BSC	Design Calculation or Analysis Cover Sheet *Complete only applicable items.*	1. QA: QA 2. Page 1

3. System	4. Document Identifier
Wet Handling Facility	050-SYC-WH00-00700-000-00C

5. Title

Wet Handling Facility Soil Spring Constants and Damping Values - 2007 Soil Data

6. Group

Civil/Structural/Architectural

7. Document Status Designation

☐ Preliminary ☒ Committed ☐ Confirmed ☐ Cancelled/Superseded

8. Notes/Comments

Revisions A & B of this calculation were based on strain compatible soil properties given in Data Tracking Numbers (DTN) MO0706SCSPS5E4.002 and MO0706SCSPS1E4.002. These DTNs were unqualified and were subsequently superseded by DTN: MO0801SCSPS5E4.003 and DTN: MO0801SCSPS1E4.003.

Revision C of this calculation evaluates the new DTNs noted above and assess the impact on the computed impedence functions. Further explanation is provided in Section 7.1.

Attachments	Total Number of Pages
Attachment A – Wet Handling Facility Plans & Sections	17
Attachment B – Newmark Influence Charts	7
Attachment C – Exile Hill Fault Splay Location Plan	1
Attachment D – Assessment of Revised Soil Properties	16

RECORD OF REVISIONS

9. No.	10. Reason For Revision	11. Total # of Pgs.	12. Last Pg. #	13. Originator (Print/Sign/Date)	14. Checker (Print/Sign/Date)	15. EGS (Print/Sign/Date)	16. Approved/Accepted (Print/Sign/Date)
00A	Initial Issue	69	C2	Y. Sen 8/6/07	P. Gandhi 8/6/07	M. Ruben 8/7/07	Raj Rajagopal 8/7/07
00B	This revision closes CR Action #11089-001 by replacing previous Attachment C with a new Attachment C and adding Ref. 2.2.20 & 2.2.21. Pages 3, 6, 7 & 9 are revised.	68	C1	Y. Sen 11/13/07	P. Gandhi 11/13/07	J. Dockery 11/13/07	Raj Rajagopal 11/14/07
00C	See Note in Section 8 above. Pages 1, 3, 4, 6, 7-9, 11-15, 17-28, and 43 are revised and attachment D is added.	84	D16	Anant Varkekar [signature] 2/29/08	Ken McEwan [signature] 2/29/2008	J. Dockery T. FRANKERT for J.D. Thomas Frankert 2/28/08	Raj Rajagopal [signature] 2/29/08

DISCLAIMER

The calculations contained in this document were developed by Bechtel SAIC Company, LLC (BSC) and are intended solely for the use of BSC in its work for the Yucca Mountain Project.

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ACRONYMS and ABBREVIATIONS

APE	Annual Probability of Exceedance
ASCE	American Society of Civil Engineers
BSC	Bechtel SAIC Company, LLC
FEM	Finite Element Method
ITS	Important To Safety
LBE 30’, LBE100’	Lower bound estimate for 30’ and 100’ deep alluvium respectively
ME 30’, ME 100’	Median estimate for 30’ and 100’ deep alluvium respectively
NRC	U.S. Nuclear Regulatory Commission
SADA	Seismic Analysis and Design Approach Document
SASSI	System for Analysis of Soil Structure Interaction
SC	Safety Category
SNF	Spent Nuclear Fuel
SSI	Soil Structure Interaction
UBE 30’, UBE100’	Upper bound estimate for 30’ and 100’ deep alluvium respectively
WHF	Wet Handling Facility

1.0 PURPOSE

The purpose of this calculation is to compute foundation impedance functions (Soil Spring Constants and Damping Coefficients) using the 2007 strain compatible soil properties for use in seismic analysis of the Wet Handling Facility (WHF). Soil Spring values computed in the body of this calculation are based on DTNs MO0706SCSPS5E4.002 and MO0706SCSPS1E4.002 which have been superseded by DTNs shown in Refs. 2.2.2 and 2.2.3 respectively. An assessment of the impact of the super session is provided in Attachment D. The basis of design for the WHF is defined in the 000-3DR-MGR0-00300-000, *Basis of Design for the TAD Canister-Based Repository Design Concept* (Ref. 2.2.10).

The WHF is a partially embedded concrete structure with a below-grade Pool. For Tier 1 seismic analysis of the WHF, a lumped mass multiple stick model will be utilized to represent the structure. A lumped representation of the structure-foundation interaction at the base of the above ground structure at grade and at the bottom of the below ground pool will consist of soil springs computed in accordance with ASCE4-98 (Ref. 2.2.1), section 3.3.4.2. Results of this calculation will provide soil spring constants for use in the seismic analysis. Damping coefficients will also be computed for use in the seismic analysis.

Soil Spring Constants and Damping Coefficients are calculated for 2000-year return period (Annual Exceedance Frequency of 5E-4) and 10,000-year return period (Annual Exceedance Frequency 1E-4) seismic events (Ref.2.2.9).

2.0 REFERENCES

2.1 PROCEDURES/DIRECTIVES

2.1.1 (Not used)

2.1.2 BSC (Bechtel SAIC Company) IT-PRO-0011, Rev. 7, *Software Management.* Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070905.0007.

2.1.3 BSC (Bechtel SAIC Company) EG-PRO-3DP-G04B-00037, Rev. 10, *Calculations and Analyses.* Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071018.0001.

2.2 DESIGN INPUTS

2.2.1 ASCE 4-98. 2000. *Seismic Analysis of Safety-Related Nuclear Structures and Commentary*. Reston, Virginia: American Society of Civil Engineers. TIC: 253158. ISBN 0-7844-0433-X

2.2.2 MO0801SCSPS5E4.003 Strain Compatible Material Properties for the Surface Facilities Area at 5E-4 Annual Probability of Exceedance. Submittal date: 01/11/2008 2008. [DIRS 184682]

2.2.3 MO0801SCSPS1E4.003 Strain Compatible Material Properties for the Surface Facilities Area at 1E-4 Annual Probability of Exceedance. Submittal date: 01/11/2008. [DIRS 184683]

2.2.4 BSC (Bechtel SAIC Company) *Wet Handling Facility (WHF) Mass Properties.* 050-SYC-WH00-00300-000-00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070326.0001.

2.2.5 Young, W.C. 1989. *Roark's Formulas for Stress and Strain.* 6th Edition. New York, New York: McGraw-Hill. TIC: 10191. ISBN 0-072541-1

2.2.6 Bowles, J.E. 1996. *Foundation Analysis and Design.* 5th Edition. New York, New York: McGraw-Hill. TIC: 247039. ISBN 0-07-912247-7

2.2.7 Hadjian, A.H. and Ellison, B. 1985. *"Equivalent Properties for Layered Media*." *Soil Dynamics and Earthquake Engineering, 4,* (4), 203-209. [Southampton, England]: CML Publications. TIC: 255744. ISSN 0267-7261

2.2.8 Biggs, J.M. 1964. *Introduction to Structural Dynamics.* New York, New York: McGraw-Hill. TIC: 240633. ISBN 07-005255-7

2.2.9 BSC (Bechtel SAIC Company) *Project Design Criteria Document*. 000-3DR-MGR0-00100-000-007, November 2006. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071016.0005

2.2.10 BSC (Bechtel SAIC Company) *Basis of Design for the TAD Canister-Based Repository Design Concept*. 000-3DR-MGR0-00300-000-001. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071002.0042.

2.2.11 BSC (Bechtel SAIC Company) *Seismic Analysis and Design Approach Document*. 000-30R-MGR0-02000-000, Revision 001 December 2007. ACC: ENG.20071220.0029

2.2.12 (Not used)

2.2.13 (Not used)

2.2.14 (Not used)

2.2.15 (Not used)

2.2.16 BSC (Bechtel SAIC Company) *Wet Handling Facility Preliminary Layout Ground Floor and Pool Basemat Floor Plans*. 050-P0K-WH00-10101-000 Revision 00A February 2007.ACC: ENG.20070221.0002

2.2.17 BSC (Bechtel SAIC Company*) Wet Handling Facility Preliminary Layout Second Floor Plan*. 050-P0K-WH00-10102-000 Revision 00A February 2007.ACC: ENG.20070221.0003

2.2.18 BSC (Bechtel SAIC Company) *Wet Handling Facility Preliminary Layout Section A*. 050-P0K-WH00-10103-000 Revision 00A February 2007.ACC: ENG.20070221.0004

2.2.19 BSC (Bechtel SAIC Company) *Wet Handling Facility Preliminary Layout Section B*. 050-P0K-WH00-10104-000 Revision 00A February 2007.ACC: ENG.20070221.0005

2.2.20 SNL (Sandia National Laboratories) 2008. Technical Report: *Geotechnical Data for a Geological Repository at Yucca Mountain, Site Nevada.* TDR-MGR-GE-000010. Rev 00. Las Vegas, Nevada: Sandia National Laboratories. [DIRS 183779]

2.2.21 BSC (Bechtel SAIC Company) 2007. *Nuclear Facilities Buildings Exile Hill Fault Splay Location Plan*. 100-S0K-MGR0-00101-000 Revision 00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071107.0001.

2.3 DESIGN CONSTRAINTS

None.

2.4 DESIGN OUTPUTS

This Calculation will be used as input for calculation 050-SYC-WH00-00800-000, WHF Tier 1 Seismic Analysis – 2007 Geotechnical Data.

3.0 ASSUMPTIONS

3.1 ASSUMPTIONS REQUIRING VERIFICATION

3.1.1 This calculation is based on WHF plans and sections shown in *Wet Handling Facility Preliminary Layout* 050-P0K-WH00-10301-000 to 050-P0K-WH00-10601-000 Rev. 00A (ACC: ENG.20060920.0004 to ENG.20060920.0007) and sketches shown in Attachment A. Although the layout drawings have been superseded by references 2.2.16, 2.2.17, 2.2.18, and 2.2.19, there are no significant changes to building dimensions or wall locations. The pool configuration and dimensions are taken from the later sketches in Ref. 2.2.16 to 2.2.19.

Rationale: The main difference between the two sets of drawings is the changing column lines and wall openings in the revised WHF floor plans and Attachment A is used to provide a general draft layout only. These changes or differences do not impact the mass properties, soil spring constants and the stick model results. A soil-structure interaction analysis using SASSI and detailed FEM using References 2.2.16, 2.2.17, 2.2.18, 2.2.19 and approved WHF general arrangement drawings will supersede the results of this preliminary analysis. This assumption is being tracked in CalcTrac.

Where used: Section 6 and Attachment A.

3.1.2 The lateral soil resistance provided by the vertical walls of the subgrade pool is neglected.

Rationale: Neglecting the lateral soil resistance will result in a conservative dynamic behavior for the structure as a whole in this preliminary analysis. To assess their effects, such as static and dynamic lateral earth pressures, hydrostatic and hydrodynamic pressures, etc., on the underground pool walls, an evaluation will be made in a separate future calculation. Eventually, more realistic results from more sophisticated finite element structural model along with SASSI analysis in Tier 2 will be used to supersede results of the Tier 1 analysis. This assumption is being tracked in CalcTrac.

Where used: Section 4.3.

3.1.3 Per ASCE 4-98 (Ref. 2.2.1), section 3.3.4.2, the equivalent damping coefficients will be calculated based on the gross footprint dimensions of the basemat at the grade ignoring the pool pit, which includes the net area of the basemat at the grade and the area of the pool basemat.

Rationale: The approach is reasonable since the soil damping is typically due to the radiation damping from equivalent footprint (soil contact area dimensions). The effects of embedment (side contact area) is conservatively disregarded. Neglecting effects of embedment is conservative because the embedment effects tend to increase damping values, see Table C.3.3-1 of ASCE 4-98 (Ref. 2.2.1). Eventually, more realistic results from more sophisticated finite element structural model along with SASSI analysis in Tier 2 will be used to supersede results of the Tier 1 analysis. This assumption is being tracked in CalcTrac.

Where used: Section 6.2.3.2.

3.2 ASSUMPTIONS NOT REQUIRING VERIFICATION

None

4.0 METHODOLOGY

4.1 QUALITY ASSURANCE

This calculation was prepared in accordance with procedure EG-PRO-3DP-G04B-00037, *Calculation and Analysis,* (Ref. 2.1.3). Section 5.1.2 of the *Basis of Design for the TAD Canister-Based Repository Design Concept* (Ref. 2.2.10), classifies the WHF structure as ITS. Therefore, this calculation is subject to the requirements of the BSC *Quality Management Directive*. The approved record version of this calculation is designated QA: QA.

4.2 USE OF SOFTWARE

The commercially available software Microsoft Excel 2003 and Microsoft Word 2003, which are the components of Microsoft Office 2003 Professional, are used in preparing this calculation. The use of Microsoft 2003 Professional in this calculation constitutes Level 2 software usage as defined in Section 4 and Attachment 12 of IT-PRO-0011, *Software Management* (Ref. 2.1.1). Microsoft 2003 Professional is listed in the current Controlled Software Report. Microsoft Office was executed on a PC with X86 Architecture running the Microsoft Windows XP Professional Version 2002 Service Pack 2 operating system.

The Microsoft Word 2003 was utilized in general to prepare this calculation. The excel spreadsheet of the Microsoft Excel 2003 was utilized to calculate common formulas; such as, additions, multiplication, division, etc. The related formulas are listed in section 6 and the calculated results were verified by checks using manual calculations. The figures, sketches and graphical representations have been verified versus source data by visual inspection. The calculation process and equations are documented in Section 6 of this calculation.

4.3 DESIGN METHOD

The soil impedence functions computed in Section 6 and summarized in Section 7.1 are based on data contained in DTN MO0706SCSPS5E4.002 and MO0706SCSPS1E4.002 which have been superseded by Ref 2.2.2 and 2.2.3 respectively. The impact of the superseding data given in references 2.2.2 and 2.2.3 on the computed impedence functions is addressed in Appendix D of this calculation. Results of this assessment are discussed in Section 7.1.

The "frozen" structural layout as of 9/25/06 of the Wet Handling Facility, 270' x 214', as shown in Attachment A, is based on the general layout as discussed in Assumption 3.1.1. This "frozen" WHF layout, Attachment A, forms the basis for defining the structural configuration of the building, basemat, shear walls, diaphragms and known penetrations (block outs/openings).

The WHF is located south of the Exile Hill Fault Splay as shown in Attachment C (Ref. 2.2.21). Per Ref 2.2.20, the soil data indicates 30, 70 and 100 ft thick alluvium under the WHF. To envelope the potential seismic effects, the bounding soil properties of 30 ft and 100 ft thick alluvium will be used in the evaluation.

The lateral soil resistance provided by the vertical walls of the subgrade pool is neglected as discussed in assumption 3.1.2.

Frequency independent soil springs and corresponding damping coefficients are computed in accordance with ASCE 4-98 Section 3.3.4.2 (Ref. 2.2.1) using equations for a rectangular foundation given in ASCE 4-98, Table 3.3-3 (Ref. 2.2.1). Soil springs are a function of the foundation plan dimensions B and L, the soil dynamic shear modulus and Poisson's ratio. Damping coefficients are computed using Table 3.3-1 from ASCE 4-98 (Ref. 2.2.1). Computation of the dynamic shear modulus is discussed in Section 6 of this calculation.

5.0 LIST OF ATTACHMENTS

		Number of Pages
Attachment A	Wet Handling Facility Plan & Sections	17
Attachment B	Newmark Influence Charts	7
Attachment C	Exile Hill Fault Splay Location Plan	1
Attachment D	Assessment of revised soil properties	16

6.0 BODY OF CALCULATIONS

6.1 INPUTS

Per "*Basis of Design for the TAD Canister-Based Repository Design Concept*" (Ref. 2.2.10) and "*Seismic Analysis and Design Approach Document"* (Ref. 2.2.11), the following soil property will be utilized for the Wet Handling Building in this calculation.

- MO0801SCSPS5E4.003 (Ref. 2.2.2), *Strain Compatible Soil Properties for the Surface Facilities Area at 5E-4 APE* and MO0801SCSPS1E4.003 (Ref. 2.2.3), *Strain Compatible Soil Properties for the Surface Facilities Area at 1E-4 APE* provide the soil properties used in this calculation.

- Mass and mass moment of inertia calculated in Ref. 2.2.4 (which use coordinate system : x- , y- , and z- corresponding to east, upward, and south, respectively), are used in this calculation. This 'WHF Soil Springs' calculation uses X as east/west, Y as north/south and Z as vertical.

- This calculation is based on WHF plans and sections shown in Attachment A, with references discussed in Assumption 3.1.1.

6.2 CALCULATIONS

6.2.1 Basic Equations

The Wet Handling Facility (WHF) rests on a layered alluvial material with varying properties. For purposes of dynamic analysis of the soil-structure interaction problem, it will be necessary to define the foundation impedance functions. For use in the preliminary seismic analysis, a set of frequency independent soils springs and corresponding damping coefficients will be computed in accordance with ASCE 4-98 Section 3.3.4.2 (Ref. 2.2.1).

Since the shear wave velocity and thus the dynamic shear modulus varies with depth, an equivalent shear modulus needs to be computed for use in determining the frequency independent soil springs. A method for solving this problem is discussed in a paper " *Equivalent Properties for Layered Media*" by A.H Hadjian and Byrwec Ellison published in *Soil Dynamics and Earthquake Engineering*, 1985 Volume 4 No. 4 (Ref. 2.2.7). The method derived in this paper is appropriate for computing soil spring in layered media in soil-structure interaction analysis. The method discussed in the paper is summarized below:

The relative vertical layer displacements are given by:

$\Delta_1 = (P * h_1)/ (A_1*E_1) = (q_1*h_1)/ E_1$ Where P = Dead Weight of Building

$\Delta_2 = (P * h_2)/ (A_2*E_2) = (q_2*h_2)/ E_2$ h_n = Thickness of soil layer n

$\Delta_n = (P * h_n)/ (A_n*E_n) = (q_n*h_n)/ E_n$ A_n= Effective area at layer n

(Ref. Young 1989, Page 76, eq. 3) (Reference 2.2.5)

E_n = Modulus of Elasticity for soil layer, n

q_n = Boussinesq coefficient from Newmark's influence diagrams (Ref. 2.2.6)

Thus the total displacement is : $\Delta = (q_1*h_1)/ E_1 + (q_2*h_2)/ E_2 + \ldots..(q_n*h_n)/ E_n$ (Eq 1)

If the elastic modulus were uniform throughout the medium, the total displacement would be calculated as:

$$\Delta = (q_1*h_1)/ E + (q_2*h_2)/ E + \ldots..(q_n*h_n)/ E$$

or

$$\Delta = \{(q_1*h_1) + (q_2*h_2) + \ldots..(q_n*h_n)\} / E \qquad \text{(Eq 2)}$$

For the displacements to be equal, the equivalent modulus of elasticity may be computed by equating Eq. 1 and Eq. 2, which yields:

$$E = \{(q_1*h_1) + (q_2*h_2) + \ldots..(q_n*h_n)\} / \{(q_1*h_1)/ E_1 + (q_2*h_2)/ E_2 + \ldots..(q_n*h_n)/ E_n\}$$

Which may be rewritten as:

$$E = \frac{\sum_{i=1}^{n}(q_i * h_i)}{\sum_{i=1}^{n}(q_{i*}h_i / E_i)} \qquad \text{(Eq 3)}$$

Once E has been determined the dynamic shear modulus of soil can be computed as G' = E / 2*(1 + μ) where μ is Poisson's ratio for the soil.

Process

1. Divide the soil media into layers and determine the representative shear wave velocity for each layer. Figures 1 through 4 are plots of the shear wave velocity versus depth for the 30' and 100' alluvium cases. The soil has been divided into 45 layers for the 30' and the 100' alluvium cases. The shear wave velocity for each layer was taken from MO0706SCSPS5E4.002 and MO0706SCSPS1E4.002.

2. Compile a table of shear and compression wave velocities and densities for each layer based on MO0706SCSPS5E4.002 and MO0706SCSPS1E4.002 strain compatible soil properties.

3. Compute dynamic shear modulus, G_n, for each layer based on the shear wave velocities for each layer using Eq. 20-15 from Bowles' *Foundation Analysis and Design*, 5th Edition (Ref. 2.2.6).

4. Compile the Poisson's ratio for each individual soil layer based on MO0706SCSPS5E4.002 and MO0706SCSPS1E4.002 strain compatible soil properties and compute the average equivalent Poisson's ratio as $\nu_a = \Sigma h_n * \nu_n / \Sigma h_n$.

5. Compute soil modulus E_n using the calculated Poisson's ratio for each individual soil layer based on the G' value computed in step 3.

6. Determine the Newmark influence coefficient (q_n) using Figure 5 for the midpoint depth of each layer. A discussion of Newmark's influence coefficient is given below.

   To determine the Newmark influence coefficient, the foundation is plotted to scale on Newmark's influence chart (Ref. Bowles' *Foundation Analysis and Design*, 5th ed. Page 290) (Reference 2.2.6). The scale of the drawing is determined by the depth at which the soil stress is being evaluated. The 'scale line' segment is set equal to the depth at which the soil stress is desired, thus if the desired depth is 300 feet then 'scale line' is set equal to 300 ft and the foundation is drawn at that scale. The number of units covered by the foundation are counted and the influence coefficient is calculated by multiplying the number of units counted by the influence value of the chart, in our case the charts influence value is .005 (There are 200 units on the chart; therefore, the influence value is 1/200 = 0.005). This procedure was done for depths of 50', 100', 200', 300', 400', and 500'. These plots are shown in Attachment B. A smoothed plot of the resulting influence coefficients as a function of depth with data tabulation is given in Figure 5.

7. For the grade basemat, compute an equivalent E for the entire depth to 460' using equation 3. Similarly, an equivalent E for pool basemat are computed for depth from 55' and 56' to 460'. (Note as the soil properties in MO0706SCSPS5E4.002 and MO0706SCSPS1E4.002 are given at layer depth 55' and 56' respectively, those values are used in the calculation. This will not have any significant effect in the results.)

8. Using the equivalent E from step 6 compute an equivalent shear modulus, Gs (see section 6.2.2).

9. Compute soil spring constants (see section 6.2.3.1) using ASCE 4-98 (Ref. 2.2.1) with the shear modulus values computed in step 8.

10. Compute soil damping coefficients (see section 6.2.3.2) using ASCE 4-98 (Ref. 2.2.1).

Source: MO0706SCSPS5E4.002

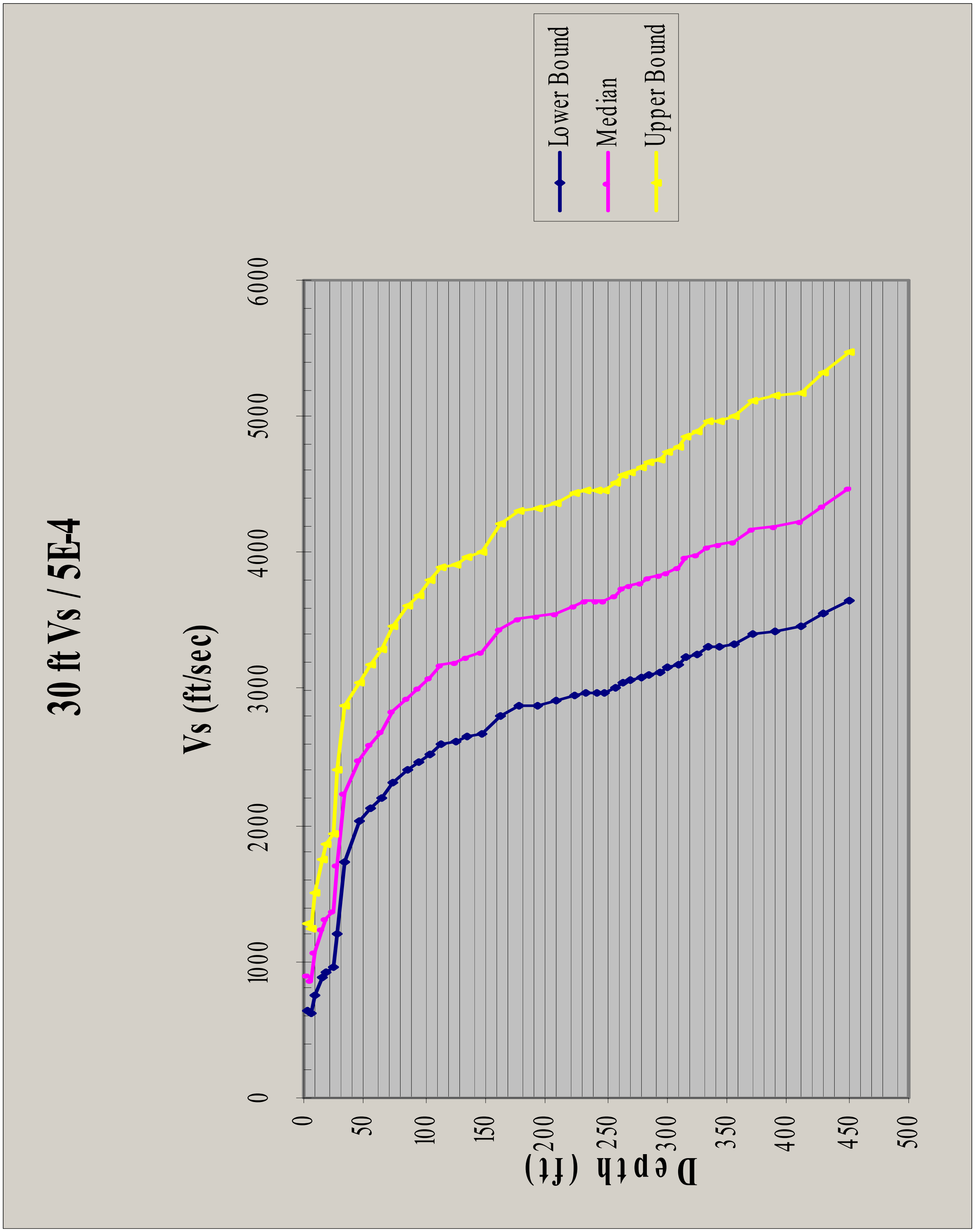


Figure 1. 5E-4 Shear Wave Velocity for 30' Alluvium Over Tuff

Source:MO0706SCSPS5E4.002

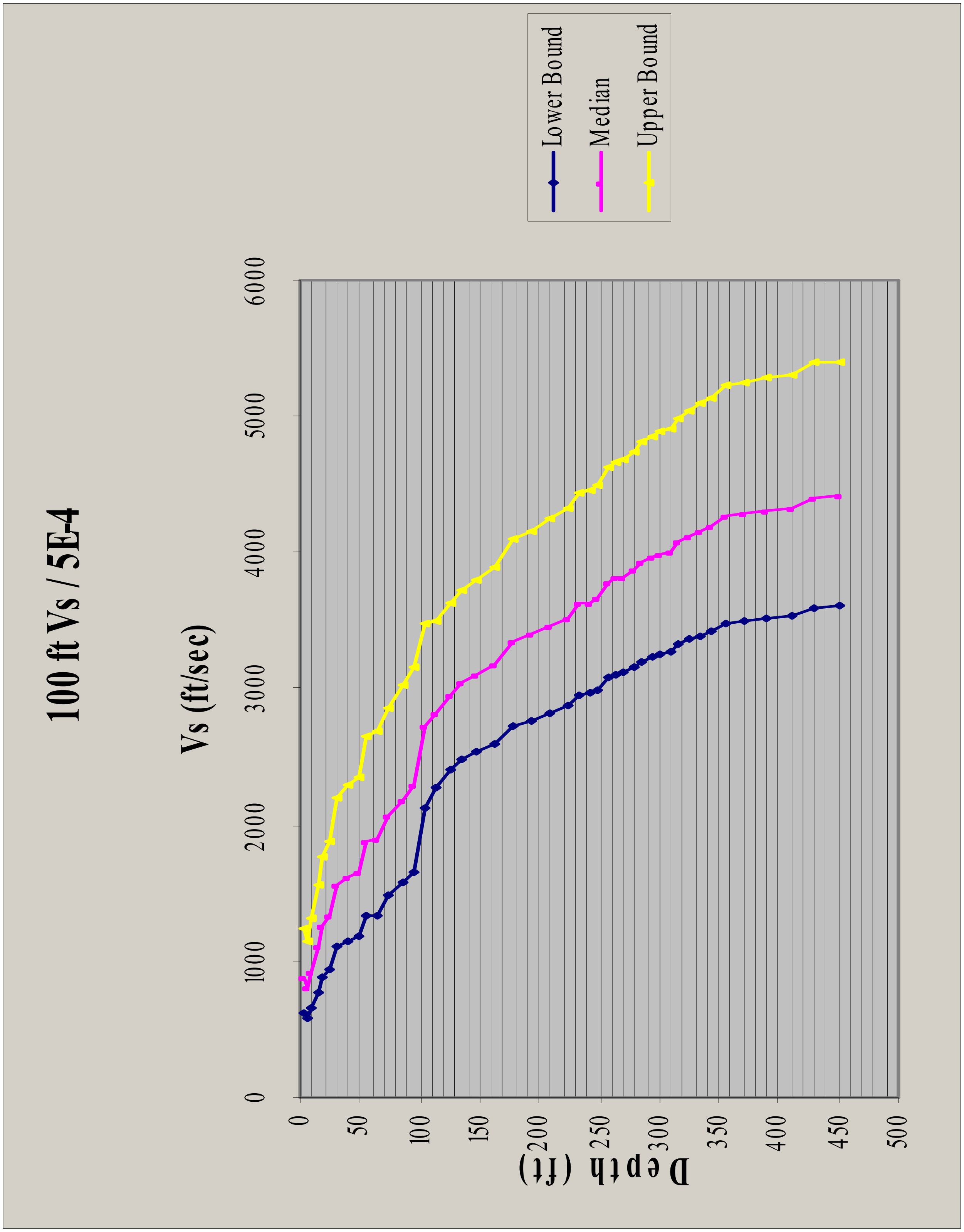


Figure 2. 5E-4 Shear Wave Velocity for 100' Alluvium Over Tuff

Source: MO0706SCSPS1E4.002

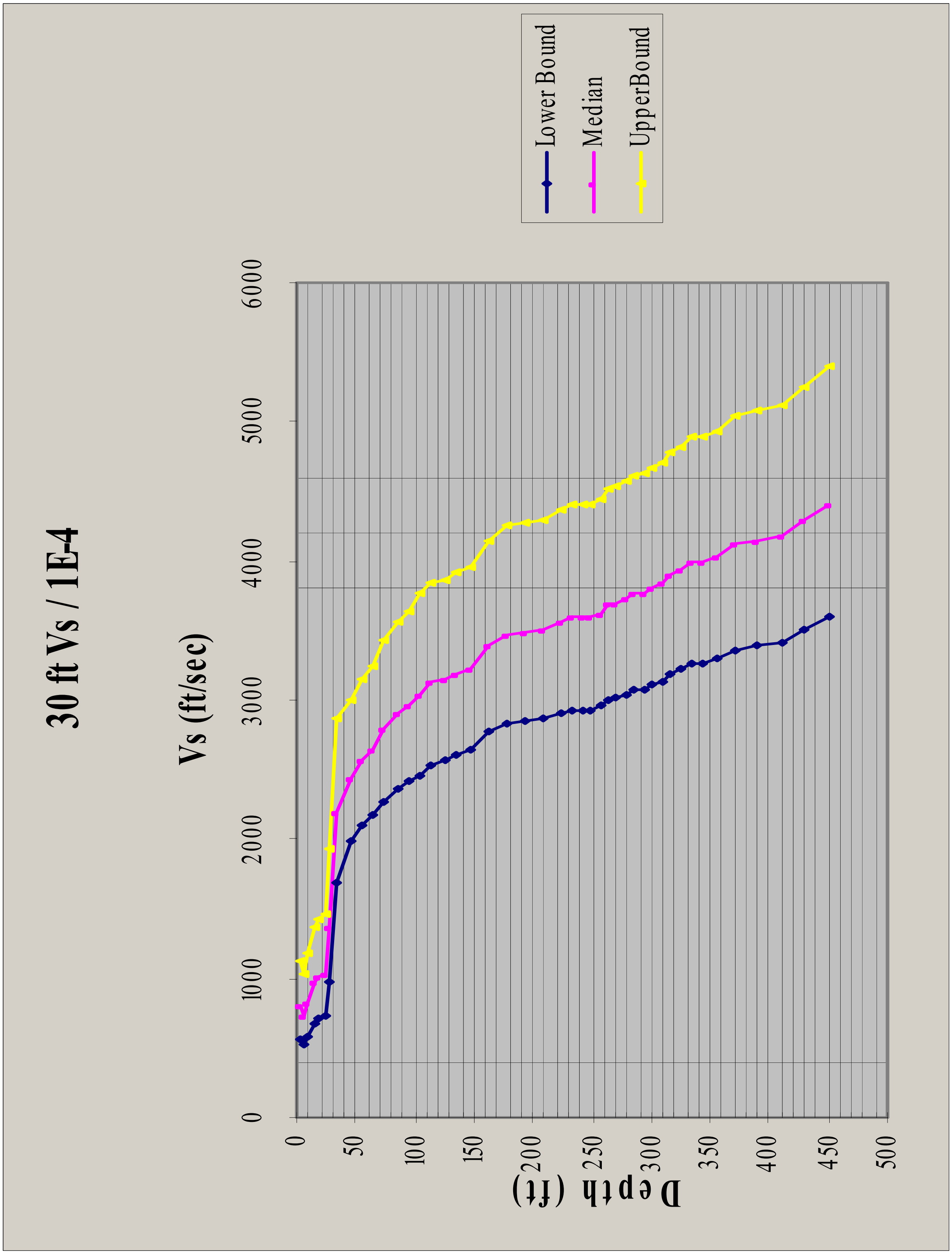


Figure 3. 1E-4 Shear Wave Velocity for 30’ Alluvium Over Tuff

Source: MO0706SCSPS1E4.002

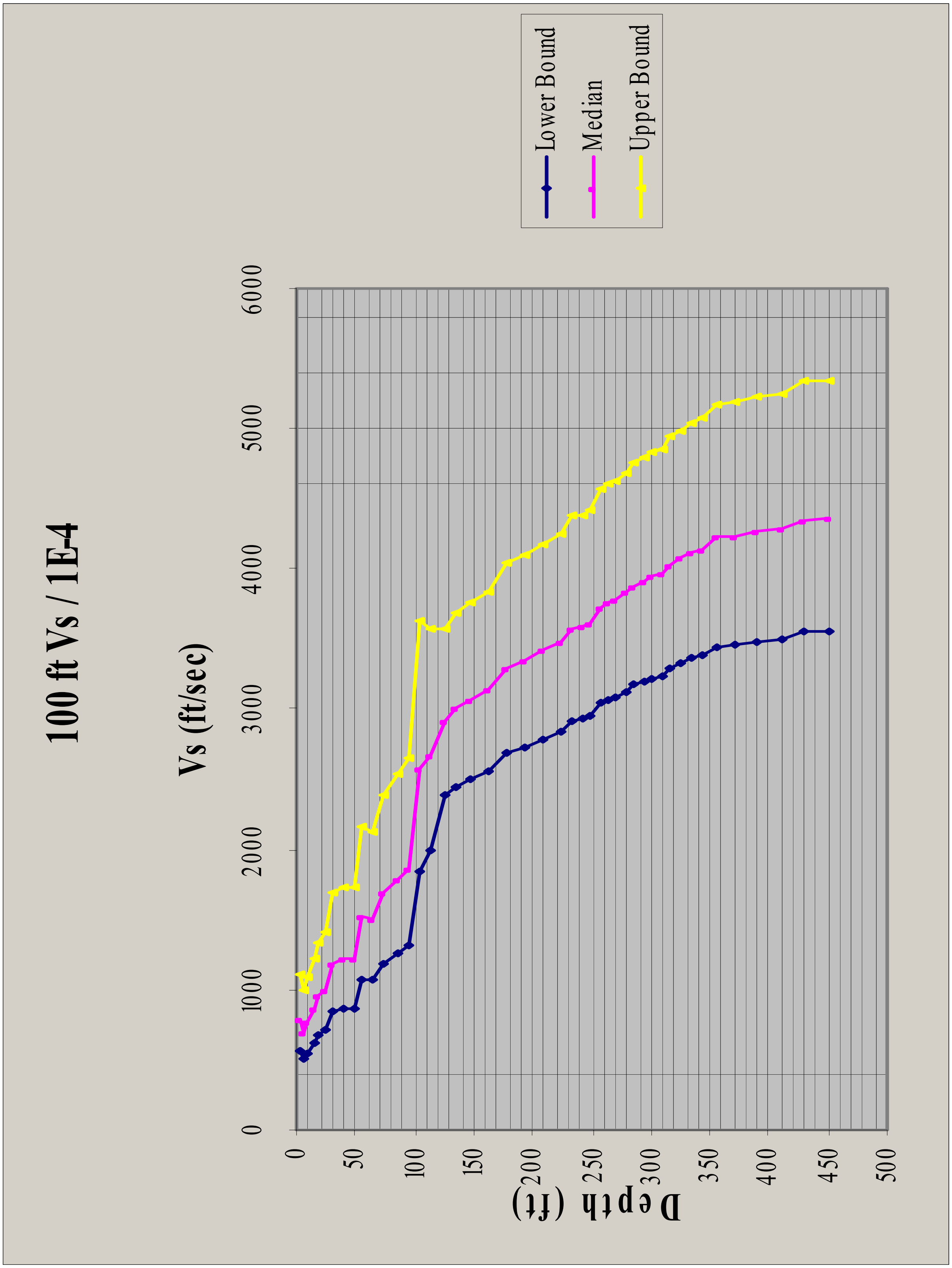
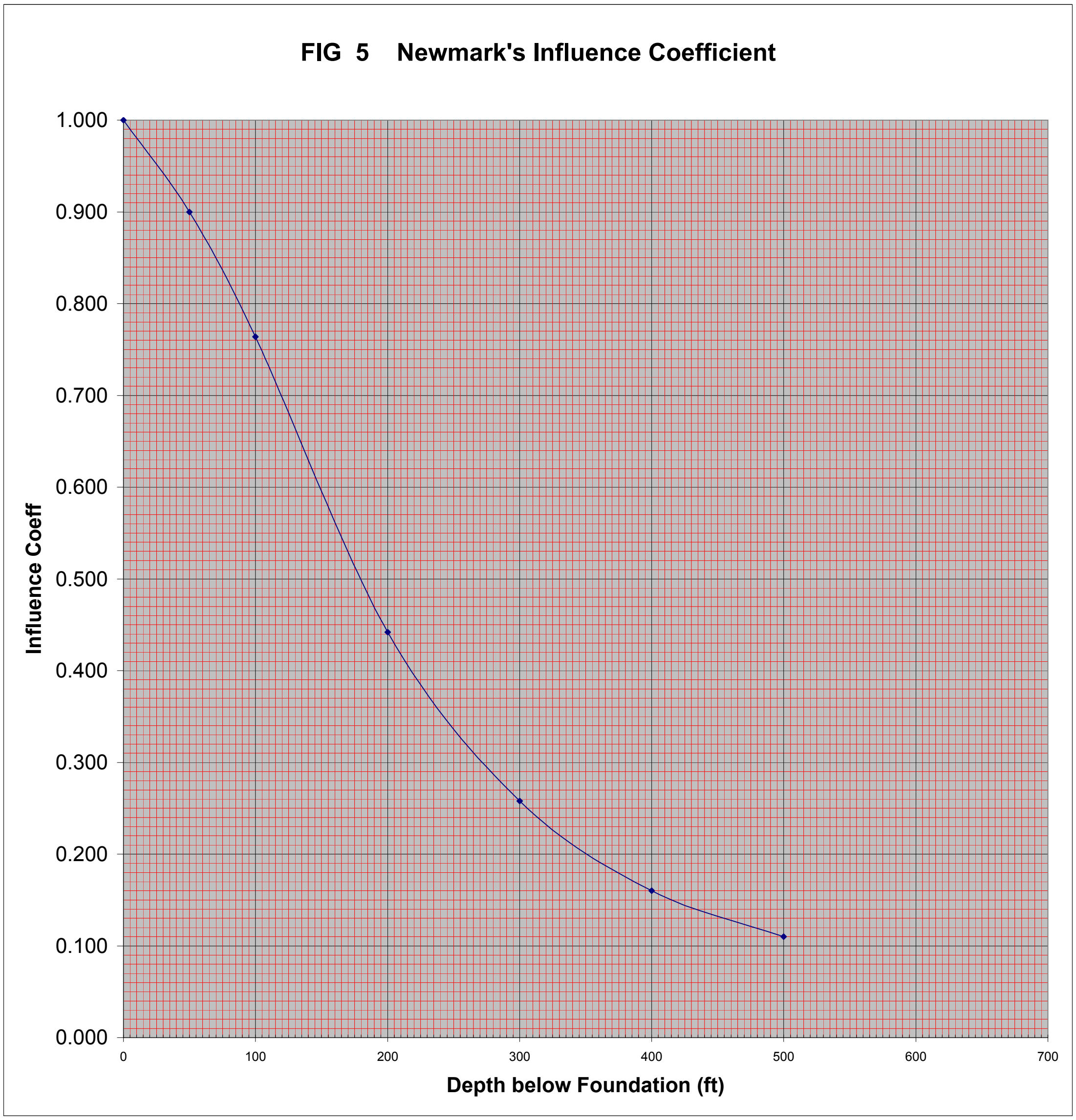


Figure 4. 1E-4 Shear Wave Velocity for 100' Alluvium Over Tuff



(Smoothed plot per section 6.2.1 & Attachment B)

Depth	Coeff
0.0	1.000
2.0	0.996
6.0	0.988
10.0	0.981
14.0	0.973
18.0	0.964
24.0	0.953
29.0	0.944
32.0	0.938
35.0	0.932
40.0	0.922
45.0	0.911
48.0	0.903
50	0.9
55.0	0.876
56.0	0.886
65.0	0.862
75.0	0.836
85.0	0.808
95.0	0.778
100	0.764
105.0	0.748
115.0	0.715
125.0	0.681
135.0	0.645
147.5	0.605
162.5	0.554
177.5	0.507
192.5	0.461
200	0.442
207.5	0.424
222.5	0.39
233.8	0.366
241.3	0.352
248.8	0.338
256.3	0.326
263.8	0.312
271.3	0.302
278.8	0.289
286.3	0.278
293.8	0.267
300	0.258
301.3	0.257
308.8	0.247
316.3	0.237
325.1	0.227
335.1	0.216
345.1	0.205
355.1	0.197
370.0	0.183
390.0	0.168
400	0.16
410.0	0.154
430.0	0.142
450.0	0.132
500.0	0.11

6.2.2 Equivalent Shear Modulus

The following spreadsheets are utilized to determine the dynamic shear modulus G_s for the lower bound, median, and upper bound soil profiles for both the 30' depth of alluvium and 100' depth of alluvium conditions based on the methodology discussed above.

6.2.2.1 Equivalent Shear Modulus for 5E-4 annual exceedance frequency

5E-4 Lower Bound Estimate : 30' Depth of Alluvium

Calculation of Equivalent Shear Modulus :

(A) Lower Bound Values :
Ref.: MO0706SCSPS5E4.002 for Strain Compatible Soil Properties.

Using 30', Lower Bound Curve : Dynamic Shear Modulus of Soil, $G' = (\gamma / 32.17$, Mass Density) x (V_s, Velocity)^2
Ref.: Bowles Foundation Analysis and Design, 5th ed., Eq (20-15), Ref. 2.2.6.

Width of Building (W) = : 214 ft (Ref. 2.2.16)

NO	LAYER THICKNESS h_n (ft)	DEPTH (Z) TO CTR / LAYER (ft)	DENSITY γ (pcf)	SHEAR WAVE VELOCITY Vs (ft/s)	DYNAMIC SHEAR MODULUS G_n (ksf)	POISSON'S RATIO[a] ν		ELASTIC MODULUS E_n (ksf) [b]	Z / W	INFLUENCE COEFF q_n [c]	q_n*h_n	q_n*h_n/E_n
	(1)	(2)	(3)	(4)	(5)	(7)	(8)=(1)x(7)	(9)	(10)	(11)	(12)	(13)
1	4.00	2.00	112.32	634.96	1407.7	0.37	1.470	3849.8	0.009	0.996	3.984	1.035E-03
2	4.00	6.00	112.32	616.40	1326.6	0.39	1.548	3679.8	0.028	0.988	3.952	1.074E-03
3	4.00	10.00	112.32	756.04	1995.7	0.39	1.551	5538.7	0.047	0.981	3.924	7.085E-04
4	4.00	14.00	112.32	877.03	2685.6	0.39	1.549	7451.1	0.065	0.973	3.892	5.223E-04
5	4.00	18.00	112.32	928.65	3011.0	0.39	1.555	8363.0	0.084	0.964	3.856	4.611E-04
6	8.00	24.00	112.32	965.94	3257.7	0.39	3.128	9062.8	0.112	0.953	7.624	8.412E-04
7	2.00	29.00	112.32	1208.10	5095.8	0.36	0.730	13911.0	0.136	0.944	1.889	1.358E-04
8	10.00	35.00	137.28	1736.80	12872.3	0.28	2.823	33011.5	0.164	0.932	9.320	2.823E-04
9	10.00	45.00	137.28	2030.50	17593.9	0.28	2.777	44957.7	0.210	0.911	9.110	2.026E-04
10	10.00	55.00	137.28	2124.10	19253.3	0.27	2.737	49047.1	0.257	0.876	8.760	1.786E-04
11	10.00	65.00	137.28	2195.60	20571.3	0.27	2.731	52379.6	0.304	0.862	8.620	1.646E-04
12	10.00	75.00	137.28	2313.10	22832.1	0.27	2.680	57900.3	0.350	0.836	8.360	1.444E-04
13	10.00	85.00	137.28	2402.90	24639.3	0.27	2.704	62604.9	0.397	0.808	8.080	1.291E-04
14	10.00	95.00	137.28	2456.90	25759.1	0.27	2.731	65586.3	0.444	0.778	7.780	1.186E-04
15	10.00	105.00	137.28	2521.70	27135.8	0.28	2.756	69226.2	0.491	0.748	7.480	1.081E-04
16	10.00	115.00	137.28	2590.60	28638.9	0.28	2.760	73086.6	0.537	0.715	7.150	9.783E-05
17	10.00	125.00	137.28	2606.00	28980.4	0.28	2.756	73934.3	0.584	0.681	6.810	9.211E-05
18	10.00	135.00	137.28	2642.70	29802.4	0.28	2.771	76120.2	0.631	0.645	6.450	8.473E-05
19	15.00	147.50	137.28	2676.50	30569.7	0.28	4.192	78224.7	0.689	0.605	9.075	1.160E-04
20	15.00	162.50	137.28	2803.80	33546.7	0.28	4.206	85907.8	0.759	0.554	8.310	9.673E-05
21	15.00	177.50	137.28	2874.60	35262.3	0.28	4.254	90527.6	0.829	0.507	7.605	8.401E-05
22	15.00	192.50	137.28	2885.90	35540.1	0.28	4.256	91247.1	0.900	0.461	6.915	7.578E-05
23	15.00	207.50	137.28	2907.40	36071.6	0.28	4.243	92549.7	0.970	0.424	6.360	6.872E-05
24	15.00	222.50	137.28	2953.70	37229.7	0.29	4.277	95687.7	1.040	0.39	5.850	6.114E-05
25	7.50	233.75	137.28	2975.20	37773.6	0.29	2.151	97211.2	1.092	0.366	2.745	2.824E-05
26	7.50	241.25	137.28	2977.40	37829.5	0.29	2.168	97530.5	1.127	0.352	2.640	2.707E-05
27	7.50	248.75	137.28	2977.00	37819.3	0.29	2.146	97277.4	1.162	0.338	2.535	2.606E-05
28	7.50	256.25	137.28	3003.50	38495.6	0.29	2.162	99190.2	1.197	0.326	2.445	2.465E-05
29	7.50	263.75	137.28	3050.70	39715.1	0.29	2.159	102290.9	1.232	0.312	2.340	2.288E-05
30	7.50	271.25	137.28	3065.40	40098.7	0.29	2.164	103336.8	1.268	0.302	2.265	2.192E-05
31	7.50	278.75	137.28	3086.50	40652.6	0.29	2.157	104687.1	1.303	0.289	2.168	2.070E-05
32	7.50	286.25	137.28	3112.60	41343.1	0.29	2.153	106425.4	1.338	0.278	2.085	1.959E-05
33	7.50	293.75	137.28	3126.50	41713.2	0.29	2.169	107556.5	1.373	0.267	2.003	1.862E-05
34	7.50	301.25	137.28	3153.70	42442.1	0.29	2.163	109369.1	1.408	0.257	1.928	1.762E-05
35	7.50	308.75	137.28	3183.50	43248.0	0.29	2.173	111551.3	1.443	0.247	1.853	1.661E-05
36	7.50	316.25	137.28	3235.30	44666.8	0.29	2.153	114973.4	1.478	0.237	1.778	1.546E-05
37	10.16	325.08	137.28	3261.90	45404.4	0.29	2.928	116982.5	1.519	0.227	2.306	1.971E-05
38	9.84	335.08	137.28	3307.90	46694.0	0.29	2.815	120098.8	1.566	0.216	2.126	1.770E-05
39	10.16	345.08	137.28	3312.80	46832.4	0.29	2.898	120388.4	1.613	0.205	2.082	1.730E-05
40	9.84	355.08	137.28	3336.90	47516.3	0.28	2.798	122043.7	1.659	0.197	1.939	1.589E-05
41	20.00	370.00	137.28	3409.20	49597.7	0.28	5.669	127310.2	1.729	0.183	3.660	2.875E-05
42	20.00	390.00	137.28	3431.40	50245.7	0.28	5.649	128877.2	1.822	0.168	3.360	2.607E-05
43	20.00	410.00	137.28	3454.20	50915.6	0.28	5.636	130526.3	1.916	0.154	3.080	2.360E-05
44	20.00	430.00	137.28	3546.90	53685.1	0.28	5.626	137573.5	2.009	0.142	2.840	2.064E-05
45	20.00	450.00	137.28	3648.30	56798.6	0.28	5.623	145533.8	2.103	0.132	2.640	1.814E-05
						ν_a =						
Σ	460.00					0.29	132.741	Grade Basemat (0'--460')		SUM	211.971	7.330E-03
	410.00					0.28	115.611	Pool Basemat (55'--460')		SUM	164.420	2.068E-03

(a) Poisson's Ratio is from Ref. MO0706SCSPS5E4.002.
(b) $E' = 2(1+\nu)G'$. Ref. Bowles Foundation Analysis and Design, 5th ed., p 121 (Ref. 2.2.6).
(c) From figure 5

	Grade Basemat					Pool Basemat	
Average $E = SUM(q_n*h_n) / SUM(q_n*h_n/E_n)$ =	28917	ksf				79524	ksf
$G_s = E/(2(1+\nu_a))$ =	11221	ksf				31016	ksf
Corresponding Vel = $SQRT(32.17*G_s / \gamma)$ =	1793	ft/sec	for γ =	112.3	pcf	2981	ft/sec
	1622	ft/sec		137.3	pcf	2696	ft/sec

5E-4 Median Estimate : 30' Depth of Alluvium

Calculation of Equivalent Shear Modulus :

(B) Median Values :
Ref.: MO0706SCSPS5E4.002 for Strain Compatible Soil Properties.

