SECTION 2

SITE AND ENVIRONS

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SECTION 2
SITE AND ENVIRONS

2.1 INTRODUCTION

The site for the Prairie Island Nuclear Generating Plant was thoroughly investigated for locating nuclear power reactors and found to be suitable by the USAEC. This is evidenced by issuance of Construction Permits CPPR-45 and CPPR-46 (June 25, 1968) and Facility Operating Licenses DPR-42 (August 9, 1973) for Unit 1 and DPR-60 (October 29, 1974) for Unit 2. Information pertinent to Prairie Island is contained in USAEC Dockets 50-282 for Unit 1 and 50-306 for Unit 2.

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2.2 SITE DESCRIPTION

2.2.1 Location

The site is located within the city limits of the City of Red Wing, Minnesota (population 15,134 according to 1990 census) on the right (West) bank of the Mississippi River in Sec. 4 and 5, T113N, R15W, in Goodhue County, Minnesota, at 92° 37.9′ west longitude and 44° 37.3′ north latitude.

Approximately 578 acres of land are owned in fee by Northern States Power Company at the plant location. Figure 2.2-1 shows the plant site boundaries. This figure also shows an outline of the minimum fenced area that defines the exclusion zone, which satisfies the 10CFR100 definition. Access to the exclusion zone is restricted by a perimeter fence with No Trespassing signs posted at intervals along the fence. Access to the exclusion zone by water is not restricted by a fence; however, "No Trespassing" signs are placed at intervals along the shoreline of the river.

East of the plant the exclusion zone boundary extends to the main channel of the Mississippi River. Islands within this boundary as well as a small strip of land northeast of the plant are owned by the Corps of Engineers. An agreement (Ref. 27 & 28) has been made with the Corps of Engineers such that no residences will be built on that strip of land or islands within the exclusion zone for the life of the plant.

The distance to the closest occupied offsite residence is 3000 ft. The governing population center, Eagan (population 47,409 according to 1990 census) lies 31 miles northwest of the plant.

2.2.2 Topography

Topography near the Prairie Island site is fairly level to slightly rolling ground ranging in elevation from 675 ft. to 706 ft. Unless otherwise stated, all elevations are in feet above mean sea level (MSL), 1929 adjustment. The surface slopes gradually toward the Mississippi River on the northeast and to the Vermillion River on the southwest. Normal pool elevation is at 674.5 ft. and the maximum reported flood (1965) was at 687.7 ft.

Steep bluffs parallel this stretch of the Mississippi River and rise to above a 1,000 ft. elevation approximately 1-1/2 miles northeast and southwest of the site. Northeast and southwest of these bluffs, the ground elevation ranges from 1,000 ft. to 1,200 ft. and is marked by many deeply eroded coulees. Topography in the vicinity of the plant is shown in Figures 2.2-1 and 2.2-2.

2.2.3 Access

Highway access is available to US Highway 61 via Goodhue County Rd. 18. Figure 2.2-3 shows the location of the highways in the vicinity of the Prairie Island Site. Railroad access is available from the CP Line Railroad (formerly the Soo Line) which is about 2300 ft. southwest of the reactor buildings. The site is served by a spur from this main line. Figure 2.2-1 shows the location of this track.

Arrangements have been made with the States of Minnesota and Wisconsin Emergency Management Divisions, State Police and local law enforcement agencies to control highway, railway and waterway traffic near the site in the event of an emergency (Ref. 29).

2.2.4 Land Use

2.2.4.1 Regional Land Use

Goodhue County, in which the site is located, and the adjacent counties of Dakota and Pierce (in Wisconsin) are predominantly rural. Dairy products and livestock account for most of the three-county farm products with field crops and vegetables accounting for most of the remainder. Principal crops are corn, oats, hay, soybeans, and barley.

2.2.4.2 Local Land Use

The region within a radius of five miles of the site is devoted almost exclusively to agricultural pursuits. Principal crops include soybeans, corn, oats, hay and some cannery crops at about four miles from the plant site. The nearest dairy farm is located more than two miles southwest of the plant site. Some beef cattle are raised approximately two miles southwest of the site. Cattle are on pasture from early June to late September or early October. During the winter, cows are fed on locally-produced hay and silage. Beyond the site boundary and within a one-mile radius of the plant, there are approximately 20 to 30 permanent residences or summer cottages. The closest occupied offsite residence is approximately 3000 feet NNW from the plant.

2.2.4.3 Nearby Commercial Facilities

At about one mile NW from the plant, the Mdewakanton Sioux Indian Community owns and operates the Treasure Island Casino, a combination resort hotel/bingo/casino gambling facility. The plant's Emergency plan and the State of Minnesota Local Government Emergency Response Plans for Nuclear Power Plants include notification plans for the Treasure Island Casino in the event of a nuclear plant radiological emergency.

Another business facility, consisting of a gasoline station, convenience store and lounge, is located about two miles WNW from the plant. The emergency plans' Public Alert and Notification System provides for the facility's notification in the case of a nuclear plant radiological emergency.

2.2.4.4 Nearby Industrial, Transportation, and Military Facilities

The following industrial facilities (workforce population greater than 30) are located within 5 miles of the plant site (Reference 25):

Advertising Unlimited, 3-4 miles South
DB Industries, 3-4 miles SSE
IRC Industries, 3-4 miles SSE
Jostens, 3-4 miles SSE
Dayco PTI, 3-4 miles SSE
Protein Technologies, 4-5 miles ESE
Ram Center Inc., 3-4 miles South
Red Wing Shoe Company, 3-4 miles SSE
Republican Eagle (Manufacturing), 4-5 miles SSE
Riedell Shoe Company, 3-4 miles SSE
Riviera Cabinets, 3-4 miles SSE
Central Research Laboratory, 3-4 miles South

No activities at the above facilities present a hazard to the safe operation of the plant.

A buried natural gas supply line from Xcel Gas Energy is located in the west plant area, with a branch supplying the New Site Administration Building. 01505821

No military installations are within 5 miles of the plant site. Transportation activities which could potentially have an effect on the plant are described below.

The Red Wing airport is located about seven miles east southeast of the plant site in Bay City, Wisconsin, at 44° 35′ 15″ north, 92° 29′ 40″ west. It is at elevation 780 ft. msl and has one asphalt paved runway which is 5010 ft. long by 100 ft. wide and an adjacent taxiway. The runway designation is 09/27 with a 3° glide slope. There are 48 aircraft based at the airport. The 48 aircraft includes 42 single engine aircraft under 4,000 pounds, 2 multi-engine aircraft of approximately 4,500 pounds, and 2 jets, one of which is approximately 8,000 pounds and one approximately 12,000 pounds.

Railroad traffic occurs on the following railroads, which pass within 5 miles of the site:

CP Line Railroad (Soo Line) runs across the southwest portion of the Prairie Island Nuclear Generating Plant site.

Burlington Northern Railroad runs within 2 miles east of the plant site in Wisconsin.

Truck traffic occurs on Minnesota State Highway 61, which runs within 2.5 miles of the plant site to the south. In addition, a number of county roads and trunk highways are located within 5 miles of the site, as shown on Figure 2.2-3.

Barge traffic occurs on the Mississippi River, which flows in its main channel no closer than 0.5 miles from the plant site.

2.2.5 Population Distribution

The nearest population centers from the site are Eagan (1990 population of 47,409), 26 miles northwest of the site; Minneapolis - St. Paul metropolitan area (1990 population of 2,407,090), 30 miles northwest of the site; and Rochester (1990 population of 70,745), 41 miles south of the site. No other population centers with more than 25,000 people lie within 50 miles of the site.

Table 2.2-1 shows the estimated 2010 resident population distribution within the emergency planning zone (EPZ) of the plants. 01441917

The low population zone (LPZ) radius for the Prairie Island Facility, within which there is a reasonable probability that appropriate protective measures could be taken on behalf of the residents in the event of a serious accident, has been selected as one and one-half miles. State and local government's emergency plans and the plant's emergency plans include emergency notification plans for disseminating protective measures to the residents and transient population in the ten mile radius emergency planning zone which includes the low population zone area. Based on the 10 CFR Part 100 definition of a low population zone radius and the radiological effects presented in Section 14, the selection of a one and one-half mile radius is adequate.

No limitations on normal plant operation are envisioned as a consequence of population increase, because the objective of plant effluent control is to assure radiation levels at better than acceptable values and as low as practicable at all points beyond the nearest site boundary.

2.3 METEOROLOGY

2.3.1 General

Meteorology in the region of the site was evaluated to provide a basis for determination of annual average waste gas release limits, estimates of exposure from potential accidents and design criteria for storm protection. This evaluation was based on twenty-five months of site data from May 1968 to May 1970. The preoperational meteorological data program is discussed in Section 2.8 of the FSAR. One year of supplemental data for the period June 1, 1971 through May 31, 1972 using NRC recommended delta-T stability classification is presented in Appendix H.

The data presented in Appendix H is utilized for off-site accident dose calculations. Meteorological data is collected continuously and compiled annually. The information collected from March 22, 1974 to March 21, 1975 was used as the basis for Prairie Island's response to the requirements of 10CFR50, Appendix I. The information collected from April 1, 1977 to March 31, 1978 was used as the basis for the Offsite Dose Calculation Manual and is used for evaluating plant gaseous release rates. Tables 2.3-1 through 2.3-19 present the meteorological data collected during calendar year 1991.

FSAR Section 2.8 and associated Figures contain the wind roses and wind persistence data for the May 1968 through May 1970 time period. FSAR/USAR Appendix H contain the wind roses and wind persistence data for the June 1971 through May 1972 time period.

For the alternate source term dose analyses, new atmospheric dispersion factors have been calculated for determining dose to the control room operators. These new atmospheric dispersion factors were determined based on meteorological data for a five year time period of 1993 through 1997.

See 5AWI 8.8.0, Environmental Monitoring Program, for additional information on Prairie Island's current meteorological monitoring program.

2.3.2 Descriptive Meteorology

The climate of the site region is basically continental and influenced by the general storms which move eastward along the northern tier of the United States. The geographical location results in frequent changes in weather systems as polar and tropical air masses alternate. Climatic characteristics are illustrated in Figures 2.3-1A, B & C which shows average and extreme temperatures, precipitation, and extreme winds at Minneapolis, Minnesota. Rainfall averages about 25 inches per year, with 65 percent falling in the months of May through September. Maximum rainfall during 24 hours was 10.0 inches in July 1987 (Reference 20). Snowfall averages about 44 inches per year, with a maximum of 19.9 inches in 24 hours in January 1982.

2.3.3 Winds and Wind Loading

The Prairie Island Nuclear Generating Plant was provided with a new 60 meter tower and meteorological instruments meeting Regulatory Guide 1.23, Proposed Revision 1 (Sept. 1980) in October, 1982 (Ref. 34). Wind speed, direction, and temperature difference instrumentation is located at approximately the 10 meter level and the 60 meter level. In addition, temperature and rainfall instruments are installed. 01282511

Recent joint frequency distributions for the 10 and 60 meter tower level for the period January 1, 1991 through December 31, 1991 are presented in Tables 2.3-1 through 2.3-16. The distributions are for Stability A through G as defined in Regulatory Guide 1.23. Annual average dispersion factor (ϰ/Q) and deposition per unit area (D/Q) were computed for this period and are presented in Tables 2.3-18 and 2.3-19. The Meteorological Information and Dose Assessment System was used for these calculations (Ref. 19).

Meteorological data is used to compute dispersion (ϰ/Q) and deposition (D/Q) factors for use in the dose assessment of airborne releases in accordance with the requirements of the Offsite Dose Calculation Manual. Wind speed, direction, and atmosphere stability class are averaged over the release period and serve as inputs to a dispersion model. Stability class is determined using temperature difference measurements between the 10 meter level elevation and the 60 meter level.

2.3.3.1 Atmospheric Stability

Atmospheric stability is important in describing the diffusion capacity of the atmosphere. Atmospheric stability, as used in this report, refers to the degree of wind turbulence rather than the vertical thermal structure of the atmosphere. Stable conditions are associated with low turbulence and poor atmospheric diffusion capacity. Unstable conditions are associated with high turbulence and favorable diffusion characteristics.

A typical onsite seasonal and annual distribution of atmospheric stability is shown in Table 2.3-17. Winter is the season of greatest stability, and summer has the maximum occurrence of unstable conditions.

2.3.3.2 Tornadoes

Minnesota lies to the north of the principal tornado belt in the United States. During the seven year period 1963-1969, 15 tornadoes and 21 funnel clouds were reported in the 1°[1] square centered about the site and encompassing nearby Wisconsin and Minnesota. Over 90% of these occurrences were reported in the months of May, June, and July.

According to statistical methods proposed by Thom (Ref. 1) the probability of a tornado striking a point within a given area may be estimated as follows:

$$P = \frac{\bar{Z}\,\bar{t}}{A}$$

in which P is the mean probability per year, Z is the mean tornado path area, t is the mean number of tornadoes per year in area A. Based on available data from 1963 -1969, including the sightings of funnel clouds, the value of t for the 1° square surrounding the site is 5.1. Using as the value for A, the area of the 1° square encompassing the site yields:

$$P = 4.5 \times 10^{-3} \text{ year}^{-1}$$

At a 95% confidence interval Thom's formula becomes

$$P^1 = P \left[1 \pm \frac{1.96}{N^{0.5}}\right]$$

in which N is the total number of tornadoes in the area of concern during the seven years of record, 1963-1969.

The 95% confidence limits are 5.8×10^{-3}/yr. and 3.8×10^{-3}/yr. The mean recurrence interval, R = 1/P, is 220 years; and, at these confidence limits the recurrence intervals, R = 1/P, range between 170 and 260 years.

Damage caused by tornadoes results from three principal effects:

a. The dynamic forces resulting from the high velocity vortex winds

b. The bursting forces caused by differential static pressure resulting from the sharp pressure reduction in the immediate vicinity of a tornado funnel.

c. The impact of missiles generated by (a) and (b).

The most widely accepted values of wind speed in a tornado appear to be about 300 mph (Refs. 2, 3, 4) or less for a very severe tornado at the peak of its intensity. Some sources mention values as high as 500-600 mph (Refs. 2, 5) but these estimates appear to be based on indirect observations of phenomena such as straws driven into trees, etc., and are not regarded as authoritative.

The highest directly observed wind velocities were derived from motion pictures of debris in the Dallas tornado of April 2, 1957 (Ref. 3). These velocities range up to 170 mph tangential and 150 mph upward resulting in a maximum wind vector of 220 mph. If higher velocities were present, they must have been very localized and not typical of the average wind on large bodies.

The design wind speed of 300 mph with a forward progression of 60 mph is about 36 percent greater than that of the Dallas tornado and is thought to be quite conservative in view of the Prairie Island plant location.

The greatest recorded pressure drop associated with a tornado was equivalent to a bursting pressure of approximately 3 psi, (Ref. 2) while the greatest measured pressure drops have been on the order of 1.5 psi.(Refs. 2, 6, 7, 8, 9) For the Dallas tornado mentioned above a maximum pressure drop of about 0.9 psi was determined from calculations (Ref. 3).

The structural design criteria used to assure adequate design to accommodate the most severe storm conditions are discussed in Section 12.2.

2.3.4 Plant Design Based on Meteorology

Based on meteorological data in the region of the site, at the site, and plant operational characteristics, the offsite doses arising from routine plant operation satisfy the guidelines of Appendix I to 10CFR50 (Ref. 10).

2.4 HYDROLOGY

All elevations stated are referenced to 1929 datum mean sea level.

2.4.1 Summary

The principal surface waters in the vicinity of the site are the Mississippi River, Sturgeon Lake, the Vermillion River, and the Cannon River. The levels of the Mississippi River and Sturgeon Lake are controlled by Lock and Dam Number 3 which is located approximately one and one-half miles downstream from the plant. The Vermillion River enters the main stream of the Mississippi below the dam. The maximum flood of record occurred in 1965 when a peak stage of 687.7 ft. was recorded. Flood stages during the anticipated plant life are not expected to exceed levels attained during 1965.

The ground water table is normally within 5 to 20 feet (approximately 674.5 ft.) of the ground surface of the site and appears to slope southwest from the Mississippi River toward the Vermillion River. The nearest ground water consumption of important magnitude is in the town of Red Wing, six miles downstream.

2.4.2 Hydrological Program

A hydrological investigation of the site was performed by Dames & Moore. The scope of the hydrological program consisted of:

a. A review of pertinent data regarding the flow, usage, temperature, chemical and biological characteristics, and other properties of Mississippi River waters and other adjacent surface waters

b. A study of the hydrological interrelationship between the Mississippi River, Sturgeon Lake, the ground waters underlying the site, and other adjacent surface waters.

c. A study of the infiltration characteristics of the near-surface soils at the site, and the determination of the composition and permeability characteristics of the bottom sediments in Sturgeon Lake and the slough areas located immediately east of the site.

d. The performance of pumping tests to obtain information regarding permeability, transmissibility, and storage characteristics of the deeper soil strata.

Certain data pertaining to the Mississippi River are presented in this section. Other data and the results of the various hydrological field studies are reported in Appendix E.

2.4.3 Surface Water

2.4.3.1 Surface Drainage

Surface drainage on Prairie Island at the site is essentially nonexistent, owing to the extremely sandy nature of the soils and the topography of the island. There are no well-established drainage lines, and because of the hummocky nature of the terrain, there are many small internal drainage basins.

2.4.3.2 Stream Flow

The Mississippi River and its major local tributaries, the Vermillion River and the Cannon River, are the principal streams of the area. The location of the major streams and gauging stations are shown on Figure 2.4-1. The Mississippi River is dammed at a point about one and one-half miles downstream from the plant by Lock and Dam Number 3. Its two major local tributaries enter the main stream below the dam. The normal pool upstream from the dam is at 674.5 ft.

There are no withdrawals of river water for city water supply for at least 300 miles downstream from the site. Minor withdrawals of river water for irrigation purposes do occur, the nearest being 53 miles downstream.

Stream flow records are available for the Mississippi River at Prescott and at Winona, and for the Cannon River at Welch. Figure 2.4-2 shows flow duration curves for the two stations on the Mississippi River.

Table 2.4-1 summarizes the consecutive-day low-flow characteristics of the Mississippi River at Prescott. The discharge characteristics of the Mississippi and Cannon Rivers are summarized in Table 2.4-2.

2.4.3.3 Availability of Circulating Water and Cooling Water

2.4.3.3.1 General Characteristics of Water Supply

The circulating water intake is located in the upper pool of Lock and Dam Number 3. The lock and dam is one of a series of navigation dams on the Mississippi River for the purpose of maintaining a minimum-depth navigation channel. The flow in the river is for the most part unregulated, i.e., natural river flow is passed through the dam so as to maintain an unvarying upper pool level. The normal upper pool is at 674.5 ft. This level may be lowered to 672.5 ft. at the dam to control pool elevation at Prescott to 674.5 ft. for a river flow of approximately 17,000 cfs. The bottom of the main channel at the circulating water intake is at 655.6 ft, creating a pool with a minimum normal depth of 18.9 ft. The lowest one-day unregulated flow recorded in 37 years of record is 1,380 cfs on July 13, 1940, as shown in Table 2.4-2.

Because the flows on the days immediately before and after are significantly different than this figure, it appears that this flow was not a natural occurrence. The flows for the period in question are tabulated below:

Date	Flow (cfs)
7-10-40	6090
7-11-40	11,400
7-12-40	3760
7-13-40	1380
7-14-40	5300
7-5-40	4620
7-16-40	3350
7-17-40	2220

The St. Paul District of the Corps of Engineers, in charge of reservoir regulation, has stated that several days prior to July 13, 1940, a heavy rainfall occurred in the Upper Mississippi Valley. Anticipating an increased flow, the operator at Lock and Dam No. 2, on July 11, opened the gates excessively, allowing a flow of approximately 10,000 cfs. This resulted in an extreme draw-down of the pool behind Lock and Dam No. 2 and required that the flow for the following days be restricted in order to refill the reservoir. On July 13, the flow through Lock and Dam No. 2 was 900 cfs. According to the Corps of Engineers, the flow contributed by the St. Croix River was approximately 1800 cfs resulting in a combined flow at the Prescott gage of approximately 2700 cfs. The Corps of Engineers believes that the recording of 1380 cfs for July 13 is in error, and should be closer to 2700 cfs. For the period of record considered for design of cooling facilities at Prairie Island, the next lowest flow is 2100 cfs in 1936.

2.4.3.3.2 Accidents to Water Supply

The reliability of near-normal pool levels at the circulating water intake is dependent on the structural integrity of various elements of Lock and Dam Number 3. The vulnerable elements of the dam affecting upper pool levels are (1) the dikes, (2) the lock miter gates and (3) the spillway gates. These elements and their locations in the dam are shown in Figure 2.4-3.

Accidents or natural disasters could remove all or part of one of these elements and thereby cause a lowering of the upper pool well below the normal level. The resulting stable new pool level would be controlled by the elevation of the lower pool which in turn is established by Lock and Dam Number 4 located 44.1 river miles downstream. The normal lower pool level of Lock and Dam Number 3 is 666.5 ft. Dam Number 4 is operated to maintain water level at Wabasha at 666.5 ft. The loss of a miter gate or spillway gate will tend to equalize the pools on either side of the dam at the elevation of the lower pool. Natural flow will establish the upper pool at an elevation somewhat higher than the lower pool, depending on the flow rate.

The most probable accident to the dam involves the dike which could be breached by overtopping or embankment failure. If this occurred, the upper pool level could be lowered to the base of the dike. The lowest height of the upper pool that could be produced by an accident of this type is at 671.5 ft.

The low upper pool elevation consistent with an accident resulting in the loss of a set of miter gates, or in the loss of one spillway gate, is 666.5 ft. A loss of all gates (miter gates and four spillway gates) would equalize the upper and lower pools at the lower pool elevation. The lowest water level experienced prior to operation of Lock and Dam Number 4 was at 662 ft. in 1934.

2.4.3.3.3 High Main Channel Velocities

An accident to miter gates or spillway gates at normal upper and lower pools would temporarily cause unnaturally high flow rates in the upper pool. This in turn would cause higher than normal main channel velocities. In the case of loss of a set of miter gates, the main channel average velocity would be 1.5 fps. The loss of one spillway gate results in a main channel average velocity of 1.6 fps. The loss of all spillway gates would result in a main channel average velocity of 6.2 fps.

