1717 Wakonade Drive
Welch, MN 55089

June 10, 2020

L-PI-20-023
10 CFR 72.56

ATTN: Document Control Desk
Director, Division of Spent Fuel Management
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Prairie Island Independent Spent Fuel Storage Installation
Docket 72-10
Renewed Materials License No. SNM-2506

Response to Request for Additional Information: License Amendment Request to Expand the Storage Capacity of the Independent Spent Fuel Storage Installation (ISFSI) (EPID No. L-2019-LLA-0169)

References:
1) Letter (L-PI-19-009) from NSPM to the NRC, "License Amendment Request: Expand the Storage Capacity of the Independent Spent Fuel Storage Installation (ISFSI)", dated July 26, 2019 (ADAMS Accession No. ML19210D273)
2) Letter from the NRC to NSPM, "Prairie Island License Amendment Request – Request for Additional Information (EPID No. L-2019-LLA-0169)", dated April 13, 2020 (ADAMS Accession No. ML20077K624)

In Reference 1, Northern States Power Company, a Minnesota corporation, doing business as Xcel Energy (hereafter "NSPM"), submitted a license amendment request to renewed Special Nuclear Materials (SNM) License No. SNM-2506 to increase the maximum amount of spent fuel that may be possessed and stored at the Prairie Island Independent Spent Fuel Storage Installation (PI ISFSI) as well as approval of the design of an additional concrete pad to be built within the confines of the existing facility utilizing alternate methods from those described in the existing PI ISFSI Safety Analysis Report (SAR) and Addendum. The NRC identified the need for additional information and provided the Request for Additional Information (RAI) in Reference 2.

The Enclosure to this letter provides NSPM's response to the NRC RAI. Attachment 1 to the Enclosure provides PI ISFSI Safety Analysis Report (SAR) and Addendum pages for information only. Attachment 1 supplements and replaces the information provided in Reference 1.

Please contact Mr. Peter Gohdes at (612) 330-6503 or Peter.Gohdes@xenuclear.com if there are any questions or if additional information is needed.

Summary of Commitments

This letter makes no new commitments and no revisions to existing commitments.

I declare under penalty of perjury, that the foregoing is true and correct.
Executed on June 10, 2020.

Scott Sharp

Scott Sharp
Site Vice President, Prairie Island Nuclear Generating Plant
Northern States Power Company – Minnesota

Enclosure

cc: Administrator, Region III, USNRC
Project Manager, Prairie Island, USNRC
Resident Inspector, Prairie Island, USNRC
State of Minnesota
President of the Prairie Island Community Tribal Council

Response to Request for Additional Information

License Amendment Request to Expand the Storage Capacity of the Independent Spent Fuel Storage Installation (ISFSI)

1.0 BACKGROUND

In Reference 1, Northern States Power Company, a Minnesota corporation, doing business as Xcel Energy (hereafter "NSPM"), submitted a license amendment request to renewed Special Nuclear Materials (SNM) License No. SNM-2506 to increase the maximum amount of spent fuel that may be possessed and stored at the Prairie Island Independent Spent Fuel Storage Installation (PI ISFSI) as well as approval of the design of an additional concrete pad to be built within the confines of the existing facility utilizing alternate methods from those described in the existing PI ISFSI Safety Analysis Report (SAR) and Addendum. The NRC identified the need for additional information and provided the Request for Additional Information (RAI) in Reference 2. The enclosure to this letter provides NSPM's response to the NRC RAI.

Attachment 1 to this Enclosure provides PI ISFSI Safety Analysis Report (SAR) and Addendum pages for information only. Attachment 1 supplements and replaces the information provided in Reference 1.

2.0 RESPONSES TO REQUEST FOR ADDITIONAL INFORMATION

STRUCTURAL RAI 2.1

In Section 3.2 "Soil Liquefaction Analysis," of Enclosure 1 of the Prairie Island Independent Spent Fuel Storage Installation (ISFSI) license amendment request, the applicant discusses design inputs, acceptance criteria and conclusions related to the liquefaction analysis of the proposed pad. For the staff to ascertain that the current licensing basis is maintained, and that sufficient data is provided to make a safety finding, the following information needs to be included:

a. Provide the logs and locations of the Cone Penetrometer Testing (CPT) performed for the proposed ISFSI pad.

   Insert S-1 of Enclosure 2 states that "To support the ISFSI expansion, additional field investigations at the ISFSI site were made in July 2018. The field program consisted of performing four soundings (CPT-1 through CPT-4) located directly south of the eastern original pad as shown in Appendix 2C." The staff cannot determine from the submittal if appendix 2C was updated with the information.

b. Identify locations of potentially liquefiable soil pockets relative to the proposed ISFSI pad.

In Section 3.2.2 of the submittal, the applicant states that "For the PI ISFSI project site, the screening determined that potentially liquefiable soil types were present and that they could become saturated at some future date." The staff cannot determine from the submittal the location and the depth of these liquefiable deposits in relation to the proposed ISFSI pad.

c. Provide the values of Cyclic Resistance Ratio (CRR) and Cyclic Stress Ratio (CSR) and/or Factors of Safety (FS) in graphical or tabular form for the depths of study as related to the proposed ISFSI pad. Also provide a calculation package or sample calculations describing the efforts made for this analysis. In Section 3.2.2 of the submittal, the applicant states "the ratio of the shear resistance (CRR) of the soil under repetitive loading to earthquake-induced shear stresses (CSR) at various depths was calculated using both the CPT and SPT data." The staff cannot determine how the current CPT and SPT data correlate.

The above information is necessary to comply with Title 10 of the *Code of Federal Regulations* (10 CFR) 72.102(c) and 10 CFR 72.102(d).

<u>NSPM Response 2.1.a</u>

As discussed in Reference 1, a series of four cone penetrometer tests (CPT) were used to evaluate the subsurface data for liquefaction potential at the new ISFSI pad location, in conjunction with data from the standard penetration tests (SPT) performed in 1991 for the existing ISFSI pads within the ISFSI area as well as a boring performed in August 2014 to support construction of the nearby FLEX Equipment Storage Building. The CPT locations (CPT-1 through CPT-4) and logs are provided in new Appendix 2C. See Attachment 1 to this Enclosure for the markup to the ISFSI SAR which adds Appendix 2C.

<u>NSPM Response 2.1.b</u>

Liquefiable deposits were not identified for the ISFSI site. As discussed in Section 3.2.2 of Reference 1, a soil liquefaction analysis was required based on the identified soil types present at the ISFSI site from a depth of 12 ft below grade (the groundwater depth) to a depth of 55 ft below grade (CPT refusal). Initial site screening was performed based on the material classification, relative density and presence of groundwater. Although an initial cursory screening indicated the soils may be liquefiable, a detailed numeric analysis of these layers using both the CPT and SPT data and the expected seismic excitation clearly indicated that there is no potential for liquefaction of these soils.

<u>NSPM Response 2.1.c</u>

For numerical analysis of the soil liquefaction potential of the new ISFSI pad site, detailed calculations were performed for the site. A numerical analysis establishes the factor of safety (FS = CRR/CSR) against liquefaction for the sites. The ratio of the shear resistance (CRR) of the soil under repetitive loading to earthquake-induced shear stresses (CSR) at various depths is calculated using both CPT and SPT data. Calculation of CRR and CSR, and the liquefaction evaluation using the resulting FS, follows the procedures described in Regulatory Guide (RG) 1.198, “Procedures and Criteria for Assessing Seismic Soil Liquefaction at Nuclear Power Plant Sites” (Reference 3), and NUREG/CR-5741, “Technical Bases for Regulatory Guide for Soil Liquefaction” (Reference 4). A detailed calculation was performed following a procedure by Youd, T.L., Idriss, I.M., et al. (Reference 5), which is referenced by RG 1.198.

Figure 2.1 provides FS values at various depths of the site for both CPT and SPT data.

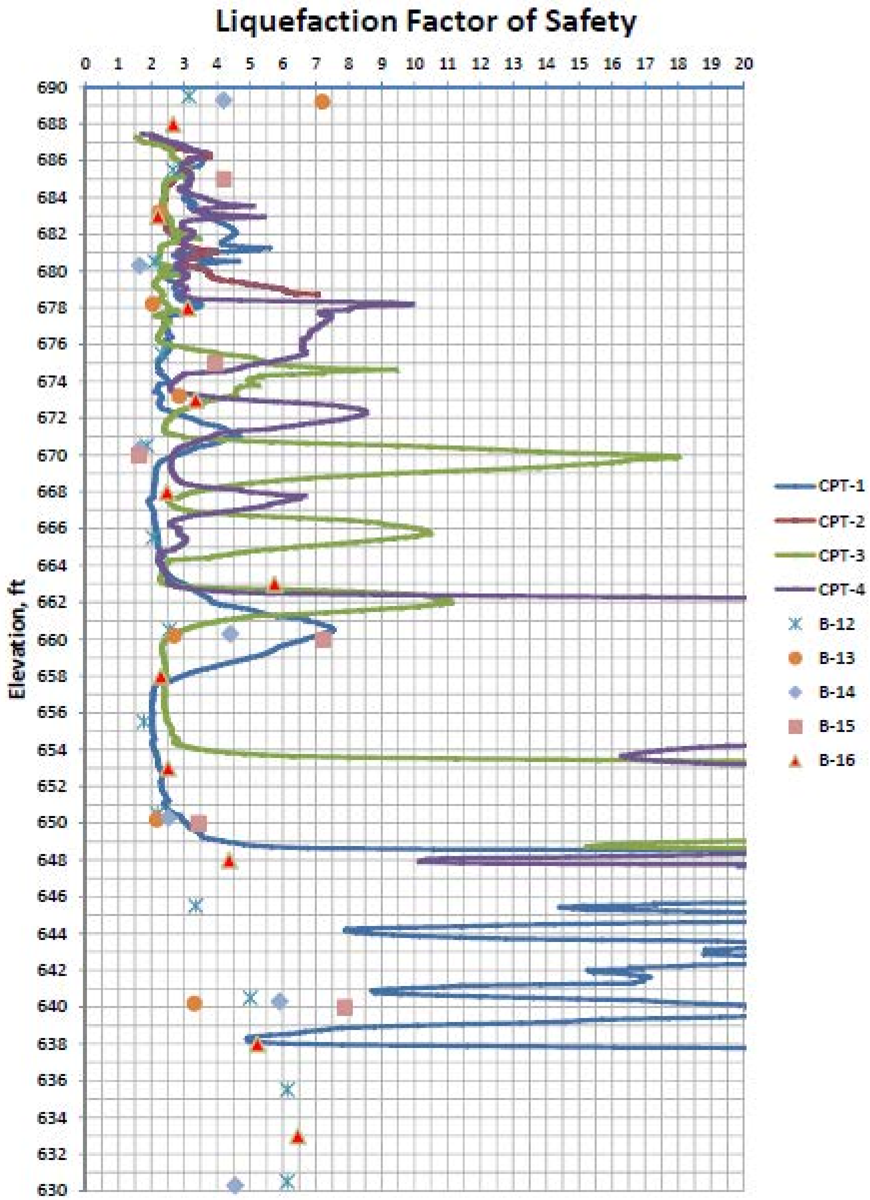

Figure 2.1: Soil Liquefaction Factor of Safety from CPT and SPT data

STRUCTURAL RAI 2.2

In Section 3.3, "Soil Structure Interaction Analysis," of the PI ISFSI license amendment request, the applicant discusses design inputs, acceptance criteria, analyses and conclusions related to soil structure interaction (SSI). For the staff to ascertain that the current licensing basis is maintained, and that sufficient data is provided to make a safety finding, the following information needs to be included:

a. Provide the Acceleration Input Motions generated per Approach 2, Option 1 of NUREG 0800, Chapter 3.7.1.

b. Provide the Upper Bound, Best estimate and Lower Bound strain compatible soil properties (shear modulus and damping) data per depth generated for the SSI analysis in graphical or tabular form.

c. Justify why Model 3 for the single cask on the corner of the pad is the governing loading case.

d. Provide a schematic of the ISFSI pad model used for SASSI2010 analysis including mesh distribution and sizes.

e. Provide results of the 36 SSI analysis cases analyzed in tabular format, as appropriate.

The above information is necessary to comply with 10 CFR 72.102(c) and 10 CFR 72.102(d).

NSPM Response 2.2.a

To perform soil-structure interaction analysis, artificial acceleration input motions that are consistent with the design input response spectra were developed following NUREG-0800, Chapter 3.7.1. The generated acceleration input motions are shown in Figures 2.2 through Figures 2.4 and acceleration response spectra comparisons are shown in Figures 2.5 through 2.7. The generated acceleration input motions also meet the requirements for the strong motion duration, the absolute values of correlation coefficient, the energy gap for the frequency range of interests, and the phase angle consistency.

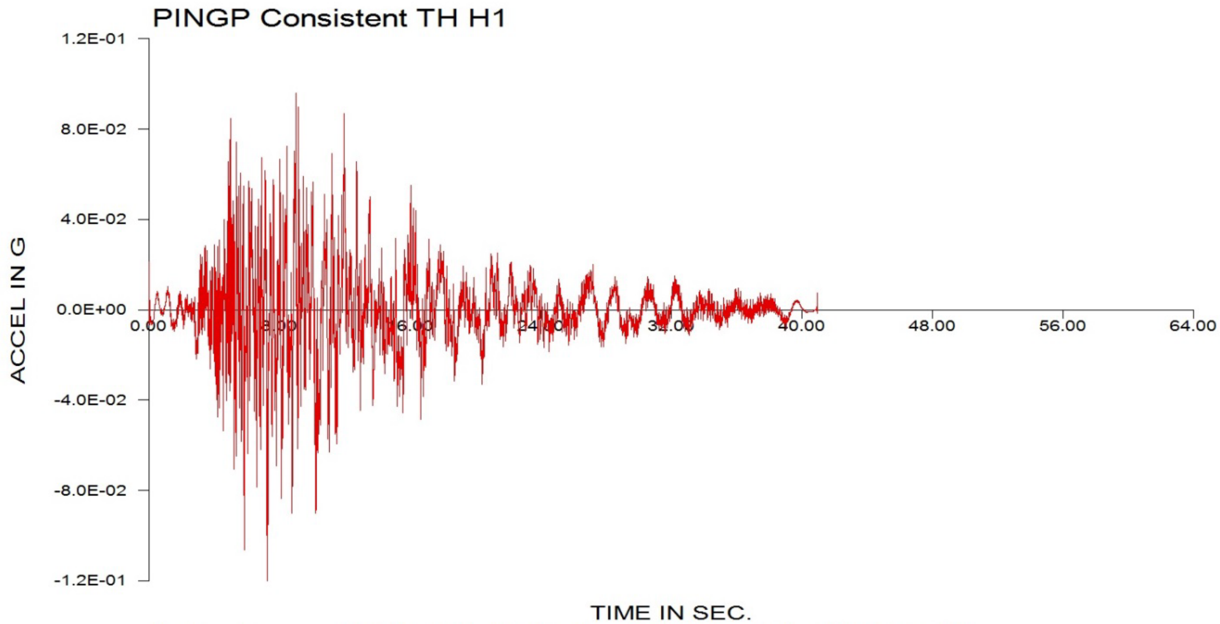

Figure 2.2: Artificial (Synthetic) Acceleration Time-History, Horizontal H1

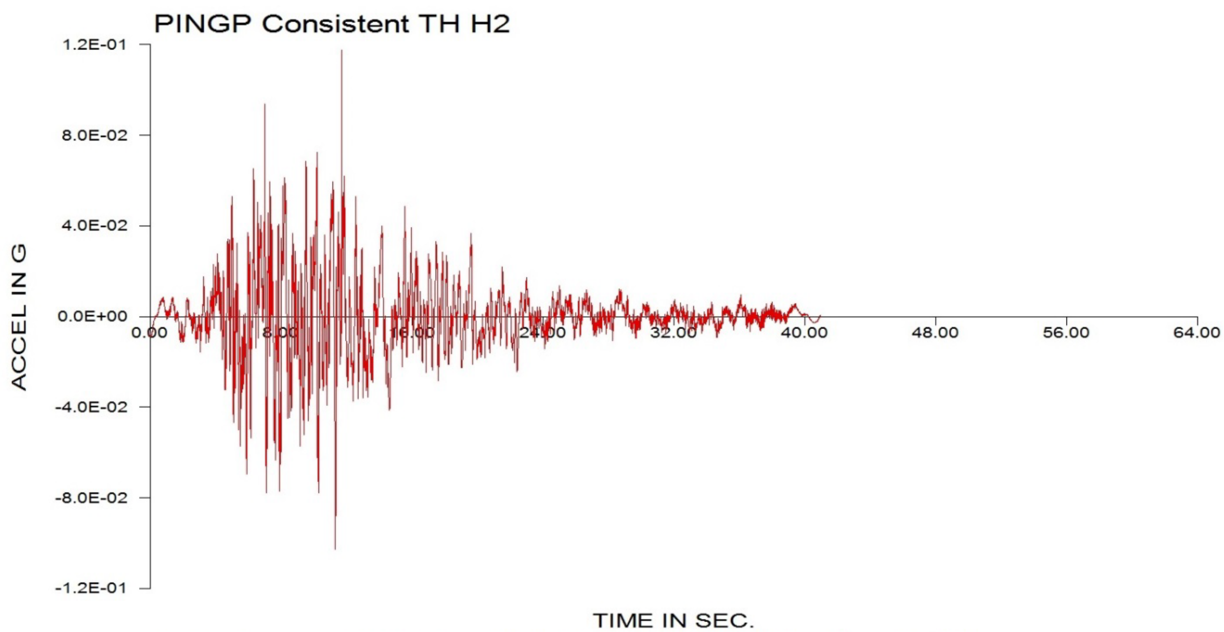

Figure 2.3: Artificial (Synthetic) Acceleration Time-History, Horizontal H2

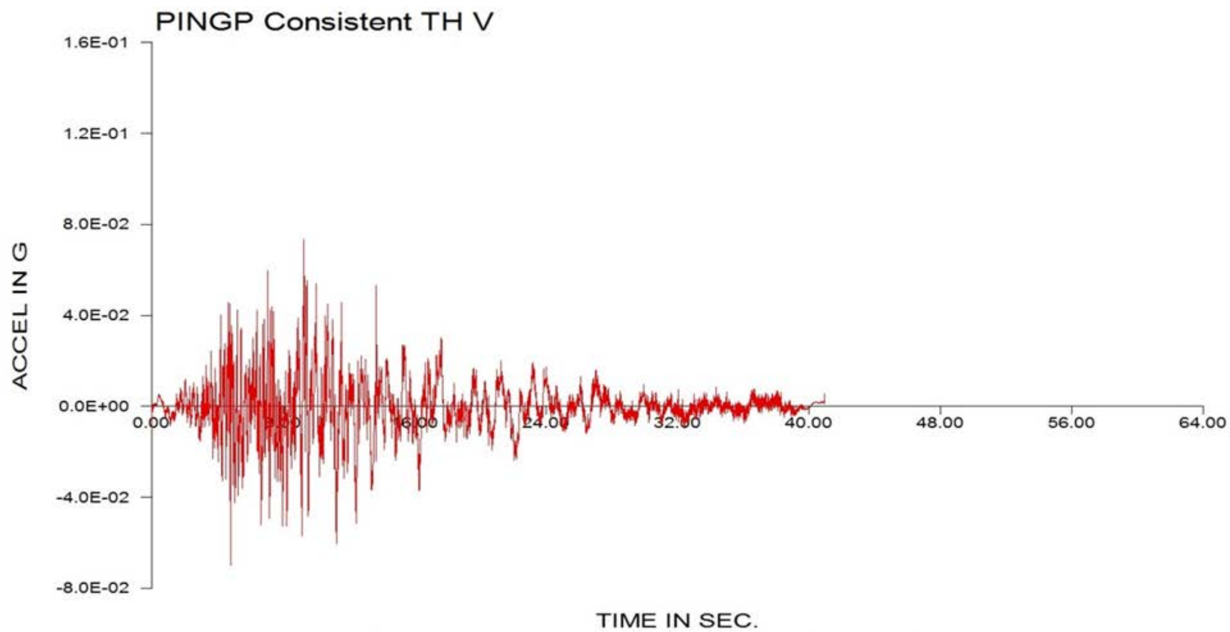

Figure 2.4: Artificial (Synthetic) Acceleration Time-History, Vertical

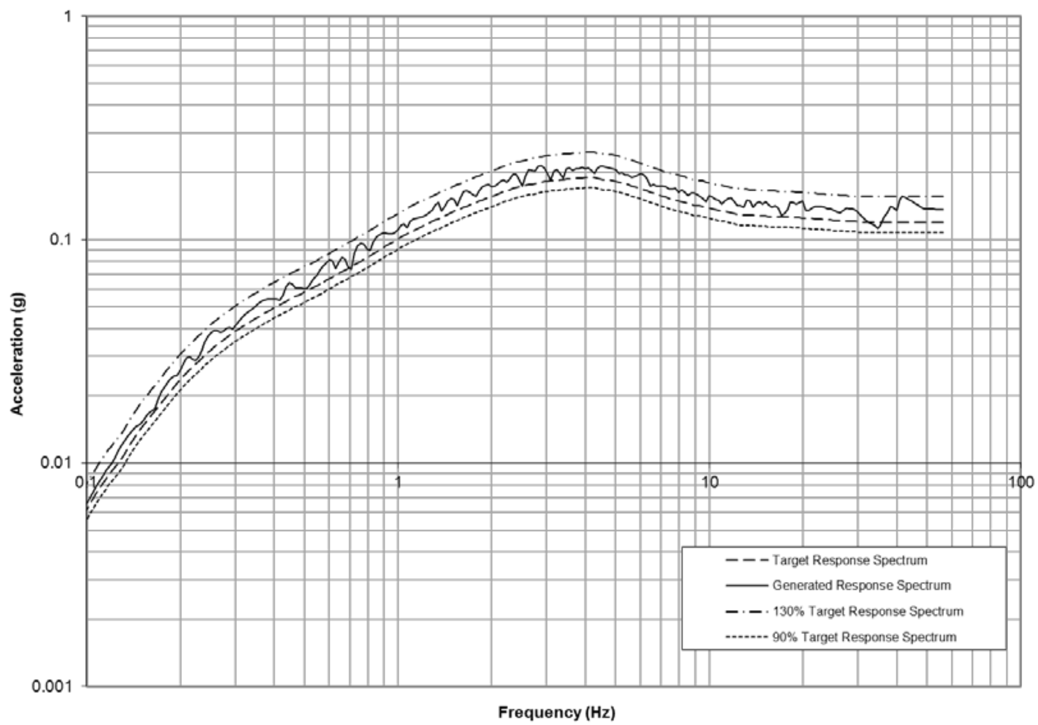

Figure 2.5: Acceleration Response Spectra Comparison between the Generated, Target, 130% Target and 90% Target Spectra – H1

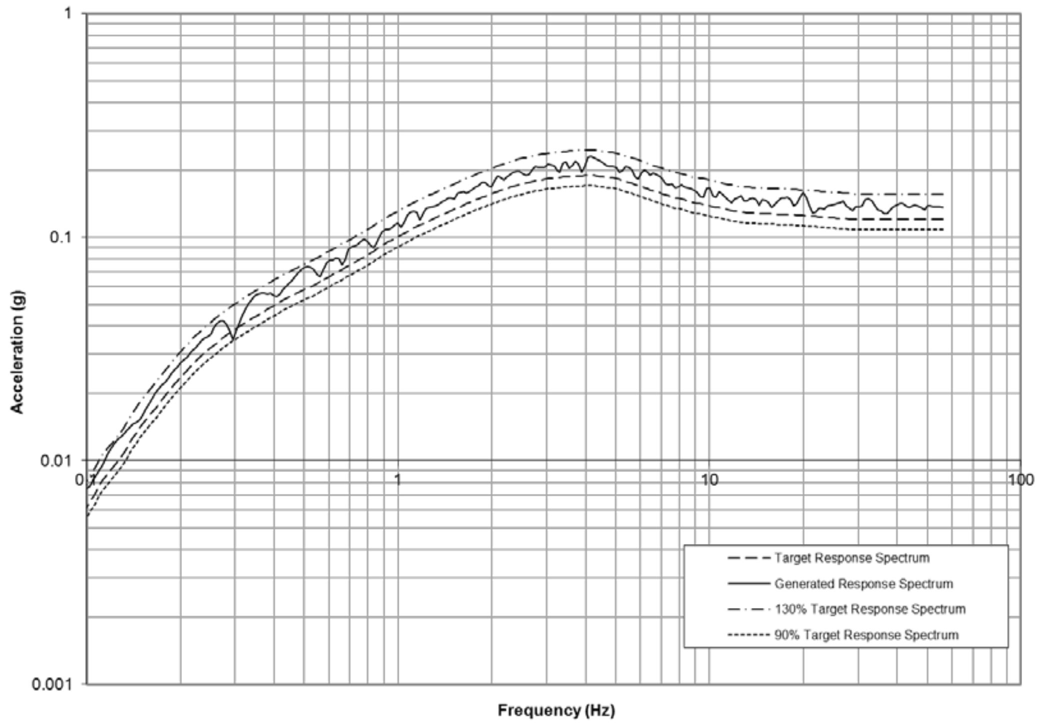

Figure 2.6: Acceleration Response Spectra Comparison between the Generated, Target, 130% Target and 90% Target Spectra – H2

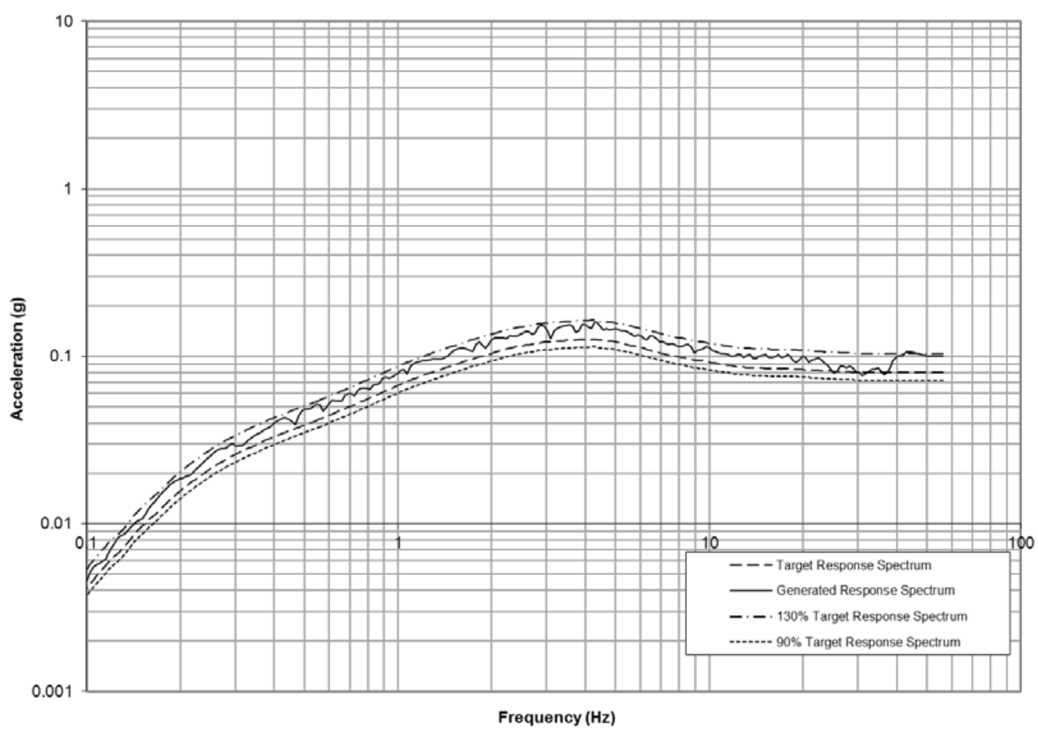

Figure 2.7: Acceleration Response Spectra Comparison between the Generated, Target, 130% Target and 90% Target Spectra – V

NSPM Response 2.2.b

To perform soil-structure interaction analysis, strain compatible soil properties considering soil variation were developed using the SHAKE2000 program for the Upper Bound (UB), Best Estimate (BE), and Lower Bound (LB) conditions. Generated soil column shear moduli and damping values are shown in Figures 2.8 and 2.9.

