November 4, 1998

Mr. Roger O. Anderson, Director
Nuclear Energy Engineering
Northern States Power Company
414 Nicollet Mall
Minneapolis, Minnesota 55401

SUBJECT: PRAIRIE ISLAND NUCLEAR GENERATING PLANT, UNITS 1 AND 2 - ISSUANCE OF AMENDMENTS RE: COOLING WATER SYSTEM EMERGENCY INTAKE DESIGN BASIS (TAC NOS. M97816 AND M97817)

Dear Mr. Anderson:

The Commission has issued the enclosed Amendment No. 140 to Facility Operating License No. DPR-42 and Amendment No. 131 to Facility Operating License No. DPR-60 for the Prairie Island Nuclear Generating Plant, Units 1 and 2, respectively. The amendments consist of changes to the Technical Specifications in response to your application dated January 29, 1997, as supplemented February 11, 12, March 7, 10, 11, 19, 20, April 29, June 30, July 10,1997, June 20, June 22, July 24, September 15, and October 1, 1998.

The amendments change the design basis of the cooling water system emergency intake line flow capacity. The changes also reclassify the intake canal for use during a seismic event, which would be an additional source of cooling water available during a design-basis earthquake. The amendments also reflect the completion of license conditions that were implemented as part of interim amendments 128/120 dated March 25, 1997, to reflect compensatory measures taken by Northern States Power until a seismically qualified emergency cooling water source could be provided.

A copy of our related Safety Evaluation is also enclosed. The notice of issuance will be included in the Commission's biweekly *Federal Register* notice.

Sincerely,

ORIGINAL SIGNED BY

Tae Kim, Senior Project Manager
Project Directorate III-1
Division of Reactor Projects - III/IV
Office of Nuclear Reactor Regulation

Docket Nos. 50-282 and 50-306

Enclosures:
1. Amendment No. 140 to DPR-42
2. Amendment No. 131 to DPR-60
3. Safety Evaluation

cc w/encl: See next page
DISTRIBUTION: See attached page

DOCUMENT NAME: G:\WPDOCS\PRAIRIE\PI97817.AMD (with comments on page 11 & the flag) *SEE PREVIOUS CONCURRENCE

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AMENDMENT NO. 140 TO FACILITY OPERATING LICENSE NO. DPR-42-PRAIRIE ISLAND UNIT 1
AMENDMENT NO. 131 TO FACILITY OPERATING LICENSE NO. DPR-60-PRAIRIE ISLAND UNIT 2

Docket File (50-282, 50-306)
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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

NORTHERN STATES POWER COMPANY

DOCKET NO. 50-282

PRAIRIE ISLAND NUCLEAR GENERATING PLANT, UNIT 1

AMENDMENT TO FACILITY OPERATING LICENSE

Amendment No. 140
License No. DPR-42

1. The Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment by Northern States Power Company (the licensee) dated January 29, 1997, as supplemented February 11, 12, March 7, 10, 11, 19, 20, April 29, June 30, July 10,1997, June 20, June 22, July 24, September 15, and October 1, 1998, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, the license is hereby amended to authorize the licensee to change the design basis of the intake canal in its Updated Safety Analysis Report (USAR) as described in its application dated January 29, 1997, as supplemented February 11, 12, March 7, 10, 11, 19, 20, April 29, June 30, July 10,1997, June 20, June 22, July 24, September 15, and October 1, 1998, and evaluated in the staff's safety evaluation attached to this amendment. In addition, the license is also amended by changes to Appendix B, "Additional Conditions" as indicated in the attachment to this license amendment, and paragraph 2.C.(5) of Facility Operating License No. DPR-42 is hereby amended to read as follows:

<u>Additional Conditions</u>

The Additional Conditions contained in Appendix B, as revised through Amendment No. 140 , are hereby incorporated in the license. The licensee shall operate the facility in accordance with the Additional Conditions.

3. This license amendment is effective as of the date of issuance, with implementation within 30 days and implementation of the USAR update no later than June 1, 1999, as stated in License Condition 3.

FOR THE NUCLEAR REGULATORY COMMISSION

Tae Kim, Senior Project Manager
Project Directorate III-1
Division of Reactor Projects - III/IV
Office of Nuclear Reactor Regulation

Attachment: Appendix B - Additional Conditions

Date of Issuance: November 4, 1998

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

NORTHERN STATES POWER COMPANY

DOCKET NO. 50-306

PRAIRIE ISLAND NUCLEAR GENERATING PLANT, UNIT 2

AMENDMENT TO FACILITY OPERATING LICENSE

Amendment No. 131
License No. DPR-60

1. The Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment by Northern States Power Company (the licensee) dated January 29, 1997, as supplemented February 11, 12, March 7, 10, 11, 19, 20, April 29, June 30, July 10,1997, June 20, June 22, July 24, September 15, and October 1, 1998, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, the license is hereby amended to authorize the licensee to change the design basis of the intake canal in its Updated Safety Analysis Report (USAR) as described in its application dated January 29, 1997, as supplemented February 11, 12, March 7, 10, 11, 19, 20, April 29, June 30, July 10,1997, June 20, June 22, July 24, September 15, and October 1, 1998, and evaluated in the staff's safety evaluation attached to this amendment. In addition, the license is also amended by changes to Appendix B, "Additional Conditions" as indicated in the attachment to this license amendment, and paragraph 2.C.(5) of Facility Operating License No. DPR-60 is hereby amended to read as follows:

<u>Additional Conditions</u>

The Additional Conditions contained in Appendix B, as revised through Amendment No. 131 , are hereby incorporated in the license. The licensee shall operate the facility in accordance with the Additional Conditions.

