluff by an individual storm would not affect the operation or the safety of the PNPP. Data presented herein shows that the range of bluff recession in the vicinity of the emergency service water pumphouse has been less than 2 feet per year since 1937.

Erosion of the shoreline bluff is caused by groundwater seepage and direct runoff on the upper portions of the bluff, and by wave attack and runup at the lower portions. To monitor the combined effect of shoreline recession and bluff erosion, a semiannual (Spring and Fall) survey is being made at six profile locations established at regular intervals along the shoreline. This survey will continue on a semiannual basis from 1984 through 1989, at which time it will be continued on an annual basis (spring) for the life of the plant. <Figure 2.4-32> shows the exact locations of the survey lines. The sections that follow describe the bluff recession process.

2.4.5.5.1.2 Introduction

This section presents the findings of shoreline erosion studies and investigations for a 6,000 foot reach of the Lake Erie shoreline north

of the site. The shoreline investigated lies between Perry Township Park and North Perry Park, Lake County, Ohio, and forms most of the north boundary of the site. The purpose of the erosion study was to investigate historical shoreline recession to develop a more reliable estimate of the expected future rate of recession, and to evaluate the effects of such erosion on PNPP. Previous investigations of the shoreline recession done by others revealed variable rates of landward movement over relatively short segments of the shore. Therefore, a detailed study was undertaken to find more definitive recession data for the north site boundary and is discussed herein.

The assessment of the effects and magnitude of bluff and shoreline recession included the following:

a. The review and collection of prior reports, topographic and lake bottom maps, lake level records, contacts with state, county and township officials.

b. A field examination of the shoreline to evaluate contributing factors to bluff erosion.

c. An aerial photograph comparison and plotting of top of bluff recession lines for the years 1937, 1957, 1964, 1972, and 1975.

d. A search of "old" property deeds of land parcels located along the shoreline of the site boundary. A plot of property surveys defining the shoreline for the years 1798, 1852, 1858, 1867, and 1917.

e. A plot of the 1876 Lake Erie lake survey top of bluff line on the 1972 topographic base map of the site.

f. The establishment of an erosion base line (1972) paralleling the top of the bluff from which 12 bluff profiles for monitoring bluff recession have been and are obtained twice yearly.

Previous comprehensive reports related to shoreline erosion in the vicinity of the site are few in number. Most past investigations deal more with the causes of beach and shoreline erosion and the methods of protection than with the details of specific shoreline erosion rates. The Corps of Engineers prepared a comprehensive report (Reference 24) in 1953 covering shoreline recession. The Corps of Engineers study indicates shoreline movements between 1876 and 1948 of approximately 35 feet (0.5 ft/yr) in the vicinity of the site, and at Perry Township Park (a little more than a mile west of the site) a shoreline erosion rate of 4 ft/yr is reported.

The Ohio Division of Geological Survey, Department of Natural Resources has published a number of short reports related to shore erosion. One of these reports (Reference 25), in 1961, reported a recession rate of 5 to 15 ft/yr at Perry Township Park. Another report on shoreline erosion was made by Stanley Consultants (Reference 26) in 1969. The Stanley report investigates a four mile reach of Lake Erie shoreline west of the Chagrin River approximately 14 miles from the site. The findings of this report are not applicable to the shoreline at the site except in a general way. The shoreline covered by the Stanley report is highly developed with many projecting structures such as breakwaters, jetties, intakes, and groins which affect the erosion processes. These features are not present along the shoreline at the site. From the description given, the composition of the bluff discussed in the Stanley report may be less resistant to wave attack than the bluff at the Perry site.

A more recent report by Charles H. Carter (Reference 27) in 1976 investigates the 30 mile long Lake County shore along Lake Erie. It indicates very slow top of bluff recession rates of less than 1 foot per year at the site, based on both field measurements of the 1948 to 1970

period and map measurements of the 1937 to 1973 period. In addition, aerial photograph comparisons in the report for the periods 1876 to 1937 and 1937 to 1973 have also indicated very slow top of bluff recession rates of less than 1 foot per year at the site. The report forecasts no change in the top of bluff at a location north of the emergency service water pumphouse between the period 1973 and 2010.

2.4.5.5.1.3 Geology and Bluff Characteristics

The shoreline of Lake Erie in Lake County is formed by eroding steep bluffs and discontinuous narrow beaches. No bedrock is exposed in the bluff or along the shore. Bluff materials overlying shale bedrock are comprised of glacial till which in turn are covered by lacustrine (lake) deposits. The geologic characteristics of the surface materials are the result of glacial action during the Pleistocene age.

For the 6,000 feet of shoreline along the northern boundary of the site, the bluffs are approximately 45 feet high. One beach exists, approximately 900 feet long and 50 to 75 feet wide, northwest of the site. At other points along the shore, narrow beaches 5 to 25 feet wide emerge at the base of the bluffs during calm lake conditions. The bluff consists of 5 to 15 feet of dense, glacial till at their base and are overlain by lacustrine silt and clay deposits. The till is approximately 75 percent silt and clay, 15 to 20 percent sand and the remainder is rock fragments. A stratum of silty fine sand from about 4 to 7 feet in thickness prevails along the top of the bluffs. Materials exposed in the bluff are of similar geologic cross-section as those encountered at the plant site proper. Data from borings <Section 2.5.1> drilled on the beach northwest of the plant indicate the beach sands overlying till are about 5 feet in thickness. Chagrin shale bedrock is approximately 20 feet below the surface of the beach.

Lake bottom probes taken offshore appear to indicate that a thin veneer of till and shale rock fragments mantles the shale bedrock, perhaps

locally as much as 1,500 feet offshore. The lake bottom north of the site boundary is irregular but generally slopes at about 2.5 feet per 100 feet for the first 300 feet offshore, decreasing to about 5 feet in 1,000 feet for the next 4,000 feet or more.

2.4.5.5.1.4 Nature of Bluff Erosion

The principal factors affecting shoreline recession are variations in Lake Erie levels, wind (storm waves), water seepage and frost action. The composition and degree of compaction of the bluff materials are limiting factors in the rate of recession. Widespread slumping of the upper half of the bluff is the most prevalent bluff feature in the vicinity of the site. Slumping within the lacustrine and upper till deposits is caused mainly by groundwater seepage forces and frost action. Undercutting and removal of slump material by wave action complete the cycle of bluff recession.

2.4.5.5.1.5 Wind, Littoral Drift and Beaches

Local storms are the main cause of significant wave action. The shoreline at the site is subjected to waves from the southwest through the north to the northwest. Winds from the southwesterly direction set up the prevailing littoral current from the west to the east.

Generally, the west to east direction of littoral drift results in accretion of sand at the west side and the depletion of material to the east side of structures projecting from the shore. There are, however, no projecting permanent structures along the shoreline boundary of the site. The nearest such structure is located near the northwest corner of the site boundary on the Neff Perkins property. This structure, a sheet piled water conveyance channel, projects into Lake Erie about 135 feet. With the exception of the small beach northwest of the site, beaches along the shore in the study area are narrow, short in length and frequently transitory or submerged.

2.4.5.5.1.6 Lake Levels

Shoreline erosion is noticeably influenced by lake levels and the related storm waves. High levels allow the waves to directly contact the toe of bluff while waves from low lake levels are dissipated by wider beaches. Lake levels vary with climatic conditions which affect evaporation and inflows. Minimum lake levels usually occur in February and maximum levels occur in mid-summer. The maximum seasonal fluctuation is nearly three feet, but long term cycles of fluctuation, resulting from wet and dry periods are as much as eight feet. Predictions of future lake levels are difficult to make. However, future long term cycles of fluctuation are not expected to differ significantly from those presented in <Figure 2.4-33>.

<Figure 2.4-34> presents monthly recorded mean lake levels, from 1904 to 1979, which show short and long term trends. Long term annual fluctuations are shown in <Figure 2.4-33>. The 1973 mean level of Lake Erie was about four feet above the Lake Erie Low Water Datum (LWD) established at 570.5 feet (USGS) above mean tide at New York City; that mean level was at the peak of a high lake level cycle. Reducing lake levels to a common datum for the various years studied was not possible because dates (day and month) were not always given on the property survey information.

2.4.5.5.1.7 Effects of Ice

Almost every year, ice forms along the shore of Lake Erie. In winters with sustained periods of sub-zero temperatures, the entire lake freezes over; during the winter months, wave action upon the beach and the shoreline bluff is minimal or non-existent due to the buildup of ice along the shoreline. However, freezing and thawing of the groundwater seepage produces a detrimental effect on the bluff face that contributes to the rate of bluff erosion.

2.4.5.5.1.8 Shoreline Changes

To predict probable future bluff and shoreline changes, local historical data pertaining to shoreline and bluff erosion was researched and developed. Previous shoreline surveys to include the site boundary on Lake Erie were made by the U.S. Lake Survey (Corps of Engineers) in 1876 and 1948. These surveys formed the bases of the shoreline recession reported by the 1953 Corps of Engineers report (Reference 24). That study gave a shoreline change of 35 feet in the site vicinity for the 72 year period (approximately 1/2 ft/yr). The Ohio Division of Geological Survey, Department of Natural Resources has also conducted shoreline erosion studies in the past and has published a bluff erosion report for Lake County, Ohio (Reference 27). The results of the Lake County bluff erosion report indicate recession rates of less than 1 foot per year at the site between 1876 and 1973.

Previous shoreline erosion studies, which included the site boundary, were based on long time intervals and widely spaced shoreline profiles; therefore, the need for more detailed studies of bluff recession became apparent. A comparison was made of five sets of aerial photographs taken of the site over the period from 1937 to 1975. Landward movements of the site top of bluff line were determined by comparing relative bluff locations for the years 1937, 1957, 1964, 1972, and 1975. For these years, the top of bluff lines shown on <Figure 2.4-35> for approximately 6,000 feet of shoreline were superimposed on a topographic base map (original scale of 1” = 200’) produced from the 1972 aerial photographs.

The following bluff recession summary includes all available information up to 1972 when the semiannual onsite field survey of bluff recession was initiated. Recent onsite bluff erosion survey data and its evaluation is discussed in <Section 2.4.5.5.1.9>.

The total top of bluff change indicated by <Figure 2.4-35> for a 2,000 foot central reach of shoreline northwest of the plant ranges from 20 to 85 feet (<1 to 2 ft/yr) from 1937 to 1972 (35 years). For the same period, total top of bluff recession of reaches to the west and east of the central section ranged from 1 to 3 ft/yr and 4 to 5 ft/yr, respectively. Fluctuations of Lake Erie <Figure 2.4-34> indicate long term mean lake levels from 1934 were on an up cycle, peaking in 1952 and again in 1973. A correlation of larger changes in bluff erosion during periods of high lake levels could not be evaluated with certainty due to lack of data, but high lake levels undoubtedly have a significant effect. <Table 2.4-2> shows annual recession rates relative to 1972 for each of the twelve erosion monitoring lines <Figure 2.4-32> and is summarized below:

Range (Ft/Yr) of Top of Bluff Recession Relative to 1972

Section	1937	1957	1964
West (J-I-H-G)	1-3	2-6	3-7
Central (F-L-K-A-B)	<1-2	1-5	1-7
East (C-D-E)	4-5	5	4-5

It should be remembered that the bluff erosion is a two-step process. One step is wave action on the lower till which forms the toe of the bluff. As previously discussed, the location of the toe of bluff is the factor that will determine the need for bluff protection. The other step is the random occurrence of localized slumping induced by groundwater seepage and frost action. Although a single slump (at Profile Line C between 10/72 and 4/73) indicated a significant change of 33 feet in the top of bluff location, future movement at the slumped location most likely will not occur again until the toe of bluff has receded to a point where most of the slumped material has been removed. The more recent comparisons (1957 and 1964) show the effects of the random slumping process on the relative top of bluff recession rates.

Therefore, it is felt that the 1937 erosion comparison is the most representative of the actual movement of the toe of bluff.

In 1876, the U.S. Lake Survey (Corps of Engineers) published a chart (1:10,000 scale) of the south Lake Erie shoreline. Copies of the charts, Field Sheets 1-687 and 1-686, covering the site boundary were obtained. The top of bluff and shoreline, shown on <Figure 2.4-36> and <Figure 2.4-37>, respectively, were scaled from the 1876 charts and replotted on a 1972 topographic base map. Rates of erosion vary from 1 ft/yr for the central portion northwest of the site to 2 and 3 ft/yr west and east of the central reach, respectively. Comparisons between the 1876 and 1972 survey are subject to some doubt owing to uncertainties of the 1876 survey. As the 1953 Corps of Engineers report (Reference 24) indicates, uncertainties such as lake stage correction, lack of sufficient common control points and insufficient onshore data reduce the confidence in accuracy of the 1876 data.

A second source of shoreline recession data was developed by a research of records at the Lake County, Ohio courthouse and the Land Title Company, Painesville, Ohio. Copies (duplicates of county records) of "old" property deeds and survey descriptions of land parcels along the shoreline north of the site were obtained from the Land Title Company.

Locations of the shoreline described by the property deeds (Reference 28) were plotted for the years 1798, 1829-30, 1852-1858, 1865-1867, 1876, 1917, and 1975. The series of plots was connected by continuous lines shown in <Figure 2.4-37>, which represent corresponding approximate shorelines. Most of the deed descriptions of the north property boundary indicated the shoreline but did not mention the top of bluff, except in a few instances. The exact date (day of the month) was not given in most cases, therefore it was not practical to relate plotted shorelines to lake levels or to a common datum. Consequently, the location of the bluff for the years studied relative to the shoreline could not be determined with any degree of certainty. The toe

of bluff was conservatively assumed to be at or near the shoreline for the various years investigated. This assumption should provide the maximum long term shoreline change relative to 1972. Shoreline changes relative to 1972 based on "old" property deed descriptions are shown on <Figure 2.4-37> and presented in <Table 2.4-2>. An average change since 1798 for the central 2,000-foot sector is approximately 1 ft/yr for the 174 year period. During the 1917 to 1972 period, a rate of 1 to 2 feet per year was determined.

It appears the landward recession of the shoreline has been accompanied by a corresponding recession of the bluff. A petition from the owners of property in Perry Township, dated 1839, requested that the existing Lockwood Road paralleling the shore north of the site replace an earlier road along the shore that was lost due to erosion. At Perry Township Park, a little over a mile west of the site (not shown on erosion maps), shoreline recession based on plots from deed descriptions from 1903 to 1952 was approximately 3 ft/yr. Between 1952 and 1972, the landward movement was approximately 4 ft/yr. This compares favorably with that of the Corps of Engineers (1953) report (Reference 24) for Perry Township Park between 1876 and 1948 which set the rate at 4 ft/yr.

2.4.5.5.1.9 Recent Onsite Bluff Erosion Surveys

The Seismic Category I emergency service water pumphouse is approximately 305 feet from the 1978 top of bluff and 380 feet from the 1978 Lake Erie shoreline. A base line about 5,230 feet in length with permanent ground markers was laid out in the field for the purpose of monitoring future bluff erosion. From the base line, twelve parallel transect lines <Figure 2.4-32>, spaced approximately 300 to 600 feet apart, extend northward to the Lake Erie shoreline. Initially (10/72 to 9/73), elevations and measurements to the top of bluff were taken along each line, but this procedure was altered in November 1973 to that of taking complete ground surface profiles from the base line to the shoreline. Profile surveys for monitoring bluff erosion are conducted

in the spring and fall of each year. The first complete profiles were taken in November, 1973, and are presented in <Figure 2.4-38>. Readings of the net changes in the bluff, at two year intervals, taken to date are also shown in <Figure 2.4-38>.

<Table 2.4-2> summarizes the recession rates for the profiles shown in <Figure 2.4-38> using profile information through September, 1978. In general, between 1972 and 1978, the top of bluff erosion rate varied (from <1 to 2 ft/yr) within the central shoreline reach. The eastern end of the central reach receded at about 7 ft/yr during this relatively short (six-year) period. This same area receded only 2 ft/yr between 1876 and 1978. The eastern and western tops of bluff receded from 2 to 6 ft/yr and 5 to 9 ft/yr, respectively, between 1972 and 1978. Again, the long term (1876 to 1978) top of bluff recession rates were 2 to 3 ft/yr and 1 to 4 ft/yr for the eastern and western reaches, respectively. In addition, the 1975 aerial survey was examined to assure that excessive erosion of the bluff did not take place between the ground survey profile lines.

<Table 2.4-2> shows that the shorter the time interval investigated, the greater is the recession rate for that time interval. This is due to significant, localized slumps being averaged over a relatively short time period. However, these short term, localized slumps are part of the overall recession cycle; in addition, they are attributable to the sustained high lake levels which peaked in 1975 and, therefore, allowed wave attack to undermine the toe of bluff during the high lake level period. The entire recession process is time and water level dependent; i.e., it occurs in a stop-start sequence, and should be averaged over a long period of time to obtain meaningful results.

2.4.5.5.1.10 Man Made Effects of Erosion

With the exception of the potential future bluff protection described later in this section, no permanent structures exist on the bluff.

Grading and clearing of the site were performed in such a manner that surface runoff was controlled and erosion minimized. The closest building structure (service water pumphouse) to the bluff is approximately 280 feet away. This structure is founded on shale rock well below the overlying glacial deposits. Controlled blasting (instrumentally monitored) was conducted during construction of PNPP. An interim revetment, described in <Section 2.4.5.5.9>, has been built along the shoreline from the Minor Stream discharge to the Northwest Storm Impoundment Spillway.

Changes in littoral drift accretion and depletion along the shoreline forming the north site boundary is not expected to change greatly as a result of possible future industrial development to the east and west of the site boundary. Both the State and Federal agencies play an active role in restricting construction of new structures projecting into Lake Erie that might affect littoral drift patterns or increase the rate of shoreline recession of neighboring shoreline property.

2.4.5.5.2 Maximum Allowable Shoreline Recession

<Section 2.5.5> describes the point to which bluff recession could progress without threatening the function of safety class structures. Bluff protection will be installed if the retreat closely approaches this limit.

2.4.5.5.3 Protective Measures

2.4.5.5.3.1 Protective Measures Description

If the shoreline retreat becomes threatening to the safety-related structures, the shoreline will be protected by a suitable permanent construction that will protect the face and toe of the bluff. Final design and permit applications for the shoreline permanent protection construction will be initiated when the lake shoreline (toe of bluff)

has receded to a point 250 feet away from the closest safety class structure (emergency service water pumphouse). However, if the State of Ohio or the Federal Government develops an area-wide plan for shoreline protection that includes the plant, CEI will fully cooperate in implementing the plan on its property. The protective construction (Reference 29) (Reference 39) considers grading of the shoreline bluff and construction of a permanent protective revetment. Interim protective measures are described in <Section 2.4.5.5.9>.

a. Bluff Grading

Prior to installation of the shoreline protective revetment, the bluff will be graded to the dimensions shown in <Figure 2.4-39>. The bluff grading will be as follows:

1. Prior to the placement of the protective revetment, the bluff will be graded to a 2:1 slope between Elevation 555 feet (USGS) and Elevation 605 feet (USGS).

2. After the 2:1 grading is finished, a 10-foot wide berm will be cut at Elevation 605 feet (USGS).

3. After the berm is finished, further grading of the bluff to a 3:1 slope is required between Elevation 605 feet (USGS) and the top of the bluff.

b. Protective Revetment

The maximum wave runup, corresponding to the 9.7-foot high maximum wave breaker height (Reference 31) breaking on the rough 2:1 slope of the protective revetment, is found in (Reference 22) to be 16.4 ft. The wave runup would therefore reach Elevation 596.9 feet (USGS) when the lake is at Elevation 580.5 feet (USGS) i.e., maximum stillwater level PMS. However, it should be pointed out

that the freeboard between the top of the protective revetment, located at Elevation 605.0 feet (USGS), and the maximum wave breaker height runup is 8.1 feet. Therefore, it is not expected that the wave runup produced by the PMS will ever overtop the crest of the revetment. The shoreline protective revetment will protect a section of the lake shoreline approximately 2,000 feet long, comprised of the distance between the entrance to the barge unloading area and the outlet of the minor stream diversion.

The protective revetment as shown in <Figure 2.4-39> will offer sufficient protection to the emergency service water pumphouse. The shoreline protective revetment will be a rubble mound structure composed of the following layers of material:

1. The first layer is a permeable plastic fabric sheet, which is placed on the lake bed and over the area cut to the 2:1 slope.

2. On top of the permeable plastic fabric a 2-foot thick gravel filter blanket will be placed, as specified and shown in <Figure 2.4-39>.

3. The filter will be covered with two layers of 1,000 to 2,000 pound quarry stones fitted into the gravel material.

4. The two layers of large quarry stones will be surmounted by two layers of heavy armor stones having a weight of between 6 and 10 tons. The heavy armor stones will not only be randomly placed over the sloped surface, but will become an integral part of the protective toe of the rubble mound protection. The toe protection will extend 47 feet into the lake and will be founded on weathered bedrock at approximate Elevation 555.0 feet.

5. As an alternate to the use of the heavy armor stone, consideration will be given to the use of two layers of 5-ton tetrapods or two layers of 2-ton Dolosse.

6. The area between the upper end of the revetment and the upper edge of the graded bluff will be stabilized with a vegetative cover, placed on the 3:1 slope. Since this slope is stable <Section 2.5.5>, local sloughing resulting from ground water seepage will not occur. The installation of additional protective measures such as french drains or well point dewatering systems is not required.

2.4.5.5.3.2 Protective Measures Construction

The permanent shoreline protective revetment will be final designed when the distance between the lake shoreline and the emergency service water pumphouse (nearest safety-related structure to Lake Erie) is 250 feet. Since the range of toe of bluff recession has been less than 2 feet per year since 1937 in the vicinity of the emergency service water pumphouse, there is sufficient time to design, obtain necessary permits and construct the shoreline revetment before the minimum allowable distance of 204’-2” is reached <Figure 2.4-39>. Construction of the shoreline revetment requires dredging along the shoreline for the purpose of building the revetment protective toe. The dredging operation will be carried out in such a way that turbidity of the lake water in the local area is maintained at a minimum. The material spoils from the dredging operation and the bluff excavation will be disposed of upland at the plant site in a special confinement area, taking special care that no leaching out or overflow of water or spoil materials from within the confinement area can occur. The materials used for construction of the shoreline revetment protection will be clean of debris or any harmful material that might affect the quality of the lake

water. Measures will be taken to avoid oil contamination or oil spillages that could be produced by the mechanical equipment used during installation of the shoreline protection.

