Calculation Cover Sheet

Project	Calculation No.	Project Number
N.A.	K-CLC-Z-00001	N.A.
Title Liquefaction Potential for Saltstone Disposal Facility Vault No. 4 (U)	**Functional Classification** GS **Discipline** Geotechnical	Sheet 1 of ~~125~~ 126 and 1 computer disk MDM 8/27/02

☐ Preliminary ☒ Confirmed

Computer Program No.	Version / Release No.
☐ N/A	N/A

Purpose and Objective

This calculation evaluates the liquefaction potential for the Saltstone Disposal Facility Vault No. 4 when subjected to the Design Basis Earthquake (DBE). Liquefaction potential was evaluated for post closure conditions (i.e., after placement of 20 feet of capping soil over the vault roof). In addition, the amount of settlement resulting from liquefaction and partial liquefaction is estimated.

Summary of Conclusion

See Conclusion Section.

UNCLASSIFIED
DOES NOT CONTAIN
UNCLASSIFIED CONTROLLED
NUCLEAR INFORMATION
ADC & Reviewing Official Michael D. McHood
(Name and Title)
Date: 11-3-02

Revision

Rev. No.	Revision Description
0	Original

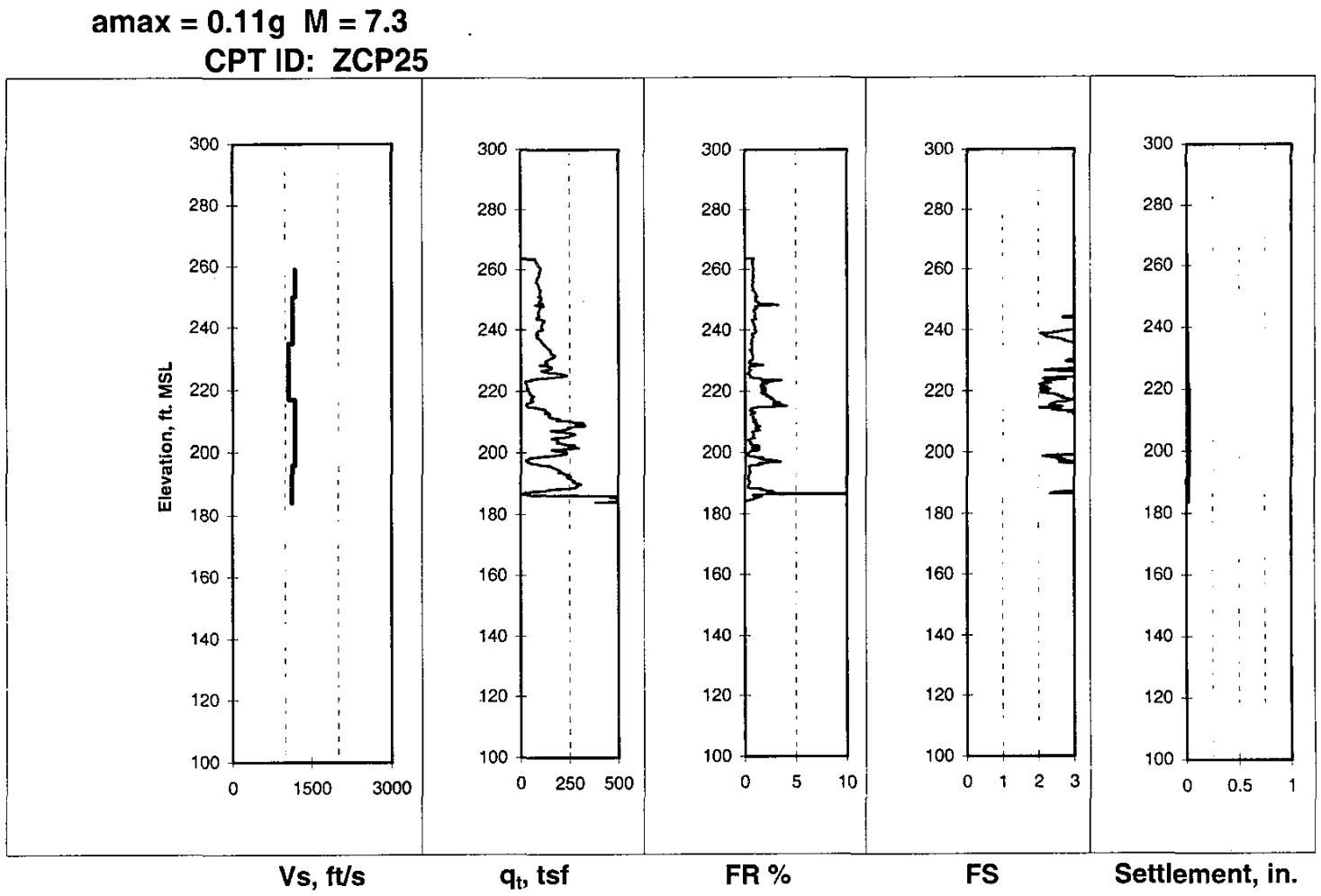
Sign Off

Rev. No.	Originator (Print) Sign / Date	Verification / Checking Method	Verifier / Checker (Print) Sign / Date	Manager (Print) Sign / Date
0	Michael McHood Michael McHood 8-22-02	Document Review	William T. Li William T. Li 8-22-02	Michael R. Lewis M.R. Lewis 8/22/02

Release to Outside Agency – Design Authority (Print)	Signature	Date

Security Classification of the Calculation
Unclassified

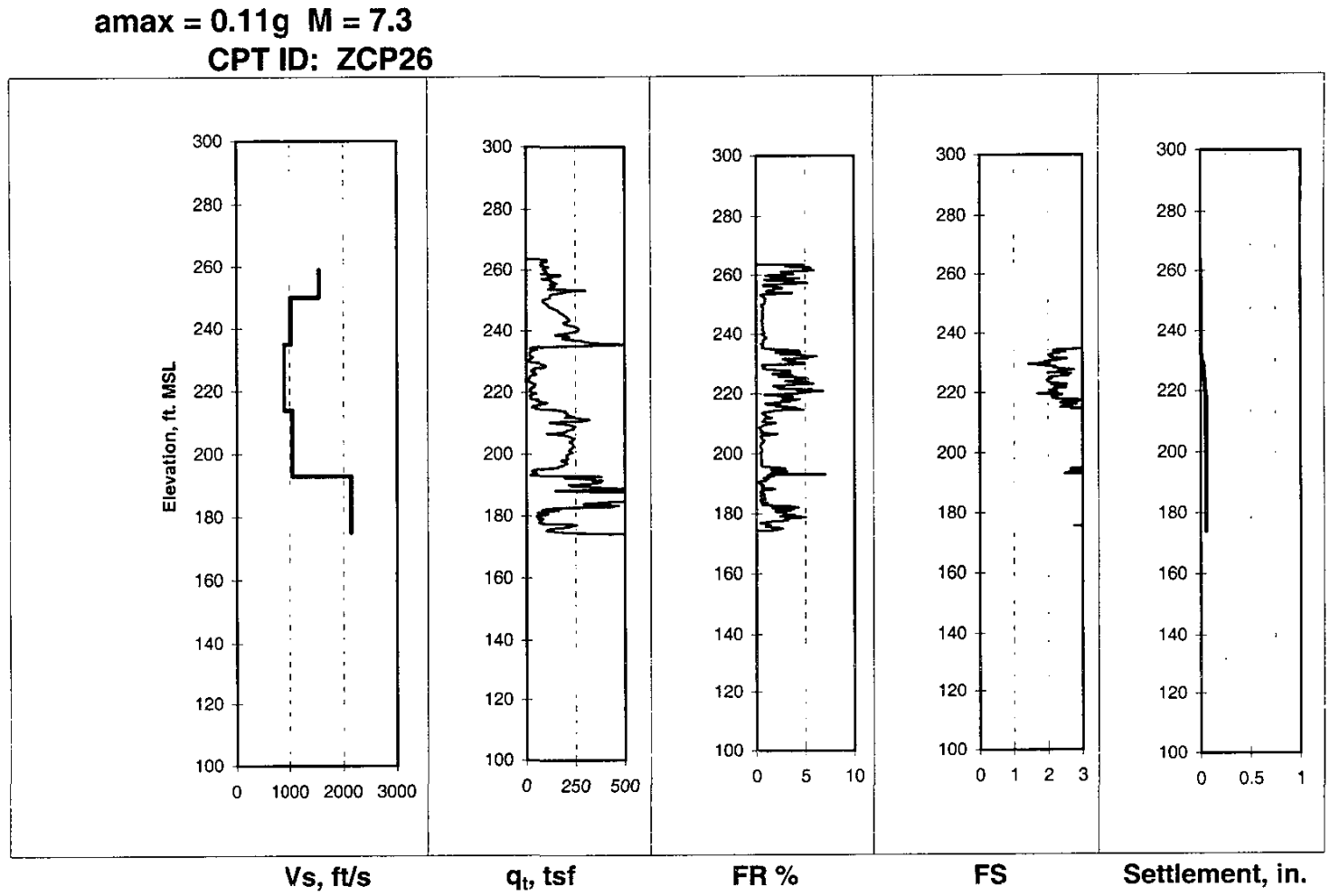
ENGINEERING DOC. CONTROL – SRS
00625632



Zcp25-liq-ch.xls

Calculation No. K-CLC-Z-00001	Sheet No. 100	Rev. 0

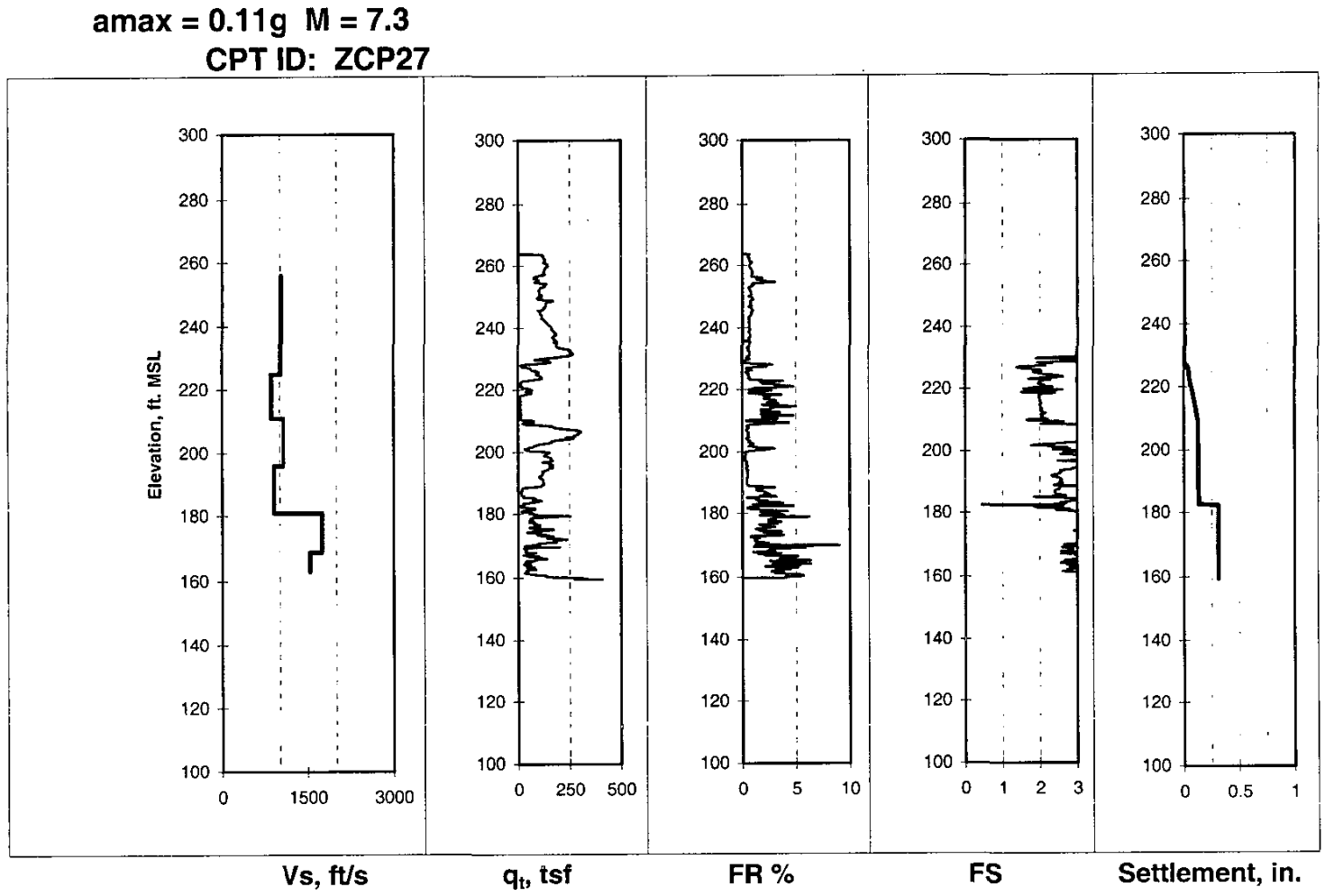
Figure 26d – Factor of Safety and Settlement vs. Elevation for SCPTu ZCP-25 and Charleston Earthquake
(Calculated using q_{t1} data, CPTu determined percent fines and Equations 17 – 43)



Zcp26-liq-ch.xls

Calculation No. K-CLC-Z-00001	
Sheet No. 101	Rev. 0

Figure 26e – Factor of Safety and Settlement vs. Elevation for SCPTu ZCP-26 and Charleston Earthquake
(Calculated using q_{tl} data, CPTu determined percent fines and Equations 17 – 43)

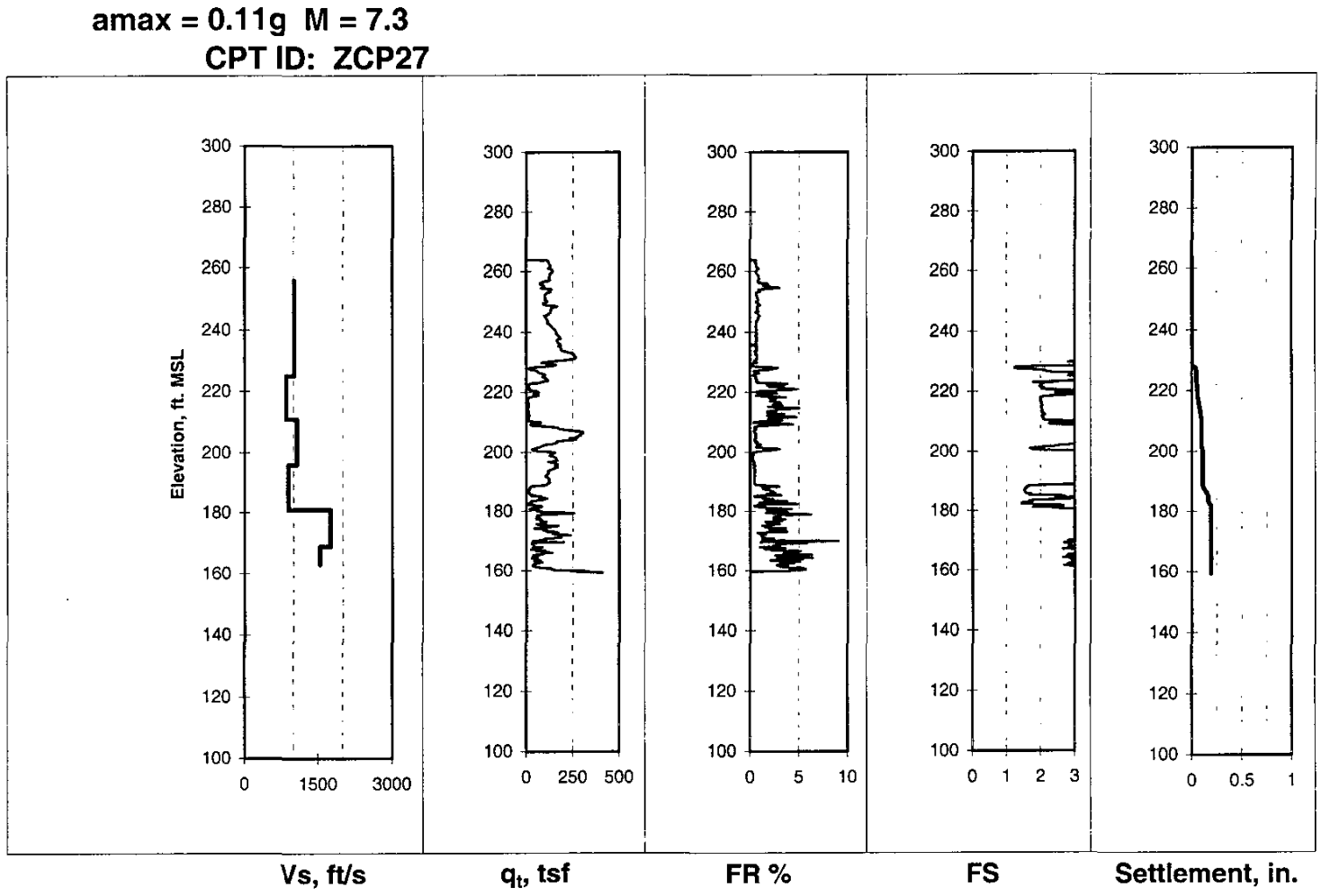


Zcp27-liq-ch.xls

Calculation No. K-CLC-Z-00001	
Sheet No. 102	Rev. 0

Figure 26f – Factor of Safety and Settlement vs. Elevation for SCPTu ZCP-27 and Charleston Earthquake

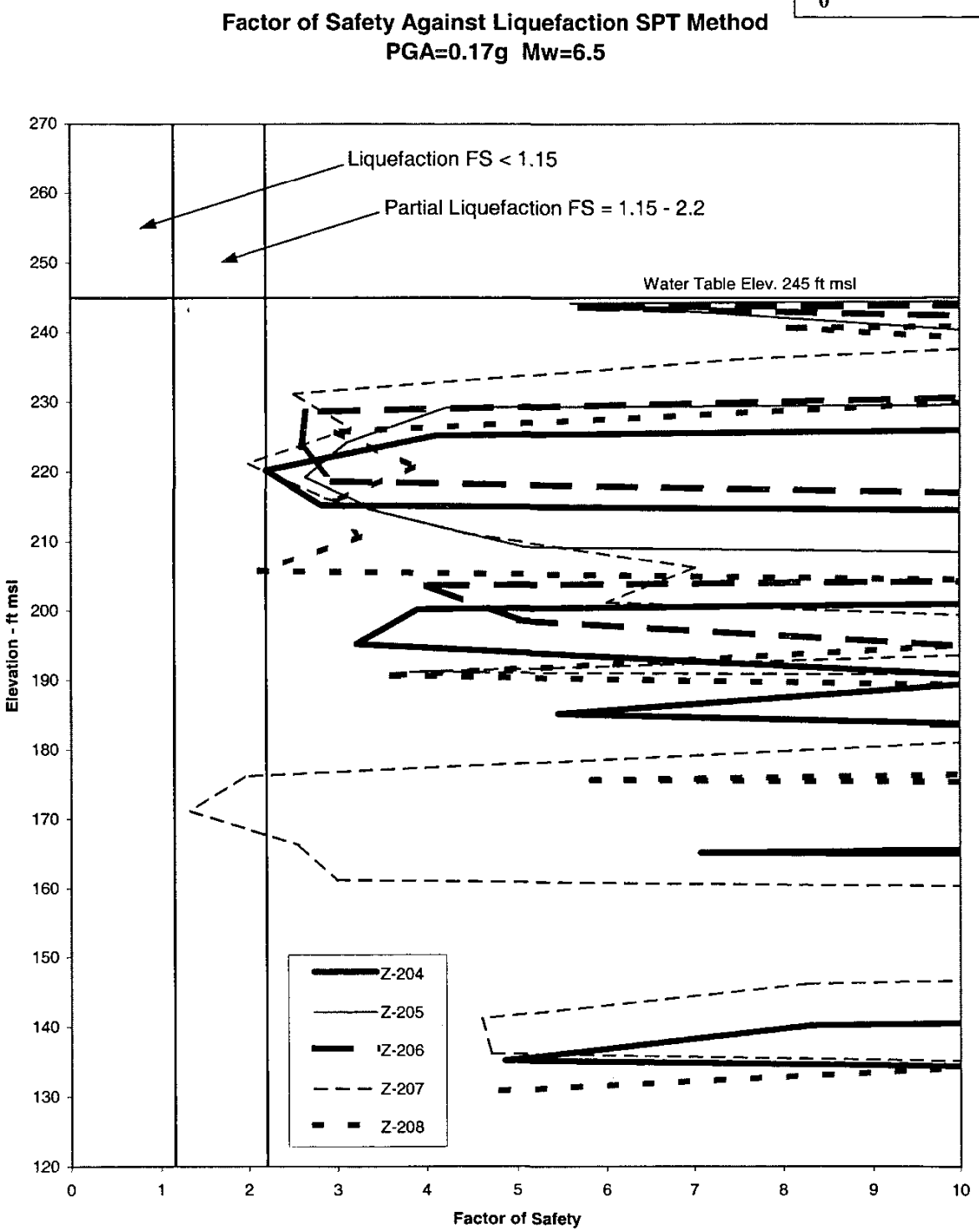
(Calculated using q_{t1} data, CPTu determined percent fines and Equations 17 – 43)



Zcp27-liq-ch-lab.xls

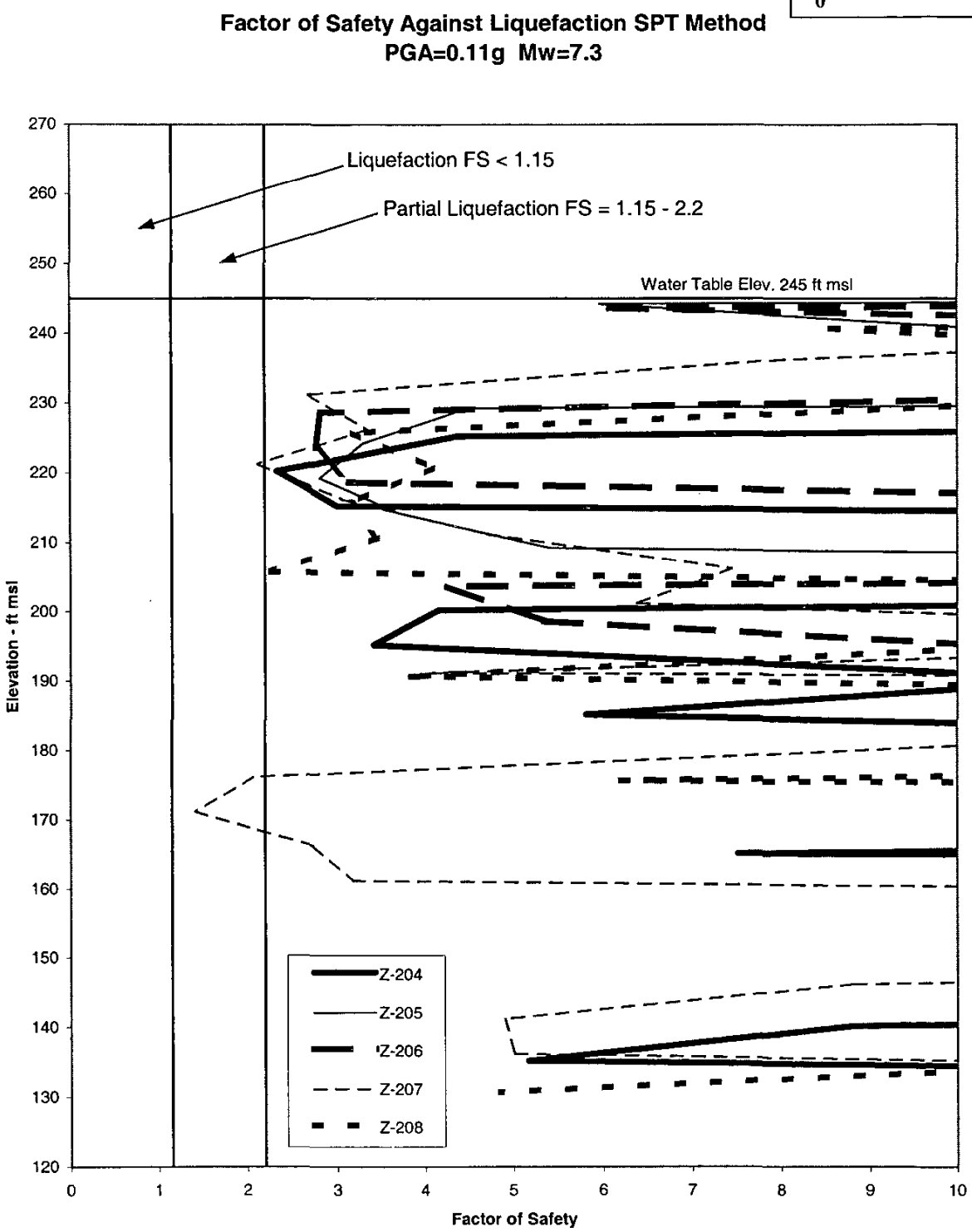
Calculation No. K-CLC-Z-00001	Sheet No. 103	Rev. 0

Figure 27 – Factor of Safety and Settlement vs. Elevation for SCPTu ZCP-27 and Charleston Earthquake
(Calculated using q_{t1} data, laboratory percent fines (Table 1) and Equations 17 – 23 and 26 – 43)



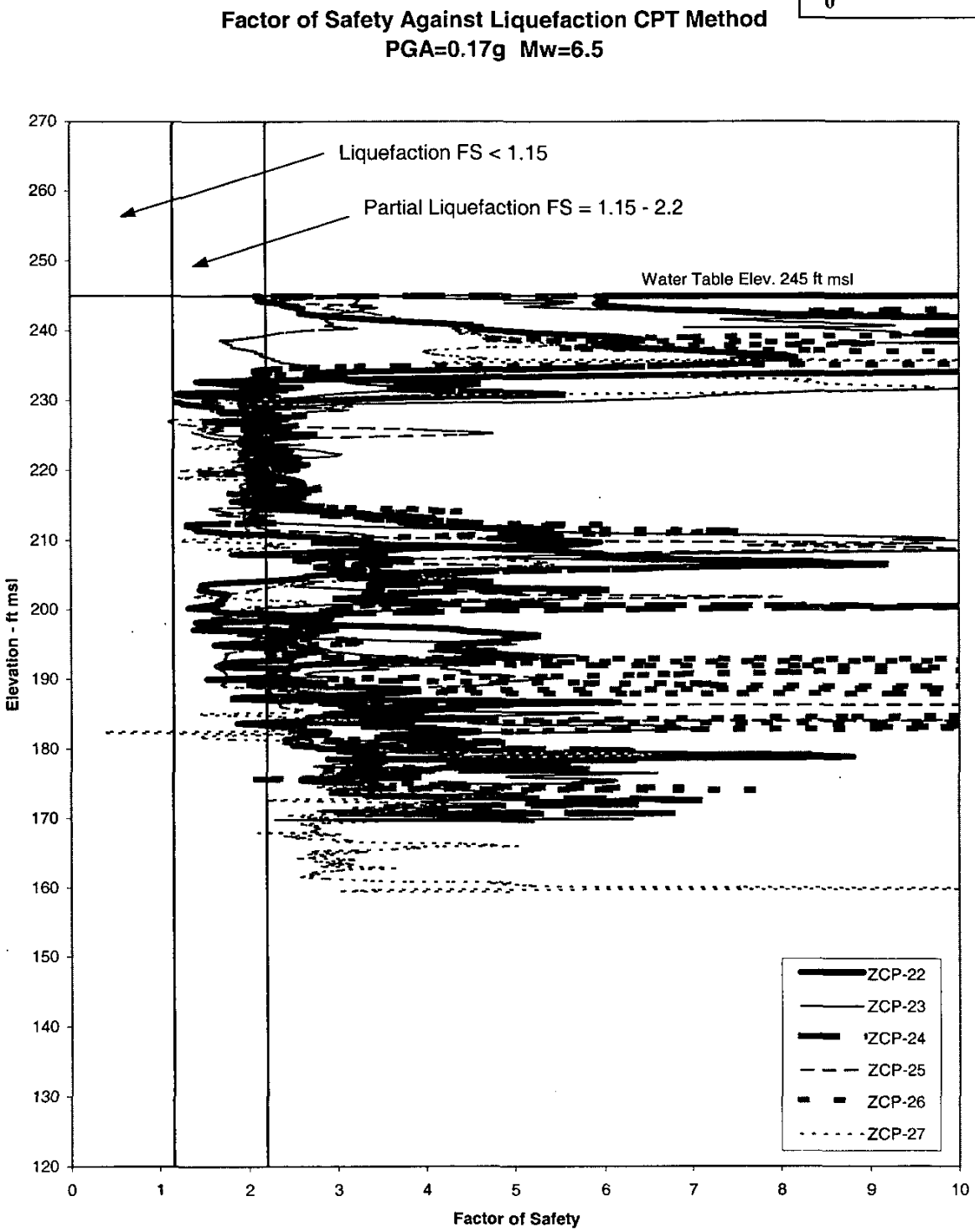
FS-SPT-summary.xls

Figure 28 - Liquefaction Factor of Safety vs. Elev. for 5 SPT Borings and DBE
(Calculated using N_{160} data and Equation 14)



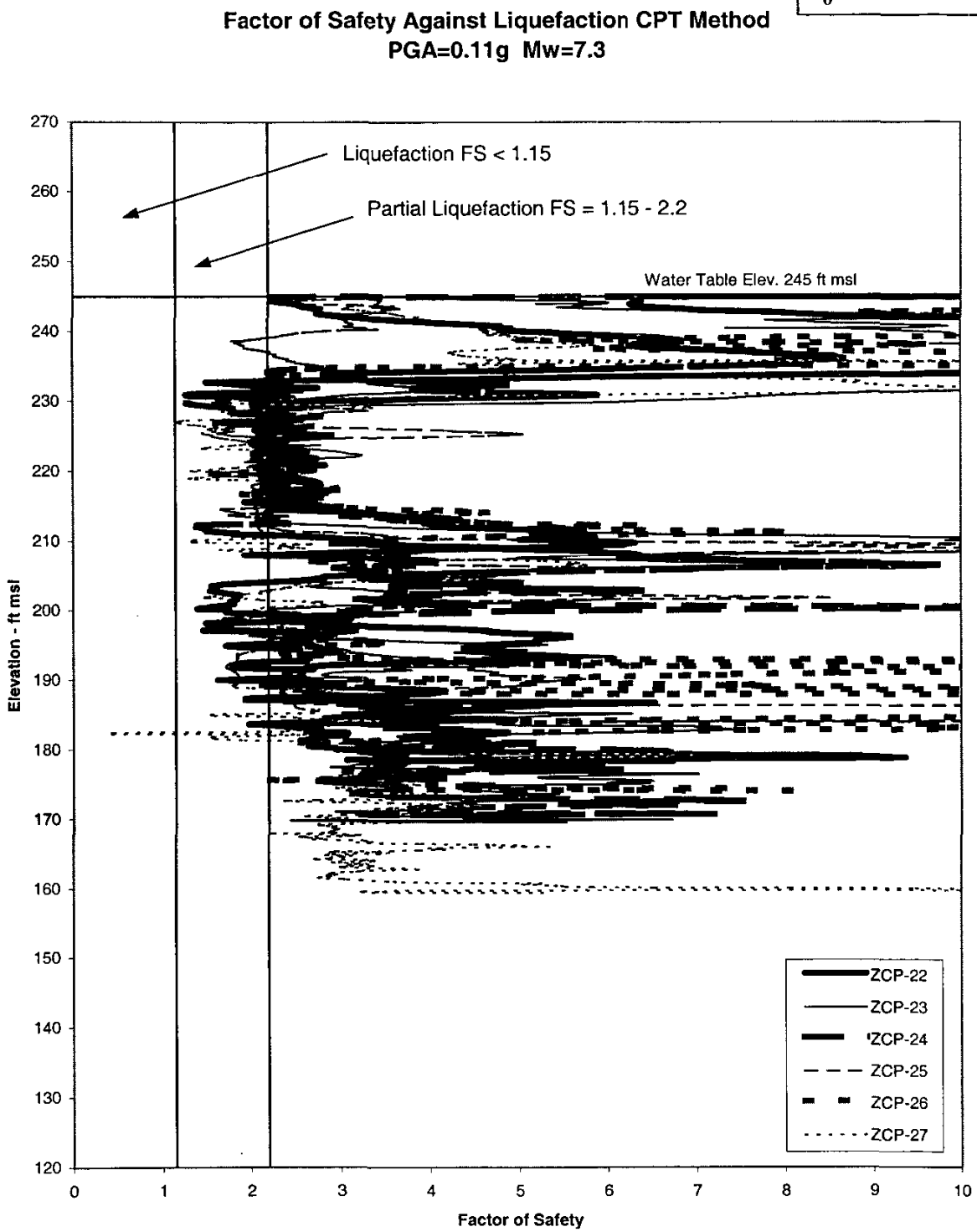
FS-SPT-summary.xls

Figure 29 - Factor of Safety vs. Elev. for 5 SPT Borings and Charleston Earthquake
(Calculated using N_{160} data and Equation 14)



FS-CPT-summary.xls

Figure 30 - Liquefaction Factor of Safety vs. Elev. for 6 SCPTu Soundings and DBE
(Calculated using q_{t1} data, CPTu determined percent fines and Equations 17 – 43)



FS-CPT-summary.xls

Figure 31 - Factor of Safety vs. Elev. for 6 SCPTu Soundings and Charleston Earthquake
(Calculated using q_{t1} data, CPTu determined percent fines and Equations 17 – 43)

Attachment A

Response Spectra for Saltstone Vault No. 4 based on International Building Code 2000 Section 1615

Response Spectra for Saltstone Vault No. 4 based on International Building Code 2000 Section 1615

Period T	Freq	IBC	IBC x 0.8
0.01	100.00	0.214	0.171
0.02	50.00	0.241	0.193
0.03	33.33	0.268	0.215
0.03333	30.00	0.277	0.222
0.04	25.00	0.295	0.236
0.05	20.00	0.323	0.258
0.06	16.67	0.350	0.280
0.07	14.29	0.377	0.302
0.08	12.50	0.404	0.323
0.09	11.11	0.431	0.345
0.10	10.00	0.459	0.367
0.103	9.71	0.467	0.373
0.515	1.94	0.467	0.373
0.54	1.85	0.445	0.356
0.75	1.33	0.320	0.256
1	1.00	0.240	0.192
1.5	0.67	0.160	0.128
2	0.50	0.120	0.096
2.5	0.40	0.096	0.077
3	0.33	0.080	0.064
4	0.25	0.060	0.048
5	0.20	0.048	0.038
10	0.10	0.024	0.019

$Ss = 0.50$ g — from IBC Figure 1615(1) or USGS web site with Lat. 33.3 and Long. -81.63

$S_1 = 0.17$ g — from IBC Figure 1615(2) or USGS web site with Lat. 33.3 and Long. -81.63

$Fa = 1.40$ — from IBC Table 1615.1.2(1) Site Class D

$Fv = 2.12$ — from IBC Table 1615.1.2(2) Site Class D

$S_{MS} = 0.70$ — $S_{MS} = Fa \times Ss$ (IBC Equatoin 16-16)

$S_{M1} = 0.36$ — $S_{M1} = Fv \times S_1$ (IBC Equatoin 16-17)

$S_{DS} = 0.467$ — $S_{DS} = (2/3)S_{MS}$ (IBC Equation 16-18)

$S_{D1} = 0.240$ — $S_{D1} = (2/3)S_{M1}$ (IBC Equation 16-19)

$T_0 = 0.103$ — $T_0 = 0.2(S_{D1}/S_{DS})$ from IBC Section 1615.1.4

$T_S = 0.515$ — $T_S = (S_{D1}/S_{DS})$ from IBC Section 1615.1.4

from IBC Section 1615.1.4

$Sa = 0.6(S_{DS}/T_O)T + 0.4S_{DS}$ for periods less than or equal to T_O

$Sa = S_{DS}$ for periods greater than or equal to T_O and less than or equal to T_S

$Sa = S_{D1}/T$ for periods greater than T_S

Section 1615.2.4

Reduction allowed up to 20% where site-specific studies are performed.

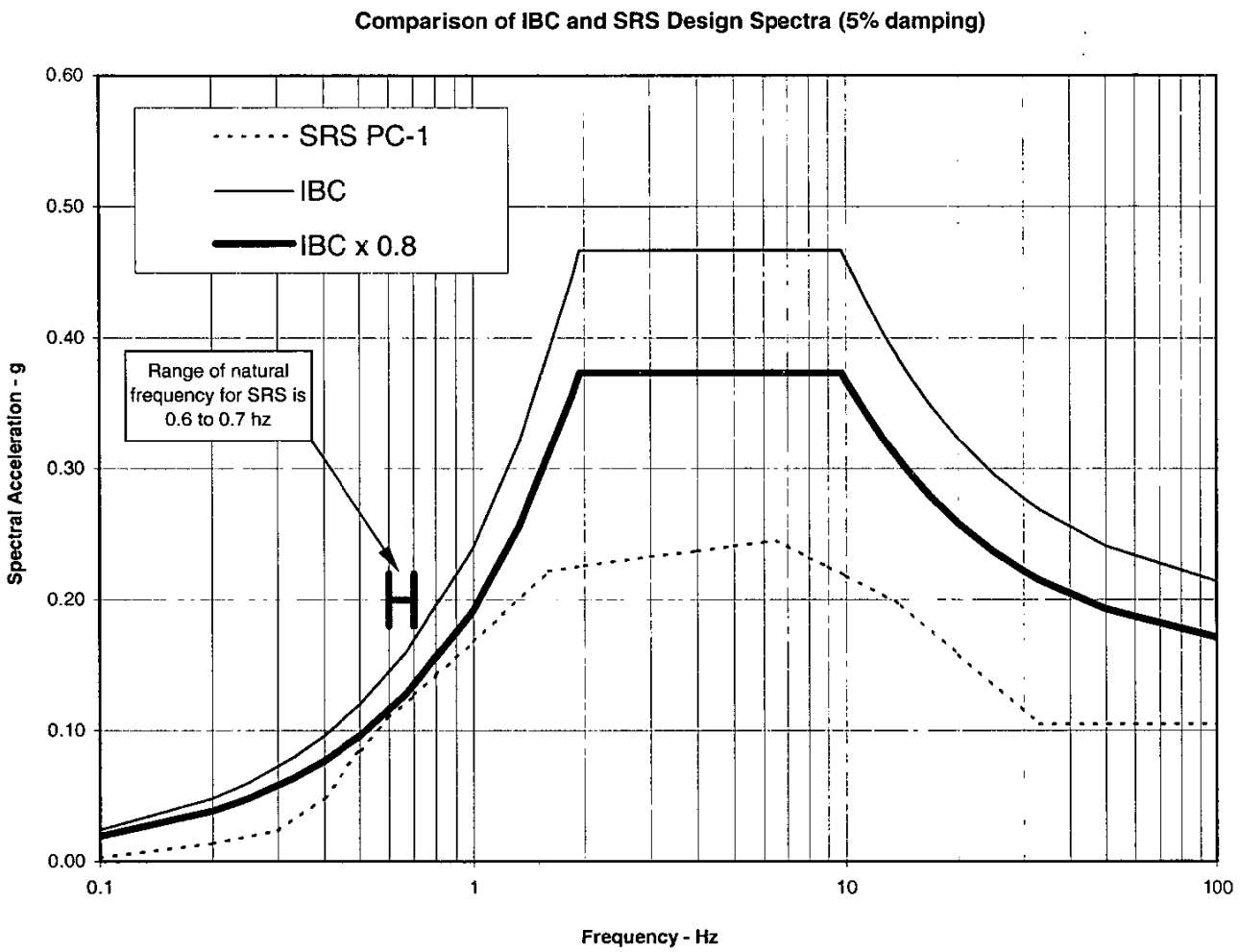
Calculation No.	Sheet No.	Rev.
K-CLC-Z-00001	109	0