3. This license amendment is effective as of the date of issuance, with implementation within 30 days and implementation of the USAR update no later than June 1, 1999, as stated in License Condition 3.

FOR THE NUCLEAR REGULATORY COMMISSION

Tae Kim

Tae Kim, Senior Project Manager
Project Directorate III-1
Division of Reactor Projects - III/IV
Office of Nuclear Reactor Regulation

Attachment: Changes to the Technical Specifications

Date of Issuance: November 4, 1998

APPENDIX B

ADDITIONAL CONDITIONS

FACILITY OPERATING LICENSE NO. DPR-42

Northern States Power Company shall comply with the following conditions on the schedules noted below:

Amendment Number	Additional Condition	Implementation Date
128	1. NSP will provide a licensed operator in the control room on an interim basis for the dedicated purpose of identifying an earthquake which results in a decreasing safeguards cooling water bay level. This operator will be in addition to the normal NSP administrative control room staffing requirements and will be provided until License Condition 2 is satisfied.	Prior to Unit 2 entering Mode 2. Completed - See Amendment No. 140
128	2. NSP will submit dynamic finite element analyses of the intake canal banks by July 1, 1997 for NRC review. By December 31, 1998, NSP will complete, as required, additional analyses or physical modifications which provide the basis for extending the time for operator post-seismic cooling water load management and eliminating the dedicated operator specified in License Condition 1.	July 1, 1997, and December 31, 1998, as stated in Condition 2. Completed - See Amendment No. 140
128	3. Based on the results of License Condition 2, NSP will revise the Updated Safety Analysis Report to incorporate the changes into the plant design bases. These changes will be included in the next scheduled revision of the Updated Safety Analysis Report following completion of License Condition 2 activities.	At the next USAR update following completion of Condition 2, but no later than June 1, 1999.
130	4. Prairie Island will assure that heavy loads do not present a potential for damaging irradiated fuel through use of 1) a single-failure-proof crane with rigging and procedures which implement Prairie Island commitments to NUREG-0612; or 2) spent fuel pool covers with their implementing plant procedures for installation and use.	This is effective immediately upon issuance of the amendment.
133	5. NSP will assure that during the implementation of steam generator repairs utilizing the voltage-based repair criteria, the total calculated primary to secondary side leakage from the faulted steam generator, under main steamline break conditions (outside containment and upstream of the main steam isolation valves), will not exceed 1.42 gallons per minute (based on a reactor coolant system temperature of 578 °F).	This is effective immediately upon issuance of the amendment.

APPENDIX B

ADDITIONAL CONDITIONS

FACILITY OPERATING LICENSE NO. DPR-60

Northern States Power Company shall comply with the following conditions on the schedules noted below:

Amendment Number	Additional Condition	Implementation Date
120	1. NSP will provide a licensed operator in the control room on an interim basis for the dedicated purpose of identifying an earthquake which results in a decreasing safeguards cooling water bay level. This operator will be in addition to the normal NSP administrative control room staffing requirements and will be provided until License Condition 2 is satisfied.	Prior to Unit 2 entering Mode 2. Completed - See Amendment No. 131
120	2. NSP will submit dynamic finite element analyses of the intake canal banks by July 1, 1997 for NRC review. By December 31, 1998, NSP will complete, as required, additional analyses or physical modifications which provide the basis for extending the time for operator post-seismic cooling water load management and eliminating the dedicated operator specified in License Condition 1.	July 1, 1997, and December 31, 1998, as stated in Condition 2. Completed - See Amendment No. 131
120	3. Based on the results of License Condition 2, NSP will revise the Updated Safety Analysis Report to incorporate the changes into the plant design bases. These changes will be included in the next scheduled revision of the Updated Safety Analysis Report following completion of License Condition 2 activities.	At the next USAR update following completion of Condition 2, but no later than June 1, 1999.
122	4. Prairie Island will assure that heavy loads do not present a potential for damaging irradiated fuel through use of 1) a single-failure-proof crane with rigging and procedures which implement Prairie Island commitments to NUREG-0612; or 2) spent fuel pool covers with their implementing plant procedures for installation and use.	This is effective immediately upon issuance of the amendment.
125	5. NSP will assure that during the implementation of steam generator repairs utilizing the voltage-based repair criteria, the total calculated primary to secondary side leakage from the faulted steam generator, under main steamline break conditions (outside containment and upstream of the main steam isolation valves), will not exceed 1.42 gallons per minute (based on a reactor coolant system temperature of 578 °F).	This is effective immediately upon issuance of the amendment.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 140

TO FACILITY OPERATING LICENSE NO. DPR-42

AND AMENDMENT NO. 131 TO FACILITY OPERATION LICENSE NO. DPR-60

NORTHERN STATES POWER COMPANY

PRAIRIE ISLAND NUCLEAR GENERATING PLANT, UNITS 1 AND 2

DOCKET NOS. 50-282 AND 50-306

1.0 INTRODUCTION

By letter dated January 29, 1997, as supplemented February 11, 12, March 7, 10, 11, 19, 20, April 29, June 30, July 10,1997, June 20, June 22, July 24, September 15, and October 1, 1998 the Northern States Power Company (NSP or the licensee) submitted a license amendment request for the Prairie Island Nuclear Generating Plant, Units 1 and 2. The request was submitted in accordance with the provisions of 10 CFR Part 50, Sections 50.59 and 50.90 to address an unreviewed safety question (USQ) related to the cooling water system emergency intake line flow capacity. The emergency intake line is described in the Updated Safety Analysis Report (USAR) as having the capacity to be the sole source of water from the Mississippi River (the ultimate heat sink or UHS) to the intake bay for the cooling water system pumps following a design-basis seismic event. The cooling water system pumps are necessary for safe plant shutdown under all postulated conditions including seismic events.