2.4.5.5.3.3 Protective Measures Effects

At the estimated average recession rate of 2 feet per year (since 1937) in the vicinity of the emergency service water pumphouse, approximately 65 years will expire for the toe of the bluff to recede 130 feet from the present location, about 380 feet shoreward of the emergency service water pumphouse, to the location 250 feet from the structure when shoreline protection final design would be initiated <Section 2.4.5.5.3>. Therefore, shore protection for the site is not expected to be necessary during the operating life of the PNPP.

If the shore protection were to be constructed, the possibility exists that the plant site could eventually project into the lake beyond the adjoining areas, assuming that protective measures are not taken at adjacent properties. The projection of the protected shoreline of the plant site into the lake beyond the receding adjoining shoreline would be very gradual and in time might result in accretion on the updrift side beach and/or in erosion of the downdrift side beach. Since the recession rate of adjacent unprotected shoreline is slow and since the protection for the site would, if required at all, be constructed at some future time, the “projection” (relative to the receding adjacent shore) of the protected shoreline would be small. Therefore, it would not act as a complete barrier to the movement of beach materials as have some jettys, for instance, in the Great Lakes. Consequently, the accretion and accelerated erosion caused during the plant life would be expected to be minimal. If these effects do occur, they would be local and confined to the site which extends 4,180 feet westward from the protected shore <Figure 2.4-39> and 2,600 feet eastward.

If this assessment of shore processes and effects (which is based on site field data and considerable qualitative evaluation) is found totally incorrect, and accretion and accelerated erosion could threaten adjacent property, control measures such as a mechanical system for passing material from the updrift to the downdrift side could be installed. However, the most effective measure should be selected only after there has been experience with the indicated shore protection. The effects of accretion and erosion were considered at the flanks of any site shore protection; accretion would serve to protect one flank from wave attack, while erosion at the other flank (downdrift side) might require occasional remedial treatment. Because of the great separation distance between these areas and the plant facilities, the safety-related structures would not be threatened.

Except for the relatively brief obstruction of the littoral movement produced by the temporary channel dredged into the lake for the barge unloading area, the development of the plant site should not affect the adjacent shoreline. The channel will exist only at times of barge delivery during and shortly after construction. Since it is expected that the channel will fill rapidly, this brief obstruction of littoral movement will not adversely affect local residents. However, the temporary sunken barges <Section 2.4.5.5.6> will have a minor effect upon littoral movement until they are removed.

2.4.5.5.3.4 State and Federal Approvals

The following permits will be required if the erosion protection plan of the shoreline bluff at the site becomes necessary:

a. Department of the Army construction permit

   This permit will be issued by the Buffalo District of the U.S. Army Corps of Engineers after submission and acceptance of an

environmental impact report. This is required for any structure that will be built in Lake Erie below Elevation 572.8 feet IGLD (574.7 feet USGS).

b. Shore erosion permit

This permit will be issued by the Ohio Department of Natural Resources and requires detailed drawings of the proposed shoreline protection structures.

2.4.5.5.4 (Deleted)

2.4.5.5.5 (Deleted)

2.4.5.5.6 Barge Slip

A nonsafety-related barge slip was constructed northwest of the plant along the southern shoreline of Lake Erie. It is located in the general area incised by the minor stream where it originally entered the Lake.

An approach channel (averaging about seven feet in depth) was dredged from the lake to the barge slip. Lake dredging was performed to initially open the channel and then as required to maintain the opening prior to barge deliveries. Dredged material was disposed of on the plant site. The barge slip was constructed of steel sheet piling with tie-backs. The lake end of the barge slip was constructed about 30 feet south of the 1972 shoreline, with sheet pile wings being constructed toward the shoreline.

To protect the side slopes and shoreline at the lake end of the barge slip, a rubble mound protective revetment structure was installed along the shoreline, extending 50 and 80 feet, respectively, east and west of

the sheet pile wings. The top of the protective revetment is at Elevation 579 feet (USGS) and the bottom at Elevation 570 feet (USGS) at the entrance of the barge slip.

Prior to placement of the protective revetment on either side of the barge slip sheet pile wings, the area where the rubble mound is founded was graded to a 2:1 slope. The rubble mound protective revetment between Elevations 579 and 570 feet is composed of the following layers of material:

a. The first layer is a permeable plastic filter cloth fabric sheet placed directly on the graded slope.

b. The second layer is an 18-inch thick crushed stone filter layer placed above the plastic fabric sheet.

c. The third layer covers the filter layer and is composed of a 3-foot thick (minimum) layer of armor stone, 300 to 500 pounds each, with a grouted surface.

Temporary sunken barges that extend about 120 feet into the lake from the shoreline were placed on the east and west sides of the barge slip entrance to temporarily reduce the amount of sand entering the barge slip due to littoral drift. Dredged material was placed in these anchored barges to act as ballast for sinking the barges.

Upon completion of maintenance dredging and after the plant equipment and/or materials were delivered, the barge slip and approach channel were abandoned and left to silt in by natural lake processes. The barge slip entrance rubble mound revetment protection was left in place when the barge slip was abandoned.

2.4.5.5.7 Northwest Sediment Control Dam

A nonsafety-related sediment control earthen dam and associated concrete spillway were constructed at the northwest corner of the plant site. The toe of the spillway is approximately 90 feet south of the 1975 shoreline. The channel bottom between the spillway toe and the shoreline is protected by 2-foot-6-inch thick dumped riprap placed over a 1-foot-3-inch thick gravel filter.

2.4.5.5.8 Minor Stream Diversion Channel Outlet

The minor stream, which originally entered the lake at the present barge slip location, was diverted east of the plant site. The channel outfall to the lake was constructed using 96 inch diameter corrugated metal pipe installed over a layer of 500 to 8,000 pound dumped stone riprap. The pipe was terminated at the sheet piling protection installed along the lake shoreline in front of the plant site.

2.4.5.5.9 Interim Shore Protection

In the early spring of 1975, significant shore erosion was observed at three localized areas of the plant site in the vicinity of site construction operations. These accelerated erosion rates were directly attributed to the sustained high lake levels which peaked in 1975 and which allowed wave attack to undermine the toe of the bluff during the high lake level period. In 1983, a rock protected sheet pile breakwall was erected. This sheet pile breakwall protects the section of the lake shoreline approximately 2,200 feet long, composed of the distance between the entrance to the barge unloading area and the outlet of the minor stream diversion as shown in <Figure 2.4-39A>. In 1992, the temporary sunken barges were removed and the interim revetment was extended 1300 feet west to the northwest storm impoundment spillway as shown in <Figure 2.4-39A>. The design of the extension was essentially the same as the original 2200 foot revetment.

The breakwall was constructed in the following manner:

1. A sheet pile breakwall was driven along a line approximately 25 feet out into the lake from the toe of the sloped bluff. The sheet piling was cut off at approximate Elevation 580’-3”. Whaler was bolted to the piling.

2. The shore side of the breakwall was finished as follows:

   (a) Filter cloth was installed against the sheet piling.

   (b) A causeway was formed of clean sandstone and concrete fill to Elevation 576’-0”.

   (c) An underlayer of 2 to 14 inches of sandstone was installed to Elevation 577’-0”.

   (d) Armor stones were installed to Elevation 579’-0”.

3. The lake side of the breakwall was finished as follows:

   (a) Filter cloth was placed on the lake bottom approximately 9’-0” out from sheet piling.

   (b) Armor stones were placed on filter cloth at an approximate slope of one to one to an elevation of approximately 577’-0”.

d. The eastern end of the breakwall was gradually curved into the shoreline and the lake side armor stones were installed up to the top of the sheet piling. The western end of the breakwall was curved into the shoreline at the east edge of the northwest storm impoundment spillway and the lakeward side was protected by armor stone placed at the base of the spillway.

The top of the bluff should stabilize at approximately 300 feet from the emergency service water pumphouse. Therefore, this breakwall will provide significant protection to the shoreline and to the emergency service water pumphouse.

2.4.6 PROBABLE MAXIMUM TSUNAMI FLOODING

Since the site is located on Lake Erie, an inland lake, tsunami occurrence is not applicable. The Lake Survey Center (NOAA) has found no evidence of earthquake related seiches.

2.4.7 ICE EFFECTS

2.4.7.1 Regional Ice Formation History

Lake Erie, the shallowest of the Great Lakes, is also the most thermally variable. It reacts rapidly to seasonal temperature changes and can build an appreciable ice cover in a comparatively short time (Reference 33).

As winter progresses, ice on Lake Erie spreads from west to east. In mid-December, ice begins to form in the extreme western portion of Lake Erie. It spreads eastward, partially aided by a prevailing west wind, until the beginning of March when the eastern end of the lake is completely ice covered. At this time, the probability of ice cover in the site area exceeds 76 percent (Reference 32). The ice disappears from the western and central portions of Lake Erie by the end of March and by mid-April only a small area near Buffalo, New York, is still ice covered (Reference 33). Available information indicates that the critical period for ice development in the site area is from mid-February through mid-March with ice block formation prevalent during the spring ice breakup.

The maximum recorded ice thicknesses at locations shown in <Figure 2.4-40> on the periphery of Lake Erie are given in <Table 2.4-3>. <Table 2.4-4> tabulates the maximum recorded ice thicknesses along the Ohio shoreline of Lake Erie during the period 1961-1973 at Ashtabula and Cleveland Harbor. The surface ice and ice thicknesses were surveyed along the shoreline of the site during the winters of 1975-1976 and 1976-1977. The results of the field survey are shown in <Figure 2.4-41>, <Figure 2.4-42>, <Figure 2.4-43>, <Figure 2.4-44>, <Figure 2.4-45>, and <Figure 2.4-46>. A maximum ice thickness of 2.3 feet was observed on February 10, 1977.

2.4.7.2 Ice Blockage

The intake structures are approximately 2,600 feet offshore and are totally submerged in the lake at a depth of 13.3 feet or more (from low water datum), depending on lake level. There are no trash racks at the ports of the intake heads since they would be subjected to the formation of frazil ice and eventual blockage of the ports. The possibility of floating ice sheets being pulled down and blocking the ports is very remote because of the very low intake velocities (Reference 34).

The intake structures are protected by reinforced concrete ice protection caissons around them which will act as a barrier to any floating ice island which could block the intake ports. For the very unlikely case where complete blockage of the intake structures would occur, water for the emergency service water system will be drawn from the discharge tunnel.

2.4.7.3 Ice Forces and Protective Structures

The submerged offshore structures could be subjected to ice forces by the ice islands driven by strong wind and/or large waves (Reference 34). For a discussion of these loads and forces, refer to <Section 3.8.4>.

The intake structures are protected against the impact of ice islands by 10 vertical reinforced concrete caissons, each 6 or 7 feet in diameter, placed in a 70-foot diameter circle around each of the submerged intake structures. The spacing between the caissons is such that the intake water approach velocity will not be increased.

The three foot diameter discharge nozzle is encased in a 17-foot diameter reinforced concrete caisson for protection against the ice loads produced by the impact of a floating ice island crushing against the structure. <Figure 3.8-67> and <Figure 3.8-68> show details of caissons for the intake and discharge structures.

2.4.7.4 Ice Flooding

Ice flooding cannot occur because of the high bluffs between the buildings and the lake. Also, safety-related onshore buildings are set back from the top of the 45-foot high bluff to preclude ice forces being a problem.

2.4.8 COOLING WATER TUNNELS AND OFFSHORE STRUCTURES

2.4.8.1 Cooling Water Tunnels

Service and cooling water for PNPP will be obtained from Lake Erie at approximately 2,600 feet offshore and carried to the plant site through a 10-foot diameter intake tunnel located in the underlying bedrock. The water is then returned to the lake through a similar discharge tunnel of shorter length. Short tunnels of the same diameter are used near the shore facilities to tap the cooling water tunnels for the emergency service water system. Tunnel locations are shown on <Figure 3.8-65> and <Figure 3.8-66>. A discussion of the tunnel function is given in <Section 2.4.11.6> and <Section 9.2.1>.

2.4.8.2 Offshore Structures

2.4.8.2.1 Intake Structure

The offshore intake structure consists of two independent, circular intake heads, each connected to a six-foot diameter vertical shaft. The two vertical shafts convey the cooling water into the underground 10 foot diameter intake tunnel.

Each of the two intake heads is provided with a horizontal, circular velocity cap and vertical inflow ports around the periphery. Inflow to the ports is expected to be predominantly horizontal, except in the zones near the top and bottom of the port openings where the stream lines will have a more vertical orientation.

Flow of cooling water into the intake heads will be through the vertical ports around the perimeter of each circular structure. Since the diameter of the circular intake heads is 36 feet, and the vertical ports are 3 feet-7-1/2 inches high, the expected approach velocity to the ports will be less than 0.5 foot per second (Reference 34). Provisions are available around the periphery of each structure for backfitting trash racks; this will allow for filtering of intake water to remove large pieces of flotsam, if necessary.

The intake structure is a safety class structure as it supplies water to both the emergency service water pumphouse and the service water pumphouse.

For the unlikely case of a complete blockage of the intake structure heads, an alternate supply of water can be obtained from the discharge nozzle. For details of the functional criteria, backup systems, hydraulic details, etc., refer to <Section 9.2>. The design of the intake structure is shown in <Figure 3.8-67>.

2.4.8.2.2 Discharge Structure

A single, 3-foot diameter nozzle will discharge perpendicularly away from the shoreline to dissipate waste heat from the closed cycle steam condenser cooling system through the cooling tower blowdown.

A single, round submerged jet was chosen as the generic discharge type to promote rapid mixing of the discharge with the lake, thereby quickly reducing the elevated temperature and chemical concentrations of the discharge. The greater the discharge velocity for a given flow, the more rapid the mixing processes between discharge and lake. However, high velocities also result in erosion of the lake bottom and large induced currents at the lake surface. A maximum velocity of 35 ft/sec, previously determined as an acceptable upper velocity at the site (Reference 35), was chosen at the maximum discharge flow of 100,000 gpm. This criterion results in a minimum port diameter of 2.85 feet. The other criteria used to arrive at a design were:

a. A maximum calculated surface temperature rise of 2.75°F. The requirements in most jurisdictions specify a 3°F rise on the water surface outside of a specified mixing zone. Therefore, the criteria is quite restrictive since a 2.75°F (rather than 3°F) rise is specified and the mixing zone area is taken as zero.

b. A minimum 12-foot clearance above the discharge structure for navigational clearance.

c. A minimum two-foot separation between the discharge bottom and lake bedrock; this will provide for initial dilution water below the discharge and diminish the velocity effects of the discharge on the lake bottom.

The computer code MUDSUB (see PNPP Environmental Report) was used to arrive at acceptable diameters consistent with the criteria given above.

A three-foot diameter discharge was chosen as the best design for environmental protection. Details of the analysis are given in (Reference 36).

The design of the diffuser discharge structure is shown in <Figure 3.8-67>.

2.4.9 CHANNEL DIVERSIONS

This section is not applicable to PNPP since no cooling water channels exist from which flow could be diverted.

2.4.10 FLOODING PROTECTION REQUIREMENTS

Four prospective sources of flooding exist at the Perry site: Lake Erie, intense local precipitation, and flooding by two small, nameless streams which border the site to the east and south.

<Section 2.4.5> and <Section 2.4.7> discuss the possibility of flooding caused by the probable maximum surge and ice conditions in the lake. The plant grade is sufficiently high to greatly reduce the probability of general site flooding. On the intake side of the cooling water systems, all safety-related pumps and equipment will be located above Elevation 586′-6″ (USGS) in the emergency service water pumphouse. This elevation allows approximately three feet of freeboard over the simultaneous occurrence of the probable maximum setup, the maximum monthly mean lake level of record, and the associated oscillation of the pump chamber water level due to wave action over either the main or alternate submerged offshore intake structure.

Plant flooding by intense local precipitation is prevented by the design of the storm drainage and roof drainage systems. For details, see <Section 2.4.2.3>.

2.4.11 LOW WATER CONSIDERATIONS

2.4.11.1 Low Flow in Streams

Cooling water will be supplied from Lake Erie rather than from a river or stream. The ability of Lake Erie to perform adequately under severe low level conditions is discussed in the sections that follow.

2.4.11.2 Low Water Resulting From Surges, Seiches or Tsunami

Surges and seiches in Lake Erie are due primarily to wind effects. Astronomical tides reach only 0.6 inch and the effects of atmospheric pressure gradients are also small (Reference 37). The Lake Survey Center (NOAA) has found no evidence of earthquake related lake fluctuations.

This section describes the maximum decrease in lake level (setdown) at the site which would result from combinations of the most severe meteorological parameters that are reasonably possible in the Lake Erie area.

2.4.11.2.1 Probable Maximum Winds and Associated Meteorological Parameters

2.4.11.2.1.1 Meteorological Synoptic System for Lake Level Setdown

Lake level setdown is the decrease of the lake level caused by the wind moving the surface water from one position to another with sufficient speed so that the surface of the lake becomes tilted. Since a body of water tends to remain level, this wind must be of sufficient strength and duration to maintain a steady-state of the lake surface tilt (Reference 7) (Reference 8).

The magnitude of wind surges depends primarily on the wind speed, the fetch length over which the wind blows and the depth of the lake (Reference 9). In the Perry area, a meteorological synoptic situation with winds from magnetic SSW through ESE, a minimum velocity equal to a drag coefficient critical velocity of 14 knots (Reference 10), and a duration of at least 10 hours (Reference 11) to eliminate local thunderstorms is needed to generate significant setdown. The sensitivity of setdown to wind direction is described in <Section 2.4.11.2.2.2>.

Several meteorological synoptic situations were analyzed to determine the type of situation that produced these required conditions (Reference 10) (Reference 11) (Reference 12). <Figure 2.4-47> is an example of the meteorological synoptic situation that meets these requirements. It is noted that in the site area, hurricanes are not associated with the PMS. As a rule, hurricanes do not penetrate into the site area (Reference 11), since hurricanes tend to decrease in strength as they penetrate inland from the coast.

2.4.11.2.1.2 Procedure to Develop the Probable Maximum Storm for Lake Level Setdown

To generate a reasonable possible meteorological situation which has virtually no chance of being exceeded, the high pressure center was assigned the value of the highest pressure recorded in the United States (1,063.3 mb - 31.40 inches Hg, which occurred during January 9, 1962) (Reference 12) and the low pressure center was assigned the lowest pressure (non-hurricane) recorded in the United States (954.56 mb - 28.20 inches Hg, which occurred during 1913) (Reference 12).

The use of these extreme values develops a very strong pressure gradient between the pressure centers. This pressure gradient exceeds any

previously observed pressure gradient, excluding hurricanes over the ocean. The postulated wind speeds for this system have virtually no chance of being exceeded.

To synthesize the sequence of the movement and the life cycle of the PMS a series of meteorological charts were developed. The PMS is assumed to occur over a 72-hour period; during this time, the winds increase from 15 mph to the maximum speed and then decrease to less than 15 mph in the Perry, Ohio, area.

The first chart developed was based on an assumed 1,033-mb high pressure center and was located at the first 12-hour center position of the high <Figure 2.4-47>. The low pressure center was assumed to have a pressure of 985 mb and was located at the first 12-hour center position of the low as shown on the same figure. Subsequent 12-hour positions of the high and low centers are also shown. The high and low pressure systems were intensified at the rate of 10 mb per 12 hours, attaining the values for the PMS 36 hours after the initial chart. The centers then continued to move eastward for the next 36 hours and decreased in intensity at the rate of 10 mb per 12 hours. This procedure was followed to develop a meteorological situation which would result in a decrease of the surface winds at Perry to less than 15 mph at the end of the PMS episode.

2.4.11.2.1.3 Procedures Used to Generate the Individual Meteorological Charts

The procedures used to develop the meteorological charts for the maximum setdown are identical to the procedures for maximum setup, as outlined in <Section 2.4.5.1.4>, and the results of these procedures are presented in <Figure 2.4-48>.

<Figure 2.4-49>, <Figure 2.4-50>, <Figure 2.4-51>, <Figure 2.4-52>, <Figure 2.4-53>, <Figure 2.4-54>, <Figure 2.4-55>, <Figure 2.4-56>,

<Figure 2.4-57>, <Figure 2.4-58>, <Figure 2.4-59>, and <Figure 2.4-60> are the isotach patterns of the PMS at 6 hour intervals for the lake level setdown.

2.4.11.2.1.4 Supporting Data for the Uniqueness of the PMS

Data supporting the uniqueness of the maximum setdown is the same data presented in <Section 2.4.5.1.5>, except that the maximum steady wind speed calculated for the PMS setdown is 100 mph at the site.

2.4.11.2.2 Maximum Lake Level Setdown

2.4.11.2.2.1 Method Used to Predict Setdown at Site

To determine the setdown caused by the associated PMS, the one dimensional numerical prediction model described in Technical Report No. 4 (Reference 22) was applied using the PMS setdown winds.

2.4.11.2.2.2 Probable Maximum Setdown

Wind speed magnitudes and directions for the PMS setdown case were generated for the ten stations shown on <Figure 2.4-26>. Wind stress magnitudes (Tx and Ty) for the other grid points of the numerical analog model were obtained by temporal and spatial linear interpolation. <Figure 2.4-61> and <Figure 2.4-62> describe the variation of wind speed and direction for the two stations adjacent to the Perry site and for the two stations directly across the lake from the Perry site; respectively. The coordinates for the PNPP site are (36,3).

For the stations adjacent to the Perry site (20,1) and (40,1), the wind speed averages above 80 mph for a period of approximately 14 hours. The wind direction is toward 345 to 340 degrees azimuth for this period. This corresponds to a wind from the south on the model grid. For the stations across from the Perry site, the wind speeds average above

80 mph for approximately 18 hours. For station (20,21), the wind direction varies from 340 to 310 degrees during the maximum wind period. For station (40,21), the wind direction varies from 340 to 320 in this period. The total distance that these winds travel over water is approximately 56 miles.

The computed setdown hydrograph for the site during the period of the PMS is shown in <Figure 2.4-63>. With the 4.04 foot maximum setdown, the minimum water surface elevation at the plant site would be 563.36 feet IGLD (565.26 feet USGS). This is based on an antecedent water elevation of 567.4 feet (IGLD), the minimum monthly level of record. The wave action coincident with this setdown was determined by procedures described in Technical Report No. 4 (Reference 22). Using an average 90 mph offshore, over water wind of unlimited duration with a 30 percent reduction to account for land effects in the nearshore zone, the Bretschneider method gives a 2.6 foot significant wave height and a 4.7 second period. Since the alternate intake (normal discharge structure) is closer to shore, the wave heights would be less than at the normal intake structure.

