Attachment E

Geotechnical Investigation for WCS CISF

(347 pages)

GEOServices, LLC, Geotechnical and Materials Engineers

February 18, 2020

Waste Control Specialists, LLC
17101 Preston Road, Suite 15
Dallas, Texas 75248

ATTENTION: Mr. Ben Mason, Director of Engineering
bmason@wcstexas.com

Subject: **REPORT OF GEOTECHNICAL EXPLORATION**
Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No. 31-151247.R2

Dear Mr. Mason:

We are submitting the results of the geotechnical exploration performed for the proposed Consolidated Interim Storage Facility (CISF) in Andrews, Texas. The geotechnical exploration was performed in accordance with GEOServices' Proposal No. 13-151124Rev1 dated June 23, 2015 and authorized by you.

The following report presents our findings and recommendations for the proposed construction of the Consolidated Interim Storage Facility project. Should you have any questions regarding this report, or if we can be of any further assistance, please contact us at your convenience.

Sincerely,

GEOServices, LLC

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Submitted to:

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REPORT OF GEOTECHNICAL EXPLORATION

CONSOLIDATED INTERIM STORAGE FACILITY (CISF)

ANDREWS, TEXAS

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GEOSERVICES, LLC
PROJECT NO. 31-151247.R2

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1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this geotechnical exploration was to characterize the subsurface conditions for the design and construction of the Consolidated Interim Storage Facility (CISF) in Andrews, Texas. This report provides recommendations for general site preparation, foundation design and slab-on-grade construction.

1.2 PROJECT DESCRIPTION

The project site is located at the existing Waste Control Specialists (WCS) Andrews facility located at 9998 Highway 176 West in Andrews, Texas. The proposed construction will consist of a 200-acre storage facility. The Consolidated Interim Storage Facility (CISF) will consist of eight consolidated interim storage facilities, transfer facility (Cask Handling Building), and administration building. The scope of this exploration was limited to one of the consolidated interim storage facilities, the transfer facility, and the administration building.

Each of the consolidated interim storage facilities (CISF) are planned to be 280,000 square feet (800 feet by 350 feet) in size. We understand that each CISF will consist of a gravel pad with a number of smaller cast-in-place reinforced concrete mat foundations that will each hold 24 (3x8 array) storage casks when full loaded. The individual mat foundations measure approximately 7,425 square feet (55 feet by 135 feet). Based on the loading provided by Enercon, each of the casks will have a diameter of 11’-4” and a height of just under 19 feet. The casks will have a maximum loaded weight of 360 kips. In addition to the weight of the casks, an operational and

occupancy live load of 200 psf will be utilized. Based on the provided loading, the mats will impart a bearing pressure of 4,500 psf or less to the underlying subgrade.

The transfer facility (Cask Handling Building) is a two-bay Important to Safety (ITS) – Category B steel structure. The Cask Handling Building measures 175 feet by 193 feet in plan dimension and has a height of 72 feet. The structure will have rail access to facilitate cask unloading operations, canister transfer operations, and other maintenance activities. Two overhead bridge cranes will be utilized within the structure to facilitate rail car unloading. Based on information provided by AECOM, we understand that the foundations for the proposed cask handling building will bear at a depth of 10 to 11 feet below existing grade. Based on the loading information provided, we understand that maximum service level bearing pressure of less than 3.5 kips per square foot (ksf) are expected, while maximum limit state bearing pressures will approach 5.5 ksf.

The administration building will be traditional commercial construction and will consist of a single-story steel frame construction with a slab-on-grade. At the time this report was prepared, the administration building had not yet been designed. However, based on our experience with similar structures, we anticipate maximum column loads of less than 75 kips and maximum wall loads of 2 to 4 kips per linear foot.

The 200-acre tract of land is currently undeveloped with the exception of access roads that cross from one property to the adjacent property. Based on information obtained from internet research, site elevations range from approximately 3,505 feet Mean Sea Level (MSL) along the eastern property boundary to approximately 3,490 feet MSL along the western property boundary. Based on the provided grading plan, we anticipate average cuts and fills on the order of three feet or less will be required for this project.

1.3 SCOPE OF SERVICES

This geotechnical exploration involved a site reconnaissance, field exploration, laboratory testing, and engineering analysis. The following sections of this report present discussions of the field exploration, laboratory testing programs, site conditions, and conclusions and recommendations. Following the text of this report, figures, boring logs, and laboratory test results are provided in the appendices. Appendix A provides figures and boring logs. Appendix B provides laboratory tests performed and the results of these tests. Appendix C provides a summary table of the Site Soil Characteristics. Appendix D provides the static elastic modulus calculation. Appendix E provides the results of the on-site shear wave velocity study. Appendix F provides the seismic densification analysis calculations. Appendix G provides bearing capacity analyses and commentary. Appendix H provides the settlement analysis for the CISF pads and Cask Handling Building.

The scope of services did not include an environmental assessment for determining the presence or absence of wetlands, or hazardous or toxic materials in the soil, bedrock, surface water, subsurface water, or air, on, or below, or around this site. Any statements in this report or on the boring logs regarding odors, colors, and unusual or suspicious items or conditions are strictly for informational purposes.

2.0 EXPLORATION AND TESTING PROGRAMS

2.1 FIELD EXPLORATION

The site subsurface conditions were explored with eighteen soil test borings. The following is a breakdown of the boring layout:

STRUCTURE	Number of Borings	Boring Designation
Proposed Transfer Facility	5	TF-1 and TF-4
		TF-2, TF-3, and TF-5
CISF – Phase I	11	B-101 and B-111
		B-102 through B-110
Administration Building	2	AB-1 and AB-2

Table 1 – Boring Breakdown

The boring locations and depths were selected by GEOServices. The borings were surveyed in the field by WCS personnel. Drilling was performed between July 13th and July 21st, 2015. The soil test borings were advanced using a Cannon skid rig (air rotary) and a CME-55 track rig. The drill crew worked in general accordance with ASTM D6151 (HSA Drilling). Sampling of overburden soils was accomplished using the standard penetration test procedure (ASTM D1586). The borings were backfilled with soil cuttings prior to leaving the site.

In split–spoon sampling, a standard 2-inch O.D. split-spoon sampler is driven into the bottom of the boring with a 140 pound hammer falling a distance of 30 inches. The number of blows required to advance the sampler the last 12 inches of the standard 18 inches of total penetration

is recorded as the Standard Penetration Resistance (N-value). These N-values are indicated on the boring logs at the testing depth, and provide an indication of the relative density of granular materials and strength of cohesive materials.

2.2 LABORATORY TEST PROGRAM

Soil samples collected during drilling were transported to our laboratory for visual classification and laboratory testing. The following laboratory testing was performed on select samples to determine the various soil properties.

- <u>Atterberg Limits (ASTM D4318):</u> Three Atterberg Limits tests were performed. These tests help us to confirm our visual classifications according to the AASHTO Classification System and the Unified Soil Classification System (USCS). The plastic limit and liquid limit represent the moisture content at which a cohesive soil changes from a semi-solid to a plastic state and from a plastic state to liquid state, respectively.
- <u>Natural Moisture Content (ASTM D2216):</u> One-hundred thirty-four moisture content determinations were performed. The natural moisture content is defined as the ratio of the weight of water present in the soil to the dry weight of soil.
- <u>200 Wash Analysis (ASTM D1140):</u> Nine particle size analyses were performed. The particle size analysis is used to determine the soil classification and determine drainage properties of the material.
- <u>Resistivity of Soil (ASTM G187):</u> Four soil resistivity tests were performed. The resistivity tests provide information related to corrosive properties of soil.
- <u>Consolidated Undrained Triaxial Test (ASTM D4767):</u> Consolidated undrained triaxial tests were planned, however, undisturbed Shelby tubes were not able to be performed due to the caliche

present. This test provides data useful in determining strength and deformation properties of cohesive soils.

- Standard Proctor Moisture-Density Tests (ASTM D698): One standard Proctor test was performed on a composite soil sample. This test provides information concerning the relationship between moisture content, compaction effort, and density.
- California Bearing Ratio (CBR) Tests (ASTM D1883): One CBR test was performed on a composite soil sample. This test provides a CBR value, which is used in pavement design to represent the support of the soil subgrade.
- Consolidation (ASTM D2435): Consolidation tests were originally planned, however, undisturbed Shelby tube samples could not be obtained due to the caliche. The test results are used to evaluate the settlement potential of the clay stratum.

The test results of the laboratory testing are presented in the Soil Data Summary enclosed in Appendix B.

3.0 SITE CONDITIONS

3.1 GEOLOGIC CONDITIONS

The WCS site is located over the north-central portion of a prominent subsurface structural feature known as the Central Basin Platform. The geologic formations of concern, beneath of the WCS facility comprise, from oldest to youngest, the Triassic Dockum Group, the Cretaceous Trinity Group Antlers Formation, the Late Tertiary Ogallala Formation, the Late Tertiary/Quaternary Gatuña Formation or Cenozoic Alluvium (note that the Gatuña Formation and Cenozoic Alluvium are sometimes used interchangeably), the Pleistocene windblown sands of the Blackwater Draw Formation, Holocene windblown sands and playa deposits. A regional hard caliche pedisol, termed the Caprock caliche, developed on all pre-Quaternary formations before the Blackwater Draw sands were deposited.

3.2 SUBSURFACE CONDITIONS

3.2.1 Encountered Soils

The geologic profile for the CISF area consists of loose cover sands which overlay caliche, the Blackwater Draw, and Ogallala Formation. A combination of these materials was encountered in each of the eighteen soil test borings to auger refusal and/or boring termination depths ranging from 25 to 45 feet below the existing ground surface elevation.

Cover sands were encountered in five of the eighteen soil test borings (AB-2, B-101, B-102, B-103, TF-2, and TF-5) to depths ranging from 2.5 to 6.5 feet. These sands were generally loose to very loose in consistency. We anticipate that the cover sands will be encountered in other area

of the site as well. Clearing activities to access some of the boring locations likely removed some of the thinner layers of cover sands.

Beneath the cover sands, caliche with silty sands (SM) were encountered to auger refusal and/or boring termination depths ranging from 25 to 45 feet below the existing ground surface elevation. The N-values of the standard penetration resistance test (SPT) are used to evaluate the relative consistency or density of the subsurface soils. The N-values for the encountered soils ranged from 13 bpf to 100 blows per 1 inch of penetration, indicating a relative density of medium dense to very dense.

The natural moisture content of the sampled soils ranged from 2.5 to 9 percent. Atterberg limits testing on three selected residual samples revealed liquid limits (LL) ranging from 26 to 29 percent and each sample was non-plastic. Wash 200 tests performed on eight soil samples revealed 24 to 45 percent finer than the 200 sieve.

3.2.2 Subsurface Water

Subsurface water was not observed in any of the soil test borings either during or at the completion of drilling activities. Subsurface water levels may fluctuate due to seasonal changes in precipitation amounts or due to construction activities in the area. The groundwater information presented in this report is the information that was collected at the time of our field activities.

3.2.3 Auger Refusal Conditions

Auger refusal materials were encountered in four of the eighteen soil test borings (B-101, B-111, TF-1, and TF-4) at depths ranging from 37 to 45 feet below the existing ground surface elevation. The remaining soil test borings were terminated at a depth of 25 feet prior to encountering

refusal materials. Refusal is a designation applied to any material that cannot be penetrated by the power auger. The following table presents the auger refusal depths. Auger refusals could indicate a number of materials, however, we understand that in the CISF area the altered portion of the Ogallala Formation, or the Caprock Caliche, is horizontally present across the entire CISF footprint. The caliche is present in various stages of development (Machette, 1985) both vertically and horizontally across the CISF site. The location of the well-developed (stage 3-5) caliche at the CISF is generally indicated by auger refusal in geotechnical borings. Based on this information, it appears the auger refusal materials consisted of stage 3-5 caliche. Rock coring was beyond the scope of this exploration, so the character and continuity of the refusal materials was not determined. The following table should be reviewed for auger refusal depths:

AUGER REFUSAL DEPTHS	
Location	Refusal Depth (feet)
B-101	45
B-111	37
TF-1	40
TF-4	40

Table 2 – Auger Refusal Depths

3.2.4 General

The above subsurface description is of a generalized nature to highlight the major subsurface stratification features and material characteristics. The boring logs included in Appendix A should be reviewed for specific information at individual boring locations. The depth and thickness of the subsurface strata indicated on the test records were generalized from and interpolated between boring locations. The transition between materials will be more or less gradual than indicated and may be abrupt. Information on actual subsurface conditions exists only at the specific test locations and is relevant to the time the exploration was performed. Variations may occur and should be

expected between boring locations. The stratification lines were used for our analytical purposes and, unless specifically stated otherwise, should not be used as the basis for design or construction cost estimates.

3.2.5 Additional Provided Resources

As mentioned previously, of the eighteen borings performed for the CISF project only four of the borings encountered auger refusal. The auger refusal depths ranged from 37 to 45 feet below the ground surface (bgs). Industry standards would typically result in an extension of one or more of the borings to a greater depth. The purpose of the extension would be to obtain the soil parameters necessary for settlement analysis. In this case, shear wave surveys were performed in conjunction with the geotechnical exploration and shear wave velocities are provided to depths of 100 feet bgs. Additionally, multiple previous geotechnical investigations have been performed on the WCS property as well as shear wave testing. The historical data outlined below was utilized to extend the soil profile and engineering parameters to a depth of 600 feet. This depth satisfies general industry guidance for settlement evaluation depth. The depth of 600 feet was selected as the termination depth due to encountering the Trujillo Sandstone Layer.

The section below outlines the previous studies which were utilized to extend the soil column to a depth of 600 feet. Additional information regarding the soil column development and soil parameters obtained for use in the settlement analysis are provided in Appendices C, D and H.

<u>Provided Additional Documents:</u>

1. AECOM. (2016). Site-Specific Seismic Hazard Evaluation and Development of Seismic Design Ground Motions, WCS Centralized Interim Storage Facility Project. Dated March 18, 2016.
2. WCS. (2007). (Waste Control Specialists LLC). Application for License to Authorize Near Surface Land Disposal of Low-Level Radioactive Waste. Dated March 2007.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 SITE ASSESSMENT

The results of the subsurface exploration indicate that the site is adaptable for the proposed construction. However, as is the case with most sites, some inherent challenges are associated with this development of this site. These challenges include the presence of isolated zones of loose cover sands.

As mentioned previously, very loose to loose sands were encountered in five of the eighteen soil test borings (AB-2, B-101, B-102, B-103, TF-2, and TF-5) to depths ranging from 2.5 to 6.5 feet. While we anticipate that foundation excavations would penetrate the majority of the loose cover sands, we anticipate that some undercutting of cover sands will be required were encountered in structural and roadway areas. Where undercutting is required, the depths of undercut and replacement materials should be provided by the geotechnical engineer of record during constructions. Based on the proposed foundation loads and bearing elevations, we anticipate the undercuts can be backfilled with caliche compacted to the requirements outlined in Section 4.2.2.

4.2 SITE PREPARATION

4.2.1 Subgrade

All vegetation, organic soils, rock fragments greater than 6 inches, and other debris should be removed from the proposed construction area. The actual depth of removal should be determined by a representative of the geotechnical engineer at the time of construction.

After completion of stripping operations and any required excavations to reach planned subgrade elevation, we recommend that the subgrade be proofrolled with a fully-loaded, tandem-axle dump truck or other pneumatic-tired construction equipment of similar weight. The geotechnical engineer or his representative should observe proofrolling. Areas to receive structural soil fill should also be proofrolled prior to the placement of any fill. Based on the results of the drilling activities, very loose to loose sands were encountered in five of the 18 soil test borings (AB-2, B-101, B-102, B-103,TF-2, and TF-5) to depths ranging from 2.5 to 6.5 feet. We anticipate that these soils encountered will perform unsatisfactorily during proofrolling activities. The project budget should include a contingency for required undercutting of the upper loose soils within the proposed building footprints and roadway sections and replacement with properly compacted fill.

4.2.2 Structural Soil Fill

Characteristics of recommended fill soils and the placement and compaction criteria for fill are provided in the table on the following page. The results of our limited laboratory testing indicate that **SOME** of the on-site materials **DO** meet the criteria for reuse as structural fill. However, we recommend that the near surface silty sands NOT be reused as compacted fill. Therefore, dependent on grading requirements, some fill materials may need to be imported during grading. The grading contractor should include provisions in their bid for importing new soil materials and exporting excess materials.

The near surface fill materials consists of sands that contain more than 15 percent fines. Experience indicates these materials can be moisture sensitive and degrade rapidly under heavy rubber-tired equipment. Therefore, the contractor should be aware that if these materials will be reused as fill or are present at the subgrade level, some repairs of subgrades that degrade during the construction may be required prior to pavement construction.

Prior to initiating grading activities, samples of proposed fill soils should be submitted for Atterberg limits and moisture-density relationship determination testing (i.e., standard Proctor). This testing typically requires at least 3 to 4 days to complete. To avoid delays during grading, samples of proposed fill materials (both on-site and off-site) should be collected during site preparation activities.

SUMMARY OF RECOMMENDED FILL CRITERIA

MATERIAL TYPE	CHARACTERISTICS	COMPACTION PROCEDURES	COMPACTION CONTROL
COARSE-GRAINED SOILS (CALICHE)	▪ Maximum gravel size – 1 inch ▪ Maximum gravel content – 30 percent retained on a ¾-inch sieve ▪ Maximum allowable organic content – 5 percent by weight, but no large roots should be allowed ▪ USCS Classification SP, SC, SM	▪ Maximum loose lift thickness – 6 inches **Compaction requirement[1]:** ▪ The fill should be compacted by making multiple passes with an appropriately sized sheepsfoot roller. ▪ Compaction should be at least 95 percent of the standard Proctor maximum (ASTM D 698) **Moisture content for fill:** ▪ At time of compaction – within minus 2 and plus 2 percent of the optimum moisture content	**Building and pavement areas:** ▪ One test every 2,500 to 5,000 square feet per lift, with a minimum of two tests per lift **Trench areas:** ▪ One test every 100 linear feet per lift **Minimum requirement:** ▪ Two tests per lift ***(for preliminary planning only, our technician or engineer should determine the actual test frequency)***
[1] In addition, the fill must be stable under the influence of the compaction equipment. After the soil fill is properly placed and compacted, it will be advisable to limit the amount of heavy construction traffic on the soil subgrade.			

Table 3 – Summary of Fill Criteria

4.3 FOUNDATION AND STRUCTURAL RECOMMENDATIONS

4.3.1 Administration Building Foundations

The security and administration building will be traditional commercial construction and will consist of a single-story steel frame construction with a slab-on-grade. Foundations for the proposed construction will be supported on the underlying caliche with sand and/or properly compacted structural fill materials. The recommended preliminary allowable bearing capacity for design of the foundations is 3,000 pounds per square foot (psf) or less. A one-third increase in the allowable bearing capacity for all load conditions that include transient loads (wind, seismic, other short term loads) is permitted. The 33% increase in allowable bearing capacity (stress) can be applied to load combinations that consider transient loads in conjunction with dead loads. This increase in allowable stress cannot be applied solely to dead loads. We recommend that continuous foundations be a minimum of 18 inches wide and isolated spread footings be a minimum of 24 inches wide to reduce the possibility of a localized punching shear failure. All exterior footings should be designed to bear at least 36 inches below finished exterior grade.

Foundation excavations should be opened, the subgrade evaluated, remedial work performed, and concrete placed in an expeditious manner. Exposure to weather often reduces foundation support capabilities, thus necessitating remedial measures prior to concrete placement. It is also important that proper surface drainage be maintained both during construction (especially in terms of maintaining dry footing trenches) and after construction.

4.3.1.1 Administration Building Settlement

As mentioned previously, at the time this report was prepared the Administration Building was still being designed. Therefore detailed loading and foundations sizes were not available. Based on the conditions encountered in our borings, and the anticipated loading (maximum column loads of 75 kips or less) we anticipate that total settlements will be less 0.5 inches for the administration building. This is based on the assumption the foundations will bear in the caliche and sand matrix or newly placed structural soil fill. Once the building design is finalized these settlement calculations can be updated to include the actual foundation loads and sizes.

4.3.1.2 Slabs-on-Grade (Administration Building)

For slab-on-grade construction for the administration building, the site should be prepared as previously described. If moisture mitigation through the slab is a concern, we recommend that the subgrade be topped with a minimum 6-inch layer of crushed stone. A polyethylene vapor barrier is not required if the designer utilizes a dense graded aggregate base. If a dense aggregate base is not utilized a vapor barrier should be placed beneath the slab. The vapor barrier material should be in compliance with ASTM E 1745 and have a thickness of at least 10 mils (0.3 mm), as recommended by ACI 302.1R-04 “Guide for Concrete Floor and Slab Construction”. The vapor barrier material should be of sufficient strength and durability to resist puncture during reinforcing steel and concrete placement. Placement of the vapor barrier should be in accordance with manufacturer’s recommendations.

The subgrade should be proofrolled and approved prior to the placement of the crushed stone. Based on the conditions encountered on this site, we recommend that the floor slabs be designed using a subgrade modulus of 150 pounds per cubic inch (pci). This subgrade modulus value is for small diameter loads (i.e., a 1 foot by 1 foot plate) and should be adjusted for wider loads such as large mat foundations.

4.3.2 Transfer Facility (Cask Handling Building) Foundations

The transfer facility (Cask Handling Building) is a two-bay ITS – Category B steel structure. The Cask Handling Building measures 175 feet by 193 feet in plan dimension and has a height of 72 feet. Based on information provided by AECOM, we understand that the foundations for the proposed cask handling building will bear at a depth of 10 to 11 feet below existing grade. Foundations for the cask handling building will bear in the Caliche with Sand Matrix. The recommended allowable bearing capacity for the service level design of the foundations is 4,000 pounds per square foot (psf) or less. An allowable bearing pressure for limit state loadings of 6,000 psf can be utilized. This bearing pressure is based on a foundation bearing depth of 10 feet below grade. Should the foundation elevations be changed, the geotechnical engineer should be contacted to evaluate the bearing capacity and settlement at the new foundation elevation. Bearing capacity calculations are provided in Appendix G of this report.

4.3.2.1 Transfer Facility (Cask Handling Building) Settlement Analysis

Settlement analysis for the transfer facility was performed using the soil column outlined in Appendix D. The settlement calculation was performed utilizing Settle3 a finite difference software produced by RocScience. Settle3 allows for the input of the foundation loads for the entire footprint so that any stress overlaps between adjacent foundations can be analyzed. For the Cask Handling Building the service level loads shown on AECOM drawing WCS01-13-2001 dated December 24, 2019 were utilized for the analysis. Both a dead load sustained case and a seismic case were analyzed. The gross bearing pressures provided were used for the analysis. It should be noted that if the bearing pressure or bearing depth changes, the geotechnical engineer should be contacted to update the calculations. The results of the analysis are shown below. Detailed settlement calculations are provided in Appendix H.

Load Combination	Maximum Total Settlement
Dead (1.0D)	Less Than 0.25 inches
Seismic (1.0D + 0.7E)	Less Than 0.50 inches

Table 4 – Summary of Cask Handling Building Settlement Results

4.3.2.2 Slabs-on-Grade (Cask Handling Building)

For slab-on-grade construction for the administration building, the site should be prepared as previously described. If moisture mitigation through the slab is a concern, we recommend that the subgrade be topped with a minimum 6-inch layer of crushed stone. A polyethylene vapor barrier is not required if the designer utilizes a dense graded aggregate base. If a dense aggregate base is not utilized a vapor barrier should be placed beneath the slab. The vapor barrier material should be in compliance with ASTM E 1745 and have a thickness of at least 10 mils (0.3 mm), as recommended by ACI 302.1R-04 "Guide for Concrete Floor and Slab Construction". The vapor barrier material should be of sufficient strength and durability to resist puncture during reinforcing steel and concrete placement. Placement of the vapor barrier should be in accordance with manufacturer's recommendations.

The subgrade should be proofrolled and approved prior to the placement of the crushed stone. Based on the conditions encountered on this site, we recommend that the floor slabs be designed using a subgrade modulus of 150 pounds per cubic inch (pci). This subgrade modulus value is for small diameter loads (i.e., a 1 foot by 1 foot plate) and should be adjusted for wider loads such as large mat foundations. Once preliminary slab pressures are provided we can assist the structural engineer in adjusting the subgrade modulus values to account for wider loads. The procedure outlined in section 4.3.3.1 of this report can be utilized.

4.3.3 CISF Pad Foundations

Each of the consolidated interim storage facilities (CISF) are planned to be 280,000 square feet (800 feet by 350 feet) in size. We understand that each CISF will consist of a gravel pad with a number of smaller cast-in-place reinforced concrete mat foundations that will each hold 24 (3x8 array) storage casks when full loaded. The individual mat foundations measure approximately 7,425 square feet (55 feet by 135 feet). The concrete mat foundation will measure 36 inches in thickness and bear at a depth of 4 feet below grade. The concrete mat foundation will be based on a minimum of 12 inches of dense graded aggregate.

As mentioned previously in the site assessment, loose cover sands are prevalent beneath the CISF site to depths of up to depths of up to 7.5 feet. Where encountered, these soils will have to be undercut and replaced with properly compacted caliche or crushed stone to provide adequate support of the proposed CISF pads. Provided the recommendations in the site assessment are followed, an allowable bearing pressure of 5 ksf can be utilized for design. Bearing capacity calculations are provided in Appendix G of this report.

4.3.3.1 CISF Mat Foundation Recommendations

The CISF Pads experience a series of complex loadings due to the number of casks on the pads and the fact the casks are loaded individually onto the pads. The use of a single modulus of subgrade reaction (k_s) for a mat with a loading of this complexity will not generate realistic deflections. In order to obtain realistic deflections with the complex loading, the subgrade modulus values must be adjusted to account for wider loads. To address this issue, GEOServices has worked with the structural engineer (Enercon) to adjust the subgrade modulus through an iterative process. The process proceeded as follows:

1) The first iteration of the settlement analysis was performed using mat pressures provided by Enercon.
2) These pressures were used to develop a Settle3 model (finite difference software) with the end goal of formulating values of subgrade modulus (k). The program calculates settlements beneath the mat based on the pressures provided. The modulus values are calculated at distinct points by dividing pressure/settlement.
3) The resulting new values of subgrade modulus were then submitted to Enercon to be integrated into the GTSTRUDL analysis.
4) The next iteration combined the applied loads with a much more accurate estimate of soil response (calculate k-values) thus refining the mat pressure distribution.
5) The results of the refined GTSTRUDL analysis were then provided and used to update the pressures in the Settle3 model. The result was an updated set of subgrade modulus for the entire mat.
6) This iterative process was continued until model convergence (calculated soil modulus values and displacements did not change more than 10 percent between consecutive iterations) was achieved.

The analysis was performed on the four loading configurations shown on Figure 7-9 in Chapter 7 of the SAR. These configurations include fully loaded, quarter loaded, half loaded, and three quarter loaded. Plots showing the converged models and the subsequent subgrade modulus values are provided in Appendix H of this document.

4.3.3.2 CISF Settlement Analysis

Settlement analysis for the CISF pads was performed using the soil column outlined in Appendix D. The settlement calculation was performed utilizing Settle3 a finite difference software produced by RocScience. Settle3 allows for the input of the foundation loads for the entire footprint so that any

stress overlaps between adjacent foundations can be analyzed. For the CISF pads, the final pressures from the iterative process (designed to provide an accurate estimate of soils response beneath the mat) were utilized. For the CISF pads, a settlement distribution for each of the four loading configurations shown of Figure 7-9 in Chapter of SAR is provided. Additionally, due to the number of pads which will be installed in the CISF Area (18 total) and the spacing between pads (20 feet edge to edge) an additional case including four pads was analyzed. This analysis was performed to take into account any stress overlap between adjacent pads and provide the impacts in terms of settlement. In each instance the maximum total settlements were less than 0.75 inches. The comprehensive results of the analysis are provided in Appendix H of this document.

4.3.4 Shear Wave Testing Results

We evaluated the site seismic class of the upper 100 feet to determine the seismic site class per the criteria in Table 1613.5.2 of the International Building Code (IBC, 2006/2012). The on-site shear wave velocity was determined using the refraction micro-tremor (ReMi) method. The testing used a Seismic Source DAQ Link II 24 seismograph and 10 Hz vertical geophones. The geophones were deployed along an approximately 300-foot long linear array and spaced on approximately 26-foot centers. Once the field data was collected, a computer model was used to determine the subsurface shear wave velocity profile. The test results are attached to this report.

The attached seismic velocity model displays the shear-wave velocity profiles for the upper 100 feet. The results of the models revealed the following shear wave velocities.

Depth (feet)	Run 1 Shear Wave Velocity (feet/sec)	Run 2 Shear Wave Velocity (feet/sec)	Run 3 Shear Wave Velocity (feet/sec)	Run 4 Shear Wave Velocity (feet/sec)	Average Shear Wave Velocity (feet/sec)
0 - 5	820	1020	989	843	918
5 - 15	1107	985	978	1036	1027
15 - 25	1498	1302	1549	1432	1445
25 - 35	1498	2253	2120	1889	1940
35 - 55	2558	2731	2252	2058	2400
55 - 75	2228	1231	1417	2153	1757
75 - 100	2228	3205	3383	3322	3035

Table 5 – Summary of Shear Wave Velocity Results

The location of each of the shear wave arrays as well as the plot for each individual run is provided in Appendix E of this report.

4.3.5 Liquefaction Potential

Liquefaction occurs when soil, primarily saturated cohesionless soils, undergo a loss in strength due to monotonic, transient, or repeated disturbance that commonly occurs during a seismic event (Kramer 1996). This loss of strength occurs due to increased pore water pressures caused by an undrained condition. The increase in pore water pressure decreases the effective stress in the soil, thus reducing the soils ability to support any applied loads. For liquefaction to occur, there must be an increase in poor pressure meaning the soil must be saturated and be able to behave in an undrained condition. According to the NHI 2011 Reference Manual on LRFD Seismic Analysis and Design of Transportation Geotechnical Features and Structural Foundations, if any of the following criteria are satisfied then a significant liquefaction hazard does not exist:

- The geologic materials underlying the site are either bedrock or have very low liquefaction susceptibility according to the relative susceptibility ratings shown in the Estimated Susceptibility of Sedimentary Deposits to Liquefaction During Strong Ground Motion table presented by Youd and Perkins in 1978.
- The soils below the groundwater table at the site are one of the following
  - Clayey soils which have a clay content greater than 15%, liquid limit greater than 35%, or natural water content less than 90% of the liquid limit.
  - Sand with a minimum corrected SPT $(N_1)_{60}$ value of 30 blows/foot.
  - The water table is deeper than 50 feet below the ground surface or proposed finished grade at the site.

Since groundwater was not encountered in any of the eighteen soil test borings and given that some of the borings penetrated as deep as 45 feet below the ground surface, it can be concluded that a liquefaction hazard does not exist for the subject development.

4.3.6 Seismic Densification Analysis

While a liquefaction hazard does not exist for the subject project, there is a potential for settlement of the loose sands that exist in some areas of the CISF. According to Kramer (1996), the tendency of sands to densify when subjected to earthquake shaking is well documented and occurs very rapidly. This densification is usually completed by the end of the earthquake.

Calculations were performed to determine the magnitudes of settlements/densification that could occur during an earthquake event using the Pradel method. The calculations show that the seismic densification for the design earthquake will be negligible (on the order of 0.02 inches or less). Detailed information regarding the calculation, results, and procedure can be found in Appendix F.

4.4 LATERAL EARTH PRESSURES

At this time, we are not aware of planned retaining walls for the CISF project, however, we understand that some foundations may bear as deep as 10 to 11 feet below grade. Therefore, we are providing soil parameters and earth pressure coefficients for the materials we expect to be encountered on site as well as the potential backfill materials.

Earth Pressure Condition	Backfill Type	Unit Weight (pcf)	Friction Angle (deg.)	Earth Pressure Coefficient
Active (Ka)	Silty Sands	95	27	0.376
	Caliche	130	35	0.271
At-Rest (Ko)	Silty Sands	95	27	0.546
	Caliche	130	35	0.426
Passive (Kp)	Silty Sands	95	27	2.663
	Caliche	130	35	3.690

Table 6 – Earth Pressure Summary

Note: In each instance the earth pressure coefficients provided are unfactored.

For rigid, cast-in-place concrete walls, a friction factor of 0.45 between foundation concrete and the bearing soils may be used when evaluating friction. If a stone leveling course is utilized beneath the foundation, a friction factor of 0.55 between foundation concrete and the dense graded aggregate base may be used when evaluating friction.

5.0 CONSTRUCTION CONSIDERATIONS

5.1 EXCAVATIONS

Auger refusal materials were encountered in four of the 18 soil test borings (B-101, B-111, TF-1, and TF-4) at depths ranging from 37 to 45 feet below the existing ground surface elevation. Typically, soils penetrated by augers can be removed with conventional earthmoving equipment. However, excavation equipment varies, and field refusal conditions may vary. Some of the very dense caliche may require difficult excavation techniques such as ripping, prior to excavation.

Excavations should be sloped or shored in accordance with local, state, and federal regulations, including OSHA (29 CFR Part 1926) excavation trench safety standards. The contractor is usually solely responsible for site safety. This information is provided only as a service and under no circumstances should GEOServices be assumed to be responsible for construction site safety.

5.2 FOUNDATION CONSTRUCTION

Foundation excavations should be opened, the subgrade evaluated, remedial work performed, and concrete placed in an expeditious manner. Exposure to weather often reduces foundation support capabilities, thus necessitating remedial measures prior to concrete placement. It is also important that proper surface drainage be maintained both during construction (especially in terms of maintaining dry footing trenches) and after construction. Soil backfill for footings should be placed in accordance with the recommendations for structural fill presented herein.

Foundation subgrade observations should be performed by a GEOServices geotechnical engineer, or his qualified representative, so that the recommendations provided in this report are consistent with the site conditions encountered. A dynamic cone penetrometer (DCP) is commonly utilized to provide information that is compared to the data obtained in the geotechnical report. Where unacceptable materials are encountered, the material should be excavated to stiff, suitable soils or remediated at the geotechnical engineer's direction. Typical remedial measures consist of undercutting, overexcavation, or combinations thereof.

5.3 MOISTURE SENSITIVE SOILS

The upper fine-grained soils encountered at this site will be sensitive to disturbances caused by construction traffic and changes in moisture content. During wet weather periods, increases in the moisture content of the soil can cause significant reduction in the soil strength and support capabilities. Construction traffic patterns should be varied to prevent the degradation of previously stable subgrade.

In addition, soils which become wet may be slow to dry and thus significantly retard the progress of grading and compaction activities. It will, therefore, be advantageous to perform earthwork and foundation construction activities during dry weather. Climate data for Andrews, Texas, obtained from Weatherbase indicate in the following table the average monthly precipitation. The average amount of precipitation does not vary much throughout the year.

PRECIPITATION AVERAGES

Month	Monthly Precipitation Average (Inches)	Month	Monthly Precipitation Average (Inches)
January	0.7	July	1.9
February	0.5	August	1.5
March	0.3	September	1.5
April	0.9	October	1.8
May	2.1	November	0.4
June	1.6	December	0.6

Table 7 – Average Monthly Precipitation

5.4 DRAINAGE AND SURFACE WATER CONCERNS

To reduce the potential for undercut activities, water should not be allowed to collect in the foundation excavations, on floor slab areas, or on prepared subgrades of the construction area either during or after construction. Undercut or excavated areas should be sloped toward one corner to facilitate removal of any collected rainwater, subsurface water, or surface runoff. Positive site surface drainage should be provided to reduce infiltration of surface water around the perimeter of the buildings and beneath the floor slab. The grades should be sloped away from the buildings and surface drainage should be collected and discharged such that water is not permitted to infiltrate the backfill and floor slab areas of the buildings.

6.0 LIMITATIONS

This report has been prepared in accordance with generally accepted geotechnical engineering practice for specific application to this project. This report is for our geotechnical work only, and no environmental assessment efforts have been performed. The conclusions and recommendations contained in this report are based upon applicable standards of our practice in this geographic area at the time this report was prepared. No other warranty, express or implied, is made.

The analyses and recommendations submitted herein are based, in part, upon the data obtained from the exploration. The nature and extent of variations between the borings will not become evident until construction. We recommend that GEOServices be retained to observe the project construction in the field. GEOServices cannot accept responsibility for conditions which deviate from those described in this report if not retained to perform construction observation and testing. If variations appear evident, then we will re-evaluate the recommendations of this report. In the event that any changes in the nature, design, or location of the structures are planned, the conclusions and recommendations contained in this report will not be considered valid unless the changes are reviewed and conclusions modified or verified in writing. Also, if the scope of the project should change significantly from that described herein, these recommendations may have to be re-evaluated.

GEOServices, LLC, Geotechnical and Materials Engineers

APPENDICES

GEOServices, LLC, Geotechnical and Materials Engineers

APPENDIX A

Figures and Boring Logs

N

Notes:

1) Aerial Provided by: Google Earth Pro, (02/12/2014)

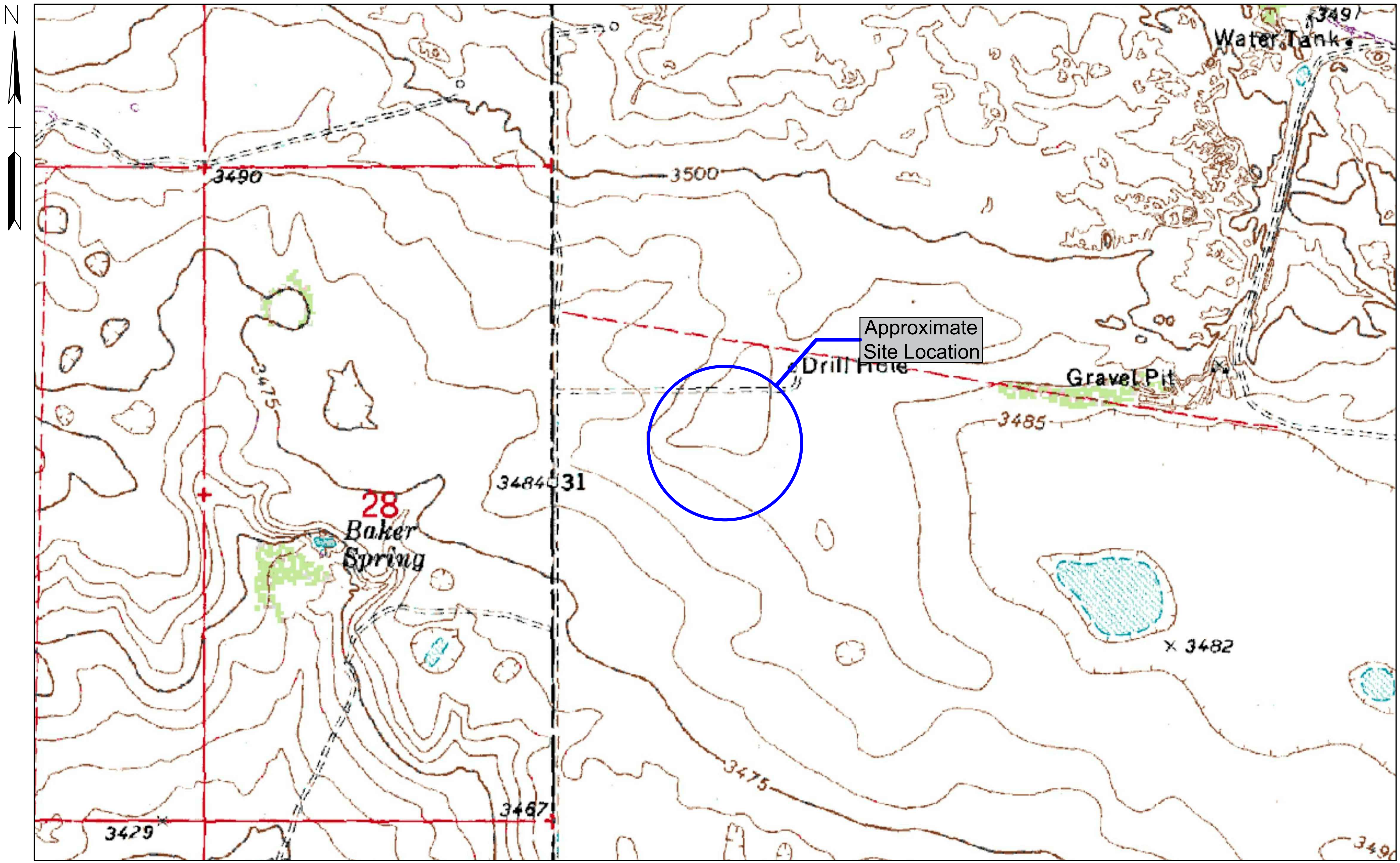
GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Site Vicinity Plan
WCS Consolidated Interim Storage Facility
WCS
Andrews, Texas

DATE:
08/10/2015

GEOS Project No.
31-151247

FIGURE:
1



Source Provided by: MYTOPO

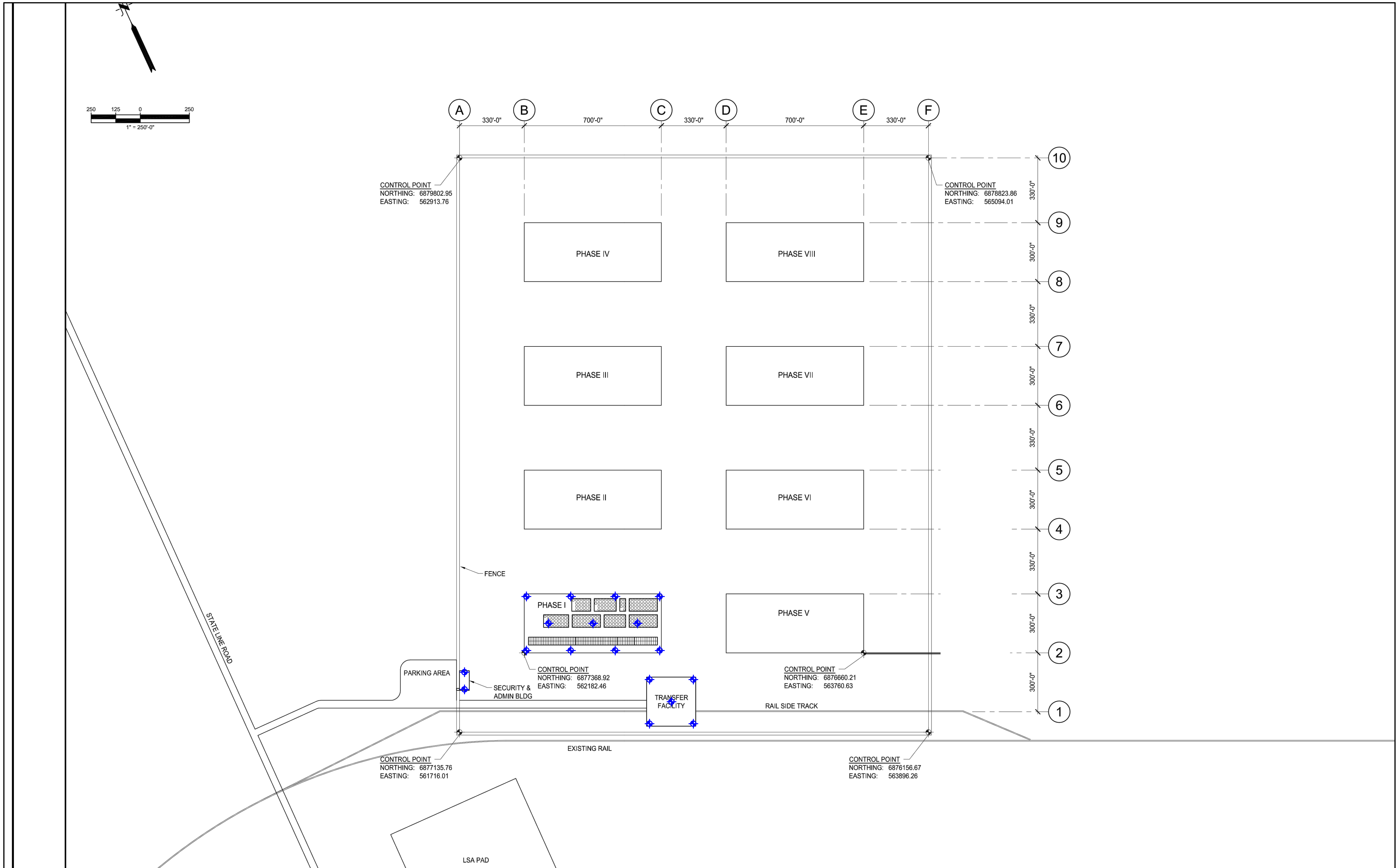
GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

USGS Site Vicinity Plan
WCS Consolidated Interim Storage Facility
WCS
Andrews, Texas

DATE:
08/10/2015

GEOS Project No.
31-151247

FIGURE:
2



Notes:

1) Site Source Provided by: WCS, (06/12/2015)
2) Boring Locations are shown in general arrangement only
3) Do Not use Boring Locations for determinations of Distance or Quantities

Boring Location & Identifier

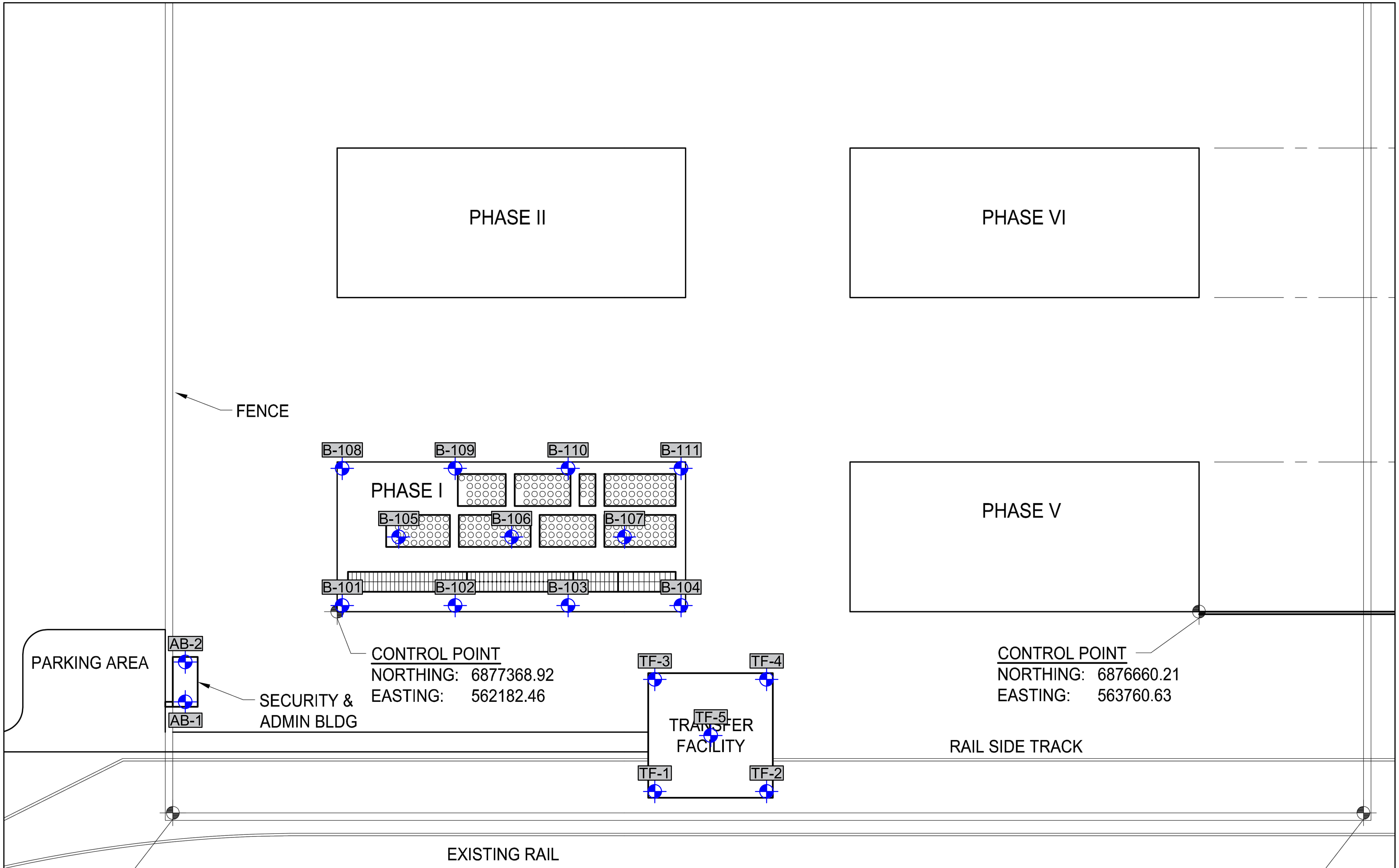
GEOServices, LLC-Geotechnical and Materials Engineers

Boring Location Plan
WCS Consolidated Interim Storage Facility
WCS
Andrews, Texas

DATE: 08/10/2015

GEOS Project No. 31-151247

FIGURE: 3



Notes:

1) Site Source Provided by: WCS, (06/12/2015)

2) Boring Locations are shown in general arrangement only

3) Do Not use Boring Locations for determinations of Distance or Quantities

Boring Location & Identifier

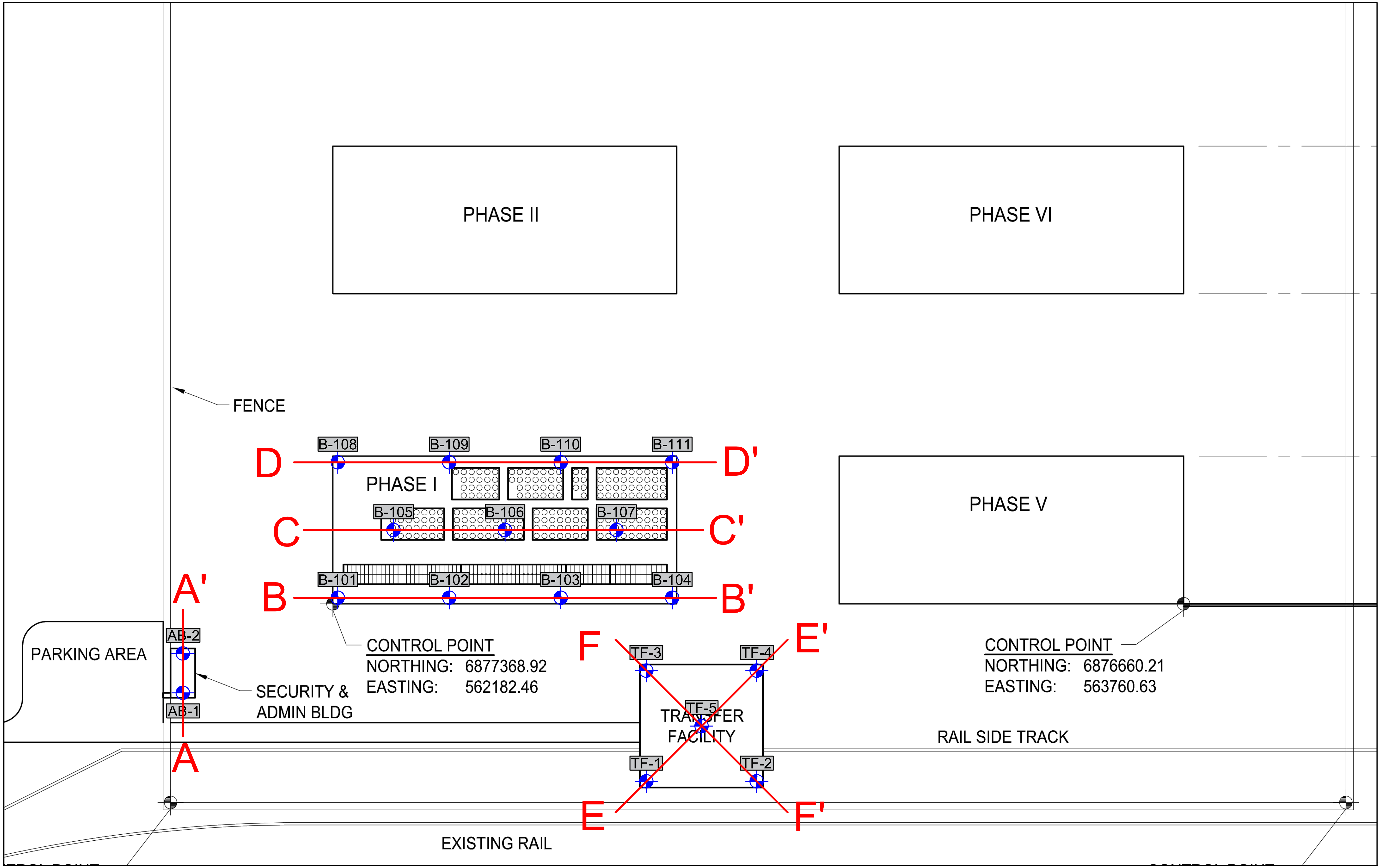
GEOServices, LLC-Geotechnical and Materials Engineers

Boring Location Plan
WCS Consolidated Interim Storage Facility
WCS
Andrews, Texas

DATE:
08/10/2015

GEOS Project No.
31-151247

FIGURE:
4



GEOServices, LLC-Geotechnical and Materials Engineers

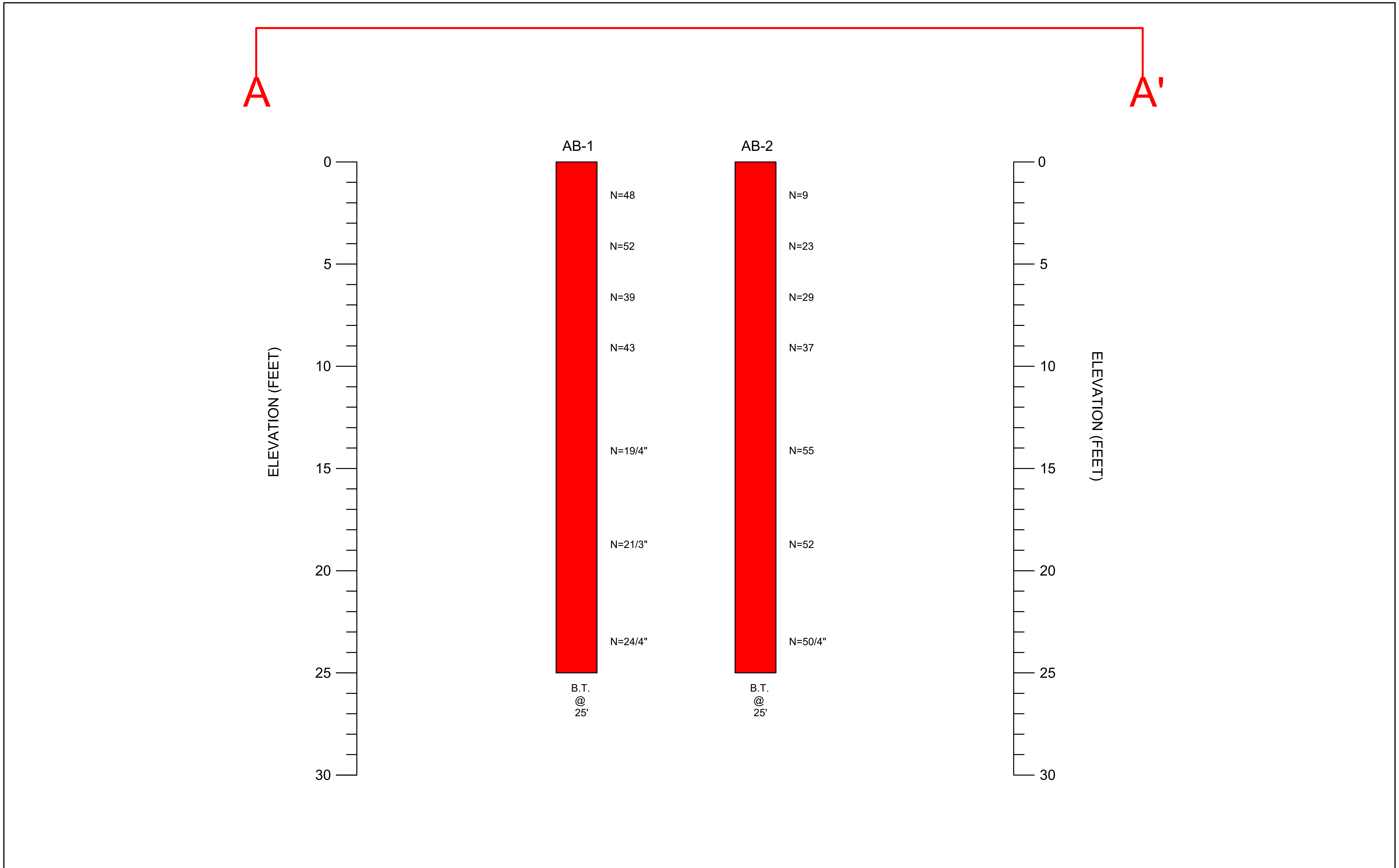
Cross Section-Location Plan
WCS Consolidated Interim Storage Facility
WCS
Andrews, Texas

Notes:
1) Site Source Provided by: WCS, (06/12/2015)
2) Boring Locations are shown in general arrangement only
3) Do Not use Boring Locations for determinations of Distance or Quantities

Boring Location & Identifier

Cross Section line (Start - End')

DATE: 08/10/2015
GEOS Project No. 31-151247
FIGURE: 5



Notes:

1) B.T. = Boring Termination
2) A.R. = Auger Refusal
3) Not To Scale

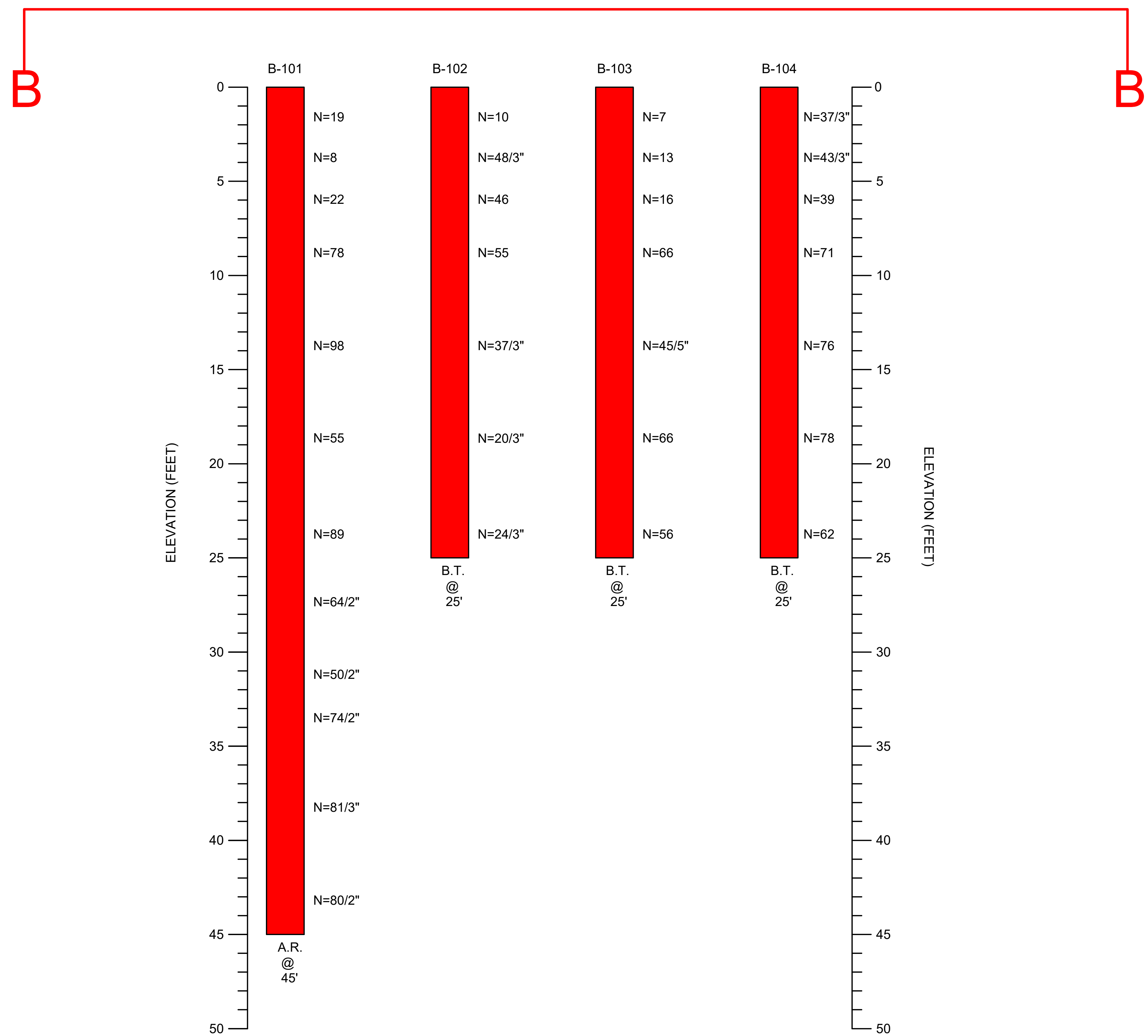
GEOServices, LLC-Geotechnical and Materials Engineers

Boring Cross-Section
WCS Consolidated Interim Storage Facility
WCS
Andrews, Texas

DATE: 08/10/2015

GEOS Project No. 31-151247

FIGURE: 6



Notes:

1) B.T. = Boring Termination
2) A.R. = Auger Refusal
3) Not To Scale

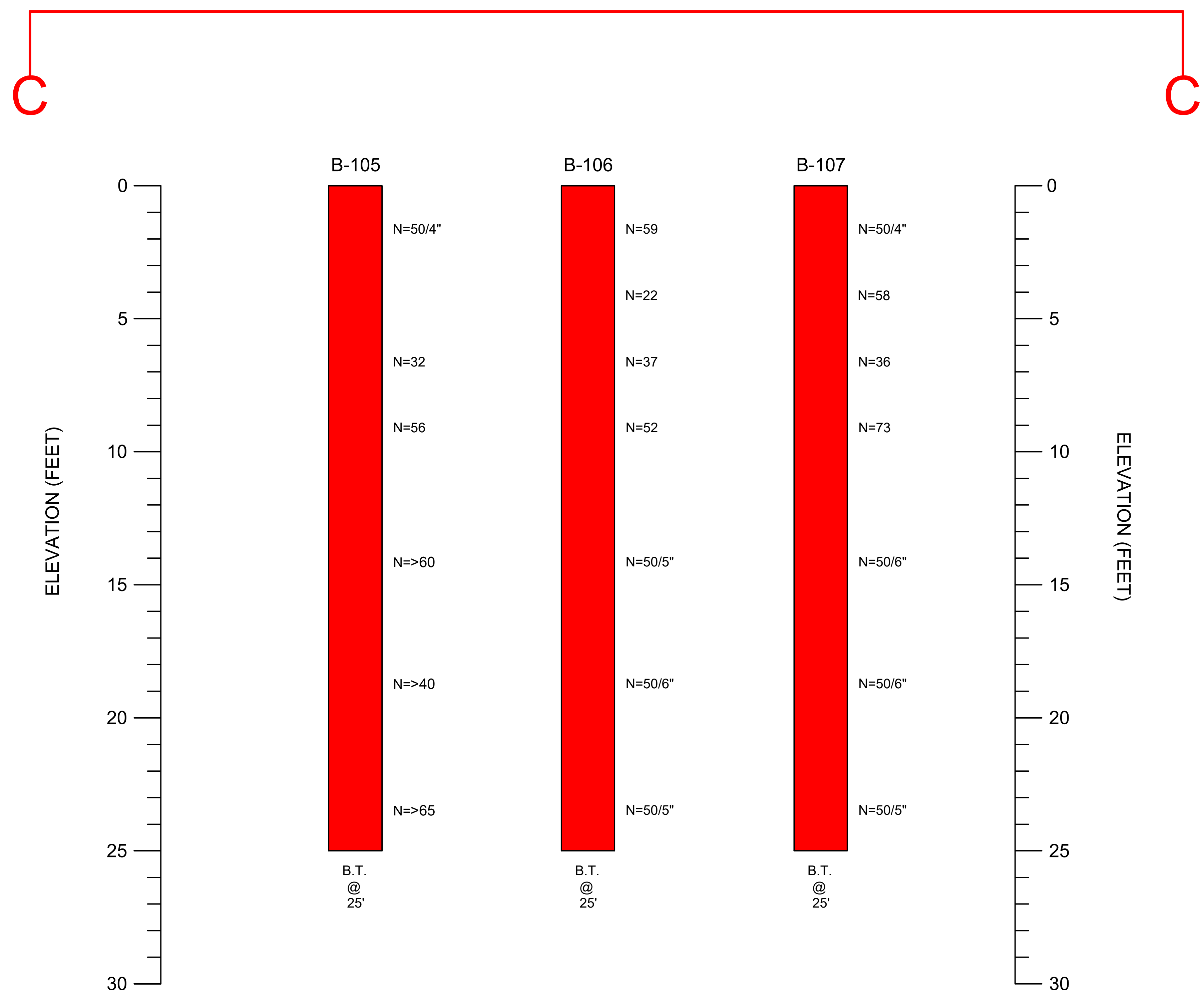
GEOServices, LLC-Geotechnical and Materials Engineers

Boring Cross-Section
WCS Consolidated Interim Storage Facility
WCS
Andrews, Texas

DATE:
08/10/2015

GEOS Project No.
31-151247

FIGURE:
7



Notes:

1) B.T. = Boring Termination
2) A.R. = Auger Refusal
3) Not To Scale

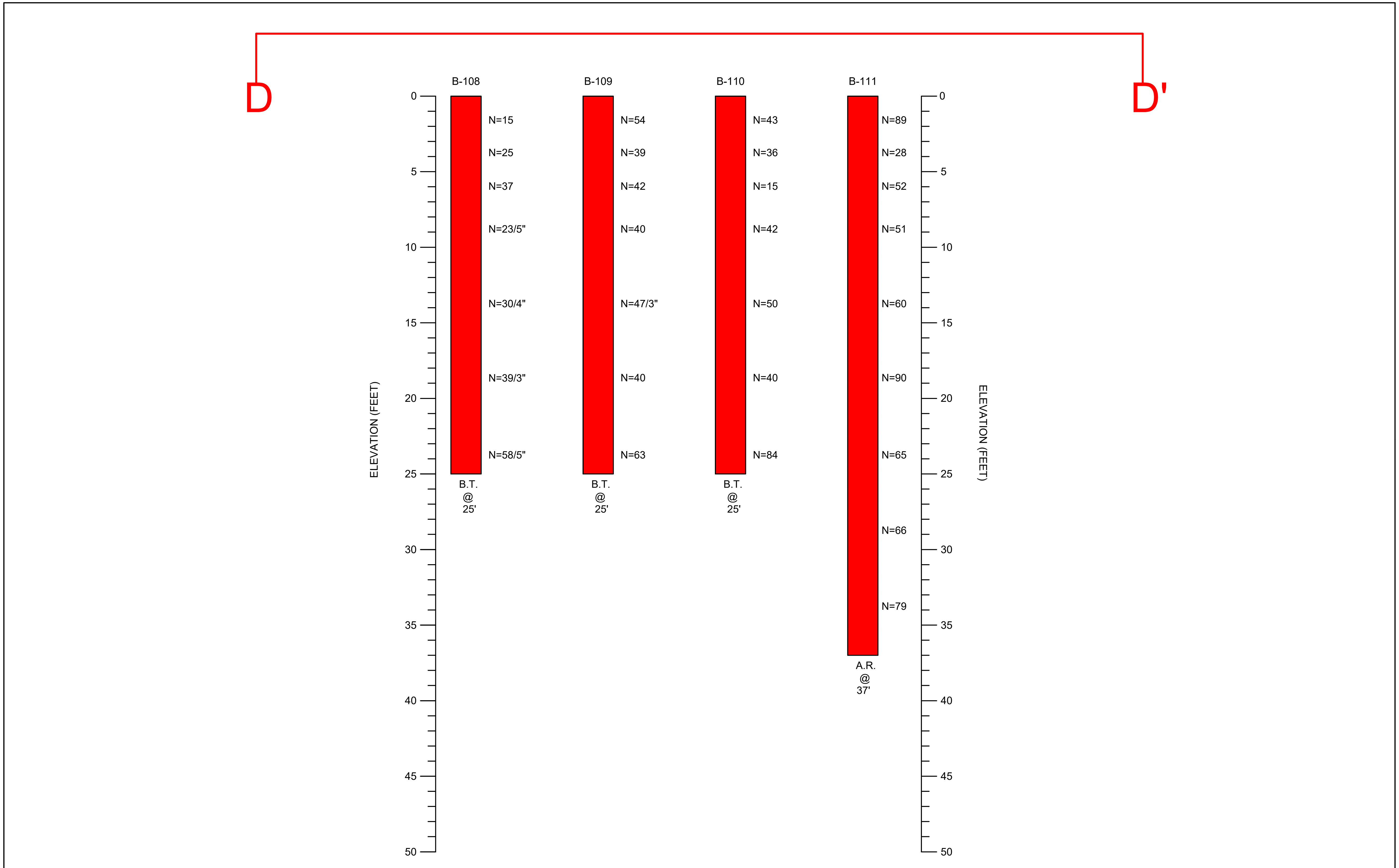
GEOServices, LLC-Geotechnical and Materials Engineers

Boring Cross-Section
WCS Consolidated Interim Storage Facility
WCS
Andrews, Texas

DATE: 08/10/2015

GEOS Project No. 31-151247

FIGURE: 8



Notes:

1) B.T. = Boring Termination
2) A.R. = Auger Refusal
3) Not To Scale

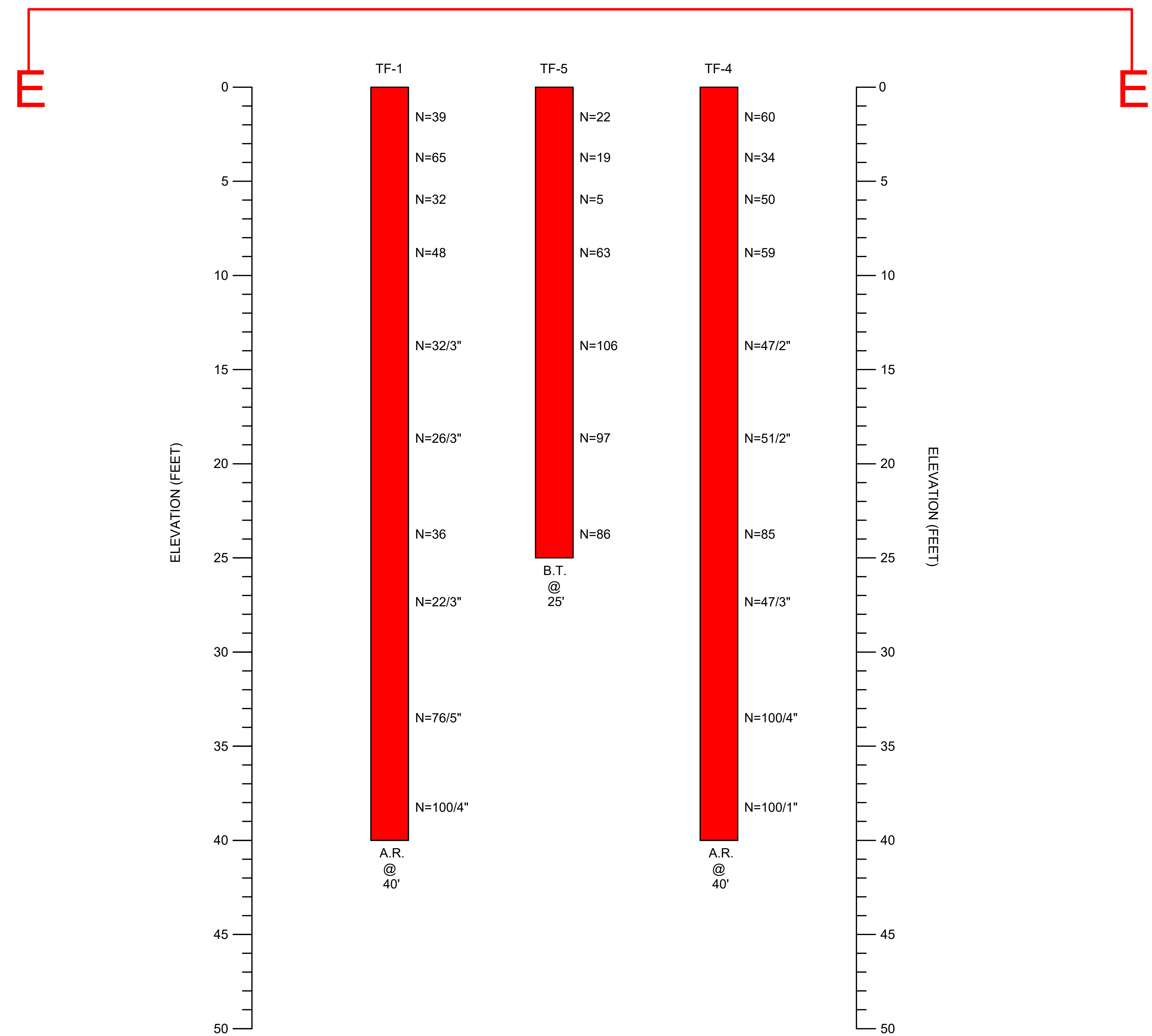
GEOServices, LLC-Geotechnical and Materials Engineers

Boring Cross-Section
WCS Consolidated Interim Storage Facility
WCS
Andrews, Texas

DATE:
08/10/2015

GEOS Project No.
31-151247

FIGURE:
9



Notes:

1) B.T. = Boring Termination
2) A.R. = Auger Refusal
3) Not To Scale

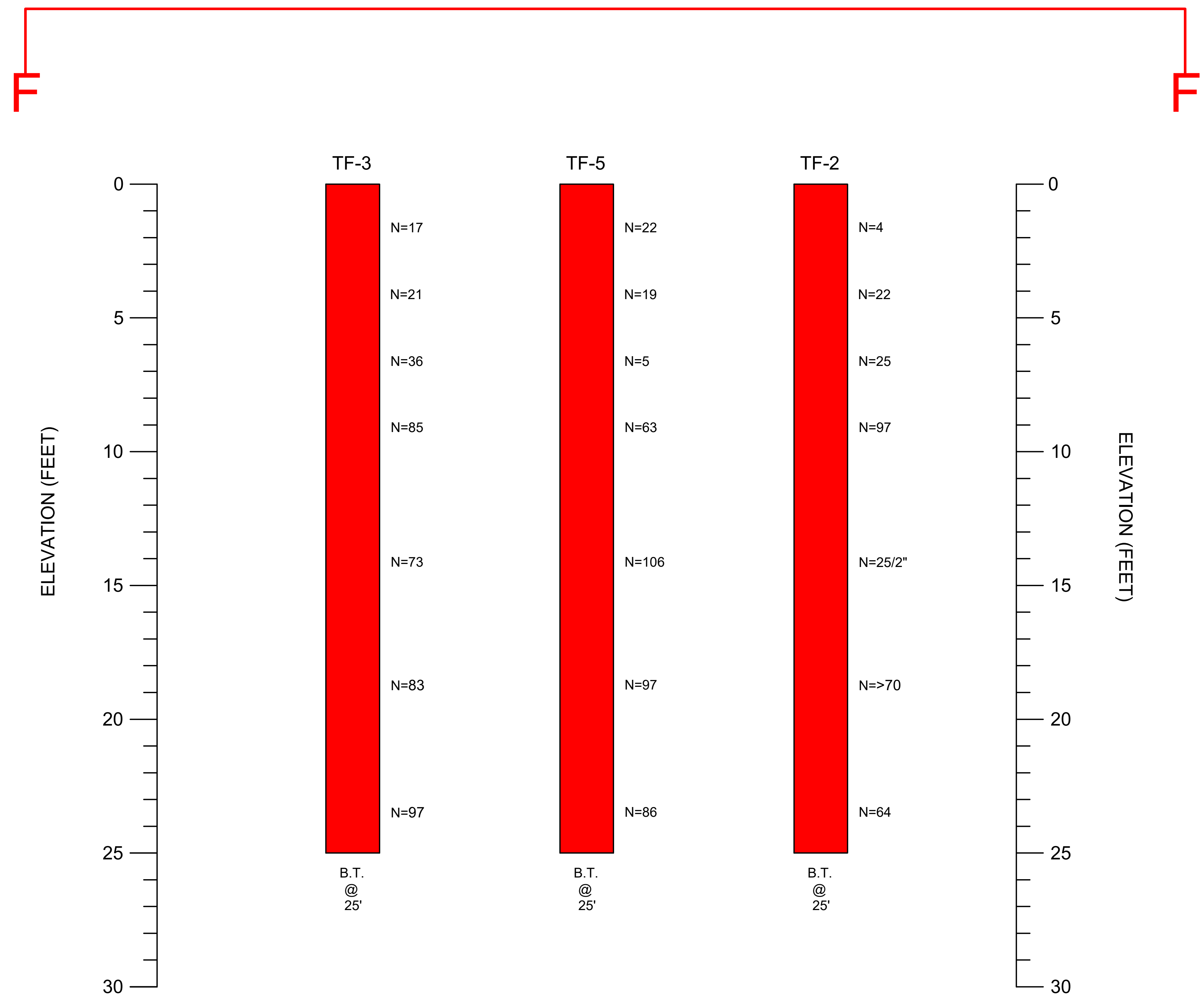
GEOServices, LLC-Geotechnical and Materials Engineers

Boring Cross-Section
WCS Consolidated Interim Storage Facility
WCS
Andrews, Texas

DATE: 08/10/2015

GEOS Project No. 31-151247

FIGURE: 10



Notes:

1) B.T. = Boring Termination
2) A.R. = Auger Refusal
3) Not To Scale

GEOServices, LLC-Geotechnical and Materials Engineers

Boring Cross-Section
WCS Consolidated Interim Storage Facility
WCS
Andrews, Texas

DATE: 08/10/2015

GEOS Project No. 31-151247

FIGURE: 11

GENERAL NOTES

FINE AND COARSE GRAINED SOIL PROPERTIES

PARTICLE SIZE

BOULDERS:	GREATER THAN 300 mm
COBBLES:	75 mm to 300 mm
GRAVEL:	4.74 mm to 75 mm
COARSE SAND:	2 mm to 4.74 mm
MEDIUM SAND:	0.425 mm to 2 mm
FINE SAND:	0.075 mm to 0.425 mm
SILTS & CLAYS:	LESS THAN 0.075 mm

COARSE GRAINED SOILS (SANDS & GRAVELS)

N-VALUE	RELATIVE DENSITY
0 - 4	VERY LOOSE
5 - 10	LOOSE
11 - 30	MEDIUM DENSE
31 - 50	DENSE
OVER 50	VERY DENSE

FINE GRAINED SOILS (SILTS & CLAYS)

N-VALUE	CONSISTENCY	Qu, PSF
0 - 2	VERY SOFT	0 - 500
3 - 4	SOFT	500 - 1000
5 - 8	FIRM	1000 - 2000
9 - 15	STIFF	2000 - 4000
16 - 30	VERY STIFF	4000 - 8000
OVER 31	HARD	8000 +

STANDARD PENETRATION TEST (ASTM D1586)

THE STANDARD PENETRATION TEST AS DEFINED BY ASTM D1586 IS A METHOD TO OBTAIN A DISTURBED SOIL SAMPLE FOR EXAMINATION AND TESTING AND TO OBTAIN RELATIVE DENSITY AND CONSISTENCY INFORMATON. THE 1.4 INCH I.D./2.0 INCH O.D. SAMPLER IS DRIVEN 3-SIX INCH INCREMENTS WITH A 140 LB. HAMMER FALLING 30 INCHES. THE BLOW COUNTS REQUIRED TO DRIVE THE SAMPLER THE FINAL 2 INCREMENTS ARE ADDED TOGETHER AND DESIGNATED THE N-VALUE. AT TIMES, THE SAMPLER CAN NOT BE DRIVEN THE FULL 18 INCHES. THE FOLLOWING REPRESENTS OUR INTERPRETATION OF THE STANDARD PENETRATION TEST WITH VARIATIONS.

BLOWS/FOOT (N-VALUE)	DESCRIPTION
25	25 BLOWS DROVE SAMPLER 12" AFTER INITIAL 6" SEATING
75/10"	75 BLOWS DROVE SAMPLER 10" AFTER INITIAL 6" SEATING
50/PR	PENETRATION REFUSAL OF SAMPLER AFTER INITIAL 6" SEATING

SAMPLING SYMBOLS

ST:	UNDISTURBED SAMPLE
SS:	SPLIT SPOON SAMPLE
CORE:	ROCK CORE SAMPLE
AU:	AUGER OR BAG SAMPLE

SOIL PROPERTY SYMBOLS

N:	STANDARD PENETRATION, BPF
M:	MOISTURE CONTENT %
LL:	LIQUID LIMIT %
PI:	PLASTICITY INDEX %
Qp:	POCKET PENETROMETER VALUE, TSF
Qu:	UNCONFINED COMPRESSIVE STRENGTH, TSF
DUW:	DRY UNIT WEIGHT, PCF

ROCK PROPERTIES

ROCK QUALITY DESIGNATION (RQD)

PERCENT	QUALITY
90 TO 100	EXCELLENT
75 TO 90	GOOD
50 TO 75	FAIR
25 TO 50	POOR
0 TO 25	VERY POOR

ROCK HARDNESS

VERY SOFT:	ROCK DISINTEGRATES OR EASILY COMPRESSES TO TOUCH: CAN BE HARD TO VERY HARD SOIL.
SOFT:	ROCK IS COHERANT BUT BREAKS EASILY TO THUMB PRESSURE AT SHARP EDGES AND CRUMBLES WITH FIRM HAND PRESSURE.
MODERATELY HARD:	SMALL PIECES CAN BE BROKEN OFF ALONG SHARP EDGES BY CONSIDERABLE HARD THUMB PRESSURE: CAN BE BROKEN BY LIGHT HAMMER BLOWS.
HARD:	ROCK CAN NOT BE BROKEN BY THUMB PRESSURE, BUT CAN BE BROKEN BY MODERATE HAMMER BLOWS.
VERY HARD:	ROCK CAN BE BROKEN BY HEAVY HAMMER BLOWS.

GEOS

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GEOS
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Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

DRILLING CO Apex Geoscience Inc.
DRILLER
LOGGED BY Sammy Joe Allison

BORING NO. / LOCATION B-101

DATE	July 21, 2015		SURFACE ELEV. ____ FT.	
REFUSAL:	Yes	DEPTH 45.0 FT.	ELEV. ____ FT.	
SAMPLED	45.0 FT.	13.7 M		
TOP OF ROCK		DEPTH 45.0 FT.	ELEV. ____ FT.	
BEGAN CORING		DEPTH ____ FT.	ELEV. ____ FT.	
FOOTAGE CORED (LF)		____ FT.		
BOTTOM OF HOLE DEPTH		45.0 FT.	ELEV. ____ FT.	

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. ELEV. ____ FT.
AFTER 24 HRS. DEPTH N/A FT. ELEV. ____ FT.

BORING ADVANCED BY: POWER AUGERING X WASHBORING ____

STRATUM DEPTH FT.	ELEV.	SAMPLE DEPTH FROM FT.	TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	Qp	LABORATORY RESULTS LL	PI	%M	STRATUM DESCRIPTION
		1.0	2.5	1	SS	3-12-7 N=19				3.6	**Silty SAND (SM)** with caliche - brown; fine grained; loose and medium dense; dry
2.5	-2.5										
		3.0	4.5	2	SS	5-5-3 N=8				3.9	
5.0	-5.0	5.0	6.5	3	SS	4-10-12 N=22				6.5	
7.5	-7.5										**Silty SAND (SM)** with caliche - orangish brown; fine grained; very dense; dry
		8.0	9.5	4	SS	17-30-48 N=78				7.8	
10.0	-10.0										
12.5	-12.5										
		13.0	14.5	5	SS	30-59-39 N=98				6.7	
15.0	-15.0										
17.5	-17.5										
		18.0	19.5	6	SS	20-24-31 N=55				5.7	
20.0	-20.0										

REMARKS:

GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

DRILLING CO: Apex Geoscience Inc.
DRILLER:
LOGGED BY: Sammy Joe Allison

BORING NO. / LOCATION: B-101

DATE: July 21, 2015 | SURFACE ELEV. ___ FT.
REFUSAL: Yes | DEPTH 45.0 FT. | ELEV. ___ FT.
SAMPLED: 45.0 FT. | 13.7 M
TOP OF ROCK: DEPTH 45.0 FT. | ELEV. ___ FT.
BEGAN CORING: DEPTH ___ FT. | ELEV. ___ FT.
FOOTAGE CORED (LF): ___ FT.
BOTTOM OF HOLE DEPTH: 45.0 FT. | ELEV. ___ FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. ELEV. ___ FT.
AFTER 24 HRS. DEPTH N/A FT. ELEV. ___ FT.

BORING ADVANCED BY: POWER AUGERING X | WASHBORING ___

STRATUM DEPTH FT.	ELEV.	SAMPLE DEPTH FROM FT.	TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	Qp	LABORATORY RESULTS LL	PI	%M	STRATUM DESCRIPTION
											CONTINUED
22.5	-22.5										
		23.0	24.5	7	SS	23-34-55 N=89				5.7	
25.0	-25.0										
27.5	-27.5										
		28.0	28.7	8	SS	42-64/2" N=64/2"					
30.0	-30.0										**Silty SAND (SM)** with caliche - orangish brown; fine grained; very dense; dry
		31.0	31.2	9	SS	N=50/2"				5.7	
32.5	-32.5										
		33.0	33.2	10	SS	N=74/2"				7.7	
35.0	-35.0										
37.5	-37.5										
		38.0	38.3	11	SS	N=81/3"					
40.0	-40.0										

REMARKS:

GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING B-101
SHEET 3 OF 3

DRILLING CO Apex Geoscience Inc.
DRILLER
LOGGED BY Sammy Joe Allison

BORING NO. / LOCATION B-101

DATE July 21, 2015 SURFACE ELEV. FT.
REFUSAL: Yes DEPTH 45.0 FT. ELEV. FT.
SAMPLED 45.0 FT. 13.7 M
TOP OF ROCK DEPTH 45.0 FT. ELEV. FT.
BEGAN CORING DEPTH FT. ELEV. FT.
FOOTAGE CORED (LF) FT.
BOTTOM OF HOLE DEPTH 45.0 FT. ELEV. FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. ELEV. FT.
AFTER 24 HRS. DEPTH N/A FT. ELEV. FT.

BORING ADVANCED BY: POWER AUGERING X WASHBORING

STRATUM DEPTH FT.	STRATUM DEPTH ELEV.	SAMPLE DEPTH FROM FT.	SAMPLE DEPTH TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	FIELD RESULTS Qp	LABORATORY RESULTS LL	LABORATORY RESULTS PI	LABORATORY RESULTS %M	STRATUM DESCRIPTION
											CONTINUED
42.5	-42.5	43.0	43.2	12	SS	N=80/2"					**Silty SAND (SM)** with caliche - orangish brown; fine grained; very dense; dry
45.0	-45.0										**AUGER REFUSAL AT 45 FEET**
47.5	-47.5										
50.0	-50.0										
52.5	-52.5										
55.0	-55.0										
57.5	-57.5										
60.0	-60.0										

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING B-102
SHEET 1 OF 2

DRILLING CO Apex Geoscience Inc.
DRILLER
LOGGED BY Sammy Joe Allison

BORING NO. / LOCATION B-102

DATE July 16, 2015 SURFACE ELEV. ____ FT.
REFUSAL: No DEPTH ____ FT. ELEV. ____ FT.
SAMPLED 25.0 FT. 7.6 M
TOP OF ROCK DEPTH ____ FT. ELEV. ____ FT.
BEGAN CORING DEPTH ____ FT. ELEV. ____ FT.
FOOTAGE CORED (LF) ____ FT.
BOTTOM OF HOLE DEPTH 25.0 FT. ELEV. ____ FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT.
ELEV. ____ FT.
AFTER 24 HRS. DEPTH N/A FT.
ELEV. ____ FT.

BORING ADVANCED BY: POWER AUGERING X WASHBORING ____

STRATUM DEPTH FT.	STRATUM DEPTH ELEV.	SAMPLE DEPTH FROM FT.	SAMPLE DEPTH TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	FIELD RESULTS Qp	LABORATORY RESULTS LL	LABORATORY RESULTS PI	%M	STRATUM DESCRIPTION
		1.0	2.5	1	SS	7-6-4 N=10				3.4	**Silty SAND (SM)** with caliche - brown; fine grained; loose to very dense; dry
2.5	-2.5										
		3.0	3.8	2	SS	10-48/3" N=48/3"				2.8	
5.0	-5.0	5.0	6.5	3	SS	16-26-20 N=46				2.9	**Silty SAND (SM)** with caliche - light brown; fine grained; dense to very dense; dry
7.5	-7.5										
		8.0	9.5	4	SS	25-28-27 N=55				4.0	
10.0	-10.0										
12.5	-12.5										**Silty SAND (SM)** with caliche - orangish brown; fine grained; very dense; dry
		13.0	13.8	5	SS	34-37/3" N=37/3"				6.0	
15.0	-15.0										
17.5	-17.5										
		18.0	18.8	6	SS	43-20/3" N=20/3"				5.8	
20.0	-20.0										

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING B-102
SHEET 2 OF 2

DRILLING CO Apex Geoscience Inc.
DRILLER
LOGGED BY Sammy Joe Allison

BORING NO. / LOCATION B-102

DATE July 16, 2015 SURFACE ELEV. ____ FT.
REFUSAL: No DEPTH ____ FT. ELEV. ____ FT.
SAMPLED 25.0 FT. 7.6 M
TOP OF ROCK DEPTH ____ FT. ELEV. ____ FT.
BEGAN CORING DEPTH ____ FT. ELEV. ____ FT.
FOOTAGE CORED (LF) ____ FT.
BOTTOM OF HOLE DEPTH 25.0 FT. ELEV. ____ FT.
BORING ADVANCED BY: POWER AUGERING X WASHBORING ____

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT.
ELEV. ____ FT.
AFTER 24 HRS. DEPTH N/A FT.
ELEV. ____ FT.

STRATUM DEPTH FT.	STRATUM DEPTH ELEV.	SAMPLE DEPTH FROM FT.	SAMPLE DEPTH TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	FIELD RESULTS Qp	LABORATORY RESULTS LL	LABORATORY RESULTS PI	LABORATORY RESULTS %M	STRATUM DESCRIPTION
											CONTINUED
22.5	-22.5										**Silty SAND (SM)** with caliche - orangish brown; fine grained; very dense; dry
		23.0	23.8	7	SS	26-24/3" N=24/3"				2.9	
25.0	-25.0										**BORING TERMINATED AT 25 FEET**
27.5	-27.5										
30.0	-30.0										
32.5	-32.5										
35.0	-35.0										
37.5	-37.5										
40.0	-40.0										

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas

GEOServices Project No.: 31-151247

LOG OF BORING B-103
SHEET 1 OF 2

DRILLING CO: Apex Geoscience Inc.
DRILLER:
LOGGED BY: Sammy Joe Allison

BORING NO. / LOCATION: B-103

DATE: July 17, 2015 | SURFACE ELEV. ____ FT.
REFUSAL: No | DEPTH ____ FT. | ELEV. ____ FT.
SAMPLED: 25.0 FT. | 7.6 M
TOP OF ROCK | DEPTH ____ FT. | ELEV. ____ FT.
BEGAN CORING | DEPTH ____ FT. | ELEV. ____ FT.
FOOTAGE CORED (LF) ____ FT.
BOTTOM OF HOLE DEPTH 25.0 FT. | ELEV. ____ FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. ELEV. ____ FT.
AFTER 24 HRS. DEPTH N/A FT. ELEV. ____ FT.

BORING ADVANCED BY: POWER AUGERING X | WASHBORING ____

STRATUM DEPTH FT.	STRATUM DEPTH ELEV.	SAMPLE DEPTH FROM FT.	SAMPLE DEPTH TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	FIELD RESULTS Qp	LABORATORY RESULTS LL	LABORATORY RESULTS PI	%M	STRATUM DESCRIPTION
		1.0	2.5	1	SS	2-3-4 N=7		26	NP	4.3	**Silty SAND (SM)** with caliche - brown; fine grained; loose; dry
2.5	-2.5										
		3.0	4.5	2	SS	8-5-8 N=13				4.8	
5.0	-5.0	5.0	6.5	3	SS	7-7-9 N=16				5.8	
7.5	-7.5										
		8.0	9.5	4	SS	16-27-39 N=66				7.1	**Silty SAND (SM)** with caliche - light brown; fine grained; medium dense to very dense; dry
10.0	-10.0										
12.5	-12.5										
		13.0	14.4	5	SS	23-35-45/5" N=45/5"				6.3	
15.0	-15.0										
17.5	-17.5										
		18.0	19.5	6	SS	17-26-40 N=66				6.1	**Silty SAND (SM)** with trace caliche - orangish brown; fine grained; very dense; dry
20.0	-20.0										

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING B-103
SHEET 2 OF 2

DRILLING CO Apex Geoscience Inc.
DRILLER
LOGGED BY Sammy Joe Allison

BORING NO. / LOCATION B-103

DATE July 17, 2015 SURFACE ELEV. ____ FT.
REFUSAL: No DEPTH ____ FT. ELEV. ____ FT.
SAMPLED 25.0 FT. 7.6 M
TOP OF ROCK DEPTH ____ FT. ELEV. ____ FT.
BEGAN CORING DEPTH ____ FT. ELEV. ____ FT.
FOOTAGE CORED (LF) ____ FT.
BOTTOM OF HOLE DEPTH 25.0 FT. ELEV. ____ FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT.
ELEV. ____ FT.
AFTER 24 HRS. DEPTH N/A FT.
ELEV. ____ FT.

BORING ADVANCED BY: POWER AUGERING X WASHBORING ____

STRATUM DEPTH FT.	ELEV.	SAMPLE DEPTH FROM FT.	TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	Qp	LABORATORY RESULTS LL	PI	%M	STRATUM DESCRIPTION
											CONTINUED
22.5	-22.5										**Silty SAND (SM)** with trace caliche - orangish brown; fine grained; very dense; dry
		23.0	24.5	7	SS	17-23-33 N=56				4.5	
25.0	-25.0										**BORING TERMINATED AT 25 FEET**
27.5	-27.5										
30.0	-30.0										
32.5	-32.5										
35.0	-35.0										
37.5	-37.5										
40.0	-40.0										

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING B-104
SHEET 1 OF 2

DRILLING CO: Apex Geoscience Inc.
DRILLER:
LOGGED BY: Sammy Joe Allison

BORING NO. / LOCATION: B-104

DATE: July 16, 2015 | SURFACE ELEV. ____ FT.
REFUSAL: No | DEPTH ____ FT. | ELEV. ____ FT.
SAMPLED: 25.0 FT. | 7.6 M
TOP OF ROCK | DEPTH ____ FT. | ELEV. ____ FT.
BEGAN CORING | DEPTH ____ FT. | ELEV. ____ FT.
FOOTAGE CORED (LF) ____ FT.
BOTTOM OF HOLE DEPTH 25.0 FT. | ELEV. ____ FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. | ELEV. ____ FT.
AFTER 24 HRS. DEPTH N/A FT. | ELEV. ____ FT.

BORING ADVANCED BY: POWER AUGERING X | WASHBORING ____

STRATUM DEPTH FT.	ELEV.	SAMPLE DEPTH FROM FT.	SAMPLE DEPTH TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	Qp	LABORATORY RESULTS LL	PI	%M	STRATUM DESCRIPTION
		1.0	2.3	1	SS	2-32-37/3" N=37/3"				3.1	**Silty SAND (SM)** with caliche - brown; fine grained; very dense; dry
2.5	-2.5										
		3.0	3.8	2	SS	64-43/3" N=43/3"				2.5	**Silty SAND (SM)** with caliche - light brown; fine grained; very dense; dry
5.0	-5.0										
		5.0	6.5	3	SS	13-18-21 N=39				4.1	
7.5	-7.5										
		8.0	9.5	4	SS	17-26-45 N=71				6.9	
10.0	-10.0										
12.5	-12.5										**Silty SAND (SM)** with trace caliche - orangish brown; fine grained; very dense; dry
		13.0	14.5	5	SS	18-33-43 N=76				6.0	
15.0	-15.0										
17.5	-17.5										
		18.0	19.5	6	SS	23-28-50 N=78				4.6	
20.0	-20.0										

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING B-104
SHEET 2 OF 2

DRILLING CO: Apex Geoscience Inc.
DRILLER:
LOGGED BY: Sammy Joe Allison

BORING NO. / LOCATION: B-104

DATE: July 16, 2015 | SURFACE ELEV. ___ FT.
REFUSAL: No | DEPTH ___ FT. | ELEV. ___ FT.
SAMPLED: 25.0 FT. 7.6 M
TOP OF ROCK: DEPTH ___ FT. | ELEV. ___ FT.
BEGAN CORING: DEPTH ___ FT. | ELEV. ___ FT.
FOOTAGE CORED (LF): ___ FT.
BOTTOM OF HOLE DEPTH: 25.0 FT. | ELEV. ___ FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. ELEV. ___ FT.
AFTER 24 HRS. DEPTH N/A FT. ELEV. ___ FT.

BORING ADVANCED BY: POWER AUGERING X | WASHBORING ___

STRATUM DEPTH FT.	STRATUM DEPTH ELEV.	SAMPLE DEPTH FROM FT.	SAMPLE DEPTH TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	FIELD RESULTS Qp	LABORATORY RESULTS LL	LABORATORY RESULTS PI	LABORATORY RESULTS %M	STRATUM DESCRIPTION
											CONTINUED
22.5	-22.5										**Silty SAND (SM)** with trace caliche - orangish brown; fine grained; very dense; dry
		23.0	24.5	7	SS	15-23-39 N=62				3.1	
25.0	-25.0										**BORING TERMINATED AT 25 FEET**
27.5	-27.5										
30.0	-30.0										
32.5	-32.5										
35.0	-35.0										
37.5	-37.5										
40.0	-40.0										

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING B-105
SHEET 1 OF 2

DRILLING CO: Apex Geoscience Inc.
DRILLER:
LOGGED BY: Sammy Joe Allison

BORING NO. / LOCATION: B-105

DATE: July 15, 2015 | SURFACE ELEV. ___ FT.
REFUSAL: No | DEPTH ___ FT. | ELEV. ___ FT.
SAMPLED: 25.0 FT. | 7.6 M
TOP OF ROCK | DEPTH ___ FT. | ELEV. ___ FT.
BEGAN CORING | DEPTH ___ FT. | ELEV. ___ FT.
FOOTAGE CORED (LF) ___ FT.
BOTTOM OF HOLE DEPTH 25.0 FT. | ELEV. ___ FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. | ELEV. ___ FT.
AFTER 24 HRS. DEPTH N/A FT. | ELEV. ___ FT.

BORING ADVANCED BY: POWER AUGERING X | WASHBORING ___

STRATUM DEPTH FT.	STRATUM ELEV.	SAMPLE DEPTH FROM FT.	SAMPLE DEPTH TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	Qp	LABORATORY RESULTS LL	PI	%M	STRATUM DESCRIPTION
		1.0	1.8	1	SS	6-50/4" N=50/4"				3.3	**Silty SAND (SM)** with caliche - brown; fine grained; very dense; dry
2.5	-2.5										
5.0	-5.0	5.0	6.5	2	SS	10-14-18 N=32				5.3	
7.5	-7.5	8.0	9.5	3	SS	14-27-29 N=56				8.1	
10.0	-10.0										**Silty SAND (SM)** with caliche - orangish brown; fine grained; dense to very dense; dry
12.5	-12.5	13.0	13.5	4	SS	60+ N=>60				4.8	
15.0	-15.0										
17.5	-17.5	18.0	19.0	5	SS	30-40+ N=>40				4.1	
20.0	-20.0										

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

DRILLING CO: Apex Geoscience Inc.
DRILLER:
LOGGED BY: Sammy Joe Allison

BORING NO. / LOCATION: B-105

DATE: July 16, 2015 | SURFACE ELEV. ____ FT.
REFUSAL: No | DEPTH ____ FT. | ELEV. ____ FT.
SAMPLED: 25.0 FT. 7.6 M
TOP OF ROCK | DEPTH ____ FT. | ELEV. ____ FT.
BEGAN CORING | DEPTH ____ FT. | ELEV. ____ FT.
FOOTAGE CORED (LF) ____ FT.
BOTTOM OF HOLE DEPTH 25.0 FT. | ELEV. ____ FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. ELEV. ____ FT.
AFTER 24 HRS. DEPTH N/A FT. ELEV. ____ FT.

BORING ADVANCED BY: POWER AUGERING X WASHBORING ____

STRATUM DEPTH FT.	STRATUM DEPTH ELEV.	SAMPLE DEPTH FROM FT.	SAMPLE DEPTH TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	FIELD RESULTS Qp	LABORATORY RESULTS LL	LABORATORY RESULTS PI	LABORATORY RESULTS %M	STRATUM DESCRIPTION
											CONTINUED
22.5	-22.5										**Silty SAND (SM)** with caliche - orangish brown; fine grained; dense to very dense; dry
		23.0	23.5	6	SS	65+ N=>65					
25.0	-25.0										**BORING TERMINATED AT 25 FEET**
27.5	-27.5										
30.0	-30.0										
32.5	-32.5										
35.0	-35.0										
37.5	-37.5										
40.0	-40.0										

REMARKS:

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

GEOServices, LLC-Geotechnical and Materials Engineers

LOG OF BORING B-106
SHEET 1 OF 2

DRILLING CO: Apex Geoscience Inc.
DRILLER:
LOGGED BY: Sammy Joe Allison

BORING NO. / LOCATION: B-106

DATE: July 16, 2015 SURFACE ELEV. ____ FT.
REFUSAL: No DEPTH ____ FT. ELEV. ____ FT.
SAMPLED: 25.0 FT. 7.6 M
TOP OF ROCK DEPTH ____ FT. ELEV. ____ FT.
BEGAN CORING DEPTH ____ FT. ELEV. ____ FT.
FOOTAGE CORED (LF) ____ FT.
BOTTOM OF HOLE DEPTH 25.0 FT. ELEV. ____ FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. ELEV. ____ FT.
AFTER 24 HRS. DEPTH N/A FT. ELEV. ____ FT.

BORING ADVANCED BY: POWER AUGERING X WASHBORING ____

STRATUM DEPTH FT.	ELEV.	SAMPLE DEPTH FROM FT.	TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	Qp	LABORATORY RESULTS LL	PI	%M	STRATUM DESCRIPTION
		1.0	2.5	1	SS	13-33-26 N=59				4.5	**Silty SAND (SM)** with caliche - brown; fine grained; very dense; dry
2.5	-2.5										
		3.0	4.5	2	SS	9-14-8 N=22				3.9	**Silty SAND (SM)** with trace caliche - light brown; fine grained; medium dense to very dense; dry
5.0	-5.0	5.0	6.5	3	SS	11-16-21 N=37				3.9	
7.5	-7.5										
		8.0	9.5	4	SS	7-19-33 N=52				5.3	
10.0	-10.0										
12.5	-12.5										**Silty SAND (SM)** with trace caliche - orangish brown; fine grained; very dense; dry
		13.0	13.9	5	SS	33-50/5" N=50/5"				6.7	
15.0	-15.0										
17.5	-17.5										
		18.0	19.5	6	SS	25-35-50/6" N=50/6"				6.8	
20.0	-20.0										

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING B-106
SHEET 2 OF 2

DRILLING CO: Apex Geoscience Inc.
DRILLER:
LOGGED BY: Sammy Joe Allison

BORING NO. / LOCATION: B-106

DATE: July 16, 2015
SURFACE ELEV. ____ FT.
REFUSAL: No DEPTH ____ FT. ELEV. ____ FT.
SAMPLED: 25.0 FT. 7.6 M
TOP OF ROCK DEPTH ____ FT. ELEV. ____ FT.
BEGAN CORING DEPTH ____ FT. ELEV. ____ FT.
FOOTAGE CORED (LF) ____ FT.
BOTTOM OF HOLE DEPTH 25.0 FT. ELEV. ____ FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT.; ELEV. ____ FT.
AFTER 24 HRS. DEPTH N/A FT.; ELEV. ____ FT.

BORING ADVANCED BY: POWER AUGERING X WASHBORING ____

STRATUM DEPTH FT.	STRATUM DEPTH ELEV.	SAMPLE DEPTH FROM FT.	SAMPLE DEPTH TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	FIELD RESULTS Qp	LABORATORY RESULTS LL	LABORATORY RESULTS PI	LABORATORY RESULTS %M	STRATUM DESCRIPTION
											CONTINUED
22.5	-22.5										**Silty SAND (SM)** with trace caliche - orangish brown; fine grained; very dense; dry
		23.0	24.4	7	SS	12-37-50/5" N=50/5"				6.2	
25.0	-25.0										**BORING TERMINATED AT 25 FEET**
27.5	-27.5										
30.0	-30.0										
32.5	-32.5										
35.0	-35.0										
37.5	-37.5										
40.0	-40.0										

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING B-107
SHEET 1 OF 2

DRILLING CO: Apex Geoscience Inc.
DRILLER:
LOGGED BY: Sammy Joe Allison

BORING NO. / LOCATION: B-107

DATE: July 16, 2015 | SURFACE ELEV. ____ FT.
REFUSAL: No | DEPTH ____ FT. | ELEV. ____ FT.
SAMPLED: 25.0 FT. | 7.6 M
TOP OF ROCK | DEPTH ____ FT. | ELEV. ____ FT.
BEGAN CORING | DEPTH ____ FT. | ELEV. ____ FT.
FOOTAGE CORED (LF) ____ FT.
BOTTOM OF HOLE DEPTH 25.0 FT. | ELEV. ____ FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. | ELEV. ____ FT.
AFTER 24 HRS. DEPTH N/A FT. | ELEV. ____ FT.

BORING ADVANCED BY: POWER AUGERING X | WASHBORING ____

STRATUM DEPTH FT.	STRATUM ELEV.	SAMPLE DEPTH FROM FT.	SAMPLE DEPTH TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	Qp	LAB LL	LAB PI	%M	STRATUM DESCRIPTION
		1.0	1.8	1	SS	7-50/4" N=50/4"				5.3	**Silty SAND (SM)** with caliche - brown; fine grained; very dense; dry
2.5	-2.5										
		3.0	4.5	2	SS	7-25-33 N=58				4.5	**Silty SAND (SM)** with trace caliche - light brown; fine grained; very dense; dry
5.0	-5.0	5.0	6.5	3	SS	9-16-20 N=36				4.1	
7.5	-7.5										
		8.0	9.5	4	SS	22-32-41 N=73				5.7	
10.0	-10.0										
12.5	-12.5										**Silty SAND (SM)** with trace caliche - orangish brown; fine grained; very dense; dry
		13.0	14.0	5	SS	31-50/6" N=50/6"				7.2	
15.0	-15.0										
17.5	-17.5										
		18.0	19.5	6	SS	16-32-50/6" N=50/6"				6.3	
20.0	-20.0										

REMARKS:

GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

DRILLING CO: Apex Geoscience Inc.
DRILLER:
LOGGED BY: Sammy Joe Allison

BORING NO. / LOCATION: B-107

DATE: July 16, 2015 SURFACE ELEV. ______ FT.
REFUSAL: No DEPTH ______ FT. ELEV. ______ FT.
SAMPLED: 25.0 FT. 7.6 M
TOP OF ROCK DEPTH ______ FT. ELEV. ______ FT.
BEGAN CORING DEPTH ______ FT. ELEV. ______ FT.
FOOTAGE CORED (LF) ______ FT.
BOTTOM OF HOLE DEPTH 25.0 FT. ELEV. ______ FT.
BORING ADVANCED BY: POWER AUGERING X WASHBORING ______

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. ELEV. ______ FT.
AFTER 24 HRS. DEPTH N/A FT. ELEV. ______ FT.

STRATUM DEPTH FT.	STRATUM DEPTH ELEV.	SAMPLE DEPTH FROM FT.	SAMPLE DEPTH TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	FIELD RESULTS Qp	LABORATORY RESULTS LL	LABORATORY RESULTS PI	LABORATORY RESULTS %M	STRATUM DESCRIPTION
											CONTINUED
22.5	-22.5										**Silty SAND (SM)** with trace caliche - orangish brown; fine grained; very dense; dry
		23.0	24.4	7	SS	15-32-50/5" N=50/5"				4.2	
25.0	-25.0										**BORING TERMINATED AT 25 FEET**
27.5	-27.5										
30.0	-30.0										
32.5	-32.5										
35.0	-35.0										
37.5	-37.5										
40.0	-40.0										

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING B-108
SHEET 1 OF 2

DRILLING CO: Apex Geoscience Inc.
DRILLER:
LOGGED BY: Sammy Joe Allison

BORING NO. / LOCATION: B-108

DATE: July 15, 2015 | SURFACE ELEV. ____ FT.
REFUSAL: No | DEPTH ____ FT. | ELEV. ____ FT.
SAMPLED: 25.0 FT. | 7.6 M
TOP OF ROCK: DEPTH ____ FT. | ELEV. ____ FT.
BEGAN CORING: DEPTH ____ FT. | ELEV. ____ FT.
FOOTAGE CORED (LF): ____ FT.
BOTTOM OF HOLE DEPTH: 25.0 FT. | ELEV. ____ FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. | ELEV. ____ FT.
AFTER 24 HRS. DEPTH N/A FT. | ELEV. ____ FT.

BORING ADVANCED BY: POWER AUGERING X | WASHBORING ____

STRATUM DEPTH FT.	ELEV.	SAMPLE DEPTH FROM FT.	TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	Qp	LABORATORY RESULTS LL	PI	%M	STRATUM DESCRIPTION
		1.0	2.5	1	SS	1-5-10 N=15				4.9	**Silty SAND (SM)** with caliche - brown to light brown; fine grained; medium dense; dry
2.5	-2.5										
		3.0	4.5	2	SS	2-9-16 N=25				4.9	
5.0	-5.0										
		5.0	6.5	3	SS	10-17-20 N=37				6.0	**Silty SAND (SM)** with caliche - orangish brown; fine grained; dense to very dense; dry
7.5	-7.5										
		8.0	9.4	4	SS	14-32-23/5" N=23/5"				6.3	
10.0	-10.0										
12.5	-12.5										
		13.0	13.8	5	SS	22-30/4" N=30/4"				8.4	
15.0	-15.0										
17.5	-17.5										
		18.0	18.8	6	SS	38-39/3" N=39/3"				6.6	
20.0	-20.0										

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING B-108
SHEET 2 OF 2

DRILLING CO: Apex Geoscience Inc.
DRILLER:
LOGGED BY: Sammy Joe Allison

BORING NO. / LOCATION: B-108

DATE: July 15, 2015 | SURFACE ELEV. ___ FT.
REFUSAL: No | DEPTH ___ FT. | ELEV. ___ FT.
SAMPLED: 25.0 FT. | 7.6 M
TOP OF ROCK: DEPTH ___ FT. | ELEV. ___ FT.
BEGAN CORING: DEPTH ___ FT. | ELEV. ___ FT.
FOOTAGE CORED (LF): ___ FT.
BOTTOM OF HOLE DEPTH: 25.0 FT. | ELEV. ___ FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. ELEV. ___ FT.
AFTER 24 HRS. DEPTH N/A FT. ELEV. ___ FT.

BORING ADVANCED BY: POWER AUGERING X | WASHBORING ___

STRATUM DEPTH FT.	ELEV.	SAMPLE DEPTH FROM FT.	TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	Qp	LABORATORY RESULTS LL	PI	%M	STRATUM DESCRIPTION
											CONTINUED
22.5	-22.5	23.0	23.4	7	SS	N=58/5"				6	**Silty SAND (SM)** with caliche - orangish brown; fine grained; dense to very dense; dry
25.0	-25.0										**BORING TERMINATED AT 25 FEET**
27.5	-27.5										
30.0	-30.0										
32.5	-32.5										
35.0	-35.0										
37.5	-37.5										
40.0	-40.0										

REMARKS:

GEOS GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas

GEOServices Project No.: 31-151247

LOG OF BORING B-109

SHEET 1 OF 2

DRILLING CO: Apex Geoscience Inc.

DRILLER:

LOGGED BY: Sammy Joe Allison

BORING NO. / LOCATION: B-109

DATE: July 15, 2015 SURFACE ELEV. ____ FT.

REFUSAL: No DEPTH ____ FT. ELEV. ____ FT.

SAMPLED: 25.0 FT. 7.6 M

TOP OF ROCK DEPTH ____ FT. ELEV. ____ FT.

BEGAN CORING DEPTH ____ FT. ELEV. ____ FT.

FOOTAGE CORED (LF) ____ FT.

BOTTOM OF HOLE DEPTH 25.0 FT. ELEV. ____ FT.

BORING ADVANCED BY: POWER AUGERING X WASHBORING ____

WATER LEVEL DATA (IF APPLICABLE)

COMPLETION: DEPTH Dry FT. ELEV. ____ FT.

AFTER 24 HRS. DEPTH N/A FT. ELEV. ____ FT.

STRATUM DEPTH FT.	ELEV.	SAMPLE DEPTH FROM FT.	TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	Qp	LABORATORY RESULTS LL	PI	%M	STRATUM DESCRIPTION
		1.0	2.5	1	SS	3-31-23 N=54				3.4	**Silty SAND (SM)** with caliche - brown; fine grained; very dense; dry
2.5	-2.5										
		3.0	4.5	2	SS	6-15-24 N=39				4.2	**Silty SAND (SM)** with caliche - light brown; fine grained; dense to very dense; dry
5.0	-5.0	5.0	6.5	3	SS	10-18-24 N=42				3.8	
7.5	-7.5										
		8.0	9.0	4	SS	29-40+ N=>40				3.2	
10.0	-10.0										
12.5	-12.5										**Silty SAND (SM)** with caliche - orangish brown; fine grained; very dense; dry
		13.0	13.3	5	SS	47/3" N=47/3"				8.5	
15.0	-15.0										
17.5	-17.5										
		18.0	18.7	6	SS	42-40+ N=>40				6.3	
20.0	-20.0										

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING B-109
SHEET 2 OF 2

DRILLING CO	Apex Geoscience Inc.
DRILLER	
LOGGED BY	Sammy Joe Allison

BORING NO. / LOCATION: B-109

DATE	July 15, 2015			SURFACE ELEV.	FT.		
REFUSAL:	No	DEPTH	FT.	ELEV.	FT.		
SAMPLED	25.0 FT.	7.6	M				
TOP OF ROCK		DEPTH	FT.	ELEV.	FT.		
BEGAN CORING		DEPTH	FT.	ELEV.	FT.		
FOOTAGE CORED (LF)			FT.				
BOTTOM OF HOLE DEPTH		25.0	FT.	ELEV.	FT.		

WATER LEVEL DATA (IF APPLICABLE)

COMPLETION:	DEPTH	Dry	FT.
	ELEV.		FT.
AFTER 24 HRS.	DEPTH	N/A	FT.
	ELEV.		FT.

BORING ADVANCED BY: POWER AUGERING X WASHBORING

STRATUM DEPTH FT.	ELEV.	SAMPLE DEPTH FROM FT.	TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	Qp	LABORATORY RESULTS LL	PI	%M	STRATUM DESCRIPTION
											CONTINUED
22.5	-22.5	23.0	24.5	7	SS	32-33-30 N=63				4.7	**Silty SAND (SM)** with caliche - orangish brown; fine grained; very dense; dry
25.0	-25.0										**BORING TERMINATED AT 25 FEET**
27.5	-27.5										
30.0	-30.0										
32.5	-32.5										
35.0	-35.0										
37.5	-37.5										
40.0	-40.0										

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING B-110
SHEET 1 OF 2

DRILLING CO: Apex Geoscience Inc.
DRILLER:
LOGGED BY: Sammy Joe Allison

BORING NO. / LOCATION: B-110

DATE: July 16, 2015 | SURFACE ELEV. ____ FT.
REFUSAL: No | DEPTH ____ FT. | ELEV. ____ FT.
SAMPLED: 25.0 FT. | 7.6 M
TOP OF ROCK | DEPTH ____ FT. | ELEV. ____ FT.
BEGAN CORING | DEPTH ____ FT. | ELEV. ____ FT.
FOOTAGE CORED (LF) ____ FT.
BOTTOM OF HOLE DEPTH 25.0 FT. | ELEV. ____ FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. ELEV. ____ FT.
AFTER 24 HRS. DEPTH N/A FT. ELEV. ____ FT.

BORING ADVANCED BY: POWER AUGERING X WASHBORING ____

STRATUM DEPTH FT.	ELEV.	SAMPLE DEPTH FROM FT.	TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	Qp	LAB LL	PI	%M	STRATUM DESCRIPTION
		1.0	2.5	1	SS	4-27-16 N=43		29	NP	5.0	**Silty SAND (SM)** with caliche - brown; fine grained; dense; dry
2.5	-2.5										
		3.0	4.5	2	SS	14-18-18 N=36				4.7	**Silty SAND (SM)** with caliche - light brown; fine grained; medium dense to very dense; dry
5.0	-5.0	5.0	6.5	3	SS	8-7-6 N=15				6.0	
7.5	-7.5										
		8.0	9.5	4	SS	9-14-28 N=42				8.9	
10.0	-10.0										
12.5	-12.5										
		13.0	14.0	5	SS	23-50+ N=>50				7.1	
15.0	-15.0										
17.5	-17.5										**Silty SAND (SM)** with caliche - orangish brown; fine grained; very dense; dry
		18.0	19.0	6	SS	36-40+ N=>40				5.1	
20.0	-20.0										

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING B-110
SHEET 2 OF 2

DRILLING CO	Apex Geoscience Inc.
DRILLER	
LOGGED BY	Sammy Joe Allison

BORING NO. / LOCATION: B-110

DATE	July 16, 2015	SURFACE ELEV.	FT.
REFUSAL:	No	DEPTH FT.	ELEV. FT.
SAMPLED	25.0 FT.	7.6 M	
TOP OF ROCK		DEPTH FT.	ELEV. FT.
BEGAN CORING		DEPTH FT.	ELEV. FT.
FOOTAGE CORED (LF)		FT.	
BOTTOM OF HOLE DEPTH	25.0 FT.		ELEV. FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. ELEV. FT.
AFTER 24 HRS. DEPTH N/A FT. ELEV. FT.

BORING ADVANCED BY: POWER AUGERING X WASHBORING

STRATUM DEPTH FT.	ELEV.	SAMPLE DEPTH FROM FT.	TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	Qp	LABORATORY RESULTS LL	PI	%M	STRATUM DESCRIPTION
											CONTINUED
22.5	-22.5										**Silty SAND (SM)** with caliche - orangish brown; fine grained; very dense; dry
		23.0	24.5	7	SS	20-32-52 N=84				4.4	
25.0	-25.0										**BORING TERMINATED AT 25 FEET**
27.5	-27.5										
30.0	-30.0										
32.5	-32.5										
35.0	-35.0										
37.5	-37.5										
40.0	-40.0										

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING B-111
SHEET 1 OF 2

DRILLING CO Apex Geoscience Inc.
DRILLER
LOGGED BY Sammy Joe Allison

BORING NO. / LOCATION B-111

DATE July 20, 2015 SURFACE ELEV. ____ FT.
REFUSAL: Yes DEPTH 37.0 FT. ELEV. ____ FT.
SAMPLED 37.0 FT. 11.3 M
TOP OF ROCK DEPTH 37.0 FT. ELEV. ____ FT.
BEGAN CORING DEPTH ____ FT. ELEV. ____ FT.
FOOTAGE CORED (LF) ____ FT.
BOTTOM OF HOLE DEPTH 37.0 FT. ELEV. ____ FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT.
ELEV. ____ FT.
AFTER 24 HRS. DEPTH N/A FT.
ELEV. ____ FT.

BORING ADVANCED BY: POWER AUGERING X WASHBORING ____

STRATUM DEPTH FT.	ELEV.	SAMPLE DEPTH FROM FT.	TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	Qp	LABORATORY RESULTS LL	PI	%M	STRATUM DESCRIPTION
		1.0	2.5	1	SS	5-24-65 N=89				6.7	**Silty SAND (SM)** with caliche - brown; fine grained; very dense; dry
2.5	-2.5										
		3.0	4.5	2	SS	15-16-12 N=28				4.5	**Silty SAND (SM)** with trace caliche - light brown; fine grained; medium dense to very dense; dry
5.0	-5.0	5.0	6.5	3	SS	12-19-33 N=52				5.2	
7.5	-7.5										
		8.0	9.5	4	SS	14-19-32 N=51				4.3	
10.0	-10.0										
12.5	-12.5	13.0	14.0	5	SS	35-60+ N=>60				6.6	**Silty SAND (SM)** with trace caliche - orangish brown; fine grained; very dense; dry
15.0	-15.0										
17.5	-17.5	18.0	19.0	6	SS	32-90+ N=>90				5.8	
20.0	-20.0										

REMARKS:

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

GEOServices, LLC-Geotechnical and Materials Engineers

LOG OF BORING B-111
SHEET 2 OF 2

DRILLING CO: Apex Geoscience Inc.
DRILLER:
LOGGED BY: Sammy Joe Allison

BORING NO. / LOCATION: B-111

DATE: July 20, 2015
SURFACE ELEV. ____ FT.
REFUSAL: Yes DEPTH 37.0 FT. ELEV. ____ FT.
SAMPLED: 37.0 FT. 11.3 M
TOP OF ROCK DEPTH 37.0 FT. ELEV. ____ FT.
BEGAN CORING DEPTH ____ FT. ELEV. ____ FT.
FOOTAGE CORED (LF) ____ FT.
BOTTOM OF HOLE DEPTH 37.0 FT. ELEV. ____ FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT.
ELEV. ____ FT.
AFTER 24 HRS. DEPTH N/A FT.
ELEV. ____ FT.

BORING ADVANCED BY: POWER AUGERING X WASHBORING ____

STRATUM DEPTH FT.	ELEV.	SAMPLE DEPTH FROM FT.	TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	Qp	LABORATORY RESULTS LL	PI	%M	STRATUM DESCRIPTION
											CONTINUED
22.5	-22.5										
		23.0	24.0	7	SS	37-65+ N=>65				6	
25.0	-25.0										
27.5	-27.5										
		28.0	29.5	8	SS	34-33-33 N=66				4.3	**Silty SAND (SM)** with trace caliche - orangish brown; fine grained; very dense; dry
30.0	-30.0										
32.5	-32.5										
		33.0	34.5	9	SS	24-31-48 N=79				2.5	
35.0	-35.0										
											AUGER REFUSAL AT 37 FEET
37.5	-37.5										
40.0	-40.0										

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING AB-1
SHEET 1 OF 2

DRILLING CO: Apex Geoscience Inc.
DRILLER:
LOGGED BY: Sammy Joe Allison

BORING NO. / LOCATION: AB-1

DATE: July 15, 2015 | SURFACE ELEV. ____ FT.
REFUSAL: No | DEPTH ____ FT. | ELEV. ____ FT.
SAMPLED: 25.0 FT. | 7.6 M
TOP OF ROCK: DEPTH ____ FT. | ELEV. ____ FT.
BEGAN CORING: DEPTH ____ FT. | ELEV. ____ FT.
FOOTAGE CORED (LF): ____ FT.
BOTTOM OF HOLE DEPTH: 25.0 FT. | ELEV. ____ FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. ELEV. ____ FT.
AFTER 24 HRS. DEPTH N/A FT. ELEV. ____ FT.

BORING ADVANCED BY: POWER AUGERING X | WASHBORING ____

STRATUM DEPTH FT.	ELEV.	SAMPLE DEPTH FROM FT.	SAMPLE DEPTH TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	Qp	LABORATORY RESULTS LL	PI	%M	STRATUM DESCRIPTION
		1.0	2.5	1	SS	20-32-16 N=48				3.3	**Silty SAND (SM)** with caliche - brown; fine grained; dense; dry
2.5	-2.5										
		3.0	4.5	2	SS	22-30-22 N=52				3.9	**Silty SAND (SM)** with caliche - light brown; fine grained; very dense; dry
5.0	-5.0	5.0	6.5	3	SS	13-20-19 N=39				6.7	**Silty SAND (SM)** with caliche - orangish brown; fine grained; dense to very dense; dry
7.5	-7.5										
		8.0	9.5	4	SS	13-19-24 N=43				6.2	
10.0	-10.0										
12.5	-12.5										
		13.0	14.3	5	SS	16-19-19/4" N=19/4"				4.3	
15.0	-15.0										
17.5	-17.5										
		18.0	18.8	6	SS	29-21/3" N=21/3"				4.9	**Silty SAND (SM)** with trace caliche - orangish brown; fine grained; very dense; dry
20.0	-20.0										

REMARKS:

GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING AB-1
SHEET 2 OF 2

DRILLING CO Apex Geoscience Inc.
DRILLER
LOGGED BY Sammy Joe Allison

BORING NO. / LOCATION AB-1

DATE July 15, 2015 SURFACE ELEV. FT.
REFUSAL: No DEPTH FT. ELEV. FT.
SAMPLED 25.0 FT. 7.6 M
TOP OF ROCK DEPTH FT. ELEV. FT.
BEGAN CORING DEPTH FT. ELEV. FT.
FOOTAGE CORED (LF) FT.
BOTTOM OF HOLE DEPTH 25.0 FT. ELEV. FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT.
ELEV. FT.
AFTER 24 HRS. DEPTH N/A FT.
ELEV. FT.

BORING ADVANCED BY: POWER AUGERING X WASHBORING

STRATUM DEPTH FT.	STRATUM DEPTH ELEV.	SAMPLE DEPTH FROM FT.	SAMPLE DEPTH TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	FIELD RESULTS Qp	LABORATORY RESULTS LL	LABORATORY RESULTS PI	LABORATORY RESULTS %M	STRATUM DESCRIPTION
											CONTINUED
22.5	-22.5										**Silty SAND (SM)** with trace caliche - orangish brown; fine grained; very dense; dry
		23.0	23.8	7	SS	26-24/4" N=24/4"				3.2	
25.0	-25.0										**BORING TERMINATED AT 25 FEET**
27.5	-27.5										
30.0	-30.0										
32.5	-32.5										
35.0	-35.0										
37.5	-37.5										
40.0	-40.0										

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING AB-2
SHEET 1 OF 2

DRILLING CO Apex Geoscience Inc.
DRILLER
LOGGED BY Sammy Joe Allison

BORING NO. / LOCATION AB-2

DATE July 13, 2015 SURFACE ELEV. ___ FT.
REFUSAL: No DEPTH ___ FT. ELEV. ___ FT.
SAMPLED 25.0 FT. 7.6 M
TOP OF ROCK DEPTH ___ FT. ELEV. ___ FT.
BEGAN CORING DEPTH ___ FT. ELEV. ___ FT.
FOOTAGE CORED (LF) ___ FT.
BOTTOM OF HOLE DEPTH 25.0 FT. ELEV. ___ FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT.
ELEV. ___ FT.
AFTER 24 HRS. DEPTH N/A FT.
ELEV. ___ FT.

BORING ADVANCED BY: POWER AUGERING X WASHBORING ___

STRATUM DEPTH FT.	STRATUM DEPTH ELEV.	SAMPLE DEPTH FROM FT.	SAMPLE DEPTH TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	FIELD RESULTS Qp	LABORATORY RESULTS LL	LABORATORY RESULTS PI	%M	STRATUM DESCRIPTION
		1.0	2.5	1	SS	4-4-5 N=9				4.8	**Silty SAND (SM)** with caliche - brown; fine grained; loose; dry
2.5	-2.5										
		3.0	4.5	2	SS	10-10-13 N=23				5.7	**Silty SAND (SM)** with caliche - light brown; fine grained; medium dense; dry
5.0	-5.0	5.0	6.5	3	SS	11-12-17 N=29				5.5	
7.5	-7.5	8.0	9.5	4	SS	10-17-20 N=37				3.7	**Silty SAND (SM)** with trace caliche - orangish brown; dense; dry
10.0	-10.0										
12.5	-12.5	13.0	14.5	5	SS	7-25-30 N=55				3.4	**Silty SAND (SM)** with caliche - orangish brown; fine grained; very dense; dry
15.0	-15.0										
17.5	-17.5	18.0	19.5	6	SS	16-22-30 N=52				3.1	
20.0	-20.0										

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

DRILLING CO: Apex Geoscience Inc.
DRILLER:
LOGGED BY: Sammy Joe Allison

BORING NO. / LOCATION: AB-2

DATE	July 13, 2015	SURFACE ELEV.	FT.
REFUSAL:	No	DEPTH FT.	ELEV. FT.
SAMPLED	25.0 FT.	7.6 M	
TOP OF ROCK		DEPTH FT.	ELEV. FT.
BEGAN CORING		DEPTH FT.	ELEV. FT.
FOOTAGE CORED (LF)		FT.	
BOTTOM OF HOLE DEPTH	25.0 FT.		ELEV. FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT.; ELEV. FT.
AFTER 24 HRS. DEPTH N/A FT.; ELEV. FT.

BORING ADVANCED BY: POWER AUGERING X WASHBORING

STRATUM DEPTH FT.	ELEV.	SAMPLE DEPTH FROM FT.	TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	Qp	LABORATORY RESULTS LL	PI	%M	STRATUM DESCRIPTION
											CONTINUED
22.5	-22.5										**Silty SAND (SM)** with caliche - orangish brown; fine grained; very dense; dry
		23.0	23.8	7	SS	38-50/4" N=50/4"					
25.0	-25.0										**BORING TERMINATED AT 25 FEET**
27.5	-27.5										
30.0	-30.0										
32.5	-32.5										
35.0	-35.0										
37.5	-37.5										
40.0	-40.0										

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING TF-1
SHEET 1 OF 2

DRILLING CO: Apex Geoscience Inc.
DRILLER:
LOGGED BY: Sammy Joe Allison

BORING NO. / LOCATION: TF-1

DATE: July 16, 2015 | SURFACE ELEV. ______ FT.
REFUSAL: Yes | DEPTH 40.0 FT. | ELEV. ______ FT.
SAMPLED: 40.0 FT. | 12.2 M
TOP OF ROCK | DEPTH 40.0 FT. | ELEV. ______ FT.
BEGAN CORING | DEPTH ______ FT. | ELEV. ______ FT.
FOOTAGE CORED (LF) ______ FT.
BOTTOM OF HOLE DEPTH 40.0 FT. | ELEV. ______ FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. ELEV. ______ FT.
AFTER 24 HRS. DEPTH N/A FT. ELEV. ______ FT.