The October 1, 1998, submittal provided revised USAR pages reflecting the change to the cooling water system emergency intake design bases. This information was within the scope of the October 1, 1998, *Federal Register* notice and did not change the staff's initial proposed no significant hazards considerations determination.

The staff issued Amendment No. 128 to Facility Operating License No. DPR-42 and Amendment No. 120 to Facility Operating License No. DPR-60 on March 25, 1997. These amendments authorized the licensee to continue operation of Prairie Island Units 1 and 2 on an interim basis, through the incorporation of three license conditions into the licenses, until a seismically qualified emergency cooling water source could be provided that would provide the basis to extend the time for operator post-seismic cooling water load management.

The third license condition identified in the March 25, 1997, amendments stated that the licensee would revise the USAR to incorporate the changes to the plant design-basis that result from the finalization of the seismic design (including a dynamic finite element analysis) of the intake canal banks to ensure a seismically qualified emergency cooling water source following a design-basis earthquake (DBE). The licensee has performed a seismic analysis of the intake canal and the staff has completed its evaluation of the licensee's analysis. This safety evaluation summarizes the staff's evaluation of the licensee's seismic analysis and the staff's evaluation of USAR changes.

2.0 DISCUSSION

2.1 Seismic Analysis

Exhibit F of NSP's January 29, 1997, amendment request contained an evaluation by STS Consultants, Ltd. (STS) of the stability of the Prairie Island Nuclear Generating Plant intake canal banks under a DBE load. This evaluation concluded, based on three Standard Penetration Test (SPT) soil borings, laboratory testing of soil samples, and eight Cone Penetration Tests (CPT), that the minimum Factor of Safety against soil liquefaction (FS_L) is at least 1.5. An FS_L greater than 1 indicates that the equivalent cyclic shear stress induced by the DBE load (τ_{cyc}) is less than the cyclic shear stress required to cause liquefaction ($\tau_{cyc,L}$). Since the liquefaction analysis determined that the intake canal embankments would not liquefy during the DBE, STS performed a pseudo-static slope stability analysis. This analysis indicated that a minimum static Factor of Safety of 1.25 existed for the slope under the DBE load. Thus, NSP concluded that "the intake canal walls will not liquefy or lose strength during a seismic event with the intake canal at normal pool level." (Ref. 1)

Staff review of the STS slope stability analysis resulted in a request for additional information (RAI) dated February 21, 1997. In the RAI the staff questioned (1) the correlation between the CPT and SPT, (2) the correction factors used for the overburden pressure (C_n), (3) the location and extent of the eight CPT, (4) the difference between standard penetration resistance values (N) from CPT and SPT at adjacent boreholes, and (5) the different conclusions, concerning the liquefaction susceptibility of the intake canal, reached by STS and an earlier 1967 Dames and Moore evaluation. Furthermore, the staff requested a finite element analysis of the canal embankment using the safe shutdown earthquake (SSE) response spectrum to generate the dynamic loading of the DBE in place of the pseudo-static methodology used by STS.

NSP responded to the staff RAI by letter dated February 28, 1997. Although the NSP response defended the use of the CPT to generate N values, NSP decided to use N values from the three 1996 and the seven 1967 Dames and Moore SPT. In addition, since only one of the 1967 Dames and Moore SPT soil borings is located near the intake canal, NSP performed thirteen additional SPT borings at the crest, mid-slopes, and base of the canal. The N values from these soil borings were used to more accurately characterize $\tau_{cyc,L}$ for the two-dimensional finite element analysis of the intake canal.

On June 30, 1997, NSP submitted a two-volume intake canal liquefaction analysis that showed limited liquefaction triggering along the submerged face of the intake canal slope between Elevation (El.) 664 and 674. However, a post-stability earthquake analysis indicated that a liquefaction flow slide failure would not occur. In addition, a permanent deformation analysis showed that the movement of the canal slopes would be less than 1 inch for the DBE. (Ref. 2)

The staff review of this two-volume NSP submittal included a confirmatory analysis that showed more widespread liquefaction than that predicted by NSP. Rather than using the median of the corrected blow count values, $(N_1)_{60}$, for each soil layer, the staff analysis used actual $(N_1)_{60}$

values from each soil boring to determine the cyclic shear stress required to cause liquefaction. Since several of the soil borings have $(N_1)_{60}$ values lower than 5 for the critical saturated loose sand layer (El. 671 to 674), the FS_L for these locations along the canal embankment are less than 1. As a result of these differences, the staff requested, at a meeting with NSP and STS representatives on December 11, 1997, that NSP revise its liquefaction analysis by using the Idriss (1990) soil damping curve rather than the outdated Seed and Idriss (1970) damping curve and that NSP perform two bounding analyses. The staff requested the first bounding analysis to determine the minimum volume of water needed in the intake canal to provide adequate time for operator action to manage cooling water system loads following a DBE and the second bounding analysis to provide an estimate of the water volume that would be lost due to material entering the canal following a DBE, assuming very conservative soil strength values. By letter dated March 23, 1998, NSP provided the two bounding analyses (Ref. 3) and a revision of its June 30, 1997, two-volume liquefaction analysis report (Ref. 4) for staff review.