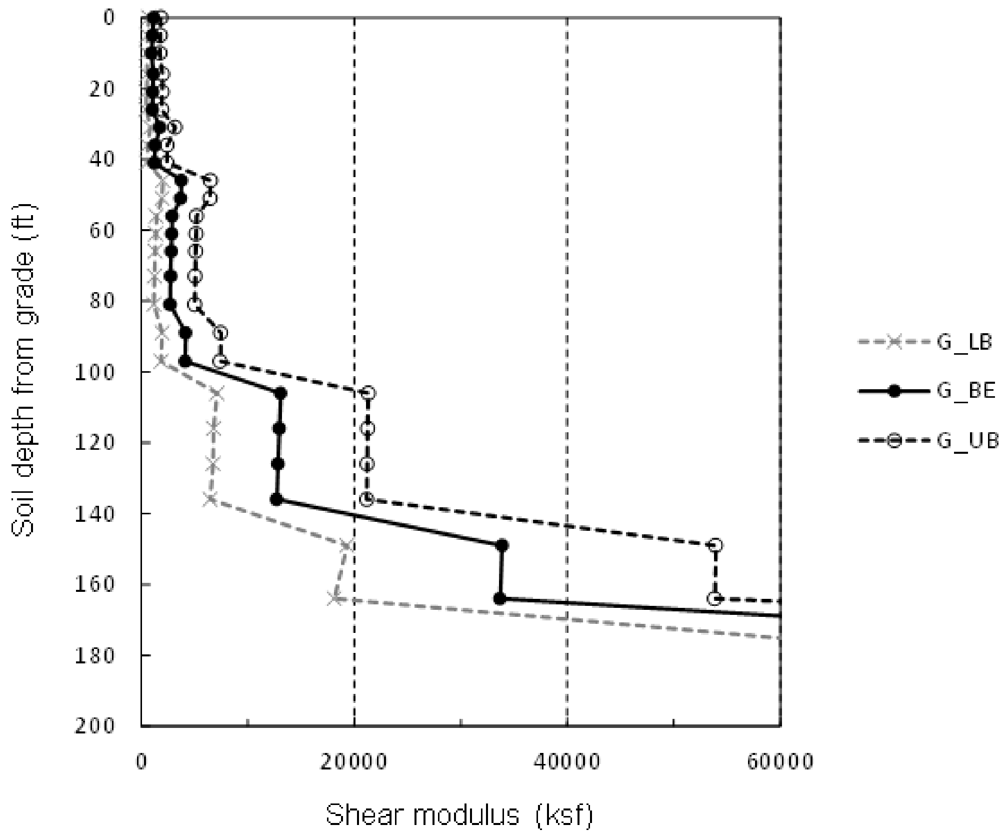

Figure 2.8: Comparison of Shear Modulus

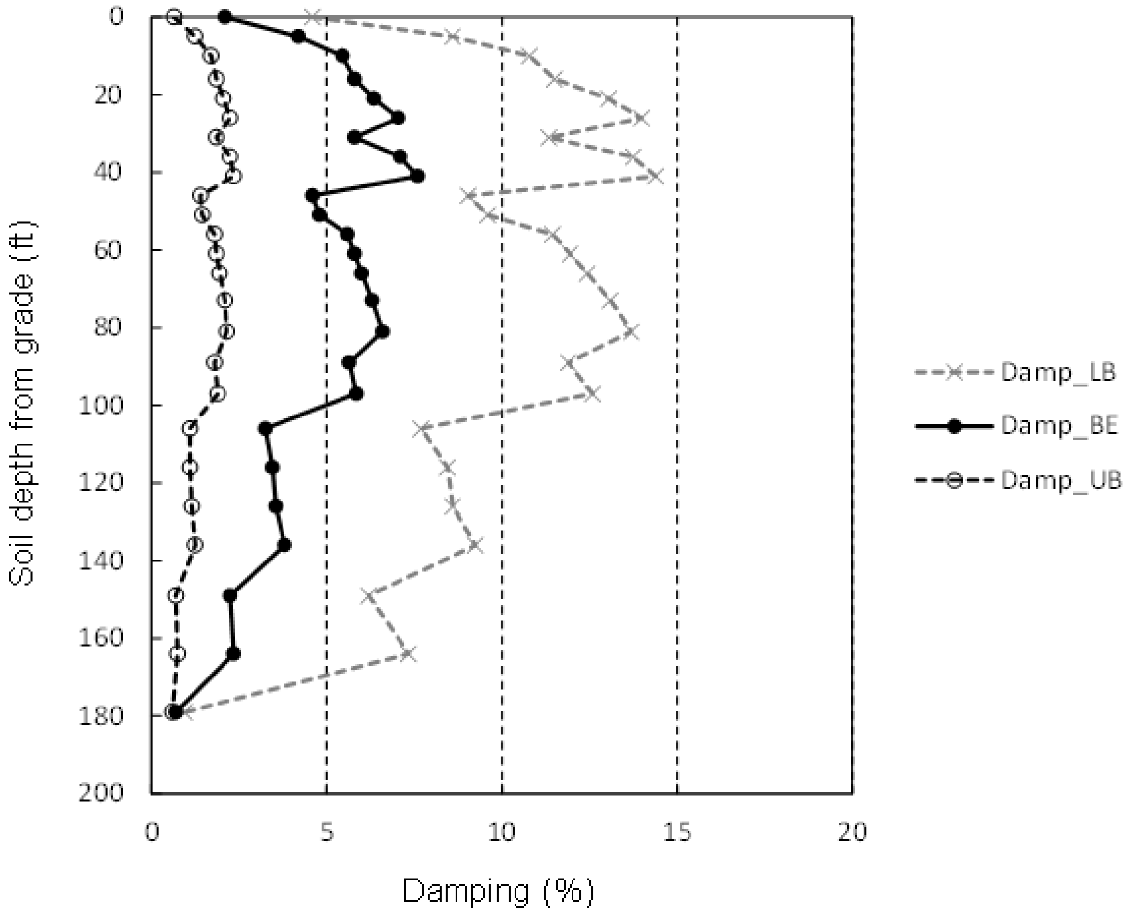

Figure 2.9: Comparison of Damping

<u>NSPM Response 2.2.c</u>

Three cask loading configurations were used in the soil-structure interaction analysis. Model 3 (single cask case) analysis results show the highest accelerations for structural design and stability evaluation as listed in Tables 2.1 and 2.2. The results are consistent with NUREG/CR-6865, "Parametric Evaluation of Seismic Behavior of Freestanding Spent Fuel Dry Cask Storage Systems" (Reference 6), in which the single cask case is the controlling case.

Table 2.1: Summary of Cask Stability Check
Uncracked Pad

Soil Profile	Model No.	Node No.	FS_{slide}
LB	Model 1	1690	1.891
	Model 2	1696	1.812
	Model 3	1696	1.771
BE	Model 1	1996	1.733
	Model 2	1688	1.636
	Model 3	1696	1.629
UB	Model 1	1690	1.692
	Model 2	1686	1.550
	Model 3	1696	1.494

Table 2.2: Summary of Cask Stability Check
Cracked Pad

Soil Profile	Model No.	Node No.	FS_{slide}
UB	Model 1	1686	1.599
	Model 2	1692	1.540
	Model 3	1696	1.300

NSPM Response 2.2.d

Schematic drawings of finite element analysis models used for the soil-structure interaction analysis are shown in Figures 2.10 through 2.13. The average mesh size is 2.25 ft by 2.50 ft. The pad is meshed to have a minimum of four elements at the bottom of a cask and between adjacent casks and to have aspect ratio less than 2.0.

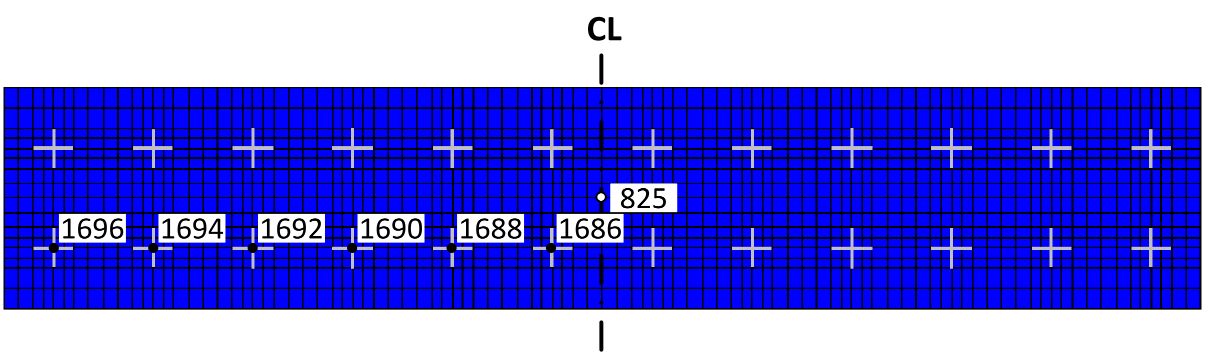

Figure 2.10: Cask Nodes at Center of Gravity Used for Maximum Accelerations and Transfer Functions – Model 1

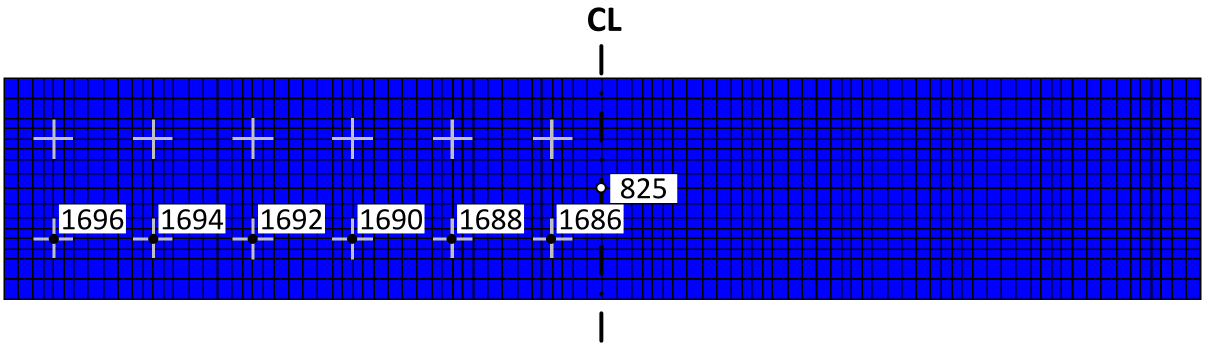

Figure 2.11: Cask Nodes at Center of Gravity Used for Maximum Accelerations and Transfer Functions – Model 2

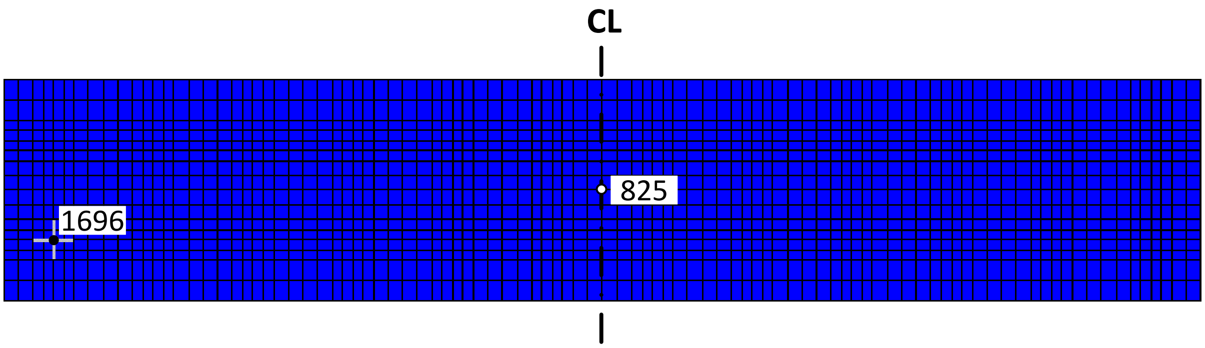

Figure 2.12: Cask Nodes at Center of Gravity Used for Maximum Accelerations and Transfer Functions – Model 3

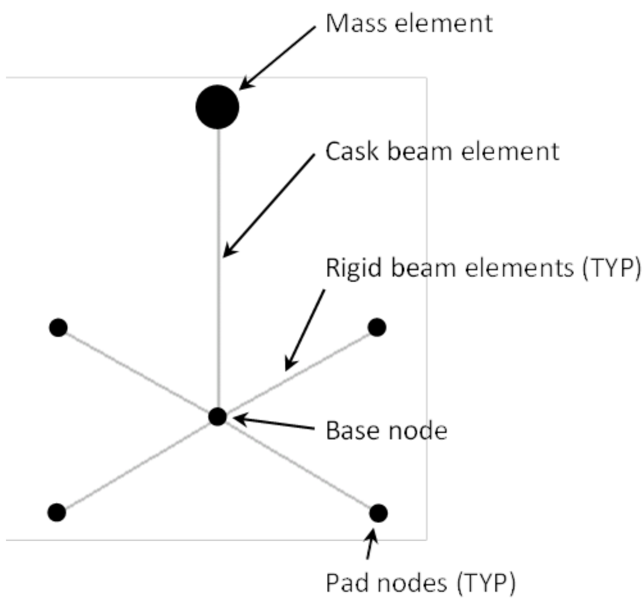

Figure 2.13: Finite Element Model for Cask

NSPM Response 2.2.e

Seismic analysis was performed for 36 cases and analysis summary is provided in Tables 2.3 through 2.14. Node locations are shown in Figures 2.10 through 2.12.

Table 2.3: Maximum Accelerations and Cask Stability Check – Uncracked Pad and LB Soil Profile – Model 1

Node No.	X-Direction Input Motion			Y-Direction Input Motion			Z-Direction Input Motion			SRSS(1)			Check(2)(3)	
	A_{XX}	A_{YX}	A_{ZX}	A_{XY}	A_{YY}	A_{ZY}	A_{XZ}	A_{YZ}	A_{ZZ}	A_X	A_Y	A_Z (or A_V)	A_H	FS_{slide}
1686	0.079	0.001	0.003	0.001	0.093	0.014	0.003	0.012	0.059	0.079	0.094	0.061	0.123	1.909
1688	0.080	0.001	0.003	0.001	0.093	0.014	0.002	0.011	0.059	0.080	0.094	0.061	0.123	1.909
1690	0.081	0.001	0.004	0.001	0.093	0.014	0.004	0.011	0.060	0.081	0.094	0.062	0.124	**1.891**
1692	0.080	0.001	0.004	0.001	0.093	0.014	0.006	0.012	0.063	0.080	0.094	0.065	0.123	1.900
1694	0.080	0.001	0.003	0.002	0.092	0.014	0.002	0.013	0.065	0.080	0.093	0.067	0.123	1.896
1696	0.080	0.002	0.010	0.001	0.092	0.013	0.008	0.012	0.064	0.080	0.093	0.066	0.123	1.898

Table 2.4: Maximum Accelerations and Cask Stability Check – Uncracked Pad and LB Soil Profile – Model 2

Node No.	X-Direction Input Motion			Y-Direction Input Motion			Z-Direction Input Motion			SRSS(1)			Check(2)(3)	
	A_{XX}	A_{YX}	A_{ZX}	A_{XY}	A_{YY}	A_{ZY}	A_{XZ}	A_{YZ}	A_{ZZ}	A_X	A_Y	A_Z (or A_V)	A_H	FS_{slide}
1686	0.086	0.002	0.006	0.006	0.095	0.014	0.006	0.012	0.061	0.086	0.096	0.063	0.129	1.816
1688	0.089	0.002	0.005	0.007	0.092	0.015	0.004	0.012	0.060	0.089	0.093	0.062	0.129	1.818
1690	0.085	0.001	0.006	0.004	0.092	0.014	0.005	0.012	0.062	0.085	0.093	0.064	0.126	1.857
1692	0.085	0.001	0.004	0.002	0.093	0.014	0.006	0.012	0.063	0.085	0.094	0.065	0.127	1.841
1694	0.083	0.002	0.005	0.003	0.093	0.014	0.003	0.013	0.064	0.083	0.094	0.066	0.125	1.868
1696	0.088	0.003	0.011	0.003	0.093	0.014	0.007	0.012	0.063	0.088	0.094	0.065	0.129	**1.812**

Table 2.5: Maximum Accelerations and Cask Stability Check – Uncracked Pad and LB Soil Profile – Model 3

Node No.	X-Direction Input Motion			Y-Direction Input Motion			Z-Direction Input Motion			SRSS(1)			Check(2)(3)	
	A_{XX}	A_{YX}	A_{ZX}	A_{XY}	A_{YY}	A_{ZY}	A_{XZ}	A_{YZ}	A_{ZZ}	A_X	A_Y	A_Z (or A_V)	A_H	FS_{slide}
1696	0.095	0.002	0.007	0.003	0.091	0.004	0.003	0.001	0.065	0.095	0.091	0.065	0.132	**1.771**

(1) $A_X = \sqrt{A_{XX}^2 + A_{XY}^2 + A_{XZ}^2}$; $A_Y = \sqrt{A_{YX}^2 + A_{YY}^2 + A_{YZ}^2}$; and $A_Z = \sqrt{A_{ZX}^2 + A_{ZY}^2 + A_{ZZ}^2}$

(2) $A_H = \sqrt{A_X^2 + A_Y^2}$

(3) $FS_{slide} = \frac{\mu(W - g_V W)}{g_h W}$

Where:

W = Weight of cask on a pad.

g_h = Horizontal acceleration of the cask, which is calculated as the vector sum of two horizontal Zero Period Accelerations (ZPAs) from the analysis.

g_V = Vertical acceleration of the cask, which is calculated as the vertical ZPA of casks at the center of gravity location.

μ = Coefficient of friction between the cask in an upright position and concrete.

Table 2.6: Maximum Accelerations and Cask Stability Check – Uncracked Pad and BE Soil Profile – Model 1

Node No.	X-Direction Input Motion			Y-Direction Input Motion			Z-Direction Input Motion			SRSS(1)			Check(2)(3)	
	A_{XX}	A_{YX}	A_{ZX}	A_{XY}	A_{YY}	A_{ZY}	A_{XZ}	A_{YZ}	A_{ZZ}	A_X	A_Y	A_Z (or A_V)	A_H	FS_{slide}
1686	0.088	0.000	0.004	0.001	0.094	0.014	0.006	0.020	0.071	0.088	0.096	0.072	0.130	1.785
1688	0.087	0.001	0.004	0.001	0.094	0.014	0.006	0.020	0.070	0.087	0.096	0.071	0.130	1.787
1690	0.088	0.001	0.005	0.001	0.094	0.014	0.004	0.019	0.070	0.088	0.096	0.072	0.130	1.785
1692	0.087	0.002	0.007	0.002	0.093	0.014	0.009	0.019	0.072	0.087	0.095	0.074	0.129	1.795
1694	0.084	0.003	0.005	0.003	0.094	0.015	0.007	0.019	0.070	0.084	0.096	0.072	0.128	1.813
1696	0.092	0.003	0.010	0.002	0.094	0.014	0.010	0.017	0.069	0.093	0.096	0.071	0.134	**1.733**

Table 2.7: Maximum Accelerations and Cask Stability Check – Uncracked Pad and BE Soil Profile – Model 2

Node No.	X-Direction Input Motion			Y-Direction Input Motion			Z-Direction Input Motion			SRSS(1)			Check(2)(3)	
	A_{XX}	A_{YX}	A_{ZX}	A_{XY}	A_{YY}	A_{ZY}	A_{XZ}	A_{YZ}	A_{ZZ}	A_X	A_Y	A_Z (or A_V)	A_H	FS_{slide}
1686	0.101	0.003	0.009	0.007	0.095	0.014	0.007	0.017	0.070	0.101	0.097	0.072	0.140	1.657
1688	0.103	0.005	0.007	0.008	0.094	0.016	0.009	0.021	0.069	0.104	0.096	0.071	0.142	**1.636**
1690	0.097	0.003	0.008	0.004	0.094	0.014	0.008	0.020	0.071	0.097	0.096	0.073	0.136	1.704
1692	0.099	0.002	0.006	0.003	0.093	0.014	0.010	0.019	0.072	0.100	0.095	0.074	0.138	1.678
1694	0.088	0.004	0.007	0.006	0.094	0.015	0.009	0.019	0.070	0.089	0.096	0.072	0.131	1.771
1696	0.100	0.006	0.011	0.004	0.096	0.014	0.008	0.016	0.069	0.100	0.098	0.071	0.140	1.659

Table 2.8: Maximum Accelerations and Cask Stability Check – Uncracked Pad and BE Soil Profile – Model 3

Node No.	X-Direction Input Motion			Y-Direction Input Motion			Z-Direction Input Motion			SRSS(1)			Check(2)(3)	
	A_{XX}	A_{YX}	A_{ZX}	A_{XY}	A_{YY}	A_{ZY}	A_{XZ}	A_{YZ}	A_{ZZ}	A_X	A_Y	A_Z (or A_V)	A_H	FS_{slide}
1696	0.103	0.003	0.006	0.003	0.099	0.003	0.004	0.003	0.068	0.103	0.099	0.068	0.143	**1.629**

(1) $A_X = \sqrt{{A_{XX}}^2 + {A_{XY}}^2 + {A_{XZ}}^2}$; $A_Y = \sqrt{{A_{YX}}^2 + {A_{YY}}^2 + {A_{YZ}}^2}$; and $A_Z = \sqrt{{A_{ZX}}^2 + {A_{ZY}}^2 + {A_{ZZ}}^2}$

(2) $A_H = \sqrt{{A_X}^2 + {A_Y}^2}$

(3) $FS_{slide} = \frac{\mu(W - g_V W)}{g_h W}$

Where:

W = Weight of cask on a pad.

g_h = Horizontal acceleration of the cask, which is calculated as the vector sum of two horizontal Zero Period Accelerations (ZPAs) from the analysis.

g_V = Vertical acceleration of the cask, which is calculated as the vertical ZPA of casks at the center of gravity location.

μ = Coefficient of friction between the cask in an upright position and concrete.

Table 2.9: Maximum Accelerations and Cask Stability Check – Uncracked Pad and UB Soil Profile – Model 1

Node No.	X-Direction Input Motion			Y-Direction Input Motion			Z-Direction Input Motion			SRSS(1)			Check(2)(3)	
	A_{XX}	A_{YX}	A_{ZX}	A_{XY}	A_{YY}	A_{ZY}	A_{XZ}	A_{YZ}	A_{ZZ}	A_X	A_Y	A_Z (or A_V)	A_H	FS_{slide}
1686	0.094	0.001	0.006	0.002	0.095	0.014	0.009	0.020	0.074	0.094	0.097	0.076	0.135	1.711
1688	0.091	0.001	0.006	0.002	0.094	0.014	0.009	0.021	0.072	0.091	0.096	0.074	0.132	1.754
1690	0.096	0.002	0.006	0.002	0.095	0.013	0.010	0.021	0.072	0.097	0.097	0.073	0.137	**1.692**
1692	0.089	0.002	0.008	0.003	0.094	0.014	0.009	0.020	0.071	0.090	0.096	0.073	0.132	1.756
1694	0.093	0.003	0.006	0.005	0.092	0.015	0.011	0.020	0.069	0.094	0.094	0.071	0.133	1.746
1696	0.098	0.006	0.011	0.003	0.093	0.014	0.010	0.018	0.069	0.099	0.095	0.071	0.137	1.695

Table 2.10: Maximum Accelerations and Cask Stability Check – Uncracked Pad and UB Soil Profile – Model 2

Node No.	X-Direction Input Motion			Y-Direction Input Motion			Z-Direction Input Motion			SRSS[1]			Check[2][3]	
	A_{XX}	A_{YX}	A_{ZX}	A_{XY}	A_{YY}	A_{ZY}	A_{XZ}	A_{YZ}	A_{ZZ}	A_X	A_Y	A_Z (or A_V)	A_H	FS_{slide}
1686	0.107	0.005	0.011	0.007	0.100	0.014	0.010	0.019	0.074	0.108	0.102	0.076	0.149	**1.550**
1688	0.106	0.005	0.007	0.011	0.094	0.015	0.016	0.022	0.070	0.108	0.097	0.072	0.145	1.600
1690	0.103	0.003	0.009	0.006	0.093	0.014	0.009	0.022	0.075	0.104	0.096	0.077	0.142	1.625
1692	0.097	0.002	0.007	0.004	0.094	0.014	0.012	0.020	0.073	0.098	0.096	0.075	0.137	1.688
1694	0.093	0.004	0.008	0.009	0.094	0.015	0.014	0.021	0.067	0.094	0.096	0.069	0.134	1.737
1696	0.097	0.010	0.013	0.004	0.094	0.014	0.011	0.018	0.068	0.098	0.096	0.071	0.137	1.695

Table 2.11: Maximum Accelerations and Cask Stability Check – Uncracked Pad and UB Soil Profile – Model 3

Node No.	X-Direction Input Motion			Y-Direction Input Motion			Z-Direction Input Motion			SRSS[1]			Check[2][3]	
	A_{XX}	A_{YX}	A_{ZX}	A_{XY}	A_{YY}	A_{ZY}	A_{XZ}	A_{YZ}	A_{ZZ}	A_X	A_Y	A_Z (or A_V)	A_H	FS_{slide}
1696	0.110	0.005	0.005	0.004	0.110	0.002	0.003	0.004	0.068	0.110	0.110	0.068	0.156	**1.494**

(1) $A_X = \sqrt{{A_{XX}}^2 + {A_{XY}}^2 + {A_{XZ}}^2}$; $A_Y = \sqrt{{A_{YX}}^2 + {A_{YY}}^2 + {A_{YZ}}^2}$; and $A_Z = \sqrt{{A_{ZX}}^2 + {A_{ZY}}^2 + {A_{ZZ}}^2}$

(2) $A_H = \sqrt{{A_X}^2 + {A_Y}^2}$

(3) $FS_{slide} = \frac{\mu(W - g_V W)}{g_h W}$

Where:

W = Weight of cask on a pad.

g_h = Horizontal acceleration of the cask, which is calculated as the vector sum of two horizontal Zero Period Accelerations (ZPAs) from the analysis.

g_v = Vertical acceleration of the cask, which is calculated as the vertical ZPA of casks at the center of gravity location.

μ = Coefficient of friction between the cask in an upright position and concrete.

Table 2.12: Maximum Accelerations and Cask Stability Check – Cracked Pad and UB Soil Profile – Model 1

Node No.	X-Direction Input Motion			Y-Direction Input Motion			Z-Direction Input Motion			SRSS(1)			Check(2)(3)	
	A_{XX}	A_{YX}	A_{ZX}	A_{XY}	A_{YY}	A_{ZY}	A_{XZ}	A_{YZ}	A_{ZZ}	A_X	A_Y	A_Z (or A_V)	A_H	FS_{slide}
1686	0.104	0.002	0.007	0.003	0.095	0.013	0.009	0.029	0.078	0.104	0.099	0.079	0.144	**1.599**
1688	0.098	0.001	0.007	0.002	0.094	0.014	0.007	0.028	0.071	0.098	0.098	0.073	0.139	1.667
1690	0.099	0.003	0.007	0.003	0.095	0.012	0.010	0.028	0.070	0.100	0.099	0.071	0.141	1.647
1692	0.103	0.003	0.009	0.004	0.096	0.012	0.008	0.026	0.075	0.103	0.100	0.076	0.144	1.604
1694	0.102	0.003	0.007	0.007	0.097	0.015	0.014	0.026	0.070	0.103	0.100	0.072	0.144	1.611
1696	0.102	0.007	0.010	0.005	0.097	0.015	0.015	0.024	0.069	0.103	0.100	0.071	0.144	1.613

Table 2.13: Maximum Accelerations and Cask Stability Check – Cracked Pad and UB Soil Profile – Model 2

Node No.	X-Direction Input Motion			Y-Direction Input Motion			Z-Direction Input Motion			SRSS(1)			Check(2)(3)	
	A_{XX}	A_{YX}	A_{ZX}	A_{XY}	A_{YY}	A_{ZY}	A_{XZ}	A_{YZ}	A_{ZZ}	A_X	A_Y	A_Z (or A_V)	A_H	FS_{slide}
1686	0.105	0.009	0.014	0.013	0.096	0.016	0.010	0.027	0.075	0.106	0.100	0.078	0.146	1.579
1688	0.099	0.005	0.012	0.013	0.094	0.017	0.011	0.029	0.071	0.100	0.098	0.074	0.140	1.654
1690	0.107	0.004	0.010	0.009	0.098	0.013	0.008	0.028	0.075	0.108	0.102	0.077	0.149	1.549
1692	0.108	0.003	0.008	0.006	0.099	0.013	0.009	0.027	0.074	0.109	0.103	0.076	0.150	**1.540**
1694	0.105	0.004	0.009	0.009	0.098	0.015	0.013	0.028	0.068	0.106	0.102	0.070	0.147	1.582
1696	0.104	0.009	0.012	0.004	0.095	0.015	0.015	0.024	0.068	0.105	0.098	0.071	0.144	1.613

Table 2.14: Maximum Accelerations and Cask Stability Check – Cracked Pad and UB Soil Profile – Model 3

Node No.	X-Direction Input Motion			Y-Direction Input Motion			Z-Direction Input Motion			SRSS(1)			Check(2)(3)	
	A_{XX}	A_{YX}	A_{ZX}	A_{XY}	A_{YY}	A_{ZY}	A_{XZ}	A_{YZ}	A_{ZZ}	A_X	A_Y	A_Z (or A_V)	A_H	FS_{slide}
1696	0.125	0.006	0.004	0.006	0.128	0.003	0.004	0.007	0.069	0.125	0.128	0.069	0.179	**1.300**

(1) $A_X = \sqrt{A_{XX}^2 + A_{XY}^2 + A_{XZ}^2}$; $A_Y = \sqrt{A_{YX}^2 + A_{YY}^2 + A_{YZ}^2}$; and $A_Z = \sqrt{A_{ZX}^2 + A_{ZY}^2 + A_{ZZ}^2}$

(2) $A_H = \sqrt{A_X^2 + A_Y^2}$

(3) $FS_{slide} = \frac{\mu(W - g_V W)}{g_h W}$

Where:

W = Weight of cask on a pad.
g_h = Horizontal acceleration of the cask, which is calculated as the vector sum of two horizontal Zero Period Accelerations (ZPAs) from the analysis.
g_V = Vertical acceleration of the cask, which is calculated as the vertical ZPA of casks at the center of gravity location.
μ = Coefficient of friction between the cask in an upright position and concrete.