USGS Earthquake Hazards Program - Seismic Hazard Mapping Project d

```
The ground motion values for the requested point:
LOCATION                33.30 Lat.  -81.63 Long.
DISTANCE TO
  NEAREST GRID POINT    2.79401733965331 kms
NEAREST GRID POINT      33.30000  Lat.   -81.60000  Long.
Probabilistic ground motion values, in %g, at the Nearest Grid point are:
            10%PE in 50 yr   5%PE in 50 yr   2%PE in 50 yr
   PGA          7.566638       13.14327       23.69023
0.2 sec SA      17.18540       28.02243       50.20057
0.3 sec SA      13.55839       23.43204       40.36540
1.0 sec SA      5.531499       9.420448       17.34955
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

The program has detected a zero latitude and has assumed the end of valid input data.

PROJECT INFO: Home Page
SEISMIC HAZARD: Hazard by Lat/Lon



Note: SRS PC-1 spectrum from Lee (1998)
IBC spectra from ICC (2000)

IBC spectra.xls

Attachment B

Seismic Piezocone Penetration Test Data for Saltstone Vault No. 4

(ARA, 2002)

Calculation No.
K-CLC-Z-00001
Sheet No.
113
Rev.
0

June 28, 2002

L. Bruce Triplett
Westinghouse Savannah River Company
Building 730-2B, Rm. 1086
Aiken, SC 29808

Dear Mr. Triplett:

Attached is the cone penetrometer data for the seismic cone penetrometer tests conducted at SRS Z Area, performed under WSRC subcontract AC07778N, task 11. A total of 6 penetrometer tests were performed. The cone penetrometer tests are summarized in Table 1.

The information provided for each cone penetration test includes: corrected tip stress, sleeve stress, friction ratio, pore pressure, soil classification based on friction ratio, and estimated blow counts. The seismic data includes: time history plots, seismic wave time of peak plots, and wave speed profiles for shear and compression wave forms. At location ZCP-23 the compression wave forms could not be analyzed with adequate confidence. Therefore, the time history plot for the compression waves at location ZCP-23 contain the wave forms only and do not present the arrows indicating the time of peak picks, the time of peak plot or the compression wave speed profile. The enclosed CD provides the ECP files that contain the plotted data in ASCII format, seismic wave speed files (*.VEL), a copy of this letter, and Table 1 in Excel format.

This data presented on the attached sheets was obtained and interpreted by qualified ARA personnel in accordance with the requirements of SRS Subcontract No. AC07778N and contained in Specification K-SPC-G-00016, Rev. 2. The information contained on the data sheets and computer disks shall be considered as final and correct.

Please feel free to call us if you have any questions regarding the enclosed information.

Sincerely,

Bryan E. Fisk
Senior Engineer

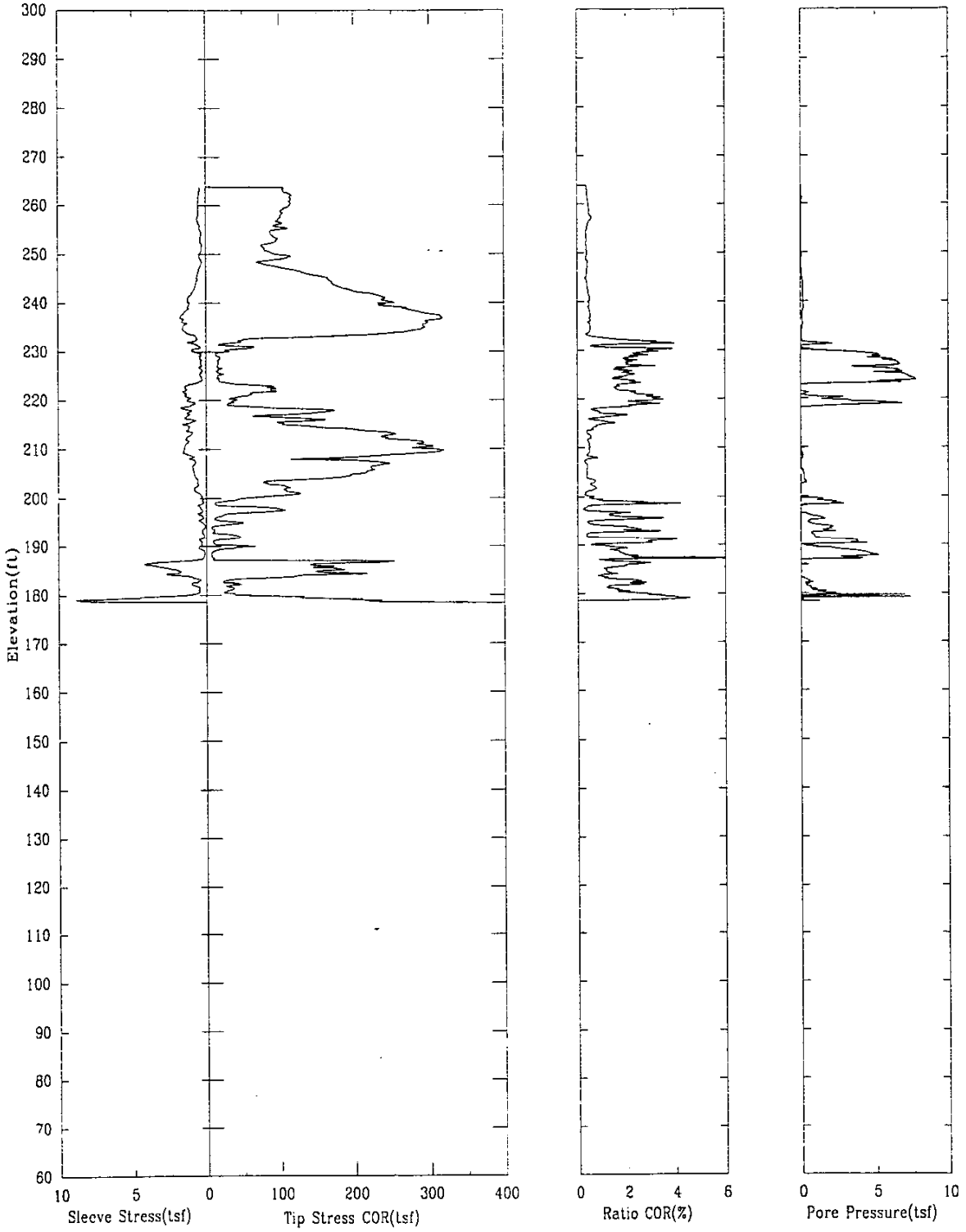
BEF
d:\0431\Task Reports\Task11\0431_11_ltr_rpt.doc

415 WATERMAN ROAD ■ SOUTH ROYALTON, VT 05068
(802) 763-8348 ■ FAX (802) 763-8283

Calculation No. K-CLC-Z-00001
Sheet No. 114
Rev. 0

ZCP-22 APPLIED RESEARCH ASSOCIATES, INC. 06/21/02

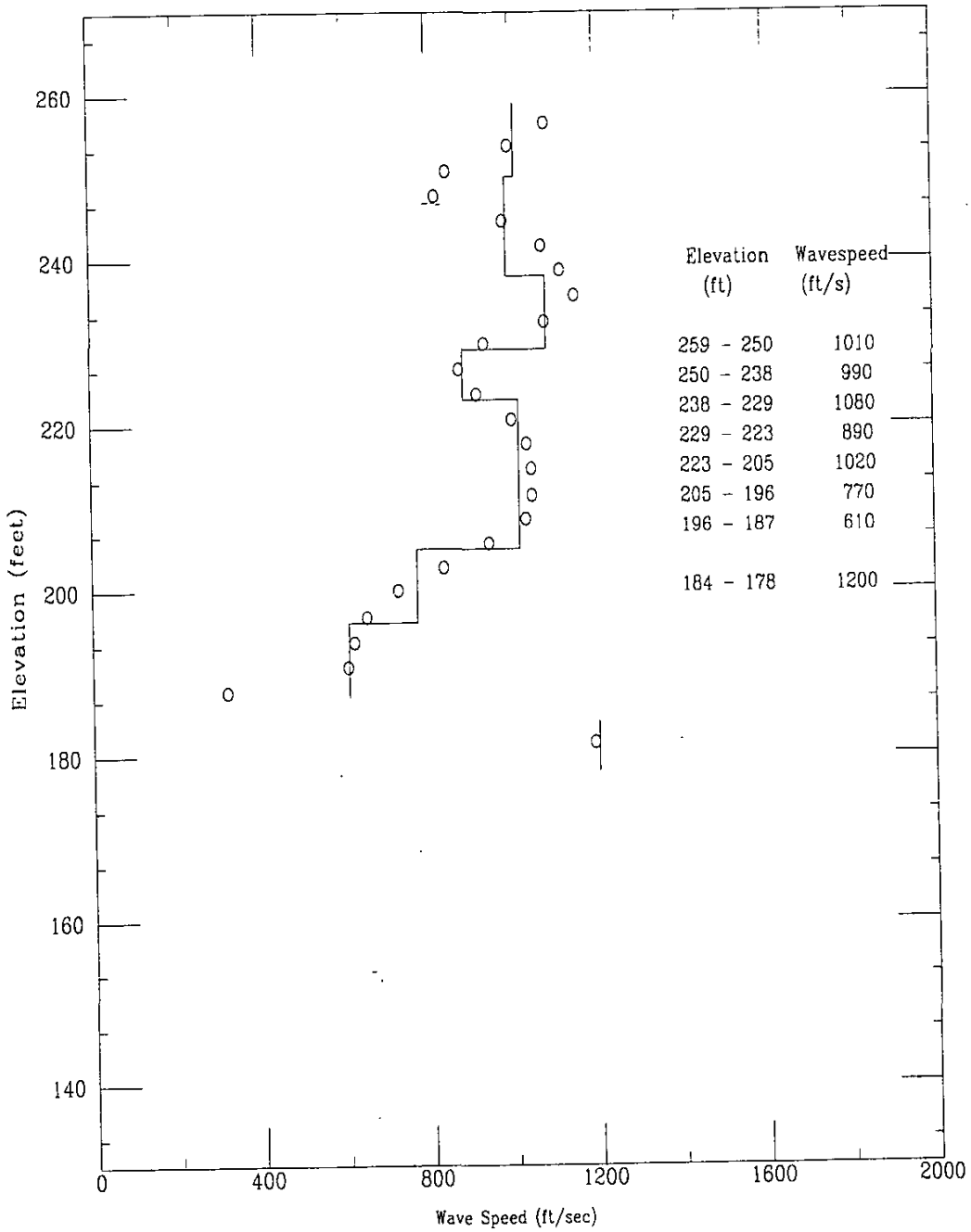
North 76318.36 East 66951.40 Elevation 269.78



File 421u202.ECP

ZCP-22 APPLIED RESEARCH ASSOCIATES, INC. 06/21/02

Shear Wave Speeds

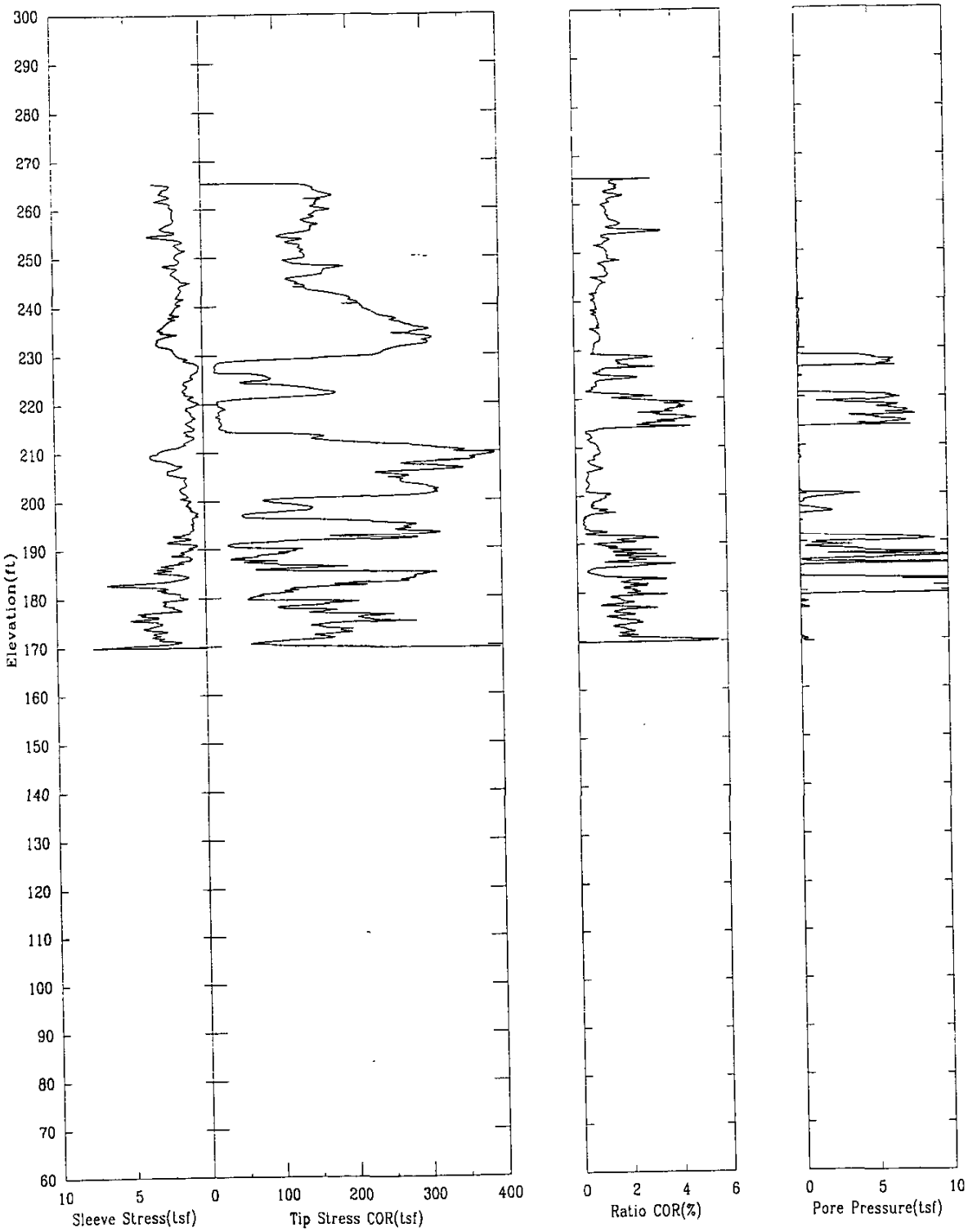


File 421u202S

Calculation No. K-CLC-Z-00001
Sheet No. 116
Rev. 0

ZCP-23 APPLIED RESEARCH ASSOCIATES, INC. 06/19/02

North 76166.36 East 67116.88 Elevation 271.30

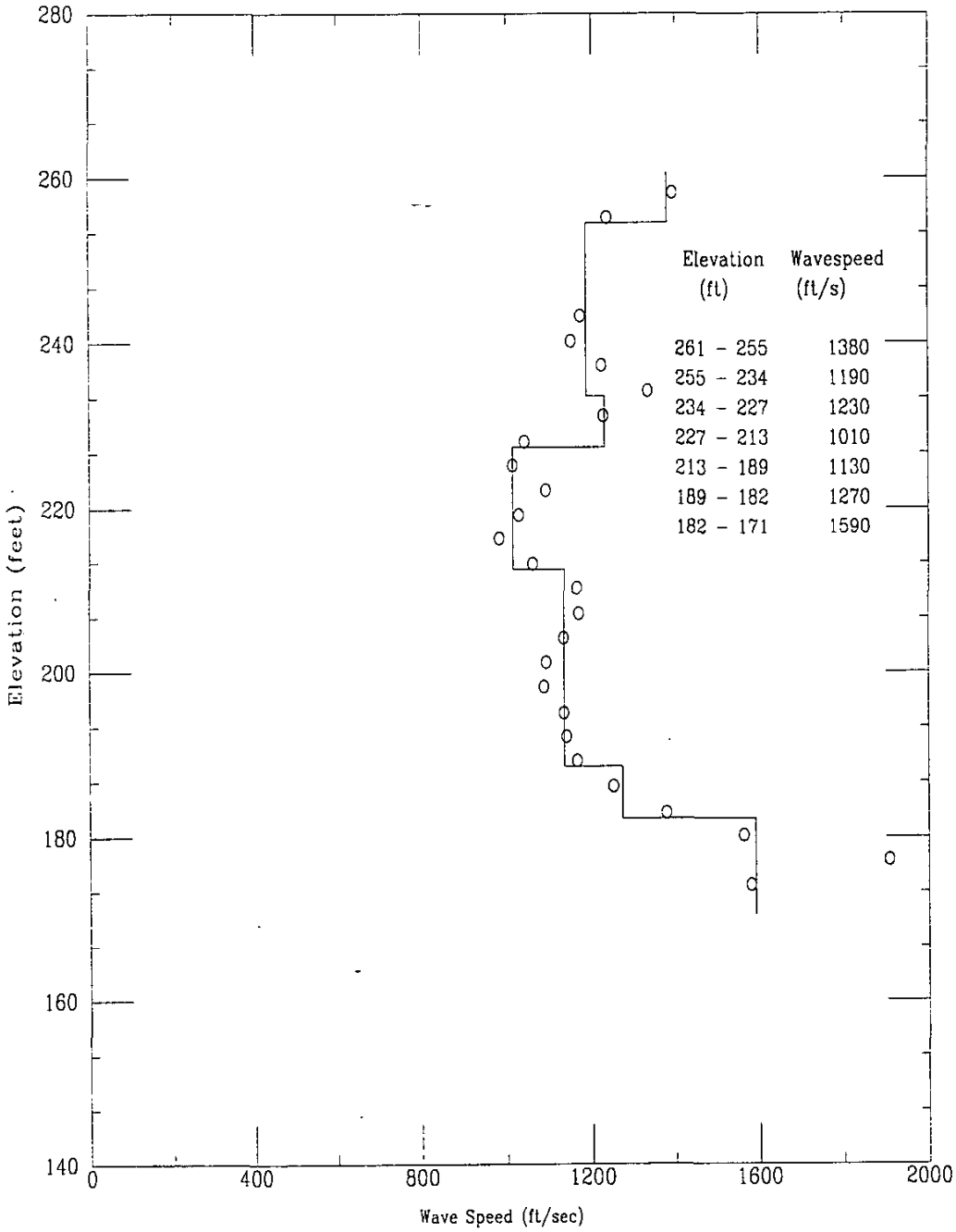


File 419u201.ECP

Calculation No. K-CLC-Z-00001
Sheet No. 117
Rev. 0

ZCP-23 APPLIED RESEARCH ASSOCIATES, INC. 06/19/02

Shear Wave Speeds

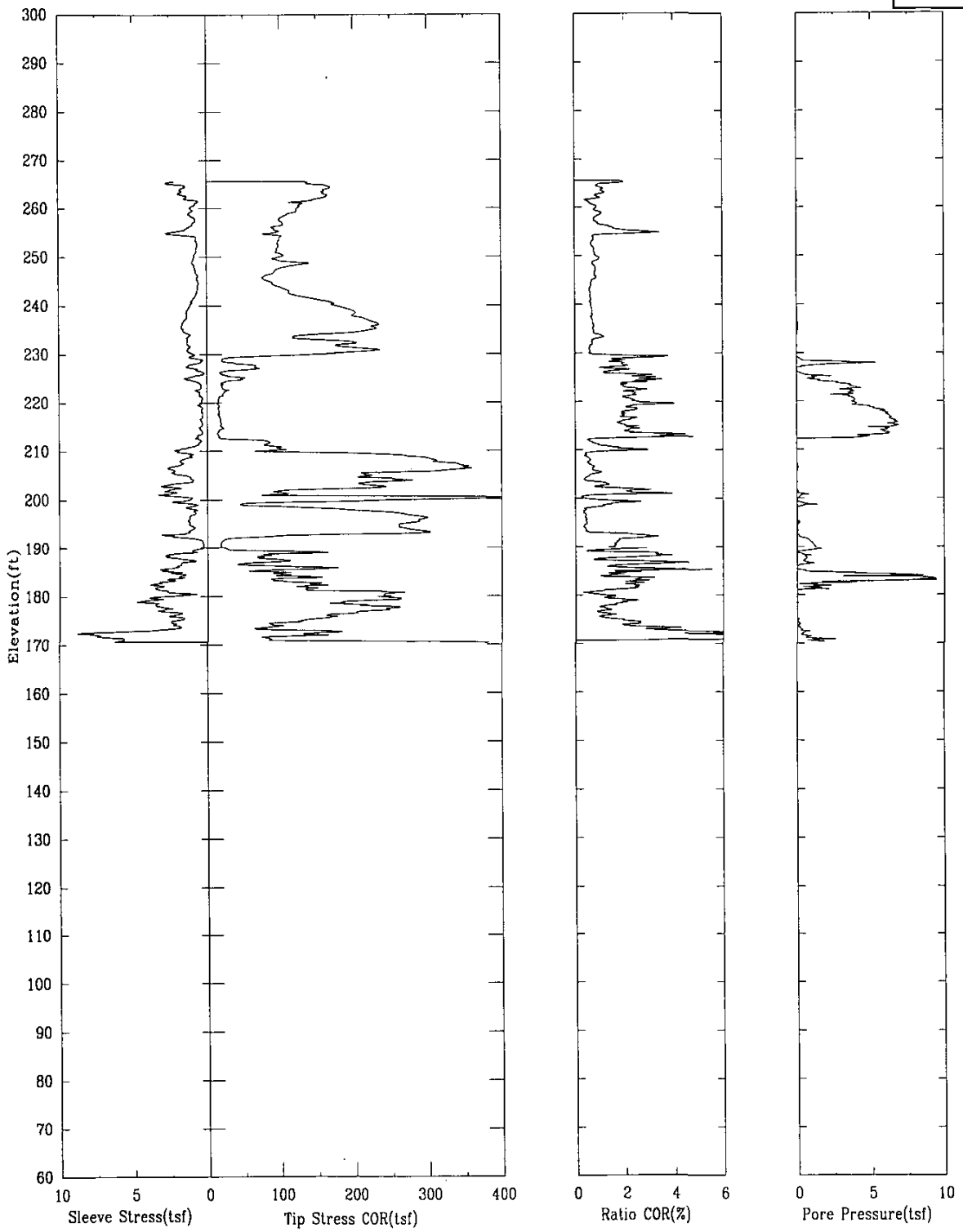


File 419u201S

Calculation No. K-CLC-Z-00001
Sheet No. 118
Rev. 0

ZCP-24 APPLIED RESEARCH ASSOCIATES, INC. 06/19/02

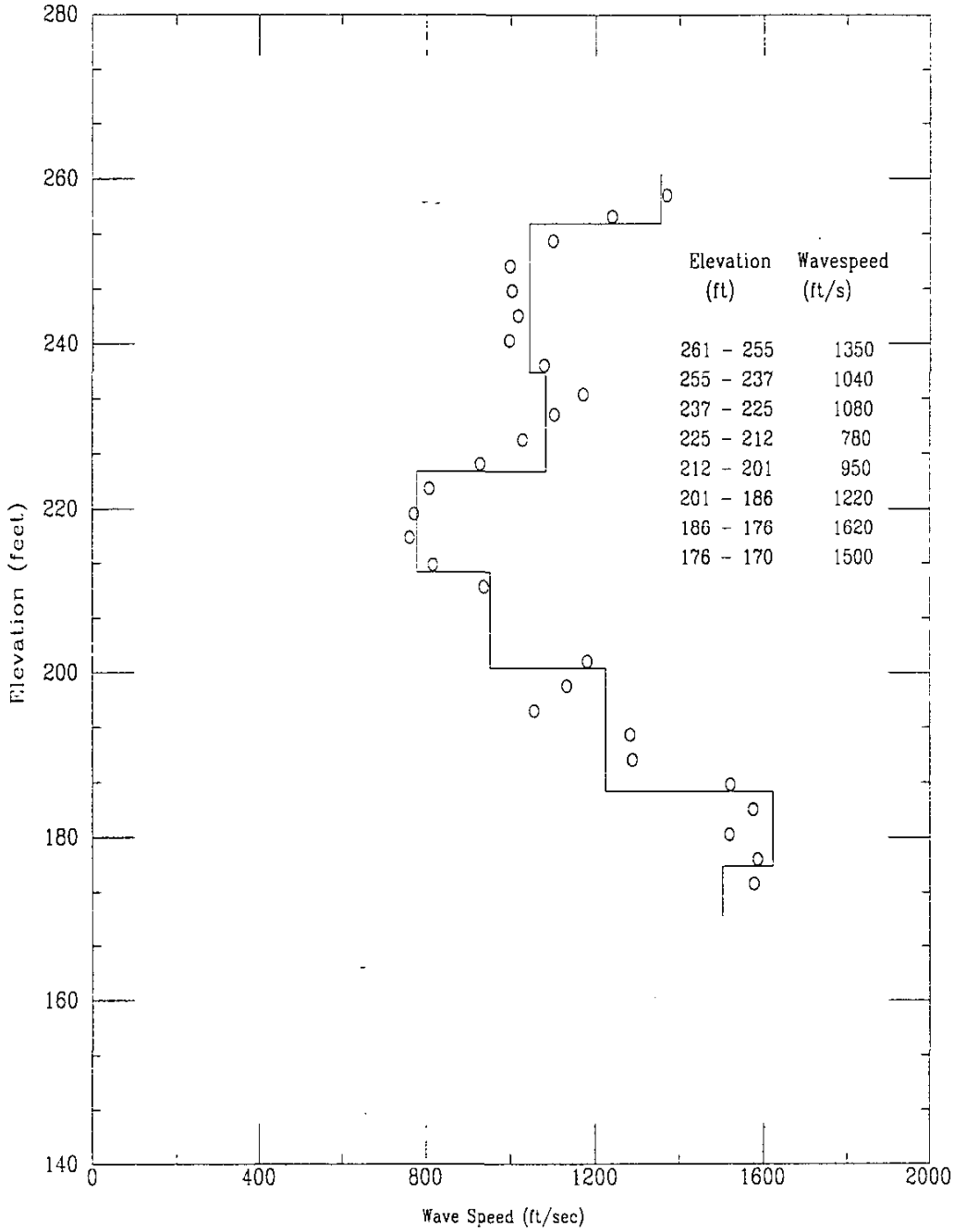
North 75972.85 East 67179.29 Elevation 271.49



File 419u205.ECP

ZCP-24 APPLIED RESEARCH ASSOCIATES, INC. 06/19/02

Shear Wave Speeds

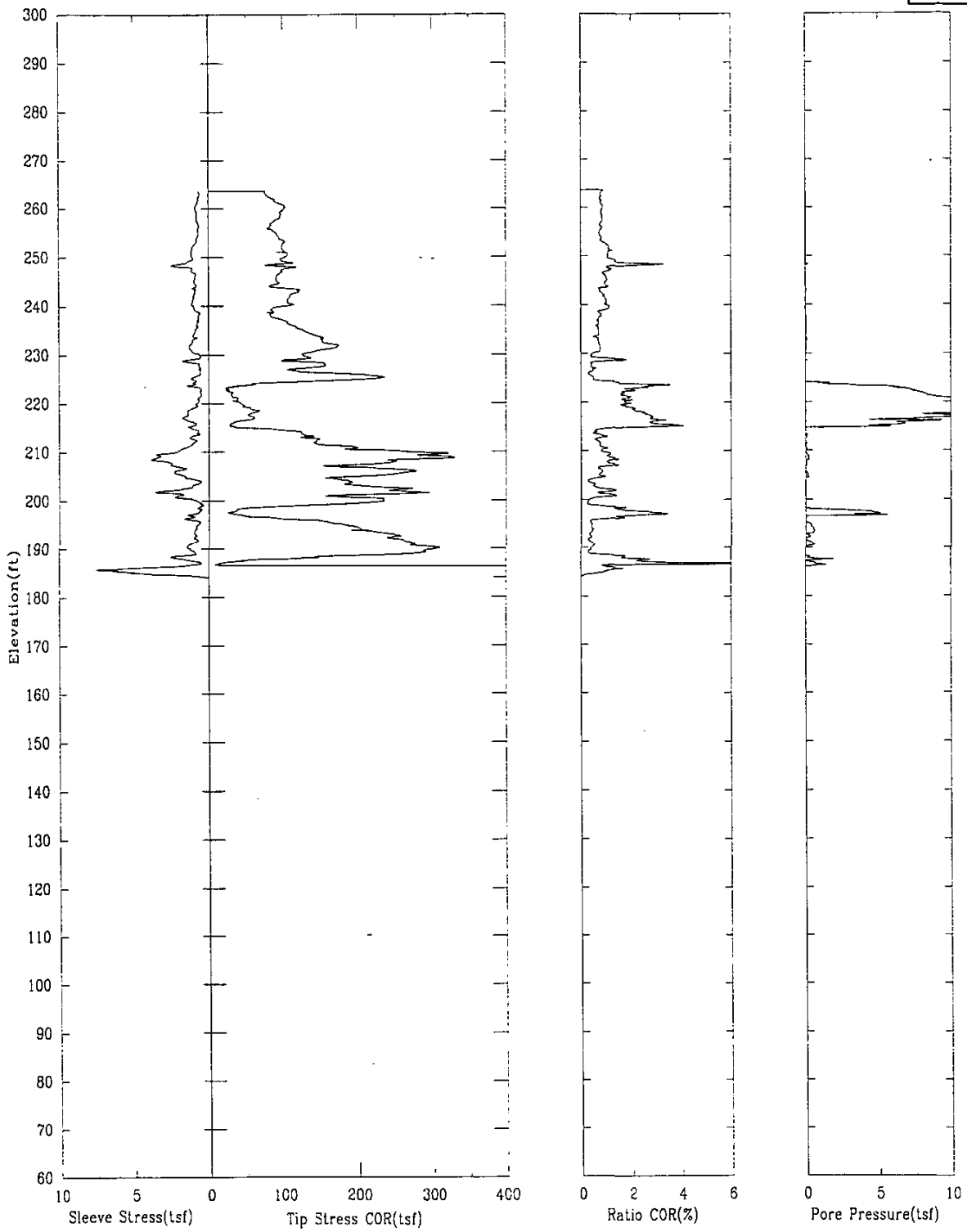


File 419u205S

Calculation No.
K-CLC-Z-00001
Sheet No.
120
Rev.
0

ZCP-25 APPLIED RESEARCH ASSOCIATES, INC. 06/20/02

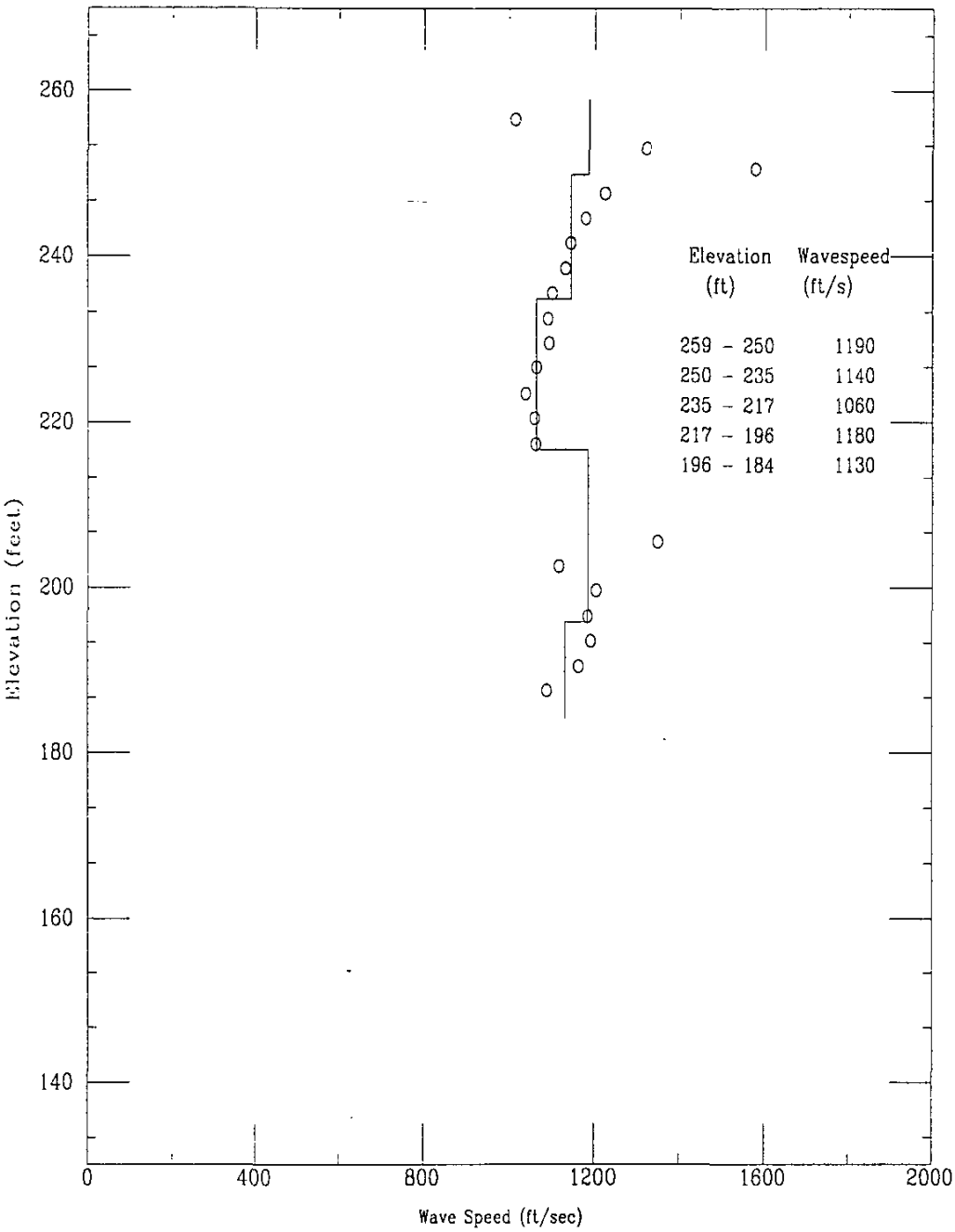
North 75720.25 East 67140.79 Elevation 269.60



File 420u201.ECP

ZCP-25 APPLIED RESEARCH ASSOCIATES, INC. 06/20/02

Shear Wave Speeds

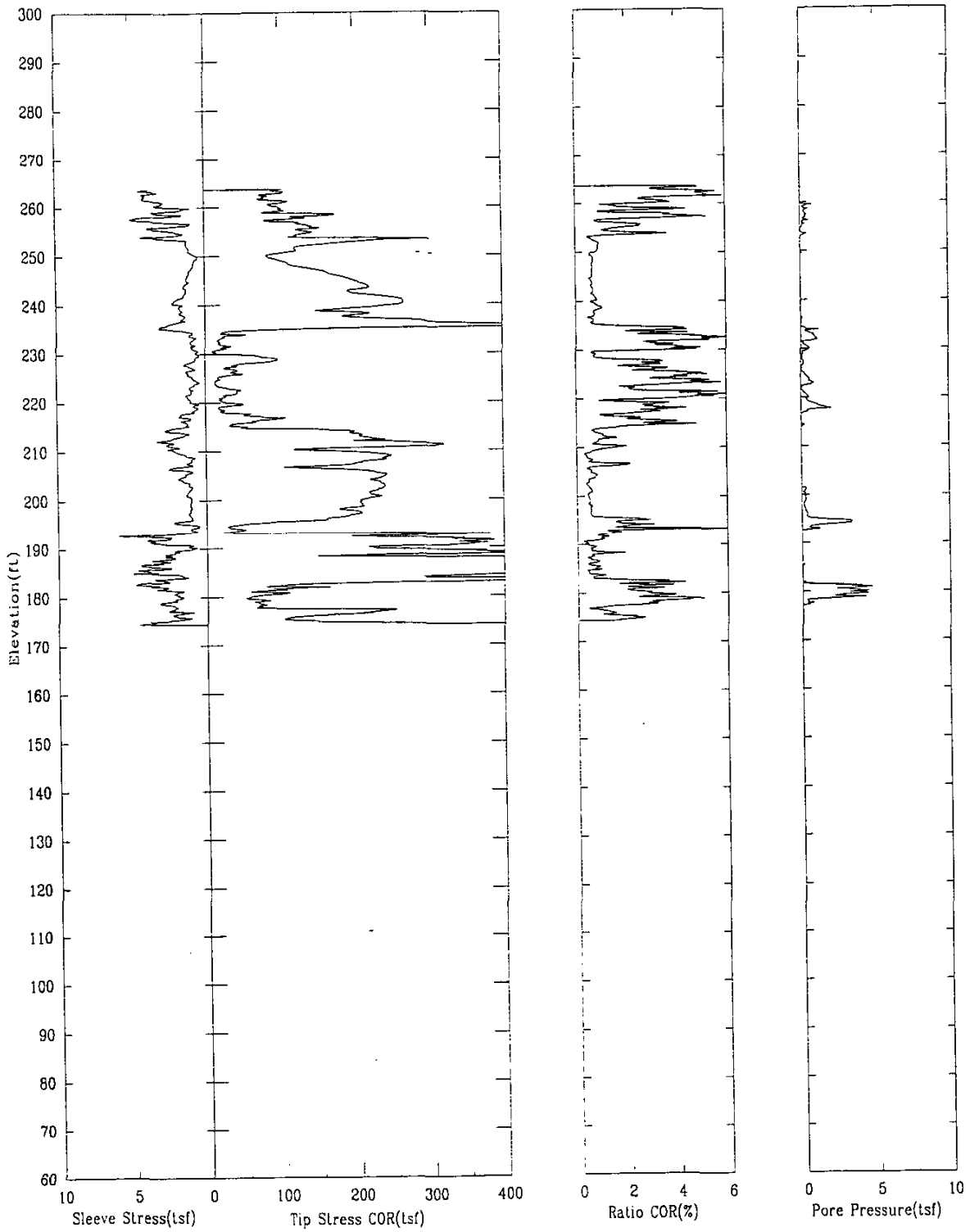


File 420u201S

Calculation No. K-CLC-Z-00001
Sheet No. 122
Rev. 0

ZCP-26 APPLIED RESEARCH ASSOCIATES, INC. 06/20/02

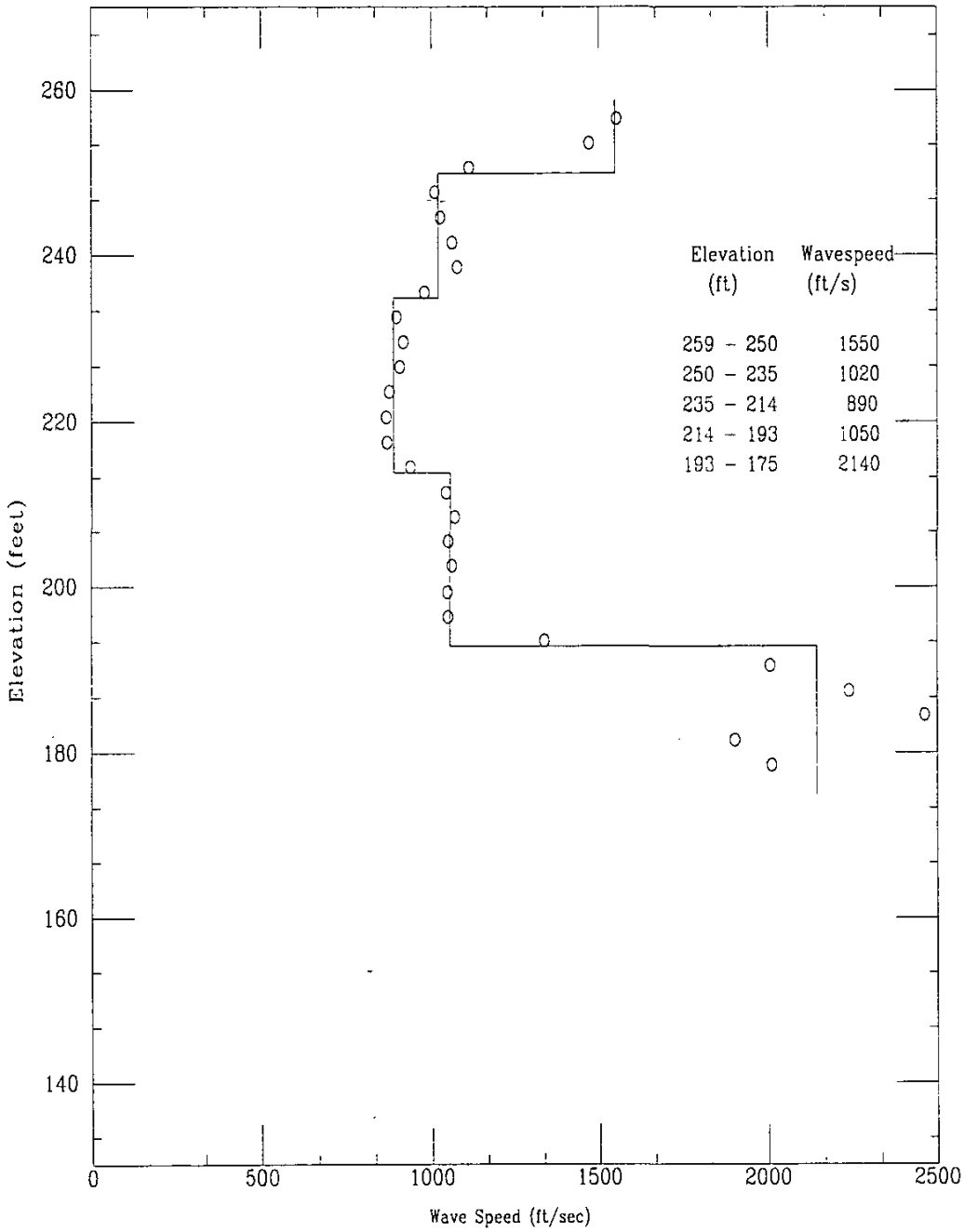
North 75925.81 East 66944.22 Elevation 269.62



File 420U203.ECP

ZCP-26 APPLIED RESEARCH ASSOCIATES, INC. 06/20/02

Shear Wave Speeds

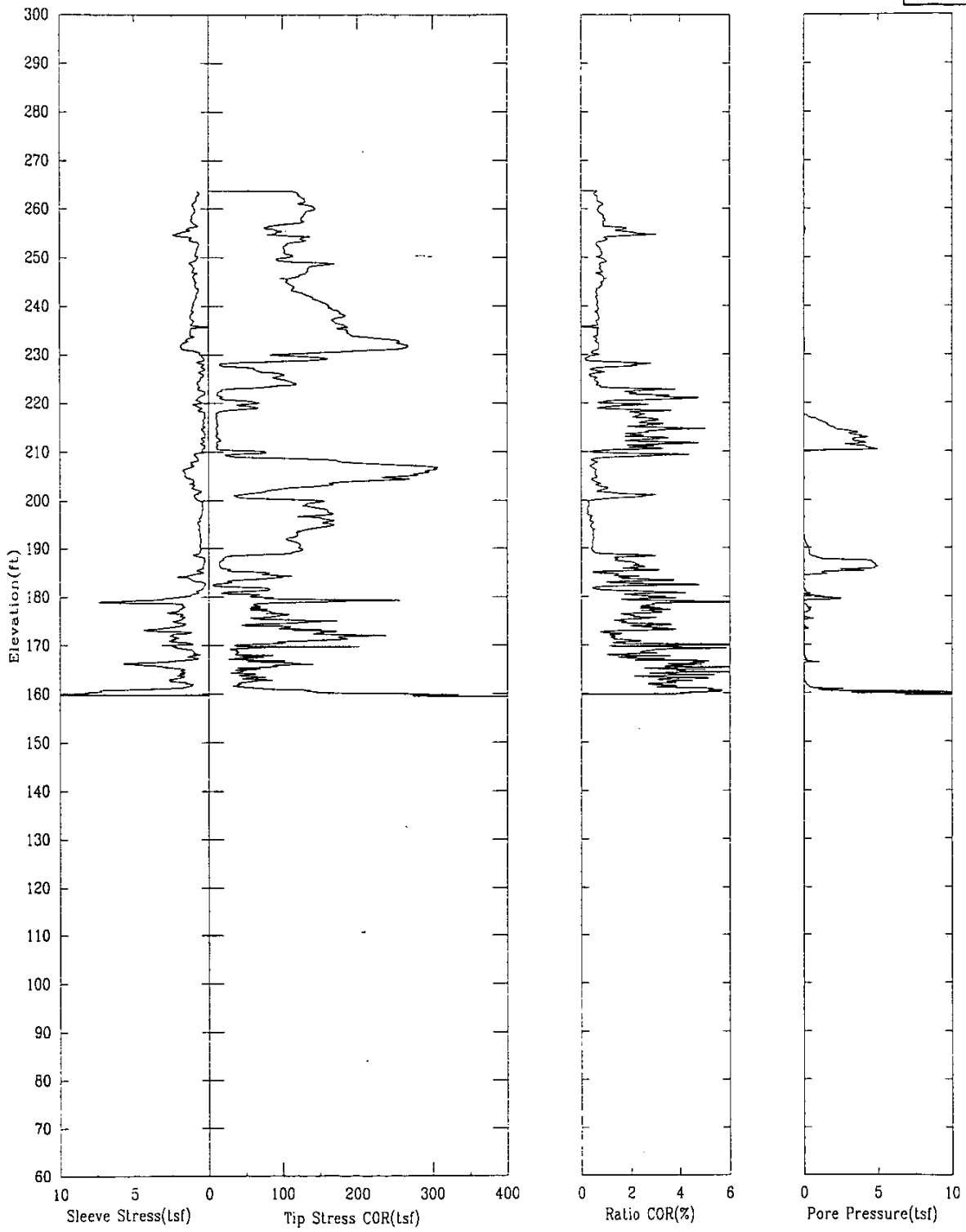


File 420u203S

Calculation No.
K-CLC-Z-00001
Sheet No.
124
Rev.
0

ZCP-27 APPLIED RESEARCH ASSOCIATES, INC. 06/20/02

North 76103.75 East 66886.21 Elevation 269.69

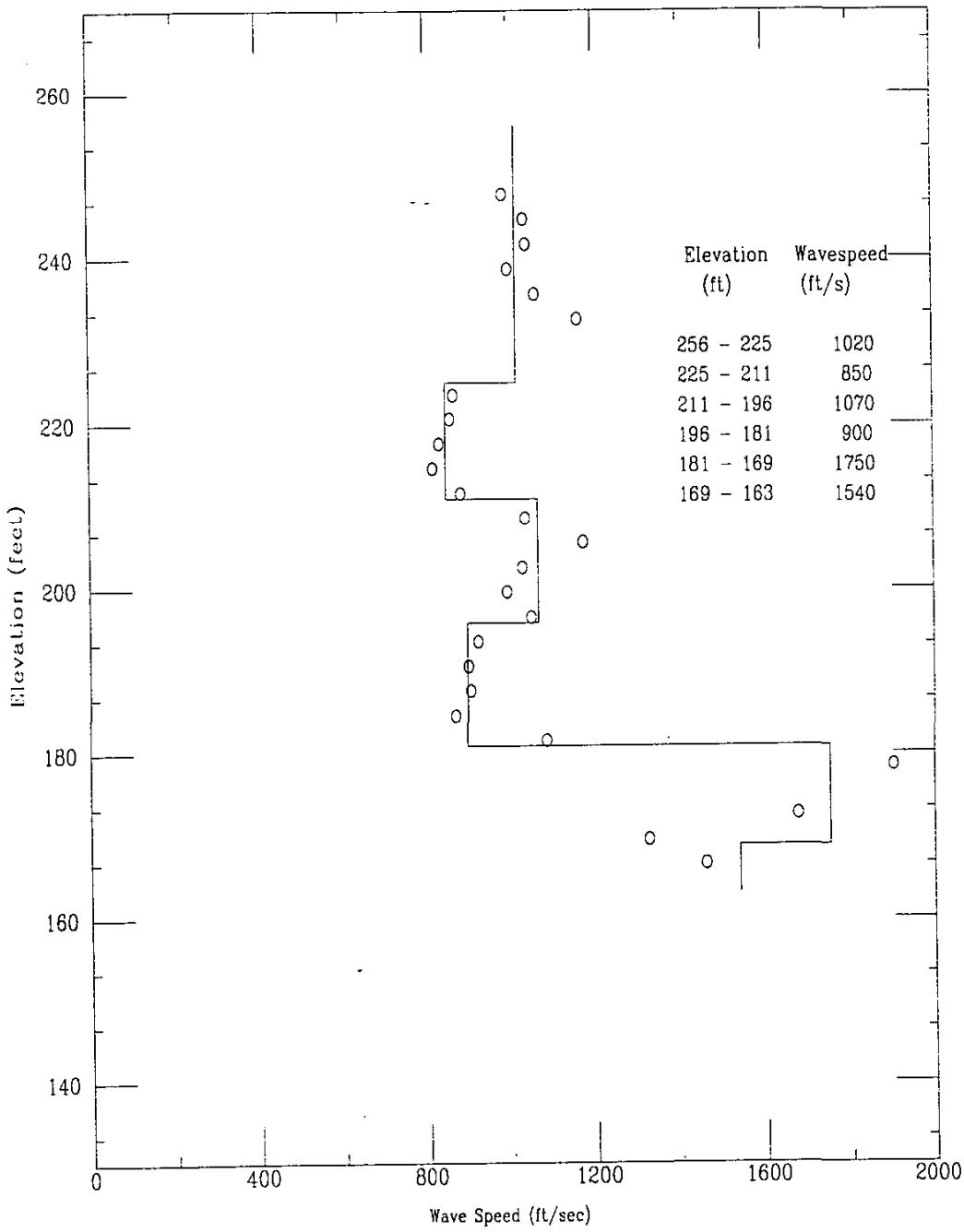


File 420u205.ECP

Calculation No. K-CLC-Z-00001
Sheet No. 125
Rev. 0

ZCP-27 APPLIED RESEARCH ASSOCIATES, INC. 06/20/02

Shear Wave Speeds



File 420u205S

Attachment C

Listing of computer files containing liquefaction susceptibility and estimated settlement calculations using CPTu sounding data

Date	Time	File Size	File Name	Description
8/27/02	01:37p	2,838,016	Zcp22-liq.xls	DBE & CPTu determined % fines
8/27/02	01:37p	3,032,064	Zcp23-liq.xls	DBE & CPTu determined % fines
8/27/02	01:37p	3,145,216	Zcp24-liq.xls	DBE & CPTu determined % fines
8/27/02	01:37p	2,739,712	Zcp25-liq.xls	DBE & CPTu determined % fines
8/27/02	01:37p	2,875,904	Zcp26-liq.xls	DBE & CPTu determined % fines
8/27/02	01:37p	3,173,888	Zcp27-liq.xls	DBE & CPTu determined % fines
8/27/02	01:40p	2,837,504	Zcp22-liq-ch.xls	Charleston & CPTu determined % fines
8/27/02	01:40p	3,031,552	Zcp23-liq-ch.xls	Charleston & CPTu determined % fines
8/27/02	01:40p	3,145,216	Zcp24-liq-ch.xls	Charleston & CPTu determined % fines
8/27/02	01:40p	2,739,712	Zcp25-liq-ch.xls	Charleston & CPTu determined % fines
8/27/02	01:40p	2,875,392	Zcp26-liq-ch.xls	Charleston & CPTu determined % fines
8/27/02	01:40p	3,173,888	Zcp27-liq-ch.xls	Charleston & CPTu determined % fines
8/27/02	01:41p	3,213,824	Zcp27-liq-dbe-lab.xls	DBE & Laboratory determined % fines
8/27/02	01:41p	3,213,824	Zcp27-liq-ch-lab.xls	Charleston & Laboratory determined % fines
8/27/02	01:42p	2,222,592	CPT-fines-for Vs.xls	Average CPTu determined % fines for Vs layers

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Attachment B - Seismic Piezocone Penetration Test Data for Saltstone Vault No. 4 112

Attachment C – Listing of computer files containing liquefaction susceptibility and estimated settlement calculations using CPTu sounding data 126

Purpose

This calculation evaluates the liquefaction potential for the Saltstone Disposal Facility Vault No. 4 when subjected to the Design Basis Earthquake (DBE). Liquefaction potential was evaluated for post closure conditions (i.e., after placement of 20 feet of capping soil over the vault roof). In addition, the amount of settlement resulting from liquefaction and partial liquefaction is estimated. Static settlements are not part of this calculation. However, previous investigators have estimated the static settlement, after placement of the cap, at about 2½ to 4½ inches (MRCE, 1986a).

Input Data

Several deep Standard Penetration Tests (SPTs) were performed during 1986 to investigate subsurface conditions for saltstone vaults in Z-Area at the Savannah River Site (SRS) (MRCE, 1986a). Five 150-foot SPT borings fall beneath Vault No. 4 (Z-204, Z-205, Z-206, Z-207 and Z-208) and are used in this calculation to determine liquefaction susceptibility. The locations of these SPTs are presented in Figure 1. The N-values for the five SPTs are presented in Figure 2. No energy measurement documentation is available for the N-values. However, documentation shows N-values were measured using Standard Penetration Test techniques and it is assumed the N-values are N_{60} (i.e., standard 60% energy efficiency).

During the Mueser Rutledge Consulting Engineers (MRCE) investigation subsurface layers were delineated (e.g., S1, S2, C2 etc.) (MRCE, 1986a). Cross-sections showing MRCE subsurface soil layers beneath Vault No. 4 are presented in Figures 3a and 3b. The geologic formation nomenclature developed and used for many SRS investigations is also presented on the cross-sections (e.g., Tobacco Road, Dry Branch, and Santee Formations). The table below shows general relationships between MRCE soil layers and SRS geologic formations (SRS, 2002).

MRCE Soil Strata	SRS Geologic Formations and Units
S1 upper	Upland Formation
S2, lower S1, & upper S3a	Tobacco Road / Dry Branch Formations
C2	Tan Clay Unit within Dry Branch Formation
S3a & S3b	Dry Branch Formation
S4	Santee/Tinker Formation
M1	Warley Hill Formation

In addition to the historic data, six Seismic Piezocone Penetration Tests (SCPTu) were performed specifically for this liquefaction evaluation (ARA, 2002). The SCPTu were pushed to refusal and penetrated to elevations ranging from about 185 to 160 ft msl. The locations of these SCPTu are presented in Figure 1. The shear wave velocities from the SCPTu data are provided in Attachment B. Shear wave velocity data from the SCPTu are summarized in Figure 5. The subsurface conditions at Vault No. 4 are generally consistent with subsurface conditions in the GSA. The strata breaks shown in Figures 2, 5 and 7 are averages beneath Vault No. 4. Analyses were performed using strata specific to each boring or SCPTu.

The water table in the vicinity of Vault No. 4, based on Well ZBG-2, varies between 213 and 228 ft-msl (see Figure 6). However, the groundwater elevation used for the liquefaction analysis is conservatively placed at 245 feet mean sea level. This conservative assumption is based on water levels observed in boreholes during drilling (MRCE, 1986a) historical readings (Cook, 1983) and reports of perched water in Z-Area (MRCE, 1986b and Cook, 1986).

Fines content (i.e., percent passing the No. 200 sieve) is important in determining liquefaction resistance. Fines content for each of the engineering layers was determined using laboratory data from borings Z-201U, Z-202PU, Z-210PU, Z-211U, Z-216PU, Z-218U, Z-219U, Z-220U, Z-224U, Z-225U, ZB-1, ZB-2, ZB-3, ZB-4, ZB-5, ZB-6, ZB-7 and ZB-8 all located around Vault No. 4 (see Figure 1). Fines content data and averages for each of the engineering layers are presented in Table 1. The fines content data from Table 1 is plotted versus elevation in Figure 7.

The DBE is based on the USGS seismic hazard maps (Frankel et. al, 1996) and the International Building Code (IBC) (ICC, 2000) which has adopted the USGS seismic hazard maps. Figure 8 presents the USGS PGA map for firm rock with 2% probability of exceedance in 50 years. This map does not account for soil response at a given site. Attachment A presents the calculation of the response spectra (including PGA) for Z-Area based on the IBC and site specific soil conditions. The PGA calculated for Z-Area using the IBC is 0.21g. However, the International Building Code allows a reduction of up to 20% in cases where site specific studies have been performed. Extensive ground response modeling has been performed for the SRS (Lee et. al, 1997; Lee, 1998). Based on the SRS ground response modeling the reduction is warranted. For this calculation a PGA of 0.17g (i.e., 0.21 x 0.8) is used. This PGA is very conservative when compared with the PGA of 0.11g determined for Performance Category 1 structures at SRS (see Attachment A), which is the performance category of the Saltstone Vaults.

The USGS has also performed a Probabilistic Seismic Hazard Analysis (PSHA) for the SRS (Frankel, 1999). The SRS PGA hazard dissagregation for the 2500 return period is presented in Table 2 and Figure 9. The hazard dissagregation is used to establish average earthquake magnitude for the DBE. The weighted average magnitude for the DBE is Mw = 6.5 (see Table 2).

The largest earthquake to occur in the southeastern United States was the 1886 Charleston earthquake. Magnitude for the Charleston earthquake is estimated at Mw = 7.3 (WSRC, 1994; Johnston, 1996). Examination of the hazard dissagregation for the SRS (Figure 9) shows significant contribution from a Charleston type earthquake. In addition to the DBE, a repeat of the Charleston earthquake was analyzed as a check. The PGA at the SRS due to a repeat of the Charleston earthquake is 0.11g (Lee et al., 1997) and Mw = 7.3 (WSRC, 1994; Johnston, 1996).

Calculation Approach

Qualitative Evaluation of Liquefaction Potential

Both laboratory tests and field performance data have shown that the great majority of clayey soils will not liquefy during earthquakes Wang (1979). Criteria to express these observations (i.e., "Modified Chinese Criteria") have been formulated. The criteria state that liquefaction can only occur if the three following conditions are met (Youd et al., 2001):

1. Clay content (particles smaller than 5μ) is < 15 percent by weight;
2. Liquid limit is < 35 percent; and
3. Natural moisture content is > 0.9 times the liquid limit.

The soils at Vault No. 4 generally classify as clayey sands (see Figures 3a, 3b and 4). Liquid and Plastic Limits, Plasticity Index, natural water content and percent fines for samples obtained in the vicinity of Vault No. 4 were evaluated according to the "Modified Chinese Criteria" to check their liquefaction potential. Test data summarized in Table 1 are plotted on Figure 10. About half of the samples in Table 1 do not have moisture content or liquid limit and could not be evaluated using the "Modified Chinese Criteria." Application of the criteria to the individual samples for which data are available show that the vulnerability to liquefaction is negligible at Saltstone Vault No. 4. None of the samples lie within the range where further testing is recommended (see Figure 10).

Quantitative Evaluation of Liquefaction Potential

In this calculation the liquefaction potential at Vault No. 4 is evaluated using a modified versions of the "Simplified Procedure for Evaluating Soil Liquefaction Potential" (Seed and Idriss, 1971; NCEER, 1997; Youd et al., 2001). The simplified procedure calculates the liquefaction factor of safety as the ratio of Cyclic Resistance Ratio (CRR) to the Cyclic Stress Ratio (CSR) generated by the earthquake.

$$\text{Factor of Safety} = \text{CRR} / \text{CSR} \qquad \text{(Eq. 1)}$$

It should be noted that CRR was previously termed CSR required to induce liquefaction, but has been changed to more clearly distinguish the term from the CSR induced by the earthquake (NCEER, 1997). The CRR and CSR are defined in Equations 2 and 3.

$$\text{CRR} = \tau_{ave} / \sigma'_{vo} \text{ (soil capacity)} \qquad \text{(Eq. 2)}$$

where: τ_{ave} is average shear stress required to induce liquefaction and
σ'_{vo} is the effective vertical overburden stress

$$\text{CSR} = \tau_{ave} / \sigma'_{vo} \text{ (earthquake demand)} \qquad \text{(Eq. 3)}$$

where: τ_{ave} is average shear stress induced by the earthquake and
σ'_{vo} is the effective vertical overburden stress

Earthquake Demand or Cyclic Stress Ratio (CSR)

The "Simplified Procedure for Evaluating Soil Liquefaction Potential" uses PGA to estimate shear stress (τ_{ave}) at ground surface and a stress reduction factor (r_d) to calculate τ_{ave} as a function of depth (Seed and Idriss, 1971; NCEER, 1997). More sophisticated ground response modeling can be performed to determine CSR (Richardson et al., 1995), but is not warranted if the simplified techniques show adequate liquefaction resistance. The simplified method for calculating CSR is given by Equation 4:

$$CSR = \tau_{ave} / \sigma'_{vo} = 0.65\,(a_{max} / g)\,(\sigma_{vo} / \sigma'_{vo})\,r_d \qquad \text{(Eq. 4)}$$

where:

(a_{max} / g) = maximum horizontal acceleration at ground surface divided by acceleration of gravity (a_{max} and g are in the same units)

σ_{vo} = the total vertical overburden stress (from Eq. 5)

σ'_{vo} = the effective vertical overburden stress (from Eq. 6)

r_d = the depth dependent stress reduction factor (from Eq. 7)

The total vertical overburden stress is calculated using Equation 5.

$$\sigma_{vo} = (\text{depth})\cdot(\gamma) \qquad \text{(Eq. 5)}$$

The effective vertical overburden stress is calculated using Equation 6.

$$\sigma'_{vo} = (\text{layer thickness layer above water table})\cdot(\gamma) + (\text{depth below water table})\cdot(\gamma_b) \qquad \text{(Eq. 6)}$$

where:

σ'_{vo} = the effective stress

γ = unit weight of soil

γ_b = buoyant unit weight of soil (unit weight of soil - unit weight of water)

The stress reduction factor (r_d) is calculated using Equation 7 (NCEER, 1997). It is important to note that σ_{vo} and σ'_{vo} and r_d are calculated for the post closure conditions (i.e., after placement of 20 feet of capping soil over the vault roof).

$$r_d = 1.0 - 0.00765\,z \quad \text{for } z \leq 9.15 \text{ m} \qquad \text{(Eq. 7a)}$$

$$= 1.174 - 0.0267\,z \quad \text{for } 9.15 \text{ m} < z \leq 23 \text{ m} \qquad \text{(Eq. 7b)}$$

$$= 0.744 - 0.008\,z \quad \text{for } 23 \text{ m} < z \leq 30 \text{ m} \qquad \text{(Eq. 7c)}$$

$$= 0.5 \quad \text{for } z > 30 \text{ m} \qquad \text{(Eq. 7d)}$$

where: z is depth in meters

Attachment A presents the calculation of the response spectra (including PGA) for Z-Area based on the IBC and site specific soil conditions. Based on the USGS seismic hazard maps (Frankel et al., 1996, see Figure 8) and the International Building Code (ICC, 2000) a PGA of 0.21 g would be selected for Z-Area. However, the International Building Code allows a reduction of up to 20% in cases where site specific studies have been performed. Extensive ground response

modeling has been performed for the SRS (Lee et. al, 1997; Lee, 1998). Based on the SRS ground response modeling the reduction is warranted (see Attachment A). The DBE for this calculation has a PGA of 0.17g (i.e., 0.21 x 0.8). The DBE PGA of 0.17g is used to calculate CSR, along with the design water table elevation of 245 feet msl and soil unit weight (γ) of 120 pcf. This PGA is very conservative when compared with the PGA of 0.11g determined for Performance Category 1 structures at SRS (see Attachment A), which is the performance category of the Saltstone Vaults. In addition, a PGA of 0.11g is used to calculate CSR for the Charleston earthquake check.

Soil Capacity or Cyclic Resistance Ratio (CRR)

The original simplified procedure determines CRR using Standard Penetration Test (SPT) N_{160} values and a curve delineating liquefaction. The CRR from the curve is further modified by several factors that have been developed over time. These factors correct for: aging, static driving shear stress, overburden pressure and earthquake magnitude. For this calculation curves based on SPT N_{160} values, CPTu tip stress data (q_{t1}) and shear wave data (V_{s1}) are used to determine CRR. This calculation uses N_{160} and q_{t1} curves developed from testing of SRS soils in lieu of the standard SPT and CPTu liquefaction methods developed for Holocene and younger deposits. The Andrus and Stokoe (2000) shear wave method is used in this calculation. When applying the correction factors Equation 1 becomes Equation 1a. Each of the correction factors and the methods for determining CRR are discussed in the following sections.

$$\text{Factor of Safety} = \frac{CRR_{7.5} \cdot K_{\sigma} \cdot K_{age} \cdot K_{\alpha} \cdot MSF}{CSR} \qquad \text{(Eq. 1a)}$$

Age Correction Factor K_{age}

The N_{160} and q_{t1} curves used for this calculation were developed specifically for SRS using data from nearby investigations in H-Area (BSRI, 1993 and SRS 1994a) after extensive field and laboratory testing programs. Because the SRS N_{160} and q_{t1} CRR curves were developed from testing of the Tobacco Road and Dry Branch sediments, aging is incorporated into the curves. The curves may be directly applied to calculate liquefaction susceptibility without applying an age correction factor. However, the Andrus and Stokoe (2000) shear wave velocity method is used in this calculation. The shear wave method was develop from Holocene and younger deposits, but should account for the increased soil capacity since shear wave velocity increases with time. In this calculation the CPTu, SPT and Vs methods are applied directly without an age correction (i.e., $K_{age} = 1.0$).

Static Driving Shear Stress Correction Factor, $K\alpha$

Relationships proposed by Seed and Harder (1990) suggest that a static driving shear stress can increase or decrease the soil's resistance to liquefaction, depending on the magnitude of the driving stress and the relative density of the soil. A static driving shear stress correction factor ($K\alpha$) has been proposed by Seed and Harder to correct CRR. However, the proposed chart to estimate $K\alpha$ is preliminary and this correction factor is a subject of current research (NCEER, 1997, pp. 172-176). For this calculation, no $K\alpha$ correction was used (i.e., $K\alpha = 1.0$).

Static Effective Overburden Pressure Correction Factor, $K\sigma$

Most of the case history data used to develop the standard liquefaction curves (Seed and Idriss, 1982 and NRC, 1985) were taken from cases of level ground with relatively small initial effective overburden stresses ($\sigma'_o \leq 1$ tsf). However, at higher effective overburden stresses ($\sigma'_o > 1$ tsf), the liquefaction susceptibility of the soil will increase for a given CSR (Seed and Harder, 1990). Thus, the CRR must be corrected for the influence of the static overburden stresses. This is done by multiplying CRR by the correction factor ($K\sigma$). Figure 11 shows the SRS $K\sigma$ curve along with data used to develop the curve (WSRC, 1995). The NCEER recommended $K\sigma$ curves (Youd et al., 2001) are also shown on Figure 11 for comparison. The polynomial representing the SRS $K\sigma$ curve shown in Figure 11 is given in Equation 8.

$$K\sigma = 1.009376 - 0.18326 \log(\sigma'_{vo}) - 0.08340 \log(\sigma'_{vo})^2 \qquad \text{(Eq. 8)}$$

where: σ'_{vo} is Effective Vertical Overburden Pressure in tsf.

It is important to note that $K\sigma$ was calculated using σ'_{vo} for the post closure conditions (i.e., after placement of 20 feet of capping soil over the vault roof). Also note that the $K\sigma$ used for this calculation (Eq. 8) is a site-specific relationship developed using data from nearby investigations in H-Area (WSRC, 1995; SRS, 1994b and SRS, 1995) and not the standard $K\sigma$ relationship proposed by NCEER (Youd et al, 2001). The SRS $K\sigma$ used is applicable for the Saltstone vaults, but less stringent than the $K\sigma$ proposed by NCEER.

Earthquake Magnitude Scaling Factor, MSF

The CRR curves used for liquefaction analysis are only valid for M = 7.5 earthquakes. For earthquakes with differing magnitudes, the CRR values must be multiplied by a magnitude scaling factor (MSF). Values of the MSF and corresponding earthquake magnitude are shown on Figure 12 (NCEER, 1997).