2.2 Changes to USAR

In its June 22, 1998, submittal, the licensee provided the USAR changes that resulted from the completed analyses related to this issue. The June 22, 1998, submittal superseded the proposed USAR changes identified in the original January 29, 1997, license amendment request. On October 1, 1998, the licensee submitted a supplement that revised the wording in one paragraph of USAR page 10.4-7. The final changes to the Prairie Island design basis resulted in changes to Sections 10.4.1.22 and 12.2.1 of the USAR. USAR Section 10.4.1.2.2 has been revised to reflect the fact that both the emergency intake line and the intake canal are relied upon for safe plant shutdown following a DBE. USAR Section 12.2.1 has been changed to reflect a revised definition for the Nuclear Safety Design Classification, Class I* and a reclassification of the intake canal from a Class III to Class I* structure.

2.3 License Conditions

The following three license conditions were proposed by the licensee in its March 19, 1997, submittal and implemented by the March 25, 1997, amendments:

> License Condition 1. NSP will provide a licensed operator in the control room on an interim basis for the dedicated purpose of identifying an earthquake which results in a decreasing safeguards cooling water bay level. This operator will be in addition to the normal NSP administrative control room staffing requirements and will be provided until License Condition 2 is satisfied.
>
> License Condition 2. NSP will submit dynamic finite element analyses of the intake canal banks by July 1, 1997 for NRC review. By December 31, 1998, NSP will complete, as required, additional analyses or physical modifications which provide the basis for extending the time for operator post-seismic cooling water load management and eliminating the dedicated operator specified in License Condition 1.
>
> License Condition 3. Based on the results of License Condition 2, NSP will revise the Updated Safety Analysis Report to incorporate the changes into the plant design bases. These changes will be included in the next scheduled revision of the Updated Safety Analysis Report following completion of License Condition 2 activities.

3.0 EVALUATION

3.1 Seismic Analysis

3.1.1 Two-Volume Intake Canal Liquefaction Analysis Report

The revised two-volume intake canal liquefaction analysis report, prepared by STS Consultants, presents

field exploration and laboratory testing results,
a description of the intake canal soil profile,
a static stress analysis,
a description of the method used to generate the DBE input motions for the dynamic analysis,
a one-dimensional wave propagation procedure,
a dynamic stress analysis,
a liquefaction triggering analysis,
an evaluation of the residual shear strength,
a post-earthquake stability analysis, and
a permanent deformation analysis.

3.1.1.1 Field Exploration and Laboratory Test Results

Field explorations conducted by STS include SPT borings, CPT, the excavation of three test pits, spectral analysis of surface waves (SASW) tests, and measurement of ground water elevations.

STS performed a total of 23 SPT soil borings and reviewed 7 SPT borings performed by Dames and Moore for the plant design. SPT soil borings were located along the canal crest, side slopes, and bottom and performed in accordance with American Society for Testing and Materials (ASTM) standard ASTM D-1586. STS derived corrected blow count values, $(N_1)_{60}$, from the SPT N values by correcting for effective overburden stress, rod energy, rod length, and the presence of a sample liner. Using the SPT soil borings and CPT as well as construction records, STS prepared soil profiles of the project site both perpendicular and parallel to the intake canal.

NSP and STS excavated three test pits on the north slope of the canal just above the water level (El. 675) to determine the relative density, water content, specific gravity, triaxial shear strength, and void ratio for the loose fine sand layer. The relative density, a measure of in-situ denseness or looseness, ranges from about 56% to 82%. Relative densities in this range correspond to medium (50 - 70%) and dense (70 - 85%) soil deposits. (Ref. 5) The water content or moisture content of the three test pits varies from 8 to 10% and the specific gravity varies from 2.64 to 2.70. In-situ void ratio measurements vary from 0.55 (dense uniform sand) for test pit TP-1 to 0.78 (loose uniform sand) for test pit TP-3. To determine shear strength parameters, STS performed consolidated-undrained triaxial shear tests. Plots of the pore water pressure versus axial strain show an initial increase in pore water pressure with strain and then a sharp decrease due to dilation of the soil, which is typical for medium-dense to dense sand

(Ref. 5). The drained friction angle for the test pits TP-1 and TP-2 is about 33 degrees and the effective stress at failure, σ_3', varies from 2,300 to 23,000 psf.

To determine shear wave velocities, STS used the SASW test along four linear profiles adjacent to the canal. A 1,000 lb weight dropped from a crane was used for the energy source. Calculated shear wave velocities vary from about 500 ft/sec at the top of the canal bank (El. 680) to 2250 ft/sec at a depth of 180 feet (El. 500). For its seven-layer soil profile, STS used a shear wave velocity of 650 ft/sec for the top three loose sand layers and velocities ranging from 820 to 1950 ft/sec for the more dense sand and gravelly sand layers. STS also estimated shear wave velocities using an empirical relationship between SPT standard penetration resistance and shear wave velocity. This empirical procedure was used to estimate the shear wave velocity of the fill underlying the base of the canal.

STS and NSP monitored ground water elevations in two wells at the site from May 1, 1997, to June 5, 1997, during the receding spring flood. Since the ground water recession rate is nearly equal to the canal/river recession rate and the sands are very permeable, STS concluded that river levels and stabilized ground water levels 60 to 100 feet away from the canal water line match within about 0.5 foot. As such, since the median river level is El. 673.9, STS used a water table level of 674 feet for its dynamic finite element analysis. For the post-earthquake stability analysis, STS used a water table level of 675 feet to account for the combined effect of capillary rise and water level rise due to pore pressure increases during the DBE.

Grain size analyses were performed using the six soil samples taken from the three test pits (El. 675). Particle-size distribution curves show that the six soil samples are poorly graded since most of the soil grains are the same size (0.1 - 0.5 mm). Grain size analyses of samples taken from the SPT borings show that the soil becomes coarser and better graded with depth.