2.4.3.3.4 Overall Reliability of Cooling Water Supply

An adequate water supply from the Mississippi River is assured to meet cooling water requirements. The minimum natural river flow is 2100 cfs (942,500 gpm). An accident to the dam concurrent with normal water flows would produce a pool elevation at the intake of 666.5 ft. This latter condition is the one consistent with safeguards philosophy and provides a pool 10.9 ft. deep at the circulating water intake.

Flow velocities past the intake after an accident to the dam will not divert flow from the intake. The design of the cooling water supply is such that adequate water will be delivered into the plant under any condition. See Section 10.4 for details of the intake structure and the emergency cooling water intake.

2.4.3.4 River Temperature

The design maximum temperature for the Cooling Water System is 85°F. This value was chosen based on historical data gathered at several sites on the Mississippi River. The value is that temperature that is not expected to be exceeded more than 1% of the time.

A temperature curve showing the average monthly temperature of the Mississippi River at St. Paul is presented in Figure 2.4-4. Indications are that, on the average, these temperatures are from two to three degrees higher than those at the site.

2.4.3.5 Floods

According to the U.S. Army, Corps of Engineers, the 1965 flood, which is the highest on record, has a recurrence interval of 150 years. The peak stage at Lock and Dam Number 3 during this flood was 687.7 ft. It is estimated by the Corps of Engineers that a flood having a 1000-year recurrence interval would have a peak stage of about 691.8 ft. at Lock and Dam Number 3, and a discharge of about 335,000 cfs.

A stream profile of the section of the river near the site is presented in Figure 2.4-5 showing profiles of the highest and lowest flow of record. An approximate longitudinal land profile of the Prairie Island site is also shown in Figure 2.4-5.

A study to determine the magnitude of the probable maximum flood has been done for this area of the Mississippi River by Harza Engineering Company. The probable maximum discharge was determined to be 910,300 cfs and to have a corresponding peak stage of 703.6 ft. The flood would result from meteorological conditions which could occur in the Spring and could reach maximum river level in about 12 days. It was estimated that the flood stage would remain above 695 ft. for approximately 13 days. The detailed results of the study are presented in Appendix F. Wind generated waves would be of maximum height when the wind is from east to west in the direction of the circulating water intake canal. With a persistent wind speed of 45 mph the height of the significant wave[1] would be less than 1.8 feet (crest to trough). The maximum one percent wave height, consistent with the highest significant wave, is estimated to be less than 3.10 feet. If the conservative assumption is made that run-up equals the approaching wave height, then the maximum water level would be 706.7 ft.

The main powerhouse structure consisting of the reactor buildings, the auxiliary and fuel handling building, the turbine building, the D5/D6 diesel generator building, and the pump section of the screenhouse structure are protected against the probable maximum flood of 703.6 ft. This is equivalent to 704.1 ft. (1912 adj) from the Harza Engineering Study. The base slabs of these structures have been designed to resist the full hydrostatic head of the probable maximum flood. The top of the substructure and/or superstructure flood protection walls are at 705.0 ft, and are designed to resist the probable maximum flood. These structures are capable of withstanding the hydrostatic forces associated with the probable maximum flood and associated maximum wave run-up to 706.7 ft. Some water leakage would occur whenever wave action exceeds 705 ft. on certain portions of the turbine building and auxiliary building walls. This leakage would occur through the joint between the top of the concrete wall and the bottom of the metal siding. This event would not compromise, or cause a loss of, any safety related function for two reasons. First, the leakage would represent a relatively small quantity of water which could be easily handled by plant sump pumps.

[1] Significant and maximum one percent wave height and run up are defined in "Shore Protection and Planning an Design,: Technical Report No.4, 3rd Edition, 1966 U.S. Army Corps of Engineers Coastal Engineering Research Center.

Second, the leakage would occur at a great enough distance from safety related equipment that there would be no direct contact of the water with such equipment.

All construction joints are keyed and provided with water stops. Penetrations through the foundation base slabs and flood protection walls below 703.6 ft. were held at a minimum. Necessary penetrations are closed prior to flooding with bulkheads stored on site. Hydrostatic pressures compress sealant materials along outside edges to assure a water tight fit on bulkhead closures. Figure 2.4-7 shows the location and details of all bulkhead closures and flood protection walls.

The only safeguards related equipment located outside the structures mentioned above are the diesel fuel tanks and fuel storage vaults, pipes and control cables all of which are buried and are designed to resist hydrostatic forces as well as other effects associated with the probable maximum flood.

The cooling tower pump house and the generator step-up transformer are protected from floods to 695.0′. The substation and cooling tower transformers will function when flooded up to 698.0 ft. Normal plant operation is limited to flooding below 695.0 ft.

The Prairie Island plant is designed such that all areas critical to nuclear safety are protected against the effects of the probable maximum flood and associated maximum wave run-up. Plant operating procedures and emergency plans state the flood stage elevations at which plant protective measures must be taken. These procedures will require placing the unit in Mode 3, Hot Standby, when flood stage elevations exceed 692 feet at the plant site. 01420553

Long range advisory projections and short-term forecasts of river stage and crest are supplied by the National Weather Service Office, Minnesota River District for gage stations on the Mississippi River and its major tributaries. Gage stations covered include Hastings and Red Wing, up river and down river from the plant site. Advisory and forecast reports are received directly in the NSP system dispatch center. The basis to readily interpret these projections for specific locations between gage stations is developed in cooperation with the Corps of Engineers and Department of Commerce National Oceanic and Atmospheric Administration.

NSP has had extensive experience in using these advisories and forecasts to develop and use flood procedures for successful continued operation of many river-site plants subject to seasonal floods of varying degree.

Advance planning and preliminary arrangements for operation during floods would be based on the advisory reports of flood potential. Implementation of flood procedures would be based on the three-day forecasts of flood stage and actual flood stage at the plant site.

In the event that three-day flood forecasts project crests greater than the minimum access road elevations, plant emergency fuel oil storage tanks will be maintained on a “keep-full” status until the access road becomes impassable or the flood crest has subsided below this level. Backup provisions for transportation of plant personnel and other plant supplies will be instituted.

In the event that three-day forecasts project a crest in excess of those stated in the plant operating procedures, bulkheads, which are stored onsite, will be installed to close all openings in the flood protection walls and sandbag barriers will be constructed around the substation control house. Normal operation will continue to a flood stage elevation stated in the plant operating procedures.

When flood stage exceeds elevations (692 ft.) stated in the plant operating procedures, both units would be taken to Mode 3, Hot Standby, and actions taken to assure availability of offsite power. Control circuitry for the respective source breakers in the plant substation would be defeated and fault protection would be provided at the source end of all offsite transmission lines.

The emergency and normal cooling water pumps are operable to a flood stage of elevation 695.0 ft. with no additional protective measures required. The cooling water pumps and their associated equipment are located in the Class I, Type I portion of the screen house which is designed for the probable maximum flood. When three day forecasts project crests in excess of those stated in the plant operating procedures, bulkhead closures in the flood openings of this structure will be installed and the normal cooling water pumps could continue service as long as station auxiliary electrical power is available. In the event emergency diesel power use becomes necessary, the emergency cooling water pumps are capable of providing all essential and normal cooling water service up to the maximum probable flood stage considerations.

As discussed in Section 10.3.13, any combination of the six Unit 1 Design Class I fuel oil storage tanks will allow operation of one safety related Unit 1 emergency diesel generator, D1 or D2, and one diesel driven cooling water pump, 12 or 22, for 14 days. Any combination of the four Unit 2 Design Class I fuel oil storage tanks will allow operation of one Unit 2 emergency diesel generator, D5 or D6 for 14 days. This is longer than the 13 days that the river flood level for the probable maximum flood will remain above the plant grade elevation. The emergency diesel fuel oil storage tanks will be filled to capacity for the extended period the access road may be impassable during flooding conditions, as discussed above as a “keep full” requirement.

2.4.3.5.1 Floods from Dam Failure

Lock and Dam Number 2 is located 17 miles upstream of the plant site. The difference in normal pool elevations across the dam is 12.2 feet. Failure of the dam could result in a sudden release of water, temporarily producing the effect of a flood in the river channel downstream of the dam. The storage effect of the lower channel basin and the resulting loss of head in the upper reservoir will greatly attenuate flooding effects at the Prairie Island site.

There is no flood hazard resulting from a dam break at Lock and Dam Number 2. This conclusion was substantiated by determining stable water level elevations at Lock and Dam Number 3 resulting from sustained flow with the loss of 10 tainter gates at Lock and Dam Number 2. Sustained flow will maintain the upper pool elevation at Lock and Dam Number 3, and will provide the volume of water needed in the lower pool to produce the maximum pool level consistent with steady flow supplied through 10 spillway bays. The flow resulting from these postulated extreme conditions would produce a river level at 684.5 ft. in the lower pool at Lock and Dam Number 2 with a corresponding level in the upper pool at Lock and Dam Number 3 of 676.5 ft.

2.4.4 Ground Water

2.4.4.1 Regional Characteristics

Regionally, the movement of ground water is toward the Mississippi River and its main tributaries. The ground water table slopes from the higher, glaciated bedrock areas toward these surface streams, generally at low gradients. Ground water enters the river valley from along the base of the bordering bedrock bluffs in the form of springs or as subsurface flow.

Beneath the flood plains and low terraces which border the Mississippi River, ground water levels closely coincide with the elevations of the river surface, and vary in accordance with river fluctuations. The average ground water gradient in these bottom lands is downstream, and essentially parallel to the stream gradient.

Pool elevation on the Mississippi River adjacent to the site is controlled by Lock and Dam Number 3. The Vermillion River by-passes the dam and therefore is not directly controlled by it. Elevations on the Vermillion River and connected lakes are therefore lower than the Mississippi River and the ground water table slopes southwestward between the two rivers. Due to the permeable nature of the sandy alluvial soils forming Prairie Island, the ground water table responds quickly to changes in river stage.

There is only minor usage of ground water for domestic, agricultural and irrigation purposes near the site or immediately downstream. A deep well believed to penetrate bedrock aquifiers exists at Lock and Dam Number 3. The nearest ground water consumption of important magnitude is in the town of Red Wing, six miles downstream. This community derives its water supply from four deep wells which penetrate sandstone aquifier of the Dresbach and Hinckley formations. The wells pump from depths of 400 to 730 ft., and each well is capable of providing the municipal requirements of about 1400 gpm. A high degree of hardness is characteristic of the water from these wells.

Several industries in the Red Wing area also utilize ground water in quantities exceeding the municipal consumption, and derive their supplies principally from the bedrock aquifers. Total well production from the bedrock at Red Wing probably exceeds 3000 gpm, and fairly large quantities may also be extracted from the alluvium for certain industrial uses.

Communities further downstream from the plant site which supply their water needs from wells in bedrock are Lake City, 25 river miles downstream, and Wabasha, 37 miles downstream.

A survey of 58 wells in the vicinity of the plant site is summarized in Table 2.4-3. The location of the wells and an outline of the survey area are shown on Figure 2.4-6.

2.4.4.2 Movements of Effluents

Dispersion of effluents entering the ground water system from the plant would take place principally in the upper portion of the saturated zone of the river alluvium. Due to the numerous surface waterways in the vicinity of the site, the majority of effluents would permanently leave the ground water environment and would mix with surface waters at the borders of Prairie Island.

The coefficient of horizontal permeability for the shallow aquifer beneath the site is:

K_h = 1,000 to 4,000 gallons/day/sq ft

Vertical permeability is about 30 percent of horizontal permeability. Due to the relatively permeable nature of the soils at the site, a path exists to the deeper bedrock aquifers directly below the site. Silt deposits lining the bottom of the river channels, however, have virtually eliminated exposure of bedrock aquifers to the main stream of the river. There is no reason to believe effluents will penetrate to the depth of bedrock aquifers. It is very unlikely that significant amounts of effluents could succeed in reaching shallow wells at Red Wing by way of continuous ground water paths.

Any possible recharging of the shallow aquifer at Red Wing by river water would be expected to entail dilution of the river water with stored ground water and other sources, time decay of activity, and removal of activities other than tritium by filtration through the soil.

The annual average dilution factor for the Mississippi River at Red Wing considering substantial use of cooling water is about 18. A minimum factor is 3.3 based on the 7-day average low flow having a once-in-ten-year probability of recurrence. Credit is not taken for the relatively minor flows contributed between the site and Red Wing by the Vermillion and Cannon Rivers.

The overall dilution factor includes that accomplished before release to the Mississippi River, which is expected to result in less than 0.1 MPC discharge to the river. Therefore, an overall minimum dilution factor of at least 33 would occur at Red Wing.

2.4.5 Plant Design Basis Dependent on Hydrology

Water movements passing the site are subject to large variations in the course of a year. Plant design with respect to operation and liquid waste disposal accounts for large variations in water flow from less than 2000 cfs to flood flows. Plant grade is about 695 ft. which is 7 ft. above record historical floods. The plant is designed to withstand the effects of the probable maximum flood.

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2.5 GEOLOGY AND SOIL INVESTIGATION

2.5.1 General

A detailed geological investigation was performed at the site by Dames & Moore. The geological program consisted of:

a. A review of pertinent literature and preliminary boring data, and discussions with local geologists, in order to describe regional characteristics, bedrock structure, and the general character and thickness of overburden soils at the site.

b. A study of the geological features of the site and environs by means of visual field reconnaissance and interpretation of maps and aerial photographs.

c. A detailed test boring and laboratory test program performed to identify predominant soil and rock types and to evaluate pertinent physical properties of the soil and rock strata present at the site.

d. Analyses to develop a suitable foundation system.

Certain pertinent data concerning regional and site geology are presented in this section. Other data and the results of field studies are reported in Appendix E.

The location and general topographic features of the site are shown on Figures 2.2-1 and 2.2-2.

The sub-surface soils at the site consist of permeable sandy alluvium. The sandy alluvium ranges in thickness from 158 to 185 feet and is variable with respect to engineering properties. The soils are generally suitable from a bearing capacity (shear failure) standpoint for support of the structures, but settlement restrictions and/or a low margin of safety against liquefaction of the upper 50 feet (above elevation 645) of alluvium required that certain critical structures be supported on densified sand. Several hundred feet of sound sandstone underlie the alluvial soils.

The plant site is located in a region of very low seismic activity. There is no evidence of even ancient inactive faulting within six miles of the site. Inactive faults are located approximately 6 and 13 miles from the site. No activity has occurred along either of these faults in recent geologic times.

2.5.2 Regional Geology

Precambrian granite, gneiss, schist, and volcanics comprise the oldest bedrock in the Minnesota-Wisconsin region. The basement rock is overlain by as much as 800 ft. of Paleozoic sandstone, shale and dolomite. Younger formations originally present in the region have been removed by erosion, and an irregular topography has been developed on the exposed bedrock surface. Except for local areas in southeastern Minnesota and parts of Wisconsin, bedrock is concealed under 100 to 300 feet of Pleistocene glacial drift. In contrast, the extreme southeastern tip of Minnesota, including the site vicinity, is covered by only a thin veneer of drift. It is therefore considered a part of the “driftless” area commonly referred to by glacial geologists. In this driftless area of Minnesota and central and southwestern Wisconsin, the unconsolidated materials consist primarily of loess, recent alluvium, and residual soil.

Drainage in the region is controlled by the Mississippi River. The Mississippi River originated as an outlet for early glacial meltwaters. Its major present day tributaries were developed by the draining of glacial lakes at the close of the Pleistocene.

A geologic column showing the thicknesses and age relationships of the various bedrock units and surficial deposits of the region is presented on the generalized stratigraphic column presented in Table 2.5-1.

The regional extent of the consolidated strata is shown in Figure 2.5-1.

2.5.2.1 Structure and Faulting

The dominant structural feature in Southeastern Minnesota and adjacent areas of Wisconsin and Iowa is the Keweenawan Basin. This basin was formed in early Precambrian time and extended from Lake Superior into Iowa. It provided a site for the deposition of thick sequences of later Precambrian and Paleozoic strata consisting of volcanics and sediments. These beds were gently warped by subsequent compressive forces into several subordinate structures. A large basin in the Paleozoic rocks extended northward from Iowa into the southeastern corner of Minnesota. This basin is separated from a smaller basin in the Twin Cities area by the Afton-Hudson anticline. The anticline begins at Farmington and trends northeastward through Hastings, Minnesota and Hudson, Wisconsin. A syncline lies to the east of this structure in the vicinity of River Falls, Wisconsin. Near the extreme southeastern corner of Minnesota, a second anticline extends from Rochester through Red Wing and is postulated to extend a short distance into Wisconsin.

Several major faults in the Minnesota-Wisconsin region have been inferred from geophysical surveys. The principal movements along these faults, which amounted to thousands of feet, appear to have been restricted to Precambrian time. The Douglas fault and the Lake Owen fault penetrate Precambrian rocks along the North and South sides of the Keweenawan Basin, respectively. A southern extension of the Lake Owens fault, which is known as the Hastings fault, trends southwest near the city of Hastings, about 13 miles northwest of the site. Minor activity occurred along the Hastings fault during both Precambrian and Paleozoic times. Other minor movements occurred in the Paleozoic strata six miles southeast of the site near the city of Red Wing, and approximately 20 miles northeast of the site in the River Falls syncline near Waverly, Wisconsin.

There is no evidence of recent activity along any of the known fault zones in the Minnesota-Wisconsin region.

The locations of these structural features are shown in Figure 2.5-1. Regional geology is further shown in Figure 2.5-2, and in Figure 2.5-3.

2.5.3 Site Geology

Prairie Island is a low island terrace associated with the Mississippi River flood plain. It is separated from other parts of the lowland by the Vermillion River on the west, and by the Mississippi River on the east. Ground surface elevations range from approximately 675 to 706 feet. Most of Prairie Island is under cultivation. Other lowland areas near the site are forested or covered by swamp vegetation.

The Mississippi River flood plain in this area is confined within a valley about three miles wide. Rocky bluffs and heavily forested slopes rise abruptly from both sides of the valley to a height of about 300 feet. The uplands immediately surrounding the valley reach elevations ranging from approximately 1000 to 1200 feet. They are deeply trenched by numerous streams emptying into the Mississippi River.

The overburden materials at the site are permeable sandy alluvial soils which were deposited as glacial outwash and as recent river sedimentation. Preliminary borings, such as that shown in Figure 2.5-4 and other borings (see Appendix E) indicated that the overburden soils at the site vary from 158 to 185 feet thick.

The uppermost bedrock unit at the site is sandstone and is believed to be part of the Franconia formation (See Table 2.5-1). Its thickness at this location is unknown, but would be much less than 180 feet, the total measured thickness of the Franconia formation in complete sections. Underneath the Franconia formation are several hundred feet of lower Cambrian and Precambrian sandstone with minor shale horizons.

The site is located on the west limb of the Red Wing anticline, as evidenced by a gentle westward dip of the bedrock.

2.5.4 Foundation Investigation

The location of the principal structures, including the turbine and reactor buildings, intake structure, and discharge facilities are shown in Figure 2.2-1. The location of soil borings is shown in Appendix E and the log of a typical boring is shown in Figure 2.5-4.

Dynamic soil tests were conducted because the probability of liquefaction is high under the cyclic loadings produced by the 1952 Taft earthquake (see Appendix E), considering the density of the sand and overburden pressure. Sands which are typically vulnerable to liquefaction are saturated, under low confining pressures, and have standard penetration test values of about N=5. Laboratory studies by Seed and Lee (Reference 11) demonstrate that sands denser than the critical void ratio can be made to liquefy under cyclic loading.

2.5.5 Soil Compaction

According to the Dames & Moore report in Appendix E, soils above elevation 645 have 01498299
a low margin of safety against liquefaction under the postulated maximum credible earthquake. To provide for a suitable margin of safety against liquefaction it was recommended to either:

a. Support critical plant structures on piling founded in the dense sands below elevation 645.

b. Densify the in-place granular soils above elevation 645 by the vibro-flotation method.

c. Densify the soils above elevation 645 by excavation and recompaction.

Economic studies of all three above methods were conducted. Method (c) was selected; design and construction commenced. The final design called for dewatering the foundation area to elevation 642, excavation of the area to elevation 645, and recompacting the area using the excavated material as fill. The fill was placed in three-inch layers and compacted to 100% maximum density as determined by the American Association of State Highway Officials Test Designation T 180 - 57. This corresponds to at least 85% relative density -- the figure above which soils of this type will not liquefy. The fill was replaced and compacted to the appropriate elevations upon which the foundation slabs were placed.

The results of the field testing done by Dames & Moore during the excavation and recompaction procedure revealed that the required densities were obtained throughout the area and the foundation design and construction meet all safety criteria.

2.6 SEISMOLOGY

2.6.1 General

A seismological investigation of the site was performed by Dames and Moore. The seismological program consisted of:

a. An evaluation of the seismicity of the area.

b. A study of geologic structure as related to earthquake activity.

c. The postulation of “operational” and “design” earthquake accelerations, and the preparation of recommended response spectra.

d. Field and laboratory measurements of the dynamic response characteristics of the soil and rock strata underlying the site.

The results of the seismological program are reported in Appendix E.

The State of Minnesota has experienced only a few moderate earthquake shocks in the relatively short period since 1860 during which earthquakes have been recorded in the State. A tabulation of earthquakes having epicenters in Minnesota, together with certain out-of-state earthquakes felt in Minnesota, is presented in Table 2.6-1 and in Figure 2.6-1. Earthquake intensities are described in terms of the Modified Mercalli Intensity Scale of 1931, which is explained in Table 2.6-2.

Based on the seismic history and the regional tectonics, it is anticipated that the site will not experience any significant earthquake motion during the economic life of the nuclear facility. Historically, there is no basis for expecting ground motion of more than a few percent of gravity. However, for conservatism, the plant is designed to respond elastically to earthquake ground motion as high as 6 percent gravity, with no loss of function. Provisions have also been made for safe shutdown of the reactor if ground motions reach as high as 12 percent of gravity in the overburden soils at the site. In the event of an earthquake, plant operating procedures identify the action thresholds for plant shutdown and post event physical inspection of the facility.

Because of a low margin of safety against liquefaction during a design basis earthquake, all critical structures at elevation 645 or higher have been supported on densified sand. All foundations are within the sand above the bedrock. 01498299

The design of the structures and their foundations took into account the dynamic effects of earthquake motion. Consideration was given in the design to maximum expected ground motions, response spectra, and elastic moduli and damping values of the various soil and rock. Seismic design criteria are provided in Section 12.