BORING ADVANCED BY: POWER AUGERING X | WASHBORING ______

STRATUM DEPTH FT.	ELEV.	SAMPLE DEPTH FROM FT.	SAMPLE DEPTH TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	Qp	LABORATORY RESULTS LL	PI	%M	STRATUM DESCRIPTION
		1.0	2.5	1	SS	4-24-15 N=39				3.0	**Silty SAND (SM)** with caliche - grayish brown and brown; fine grained; dense; dry
2.5	-2.5										
		3.0	4.5	2	SS	24-38-27 N=65				2.8	**Silty SAND (SM)** with caliche -light brown to brown; fine grained; very dense to dense; dry
5.0	-5.0										
		5.0	6.5	3	SS	11-12-20 N=32				4.8	
7.5	-7.5										
		8.0	9.5	4	SS	20-20-28 N=48				2.8	
10.0	-10.0										
12.5	-12.5										**Silty SAND (SM)** with trace caliche - orangish brown; fine grained; very dense; dry
		13.0	14.3	5	SS	20-48-32/3" N=32/3"				5.8	
15.0	-15.0										
17.5	-17.5										
		18.0	19.3	6	SS	26-48-26/3" N=26/3"				5.4	
20.0	-20.0										

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING TF-1
SHEET 2 OF 2

DRILLING CO: Apex Geoscience Inc.
DRILLER:
LOGGED BY: Sammy Joe Allison

BORING NO. / LOCATION: TF-1

DATE: July 21, 2015 — SURFACE ELEV. ____ FT.
REFUSAL: Yes — DEPTH 40.0 FT. — ELEV. ____ FT.
SAMPLED: 40.0 FT. 12.2 M
TOP OF ROCK: DEPTH 40.0 FT. — ELEV. ____ FT.
BEGAN CORING: DEPTH ____ FT. — ELEV. ____ FT.
FOOTAGE CORED (LF): ____ FT.
BOTTOM OF HOLE DEPTH: 40.0 FT. — ELEV. ____ FT.
BORING ADVANCED BY: POWER AUGERING X — WASHBORING ____

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. — ELEV. ____ FT.
AFTER 24 HRS.: DEPTH N/A FT. — ELEV. ____ FT.

STRATUM DEPTH FT.	ELEV.	SAMPLE DEPTH FROM FT.	TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	Qp	LAB LL	PI	%M	STRATUM DESCRIPTION
											CONTINUED
22.5	-22.5										
		23.0	24.5	7	SS	15-16-20 N=36				2.7	
25.0	-25.0										**Silty SAND (SM)** with trace caliche - orangish brown; fine grained; very dense; dry
27.5	-27.5										
		28.0	29.3	8	SS	28-50-22/3" N=22/3"				3.0	
30.0	-30.0										
32.5	-32.5										
		33.0	33.4	10	SS	N=76/5"				3.7	
35.0	-35.0										**Silty SAND (SM)** with trace caliche - orangish brown; fine grained; very dense; dry
37.5	-37.5										
		38.0	38.3	11	SS	N=100/4"				4.6	
40.0	-40.0										

AUGER REFUSAL AT 40 FEET

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING TF-2
SHEET 1 OF 2

DRILLING CO Apex Geoscience Inc.
DRILLER
LOGGED BY Sammy Joe Allison

BORING NO. / LOCATION TF-2

DATE July 16, 2015 SURFACE ELEV. ____ FT.
REFUSAL: No DEPTH ____ FT. ELEV. ____ FT.
SAMPLED 25.0 FT. 7.6 M
TOP OF ROCK DEPTH ____ FT. ELEV. ____ FT.
BEGAN CORING DEPTH ____ FT. ELEV. ____ FT.
FOOTAGE CORED (LF) ____ FT.
BOTTOM OF HOLE DEPTH 25.0 FT. ELEV. ____ FT.
BORING ADVANCED BY: POWER AUGERING X WASHBORING ____

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT.
ELEV. ____ FT.
AFTER 24 HRS. DEPTH N/A FT.
ELEV. ____ FT.

STRATUM DEPTH FT.	STRATUM DEPTH ELEV.	SAMPLE DEPTH FROM FT.	SAMPLE DEPTH TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	Qp	LABORATORY RESULTS LL	PI	%M	STRATUM DESCRIPTION
		1.0	2.5	1	SS	1-2-2 N=4		28	NP	4.3	**Silty SAND (SM)** with trace caliche - brown; fine grained; very loose; dry
2.5	-2.5										
		3.0	4.5	2	SS	9-11-11 N=22				4.8	
5.0	-5.0										
		5.0	6.5	3	SS	8-10-15 N=25				3.9	**Silty SAND (SM)** with trace caliche - light brown; fine grained; medium dense to very dense; dry
7.5	-7.5										
		8.0	9.5	4	SS	15-40-57 N=97				6.7	
10.0	-10.0										
12.5	-12.5										
		13.0	14.2	5	SS	25-55-25/2" N=25/2"				5.9	
15.0	-15.0										**Silty SAND (SM)** with trace caliche - orangish brown; fine grained; very dense; dry
17.5	-17.5										
		18.0	18.8	6	SS	23-70+ N=>70				5.9	
20.0	-20.0										

REMARKS:

GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING TF-2
SHEET 2 OF 2

DRILLING CO Apex Geoscience Inc.
DRILLER
LOGGED BY Sammy Joe Allison

BORING NO. / LOCATION TF-2

DATE July 16, 2015 SURFACE ELEV. ___ FT.
REFUSAL: No DEPTH ___ FT. ELEV. ___ FT.
SAMPLED 25.0 FT. 7.6 M
TOP OF ROCK DEPTH ___ FT. ELEV. ___ FT.
BEGAN CORING DEPTH ___ FT. ELEV. ___ FT.
FOOTAGE CORED (LF) ___ FT.
BOTTOM OF HOLE DEPTH 25.0 FT. ELEV. ___ FT.

BORING ADVANCED BY: POWER AUGERING X WASHBORING ___

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. ELEV. ___ FT.
AFTER 24 HRS. DEPTH N/A FT. ELEV. ___ FT.

STRATUM DEPTH FT.	ELEV.	SAMPLE DEPTH FROM FT.	TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	Qp	LABORATORY RESULTS LL	PI	%M	STRATUM DESCRIPTION
											CONTINUED
22.5	-22.5										**Silty SAND (SM)** with trace caliche - orangish brown; fine grained; very dense; dry
		23.0	24.5	7	SS	8-29-35 N=64				4.2	
25.0	-25.0										**BORING TERMINATED AT 25 FEET**
27.5	-27.5										
30.0	-30.0										
32.5	-32.5										
35.0	-35.0										
37.5	-37.5										
40.0	-40.0										

REMARKS: ___

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING TF-3
SHEET 1 OF 2

DRILLING CO Apex Geoscience Inc.
DRILLER
LOGGED BY Sammy Joe Allison

BORING NO. / LOCATION TF-3

DATE July 16, 2015 SURFACE ELEV. ____ FT.
REFUSAL: No DEPTH ____ FT. ELEV. ____ FT.
SAMPLED 25.0 FT. 7.6 M
TOP OF ROCK DEPTH ____ FT. ELEV. ____ FT.
BEGAN CORING DEPTH ____ FT. ELEV. ____ FT.
FOOTAGE CORED (LF) ____ FT.
BOTTOM OF HOLE DEPTH 25.0 FT. ELEV. ____ FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. ELEV. ____ FT.
AFTER 24 HRS. DEPTH N/A FT. ELEV. ____ FT.

BORING ADVANCED BY: POWER AUGERING X WASHBORING ____

STRATUM DEPTH FT.	ELEV.	SAMPLE DEPTH FROM FT.	TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	Qp	LABORATORY RESULTS LL	PI	%M	STRATUM DESCRIPTION
		1.0	2.5	1	SS	11-9-8 N=17				4.3	**Silty SAND (SM)** with caliche - grayish brown; fine grained; medium desne; dry
2.5	-2.5										
		3.0	4.5	2	SS	17-11-10 N=21				4.6	**Silty SAND (SM)** with caliche - brown; fine grained; very dense to dense; dry
5.0	-5.0	5.0	6.5	3	SS	14-16-20 N=36				3.9	
7.5	-7.5										
		8.0	9.5	4	SS	17-37-48 N=85				5.5	**Silty SAND (SM)** with trace caliche - orangish brown; fine grained; very dense; dry
10.0	-10.0										
12.5	-12.5										
		13.0	14.5	5	SS	18-28-45 N=73				9.0	
15.0	-15.0										
17.5	-17.5										
		18.0	19.5	6	SS	17-33-50 N=83				4.5	
20.0	-20.0										

REMARKS:

GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING TF-3
SHEET 2 OF 2

DRILLING CO: Apex Geoscience Inc.
DRILLER:
LOGGED BY: Sammy Joe Allison

BORING NO. / LOCATION: TF-3

DATE: July 16, 2015 | SURFACE ELEV. ___ FT.
REFUSAL: No | DEPTH ___ FT. | ELEV. ___ FT.
SAMPLED: 25.0 FT. | 7.6 M
TOP OF ROCK | DEPTH ___ FT. | ELEV. ___ FT.
BEGAN CORING | DEPTH ___ FT. | ELEV. ___ FT.
FOOTAGE CORED (LF) ___ FT.
BOTTOM OF HOLE DEPTH 25.0 FT. | ELEV. ___ FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. ELEV. ___ FT.
AFTER 24 HRS. DEPTH N/A FT. ELEV. ___ FT.

BORING ADVANCED BY: POWER AUGERING X | WASHBORING ___

STRATUM DEPTH FT.	STRATUM DEPTH ELEV.	SAMPLE DEPTH FROM FT.	SAMPLE DEPTH TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	FIELD RESULTS Qp	LABORATORY RESULTS LL	LABORATORY RESULTS PI	LABORATORY RESULTS %M	STRATUM DESCRIPTION
											CONTINUED
22.5	-22.5										**Silty SAND (SM)** with trace caliche - orangish brown; fine grained; very dense; dry
		23.0	24.5	7	SS	34-37-60 N=97				3.8	
25.0	-25.0										**BORING TERMINATED AT 25 FEET**
27.5	-27.5										
30.0	-30.0										
32.5	-32.5										
35.0	-35.0										
37.5	-37.5										
40.0	-40.0										

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING TF-4
SHEET 1 OF 2

DRILLING CO Apex Geoscience Inc.
DRILLER
LOGGED BY Sammy Joe Allison

BORING NO. / LOCATION TF-4

DATE July 16, 2015 SURFACE ELEV. ____ FT.
REFUSAL: Yes DEPTH 40.0 FT. ELEV. ____ FT.
SAMPLED 40.0 FT. 12.2 M
TOP OF ROCK DEPTH ____ FT. ELEV. ____ FT.
BEGAN CORING DEPTH ____ FT. ELEV. ____ FT.
FOOTAGE CORED (LF) ____ FT.
BOTTOM OF HOLE DEPTH 40.0 FT. ELEV. ____ FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT.
ELEV. ____ FT.
AFTER 24 HRS. DEPTH N/A FT.
ELEV. ____ FT.

BORING ADVANCED BY: POWER AUGERING X WASHBORING ____

STRATUM DEPTH FT.	ELEV.	SAMPLE DEPTH FROM FT.	TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	Qp	LABORATORY RESULTS LL	PI	%M	STRATUM DESCRIPTION
		1.0	2.5	1	SS	4-40-20 N=60				3.7	**Silty SAND (SM)** with caliche - grayish brown; fine grained; very dense; dry
2.5	-2.5										
		3.0	4.5	2	SS	18-18-16 N=34				3.9	**Silty SAND (SM)** with trace caliche - light brown; fine grained; dense to very dense; dry
5.0	-5.0	5.0	6.5	3	SS	20-20-30 N=50				6.6	
7.5	-7.5										
		8.0	9.5	4	SS	14-24-35 N=59				7.4	**Silty SAND (SM)** with trace caliche - brown; fine grained; very dense; dry
10.0	-10.0										
12.5	-12.5										
		13.0	14.2	5	SS	20-35-47/2" N=47/2"				5.2	
15.0	-15.0										
17.5	-17.5										
		18.0	19.2	6	SS	19-34-51/2" N=51/2"				4.3	
20.0	-20.0										

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING TF-4
SHEET 2 OF 2

DRILLING CO: Apex Geoscience Inc.
DRILLER:
LOGGED BY: Sammy Joe Allison

BORING NO. / LOCATION: TF-4

DATE: July 21, 2015 | SURFACE ELEV. ____ FT.
REFUSAL: Yes | DEPTH 40.0 FT. | ELEV. ____ FT.
SAMPLED: 40.0 FT. | 12.2 M
TOP OF ROCK | DEPTH 40.0 FT. | ELEV. ____ FT.
BEGAN CORING | DEPTH ____ FT. | ELEV. ____ FT.
FOOTAGE CORED (LF) ____ FT.
BOTTOM OF HOLE DEPTH 40.0 FT. | ELEV. ____ FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. ELEV. ____ FT.
AFTER 24 HRS. DEPTH N/A FT. ELEV. ____ FT.

BORING ADVANCED BY: POWER AUGERING X WASHBORING ____

STRATUM DEPTH FT.	ELEV.	SAMPLE DEPTH FROM FT.	TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	Qp	LABORATORY RESULTS LL	PI	%M	STRATUM DESCRIPTION
											CONTINUED
22.5	-22.5										
		23.0	24.5	7	SS	20-34-51 N=85				3.9	
25.0	-25.0										**Silty SAND (SM)** - orangish brown; fine grained; very dense; dry
27.5	-27.5										
		28.0	28.8	8	SS	62-47/3" N=47/3"				6.5	
30.0	-30.0										
32.5	-32.5										
		33.0	33.3	9	SS	N=100/4"				3.3	
35.0	-35.0										**Silty SAND (SM)** - orangish brown; fine grained; very dense; dry
37.5	-37.5										
		38.0	38.1	10	SS	N=100/1"				3.5	
40.0	-40.0										**AUGER REFUSAL AT 40 FEET**

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING TF-5
SHEET 1 OF 2

DRILLING CO Apex Geoscience Inc.
DRILLER
LOGGED BY Sammy Joe Allison

BORING NO. / LOCATION TF-5

DATE July 16, 2015 SURFACE ELEV. ____ FT.
REFUSAL: No DEPTH ____ FT. ELEV. ____ FT.
SAMPLED 25.0 FT. 7.6 M
TOP OF ROCK DEPTH ____ FT. ELEV. ____ FT.
BEGAN CORING DEPTH ____ FT. ELEV. ____ FT.
FOOTAGE CORED (LF) ____ FT.
BOTTOM OF HOLE DEPTH 25.0 FT. ELEV. ____ FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. ELEV. ____ FT.
AFTER 24 HRS. DEPTH N/A FT. ELEV. ____ FT.

BORING ADVANCED BY: POWER AUGERING X WASHBORING ____

STRATUM DEPTH FT.	ELEV.	SAMPLE DEPTH FROM FT.	TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	Qp	LABORATORY RESULTS LL	PI	%M	STRATUM DESCRIPTION
		1.0	2.5	1	SS	18-10-12 N=22				4.6	**Silty SAND (SM)** with caliche - grayish brown; fine grained; medium dense; dry
2.5	-2.5										
		3.0	4.5	2	SS	6-11-8 N=19				5.2	**Silty SAND (SM)** with caliche - light brown; fine grained; medium dense to loose to very dense; dry
5.0	-5.0	5.0	6.5	3	SS	2-2-3 N=5				5.5	
7.5	-7.5										
		8.0	9.5	4	SS	15-24-39 N=63				8.1	
10.0	-10.0										
12.5	-12.5										**Silty SAND (SM)** with trace caliche - orangish brown; fine grained; very dense; dry
		13.0	14.5	5	SS	26-46-60 N=106				6.4	
15.0	-15.0										
17.5	-17.5										
		18.0	19.3	6	SS	22-39-58 N=97				5.0	
20.0	-20.0										

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Consolidated Interim Storage Facility
Andrews, Texas
GEOServices Project No.: 31-151247

LOG OF BORING TF-5
SHEET 2 OF 2

DRILLING CO: Apex Geoscience Inc.
DRILLER:
LOGGED BY: Sammy Joe Allison

BORING NO. / LOCATION: TF-5

DATE: July 16, 2015 | SURFACE ELEV. ____ FT.
REFUSAL: No | DEPTH ____ FT. | ELEV. ____ FT.
SAMPLED: 25.0 FT. | 7.6 M
TOP OF ROCK | DEPTH ____ FT. | ELEV. ____ FT.
BEGAN CORING | DEPTH ____ FT. | ELEV. ____ FT.
FOOTAGE CORED (LF) ____ FT.
BOTTOM OF HOLE DEPTH 25.0 FT. | ELEV. ____ FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. | ELEV. ____ FT.
AFTER 24 HRS. DEPTH N/A FT. | ELEV. ____ FT.

BORING ADVANCED BY: POWER AUGERING X | WASHBORING ____

STRATUM DEPTH FT.	STRATUM DEPTH ELEV.	SAMPLE DEPTH FROM FT.	SAMPLE DEPTH TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	FIELD RESULTS Qp	LABORATORY RESULTS LL	LABORATORY RESULTS PI	LABORATORY RESULTS %M	STRATUM DESCRIPTION
											CONTINUED
22.5	-22.5										**Silty SAND (SM)** with trace caliche - orangish brown; fine grained; very dense; dry
		23.0	24.5	7	SS	24-41-45 N=86				4.2	
25.0	-25.0										**BORING TERMINATED AT 25 FEET**
27.5	-27.5										
30.0	-30.0										
32.5	-32.5										
35.0	-35.0										
37.5	-37.5										
40.0	-40.0										

REMARKS:

GEOServices, LLC, Geotechnical and Materials Engineers

APPENDIX B

Soil Laboratory Data

SOIL DATA SUMMARY Consolidated Interim Storage Facility - Andrews, Texas GEOServices Project No. 31-151247 August 5, 2015								
Boring Number	Sample Number	Depth (feet)	Natural Moisture Content	Atterberg Limits			Finer than 200 Sieve (%)	Soil Type
				LL	PL	PI		
B-101	1	1.0 - 2.5	3.6%				48	
	2	3.0 - 4.5	3.9%					
	3	5.0 - 6.5	6.5%					
	4	8.0 - 9.5	7.8%				37	
	5	13.0 - 14.5	6.7%					
	6	18.0 - 19.5	5.7%					
	7	23.0 - 24.5	5.7%					
	9	31.0 - 31.2	5.7%					
	10	33.0 - 33.2	7.7%					
B-102	1	1.0 - 2.5	3.4%					
	2	3.0 - 3.8	2.8%					
	3	5.0 - 6.5	2.9%					
	4	8.0 - 9.5	4.0%					
	5	13.0 - 13.8	6.0%					
	6	18.0 - 18.8	5.8%					
	7	23.0 - 23.8	2.9%					
B-103	1	1.0 - 2.5	4.3%	26	N.P.			
	2	3.0 - 4.5	4.8%					
	3	5.0 - 6.5	5.8%					
	4	8.0 - 9.5	7.1%					
	5	13.0 - 14.4	6.3%					
	6	18.0 - 19.5	6.1%					
	7	23.0 - 24.5	4.5%					
B-104	1	1.0 - 2.3	3.1%					
	2	3.0 - 3.8	2.5%					
	3	5.0 - 6.5	4.1%					
	4	8.0 - 9.5	6.9%					
	5	13.0 - 14.5	6.0%					
	6	18.0 - 19.5	4.6%					
	7	23.0 - 24.5	3.1%					
B-105	1	1.0 - 1.8	3.3%					
	2	5.0 - 6.5	5.3%					
	3	8.0 - 9.5	8.1%					
	4	13.0 - 13.5	4.8%					
	6	18.0 - 19.0	4.1%					

SOIL DATA SUMMARY Consolidated Interim Storage Facility - Andrews, Texas GEOServices Project No. 31-151247 August 5, 2015								
Boring Number	Sample Number	Depth (feet)	Natural Moisture Content	Atterberg Limits			Finer than 200 Sieve (%)	Soil Type
				LL	PL	PI		
B-106	1	1.0 - 2.5	4.5%					
	2	3.0 - 4.5	3.9%					
	3	5.0 - 6.5	3.9%					
	4	8.0 - 9.5	5.3%				41	
	5	13.0 - 13.9	6.7%					
	6	18.0 - 19.5	6.8%					
	7	23.0 - 24.4	6.2%					
B-107	1	1.0 - 1.8	5.3%					
	2	3.0 - 4.5	4.5%					
	3	5.0 - 6.5	4.1%					
	4	8.0 - 9.5	5.7%					
	5	13.0 - 14.0	7.2%					
	6	18.0 - 19.5	6.3%					
	7	23.0 - 24.4	4.2%					
B-108	1	1.0 - 2.5	4.9%					
	2	3.0 - 4.5	4.9%					
	3	5.0 - 6.5	6.0%					
	4	8.0 - 9.4	6.3%					
	5	13.0 - 13.8	8.4%					
	6	18.0 - 18.8	6.6%					
	7	23.0 - 23.4	6.0%					
B-109	1	1.0 - 2.5	3.4%					
	2	3.0 - 4.5	4.2%					
	3	5.0 - 6.5	3.8%					
	4	8.0 - 9.0	3.2%					
	5	13.0 - 13.3	8.5%					
	6	18.0 - 18.7	6.3%					
	7	23.0 - 24.5	4.7%					
B-110	1	1.0 - 2.5	5.0%	29	N.P.			
	2	3.0 - 4.5	4.7%					
	3	5.0 - 6.5	6.0%					
	4	8.0 - 9.5	8.9%					
	5	13.0 - 14.0	7.1%					
	6	18.0 - 19.0	5.1%					
	7	23.0 - 24.5	4.4%					

SOIL DATA SUMMARY Consolidated Interim Storage Facility - Andrews, Texas GEOServices Project No. 31-151247 August 5, 2015								
Boring Number	Sample Number	Depth (feet)	Natural Moisture Content	Atterberg Limits			Finer than 200 Sieve (%)	Soil Type
				LL	PL	PI		
B-111	1	1.0 - 2.5	6.7%					
	2	3.0 - 4.5	4.5%				44	
	3	5.0 - 6.5	5.2%					
	4	8.0 - 9.5	4.3%					
	5	13.0 - 14.0	6.6%				30	
	6	18.0 - 19.0	5.8%					
	7	23.0 - 24.0	6.0%					
	8	28.0 - 29.5	4.3%					
	9	33.0 - 34.5	2.5%					
AB-1	1	1.0 - 2.5	3.3%					
	2	3.0 - 4.5	3.9%					
	3	5.0 - 6.5	6.7%					
	4	8.0 - 9.5	6.2%				24	
	5	13.0 - 14.3	4.3%					
	6	18.0 - 18.8	4.9%					
	7	23.0 - 23.8	3.2%					
AB-2	1	1.0 - 2.5	4.8%				35	
	2	3.0 - 4.5	5.7%					
	3	5.0 - 6.5	5.5%					
	4	8.0 - 9.5	3.7%					
	5	13.0 - 14.5	3.4%					
	6	18.0 - 19.5	3.1%					
TF-1	1	1.0 - 2.5	3.0%					
	2	3.0 - 4.5	2.8%				45	
	3	5.0 - 6.5	4.8%					
	4	8.0 - 9.5	2.8%					
	5	13.0 - 14.3	5.8%					
	6	18.0 - 19.3	5.4%					
	7	23.0 - 24.5	2.7%					
	8	28.0 - 29.3	3.0%					
	9	33.0 - 33.4	3.7%					
	10	38.0 - 38.3	4.6%					
TF-2	1	1.0 - 2.5	4.3%	28	N.P.			
	2	3.0 - 4.5	4.8%					
	3	5.0 - 6.5	3.9%					
	4	8.0 - 9.5	6.7%					
	5	13.0 - 14.2	5.9%					
	6	18.0 - 18.8	5.9%					
	7	23.0 - 24.5	4.2%					

SOIL DATA SUMMARY Consolidated Interim Storage Facility - Andrews, Texas GEOServices Project No. 31-151247 August 5, 2015								
Boring Number	Sample Number	Depth (feet)	Natural Moisture Content	Atterberg Limits			Finer than 200 Sieve (%)	Soil Type
				LL	PL	PI		
TF-3	1	1.0 - 2.5	4.3%					
	2	3.0 - 4.5	4.6%					
	3	5.0 - 6.5	3.9%					
	4	8.0 - 9.5	5.5%					
	5	13.0 - 14.5	9.0%					
	6	18.0 - 19.5	4.5%					
	7	23.0 - 24.5	3.8%					
TF-4	1	1.0 - 2.5	3.7%					
	2	3.0 - 4.5	3.9%					
	3	5.0 - 6.5	6.6%					
	4	8.0 - 9.5	7.4%					
	5	13.0 - 14.2	5.2%				34	
	6	18.0 - 19.2	4.3%					
	7	23.0 - 24.5	3.9%					
	8	28.0 - 28.8	6.5%					
	9	33.0 - 33.3	3.3%					
	10	38.0 - 38.1	3.5%					
TF-5	1	1.0 - 2.5	4.6%					
	2	3.0 - 4.5	5.2%					
	3	5.0 - 6.5	5.5%					
	4	8.0 - 9.5	8.1%					
	5	13.0 - 14.5	6.4%					
	6	18.0 - 19.5	5.0%					
	7	23.0 - 24.5	4.2%					

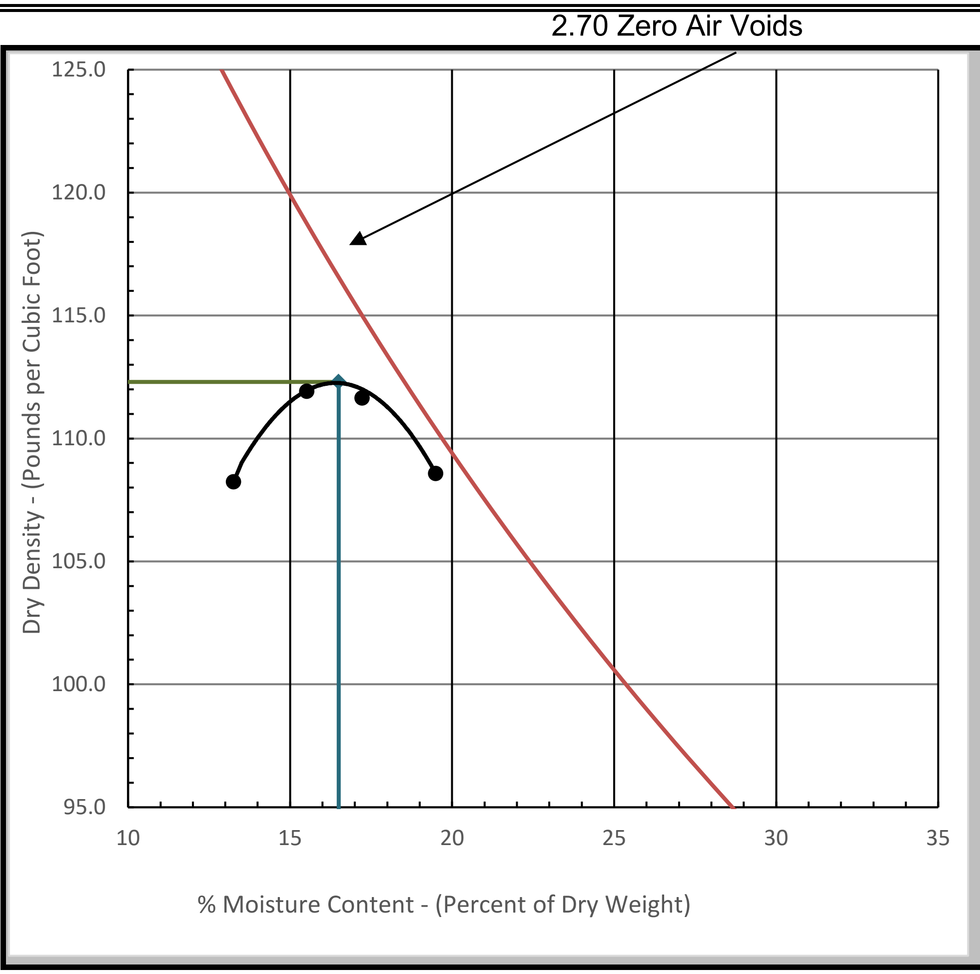
GEOServices, LLC-Geotechnical and Materials Engineers

LABORATORY COMPACTION OF SOILS
ASTM D 698 Method C

GEOServices, LLC-Geotechnical and Materials Engineers

GEOS Project Name:	WCS CISF - Andrews, TX		
GEOS Project Number:	31-151247	Report Date:	December 31, 2018
GEOS Log #:	NA	Date Received:	December 24, 2018

Sample Location:	B-101
Sample Depth:	0 - 10'
Sample Description:	Brown Silty Sandy Clay with rock



Max. Dry Density (pcf)
112.3
Optimum Moisture (%)
16.5

As Received W%	TNP
Rammer Type	Manual
Prep Method	Dry

ASTM D4718
Percent Oversize Material
60.09
OS Bulk Specific Gravity
TNP
Oversize Corrected Data Corrected MDD (pcf)
NA
Corrected Opt Moisture %
7.2

LL / PL / PI - Data By:		ASTM D4318	
Liquid Limit	22	Plasticity Index	9
Plastic Limit	13	Soil Type	CL

SOIL SPECIFIC GRAVITY BY ASTM D854
ASSUMED 2.70

NOTES

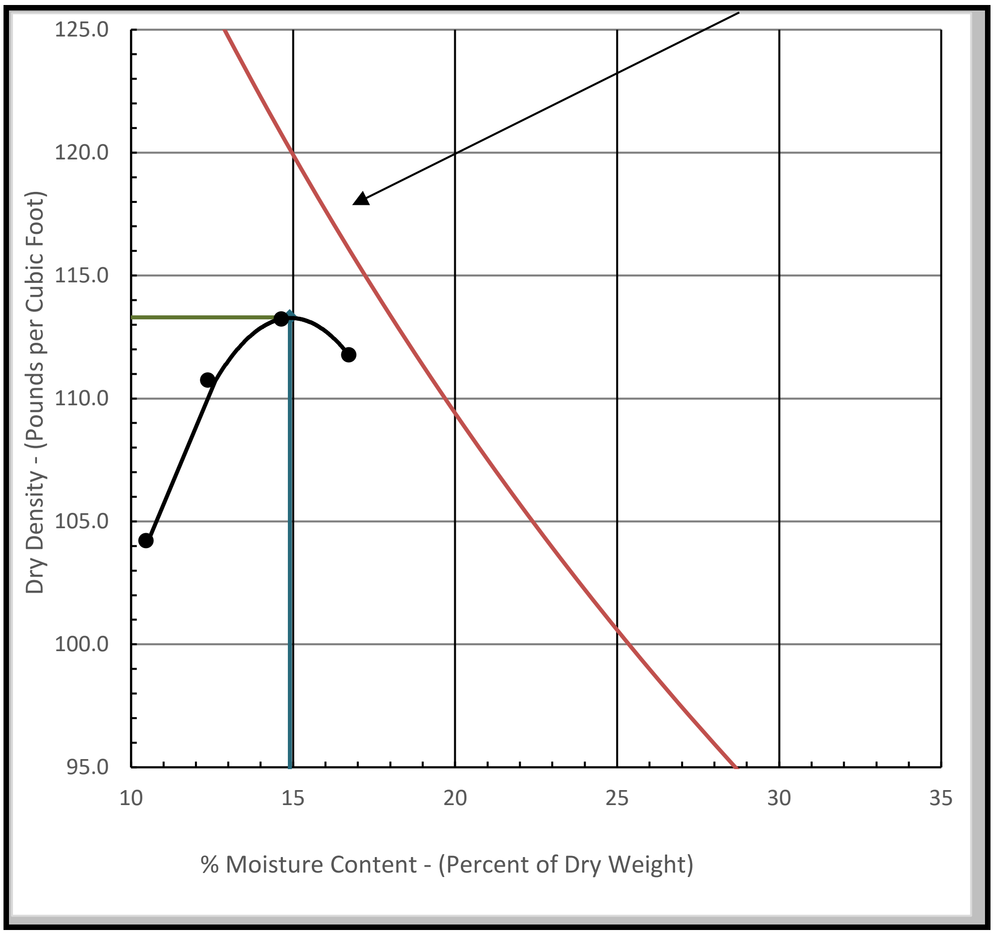
TIP = Test In Progress

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

LABORATORY COMPACTION OF SOILS
ASTM D 698 Method B

GEOS Project Name:	WCS CISF - Andrews, TX		
GEOS Project Number:	31-151247	Report Date:	December 31, 2018
GEOS Log #:		Date Received:	December 24, 2018

Sample Location:	B-111
Sample Depth:	0 - 10'
Sample Description:	Brown Silty Clay with rock



Max. Dry Density (pcf)
113.3
Optimum Moisture (%)
14.9

As Received W%	TNP
Rammer Type	Manual
Prep Method	Dry

ASTM D4718
Percent Oversize Material
47.72
OS Bulk Specific Gravity
TNP
Oversize Corrected Data Corrected MDD (pcf)
TNP
Corrected Opt Moisture %
8.3

LL / PL / PI - Data By:		ASTM D4318	
Liquid Limit	TIP	Plasticity Index	TIP
Plastic Limit	TIP	Soil Type	TIP

SOIL SPECIFIC GRAVITY BY ASTM D854
ASSUMED 2.70

NOTES

TIP = Test In Progress

CALIFORNIA BEARING RATIO
ASTM D1883

GEOServices, LLC-Geotechnical and Materials Engineers

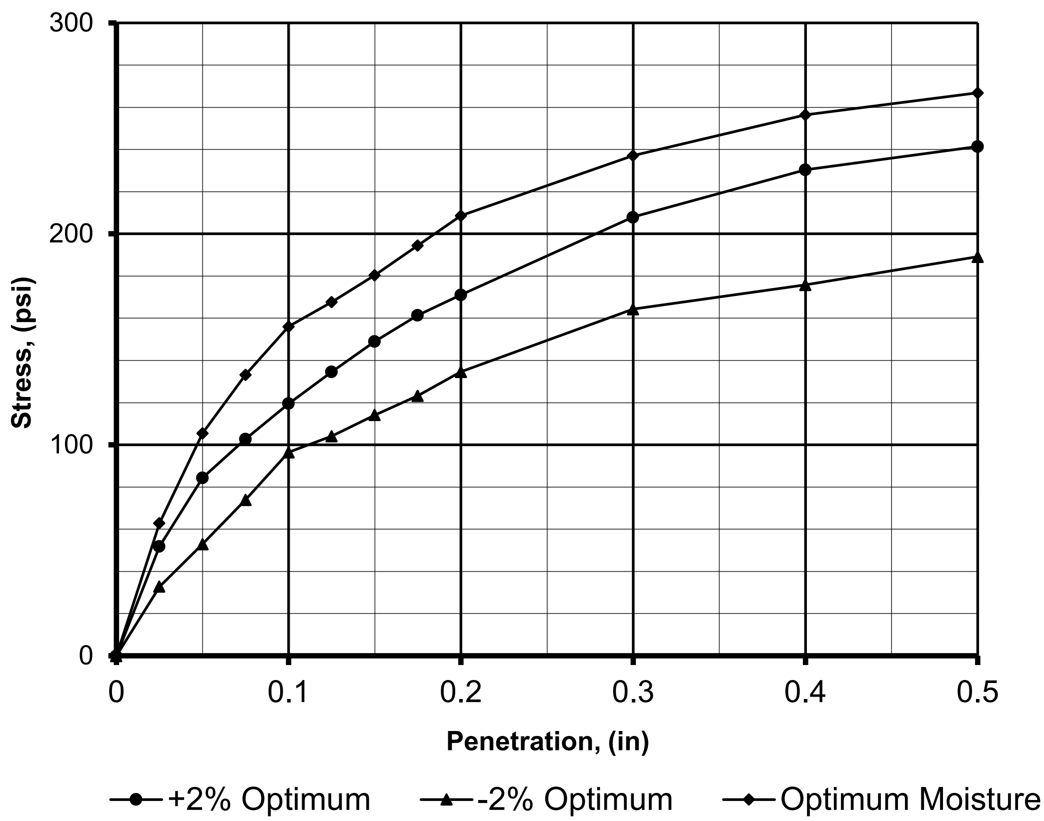
Project Name: **WCS - CISF**

Project #: **31-151247**

Sample ID: **B-101**

Sample Description: **Brown Silty Sand with Rock (CBR on -3/4 material)**

	@ + 2% Optimum Moisture		@ Optimum Moisture Content		@ -2% Optimum Moisture	
Wet Density	128.0	pcf	124.8	pcf	120.4	pcf
Dry Density	108.5	pcf	107.1	pcf	105.1	pcf
Water Content	17.9%		16.6%		14.5%	
Compaction	96.6%		95.4%		93.6%	
Swell	0.09%		0.11%		-0.07%	
CBR @ .1"	**12.0**		**15.6**		**9.6**	
CBR @ .2"	**11.4**		**13.9**		**9.0**	



GEOServices, LLC-Geotechnical and Materials Engineers

CALIFORNIA BEARING RATIO
ASTM D1883

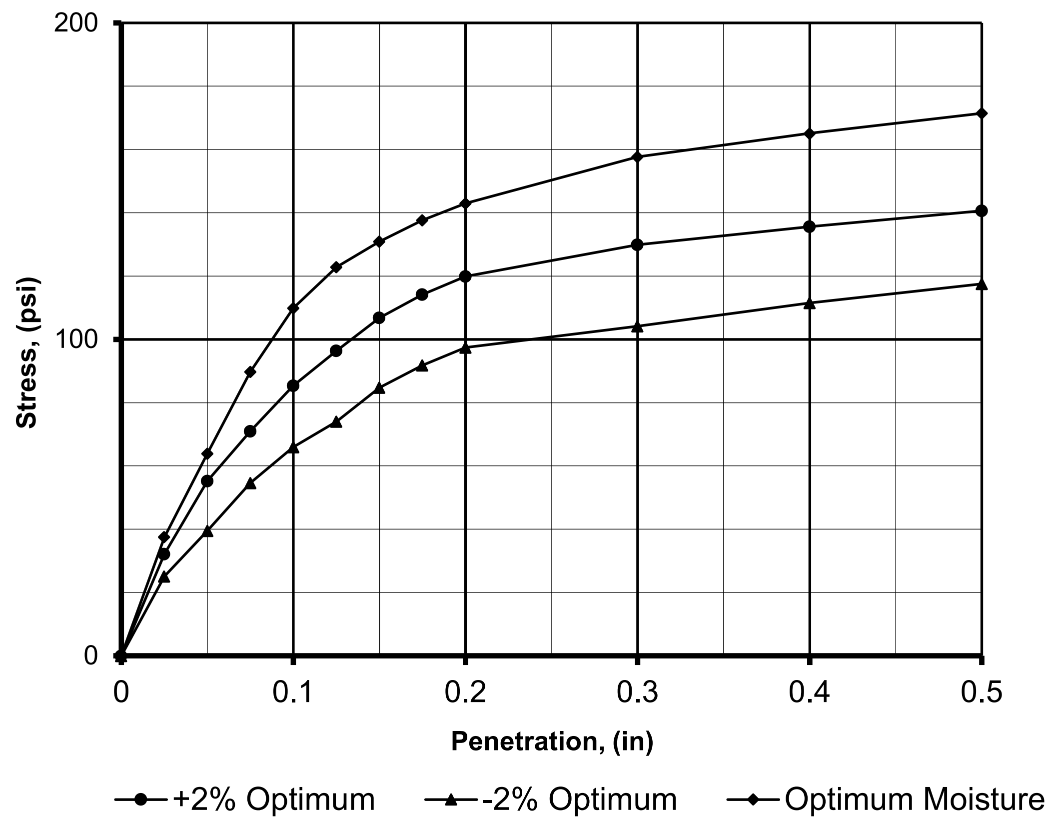
Project Name: **WCS CISF**

Project #: **31-151247**

Sample ID: **B-111**

Sample Description: **Brown Silty Sand with Rock (CBR on -3/8 material)**

@ + 2% Optimum Moisture			**@ Optimum Moisture Content**			**@ -2% Optimum Moisture**		
Wet Density	126.8	pcf	Wet Density	125.1	pcf	Wet Density	122.5	pcf
Dry Density	109.1	pcf	Dry Density	109.1	pcf	Dry Density	109.3	pcf
Water Content	16.2%		Water Content	14.6%		Water Content	12.1%	
Compaction	96.3%		Compaction	96.3%		Compaction	96.5%	
Swell	0.31%		Swell	0.13%		Swell	0.48%	
CBR @ .1"	**8.5**		**CBR @ .1"**	**11.0**		**CBR @ .1"**	**6.6**	
CBR @ .2"	**8.0**		**CBR @ .2"**	**9.5**		**CBR @ .2"**	**6.5**	



SOIL RESISTIVITY & pH

ASTM G57 & D4972

GEOServices, LLC-Geotechnical and Materials Engineers

GEOS Project Name: WCS CISF

Report Date: January 7, 2019

GEOS Project Number: 31-151247

Date Received:

Sample ID	Depth	Resistivity (ohm/cm)	pH
B-101 / Bulk	1.0 - 2.5'	2,550	7.9
B-111 / Bulk	3.5 - 5.0'	2,900	8.1

Notes:

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APPENDIX C

Generalized Soil Column

Appendix C – Generalized Soil Column CISF Site

Top (feet)	Bottom (feet)	Layer Description
0	2	Cover Sands
2	10	Caliche with Sand Matrix - Moderately Hard
10	20	Caliche with Sand Matrix - Moderately Hard
20	25	Caliche - Very Hard
25	35	Caliche - Very Hard
35	50	Ogallala - Sand with Gravel
50	80	Ogallala - Sand with Gravel
80	100	Ogallala - Sand with Gravel
100	130	Dockum - Claystone and Siltstone
130	230	Claystone and Siltstone
230	275	Dockum – Claystone
275	300	Dockum - Silty Sands
300	360	Dockum – Claystone
360	600	Dockum – Claystone

As can be seen above the soil column for the site was extended to 600 feet. Only four of the eighteen borings performed for the CISF project encountered auger refusal. The auger refusal depths ranged from 37 to 45 feet below the ground surface (bgs) that existed at the time of the exploration. Shear wave surveys were performed in conjunction with the geotechnical exploration and shear wave velocities are provided to depths of 100 feet bgs. Additionally, multiple previous geotechnical investigations have been performed at the site as well as shear wave testing. The historical data outlined below was utilized to extend the soil profile and engineering parameters to a depth of 600 feet. The depth of 600 feet was selected as the termination depth due to encountering the Trujillo Sandstone Layer.

The sections below reference the previous studies which were performed along with the methodology for obtaining the necessary soil parameters to perform the settlement analyses.

Provided Additional Documents:

1. Cook-Joyce, Inc. (2007). Geology Report. Dated May 1, 2007.
2. AECOM. (2016). Site-Specific Seismic Hazard Evaluation and Development of Seismic Design Ground Motions, WCS Centralized Interim Storage Facility Project. Dated March 18, 2016.
3. WCS. (2007). (Waste Control Specialists LLC). Application for License to Authorize Near Surface Land Disposal of Low-Level Radioactive Waste. Dated March 2007.

Methodology:

The information from the eighteen borings and shear wave data included in this Report of Geotechnical Exploration was supplemented with data obtained from the additionally provided documents. This data was used to produce a soil stratigraphic column to 600 feet. Figure 1 shown below displays the locations of the historical borings provided.

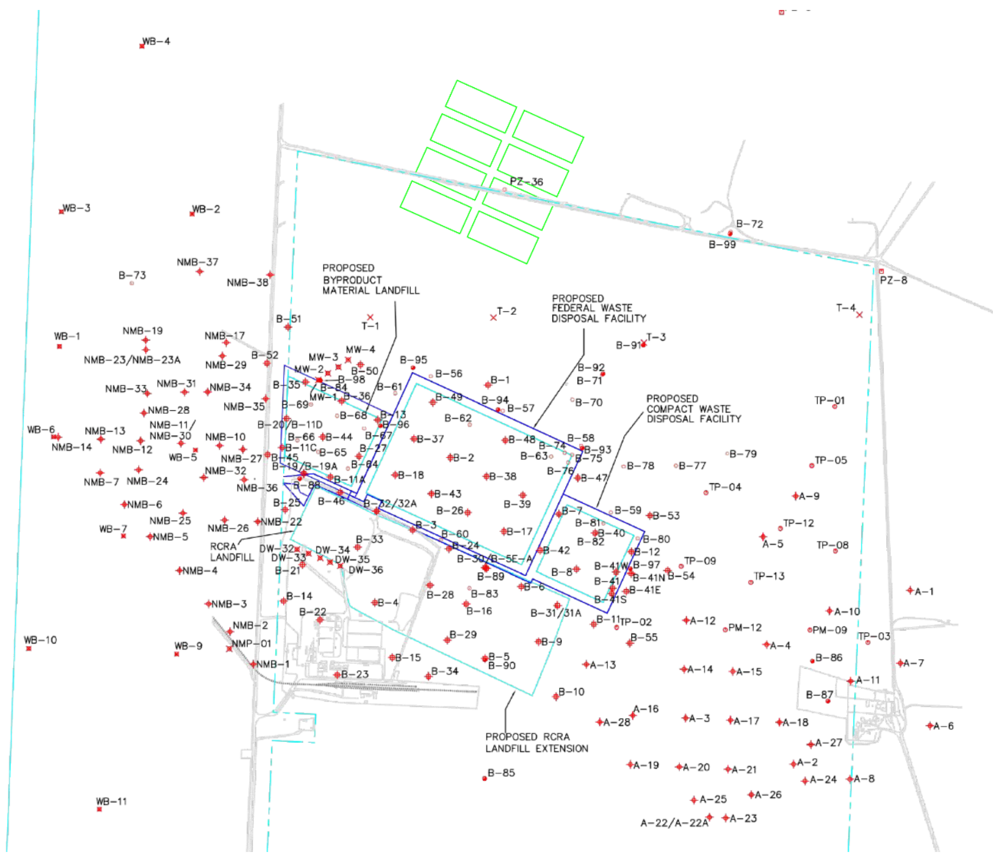

Figure 1: Historical Borings at WCS Site

Stratigraphy Development:

- The upper stratigraphy (to a depth of 45 feet) was based solely on the results of the eighteen soil test borings
- From a depth of 45 to 100 feet below ground surface (bgs) the stratigraphy was based on the Geologic Column of the CISF Area (Figure 7-30 of the SAR).
- From 100 feet to 600 feet bgs, the Geologic Column of the CISF Area (Figure 7-30 of the SAR), WCS (2007) Plate 2-2, and deeper historical borings were utilized to generate the stratigraphy.

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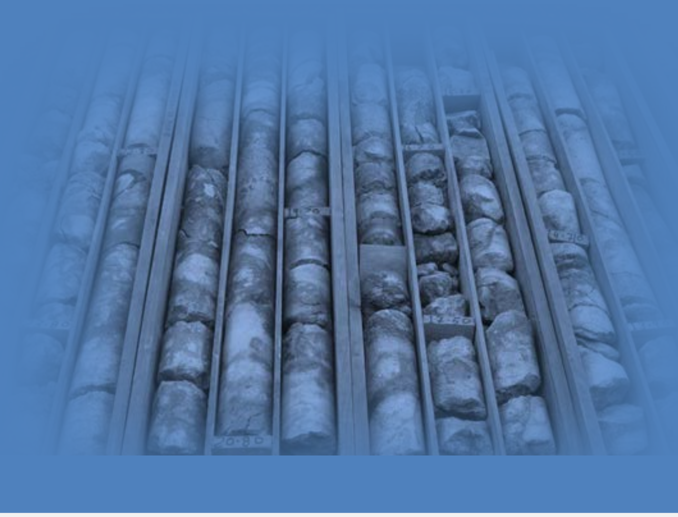
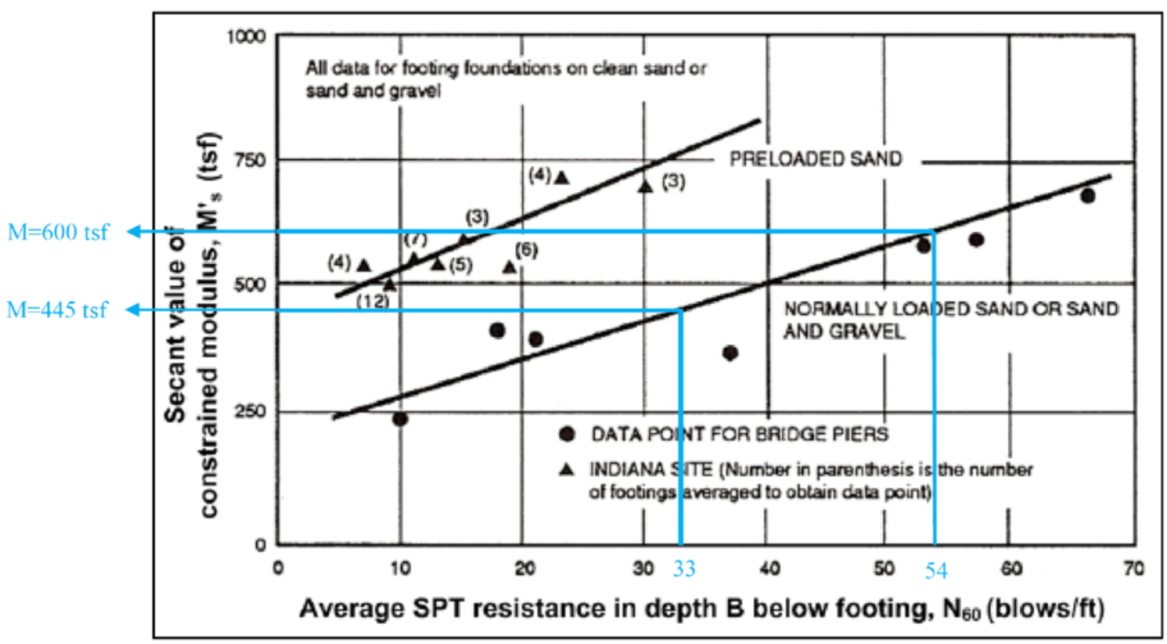
APPENDIX D

Static Elastic Modulus Calculation



As mentioned previously, it was determined that the settlement analysis would be extended to a depth of 600 feet (the top of the Trujillo Sandstone Formation). Therefore, constrained modulus values needed to be calculated for each of the stratigraphic layers. This was accomplished utilizing two distinct methodologies. The methodologies were selected due to the information available from the borings and shear wave profiles performed as part of this study and the available historical data.

Methodology 1:
To a depth of 20 feet bgs the constrained modulus was correlated to the SPT N-values obtained in the borings. The SPT N-Values were correlated to constrained modulus using the method outlined in Tan, C.K., Duncan, J.M., Rojiani, K.B., and Barker, R.M. (1991). This methodology allows correlation of constrained modulus to N-value for N-values up to 70 blows per foot. The graphical representation is shown below.



Methodology 2:
The borings performed for the CISF site were only advanced to maximum depths of 45 feet. Additionally, the methodology outlined in Tan, C.K., Duncan, J.M., Rojiani, K.B., and Barker, R.M. (1991) is only valid up to N-values of 70 blows per foot. Based on the N-values obtained

this methodology could only be extended to a depth of 20 feet below ground surface. Therefore, a second methodology had to be utilized to generate the constrained modulus from depths of 20 feet to 600 feet.

To supplement the information obtained in preparation of the Report of Geotechnical Exploration, GEOServices was provided with a Site-Specific Seismic Hazard Evaluation and Development of Seismic Ground Motions prepared by AECOM (2016). This document provided shear wave velocity profiles at the site to depths of approximately 1200 feet.

The shear wave velocities were converted to constrained modulus using the following relationship:

$$V_s \xrightarrow{G=V_S^2*\rho} G \xrightarrow{M=\frac{2G(1-\nu)}{(1-2\nu)}} M$$

Where, Vs = shear wave velocity

G = shear modulus

M = constrained modulus

ν = Poisson's ratio

ρ = unit weight

- From 20 feet to 100 feet bgs, constrained modulus values were obtained from converting the shear wave velocities provided in this study to constrained modulus using the unit weight and Poisson's ratio.
- From 100 feet to 600 feet bgs, constrained modulus values were obtained from converting the shear wave velocities provided in AECOM (2016) to constrained modulus using the unit weight and Poisson's ratio.

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Results

The table below provides the constrained modulus values for each of the stratigraphic layers. These values were utilized to calculate the anticipated settlements for the CISF pads and Cask Handling Building. The results of the settlement analysis are provided in Appendix H of this document.

Top (feet)	Bottom (feet)	N-Value (bpf)	Average Shear Wave Velocity (ft/s)	Layer Description	Constrained Modulus (ksf)
0	2	33		Cover Sands	890
2	10	54		Caliche with Sand Matrix - Moderately Hard	1200
10	20	54		Caliche with Sand Matrix - Moderately Hard	1200
20	25		1530	Caliche - Very Hard	35815
25	35		1900	Caliche - Very Hard	55232
35	50		2290	Ogallala - Sand with Gravel	80233
50	80		1840	Ogallala - Sand with Gravel	53870
80	100		2790	Ogallala - Sand with Gravel	123857
100	130		2300	Dockum - Claystone and Siltstone	84172
130	230		2755	Claystone and Siltstone	120769
230	275		2755	Dockum - Claystone	120769
275	300		2755	Dockum - Silty Sands	120679
300	360		2755	Dockum - Claystone	120679
360	600		3115	Dockum - Claystone	154394

References:

Tan, C.K., Duncan, J.M., Rojiani, K.B., and Barker, R.M. (1991). Engineering Manual for Shallow Foundations, prepared for the National Cooperative Highway Research Program (NCHRP Project 24-4) in cooperation with Virginia Polytechnic Institute and State University. Sponsored by American Association of State Highway and Transportation Officials and Federal Highway Administration, Washington, D.C., Blacksburg, VA, 171 pp.

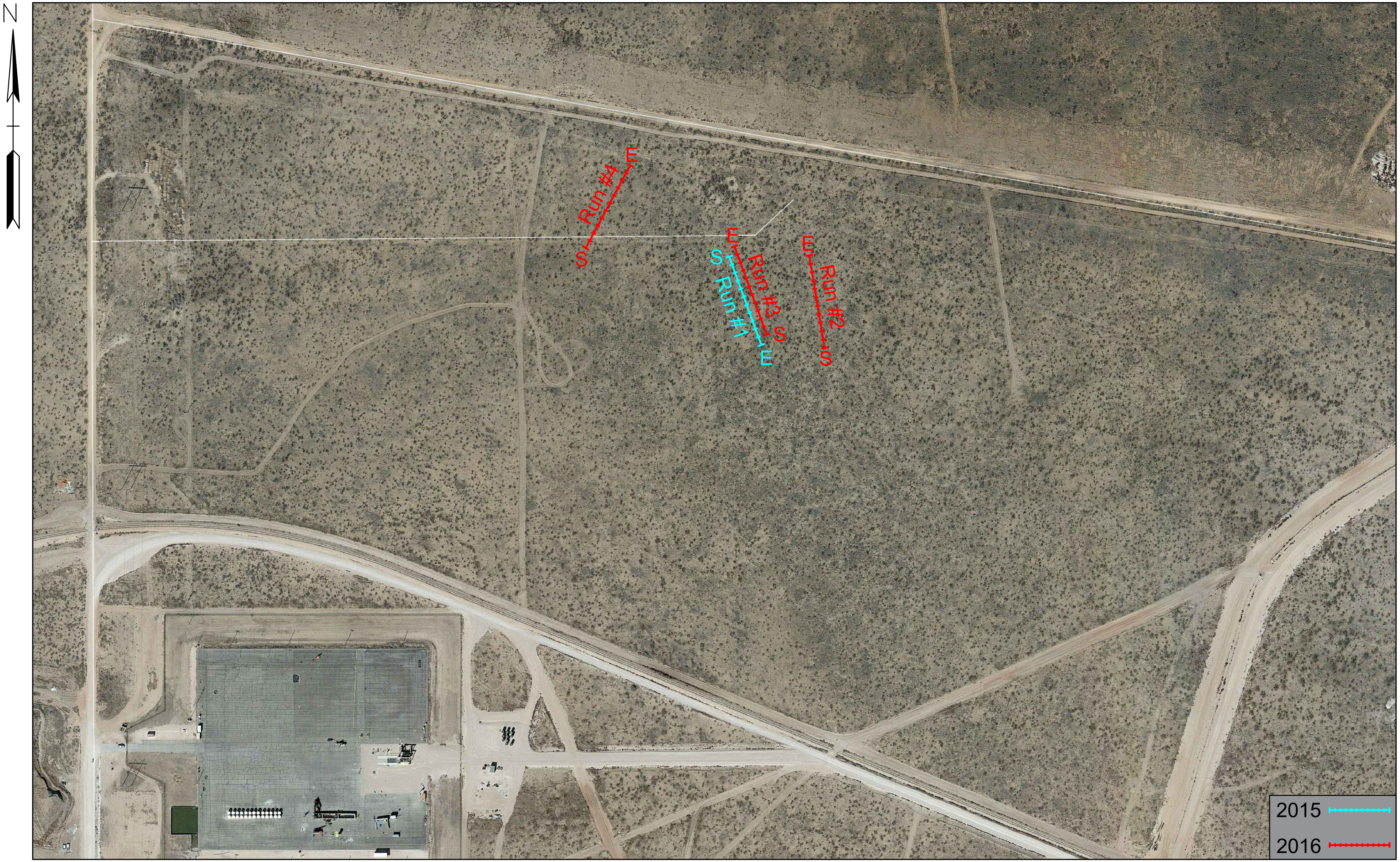
WCS. (2007). (Waste Control Specialists LLC). Application for License to Authorize Near Surface Land Disposal of Low-Level Radioactive Waste. Dated March 2007.

AECOM. (2016). Site-Specific Seismic Hazard Evaluation and Development of Seismic Design Ground Motions, WCS Centralized Interim Storage Facility Project. Dated March 18, 2016.