3.1.1.2 Soil Profile

CPT and SPT performed by STS and Dames and Moore, in addition to survey data and construction records, indicate that the stratigraphy at the site is essentially horizontal layering and that there are four main soil units:

1) compacted sand fill,
2) loose fine to medium sand with a trace of silt,
3) medium dense higher graded sand with a trace of silt, and
4) coarser medium dense to dense gravelly sand.

The following table shows some of the soil parameters used by STS to define the seven soil layers and two rock units for the static and dynamic finite element analyses:

Layer	Description	Elev. (ft)	z (ft)	V_s (ft/s)	G (ksf)	ζ	γ (pcf)
L1	Moist Sand Fill	694.0-680.0	14.0	650	1575	7	120
L2	Moist Loose Sand	680.0-674.0	6.0	650	1443	12	110
L3	Sat. Loose Sand	674.0-671.0	3.0	650	1509	12	115
L4	Med. Dense Sand	671.0-647.0	24.0	820	2610	10	125
L5	Med. Dense Sand	647.0-585.0	62.0	1000	4037	7	130
L6	Sat. Sand Fill	664.0-635.0	29.0	1200	5590	7	125
L7a	Dense Grav. Sand	585.0-567.5	17.5	1130	5155	7	130
L7b	Dense Grav. Sand	567.5-550.0	17.5	1225	6058	7	130
L7c	Dense Grav. Sand	550.0-532.5	17.5	1590	10207	7	130
L7d	Dense Grav. Sand	532.5-515.0	17.5	1950	15352	7	130
L8	Weathered Sandstone	515.0-495.0	20.0	2500	30085	7	155
L9	Sandstone Bedrock	495.0-		5000	120341	0	155

where z is the layer thickness, V_s is the shear wave velocity, G is the shear modulus, ζ is the critical damping parameter, and γ is the unit weight. Sixteenth percentile blow count values, used in the bounding analysis, and 50th percentile blow count values for each layer are given in the table below.

Layer	Description	16th P. $(N_1)_{60}$	50th P. $(N_1)_{60}$
1	Moist Sand Fill	15.3	49.3
2	Moist Loose Sand		6.1
3	Sat. Loose Sand	4.5	6.1
4	Med. Dense Sand	8.8	12.6
5	Med. Dense Sand	9.4	16.0
6	Sat. Sand Fill	15.3	49.3
7	Dense Grav. Sand	13.5	17.6

3.1.1.3 Static Stress Analysis

Using the computer code FEADAM84, STS estimated the static stresses throughout the soil profile. Specifically, STS estimated the vertical effective stress, σ'_v, and the horizontal shear stress, ϕ'_{hv}, for an "idealized" cross-section of the intake canal. This cross-section was discretized into a number of elements for the subsequent dynamic analysis. Using these static stress parameters, STS then determined the appropriate correction factor for initial shear stress, K_α, and effective overburden pressure, K_σ, for each element. These correction factors were used in the liquefaction triggering analysis to modify the cyclic shear stress required to cause liquefaction, $\tau_{cyc,L}$.

3.1.1.4 Dynamic Analysis

To generate the DBE ground motion, STS matched the operating basis earthquake (OBE) response spectrum. The spectral content of the two resulting independent time histories was verified by the staff to be in accordance with Section 3.7.1 of the Standard Review Plan (NUREG-0800). Since STS used the OBE response spectrum, the resulting time histories were scaled up to provide the appropriate SSE peak ground acceleration values of 0.12 g for the horizontal component and 0.08 g for the vertical component.

STS used the DBE ground motion, developed from matching the OBE response spectrum, as the rock outcropping ground motion and then used the computer program SHAKE88 to convolve this ground motion with the appropriate transfer function to obtain the bedrock ground motion at the top of Layer 8 at El. 515. STS then propagated this bedrock ground motion to the base of its finite element model at El. 620. STS approximated the nonlinear soil behavior by using the Sun (1988) moduli reduction curves and the Idriss (1990) damping curves. Using the computer program CARES (Ref. 6), the staff performed a confirmatory analysis with the Idriss (1990) modulus reduction and damping curves. Ground motions for the two analyses are very similar both at the bedrock level (El. 515) and at the finite element base (El. 620).

To compute the peak cyclic shear stresses resulting from the horizontal and vertical DBE ground motions, STS used the two-dimensional finite element computer program QUAD4M. The finite element model used by STS extends 900 feet on either side of the center of the canal and down to El. 620, which is within a zone of dense sand and gravel (Layer 5). As such, the region evaluated by this finite element model includes the liquefaction susceptible soil zones that start at El. 675. Soil properties obtained from the SASW tests were used to define each element in the mesh, with appropriate corrections for the level of overburden stress beneath the slopes and bottom of the intake canal. The resulting horizontal peak acceleration at the slope crest of the intake canal (0.20 g) matches the result obtained by the staff using the CARES computer program from bedrock (El. 515) to the crest of the canal (El. 694).

3.1.1.5 Liquefaction Triggering Analysis

For each element in the finite element model, STS computed the factor of safety against liquefaction FS_L. Peak cyclic shear stresses, obtained from the dynamic stress analysis, were multiplied by 65% to determine the cyclic shear stress, τ_{cyc}. The cyclic shear stress represents the earthquake-induced loading. To characterize the liquefaction resistance of the soil, STS used the median $(N_1)_{60}$ value for each layer to obtain the cyclic stress ratio (CSR) value. This CSR value was then corrected for a magnitude 5 DBE by multiplying the CSR by the magnitude scaling factor of 1.62. STS then applied the correction factors for static shear stress and effective confining pressure, K_α and K_σ, to further modify the CSR. The cyclic shear stress required to initiate liquefaction, $\tau_{cyc,L}$, is then given by multiplying the CSR by the vertical effective stress, σ'_v. STS then divided $\tau_{cyc,L}$ by τ_{cyc} to determine FS_L. Where the loading exceeds the resistance, or FS_L is less than 1, liquefaction can be expected. STS conservatively modified this criteria by defining liquefaction for those elements with FS_L less than 1.1.