Using 30', Median Curve : Dynamic Shear Modulus of Soil, G' = (γ /32.17, Mass Density) x (V_s , Velocity)^2
Ref.: Bowles Foundation Analysis and Design, 5th ed., Eq (20-15), Ref. 2.2.6.

Width of Building (W) = : 214 ft (Ref. 2.2.16)

NO	LAYER THICKNESS h_n (ft)	DEPTH (Z) TO CTR / LAYER (ft)	DENSITY γ (pcf)	SHEAR WAVE VELOCITY Vs (ft/s)	DYNAMIC SHEAR MODULUS G_n (ksf)	POISSON'S RATIO[(a)] ν		ELASTIC MODULUS E_n (ksf) [(b)]	Z / W	INFLUENCE COEFF q_n [(c)]	q_n*h_n	q_n*h_n/ E_n
	(1)	(2)	(3)	(4)	(5)	(7)	(8)=(1)x(7)	(9)	(10)	(11)	(12)	(13)
1	4.00	2.00	112.32	897.97	2815.3	0.37	1.470	7699.7	0.009	0.996	3.984	5.174E-04
2	4.00	6.00	112.32	871.73	2653.2	0.39	1.548	7359.7	0.028	0.988	3.952	5.370E-04
3	4.00	10.00	112.32	1069.20	3991.4	0.39	1.551	11077.4	0.047	0.981	3.924	3.542E-04
4	4.00	14.00	112.32	1240.30	5371.1	0.39	1.549	14902.0	0.065	0.973	3.892	2.612E-04
5	4.00	18.00	112.32	1313.30	6021.9	0.39	1.555	16725.7	0.084	0.964	3.856	2.305E-04
6	8.00	24.00	112.32	1366.00	6514.9	0.39	3.128	18124.3	0.112	0.953	7.624	4.207E-04
7	2.00	29.00	112.32	1708.50	10191.5	0.36	0.730	27821.6	0.136	0.944	1.889	6.789E-05
8	10.00	35.00	137.28	2237.60	21365.9	0.28	2.823	54793.7	0.164	0.932	9.320	1.701E-04
9	10.00	45.00	137.28	2486.90	26392.0	0.28	2.777	67439.6	0.210	0.911	9.110	1.351E-04
10	10.00	55.00	137.28	2601.50	28880.4	0.27	2.737	73571.8	0.257	0.876	8.760	1.191E-04
11	10.00	65.00	137.28	2689.10	30858.2	0.27	2.731	78572.3	0.304	0.862	8.620	1.097E-04
12	10.00	75.00	137.28	2833.00	34249.1	0.27	2.680	86853.0	0.350	0.836	8.360	9.625E-05
13	10.00	85.00	137.28	2943.00	36960.4	0.27	2.704	93911.2	0.397	0.808	8.080	8.604E-05
14	10.00	95.00	137.28	3009.10	38639.3	0.27	2.731	98381.1	0.444	0.778	7.780	7.908E-05
15	10.00	105.00	137.28	3093.40	40834.6	0.28	2.756	104173.2	0.491	0.748	7.480	7.180E-05
16	10.00	115.00	137.28	3172.80	42957.8	0.28	2.760	109628.2	0.537	0.715	7.150	6.522E-05
17	10.00	125.00	137.28	3191.70	43471.1	0.28	2.756	110902.5	0.584	0.681	6.810	6.141E-05
18	10.00	135.00	137.28	3236.60	44702.8	0.28	2.771	114178.0	0.631	0.645	6.450	5.649E-05
19	15.00	147.50	137.28	3278.00	45853.7	0.28	4.192	117335.0	0.689	0.605	9.075	7.734E-05
20	15.00	162.50	137.28	3434.00	50321.9	0.28	4.206	128866.3	0.759	0.554	8.310	6.449E-05
21	15.00	177.50	137.28	3520.60	52892.0	0.28	4.254	135787.4	0.829	0.507	7.605	5.601E-05
22	15.00	192.50	137.28	3534.50	53310.4	0.28	4.256	136871.3	0.900	0.461	6.915	5.052E-05
23	15.00	207.50	137.28	3560.80	54106.7	0.28	4.243	138822.7	0.970	0.424	6.360	4.581E-05
24	15.00	222.50	137.28	3617.50	55843.6	0.29	4.277	143529.2	1.040	0.39	5.850	4.076E-05
25	7.50	233.75	137.28	3643.90	56661.6	0.29	2.151	145819.9	1.092	0.366	2.745	1.882E-05
26	7.50	241.25	137.28	3646.60	56745.6	0.29	2.168	146299.3	1.127	0.352	2.640	1.805E-05
27	7.50	248.75	137.28	3646.00	56727.0	0.29	2.146	145910.8	1.162	0.338	2.535	1.737E-05
28	7.50	256.25	137.28	3678.50	57742.8	0.29	2.162	148783.5	1.197	0.326	2.445	1.643E-05
29	7.50	263.75	137.28	3736.40	59574.8	0.29	2.159	153442.2	1.232	0.312	2.340	1.525E-05
30	7.50	271.25	137.28	3754.30	60147.0	0.29	2.164	155002.5	1.268	0.302	2.265	1.461E-05
31	7.50	278.75	137.28	3780.20	60979.8	0.29	2.157	157032.7	1.303	0.289	2.168	1.380E-05
32	7.50	286.25	137.28	3812.10	62013.3	0.29	2.153	159634.6	1.338	0.278	2.085	1.306E-05
33	7.50	293.75	137.28	3829.10	62567.6	0.29	2.169	161329.4	1.373	0.267	2.003	1.241E-05
34	7.50	301.25	137.28	3862.50	63663.9	0.29	2.163	164055.5	1.408	0.257	1.928	1.175E-05
35	7.50	308.75	137.28	3899.00	64872.8	0.29	2.173	167329.0	1.443	0.247	1.853	1.107E-05
36	7.50	316.25	137.28	3962.40	66999.7	0.29	2.153	172458.6	1.478	0.237	1.778	1.031E-05
37	10.16	325.08	137.28	3995.00	68106.7	0.29	2.928	175474.2	1.519	0.227	2.306	1.314E-05
38	9.84	335.08	137.28	4051.30	70039.8	0.29	2.815	180145.2	1.566	0.216	2.126	1.180E-05
39	10.16	345.08	137.28	4057.40	70250.9	0.29	2.898	180588.4	1.613	0.205	2.082	1.153E-05
40	9.84	355.08	137.28	4086.80	71272.7	0.28	2.798	183061.0	1.659	0.197	1.939	1.059E-05
41	20.00	370.00	137.28	4175.30	74392.9	0.28	5.669	190956.2	1.729	0.183	3.660	1.917E-05
42	20.00	390.00	137.28	4202.50	75365.3	0.28	5.649	193307.6	1.822	0.168	3.360	1.738E-05
43	20.00	410.00	137.28	4230.50	76373.0	0.28	5.636	195788.2	1.916	0.154	3.080	1.573E-05
44	20.00	430.00	137.28	4344.10	80529.7	0.28	5.626	206365.3	2.009	0.142	2.840	1.376E-05
45	20.00	450.00	137.28	4468.20	85196.4	0.28	5.623	218297.1	2.103	0.132	2.640	1.209E-05
						ν_a =						
Σ	460.00					0.29	132.741	Grade Basemat (0'--460')		SUM	211.971	4.072E-03
	410.00					0.28	115.611	Pool Basemat (55'--460')		SUM	164.420	1.378E-03

(a) Poisson's Ratio is from Ref. MO0706SCSPS5E4.002.
(b) E' = 2(1+ν)G'. Ref. Bowles Foundation Analysis and Design, 5th ed., p 121 (Ref. 2.2.6).
(c) From figure 5

	Grade Basemat					Pool Basemat	
Average E = SUM(q_n*h_n) / SUM(q_n*h_n/E_n) =	52053	ksf				119306	ksf
G_s = E/(2(1+ν_a)) =	20198	ksf				46532	ksf
Corresponding Vel = SQRT(32.17*G_s / γ) =	2405	ft/sec	for γ =	112.3	pcf	3651	ft/sec
	2176	ft/sec		137.3	pcf	3302	ft/sec

5E-4 Upper Bound Estimate : 30' Depth of Alluvium

Calculation of Equivalent Shear Modulus :

(C) Upper Bound Values :
Ref.: MO0706SCSPS5E4.002 for Strain Compatible Soil Properties.

Using 30', Upper Bound) Curve : Dynamic Shear Modulus of Soil, $G' = (\gamma/32.17, \text{Mass Density}) \times (V_s, \text{Velocity})^2$
Ref.: Bowles Foundation Analysis and Design, 5th ed., Eq (20-15), Ref. 2.2.6.

Width of Building (W) = : 214 ft (Ref. 2.2.16)

NO	LAYER THICKNESS h_n (ft)	DEPTH (Z) TO CTR / LAYER (ft)	DENSITY γ (pcf)	SHEAR WAVE VELOCITY Vs (ft/s)	DYNAMIC SHEAR MODULUS G_n (ksf)	POISSON'S RATIO[a] ν		ELASTIC MODULUS E_n (ksf) [b]	Z / W	INFLUENCE COEFF q_n [c]	q_n*h_n	q_n*h_n/E_n
	(1)	(2)	(3)	(4)	(5)	(7)	(8)=(1)x(7)	(9)	(10)	(11)	(12)	(13)
1	4.00	2.00	112.32	1269.90	5630.5	0.37	1.470	15398.8	0.009	0.996	3.984	2.587E-04
2	4.00	6.00	112.32	1232.80	5306.3	0.39	1.548	14719.1	0.028	0.988	3.952	2.685E-04
3	4.00	10.00	112.32	1512.10	7983.0	0.39	1.551	22155.4	0.047	0.981	3.924	1.771E-04
4	4.00	14.00	112.32	1754.10	10742.7	0.39	1.549	29805.7	0.065	0.973	3.892	1.306E-04
5	4.00	18.00	112.32	1857.30	12044.0	0.39	1.555	33451.9	0.084	0.964	3.856	1.153E-04
6	8.00	24.00	112.32	1931.90	13030.9	0.39	3.128	36251.8	0.112	0.953	7.624	2.103E-04
7	2.00	29.00	112.32	2416.20	20383.2	0.36	0.730	55644.0	0.136	0.944	1.889	3.395E-05
8	10.00	35.00	137.28	2882.70	35461.3	0.28	2.823	90942.0	0.164	0.932	9.320	1.025E-04
9	10.00	45.00	137.28	3045.80	39587.6	0.28	2.777	101158.1	0.210	0.911	9.110	9.006E-05
10	10.00	55.00	137.28	3186.10	43318.7	0.27	2.737	110352.6	0.257	0.876	8.760	7.938E-05
11	10.00	65.00	137.28	3293.40	46285.5	0.27	2.731	117854.0	0.304	0.862	8.620	7.314E-05
12	10.00	75.00	137.28	3469.60	51370.6	0.27	2.680	130271.8	0.350	0.836	8.360	6.417E-05
13	10.00	85.00	137.28	3604.40	55439.9	0.27	2.704	140864.9	0.397	0.808	8.080	5.736E-05
14	10.00	95.00	137.28	3685.40	57959.6	0.27	2.731	147573.3	0.444	0.778	7.780	5.272E-05
15	10.00	105.00	137.28	3794.60	61445.2	0.28	2.756	156752.9	0.491	0.748	7.480	4.772E-05
16	10.00	115.00	137.28	3885.90	64437.6	0.28	2.760	164444.8	0.537	0.715	7.150	4.348E-05
17	10.00	125.00	137.28	3909.10	65209.3	0.28	2.756	166360.8	0.584	0.681	6.810	4.094E-05
18	10.00	135.00	137.28	3964.00	67053.8	0.28	2.771	171266.2	0.631	0.645	6.450	3.766E-05
19	15.00	147.50	137.28	4014.70	68780.0	0.28	4.192	176001.2	0.689	0.605	9.075	5.156E-05
20	15.00	162.50	137.28	4205.70	75480.2	0.28	4.206	193292.6	0.759	0.554	8.310	4.299E-05
21	15.00	177.50	137.28	4311.90	79340.3	0.28	4.254	203687.1	0.829	0.507	7.605	3.734E-05
22	15.00	192.50	137.28	4328.90	79967.1	0.28	4.256	205310.7	0.900	0.461	6.915	3.368E-05
23	15.00	207.50	137.28	4361.10	81161.2	0.28	4.243	208236.8	0.970	0.424	6.360	3.054E-05
24	15.00	222.50	137.28	4430.50	83764.8	0.29	4.277	215292.4	1.040	0.39	5.850	2.717E-05
25	7.50	233.75	137.28	4462.80	84990.6	0.29	2.151	218725.1	1.092	0.366	2.745	1.255E-05
26	7.50	241.25	137.28	4466.20	85120.2	0.29	2.168	219453.4	1.127	0.352	2.640	1.203E-05
27	7.50	248.75	137.28	4465.40	85089.7	0.29	2.146	218864.3	1.162	0.338	2.535	1.158E-05
28	7.50	256.25	137.28	4505.30	86617.1	0.29	2.162	223182.8	1.197	0.326	2.445	1.096E-05
29	7.50	263.75	137.28	4576.10	89360.8	0.29	2.159	230159.6	1.232	0.312	2.340	1.017E-05
30	7.50	271.25	137.28	4598.10	90222.1	0.29	2.164	232507.8	1.268	0.302	2.265	9.742E-06
31	7.50	278.75	137.28	4629.80	91470.4	0.29	2.157	235551.0	1.303	0.289	2.168	9.202E-06
32	7.50	286.25	137.28	4668.90	93021.9	0.29	2.153	239457.1	1.338	0.278	2.085	8.707E-06
33	7.50	293.75	137.28	4689.70	93852.6	0.29	2.169	241997.1	1.373	0.267	2.003	8.275E-06
34	7.50	301.25	137.28	4730.60	95496.8	0.29	2.163	246085.6	1.408	0.257	1.928	7.833E-06
35	7.50	308.75	137.28	4775.20	97305.9	0.29	2.173	250985.1	1.443	0.247	1.853	7.381E-06
36	7.50	316.25	137.28	4852.90	100498.3	0.29	2.153	258684.7	1.478	0.237	1.778	6.871E-06
37	10.16	325.08	137.28	4892.90	102161.9	0.29	2.928	263216.0	1.519	0.227	2.306	8.759E-06
38	9.84	335.08	137.28	4961.90	105063.6	0.29	2.815	270227.7	1.566	0.216	2.126	7.868E-06
39	10.16	345.08	137.28	4969.30	105377.2	0.29	2.898	270884.7	1.613	0.205	2.082	7.687E-06
40	9.84	355.08	137.28	5005.30	106909.5	0.28	2.798	274592.9	1.659	0.197	1.939	7.062E-06
41	20.00	370.00	137.28	5113.70	111590.4	0.28	5.669	286436.8	1.729	0.183	3.660	1.278E-05
42	20.00	390.00	137.28	5147.00	113048.4	0.28	5.649	289962.4	1.822	0.168	3.360	1.159E-05
43	20.00	410.00	137.28	5181.30	114560.2	0.28	5.636	293684.2	1.916	0.154	3.080	1.049E-05
44	20.00	430.00	137.28	5320.40	120793.8	0.28	5.626	309546.3	2.009	0.142	2.840	9.175E-06
45	20.00	450.00	137.28	5472.40	127794.4	0.28	5.623	327445.1	2.103	0.132	2.640	8.062E-06
Σ	460.00						132.74					
						ν_a =						
Σ	460.00					0.29	132.741	Grade Basemat (0'--460')		SUM	211.971	2.306E-03
	410.00					0.28	115.611	Pool Basemat (55'--460')		SUM	164.420	9.186E-04

(a) Poisson's Ratio is from Ref. MO0706SCSPS5E4.002.
(b) $E' = 2(1+\nu)G'$. Ref. Bowles Foundation Analysis and Design, 5th ed., p 121 (Ref. 2.2.6).
(c) From figure 5

	Grade Basemat					Pool Basemat	
Average $E = SUM(q_n*h_n) / SUM(q_n*h_n/E_n)$ =	91938	ksf				178987	ksf
$G_s = E/(2(1+\nu_a))$ =	35675	ksf				69809	ksf
Corresponding Vel = $SQRT(32.17*G_s / \gamma)$ =	3197	ft/sec	for γ =	112.3	pcf	4471	ft/sec
	2891	ft/sec		137.3	pcf	4045	ft/sec

5E-4 Lower Bound Estimate : 100' Depth of Alluvium

Calculation of Equivalent Shear Modulus :

(A) Lower Bound Values :
Ref.: MO0706SCSPS5E4.002 for Strain Compatible Soil Properties.

Using 100', Lower Bound Curve : Dynamic Shear Modulus of Soil, G' = (γ /32.17, Mass Density) x (V_s , Velocity)^2
Ref.: Bowles Foundation Analysis and Design, 5th ed., Eq (20-15), Ref. 2.2.6.

Width of Building (W) = : 214 ft (Ref. 2.2.16)

NO	LAYER THICKNESS h_n (ft)	DEPTH (Z) TO CTR / LAYER (ft)	DENSITY γ (pcf)	SHEAR WAVE VELOCITY Vs (ft/s)	DYNAMIC SHEAR MODULUS G_n (ksf)	POISSON'S RATIO[a] ν		ELASTIC MODULUS E_n (ksf) [b]	Z / W	INFLUENCE COEFF q_n [c]	q_n*h_n	q_n*h_n/E_n
	(1)	(2)	(3)	(4)	(5)	(7)	(8)=(1)x(7)	(9)	(10)	(11)	(12)	(13)
1	4.00	2.00	112.32	620.92	1346.1	0.37	1.470	3681.4	0.009	0.996	3.984	1.082E-03
2	4.00	6.00	112.32	576.36	1159.8	0.39	1.563	3226.1	0.028	0.988	3.952	1.225E-03
3	4.00	10.00	112.32	655.23	1499.0	0.39	1.577	4180.0	0.047	0.981	3.924	9.387E-04
4	4.00	14.00	112.32	780.00	2124.2	0.39	1.573	5919.6	0.065	0.973	3.892	6.575E-04
5	4.00	18.00	112.32	885.18	2735.7	0.39	1.570	7619.5	0.084	0.964	3.856	5.061E-04
6	8.00	24.00	112.32	944.77	3116.4	0.39	3.154	8689.8	0.112	0.953	7.624	8.773E-04
7	8.00	32.00	112.32	1103.30	4250.0	0.37	2.992	11678.6	0.150	0.938	7.504	6.425E-04
8	8.00	40.00	112.32	1148.80	4607.8	0.36	2.901	12557.0	0.187	0.922	7.376	5.874E-04
9	8.00	48.00	112.32	1176.50	4832.7	0.36	2.860	13120.9	0.224	0.903	7.224	5.506E-04
10	8.00	56.00	112.32	1339.60	6265.5	0.34	2.729	16806.1	0.262	0.886	7.088	4.218E-04
11	10.00	65.00	112.32	1340.80	6276.7	0.34	3.422	16849.4	0.304	0.862	8.620	5.116E-04
12	10.00	75.00	112.32	1489.30	7744.1	0.34	3.365	20699.2	0.350	0.836	8.360	4.039E-04
13	10.00	85.00	112.32	1581.80	8735.9	0.33	3.349	23323.7	0.397	0.808	8.080	3.464E-04
14	10.00	95.00	112.32	1663.40	9660.5	0.33	3.343	25779.0	0.444	0.778	7.780	3.018E-04
15	10.00	105.00	137.28	2120.20	19182.7	0.30	3.035	50010.5	0.491	0.748	7.480	1.496E-04
16	10.00	115.00	137.28	2267.60	21942.7	0.30	3.031	57185.6	0.537	0.715	7.150	1.250E-04
17	10.00	125.00	137.28	2414.20	24871.5	0.28	2.758	63460.2	0.584	0.681	6.810	1.073E-04
18	10.00	135.00	137.28	2487.30	26400.5	0.28	2.762	67382.1	0.631	0.645	6.450	9.572E-05
19	15.00	147.50	137.28	2538.80	27505.1	0.28	4.140	70193.6	0.689	0.605	9.075	1.293E-04
20	15.00	162.50	137.28	2596.20	28762.9	0.28	4.164	73496.7	0.759	0.554	8.310	1.131E-04
21	15.00	177.50	137.28	2729.50	31792.3	0.28	4.194	81362.3	0.829	0.507	7.605	9.347E-05
22	15.00	192.50	137.28	2773.10	32816.1	0.28	4.214	84072.3	0.900	0.461	6.915	8.225E-05
23	15.00	207.50	137.28	2829.60	34167.0	0.28	4.265	87764.0	0.970	0.424	6.360	7.247E-05
24	15.00	222.50	137.28	2879.20	35375.3	0.28	4.265	90866.4	1.040	0.39	5.850	6.438E-05
25	7.50	233.75	137.28	2958.70	37355.8	0.28	2.124	95870.7	1.092	0.366	2.745	2.863E-05
26	7.50	241.25	137.28	2969.90	37639.2	0.29	2.141	96770.3	1.127	0.352	2.640	2.728E-05
27	7.50	248.75	137.28	2991.40	38186.1	0.29	2.153	98297.1	1.162	0.338	2.535	2.579E-05
28	7.50	256.25	137.28	3079.50	40468.5	0.29	2.162	104267.0	1.197	0.326	2.445	2.345E-05
29	7.50	263.75	137.28	3110.10	41276.7	0.29	2.139	106092.7	1.232	0.312	2.340	2.206E-05
30	7.50	271.25	137.28	3121.40	41577.2	0.29	2.159	107090.4	1.268	0.302	2.265	2.115E-05
31	7.50	278.75	137.28	3163.70	42711.7	0.29	2.154	109962.1	1.303	0.289	2.168	1.971E-05
32	7.50	286.25	137.28	3206.50	43875.2	0.29	2.159	113012.8	1.338	0.278	2.085	1.845E-05
33	7.50	293.75	137.28	3233.00	44603.4	0.29	2.151	114796.6	1.373	0.267	2.003	1.744E-05
34	7.50	301.25	137.28	3254.80	45206.9	0.29	2.148	116305.6	1.408	0.257	1.928	1.657E-05
35	7.50	308.75	137.28	3271.20	45663.6	0.29	2.164	117675.2	1.443	0.247	1.853	1.574E-05
36	7.50	316.25	137.28	3327.10	47237.6	0.29	2.157	121648.2	1.478	0.237	1.778	1.461E-05
37	10.16	325.08	137.28	3362.80	48256.8	0.29	2.934	124393.4	1.519	0.227	2.306	1.854E-05
38	9.84	335.08	137.28	3394.10	49159.3	0.29	2.818	126462.2	1.566	0.216	2.126	1.681E-05
39	10.16	345.08	137.28	3419.60	49900.7	0.29	2.921	128498.4	1.613	0.205	2.082	1.620E-05
40	9.84	355.08	137.28	3486.10	51860.4	0.29	2.808	133308.2	1.659	0.197	1.939	1.455E-05
41	20.00	370.00	137.28	3495.50	52140.5	0.28	5.691	133953.0	1.729	0.183	3.660	2.732E-05
42	20.00	390.00	137.28	3518.10	52816.9	0.28	5.670	135579.8	1.822	0.168	3.360	2.478E-05
43	20.00	410.00	137.28	3533.10	53268.2	0.28	5.658	136676.6	1.916	0.154	3.080	2.253E-05
44	20.00	430.00	137.28	3594.10	55123.5	0.28	5.638	141325.5	2.009	0.142	2.840	2.010E-05
45	20.00	450.00	137.28	3602.90	55393.7	0.28	5.625	141946.4	2.103	0.132	2.640	1.860E-05
						ν_a =						
Σ	460.00					0.30	138.268	Grade Basemat (0'--460')		SUM	212.084	1.052E-02
	408.00					0.29	118.609	Pool Basemat (56'--460')		SUM	162.748	3.448E-03

(a) Poisson's Ratio is from Ref. MO0706SCSPS5E4.002.
(b) E' = 2(1+ν)G'. Ref. Bowles Foundation Analysis and Design, 5th ed., p 121 (Ref. 2.2.6).
(c) From figure 5

	Grade Basemat					Pool Basemat	
Average E = SUM(q_n*h_n) / SUM(q_n*h_n/E_n) =	20168	ksf				47196	ksf
G_s = E/(2(1+ν_a)) =	7754	ksf				18283	ksf
Corresponding Vel = SQRT(32.17*G_s / γ) =	1490	ft/sec	for γ =	112.3	pcf	2288	ft/sec
	1348	ft/sec		137.3	pcf	2070	ft/sec

5E-4 Median Estimate : 100' Depth of Alluvium

Calculation of Equivalent Shear Modulus :

(B) Median Values :
Ref.: MO0706SCSPS5E4.002 for Strain Compatible Soil Properties.

Using 100', Median Curve : Dynamic Shear Modulus of Soil, G' = (γ /32.17, Mass Density) x (V_s , Velocity)^2
Ref.: Bowles Foundation Analysis and Design, 5th ed., Eq (20-15), Ref. 2.2.6.

Width of Building (W) = : 214 ft (Ref. 2.2.16)

NO	LAYER THICKNESS h_n (ft)	DEPTH (Z) TO CTR / LAYER (ft)	DENSITY γ (pcf)	SHEAR WAVE VELOCITY Vs (ft/s)	DYNAMIC SHEAR MODULUS G_n (ksf)	POISSON'S RATIO[a] ν		ELASTIC MODULUS E_n (ksf) [b]	Z / W	INFLUENCE COEFF q_n [c]	q_n*h_n	q_n*h_n/E_n
	(1)	(2)	(3)	(4)	(5)	(7)	(8)=(1)x(7)	(9)	(10)	(11)	(12)	(13)
1	4.00	2.00	112.32	878.11	2692.2	0.37	1.470	7362.7	0.009	0.996	3.984	5.411E-04
2	4.00	6.00	112.32	815.09	2319.6	0.39	1.563	6452.2	0.028	0.988	3.952	6.125E-04
3	4.00	10.00	112.32	926.63	2997.9	0.39	1.577	8360.0	0.047	0.981	3.924	4.694E-04
4	4.00	14.00	112.32	1103.10	4248.5	0.39	1.573	11839.5	0.065	0.973	3.892	3.287E-04
5	4.00	18.00	112.32	1251.80	5471.1	0.39	1.570	15238.2	0.084	0.964	3.856	2.530E-04
6	8.00	24.00	112.32	1336.10	6232.8	0.39	3.154	17379.4	0.112	0.953	7.624	4.387E-04
7	8.00	32.00	112.32	1560.30	8500.1	0.37	2.992	23357.2	0.150	0.938	7.504	3.213E-04
8	8.00	40.00	112.32	1624.60	9215.1	0.36	2.901	25112.6	0.187	0.922	7.376	2.937E-04
9	8.00	48.00	112.32	1663.90	9666.3	0.36	2.860	26244.2	0.224	0.903	7.224	2.753E-04
10	8.00	56.00	112.32	1884.60	12400.6	0.34	2.729	33262.5	0.262	0.886	7.088	2.131E-04
11	10.00	65.00	112.32	1896.20	12553.8	0.34	3.422	33699.6	0.304	0.862	8.620	2.558E-04
12	10.00	75.00	112.32	2065.10	14889.8	0.34	3.365	39798.9	0.350	0.836	8.360	2.101E-04
13	10.00	85.00	112.32	2188.90	16728.5	0.33	3.349	44662.8	0.397	0.808	8.080	1.809E-04
14	10.00	95.00	112.32	2291.60	18335.1	0.33	3.343	48927.3	0.444	0.778	7.780	1.590E-04
15	10.00	105.00	137.28	2719.30	31555.2	0.30	3.035	82266.2	0.491	0.748	7.480	9.092E-05
16	10.00	115.00	137.28	2813.20	33772.1	0.30	3.031	88014.7	0.537	0.715	7.150	8.124E-05
17	10.00	125.00	137.28	2956.80	37307.8	0.28	2.758	95191.7	0.584	0.681	6.810	7.154E-05
18	10.00	135.00	137.28	3046.20	39598.0	0.28	2.762	101065.9	0.631	0.645	6.450	6.382E-05
19	15.00	147.50	137.28	3109.40	41258.1	0.28	4.140	105291.5	0.689	0.605	9.075	8.619E-05
20	15.00	162.50	137.28	3179.60	43142.1	0.28	4.164	110239.3	0.759	0.554	8.310	7.538E-05
21	15.00	177.50	137.28	3342.90	47687.3	0.28	4.194	122040.5	0.829	0.507	7.605	6.232E-05
22	15.00	192.50	137.28	3396.30	49223.0	0.28	4.214	126105.5	0.900	0.461	6.915	5.484E-05
23	15.00	207.50	137.28	3465.50	51249.3	0.28	4.265	131643.1	0.970	0.424	6.360	4.831E-05
24	15.00	222.50	137.28	3526.20	53060.3	0.28	4.265	136292.9	1.040	0.39	5.850	4.292E-05
25	7.50	233.75	137.28	3623.70	56035.2	0.28	2.124	143809.8	1.092	0.366	2.745	1.909E-05
26	7.50	241.25	137.28	3637.30	56456.6	0.29	2.141	145149.8	1.127	0.352	2.640	1.819E-05
27	7.50	248.75	137.28	3663.70	57279.1	0.29	2.153	147445.5	1.162	0.338	2.535	1.719E-05
28	7.50	256.25	137.28	3771.50	60699.4	0.29	2.162	156392.0	1.197	0.326	2.445	1.563E-05
29	7.50	263.75	137.28	3809.00	61912.5	0.29	2.139	159132.4	1.232	0.312	2.340	1.470E-05
30	7.50	271.25	137.28	3822.90	62365.2	0.29	2.159	160634.0	1.268	0.302	2.265	1.410E-05
31	7.50	278.75	137.28	3874.70	64066.7	0.29	2.154	164941.0	1.303	0.289	2.168	1.314E-05
32	7.50	286.25	137.28	3927.20	65814.6	0.29	2.159	169523.9	1.338	0.278	2.085	1.230E-05
33	7.50	293.75	137.28	3959.60	66905.0	0.29	2.151	172194.8	1.373	0.267	2.003	1.163E-05
34	7.50	301.25	137.28	3986.30	67810.4	0.29	2.148	174458.5	1.408	0.257	1.928	1.105E-05
35	7.50	308.75	137.28	4006.40	68495.9	0.29	2.164	176514.0	1.443	0.247	1.853	1.049E-05
36	7.50	316.25	137.28	4074.80	70854.7	0.29	2.157	182467.9	1.478	0.237	1.778	9.741E-06
37	10.16	325.08	137.28	4118.60	72386.1	0.29	2.934	186592.7	1.519	0.227	2.306	1.236E-05
38	9.84	335.08	137.28	4157.00	73742.2	0.29	2.818	189701.9	1.566	0.216	2.126	1.121E-05
39	10.16	345.08	137.28	4188.20	74853.3	0.29	2.921	192753.3	1.613	0.205	2.082	1.080E-05
40	9.84	355.08	137.28	4269.50	77787.6	0.29	2.808	199954.5	1.659	0.197	1.939	9.698E-06
41	20.00	370.00	137.28	4281.10	78210.8	0.28	5.691	200929.9	1.729	0.183	3.660	1.822E-05
42	20.00	390.00	137.28	4308.80	79226.2	0.28	5.670	203372.1	1.822	0.168	3.360	1.652E-05
43	20.00	410.00	137.28	4327.10	79900.6	0.28	5.658	205010.6	1.916	0.154	3.080	1.502E-05
44	20.00	430.00	137.28	4401.90	82686.9	0.28	5.638	211992.6	2.009	0.142	2.840	1.340E-05
45	20.00	450.00	137.28	4412.60	83089.3	0.28	5.625	212916.4	2.103	0.132	2.640	1.240E-05
						$ν_a$ =						
Σ	460.00					0.30	138.268	Grade Basemat (0'--460')		SUM	212.084	5.517E-03
	408.00					0.29	118.609	Pool Basemat (56'--460')		SUM	162.748	1.983E-03

(a) Poisson's Ratio is from Ref. MO0706SCSPS5E4.002.
(b) E' = 2(1+ν)G'. Ref. Bowles Foundation Analysis and Design, 5th ed., p 121 (Ref. 2.2.6).
(c) From figure 5

	Grade Basemat					Pool Basemat	
Average E = SUM(q_n*h_n) / SUM(q_n*h_n/E_n) =	38443	ksf				82063	ksf
G_s = E/(2(1+$ν_a$)) =	14779	ksf				31790	ksf
Corresponding Vel = SQRT(32.17*G_s / γ) =	2057	ft/sec	for γ =	112.3	pcf	3017	ft/sec
	1861	ft/sec		137.3	pcf	2729	ft/sec

5E-4 Upper Bound Estimate : 100' Depth of Alluvium

Calculation of Equivalent Shear Modulus :

(C) Upper Bound Values :
Ref.: MO0706SCSPS5E4.002 for Strain Compatible Soil Properties.

Using 100', Upper Bound Curve : Dynamic Shear Modulus of Soil, G' = (γ /32.17, Mass Density) x (V_s , Velocity)^2
Ref.: Bowles Foundation Analysis and Design, 5th ed., Eq (20-15), Ref. 2.2.6.

Width of Building (W) = : 214 ft (Ref. 2.2.16)

NO	LAYER THICKNESS h_n (ft)	DEPTH (Z) TO CTR / LAYER (ft)	DENSITY γ (pcf)	SHEAR WAVE VELOCITY Vs (ft/s)	DYNAMIC SHEAR MODULUS G_n (ksf)	POISSON'S RATIO[a] ν		ELASTIC MODULUS E_n (ksf) [b]	Z / W	INFLUENCE COEFF q_n [c]	q_n*h_n	q_n*h_n/E_n
	(1)	(2)	(3)	(4)	(5)	(7)	(8)=(1)x(7)	(9)	(10)	(11)	(12)	(13)
1	4.00	2.00	112.32	1241.80	5384.1	0.37	1.470	14724.6	0.009	0.996	3.984	2.706E-04
2	4.00	6.00	112.32	1152.70	4639.2	0.39	1.563	12904.1	0.028	0.988	3.952	3.063E-04
3	4.00	10.00	112.32	1310.50	5996.3	0.39	1.577	16721.2	0.047	0.981	3.924	2.347E-04
4	4.00	14.00	112.32	1560.00	8496.8	0.39	1.573	23678.4	0.065	0.973	3.892	1.644E-04
5	4.00	18.00	112.32	1770.40	10943.3	0.39	1.570	30479.3	0.084	0.964	3.856	1.265E-04
6	8.00	24.00	112.32	1889.50	12465.2	0.39	3.154	34757.8	0.112	0.953	7.624	2.193E-04
7	8.00	32.00	112.32	2206.70	17001.7	0.37	2.992	46718.7	0.150	0.938	7.504	1.606E-04
8	8.00	40.00	112.32	2297.60	18431.3	0.36	2.901	50228.1	0.187	0.922	7.376	1.469E-04
9	8.00	48.00	112.32	2353.10	19332.4	0.36	2.860	52488.0	0.224	0.903	7.224	1.376E-04
10	8.00	56.00	112.32	2651.30	24542.8	0.34	2.729	65831.6	0.262	0.886	7.088	1.077E-04
11	10.00	65.00	112.32	2681.70	25108.8	0.34	3.422	67402.6	0.304	0.862	8.620	1.279E-04
12	10.00	75.00	112.32	2863.50	28628.6	0.34	3.365	76521.4	0.350	0.836	8.360	1.093E-04
13	10.00	85.00	112.32	3028.90	32031.4	0.33	3.349	85519.4	0.397	0.808	8.080	9.448E-05
14	10.00	95.00	112.32	3156.90	34795.9	0.33	3.343	92852.8	0.444	0.778	7.780	8.379E-05
15	10.00	105.00	137.28	3487.60	51905.0	0.30	3.035	135319.6	0.491	0.748	7.480	5.528E-05
16	10.00	115.00	137.28	3490.00	51976.5	0.30	3.031	135458.0	0.537	0.715	7.150	5.278E-05
17	10.00	125.00	137.28	3621.30	55961.0	0.28	2.758	142785.5	0.584	0.681	6.810	4.769E-05
18	10.00	135.00	137.28	3730.90	59399.6	0.28	2.762	151605.6	0.631	0.645	6.450	4.254E-05
19	15.00	147.50	137.28	3808.20	61886.5	0.28	4.140	157935.5	0.689	0.605	9.075	5.746E-05
20	15.00	162.50	137.28	3894.20	64713.2	0.28	4.164	165359.0	0.759	0.554	8.310	5.025E-05
21	15.00	177.50	137.28	4094.30	71534.5	0.28	4.194	183069.7	0.829	0.507	7.605	4.154E-05
22	15.00	192.50	137.28	4159.60	73834.5	0.28	4.214	189158.1	0.900	0.461	6.915	3.656E-05
23	15.00	207.50	137.28	4244.40	76875.7	0.28	4.265	197469.0	0.970	0.424	6.360	3.221E-05
24	15.00	222.50	137.28	4318.70	79590.7	0.28	4.265	204439.8	1.040	0.39	5.850	2.861E-05
25	7.50	233.75	137.28	4438.10	84052.4	0.28	2.124	215713.9	1.092	0.366	2.745	1.273E-05
26	7.50	241.25	137.28	4454.80	84686.2	0.29	2.141	217728.2	1.127	0.352	2.640	1.213E-05
27	7.50	248.75	137.28	4487.10	85918.7	0.29	2.153	221168.5	1.162	0.338	2.535	1.146E-05
28	7.50	256.25	137.28	4619.20	91052.1	0.29	2.162	234595.6	1.197	0.326	2.445	1.042E-05
29	7.50	263.75	137.28	4665.10	92870.6	0.29	2.139	238703.4	1.232	0.312	2.340	9.803E-06
30	7.50	271.25	137.28	4682.10	93548.7	0.29	2.159	240953.3	1.268	0.302	2.265	9.400E-06
31	7.50	278.75	137.28	4745.60	96103.3	0.29	2.154	247420.0	1.303	0.289	2.168	8.760E-06
32	7.50	286.25	137.28	4809.80	98721.2	0.29	2.159	254284.0	1.338	0.278	2.085	8.199E-06
33	7.50	293.75	137.28	4849.50	100357.6	0.29	2.151	258292.3	1.373	0.267	2.003	7.753E-06
34	7.50	301.25	137.28	4882.20	101715.5	0.29	2.148	261687.7	1.408	0.257	1.928	7.366E-06
35	7.50	308.75	137.28	4906.80	102743.2	0.29	2.164	264769.1	1.443	0.247	1.853	6.997E-06
36	7.50	316.25	137.28	4990.60	106282.5	0.29	2.157	273702.9	1.478	0.237	1.778	6.494E-06
37	10.16	325.08	137.28	5044.30	108582.0	0.29	2.934	279896.3	1.519	0.227	2.306	8.237E-06
38	9.84	335.08	137.28	5091.20	110610.5	0.29	2.818	284545.6	1.566	0.216	2.126	7.472E-06
39	10.16	345.08	137.28	5129.40	112276.6	0.29	2.921	289121.3	1.613	0.205	2.082	7.202E-06
40	9.84	355.08	137.28	5229.10	116683.7	0.29	2.808	299937.7	1.659	0.197	1.939	6.465E-06
41	20.00	370.00	137.28	5243.30	117318.3	0.28	5.691	301400.0	1.729	0.183	3.660	1.214E-05
42	20.00	390.00	137.28	5277.10	118835.7	0.28	5.670	305048.8	1.822	0.168	3.360	1.101E-05
43	20.00	410.00	137.28	5299.60	119851.2	0.28	5.658	307516.6	1.916	0.154	3.080	1.002E-05
44	20.00	430.00	137.28	5391.20	124030.1	0.28	5.638	317988.4	2.009	0.142	2.840	8.931E-06
45	20.00	450.00	137.28	5404.30	124633.6	0.28	5.625	319373.6	2.103	0.132	2.640	8.266E-06
						ν_a =						
Σ	460.00					0.30	138.268	Grade Basemat (0'--460')		SUM	212.084	2.926E-03
	408.00					0.29	118.609	Pool Basemat (56'--460')		SUM	162.748	1.159E-03

(a) Poisson's Ratio is from Ref. MO0706SCSPS5E4.002.
(b) E' = 2(1+ν)G'. Ref. Bowles Foundation Analysis and Design, 5th ed., p 121 (Ref. 2.2.6).
(c) From figure 5

	Grade Basemat						Pool Basemat	
Average E = SUM(q_n*h_n) / SUM(q_n*h_n/E_n) =	72480	ksf					140389	ksf
G_s = E/(2(1+ν_a)) =	27865	ksf					54385	ksf
Corresponding Vel = SQRT(32.17*G_s / γ) =	2825	ft/sec	for γ =	112.3	pcf		3947	ft/sec
	2555	ft/sec		137.3	pcf		3570	ft/sec

6.2.2.2 Equivalent Shear Modulus for 1E-4 annual exceedance frequency

1E-4 Lower Bound Estimate : 30' Depth of Alluvium

Calculation of Equivalent Shear Modulus :

(A) Lower Bound Values :
Ref.: MO0706SCSPS1E4.002 for Strain Compatible Soil Properties.

Using 30', Lower Bound Curve : Dynamic Shear Modulus of Soil, G' = (γ /32.17, Mass Density) x (V_s , Velocity)^2
Ref.: Bowles Foundation Analysis and Design, 5th ed., Eq (20-15), Ref. 2.1.6.

Width of Building (W) = : 214 ft (Ref. 2.2.16)

NO	LAYER THICKNESS h_n (ft)	DEPTH (Z) TO CTR / LAYER (ft)	DENSITY γ (pcf)	SHEAR WAVE VELOCITY Vs (ft/s)	DYNAMIC SHEAR MODULUS G_n (ksf)	POISSON'S RATIO[a] ν		ELASTIC MODULUS E_n (ksf) [b]	Z / W	INFLUENCE COEFF q_n [c]	q_n*h_n	q_n*h_n/ E_n
	(1)	(2)	(3)	(4)	(5)	(7)	(8)=(1)x(7)	(9)	(10)	(11)	(12)	(13)
1	4.00	2.00	112.32	566.84	1121.8	0.39	1.543	3109.3	0.009	0.996	3.984	1.281E-03
2	4.00	6.00	112.32	518.09	937.2	0.41	1.642	2643.8	0.028	0.988	3.952	1.495E-03
3	4.00	10.00	112.32	589.65	1213.9	0.41	1.649	3429.0	0.047	0.981	3.924	1.144E-03
4	4.00	14.00	112.32	683.33	1630.3	0.41	1.649	4605.1	0.065	0.973	3.892	8.452E-04
5	4.00	18.00	112.32	711.22	1766.1	0.41	1.657	4995.3	0.084	0.964	3.856	7.719E-04
6	8.00	24.00	112.32	735.48	1888.6	0.42	3.336	5352.2	0.112	0.953	7.624	1.424E-03
7	2.00	29.00	112.32	969.86	3284.2	0.39	0.790	9160.3	0.136	0.944	1.889	2.062E-04
8	10.00	35.00	137.28	1691.60	12211.0	0.29	2.906	31517.8	0.164	0.932	9.320	2.957E-04
9	10.00	45.00	137.28	1992.80	16946.6	0.29	2.863	43596.9	0.210	0.911	9.110	2.090E-04
10	10.00	55.00	137.28	2098.00	18783.1	0.28	2.809	48120.0	0.257	0.876	8.760	1.820E-04
11	10.00	65.00	137.28	2166.30	20026.0	0.28	2.809	51302.9	0.304	0.862	8.620	1.680E-04
12	10.00	75.00	137.28	2274.90	22084.2	0.28	2.763	56372.9	0.350	0.836	8.360	1.483E-04
13	10.00	85.00	137.28	2368.00	23928.7	0.28	2.788	61202.0	0.397	0.808	8.080	1.320E-04
14	10.00	95.00	137.28	2420.60	25003.6	0.28	2.815	64085.2	0.444	0.778	7.780	1.214E-04
15	10.00	105.00	137.28	2462.60	25878.8	0.28	2.841	66461.4	0.491	0.748	7.480	1.125E-04
16	10.00	115.00	137.28	2533.60	27392.5	0.28	2.847	70380.2	0.537	0.715	7.150	1.016E-04
17	10.00	125.00	137.28	2565.80	28093.2	0.28	2.832	72097.9	0.584	0.681	6.810	9.445E-05
18	10.00	135.00	137.28	2607.30	29009.4	0.28	2.847	74536.1	0.631	0.645	6.450	8.654E-05
19	15.00	147.50	137.28	2639.70	29734.8	0.29	4.307	76544.0	0.689	0.605	9.075	1.186E-04
20	15.00	162.50	137.28	2767.00	32671.9	0.29	4.317	84147.8	0.759	0.554	8.310	9.875E-05
21	15.00	177.50	137.28	2836.80	34341.1	0.29	4.362	88654.2	0.829	0.507	7.605	8.578E-05
22	15.00	192.50	137.28	2846.50	34576.3	0.29	4.367	89283.6	0.900	0.461	6.915	7.745E-05
23	15.00	207.50	137.28	2866.40	35061.4	0.29	4.358	90493.6	0.970	0.424	6.360	7.028E-05
24	15.00	222.50	137.28	2911.40	36171.0	0.29	4.391	93517.1	1.040	0.39	5.850	6.256E-05
25	7.50	233.75	137.28	2931.90	36682.1	0.29	2.208	94963.4	1.092	0.366	2.745	2.891E-05
26	7.50	241.25	137.28	2933.30	36717.2	0.30	2.226	95225.2	1.127	0.352	2.640	2.772E-05
27	7.50	248.75	137.28	2932.10	36687.1	0.29	2.205	94945.6	1.162	0.338	2.535	2.670E-05
28	7.50	256.25	137.28	2961.70	37431.6	0.30	2.218	97006.2	1.197	0.326	2.445	2.520E-05
29	7.50	263.75	137.28	3008.60	38626.5	0.30	2.214	100061.1	1.232	0.312	2.340	2.339E-05
30	7.50	271.25	137.28	3022.60	38986.8	0.30	2.220	101052.2	1.268	0.302	2.265	2.241E-05
31	7.50	278.75	137.28	3043.90	39538.2	0.30	2.213	102405.5	1.303	0.289	2.168	2.117E-05
32	7.50	286.25	137.28	3069.60	40208.7	0.29	2.209	104105.1	1.338	0.278	2.085	2.003E-05
33	7.50	293.75	137.28	3083.00	40560.5	0.30	2.225	105184.7	1.373	0.267	2.003	1.904E-05
34	7.50	301.25	137.28	3110.00	41274.0	0.30	2.219	106972.4	1.408	0.257	1.928	1.802E-05
35	7.50	308.75	137.28	3139.70	42066.1	0.30	2.228	109119.5	1.443	0.247	1.853	1.698E-05
36	7.50	316.25	137.28	3191.50	43465.6	0.29	2.208	112518.6	1.478	0.237	1.778	1.580E-05
37	10.16	325.08	137.28	3218.00	44190.4	0.30	3.001	114495.7	1.519	0.227	2.306	2.014E-05
38	9.84	335.08	137.28	3264.10	45465.6	0.29	2.887	117598.6	1.566	0.216	2.126	1.808E-05
39	10.16	345.08	137.28	3268.40	45585.5	0.29	2.973	117854.0	1.613	0.205	2.082	1.767E-05
40	9.84	355.08	137.28	3292.10	46249.0	0.29	2.871	119475.9	1.659	0.197	1.939	1.623E-05
41	20.00	370.00	137.28	3364.40	48302.7	0.29	5.815	124691.5	1.729	0.183	3.660	2.935E-05
42	20.00	390.00	137.28	3385.90	48922.0	0.29	5.797	126202.2	1.822	0.168	3.360	2.662E-05
43	20.00	410.00	137.28	3407.80	49556.9	0.29	5.784	127779.6	1.916	0.154	3.080	2.410E-05
44	20.00	430.00	137.28	3500.60	52292.7	0.29	5.772	134769.8	2.009	0.142	2.840	2.107E-05
45	20.00	450.00	137.28	3601.70	55356.8	0.29	5.765	142628.0	2.103	0.132	2.640	1.851E-05
						ν_a =						
Σ	460.00					0.30	136.742	Grade Basemat (0'--460')		SUM	211.971	9.790E-03
	410.00					0.29	118.708	Pool Basemat (55'--460')		SUM	164.420	2.117E-03

(a) Poisson's Ratio is from Ref. MO0706SCSPS1E4.002.
(b) E' = 2(1+ν)G'. Ref. Bowles Foundation Analysis and Design, 5th ed., p 121 (Ref. 2.2.6).
(c) From figure 5

	Grade Basemat					Pool Basemat	
Average E = SUM(q_n*h_n) / SUM(q_n*h_n/E_n) =	21651	ksf				77651	ksf
G_s = E/(2(1+ν_a)) =	8345	ksf				30108	ksf
Corresponding Vel = SQRT(32.17*G_s / γ) =	1546	ft/sec	for γ =	112.3	pcf	2937	ft/sec
	1398	ft/sec		137.3	pcf	2656	ft/sec

1E-4 Median Estimate : 30' Depth of Alluvium

Calculation of Equivalent Shear Modulus :

(B) Median Values :
Ref.: MO0706SCSPS1E4.002 for Strain Compatible Soil Properties.