2.4.11.2.2.3 One-Dimensional Model for Setdown Surge

The analysis of the lake setdown surge at the plant site was made using the one-dimensional model described in Technical Report No. 4 (Reference 22), and briefly characterized in <Section 2.4.5.2.2>. The probable maximum setdown was computed with this method using a fetch defined by a line connecting grid points (36,3) (plant site) and (36,21) <Figure 2.4-26>.

<Figure 2.4-63> shows the hydrographs of computed setdown at the site for the PMS setdown wind data. Note that the curve does not reflect any adjustment for lake volume balance, pressure or precipitation. The maximum setdown shown on this curve is 4.03 feet (122.95 cm).

Volume adjustment was made on the basis of Equation 2.4-1. <Figure 2.4-29> summarizes the results of the volume computations for both the setup and setdown cases at the time of their peak occurrence. The pressure adjustments were made by looking at the PMS pressure data and choosing the maximum pressure difference between adjacent stations across the lake. For both the PMS setup and setdown cases, the maximum pressure difference was found to be 10 mb ≅ 10 cm of water. No precipitation adjustment was included for the setdown case since it would only reduce the setdown and would not be indicative of the most conservative case.

2.4.11.3 Historical Low Water

Two gauges have provided data for the study of the variation in surface elevation of Lake Erie. The Cleveland gauge has a period of record for monthly and annual means dating back to 1860, with instantaneously recorded data since 1904. The gauge at Erie has continuous data from 1960 to the present. A third gauge at Ashtabula, installed in 1954, has been neglected for extended periods since its installation and much of the data recorded by this gauge is incomplete and unreliable due to malfunction of the gauge and its recording mechanism.

<Figure 2.4-2> reveals that the mean lake level has a cyclic variation. At Cleveland, the minimum monthly mean level of record was 567.4 feet IGLD (569.3 feet USGS) recorded in December 1934. The minimum recorded instantaneous level was 565.71 feet IGLD (567.61 feet USGS), which occurred on February 4, 1936. The maximum seiche setdown for each year was computed by subtracting the minimum instantaneous lake level from the mean level for the month in which it occurred. The peak setdown at Cleveland for the period of record was -3.04 feet, occurring December 8, 1927.

At Erie, the minimum monthly mean level was 568.27 feet IGLD (570.17 feet USGS) for December 1964 and the minimum recorded

instantaneous level was 566.00 feet IGLD (567.90 feet USGS), which occurred on March 10, 1964. The peak seiche setdown at Erie for the period of record is -2.90 feet, occurring March 10, 1964.

A frequency study of seiche setdown and minimum monthly mean stages was made for both the Cleveland and Erie gauges. The results obtained are shown in <Figure 2.4-64> and <Figure 2.4-65>, respectively. Log Pearson Type III and Linear Gumbel distributions are presented for each case.

Comparison of the seiche setdown curves in these figures shows that at a particular frequency the seiche at Erie exceeds that at Cleveland. This is felt to be attributable to dissimilar lengths of gauge records and topography in the vicinity of the gauging stations.

2.4.11.4 Future Controls

There are three hydrologic features which influence the site: Lake Erie and the two small, nameless streams which border the site. The safety-related structures are located outside the drainage basin of the larger (major) stream. No developments are foreseen for the streams as the mean flow of each is less than 10 cfs, and except for intermittent withdrawal by an adjacent industry from the downstream end of the major stream, the only use is for drainage.

Lake Erie drains into Lake Ontario via the Niagara River and is also connected to Lake Ontario by the Welland Canal. The Niagara River has two major control structures for power generation before reaching Niagara Falls. The upstream east channel has also been channelized for navigational purposes. However, no new developments involving control structures are envisioned.

The Welland Canal is approximately 26.5 miles long and has 8 locks capable of raising ocean-going vessels 326 feet from Lake Ontario to Lake Erie. A more complete description of the canal may be found in

<Section 2.4.11.6>. A section of the canal is being straightened between Miles 23.8 and 15 (Mile 23.8 is approximately 4 miles from the Lake Erie end). The new cross section will have a bottom width of 350 feet compared with 192 feet in the existing channel. The depth of the new channel will be 30 feet, three feet deeper than the present system it will replace.

For reasons outlined in the <Section 2.4.11.6>, it is considered most unlikely that any developments of the canal will influence the surface elevation of Lake Erie.

2.4.11.5 Plant Requirements

As described in <Section 2.4.11.2>, the probable minimum lake level at Perry is Elevation 565.26 feet (USGS). With the inverts of the intake ports at an average elevation of 552.65 feet, inflow of sufficient cooling water during this period is assured. The corresponding water level in the emergency service water pump chamber would be at Elevation 562.09 feet.

During this condition, water for the emergency service water system could also be supplied by the alternate intake system discussed in <Section 2.4.5.4> and <Section 9.2.5>. The crown and invert elevations of the diffuser nozzle of the discharge structure are 555.8 and 552.8 feet (USGS), respectively. The available 12.2-foot submergence over the diffuser nozzle would prevent air entrainment due to the inflow velocity (approximately 15.85 fps through the nozzle).

The minimum water level in the emergency service water pumphouse will occur during the hot standby condition when only the emergency service water systems are operating. At the probable minimum lake level with coincident wave action, the level in the emergency service water pump chamber for this condition will be Elevation 562.09 feet (USGS). With the invert of the chamber at Elevation 537.0 feet, the 10-foot minimum

depth requirement of the pumps is assured. These safety-related pumps meet this cooling water requirement during this extreme low lake level condition.

2.4.11.6 Heat Sink Dependability Requirements

Emergency service water for the PNPP is supplied from Lake Erie. The emergency service water pumphouse and emergency service water pumps are designed to provide service capacity <Section 9.2.1> under all lake level conditions down to the 563.36 feet IGLD (565.26 feet USGS) level caused by the probable maximum setdown <Section 2.4.11.2> superimposed on the minimum monthly mean lake level.

Lake Erie, as part of the Great Lakes system, is well regulated with only a 1.2-foot range in the average monthly levels <Figure 2.4-2>. Inflow from the Detroit River, connecting Lake Erie to Lake St. Clair and eventually to Lake Huron, is in the order of 178,000 cfs. Outflow from the Niagara River, connecting Lake Erie with Lake Ontario, is approximately 194,000 cfs. The difference between inflow and outflow is due to the extra runoff from the portion of the Great Lakes drainage basin occupied by Lake Erie and its environs.

Lake Erie is also connected to Lake Ontario by the Welland Canal. The mean annual outflow by this route is approximately 8,000 cfs (Reference 1). Relative to the lake volume and inflow rate, this outflow is of no significance to the level of Lake Erie.

Assuming that a complete catastrophe destroyed all the locks in the canal, sizable outflow through the canal would occur. To maximize the effect of such a disaster, the hydraulics of the canal were simulated by an uncontrolled weir of 270 feet in length and crest Elevation 538.00 feet IGLD (539.90 feet USGS) at the canal entrance to Lake Erie. The canal itself has a width of 192 feet, an invert level of 538.00 feet IGLD (539.90 feet USGS) and is 26.5 miles in length with a total head

loss of 326 feet. With no inflow to Lake Erie and discharge occurring through the Niagara River and the canal, it would take 350 days for the lake level to drop 5 feet from 573.00 feet IGLD (574.90 feet USGS) to 568.00 feet IGLD (569.90 feet USGS). Further conservatism in this estimate was gained by using the initial outflow head (the outflow for a lake level of 573.00 feet IGLD) rather than a falling head relationship for both the canal and the river for the whole head increment.

The result of this conservative evaluation shows that a total failure of the Welland Canal lock system will not compromise the safety of the plant. The likelihood of such a failure is remote due to the redundancy of protective devices and the structural enormity of the system.

Service and makeup water for the power plant will be obtained from Lake Erie approximately 2,600 feet offshore and carried to the plant through a 10-foot diameter intake tunnel; after passing through the plant, the water will be returned to the lake through a similar discharge tunnel. Two short tunnels of 10 feet diameter, shown in <Figure 3.8-65>, intersect the main cooling water tunnels near the shore facilities. Their only purpose is to draw cooling water for the emergency service water pumphouse, either from the intake or the discharge tunnel.

Normally, as explained in this section and <Section 3.8.4> and <Section 9.2.1>, the intake tunnel supplies water to both the emergency service water pumphouse and the service water pumphouse. In the unlikely event of a complete blockage of the intake structure or intake tunnel, water for the emergency service system must be drawn from the discharge tunnel. During this time, the heated effluent from the service water system will be discharged onshore and will flow by gravity down to the lake shoreline.

Discharge will be through the Safety Class 3 standpipe on the downstream side of the heat exchangers, as shown on <Figure 9.2-1> and discussed in

<Section 9.2.1>. The water will discharge outside the auxiliary building onto the ground. The slopes and elevations are set so that the flow will be away from the plant, across the road and down a graded swale between the cooling towers to the diverted stream <Figure 2.4-3>. The water will flow down to the stream and discharge into Lake Erie. A longitudinal profile through the emergency service water alternate discharge area (minor stream diversion channel) is depicted in <Figure 2.4-8> and shows the elevations of the flow paths through the stream to the lake. Flow through all paths for both units will result in a total flow to the stream of approximately 50,000 gpm initially, which will be reduced to 25,000 gpm in a short period of time. These flow rates represent original plant design (two units). Since then, Unit 2 has been abandoned. As a result, the actual total flow exiting the ESW standpipes will be much less. In addition, the required ESW flow rates for Unit 1 have been analytically decreased to values less than those originally specified (reference <Figure 9.2-1(3)> for the required ESW system flow rates).

The contours of the site will be set to provide a depressed area east of the auxiliary buildings <Figure 2.4-3>. This depressed area will slope away from the plant buildings, over the road and through the swale to the minor stream. Elevations of the depressed areas will be such that no water exiting the plant under this unlikely event will flow back to the plant.

The main intake structures shown on <Figure 3.8-65> and <Figure 3.8-67> consist of two independent intake heads that are each connected to a six foot diameter shaft. The two vertical shafts convey the water into the 10-foot diameter intake tunnel shown in <Figure 3.8-65> and <Figure 3.8-66>. The intake heads are circular in plan and are covered with a velocity cap placed at a minimum of 13.3 feet below the low water datum (LWD), as shown in <Figure 3.8-67>. Inflow is through vertical openings around the periphery of the intake heads. The discharge

structure, shown in <Figure 3.8-65> and <Figure 3.8-67>, consists of one 3-foot diameter diffuser nozzle encased in a 17-foot diameter protective concrete caisson, the top of which is 12.2 feet below LWD. The intake and discharge structures are located approximately 2,600 feet and 1,700 feet, respectively, offshore. Approximately 1,550 feet of horizontal separation exists between the two structures.

Since the size and extent of these offshore structures are based on the entire normal operation cooling water requirements of the plant, it greatly exceeds the requirement for the safety-related systems. The likelihood that both the main intake and the alternate intake would be blocked by ice, or a waterborne transportation accident would occur that would affect flow capacity, is extremely remote. The separation between the normal and alternate intakes and the fact that they are installed at different depths greatly reduces the probability that a single event or accident could affect both intakes.

2.4.12 DISPERSION, DILUTION AND TRAVEL TIMES OF ACCIDENTAL RELEASES OF RADIOACTIVE EFFLUENTS IN LAKE ERIE

Lake Erie is long, narrow and shallow (average depth approximately 60 feet) with a 220 foot deep basin at the eastern end (Reference 38). The Perry plant is located along the southern shoreline in the Lake Erie central basin. Currents in the lake are driven by wind and seiche activity.

Seiches are periodic oscillatory lake motions that occur when a wedge of water has developed at one end of a water body and the wind or pressure forces causing the wedge have been removed. The currents then flow from the region of higher energy across the lake, build another wedge at the opposite end, and reverse to reproduce the original energy difference. This harmonic activity continues until damped out by external forces and friction. Current reversals due to seiche will occur whenever a wind that has piled up water at one end of the system dies down or changes direction (Reference 39). In Lake Erie, changes in barometric pressure have also been shown to cause significant seiche activity (Reference 40) (Reference 41).

A conservative condition for calculating far-field dilution factors (discharge concentration/intake concentration) is one in which the effluents are carried from the discharge point directly to a given

intake before any current reversal can occur. Current reversals result in elongated transport paths and increased turbulent mixing. In his studies of Lake Ontario, Csanady (Reference 42) (Reference 43) found also that under certain conditions current reversals will transport effluents from the near-shore zone, through the medium of mass exchange between coastal zone boundary layers and the rest of the lake.

The maximum period between current reversals was estimated using 5 years of wind persistence data from the Cleveland and Toledo NWS weather stations located near Lake Erie. The highest observed period of wind persistence in five contiguous wind direction sectors was found to be 200 hours. Five adjacent sectors represent an arc of 112.5 degrees, and any change in wind direction of this magnitude would be expected to result in current reversals, due both to seiches and wind stress. This value of 200 hours compares conservatively with the nominal period between reversals of 72 hours cited in <Regulatory Guide 1.113>, and also with a maximum period between current reversals of 85 hours observed at the Perry site during a one year underwater monitoring program (Reference 44).

The value is conservative since barometric seiches, which usually precede or accompany wind seiches (Reference 39) (Reference 31), have not been included in the analysis. Inclusion of these oscillations would hasten the projected onset of seiche motion.

The dilution factors shown in <Table 2.4-5> were developed for a shoreline discharge of 25,080 gpm. This discharge was estimated to occur as a result of earthquake damage to the diffuser tunnel as discussed in <Chapter 15>. Equation 14 from <Regulatory Guide 1.113> was used to compute minimum dilutions for each potable water intake within 50 miles of the plant, based on distances given in

<Section 2.4.1.2>. Because the lowest dilution factors occur for low values of ambient velocity, velocities were taken to be the minimum that would transport effluents to each intake prior to current reversal. This is;

$$U_i = \frac{d_i(5280)}{t_r(3600)}$$

where

U_i = Ambient velocity used to compute dilution for i^{th} intake, ft/sec.

d_i = Distance to i^{th} intake, miles.

t_r = Maximum time between reversals, 200 hours.

In those cases where the computed value U_i exceeded an average net drift velocity of 0.33 ft/sec (Reference 1) (Reference 38), the average value was used to ensure conservatively low dilution factors.

The effect of using the computed velocity values was particularly significant for those intakes located near the plant. For the nearest intake, 3.5 miles from the plant, the current velocity was computed to be 0.03 ft/sec. This resulted in a dilution factor of 7.8. If the current velocity had been taken to be the average net drift value of 0.33 ft/sec instead, the resulting dilution factor would have been 22.5.

Other required inputs to the model were diffusion coefficients and ambient depth. The lateral and vertical turbulent diffusion coefficients were taken to be 0.5 and 0.001 ft^2/sec, respectively. These are the most conservative of the values suggested for the Great Lakes by <Regulatory Guide 1.113>.

An examination of potable water intakes within twenty miles of the plant located no intake operating in less than 16 feet of water (Reference 45). Since the subject discharge was at the shoreline, and it was assumed that the discharge plume centerline passed directly over each intake studied, the average ambient depth for each discharge path was taken to be eight feet.

The dilution values shown in <Table 2.4-5> are conservative for use in evaluations of dilution from the subsurface diffuser nozzle since no credit has been taken for the initial dilution of the subsurface jet. Subsurface dilution effects can be considerable, as shown by the work of Koh and Fan (Reference 46) and Jirka et al. (Reference 47).

Low ambient velocities, such as those used in <Table 2.4-5>, result in conservatively low dilution factors due to decreased mixing. High ambient velocities, on the other hand, result in conservatively low travel times. It is therefore recommended that the net drift velocity of 0.33 ft/sec (0.225 mph), which is greater than or equal to all of the velocity values in <Table 2.4-5>, be used to compute conservative travel times for use with the dilution factors presented in <Table 2.4-5>. The travel time associated with a dilution of 7.8 for the IRC Fibers Company intake, for example, would then be 15.6 hours. This compares with the travel time of 200 hours for which the dilution factor has defined.

2.4.13 GROUNDWATER

2.4.13.1 Description and Onsite Use

Glaciolacustrine deposits and till, ranging in thickness from a few feet to as much as 250 feet, cover most of the surface in northeastern Ohio. Wells penetrating glacial deposits frequently yield small amounts (generally less than 10 gpm) of water after the water table is penetrated. Small domestic supplies are available from glaciolacustrine deposits nearly everywhere in the region.

The southward-dipping bedrock which underlies the glacial deposits in the region is composed mainly of thin-bedded medium gray shale, with some thin, light gray fine grained sandstone to siltstone layers. The amount of water which these rocks yield is generally small. Available data indicates that the maximum water that can be pumped from the shale is generally less than 5 gpm.

Recharge to the glacial deposits and bedrock is primarily by infiltration of precipitation. Downward infiltration is retarded in large part by the heterogeneous nature and low permeability of the glacial till. A minor portion of the infiltrating water eventually percolates to the underlying jointed bedrock. The regional groundwater table is variable and generally shallow, ranging from two to eight feet below the ground surface. The bases for regional groundwater descriptions were largely from (Reference 38) and other references in <Section 2.4.16>.

Locally, the site is underlaid by about 55 to 60 feet of lacustrine deposits and glacial till resting on a shale bedrock erosional surface that slopes gently toward Lake Erie with an average inclination of about one percent. Lacustrine soil deposits, the main source of groundwater, consist of low permeability interbedded silty and clayey fine sand, clayey silt and silty clay with an average thickness of 28 feet. The dense glacial till beneath the lacustrine deposits is of very low permeability. Except along joints and within the thin, weathered and somewhat fractured zone near the bedrock over burden contact, the bedrock is relatively impervious.

Well supplies are inadequate for plant needs. All water for plant use, except potable water and backup fire service water supplied by the Ohio Water Service Company, will be obtained from Lake Erie. A sustained well pumping test, performed on the PNPP site to evaluate the effects of the plant underdrain system on the surrounding groundwater regime, yielded only 0.12 gpm.

2.4.13.2 Sources

2.4.13.2.1 Regional and Local Groundwater Conditions

The primary source of potable water for most municipalities in the site area is Lake Erie. Nearby communities of Perry, Madison-on-the-Lake, Madison, and North Madison are serviced from underground distribution lines. In large part, the Ohio Water Service Company obtains its water supply from Lake Erie. Intermixed to a degree are domestic users with private wells. A distribution line has been added along Center Road to supply the Perry site and residents bordering on Center Road with potable water. Domestic water users beyond the distribution system rely upon groundwater supplied from wells.

In the vicinity of the Perry site, many residential users obtain their water supplies from shallow wells. Most of the well supplies are used for drinking and other domestic purposes. Wells, both drilled and hand dug, generally obtain water from the lacustrine deposits with yields usually less than 5 gpm. Deeper wells into shale yield relatively minor quantities of water. Near Lake Erie, wells penetrating shale commonly encounter salty water, sulphurous water or even gas at shallow depths. An inventory of the users within a two mile radius of the plant site produced 295 water wells. Locations of the wells are shown in <Figure 2.4-66>. A tabulated list of users, groundwater levels, well depths, and yields are given in <Table 2.4-6>. The inventory was compiled by abstracting data from drillers' logs and from interviewing local residents.

A regional groundwater table occurs at the site. Preconstruction groundwater levels ranged from Elevation 624.0' to 613.0'. Very dense, relatively impervious glacial till at a depth of about 25 to 30 feet, acts as a retarding barrier to downward infiltration of precipitation. Water collecting above the till in the surficial silty and clayey fine sand, clayey silt and silty clay lacustrine materials results in a

semi-perched groundwater condition, constituting the main water-bearing zone. Permeable materials within the fine-grained lacustrine deposits are comprised generally of thin layers (a few inches thick) of silty sand. Water levels in observation wells in the lacustrine deposits rise rapidly during and immediately after periods of precipitation, then drop during dry periods. The preconstruction piezometric groundwater surface was approximately three to five feet below the ground surface at the plant location.

The principal direction of groundwater movement is from the plant site toward Lake Erie. Preconstruction groundwater contours in the area of the plant site <Figure 2.4-67> were developed from measurements of static water levels taken in both the test borings and the domestic water wells within a two mile radius of the plant <Figure 2.4-66>. The contours are still representative and indicate a piezometric gradient of approximately 26 ft/mile in a northerly direction toward Lake Erie.

As part of the plant foundation investigation, sealed piezometers were installed in the glacial till deposits and in the underlying bedrock, as described in <Section 2.5.4>. Little water is found in the glacial till overlying the shale. Locally, the shale bedrock receives only very small amounts of recharge because the till serves as a barrier to downward movement of water. Although bedrock surface in the test borings is slightly lower than lake level (Elevation 572.0’ to 556.0’, as compared to Elevation 574.0’), transmission of water from the lake toward the plant site was not evidenced in the borings. Groundwater in the bedrock, affected by very small gradients, flows generally from the plant area toward the lake.

The groundwater level in the site locality was measured in numerous test borings with an observed gradient of 12 to 26 ft/mile. The seasonal variation of the groundwater level, mainly attributable to the amount of precipitation, is expected to be about three feet above to three feet below the mean groundwater level. Groundwater observation wells

installed at the site in 1975 have shown a maximum seasonal variation of 6.4 feet, peak to trough <Section 2.5.4>. A long term continuous water level record was obtained from the Ohio Division of Water for a well at Mentor, Ohio, in Lake County. Although this well is at a considerable distance from the site (approximately 15 miles west), the geologic environs and climatic conditions are quite similar. Observations by automatic recorder were made from April 1948 to August 1970. The record indicates that the maximum seasonal change within the 22 year period was five feet, peak to trough, but the average change was approximately three feet. A total static groundwater decline of approximately two feet was experienced for the 22 year period.

Groundwater migrates toward the natural drainage channels during the wetter periods when the aquifer becomes filled to capacity. The source of water present in the small stream that passed through the plant site prior to construction was principally from effluent collected from drainage tile in the cultivated fields. Groundwater seepage from the lacustrine deposits occurs also along the face of the Lake Erie shoreline bluff.

Groundwater recharge in the plant area is mostly from precipitation rather than inflow from adjacent land. Field permeability tests were performed in the lacustrine materials, the principal water-bearing zone. The average measured horizontal permeabilities ranged from 1.2×10^{-4} to 4.2×10^{-7} cm/sec with an estimated mean value of approximately 1.0×10^{-5} cm/sec. The vertical permeability is estimated to range from 1/5 to 1/50 of the horizontal permeability. A description of the permeability testing program is provided in <Section 2.5.4>.