2.6.2 Seismic History

Southeastern Minnesota is considered one of the least active seismic zones of the United States. King's distribution of epicenters contours the area as having less than one epicenter per 10,000 sq. km, the "least active" classification (Ref. 26). However, earthquakes are not unknown in Minnesota. At least six (1860, 1865-70, 1917, 1928, 1939, and 1950) have had local origins, and certain others, with epicenters outside the state, have been felt within the borders of Minnesota. These events are discussed in Appendix E, Section 4. There has been no seismic activity of any consequence in recent years in the vicinity of the plant.

2.6.3 Recent Seismic History

An extensive seismic monitoring system is installed at Prairie Island. Only one seismic event has been recorded at the plant. An earthquake triggered the seismic alarm about 0650 on June 10, 1987. The seismic acceleration was measured at about 0.01 g, the lower limit of detectability for the installed instrumentation. The quake was centered in southeastern Illinois and caused tremors in fifteen states and Canada. The quake was not detectable at the Monticello Nuclear Generating Plant.

2.7 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM 98118

The Radiological Environmental Monitoring Program (REMP) for the Prairie Island site environs was initiated in May 1970 and has continued through start-up and plant operation. The purpose of the REMP is to assess the impact of plant operation on the surrounding environment and evaluate the performance of systems and equipment installed in the plant to control releases of radioactive materials. 99032

The monitoring system design is based on the indicator-control concept. Most types of samples are collected both at indicator locations (nearby, downwind or downstream) and at control locations (distant, upwind or upstream). A plant effect would be indicated if the radiation level at an indicator location was significantly larger than that at the control location and could not be accounted for by typical fluctuations in radiation levels arising from other sources. 99032

The environment near the plant is sampled and analyzed for selected radioactive isotopes in accordance with the requirements of the Offsite Dose Calculation Manual (ODCM). These samples include air, direct radiation, terrestrial (well water, drinking water, milk and cultivated crops) and river (water, fish and sediment). 99032

A census is conducted annually to determine that location of the nearest milk animal and garden (larger than 500 square feet) producing broad leaf vegetation. 98118

The results of the radioanalysis of these samples and the data collected from the environmental monitors are reported to the NRC in the Annual Radiological Environmental Monitoring Report in accordance with the requirements of the Technical Specifications. 98118

In February, 1982, changes to the Technical Specifications deleting the Appendix B Environmental Technical Specifications (and inserting certain environmental reporting requirements previously included in Appendix B into Appendix A) were approved by the NRC (Reference 15). Other changes to the Technical Specifications to implement the requirements of Appendix I of 10 CFR Part 50, based on the guidance provided by NUREG-0472 and NUREG-0133, were approved by the NRC in October, 1982, and are effective January 1, 1983 (Reference 16). The Offsite Dose Calculation Manual and the Process Control Program were also accepted by the NRC at the same time. The NRC further concluded that the radwaste systems presently installed and the provisions in the revised Technical Specifications are adequate to reduce releases of radioactive material in liquid and gaseous effluents to as low as reasonably achievable (ALARA) levels.

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2.8 ECOLOGICAL AND BIOLOGICAL STUDIES

On January 19, 1981, the Minnesota Pollution Control Agency, the permitting agency under the U. S. Environmental Protection Agency, issued the National Pollution Discharge Elimination System (NPDES) Permit No. MN0004006 [Ref. 30] covering the Prairie Island Nuclear Generating Plant. This permit is reissued with any modifications every 5 years. The NPDES effluent limitations and monitoring requirements, thermal studies and ecological monitoring requirements provide appropriate protection for the environment. There are no ecological or biological monitoring requirements under NRC jurisdiction. Pre-operational and early operational ecological and biological studies are described in the FSAR. 00252

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2.9 CONSEQUENCES OF HYPOTHETICAL LOCAL CATASTROPHES

2.9.1 Effects of Oil Spillage

The plant is fully protected from possible effects of oil spillage on the river by the design of the intake screenhouse and earthen dikes which prevent floating oil from entering the plant. The only water intake that bypasses these barriers is the emergency intake to the cooling water system and this intake is located in a crib at the bottom of the river branch beyond the intake canal.

In addition, the suction intakes for the circulating water pumps, the cooling water pumps, and the fire pumps are submerged in bays within the screenhouse.

Another purpose of these barriers is to prevent uncontrolled return of hot surface water to the river when the plant is operated with cooling towers, the return flow from which is by a return canal that merges with the plant intake canal.

In conclusion, the operation of the circulating water system, the engineered safety feature cooling water system, and other systems is unaffected by the occurrence of an oil spill.

2.9.2 Postulated Explosion of Munitions Barge

In the absence of reported bulk shipments of munitions or other explosives this far north on the Mississippi River, the question of a barge explosion can be relevant only in the sense that such cargo is not restricted.

The size and nature of a hypothetical cargo that might be postulated to explode is entirely speculative; therefore it is assumed conservatively that a jumbo barge (195 ft. length, 35 ft. width, 8-1/2 ft. draft), the largest hauler of dry cargo, is completely laden with 1400 tons of TNT, and that this cargo detonates in mid-channel directly opposite the plant. The resulting 1.4 kiloton explosion would be comparable to the Texas City disaster (April 1947) which resulted from detonation of 2 to 4 kilotons of equivalent explosive.

A mid-channel location opposite the plant would be along the Minnesota-Wisconsin line, which is a minimum of 2600 feet distance from the control room, at a point nearly due east from it. An overestimate of the blast effect is given by assuming the occurrence of a surface blast at this point.

Surface detonation of 1.4 kilotons would result in a peak overpressure of 2-1/4 psi at 2600 feet distance, plus a minor dynamic pressure due to a 78 mph transient wind, as determined directly by use of “The Nuclear Bomb Effects Computer” (Ref. 12). The overpressure would actually be substantially less because of the attenuation and vertical blast deflection that would occur due to the fact that much of the full cargo would necessarily be located below the waterline.

The effects of this pressure on either of the shield buildings can be scaled conservatively from the results of previous calculations of tornado loading. The tornado-induced stresses were based on a 1.56 psi frontal overpressure with resultant areas of depression up to minus 3 psi on the sides of the structure. The maximum local tensile stress in any steel reinforcement member was determined to be 50,000 psi, relative to a minimum yield strength of 60,000 psi and a minimum ultimate strength of 90,000 psi. This occurred for certain more highly loaded members at mid-elevation in the structure. The concrete was nowhere compressively stressed to more than about one-half its compressive strength.

The calculated frontal overpressure of the blast, and the overall blast loading, will momentarily be 1.44 times as great as for the tornado, and should correspondingly cause a maximum local tensile stress of 72,000 psi. This is between the yield strength and the ultimate tensile strength, indicating that some local deformation and concrete cracking could possibly occur for sustained loading of such magnitude, depending on the extent to which the actual yield strength of the affected members exceeded the minimum specified value, but that no extensive structural failure and no structural collapse would occur.

Both the yield strength of the steel and the compressive strength of the concrete will actually be much greater for the pulse loading of the blast, which falls nearly linearly to zero from the initial overpressure over a time duration of 0.5 seconds, as determined by the referenced computer. It can be inferred from Figures 6-2 and 6-5 of the Air Force Design Manual (Ref. 13) that the short-term minimum yield strength would not be exceeded under these conditions. Considering also the attenuation effects due to partial submergence of the explosion source at the time of detonation, it may be concluded that there would actually be no local deformation whatever.

In any case, the free-standing containment vessel within the shield building would be unaffected, as would the components of the reactor system within the containment.

The control room should readily survive the postulated blast without injury to its occupants. The entire room is enclosed with two-foot thick concrete walls, except for the north wall which is 18 inches thick, and it is surrounded by other structures. Conservative application of the linear and rotational components of tornado velocities for those areas of the structure that would be exposed to the blast has effectively resulted in design for a 2-1/4 psi internal loading, plus allowance for missiles and earthquakes. The reinforcement in the structure is symmetrical and it can be concluded that the design is also adequate for such pressure loading applied externally.

Similarly, it can be concluded that the massive structure of the spent fuel storage area would be unaffected.

Damage may be expected to occur to light external structures that are exposed to the blast. In particular, the metal siding and roof decking of certain structures such as the turbine building would be blown off, consistent with the intent of their design with regard to tornado forces. Extensive minor damage would be expected to occur throughout the plant and switchyard.

Despite such superficial and repairable damage to the plant from an occurrence for which it was not specifically designed, no reduction in effectiveness would be expected for either the containment system or the engineered safety features that are provided to respond to a nuclear accident. The only realistic concern is that the blast could cause a nuclear accident or incapacitate the operators before they can accomplish an orderly shutdown.

No consequence of the postulated explosion is foreseen that would either initiate a nuclear accident or prevent safe shutdown of the plant.

2.9.3 Vulnerability of Cooling Water Intakes to Barge Collision

Plant safety with regard to continued availability of cooling water supply requires only that there be sufficient flow to satisfy normal shutdown and post-accident requirements. Such assurance is provided by redundancy and reliability of adequate sources of cooling water supply.

The possible consequences of a storm-driven or flood-driven barge colliding with any structure or earthwork related to the plant are therefore of interest only to the extent that such collision might conceivably disable all redundant sources of supply.

The post-shutdown or post-accident supply paths of interest are those to the five cooling water pumps, any one of which can accommodate the total demand for both units with an accident having occurred in one and Mode 3, Hot Standby in the other. Two means of supply of intake canal water are provided for the safeguards pumps. Two horizontal pumps take suction from the main intake bays in the screenhouse, and three vertical pumps take suction from a safeguards bay in the screenhouse. The safeguards bay is a concrete structure enclosed on all sides and normally supplied by underwater ports on each side of the structure which are open to the water in the other bays. This island structure is located well back in the screenhouse and is protected on the canal side by the massive concrete piers that define the other bays.

The safeguards bay has further redundancy of supply in that it can also be fed by the emergency intake line described in Section 10.4. This source of supply is delivered through underground piping which becomes embedded within the piers, and is particularly invulnerable to any barge accident condition. The pipe is buried approximately 40 feet below the canal and emerges at a submerged intake in the branch channel of the river between the intake canal and the approach canal (see Figure 10.4-3). The intake terminal protrudes four feet upward from its crib structure, which is depressed relative to the two canals such that the highest elevation of the intake is below the bottom of the two canals.

To disable all supplies of cooling water, an accident would have to result in concurrently blocking the intake screenhouse structure screens and totally damaging or blocking the emergency intake structure. Screen bypass gates are provided in the intake screenhouse and the emergency intake structure is designed and located to preclude total blocking by the postulated barge accident. There is no credible way in which an uncontrolled barge could cause total loss of necessary cooling water supply capability.

2.9.4 Toxic Chemical Study

Due to the toxicity of commonly used chemicals, which may be transported near the Prairie Island Nuclear Generating Plant by railroad, highway or the Mississippi River, a survey was performed to predict which chemicals may become hazardous in the event of a spill. The analysis was performed in conformance with the guidance set forth by the Nuclear Regulatory Guide 1.78 and NUREG 0570.

Due to recent design changes, chlorine is no longer stored onsite and regulations requiring early warning of onsite chlorine releases no longer apply. Recognizing that removal of onsite chlorine may eliminate the need for the control room HVAC chlorine detectors and also realizing that the detectors were installed in response to a Control Room Habitability Study based on survey results which were ten years old, it was decided to revise the survey and reassess the need for toxic chemical detectors.

Surveys (Ref. 23, 2) were performed which identified toxic chemicals either stored onsite in sufficient quantities or shipped near the plant at sufficient frequencies to warrant further evaluation. These toxic chemicals were evaluated in accordance with applicable regulatory requirements.

Installation of the natural gas supply line in the west plant area elicits the need to account for a natural gas release, for its effect on control room habitability and operation of emergency diesel generator. Using U.S. NRC Regulatory Guide 1.78, Revision 1 methodology, references 36 and 37 determine that natural gas released from this supply line will not result in natural gas concentrations in the control room or near the diesel generator combustion air intakes, security diesel intakes or intakes for the diesel driven cooling water pumps that challenge the environments for habitability or operation. 01505821

Potential hazardous releases from all identified sources need not be considered in the design of the plant and no special control room HVAC detectors are required. Table 2.9-1 lists the chemicals which were considered. Table 2.9-1 is updated periodically to evaluate any changes in stored or transported toxic chemicals.

2.9.5 Blast Release from Natural Gas Supply Line

A Blast Analysis (Ref. 35) was performed to estimate the blast load effects that could potentially threaten the plant structures, systems and components (SSCs) important to safety in the event of a gas Vapor Cloud Explosion (VCE). A VCE could occur in the event of delayed ignition of flammable gas or vapor released from a postulated leak in the gas line. A VCE explosion would result in a pressure wave that manifests a certain distance from the place of ignition. This pressure wave has the potential to damage any SSCs that are within the envelope of the pressure wave. This Blast Analysis implements the methodology found in US NRC Regulatory Guide 1.91, Rev. 2, Evaluations of Explosions Postulated to Occur at Nearby Facilities and on Transportation Routes Near Nuclear Power Plants (RG 1.91, Ref. 38). 01505821

In order to determine the maximum blast pressure using RG 1.91 methodology, a full guillotine break was assumed at any location along the planned gas line routing. The flammable mass contained in the vapor cloud was estimated based on the full bore release size and the release was considered to be pure methane. Once the amount of material release was determined, the energy in the vapor cloud was calculated and the mass of flammable material was converted into an equivalent mass of TNT. This TNT equivalent was then used to determine the 1-psi incident pressure distance.

The 1 psi blast effect distances were then mapped graphically. The boundaries of the 1 psi blast contour and its location relative to plant structures was determined. This map shows that no plant SSCs inside the protected area would be affected by this 1 psi pressure wave. However it does show that a portion of the sub-station could be affected by this pressure wave. It was determined that the postulated explosion could affect electrical systems resulting in a Loss Of Offiste Power (LOOP) event, although the frequency of such an event was found to be less than minimal. Since it is unknown what kind of affect the blast wave would have on the sub-station components it was assumed that this could possibly result in a loss of offsite power event.

2.9.6 Summary of Analysis of Effects of Local Disasters

The possible consequences of various hypothetical local disasters have been investigated and it is concluded, for the conditions or assumptions specified for each occurrence except the toxic chemical study (Reference 23), that the plant would either be relatively unaffected in its operation or that it could safely be shutdown without initiation of a nuclear accident.

These conclusions are not entirely surprising in view of the plant design requirements which include the effects of earthquakes, floods, tornadoes, and gross release of radioactivity. Once designed consistent with these requirements, the plant is found to be relatively invulnerable to lesser local disasters, even though its design has not specifically anticipated their occurrence.

It is noted with some concern, however, that the relevance of vulnerability of any nuclear plant to the more severe offsite catastrophes that can be postulated is questionable. As in the Texas City-type explosion, the role of the nuclear plant would essentially be that of victim rather than potential offender. The direct consequences of such an accident would reasonably be expected to exceed greatly in severity any likely secondary consequences of a nuclear accident that might be provoked by the blast, provided such secondary consequences were evaluated consistent with the assumed reality of the primary event. With engineered safety features presumed to be effective unless they are directly affected by the disaster, and with activity release, if any, considered on the basis of reasonable expectation, the predicted nuclear consequences would be relatively minor.

The more severe consequences of a nuclear accident that are predicted on the traditional basis of sequential conservative assumptions, and which we apply to the nuclear plant when it is regarded by itself as a potential offender, would not logically be applied to overall evaluation of a composite accident, the severe primary consequences of which are directly predictable and not a matter of consistently conservative assumption.

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TABLE 2.2-1 ESTIMATED 2010 RESIDENT POPULATION DISTRIBUTION WITHIN THE PRAIRIE ISLAND EMERGENCY PLANNING ZONE (REFERENCE 25)

Radius (MILES)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0-1	0	0	0	0	0	0	0	0	0	0	0	0	6	164	0	22	192
1-2	27	34	74	0	6	0	0	0	0	21	0	13	0	20	11	0	206
2-3	23	75	75	12	4	0	0	0	7	20	23	30	0	0	0	1	270
3-4	16	59	30	2	165	137	0	614	458	111	1	40	68	84	0	0	1,785
4-5	20	21	35	34	50	148	476	901	281	0	17	30	45	5	0	13	2,076
5-6	77	35	120	80	172	296	1,445	677	4	35	75	0	99	218	46	117	3,496
6-7	6	169	101	48	38	601	6,655	56	48	73	57	98	239	331	0	0	8,520
7-8	171	59	166	74	223	331	4,113	146	44	43	51	53	162	461	146	658	6,901
8-9	86	166	148	106	41	265	127	107	17	114	57	91	115	593	176	106	2,315
9-10	288	260	290	82	24	484	136	78	62	108	98	100	89	109	297	224	2,729
10-11*	70	394	276	17	78	8	45	12	8	57	74	35	0	595	52	264	1,985
TOTAL	**784**	**1,272**	**1,315**	**455**	**801**	**2,270**	**12,997**	**2,591**	**929**	**582**	**453**	**490**	**823**	**2,580**	**728**	**1,405**	**30,475**

* Note this population is the remainder of the 10-Mile EPZ due to geopolitical boundaries which extend into the 10-11 mile range.

01441917

TABLE 2.3-1 JOINT FREQUENCY DISTRIBUTIONS AT 10 METERS, STABILITY CLASS A (HOURS AT EACH WIND SPEED AND DIRECTION) 1991 DATA

WIND DIRECTION	WIND SPEED (MPH) 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	1	7	2	0	0	0	10
NNE	4	5	2	0	0	0	11
NE	2	5	3	0	0	0	10
ENE	2	8	7	0	0	0	17
E	1	15	21	0	0	0	37
ESE	0	10	25	4	1	0	40
SE	0	3	0	1	0	0	4
SSE	1	3	6	3	0	0	13
S	0	2	16	2	0	0	20
SSW	0	5	5	3	0	0	13
SW	1	2	3	3	0	0	9
WSW	1	3	4	1	0	0	9
W	0	7	12	5	0	0	24
WNW	0	10	17	10	0	0	37
NW	1	17	23	18	1	0	60
NNW	0	7	17	2	0	0	26
TOTAL	14	109	163	52	2	0	340

91076

PERCENT OF ALL DATA THIS CLASS: 3.88%

TABLE 2.3-2 JOINT FREQUENCY DISTRIBUTIONS AT 10 METERS, STABILITY CLASS B (HOURS AT EACH WIND SPEED AND DIRECTION) 1991 DATA

WIND DIRECTION	WIND SPEED (MPH) 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	1	4	2	1	0	0	8
NNE	0	7	1	0	0	0	8
NE	1	5	3	0	0	0	9
ENE	0	2	1	0	0	0	3
E	0	13	21	1	0	0	23
ESE	1	7	12	2	0	0	22
SE	0	3	4	1	0	0	8
SSE	1	3	12	4	0	0	20
S	0	8	17	3	0	0	28
SSW	0	4	13	3	0	0	20
SW	2	2	5	2	0	0	11
WSW	0	2	4	1	0	0	7
W	0	6	6	1	0	0	13
WNW	0	12	26	8	0	0	46
NW	0	13	17	10	2	0	42
NNW	1	10	5	2	0	0	8
TOTAL	7	101	137	39	2	0	286

91076

PERCENT OF ALL DATA THIS CLASS: 3.26%

TABLE 2.3-3 JOINT FREQUENCY DISTRIBUTIONS AT 10 METERS, STABILITY CLASS C (HOURS AT EACH WIND SPEED AND DIRECTION) 1991 DATA

	WIND SPEED (MPH)						
WIND DIRECTION	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	1	7	2	1	0	0	11
NNE	1	15	0	0	0	0	16
NE	2	3	0	0	0	0	5
ENE	3	6	4	0	0	0	13
E	2	25	7	2	0	0	36
ESE	2	11	20	6	0	0	39
SE	2	2	4	7	0	0	15
SSE	2	5	14	3	0	0	24
S	1	6	23	2	0	0	32
SSW	1	8	14	1	0	0	24
SW	1	7	7	8	0	0	23
WSW	0	6	7	3	0	0	16
W	1	9	6	4	0	0	20
WNW	1	16	14	5	1	0	37
NW	1	19	21	11	3	0	55
NNW	3	15	8	1	0	0	27
TOTAL	24	160	151	54	4	0	393

91076

PERCENT OF ALL DATA THIS CLASS: 4.49%

TABLE 2.3-4 JOINT FREQUENCY DISTRIBUTIONS AT 10 METERS, STABILITY CLASS D (HOURS AT EACH WIND SPEED AND DIRECTION) 1991 DATA

WIND DIRECTION	WIND SPEED (MPH) 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	19	67	27	5	0	0	118
NNE	30	47	5	0	0	0	82
NE	41	64	16	2	0	0	123
ENE	28	68	32	3	0	0	121
E	25	192	127	30	0	0	375
ESE	11	73	222	130	13	0	449
SE	12	103	91	27	3	0	236
SSE	19	91	92	26	0	0	228
S	18	79	115	10	0	0	222
SSW	14	59	55	9	0	0	137
SW	16	39	30	21	0	0	106
WSW	8	51	44	17	1	0	121
W	17	76	129	61	3	0	286
WNW	23	106	139	85	5	0	358
NW	28	84	132	108	20	0	372
NNW	26	79	66	25	2	0	198
TOTAL	335	1278	1322	559	47	0	3542

91076

PERCENT OF ALL DATA THIS CLASS: 40.43%

TABLE 2.3-5 JOINT FREQUENCY DISTRIBUTIONS AT 10 METERS, STABILITY CLASS E (HOURS AT EACH WIND SPEED AND DIRECTION) 1991 DATA

WIND SPEED (MPH)

WIND DIRECTION	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	37	26	19	1	0	0	85
NNE	35	16	4	1	0	0	57
NE	31	27	1	0	0	0	59
ENE	50	42	7	0	0	0	101
E	85	174	29	6	0	0	294
ESE	65	181	100	22	4	0	374
SE	44	237	125	16	3	0	423
SSE	50	115	69	12	0	0	249
S	33	101	120	4	0	0	260
SSW	21	40	43	5	0	0	109
SW	28	27	27	9	0	0	91
WSW	37	40	22	7	3	0	109
W	74	145	52	21	4	0	297
WNW	79	173	93	47	2	0	394
NW	72	138	77	38	1	0	327
NNW	50	37	28	7	0	0	124
TOTAL	791	1519	816	196	14	0	3353

91076

PERCENT OF ALL DATA THIS CLASS: 38.28%

TABLE 2.3-6 JOINT FREQUENCY DISTRIBUTIONS AT 10 METERS, STABILITY CLASS F (HOURS AT EACH WIND SPEED AND DIRECTION)
1991 DATA