The PGA (i.e., 0.17g) is based on the USGS seismic hazard maps (Frankel et al., 1996) and the International Building Code (ICC, 2000). Because the USGS hazard maps are a combination of many credible earthquake events a single magnitude isn't assigned. The USGS performed a Probabilistic Seismic Hazard Assessment specifically for SRS. The PGA hazard dissagregation for the 2500 return period is presented in Table 2 and Figure 9. The DBE based on the average earthquake magnitude comprised from the USGS SRS seismic hazard is Mw = 6.5 (see Table 2). The MSF used for the DBE with Mw = 6.5 is 1.6. The MSF used for the Charleston earthquake check with Mw = 7.3 is 1.1.

CRR from Shear Wave Velocity

Figure 13 presents the V_{s1} versus CRR curves. Equation 9 represents the V_{s1} curves mathematically (Youd et al., 2001).

$$CRR = 0.022\,(V_{s1}/100)^2 + 2.8\,[1 / (V^*_{s1} - V_{s1}) - 1 / V^*_{s1}] \qquad \text{(Eq. 9)}$$

where:

V_{s1} is overburden stress-corrected shear wave velocity (see Eq. 10)

V^*_{s1} is the limiting value of V_{s1} for cyclic liquefaction occurrence (see Eqs. 11-13)

$$V_{s1} = V_s\,(Pa / \sigma'_{vo})^{0.25} \qquad \text{(Eq. 10)}$$

where:

V_s is shear wave velocity

Pa is reference stress of about atmospheric pressure

σ'_{vo} is the effective vertical overburden stress

(P_a and σ'_{vo} must be in the same units)

$V^*_{s1} = 215$ m/s, for sands with fines content (FC) $\leq 5\%$ (Eq. 11)

$V^*_{s1} = 215 - 0.5(FC - 5)$ m/s, for sands with $5\% < FC < 35\%$ (Eq. 12)

$V^*_{s1} = 200$ m/s, for sands with $FC \geq 35\%$ (Eq. 13)

CRR from the SRS SPT N_{160} versus CRR Curve

Figure 14 presents the SRS N_{160} versus CRR curve developed for the Tobacco Road and Dry Branch Formations at RTF. Also shown as open circles on Figure 14 are the Replacement Tritium Facility (RTF) laboratory test results representing 9, 14, and 24 percent fines (BSRI, 1993). The design curve does not vary with fines content, but does incorporate increased liquefaction resistance due to fines and aging. Laboratory testing and development of the N_{160} design curve are discussed in BSRI (1993). Equation 14 is a polynomial developed by the originator of this calculation for computer application of the SRS N_{160} design curve.

$$CRR = 0.0000685(N_{160})^3 - 0.0010089(N_{160})^2 + 0.0177243(N_{160}) + 0.0645105 \qquad \text{(Eq. 14)}$$

The SPT N value (N_{60}) must be normalized (N_{160}) for overburden stress prior to applying the design curve. This is done using an overburden correction factor C_N shown in Equations 15 and 16 (Youd et al., 2001).

$$N_{160} = C_N \times N_{60} \qquad \text{(Eq. 15)}$$

$$C_N = 2.2 / (1.2 + \sigma'_{vo}/Pa) \quad \text{with } C_N \leq 1.7 \qquad \text{(Eq. 16)}$$

where: C_N = SPT overburden normalization factor

Pa = Atmospheric pressure

σ'_{vo} = Effective vertical overburden pressure at time of testing

(P_a and σ'_{vo} must be in the same units)

CRR from the SRS q_{t1} versus CRR Curves

Figure 15 presents the SRS q_{t1} versus CRR curves (WSRC, 1995). Equations 17 through 21 (SRS, 1995) were developed for computer application of the SRS q_{t1} versus CRR curves. Laboratory testing and development of the curves are discussed in SRS (1994a; 1995) and WSRC (1995).

for fines content 30%:

$$CRR = 0.125721 + 0.002537\,(q_{t1}) + 0.000040\,(q_{t1})^2 \qquad \text{(Eq. 17)}$$

for fines content 22.5%:

$$CRR = 0.093309 + 0.001757\,(q_{t1}) + 0.000029\,(q_{t1})^2 \qquad \text{(Eq. 18)}$$

for fines content 15%:

$$CRR = 0.072666 + 0.001141\,(q_{t1}) + 0.000028\,(q_{t1})^2 \qquad \text{(Eq. 19)}$$

for fines content 10%:

$$CRR = 0.046881 + 0.001190\,(q_{t1}) + 0.000015\,(q_{t1})^2 \qquad \text{(Eq. 20)}$$

for fines content 0%:

$$CRR = 0.021215 + 0.001408\,(q_{t1}) + 0.000007\,(q_{t1})^2 \qquad \text{(Eq. 21)}$$

The CPTu tip stress (q_t) must be normalized (q_{t1}) for overburden stress prior to applying the curves. This is done using an overburden correction factor C_Q shown in Equations 22 and 23 (Youd et al., 2001).

$$q_{t1} = C_Q \times q_t \qquad \text{(Eq. 22)}$$

$$C_Q = (P_a / \sigma'_{vo})^n \text{ with } C_Q \leq 1.7 \qquad \text{(Eq. 23)}$$

where: C_Q = CPTu Overburden Normalization Factor
Pa = Atmospheric pressure
σ'_{vo} = Effective vertical overburden pressure at time of testing
P_a and σ'_{vo} must be in the same units
n = exponent ranges between 0.5 for clean sand and 1.0 for clays

For this calculation the n exponent in Equation 23 was varied linearly, based on percent fines, between 0.5 for clean sand (i.e., fines $\leq 5\%$) and 1.0 for clays (i.e., fines $\geq 50\%$). It is important to note that normalization of q_t to q_{t1} is performed using effective vertical overburden pressure at the time of data collection.

Percent Fines

The SRS N_{160} has a range of fines content incorporated into the CRR design curve and does not require percent fines to determine CRR. However, the laboratory determined percent fines content for the Z-Area soil strata (S2≈16%, C2≈45%, S3≈17%, see Table 1) are comparable or greater than the percent fines used to establish the Tobacco Road and Dry Branch design curve (9%, 14% and 24%), Figure 14.

The SRS q_{t1} and the Andrus and Stokoe (2000) shear wave velocity methods used in this calculation require percent fines to determine CRR. Percent fines is determined two ways, with liquefaction potential calculated for both fines content determinations for both methods. Fines content and liquefaction potential are calculated using average laboratory determinations summarized in Table 1. Fines content and liquefaction potential are also determined using an SRS site specific CPTu method.

The SRS CPTu method for determining percent fines was developed by correlating laboratory determined fines content from borings with nearby CPTu results (SRS, 2001). The SRS method uses a classification index (I_c) to calculate percent fines. The SRS method is given in Equations 24 and 25.

$$\text{Percent Fines} = 29.47(I_c)^{1.21} - 0.09 \qquad \text{(Eq. 24)}$$

$$I_c = [(1.60-\log Q_t)^2 + (\log Fr + 0.41)^2]^{0.5} \qquad \text{(Eq. 25)}$$

Where: Q_t is normalized tip resistance $Q_t = (q_t-\sigma_{vo})/\sigma'_{vo}$
Fr is stress normalized friction ratio $Fr = [(f_s/q_t-\sigma_{vo}) \times 100]$
q_t is CPTu tip stress corrected for unequal area effects
f_s is CPTu sleeve friction
σ_{vo} is the total vertical overburden stress (from Eq. 5)
σ'_{vo} is the effective vertical overburden stress (from Eq. 6)

Figure 16 presents the laboratory determined percent fines from Table 1 along with the CPTu calculated percent fines for the ZCP-23 SCPTu location. The CPTu calculated percent fines compare reasonably well with the laboratory determined percent fines except for the C2 stratum (around elev. 210 to 225) where percent fines varies widely. The C2 stratum should not be particularly vulnerable to liquefaction due to the relatively high fines content, therefore some error in fines content is tolerable for this layer and this calculation.

Settlement Resulting from Liquefaction and Partial Liquefaction

Settlement due to liquefaction and partial liquefaction can be calculated using standard techniques from the geotechnical engineering literature or techniques based on site specific testing. Due to the age and increased strength it was necessary to sample and test SRS soils to quantify strain due to cyclic loading. SRS specific volumetric strain curves were developed during sampling and laboratory testing programs from nearby H-Area (SRS, 1994a; 1994c; 1995; BSRI, 1993). The SRS volumetric strain curves (Figure 17) give volumetric strain as a function of CPTu tip resistance and factor of safety. Because the SRS volumetric strain curves were developed from testing of the Tobacco Road and Dry Branch sediments, the curves incorporate strength due to aging.

For conservatism, the SRS volumetric strain curves considered liquefaction triggered in all zones having a factor of safety less than or equal to 1.15 (BSRI, 1993 and WSRC, 1995). Soils having factors of safety between 1.15 and 2.2 are considered to be partially liquefied. Soils with a factor of safety > 2.2 are considered to be non-liquefiable. No settlement is expected for Factors of Safety greater than 2.2.

For this calculation, dynamic settlement of unsaturated (i.e., above the water table) sands was ignored, because of their small contribution to the total dynamic settlement.

It was assumed that all liquefiable and partially liquefiable zones within the profile will settle and the resulting settlement will be cumulative at the surface. No consideration is given for dilation or bridging effects of interspersed or overlying, non-liquefied layers. This is a conservative assumption and actual settlements may be less, especially if the thickness of the non-liquefied layer(s) is great. Total cumulative settlement resulting from liquefaction and partial liquefaction is estimated for the profile by summing the liquefaction settlement (i.e., $FS \leq 1.15$) and partial liquefaction settlement (i.e., $1.15 < FS \leq 2.2$) for each increment:

$$S_{Total} = \Sigma\, S_{Liq} + \Sigma\, S_{P\,Liq} \qquad \text{(Eq. 26)}$$

where:

S_{Total} = cumulative settlement,
S_{Liq} = settlement of the increment due to liquefaction, and
$S_{P\,Liq}$ = settlement of the increment due to partial liquefaction.

The value of S_{Liq} is calculated from:

$$S_{Liq} = \text{(volumetric strain due to liquefaction) } dz \qquad \text{(Eq. 27)}$$

and the value of $S_{P\,Liq}$ is calculated from:

$$S_{P\,Liq} = \text{(volumetric strain due to partial liquefaction) } dz \qquad \text{(Eq. 28)}$$

where: dz = thickness of the increment.

Volumetric Strain Curves

The volumetric strain curves developed for SRS using H-Area data and used in this calculation are presented in Figure 17 (SRS, 1994a; 1994c; WSRC, 1995). The volumetric strain curves for various values of q_{t_1} are a function of factor or safety. These curves have been fitted with the following regression equations, which were derived and presented in calculation C-CLC-H-00815 (SRS, 1995).

for $q_{t_1} = 160$, $0.4 < FS < 1.15$

$$\text{strain (\%)} = 0.65 \qquad \text{(Eq. 29)}$$

for $q_{t_1} = 130$, $0.4 < FS < 1.15$

$$\text{strain (\%)} = 2.9883 + 10.354(FS)^4 - 30.258(FS)^3 + 30.7(FS)^2 - 13.064(FS) \qquad \text{(Eq. 30)}$$

for $q_{t_1} = 100$, $0.4 < FS < 1.15$

$$\text{strain (\%)} = 2.0308 + 8.3929(FS)^4 - 21.111(FS)^3 + 16.12(FS)^2 - 4.5756(FS) \qquad \text{(Eq. 31)}$$

for $q_{t_1} = 50$, $0.4 < FS < 0.65$

$$\text{strain (\%)} = -41.6495 - 756.666(FS)^4 + 1505.222(FS)^3 - 1123.65(FS)^2 + 371.2387(FS) \qquad \text{(Eq. 32)}$$

for $q_{t_1} = 50$, $0.65 < FS < 1.15$

$$\text{log strain (\%)} = 1.256225 - 0.21100(FS)^2 - 1.01242(FS) \qquad \text{(Eq. 33)}$$

for $q_{t_1} = 30$, $0.4 < FS < 0.65$

$$\text{strain (\%)} = -45.4815 - 830.0000(FS)^4 + 1651.074(FS)^3 - 1231.64(FS)^2 + 406.5062(FS) \qquad \text{(Eq. 34)}$$

for $q_{t_1} = 30$, $0.65 < FS < 1.15$

$$\text{log strain (\%)} = 1.181442 - 0.47909(FS)^2 - 0.63184(FS) \qquad \text{(Eq. 35)}$$

for $q_{t_1} = 20$, $0.4 < FS < 0.65$

$$\text{strain (\%)} = -45.2315 - 830.0000(FS)^4 + 1651.074(FS)^3 - 1231.64(FS)^2 + 406.5062(FS) \qquad \text{(Eq. 36)}$$

for $q_{t_1} = 20$, $0.65 < FS < 1.15$

$$\text{log strain (\%)} = 0.679601 - 1.17026(FS)^2 + 0.616392(FS) \qquad \text{(Eq. 37)}$$

for $q_{t_1} = 10$, $0.4 < FS < 0.65$

$$\text{strain (\%)} = -29.6577 - 560.0000(FS)^4 + 1114.074(FS)^3 - 836.066(FS)^2 + 278.6576(FS) \quad \text{(Eq. 38)}$$

for $q_{t_1} = 10$, $0.65 < FS < 1.15$

$$\log \text{strain (\%)} = 0.454166 - 1.56185(FS)^2 + 1.272068(FS) \quad \text{(Eq. 39)}$$

for $q_{t_1} = 5$, $0.4 < FS < 0.65$

$$\text{strain (\%)} = -29.7775 - 566.666(FS)^4 + 1127.333(FS)^3 - 845.883(FS)^2 + 281.8638(FS) \quad \text{(Eq. 40)}$$

for $q_{t_1} = 5$, $0.65 < FS < 1.15$

$$\log \text{strain (\%)} = 0.367762 - 1.73636(FS)^2 + 1.555255(FS) \quad \text{(Eq. 41)}$$

for partial liquefaction $1.15 < FS < 1.6$ and all q_{t_1} values

$$\log \text{strain (\%)} = 1.256225 - 0.21100(FS)^2 - 1.01242(FS) \quad \text{(Eq. 42)}$$

for partial liquefaction $1.6 < FS < 2.2$ and all q_{t_1} values

$$\text{strain (\%)} = 0.728794 + 0.100221(FS)^2 - 0.54090(FS) \quad \text{(Eq. 43)}$$

Assumptions

1. The CRR and volumetric strain relationships developed for SRS (Figures 14, 15 and 17) using data from nearby investigations in H-Area (BSRI, 1993 and SRS, 1994a) are applicable to Z-Area soils. These curves were developed from samples of the Tobacco Road and Dry Branch Formations. In applying these curves in Z-Area, it is assumed the liquefaction resistance of the Tobacco Road and Dry Branch Formations in Z-Area is similar to the Tobacco Road and Dry Branch Formations in H-Area.
2. Because the SRS CRR and volumetric strain relationships (Figures 14, 15 and 17) incorporate aging of the Tobacco Road and Dry Branch Formations, the curves may be directly applied to calculate liquefaction susceptibility without applying an age correction factor.
3. The static effective overburden correction factor (K_σ) developed for SRS (Figure 11) using data from nearby investigations in H-Area (WSRC, 1995; SRS, 1994b and SRS, 1995) is applicable for Z-Area soils.
4. Even though the Andrus and Stokoe (2000) shear wave method was develop from Holocene and younger deposits, it is assumed that it accounts for increased liquefaction resistance due to aging since shear wave velocity increases with time.
5. In order to calculate percent fines to be used with the Andrus and Stokoe V_{s1} and SRS N_{160} CRR curves (Figures 13 and 14) the SRS site specific relationship (Equations 24 and 25)

developed using data gathered from several locations at the SRS was used. It is assumed that this relationship is valid for Z-Area.

6. These calculations were done for free field conditions. The effects of static driving shear stresses were ignored. No $K\alpha$ correction was made (i.e., $K\alpha = 1$). The factor, $K\alpha$, has been proposed to account for static driving stresses. However, this factor is a subject of current research (NCEER, 1997).
7. For conservatism, liquefaction was considered triggered in all zones having a factor of safety less than or equal to 1.15. Soils having factors of safety between 1.15 and 2.2 were considered to be partially liquefiable. Soils with a factor of safety > 2.2 are considered to be non-liquefiable with no dynamic settlement.
8. The water level elevation near Vault No. 4 ranges between 213 and 228 ft-msl (see Figure 6). However, the groundwater elevation used for the liquefaction analysis is 245 ft-msl. This is based on water levels observed in boreholes during drilling (see Figures 3a and 3b) and reports of perched water in Z-Area (MRCE, 1986b and Cook, 1986). Soils above 245 ft-msl were excluded from the analyses because they are not saturated and therefore not susceptible to liquefaction. Dynamic settlement occurring in dry sands is small in comparison to liquefaction and partial liquefaction settlement and can be neglected. (Volumetric strains in dry sands are about an order of magnitude smaller than those in liquefied saturated sands at equal relative densities and under the same intensity of ground shaking [Soydemir, 1993]).
9. For the liquefaction and partial liquefaction settlement calculations, it was assumed that all liquefiable and partially liquefiable zones within the profile will settle and the resulting settlement will be cumulative at the surface. No consideration is given for dilation or bridging effects of interspersed or overlying, non-liquefied layers. This is a conservative assumption and actual settlements may be less, especially if the thickness of the non-liquefied layer(s) is great.
10. The DBE PGA established for Z-Area (0.17g) and used to determine CSR is assigned an earthquake with a magnitude of 6.5. This magnitude is an average based on the composition of the USGS PGA earthquake hazard for the 2500 year return period (see Table 2).
11. The middle of the Magnitude Scaling Factor (MSF) range recommended by NCEER workshop (NCEER, 1997) is used in this calculation (see Figure 12). It is assumed that these MSFs best account for differences in earthquake energy or magnitude.

Calculation

The "Modified Chinese Criteria" was used to qualitatively evaluate liquefaction susceptibility. The criteria show that the vulnerability to liquefaction is negligible at Saltstone Vault No. 4. None of the samples lie within the range where further testing is recommended (see Figure 10).

The "Simplified Procedure for Evaluating Soil Liquefaction Potential" (Youd et al., 2001) was also used to evaluate liquefaction susceptibility. However, site specific N_{160} and q_{t1} liquefaction susceptibility CRR curves were substituted in lieu of Holocene N_{160} and q_{t1} liquefaction susceptibility CRR curves available in the geotechnical literature. The Andrus and Stokoe (2000) V_{s1} versus CRR relationship was also used. Site specific volumetric strain curves utilizing CPTu tip stress were used to estimate settlement.

To summarize, three methods for determining CRR were used to quantitatively evaluate liquefaction susceptibility: 1) the SPT (N_{160}) method, 2) the shear wave (V_{s1}) method, and 3) the CPTu (q_{t1}) method. These three methods were used in conjunction with two earthquakes: 1) the DBE and 2) the Charleston earthquake. Where percent fines were required two methods were used to determine percent fines (i.e., CPTu calculated and laboratory).

Method 1 SPT (N_{160}) Method
Liquefaction susceptibility calculations for the DBE using N_{160} data from the five Vault No. 4 SPT borings (Z-204, Z-205, Z-206, Z-207 and Z-208) are presented on sheets 18 through 22. The liquefaction susceptibility plots for the DBE (i.e., factor of safety versus elevation) are presented in Figures 18a through 18e. Liquefaction susceptibility calculations for the Charleston earthquake check using N_{160} data are presented on sheets 23 through 27. The liquefaction susceptibility plots for the Charleston earthquake check are presented in Figures 19a through 19e. The DBE and Charleston earthquake results are comparable with the DBE giving slightly lower factors of safety.

Method 2 Shear Wave (V_{s1}) Method
Liquefaction susceptibility calculations for the DBE using V_{s1}data from the six Vault No. 4 SCPTu soundings (ZCP-22, ZCP-23, ZCP-24, ZCP-25, ZCP-26 and ZCP-27) are presented on sheets 28 through 33 for CPTu determined percent fines and on sheets 34 through 39 for average laboratory determined percent fines. The liquefaction susceptibility (i.e., factor of safety versus elevation) is presented on Figure 20 for CPTu determined percent fines and on Figure 21 for average laboratory determined. Liquefaction susceptibility calculations for the Charleston earthquake check using V_{s1}data are presented on sheets 40 through 45 for CPTu determined percent fines and on sheet 46 through 51 for average laboratory determined percent fines. The liquefaction susceptibility is presented on Figure 22 for CPTu determined percent fines and on Figure 23 for average laboratory determined percent fines. As with the N_{160} method, the DBE and Charleston earthquake results are comparable with the DBE giving slightly lower factors of safety. The results using CPTu determined percent fines are comparable to the results using laboratory determined percent fines with the laboratory determined percent fines giving slightly lower factors of safety.

Method 3 CPTu (q_{t1}) method
Liquefaction susceptibility and estimated settlement calculations for the DBE and Charleston earthquake check using q_{t1} data from the six Vault No. 4 SCPTu soundings are not provided as hard copy due to the volume of data, but are provided on the disk accompanying this calculation. The liquefaction factor of safety versus elevation and settlement versus elevation for the DBE using q_{t1} data are presented in Figure 24a through 24f for CPTu determined percent fines and on Figure 25 for average laboratory determined percent fines. To limit the analyses, only ZCP-27 was run for the laboratory determined fines because CPTU estimated fines generally gives lower factors of safety and because ZCP-27 gives the greatest settlement. The liquefaction factor of safety versus elevation and settlement versus elevation for the Charleston earthquake check using q_{t1} data

are presented in Figure 26a through 26f for CPTu determined percent fines and on Figure 27 for average laboratory determined percent fines. Again, only ZCP-27 was run for the laboratory determined fines.

Settlements calculated using the SRS volumetric strain relationship for each of the SCPTu locations are summarized below.

SCPTu ID	Settlement DBE PGA = 0.17g Mw = 6.5 CPTu Fines (inch)	Settlement DBE PGA = 0.17g Mw = 6.5 Laboratory Fines (inch)	Settlement Charleston 1886 PGA = 0.11g Mw = 7.3 CPTu Fines (inch)	Settlement Charleston 1886 PGA = 0.11g Mw = 7.3 Laboratory Fines (inch)
ZCP-22	0.13	-	0.08	-
ZCP-23	0.06	-	0.03	-
ZCP-24	0.09	-	0.05	-
ZCP-25	0.04	-	0.02	-
ZCP-26	0.09	-	0.05	-
ZCP-27	0.37	0.27	0.31	0.19
Average =	0.13		0.09	

As an additional check, settlements were calculated for SCPTu location ZCP-27, with CPTu determined percent fines, PGA=0.17g and for all magnitudes in the USGS seismic hazard for SRS (i.e., Mw of 4.75, 5.25, 5.75, 6.25, 6.75 and 7.5, see Table 2). Only ZCP-27 was run because it gives the greatest settlement. These calculations are not provided as hard copy due to the volume of data, but are provided on the disk accompanying this calculation. Settlements calculated for ZCP-27 at these magnitudes are summarized below. Also given is the weighted average.

SCPTu ID	Mw =4.75 MSF=3.4	Mw =5.25 MSF=2.8	Mw =5.75 MSF=2.2	Mw =6.25 MSF=1.7	Mw =6.75 MSF=1.4	Mw =7.5 MSF=1.0
ZCP-27	0.08	0.12	0.18	0.31	0.59	2.36

Weighted Average = 1.22 inch

Notes:

Weighted Average = [(0.08x15.52)+(0.12x12.16)+(0.18x10.76)+(0.31x10.25)+(0.59x3.92)+(2.36x47.40)] / 100

Weights are from USGS hazard disaggregation given in Table 2.

Boring Z-204

Site: Z-AREA
Surface Elev.: 281.2
Northing: 76,155
Easting: 67,098

Original Surface Elevation = 281.2
Original Water Elevation = 242
Original Depth to Water Table = 39.2

Final Surface Elevation = 318
Design Water Elevation = 245
Depth to Water Table = 73

M = 6.5
MSF = 1.6

amax = 0.17 g

Original Mid Depth (ft)	Final Mid Depth (ft)	Elevation (ft)	SPT N60 (blows/ft)	Original Overburden (tsf)	Original Effecive Overburden (tsf)	Final Overburden (tsf)	Final Effecive Overburden (tsf)	Wet Density (pcf)	Overburden Correction Factor C_N Eq. 16	SPT (N1)60 (blows/ft)	CRR M=7.5 RTF Design Curve Eq. 14	Static Shear Stress Correction Ka	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR corrected for Ksigma magnitude and Ka Eq.1a	rd Eq. 7	CSR Eq. 4	Factor of Safety FS Eq.1a
1	37.8	280.2	3	0.06	0.06	2.27	2.27	120	1.70	5.1	0.138	1	0.934	0.206	0.866	0.096	above WT
3.5	40.3	277.7	5	0.21	0.21	2.42	2.42	120	1.56	7.8	0.174	1	0.927	0.258	0.846	0.093	above WT
6	42.8	275.2	10	0.36	0.36	2.57	2.57	120	1.41	14.1	0.306	1	0.920	0.451	0.826	0.091	above WT
8.5	45.3	272.7	21	0.51	0.51	2.72	2.72	120	1.29	27.0	1.158	1	0.914	1.693	0.805	0.089	above WT
11	47.8	270.2	49	0.66	0.66	2.87	2.87	120	1.18	58.0	11.038	1	0.908	16.037	0.785	0.087	above WT
13.5	50.3	267.7	57	0.81	0.81	3.02	3.02	120	1.09	62.4	13.877	1	0.902	20.034	0.765	0.084	above WT