Using 30', Median Curve : Dynamic Shear Modulus of Soil, G' = (γ /32.17, Mass Density) x (V_s , Velocity)^2
Ref.: Bowles Foundation Analysis and Design, 5th ed., Eq (20-15), Ref. 2.2.6.

Width of Building (W) = : 214 ft (Ref. 2.2.16)

NO	LAYER THICKNESS h_n (ft)	DEPTH (Z) TO CTR / LAYER (ft)	DENSITY γ (pcf)	SHEAR WAVE VELOCITY Vs (ft/s)	DYNAMIC SHEAR MODULUS G_n (ksf)	POISSON'S RATIO[a] ν		ELASTIC MODULUS E_n (ksf)[b]	Z / W	INFLUENCE COEFF q_n[c]	q_n*h_n	q_n*h_n/E_n
	(1)	(2)	(3)	(4)	(5)	(7)	(8)=(1)x(7)	(9)	(10)	(11)	(12)	(13)
1	4.00	2.00	112.32	801.63	2243.6	0.39	1.543	6218.6	0.009	0.996	3.984	6.407E-04
2	4.00	6.00	112.32	732.70	1874.4	0.41	1.642	5287.7	0.028	0.988	3.952	7.474E-04
3	4.00	10.00	112.32	833.89	2427.9	0.41	1.649	6858.0	0.047	0.981	3.924	5.722E-04
4	4.00	14.00	112.32	966.38	3260.6	0.41	1.649	9210.2	0.065	0.973	3.892	4.226E-04
5	4.00	18.00	112.32	1005.80	3532.1	0.41	1.657	9990.2	0.084	0.964	3.856	3.860E-04
6	8.00	24.00	112.32	1040.10	3777.1	0.42	3.336	10703.8	0.112	0.953	7.624	7.123E-04
7	2.00	29.00	112.32	1371.60	6568.4	0.39	0.790	18320.9	0.136	0.944	1.889	1.031E-04
8	10.00	35.00	137.28	2200.70	20667.0	0.29	2.906	53343.6	0.164	0.932	9.320	1.747E-04
9	10.00	45.00	137.28	2445.90	25529.0	0.29	2.863	65675.9	0.210	0.911	9.110	1.387E-04
10	10.00	55.00	137.28	2569.50	28174.3	0.28	2.809	72179.2	0.257	0.876	8.760	1.214E-04
11	10.00	65.00	137.28	2653.10	30037.5	0.28	2.809	76950.6	0.304	0.862	8.620	1.120E-04
12	10.00	75.00	137.28	2793.80	33307.9	0.28	2.763	85023.0	0.350	0.836	8.360	9.833E-05
13	10.00	85.00	137.28	2901.00	35913.0	0.28	2.788	91854.0	0.397	0.808	8.080	8.797E-05
14	10.00	95.00	137.28	2964.60	37504.9	0.28	2.815	96126.6	0.444	0.778	7.780	8.093E-05
15	10.00	105.00	137.28	3045.80	39587.6	0.28	2.841	101668.0	0.491	0.748	7.480	7.357E-05
16	10.00	115.00	137.28	3123.30	41627.8	0.28	2.847	106955.2	0.537	0.715	7.150	6.685E-05
17	10.00	125.00	137.28	3149.70	42334.5	0.28	2.832	108646.5	0.584	0.681	6.810	6.268E-05
18	10.00	135.00	137.28	3193.20	43511.9	0.28	2.847	111798.7	0.631	0.645	6.450	5.769E-05
19	15.00	147.50	137.28	3233.00	44603.4	0.29	4.307	114818.9	0.689	0.605	9.075	7.904E-05
20	15.00	162.50	137.28	3388.80	49005.9	0.29	4.317	126216.6	0.759	0.554	8.310	6.584E-05
21	15.00	177.50	137.28	3474.30	51509.9	0.29	4.362	132977.0	0.829	0.507	7.605	5.719E-05
22	15.00	192.50	137.28	3486.30	51866.4	0.29	4.367	133930.3	0.900	0.461	6.915	5.163E-05
23	15.00	207.50	137.28	3510.60	52591.9	0.29	4.358	135739.7	0.970	0.424	6.360	4.685E-05
24	15.00	222.50	137.28	3565.80	54258.8	0.29	4.391	140281.8	1.040	0.39	5.850	4.170E-05
25	7.50	233.75	137.28	3590.80	55022.3	0.29	2.208	142442.8	1.092	0.366	2.745	1.927E-05
26	7.50	241.25	137.28	3592.60	55077.5	0.30	2.226	142842.3	1.127	0.352	2.640	1.848E-05
27	7.50	248.75	137.28	3591.10	55031.5	0.29	2.205	142420.4	1.162	0.338	2.535	1.780E-05
28	7.50	256.25	137.28	3627.30	56146.6	0.30	2.218	145507.2	1.197	0.326	2.445	1.680E-05
29	7.50	263.75	137.28	3684.70	57937.6	0.30	2.214	150086.2	1.232	0.312	2.340	1.559E-05
30	7.50	271.25	137.28	3701.90	58479.8	0.30	2.220	151577.2	1.268	0.302	2.265	1.494E-05
31	7.50	278.75	137.28	3728.00	59307.3	0.30	2.213	153608.2	1.303	0.289	2.168	1.411E-05
32	7.50	286.25	137.28	3759.50	60313.8	0.29	2.209	156159.6	1.338	0.278	2.085	1.335E-05
33	7.50	293.75	137.28	3775.90	60841.1	0.30	2.225	157778.1	1.373	0.267	2.003	1.269E-05
34	7.50	301.25	137.28	3809.00	61912.5	0.30	2.219	160462.3	1.408	0.257	1.928	1.201E-05
35	7.50	308.75	137.28	3845.40	63101.4	0.30	2.228	163685.1	1.443	0.247	1.853	1.132E-05
36	7.50	316.25	137.28	3908.70	65196.0	0.29	2.208	168771.6	1.478	0.237	1.778	1.053E-05
37	10.16	325.08	137.28	3941.20	66284.7	0.30	3.001	171741.0	1.519	0.227	2.306	1.343E-05
38	9.84	335.08	137.28	3997.70	68198.8	0.29	2.887	176398.9	1.566	0.216	2.126	1.205E-05
39	10.16	345.08	137.28	4003.00	68379.7	0.29	2.973	176784.9	1.613	0.205	2.082	1.178E-05
40	9.84	355.08	137.28	4032.00	69374.1	0.29	2.871	179215.5	1.659	0.197	1.939	1.082E-05
41	20.00	370.00	137.28	4120.60	72456.5	0.29	5.815	187043.5	1.729	0.183	3.660	1.957E-05
42	20.00	390.00	137.28	4146.90	73384.3	0.29	5.797	189306.6	1.822	0.168	3.360	1.775E-05
43	20.00	410.00	137.28	4173.70	74335.9	0.29	5.784	191670.7	1.916	0.154	3.080	1.607E-05
44	20.00	430.00	137.28	4287.30	78437.5	0.29	5.772	202150.8	2.009	0.142	2.840	1.405E-05
45	20.00	450.00	137.28	4411.20	83036.6	0.29	5.765	213945.5	2.103	0.132	2.640	1.234E-05
						ν_a =						
Σ	460.00					0.30	136.742	Grade Basemat (0'--460')		SUM	211.971	5.306E-03
	410.00					0.29	118.708	Pool Basemat (55'--460')		SUM	164.420	1.408E-03

(a) Poisson's Ratio is from Ref. MO0706SCSPS1E4.002.
(b) E' = 2(1+ν)G'. Ref. Bowles Foundation Analysis and Design, 5th ed., p 121 (Ref. 2.2.6).
(c) From figure 5

	Grade Basemat					Pool Basemat	
Average E = SUM(q_n*h_n) / SUM(q_n*h_n/E_n) =	39949	ksf				116741	ksf
G_s = E/(2(1+ν_a)) =	15398	ksf				45265	ksf
Corresponding Vel = SQRT(32.17*G_s / γ) =	2100	ft/sec	for γ =	112.3	pcf	3601	ft/sec
	1900	ft/sec		137.3	pcf	3257	ft/sec

1E-4 Upper Bound Estimate : 30' Depth of Alluvium

Calculation of Equivalent Shear Modulus :

(C) Upper Bound Values :
Ref.: MO0706SCSPS1E4.002 for Strain Compatible Soil Properties.

Using 30', Upper Bound Curve : Dynamic Shear Modulus of Soil, G' = (γ /32.17, Mass Density) x (V_s , Velocity)^2
Ref.: Bowles Foundation Analysis and Design, 5th ed., Eq (20-15), Ref. 2.2.6.

Width of Building (W) = : 214 ft (Ref. 2.2.16)

NO	LAYER THICKNESS h_n (ft)	DEPTH (Z) TO CTR / LAYER (ft)	DENSITY γ (pcf)	SHEAR WAVE VELOCITY Vs (ft/s)	DYNAMIC SHEAR MODULUS G_n (ksf)	POISSON'S RATIO[a] ν		ELASTIC MODULUS E_n (ksf) [b]	Z / W	INFLUENCE COEFF q_n [c]	q_n*h_n	q_n*h_n/ E_n
	(1)	(2)	(3)	(4)	(5)	(7)	(8)=(1)x(7)	(9)	(10)	(11)	(12)	(13)
1	4.00	2.00	112.32	1133.70	4487.5	0.39	1.543	12437.7	0.009	0.996	3.984	3.203E-04
2	4.00	6.00	112.32	1036.20	3748.8	0.41	1.642	10575.6	0.028	0.988	3.952	3.737E-04
3	4.00	10.00	112.32	1179.30	4855.7	0.41	1.649	13716.0	0.047	0.981	3.924	2.861E-04
4	4.00	14.00	112.32	1366.70	6521.6	0.41	1.649	18421.4	0.065	0.973	3.892	2.113E-04
5	4.00	18.00	112.32	1422.40	7064.0	0.41	1.657	19980.0	0.084	0.964	3.856	1.930E-04
6	8.00	24.00	112.32	1471.00	7554.9	0.42	3.336	21409.8	0.112	0.953	7.624	3.561E-04
7	2.00	29.00	112.32	1939.70	13136.4	0.39	0.790	36640.5	0.136	0.944	1.889	5.155E-05
8	10.00	35.00	137.28	2863.00	34978.3	0.29	2.906	90282.5	0.164	0.932	9.320	1.032E-04
9	10.00	45.00	137.28	3001.90	38454.6	0.29	2.863	98928.4	0.210	0.911	9.110	9.209E-05
10	10.00	55.00	137.28	3147.00	42262.0	0.28	2.809	108270.1	0.257	0.876	8.760	8.091E-05
11	10.00	65.00	137.28	3249.40	45057.0	0.28	2.809	115428.0	0.304	0.862	8.620	7.468E-05
12	10.00	75.00	137.28	3430.90	50231.1	0.28	2.763	128221.8	0.350	0.836	8.360	6.520E-05
13	10.00	85.00	137.28	3554.10	53903.3	0.28	2.788	137867.4	0.397	0.808	8.080	5.861E-05
14	10.00	95.00	137.28	3630.90	56258.1	0.28	2.815	144191.7	0.444	0.778	7.780	5.396E-05
15	10.00	105.00	137.28	3767.10	60557.9	0.28	2.841	155523.5	0.491	0.748	7.480	4.810E-05
16	10.00	115.00	137.28	3850.20	63259.1	0.28	2.847	162532.8	0.537	0.715	7.150	4.399E-05
17	10.00	125.00	137.28	3866.60	63799.1	0.28	2.832	163732.8	0.584	0.681	6.810	4.159E-05
18	10.00	135.00	137.28	3910.90	65269.4	0.28	2.847	167701.9	0.631	0.645	6.450	3.846E-05
19	15.00	147.50	137.28	3959.60	66905.0	0.29	4.307	172228.3	0.689	0.605	9.075	5.269E-05
20	15.00	162.50	137.28	4150.40	73508.3	0.29	4.317	189323.5	0.759	0.554	8.310	4.389E-05
21	15.00	177.50	137.28	4255.10	77263.7	0.29	4.362	199462.5	0.829	0.507	7.605	3.813E-05
22	15.00	192.50	137.28	4269.80	77798.5	0.29	4.367	200892.9	0.900	0.461	6.915	3.442E-05
23	15.00	207.50	137.28	4299.60	78888.2	0.29	4.358	203610.6	0.970	0.424	6.360	3.124E-05
24	15.00	222.50	137.28	4367.10	81384.6	0.29	4.391	210413.5	1.040	0.39	5.850	2.780E-05
25	7.50	233.75	137.28	4397.90	82536.7	0.29	2.208	213672.6	1.092	0.366	2.745	1.285E-05
26	7.50	241.25	137.28	4400.00	82615.5	0.30	2.226	214261.7	1.127	0.352	2.640	1.232E-05
27	7.50	248.75	137.28	4398.20	82547.9	0.29	2.205	213632.4	1.162	0.338	2.535	1.187E-05
28	7.50	256.25	137.28	4442.50	84219.2	0.30	2.218	218259.1	1.197	0.326	2.445	1.120E-05
29	7.50	263.75	137.28	4512.90	86909.6	0.30	2.214	225137.5	1.232	0.312	2.340	1.039E-05
30	7.50	271.25	137.28	4533.90	87720.3	0.30	2.220	227367.5	1.268	0.302	2.265	9.962E-06
31	7.50	278.75	137.28	4565.90	88962.9	0.30	2.213	230417.5	1.303	0.289	2.168	9.407E-06
32	7.50	286.25	137.28	4604.40	90469.5	0.29	2.209	234236.5	1.338	0.278	2.085	8.901E-06
33	7.50	293.75	137.28	4624.60	91265.1	0.30	2.225	236675.9	1.373	0.267	2.003	8.461E-06
34	7.50	301.25	137.28	4665.00	92866.6	0.30	2.219	240687.9	1.408	0.257	1.928	8.008E-06
35	7.50	308.75	137.28	4709.60	94650.8	0.30	2.228	245524.2	1.443	0.247	1.853	7.545E-06
36	7.50	316.25	137.28	4787.20	97795.6	0.29	2.208	253161.5	1.478	0.237	1.778	7.021E-06
37	10.16	325.08	137.28	4827.00	99428.5	0.30	3.001	257615.2	1.519	0.227	2.306	8.950E-06
38	9.84	335.08	137.28	4896.20	102299.7	0.29	2.887	264602.4	1.566	0.216	2.126	8.035E-06
39	10.16	345.08	137.28	4902.70	102571.5	0.29	2.973	265182.3	1.613	0.205	2.082	7.852E-06
40	9.84	355.08	137.28	4938.10	104058.1	0.29	2.871	268815.4	1.659	0.197	1.939	7.213E-06
41	20.00	370.00	137.28	5046.60	108681.1	0.29	5.815	280555.9	1.729	0.183	3.660	1.305E-05
42	20.00	390.00	137.28	5078.80	110072.4	0.29	5.797	283949.4	1.822	0.168	3.360	1.183E-05
43	20.00	410.00	137.28	5111.80	111507.5	0.29	5.784	287515.3	1.916	0.154	3.080	1.071E-05
44	20.00	430.00	137.28	5250.90	117658.6	0.29	5.772	303232.1	2.009	0.142	2.840	9.366E-06
45	20.00	450.00	137.28	5402.60	124555.2	0.29	5.765	320918.9	2.103	0.132	2.640	8.226E-06
						$ν_a$ =						
Σ	460.00					0.30	136.742	Grade Basemat (0'--460')		SUM	211.971	2.924E-03
	410.00					0.29	118.708	Pool Basemat (55'--460')		SUM	164.420	9.368E-04

(a) Poisson's Ratio is from Ref. MO0706SCSPS1E4.002.
(b) E' = 2(1+ν)G'. Ref. Bowles Foundation Analysis and Design, 5th ed., p 121 (Ref. 2.2.6).
(c) From figure 5

	Grade Basemat					Pool Basemat	
Average E = SUM(q_n*h_n) / SUM(q_n*h_n/E_n) =	72490	ksf				175507	ksf
G_s = E/(2(1+$ν_a$)) =	27939	ksf				68051	ksf
Corresponding Vel = SQRT(32.17*G_s / γ) =	2829	ft/sec	for γ =	112.3	pcf	4415	ft/sec
	2559	ft/sec		137.3	pcf	3993	ft/sec

1E-4 Lower Bound Estimate : 100' Depth of Alluvium

Calculation of Equivalent Shear Modulus :

(A) Lower Bound Values :
Ref.: MO0706SCSPS1E4.002 for Strain Compatible Soil Properties.

Using 100', Lower Bound Curve : Dynamic Shear Modulus of Soil, G' = (γ /32.17, Mass Density) x (V_s , Velocity)^2
Ref.: Bowles Foundation Analysis and Design, 5th ed., Eq (20-15), Ref. 2.2.6.

Width of Building (W) = : 214 ft (Ref. 2.2.16)

NO	LAYER THICKNESS h_n (ft)	DEPTH (Z) TO CTR / LAYER (ft)	DENSITY γ (pcf)	SHEAR WAVE VELOCITY Vs (ft/s)	DYNAMIC SHEAR MODULUS G_n (ksf)	POISSON'S RATIO[a] ν		ELASTIC MODULUS E_n (ksf) [b]	Z / W	INFLUENCE COEFF q_n [c]	q_n*h_n	q_n*h_n/ E_n
	(1)	(2)	(3)	(4)	(5)	(7)	(8)=(1)x(7)	(9)	(10)	(11)	(12)	(13)
1	4.00	2.00	112.32	559.38	1092.5	0.38	1.540	3026.2	0.009	0.996	3.984	1.317E-03
2	4.00	6.00	112.32	500.00	872.9	0.42	1.660	2470.3	0.028	0.988	3.952	1.600E-03
3	4.00	10.00	112.32	546.23	1041.7	0.42	1.677	2956.8	0.047	0.981	3.924	1.327E-03
4	4.00	14.00	112.32	611.99	1307.7	0.42	1.674	3709.9	0.065	0.973	3.892	1.049E-03
5	4.00	18.00	112.32	672.28	1578.0	0.42	1.671	4474.6	0.084	0.964	3.856	8.618E-04
6	8.00	24.00	112.32	709.19	1756.0	0.42	3.357	4985.6	0.112	0.953	7.624	1.529E-03
7	8.00	32.00	112.32	842.88	2480.5	0.40	3.233	6966.0	0.150	0.938	7.504	1.077E-03
8	8.00	40.00	112.32	865.87	2617.6	0.40	3.178	7315.0	0.187	0.922	7.376	1.008E-03
9	8.00	48.00	112.32	866.35	2620.6	0.40	3.162	7312.5	0.224	0.903	7.224	9.879E-04
10	8.00	56.00	112.32	1080.70	4077.7	0.38	3.053	11268.0	0.262	0.886	7.088	6.290E-04
11	10.00	65.00	112.32	1063.00	3945.2	0.38	3.841	10921.4	0.304	0.862	8.620	7.893E-04
12	10.00	75.00	112.32	1193.20	4970.9	0.38	3.788	13708.0	0.350	0.836	8.360	6.099E-04
13	10.00	85.00	112.32	1265.30	5589.8	0.38	3.772	15396.9	0.397	0.808	8.080	5.248E-04
14	10.00	95.00	112.32	1322.90	6110.3	0.38	3.769	16826.0	0.444	0.778	7.780	4.624E-04
15	10.00	105.00	137.28	1834.80	14365.9	0.32	3.165	37825.2	0.491	0.748	7.480	1.978E-04
16	10.00	115.00	137.28	2002.20	17106.9	0.32	3.163	45034.6	0.537	0.715	7.150	1.588E-04
17	10.00	125.00	137.28	2382.50	24222.7	0.28	2.832	62165.1	0.584	0.681	6.810	1.095E-04
18	10.00	135.00	137.28	2453.80	25694.2	0.28	2.837	65967.2	0.631	0.645	6.450	9.778E-05
19	15.00	147.50	137.28	2504.30	26762.6	0.28	4.254	68704.0	0.689	0.605	9.075	1.321E-04
20	15.00	162.50	137.28	2559.50	27955.4	0.29	4.280	71864.5	0.759	0.554	8.310	1.156E-04
21	15.00	177.50	137.28	2692.30	30931.7	0.29	4.305	79618.7	0.829	0.507	7.605	9.552E-05
22	15.00	192.50	137.28	2734.10	31899.6	0.29	4.328	82207.1	0.900	0.461	6.915	8.412E-05
23	15.00	207.50	137.28	2788.80	33188.8	0.29	4.379	85754.4	0.970	0.424	6.360	7.417E-05
24	15.00	222.50	137.28	2837.00	34345.9	0.29	4.380	88749.8	1.040	0.39	5.850	6.592E-05
25	7.50	233.75	137.28	2916.20	36290.3	0.29	2.181	93687.1	1.092	0.366	2.745	2.930E-05
26	7.50	241.25	137.28	2926.50	36547.1	0.29	2.198	94516.7	1.127	0.352	2.640	2.793E-05
27	7.50	248.75	137.28	2947.40	37071.0	0.29	2.210	95988.7	1.162	0.338	2.535	2.641E-05
28	7.50	256.25	137.28	3044.60	39556.4	0.29	2.208	102406.0	1.197	0.326	2.445	2.388E-05
29	7.50	263.75	137.28	3075.00	40350.3	0.29	2.186	104221.5	1.232	0.312	2.340	2.245E-05
30	7.50	271.25	137.28	3085.80	40634.2	0.29	2.206	105169.4	1.268	0.302	2.265	2.154E-05
31	7.50	278.75	137.28	3127.90	41750.5	0.29	2.201	108007.8	1.303	0.289	2.168	2.007E-05
32	7.50	286.25	137.28	3170.70	42900.9	0.29	2.205	111031.0	1.338	0.278	2.085	1.878E-05
33	7.50	293.75	137.28	3198.60	43659.2	0.29	2.196	112880.9	1.373	0.267	2.003	1.774E-05
34	7.50	301.25	137.28	3220.00	44245.4	0.29	2.192	114356.6	1.408	0.257	1.928	1.686E-05
35	7.50	308.75	137.28	3236.00	44686.2	0.29	2.208	115682.7	1.443	0.247	1.853	1.601E-05
36	7.50	316.25	137.28	3292.00	46246.2	0.29	2.201	119633.3	1.478	0.237	1.778	1.486E-05
37	10.16	325.08	137.28	3327.60	47251.8	0.29	2.992	122345.3	1.519	0.227	2.306	1.885E-05
38	9.84	335.08	137.28	3358.60	48136.3	0.29	2.875	124392.9	1.566	0.216	2.126	1.709E-05
39	10.16	345.08	137.28	3383.60	48855.6	0.29	2.979	126373.8	1.613	0.205	2.082	1.648E-05
40	9.84	355.08	137.28	3450.10	50794.8	0.29	2.865	131155.3	1.659	0.197	1.939	1.478E-05
41	20.00	370.00	137.28	3458.70	51048.4	0.29	5.808	131747.7	1.729	0.183	3.660	2.778E-05
42	20.00	390.00	137.28	3480.40	51691.0	0.29	5.790	133311.0	1.822	0.168	3.360	2.520E-05
43	20.00	410.00	137.28	3494.50	52110.6	0.29	5.781	134346.4	1.916	0.154	3.080	2.293E-05
44	20.00	430.00	137.28	3555.00	53930.6	0.29	5.761	138929.6	2.009	0.142	2.840	2.044E-05
45	20.00	450.00	137.28	3562.80	54167.5	0.29	5.750	139483.6	2.103	0.132	2.640	1.893E-05
						ν_a =						
Σ	460.00					0.31	144.292	Grade Basemat (0'--460')		SUM	212.084	1.534E-02
	408.00					0.30	123.140	Pool Basemat (56'--460')		SUM	162.748	4.585E-03

(a) Poisson's Ratio is from Ref. MO0706SCSPS1E4.002.
(b) E' = 2(1+ν)G'. Ref. Bowles Foundation Analysis and Design, 5th ed., p 121 (Ref. 2.2.6).
(c) From figure 5

	Grade Basemat					Pool Basemat	
Average E = SUM(q_n*h_n) / SUM(q_n*h_n/E_n) =	13824	ksf				35497	ksf
G_s = E/(2(1+ν_a)) =	5262	ksf				13633	ksf
Corresponding Vel = SQRT(32.17*G_s / γ) =	1228	ft/sec	for γ =	112.3	pcf	1976	ft/sec
	1110	ft/sec		137.3	pcf	1787	ft/sec

1E-4 Median Estimate : 100' Depth of Alluvium

Calculation of Equivalent Shear Modulus :

(B) Median Values :
Ref.: MO0706SCSPS1E4.002 for Strain Compatible Soil Properties.

Using 100', Median Curve : Dynamic Shear Modulus of Soil, $G' = (\gamma /32.17$, Mass Density) x (V_s , Velocity)^2
Ref.: Bowles Foundation Analysis and Design, 5th ed., Eq (20-15), Ref. 2.2.6.

Width of Building (W) = : 214 ft (Ref. 2.2.16)

NO	LAYER THICKNESS h_n (ft)	DEPTH (Z) TO CTR / LAYER (ft)	DENSITY γ (pcf)	SHEAR WAVE VELOCITY Vs (ft/s)	DYNAMIC SHEAR MODULUS G_n (ksf)	POISSON'S RATIO[(a)] ν		ELASTIC MODULUS E_n (ksf) [(b)]	Z / W	INFLUENCE COEFF q_n [(c)]	$q_n{*}h_n$	$q_n{*}h_n/E_n$
	(1)	(2)	(3)	(4)	(5)	(7)	(8)=(1)x(7)	(9)	(10)	(11)	(12)	(13)
1	4.00	2.00	112.32	791.08	2185.0	0.38	1.540	6052.3	0.009	0.996	3.984	6.583E-04
2	4.00	6.00	112.32	700.85	1715.0	0.42	1.660	4853.6	0.028	0.988	3.952	8.142E-04
3	4.00	10.00	112.32	772.49	2083.5	0.42	1.677	5913.7	0.047	0.981	3.924	6.635E-04
4	4.00	14.00	112.32	865.48	2615.3	0.42	1.674	7419.7	0.065	0.973	3.892	5.246E-04
5	4.00	18.00	112.32	950.75	3156.0	0.42	1.671	8949.3	0.084	0.964	3.856	4.309E-04
6	8.00	24.00	112.32	1003.00	3512.4	0.42	3.357	9972.4	0.112	0.953	7.624	7.645E-04
7	8.00	32.00	112.32	1192.00	4960.9	0.40	3.233	13931.6	0.150	0.938	7.504	5.386E-04
8	8.00	40.00	112.32	1224.50	5235.1	0.40	3.178	14629.4	0.187	0.922	7.376	5.042E-04
9	8.00	48.00	112.32	1225.20	5241.1	0.40	3.162	14624.9	0.224	0.903	7.224	4.940E-04
10	8.00	56.00	112.32	1528.40	8156.1	0.38	3.053	22537.8	0.262	0.886	7.088	3.145E-04
11	10.00	65.00	112.32	1503.30	7890.4	0.38	3.841	21842.6	0.304	0.862	8.620	3.946E-04
12	10.00	75.00	112.32	1687.50	9942.5	0.38	3.788	27417.9	0.350	0.836	8.360	3.049E-04
13	10.00	85.00	112.32	1789.30	11178.2	0.38	3.772	30790.2	0.397	0.808	8.080	2.624E-04
14	10.00	95.00	112.32	1870.80	12219.7	0.38	3.769	33649.6	0.444	0.778	7.780	2.312E-04
15	10.00	105.00	137.28	2579.20	28387.4	0.32	3.165	74743.6	0.491	0.748	7.480	1.001E-04
16	10.00	115.00	137.28	2676.20	30562.8	0.32	3.163	80457.8	0.537	0.715	7.150	8.887E-05
17	10.00	125.00	137.28	2917.90	36332.6	0.28	2.832	93244.1	0.584	0.681	6.810	7.303E-05
18	10.00	135.00	137.28	3005.30	38541.8	0.28	2.837	98952.2	0.631	0.645	6.450	6.518E-05
19	15.00	147.50	137.28	3067.10	40143.2	0.28	4.254	103054.0	0.689	0.605	9.075	8.806E-05
20	15.00	162.50	137.28	3134.80	41934.9	0.29	4.280	107801.3	0.759	0.554	8.310	7.709E-05
21	15.00	177.50	137.28	3297.40	46398.0	0.29	4.305	119429.4	0.829	0.507	7.605	6.368E-05
22	15.00	192.50	137.28	3348.60	47850.1	0.29	4.328	123312.6	0.900	0.461	6.915	5.608E-05
23	15.00	207.50	137.28	3415.60	49784.0	0.29	4.379	128634.0	0.970	0.424	6.360	4.944E-05
24	15.00	222.50	137.28	3474.60	51518.8	0.29	4.380	133124.6	1.040	0.39	5.850	4.394E-05
25	7.50	233.75	137.28	3571.60	54435.5	0.29	2.181	140530.6	1.092	0.366	2.745	1.953E-05
26	7.50	241.25	137.28	3584.20	54820.2	0.29	2.198	141773.8	1.127	0.352	2.640	1.862E-05
27	7.50	248.75	137.28	3609.80	55606.1	0.29	2.210	143982.0	1.162	0.338	2.535	1.761E-05
28	7.50	256.25	137.28	3728.80	59332.7	0.29	2.208	153604.2	1.197	0.326	2.445	1.592E-05
29	7.50	263.75	137.28	3766.10	60525.7	0.29	2.186	156333.1	1.232	0.312	2.340	1.497E-05
30	7.50	271.25	137.28	3779.30	60950.7	0.29	2.206	157752.7	1.268	0.302	2.265	1.436E-05
31	7.50	278.75	137.28	3830.90	62626.5	0.29	2.201	162013.4	1.303	0.289	2.168	1.338E-05
32	7.50	286.25	137.28	3883.30	64351.4	0.29	2.205	166546.6	1.338	0.278	2.085	1.252E-05
33	7.50	293.75	137.28	3917.50	65489.9	0.29	2.196	169324.1	1.373	0.267	2.003	1.183E-05
34	7.50	301.25	137.28	3943.70	66368.8	0.29	2.192	171536.8	1.408	0.257	1.928	1.124E-05
35	7.50	308.75	137.28	3963.20	67026.8	0.29	2.208	173517.5	1.443	0.247	1.853	1.068E-05
36	7.50	316.25	137.28	4031.80	69367.2	0.29	2.201	179444.6	1.478	0.237	1.778	9.906E-06
37	10.16	325.08	137.28	4075.50	70879.1	0.29	2.992	183521.5	1.519	0.227	2.306	1.256E-05
38	9.84	335.08	137.28	4113.40	72203.5	0.29	2.875	186586.8	1.566	0.216	2.126	1.139E-05
39	10.16	345.08	137.28	4144.00	73281.7	0.29	2.979	189556.4	1.613	0.205	2.082	1.098E-05
40	9.84	355.08	137.28	4225.40	76188.9	0.29	2.865	196724.4	1.659	0.197	1.939	9.857E-06
41	20.00	370.00	137.28	4236.10	76575.3	0.29	5.808	197628.6	1.729	0.183	3.660	1.852E-05
42	20.00	390.00	137.28	4262.70	77540.0	0.29	5.790	199975.6	1.822	0.168	3.360	1.680E-05
43	20.00	410.00	137.28	4279.90	78167.0	0.29	5.781	201522.3	1.916	0.154	3.080	1.528E-05
44	20.00	430.00	137.28	4354.00	80897.1	0.29	5.761	208397.5	2.009	0.142	2.840	1.363E-05
45	20.00	450.00	137.28	4363.50	81250.5	0.29	5.750	209223.3	2.103	0.132	2.640	1.262E-05
						ν_a =						
Σ	460.00					0.31	144.292	Grade Basemat (0'--460')		SUM	212.084	7.898E-03
	408.00					0.30	123.140	Pool Basemat (56'--460')		SUM	162.748	2.505E-03

(a) Poisson's Ratio is from Ref. MO0706SCSPS1E4.002.
(b) $E' = 2(1+\nu)G'$. Ref. Bowles Foundation Analysis and Design, 5th ed., p 121 (Ref. 2.2.6).
(c) From figure 5

	Grade Basemat					Pool Basemat	
Average $E = SUM(q_n{*}h_n) / SUM(q_n{*}h_n/E_n)$ =	26853	ksf				64961	ksf
$G_s = E/(2(1+\nu_a))$ =	10220	ksf				24950	ksf
Corresponding Vel = $SQRT(32.17{*}G_s / \gamma)$ =	1711	ft/sec	for γ =	112.3	pcf	2673	ft/sec
	1548	ft/sec		137.3	pcf	2418	ft/sec

1E-4 Upper Bound Estimate : 100' Depth of Alluvium

Calculation of Equivalent Shear Modulus :

(C) Upper Bound Values :
Ref.: MO0706SCSPS1E4.002 for Strain Compatible Soil Properties.

Using 100', Upper Bound Curve : Dynamic Shear Modulus of Soil, $G' = (\gamma /32.17$, Mass Density) x (V_s , Velocity)^2
Ref.: Bowles Foundation Analysis and Design, 5th ed., Eq (20-15), Ref. 2.2.6.

Width of Building (W) = : 214 ft (Ref. 2.2.16)

NO	LAYER THICKNESS h_n (ft)	DEPTH (Z) TO CTR / LAYER (ft)	DENSITY γ (pcf)	SHEAR WAVE VELOCITY Vs (ft/s)	DYNAMIC SHEAR MODULUS G_n (ksf)	POISSON'S RATIO[a] ν		ELASTIC MODULUS E_n (ksf) [b]	Z / W	INFLUENCE COEFF q_n [c]	q_n*h_n	q_n*h_n/E_n
	(1)	(2)	(3)	(4)	(5)	(7)	(8)=(1)x(7)	(9)	(10)	(11)	(12)	(13)
1	4.00	2.00	112.32	1118.80	4370.3	0.38	1.540	12105.6	0.009	0.996	3.984	3.291E-04
2	4.00	6.00	112.32	991.15	3429.9	0.42	1.660	9707.1	0.028	0.988	3.952	4.071E-04
3	4.00	10.00	112.32	1092.50	4167.2	0.42	1.677	11828.2	0.047	0.981	3.924	3.317E-04
4	4.00	14.00	112.32	1224.00	5230.8	0.42	1.674	14840.0	0.065	0.973	3.892	2.623E-04
5	4.00	18.00	112.32	1344.60	6312.4	0.42	1.671	17899.5	0.084	0.964	3.856	2.154E-04
6	8.00	24.00	112.32	1418.40	7024.3	0.42	3.357	19943.1	0.112	0.953	7.624	3.823E-04
7	8.00	32.00	112.32	1685.80	9922.4	0.40	3.233	27865.2	0.150	0.938	7.504	2.693E-04
8	8.00	40.00	112.32	1731.70	10470.1	0.40	3.178	29258.7	0.187	0.922	7.376	2.521E-04
9	8.00	48.00	112.32	1732.70	10482.2	0.40	3.162	29250.0	0.224	0.903	7.224	2.470E-04
10	8.00	56.00	112.32	2161.50	16312.3	0.38	3.053	45076.2	0.262	0.886	7.088	1.572E-04
11	10.00	65.00	112.32	2126.10	15782.4	0.38	3.841	43689.8	0.304	0.862	8.620	1.973E-04
12	10.00	75.00	112.32	2386.40	19883.5	0.38	3.788	54831.9	0.350	0.836	8.360	1.525E-04
13	10.00	85.00	112.32	2530.50	22357.3	0.38	3.772	61582.6	0.397	0.808	8.080	1.312E-04
14	10.00	95.00	112.32	2645.70	24439.2	0.38	3.769	67298.8	0.444	0.778	7.780	1.156E-04
15	10.00	105.00	137.28	3625.60	56093.9	0.32	3.165	147694.2	0.491	0.748	7.480	5.065E-05
16	10.00	115.00	137.28	3577.10	54603.2	0.32	3.163	143745.2	0.537	0.715	7.150	4.974E-05
17	10.00	125.00	137.28	3573.70	54499.5	0.28	2.832	139867.5	0.584	0.681	6.810	4.869E-05
18	10.00	135.00	137.28	3680.80	57815.0	0.28	2.837	148434.3	0.631	0.645	6.450	4.345E-05
19	15.00	147.50	137.28	3756.50	60217.5	0.28	4.254	154588.1	0.689	0.605	9.075	5.870E-05
20	15.00	162.50	137.28	3839.30	62901.4	0.29	4.280	161699.4	0.759	0.554	8.310	5.139E-05
21	15.00	177.50	137.28	4038.40	69594.5	0.29	4.305	179137.6	0.829	0.507	7.605	4.245E-05
22	15.00	192.50	137.28	4101.20	71775.8	0.29	4.328	184970.6	0.900	0.461	6.915	3.738E-05
23	15.00	207.50	137.28	4183.30	74678.3	0.29	4.379	192956.7	0.970	0.424	6.360	3.296E-05
24	15.00	222.50	137.28	4255.50	77278.3	0.29	4.380	199687.1	1.040	0.39	5.850	2.930E-05
25	7.50	233.75	137.28	4374.30	81653.2	0.29	2.181	210796.0	1.092	0.366	2.745	1.302E-05
26	7.50	241.25	137.28	4389.70	82229.2	0.29	2.198	212657.8	1.127	0.352	2.640	1.241E-05
27	7.50	248.75	137.28	4421.10	83409.8	0.29	2.210	215974.6	1.162	0.338	2.535	1.174E-05
28	7.50	256.25	137.28	4566.90	89001.9	0.29	2.208	230413.4	1.197	0.326	2.445	1.061E-05
29	7.50	263.75	137.28	4612.50	90788.1	0.29	2.186	234498.4	1.232	0.312	2.340	9.979E-06
30	7.50	271.25	137.28	4628.70	91427.0	0.29	2.206	236631.3	1.268	0.302	2.265	9.572E-06
31	7.50	278.75	137.28	4691.90	93940.7	0.29	2.201	243022.7	1.303	0.289	2.168	8.919E-06
32	7.50	286.25	137.28	4756.00	96525.0	0.29	2.205	249814.5	1.338	0.278	2.085	8.346E-06
33	7.50	293.75	137.28	4797.90	98233.3	0.29	2.196	253982.1	1.373	0.267	2.003	7.884E-06
34	7.50	301.25	137.28	4830.00	99552.1	0.29	2.192	257302.4	1.408	0.257	1.928	7.491E-06
35	7.50	308.75	137.28	4853.90	100539.8	0.29	2.208	260275.3	1.443	0.247	1.853	7.117E-06
36	7.50	316.25	137.28	4938.00	104053.9	0.29	2.201	269175.0	1.478	0.237	1.778	6.604E-06
37	10.16	325.08	137.28	4991.40	106316.6	0.29	2.992	275277.0	1.519	0.227	2.306	8.376E-06
38	9.84	335.08	137.28	5037.80	108302.4	0.29	2.875	279872.9	1.566	0.216	2.126	7.597E-06
39	10.16	345.08	137.28	5075.30	109920.7	0.29	2.979	284329.8	1.613	0.205	2.082	7.323E-06
40	9.84	355.08	137.28	5175.10	114286.2	0.29	2.865	295093.8	1.659	0.197	1.939	6.571E-06
41	20.00	370.00	137.28	5188.10	114861.1	0.29	5.808	296438.1	1.729	0.183	3.660	1.235E-05
42	20.00	390.00	137.28	5220.70	116309.1	0.29	5.790	299961.2	1.822	0.168	3.360	1.120E-05
43	20.00	410.00	137.28	5241.70	117246.7	0.29	5.781	302273.7	1.916	0.154	3.080	1.019E-05
44	20.00	430.00	137.28	5332.50	121343.9	0.29	5.761	312591.6	2.009	0.142	2.840	9.085E-06
45	20.00	450.00	137.28	5344.20	121877.0	0.29	5.750	313838.0	2.103	0.132	2.640	8.412E-06
						ν_a =						
Σ	460.00					0.31	144.292	Grade Basemat (0'--460')		SUM	212.084	4.090E-03
	408.00					0.30	123.140	Pool Basemat (56'--460')		SUM	162.748	1.393E-03

(a) Poisson's Ratio is from Ref. MO0706SCSPS1E4.002.
(b) $E' = 2(1+\nu)G'$. Ref. Bowles Foundation Analysis and Design, 5th ed., p 121 (Ref. 2.2.6).
(c) From figure 5

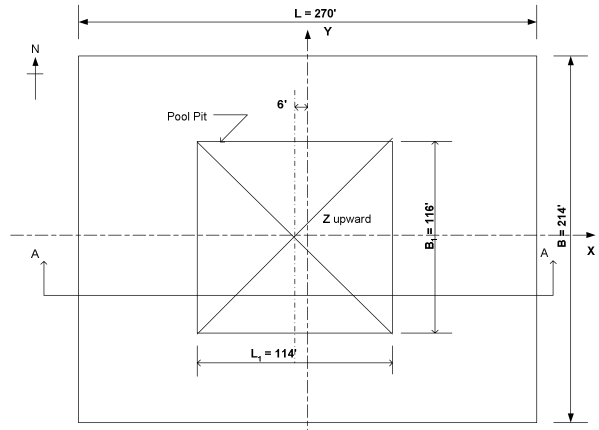
	Grade Basemat					Pool Basemat	
Average $E = SUM(q_n*h_n) / SUM(q_n*h_n/E_n)$ =	51859	ksf				116805	ksf
$G_s = E/(2(1+\nu_a))$ =	19738	ksf				44862	ksf
Corresponding $Vel = SQRT(32.17*G_s / \gamma)$ =	2378	ft/sec	for γ =	112.3	pcf	3585	ft/sec
	2151	ft/sec		137.3	pcf	3242	ft/sec

6.2.3 Soil Impedances

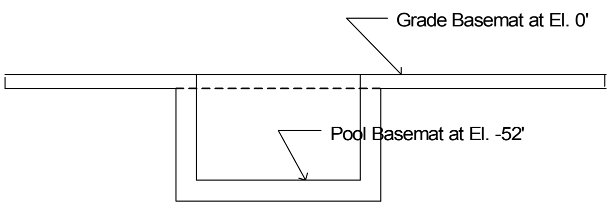
The foundation impedances (soil spring constants and soil damping coefficients) will be calculated per Ref. 2.2.1, section 3.3.4.2.

As shown on the right is the footprint of the grade basemat with pool pit at the middle for the Wet Handling Facility.

L =	270	ft
B =	214	ft
L_1 =	114	ft
B_1 =	116	ft



PLAN



Cross-section A-A

6.2.3.1 Soil Spring Constants

The following calculations determinate translational and rotational springs per methodology of ASCE 4-98, section 3.3 (Ref. 2.2.1) for the Wet Handling Facility.

Note: All variables used in the computation of the equivalent soil spring constants and damping coefficients are defined in ASCE 4-98, section 3.3, unless otherwise noted.

Soil Properties: Shear Modulus for 5E-4 & 1E-4 Annual Probablity of Exceedance (APE), respectively :

For Grade Basemat

	APE : 5E-4	1E-4	
G_s (ksf) =	11221	8345	**L**ower **B**ound **E**stimate for 30' alluvium, sheets 17 & 23
	20198	15398	**M**edian **E**stimate for 30' alluvium, sheets 18 & 24
	35675	27939	**U**pper **B**ound **E**stimate for 30' alluvium, sheets 19 & 25
	7754	5262	**L**ower **B**ound **E**stimate for 100' alluvium, sheets 20 & 26
	14779	10220	**M**edian **E**stimate for 100' alluvium, sheets 21 & 27
	27865	19738	**U**pper **B**ound **E**stimate for 100' alluvium, sheets 22 & 28
			Corresponding Poisson ratio
ν =	0.29	0.30	Lower Bound Estimate for30' alluvium
	0.29	0.30	Median Estimate for 30' alluvium
	0.29	0.30	Upper Bound Estimate for 30' alluvium
	0.30	0.31	Lower Bound Estimate for 100' alluvium
	0.30	0.31	Median Estimate for 100' alluvium
	0.30	0.31	Upper Bound Estimate for 100' alluvium

For Pool Basemat

	APE : 5E-4	1E-4
G'_s (ksf) =	31016	30108
	46532	45265
	69809	68051
	18283	13633
	31790	24950
	54385	44862
ν =	0.28	0.29
	0.28	0.29
	0.28	0.29
	0.29	0.30
	0.29	0.30
	0.29	0.30

6.2.3.1.1 Spring Constants for gross Grade Basemat, dimensions 270' by 214'

For x-direction (E-W) seismic loads:

L (ft) = 270 length along x-direction (E-W) B (ft) = 214 length along y-direction (N-S)

Per Ref. 2.2.1, ASCE 4-98, Fig. 3.3-3, for $\alpha_x = L/B =$ 1.262

$\beta_x =$ 0.96 $\beta_z = 2.15$ $\beta_{\psi y} = 0.57$

Per Ref. 2.2.1, ASCE 4-98, Table 3.3-3 :

Horizontal along x-axis (E-W) : $k_x = 2(1+\nu) * G_s * \beta_x * \sqrt{B * L}$

APE :	5E-4	1E-4	
k_x (k/ft) =	6.6729E+06	4.9962E+06	Lower Bound Estimate for30' alluvium
	1.2012E+07	9.2187E+06	Median Estimate for 30' alluvium
	2.1216E+07	1.6728E+07	Upper Bound Estimate for 30' alluvium
	4.6541E+06	3.1900E+06	Lower Bound Estimate for 100' alluvium
	8.8710E+06	6.1965E+06	Median Estimate for 100' alluvium
	1.6726E+07	1.1967E+07	Upper Bound Estimate for 100' alluvium

Rocking about y-axis : $k_{\psi y} = \frac{G_s}{1-\nu} * \beta_{\psi y} * B * L^2$

APE :	5E-4	1E-4	
$k_{\psi y}$ = (k-ft/rad)	1.4025E+11	1.0560E+11	Lower Bound Estimate for30' alluvium
	2.5246E+11	1.9484E+11	Median Estimate for 30' alluvium
	4.4590E+11	3.5354E+11	Upper Bound Estimate for 30' alluvium
	9.8579E+10	6.8171E+10	Lower Bound Estimate for 100' alluvium
	1.8790E+11	1.3242E+11	Median Estimate for 100' alluvium
	3.5427E+11	2.5574E+11	Upper Bound Estimate for 100' alluvium

Vertical along z-axis : $k_z = \frac{G_s}{1-\nu} * \beta_z * \sqrt{B * L}$

APE :	5E-4	1E-4	
k_z (k/ft) =	8.1510E+06	6.1370E+06	Lower Bound Estimate for30' alluvium
	1.4672E+07	1.1324E+07	Median Estimate for 30' alluvium
	2.5915E+07	2.0547E+07	Upper Bound Estimate for 30' alluvium
	5.7292E+06	3.9620E+06	Lower Bound Estimate for 100' alluvium
	1.0920E+07	7.6961E+06	Median Estimate for 100' alluvium
	2.0589E+07	1.4863E+07	Upper Bound Estimate for 100' alluvium

Torsional about z-axis :

$R_t = \sqrt[4]{B * L(B^2 + L^2)/(6\pi)} =$ 138.11 ft

$k_{\psi z} = \frac{16}{3} * G_s * R_t^3$ Per Ref. 2.2.1, ASCE 4-98, Table 3.3-1

$k_{\psi z}$ = (k-ft/rad)

APE :	5E-4	1E-4	
	1.5765E+11	1.1725E+11	Lower Bound Estimate for30' alluvium
	2.8379E+11	2.1634E+11	Median Estimate for 30' alluvium
	5.0124E+11	3.9255E+11	Upper Bound Estimate for 30' alluvium
	1.0894E+11	7.3926E+10	Lower Bound Estimate for 100' alluvium
	2.0765E+11	1.4360E+11	Median Estimate for 100' alluvium
	3.9150E+11	2.7732E+11	Upper Bound Estimate for 100' alluvium

For y-direction (N-S) seismic loads:

L (ft) = 270 length along x-direction (E-W) B (ft) = 214 length along y-direction (N-S)

Per Ref. 2.2.1, ASCE 4-98, Fig. 3.3-3, for $\alpha_y = B/L =$ 0.793

$\beta_y =$ 0.98 $\beta_{\psi x} = 0.52$

Per Ref. 2.2.1, ASCE 4-98, Table 3.3-3 :

Horizontal along y-axis (N-S) : $k_y = 2(1 + \nu)*G_s*\beta_y*\sqrt{B * L}$

k_y (k/ft) =

APE :	5E-4	1E-4	
	6.8120E+06	5.1003E+06	Lower Bound Estimate for30' alluvium
	1.2262E+07	9.4108E+06	Median Estimate for 30' alluvium
	2.1658E+07	1.7076E+07	Upper Bound Estimate for 30' alluvium
	4.7510E+06	3.2565E+06	Lower Bound Estimate for 100' alluvium
	9.0558E+06	6.3256E+06	Median Estimate for 100' alluvium
	1.7074E+07	1.2216E+07	Upper Bound Estimate for 100' alluvium

Rocking about x-axis : $k_{\psi x} = \frac{G_s}{1-\nu} * \beta_{\psi x} * B^2 * L$

$k_{\psi x}$ = (k-ft/rad)

APE :	5E-4	1E-4	
	1.0141E+11	7.6353E+10	Lower Bound Estimate for30' alluvium
	1.8255E+11	1.4088E+11	Median Estimate for 30' alluvium
	3.2242E+11	2.5563E+11	Upper Bound Estimate for 30' alluvium
	7.1279E+10	4.9292E+10	Lower Bound Estimate for 100' alluvium
	1.3586E+11	9.5749E+10	Median Estimate for 100' alluvium
	2.5616E+11	1.8491E+11	Upper Bound Estimate for 100' alluvium

6.2.3.1.2 Spring Constants for Pool Basemat, dimensions 114' by 116'

There are two sets of soil Spring Constants to be calculated for the Pool area. First set (k'_1's) is based on the G_s for the grade basemat; second set (k_1's) is based on the G'_s for the actual pool basemat (see figure on sheet 29).