Ten of the eight hundred eighty-eight elements of the soil profile have FS_L less than 1.1. The 10 elements that liquefy are located at the slope face on both sides of the canal between El. 664 and 674. A critical parameter in the liquefaction triggering analysis is the correction factor K_α. STS conservatively used a relative density (D_r) value of 45% to determine K_α for the elements between El. 664 and 674 even though actual measured values of D_r varied from 56 to 82% for the three test pits. Using a higher D_r value would have increased K_α and as a result increased the cyclic shear stress required to initiate liquefaction.

3.1.1.6 Residual Shear Strength Evaluation

To evaluate the post-DBE stability of the intake canal, STS first calculated both the undrained, S_r, and drained, S_{ds}, residual shear strengths for each element below the water table. STS used a best-fit curve through historic data, specifically developed by Dr. Idriss for STS, to define the undrained residual shear strength, S_r, as a function of the corrected blow count value, $(N_1)_{60}$. The drained residual shear strength of the soil, S_{ds}, is directly proportional to the effective overburden stress, σ_v', as modified by the tangent of the angle of friction, ϕ. For elements near the canal slope, shallower than 8 feet, STS selected the drained residual shear strength rather than the undrained shear strength. This residual shear strength selection by STS is conservative since the drained shear strength values are lower than undrained shear strengths for soil elements near the canal slope. In addition, STS points out that soil near the canal slope would likely be drained due to the proximity of the sand to the free drainage surface. For deeper soil elements, STS based the selection of the residual shear strength on the factor of safety against liquefaction, FS_L, using a criteria developed by Seed and Harder (1990) (Ref. 7).

To further evaluate the residual shear strength, STS measured the friction angle, maximum and minimum densities, and steady-state shear strengths over a range of void ratios of bulk soil samples obtained from the three test pits between El. 674 and 671. The steady-state strengths of the three bulk samples, as measured in the laboratory by STS, are at least 2000 psf. Combined, the dynamic stresses, from the DBE (Section 2.14), and the static stresses (Section 2.13) range from 390 to 1070 psf. A confirmatory analysis, performed by the staff, verified the accuracy of these static and dynamic stress values from the canal crest (El. 694) to the deepest SPT soil borings (El. 617). This result implies that the shear stress induced by the DBE load and the canal configuration are less than or equal to one-half the value of the steady-state shear strength of the three bulk samples. Thus, the FS_L, as measured by this method, is at least 2.

3.1.1.7 Post-Earthquake Stability and Permanent Deformation Analyses

To evaluate the possibility of a slope instability failure resulting from the DBE, STS used the residual soil strengths, S_{STAB}, and reduced drained strengths, ϕ'_{STAB}, for elements that exhibited pore pressure build-up as input to the computer program XSTABL. STS also used the Janbu method of slices to search the entire canal profile for the most critical failure surfaces. For the stability analysis, STS used a water level of 675 rather than the actual level of 674 to account for a potential water level increase due to the DBE. The results of this stability analysis indicate a factor of safety of 1.2, implying that the canal slope is stable even though elements of soil on the face of the embankment liquefy. In addition the most critical slip surface is close to the face of the of the slope and as a result does not contain a large volume of soil. Next, STS calculated the yield acceleration for this critical slip surface to compare with the DBE ground acceleration at the base of the slip surface. With the computer program DISPLMT, STS compared these two accelerations to calculate the permanent displacement by double integrating the areas of the DBE acceleration time history that exceed the yield acceleration. The computed permanent displacement is less than 2 inches.

3.1.2 Bounding Analysis

For the bounding analysis, STS repeated the liquefaction triggering analysis, the residual shear strength evaluation, and the post-earthquake stability and permanent deformation analyses using the 16th percentile corrected blow count value, $(N_1)_{60}$, for each layer rather than the median $(N_1)_{60}$ value. To determine the CSR as a function of $(N_1)_{60}$, STS conservatively used the 5-10% liquefaction triggering boundary line rather than the previously used median line. The results of the triggering analysis are that 27 of the elements have FS_L less than 1.1 The 16th percentile $(N_1)_{60}$ blow count value in the saturated loose sand layer (El. 671 to 674) is 4.5 resulting in a residual shear strength, S_r, of 104 psf. This value is higher than the full drained strength, S_{ds}, for the liquefied soil elements on the canal face (approximately 35 psf) so STS assigned this lower strength to these elements for the post-earthquake stability analysis. The results of the stability analysis show a minimum factor of safety against sliding to be 1.08 for a circular surface and 1.01 for a wedge-shaped sliding surface. Even though these factors of safety against sliding are greater than 1, assuming that 50% of the critical wedge volume enters the canal replacing the water rather than forcing a water level increase, the total volume of lost water would be about 500,000 gallons. Increasing the wedge volume entering the canal to 100%, the total volume of lost water would be about 3,250,000 gallons. As verified elsewhere in this safety evaluation, the total volume of the intake canal is 9,000,000 gallons and the minimum water volume required to provide adequate time for operators to manage cooling water loads after a DBE is about 2,500,000 gallons. Thus the margin of 6,500,000 gallons is much larger than the volume of lost water resulting from canal slope instability assuming very conservative soil strength values.