16	52.8	265.2	31	0.96	0.96	3.17	3.17	120	1.02	31.6	1.775	1	0.897	2.546	0.744	0.082	above WT
21	57.8	260.2	30	1.26	1.26	3.47	3.47	120	0.89	26.8	1.137	1	0.886	1.612	0.704	0.078	above WT
26	62.8	255.2	28	1.56	1.56	3.77	3.77	120	0.80	22.3	0.719	1	0.876	1.008	0.663	0.073	above WT
31	67.8	250.2	20	1.86	1.86	4.07	4.07	120	0.72	14.4	0.314	1	0.867	0.436	0.622	0.069	above WT
36	72.8	245.2	26	2.16	2.16	4.37	4.37	120	0.65	17.0	0.412	1	0.858	0.565	0.582	0.064	above WT
41	77.8	240.2	41	2.46	2.40	4.67	4.52	120	0.61	25.0	0.950	1	0.854	1.298	0.554	0.063	20.51
46	82.8	235.2	66	2.76	2.55	4.97	4.66	120	0.59	38.7	3.220	1	0.850	4.377	0.542	0.064	68.57
51	87.8	230.2	59	3.06	2.69	5.27	4.81	120	0.57	33.4	2.075	1	0.846	2.807	0.530	0.064	43.74
56	92.8	225.2	17	3.36	2.84	5.57	4.95	120	0.55	9.3	0.197	1	0.842	0.265	0.518	0.064	4.12
61	97.8	220.2	5	3.66	2.98	5.87	5.09	120	0.53	2.6	0.105	1	0.838	0.141	0.506	0.064	2.20
66	102.8	215.2	10	3.96	3.12	6.17	5.24	120	0.51	5.1	0.138	1	0.834	0.184	0.500	0.065	2.82
71	107.8	210.2	74	4.26	3.27	6.47	5.38	120	0.49	36.4	2.685	1	0.831	3.569	0.500	0.066	53.76
76	112.8	205.2	73	4.56	3.41	6.77	5.53	120	0.48	34.8	2.351	1	0.827	3.112	0.500	0.068	45.99
81	117.8	200.2	21	4.86	3.56	7.07	5.67	120	0.46	9.7	0.204	1	0.824	0.269	0.500	0.069	3.91
86	122.8	195.2	17	5.16	3.70	7.37	5.81	120	0.45	7.6	0.171	1	0.821	0.225	0.500	0.070	3.22
91	127.8	190.2	47	5.46	3.84	7.67	5.96	120	0.44	20.5	0.594	1	0.817	0.777	0.500	0.071	10.92
96	132.8	185.2	33	5.76	3.99	7.97	6.10	120	0.42	14.0	0.303	1	0.814	0.394	0.500	0.072	5.46
101	137.8	180.2	66	6.06	4.13	8.27	6.25	120	0.41	27.2	1.182	1	0.811	1.534	0.500	0.073	20.97
106	142.8	175.2	52	6.36	4.28	8.57	6.39	120	0.40	20.9	0.619	1	0.808	0.800	0.500	0.074	10.80
110.2	147	171	101	6.61	4.40	8.82	6.51	120	0.39	39.7	3.464	1	0.805	4.463	0.500	0.075	59.63
116	152.8	165.2	45	6.96	4.56	9.17	6.68	120	0.38	17.2	0.418	1	0.802	0.537	0.500	0.076	7.07
120	156.8	161.2	101	7.20	4.68	9.41	6.79	120	0.37	37.8	2.992	1	0.799	3.825	0.500	0.077	49.99
125.1	161.9	156.1	101	7.51	4.83	9.71	6.94	120	0.37	36.9	2.781	1	0.796	3.542	0.500	0.077	45.81
131	167.8	150.2	72	7.86	5.00	10.07	7.11	120	0.36	25.6	1.003	1	0.793	1.272	0.500	0.078	16.26
135.6	172.4	145.6	101	8.14	5.13	10.34	7.24	120	0.35	35.1	2.408	1	0.790	3.044	0.500	0.079	38.58
141	177.8	140.2	57	8.46	5.28	10.67	7.40	120	0.34	19.3	0.525	1	0.787	0.662	0.500	0.080	8.31
146	182.8	135.2	43	8.76	5.43	10.97	7.54	120	0.33	14.3	0.311	1	0.784	0.390	0.500	0.080	4.86
150.2	187	131	101	9.01	5.55	11.22	7.66	120	0.33	32.9	1.999	1	0.782	2.502	0.500	0.081	30.92

Boring Z-205

Site: Z-AREA
Surface Elev.: 280.2
Northing: 75,965
Easting: 67,610

Original Surface Elevation = 280.2
Original Water Elevation = 240
Original Depth to Water Table = 40.2

Final Surface Elevation = 318
Design Water Elevation = 245
Depth to Water Table = 73

M = 6.5
MSF = 1.6

amax = 0.17 g

Original Mid Depth (ft)	Final Mid Depth (ft)	Elevation (ft)	SPT N60 (blows/ft)	Original Overburden (tsf)	Original Effecive Overburden (tsf)	Final Overburden (tsf)	Final Effecive Overburden (tsf)	Wet Density (pcf)	Overburden Correction Factor C_N Eq. 16	SPT (N1)60 (blows/ft)	CRR M=7.5 RTF Design Curve Eq. 14	Static Shear Stress Correction Ka	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR corrected for Ksigma magnitude and Ka Eq.1a	rd Eq. 7	CSR Eq. 4	Factor of Safety FS Eq.1a
1	38.8	279.2	6	0.06	0.06	2.33	2.33	120	1.70	10.2	0.213	1	0.931	0.317	0.858	0.095	above WT
3.5	41.3	276.7	9	0.21	0.21	2.48	2.48	120	1.56	14.0	0.304	1	0.924	0.450	0.838	0.093	above WT
6	43.8	274.2	45	0.36	0.36	2.63	2.63	120	1.41	63.5	14.634	1	0.918	21.489	0.818	0.090	above WT
8.5	46.3	271.7	39	0.51	0.51	2.78	2.78	120	1.29	50.2	7.067	1	0.912	10.308	0.797	0.088	above WT
11	48.8	269.2	35	0.66	0.66	2.93	2.93	120	1.18	41.4	3.929	1	0.906	5.694	0.777	0.086	above WT
13.5	51.3	266.7	33	0.81	0.81	3.08	3.08	120	1.09	36.1	2.616	1	0.900	3.768	0.757	0.084	above WT
16	53.8	264.2	26	0.96	0.96	3.23	3.23	120	1.02	26.5	1.098	1	0.895	1.572	0.736	0.081	above WT
21	58.8	259.2	19	1.26	1.26	3.53	3.53	120	0.89	17.0	0.410	1	0.884	0.581	0.695	0.077	above WT
26	63.8	254.2	21	1.56	1.56	3.83	3.83	120	0.80	16.7	0.400	1	0.874	0.559	0.655	0.072	above WT
31	68.8	249.2	21	1.86	1.86	4.13	4.13	120	0.72	15.1	0.338	1	0.865	0.468	0.614	0.068	above WT
36	73.8	244.2	19	2.16	2.16	4.43	4.40	120	0.65	12.4	0.261	1	0.857	0.357	0.573	0.064	5.61
41	78.8	239.2	32	2.46	2.44	4.73	4.55	120	0.61	19.4	0.527	1	0.853	0.719	0.552	0.063	11.34
45.7	83.5	234.5	101	2.74	2.57	5.01	4.68	120	0.58	58.9	11.625	1	0.849	15.792	0.540	0.064	247.17
51	88.8	229.2	17	3.06	2.72	5.33	4.84	120	0.56	9.5	0.201	1	0.845	0.272	0.527	0.064	4.23
56	93.8	224.2	11	3.36	2.87	5.63	4.98	120	0.54	6.0	0.149	1	0.841	0.200	0.515	0.064	3.11
61	98.8	219.2	8	3.66	3.01	5.93	5.12	120	0.52	4.2	0.126	1	0.837	0.169	0.500	0.064	2.64
66	103.8	214.2	15	3.96	3.16	6.23	5.27	120	0.51	7.6	0.171	1	0.834	0.228	0.500	0.065	3.49
71	108.8	209.2	25	4.26	3.30	6.53	5.41	120	0.49	12.2	0.256	1	0.830	0.339	0.500	0.067	5.09
76	113.8	204.2	71	4.56	3.44	6.83	5.56	120	0.47	33.6	2.127	1	0.827	2.813	0.500	0.068	41.43
80.5	118.3	199.7	101	4.83	3.57	7.10	5.68	120	0.46	46.6	5.616	1	0.824	7.400	0.500	0.069	107.26
86	123.8	194.2	77	5.16	3.73	7.43	5.84	120	0.45	34.4	2.260	1	0.820	2.965	0.500	0.070	42.21
91	128.8	189.2	50	5.46	3.88	7.73	5.99	120	0.43	21.7	0.672	1	0.817	0.878	0.500	0.071	12.31
96	133.8	184.2	59	5.76	4.02	8.03	6.13	120	0.42	24.9	0.935	1	0.813	1.217	0.500	0.072	16.82
101	138.8	179.2	54	6.06	4.16	8.33	6.28	120	0.41	22.2	0.707	1	0.810	0.916	0.500	0.073	12.49
105.6	143.4	174.6	101	6.34	4.30	8.60	6.41	120	0.40	40.4	3.660	1	0.807	4.727	0.500	0.074	63.71
110.3	148.1	169.9	101	6.62	4.43	8.89	6.54	120	0.39	39.5	3.402	1	0.804	4.378	0.500	0.075	58.35
115.6	153.4	164.6	101	6.94	4.58	9.20	6.70	120	0.38	38.4	3.141	1	0.801	4.026	0.500	0.076	53.01
120.4	158.2	159.8	101	7.22	4.72	9.49	6.83	120	0.37	37.5	2.928	1	0.798	3.740	0.500	0.077	48.73
125.3	163.1	154.9	101	7.52	4.86	9.79	6.97	120	0.36	36.6	2.731	1	0.795	3.476	0.500	0.078	44.84
130.2	168	150	101	7.81	5.00	10.08	7.12	120	0.35	35.8	2.552	1	0.793	3.237	0.500	0.078	41.36
135.6	173.4	144.6	101	8.14	5.16	10.40	7.27	120	0.35	34.9	2.374	1	0.790	2.999	0.500	0.079	37.94
141	178.8	139.2	66	8.46	5.32	10.73	7.43	120	0.34	22.3	0.717	1	0.787	0.902	0.500	0.080	11.30
146	183.8	134.2	81	8.76	5.46	11.03	7.57	120	0.33	26.8	1.129	1	0.784	1.416	0.500	0.080	17.59
150.3	188.1	129.9	101	9.02	5.58	11.29	7.69	120	0.32	32.8	1.971	1	0.781	2.464	0.500	0.081	30.41

Z205-liq-RTF.XLS

Boring Z-206

Site: Z-AREA
Surface Elev.: 284.6
Northing: 76,202
Easting: 66,924

Original Surface Elevation = 284.6
Original Water Elevation = 240
Original Depth to Water Table = 44.6

Final Surface Elevation = 318
Design Water Elevation = 245
Depth to Water Table = 73

M = 6.5
MSF = 1.6

amax = 0.17 g

Original Mid Depth (ft)	Final Mid Depth (ft)	Elevation (ft)	SPT N60 (blows/ft)	Original Overburden (tsf)	Original Effecive Overburden (tsf)	Final Overburden (tsf)	Final Effecive Overburden (tsf)	Wet Density (pcf)	Overburden Correction Factor C_N Eq. 16	SPT (N1)60 (blows/ft)	CRR M=7.5 RTF Design Curve Eq. 14	Static Shear Stress Correction Ka	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR corrected for Ksigma magnitude and Ka Eq.1a	rd Eq. 7	CSR Eq. 4	Factor of Safety FS Eq.1a
1	34.4	283.6	5	0.06	0.06	2.06	2.06	120	1.70	8.5	0.184	1	0.943	0.278	0.894	0.099	above WT
3.5	36.9	281.1	20	0.21	0.21	2.21	2.21	120	1.56	31.2	1.717	1	0.936	2.571	0.874	0.097	above WT
6	39.4	278.6	23	0.36	0.36	2.36	2.36	120	1.41	32.4	1.916	1	0.929	2.848	0.853	0.094	above WT
8.5	41.9	276.1	23	0.51	0.51	2.51	2.51	120	1.29	29.6	1.480	1	0.923	2.185	0.833	0.092	above WT
11	44.4	273.6	23	0.66	0.66	2.66	2.66	120	1.18	27.2	1.179	1	0.916	1.729	0.813	0.090	above WT
13.5	46.9	271.1	22	0.81	0.81	2.81	2.81	120	1.09	24.1	0.863	1	0.910	1.256	0.792	0.088	above WT
16	49.4	268.6	23	0.96	0.96	2.96	2.96	120	1.02	23.4	0.807	1	0.904	1.167	0.772	0.085	above WT
21	54.4	263.6	21	1.26	1.26	3.26	3.26	120	0.89	18.8	0.495	1	0.893	0.708	0.731	0.081	above WT
26	59.4	258.6	25	1.56	1.56	3.56	3.56	120	0.80	19.9	0.559	1	0.883	0.790	0.691	0.076	above WT
31	64.4	253.6	24	1.86	1.86	3.86	3.86	120	0.72	17.3	0.422	1	0.873	0.589	0.650	0.072	above WT
36	69.4	248.6	23	2.16	2.16	4.16	4.16	120	0.65	15.1	0.337	1	0.864	0.465	0.609	0.067	above WT
41	74.4	243.6	21	2.46	2.46	4.46	4.42	120	0.60	12.6	0.265	1	0.856	0.363	0.569	0.063	5.73
46	79.4	238.6	47	2.76	2.72	4.76	4.56	120	0.56	26.4	1.090	1	0.852	1.486	0.550	0.063	23.41
51	84.4	233.6	47	3.06	2.86	5.06	4.71	120	0.54	25.5	0.993	1	0.848	1.348	0.538	0.064	21.07
56	89.4	228.6	8	3.36	3.00	5.36	4.85	120	0.52	4.2	0.126	1	0.844	0.170	0.526	0.064	2.65
61	94.4	223.6	8	3.66	3.15	5.66	5.00	120	0.51	4.0	0.124	1	0.841	0.167	0.514	0.064	2.60
66	99.4	218.6	11	3.96	3.29	5.96	5.14	120	0.49	5.4	0.141	1	0.837	0.189	0.500	0.064	2.95
71	104.4	213.6	58	4.26	3.44	6.26	5.28	120	0.47	27.5	1.216	1	0.833	1.621	0.500	0.065	24.76
76	109.4	208.6	80	4.56	3.58	6.56	5.43	120	0.46	36.8	2.768	1	0.830	3.675	0.500	0.067	55.01
81	114.4	203.6	22	4.86	3.72	6.86	5.57	120	0.45	9.8	0.206	1	0.826	0.273	0.500	0.068	4.01
86	119.4	198.6	29	5.16	3.87	7.16	5.72	120	0.43	12.6	0.264	1	0.823	0.348	0.500	0.069	5.03
91	124.4	193.6	50	5.46	4.01	7.46	5.86	120	0.42	21.1	0.633	1	0.819	0.830	0.500	0.070	11.80
96	129.4	188.6	70	5.76	4.16	7.76	6.00	120	0.41	28.8	1.368	1	0.816	1.787	0.500	0.071	25.01
101	134.4	183.6	49	6.06	4.30	8.06	6.15	120	0.40	19.6	0.540	1	0.813	0.702	0.500	0.072	9.69
105.5	138.9	179.1	101	6.33	4.43	8.33	6.28	120	0.39	39.5	3.404	1	0.810	4.412	0.500	0.073	60.15
111	144.4	173.6	67	6.66	4.59	8.66	6.44	120	0.38	25.5	0.993	1	0.807	1.281	0.500	0.074	17.23
115.3	148.7	169.3	101	6.92	4.71	8.92	6.56	120	0.37	37.6	2.942	1	0.804	3.785	0.500	0.075	50.37
120.1	153.5	164.5	101	7.21	4.85	9.21	6.70	120	0.36	36.7	2.748	1	0.801	3.522	0.500	0.076	46.36
125.3	158.7	159.3	101	7.52	5.00	9.52	6.85	120	0.35	35.8	2.557	1	0.798	3.265	0.500	0.077	42.50
130.4	163.8	154.2	101	7.82	5.15	9.83	7.00	120	0.35	35.0	2.388	1	0.795	3.037	0.500	0.078	39.13
135.5	168.9	149.1	101	8.13	5.29	10.13	7.14	120	0.34	34.2	2.234	1	0.792	2.831	0.500	0.078	36.11
140.4	173.8	144.2	101	8.42	5.44	10.43	7.28	120	0.33	33.5	2.099	1	0.789	2.651	0.500	0.079	33.51
146	179.4	138.6	73	8.76	5.60	10.76	7.44	120	0.32	23.6	0.824	1	0.786	1.036	0.500	0.080	12.97
150.3	183.7	134.3	101	9.02	5.72	11.02	7.57	120	0.32	32.1	1.861	1	0.784	2.334	0.500	0.080	29.01

Z206-liq-RTF.XLS

Boring Z-207

Site: Z-AREA
Surface Elev.: 282.2
Northing: 76,012
Easting: 66,987

Original Surface Elevation = 282
Original Water Elevation = 233
Original Depth to Water Table = 49.2

Final Surface Elevation = 318
Design Water Elevation = 245
Depth to Water Table = 73

M = 6.5
MSF = 1.6

amax = 0.17 g

Original Mid Depth (ft)	Final Mid Depth (ft)	Elevation (ft)	SPT N60 (blows/ft)	Original Overburden (tsf) Eq. 4	Original Effecive Overburden (tsf) Eq. 5 & 6	Final Overburden (tsf) Eq. 4	Final Effecive Overburden (tsf) Eq. 5 & 6	Wet Density (pcf)	Overburden Correction Factor C_N Eq. 16	SPT (N1)60 (blows/ft)	CRR M=7.5 RTF Design Curve Eq. 14	Static Shear Stress Correction Ka	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR corrected for Ksigma magnitude and Ka Eq.1a	rd Eq. 7	CSR Eq. 4	Factor of Safety FS Eq.1a
1	36.8	281.2	4	0.06	0.06	2.21	2.21	120	1.70	6.8	0.160	1	0.936	0.240	0.875	0.097	above WT
3.5	39.3	278.7	6	0.21	0.21	2.36	2.36	120	1.56	9.4	0.198	1	0.930	0.295	0.854	0.094	above WT
6	41.8	276.2	22	0.36	0.36	2.51	2.51	120	1.41	31.0	1.689	1	0.923	2.494	0.834	0.092	above WT
8.5	44.3	273.7	70	0.51	0.51	2.66	2.66	120	1.29	90.1	43.512	1	0.917	63.809	0.813	0.090	above WT
11	46.8	271.2	33	0.66	0.66	2.81	2.81	120	1.18	39.0	3.293	1	0.910	4.796	0.793	0.088	above WT
13.5	49.3	268.7	50	0.81	0.81	2.96	2.96	120	1.09	54.7	9.240	1	0.905	13.373	0.773	0.085	above WT
16	51.8	266.2	26	0.96	0.96	3.11	3.11	120	1.02	26.5	1.098	1	0.899	1.580	0.752	0.083	above WT
21	56.8	261.2	19	1.26	1.26	3.41	3.41	120	0.89	17.0	0.410	1	0.888	0.583	0.712	0.079	above WT
26	61.8	256.2	19	1.56	1.56	3.71	3.71	120	0.80	15.1	0.339	1	0.878	0.477	0.671	0.074	above WT
31	66.8	251.2	27	1.86	1.86	4.01	4.01	120	0.72	19.4	0.529	1	0.869	0.736	0.630	0.070	above WT
36	71.8	246.2	25	2.16	2.16	4.31	4.31	120	0.65	16.4	0.385	1	0.860	0.529	0.590	0.065	above WT
41	76.8	241.2	38	2.46	2.46	4.61	4.49	120	0.60	22.8	0.759	1	0.854	1.038	0.557	0.063	16.44
46	81.8	236.2	28	2.76	2.76	4.91	4.63	120	0.56	15.6	0.354	1	0.850	0.482	0.545	0.064	7.56
51	86.8	231.2	7	3.06	3.00	5.21	4.78	120	0.52	3.7	0.119	1	0.846	0.162	0.532	0.064	2.52
56	91.8	226.2	12	3.36	3.15	5.51	4.92	120	0.51	6.1	0.150	1	0.843	0.203	0.520	0.064	3.15
61	96.8	221.2	4	3.66	3.29	5.81	5.07	120	0.49	2.0	0.096	1	0.839	0.129	0.508	0.064	2.00
66	101.8	216.2	11	3.96	3.44	6.11	5.21	120	0.47	5.2	0.139	1	0.835	0.186	0.500	0.065	2.87
71	106.8	211.2	23	4.26	3.58	6.41	5.35	120	0.46	10.6	0.220	1	0.832	0.293	0.500	0.066	4.43
76	111.8	206.2	35	4.56	3.72	6.71	5.50	120	0.45	15.6	0.357	1	0.828	0.473	0.500	0.067	7.01
81	116.8	201.2	33	4.86	3.87	7.01	5.64	120	0.43	14.3	0.313	1	0.825	0.413	0.500	0.069	6.01
86	121.8	196.2	58	5.16	4.01	7.31	5.79	120	0.42	24.5	0.899	1	0.821	1.181	0.500	0.070	16.92
91	126.8	191.2	24	5.46	4.16	7.61	5.93	120	0.41	9.9	0.207	1	0.818	0.271	0.500	0.071	3.82
95.1	130.9	187.1	101	5.71	4.27	7.85	6.05	120	0.40	40.6	3.703	1	0.815	4.830	0.500	0.072	67.32
101	136.8	181.2	52	6.06	4.44	8.21	6.22	120	0.39	20.3	0.580	1	0.811	0.753	0.500	0.073	10.32
106	141.8	176.2	8	6.36	4.59	8.51	6.36	120	0.38	3.0	0.111	1	0.808	0.144	0.500	0.074	1.94
111	146.8	171.2	2	6.66	4.73	8.81	6.51	120	0.37	0.7	0.077	1	0.805	0.099	0.500	0.075	1.33
116	151.8	166.2	17	6.96	4.88	9.11	6.65	120	0.36	6.2	0.151	1	0.802	0.194	0.500	0.076	2.57
121	156.8	161.2	23	7.26	5.02	9.41	6.79	120	0.35	8.1	0.179	1	0.799	0.229	0.500	0.077	2.99
125.7	161.5	156.5	101	7.54	5.16	9.69	6.93	120	0.35	35.0	2.379	1	0.796	3.031	0.500	0.077	39.23
130	165.8	152.2	101	7.80	5.28	9.95	7.05	120	0.34	34.3	2.249	1	0.794	2.856	0.500	0.078	36.65
136	171.8	146.2	58	8.16	5.45	10.31	7.23	120	0.33	19.2	0.517	1	0.790	0.654	0.500	0.079	8.29
141	176.8	141.2	42	8.46	5.60	10.61	7.37	120	0.32	13.6	0.291	1	0.788	0.367	0.500	0.080	4.61
146	181.8	136.2	44	8.76	5.74	10.91	7.51	120	0.32	13.9	0.301	1	0.785	0.378	0.500	0.080	4.72
150.6	186.4	131.6	101	9.04	5.87	11.18	7.65	120	0.31	31.4	1.750	1	0.782	2.191	0.500	0.081	27.11

Boring Z-208

Site: Z-AREA
Surface Elev.: 281.7
Northing: 75,823
Easting: 67,049

Original Surface Elevation = 281.7
Original Water Elevation = 244
Original Depth to Water Table = 37.7

Final Surface Elevation = 318
Design Water Elevation = 245
Depth to Water Table = 73

M = 6.5
MSF = 1.6

amax = 0.17 g

Original Mid Depth (ft)	Final Mid Depth (ft)	Elevation (ft)	SPT N60 (blows/ft)	Original Overburden (tsf)	Original Effecive Overburden (tsf)	Final Overburden (tsf)	Final Effecive Overburden (tsf)	Wet Density (pcf)	Overburden Correction Factor C_N Eq. 16	SPT (N1)60 (blows/ft)	CRR M=7.5 RTF Design Curve Eq. 14	Static Shear Stress Correction Ka	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR corrected for Ksigma magnitude and Ka Eq.1a	rd Eq. 7	CSR Eq. 4	Factor of Safety FS Eq.1a
1	37.3	280.7	3	0.06	0.06	2.24	2.24	120	1.70	5.1	0.138	1	0.935	0.206	0.870	0.096	above WT
3.5	39.8	278.2	8	0.21	0.21	2.39	2.39	120	1.56	12.5	0.262	1	0.928	0.389	0.850	0.094	above WT
6	42.3	275.7	38	0.36	0.36	2.54	2.54	120	1.41	53.6	8.659	1	0.922	12.769	0.830	0.092	above WT
8.5	44.8	273.2	30	0.51	0.51	2.69	2.69	120	1.29	38.6	3.184	1	0.915	4.663	0.809	0.089	above WT
11	47.3	270.7	30	0.66	0.66	2.84	2.84	120	1.18	35.5	2.484	1	0.909	3.613	0.789	0.087	above WT
13.5	49.8	268.2	37	0.81	0.81	2.99	2.99	120	1.09	40.5	3.677	1	0.903	5.315	0.769	0.085	above WT
16	52.3	265.7	34	0.96	0.96	3.14	3.14	120	1.02	34.6	2.313	1	0.898	3.323	0.748	0.083	above WT
21	57.3	260.7	25	1.26	1.26	3.44	3.44	120	0.89	22.4	0.722	1	0.887	1.025	0.708	0.078	above WT
26	62.3	255.7	26	1.56	1.56	3.74	3.74	120	0.80	20.7	0.608	1	0.877	0.854	0.667	0.074	above WT
31	67.3	250.7	26	1.86	1.86	4.04	4.04	120	0.72	18.7	0.491	1	0.868	0.681	0.626	0.069	above WT
36	72.3	245.7	24	2.16	2.16	4.34	4.34	120	0.65	15.7	0.360	1	0.859	0.494	0.586	0.065	above WT
41	77.3	240.7	26	2.46	2.36	4.64	4.50	120	0.62	16.1	0.373	1	0.854	0.510	0.556	0.063	8.07
46	82.3	235.7	37	2.76	2.50	4.94	4.65	120	0.59	22.0	0.695	1	0.850	0.945	0.543	0.064	14.82
51	87.3	230.7	34	3.06	2.65	5.24	4.79	120	0.57	19.5	0.532	1	0.846	0.720	0.531	0.064	11.22
56	92.3	225.7	10	3.36	2.79	5.54	4.94	120	0.55	5.5	0.143	1	0.842	0.193	0.519	0.064	3.00
61	97.3	220.7	16	3.66	2.93	5.84	5.08	120	0.53	8.5	0.185	1	0.838	0.248	0.507	0.064	3.85
66	102.3	215.7	11	3.96	3.08	6.14	5.22	120	0.51	5.7	0.145	1	0.835	0.194	0.500	0.065	2.98
71	107.3	210.7	14	4.26	3.22	6.44	5.37	120	0.50	7.0	0.162	1	0.831	0.216	0.500	0.066	3.26
76	112.3	205.7	6	4.56	3.37	6.74	5.51	120	0.48	2.9	0.109	1	0.828	0.144	0.500	0.068	2.14
81	117.3	200.7	67	4.86	3.51	7.04	5.66	120	0.47	31.3	1.732	1	0.824	2.284	0.500	0.069	33.22
86	122.3	195.7	45	5.16	3.65	7.34	5.80	120	0.45	20.4	0.588	1	0.821	0.772	0.500	0.070	11.04
91	127.3	190.7	21	5.46	3.80	7.64	5.94	120	0.44	9.2	0.196	1	0.818	0.257	0.500	0.071	3.62
96	132.3	185.7	69	5.76	3.94	7.94	6.09	120	0.43	29.5	1.472	1	0.814	1.917	0.500	0.072	26.62
101	137.3	180.7	80	6.05	4.09	8.24	6.23	120	0.42	33.3	2.066	1	0.811	2.681	0.500	0.073	36.70
106	142.3	175.7	37	6.36	4.23	8.54	6.38	120	0.41	15.0	0.334	1	0.808	0.432	0.500	0.074	5.84
110.7	147	171	101	6.64	4.36	8.82	6.51	120	0.40	39.9	3.525	1	0.805	4.541	0.500	0.075	60.67
115.4	151.7	166.3	101	6.92	4.50	9.10	6.65	120	0.39	39.0	3.281	1	0.802	4.211	0.500	0.076	55.65
120.5	156.8	161.2	101	7.23	4.65	9.41	6.79	120	0.38	38.0	3.041	1	0.799	3.888	0.500	0.077	50.82
125.3	161.6	156.4	101	7.52	4.78	9.70	6.93	120	0.37	37.1	2.837	1	0.796	3.615	0.500	0.077	46.78
130.1	166.4	151.6	101	7.81	4.92	9.98	7.07	120	0.36	36.3	2.653	1	0.794	3.368	0.500	0.078	43.16
136	172.3	145.7	72	8.16	5.09	10.34	7.24	120	0.35	25.2	0.964	1	0.790	1.219	0.500	0.079	15.45
140.6	176.9	141.1	101	8.44	5.23	10.61	7.37	120	0.34	34.6	2.304	1	0.788	2.903	0.500	0.080	36.49
146	182.3	135.7	70	8.76	5.38	10.94	7.53	120	0.33	23.4	0.805	1	0.785	1.010	0.500	0.080	12.58
151	187.3	130.7	42	9.06	5.53	11.24	7.67	120	0.33	13.7	0.295	1	0.782	0.369	0.500	0.081	4.56

Boring Z-204

Site: Z-AREA
Surface Elev.: 281.2
Northing: 76,155
Easting: 67,098

Original Surface Elevation = 281.2
Original Water Elevation = 242
Original Depth to Water Table = 39.2

Final Surface Elevation = 318
Design Water Elevation = 245
Depth to Water Table = 73

M = 7.3
MSF = 1.1

amax = 0.11 g

Original Mid Depth (ft)	Final Mid Depth (ft)	Elevation (ft)	SPT N60 (blows/ft)	Original Overburden (tsf)	Original Effecive Overburden (tsf)	Final Overburden (tsf)	Final Effecive Overburden (tsf)	Wet Density (pcf)	Overburden Correction Factor C_N Eq. 16	SPT (N1)60 (blows/ft)	CRR M=7.5 RTF Design Curve Eq. 14	Static Shear Stress Correction Ka	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR corrected for Ksigma magnitude and Ka Eq.1a	rd Eq. 7	CSR Eq. 4	Factor of Safety FS Eq.1a
1	37.8	280.2	3	0.06	0.06	2.27	2.27	120	1.70	5.1	0.138	1	0.934	0.141	0.866	0.062	above WT
3.5	40.3	277.7	5	0.21	0.21	2.42	2.42	120	1.56	7.8	0.174	1	0.927	0.177	0.846	0.060	above WT
6	42.8	275.2	10	0.36	0.36	2.57	2.57	120	1.41	14.1	0.306	1	0.920	0.310	0.826	0.059	above WT
8.5	45.3	272.7	21	0.51	0.51	2.72	2.72	120	1.29	27.0	1.158	1	0.914	1.164	0.805	0.058	above WT
11	47.8	270.2	49	0.66	0.66	2.87	2.87	120	1.18	58.0	11.038	1	0.908	11.026	0.785	0.056	above WT
13.5	50.3	267.7	57	0.81	0.81	3.02	3.02	120	1.09	62.4	13.877	1	0.902	13.773	0.765	0.055	above WT
16	52.8	265.2	31	0.96	0.96	3.17	3.17	120	1.02	31.6	1.775	1	0.897	1.750	0.744	0.053	above WT
21	57.8	260.2	30	1.26	1.26	3.47	3.47	120	0.89	26.8	1.137	1	0.886	1.108	0.704	0.050	above WT
26	62.8	255.2	28	1.56	1.56	3.77	3.77	120	0.80	22.3	0.719	1	0.876	0.693	0.663	0.047	above WT
31	67.8	250.2	20	1.86	1.86	4.07	4.07	120	0.72	14.4	0.314	1	0.867	0.300	0.622	0.044	above WT
36	72.8	245.2	26	2.16	2.16	4.37	4.37	120	0.65	17.0	0.412	1	0.858	0.389	0.582	0.042	above WT
41	77.8	240.2	41	2.46	2.40	4.67	4.52	120	0.61	25.0	0.950	1	0.854	0.892	0.554	0.041	21.79
46	82.8	235.2	66	2.76	2.55	4.97	4.66	120	0.59	38.7	3.220	1	0.850	3.009	0.542	0.041	72.86
51	87.8	230.2	59	3.06	2.69	5.27	4.81	120	0.57	33.4	2.075	1	0.846	1.930	0.530	0.042	46.47
56	92.8	225.2	17	3.36	2.84	5.57	4.95	120	0.55	9.3	0.197	1	0.842	0.182	0.518	0.042	4.37
61	97.8	220.2	5	3.66	2.98	5.87	5.09	120	0.53	2.6	0.105	1	0.838	0.097	0.506	0.042	2.33
66	102.8	215.2	10	3.96	3.12	6.17	5.24	120	0.51	5.1	0.138	1	0.834	0.126	0.500	0.042	3.00
71	107.8	210.2	74	4.26	3.27	6.47	5.38	120	0.49	36.4	2.685	1	0.831	2.454	0.500	0.043	57.12
76	112.8	205.2	73	4.56	3.41	6.77	5.53	120	0.48	34.8	2.351	1	0.827	2.140	0.500	0.044	48.87
81	117.8	200.2	21	4.86	3.56	7.07	5.67	120	0.46	9.7	0.204	1	0.824	0.185	0.500	0.045	4.15
86	122.8	195.2	17	5.16	3.70	7.37	5.81	120	0.45	7.6	0.171	1	0.821	0.155	0.500	0.045	3.42
91	127.8	190.2	47	5.46	3.84	7.67	5.96	120	0.44	20.5	0.594	1	0.817	0.534	0.500	0.046	11.61
96	132.8	185.2	33	5.76	3.99	7.97	6.10	120	0.42	14.0	0.303	1	0.814	0.271	0.500	0.047	5.81
101	137.8	180.2	66	6.06	4.13	8.27	6.25	120	0.41	27.2	1.182	1	0.811	1.055	0.500	0.047	22.28
106	142.8	175.2	52	6.36	4.28	8.57	6.39	120	0.40	20.9	0.619	1	0.808	0.550	0.500	0.048	11.47
110.2	147	171	101	6.61	4.40	8.82	6.51	120	0.39	39.7	3.464	1	0.805	3.068	0.500	0.048	63.35
116	152.8	165.2	45	6.96	4.56	9.17	6.68	120	0.38	17.2	0.418	1	0.802	0.369	0.500	0.049	7.52
120	156.8	161.2	101	7.20	4.68	9.41	6.79	120	0.37	37.8	2.992	1	0.799	2.630	0.500	0.050	53.12
125.1	161.9	156.1	101	7.51	4.83	9.71	6.94	120	0.37	36.9	2.781	1	0.796	2.435	0.500	0.050	48.67
131	167.8	150.2	72	7.86	5.00	10.07	7.11	120	0.36	25.6	1.003	1	0.793	0.874	0.500	0.051	17.27
135.6	172.4	145.6	101	8.14	5.13	10.34	7.24	120	0.35	35.1	2.408	1	0.790	2.093	0.500	0.051	40.99
141	177.8	140.2	57	8.46	5.28	10.67	7.40	120	0.34	19.3	0.525	1	0.787	0.455	0.500	0.052	8.83
146	182.8	135.2	43	8.76	5.43	10.97	7.54	120	0.33	14.3	0.311	1	0.784	0.268	0.500	0.052	5.16
150.2	187	131	101	9.01	5.55	11.22	7.66	120	0.33	32.9	1.999	1	0.782	1.720	0.500	0.052	32.86

Boring Z-205

Site: Z-AREA
Surface Elev.: 280.2
Northing: 75,965
Easting: 67,610

Original Surface Elevation = 280.2
Original Water Elevation = 240
Original Depth to Water Table = 40.2

Final Surface Elevation = 318
Design Water Elevation = 245
Depth to Water Table = 73

M = 7.3
MSF = 1.1

amax = 0.11 g

Original Mid Depth (ft)	Final Mid Depth (ft)	Elevation (ft)	SPT N60 (blows/ft)	Original Overburden (tsf)	Original Effecive Overburden (tsf)	Final Overburden (tsf)	Final Effecive Overburden (tsf)	Wet Density (pcf)	Overburden Correction Factor C_N Eq. 16	SPT (N1)60 (blows/ft)	CRR M=7.5 RTF Design Curve Eq. 14	Static Shear Stress Correction Ka	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR corrected for Ksigma magnitude and Ka Eq.1a	rd Eq. 7	CSR Eq. 4	Factor of Safety FS Eq.1a
1	38.8	279.2	6	0.06	0.06	2.33	2.33	120	1.70	10.2	0.213	1	0.931	0.218	0.858	0.061	above WT
3.5	41.3	276.7	9	0.21	0.21	2.48	2.48	120	1.56	14.0	0.304	1	0.924	0.309	0.838	0.060	above WT
6	43.8	274.2	45	0.36	0.36	2.63	2.63	120	1.41	63.5	14.634	1	0.918	14.774	0.818	0.058	above WT
8.5	46.3	271.7	39	0.51	0.51	2.78	2.78	120	1.29	50.2	7.067	1	0.912	7.087	0.797	0.057	above WT
11	48.8	269.2	35	0.66	0.66	2.93	2.93	120	1.18	41.4	3.929	1	0.906	3.915	0.777	0.056	above WT