GEOServices, LLC, Geotechnical and Materials Engineers

APPENDIX E

On-Site Shear Wave Velocity Study



Notes:

1) S = Start of Seismic Shear Wave Velocity Profile
2) E = End of Seismic Shear Wave Velocity Profile

Seismic Shear Wave Velocity Profile Location & Identifier

Aerial Source Provided by: Google Earth Pro, (02/12/2014)

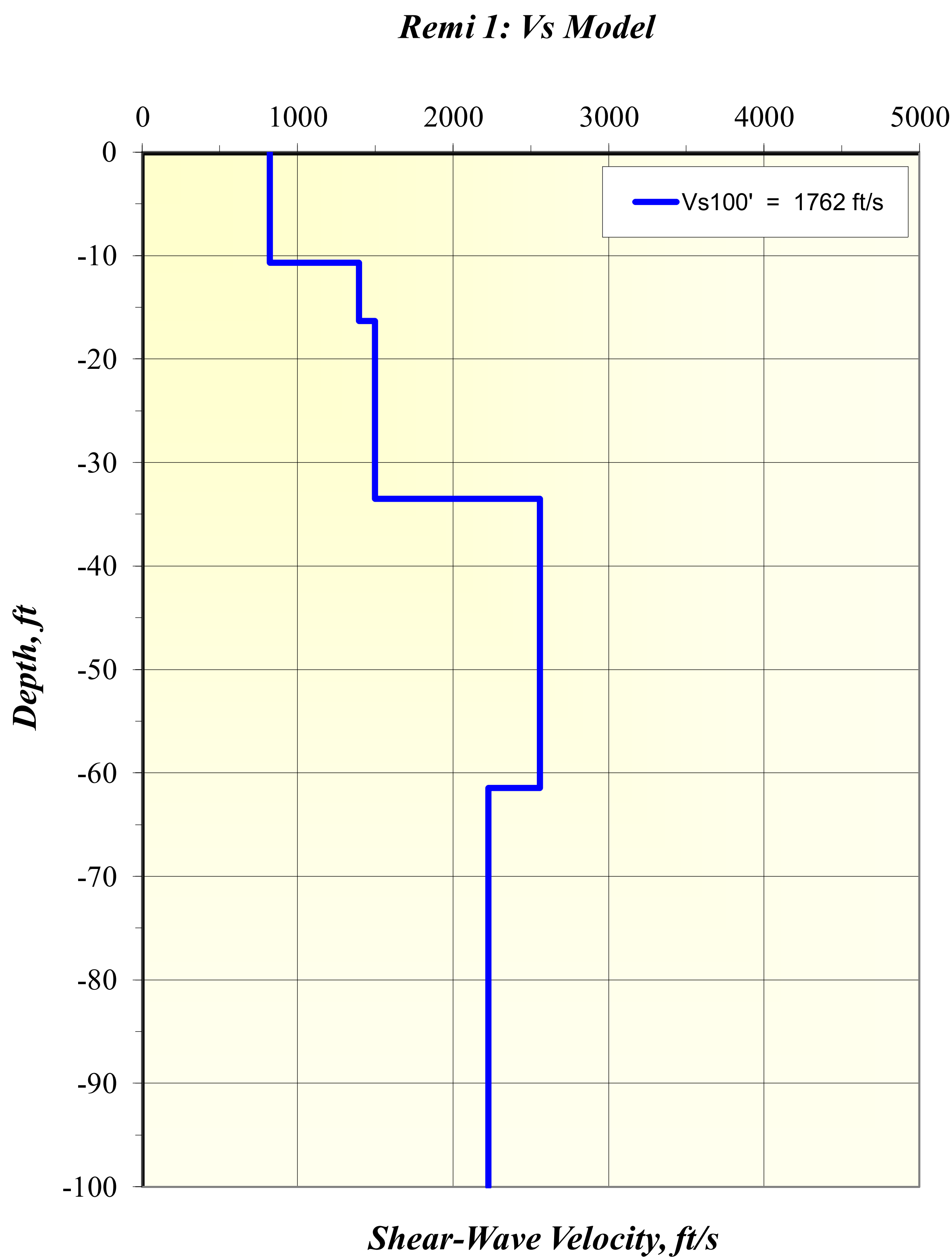
GEOServices, LLC-Geotechnical and Materials Engineers

Seismic Shear Wave Velocity Location Plan
Consolidated Interim Storage Facility
Andrews, Texas

DATE:
07/14/2016

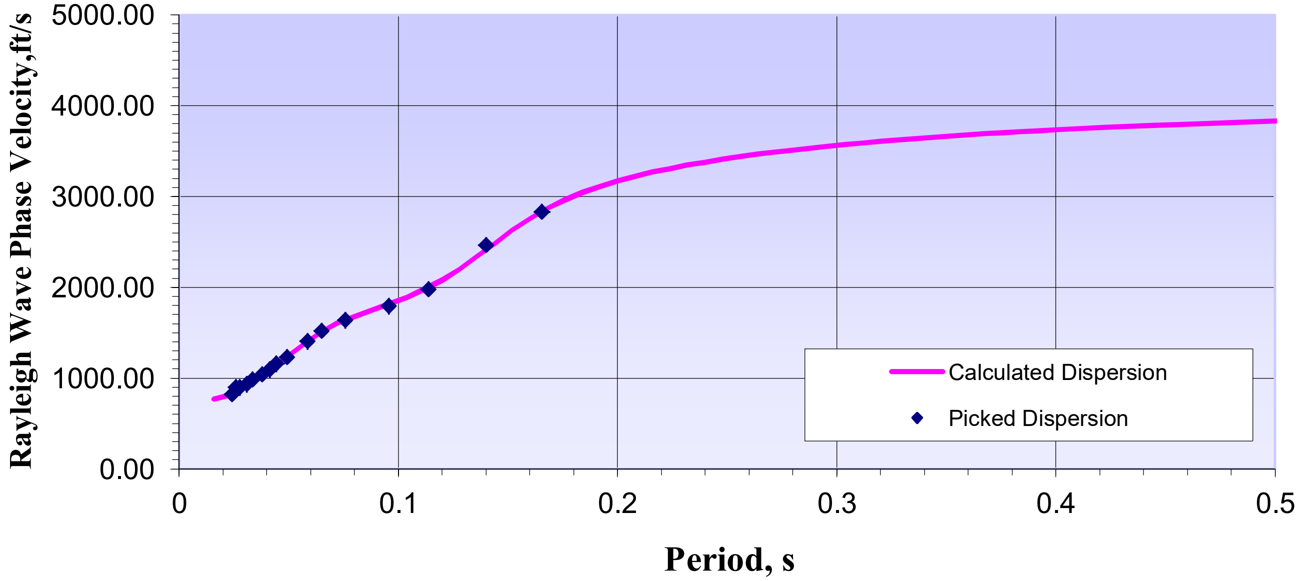
GEOS Project No.
31-151247

FIGURE:
12

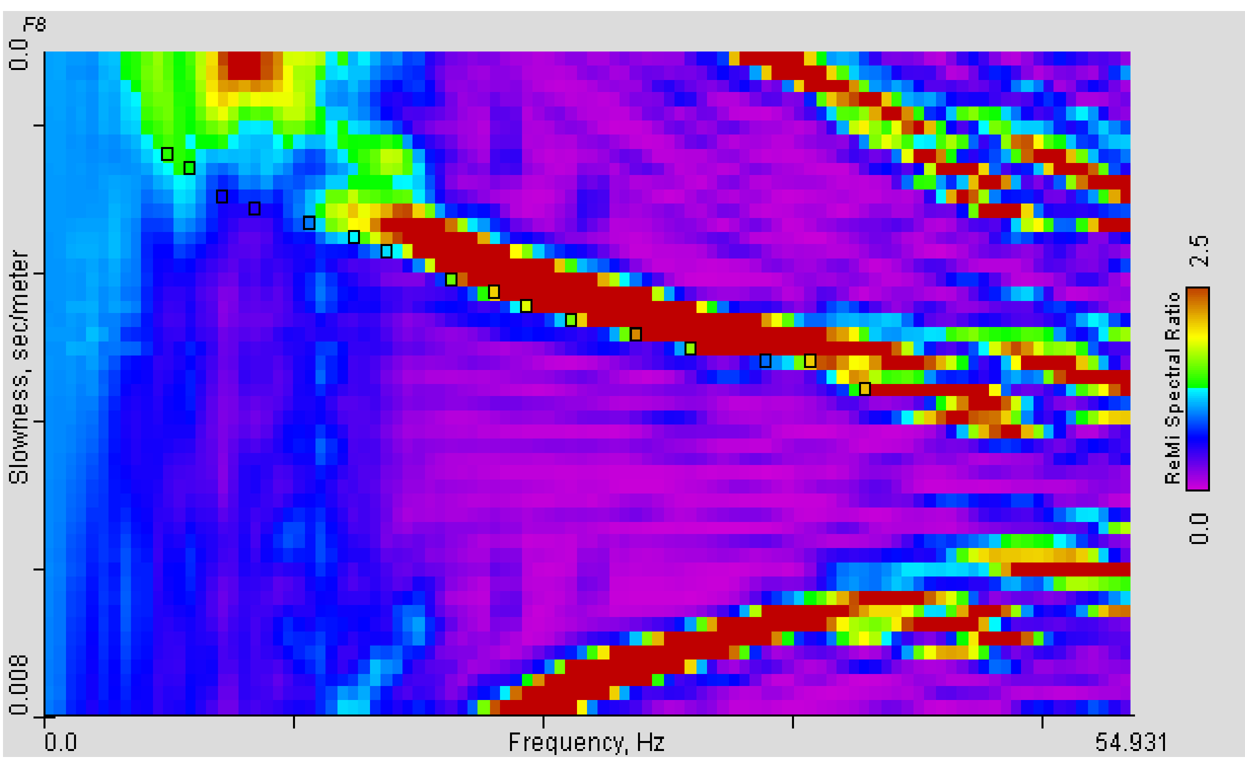

Remi 1: Vs Model
0
1000
2000
3000
4000
5000
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Depth, ft
Vs100' = 1762 ft/s
Shear-Wave Velocity, ft/s

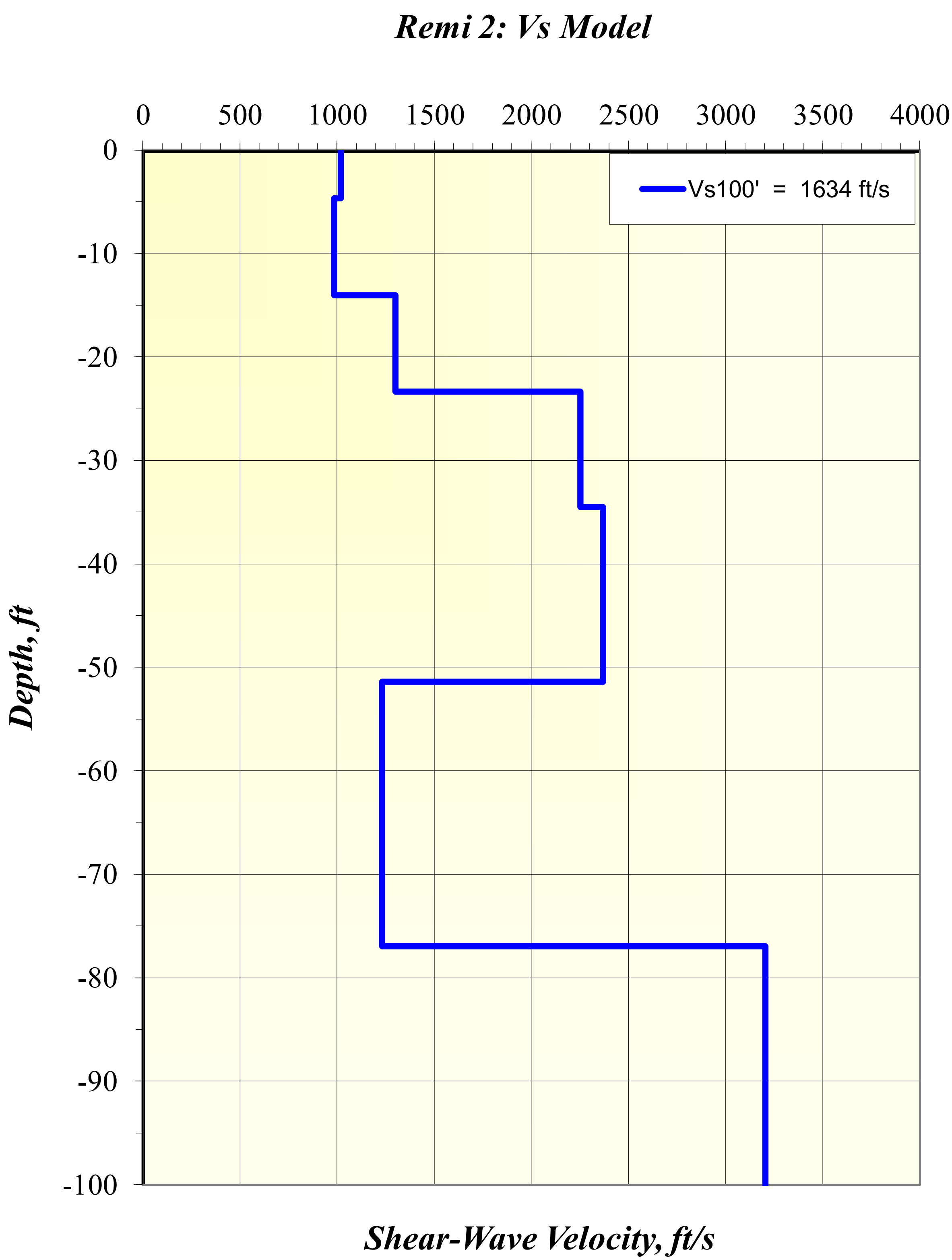
Remi 1: Supportive Illustration

Dispersion Curve Showing Picks and Fit



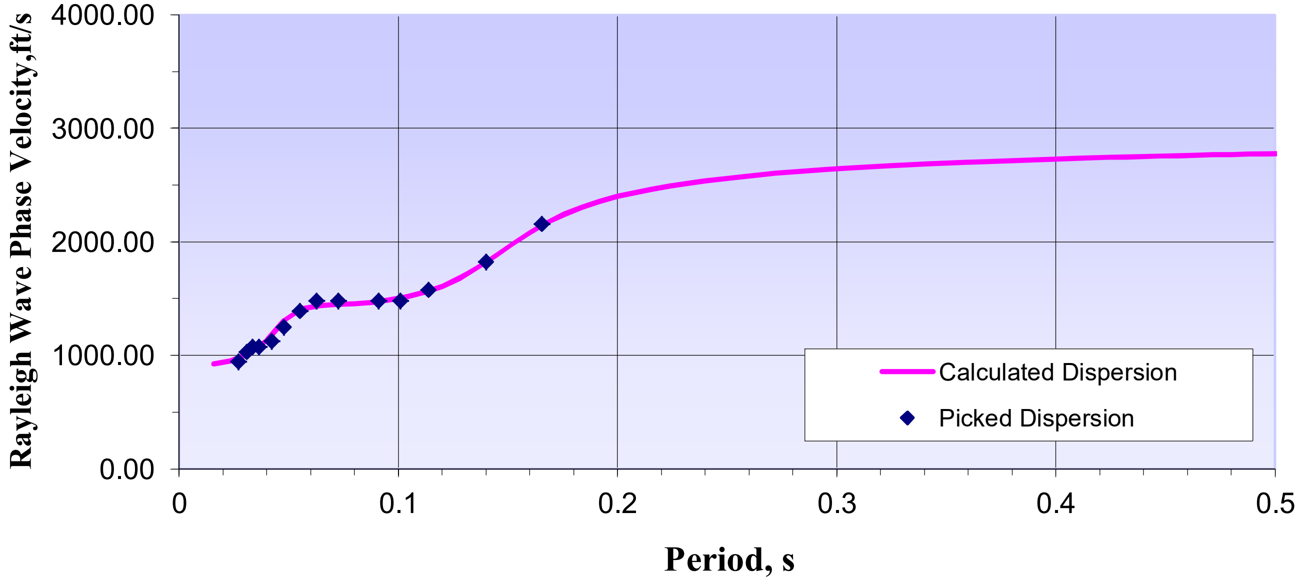
p-f Image with Dispersion Modeling Picks



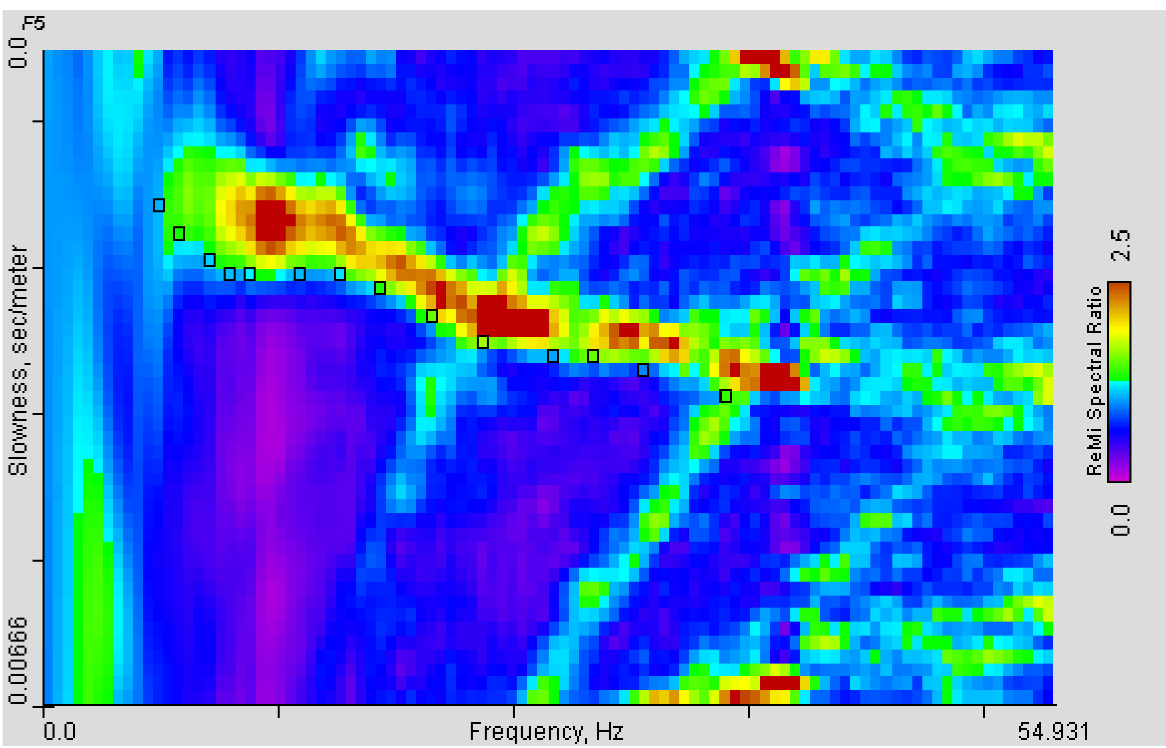

Remi 2: Vs Model
0
500
1000
1500
2000
2500
3000
3500
4000
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Vs100' = 1634 ft/s
Depth, ft
Shear-Wave Velocity, ft/s

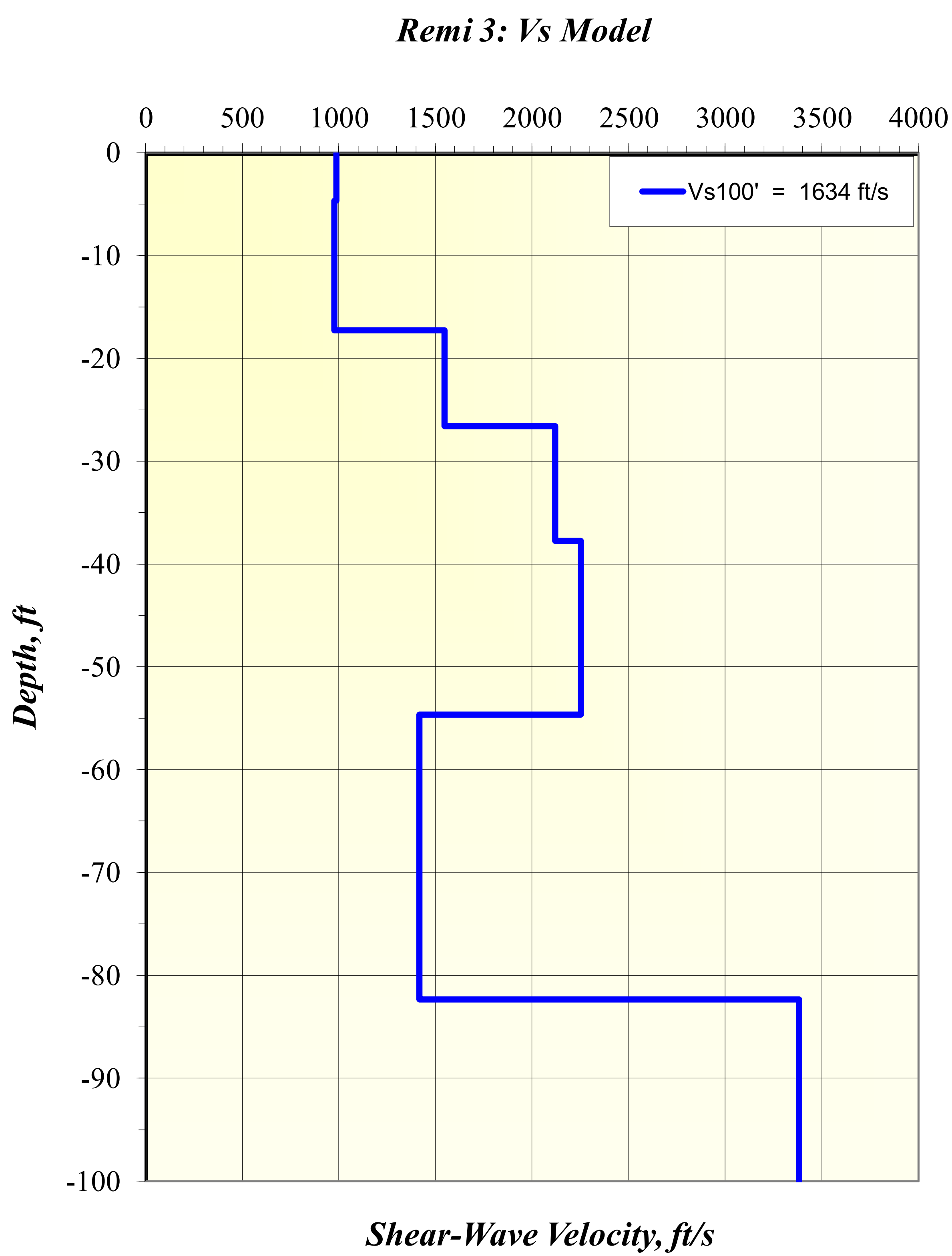
Remi 2: Supportive Illustration

Dispersion Curve Showing Picks and Fit



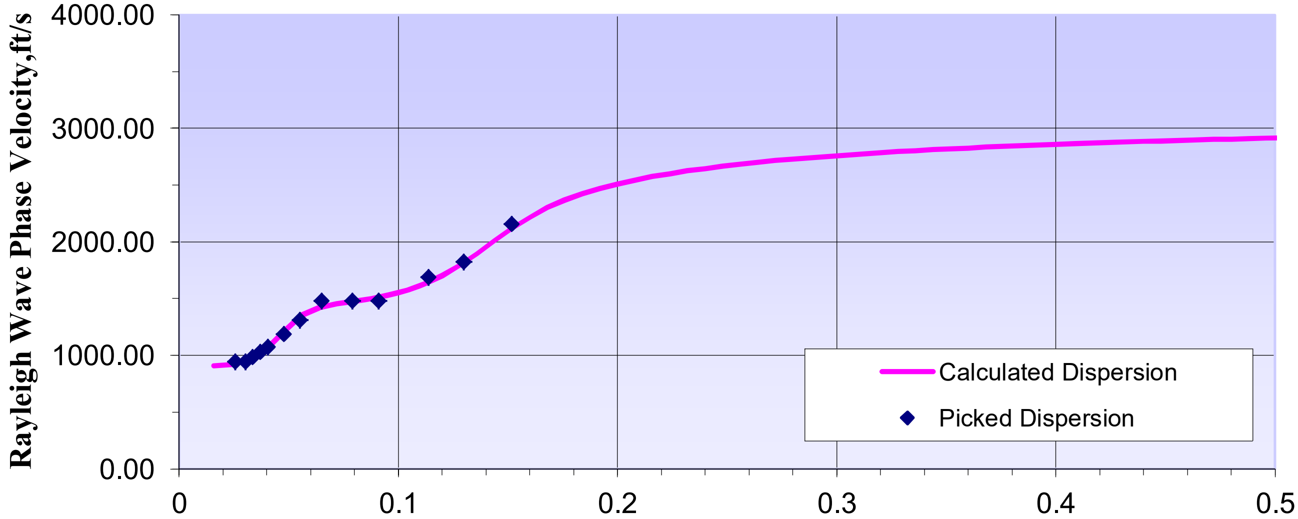
p-f Image with Dispersion Modeling Picks



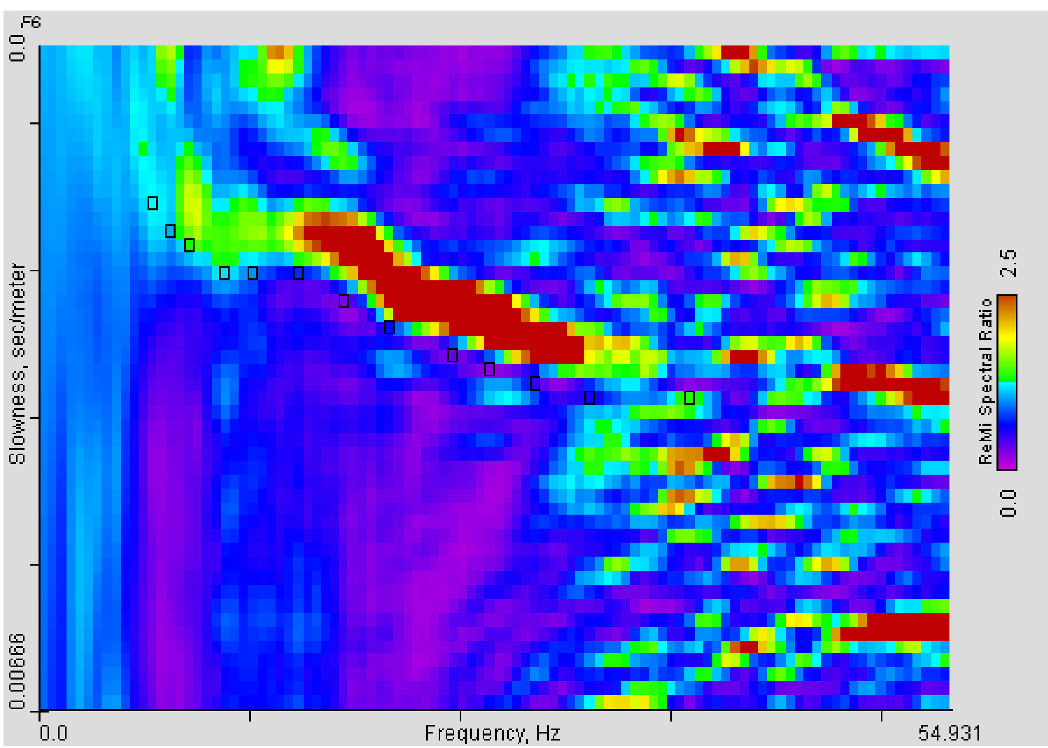

Remi 3: Vs Model
0
500
1000
1500
2000
2500
3000
3500
4000
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Vs100' = 1634 ft/s
Depth, ft
Shear-Wave Velocity, ft/s

Remi 3: Supportive Illustration

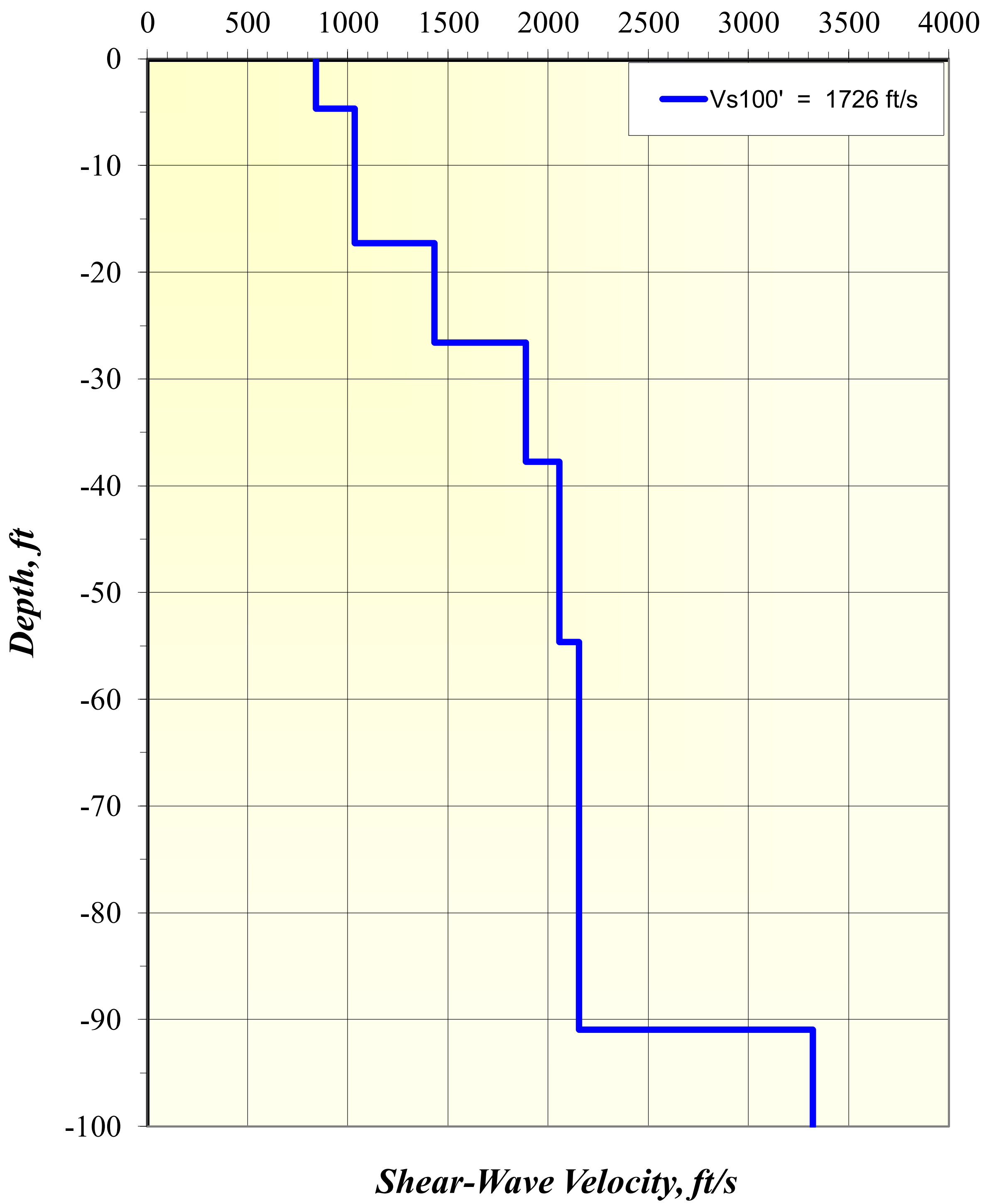
Dispersion Curve Showing Picks and Fit



p-f Image with Dispersion Modeling Picks

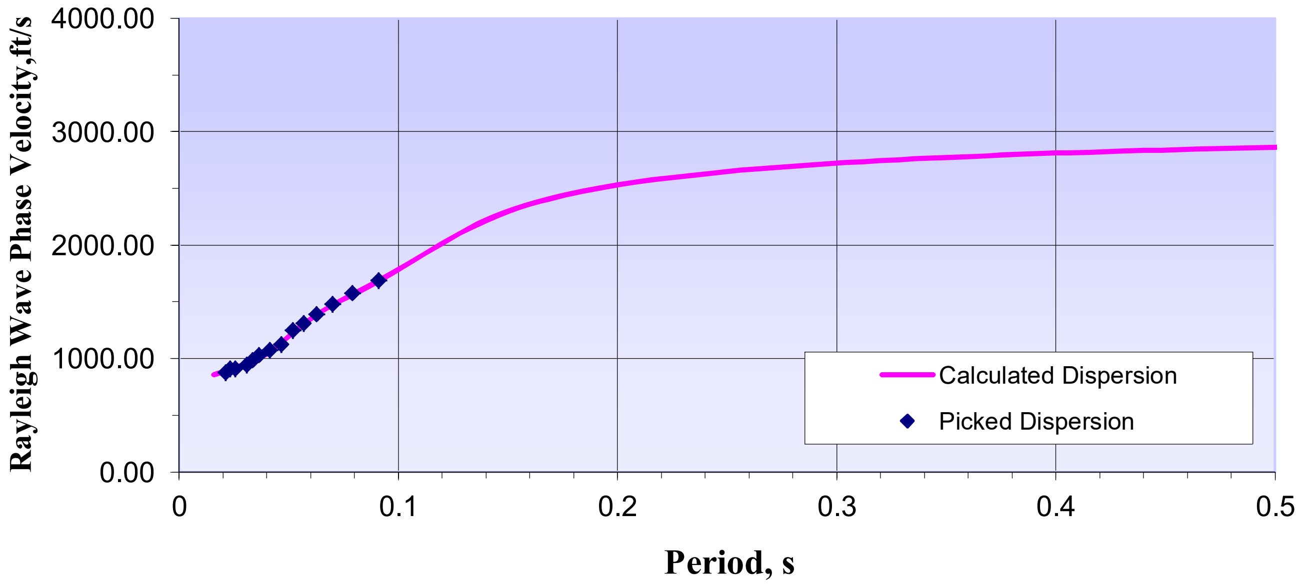


Remi 4: Vs Model

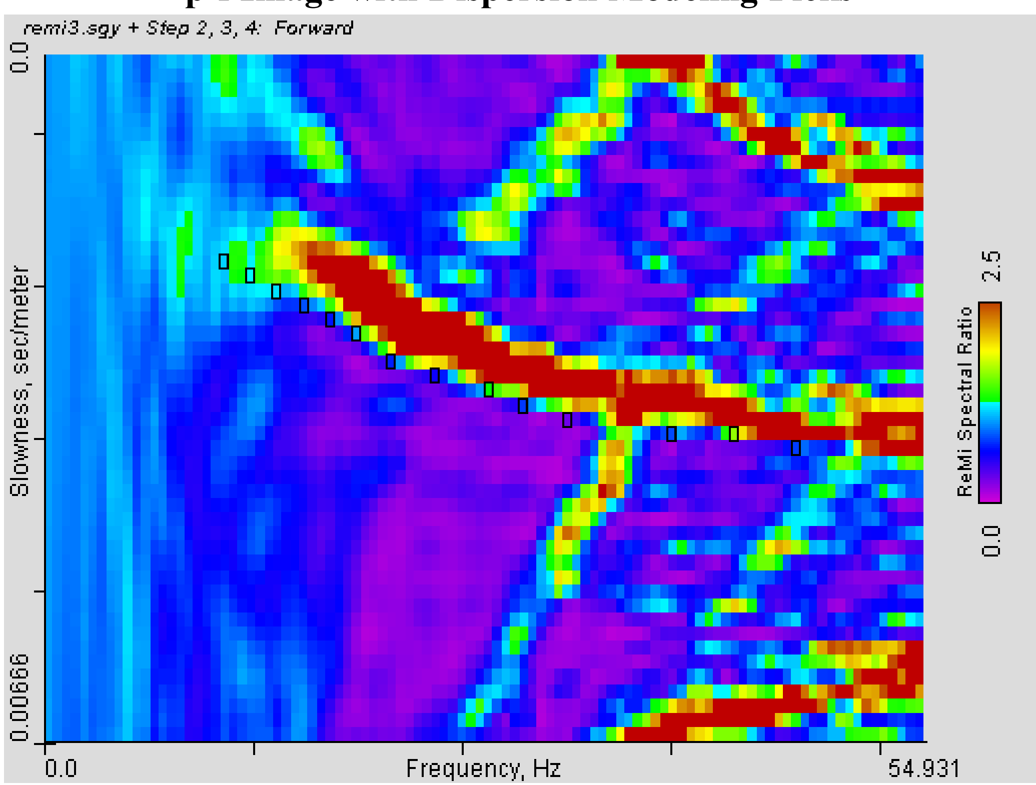


Remi 4: Supportive Illustration

Dispersion Curve Showing Picks and Fit



p-f Image with Dispersion Modeling Picks



GEOServices, LLC, Geotechnical and Materials Engineers

APPENDIX F

Seismic Densification Analysis

DAN BROWN AND ASSOCIATES

P.O. Box 309
Jasper, TN 37347
(423)942-8681
www.danbrownandassociates.com

TECHNICAL MEMORANDUM

Seismic Densification
CISF Site
Andrews, TX
DBA Project No. 19-017

To:	Derek Kilday, P.E./GEOServices
From:	Timothy C. Siegel, P.E, G.E., D.GE Tayler J. Day, P.E.
Date:	18 February 2020

STATE OF TEXAS
TIMOTHY C. SIEGEL
117477
LICENSED
PROFESSIONAL ENGINEER

1. Introduction

Dan Brown and Associates, P.C. (DBA) performed seismic densification calculations as part of our scope of services for the subject project. The calculations show that the seismic densification for the design earthquake will be negligible (on the order of 0.02 inches or less). The basis of our calculations is described in the remaining sections of this TM. The calculations are provided in the Attachments.

2. Design Earthquake

Our calculations use an earthquake magnitude of 5 and a peak ground acceleration of 0.25g. According the AECOM report[1], these values represent the design earthquake determined as part of the site-specific seismic hazard evaluation.

3. Soil Profile

The soil column at the CISF Storage Pad site consists of approximately 2 ft of cover sands overylying a caliche and sand matrix with normalized SPT N-values ranging 10 to 57 over the top 20 feet. This profile was developed based on the boring information (B-101 thru B-110) and laboratory test results presented in the GEOServices report[2]. We expect the cemented caliche materials described below a depth of 20ft to exhibit significantly more resistance to seismic densification than the partially cemented and uncemented sands near the ground surface. Therefore, we intentionally limited our calculations to the upper 20 ft where the sands and caliche/sand matrix appear to exhibit less cementation.

---

[1] AECOM (2016) Site-Specific Seismic Hazard Evaluation and Development of Seismic Design Ground Motions, WCS Centralized Interim Storage Facility, Project No. 31787-001, Study No. WCS-12-05-100-001.

[2] GEOServices (2020) Report of Geotechnical Exploration, Consolidated Interim Storage Facility, Andrews, TX, GEOServices Project No. 31-151247.R1.

4. Methodology

DBA used the methodology proposed by Pradel[3] to compute the seismic densification. The Pradel method is applicable to sands and silty sands and we expect that it could tend to overpredict the seismic densification of soils with partial to full cementation. For the design earthquake and soil profile for this project, the computed seismic densification above the cemented layers is very small.

5. Concluding Remarks

DBA appreciates the opportunity be a part of this project. Please contact the following if you would like to discuss this document or this project.

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Tayler J. Day, P.E.
Project Engineer
Dan Brown and Associates PC
6424 Baum Dr.
Knoxville, TN 37919
Mobile: 217-371-2185
tday@dba.world

[3] Pradel, D. (1998) Procedure to Evaluate the Earthquake-Induced Settlements of Dry Sandy Soils, Journal of Geotech. and Geo-env. Engineering, 124(4), 364-368.

Attachments

Seismic Densification Calculations

Seismic Densification Calculation for Upper 20 ft
CISF
Andrews, TX
18-Feb-20

M = 5.00
Nc = 1.0

Depth (ft)	(N1)60	σ'v (tsf)	CSR	CSR * σ'v (tsf)	ϕ (deg)	Go (tsf)	K	p (tsf)	R	a	b	γ(%)	evol15 (%)	evol (%)	
2.00	21	0.12	0.13	0.015	30	345.291	0.500	0.080	0.004%	0.127	30131.266	0.01%	0.01%	0.00%	0.001
4.00	10	0.24	0.16	0.038	30	382.268	0.500	0.160	0.010%	0.130	19879.222	0.02%	0.04%	0.01%	0.006
6.00	13	0.36	0.16	0.057	30	510.522	0.500	0.240	0.011%	0.133	15586.357	0.02%	0.03%	0.01%	0.004
8.00	35	0.48	0.16	0.075	30	817.382	0.500	0.320	0.009%	0.136	13115.395	0.01%	0.01%	0.00%	0.001
14.00	57	0.84	0.15	0.124	30	1270.107	0.500	0.560	0.010%	0.145	9374.725	0.01%	0.00%	0.00%	0.001
19.00	36	1.14	0.14	0.161	30	1271.435	0.500	0.760	0.013%	0.152	7805.185	0.02%	0.01%	0.00%	0.003

S (IN) = 0.016

M	Earthquake magnitude	
Nc	Number of equivalent cycles	
(N1)60	Normalized N-value	Computed from SPT boring data
σ'v (tsf)	Effective vertical stress	Computed from depth x soil unit weight
CSR	Cyclic stress ratio	Computed from design earthquake acceleration (No reduction for M lower than 7.5)
ϕ (deg)	Effective friction angle	Typical value of sand
Go (tsf)	Small strain shear modulus	Computed based on based on Seed and Idriss (1970)
K	At-rest horizontal pressure coefficient	
p (tsf)	Mean stress	
R	Ave shear stress/G	
a	coefficient to determine shear strain	
b	coefficient to determine shear strain	
γ(%)	Shear strain	
(N1)60, cs	Normalized N-value, clean sand	
Ic	Soil behavior type index	
evol15 (%)	Volumetric strain after 15 cycles	
evol (%)	olumetric strain adjusted for actual cycles	
S (in)	Ground surface settlement from seismic compression	

References:

Pradel, D. (1998) "Procedure to Evaluate Earthquake-Induced Settlement in Dry Sandy Soils" J. Geotech Engrg, ASCE, 124(4), 364-368
Robertson, P.K. and Shao, L. (2010) "Estimation of Seismic Compression of Dry Soils Using the CPT" Proc, Fifth International Conf on Recent Advances in Earthquake Engineering and Soil Dynamics.
Seed, H.B. and Idriss, I.M. (1970) "Soil moduli and damping factors for dynamic response analyses" Rep No. EERC 70-10, Earthquake Engineering Research Center, University of CA, Berkeley.

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The following calculations for liquefaction of soils with sand-like behavior are based on Soil Liquefaction During Earthquakes - Monograph MNO-12 by I.M. Idriss and R.W. Boulanger (2008) published by the Earthquake Engineering Research Institute.

Soil Stress Conditions -

average total unit weight of soil $\gamma_{total} := 120pcf$

unit weight of water $\gamma_{water} := 62.4pcf$

water table depth below ground surface....very deep

sample depth Boring B-103 Sample No. 1 $z := 2ft$

total vertical stress $\sigma tot_v := \gamma_{total} \cdot z$ $\sigma tot_v = 240 \cdot psf$

static water pressure $u_o := 0$ $u_o = 0 \cdot psf$

effective vertical stress $\sigma eff_v := \sigma tot_v - u_o$ $\sigma eff_v = 240 \cdot psf$

Standard Penetration N-value Correction -

Hammer	CE
Doughnut	0.5-1.0
Safety	0.7-1.2
Automatic	0.8-1.3
(Skempton, 1986)	

Standard Penetration Test N-value $N_m := 12$

fines content $FC := 48$

energy correction $C_E := 0.75$

borehole diameter correction $C_B := 1.05$

rod length correction $C_R := 0.75$

sampler correction $C_S := 1$

Borehole dia.	CB
65-115mm	1.0
150mm	1.05
200mm	1.15
(Skempton, 1986)	

SPT N-value for an energy ratio of 60% $N_{60} := C_E C_B \cdot C_R \cdot C_S \cdot N_m$

$N_{60} = 7.1$

Rod length	CR
< 3m	0.75
3-4m	0.80
4-6m	0.85
6-10m	0.95
10-30m	1.00

overburden correction factor (based on overburden stress only) $C_{N\_a} := \left(\frac{P_a}{\sigma eff_v}\right)^{0.5}$

$C_{N\_a} = 2.969$

normalized SPT N-value (based on overburden stress only) $N_{1\_60} := C_{N\_a} \cdot N_{60}$ $N_{1\_60} = 21$

overburden correction factor (based on overburden stress and relative density)

$$C_{N\_b} := \left(\frac{P_a}{\sigma eff_v}\right)^{0.784-0.078\cdot\left(N_{1\_60}\right)^{0.5}}$$

$$C_{N\_b} = 2.529$$

overburden correction factor used in liquefaction analysis (max CN = 1.7)

$$C_N := 2.64$$

recalculated normalized SPT N-value

$$N_{1\_60} := C_N \cdot N_{60}$$

$$N_{1\_60} = 18.7$$

overburden correction factor used in liquefaction analysis

$$C_{N\_check} := \left(\frac{P_a}{\sigma eff_v}\right)^{0.784-0.078\cdot\left(N_{1\_60}\right)^{0.5}}$$

$$C_{N\_check} = 2.643$$

fines content adjustment to SPT N-value

$$\Delta N_{1\_60} := \exp\left[1.63 + \frac{9.7}{FC + 0.01} - \left(\frac{15.7}{FC + 0.01}\right)^2\right]$$

$$\Delta N_{1\_60} = 5.6$$

normalized SPT N-value (clean sands)

$$N_{1\_60\_cs} := N_{1\_60} + \Delta N_{1\_60}$$

$$N_{1\_60\_cs} = 24.324$$

Earthquake Conditions -

peak ground accelerationl $a_{max} := 0.25\cdot g$

earthquake moment magnitude $M_w := 5$

variable α for stress reduction factor

$$\alpha := -1.012 - 1.126\cdot\sin\left(\frac{\frac{z}{3.28ft}}{11.73} + 5.133\right)$$

variable β for stress reduction factor

$$\beta := 0.106 + 0.118\sin\left(\frac{\frac{z}{3.28ft}}{11.28} + 5.142\right)$$

stress reduction factor $r_d := \exp(\alpha + \beta \cdot M_w)$ $r_d = 0.998$

Liquefaction Calculations -

cyclic stress ratio $CSR := 0.65 \cdot \frac{\sigma tot_v}{\sigma eff_v} \cdot \frac{a_{max}}{g} \cdot r_d$ $CSR = 0.162$

cyclic resistance ratio

$$CRR_{M7.5\_\sigma eff1} := \exp\left[\frac{N_{1\_60\_cs}}{14.1} + \left(\frac{N_{1\_60\_cs}}{126}\right)^2 - \left(\frac{N_{1\_60\_cs}}{23.6}\right)^3 + \left(\frac{N_{1\_60\_cs}}{25.4}\right)^4 - 2.8\right]$$

magnitude scaling factor
(maximum MSF = 1.8) $MSF := 6.9 \exp\left(\frac{-M_w}{4}\right) - 0.058$ $MSF = 1.919$

coefficient for overburden correction factor
(maximum Cσ=0.3) $C_\sigma := \frac{1}{18.9 - 2.55 \cdot (N_{1\_60})^{0.5}}$ $C_\sigma = 0.127$

overburden correction factor
(maximum Kσ=1.1) $K_\sigma := 1 - C_\sigma \cdot \ln\left(\frac{\sigma eff_v}{P_a}\right)$ $K_\sigma = 1.277$

static shear stress on horizontal plane $\tau_{ho} := 0psf$

effective friction angle $\phi_{eff} := \text{atan}\left(\frac{N_{60}}{12.2 + 20.3 \cdot \frac{\sigma eff_v}{P_a}}\right)^{0.34}$ $\phi_{eff} = 43.824 \cdot deg$

Ko for NC soil $K_o := (1 - \sin(\phi_{eff}))$ $K_o = 0.308$

empirical constant for dilatancy $Q := 10$

Grain type.	Q
quartz and feldspar	10
limestone	8
anthracite	7
chalk	5.5

relative state parameter
(-0.61<ξR<0.11)

$$\zeta_R := \frac{1}{Q - \ln\left[\frac{100\cdot\left(1 + 2K_o\right)\sigma eff_v}{3\cdot P_a}\right]} - \left(\frac{N_{1\_60}}{46}\right)^{0.5} \qquad \zeta_R = -0.516$$

alpha factor
(maximum α=0.35)

$$\alpha\_factor := \frac{\tau_{ho}}{\sigma eff_v} \qquad \alpha\_factor = 0$$

$$a := 1267 + 636\alpha\_factor^2 - 634\cdot\exp(\alpha\_factor) - 632\cdot\exp(-\alpha\_factor)$$

$$b := \exp\left(-1.11 + 12.3\alpha\_factor^2 + 1.31\cdot\ln(\alpha\_factor + 0.0001)\right)$$

$$c := 0.138 + 0.126\cdot\alpha\_factor + 2.52\cdot\alpha\_factor^3$$

static shear stress correction factor

$$K_\alpha := a + b\cdot\exp\left(\frac{-\zeta_R}{c}\right) \qquad K_\alpha = 1$$

corrected cyclic stress ratio

$$CRR_{M\_\sigma effv} := CRR_{M7.5\_\sigma eff1}\cdot MSF\cdot K_\sigma\cdot K_\alpha$$

factor of safety for liquefaction

$$FS_{liq} := \frac{CRR_{M\_\sigma effv}}{CSR} \qquad FS_{liq} = 4.151$$

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The following calculations for liquefaction of soils with sand-like behavior are based on Soil Liquefaction During Earthquakes - Monograph MNO-12 by I.M. Idriss and R.W. Boulanger (2008) published by the Earthquake Engineering Research Institute.

Soil Stress Conditions -

average total unit weight of soil $\gamma_{total} := 120\,pcf$

unit weight of water $\gamma_{water} := 62.4\,pcf$

water table depth below ground surface....very deep

sample depth Boring B-101 Sample No. 2 $z := 4ft$

total vertical stress $\sigma tot_v := \gamma_{total} \cdot z$ $\sigma tot_v = 480 \cdot psf$

static water pressure $u_o := 0$ $u_o = 0 \cdot psf$

effective vertical stress $\sigma eff_v := \sigma tot_v - u_o$ $\sigma eff_v = 480 \cdot psf$

Standard Penetration N-value Correction -

Hammer	CE
Doughnut	0.5-1.0
Safety	0.7-1.2
Automatic	0.8-1.3

(Skempton, 1986)

Standard Penetration Test N-value $N_m := 8$

fines content $FC := 48$

energy correction $C_E := 0.75$

borehole diameter correction $C_B := 1.05$

rod length correction $C_R := 0.75$

sampler correction $C_S := 1$

Borehole dia.	CB
65-115mm	1.0
150mm	1.05
200mm	1.15

(Skempton, 1986)

SPT N-value for an energy ratio of 60% $N_{60} := C_E \cdot C_B \cdot C_R \cdot C_S \cdot N_m$

$N_{60} = 4.7$

Rod length	CR
< 3m	0.75
3-4m	0.80
4-6m	0.85
6-10m	0.95
10-30m	1.00

overburden correction factor (based on overburden stress only)

$$C_{N\_a} := \left(\frac{P_a}{\sigma eff_v}\right)^{0.5}$$

$C_{N\_a} = 2.1$

normalized SPT N-value (based on overburden stress only) $N_{1\_60} := C_{N\_a} \cdot N_{60}$ $N_{1\_60} = 9.9$

overburden correction factor (based on overburden stress and relative density)

$$C_{N\_b} := \left(\frac{P_a}{\sigma eff_v}\right)^{0.784-0.078\cdot\left(N_{1\_60}\right)^{0.5}}$$

$$C_{N\_b} = 2.222$$

overburden correction factor used in liquefaction analysis (max CN = 1.7)

$$C_N := 2.22$$

recalculated normalized SPT N-value

$$N_{1\_60} := C_N \cdot N_{60}$$

$$N_{1\_60} = 10.5$$

overburden correction factor used in liquefaction analysis

$$C_{N\_check} := \left(\frac{P_a}{\sigma eff_v}\right)^{0.784-0.078\cdot\left(N_{1\_60}\right)^{0.5}}$$

$$C_{N\_check} = 2.2$$

fines content adjustment to SPT N-value

$$\Delta N_{1\_60} := \exp\left[1.63 + \frac{9.7}{FC + 0.01} - \left(\frac{15.7}{FC + 0.01}\right)^2\right]$$

$$\Delta N_{1\_60} = 5.6$$

normalized SPT N-value (clean sands)

$$N_{1\_60\_cs} := N_{1\_60} + \Delta N_{1\_60}$$

$$N_{1\_60\_cs} = 16.103$$

Earthquake Conditions -

peak ground accelerationl $a_{max} := 0.25\cdot g$

earthquake moment magnitude $M_w := 5$

variable α for stress reduction factor

$$\alpha := -1.012 - 1.126\cdot\sin\left(\frac{\frac{z}{3.28ft}}{11.73} + 5.133\right)$$

variable β for stress reduction factor

$$\beta := 0.106 + 0.118\sin\left(\frac{\frac{z}{3.28ft}}{11.28} + 5.142\right)$$

stress reduction factor $r_d := \exp(\alpha + \beta \cdot M_w)$ $r_d = 0.986$

Liquefaction Calculations -

cyclic stress ratio $CSR := 0.65 \cdot \frac{\sigma tot_v}{\sigma eff_v} \cdot \frac{a_{max}}{g} \cdot r_d$ $CSR = 0.16$

cyclic resistance ratio

$$CRR_{M7.5\_\sigma eff1} := \exp\left[\frac{N_{1\_60\_cs}}{14.1} + \left(\frac{N_{1\_60\_cs}}{126}\right)^2 - \left(\frac{N_{1\_60\_cs}}{23.6}\right)^3 + \left(\frac{N_{1\_60\_cs}}{25.4}\right)^4 - 2.8\right]$$

magnitude scaling factor
(maximum MSF = 1.8) $MSF := 6.9\exp\left(\frac{-M_w}{4}\right) - 0.058$ $MSF = 1.919$

coefficient for overburden correction factor
(maximum Cσ=0.3) $C_\sigma := \frac{1}{18.9 - 2.55 \cdot (N_{1\_60})^{0.5}}$ $C_\sigma = 0.094$

overburden correction factor
(maximum Kσ=1.1) $K_\sigma := 1 - C_\sigma \cdot \ln\left(\frac{\sigma eff_v}{P_a}\right)$ $K_\sigma = 1.139$

static shear stress on horizontal plane $\tau_{ho} := 0\text{psf}$

effective friction angle $\phi_{eff} := \operatorname{atan}\left(\frac{N_{60}}{12.2 + 20.3 \cdot \frac{\sigma eff_v}{P_a}}\right)^{0.34}$ $\phi_{eff} = 36.898 \cdot \text{deg}$

Ko for NC soil $K_o := (1 - \sin(\phi_{eff}))$ $K_o = 0.4$

empirical constant for dilatancy $Q := 10$

Grain type.	Q
quartz and feldspar	10
limestone	8
anthracite	7
chalk	5.5

relative state parameter
(-0.61<ξR<0.11)

$$\zeta_R := \frac{1}{Q - \ln\left[\frac{100\cdot(1 + 2K_o)\sigma eff_v}{3\cdot P_a}\right]} - \left(\frac{N_{1\_60}}{46}\right)^{0.5} \qquad \zeta_R = -0.342$$

alpha factor
(maximum α=0.35)

$$\alpha\_factor := \frac{\tau_{ho}}{\sigma eff_v} \qquad \alpha\_factor = 0$$

$$a := 1267 + 636\alpha\_factor^2 - 634\cdot\exp(\alpha\_factor) - 632\cdot\exp(-\alpha\_factor)$$

$$b := \exp\left(-1.11 + 12.3\alpha\_factor^2 + 1.31\cdot\ln(\alpha\_factor + 0.0001)\right)$$

$$c := 0.138 + 0.126\cdot\alpha\_factor + 2.52\cdot\alpha\_factor^3$$

static shear stress correction factor

$$K_\alpha := a + b\cdot\exp\left(\frac{-\zeta_R}{c}\right) \qquad K_\alpha = 1$$

corrected cyclic stress ratio

$$CRR_{M\_\sigma effv} := CRR_{M7.5\_\sigma eff1}\cdot MSF\cdot K_\sigma\cdot K_\alpha$$

factor of safety for liquefaction

$$FS_{liq} := \frac{CRR_{M\_\sigma effv}}{CSR} \qquad FS_{liq} = 2.261$$

The following calculations for liquefaction of soils with sand-like behavior are based on Soil Liquefaction During Earthquakes - Monograph MNO-12 by I.M. Idriss and R.W. Boulanger (2008) published by the Earthquake Engineering Research Institute.

Soil Stress Conditions -

average total unit weight of soil $\gamma_{total} := 120pcf$

unit weight of water $\gamma_{water} := 62.4pcf$

water table depth below ground surface....very deep

sample depth Boring B-110 Sample No. 3 $z := 6ft$

total vertical stress $\sigma tot_v := \gamma_{total} \cdot z$ $\sigma tot_v = 720 \cdot psf$

static water pressure $u_o := 0$ $u_o = 0 \cdot psf$

effective vertical stress $\sigma eff_v := \sigma tot_v - u_o$ $\sigma eff_v = 720 \cdot psf$

Standard Penetration N-value Correction -

Hammer	CE
Doughnut	0.5-1.0
Safety	0.7-1.2
Automatic	0.8-1.3

(Skempton, 1986)

Standard Penetration Test N-value $N_m := 13$

fines content $FC := 37$

energy correction $C_E := 0.75$

borehole diameter correction $C_B := 1.05$

rod length correction $C_R := 0.75$

sampler correction $C_S := 1$

Borehole dia.	CB
65-115mm	1.0
150mm	1.05
200mm	1.15

(Skempton, 1986)

SPT N-value for an energy ratio of 60% $N_{60} := C_E \cdot C_B \cdot C_R \cdot C_S \cdot N_m$

$N_{60} = 7.7$

Rod length	CR
< 3m	0.75
3-4m	0.80
4-6m	0.85
6-10m	0.95
10-30m	1.00

overburden correction factor (based on overburden stress only)

$$C_{N\_a} := \left(\frac{P_a}{\sigma eff_v}\right)^{0.5}$$

$C_{N\_a} = 1.714$

normalized SPT N-value (based on overburden stress only) $N_{1\_60} := C_{N\_a} \cdot N_{60}$ $N_{1\_60} = 13.2$

overburden correction factor (based on overburden stress and relative density)

$$C_{N\_b} := \left(\frac{P_a}{\sigma eff_v}\right)^{0.784-0.078\cdot\left(N_{1\_60}\right)^{0.5}}$$

$$C_{N\_b} = 1.716$$

overburden correction factor used in liquefaction analysis (max CN = 1.7)

$$C_N := 1.71$$

recalculated normalized SPT N-value

$$N_{1\_60} := C_N \cdot N_{60}$$

$$N_{1\_60} = 13.1$$

overburden correction factor used in liquefaction analysis

$$C_{N\_check} := \left(\frac{P_a}{\sigma eff_v}\right)^{0.784-0.078\cdot\left(N_{1\_60}\right)^{0.5}}$$

$$C_{N\_check} = 1.717$$

fines content adjustment to SPT N-value

$$\Delta N_{1\_60} := \exp\left[1.63 + \frac{9.7}{FC + 0.01} - \left(\frac{15.7}{FC + 0.01}\right)^2\right]$$

$$\Delta N_{1\_60} = 5.5$$

normalized SPT N-value (clean sands)

$$N_{1\_60\_cs} := N_{1\_60} + \Delta N_{1\_60}$$

$$N_{1\_60\_cs} = 18.67$$

Earthquake Conditions -

peak ground accelerationl $a_{max} := 0.25\cdot g$

earthquake moment magnitude $M_w := 5$

variable α for stress reduction factor

$$\alpha := -1.012 - 1.126\cdot\sin\left(\frac{\frac{z}{3.28ft}}{11.73} + 5.133\right)$$

variable β for stress reduction factor

$$\beta := 0.106 + 0.118\,\sin\left(\frac{\frac{z}{3.28ft}}{11.28} + 5.142\right)$$

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stress reduction factor $r_d := \exp(\alpha + \beta \cdot M_w)$ $r_d = 0.973$

Liquefaction Calculations -

cyclic stress ratio $CSR := 0.65 \cdot \frac{\sigma tot_v}{\sigma eff_v} \cdot \frac{a_{max}}{g} \cdot r_d$ $CSR = 0.158$

cyclic resistance ratio

$$CRR_{M7.5\_\sigma eff1} := \exp\left[\frac{N_{1\_60\_cs}}{14.1} + \left(\frac{N_{1\_60\_cs}}{126}\right)^2 - \left(\frac{N_{1\_60\_cs}}{23.6}\right)^3 + \left(\frac{N_{1\_60\_cs}}{25.4}\right)^4 - 2.8\right]$$

magnitude scaling factor
(maximum MSF = 1.8)

$MSF := 6.9 \exp\left(\frac{-M_w}{4}\right) - 0.058$ $MSF = 1.919$

coefficient for overburden correction factor
(maximum Cσ=0.3)

$C_\sigma := \frac{1}{18.9 - 2.55 \cdot (N_{1\_60})^{0.5}}$ $C_\sigma = 0.104$

overburden correction factor
(maximum Kσ=1.1)

$K_\sigma := 1 - C_\sigma \cdot \ln\left(\frac{\sigma eff_v}{P_a}\right)$ $K_\sigma = 1.112$

static shear stress on horizontal plane $\tau_{ho} := 0psf$

effective friction angle $\phi_{eff} := \operatorname{atan}\left(\frac{N_{60}}{12.2 + 20.3 \cdot \frac{\sigma eff_v}{P_a}}\right)^{0.34}$ $\phi_{eff} = 41.31 \cdot deg$

Ko for NC soil $K_o := (1 - \sin(\phi_{eff}))$ $K_o = 0.34$

empirical constant for dilatancy $Q := 10$

Grain type.	Q
quartz and feldspar	10
limestone	8
anthracite	7
chalk	5.5

relative state parameter
(-0.61<ξR<0.11)

$$\zeta_R := \frac{1}{Q - \ln\left[\frac{100\cdot\left(1 + 2K_o\right)\sigma eff_v}{3\cdot P_a}\right]} - \left(\frac{N_{1\_60}}{46}\right)^{0.5} \qquad \zeta_R = -0.392$$

alpha factor
(maximum α=0.35)

$$\alpha\_factor := \frac{\tau_{ho}}{\sigma eff_v} \qquad \alpha\_factor = 0$$

$$a := 1267 + 636\alpha\_factor^2 - 634\cdot\exp(\alpha\_factor) - 632\cdot\exp(-\alpha\_factor)$$

$$b := \exp\left(-1.11 + 12.3\alpha\_factor^2 + 1.31\cdot\ln(\alpha\_factor + 0.0001)\right)$$

$$c := 0.138 + 0.126\cdot\alpha\_factor + 2.52\cdot\alpha\_factor^3$$

static shear stress correction factor

$$K_\alpha := a + b\cdot\exp\left(\frac{-\zeta_R}{c}\right) \qquad K_\alpha = 1$$

corrected cyclic stress ratio

$$CRR_{M\_\sigma effv} := CRR_{M7.5\_\sigma eff1}\cdot MSF\cdot K_\sigma\cdot K_\alpha$$

factor of safety for liquefaction

$$FS_{liq} := \frac{CRR_{M\_\sigma effv}}{CSR} \qquad FS_{liq} = 2.573$$

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Soil Stress Conditions -

average total unit weight of soil $\gamma_{total} := 120pcf$

unit weight of water $\gamma_{water} := 62.4pcf$

water table depth below ground surface....very deep

sample depth Boring B-110 Sample No. 4 $z := 8ft$

total vertical stress $\sigma tot_v := \gamma_{total} \cdot z$ $\sigma tot_v = 960 \cdot psf$

static water pressure $u_o := 0$ $u_o = 0 \cdot psf$

effective vertical stress $\sigma eff_v := \sigma tot_v - u_o$ $\sigma eff_v = 960 \cdot psf$

Standard Penetration N-value Correction -

Hammer	CE
Doughnut	0.5-1.0
Safety	0.7-1.2
Automatic	0.8-1.3
(Skempton, 1986)	

Standard Penetration Test N-value $N_m := 40$

fines content $FC := 41$

energy correction $C_E := 0.75$

borehole diameter correction $C_B := 1.05$

rod length correction $C_R := 0.75$

sampler correction $C_S := 1$

Borehole dia.	CB
65-115mm	1.0
150mm	1.05
200mm	1.15
(Skempton, 1986)	

SPT N-value for an energy ratio of 60% $N_{60} := C_E \cdot C_B \cdot C_R \cdot C_S \cdot N_m$

$N_{60} = 23.6$

Rod length	CR
< 3m	0.75
3-4m	0.80
4-6m	0.85
6-10m	0.95
10-30m	1.00

overburden correction factor (based on overburden stress only) $C_{N\_a} := \left(\frac{P_a}{\sigma eff_v}\right)^{0.5}$

$C_{N\_a} = 1.485$

normalized SPT N-value (based on overburden stress only) $N_{1\_60} := C_{N\_a} \cdot N_{60}$ $N_{1\_60} = 35.1$

overburden correction factor (based on overburden stress and relative density)

$$C_{N\_b} := \left(\frac{P_a}{\sigma eff_v}\right)^{0.784-0.078\cdot\left(N_{1\_60}\right)^{0.5}}$$

$$C_{N\_b} = 1.29$$

overburden correction factor used in liquefaction analysis (max CN = 1.7)

$$C_N := 1.31$$

recalculated normalized SPT N-value

$$N_{1\_60} := C_N \cdot N_{60}$$

$$N_{1\_60} = 30.9$$

overburden correction factor used in liquefaction analysis

$$C_{N\_check} := \left(\frac{P_a}{\sigma eff_v}\right)^{0.784-0.078\cdot\left(N_{1\_60}\right)^{0.5}}$$

$$C_{N\_check} = 1.319$$

fines content adjustment to SPT N-value

$$\Delta N_{1\_60} := \exp\left[1.63 + \frac{9.7}{FC + 0.01} - \left(\frac{15.7}{FC + 0.01}\right)^2\right]$$

$$\Delta N_{1\_60} = 5.6$$

normalized SPT N-value (clean sands)

$$N_{1\_60\_cs} := N_{1\_60} + \Delta N_{1\_60}$$

$$N_{1\_60\_cs} = 36.533$$

Earthquake Conditions -

peak ground accelerationl $a_{max} := 0.25\cdot g$

earthquake moment magnitude $M_w := 5$

variable α for stress reduction factor

$$\alpha := -1.012 - 1.126\cdot\sin\left(\frac{\frac{z}{3.28ft}}{11.73} + 5.133\right)$$

variable β for stress reduction factor

$$\beta := 0.106 + 0.118\sin\left(\frac{\frac{z}{3.28ft}}{11.28} + 5.142\right)$$

stress reduction factor $r_d := \exp(\alpha + \beta \cdot M_w)$ $r_d = 0.959$

Liquefaction Calculations -

cyclic stress ratio $CSR := 0.65 \cdot \frac{\sigma tot_v}{\sigma eff_v} \cdot \frac{a_{max}}{g} \cdot r_d$ $CSR = 0.156$

cyclic resistance ratio

$$CRR_{M7.5\_\sigma eff1} := \exp\left[\frac{N_{1\_60\_cs}}{14.1} + \left(\frac{N_{1\_60\_cs}}{126}\right)^2 - \left(\frac{N_{1\_60\_cs}}{23.6}\right)^3 + \left(\frac{N_{1\_60\_cs}}{25.4}\right)^4 - 2.8\right]$$

magnitude scaling factor
(maximum MSF = 1.8) $MSF := 6.9 \exp\left(\frac{-M_w}{4}\right) - 0.058$ $MSF = 1.919$

coefficient for overburden correction factor
(maximum Cσ=0.3) $C_\sigma := \frac{1}{18.9 - 2.55 \cdot (N_{1\_60})^{0.5}}$ $C_\sigma = 0.212$

overburden correction factor
(maximum Kσ=1.1) $K_\sigma := 1 - C_\sigma \cdot \ln\left(\frac{\sigma eff_v}{P_a}\right)$ $K_\sigma = 1.168$

static shear stress on horizontal plane $\tau_{ho} := 0psf$

effective friction angle $\phi_{eff} := \operatorname{atan}\left(\frac{N_{60}}{12.2 + 20.3 \cdot \frac{\sigma eff_v}{P_a}}\right)^{0.34}$ $\phi_{eff} = 53.879 \cdot deg$

Ko for NC soil $K_o := (1 - \sin(\phi_{eff}))$ $K_o = 0.192$

empirical constant for dilatancy $Q := 10$

Grain type.	Q
quartz and feldspar	10
limestone	8
anthracite	7
chalk	5.5

relative state parameter
(-0.61<ξR<0.11)

$$\zeta_R := \frac{1}{Q - \ln\left[\frac{100\cdot\left(1 + 2K_o\right)\sigma eff_v}{3\cdot P_a}\right]} - \left(\frac{N_{1\_60}}{46}\right)^{0.5} \qquad \zeta_R = -0.677$$

alpha factor
(maximum α=0.35)

$$\alpha\_factor := \frac{\tau_{ho}}{\sigma eff_v} \qquad \alpha\_factor = 0$$

$$a := 1267 + 636\alpha\_factor^2 - 634\cdot \exp(\alpha\_factor) - 632\cdot \exp(-\alpha\_factor)$$

$$b := \exp\left(-1.11 + 12.3\alpha\_factor^2 + 1.31\cdot \ln(\alpha\_factor + 0.0001)\right)$$

$$c := 0.138 + 0.126\cdot\alpha\_factor + 2.52\cdot\alpha\_factor^3$$

static shear stress correction factor

$$K_\alpha := a + b\cdot \exp\left(\frac{-\zeta_R}{c}\right) \qquad K_\alpha = 1$$

corrected cyclic stress ratio

$$CRR_{M\_\sigma effv} := CRR_{M7.5\_\sigma eff1}\cdot MSF\cdot K_\sigma\cdot K_\alpha$$

factor of safety for liquefaction

$$FS_{liq} := \frac{CRR_{M\_\sigma effv}}{CSR} \qquad FS_{liq} = 22.457$$

DAN BROWN AND ASSOCIATES

Project CISF
Project No. 19-017
Sheet 1 of 4
Date 2 / 17 / 2020
Engineer TCS
Checked by TJD

The following calculations for liquefaction of soils with sand-like behavior are based on Soil Liquefaction During Earthquakes - Monograph MNO-12 by I.M. Idriss and R.W. Boulanger (2008) published by the Earthquake Engineering Research Institute.