For x-direction (E-W) seismic loads:

L_1 (ft) = 114 length along x-direction (E-W) B_1 (ft) = 116 length along y-direction (N-S)

Per Ref. 2.2.1, ASCE 4-98, Fig. 3.3-3, for $\alpha_{x1} = L_1/B_1 =$ 0.983

$\beta_{x1} =$ 0.98 $\beta_{z1} = 2.15$ $\beta_{\psi y1} = 0.51$

Per Ref. 2.2.1, ASCE 4-98, Table 3.3-3 :

Horizontal along x-axis (E-W) :

$k'_{x1} = 2(1+\nu) * G_s * \beta_{x1} * \sqrt{B_1 * L_1}$ $k_{x1} = 2(1+\nu) * G'_s * \beta_{x1} * \sqrt{B_1 * L_1}$

APE :	k'_{x1} (k/ft) 5E-4	k'_{x1} (k/ft) 1E-4		k_{x1} (k/ft) 5E-4	k_{x1} (k/ft) 1E-4
	3.2588E+06	2.4400E+06	Lower Bound Estimate for 30' alluvium	8.9620E+06	8.7509E+06
	5.8662E+06	4.5021E+06	Median Estimate for 30' alluvium	1.3445E+07	1.3156E+07
	1.0361E+07	8.1693E+06	Upper Bound Estimate for 30' alluvium	2.0171E+07	1.9779E+07
	2.2729E+06	1.5579E+06	Lower Bound Estimate for 100' alluvium	5.3188E+06	4.0003E+06
	4.3323E+06	3.0262E+06	Median Estimate for 100' alluvium	9.2481E+06	7.3209E+06
	8.1682E+06	5.8443E+06	Upper Bound Estimate for 100' alluvium	1.5821E+07	1.3163E+07

Rocking about y-axis :

$k'_{\psi y1} = \frac{G_s}{1-\nu} * \beta_{\psi y1} * B_1 * L_1^2$ $k_{\psi y1} = \frac{G_s'}{1-\nu} * \beta_{\psi y1} * B_1 * L_1^2$

APE :	$k'_{\psi y1}$ (k-ft/rad) 5E-4	$k'_{\psi y1}$ (k-ft/rad) 1E-4		$k_{\psi y1}$ (k-ft/rad) 5E-4	$k_{\psi y1}$ (k-ft/rad) 1E-4
	1.2126E+10	9.1299E+09	LBE 30'	3.3211E+10	3.2582E+10
	2.1828E+10	1.6846E+10	ME 30'	4.9826E+10	4.8984E+10
	3.8553E+10	3.0568E+10	UBE 30'	7.4750E+10	7.3642E+10
	8.5233E+09	5.8942E+09	LBE 100'	1.9818E+10	1.5013E+10
	1.6246E+10	1.1449E+10	ME 100'	3.4459E+10	2.7475E+10
	3.0631E+10	2.2111E+10	UBE 100'	5.8951E+10	4.9402E+10

Vertical along z-axis :

$k'_{z1} = \frac{G_s}{1-\nu} * \beta_{z1} * \sqrt{B_1 * L_1}$ $k_{z1} = \frac{G_s'}{1-\nu} * \beta_{z1} * \sqrt{B_1 * L_1}$

APE :	k'_{z1} (k/ft) 5E-4	k'_{z1} (k/ft) 1E-4		k_{z1} (k/ft) 5E-4	k_{z1} (k/ft) 1E-4
	3.8995E+06	2.9360E+06	LBE 30'	1.0680E+07	1.0478E+07
	7.0193E+06	5.4173E+06	ME 30'	1.6023E+07	1.5752E+07
	1.2398E+07	9.8298E+06	UBE 30'	2.4038E+07	2.3681E+07
	2.7409E+06	1.8954E+06	LBE 100'	6.3730E+06	4.8279E+06
	5.2243E+06	3.6818E+06	ME 100'	1.1081E+07	8.8354E+06
	9.8500E+06	7.1104E+06	UBE 100'	1.8957E+07	1.5887E+07

Torsional about z-axis :

$$R_{t1} = \sqrt[4]{B_1 * L_1(B_1^2 + L_1^2)/(6\pi)} = 65.63 \text{ ft}$$

$$k'_{\psi z1} = \frac{16}{3} * G_s * R_{t1}^3 \qquad k_{\psi z1} = \frac{16}{3} * G_s' * R_{t1}^3$$

$k'_{\psi z1}$ (k-ft/rad):

APE :	5E-4	1E-4
LBE 30'	1.6920E+10	1.2584E+10
ME 30'	3.0458E+10	2.3219E+10
UBE 30'	5.3796E+10	4.2131E+10
LBE 100'	1.1692E+10	7.9342E+09
ME 100'	2.2286E+10	1.5412E+10
UBE 100'	4.2019E+10	2.9764E+10

$k_{\psi z1}$ (k-ft/rad):

APE :	5E-4	1E-4
	4.6771E+10	4.5402E+10
	7.0168E+10	6.8258E+10
	1.0527E+11	1.0262E+11
	2.7570E+10	2.0559E+10
	4.7938E+10	3.7624E+10
	8.2010E+10	6.7650E+10

For y-direction (N-S) seismic loads:

L_1 (ft) = 114 length along x-direction (E-W) B_1 (ft) = 116 length along y-direction (N-S)

Per Ref. 2.2.1, ASCE 4-98, Fig. 3.3-3, for $\alpha_{y1} = B_1/L_1 =$ 1.018

$\beta_{y1} =$ 0.97 $\beta_{\psi x1} = 0.52$

Per Ref. 2.2.1, ASCE 4-98, Table 3.3-3 :

Horizontal along y-axis (N-S) : $k'_{y1} = 2(1+\nu) * G_s * \beta_{y1} * \sqrt{B_1 * L_1}$ $k_{y1} = 2(1+\nu) * G_s' * \beta_{y1} * \sqrt{B_1 * L_1}$

k'_{y1} (k/ft):

APE :	5E-4	1E-4
LBE 30'	3.2256E+06	2.4151E+06
ME 30'	5.8063E+06	4.4562E+06
UBE 30'	1.0255E+07	8.0859E+06
LBE 100'	2.2497E+06	1.5420E+06
ME 100'	4.2881E+06	2.9953E+06
UBE 100'	8.0849E+06	5.7846E+06

k_{y1} (k/ft):

APE :	5E-4	1E-4
	8.8705E+06	8.6616E+06
	1.3308E+07	1.3022E+07
	1.9965E+07	1.9577E+07
	5.2646E+06	3.9595E+06
	9.1538E+06	7.2462E+06
	1.5660E+07	1.3029E+07

Rocking about x-axis : $k'_{\psi x1} = \frac{G_s}{1-\nu} * \beta_{\psi x1} * B_1^2 * L_1$ $k_{\psi x1} = \frac{G_s'}{1-\nu} * \beta_{\psi x1} * B_1^2 * L_1$

$k'_{\psi x1}$ (k-ft/rad):

APE :	5E-4	1E-4
LBE 30'	1.2581E+10	9.4722E+09
ME 30'	2.2646E+10	1.7478E+10
UBE 30'	3.9999E+10	3.1714E+10
LBE 100'	8.8428E+09	6.1152E+09
ME 100'	1.6855E+10	1.1879E+10
UBE 100'	3.1779E+10	2.2940E+10

$k_{\psi x1}$ (k-ft/rad):

APE :	5E-4	1E-4
	3.4457E+10	3.3804E+10
	5.1694E+10	5.0821E+10
	7.7553E+10	7.6403E+10
	2.0561E+10	1.5576E+10
	3.5751E+10	2.8505E+10
	6.1161E+10	5.1255E+10

6.2.3.1.3 Net Spring Constants for Grade Basemat with Pool Pit

As shown in the calculation above, the spring constants are expressed as functions of the basemat geometrical properties. The spring constants for the Pool Basemat are as calculated (k_1's) and applied at the Pool Basemat. For the Grade Basemat, its outline envelopes the Pool area which is a pit, see figure on sheet 29. The spring constants calculated based on the gross dimensions contain the spring constants of the Pool pit area. Considering the depth of the pit area, adjustments are needed to determine the spring constants for the Net Grade Basemat. Therefore, the spring constants (k_2's) for the Net Grade Basemat and applied at the grade can be calculated by subtracting the spring constants (k_1''s) for Pool Basemat from the spring constants (k's) for the gross Grade Basemat as follows:

Horizontal along x-axis (E-W) :
$k_{x2} = k_x - k'_{x1}$

k_{x2} (k/ft) =

5E-4	1E-4	: APE
3.414E+06	2.556E+06	LBE 30'
6.146E+06	4.717E+06	ME 30'
1.085E+07	8.558E+06	UBE 30'
2.381E+06	1.632E+06	LBE 100'
4.539E+06	3.170E+06	ME 100'
8.557E+06	6.123E+06	UBE 100'

Rocking about y-axis :
$k_{\psi y2} = k_{\psi y} - k'_{\psi y1}$

$k_{\psi y2}$ (k-ft/rad) =

5E-4	1E-4	: APE
1.281E+11	9.647E+10	
2.306E+11	1.780E+11	
4.074E+11	3.230E+11	
9.006E+10	6.228E+10	
1.717E+11	1.210E+11	
3.236E+11	2.336E+11	

Vertical along z-axis :
$k_{z2} = k_z - k'_{z1}$

k_{z2} (k/ft) =

5E-4	1E-4	: APE
4.252E+06	3.201E+06	LBE 30'
7.653E+06	5.906E+06	ME 30'
1.352E+07	1.072E+07	UBE 30'
2.988E+06	2.067E+06	LBE 100'
5.696E+06	4.014E+06	ME 100'
1.074E+07	7.752E+06	UBE 100'

Torsional about z-axis :
$k_{\psi z2} = k_{\psi z} - k'_{\psi z1}$

$k_{\psi z2}$ (k-ft/rad) =

5E-4	1E-4	: APE
1.407E+11	1.047E+11	
2.533E+11	1.931E+11	
4.474E+11	3.504E+11	
9.725E+10	6.599E+10	
1.854E+11	1.282E+11	
3.495E+11	2.476E+11	

Horizontal along y-axis (N-S) :
$k_{y2} = k_y - k'_{y1}$

k_{y2} (k/ft) =

5E-4	1E-4	: APE
3.586E+06	2.685E+06	LBE 30'
6.456E+06	4.955E+06	ME 30'
1.140E+07	8.990E+06	UBE 30'
2.501E+06	1.714E+06	LBE 100'
4.768E+06	3.330E+06	ME 100'
8.989E+06	6.432E+06	UBE 100'

Rocking about x-axis :
$k_{\psi x2} = k_{\psi x} - k'_{\psi x1}$

$k_{\psi x2}$ (k-ft/rad) =

5E-4	1E-4	: APE
8.883E+10	6.688E+10	
1.599E+11	1.234E+11	
2.824E+11	2.239E+11	
6.244E+10	4.318E+10	
1.190E+11	8.387E+10	
2.244E+11	1.620E+11	

Title : Wet Handling Facility Soil Spring Constants and Damping Values

6.2.3.2 SOIL DAMPING COEFFICIENTS

LEGEND:
Gs = shear modulus of foundation medium
R = Equivalent radius of circular basement
γ = density of foundation medium
g = acceleration of gravity, 32.17 ft/sec
ρ = mass density of foundation medium
I_t (m_t) = polar mass moment of inertia of structure and basemat
I_{ox} ($m_{\psi x}$), I_{oy} ($m_{\psi y}$) = total mass moment of inertia of structure and basemat about the rocking axis at the base
k_x, k_y, $k_{\psi y}$, $k_{\psi x}$, k_z, k_ψ = equivalent spring constants
C_x, C_y, $C_{\psi y}$, $C_{\psi x}$, C_z, C_ψ = equivalent damping coefficients
C_c = critical damping value
β_ψ = constants that are functions of the basement dimensional ratio, L/B

UNITS:
kips (k), feet (ft), radians (rad), seconds (sec)
Note : The last digit of a number may be rounded-off differently due to different effective digits used in different location .

Determine Equivalent Damping Coefficient per ASCE 4-98 section 3.3, (Ref. 2.2.1) methodology for the Wet Handling Facility. As stated in Assumption section 3.1.3 for the calculation of soil damping coefficients, the soil damping coefficients are calculated as function of gross basemat foot print dimensions (gross basemat area at the grade ignoring the pool pit.)

Shear modulus as calculated in pp 17-28 :

Grade Basemat — Annual Probablity of Exceedance (APE used henceforth)

	5E-4	1E-4	
G_s (ksf) = (sheet 29)	11221	8345	LBE 30'
	20198	15398	ME 30'
	35675	27939	UBE 30'
	7754	5262	LBE 100'
	14779	10220	ME 100'
	27865	19738	UBE 100'

Pool Basemat — APE

	5E-4	1E-4
G'_s (ksf) = (sheet 29)	31016	30108
	46532	45265
	69809	68051
	18283	13633
	31790	24950
	54385	44862

The average density of foundation medium for 30' and 100' alluvium are:

γ_1 = (30*112.32+430*137.28)/460 = 135.65 pcf,
γ_2 = (100*112.32+360*137.28)/460 = 131.85 pcf,
ρ_1 = 0.00422 k-sec^2/ft^4
ρ_2 = 0.00410 k-sec^2/ft^4

γ1 = (0*112.32+406*137.28)/406 = 137.28 pcf
γ2 = (46*112.32+360*137.28)/406 = 134.45 pcf
ρ_1 = 0.00427 k-sec^2/ft^4
ρ_2 = 0.00418 k-sec^2/ft^4

Wet Handling Facility Weight (kip) :

Per DI# 050-SYC-WH00-00300-000-00B (Ref. 2.2.4).

Penthouse (+99')	7862
roof Level (+79')	48101
2nd floor Level (+39')	44617
mezzanine Level (+30')	15334
grade Level (-3')	101438
Total W =	217351 kip

Wet Handling Facility Mass, m = W/g = 6756 k-sec^2/ft where g = 32.17 ft/sec

Mass moment of Inertia about axes of center of gravity (Xo & Yo) and additional ΔI due to transferring axes to center of grade basemat (X & Y); where Δx & Δy are the off-set of the axes (Ref. 2.2.4, page 26 & 37) :

		ROT X (kip-ft-sec^2)		ROT Y (kip-ft-sec^2)		ROT Z	
	Off-set		$w(\Delta y)^2/g$		$w(\Delta x)^2/g$	I_{ot}	Off-set
Z (center/slab)	Δy (ft)	I_{ox}	ΔI_x	I_{oy}	ΔI_y	(kip-ft-sec^2)	Δx (ft)
elev. +99'	20.2-105	9.880E+04	1.757E+06	3.870E+05	1.525E+06	4.858E+05	212-133
elev. +79'	113.3-105	6.286E+06	1.030E+05	1.055E+07	2.392E+02	1.684E+07	132.6-133
elev. +39'	118.9-105	5.110E+06	9.763E+06	4.392E+06	2.771E+06	9.502E+06	88.3-133
elev. +30'	25.2-105	2.152E+05	3.035E+06	6.980E+05	2.760E+06	9.131E+05	209.1-133
elev. -3'	104.2-105	1.218E+07	2.018E+03	1.942E+07	1.971E+04	3.160E+07	130.5-133

Total (99'~-3' for Grade base)	2.389E+07	1.466E+07	3.545E+07	7.077E+06	5.934E+07

Using the parallel axis theorem to transfer mass moment of Inertia to Grade base (-6'), additional wh^2/g

Inertia about grade base

	w (kip)	h (ft)	wh^2/g (k-ft-sec^2)
penthouse(+99')	7862	105.0	2.6943E+06
roof Level (+79')	48101	85.0	1.0803E+07
2nd floor Level (+39')	44617	45.0	2.8085E+06
mezzanine Level (+30')	15334	36.0	6.1773E+05
grade Level (-3')	101438	3.0	2.8379E+04
		Σ	1.6952E+07

Masses & Mass moment of inertia used in the calcuation of the Damping Coefficient for Grade & Pool bases are calculated based on assumpiont 3.1.3 :

	Grade base		Gross	
Horizontal (x), m_x =	(N/A)	k-sec^2/ft	6.756E+03	
Horizontal (y), m_y =	(N/A)	k-sec^2/ft	6.756E+03	
Rocking (x), $I_x = I_{ox} + \Delta I_x + wh^2/g$ =	5.550E+07	k-ft-sec^2	5.550E+07	‡
Rocking (y), $I_y = I_{oy} + \Delta I_y + wh^2/g$ =	5.948E+07	k-ft-sec^2	5.948E+07	‡
Vertical (z), m_z =	(N/A)	k-sec^2/ft	6.756E+03	
Torsion (z), $I_t = I_{ot} + \Delta I_x + \Delta I_y$ =	8.108E+07	k-ft-sec^2	8.108E+07	‡

‡ Note that it is calculated as the sum from +99' to -3' for Grade Base

6.2.3.2.1 Damping Coefficients for gross Grade Basemat, dimensions 270' by 214'

The damping coefficients are functions of the associated soil springs, soil properties, the mass moment inertia of the structure and the basemat geometrical properties. Per Ref. 2.2.1, section 3.3.4 with Tables 3.3-1 & 3.3-3, the damping coefficients are calculated below.

Considering the gross grade basemat without the pit opening for the pool, Gross Grade Basemat damping coefficients can be calculated based on :

L = 270 ft, B = 214 ft;

For x-direction (E-W) seismic loads :

Horizontal along x-axis (E-W) :

$R' = \sqrt{B * L / \pi}$ = 135.62 ft

$c_x = 0.576 * k_x * R' * \sqrt{\rho_i / G_s}$

	5E-4	1E-4	: APE	c_x (k-sec/ft) = 5E-4	1E-4 : APE
k_x (k/ft) = (sheet 30)	6.673E+06	4.996E+06	LBE 30'	3.195E+05	2.774E+05
	1.201E+07	9.219E+06	ME 30'	4.287E+05	3.769E+05
	2.122E+07	1.673E+07	UBE 30'	5.698E+05	5.076E+05
	4.654E+06	3.190E+06	LBE 100'	2.643E+05	2.199E+05
	8.871E+06	6.197E+06	ME 100'	3.649E+05	3.065E+05
	1.673E+07	1.197E+07	UBE 100'	5.011E+05	4.260E+05

Rocking about y-axis :

$R' = \sqrt[4]{B * L^3 / 3\pi}$ = 145.40 ft

I_{oy} = 5.948E+07 k-ft-sec^2

$$B_{\psi y} = \frac{3(1-\nu) I_{oy}}{8 * \rho_i * R^5} =$$

5E-4	1E-4	: APE
0.0579	0.0572	LBE 30'
0.0579	0.0572	ME 30'
0.0579	0.0572	UBE 30'
0.0586	0.0575	LBE 100'
0.0586	0.0575	ME 100'
0.0586	0.0575	UBE 100'

$$c_{\psi y} = \frac{0.3}{1 + B_{\psi y}} k_{\psi y} * R' \sqrt{\frac{\rho_i}{G_s}}$$

$k_{\psi y}$ (k-ft/rad) = (sheet 30)

5E-4	1E-4	: APE
1.402E+11	1.056E+11	LBE 30'
2.525E+11	1.948E+11	ME 30'
4.459E+11	3.535E+11	UBE 30'
9.858E+10	6.817E+10	LBE 100'
1.879E+11	1.324E+11	ME 100'
3.543E+11	2.557E+11	UBE 100'

$c_{\psi y}$ (k-ft-sec/rad) =

5E-4	1E-4	: APE
3.545E+09	3.097E+09	
4.756E+09	4.207E+09	
6.321E+09	5.667E+09	
2.953E+09	2.482E+09	
4.077E+09	3.459E+09	
5.599E+09	4.807E+09	

For z-direction (Vertical) seismic loads :

Vertical along z-axis (Vertical) :

$R' = \sqrt{B * L / \pi}$ = 135.62 ft

$c_z = 0.85 * k_z * R' * \sqrt{\rho_i / G_s}$

k_z (k/ft) = (sheet 30)

5E-4	1E-4	: APE
8.151E+06	6.137E+06	LBE 30'
1.467E+07	1.132E+07	ME 30'
2.592E+07	2.055E+07	UBE 30'
5.729E+06	3.962E+06	LBE 100'
1.092E+07	7.696E+06	ME 100'
2.059E+07	1.486E+07	UBE 100'

c_z (k-sec/ft) =

5E-4	1E-4	: APE
5.760E+05	5.029E+05	
7.728E+05	6.831E+05	
1.027E+06	9.202E+05	
4.802E+05	4.031E+05	
6.629E+05	5.618E+05	
9.103E+05	7.807E+05	

Rotation about z-axis :

$R' = \sqrt[4]{B * L (B^2 + L^2) / 6\pi}$ = 138.11 ft

I_{ot} = 8.108E+07 k-ft-sec^2

$$c_{\psi t} = \frac{\sqrt{k_t * I_t}}{1 + \frac{2 I_t}{\rho_i * R'^5}}$$

$k_{\psi z}$ (k-ft/rad) = (sheet 31)

5E-4	1E-4	: APE
1.577E+11	1.172E+11	LBE 30'
2.838E+11	2.163E+11	ME 30'
5.012E+11	3.926E+11	UBE 30'
1.089E+11	7.393E+10	LBE 100'
2.076E+11	1.436E+11	ME 100'
3.915E+11	2.773E+11	UBE 100'

$c_{\psi z}$ (k-ft-sec/rad) =

5E-4	1E-4	: APE
2.025E+09	1.747E+09	
2.717E+09	2.372E+09	
3.611E+09	3.196E+09	
1.663E+09	1.370E+09	
2.296E+09	1.909E+09	
3.152E+09	2.653E+09	

For y-direction (N-S) seismic loads :

Horizontal along y-axis (N-S) :

$R' = \sqrt{B * L / \pi} =$ 135.62 ft

$c_y = 0.576 * k_y * R' * \sqrt{\rho_i / G_s}$

k_y (k/ft) = (sheet 31)

5E-4	1E-4	: APE
6.812E+06	5.100E+06	LBE 30'
1.226E+07	9.411E+06	ME 30'
2.166E+07	1.708E+07	UBE 30'
4.751E+06	3.256E+06	LBE 100'
9.056E+06	6.326E+06	ME 100'
1.707E+07	1.222E+07	UBE 100'

c_y (k-sec/ft) =

5E-4	1E-4	: APE
3.262E+05	2.832E+05	
4.377E+05	3.847E+05	
5.816E+05	5.182E+05	
2.698E+05	2.245E+05	
3.725E+05	3.129E+05	
5.115E+05	4.349E+05	

Rocking about x-axis :

$R' = \sqrt[4]{B^3 * L / 3\pi} =$ 129.44 ft

$I_{ox} =$ 5.550E+07 k-ft-sec^2

$$c_{\psi x} = \frac{0.3}{1 + B_{\psi x}} k_{\psi x} * R' \sqrt{\frac{\rho_i}{G_s}}$$

$$B_{\psi x} = \frac{3(1-\nu) I_{ox}}{8 * \rho_i * R^5} =$$

5E-4	1E-4	: APE
0.0966	0.0954	LBE 30'
0.0966	0.0954	ME 30'
0.0966	0.0954	UBE 30'
0.0977	0.0959	LBE 100'
0.0977	0.0959	ME 100'
0.0977	0.0959	UBE 100'

$k_{\psi x}$ (k-ft/rad) = (sheet 31)

5E-4	1E-4	: APE
1.014E+11	7.635E+10	LBE 30'
1.825E+11	1.409E+11	ME 30'
3.224E+11	2.556E+11	UBE 30'
7.128E+10	4.929E+10	LBE 100'
1.359E+11	9.575E+10	ME 100'
2.562E+11	1.849E+11	UBE 100'

$c_{\psi x}$ (k-ft-sec/rad) =

5E-4	1E-4	: APE
2.201E+09	1.924E+09	
2.954E+09	2.614E+09	
3.925E+09	3.521E+09	
1.833E+09	1.542E+09	
2.531E+09	2.149E+09	
3.475E+09	2.986E+09	

Based on Spring Constants and Damping Coefficients, the Critical Dampings and Damping Ratio's can be calculated; however, to facilitate the calculation and tabulation, they are calculated and tabulated in section 7 after tables for Spring Constants and Damping Coefficients.

7.0 RESULTS and CONCLUSIONS

7.1 RESULTS

Tables 1 through 8 present the lower bound, median and upper bound soil spring constants and damping coefficients for 30' and 100' alluvium of 5E-4 and 1E-4 annual exceedance frequency, suitable for use in a lumped mass stick model seismic analysis of the Wet Handling Facility. Use of this set of soil spring constants and damping coefficients is reasonable for Tier 1 seismic analysis. As the design matures, soil structure interaction effects will be included in the analysis by modeling the actual soil properties in SASSI (A System for Analysis of Soil Structure Interaction).

Table 1 -- Equiv Soil Spring for 30' Alluvium - 5E-4 APE

At	Equivalent Soil Spring	L. Bound	Median	U. Bound
k_2 grade basemat (net) (section 6.2.3.1.3)	k_x - Horizontal along x-axis (k/ft)	3.414E+06	6.146E+06	1.085E+07
	k_y - Horizontal along y-axis (k/ft)	3.586E+06	6.456E+06	1.140E+07
	k_z - Vertical along z-axis (k/ft)	4.252E+06	7.653E+06	1.352E+07
	$k_{\psi x}$ - Rocking about x-axis (k-ft/rad)	8.883E+10	1.599E+11	2.824E+11
	$k_{\psi y}$ - Rocking about y-axis (k-ft/rad)	1.281E+11	2.306E+11	4.074E+11
	$k_{\psi z}$ - Rotation about z-axis (k-ft/rad)	1.407E+11	2.533E+11	4.474E+11
k_1 pool basemat (section 6.2.3.1.2)	k_x - Horizontal along x-axis (k/ft)	8.962E+06	1.345E+07	2.017E+07
	k_y - Horizontal along y-axis (k/ft)	8.871E+06	1.331E+07	1.997E+07
	k_z - Vertical along z-axis (k/ft)	1.068E+07	1.602E+07	2.404E+07
	$k_{\psi x}$ - Rocking about x-axis (k-ft/rad)	3.446E+10	5.169E+10	7.755E+10
	$k_{\psi y}$ - Rocking about y-axis (k-ft/rad)	3.321E+10	4.983E+10	7.475E+10
	$k_{\psi z}$ - Rotation about z-axis (k-ft/rad)	4.677E+10	7.017E+10	1.053E+11
k_s (sum)	k_x - Horizontal along x-axis (k/ft)	1.238E+07	1.959E+07	3.103E+07
	k_y - Horizontal along y-axis (k/ft)	1.246E+07	1.976E+07	3.137E+07
	k_z - Vertical along z-axis (k/ft)	1.493E+07	2.368E+07	3.755E+07
	$k_{\psi x}$ - Rocking about x-axis (k-ft/rad)	1.233E+11	2.116E+11	3.600E+11
	$k_{\psi y}$ - Rocking about y-axis (k-ft/rad)	1.613E+11	2.805E+11	4.821E+11
	$k_{\psi z}$ - Rotation about z-axis (k-ft/rad)	1.875E+11	3.235E+11	5.527E+11

Table 2 -- Equiv Soil Spring for 100' Alluvium - 5E-4 APE

At	Equivalent Soil Spring	L. Bound	Median	U. Bound
k_2 grade basemat (net) (section 6.2.3.1.3)	k_x - Horizontal along x-axis (k/ft)	2.381E+06	4.539E+06	8.557E+06
	k_y - Horizontal along y-axis (k/ft)	2.501E+06	4.768E+06	8.989E+06
	k_z - Vertical along z-axis (k/ft)	2.988E+06	5.696E+06	1.074E+07
	$k_{\psi x}$ - Rocking about x-axis (k-ft/rad)	6.244E+10	1.190E+11	2.244E+11
	$k_{\psi y}$ - Rocking about y-axis (k-ft/rad)	9.006E+10	1.717E+11	3.236E+11
	$k_{\psi z}$ - Rotation about z-axis (k-ft/rad)	9.725E+10	1.854E+11	3.495E+11
k_1 pool basemat (section 6.2.3.1.2)	k_x - Horizontal along x-axis (k/ft)	5.319E+06	9.248E+06	1.582E+07
	k_y - Horizontal along y-axis (k/ft)	5.265E+06	9.154E+06	1.566E+07
	k_z - Vertical along z-axis (k/ft)	6.373E+06	1.108E+07	1.896E+07
	$k_{\psi x}$ - Rocking about x-axis (k-ft/rad)	2.056E+10	3.575E+10	6.116E+10
	$k_{\psi y}$ - Rocking about y-axis (k-ft/rad)	1.982E+10	3.446E+10	5.895E+10
	$k_{\psi z}$ - Rotation about z-axis (k-ft/rad)	2.757E+10	4.794E+10	8.201E+10
k_s (sum)	k_x - Horizontal along x-axis (k/ft)	7.700E+06	1.379E+07	2.438E+07
	k_y - Horizontal along y-axis (k/ft)	7.766E+06	1.392E+07	2.465E+07
	k_z - Vertical along z-axis (k/ft)	9.361E+06	1.678E+07	2.970E+07
	$k_{\psi x}$ - Rocking about x-axis (k-ft/rad)	8.300E+10	1.548E+11	2.855E+11
	$k_{\psi y}$ - Rocking about y-axis (k-ft/rad)	1.099E+11	2.061E+11	3.826E+11
	$k_{\psi z}$ - Rotation about z-axis (k-ft/rad)	1.248E+11	2.333E+11	4.315E+11

Table 3 -- Equiv Soil Damping for 30' Alluvium - 5E-4 APE				
At	Equivalent Soil Damping	L. Bound	Median	U. Bound
c	c_x - Horizontal along x-axis (k-sec/ft)	3.195E+05	4.287E+05	5.698E+05
grade	c_y - Horizontal along y-axis (k-sec/ft)	3.262E+05	4.377E+05	5.816E+05
basemat	c_z - Vertical along z-axis (k-sec/ft)	5.760E+05	7.728E+05	1.027E+06
(gross)	$c_{\psi x}$ - Rocking about x-axis (k-ft-sec/rad)	2.201E+09	2.954E+09	3.925E+09
(section	$c_{\psi y}$ - Rocking about y-axis (k-ft-sec/rad)	3.545E+09	4.756E+09	6.321E+09
6.2.3.2.1)	$c_{\psi z}$ - Rotation about z-axis (k-ft-sec/rad)	2.025E+09	2.717E+09	3.611E+09

Table 4 -- Equiv Soil Damping for 100' Alluvium - 5E-4 APE				
At	Equivalent Soil Damping	L. Bound	Median	U. Bound
c	c_x - Horizontal along x-axis (k-sec/ft)	2.643E+05	3.649E+05	5.011E+05
grade	c_y - Horizontal along y-axis (k-sec/ft)	2.698E+05	3.725E+05	5.115E+05
basemat	c_z - Vertical along z-axis (k-sec/ft)	4.802E+05	6.629E+05	9.103E+05
(gross)	$c_{\psi x}$ - Rocking about x-axis (k-ft-sec/rad)	1.833E+09	2.531E+09	3.475E+09
(section	$c_{\psi y}$ - Rocking about y-axis (k-ft-sec/rad)	2.953E+09	4.077E+09	5.599E+09
6.2.3.2.1)	$c_{\psi z}$ - Rotation about z-axis (k-ft-sec/rad)	1.663E+09	2.296E+09	3.152E+09

Table 5 -- Equiv Soil Spring for 30' Alluvium - 1E-4 APE				
At	Equivalent Soil Spring	L. Bound	Median	U. Bound
k_2	k_x - Horizontal along x-axis (k/ft)	2.556E+06	4.717E+06	8.558E+06
grade	k_y - Horizontal along y-axis (k/ft)	2.685E+06	4.955E+06	8.990E+06
basemat	k_z - Vertical along z-axis (k/ft)	3.201E+06	5.906E+06	1.072E+07
(net)	$k_{\psi x}$ - Rocking about x-axis (k-ft/rad)	6.688E+10	1.234E+11	2.239E+11
(section	$k_{\psi y}$ - Rocking about y-axis (k-ft/rad)	9.647E+10	1.780E+11	3.230E+11
6.2.3.1.3)	$k_{\psi z}$ - Rotation about z-axis (k-ft/rad)	1.047E+11	1.931E+11	3.504E+11
	k_x - Horizontal along x-axis (k/ft)	8.751E+06	1.316E+07	1.978E+07
k_1	k_y - Horizontal along y-axis (k/ft)	8.662E+06	1.302E+07	1.958E+07
pool	k_z - Vertical along z-axis (k/ft)	1.048E+07	1.575E+07	2.368E+07
basemat	$k_{\psi x}$ - Rocking about x-axis (k-ft/rad)	3.380E+10	5.082E+10	7.640E+10
(section	$k_{\psi y}$ - Rocking about y-axis (k-ft/rad)	3.258E+10	4.898E+10	7.364E+10
6.2.3.1.2)	$k_{\psi z}$ - Rotation about z-axis (k-ft/rad)	4.540E+10	6.826E+10	1.026E+11
	k_x - Horizontal along x-axis (k/ft)	1.131E+07	1.787E+07	2.834E+07
	k_y - Horizontal along y-axis (k/ft)	1.135E+07	1.798E+07	2.857E+07
k_s	k_z - Vertical along z-axis (k/ft)	1.368E+07	2.166E+07	3.440E+07
(sum)	$k_{\psi x}$ - Rocking about x-axis (k-ft/rad)	1.007E+11	1.742E+11	3.003E+11
	$k_{\psi y}$ - Rocking about y-axis (k-ft/rad)	1.290E+11	2.270E+11	3.966E+11
	$k_{\psi z}$ - Rotation about z-axis (k-ft/rad)	1.501E+11	2.614E+11	4.530E+11

Table 6 -- Equiv Soil Spring for 100' Alluvium - 1E-4 APE				
At	Equivalent Soil Spring	L. Bound	Median	U. Bound
k_2 grade basemat (net) (section 6.2.3.1.3)	k_x - Horizontal along x-axis (k/ft)	1.632E+06	3.170E+06	6.123E+06
	k_y - Horizontal along y-axis (k/ft)	1.714E+06	3.330E+06	6.432E+06
	k_z - Vertical along z-axis (k/ft)	2.067E+06	4.014E+06	7.752E+06
	$k_{\psi x}$ - Rocking about x-axis (k-ft/rad)	4.318E+10	8.387E+10	1.620E+11
	$k_{\psi y}$ - Rocking about y-axis (k-ft/rad)	6.228E+10	1.210E+11	2.336E+11
	$k_{\psi z}$ - Rotation about z-axis (k-ft/rad)	6.599E+10	1.282E+11	2.476E+11
k_1 pool basemat (section 6.2.3.1.2)	k_x - Horizontal along x-axis (k/ft)	4.000E+06	7.321E+06	1.316E+07
	k_y - Horizontal along y-axis (k/ft)	3.959E+06	7.246E+06	1.303E+07
	k_z - Vertical along z-axis (k/ft)	4.828E+06	8.835E+06	1.589E+07
	$k_{\psi x}$ - Rocking about x-axis (k-ft/rad)	1.558E+10	2.851E+10	5.125E+10
	$k_{\psi y}$ - Rocking about y-axis (k-ft/rad)	1.501E+10	2.748E+10	4.940E+10
	$k_{\psi z}$ - Rotation about z-axis (k-ft/rad)	2.056E+10	3.762E+10	6.765E+10
k_s (sum)	k_x - Horizontal along x-axis (k/ft)	5.632E+06	1.049E+07	1.929E+07
	k_y - Horizontal along y-axis (k/ft)	5.674E+06	1.058E+07	1.946E+07
	k_z - Vertical along z-axis (k/ft)	6.894E+06	1.285E+07	2.364E+07
	$k_{\psi x}$ - Rocking about x-axis (k-ft/rad)	5.875E+10	1.124E+11	2.132E+11
	$k_{\psi y}$ - Rocking about y-axis (k-ft/rad)	7.729E+10	1.484E+11	2.830E+11
	$k_{\psi z}$ - Rotation about z-axis (k-ft/rad)	8.655E+10	1.658E+11	3.152E+11

Table 7 -- Equiv Soil Damping for 30' Alluvium - 1E-4 APE				
At	Equivalent Soil Damping	L. Bound	Median	U. Bound
c grade basemat (gross) (section 6.2.3.2.1)	c_x - Horizontal along x-axis (k-sec/ft)	2.774E+05	3.769E+05	5.076E+05
	c_y - Horizontal along y-axis (k-sec/ft)	2.832E+05	3.847E+05	5.182E+05
	c_z - Vertical along z-axis (k-sec/ft)	5.029E+05	6.831E+05	9.202E+05
	$c_{\psi x}$ - Rocking about x-axis (k-ft-sec/rad)	1.924E+09	2.614E+09	3.521E+09
	$c_{\psi y}$ - Rocking about y-axis (k-ft-sec/rad)	3.097E+09	4.207E+09	5.667E+09
	$c_{\psi z}$ - Rotation about z-axis (k-ft-sec/rad)	1.747E+09	2.372E+09	3.196E+09

Table 8 -- Equiv Soil Damping for 100' Alluvium - 1E-4 APE				
At	Equivalent Soil Damping	L. Bound	Median	U. Bound
c grade basemat (gross) (section 6.2.3.2.1)	c_x - Horizontal along x-axis (k-sec/ft)	2.199E+05	3.065E+05	4.260E+05
	c_y - Horizontal along y-axis (k-sec/ft)	2.245E+05	3.129E+05	4.349E+05
	c_z - Vertical along z-axis (k-sec/ft)	4.031E+05	5.618E+05	7.807E+05
	$c_{\psi x}$ - Rocking about x-axis (k-ft-sec/rad)	1.542E+09	2.149E+09	2.986E+09
	$c_{\psi y}$ - Rocking about y-axis (k-ft-sec/rad)	2.482E+09	3.459E+09	4.807E+09
	$c_{\psi z}$ - Rotation about z-axis (k-ft-sec/rad)	1.370E+09	1.909E+09	2.653E+09

Masses for critical Damping:

Since the Grade Basemat and the Pool Basemat are integrated structurally by the subgrade walls, the critical damping will be calculated for the overall WHF structure as a whole. The total mass and mass moment of inertia of the WHF, and the sum of soil springs (k_s) and the sum of soil dampings (c_s) from calculation above are used therefore in the following calculation :

Horizontal (x), m_x =	6.756E+03	k-sec^2/ft
Horizontal (y),m_y =	6.756E+03	k-sec^2/ft
Rocking (x), I_{ox} =	5.550E+07	k-ft-sec^2
Rocking (y), I_{oy} =	5.948E+07	k-ft-sec^2
Vertical (z), m_z =	6.756E+03	k-sec^2/ft
Torsion (z), I_t =	8.108E+07	k-ft-sec^2

The equivalent critical soil dampings are calculated as Cc = $2\sqrt{k_s m}$ (Ref. 2.2.8, eq. 1.13)

Equiv Critical Soil Damping for 30' Alluvium - 5E-4 APE

	Equivalent Soil Damping	L. Bound	Median	U. Bound
Cc	c_x - Horizontal along x-axis (k-sec/ft)	5.783E+05	7.276E+05	9.157E+05
	c_y - Horizontal along y-axis (k-sec/ft)	5.802E+05	7.308E+05	9.207E+05
	c_z - Vertical along z-axis (k-sec/ft)	6.352E+05	7.999E+05	1.007E+06
	$c_{\psi x}$ - Rocking about x-axis (k-ft-sec/rad)	5.232E+09	6.854E+09	8.940E+09
	$c_{\psi y}$ - Rocking about y-axis (k-ft-sec/rad)	6.195E+09	8.168E+09	1.071E+10
	$c_{\psi z}$ - Rotation about z-axis (k-ft-sec/rad)	7.798E+09	1.024E+10	1.339E+10

Critical Soil Damping for 100' Alluvium - 5E-4 APE

	Equivalent Soil Damping	L. Bound	Median	U. Bound
Cc	c_x - Horizontal along x-axis (k-sec/ft)	4.562E+05	6.104E+05	8.117E+05
	c_y - Horizontal along y-axis (k-sec/ft)	4.581E+05	6.134E+05	8.162E+05
	c_z - Vertical along z-axis (k-sec/ft)	5.030E+05	6.734E+05	8.959E+05
	$c_{\psi x}$ - Rocking about x-axis (k-ft-sec/rad)	4.293E+09	5.861E+09	7.962E+09
	$c_{\psi y}$ - Rocking about y-axis (k-ft-sec/rad)	5.113E+09	7.003E+09	9.541E+09
	$c_{\psi z}$ - Rotation about z-axis (k-ft-sec/rad)	6.362E+09	8.698E+09	1.183E+10

Equiv Critical Soil Damping for 30' Alluvium - 1E-4 APE

	Equivalent Soil Damping	L. Bound	Median	U. Bound
Cc	c_x - Horizontal along x-axis (k-sec/ft)	5.528E+05	6.950E+05	8.751E+05
	c_y - Horizontal along y-axis (k-sec/ft)	5.538E+05	6.970E+05	8.787E+05
	c_z - Vertical along z-axis (k-sec/ft)	6.080E+05	7.651E+05	9.642E+05
	$c_{\psi x}$ - Rocking about x-axis (k-ft-sec/rad)	4.728E+09	6.219E+09	8.165E+09
	$c_{\psi y}$ - Rocking about y-axis (k-ft-sec/rad)	5.541E+09	7.349E+09	9.714E+09
	$c_{\psi z}$ - Rotation about z-axis (k-ft-sec/rad)	6.976E+09	9.207E+09	1.212E+10

Equiv Critical Soil Damping for 100' Alluvium - 1E-4 APE

	Equivalent Soil Damping	L. Bound	Median	U. Bound
Cc	c_x - Horizontal along x-axis (k-sec/ft)	3.902E+05	5.325E+05	7.219E+05
	c_y - Horizontal along y-axis (k-sec/ft)	3.916E+05	5.346E+05	7.252E+05
	c_z - Vertical along z-axis (k-sec/ft)	4.317E+05	5.893E+05	7.993E+05
	$c_{\psi x}$ - Rocking about x-axis (k-ft-sec/rad)	3.612E+09	4.995E+09	6.880E+09
	$c_{\psi y}$ - Rocking about y-axis (k-ft-sec/rad)	4.288E+09	5.943E+09	8.206E+09
	$c_{\psi z}$ - Rotation about z-axis (k-ft-sec/rad)	5.298E+09	7.333E+09	1.011E+10

Based on tables above, the Equivalent Soil Damping Ratios β = Ϛ / Cc are tabulated as follow :

Table 9 -- Equiv Soil Damping Ratio for 30' Alluvium - 5E-4 APE				
	Equivalent Soil Damping	L. Bound	Median	U. Bound
β (%)	Horizontal along x-axis	55.25	58.92	62.22
	Horizontal along y-axis	56.22	59.88	63.17
	Vertical along z-axis	90.67	96.61	101.95
	Rocking about x-axis	42.08	43.09	43.91
	Rocking about y-axis	57.22	58.23	59.02
	Rotation about z-axis	25.97	26.53	26.97

Table 10 -- Equiv Soil Damping Ratio for 100' Alluvium - 5E-4 APE				
	Equivalent Soil Damping	L. Bound	Median	U. Bound
β (%)	Horizontal along x-axis	57.94	59.78	61.73
	Horizontal along y-axis	58.90	60.73	62.67
	Vertical along z-axis	95.46	98.45	101.61
	Rocking about x-axis	42.71	43.18	43.65
	Rocking about y-axis	57.76	58.23	58.68
	Rotation about z-axis	26.14	26.39	26.65

Table 11 -- Equiv Soil Damping Ratio for 30' Alluvium - 1E-4 APE				
	Equivalent Soil Damping	L. Bound	Median	U. Bound
β (%)	Horizontal along x-axis	50.19	54.22	58.01
	Horizontal along y-axis	51.14	55.19	58.98
	Vertical along z-axis	82.71	89.29	95.44
	Rocking about x-axis	40.70	42.02	43.12
	Rocking about y-axis	55.89	57.25	58.34
	Rotation about z-axis	25.04	25.77	26.37

Table 12 -- Equiv Soil Damping Ratio for 100' Alluvium - 1E-4 APE				
	Equivalent Soil Damping	L. Bound	Median	U. Bound
β (%)	Horizontal along x-axis	56.37	57.57	59.00
	Horizontal along y-axis	57.33	58.53	59.96
	Vertical along z-axis	93.38	95.34	97.68
	Rocking about x-axis	42.69	43.02	43.40
	Rocking about y-axis	57.88	58.20	58.58
	Rotation about z-axis	25.85	26.03	26.24

The above frequency independent percent of critical damping ratios for the six degrees of freedom are approximated soil-structure radiation dampings for the layered soil conditions at the Wet Handling Facility site location. Ref. 2.2.7 and 2.2.11 (SADA) recommend a blanket reduction factor, 75%, for translational damping coefficients and ASCE 4-98 (Ref. 2.2.1), section 3.1.5.4 and Ref. 2.2.11 require a maximum damping ratio of 20% for SSI modal damping. For structural modes and mixed structural and rigid body SSI modes, the damping values given in SADA (Ref. 2.2.11), section 7.2.4 should be used. Future detail design will be based on a detailed SSI analysis using SASSI that will account for the frequency dependent damping values of the layered soils beneath the Wet Handling Facility.
The new soil impedence functions based on new DTN MO0801SCSPS5E4.003 and DTN MO0801SCSPS1E4.003 (Ref. 2.2.2 and 2.2.3) are computed in Appendix D and new shear modulus values are compared in Tables D1 through D4.
As seen in Tables D1 through D4 the maximum % change in G and thus the corresponding % change in spring stiffness values from the qualified data compared to the superseded data used in the soil spring calculations is not more than 4.16%. The effect of this change in soil stiffness on the seismic analysis results is even less since the frequency of a system is a function of stiffness and mass given by: $f = \sqrt{k / m}$. Thus a 4.16% change in stiffness wiil result in a $\sqrt{1.0416}$ or 2.06% shift in frequency. Given the broad band nature of YMP input ground spectra (Ref. 2.2.11) the effect of this 2.06% change in the frequency will have a negligible impact on the computed seismic analysis results. Therefore, the conclusion as stated in Section 7.2 remains valid.

7.2 CONCLUSIONS

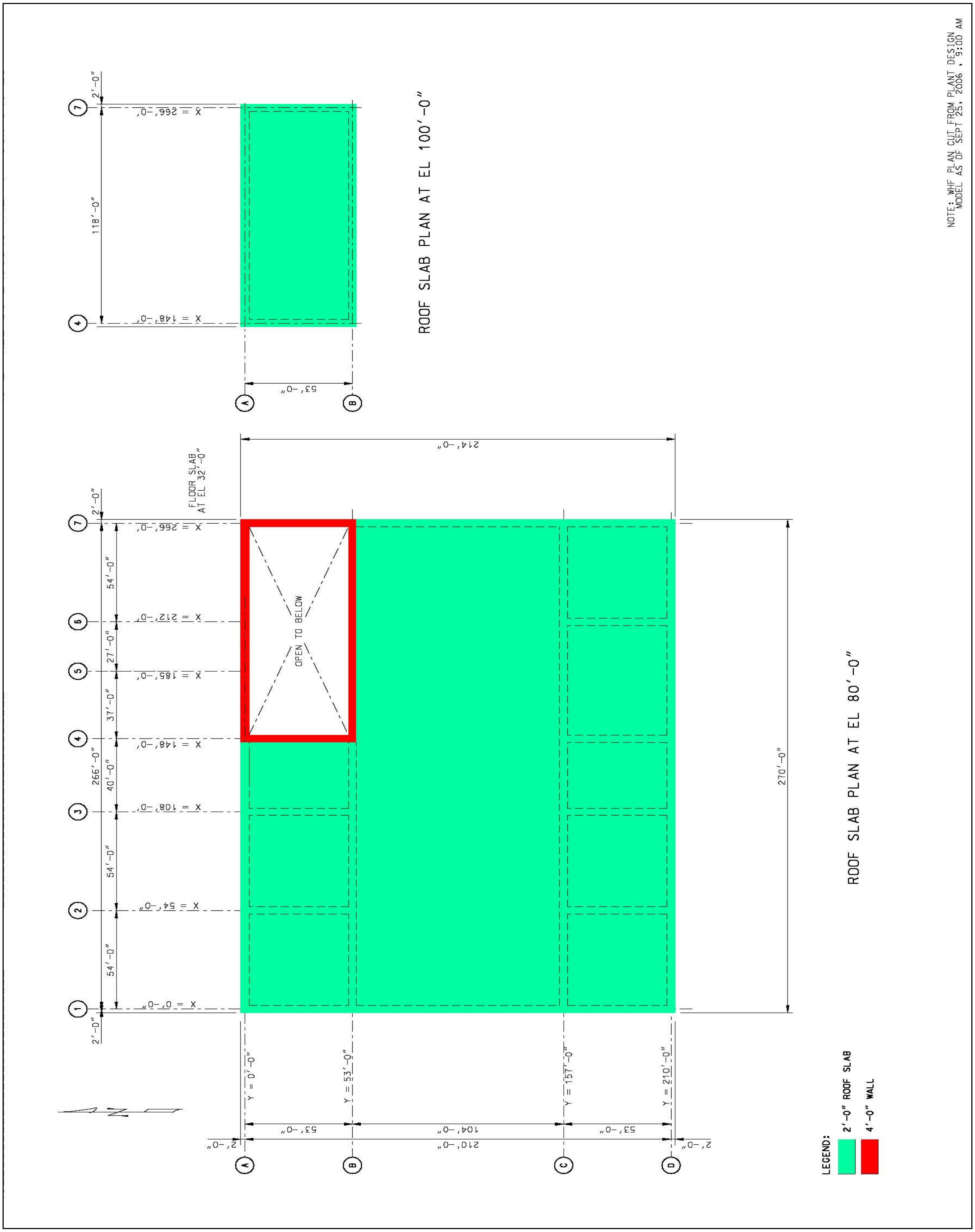
The above computed results (Tables 1 through 12) are reasonable compared to the input and are suitable for use in Tier 1 seismic analysis of the Wet Handling Facility.