	WIND SPEED (MPH)						
WIND DIRECTION	**1-3**	**4-7**	**8-12**	**13-18**	**19-24**	**>24**	**TOTAL**
N	15	1	0	0	0	0	17
NNE	10	0	0	0	0	0	11
NE	12	0	0	0	0	0	12
ENE	23	4	0	0	0	0	27
E	38	16	2	0	0	0	58
ESE	43	19	0	0	0	0	62
SE	34	13	0	0	3	0	48
SSE	29	9	2	0	0	0	42
S	10	3	0	0	0	0	13
SSW	11	2	0	0	0	0	13
SW	17	6	0	0	0	0	25
WSW	25	7	0	0	0	0	32
W	40	11	2	0	0	0	53
WNW	73	45	3	0	0	0	121
NW	47	23	1	0	0	0	71
NNW	29	2	0	0	0	0	31
TOTAL	456	161	10	0	0	0	636

91076

PERCENT OF ALL DATA THIS CLASS: 7.26%

TABLE 2.3-7 JOINT FREQUENCY DISTRIBUTIONS AT 10 METERS, STABILITY CLASS G (HOURS AT EACH WIND SPEED AND DIRECTION) 1991 DATA

WIND DIRECTION	WIND SPEED (MPH) 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	2	0	0	0	0	0	2
NNE	5	0	0	0	0	0	7
NE	4	0	0	0	0	0	4
ENE	5	2	0	0	0	0	9
E	16	10	0	0	0	0	29
ESE	14	4	0	0	0	0	19
SE	22	2	0	0	3	0	24
SSE	12	1	0	0	0	0	14
S	11	0	0	0	0	0	11
SSW	4	1	0	0	0	0	5
SW	4	0	0	0	0	0	4
WSW	9	0	0	0	0	0	9
W	12	1	0	0	0	0	13
WNW	20	9	0	0	0	0	29
NW	23	2	0	0	0	0	26
NNW	4	1	0	0	0	0	5
TOTAL	167	33	0	0	0	0	210

91076

PERCENT OF ALL DATA THIS CLASS: 2.40%

TABLE 2.3-8 JOINT FREQUENCY DISTRIBUTIONS AT 10 METERS, STABILITY ALL CLASSES COMBINED (HOURS AT EACH WIND SPEED AND DIRECTION) 1991 DATA (Page 1 of 2)

	WIND SPEED (MPH)						
WIND DIRECTION	1-3	4-7	8-12	13-18	19-24	>24	TOTA L
N	76	112	52	8	0	0	251
NNE	85	90	12	1	0	0	192
NE	93	104	23	2	0	0	222
ENE	111	132	51	3	0	0	301
E	167	445	195	39	0	0	852
ESE	136	305	379	164	18	0	1005
SE	114	363	224	52	3	0	758
SSE	114	227	195	48	0	0	590
S	73	199	291	21	0	0	586
SSW	51	119	130	21	0	0	321
SW	69	83	72	43	0	0	269
WSW	80	109	81	29	4	0	303
W	144	255	207	92	7	0	706
WNW	196	371	292	155	8	0	1022
NW	172	296	271	185	27	0	953
NNW	113	151	124	37	2	0	429
TOTAL	1794	3361	2599	900	69	0	760

91076

HOURS OF CALM TOTAL: 41
HOURS OF MISSING DATA: 0
HOURS WITH VARIABLE DIRECTION: 0

TABLE 2.3-8 JOINT FREQUENCY DISTRIBUTIONS AT 10 METERS, STABILITY ALL CLASSES COMBINED (HOURS AT EACH WIND SPEED AND DIRECTION) 1991 DATA (Page 2 of 2)

Percent Occurrence in each Stability Class

Class A	3.88%
Class B	3.26%
Class C	4.49%
Class D	40.43%
Class E	38.28%
Class F	7.26%
Class G	2.40%

91076

TABLE 2.3-9 JOINT FREQUENCY DISTRIBUTIONS AT 60 METERS, STABILITY CLASS A (HOURS AT EACH WIND SPEED AND DIRECTION) 1991 DATA

	WIND SPEED (MPH)						
WIND DIRECTION	**1-3**	**4-7**	**8-12**	**13-18**	**19-24**	**>24**	**TOTAL**
N	1	3	3	0	0	0	7
NNE	0	3	3	1	0	0	7
NE	1	3	5	2	0	0	11
ENE	1	5	6	2	0	0	14
E	1	15	19	4	0	0	39
ESE	1	5	22	10	2	0	40
SE	0	1	1	1	0	0	3
SSE	0	3	5	8	0	0	16
S	0	1	11	6	0	0	18
SSW	1	3	5	5	0	0	14
SW	0	2	1	3	2	0	8
WSW	0	2	5	1	1	0	9
W	0	3	14	7	6	1	31
WNW	1	6	10	14	5	0	36
NW	1	5	26	13	14	1	60
NNW	1	7	9	9	1	0	27
TOTAL	9	67	145	86	31	2	340

91076

PERCENT OF ALL DATA THIS CLASS: 3.88%

TABLE 2.3-10 JOINT FREQUENCY DISTRIBUTIONS AT 60 METERS, STABILITY CLASS B (HOURS AT EACH WIND SPEED AND DIRECTION) 1991 DATA

	WIND SPEED (MPH)						
WIND DIRECTION	**1-3**	**4-7**	**8-12**	**13-18**	**19-24**	**>24**	**TOTAL**
N	0	4	0	0	0	0	4
NNE	3	5	1	1	0	0	10
NE	0	5	3	1	0	0	9
ENE	0	1	1	1	0	0	3
E	0	7	10	2	1	0	20
ESE	0	2	15	4	1	0	22
SE	0	3	10	0	3	0	16
SSE	1	0	12	3	3	0	19
S	0	3	16	6	1	0	26
SSW	0	1	6	8	1	0	16
SW	0	2	2	7	1	0	12
WSW	0	1	6	1	0	0	8
W	0	2	5	3	3	0	13
WNW	0	9	23	11	5	3	51
NW	0	5	16	12	3	1	37
NNW	0	9	5	5	1	0	20
TOTAL	4	59	131	65	23	4	286

91076

PERCENT OF ALL DATA THIS CLASS: 3.26%

TABLE 2.3-11 JOINT FREQUENCY DISTRIBUTIONS AT 60 METERS, STABILITY CLASS C (HOURS AT EACH WIND SPEED AND DIRECTION) 1991 DATA

	WIND SPEED (MPH)						
WIND DIRECTION	**1-3**	**4-7**	**8-12**	**13-18**	**19-24**	**>24**	**TOTAL**
N	1	10	1	1	1	0	14
NNE	5	7	2	0	0	0	14
NE	1	2	0	0	0	0	3
ENE	1	6	6	4	0	0	17
E	1	15	12	3	2	0	33
ESE	1	4	22	7	4	0	38
SE	0	4	6	4	4	0	18
SSE	0	0	10	9	2	0	21
S	1	6	15	14	0	0	36
SSW	2	2	8	9	1	0	22
SW	0	5	4	8	2	0	19
WSW	0	4	7	2	1	1	15
W	0	7	7	6	3	2	25
WNW	2	10	9	12	4	0	37
NW	1	13	19	13	6	3	55
NNW	1	11	10	3	1	0	26
TOTAL	17	106	138	95	31	6	393

91076

PERCENT OF ALL DATA THIS CLASS: 4.49%

TABLE 2.3-12 JOINT FREQUENCY DISTRIBUTIONS AT 60 METERS, STABILITY CLASS D (HOURS AT EACH WIND SPEED AND DIRECTION) 1991 DATA

WIND DIRECTION	WIND SPEED (MPH) 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	10	41	33	14	2	0	100
NNE	15	42	32	2	1	0	92
NE	16	47	32	15	2	0	112
ENE	10	54	47	24	7	0	142
E	11	99	136	78	25	1	350
ESE	12	56	163	132	79	13	455
SE	13	57	125	50	17	2	264
SSE	15	39	92	64	13	0	223
S	7	57	101	58	4	0	227
SSW	3	36	47	35	8	0	129
SW	9	32	34	23	10	0	108
WSW	10	27	59	24	7	1	128
W	7	49	93	110	53	9	321
WNW	15	45	100	130	65	15	370
NW	21	41	64	98	62	28	314
NNW	21	46	67	58	15	0	207
TOTAL	195	768	1225	915	370	69	3542

91076

PERCENT OF ALL DATA THIS CLASS: 40.43%

TABLE 2.3-13 JOINT FREQUENCY DISTRIBUTIONS AT 60 METERS, STABILITY CLASS E (HOURS AT EACH WIND SPEED AND DIRECTION) 1991 DATA

	WIND SPEED (MPH)						
WIND DIRECTION	**1-3**	**4-7**	**8-12**	**13-18**	**19-24**	**>24**	**TOTAL**
N	10	25	22	14	4	0	75
NNE	15	26	19	6	0	0	66
NE	25	30	20	2	0	0	77
ENE	18	23	21	7	1	0	70
E	21	87	77	19	25	1	210
ESE	28	147	166	54	79	4	418
SE	41	133	223	85	17	0	493
SSE	22	69	115	43	13	0	260
S	13	61	102	85	4	0	265
SSW	10	23	36	39	8	0	113
SW	9	26	27	24	10	1	92
WSW	15	45	43	27	7	3	139
W	21	89	139	64	53	4	336
WNW	22	72	116	108	65	6	378
NW	14	55	93	84	62	1	267
NNW	13	31	30	18	15	0	94
TOTAL	297	942	1249	679	162	20	3353

91076

PERCENT OF ALL DATA THIS CLASS: 38.28%

TABLE 2.3-14 JOINT FREQUENCY DISTRIBUTIONS AT 60 METERS, STABILITY CLASS F (HOURS AT EACH WIND SPEED AND DIRECTION) 1991 DATA

WIND DIRECTION	WIND SPEED (MPH) 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	8	5	0	0	0	0	13
NNE	6	3	1	0	0	0	10
NE	6	5	1	0	0	0	12
ENE	10	4	0	0	0	0	14
E	10	12	2	0	0	0	24
ESE	10	55	32	1	0	0	98
SE	24	33	21	1	0	0	80
SSE	9	7	1	1	0	0	18
S	11	8	1	0	0	0	22
SSW	6	3	0	0	0	0	9
SW	15	6	3	1	0	0	25
WSW	8	15	4	0	0	0	27
W	18	29	17	1	1	0	66
WNW	11	30	54	8	1	0	106
NW	14	43	22	5	0	0	84
NNW	10	13	5	0	0	0	28
TOTAL	176	271	164	18	2	0	636

91076

PERCENT OF ALL DATA THIS CLASS: 7.26%

TABLE 2.3-15 JOINT FREQUENCY DISTRIBUTIONS AT 60 METERS, STABILITY CLASS G (HOURS AT EACH WIND SPEED AND DIRECTION) 1991 DATA

	WIND SPEED (MPH)						
WIND DIRECTION	**1-3**	**4-7**	**8-12**	**13-18**	**19-24**	**>24**	**TOTAL**
N	0	0	0	0	0	0	0
NNE	2	1	0	0	0	0	3
NE	1	1	0	0	0	0	3
ENE	1	0	0	0	0	0	1
E	1	1	0	0	0	0	2
ESE	4	19	4	0	0	0	27
SE	5	21	5	0	0	0	31
SSE	4	7	1	0	0	0	12
S	4	7	0	0	0	0	11
SSW	10	2	1	0	0	0	13
SW	7	3	0	0	0	0	10
WSW	3	7	1	0	0	0	11
W	7	9	2	0	0	0	18
WNW	6	16	14	1	0	0	37
NW	3	16	8	0	0	0	27
NNW	0	4	0	0	0	0	4
TOTAL	58	114	36	1	0	0	210

99032

PERCENT OF ALL DATA THIS CLASS: 2.40%

TABLE 2.3-16 JOINT FREQUENCY DISTRIBUTIONS AT 60 METERS, STABILITY ALL CLASSES COMBINED (HOURS AT EACH WIND SPEED AND DIRECTION) 1991 DATA (Page 1 of 2)

	WIND SPEED (MPH)						
WIND DIRECTION	**1-3**	**4-7**	**8-12**	**13-18**	**19-24**	**>24**	**TOTAL**
N	30	88	59	29	7	0	213
NNE	46	87	58	10	1	0	202
NE	50	93	61	20	2	0	227
ENE	41	93	81	38	8	0	261
E	45	236	256	106	32	2	678
ESE	56	288	424	208	105	17	1098
SE	83	252	391	141	35	2	905
SSE	51	125	236	128	29	0	569
S	36	143	246	169	8	0	605
SSW	32	70	103	96	15	0	316
SW	40	76	71	66	20	1	274
WSW	36	101	125	55	15	5	337
W	53	188	277	191	84	16	810
WNW	57	188	326	284	134	24	1015
NW	54	178	248	225	105	34	844
NNW	46	121	126	93	19	0	406
TOTAL	756	2327	3088	1859	619	101	8760

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HOURS OF CALM TOTAL: 25
HOURS OF MISSING DATA: 0
HOURS WITH VARIABLE DIRECTION: 0

TABLE 2.3-16 JOINT FREQUENCY DISTRIBUTIONS AT 60 METERS, STABILITY ALL CLASSES COMBINED (HOURS AT EACH WIND SPEED AND DIRECTION) 1991 DATA (Page 2 of 2)

Percent Occurrence in each Stability Class

Class A	3.88%
Class B	3.26%
Class C	4.49%
Class D	40.43%
Class E	38.28%
Class F	7.26%
Class G	2.40%

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Table 2.3-17
ANNUAL AVERAGE DISPERSION FACTOR (__/Q)
1991 DATA

For Release Point 1, Building Vents
Annual Ground Average __/Q (Sec/m^3)

DISTANCE IN MILES

Direction	0.5	1.5	2.5	3.5	4.5	7.5	15	25	35	45
N	1.4569E-06	2.9406E-07	1.3898E-07	8.2836E-08	5.8196E-08	2.9101E-08	1.1268E-08	5.5804E-09	3.5619E-09	2.5544E-09
NNE	1.5352E-06	2.9433E-07	1.3925E-07	8.4574E-08	5.9972E-08	3.0474E-08	1.2087E-08	6.0402E-09	3.8715E-09	2.8040E-09
NE	1.4247E-06	2.7854E-07	1.3061E-07	7.8058E-08	5.4776E-08	2.7275E-08	1.0518E-08	5.1858E-09	3.2958E-09	2.3596E-09
ENE	2.0911E-06	4.1381E-07	1.9629E-07	1.1839E-07	8.3723E-08	4.2357E-08	1.6676E-08	8.3099E-09	5.3191E-09	3.8383E-09
E	4.5640E-06	8.9561E-07	4.2480E-07	2.5677E-07	1.8173E-07	9.2069E-08	3.6334E-08	1.8122E-08	1.1605E-08	8.3822E-09
ESE	4.1136E-06	8.1691E-07	3.8905E-07	2.3496E-07	1.6629E-07	8.4258E-08	3.3264E-08	1.6611E-08	1.065E-08	7.6919E-09
SE	4.0346E-06	7.9787E-07	3.7950E-07	2.3048E-07	1.6405E-07	8.4088E-08	3.3597E-08	1.6828E-08	1.0800E-08	7.8328E-09
SSE	3.1943E-06	6.3196E-07	3.0154E-07	1.8268E-07	1.2949E-07	6.5792E-08	2.6078E-08	1.3043E-08	8.3689E-09	6.0520E-09
S	2.5327E-06	5.0213E-07	2.3484E-07	1.4043E-07	9.9226E-08	5.0248E-08	1.9685E-08	9.7643E-09	6.2315E-09	4.4923E-09
SSW	1.4161E-06	2.7870E-07	1.3145E-07	7.8821E-08	5.5530E-08	2.7901E-08	1.0885E-08	5.4059E-09	3.4550E-09	2.4868E-09
SW	1.5642E-06	3.0634E-07	1.4800E-07	9.0273E-08	6.3950E-08	3.2386E-08	1.2869E-08	6.4656E-09	4.1632E-09	3.0134E-09
WSW	1.9328E-06	3.7676E-07	1.8249E-07	1.1197E-07	7.9620E-08	4.0596E-08	1.6268E-08	8.1933E-09	5.2797E-09	3.8312E-09
W	3.2843E-06	6.5951E-07	3.1290E-07	1.8820E-07	1.3315E-07	6.7512E-08	2.6596E-08	1.3257E-08	8.4894E-09	6.1262E-09
WNW	4.6477E-06	9.1779E-07	4.4245E-07	2.6943E-07	1.9110E-07	9.7098E-08	3.8645E-08	1.9410E-08	1.2492E-08	9.0444E-09
NW	4.0554E-06	7.9646E-07	3.7855E-07	2.2897E-07	1.6218E-07	8.2301E-08	3.2561E-08	1.6274E-08	1.0439E-08	7.5486E-09
NNW	2.1511E-06	4.2964E-07	2.0336E-07	1.2158E-07	8.5501E-08	4.2820E-08	1.6642E-08	8.2662E-09	5.2830E-09	3.7961E-09

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TABLE 2.3-18

RELATIVE DISPERSION PER UNIT AREA (D/Q)
1991 DATA

For Release Point 1, Building Vents
Annual Average D/Q (1/m^2)

DISTANCE IN MILES

Direction	0.5	1.5	2.5	3.5	4.5	7.5	15	25	35	45
N	5.8255E-09	8.9269E-10	4.0369E-10	2.1189E-10	1.3524E-10	5.6487E-11	1.8392E-11	6.7715E-12	3.6142E-12	2.2706E-12
NNE	4.4562E-09	6.8285E-10	3.0880E-10	1.6209E-10	1.0345E-10	4.3209E-11	1.4068E-11	5.1798E-12	2.7646E-12	1.7368E-12
NE	5.1524E-09	7.8955E-10	3.5705E-10	1.8741E-10	1.1961E-10	4.9960E-11	1.6267E-11	5.9891E-12	3.1966E-12	2.0082E-12
ENE	6.9860E-09	1.0705E-09	4.8411E-10	2.5411E-10	1.6218E-10	6.7739E-11	2.2055E-11	8.1204E-12	4.3341E-12	2.7229E-12
E	1.9774E-08	3.0302E-09	1.3703E-09	7.1926E-10	4.5905E-10	1.9174E-10	6.2429E-11	2.2985E-11	1.2268E-11	7.7073E-12
ESE	2.3326E-08	3.5743E-09	1.6164E-09	8.4842E-10	5.4149E-10	2.6217E-10	7.3640E-11	2.7113E-11	1.4471E-11	9.0914E-12
SE	1.7593E-08	2.6958E-09	1.2191E-09	6.3991E-10	4.0840E-10	1.7059E-10	5.5541E-11	2.0449E-11	1.0915E-11	6.8569E-12
SSE	1.3693E-08	2.0983E-09	9.4892E-10	4.9808E-10	3.1789E-10	1.3278E-10	4.3231E-11	1.5917E-11	8.4955E-12	5.3372E-12
S	1.3601E-08	2.0841E-09	9.4248E-10	4.9471E-10	3.1573E-10	1.3188E-10	4.2938E-11	1.5809E-11	8.4379E-12	5.3010E-12
SSW	7.4501E-09	1.1416E-09	5.1627E-10	2.7099E-10	1.7295E-10	7.2240E-11	2.3521E-11	8.6599E-12	4.6221E-12	2.9039E-12
SW	6.2433E-09	9.5670E-10	4.3264E-10	2.2709E-10	1.4493E-10	6.0537E-11	1.9711E-11	7.2571E-12	3.8734E-12	2.4334E-12
WSW	7.0324E-09	1.0776E-09	4.8732E-10	2.5579E-10	1.6325E-10	6.8189E-11	2.2202E-11	8.1743E-12	4.3629E-12	2.7410E-12
W	1.6386E-08	2.5109E-09	1.1355E-09	5.9601E-10	3.8039E-10	1.5888E-10	5.1731E-11	1.9046E-11	1.0166E-11	6.3865E-12
WNW	2.3720E-08	3.6348E-09	1.6437E-09	8.6277E-10	5.5064E-10	2.3999E-10	7.4885E-11	2.7571E-11	1.4716E-11	9.2452E-12
NW	2.2119E-08	3.3894E-09	1.5327E-09	8.0452E-10	5.1347E-10	2.1447E-10	6.9830E-11	2.5710E-11	1.3722E-11	8.6210E-12
NNW	9.9567E-09	1.5257E-09	6.8997E-10	3.6217E-10	2.3114E-10	9.6545E-11	3.1434E-11	1.1574E-11	6.1772E-12	3.8808E-12

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TABLE 2.3-19

SITE BOUNDARY X/Q AND D/Q

BUILDING VENTS
CORRECTED FOR OPEN TERRAIN RECIRCULATION
SPECIFIC POINTS OF INTEREST

RELEASE ID	TYPE OF LOCATION	DIRECTION	DISTANCE (MILES)	DISTANCE (METERS)	X/Q (SEC/CUB METER) NO DECAY UNDEPLETED	X/Q (SEC/CUB METER) 2.260 DAY DECAY UNDEPLETED	X/Q (SEC/CUB METER) 8.000 DAY DECAY DEPLETED	D/Q (PER SQ. METER
V	SITE BOUNDARY	S	0.43	692.	8.84E-06	8.78E-06	8.13E-06	3.46E-08
V	SITE BOUNDARY	SSW	0.40	644.	9.86E-06	9.80E-06	9.11E-06	3.68E-08
V	SITE BOUNDARY	SW	0.40	644.	9.79E-06	9.72E-06	9.04E-06	3.45E-08
V	SITE BOUNDARY	WSW	0.37	595.	1.62E-05	1.61E-05	1.50E-05	5.44E-08
V	SITE BOUNDARY	W	0.36	579.	2.76E-05	2.74E095	2.56E-05	1.06E-07
V	SITE BOUNDARY	WNW	0.36	579.	2.39E-05	2.38E-05	2.22E-05	9.97E-08
V	SITE BOUNDARY	NW	0.43	692.	1.88E-05	1.87E-05	1.73E-05	7.84E-08
V	SITE BOUNDARY	NNW	0.48	772.	1.11E-05	1.11E-05	1.02E-05	5.82E-08
V	SITE BOUNDARY	N	0.28	451.	2.04E-05	2.03E-05	1.92E-05	9.65E-08
V	SITE BOUNDARY	NNE	0.26	418.	1.91E-05	1.90E-05	1.80E-05	7.40E-08
V	SITE BOUNDARY	NE	0.84	1352.	2.82E-06	2.78E-06	2.49E-06	9.70E-09
V	SITE BOUNDARY	ENE	0.62	998.	1.01E-05	9.99E-06	9.06E-06	4.24E-08
V	SITE BOUNDARY	E	0.59	950.	1.33E-05	1.32E-05	1.20E-05	3.80E-08
V	SITE BOUNDARY	ESE	0.61	982.	1.76E-05	1.75E-05	1.59E-05	5.87E-08
V	SITE BOUNDARY	SE	0.67	1078.	1.75E-05	1.74E-05	1.57E-05	5.99E-08
V	SITE BOUNDARY	SSE	0.43	692.	2.00E-05	1.98E-05	1.84E-05	7.16E-08

TABLE 2.4-1 MINIMUM CONSECUTIVE-DAY LOW-FLOW, IN CFS, FOR THE FIVE LOWEST YEARS OF RECORD

1 Day (Year)		7 Days (Year)	14 Days (Year) 30 Days (Year)	
1380 (1940)	2190 (1936)	2260 (1936)	2350 (1934)	
2100 (1936)	2240 (1934)	2260 (1934)	2650 (1936)	
2210 (1934)	2640 (1933)	2650 (1933)	2860 (1933)	
2270 (1939)	3110 (1931)	3190 (1931)	3360 (1932)	99032
2520 (1933)	3270 (1932)	3320 (1932)	3370 (1931)	

Note: Gaged at Prescott, about 15 miles upstream from site. Since no severe low flows have occurred after 1940, it is believed that construction of facilities on the river since that time assist in augmenting low flow.