Soil Stress Conditions -

average total unit weight of soil $\gamma_{total} := 120pcf$

unit weight of water $\gamma_{water} := 62.4pcf$

water table depth below ground surface....very deep

sample depth Boring B-104 Sample No. 5 $z := 14ft$

total vertical stress $\sigma tot_v := \gamma_{total} \cdot z$ $\sigma tot_v = 1680 \cdot psf$

static water pressure $u_o := 0$ $u_o = 0 \cdot psf$

effective vertical stress $\sigma eff_v := \sigma tot_v - u_o$ $\sigma eff_v = 1680 \cdot psf$

Standard Penetration N-value Correction -

Hammer	CE
Doughnut	0.5-1.0
Safety	0.7-1.2
Automatic	0.8-1.3
(Skempton, 1986)	

Standard Penetration Test N-value $N_m := 76$

fines content $FC := 41$

energy correction $C_E := 0.75$

borehole diameter correction $C_B := 1.05$

rod length correction $C_R := 0.85$

sampler correction $C_S := 1$

Borehole dia.	CB
65-115mm	1.0
150mm	1.05
200mm	1.15
(Skempton, 1986)	

SPT N-value for an energy ratio of 60% $N_{60} := C_E \cdot C_B \cdot C_R \cdot C_S \cdot N_m$

$N_{60} = 50.9$

Rod length	CR
< 3m	0.75
3-4m	0.80
4-6m	0.85
6-10m	0.95
10-30m	1.00

overburden correction factor (based on overburden stress only)

$$C_{N\_a} := \left(\frac{P_a}{\sigma eff_v}\right)^{0.5}$$

$C_{N\_a} = 1.122$

normalized SPT N-value (based on overburden stress only) $N_{1\_60} := C_{N\_a} \cdot N_{60}$ $N_{1\_60} = 57.1$

overburden correction factor (based on overburden stress and relative density)

$$C_{N\_b} := \left(\frac{P_a}{\sigma eff_v}\right)^{0.784-0.078\cdot\left(N_{1\_60}\right)^{0.5}}$$

$$C_{N\_b} = 1.046$$

overburden correction factor used in liquefaction analysis (max CN = 1.7)

$$C_N := 1.05$$

recalculated normalized SPT N-value

$$N_{1\_60} := C_N \cdot N_{60}$$

$$N_{1\_60} = 53.4$$

overburden correction factor used in liquefaction analysis

$$C_{N\_check} := \left(\frac{P_a}{\sigma eff_v}\right)^{0.784-0.078\cdot\left(N_{1\_60}\right)^{0.5}}$$

$$C_{N\_check} = 1.051$$

fines content adjustment to SPT N-value

$$\Delta N_{1\_60} := \exp\left[1.63 + \frac{9.7}{FC + 0.01} - \left(\frac{15.7}{FC + 0.01}\right)^2\right]$$

$$\Delta N_{1\_60} = 5.6$$

normalized SPT N-value (clean sands)

$$N_{1\_60\_cs} := N_{1\_60} + \Delta N_{1\_60}$$

$$N_{1\_60\_cs} = 59$$

Earthquake Conditions -

peak ground accelerationl $a_{max} := 0.25\cdot g$

earthquake moment magnitude $M_w := 5$

variable α for stress reduction factor

$$\alpha := -1.012 - 1.126\cdot\sin\left(\frac{\frac{z}{3.28ft}}{11.73} + 5.133\right)$$

variable β for stress reduction factor

$$\beta := 0.106 + 0.118\sin\left(\frac{\frac{z}{3.28ft}}{11.28} + 5.142\right)$$

DAN BROWN AND ASSOCIATES

Project CISF
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Checked by TJD

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stress reduction factor $r_d := \exp(\alpha + \beta \cdot M_w)$ $r_d = 0.911$

Liquefaction Calculations -

cyclic stress ratio $CSR := 0.65 \cdot \frac{\sigma tot_v}{\sigma eff_v} \cdot \frac{a_{max}}{g} \cdot r_d$ $CSR = 0.148$

cyclic resistance ratio

$$CRR_{M7.5\_\sigma eff1} := \exp\left[\frac{N_{1\_60\_cs}}{14.1} + \left(\frac{N_{1\_60\_cs}}{126}\right)^2 - \left(\frac{N_{1\_60\_cs}}{23.6}\right)^3 + \left(\frac{N_{1\_60\_cs}}{25.4}\right)^4 - 2.8\right]$$

magnitude scaling factor
(maximum MSF = 1.8)

$MSF := 6.9\exp\left(\frac{-M_w}{4}\right) - 0.058$ $MSF = 1.919$

coefficient for overburden correction factor
(maximum Cσ=0.3)

$C_\sigma := \frac{1}{18.9 - 2.55 \cdot (N_{1\_60})^{0.5}}$ $C_\sigma = 3.803$

overburden correction factor
(maximum Kσ=1.1)

$K_\sigma := 1 - C_\sigma \cdot \ln\left(\frac{\sigma eff_v}{P_a}\right)$ $K_\sigma = 1.877$

static shear stress on horizontal plane $\tau_{ho} := 0psf$

effective friction angle $\phi_{eff} := \operatorname{atan}\left(\frac{N_{60}}{12.2 + 20.3 \cdot \frac{\sigma eff_v}{P_a}}\right)^{0.34}$ $\phi_{eff} = 58.496 \cdot deg$

Ko for NC soil $K_o := (1 - \sin(\phi_{eff}))$ $K_o = 0.147$

empirical constant for dilatancy $Q := 10$

Grain type.	Q
quartz and feldspar	10
limestone	8
anthracite	7
chalk	5.5

relative state parameter
(-0.61<ξR<0.11)

$$\zeta_R := \frac{1}{Q - \ln\left[\frac{100\cdot(1 + 2K_o)\sigma eff_v}{3\cdot P_a}\right]} - \left(\frac{N_{1\_60}}{46}\right)^{0.5} \qquad \zeta_R = -0.923$$

alpha factor
(maximum α=0.35)

$$\alpha\_factor := \frac{\tau_{ho}}{\sigma eff_v} \qquad \alpha\_factor = 0$$

$$a := 1267 + 636\alpha\_factor^2 - 634\cdot\exp(\alpha\_factor) - 632\cdot\exp(-\alpha\_factor)$$

$$b := \exp\left(-1.11 + 12.3\alpha\_factor^2 + 1.31\cdot\ln(\alpha\_factor + 0.0001)\right)$$

$$c := 0.138 + 0.126\cdot\alpha\_factor + 2.52\cdot\alpha\_factor^3$$

static shear stress correction factor

$$K_\alpha := a + b\cdot\exp\left(\frac{-\zeta_R}{c}\right) \qquad K_\alpha = 1.002$$

corrected cyclic stress ratio

$$CRR_{M\_\sigma effv} := CRR_{M7.5\_\sigma eff1}\cdot MSF\cdot K_\sigma\cdot K_\alpha$$

factor of safety for liquefaction

$$FS_{liq} := \frac{CRR_{M\_\sigma effv}}{CSR} \qquad FS_{liq} = 8.725\times 10^7$$

Project CISF
Project No. 19-017
Sheet 1 of 4
Date 2 / 17 / 2020
Engineer TCS
Checked by TJD

The following calculations for liquefaction of soils with sand-like behavior are based on Soil Liquefaction During Earthquakes - Monograph MNO-12 by I.M. Idriss and R.W. Boulanger (2008) published by the Earthquake Engineering Research Institute.

Soil Stress Conditions -

average total unit weight of soil $\gamma_{total} := 120pcf$

unit weight of water $\gamma_{water} := 62.4pcf$

water table depth below ground surface....very deep

sample depth Boring B-101 Sample No. 6 $z := 19ft$

total vertical stress $\sigma tot_v := \gamma_{total} \cdot z$ $\sigma tot_v = 2280 \cdot psf$

static water pressure $u_o := 0$ $u_o = 0 \cdot psf$

effective vertical stress $\sigma eff_v := \sigma tot_v - u_o$ $\sigma eff_v = 2280 \cdot psf$

Standard Penetration N-value Correction -

Hammer	CE
Doughnut	0.5-1.0
Safety	0.7-1.2
Automatic	0.8-1.3
(Skempton, 1986)	

Standard Penetration Test N-value $N_m := 55$

fines content $FC := 41$

energy correction $C_E := 0.75$

borehole diameter correction $C_B := 1.05$

rod length correction $C_R := 0.85$

sampler correction $C_S := 1$

Borehole dia.	CB
65-115mm	1.0
150mm	1.05
200mm	1.15
(Skempton, 1986)	

SPT N-value for an energy ratio of 60% $N_{60} := C_E \cdot C_B \cdot C_R \cdot C_S \cdot N_m$

$N_{60} = 36.8$

Rod length	CR
< 3m	0.75
3-4m	0.80
4-6m	0.85
6-10m	0.95
10-30m	1.00

overburden correction factor (based on overburden stress only)

$$C_{N\_a} := \left(\frac{P_a}{\sigma eff_v}\right)^{0.5}$$

$C_{N\_a} = 0.963$

normalized SPT N-value (based on overburden stress only) $N_{1\_60} := C_{N\_a} \cdot N_{60}$ $N_{1\_60} = 35.5$

overburden correction factor (based on overburden stress and relative density)

$$C_{N\_b} := \left(\frac{P_a}{\sigma eff_v}\right)^{0.784-0.078\cdot\left(N_{1\_60}\right)^{0.5}}$$

$$C_{N\_b} = 0.976$$

overburden correction factor used in liquefaction analysis (max CN = 1.7)

$$C_N := 0.976$$

recalculated normalized SPT N-value

$$N_{1\_60} := C_N\cdot N_{60}$$

$$N_{1\_60} = 35.9$$

overburden correction factor used in liquefaction analysis

$$C_{N\_check} := \left(\frac{P_a}{\sigma eff_v}\right)^{0.784-0.078\cdot\left(N_{1\_60}\right)^{0.5}}$$

$$C_{N\_check} = 0.977$$

fines content adjustment to SPT N-value

$$\Delta N_{1\_60} := \exp\left[1.63 + \frac{9.7}{FC + 0.01} - \left(\frac{15.7}{FC + 0.01}\right)^2\right]$$

$$\Delta N_{1\_60} = 5.6$$

normalized SPT N-value (clean sands)

$$N_{1\_60\_cs} := N_{1\_60} + \Delta N_{1\_60}$$

$$N_{1\_60\_cs} = 41.516$$

Earthquake Conditions -

peak ground accelerationl $a_{max} := 0.25\cdot g$

earthquake moment magnitude $M_w := 5$

variable α for stress reduction factor

$$\alpha := -1.012 - 1.126\cdot\sin\left(\frac{\frac{z}{3.28ft}}{11.73} + 5.133\right)$$

variable β for stress reduction factor

$$\beta := 0.106 + 0.118\,\sin\left(\frac{\frac{z}{3.28ft}}{11.28} + 5.142\right)$$

stress reduction factor $r_d := \exp(\alpha + \beta \cdot M_w)$ $r_d = 0.868$

Liquefaction Calculations -

cyclic stress ratio $CSR := 0.65 \cdot \frac{\sigma tot_v}{\sigma eff_v} \cdot \frac{a_{max}}{g} \cdot r_d$ $CSR = 0.141$

cyclic resistance ratio

$$CRR_{M7.5\_\sigma eff1} := \exp\left[\frac{N_{1\_60\_cs}}{14.1} + \left(\frac{N_{1\_60\_cs}}{126}\right)^2 - \left(\frac{N_{1\_60\_cs}}{23.6}\right)^3 + \left(\frac{N_{1\_60\_cs}}{25.4}\right)^4 - 2.8\right]$$

magnitude scaling factor
(maximum MSF = 1.8) $MSF := 6.9\exp\left(\frac{-M_w}{4}\right) - 0.058$ $MSF = 1.919$

coefficient for overburden correction factor
(maximum Cσ=0.3) $C_\sigma := \frac{1}{18.9 - 2.55 \cdot (N_{1\_60})^{0.5}}$ $C_\sigma = 0.277$

overburden correction factor
(maximum Kσ=1.1) $K_\sigma := 1 - C_\sigma \cdot \ln\left(\frac{\sigma eff_v}{P_a}\right)$ $K_\sigma = 0.979$

static shear stress on horizontal plane $\tau_{ho} := 0psf$

effective friction angle $\phi_{eff} := \operatorname{atan}\left(\frac{N_{60}}{12.2 + 20.3 \cdot \frac{\sigma eff_v}{P_a}}\right)^{0.34}$ $\phi_{eff} = 53.647 \cdot deg$

Ko for NC soil $K_o := (1 - \sin(\phi_{eff}))$ $K_o = 0.195$

empirical constant for dilatancy $Q := 10$

Grain type.	Q
quartz and feldspar	10
limestone	8
anthracite	7
chalk	5.5

relative state parameter
(-0.61<ξR<0.11)

$$\zeta_R := \frac{1}{Q - \ln\left[\frac{100\cdot\left(1 + 2K_o\right)\sigma eff_v}{3\cdot P_a}\right]} - \left(\frac{N_{1\_60}}{46}\right)^{0.5} \qquad \zeta_R = -0.72$$

alpha factor
(maximum α=0.35)

$$\alpha\_factor := \frac{\tau_{ho}}{\sigma eff_v} \qquad \alpha\_factor = 0$$

$$a := 1267 + 636\alpha\_factor^2 - 634\cdot\exp(\alpha\_factor) - 632\cdot\exp(-\alpha\_factor)$$

$$b := \exp\left(-1.11 + 12.3\alpha\_factor^2 + 1.31\cdot\ln(\alpha\_factor + 0.0001)\right)$$

$$c := 0.138 + 0.126\cdot\alpha\_factor + 2.52\cdot\alpha\_factor^3$$

static shear stress correction factor

$$K_\alpha := a + b\cdot\exp\left(\frac{-\zeta_R}{c}\right) \qquad K_\alpha = 1$$

corrected cyclic stress ratio

$$CRR_{M\_\sigma effv} := CRR_{M7.5\_\sigma eff1}\cdot MSF\cdot K_\sigma\cdot K_\alpha$$

factor of safety for liquefaction

$$FS_{liq} := \frac{CRR_{M\_\sigma effv}}{CSR} \qquad FS_{liq} = 93.321$$

GEOServices, LLC, Geotechnical and Materials Engineers

APPENDIX G

Sample Bearing Capacity Calculations

Bearing Capacity Calculation

CISF Storage Pad

Date: 2/17/2020
Project: CISF Cask Storage Pads
Location: Andrews, Texas
Project No: 31-151247.R2

BEARING CAPACITY CALCULATIONS

Vesic Bearing Capacity Formulas

$$q_{ult} = c'N_cs_cd_ci_cb_cg_c + \sigma'_{ZD}N_qs_qd_qi_qb_qg_q + 0.5\Upsilon'BN_\Upsilon s_\Upsilon d_\Upsilon i_\Upsilon b_\Upsilon g_\Upsilon$$

where,

q_{ult}	=	ultimate bearing capacity
c'	=	effective cohesion for soil beneath foundation
ϕ'	=	effective friction angle for soil beneath foundation
σ'_{ZD}	=	vertical effective stress at depth D below ground surface
ϒ'	=	effective unit weight of the soil
D	=	depth of foundation below ground surface
B	=	width of foundation
L	=	length of foundation
N_c, N_q, N_Υ	=	Vesic bearing capacity factors = f(ϕ'), factors follow
s_c, s_q, s_Υ	=	shape factors
d_c, d_q, d_Υ	=	depth factors
i_c, i_q, i_Υ	=	load inclination factors, not applicable in this analysis
b_c, b_q, b_Υ	=	base inclination factors, not applicable in this analysis
g_c, g_q, g_Υ	=	ground inclination factors, not applicable in this analysis

Vesic Bearing Capacity Factors											
ϕ' (deg)	N_c	N_q	N_Υ	ϕ' (deg)	N_c	N_q	N_Υ	ϕ' (deg)	N_c	N_q	N_Υ
11	8.8	2.7	1.4	21.0	15.8	7.1	6.2	31.0	32.7	20.6	26.0
12	9.3	3.0	1.7	22.0	16.9	7.8	7.1	32.0	35.5	23.2	30.2
13	9.8	3.3	2.0	23.0	18.0	8.7	8.2	33.0	38.6	26.1	35.2
14	10.4	3.6	2.3	24.0	19.3	9.6	9.4	34.0	42.2	29.4	41.1
15	11.0	3.9	2.6	25.0	20.7	10.7	10.9	35.0	46.1	33.3	48.0
16	11.6	4.3	3.1	26.0	22.3	11.9	12.5	36.0	50.6	37.8	56.3
17	12.3	4.8	3.5	27.0	23.9	13.2	14.5	37.0	55.6	42.9	66.2
18	13.1	5.3	4.1	28.0	25.8	14.7	16.7	38.0	61.4	48.9	78.0
19	13.9	5.8	4.7	29.0	27.9	16.4	19.3	39.0	67.9	56.0	92.2
20	14.8	6.4	5.4	30.0	30.1	18.4	22.4	40.0	75.3	64.2	109.4

Project Specific Information:

The CISF Pads will bear at an elevation of 4 feet below ground surface. The pads will consist of a reinforced concrete mat measuring 36 inches in thickness. Plan dimensions of the mat are 135 feet by 55 feet. The CISF Pads are anticipated to bear in the Caliche with Sand Matrix. An effective friction angle of 27 degrees and an effective unit weight of 95 pounds per cubic foot were utilized for the calculation.

c'	=	0	psf
ϕ'	=	27	degrees
σ'_{ZD}	=	380	psf
Υ'	=	95	pcf
D	=	4	feet
B	=	55	feet
L	=	135	feet

Step 1: Calculate Shape Factors

$s_c = 1 + (B/L)(N_q/N_c)$ $s_c =$ 1.225

$s_q = 1 + (B/L)\tan\phi'$ $s_q =$ 1.208

$s_\Upsilon = 1 - 0.4(B/L)$ $s_\Upsilon =$ 0.837

Step 2: Calculate Depth Factors

$d_c = 1 + 0.4k$ where $k = D/B$ $d_c =$ 1.029

$d_q = 1 + 2k\tan\phi'(1-\sin\phi')^2$ $d_q =$ 1.022

$d_\Upsilon = 1$ $d_\Upsilon =$ 1.000

Step 3: Calculate Load Inclination Factors

Since the loads act perpendicular to the base of the footing, the I factors equal 1 and may be neglected.

Step 4: Calculate the Base Inclination Factors

Since the base of the footing is level, all of the b factors equal to 1 and may be neglected.

Step 5: Calculate the Ground Inclination Factors

Since the ground surfaceis level the g factors equal to 1 and may be neglected.

Step 6: Calculate the Ultimate Bearing Capacity

$q_{ult} = c'N_c s_c d_c i_c b_c g_c + \sigma'_{ZD} N_q s_q d_q i_q b_q g_q + 0.5\Upsilon' B N_\Upsilon s_\Upsilon d_\Upsilon i_\Upsilon b_\Upsilon g_\Upsilon$

removing the values which were equal to 1 results in the following:

$q_{ult} = c'N_c s_c d_c + \sigma'_{ZD} N_q s_q d_q + 0.5\Upsilon' B N_\Upsilon s_\Upsilon d_\Upsilon$

q_{ult} = 37899 psf

Step 7: Calculate the Allowable Bearing Capacity

$q_{all} = q_{ult}/FOS$ Factor of Safety of 3 utilized for bearing capacity

q_{all} = 12633 psf

Based on the loading provided by Enercon the CISF Mat Foundations will impart a maximum pressure of 4,500 psf to the subgrade

12633 > 4,500 Bearing Capacity OK

You will note that the calculated allowable bearing capacities often exceed those provided in the text of the report. Typically, on structures which are supported on shallow foundations bearing capacity (of the soil) does not control the foundation size.

GEOS

Bearing Capacity Calculation

Cask Handling Building – Main Columns

Date: 2/17/2020
Project: CISF - Cask Handling Building (Main Columns)
Location: Andrews, Texas
Project No: 31-151247.R2

BEARING CAPACITY CALCULATIONS

Vesic Bearing Capacity Formulas

$$q_{ult} = c'N_c s_c d_c i_c b_c g_c + \sigma'_{ZD} N_q s_q d_q i_q b_q g_q + 0.5\Upsilon' B N_\Upsilon s_\Upsilon d_\Upsilon i_\Upsilon b_\Upsilon g_\Upsilon$$

where,

q_{ult}	=	ultimate bearing capacity
c'	=	effective cohesion for soil beneath foundation
ϕ'	=	effective friction angle for soil beneath foundation
σ'_{ZD}	=	vertical effective stress at depth D below ground surface
Υ'	=	effective unit weight of the soil
D	=	depth of foundation below ground surface
B	=	width of foundation
L	=	length of foundation
N_c, N_q, N_Υ	=	Vesic bearing capacity factors = f(ϕ'), factors follow
s_c, s_q, s_Υ	=	shape factors
d_c, d_q, d_Υ	=	depth factors
i_c, i_q, i_Υ	=	load inclination factors, not applicable in this analysis
b_c, b_q, b_Υ	=	base inclination factors, not applicable in this analysis
g_c, g_q, g_Υ	=	ground inclination factors, not applicable in this analysis

Vesic Bearing Capacity Factors											
ϕ' (deg)	N_c	N_q	N_Υ	ϕ' (deg)	N_c	N_q	N_Υ	ϕ' (deg)	N_c	N_q	N_Υ
11	8.8	2.7	1.4	21.0	15.8	7.1	6.2	31.0	32.7	20.6	26.0
12	9.3	3.0	1.7	22.0	16.9	7.8	7.1	32.0	35.5	23.2	30.2
13	9.8	3.3	2.0	23.0	18.0	8.7	8.2	33.0	38.6	26.1	35.2
14	10.4	3.6	2.3	24.0	19.3	9.6	9.4	34.0	42.2	29.4	41.1
15	11.0	3.9	2.6	25.0	20.7	10.7	10.9	35.0	46.1	33.3	48.0
16	11.6	4.3	3.1	26.0	22.3	11.9	12.5	36.0	50.6	37.8	56.3
17	12.3	4.8	3.5	27.0	23.9	13.2	14.5	37.0	55.6	42.9	66.2
18	13.1	5.3	4.1	28.0	25.8	14.7	16.7	38.0	61.4	48.9	78.0
19	13.9	5.8	4.7	29.0	27.9	16.4	19.3	39.0	67.9	56.0	92.2
20	14.8	6.4	5.4	30.0	30.1	18.4	22.4	40.0	75.3	64.2	109.4

Project Specific Information:

The foundations for the Cask Handling Building will bear at an elevation of 10 to 11 feet below ground surface. The foundations for the main columns measure 28 feet by 183 feet while the foundations for the wind columns measure 26 feet 3 inches by 40 feet. The foundations for the cask handling building are anticipated to bear in the Caliche with Sand Matrix. An effective friction angle of 35 degrees and an effective unit weight of 130 pounds per cubic foot were utilized for the calculation.

c'	=	0	psf
ϕ'	=	35	degrees
σ'_{ZD}	=	1300	psf
Υ'	=	130	pcf
D	=	10	feet
B	=	28	feet
L	=	183	feet

Step 1: Calculate Shape Factors

$s_c = 1 + (B/L)(N_q/N_c)$ $s_c =$ 1.111

$s_q = 1 + (B/L)\tan\phi'$ $s_q =$ 1.285

$s_\Upsilon = 1 - 0.4(B/L)$ $s_\Upsilon =$ 0.837

Step 2: Calculate Depth Factors

$d_c = 1 + 0.4k$ where $k = D/B$ $d_c =$ 1.143

$d_q = 1 + 2k\tan\phi'(1-\sin\phi')^2$ $d_q =$ 1.091

$d_\Upsilon = 1$ $d_\Upsilon =$ 1.000

Step 3: Calculate Load Inclination Factors

Since the loads act perpendicular to the base of the footing, the I factors equal 1 and may be neglected.

Step 4: Calculate the Base Inclination Factors

Since the base of the footing is level, all of the b factors equal to 1 and may be neglected.

Step 5: Calculate the Ground Inclination Factors

Since the ground surfaceis level the g factors equal to 1 and may be neglected.

Step 6: Calculate the Ultimate Bearing Capacity

$q_{ult} = c'N_c s_c d_c i_c b_c g_c + \sigma'_{ZD} N_q s_q d_q i_q b_q g_q + 0.5\Upsilon' B N_\Upsilon s_\Upsilon d_\Upsilon i_\Upsilon b_\Upsilon g_\Upsilon$

removing the values which were equal to 1 results in the following:

$q_{ult} = c'N_c s_c d_c + \sigma'_{ZD} N_q s_q d_q + 0.5\Upsilon' B N_\Upsilon s_\Upsilon d_\Upsilon$

q_{ult} = 133823 psf

Step 7: Calculate the Allowable Bearing Capacity

$q_{all} = q_{ult}/FOS$ Factor of Safety of 3 utilized for bearing capacity

q_{all} = 44608 psf

Based on the loading provided by AECOM the Cask Handling Building Main Columns will impart a maximum service level pressure of 3,340 psf to the subgrade

44608 > 3,340 Bearing Capacity OK

You will note that the calculated allowable bearing capacities often exceed those provided in the text of the report. Typically, on structures which are supported on shallow foundations bearing capacity (of the soil) does not control the foundation size.

GEOS

Bearing Capacity Calculation

Cask Handling Building – Wind Columns

Date: 2/17/2020
Project: CISF - Cask Handling Building (Wind Columns)
Location: Andrews, Texas
Project No: 31-151247.R2

BEARING CAPACITY CALCULATIONS

Vesic Bearing Capacity Formulas

$$q_{ult} = c'N_c s_c d_c i_c b_c g_c + \sigma'_{ZD} N_q s_q d_q i_q b_q g_q + 0.5\Upsilon' B N_\Upsilon s_\Upsilon d_\Upsilon i_\Upsilon b_\Upsilon g_\Upsilon$$

where,

q_{ult}	=	ultimate bearing capacity
c'	=	effective cohesion for soil beneath foundation
ϕ'	=	effective friction angle for soil beneath foundation
σ'_{ZD}	=	vertical effective stress at depth D below ground surface
ϒ'	=	effective unit weight of the soil
D	=	depth of foundation below ground surface
B	=	width of foundation
L	=	length of foundation
N_c, N_q, N_Υ	=	Vesic bearing capacity factors = f(ϕ'), factors follow
s_c, s_q, s_Υ	=	shape factors
d_c, d_q, d_Υ	=	depth factors
i_c, i_q, i_Υ	=	load inclination factors, not applicable in this analysis
b_c, b_q, b_Υ	=	base inclination factors, not applicable in this analysis
g_c, g_q, g_Υ	=	ground inclination factors, not applicable in this analysis

Vesic Bearing Capacity Factors											
ϕ' (deg)	N_c	N_q	N_Υ	ϕ' (deg)	N_c	N_q	N_Υ	ϕ' (deg)	N_c	N_q	N_Υ
11	8.8	2.7	1.4	21.0	15.8	7.1	6.2	31.0	32.7	20.6	26.0
12	9.3	3.0	1.7	22.0	16.9	7.8	7.1	32.0	35.5	23.2	30.2
13	9.8	3.3	2.0	23.0	18.0	8.7	8.2	33.0	38.6	26.1	35.2
14	10.4	3.6	2.3	24.0	19.3	9.6	9.4	34.0	42.2	29.4	41.1
15	11.0	3.9	2.6	25.0	20.7	10.7	10.9	35.0	46.1	33.3	48.0
16	11.6	4.3	3.1	26.0	22.3	11.9	12.5	36.0	50.6	37.8	56.3
17	12.3	4.8	3.5	27.0	23.9	13.2	14.5	37.0	55.6	42.9	66.2
18	13.1	5.3	4.1	28.0	25.8	14.7	16.7	38.0	61.4	48.9	78.0
19	13.9	5.8	4.7	29.0	27.9	16.4	19.3	39.0	67.9	56.0	92.2
20	14.8	6.4	5.4	30.0	30.1	18.4	22.4	40.0	75.3	64.2	109.4

Project Specific Information:

The foundations for the Cask Handling Building will bear at an elevation of 10 to 11 feet below ground surface. The foundations for the main columns measure 28 feet by 183 feet while the foundations for the wind columns measure 26 feet 3 inches by 40 feet. The foundations for the cask handling building are anticipated to bear in the Caliche with Sand Matrix. An effective friction angle of 35 degrees and an effective unit weight of 130 pounds per cubic foot were utilized for the calculation.

c'	=	0	psf
ϕ'	=	35	degrees
σ'_{ZD}	=	1300	psf
γ'	=	130	pcf
D	=	10	feet
B	=	26.25	feet
L	=	40	feet

Step 1: Calculate Shape Factors

$s_c = 1 + (B/L)(N_q/N_c)$ — $s_c =$ 1.474

$s_q = 1 + (B/L)\tan\phi'$ — $s_q =$ 1.285

$s_\gamma = 1 - 0.4(B/L)$ — $s_\gamma =$ 0.837

Step 2: Calculate Depth Factors

$d_c = 1 + 0.4k$ where $k = D/B$ — $d_c =$ 1.152

$d_q = 1 + 2k\tan\phi'(1-\sin\phi')^2$ — $d_q =$ 1.097

$d_\gamma = 1$ — $d_\gamma =$ 1.000

Step 3: Calculate Load Inclination Factors

Since the loads act perpendicular to the base of the footing, the I factors equal 1 and may be neglected.

Step 4: Calculate the Base Inclination Factors

Since the base of the footing is level, all of the b factors equal to 1 and may be neglected.

Step 5: Calculate the Ground Inclination Factors

Since the ground surfaceis level the g factors equal to 1 and may be neglected.

Step 6: Calculate the Ultimate Bearing Capacity

$q_{ult} = c'N_c s_c d_c i_c b_c g_c + \sigma'_{ZD} N_q s_q d_q i_q b_q g_q + 0.5\Upsilon' B N_\Upsilon s_\Upsilon d_\Upsilon i_\Upsilon b_\Upsilon g_\Upsilon$

removing the values which were equal to 1 results in the following:

$q_{ult} = c'N_c s_c d_c + \sigma'_{ZD} N_q s_q d_q + 0.5\Upsilon' B N_\Upsilon s_\Upsilon d_\Upsilon$

q_{ult} = 129590 psf

Step 7: Calculate the Allowable Bearing Capacity

$q_{all} = q_{ult}/FOS$ Factor of Safety of 3 utilized for bearing capacity

q_{all} = 43197 psf

Based on the loading provided by AECOM the Cask Handling Building Wind Columns will impart a maximum service level pressure of 1,860 psf to the subgrade

43197 > 1,860 Bearing Capacity OK

You will note that the calculated allowable bearing capacities often exceed those provided in the text of the report. Typically, on structures which are supported on shallow foundations bearing capacity (of the soil) does not control the foundation size.

APPENDIX H

Settlement Calculations

DAN BROWN AND ASSOCIATES

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(423)942-8681
www.danbrownandassociates.com

TECHNICAL MEMORANDUM

Settlement Analyses
CISF Storage Pad Site
Andrews TX
DBA Project No. 19-017

To:	Derek Kilday, P.E./GEOServices
From:	Timothy C. Siegel, P.E, G.E., D.GE Tayler J. Day, P.E.
Date:	17 February 2020

1. Introduction

This Technical Memorandum (TM) presents the results of settlement analyses for the waste interim storage pad system at the subject site in Andrews, Texas. Subsurface conditions were described as a soil column in correspondence from GEOServices as part of their revised recommendations to be included in the final geotechnical report. Loading and pad dimensions were provided to DBA by Enercon. The remaining sections of this TM briefly describe the soil column, analysis considerations and results.

2. Soil Column Used for Analysis

The settlement analyses were performed based on soil properties and stresses applied to the ground by the proposed structure. Geotechnical explorations were performed by AECOM[1] and GEOServices[2]. Boring information collected by GEOServices extends to auger refusal at approximately 45 feet below the ground surface that existed at time of exploration. Typical settlement analyses consider a depth of influence of twice the least dimension of the loaded area. DBA understands that for this project, the team prefers to consider a greater depth. DBA's analyses consider the soil column to 600 feet below ground surface (top of the Trujillo Sandstone Formation) with the layers presented in Table 1.

[1] AECOM. (2016). Site-Specific Seismic Hazard Evaluation and Development of Seismic Design Ground Motions, WCS Centralized Interim Storage Facility Project. Dated March 18, 2016.

[2] GEOServices (2018) Report of Geotechnical Exploration: Consolidated Interim Storage Facility (CISF) Andrews, Texas Geoservices,, LLC Project No. 31-151247.R1. Submitted to Waste Control Specialists, LLC. Dated 15 July 2016

Table 1 - Soil column layer information provided in revised GEOServices Report of Geotechnical Exploration

Top (feet)	Bottom (feet)	Layer Description
0	2	Cover Sands
2	10	Caliche with Sand Matrix - Moderately Hard
10	20	Caliche with Sand Matrix - Moderately Hard
20	25	Caliche - Very Hard
25	35	Caliche - Very Hard
35	50	Ogallala - Sand with Gravel
50	80	Ogallala - Sand with Gravel
80	100	Ogallala - Sand with Gravel
100	130	Dockum - Claystone and Siltstone
130	230	Claystone and Siltstone
230	275	Dockum - Claystone
275	300	Dockum - Silty Sands
300	360	Dockum - Claystone
360	600	Dockum - Claystone

3. Settlement Analysis Parameters

Settlement analyses were performed using Settle3 ver. 5.001, a 3-dimensional program for the analysis of vertical consolidation and settlement under foundations and surface loads. Settle3 is designed to compute both immediate compression settlement and settlement due to consolidation. Immediate settlement occurs when a load is applied to materials that can be assumed to behave linear elastically. In this case, the composition of the soil column and relative stiffness (reported in boring logs and shear wave velocity profiles) coupled with the absence of a consistent high groundwater table identifies Immediate Settlement as the dominant deflection mechanism. Consolidation occurs in materials where excess pore pressures gradually dissipate. As there is no consistent permanent water table observed in the extensive geotechnical exploration of the areas, excess porewater pressures are unlikely to be generated so DBA concludes that primary consolidation will not significantly contribute to storage pad deflections in the reported conditions. The stress computation method used in this analysis was the Westergaard Solution for consideration of multiple layers with Poisson's ratio inputs.

Immediate settlement can be estimated in Settle3 using constrained modulus to represent the compressibility of the geotechnical material. Constrained modulus was not directly provided in the provided geotechnical explorations. The constrained modulus of soil was determined using a correlation with average standard penetration test (SPT) N-value that was proposed by Tan et al.[3] The average SPT N-values (excluding refusal) in the GEOServices borings were compared to the "Normally Loaded Sand or Sand and Gravel" relationship to estimate the constrained modulus using the highest resolution measurements available. The majority of the SPT N-values

[3] Tan, C.K., Duncan, J.M., Rojiani, K.B., and Barker, R.M.(1991) Engineering Manual for Shallow Foundations, prepared for the National Cooperative Highway Research Program (NCHRP Project 24-4) Sponsored by AASHTO and FHWA, Washington, D.C., 171pp

measured in the remaining layers of the GEOServices borings were larger than 70 blows/ft and are therefore considered outside the range of the correlation.

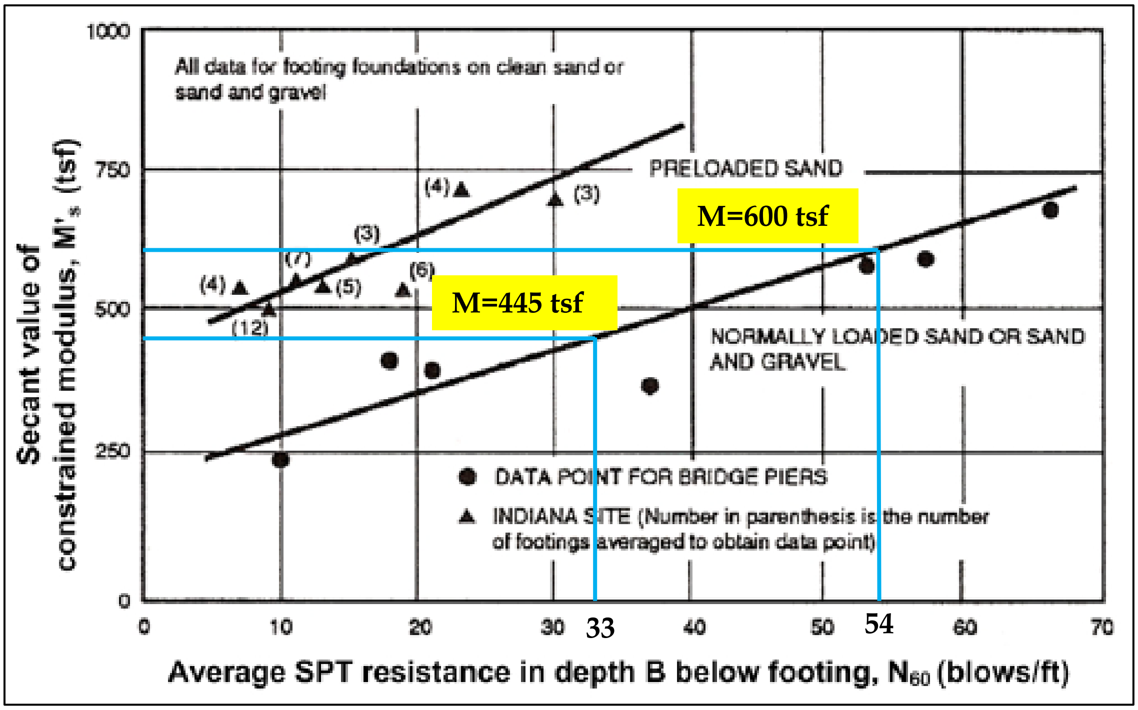

Figure 1 - Relationship between SPT resistance and constrained modulus used for top 20 feet of soil column (after Tan et al., 1991)

A summary of the estimated constrained moduli for the top 20 feet of the soil column is presented in Table 2. Several refusal SPT N-values in the top 20 feet were intentionally excluded from the average in recognition of potential reductions in modulus due to inconsistent or partial cementation in the Caliche Sand matrix as described to DBA by GEOServices.

Table 2 - Correlated constrained modulus values for top 20feet of soil column using Tan et al. (1991).

Top (feet)	Bottom (feet)	Average N-Value (bpf)	Layer Material (from GEOS Soil Column)	Constrained Modulus (tsf) from Tan et al. (1991) correlation
0	2	33	Cover Sands	445
2	10	54	Caliche with Sand Matrix - Moderately Hard	600
10	20	54	Caliche with Sand Matrix - Moderately Hard	600

Below a depth of 20feet, DBA relied upon the shear wave velocity profiles collected by GEOServices and the Site-Specific Seismic Hazard Evaluation and Development of Seismic Ground Motions prepared by AECOM (2016). The GEOServices study targeted the top 100feet of the profile while the AECOM study collected shear wave velocity measurements in the area to depths of 600feet below ground surface. Each layer in the soil column between 20feet and 100feet below ground surface were assigned average shear wave velocities using the GEOServices shear wave velocity

measurements. Layers between 100feet and 600feet below ground surface were assigned average shear wave velocities using the AECOM measurements. A summary of the layers, their associated Settle3 model layer names, and the average shear wave velocities is provided in Table 3.

Table 3 - Average shear wave velocities assigned to each soil column layer between 20 feet and 600 feet below ground surface.

Top (feet)	Bottom (feet)	Avg. Layer Shear Wave Velocity (ft/s)	Layer Material (From GEOS Column)
20	25	1530	Caliche - Very Hard
25	35	1900	Caliche - Very Hard
35	50	2290	Ogallala - Sand with Gravel
50	80	1840	Ogallala - Sand with Gravel
80	100	2790	Ogallala - Sand with Gravel
100	130	2300	Dockum - Claystone and Siltstone
130	230	2755	Claystone and Siltstone
230	275	2755	Dockum - Claystone
275	300	2755	Dockum - Silty Sands
300	360	2755	Dockum - Claystone
360	600	3115	Dockum - Claystone

Average shear wave velocities were then converted to constrained modulus using the following relationship:

$$V_s \xrightarrow{G=V_S^2*\rho} G \xrightarrow{M=\frac{2G(1-\nu)}{(1-2\nu)}} M$$

Where, Vs = shear wave velocity;
G = shear modulus;
M = constrained modulus;
v = Poisson's ratio (from AECOM report); and,
ρ = unit weight.

The correlations between shear wave velocity and moduli are based on small-strain wave theory which is reasonable for use in engineering analysis of settlement of these hard/stiff layers which are unlikely to experience large strains as a result of the pressures exerted by the storage pads. A summary of the layers and modulus values used in this Settle 3 soil column is presented in Table 5.

Table 4 - Soil Layers and Parameters used in Settle3

Top (feet)	Bottom (feet)	N-Value (bpf)	Average Shear Wave Velocity (ft/s)	Layer Description	Constrained Modulus (ksf)
0	2	33		Cover Sands	890
2	10	54		Caliche with Sand Matrix - Moderately Hard	1200
10	20	54		Caliche with Sand Matrix - Moderately Hard	1200
20	25		1530	Caliche - Very Hard	35815
25	35		1900	Caliche - Very Hard	55232
35	50		2290	Ogallala - Sand with Gravel	80233
50	80		1840	Ogallala - Sand with Gravel	53870
80	100		2790	Ogallala - Sand with Gravel	123857
100	130		2300	Dockum - Claystone and Siltstone	84172
130	230		2755	Claystone and Siltstone	120769
230	275		2755	Dockum - Claystone	120769
275	300		2755	Dockum - Silty Sands	120679
300	360		2755	Dockum - Claystone	120679
360	600		3115	Dockum - Claystone	154394

4. Single Storage Pad Analysis and Results

The first objective of the settlement analyses was to perform multiple iterations between Settle3 and GTSTRUDL for four construction conditions of a single storage pad (135ft by 55ft in plan dimension) to develop appropriate bearing pressures and structural loads for pad design. Considered single storage pad configurations are summarized in Table 5.

Table 5 - Summary of analysis conditions and loading.

Condition	Loading
Configuration 1	Single Pad – 24 Loaded Casks
Configuration 2	Single Pad – 6 Loaded Casks
Configuration 3	Single Pad – 12 Loaded Casks
Configuration 4	Single Pad – 18 Loaded Casks

The first iteration of the settlement analysis was performed using the dead loads of the casks provided in WCS Consolidated Interim Storage Facility System Safety Analysis Report (Revision 2- June 2018) and the estimated footing weight. The resulting bearing pressures were used to develop an initial Settle3 model for each configuration using the soil column described previously with the end goal of estimating settlement and values of subgrade modulus k (psf/in). The calculated values of subgrade modulus were then submitted to Enercon to be integrated into the GTSTRUDL structural analysis of the storage pad. The resulting load distribution reported by Enercon was then a more accurate estimate of soil response thus refining the slab pressure

distribution. The results of the refined slab analysis were provided to DBA and used to update the Settle3 model resulting in revised subgrade modulus values.

4.1. Configurations 1-4 Loading Information and Iteration

After initial modeling of the dead loads applied directly to the soil column, DBA used the loading information provided by Enercon in the form of GTSTRUDL output of loads at individual node locations. DBA understands that Enercon grouped nodes into zones of similar modulus of subgrade reaction as identified in the initial Settle3 model (20+ zones for each configuration shown in the attachments). When revised loading was returned, DBA integrated the nodal loads in each zone to determine the revised zone bearing pressures. This approach considers effects of mat stiffness on the distribution of stresses to the soil. The resulting bearing pressures were then updated in the Settle3 model and revised values of modulus of subgrade reaction were determined for each zone. This iterative process continued for Configurations 1-4 until the change in modulus of subgrade reaction values was less than or equal to 10% when compared to the values resulting from the previous iteration. Generally, the zones identified in the analysis were one of four groups:

- Loaded Casks
- Mat Edges
- Intermediate (between casks) Areas
- Indirectly Loaded (no casks) Areas for Configurations 2, 3 and 4

The final pressure distributions for each configuration can be found in the attachments.

4.2. Configurations 1-4 Settlement Analysis Results

Computed settlements for Configurations 1-4 are summarized in Table 6. Maximum estimated settlements for all configurations occur under the center of the cask nearest the center of the loaded group. Settlements decrease radially from the heavier loaded cask zones. This behavior matches the expected behavior of a loaded mat. Settlement plots for each configuration and the inputs used for Settle3 are attached to this TM. It is important to note that the results of geotechnical settlement models are estimates that are input dependent. Therefore, settlement recommendations should be based on a combination of calculations and experience that acknowledges the calculations are not precise to the multiple decimal places reported by the program.

Table 6 - Summary of single pad settlement estimates.

Condition	Loading	Estimated maximum settlement (in.)
Configuration 1	Single Pad – 24 Loaded Casks	0.7
Configuration 2	Single Pad – 6 Loaded Casks	0.6
Configuration 3	Single Pad – 12 Loaded Casks	0.7
Configuration 4	Single Pad – 18 Loaded Casks	0.7

The Settle3 bearing pressure input files report a lower bearing pressure than the calculated zone bearing pressure in the attachments. To avoid loading edge effects caused by drastic changes in

bearing pressure over very small distance, the bearing pressure zones input into Settle3 are cumulative. An example of this concept is shown in Figure 2.

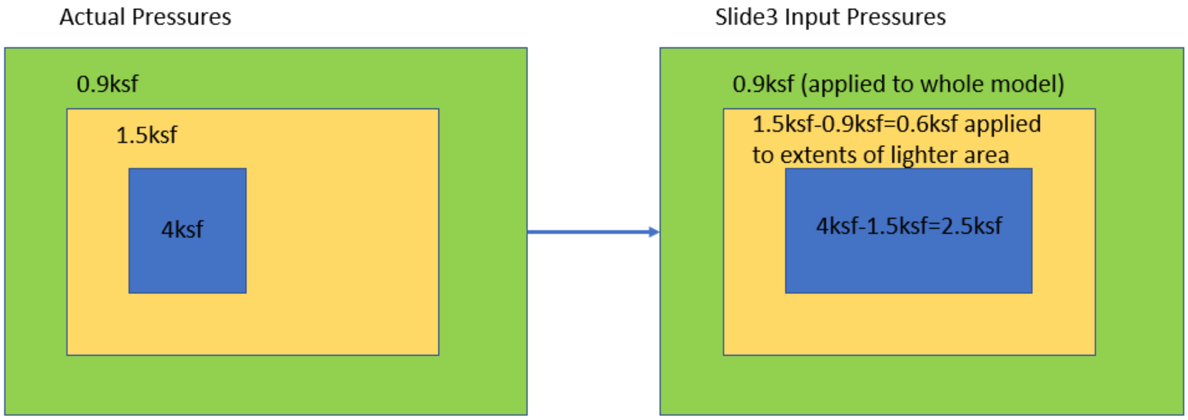

Figure 2 - Example of Slide3 bearing pressure input determination

5. Multiple Pad Analysis and Results

The second objective of the settlement analyses is to estimate the settlement of a configuration of four fully loaded pads in their final constructed condition. The converged Configuration 1 loads were applied in an orientation of four pads spaced per Figure 1-6 in the WCS CISF Safety Analysis Report. The maximum predicted settlement for the four pad scenario is similar to the single pad Configuration 1 case (0.7inches at the center of each pad). The main effect of the adjacent loaded pads is an increase of settlement estimated at the corner of the pads (0.2inches compared to 0.1inches), and the related slight decrease in predicted differential settlement between the center of the footings and the corners of the pads. This behavior results from overlapping stress influence from the loaded footings, which is consistent with predicted behavior. Inputs and results of the model are shown in the attachments.

6. Cask Handling Building Analysis and Results

DBA understands that an auxiliary structure will be utilized for handling the filling of the casks before they are moved to the storage pads. According to Chapter 7 of the WCS CISF Safety Analysis report, the Cask Handling Building (CHB) is a two-bay steel structure measuring 175ft by 193ft with a height of 72ft. Based on a preliminary foundation layout plan for the building, DBA understands the main column footings and wind column footings will be constructed to bear 10ft below ground surface. The soil column developed for storage pad analysis was used to estimate settlements of the CHB.

Based on provided loading information, DBA understands the maximum service level bearing pressure is approximately 3.5ksf or less with maximum limit state bearing pressures approaching 5.5ksf. It is standard practice in geotechnical shallow foundation design to analyze settlements for sustained loading and service loading so two models were developed for the CHB. Two dead load only cases were analyzed: 1.0 DL (1.79ksf for main column footings and 1.67ksf for wind column footings); and a net bearing pressure from Dead loading case (0.66ksf for main column

footings and 0.55ksf for wind column footings. The resulting settlements for both dead load cases are 0.25inches or less at the center of the footings. Estimated settlement for the maximum service load (3.5ksf for all footings) case is 0.5inches or less at the center of the footings.

7. Concluding Remarks

Please contact the following if you would like to discuss this document or this project.

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Attachments

Summary of Analysis Basis.
GEOS Blow Count Profiles.
GEOS Shear Wave Velocity Profiles.
AECOM Shear Wave Velocity Profile.
Enercon Model Configurations.
Configuration 1 Final Bearing Zones and Pressures, Settlement Results, and Modulus of Subgrade Reaction Values for Enercon Models.
Configuration 1 Settle3 Inputs .
Configuration 2 Final Bearing Zones and Pressures, Settlement Results, and Modulus of Subgrade Reaction Values for Enercon Models.
Configuration 2 Settle3 Inputs .
Configuration 3 Final Bearing Zones and Pressures, Settlement Results, and Modulus of Subgrade Reaction Values for Enercon Models.
Configuration 3 Settle3 Inputs .
Configuration 4 Final Bearing Zones and Pressures, Settlement Results, and Modulus of Subgrade Reaction Values for Enercon Models
Configuration 4 Settle3 Inputs.
Overall Pad Layout From WCS CISF Safety Analysis Report
Four Pad Settle3 Analysis, Inputs and Results.
Cask Handling Building Settle3 Analysis, Inputs, and Results.

CISF Site
Andrews, TX
Settlement Analysis
Methodology

Problem Statement

- Nuclear waste storage pads
- Settlement concerns so calculation of footing settlement required

DBA Approach

- Utilize extensive shear wave velocity data and soil boring explorations to create a constrained modulus profile
    - In general, the soil profile is caliche & sand with gravel to a depth of ~100ft overlying rock
- Convert SPT N-Values to constrained modulus using Tan, C. K., Duncan, J. M., Rojiani, K. B., and Barker, R. M. (1991) in top 20 feet.
- Convert the shear wave velocity to constrained modulus (M)

$$V_s \xrightarrow{G=V_s^2 * \rho} G \xrightarrow{M=\frac{2G(1-\nu)}{(1-2\nu)}} M$$

- Create the constrained modulus profile combining the SPT data from 0 to 20 ft depth with the shear wave velocity data beyond 20 ft depth
- Use Westergaard's stress calculation method and the constrained modulus profile to calculate settlement in *Settle3 by Rocscience*
    - Loading information provided by the structural

CISF Site
Andrews, TX
Settlement Analysis
Methodology

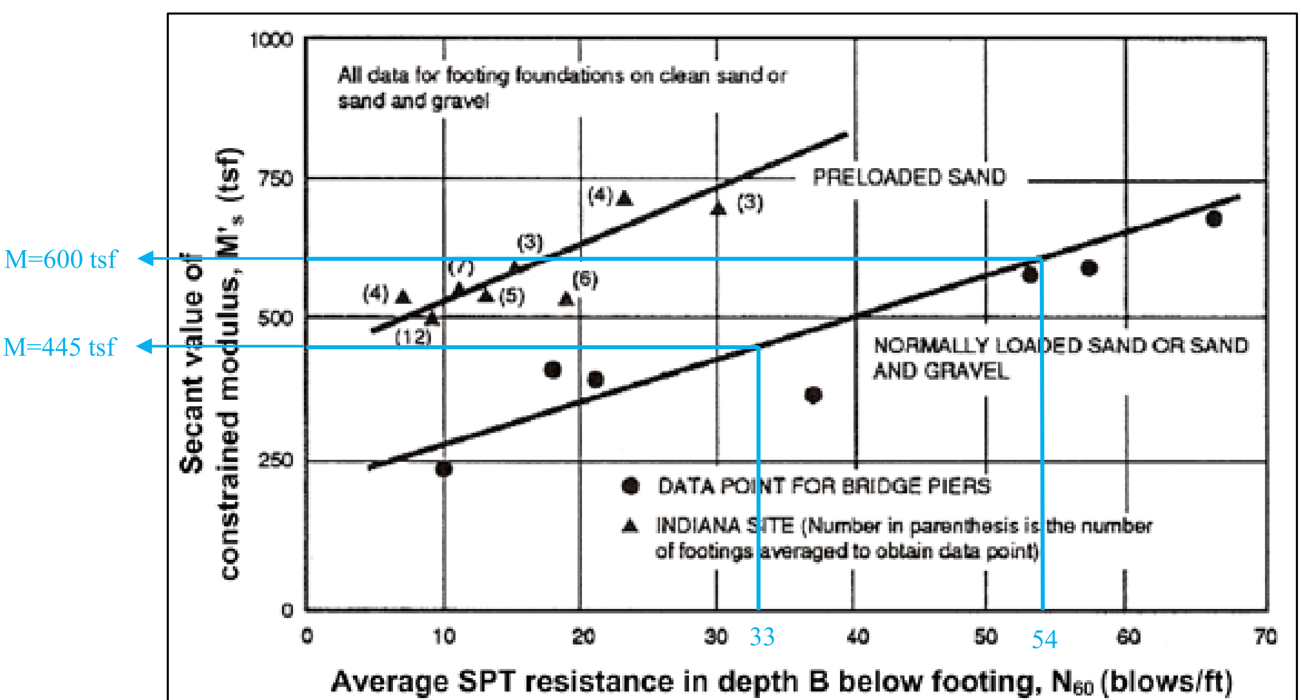
Layers based on Borings Performed by GEOS

- Interpreted from GEOS borings – data only to 45 ft depth
- Layers below 20 ft will be determined using the shear wave velocity data. SPT N-Values from 20 to 45 ft are beyond the range of the correlation shown below

Top of Layer (ft)	Bottom of Layer (ft)	N-Value (bpf)	Layer Material (From GEOS Column)	Constrained Modulus (tsf)
0	2	33	Cover Sands	445
2	10	54	Caliche w/ Sand Matrix – Mod. Hard	600
10	20	54	Caliche w/ Sand Matrix – Mod. Hard	600

SPT N-Value to Constrained Modulus Correlation

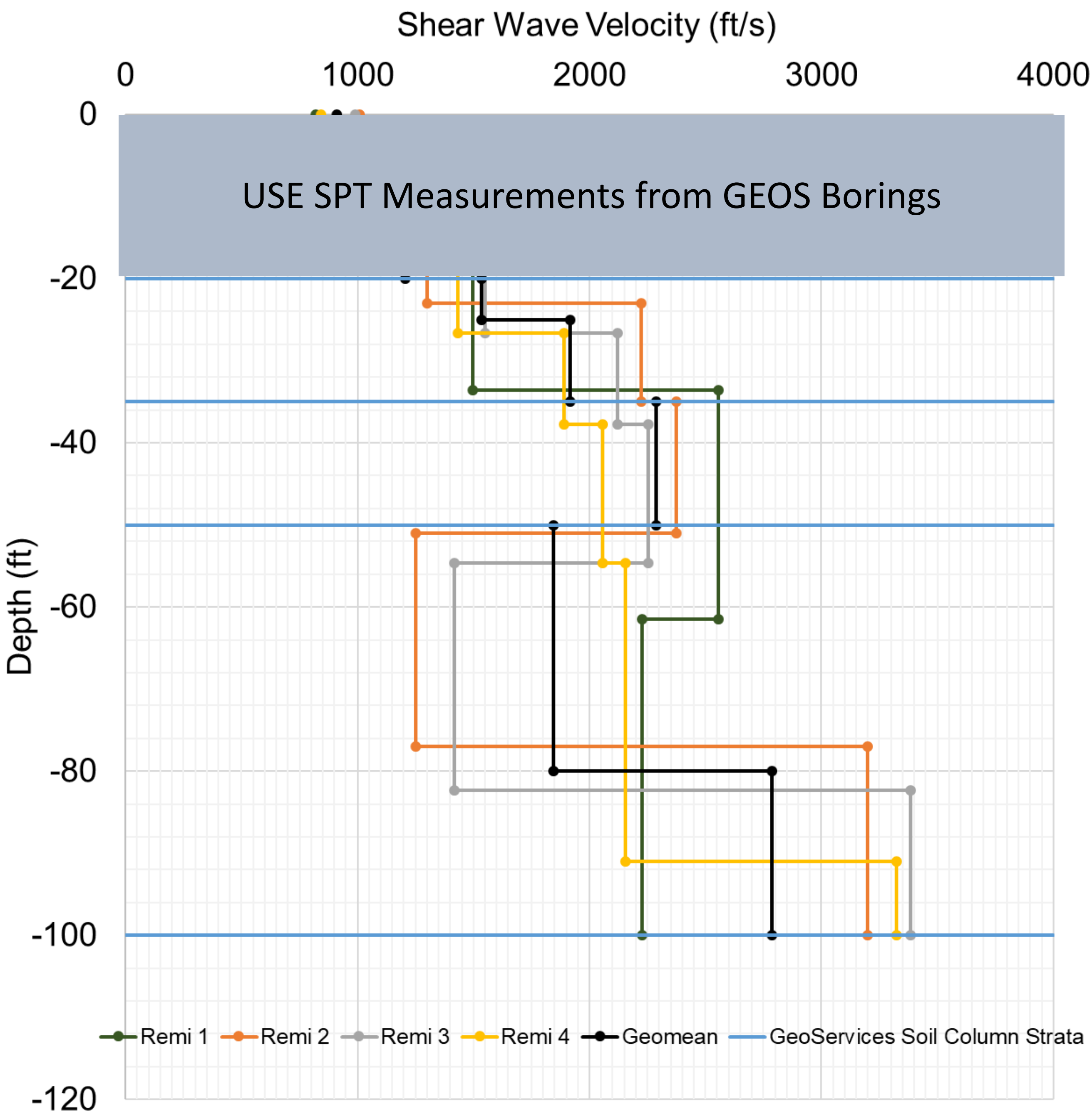
- Tan, C. K., Duncan, J. M., Rojiani, K. B., and Barker, R. M. (1991). Engineering Manual for Shallow Foundations, prepared for the National Cooperative Highway Research Program (NCHRP Project 24-4) in cooperation with Virginia Polytechnic Institute and State University. Sponsored by American Association of State Highway and Transportation Officials and Federal Highway Administration, Washington, DC., Blacksburg, VA, 171 pp.