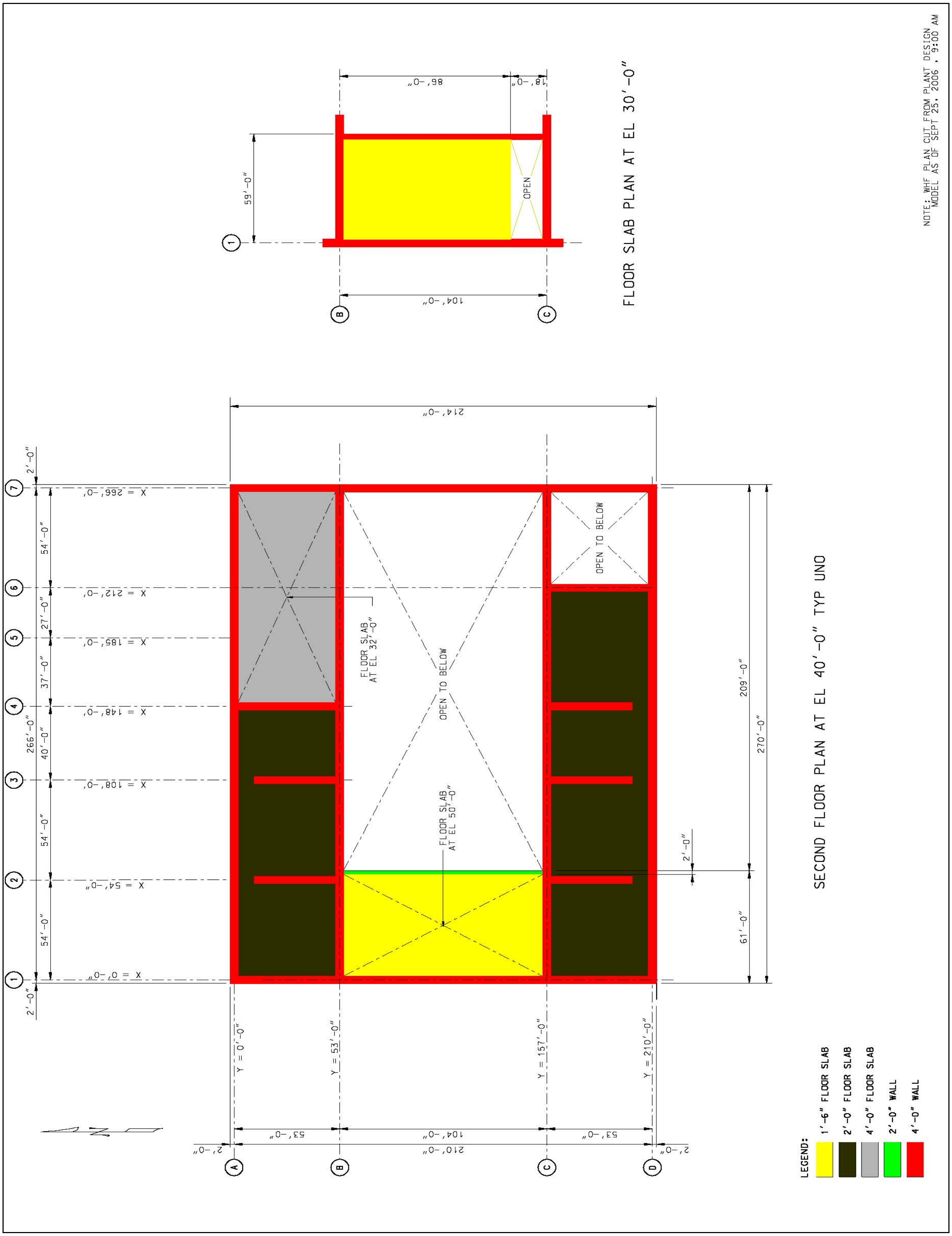
ATTACHMENT A

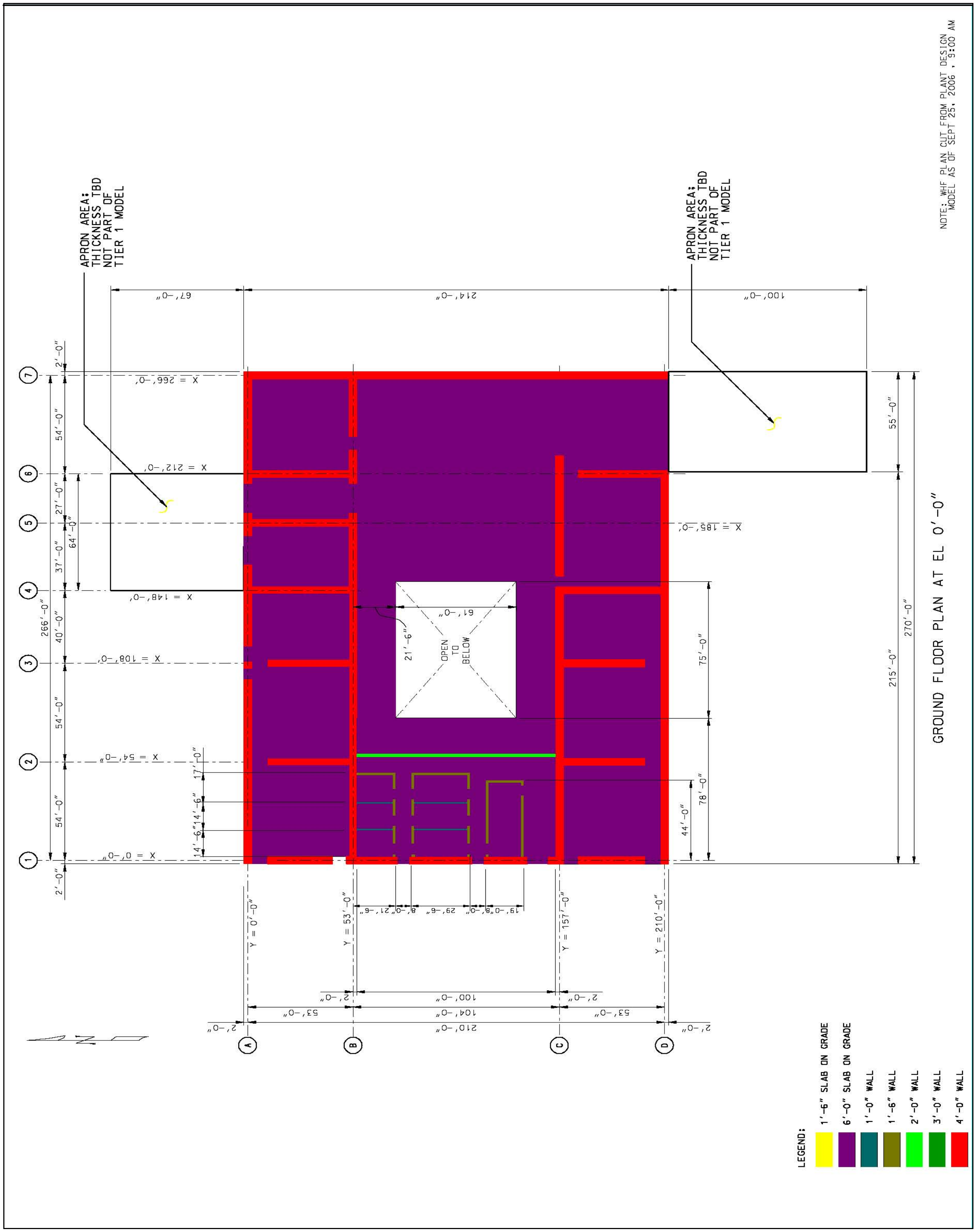
WET HANDLING FACILITY

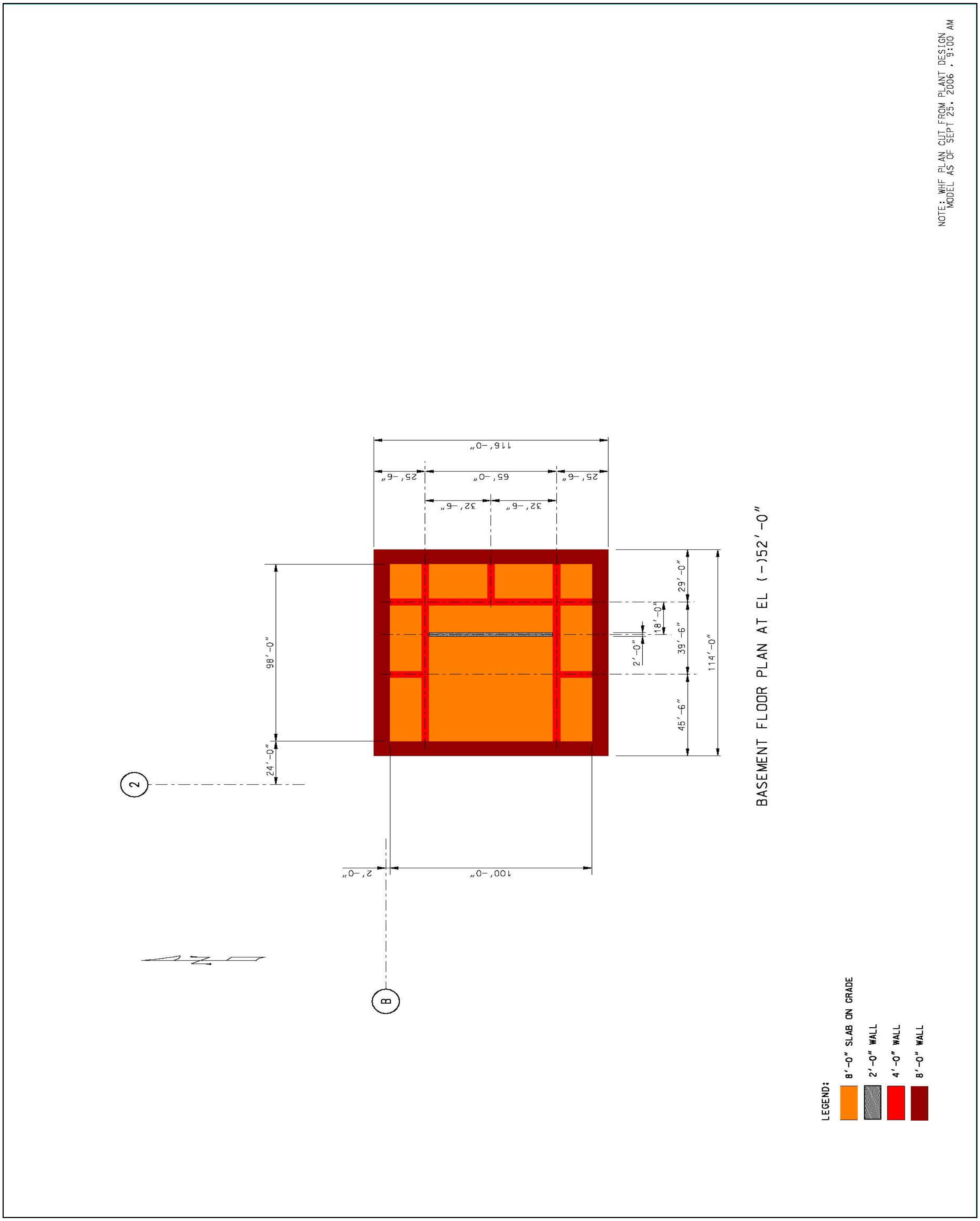
PLANS & SECTIONS

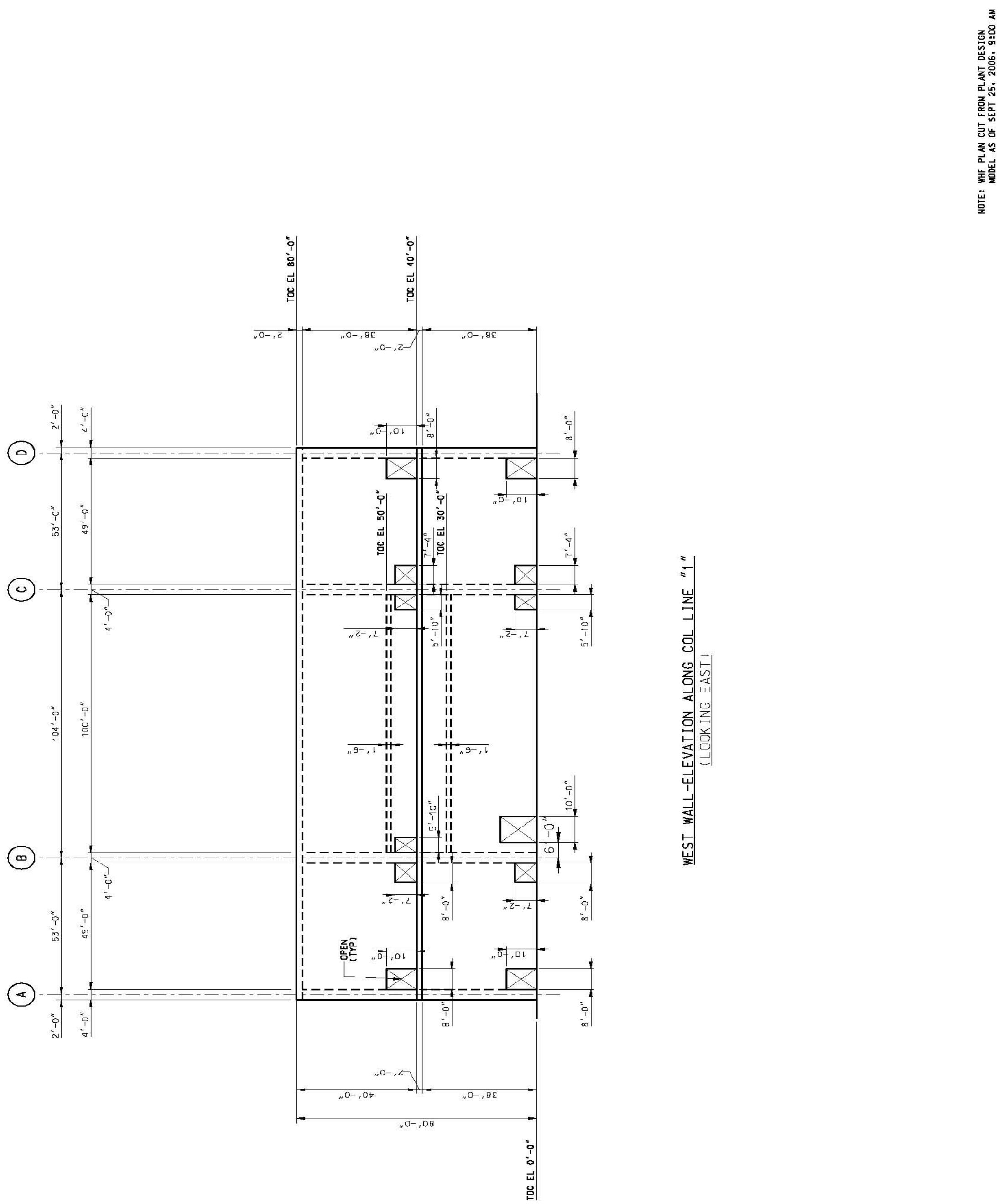
(Section 4.3 with assumption 3.1.1)

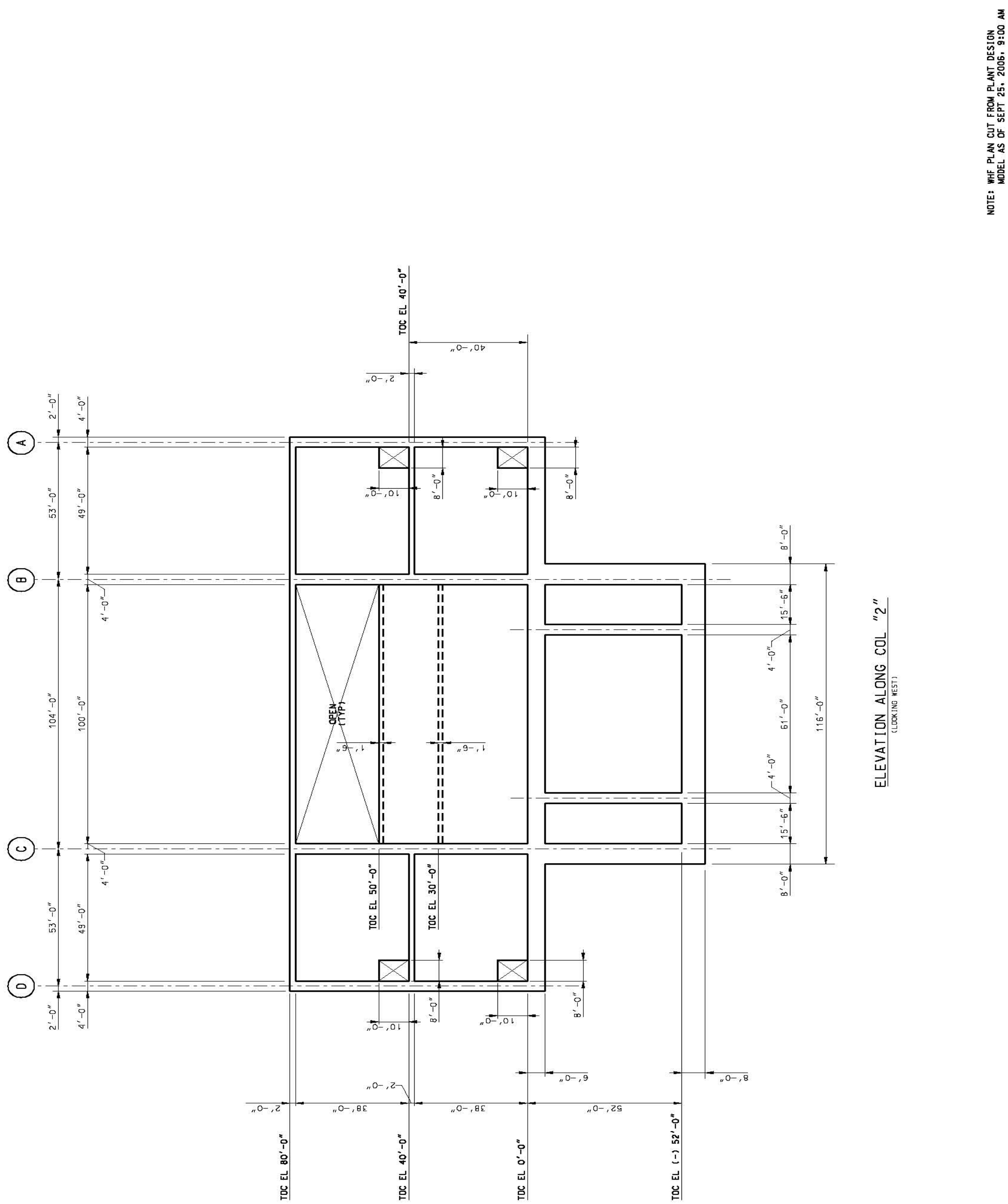

ROOF SLAB PLAN AT EL 100'-0"
ROOF SLAB PLAN AT EL 80'-0"
NOTE: WHF PLAN CUT FROM PLANT DESIGN MODEL AS OF SEPT 25, 2006, 9:00 AM
FLOOR SLAB AT EL 32'-0"
OPEN TO BELOW
X = 0'-0"
X = 54'-0"
X = 108'-0"
X = 148'-0"
X = 185'-0"
X = 212'-0"
X = 266'-0"
Y = 0'-0"
Y = 53'-0"
Y = 157'-0"
Y = 210'-0"
118'-0"
53'-0"
214'-0"
270'-0"
266'-0"
210'-0"
104'-0"
54'-0"
40'-0"
37'-0"
27'-0"
2'-0"
LEGEND:
2'-0" ROOF SLAB
4'-0" WALL

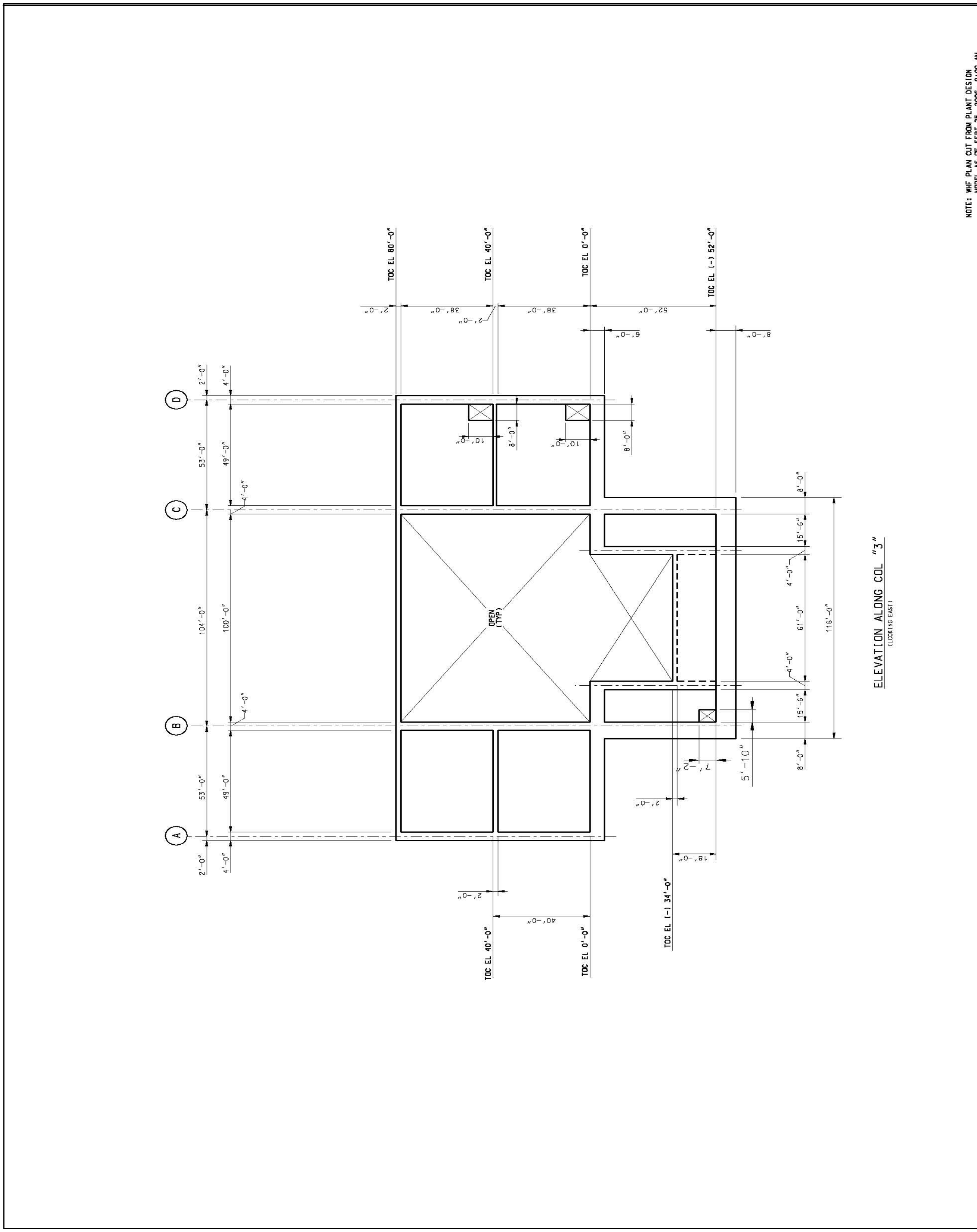

FLOOR SLAB PLAN AT EL 30'-0"
SECOND FLOOR PLAN AT EL 40'-0" TYP UNO
NOTE: WHF PLAN CUT FROM PLANT DESIGN
MODEL AS OF SEPT 25, 2006 , 9:00 AM
OPEN
OPEN TO BELOW
FLOOR SLAB AT EL 32'-0"
FLOOR SLAB AT EL 50'-0"
X = 0'-0"
X = 54'-0"
X = 108'-0"
X = 148'-0"
X = 185'-0"
X = 212'-0"
X = 266'-0"
Y = 0'-0"
Y = 53'-0"
Y = 157'-0"
Y = 210'-0"
LEGEND:
1'-6" FLOOR SLAB
2'-0" FLOOR SLAB
4'-0" FLOOR SLAB
2'-0" WALL
4'-0" WALL

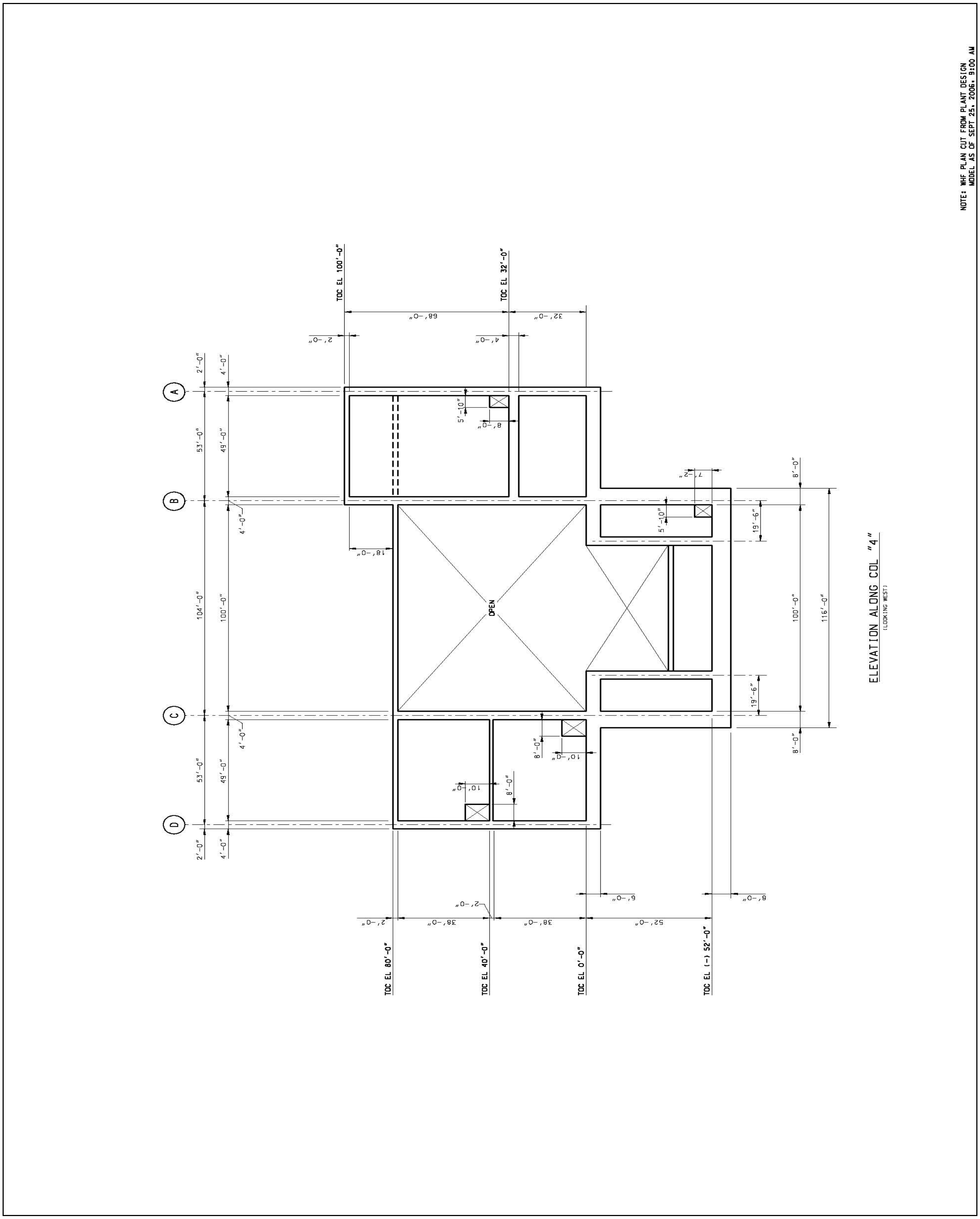

GROUND FLOOR PLAN AT EL 0'-0"
APRON AREA: THICKNESS TBD NOT PART OF TIER 1 MODEL
APRON AREA: THICKNESS TBD NOT PART OF TIER 1 MODEL
NOTE: WHF PLAN CUT FROM PLANT DESIGN MODEL AS OF SEPT 25, 2006, 9:00 AM
OPEN TO BELOW
LEGEND:
1'-6" SLAB ON GRADE
6'-0" SLAB ON GRADE
1'-0" WALL
1'-6" WALL
2'-0" WALL
3'-0" WALL
4'-0" WALL

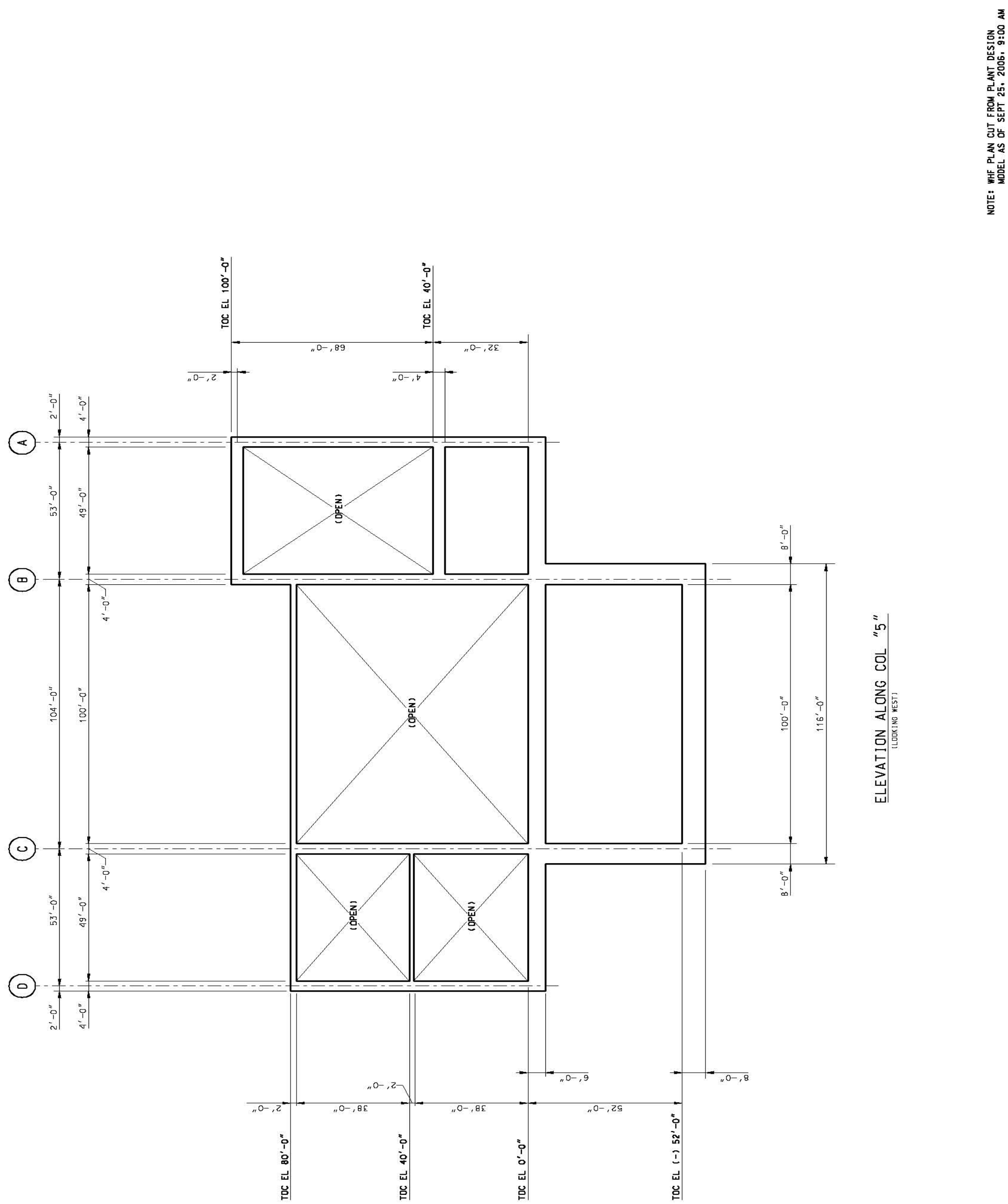

NOTE: WHF PLAN CUT FROM PLANT DESIGN
MODEL AS OF SEPT 25, 2006 , 9:00 AM
BASEMENT FLOOR PLAN AT EL (-)52'-0"
116'-0"
65'-0"
98'-0"
114'-0"
100'-0"
LEGEND:
8'-0" SLAB ON GRADE
2'-0" WALL
4'-0" WALL
8'-0" WALL

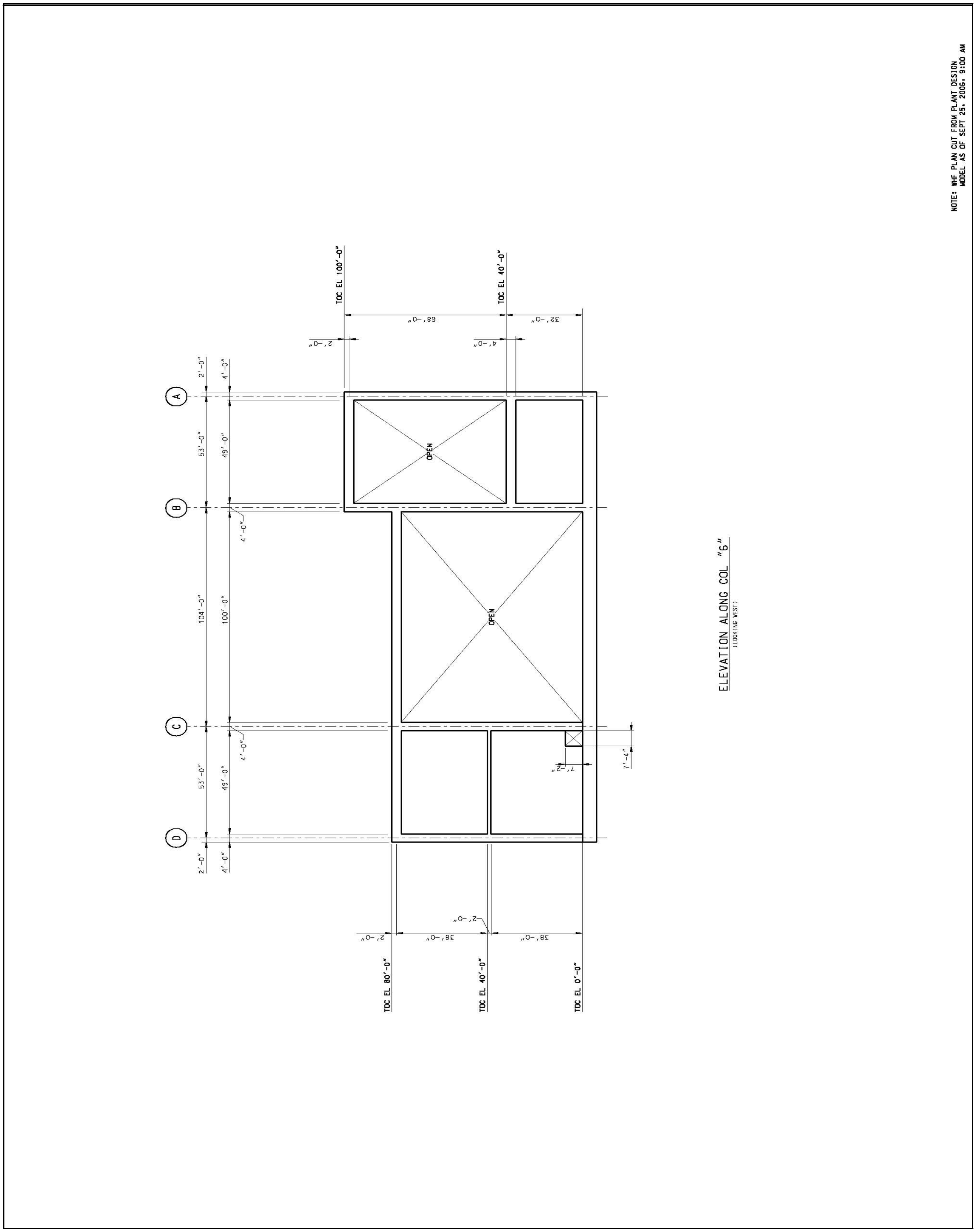

NOTE: WHF PLAN CUT FROM PLANT DESIGN
MODEL AS OF SEPT 25, 2006, 9:00 AM
TOC EL 80'-0"
TOC EL 40'-0"
TOC EL 50'-0"
TOC EL 30'-0"
TOC EL 0'-0"
OPEN (TYP)
WEST WALL-ELEVATION ALONG COL LINE "1"
(LOOKING EAST)

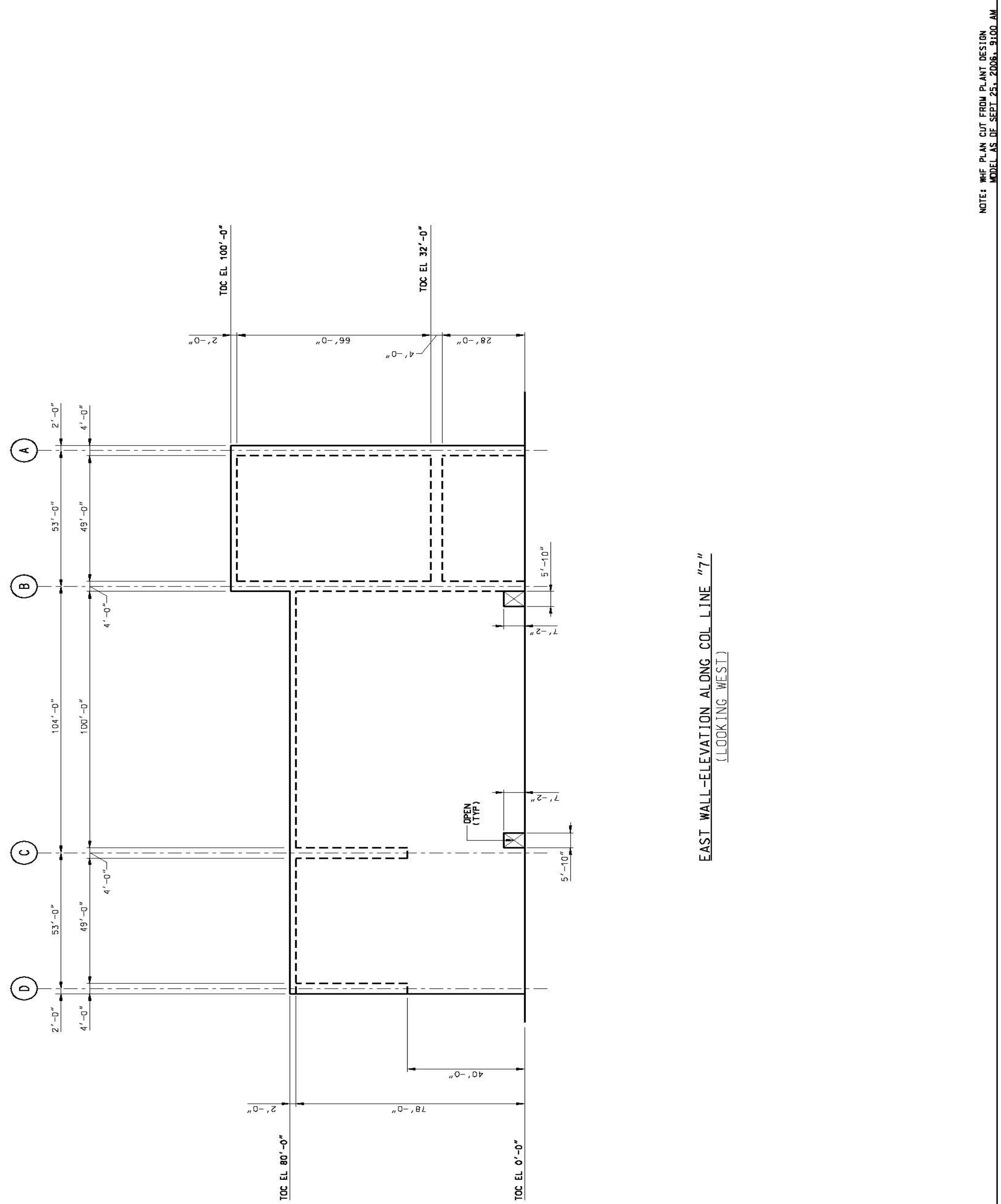

NOTE: WHF PLAN CUT FROM PLANT DESIGN
MODEL AS OF SEPT 25, 2006; 9:00 AM
ELEVATION ALONG COL "2"
(LOOKING WEST)
TOC EL 80'-0"
TOC EL 40'-0"
TOC EL 0'-0"
TOC EL (-) 52'-0"
TOC EL 50'-0"
TOC EL 30'-0"
OPEN (TYP)
A
B
C
D

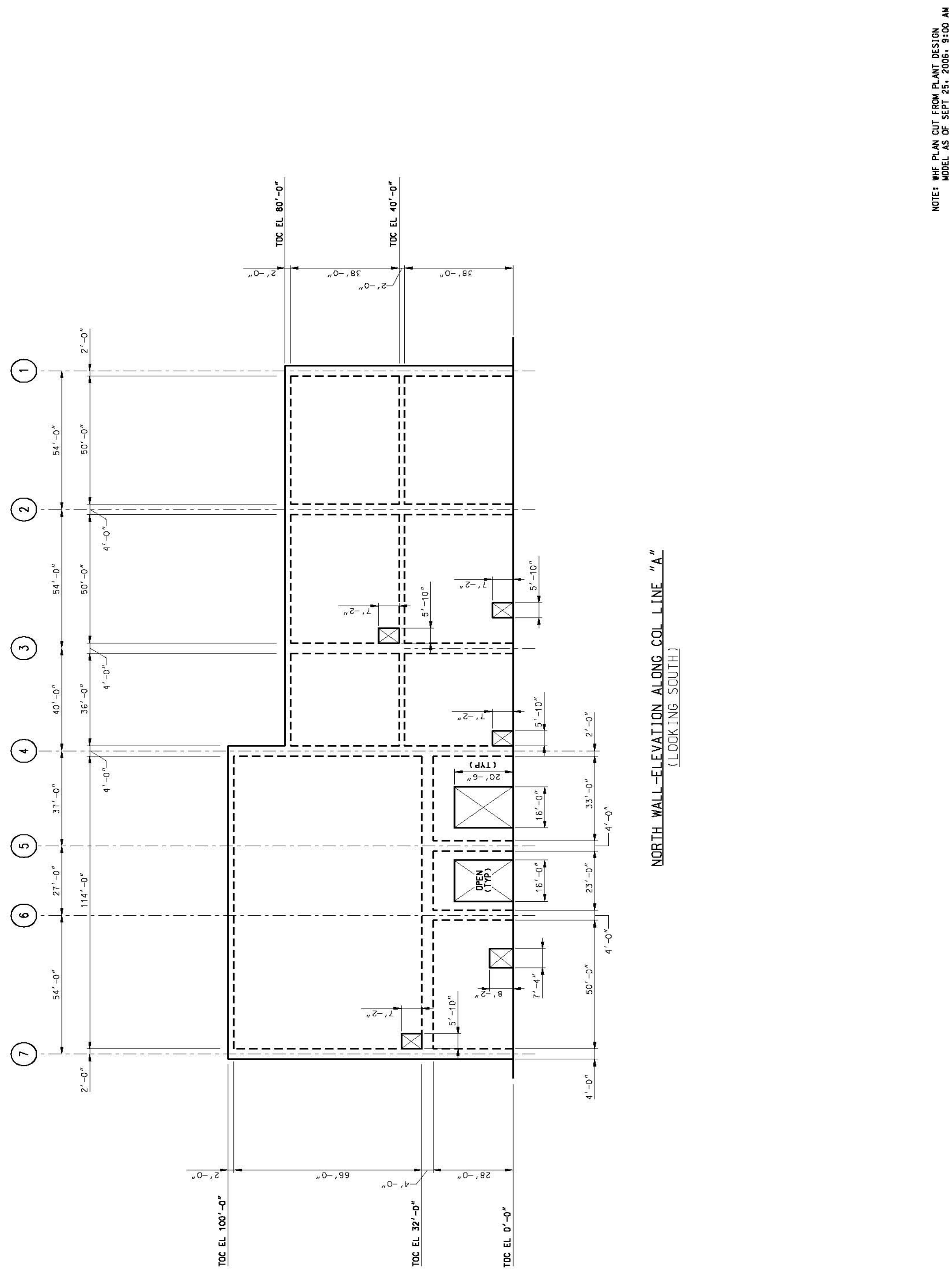

NOTE: WHF PLAN CUT FROM PLANT DESIGN
MODEL AS OF SEPT 25, 2006; 9:00 AM
TOC EL 80'-0"
TOC EL 40'-0"
TOC EL 0'-0"
TOC EL (-) 52'-0"
TOC EL (-) 34'-0"
OPEN
(TYP)
ELEVATION ALONG COL "3"
(LOOKING EAST)

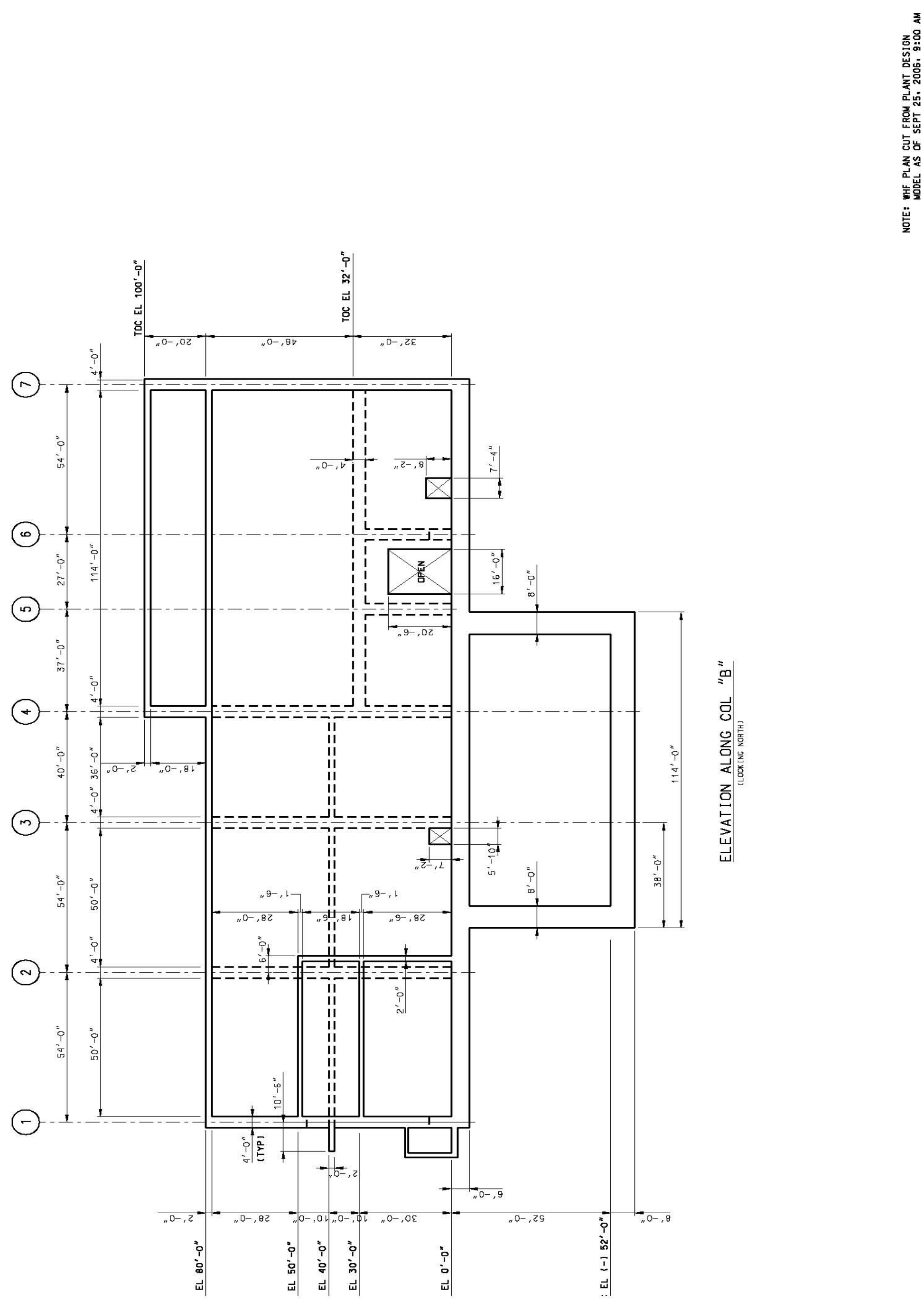

NOTE: WHF PLAN CUT FROM PLANT DESIGN
MODEL AS OF SEPT 25, 2006, 9:00 AM
TOC EL 100'-0"
TOC EL 32'-0"
TOC EL 80'-0"
TOC EL 40'-0"
TOC EL 0'-0"
TOC EL (-) 52'-0"
OPEN
ELEVATION ALONG COL "4"
(LOOKING WEST)