Several samples of groundwater obtained from the test borings and from the small stream near the site were analyzed for chemical quality. The

groundwater is moderately mineralized and very hard due to calcium bicarbonate. The water is moderately basic with pH values of 7.6 to 8.1. Analyses of the water samples are shown in <Table 2.4-7> and <Table 2.4-8>.

Owing to the generally low yield of usually less than 5 gpm in wells within lacustrine deposits (the water-bearing zone) in Perry and Madison Townships, the number of future groundwater users is not expected to increase greatly. The low permeability ($<10^{-4}$ cm/sec) and the limited storage capacity of the aquifer is expected to minimize the amount of groundwater available for the development of new well supplies.

<Section 2.1.3> estimates the projected population increase to the year 2020 as about 160 homes in the zero to one mile radius and about 820 homes in the one to two mile radius. Past experience in the area has shown that as the home density builds up, the trend has been for water users to elect for the more dependable water service provided by Ohio Water Service Company which obtains most of its water from Lake Erie. As previously stated, Ohio Water Service Company currently supplies water to the surrounding villages of Perry, Madison-on-the-Lake, Madison, and North Madison.

The effect on groundwater flow direction, gradients, rates, and water levels as a result of future groundwater withdrawals are not expected to be significantly altered or to cause groundwater flow reversal in the area outside the site boundary.

2.4.13.2.2 Effects on Groundwater After Construction

A pressure relief underdrain system is installed <Section 2.4.13.5> beneath the primary plant structures to maintain the groundwater level below Elevation 568.0’ after construction in order to reduce the hydrostatic pressures and to increase the dynamic stability of the structures. The radius of influence of groundwater drawdown during

construction has been observed to be less than 500 feet <Section 2.5.4>, a distance well within the project site boundaries. The radius of influence will not be altered significantly after construction. Thus, the effects on groundwater during construction and throughout the plant life will not extend beyond the project site.

2.4.13.3 Accident Effects

The groundwater movement in the general area of the plant <Figure 2.4-66> is to the north toward Lake Erie. As previously stated, the gradient ranges from 12 to 26 ft/mile. Additional withdrawals by future users will be significantly limited by the shallow thickness of the aquifer and the low transmissibility. Local domestic wells outside the exclusion radius are up-gradient from the plant site and will not be affected by the power plant. The low permeability of the glaciolacustrine deposits and of the shale bedrock, together with the low groundwater gradients toward the lake, would severely restrict the movement of water which might contain radioactive particles. Additionally, clay, the main constituent of the soil, has the potential for absorbing radioactive contaminants (Reference 25).

An accidental release of radioactive contamination into the ground at the site is considered to be highly unlikely because of the extensive precautions taken to preclude such an accident. Postulating an accidental release of radioactive materials occurring at the radwaste building of the PNPP, the pumps installed in the pumping manholes of the pressure relief underdrain system will be manually shut off, allowing groundwater to build up to Elevation 590.0 feet within the underdrain system and discharge via the gravity drains to the emergency service water pumphouse and eventually into Lake Erie. In addition, radiation monitors located in the gravity discharge manholes, will automatically stop the service and backup underdrain pumps upon detection of high radioactivity <Section 11.5>. A discussion of postulated radioactive release is included in <Section 15.7>.

Further, assuming an accidental release of radioactive materials was to occur at the radwaste building and was to assume a travel path through the soils, the estimated transit time to the point of discharge into Lake Erie is 25 years if the groundwater was allowed to return to Elevation 620.0'. The maximum groundwater velocity would likely occur within the lacustrine deposits (upper 25 feet) as the underlying tills are relatively impervious. Coefficient of permeability K calculated from field testing within lacustrine materials ranged between 1.2×10^{-4} cm/sec and 4.2×10^{-7} cm/sec, as discussed in <Section 2.5.4>.

The hydraulic gradient was determined from differences in gravitational groundwater levels between the radwaste building and the future protected bluff slope, and the shortest distance between these points. Groundwater levels measured in proximity to the radwaste building (Boring 1-45) averaged about Elevation 620.0'. Near the edge of the bluff, the static groundwater level range occurs at around Elevation 616.0'.

The Perry site has been graded to approximate Elevation 620.0'. The small stream between the plant and the bluff has been relocated and the abandoned channel has been filled with compacted soils to Elevation 620.0'. The maximum difference in groundwater levels expected between the plant and the bluff after completion of the site grading is conservatively estimated at 12 feet; however, the readjusted piezometric slope after grading will likely be much less. The minimum groundwater transit distance will occur when the 1979 bluff, which is approximately 1,010 feet from the radwaste building, has receded about 200 feet <Figure 2.4-39>. On the assumption that 200 feet of recession will actually occur during the life of the PNPP, a conservative distance of 800 feet has been used for establishing the groundwater gradient. For

an added degree of conservatism, a slightly larger coefficient of permeability, 4×10^{-4} cm/sec, was used in the calculation of transit time.

Method of Calculating Transit Time:

Permeability $K = 4 \times 10^{-4}$ cm/sec = 412 ft/yr

Hydraulic gradients $\frac{h}{L} = \frac{12\ \text{ft}}{800\ \text{ft}} = 0.015$

Effective Porosity n = 0.2

The Darcy velocity or specific discharge V is equal to the negative gradient of Kh when K is constant. The true average velocity in the pores of the medium is V/n in which n is the porosity of the medium (Reference 43) (Reference 44).

V = K (gradient h)

V = 412 (0.015)

V = 6.2 ft/yr

$\frac{V}{n} = \frac{6.2}{0.2} = 31.0$ ft/yr

$\frac{800}{31.0} =$ 25 years; Minimum estimated transit time from radwaste building to the receded bluff slope.

Contamination of the groundwater beneath the plant does not present a hazard to public water supplies, as described in <Section 15.7>.

2.4.13.4 Monitoring of Safeguard Requirements

Monitoring and safeguard requirements related to the groundwater fluctuation and hydrostatic uplift pressures under the foundation mats are discussed in <Section 2.4.13.5>. The preoperational and postoperational radiological groundwater monitoring program is discussed in <Section 11.5>.

2.4.13.5 Design Bases for Subsurface Hydrostatic Loadings

Although the pressure relief underdrain system is utilized to reduce the hydrostatic pressure acting on the building structures, all exterior walls and mats of safety class structures in the nuclear island are designed for hydrostatic head due to water elevation of 618.0’ under static conditions. See <Section 2.4.13.5.1> and <Section 3.8.5> for discussion of water levels and design conditions. <Section 2.4.13.5> describes the underdrain system which is designed to prevent full hydrostatic water pressures from exceeding an average elevation of 590.0’. Groundwater fluctuations beneath the site and a discussion of groundwater conditions during and after construction are described in <Section 2.4.13>.

2.4.13.5.1 Pressure Relief Underdrain System Description

The main objective of the pressure relief underdrain system is to ensure that the groundwater level around the nuclear island does not exceed Elevation 590.0 feet. Safety-related structures serviced by the underdrain system are designed to withstand all loading conditions at this maximum level. In addition, the underdrain system provided benefits during construction by dewatering the main plant area

excavation, and providing covering protection to exposed shale surfaces. The performance criteria for the system are presented below:

Design groundwater inflow rate	80 gpm
Hypothetical accident water inflow rate (includes the 80 gpm ground water inflow)	2,000 gpm - maximum
Normal elevation of water table throughout the area of the nuclear island (using pumped discharge)	568.5' - maximum
Accident condition groundwater elevation throughout the area of the nuclear island (using gravity discharge)	590.0' - maximum
Compressive strength of porous concrete	1,000 psi - minimum
Permeability of porous concrete	3 ft/min - minimum

The underdrain system consists of a porous concrete blanket, nominally one foot thick, which underlies all of the structures of the nuclear island. Between some of the buildings and around the perimeter of the nuclear island, the blanket is increased in thickness to incorporate a one foot diameter, porous concrete pipe. The pipe carries the collected water to individual pumps located in manholes on the East and West sides of the nuclear island. The underdrain pumps discharge into the gravity discharge system, and drain to Lake Erie via the emergency service water pumphouse. A layout and cross section of the system is presented in <Figure 2.4-68>, <Figure 2.4-69>, and <Figure 2.4-70>. A flow diagram

of the underdrain system is presented in <Figure 2.4-71>. The pumping and discharge portions of the system incorporate a number of redundant features.

This system includes two discharge systems (pumping and gravity drain). In the pumped discharge system, the design groundwater inflow of 80 gpm flows by gravity through the porous concrete blanket and pipes to collection manholes containing the service underdrain pumps.

Three service underdrain pumps are set to maintain a water surface elevation of 568.0’ or below. If for some reason the pumps fail to start or cannot keep up with the rising water level, then, a high water level alarm will sound in the control room and a backup pump in manhole #6 will automatically start, providing an additional 50 gpm nominal of capacity to the pumping discharge system. If desired, another backup pump (located in manhole #11) can be manually started, but it will also require the installation of a discharge hose. The hose will need to be connected to the discharge of the pump in manhole #11 and temporarily routed to the gravity drain outflow pipe in manhole #10 <Figure 2.4-71>. The temporary hose will prevent recycling of the water flow from manhole #10 back to manhole #11 via the one foot diameter porous concrete piping that connects these two manholes.

Although unlikely, should all of the underdrain service pumps and the backup pumps fail, the groundwater level would rise until it reaches the gravity discharge system which is provided to ensure that the groundwater level around the nuclear island never exceeds Elevation 590.0’. The gravity discharge system is designed to provide a redundant periphery discharge which incorporates a gravity outfall, having no active components, to handle a 15,000 gpm flow entering the underdrain system on either side of the plant. The design basis for the plant underdrain system is described in <Section 2.4.13.5>.

a. Porous Concrete Blanket

A 12-inch thickness of porous concrete was selected as the drainage medium under the plant buildings to help dissipate any pressure increase under the foundations by providing hydraulic continuity. The porous concrete blanket is classified as Seismic Category I, Safety Class 3.

The following design mix for the porous concrete was determined on the basis of a mix suitability program conducted by U.S. Testing Laboratories, at the site, under the direction of Gilbert Associates, Inc.:

Water/Cement Ratio:	0.35 by weight
Aggregate/Cement Ratio:	5.0 by weight
Aggregate Size:	No. 4 to 3/8 in. (pea gravel)

A method of placement tests, using test slabs measuring 4 feet by 4 feet by 1 foot, indicated that concrete placed by free fall with screeding and no compaction yields:

Vertical and horizontal cored cylinder average strength	1,487 psi at 28 days
Vertical and horizontal cored cylinder average permeability	4.27 ft/min at H = 4 in.

Chemical analysis of the groundwater is shown on <Table 2.4-7>. <Table 2.4-8> provides additional data acquired during pumping tests in February 1975. From the relatively low concentration (340 to 1,016 ppm) of dissolved solids, particularly the percentage of sulfates (SO_4) (42 to 186 ppm), it is not anticipated that there will be any significant chemical effects on the porous concrete or the components of the groundwater pumping system. As an additional precaution, Type II cement which is moderately sulfate resistant, was used. The pH range of 7.6-8.1 indicates minimal corrosion effects. The long term performance of the porous concrete underdrain system is discussed in more detail under <Section 2.4.13.5.5>.

Caissons under the north end of the service building and under the fuel handling building have been drilled and or blocked-out through the porous concrete blanket into the shale. Because the caissons are approximately four feet in diameter and spaced on approximate 12 to 25 foot centers, any local disturbance to the porous concrete at the outside edges of the caissons and the loss of porous concrete drainage area occupied by the caissons is minimal, thus ensuring hydraulic continuity within the porous concrete blanket. The 12-inch porous concrete pipe in these areas is located between caisson rows to eliminate the possibility of being disturbed during caisson construction.

b. Class A Fill

Class A fill was placed above and beside the porous concrete wherever it would otherwise come in contact with the natural soil or Class B fill. The Class A fill is designed and utilized to act as a filter blanket to protect the porous concrete from infiltration of fine particles present in the Class B fill and/or existing subsoils. It is also designed to serve as a drainage medium. Class A fill has been placed over the perimeter areas of the porous concrete blanket to an elevation above the upper till to provide a passage for the groundwater flow to the underdrain system <Figure 2.4-70> and <Figure 2.4-72>. Also, a minimum of two feet of Class A fill has been placed against the outside building walls to act as a wall drain.

Both laboratory and field tests of the permeability of the Class A fill were conducted, giving the following results:

	Average Value	Lowest Value
Laboratory test	0.0165 cm/sec	0.00216 cm/sec
Field test	0.0366 cm/sec	0.00945 cm/sec

The capability of the two-foot wall drain using the lowest measured permeability of 0.00216 cm/sec is 0.064 gpm/ft of width. The design basis inflow from groundwater is 0.02 gpm/ft and field observations show it to be much less. Thus, the wall drain has over three times the required capacity.

To further ensure Class A drainage capabilities and long term efficiencies, the following provisions are provided and shown in <Figure 2.4-72> and described below:

1. Below the contact of the lacustrine and upper till strata, the entire backfill zone above the porous concrete was filled with Class A fill.

2. Above the lacustrine/upper till contact, a minimum two-foot wide vertical Class A fill zone was placed along the building structure walls up to three feet below finished plant grade.

3. To monitor the effectiveness of the Class A fill drainage provisions throughout the life of the plant, piezometers were installed in the Class B backfill zone, approximately 15 feet from the main plant structures, one at each of the four sides of the plant, and were placed three feet above the Class A fill.

4. Special provisions were included in the construction drawings and specifications, including strict quality control, to ensure the integrity of the Class A fill drainage provisions. In particular, care was exercised to see that the two-foot wide Class A fill zones along the structure walls and lacustrine slopes adhered to the minimum requirements and were not contaminated with other materials. The pertinent permeability properties of the Class A fill materials placed were tested and documented during construction.

5. A minimum three foot wide filter zone of Class B fill was placed between the Class A fill and the in situ lacustrine soil/upper till interface zone on the bench at the excavation slope. The Class B fill in this zone was required to have no more than 85 percent passing the No. 200 sieve.

6. Where pipelines penetrated the Class A fill, they were completely enveloped with relatively impervious Class B fill at two locations (per pipeline) to produce an effective water stop. In the case of the P-45 pipes entering the Class A fill west of the buried diesel generator fuel oil storage tanks, a cement-bentonite slurry wall (with sheet piling) of two foot minimum width was installed parallel to the pipes in the Class A fill to produce an effective water stop between the pipes and the Class A fill around the tanks.

c. Porous Concrete Pipe

The 12-inch (inside diameter) porous concrete pipe conforms to ASTM C 654-73. The aggregate used to manufacture the pipe is similar in size to that used in the porous concrete blanket to provide uniform voids. The layout of the pipe is shown on <Figure 2.4-68>.

The pipe is located at the base of the excavation around the perimeter of the nuclear island, and beneath some of the other buildings. A 4.5-foot thick layer of porous concrete surrounds the pipe providing adequate strength to protect against static and dynamic loads. Crushing of the encased pipes is highly unlikely. However, assuming crushing does occur, the porous concrete pipe aggregate size (pea gravel) is large enough to prevent groundwater seepage from moving this aggregate into the manholes or from plugging the pipe.

The system operation, however, is not dependent on the integrity or freedom from obstruction of the porous concrete pipes. Water can flow around any obstruction in the pipes and can also enter the manholes through holes in the manhole walls formed by the pipes. Twenty 4-inch diameter weepholes constructed in the base of the manhole walls also provide drainage.

d. Manholes

The same design is used for the manholes of both the underdrain and the gravity discharge system.

Manholes are spaced at intervals around the perimeter of the porous concrete underdrain. Some of the manholes serve as pump sumps and others for inspection purposes <Figure 2.4-68>.

Manholes for inspection and service of underdrain pumps are designed as Seismic Category I structures, as shown in <Figure 2.4-70>. Manholes for the backup underdrain pumps are also designed as Seismic Category I structures. All manholes of the underdrain system are part of the Seismic Category I gravity discharge system <Figure 2.4-69>. All manholes

are designed with gasketed watertight covers, normally locked or bolted in a closed position. Safety ladders are provided in each manhole for access to the drainage pipe.

During the life of the plant, the functioning of the porous concrete underdrain system will be inspected and monitored periodically, and necessary maintenance will be performed. Inspection adits are provided to periodically examine the condition of the in situ shale; these adits are in the bottom of four inspection manholes (2, 4, 8, 14).

A total of 26 reinforced concrete Seismic Category I manholes are used in the system, as shown in <Figure 2.4-69>, 13 of which are part of the porous concrete underdrain system. Manholes are located at each major change in direction (greater than 45 degrees) of the gravity discharge pipe.

e. Pumping System

Two pumping systems are designed into the underdrain system; service underdrain pumps and backup pumps.

Service underdrain pumps have a 50 gpm nominal capacity with integral level switches set to automatically start and stop the pumps.

Each service underdrain pump discharges into the gravity discharge system piping. This piping then discharges into one of two gravity discharge system manholes at the north end of the Unit 1 heater bay.

The backup pumping system consists of two backup underdrain pumps, each a 50 gpm nominal capacity sump pump, mounted in separate manholes set to start if the service underdrain pumps cannot keep up with the rising water level. An alarm will sound in the control room and the backup pump in manhole #6 will automatically start if the water reaches the starting setpoint of the pump. Another backup pump (located in manhole #11) can be manually started, but it will require the installation of a discharge hose that is temporarily routed to the gravity drain outflow pipe in manhole #10 <Figure 2.4-71>. The temporary hose will prevent recycling of the water flow from manhole #10 back to manhole #11 via the one foot diameter porous concrete piping that connects these two manholes.

The discharge from the backup pumps is also routed to the manholes located in the gravity discharge system just north of the Unit 1 heater bay <Figure 2.4-68>. The discharge flow from the two manholes at the north end of the Unit 1 heater bay is by gravity to the emergency service water pumphouse.

The discharge lines from all underdrain pumps are configured so that backflow from the gravity discharge system cannot occur. All active electrical components are qualified to operate in the presence of volatile air/fuel mixtures, including methane.

f. Gravity Drain System

A Seismic Category I gravity discharge system is placed around the perimeter of the Perry Nuclear Power Plant, as shown on <Figure 2.4-69>.

This system is designed to act as a nonmechanical backup system if the inflow rates through the underdrain system are in excess of the pumping capability (such as for a yard circulating water pipe break), or if the service or backup pumps fail to operate.

The high points of the gravity discharge system are located in two manholes near the south wall of the Unit 2 turbine room where the discharge pipe is set at an invert elevation of 588.0'. Each of the 36-inch diameter pipes routed around the southeast and southwest sides of the plant are designed to handle a nominal 12,000 gpm flow.

The pipe is placed on a 0.005 ft/ft slope around the plant perimeter at an approximate mean invert elevation of 585.0', which is about 20 ft above the porous concrete underdrain system, but below the normal groundwater elevation of 618.0'. The pipe increases in size as it slopes in a northern direction until it reaches its maximum diameter of 48 inches at the north end of the plant. These pipes are large enough to handle a total 15,000 gpm flow from the east or west sides of the plant.

The 15,000 gpm flow capacity includes an allowance for a sludge buildup of 18" in the 48" gravity drain lines between manhole number 20 and the emergency service water pumphouse and/or manhole number 23 and the emergency service water pumphouse, as noted on <Figure 2.4-71>. The gravity drain system need only have a capacity sufficient to maintain groundwater elevation below Elevation 590.0' in order to perform its safety related function. This is accomplished with a gravity drain flow rate of greater than or equal to 1929 gpm which is equal to the maximum calculated inflow to the system following a design basis yard break in the circulating water pipe. Therefore, the gravity drain system has a large operating margin, since there is no postulated event which would cause the inflow to the system to exceed 2,000 gpm.

The peripheral piping of the gravity discharge system is a closed loop, with two discharge points at an approximate invert elevation of 580.7' located in manholes beyond the NE and NW corners of the Unit 1 heater bay.

From each of these interconnected manholes, the water would flow by gravity through two pipes to the emergency service water pumphouse at a slope of 0.005 ft/ft. The water would free fall into the pumping pool at a pipe invert elevation of 579.0' which is four feet above high mean lake level. The purpose of the dual discharge lines is to provide redundancy. The complete system is designed as a Seismic Category I system.

The top of the gravity discharge pipes entering the emergency service water pumphouse is at Elevation 583.0' which is high enough above maximum lake setup conditions to permit gravity discharge from the underdrain system under the design groundwater flow condition.

Because the system is designed to flow at velocities slightly above critical, hydraulic jumps may occur at junctions and bends in the pipeline. These jumps, if formed, will never exceed a height of eight inches. Although technically a hydraulic jump, it will take the form of a small undular wave, and will not impair the ability of the pipe to carry the design flow.

The drain pipe material is carbon steel pipe, coated and wrapped, conforming to ASME SA-106, Grade B, similar to the emergency service water piping discussed in more detail in <Section 9.2.1.2>. The next commercially available pipe wall thickness above the calculated thickness was chosen to allow for any corrosion.

The pipe selected is designed to withstand dynamic loads obtained from the analysis specified in <Section 3.7.3> in combination with static soil pressures.

2.4.13.5.2 System Design Basis

The underdrain and gravity discharge system is designed to prevent the buildup of hydrostatic pressures under the building foundations from exceeding a condition equivalent to a static water surface elevation of 590.0'. To accomplish this, the system is designed to handle a flow of 15,000 gpm.

The underdrain system was originally designed to handle a much larger volume of water than exists for the present design. The original design provided for discharging a maximum inflow rate of 30,000 gpm through the gravity discharge system, keeping the level of water stored in the underdrain system below the static water surface elevation of 590.0'. The stated inflow rate was calculated for the postulated rupture of the circulating water pipes in both Units 1 and 2 turbine buildings with subsequent failure of both turbine building floors. Under the present design, the complete volume of water which must be handled for a rupture of the circulating water pipes in the Unit 1 turbine building can be stored within the buildings and underdrain system below the static water surface elevation of 590.0' <Table 2.4-9> and <Table 2.4-10>. Some water could enter the gravity discharge system, but the discharge system would no longer be important in keeping the static water surface levels below Elevation 590.0'.

The design basis accidents (DBA) assumed for the underdrain system are (1) a yard break in the circulating water pipe outside the plant near the steam tunnels and auxiliary buildings, or (2) failed expansion joints occurring inside the turbine building via flow through a fracture in the building base mat.