STRUCTURAL RAI 2.3

Provide additional structural analysis details.

In Section 3.4 “Structural Analysis,” of enclosure 1 of the PI ISFSI LAR, the licensee discusses design inputs, acceptance criteria and conclusions related to the structural analysis of the proposed pad. In order for the staff to ascertain that the current licensing basis is maintained, and that sufficient data is provided to make a safety finding, additional details on the structural analysis need to be provided. Structural analyses or calculation packages that include the following information need to be included:

a. Details on calculation of subgrade modulus for the SAFE analysis.

b. Pad settlement and differential settlement evaluations

c. Schematic of finite element mesh generated by SAFE for ISFSI pad.

d. Results of load combination permutations used in SAFE design models as stated in the last paragraph of Section of 3.4.2.2.

e. Final pad reinforcement details resulting from shear and flexure design for the various cask load configurations and combinations.

f. Results of maximum soil bearing pressure evaluation

The above information is necessary to comply with 10 CFR 72.102(c), 10 CFR 72.102(d) and 72.24(d)

NSPM Response 2.3.a

Geotechnical tests performed for the expanded ISFSI and existing tests performed for the existing ISFSI pads were used to determine elastic modulus and settlement of each soil layer. Based on settlement of the foundation under static loading, subgrade modulus for the SAFE analysis was determined.

Immediate settlement takes place as the load is being applied or within a time period of approximately one week. Settlement of the foundation is calculated using the following formula in J.E. Bowles, Foundation Analysis and Design, Fifth Edition, 1996 (Reference 7).

$$s = \sum \Delta H = \sum_{i=1}^{n} \frac{\Delta q_i}{E_i} H_i$$

Where:

s = Settlement of the foundation.
Δq = Additional stress/load on a specific soil layer from the foundation.
E = Elastic modulus of this specific soil layer.
H = Thickness of this specific soil layer.

Using the above equation, settlements/subgrade moduli at various positions of the pad were calculated and the averaged value is used as the subgrade modulus for the SAFE analysis. Table 2.15 list the calculated settlement at various pad locations and subgrade modulus used for the SAFE analysis.

Table 2.15: ISFSI Pad Settlement and Subgrade Modulus

ISFSI Pad	Settlement, (inch)	Subgrade Modulus (pci)	Differential Settlement, (inch)
Center	1.12	5.1	
Middle of Long Edge	0.71	8.1	Center-middle of long edge: 0.42” Slope: 0.17%
Middle of Short Edge	0.57	10.0	
Corner	0.36	15.9	Center-corner: 0.76” Slope: 0.06%
Average	0.69	8.3 (Use 8.0)[1]	

Note:

1. While 8.3 was the calculated average subgrade modulus, 8.0 was used as a measure of conservatism.

NSPM Response 2.3.b

Pad settlement for the fully loaded pad is listed in Table 2.15. Since the casks will be loaded during a long period of time (not all at once), the settlement of the pad when occupied by various numbers of cask is evaluated as well. Calculated differential settlements are listed in Table 2.16 through 2.19.

**Table 2.16: ISFSI Pad Settlement (Partially Loaded Pad) –
2 Casks (18 ft x 40 ft Effective Area)**

Location	Settlement (inch)	Differential Settlement (inch)
Center	0.63	
Middle of Long Edge	0.43	Center-middle of long edge: 0.20 in. Slope: 0.19%
Middle of Short Edge	0.35	
Corner	0.25	Center-corner: 0.39 in. Slope: 0.15%

**Table 2.17: ISFSI Pad Settlement (Partially Loaded Pad) –
6 Casks – 25% Loaded (2 by 3) (40 ft x 54 ft Effective Area)**

Location	Settlement (inch)	Differential Settlement (inch)
Center	0.96	
Middle of Long Edge	0.57	Center-middle of long edge: 0.39 in. Slope: 0.16%
Middle of Short Edge	0.54	
Corner	0.33	Center-corner: 0.63 in. Slope: 0.16%

**Table 2.18: ISFSI Pad Settlement (Partially Loaded Pad) –
12 Casks – 50% Loaded (2 by 6) (40 ft x 108 ft)**

Location	Settlement (inch)	Differential Settlement (inch)
Center	1.07	
Middle of Long Edge	0.66	Center-middle of long edge: 0.41 in. Slope: 0.17%
Middle of Short Edge	0.56	
Corner	0.35	Center-corner: 0.72 in. Slope: 0.10%

Table 2.19: ISFSI Pad Settlement (Partially Loaded Pad) – 18 Casks – 75% Loaded (2 by 9) (40 ft x 162 ft)

Location	Settlement (inch)	Differential Settlement (inch)
Center	1.11	
Middle of Long Edge	0.69	Center-middle of long edge: 0.42 in. Slope: 0.17%
Middle of Short Edge	0.57	
Corner	0.36	Center-corner: 0.75 in. Slope: 0.07%

NSPM Response 2.3.c

The finite element mesh and cask locations on the pad are provided Figures 2.14 and 2.15.

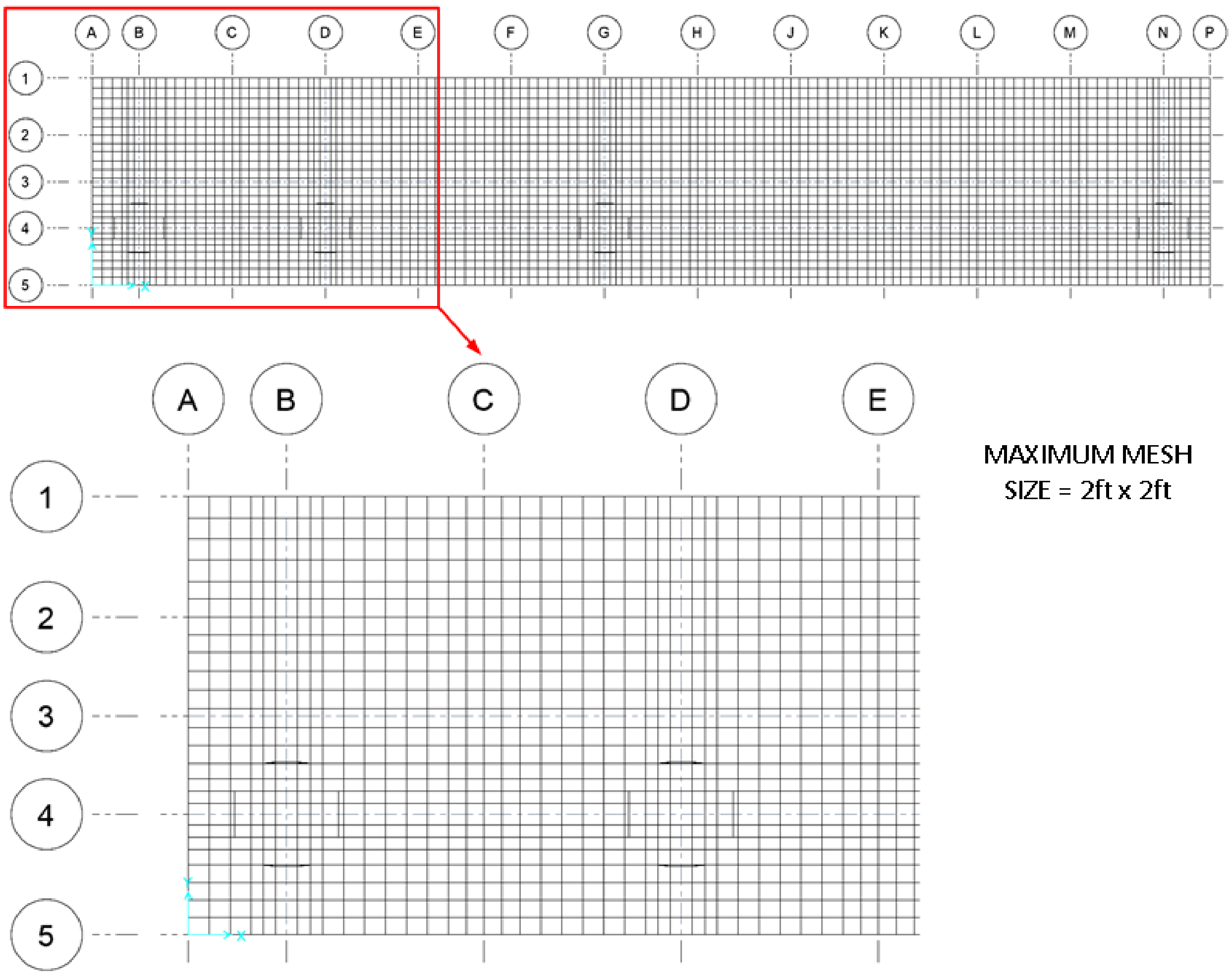

Figure 2.14: Finite Element Analysis Mesh

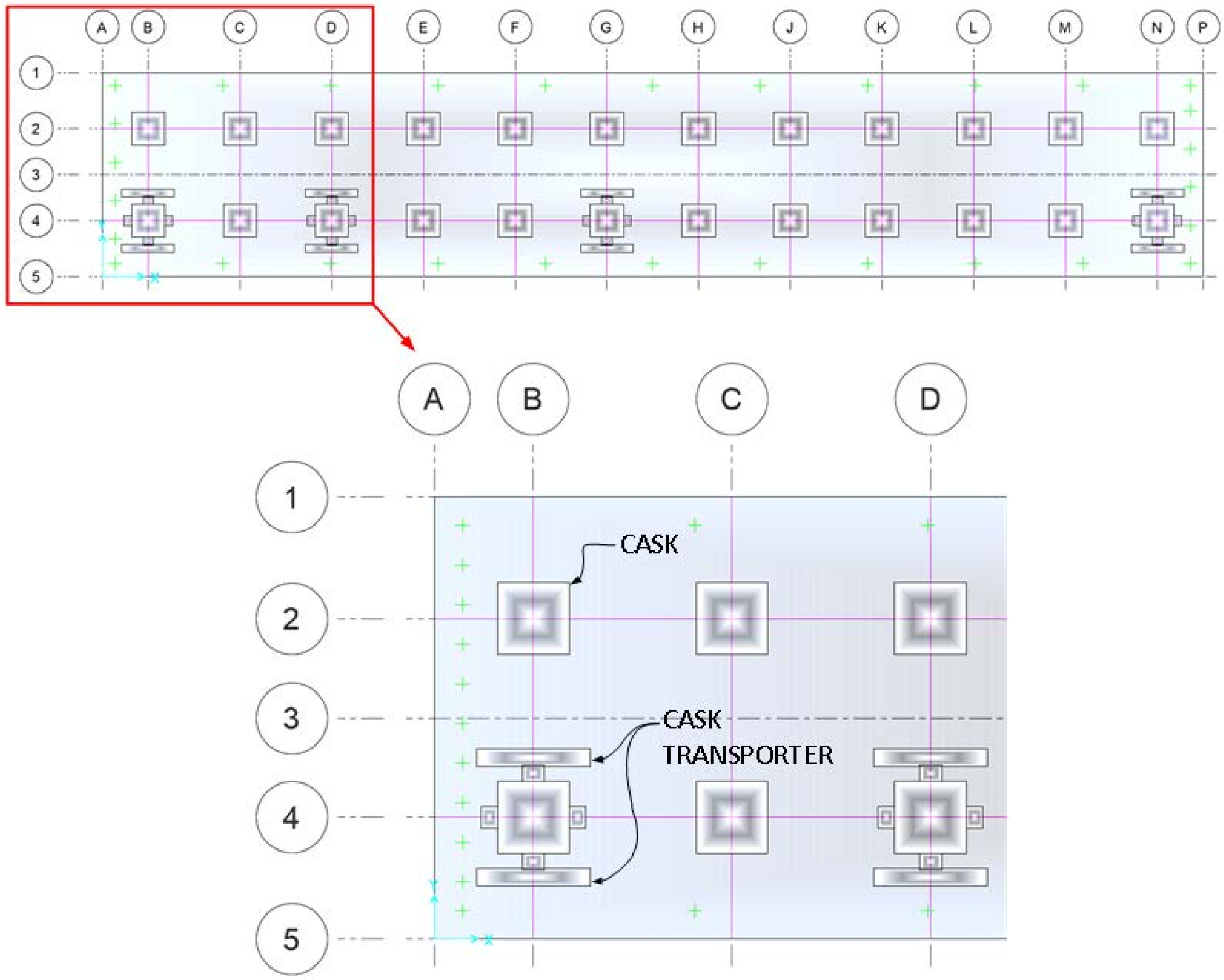

Figure 2.15: Finite Element Analysis Mesh
(Note that the orientation of the Cask Transport Vehicle (CTV) is arbitrary)

NSPM Response 2.3.d

Various cask loading configurations and load combinations (LC) were used to determine forces/moments to design the ISFSI pad and supporting foundation. Reinforcement design is controlled by vertical tornado missile cases except negative moment, which is controlled by single cask loading with the cask transport vehicle (CTV) at the corner of the pad. Static bearing pressure is controlled by the flood case with 6 casks and transient bearing pressure is controlled by the earthquake case with fully loaded pad. Controlling load combinations for the pad design are listed in Table 2.20.

Table 2.20: Summary of Structural Design Results

Failure Mode	IC	Applied		Allowed		Controlling LC[1]
Thru-Thickness Shear of Pad	0.52	17.3	kip/ft	33.4	kip/ft	731
Moment, Bottom Face Reinforcement, North-South ($M_{x,pos}$)	0.58	115.4	kip-ft/ft	199.1	kip-ft/ft	731
Moment, Bottom Face Reinforcement, East-West ($M_{y,pos}$)	0.64	134.6	kip-ft/ft	209.0	kip-ft/ft	712
Moment, Top Face Reinforcement, North-South ($M_{x,neg}$)	0.39	53.8	kip-ft/ft	136.5	kip-ft/ft	741
Moment, Top Face Reinforcement, East-West ($M_{y,neg}$)	0.71	100.0	kip-ft/ft	141.6	kip-ft/ft	011
Static Bearing Pressure	0.53	2100	psf	4000	psf	512
Transient Bearing Pressure	0.29	2300	psf	8000	psf	624

Note:

1. LC 712: Tornado missile load combination, 6 casks.
   LCs 731 and 741: Tornado missile load combination, single cask.
   LC 011: Static load combination, single cask with VCT.
   LC 512: Load combination with flooding, 6 casks.
   LC 624: Earthquake load combination, fully loaded pad (24 casks)

NSPM Response 2.3.e

The pad is reinforced with #11 reinforcing bars spaced at 12 in for the bottom face and #9 reinforcing bars at 12 in for the top face in both directions.

NSPM Response 2.3.f

The static bearing pressure is controlled by a flood case with a partially loaded pad (6 casks) and the transient bearing pressure is controlled by an earthquake case with fully loaded pad. The ratio of the applied to allowable for static bearing pressure is 0.53, indicating significant margin. See Table 2.20 for further details.

STRUCTURAL RAI 2.4

Clarify cask load configurations used in structural analysis.

Section 3.4.2, “Supporting Analysis and Acceptance Criteria”, of enclosure 1 of the PI ISFSI LAR states that “A total of four different cask load configurations were considered in order to envelope the worst-case moment, shear, and settlement in the new pad.” In section [3.4.3], “Results and Conditions” of the same document, it is stated that “The pad was analyzed using three cask configurations.” Additionally, Section 2.4, “Cask Loading Pattern” of “Soil Structure Interaction Analysis of the ISFSI Expansion Pad” also discusses the use of three cask loading patterns. Because an apparent inconsistency in the licensee's assessment of cask load configurations exists, the following information is requested:

a. Specify the cask load configurations referenced in Section 3.4.2, and

b. Confirm that the analyzed cask load patterns are conservative and bound all other possible scenarios.

The above information is necessary to comply with 10 CFR 72.102(c), 10 CFR 72.102(d) and 72.24(c)(3).

NSPM Response 2.4.a

The soil-structure interaction analysis of the ISFSI pad determines the maximum accelerations of casks. According to NUREG/CR-6865, the single cask configuration controls seismic responses of the cask on the ISFSI pad. Based on this, three cask load configurations (i.e., single cask, 12 casks and 24 casks on the pad) were considered to ensure that the maximum accelerations of casks were determined conservatively. For each cask load configuration, the seismic analyses were performed using three soil cases (i.e., Lower Bound, Best Estimate, Upper Bound). Additional seismic analyses were also performed for the cracked concrete pad using three cask load configurations and critical soil case.

In the structural design of the ISFSI pad, the controlling moment, shear, and settlement were determined by considering the three cask load configurations used for the SSI, plus one additional cask load configuration (i.e., 6 casks on the pad, 1/4 of pad capacity), for a total of four cask load configurations, to ensure all possible unbalanced loading patterns are addressed. This is because the controlling moment, shear, and settlement may not necessarily occur with the single cask load configuration but is closely related to the unbalanced loading pattern. To maximize seismic effects, the maximum acceleration determined from the SSI analysis is applied to all casks in the structural analysis.

NSPM Response 2.4.b

Four cask load configurations (single cask, 6 casks, 12 casks and 24 casks on the pad) represent critical cask loading patterns during the cask installation. This includes the single cask case, two unbalanced loading cases and the fully loaded case. Analysis results show that controlling moment, shear, and static bearing pressure occur for the single and unbalanced loading cases. The fully loaded pad with 24 casks results in the critical loading case for the transient soil bearing capacity. Design summary is listed in Table 2.20. As such, the four cask load configurations that are considered in the design will bound all other possible scenarios. Sufficient design margins are also provided for in the design (i.e., a maximum Interaction Coefficient, which is the ratio of structural/geotechnical demands to structural/geotechnical capacity, of 0.71).

THERMAL RAI 6.1

Provide a detailed discussion of the method of evaluation (MOE) used to demonstrate that the thermal performance of the TN40HT casks currently in place on the existing ISFSI pads are not adversely affected by the deployment of the proposed ISFSI pad expansion.

The applicant has provided a high-level summary of the evaluations performed, including some calculations, to demonstrate that the addition of a third ISFSI pad at the Prairie Island ISFSI will have minimal impact on the thermal performance of the casks on the existing ISFSI pads. This information was provided to support a request that the NRC review and approve an alternate methodology for demonstrating thermal performance of the spent fuel storage cask system in this license amendment request.

The differences in the alternate methodology, when compared to the existing methodology, are primarily related to the numerical modeling software used to perform the thermal analysis. In lieu of reviewing input and output parameters of the actual analysis files developed by the applicant, the NRC staff is requesting that a more thorough and complete narrative of the MOE, consistent with the guidance in NEI 12-04, draft NUREG 2215, and NUREG 2152, be included in the FSAR, such that the staff could perform appropriate inspection and oversight activities.

A thorough description of the MOE is important because it will demonstrate that the design basis functions will protect the integrity of important shielding or fission product barriers, and thus those features that protect against dose to the public or release of radioactive material. It will also control the analyses and assessment process through control of the methods and will assure that the required response of the shielding or barriers as previously established by NRC review will be maintained. This narrative may include:

1. Comparison tables of input parameters used for the existing finite element analysis of the ISFSI and those used in the CFD analysis for the alternate MOE.

2. The approach taken by the applicant was to use a previously approved modeling approach to validate the alternate modeling approach. Since a method of evaluation includes inputs and other modeling choices, it is appropriate to provide a clear representation of similarities between the existing analyses and the proposed MOE, for each of the elements relied upon to make the proposed MOE complete.

3. A thorough discussion of the following:

    a. mesh generation, including appropriate plots, and applicable sensitivity studies.
    b. treatment of boundary conditions.
    c. the final thermal radiation model used.
    d. how the heat transfer out of the top of the casks is treated.

As with item (1), a reasoned and orderly presentation of specific modeling choices is important to fully evaluate whether an element of a method of evaluation is appropriate and complete.

4. Any additional relevant information related to the numerical modeling aspects of the MOE that might be revealed during an audit of actual input and output files.

The applicant is responsible for a complete discussion of all elements of an MOE on which they rely to illustrate that said MOE is sufficient to demonstrate the performance of that design in light of the requirements presented in 10 CFR Part 72. If the essential elements of the MOE are not adequately identified in the application, the staff cannot make a finding of reasonable assurance of adequate protection. This may result in the MOE not being approved for use beyond the existing licensing action.

This information is needed to assess compliance with 10 CFR 72.122(h)(1), 10 CFR 72.128(a)(2,3,4).

<u>NSPM Response 6.1</u>

The RAI response is broken down into several major parts as identified below:

<u>Alternate Method of Evaluation</u>

Although the STAR-CCM+ software used to perform the thermal analysis can perform computational fluid dynamics (CFD) analyses, the analysis performed for this application does not utilize the STAR-CCM+ CFD capabilities. Only the thermal analysis capabilities are utilized, most notably the surface-to-surface radiation modeling features. Since the air is not modeled in the problem, as described in Section 3.5.2 of Reference 1, there is no fluid, and therefore the guidance for CFD analysis relative to solving fluid flow problems provided in NUREG-2215 and NUREG-2152 are not applicable. However, the guidance provided in NUREG-2152 regarding quality of the mesh and convergence of the results was utilized.

Section 2.5.5, “Cask Heat Transfer Evaluation”, of Enclosure 1 of Reference 1 requested NRC approval to use an alternate method for performing the cask heat transfer thermal evaluation to analyze the expanded ISFSI. The following clarifications are made for this request:

- The request to use STAR-CCM+ instead of ANSYS is limited to the use of the thermal analysis capabilities of STAR-CCM+ to analyze the increase in the cask exterior (side) temperature due to the addition of the new ISFSI pad only.

- NSPM is not requesting approval to use the CFD capabilities of STAR CCM+.

- This request is specific to this licensing action only. NSPM is not requesting generic approval for the use of STAR-CCM+.

Description of Method of Evaluation

Section 3.5 of Reference 1, Enclosure 1, provides a description of the method of evaluation (MOE) for the thermal analysis. The following discussion supplements the LAR to provide a more detailed discussion of the MOE used to demonstrate that the thermal performance of the TN-40HT casks currently in place on the existing ISFSI pads are not adversely affected by the deployment of the proposed ISFSI expansion.

Most of the inputs used in the STAR-CCM+ thermal analysis are taken directly from the existing ANSYS finite element analysis. The only inputs that are not based on the ANSYS analysis are geometry inputs that are not specifically identified in the existing analysis but are defined by the expanded ISFSI design. Only the effect of the new ISFSI pad on the cask surface temperature is evaluated, thus, detailed inputs describing the cask internal components and geometry are not required for the STAR-CCM+ analysis. Table 6.1 provides a comparison of the inputs used for the STAR-CCM+ analysis to those of the ANSYS analysis. The inputs listed in Table 6.1 are the complete set of inputs required to perform the thermal analysis as described in LAR Section 3.5.

Table 6.1: Analysis Input Comparison

Design Input	ANSYS Model Value	STAR-CCM+ Model Value
Distance between two adjacent pads	N/A	38 ft
Width of existing pad	36 ft	36 ft
Distance from cask centerline to existing pad edge	9 ft	9 ft
Width of new pad	N/A	40 ft
Distance from cask centerline to new pad edge	N/A	11 ft
Center-to-center distance between casks	18 ft	18 ft
Cask outer diameter	8.4 ft	8.4 ft
Cask height	12.8 ft	12.8 ft
Ambient temperature	100°F	100°F
Ambient (incident) emissivity	1.0	1.0
Cask emissivity	0.9	0.9
Ground (concrete) emissivity	0.9	0.9
Cask heat generation (Decay heat load + solar heat load)	116,727 BTU/hr	116,727 BTU/hr
Heat loss from bottom of cask to ground	3,492 BTU/hr	3,492 BTU/hr
Heat loss from cover of cask (to environment)	3,424 BTU/hr	3,424 BTU/hr
Solar heat flux on ground	0.853 BTU/hr-in^2	0.853 BTU/hr-in^2

Figure 6.1 shows the entire geometry of the model, while Figure 6.2 shows a cross-section through the geometry. As seen, the model includes homogenous solid cylinders (internal details of the casks are not included), which represent the casks, and a thin (1 ft) homogenous solid slab, which represents the pad/ground. The model includes external surface-to-surface

radiation heat transfer among the various cask side surfaces, the ground, and the environment. Environment is at 100°F for both natural convection and radiation and has an emissivity of 1. Air flow around the casks is not modeled, but convection heat transfer is included in the model as a boundary condition on both the cask side surfaces and the pad/ground. Heat transfer between the casks and pad/ground is included in the models; the cylinders are not in contact with the pad/ground and heat transfer from the casks to the ground is specified to be equal to that in the ANSYS analysis. The bottom surface of the pad/ground is adiabatic. See Figures 6.2 and 6.3 for a graphic representation of the boundary conditions applied to the model.

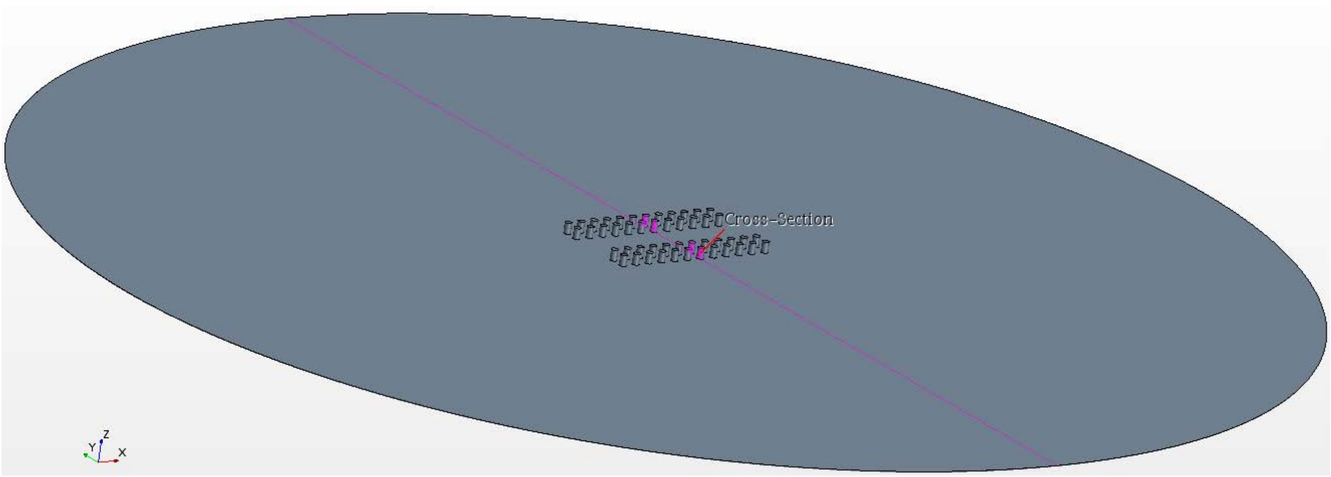

Figure 6.1: Overview of the Computational Domain (Cross-Section in Figure 6.2 is Highlighted)

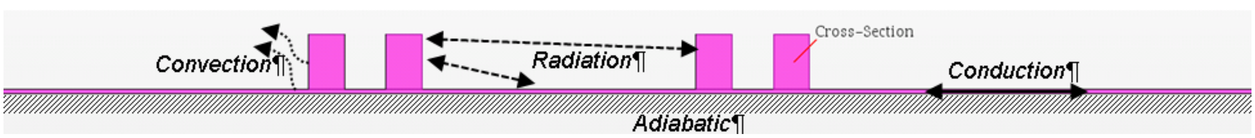

Figure 6.2: Cross-Section of the Computational Domain

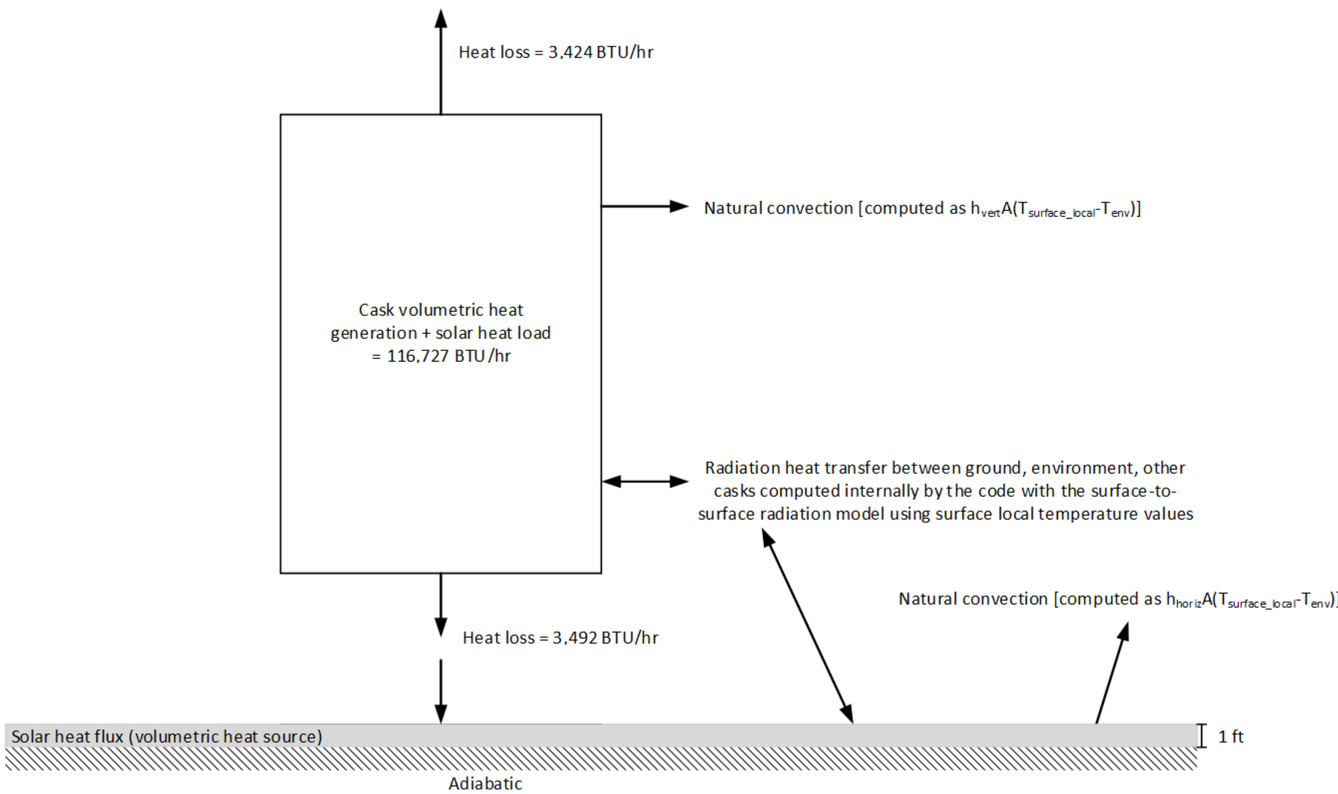

Figure 6.3: Boundary conditions

This modeling approach is conservative and justified since the cask volumetric heat generation is known and does not depend on the cask arrangement on the pads; the heat losses from the top and bottom of the pads are also known as documented in Table 6.1. Using the top and bottom heat loss from the ANSYS analysis is conservative since any increase in cask's temperature would also cause an increase in heat loss from the top and bottom of the cask. Keeping the cask's top and bottom surface heat loss the same as in the ANSYS analysis conservatively causes an overestimation of the cask's side temperature in the STAR-CCM+ analysis. Thus, the casks' side local temperatures are the only unknowns of the problem that depend on the general arrangement of the casks. The thermal model computes the casks' side temperatures balancing the heat flux on the casks' side surfaces considering the surface-to-surface radiation and convection with the surroundings – this is the main purpose and goal of the thermal model (i.e., accurately solve the local heat balance on the casks' side surfaces). This calculation could have been done by hand if the local view factors between the various surfaces were known. However, due to the complexity of the geometry, it was decided to use STAR-CCM+ to compute the view factors and solve the heat transfer problem. The CFD capability of STAR-CCM+ was not utilized for this problem (i.e., no flow of fluids was included in the model). Since the casks and pad/ground were modeled as solid volumes, heat conduction is also resolved in the model. However, the details of the pad/ground and cask internal temperature were not of interest for this calculation and have been proven to have no impact on the results of the computation. Sensitivity runs were performed by considering thermal conductivities ranging from 0.5 W/m-K to 5.0 W/m-K, which envelop typical expected values for soil, concrete, and casks. A change in thermal conductivity by a factor of 10 (0.5 to 5 W/m-K) caused a maximum change in cask side temperature of approximately 0.2°F, which is negligible and thus confirms that the main problem being solved is the heat balance on the casks' side surfaces.