TABLE 2.4-2 DISCHARGE OF MISSISSIPPI RIVER AND CANNON RIVER

	MISSISSIPPI RIVER AT PRESCOTT	MISSISSIPPI RIVER AT WINONA	CANNON RIVER AT WELCH
AVERAGE	15,020 CFS	24,520 CFS	475 CFS
MAXIMUM	228,000 cfs 4-18-65	268,000 cfs 4-19-65	36,100 cfs 4-10-65
MINIMUM	1,380 cfs 7-13-40	3,350 cfs 12-29-33	2.5 cfs 1-3-50

TABLE 2.4-3
Page 1 of 4

WELLS IN PLANT VICINITY

	Location								Use			
Well No.	Fractional Section	Sec	Twp	Range	County	Depth (ft)	Diam (in)	Demand (gpm)	Domestic	Livestock	Irrigation of acres	Other
1	NW 1/4, NW 1/4	9	113	15	Goodhue	50	2	?	X	X		
2	NW 1/4, SW 1/4	5	113	15	Goodhue	50	2	?	X	X		
3	NW 1/4, SW 1/4	5	113	15	Goodhue	80	4	12 to 15	X			
4	SW 1/4, NW 1/4	5	113	15	Goodhue	50	2	Hand pmp	X			
5	NW 1/4, SE 1/4	9	113	15	Goodhue	65	4	Hand pmp	X			
6	NE 1/4, NE 1/4	5	113	15	Goodhue	60	4	?				River Testing Station
7	SW 1/4, SE 1/4	32	113	15	Goodhue	35	1 1/2	?	X			
8	SW 1/4, SE 1/4	32	113	15	Goodhue	40 & 18	1 1/4 & 1 1/4	?	X		2	
9	SW 1/4 SE 1/4	32	113	15	Goodhue							
10	NW 1/4, SE 1/4	9	113	15	Goodhue	60	4	Hand pmp	X			Campers
11	SW 1/4, NW 1/4	10	113	15	Goodhue	595	6	?	X			Lock Uses
12	SW 1/4, SE 1/4	16	113	15	Goodhue		?	?	X	X		
13	NW 1/4, SE 1/4	16	113	15	Goodhue	60	6	?	X	X		
14	NE 1/4, SE 1/4	9	113	15	Goodhue	55 & 55	2 & 2		X			
15	SW 1/4, SW 1/4	31	113	15	Goodhue	30	1 1/4	15	X			
16	NE 1/4, NE 1/4	30	25	18	Pierce	65	4	10 to 12	X	X		
17	SE 1/4, NW 1/4	29	25	18	Pierce	91	6	?	X			
18	SE 1/4, NW 1/4	29	25	18	Pierce	90	1 1/4	?	X	X		

TABLE 2.4-3
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WELLS IN PLANT VICINITY

	Location								Use			
Well No.	Fractional Section	Sec	Twp	Range	County	Depth (ft)	Diam (in)	Demand (gpm)	Domestic	Livestock	Irrigation of acres	Other
19	SW 1/4, NE 1/4	29	25	18	Pierce	45	5	?	X			
20	SE 1/4, SW 1/4	28	25	189=	Pierce	50	2	?	X	X		
21	NE 1/4, NW 1/4	33	25	18	Pierce	85	4	?	X			
22	NE 1/4, NW 1/4	33	25	18	Pierce	85	4	?	X			
23	SE 1/4, NW 1/4	33	25	18	Pierce	100	4	?	X	X	1.5	
24	SE 1/4, NW 1/4	33	25	18	Pierce	65	4	?	X			
25	SE 1/4, NW 1/4	33	24	18	Pierce	30	2	?	X			
26	NE 1/4, SE 1/4	33	24	18	Pierce	123	4	?	X			
27	SW 1/4, NE 1/4	33	24	18	Pierce				X			
28	SE 1/4, NW 1/4	33	24	18	Pierce	90	4	?	X	X		
29	SW 1/4, NE 1/4	33	24	18	Pierce	?	?	?				
30	SW 1/4, NE 1/4	33	24	18	Pierce	?	?	?	X			
31	NW 1/4, SE 1/4	33	24	18	Pierce	65	4	?	X			
32	NW 1/4, SE 1/4	33	24	18	Pierce	160	4	?	X			
33	NW 1/4, SE 1/4	33	24	18	Pierce	?	?	?	X			
34	NW 1/4, SE 1/4	33	24	18	Pierce	300	4	?	X			
35	NW 1/4, SE 1/4	33	24	18	Pierce				X	X		
36	SE 1/4, SE 1/4	33	24	18	Pierce				X			

TABLE 2.4-3
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WELLS IN PLANT VICINITY

		Location							Use			
Well No.	Fractional Section	Sec	Twp	Range	County	Depth (ft)	Diam (in)	Demand (gpm)	Domestic	Livestock	Irrigation of acres	Other
37	NW 1/4, SE 1/4	33	24	18	Pierce	20	2	12	X			Minnows
38	SW 1/4, SE 1/4	33	24	18	Pierce	40	1 1/4	10	X			Minnows
39	NE 1/4, NE 1/4	13	24	18	Pierce	132	4	12 to 15	X			
40	NW 1/4, NW 1/4	3	24	18	Pierce	120	4	?	X			
41	NW 1/4, NW 1/4	3	24	18	Pierce	65	4	12	X	X		
42	SE 1/4, NW 1/4	5	113	15	Goodhue			300	X			Fire Protection during const.
43	SE 1/4, NW 1/4	5	113	15	Goodhue			300	X			
44	SW 1/4, SE 1/4	31	114N	15W	Goodhue	92	4	15	X			
45	SW 1/4, SW 1/4	32	114N	15W	Goodhue	92	4	15	X			
46	NW 1/4, NW 1/4	5	113N	15W	Goodhue	110	4	40	X			
47	NW 1/4, NW 1/4	5	113N	15W	Goodhue	105	4	26	X			
48	NW 1/4, NW 1/4	5	113N	15W	Goodhue	110	4	20	X			
49	NW 1/4, NW 1/4	5	113N	15W	Goodhue	101	4	20	X			
50	SW 1/4, NW 1/4	5	113N	15W	Goodhue	105	4	12	X			
51	SW 1/4, NW 1/4	5	113N	15W	Goodhue	104	4	15	X			
52	NW 1/4, NW 1/4	5	113N	15W	Goodhue	90	4	20	X			
53	NW 1/4, NW 1/4	5	113N	15W	Goodhue	92	4	20	X			
54	NW 1/4, NW 1/4	5	113N	15W	Goodhue	100	4	20	X			

TABLE 2.4-3
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WELLS IN PLANT VICINITY

	Location								Use			
Well No.	Fractional Section	Sec	Twp	Range	County	Depth (ft)	Diam (in)	Demand (gpm)	Domestic	Livestock	Irrigation of acres	Other
55	NW 1/4, NW 1/4	5	113N	15W	Goodhue	84	4	15	x			
56	NW 1/4, NW 1/4	5	113N	15W	Goodhue	80	4	20	x			
57	SW 1/4, NW 1/4	5	113N	15W	Goodhue	86	4	15	x			
58	NW 1/4, NW 1/4	5	113N	15W	Goodhue	94	4	15	x			

TABLE 2.5-1

GEOLOGIC FORMATIONS IN THE GENERAL AREA OF THE SITE

GEOLOGIC AGE ERA	GEOLOGIC AGE PERIOD	GEOLOGIC NAME	APPROX. THICKNESS IN FEET	DESCRIPTION	REMARKS	
Cenozoic	Quarternary	Recent Deposits		Unconsolidated clay, silt, sand and gravel	Largely Mississippi and Vermillion River deposits	
		Pleistocene	20 to 200	Unconsolidated clay, silt, sand, gravel and boulders deposited as till, outwash and loess	Largely from Superior and Des Moines lobes of Wisconsin glaciation	98118
Paleozoic	Ordovician	Oneota	100	Dolomite	Exposte along river bluffs	
	Cambrian	Jordan	100	Sandstone	An important aquifer	
		Saint Lawrence Formation	43	Dolomite siltstone and silty dolomite		98118
		Franconia Formation (St. Croix Series)	180	Sandstone and shale	Aquifer zones. Uppermost bedrock at site	
		Dresbach Formation (St. Croix Series)	100+	Sandstone, siltstone and shale	Aquifer zones	
Precambrian	Keweenawan	Hinckley Formation	100+	Sandstone	An important aquifer	98118
		Red Clastic Series		Sandstone and Red Shale	May not be present under the site	
		Volcanics		Mafic lava flow with thin layers of tuff and breccia	May be present under the site	
		Granite and Associated Intrusives			Principal Basement rock under the site	

TABLE 2.6-1 MINNESOTA EARTHQUAKES

YEAR	DAY	TIME	INTENSITY	LOCALITY	EPICENTER LOCATION N. LAT.	W. LONG	AREA SQ. MILES
1860			V +	Central Minnesota	-	-	
1865-70			?	Le Sueur, Minnesota	-	-	
1909	5-26	08:42	VIII III in Minn.	Dixon, Illinois	42.5	89.0	500,000
1917	9-3	15:30	V-VI	Staples, Minnesota	46.3	94.5	10,000
1928	12-23	00:10	III	Bowstring, Minnesota	47.4	94.0	Local
1935	11-1	01:04	VI I in Min.	Timiskaming, Canada	46.8	79.1	1,000,000
1938	10-11	03:37	V IV in Minn.	Sioux Falls, S.D.	43.3	96.4	3,000
1939	1-28	11:55	IV	Detroit Lakes, Minnesota	46.9	95.5	2,000
1950	2-15	04:05	V-VI	Alexandria, Minnesota	45.7	94.8	Local

TABLE 2.6-2 MODIFIED MERCALLI INTENSITY SCALE OF 1931 (Abridged)

I. Not felt except by a very few under especially favorable circumstances.

II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing

III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration like passing of truck. Duration estimated.

IV. During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed, walls make creaking sound. Sensation like heavy truck striking building. Standing motor card rocked noticeably. 98118

V. Felt by nearly everyone, many awakened. Some dishes, windows, etc. broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.

VI. Felt by all, many frightened and run indoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.

VII. Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.

TABLE 2.6-2 MODIFIED MERCALLI INTENSITY SCALE OF 1931 (Abridged)

VIII. Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Disturbs persons driving motor cars.

IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundation. Ground cracked conspicuously. Underground pipes broken.

X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.

XI. Few, if any (masonry), structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipe lines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.

XII. Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air.

TABLE 2.9-1 CONTROL ROOM HABITABILITY TOXIC CHEMICALS

CHEMICAL

Toxic Chemicals Stored Onsite

1. Boric Acid
2. Diesel Fuel #1
3. Diesel Fuel #2
4. Nitrogen (Liquid) (Note 3)
5. Oil, Diesel Lube
6. Oil, Turbine Lube
7. Hydrazine
8. Sodium Hydroxide (50%)
9. Sulfuric Acid
10. Ethylene Glycol
11. Anion/Cation Resin
12. Carbon Dioxide
13. Propane
14. Hydrogen (Note 4)
15. Natural Gas

Toxic Chemicals Stored Within Five Miles of Plant:
None (Note 1)
Toxic Chemicals Shipped by Truck:
None (Note 1)

Toxic Chemicals Shipped by Rail (SOO Line):

1. Chlorine
2. Ammonia Anhydrous
3. Isobutane
4. LPB
5. Styrene, Monomer
6. Vinyl Acetate
7. Benzene
8. Denatured Alcohol
9. Ethyl Alcohol
10. Ethyl Acetate
11. Methanol
12. Toluene
13. Flammable Liquid, N.D.S., (Pulp Mill Liquid)
14. Petroleum Naptha
15. Ammonium Nitrate Fertilizer 01505821
16. Hydrogen Peroxide
17. Phenol
18. Phosphoric Acid
19. Benzene Phosphorous Dichloride
20. Molten Sulfur
21. Nickel Sulfate
22. Hexene
23. Hydrochloric Acid

TABLE 2.9-1 CONTROL ROOM HABITABILITY TOXIC CHEMICALS

CHEMICAL

Toxic Chemicals Shipped by Rail (BNSF Line):

1. Chlorine
2. Sulfur Dioxide
3. Carbon Dioxide
4. Hydrogen Sulfide
5. Butane
6. LPG
7. Vinyl Chloride
8. Ethylene Oxide
9. Styrene Monomer
10. Benzene
11. Denatured Alcohol
12. Ethyl Alcohol
13. Methyl Alcohol
14. Paint
15. Resin Solution
16. Aromatic Concentrates
17. Diesel Fuel Oil
18. Petroleum Naptha
19. Calcium Carbide (Flammable Solid)
20. Sodium Metal (Flammable Solid)
21. Sodium Chlorate
22. Chloropierin Mixture
23. Sodium Cyanide (Solid)
24. Sulfuric Acid
25. Phosphoric Acid
26. Acetic Anhydride
27. Ferric Chloride Solution
28. Silicon Chloride
29. Titanium Tetrachloride
30. Potassium Hydroxide
31. Sodium Hydroxide
32. Molten Sulfur
33. Butadiene
34. Carbon Disulfide
35. Coal Tar Distillates
36. Propylene

Toxic Chemicals Shipped by Barge:

1. Chemical Fertilizers
2. Petroleum Pitches
3. Petroleum Naptha
4. Petroleum Solvents

Note 1: See Reference 23 for details.
Note 2: Not used.
Note 3: See Reference 31 for details.
Note 4: See Reference 33 for details.

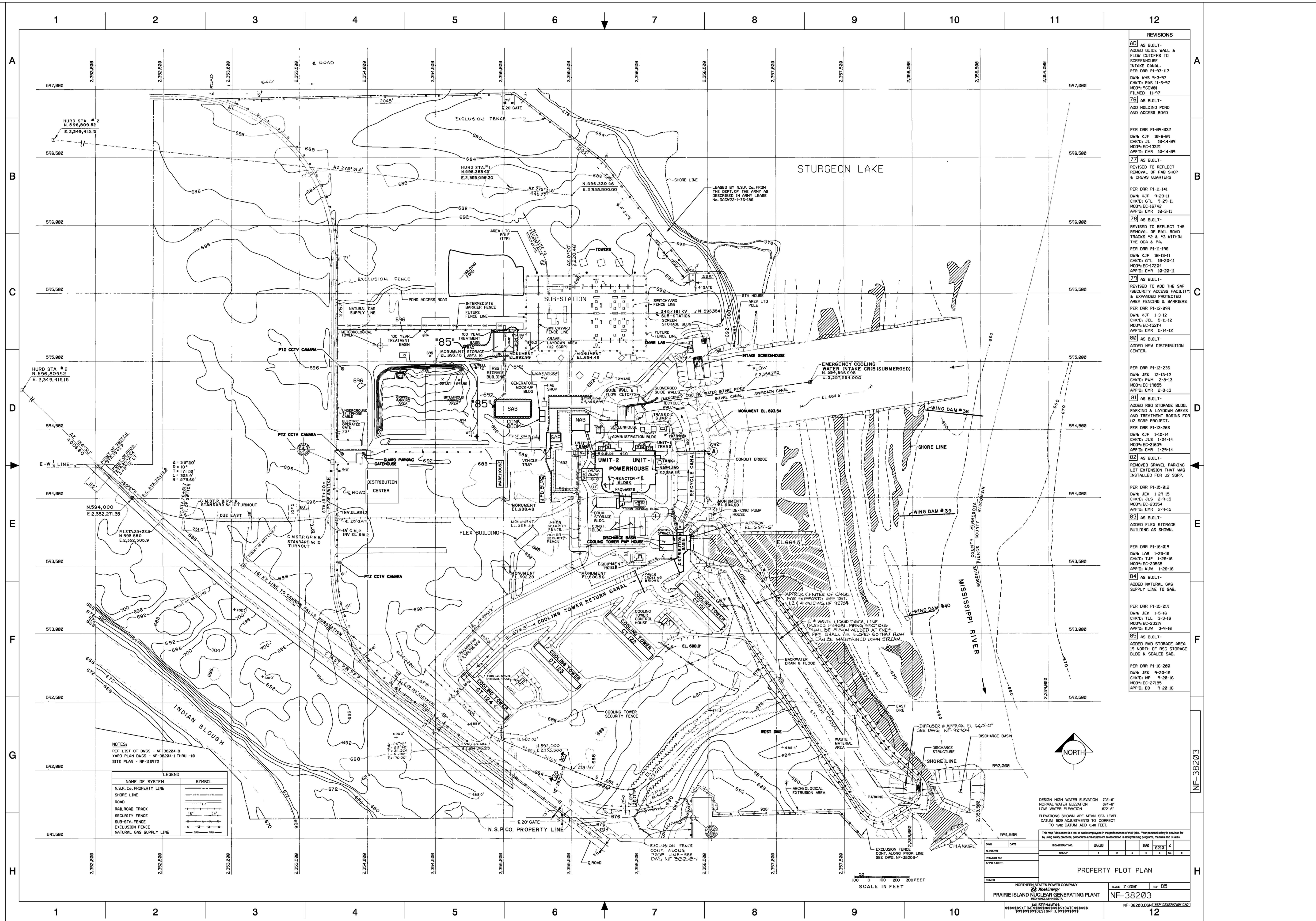


FIGURE 2.2-1 REV. 35

60300001331

CAD FILE: U02201.DGN

REVISIONS

DRN TAM	DATE 6-23-99	SIGNIFICANT NO.						
CHECKED		GROUP	1	2	3	4	5	CL 6
PROJECT NO. ETNSUR								
APP'D & CERT.								
CAD FILE: U02202.DGN								