The volume of water, which could potentially flood the turbine building complex and underdrain system, is presented in <Table 2.4-9>.

The service water (cooling tower make-up) inflow is added via the service water pumps <Section 10.4.5>. The water from the service water make-up would be shut off by the use of safety class valves activated by a signal from water level indicators in the turbine building. Based on the DBA scenario with four expansion joints failing, approximately 80 seconds would elapse from expansion joint failure until the signal is activated. Allowing additional time for operation of the valves, approximately 84,000 gallons at 56,000 gpm would enter the cooling tower basin and eventually the turbine building.

The free storage volumes, and their respective elevations, available within the buildings and the underdrain system are listed in <Table 2.4-10>. They were calculated from detailed plant layout and as-built drawings.

To provide the maximum amount of free storage within the turbine building complex, a number of the turbine building penetrations are designed to allow flooding of the adjacent heater bay and condensate demineralizer buildings. The offgas building would not be flooded. For the worst case analysis, the turbine building floors are assumed to fracture, filling the underdrain system.

At Elevation 590.0’, as shown in <Table 2.4-10>, the available free storage volumes within the buildings and underdrain system exceeds the volume of water which can fill it <Table 2.4-9> and thus the water level would remain below the static water surface elevation of 590.0’.

A discussion of the design basis accident involving a postulated expansion joint failure without the turbine building mat fracture and a yard break of the circulating water piping outside of the plant buildings is included in <Section 10.4.5>.

Emergency pumps are provided to remove water from the turbine building area. These pumps would only be used to hasten the removal of water from the building complex and are not essential to the DBA analysis.

A yard break of the circulating water piping outside of the plant buildings would have the greatest impact if it occurred directly above the Class A fill adjacent to the steam tunnel and auxiliary buildings. Based on the analysis of seismic stresses in the 12 foot diameter reinforced fiber-glass pipe, failure during the SSE is not predicted. However, if a rupture is assumed to occur it would most likely be a tensile failure in one of the straight runs, which would result in a momentary helical or circumferential gap of 1.2 inches.

The jet of water escaping from the pipe could conceivably cause a significant amount of scour. In order to determine reasonable limits of scour, a helical or circumferential break as described above was assumed to occur. The velocity of the resulting jet of escaping water was then analyzed to find at what distance the velocity would be too low to scour the surrounding bedding materials. The analysis assumed a round jet with a diameter equal to the gap in the pipe.

The jet velocity at the break was calculated to be 50 fps. At a distance of eleven feet from the pipe, the calculated centerline velocity was reduced to less than 3 fps. Velocities this low are generally regarded as nonscouring velocities in the design of earth drainage ditches in all but the finest grained materials (Reference 48). It was assumed that the scour hole created by the jet would extend twelve feet from the circumference of the pipe. The actual distance would be less than this because the jet velocity at this distance was shown to be low, and also because the analysis does not take into account the effect of water instead of air surrounding the jet and the effect of armouring. Armouring is the process which occurs in natural streams where the smaller particles are eroded leaving the larger particles which form a protective blanket over the stream bed.

The scour caused by the break is of concern because the removal of bedding material around the pipe would shorten the flow path for seepage into the underdrain, thereby increasing the potential inflow rate. The inflow rate was analyzed using a groundwater seepage analysis. The inflow calculation utilized the full hydrostatic pressure difference of 620-572 = 48 feet across the Class A fill material between the scour hole and the top of the porous concrete layer.

Assuming a yard break of the circulating water piping outside of the plant buildings, the inflow rate to the underdrain system was conservatively calculated to be approximately 4.3 cfs. Water level within the underdrain system may rise to the level of this gravity discharge system even with the underdrain system pumps operating, depending on the actual inflow rate. At the calculated maximum inflow rate of 4.5 cfs the inflow rate will exceed the capacity of the underdrain system pumps.

The resulting hydrostatic pressures beneath the building foundations would be equal to or lower than the design basis static water elevation of 590.0’.

2.4.13.5.3 Monitoring Program

a. Groundwater Inflow

During construction, groundwater inflow to the plant excavation was monitored at intervals for a period of at least 1 year in order to verify the degree of conservatism of the calculated inflow. It was estimated that, during this time, the groundwater inflow would be on the order of 4 gpm (Reference 59). During preoperational testing, groundwater inflow to the plant underdrain system was measured at 11.7 gpm.

b. Water Table

To monitor the groundwater table outside the nuclear island and within the site boundary, four arrays of piezometers were installed during construction in each of the four compass directions up to a maximum distance of 1,000 feet. The locations of the piezometers were chosen so that the groundwater drawdown profiles during construction and throughout the plant life could be established and are shown on <Figure 2.5-186>. Four piezometers are installed in the backfill zone shown on <Figure 2.4-72>. The types of piezometers are open standpipe type or porous tube type (Casagrande type). A brief description of the piezometers can be found in Foundation Instrumentation by T. H. Hanna (Reference 49).

The groundwater monitoring was conducted on a more frequent basis initially, so that the seasonal fluctuation could be established. After that, the groundwater level was measured on a regular basis. Regular monitoring will continue during the life of the plant.

The seasonal fluctuations in groundwater level were minimal. As expected, a slight drop in groundwater level occurred but did not exceed more than 3 to 5 feet in proximity to the excavation and did not represent a significant change from preconstruction groundwater levels.

c. Methane Gas

The presence of methane gas was monitored by portable detection equipment at regular intervals during the plant excavation, beyond an approximate depth of 30 feet from existing grade. Procedures will require that all manholes and the gravity drainage pipe be monitored prior to entry by personnel and be ventilated by portable equipment, if necessary <Section 2.5.4>.

d. Hydrostatic Pressure Under Foundation Mats

To measure the hydrostatic uplift pressure acting under the safety class buildings, piezometers have been installed through each of the building mats of the auxiliary buildings, control complex, intermediate building, and radwaste building. The pressure monitoring piezometers are open standpipe type. The bases for selecting these devices are primarily because of their long term reliability and (Reference 49). Details of the piezometer installations are shown in <Figure 2.4-76>.

Piezometer measurements will be taken at the following frequencies to monitor system operation:

Quarterly basis - Fuel load to 5 years after Commercial Operation Unit No. 1.

Semiannual basis - 5 years after Commercial Operation Unit 1 to decommissioning of Plant.

e. Radioactivity

The possibility of release of radioactive material from plant buildings to the pressure relief underdrain system has been considered. Postulated mechanisms include: (1) the transport of radioactive liquid from sumps to the underdrain system by leakage through small cracks in the sump liners and floors; (2) the onset of a seismic event resulting in the simultaneous failure of one Seismic Category I radioactive waste tank and cracking of a Seismic Category I safety class building, resulting in release of radioactive material to the underdrain system. It is considered highly improbable for significant cracks to develop in a Seismic Category I building and Seismic Category I radioactive waste tank.

In order to continuously monitor and detect significant amounts of radioactive concentrations discharging from the underdrain system, as a result of the postulated event, radiation monitors are located inside each of the two gravity discharge system manholes at the north end of the Unit 1 heater bay, at locations where the underdrain pump effluent travels through the gravity drain system. Details of the radiation monitor are discussed in <Section 11.5>.

The offsite effects of a hypothetical release, due to a seismic event, of radioactive liquids to the environs is described in <Section 15.7>.

2.4.13.5.4 Maintenance and Testing

Normal routine maintenance will be performed on the mechanical and electrical portions of the system. The manholes and gravity discharge pipes will be inspected annually to insure that all parts of the system, including the porous piping, are in operating condition. Any blockage in the porous concrete periphery drain pipes will be cleared by mechanical or other suitable means. The following periodic tests will be performed to ensure continuous satisfactory performance of the system.

a. Continuity Test

This test will be performed semiannually for the first five years of operation and annually thereafter. The objective of the test is to verify that water will build up and draw down at the monitoring points, to establish that the underdrain system can reduce the hydrostatic pressure on building foundations to the desired level.

b. Groundwater Inflow Test

This test will be performed semiannually in the spring and fall. The objective of the test is to verify that the total inflow of groundwater into the porous concrete underdrain system does not exceed a rate of 80 gpm.

The test program for the permanent pumped discharge system is discussed in <Chapter 14>.

2.4.13.5.5 Safety Evaluation

During the design and licensing process, numerous studies were performed to evaluate the performance of the underdrain system. The studies which follow are listed below for easy reference:

a. Groundwater recovery.

b. Permeability tests of porous concrete.

c. Long term performance of the porous concrete underdrain system.

    1. Tornados.

    2. Earthquakes.

    3. PMP (Probable Maximum Precipitation).

    4. Clogging potential.

    5. Potential flooding.

    6. Biological effects on porous concrete.

7. Physicochemical weathering of the Chagrin shale and lower till underlying the site.

d. Potential of the underdrain system to drain water from Lake Erie or along plant piping systems.

e. Infiltration due to rainfall, surface spills or lawn sprinkling.

f. Seepage increase due to excavation.

g. Pressure distribution within the porous concrete blanket under design flow conditions.

h. Evaluation of the probability of and the hydraulic consequences of an accidental clogging of the underdrain system.

i. Evaluation of the effect of non-Seismic Category I structures on the performance of the permanent dewatering system.

a. Groundwater Recovery

The groundwater recovery is calculated on the assumption that no pump is working and there is no other inflow but groundwater. An initial conservative inflow was estimated to be a maximum of 0.02 gpm per lineal foot of excavation. With the perimeter of excavation roughly equal to 4,000 feet, the total inflow at the plant would be a maximum of 80 gpm (design basis) under steady-state conditions. During construction, however, seepage into the excavation was estimated to be on the order of 4 gpm <Section 2.5.4>.

The total volume of the backfill around the plant island is conservatively calculated to be 11,340,000 cu ft. This backfill consists of porous concrete, Class A fill of coarse sand and gravel, and Class B fill of excavated lower till. <Figure 2.4-72> is a typical section of the backfill configuration. The porous concrete has an average porosity of 0.338 based on laboratory test results, while the porosity of the Class A and Class B fill are calculated to be about 0.25 and 0.32, respectively. The porosity is expressed by

$$n = \frac{V_{void}}{V}.$$

Assuming that the backfill zone possesses some moisture, the average porosity of 0.15 is available to become saturated. Therefore, in order for the groundwater level to recover to design basis flood Elevation 618.0', a total volume of voids of 1,700,000 cu ft must be filled with groundwater seepage. With the groundwater inflow at the design rate of 80 gpm, the time required is 110 days. <Figure 2.4-73> shows the groundwater recovery as a function of time.

The transient effect on the reduction of inflow rate due to the groundwater recovery has not been taken into consideration. If this effect is considered, the predicted recovery time will be longer than 110 days.

b. Permeability Tests of Porous Concrete

Permeability tests on porous concrete cylinders were performed in accordance with a modified version ASTM D 2434, "Constant Head Permeability Test for Granular Soils," to determine the coefficient of permeability of the porous concrete. This method of determination of the permeability is utilized for clean, coarse

grain soils. This test was deemed applicable because porous concrete could be characterized as a granular material.

A special permeameter for the determination of the coefficient of permeability of concrete test cylinders and test cores was designed and fabricated by U.S. Testing Laboratories, Inc. of Cleveland, Ohio. The basic design features of the primary permeability test apparatus is illustrated graphically in <Figure 2.4-74>.

The permeability tests of horizontal and vertical cored porous concrete cylinders obtained from the free fall test slab were also performed under this procedure (ASTM D 2434). The test results are shown in <Table 2.4-13>.

To examine the gravitational effect on the permeability tests which followed the normal procedures outlined in ASTM D 2434, reverse-flow permeability tests were performed on porous concrete cylinders cored from the same free fall test slab. The hydraulic grade line at the bottom of the test cylinder was maintained at a higher elevation than the water level at the top of the cylinder during the test so that water was forced to flow through the porous concrete specimen from the bottom to the collecting plexiglass tube. By performing the reverse-flow permeability test, not only could the gravitational effect be eliminated, but also the saturation of the cylinder could be assured. A schematic figure of the testing setup and flow path is shown in <Figure 2.4-75>. Three of these tests were performed on each of the cored cylinders (a horizontal core and a vertical core). The test results are shown in <Table 2.4-13>. Based on these results, the minimum design permeability of 3 ft/min can readily be achieved.

c. Long Term Performance of the Porous Concrete Underdrain System

The long term performance of the porous concrete pressure relief underdrain system is evaluated as follows:

1. Tornados

Tornados will not affect the operation of the underdrain system because it is underground. However, the manhole covers are exposed but are not considered missile proof because a missile entering the top of a manhole would not totally obstruct the flow of water in the manhole.

2. Earthquakes

The system is a Seismic Category I system. The seismic design and analysis for the gravity discharge pipe is discussed in <Section 2.4.13.5.1>. The seismic design and analysis for manholes is discussed in <Section 3.8.4>.

3. PMP (Probable Maximum Precipitation)

The effect of PMP on the underdrain system is negligible. Around the nuclear island buildings, the ground surface will be paved with asphalt or backfilled with relatively impervious Class B fill of excavated lower till soils. The rate of infiltration through the Class B fill is calculated to be less than 3 gpm and the effect on the underdrain system is insignificant.

4. Clogging Potential

A potential for blockage within the porous concrete drainage blanket would exist if the intrusion of a significant amount of fines into the blanket during the life of the plant could be postulated. A potential source of such fines is the weathering products of the shale subgrade. Consideration of this phenomena has been given in the design and construction of the subdrainage system and safeguards have been incorporated as described below.

(a) Construction Considerations

To preclude the presence of subgrade materials which have the potential to intrude the porous concrete, special subgrade preparations were incorporated during construction. These preparations included the following procedures:

(1) Construction dewatering was utilized to control deposition of sediment on the subgrade.

(2) All decomposed, excessively fractured, broken and friable or otherwise unsuitable shale was removed to expose the intact, essentially unaltered shale bearing surface.

(3) Immediately prior to placing the protective porous concrete mat, the shale surface was scaled and cleaned to remove remaining loosened or slaked materials.

(4) The shale surface was carefully examined and a detailed geologic map prepared. Any open fissures in the shale surface were sealed by slush grouting.

(5) Excavations to or into the Chagrin shale were made with a minimal disturbance of the in situ shale; i.e., blasting was minimized or avoided to the extent practicable. Exposed fresh shale was stripped, cleaned, inspected and mapped. All degraded and weathered material was removed. Joints and fractures were flushed of weathered and degraded materials. Measures taken to seal and grout the source of the seeps were not necessary because none were detected. All groutable fractures and joints were sealed by slush grouting.

(6) The structural performance of the porous concrete over the plant life is related to its strength and durability. See <Section 3.8.5> for a further discussion of porous concrete strength. The durability of the proposed mix has been considered in three parts:

- Temperature: freeze-thaw cycles will not occur due to the relatively constant, above freezing temperatures which exist at the porous concrete system elevation (approximately 55 feet below plant grade).

- Sulfate Attack: the sulfate content of the water is low. Type II cement, which is moderately sulfate resistant, was used to minimize concern. The groundwater sulfate content ranges from 42 to 186 ppm

<Table 2.4-7> and <Table 2.4-8>. Type II cement effectively resists sulfate concentrations from 150 to 1,000 ppm.

- The pH value of the groundwater is 7.6 to 8.1, which eliminates concern for acid attack <Table 2.4-7> and <Table 2.4-8>.

(b) Design Considerations

To prevent intrusion of fines from the natural subsoils or from the Class B backfill, the free draining Class A fill is designed to serve as a filter zone as well as a drainage medium. The gradation requirement is as follows:

U.S. Standard Sieve Size	Percent Passing by Dry Weight
2″	100
3/4″	85-100
No. 4	60-100
No. 10	43-80
No. 40	16-45
No. 200	0-5

In addition, the uniformity coefficient (D_{60}/D_{10}) was specified to be not less than 4 nor greater than 20 and the minimum permeability coefficient is 2×10^{-4} cm/sec.

Within the excavation limits outside of the foundation mats, where the vast majority of groundwater inflow enters the underdrain system, Class A fill is placed over the porous concrete to an elevation above the upper till. This will prevent the migration into the subdrainage system of fine materials from either Class B fill or upper soil layers. Therefore, the porous concrete

blanket will always be separated from natural subsoils or Class B backfill by Class A fill. The filtering characteristics of Class A fill (filter) satisfy the requirements for filters stated by Taylor (Reference 50).

$$\frac{D_{15}\text{ Filter Material}}{D_{85}\text{ Fine Material}} < (4\text{ or }5) < \frac{D_{15}\text{ Filter Material}}{D_{15}\text{ Fine Material}}$$

<u>NOTE</u>: D_{15} and D_{85} are the particle sizes from grain size distribution curves at 15 percent and 85 percent finer by weight, respectively.

The aggregate used in making the porous concrete ranges in size from 3/8” to No. 4 (pea gravel size). The pores in the porous concrete are smaller than D_{85} of Class A fill. The criterion

$$\frac{D_{85}\text{ of Class A}}{\text{Pore Diameter}} > 1.0$$

will prevent any migration of Class A material from entering the porous concrete drainage blanket.

(c) Potential Clogging Due To Shale Alteration

Development of subgrade fines by weathering of the shale during the 40-year life of the plant has been considered not to be a credible probability as discussed in the following paragraphs.

The principal clay mineral of Chagrin shale is illite; quartz is the second most abundant as demonstrated by the test results discussed in <Section 2.5.4>. These minerals in the prevailing and anticipated environment are not subject to rapid weathering through the mechanism

of interlayer collapse as would be brought about by an ion exchange reaction where interlayer K^+ ions are exchanged with Mg^{2+} ions, altering illite to montmorillonite.

When clay minerals such as illite are formed as a result of alteration of non-clay minerals (as is the case for the Chagrin shale), the mineral is stable in the prevailing environment (Reference 51). The pH of the groundwater has a strong influence on the ion exchange susceptibility in a given environment if the pH changes to below 5 and above 10. This may cause the ion exchangers to become soluble and induce clay structure changes. As shown in <Table 2.4-7> and <Table 2.4-8>, the pH of representative water samples taken from the Perry site ranges from 7.6 to 8.1. There is no reason to anticipate a significant change in the groundwater pH during the plant life.

Illite is stable in an aqueous environment where the ratio of the potassium ion to the hydrogen ion is high (Reference 52). Such a high ratio would be expected in the Chagrin shale. Clay minerals once formed do not change in chemical composition readily since clay mineral transformation is a slow process; 10^3 years is considered rapid whereas typical rates are 10^5 to 10^6 years.

Oxidation of minerals also causes weathering, and iron is the element most commonly oxidized in a weathering environment. The oxygen dissolved in groundwater is the oxidizing agent. The iron as Fe^{2+} in minerals is converted to Fe^{3+} which disrupts the electrostatic neutrality of the mineral crystals causing collapse or additional weathering.

Since chemical analysis of Chagrin shale by Lamborn, et al. (Reference 52) indicate iron oxides comprise less than ten percent of the shale composition, oxidation of iron as a weathering process in Chagrin shale is not considered to be a significant consideration.

In summary, clogging due to alteration of the fresh Chagrin shale, on which the porous concrete drainage mat was placed, is not expected to occur during the life of the plant.

5. Potential Flooding

Potential flooding of the underdrain system, caused by a highly improbable event such as an SSE, has been considered <Section 2.4.13.5.2>.

6. Biological Effects on Porous Concrete

Biological organisms of the types that are likely to occur in the porous concrete underdrain system can be classified as aerobic, anaerobic or chemolithotropic depending on their need for oxygen or nutrients. Other conditions that must be satisfied in order to permit growth include adaptable pH and temperature environments.

The biological water quality data have been obtained from a test well at the site of the PNPP, approximately 400 feet from the plant. The well penetrates all strata into and including the bedrock and, therefore, represents the groundwater makeup that has been entering the porous concrete. The analysis was performed by Herron Testing Laboratories, Inc., Cleveland, Ohio, and is listed in <Table 2.4-11>.

Upon examination of the biological and physical/chemical characteristics of the water, as shown in <Table 2.4-7> and <Table 2.4-8> and the data above, it is considered highly unlikely that a significant number of organisms could develop under such conditions unless additional supplies of oxygen and nutrients were made available from either an air/water interface or a pollution source. The porous concrete under the safety class buildings will be maintained in a fully saturated condition at all times by the level control switches in the pumping manholes. Of the limited number (3) of chemolithotrophic nuisance organisms known to be able to exist in the type of environment considered, two could not tolerate the alkaline pH conditions and the other requires more Ferric iron than is presently known to exist. In addition, the supply and balance of nutrients are such that maintenance of any viable culture of filamentous or nuisance micro-organisms is highly unlikely.

It is not considered likely that any organisms could develop in the porous concrete under the safety class buildings. It is possible for organisms to grow in the manholes and gravity discharge pipes. Chemical biocides will be used, as necessary, to maintain system operability under conditions that control the effluent within prescribed limits.

7. Physicochemical Weathering of the Chagrin Shale and Lower Till Underlying the Site

In ascertaining the short and long term physicochemical stability and weathering potential of the Chagrin shale and lower till, it is necessary to consider the controls of weathering on mineralogical components as well as the in situ shale bedrock and lower till. Typical controls include pH, redox potential, ionic potential, and temperature, and the

effects of these controls on the shale and till as they equilibrate to subsequent environmental conditions during excavation and construction. Fresh, unweathered rock core and till samples were consistently obtained during the extensive subsurface exploratory investigations preceding excavation during both the preliminary and preconstruction drilling programs. The competence and lack of physicochemical effects of shale and till indicate that the physical and chemical quality of groundwater has not caused any appreciable decomposition or disintegration of the rock and till forming minerals.

(a) Petrographic Analyses

Results of the petrographic analyses demonstrate that the dominant component of the Chagrin shale is an illite-chlorite matrix, comprising from 18 to 76 percent of the test specimens by volume. An X-ray diffraction analysis was conducted on materials finer than two microns which were derived from the illite-chlorite matrix of the test samples. The composition of the matrix minerals was computed from diffractograms developed with a General Electric X-ray diffraction unit using filtered radiation. The results of the X-ray diffraction test indicate the illite clay mineral dominates the illite-chlorite matrix in rates ranging from 9/1 to 1.270/1.

Lower till mineralogical components are comparable to Chagrin shale. The conspicuous lack of montmorillonite clay within the shale similarly characterizes the lower till.