The thermal radiation model used is the "Surface-to-Surface (S2S) radiative heat transfer for modeling non-participating media radiation". The S2S radiation model in STAR-CCM+ allows the analysis of thermal radiative heat transfer between surfaces of arbitrary complexity. In this model, no medium is present between the surfaces. The radiation properties and the thermal boundary conditions that are imposed on each surface define uniquely the amount of radiation that a surface receives and emits. The surface properties are quantified in terms of emissivity (ε), reflectivity (ρ), transmissivity (τ), and radiation temperature. For the STAR-CCM+ model, transmissivity is set equal to zero and thus reflectivity is computed as 1 – ε, based on the standard thermal radiation energy balance. The S2S model enforces the radiation balance on the entire set of surfaces by considering each surface and how it exchanges radiation with all other surfaces and environment. The calculation approach consists of the following main elements:

- The boundaries of the computational domain are spatially subdivided into contiguous, non-overlapping patches.

- From the center of each patch, a specified number of beams are emitted over the enclosing hemisphere with solid angles that are discretized using an angular quadrature. Each beam is traced through the computational domain until it intercepts an opposing patch, thus defining a pair of patches that exchange radiative energy (i.e., defining the view factors between the difference patches).

- The radiation energy transfer to or from each patch is then calculated from the radiation transport equation and the boundary conditions.

Approximately 1000 beams per patch and 700 patches per each cask's side surface were used in the STAR-CCM+ thermal model.

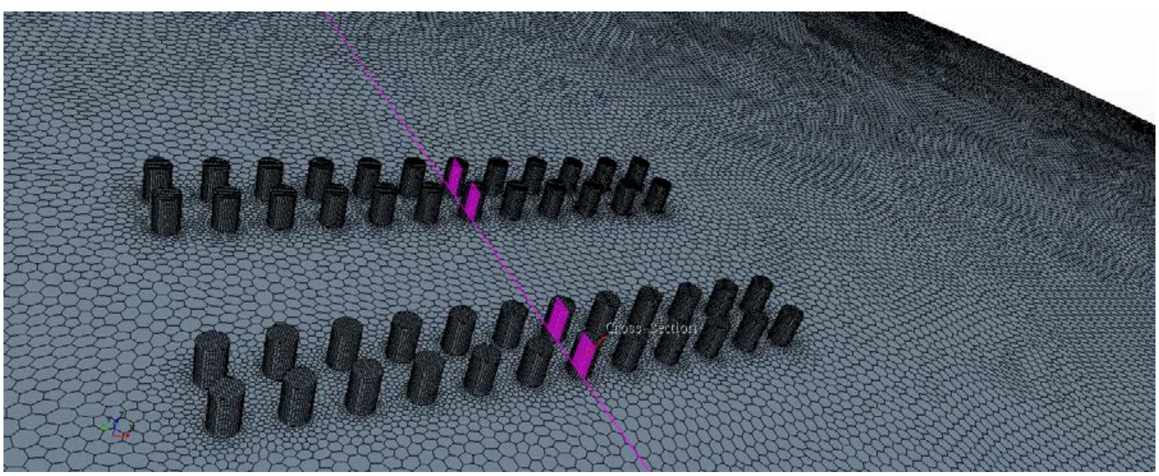

Figure 6.4: Overview of the computational domain's mesh (cross-section in Figure 6.5 is highlighted)

Figure 6.5: Cross-section of the computational domain's mesh

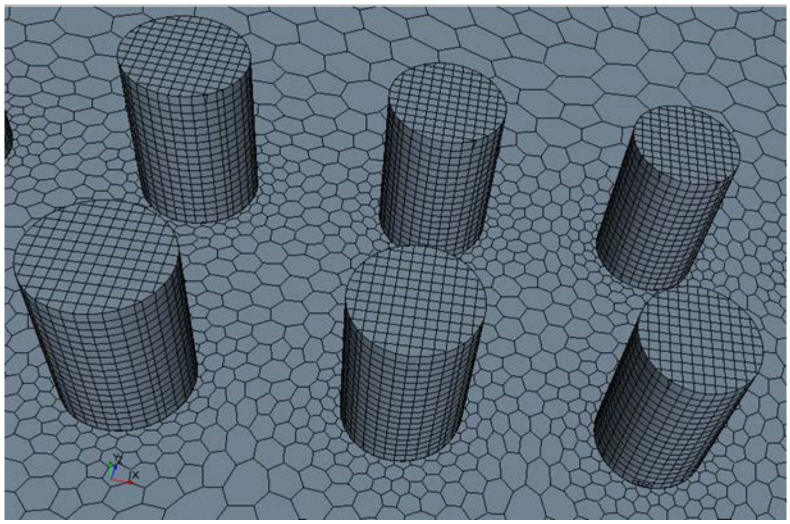

Figure 6.6: Overview of the surface mesh around the casks

Figures 6.4 and 6.5 show an overview and cross-section of the mesh used for the analysis, respectively. Figure 6.6 shows a close-up view of the surface mesh since it is relevant to the analysis performed in this calculation. The model is discretized in a total of approximately 300,000 cells. Each cask's side surface accounts for approximately 700 trimmer faces 0.7 ft wide; the pad/ground upper surface accounts for approximately 95,000 polyhedral faces between 0.7 ft (in proximity of each cask) and 5 ft wide (farther from the casks). Mesh independence studies were performed to ensure that the results were mesh independent.

ISFSI SAR Revisions

The ISFSI SAR will be revised to clarify the use of the STAR-CCM+ software as a thermal analysis tool. See Attachment 1 to this enclosure for the corresponding revisions to proposed ISFSI SAR Insert T-1 for page A3.3-28.

MATERIALS RAI 8.1

Include the use of ACI 201.2R in the safety analysis report (SAR) description of the new ISFSI pad design or provide justification for how the durability of the concrete will be ensured without SAR requirements to follow this ACI guidance.

SAR Section A4.2.1 states that the new concrete pad is designed to the requirements of ACI 349-13, "Code Requirements for Nuclear Safety-Related Concrete Structures." An exception is being taken to reduce the minimum compressive strength of the concrete from the 4,500 psi requirement of this ACI code. The staff notes that ACI 349-13 establishes the 4,500 psi minimum strength to meet durability requirements for concrete that is exposed to freezing and thawing cycles.

Enclosure 1 of the license amendment request (evaluation of the proposed change) states that the guidance in ACI 201.2R-16, "Guide to Durable Concrete," will be followed to ensure the durability of the concrete with the reduced minimum compressive strength. However, the use of ACI 201.2R-16 is not discussed in the SAR. It is unclear to the staff how the durability of the concrete will be achieved without a SAR specification for the use of ACI 201.2R-16.

This information is needed to demonstrate compliance with 10 CFR 72.24(c)(4) and 72.122(b)(1).

NSPM Response 8.1

The 4,500 psi minimum concrete strength in ACI 349-13 is not a structural requirement, but a material requirement for long-term concrete durability. Because this requirement cannot be met while still meeting the limitations of the cask drop analysis, an alternative means of ensuring long-term durability is provided by applying the ACI 201.2R requirements.

Per ACI 201.2R, durability against freeze-thaw is primarily controlled by three items: reducing freezable water (lowering water-cement ratio), entraining air to provide voids for water to expand into while freezing, and detailing to avoid standing water. The ISFSI Pad design follows the durability suggestions for Exposure Class F2 freeze-thaw protection and provides a reasonable approach to ensure durability while still meeting the cask drop analysis requirements.

See Attachment 1 to this Enclosure for the corresponding revisions to proposed ISFSI SAR Inserts S-5 and S-8.

MATERIALS RAI 8.2

Clarify apparent discrepancies between the temperature values and footnotes in SAR Table A3.3-7.

SAR Table A3.3-7 includes new footnotes that describe revisions made to the maximum component temperatures for buried casks. However, the temperature values in the table have not been revised from the prior version of the SAR in accordance with the new footnotes.

This information is needed to demonstrate compliance with 10 CFR 72.24(c) and 72.120(d).

NSPM Response 8.2

The maximum component temperature values for the buried cask condition do not need to be increased in Table A3.3-7. The cask exterior initial temperatures are increased by 5°F and the cask interior initial temperatures are increased by 2°F due to the proposed ISFSI expansion. The assumed boundary conditions for the buried cask are adiabatic, which is conservative.

Therefore, the cask temperatures are impacted only by the cask internal heat. Starting at a higher initial temperature than previously considered will result in a decreased time to reach the maximum component temperatures for the buried cask condition, as shown in the markups for Table A3.3-7.

A revised markup for Table A3.3-7 is provided in Attachment 1 to this Enclosure to provide further clarification for the new footnotes.

MATERIALS RAI 8.3

In the SAR, clarify if the existing aging management programs are to be implemented for the new pad and casks immediately upon placing them into service or sometime afterward (e.g., after 20 years of service).

SAR Sections 9.8 and A9.8 describe the aging management activities associated with Prairie Island's renewed ISFSI license. Enclosure 1 of the license amendment request states that the new SSCs will be included in the ISFSI aging management programs (AMPs). The SAR does not specifically address the inclusion of the new SSCs in the AMPs. To provide clarity for the staff's review of the amendment request (and for subsequent NRC AMP inspection activities) the SAR should state the timing for the implementation of the AMPs for the new pad and casks.

This information is needed to demonstrate compliance with 10 CFR 72.120(a).

NSPM Response 8.3

Added SSCs that are in-scope for aging management would be subject to AMP implementation beginning at 20 years of service. The basis for this is that in-scope SSCs that are not addressed via time-limiting aging analysis are subject to an AMP. The PI ISFSI AMP was described pursuant to 10 CFR 72.42(a)(2) and ultimately approved by the NRC with the renewal of the license. The aging management review performed for license renewal presumes 20 years of service prior to the effects of aging-related degradation being of concern. Thus, the description of the PI ISFSI AMP includes the provision that aging management requirements for in-scope SSCs begin at 20 years of service. The added in-scope SSCs will be included in the PI ISFSI AMP with the proviso that AMP inspection and monitoring requirements apply beginning at 20 years of service.

A markup to Section 9.8 of the PI ISFSI SAR is provided in Attachment 1 of this Enclosure to provide clarification.

3.0 REFERENCES

1. Letter (L-PI-19-009) from NSPM to the NRC, "License Amendment Request: Expand the Storage Capacity of the Independent Spent Fuel Storage Installation (ISFSI)", dated July 26, 2019 (ADAMS Accession No. ML19210D273)

2. Letter from the NRC to NSPM, “Prairie Island License Amendment Request – Request for Additional Information (EPID No. L-2019-LLA-0169)”, dated April 13, 2020 (ADAMS Accession No. ML20077K624)

3. NRC Regulatory Guide 1.198, “Procedures and Criteria for Assessing Seismic Soil Liquefaction at Nuclear Power Plant Sites”, Revision 0, dated November 2003 (ADAMS Accession No. ML033280143)

4. NRC NUREG/CR-5741, “Technical Bases for Regulatory Guide for Soil Liquefaction”, dated March 2000 (ADAMS Accession No. ML003701612)

5. Textbook, Youd, T.L., Idriss, I.M., et al., “Liquefaction Resistance of Soils: Summary from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soil”, Journal of Geotechnical and Geoenvironmental Engineering, dated October 2001”

6. NRC NUREG/CR-6865, “Parametric Evaluation of Seismic Behavior of Freestanding Spent Fuel Dry Cask Storage Systems”, dated February 2005 (ADAMS Accession No. ML051120008)

7. Textbook, J.E. Bowles, “Foundation Analysis and Design”, Fifth Edition, dated 1996

ENCLOSURE, ATTACHMENT 1

PRAIRIE ISLAND INDEPENDENT SPENT FUEL STORAGE INSTALLATION

Request for Additional Information

License Amendment Request to Expand the Storage Capacity
for the Independent Spent Fuel Storage Installation

ISFSI SAFETY ANALYSIS REPORT AND ADDENDUM
(Revised Markup – For Information Only)

(45 Pages Follow)

APPENDIX 2C

ISFSI South-East Pad

CPT DATA,

LIQUEFACTION ANALYSIS,

AND ST-5 BORING LOG

BRAUN INTERTEC
The Science You Build On.

Braun Intertec Corporation
1826 Buerkle Road
Saint Paul, MN 55110

Phone: 651.487.3245
Fax: 651.487.1812
Web: braunintertec.com

August 8, 2018 Project B1806014

Mr. Gregory M. Peebles
Program Manager
Sargent & Lundy – Mailcode 25X50
55 E. Monroe Street
Chicago, IL 60603-5780

Re: Summary of CPT Soundings
Prairie Island ISFSI Expansion
1717 Wakonade Drive
Welch, Minnesota

Dear Mr. Reyes:

This letter serves to summarize geotechnical services provided by Braun Intertec Corporation as part of Prairie Island ISFSI Expansion Geotechnical Investigation.

Background

We received written authorization for this project on June 15, 2018 in the form of Purchase Order 37234 received from Sargent & Lundy, LLC. Our authorized scope of services included performing a series of 4 Seismic Cone Penetration Test (CPT) soundings. The initial schedule of quantities included 425 feet of CPT soundings with anticipated termination depths of 100 to 125 feet below the ground surface. Our investigation was performed in accordance with ASTM D3740.

Field Procedures

Field procedures for this project were completed on July 11, 2018. Sounding locations were staked in the field by Braun personnel prior to the arrival of our testing equipment. Additional discussion of the CPT sounding procedures is provided below.

CPT Soundings: CPT soundings for this project were performed using designated push equipment manufactured by A.P. van den Berg. The rig is mounted on a rubber-tracked Marooka carrier and is capable of generating 15 tons of reaction force. CPT soundings were performed using an A.P. van den Berg icone (60 degree cone apex and 15 square centimeter tip area) with porous stones mounted in the U_2 position. The serial number of the icone used for these soundings is 170717, as noted in the attached CPT sounding logs and on the attached icone calibration record.

A new porous stone was used for each sounding and was fully saturated with silicone oil. Tip resistance (Q_t), sleeve friction (F_S) and pore pressure (U_2) were measured continuously as the probe was advanced. Seismic testing was performed at 1 meter intervals and we obtained shear wave (S-wave) and compressive wave (P-wave) data in general accordance with procedures described in ASTM D5778 and D7400 at all 4 CPT locations.

The shear wave velocity (V_s) and compression wave velocity (V_p) was estimated based on the wave arrival times to the A.P. van den Berg geophone module attached to our icone. We used the software suites CPeT-IT and SPAS by Geologismiki to reduce the data and produce the graphical CPT logs and seismic wave plots. Note that P-wave data obtained below groundwater, about 12 feet below the ground surface, is included in the attached graphical representation of the wave forms but is unreliable due to the compression waves propagating at a very high velocity through the water and less through the soil matrix. A summary of our wave velocity profiles is attached. The banded results on the attached wave velocity profiles indicate the maximum and minimum values measured from independently analyzing the arrival times from the shear wave source on the right and left side. The line in the center and the values presented are the average of the two values at each test depth. A tighter band around the data indicates less variability in the estimated V_s results.

Shallow refusal of the cone was encountered at every sounding location locations due to apparent dense soil layers or other obstructions. We terminated each sounding when our equipment reached 90 percent of its maximum capacity.

Table 1: CPT Summary

Sounding Name	Sounding Depth (ft)*	Comments	Seismic Test Depths (ft)
CPT-1	55.91	The Vs data collected at 7.5 feet appears anomalous. This could be due to the interface of the recompacted soil in the predrilled borehole.	7.5, 9.2, 12.3, 15.5, 18.6, 22.2, 25.5, 28.7, 32.1, 35.5, 38.6, 42, 45.3, 48.8, 51.9, 53.3, 55.9
CPT-2	14.76	This location was offset 7 feet north of the original testing location.	7, 9.2, 12.6
CPT-3	44.95	The Vs data collected at 6.8 feet appears anomalous. This could be due to the interface of the recompacted soil in the predrilled borehole.-	6.8, 9.2, 12.6, 15.7, 18.9, 22.3, 25.6, 28.9, 31.9, 35.4, 38.8, 42.4, 44.9
CPT-4	46.00	-	7.6, 8.9, 12.3, 15.6, 19, 22.1, 25.4, 28.7, 32.1, 35.4, 38.8, 42.1

Detailed CPT logs are attached with this report. All raw data and processed CPT logs will be provided electronically. Following the completion of testing, CPT sounding locations were abandoned per Minnesota Department of Health (MDH) regulations and sealing records were submitted to the MDH. A copy of these sealing records is included in the Appendix of this report.

The V_p data collected is presented in Table 2. We have omitted results from below a depth of about 12 feet because of the reasons previously discussed in this report.

Table 2: Compressions Wave Velocities

Test Depth (Feet)	Compressions Wave Velocity (feet/sec)			
	CPT-1	CPT-2	CPT-3	CPT-4
8	2066	1604	-*	2105
11	-*	3715	1857	1336

*Data from these locations was unreliable and we were unable to determine V_p.

This data was used to in conjunction with our shear wave velocity results to estimate values of Poisson's ratio at each of the test depths. These values are presented in Table 3.

Table 3: Estimated Poisson's Ratio

Test Depth (Feet)	Estimated Poisson's Ratio			
	CPT-1	CPT-2	CPT-3	CPT-4
8	0.38	0.25	-*	0.47
11	-*	0.48	0.44	0.33

*Data from these locations was unreliable and we were unable to determine V_p to calculate Poisson's Ratio.

Remarks

We believe that the CPT services described above were provided and performed according to the project specifications. In performing its services, Braun Intertec used that degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession currently practicing in the same locality. No warranty, express or implied, is made.

If you have any questions about this report, please contact Tyler Reich at 612.418.6116 (treich@braunintertec.com).

Sincerely,

BRAUN INTERTEC CORPORATION

Tyler J. Reich, PE
Project Engineer

Mark L. Jenkins, PE
Senior Engineer

MARK L. JENKINS
LICENSED PROFESSIONAL ENGINEER
41770
STATE OF MINNESOTA

Attachments:
Seismic Cone Penetration Testing Location Plan
CPT Locations Coordinates and Elevations
CPT Logs
Seismic Data Graphics
Icone Calibration Record
Daily work log
Well Sealing Records
Data files (attached zip file)

c: Alan Wilson, alan.k.wilson@sargentlundy.com
Daniel Kocunik, daniel.c.kocunik@sargentlundy.com
Chris Kehl, ckehl@braunintertec.com

BRAUN
INTERTEC
The Science You Build On.
11001 Hampshire Avenue S
Minneapolis, MN 55438
952.995.2000
braunintertec.com

Drawing Information

Project No:
B1806014

Drawing No:
B1806014

Drawn By: JAG
Date Drawn: 7/3/18
Checked By: MLJ
Last Modified: 8/1/18

Project Information

Prairie Island ISFSI Expansion

1717 Wakonade Drive

Welch, Minnesota

Soil Boring Location Sketch

DENOTES APPROXIMATE LOCATION OF STANDARD PENETRATION TEST BORING

N

50' 0 100'

SCALE: 1"= 100'

F:\2018\B1806014.dwg,Geotech,8/1/2018 10:54:05 AM

Points

Project : B1806014

User name	jgreenwell	**Date & Time**	1:38:06 PM 7/20/2018
Coordinate System	United States/Counties/MN	**Zone**	Goodhue
Project Datum	Goodhue		
Vertical Datum		**Geoid Model**	Minnesota GEOID12B
Coordinate Units	US survey feet		
Distance Units	US survey feet		
Height Units	US survey feet		

```
Point listing
          Name    Northing      Easting   Elevation        Feature Code
          1003  255326.839   628928.544     693.196               CPT-1
          1002  255328.560   628772.791     693.216               CPT-2
          1001  255330.048   628672.534     693.339               CPT-3
          1000  255331.592   628516.306     693.495               CPT-4
```

Back to top

Note: CPT-2 was moved north 7 feet from these

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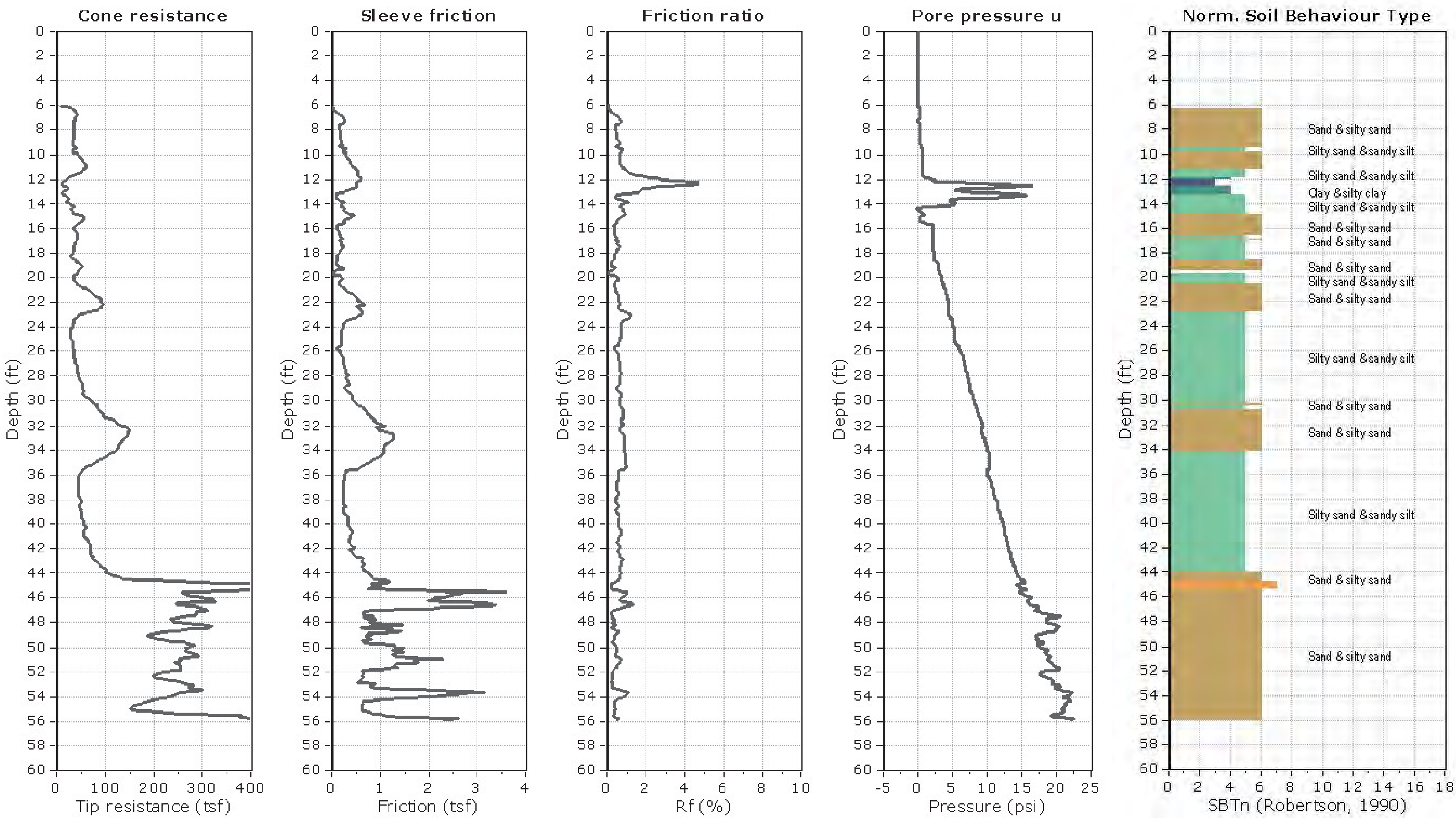
11001 Hampshire Ave S
Minneapolis, MN 55438
952-995-2000

CPT: CPT-01
Total depth: 55.91 ft, Date: 7/11/2018
Cone Type: 170717
Cone Operator: Holmbo

Project: **Prairie Island ISFSI Expansion**
Location: **Welch, MN** **Project Number: B1806014**