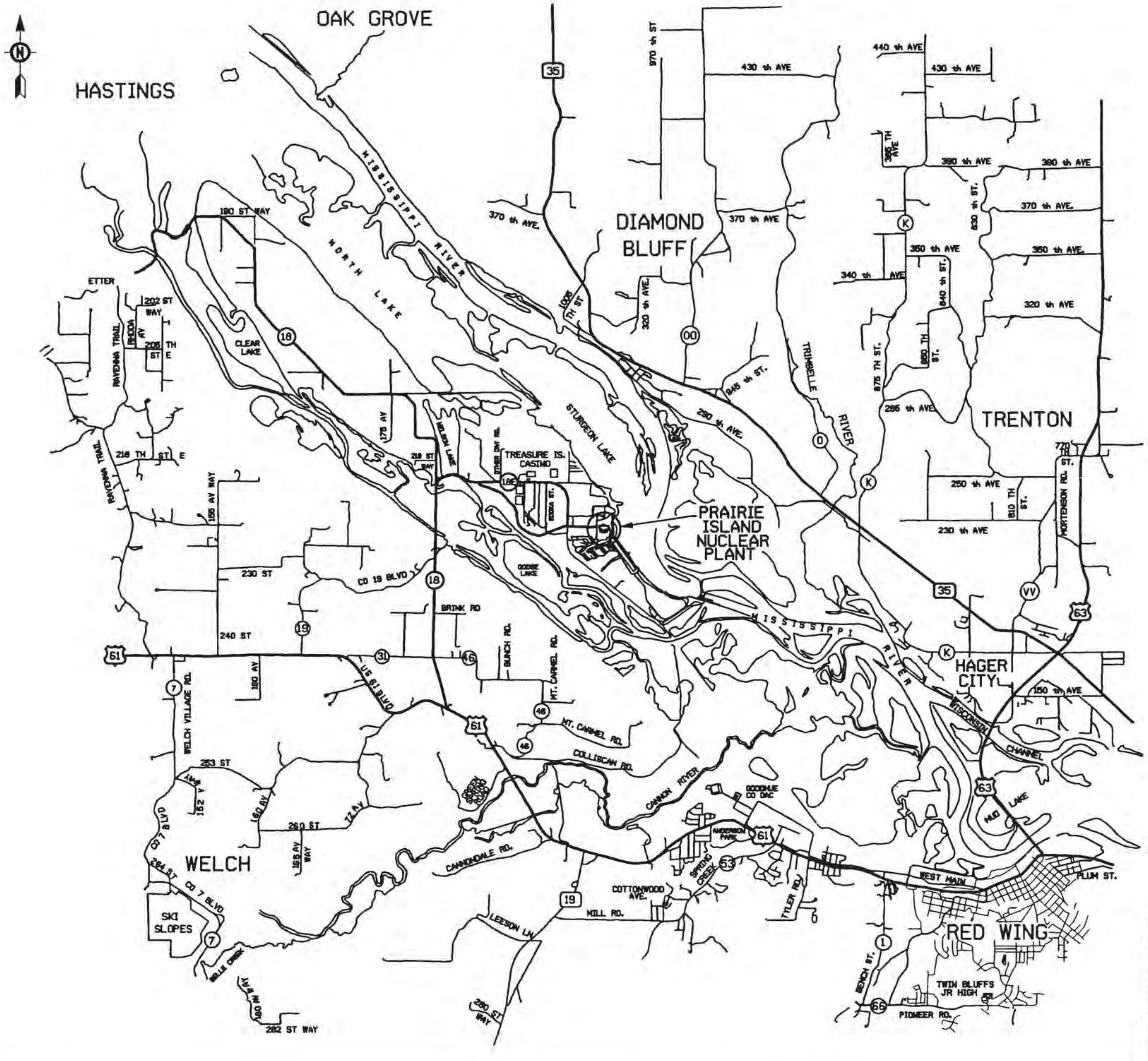
GENERAL SITE TOPOGRAPHY

NORTHERN STATES POWER COMPANY
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RED WING MINNESOTA

SCALE NONE

FIGURE 2.2-2 REV. 18

REVISIONS



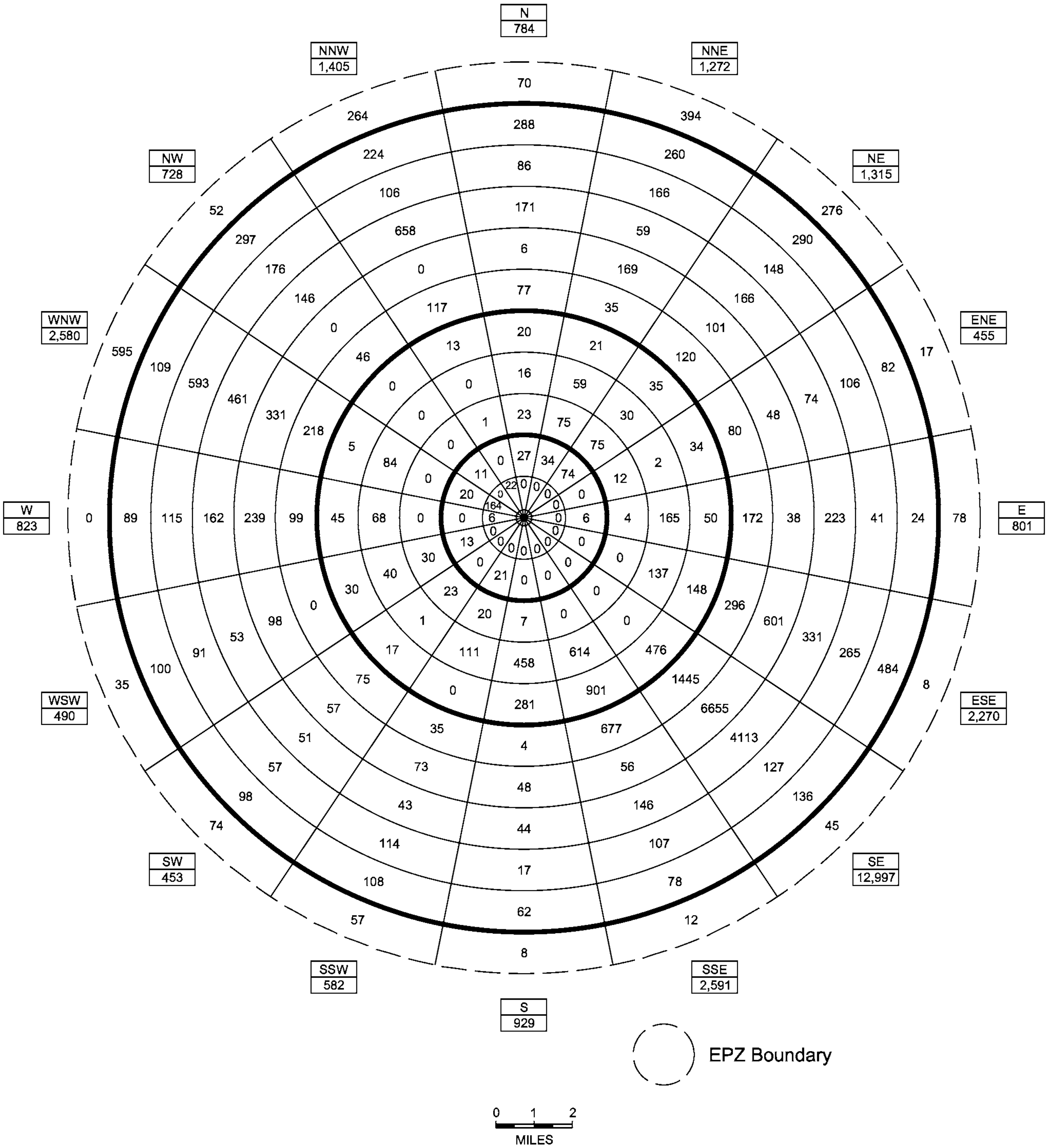
DRN TAM	DATE 6-23-99	SIGNIFICANT NO.							
CHECKED		GROUP	1	2	3	4	5	CL	6
PROJECT NO. ETNSUR									
APP'D & CERT.									
CAD FILE: U02203.DGN									

HIGHWAY TRANSPORTATION ROUTES

NORTHERN STATES POWER COMPANY
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RED WING MINNESOTA

SCALE NONE

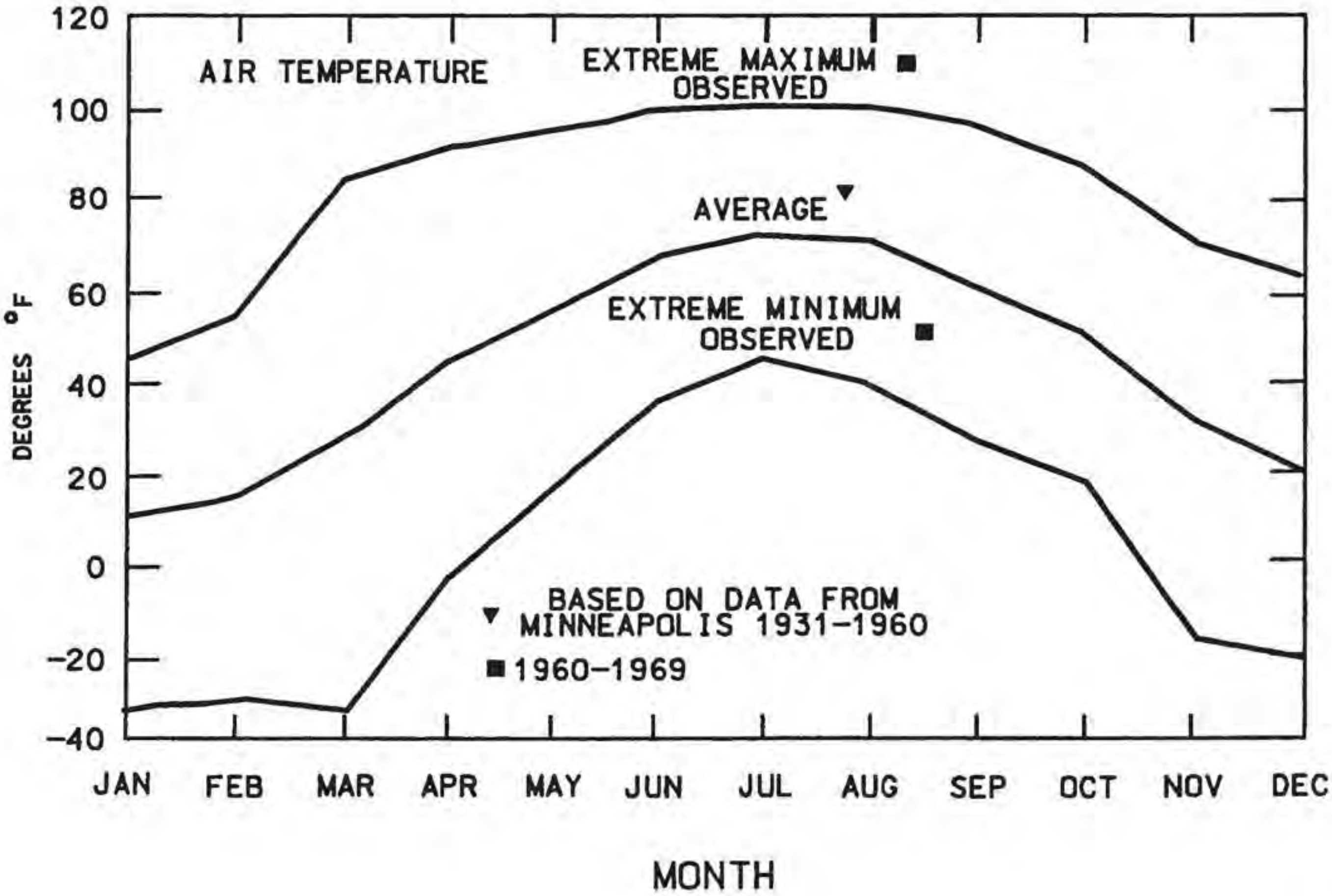
FIGURE 2.2-3 REV. 18



POPULATION DISTRIBUTION

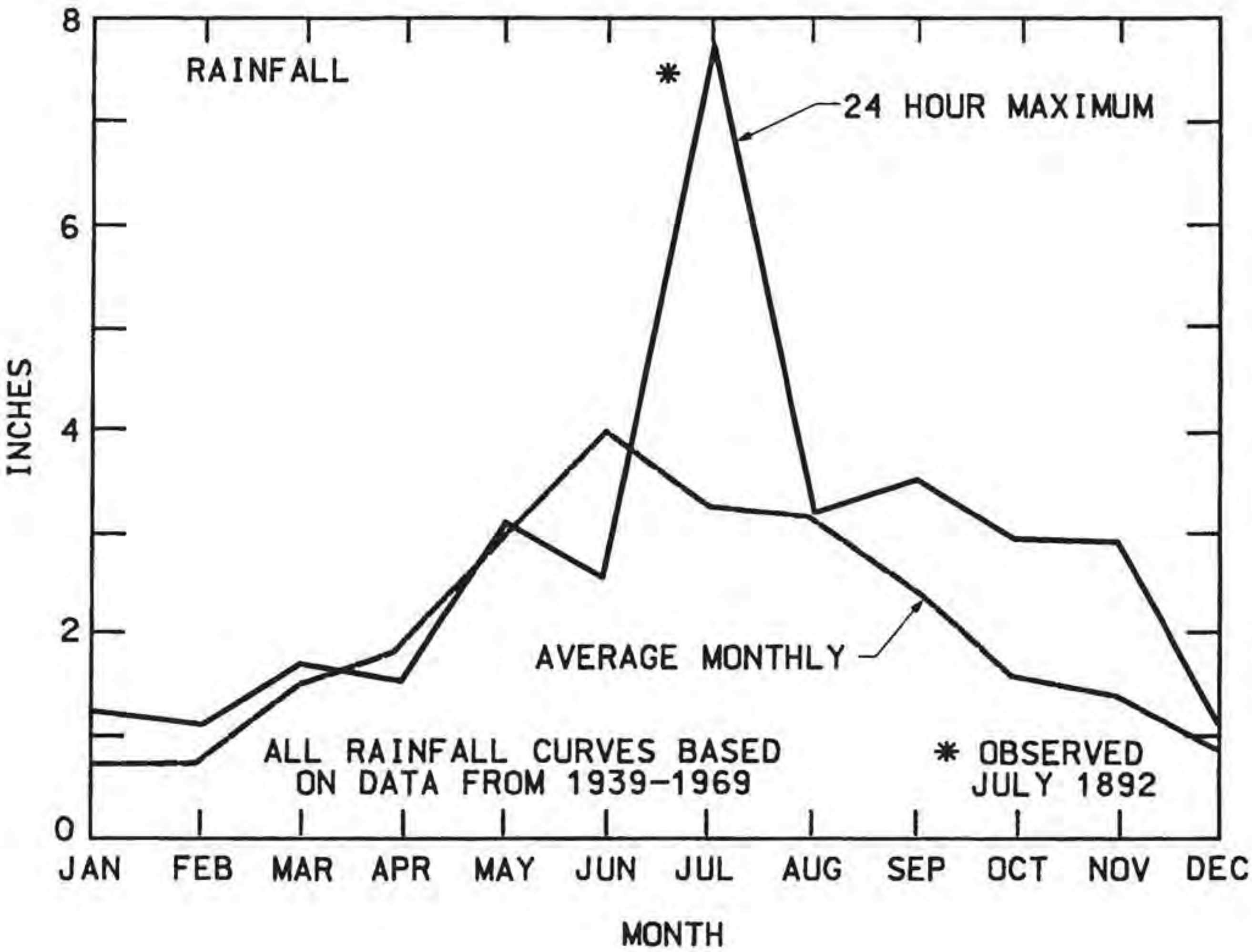
DWN: LAB	DATE: 12–15–2015	NORTHERN STATES POWER COMPANY Xcel Energy	SCALE: NONE
CHECKED:	CAD FILE: U02204.DGN	PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING, MINNESOTA	*FIGURE 2.2-4 REV. 34*

01441917



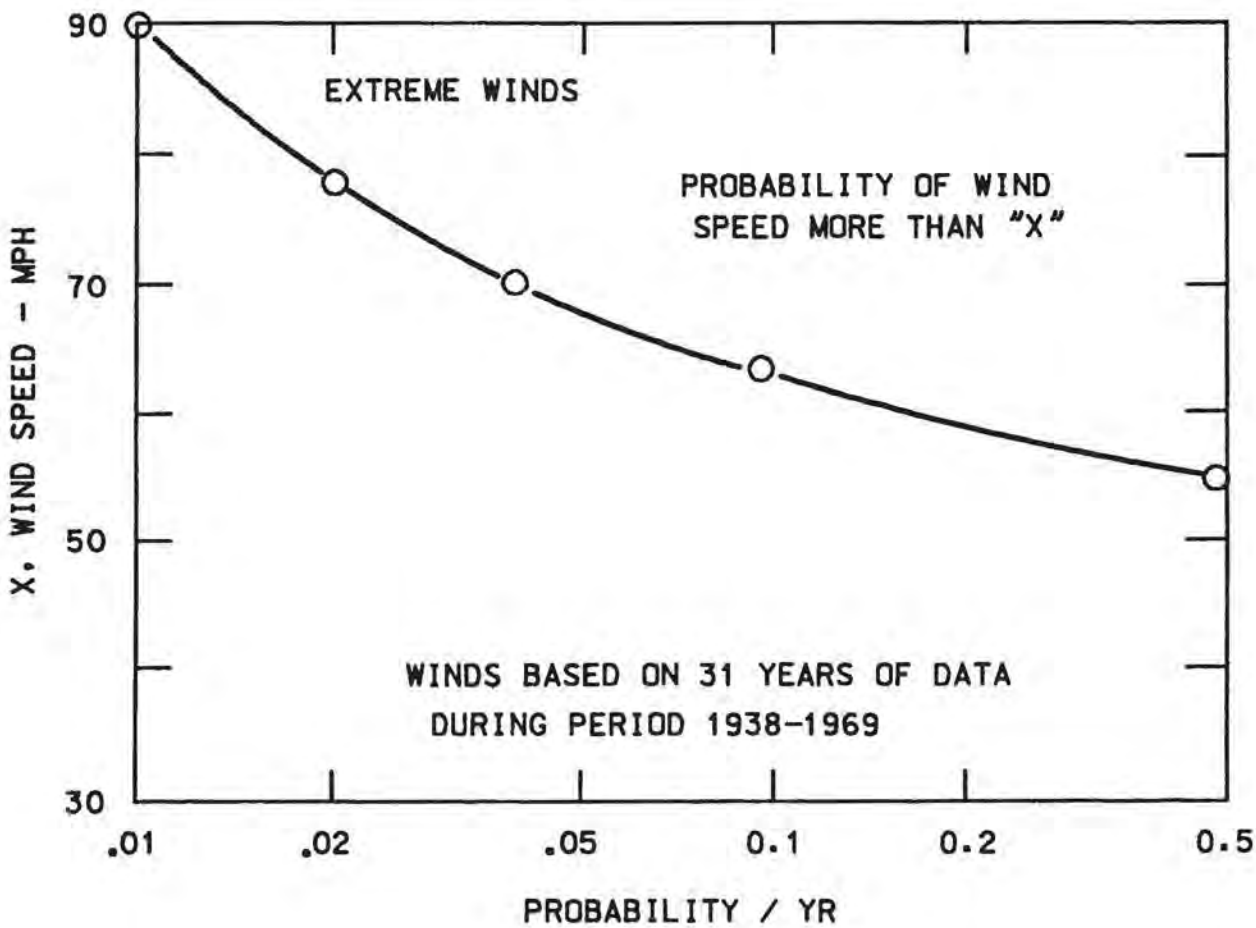
CLIMATE OF PRAIRIE ISLAND SITE REGION

DWN T. MILLER	DATE 6-23-99	NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING MINNESOTA	SCALE: NONE	
CHECKED	CAD FILE U02301A.DGN		FIGURE 2.3-1A	REV. 18



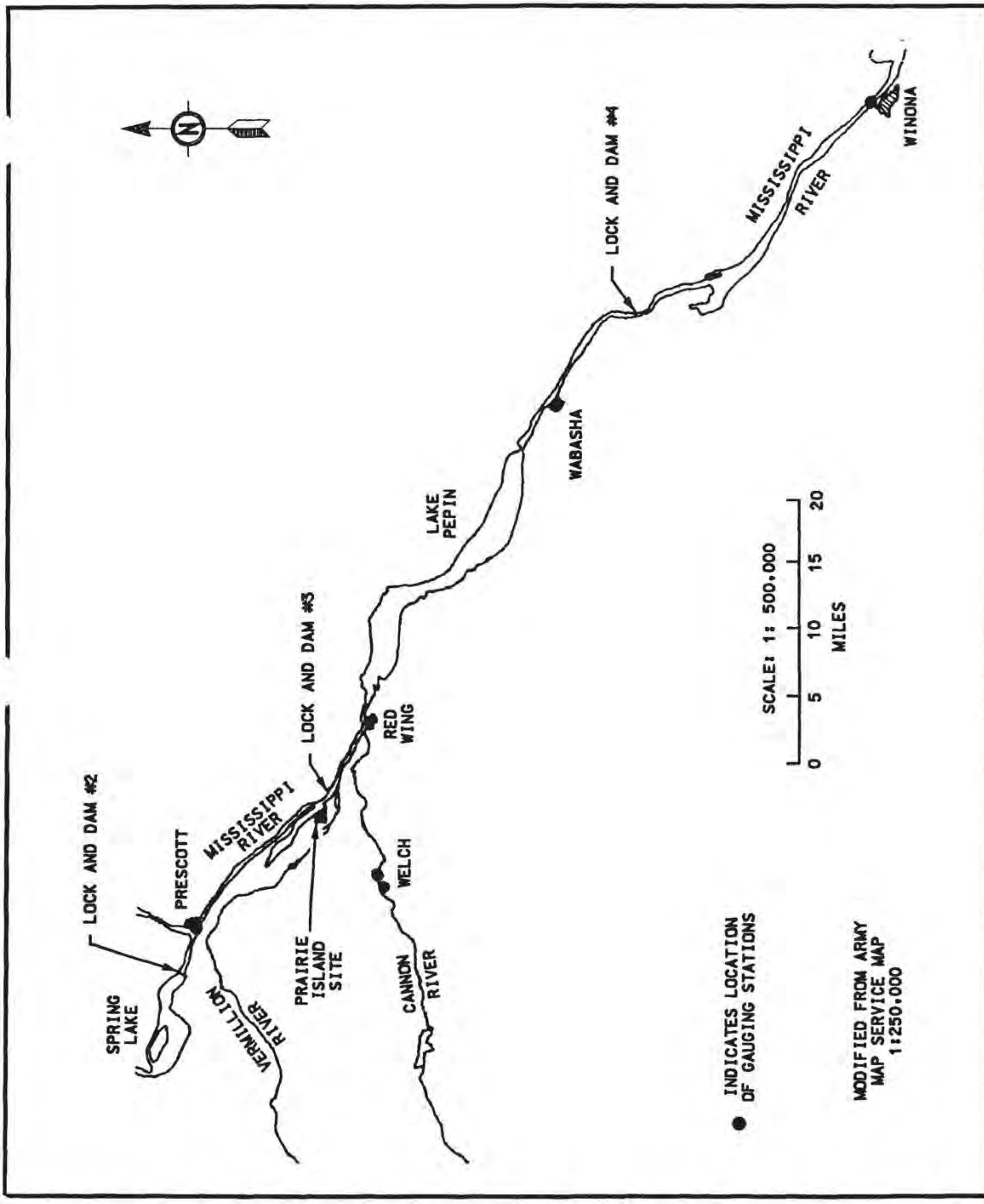
CLIMATE OF PRAIRIE ISLAND SITE REGION

DWN T. MILLER	DATE 6-23-99	NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING MINNESOTA	SCALE: NONE
CHECKED	CAD FILE U02301B.DGN		FIGURE 2.3-1B REV. 18



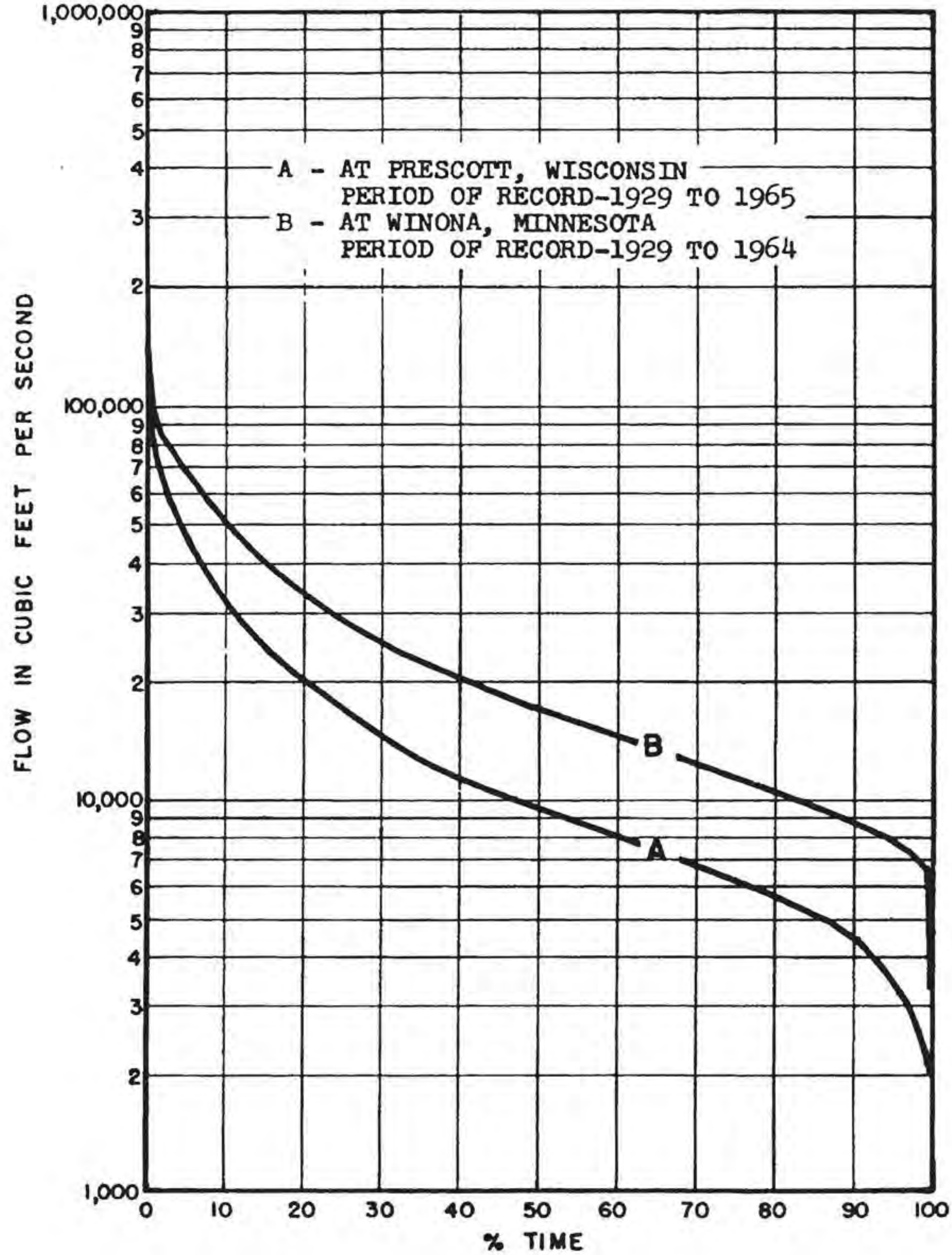
CLIMATE OF PRAIRIE ISLAND SITE REGION

DWN T. MILLER	DATE 6-23-99	NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING MINNESOTA	SCALE: NONE
CHECKED	CAD FILE U02301C.DGN		FIGURE 2.3-1C REV. 18