CISF Site
Andrews, TX
Settlement Analysis
Methodology

Layers based on Average Shear Wave Velocity Measurements

- Interpreted from all explorations and collaboration between GEOS and DBA.
- Top 100ft contains 7 stratum in 5 materials identified by GEOS



CISF Site
Andrews, TX
Settlement Analysis
Methodology

Soil Column Based on Average Shear Wave Velocity Measurements

- Interpreted from all explorations and collaboration between GEOS and DBA.
- Top 100ft contains 7 stratum in 5 materials identified by GEOS
- 100ft-600ft (approx. location of incompressible layers with sharp contrast of velocity) contains 3 average velocity values for 6 layers identified in the soil column provided by GEOS

Top (ft)	Bottom (ft)	Avg. Layer Shear Wave Velocity (ft/s)	Layer Material (From GEOS column)	Model Layer Name
20	25	1530	Caliche - Very Hard	Caliche Hard 1
25	35	1900	Caliche - Very Hard	Caliche Hard 2
35	50	2290	Ogallala - Sand with Gravel	Ogallala 1
50	80	1840	Ogallala - Sand with Gravel	Ogallala 2
80	100	2790	Ogallala - Sand with Gravel	Ogallala 3
100	130	2300	Dockum - Claystone and Siltstone	Dockum Claystone/Siltstone
130	230	2755	Claystone and Siltstone	Claystone and Siltstone
230	275	2755	Dockum - Clay/Claystone	Dockum Clay/Claystone1
275	300	2755	Dockum - Silty Sands	Dockum Silty/Sands
300	360	2755	Dockum - Clay/Claystone	Dockum Clay/Claystone 2
360	600	3115	Dockum - Clay/Claystone	Dockum Clay/Claystone 3

Top (ft)	Bottom (ft)	Avg. Layer Shear Wave Velocity (ft/s)	Unit weight (pcf)	Poisson's Ratio	Gmax (psf)
20	25	1530	125	0.33	9,087,345
25	35	1900	125	0.33	14,013,975
35	50	2290	125	0.33	20,357,531
50	80	1840	130	0.33	13,668,571
80	100	2790	130	0.33	31,426,491
100	130	2300	130	0.33	21,357,143
130	230	2755	130	0.33	30,642,958
230	275	2755	130	0.33	30,642,958
275	300	2755	130	0.33	30,642,958
300	360	2755	130	0.33	30,642,958
360	600	3115	130	0.33	39,174,511

CISF Site
Andrews, TX
Settlement Analysis
Methodology

Total Constrained Modulus Profile

- 0 to 20 ft depth
  - Constrained modulus obtained from GEOS SPT data and correlating N-Value with constrained modulus using Tan, C. K., Duncan, J. M., Rojiani, K. B., and Barker, R. M. (1991).
- 20 to 600 ft depth
  - Constrained modulus obtained from converting the GEOS shear wave velocity to constrained modulus using the unit weight and Poisson's ratio

Top (ft)	Bottom (ft)	Layer Material (From GEOS column)	Constrained Modulus (ksf)
0	2	Cover Sands	890
2	10	Caliche with Sand Matrix - Moderately Hard	1,200
10	20	Caliche with Sand Matrix - Moderately Hard	1,200
20	25	Caliche - Very Hard	35,815
25	35	Caliche - Very Hard	55,232
35	50	Ogallala - Sand with Gravel	80,233
50	80	Ogallala - Sand with Gravel	53,870
80	100	Ogallala - Sand with Gravel	123,857
100	130	Dockum - Claystone and Siltstone	84,172
130	230	Claystone and Siltstone	120,769
230	275	Dockum - Clay/Claystone	120,769
275	300	Dockum - Silty Sands	120,769
300	360	Dockum - Clay/Claystone	120,769
360	600	Dockum - Clay/Claystone	154,394

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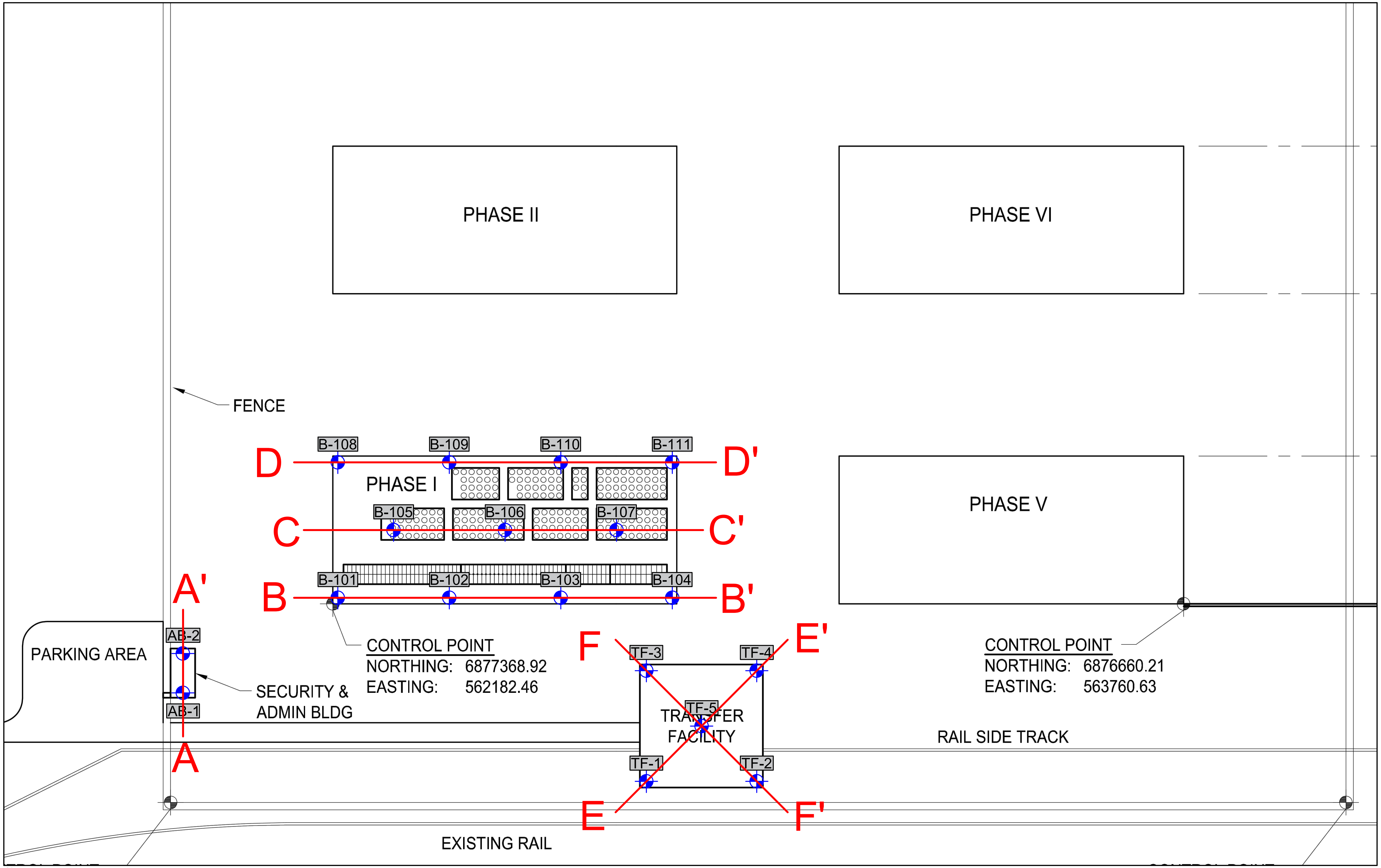
GEOS Blow Count Profiles



Notes:

1) Site Source Provided by: WCS, (06/12/2015)

2) Boring Locations are shown in general arrangement only

3) Do Not use Boring Locations for determinations of Distance or Quantities

Boring Location & Identifier

Cross Section line (Start - End')

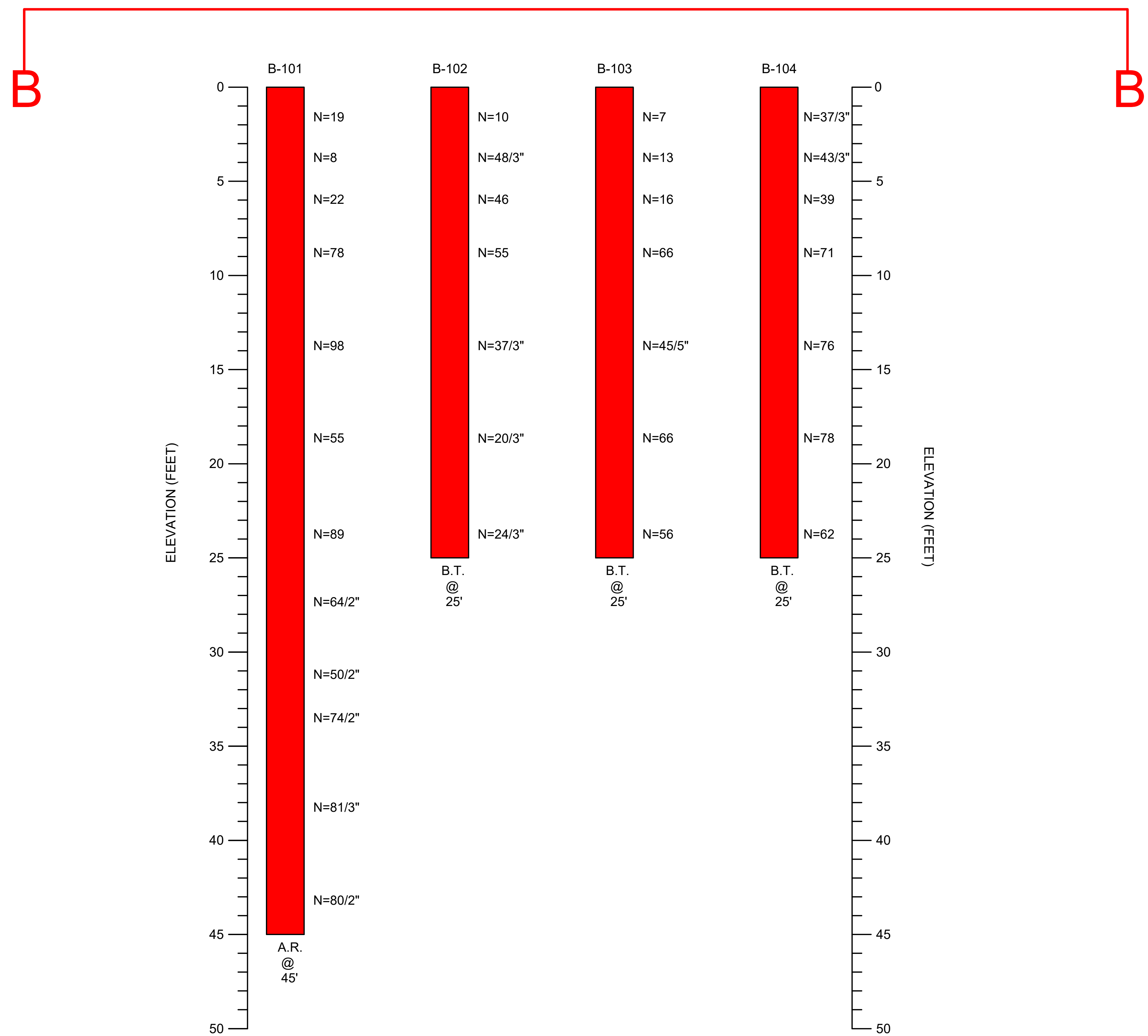
GEOServices, LLC-Geotechnical and Materials Engineers

Cross Section-Location Plan
WCS Consolidated Interim Storage Facility
WCS
Andrews, Texas

DATE: 08/10/2015

GEOS Project No. 31-151247

FIGURE: 5



Notes:

1) B.T. = Boring Termination
2) A.R. = Auger Refusal
3) Not To Scale

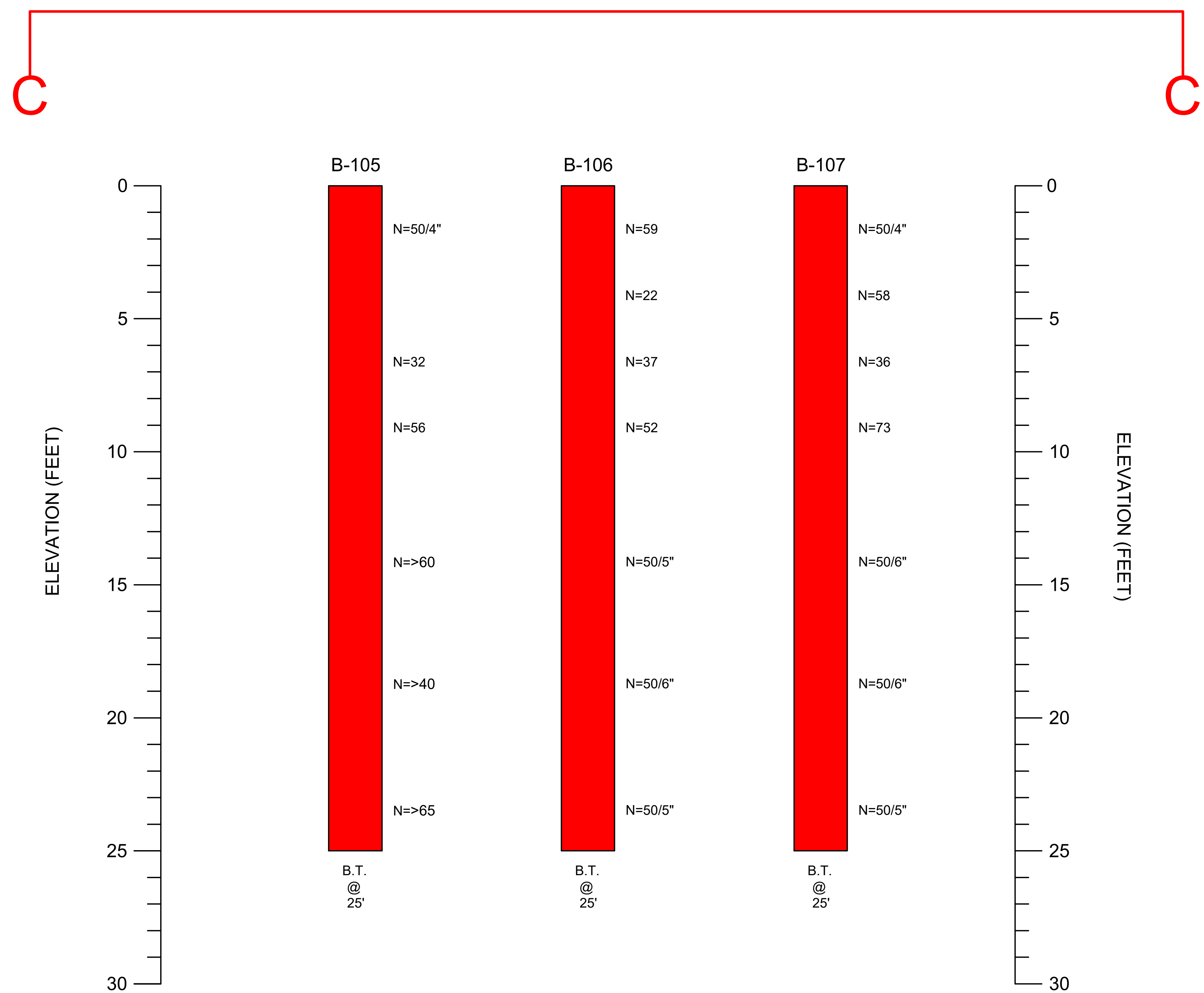
GEOServices, LLC-Geotechnical and Materials Engineers

Boring Cross-Section
WCS Consolidated Interim Storage Facility
WCS
Andrews, Texas

DATE: 08/10/2015

GEOS Project No. 31-151247

FIGURE: 7



Notes:

1) B.T. = Boring Termination
2) A.R. = Auger Refusal
3) Not To Scale

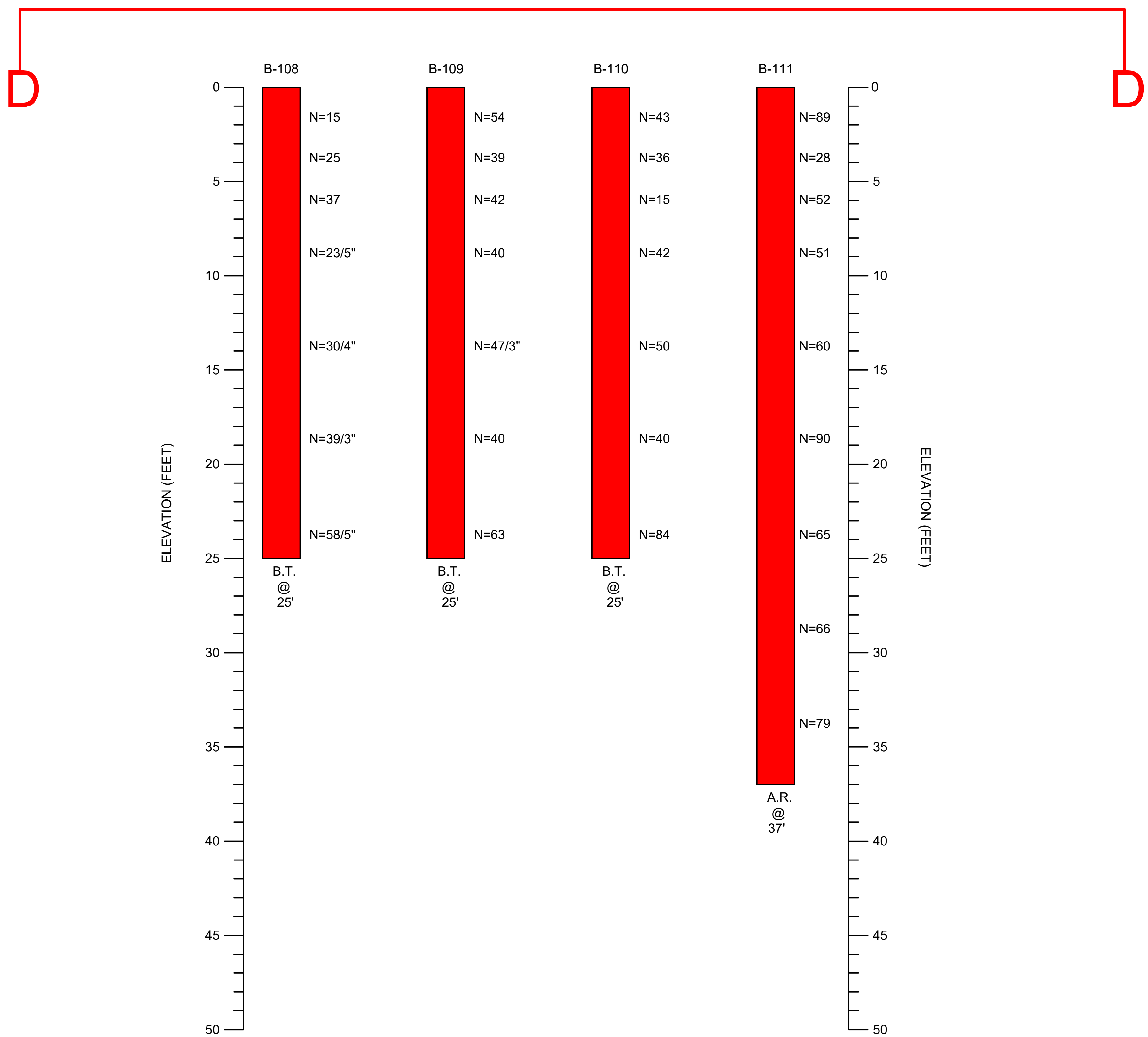
GEOServices, LLC-Geotechnical and Materials Engineers

Boring Cross-Section
WCS Consolidated Interim Storage Facility
WCS
Andrews, Texas

DATE: 08/10/2015

GEOS Project No. 31-151247

FIGURE: 8



Notes:

1) B.T. = Boring Termination
2) A.R. = Auger Refusal
3) Not To Scale

GEOServices, LLC-Geotechnical and Materials Engineers

Boring Cross-Section
WCS Consolidated Interim Storage Facility
WCS
Andrews, Texas

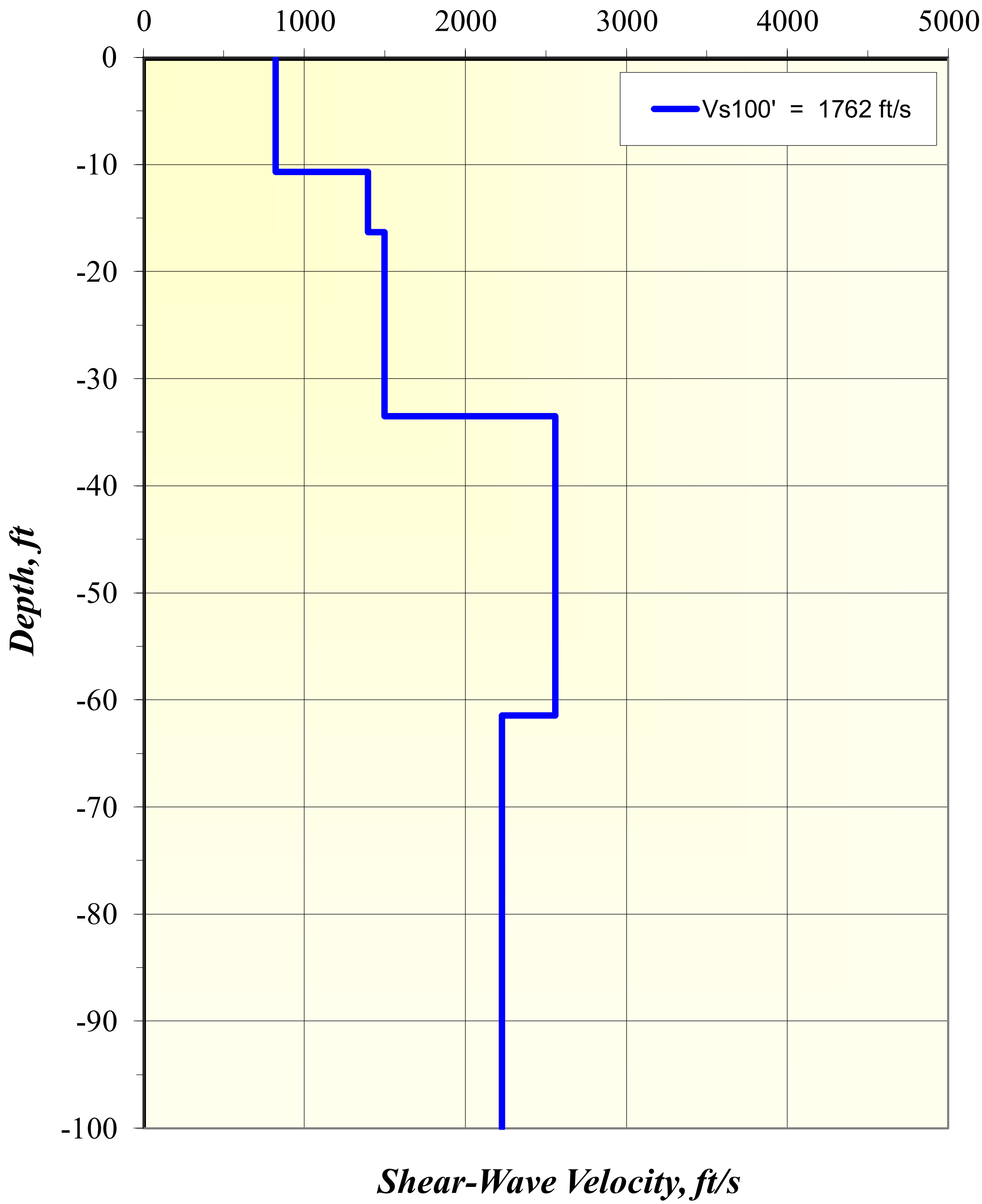
DATE: 08/10/2015

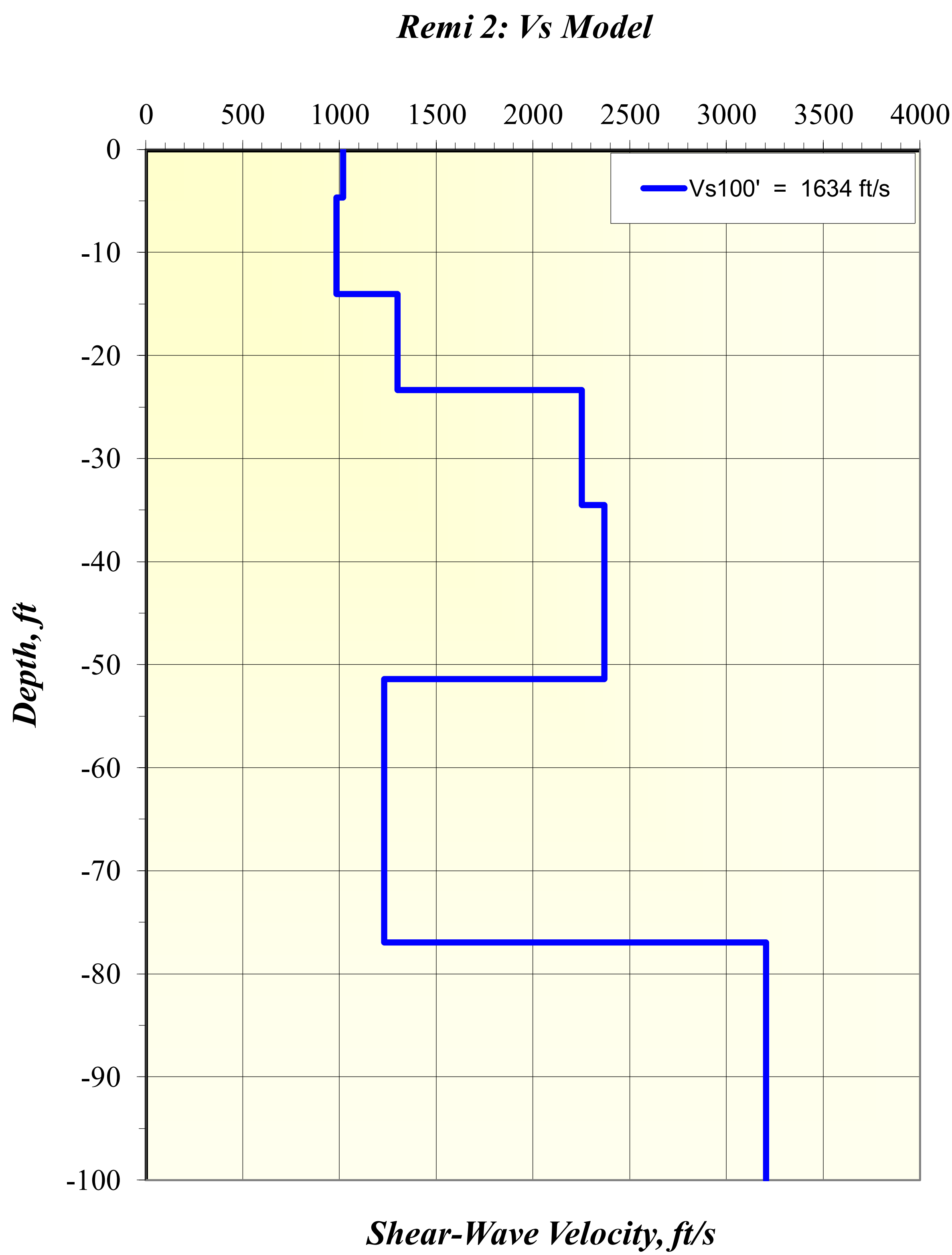
GEOS Project No. 31-151247

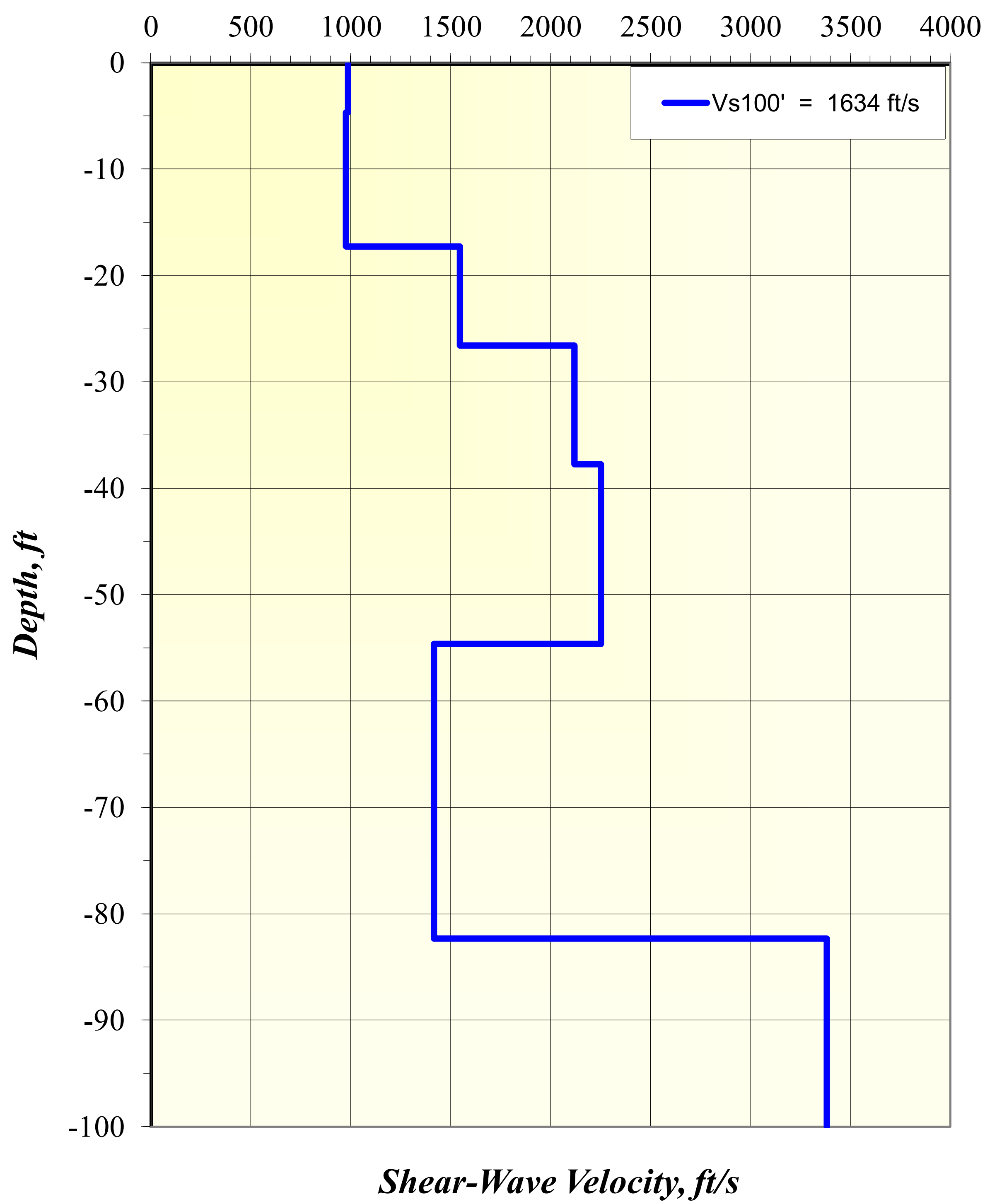
FIGURE: 9

Shear Wave Velocity Profiles

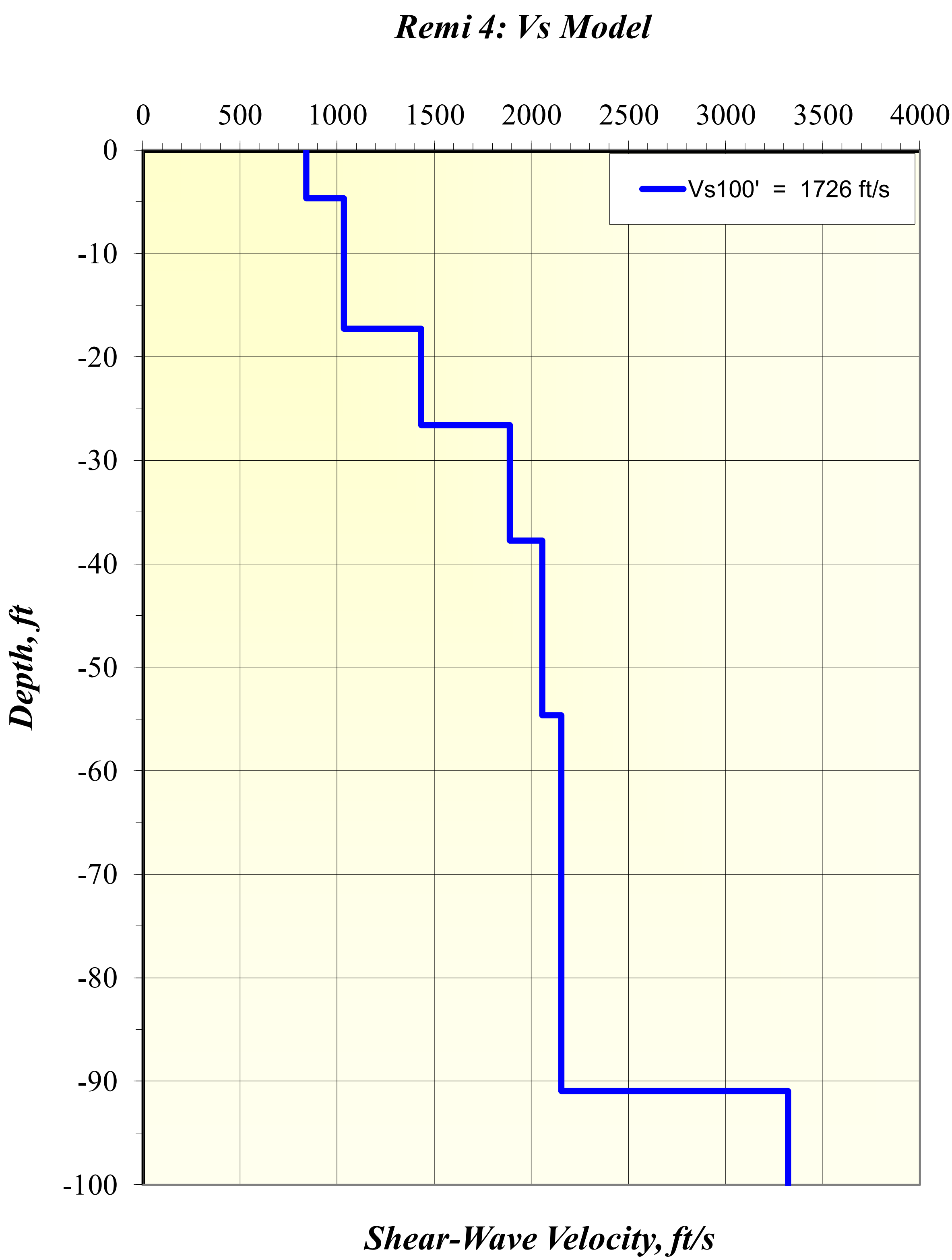
Remi 1: Vs Model




Remi 2: Vs Model
0
500
1000
1500
2000
2500
3000
3500
4000
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Vs100' = 1634 ft/s
Depth, ft
Shear-Wave Velocity, ft/s

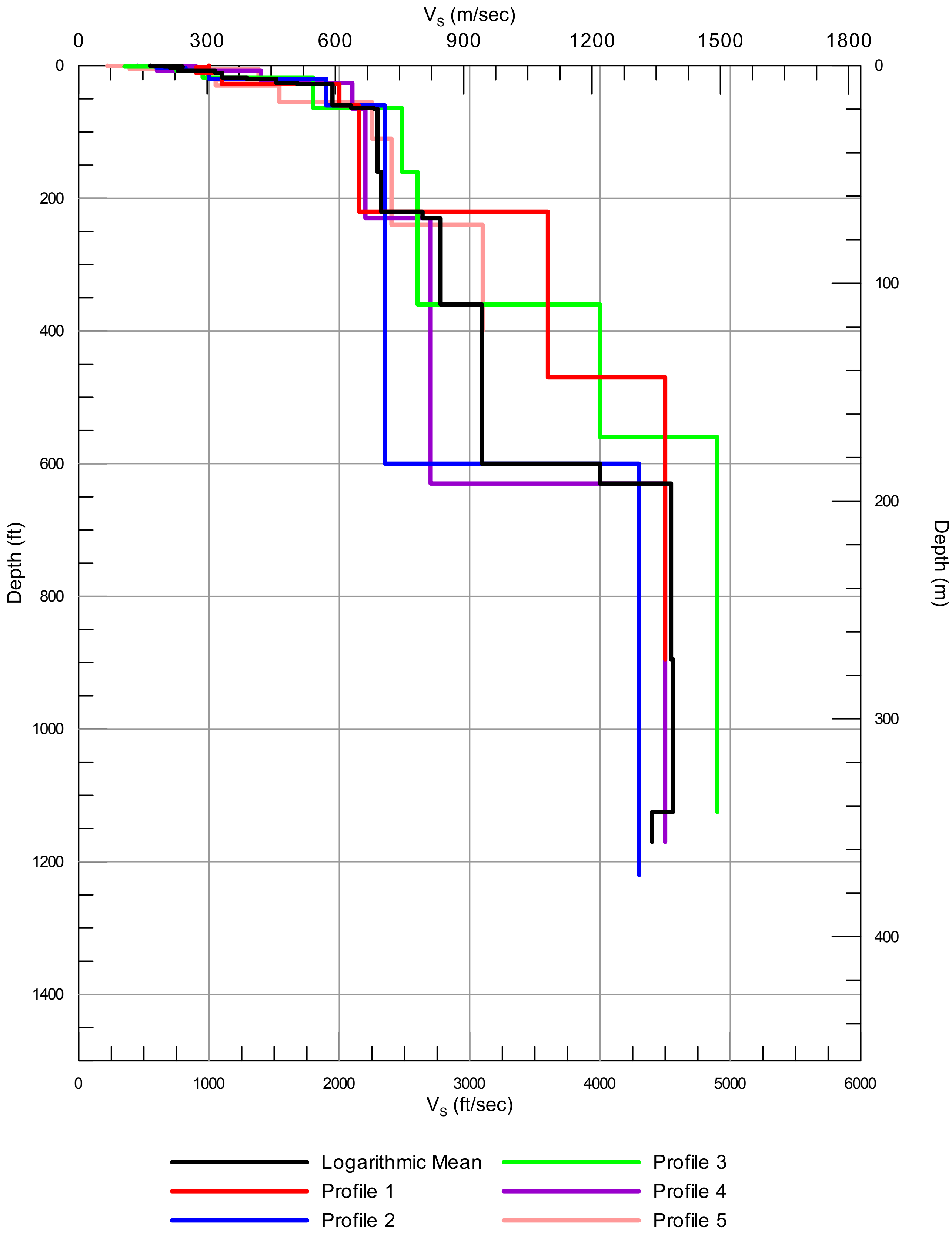


Remi 3: Vs Model



Remi 4: Vs Model
0
500
1000
1500
2000
2500
3000
3500
4000
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Vs100' = 1726 ft/s
Depth, ft
Shear-Wave Velocity, ft/s

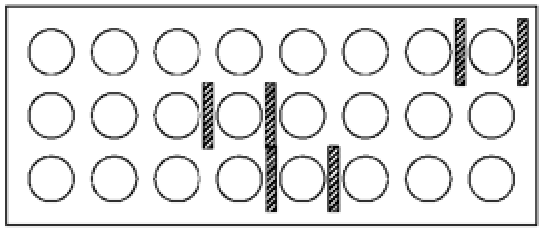
AECOM Shear Wave Velocity Profile



AECOM	Project No. 31787-001 Waste Control Specialists Andrews, Texas	V_S PROFILES FROM 2015 SASW SURVEYS	Figure 20

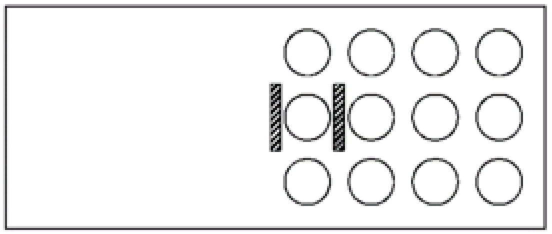
Enercon Model Configurations

CISF Site
Single Pad Analysis
Andrews, TX

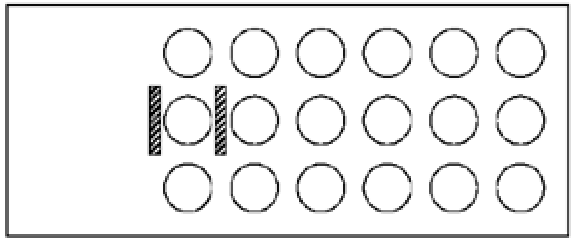


CONFIGURATION 1

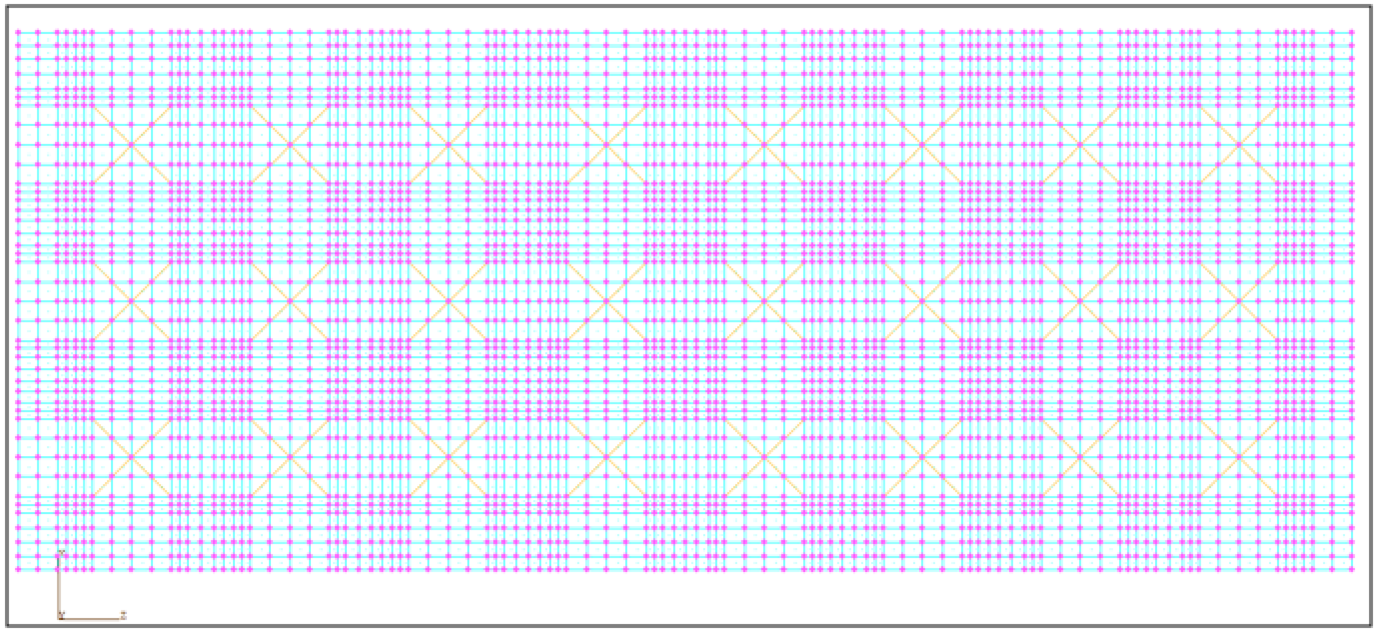
CONFIGURATION 2



CONFIGURATION 3



CONFIGURATION 4



ISFSI Pad General Layout

Configuration 1
Final Bearing Pressure Zones,
Settlement Results,
and Modulus of Subgrade Reaction
Values for Enercon Model

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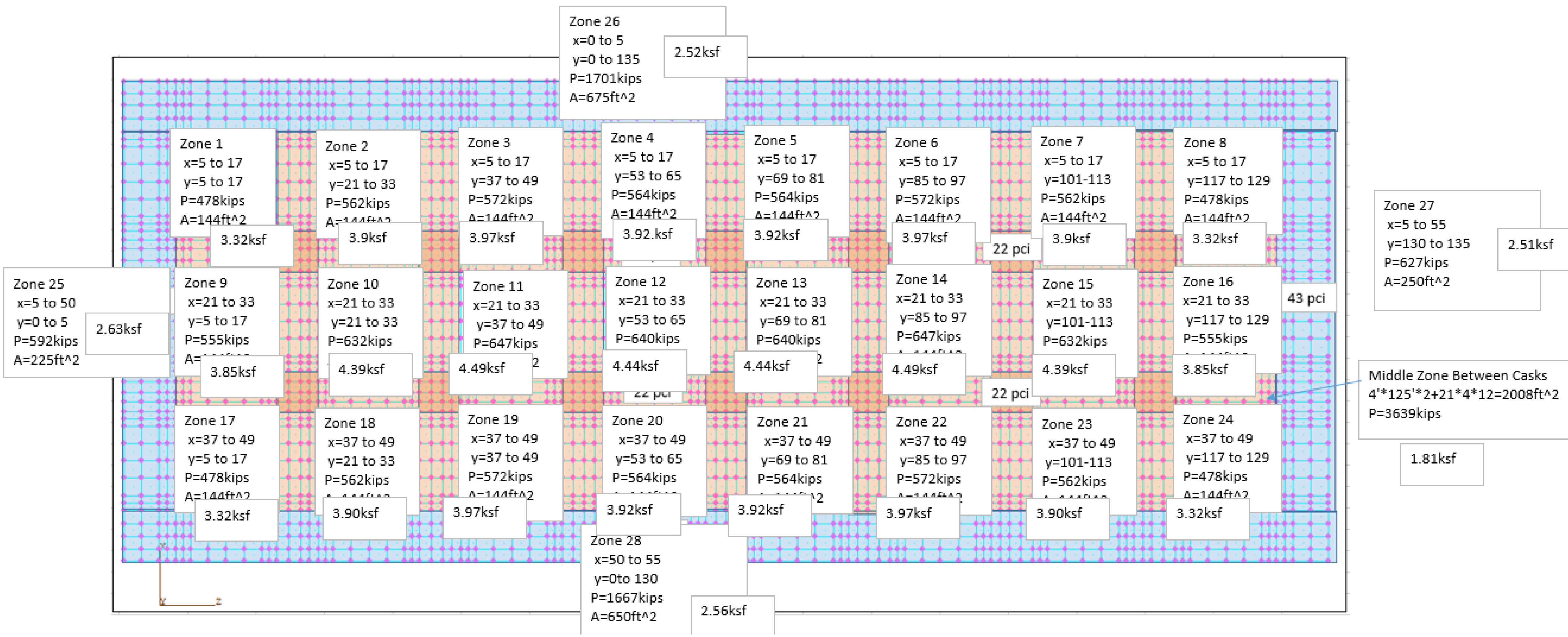
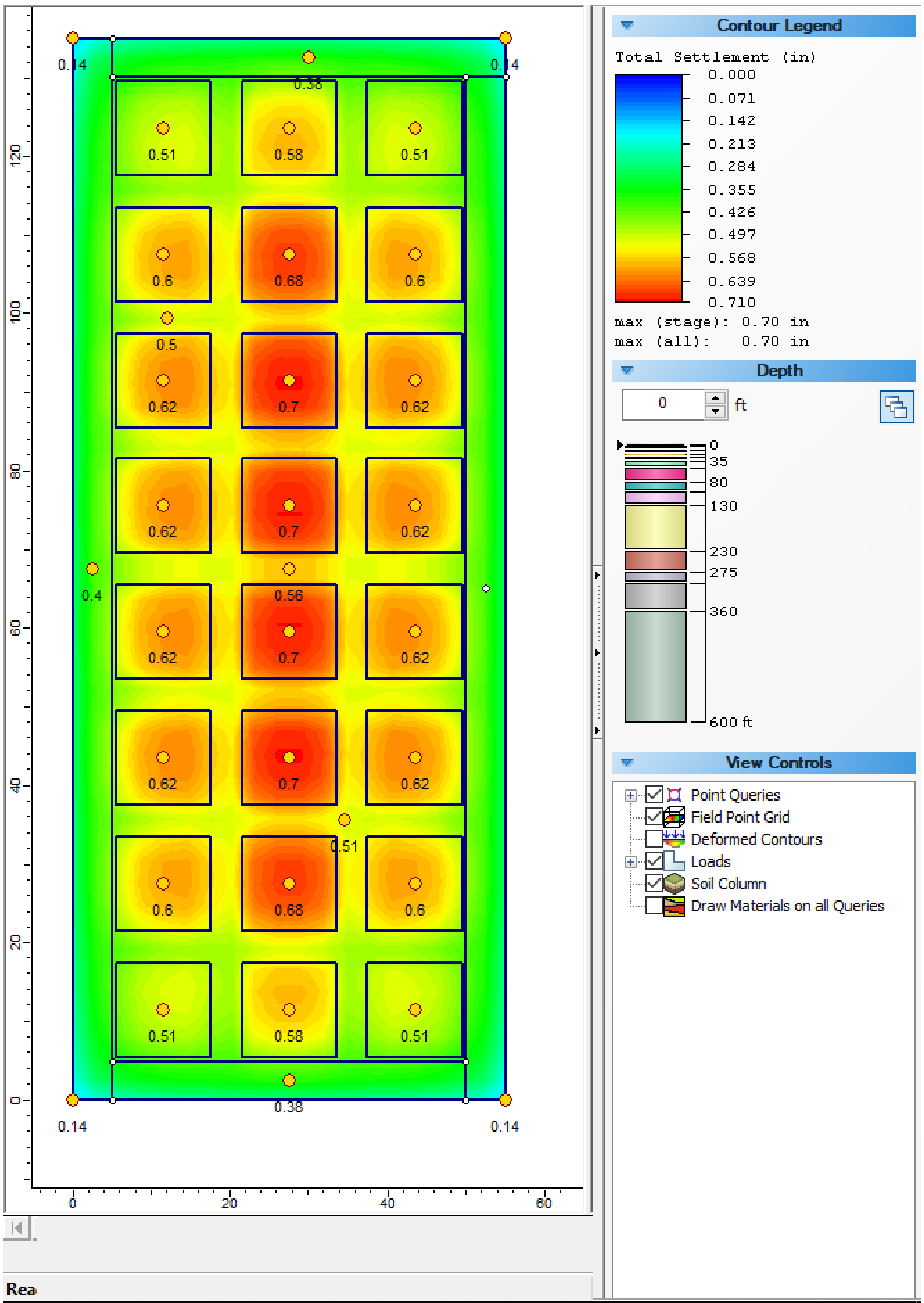
CISF Site
Single Pad Analysis
Andrews, TX

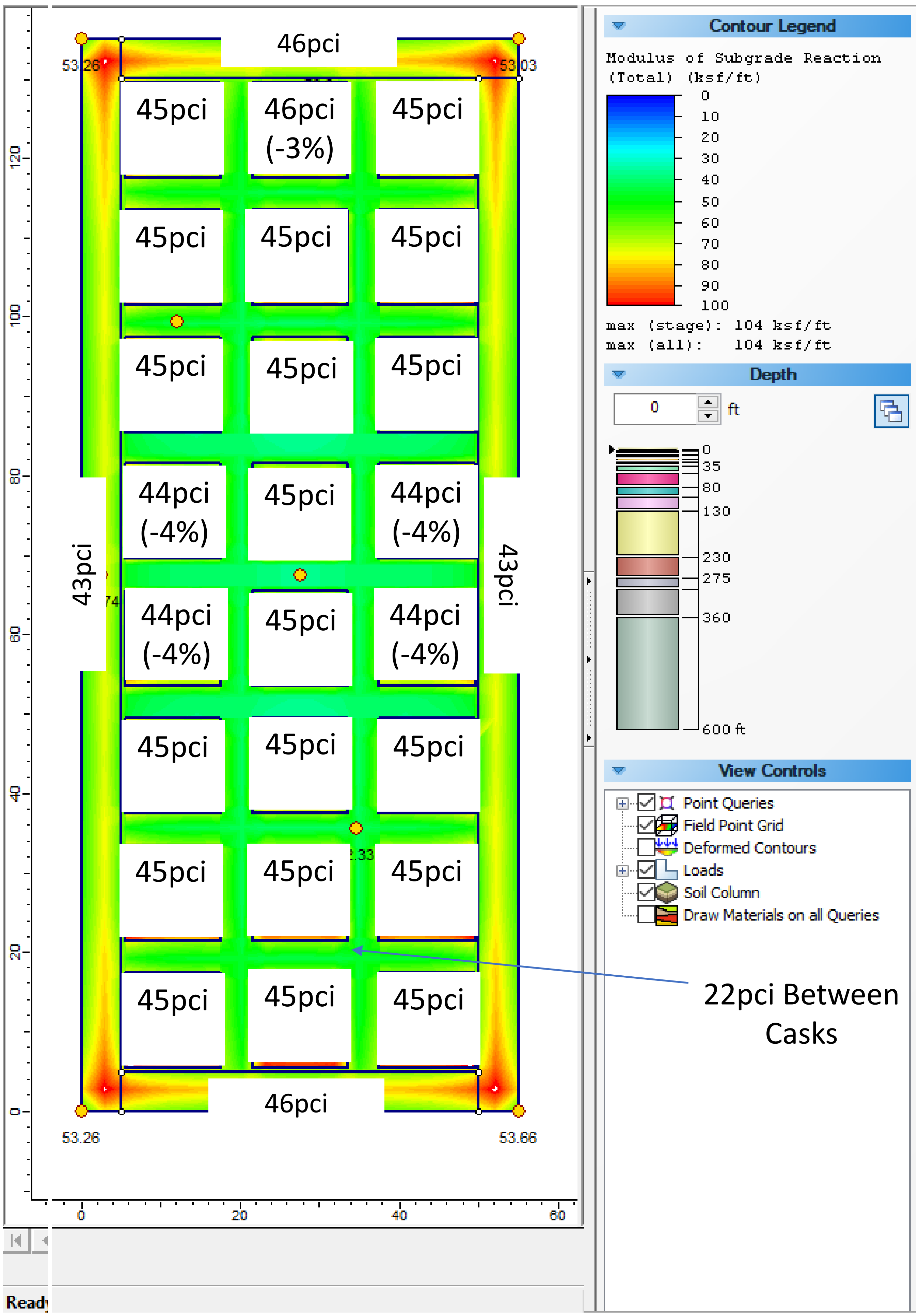
Configuration 1-Bearing Pressures (INPUT 5 Spreadsheet Loads)



Configuration 1-Settlement Estimate (INPUT 5 Spreadsheet Loads)



Configuration 1-k values (INPUT 5 Spreadsheet)



Configuration 1 Settle3 Inputs

Settle3 Analysis Information

Project Settings

Document Name	19-017 CISF Storage Pad Config 1 200214 INPUT 5.s3z
Date Created	1/16/2020, 3:00:31 PM
Stress Computation Method	Westergaard
Minimum settlement ratio for subgrade modulus	0.9

Use average properties to calculate layered stresses

Improve consolidation accuracy

Ignore negative effective stresses in settlement calculations

Stage Settings

Stage #	Name
1	Stage 1

Results

Time taken to compute: 0 seconds

Stage: Stage 1

Data Type	Minimum	Maximum
Total Settlement [in]	0	0.701508
Loading Stress ZZ [ksf]	0.034724	4.49

Loads

1. Polygonal Load: "Zone 29"

Label	Zone 29
Load Type	Flexible
Area of Load	7425 ft^2
Load	1.81 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
0	0
55	0
55	135
0	135

2. Polygonal Load: "Zone 26"

Label	Zone 26
Load Type	Flexible
Area of Load	675 ft^2
Load	0.71 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
0	0
5	0
5	135
0	135

3. Polygonal Load: "Zone 27"

Label	Zone 27
Load Type	Flexible
Area of Load	250 ft^2
Load	0.7 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
55	130
55	135
5	135
5	130

4. Polygonal Load: "Zone 28"

Label	Zone 28
Load Type	Flexible
Area of Load	650 ft^2
Load	0.75 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
50	0
55	0
55	130
50	130

5. Polygonal Load: "Zone 25"

Label	Zone 25
Load Type	Flexible
Area of Load	225 ft^2
Load	0.82 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5	0
50	0
50	5
5	5

6. Rectangular Load: "Zone 1"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.51 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	5.5
17.5	5.5
17.5	17.5
5.5	17.5

7. Rectangular Load: "Zone 17"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.51 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	5.5
49.5	5.5
49.5	17.5
37.5	17.5

8. Rectangular Load: "Zone 24"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.51 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	117.5
49.5	117.5
49.5	129.5
37.5	129.5

9. Rectangular Load: "Zone 8"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.51 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	117.5
17.5	117.5
17.5	129.5
5.5	129.5

10. Rectangular Load: "Zone 23"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.09 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	101.5
49.5	101.5
49.5	113.5
37.5	113.5

11. Rectangular Load: "Zone 22"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.16 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	85.5
49.5	85.5
49.5	97.5
37.5	97.5

12. Rectangular Load: "Zone 21"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.1 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	69.5
49.5	69.5
49.5	81.5
37.5	81.5

13. Rectangular Load: "Zone 20"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.1 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	53.5
49.5	53.5
49.5	65.5
37.5	65.5

14. Rectangular Load: "Zone 19"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.16 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	37.5
49.5	37.5
49.5	49.5
37.5	49.5

15. Rectangular Load: "Zone 18"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.09 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	21.5
49.5	21.5
49.5	33.5
37.5	33.5

16. Rectangular Load: "Zone 16"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.04 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	117.5
33.5	117.5
33.5	129.5
21.5	129.5

17. Rectangular Load: "Zone 7"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.09 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	101.5
17.5	101.5
17.5	113.5
5.5	113.5

18. Rectangular Load: "Zone 6"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.16 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	85.5
17.5	85.5
17.5	97.5
5.5	97.5

19. Rectangular Load: "Zone 5"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.1 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	69.5
17.5	69.5
17.5	81.5
5.5	81.5

20. Rectangular Load: "Zone 4"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.1 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	53.5
17.5	53.5
17.5	65.5
5.5	65.5

21. Rectangular Load: "Zone 3"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.16 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	37.5
17.5	37.5
17.5	49.5
5.5	49.5

22. Rectangular Load: "Zone 2"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.09 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	21.5
17.5	21.5
17.5	33.5
5.5	33.5

23. Rectangular Load: "Zone 9"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.04 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	5.5
33.5	5.5
33.5	17.5
21.5	17.5

24. Rectangular Load: "Zone 10"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.58 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	21.5
33.5	21.5
33.5	33.5
21.5	33.5

25. Rectangular Load: "Zone 11"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.68 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	37.5
33.5	37.5
33.5	49.5
21.5	49.5

26. Rectangular Load: "Zone 12"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.63 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	53.5
33.5	53.5
33.5	65.5
21.5	65.5

27. Rectangular Load: "Zone 13"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.63 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	69.5
33.5	69.5
33.5	81.5
21.5	81.5

28. Rectangular Load: "Zone 14"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.68 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	85.5
33.5	85.5
33.5	97.5
21.5	97.5

29. Rectangular Load: "Zone 15"

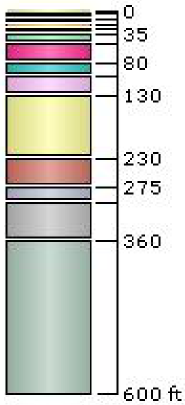
Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.57 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	101.5
33.5	101.5
33.5	113.5
21.5	113.5

Soil Layers

Layer #	Type	Thickness [ft]	Depth [ft]
1	Cover Sands	2	0
2	Caliche/Sand 1	8	2
3	Caliche/Sand 2	10	10
4	Caliche Hard 1	5	20
5	Caliche Hard 2	10	25
6	Ogallala 1	15	35
7	Ogallala 2	30	50
8	Ogallala 3	20	80
9	Dockum Claystone/Siltsone	30	100
10	Claystone and Siltstone	100	130
11	Dockum Clay/Claystone 1	45	230
12	Dockum Silty/Sands	25	275
13	Dockum Clay/Claystone 2	60	300
14	Dockum Clay/Claystone 3	240	360



Soil Properties

Property	Cover Sands	Caliche/Sand 1	Caliche/Sand 2	Caliche Hard 1
Color				
Unit Weight [kips/ft^3]	0.12	0.12	0.12	0.12
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Enabled
Es [ksf]	890	1200	1200	35815
Esur [ksf]	890	1200	1200	35815
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8

Property	Caliche Hard 2	Ogallala 1	Ogallala 2	Ogallala 3
Color				
Unit Weight [kips/ft^3]	0.12	0.12	0.13	0.13
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Enabled
Es [ksf]	55232	80233	53870	123857
Esur [ksf]	55232	80233	53870	123857
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8

Property	Dockum Claystone/ Siltstone	Claystone and Siltstone	Dockum Clay/ Claystone 1	Dockum Silty/ Sands
Color				
Unit Weight [kips/ft^3]	0.13	0.13	0.13	0.13
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Enabled
Es [ksf]	84172	120769	120769	120769
Esur [ksf]	84172	120769	120769	120769
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8

Property	Dockum Clay/Claystone 2	Dockum Clay/Claystone 3
Color		
Unit Weight [kips/ft^3]	0.13	0.13
K0	1	1
Immediate Settlement	Enabled	Enabled
Es [ksf]	120769	154394
Esur [ksf]	120769	154394
Undrained Su A [kips/ft2]	0	0
Undrained Su S	0.2	0.2
Undrained Su m	0.8	0.8

Query Points

Point #	Query Point Name	(X,Y) Location	Number of Divisions
1	Cask Point 1	11.5, 11.5	Auto: 101
2	Cask Point 2	11.5, 27.5	Auto: 101
3	Cask Point 3	11.5, 43.5	Auto: 101
4	Cask Point 4	11.5, 59.5	Auto: 101
5	Cask Point 5	11.5, 75.5	Auto: 101
6	Cask Point 6	11.5, 91.5	Auto: 101
7	Cask Point 7	11.5, 107.5	Auto: 101
8	Cask Point 8	11.5, 123.5	Auto: 101
9	Cask Point 9	27.5, 11.5	Auto: 101
10	Cask Point 10	27.5, 27.5	Auto: 101
11	Cask Point 11	27.5, 43.5	Auto: 101
12	Cask Point 12	27.5, 59.5	Auto: 101
13	Cask Point 13	27.5, 75.5	Auto: 101
14	Cask Point 14	27.5, 91.5	Auto: 101
15	Cask Point 15	27.5, 107.5	Auto: 101
16	Cask Point 16	27.5, 123.5	Auto: 101
17	Cask Point 17	43.5, 11.5	Auto: 101
18	Cask Point 18	43.5, 27.5	Auto: 101
19	Cask Point 19	43.5, 43.5	Auto: 101
20	Cask Point 20	43.5, 59.5	Auto: 101
21	Cask Point 21	43.5, 75.5	Auto: 101
22	Cask Point 22	43.5, 91.5	Auto: 101
23	Cask Point 23	43.5, 107.5	Auto: 101
24	Cask Point 24	43.5, 123.5	Auto: 101
25	Footing Bottom Left	0, 0	Auto: 101
26	Footing Bottom Right	55, 0	Auto: 101
27	Footing Top Left	0, 135	Auto: 101
28	Footing Top Right	55, 135	Auto: 101
29	Footing Center	27.5, 67.5	Auto: 101
30	Query Point 30	11.973, 99.283	Auto: 101
31	Query Point 31	30, 132.5	Auto: 101
32	Query Point 32	52.5, 65	Auto: 101
33	Query Point 33	34.543, 35.669	Auto: 101
34	Query Point 34	27.5, 2.5	Auto: 101

Field Point Grid

Number of points 1672
Expansion Factor 1

Grid Coordinates

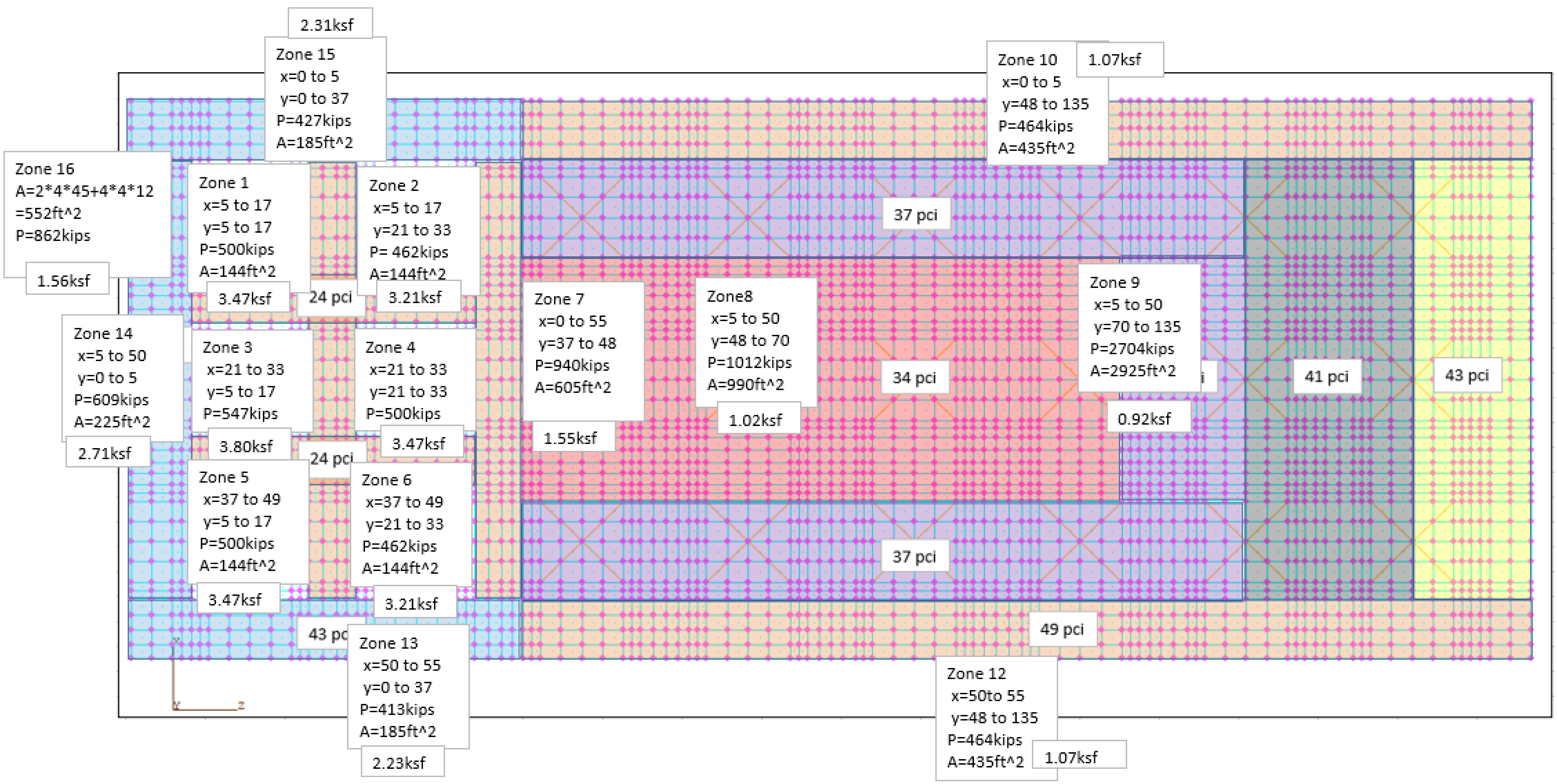
X [ft]	Y [ft]
122.5	202.5
122.5	-67.5
-67.5	-67.5
-67.5	202.5

DAN BROWN AND ASSOCIATES

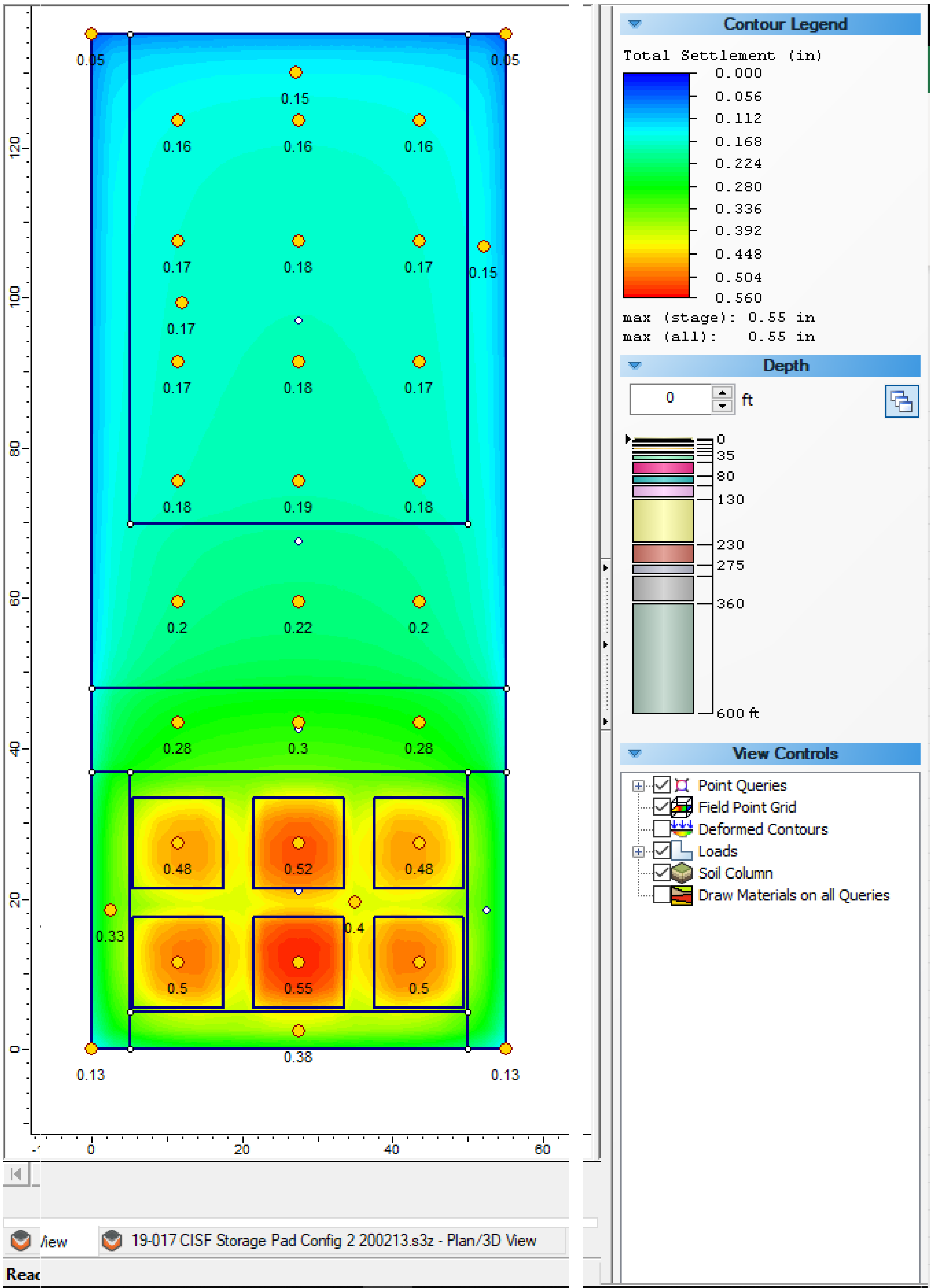
Configuration 2 Final Bearing Pressure Zones, Settlement Results, and Modulus of Subgrade Reaction Values for Enercon Model

CISF Site
Single Pad Analysis
Andrews, TX

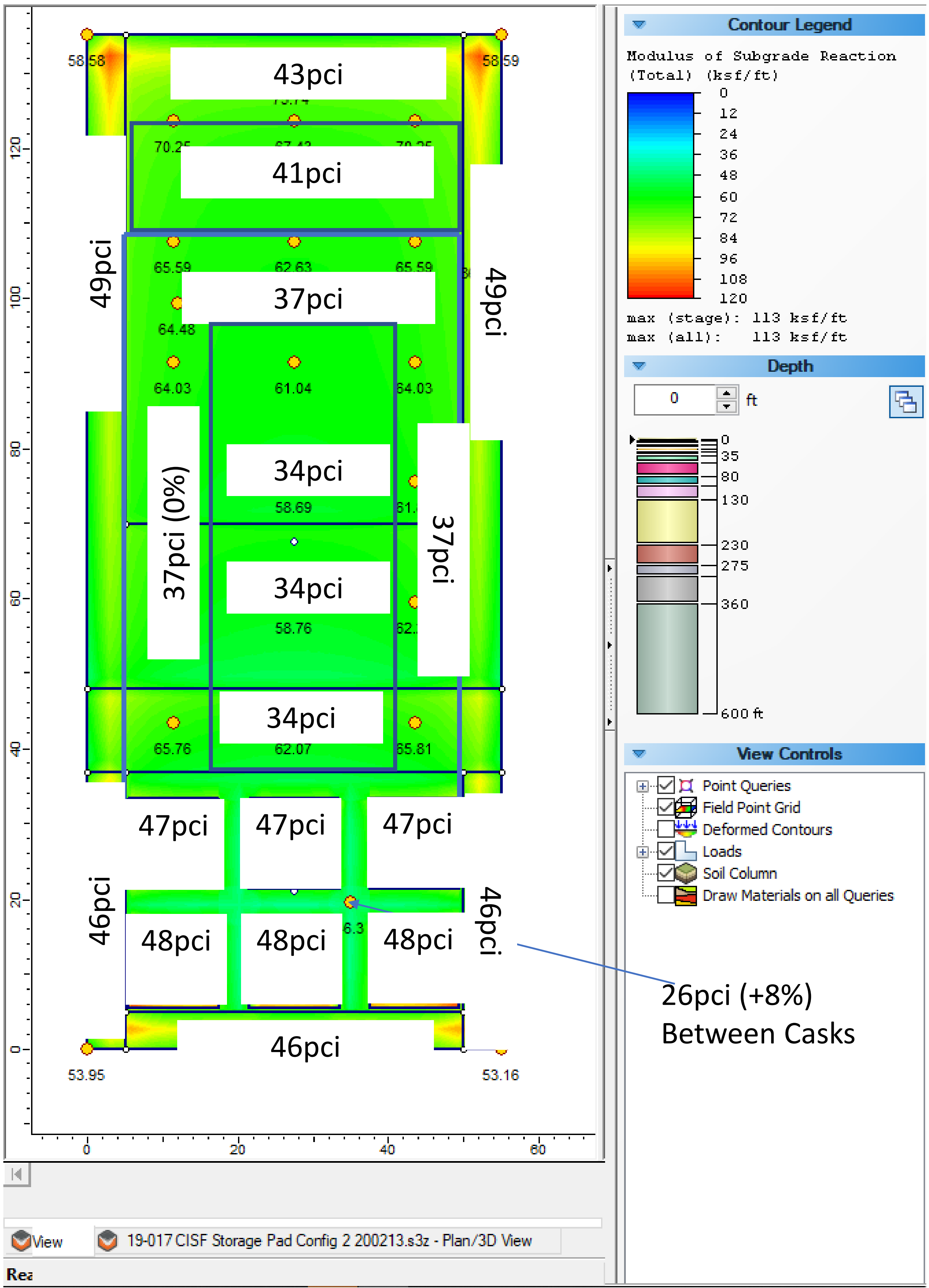
Configuration 2-Bearing Pressures (INPUT 5 Spreadsheet Loads)