(b) Cation Exchange Capacities

Factors to be considered in discussing the ion exchange status of rocks and till materials include their porosity and permeability, and ability to permit the flow of groundwater. Further, the chemical character of the migrating groundwater, the cation exchange medium, must also be considered. In impervious media such as the Chagrin shale and lower till, minimal ionic exchange is expected to occur. Although increased ionic exchange will occur in fractured rock, which exposes greater surface area to migrating groundwater, this condition does not exist in bedrock underlying the Perry site.

During excavation to bedrock, all loose and fractured rock debris was removed. The fresh, unweathered shale was protected from both physical and chemical weathering during the interim subsequent to excavation but preceding foundation construction.

As shown in <Section 2.5.4>, data are in agreement that the Chagrin shale and lower till are characterized by exceedingly low porosity and permeability. Minimal groundwater flow is restricted to generally tight fractures, oriented parallel and inclined with respect to bedding in the shale.

Chemical and physical quality of groundwater occurring at the bedrock foundation interface will control the minimal cation exchange capacities. The primary shale mineral components, illite and chlorite, have the greatest relative cation exchange capacity. Carroll

(Reference 53) has reported on the characteristics of these constituents and the results of this investigation are discussed below.

Ranges in cation exchange capacities for illite clays are 10 to 40 milliequivalents per 100 grams. Illite consists of tetrahedral and octahedral sheets combined so that the tips of the tetrahedral of each silica sheet and one of the hydroxyl layers of the octahedral sheet form a common layer. Muscovite, another dioctahedral mica, similarly has a small exchange capacity since the negative charge, as in illite, is neutralized by K^+, and no significant exchangeable cations are present.

While no firm data are available on the exchange capacity of chlorite, isomorphic substitutions in the brucite layers (trioctahedral) are considered likely, and the cation exchange capacity in milliequivalents is similar to that of illite. However, all of the above mineral constituents as well as quartz, the other primary Chagrin shale component, are markedly stable under the prevailing alkaline conditions, groundwater temperatures (approximately 54°F), and low pressures.

Several typical substitutions which may be possible from the above minerals resulting in net increases of groundwater cation concentrations are as follows: (1) in the case of muscovite, theoretically, isomorphous substitutions can occur in both the silica tetrahedral and the alumina octahedral and specifically of Al^{+3} for Si^{+4}; (2) in illite there is less substitution of Al^{+3} for Si^{+4} than in muscovite and therefore the net charge deficiency is somewhat less. The K^+ ions between units are not sufficient to neutralize all the charge and other

cations such as Ca^{+2}, Mg^{+2} and H^{+} (but the latter only under acidic conditions) may be present in the interunit structure (Reference 3). In the mixed layer structure of chlorite, considerable substitution can occur in the brucite layer (trioctahedral) situated between each montmorillonite-like layer just as muscovite is derived by the insertion of a layer of potassium ions. For example, Al^{+3}, Fe^{+2} Cr^{+3} will exchange for Al^{+3}. Al^{+3} and Fe^{+3} can also be exchanged for Si^{+4} in silica tetrahedral or chlorite.

Leaching of metallic ions from clay minerals can occur under acidic conditions in exchange for alkalic ions, but would not occur under existing conditions. In general, the illite clays including muscovite tend to be fixers of potassium. On the basis of data gathered to date, there is no evidence suggesting that the Chagrin shale is affecting groundwater such that the chemical and physical character of these waters would adversely affect Type II cement. Chemical and physical groundwater quality are as shown in <Table 2.4-7> and <Table 2.4-8>.

Cation exchange capacities for Chagrin shale and lower till samples range from 4.74 to 23.40 MEQ/100 grams. These values are as anticipated for the mineralogical constituents. Reported exchange capacities for shale, although low, possibly exceed in situ shale bedrock by a factor of ten, because testing was conducted on crushed rock core samples passing through a sieve retaining particles 2.0 mm or greater in diameter. Similarly, the reported exchange capacities for the till samples are presumed to be higher than that of the in situ lower till.

(c) Mineral Stability

The mineral components comprising the Chagrin shale and lower till are presumed to constitute a stable assemblage at a shallow crustal temperature and pressure environment. Other marine shales and siltstones of upper Devonian age, such as the Trimmers Rock Formation of northeastern Pennsylvania with a comparable mineralogical character and geologic setting, similarly have resisted subsurface disintegration and decomposition. All minerals of the Chagrin shale lie within their respective stability fields for the prevailing low pressure and temperature, and alkaline environment characterizing groundwater at the Perry site.

(d) Subsurface Erosion Potential

The potential for subsurface erosion and drainage through piping with lateral and vertical transport of lower till and Chagrin shale detritus is considered exceedingly remote, if not impossible. Features indicative of this condition such as pseudokarst topography with sinkhole and natural bridge development as well as massive landslides and landslide scars are not present at the Perry site, and none are known to occur in proximity to the site. Neither incipient nor well developed surface cracks (e.g., desiccation-stress cracks) at the Perry site have been observed or reported in the literature. Summarily, there are no known geomorphological features suggesting direct or indirect evidence of subsurface erosion and piping.

Falling head permeability testing conducted at the Perry site, reported in <Section 2.5.4>, further shows that the

velocity and transport capability of groundwater to erode either Chagrin shale or lower till are negligible. The durability of the shale and its ability to resist subaqueous disintegration and decomposition have been documented by slaking tests and are discussed in <Section 2.5.4>. Lower till is nondispersive as demonstrated by the pinhole and soil conservation service laboratory dispersion test <Section 2.5.4>.

The association of lower till and Chagrin shale properties, coupled with their demonstrated ability to withstand subsurface weathering and erosion during the Recent Epoch, show that no basis exists for assuming a subsurface erosion potential. A conspicuous absence at the Perry site of montmorillonite-type clays, which are characteristically detected in overburden and bedrock undergoing subsurface erosion as well as extensive surface erosion, is considered significant positive evidence in further refutation of this potential.

d. Potential of the Underdrain System to Drain Water From Lake Erie or Along Plant Piping Systems

All piping except the underdrain system gravity flow discharge pipes running from the main plant buildings to the emergency service water pumphouse are designed and installed above Elevation 595.0’ (i.e., 20 feet above the mean high water level for Lake Erie). The gravity discharge lines enter the emergency service water pumphouse at invert Elevation 579.0’ which is approximately four feet above mean high lake level. This ensures that no man-made flow path will exist between the pumphouses and the main plant buildings.

The lowest discharge points from any of the 13 deep plant manholes of the porous concrete underdrain system are at manholes No. 8 and 9 which have pipe invert elevations of 582.6’ and 583.5’, respectively <Figure 2.4-69>. Since these gravity discharge pipe inverts are above the maximum lake setup due to the PMS (580.5’), no backflow from the lake can occur through the Emergency Service Water Pumphouse into the porous concrete underdrain system.

The mean high water level for Lake Erie is Elevation 575.0’ which is seven feet above the groundwater level of 568.0’ maintained in the underdrain system. Because the plant is 800 feet from the lake, the possibility of seepage from the lake into the underdrain was considered.

Geologic mapping of the foundation area was conducted, and open fractures were grouted. None were seepage sources. In this way, all possible drainage paths from the lake into the underdrain systems were sealed.

Underground piping systems, which enter the main plant buildings, were set in bedding materials of granular material which have a higher permeability than the lacustrine soil through which the pipes run, and hence, provide a potential flow path for groundwater into the underdrain system. In order to prevent this flow, at two separate locations special bedding and backfill material were used around all external pipes where they enter the Class A fill at the plant buildings. The special bedding and backfill material is low permeability Class B fill.

The quantity that can flow through the backfill and bedding was included in the calculation of total groundwater flow into the underdrain system. The flow postulated through the pipe bedding material would not increase the calculated inflow to the underdrain system because that calculation assumes a saturated soil.

e. Infiltration Due to Rainfall, Surface Spills or Lawn Sprinkling

A layer of impervious Class B soil was placed over the Class A fill to reduce the amount of seepage possible from infiltration at the surface. Such seepage could result from either rainfall, surface spills, or lawn irrigation.

All underdrain system manholes have gasketed, watertight covers installed at the surface. The covers are normally locked or bolted in a closed position. The 24 outside manholes (two manholes constructed inside buildings) have heavy duty gray cast iron covers. In paved areas, the covers are installed at grade. In unpaved areas, the covers are up to six inches above grade.

In the event of the rupture or leakage of an onsite reservoir (e.g., cooling tower basins and industrial waste lagoons), the discharge will drain overland away from the plant into neighboring streams and thus to Lake Erie. The area surrounding the plant is drained by a catch basin storm drainage system which will immediately collect all surface water approaching the plant. Because of the impermeable nature of the surface materials, there will not be sufficient time available to allow significant infiltration into the permanent underdrain system.

<Table 2.4-12> summarizes the major onsite storage facilities excluding the cooling tower basins.

Roofs of all buildings are drained to the storm water drainage system which discharges into natural streams that feed into Lake Erie. Rainfall on paved and unpaved areas around the main plant buildings is directed by surface grading to catch basins which also discharge into the storm water drainage system. Rainwater or lawn

sprinkling water that falls on unpaved areas and percolates into the backfill material around the main plant buildings will add an insignificant amount to the flow in the pressure-relief underdrain system.

f. Seepage Increase Due to Excavation

Heave due to elastic rebound was not known to have induced micro-fracturing of a surficial zone of the shale upon excavation unload. This phenomenon would have been expected to slightly increase the secondary porosity of the surficial shale zone and the corresponding permeability thereof. The amount of permeability increase cannot be quantified because of the limited depth influence and the negligible effect if any, of induced micro-fracturing. Any such increase did not influence seepage quantities derived from the shale during construction, because no seepages from the shale were detected.

Upon imposition of plant loads, the shale recompressed, reversing the heave deformation. The effect of the reloading closed much, if not all, of the micro-heave fractures and restored the unexcavated shale permeability.

While the secondary porosity of the shale in a localized area might have increased due to micro-fracturing, the quantity of flow through this zone would not increase because the surrounding, sound, unfractured shale would still control the flow rate.

g. Pressure Distribution Within the Porous Concrete Blanket Under Design Flow Conditions

Under normal conditions, practically all of the groundwater inflow is collected by the porous concrete and 12-inch porous pipes around the perimeter of the drainage system. It then flows to the pumped

discharge system manholes where it is discharged from the system. In order to evaluate the potential pressure buildup under an extreme situation, a calculation was made to determine the pressure required to drain the groundwater inflow from the western edge of the underdrain, through the underdrain porous concrete, to the porous collection pipe on the eastern edge of the system. The analysis for a one-foot wide strip of underdrain was made using the preliminary assumed parameters for the system as follows:

- Groundwater inflow at 0.02 gpm/ft
- Porous concrete permeability = 1 fpm
- Maximum flow path = 400 ft
- Porous concrete is one foot thick, thus A = 1 sq ft

Using the Darcy Eq., Q = kiA, reveals that about one foot of head is required to drain the assumed inflow.

From field observations and tests during construction it was determined that groundwater inflow rates were much less than anticipated (Reference 59) and porous concrete permeability was greater than one foot/minute, indicating a maximum pressure differential in the system of much less than one foot.

h. Evaluation of the Probability of and the Hydraulic Consequences of an Accidental Clogging of the Underdrain System

The porous concrete of the underdrain is completely enveloped by either Class A fill, Chagrin shale, or the concrete of the plant buildings. None of these materials are capable of contributing or transporting fine particles that could clog the underdrain. The Class A fill (as described previously) is specifically designed to

act as a filter to prevent such materials from entering the system. The potential for the intrusion of clogging materials from the Chagrin shale was considered in Item c. of <Section 2.4.13.5.5>.

The satisfactory performance of porous concrete for the purpose of pressure relief can be demonstrated by many Bureau of Reclamation projects such as Grand Coulee Dam, Arrowrock Dam and Box Butt Dam (Reference 54).

Based on the groundwater recovery calculations for the design assumed inflow rate (80 gpm), the time required for the water level within the system to reach the critical level (590.0’) would be 14 days. Actual field measurements indicated the period to be much longer. If for any reason the underdrain system cannot maintain the water level within the designated operating limits, then the 14-day period is considered adequate to either make the necessary repairs or install portable pumping equipment.

Clogging of the periphery drainage pipes and the encasement porous concrete can only be conceived as a slow progressive process that will be detected by the monitoring system in time for remedial action to be initiated. This action can take the form of water jetting or drilling of additional pressure relief wells.

For further discussion of the structural properties of porous concrete, refer to <Section 3.8.5>.

i. Evaluation of the Effect of Non-Seismic Category I Structures on the Performance of the Permanent Dewatering System

The Category I manholes and piping at the north end of the plant have been located such that the postulated failure of non-Seismic Category I structures would not affect the overall operation of the permanent dewatering system <Figure 2.4-69>. The potential mode of

failure of the non-Seismic Category I structures is estimated to be an inward collapse of the turbine complex allowing adjacent soil material to follow the collapsing structure. Except as noted below, the permanent dewatering system components at the north end of the plant are either located outside the influence zone of soil failure or are designed for the resulting soil influence.

The generator end of the turbine building and the feedwater booster pump pit in the heater bay of Unit 1 were investigated as the most likely areas of building wall failure. In both cases, the walls are structurally adequate to withstand the effect of dynamic soil pressures without bending or shear failure. Manholes No. 8 and 9, however, are located within the influence zone of soil failure, and are designed as Seismic Category I structures. In the event of the postulated failure of adjacent non-Seismic Category I structures, these manholes can be sacrificed without impairing the overall performance of the system.

As shown on <Figure 2.4-69>, the main flow of the gravity discharge system does not pass through manholes No. 8 and 9. The postulated failure of these manholes and the connecting gravity discharge piping will, by design, not affect the integrity of the discharge manholes at the north end of the Unit 1 heater bay. Manhole #8 is an inspection manhole. An underdrain pump is installed in manhole #9 and its discharge is routed to the gravity drain outflow pipe from this manhole. Should the pump in manhole #9 fail to work or the gravity drain pipe from manhole #9 become blocked, the remaining service and backup underdrain pumps would serve to compensate for the loss of the pump. Therefore, the postulated failure of these manholes would also not affect the operation of the pumping underdrain system in keeping normal groundwater level below Elevation 568.0’ and the maximum groundwater level below 590.0’.

The system components adjacent to non-Category I structures at the south end of the plant could be postulated to fail in the event of

a seismic related failure of non-Category I structures without compromising the full operating capability of the redundant permanent dewatering system.

2.4.13.5.6 Controlled Low Strength Material (CLSM)

Controlled Low Strength Material (CLSM) may be used as a replacement for Class B and Class C fill, and as a replacement for Class A fill when the Class A fill was used as bedding and backfill for buried piping and ductbanks only, and not as part of the Plant Underdrain system, or as a foundation for safety-related buildings or structures. Since the CLSM is equivalent to or better than Class B fill in bearing capacity and impermeability, this change has no effect on the results of USAR <Section 2.4.13.5.1> and <Section 2.4.13.5.5>.

2.4.14 TECHNICAL SPECIFICATION AND EMERGENCY OPERATION REQUIREMENTS

Safety-related facilities at PNPP are protected as described in the preceding sections. Therefore, emergency protective measures and attendant technical specifications are not required.

2.4.15 LIST OF PERSONS AND AGENCIES INTERVIEWED

The following is a listing, by sections, of individuals and agencies whose assistance was elicited during preparation of the Hydrologic Engineering discussions:

<Section 2.4.5.2>

Dr. L. Bajorunas, Director, Great Lakes Research Center, NOAA, Detroit, Michigan.

Mr. Elmer Kulp, Acting Chief, Vertical Control Section, Lake Survey Center, NOAA, Detroit, Michigan.

<Section 2.4.5.3>

Dr. G. C. Dohler, Chief, Tides and Water Levels, Marine Sciences Branch, Department of the Environment, Ottawa, Canada.

Mr. A. Manning, Canadian Atmospheric Environment Service, Department of the Environment, Downsview, Ontario, Canada.

<Section 2.4.5.5>

Dr. Charles H. Carter, Geologist and Section Head, Ohio Department of Natural Resources, Division of Geological Survey, Lake Erie Section, Columbus, Ohio.

<Section 2.4.6>

Dr. L. Bajorunas, Director, Great Lakes Research Center, NOAA, Detroit, Michigan.

<Section 2.4.11.2>

Dr. L. Bajorunas, Director, Great Lakes Research Center, NOAA, Detroit, Michigan.

<Section 2.4.11.3>

Mr. Lawrence Braidech, Ohio Geological Survey, Sandusky, Ohio.

Mr. Elmer Kulp, Acting Chief, Vertical Control Section, Lake Survey Center, NOAA, Detroit, Michigan.

<Section 2.4.11.4>

Mr. M. J. Korsmit, St. Lawrence Seaway Authority, St. Catherines, Ontario, Canada.

Mr. Andred Piasenta, Buffalo District, U.S. Army Corps of Engineers, Buffalo, New York.

<Section 2.4.11.6>

Mr. M. J. Korsmit, St. Lawrence Seaway Authority, St. Catherines, Ontario, Canada.

Dr. Frank H. Quinn, Chief, Lake Hydrology Branch, Lake Survey Center, NOAA, Detroit, Michigan.

<Section 2.4.13.2>

Eagon, Jr., H. B., (1972) Hydrologist, State of Ohio, Department of Natural Resources, Division of Water, Columbus, Ohio.

Fredebaugh, Hewet, (1973), Well Driller, Grand River, Ohio.

Lago, J., (1972) Ohio Water Service Company, Geneva Br., Mentor, Ohio.

Lucia, J., (1972) Lake County Department of Health, Painesville, Ohio.

Neroda Drilling Company, Well Driller, Painesville, Ohio.

State of Ohio, Department of Natural Resources, Division of Water, Columbus, Ohio; well log data (1972).

2.4.16 REFERENCES FOR SECTION 2.4

1. International Lake Erie Water Pollution Board, and the International Lake Ontario - St. Lawrence River Water Pollution Board, "Pollution of Lake Erie, Lake Ontario and the International Section of the St. Lawrence River," Volume 2 - Lake Erie 1969.

2. Shore Erosion in Ohio, State of Ohio, Dept. of Natural Resources, Division of Shore Erosion, Columbus, Ohio, 1959.

3. U.S. Army Corps of Engineers, "Beach Erosion Control Report on Cooperative Study of the Ohio Shore Line of Lake Erie," Appendices III, VII, & XII - Fairport to Ashtabula. Beach Erosion Board, Washington, D.C., Aug. 1, 1951.

4. Riedel, Appleby and Schloemer, R., "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1,000 Square Miles and Durations of 6, 12, 24, and 48 Hours," Hydrometeorological Report No. 33, U.S. Army Corps of Engineers, Washington, D.C., April 1956.

5. Design of Small Dams, U.S. Department of the Interior, Washington, D.C., Second Edition, 1973.

6. U.S. Army Corps of Engineers, "Standard Project Flood Determinations," Civil Engineer Bulletin No. 52-8 (EM 1110-2-1411), Washington, D.C., Revised March 1965.

7. Platzman, George W., "The Dynamical Prediction of Wind Tides on Lake Erie," Meteorological Monographs, Vol. 4, No. 26.

8. Irish, S. M., Platzman, G. W., "An Investigation of the Meteorological Conditions Associated with Extreme Wind Tides on Lake Erie," Monthly Weather Review, U.S. Weather Bureau, February 1962.

9. Bajorunas, L., "Water Level Disturbances in the Great Lakes and Their Effect on Navigation," Paper delivered at Princeton University Conference, January 19 and 20, 1960.

10. National Oceanic and Atmospheric Administration, Storm Data; U.S. Department of Commerce, January 1959 - July 1972.

11. Tannehill, I. R., Hurricanes, Princeton University Press, 1956.

12. Ludlum, David M., Weather Record Book, Weatherwise, Inc., P. 9 and P. 41, 1971.

13. Petterssen, Sverre, PhD. Introduction to Meteorology, McGraw-Hill, PP. 98-106, 1941.

14. Berry, Bollay, Beers, Handbook of Meteorology, McGraw-Hill, PP. 435-438, 1945.

15. Holmboe, J., Forsythe, G. E., and Gusten, W., Dynamic Meteorology, John Wiley and Sons, PP. 173-209, 295-336, 1945.

16. Petterssen, Sverre, PhD. Introduction to Meteorology, 1941, York, Pa. McGraw-Hill Book Company (1941), Page 24.

17. Humphreys, W. J., Physics of the Air, 1964, New York, Dover Publications, Inc., (1964), Page 127.

18. Petterssen, Sverre, PhD. Weather Analysis and Forecasting, 1956, McGraw-Hill Book Company, PP. 84.

19. Shaw, Sir Napier, Manual of Meteorology, VIIV, 1931, Cambridge Univ. Press, PP. 109.

20. Graham, H. E. and Hudson, G. N., U.S. Department of Commerce, "Surface Winds Near the Center of Hurricanes (and Other Cyclones)," National Hurricane Research Project, Report No. 39, September 1960.

21. U.S. Department of Commerce, "Meteorological Characteristics of the Probable Maximum Hurricane, Atlantic and Gulf Coasts of the United States," HUR 7-97, Weather Bureau, 1968.

22. U.S. Army Corps of Engineers, "Shore Protection, Planning and Design," Technical Report No. 4, Coastal Engineering Research Center Washington, D.C., 1966.

23. Streeter, V. L. and Wylie, E. B., "Hydraulic Transients," McGraw-Hill, New York, 1967.

24. U.S. Corps of Engineers, Appendices III, VII and XII, "Report on a Cooperative Beach Erosion Control Study of the Ohio Shoreline of Lake Erie Between Fairport and Ashtabula, Beach Erosion Control Study," House Document 351, Government Printing Office, 1953.

25. Ohio Division of Geological Survey, "Preliminary Estimate of Erosion or Accretion Along the Ohio Shore of Lake Erie and Critical Erosion Areas," Technical Report No. 8, 1961.

26. State of Ohio, Department of Natural Resources, "Shoreline Erosion Study," Lake Erie Shoreline, Lake County, Ohio, prepared by Stanley Consultants, Cleveland, Ohio, 1969.

27. State of Ohio, Department of Natural Resources - Division of Geological Survey, "Lake Erie Shore Erosion, Lake County, Ohio: Setting, Processes and Recession Rates from 1976 to 1973," Report of Investigation No. 99, prepared by Charles H. Carter, 1976.

28. Land Title Company, Painesville, Ohio, copies of recorded deed descriptions and survey plots.

29. Engineering Research Institute, University of Michigan, Ann Arbor, and Michigan Water Resources Commission Low Cost Shore Protection for the Great Lakes, (Reprinted October 1959 by the Water Resources Commission).