LOCATION OF MAJOR STREAMS AND GAUGING STATIONS

DWN T. MILLER	DATE 6-23-99	NORTHERN STATES POWER COMPANY	SCALE: NONE
CHECKED	CAD FILE U02401.DGN	PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING MINNESOTA	FIGURE 2.4-1 REV. 18

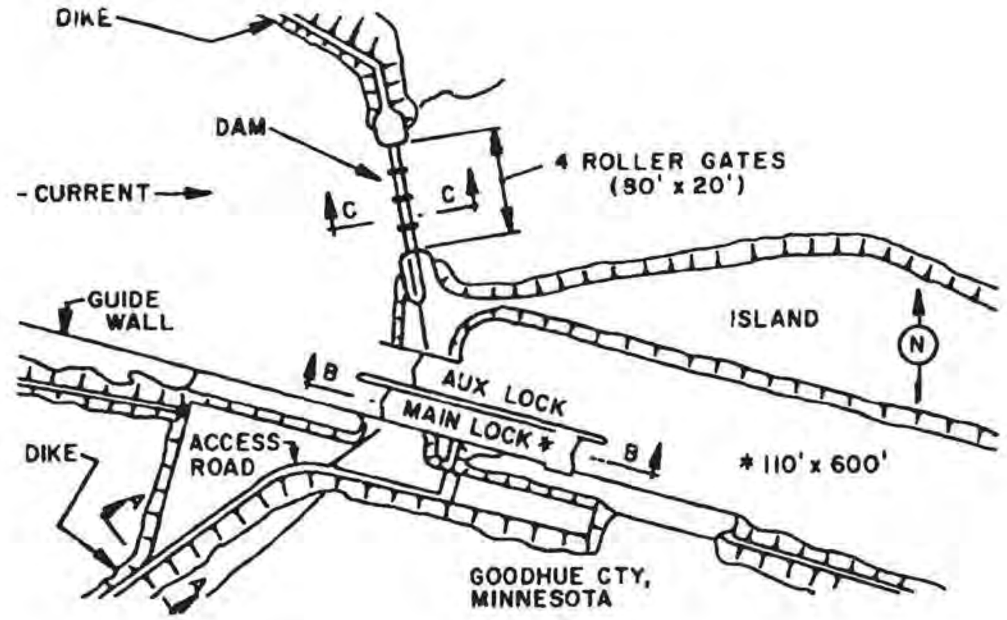


GRAPH COMPILED FROM DATA OBTAINED
FROM U.S. GEOLOGICAL SURVEY
STATISTICAL SUMMARIES

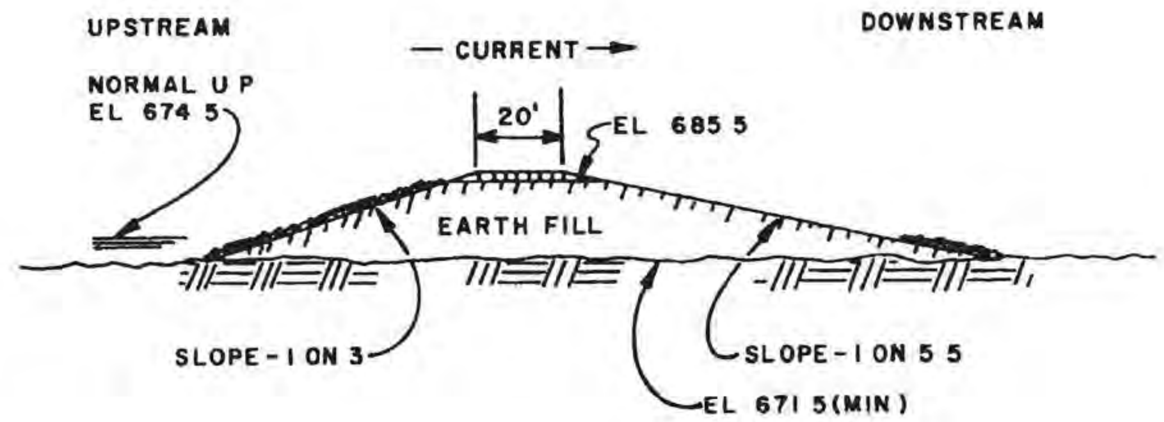
FLOW DURATION CURVES FOR MISSISSIPPI RIVER

DWN T. MILLER	DATE 6-23-99	NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING MINNESOTA	SCALE: NONE
CHECKED	CAD FILE U02402.DGN		**FIGURE 2.4-2 REV. 18**

REVISIONS

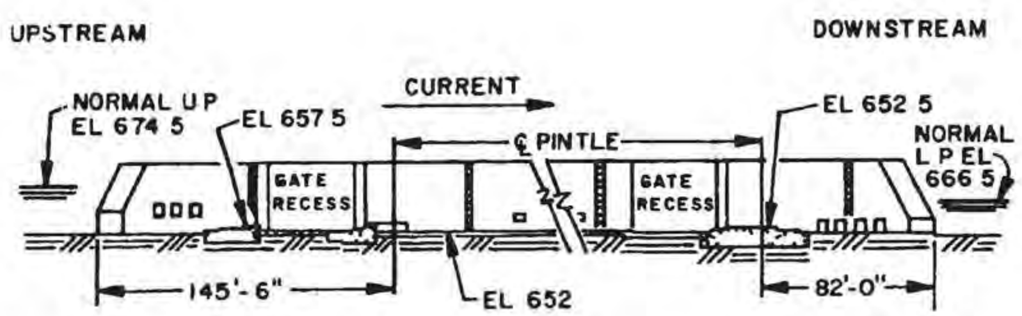


PLAN VIEW



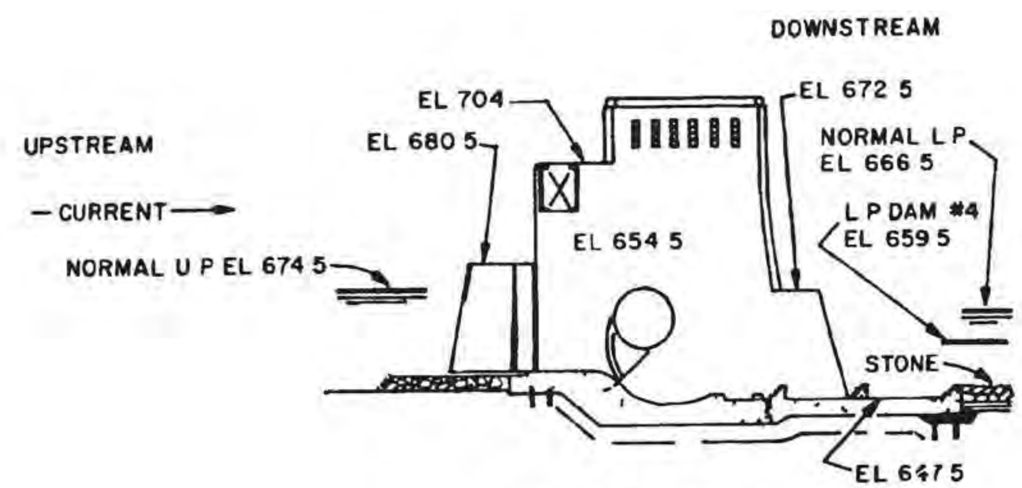
SECTION A–A

EARTH DIKE (TYP)



SECTION B–B

MAIN LOCK



SECTION C–C

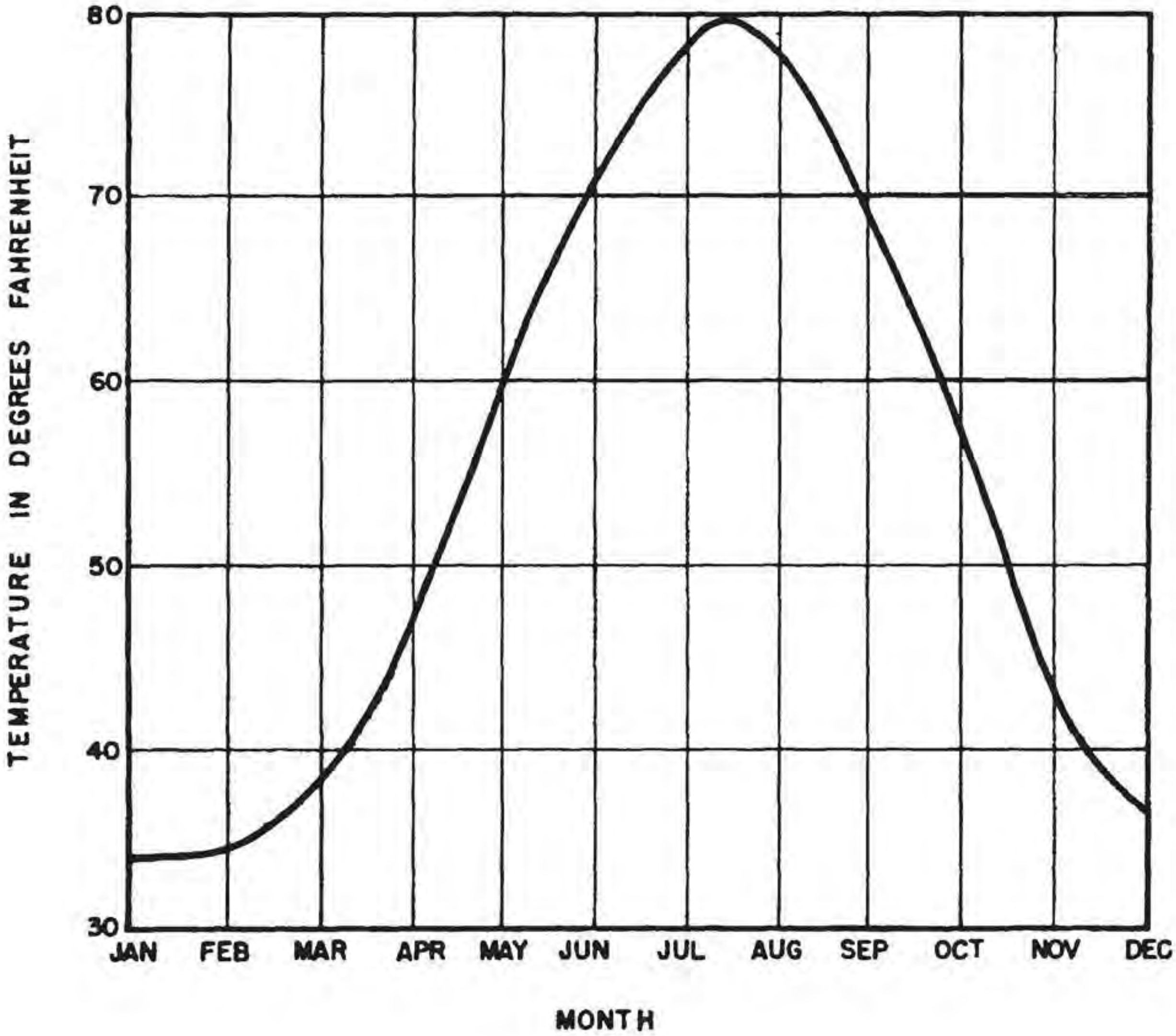
ROLLER GATE

DWN TAM	DATE 6-23-99	SIGNIFICANT NO.							
CHECKED		GROUP	1	2	3	4	5	CL	6
PROJECT NO. ETNSUR		LOCK AND DAM NO. 3 PLAN AND SECTIONS							
CAD FILE: U02403.DGN									

NORTHERN STATES POWER COMPANY
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RED WING MINNESOTA

SCALE NONE

FIGURE 2.4-3 REV. 18



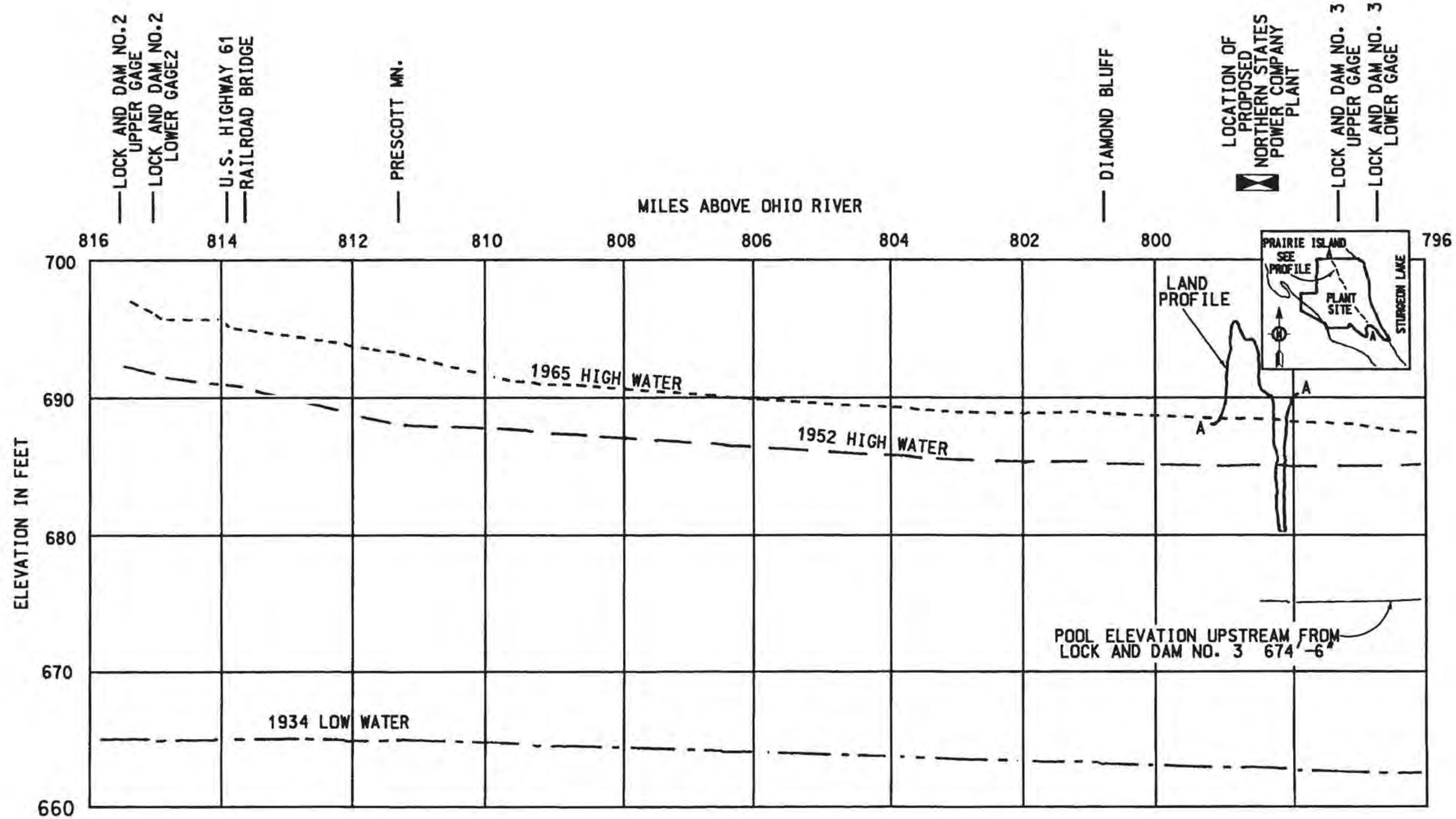
PERIOD OF RECORD 1956 TO 1964

REFERENCE:
UNPUBLISHED DATA ON STREAM TEMPERATURES FOR THE MISSISSIPPI RIVER COMPILED BY THE U. S. ARMY CORPS. OF ENGINEERS, ST. PAUL MINNESOTA

AVERAGE TEMPERATURE OF MISSISSIPPI RIVER AT ST. PAUL. MN.

DWN T. MILLER	DATE 6-23-99	NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING MINNESOTA	SCALE: NONE	
CHECKED	CAD FILE U02404.DGN		FIGURE 2.4-4	REV. 18

REVISIONS



NOTE:

MODIFIED FROM U.S. CORPS OF ENGINEERS STREAM PROFILE CURVES

DRN TAM	DATE 6-23-99	SIGNIFICANT NO.								
CHECKED		GROUP	1	2	3	4	5	CL	6	
PROJECT NO. ETNSUR		STREAM PROFILE FOR MISSISSIPPI RIVER FROM LOCK AND DAM NO. 2 TO LOCK AND DAM NO.3 INCLUDING SITE OF NUCLEAR PLANT								
APP'D & CERT.										
CAD FILE: U02405.DGN										
NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING MINNESOTA		SCALE NONE	REV							
		FIGURE 2.4-5 REV. 18								

LOCATION PLAN OF WELLS IN PLANT VICINITY

DWN T. MILLER	DATE 6-23-99	NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING MINNESOTA	SCALE: NONE
CHECKED	CAD FILE U02406.DGN		FIGURE 2.4-6 REV. 18