3.2 <u>USAR Changes</u>

3.2.1 Section 10.4.1.2.2

USAR Section 10.4.1.2.2 has been revised to reflect the fact that the both the emergency intake line and the intake canal are relied upon for safe plant shutdown following a DBE. The current USAR states that the design basis includes a complete and instantaneous blockage of the intake canal during a seismic event coupled with the destruction of Lock and Dam No. 3 downstream of the plant. The initial design basis also assumes that the failure of the downstream lock and dam resulted in the instantaneous drop in the river level down to the minimum level of 666.5 feet. The new basis as described in the revised USAR identifies that the reduction in river water level occurs gradually over the period of time it takes for the upstream and downstream pools to equalize. As identified in the staff's March 25, 1997, safety evaluation, the staff has determined that the licensee's assumptions regarding the river water level and the proposed USAR changes in this regard are acceptable.

The USAR changes identify that with no makeup from the river, the volume of the intake canal would be depleted in approximately 4.8 hours assuming the maximum cooling water system flow demand of 31,750 gallons per minute (gpm). The USAR changes state that this flow demand must be reduced (via operator actions) to within the emergency intake line capacity of 15,000 gpm before the intake canal volume is exhausted. This 15,000 gpm flow rate is more than adequate to supply the safe shutdown heat loads for both units following a DBE. The licensee's analysis to determine intake canal depletion assumed that there was no makeup flow to the intake canal from the river (i.e., instantaneous blockage of the intake screenhouse) or the recycle canal. Although there is no barrier between the recycle canal and the intake canal, the licensee assumed no credit because there was no slope stability analysis performed for the recycle canal. The maximum flow demand assumed by the licensee following a design-basis seismic event is 31,750 gpm. This is consistent with the maximum flow demand evaluated and found acceptable by the staff in its March 25, 1997, safety evaluation. The staff has reviewed the assumptions and results of the licensee's volumetric analysis for the intake canal and concluded they are acceptable. The USAR changes are consistent with the results of the licensee's analysis and are, therefore, also acceptable.

The licensee has also revised the USAR to identify the minimum required flow capacity of the emergency intake line to ensure that it is well below the actual 15,000 gpm capacity of the line. This minimum required emergency intake line flow was determined by first identifying the cooling water flow necessary to support the minimum equipment required for safe shutdown (6160 gpm). Secondly, the licensee identified the flow rates to cooling water system loads that are not isolated from the control room and also postulated cracks in each of the nonseismic, nonsafety-related unisolated lines off of the main header. The flow to these non-isolated lines was calculated to be 4,483 gpm resulting in a total minimum required flow capacity of 10,643 gpm which is well below the capacity of the emergency intake line. The 10,643 gpm minimum flow capacity is also less than the as-found actual flow capacity (11,600 gpm) of the emergency intake line that was identified in the staff's March 25, 1997, safety evaluation. Subsequent cleaning has restored the flow capacity of the emergency intake line to 15,000 gpm at the minimum river water level of 666.5 feet. Based on its review, the staff concludes that the licensee's assumptions related to the minimum required flow capacity are conservative and are consistent with the system design capabilities and the volumetric analysis performed for the intake canal. The USAR changes are, therefore, acceptable.

3.2.2 Section 12.2.1

The USAR changes revise the Nuclear Safety Design Classification of the intake canal from Class III to Class I* and revise the definition for the Nuclear Safety Design Classification, Class I* to reflect the change in design basis of the intake canal.

The new definition of Class I* is "items that have been originally designed or have been subsequently analyzed or tested to Class I, DBE dynamic loading only, and that these items are treated as Class III items in all other respects." The revised definition allows the upgrade of a lower classified structure, system, or component (SSC) to Class I*. The revised definition meets the original intent of Class I* SSCs. The intent of Class I* SSCs is to ensure that safety-related SSCs are not prevented from performing their safety functions following a DBE.

3.2.3 Quality Assurance

The licensee retained the services of a geotechnical consultant (STS Consultants, Ltd.) via its commercial grade quality process to perform the *in situ* and laboratory testing to the as-found condition of the intake canal. The testing was performed in compliance to applicable ASTM standards with calibrations traceable to National Institute of Standards Technology (NIST) standards. Analyses were independently reviewed by two industry experts (GEI Consultants, Inc. and I. M. Idriss) after an internal review. The licensee's supplier quality assurance (QA) organization also conducted two surveys of the geotechnical consultants (STS Consultants SS-96-14 and GEI Consultants SS-97-08) based on identified critical characteristics and resolved all issues.

Any proposed design change to the intake canal structure will be processed using the Prairie Island site design change process. Additionally, any routine work will be performed in accordance with the Prairie Island site Work Control Administrative Procedures. In the licensee's July 23, 1998, submittal, the licensee states that the design change and work control procedures are part of a 10 CFR Part 50 Appendix B program. The design change procedures are applicable for all design changes at Prairie Island. NSP design change procedures are contained in attachments to the licensee's submittal dated September 15, 1998, and were reviewed by the staff in support of these amendments.

The following is a brief overview of the design change process at Prairie Island. The Design Engineering organization assists in identifying the existing plant design commitments (e.g., seismic, standard, environmental, etc.) and reviews all design changes for design-basis adequacy. A checklist is used to compile all design change input issues. A safety review is required if the design change affects a safety-related function, is inconsistent with a description contained in the USAR or ISFSI [independent spent fuel storage installation] SAR, conflicts with the design bases or technical specification, or involves a possible unreviewed safety question (USQ). Each design change is verified for completeness and accuracy. All design changes are implemented with a site work order. The design change processes for any potential modifications to the intake canal are adequately controlled by planned and systematic actions to ensure the continued performance of Class I* safety functions.