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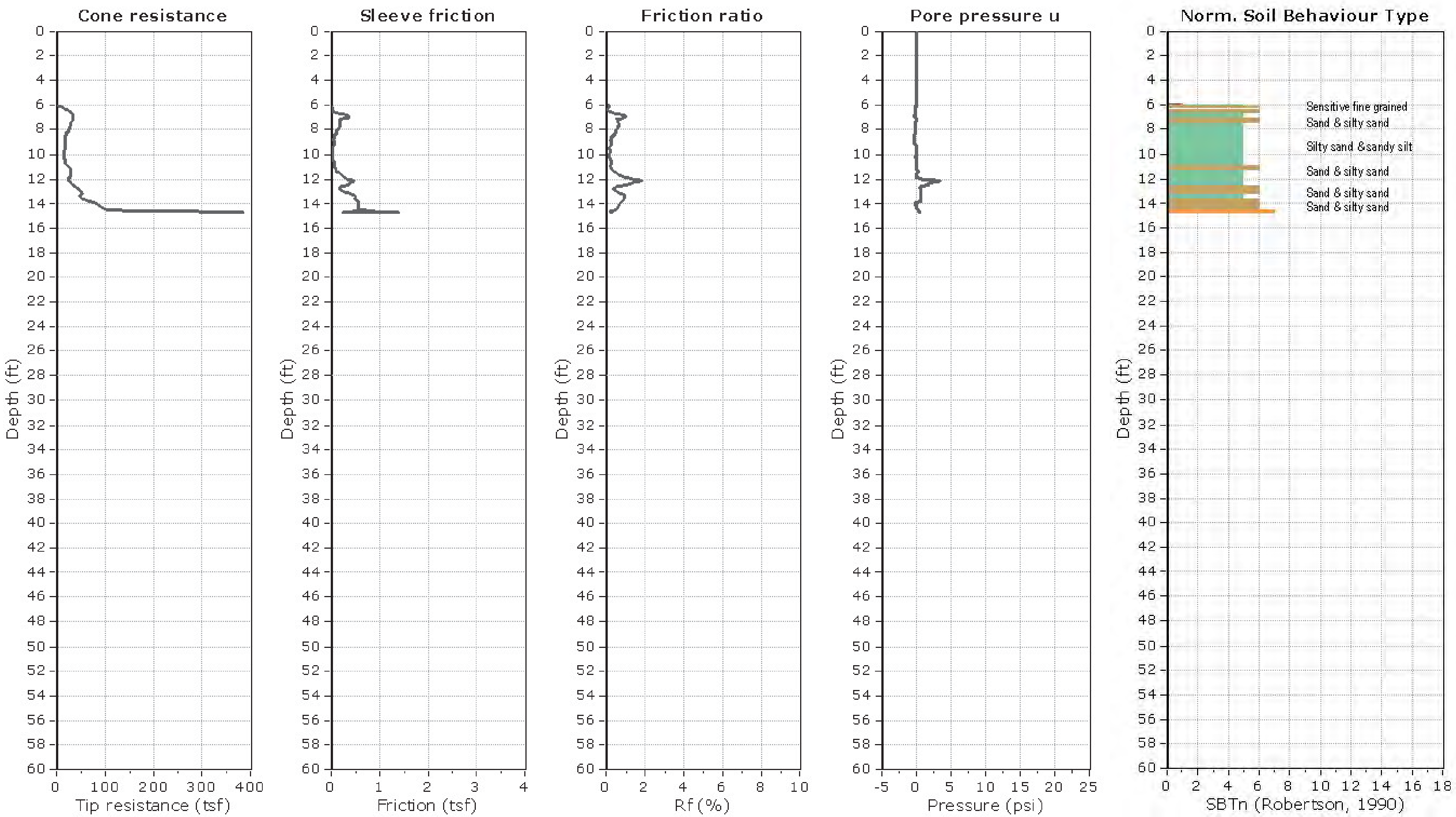
Braun Intertec Corporation
11001 Hampshire Ave S
Minneapolis, MN 55438
952-995-2000

Project: **Prairie Island ISFSI Expansion**
Location: **Welch, MN** **Project Number: B1806014**

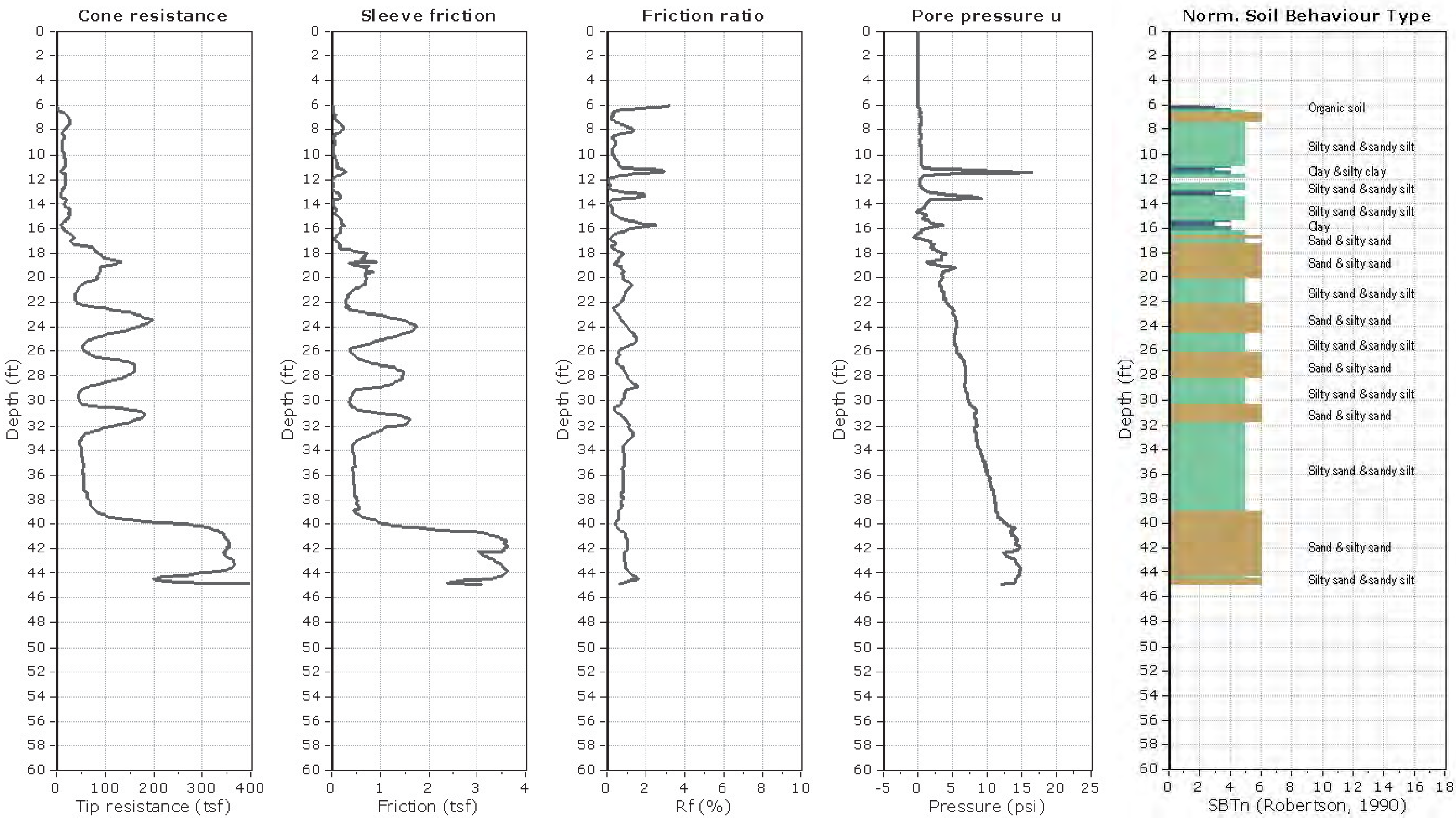
CPT: CPT-02
Total depth: 14.76 ft, Date: 7/11/2018
Cone Type: 170717
Cone Operator: Holmbo



Braun Intertec Corporation
11001 Hampshire Ave S
Minneapolis, MN 55438
952-995-2000

CPT: CPT-03
Total depth: 44.95 ft, Date: 7/11/2018
Cone Type: 170717
Cone Operator: Holmbo

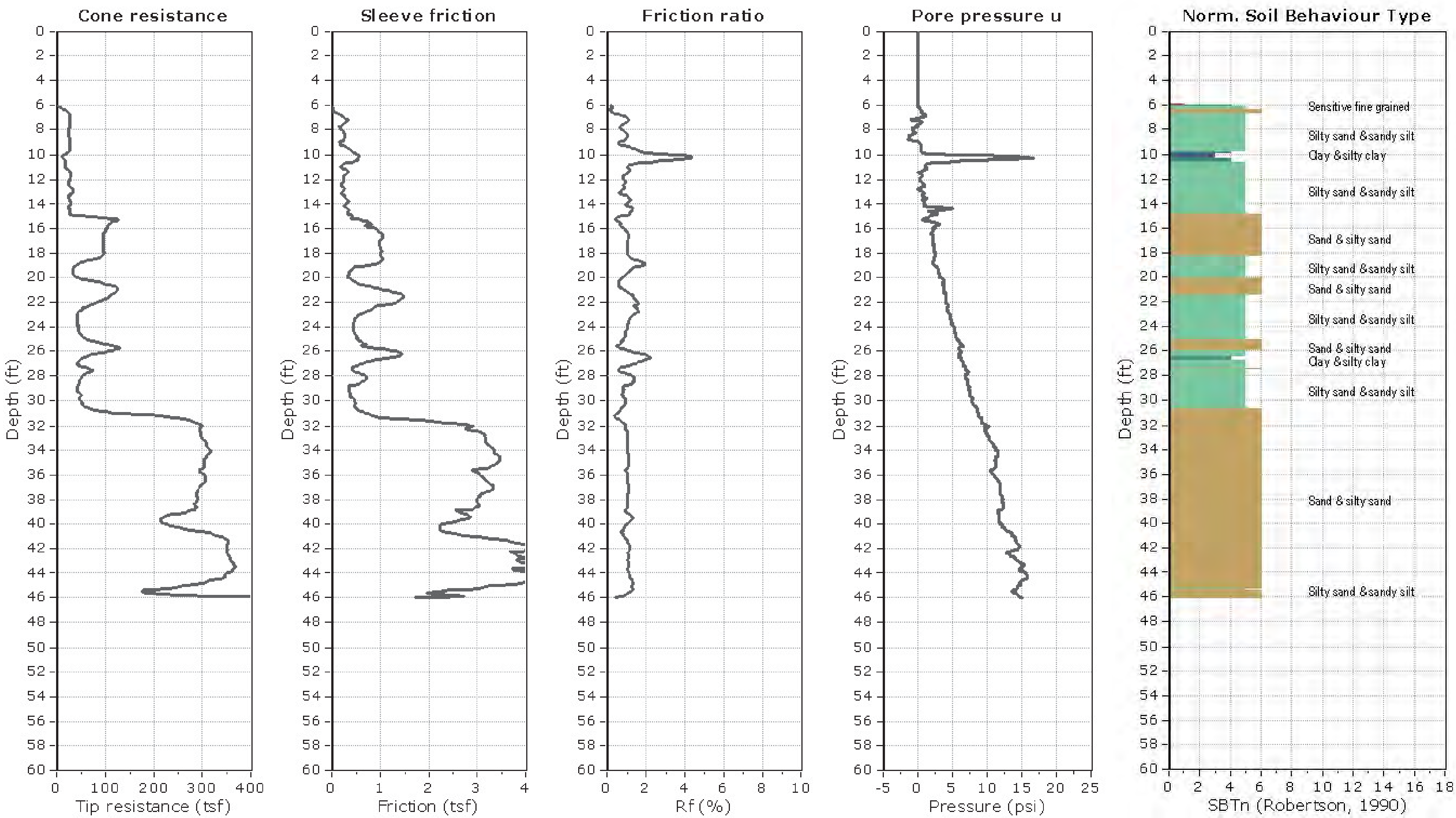
Project: **Prairie Island ISFSI Expansion**
Location: **Welch, MN** **Project Number: B1806014**



Braun Intertec Corporation
11001 Hampshire Ave S
Minneapolis, MN 55438
952-995-2000

CPT: CPT-04
Total depth: 46.00 ft, Date: 7/11/2018
Cone Type: 170717
Cone Operator: Holmbo

Project: **Prairie Island ISFSI Expansion**
Location: **Welch, MN** **Project Number: B1806014**



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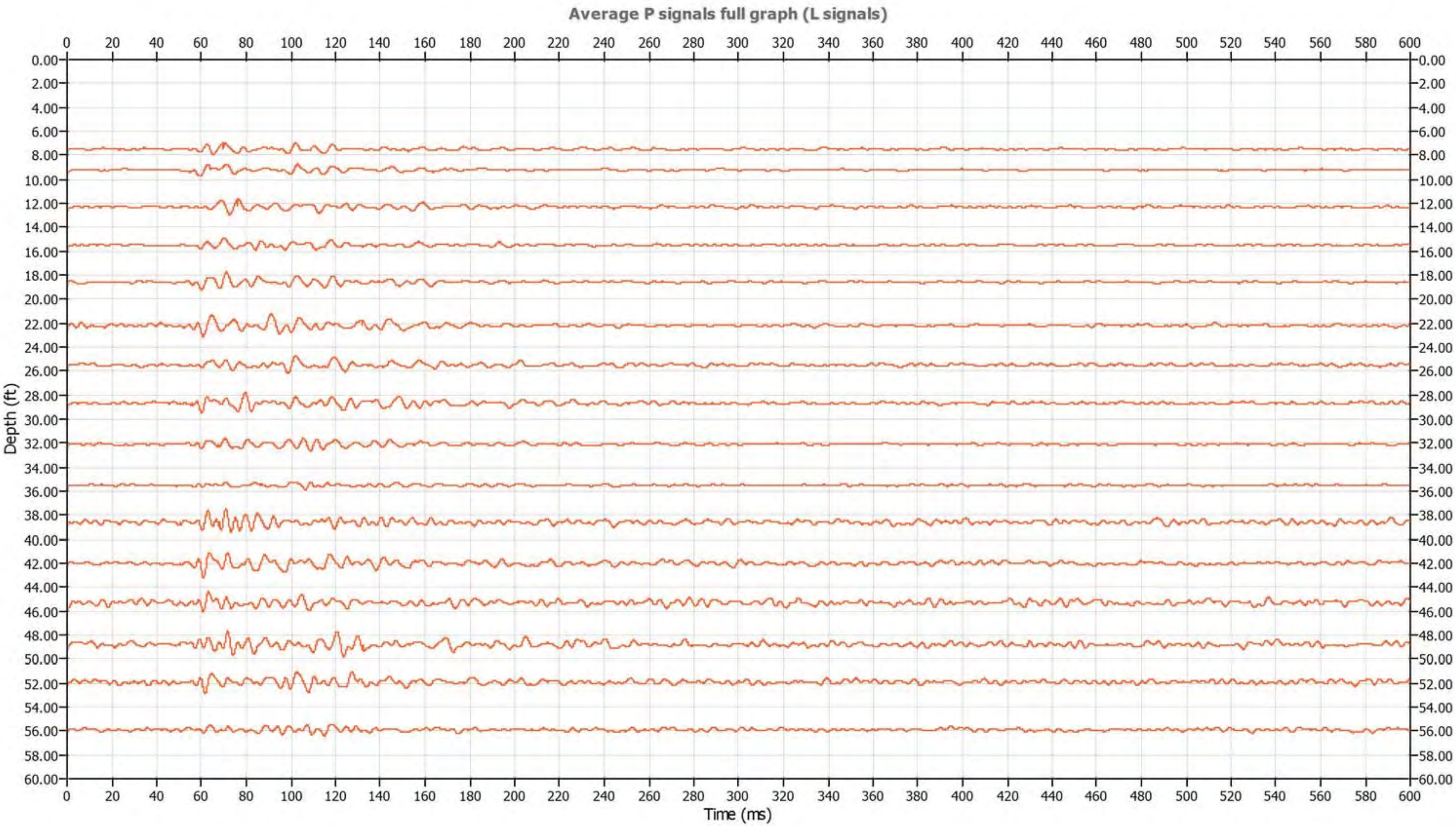
Project: B1806014 - Prairie Island ISFSI Expansion

Borehole ID: CPT-01



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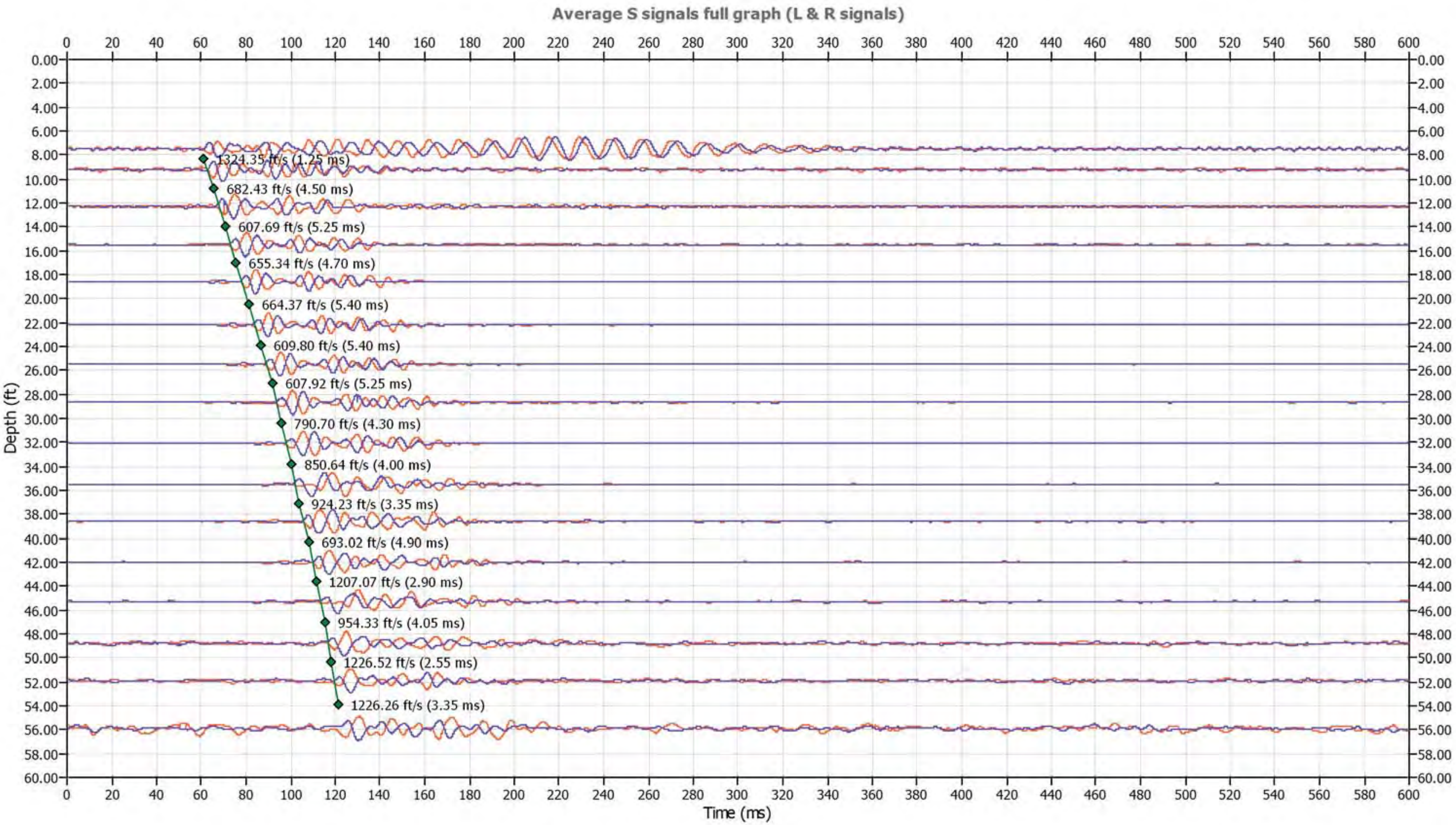
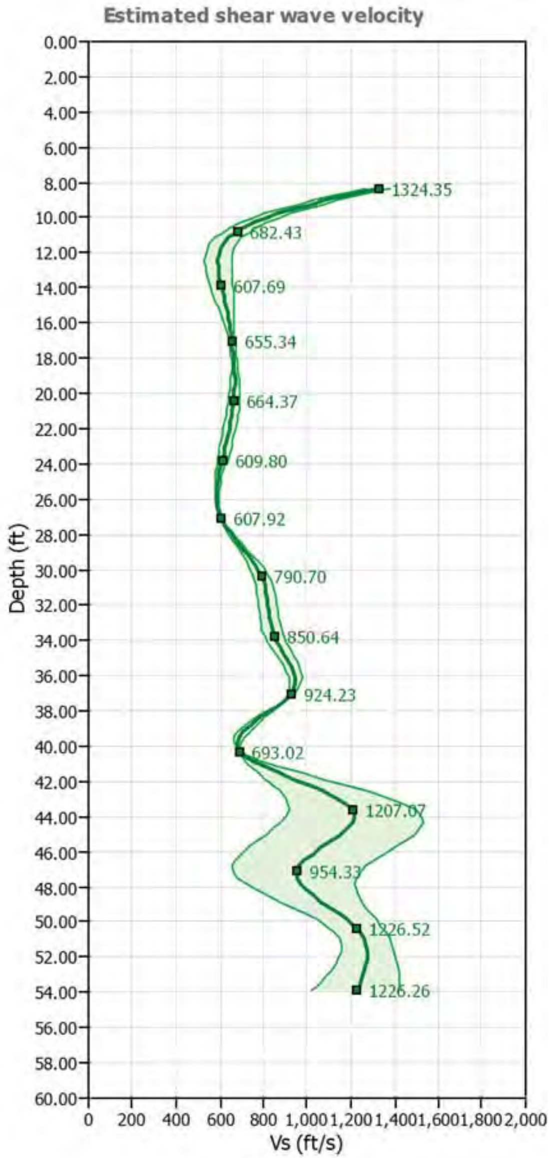
Project: B1806014 - Prairie Island ISFSI Expansion **Borehole ID: CPT-01**

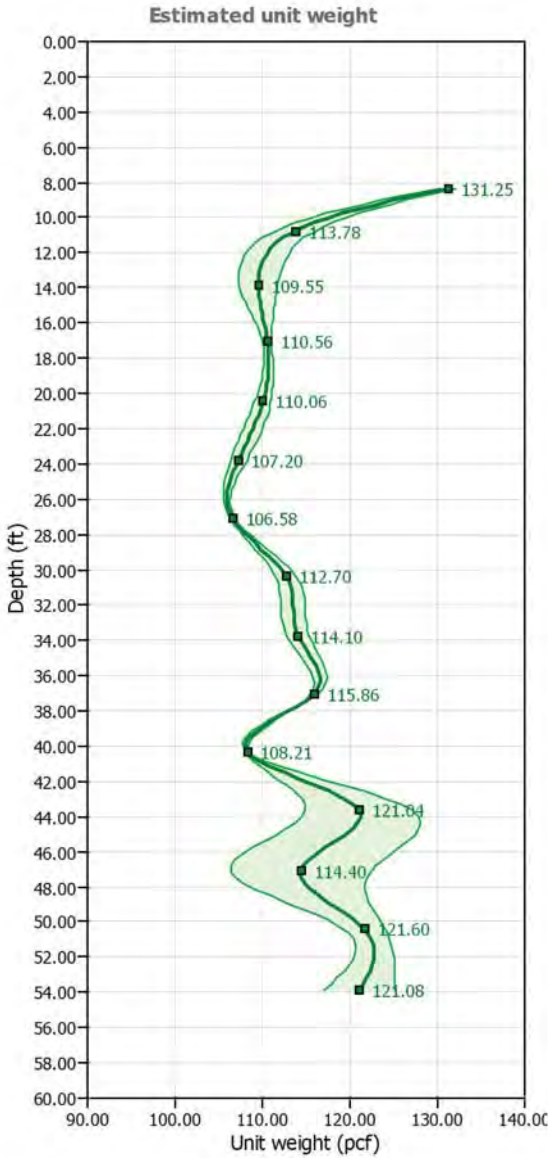


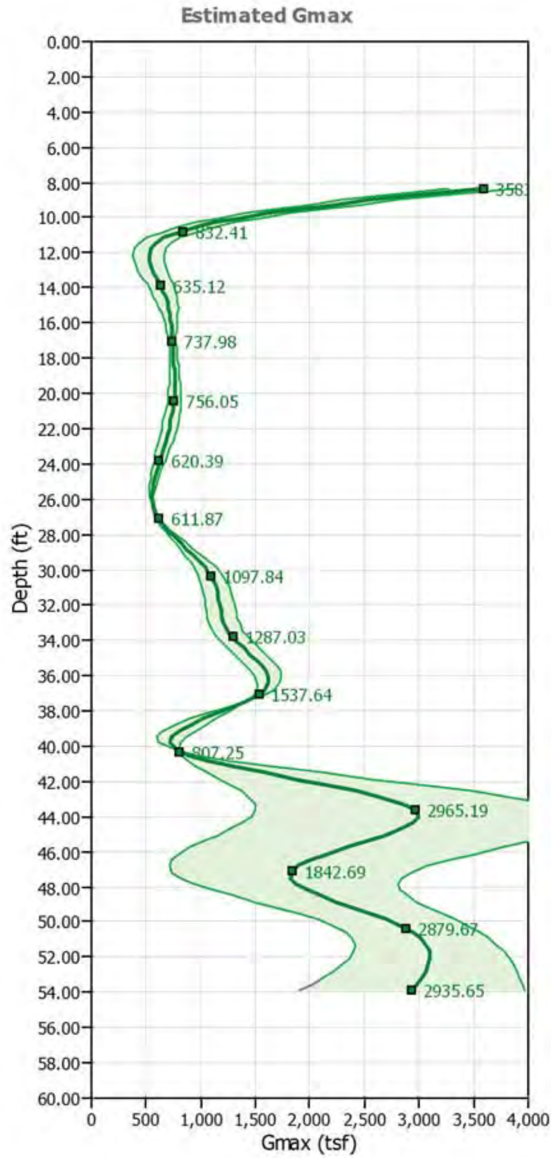
Borehole ID: CPT-01

This software is licensed to: Braun Intertec Corporation

Detailed result plots over depth







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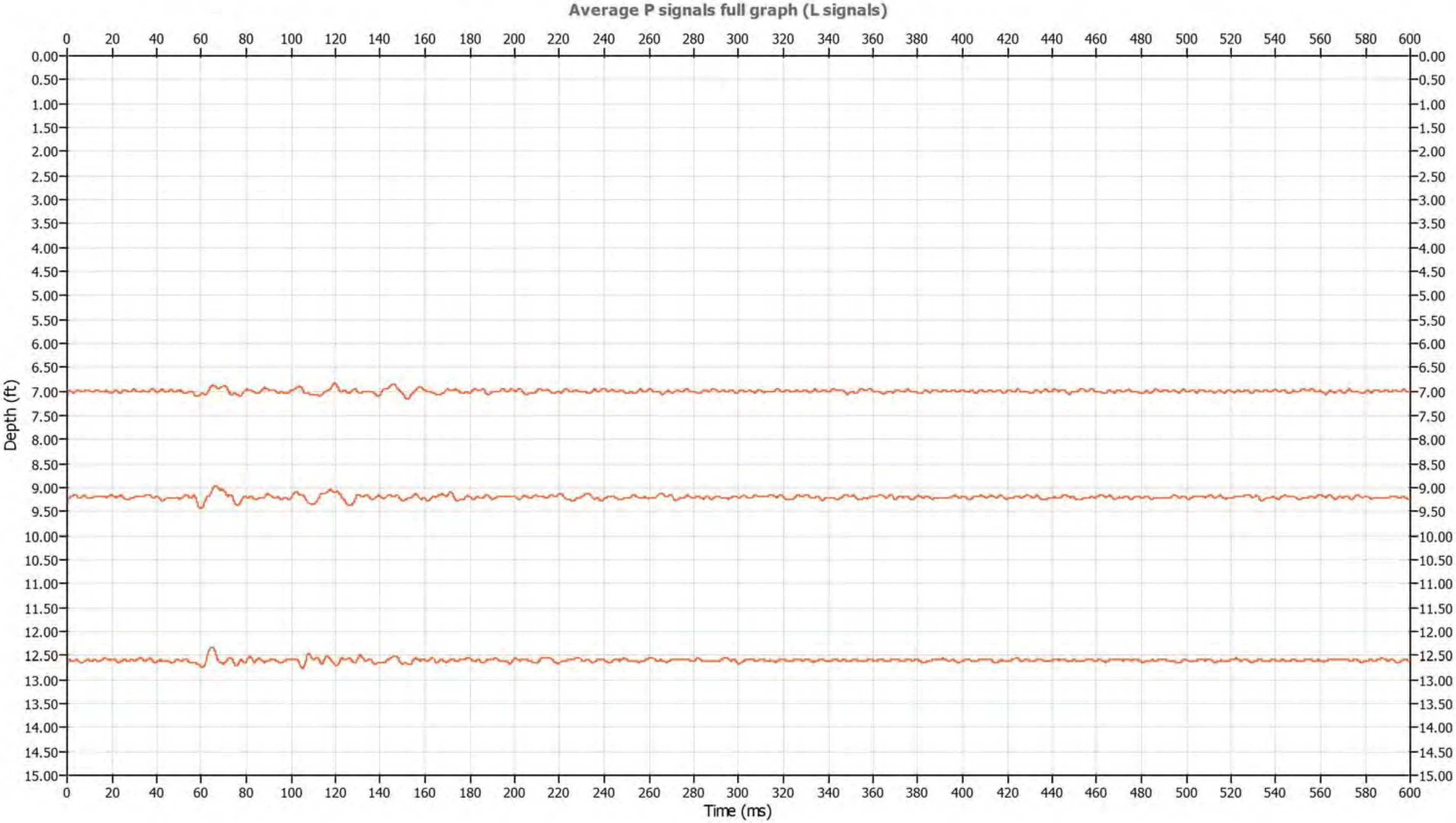
Project: B1806014 - Prairie Island ISFSI Expansion **Borehole ID: CPT-02**