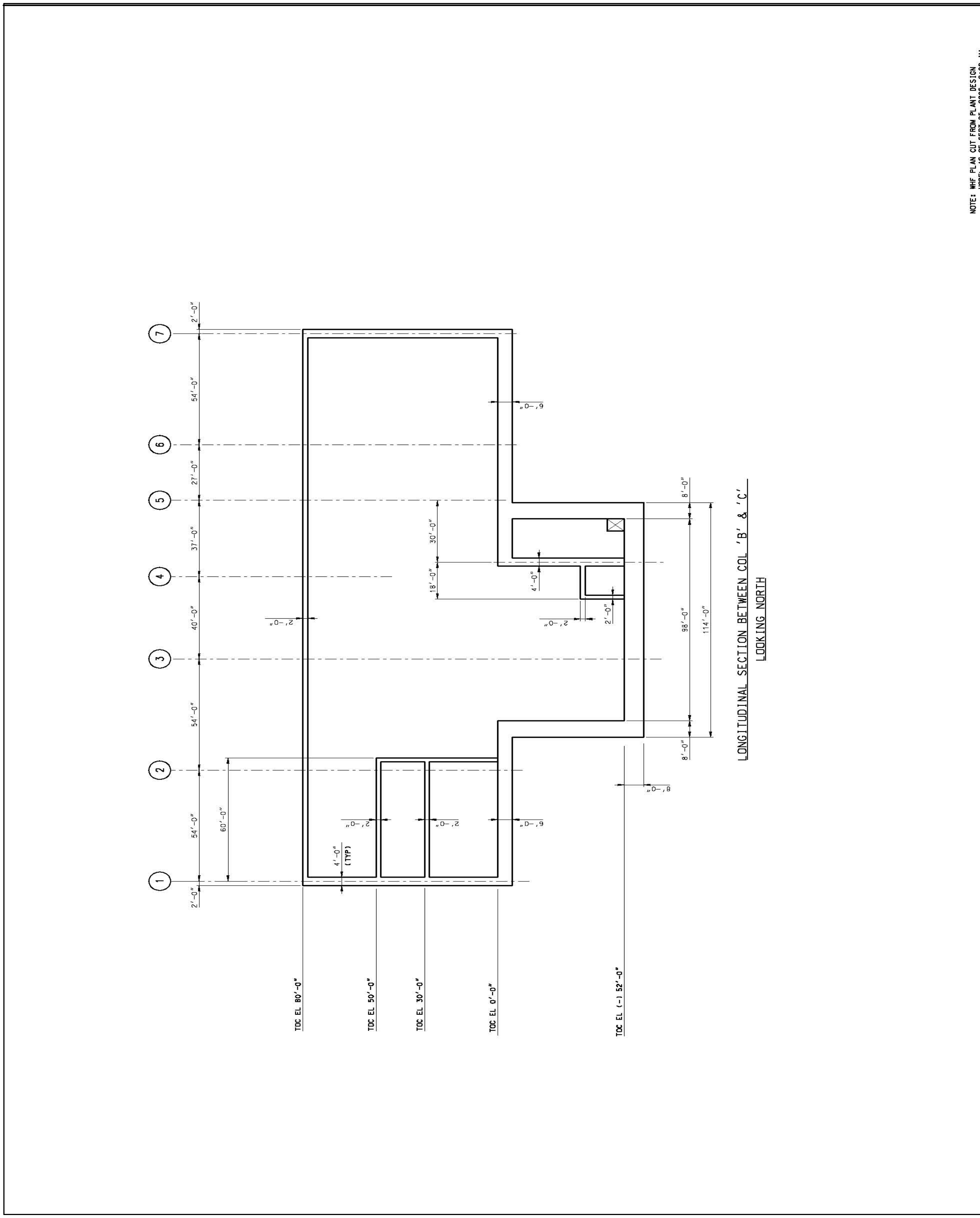

NOTE: WHF PLAN CUT FROM PLANT DESIGN
MODEL AS OF SEPT 25, 2006, 9:00 AM
ELEVATION ALONG COL "5"
(LOOKING WEST)
TOC EL 100'-0"
TOC EL 40'-0"
TOC EL 80'-0"
TOC EL 40'-0"
TOC EL 0'-0"
TOC EL (-) 52'-0"
(OPEN)

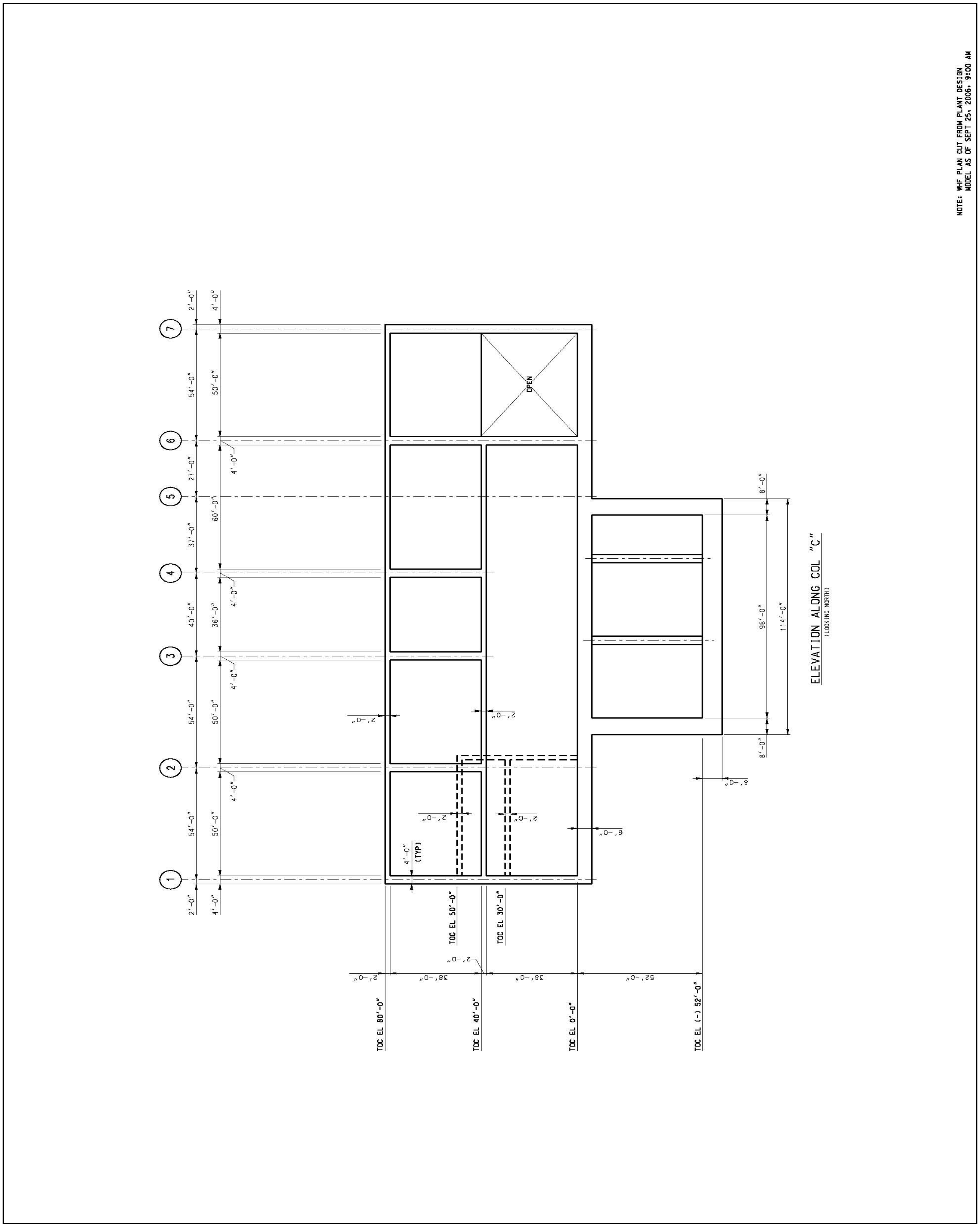

NOTE: WHF PLAN CUT FROM PLANT DESIGN
MODEL AS OF SEPT 25, 2006, 9:00 AM
TOC EL 100'-0"
TOC EL 40'-0"
68'-0"
32'-0"
2'-0"
4'-0"
A
B
C
D
2'-0"
53'-0"
104'-0"
53'-0"
2'-0"
4'-0"
49'-0"
100'-0"
49'-0"
4'-0"
OPEN
OPEN
7'-2"
7'-4"
2'-0"
38'-0"
38'-0"
TOC EL 80'-0"
TOC EL 40'-0"
TOC EL 0'-0"
ELEVATION ALONG COL "6"
(LOOKING WEST)

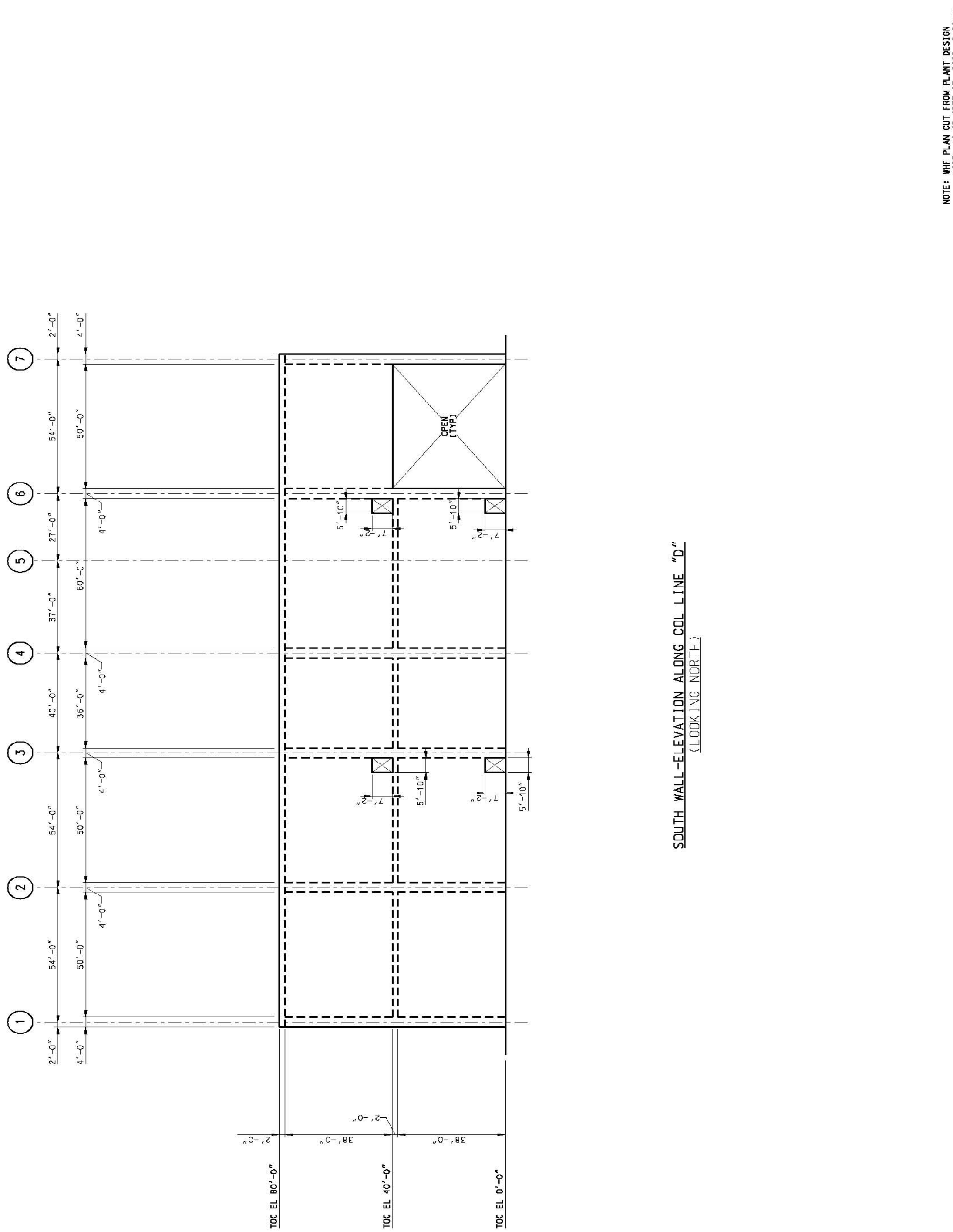

NOTE: WHF PLAN CUT FROM PLANT DESIGN MODEL AS OF SEPT 25, 2006, 9:00 AM
TOC EL 100'-0"
TOC EL 32'-0"
TOC EL 80'-0"
TOC EL 0'-0"
A
B
C
D
2'-0"
53'-0"
104'-0"
53'-0"
2'-0"
4'-0"
49'-0"
100'-0"
49'-0"
4'-0"
66'-0"
28'-0"
78'-0"
40'-0"
5'-10"
7'-2"
OPEN (TYP)
EAST WALL-ELEVATION ALONG COL LINE "7"
(LOOKING WEST)


NOTE: WHF PLAN CUT FROM PLANT DESIGN MODEL AS OF SEPT 25, 2006, 9:00 AM
NORTH WALL-ELEVATION ALONG COL LINE "A"
(LOOKING SOUTH)
TOC EL 80'-0"
TOC EL 40'-0"
TOC EL 100'-0"
TOC EL 32'-0"
TOC EL 0'-0"
OPEN (TYP)
(TYP)


NOTE: WHF PLAN CUT FROM PLANT DESIGN MODEL AS OF SEPT 25, 2006; 9:00 AM
ELEVATION ALONG COL "B"
(LOOKING NORTH)
OPEN
TOC EL 100'-0"
TOC EL 32'-0"
EL 80'-0"
EL 50'-0"
EL 40'-0"
EL 30'-0"
EL 0'-0"
EL (-) 52'-0"


NOTE: WHF PLAN CUT FROM PLANT DESIGN MODEL AS OF SEPT 25, 2006, 9:00 AM
LONGITUDINAL SECTION BETWEEN COL 'B' & 'C'
LOOKING NORTH
TOC EL 80'-0"
TOC EL 50'-0"
TOC EL 30'-0"
TOC EL 0'-0"
TOC EL (-) 52'-0"


NOTE: WHF PLAN CUT FROM PLANT DESIGN
MODEL AS OF SEPT 25, 2006, 9:00 AM
OPEN
ELEVATION ALONG COL "C"
(LOOKING NORTH)
TOC EL 50'-0"
TOC EL 30'-0"
TOC EL 80'-0"
TOC EL 40'-0"
TOC EL 0'-0"
TOC EL (-) 52'-0"

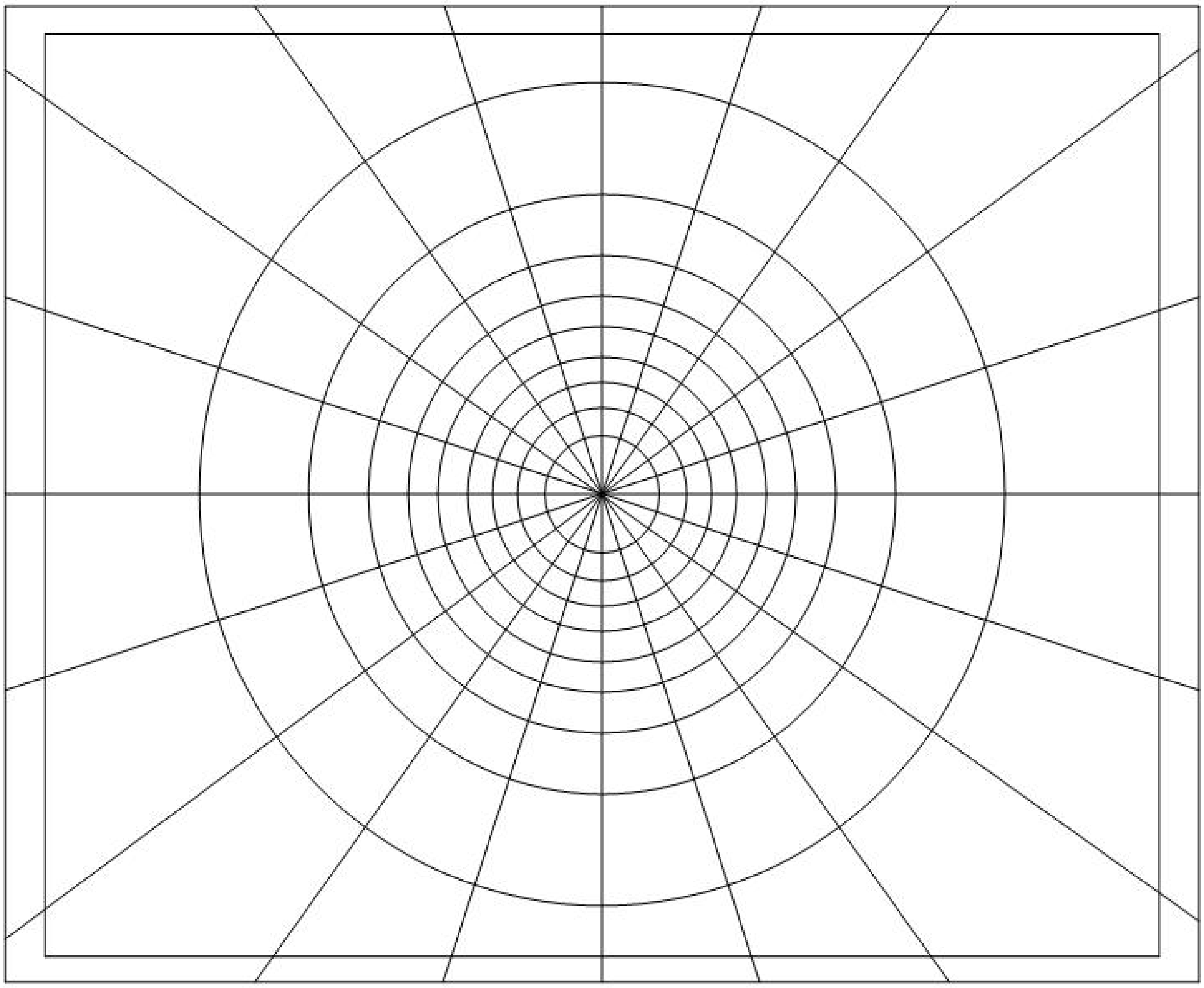

NOTE: WHF PLAN CUT FROM PLANT DESIGN MODEL AS OF SEPT 25, 2006, 9:00 AM
SOUTH WALL-ELEVATION ALONG COL LINE "D"
(LOOKING NORTH)
OPEN (TYP)
TOC EL 80'-0"
TOC EL 40'-0"
TOC EL 0'-0"

ATTACHMENT B

NEWMARK INFLUENCE CHARTS

(Section 6.2.1, Ref. 2.2.6)

Newmark Chart
Influence factor = 0.005
Depth Z = 50 ft



Scale Line
50 ft

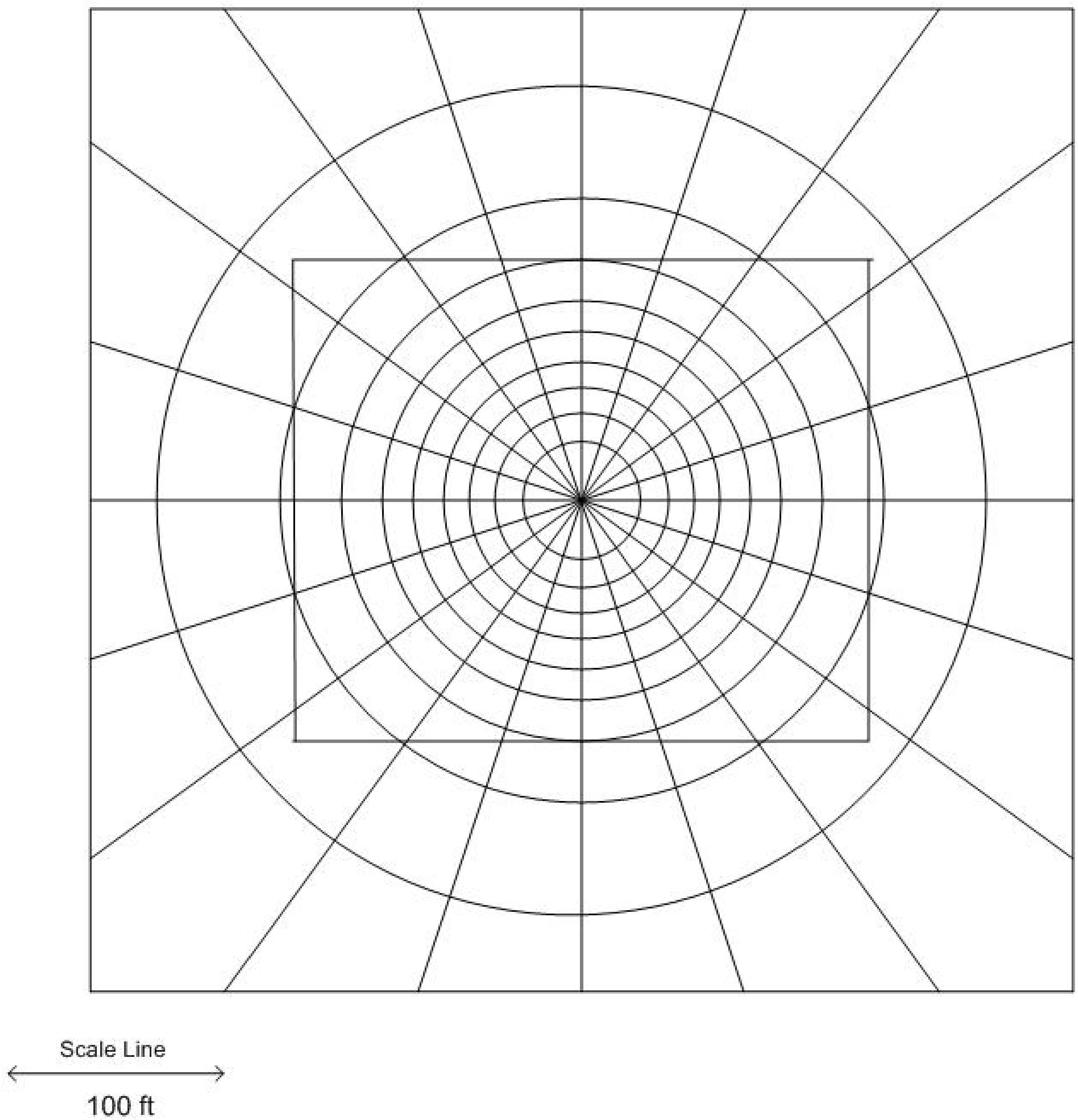
Number of units covered : 9x20 + 8x0.01 + 4x0.01 + 4x0.01 + 4x0.01 = 180

Influence coefficient = 180x0.005 = 0.90

Newmark Chart

Influence factor = 0.005

Depth Z = 100 ft



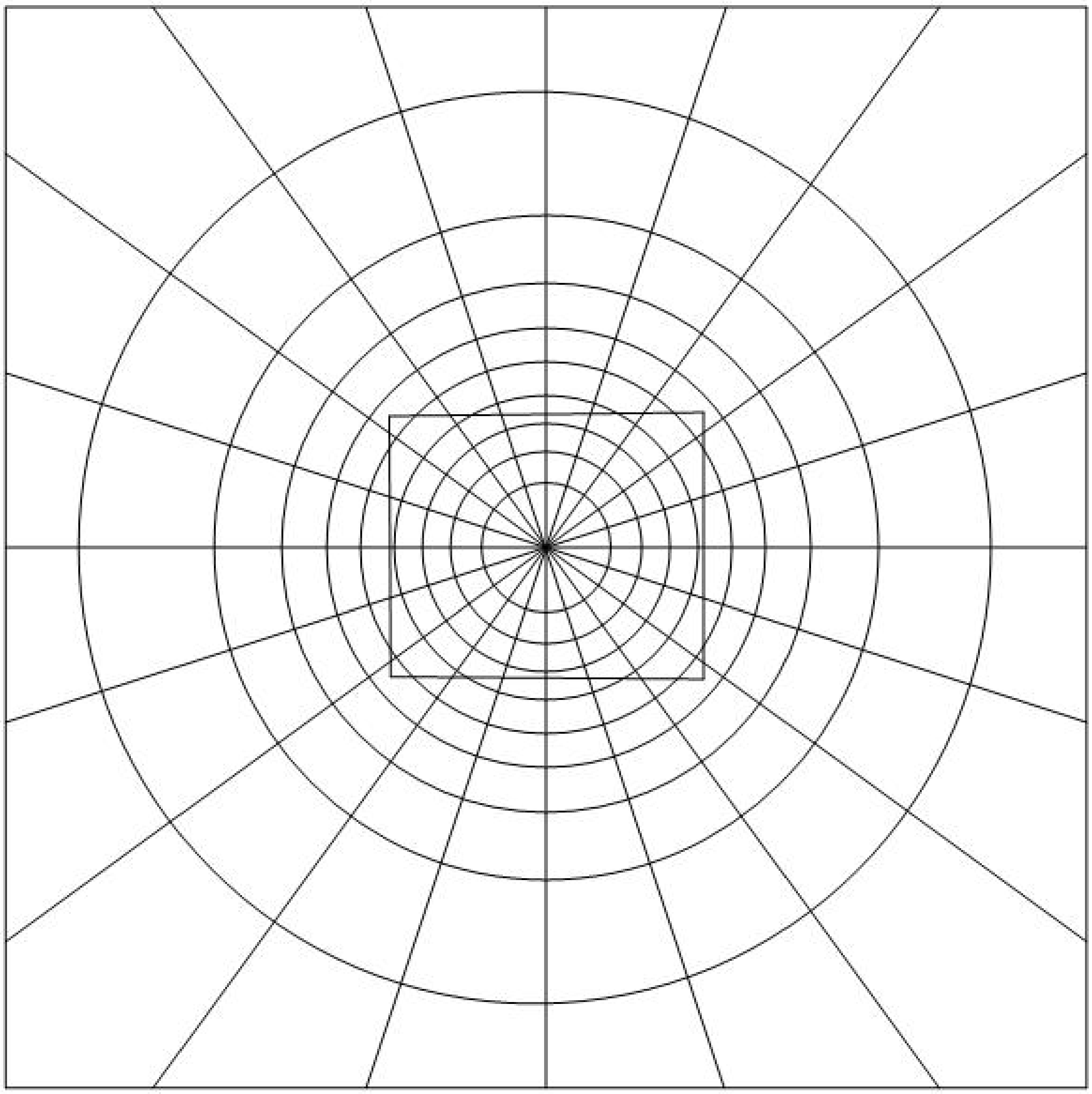
Number of units covered : 7x20 + 8x0.9 + 4x0.5 + 4x0.3 + 4x0.2 + 8x0.1 + 8x0.1 = 152.8

Influence coefficient = 152.8x0.005 = 0.764

Newmark Chart

Influence factor = 0.005

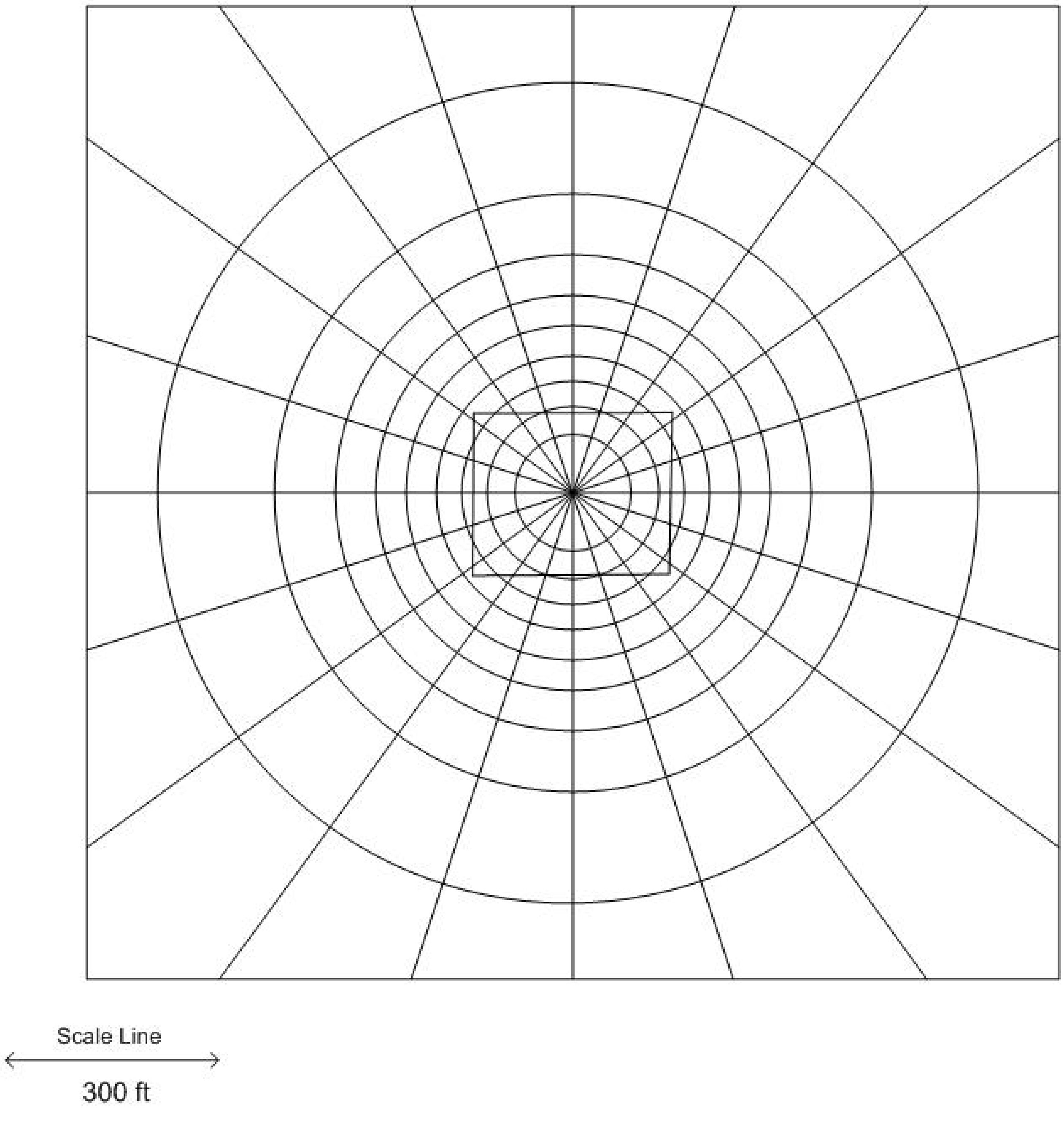
Depth Z = 200 ft



Number of units covered : 3x20 + 12 + 8x0.9 + 4x0.8 + 8x0.4 + 8x0.3 + 4x0.1 = 88.4

Influence coefficient = 88.4x0.005 = 0.442

Newmark Chart
Influence factor = 0.005
Depth Z = 300 ft



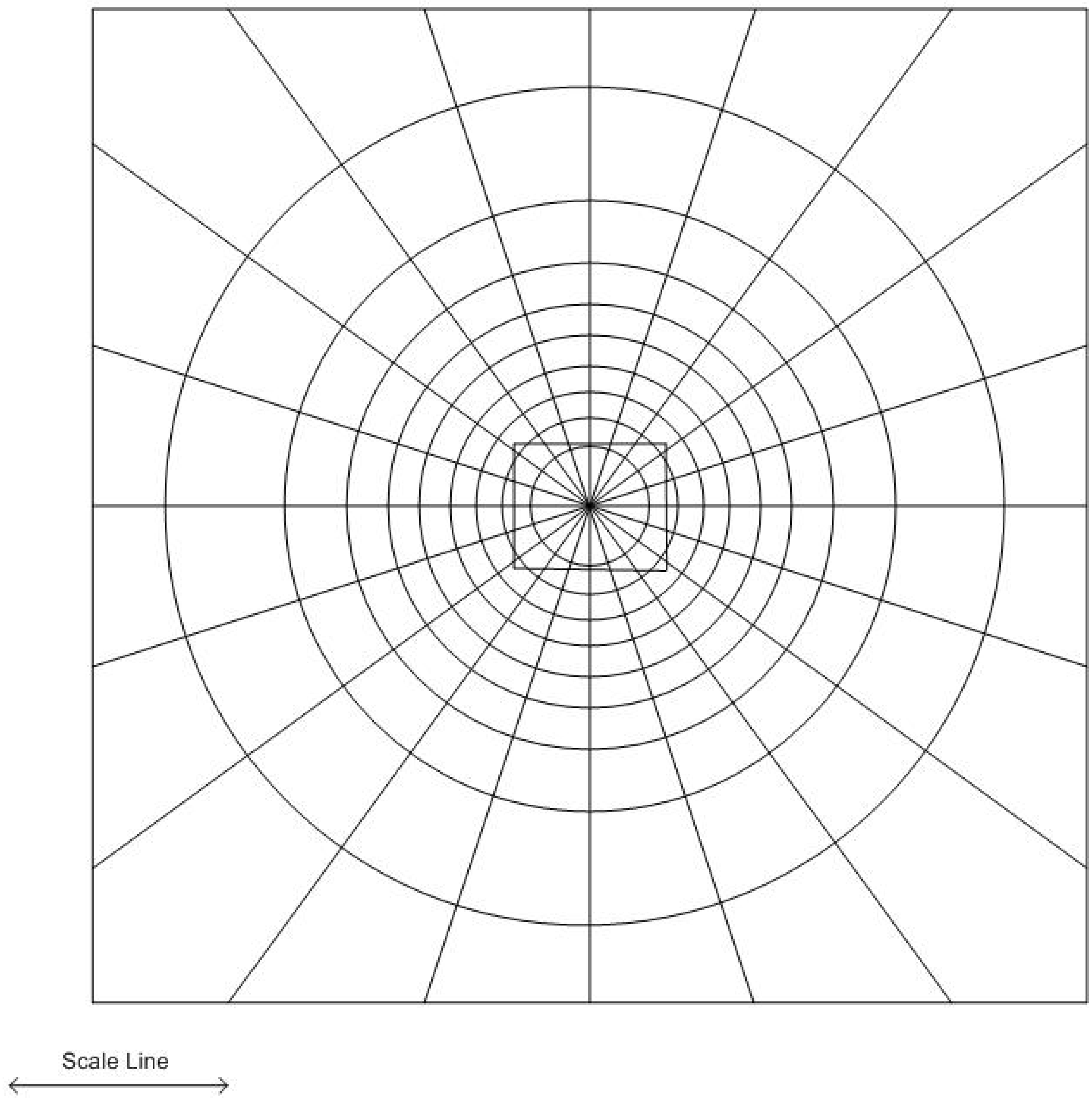
Number of units covered : 20 + 16 + 4x0.9 + 8x0.9 + 8x0.4 + 4x0.2 + 4x0.2 = 51.6

Influence coefficient = 51.6x0.005 = 0.258

Newmark Chart

Influence factor = 0.005

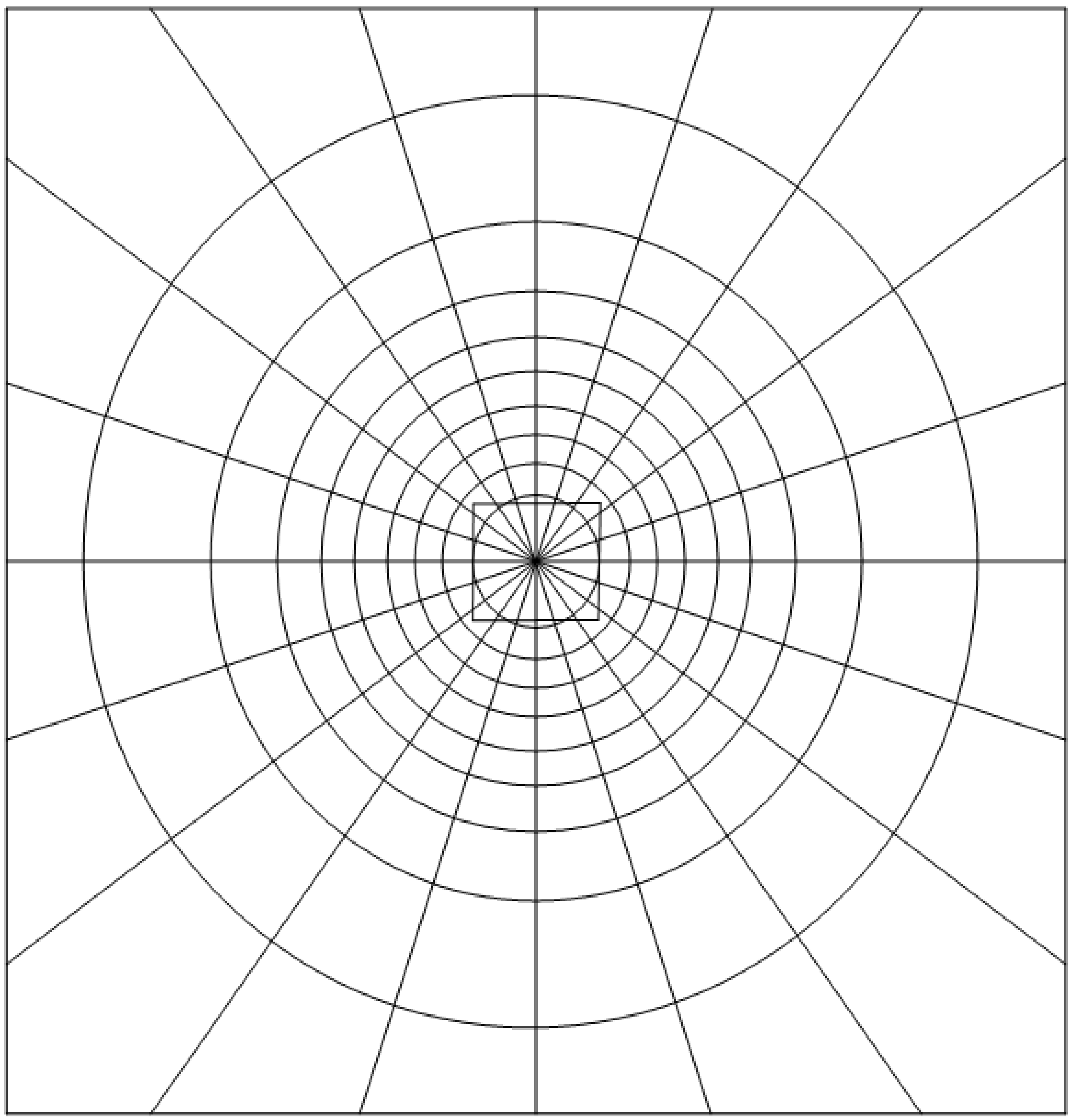
Depth Z = 400 ft



Number of units covered : 20 + 8x0.9 + 4x0.6 + 4x0.3 + 4x0.3 + 4x0.2 +4x0.1 = 32.0

Influence coefficient = 32.0x0.005 = 0.16

Newmark Chart
Influence factor = 0.005
Depth Z = 500 ft



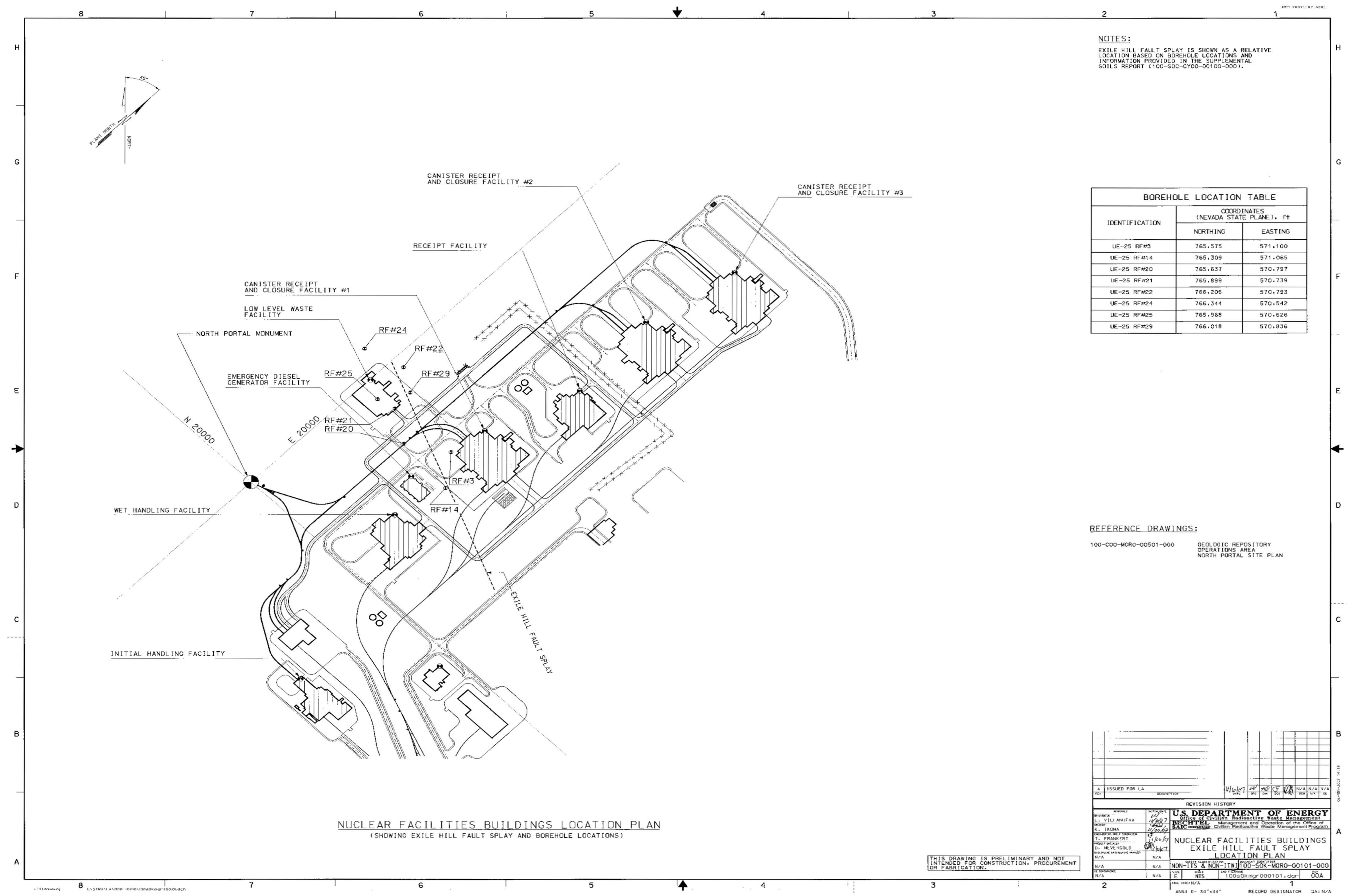
Scale Line

500 ft

Number of units covered : 16 + 4x0.9 + 4x0.4 + 4x0.2 = 22.0

Influence coefficient = 22.0x0.005 = 0.11

ATTACHMENT C
Exile Hill Fault Splay Location Plan



BOREHOLE LOCATION TABLE

IDENTIFICATION	COORDINATES (NEVADA STATE PLANE), ft	
	NORTHING	EASTING
UE-25 RF#3	765,575	571,100
UE-25 RF#14	765,309	571,065
UE-25 RF#20	765,637	570,797
UE-25 RF#21	765,899	570,739
UE-25 RF#22	766,206	570,793
UE-25 RF#24	766,344	570,542
UE-25 RF#25	765,968	570,626
UE-25 RF#29	766,018	570,836

ATTACHMENT D

ASSESSMENT OF REVISED SOIL PROPERTIES

The purpose of this attachment is to assess the impact on the computed foundation impedances for the revised strain compatible soil properties given in DTN's MO0801SCSPS5E4.003 (Ref. 2.2.2) and MO0801SCSPS1E4.003 (Ref. 2.2.3). Soil spring values computed in the body of this calculation and used in subsequent seismic analysis calculations of the WHF were based on DTN's MO0706SCSPS5E4.002 and MO0706SCSPS1E4.002 which have been superseded by the above referenced DTN's.

To assess the impact of the new strain compatible soil properties on the foundation impedance functions the composite soil column shear modulus, G's, is recomputed using the data in references 2.2.2 and 2.2.3. A comparison of the shear modulus for each of the soil cases computed using both the current data and the superseded data is made.

Soil impedances calculated in section 6 of this calculation were computed using the impedance functions given in Table 3.3-3 of ASCE 4 (Ref. 2.2.1). In reviewing the impedance functions given, it is observed that both the translation and rotational spring stiffness are linear functions of the soil shear modulus, G. Thus the computed spring values will be directly proportional to the percentage increase or decrease in the computed soil shear modulus as determined in this attachment. As stated in section 6 of the calculation, the soil damping values are independent of the shear modulus and thus are not impacted by the revised soil properties.

The equivalent soil shear modulus computed in this attachment uses the same procedure described in section 4.3 and carried out in section 6 using the applicable strain compatible soil properties given in Ref. 2.2.2 and 2.2.3. These shear modulus calculations are carried out in excel spreadsheets on the following pages.

Revised shear modulus values for each of the soil cases (upper bound, median, lower bound) and each of the alluvium depths (30' and 100') for both the 5E-4 and 1E-4 cases are summarized on Sheet D15.

Comparison of these revised shear modulus values to the values computed using the superseded data are summarized in Tables D1 through D4.

D.1 Equivalent Shear Modulus

The following spreadsheets are utilized to determine the dynamic shear modulus G_s for the lower bound, median, and upper bound soil profiles for both the 30' depth of alluvium and 100' depth of alluvium conditions based on the methodology discussed previously in Section 6.0.
The new dynamic shear modulus values computed were compared with the previous shear modulus computed in Section 6.2.2. The percentage difference between the old and new shear modulus were shown on Tables D1 through D4.

D.1.1 Equivalent Shear Modulus for 5E-4 annual exceedance frequency

5E-4 Lower Bound Estimate : 30' Depth of Alluvium

Calculation of Equivalent Shear Modulus :

(A) Lower Bound Values :
Ref.: MO0801SCSPS5E4.003 for Strain Compatible Soil Properties (Ref. 2.2.2).

Using 30', Lower Bound Curve : Dynamic Shear Modulus of Soil, G' = (γ /32.17, Mass Density) x (V_s , Velocity)^2
Ref.: Bowles Foundation Analysis and Design, 5th ed., Eq (20-15), Ref. 2.2.6.