3.2.4 Monitoring of the Intake Canal

The licensee stated that the intake canal will be monitored under the scope of the Maintenance Rule (10 CFR 50.65). The Maintenance Rule requires that the condition of structures be monitored against licensee-established goals or criteria, in a manner sufficient to provide reasonable assurance that they are capable of meeting their intended functions. Such goals or criteria shall be established commensurate with safety and, where practical, take into account industry-wide operating experience. The licensee stated that the Maintenance Rule System Basis Document, Volume 1C, defines the monitoring approaches for structures, including the intake canal.

As such, the intake canal embankments will be maintained and monitored to the extent commensurate with safety to ensure that they are capable of fulfilling their intended function. In addition, licensee personnel will perform more frequent monitoring of the external circulating water system.

4.0 SUMMARY

4.1 Seismic Analysis

The results of the two-volume intake canal liquefaction analysis report and bounding analysis by STS indicate that the intake canal slopes will not flow or deform significantly into the intake canal under DBE loading conditions. The cyclic stress approach, used by STS, for the evaluation of liquefaction potential characterizes both earthquake loading and soil liquefaction resistance, determined from SPT resistance, in terms of cyclic stresses. Even though several modeling assumptions regarding the uniformity of soil layers, soil strengths, shear wave velocities, densities, etc., are required as part of the liquefaction and slope stability analyses, STS has consistently made conservative assumptions both for the two-volume and the bounding analyses. Most significantly, STS showed in its bounding analysis that even using the most conservative soil strengths and assuming the entire volume of the critical wedge enters the canal, there is still over 3,000,000 gallons of water available for operators to manage cooling water loads after the DBE. Therefore, reliance on this canal as a source of cooling water under the design-basis conditions is acceptable.

4.2 USAR Changes

Based on its review as described above, the staff concludes that changes to Section 10.4.1.1 of the USAR are in accordance with the licensee's acceptable volumetric analysis and accurately reflect the design capabilities of the intake canal and emergency intake line.

The changes to Section 12.2.1 of the USAR are appropriate in that the revised definition for the Nuclear Safety Design Classification, Class I*, is appropriate and the upgrading of the intake canal to a Class I* structure is acceptable. The staff has concluded that the quality controls in place for the intake canal are adequate. The basis for these conclusions are as follows: (1) There are no postulated failures of the current intake canal embankment that could result in loss of safety function; (2) Testing of the intake canal was performed in compliance to applicable ASTM standards, and independently reviewed by two industry experts; (3) Future design changes of the intake canal are adequately controlled by planned and systematic actions to ensure continued performance of Class I* safety functions; and (4) The condition of the intake canal embankment will be monitored and maintained within the scope of the Maintenance Rule (10 CFR 50.65). The Maintenance Rule requirements will provide reasonable assurance that the structure is capable of meeting its intended function.

4.3 License Conditions

License Condition 1 required NSP to place an additional licensed operator in the control room as a compensatory measure for the purpose of identifying an earthquake and assisting in stripping cooling water loads if necessary for an interim period. NSP has had an additional man on shift for this purpose since implementation of this license condition.

License Condition 2 required NSP to submit dynamic finite element analyses of the intake canal banks by July 1, 1997, for the staff's review. The dynamic finite element analyses were submitted by NSP by letter dated June 30, 1997. License Condition 2 also required NSP to either perform additional analyses or physical modifications which would provide a basis for extending the time for operator post-seismic cooling water load management and thereby eliminating the dedicated operator. The licensee has met this license condition by performing seismic analyses (as described in Section 2.1 and evaluated in Section 3.1 of this safety evaluation). The licensee may now cease performing its compensatory measures because it has satisfied License Condition 2 by providing a basis to take credit for the cooling water in the intake canal during a DBE. Therefore, it is no longer necessary for the licensee to maintain an additional dedicated operator in the control room for the purpose of identifying an earthquake.

License Condition 3 requires NSP to revise the USAR to incorporate the changes into the plant design bases. The licensee provided its revised USAR wording in its submittals dated June 22 and October 1, 1998, which the staff finds acceptable. Per License Condition 3, these changes will be included in the next scheduled revision to the USAR.

5.0 STATE CONSULTATION

In accordance with the Commission's regulations, the Minnesota State official was notified of the proposed issuance of the amendments. The State official had no comments.

6.0 ENVIRONMENTAL CONSIDERATION

The amendments change a requirement with respect to installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20. The NRC staff has determined that the amendments involve no significant increase in the amounts, and no significant change in the types, of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that the amendments involve no significant hazards consideration and there has been no public comment on such finding (*63 FR* 52772). Accordingly, the amendments meet the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the issuance of the amendments.

7.0 CONCLUSION

The Commission has concluded, based on the considerations discussed above, that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendments will not be inimical to the common defense and security or to the health and safety of the public.

8.0 REFERENCES

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2. STS Consultants, Ltd. (STS), "Intake Canal Liquefaction Analysis Report for the Prairie Island Nuclear Generating Plant, Welch, Minnesota - STS Project No. 28723-A," June 24, 1997 (NSP submittal dated June 24, 1997).

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4. STS, "Response to the NSP Request of a Conservative Bounding Analysis for the Intake Canal Liquefaction Analysis for the Prairie Island Nuclear Generating Plant, Welch, Minnesota - STS Project No. 28723-A," February 20, 1998 (NSP submittal dated Marc 23, 1998).

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