13.5	51.3	266.7	33	0.81	0.81	3.08	3.08	120	1.09	36.1	2.616	1	0.900	2.590	0.757	0.054	above WT
16	53.8	264.2	26	0.96	0.96	3.23	3.23	120	1.02	26.5	1.098	1	0.895	1.081	0.736	0.053	above WT
21	58.8	259.2	19	1.26	1.26	3.53	3.53	120	0.89	17.0	0.410	1	0.884	0.399	0.695	0.050	above WT
26	63.8	254.2	21	1.56	1.56	3.83	3.83	120	0.80	16.7	0.400	1	0.874	0.384	0.655	0.047	above WT
31	68.8	249.2	21	1.86	1.86	4.13	4.13	120	0.72	15.1	0.338	1	0.865	0.321	0.614	0.044	above WT
36	73.8	244.2	19	2.16	2.16	4.43	4.40	120	0.65	12.4	0.261	1	0.857	0.246	0.573	0.041	5.96
41	78.8	239.2	32	2.46	2.44	4.73	4.55	120	0.61	19.4	0.527	1	0.853	0.494	0.552	0.041	12.05
45.7	83.5	234.5	101	2.74	2.57	5.01	4.68	120	0.58	58.9	11.625	1	0.849	10.857	0.540	0.041	262.62
51	88.8	229.2	17	3.06	2.72	5.33	4.84	120	0.56	9.5	0.201	1	0.845	0.187	0.527	0.042	4.50
56	93.8	224.2	11	3.36	2.87	5.63	4.98	120	0.54	6.0	0.149	1	0.841	0.138	0.515	0.042	3.30
61	98.8	219.2	8	3.66	3.01	5.93	5.12	120	0.52	4.2	0.126	1	0.837	0.116	0.500	0.041	2.80
66	103.8	214.2	15	3.96	3.16	6.23	5.27	120	0.51	7.6	0.171	1	0.834	0.157	0.500	0.042	3.70
71	108.8	209.2	25	4.26	3.30	6.53	5.41	120	0.49	12.2	0.256	1	0.830	0.233	0.500	0.043	5.41
76	113.8	204.2	71	4.56	3.44	6.83	5.56	120	0.47	33.6	2.127	1	0.827	1.934	0.500	0.044	44.02
80.5	118.3	199.7	101	4.83	3.57	7.10	5.68	120	0.46	46.6	5.616	1	0.824	5.087	0.500	0.045	113.97
86	123.8	194.2	77	5.16	3.73	7.43	5.84	120	0.45	34.4	2.260	1	0.820	2.038	0.500	0.045	44.85
91	128.8	189.2	50	5.46	3.88	7.73	5.99	120	0.43	21.7	0.672	1	0.817	0.604	0.500	0.046	13.08
96	133.8	184.2	59	5.76	4.02	8.03	6.13	120	0.42	24.9	0.935	1	0.813	0.837	0.500	0.047	17.87
101	138.8	179.2	54	6.06	4.16	8.33	6.28	120	0.41	22.2	0.707	1	0.810	0.630	0.500	0.047	13.27
105.6	143.4	174.6	101	6.34	4.30	8.60	6.41	120	0.40	40.4	3.660	1	0.807	3.250	0.500	0.048	67.70
110.3	148.1	169.9	101	6.62	4.43	8.89	6.54	120	0.39	39.5	3.402	1	0.804	3.010	0.500	0.049	62.00
115.6	153.4	164.6	101	6.94	4.58	9.20	6.70	120	0.38	38.4	3.141	1	0.801	2.768	0.500	0.049	56.32
120.4	158.2	159.8	101	7.22	4.72	9.49	6.83	120	0.37	37.5	2.928	1	0.798	2.571	0.500	0.050	51.78
125.3	163.1	154.9	101	7.52	4.86	9.79	6.97	120	0.36	36.6	2.731	1	0.795	2.390	0.500	0.050	47.64
130.2	168	150	101	7.81	5.00	10.08	7.12	120	0.35	35.8	2.552	1	0.793	2.225	0.500	0.051	43.94
135.6	173.4	144.6	101	8.14	5.16	10.40	7.27	120	0.35	34.9	2.374	1	0.790	2.062	0.500	0.051	40.31
141	178.8	139.2	66	8.46	5.32	10.73	7.43	120	0.34	22.3	0.717	1	0.787	0.620	0.500	0.052	12.01
146	183.8	134.2	81	8.76	5.46	11.03	7.57	120	0.33	26.8	1.129	1	0.784	0.973	0.500	0.052	18.69
150.3	188.1	129.9	101	9.02	5.58	11.29	7.69	120	0.32	32.8	1.971	1	0.781	1.694	0.500	0.052	32.31

Z205-liq-RTF-ch.XLS

Boring Z-206

Site: Z-AREA
Surface Elev.: 284.6
Northing: 76,202
Easting: 66,924

Original Surface Elevation = 284.6
Original Water Elevation = 240
Original Depth to Water Table = 44.6

Final Surface Elevation = 318
Design Water Elevation = 245
Depth to Water Table = 73

M = 7.3
MSF = 1.1

amax = 0.11 g

Original Mid Depth (ft)	Final Mid Depth (ft)	Elevation (ft)	SPT N60 (blows/ft)	Original Overburden (tsf)	Original Effecive Overburden (tsf)	Final Overburden (tsf)	Final Effecive Overburden (tsf)	Wet Density (pcf)	Overburden Correction Factor C_N Eq. 16	SPT (N1)60 (blows/ft)	CRR M=7.5 RTF Design Curve Eq. 14	Static Shear Stress Correction Ka	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR corrected for Ksigma magnitude and Ka Eq.1a	rd Eq. 7	CSR Eq. 4	Factor of Safety FS Eq.1a
1	34.4	283.6	5	0.06	0.06	2.06	2.06	120	1.70	8.5	0.184	1	0.943	0.191	0.894	0.064	above WT
3.5	36.9	281.1	20	0.21	0.21	2.21	2.21	120	1.56	31.2	1.717	1	0.936	1.768	0.874	0.062	above WT
6	39.4	278.6	23	0.36	0.36	2.36	2.36	120	1.41	32.4	1.916	1	0.929	1.958	0.853	0.061	above WT
8.5	41.9	276.1	23	0.51	0.51	2.51	2.51	120	1.29	29.6	1.480	1	0.923	1.502	0.833	0.060	above WT
11	44.4	273.6	23	0.66	0.66	2.66	2.66	120	1.18	27.2	1.179	1	0.916	1.188	0.813	0.058	above WT
13.5	46.9	271.1	22	0.81	0.81	2.81	2.81	120	1.09	24.1	0.863	1	0.910	0.864	0.792	0.057	above WT
16	49.4	268.6	23	0.96	0.96	2.96	2.96	120	1.02	23.4	0.807	1	0.904	0.802	0.772	0.055	above WT
21	54.4	263.6	21	1.26	1.26	3.26	3.26	120	0.89	18.8	0.495	1	0.893	0.487	0.731	0.052	above WT
26	59.4	258.6	25	1.56	1.56	3.56	3.56	120	0.80	19.9	0.559	1	0.883	0.543	0.691	0.049	above WT
31	64.4	253.6	24	1.86	1.86	3.86	3.86	120	0.72	17.3	0.422	1	0.873	0.405	0.650	0.046	above WT
36	69.4	248.6	23	2.16	2.16	4.16	4.16	120	0.65	15.1	0.337	1	0.864	0.320	0.609	0.044	above WT
41	74.4	243.6	21	2.46	2.46	4.46	4.42	120	0.60	12.6	0.265	1	0.856	0.250	0.569	0.041	6.09
46	79.4	238.6	47	2.76	2.72	4.76	4.56	120	0.56	26.4	1.090	1	0.852	1.022	0.550	0.041	24.88
51	84.4	233.6	47	3.06	2.86	5.06	4.71	120	0.54	25.5	0.993	1	0.848	0.926	0.538	0.041	22.38
56	89.4	228.6	8	3.36	3.00	5.36	4.85	120	0.52	4.2	0.126	1	0.844	0.117	0.526	0.042	2.82
61	94.4	223.6	8	3.66	3.15	5.66	5.00	120	0.51	4.0	0.124	1	0.841	0.115	0.514	0.042	2.76
66	99.4	218.6	11	3.96	3.29	5.96	5.14	120	0.49	5.4	0.141	1	0.837	0.130	0.500	0.041	3.14
71	104.4	213.6	58	4.26	3.44	6.26	5.28	120	0.47	27.5	1.216	1	0.833	1.115	0.500	0.042	26.30
76	109.4	208.6	80	4.56	3.58	6.56	5.43	120	0.46	36.8	2.768	1	0.830	2.526	0.500	0.043	58.44
81	114.4	203.6	22	4.86	3.72	6.86	5.57	120	0.45	9.8	0.206	1	0.826	0.187	0.500	0.044	4.26
86	119.4	198.6	29	5.16	3.87	7.16	5.72	120	0.43	12.6	0.264	1	0.823	0.239	0.500	0.045	5.34
91	124.4	193.6	50	5.46	4.01	7.46	5.86	120	0.42	21.1	0.633	1	0.819	0.571	0.500	0.046	12.53
96	129.4	188.6	70	5.76	4.16	7.76	6.00	120	0.41	28.8	1.368	1	0.816	1.228	0.500	0.046	26.57
101	134.4	183.6	49	6.06	4.30	8.06	6.15	120	0.40	19.6	0.540	1	0.813	0.483	0.500	0.047	10.30
105.5	138.9	179.1	101	6.33	4.43	8.33	6.28	120	0.39	39.5	3.404	1	0.810	3.033	0.500	0.047	63.91
111	144.4	173.6	67	6.66	4.59	8.66	6.44	120	0.38	25.5	0.993	1	0.807	0.881	0.500	0.048	18.31
115.3	148.7	169.3	101	6.92	4.71	8.92	6.56	120	0.37	37.6	2.942	1	0.804	2.602	0.500	0.049	53.52
120.1	153.5	164.5	101	7.21	4.85	9.21	6.70	120	0.36	36.7	2.748	1	0.801	2.421	0.500	0.049	49.26
125.3	158.7	159.3	101	7.52	5.00	9.52	6.85	120	0.35	35.8	2.557	1	0.798	2.244	0.500	0.050	45.15
130.4	163.8	154.2	101	7.82	5.15	9.83	7.00	120	0.35	35.0	2.388	1	0.795	2.088	0.500	0.050	41.57
135.5	168.9	149.1	101	8.13	5.29	10.13	7.14	120	0.34	34.2	2.234	1	0.792	1.946	0.500	0.051	38.37
140.4	173.8	144.2	101	8.42	5.44	10.43	7.28	120	0.33	33.5	2.099	1	0.789	1.823	0.500	0.051	35.61
146	179.4	138.6	73	8.76	5.60	10.76	7.44	120	0.32	23.6	0.824	1	0.786	0.712	0.500	0.052	13.78
150.3	183.7	134.3	101	9.02	5.72	11.02	7.57	120	0.32	32.1	1.861	1	0.784	1.605	0.500	0.052	30.82

Z206-liq-RTF-ch.XLS

Boring Z-207

Site: Z-AREA
Surface Elev.: 282.2
Northing: 76,012
Easting: 66,987

Original Surface Elevation = 282
Original Water Elevation = 233
Original Depth to Water Table = 49.2

Final Surface Elevation = 318
Design Water Elevation = 245
Depth to Water Table = 73

M = 7.3
MSF = 1.1

amax = 0.11 g

Original Mid Depth (ft)	Final Mid Depth (ft)	Elevation (ft)	SPT N60 (blows/ft)	Original Overburden (tsf) Eq. 4	Original Effecive Overburden (tsf) Eq. 5 & 6	Final Overburden (tsf) Eq. 4	Final Effecive Overburden (tsf) Eq. 5 & 6	Wet Density (pcf)	Overburden Correction Factor C_N Eq. 16	SPT (N1)60 (blows/ft)	CRR M=7.5 RTF Design Curve Eq. 14	Static Shear Stress Correction Ka	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR corrected for Ksigma magnitude and Ka Eq.1a	rd Eq. 7	CSR Eq. 4	Factor of Safety FS Eq.1a
1	36.8	281.2	4	0.06	0.06	2.21	2.21	120	1.70	6.8	0.160	1	0.936	0.165	0.875	0.063	above WT
3.5	39.3	278.7	6	0.21	0.21	2.36	2.36	120	1.56	9.4	0.198	1	0.930	0.203	0.854	0.061	above WT
6	41.8	276.2	22	0.36	0.36	2.51	2.51	120	1.41	31.0	1.689	1	0.923	1.715	0.834	0.060	above WT
8.5	44.3	273.7	70	0.51	0.51	2.66	2.66	120	1.29	90.1	43.512	1	0.917	43.868	0.813	0.058	above WT
11	46.8	271.2	33	0.66	0.66	2.81	2.81	120	1.18	39.0	3.293	1	0.910	3.298	0.793	0.057	above WT
13.5	49.3	268.7	50	0.81	0.81	2.96	2.96	120	1.09	54.7	9.240	1	0.905	9.194	0.773	0.055	above WT
16	51.8	266.2	26	0.96	0.96	3.11	3.11	120	1.02	26.5	1.098	1	0.899	1.086	0.752	0.054	above WT
21	56.8	261.2	19	1.26	1.26	3.41	3.41	120	0.89	17.0	0.410	1	0.888	0.401	0.712	0.051	above WT
26	61.8	256.2	19	1.56	1.56	3.71	3.71	120	0.80	15.1	0.339	1	0.878	0.328	0.671	0.048	above WT
31	66.8	251.2	27	1.86	1.86	4.01	4.01	120	0.72	19.4	0.529	1	0.869	0.506	0.630	0.045	above WT
36	71.8	246.2	25	2.16	2.16	4.31	4.31	120	0.65	16.4	0.385	1	0.860	0.364	0.590	0.042	above WT
41	76.8	241.2	38	2.46	2.46	4.61	4.49	120	0.60	22.8	0.759	1	0.854	0.714	0.557	0.041	17.47
46	81.8	236.2	28	2.76	2.76	4.91	4.63	120	0.56	15.6	0.354	1	0.850	0.331	0.545	0.041	8.03
51	86.8	231.2	7	3.06	3.00	5.21	4.78	120	0.52	3.7	0.119	1	0.846	0.111	0.532	0.041	2.68
56	91.8	226.2	12	3.36	3.15	5.51	4.92	120	0.51	6.1	0.150	1	0.843	0.139	0.520	0.042	3.35
61	96.8	221.2	4	3.66	3.29	5.81	5.07	120	0.49	2.0	0.096	1	0.839	0.088	0.508	0.042	2.12
66	101.8	216.2	11	3.96	3.44	6.11	5.21	120	0.47	5.2	0.139	1	0.835	0.128	0.500	0.042	3.05
71	106.8	211.2	23	4.26	3.58	6.41	5.35	120	0.46	10.6	0.220	1	0.832	0.202	0.500	0.043	4.71
76	111.8	206.2	35	4.56	3.72	6.71	5.50	120	0.45	15.6	0.357	1	0.828	0.325	0.500	0.044	7.45
81	116.8	201.2	33	4.86	3.87	7.01	5.64	120	0.43	14.3	0.313	1	0.825	0.284	0.500	0.044	6.39
86	121.8	196.2	58	5.16	4.01	7.31	5.79	120	0.42	24.5	0.899	1	0.821	0.812	0.500	0.045	17.98
91	126.8	191.2	24	5.46	4.16	7.61	5.93	120	0.41	9.9	0.207	1	0.818	0.186	0.500	0.046	4.06
95.1	130.9	187.1	101	5.71	4.27	7.85	6.05	120	0.40	40.6	3.703	1	0.815	3.321	0.500	0.046	71.52
101	136.8	181.2	52	6.06	4.44	8.21	6.22	120	0.39	20.3	0.580	1	0.811	0.517	0.500	0.047	10.96
106	141.8	176.2	8	6.36	4.59	8.51	6.36	120	0.38	3.0	0.111	1	0.808	0.099	0.500	0.048	2.06
111	146.8	171.2	2	6.66	4.73	8.81	6.51	120	0.37	0.7	0.077	1	0.805	0.068	0.500	0.048	1.41
116	151.8	166.2	17	6.96	4.88	9.11	6.65	120	0.36	6.2	0.151	1	0.802	0.134	0.500	0.049	2.73
121	156.8	161.2	23	7.26	5.02	9.41	6.79	120	0.35	8.1	0.179	1	0.799	0.157	0.500	0.050	3.17
125.7	161.5	156.5	101	7.54	5.16	9.69	6.93	120	0.35	35.0	2.379	1	0.796	2.084	0.500	0.050	41.68
130	165.8	152.2	101	7.80	5.28	9.95	7.05	120	0.34	34.3	2.249	1	0.794	1.964	0.500	0.050	38.94
136	171.8	146.2	58	8.16	5.45	10.31	7.23	120	0.33	19.2	0.517	1	0.790	0.449	0.500	0.051	8.81
141	176.8	141.2	42	8.46	5.60	10.61	7.37	120	0.32	13.6	0.291	1	0.788	0.252	0.500	0.051	4.90
146	181.8	136.2	44	8.76	5.74	10.91	7.51	120	0.32	13.9	0.301	1	0.785	0.260	0.500	0.052	5.01
150.6	186.4	131.6	101	9.04	5.87	11.18	7.65	120	0.31	31.4	1.750	1	0.782	1.506	0.500	0.052	28.80

Boring Z-208

Site: Z-AREA
Surface Elev.: 281.7
Northing: 75,823
Easting: 67,049

Original Surface Elevation = 281.7
Original Water Elevation = 244
Original Depth to Water Table = 37.7

Final Surface Elevation = 318
Design Water Elevation = 245
Depth to Water Table = 73

M = 7.3
MSF = 1.1

amax = 0.11 g

Original Mid Depth (ft)	Final Mid Depth (ft)	Elevation (ft)	SPT N60 (blows/ft)	Original Overburden (tsf)	Original Effective Overburden (tsf)	Final Overburden (tsf)	Final Effective Overburden (tsf)	Wet Density (pcf)	Overburden Correction Factor C_N Eq. 16	SPT (N1)60 (blows/ft)	CRR M=7.5 RTF Design Curve Eq. 14	Static Shear Stress Correction Ka	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR corrected for Ksigma magnitude and Ka Eq.1a	rd Eq. 7	CSR Eq. 4	Factor of Safety FS Eq.1a
1	37.3	280.7	3	0.06	0.06	2.24	2.24	120	1.70	5.1	0.138	1	0.935	0.142	0.870	0.062	above WT
3.5	39.8	278.2	8	0.21	0.21	2.39	2.39	120	1.56	12.5	0.262	1	0.928	0.267	0.850	0.061	above WT
6	42.3	275.7	38	0.36	0.36	2.54	2.54	120	1.41	53.6	8.659	1	0.922	8.778	0.830	0.059	above WT
8.5	44.8	273.2	30	0.51	0.51	2.69	2.69	120	1.29	38.6	3.184	1	0.915	3.206	0.809	0.058	above WT
11	47.3	270.7	30	0.66	0.66	2.84	2.84	120	1.18	35.5	2.484	1	0.909	2.484	0.789	0.056	above WT
13.5	49.8	268.2	37	0.81	0.81	2.99	2.99	120	1.09	40.5	3.677	1	0.903	3.654	0.769	0.055	above WT
16	52.3	265.7	34	0.96	0.96	3.14	3.14	120	1.02	34.6	2.313	1	0.898	2.284	0.748	0.054	above WT
21	57.3	260.7	25	1.26	1.26	3.44	3.44	120	0.89	22.4	0.722	1	0.887	0.705	0.708	0.051	above WT
26	62.3	255.7	26	1.56	1.56	3.74	3.74	120	0.80	20.7	0.608	1	0.877	0.587	0.667	0.048	above WT
31	67.3	250.7	26	1.86	1.86	4.04	4.04	120	0.72	18.7	0.491	1	0.868	0.468	0.626	0.045	above WT
36	72.3	245.7	24	2.16	2.16	4.34	4.34	120	0.65	15.7	0.360	1	0.859	0.340	0.586	0.042	above WT
41	77.3	240.7	26	2.46	2.36	4.64	4.50	120	0.62	16.1	0.373	1	0.854	0.351	0.556	0.041	8.58
46	82.3	235.7	37	2.76	2.50	4.94	4.65	120	0.59	22.0	0.695	1	0.850	0.650	0.543	0.041	15.75
51	87.3	230.7	34	3.06	2.65	5.24	4.79	120	0.57	19.5	0.532	1	0.846	0.495	0.531	0.042	11.92
56	92.3	225.7	10	3.36	2.79	5.54	4.94	120	0.55	5.5	0.143	1	0.842	0.133	0.519	0.042	3.18
61	97.3	220.7	16	3.66	2.93	5.84	5.08	120	0.53	8.5	0.185	1	0.838	0.170	0.507	0.042	4.09
66	102.3	215.7	11	3.96	3.08	6.14	5.22	120	0.51	5.7	0.145	1	0.835	0.133	0.500	0.042	3.17
71	107.3	210.7	14	4.26	3.22	6.44	5.37	120	0.50	7.0	0.162	1	0.831	0.148	0.500	0.043	3.46
76	112.3	205.7	6	4.56	3.37	6.74	5.51	120	0.48	2.9	0.109	1	0.828	0.099	0.500	0.044	2.27
81	117.3	200.7	67	4.86	3.51	7.04	5.66	120	0.47	31.3	1.732	1	0.824	1.570	0.500	0.044	35.29
86	122.3	195.7	45	5.16	3.65	7.34	5.80	120	0.45	20.4	0.588	1	0.821	0.531	0.500	0.045	11.73
91	127.3	190.7	21	5.46	3.80	7.64	5.94	120	0.44	9.2	0.196	1	0.818	0.177	0.500	0.046	3.84
96	132.3	185.7	69	5.76	3.94	7.94	6.09	120	0.43	29.5	1.472	1	0.814	1.318	0.500	0.047	28.28
101	137.3	180.7	80	6.06	4.09	8.24	6.23	120	0.42	33.3	2.066	1	0.811	1.843	0.500	0.047	39.00
106	142.3	175.7	37	6.36	4.23	8.54	6.38	120	0.41	15.0	0.334	1	0.808	0.297	0.500	0.048	6.21
110.7	147	171	101	6.64	4.36	8.82	6.51	120	0.40	39.9	3.525	1	0.805	3.122	0.500	0.048	64.47
115.4	151.7	166.3	101	6.92	4.50	9.10	6.65	120	0.39	39.0	3.281	1	0.802	2.895	0.500	0.049	59.13
120.5	156.8	161.2	101	7.23	4.65	9.41	6.79	120	0.38	38.0	3.041	1	0.799	2.673	0.500	0.050	54.00
125.3	161.6	156.4	101	7.52	4.78	9.70	6.93	120	0.37	37.1	2.837	1	0.796	2.485	0.500	0.050	49.70
130.1	166.4	151.6	101	7.81	4.92	9.98	7.07	120	0.36	36.3	2.653	1	0.794	2.315	0.500	0.050	45.86
136	172.3	145.7	72	8.16	5.09	10.34	7.24	120	0.35	25.2	0.964	1	0.790	0.838	0.500	0.051	16.41
140.6	176.9	141.1	101	8.44	5.23	10.61	7.37	120	0.34	34.6	2.304	1	0.788	1.996	0.500	0.051	38.78
146	182.3	135.7	70	8.76	5.38	10.94	7.53	120	0.33	23.4	0.805	1	0.785	0.694	0.500	0.052	13.37
151	187.3	130.7	42	9.06	5.53	11.24	7.67	120	0.33	13.7	0.295	1	0.782	0.254	0.500	0.052	4.85

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ZCP-22

Original Surface Elevation = 269.78 feet msl
Ground Water Elevation = 212.38 feet msl
Original Depth to Water Table = 57.4 feet

Final Surface Elevation = 318 feet msl
Design Water Elevation = 245 feet msl
Design Depth to Water Table = 73 feet

amax = 0.17 g
unit wt = 120 pcf

Mw = 6.5
MSF = 1.6

Elev. (ft-msl)	ZCP-22 Vs (ft/sec)	Original Depth (feet)	Final Depth (feet)	rd Eq. 7	Original Total Stress σv (tsf) Eq. 5	Original Effective Stress σ'v (tsf) Eq. 6	Final Total Stress σv (tsf) Eq. 5	Final Effective Stress σ'v (tsf) Eq. 6	CSR Eq. 4	Vs1 (m/sec) Eq. 10	Percent Fines Eq. 24 & 25	V*s1 (m/sec) Eq. 11-13	CRR M=7.5 Percent fines Incorporated Eq. 9	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR Ksigma and Magnitude Correction Incorporated Eq. 1a	Factor of Safety Eq. 1a
259	1010	10.8	59	0.694	0.65	0.65	3.54	3.54	0.077	343	10.2	212.4	Not Liquefiable	0.884	Not Liquefiable	above WT
250	1010	19.8	68	0.621	1.19	1.19	4.08	4.08	0.069	295	10.2	212.4	Not Liquefiable	0.866	Not Liquefiable	above WT
250	990	19.8	68	0.621	1.19	1.19	4.08	4.08	0.069	289	10.4	212.3	Not Liquefiable	0.866	Not Liquefiable	above WT
238	990	31.8	80	0.549	1.91	1.91	4.80	4.58	0.064	257	10.4	212.3	Not Liquefiable	0.852	Not Liquefiable	Not Liquefiable
238	1080	31.8	80	0.549	1.91	1.91	4.80	4.58	0.064	280	19.6	207.7	Not Liquefiable	0.852	Not Liquefiable	Not Liquefiable
229	1080	40.8	89	0.527	2.45	2.45	5.34	4.84	0.064	263	19.6	207.7	Not Liquefiable	0.845	Not Liquefiable	Not Liquefiable
229	890	40.8	89	0.527	2.45	2.45	5.34	4.84	0.064	217	34.4	200.3	Not Liquefiable	0.845	Not Liquefiable	Not Liquefiable
223	890	46.8	95	0.512	2.81	2.81	5.70	5.01	0.064	210	34.4	200.3	Not Liquefiable	0.840	Not Liquefiable	Not Liquefiable
223	1020	46.8	95	0.512	2.81	2.81	5.70	5.01	0.064	240	12.0	211.5	Not Liquefiable	0.840	Not Liquefiable	Not Liquefiable
205	1020	64.8	113	0.5	3.89	3.66	6.78	5.53	0.068	225	12.0	211.5	Not Liquefiable	0.827	Not Liquefiable	Not Liquefiable
205	770	64.8	113	0.5	3.89	3.66	6.78	5.53	0.068	170	14.7	210.1	0.119	0.827	0.158	2.3
196	770	73.8	122	0.5	4.43	3.92	7.32	5.79	0.070	167	14.7	210.1	0.113	0.821	0.148	2.1
196	610	73.8	122	0.5	4.43	3.92	7.32	5.79	0.070	132	47.2	200.0	0.066	0.821	0.086	1.2
187	610	82.8	131	0.5	4.97	4.17	7.86	6.05	0.072	130	47.2	200.0	0.063	0.815	0.082	1.1
184	1200	85.8	134	0.5	5.15	4.26	8.04	6.14	0.072	255	30.6	202.2	Not Liquefiable	0.813	Not Liquefiable	Not Liquefiable
178	1200	91.8	140	0.5	5.51	4.43	8.40	6.31	0.074	252	30.6	202.2	Not Liquefiable	0.809	Not Liquefiable	Not Liquefiable

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ZCP-23

Original Surface Elevation = 271.30 feet msl
Ground Water Elevation = 214.10 feet msl
Original Depth to Water Table = 57.20 feet

Final Surface Elevation = 318 feet msl
Design Water Elevation = 245 feet msl
Design Depth to Water Table = 73 feet

amax = 0.17 g
unit wt = 120 pcf

Mw = 6.5
MSF = 1.6

Elev. (ft-msl)	ZCP-23 Vs (ft/sec)	Original Depth (feet)	Final Depth (feet)	rd Eq. 7	Original Total Stress σv (tsf) Eq. 5	Original Effective Stress σ'v (tsf) Eq. 6	Final Total Stress σv (tsf) Eq. 5	Final Effective Stress σ'v (tsf) Eq. 6	CSR Eq. 4	Vs1 (m/sec) Eq. 10	Percent Fines Eq. 24 & 25	V*s1 (m/sec) Eq. 11-13	CRR M=7.5 Percent fines Incorporated Eq. 9	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR Ksigma and Magnitude Correction Incorporated Eq. 1a	Factor of Safety Eq. 1a
261	1380	10.3	57	0.710	0.62	0.62	3.42	3.42	0.078	474	25.1	204.9	Not Liquefiable	0.888	Not Liquefiable	above WT
255	1380	16.3	63	0.661	0.98	0.98	3.78	3.78	0.073	423	25.1	204.9	Not Liquefiable	0.876	Not Liquefiable	above WT
255	1190	16.3	63	0.661	0.98	0.98	3.78	3.78	0.073	365	16.7	209.2	Not Liquefiable	0.876	Not Liquefiable	above WT
234	1190	37.3	84	0.539	2.24	2.24	5.04	4.70	0.064	297	16.7	209.2	Not Liquefiable	0.849	Not Liquefiable	Not Liquefiable
234	1230	37.3	84	0.539	2.24	2.24	5.04	4.70	0.064	307	19.6	207.7	Not Liquefiable	0.849	Not Liquefiable	Not Liquefiable
227	1230	44.3	91	0.522	2.66	2.66	5.46	4.90	0.064	294	19.6	207.7	Not Liquefiable	0.843	Not Liquefiable	Not Liquefiable
227	1010	44.3	91	0.522	2.66	2.66	5.46	4.90	0.064	241	26.8	204.1	Not Liquefiable	0.843	Not Liquefiable	Not Liquefiable
213	1010	58.3	105	0.500	3.50	3.46	6.30	5.30	0.066	226	26.8	204.1	Not Liquefiable	0.833	Not Liquefiable	Not Liquefiable
213	1130	58.3	105	0.500	3.50	3.46	6.30	5.30	0.066	252	10.3	212.3	Not Liquefiable	0.833	Not Liquefiable	Not Liquefiable
189	1130	82.3	129	0.5	4.94	4.15	7.74	5.99	0.071	241	10.3	212.3	Not Liquefiable	0.816	Not Liquefiable	Not Liquefiable
189	1270	82.3	129	0.5	4.94	4.15	7.74	5.99	0.071	271	18.9	208.0	Not Liquefiable	0.816	Not Liquefiable	Not Liquefiable
182	1270	89.3	136	0.5	5.36	4.36	8.16	6.19	0.073	268	18.9	208.0	Not Liquefiable	0.812	Not Liquefiable	Not Liquefiable
182	1590	89.3	136	0.5	5.36	4.36	8.16	6.19	0.073	335	20.2	207.4	Not Liquefiable	0.812	Not Liquefiable	Not Liquefiable
171	1590	100.3	147	0.5	6.02	4.67	8.82	6.51	0.075	330	20.2	207.4	Not Liquefiable	0.805	Not Liquefiable	Not Liquefiable

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ZCP-24

Original Surface Elevation = 271.49 feet msl
Ground Water Elevation = 215.79 feet msl
Original Depth to Water Table = 55.7 feet

Final Surface Elevation = 318 feet msl
Design Water Elevation = 245 feet msl
Design Depth to Water Table = 73 feet

amax = 0.17 g

unit wt = 120 pcf

Mw = 6.5
MSF = 1.6

Elev. (ft-msl)	ZCP-24 Vs (ft/sec)	Original Depth (feet)	Final Depth (feet)	rd Eq. 7	Original Total Stress σv (tsf) Eq. 5	Original Effective Stress σ'v (tsf) Eq. 6	Final Total Stress σv (tsf) Eq. 5	Final Effective Stress σ'v (tsf) Eq. 6	CSR Eq. 4	Vs1 (m/sec) Eq. 10	Percent Fines Eq. 24 & 25	V*s1 (m/sec) Eq. 11-13	CRR M=7.5 Percent fines Incorporated Eq. 9	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR Ksigma and Magnitude Correction Incorporated Eq. 1a	Factor of Safety Eq. 1a
261	1350	10.5	57	0.710	0.63	0.63	3.42	3.42	0.078	462	18.5	208.2	Not Liquefiable	0.888	Not Liquefiable	above WT
255	1350	16.5	63	0.661	0.99	0.99	3.78	3.78	0.073	413	18.5	208.2	Not Liquefiable	0.876	Not Liquefiable	above WT
255	1040	16.5	63	0.661	0.99	0.99	3.78	3.78	0.073	318	10.0	212.5	Not Liquefiable	0.876	Not Liquefiable	above WT
237	1040	34.5	81	0.546	2.07	2.07	4.86	4.61	0.064	264	10.0	212.5	Not Liquefiable	0.851	Not Liquefiable	Not Liquefiable
237	1080	34.5	81	0.546	2.07	2.07	4.86	4.61	0.064	274	16.6	209.2	Not Liquefiable	0.851	Not Liquefiable	Not Liquefiable
225	1080	46.5	93	0.517	2.79	2.79	5.58	4.96	0.064	255	16.6	209.2	Not Liquefiable	0.842	Not Liquefiable	Not Liquefiable
225	780	46.5	93	0.517	2.79	2.79	5.58	4.96	0.064	184	38.2	200.0	0.235	0.842	0.316	4.9
212	780	59.5	106	0.500	3.57	3.45	6.36	5.33	0.066	174	38.2	200.0	0.162	0.832	0.216	3.3
212	950	59.5	106	0.500	3.57	3.45	6.36	5.33	0.066	212	11.4	211.8	Not Liquefiable	0.832	Not Liquefiable	Not Liquefiable
201	950	70.5	117	0.5	4.23	3.77	7.02	5.65	0.069	208	11.4	211.8	0.783	0.824	1.032	15.0
201	1220	70.5	117	0.5	4.23	3.77	7.02	5.65	0.069	267	17.8	208.6	Not Liquefiable	0.824	Not Liquefiable	Not Liquefiable
186	1220	85.5	132	0.5	5.13	4.20	7.92	6.08	0.072	260	17.8	208.6	Not Liquefiable	0.814	Not Liquefiable	Not Liquefiable
186	1620	85.5	132	0.5	5.13	4.20	7.92	6.08	0.072	345	17.8	208.6	Not Liquefiable	0.814	Not Liquefiable	Not Liquefiable
176	1620	95.5	142	0.5	5.73	4.49	8.52	6.37	0.074	339	17.8	208.6	Not Liquefiable	0.808	Not Liquefiable	Not Liquefiable
176	1500	95.5	142	0.5	5.73	4.49	8.52	6.37	0.074	314	28.1	203.5	Not Liquefiable	0.808	Not Liquefiable	Not Liquefiable
170	1500	101.5	148	0.5	6.09	4.66	8.88	6.54	0.075	311	28.1	203.5	Not Liquefiable	0.804	Not Liquefiable	Not Liquefiable

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ZCP-25

Original Surface Elevation = 269.60 feet msl
Ground Water Elevation = 214.70 feet msl
Original Depth to Water Table = 54.90 feet

Final Surface Elevation = 318 feet msl
Design Water Elevation = 245 feet msl
Design Depth to Water Table = 73 feet

amax = 0.17 g
unit wt = 120 pcf

Mw = 6.5
MSF = 1.6

Elev. (ft-msl)	ZCP-25 Vs (ft/sec)	Original Depth (feet)	Final Depth (feet)	rd Eq. 7	Original Total Stress σv (tsf) Eq. 5	Original Effective Stress σ'v (tsf) Eq. 6	Final Total Stress σv (tsf) Eq. 5	Final Effective Stress σ'v (tsf) Eq. 6	CSR Eq. 4	Vs1 (m/sec) Eq. 10	Percent Fines Eq. 24 & 25	V*s1 (m/sec) Eq. 11-13	CRR M=7.5 Percent fines Incorporated Eq. 9	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR Ksigma and Magnitude Correction Incorporated Eq. 1a	Factor of Safety Eq. 1a
259	1190	10.6	59	0.694	0.64	0.64	3.54	3.54	0.077	406	14.4	210.3	Not Liquefiable	0.884	Not Liquefiable	above WT
250	1190	19.6	68	0.621	1.18	1.18	4.08	4.08	0.069	348	14.4	210.3	Not Liquefiable	0.866	Not Liquefiable	above WT
250	1140	19.6	68	0.621	1.18	1.18	4.08	4.08	0.069	334	10.8	212.1	Not Liquefiable	0.866	Not Liquefiable	above WT
235	1140	34.6	83	0.542	2.08	2.08	4.98	4.67	0.064	289	10.8	212.1	Not Liquefiable	0.849	Not Liquefiable	Not Liquefiable