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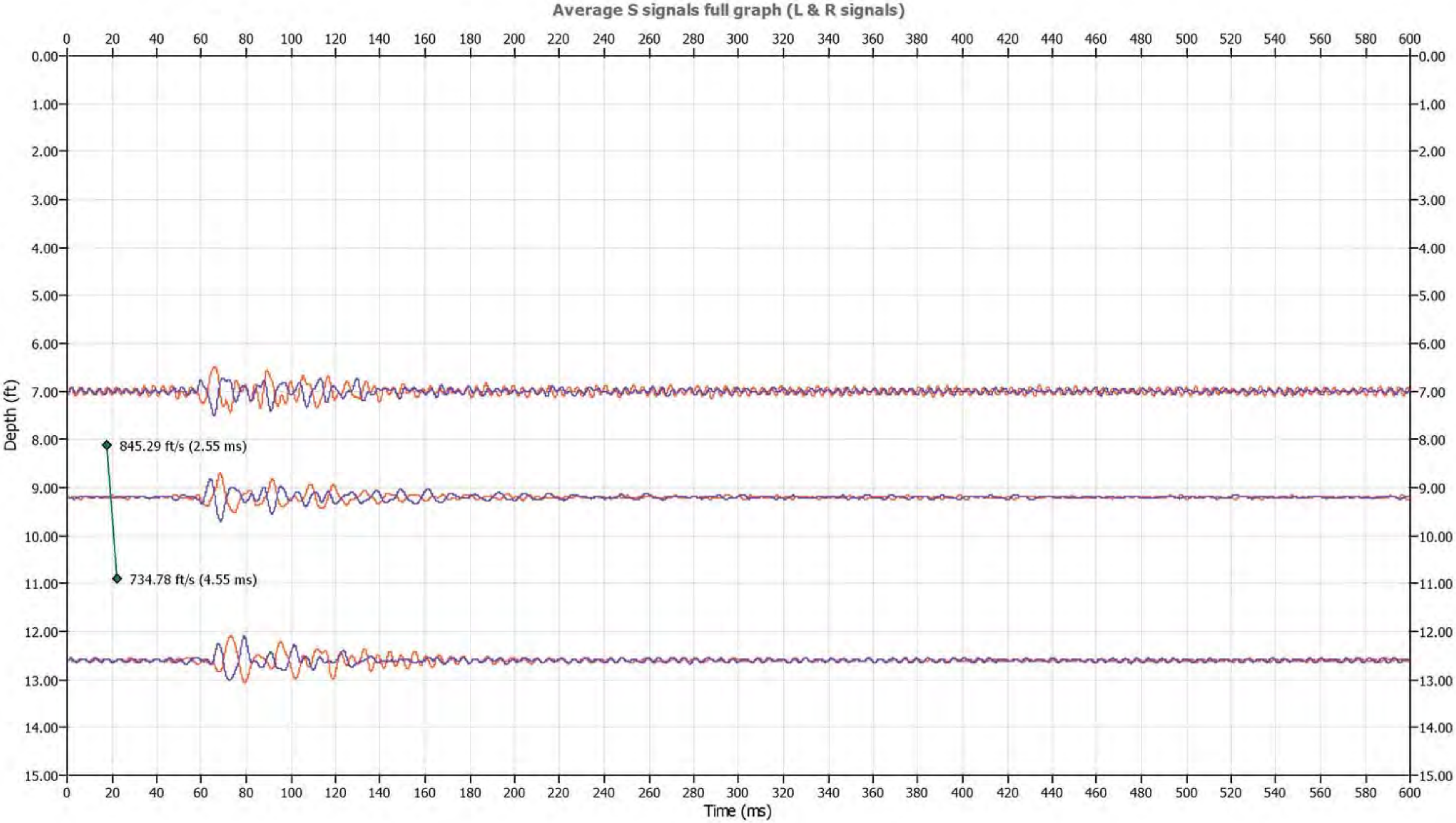
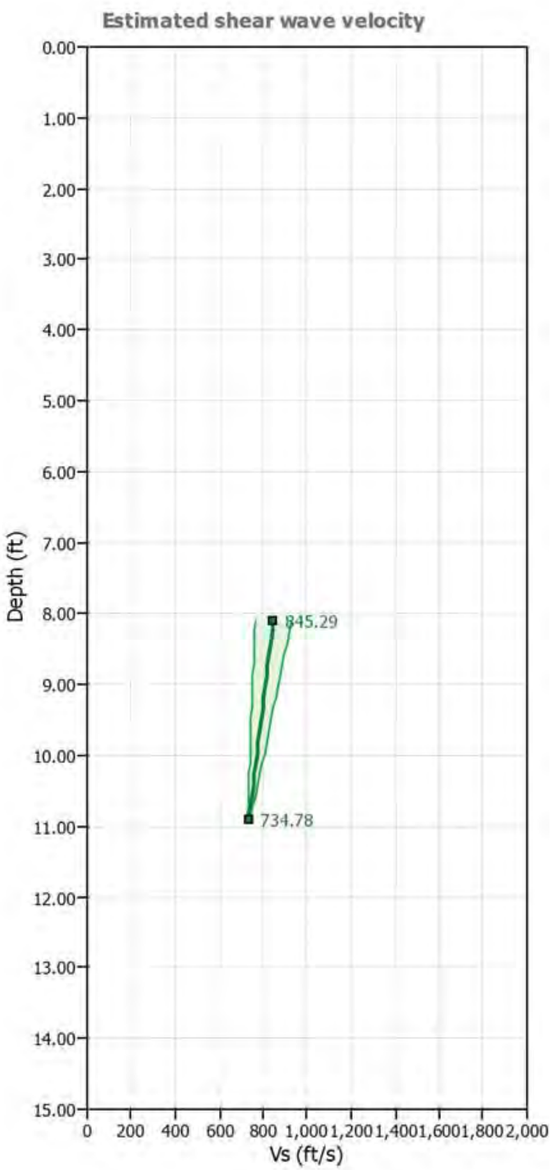
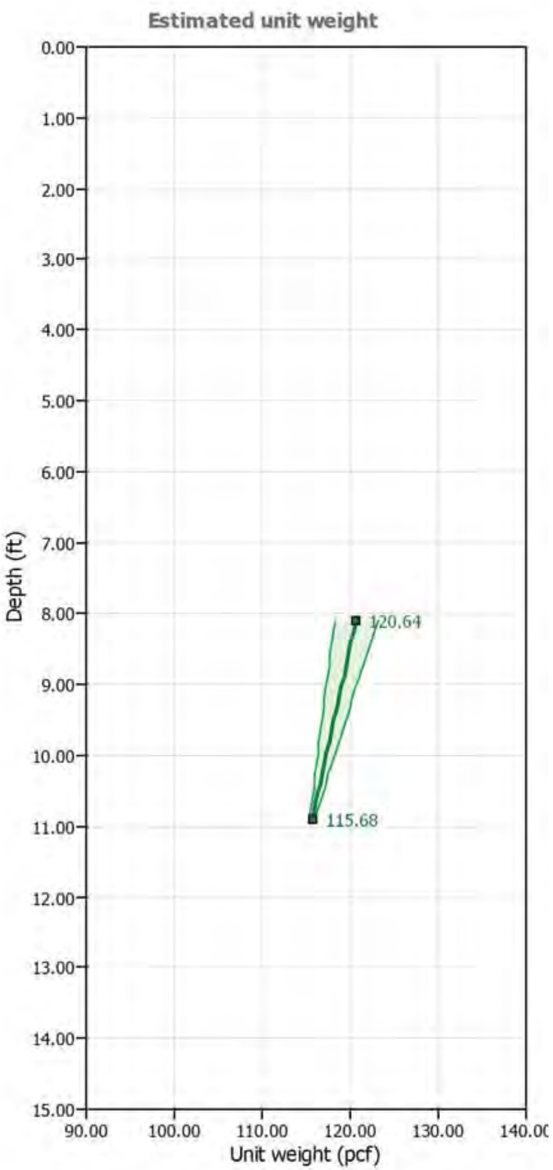
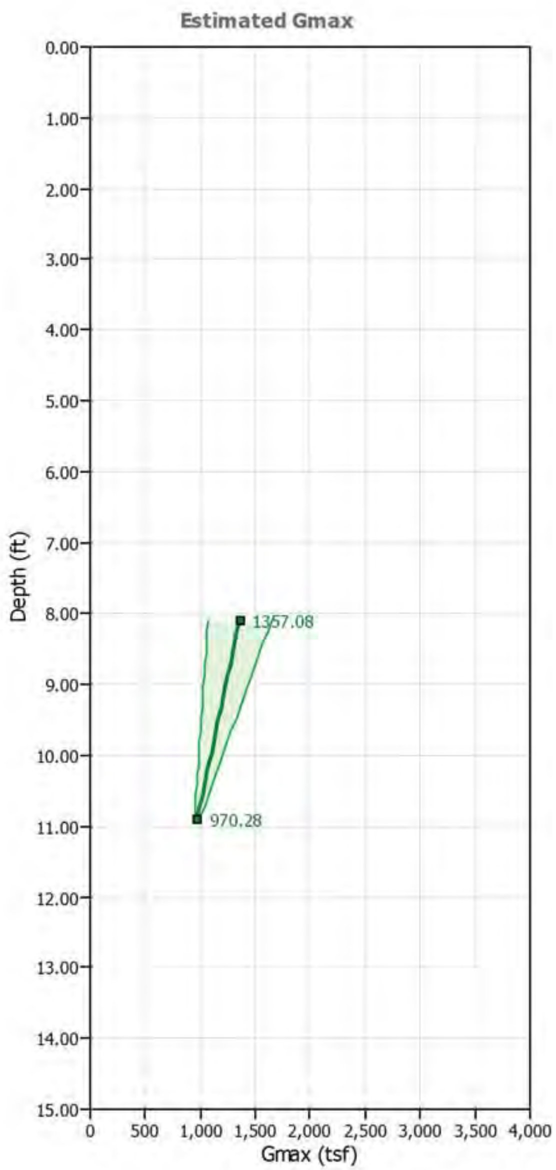
Project: B1806014 - Prairie Island ISFSI Expansion **Borehole ID: CPT-02**



Detailed result plots over depth







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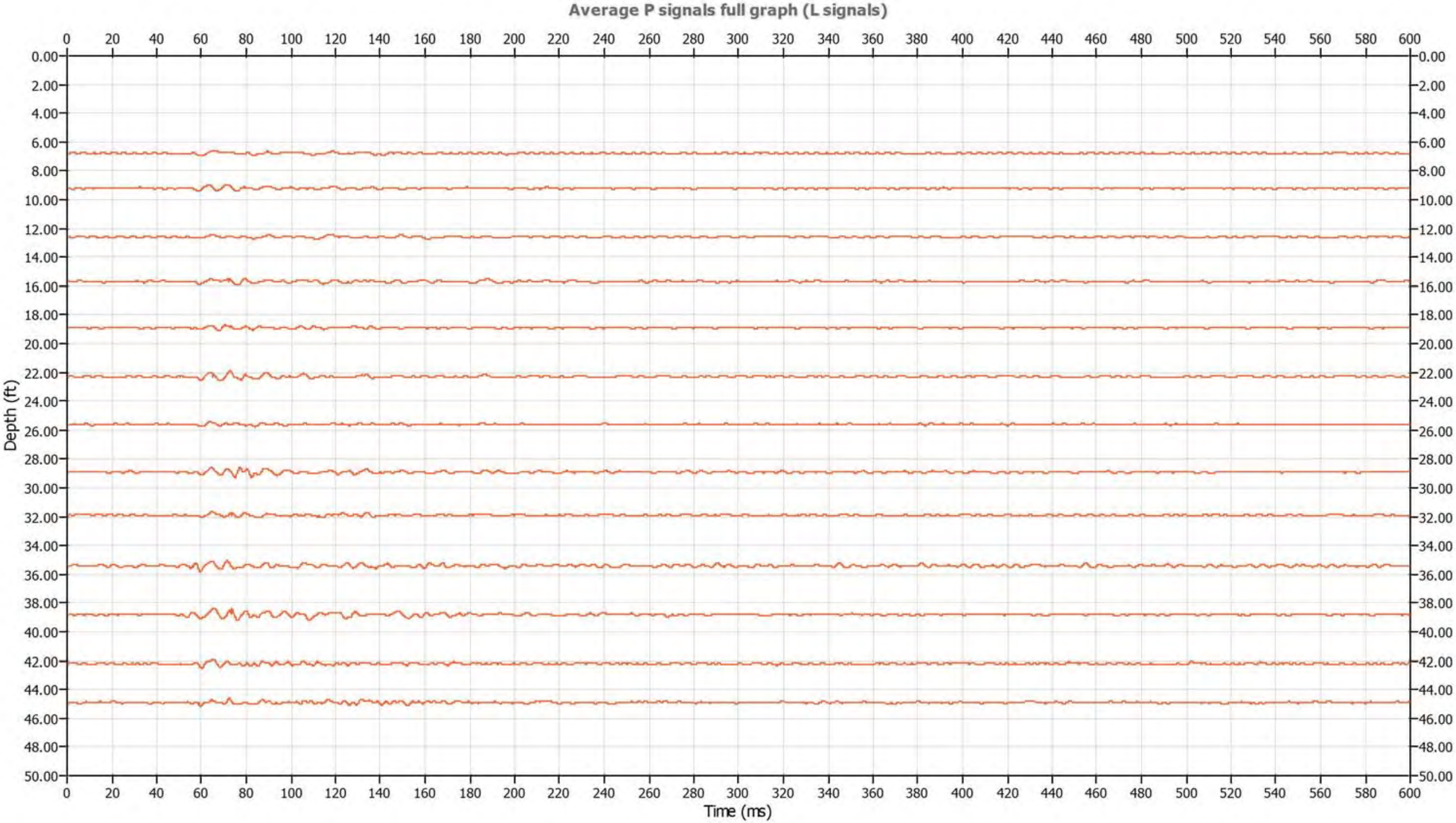
Project: B1806014 - Prairie Island ISFSI Expansion **Borehole ID: CPT-03**



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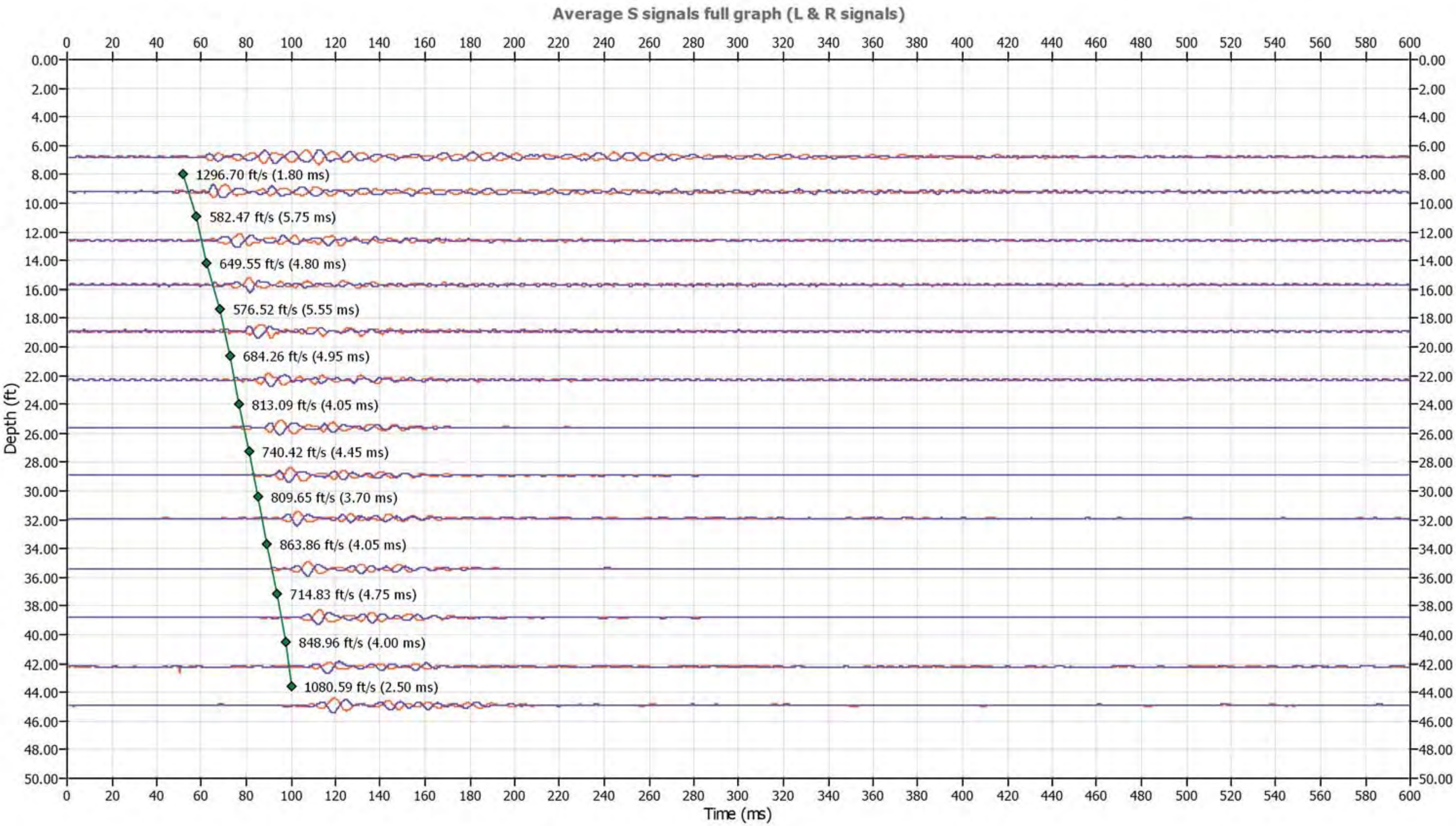
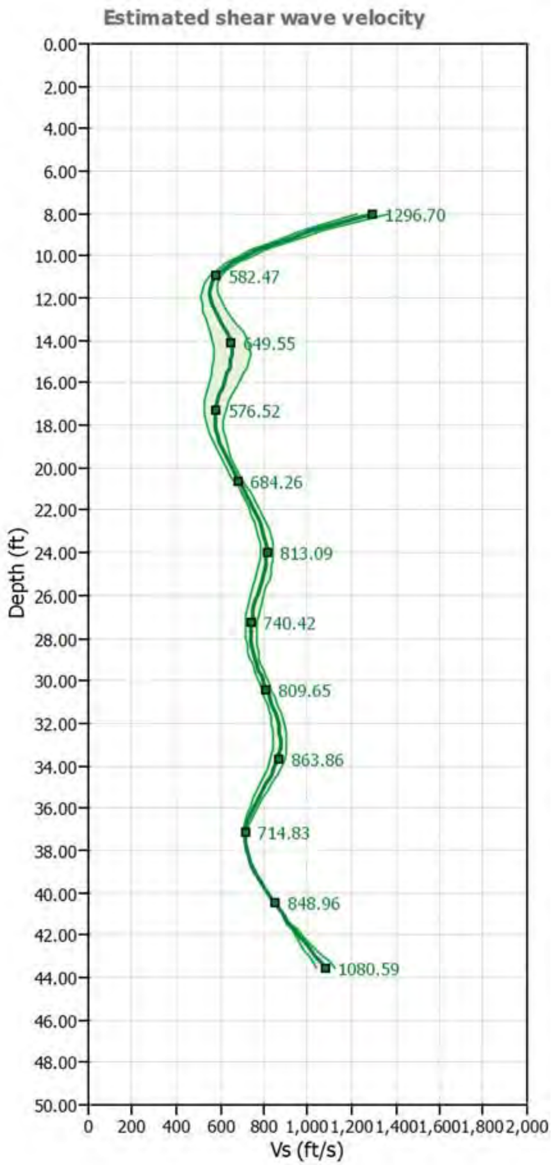
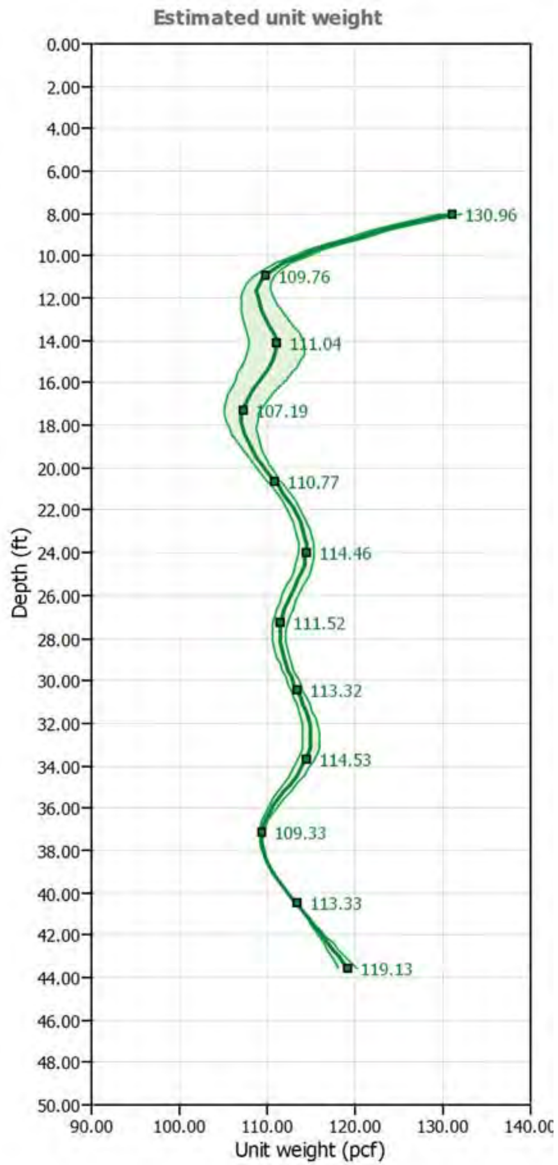
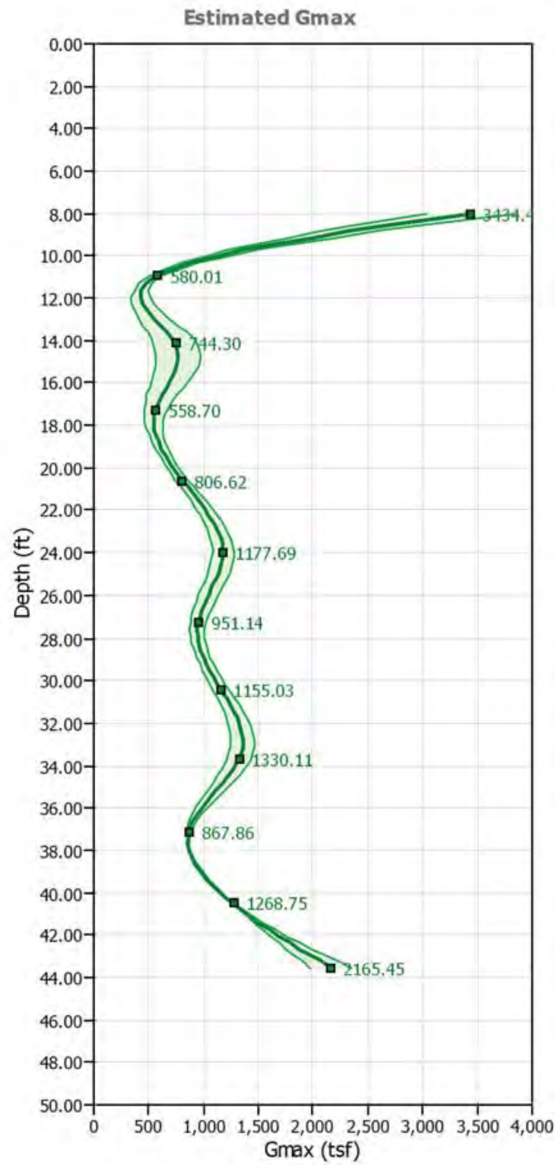
Project: B1806014 - Prairie Island ISFSI Expansion **Borehole ID: CPT-03**



Detailed result plots over depth



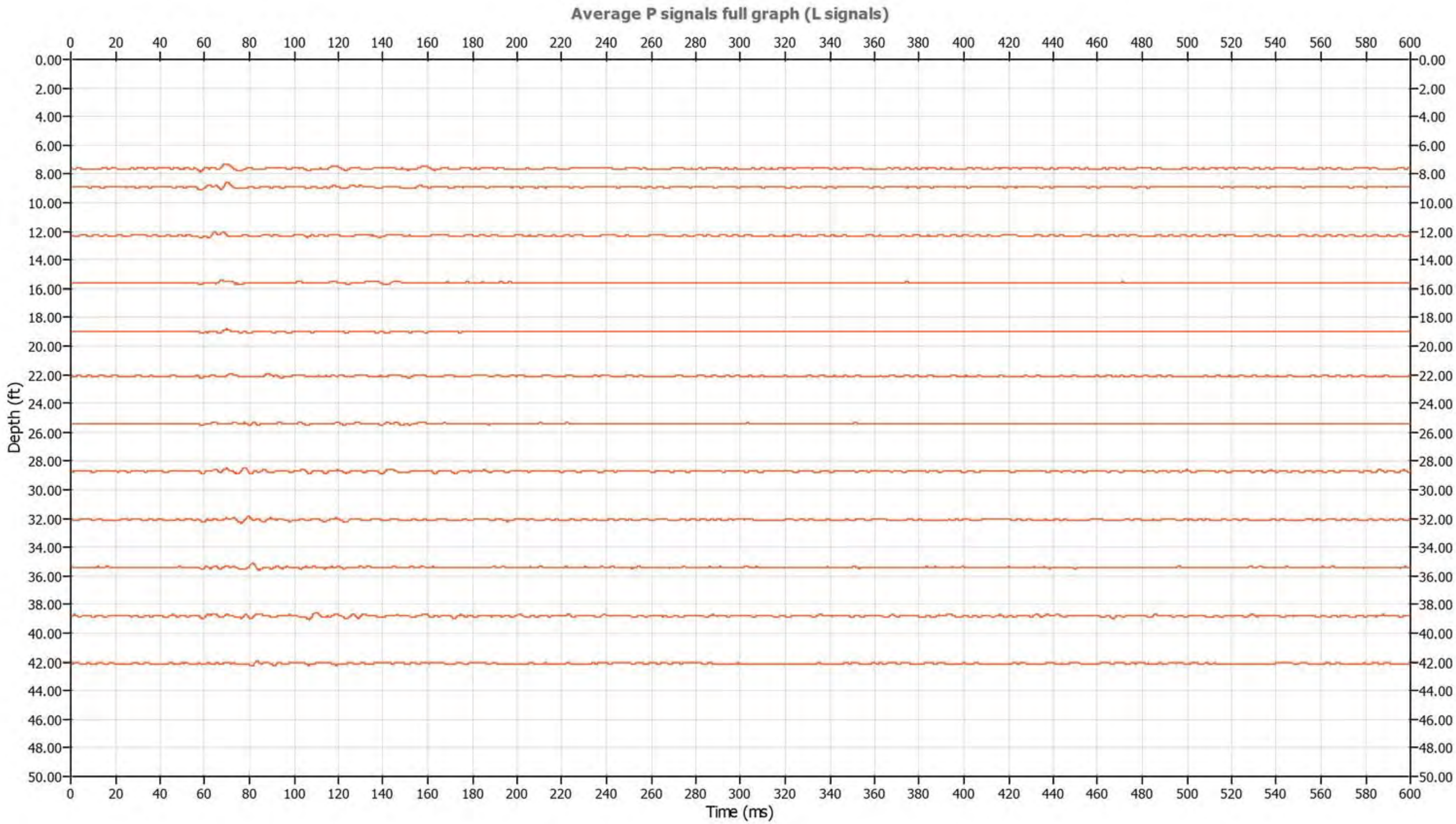




Braun Intertec Corporation

11001 Hampshire Avenue S
Minneapolis, MN 55438

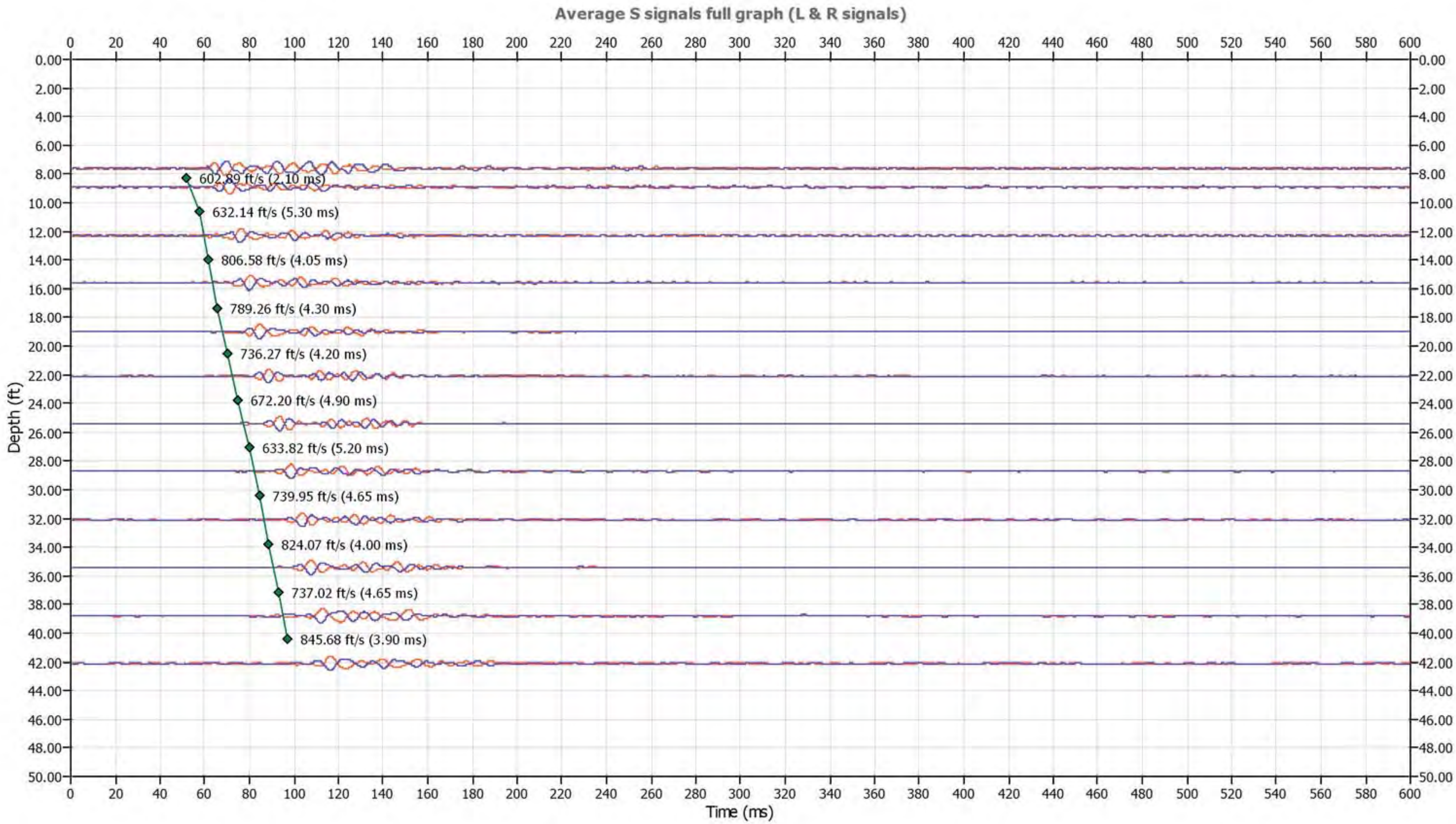
Project: B1806014 - Prairie Island ISFSI Expansion **Borehole ID: CPT-04**