30. E. F. Brater - Report to GAI on Shore Protection and Erosion Control at the Perry Plant Site, October 6, 1972.

31. Hellstrom, B., "Wind Effects on Lakes and Rivers," Bulletin No. 41, Royal Institute of Technology, Stockholm, Sweden, 1941.

32. Snider, R. C., "Great Lakes Ice Forecasting," NOAA Technical Memorandum NWS OSD 1, July 1974.

33. Rondy, Donald R., "Great Lakes Ice Atlas," NOAA Technical Memorandum NOS LSCR 1, U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Lake Survey Center, Detroit, Mich., September 1971.

34. Wahanik, R. J., "Submerged Offshore Structure for Perry Nuclear Power Plant," GAI Report No. 1891, March 1976, Revised November 1981.

35. Report for "Thermal Hydraulic Model Study of Cooling Water Discharge for the Perry Nuclear Power Plant," prepared by Acres American, Incorporated, May 1974.

36. Application for Perry Nuclear Power Plant submitted to Ohio Power Siting Commission, Appendix 1304-C-2.

37. Platzman, George W., "The Daily Variation of Water Level on Lake Erie," Journal of Geophysical Research, Vol. 71, No. 10, May 15, 1966.

38. Gedney, R., and Lick, W., "Numerical Calculations of the Steady-State, Wind-Driven Currents in Lake Erie," Proceedings of the 13th Conference on Great Lakes Research, 1970.

39. Hutchinson, G. E., A Treatise on Limnology Vol. 1, John Wiley and Sons, New York, 1957.

40. Hayford, J. F., "Effect of Winds and of Barometric Pressures on the Great Lakes," Carnegie Institute, Publication No. 317.

41. Parmenter, R., "Hydrography of Lake Erie," Bulletin of the Buffalo Society of Natural Sciences, 14:25-50.

42. Csanady, G. T., "The Coastal Boundary Layer in Lake Ontario. Part I: The Spring Regime," Journal of Physical Oceanography, Vol. 2, No. 1, January 1972.

43. Csanady, G. T., "The Coastal Boundary Layer in Lake Ontario: Part II: The Summer-Fall Regime," Journal of Physical Oceanography, Vol. 2, No. 2, April 1972.

44. Technical Report NUS-1183, "Near-Shore Temperatures in Lake Erie," NUS Corporation, 1973.

45. National Oceanic and Atmospheric Administration, Chart #14825, "Ashtabula to Chagrin River," U.S. Department of Commerce, 1974.

46. Koh, R. C. Y., and Fan, L. N., "Mathematical Models for the Prediction of Temperature Distributions Resulting from the Discharge of Heated Water into Large Bodies of Water," Water Pollution Control Series 1613ODW010/70, Environmental Protection Agency, 1970.

47. Jirka, G. H., Abraham, G., and Harleman, D. R. F., An Assessment of Techniques for Hydrothermal Prediction, Report No. 203, Ralph M. Parsons Laboratory, Cambridge, Massachusetts, 1975.

48. Chow, V., Open Channel Hydraulics, McGraw Hill, New York, 1959.

49. Hanna, T. H., Foundation Instrumentation, Technical Publication, 1973, PP. 85-95.

50. Taylor, D. W., Fundamentals of Soil Mechanics, John Wiley & Sons, 13th Edition, 1963.

51. Birkeland, B. W., Pedology, Weathering and Geomorphological Research, Oxford University Press, New York, 1974.

52. Lamborn, R. E., Austin, C. R., and Schaaf, D., "Shales and Surface Clays of Ohio," Geological Survey of Ohio, Fourth Series, Bulletin 39, 1938.

53. Caroll, D., "Ion Exchange In Clays and Other Minerals," Geological Society of America, V. 70 #6, PP. 749-780, 1959.

54. United States Bureau of Reclamation, Dams and Control Works, 1954; World Dams Today, Japan Dam Association, Tokyo, 1970.

55. American National Standard - ANS 2.8, ANSI N170-1976, "Standards for Determining Design Basis Flooding at Power Reactor Sites," American Nuclear Society, Hindsdale, Illinois, 1976.

56. Pree, H. L., Jr., "Ashtabula and Conneaut Creek Basins, and Adjacent Lake Erie Tributaries," Ohio Department of Natural Resources, Division of Water, 1960.

57. DeWiest, Roger J. M., Geohydrology, John Wiley and Sons, Inc., New York, 1967.

58. Todd, D. K., Groundwater Hydrology, John Wiley and Sons, Inc., New York, 1959.

59. Woodward-Cylde Consultants letter of November 01, 1981, to Gilbert Associates, Inc. Ref: "See page Estimate."

60. Gilbert Associates Inc. Calculation 26:12, "Perry Emergency Service Water Pumphouse – Stability Analysis", Revision 0 (Retained as Perry Calculation 26:12.000, Revision 0).

TABLE 2.4-1

PROBABLE MAXIMUM STORM FOR SETUP AT SITE

Grid Pt.	Sta	Day	6th Hour	12th Hour	18th Hour	24th Hour
(1,1)	1	1	160(1)	160	158	156
	1	1	30(1)	44	52	60
	1	1	1001(1)	1004	1006	1007
	1	2	161	166	160	154
	1	2	70	79	78	77
	1	2	1020	1032	1033	1034
	1	3	171	187	200	212
	1	3	61	44	33	22
	1	3	1035	1036	1033	1030
(1,21)	2	1	173	173	167	160
	2	1	34	45	52	59
	2	1	1003	1007	1008	1009
	2	2	163	166	163	159
	2	2	65	71	74	77
	2	2	1022	1034	1035	1036
	2	3	170	181	196	211
	2	3	64	50	36	21
	2	3	1037	1038	1035	1031
(20,1)	3	1	160	165	159	152
	3	1	23	41	52	62
	3	1	998	1000	1001	1001
	3	2	156	160	156	151
	3	2	78	94	92	90
	3	2	1013	1025	1026	1026

TABLE 2.4-1 (Continued)

Grid Pt.	Sta	Day	6th Hour	12th Hour	18th Hour	24th Hour
	3	3	168	184	198	212
	3	3	67	44	33	21
	3	3	1030	1034	1032	1029
(20,21)	4	1	178	175	168	160
	4	1	27	43	53	62
	4	1	1000	1002	1003	1003
	4	2	162	163	161	159
	4	2	80	98	94	89
	4	2	1016	1028	1028	1028
	4	3	167	175	192	208
	4	3	69	49	35	20
	4	3	1032	1036	1034	1031
(40,1)	5	1	256	164	158	151
	5	1	23	38	50	62
	5	1	995	993	994	994
	5	2	156	160	157	154
	5	2	75	88	91	94
	5	2	1006	1017	1017	1016
	5	3	166	177	194	210
	5	3	68	42	31	20
	5	3	1024	1032	1031	1029
(40,21)	6	1	235	189	179	169
	6	1	24	39	51	62
	6	1	998	999	998	997
	6	2	167	165	162	159
	6	2	76	90	96	102
	6	2	1009	1021	1020	1018
	6	3	166	172	189	206

TABLE 2.4-1 (Continued)

Grid Pt.	Sta	Day	6th Hour	12th Hour	18th Hour	24th Hour
	6	3	73	44	34	23
	6	3	1026	1034	1032	1030
(60,1)	7	1	294	248	201	153
	7	1	15	15	34	52
	7	1	993	988	988	987
	7	2	156	159	157	155
	7	2	69	85	84	82
	7	2	998	1009	1008	1006
	7	3	164	172	190	208
	7	3	62	41	32	23
	7	3	1018	1029	1029	1028
(60,21)	8	1	270	232	203	174
	8	1	25	35	43	50
	8	1	996	995	993	990
	8	2	171	167	166	164
	8	2	68	86	86	86
	8	2	1001	1012	1011	1009
	8	3	168	171	185	199
	8	3	64	42	33	24
	8	3	1020	1031	1030	1029
(78,1)	9	1	318	303	228	153
	9	1	16	15	26	37
	9	1	997	993	986	978
	9	2	156	158	158	158
	9	2	56	75	79	82
	9	2	989	999	997	995
	9	3	166	173	186	198
	9	3	61	40	33	25
	9	3	1011	1027	1027	1027

TABLE 2.4-1 (Continued)

Grid Pt.	Sta	Day	6th Hour	12th Hour	18th Hour	24th Hour
(78,21)	10	1	276	250	226	202
	10	1	20	23	31	38
	10	1	997	994	989	984
	10	2	187	171	168	165
	10	2	59	79	81	83
	10	2	993	1002	1001	1000
	10	3	167	169	183	196
	10	3	62	41	33	25
	10	3	1014	1028	1028	1028
(30,1)		1	255	160	156	152
		1	22	40	53	65
		1	997	998	998	998
		2	156	160	157	153
		2	78	90	94	98
		2	1011	1023	1023	1022
		3	167	181	196	211
		3	71	43	32	20
		3	1028	1033	1031	1029
(30,11)		1	178	173	166	159
		1	20	41	53	65
		1	997	999	999	999
		2	161	162	159	156
		2	80	95	96	97
		2	1012	1024	1024	1023
		3	167	178	194	209
		3	71	45	33	20
		3	1029	1034	1032	1030

TABLE 2.4-1 (Continued)

Grid Pt.	Sta	Day	6th Hour	12th Hour	18th Hour	24th Hour
(30,21)		1	200	181	173	165
		1	25	42	53	64
		1	998	1000	1000	1000
		2	165	164	162	159
		2	81	98	97	95
		2	1013	1025	1025	1024
		3	167	174	191	207
		3	71	47	34	21
		3	1030	1035	1033	1030
(40,11)		1	255	183	172	160
		1	996	996	996	995
		2	162	163	160	157
		2	76	89	94	98
		2	1007	1019	1018	1017
		3	166	175	192	208
		3	71	44	33	21
		3	1025	1033	1031	1029
(50,1)		1	340	183	168	152
		1	5	31	46	60
		1	994	990	991	991
		2	156	160	158	155
		2	73	86	87	87
		2	1003	1014	1013	1011
		3	165	175	192	209
		3	64	41	31	21
		3	1021	1030	1029	1028

TABLE 2.4-1 (Continued)

Grid Pt.	Sta	Day	6th Hour	12th Hour	18th Hour	24th Hour
(50,11)		1	262	196	179	162
		1	23	36	48	59
		1	996	994	993	992
		2	163	163	161	159
		2	73	87	88	89
		2	1004	1016	1015	1013
		3	167	174	190	206
		3	66	43	33	23
		3	1022	1031	1030	1029
(50,21)		1	247	195	184	172
		1	25	38	49	59
		1	997	996	995	993
		2	169	166	164	162
		2	74	88	89	90
		2	1005	1017	1016	1014
		3	167	172	188	203
		3	67	44	34	23
		3	1023	1032	1031	1030

NOTE:

(1) These entries under each station are grouped in threes as follows:

(a) First line - wind direction in degrees.

(b) Second line - wind speed in miles per hour.

(c) Third line - wind pressure in millibars.

TABLE 2.4-2

RECESSION RATES IN FEET PER YEAR

a. Top of Bluff

	1876 to 9/78 (102 yrs)	1876 to 1972 (96 yrs)	1937 to 1972 (35 yrs)	1957 to 1972 (15 yrs)	1964 to 1972 (8 yrs)	10/72 to 9/78 (6 yrs)	11/73 to 9/78 (5 yrs)
West Reach							
Profile J	3	2	3	3	5	5	3
Profile I	2	2	3	4	7	8	10
Profile H	4(1)	?	3	6	7	9	11
Profile G	1(1)	?	1	2	3	-	<1
Central Reach							
Profile F	<1(1)	?	<1	1	1	-	<1
Profile L	<1	<1	1	2	3	-	1
Profile K	<1	<1	1	2	4	-	2
Profile A	<1	<1	<1	2	3	<1	1
Profile B	2	1	2	5	7	7	7
East Reach							
Profile C	2	2	4	5	4	6	<-1
Profile D	3	3	5	5	5	5	4
Profile E	3	3	5	5	5	2	2

TABLE 2.4-2 (Continued)

b. Shoreline

	1798 to 9/78[7,8] (180 yrs)	1798 to 1972[7] (174 yrs)	1830 to 1972[7] (142 yrs)	1852 to 1972[7] (120 yrs)	1865 to 1972[7] (107 yrs)	1876 to 1972[7] (96 yrs)	1917 to 1972[7] (55 yrs)	11/73 to 9/78[8] (5 yrs)
West Reach								
Profile J	3[2]	-	-	-	-	3	4	3
Profile I	1	<1	<1	-	-	2	3	9
Profile G	<1	<1	<1	-	1[4]	<1	2	8
Central Reach								
Profile F	<1	<1	<1	-	<-1	<-1	1	-3
Profile L	<1	<1	<1	<-1	<1	<1	2	<1
Profile K	<1	<1	<1	<-1	<1	0	1	6
Profile A	<1	<1	<1	<-1	<1	<1	<1	5
Profile B	1	1	1	1	-	1	1	18
East Reach								
Profile C	2	2	2	2	-	2	3	7
Profile D	2	1	-	2	-	2	2	10
Profile E	2[3]	-	-	2[5]	-	3	4[6]	<-1

TABLE 2.4-2 (Continued)

NOTES:

(1) For the 41-year period, 1937 to 9/78.
(2) For the 102-year period, 1876 to 9/78.
(3) For the 120-year period, 1858 to 9/78.
(4) For the 105-year period, 1867 to 1972.
(5) For the 114-year period, 1858 to 1972.
(6) For the 28-year period, 1944 to 1972.
(7) Shoreline recession rates between 1798 and 1972 assumed toe of bluff to be at water line. Distances used to determine these recession rates were not corrected for lake level fluctuations.
(8) Shoreline recession rates between 11/73 and 9/78 assumed toe of bluff to be at break in bluff slope (i.e., at beaches). Some toe of bluff locations during this period were estimated due to their inaccessibility.

TABLE 2.4-3

MAXIMUM RECORDED ICE THICKNESS AT VARIOUS STATIONS

ON THE PERIPHERY OF LAKE ERIE[1]

Period	Marine Lake-Erie Harbor	Marblehead-East Harbor	Brest Bay	Buffalo Harbor	Marblehead-Catawba Island
1967-1968	13[2]	21	10	NA	NA
1968-1969	13	1	10	17	NA
1969-1970	NA[3]	NA	NA	NA	NA
1970-1971	12	NA	15	31	18
1971-1972	12	NA	14	16	13
1972-1973	10	NA	6	8	9
1973-1974	6	NA	10	8	10
1974-1975	5	NA	NA	7	4
1975-1976	16	NA	14	15	14
1976-1977	24	NA	24	NA	28
1977-1978	18	NA	20	NA	28
1978-1979	1	NA	23	NA	14

TABLE 2.4-3 (Continued)

NOTES:

[1] Source of reference: Frederick E. Sleator, "Ice Thickness and Stratigraphy at Nearshore Location on the Great Lakes," Great Lakes Environmental Research Laboratory, Ann Arbor, Michigan, July 1978.
[2] Measured in inches.
[3] NA: Not available.

TABLE 2.4-4

TABULATION OF MAXIMUM YEARLY OBSERVED ICE THICKNESS
ALONG OHIO SHORELINE OF LAKE ERIE

ASHTABULA, OHIO

Season	Ice Type[1]	Surface[2] Condition	Ice Thickness (inches)
1961-1962	None	None	0
1962-1963	Fast Field	Jammed	6
1963-1964	Fast Field	None	6
1964-1965	Fast Field	Windrowed	6
1965-1966	Fast Field	None	14
1966-1967	Fast Field	Windrowed	6
1967-1968	Fast Field	None	20
1968-1969	Fast	None	14
1969-1970	Fast Field	None	11
1970-1971	Fast Slush	None	2
1971-1972	Fast Slush	Hummocked	12
1972-1973	Fast	Leads	5

CLEVELAND HARBOR, OHIO

Season	Ice Type[1]	Surface[2] Condition	Ice Thickness (inches)
1961-1962	None	None	0
1962-1963	Fast Field	None	5
1963-1964	Fast Field	None	8
1964-1965	Drift Pancake	None	3
1965-1966	Fast Field	None	12
1966-1967	Fast Field	Jammed	10
1967-1968	Fast Field	None	15
1968-1969	Fast Field	Jammed	9
1969-1970	Draft Floe	Jammed	11
1970-1971	Fast	None	6
1971-1972	Fast Floe	Hummocked	10

NOTES:

(1) U.S. Coast Guard terminology for ice types is as follows:

(a) Field: Large bodies, 1,000 yards in width.

TABLE 2.4-4 (Continued)

NOTES: (Continued)

(b) Floe: Medium size bodies, 10 to 1,000 yards in width.

(c) Cake: Small bodies, less than 10 yards in width.

(d) Pancake: Small pieces less than 3 yards across usually oval or disc-shape, uneven, with raised rims on the surface, pieces sometimes interfrozen.

(e) Brash: Small fragments less than 6 feet across.

(f) Slush: An accumulation of crystals, may or may not be slightly frozen together, no degree of hardness.

(g) Fast: Unbroken ice which is fast to shore. Term "shore ice" may also be used where appropriate.

(h) Drift: All ice not fast to shore.

(2) U.S. Coast Guard terminology for surface conditions is as follows:

(a) Jammed: Broken ice in constricted areas, river channels or harbors. The jamming may be caused by currents or wind pressure.

(b) Windrow: Hummocky ice which has been pressed into heavy ridges or layers by strong winds, often piled up against the shore or other obstruction.

TABLE 2.4-5

MINIMAL DILUTION FACTORS FOR LAKE WATER INTAKES WITHIN 50 MILES OF PNPP

Location of Intake	Distance From Plant (Miles)	Minimum Current Speed (Ft/Sec)	Dilution Factor
IRC Fibers, Co.	3.50	0.026	7.8
East System, OWC	4.20	0.031	9.4
Fairport Harbor	7.00	0.051	15.6
Painesville	7.50	0.055	16.7
West System, OWC	10.00	0.073	22.7
Ashtabula	20.00	0.147	44.6
Union Carbide Metals	22.00	0.161	49.0
Conneaut	33.00	0.242	73.5
Cleveland	35.00	0.257	78.0
Avon Lake	50.00	0.330	105.7
Elyria	50.00	0.330	105.7
Lorain	50.00	0.330	105.7

TABLE 2.4-6

DOMESTIC WELL INVENTORY - NORTH PERRY AND PERRY, OHIO

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
1	-	-	-	-	-	Not accessible
2	4.0	639	12.5	-	-	No Fe
3	-	-	-	-	-	-
4	4.9	622	24.0	-	-	-
5	15.0	595	-	53	1/2 gpm (bail test)	Well filled in by CEI Gas well also filled in
6	4.0	616	21.0	-	-	Depth to H_2O 12 hrs & 32 hrs after heavy rain - 2 ft (April 17)
7	6.0 west 4.0 east	617 619	11.3 10.0	- -	- -	Two wells separated by 50 ft; Fe problem. West well used. After rains DTW 4.2, 3.0

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
8	8.0	615	10.0	-	-	Septic tank; Fe problem
9	15.0	610	30.0	-	-	Septic tank; no Fe
10	-	Shallow hand dug well; not accessible		-	-	95 ft well
11	8-10	615	18.0	-	-	Septic tank; no Fe
12	8-10	615	18.0	-	-	Septic tank; no Fe
13	4-5	620	14.0	-	-	Lowest levels Oct.-Nov.
14	2-3	621	15.0	-	-	-
15	7.0	614	12.0	-	-	-
16	5.0	610	9.0	-	-	Shortages
17	9.0	611	15.0	-	-	Shortages
18	14.0	606	20.0	-	-	-
19	12.5	609	17.5	-	-	-

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
20	12.5	612	17.5	-	-	12 hrs after storm
21	12.5	612	17.5	-	-	12 hrs after storm
22	13.0	613	17.0	-	-	-
23	11.0	616	16.0	-	-	-
24	14.0	612	17.0	-	-	Septic tank
25	14.0	612	16.5	-	-	Wash day
26	14.0	611	45.0	45.0	10.0	Drilled, log on hand
27	15-16	611	20.0	-	-	Hand dug 1948
28	16-18	608	24.0	-	-	-
29	14.8	610	32.0	30.5	Bail Rate-3	Not accessible
30	11.0	614	14.5	-	-	Fe problem; 12 hrs
31	9.5	615	15.0	-	-	12 hrs after rain
32	11.0	614	16.0	-	-	After rain

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
33	17.0 20.0	608 605	19.5 21.5	- -	- -	Fe (new pipes - May 1 therefore no rust) 12 hrs after rain
34	11.0	614	16.0	-	-	12 hrs after rain
35	3.0 or less	612	-	-	-	Flowing spring (?) from pipe on NW side of bldg.
36	2.0 (7-8 in summer)	623	15.0	-	-	H_2O hard (Colt) but no Fe
37	14-15	610	20.0	-	-	-
38	6.0	636	12.0	-	-	Dug
39	2.0	634	12.0	-	5.0	Dug - 70 ft to Shale
40	6.0	640	15.0	-	23.0	Dug - in 600 ft gas well
41	18.5	606	26.5	-	-	12 hrs after heavy rain
42	Not accessible	-	28.0	-	-	High Fe problem

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
43	6.0	621	16.5	-	-	Lower Fe problem than No. 42; after rain
44	2.0	623	12.0	-	-	12 hrs after rain
45	19.0	606	-	-	-	Well point
46	9.0	616	13.0	-	-	12 hrs after rain
47	8.5	616	13.5	-	-	No Fe problems 12 hrs after rain
48	10.0	620	18.0	-	-	12 hrs after rain
49	6.5	623	12.5	-	-	After rain
50	7.5	622	14.0	-	-	-
51	-	-	12-14	-	-	Inaccessible
52	11.5	616	17.0	-	-	-
53	8.5	610	15.5	-	-	-
54	9.0	610	14.0	-	-	-
55	-	-	-	-	-	-

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
56	3.2	623	14.5	-	-	-
57	2.5	623	11.5	-	-	-
58	1.5	624	24.0	24.0	8 gpm @ 6 hr 5 ft drawdown	Drilled by Neroda 1970-71; water picked up 13 ft; went down to 5 ft in Sept.
59	2.5	622	15.0	-	-	-
60	3.0	635	16.0	-	-	-
61	1.5	636	9.5	-	-	-
62	2.0	637	11.0	-	-	-
63	6.0	636	10.0	-	-	Fe problem; 6 ft bell 2 ft from surface - supplies farm animals and home
64	6.0	636	10.0	-	-	Tiled area toward 20
65	3.0	640	50.0	-	-	-