Configuration 2-Settlement Estimate(INPUT 5 Spreadsheet Loads)



Configuration 2-k values (INPUT 5 Spreadsheet)



DAN BROWN AND ASSOCIATES

Configuration 2 Settle3 Inputs

Settle3 Analysis Information

Project Settings

Document Name	19-017 CISF Storage Pad Config 2 200214.s3z
Date Created	1/16/2020, 3:00:31 PM
Stress Computation Method	Westergaard
Minimum settlement ratio for subgrade modulus	0.9

Use average properties to calculate layered stresses

Improve consolidation accuracy

Ignore negative effective stresses in settlement calculations

Stage Settings

Stage #	Name
1	Stage 1

Results

Time taken to compute: 0 seconds

Stage: Stage 1

Data Type	Minimum	Maximum
Total Settlement [in]	0	0.550882
Loading Stress ZZ [ksf]	0.0164762	3.8

Loads

1. Polygonal Load: "Base Zone"

Label	Base Zone
Load Type	Flexible
Area of Load	7425 ft^2
Load	0.92 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
0	0
55	0
55	135
0	135

2. Polygonal Load: "Zone 8, 10, and 12"

Label	Zone 8, 10, and 12
Load Type	Flexible
Area of Load	1860 ft^2
Load	0.14 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
55	48
55	135
50	135
50	70
5	70
5	135
0	135
0	48

3. Polygonal Load: "Zone 7"

Label	Zone 7
Load Type	Flexible
Area of Load	605 ft^2
Load	0.63 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
55	37
55	48
0	48
0	37

4. Polygonal Load: "Zone 15"

Label	Zone 15
Load Type	Flexible
Area of Load	185 ft^2
Load	1.38 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
0	0
5	0
5	37
0	37

5. Polygonal Load: "Zone 13"

Label	Zone 13
Load Type	Flexible
Area of Load	185 ft^2
Load	1.31 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
50	0
55	0
55	37
50	37

6. Polygonal Load: "Zone 14"

Label	Zone 14
Load Type	Flexible
Area of Load	225 ft^2
Load	1.78 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5	0
50	0
50	5
5	5

7. Polygonal Load: "Zone 16"

Label	Zone 16
Load Type	Flexible
Area of Load	1440 ft^2
Load	0.64 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5	5
50	5
50	37
5	37

8. Rectangular Load: "Zone 1"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.91 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	5.5
17.5	5.5
17.5	17.5
5.5	17.5

9. Rectangular Load: "Zone 2"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.65 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	21.5
17.5	21.5
17.5	33.5
5.5	33.5

10. Rectangular Load: "Zone 4"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.91 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	21.5
33.5	21.5
33.5	33.5
21.5	33.5

11. Rectangular Load: "Zone 3"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.24 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	5.5
33.5	5.5
33.5	17.5
21.5	17.5

12. Rectangular Load: "Zone 5"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.91 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	5.5
49.5	5.5
49.5	17.5
37.5	17.5

13. Rectangular Load: "Zone 6"

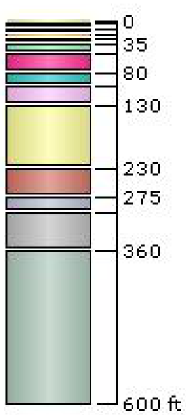
Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.65 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	21.5
49.5	21.5
49.5	33.5
37.5	33.5

Soil Layers

Layer #	Type	Thickness [ft]	Depth [ft]
1	Cover Sands	2	0
2	Caliche/Sand 1	8	2
3	Caliche/Sand 2	10	10
4	Caliche Hard 1	5	20
5	Caliche Hard 2	10	25
6	Ogallala 1	15	35
7	Ogallala 2	30	50
8	Ogallala 3	20	80
9	Dockum Claystone/Siltsone	30	100
10	Claystone and Siltstone	100	130
11	Dockum Clay/Claystone 1	45	230
12	Dockum Silty/Sands	25	275
13	Dockum Clay/Claystone 2	60	300
14	Dockum Clay/Claystone 3	240	360



Soil Properties

Property	Cover Sands	Caliche/Sand 1	Caliche/Sand 2	Caliche Hard 1
Color				
Unit Weight [kips/ft³]	0.12	0.12	0.12	0.12
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Enabled
Es [ksf]	890	1200	1200	35815
Esur [ksf]	890	1200	1200	35815
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8

Property	Caliche Hard 2	Ogallala 1	Ogallala 2	Ogallala 3
Color				
Unit Weight [kips/ft³]	0.12	0.12	0.13	0.13
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Enabled
Es [ksf]	55232	80233	53870	123857
Esur [ksf]	55232	80233	53870	123857
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8

Property	Dockum Claystone/ Siltstone	Claystone and Siltstone	Dockum Clay/ Claystone 1	Dockum Silty/ Sands
Color				
Unit Weight [kips/ft³]	0.13	0.13	0.13	0.13
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Enabled
Es [ksf]	84172	120769	120769	120769
Esur [ksf]	84172	120769	120769	120769
Undrained Su A [kips/ ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8

Property	Dockum Clay/Claystone 2	Dockum Clay/Claystone 3
Color		
Unit Weight [kips/ft³]	0.13	0.13
K0	1	1
Immediate Settlement	Enabled	Enabled
Es [ksf]	120769	154394
Esur [ksf]	120769	154394
Undrained Su A [kips/ft2]	0	0
Undrained Su S	0.2	0.2
Undrained Su m	0.8	0.8

Query Points

Point #	Query Point Name	(X,Y) Location	Number of Divisions
1	Cask Point 1	11.5, 11.5	Auto: 101
2	Cask Point 2	11.5, 27.5	Auto: 101
3	Cask Point 3	11.5, 43.5	Auto: 101
4	Cask Point 4	11.5, 59.5	Auto: 101
5	Cask Point 5	11.5, 75.5	Auto: 101
6	Cask Point 6	11.5, 91.5	Auto: 101
7	Cask Point 7	11.5, 107.5	Auto: 101
8	Cask Point 8	11.5, 123.5	Auto: 101
9	Cask Point 9	27.5, 11.5	Auto: 101
10	Cask Point 10	27.5, 27.5	Auto: 101
11	Cask Point 11	27.5, 43.5	Auto: 101
12	Cask Point 12	27.5, 59.5	Auto: 101
13	Cask Point 13	27.5, 75.5	Auto: 101
14	Cask Point 14	27.5, 91.5	Auto: 101
15	Cask Point 15	27.5, 107.5	Auto: 101
16	Cask Point 16	27.5, 123.5	Auto: 101
17	Cask Point 17	43.5, 11.5	Auto: 101
18	Cask Point 18	43.5, 27.5	Auto: 101
19	Cask Point 19	43.5, 43.5	Auto: 101
20	Cask Point 20	43.5, 59.5	Auto: 101
21	Cask Point 21	43.5, 75.5	Auto: 101
22	Cask Point 22	43.5, 91.5	Auto: 101
23	Cask Point 23	43.5, 107.5	Auto: 101
24	Cask Point 24	43.5, 123.5	Auto: 101
25	Footing Bottom Left	0, 0	Auto: 101
26	Footing Bottom Right	55, 0	Auto: 101
27	Footing Top Left	0, 135	Auto: 101
28	Footing Top Right	55, 135	Auto: 101
29	Footing Center	52.208, 106.8	Auto: 101
30	Query Point 30	11.973, 99.283	Auto: 101
31	Query Point 31	34.932, 19.529	Auto: 101
32	Query Point 32	2.5, 18.5	Auto: 101
33	Query Point 33	27.105, 129.904	Auto: 101
34	Query Point 34	27.5, 2.5	Auto: 101

Field Point Grid

Number of points 1294
Expansion Factor 1

Grid Coordinates

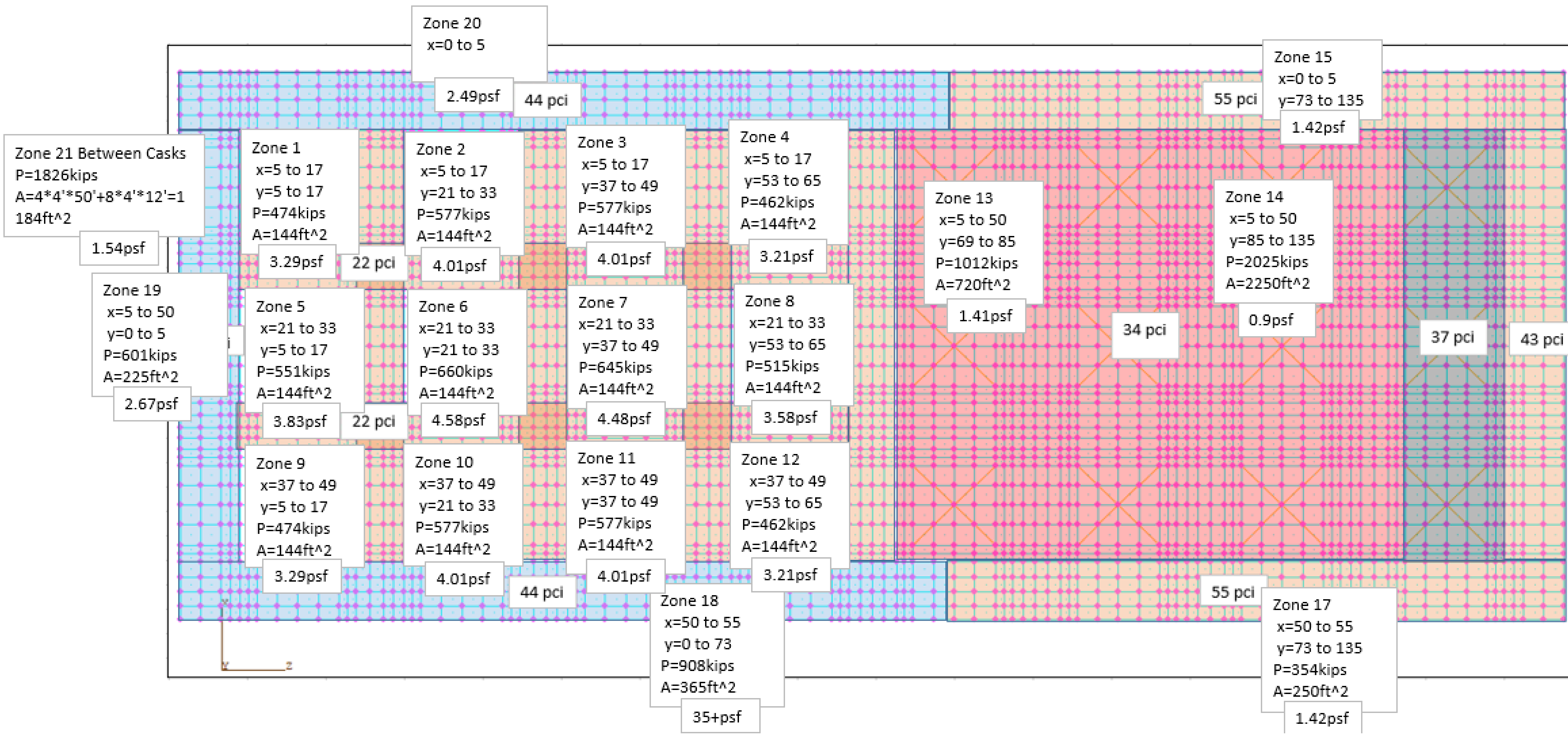
X [ft]	Y [ft]
122.5	202.5
122.5	-67.5
-67.5	-67.5
-67.5	202.5

DAN BROWN AND ASSOCIATES

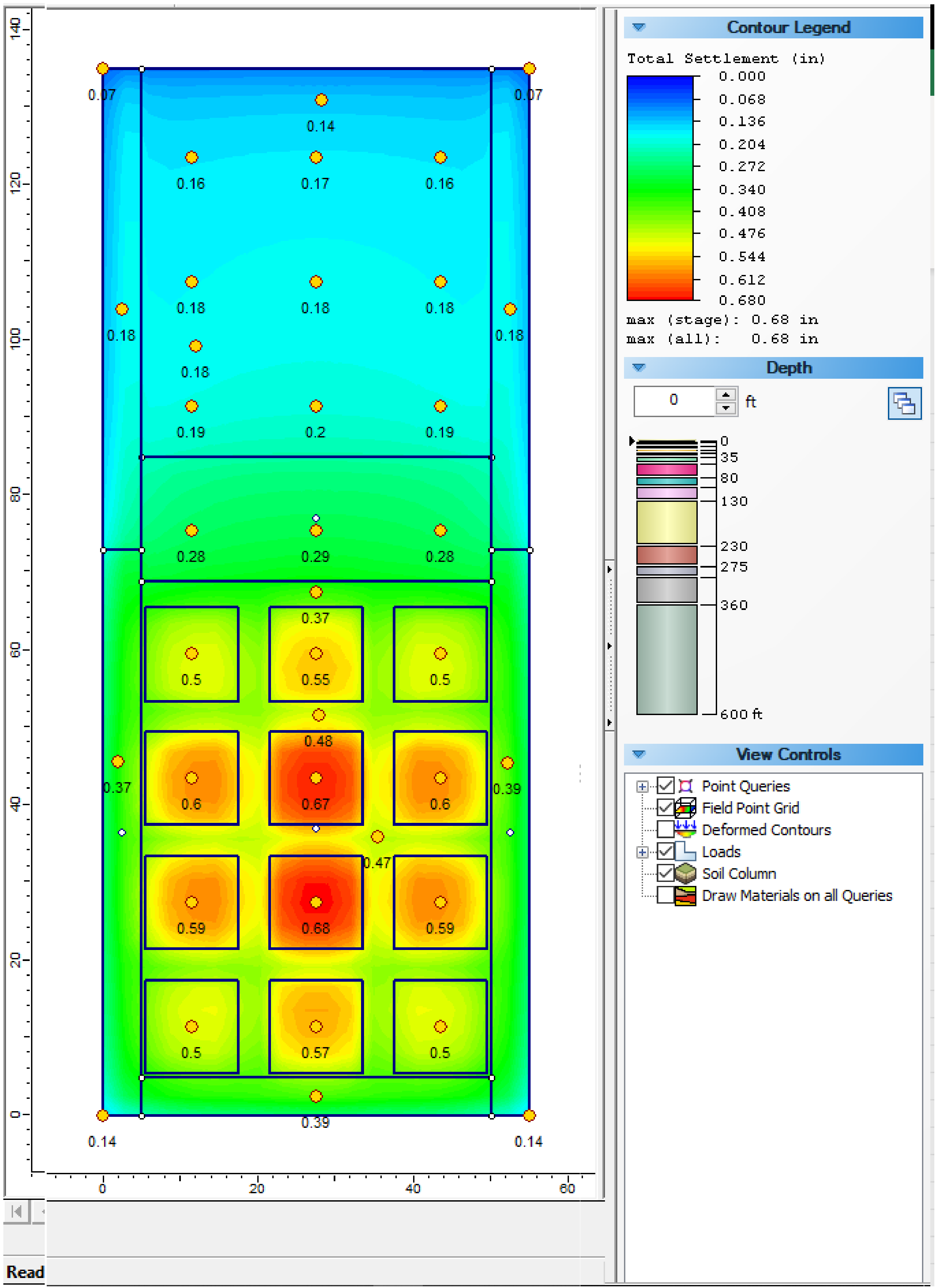
Configuration 3
Final Bearing Pressure Zones, Settlement Results, and Modulus of Subgrade Reaction Values for Enercon Model

CISF Site
Single Pad Analysis
Andrews, TX

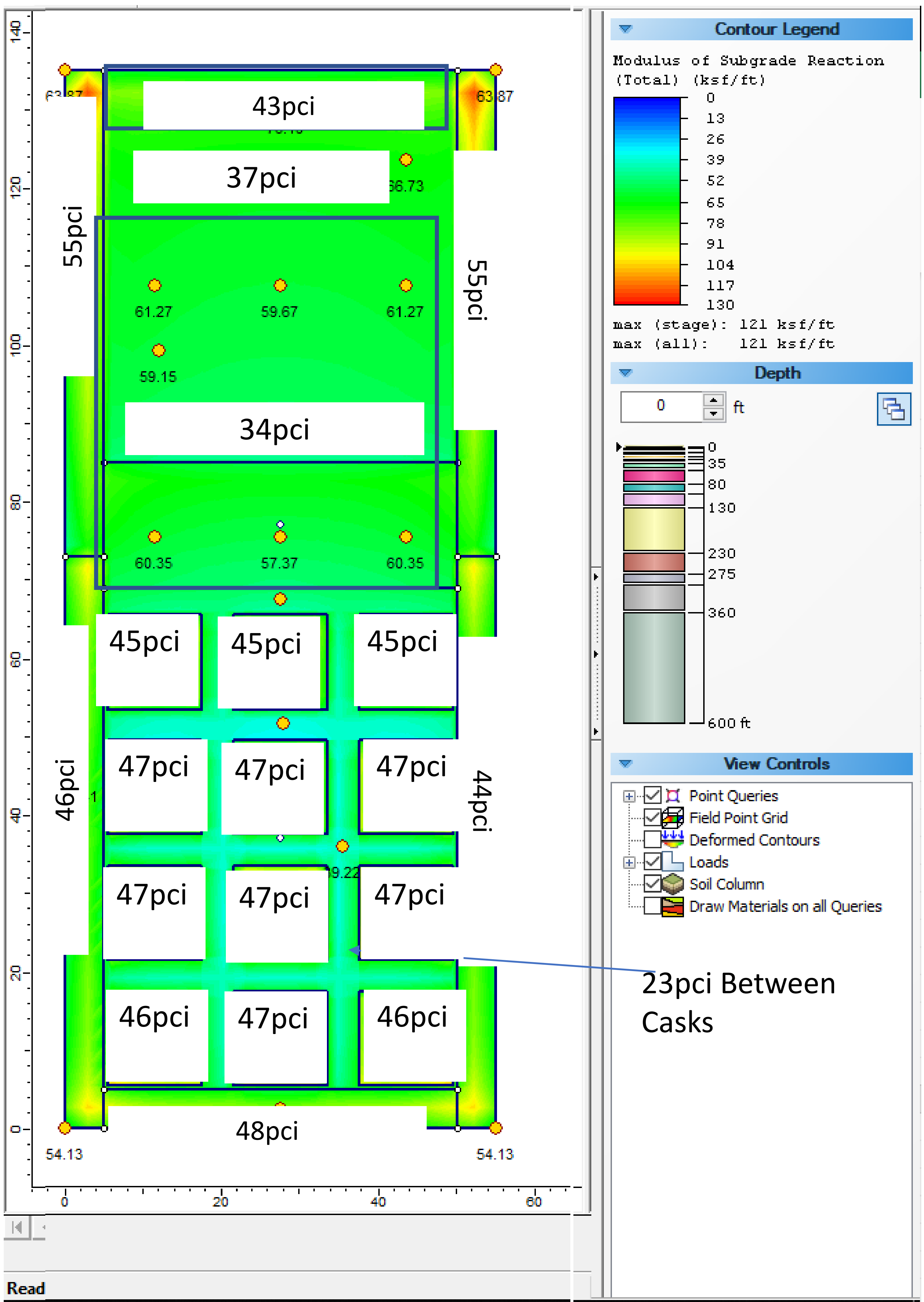
Configuration 3-Bearing Pressures (INPUT 5 Spreadsheet Loads)



Configuration 3-Settlement Estimate (INPUT 5 Spreadsheet Loads)



Configuration 3 k values (INPUT 5 Spreadsheet)



DAN BROWN AND ASSOCIATES

Configuration 3 Settle3 Inputs

Settle3 Analysis Information

Project Settings

Document Name	19-017 CISF Storage Pad Config 3 200214 Input 5.s3z
Date Created	1/16/2020, 3:00:31 PM
Stress Computation Method	Westergaard
Minimum settlement ratio for subgrade modulus	0.9

Use average properties to calculate layered stresses

Improve consolidation accuracy

Ignore negative effective stresses in settlement calculations

Stage Settings

Stage #	Name
1	Stage 1

Results

Time taken to compute: 0 seconds

Stage: Stage 1

Data Type	Minimum	Maximum
Total Settlement [in]	0	0.677157
Loading Stress ZZ [ksf]	0.02225	4.58

Loads

1. Polygonal Load: "Base Zone"

Label	Base Zone
Load Type	Flexible
Area of Load	7425 ft^2
Load	0.9 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
0	0
55	0
55	135
0	135

2. Rectangular Load: "Zone 1"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.75 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	5.5
17.5	5.5
17.5	17.5
5.5	17.5

3. Rectangular Load: "Zone 9"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.75 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	5.5
49.5	5.5
49.5	17.5
37.5	17.5

4. Rectangular Load: "Zone 12"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.67 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	53.5
49.5	53.5
49.5	65.5
37.5	65.5

5. Rectangular Load: "Zone 11"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.46 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	37.5
49.5	37.5
49.5	49.5
37.5	49.5

6. Rectangular Load: "Zone 10"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.46 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	21.5
49.5	21.5
49.5	33.5
37.5	33.5

7. Rectangular Load: "Zone 4"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.67 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	53.5
17.5	53.5
17.5	65.5
5.5	65.5

8. Rectangular Load: "Zone 3"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.46 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	37.5
17.5	37.5
17.5	49.5
5.5	49.5

9. Rectangular Load: "Zone 2"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.46 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	21.5
17.5	21.5
17.5	33.5
5.5	33.5

10. Rectangular Load: "Zone 5"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.28 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	5.5
33.5	5.5
33.5	17.5
21.5	17.5

11. Rectangular Load: "Zone 6"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	3.04 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	21.5
33.5	21.5
33.5	33.5
21.5	33.5

12. Rectangular Load: "Zone 7"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.94 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	37.5
33.5	37.5
33.5	49.5
21.5	49.5

13. Rectangular Load: "Zone 8"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.03 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	53.5
33.5	53.5
33.5	65.5
21.5	65.5

14. Polygonal Load: "Zone 13"

Label	Zone 13
Load Type	Flexible
Area of Load	720 ft^2
Load	0.51 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
50	69
50	85
5	85
5	69

15. Polygonal Load: "Zone 20"

Label	Zone 20
Load Type	Flexible
Area of Load	365 ft^2
Load	1.59 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
0	0
5	0
5	73
0	73

16. Polygonal Load: "Zone 18"

Label	Zone 18
Load Type	Flexible
Area of Load	365 ft^2
Load	1.59 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
50	0
55	0
55	73
50	73

17. Polygonal Load: "Zone 19"

Label	Zone 19
Load Type	Flexible
Area of Load	225 ft^2
Load	1.77 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5	0
50	0
50	5
5	5

18. Polygonal Load: "Zone 17"

Label	Zone 17
Load Type	Flexible
Area of Load	310 ft^2
Load	0.52 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
50	73
55	73
55	135
50	135

19. Polygonal Load: "Zone 15"

Label	Zone 15
Load Type	Flexible
Area of Load	310 ft^2
Load	0.52 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
0	73
5	73
5	135
0	135

20. Polygonal Load: "Zone 21"

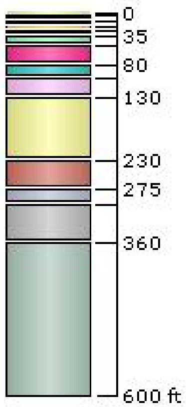
Label	Zone 21
Load Type	Flexible
Area of Load	2880 ft^2
Load	0.64 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5	5
50	5
50	69
5	69

Soil Layers

Layer #	Type	Thickness [ft]	Depth [ft]
1	Cover Sands	2	0
2	Caliche/Sand 1	8	2
3	Caliche/Sand 2	10	10
4	Caliche Hard 1	5	20
5	Caliche Hard 2	10	25
6	Ogallala 1	15	35
7	Ogallala 2	30	50
8	Ogallala 3	20	80
9	Dockum Claystone/Siltsone	30	100
10	Claystone and Siltstone	100	130
11	Dockum Clay/Claystone 1	45	230
12	Dockum Silty/Sands	25	275
13	Dockum Clay/Claystone 2	60	300
14	Dockum Clay/Claystone 3	240	360



Soil Properties

Property	Cover Sands	Caliche/Sand 1	Caliche/Sand 2	Caliche Hard 1
Color				
Unit Weight [kips/ft^3]	0.12	0.12	0.12	0.12
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Enabled
Es [ksf]	890	1200	1200	35815
Esur [ksf]	890	1200	1200	35815
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8

Property	Caliche Hard 2	Ogallala 1	Ogallala 2	Ogallala 3
Color				
Unit Weight [kips/ft^3]	0.12	0.12	0.13	0.13
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Enabled
Es [ksf]	55232	80233	53870	123857
Esur [ksf]	55232	80233	53870	123857
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8

Property	Dockum Claystone/ Siltstone	Claystone and Siltstone	Dockum Clay/ Claystone 1	Dockum Silty/ Sands
Color				
Unit Weight [kips/ft^3]	0.13	0.13	0.13	0.13
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Enabled
Es [ksf]	84172	120769	120769	120769
Esur [ksf]	84172	120769	120769	120769
Undrained Su A [kips/ ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8

Property	Dockum Clay/Claystone 2	Dockum Clay/Claystone 3
Color		
Unit Weight [kips/ft^3]	0.13	0.13
K0	1	1
Immediate Settlement	Enabled	Enabled
Es [ksf]	120769	154394
Esur [ksf]	120769	154394
Undrained Su A [kips/ft2]	0	0
Undrained Su S	0.2	0.2
Undrained Su m	0.8	0.8

Query Points

Point #	Query Point Name	(X,Y) Location	Number of Divisions
1	Cask Point 1	11.5, 11.5	Auto: 101
2	Cask Point 2	11.5, 27.5	Auto: 101
3	Cask Point 3	11.5, 43.5	Auto: 101
4	Cask Point 4	11.5, 59.5	Auto: 101
5	Cask Point 5	11.5, 75.5	Auto: 101
6	Cask Point 6	11.5, 91.5	Auto: 101
7	Cask Point 7	11.5, 107.5	Auto: 101
8	Cask Point 8	11.5, 123.5	Auto: 101
9	Cask Point 9	27.5, 11.5	Auto: 101
10	Cask Point 10	27.5, 27.5	Auto: 101
11	Cask Point 11	27.5, 43.5	Auto: 101
12	Cask Point 12	27.5, 59.5	Auto: 101
13	Cask Point 13	27.5, 75.5	Auto: 101
14	Cask Point 14	27.5, 91.5	Auto: 101
15	Cask Point 15	27.5, 107.5	Auto: 101
16	Cask Point 16	27.5, 123.5	Auto: 101
17	Cask Point 17	43.5, 11.5	Auto: 101
18	Cask Point 18	43.5, 27.5	Auto: 101
19	Cask Point 19	43.5, 43.5	Auto: 101
20	Cask Point 20	43.5, 59.5	Auto: 101
21	Cask Point 21	43.5, 75.5	Auto: 101
22	Cask Point 22	43.5, 91.5	Auto: 101
23	Cask Point 23	43.5, 107.5	Auto: 101
24	Cask Point 24	43.5, 123.5	Auto: 101
25	Footing Bottom Left	0, 0	Auto: 101
26	Footing Bottom Right	55, 0	Auto: 101
27	Footing Top Left	0, 135	Auto: 101
28	Footing Top Right	55, 135	Auto: 101
29	Footing Center	27.5, 67.5	Auto: 101
30	Query Point 30	11.973, 99.283	Auto: 101
31	Query Point 31	28.128, 130.851	Auto: 101
32	Query Point 32	2.012, 45.679	Auto: 101
33	Query Point 33	52.141, 45.546	Auto: 101
34	Query Point 34	2.5, 104	Auto: 101
35	Query Point 35	52.5, 104	Auto: 101
36	Query Point 36	27.808, 51.568	Auto: 101
37	Query Point 37	35.388, 35.978	Auto: 101
38	Query Point 38	27.5, 2.5	Auto: 101

Field Point Grid

Number of points 1428
Expansion Factor 1

Grid Coordinates

X [ft]	Y [ft]
122.5	202.5
122.5	-67.5
-67.5	-67.5
-67.5	202.5

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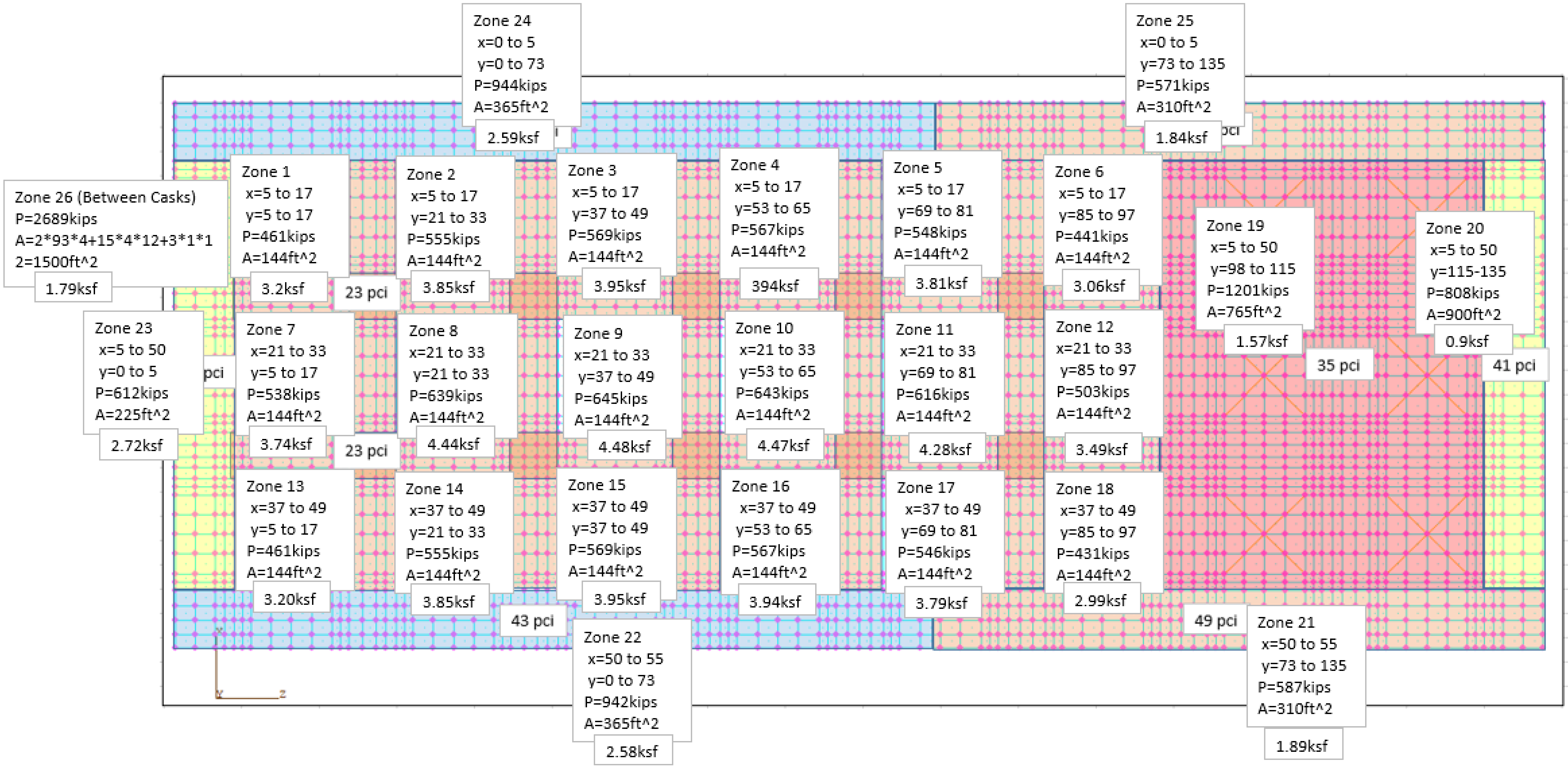
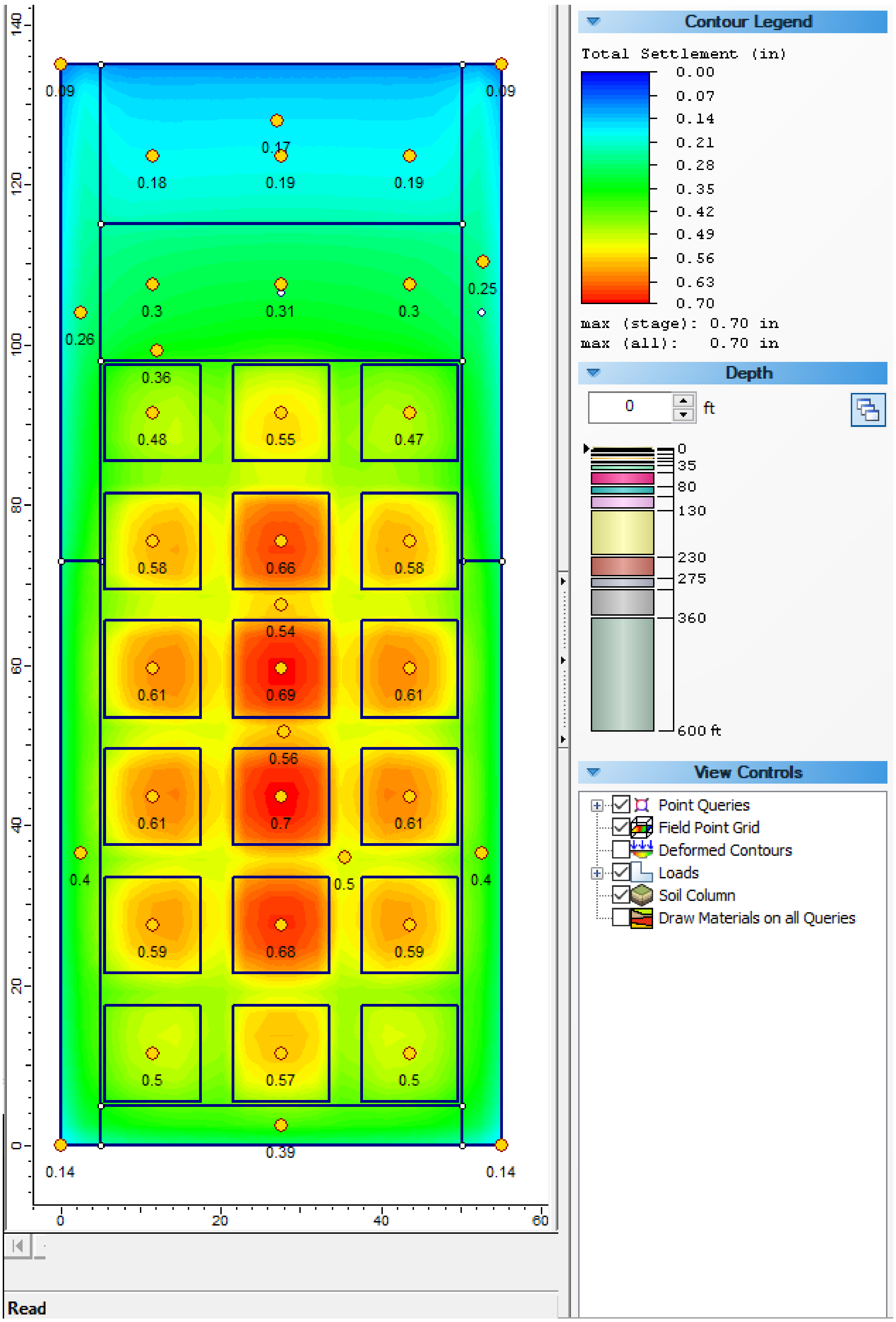
Configuration 4
Final Bearing Pressure Zones, Settlement Results, and Modulus of Subgrade Reaction Values for Enercon Model

CISF Site
Single Pad Analysis
Andrews, TX

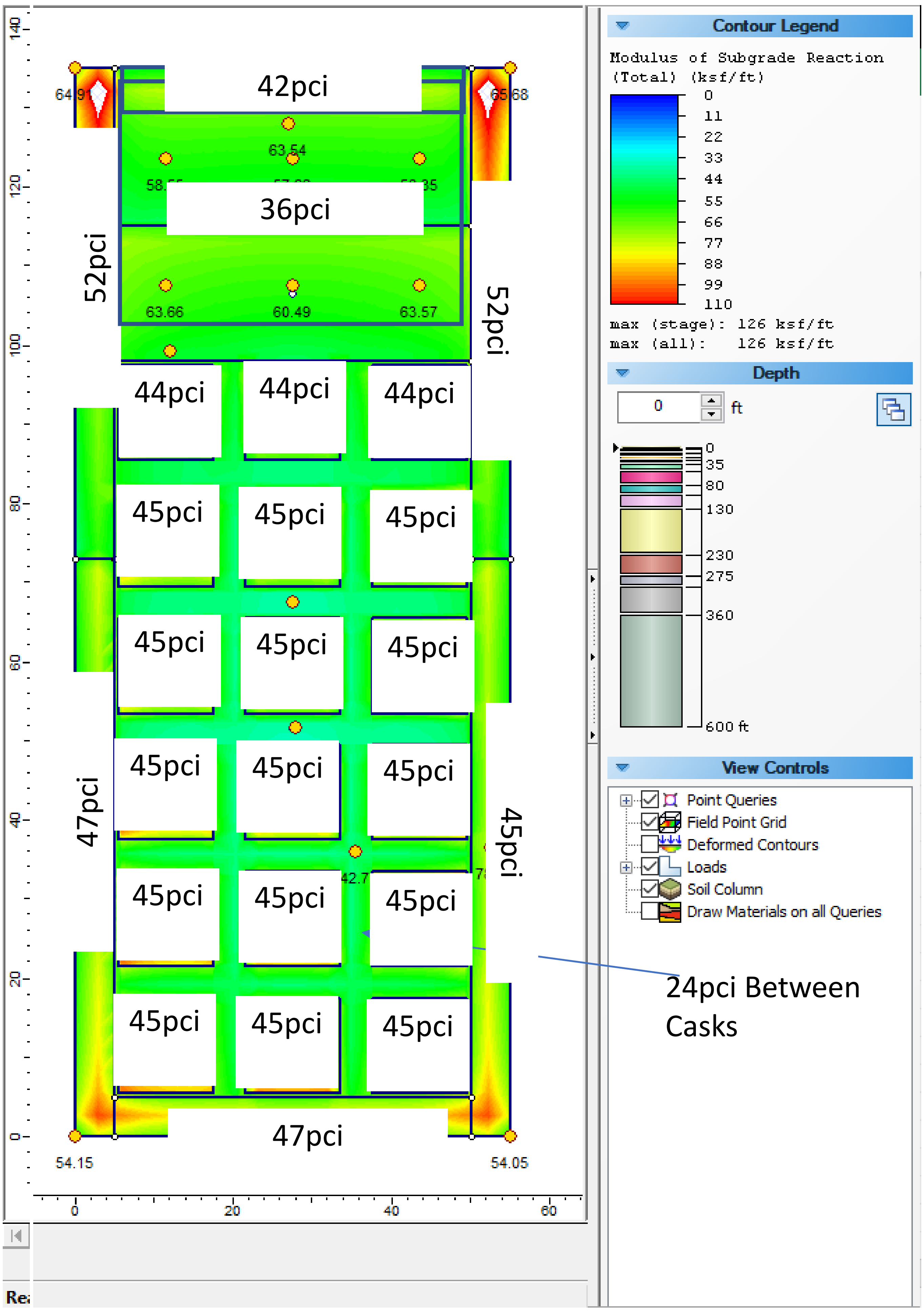
Configuration 4-Bearing Pressures (INPUT 4 Spreadsheet Loads)



Configuration 4-Settlement Estimate – Loads from INPUT4Spreadsheets)



Configuration 4 k values – Loads from INPUT 4 Spreadsheets



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Configuration 4 Settle3 Inputs

Settle3 Analysis Information

Project Settings

Document Name	19-017 CISF Storage Pad Config 4 200215 INPUT 4.s3z
Date Created	1/16/2020, 3:00:31 PM
Stress Computation Method	Westergaard
Minimum settlement ratio for subgrade modulus	0.9

Use average properties to calculate layered stresses

Improve consolidation accuracy

Ignore negative effective stresses in settlement calculations

Stage Settings

Stage #	Name
1	Stage 1

Results

Time taken to compute: 0 seconds

Stage: Stage 1

Data Type	Minimum	Maximum
Total Settlement [in]	0	0.695643
Loading Stress ZZ [ksf]	0.0283155	4.48

Loads

1. Polygonal Load: "Base Zone"

Label	Base Zone
Load Type	Flexible
Area of Load	7425 ft^2
Load	0.9 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
0	0
55	0
55	135
0	135

2. Rectangular Load: "Zone 1"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.41 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	5.5
17.5	5.5
17.5	17.5
5.5	17.5

3. Rectangular Load: "Zone 13"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.41 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	5.5
49.5	5.5
49.5	17.5
37.5	17.5

4. Rectangular Load: "Zone 16"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.14 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	53.5
49.5	53.5
49.5	65.5
37.5	65.5

5. Rectangular Load: "Zone 15"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.16 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	37.5
49.5	37.5
49.5	49.5
37.5	49.5

6. Rectangular Load: "Zone 14"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.06 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	21.5
49.5	21.5
49.5	33.5
37.5	33.5

7. Rectangular Load: "Zone 4"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.14 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	53.5
17.5	53.5
17.5	65.5
5.5	65.5

8. Rectangular Load: "Zone 3"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.16 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	37.5
17.5	37.5
17.5	49.5
5.5	49.5

9. Rectangular Load: "Zone 2"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.06 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	21.5
17.5	21.5
17.5	33.5
5.5	33.5

10. Rectangular Load: "Zone 7"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.94 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	5.5
33.5	5.5
33.5	17.5
21.5	17.5

11. Rectangular Load: "Zone 8"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.64 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	21.5
33.5	21.5
33.5	33.5
21.5	33.5

12. Rectangular Load: "Zone 9"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.69 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	37.5
33.5	37.5
33.5	49.5
21.5	49.5

13. Rectangular Load: "Zone 10"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.67 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	53.5
33.5	53.5
33.5	65.5
21.5	65.5

14. Polygonal Load: "Zone 24"

Label	Zone 24
Load Type	Flexible
Area of Load	365 ft^2
Load	1.69 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
0	0
5	0
5	73
0	73

15. Polygonal Load: "Zone 22"

Label	Zone 22
Load Type	Flexible
Area of Load	365 ft^2
Load	1.68 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
50	0
55	0
55	73
50	73

16. Polygonal Load: "Zone 23"

Label	Zone 23
Load Type	Flexible
Area of Load	225 ft^2
Load	1.82 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5	0
50	0
50	5
5	5

17. Polygonal Load: "Zone 21"

Label	Zone 21
Load Type	Flexible
Area of Load	310 ft^2
Load	1 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
50	73
55	73
55	135
50	135

18. Polygonal Load: "Zone 25"

Label	Zone 25
Load Type	Flexible
Area of Load	310 ft^2
Load	0.94 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
0	73
5	73
5	135
0	135

19. Rectangular Load: "Zone 5"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.01 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	69.5
17.5	69.5
17.5	81.5
5.5	81.5

20. Rectangular Load: "Zone 6"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.27 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	85.5
17.5	85.5
17.5	97.5
5.5	97.5

21. Rectangular Load: "Zone 11"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.49 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	69.5
33.5	69.5
33.5	81.5
21.5	81.5

22. Rectangular Load: "Zone12"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.7 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	85.5
33.5	85.5
33.5	97.5
21.5	97.5

23. Rectangular Load: "Zone 17"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	69.5
49.5	69.5
49.5	81.5
37.5	81.5

24. Rectangular Load: "Zone 18"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.2 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	85.5
49.5	85.5
49.5	97.5
37.5	97.5

25. Polygonal Load: "Zone 19"

Label	Zone 19
Load Type	Flexible
Area of Load	765 ft^2
Load	0.67 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
50	98
50	115
5	115
5	98

26. Polygonal Load: "Zone 26"

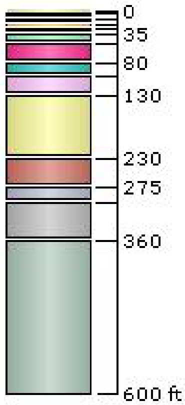
Label	Zone 26
Load Type	Flexible
Area of Load	4185 ft^2
Load	0.89 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
50	5
50	98
5	98
5	5

Soil Layers

Layer #	Type	Thickness [ft]	Depth [ft]
1	Cover Sands	2	0
2	Caliche/Sand 1	8	2
3	Caliche/Sand 2	10	10
4	Caliche Hard 1	5	20
5	Caliche Hard 2	10	25
6	Ogallala 1	15	35
7	Ogallala 2	30	50
8	Ogallala 3	20	80
9	Dockum Claystone/Siltsone	30	100
10	Claystone and Siltstone	100	130
11	Dockum Clay/Claystone 1	45	230
12	Dockum Silty/Sands	25	275
13	Dockum Clay/Claystone 2	60	300
14	Dockum Clay/Claystone 3	240	360



Soil Properties

Property	Cover Sands	Caliche/Sand 1	Caliche/Sand 2	Caliche Hard 1
Color				
Unit Weight [kips/ft^3]	0.12	0.12	0.12	0.12
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Enabled
Es [ksf]	890	1200	1200	35815
Esur [ksf]	890	1200	1200	35815
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8

Property	Caliche Hard 2	Ogallala 1	Ogallala 2	Ogallala 3
Color				
Unit Weight [kips/ft^3]	0.12	0.12	0.13	0.13
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Enabled
Es [ksf]	55232	80233	53870	123857
Esur [ksf]	55232	80233	53870	123857
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8

Property	Dockum Claystone/ Siltsone	Claystone and Siltstone	Dockum Clay/ Claystone 1	Dockum Silty/ Sands
Color				
Unit Weight [kips/ft^3]	0.13	0.13	0.13	0.13
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Enabled
Es [ksf]	84172	120769	120769	120769
Esur [ksf]	84172	120769	120769	120769
Undrained Su A [kips/ ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8

Property	Dockum Clay/Claystone 2	Dockum Clay/Claystone 3
Color		
Unit Weight [kips/ft^3]	0.13	0.13
K0	1	1
Immediate Settlement	Enabled	Enabled
Es [ksf]	120769	154394
Esur [ksf]	120769	154394
Undrained Su A [kips/ft2]	0	0
Undrained Su S	0.2	0.2
Undrained Su m	0.8	0.8

Query Points

Point #	Query Point Name	(X,Y) Location	Number of Divisions
1	Cask Point 1	11.5, 11.5	Auto: 101
2	Cask Point 2	11.5, 27.5	Auto: 101
3	Cask Point 3	11.5, 43.5	Auto: 101
4	Cask Point 4	11.5, 59.5	Auto: 101
5	Cask Point 5	11.5, 75.5	Auto: 101
6	Cask Point 6	11.5, 91.5	Auto: 101
7	Cask Point 7	11.5, 107.5	Auto: 101
8	Cask Point 8	11.5, 123.5	Auto: 101
9	Cask Point 9	27.5, 11.5	Auto: 101
10	Cask Point 10	27.5, 27.5	Auto: 101
11	Cask Point 11	27.5, 43.5	Auto: 101
12	Cask Point 12	27.5, 59.5	Auto: 101
13	Cask Point 13	27.5, 75.5	Auto: 101
14	Cask Point 14	27.5, 91.5	Auto: 101
15	Cask Point 15	27.5, 107.5	Auto: 101
16	Cask Point 16	27.5, 123.5	Auto: 101
17	Cask Point 17	43.5, 11.5	Auto: 101
18	Cask Point 18	43.5, 27.5	Auto: 101
19	Cask Point 19	43.5, 43.5	Auto: 101
20	Cask Point 20	43.5, 59.5	Auto: 101
21	Cask Point 21	43.5, 75.5	Auto: 101
22	Cask Point 22	43.5, 91.5	Auto: 101
23	Cask Point 23	43.5, 107.5	Auto: 101
24	Cask Point 24	43.5, 123.5	Auto: 101
25	Footing Bottom Left	0, 0	Auto: 101
26	Footing Bottom Right	55, 0	Auto: 101
27	Footing Top Left	0, 135	Auto: 101
28	Footing Top Right	55, 135	Auto: 101
29	Footing Center	27.5, 67.5	Auto: 101
30	Query Point 30	11.973, 99.283	Auto: 101
31	Query Point 31	26.895, 127.856	Auto: 101
32	Query Point 32	2.5, 36.5	Auto: 101
33	Query Point 33	52.5, 36.5	Auto: 101
34	Query Point 34	2.5, 104	Auto: 101
35	Query Point 35	52.794, 110.237	Auto: 101
36	Query Point 36	27.808, 51.568	Auto: 101
37	Query Point 37	35.388, 35.978	Auto: 101
38	Query Point 38	27.5, 2.5	Auto: 101

Field Point Grid

Number of points	1556
Expansion Factor	1

Grid Coordinates

X [ft]	Y [ft]
122.5	202.5
122.5	-67.5
-67.5	-67.5
-67.5	202.5

Overall Pad Layout from WCS
CISF Safety Analysis Report

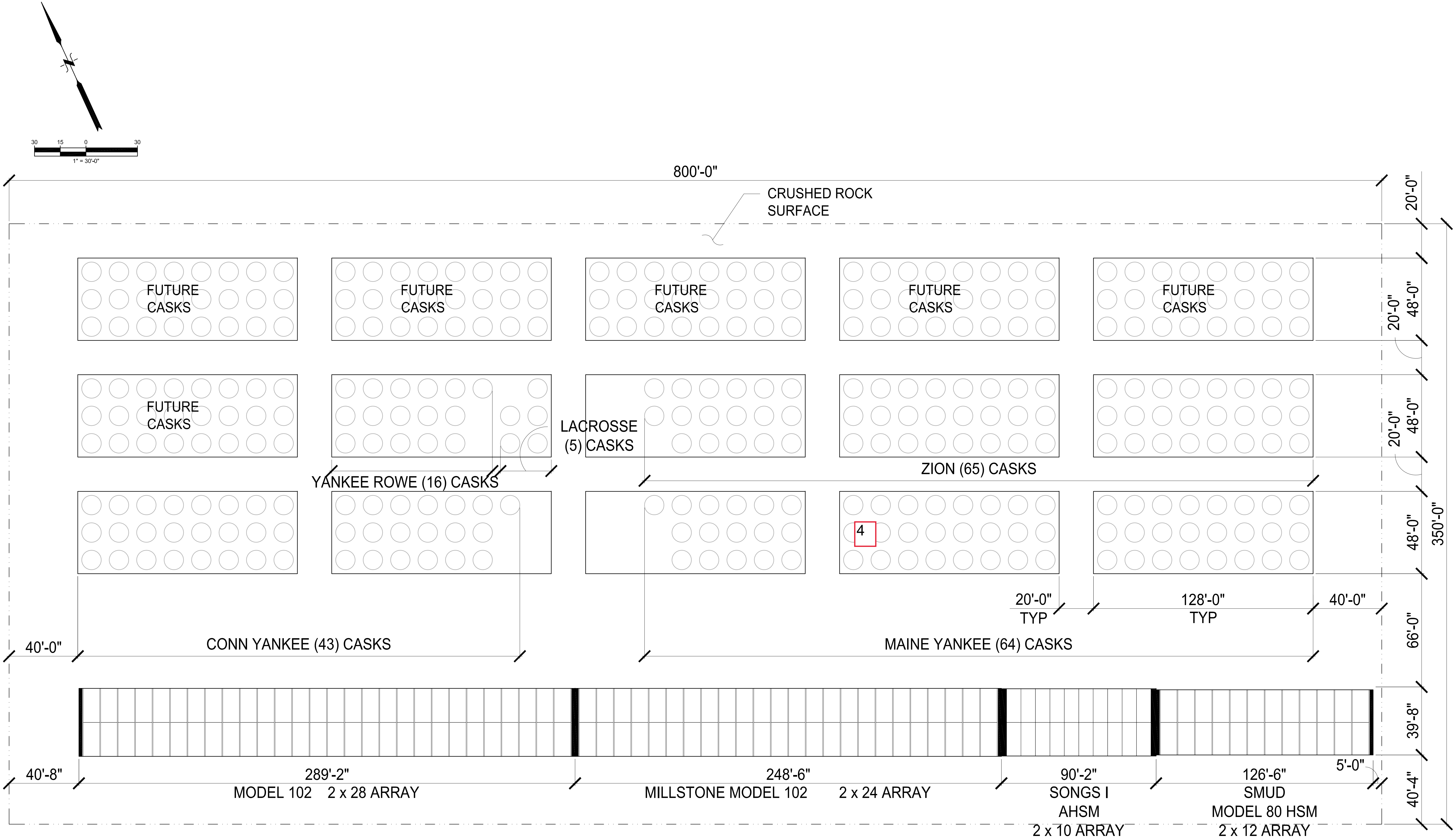


Figure 1-6
WCS CISF Storage Pad Layout

Four Pad Settle3 Inputs and Results

CISF Site
Four Storage Pads Analysis
Andrews, TX
15 February 2020

Soil Column Based on Average Shear Wave Velocity Measurements

- Interpreted from all explorations and collaboration between GEOS and DBA.
- Top 100ft contains 7 stratum in 5 materials identified by GEOS
- 100ft-600ft (approx. location of incompressible layers with sharp contrast of velocity) contains 3 average velocity values for 6 layers identified in the soil column provided by GEOS

Top (ft)	Bottom (ft)	Avg. Layer Shear Wave Velocity (ft/s)	Layer Material (From GEOS column)	Model Layer Name
20	25	1530	Caliche - Very Hard	Caliche Hard 1
25	35	1900	Caliche - Very Hard	Caliche Hard 2
35	50	2290	Ogallala - Sand with Gravel	Ogallala 1
50	80	1840	Ogallala - Sand with Gravel	Ogallala 2
80	100	2790	Ogallala - Sand with Gravel	Ogallala 3
100	130	2300	Dockum - Claystone and Siltstone	Dockum Claystone/Siltstone
130	230	2755	Claystone and Siltstone	Claystone and Siltstone
230	275	2755	Dockum - Clay/Claystone	Dockum Clay/Claystone1
275	300	2755	Dockum - Silty Sands	Dockum Silty/Sands
300	360	2755	Dockum - Clay/Claystone	Dockum Clay/Claystone 2
360	600	3115	Dockum - Clay/Claystone	Dockum Clay/Claystone 3

Top (ft)	Bottom (ft)	Avg. Layer Shear Wave Velocity (ft/s)	Unit weight (pcf)	Poisson's Ratio	Gmax (psf)
20	25	1530	125	0.33	9,087,345
25	35	1900	125	0.33	14,013,975
35	50	2290	125	0.33	20,357,531
50	80	1840	130	0.33	13,668,571
80	100	2790	130	0.33	31,426,491
100	130	2300	130	0.33	21,357,143
130	230	2755	130	0.33	30,642,958
230	275	2755	130	0.33	30,642,958
275	300	2755	130	0.33	30,642,958
300	360	2755	130	0.33	30,642,958
360	600	3115	130	0.33	39,174,511

Use Soil Column from Pad Analysis with bearing pressures from Configuration 1 Iterations (INPUT 5 final iteration).

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CISF Site
Four Storage Pads Analysis
Andrews, TX
15 February 2020

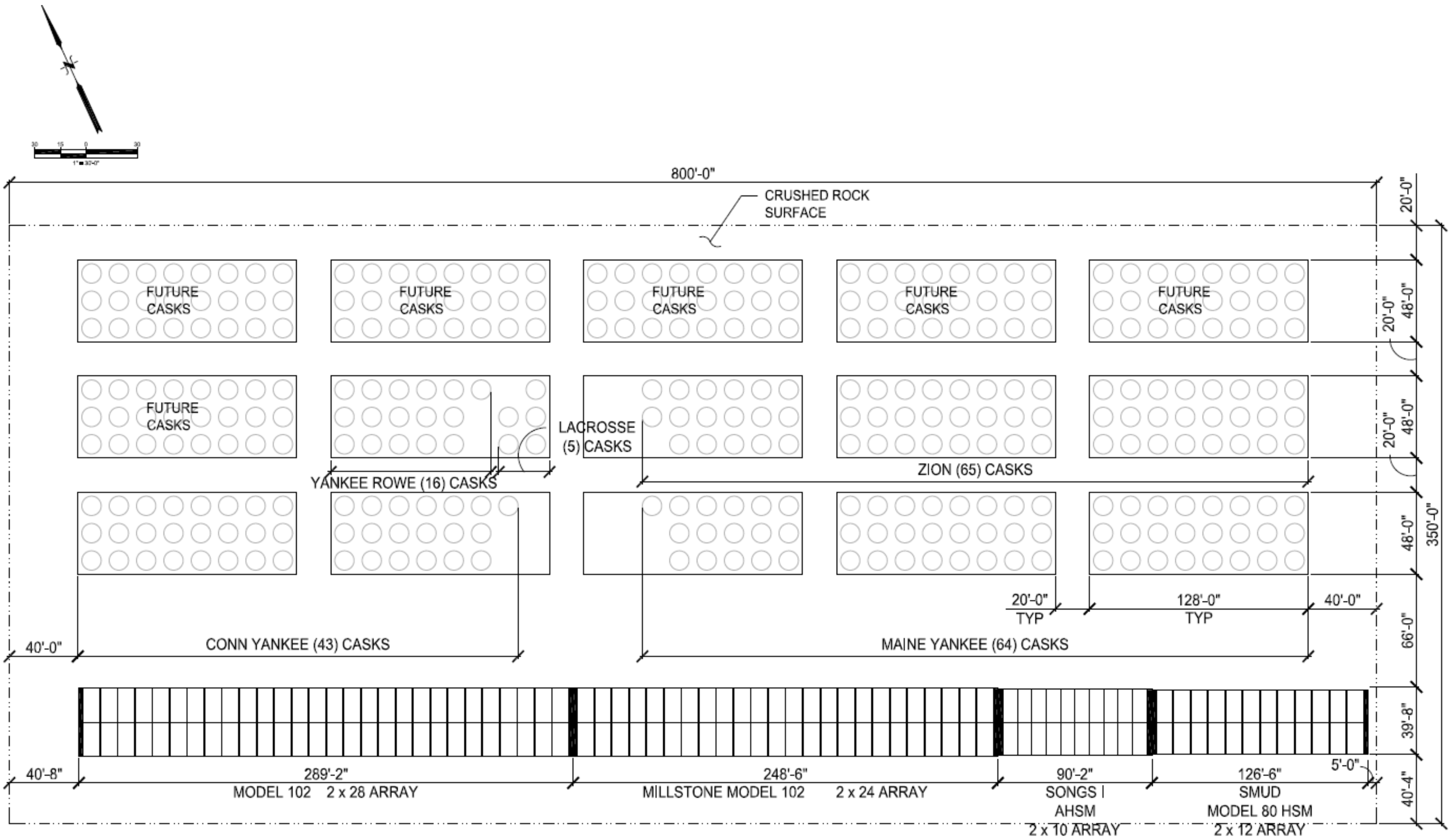
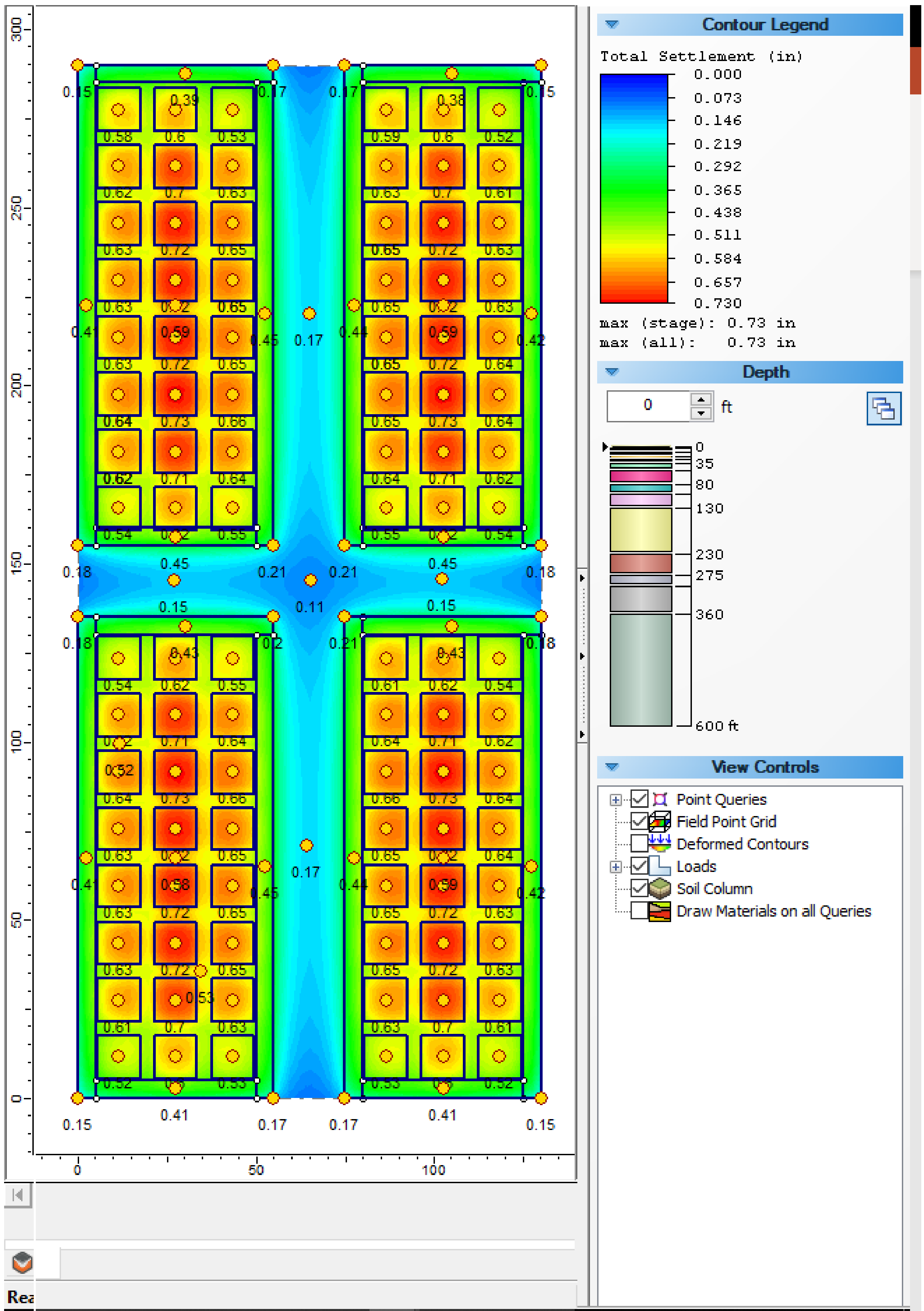


Figure 1-6

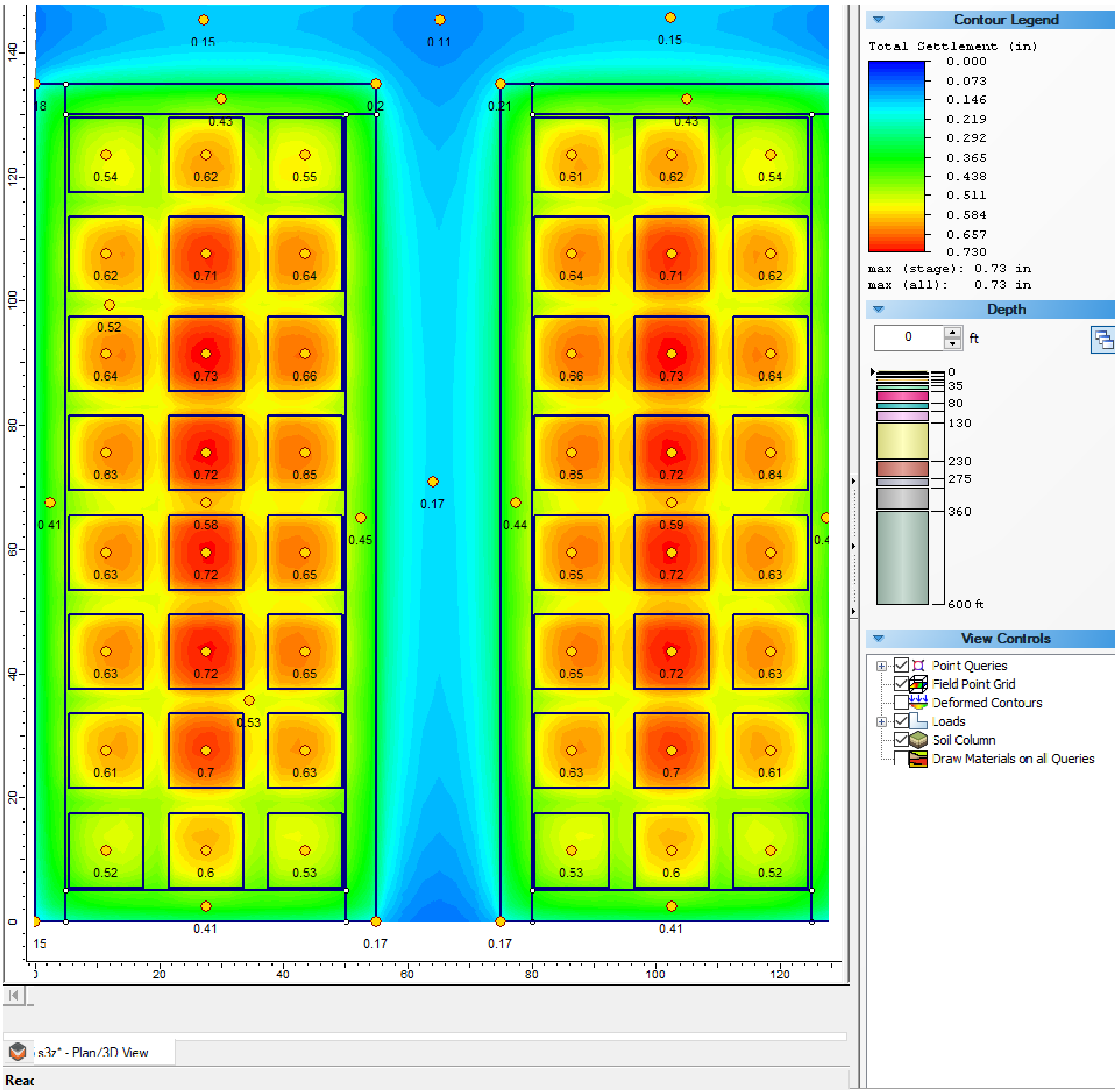
WCS Consolidated Interim Storage Facility System Safety Analysis Report, Revision 2, June 8, 2018.