Braun Intertec Corporation

11001 Hampshire Avenue S
Minneapolis, MN 55438

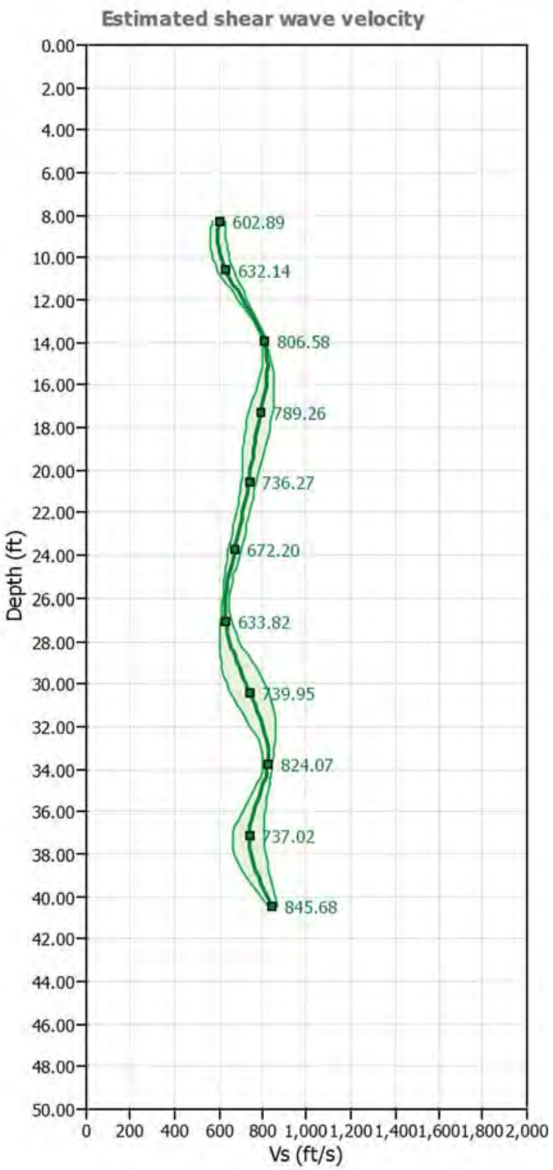
Project: B1806014 - Prairie Island ISFSI Expansion **Borehole ID: CPT-04**

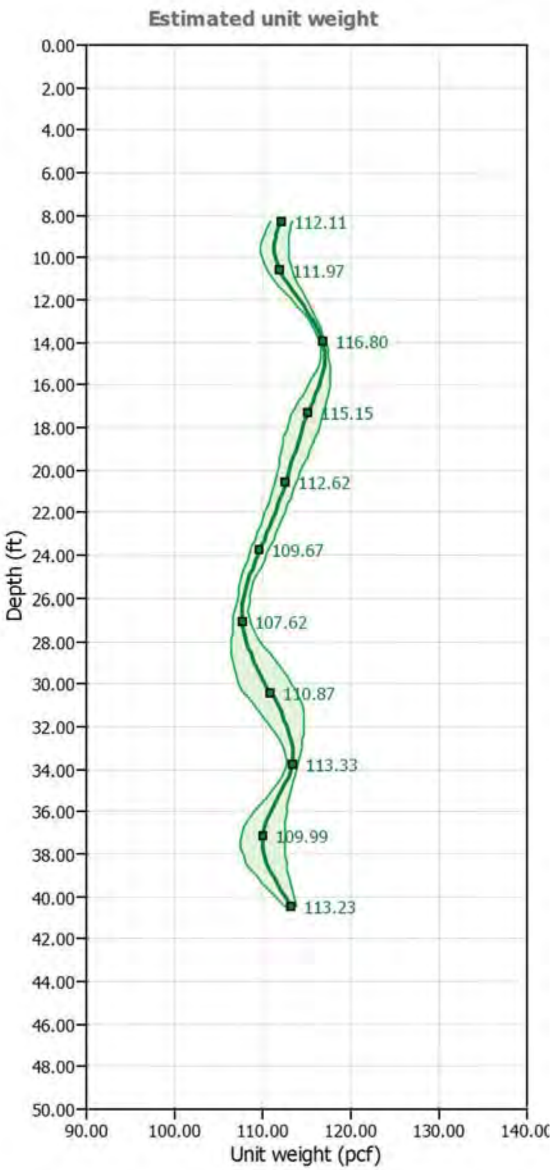


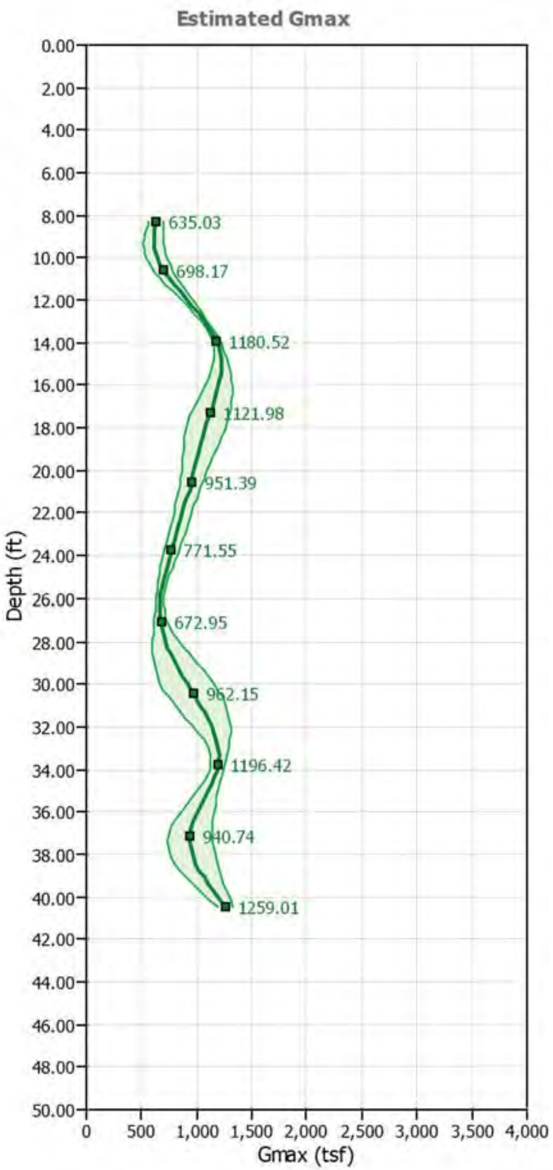
This software is licensed to: Braun Intertec Corporation

Borehole ID: CPT-04

Detailed result plots over depth







TEST CERTIFICATE
Icone (all versions)

Supplier:	A.P. v.d. Berg Machinefabriek, Heerenveen The Netherlands
Production-order:	79499
Client:	Braun Intertec
Cone-type:	I-CFXYP20-15
Cone-number:	170717

To test / To check item	Required value	Checked value
Check Quad-ring groove behind friction sleeve with check ring; **Sample testing: 1 of every 5 Icones is tested.**	Sleeve fixed	
Isolation-resistance.	>0.5 GΩ	0,5 GΩ
Straightness: Icone 5, 10 and 15 cm^2 S < 2.2. mm. At Icone base: S < 0,2 mm	S<= 2,2 mm	0,7 mm
"Classic calibration" NOT present! Check of calibration-file: "Classic calibration" removed.	O.K.	
Check alarm-settings Icone. Alarm values are set. (Kill Shutdown).	O.K.	O.K.
Software version - check at opening screen. (from 18 Jan 2018 v. 2.3)	version: 2.3	O.K.
Calibration date of Icone; check cone data [F1]..[F1].	Yes	O.K.
Initial zero-Value Tip after calibration – within 1.0 % of nominal load.	O.K.	O.K.
Initial zero-Value Local Friction after calibration – within 1.0% of nominal load.	O.K.	O.K.
Initial zero-Value Pore Pressure after calibration – within 1.0% of nominal load.	O.K.	O.K.
Initial zero-Value Inclination X. Initial zero-Value Inclination Y.	-1°< X <+1° -1° < Y <+1°	0.3 ° 0.0 °
Measurements Tip resistance OK?	Tested range:	0-75 MPa
Influence Tip load on **Local Friction and Pore Pressure:** Max. tip load: 5 cm^2: 100 MPa; 10 cm^2: 100 MPa; 15 cm^2: 75 MPa.	LF < 10 kPa PP <½% nom	7 KPa 0,2 kPa
Measurements local friction OK?	Tested range:	0-1 MPa
Local friction at max. load.	Tested value:	1,5 MPa
Measurements Pore Pressure OK?	Tested range:	0-2000 KPa
Measure Pore Pressure to 150%.	Tested value:	3000 KPa
Measurements Inclination OK?	Tested range:	24°-0-24°
Cone recognition on disconnecting and connecting Icone again?	Yes	O.K.

Remarks:

Calibrated by: Casper Oruwejan	Date: 14-06-'18	Sign.:
Final check: T. Bossche	Date: 14-06-'18	Sign.:

Calibration Certificate

a.p. van den berg

1.1 General

Cone number:	170717
Cone type:	I-CFXYP20-15
Description:	Tip 75 MPa Sleeve 1.00 MPa Inclinometer 20° Pore 2MPa
Part number:	0100297A
Certificate number:	170717-2
Client:	Braun Intertec

1.2 Calibration equipment

	calibrated
Autolog 3000	
Autolog 3000	August 2016 (Peekel: SN# 2628002)
Autolog 3000	August 2016 (Peekel: SN# 2628002)
Autolog 3000	August 2016 (Peekel: SN# 2628002)
Reference Loadcell 200kN 00287P3L	March 2016 (HBM: HBM: FT087 2016-03)
Reference Loadcell 20kN D16200	August 2016 (HBM: 56490 2016-08)
Reference Sensor 40 Bar 4318470	August 2016 (Trescal: 1607-12904)
Reference ACS-080-2-SC00-HE 08/11 470480	February 2015 (Trescal: 1502-10558)
Reference ACS-080-2-SC00-HE 08/11 470480	February 2015 (Trescal: 1502-10558)

1.3 Standard

EN ISO 22476-1 2012 Class 2

1.4 Result

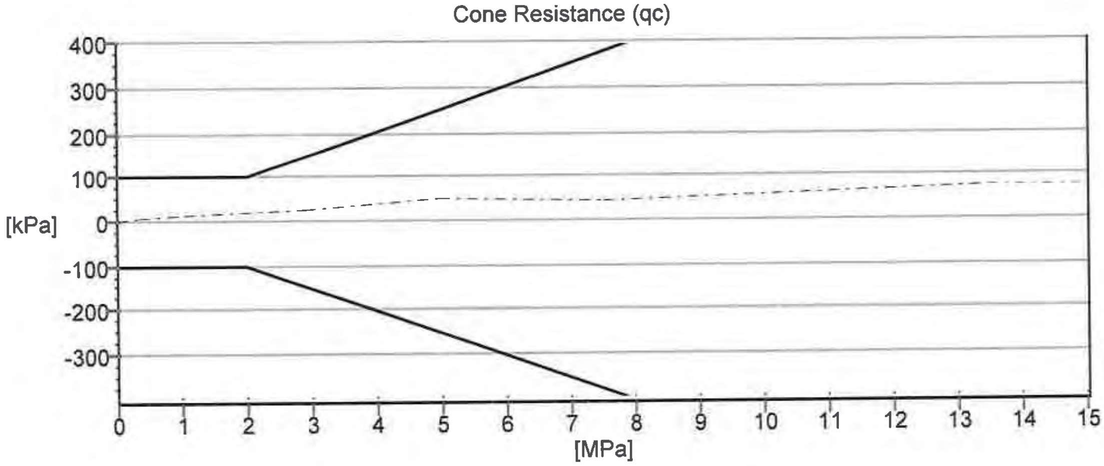
The sensor complies to the above standard

Calibrated by: C.J. Ouwejan
Date: 14/06/2018
Signature:

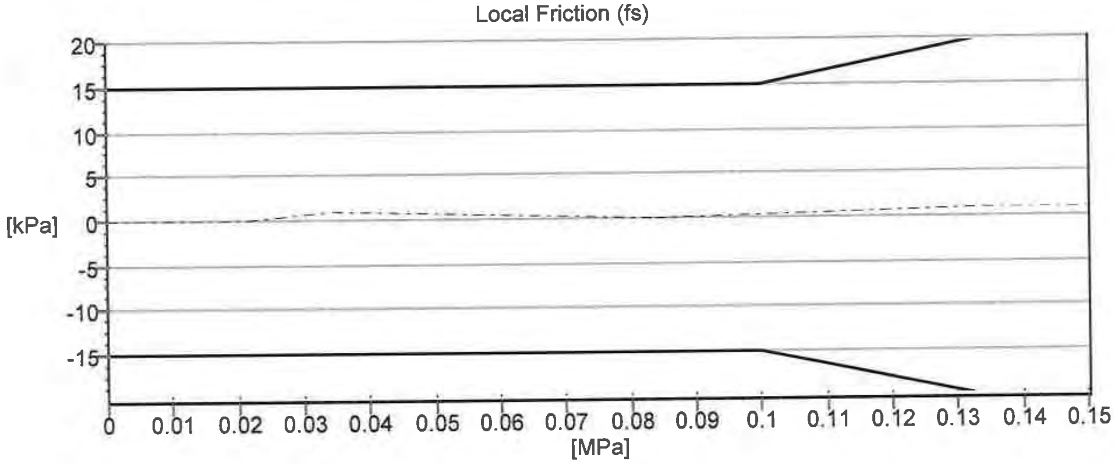
QA Manager: N.R.E. de Jong
Date: 14/06/2018
Signature:

Calibration Certificate a.p. van den berg

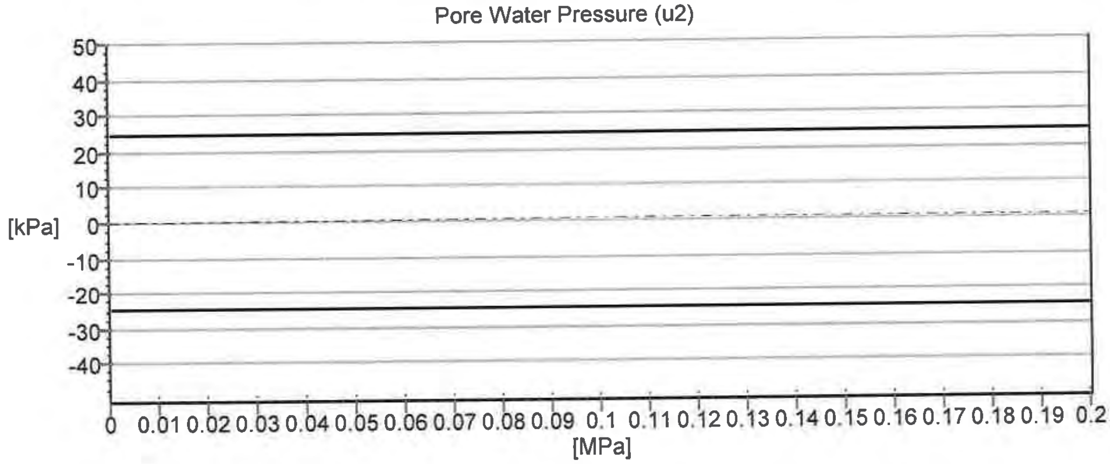
Cone Resistance (qc)



Local Friction (fs)



Pore Water Pressure (u2)



------ Deviation ——— EN ISO 22476-1 2012 Class 2

Calibration Certificate

a.p. van den berg

Zero Value			**Max. Deviation from Zero Value**		
Cone	0,015	[MPa]	Cone	3.75	[MPa]
Sleeve	0.001	[MPa]	Sleeve	0.05	[MPa]
Pore(u2)	4.1	[kPa]	Pore(u2)	100.0	[kPa]

Ref [MPa]	Cone [MPa]	Cone-Ref [kPa]
0.010	0.013	3
0.352	0.361	9
1.027	1.038	11
2.897	2.924	27
4.962	5.012	50
7.524	7.569	45
13.456	13.534	78
20.991	21.068	77
26.108	26.206	98
41.441	41.540	99
57.638	57.722	84
76.290	76.291	1

Ref [MPa]	Sleeve [MPa]	Sleeve-Ref [kPa]
0.000	0.000	0
0.021	0.021	0
0.034	0.035	1
0.084	0.084	0
0.134	0.135	1
0.178	0.179	1
0.278	0.281	3
0.360	0.361	1
0.478	0.480	2
0.636	0.637	1
0.790	0.791	1
1.013	1.014	1

Ref [MPa]	Pore(u2) [MPa]	Pore(u2)-Ref [kPa]
0.000	0.000	0
0.104	0.105	1
0.196	0.197	1
0.299	0.300	1
0.432	0.434	2
0.637	0.639	2
0.784	0.787	3
0.972	0.976	4
1.233	1.236	3
1.381	1.384	3
1.659	1.660	1
2.032	2.032	0

Data Sheet
EN ISO 22476-1 2012 Class 2

a.p. van den berg

A:	**Cone Resistance**	
	Accuracy	100.0 kPa or 5.0%
	Nom.Cone Resistance	75 MPa
	Max.Cone Resistance	150 MPa
	Effective Area	15 cm²
B:	**Local Friction**	
	Accuracy	15.0 kPa or 15.0%
	Nom.Local Friction	1.00 MPa
	Max.Local Friction	1.5 MPa
	Effective Area	225 cm²
C:	**Pore Water Pressure**	
	Accuracy	25.0 kPa or 3.0%
	Nom.Pore Water Pressure	2 MPa
	Max.Pore Water Pressure	3 MPa
D:	**Inclination X**	
	Accuracy	1.0°
	Nom.Inclination X	20°
	Max.Inclination X	25°
E:	**Inclination Y**	
	Accuracy	1.0°
	Nom.Inclination Y	20°
	Max.Inclination Y	25°

BRAUN INTERTEC

Drilling Production Report

DrillRpt03 rev. 10/12

Project Number	B1806014	**City**	Welch	**Date**	7/11/18
Project Name	Prairie Island	**State**	Minnesota	**Day**	
Project Manager	Tyler Reid	**Crew Chief (CC)**	Holmbo	**Assistant (DA)**	Rentz
		Dept.	Drill	**Addtnl. Person (AP)**	~~[illegible]~~

Vehicle	Number	Act. Miles	Est. Miles
Drill Rig			
Support Truck	—	106	
Low Boy		106	

Drilling Method	Size	Footage	Hours	Est. Ftg.	Est. Hrs.	Task	CC Hrs.	DA Hrs.	AP Hrs.	Est. Hrs.
~~Rotary Auger~~ CPT	—	166	~8			Preparation	5	–		
H S A						Travel	3	3		
Mud Rotary						Stake				
Well Installation						Utility				
Rock Coring						Drilling	8	8		
Grouting						Surveying				
Continuous Sample						Standby				
Push Probe						Repairs				
GW Sampling						**Total**	16	16		

Crew Chief Comments/Notes (if no, provide additional informaton, attach additional sheet if needed)

(X) Yes ( ) No Blue File provided?

(X) Yes ( ) No Blue File information complete?

(X) Yes ( ) No Sufficient time estimated to complete drilling?

(X) Yes ( ) No PM avaliable to discuss?

CPT-1 to 55.87 ft to refusal (gravel)

CPT-2 to 14.76 ft to refusal (possible boulder/cobble)

CPT-3 to 42.86 ft to refusal (gravel)

CPT-4 to 45.98 ft to refusal (gravel)

Project Manager Comments (if no, provide additional informaton, attach additional sheet if needed)

(X) Yes ( ) No Crew followed Instructions provided?

(X) Yes ( ) No Communication prior to, during, or after drilling?

(X) Yes ( ) No Drilling completed within estimated time?

(X) Yes ( ) No Drilling informaton complete?

~5 hours of safety training & access

(to be completed by Crew Chief) Consumables: Materials and Supplies (item 1068)

Item	Type	Qty	Item	Type	Qty
Well Screens			Redi Mix		
Riser Pipe			Portland Cement		
Couplings			Blacktop Patch		
Caps/Plugs			Thin Wall Tubes		
Protective Casing			Auger Teeth		
Locks			Bentonite	—	166
Bumper Posts			Quick Grout		
Manholes			Steam Clean		
Filter Sand			Per Diem		

(to be completed by Project Manager) For Cost Plus Project

Item	Description	Qty	Rate	Extension
1087	Mob/DeMob/day			
1004	Per Hr. Charges			
1005	Travel Time			
1007	Per Ft. Charges			
1062	per hr. all-terrain			
1067	Tractor/Lowboy			
1070	Abandonment/ft			
1018	Overtime			
1080	Steam Clean			
1012	Well Installation			
1011	Well mtrls PVC			
1039	Well mtrls iron			
1088	Well screen			
1028	Protect. Posts			
1058	Protective casing			
1022	Thin wall			
1068	Materials/other			

(to be completed by Project Manager) For Lump Sum Project

$ per hour per person

Department	Amount	Reviewed by	(initial)
		Project Manager	
		Drill Coordinator	
		Unit Pricing by PA	

Attach and modify Cost Estimate sheet from PAS if needed

Drilling Complete? (X) Yes ( ) No

Completed form sent to Drilling Coordinator for review.

WELL OR BORING LOCATION

County Name: Goodhue

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING SEALING RECORD

Minnesota Statutes, Chapter 103I

Minnesota Well and Boring Sealing No. Minnesota Unique Well No. or W-series No. (Leave blank if not known): H 354440

Township Name	Township No.	Range No.	Section No.	Fraction (sm. → lg.)
Welch	113	15	5	SE NW SE

Date Sealed: 7/11/18

Date Well or Boring Constructed: 7/11/18

GPS LOCATION – decimal degrees (to four decimal places)

Latitude ______ Longitude ______

Depth at Time of Sealing: 56 ft. Original Depth: 56 ft.

Numerical Street Address or Fire Number and City of Well or Boring Location: 55089

1717 Wakonade Dr

AQUIFER(S): [x] Single Aquifer [ ] Multiaquifer

WELL/BORING: [ ] Water-Supply Well [ ] Monit. Well [x] Env. Bore Hole [ ] Other

STATIC WATER LEVEL: [ ] Measured Date Measured 7/11/18 [x] Estimated

14 ft. [x] below [ ] above land surface

Show exact location of well or boring in section grid with "X".

Sketch map of well or boring location, showing property lines, roads, and buildings.

See attached site plan

N / W / E / S — X — ½ Mile — 1 Mile

CASING TYPE(S): [ ] Steel [ ] Plastic [ ] Tile [ ] Other NA

WELLHEAD COMPLETION

Outside: [ ] Pitless Adapter/Unit [ ] At Grade [ ] Well Pit [ ] Buried [ ] Other NA

Inside: [ ] Basement Offset [ ] Well House [ ] Well Pit [ ] Buried [ ] Other

PROPERTY OWNER'S NAME/COMPANY NAME: Northern States Power

Property owner's mailing address if different than well location address indicated above:

1717 Wakonade Dr
Welch, MN 55089

CASING(S)

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
NA in. from ___	to ___ ft.	[ ] Yes [ ] No	[ ] Yes [ ] No [ ] Unknown
___ in. from ___	to ___ ft.	[ ] Yes [ ] No	[ ] Yes [ ] No [ ] Unknown
___ in. from ___	to ___ ft.	[ ] Yes [ ] No	[ ] Yes [ ] No [ ] Unknown

WELL OWNER'S NAME/COMPANY NAME: Same as Above

Well owner's mailing address if different than property owner's address indicated above

SCREEN/OPEN HOLE

Screen from NA to ___ ft. Open Hole from ___ to ___ ft.

OBSTRUCTIONS

[ ] Rods/Drop Pipe [ ] Check Valve(s) [ ] Debris [ ] Fill [ ] No Obstruction

Type of Obstructions (Describe): NA

Obstructions removed? [ ] Yes [ ] No Describe

PUMP

[ ] Not Present [ ] Present, Removed Prior to Sealing [ ] Other

Type: NA

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
Silty Sand			0	12
Silty Clay			12	13
Silty Sand			13	56

If not known, indicate estimated formation log from nearby well or boring.

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE

[x] No Annular Space Exists [ ] Annular Space Grouted with Tremie Pipe [ ] Casing Perforation/Removal

Casing Diameter

___ in. from ___ to ___ ft. [ ] Perforated [ ] Removed

___ in. from ___ to ___ ft. [ ] Perforated [ ] Removed

Type of Perforator ___

VARIANCE

Was a variance granted from the MDH for this well? [ ] Yes [x] No TN#

GROUTING MATERIAL(S) (One bag of cement = 94 lbs., one bag of bentonite = 50 lbs.)

Grouting Material: Quik Grout from 2 to 56 ft. ___ yards 1 bags

___ from ___ to ___ ft. ___ yards ___ bags

___ from ___ to ___ ft. ___ yards ___ bags

OTHER WELLS AND BORINGS

Other unsealed and unused well or boring on property? [ ] Yes [x] No How many?

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING

CPT-01, 03, 04

B1806014 Mark Jenkins

LICENSED OR REGISTERED CONTRACTOR CERTIFICATION

This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.