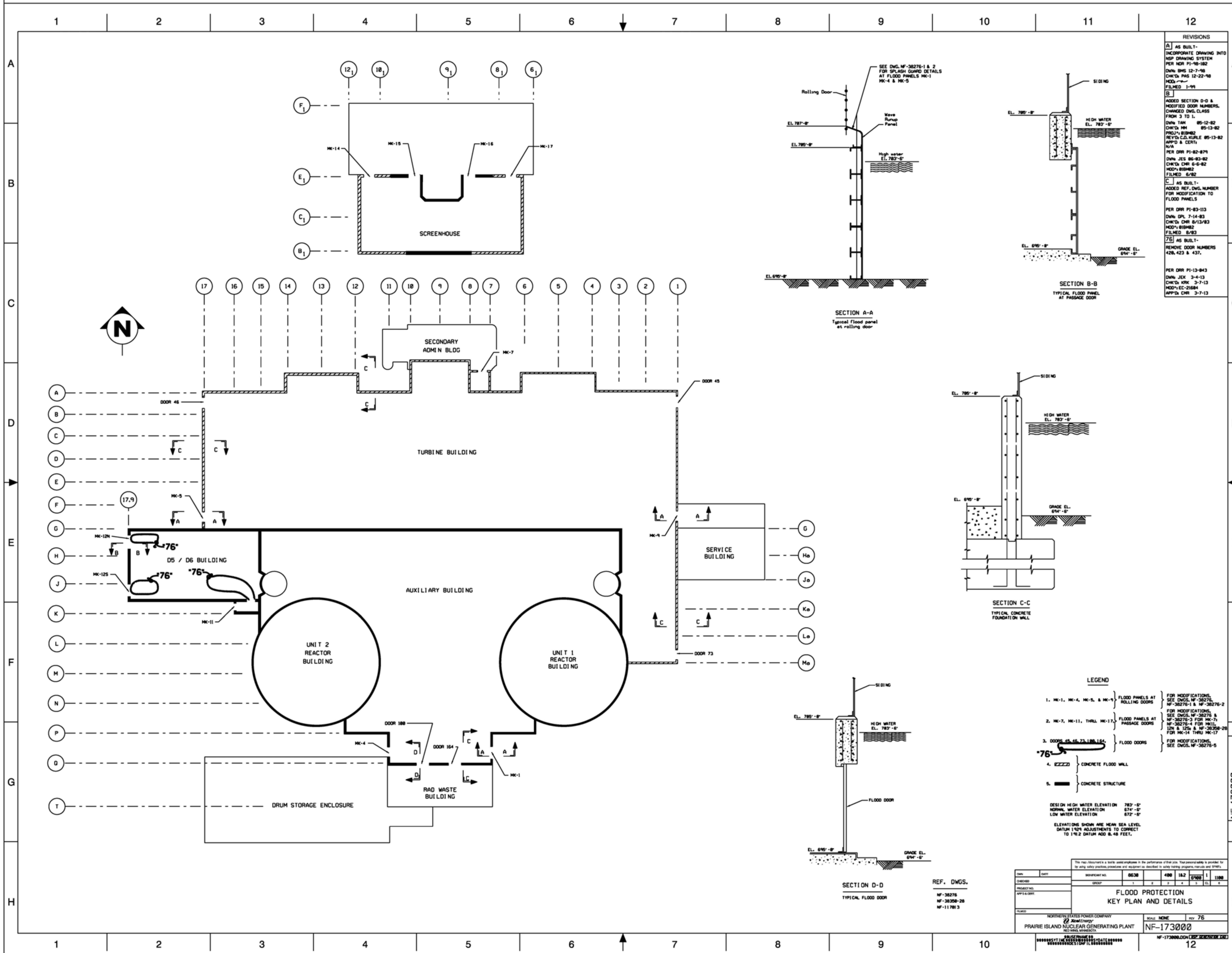
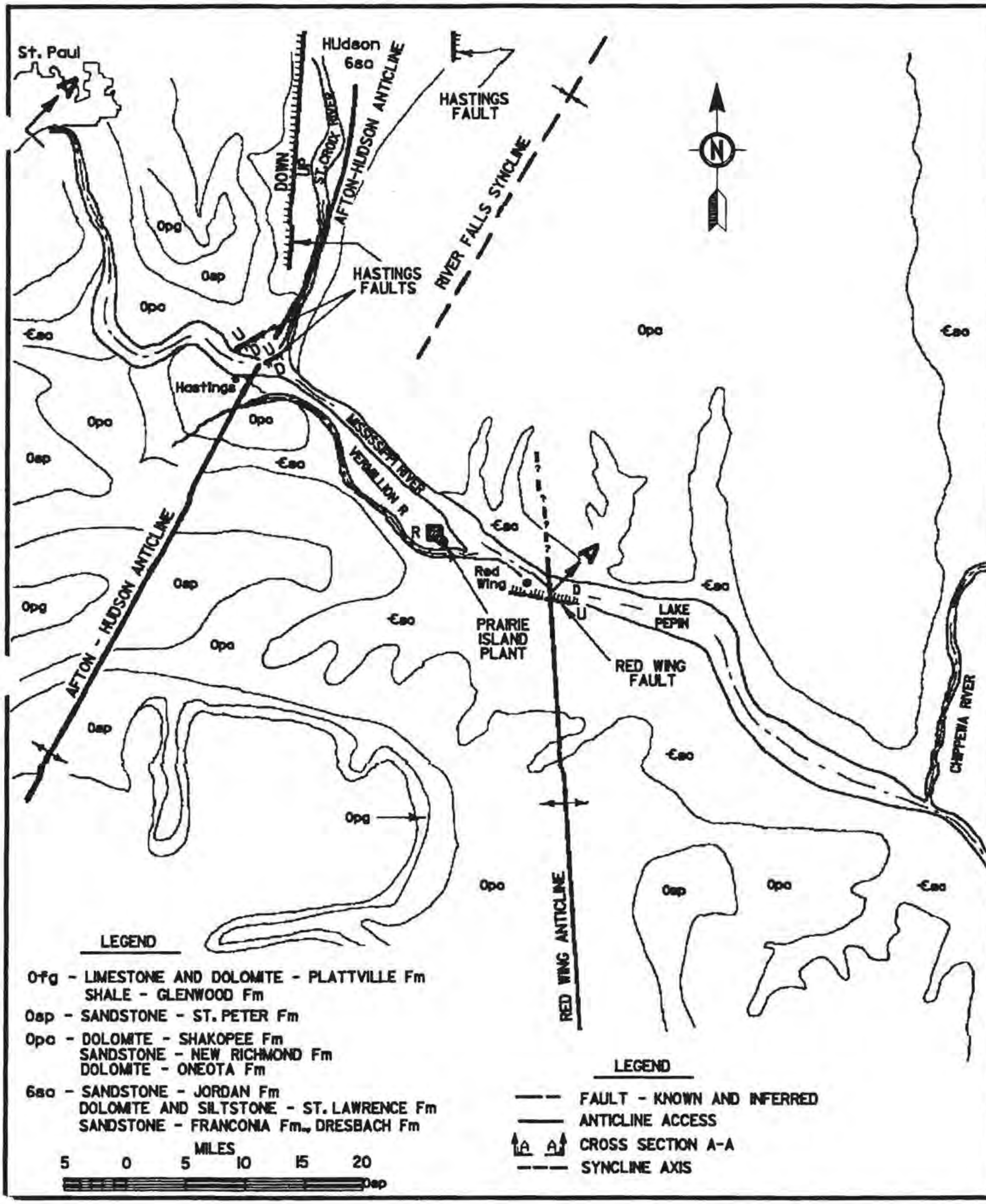


FIGURE 2.4-7 REV. 33

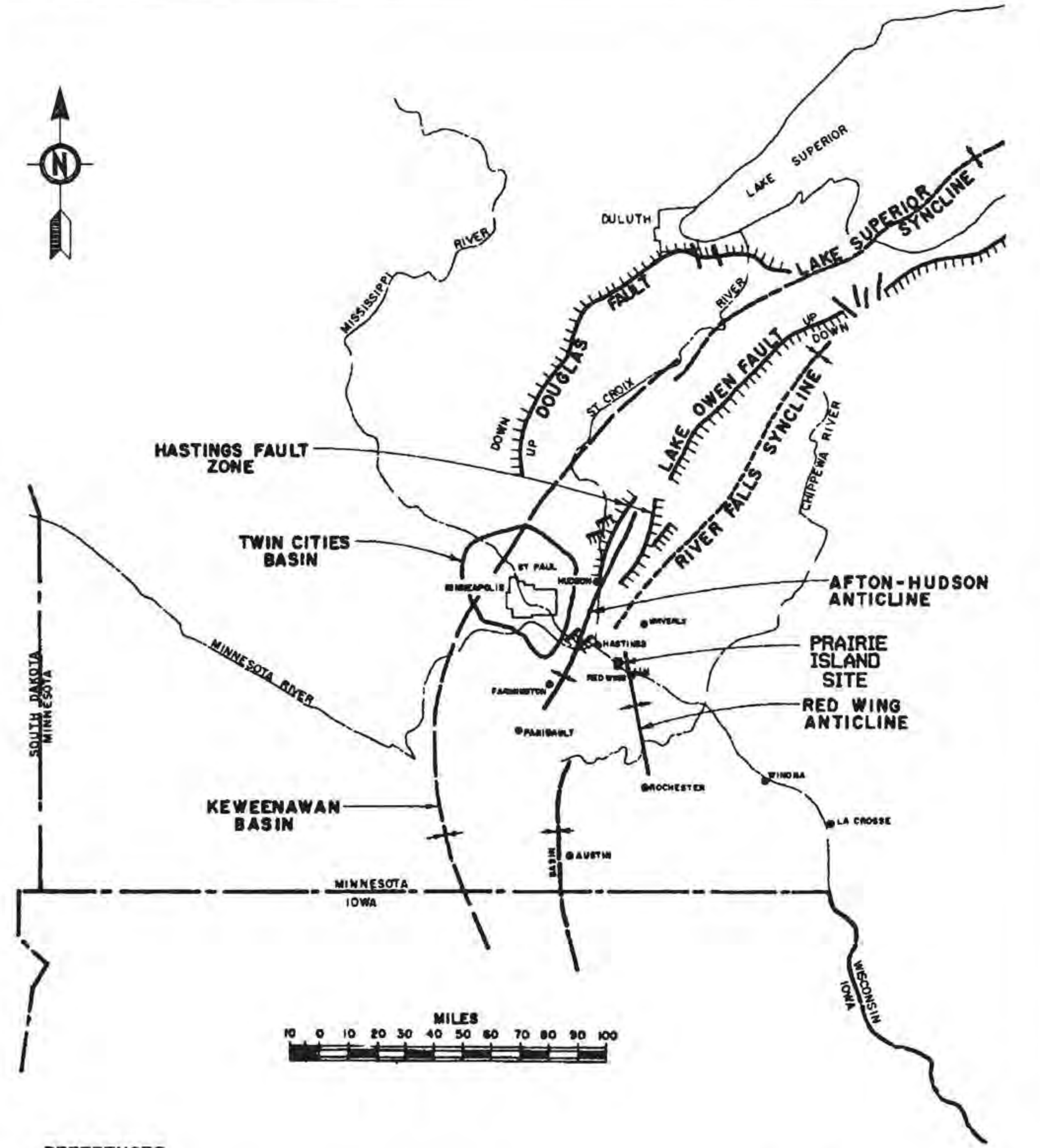
01429088

CAD FILE: U02407.DGN



REGIONAL GEOLOGIC MAP OF BEDROCK FORMATIONS

DWN T. MILLER	DATE 6-23-99	NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING MINNESOTA	SCALE: NONE	
CHECKED	CAD FILE U02501.DGN		FIGURE 2.5-1	REV. 18

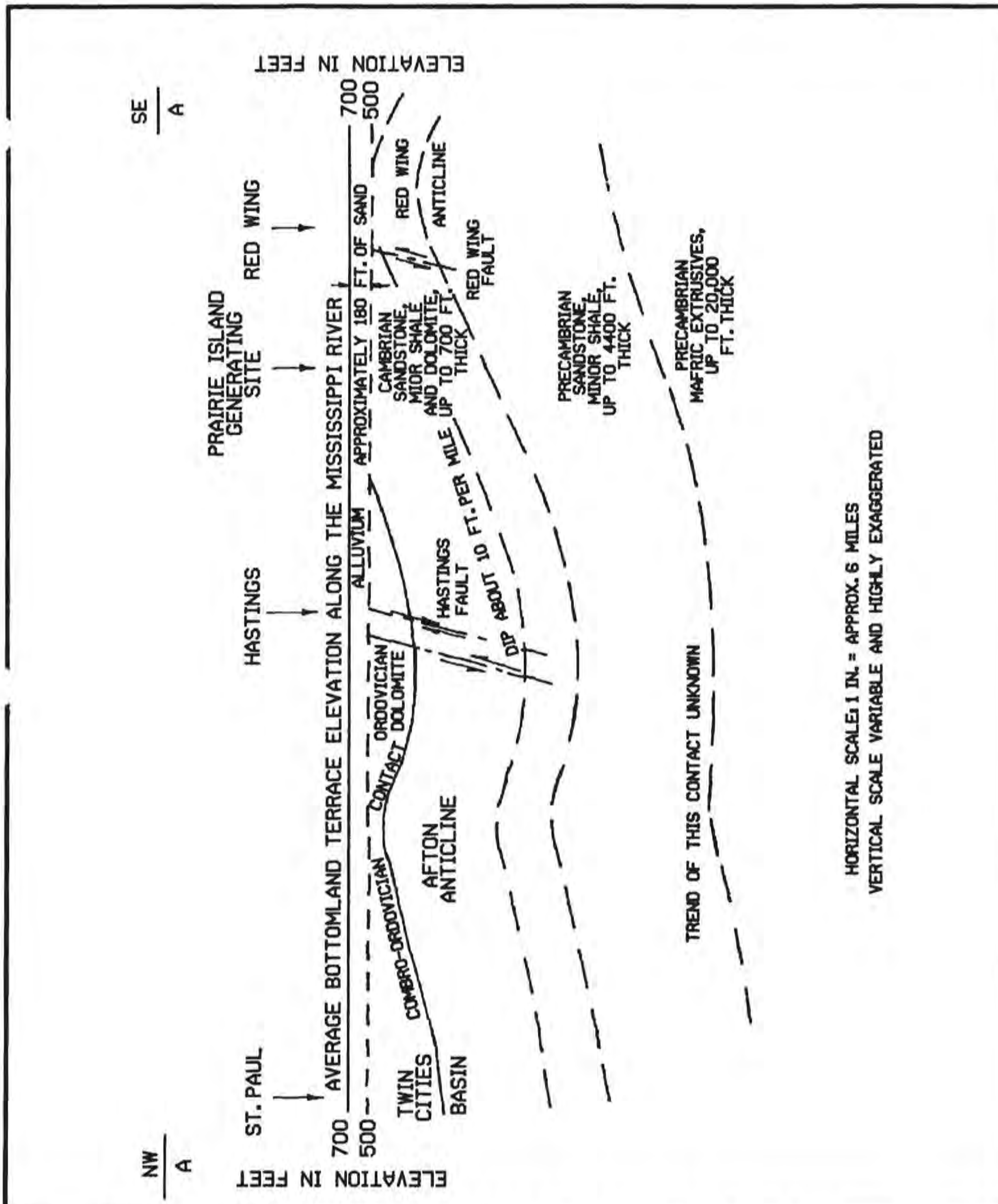


REFERENCES

1. TECTONIC MAP OF THE UNITED STATES BY U S G S AND THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS 1961
2. UNPUBLISHED STRUCTURE MAP BY MINNESOTA GEOLOGICAL SURVEY.

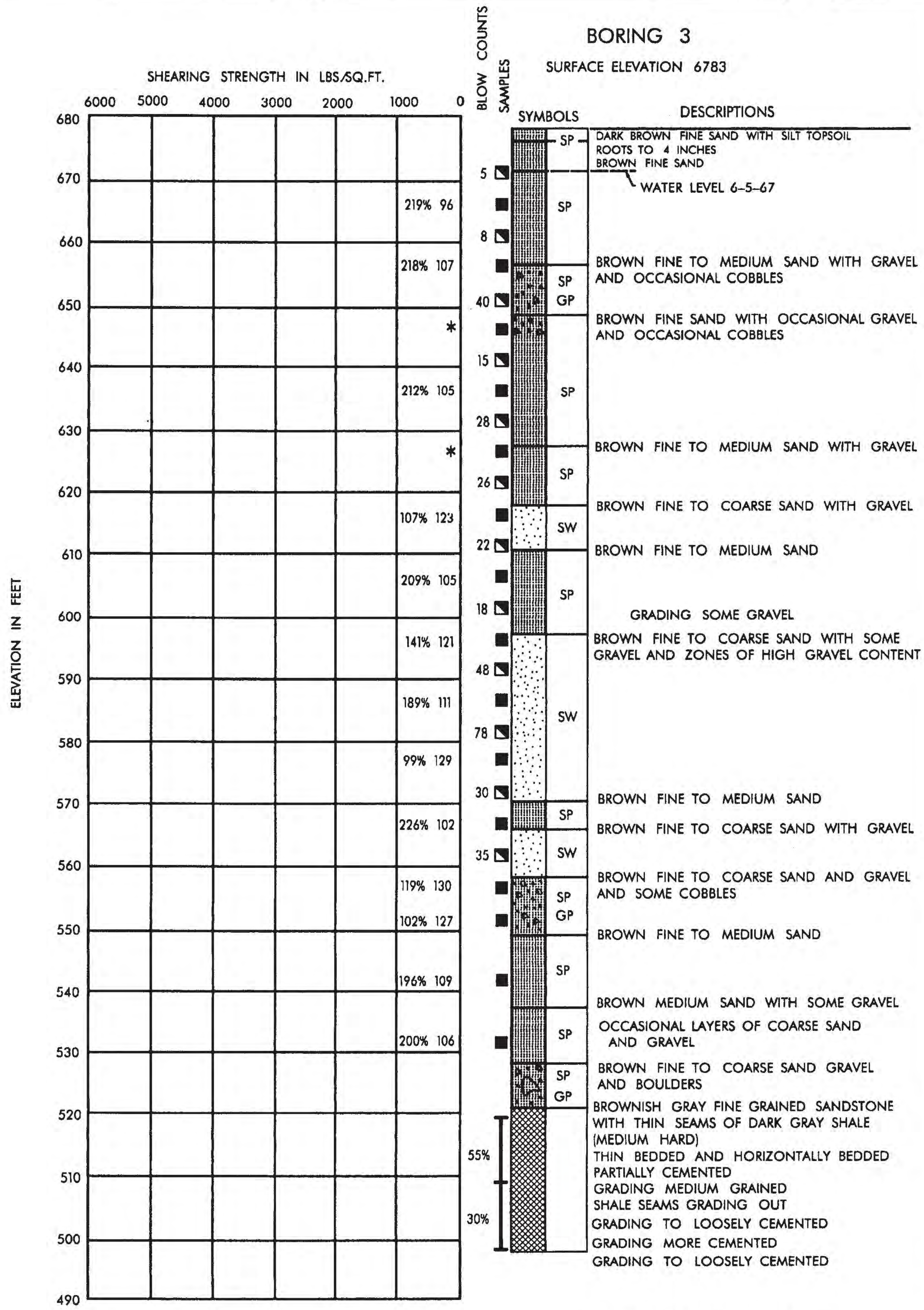
REGIONAL GEOLOGIC STRUCTURE

DWN T. MILLER	DATE 6-23-99	NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING MINNESOTA	SCALE: NONE
CHECKED	CAD FILE U02502.DGN		FIGURE 2.5-2 REV. 18



REGIONAL GEOLOGIC CROSS SECTION A-A

DWN T. MILLER	DATE 6-23-99	NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING MINNESOTA	SCALE: NONE
CHECKED	CAD FILE U02503.DGN		FIGURE 2.5-3 REV. 18



BORING COMPLETED AT 178.5 FEET ON 5-24-67
CASING USED TO A DEPTH OF 28.3 FEET
PIEZOMETER INSTALLED AT 10 FEET ON 5-24-67

NOTES:

GROUND SURFACE ELEVATIONS REFER TO MEAN SEA LEVEL DATUM - 1929 ADJUSTMENT.

■ INDICATES A DAMES AND MOORE UNDISTURBED SAMPLE. (TYPE U SAMPLER)

◪ INDICATES STANDARD PENETRATION TEST. FIGURES UNDER THE BLOW COUNT COLUMN INDICATE THE NUMBER OF BLOWS REQUIRED TO DRIVE A SAMPLER, WITH AN OUTSIDE DIAMETER OF 2 INCHES, ONE FOOT WITH A 140 POUND WEIGHT FALLING 30 INCHES.

100% I INDICATES DEPTH, LENGTH, AND PERCENT OF CORE RUN RECOVERED.

* INDICATES SAMPLE SUBJECTED TO DYNAMIC TRIAXIAL COMPRESSION TEST. DATA REGARDING TEST IS LOCATED IN PART 6 OF REPORT.

** INDICATES SAMPLE SUBJECTED TO DYNAMIC CONFINED COMPRESSION TEST. DATA REGARDING TEST IS LOCATED IN PART 6 OF REPORT.

REVISIONS

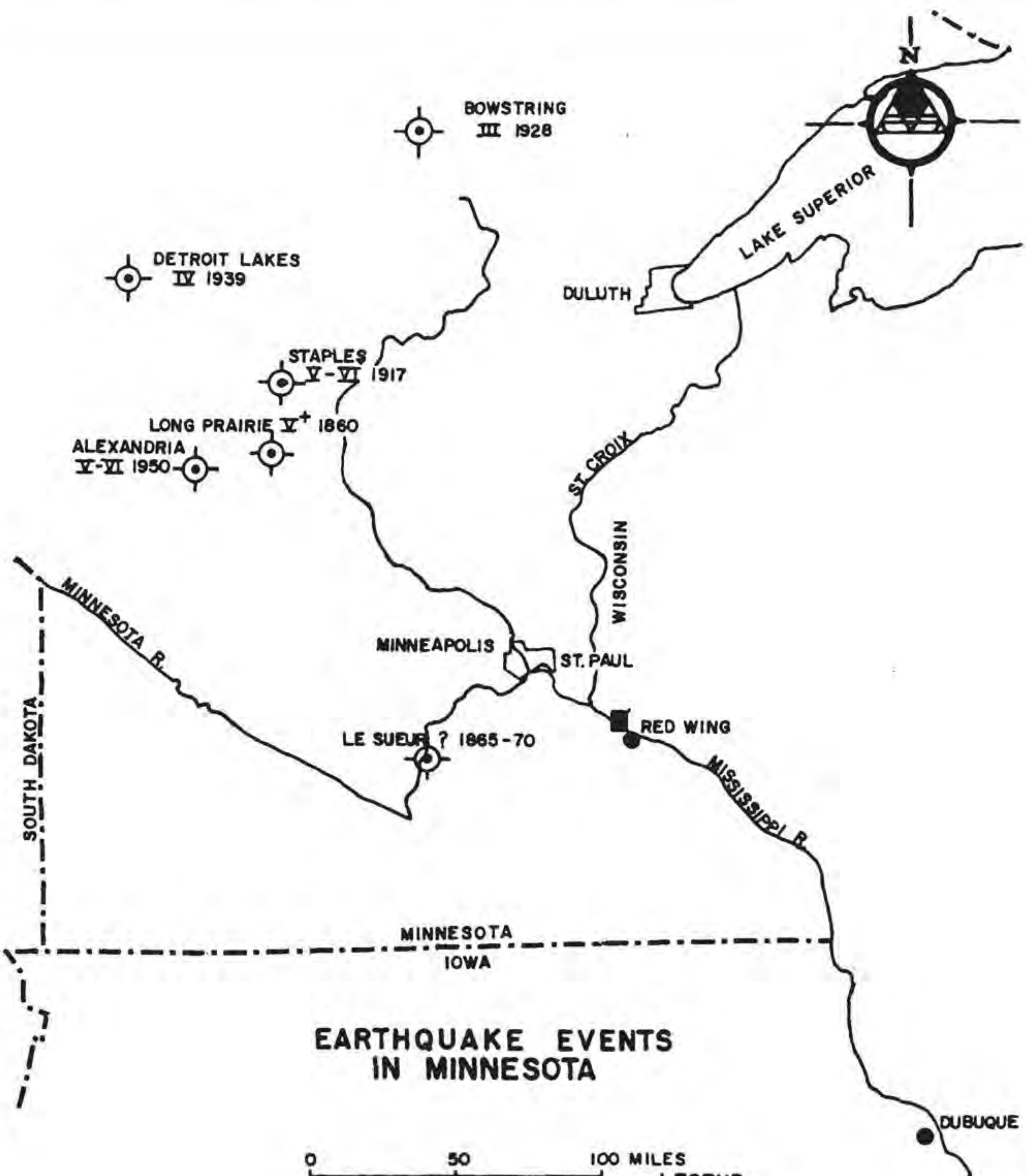
DWN TAM	DATE 6-23-99	SIGNIFICANT NO.							
CHECKED		GROUP	1	2	3	4	5	CL	6
PROJECT NO. ETNSUR									
APP'D & CERT.									
CAD FILE U02505.DGN									

LOG OF BORINGS

NORTHERN STATES POWER COMPANY
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RED WING MINNESOTA

SCALE NONE

FIGURE 2.5-4 REV. 18



LEGEND:

LOCATION OF EPICENTER

1939 DATE OF EARTHQUAKE

VI INTENSITY OF EARTHQUAKE

REFERENCE:

EARTHQUAKE HISTORY OF THE UNITED STATES PART I: STRONGER EARTHQUAKES OF THE UNITED STATES U. S. COAST AND GEODETIC SURVEY PUBLICATION NO. 41-1

EARTHQUAKE EVENTS IN MINNESOTA

DWN T. MILLER	DATE 6-23-99	NORTHERN STATES POWER COMPANY PRAIRIE ISLAND NUCLEAR GENERATING PLANT RED WING MINNESOTA	SCALE: NONE
CHECKED	CAD FILE U02601.DGN		FIGURE 2.6-1 REV. 18