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
66	4.0	639	10.0	-	-	Fe problem
67	3.5	644	6.0	-	-	-
68	6.0	640	920.0	-	-	Inaccessible; no Fe
69	18.0	637	42.0	39.6	-	Drilled well
70	-	-	-	-	-	2 well points
71	5.4	622.7	10.0	-	-	No Fe
72	-	-	30.0	-	-	Well point (never dry in 14 years)
73	6.0	623	12.0	-	-	-
74	-	-	-	-	-	-
75	-	-	11-12	-	-	Well point
76	6.6	623.7	14.2	-	-	Hard water
77	4.4	624.2	11.5	-	-	-
78	-	-	-	-	-	-

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
79	2.0	626	10.0	-	-	-
80	6.4	621.4	9.3	-	-	Wash day
81	6.7	622.5	-	-	-	-
82	16.0	614	28.0	-	-	1 point to 14 ft Well in basement Good pumping
83	14.2	613.8	16.3	-	-	Septic tank
84	6.6	622.7	15.0	-	-	Septic tank; some Fe
85	8.0	617	14.0	-	-	Septic tank (no water in basement)
86	6.0	621	14.0	-	-	-
87	3.0	625	16-17	-	-	Septic tank
88	3.0	625	20.0	-	-	Fe
89	6.4 max.	624.6 max.	12.6	-	-	-
90	5.0	626	-	-	-	-

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
91	14.3 max.	621.6 max.	15	-	-	-
92	8.0	622	20.0	-	-	No Fe; septic tank
93	1.0	629	-	-	-	Top slightly open to rains
94	3.3	630	13-15	-	-	No Fe; septic tank
95	4.5	629	-	-	-	No Fe; septic tank
96	3.0	629.0	10.8	-	-	-
97	7.0	632.5	10.4	-	-	No Fe; septic tank
98	5.0	632	14.0	-	-	No Fe; septic tank; also supplies 2831 Antioch Rd
99	1.5	636	7.5	-	-	Well 2.5 ft below grade in barn; no Fe; septic tank
100	4.0	636	6.5	-	-	Some Fe; septic tank
101	1.6	638	6.5	-	-	Some Fe; septic tank

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
102	3.2	638	7.67	-	-	Some Fe; septic tank
103	3.0	641	15.0	-	-	Some Fe; septic tank
104	5.8	642	7.8	-	-	No Fe; septic tank
105	4.0	644	6.9	-	-	No Fe; septic tank
106	7.8	640.2	9.0	-	-	No Fe; septic tank
107	-	-	-	-	-	Well point; old well 8 ft deep; insufficient; point 6 ft deeper
108	-	-	-	-	-	Well point; no Fe; septic tank
109	3.0	648	10.0	-	-	Septic tank
110	2.5	642	11.0	-	-	18 ft cistern; no Fe; recharges in 2 hrs
111	-	-	-	-	-	Replaced point w/due well

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
112	4.5	655	15.5	-	-	Septic tank
113	12.0	653	30.0	-	-	Submersible pumps; some Fe
114	14.5	640	32.0	32.0	12.0	Drilled 7/21/70
115	6.00	640	10.25	-	-	Fe; not enough water in dry spell; septic tank
116	3.0	638	10.0	-	-	-
117	5.5	631	10.0	-	-	Runs dry in summer
118	5.9	626	11.6	-	-	Water level @ Culvert ±625
119	7.0	628	12.6	-	-	No Fe; septic tank
120	11.0	624	13.8	-	-	Filled swimming pool; septic tank
121	10.0	627	17.1	-	-	No Fe; septic tank
122	5.9	630	14.9	-	-	-

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	remarks
123	±5.0	625	17.0	-	-	Trace Fe; septic tank
124	7.2	625	20.0	-	-	Some Fe; septic tank
125	5.0	625	20.0	-	-	Septic tank
126	8.7	621	14.7	-	-	Septic tank
127	4.0	626	15.0	-	5000 ?	Septic tank
128	-	-	-	-	-	-
129	10.0	670	25.0	-	-	Fe, very hard; septic tank
130	12.5	668	31.0	30.0	13.0	Drilled 10/31/64; Well in basement, sealed
131	-	-	9.0	-	-	Bad odor; Fe
132	7.0	669	12.0	-	-	-
133	7.0	699	11.0	-	-	No Fe; septic tank
134	13.5	663	16.0	-	-	-

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
135	10.8	661	30.0	28.8	8 (Bail)	Drilled 3/31/67; capped
136	17.0	663	30.0	-	-	-
137	-	-	-	-	-	-
138	-	-	-	-	-	2 drilled wells; capped
139	14.8	660	203.0	-	-	-
140	12.0	668	108.0	103.0	4	12/16/70; not sufficient
141	-	-	-	-	-	Drilled well; septic tank
142	-	-	-	-	-	Drilled well; septic tank
143	14.0	661	32.0	31.0	5 (Bail)	10/2/62 well; septic tank

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
144	12.0	663	17.0	-	-	Serves both residence & gas station; filled 2,000 gal. plus 2 times in 30 days
145	-	-	-	-	-	-
146	19.0	656	24.0	-	-	Serves 3 houses
147	12.8	662	16.3	-	-	-
148	-	-	-	-	-	Well point
149	11.6	653	15.6	-	-	Fe; septic tank
	-	-	-	-	-	Serves 3 houses; no Fe; septic tank
	11.5	653	18.0	-	-	-
	-	-	-	-	-	-
150	-	-	-	-	-	-
151	-	643	-	-	-	Salty water

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
152	±9.0	656	±33.0	-	-	-
153	14.0	656	24.0	-	-	Water level measures over 3 yrs; fluctuates from 17.7 ft - 20.4 ft
154	10.0	660	17.0	-	-	Some Fe; septic tank
155	25.0	665	30.0	-	-	-
156	20.0	652	25.0	-	-	Salty water; septic tank
157	7.5	653	10.0	-	-	Well near creek; ±15 ft below road level
158	6.3	663	14.3	-	-	Well ±10 ft below road; some Fe; septic tank
159	±18.0	657	35.0	-	-	Drilled well; some Fe
160	12.0	668	35.0	-	-	8/20/67

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
161	14.0	651	18.0	-	-	Some Fe; serves house and workshop
162	17.0	658	25.0	-	-	Water 15 horses, 3 or 4 times/day
163	18.0	662	25.0	-	-	8 ft-10 ft above road level
163A	12.0	666	30.0	29.0	4.0 (Bail)	Drilled 5/1/78
164	14.7	667	25.2	-	-	-
165	23.5	657	46.0	46.0	6.0	Drilled 8/31/65;
	23.0	657	46.0	47.5	10.0 (Bail)	Drilled 1/21/69; septic tank
166	31.0	649	64.0	66.0	4.0	Drilled 1/28/64
167	-	-	22.0	-	-	No Fe; septic tank
	12.0	663	105.0	102.0	1.5	Drilled 4/10/69
168	20.5	655	26.0	-	-	No Fe; septic tank

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
169	-	-	±17.0	-	-	Used for green-houses; no Fe; septic tank
170	-	-	±20.0	-	-	Well point; no Fe
171	14'-15'	665	18.0	-	-	No Fe; septic tank
172	11'-12'	668	±16.0	-	-	No Fe; septic tank
173	15.8	662	19.75	-	-	No Fe; septic tank
174	10.0	668	16.0	-	-	No Fe; 14 ft cistern, 17 ft deep and 3 wells
175	82.0	670	17.0	-	-	-
176	10.0	668	±25.0	-	-	Some Fe; septic tank
177	-	-	-	-	-	Well point; some Fe
178	7.2	673	12.7	-	-	Well in basement; 3 ft above road level; some Fe; septic tank

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
179	12.5	665	19.0	-	-	Well 2 ft-3 ft above road; septic tank
180	16.0	664	21.5	-	-	Some Ca; septic tank
181	19.0	661	41.0	40.5	-	Drilled 7/31/66
182	15.5	673	20.0	-	-	-
183	16.5	672	23.0	-	-	-
184	13.0	676	16.0	-	-	Some Fe; not sufficient
185	16.0	673	22.0	-	-	-
186	±15.0	680	±25.0	-	.42	-
187	9.0	683	30.0	28.0	10.0	Drilled 6/16/67; Fe; septic tank
188	11.6	682	30.0	29.0	10.0 (Bail)	8/13/62
189	8.6	685	14.6	-	-	Fe; septic tank
190	±8.0	684	±10.0	-	-	Septic tank

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
191	10.0	681	±22.0	-	-	In basement; some Fe; septic tank
192	±3.5	686	± 6.5	-	-	Septic tank
193	18.0	672	30.0	29.5	3.0	Drilled 6/10/58; septic tank
194	±18.0	672	40.0	-	-	Drilled; septic tank
195	7.5'	682	25.0	23.5	15.0	Drilled 9/15/59; septic tank
196	22.0	678	±28.0	-	-	Some Ca; septic tank
197	±22.0	678	±22.0	-	-	Septic tank
198	19.0	671	±22.0	-	-	Septic tank
199	7.0	683	15.0	-	-	Septic tank
200	22.0	678	25.0	-	-	Some Ca; septic tank
	-	-	-	-	-	Septic tank
201	12.0	672	30.0	-	12.0 (Bail)	Drilled 4/4/58

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
202	7.4	689	13.1	-	-	Septic tank
203	7.5	689	14.0	-	-	Septic tank
204	16.0	689	36.0	36.0	20.0	Drilled 6/26/56; septic tank
205	15.0	685	35.0	36.0	10.0	Drilled 10/21/71; septic tank
206	7.0	693	34.0	31.0	10.0	Drilled 10/21/71; septic tank
207	6.5	684	27.0	26.0	20.0 (Bail)	Drilled 10/29/63; septic tank
208	10.5	689	30.0	31.6	15.0 (Bail)	Drilled 7/21/64; septic tank
209	14.0	686	57.0	57.0	12.0	Drilled 7/22/52; septic tank
210	15.0	685	36.0	36.5	10.0 (Bail)	Drilled 11/16/65; septic tank
211	10.5	689	1915.0	-	-	Septic tank

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
212	13.0	687	44.0	37.0	1.5	Drilled 6/9/54; septic tank
213	18.0	682	25.0	-	-	Septic tank
214	8.0	691	17.0	-	-	Septic tank
215	8.0	691	17.0	-	-	Septic tank
216	24.0	671	40.0	39.5	8.0	Drilled 11/27/67; septic tank
217	24.0	671	40.0	38.5	10.0 (Bail)	Drilled 9/10/68; septic tank
218	22.0	673	40.0	37.0	15.0 (Bail)	Drilled 5/2/68; septic tank
219	17.0	675	38.0	36.5	8.0 (Bail)	Drilled 3/10/71; septic tank
220	16.0	669	86.0	31.0	5.0 (Bail)	Drilled 9/27/48; some Fe; septic tank
221	9.0	678	17.0	-	-	Septic tank
222	8.0	679	15.0	-	-	Septic tank

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
223	7.0	680	21.5	-	-	Septic tank
224	10.0	677	15.0	-	-	Septic tank
225	10.0	677	15.0	-	-	Septic tank
226	9.0	656	18.0	-	-	Septic tank
227	11.0	679	16.0	-	-	Some Fe; septic tank
228	11.5	683	19.0	-	-	Some Fe; septic tank
229	145.0	681	220.0	-	-	Some Fe; septic tank
230	14.0	681	215.0	-	-	Some Fe; septic tank
231	13.5	683	34.0	31.0	10.0	Drilled 9/4/59; septic tank
232	13.0	683	29.3	29.5	12.0 (Bail)	Drilled 4/4/58; septic tank
233	8.0	682	21.0	-	-	Septic tank
234	9.0	681	31.0	30.0	20.0	Drilled 4/11/59; septic tank

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
235	9.0	681	31.0	26.0	15.0	Drilled 6/5/68; septic tank
236	9.0	682	26.0	25.0	10.0 (Bail)	Drilled 1/11/63; septic tank
237	8.0	622	22.0	-	-	Septic tank
238	8.7	621	20.2	-	-	Septic tank
239	5.0	620	25.0	-	-	Well + 10,000 gal. cistern
240	5.0	618	25.0	-	-	Septic tank
241	0.0	620	25.0	-	-	-
242	3.5	621	14.5	-	-	Septic tank
243	4.8	621	12.3	-	-	Septic tank
244	9.0	616	16.5	-	-	Septic tank
245	1.0	619	14.0	-	-	Some Fe; septic tank
246	2.5	615	16.5	-	-	Some Fe; septic tank

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
247	2.0	620	14.0	-	-	Septic tank
248	2.8	620	22.8	-	-	Septic tank
249	4.0	619	16.0	-	-	Septic tank
250	5.5	644.5	9.0	-	-	Septic tank
251	5.5	639.5	13.0	-	-	Septic tank
252	6.0	648	10.0	-	-	Septic tank
253	13.7	617	15.5	-	-	Septic tank
254	5.5	625	14.0	-	-	Septic tank
255	14.0	608	32.0	-	12.0	Septic tank
256	4.0	616	11.0	-	-	Shale @ 25.0 ft; septic tank
257	5.0	665	25.0	-	-	Septic tank
258	16.5	669	36.0	35.0	20.0	Drilled 5/6/63; septic tank

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
259	15.5	671	38.0	36.0	15.0	Drilled 8/4/67; septic tank
260	17.5	667	32.0	32.0	14.0	Drilled 5/15/64; septic tank
261	20.0	665	40.0	36.0	10.0	Drilled 9/10/63; septic tank
262	20.0	665	39.0	39.0	12.0	Drilled 5/4/63; septic tank
263	18.5	667	32.0	31.6	10.0	Drilled 5/19/63; septic tank
264	20.5	666	40.0	38.0	7.0	Drilled 6/16/62; septic tank
265	20.0	666	40.0	37.6	-	Drilled 7/16/64; septic tank
266	21.0	666	40.0	39.0	20.0	Drilled 6/20/63; septic tank
267	18.0	669	40.0	39.0	15.0	Drilled 5/19/67; septic tank

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
268	18.5	669	40.0	37.0	15.0	Drilled 5/16/67; septic tank
269	21.0	666	42.0	42.0	8.0	Drilled 8/27/65; septic tank
270	17.75	666	39.0	37.0	15.0	Drilled 5/15/67; septic tank
271	21.0	666	38.0	37.0	6.0	Drilled 11/6/65; septic tank
272	18.5	669	37.0	37.0	15.0	Drilled 6/28/66; septic tank
273	16.5	669	40.0	40.0	15.0	Drilled 8/4/67; septic tank
274	16.6	669	38.0	38.0	20.0	Drilled 6/23/63; septic tank
275	14.75	607	32.0	30.5	3.0	Drilled 9/15/64; septic tank
276	6.25	619	30.0	25.0	6.0	Drilled 3/12/69; septic tank

TABLE 2.4-6 (Continued)

Well Location Number	Depth to Static Water	Approximate Static Water Elevation	Well Depth	Casing Depth	Yield (gpm)	Remarks
277	10.5	609	30.0	29.0	8.0	Drilled 5/21/64; septic tank
278	2.0	618	24.0	24.0	8.0	Drilled 1/26/71; septic tank
279	2.0	618	24.0	24.0	8.0	Drilled 1/26/71; septic tank
280	4.0	621	26.0	25.5	10.0	Drilled 1/17/71; septic tank
281	2.0	623	22.0	21.0	8.0	Drilled 4/30/59; septic tank
282	5.0	618	-	-	-	Measured on 7/28/72
283	4.6	616	-	-	-	Measured on 6/7/72
284	3.3	616	-	-	-	Measured on 7/28/72
285	3.3	620	-	-	-	Measured on 7/28/72
286	4.1	622	-	-	-	Measured on 7/28/72

TABLE 2.4-7

ANALYSIS OF WATER SAMPLES

Boring	1-1	1-2	1-3	1-5	Stream, 50 Yds N.
Depth, ft	10-18	10	26-30	7-14	
Date	4-11-72	4-21-72	4-3-72	4-7-72	4-24-72
Lab Designation	1	4	2	3	5
pH	8.1	7.6	7.9	7.7	8.0
Conductivity Micro Mhos/CM 24°C	465	540	740	470	370
Total Dissolved Solids, mg/L 103-105°C	370	460	610	340	290[(1)]
Turbidity					5
Alkalinity, mg/L as $CaCO_3$	229	92	271	207	81
Chloride, mg/L as Cl	21	48	49	35	35
Sulfate, mg/L as SO_4	57	106	186	42	93

NOTE:

[(1)] Total Solids

TABLE 2.4-8

SAMPLES FROM DW NO. 1 DURING PUMPING TEST ANALYSIS[1]

Sample No.	2-5-75 3:00 PM 1	2-6-75 10:30 PM 2	2-6-75 1:15 PM 3
Color, Pt - Co Units, Diss	0	0	0
Color	Light green-brown	Light gray	Light gray
Odor	None	None	None
Conductivity, micromhos per cm^2, 25°C	1,680	1,590	1,635
Total Coli per 100 ml	<2	<2	<2
Fecal Coli per 100 ml	<2	<2	<2
BOD, 5 day	4.0	1.4	0.9
Aluminum, Diss	0.0	0.1	0.0
Alkalinity, MeOr, Diss	171	174	171
Ammonia, N, Diss	0.9	0.7	0.9
Arsenic, Diss	0.004	0.004	0.004
Barium, Diss	0.1	0.1	0.1
Boron, Diss	0.23	0.18	0.18
Cadmium, Diss	<0.01	<0.01	<0.01
Calcium, Diss	87	92	83
Chloride, Diss	399	390	388
Chromium, Diss	<0.01	<0.01	<0.01

NOTE:

(1) In units of mg/l.

TABLE 2.4-8 (Continued)

Sample No.	2-5-75 3:00 PM 1	2-6-75 10:30 PM 2	2-6-75 1:15 PM 3
COD, Total	24	33	13
Copper, Diss	<0.01	<0.03	<0.02
Fluoride, Diss	0.47	0.37	0.43
Hardness, as $CaCO_3$, Diss	253	259	250
Iron, Diss	0.05	0.10	0.03
Lead, Diss	<0.05	0.05	<0.05
Magnesium, Diss	20	21	20
Manganese, Diss	0.07	0.09	0.08
Mercury, Total	<0.0002	<0.0002	<0.0002
Nitrate, N, Diss	0.8	0.6	0.9
Oil and Grease, Total	22	31	32
Dissolved Oxygen	6.3	9.1	10.3
pH, pH units	7.6	7.7	7.8
Phosphorus, P, Diss	<.01	<.01	<.01
Potassium, Diss	4.5	4.4	4.9
Selenium, Diss	0.003	<0.001	<0.001
Silica, Diss	7.5	9.4	9.8
Silver, Diss	0.07	0.06	0.06
Sodium, Diss	226	226	200
Sulfate, Diss	86	88	88

TABLE 2.4-8 (Continued)

	2-5-75 3:00 PM	2-6-75 10:30 PM	2-6-75 1:15 PM
Sample No.	1	2	3
Solids, Diss, 103°C	1,016	965	971
Solids, Diss, 180°C	990	923	928
Solids, Susp.	356	175	46
Zinc, Diss	0.5	0.8	0.8

TABLE 2.4-9

POTENTIALLY FLOODING VOLUME

(UNIT 1)

Source	(Gallons)
Cooling tower basin	3,269,241 (Elev. 623'-9" HWL)
Cooling tower distribution system and fill	370,331
Circulating water pumphouse forebay and forebay flume	1,137,707 (Elev. 623'-9" HWL)
Condenser tubes, water boxes, and crossover piping	364,961
Circulating water piping including auxiliary condenser	1,178,012
Service water inflow	84,000
Total Flooding Volume Within the Circulating Water System Unit 1	6,404,252

TABLE 2.4-10

FREE STORAGE VOLUMES

(UNIT 1)

Buildings	With Mat Fracture to Elev. 590′ (Gallons)	Without Mat Elev. 599′ (Gallons)
Turbine Building	2,208,400	3,884,199
Condensate demineralizer area	1,867,600	2,422,325
Heater Bay	1,195,500	1,732,754
Total Building Volume	5,271,500	8,039,278

Underdrain System	From Elev. 568′ to Elev. 590′
Porous concrete blanket	157,100
Manholes and pipes	159,500
Class A fill beneath buildings	41,100
Class A fill along buildings	1,139,300
Total Underdrain Per Unit	1,497,000
Total Free Storage Volume to Elevation 590′-0″ Per Unit	6,768,500

TABLE 2.4-11

WATER QUALITY DATA[1]

Sample No.	1	2	3
Color, Pt - Co Units, Diss	0	0	0
Color	Lt. Gray-Brown	Lt. Gray	Lt. Gray
Odor	None	None	None
Total Coli per 100 ml	<2	<2	<2
Fecal Coli per 100 ml	<2	<2	<2
BOD, 5 day	4.0	1.4	0.9
COD, Total	24	33	13
Dissolved Oxygen	6.3	9.1	10.3
pH, pH Units	7.6	7.7	7.8

NOTE:

[1] Coliform organisms are facultative anaerobes; i.e., they can grow either in the presence or absence of oxygen.

TABLE 2.4-12

MAJOR ONSITE STORAGE FACILITIES

Amount	Surface Storage Facility	Capacity (gallons each)	Comments
1	Condensate storage tank	500,000	Tank is located inside a Category I retaining basin sized to hold the maximum capacity of the tank.
2	Demineralized water storage tanks	100,000 & 400,000	Tanks are 125 feet from the nearest building. Any spill is directed away from the building by the site grading.
2	Industrial waste lagoons	2,200,000	Any spill would be directed to Lake Erie either through the plant surface drainage system or by overland flow.
1	Chemical cleaning lagoon	1,000,000	Any spill would be directed away from the plant and toward the minor stream diversion east of the plant.
1	Fire protection storage tank	300,000	A spill would flow to Lake Erie either through the surface drainage system or by overland flow.

TABLE 2.4-13

POROUS CONCRETE
PERMEABILITY TEST DATA

(ft/min)

(Days)	Cylinder No. 1	Cylinder No. 2	Cylinder No. 3	Average
3	4.00	3.56	4.33	3.96
7	4.14	3.69	1.15	2.99
14	4.64	3.60	4.30	4.18
14	4.56	5.14	4.14	4.61
21	2.81	3.54	2.56	2.97
28	3.93	4.47	4.38	4.26
28	4.74	4.22	-	4.48
28	4.11	3.77	5.01	4.30