Licensee Business Name: Brown Traxler — License or Registration No.: 1323

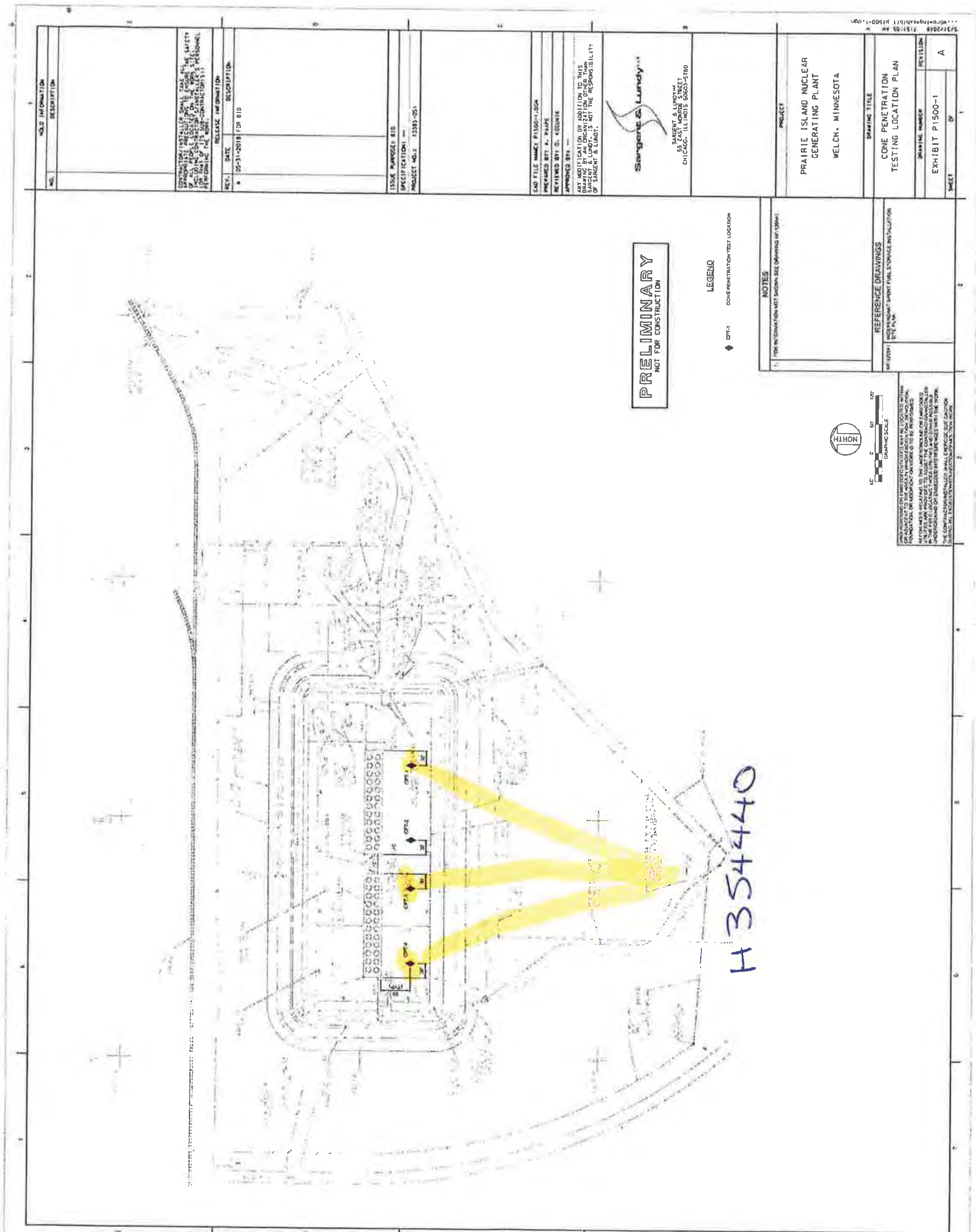
Certified Representative Signature: Greg Scallon — Certified Rep. No.: 870 — Date: 8-6-18

Name of Person Sealing Well or Boring: Adam Holmbo

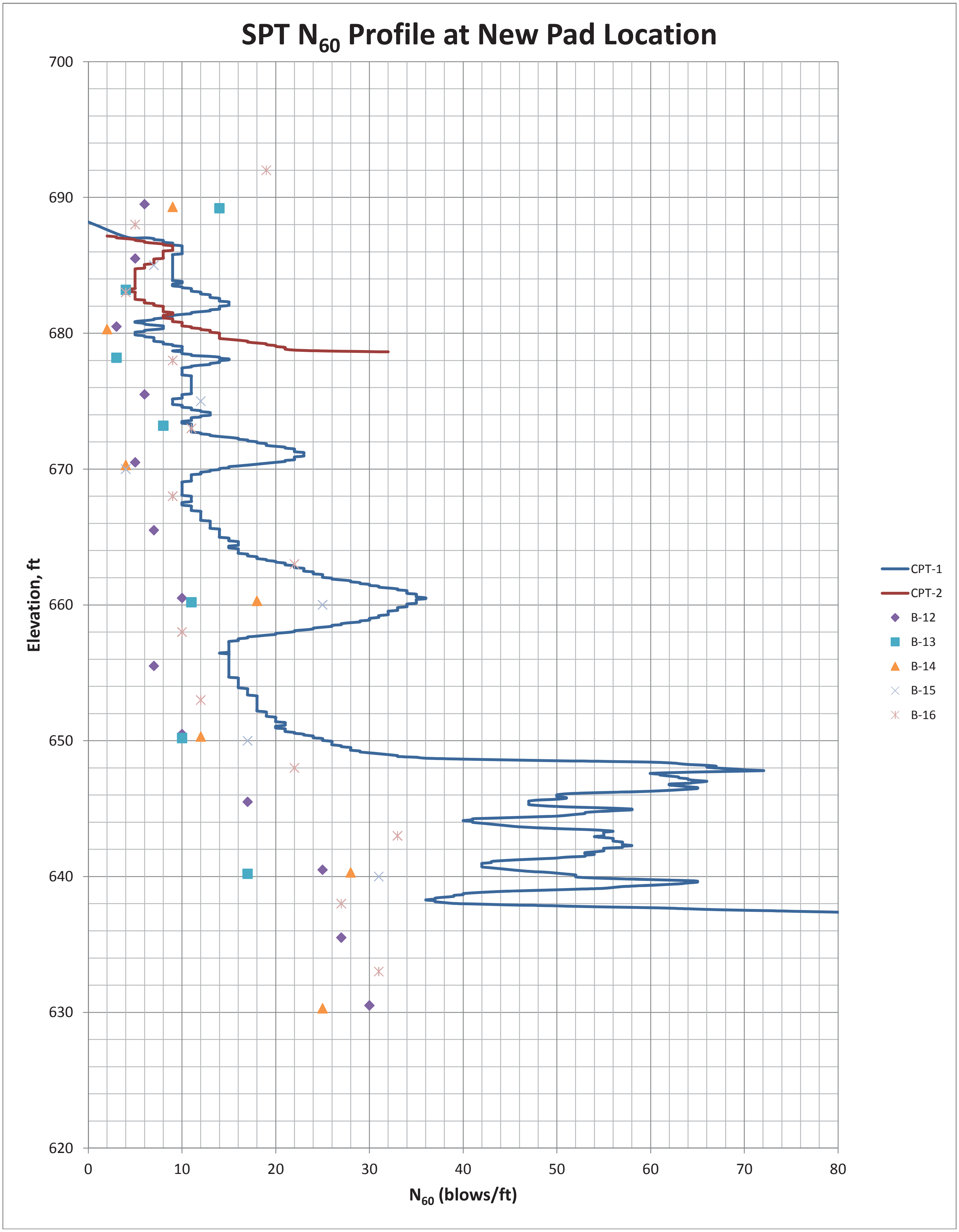
IMPORTANT-FILE WITH PROPERTY PAPERS-WELL OWNER COPY — H 354440

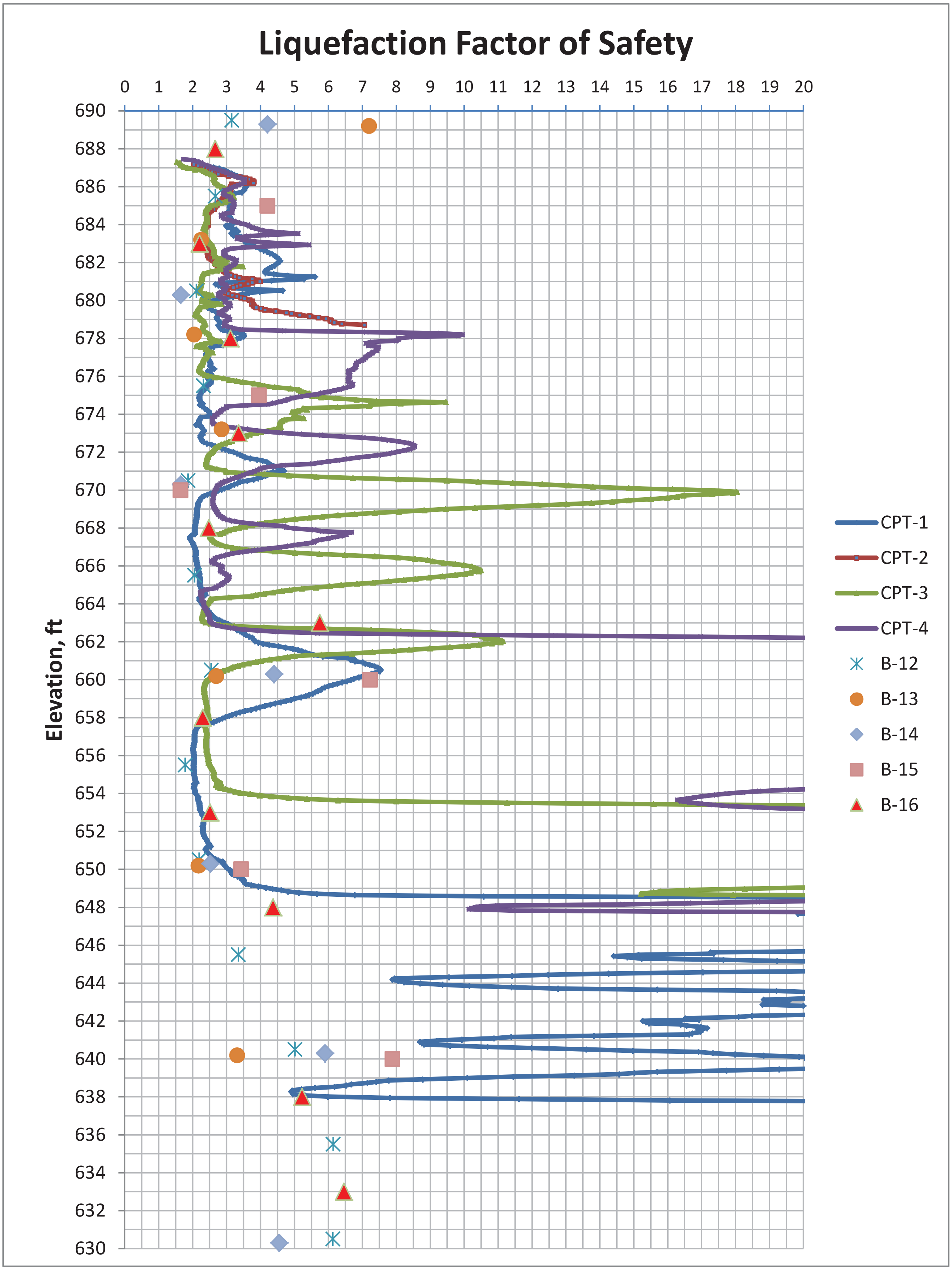
HE-01434-15 ID# 53159 8/16R

Appendix 2C



PRELIMINARY
NOT FOR CONSTRUCTION
LEGEND
CONE PENETRATION TEST LOCATION
NOTES
REFERENCE DRAWINGS
Sargent & Lundy
SARGENT & LUNDY
55 EAST MONROE STREET
CHICAGO, ILLINOIS 60603-5780
PRAIRIE ISLAND NUCLEAR
GENERATING PLANT
WELCH, MINNESOTA
CONE PENETRATION
TESTING LOCATION PLAN
EXHIBIT P1500-1
A
NORTH
GRAPHIC SCALE
CPT-1
CPT-2
CPT-3
CPT-4
H354440


SPT N_{60} Profile at New Pad Location
Elevation, ft
700
690
680
670
660
650
640
630
620
0
10
20
30
40
50
60
70
80
N_{60} (blows/ft)
CPT-1
CPT-2
B-12
B-13
B-14
B-15
B-16



Liquefaction Factor of Safety
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
690 688 686 684 682 680 678 676 674 672 670 668 666 664 662 660 658 656 654 652 650 648 646 644 642 640 638 636 634 632 630
Elevation, ft
CPT-1
CPT-2
CPT-3
CPT-4
B-12
B-13
B-14
B-15
B-16

Appendix 2C


BRAUN INTERTEC
SOIL BORING LOCATION SKETCH
GEOTECHNICAL EVALUATION
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
1717 WAKONADE DRIVE EAST
WELCH, MINNESOTA
SITE 1
SITE 2
SITE 3
DENOTES APPROXIMATE LOCATION OF STANDARD PENETRATION TEST BORING
DENOTES APPROXIMATE LOCATION OF CPT SOUNDING
SCALE: 1" = 200'

BRAUN℠ INTERTEC

' Ā(Ā)ĀĀ(Ā*ĀĀĀ-(Ā,Ā-ĀĀ,

Braun Project B14-05624
Geotechnical Evaluation
Proposed Warehouse Buildings
1717 Wakonade Drive East
Welch, Minnesota

"P QE6 + /0 14

FPXI GEPJ+ĀĀ+ĀĀ!?VT;U ?ĀĀ+ĀĀ]?!V;]?ĀĀ8## (00(%&#2Ā*1#0%;&

KQEFFĐQ+ "; [(' ' #)' #-#) | <D G=P K+ VĀ YTZĀ=8ILĀ0,&(' ' #) | KI GD+ Ā!! "# | 8XI FD+ "$ĀĀ#&

D/#3; @#0 ?ĀĀ;U	K#:0& @#0 W;W	8B'A,/		K#1%)-:0-$Ā,@Ā<(0#)-(/1 N8,-/M8G<ĀK!T ĀĀĀ,)ĀK!TĀULĀQ,%*M^8IXDĀDĀ< WMM!WĀO	"7R	SF	<X a	7! WW a	G#101Ā,)ĀJ0#
				=($2Ā#>%(0#2Ā0,Ā?@#0ĀBĀC%#/ĐĀ$#).B;					
?ĀĀ!;U	?;W	8<		8EFGHĀ8 JK LĀ@#M.)(-$#2LĀA),4$LĀ',-10LĀ,1# ; NI//53-5' O	Ā				
					\				
?U?;U	!;W	87M 8<		7PP QFHĀ6QI KDKĀ8I JK Ā4-0&Ā8FGĀ@#MĀ0 '#2- 5'M.)(- $#2LĀ(%#Ā,@6)(3#/LĀ),4 $LĀ', -10LĀ/,1#; NI//53-5' O	?_		T	?	_N##Ā(0(%&#2 .)(-$Ā1-`# (%%'5'5/ (0-,$ %5)3#O
?UT;U	T;W	87		7PP QFHĀ6QI KDKĀ8I JK LĀ@#MĀ0%()1#M.)(-$#2L 0)(%#Ā@Ā6)(3#/LĀ),4 $LĀ', -10Ā0,ĀW#@Ā0#$ 4(0#)A#()-$.LĀ3#)BĀ/,,1#Ā0,Ā/,1# ; NI//53-5' O	!_		!	!	_N##Ā(0(%&#2 .)(-$Ā1-`# (%%'5'5/ (0-,$ %5)3#O
					?_	▽	\	V	_N##Ā(0(%&#2 .)(-$Ā1-`# (%%'5'5/ (0-,$ %5)3#O
??\;U	!V;W	87		7PP QFHĀ6QI KDKĀ8I JK LĀ@#MĀ0# 2-5' M.)(-$#2L A),4 $LĀ(0#)A#()-$.LĀ,1 #; NI//53-5' O	Ā_				_$,Ā)#%3 #)B
					W_		!\	V	_N##Ā(0(%&#2 .)(-$Ā1-`# (%%'5'5/ (0-,$

LOG OF BORING N:\GINT\PROJECTS\AX PROJECTS\2014\05624.GPJ BRAUN_V8_CURRENT.GDT 9/17/14 13:50

N8##Ā'#1%)-:0-$Ā,@Ā<(0#)-(/1 .BĀ&##0ĀA(@Ā#>:/($(0-$Ā,@Ā(/#)$,(0$1O

BRAUN℠ INTERTEC

' Ā(Ā)ĀĀ(Ā*ĀĀĀ(Ā,Ā-ĀĀ,

Braun Project B14-05624 **Geotechnical Evaluation** **Proposed Warehouse Buildings** **1717 Wakonade Drive East** **Welch, Minnesota**	"P QE6 + /01 4Ā56789:; FPXI GEPJ+ĀĀĀ!?VT; U ?ĀĀ+ĀĀ?!V;] ?ĀĀ8## (00(%&#2Ā*1#0%;&
KQEFFIQ+ "; [(' ' #)' #-#) <D G=P K+ VĀ YTZĀ=8ILĀ0,&(' ' #)	KI GD+ Ā!! "# 8XI FD+ "$ĀĀ#&

D/#3; @#0 ?\?;U	K#:0& @#0 V!;W	8B'A,/	K#1%-:0-$Ā,@Ā<(0#)-(/1 N8,-/M8G<ĀK!TĀĀĀ,)ĀK!TĀULĀQ,%*M^8IXDĀD< WMM!WĀO	"7R	SF	<X a	7! WW a	G#101Ā,)Ā,J0#I
			7PP QFHĀ6QI KDKĀ8I JK LĀ@#MĀ0# 2-5' M.)(-$#2L A),4 $LĀ(0#)A#()-$.LĀ,1 #; NI//53-5' OĀ!"#$"%&'(					%5)3#O
				]_		!?	V	_N##Ā(0(%&#2 .)(-$Ā1-`# (%%5'5/ (0-,$ %5)3#O
?\W;U	VĀ;W	67 M 6<	7P PQFHĀ6 QIK DKĀ6QIbDF Ā4-0&Ā3 EGĀ$2Ā8I JK L @$#MĀ0%,5)1#M.)(-$#2LĀA),4$LĀ(0#)A#()-$.LĀ2#$1#; NI//53-5' O					
				\W_			?	_N##Ā(0(%&#2 .)(-$Ā1-`# (%%5'5/ (0-,$ %5)3#O
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Braun Project B14-05624
Geotechnical Evaluation
Proposed Warehouse Buildings
1717 Wakonade Drive East
Welch, Minnesota

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The discussion of the two original ISFSI pads in Section 4.2.1 is independent of cask design. Likewise, the discussion of the ISFSI expansion pad in this section is independent of cask design. The location of the cask drop accident analyses of the TN-40HT cask applicable to all three pads is in Section A8.2.8.

ISFSI Expansion

The primary function of the ISFSI expansion concrete pad is to provide a uniform level surface for storing the casks. The “minimum” pad elevation criterion has been set at 693 ft.-0 in. msl to preclude immersion of the cask seals during the probable maximum flood. The actual pad minimum elevation is 694 ft.-1 in. The southeast pad is slightly wider (4 ft. total) than the original pads. The gravel areas around the pads are compacted to allow for movement and positioning of the transport vehicle and tow vehicle. The subgrade preparation regimen (e.g., design of the mudmat foundation, use of compacted structural fill) for the southeast pad is the same as for the original pads.

The design of the southeast ISFSI pad used the guidance in NUREG-1536, Revision 1, “Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility” (Reference 24), for the design load requirements of the concrete pad. Note that an additional load combination is also considered to check overturning and sliding for the flooding condition so that the design load combinations for the new ISFSI pad are also consistent with the design requirements for the original ISFSI pads, discussed in Section 4.2.1. In addition, the computer program SAFE (Reference 25), was used to perform the finite element analysis for the static analysis ~~used to evaluate the design~~ of the southeast ISFSI pad. The analysis was performed to verify that the strength of the pad was adequate to prevent unacceptable cracking or differential settlement and that the casks would not tip under design loads.

The original ISFSI pads were designed for a minimum concrete compressive strength of 3,000 psi at 28 days in accordance with ACI 349-85, and the 1990 supplement. The cask drop analysis for the TN-40HT cask design is based on a maximum compressive strength of 4,000 psi. The southeast ISFSI expansion pad design is based on the requirements in ACI 349-13, consistent with the guidance in NRC NUREG-1536, Revision 1. Note that later editions of ACI 349 (beyond ACI 349-85) required a higher minimum compressive strength (> 4,000 psi) to meet freeze-thaw and durability requirements. Therefore, for the design of the southeast ISFSI pad, an exception is taken to the code provision requiring 4,500 psi minimum compressive strength to meet durability requirements so that the specified compression strength of the southeast ISFSI pad is 3,000 to 4,000 psi. Thus, the pad will represent a target of similar or lesser stiffness than the original ISFSI pads so that the existing cask drop analysis remains valid for the southeast ISFSI pad.

The 4,500 psi minimum concrete strength in ACI 349-13 is not a structural requirement, but a material requirement for long-term concrete durability. The durability suggestions for Exposure Class F2 freeze-thaw protection in ACI 201.2R-16, “Guide to Durable Concrete” (Reference 29), are applied to ensure the durability of the new ISFSI pad while still meeting the cask drop analysis requirements.

Sliding and overturning of casks is not reevaluated for the southeast pad, except for seismic loads, because hydrological loads (i.e., design basis flooding) and accident loads (i.e., the design basis munitions barge explosion) are enveloped by the tornado wind load. The tornado wind load and missile impact analysis in this addendum remains applicable (i.e., the coefficient of friction for the southeast pad is the same as for the original pads). The effect of seismic loads associated with the design basis safe shutdown earthquake (SSE) was reevaluated because the dynamic analysis is performed using a different method which results in the development of new seismic loads (see Section A4.2.1.2).

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For Page A4.7-2

24. NUREG-1536, Revision 1, “Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility”, July 2010.

25. SAFE, Version 12.3.1, Computers & Structures, Inc. (Sargent & Lundy, LLC (S&L) Program No. 03.7.241-12.3.1).

26. SHAKE2000, Version 9.95 (S&L Program No. 03.7.402-9.95)

27. SASSI2010, Version 1.0 (S&L Program No. 03.7.316-1.0-250USER-M01)

28. Response Spectrum Generator (RSG), Version 2.0 (S&L Program No. 03.7.414-2.0)

29. American Concrete Institute, ACI 201.2R-16, “Guide to Durable Concrete”

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Impact of Southeast ISFSI Pad Expansion

As discussed in Section A3.3.2.2.4.1, the view factor in the detailed TN-40HT cask model is based on a cask alignment of two rows of infinite length, which is conservative for the original configuration of two ISFSI pads. As shown in Figure A3.3-20 and documented in the associated analysis, the view factors from the emitting cask to the receiving casks beyond cask 5 are not considered in the calculation due to their negligible effect.

The distance from the emitting cask to cask 5 is approximately,
$(18\text{ ft.}^2 + (4 \times 18\text{ ft.})^2)^{0.5} \approx 74$ ft.
The distance between the closest cask on the original northwest ISFSI pad and the southeast ISFSI pad is approximately,
$((9\text{ ft.} + 40\text{ ft.} + 9\text{ ft.})^2 + (11\text{ ft.} + 38\text{ ft.} + 9\text{ ft.})^2)^{0.5} \approx 82$ ft.
Thus, the southeast ISFSI pad does not affect the original northwest ISFSI pad.

The calculated view factors used in the detailed TN-40HT cask model are not changed as a result of the southeast ISFSI pad. However, similar to how to the storage array model was used to estimate the increase in the cask outer shell temperature due to the concrete pad and the service road, the effect on the average cask surface temperature due to the addition of a southeastern ISFSI pad is evaluated for the original northeastern pad. The impact of the southeast ISFSI pad, fully loaded with TN-40HT casks, on the original northeast ISFSI pad, fully loaded with TN-40HT casks, for the radiant heat transfer between the casks, ground, and environment is evaluated with the use of ~~a computational fluid dynamics (CFD) model. The CFD model is developed using~~the surface-to-surface radiation modeling capabilities of the STAR-CCM+ (Reference 49) software.

~~This~~ The STAR-CCM+ model evaluated the radiation heat transfer between the casks, ground, and environment but did not model air flow around the cask (i.e., convection is modeled as a boundary condition), similar to how the ANSYS model evaluates radiant heat transfer. Although heat conduction through the casks and ground is also included in the models, only the temperature distributions on the outer surfaces of the casks are to be regarded as valid results since the internal details of the casks and conduction heat transfer through solid casks were modeled in a simplified manner. Sensitivity runs were performed to ensure that the temperature distributions inside the casks and the ground did not impact the results of the analysis. For both casks and ground, the thermal conductivity is considered using three parametric runs with values ranging from 0.5 W/m-K to 5.0 W/m-K in order to envelop typical expected values. The model is discretized in approximately 300,000 cells. A benchmark was performed against the results of the existing storage array model using a STAR-CCM+~~CFD~~ model case with one set of two rows of casks, and it was determined that the STAR-CCM+~~CFD~~ model yields cask exterior temperature results that were essentially the same as the ANSYS storage array model. Another case with two sets of two rows of casks with pads spaced 38 ft~~.~~ apart was used to determine the maximum and average cask exterior temperatures, as shown in Table A3.3-10A. This model is shown in Figure A3.3-21A. Additional conservatism to address the modeling uncertainty was then incorporated into the results of the STAR-CCM+~~CFD~~ analysis so that the cask surface temperature is conservatively considered to increase by 5 °F.

As previously discussed in this section, the storage array model results in Table A3.3-10 demonstrated an increase in the average cask surface temperature of 18 °F that corresponded to an increase in the average cask inner shell temperature of 1 °F or less, as compared to the detailed TN-40HT cask model. These results are scaled to estimate an increase in the internal cask temperatures, due to the addition of the southeast ISFSI pad, as shown below.

$$\Delta T_{\text{ave increase}} = \frac{(18°\text{F} + 5°\text{F})}{18°\text{F}} \cdot 1°\text{F} = 1.28°\text{F}$$

This would indicate the effect of the southeast ISFSI pad on average cask interior temperature is also less than 1 °F (i.e., 0.28 °F). In order to conservatively evaluate the impact of the southeast ISFSI pad. The overall increase in cask inner average temperatures of 1.28 °F (i.e., 1 °F from the existing storage array model and an additional 0.28 °F for the effect of the southeast ISFSI pad) is conservatively rounded to 2 °F and used to confirm the remaining margin for design limits is sufficient.

As before, since the basket temperatures calculated in the TN-40HT detailed model remain relatively unaffected, these temperatures can continue to be used for calculation of the thermal stress, thermal expansion, and cask cavity pressure for the structural evaluation.

Further thermal analysis and review of allowable limits associated with cask exterior and interior temperatures (including the effects on internal pressure and thermal expansion) was performed and demonstrated that there is sufficient margin to account for an increase in the cask exterior temperatures of 5°F and increase in the interior temperatures of 2 °F.

TABLE A3.3-7
MAXIMUM COMPONENT TEMPERATURES FOR BURIED CASK
(FUEL ASSEMBLY WITHOUT BPRAS)

Component	Temperature (°F)	Time (hr)	Limit (°F)
Fuel Cladding**	1058	~~93~~ 92.49	1058
Fuel Compartment**	1024	~~93~~ 92.51	---
Basket Rails**	889	~~93~~ 92.56	---
Cask Inner Shell *,**	774	~~93~~ 92.6	---
Shield Shell *, ‡	769	~~93~~ 92.61	---
Radial Resin ~~*~~ †, ‡	300	~~1.85~~ 1.23	300
Cask Outer Shell ~~*~~ †, ‡	779	~~93~~ 92.1	---
Top Shield Plate ~~**~~ ‡	319	~~93~~ 91.92	---
Cask Lid ~~**~~ ‡	316	~~93~~ 91.92	---
Top Resin‡	300	~~85.75~~ 81.82	300
Protective Cover ~~**~~ ‡	316	~~93~~ 92.7	---
Lid Seal ~~**~~ ‡	317	~~93~~ 92.15	536
Vent & Port Seal ~~**~~ ‡	316	~~93~~ 92.1	536

* This value is the volumetric average temperature at the hottest cross section.

† ~~*~~ This value is the volumetric average temperature at the hottest cross section plus 18 °F to bound the view factor effects on the initial temperatures. See Section A3.3.2.2.4 for discussion.

~~** Based on conservative results for 95.75 hours after the cask is buried.~~

‡ An additional 5 °F **was** added to **the initial temperature to** account for the effect of the southeast ISFSI pad expansion on cask exterior temperatures. See Section A3.3.2.2.4.1.1 for discussion.

** An additional 2 °F **was** added to **the initial temperature to** account for the effect of the southeast ISFSI pad expansion on cask interior temperatures. See Section A3.3.2.2.4.1.1 for discussion.

9.8 AGING MANAGEMENT

9.8.1 Aging Management Review

An aging management review (AMR) of the ISFSI systems, structures, and components (SSC) was conducted as part of the ISFSI License Renewal process. The AMR addresses aging effects/mechanisms that could adversely affect the ability of the SSCs to perform their safety functions during the period of extended operation. The results of the AMR determined that there were aging effects that require aging management activities for the casks, concrete pads, and earthen berm. Although the AMR did not identify any aging effects for the spent fuel assemblies that could lead to a loss of intended function, a High Burnup Fuel Monitoring Program as described in Section A9.8.4 will be used to confirm that the intended function(s) of high burnup fuel stored in TN-40HT casks are maintained during the period of extended operation. The potential aging effects for the casks, concrete pads, and earthen berm are identified in the ISFSI Inspection and Monitoring Activities Program and the Time-Limited Aging Analyses.

9.8.2 ISFSI Inspection and Monitoring Activities Program

The purpose of the ISFSI Inspection and Monitoring Activities Program is to ensure that the structure's or component's intended functions(s) is not degraded for the in-service dry fuel storage casks, reinforced concrete storage pads or earthen berm.

The ISFSI Inspection and Monitoring Activities Program will perform periodic inspection activities that monitor the condition of ISFSI structures and subcomponents that are classified as Safety Related (or Important To Safety for the TN-40HT casks) or whose failure could prevent fulfillment of a function that is important to safety, or its failure as a support structure or component could prevent fulfillment of a function that is important to safety. Added in-scope SSCs are included in the ISFSI Inspection and Monitoring Activities Program beginning at 20 years of service.

The aging effects managed by this program are included in Table 9.8-1. The aging effects/mechanisms applicable to each structure and component are dependent upon the associated material/environment combinations, design, and installation. Those structures and components that have been grouped together for aging management review (e.g., Carbon Steel in Atmosphere/Weather) have been evaluated and based upon the materials of construction, design, installation, and environments, will have the same aging effects.