235	1060	34.6	83	0.542	2.08	2.08	4.98	4.67	0.064	269	14.1	210.4	Not Liquefiable	0.849	Not Liquefiable	Not Liquefiable
217	1060	52.6	101	0.500	3.16	3.16	6.06	5.19	0.065	242	14.1	210.4	Not Liquefiable	0.836	Not Liquefiable	Not Liquefiable
217	1180	52.6	101	0.500	3.16	3.16	6.06	5.19	0.065	270	13.7	210.7	Not Liquefiable	0.836	Not Liquefiable	Not Liquefiable
196	1180	73.6	122	0.500	4.42	3.83	7.32	5.79	0.070	257	13.7	210.7	Not Liquefiable	0.821	Not Liquefiable	Not Liquefiable
196	1130	73.6	122	0.500	4.42	3.83	7.32	5.79	0.070	246	12.6	211.2	Not Liquefiable	0.821	Not Liquefiable	Not Liquefiable
184	1130	85.6	134	0.5	5.14	4.18	8.04	6.14	0.072	241	12.6	211.2	Not Liquefiable	0.813	Not Liquefiable	Not Liquefiable

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ZCP-26

Original Surface Elevation = 269.62 feet msl
Ground Water Elevation = 209.12 feet msl
Original Depth to Water Table = 60.50 feet

Final Surface Elevation = 318 feet msl
Design Water Elevation = 245 feet msl
Design Depth to Water Table = 73 feet

amax = 0.17 g
unit wt = 120 pcf

Mw = 6.5
MSF = 1.6

Elev. (ft-msl)	ZCP-26 Vs (ft/sec)	Original Depth (feet)	Final Depth (feet)	rd Eq. 7	Original Total Stress σv (tsf) Eq. 5	Original Effective Stress σ'v (tsf) Eq. 6	Final Total Stress σv (tsf) Eq. 5	Final Effective Stress σ'v (tsf) Eq. 6	CSR Eq. 4	Vs1 (m/sec) Eq. 10	Percent Fines Eq. 24 & 25	V*s1 (m/sec) Eq. 11-13	CRR M=7.5 Percent fines Incorporated Eq. 9	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR Ksigma and Magnitude Correction Incorporated Eq. 1a	Factor of Safety Eq. 1a
259	1550	10.6	59	0.694	0.64	0.64	3.54	3.54	0.077	529	23.8	205.6	Not Liquefiable	0.884	Not Liquefiable	above WT
250	1550	19.6	68	0.621	1.18	1.18	4.08	4.08	0.069	454	23.8	205.6	Not Liquefiable	0.866	Not Liquefiable	above WT
250	1020	19.6	68	0.621	1.18	1.18	4.08	4.08	0.069	298	14.1	210.4	Not Liquefiable	0.866	Not Liquefiable	above WT
235	1020	34.6	83	0.542	2.08	2.08	4.98	4.67	0.064	259	14.1	210.4	Not Liquefiable	0.849	Not Liquefiable	Not Liquefiable
235	890	34.6	83	0.542	2.08	2.08	4.98	4.67	0.064	226	32.7	201.2	Not Liquefiable	0.849	Not Liquefiable	Not Liquefiable
214	890	55.6	104	0.500	3.34	3.34	6.24	5.27	0.065	201	32.7	201.2	6.219	0.834	8.294	126.9
214	1050	55.6	104	0.500	3.34	3.34	6.24	5.27	0.065	237	9.7	212.6	Not Liquefiable	0.834	Not Liquefiable	Not Liquefiable
193	1050	76.6	125	0.500	4.60	4.09	7.50	5.88	0.071	225	9.7	212.6	Not Liquefiable	0.819	Not Liquefiable	Not Liquefiable
193	2140	76.6	125	0.500	4.60	4.09	7.50	5.88	0.071	459	17.2	208.9	Not Liquefiable	0.819	Not Liquefiable	Not Liquefiable
175	2140	94.6	143	0.500	5.68	4.61	8.58	6.40	0.074	445	17.2	208.9	Not Liquefiable	0.808	Not Liquefiable	Not Liquefiable

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ZCP-27

Original Surface Elevation = 269.69 feet msl
Ground Water Elevation = 210.69 feet msl
Original Depth to Water Table = 59.0 feet

Final Surface Elevation = 318 feet msl
Design Water Elevation = 245 feet msl
Design Depth to Water Table = 73 feet

amax = 0.17 g
unit wt = 120 pcf

Mw = 6.5
MSF = 1.6

Elev. (ft-msl)	ZCP-27 Vs (ft/sec)	Original Depth (feet)	Final Depth (feet)	rd Eq. 7	Original Total Stress σv (tsf) Eq. 5	Original Effective Stress σ'v (tsf) Eq. 6	Final Total Stress σv (tsf) Eq. 5	Final Effective Stress σ'v (tsf) Eq. 6	CSR Eq. 4	Vs1 (m/sec) Eq. 10	Percent Fines Eq. 24 & 25	V*s1 (m/sec) Eq. 11-13	CRR M=7.5 Percent fines Incorporated Eq. 9	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR Ksigma and Magnitude Correction Incorporated Eq. 1a	Factor of Safety Eq. 1a
256	1020	13.7	62	0.669	0.82	0.82	3.72	3.72	0.074	327	11.8	211.6	Not Liquefiable	0.878	Not Liquefiable	above WT
225	1020	44.7	93	0.517	2.68	2.68	5.58	4.96	0.064	243	11.8	211.6	Not Liquefiable	0.842	Not Liquefiable	Not Liquefiable
225	850	44.7	93	0.517	2.68	2.68	5.58	4.96	0.064	202	37.3	200.0	Not Liquefiable	0.842	Not Liquefiable	Not Liquefiable
211	850	58.7	107	0.500	3.52	3.52	6.42	5.36	0.066	189	37.3	200.0	0.322	0.831	0.428	6.5
211	1070	58.7	107	0.500	3.52	3.52	6.42	5.36	0.066	238	11.5	211.7	Not Liquefiable	0.831	Not Liquefiable	Not Liquefiable
196	1070	73.7	122	0.500	4.42	3.96	7.32	5.79	0.070	231	11.5	211.7	Not Liquefiable	0.821	Not Liquefiable	Not Liquefiable
196	900	73.7	122	0.500	4.42	3.96	7.32	5.79	0.070	194	17.3	208.8	0.264	0.821	0.347	5.0
181	900	88.7	137	0.500	5.32	4.40	8.22	6.22	0.073	189	17.3	208.8	0.210	0.811	0.273	3.7
181	1750	88.7	137	0.500	5.32	4.40	8.22	6.22	0.073	368	26.1	204.4	Not Liquefiable	0.811	Not Liquefiable	Not Liquefiable
169	1750	100.7	149	0.5	6.04	4.74	8.94	6.57	0.075	361	26.1	204.4	Not Liquefiable	0.804	Not Liquefiable	Not Liquefiable
169	1540	100.7	149	0.5	6.04	4.74	8.94	6.57	0.075	318	35.1	200.0	Not Liquefiable	0.804	Not Liquefiable	Not Liquefiable
163	1540	106.7	155	0.5	6.40	4.91	9.30	6.74	0.076	315	35.1	200.0	Not Liquefiable	0.800	Not Liquefiable	Not Liquefiable

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ZCP-22

Original Surface Elevation = 269.78 feet msl
Ground Water Elevation = 212.38 feet msl
Original Depth to Water Table = 57.4 feet

Final Surface Elevation = 318 feet msl
Design Water Elevation = 245 feet msl
Design Depth to Water Table = 73 feet

amax = 0.17 g
unit wt = 120 pcf

Mw = 6.5
MSF = 1.6

Elev. (ft-msl)	ZCP-22 Vs (ft/sec)	Original Depth (feet)	Final Depth (feet)	rd Eq. 7	Original Total Stress σv (tsf) Eq. 5	Original Effective Stress σ'v (tsf) Eq. 6	Final Total Stress σv (tsf) Eq. 5	Final Effective Stress σ'v (tsf) Eq. 6	CSR Eq. 4	Vs1 (m/sec) Eq. 10	MRCE Stratum	Percent Fines Table 1	V*s1 (m/sec) Eq. 11-13	CRR M=7.5 Percent fines Incorporated Eq. 9	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR Ksigma and Magnitude Correction Incorporated Eq. 1a	Factor of Safety Eq. 1a
259	1010	10.8	59	0.694	0.65	0.65	3.54	3.54	0.077	343	S1	28.6	203.2	Not Liquefiable	0.884	Not Liquefiable	above WT
250	1010	19.8	68	0.621	1.19	1.19	4.08	4.08	0.069	295	S1	28.6	203.2	Not Liquefiable	0.866	Not Liquefiable	above WT
250	990	19.8	68	0.621	1.19	1.19	4.08	4.08	0.069	289	S2	16.3	209.4	Not Liquefiable	0.866	Not Liquefiable	above WT
238	990	31.8	80	0.549	1.91	1.91	4.80	4.58	0.064	257	S2	16.3	209.4	Not Liquefiable	0.852	Not Liquefiable	Not Liquefiable
238	1080	31.8	80	0.549	1.91	1.91	4.80	4.58	0.064	280	S2	16.3	209.4	Not Liquefiable	0.852	Not Liquefiable	Not Liquefiable
232	1080	37.8	86	0.534	2.27	2.27	5.16	4.75	0.064	268	S2	16.3	209.4	Not Liquefiable	0.847	Not Liquefiable	Not Liquefiable
232	1080	37.8	86	0.534	2.27	2.27	5.16	4.75	0.064	268	C2	44.5	200.0	Not Liquefiable	0.847	Not Liquefiable	Not Liquefiable
229	1080	40.8	89	0.527	2.45	2.45	5.34	4.84	0.064	263	C2	44.5	200.0	Not Liquefiable	0.845	Not Liquefiable	Not Liquefiable
229	890	40.8	89	0.527	2.45	2.45	5.34	4.84	0.064	217	C2	44.5	200.0	Not Liquefiable	0.845	Not Liquefiable	Not Liquefiable
223	890	46.8	95	0.512	2.81	2.81	5.70	5.01	0.064	210	C2	44.5	200.0	Not Liquefiable	0.840	Not Liquefiable	Not Liquefiable
223	1020	46.8	95	0.512	2.81	2.81	5.70	5.01	0.064	240	C2	44.5	200.0	Not Liquefiable	0.840	Not Liquefiable	Not Liquefiable
218	1020	51.8	100	0.5	3.11	3.11	6.00	5.16	0.064	234	C2	44.5	200.0	Not Liquefiable	0.836	Not Liquefiable	Not Liquefiable
218	1020	51.8	100	0.5	3.11	3.11	6.00	5.16	0.064	234	S3	16.7	209.1	Not Liquefiable	0.836	Not Liquefiable	Not Liquefiable
205	1020	64.8	113	0.5	3.89	3.66	6.78	5.53	0.068	225	S3	16.7	209.1	Not Liquefiable	0.827	Not Liquefiable	Not Liquefiable
205	770	64.8	113	0.5	3.89	3.66	6.78	5.53	0.068	170	S3	16.7	209.1	0.121	0.827	0.160	2.4
196	770	73.8	122	0.5	4.43	3.92	7.32	5.79	0.070	167	S3	16.7	209.1	0.114	0.821	0.150	2.1
196	610	73.8	122	0.5	4.43	3.92	7.32	5.79	0.070	132	S3	16.7	209.1	0.061	0.821	0.081	1.2
187	610	82.8	131	0.5	4.97	4.17	7.86	6.05	0.072	130	S3	16.7	209.1	0.059	0.815	0.077	1.1
184	1200	85.8	134	0.5	5.15	4.26	8.04	6.14	0.072	255	S4	33.6	200.7	Not Liquefiable	0.813	Not Liquefiable	Not Liquefiable
178	1200	91.8	140	0.5	5.51	4.43	8.40	6.31	0.074	252	S4	33.6	200.7	Not Liquefiable	0.809	Not Liquefiable	Not Liquefiable

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ZCP-23

Original Surface Elevation = 271.30 feet msl
Ground Water Elevation = 214.10 feet msl
Original Depth to Water Table = 57.20 feet

Final Surface Elevation = 318 feet msl
Design Water Elevation = 245 feet msl
Design Depth to Water Table = 73 feet

amax = 0.17 g
unit wt = 120 pcf

Mw = 6.5
MSF = 1.6

Elev. (ft-msl)	ZCP-23 Vs (ft/sec)	Original Depth (feet)	Final Depth (feet)	rd Eq. 7	Original Total Stress σv (tsf) Eq. 5	Original Effective Stress σ'v (tsf) Eq. 6	Final Total Stress σv (tsf) Eq. 5	Final Effective Stress σ'v (tsf) Eq. 6	CSR Eq. 4	Vs1 (m/sec) Eq. 10	MRCE Stratum	Percent Fines Table 1	V*s1 (m/sec) Eq. 11-13	CRR M=7.5 Percent fines Incorporated Eq. 9	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR Ksigma and Magnitude Correction Incorporated Eq. 1a	Factor of Safety Eq. 1a
261	1380	10.3	57	0.710	0.62	0.62	3.42	3.42	0.078	474	S1	28.6	203.2	Not Liquefiable	0.888	Not Liquefiable	above WT
255	1380	16.3	63	0.661	0.98	0.98	3.78	3.78	0.073	423	S1	28.6	203.2	Not Liquefiable	0.876	Not Liquefiable	above WT
255	1190	16.3	63	0.661	0.98	0.98	3.78	3.78	0.073	365	S1	28.6	203.2	Not Liquefiable	0.876	Not Liquefiable	above WT
245	1190	26.3	73	0.580	1.58	1.58	4.38	4.38	0.064	324	S1	28.6	203.2	Not Liquefiable	0.858	Not Liquefiable	Not Liquefiable
245	1190	26.3	73	0.580	1.58	1.58	4.38	4.38	0.064	324	S2	16.3	209.4	Not Liquefiable	0.858	Not Liquefiable	Not Liquefiable
234	1190	37.3	84	0.539	2.24	2.24	5.04	4.70	0.064	297	S2	16.3	209.4	Not Liquefiable	0.849	Not Liquefiable	Not Liquefiable
234	1230	37.3	84	0.539	2.24	2.24	5.04	4.70	0.064	307	S2	16.3	209.4	Not Liquefiable	0.849	Not Liquefiable	Not Liquefiable
227	1230	44.3	91	0.522	2.66	2.66	5.46	4.90	0.064	294	S2	16.3	209.4	Not Liquefiable	0.843	Not Liquefiable	Not Liquefiable
227	1010	44.3	91	0.522	2.66	2.66	5.46	4.90	0.064	241	C2	44.5	200.0	Not Liquefiable	0.843	Not Liquefiable	Not Liquefiable
214	1010	57.3	104	0.500	3.44	3.43	6.24	5.27	0.065	226	C2	44.5	200.0	Not Liquefiable	0.834	Not Liquefiable	Not Liquefiable
214	1010	57.3	104	0.500	3.44	3.43	6.24	5.27	0.065	226	S3	16.7	209.1	Not Liquefiable	0.834	Not Liquefiable	Not Liquefiable
213	1010	58.3	105	0.500	3.50	3.46	6.30	5.30	0.066	226	S3	16.7	209.1	Not Liquefiable	0.833	Not Liquefiable	Not Liquefiable
213	1130	58.3	105	0.500	3.50	3.46	6.30	5.30	0.066	252	S3	16.7	209.1	Not Liquefiable	0.833	Not Liquefiable	Not Liquefiable
189	1130	82.3	129	0.5	4.94	4.15	7.74	5.99	0.071	241	S3	16.7	209.1	Not Liquefiable	0.816	Not Liquefiable	Not Liquefiable
189	1270	82.3	129	0.500	4.94	4.15	7.74	5.99	0.071	271	S3	16.7	209.1	Not Liquefiable	0.816	Not Liquefiable	Not Liquefiable
185	1270	86.3	133	0.500	5.18	4.27	7.98	6.11	0.072	269	S3	16.7	209.1	Not Liquefiable	0.814	Not Liquefiable	Not Liquefiable
185	1270	86.3	133	0.500	5.18	4.27	7.98	6.11	0.072	269	S4	33.6	200.7	Not Liquefiable	0.814	Not Liquefiable	Not Liquefiable
182	1270	89.3	136	0.500	5.36	4.36	8.16	6.19	0.073	268	S4	33.6	200.7	Not Liquefiable	0.812	Not Liquefiable	Not Liquefiable
182	1590	89.3	136	0.5	5.36	4.36	8.16	6.19	0.073	335	S4	33.6	200.7	Not Liquefiable	0.812	Not Liquefiable	Not Liquefiable
171	1590	100.3	147	0.5	6.02	4.67	8.82	6.51	0.075	330	S4	33.6	200.7	Not Liquefiable	0.805	Not Liquefiable	Not Liquefiable

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ZCP-24

Original Surface Elevation = 271.49 feet msl
Ground Water Elevation = 215.79 feet msl
Original Depth to Water Table = 55.7 feet

Final Surface Elevation = 318 feet msl
Design Water Elevation = 245 feet msl
Design Depth to Water Table = 73 feet

amax = 0.17 g
unit wt = 120 pcf

Mw = 6.5
MSF = 1.6

Elev. (ft-msl)	ZCP-24 Vs (ft/sec)	Original Depth (feet)	Final Depth (feet)	rd Eq. 7	Original Total Stress σv (tsf) Eq. 5	Original Effective Stress σ'v (tsf) Eq. 6	Final Total Stress σv (tsf) Eq. 5	Final Effective Stress σ'v (tsf) Eq. 6	CSR Eq. 4	Vs1 (m/sec) Eq. 10	MRCE Stratum	Percent Fines Table 1	V*s1 (m/sec) Eq. 11-13	CRR M=7.5 Percent fines Incorporated Eq. 9	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR Ksigma and Magnitude Correction Incorporated Eq. 1a	Factor of Safety Eq. 1a
261	1350	10.5	57	0.710	0.63	0.63	3.42	3.42	0.078	462	S1	28.6	203.2	Not Liquefiable	0.888	Not Liquefiable	above WT
255	1350	16.5	63	0.661	0.99	0.99	3.78	3.78	0.073	413	S1	28.6	203.2	Not Liquefiable	0.876	Not Liquefiable	above WT
255	1040	16.5	63	0.661	0.99	0.99	3.78	3.78	0.073	318	S1	28.6	203.2	Not Liquefiable	0.876	Not Liquefiable	above WT
245	1040	26.5	73	0.580	1.59	1.59	4.38	4.38	0.064	282	S1	28.6	203.2	Not Liquefiable	0.858	Not Liquefiable	Not Liquefiable
245	1040	26.5	73	0.580	1.59	1.59	4.38	4.38	0.064	282	S2	16.3	209.4	Not Liquefiable	0.858	Not Liquefiable	Not Liquefiable
237	1040	34.5	81	0.546	2.07	2.07	4.86	4.61	0.064	264	S2	16.3	209.4	Not Liquefiable	0.851	Not Liquefiable	Not Liquefiable
237	1080	34.5	81	0.546	2.07	2.07	4.86	4.61	0.064	274	S2	16.3	209.4	Not Liquefiable	0.851	Not Liquefiable	Not Liquefiable
229	1080	42.5	89	0.527	2.55	2.55	5.34	4.84	0.064	261	S2	16.3	209.4	Not Liquefiable	0.845	Not Liquefiable	Not Liquefiable
229	1080	42.5	89	0.527	2.55	2.55	5.34	4.84	0.064	261	C2	44.5	200.0	Not Liquefiable	0.845	Not Liquefiable	Not Liquefiable
225	1080	46.5	93	0.517	2.79	2.79	5.58	4.96	0.064	255	C2	44.5	200.0	Not Liquefiable	0.842	Not Liquefiable	Not Liquefiable
225	780	46.5	93	0.517	2.79	2.79	5.58	4.96	0.064	184	C2	44.5	200.0	0.235	0.842	0.316	4.9
212	780	59.5	106	0.500	3.57	3.45	6.36	5.33	0.066	174	C2	44.5	200.0	0.162	0.832	0.216	3.3
212	950	59.5	106	0.500	3.57	3.45	6.36	5.33	0.066	212	S3	16.7	209.1	Not Liquefiable	0.832	Not Liquefiable	Not Liquefiable
201	950	70.5	117	0.500	4.23	3.77	7.02	5.65	0.069	208	S3	16.7	209.1	2.201	0.824	2.904	42.3
201	1220	70.5	117	0.500	4.23	3.77	7.02	5.65	0.069	267	S3	16.7	209.1	Not Liquefiable	0.824	Not Liquefiable	Not Liquefiable
192	1220	79.5	126	0.500	4.77	4.03	7.56	5.91	0.071	262	S3	16.7	209.1	Not Liquefiable	0.818	Not Liquefiable	Not Liquefiable
192	1220	79.5	126	0.500	4.77	4.03	7.56	5.91	0.071	262	S4	33.6	200.7	Not Liquefiable	0.818	Not Liquefiable	Not Liquefiable
186	1220	85.5	132	0.500	5.13	4.20	7.92	6.08	0.072	260	S4	33.6	200.7	Not Liquefiable	0.814	Not Liquefiable	Not Liquefiable
186	1620	85.5	132	0.500	5.13	4.20	7.92	6.08	0.072	345	S4	33.6	200.7	Not Liquefiable	0.814	Not Liquefiable	Not Liquefiable
176	1620	95.5	142	0.5	5.73	4.49	8.52	6.37	0.074	339	S4	33.6	200.7	Not Liquefiable	0.808	Not Liquefiable	Not Liquefiable
176	1500	95.5	142	0.5	5.73	4.49	8.52	6.37	0.074	314	S4	33.6	200.7	Not Liquefiable	0.808	Not Liquefiable	Not Liquefiable
170	1500	101.5	148	0.5	6.09	4.66	8.88	6.54	0.075	311	S4	33.6	200.7	Not Liquefiable	0.804	Not Liquefiable	Not Liquefiable

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ZCP-25

Original Surface Elevation = 269.60 feet msl
Ground Water Elevation = 214.70 feet msl
Original Depth to Water Table = 54.90 feet

Final Surface Elevation = 318 feet msl
Design Water Elevation = 245 feet msl
Design Depth to Water Table = 73 feet

amax = 0.17 g
unit wt = 120 pcf

Mw = 6.5
MSF = 1.6

Elev. (ft-msl)	ZCP-25 Vs (ft/sec)	Original Depth (feet)	Final Depth (feet)	rd Eq. 7	Original Total Stress σv (tsf) Eq. 5	Original Effective Stress σ'v (tsf) Eq. 6	Final Total Stress σv (tsf) Eq. 5	Final Effective Stress σ'v (tsf) Eq. 6	CSR Eq. 4	Vs1 (m/sec) Eq. 10	MRCE Stratum	Percent Fines Table 1	V*s1 (m/sec) Eq. 11-13	CRR M=7.5 Percent fines Incorporated Eq. 9	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR Ksigma and Magnitude Correction Incorporated Eq. 1a	Factor of Safety Eq. 1a
259	1190	10.6	59	0.694	0.64	0.64	3.54	3.54	0.077	406	S1	28.6	203.2	Not Liquefiable	0.884	Not Liquefiable	above WT
250	1190	19.6	68	0.621	1.18	1.18	4.08	4.08	0.069	348	S1	28.6	203.2	Not Liquefiable	0.866	Not Liquefiable	above WT
250	1140	19.6	68	0.621	1.18	1.18	4.08	4.08	0.069	334	S1	28.6	203.2	Not Liquefiable	0.866	Not Liquefiable	above WT
239	1140	30.6	79	0.551	1.84	1.84	4.74	4.55	0.063	298	S1	28.6	203.2	Not Liquefiable	0.853	Not Liquefiable	Not Liquefiable
239	1140	30.6	79	0.551	1.84	1.84	4.74	4.55	0.063	298	S2	16.3	209.4	Not Liquefiable	0.853	Not Liquefiable	Not Liquefiable
235	1140	34.6	83	0.542	2.08	2.08	4.98	4.67	0.064	289	S2	16.3	209.4	Not Liquefiable	0.849	Not Liquefiable	Not Liquefiable
235	1060	34.6	83	0.542	2.08	2.08	4.98	4.67	0.064	269	S2	16.3	209.4	Not Liquefiable	0.849	Not Liquefiable	Not Liquefiable
224	1060	45.6	94	0.515	2.74	2.74	5.64	4.98	0.064	251	S2	16.3	209.4	Not Liquefiable	0.841	Not Liquefiable	Not Liquefiable
224	1060	45.6	94	0.515	2.74	2.74	5.64	4.98	0.064	251	C2	44.5	200.0	Not Liquefiable	0.841	Not Liquefiable	Not Liquefiable
217	1060	52.6	101	0.500	3.16	3.16	6.06	5.19	0.065	242	C2	44.5	200.0	Not Liquefiable	0.836	Not Liquefiable	Not Liquefiable
217	1180	52.6	101	0.500	3.16	3.16	6.06	5.19	0.065	270	C2	44.5	200.0	Not Liquefiable	0.836	Not Liquefiable	Not Liquefiable
214	1180	55.6	104	0.500	3.34	3.31	6.24	5.27	0.065	267	C2	44.5	200.0	Not Liquefiable	0.834	Not Liquefiable	Not Liquefiable
214	1180	55.6	104	0.500	3.34	3.31	6.24	5.27	0.065	267	S3	16.7	209.1	Not Liquefiable	0.834	Not Liquefiable	Not Liquefiable
196	1180	73.6	122	0.500	4.42	3.83	7.32	5.79	0.070	257	S3	16.7	209.1	Not Liquefiable	0.821	Not Liquefiable	Not Liquefiable
196	1130	73.6	122	0.500	4.42	3.83	7.32	5.79	0.070	246	S4	33.6	200.7	Not Liquefiable	0.821	Not Liquefiable	Not Liquefiable
184	1130	85.6	134	0.5	5.14	4.18	8.04	6.14	0.072	241	S4	33.6	200.7	Not Liquefiable	0.813	Not Liquefiable	Not Liquefiable

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ZCP-26

Original Surface Elevation = 269.62 feet msl
Ground Water Elevation = 209.12 feet msl
Original Depth to Water Table = 60.50 feet

Final Surface Elevation = 318 feet msl
Design Water Elevation = 245 feet msl
Design Depth to Water Table = 73 feet

amax = 0.17 g
unit wt = 120 pcf

Mw = 6.5
MSF = 1.6

Elev. (ft-msl)	ZCP-26 Vs (ft/sec)	Original Depth (feet)	Final Depth (feet)	rd Eq. 7	Original Total Stress σv (tsf) Eq. 5	Original Effective Stress σ'v (tsf) Eq. 6	Final Total Stress σv (tsf) Eq. 5	Final Effective Stress σ'v (tsf) Eq. 6	CSR Eq. 4	Vs1 (m/sec) Eq. 10	MRCE Stratum	Percent Fines Table 1	V*s1 (m/sec) Eq. 11-13	CRR M=7.5 Percent fines Incorporated Eq. 9	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR Ksigma and Magnitude Correction Incorporated Eq. 1a	Factor of Safety Eq. 1a
259	1550	10.6	59	0.694	0.64	0.64	3.54	3.54	0.077	529	S1	28.6	203.2	Not Liquefiable	0.884	Not Liquefiable	above WT
250	1550	19.6	68	0.621	1.18	1.18	4.08	4.08	0.069	454	S1	28.6	203.2	Not Liquefiable	0.866	Not Liquefiable	above WT
250	1020	19.6	68	0.621	1.18	1.18	4.08	4.08	0.069	298	S2	16.3	209.4	Not Liquefiable	0.866	Not Liquefiable	above WT
235	1020	34.6	83	0.542	2.08	2.08	4.98	4.67	0.064	259	S2	16.3	209.4	Not Liquefiable	0.849	Not Liquefiable	Not Liquefiable
235	890	34.6	83	0.542	2.08	2.08	4.98	4.67	0.064	226	C2	44.5	200.0	Not Liquefiable	0.849	Not Liquefiable	Not Liquefiable
214	890	55.6	104	0.500	3.34	3.34	6.24	5.27	0.065	201	C2	44.5	200.0	Not Liquefiable	0.834	Not Liquefiable	Not Liquefiable
214	1050	55.6	104	0.500	3.34	3.34	6.24	5.27	0.065	237	S3	16.7	209.1	Not Liquefiable	0.834	Not Liquefiable	Not Liquefiable
193	1050	76.6	125	0.500	4.60	4.09	7.50	5.88	0.071	225	S3	16.7	209.1	Not Liquefiable	0.819	Not Liquefiable	Not Liquefiable
193	2140	76.6	125	0.500	4.60	4.09	7.50	5.88	0.071	459	S4	33.6	200.7	Not Liquefiable	0.819	Not Liquefiable	Not Liquefiable
175	2140	94.6	143	0.500	5.68	4.61	8.58	6.40	0.074	445	S4	33.6	200.7	Not Liquefiable	0.808	Not Liquefiable	Not Liquefiable

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ZCP-27

Original Surface Elevation = 269.69 feet msl
Ground Water Elevation = 210.69 feet msl
Original Depth to Water Table = 59.0 feet

Final Surface Elevation = 318 feet msl
Design Water Elevation = 245 feet msl
Design Depth to Water Table = 73 feet

amax = 0.17 g
unit wt = 120 pcf

Mw = 6.5
MSF = 1.6

Elev. (ft-msl)	ZCP-27 Vs (ft/sec)	Original Depth (feet)	Final Depth (feet)	rd Eq. 7	Original Total Stress σv (tsf) Eq. 5	Original Effective Stress σ'v (tsf) Eq. 6	Final Total Stress σv (tsf) Eq. 5	Final Effective Stress σ'v (tsf) Eq. 6	CSR Eq. 4	Vs1 (m/sec) Eq. 10	MRCE Stratum	Percent Fines Table 1	V*s1 (m/sec) Eq. 11-13	CRR M=7.5 Percent fines Incorporated Eq. 9	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR Ksigma and Magnitude Correction Incorporated Eq. 1a	Factor of Safety Eq. 1a
256	1020	13.7	62	0.669	0.82	0.82	3.72	3.72	0.074	327	S1	28.6	203.2	Not Liquefiable	0.878	Not Liquefiable	above WT
250	1020	19.7	68	0.621	1.18	1.18	4.08	4.08	0.069	298	S1	28.6	203.2	Not Liquefiable	0.866	Not Liquefiable	above WT
250	1020	19.7	68	0.621	1.18	1.18	4.08	4.08	0.069	298	S2	16.3	209.4	Not Liquefiable	0.866	Not Liquefiable	above WT
225	1020	44.7	93	0.517	2.68	2.68	5.58	4.96	0.064	243	S2	16.3	209.4	Not Liquefiable	0.842	Not Liquefiable	Not Liquefiable
225	850	44.7	93	0.517	2.68	2.68	5.58	4.96	0.064	202	S2	16.3	209.4	0.481	0.842	0.648	10.1
223	850	46.7	95	0.512	2.80	2.80	5.70	5.01	0.064	200	S2	16.3	209.4	0.382	0.840	0.513	8.0
223	850	46.7	95	0.512	2.80	2.80	5.70	5.01	0.064	200	C2	44.5	200.0	Not Liquefiable	0.840	Not Liquefiable	Not Liquefiable
211	850	58.7	107	0.500	3.52	3.52	6.42	5.36	0.066	189	C2	44.5	200.0	0.322	0.831	0.428	6.5
211	1070	58.7	107	0.500	3.52	3.52	6.42	5.36	0.066	238	C2	44.5	200.0	Not Liquefiable	0.831	Not Liquefiable	Not Liquefiable
208	1070	61.7	110	0.500	3.70	3.62	6.60	5.45	0.067	236	C2	44.5	200.0	Not Liquefiable	0.829	Not Liquefiable	Not Liquefiable
208	1070	61.7	110	0.500	3.70	3.62	6.60	5.45	0.067	236	S3	16.7	209.1	Not Liquefiable	0.829	Not Liquefiable	Not Liquefiable
196	1070	73.7	122	0.500	4.42	3.96	7.32	5.79	0.070	231	S3	16.7	209.1	Not Liquefiable	0.821	Not Liquefiable	Not Liquefiable
196	900	73.7	122	0.500	4.42	3.96	7.32	5.79	0.070	194	S3	16.7	209.1	0.260	0.821	0.341	4.9
181	900	88.7	137	0.500	5.32	4.40	8.22	6.22	0.073	189	S3	16.7	209.1	0.208	0.811	0.270	3.7
181	1750	88.7	137	0.500	5.32	4.40	8.22	6.22	0.073	368	S4	33.6	200.7	Not Liquefiable	0.811	Not Liquefiable	Not Liquefiable
169	1750	100.7	149	0.5	6.04	4.74	8.94	6.57	0.075	361	S4	33.6	200.7	Not Liquefiable	0.804	Not Liquefiable	Not Liquefiable
169	1540	100.7	149	0.5	6.04	4.74	8.94	6.57	0.075	318	S4	33.6	200.7	Not Liquefiable	0.804	Not Liquefiable	Not Liquefiable
163	1540	106.7	155	0.5	6.40	4.91	9.30	6.74	0.076	315	S4	33.6	200.7	Not Liquefiable	0.800	Not Liquefiable	Not Liquefiable

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ZCP-22

Original Surface Elevation = 269.78 feet msl
Ground Water Elevation = 212.38 feet msl
Original Depth to Water Table = 57.4 feet

Final Surface Elevation = 318 feet msl
Design Water Elevation = 245 feet msl
Design Depth to Water Table = 73 feet

amax = 0.11 g
unit wt = 120 pcf

Mw = 7.3
MSF = 1.1

Elev. (ft-msl)	ZCP-22 Vs (ft/sec)	Original Depth (feet)	Final Depth (feet)	rd Eq. 7	Original Total Stress σv (tsf) Eq. 5	Original Effective Stress σ'v (tsf) Eq. 6	Final Total Stress σv (tsf) Eq. 5	Final Effective Stress σ'v (tsf) Eq. 6	CSR Eq. 4	Vs1 (m/sec) Eq. 10	Percent Fines Eq. 24 & 25	V*s1 (m/sec) Eq. 11-13	CRR M=7.5 Percent fines Incorporated Eq. 9	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR Ksigma and Magnitude Correction Incorporated Eq. 1a	Factor of Safety Eq. 1a
259	1010	10.8	59	0.694	0.65	0.65	3.54	3.54	0.050	343	10.2	212.4	Not Liquefiable	0.884	Not Liquefiable	above WT