Width of Building (W) = : 214 ft (Ref. 2.2.16)

NO	LAYER THICKNESS h_n (ft) (1)	DEPTH (Z) TO CTR / LAYER (ft) (2)	DENSITY γ (pcf) (3)	SHEAR WAVE VELOCITY Vs (ft/s) (4)	DYNAMIC SHEAR MODULUS G_n (ksf) (5)	POISSON'S RATIO[a] ν (7)	(8)=(1)x(7)	ELASTIC MODULUS E_n (ksf) [b] (9)	Z / W (10)	INFLUENCE COEFF q_n [c] (11)	q_n*h_n (12)	q_n*h_n/E_n (13)
1	4.00	2.00	112.32	646.44	1459.0	0.37	1.469	3989.4	0.009	0.996	3.984	9.986E-04
2	4.00	6.00	112.32	618.81	1337.0	0.39	1.548	3709.0	0.028	0.988	3.952	1.066E-03
3	4.00	10.00	112.32	754.14	1985.7	0.39	1.553	5513.1	0.047	0.981	3.924	7.118E-04
4	4.00	14.00	112.32	883.28	2724.0	0.39	1.549	7557.1	0.065	0.973	3.892	5.150E-04
5	4.00	18.00	112.32	929.70	3017.8	0.39	1.556	8382.8	0.084	0.964	3.856	4.600E-04
6	8.00	24.00	112.32	979.83	3352.0	0.39	3.126	9323.3	0.112	0.953	7.624	8.177E-04
7	2.00	29.00	112.32	1221.10	5206.1	0.36	0.730	14212.3	0.136	0.944	1.889	1.329E-04
8	10.00	35.00	137.28	1728.60	12751.0	0.28	2.826	32709.4	0.164	0.932	9.320	2.849E-04
9	10.00	45.00	137.28	2040.00	17758.9	0.28	2.778	45385.1	0.210	0.911	9.110	2.007E-04
10	10.00	55.00	137.28	2132.20	19400.5	0.27	2.738	49424.6	0.257	0.876	8.760	1.772E-04
11	10.00	65.00	137.28	2211.80	20876.0	0.27	2.732	53157.1	0.304	0.862	8.620	1.622E-04
12	10.00	75.00	137.28	2327.00	23107.3	0.27	2.680	58599.6	0.350	0.836	8.360	1.427E-04
13	10.00	85.00	137.28	2428.80	25173.3	0.27	2.704	63957.7	0.397	0.808	8.080	1.263E-04
14	10.00	95.00	137.28	2481.40	26275.4	0.27	2.730	66898.3	0.444	0.778	7.780	1.163E-04
15	10.00	105.00	137.28	2539.50	27520.3	0.28	2.755	70203.7	0.491	0.748	7.480	1.065E-04
16	10.00	115.00	137.28	2610.70	29085.1	0.28	2.760	74224.5	0.537	0.715	7.150	9.633E-05
17	10.00	125.00	137.28	2622.00	29337.4	0.28	2.755	74836.8	0.584	0.681	6.810	9.100E-05
18	10.00	135.00	137.28	2655.20	30085.0	0.28	2.770	76834.8	0.631	0.645	6.450	8.395E-05
19	15.00	147.50	137.28	2688.30	30839.8	0.28	4.200	78950.5	0.689	0.605	9.075	1.149E-04
20	15.00	162.50	137.28	2818.20	33892.2	0.28	4.231	86903.7	0.759	0.554	8.310	9.562E-05
21	15.00	177.50	137.28	2873.90	35245.2	0.28	4.247	90449.0	0.829	0.507	7.605	8.408E-05
22	15.00	192.50	137.28	2896.70	35806.6	0.28	4.259	91944.2	0.900	0.461	6.915	7.521E-05
23	15.00	207.50	137.28	2907.80	36081.6	0.29	4.318	92936.0	0.970	0.424	6.360	6.843E-05
24	15.00	222.50	137.28	2956.00	37287.7	0.29	4.309	96000.1	1.040	0.39	5.850	6.094E-05
25	7.50	233.75	137.28	2992.10	38204.0	0.29	2.161	98421.0	1.092	0.366	2.745	2.789E-05
26	7.50	241.25	137.28	2989.90	38147.8	0.29	2.165	98319.1	1.127	0.352	2.640	2.685E-05
27	7.50	248.75	137.28	2998.00	38354.8	0.29	2.165	98851.8	1.162	0.338	2.535	2.564E-05
28	7.50	256.25	137.28	3017.30	38850.2	0.29	2.158	100055.6	1.197	0.326	2.445	2.444E-05
29	7.50	263.75	137.28	3071.70	40263.7	0.29	2.154	103652.5	1.232	0.312	2.340	2.258E-05
30	7.50	271.25	137.28	3083.90	40584.2	0.29	2.165	104596.8	1.268	0.302	2.265	2.165E-05
31	7.50	278.75	137.28	3113.50	41367.0	0.29	2.168	106644.9	1.303	0.289	2.168	2.032E-05
32	7.50	286.25	137.28	3147.30	42270.0	0.29	2.163	108920.6	1.338	0.278	2.085	1.914E-05
33	7.50	293.75	137.28	3159.30	42593.0	0.29	2.173	109868.6	1.373	0.267	2.003	1.823E-05
34	7.50	301.25	137.28	3180.80	43174.7	0.29	2.160	111223.1	1.408	0.257	1.928	1.733E-05
35	7.50	308.75	137.28	3207.00	43888.8	0.29	2.157	113018.2	1.443	0.247	1.853	1.639E-05
36	7.50	316.25	137.28	3240.20	44802.3	0.29	2.163	115445.5	1.478	0.237	1.778	1.540E-05
37	10.16	325.08	137.28	3238.10	44744.2	0.29	2.908	115109.8	1.519	0.227	2.306	2.003E-05
38	9.84	335.08	137.28	3293.50	46288.3	0.29	2.810	119001.8	1.566	0.216	2.126	1.787E-05
39	10.16	345.08	137.28	3304.30	46592.4	0.28	2.888	119684.7	1.613	0.205	2.082	1.740E-05
40	9.84	355.08	137.28	3347.60	47821.5	0.28	2.792	122772.2	1.659	0.197	1.939	1.579E-05
41	20.00	370.00	137.28	3423.40	50011.7	0.28	5.643	128246.0	1.729	0.183	3.660	2.854E-05
42	20.00	390.00	137.28	3429.30	50184.2	0.28	5.632	128633.2	1.822	0.168	3.360	2.612E-05
43	20.00	410.00	137.28	3479.40	51661.3	0.28	5.664	132581.4	1.916	0.154	3.080	2.323E-05
44	20.00	430.00	137.28	3608.10	55553.7	0.28	5.679	142654.2	2.009	0.142	2.840	1.991E-05
45	20.00	450.00	137.28	3668.00	57413.6	0.28	5.670	147383.0	2.103	0.132	2.640	1.791E-05
						ν_a =						
Σ	460.00					0.29	132.957		Grade Basemat (0'--460')	SUM	211.971	7.232E-03
	410.00					0.28	115.823		Pool Basemat (55'--460')	SUM	164.420	2.044E-03

(a) Poisson's Ratio is from Ref. 2.2.2.
(b) E' = 2(1+ν)G'. Ref. Bowles Foundation Analysis and Design, 5th ed., p 121 (Ref. 2.2.6).
(c) From figure 5

	Grade Basemat						Pool Basemat	
Average E = SUM(q_n*h_n) / SUM(q_n*h_n/E_n) =	29312	ksf					80425	ksf
G_s = E/(2(1+ν_a)) =	11370	ksf					31355	ksf
Corresponding Vel = SQRT(32.17*G_s / γ) =	1805	ft/sec	for γ =	112.3	pcf		2997	ft/sec
	1632	ft/sec		137.3	pcf		2711	ft/sec

5E-4 Median Estimate : 30' Depth of Alluvium

Calculation of Equivalent Shear Modulus :

(B) Median Values :
Ref.: MO0801SCSPS5E4.003 for Strain Compatible Soil Properties (Ref. 2.2.2).

Using 30', Median Curve : Dynamic Shear Modulus of Soil, G' = (γ /32.17, Mass Density) x (V_s , Velocity)^2
Ref.: Bowles Foundation Analysis and Design, 5th ed., Eq (20-15), Ref. 2.2.6.

Width of Building (W) = : 214 ft (Ref. 2.2.16)

NO	LAYER THICKNESS h_n (ft)	DEPTH (Z) TO CTR / LAYER (ft)	DENSITY γ (pcf)	SHEAR WAVE VELOCITY Vs (ft/s)	DYNAMIC SHEAR MODULUS G_n (ksf)	POISSON'S RATIO[a] ν		ELASTIC MODULUS E_n (ksf) [b]	Z / W	INFLUENCE COEFF q_n [c]	q_n*h_n	q_n*h_n/ E_n
	(1)	(2)	(3)	(4)	(5)	(7)	(8)=(1)x(7)	(9)	(10)	(11)	(12)	(13)
1	4.00	2.00	112.32	914.20	2918.0	0.37	1.469	7978.8	0.009	0.996	3.984	4.993E-04
2	4.00	6.00	112.32	875.13	2673.9	0.39	1.548	7418.1	0.028	0.988	3.952	5.328E-04
3	4.00	10.00	112.32	1066.50	3971.3	0.39	1.553	11025.8	0.047	0.981	3.924	3.559E-04
4	4.00	14.00	112.32	1249.10	5447.5	0.39	1.549	15113.1	0.065	0.973	3.892	2.575E-04
5	4.00	18.00	112.32	1314.80	6035.7	0.39	1.556	16765.8	0.084	0.964	3.856	2.300E-04
6	8.00	24.00	112.32	1385.70	6704.2	0.39	3.126	18647.0	0.112	0.953	7.624	4.089E-04
7	2.00	29.00	112.32	1726.90	10412.1	0.36	0.730	28424.8	0.136	0.944	1.889	6.645E-05
8	10.00	35.00	137.28	2238.40	21381.2	0.28	2.826	54847.8	0.164	0.932	9.320	1.699E-04
9	10.00	45.00	137.28	2498.50	26638.8	0.28	2.778	68078.7	0.210	0.911	9.110	1.338E-04
10	10.00	55.00	137.28	2611.40	29100.7	0.27	2.738	74136.9	0.257	0.876	8.760	1.182E-04
11	10.00	65.00	137.28	2708.90	31314.3	0.27	2.732	79736.1	0.304	0.862	8.620	1.081E-04
12	10.00	75.00	137.28	2853.60	34749.0	0.27	2.680	88122.8	0.350	0.836	8.360	9.487E-05
13	10.00	85.00	137.28	2974.70	37760.9	0.27	2.704	95939.2	0.397	0.808	8.080	8.422E-05
14	10.00	95.00	137.28	3039.10	39413.6	0.27	2.730	100348.6	0.444	0.778	7.780	7.753E-05
15	10.00	105.00	137.28	3124.20	41651.8	0.28	2.755	106252.9	0.491	0.748	7.480	7.040E-05
16	10.00	115.00	137.28	3197.40	43626.5	0.28	2.760	111333.9	0.537	0.715	7.150	6.422E-05
17	10.00	125.00	137.28	3211.30	44006.6	0.28	2.755	112256.5	0.584	0.681	6.810	6.066E-05
18	10.00	135.00	137.28	3251.90	45126.4	0.28	2.770	115249.2	0.631	0.645	6.450	5.597E-05
19	15.00	147.50	137.28	3292.50	46260.2	0.28	4.200	118427.1	0.689	0.605	9.075	7.663E-05
20	15.00	162.50	137.28	3451.60	50839.0	0.28	4.231	130357.3	0.759	0.554	8.310	6.375E-05
21	15.00	177.50	137.28	3519.80	52867.9	0.28	4.247	135673.9	0.829	0.507	7.605	5.605E-05
22	15.00	192.50	137.28	3547.70	53709.4	0.28	4.259	137914.9	0.900	0.461	6.915	5.014E-05
23	15.00	207.50	137.28	3561.40	54125.0	0.29	4.318	139410.8	0.970	0.424	6.360	4.562E-05
24	15.00	222.50	137.28	3620.40	55933.2	0.29	4.309	144004.4	1.040	0.39	5.850	4.062E-05
25	7.50	233.75	137.28	3664.50	57304.1	0.29	2.161	147626.8	1.092	0.366	2.745	1.859E-05
26	7.50	241.25	137.28	3661.90	57222.8	0.29	2.165	147481.5	1.127	0.352	2.640	1.790E-05
27	7.50	248.75	137.28	3671.70	57529.5	0.29	2.165	148270.8	1.162	0.338	2.535	1.710E-05
28	7.50	256.25	137.28	3695.40	58274.6	0.29	2.158	150081.5	1.197	0.326	2.445	1.629E-05
29	7.50	263.75	137.28	3762.00	60394.0	0.29	2.154	155474.7	1.232	0.312	2.340	1.505E-05
30	7.50	271.25	137.28	3777.00	60876.6	0.29	2.165	156896.0	1.268	0.302	2.265	1.444E-05
31	7.50	278.75	137.28	3813.20	62049.1	0.29	2.168	159963.8	1.303	0.289	2.168	1.355E-05
32	7.50	286.25	137.28	3854.60	63403.7	0.29	2.163	163377.5	1.338	0.278	2.085	1.276E-05
33	7.50	293.75	137.28	3869.30	63888.3	0.29	2.173	164799.7	1.373	0.267	2.003	1.215E-05
34	7.50	301.25	137.28	3895.60	64759.7	0.29	2.160	166828.8	1.408	0.257	1.928	1.155E-05
35	7.50	308.75	137.28	3927.80	65834.7	0.29	2.157	169531.0	1.443	0.247	1.853	1.093E-05
36	7.50	316.25	137.28	3968.40	67202.8	0.29	2.163	173166.7	1.478	0.237	1.778	1.026E-05
37	10.16	325.08	137.28	3965.80	67114.7	0.29	2.908	172660.7	1.519	0.227	2.306	1.335E-05
38	9.84	335.08	137.28	4033.70	69432.6	0.29	2.810	178502.9	1.566	0.216	2.126	1.191E-05
39	10.16	345.08	137.28	4046.90	69887.8	0.28	2.888	179524.9	1.613	0.205	2.082	1.160E-05
40	9.84	355.08	137.28	4100.00	71733.8	0.28	2.792	184162.2	1.659	0.197	1.939	1.053E-05
41	20.00	370.00	137.28	4192.80	75017.8	0.28	5.643	192369.7	1.729	0.183	3.660	1.903E-05
42	20.00	390.00	137.28	4200.10	75279.3	0.28	5.632	192957.4	1.822	0.168	3.360	1.741E-05
43	20.00	410.00	137.28	4261.30	77489.1	0.28	5.664	198864.8	1.916	0.154	3.080	1.549E-05
44	20.00	430.00	137.28	4418.90	83326.8	0.28	5.679	213971.5	2.009	0.142	2.840	1.327E-05
45	20.00	450.00	137.28	4492.30	86118.0	0.28	5.670	221068.2	2.103	0.132	2.640	1.194E-05
						$ν_a$ =						
Σ	460.00					0.29	132.957		Grade Basemat (0'--460')	SUM	211.971	4.017E-03
	410.00					0.28	115.823		Pool Basemat (55'--460')	SUM	164.420	1.362E-03

(a) Poisson's Ratio is from Ref. 2.2.2.
(b) E' = 2(1+ν)G'. Ref. Bowles Foundation Analysis and Design, 5th ed., p 121 (Ref. 2.2.6).
(c) From figure 5

	Grade Basemat					Pool Basemat	
Average E = SUM(q_n*h_n) / SUM(q_n*h_n/E_n) =	52774	ksf				120715	ksf
G_s = E/(2(1+$ν_a$)) =	20470	ksf				47062	ksf
Corresponding Vel = SQRT(32.17*G_s / γ) =	2421	ft/sec	for γ =	112.3	pcf	3671	ft/sec
	2190	ft/sec		137.3	pcf	3321	ft/sec

5E-4 Upper Bound Estimate : 30' Depth of Alluvium

Calculation of Equivalent Shear Modulus :

(C) Upper Bound Values :
Ref.: MO0801SCSPS5E4.003 for Strain Compatible Soil Properties (Ref. 2.2.2).

Using 30', Upper Bound) Curve : Dynamic Shear Modulus of Soil, G' = (γ /32.17, Mass Density) x (V_s , Velocity)^2
Ref.: Bowles Foundation Analysis and Design, 5th ed., Eq (20-15), Ref. 2.2.6.

Width of Building (W) = : 214 ft (Ref. 2.2.16)

NO	LAYER THICKNESS h_n (ft)	DEPTH (Z) TO CTR / LAYER (ft)	DENSITY γ (pcf)	SHEAR WAVE VELOCITY Vs (ft/s)	DYNAMIC SHEAR MODULUS G_n (ksf)	POISSON'S RATIO[a] ν		ELASTIC MODULUS E_n (ksf) [b]	Z / W	INFLUENCE COEFF q_n [c]	q_n*h_n	q_n*h_n/ E_n
	(1)	(2)	(3)	(4)	(5)	(7)	(8)=(1)x(7)	(9)	(10)	(11)	(12)	(13)
1	4.00	2.00	112.32	1292.90	5836.3	0.37	1.469	15958.2	0.009	0.996	3.984	2.497E-04
2	4.00	6.00	112.32	1237.60	5347.7	0.39	1.548	14835.7	0.028	0.988	3.952	2.664E-04
3	4.00	10.00	112.32	1508.30	7942.9	0.39	1.553	22052.8	0.047	0.981	3.924	1.779E-04
4	4.00	14.00	112.32	1766.60	10896.4	0.39	1.549	30229.8	0.065	0.973	3.892	1.287E-04
5	4.00	18.00	112.32	1859.40	12071.2	0.39	1.556	33531.2	0.084	0.964	3.856	1.150E-04
6	8.00	24.00	112.32	1959.70	13408.7	0.39	3.126	37294.8	0.112	0.953	7.624	2.044E-04
7	2.00	29.00	112.32	2442.20	20824.2	0.36	0.730	56849.3	0.136	0.944	1.889	3.323E-05
8	10.00	35.00	137.28	2898.60	35853.6	0.28	2.826	91973.1	0.164	0.932	9.320	1.013E-04
9	10.00	45.00	137.28	3060.00	39957.6	0.28	2.778	102116.4	0.210	0.911	9.110	8.921E-05
10	10.00	55.00	137.28	3198.30	43651.0	0.27	2.738	111205.4	0.257	0.876	8.760	7.877E-05
11	10.00	65.00	137.28	3317.70	46971.1	0.27	2.732	119603.4	0.304	0.862	8.620	7.207E-05
12	10.00	75.00	137.28	3499.30	52253.9	0.27	2.680	132514.8	0.350	0.836	8.360	6.309E-05
13	10.00	85.00	137.28	3643.20	56639.9	0.27	2.704	143904.9	0.397	0.808	8.080	5.615E-05
14	10.00	95.00	137.28	3722.10	59119.7	0.27	2.730	150521.1	0.444	0.778	7.780	5.169E-05
15	10.00	105.00	137.28	3843.50	63039.1	0.28	2.755	160811.5	0.491	0.748	7.480	4.651E-05
16	10.00	115.00	137.28	3916.00	65439.7	0.28	2.760	167000.9	0.537	0.715	7.150	4.281E-05
17	10.00	125.00	137.28	3933.00	66009.1	0.28	2.755	168382.7	0.584	0.681	6.810	4.044E-05
18	10.00	135.00	137.28	3982.80	67691.4	0.28	2.770	172878.3	0.631	0.645	6.450	3.731E-05
19	15.00	147.50	137.28	4032.40	69387.8	0.28	4.200	177634.3	0.689	0.605	9.075	5.109E-05
20	15.00	162.50	137.28	4227.40	76261.1	0.28	4.231	195542.5	0.759	0.554	8.310	4.250E-05
21	15.00	177.50	137.28	4310.80	79299.8	0.28	4.247	203505.4	0.829	0.507	7.605	3.737E-05
22	15.00	192.50	137.28	4345.00	80563.0	0.28	4.259	206869.7	0.900	0.461	6.915	3.343E-05
23	15.00	207.50	137.28	4361.80	81187.2	0.29	4.318	209115.6	0.970	0.424	6.360	3.041E-05
24	15.00	222.50	137.28	4434.00	83897.2	0.29	4.309	216000.1	1.040	0.39	5.850	2.708E-05
25	7.50	233.75	137.28	4488.10	85957.0	0.29	2.161	221442.4	1.092	0.366	2.745	1.240E-05
26	7.50	241.25	137.28	4484.90	85834.5	0.29	2.165	221222.9	1.127	0.352	2.640	1.193E-05
27	7.50	248.75	137.28	4496.90	86294.4	0.29	2.165	222406.6	1.162	0.338	2.535	1.140E-05
28	7.50	256.25	137.28	4525.90	87411.0	0.29	2.158	225120.1	1.197	0.326	2.445	1.086E-05
29	7.50	263.75	137.28	4607.50	90591.4	0.29	2.154	233213.0	1.232	0.312	2.340	1.003E-05
30	7.50	271.25	137.28	4625.80	91312.4	0.29	2.165	235337.7	1.268	0.302	2.265	9.624E-06
31	7.50	278.75	137.28	4670.20	93073.7	0.29	2.168	239946.0	1.303	0.289	2.168	9.033E-06
32	7.50	286.25	137.28	4721.00	95109.6	0.29	2.163	245076.4	1.338	0.278	2.085	8.508E-06
33	7.50	293.75	137.28	4738.90	95832.2	0.29	2.173	247199.1	1.373	0.267	2.003	8.101E-06
34	7.50	301.25	137.28	4771.10	97138.9	0.29	2.160	250241.5	1.408	0.257	1.928	7.703E-06
35	7.50	308.75	137.28	4810.60	98754.0	0.29	2.157	254301.4	1.443	0.247	1.853	7.285E-06
36	7.50	316.25	137.28	4860.20	100800.9	0.29	2.163	259741.8	1.478	0.237	1.778	6.843E-06
37	10.16	325.08	137.28	4857.10	100672.4	0.29	2.908	258991.8	1.519	0.227	2.306	8.902E-06
38	9.84	335.08	137.28	4940.20	104146.6	0.29	2.810	267748.5	1.566	0.216	2.126	7.941E-06
39	10.16	345.08	137.28	4956.40	104830.8	0.28	2.888	269285.2	1.613	0.205	2.082	7.732E-06
40	9.84	355.08	137.28	5021.40	107598.4	0.28	2.792	276237.4	1.659	0.197	1.939	7.020E-06
41	20.00	370.00	137.28	5135.10	112526.3	0.28	5.643	288553.4	1.729	0.183	3.660	1.268E-05
42	20.00	390.00	137.28	5144.00	112916.7	0.28	5.632	289430.3	1.822	0.168	3.360	1.161E-05
43	20.00	410.00	137.28	5219.00	116233.4	0.28	5.664	298296.7	1.916	0.154	3.080	1.033E-05
44	20.00	430.00	137.28	5412.10	124993.6	0.28	5.679	320966.1	2.009	0.142	2.840	8.848E-06
45	20.00	450.00	137.28	5502.00	129180.6	0.28	5.670	331611.8	2.103	0.132	2.640	7.961E-06
Σ	460.00						132.96					
						$ν_a$ =						
Σ	460.00					0.29	132.957		Grade Basemat (0'--460')	SUM	211.971	2.273E-03
	410.00					0.28	115.823		Pool Basemat (55'--460')	SUM	164.420	9.075E-04

(a) Poisson's Ratio is from Ref. 2.2.2.
(b) E' = 2(1+ν)G'. Ref. Bowles Foundation Analysis and Design, 5th ed., p 121 (Ref. 2.2.6).
(c) From figure 5

	Grade Basemat					Pool Basemat	
Average E = SUM(q_n*h_n) / SUM(q_n*h_n/E_n) =	93240	ksf				181186	ksf
G_s = E/(2(1+$ν_a$)) =	36167	ksf				70638	ksf
Corresponding Vel = SQRT(32.17*G_s / γ) =	3218	ft/sec	for γ =	112.3	pcf	4498	ft/sec
	2911	ft/sec		137.3	pcf	4069	ft/sec

5E-4 Lower Bound Estimate : 100' Depth of Alluvium

Calculation of Equivalent Shear Modulus :

(A) Lower Bound Values :
Ref.: MO0801SCSPS5E4.003 for Strain Compatible Soil Properties (Ref. 2.2.2).

Using 100', Lower Bound Curve : Dynamic Shear Modulus of Soil, G' = (γ /32.17, Mass Density) x (V_s , Velocity)^2
Ref.: Bowles Foundation Analysis and Design, 5th ed., Eq (20-15), Ref. 2.2.6.

Width of Building (W) = : 214 ft (Ref. 2.2.16)

NO	LAYER THICKNESS h_n (ft) (1)	DEPTH (Z) TO CTR / LAYER (ft) (2)	DENSITY γ (pcf) (3)	SHEAR WAVE VELOCITY Vs (ft/s) (4)	DYNAMIC SHEAR MODULUS G_n (ksf) (5)	POISSON'S RATIO[(a)] ν (7)	(8)=(1)x(7)	ELASTIC MODULUS E_n (ksf) [(b)] (9)	Z / W (10)	INFLUENCE COEFF q_n [(c)] (11)	q_n*h_n (12)	q_n*h_n/ E_n (13)
1	4.00	2.00	112.32	638.49	1423.4	0.37	1.466	3889.9	0.009	0.996	3.984	1.024E-03
2	4.00	6.00	112.32	603.69	1272.4	0.39	1.557	3535.6	0.028	0.988	3.952	1.118E-03
3	4.00	10.00	112.32	663.72	1538.1	0.39	1.576	4287.9	0.047	0.981	3.924	9.151E-04
4	4.00	14.00	112.32	798.01	2223.4	0.39	1.572	6194.7	0.065	0.973	3.892	6.283E-04
5	4.00	18.00	112.32	912.58	2907.7	0.39	1.567	8094.1	0.084	0.964	3.856	4.764E-04
6	8.00	24.00	112.32	972.58	3302.6	0.39	3.147	9203.2	0.112	0.953	7.624	8.284E-04
7	8.00	32.00	112.32	1125.50	4422.8	0.37	2.995	12157.2	0.150	0.938	7.504	6.172E-04
8	8.00	40.00	112.32	1158.60	4686.8	0.36	2.887	12756.7	0.187	0.922	7.376	5.782E-04
9	8.00	48.00	112.32	1190.10	4945.1	0.36	2.859	13424.9	0.224	0.903	7.224	5.381E-04
10	8.00	56.00	112.32	1337.60	6246.8	0.34	2.702	16712.6	0.262	0.886	7.088	4.241E-04
11	10.00	65.00	112.32	1353.50	6396.2	0.34	3.397	17138.4	0.304	0.862	8.620	5.030E-04
12	10.00	75.00	112.32	1457.00	7411.8	0.34	3.375	19827.1	0.350	0.836	8.360	4.216E-04
13	10.00	85.00	112.32	1567.50	8578.7	0.34	3.356	22914.7	0.397	0.808	8.080	3.526E-04
14	10.00	95.00	112.32	1715.00	10269.1	0.33	3.344	27405.3	0.444	0.778	7.780	2.839E-04
15	10.00	105.00	137.28	2327.50	23117.2	0.28	2.761	58999.8	0.491	0.748	7.480	1.268E-04
16	10.00	115.00	137.28	2398.00	24538.9	0.28	2.765	62647.2	0.537	0.715	7.150	1.141E-04
17	10.00	125.00	137.28	2451.90	25654.4	0.28	2.756	65448.5	0.584	0.681	6.810	1.041E-04
18	10.00	135.00	137.28	2516.50	27024.0	0.28	2.770	69021.0	0.631	0.645	6.450	9.345E-05
19	15.00	147.50	137.28	2581.40	28435.9	0.28	4.200	72796.4	0.689	0.605	9.075	1.247E-04
20	15.00	162.50	137.28	2637.10	29676.3	0.28	4.238	76120.8	0.759	0.554	8.310	1.092E-04
21	15.00	177.50	137.28	2763.00	32577.5	0.28	4.249	83610.2	0.829	0.507	7.605	9.096E-05
22	15.00	192.50	137.28	2827.70	34121.1	0.28	4.258	87614.1	0.900	0.461	6.915	7.893E-05
23	15.00	207.50	137.28	2878.80	35365.5	0.29	4.317	91086.5	0.970	0.424	6.360	6.982E-05
24	15.00	222.50	137.28	2919.10	36362.5	0.29	4.309	93616.1	1.040	0.39	5.850	6.249E-05
25	7.50	233.75	137.28	3004.30	38516.1	0.29	2.159	99208.3	1.092	0.366	2.745	2.767E-05
26	7.50	241.25	137.28	3004.30	38516.1	0.29	2.163	99251.5	1.127	0.352	2.640	2.660E-05
27	7.50	248.75	137.28	3028.20	39131.4	0.29	2.163	100830.6	1.162	0.338	2.535	2.514E-05
28	7.50	256.25	137.28	3108.70	41239.5	0.29	2.155	106177.8	1.197	0.326	2.445	2.303E-05
29	7.50	263.75	137.28	3150.00	42342.6	0.29	2.151	108973.7	1.232	0.312	2.340	2.147E-05
30	7.50	271.25	137.28	3160.60	42628.0	0.29	2.162	109833.7	1.268	0.302	2.265	2.062E-05
31	7.50	278.75	137.28	3188.20	43375.8	0.29	2.165	111797.6	1.303	0.289	2.168	1.939E-05
32	7.50	286.25	137.28	3238.80	44763.5	0.29	2.161	115317.2	1.338	0.278	2.085	1.808E-05
33	7.50	293.75	137.28	3270.90	45655.3	0.29	2.170	117726.6	1.373	0.267	2.003	1.701E-05
34	7.50	301.25	137.28	3289.30	46170.4	0.29	2.157	118897.0	1.408	0.257	1.928	1.621E-05
35	7.50	308.75	137.28	3309.30	46733.5	0.29	2.154	120306.1	1.443	0.247	1.853	1.540E-05
36	7.50	316.25	137.28	3389.20	49017.4	0.29	2.159	126250.3	1.478	0.237	1.778	1.408E-05
37	10.16	325.08	137.28	3407.20	49539.5	0.29	2.901	127380.9	1.519	0.227	2.306	1.810E-05
38	9.84	335.08	137.28	3438.90	50465.6	0.28	2.804	129679.4	1.566	0.216	2.126	1.639E-05
39	10.16	345.08	137.28	3438.50	50453.8	0.28	2.883	129547.3	1.613	0.205	2.082	1.607E-05
40	9.84	355.08	137.28	3496.80	52179.2	0.28	2.786	133899.2	1.659	0.197	1.939	1.448E-05
41	20.00	370.00	137.28	3504.30	52403.3	0.28	5.637	134344.3	1.729	0.183	3.660	2.724E-05
42	20.00	390.00	137.28	3526.90	53081.4	0.28	5.625	136020.1	1.822	0.168	3.360	2.470E-05
43	20.00	410.00	137.28	3558.90	54049.0	0.28	5.659	138682.2	1.916	0.154	3.080	2.221E-05
44	20.00	430.00	137.28	3646.40	56739.4	0.28	5.676	145684.1	2.009	0.142	2.840	1.949E-05
45	20.00	450.00	137.28	3662.50	57241.6	0.28	5.670	146936.8	2.103	0.132	2.640	1.797E-05
						ν_a =						
Σ	460.00					0.30	137.980		Grade Basemat (0'--460')	SUM	212.084	1.010E-02
	408.00					0.29	118.353		Pool Basemat (56'--460')	SUM	162.748	3.381E-03

(a) Poisson's Ratio is from Ref. 2.2.2.
(b) E' = 2(1+v)G'. Ref. Bowles Foundation Analysis and Design, 5th ed., p 121 (Ref. 2.2.6).
(c) From figure 5

	Grade Basemat					Pool Basemat	
Average E = SUM(q_n*h_n) / SUM(q_n*h_n/E_n) =	20989	ksf				48136	ksf
G_s = E/(2(1+ν_a)) =	8073	ksf				18656	ksf
Corresponding Vel = SQRT(32.17*G_s / γ) =	1521	ft/sec	for γ =	112.3	pcf	2312	ft/sec
	1375	ft/sec		137.3	pcf	2091	ft/sec

5E-4 Median Estimate : 100' Depth of Alluvium

Calculation of Equivalent Shear Modulus :

(B) Median Values :
Ref.: MO0801SCSPS5E4.003 for Strain Compatible Soil Properties (Ref. 2.2.2).

Using 100', Median Curve :

Dynamic Shear Modulus of Soil, G' = (γ /32.17, Mass Density) x (V_s , Velocity)^2
Ref.: Bowles Foundation Analysis and Design, 5th ed., Eq (20-15), Ref. 2.2.6.

Width of Building (W) = : 214 ft (Ref. 2.2.16)

NO	LAYER THICKNESS h_n (ft)	DEPTH (Z) TO CTR / LAYER (ft)	DENSITY γ (pcf)	SHEAR WAVE VELOCITY Vs (ft/s)	DYNAMIC SHEAR MODULUS G_n (ksf)	POISSON'S RATIO[a] ν		ELASTIC MODULUS E_n (ksf) [b]	Z / W	INFLUENCE COEFF q_n [c]	q_n*h_n	q_n*h_n/E_n
	(1)	(2)	(3)	(4)	(5)	(7)	(8)=(1)x(7)	(9)	(10)	(11)	(12)	(13)
1	4.00	2.00	112.32	902.96	2846.7	0.37	1.466	7779.8	0.009	0.996	3.984	5.121E-04
2	4.00	6.00	112.32	853.75	2544.9	0.39	1.557	7071.3	0.028	0.988	3.952	5.589E-04
3	4.00	10.00	112.32	938.64	3076.1	0.39	1.576	8575.8	0.047	0.981	3.924	4.576E-04
4	4.00	14.00	112.32	1128.60	4447.2	0.39	1.572	12390.3	0.065	0.973	3.892	3.141E-04
5	4.00	18.00	112.32	1290.60	5815.5	0.39	1.567	16188.6	0.084	0.964	3.856	2.382E-04
6	8.00	24.00	112.32	1375.40	6604.9	0.39	3.147	18405.5	0.112	0.953	7.624	4.142E-04
7	8.00	32.00	112.32	1591.70	8845.6	0.37	2.995	24314.5	0.150	0.938	7.504	3.086E-04
8	8.00	40.00	112.32	1638.50	9373.4	0.36	2.887	25513.2	0.187	0.922	7.376	2.891E-04
9	8.00	48.00	112.32	1683.00	9889.5	0.36	2.859	26848.0	0.224	0.903	7.224	2.691E-04
10	8.00	56.00	112.32	1891.70	12494.3	0.34	2.702	33426.9	0.262	0.886	7.088	2.120E-04
11	10.00	65.00	112.32	1914.10	12791.9	0.34	3.397	34275.4	0.304	0.862	8.620	2.515E-04
12	10.00	75.00	112.32	2060.50	14823.5	0.34	3.375	39653.8	0.350	0.836	8.360	2.108E-04
13	10.00	85.00	112.32	2205.40	16981.7	0.34	3.356	45360.1	0.397	0.808	8.080	1.781E-04
14	10.00	95.00	112.32	2326.10	18891.3	0.33	3.344	50415.3	0.444	0.778	7.780	1.543E-04
15	10.00	105.00	137.28	2850.60	34676.0	0.28	2.761	88500.0	0.491	0.748	7.480	8.452E-05
16	10.00	115.00	137.28	2936.90	36807.3	0.28	2.765	93968.4	0.537	0.715	7.150	7.609E-05
17	10.00	125.00	137.28	3003.00	38482.8	0.28	2.756	98175.8	0.584	0.681	6.810	6.937E-05
18	10.00	135.00	137.28	3082.10	40536.8	0.28	2.770	103533.5	0.631	0.645	6.450	6.230E-05
19	15.00	147.50	137.28	3161.50	42652.3	0.28	4.200	109190.8	0.689	0.605	9.075	8.311E-05
20	15.00	162.50	137.28	3229.70	44512.4	0.28	4.238	114176.0	0.759	0.554	8.310	7.278E-05
21	15.00	177.50	137.28	3384.00	48867.1	0.28	4.249	125417.5	0.829	0.507	7.605	6.064E-05
22	15.00	192.50	137.28	3463.20	51181.3	0.28	4.258	131420.3	0.900	0.461	6.915	5.262E-05
23	15.00	207.50	137.28	3525.80	53048.3	0.29	4.317	136630.2	0.970	0.424	6.360	4.655E-05
24	15.00	222.50	137.28	3575.20	54545.2	0.29	4.309	140427.8	1.040	0.39	5.850	4.166E-05
25	7.50	233.75	137.28	3679.50	57774.2	0.29	2.159	148812.4	1.092	0.366	2.745	1.845E-05
26	7.50	241.25	137.28	3679.50	57774.2	0.29	2.163	148877.1	1.127	0.352	2.640	1.773E-05
27	7.50	248.75	137.28	3708.80	58698.0	0.29	2.163	151248.2	1.162	0.338	2.535	1.676E-05
28	7.50	256.25	137.28	3807.40	61860.5	0.29	2.155	159269.7	1.197	0.326	2.445	1.535E-05
29	7.50	263.75	137.28	3858.00	63515.6	0.29	2.151	163465.1	1.232	0.312	2.340	1.431E-05
30	7.50	271.25	137.28	3871.00	63944.4	0.29	2.162	164756.6	1.268	0.302	2.265	1.375E-05
31	7.50	278.75	137.28	3904.70	65062.6	0.29	2.165	167693.7	1.303	0.289	2.168	1.293E-05
32	7.50	286.25	137.28	3966.70	67145.2	0.29	2.161	172975.4	1.338	0.278	2.085	1.205E-05
33	7.50	293.75	137.28	4006.00	68482.3	0.29	2.170	176588.4	1.373	0.267	2.003	1.134E-05
34	7.50	301.25	137.28	4028.50	69253.7	0.29	2.157	178340.7	1.408	0.257	1.928	1.081E-05
35	7.50	308.75	137.28	4053.00	70098.6	0.29	2.154	180454.9	1.443	0.247	1.853	1.027E-05
36	7.50	316.25	137.28	4150.90	73526.0	0.29	2.159	189375.0	1.478	0.237	1.778	9.386E-06
37	10.16	325.08	137.28	4172.90	74307.4	0.29	2.901	191066.7	1.519	0.227	2.306	1.207E-05
38	9.84	335.08	137.28	4211.80	75699.3	0.28	2.804	194521.4	1.566	0.216	2.126	1.093E-05
39	10.16	345.08	137.28	4211.20	75677.7	0.28	2.883	194313.1	1.613	0.205	2.082	1.072E-05
40	9.84	355.08	137.28	4282.70	78269.3	0.28	2.786	200850.0	1.659	0.197	1.939	9.654E-06
41	20.00	370.00	137.28	4291.80	78602.3	0.28	5.637	201509.5	1.729	0.183	3.660	1.816E-05
42	20.00	390.00	137.28	4319.50	79620.2	0.28	5.625	204025.1	1.822	0.168	3.360	1.647E-05
43	20.00	410.00	137.28	4358.80	81075.6	0.28	5.659	208028.6	1.916	0.154	3.080	1.481E-05
44	20.00	430.00	137.28	4465.90	85108.7	0.28	5.676	218525.2	2.009	0.142	2.840	1.300E-05
45	20.00	450.00	137.28	4485.60	85861.3	0.28	5.670	220402.4	2.103	0.132	2.640	1.198E-05
						ν_a =						
Σ	460.00					0.30	137.980		Grade Basemat (0'--460')	SUM	212.084	5.299E-03
	408.00					0.29	118.353		Pool Basemat (56'--460')	SUM	162.748	1.937E-03

(a) Poisson's Ratio is from Ref. 2.2.2.
(b) E' = 2(1+ν)G'. Ref. Bowles Foundation Analysis and Design, 5th ed., p 121 (Ref. 2.2.6).
(c) From figure 5

	Grade Basemat					Pool Basemat	
Average E = SUM(q_n*h_n) / SUM(q_n*h_n/E_n) =	40022	ksf				84006	ksf
G_s = E/(2(1+ν_a)) =	15394	ksf				32558	ksf
Corresponding Vel = SQRT(32.17*G_s / γ) =	2100	ft/sec	for γ =	112.3	pcf	3054	ft/sec
	1899	ft/sec		137.3	pcf	2762	ft/sec

5E-4 Upper Bound Estimate : 100' Depth of Alluvium

Calculation of Equivalent Shear Modulus :

(C) Upper Bound Values :
Ref.: MO0801SCSPS5E4.003 for Strain Compatible Soil Properties (Ref. 2.2.2).

Using 100', Upper Bound Curve : Dynamic Shear Modulus of Soil, $G' = (\gamma /32.17$, Mass Density) x (V_s , Velocity)^2
Ref.: Bowles Foundation Analysis and Design, 5th ed., Eq (20-15), Ref. 2.2.6.

Width of Building (W) = : 214 ft (Ref. 2.2.16)

NO	LAYER THICKNESS h_n (ft) (1)	DEPTH (Z) TO CTR / LAYER (ft) (2)	DENSITY γ (pcf) (3)	SHEAR WAVE VELOCITY Vs (ft/s) (4)	DYNAMIC SHEAR MODULUS G_n (ksf) (5)	POISSON'S RATIO[(a)] ν (7)	(8)=(1)x(7)	ELASTIC MODULUS E_n (ksf)[(b)] (9)	Z / W (10)	INFLUENCE COEFF q_n[(c)] (11)	q_n*h_n (12)	q_n*h_n/E_n (13)
1	4.00	2.00	112.32	1277.00	5693.6	0.37	1.466	15560.1	0.009	0.996	3.984	2.560E-04
2	4.00	6.00	112.32	1207.40	5089.9	0.39	1.557	14143.0	0.028	0.988	3.952	2.794E-04
3	4.00	10.00	112.32	1327.40	6151.9	0.39	1.576	17150.7	0.047	0.981	3.924	2.288E-04
4	4.00	14.00	112.32	1596.00	8893.5	0.39	1.572	24778.1	0.065	0.973	3.892	1.571E-04
5	4.00	18.00	112.32	1825.20	11631.3	0.39	1.567	32377.7	0.084	0.964	3.856	1.191E-04
6	8.00	24.00	112.32	1945.20	13211.0	0.39	3.147	36814.5	0.112	0.953	7.624	2.071E-04
7	8.00	32.00	112.32	2251.00	17691.2	0.37	2.995	48628.8	0.150	0.938	7.504	1.543E-04
8	8.00	40.00	112.32	2317.20	18747.1	0.36	2.887	51026.9	0.187	0.922	7.376	1.446E-04
9	8.00	48.00	112.32	2380.20	19780.3	0.36	2.859	53699.6	0.224	0.903	7.224	1.345E-04
10	8.00	56.00	112.32	2675.20	24987.3	0.34	2.702	66850.4	0.262	0.886	7.088	1.060E-04
11	10.00	65.00	112.32	2706.90	25582.9	0.34	3.397	68548.5	0.304	0.862	8.620	1.258E-04
12	10.00	75.00	112.32	2914.00	29647.3	0.34	3.375	79308.3	0.350	0.836	8.360	1.054E-04
13	10.00	85.00	112.32	3103.10	33620.0	0.34	3.356	89803.0	0.397	0.808	8.080	8.997E-05
14	10.00	95.00	112.32	3154.90	34751.8	0.33	3.344	92742.1	0.444	0.778	7.780	8.389E-05
15	10.00	105.00	137.28	3491.30	52015.2	0.28	2.761	132753.3	0.491	0.748	7.480	5.635E-05
16	10.00	115.00	137.28	3597.00	55212.5	0.28	2.765	140956.3	0.537	0.715	7.150	5.072E-05
17	10.00	125.00	137.28	3677.90	57724.0	0.28	2.756	147263.0	0.584	0.681	6.810	4.624E-05
18	10.00	135.00	137.28	3774.80	60805.7	0.28	2.770	155301.3	0.631	0.645	6.450	4.153E-05
19	15.00	147.50	137.28	3872.10	63980.8	0.28	4.200	163792.0	0.689	0.605	9.075	5.541E-05
20	15.00	162.50	137.28	3955.60	66769.9	0.28	4.238	171267.6	0.759	0.554	8.310	4.852E-05
21	15.00	177.50	137.28	4144.50	73299.4	0.28	4.249	188122.9	0.829	0.507	7.605	4.043E-05
22	15.00	192.50	137.28	4241.60	76774.3	0.28	4.258	197136.3	0.900	0.461	6.915	3.508E-05
23	15.00	207.50	137.28	4318.20	79572.3	0.29	4.317	204944.7	0.970	0.424	6.360	3.103E-05
24	15.00	222.50	137.28	4378.70	81817.6	0.29	4.309	210641.0	1.040	0.39	5.850	2.777E-05
25	7.50	233.75	137.28	4506.40	86659.4	0.29	2.159	223213.8	1.092	0.366	2.745	1.230E-05
26	7.50	241.25	137.28	4506.40	86659.4	0.29	2.163	223310.9	1.127	0.352	2.640	1.182E-05
27	7.50	248.75	137.28	4542.30	88045.6	0.29	2.163	226869.0	1.162	0.338	2.535	1.117E-05
28	7.50	256.25	137.28	4663.10	92791.0	0.29	2.155	238905.2	1.197	0.326	2.445	1.023E-05
29	7.50	263.75	137.28	4725.10	95274.8	0.29	2.151	245201.2	1.232	0.312	2.340	9.543E-06
30	7.50	271.25	137.28	4740.90	95913.1	0.29	2.162	247125.8	1.268	0.302	2.265	9.165E-06
31	7.50	278.75	137.28	4782.20	97591.4	0.29	2.165	251534.1	1.303	0.289	2.168	8.617E-06
32	7.50	286.25	137.28	4858.20	100718.0	0.29	2.161	259463.6	1.338	0.278	2.085	8.036E-06
33	7.50	293.75	137.28	4906.30	102722.2	0.29	2.170	264879.5	1.373	0.267	2.003	7.560E-06
34	7.50	301.25	137.28	4933.90	103881.2	0.29	2.157	267512.8	1.408	0.257	1.928	7.205E-06
35	7.50	308.75	137.28	4963.90	105148.3	0.29	2.154	270683.3	1.443	0.247	1.853	6.844E-06
36	7.50	316.25	137.28	5083.80	110289.2	0.29	2.159	284063.2	1.478	0.237	1.778	6.257E-06
37	10.16	325.08	137.28	5110.80	111463.8	0.29	2.901	286607.0	1.519	0.227	2.306	8.045E-06
38	9.84	335.08	137.28	5158.40	113549.8	0.28	2.804	291784.3	1.566	0.216	2.126	7.287E-06
39	10.16	345.08	137.28	5157.70	113518.9	0.28	2.883	291475.8	1.613	0.205	2.082	7.144E-06
40	9.84	355.08	137.28	5245.30	117407.8	0.28	2.786	301284.8	1.659	0.197	1.939	6.436E-06
41	20.00	370.00	137.28	5256.40	117905.2	0.28	5.637	302268.9	1.729	0.183	3.660	1.211E-05
42	20.00	390.00	137.28	5290.30	119430.9	0.28	5.625	306039.4	1.822	0.168	3.360	1.098E-05
43	20.00	410.00	137.28	5338.40	121612.6	0.28	5.659	312040.8	1.916	0.154	3.080	9.871E-06
44	20.00	430.00	137.28	5469.50	127659.0	0.28	5.676	327777.3	2.009	0.142	2.840	8.664E-06
45	20.00	450.00	137.28	5493.80	128795.9	0.28	5.670	330613.8	2.103	0.132	2.640	7.985E-06
						ν_a =						
Σ	460.00					0.30	137.980		Grade Basemat (0'--460')	SUM	212.084	2.812E-03
	408.00					0.29	118.353		Pool Basemat (56'--460')	SUM	162.748	1.131E-03

(a) Poisson's Ratio is from Ref. 2.2.2.
(b) $E' = 2(1+\nu)G'$. Ref. Bowles Foundation Analysis and Design, 5th ed., p 121 (Ref. 2.2.6).
(c) From figure 5

	Grade Basemat						Pool Basemat	
Average $E = SUM(q_n*h_n) / SUM(q_n*h_n/E_n)$ =	75413	ksf					143846	ksf
$G_s = E/(2(1+\nu_a))$ =	29006	ksf					55751	ksf
Corresponding Vel = SQRT(32.17*G_s / γ) =	2882	ft/sec	for γ =	112.3	pcf		3996	ft/sec
	2607	ft/sec		137.3	pcf		3614	ft/sec

D.1.2 Equivalent Shear Modulus for 1E-4 annual exceedance frequency

1E-4 Lower Bound Estimate : 30' Depth of Alluvium

Calculation of Equivalent Shear Modulus :

(A) Lower Bound Values :
Ref.: MO0801SCSPS1E4.003 for Strain Compatible Soil Properties (Ref. 2.2.3).

Using 30', Lower Bound Curve : Dynamic Shear Modulus of Soil, $G' = (\gamma /32.17, \text{Mass Density}) \times (V_s , \text{Velocity})^2$
Ref.: Bowles Foundation Analysis and Design, 5th ed., Eq (20-15), Ref. 2.1.6.

Width of Building (W) = : 214 ft (Ref. 2.2.16)

NO	LAYER THICKNESS h_n (ft)	DEPTH (Z) TO CTR / LAYER (ft)	DENSITY γ (pcf)	SHEAR WAVE VELOCITY Vs (ft/s)	DYNAMIC SHEAR MODULUS G_n (ksf)	POISSON'S RATIO[a] ν		ELASTIC MODULUS E_n (ksf) [b]	Z / W	INFLUENCE COEFF q_n [c]	q_n*h_n	q_n*h_n/E_n
	(1)	(2)	(3)	(4)	(5)	(7)	(8)=(1)x(7)	(9)	(10)	(11)	(12)	(13)
1	4.00	2.00	112.32	577.59	1164.8	0.39	1.542	3227.5	0.009	0.996	3.984	1.234E-03
2	4.00	6.00	112.32	520.07	944.3	0.41	1.643	2664.5	0.028	0.988	3.952	1.483E-03
3	4.00	10.00	112.32	585.68	1197.6	0.41	1.651	3383.9	0.047	0.981	3.924	1.160E-03
4	4.00	14.00	112.32	690.36	1664.0	0.41	1.648	4699.3	0.065	0.973	3.892	8.282E-04
5	4.00	18.00	112.32	713.83	1779.1	0.41	1.657	5032.1	0.084	0.964	3.856	7.663E-04
6	8.00	24.00	112.32	742.24	1923.5	0.42	3.333	5449.8	0.112	0.953	7.624	1.399E-03
7	2.00	29.00	112.32	982.13	3367.8	0.39	0.789	9392.7	0.136	0.944	1.889	2.011E-04
8	10.00	35.00	137.28	1681.30	12062.8	0.29	2.909	31143.6	0.164	0.932	9.320	2.993E-04
9	10.00	45.00	137.28	1989.20	16885.5	0.29	2.865	43444.6	0.210	0.911	9.110	2.097E-04
10	10.00	55.00	137.28	2105.80	18923.0	0.28	2.811	48482.7	0.257	0.876	8.760	1.807E-04
11	10.00	65.00	137.28	2182.20	20321.0	0.28	2.809	52058.8	0.304	0.862	8.620	1.656E-04
12	10.00	75.00	137.28	2280.90	22200.8	0.28	2.763	56668.0	0.350	0.836	8.360	1.475E-04
13	10.00	85.00	137.28	2384.90	24271.5	0.28	2.786	62069.0	0.397	0.808	8.080	1.302E-04
14	10.00	95.00	137.28	2437.50	25353.9	0.28	2.814	64974.5	0.444	0.778	7.780	1.197E-04
15	10.00	105.00	137.28	2480.90	26264.8	0.28	2.839	67443.4	0.491	0.748	7.480	1.109E-04
16	10.00	115.00	137.28	2550.80	27765.7	0.28	2.846	71334.0	0.537	0.715	7.150	1.002E-04
17	10.00	125.00	137.28	2581.80	28444.7	0.28	2.831	72992.5	0.584	0.681	6.810	9.330E-05
18	10.00	135.00	137.28	2619.30	29277.0	0.28	2.846	75219.7	0.631	0.645	6.450	8.575E-05
19	15.00	147.50	137.28	2650.90	29987.7	0.29	4.316	77231.5	0.689	0.605	9.075	1.175E-04
20	15.00	162.50	137.28	2780.70	32996.2	0.29	4.342	85093.3	0.759	0.554	8.310	9.766E-05
21	15.00	177.50	137.28	2835.00	34297.5	0.29	4.358	88525.3	0.829	0.507	7.605	8.591E-05
22	15.00	192.50	137.28	2856.10	34809.9	0.29	4.372	89912.6	0.900	0.461	6.915	7.691E-05
23	15.00	207.50	137.28	2865.50	35039.4	0.30	4.433	90788.6	0.970	0.424	6.360	7.005E-05
24	15.00	222.50	137.28	2912.40	36195.8	0.30	4.426	93751.5	1.040	0.39	5.850	6.240E-05
25	7.50	233.75	137.28	2947.40	37071.0	0.30	2.219	96079.1	1.092	0.366	2.745	2.857E-05
26	7.50	241.25	137.28	2944.50	36998.1	0.30	2.224	95939.8	1.127	0.352	2.640	2.752E-05
27	7.50	248.75	137.28	2951.70	37179.3	0.30	2.225	96415.5	1.162	0.338	2.535	2.629E-05
28	7.50	256.25	137.28	2975.30	37776.2	0.30	2.214	97855.3	1.197	0.326	2.445	2.499E-05
29	7.50	263.75	137.28	3029.50	39165.0	0.29	2.209	101404.4	1.232	0.312	2.340	2.308E-05
30	7.50	271.25	137.28	3041.30	39470.7	0.30	2.220	102310.4	1.268	0.302	2.265	2.214E-05
31	7.50	278.75	137.28	3070.50	40232.3	0.30	2.223	104313.4	1.303	0.289	2.168	2.078E-05
32	7.50	286.25	137.28	3104.20	41120.2	0.30	2.218	106563.1	1.338	0.278	2.085	1.957E-05
33	7.50	293.75	137.28	3115.70	41425.5	0.30	2.228	107465.1	1.373	0.267	2.003	1.863E-05
34	7.50	301.25	137.28	3137.00	41993.8	0.30	2.216	108804.3	1.408	0.257	1.928	1.772E-05
35	7.50	308.75	137.28	3163.30	42700.9	0.29	2.212	110590.2	1.443	0.247	1.853	1.675E-05
36	7.50	316.25	137.28	3196.10	43591.0	0.30	2.218	112964.4	1.478	0.237	1.778	1.574E-05
37	10.16	325.08	137.28	3193.40	43517.4	0.29	2.985	112609.1	1.519	0.227	2.306	2.047E-05
38	9.84	335.08	137.28	3249.00	45045.9	0.29	2.883	116478.9	1.566	0.216	2.126	1.825E-05
39	10.16	345.08	137.28	3259.30	45332.0	0.29	2.965	117131.5	1.613	0.205	2.082	1.778E-05
40	9.84	355.08	137.28	3302.30	46536.0	0.29	2.866	120170.9	1.659	0.197	1.939	1.614E-05
41	20.00	370.00	137.28	3378.30	48702.7	0.29	5.791	125609.0	1.729	0.183	3.660	2.914E-05
42	20.00	390.00	137.28	3383.10	48841.1	0.29	5.783	125928.1	1.822	0.168	3.360	2.668E-05
43	20.00	410.00	137.28	3432.30	50272.1	0.29	5.813	129765.3	1.916	0.154	3.080	2.374E-05
44	20.00	430.00	137.28	3561.00	54112.8	0.29	5.822	139728.0	2.009	0.142	2.840	2.033E-05
45	20.00	450.00	137.28	3620.30	55930.1	0.29	5.814	144375.6	2.103	0.132	2.640	1.829E-05
						ν_a =						
Σ	460.00					0.30	136.974	Grade Basemat (0'--460')		SUM	211.971	9.678E-03
	410.00					0.29	118.938	Pool Basemat (55'--460')		SUM	164.420	2.097E-03

(a) Poisson's Ratio is from Ref. 2.2.3.
(b) $E' = 2(1+\nu)G'$. Ref. Bowles Foundation Analysis and Design, 5th ed., p 121 (Ref. 2.2.6).
(c) From figure 5

	Grade Basemat					Pool Basemat	
Average $E = SUM(q_n*h_n) / SUM(q_n*h_n/E_n)$ =	21903	ksf				78412	ksf
$G_s = E/(2(1+\nu_a))$ =	8439	ksf				30390	ksf
Corresponding Vel = $SQRT(32.17*G_s / \gamma)$ =	1555	ft/sec	for γ =	112.3	pcf	2950	ft/sec
	1406	ft/sec		137.3	pcf	2669	ft/sec

1E-4 Median Estimate : 30' Depth of Alluvium

Calculation of Equivalent Shear Modulus :

(B) Median Values :
Ref.: MO0801SCSPS1E4.003 for Strain Compatible Soil Properties (Ref. 2.2.3).

Using 30', Median Curve : Dynamic Shear Modulus of Soil, G' = (γ /32.17, Mass Density) x (V_s , Velocity)^2
Ref.: Bowles Foundation Analysis and Design, 5th ed., Eq (20-15), Ref. 2.2.6.

Width of Building (W) = : 214 ft (Ref. 2.2.16)

NO	LAYER THICKNESS h_n (ft)	DEPTH (Z) TO CTR / LAYER (ft)	DENSITY γ (pcf)	SHEAR WAVE VELOCITY Vs (ft/s)	DYNAMIC SHEAR MODULUS G_n (ksf)	POISSON'S RATIO[a] ν		ELASTIC MODULUS E_n (ksf) [b]	Z / W	INFLUENCE COEFF q_n [c]	q_n*h_n	q_n*h_n/ E_n
	(1)	(2)	(3)	(4)	(5)	(7)	(8)=(1)x(7)	(9)	(10)	(11)	(12)	(13)
1	4.00	2.00	112.32	816.84	2329.6	0.39	1.542	6455.2	0.009	0.996	3.984	6.172E-04
2	4.00	6.00	112.32	735.49	1888.7	0.41	1.643	5329.0	0.028	0.988	3.952	7.416E-04
3	4.00	10.00	112.32	828.28	2395.3	0.41	1.651	6767.8	0.047	0.981	3.924	5.798E-04
4	4.00	14.00	112.32	976.32	3328.1	0.41	1.648	9398.8	0.065	0.973	3.892	4.141E-04
5	4.00	18.00	112.32	1009.50	3558.1	0.41	1.657	10064.1	0.084	0.964	3.856	3.831E-04
6	8.00	24.00	112.32	1049.70	3847.1	0.42	3.333	10899.8	0.112	0.953	7.624	6.995E-04
7	2.00	29.00	112.32	1388.90	6735.2	0.39	0.789	18784.2	0.136	0.944	1.889	1.006E-04
8	10.00	35.00	137.28	2200.80	20668.9	0.29	2.909	53363.0	0.164	0.932	9.320	1.747E-04
9	10.00	45.00	137.28	2456.90	25759.1	0.29	2.865	66275.7	0.210	0.911	9.110	1.375E-04
10	10.00	55.00	137.28	2579.10	28385.2	0.28	2.811	72725.8	0.257	0.876	8.760	1.205E-04
11	10.00	65.00	137.28	2672.60	30480.6	0.28	2.809	78085.9	0.304	0.862	8.620	1.104E-04
12	10.00	75.00	137.28	2814.10	33793.7	0.28	2.763	86259.0	0.350	0.836	8.360	9.692E-05
13	10.00	85.00	137.28	2932.50	36697.1	0.28	2.786	93844.9	0.397	0.808	8.080	8.610E-05
14	10.00	95.00	137.28	2994.40	38262.7	0.28	2.814	98055.9	0.444	0.778	7.780	7.934E-05
15	10.00	105.00	137.28	3076.60	40392.3	0.28	2.839	103720.1	0.491	0.748	7.480	7.212E-05
16	10.00	115.00	137.28	3147.90	42286.1	0.28	2.846	108639.0	0.537	0.715	7.150	6.581E-05
17	10.00	125.00	137.28	3168.90	42852.2	0.28	2.831	109963.9	0.584	0.681	6.810	6.193E-05
18	10.00	135.00	137.28	3208.00	43916.2	0.28	2.846	112831.3	0.631	0.645	6.450	5.716E-05
19	15.00	147.50	137.28	3246.70	44982.2	0.29	4.316	115848.9	0.689	0.605	9.075	7.833E-05
20	15.00	162.50	137.28	3405.60	49493.0	0.29	4.342	127636.4	0.759	0.554	8.310	6.511E-05
21	15.00	177.50	137.28	3472.20	51447.7	0.29	4.358	132791.6	0.829	0.507	7.605	5.727E-05
22	15.00	192.50	137.28	3498.00	52215.1	0.29	4.372	134869.4	0.900	0.461	6.915	5.127E-05
23	15.00	207.50	137.28	3509.50	52559.0	0.30	4.433	136182.3	0.970	0.424	6.360	4.670E-05
24	15.00	222.50	137.28	3566.90	54292.3	0.30	4.426	140623.5	1.040	0.39	5.850	4.160E-05
25	7.50	233.75	137.28	3609.80	55606.1	0.30	2.219	144117.7	1.092	0.366	2.745	1.905E-05
26	7.50	241.25	137.28	3606.20	55495.3	0.30	2.224	143904.7	1.127	0.352	2.640	1.835E-05
27	7.50	248.75	137.28	3615.10	55769.5	0.30	2.225	144624.8	1.162	0.338	2.535	1.753E-05
28	7.50	256.25	137.28	3644.00	56664.7	0.30	2.214	146784.4	1.197	0.326	2.445	1.666E-05
29	7.50	263.75	137.28	3710.40	58748.6	0.29	2.209	152109.6	1.232	0.312	2.340	1.538E-05
30	7.50	271.25	137.28	3724.80	59205.5	0.30	2.220	153464.2	1.268	0.302	2.265	1.476E-05
31	7.50	278.75	137.28	3760.60	60349.1	0.30	2.223	156471.8	1.303	0.289	2.168	1.385E-05
32	7.50	286.25	137.28	3801.80	61678.6	0.30	2.218	159840.2	1.338	0.278	2.085	1.304E-05
33	7.50	293.75	137.28	3815.90	62137.0	0.30	2.228	161194.5	1.373	0.267	2.003	1.242E-05
34	7.50	301.25	137.28	3842.00	62989.9	0.30	2.216	163204.3	1.408	0.257	1.928	1.181E-05
35	7.50	308.75	137.28	3874.20	64050.2	0.29	2.212	165882.3	1.443	0.247	1.853	1.117E-05
36	7.50	316.25	137.28	3914.40	65386.3	0.30	2.218	169445.9	1.478	0.237	1.778	1.049E-05
37	10.16	325.08	137.28	3911.10	65276.1	0.29	2.985	168913.6	1.519	0.227	2.306	1.365E-05
38	9.84	335.08	137.28	3979.20	67569.0	0.29	2.883	174718.7	1.566	0.216	2.126	1.217E-05
39	10.16	345.08	137.28	3991.80	67997.6	0.29	2.965	175696.3	1.613	0.205	2.082	1.185E-05
40	9.84	355.08	137.28	4044.50	69804.9	0.29	2.866	180258.6	1.659	0.197	1.939	1.076E-05
41	20.00	370.00	137.28	4137.50	73052.0	0.29	5.791	188408.5	1.729	0.183	3.660	1.943E-05
42	20.00	390.00	137.28	4143.40	73260.5	0.29	5.783	188889.0	1.822	0.168	3.360	1.779E-05
43	20.00	410.00	137.28	4203.60	75404.8	0.29	5.813	194639.4	1.916	0.154	3.080	1.582E-05
44	20.00	430.00	137.28	4361.40	81172.3	0.29	5.822	209600.0	2.009	0.142	2.840	1.355E-05
45	20.00	450.00	137.28	4433.90	83893.4	0.29	5.814	216559.2	2.103	0.132	2.640	1.219E-05
						ν_a =						
Σ	460.00					0.30	136.974		Grade Basemat (0'--460')	SUM	211.971	5.240E-03
	410.00					0.29	118.938		Pool Basemat (55'--460')	SUM	164.420	1.392E-03

(a) Poisson's Ratio is from Ref. 2.2.3.
(b) E' = 2(1+ν)G'. Ref. Bowles Foundation Analysis and Design, 5th ed., p 121 (Ref. 2.2.6).
(c) From figure 5

	Grade Basemat					Pool Basemat	
Average E = SUM(q_n*h_n) / SUM(q_n*h_n/E_n) =	40451	ksf				118099	ksf
G_s = E/(2(1+ν_a)) =	15585	ksf				45771	ksf
Corresponding Vel = SQRT(32.17*G_s / γ) =	2113	ft/sec	for γ =	112.3	pcf	3621	ft/sec
	1911	ft/sec		137.3	pcf	3275	ft/sec

1E-4 Upper Bound Estimate : 30' Depth of Alluvium

Calculation of Equivalent Shear Modulus :

(C) Upper Bound Values :
Ref.: MO0801SCSPS1E4.003 for Strain Compatible Soil Properties (Ref. 2.2.3).

Using 30', Upper Bound Curve : Dynamic Shear Modulus of Soil, G' = (γ /32.17, Mass Density) x (V_s , Velocity)^2
Ref.: Bowles Foundation Analysis and Design, 5th ed., Eq (20-15), Ref. 2.2.6.

Width of Building (W) = : 214 ft (Ref. 2.2.16)

NO	LAYER THICKNESS h_n (ft)	DEPTH (Z) TO CTR / LAYER (ft)	DENSITY γ (pcf)	SHEAR WAVE VELOCITY Vs (ft/s)	DYNAMIC SHEAR MODULUS G_n (ksf)	POISSON'S RATIO[a] ν		ELASTIC MODULUS E_n (ksf) [b]	Z / W	INFLUENCE COEFF q_n [c]	q_n*h_n	q_n*h_n/ E_n
	(1)	(2)	(3)	(4)	(5)	(7)	(8)=(1)x(7)	(9)	(10)	(11)	(12)	(13)
1	4.00	2.00	112.32	1155.20	4659.3	0.39	1.542	12910.6	0.009	0.996	3.984	3.086E-04
2	4.00	6.00	112.32	1040.10	3777.1	0.41	1.643	10657.1	0.028	0.988	3.952	3.708E-04
3	4.00	10.00	112.32	1171.40	4790.9	0.41	1.651	13536.5	0.047	0.981	3.924	2.899E-04
4	4.00	14.00	112.32	1380.70	6655.9	0.41	1.648	18796.8	0.065	0.973	3.892	2.071E-04
5	4.00	18.00	112.32	1427.70	7116.7	0.41	1.657	20129.6	0.084	0.964	3.856	1.916E-04
6	8.00	24.00	112.32	1484.50	7694.3	0.42	3.333	21799.7	0.112	0.953	7.624	3.497E-04
7	2.00	29.00	112.32	1964.30	13471.7	0.39	0.789	37572.2	0.136	0.944	1.889	5.027E-05
8	10.00	35.00	137.28	2880.60	35409.7	0.29	2.909	91420.7	0.164	0.932	9.320	1.019E-04
9	10.00	45.00	137.28	3034.70	39299.6	0.29	2.865	101113.8	0.210	0.911	9.110	9.010E-05
10	10.00	55.00	137.28	3158.70	42576.8	0.28	2.811	109086.0	0.257	0.876	8.760	8.030E-05
11	10.00	65.00	137.28	3273.30	45722.3	0.28	2.809	117132.2	0.304	0.862	8.620	7.359E-05
12	10.00	75.00	137.28	3472.10	51444.7	0.28	2.763	131313.6	0.350	0.836	8.360	6.366E-05
13	10.00	85.00	137.28	3606.00	55489.1	0.28	2.786	141901.2	0.397	0.808	8.080	5.694E-05
14	10.00	95.00	137.28	3678.60	57745.9	0.28	2.814	147985.5	0.444	0.778	7.780	5.257E-05
15	10.00	105.00	137.28	3815.30	62117.4	0.28	2.839	159506.4	0.491	0.748	7.480	4.689E-05
16	10.00	115.00	137.28	3884.70	64397.8	0.28	2.846	165447.0	0.537	0.715	7.150	4.322E-05
17	10.00	125.00	137.28	3889.60	64560.4	0.28	2.831	165669.7	0.584	0.681	6.810	4.111E-05
18	10.00	135.00	137.28	3929.00	65874.9	0.28	2.846	169248.5	0.631	0.645	6.450	3.811E-05
19	15.00	147.50	137.28	3976.40	67474.0	0.29	4.316	173775.2	0.689	0.605	9.075	5.222E-05
20	15.00	162.50	137.28	4171.00	74239.8	0.29	4.342	191455.4	0.759	0.554	8.310	4.340E-05
21	15.00	177.50	137.28	4252.50	77169.4	0.29	4.358	199181.8	0.829	0.507	7.605	3.818E-05
22	15.00	192.50	137.28	4284.20	78324.1	0.29	4.372	202308.1	0.900	0.461	6.915	3.418E-05
23	15.00	207.50	137.28	4298.30	78840.6	0.30	4.433	204279.0	0.970	0.424	6.360	3.113E-05
24	15.00	222.50	137.28	4368.50	81436.8	0.30	4.426	210931.2	1.040	0.39	5.850	2.773E-05
25	7.50	233.75	137.28	4421.10	83409.8	0.30	2.219	216178.1	1.092	0.366	2.745	1.270E-05
26	7.50	241.25	137.28	4416.70	83243.8	0.30	2.224	215859.6	1.127	0.352	2.640	1.223E-05
27	7.50	248.75	137.28	4427.60	83655.2	0.30	2.225	216939.7	1.162	0.338	2.535	1.169E-05
28	7.50	256.25	137.28	4463.00	84998.2	0.30	2.214	220179.5	1.197	0.326	2.445	1.110E-05
29	7.50	263.75	137.28	4544.30	88123.2	0.29	2.209	228165.0	1.232	0.312	2.340	1.026E-05
30	7.50	271.25	137.28	4561.90	88807.1	0.30	2.220	230193.4	1.268	0.302	2.265	9.840E-06
31	7.50	278.75	137.28	4605.80	90524.5	0.30	2.223	234710.2	1.303	0.289	2.168	9.235E-06
32	7.50	286.25	137.28	4656.30	92520.5	0.30	2.218	239767.0	1.338	0.278	2.085	8.696E-06
33	7.50	293.75	137.28	4673.60	93209.3	0.30	2.228	241801.7	1.373	0.267	2.003	8.282E-06
34	7.50	301.25	137.28	4705.50	94486.1	0.30	2.216	244809.6	1.408	0.257	1.928	7.873E-06
35	7.50	308.75	137.28	4744.90	96075.0	0.29	2.212	248822.7	1.443	0.247	1.853	7.445E-06
36	7.50	316.25	137.28	4794.10	98077.7	0.30	2.218	254164.5	1.478	0.237	1.778	6.994E-06
37	10.16	325.08	137.28	4790.00	97910.0	0.29	2.985	253359.9	1.519	0.227	2.306	9.100E-06
38	9.84	335.08	137.28	4873.50	101353.4	0.29	2.883	262077.5	1.566	0.216	2.126	8.112E-06
39	10.16	345.08	137.28	4888.90	101994.9	0.29	2.965	263540.6	1.613	0.205	2.082	7.901E-06
40	9.84	355.08	137.28	4953.50	104708.2	0.29	2.866	270390.0	1.659	0.197	1.939	7.171E-06
41	20.00	370.00	137.28	5067.40	109578.8	0.29	5.791	282614.7	1.729	0.183	3.660	1.295E-05
42	20.00	390.00	137.28	5074.70	109894.8	0.29	5.783	283343.8	1.822	0.168	3.360	1.186E-05
43	20.00	410.00	137.28	5148.40	113109.9	0.29	5.813	291966.2	1.916	0.154	3.080	1.055E-05
44	20.00	430.00	137.28	5341.60	121758.4	0.29	5.822	314399.7	2.009	0.142	2.840	9.033E-06
45	20.00	450.00	137.28	5430.40	125840.3	0.29	5.814	324839.2	2.103	0.132	2.640	8.127E-06
						ν_a =						
Σ	460.00					0.30	136.974		Grade Basemat (0'--460')	SUM	211.971	2.884E-03
	410.00					0.29	118.938		Pool Basemat (55'--460')	SUM	164.420	9.244E-04

(a) Poisson's Ratio is from Ref. 2.2.3.
(b) E' = 2(1+ν)G'. Ref. Bowles Foundation Analysis and Design, 5th ed., p 121 (Ref. 2.2.6).
(c) From figure 5

	Grade Basemat					Pool Basemat	
Average E = SUM(q_n*h_n) / SUM(q_n*h_n/E_n) =	73490	ksf				177868	ksf
G_s = E/(2(1+ν_a)) =	28314	ksf				68936	ksf
Corresponding Vel = SQRT(32.17*G_s / γ) =	2848	ft/sec	for γ =	112.3	pcf	4443	ft/sec
	2576	ft/sec		137.3	pcf	4019	ft/sec

1E-4 Lower Bound Estimate : 100' Depth of Alluvium

Calculation of Equivalent Shear Modulus :

(A) Lower Bound Values :
Ref.: MO0801SCSPS1E4.003 for Strain Compatible Soil Properties (Ref. 2.2.3).

Using 100', Lower Bound Curve : Dynamic Shear Modulus of Soil, G' = (γ /32.17, Mass Density) x (V_s , Velocity)^2
Ref.: Bowles Foundation Analysis and Design, 5th ed., Eq (20-15), Ref. 2.2.6.

Width of Building (W) = : 214 ft (Ref. 2.2.16)

NO	LAYER THICKNESS h_n (ft)	DEPTH (Z) TO CTR / LAYER (ft)	DENSITY γ (pcf)	SHEAR WAVE VELOCITY Vs (ft/s)	DYNAMIC SHEAR MODULUS G_n (ksf)	POISSON'S RATIO[a] ν		ELASTIC MODULUS E_n (ksf) [b]	Z / W	INFLUENCE COEFF q_n [c]	q_n*h_n	q_n*h_n/ E_n
	(1)	(2)	(3)	(4)	(5)	(7)	(8)=(1)x(7)	(9)	(10)	(11)	(12)	(13)
1	4.00	2.00	112.32	578.18	1167.2	0.38	1.535	3230.3	0.009	0.996	3.984	1.233E-03
2	4.00	6.00	112.32	510.45	909.7	0.41	1.655	2572.2	0.028	0.988	3.952	1.536E-03
3	4.00	10.00	112.32	549.26	1053.3	0.42	1.677	2989.9	0.047	0.981	3.924	1.312E-03
4	4.00	14.00	112.32	617.00	1329.2	0.42	1.673	3770.4	0.065	0.973	3.892	1.032E-03
5	4.00	18.00	112.32	699.07	1706.3	0.42	1.668	4835.4	0.084	0.964	3.856	7.975E-04
6	8.00	24.00	112.32	746.58	1946.1	0.42	3.350	5522.1	0.112	0.953	7.624	1.381E-03
7	8.00	32.00	112.32	864.76	2610.9	0.41	3.242	7337.9	0.150	0.938	7.504	1.023E-03
8	8.00	40.00	112.32	861.89	2593.6	0.40	3.175	7246.1	0.187	0.922	7.376	1.018E-03
9	8.00	48.00	112.32	865.17	2613.4	0.40	3.165	7294.7	0.224	0.903	7.224	9.903E-04
10	8.00	56.00	112.32	1076.40	4045.3	0.38	3.037	11161.9	0.262	0.886	7.088	6.350E-04
11	10.00	65.00	112.32	1072.30	4014.6	0.38	3.825	11100.5	0.304	0.862	8.620	7.765E-04
12	10.00	75.00	112.32	1162.70	4720.0	0.38	3.802	13028.6	0.350	0.836	8.360	6.417E-04
13	10.00	85.00	112.32	1249.80	5453.6	0.38	3.780	15030.4	0.397	0.808	8.080	5.376E-04
14	10.00	95.00	112.32	1321.50	6097.3	0.38	3.771	16793.7	0.444	0.778	7.780	4.633E-04
15	10.00	105.00	137.28	2294.10	22458.5	0.28	2.841	57678.4	0.491	0.748	7.480	1.297E-04
16	10.00	115.00	137.28	2362.60	23819.7	0.28	2.846	61197.1	0.537	0.715	7.150	1.168E-04
17	10.00	125.00	137.28	2421.50	25022.2	0.28	2.827	64191.9	0.584	0.681	6.810	1.061E-04
18	10.00	135.00	137.28	2484.50	26341.1	0.28	2.843	67657.2	0.631	0.645	6.450	9.533E-05
19	15.00	147.50	137.28	2547.40	27691.8	0.29	4.309	71291.9	0.689	0.605	9.075	1.273E-04
20	15.00	162.50	137.28	2600.90	28867.1	0.29	4.348	74470.3	0.759	0.554	8.310	1.116E-04
21	15.00	177.50	137.28	2726.70	31727.1	0.29	4.356	81880.8	0.829	0.507	7.605	9.288E-05
22	15.00	192.50	137.28	2790.00	33217.3	0.29	4.366	85771.8	0.900	0.461	6.915	8.062E-05
23	15.00	207.50	137.28	2839.20	34399.2	0.30	4.425	89094.6	0.970	0.424	6.360	7.138E-05
24	15.00	222.50	137.28	2878.10	35348.3	0.29	4.420	91527.2	1.040	0.39	5.850	6.392E-05
25	7.50	233.75	137.28	2963.10	37467.0	0.30	2.213	97047.0	1.092	0.366	2.745	2.829E-05
26	7.50	241.25	137.28	2962.30	37446.8	0.30	2.218	97044.8	1.127	0.352	2.640	2.720E-05
27	7.50	248.75	137.28	2985.60	38038.2	0.30	2.218	98574.4	1.162	0.338	2.535	2.572E-05
28	7.50	256.25	137.28	3070.40	40229.6	0.29	2.205	104117.5	1.197	0.326	2.445	2.348E-05
29	7.50	263.75	137.28	3111.40	41311.2	0.29	2.201	106872.9	1.232	0.312	2.340	2.190E-05
30	7.50	271.25	137.28	3121.30	41574.5	0.29	2.212	107677.2	1.268	0.302	2.265	2.104E-05
31	7.50	278.75	137.28	3148.30	42296.9	0.30	2.216	109584.5	1.303	0.289	2.168	1.978E-05
32	7.50	286.25	137.28	3199.10	43672.9	0.29	2.210	113087.4	1.338	0.278	2.085	1.844E-05
33	7.50	293.75	137.28	3231.10	44551.0	0.30	2.219	115463.6	1.373	0.267	2.003	1.734E-05
34	7.50	301.25	137.28	3249.20	45051.5	0.29	2.207	116613.1	1.408	0.257	1.928	1.653E-05
35	7.50	308.75	137.28	3268.80	45596.6	0.29	2.204	117987.7	1.443	0.247	1.853	1.570E-05
36	7.50	316.25	137.28	3349.00	47861.5	0.29	2.207	123889.5	1.478	0.237	1.778	1.435E-05
37	10.16	325.08	137.28	3366.60	48365.9	0.29	2.968	124996.8	1.519	0.227	2.306	1.845E-05
38	9.84	335.08	137.28	3397.90	49269.4	0.29	2.868	127255.0	1.566	0.216	2.126	1.671E-05
39	10.16	345.08	137.28	3396.70	49234.6	0.29	2.951	127078.5	1.613	0.205	2.082	1.639E-05
40	9.84	355.08	137.28	3455.30	50948.1	0.29	2.852	131417.5	1.659	0.197	1.939	1.476E-05
41	20.00	370.00	137.28	3461.80	51139.9	0.29	5.773	131802.9	1.729	0.183	3.660	2.777E-05
42	20.00	390.00	137.28	3483.40	51780.1	0.29	5.764	133407.3	1.822	0.168	3.360	2.519E-05
43	20.00	410.00	137.28	3514.20	52699.8	0.29	5.798	135956.1	1.916	0.154	3.080	2.265E-05
44	20.00	430.00	137.28	3601.00	55335.3	0.29	5.813	142837.1	2.009	0.142	2.840	1.988E-05
45	20.00	450.00	137.28	3616.00	55797.3	0.29	5.809	144005.0	2.103	0.132	2.640	1.833E-05
						$ν_a$ =						
Σ	460.00					0.31	144.062		Grade Basemat (0'--460')	SUM	212.084	1.480E-02
	408.00					0.30	122.922		Pool Basemat (56'--460')	SUM	162.748	4.480E-03

(a) Poisson's Ratio is from Ref. 2.2.3.
(b) E' = 2(1+ν)G'. Ref. Bowles Foundation Analysis and Design, 5th ed., p 121 (Ref. 2.2.6).
(c) From figure 5

	Grade Basemat					Pool Basemat	
Average E = SUM(q_n*h_n) / SUM(q_n*h_n/E_n) =	14327	ksf				36331	ksf
G_s = E/(2(1+$ν_a$)) =	5455	ksf				13960	ksf
Corresponding Vel = SQRT(32.17*G_s / γ) =	1250	ft/sec	for γ =	112.3	pcf	2000	ft/sec
	1131	ft/sec		137.3	pcf	1809	ft/sec

1E-4 Median Estimate : 100' Depth of Alluvium

Calculation of Equivalent Shear Modulus :

(B) Median Values :
Ref.: MO0801SCSPS1E4.003 for Strain Compatible Soil Properties (Ref. 2.2.3).

Using 100', Median Curve : Dynamic Shear Modulus of Soil, $G' = (\gamma /32.17$, Mass Density) x (V_s , Velocity)^2
Ref.: Bowles Foundation Analysis and Design, 5th ed., Eq (20-15), Ref. 2.2.6.

Width of Building (W) = : 214 ft (Ref. 2.2.16)

NO	LAYER THICKNESS h_n (ft)	DEPTH (Z) TO CTR / LAYER (ft)	DENSITY γ (pcf)	SHEAR WAVE VELOCITY Vs (ft/s)	DYNAMIC SHEAR MODULUS G_n (ksf)	POISSON'S RATIO[a] ν		ELASTIC MODULUS E_n (ksf) [b]	Z / W	INFLUENCE COEFF q_n [c]	q_n*h_n	q_n*h_n/E_n
	(1)	(2)	(3)	(4)	(5)	(7)	(8)=(1)x(7)	(9)	(10)	(11)	(12)	(13)
1	4.00	2.00	112.32	817.67	2334.3	0.38	1.535	6460.5	0.009	0.996	3.984	6.167E-04
2	4.00	6.00	112.32	721.88	1819.4	0.41	1.655	5144.2	0.028	0.988	3.952	7.682E-04
3	4.00	10.00	112.32	776.77	2106.6	0.42	1.677	5979.8	0.047	0.981	3.924	6.562E-04
4	4.00	14.00	112.32	872.57	2658.3	0.42	1.673	7540.9	0.065	0.973	3.892	5.161E-04
5	4.00	18.00	112.32	988.64	3412.6	0.42	1.668	9670.9	0.084	0.964	3.856	3.987E-04
6	8.00	24.00	112.32	1055.80	3892.0	0.42	3.350	11043.6	0.112	0.953	7.624	6.904E-04
7	8.00	32.00	112.32	1223.00	5222.3	0.41	3.242	14676.9	0.150	0.938	7.504	5.113E-04
8	8.00	40.00	112.32	1218.90	5187.3	0.40	3.175	14492.2	0.187	0.922	7.376	5.090E-04
9	8.00	48.00	112.32	1223.50	5226.5	0.40	3.165	14588.6	0.224	0.903	7.224	4.952E-04
10	8.00	56.00	112.32	1522.30	8091.1	0.38	3.037	22324.9	0.262	0.886	7.088	3.175E-04
11	10.00	65.00	112.32	1516.40	8028.5	0.38	3.825	22199.2	0.304	0.862	8.620	3.883E-04
12	10.00	75.00	112.32	1644.30	9439.9	0.38	3.802	26057.0	0.350	0.836	8.360	3.208E-04
13	10.00	85.00	112.32	1767.40	10906.3	0.38	3.780	30057.9	0.397	0.808	8.080	2.688E-04
14	10.00	95.00	112.32	1868.80	12193.6	0.38	3.771	33584.3	0.444	0.778	7.780	2.317E-04
15	10.00	105.00	137.28	2809.60	33685.7	0.28	2.841	86512.2	0.491	0.748	7.480	8.646E-05
16	10.00	115.00	137.28	2893.60	35730.0	0.28	2.846	91796.8	0.537	0.715	7.150	7.789E-05
17	10.00	125.00	137.28	2965.70	37532.8	0.28	2.827	96286.6	0.584	0.681	6.810	7.073E-05
18	10.00	135.00	137.28	3042.80	39509.6	0.28	2.843	101480.5	0.631	0.645	6.450	6.356E-05
19	15.00	147.50	137.28	3119.90	41537.2	0.29	4.309	106936.8	0.689	0.605	9.075	8.486E-05
20	15.00	162.50	137.28	3185.40	43299.6	0.29	4.348	111702.6	0.759	0.554	8.310	7.439E-05
21	15.00	177.50	137.28	3339.50	47590.4	0.29	4.356	122820.3	0.829	0.507	7.605	6.192E-05
22	15.00	192.50	137.28	3417.10	49827.8	0.29	4.366	128662.3	0.900	0.461	6.915	5.375E-05
23	15.00	207.50	137.28	3477.30	51598.9	0.30	4.425	133642.2	0.970	0.424	6.360	4.759E-05
24	15.00	222.50	137.28	3524.90	53021.2	0.29	4.420	137287.9	1.040	0.39	5.850	4.261E-05
25	7.50	233.75	137.28	3629.00	56199.2	0.30	2.213	145567.2	1.092	0.366	2.745	1.886E-05
26	7.50	241.25	137.28	3628.00	56168.2	0.30	2.218	145562.2	1.127	0.352	2.640	1.814E-05
27	7.50	248.75	137.28	3656.60	57057.3	0.30	2.218	147861.7	1.162	0.338	2.535	1.714E-05
28	7.50	256.25	137.28	3760.50	60345.8	0.29	2.205	156179.9	1.197	0.326	2.445	1.566E-05
29	7.50	263.75	137.28	3810.70	61967.8	0.29	2.201	160311.8	1.232	0.312	2.340	1.460E-05
30	7.50	271.25	137.28	3822.90	62365.2	0.29	2.212	161524.5	1.268	0.302	2.265	1.402E-05
31	7.50	278.75	137.28	3855.90	63446.5	0.30	2.216	164379.8	1.303	0.289	2.168	1.319E-05
32	7.50	286.25	137.28	3918.10	65509.9	0.29	2.210	169632.8	1.338	0.278	2.085	1.229E-05
33	7.50	293.75	137.28	3957.20	66824.0	0.30	2.219	173189.0	1.373	0.267	2.003	1.156E-05
34	7.50	301.25	137.28	3979.50	67579.2	0.29	2.207	174924.8	1.408	0.257	1.928	1.102E-05
35	7.50	308.75	137.28	4003.40	68393.4	0.29	2.204	176977.5	1.443	0.247	1.853	1.047E-05
36	7.50	316.25	137.28	4101.70	71793.3	0.29	2.207	185837.0	1.478	0.237	1.778	9.565E-06
37	10.16	325.08	137.28	4123.20	72547.9	0.29	2.968	187492.9	1.519	0.227	2.306	1.230E-05
38	9.84	335.08	137.28	4161.60	73905.5	0.29	2.868	190886.1	1.566	0.216	2.126	1.114E-05
39	10.16	345.08	137.28	4160.10	73852.3	0.29	2.951	190618.6	1.613	0.205	2.082	1.092E-05
40	9.84	355.08	137.28	4231.90	76423.5	0.29	2.852	197129.9	1.659	0.197	1.939	9.837E-06
41	20.00	370.00	137.28	4239.80	76709.1	0.29	5.773	197702.4	1.729	0.183	3.660	1.851E-05
42	20.00	390.00	137.28	4266.20	77667.4	0.29	5.764	200103.8	1.822	0.168	3.360	1.679E-05
43	20.00	410.00	137.28	4304.00	79049.8	0.29	5.798	203934.2	1.916	0.154	3.080	1.510E-05
44	20.00	430.00	137.28	4410.30	83002.7	0.29	5.813	214255.0	2.009	0.142	2.840	1.326E-05
45	20.00	450.00	137.28	4428.70	83696.8	0.29	5.809	216009.7	2.103	0.132	2.640	1.222E-05
						ν_a =						
Σ	460.00					0.31	144.062		Grade Basemat (0'--460')	SUM	212.084	7.639E-03
	408.00					0.30	122.922		Pool Basemat (56'--460')	SUM	162.748	2.477E-03

(a) Poisson's Ratio is from Ref. 2.2.3.
(b) $E' = 2(1+\nu)G'$. Ref. Bowles Foundation Analysis and Design, 5th ed., p 121 (Ref. 2.2.6).
(c) From figure 5

	Grade Basemat					Pool Basemat	
Average $E = SUM(q_n*h_n) / SUM(q_n*h_n/E_n)$ =	27763	ksf				65692	ksf
$G_s = E/(2(1+\nu_a))$ =	10571	ksf				25241	ksf
Corresponding Vel = $SQRT(32.17*G_s / \gamma)$ =	1740	ft/sec	for γ =	112.3	pcf	2689	ft/sec
	1574	ft/sec		137.3	pcf	2432	ft/sec

1E-4 Upper Bound Estimate : 100' Depth of Alluvium

Calculation of Equivalent Shear Modulus :

(C) Upper Bound Values :
Ref.: MO0801SCSPS1E4.003 for Strain Compatible Soil Properties (Ref. 2.2.3).

Using 100', Upper Bound Curve : Dynamic Shear Modulus of Soil, G' = (γ /32.17, Mass Density) x (V_s , Velocity)^2
Ref.: Bowles Foundation Analysis and Design, 5th ed., Eq (20-15), Ref. 2.2.6.

Width of Building (W) = : 214 ft (Ref. 2.2.16)

NO	LAYER THICKNESS h_n (ft) (1)	DEPTH (Z) TO CTR / LAYER (ft) (2)	DENSITY γ (pcf) (3)	SHEAR WAVE VELOCITY Vs (ft/s) (4)	DYNAMIC SHEAR MODULUS G_n (ksf) (5)	POISSON'S RATIO[(a)] ν (7)	(8)=(1)x(7)	ELASTIC MODULUS E_n (ksf) [(b)] (9)	Z / W (10)	INFLUENCE COEFF q_n [(c)] (11)	q_n*h_n (12)	q_n*h_n/ E_n (13)
1	4.00	2.00	112.32	1156.40	4669.0	0.38	1.535	12922.0	0.009	0.996	3.984	3.083E-04
2	4.00	6.00	112.32	1020.90	3638.9	0.41	1.655	10288.6	0.028	0.988	3.952	3.841E-04
3	4.00	10.00	112.32	1098.50	4213.1	0.42	1.677	11959.2	0.047	0.981	3.924	3.281E-04
4	4.00	14.00	112.32	1234.00	5316.6	0.42	1.673	15081.8	0.065	0.973	3.892	2.581E-04
5	4.00	18.00	112.32	1398.10	6824.7	0.42	1.668	19340.5	0.084	0.964	3.856	1.994E-04
6	8.00	24.00	112.32	1493.20	7784.7	0.42	3.350	22089.4	0.112	0.953	7.624	3.451E-04
7	8.00	32.00	112.32	1729.50	10443.5	0.41	3.242	29350.9	0.150	0.938	7.504	2.557E-04
8	8.00	40.00	112.32	1723.80	10374.8	0.40	3.175	28984.9	0.187	0.922	7.376	2.545E-04
9	8.00	48.00	112.32	1730.30	10453.2	0.40	3.165	29177.6	0.224	0.903	7.224	2.476E-04
10	8.00	56.00	112.32	2152.90	16182.8	0.38	3.037	44651.6	0.262	0.886	7.088	1.587E-04
11	10.00	65.00	112.32	2144.50	16056.8	0.38	3.825	44397.9	0.304	0.862	8.620	1.942E-04
12	10.00	75.00	112.32	2325.40	18880.0	0.38	3.802	52114.4	0.350	0.836	8.360	1.604E-04
13	10.00	85.00	112.32	2499.50	21812.8	0.38	3.780	60116.6	0.397	0.808	8.080	1.344E-04
14	10.00	95.00	112.32	2643.00	24389.4	0.38	3.771	67174.6	0.444	0.778	7.780	1.158E-04
15	10.00	105.00	137.28	3441.10	50530.2	0.28	2.841	129772.6	0.491	0.748	7.480	5.764E-05
16	10.00	115.00	137.28	3543.90	53594.4	0.28	2.846	137693.6	0.537	0.715	7.150	5.193E-05
17	10.00	125.00	137.28	3632.20	56298.4	0.28	2.827	144427.8	0.584	0.681	6.810	4.715E-05
18	10.00	135.00	137.28	3726.70	59265.9	0.28	2.843	152224.5	0.631	0.645	6.450	4.237E-05
19	15.00	147.50	137.28	3821.10	62306.5	0.29	4.309	160406.7	0.689	0.605	9.075	5.657E-05
20	15.00	162.50	137.28	3901.30	64949.4	0.29	4.348	167553.8	0.759	0.554	8.310	4.960E-05
21	15.00	177.50	137.28	4090.00	71384.3	0.29	4.356	184227.2	0.829	0.507	7.605	4.128E-05
22	15.00	192.50	137.28	4185.00	74739.0	0.29	4.366	192986.5	0.900	0.461	6.915	3.583E-05
23	15.00	207.50	137.28	4258.80	77398.2	0.30	4.425	200462.8	0.970	0.424	6.360	3.173E-05
24	15.00	222.50	137.28	4317.10	79531.7	0.29	4.420	205931.5	1.040	0.39	5.850	2.841E-05
25	7.50	233.75	137.28	4444.70	84302.6	0.30	2.213	218360.7	1.092	0.366	2.745	1.257E-05
26	7.50	241.25	137.28	4443.40	84253.3	0.30	2.218	218345.9	1.127	0.352	2.640	1.209E-05
27	7.50	248.75	137.28	4478.40	85585.9	0.30	2.218	221792.3	1.162	0.338	2.535	1.143E-05
28	7.50	256.25	137.28	4605.60	90516.7	0.29	2.205	234264.4	1.197	0.326	2.445	1.044E-05
29	7.50	263.75	137.28	4667.10	92950.2	0.29	2.201	240464.1	1.232	0.312	2.340	9.731E-06
30	7.50	271.25	137.28	4682.00	93544.7	0.29	2.212	242278.8	1.268	0.302	2.265	9.349E-06
31	7.50	278.75	137.28	4722.50	95170.0	0.30	2.216	246570.3	1.303	0.289	2.168	8.791E-06
32	7.50	286.25	137.28	4798.70	98266.0	0.29	2.210	254452.0	1.338	0.278	2.085	8.194E-06
33	7.50	293.75	137.28	4846.60	100237.6	0.30	2.219	259787.7	1.373	0.267	2.003	7.708E-06
34	7.50	301.25	137.28	4873.80	101365.8	0.29	2.207	262379.4	1.408	0.257	1.928	7.346E-06
35	7.50	308.75	137.28	4903.10	102588.3	0.29	2.204	265461.5	1.443	0.247	1.853	6.978E-06
36	7.50	316.25	137.28	5023.50	107688.4	0.29	2.207	278751.5	1.478	0.237	1.778	6.377E-06
37	10.16	325.08	137.28	5049.90	108823.3	0.29	2.968	281242.9	1.519	0.227	2.306	8.198E-06
38	9.84	335.08	137.28	5096.80	110854.0	0.29	2.868	286318.2	1.566	0.216	2.126	7.426E-06
39	10.16	345.08	137.28	5095.10	110780.1	0.29	2.951	285932.2	1.613	0.205	2.082	7.282E-06
40	9.84	355.08	137.28	5183.00	114635.4	0.29	2.852	295695.1	1.659	0.197	1.939	6.558E-06
41	20.00	370.00	137.28	5192.60	115060.4	0.29	5.773	296545.2	1.729	0.183	3.660	1.234E-05
42	20.00	390.00	137.28	5225.00	116500.8	0.29	5.764	300154.9	1.822	0.168	3.360	1.119E-05
43	20.00	410.00	137.28	5271.30	118574.6	0.29	5.798	305901.1	1.916	0.154	3.080	1.007E-05
44	20.00	430.00	137.28	5401.50	124504.5	0.29	5.813	321383.4	2.009	0.142	2.840	8.837E-06
45	20.00	450.00	137.28	5424.00	125543.9	0.29	5.809	324011.2	2.103	0.132	2.640	8.148E-06
						$ν_a$ =						
Σ	460.00					0.31	144.062		Grade Basemat (0'--460')	SUM	212.084	3.978E-03
	408.00					0.30	122.922		Pool Basemat (56'--460')	SUM	162.748	1.397E-03

(a) Poisson's Ratio is from Ref. 2.2.3.
(b) E' = 2(1+ν)G'. Ref. Bowles Foundation Analysis and Design, 5th ed., p 121 (Ref. 2.2.6).
(c) From figure 5

	Grade Basemat					Pool Basemat	
Average E = SUM(q_n*h_n) / SUM(q_n*h_n/E_n) =	53315	ksf				116491	ksf
G_s = E/(2(1+$ν_a$)) =	20300	ksf				44760	ksf
Corresponding Vel = SQRT(32.17*G_s / γ) =	2411	ft/sec	for γ =	112.3	pcf	3580	ft/sec
	2181	ft/sec		137.3	pcf	3239	ft/sec

D.1.3 RESULTS

The following calculations are summarized as below.
Soil Properties: Shear Modulus for 5E-4 & 1E-4 Annual Probablity of Exceedance (APE) are:

For Grade Basemat

	APE : 5E-4	1E-4	
G_s (ksf) =	11370	8439	**L**ower **B**ound **E**stimate for 30' alluvium, sheets D2 & D8.
	20470	15585	**M**edian **E**stimate for 30' alluvium, sheets D3 & D9.
	36167	28314	**U**pper **B**ound **E**stimate for 30' alluvium, sheets D4 & D10.
	8073	5455	**L**ower **B**ound **E**stimate for 100' alluvium, sheets D5 & D11.
	15394	10571	**M**edian **E**stimate for 100' alluvium, sheets D6 & D12.
	29006	20300	**U**pper **B**ound **E**stimate for 100' alluvium, sheets D7 & D13.

For Pool Basemat

	APE : 5E-4	1E-4
G'_s (ksf) =	31355	30390
	47062	45771
	70638	68936
	18656	13960
	32558	25241
	55751	44760

TABLE D1 : SHEAR MODULUS COMPARISION: 5x10^{-4} (Grade Basemat)

	SHEAR MODULUS G (ksf)					
	SOUTH 30' DEPTH OF ALLUVIUM			SOUTH 100' DEPTH OF ALLUVIUM		
	LOWER BOUND	MEDIAN	UPPER BOUND	LOWER BOUND	MEDIAN	UPPER BOUND
MO0706SCSPS5E4.002	11221	20198	35675	7754	14779	27865
MO0801SCSPS5E4.003 (REF: 2.2.2)	11370	20470	36167	8073	15394	29006
% CHANGE	1.33	1.35	1.38	4.11	4.16	4.09

TABLE D2 : SHEAR MODULUS COMPARISION: 5x10^{-4} (Pool Basemat)

	SHEAR MODULUS G (ksf)					
	SOUTH 30' DEPTH OF ALLUVIUM			SOUTH 100' DEPTH OF ALLUVIUM		
	LOWER BOUND	MEDIAN	UPPER BOUND	LOWER BOUND	MEDIAN	UPPER BOUND
MO0706SCSPS5E4.002	31016	46532	69809	18283	31790	54385
MO0801SCSPS5E4.003 (REF: 2.2.2)	31355	47062	70638	18656	32558	55751
% CHANGE	1.09	1.14	1.19	2.04	2.42	2.51

TABLE D3 : SHEAR MODULUS COMPARISION: 1x10^{-4} (Grade Basemat)

	SHEAR MODULUS G (ksf)					
	SOUTH 30' DEPTH OF ALLUVIUM			SOUTH 100' DEPTH OF ALLUVIUM		
	LOWER BOUND	MEDIAN	UPPER BOUND	LOWER BOUND	MEDIAN	UPPER BOUND
MO0706SCSPS1E4.002	8345	15398	27939	5262	10220	19738
MO0801SCSPS1E4.003 (REF: 2.2.3)	8439	15585	28314	5455	10571	20300
% CHANGE	1.13	1.23	1.34	3.67	3.43	2.85

TABLE D4 : SHEAR MODULUS COMPARISION: 1x10^{-4} (Pool Basemat)

	SHEAR MODULUS G (ksf)					
	SOUTH 30' DEPTH OF ALLUVIUM			SOUTH 100' DEPTH OF ALLUVIUM		
	LOWER BOUND	MEDIAN	UPPER BOUND	LOWER BOUND	MEDIAN	UPPER BOUND
MO0706SCSPS1E4.002	30108	45265	68051	13633	24950	44862
MO0801SCSPS1E4.003 (REF: 2.2.3)	30390	45771	68936	13960	25241	44760
% CHANGE	0.94	1.12	1.3	2.4	1.17	-0.23

As seen in Tables D1 through D4 the maximum % change in G and thus the corresponding % change in spring stiffness values from the qualified data compare to the superseded data used in the soil spring calculations is not more than 4.16%. The effect of this change in soil stiffness on the seismic analysis results is even less since the frequency of a system is a function of stiffness and mass given by : $f = \sqrt{k/m}$. Thus a 4.16% change in stiffness will result in a $\sqrt{1.0416}$ or 2.06% shift in frequency. Given the broad band nature of the YMP input ground spectra (Ref. 2.2.11) the effect of this 2.06% change in frequency will have a negligible impact on the computed seismic analysis results. The existing seismic analysis results based on the soil springs computed using the superseded data contained in MO0706SCSPS5E4.002 and MO0706SCSPS1E4.002 are adequate for use in the preliminary design of the Wet Handling Facility.