250	1010	19.8	68	0.621	1.19	1.19	4.08	4.08	0.044	295	10.2	212.4	Not Liquefiable	0.866	Not Liquefiable	above WT
250	990	19.8	68	0.621	1.19	1.19	4.08	4.08	0.044	289	10.4	212.3	Not Liquefiable	0.866	Not Liquefiable	above WT
238	990	31.8	80	0.549	1.91	1.91	4.80	4.58	0.041	257	10.4	212.3	Not Liquefiable	0.852	Not Liquefiable	Not Liquefiable
238	1080	31.8	80	0.549	1.91	1.91	4.80	4.58	0.041	280	19.6	207.7	Not Liquefiable	0.852	Not Liquefiable	Not Liquefiable
229	1080	40.8	89	0.527	2.45	2.45	5.34	4.84	0.042	263	19.6	207.7	Not Liquefiable	0.845	Not Liquefiable	Not Liquefiable
229	890	40.8	89	0.527	2.45	2.45	5.34	4.84	0.042	217	34.4	200.3	Not Liquefiable	0.845	Not Liquefiable	Not Liquefiable
223	890	46.8	95	0.512	2.81	2.81	5.70	5.01	0.042	210	34.4	200.3	Not Liquefiable	0.840	Not Liquefiable	Not Liquefiable
223	1020	46.8	95	0.512	2.81	2.81	5.70	5.01	0.042	240	12.0	211.5	Not Liquefiable	0.840	Not Liquefiable	Not Liquefiable
205	1020	64.8	113	0.5	3.89	3.66	6.78	5.53	0.044	225	12.0	211.5	Not Liquefiable	0.827	Not Liquefiable	Not Liquefiable
205	770	64.8	113	0.5	3.89	3.66	6.78	5.53	0.044	170	14.7	210.1	0.119	0.827	0.109	2.5
196	770	73.8	122	0.5	4.43	3.92	7.32	5.79	0.045	167	14.7	210.1	0.113	0.821	0.102	2.2
196	610	73.8	122	0.5	4.43	3.92	7.32	5.79	0.045	132	47.2	200.0	0.066	0.821	0.059	1.3
187	610	82.8	131	0.5	4.97	4.17	7.86	6.05	0.046	130	47.2	200.0	0.063	0.815	0.057	1.2
184	1200	85.8	134	0.5	5.15	4.26	8.04	6.14	0.047	255	30.6	202.2	Not Liquefiable	0.813	Not Liquefiable	Not Liquefiable
178	1200	91.8	140	0.5	5.51	4.43	8.40	6.31	0.048	252	30.6	202.2	Not Liquefiable	0.809	Not Liquefiable	Not Liquefiable

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ZCP-23

Original Surface Elevation = 271.30 feet msl
Ground Water Elevation = 214.10 feet msl
Original Depth to Water Table = 57.20 feet

Final Surface Elevation = 318 feet msl
Design Water Elevation = 245 feet msl
Design Depth to Water Table = 73 feet

amax = 0.11 g
unit wt = 120 pcf

Mw = 7.3
MSF = 1.1

Elev. (ft-msl)	ZCP-23 Vs (ft/sec)	Original Depth (feet)	Final Depth (feet)	rd Eq. 7	Original Total Stress σv (tsf) Eq. 5	Original Effective Stress σ'v (tsf) Eq. 6	Final Total Stress σv (tsf) Eq. 5	Final Effective Stress σ'v (tsf) Eq. 6	CSR Eq. 4	Vs1 (m/sec) Eq. 10	Percent Fines Eq. 24 & 25	V*s1 (m/sec) Eq. 11-13	CRR M=7.5 Percent fines Incorporated Eq. 9	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR Ksigma and Magnitude Correction Incorporated Eq. 1a	Factor of Safety Eq. 1a
261	1380	10.3	57	0.710	0.62	0.62	3.42	3.42	0.051	474	25.1	204.9	Not Liquefiable	0.888	Not Liquefiable	above WT
255	1380	16.3	63	0.661	0.98	0.98	3.78	3.78	0.047	423	25.1	204.9	Not Liquefiable	0.876	Not Liquefiable	above WT
255	1190	16.3	63	0.661	0.98	0.98	3.78	3.78	0.047	365	16.7	209.2	Not Liquefiable	0.876	Not Liquefiable	above WT
234	1190	37.3	84	0.539	2.24	2.24	5.04	4.70	0.041	297	16.7	209.2	Not Liquefiable	0.849	Not Liquefiable	Not Liquefiable
234	1230	37.3	84	0.539	2.24	2.24	5.04	4.70	0.041	307	19.6	207.7	Not Liquefiable	0.849	Not Liquefiable	Not Liquefiable
227	1230	44.3	91	0.522	2.66	2.66	5.46	4.90	0.042	294	19.6	207.7	Not Liquefiable	0.843	Not Liquefiable	Not Liquefiable
227	1010	44.3	91	0.522	2.66	2.66	5.46	4.90	0.042	241	26.8	204.1	Not Liquefiable	0.843	Not Liquefiable	Not Liquefiable
213	1010	58.3	105	0.500	3.50	3.46	6.30	5.30	0.042	226	26.8	204.1	Not Liquefiable	0.833	Not Liquefiable	Not Liquefiable
213	1130	58.3	105	0.500	3.50	3.46	6.30	5.30	0.042	252	10.3	212.3	Not Liquefiable	0.833	Not Liquefiable	Not Liquefiable
189	1130	82.3	129	0.5	4.94	4.15	7.74	5.99	0.046	241	10.3	212.3	Not Liquefiable	0.816	Not Liquefiable	Not Liquefiable
189	1270	82.3	129	0.5	4.94	4.15	7.74	5.99	0.046	271	18.9	208.0	Not Liquefiable	0.816	Not Liquefiable	Not Liquefiable
182	1270	89.3	136	0.5	5.36	4.36	8.16	6.19	0.047	268	18.9	208.0	Not Liquefiable	0.812	Not Liquefiable	Not Liquefiable
182	1590	89.3	136	0.5	5.36	4.36	8.16	6.19	0.047	335	20.2	207.4	Not Liquefiable	0.812	Not Liquefiable	Not Liquefiable
171	1590	100.3	147	0.5	6.02	4.67	8.82	6.51	0.048	330	20.2	207.4	Not Liquefiable	0.805	Not Liquefiable	Not Liquefiable

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ZCP-24

Original Surface Elevation = 271.49 feet msl
Ground Water Elevation = 215.79 feet msl
Original Depth to Water Table = 55.7 feet

Final Surface Elevation = 318 feet msl
Design Water Elevation = 245 feet msl
Design Depth to Water Table = 73 feet

amax = 0.11 g
unit wt = 120 pcf

Mw = 7.3
MSF = 1.1

Elev. (ft-msl)	ZCP-24 Vs (ft/sec)	Original Depth (feet)	Final Depth (feet)	rd Eq. 7	Original Total Stress σv (tsf) Eq. 5	Original Effective Stress σ'v (tsf) Eq. 6	Final Total Stress σv (tsf) Eq. 5	Final Effective Stress σ'v (tsf) Eq. 6	CSR Eq. 4	Vs1 (m/sec) Eq. 10	Percent Fines Eq. 24 & 25	V*s1 (m/sec) Eq. 11-13	CRR M=7.5 Percent fines Incorporated Eq. 9	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR Ksigma and Magnitude Correction Incorporated Eq. 1a	Factor of Safety Eq. 1a
261	1350	10.5	57	0.710	0.63	0.63	3.42	3.42	0.051	462	18.5	208.2	Not Liquefiable	0.888	Not Liquefiable	above WT
255	1350	16.5	63	0.661	0.99	0.99	3.78	3.78	0.047	413	18.5	208.2	Not Liquefiable	0.876	Not Liquefiable	above WT
255	1040	16.5	63	0.661	0.99	0.99	3.78	3.78	0.047	318	10.0	212.5	Not Liquefiable	0.876	Not Liquefiable	above WT
237	1040	34.5	81	0.546	2.07	2.07	4.86	4.61	0.041	264	10.0	212.5	Not Liquefiable	0.851	Not Liquefiable	Not Liquefiable
237	1080	34.5	81	0.546	2.07	2.07	4.86	4.61	0.041	274	16.6	209.2	Not Liquefiable	0.851	Not Liquefiable	Not Liquefiable
225	1080	46.5	93	0.517	2.79	2.79	5.58	4.96	0.042	255	16.6	209.2	Not Liquefiable	0.842	Not Liquefiable	Not Liquefiable
225	780	46.5	93	0.517	2.79	2.79	5.58	4.96	0.042	184	38.2	200.0	0.235	0.842	0.218	5.2
212	780	59.5	106	0.500	3.57	3.45	6.36	5.33	0.043	174	38.2	200.0	0.162	0.832	0.149	3.5
212	950	59.5	106	0.500	3.57	3.45	6.36	5.33	0.043	212	11.4	211.8	Not Liquefiable	0.832	Not Liquefiable	Not Liquefiable
201	950	70.5	117	0.5	4.23	3.77	7.02	5.65	0.044	208	11.4	211.8	0.783	0.824	0.710	16.0
201	1220	70.5	117	0.5	4.23	3.77	7.02	5.65	0.044	267	17.8	208.6	Not Liquefiable	0.824	Not Liquefiable	Not Liquefiable
186	1220	85.5	132	0.5	5.13	4.20	7.92	6.08	0.047	260	17.8	208.6	Not Liquefiable	0.814	Not Liquefiable	Not Liquefiable
186	1620	85.5	132	0.5	5.13	4.20	7.92	6.08	0.047	345	17.8	208.6	Not Liquefiable	0.814	Not Liquefiable	Not Liquefiable
176	1620	95.5	142	0.5	5.73	4.49	8.52	6.37	0.048	339	17.8	208.6	Not Liquefiable	0.808	Not Liquefiable	Not Liquefiable
176	1500	95.5	142	0.5	5.73	4.49	8.52	6.37	0.048	314	28.1	203.5	Not Liquefiable	0.808	Not Liquefiable	Not Liquefiable
170	1500	101.5	148	0.5	6.09	4.66	8.88	6.54	0.049	311	28.1	203.5	Not Liquefiable	0.804	Not Liquefiable	Not Liquefiable

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ZCP-25

Original Surface Elevation = 269.60 feet msl
Ground Water Elevation = 214.70 feet msl
Original Depth to Water Table = 54.90 feet

Final Surface Elevation = 318 feet msl
Design Water Elevation = 245 feet msl
Design Depth to Water Table = 73 feet

amax = 0.11 g
unit wt = 120 pcf

Mw = 7.3
MSF = 1.1

Elev. (ft-msl)	ZCP-25 Vs (ft/sec)	Original Depth (feet)	Final Depth (feet)	rd Eq. 7	Original Total Stress σv (tsf) Eq. 5	Original Effective Stress σ'v (tsf) Eq. 6	Final Total Stress σv (tsf) Eq. 5	Final Effective Stress σ'v (tsf) Eq. 6	CSR Eq. 4	Vs1 (m/sec) Eq. 10	Percent Fines Eq. 24 & 25	V*s1 (m/sec) Eq. 11-13	CRR M=7.5 Percent fines Incorporated Eq. 9	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR Ksigma and Magnitude Correction Incorporated Eq. 1a	Factor of Safety Eq. 1a
259	1190	10.6	59	0.694	0.64	0.64	3.54	3.54	0.050	406	14.4	210.3	Not Liquefiable	0.884	Not Liquefiable	above WT
250	1190	19.6	68	0.621	1.18	1.18	4.08	4.08	0.044	348	14.4	210.3	Not Liquefiable	0.866	Not Liquefiable	above WT
250	1140	19.6	68	0.621	1.18	1.18	4.08	4.08	0.044	334	10.8	212.1	Not Liquefiable	0.866	Not Liquefiable	above WT
235	1140	34.6	83	0.542	2.08	2.08	4.98	4.67	0.041	289	10.8	212.1	Not Liquefiable	0.849	Not Liquefiable	Not Liquefiable
235	1060	34.6	83	0.542	2.08	2.08	4.98	4.67	0.041	269	14.1	210.4	Not Liquefiable	0.849	Not Liquefiable	Not Liquefiable
217	1060	52.6	101	0.500	3.16	3.16	6.06	5.19	0.042	242	14.1	210.4	Not Liquefiable	0.836	Not Liquefiable	Not Liquefiable
217	1180	52.6	101	0.500	3.16	3.16	6.06	5.19	0.042	270	13.7	210.7	Not Liquefiable	0.836	Not Liquefiable	Not Liquefiable
196	1180	73.6	122	0.500	4.42	3.83	7.32	5.79	0.045	257	13.7	210.7	Not Liquefiable	0.821	Not Liquefiable	Not Liquefiable
196	1130	73.6	122	0.500	4.42	3.83	7.32	5.79	0.045	246	12.6	211.2	Not Liquefiable	0.821	Not Liquefiable	Not Liquefiable
184	1130	85.6	134	0.5	5.14	4.18	8.04	6.14	0.047	241	12.6	211.2	Not Liquefiable	0.813	Not Liquefiable	Not Liquefiable

Liquefaction Resistance of Soils from Shear-Wave Velocity
by Andurs and Stokoe
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ZCP-26

Original Surface Elevation = 269.62 feet msl
Ground Water Elevation = 209.12 feet msl
Original Depth to Water Table = 60.50 feet

Final Surface Elevation = 318 feet msl
Design Water Elevation = 245 feet msl
Design Depth to Water Table = 73 feet

amax = 0.11 g
unit wt = 120 pcf

Mw = 7.3
MSF = 1.1

Elev. (ft-msl)	ZCP-26 Vs (ft/sec)	Original Depth (feet)	Final Depth (feet)	rd Eq. 7	Original Total Stress σv (tsf) Eq. 5	Original Effective Stress σ'v (tsf) Eq. 6	Final Total Stress σv (tsf) Eq. 5	Final Effective Stress σ'v (tsf) Eq. 6	CSR Eq. 4	Vs1 (m/sec) Eq. 10	Percent Fines Eq. 24 & 25	V*s1 (m/sec) Eq. 11-13	CRR M=7.5 Percent fines Incorporated Eq. 9	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR Ksigma and Magnitude Correction Incorporated Eq. 1a	Factor of Safety Eq. 1a
259	1550	10.6	59	0.694	0.64	0.64	3.54	3.54	0.050	529	23.8	205.6	Not Liquefiable	0.884	Not Liquefiable	above WT
250	1550	19.6	68	0.621	1.18	1.18	4.08	4.08	0.044	454	23.8	205.6	Not Liquefiable	0.866	Not Liquefiable	above WT
250	1020	19.6	68	0.621	1.18	1.18	4.08	4.08	0.044	298	14.1	210.4	Not Liquefiable	0.866	Not Liquefiable	above WT
235	1020	34.6	83	0.542	2.08	2.08	4.98	4.67	0.041	259	14.1	210.4	Not Liquefiable	0.849	Not Liquefiable	Not Liquefiable
235	890	34.6	83	0.542	2.08	2.08	4.98	4.67	0.041	226	32.7	201.2	Not Liquefiable	0.849	Not Liquefiable	Not Liquefiable
214	890	55.6	104	0.500	3.34	3.34	6.24	5.27	0.042	201	32.7	201.2	6.219	0.834	5.702	134.8
214	1050	55.6	104	0.500	3.34	3.34	6.24	5.27	0.042	237	9.7	212.6	Not Liquefiable	0.834	Not Liquefiable	Not Liquefiable
193	1050	76.6	125	0.500	4.60	4.09	7.50	5.88	0.046	225	9.7	212.6	Not Liquefiable	0.819	Not Liquefiable	Not Liquefiable
193	2140	76.6	125	0.500	4.60	4.09	7.50	5.88	0.046	459	17.2	208.9	Not Liquefiable	0.819	Not Liquefiable	Not Liquefiable
175	2140	94.6	143	0.500	5.68	4.61	8.58	6.40	0.048	445	17.2	208.9	Not Liquefiable	0.808	Not Liquefiable	Not Liquefiable

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ZCP-27

Original Surface Elevation = 269.69 feet msl
Ground Water Elevation = 210.69 feet msl
Original Depth to Water Table = 59.0 feet

Final Surface Elevation = 318 feet msl
Design Water Elevation = 245 feet msl
Design Depth to Water Table = 73 feet

amax = 0.11 g
unit wt = 120 pcf

Mw = 7.3
MSF = 1.1

Elev. (ft-msl)	ZCP-27 Vs (ft/sec)	Original Depth (feet)	Final Depth (feet)	rd Eq. 7	Original Total Stress σv (tsf) Eq. 5	Original Effective Stress σ'v (tsf) Eq. 6	Final Total Stress σv (tsf) Eq. 5	Final Effective Stress σ'v (tsf) Eq. 6	CSR Eq. 4	Vs1 (m/sec) Eq. 10	Percent Fines Eq. 24 & 25	V*s1 (m/sec) Eq. 11-13	CRR M=7.5 Percent fines Incorporated Eq. 9	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR Ksigma and Magnitude Correction Incorporated Eq. 1a	Factor of Safety Eq. 1a
256	1020	13.7	62	0.669	0.82	0.82	3.72	3.72	0.048	327	11.8	211.6	Not Liquefiable	0.878	Not Liquefiable	above WT
225	1020	44.7	93	0.517	2.68	2.68	5.58	4.96	0.042	243	11.8	211.6	Not Liquefiable	0.842	Not Liquefiable	Not Liquefiable
225	850	44.7	93	0.517	2.68	2.68	5.58	4.96	0.042	202	37.3	200.0	Not Liquefiable	0.842	Not Liquefiable	Not Liquefiable
211	850	58.7	107	0.500	3.52	3.52	6.42	5.36	0.043	189	37.3	200.0	0.322	0.831	0.294	6.9
211	1070	58.7	107	0.500	3.52	3.52	6.42	5.36	0.043	238	11.5	211.7	Not Liquefiable	0.831	Not Liquefiable	Not Liquefiable
196	1070	73.7	122	0.500	4.42	3.96	7.32	5.79	0.045	231	11.5	211.7	Not Liquefiable	0.821	Not Liquefiable	Not Liquefiable
196	900	73.7	122	0.500	4.42	3.96	7.32	5.79	0.045	194	17.3	208.8	0.264	0.821	0.238	5.3
181	900	88.7	137	0.500	5.32	4.40	8.22	6.22	0.047	189	17.3	208.8	0.210	0.811	0.187	4.0
181	1750	88.7	137	0.500	5.32	4.40	8.22	6.22	0.047	368	26.1	204.4	Not Liquefiable	0.811	Not Liquefiable	Not Liquefiable
169	1750	100.7	149	0.5	6.04	4.74	8.94	6.57	0.049	361	26.1	204.4	Not Liquefiable	0.804	Not Liquefiable	Not Liquefiable
169	1540	100.7	149	0.5	6.04	4.74	8.94	6.57	0.049	318	35.1	200.0	Not Liquefiable	0.804	Not Liquefiable	Not Liquefiable
163	1540	106.7	155	0.5	6.40	4.91	9.30	6.74	0.049	315	35.1	200.0	Not Liquefiable	0.800	Not Liquefiable	Not Liquefiable

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ZCP-22

Original Surface Elevation = 269.78 feet msl
Ground Water Elevation = 212.38 feet msl
Original Depth to Water Table = 57.4 feet

Final Surface Elevation = 318 feet msl
Design Water Elevation = 245 feet msl
Design Depth to Water Table = 73 feet

amax = 0.11 g
unit wt = 120 pcf

Mw = 7.3
MSF = 1.1

Elev. (ft-msl)	ZCP-22 Vs (ft/sec)	Original Depth (feet)	Final Depth (feet)	rd Eq. 7	Original Total Stress σv (tsf) Eq. 5	Original Effective Stress σ'v (tsf) Eq. 6	Final Total Stress σv (tsf) Eq. 5	Final Effective Stress σ'v (tsf) Eq. 6	CSR Eq. 4	Vs1 (m/sec) Eq. 10	MRCE Stratum	Percent Fines Table 1	V*s1 (m/sec) Eq. 11-13	CRR M=7.5 Percent fines Incorporated Eq. 9	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR Ksigma and Magnitude Correction Incorporated Eq. 1a	Factor of Safety Eq. 1a
259	1010	10.8	59	0.694	0.65	0.65	3.54	3.54	0.050	343	S1	28.6	203.2	Not Liquefiable	0.884	Not Liquefiable	above WT
250	1010	19.8	68	0.621	1.19	1.19	4.08	4.08	0.044	295	S1	28.6	203.2	Not Liquefiable	0.866	Not Liquefiable	above WT
250	990	19.8	68	0.621	1.19	1.19	4.08	4.08	0.044	289	S2	16.3	209.4	Not Liquefiable	0.866	Not Liquefiable	above WT
238	990	31.8	80	0.549	1.91	1.91	4.80	4.58	0.041	257	S2	16.3	209.4	Not Liquefiable	0.852	Not Liquefiable	Not Liquefiable
238	1080	31.8	80	0.549	1.91	1.91	4.80	4.58	0.041	280	S2	16.3	209.4	Not Liquefiable	0.852	Not Liquefiable	Not Liquefiable
232	1080	37.8	86	0.534	2.27	2.27	5.16	4.75	0.041	268	S2	16.3	209.4	Not Liquefiable	0.847	Not Liquefiable	Not Liquefiable
232	1080	37.8	86	0.534	2.27	2.27	5.16	4.75	0.041	268	C2	44.5	200.0	Not Liquefiable	0.847	Not Liquefiable	Not Liquefiable
229	1080	40.8	89	0.527	2.45	2.45	5.34	4.84	0.042	263	C2	44.5	200.0	Not Liquefiable	0.845	Not Liquefiable	Not Liquefiable
229	890	40.8	89	0.527	2.45	2.45	5.34	4.84	0.042	217	C2	44.5	200.0	Not Liquefiable	0.845	Not Liquefiable	Not Liquefiable
223	890	46.8	95	0.512	2.81	2.81	5.70	5.01	0.042	210	C2	44.5	200.0	Not Liquefiable	0.840	Not Liquefiable	Not Liquefiable
223	1020	46.8	95	0.512	2.81	2.81	5.70	5.01	0.042	240	C2	44.5	200.0	Not Liquefiable	0.840	Not Liquefiable	Not Liquefiable
218	1020	51.8	100	0.5	3.11	3.11	6.00	5.16	0.042	234	C2	44.5	200.0	Not Liquefiable	0.836	Not Liquefiable	Not Liquefiable
218	1020	51.8	100	0.5	3.11	3.11	6.00	5.16	0.042	234	S3	16.7	209.1	Not Liquefiable	0.836	Not Liquefiable	Not Liquefiable
205	1020	64.8	113	0.5	3.89	3.66	6.78	5.53	0.044	225	S3	16.7	209.1	Not Liquefiable	0.827	Not Liquefiable	Not Liquefiable
205	770	64.8	113	0.5	3.89	3.66	6.78	5.53	0.044	170	S3	16.7	209.1	0.121	0.827	0.110	2.5
196	770	73.8	122	0.5	4.43	3.92	7.32	5.79	0.045	167	S3	16.7	209.1	0.114	0.821	0.103	2.3
196	610	73.8	122	0.5	4.43	3.92	7.32	5.79	0.045	132	S3	16.7	209.1	0.061	0.821	0.055	1.2
187	610	82.8	131	0.5	4.97	4.17	7.86	6.05	0.046	130	S3	16.7	209.1	0.059	0.815	0.053	1.1
184	1200	85.8	134	0.5	5.15	4.26	8.04	6.14	0.047	255	S4	33.6	200.7	Not Liquefiable	0.813	Not Liquefiable	Not Liquefiable
178	1200	91.8	140	0.5	5.51	4.43	8.40	6.31	0.048	252	S4	33.6	200.7	Not Liquefiable	0.809	Not Liquefiable	Not Liquefiable

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ZCP-23

Original Surface Elevation = 271.30 feet msl
Ground Water Elevation = 214.10 feet msl
Original Depth to Water Table = 57.20 feet

Final Surface Elevation = 318 feet msl
Design Water Elevation = 245 feet msl
Design Depth to Water Table = 73 feet

amax = 0.11 g
unit wt = 120 pcf

Mw = 7.3
MSF = 1.1

Elev. (ft-msl)	ZCP-23 Vs (ft/sec)	Original Depth (feet)	Final Depth (feet)	rd Eq. 7	Original Total Stress σv (tsf) Eq. 5	Original Effective Stress σ'v (tsf) Eq. 6	Final Total Stress σv (tsf) Eq. 5	Final Effective Stress σ'v (tsf) Eq. 6	CSR Eq. 4	Vs1 (m/sec) Eq. 10	MRCE Stratum	Percent Fines Table 1	V*s1 (m/sec) Eq. 11-13	CRR M=7.5 Percent fines Incorporated Eq. 9	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR Ksigma and Magnitude Correction Incorporated Eq. 1a	Factor of Safety Eq. 1a
261	1380	10.3	57	0.710	0.62	0.62	3.42	3.42	0.051	474	S1	28.6	203.2	Not Liquefiable	0.888	Not Liquefiable	above WT
255	1380	16.3	63	0.661	0.98	0.98	3.78	3.78	0.047	423	S1	28.6	203.2	Not Liquefiable	0.876	Not Liquefiable	above WT
255	1190	16.3	63	0.661	0.98	0.98	3.78	3.78	0.047	365	S1	28.6	203.2	Not Liquefiable	0.876	Not Liquefiable	above WT
245	1190	26.3	73	0.580	1.58	1.58	4.38	4.38	0.041	324	S1	28.6	203.2	Not Liquefiable	0.858	Not Liquefiable	Not Liquefiable
245	1190	26.3	73	0.580	1.58	1.58	4.38	4.38	0.041	324	S2	16.3	209.4	Not Liquefiable	0.858	Not Liquefiable	Not Liquefiable
234	1190	37.3	84	0.539	2.24	2.24	5.04	4.70	0.041	297	S2	16.3	209.4	Not Liquefiable	0.849	Not Liquefiable	Not Liquefiable
234	1230	37.3	84	0.539	2.24	2.24	5.04	4.70	0.041	307	S2	16.3	209.4	Not Liquefiable	0.849	Not Liquefiable	Not Liquefiable
227	1230	44.3	91	0.522	2.66	2.66	5.46	4.90	0.042	294	S2	16.3	209.4	Not Liquefiable	0.843	Not Liquefiable	Not Liquefiable
227	1010	44.3	91	0.522	2.66	2.66	5.46	4.90	0.042	241	C2	44.5	200.0	Not Liquefiable	0.843	Not Liquefiable	Not Liquefiable
214	1010	57.3	104	0.500	3.44	3.43	6.24	5.27	0.042	226	C2	44.5	200.0	Not Liquefiable	0.834	Not Liquefiable	Not Liquefiable
214	1010	57.3	104	0.500	3.44	3.43	6.24	5.27	0.042	226	S3	16.7	209.1	Not Liquefiable	0.834	Not Liquefiable	Not Liquefiable
213	1010	58.3	105	0.500	3.50	3.46	6.30	5.30	0.042	226	S3	16.7	209.1	Not Liquefiable	0.833	Not Liquefiable	Not Liquefiable
213	1130	58.3	105	0.500	3.50	3.46	6.30	5.30	0.042	252	S3	16.7	209.1	Not Liquefiable	0.833	Not Liquefiable	Not Liquefiable
189	1130	82.3	129	0.5	4.94	4.15	7.74	5.99	0.046	241	S3	16.7	209.1	Not Liquefiable	0.816	Not Liquefiable	Not Liquefiable
189	1270	82.3	129	0.500	4.94	4.15	7.74	5.99	0.046	271	S3	16.7	209.1	Not Liquefiable	0.816	Not Liquefiable	Not Liquefiable
185	1270	86.3	133	0.500	5.18	4.27	7.98	6.11	0.047	269	S3	16.7	209.1	Not Liquefiable	0.814	Not Liquefiable	Not Liquefiable
185	1270	86.3	133	0.500	5.18	4.27	7.98	6.11	0.047	269	S4	33.6	200.7	Not Liquefiable	0.814	Not Liquefiable	Not Liquefiable
182	1270	89.3	136	0.500	5.36	4.36	8.16	6.19	0.047	268	S4	33.6	200.7	Not Liquefiable	0.812	Not Liquefiable	Not Liquefiable
182	1590	89.3	136	0.5	5.36	4.36	8.16	6.19	0.047	335	S4	33.6	200.7	Not Liquefiable	0.812	Not Liquefiable	Not Liquefiable
171	1590	100.3	147	0.5	6.02	4.67	8.82	6.51	0.048	330	S4	33.6	200.7	Not Liquefiable	0.805	Not Liquefiable	Not Liquefiable

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ZCP-24

Original Surface Elevation = 271.49 feet msl
Ground Water Elevation = 215.79 feet msl
Original Depth to Water Table = 55.7 feet

Final Surface Elevation = 318 feet msl
Design Water Elevation = 245 feet msl
Design Depth to Water Table = 73 feet

amax = 0.11 g
unit wt = 120 pcf

Mw = 7.3
MSF = 1.1

Elev. (ft-msl)	ZCP-24 Vs (ft/sec)	Original Depth (feet)	Final Depth (feet)	rd Eq. 7	Original Total Stress σv (tsf) Eq. 5	Original Effective Stress σ'v (tsf) Eq. 6	Final Total Stress σv (tsf) Eq. 5	Final Effective Stress σ'v (tsf) Eq. 6	CSR Eq. 4	Vs1 (m/sec) Eq. 10	MRCE Stratum	Percent Fines Table 1	V*s1 (m/sec) Eq. 11-13	CRR M=7.5 Percent fines Incorporated Eq. 9	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR Ksigma and Magnitude Correction Incorporated Eq. 1a	Factor of Safety Eq. 1a
261	1350	10.5	57	0.710	0.63	0.63	3.42	3.42	0.051	462	S1	28.6	203.2	Not Liquefiable	0.888	Not Liquefiable	above WT
255	1350	16.5	63	0.661	0.99	0.99	3.78	3.78	0.047	413	S1	28.6	203.2	Not Liquefiable	0.876	Not Liquefiable	above WT
255	1040	16.5	63	0.661	0.99	0.99	3.78	3.78	0.047	318	S1	28.6	203.2	Not Liquefiable	0.876	Not Liquefiable	above WT
245	1040	26.5	73	0.580	1.59	1.59	4.38	4.38	0.041	282	S1	28.6	203.2	Not Liquefiable	0.858	Not Liquefiable	Not Liquefiable
245	1040	26.5	73	0.580	1.59	1.59	4.38	4.38	0.041	282	S2	16.3	209.4	Not Liquefiable	0.858	Not Liquefiable	Not Liquefiable
237	1040	34.5	81	0.546	2.07	2.07	4.86	4.61	0.041	264	S2	16.3	209.4	Not Liquefiable	0.851	Not Liquefiable	Not Liquefiable
237	1080	34.5	81	0.546	2.07	2.07	4.86	4.61	0.041	274	S2	16.3	209.4	Not Liquefiable	0.851	Not Liquefiable	Not Liquefiable
229	1080	42.5	89	0.527	2.55	2.55	5.34	4.84	0.042	261	S2	16.3	209.4	Not Liquefiable	0.845	Not Liquefiable	Not Liquefiable
229	1080	42.5	89	0.527	2.55	2.55	5.34	4.84	0.042	261	C2	44.5	200.0	Not Liquefiable	0.845	Not Liquefiable	Not Liquefiable
225	1080	46.5	93	0.517	2.79	2.79	5.58	4.96	0.042	255	C2	44.5	200.0	Not Liquefiable	0.842	Not Liquefiable	Not Liquefiable
225	780	46.5	93	0.517	2.79	2.79	5.58	4.96	0.042	184	C2	44.5	200.0	0.235	0.842	0.218	5.2
212	780	59.5	106	0.500	3.57	3.45	6.36	5.33	0.043	174	C2	44.5	200.0	0.162	0.832	0.149	3.5
212	950	59.5	106	0.500	3.57	3.45	6.36	5.33	0.043	212	S3	16.7	209.1	Not Liquefiable	0.832	Not Liquefiable	Not Liquefiable
201	950	70.5	117	0.500	4.23	3.77	7.02	5.65	0.044	208	S3	16.7	209.1	2.201	0.824	1.996	44.9
201	1220	70.5	117	0.500	4.23	3.77	7.02	5.65	0.044	267	S3	16.7	209.1	Not Liquefiable	0.824	Not Liquefiable	Not Liquefiable
192	1220	79.5	126	0.500	4.77	4.03	7.56	5.91	0.046	262	S3	16.7	209.1	Not Liquefiable	0.818	Not Liquefiable	Not Liquefiable
192	1220	79.5	126	0.500	4.77	4.03	7.56	5.91	0.046	262	S4	33.6	200.7	Not Liquefiable	0.818	Not Liquefiable	Not Liquefiable
186	1220	85.5	132	0.500	5.13	4.20	7.92	6.08	0.047	260	S4	33.6	200.7	Not Liquefiable	0.814	Not Liquefiable	Not Liquefiable
186	1620	85.5	132	0.500	5.13	4.20	7.92	6.08	0.047	345	S4	33.6	200.7	Not Liquefiable	0.814	Not Liquefiable	Not Liquefiable
176	1620	95.5	142	0.5	5.73	4.49	8.52	6.37	0.048	339	S4	33.6	200.7	Not Liquefiable	0.808	Not Liquefiable	Not Liquefiable
176	1500	95.5	142	0.5	5.73	4.49	8.52	6.37	0.048	314	S4	33.6	200.7	Not Liquefiable	0.808	Not Liquefiable	Not Liquefiable
170	1500	101.5	148	0.5	6.09	4.66	8.88	6.54	0.049	311	S4	33.6	200.7	Not Liquefiable	0.804	Not Liquefiable	Not Liquefiable

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ZCP-25

Original Surface Elevation = 269.60 feet msl
Ground Water Elevation = 214.70 feet msl
Original Depth to Water Table = 54.90 feet

Final Surface Elevation = 318 feet msl
Design Water Elevation = 245 feet msl
Design Depth to Water Table = 73 feet

amax = 0.11 g
unit wt = 120 pcf

Mw = 7.3
MSF = 1.1

Elev. (ft-msl)	ZCP-25 Vs (ft/sec)	Original Depth (feet)	Final Depth (feet)	rd Eq. 7	Original Total Stress σv (tsf) Eq. 5	Original Effective Stress σ'v (tsf) Eq. 6	Final Total Stress σv (tsf) Eq. 5	Final Effective Stress σ'v (tsf) Eq. 6	CSR Eq. 4	Vs1 (m/sec) Eq. 10	MRCE Stratum	Percent Fines Table 1	V*s1 (m/sec) Eq. 11-13	CRR M=7.5 Percent fines Incorporated Eq. 9	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR Ksigma and Magnitude Correction Incorporated Eq. 1a	Factor of Safety Eq. 1a
259	1190	10.6	59	0.694	0.64	0.64	3.54	3.54	0.050	406	S1	28.6	203.2	Not Liquefiable	0.884	Not Liquefiable	above WT
250	1190	19.6	68	0.621	1.18	1.18	4.08	4.08	0.044	348	S1	28.6	203.2	Not Liquefiable	0.866	Not Liquefiable	above WT
250	1140	19.6	68	0.621	1.18	1.18	4.08	4.08	0.044	334	S1	28.6	203.2	Not Liquefiable	0.866	Not Liquefiable	above WT
239	1140	30.6	79	0.551	1.84	1.84	4.74	4.55	0.041	298	S1	28.6	203.2	Not Liquefiable	0.853	Not Liquefiable	Not Liquefiable
239	1140	30.6	79	0.551	1.84	1.84	4.74	4.55	0.041	298	S2	16.3	209.4	Not Liquefiable	0.853	Not Liquefiable	Not Liquefiable
235	1140	34.6	83	0.542	2.08	2.08	4.98	4.67	0.041	289	S2	16.3	209.4	Not Liquefiable	0.849	Not Liquefiable	Not Liquefiable
235	1060	34.6	83	0.542	2.08	2.08	4.98	4.67	0.041	269	S2	16.3	209.4	Not Liquefiable	0.849	Not Liquefiable	Not Liquefiable
224	1060	45.6	94	0.515	2.74	2.74	5.64	4.98	0.042	251	S2	16.3	209.4	Not Liquefiable	0.841	Not Liquefiable	Not Liquefiable
224	1060	45.6	94	0.515	2.74	2.74	5.64	4.98	0.042	251	C2	44.5	200.0	Not Liquefiable	0.841	Not Liquefiable	Not Liquefiable
217	1060	52.6	101	0.500	3.16	3.16	6.06	5.19	0.042	242	C2	44.5	200.0	Not Liquefiable	0.836	Not Liquefiable	Not Liquefiable
217	1180	52.6	101	0.500	3.16	3.16	6.06	5.19	0.042	270	C2	44.5	200.0	Not Liquefiable	0.836	Not Liquefiable	Not Liquefiable
214	1180	55.6	104	0.500	3.34	3.31	6.24	5.27	0.042	267	C2	44.5	200.0	Not Liquefiable	0.834	Not Liquefiable	Not Liquefiable
214	1180	55.6	104	0.500	3.34	3.31	6.24	5.27	0.042	267	S3	16.7	209.1	Not Liquefiable	0.834	Not Liquefiable	Not Liquefiable
196	1180	73.6	122	0.500	4.42	3.83	7.32	5.79	0.045	257	S3	16.7	209.1	Not Liquefiable	0.821	Not Liquefiable	Not Liquefiable
196	1130	73.6	122	0.500	4.42	3.83	7.32	5.79	0.045	246	S4	33.6	200.7	Not Liquefiable	0.821	Not Liquefiable	Not Liquefiable
184	1130	85.6	134	0.5	5.14	4.18	8.04	6.14	0.047	241	S4	33.6	200.7	Not Liquefiable	0.813	Not Liquefiable	Not Liquefiable

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ZCP-26

Original Surface Elevation = 269.62 feet msl
Ground Water Elevation = 209.12 feet msl
Original Depth to Water Table = 60.50 feet

Final Surface Elevation = 318 feet msl
Design Water Elevation = 245 feet msl
Design Depth to Water Table = 73 feet

amax = 0.11 g
unit wt = 120 pcf

Mw = 7.3
MSF = 1.1

Elev. (ft-msl)	ZCP-26 Vs (ft/sec)	Original Depth (feet)	Final Depth (feet)	rd Eq. 7	Original Total Stress σv (tsf) Eq. 5	Original Effective Stress σ'v (tsf) Eq. 6	Final Total Stress σv (tsf) Eq. 5	Final Effective Stress σ'v (tsf) Eq. 6	CSR Eq. 4	Vs1 (m/sec) Eq. 10	MRCE Stratum	Percent Fines Table 1	V*s1 (m/sec) Eq. 11-13	CRR M=7.5 Percent fines Incorporated Eq. 9	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR Ksigma and Magnitude Correction Incorporated Eq. 1a	Factor of Safety Eq. 1a
259	1550	10.6	59	0.694	0.64	0.64	3.54	3.54	0.050	529	S1	28.6	203.2	Not Liquefiable	0.884	Not Liquefiable	above WT
250	1550	19.6	68	0.621	1.18	1.18	4.08	4.08	0.044	454	S1	28.6	203.2	Not Liquefiable	0.866	Not Liquefiable	above WT
250	1020	19.6	68	0.621	1.18	1.18	4.08	4.08	0.044	298	S2	16.3	209.4	Not Liquefiable	0.866	Not Liquefiable	above WT
235	1020	34.6	83	0.542	2.08	2.08	4.98	4.67	0.041	259	S2	16.3	209.4	Not Liquefiable	0.849	Not Liquefiable	Not Liquefiable
235	890	34.6	83	0.542	2.08	2.08	4.98	4.67	0.041	226	C2	44.5	200.0	Not Liquefiable	0.849	Not Liquefiable	Not Liquefiable
214	890	55.6	104	0.500	3.34	3.34	6.24	5.27	0.042	201	C2	44.5	200.0	Not Liquefiable	0.834	Not Liquefiable	Not Liquefiable
214	1050	55.6	104	0.500	3.34	3.34	6.24	5.27	0.042	237	S3	16.7	209.1	Not Liquefiable	0.834	Not Liquefiable	Not Liquefiable
193	1050	76.6	125	0.500	4.60	4.09	7.50	5.88	0.046	225	S3	16.7	209.1	Not Liquefiable	0.819	Not Liquefiable	Not Liquefiable
193	2140	76.6	125	0.500	4.60	4.09	7.50	5.88	0.046	459	S4	33.6	200.7	Not Liquefiable	0.819	Not Liquefiable	Not Liquefiable
175	2140	94.6	143	0.500	5.68	4.61	8.58	6.40	0.048	445	S4	33.6	200.7	Not Liquefiable	0.808	Not Liquefiable	Not Liquefiable

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ZCP-27

Original Surface Elevation = 269.69 feet msl
Ground Water Elevation = 210.69 feet msl
Original Depth to Water Table = 59.0 feet

Final Surface Elevation = 318 feet msl
Design Water Elevation = 245 feet msl
Design Depth to Water Table = 73 feet

amax = 0.11 g
unit wt = 120 pcf

Mw = 7.3
MSF = 1.1

Elev. (ft-msl)	ZCP-27 Vs (ft/sec)	Original Depth (feet)	Final Depth (feet)	rd Eq. 7	Original Total Stress σv (tsf) Eq. 5	Original Effective Stress σ'v (tsf) Eq. 6	Final Total Stress σv (tsf) Eq. 5	Final Effective Stress σ'v (tsf) Eq. 6	CSR Eq. 4	Vs1 (m/sec) Eq. 10	MRCE Stratum	Percent Fines Table 1	V*s1 (m/sec) Eq. 11-13	CRR M=7.5 Percent fines Incorporated Eq. 9	SRS-ITP Overburden Correction Ksigma Eq. 8	CRR Ksigma and Magnitude Correction Incorporated Eq. 1a	Factor of Safety Eq. 1a
256	1020	13.7	62	0.669	0.82	0.82	3.72	3.72	0.048	327	S1	28.6	203.2	Not Liquefiable	0.878	Not Liquefiable	above WT
250	1020	19.7	68	0.621	1.18	1.18	4.08	4.08	0.044	298	S1	28.6	203.2	Not Liquefiable	0.866	Not Liquefiable	above WT
250	1020	19.7	68	0.621	1.18	1.18	4.08	4.08	0.044	298	S2	16.3	209.4	Not Liquefiable	0.866	Not Liquefiable	above WT
225	1020	44.7	93	0.517	2.68	2.68	5.58	4.96	0.042	243	S2	16.3	209.4	Not Liquefiable	0.842	Not Liquefiable	Not Liquefiable
225	850	44.7	93	0.517	2.68	2.68	5.58	4.96	0.042	202	S2	16.3	209.4	0.481	0.842	0.446	10.7
223	850	46.7	95	0.512	2.80	2.80	5.70	5.01	0.042	200	S2	16.3	209.4	0.382	0.840	0.353	8.5
223	850	46.7	95	0.512	2.80	2.80	5.70	5.01	0.042	200	C2	44.5	200.0	Not Liquefiable	0.840	Not Liquefiable	Not Liquefiable
211	850	58.7	107	0.500	3.52	3.52	6.42	5.36	0.043	189	C2	44.5	200.0	0.322	0.831	0.294	6.9
211	1070	58.7	107	0.500	3.52	3.52	6.42	5.36	0.043	238	C2	44.5	200.0	Not Liquefiable	0.831	Not Liquefiable	Not Liquefiable
208	1070	61.7	110	0.500	3.70	3.62	6.60	5.45	0.043	236	C2	44.5	200.0	Not Liquefiable	0.829	Not Liquefiable	Not Liquefiable
208	1070	61.7	110	0.500	3.70	3.62	6.60	5.45	0.043	236	S3	16.7	209.1	Not Liquefiable	0.829	Not Liquefiable	Not Liquefiable
196	1070	73.7	122	0.500	4.42	3.96	7.32	5.79	0.045	231	S3	16.7	209.1	Not Liquefiable	0.821	Not Liquefiable	Not Liquefiable
196	900	73.7	122	0.500	4.42	3.96	7.32	5.79	0.045	194	S3	16.7	209.1	0.260	0.821	0.235	5.2
181	900	88.7	137	0.500	5.32	4.40	8.22	6.22	0.047	189	S3	16.7	209.1	0.208	0.811	0.185	3.9
181	1750	88.7	137	0.500	5.32	4.40	8.22	6.22	0.047	368	S4	33.6	200.7	Not Liquefiable	0.811	Not Liquefiable	Not Liquefiable
169	1750	100.7	149	0.5	6.04	4.74	8.94	6.57	0.049	361	S4	33.6	200.7	Not Liquefiable	0.804	Not Liquefiable	Not Liquefiable
169	1540	100.7	149	0.5	6.04	4.74	8.94	6.57	0.049	318	S4	33.6	200.7	Not Liquefiable	0.804	Not Liquefiable	Not Liquefiable
163	1540	106.7	155	0.5	6.40	4.91	9.30	6.74	0.049	315	S4	33.6	200.7	Not Liquefiable	0.800	Not Liquefiable	Not Liquefiable

Conclusion

Liquefaction analyses using "Modified Chinese Criteria," SPT N_{160} values, CPTu tip stress data (q_{t1}) and shear wave data (V_{s1}) suggest that the soils beneath Vault No. 4 are not susceptible to significant liquefaction for earthquakes having PGA less than or equal to 0.17g and magnitude less than or equal to 6.5. Nor are the soils beneath Vault No. 4 susceptible to significant liquefaction for a Charleston earthquake. Figures 28 and 29 summarize factor of safety versus elevation for the SPT N_{160} method for the DBE and Charleston earthquake. Figures 20 through 23 summarize factor of safety versus elevation for the Andrus and Stokoe shear wave method for the DBE and Charleston earthquake using CPTu and laboratory determined percent fines. Figures 30 and 31 summarize factor of safety versus elevation for the CPTu q_{t1} method for the DBE and Charleston earthquake using CPTu determined percent fines (laboratory percent fines appears not to control).

Settlement due to partial liquefaction for both the DBE and Charleston earthquake ranges from near zero to less than ½ inch with an average of less than ¼ inch. Worst case settlement (i.e., PGA=0.17g and weighted average of all magnitudes and distances at ZCP-27) is about 1¼ inch.

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Table 1 – Soil Properties Determined from Laboratory Index Tests for Borings in the Vicinity of Vault No. 4
(MRCE, 1986a and BSRI, 1992)

Source SGS File No.	Boring ID	Sample ID	Mid. Elev. (ft-msl)	Mid. Depth (ft)	MRCE Stratum	Natural Water Content (%)	PL	LL	PI	Fines (%)	UCSC	
Z-SDF-2	Z-202U	1 UD	263.8	14.5	S1	19	23	49	26	31	SC&CL	
Z-SDF-2	Z-202U	2 UD	258.8	19.5	S1	16	23	44	21	32	SC	
Z-SDF-2	Z-202U	3 UD	253.8	24.5	S1	16	27	42	15	18	SC	
Z-SDF-2	Z-210U	1 UD	270.6	17.5	S1	17	21	45	24	28	SC	
Z-SDF-2	Z-210U	2 UD	265.6	22.5	S1	17	23	35	12	23	SC	
Z-SDF-2	Z-210U	3 U	258.6	29.5	S1	15	23	49	26	26	SC	
Z-SDF-2	Z-216U	1 U	275.0	19.5	S1	13	27	51	24	21	SC	
Z-SDF-2	Z-216U	2 U	270.5	24.0	S1	21	24	31	7	32	SC	
Z-SDF-2	Z-216U	3 UD	265.2	29.3	S1	17	24	38	14	45	SC	
Z-SDF-9	ZB-2	UD-3	261	21	S1	13.4	25	32	7	14.9	SM	
Z-SDF-9	ZB-5	UD-1	273.5	11	S1	-	24	33	9	43.7	SM	
Z-SDF-9	ZB-5	SS-3	269	15.5	S1	-	23	38	15	39.9	SC	
Z-SDF-9	ZB-8	ST-1	271	11	S1	15.8	22	36	14	32.3	SC	S1
Z-SDF-9	ZB-8	SS-3	261	21	S1	-	23	25	2	13.9	SM	Average 28.6
Z-SDF-9	ZB-2	SS-8	231	51	S2	-	-	-	-	9.2	-	
Z-SDF-9	ZB-4	SS-13	221	61	S2	-	28	48	20	32.5	SM	
Z-SDF-9	ZB-5	SS-8	243.5	41	S2	-	NP	NL	NP	14.2	SM	
Z-SDF-9	ZB-7	SS-9	244	41	S2	-	NP	NL	NP	16.4	SM	
Z-SDF-9	ZB-7	SS-14	219	66	S2	-	-	-	-	7.5	-	S2
Z-SDF-9	ZB-8	SS-6	247	35	S2	-	NP	NL	NP	17.7	SM	Average 16.3
Z-SDF-2	Z-201U	18S top	220.8	58.5	C2	31	25	42	17	27	SC	
Z-SDF-2	Z-201U	18S bot	219.8	59.5	C2	-	-	-	-	18	SC	
Z-SDF-2	Z-218U	18U	215.6	63.3	C2	69	101	136	35	98	MH	
Z-SDF-2	Z-219U	19U	218.5	72.0	C2	30	19	62	43	-	SC&CH	
Z-SDF-2	Z-219U	19U	217.5	73.0	C2	-	-	-	-	33	SC	
Z-SDF-2	Z-219U	22U	211.5	79.0	C2	33	21	68	47	13	SC	
Z-SDF-2	Z-224U	6U top	225.2	56.0	C2	-	-	-	-	19	SC	
Z-SDF-2	Z-224U	6U bot	224.2	57.0	C2	40	46	84	38	38	SC	
Z-SDF-2	Z-224U	8U	221.3	59.9	C2	58	30	114	84	66	CH	
Z-SDF-2	Z-224U	10U	218.2	63.0	C2	80	51	134	83	81	CH	
Z-SDF-2	Z-224U	13U	213.7	67.5	C2	35	26	62	36	54	CH	
Z-SDF-2	Z-224U	13U	212.7	68.5	C2	-	-	-	-	35	SC	
Z-SDF-2	Z-224U	15U	210.5	70.7	C2	31	21	104	83	14	SC	
Z-SDF-2	Z-225U	6U	216.0	61.0	C2	61	31	131	100	77	CH	
Z-SDF-2	Z-225U	7U	214.5	62.5	C2	54	22	94	72	59	CH	
Z-SDF-2	Z-225U	7U	213.5	63.5	C2	-	-	-	-	44	SC	
Z-SDF-9	ZB-2	SS-10	221	61	C2	-	31	45	14	42.3	SM	C2
Z-SDF-9	ZB-4	SS-14	216	66	C2	-	30	54	24	38.3	SM	Average 44.5
Z-SDF-2	Z-225U	4U	219.5	57.5	S3a	31	20	56	36	26	SC	
Z-SDF-2	Z-218U	18U	214.6	64.3	S3a	-	-	-	-	32	SC	
Z-SDF-2	Z-219U	23S	209.5	81.0	S3a	28	22	66	44	12	SC	
Z-SDF-2	Z-211U	25S	192.0	97.5	S3a	47	24	60	36	-	SC	
Z-SDF-2	Z-220U	17U	219.3	67.0	S3b	-	-	-	-	9	SP-SC	
Z-SDF-2	Z-220U	18U	218.3	68.0	S3b	-	-	-	-	10	SP-SC	
Z-SDF-2	Z-220U	18U	217.3	69.0	S3b	104	29	127	98	-	CH	
Z-SDF-9	ZB-3	UD-1	259	26	S3a	-	26	29	3	15.4	SM	
Z-SDF-9	ZB-2	SS-9	226	56	S3b	-	NP	NL	NP	20.1	SM	
Z-SDF-9	ZB-6	UD-2	214	68	S3b	-	NP	NL	NP	28.1	SM	
Z-SDF-9	ZB-2	SS-12	211	71	S3b	-	NP	NL	NP	17.3	SM	
Z-SDF-9	ZB-7	SS-15	214	71	S3b	-	NP	NL	NP	19	SM	
Z-SDF-9	ZB-2	UD-4	206.5	75.5	S3b	-	NP	NL	NP	4.4	SP	
Z-SDF-9	ZB-1	SS-19	192	91	S3b	-	-	-	-	8.7	-	
Z-SDF-9	ZB-3	SS-21	184	101	S3b	-	-	-	-	5.9	-	S3
Z-SDF-9	ZB-1	SS-22	177	106	S3b	-	NP	NL	NP	26.1	SM	Average 16.7
Z-SDF-9	ZB-1	SS-24	167	116	S4	-	20	24	4	45.8	SC-SM	
Z-SDF-9	ZB-3	UD-2	152	133	S4	-	24	28	4	26.7	SM	S4
Z-SDF-9	ZB-4	UD-1	184	98	S4	-	23	49	26	28.2	SC	Average 33.6

Table 2 – USGS Rock Seismic Hazard for Savannah River Site
Peak Ground Acceleration Return Period 2500 years PGA = 0.15g
(Frankel, 1999)

Distance	Mw = 4.5 to 5.0	Mw = 5.0 to 5.5	Mw = 5.5 to 6.0	Mw = 6.0 to 6.5	Mw = 6.5 to 7.0	Mw = 7.0 to 8.0
7.5 km	7.13	3.56	1.73	0.78	0.42	0.00
20 km	4.93	3.64	2.35	1.28	0.78	0.00
37.5 km	3.11	3.90	4.04	3.24	2.72	0.00
75 km	0.33	0.93	2.05	3.24	0.00	16.45
150 km	0.03	0.14	0.59	1.68	0.00	29.25
250 km	0.00	0.00	0.00	0.04	0.00	1.63
550 km	0.00	0.00	0.00	0.00	0.00	0.08
Mw Bin Sum =	15.52	12.16	10.76	10.25	3.92	47.40

Average Magnitude = 6.5

Notes:
Average Mw = [(4.75x15.52)+(5.25x12.16)+(5.75x10.76)+(6.25x10.25)+(6.75x3.92)+(7.5x47.40)] / 100
1/3 wt Frankel et al. attenuation model, 1/3 wt Toro et al. attenuation model and 1/3 wt AB95 attenuation model

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Z-Area Vault No. 4

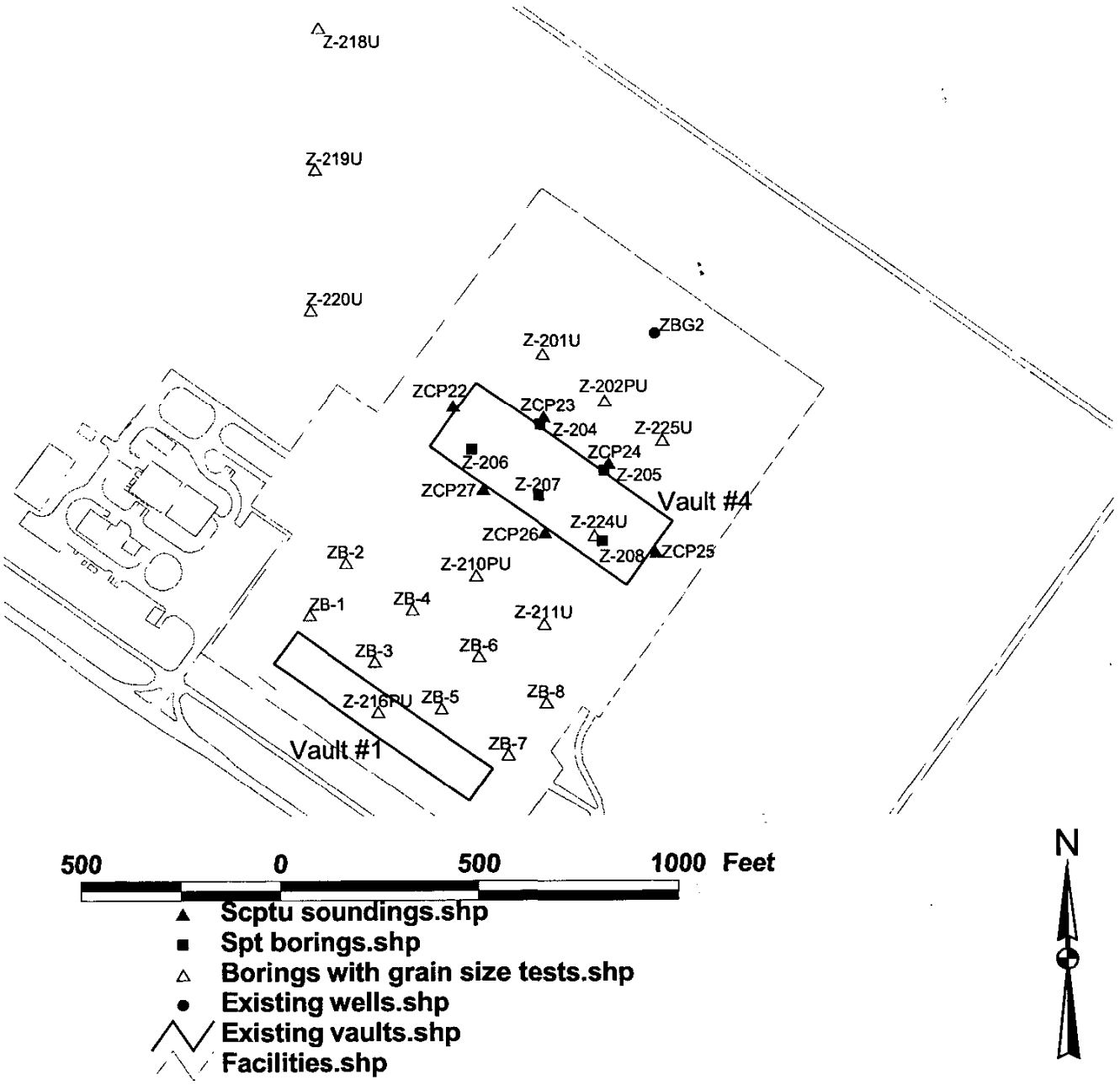

Figure 1 - Location of Vault No. 4, SCPTu Soundings, SPT Borings and Well ZBG-2

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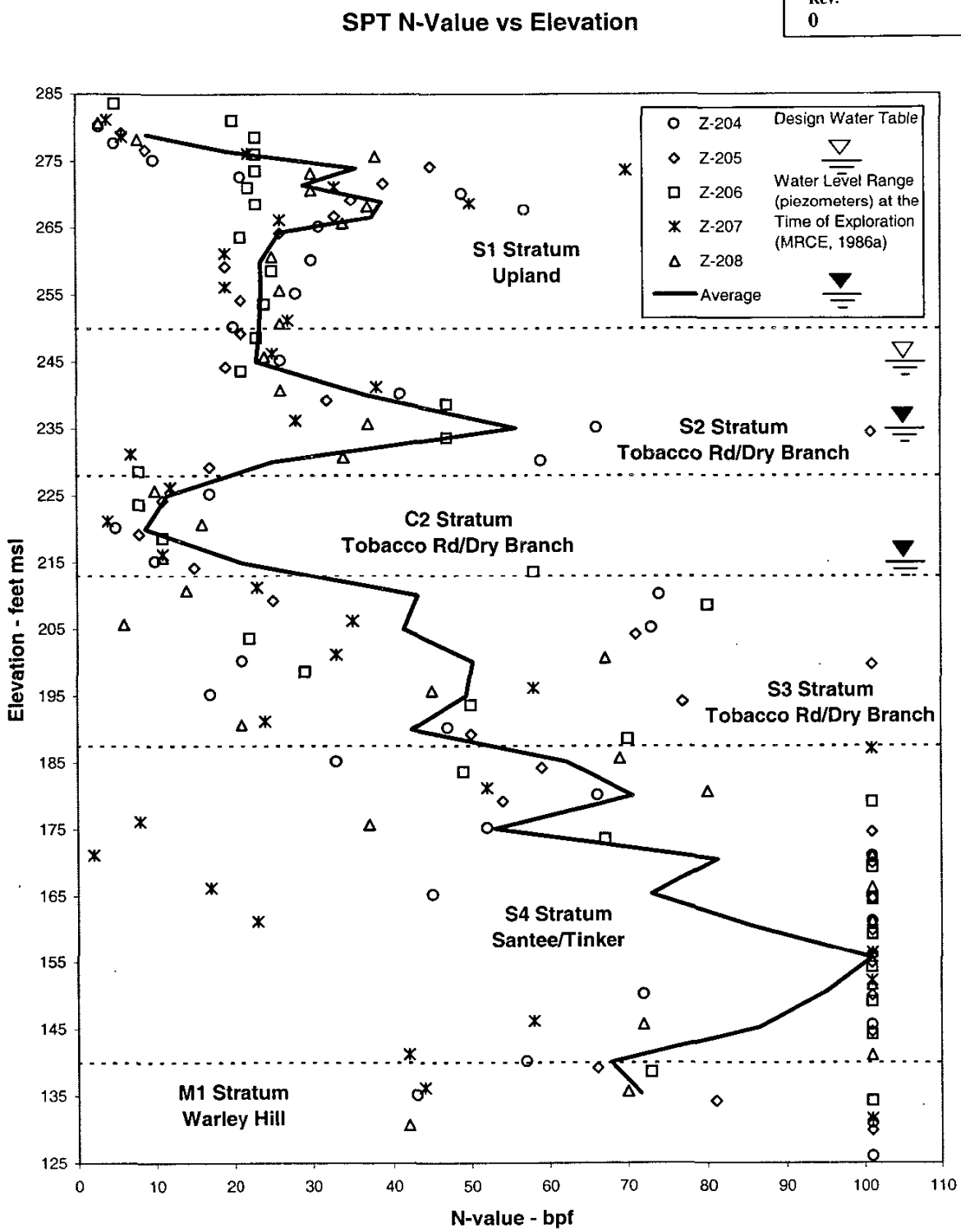


Note: Stratum elevations are averages beneath Vault No. 4

Valut4-Nvalues.xls

Figure 2 - SPT N Values vs. Elevation for Borings Beneath Vault No. 4
(MRCE, 1986a)

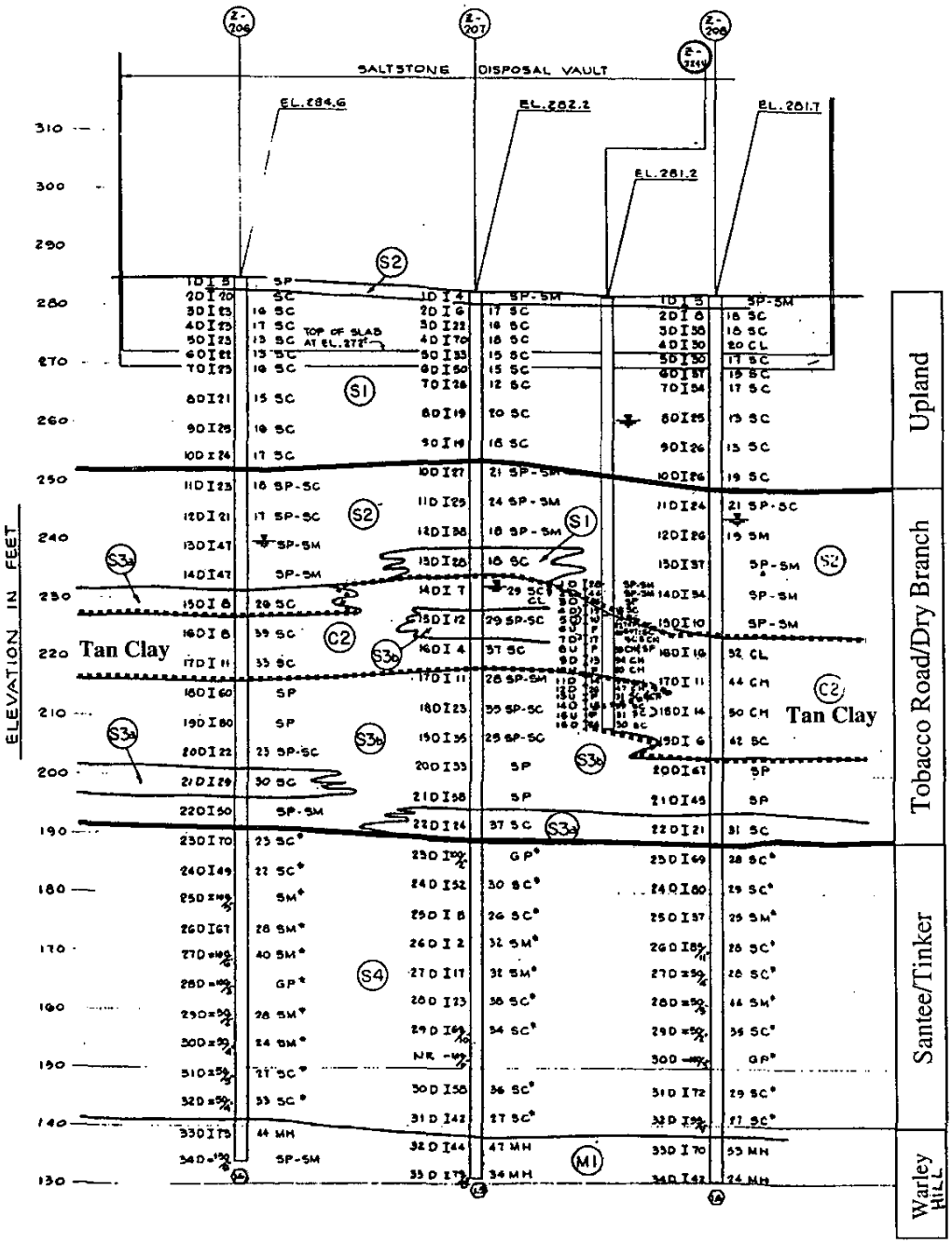


Figure 3a - Section 1-1 Beneath Vault No. 4 (see Figure 4 for legend)
(MRCE, 1986a)

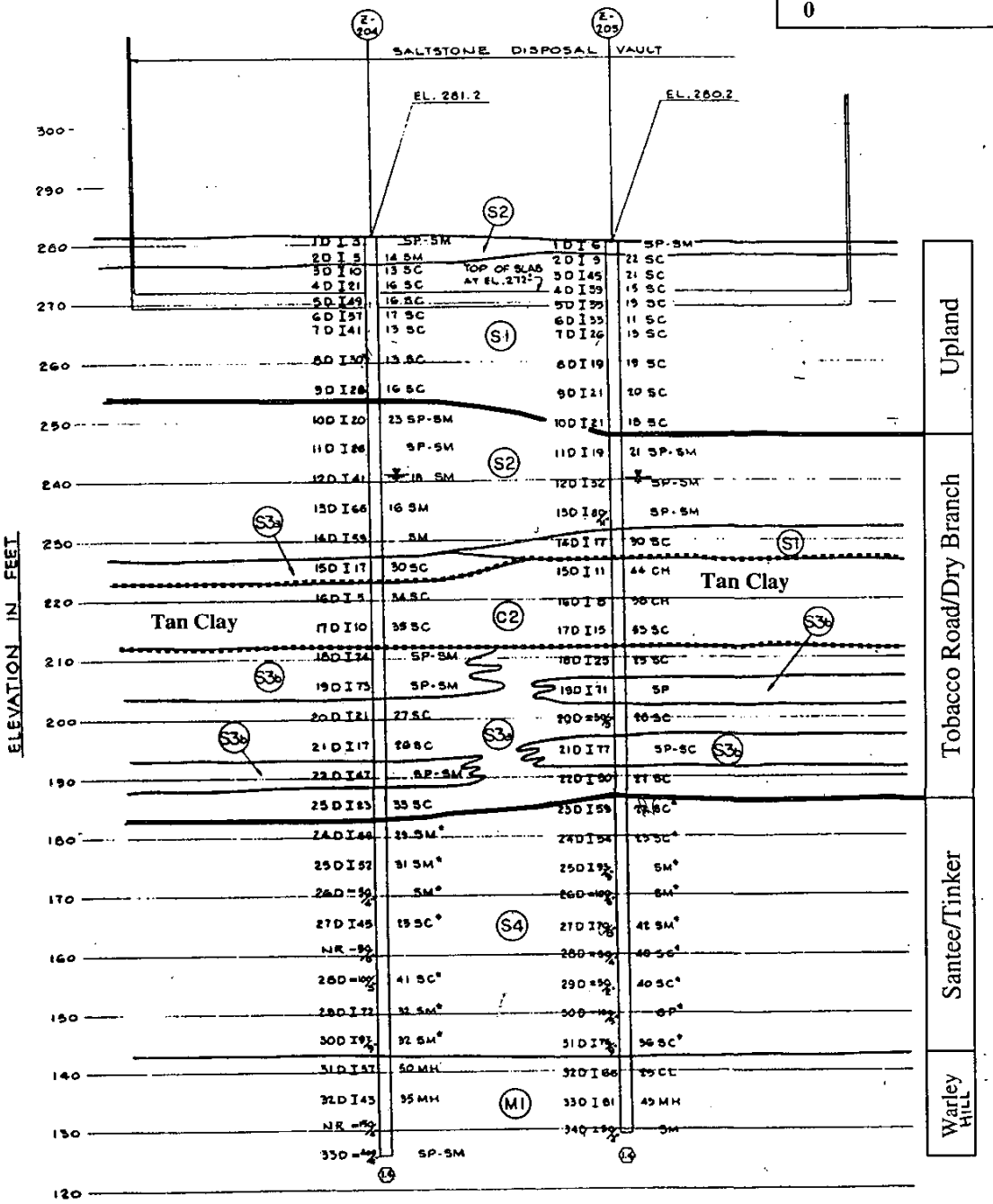
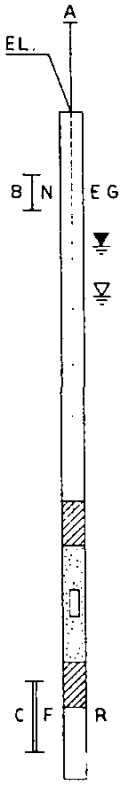


Figure 3b - Section 2-2 Beneath Vault No. 4 (see Figure 4 for legend)
(MRCE, 1986a)



BORING LEGEND

A — NUMBER, TYPE AND LOCATION OF BORING.

EL — GROUND SURFACE ELEVATION AT BORING.

B — NUMBER AND TYPE OF SAMPLE.

- D - DRY SAMPLE TAKEN WITH 2 INCH O.D. SPLIT SPOON.
- U - UNDISTURBED SAMPLE TAKEN WITH 3 INCH O.D. FIXED PISTON TYPE SAMPLER.
- UD - UNDISTURBED SAMPLE EXTRUDED IN FIELD AND PLACED IN JAR DUE TO POOR RECOVERY.
- S - UNDISTURBED SAMPLE TAKEN WITH 3 INCH O.D. SHELBY TYPE SAMPLER.
- W - WASH SAMPLE.
- NR - NO RECOVERY.

I — LOCATION AND LENGTH OF SAMPLE ATTEMPT.

N — STANDARD PENETRATION RESISTANCE. NUMBER OF BLOWS FROM 140 LB. HAMMER FREE FALLING 30 INCHES. REQUIRED TO DRIVE 2 INCH O.D. SPLIT SPOON SAMPLER ONE FOOT AFTER INITIAL PENETRATION OF 6 INCHES, UNLESS A SPECIFIC PENETRATION IS INDICATED.

- P - PRESSED OR PUSH SAMPLE.
- WH - SAMPLE TAKEN UNDER WEIGHT OF HAMMER AND RODS.
- WR - SAMPLE TAKEN UNDER WEIGHT OF RODS.

E — AVERAGE NATURAL WATER CONTENT OF SAMPLE IN PERCENT OF DRY WEIGHT.

G — UNIFIED SOIL CLASSIFICATION SYMBOL OF SAMPLE.

▼ — GROUND WATER LEVEL OBSERVED IN BORING.

▽ — GROUND WATER LEVEL OBSERVED IN PIEZOMETER.

C — ROCK CORE.

I — LENGTH OF CORE.

F — LENGTH OF CORE RECOVERED EXPRESSED AS A PERCENT OF THE LENGTH OF CORE RUN.

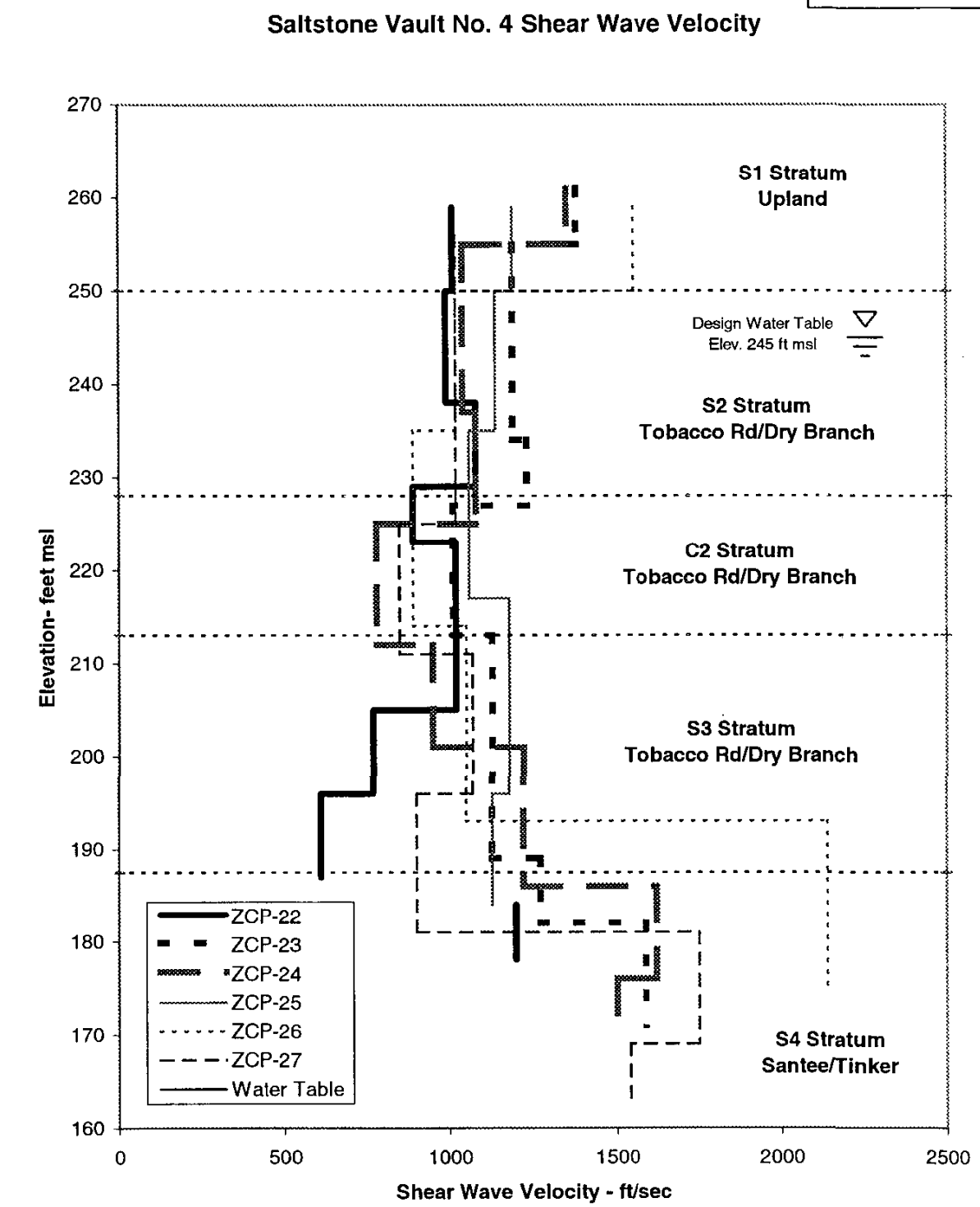
R — ROCK QUALITY DESIGNATION-THE SUM OF THE LENGTHS OF PIECES OF RECOVERED CORE WHICH ARE EQUAL TO OR GREATER THAN FOUR INCHES IN LENGTH EXPRESSED AS A PERCENTAGE OF THE TOTAL LENGTH OF THE CORE RUN. LENGTHS ARE MEASURED BETWEEN IN-SITU SEPARATIONS, AND BREAKS RESULTING FROM CORING ARE IGNORED.

▨ — IMPERVIOUS SEAL.

▒ — SAND FILTER SURROUNDING PIEZOMETER INTAKE POINT.

⊓ — INTAKE POINT.

Figure 4 - Boring Legend for Subsurface Sections (Figures 3a and 3b)
(MRCE, 1986a)



Note: Stratum elevations are averages beneath Vault No. 4

Z-Area-Vs-data.XLS

Figure 5 – SCPTu Shear Wave Velocity vs. Elevation for Vault No. 4
(ARA, 2002)

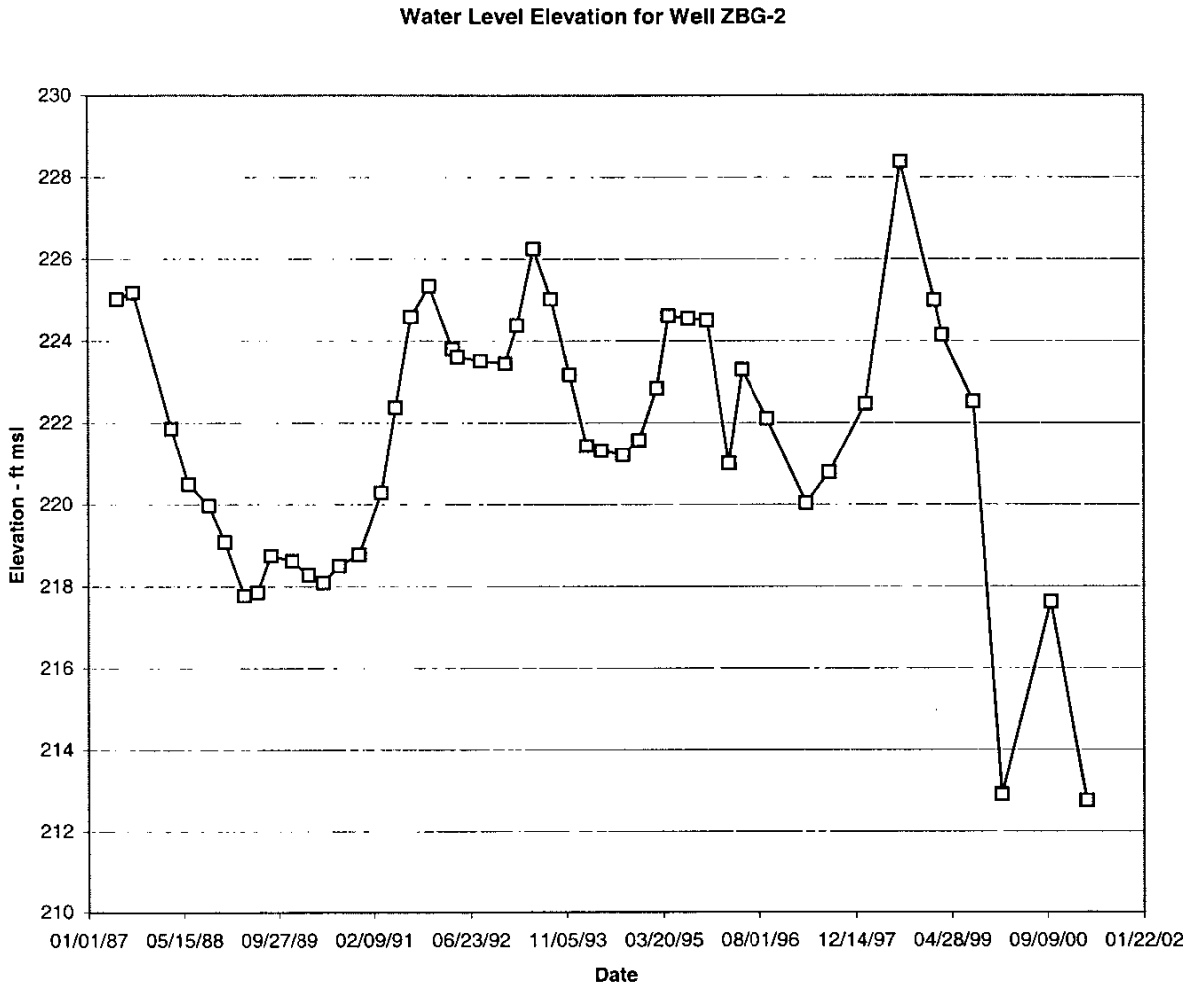
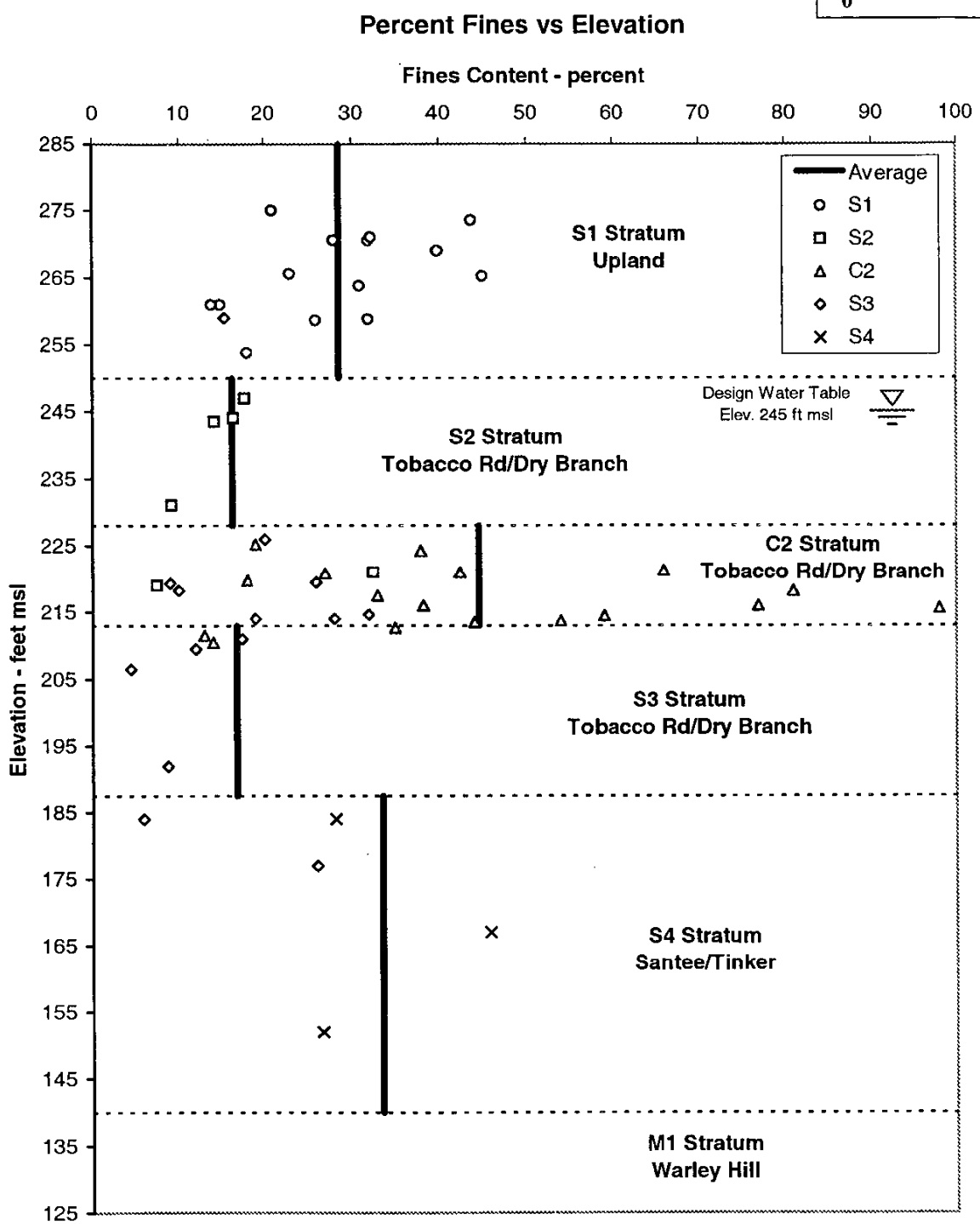


Figure 6 - Water Table Elevation Measured in Well ZBG-2
(SRS Groundwater Information Management System)

well-zbg-2.xls



Note: Stratum elevations are averages beneath Vault No. 4

Zcp23-liq.xls

Figure 7 – Laboratory Determined Percent Fines vs. Elevation
(Data from Table 2)

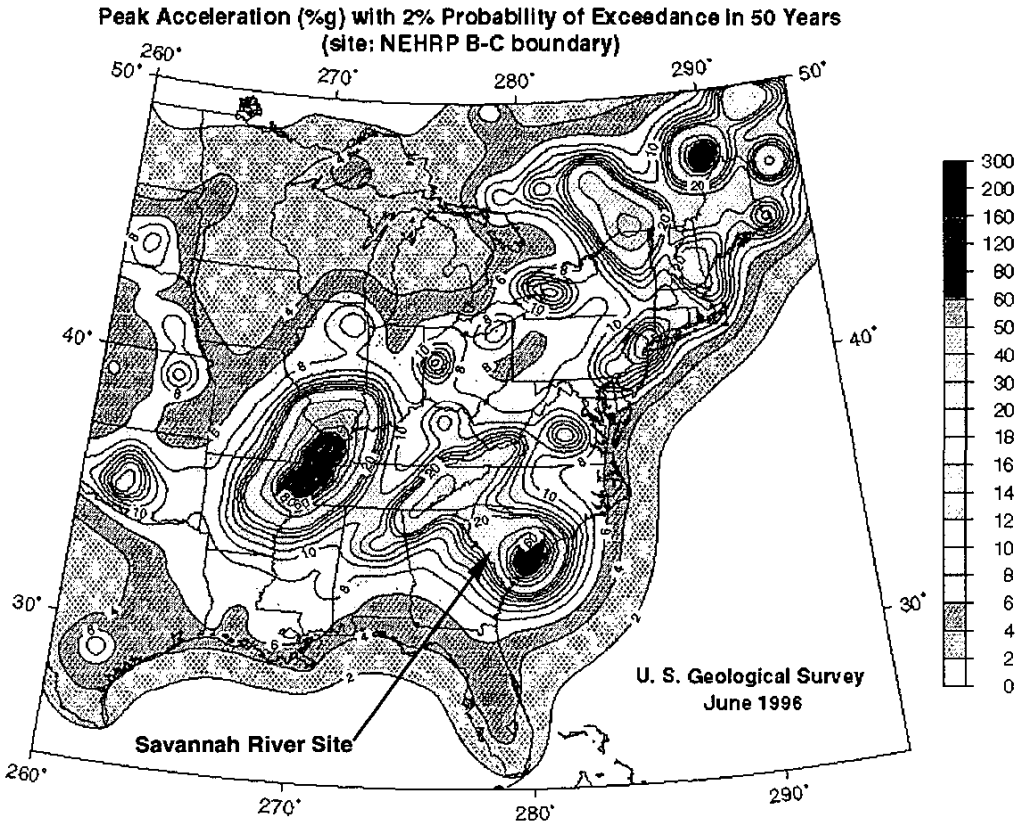


Figure 8 - USGS Hazard Map for Peak Ground Acceleration at Firm Rock
2% Probability of Exccedence in 50 Years
(Frankel et al., 1996)

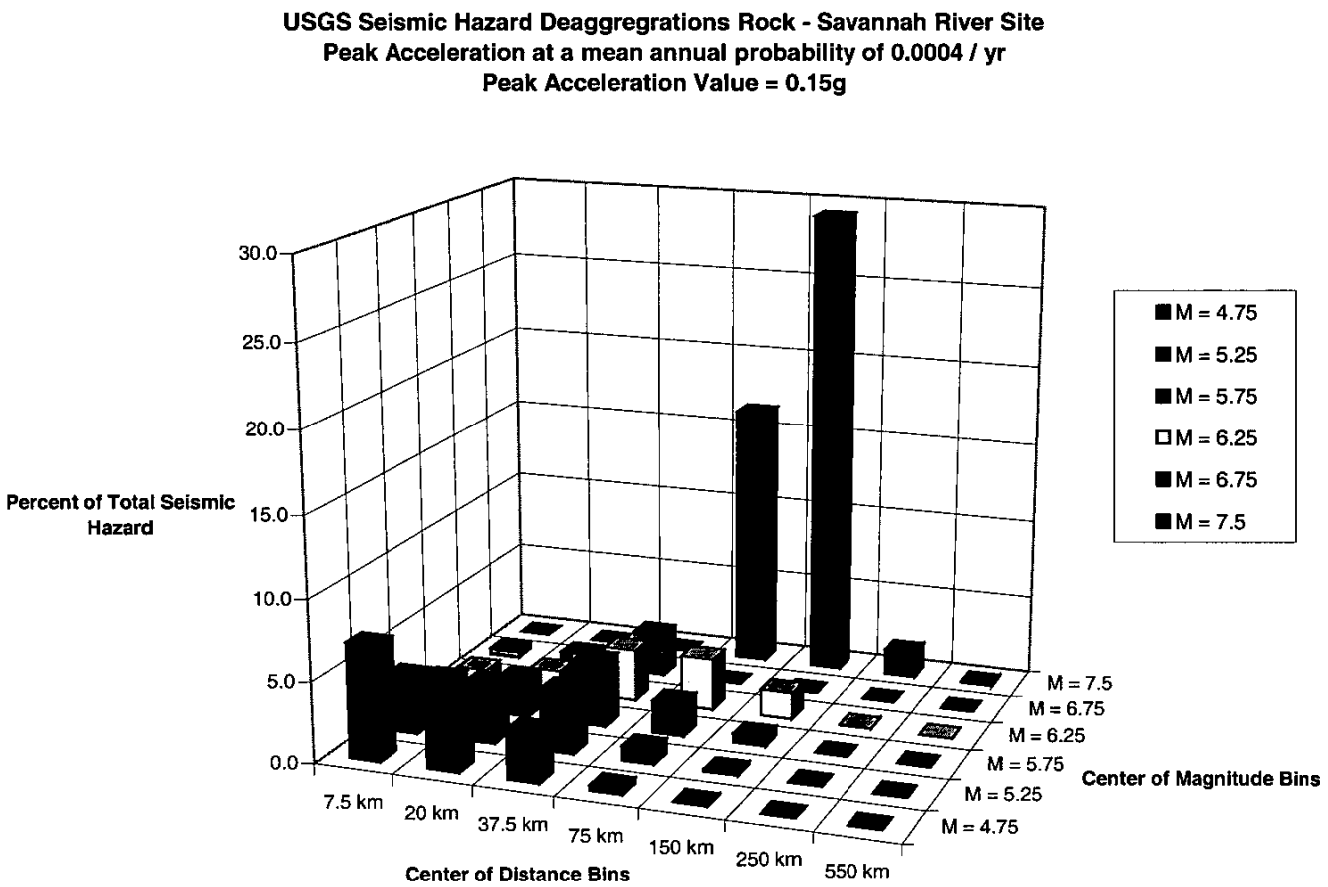
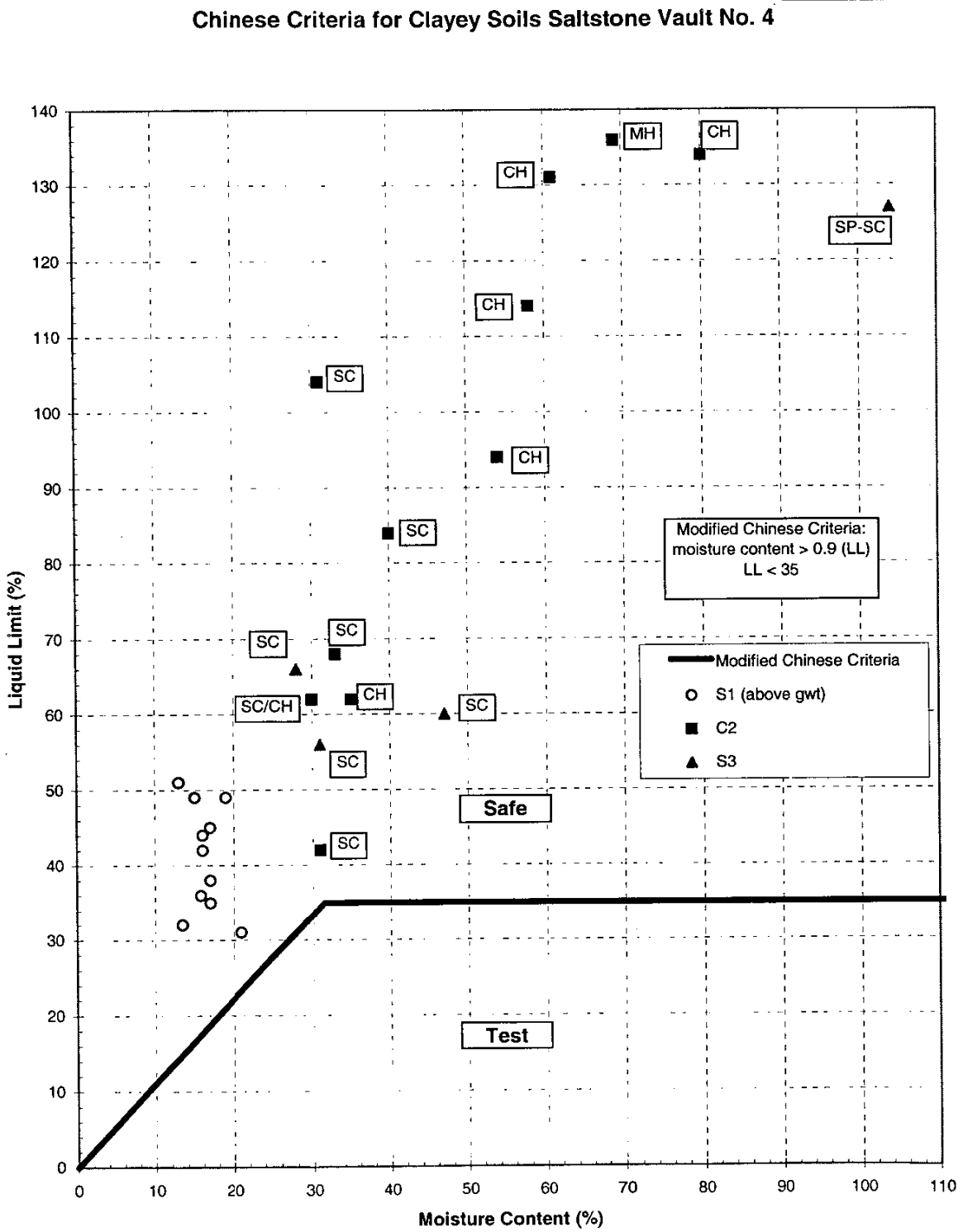


Figure 9 – USGS Seismic Hazard Deaggregation for SRS PGA and 2,500 Year Return Period
(Frankel, 1999)



Index-tests.xls

Figure 10 – Evaluation of Liquefaction Potential at Saltstone Vault No. 4 Based on "Modified Chinese Criteria"

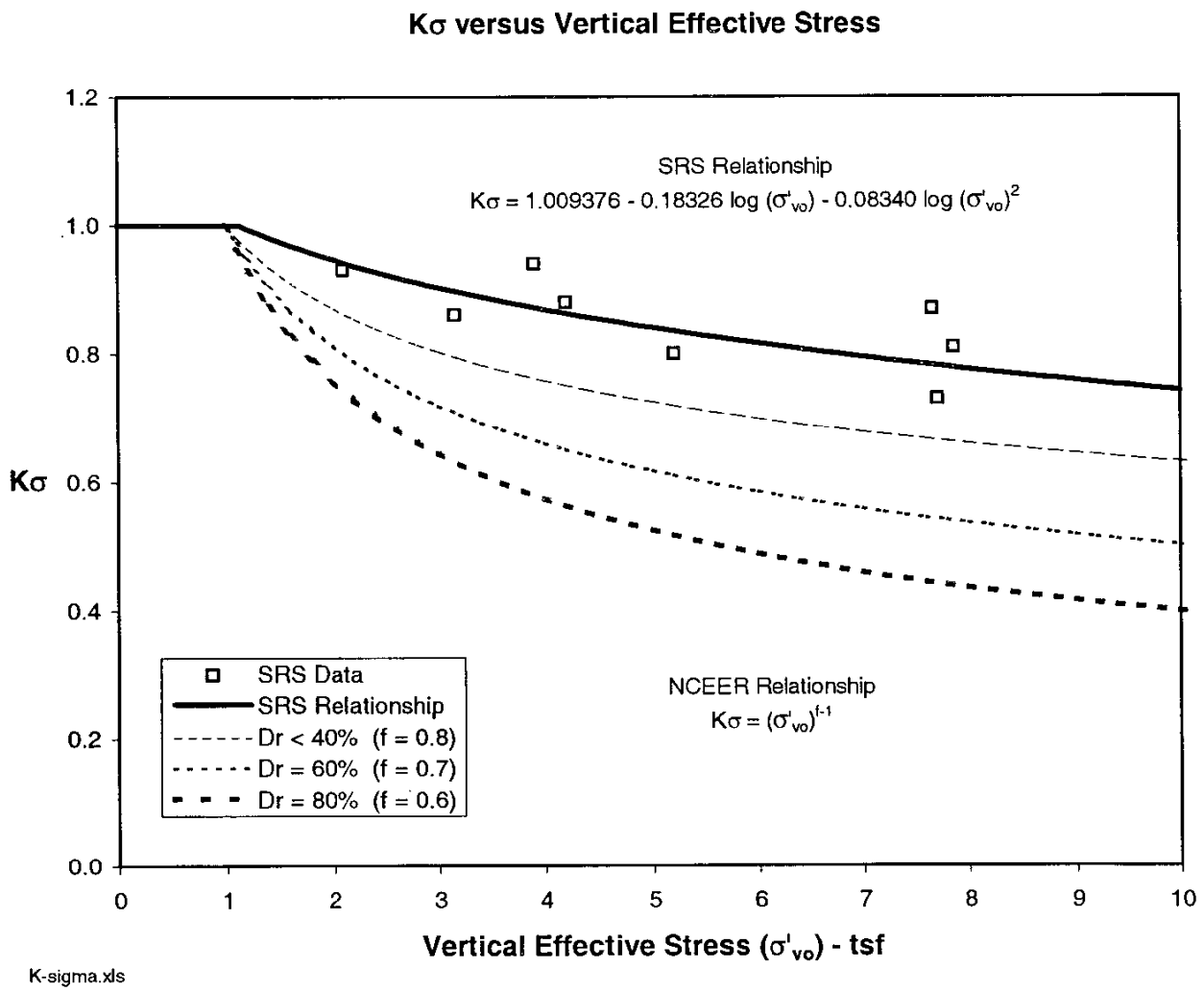


Figure 11 – Comparison of Effective Overburden Correction Factors (Kσ)
(SRS, 1994b; WSRC, 1995; Youd et al., 2001)

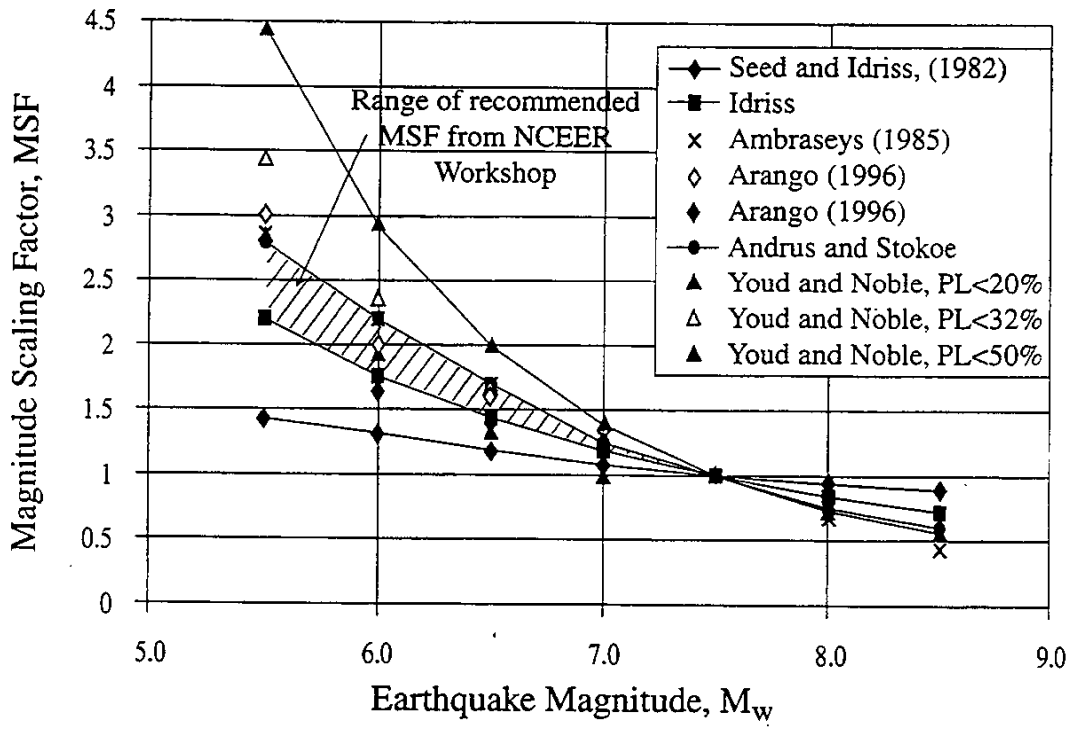


Figure 12 - Magnitude Scaling Factors Proposed by Various Investigators With Range Recommended by NCEER Workshop
(NCEER, 1997)

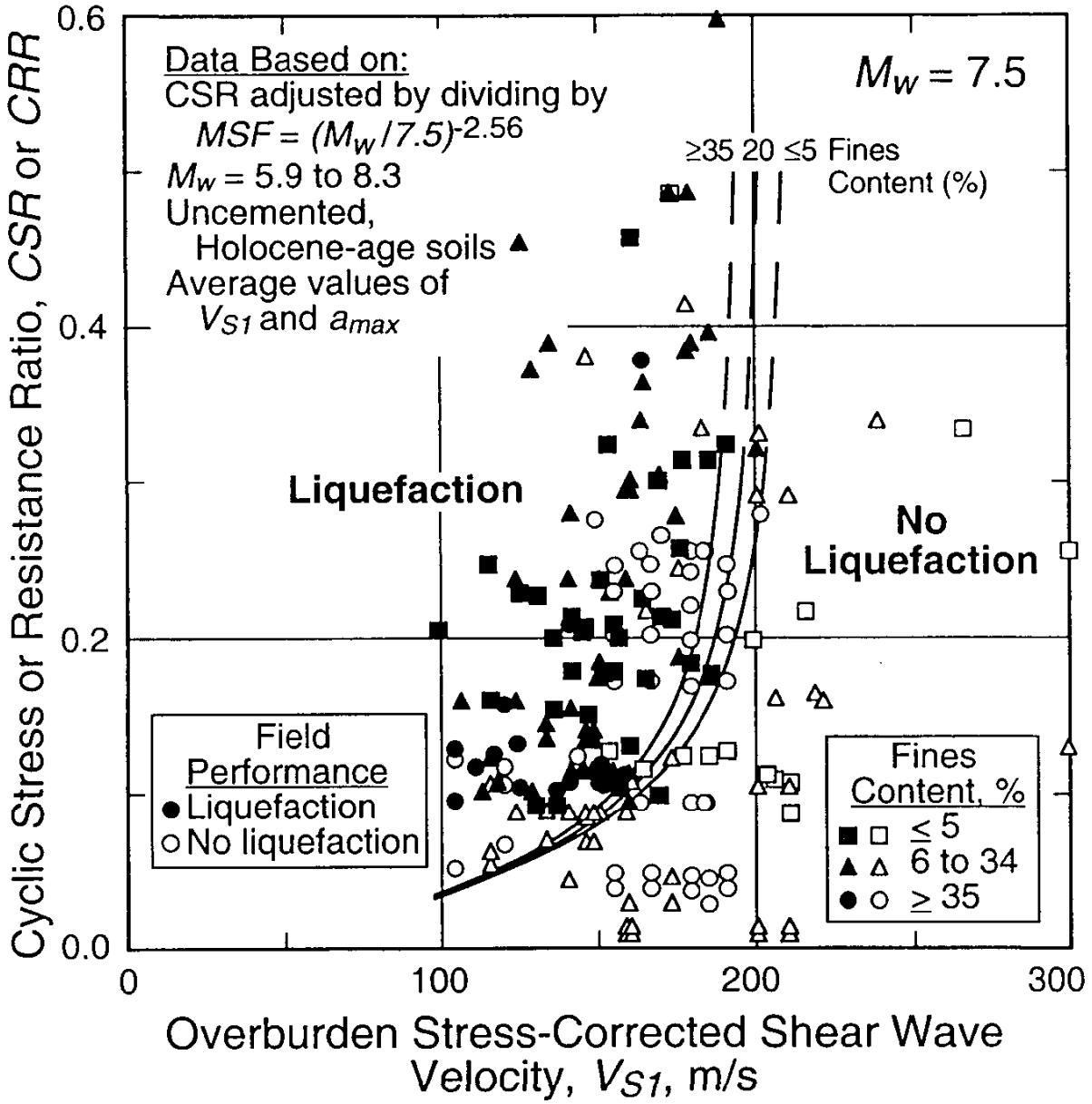
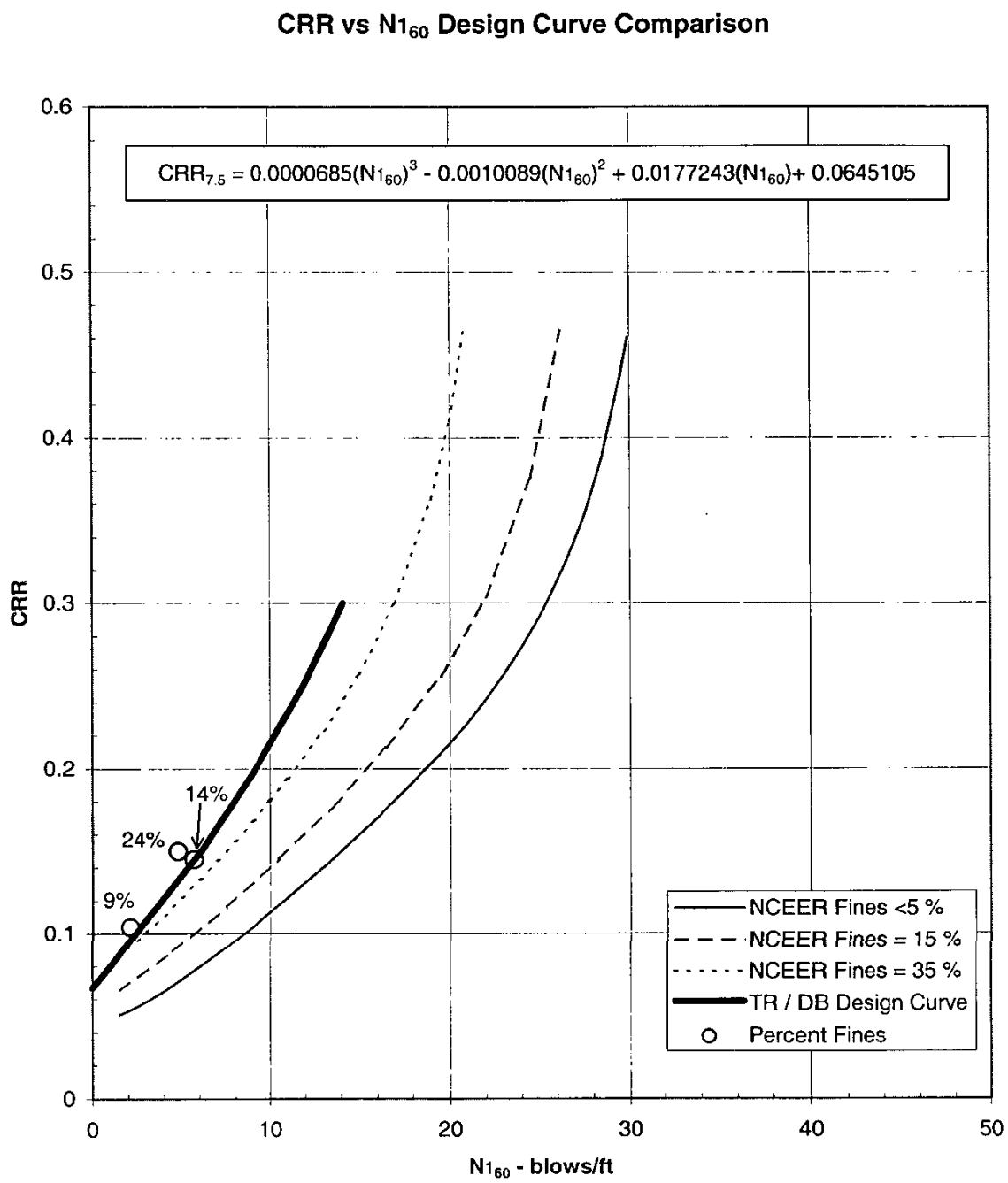


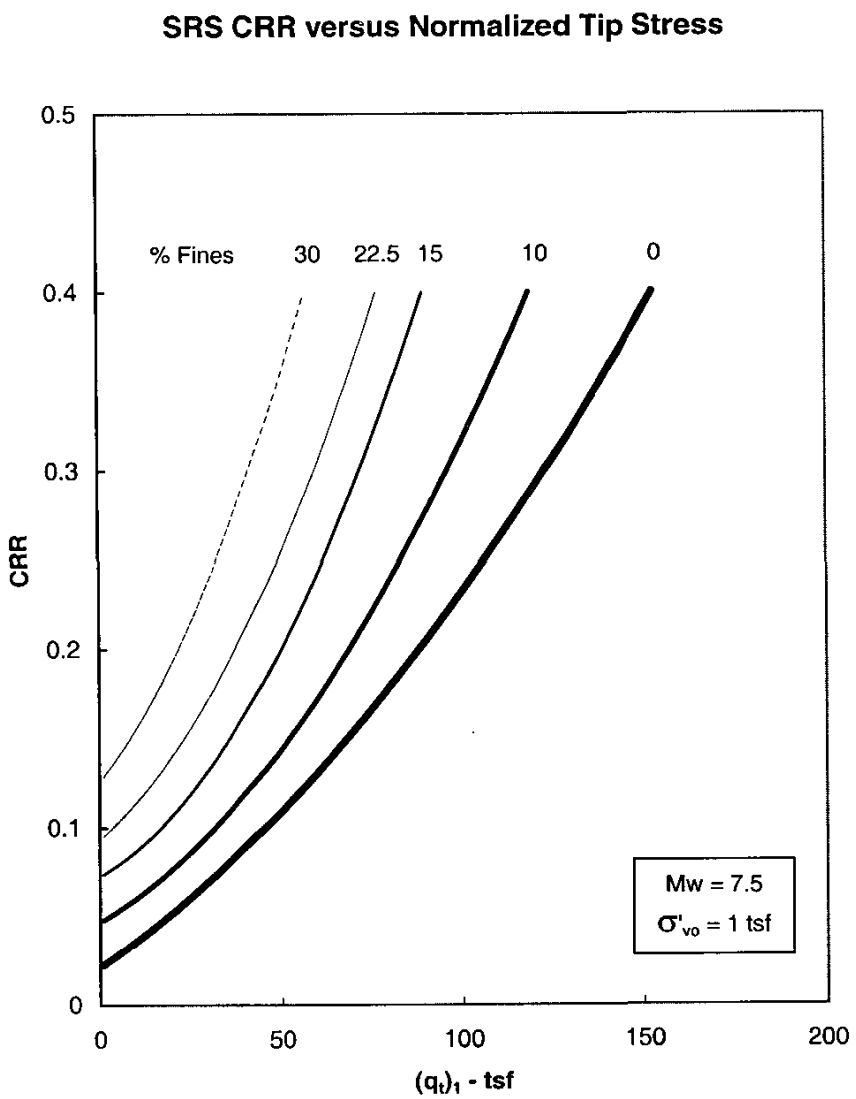
Figure 13 - Relationship Between Cyclic Resistance Ratio (CRR) and Overburden Stress-Corrected Shear Wave Velocity (V_{s1})
(Andrus and Stokoe, 2000)



Note: Number by open circles indicates percent fines.

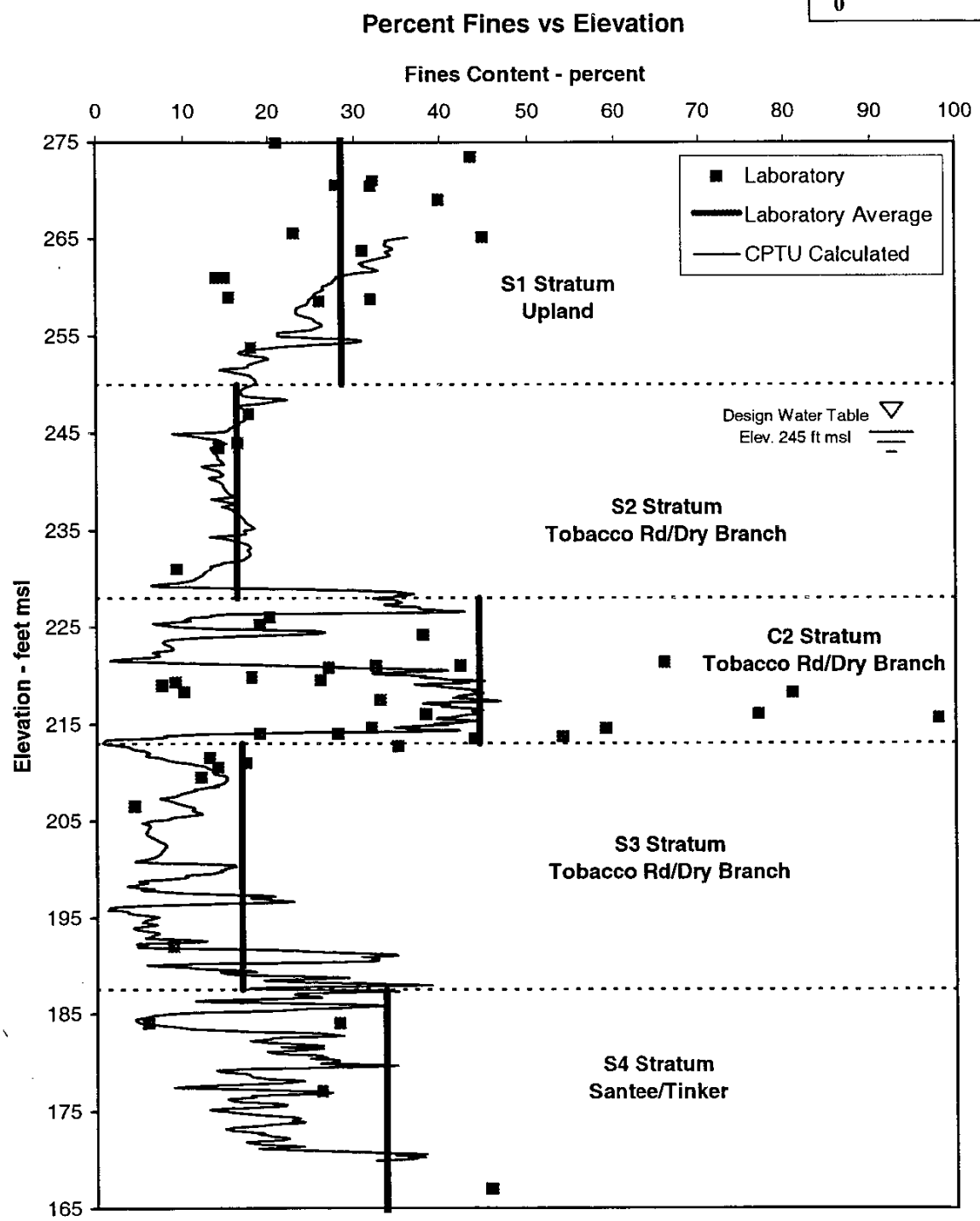
figures.XLS

Figure 14 - Relationship Between Cyclic Resistance Ratio and SPT N_{160} SRS Tobacco Road and Dry Branch Compared with NCEER
(BSRI, 1993; Youd et al., 2001)



figures.XLS

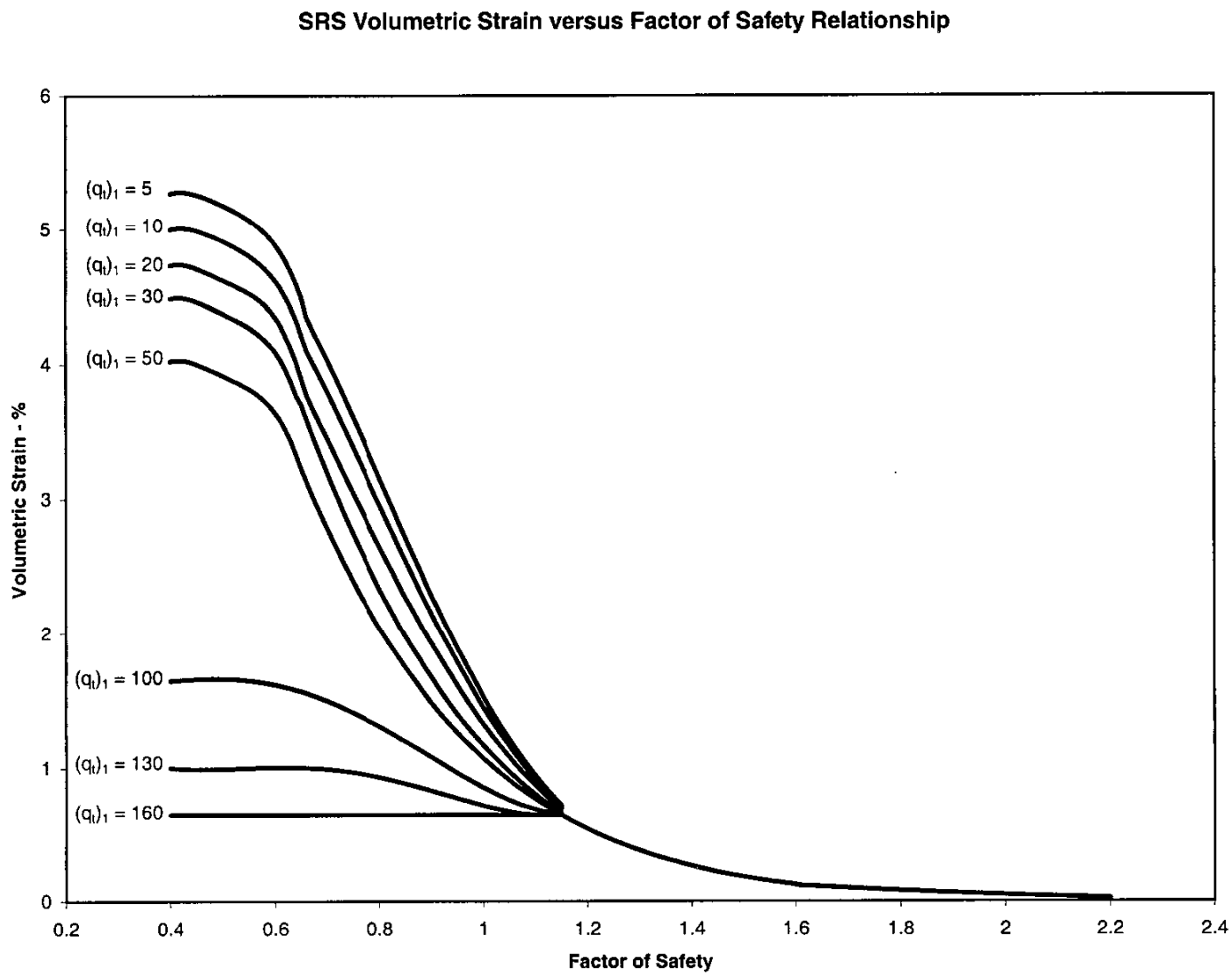
Figure 15 - Relationship Between Cyclic Resistance Ratio (CRR) and Normalized CPTu Tip Resistance (q_{t1}) for SRS
(SRS, 1994a; 1995 and WSRC, 1995)



Note: CTPU calcualted fines is for ZCP-23
Stratum elevations are averages beneath Vault No. 4

Zcp23-liq.xls

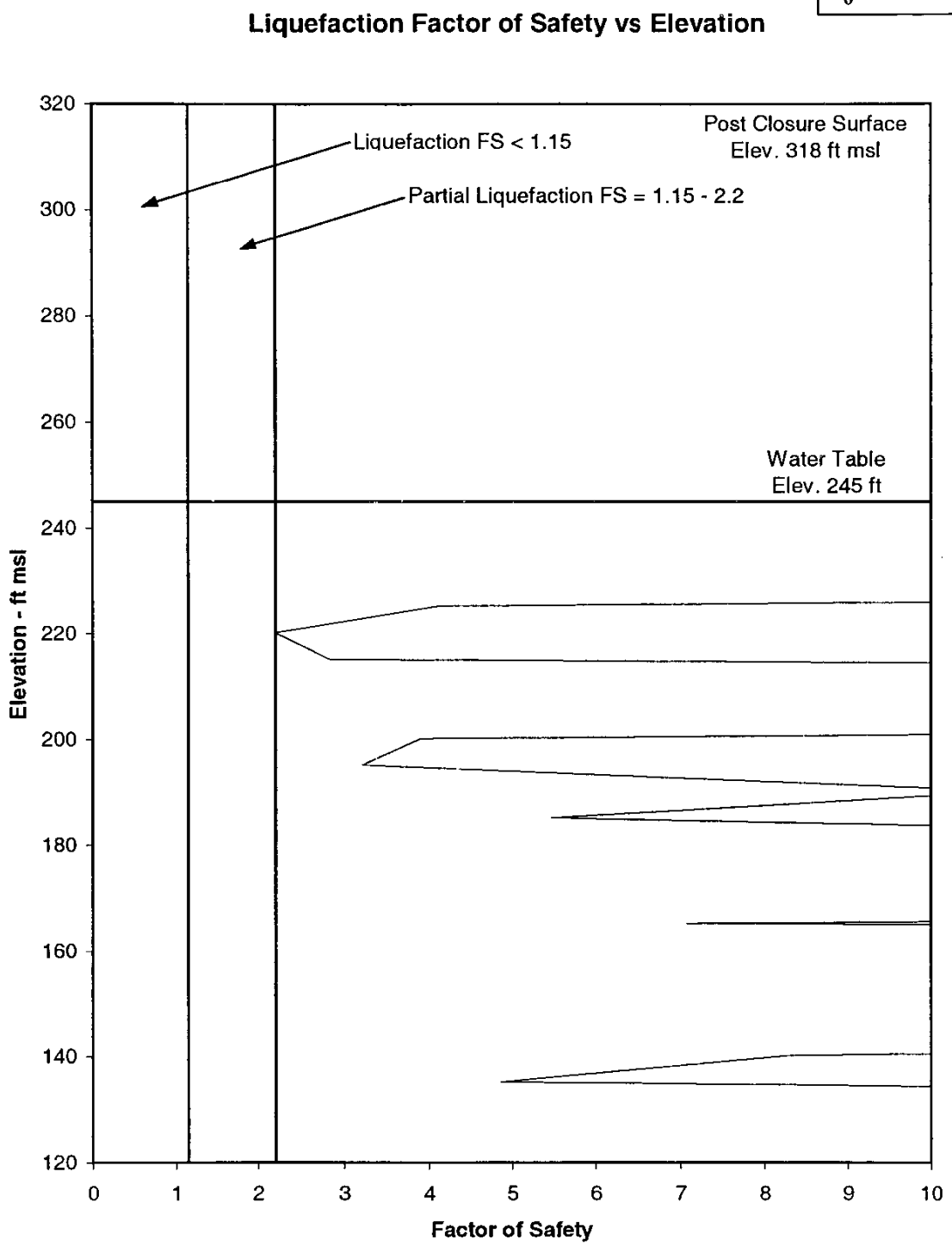
Figure 16 – Percent Fines Calculated Using CPTu Data from ZCP-23 Compared with Laboratory Determined Percent Fines
(Laboratory data from Table 1, CPTu fines calculated using Eq. 24 and 25)



figures.XLS

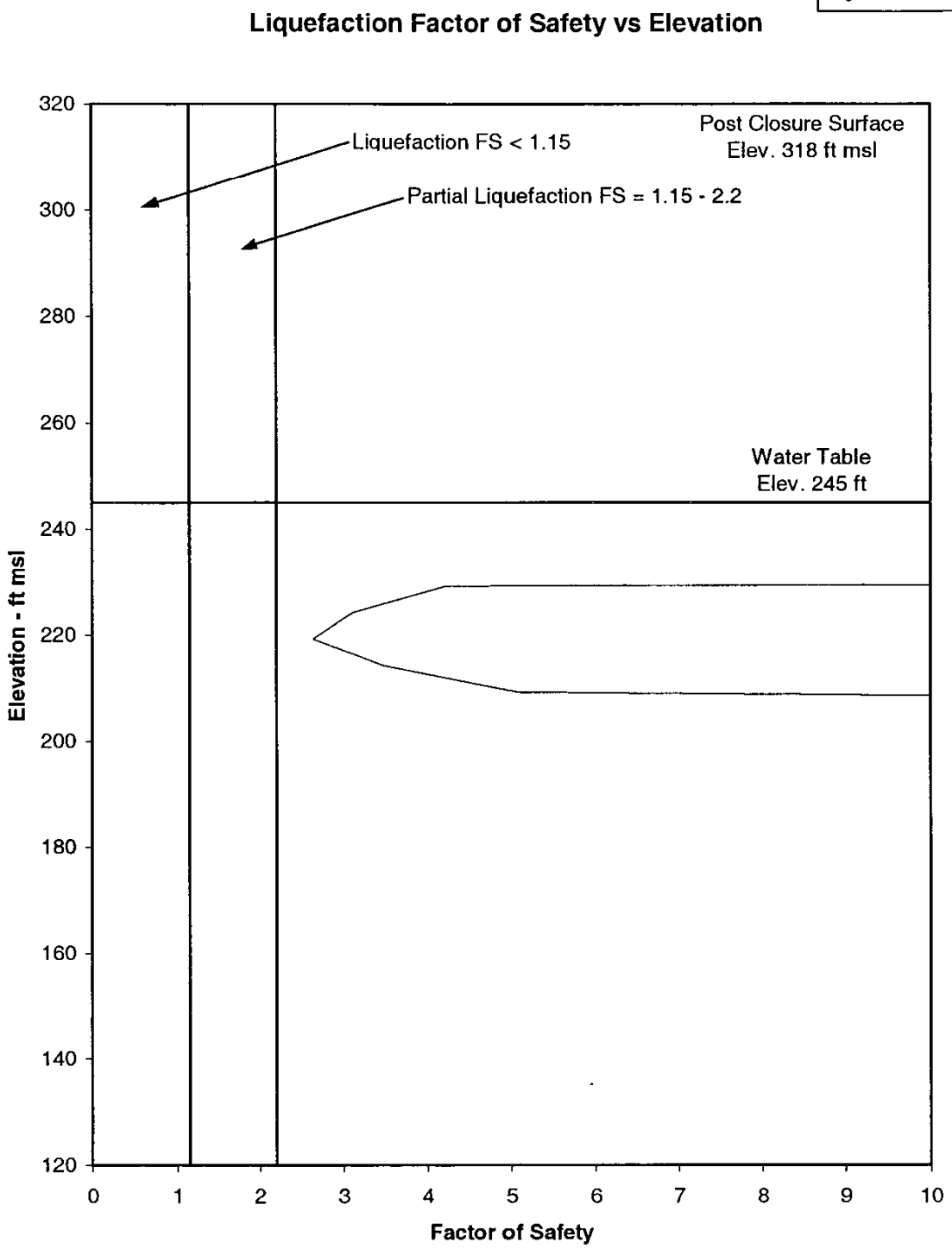
Figure 17 – SRS Relationship Between Volumetric Strain Normalized CPTu Tip Resistance $(q_t)_1$ and Factor of Safety Against Liquefaction

(SRS, 1994a; 1994c and WSRC, 1995)



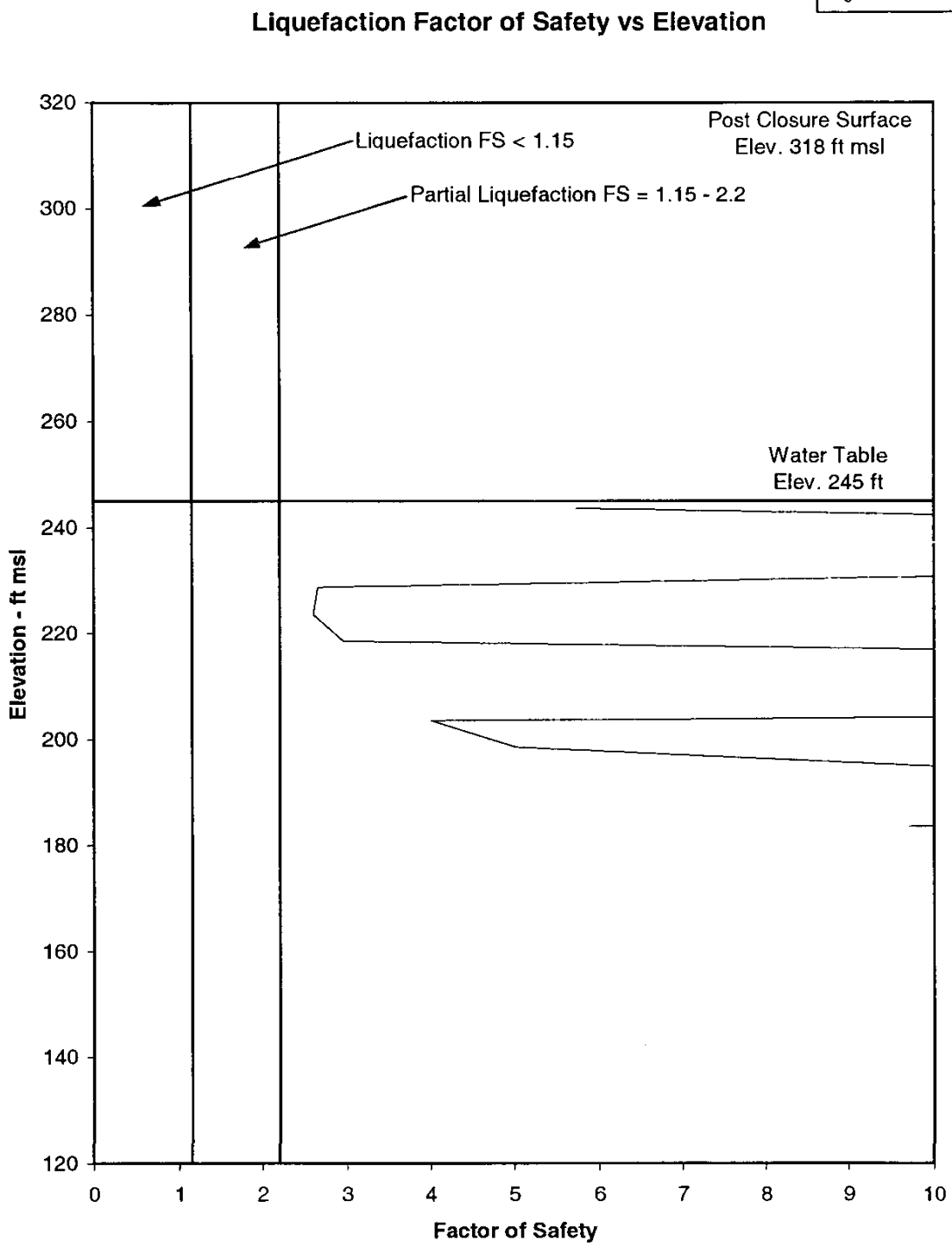
Z204-liq-RTF.XLS

Figure 18a - Liquefaction Factor of Safety vs. Elevation for SPT Boring Z-204 and DBE
(Calculated using N_{160} data and Equation 14)



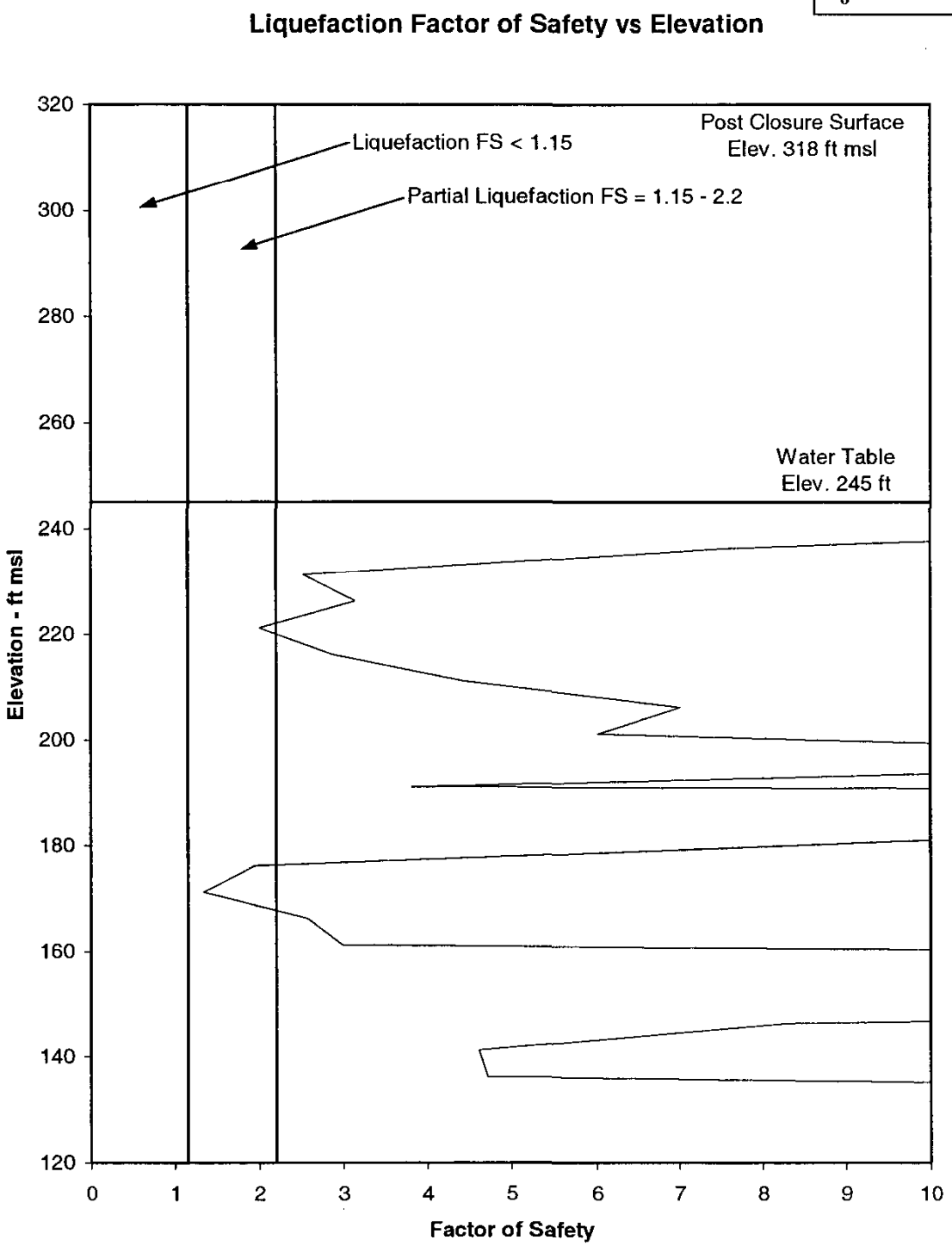
Z205-liq-RTF.XLS

Figure 18b - Liquefaction Factor of Safety vs. Elevation for SPT Boring Z-205 and DBE
(Calculated using N_{160} data and Equation 14)



Z206-liq-RTF.XLS

Figure 18c - Liquefaction Factor of Safety vs. Elevation for SPT Boring Z-206 and DBE
(Calculated using N_{160} data and Equation 14)



Z207-liq-RTF.XLS

Figure 18d - Liquefaction Factor of Safety vs. Elevation for SPT Boring Z-207 and DBE
(Calculated using N_{160} data and Equation 14)

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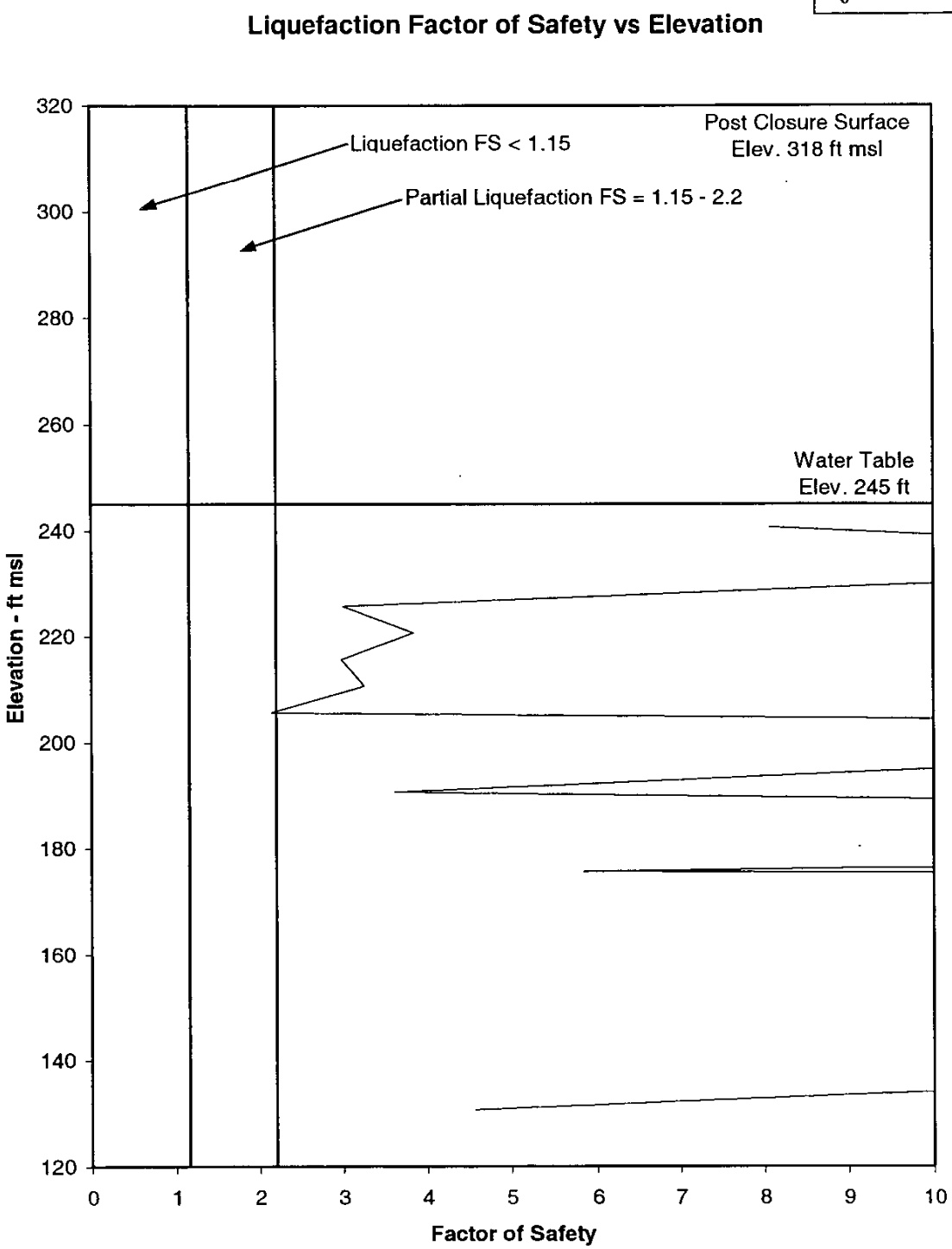
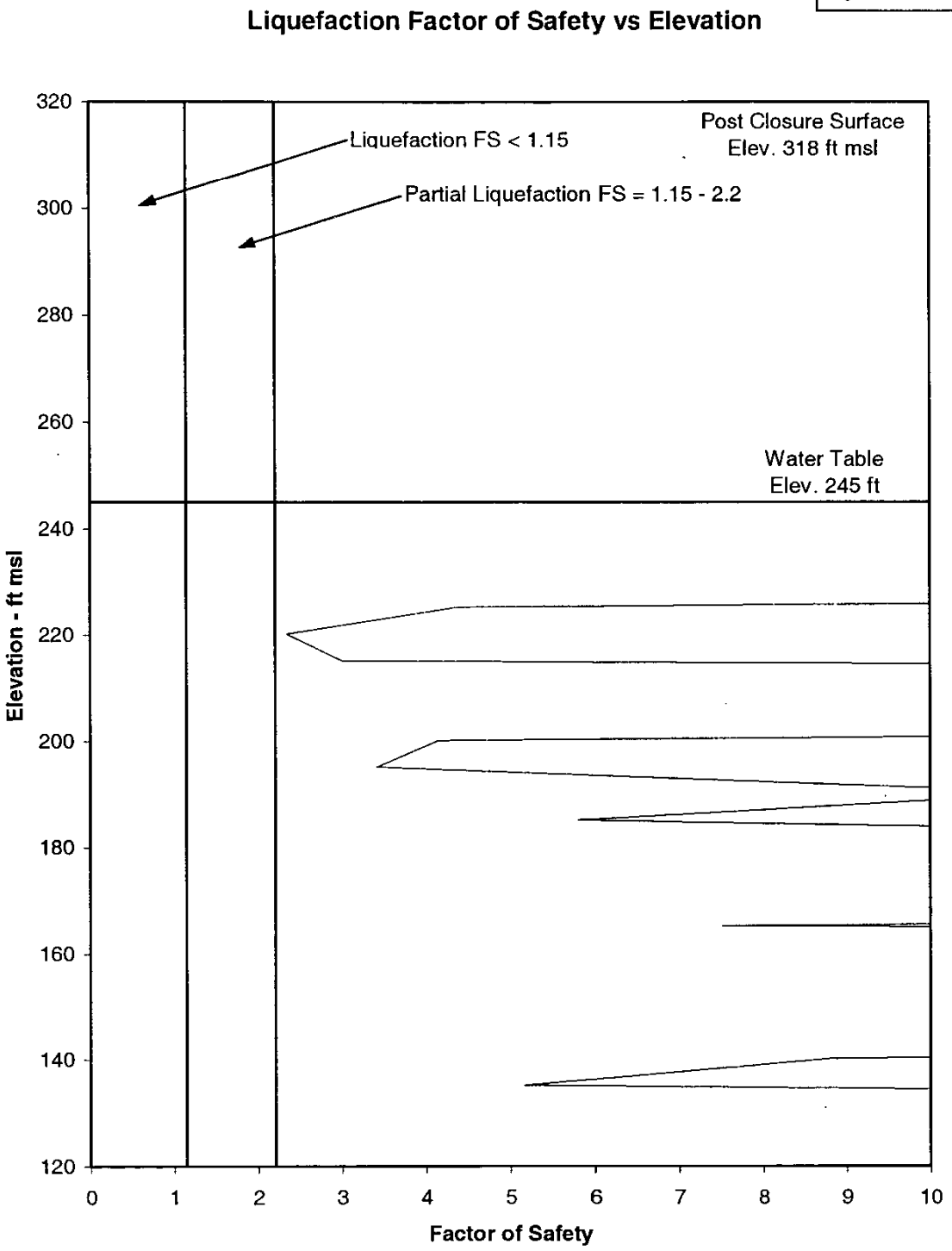


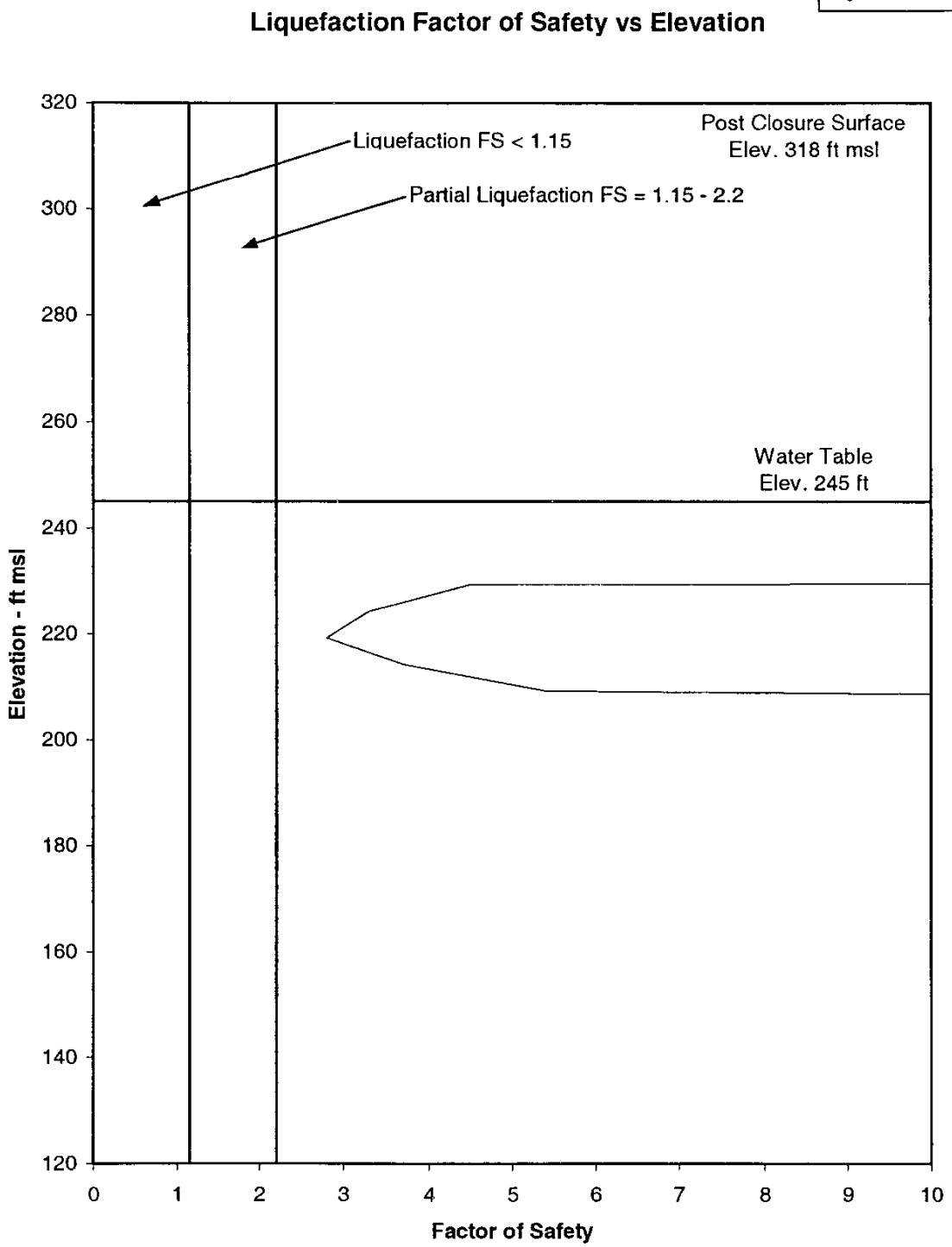
Z208-liq-RTF.XLS

Figure 18e - Liquefaction Factor of Safety vs. Elevation for SPT Boring Z-208 and DBE
(Calculated using N_{160} data and Equation 14)



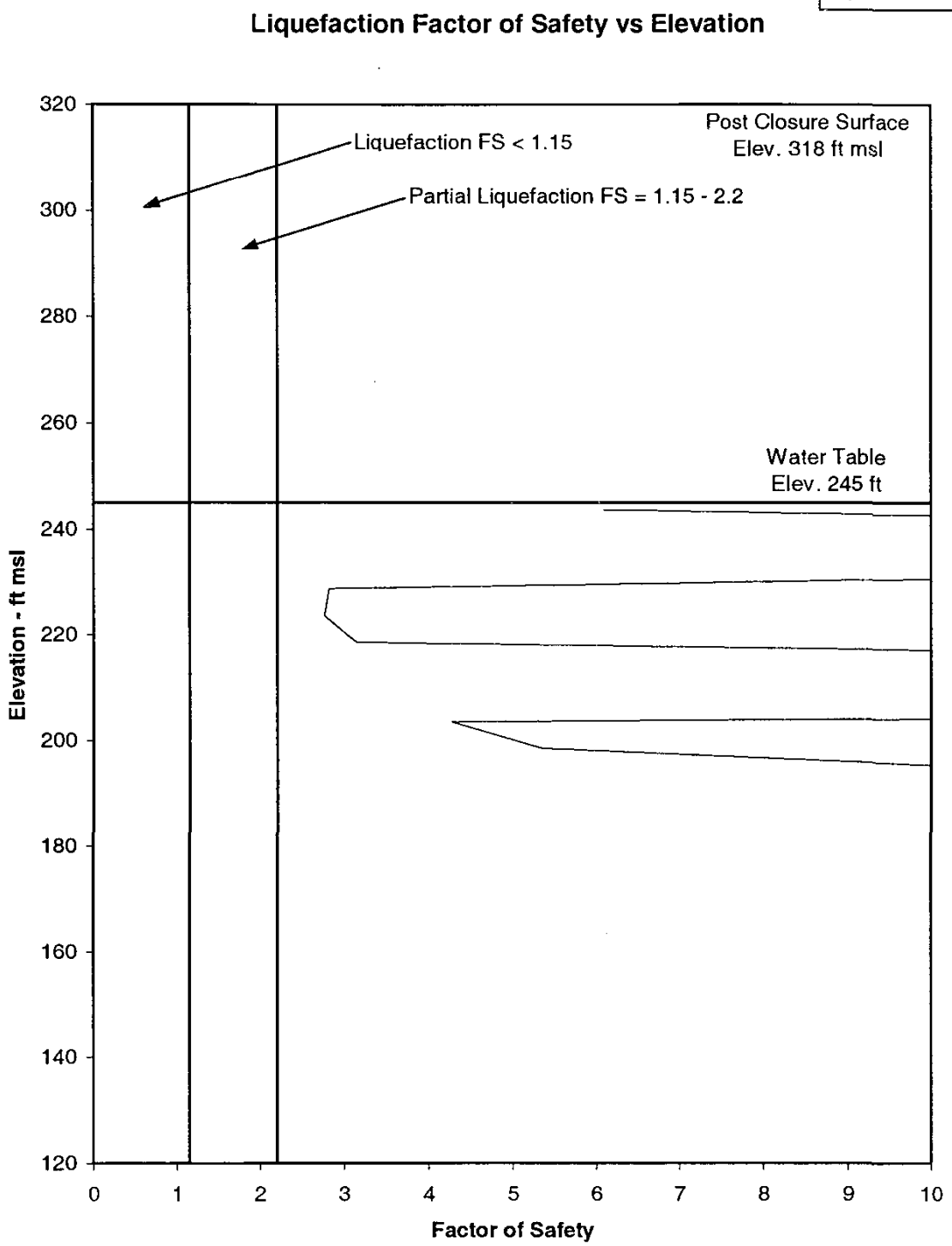
Z204-liq-RTF-ch.XLS

Figure 19a - Factor of Safety vs. Elev. for SPT Boring Z-204 and Charleston Earthquake
(Calculated using N_{160} data and Equation 14)



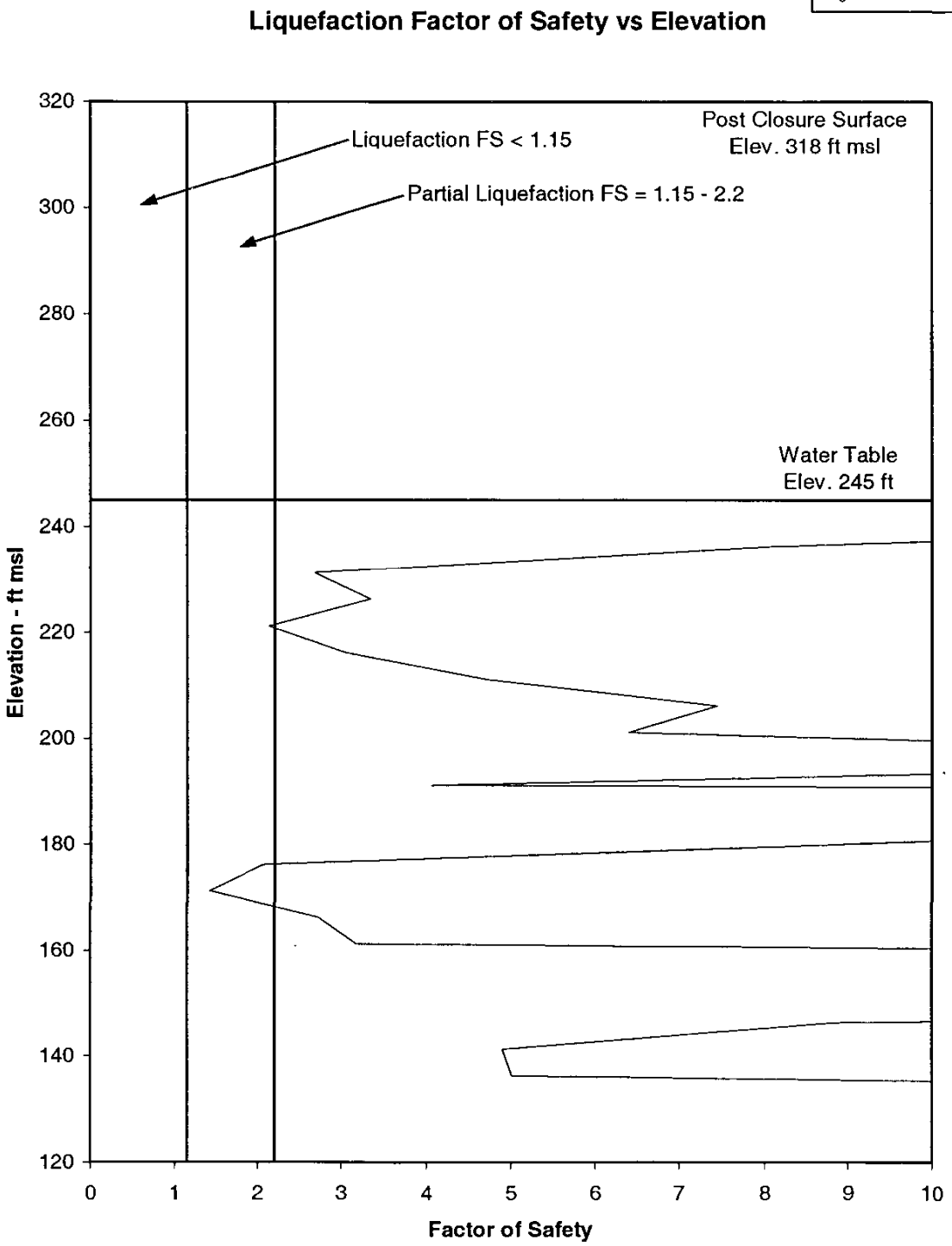
Z205-liq-RTF-ch.XLS

Figure 19b - Factor of Safety vs. Elev. for SPT Boring Z-205 and Charleston Earthquake
(Calculated using N_{160} data and Equation 14)



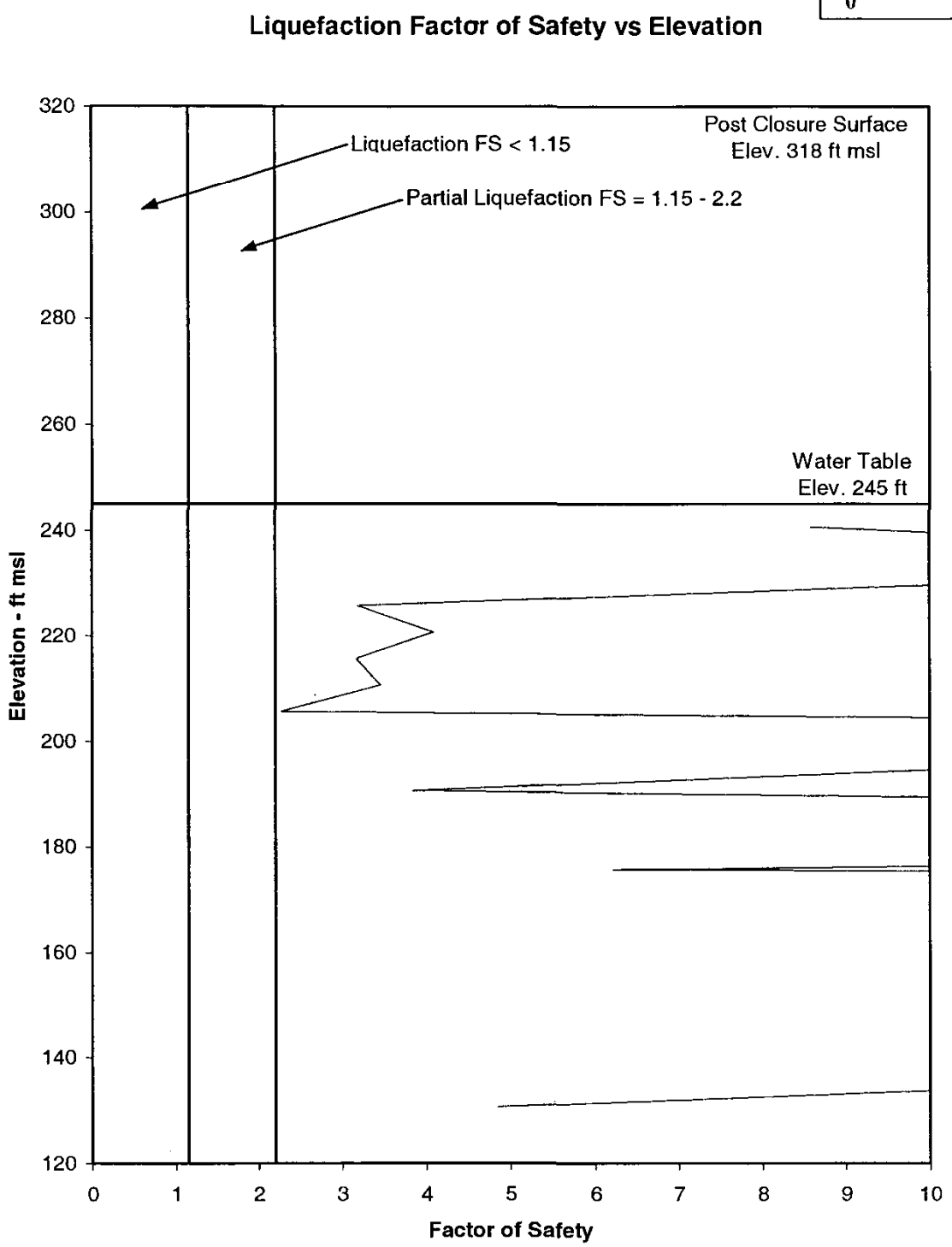
Z206-liq-RTF-ch.XLS

Figure 19c - Factor of Safety vs. Elev. for SPT Boring Z-206 and Charleston Earthquake
(Calculated using N_{160} data and Equation 14)



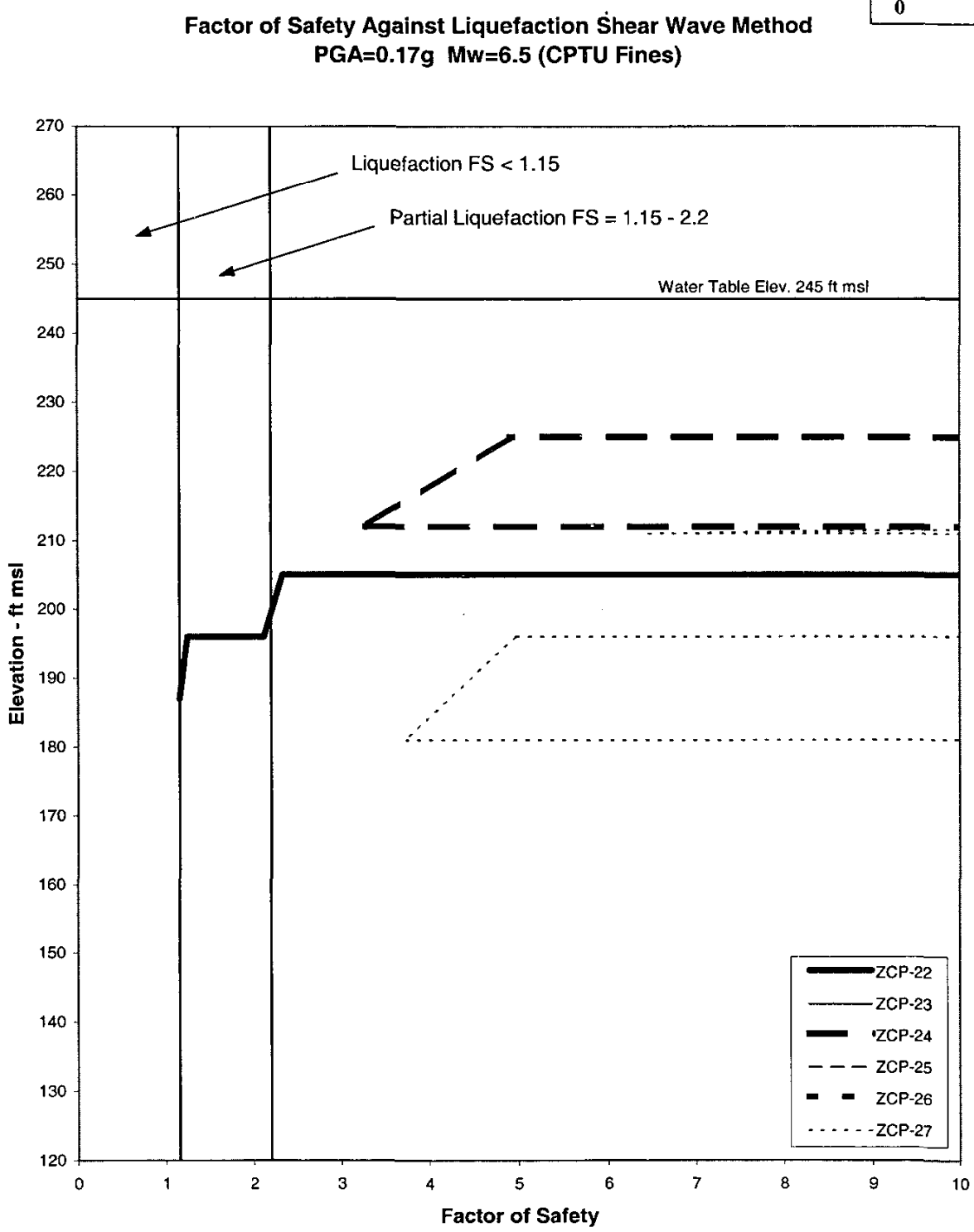
Z207-liq-RTF-ch.XLS

Figure 19d - Factor of Safety vs. Elev. for SPT Boring Z-207 and Charleston Earthquake
(Calculated using N_{160} data and Equation 14)



Z208-liq-RTF-ch.XLS

Figure 19e - Factor of Safety vs. Elev. for SPT Boring Z-208 and Charleston Earthquake
(Calculated using N_{160} data and Equation 14)



FS-Vs-summary.xls

Figure 20 - Liquefaction Factor of Safety vs. Elev. for 6 SCPTu Soundings and DBE
(Calculated using V_{s1} data, CPTu determined percent fines and Equation 9)

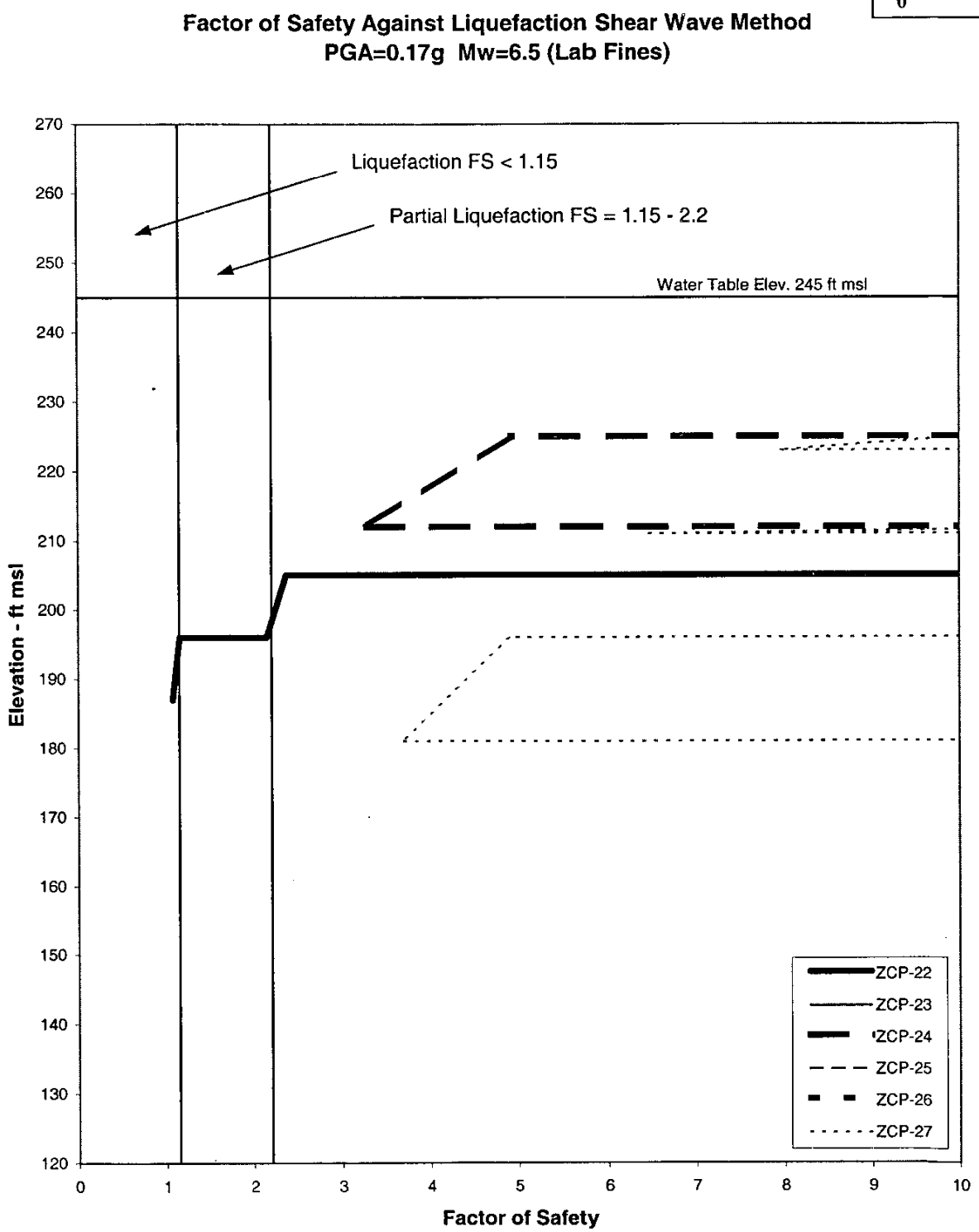
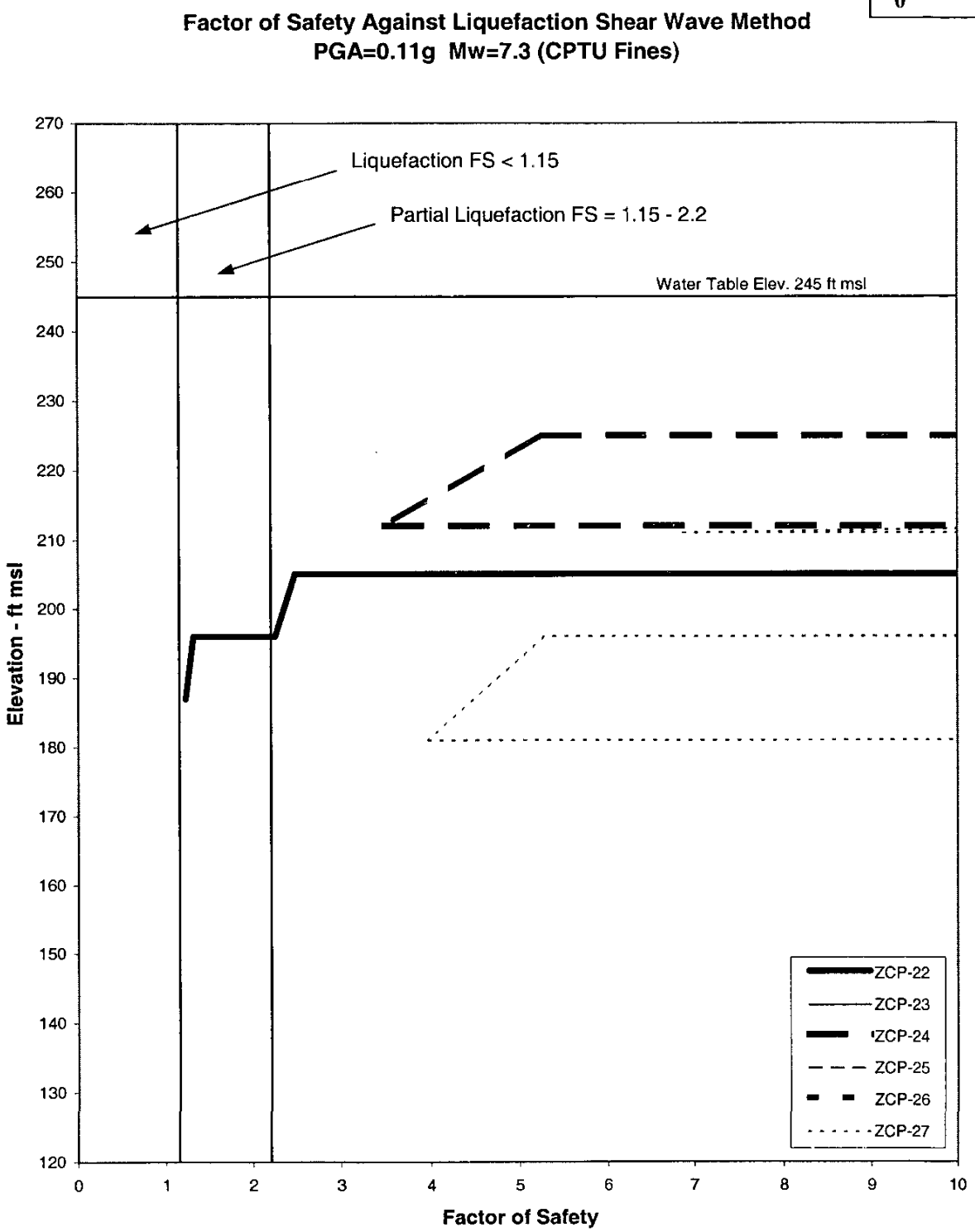
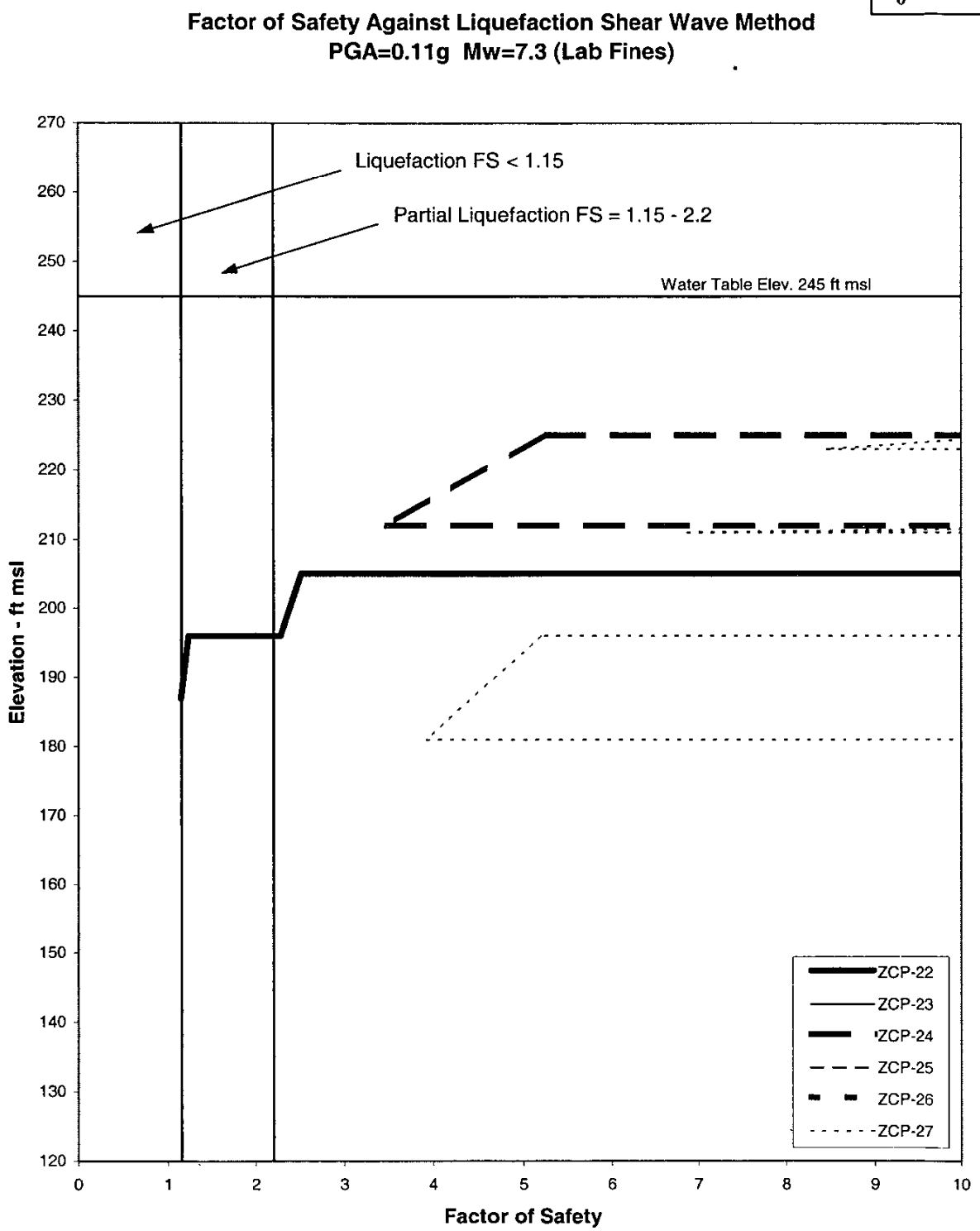


Figure 21 - Liquefaction Factor of Safety vs. Elev. for 6 SCPTu Soundings and DBE
(Calculated using V_{s1} data, laboratory percent fines and Equation 9)



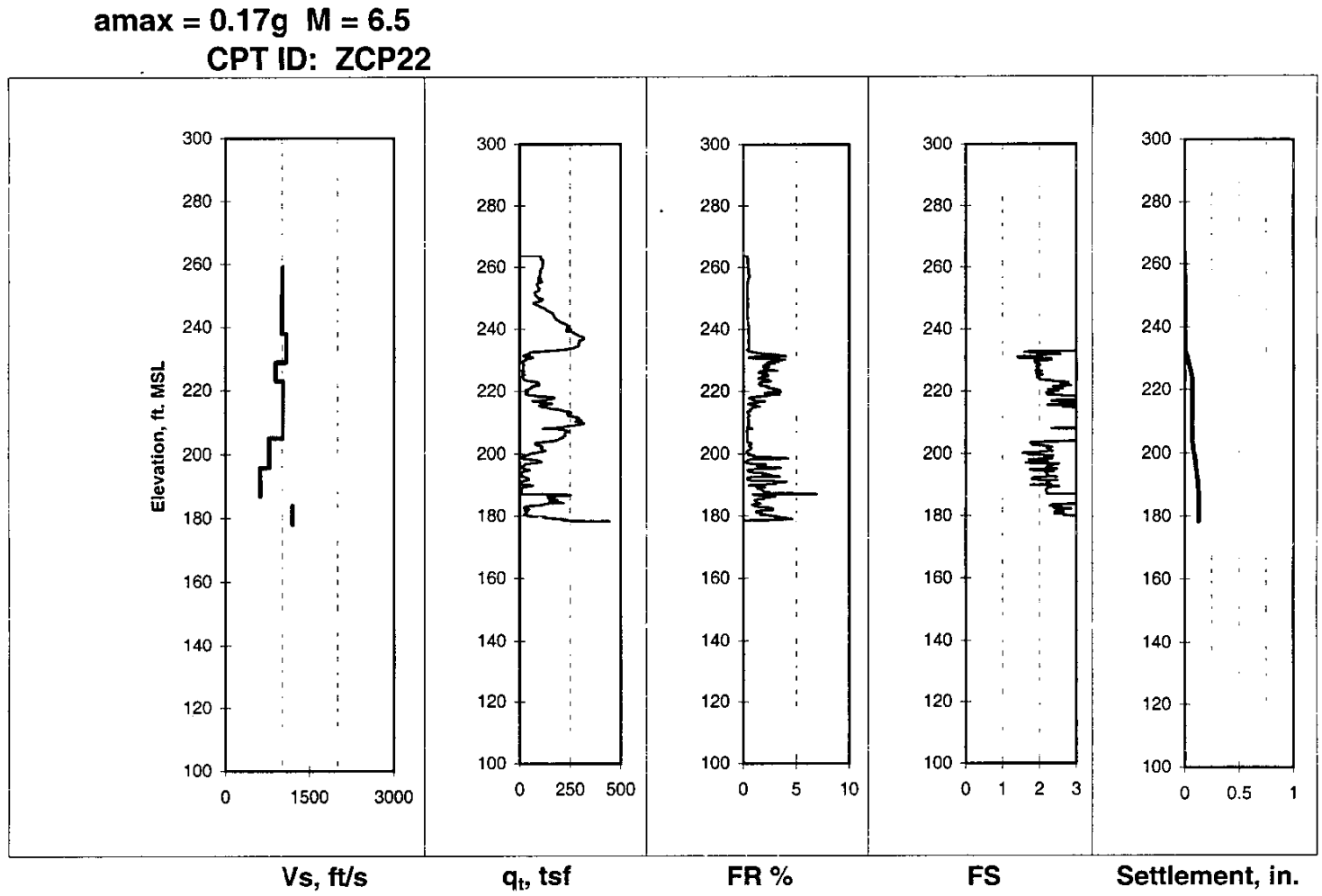
FS-Vs-summary.xls

Figure 22 - Factor of Safety vs. Elev. for 6 SCPTu Soundings and Charleston Earthquake
(Calculated using V_{s1} data, CPTu determined percent fines and Equation 9)



FS-Vs-summary.xls

Figure 23 - Factor of Safety vs. Elev. for 6 SCPTu Soundings and Charleston Earthquake
(Calculated using V_{s1} data, laboratory percent fines and Equation 9)



Zcp22-liq.xls

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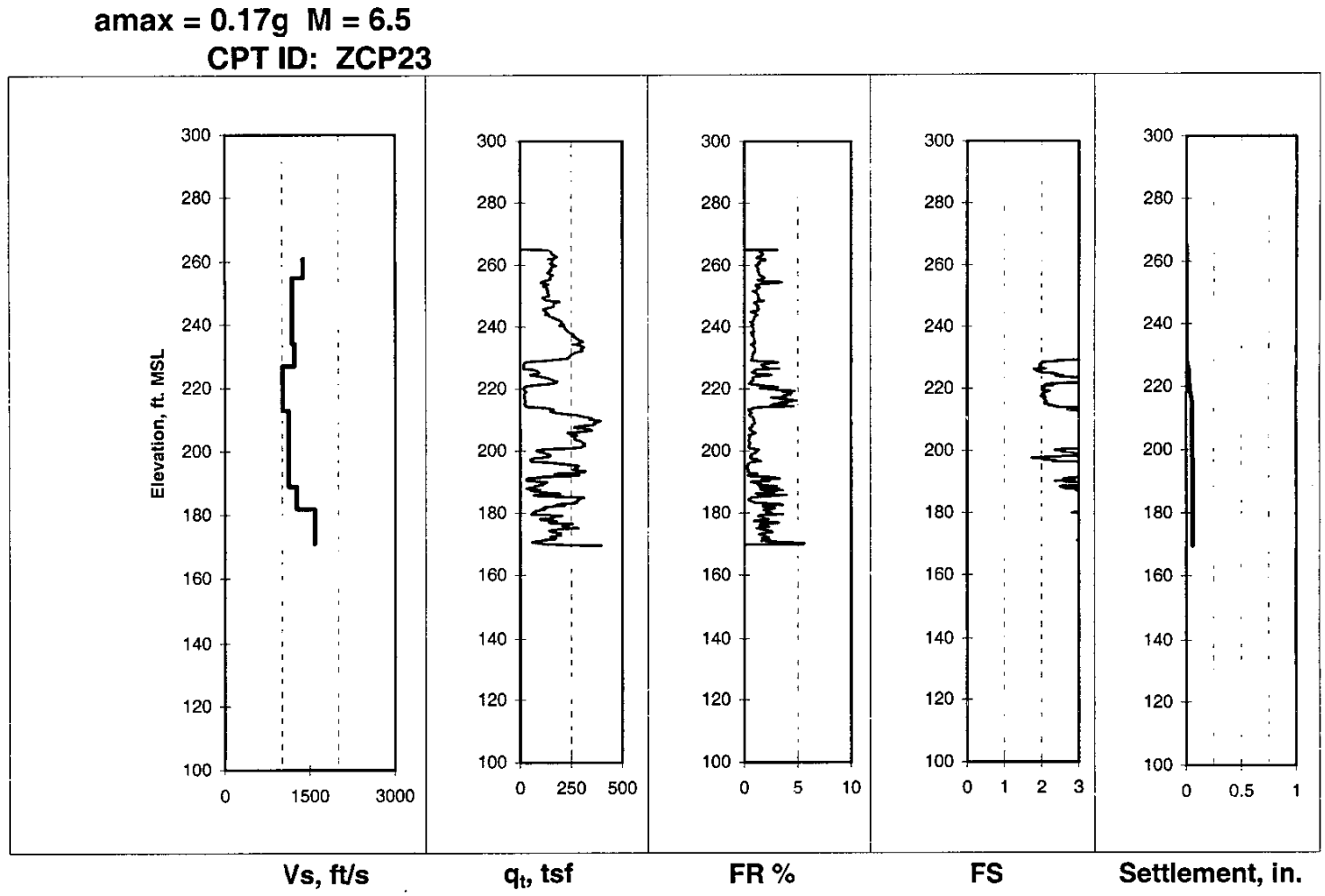
Figure 24a – Liquefaction Factor of Safety and Settlement vs. Elevation for SCPTu ZCP-22 and DBE
(Calculated using q_{tl} data, CPTu determined percent fines and Equations 17 – 43)



Zcp23-liq.xls

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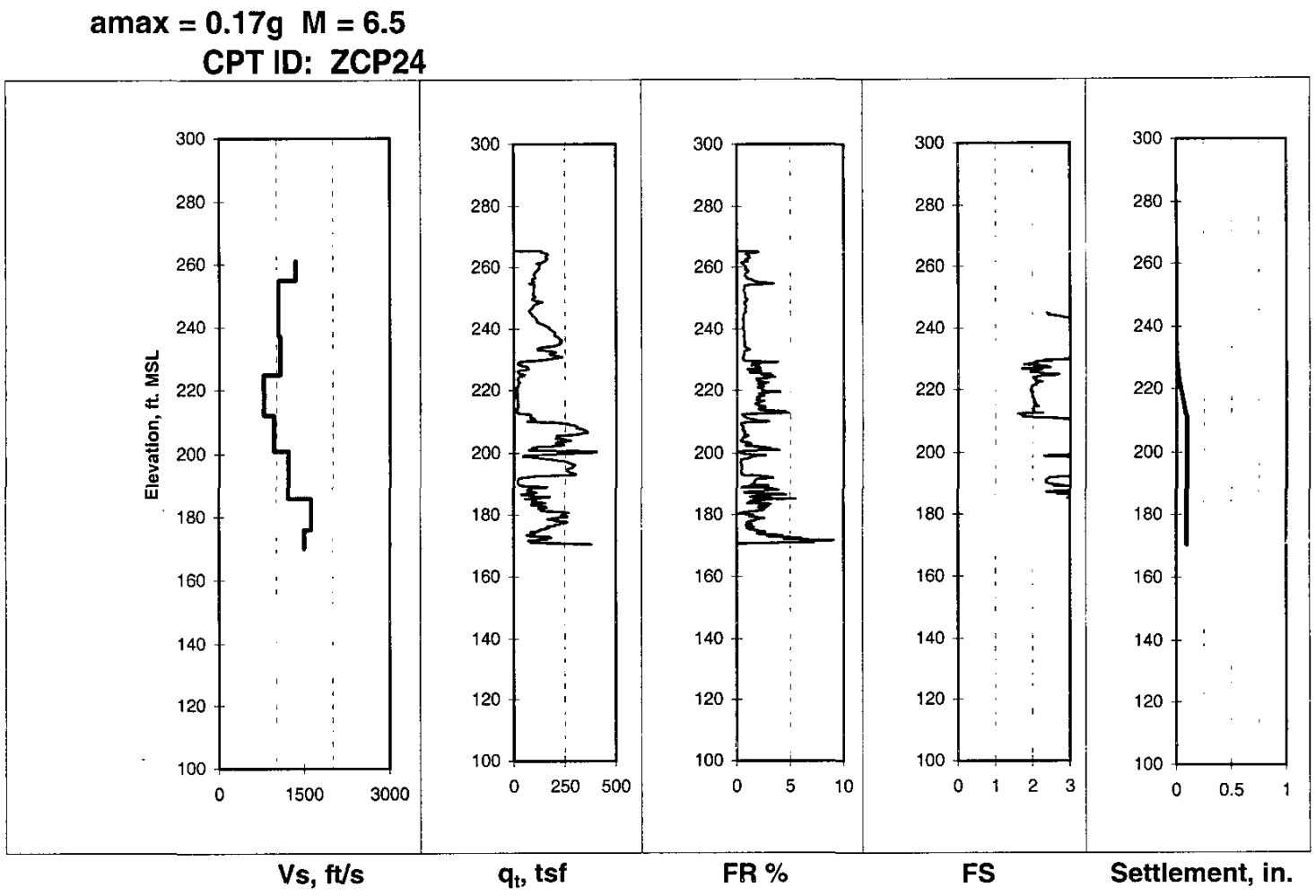
Figure 24b - Liquefaction Factor of Safety and Settlement vs. Elevation for SCPTu ZCP-23 and DBE

(Calculated using q_{t1} data, CPTu determined percent fines and Equations 17 – 43)

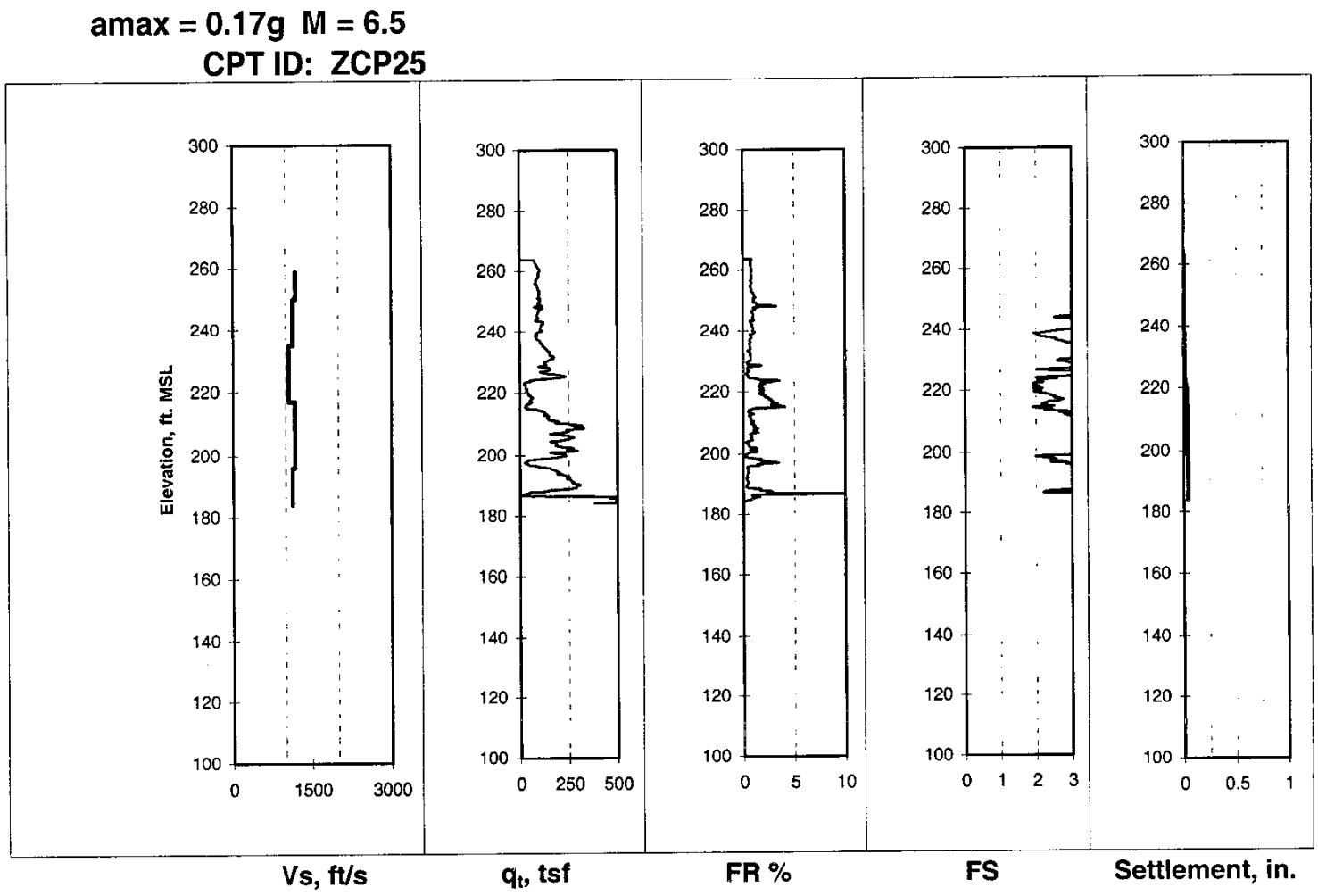


Zcp24-liq.xls

Calculation No. K-CLC-Z-00001	Sheet No. 92	Rev. 0

Figure 24c - Liquefaction Factor of Safety and Settlement vs. Elevation for SCPTu ZCP-24 and DBE

(Calculated using q_{t1} data, CPTu determined percent fines and Equations 17 – 43)

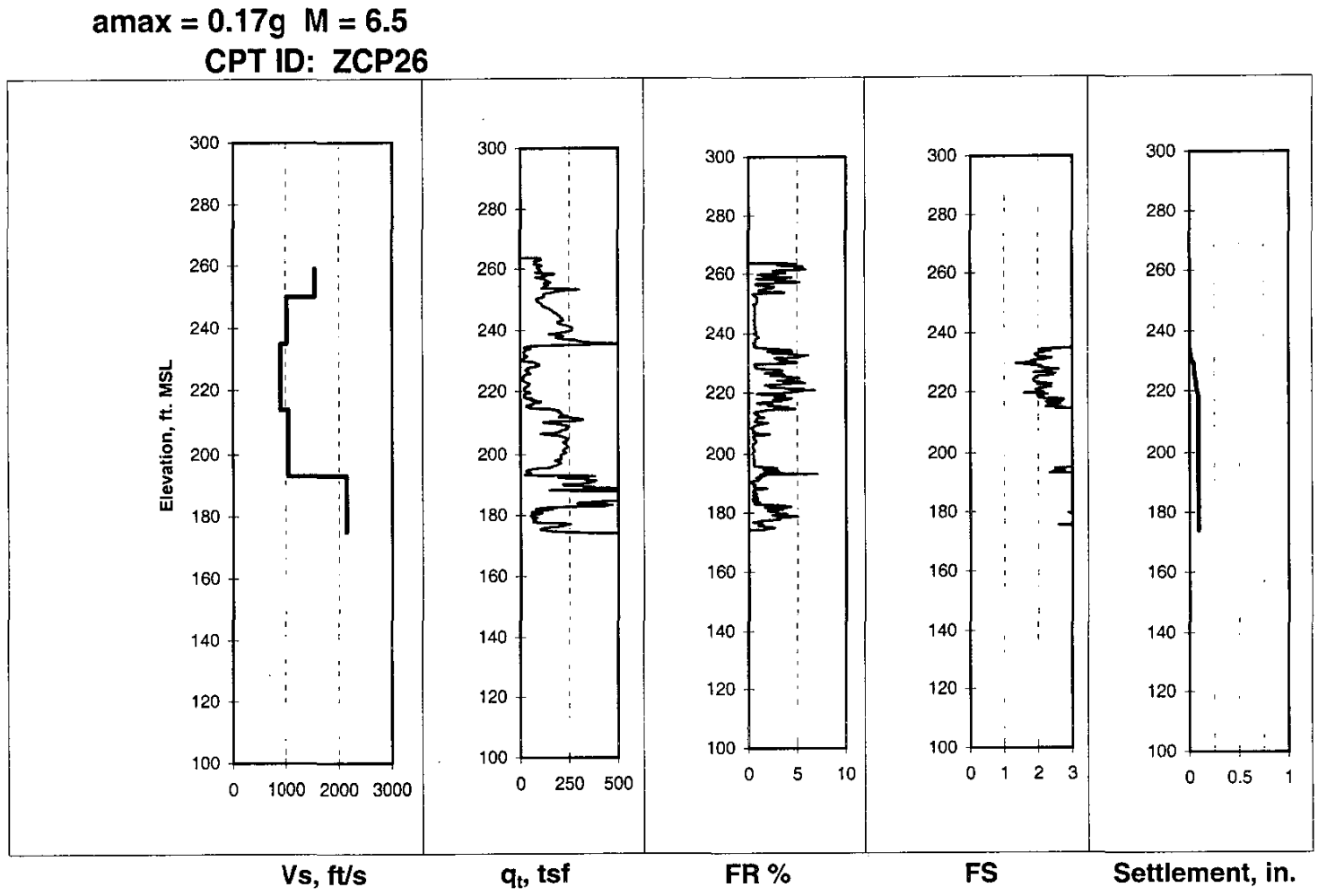


Zcp25-liq.xls

Calculation No. K-CLC-Z-00001	Sheet No. 93	Rev. 0

Figure 24d - Liquefaction Factor of Safety and Settlement vs. Elevation for SCPTu ZCP-25 and DBE

(Calculated using q_{t1} data, CPTu determined percent fines and Equations 17 – 43)

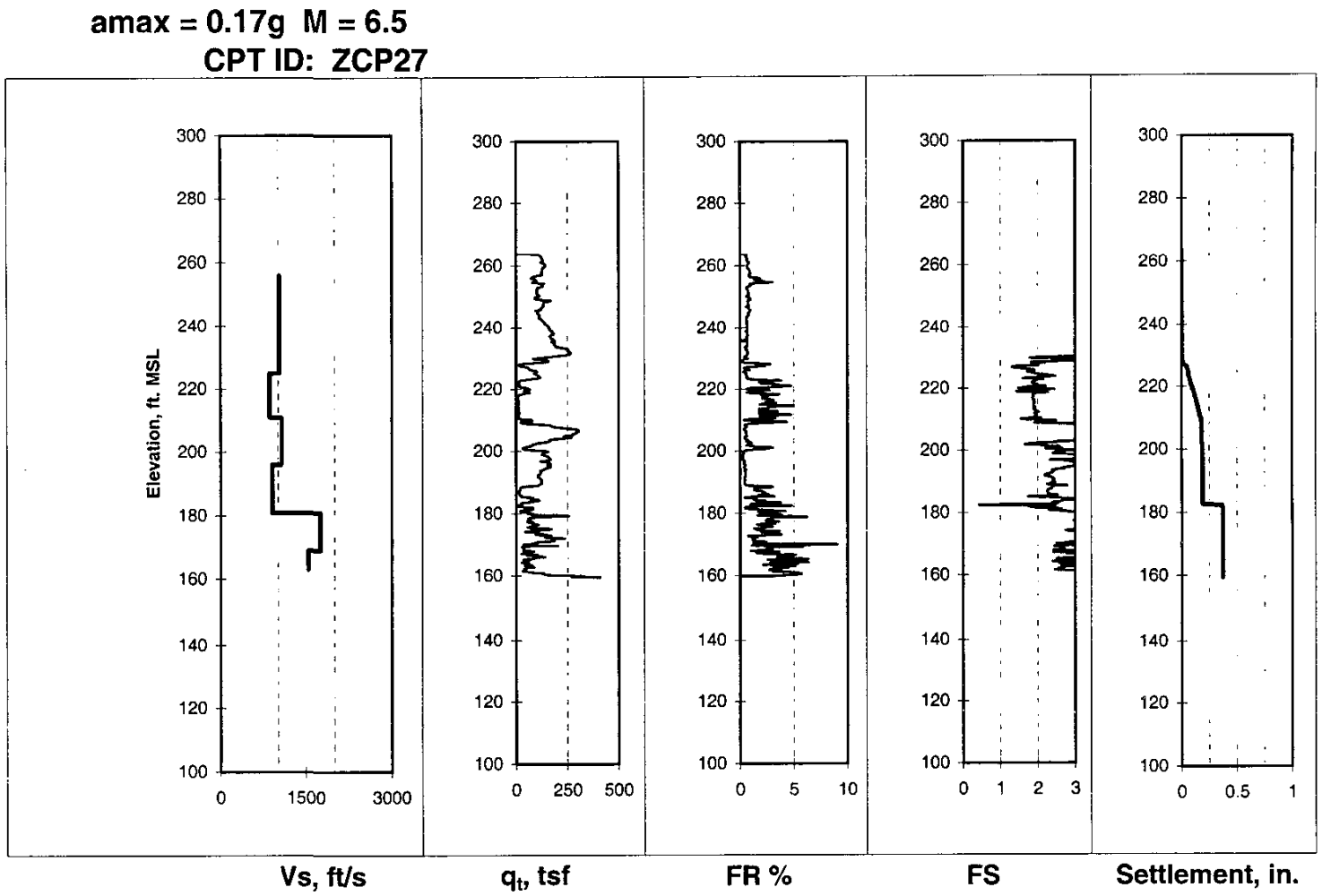


Zcp26-liq.xls

Calculation No. K-CLC-Z-00001	Sheet No. 94	Rev. 0

Figure 24e - Liquefaction Factor of Safety and Settlement vs. Elevation for SCPTu ZCP-26 and DBE

(Calculated using q_{t1} data, CPTu determined percent fines and Equations 17 – 43)

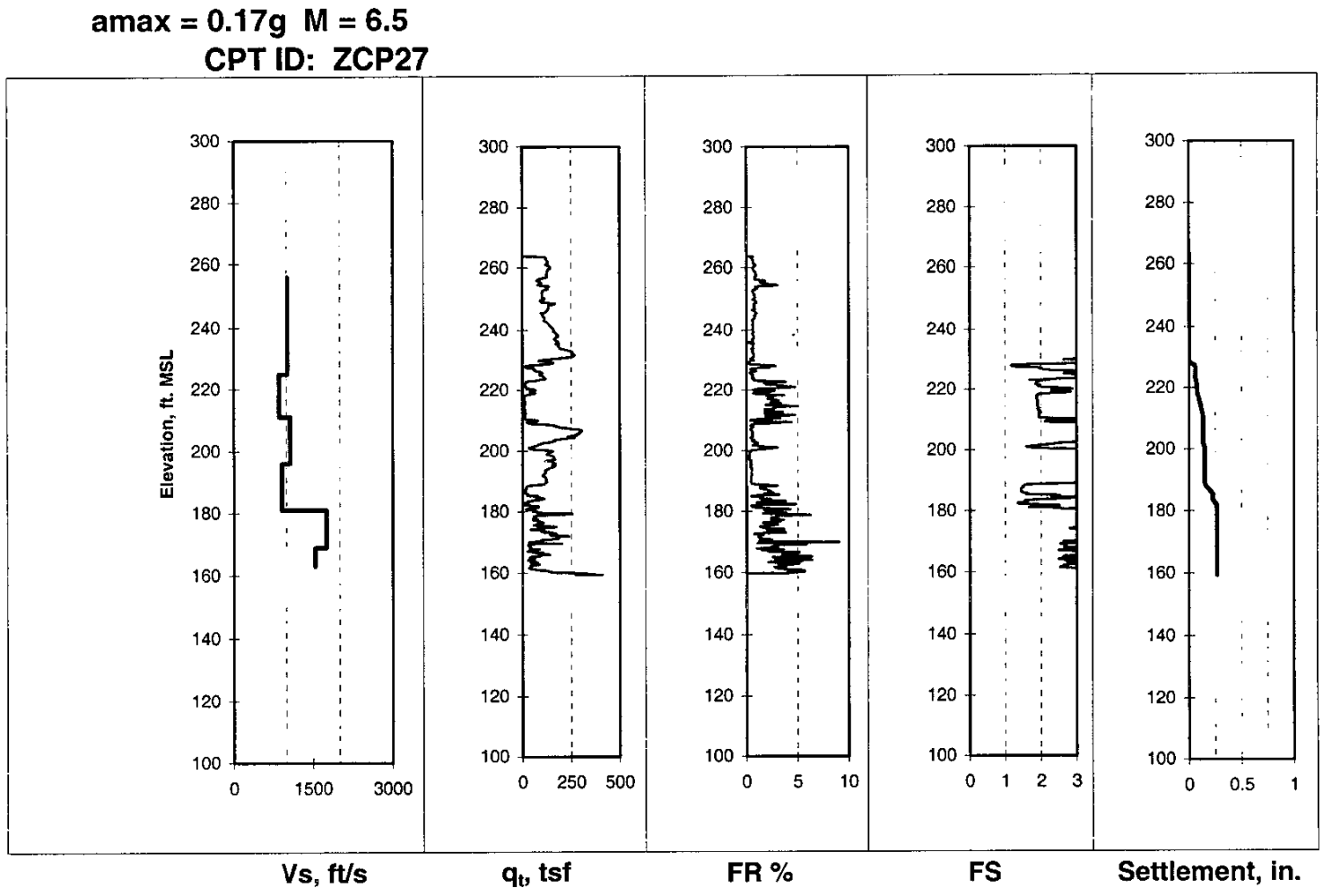


Zcp27-liq.xls

Calculation No. K-CLC-Z-00001	Sheet No. 95	Rev. 0

Figure 24f - Liquefaction Factor of Safety and Settlement vs. Elevation for SCPTu ZCP-27 and DBE

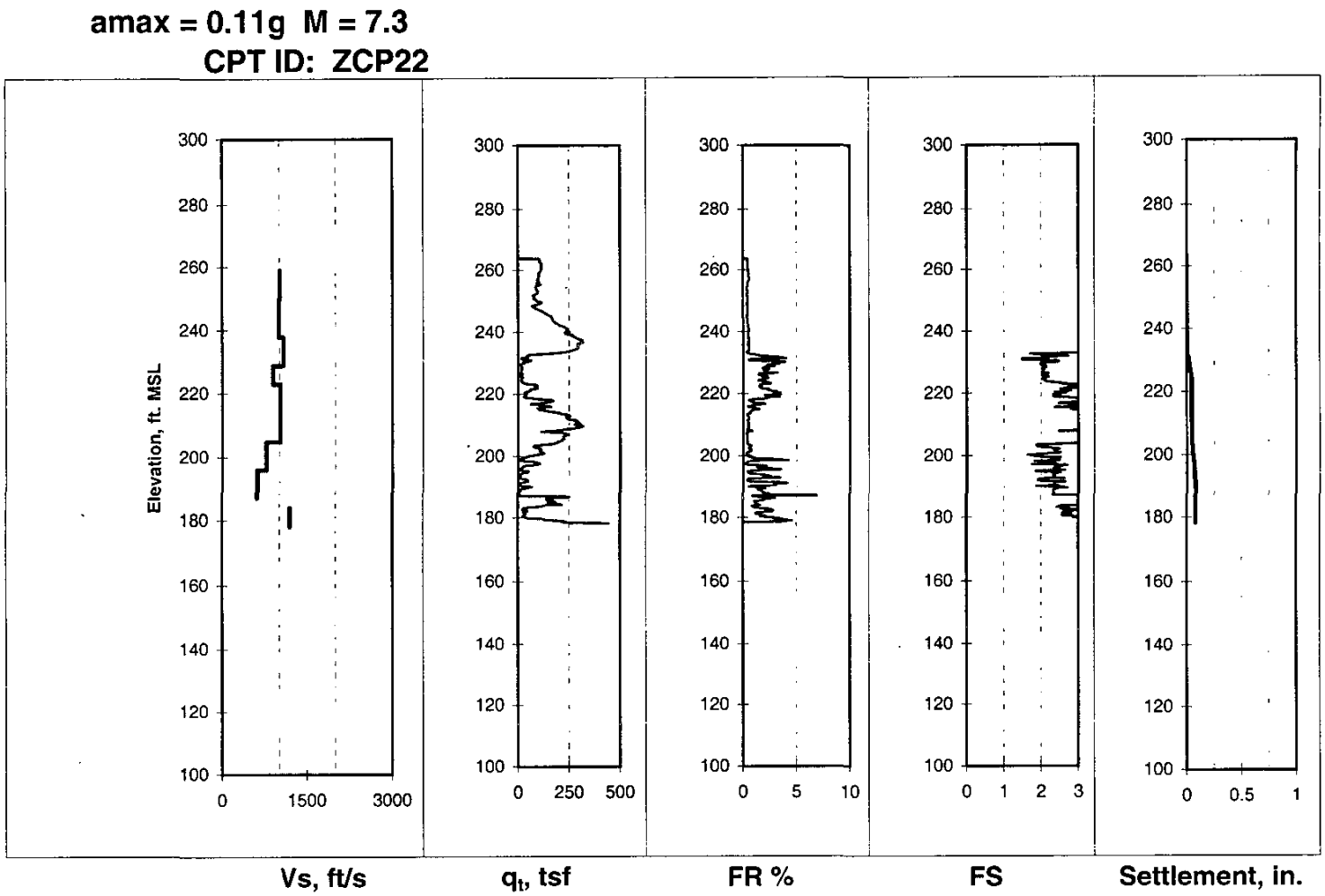
(Calculated using q_{tl} data, CPTu determined percent fines and Equations 17 – 43)



Zcp27-liq-dbe-lab.xls

Calculation No. K-CLC-Z-00001	Sheet No. 96	Rev. 0

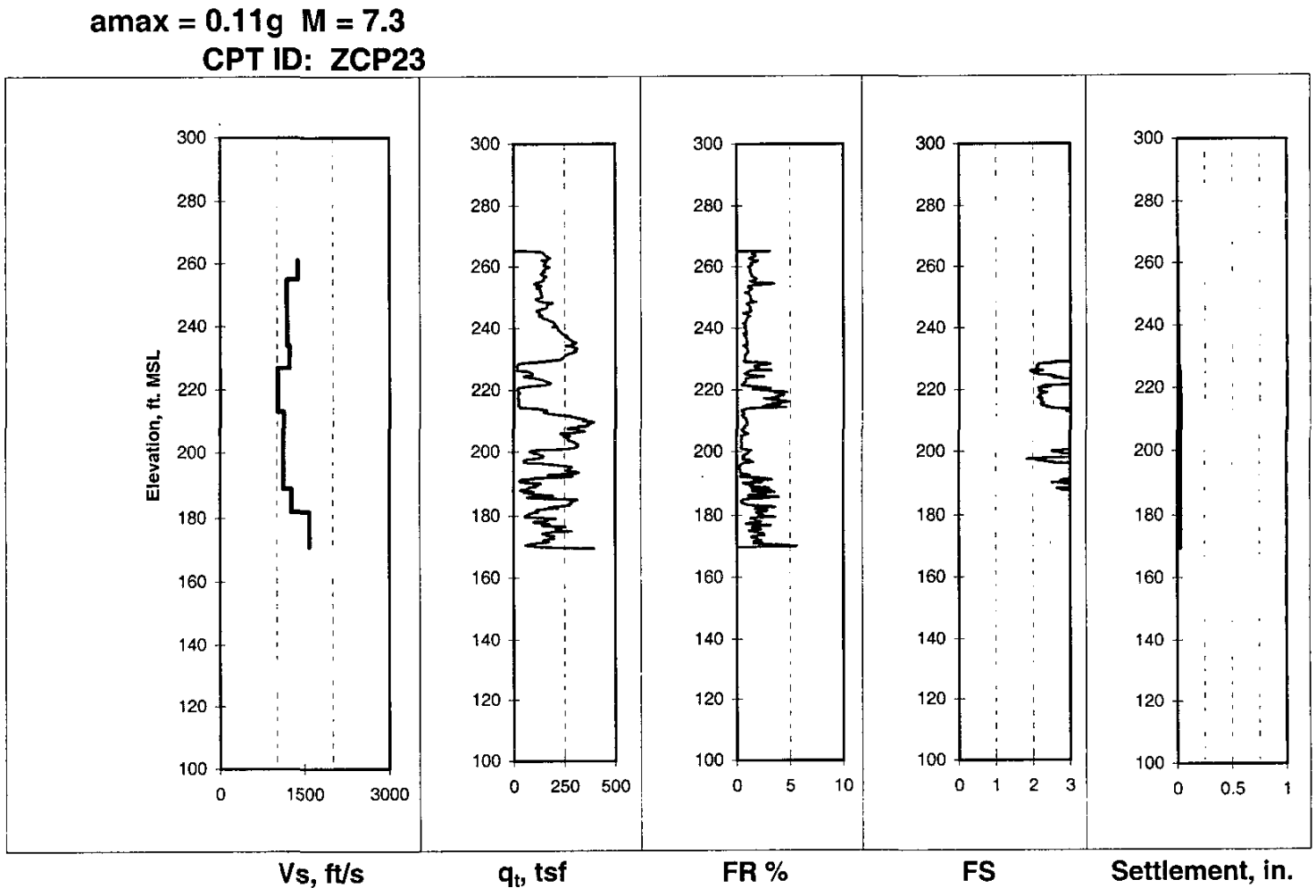
Figure 25 - Liquefaction Factor of Safety and Settlement vs. Elevation for SCPTu ZCP-27 and DBE
(Calculated using q_{tl} data, laboratory percent fines (Table 1) and Equations 17 – 23 and 26 – 43)



Zcp22-liq-ch.xls

Calculation No. K-CLC-Z-00001	Sheet No. 97	Rev. 0

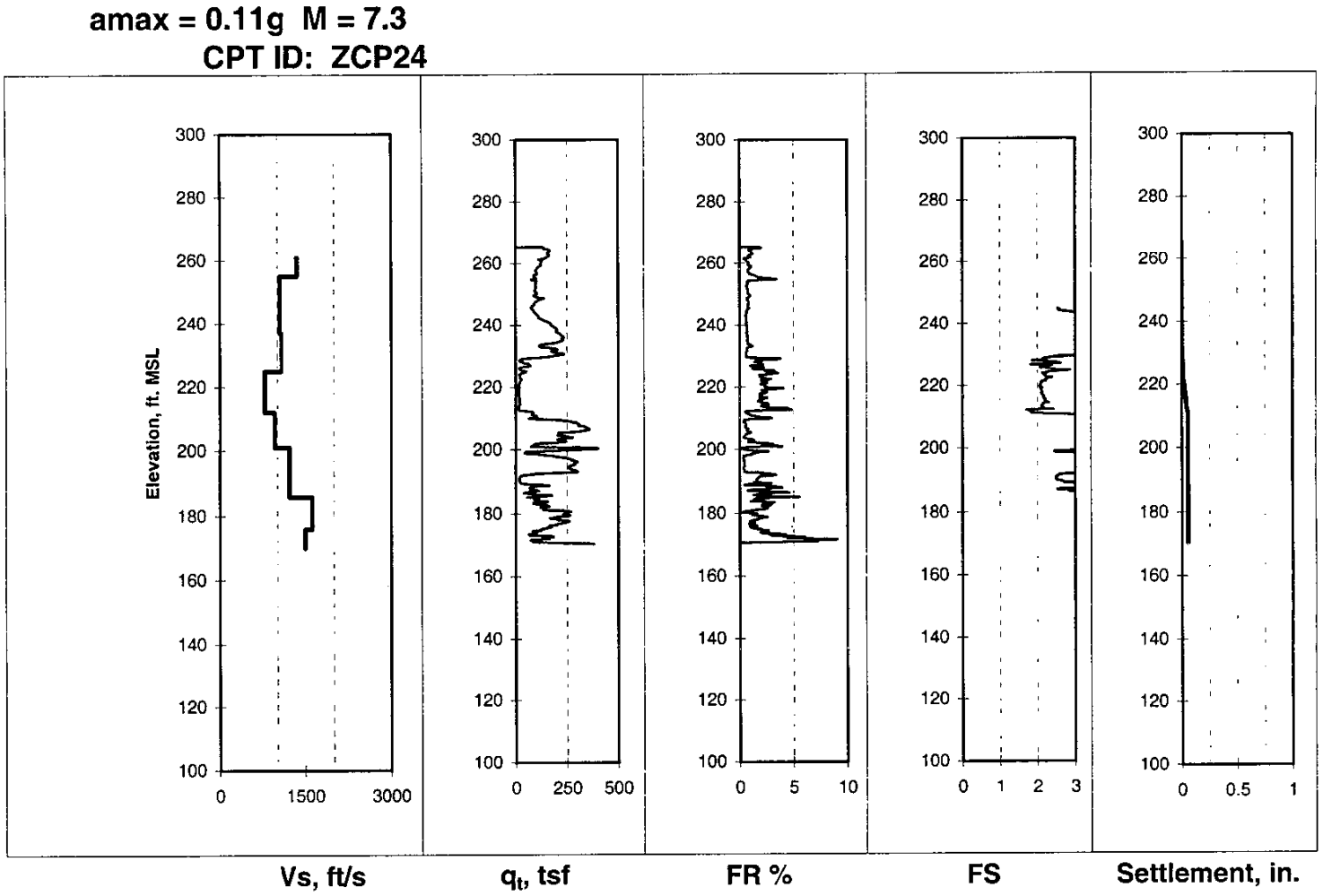
Figure 26a – Factor of Safety and Settlement vs. Elevation for SCPTu ZCP-22 and Charleston Earthquake
(Calculated using q_{t1} data, CPTu determined percent fines and Equations 17 – 43)



Zcp23-liq-ch.xls

Calculation No. K-CLC-Z-00001	Sheet No. 98	Rev. 0

Figure 26b – Factor of Safety and Settlement vs. Elevation for SCPTu ZCP-23 and Charleston Earthquake
(Calculated using q_{tl} data, CPTu determined percent fines and Equations 17 – 43)



Zcp24-liq-ch.xls

Calculation No. K-CLC-Z-00001	Sheet No. 99	Rev. 0

Figure 26c – Factor of Safety and Settlement vs. Elevation for SCPTu ZCP-24 and Charleston Earthquake
(Calculated using q_{t1} data, CPTu determined percent fines and Equations 17 – 43)