Total settlement check when four pads are fully loaded simultaneously

CISF Site
Four Storage Pads Analysis
Andrews, TX
15 February 2020



CISF Site
Four Storage Pads Analysis
Andrews, TX
15 February 2020



Stress overlap reduces differential settlement between center and corners of footings.

Settle3 Analysis Information

Project Settings

Document Name	19-017 CISF Storage Pads Four Pad 200215.s3z
Date Created	1/16/2020, 3:00:31 PM
Stress Computation Method	Westergaard
Minimum settlement ratio for subgrade modulus	0.9

Use average properties to calculate layered stresses

Improve consolidation accuracy

Ignore negative effective stresses in settlement calculations

Stage Settings

Stage #	Name
1	Stage 1

Results

Time taken to compute: 0 seconds

Stage: Stage 1

Data Type	Minimum	Maximum
Total Settlement [in]	0	0.726985
Loading Stress ZZ [ksf]	0	4.49

Loads

1. Polygonal Load: "Zone 29"

Label	Zone 29
Load Type	Flexible
Area of Load	7425 ft^2
Load	1.81 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
0	0
55	0
55	135
0	135

2. Polygonal Load: "Zone 26"

Label	Zone 26
Load Type	Flexible
Area of Load	675 ft^2
Load	0.71 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
0	0
5	0
5	135
0	135

3. Polygonal Load: "Zone 27"

Label	Zone 27
Load Type	Flexible
Area of Load	250 ft^2
Load	0.7 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
55	130
55	135
5	135
5	130

4. Polygonal Load: "Zone 28"

Label	Zone 28
Load Type	Flexible
Area of Load	650 ft^2
Load	0.75 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
50	0
55	0
55	130
50	130

5. Polygonal Load: "Zone 25"

Label	Zone 25
Load Type	Flexible
Area of Load	225 ft^2
Load	0.82 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5	0
50	0
50	5
5	5

6. Rectangular Load: "Zone 1"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.51 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	5.5
17.5	5.5
17.5	17.5
5.5	17.5

7. Rectangular Load: "Zone 17"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.51 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	5.5
49.5	5.5
49.5	17.5
37.5	17.5

8. Rectangular Load: "Zone 24"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.51 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	117.5
49.5	117.5
49.5	129.5
37.5	129.5

9. Rectangular Load: "Zone 8"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.51 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	117.5
17.5	117.5
17.5	129.5
5.5	129.5

10. Rectangular Load: "Zone 23"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.09 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	101.5
49.5	101.5
49.5	113.5
37.5	113.5

11. Rectangular Load: "Zone 22"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.16 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	85.5
49.5	85.5
49.5	97.5
37.5	97.5

12. Rectangular Load: "Zone 21"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.1 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	69.5
49.5	69.5
49.5	81.5
37.5	81.5

13. Rectangular Load: "Zone 20"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.1 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	53.5
49.5	53.5
49.5	65.5
37.5	65.5

14. Rectangular Load: "Zone 19"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.16 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	37.5
49.5	37.5
49.5	49.5
37.5	49.5

15. Rectangular Load: "Zone 18"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.09 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	21.5
49.5	21.5
49.5	33.5
37.5	33.5

16. Rectangular Load: "Zone 16"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.04 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	117.5
33.5	117.5
33.5	129.5
21.5	129.5

17. Rectangular Load: "Zone 7"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.09 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	101.5
17.5	101.5
17.5	113.5
5.5	113.5

18. Rectangular Load: "Zone 6"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.16 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	85.5
17.5	85.5
17.5	97.5
5.5	97.5

19. Rectangular Load: "Zone 5"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.1 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	69.5
17.5	69.5
17.5	81.5
5.5	81.5

20. Rectangular Load: "Zone 4"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.1 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	53.5
17.5	53.5
17.5	65.5
5.5	65.5

21. Rectangular Load: "Zone 3"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.16 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	37.5
17.5	37.5
17.5	49.5
5.5	49.5

22. Rectangular Load: "Zone 2"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.09 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	21.5
17.5	21.5
17.5	33.5
5.5	33.5

23. Rectangular Load: "Zone 9"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.04 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	5.5
33.5	5.5
33.5	17.5
21.5	17.5

24. Rectangular Load: "Zone 10"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.58 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	21.5
33.5	21.5
33.5	33.5
21.5	33.5

25. Rectangular Load: "Zone 11"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.68 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	37.5
33.5	37.5
33.5	49.5
21.5	49.5

26. Rectangular Load: "Zone 12"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.63 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	53.5
33.5	53.5
33.5	65.5
21.5	65.5

27. Rectangular Load: "Zone 13"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.63 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	69.5
33.5	69.5
33.5	81.5
21.5	81.5

28. Rectangular Load: "Zone 14"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.68 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	85.5
33.5	85.5
33.5	97.5
21.5	97.5

29. Rectangular Load: "Zone 15"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.57 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	101.5
33.5	101.5
33.5	113.5
21.5	113.5

30. Polygonal Load: "Zone 26"

Label	Zone 26
Load Type	Flexible
Area of Load	675 ft^2
Load	0.71 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
75	0
80	0
80	135
75	135

31. Polygonal Load: "Zone 27"

Label	Zone 27
Load Type	Flexible
Area of Load	250 ft^2
Load	0.7 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
130	130
130	135
80	135
80	130

32. Polygonal Load: "Zone 28"

Label	Zone 28
Load Type	Flexible
Area of Load	650 ft^2
Load	0.75 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
125	0
130	0
130	130
125	130

33. Polygonal Load: "Zone 25"

Label	Zone 25
Load Type	Flexible
Area of Load	225 ft^2
Load	0.82 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
80	0
125	0
125	5
80	5

34. Polygonal Load: "Zone 29"

Label	Zone 29
Load Type	Flexible
Area of Load	7425 ft^2
Load	1.81 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
75	0
130	0
130	135
75	135

35. Polygonal Load: "Zone 29"

Label	Zone 29
Load Type	Flexible
Area of Load	7425 ft^2
Load	1.81 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
0	155
55	155
55	290
0	290

36. Polygonal Load: "Zone 29"

Label	Zone 29
Load Type	Flexible
Area of Load	7425 ft^2
Load	1.81 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
75	155
130	155
130	290
75	290

37. Polygonal Load: "Zone 26"

Label	Zone 26
Load Type	Flexible
Area of Load	675 ft^2
Load	0.71 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
75	155
80	155
80	290
75	290

38. Polygonal Load: "Zone 26"

Label	Zone 26
Load Type	Flexible
Area of Load	675 ft^2
Load	0.71 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
0	155
5	155
5	290
0	290

39. Polygonal Load: "Zone 28"

Label	Zone 28
Load Type	Flexible
Area of Load	650 ft^2
Load	0.75 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
125	155
130	155
130	285
125	285

40. Polygonal Load: "Zone 27"

Label	Zone 27
Load Type	Flexible
Area of Load	250 ft^2
Load	0.7 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
130	285
130	290
80	290
80	285

41. Polygonal Load: "Zone 27"

Label	Zone 27
Load Type	Flexible
Area of Load	250 ft^2
Load	0.7 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
55	285
55	290
5	290
5	285

42. Polygonal Load: "Zone 28"

Label	Zone 28
Load Type	Flexible
Area of Load	650 ft^2
Load	0.75 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
50	155
55	155
55	285
50	285

43. Polygonal Load: "Zone 25"

Label	Zone 25
Load Type	Flexible
Area of Load	225 ft^2
Load	0.82 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
80	155
125	155
125	160
80	160

44. Polygonal Load: "Zone 25"

Label	Zone 25
Load Type	Flexible
Area of Load	225 ft^2
Load	0.82 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5	155
50	155
50	160
5	160

45. Rectangular Load: "Zone 1"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.51 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
80.5	5.5
92.5	5.5
92.5	17.5
80.5	17.5

46. Rectangular Load: "Zone 1"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.51 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
80.5	159.5
92.5	159.5
92.5	171.5
80.5	171.5

47. Rectangular Load: "Zone 1"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.51 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	159.5
17.5	159.5
17.5	171.5
5.5	171.5

48. Rectangular Load: "Zone 2"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.09 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
80.5	21.5
92.5	21.5
92.5	33.5
80.5	33.5

49. Rectangular Load: "Zone 2"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.09 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
80.5	175.5
92.5	175.5
92.5	187.5
80.5	187.5

50. Rectangular Load: "Zone 2"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.09 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	175.5
17.5	175.5
17.5	187.5
5.5	187.5

51. Rectangular Load: "Zone 3"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.16 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	191.5
17.5	191.5
17.5	203.5
5.5	203.5

52. Rectangular Load: "Zone 3"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.16 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
80.5	191.5
92.5	191.5
92.5	203.5
80.5	203.5

53. Rectangular Load: "Zone 3"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.16 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
80.5	37.5
92.5	37.5
92.5	49.5
80.5	49.5

54. Rectangular Load: "Zone 4"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.1 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	207.5
17.5	207.5
17.5	219.5
5.5	219.5

55. Rectangular Load: "Zone 4"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.1 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
80.5	207.5
92.5	207.5
92.5	219.5
80.5	219.5

56. Rectangular Load: "Zone 4"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.1 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
80.5	53.5
92.5	53.5
92.5	65.5
80.5	65.5

57. Rectangular Load: "Zone 5"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.1 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	223.5
17.5	223.5
17.5	235.5
5.5	235.5

58. Rectangular Load: "Zone 5"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.1 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
80.5	223.5
92.5	223.5
92.5	235.5
80.5	235.5

59. Rectangular Load: "Zone 6"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.16 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	239.5
17.5	239.5
17.5	251.5
5.5	251.5

60. Rectangular Load: "Zone 6"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.16 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
80.5	239.5
92.5	239.5
92.5	251.5
80.5	251.5

61. Rectangular Load: "Zone 7"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.09 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	255.5
17.5	255.5
17.5	267.5
5.5	267.5

62. Rectangular Load: "Zone 7"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.09 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
80.5	255.5
92.5	255.5
92.5	267.5
80.5	267.5

63. Rectangular Load: "Zone 7"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.09 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	271.5
17.5	271.5
17.5	283.5
5.5	283.5

64. Rectangular Load: "Zone 7"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.09 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
80.5	271.5
92.5	271.5
92.5	283.5
80.5	283.5

65. Rectangular Load: "Zone 9"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.04 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
96.5	5.5
108.5	5.5
108.5	17.5
96.5	17.5

66. Rectangular Load: "Zone 5"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.1 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
80.5	69.5
92.5	69.5
92.5	81.5
80.5	81.5

67. Rectangular Load: "Zone 6"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.16 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
80.5	85.5
92.5	85.5
92.5	97.5
80.5	97.5

68. Rectangular Load: "Zone 7"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.09 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
80.5	101.5
92.5	101.5
92.5	113.5
80.5	113.5

69. Rectangular Load: "Zone 7"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.09 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
80.5	117.5
92.5	117.5
92.5	129.5
80.5	129.5

70. Rectangular Load: "Zone 10"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.58 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
96.5	21.5
108.5	21.5
108.5	33.5
96.5	33.5

71. Rectangular Load: "Zone 10"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.58 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
96.5	175.5
108.5	175.5
108.5	187.5
96.5	187.5

72. Rectangular Load: "Zone 10"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.58 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	175.5
33.5	175.5
33.5	187.5
21.5	187.5

73. Rectangular Load: "Zone 9"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.04 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	159.5
33.5	159.5
33.5	171.5
21.5	171.5

74. Rectangular Load: "Zone 9"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.04 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
96.5	159.5
108.5	159.5
108.5	171.5
96.5	171.5

75. Rectangular Load: "Zone 11"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.68 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	191.5
33.5	191.5
33.5	203.5
21.5	203.5

76. Rectangular Load: "Zone 11"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.68 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
96.5	191.5
108.5	191.5
108.5	203.5
96.5	203.5

77. Rectangular Load: "Zone 11"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.68 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
96.5	37.5
108.5	37.5
108.5	49.5
96.5	49.5

78. Rectangular Load: "Zone 12"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.63 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
96.5	53.5
108.5	53.5
108.5	65.5
96.5	65.5

79. Rectangular Load: "Zone 12"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.63 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
96.5	207.5
108.5	207.5
108.5	219.5
96.5	219.5

80. Rectangular Load: "Zone 12"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.63 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	207.5
33.5	207.5
33.5	219.5
21.5	219.5

81. Rectangular Load: "Zone 13"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.63 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
96.5	69.5
108.5	69.5
108.5	81.5
96.5	81.5

82. Rectangular Load: "Zone 13"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.63 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
96.5	223.5
108.5	223.5
108.5	235.5
96.5	235.5

83. Rectangular Load: "Zone 13"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.63 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	223.5
33.5	223.5
33.5	235.5
21.5	235.5

84. Rectangular Load: "Zone 14"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.68 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
96.5	85.5
108.5	85.5
108.5	97.5
96.5	97.5

85. Rectangular Load: "Zone 14"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.68 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
96.5	239.5
108.5	239.5
108.5	251.5
96.5	251.5

86. Rectangular Load: "Zone 14"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.68 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	239.5
33.5	239.5
33.5	251.5
21.5	251.5

87. Rectangular Load: "Zone 15"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.57 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	255.5
33.5	255.5
33.5	267.5
21.5	267.5

88. Rectangular Load: "Zone 15"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.57 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
96.5	255.5
108.5	255.5
108.5	267.5
96.5	267.5

89. Rectangular Load: "Zone 15"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.57 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
96.5	101.5
108.5	101.5
108.5	113.5
96.5	113.5

90. Rectangular Load: "Zone 16"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.04 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	271.5
33.5	271.5
33.5	283.5
21.5	283.5

91. Rectangular Load: "Zone 16"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.04 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
96.5	271.5
108.5	271.5
108.5	283.5
96.5	283.5

92. Rectangular Load: "Zone 24"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.51 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	271.5
49.5	271.5
49.5	283.5
37.5	283.5

93. Rectangular Load: "Zone 24"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.51 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
112.5	271.5
124.5	271.5
124.5	283.5
112.5	283.5

94. Rectangular Load: "Zone 24"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.51 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
112.5	117.5
124.5	117.5
124.5	129.5
112.5	129.5

95. Rectangular Load: "Zone 16"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.04 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
96.5	117.5
108.5	117.5
108.5	129.5
96.5	129.5

96. Rectangular Load: "Zone 23"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.09 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
112.5	101.5
124.5	101.5
124.5	113.5
112.5	113.5

97. Rectangular Load: "Zone 23"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.09 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
112.5	255.5
124.5	255.5
124.5	267.5
112.5	267.5

98. Rectangular Load: "Zone 23"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.09 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	255.5
49.5	255.5
49.5	267.5
37.5	267.5

99. Rectangular Load: "Zone 22"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.16 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
112.5	85.5
124.5	85.5
124.5	97.5
112.5	97.5

100. Rectangular Load: "Zone 22"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.16 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
112.5	239.5
124.5	239.5
124.5	251.5
112.5	251.5

101. Rectangular Load: "Zone 22"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.16 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	239.5
49.5	239.5
49.5	251.5
37.5	251.5

102. Rectangular Load: "Zone 21"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.1 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
112.5	69.5
124.5	69.5
124.5	81.5
112.5	81.5

103. Rectangular Load: "Zone 21"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.1 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
112.5	223.5
124.5	223.5
124.5	235.5
112.5	235.5

104. Rectangular Load: "Zone 21"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.1 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	223.5
49.5	223.5
49.5	235.5
37.5	235.5

105. Rectangular Load: "Zone 20"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.1 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
112.5	53.5
124.5	53.5
124.5	65.5
112.5	65.5

106. Rectangular Load: "Zone 20"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.1 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
112.5	207.5
124.5	207.5
124.5	219.5
112.5	219.5

107. Rectangular Load: "Zone 20"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.1 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	207.5
49.5	207.5
49.5	219.5
37.5	219.5

108. Rectangular Load: "Zone 19"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.16 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
112.5	37.5
124.5	37.5
124.5	49.5
112.5	49.5

109. Rectangular Load: "Zone 19"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.16 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
112.5	191.5
124.5	191.5
124.5	203.5
112.5	203.5

110. Rectangular Load: "Zone 19"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.16 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	191.5
49.5	191.5
49.5	203.5
37.5	203.5

111. Rectangular Load: "Zone 18"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.09 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	175.5
49.5	175.5
49.5	187.5
37.5	187.5

112. Rectangular Load: "Zone 18"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.09 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
112.5	175.5
124.5	175.5
124.5	187.5
112.5	187.5

113. Rectangular Load: "Zone 17"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.51 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	159.5
49.5	159.5
49.5	171.5
37.5	171.5

114. Rectangular Load: "Zone 17"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.51 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
112.5	159.5
124.5	159.5
124.5	171.5
112.5	171.5

115. Rectangular Load: "Zone 17"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	1.51 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
112.5	5.5
124.5	5.5
124.5	17.5
112.5	17.5

116. Rectangular Load: "Zone 18"

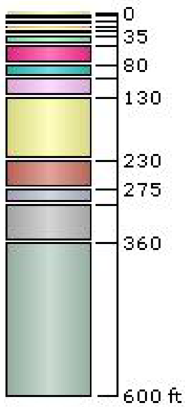
Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.09 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
112.5	21.5
124.5	21.5
124.5	33.5
112.5	33.5

Soil Layers

Layer #	Type	Thickness [ft]	Depth [ft]
1	Cover Sands	2	0
2	Caliche/Sand 1	8	2
3	Caliche/Sand 2	10	10
4	Caliche Hard 1	5	20
5	Caliche Hard 2	10	25
6	Ogallala 1	15	35
7	Ogallala 2	30	50
8	Ogallala 3	20	80
9	Dockum Claystone/Siltsone	30	100
10	Claystone and Siltstone	100	130
11	Dockum Clay/Claystone 1	45	230
12	Dockum Silty/Sands	25	275
13	Dockum Clay/Claystone 2	60	300
14	Dockum Clay/Claystone 3	240	360



Soil Properties

Property	Cover Sands	Caliche/Sand 1	Caliche/Sand 2	Caliche Hard 1
Color				
Unit Weight [kips/ft^3]	0.12	0.12	0.12	0.12
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Enabled
Es [ksf]	890	1200	1200	35815
Esur [ksf]	890	1200	1200	35815
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8

Property	Caliche Hard 2	Ogallala 1	Ogallala 2	Ogallala 3
Color				
Unit Weight [kips/ft^3]	0.12	0.12	0.13	0.13
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Enabled
Es [ksf]	55232	80233	53870	123857
Esur [ksf]	55232	80233	53870	123857
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8

Property	Dockum Claystone/ Siltsone	Claystone and Siltstone	Dockum Clay/ Claystone 1	Dockum Silty/ Sands
Color				
Unit Weight [kips/ft^3]	0.13	0.13	0.13	0.13
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Enabled
Es [ksf]	84172	120769	120769	120769
Esur [ksf]	84172	120769	120769	120769
Undrained Su A [kips/ ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8

Property	Dockum Clay/Claystone 2	Dockum Clay/Claystone 3
Color		
Unit Weight [kips/ft^3]	0.13	0.13
K0	1	1
Immediate Settlement	Enabled	Enabled
Es [ksf]	120769	154394
Esur [ksf]	120769	154394
Undrained Su A [kips/ft2]	0	0
Undrained Su S	0.2	0.2
Undrained Su m	0.8	0.8

Query Points

Point #	Query Point Name	(X,Y) Location	Number of Divisions
1	Cask Point 1	11.5, 11.5	Auto: 101
2	Cask Point 2	11.5, 27.5	Auto: 101
3	Cask Point 3	11.5, 43.5	Auto: 101
4	Cask Point 4	11.5, 59.5	Auto: 101
5	Cask Point 5	11.5, 75.5	Auto: 101
6	Cask Point 6	11.5, 91.5	Auto: 101
7	Cask Point 7	11.5, 107.5	Auto: 101
8	Cask Point 8	11.5, 123.5	Auto: 101
9	Cask Point 9	27.5, 11.5	Auto: 101
10	Cask Point 10	27.5, 27.5	Auto: 101
11	Cask Point 11	27.5, 43.5	Auto: 101
12	Cask Point 12	27.5, 59.5	Auto: 101
13	Cask Point 13	27.5, 75.5	Auto: 101
14	Cask Point 14	27.5, 91.5	Auto: 101
15	Cask Point 15	27.5, 107.5	Auto: 101
16	Cask Point 16	27.5, 123.5	Auto: 101
17	Cask Point 17	43.5, 11.5	Auto: 101
18	Cask Point 18	43.5, 27.5	Auto: 101
19	Cask Point 19	43.5, 43.5	Auto: 101
20	Cask Point 20	43.5, 59.5	Auto: 101
21	Cask Point 21	43.5, 75.5	Auto: 101
22	Cask Point 22	43.5, 91.5	Auto: 101
23	Cask Point 23	43.5, 107.5	Auto: 101
24	Cask Point 24	43.5, 123.5	Auto: 101
25	Pad 1 Bottom Left	0, 0	Auto: 101
26	Pad 1 Bottom Right	55, 0	Auto: 101
27	Pad 1 Top Left	0, 135	Auto: 101
28	Pad 1 Top Right	55, 135	Auto: 101
29	Pad 1 Center	27.5, 67.5	Auto: 101
30	Query Point 30	11.973, 99.283	Auto: 101
31	Pad 1 Top Edge	30, 132.5	Auto: 101
32	Pad 1 Right Edge	52.5, 65	Auto: 101
33	Query Point 33	34.543, 35.669	Auto: 101
34	Pad 1 Bottom Edge	27.5, 2.5	Auto: 101
35	Pad 2 Cask 1	11.5, 165.5	Auto: 101
36	Query Point 36	11.5, 181.5	Auto: 101
37	Query Point 37	11.5, 197.5	Auto: 101
38	Pad 2 Cask 4	11.5, 213.5	Auto: 101
39	Pad 2 Cask 5	11.5, 229.5	Auto: 101
40	Pad 2 Cask 6	11.5, 245.5	Auto: 101
41	Pad 2 Cask 7	11.5, 261.5	Auto: 101
42	Pad 2 Cask 8	11.5, 277.5	Auto: 101
43	Pad 2 Cask 9	27.5, 165.5	Auto: 101
44	Pad 2 Cask 10	27.5, 181.5	Auto: 101
45	Pad 2 Cask 11	27.5, 197.5	Auto: 101
46	Pad 2 Cask 12	27.5, 213.5	Auto: 101
47	Pad 2 Cask 13	27.5, 229.5	Auto: 101
48	Pad 2 Cask 14	27.5, 245.5	Auto: 101
49	Pad 2 Cask 15	27.5, 261.5	Auto: 101
50	Pad 2 Cask 16	27.5, 277.5	Auto: 101
51	Pad 2 Cask 17	43.5, 165.5	Auto: 101
52	Pad 2 Cask 18	43.5, 181.5	Auto: 101
53	Pad 2 Cask 19	43.5, 197.5	Auto: 101
54	Pad 2 Cask 20	43.5, 213.5	Auto: 101
55	Query Point 55	43.5, 229.5	Auto: 101
56	Pad 2 Cask 21	43.5, 229.5	Auto: 101
57	Pad 2 Cask 22	43.5, 245.5	Auto: 101

58	Pad 2 Cask 23	43.5, 261.5	Auto: 101
59	Pad 2 Cask 24	43.5, 277.5	Auto: 101
60	Pad 4 Cask 1	86.5, 11.5	Auto: 101
61	Query Point 61	11.5, 181.5	Auto: 101
62	Pad 2 Cask 3	11.5, 197.5	Auto: 101
63	Pad 2 Cask 2	11.5, 181.5	Auto: 101
64	Pad 4 Cask 2	86.5, 27.5	Auto: 101
65	Pad 4 Cask 3	86.5, 43.5	Auto: 101
66	Pad 4 Cask 4	86.5, 59.5	Auto: 101
67	Pad 4 Cask 6	86.5, 91.5	Auto: 101
68	Pad 4 Cask 5	86.5, 75.5	Auto: 101
69	Pad 4 Cask 7	86.5, 107.5	Auto: 101
70	Pad 4 Cask 8	86.5, 123.5	Auto: 101
71	Pad 4 Cask 9	102.5, 11.5	Auto: 101
72	Pad 4 Cask 10	102.5, 27.5	Auto: 101
73	Pad 4 Cask 11	102.5, 43.5	Auto: 101
74	Pad 4 Cask 12	102.5, 59.5	Auto: 101
75	Pad 4 Cask 13	102.5, 75.5	Auto: 101
76	Pad 4 Cask 14	102.5, 91.5	Auto: 101
77	Pad 4 Cask 15	102.5, 107.5	Auto: 101
78	Pad 4 Cask 16	102.5, 123.5	Auto: 101
79	Pad 4 Cask 17	118.5, 11.5	Auto: 101
80	Pad 4 Cask 18	118.5, 27.5	Auto: 101
81	Pad 4 Cask 20	118.5, 59.5	Auto: 101
82	Pad 4 Cask 19	118.5, 43.5	Auto: 101
83	Pad 4 Cask 21	118.5, 75.5	Auto: 101
84	Pad 4 Cask 22	118.5, 91.5	Auto: 101
85	Pad 4 Cask 23	118.5, 107.5	Auto: 101
86	Pad 4 Cask 24	118.5, 123.5	Auto: 101
87	Pad 3 Cask 1	86.5, 165.5	Auto: 101
88	Pad 3 Cask 2	86.5, 181.5	Auto: 101
89	Pad 3 Cask 3	86.5, 197.5	Auto: 101
90	Query Point 90	86.5, 213.5	Auto: 101
91	Pad 3 Cask 4	86.5, 213.5	Auto: 101
92	Query Point 92	86.5, 245.5	Auto: 101
93	Pad 3 Cask 6	86.5, 245.5	Auto: 101
94	Pad 3 Cask 5	86.5, 229.5	Auto: 101
95	Pad 3 Cask 7	86.5, 261.5	Auto: 101
96	Pad 3 Cask 8	86.5, 277.5	Auto: 101
97	Pad 3 Cask 9	102.5, 165.5	Auto: 101
98	Pad 3 Cask 11	102.5, 197.5	Auto: 101
99	Pad 3 Cask 10	102.5, 181.5	Auto: 101
100	Pad 3 Cask 12	102.5, 213.5	Auto: 101
101	Pad 3 Cask 13	102.5, 229.5	Auto: 101
102	Pad 3 Cask 14	102.5, 245.5	Auto: 101
103	Pad 3 Cask 15	102.5, 261.5	Auto: 101
104	Pad 3 Cask 16	102.5, 277.5	Auto: 101
105	Pad 3 Cask 17	118.5, 165.5	Auto: 101
106	Pad 3 Cask 18	118.5, 181.5	Auto: 101
107	Pad 3 Cask 19	118.5, 197.5	Auto: 101
108	Pad 3 Cask 20	118.5, 213.5	Auto: 101
109	Pad 3 Cask 21	118.5, 229.5	Auto: 101
110	Pad 3 Cask 22	118.5, 245.5	Auto: 101
111	Pad 3 Cask 23	118.5, 261.5	Auto: 101
112	Pad 3 Cask 24	118.5, 277.5	Auto: 101
113	Pad 1 Left edge	2.5, 67.5	Auto: 101
114	Query Point 114	27.5, 157.5	Auto: 101
115	Query Point 115	2.5, 222.5	Auto: 101
116	Query Point 116	52.5, 220	Auto: 101
117	Query Point 117	30, 287.5	Auto: 101
118	Query Point 118	105, 287.5	Auto: 101

119	Query Point 119	127.5, 220	Auto: 101
120	Query Point 120	77.5, 222.5	Auto: 101
121	Query Point 121	102.5, 157.5	Auto: 101
122	Query Point 122	105, 132.5	Auto: 101
123	Query Point 123	102.5, 2.5	Auto: 101
124	Query Point 124	77.5, 67.5	Auto: 101
125	Query Point 125	127.5, 65	Auto: 101
126	Query Point 126	130, 135	Auto: 101
127	Pad 4 Top Left	75, 135	Auto: 101
128	Pad 3 Bottom Left	75, 155	Auto: 101
129	Pad 3 Bottom Right	130, 155	Auto: 101
130	Pad 3 Top Left	75, 290	Auto: 101
131	Pad 3 Top Right	130, 290	Auto: 101
132	Pad 2 Top Left	0, 290	Auto: 101
133	Pad 2 Top Right	55, 290	Auto: 101
134	Pad 2 Bottom Left	0, 155	Auto: 101
135	Pad 2 Bottom Right	55, 155	Auto: 101
136	Pad 4 Bottom Left	75, 0	Auto: 101
137	Pad 4 Bottom Right	130, 0	Auto: 101
138	Pad 4 Top Right	130, 135	Auto: 101
139	Center of Pads	65.278, 145.171	Auto: 89
140	Between Pad 1 and Pad 2	27.143, 145.171	Auto: 89
141	Between Pad 3 and Pad 4	102.269, 145.552	Auto: 89
142	Between Pad 1 and Pad 4	64.134, 70.808	Auto: 89
143	Between Pad 2 and Pad 3	64.897, 220.297	Auto: 89
144	Pad 2 Center	27.5, 222.5	Auto: 101
145	Pad 3 Center	102.5, 222.5	Auto: 101
146	Pad 4 Center	102.5, 67.5	Auto: 101

Field Point Grid

Number of points 7876
Expansion Factor 1

Grid Coordinates

X [ft]	Y [ft]
197.5	357.5
197.5	-67.5
-67.5	-67.5
-67.5	357.5

DAN BROWN AND ASSOCIATES

Cask Handling Building Settle3 Analysis, Inputs and Results

Cask Handling Building: Two-bay Category B steel struction measuring approximately 175feet by 193 feet in plan dimension with a height of 72 feet.

SERVICE LEVEL MAXIMUM BEARING PRESSURES

Load Combination	Foundations for Main Columns		Foundations for Wind Columns	
	Gross Bearing Pressure (ksf)	Net Bearing Pressure (ksf)	Bearing Pressure (ksf)	Net Bearing Pressure (ksf)
Dead 1.0D	1.79	0.66	1.67	0.55
Operating Wind 1.0D + 0.6W	2.59	1.47	1.85	0.73
Seismic 1.0D + 0.7E	3.34	2.21	1.86	0.74

LIMIT STATE MAXIMUM BEARING PRESSURES

Load Combination	Foundations for Main Columns		Foundations for Wind Columns	
	Gross Bearing Pressure (ksf)	Net Bearing Pressure (ksf)	Bearing Pressure (ksf)	Net Bearing Pressure (ksf)
Tornado 1.2D + 1.0W_t	4.67	2.51	5.44	4.32
Seismic 1.2D + 1.0E	4.21	3.09	2.23	1.11

Use Soil Column from Pad Analysis with bottom of footing 10ft below GS.

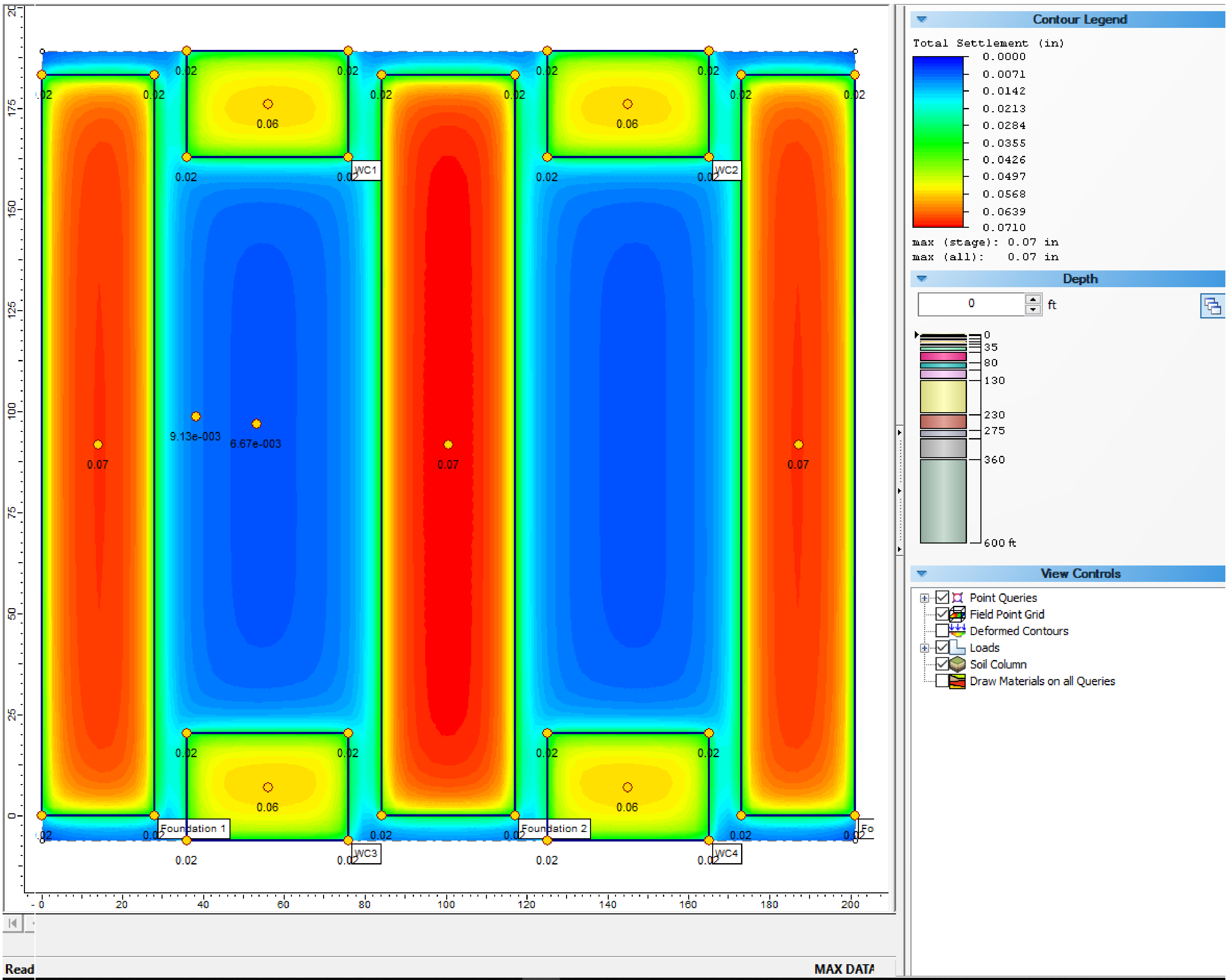
Soil Column Based on Average Shear Wave Velocity Measurements

- Interpreted from all explorations and collaboration between GEOS and DBA.
- Top 100ft contains 7 stratum in 5 materials identified by GEOS
- 100ft-600ft (approx. location of incompressible layers with sharp contrast of velocity) contains 3 average velocity values for 6 layers identified in the soil column provided by GEOS

Top (ft)	Bottom (ft)	Avg. Layer Shear Wave Velocity (ft/s)	Layer Material (From GEOS column)	Model Layer Name
20	25	1530	Caliche - Very Hard	Caliche Hard 1
25	35	1900	Caliche - Very Hard	Caliche Hard 2
35	50	2290	Ogallala - Sand with Gravel	Ogallala 1
50	80	1840	Ogallala - Sand with Gravel	Ogallala 2
80	100	2790	Ogallala - Sand with Gravel	Ogallala 3
100	130	2300	Dockum - Claystone and Siltstone	Dockum Claystone/Siltstone
130	230	2755	Claystone and Siltstone	Claystone and Siltstone
230	275	2755	Dockum - Clay/Claystone	Dockum Clay/Claystone1
275	300	2755	Dockum - Silty Sands	Dockum Silty/Sands
300	360	2755	Dockum - Clay/Claystone	Dockum Clay/Claystone 2
360	600	3115	Dockum - Clay/Claystone	Dockum Clay/Claystone 3

Top (ft)	Bottom (ft)	Avg. Layer Shear Wave Velocity (ft/s)	Unit weight (pcf)	Poisson's Ratio	Gmax (psf)
20	25	1530	125	0.33	9,087,345
25	35	1900	125	0.33	14,013,975
35	50	2290	125	0.33	20,357,531
50	80	1840	130	0.33	13,668,571
80	100	2790	130	0.33	31,426,491
100	130	2300	130	0.33	21,357,143
130	230	2755	130	0.33	30,642,958
230	275	2755	130	0.33	30,642,958
275	300	2755	130	0.33	30,642,958
300	360	2755	130	0.33	30,642,958
360	600	3115	130	0.33	39,174,511

CISF Site
Cask Handling Building
Andrews, TX



Net Bearing for DL Case per AECOM Request (0.660ksf on Foundations 1-3 and 0.550ksf on Wind Column Footings). 0.10" or less reported at foundation centers. Likely outside of the reasonable bounds of the calculation. Recommend considering 0.25" or less

Settle3 Analysis Information

Project Settings

Document Name	19-017 CISF CHB 200214 Net DL Only.s3z
Date Created	1/16/2020, 3:00:31 PM
Stress Computation Method	Westergaard
Minimum settlement ratio for subgrade modulus	0.9

Use average properties to calculate layered stresses

Improve consolidation accuracy

Ignore negative effective stresses in settlement calculations

Stage Settings

Stage #	Name
1	Stage 1

Results

Time taken to compute: 17.0959 seconds

Stage: Stage 1

Data Type	Minimum	Maximum
Total Settlement [in]	0	0.0706837
Loading Stress ZZ [ksf]	0	0.66002

Loads

1. Polygonal Load: "Foundation 1"

Label	Foundation 1
Load Type	Flexible
Area of Load	5126.8 ft^2
Load	0.66 ksf
Depth	10 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
0	0
28	0
28	183.1
0	183.1

2. Polygonal Load: "Foundation 2"

Label	Foundation 2
Load Type	Flexible
Area of Load	6042.3 ft^2
Load	0.66 ksf
Depth	10 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
84	0
117	0
117	183.1
84	183.1

3. Polygonal Load: "Foundation 3"

Label	Foundation 3
Load Type	Flexible
Area of Load	5126.8 ft^2
Load	0.66 ksf
Depth	10 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
173.1	0
201.1	0
201.1	183.1
173.1	183.1

4. Polygonal Load: "WC3"

Label	WC3
Load Type	Flexible
Area of Load	1064 ft^2
Load	0.55 ksf
Depth	10 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
76	-6.3
76	20.3
36	20.3
36	-6.3

5. Polygonal Load: "WC1"

Label	WC1
Load Type	Flexible
Area of Load	1052 ft^2
Load	0.55 ksf
Depth	10 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
76	162.8
76	189.1
36	189.1
36	162.8

6. Polygonal Load: "WC4"

Label	WC4
Load Type	Flexible
Area of Load	1064 ft^2
Load	0.55 ksf
Depth	10 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
165	-6.3
165	20.3
125	20.3
125	-6.3

7. Polygonal Load: "WC2"

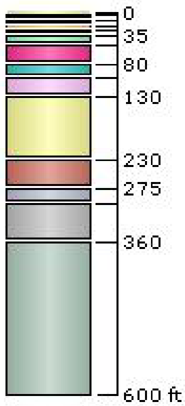
Label	WC2
Load Type	Flexible
Area of Load	1052 ft^2
Load	0.55 ksf
Depth	10 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
165	162.8
165	189.1
125	189.1
125	162.8

Soil Layers

Layer #	Type	Thickness [ft]	Depth [ft]
1	Cover Sands	2	0
2	Caliche/Sand 1	8	2
3	Caliche/Sand 2	10	10
4	Caliche Hard 1	5	20
5	Caliche Hard 2	10	25
6	Ogallala 1	15	35
7	Ogallala 2	30	50
8	Ogallala 3	20	80
9	Dockum Claystone/Siltsone	30	100
10	Claystone and Siltstone	100	130
11	Dockum Clay/Claystone 1	45	230
12	Dockum Silty/Sands	25	275
13	Dockum Clay/Claystone 2	60	300
14	Dockum Clay/Claystone 3	240	360



Soil Properties

Property	Cover Sands	Caliche/Sand 1	Caliche/Sand 2	Caliche Hard 1
Color				
Unit Weight [kips/ft^3]	0.12	0.12	0.12	0.12
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Enabled
Es [ksf]	890	1200	1200	35815
Esur [ksf]	890	1200	1200	35815
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8

Property	Caliche Hard 2	Ogallala 1	Ogallala 2	Ogallala 3
Color				
Unit Weight [kips/ft^3]	0.12	0.12	0.13	0.13
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Enabled
Es [ksf]	55232	80233	53870	123857
Esur [ksf]	55232	80233	53870	123857
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8

Property	Dockum Claystone/ Siltsone	Claystone and Siltstone	Dockum Clay/Claystone 1	Dockum Silty/ Sands
Color				
Unit Weight [kips/ft^3]	0.13	0.13	0.13	0.13
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Enabled
Es [ksf]	84172	120769	120769	120769
Esur [ksf]	84172	120769	120769	120769
Undrained Su A [kips/ ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8

Property	Dockum Clay/Claystone 2	Dockum Clay/Claystone 3
Color		
Unit Weight [kips/ft^3]	0.13	0.13
K0	1	1
Immediate Settlement	Enabled	Enabled
Es [ksf]	120769	154394
Esur [ksf]	120769	154394
Undrained Su A [kips/ft2]	0	0
Undrained Su S	0.2	0.2
Undrained Su m	0.8	0.8

Query Points

Point #	Query Point Name	(X,Y) Location	Number of Divisions
1	Query Point 1	0, 0	Auto: 101
2	Query Point 2	0, 183.1	Auto: 101
3	Query Point 3	28, 183.1	Auto: 101
4	Query Point 4	28, 0	Auto: 101
5	Query Point 5	14, 91.55	Auto: 101
6	Query Point 6	36, -6.3	Auto: 101
7	Query Point 7	36, 20.3	Auto: 101
8	Query Point 8	76, 20.3	Auto: 101
9	Query Point 9	76, -6.3	Auto: 101
10	Query Point 10	56, 7	Auto: 101
11	Query Point 11	36, 162.8	Auto: 101
12	Query Point 12	36, 189.1	Auto: 101
13	Query Point 13	76, 189.1	Auto: 101
14	Query Point 14	76, 162.8	Auto: 101
15	Query Point 15	56, 175.95	Auto: 101
16	Query Point 16	84, 0	Auto: 101
17	Query Point 17	84, 183.1	Auto: 101
18	Query Point 18	117, 183.1	Auto: 101
19	Query Point 19	117, 0	Auto: 101
20	Query Point 20	100.5, 91.55	Auto: 101
21	Query Point 21	125, -6.3	Auto: 101
22	Query Point 22	125, 20.3	Auto: 101
23	Query Point 23	165, 20.3	Auto: 101
24	Query Point 24	165, -6.3	Auto: 101
25	Query Point 25	145, 7	Auto: 101
26	Query Point 26	125, 162.8	Auto: 101
27	Query Point 27	125, 189.1	Auto: 101
28	Query Point 28	165, 189.1	Auto: 101
29	Query Point 29	165, 162.8	Auto: 101
30	Query Point 30	145, 175.95	Auto: 101
31	Query Point 31	173.1, 0	Auto: 101
32	Query Point 32	173.1, 183.1	Auto: 101
33	Query Point 33	201.1, 183.1	Auto: 101
34	Query Point 34	201.1, 0	Auto: 101
35	Query Point 35	187.1, 91.55	Auto: 101
36	Query Point 36	38.215, 98.684	Auto: 89
37	Query Point 37	53.261, 96.899	Auto: 89

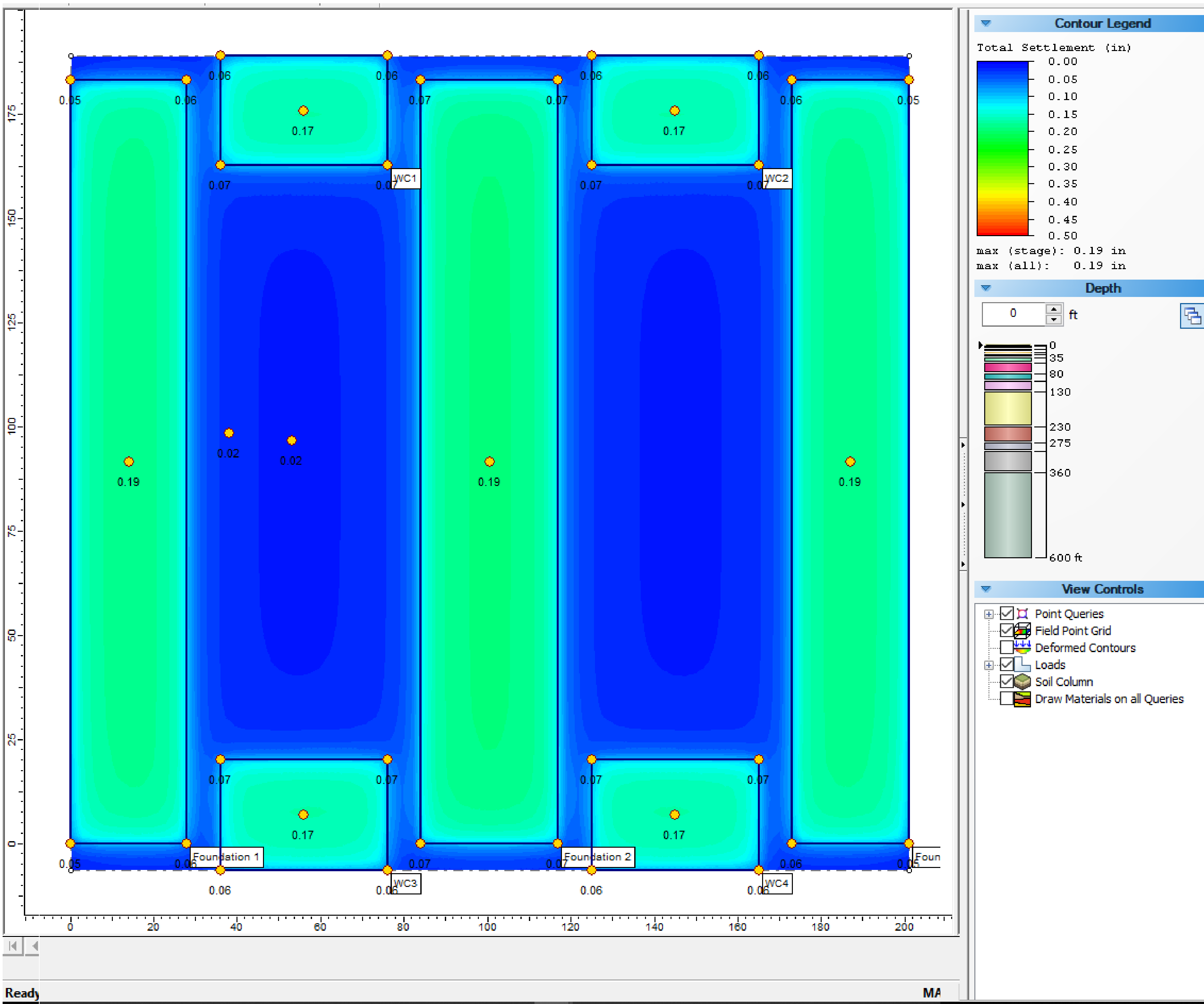
Field Point Grid

Number of points	5512
Expansion Factor	1

Grid Coordinates

X [ft]	Y [ft]
286.65	274.65
286.65	-91.85
-85.55	-91.85
-85.55	274.65

CISF Site
Cask Handling Building
Andrews, TX



Sustained Dead Loading Pressure Only (1.79ksf on Foundations 1-3 and 1.67ksf on Wind Column Footings). 0.25" or less at foundation centers

Settle3 Analysis Information

Project Settings

Document Name	19-017 CISF CHB 200214 DL Only.s3z
Date Created	1/16/2020, 3:00:31 PM
Stress Computation Method	Westergaard
Minimum settlement ratio for subgrade modulus	0.9

Use average properties to calculate layered stresses

Improve consolidation accuracy

Ignore negative effective stresses in settlement calculations

Stage Settings

Stage #	Name
1	Stage 1

Results

Time taken to compute: 0 seconds

Stage: Stage 1

Data Type	Minimum	Maximum
Total Settlement [in]	0	0.375565
Loading Stress ZZ [ksf]	0	3.51092

Loads

1. Polygonal Load: "Foundation 1"

Label	Foundation 1
Load Type	Flexible
Area of Load	5126.8 ft^2
Load	3.5 ksf
Depth	10 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
0	0
28	0
28	183.1
0	183.1

2. Polygonal Load: "Foundation 2"

Label	Foundation 2
Load Type	Flexible
Area of Load	6042.3 ft^2
Load	3.5 ksf
Depth	10 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
84	0
117	0
117	183.1
84	183.1

3. Polygonal Load: "Foundation 3"

Label	Foundation 3
Load Type	Flexible
Area of Load	5126.8 ft^2
Load	3.5 ksf
Depth	10 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
173.1	0
201.1	0
201.1	183.1
173.1	183.1

4. Polygonal Load: "WC3"

Label	WC3
Load Type	Flexible
Area of Load	1064 ft^2
Load	3.5 ksf
Depth	10 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
76	-6.3
76	20.3
36	20.3
36	-6.3

5. Polygonal Load: "WC1"

Label	WC1
Load Type	Flexible
Area of Load	1052 ft^2
Load	3.5 ksf
Depth	10 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
76	162.8
76	189.1
36	189.1
36	162.8

6. Polygonal Load: "WC4"

Label	WC4
Load Type	Flexible
Area of Load	1064 ft^2
Load	3.5 ksf
Depth	10 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
165	-6.3
165	20.3
125	20.3
125	-6.3

7. Polygonal Load: "WC2"

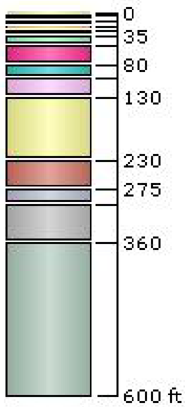
Label	WC2
Load Type	Flexible
Area of Load	1052 ft^2
Load	3.5 ksf
Depth	10 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
165	162.8
165	189.1
125	189.1
125	162.8

Soil Layers

Layer #	Type	Thickness [ft]	Depth [ft]
1	Cover Sands	2	0
2	Caliche/Sand 1	8	2
3	Caliche/Sand 2	10	10
4	Caliche Hard 1	5	20
5	Caliche Hard 2	10	25
6	Ogallala 1	15	35
7	Ogallala 2	30	50
8	Ogallala 3	20	80
9	Dockum Claystone/Siltsone	30	100
10	Claystone and Siltstone	100	130
11	Dockum Clay/Claystone 1	45	230
12	Dockum Silty/Sands	25	275
13	Dockum Clay/Claystone 2	60	300
14	Dockum Clay/Claystone 3	240	360



Soil Properties

Property	Cover Sands	Caliche/Sand 1	Caliche/Sand 2	Caliche Hard 1
Color				
Unit Weight [kips/ft^3]	0.12	0.12	0.12	0.12
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Enabled
Es [ksf]	890	1200	1200	35815
Esur [ksf]	890	1200	1200	35815
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8

Property	Caliche Hard 2	Ogallala 1	Ogallala 2	Ogallala 3
Color				
Unit Weight [kips/ft^3]	0.12	0.12	0.13	0.13
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Enabled
Es [ksf]	55232	80233	53870	123857
Esur [ksf]	55232	80233	53870	123857
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8

Property	Dockum Claystone/ Siltsone	Claystone and Siltstone	Dockum Clay/ Claystone 1	Dockum Silty/ Sands
Color				
Unit Weight [kips/ft^3]	0.13	0.13	0.13	0.13
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Enabled
Es [ksf]	84172	120769	120769	120769
Esur [ksf]	84172	120769	120769	120769
Undrained Su A [kips/ ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8

Property	Dockum Clay/Claystone 2	Dockum Clay/Claystone 3
Color		
Unit Weight [kips/ft^3]	0.13	0.13
K0	1	1
Immediate Settlement	Enabled	Enabled
Es [ksf]	120769	154394
Esur [ksf]	120769	154394
Undrained Su A [kips/ft2]	0	0
Undrained Su S	0.2	0.2
Undrained Su m	0.8	0.8

Query Points

Point #	Query Point Name	(X,Y) Location	Number of Divisions
1	Query Point 1	0, 0	Auto: 101
2	Query Point 2	0, 183.1	Auto: 101
3	Query Point 3	28, 183.1	Auto: 101
4	Query Point 4	28, 0	Auto: 101
5	Query Point 5	14, 91.55	Auto: 101
6	Query Point 6	36, -6.3	Auto: 101
7	Query Point 7	36, 20.3	Auto: 101
8	Query Point 8	76, 20.3	Auto: 101
9	Query Point 9	76, -6.3	Auto: 101
10	Query Point 10	56, 7	Auto: 101
11	Query Point 11	36, 162.8	Auto: 101
12	Query Point 12	36, 189.1	Auto: 101
13	Query Point 13	76, 189.1	Auto: 101
14	Query Point 14	76, 162.8	Auto: 101
15	Query Point 15	56, 175.95	Auto: 101
16	Query Point 16	84, 0	Auto: 101
17	Query Point 17	84, 183.1	Auto: 101
18	Query Point 18	117, 183.1	Auto: 101
19	Query Point 19	117, 0	Auto: 101
20	Query Point 20	100.5, 91.55	Auto: 101
21	Query Point 21	125, -6.3	Auto: 101
22	Query Point 22	125, 20.3	Auto: 101
23	Query Point 23	165, 20.3	Auto: 101
24	Query Point 24	165, -6.3	Auto: 101
25	Query Point 25	145, 7	Auto: 101
26	Query Point 26	125, 162.8	Auto: 101
27	Query Point 27	125, 189.1	Auto: 101
28	Query Point 28	165, 189.1	Auto: 101
29	Query Point 29	165, 162.8	Auto: 101
30	Query Point 30	145, 175.95	Auto: 101
31	Query Point 31	173.1, 0	Auto: 101
32	Query Point 32	173.1, 183.1	Auto: 101
33	Query Point 33	201.1, 183.1	Auto: 101
34	Query Point 34	201.1, 0	Auto: 101
35	Query Point 35	187.1, 91.55	Auto: 101
36	Query Point 36	38.215, 98.684	Auto: 89
37	Query Point 37	53.261, 96.899	Auto: 89

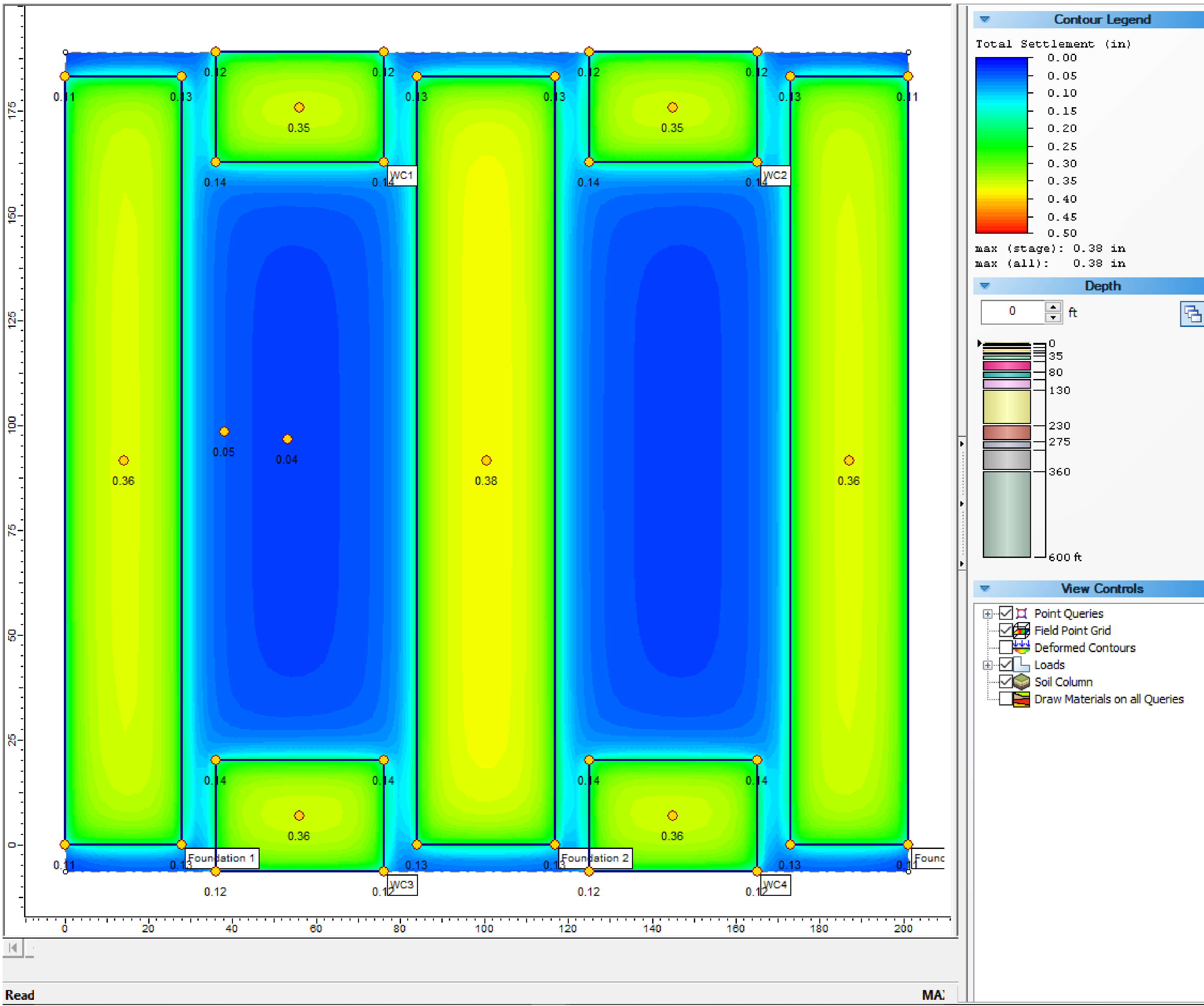
Field Point Grid

Number of points	5512
Expansion Factor	1

Grid Coordinates

X [ft]	Y [ft]
286.65	274.65
286.65	-91.85
-85.55	-91.85
-85.55	274.65

CISF Site
Cask Handling Building
Andrews, TX



Max Pressure 3.5 ksf on all footings. 0.5" or less at foundation centers

Settle3 Analysis Information

Project Settings

Document Name	19-017 CISF CHB 200214.s3z
Date Created	1/16/2020, 3:00:31 PM
Stress Computation Method	Westergaard
Minimum settlement ratio for subgrade modulus	0.9

Use average properties to calculate layered stresses

Improve consolidation accuracy

Ignore negative effective stresses in settlement calculations

Stage Settings

Stage #	Name
1	Stage 1

Results

Time taken to compute: 0 seconds

Stage: Stage 1

Data Type	Minimum	Maximum
Total Settlement [in]	0	0.709451
Loading Stress ZZ [ksf]	0.0346785	4.58

Loads

1. Polygonal Load: "Zone 29"

Label	Zone 29
Load Type	Flexible
Area of Load	7425 ft^2
Load	1.64 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
0	0
55	0
55	135
0	135

2. Polygonal Load: "Zone 26"

Label	Zone 26
Load Type	Flexible
Area of Load	675 ft^2
Load	0.61 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
0	0
5	0
5	135
0	135

3. Polygonal Load: "Zone 27"

Label	Zone 27
Load Type	Flexible
Area of Load	250 ft^2
Load	0.65 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
55	130
55	135
5	135
5	130

4. Polygonal Load: "Zone 28"

Label	Zone 28
Load Type	Flexible
Area of Load	650 ft^2
Load	0.64 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
50	0
55	0
55	130
50	130

5. Polygonal Load: "Zone 25"

Label	Zone 25
Load Type	Flexible
Area of Load	225 ft^2
Load	0.7 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5	0
50	0
50	5
5	5

6. Rectangular Load: "Zone 1"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.01 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	5.5
17.5	5.5
17.5	17.5
5.5	17.5

7. Rectangular Load: "Zone 17"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.01 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	5.5
49.5	5.5
49.5	17.5
37.5	17.5

8. Rectangular Load: "Zone 24"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.01 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	117.5
49.5	117.5
49.5	129.5
37.5	129.5

9. Rectangular Load: "Zone 8"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.01 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	117.5
17.5	117.5
17.5	129.5
5.5	129.5

10. Rectangular Load: "Zone 23"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.51 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	101.5
49.5	101.5
49.5	113.5
37.5	113.5

11. Rectangular Load: "Zone 22"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.6 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	85.5
49.5	85.5
49.5	97.5
37.5	97.5

12. Rectangular Load: "Zone 21"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.55 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	69.5
49.5	69.5
49.5	81.5
37.5	81.5

13. Rectangular Load: "Zone 20"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.6 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	53.5
49.5	53.5
49.5	65.5
37.5	65.5

14. Rectangular Load: "Zone 19"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.6 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	37.5
49.5	37.5
49.5	49.5
37.5	49.5

15. Rectangular Load: "Zone 18"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.51 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
37.5	21.5
49.5	21.5
49.5	33.5
37.5	33.5

16. Rectangular Load: "Zone 16"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.48 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	117.5
33.5	117.5
33.5	129.5
21.5	129.5

17. Rectangular Load: "Zone 7"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.51 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	101.5
17.5	101.5
17.5	113.5
5.5	113.5

18. Rectangular Load: "Zone 6"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.6 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	85.5
17.5	85.5
17.5	97.5
5.5	97.5

19. Rectangular Load: "Zone 5"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.55 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	69.5
17.5	69.5
17.5	81.5
5.5	81.5

20. Rectangular Load: "Zone 4"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.55 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	53.5
17.5	53.5
17.5	65.5
5.5	65.5

21. Rectangular Load: "Zone 3"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.6 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	37.5
17.5	37.5
17.5	49.5
5.5	49.5

22. Rectangular Load: "Zone 2"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.51 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
5.5	21.5
17.5	21.5
17.5	33.5
5.5	33.5

23. Rectangular Load: "Zone 9"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.48 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	5.5
33.5	5.5
33.5	17.5
21.5	17.5

24. Rectangular Load: "Zone 10"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.83 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	21.5
33.5	21.5
33.5	33.5
21.5	33.5

25. Rectangular Load: "Zone 11"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.94 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	37.5
33.5	37.5
33.5	49.5
21.5	49.5

26. Rectangular Load: "Zone 12"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.91 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	53.5
33.5	53.5
33.5	65.5
21.5	65.5

27. Rectangular Load: "Zone 13"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.91 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	69.5
33.5	69.5
33.5	81.5
21.5	81.5

28. Rectangular Load: "Zone 14"

Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.94 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	85.5
33.5	85.5
33.5	97.5
21.5	97.5

29. Rectangular Load: "Zone 15"

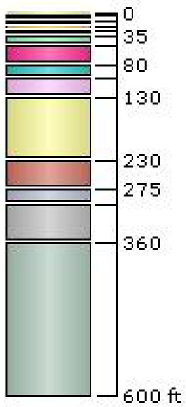
Length	12 ft
Width	12 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	144 ft^2
Load	2.83 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
21.5	101.5
33.5	101.5
33.5	113.5
21.5	113.5

Soil Layers

Layer #	Type	Thickness [ft]	Depth [ft]
1	Cover Sands	2	0
2	Caliche/Sand 1	8	2
3	Caliche/Sand 2	10	10
4	Caliche Hard 1	5	20
5	Caliche Hard 2	10	25
6	Ogallala 1	15	35
7	Ogallala 2	30	50
8	Ogallala 3	20	80
9	Dockum Claystone/Siltsone	30	100
10	Claystone and Siltstone	100	130
11	Dockum Clay/Claystone 1	45	230
12	Dockum Silty/Sands	25	275
13	Dockum Clay/Claystone 2	60	300
14	Dockum Clay/Claystone 3	240	360



Soil Properties

Property	Cover Sands	Caliche/Sand 1	Caliche/Sand 2	Caliche Hard 1
Color				
Unit Weight [kips/ft^3]	0.12	0.12	0.12	0.12
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Enabled
Es [ksf]	890	1200	1200	35815
Esur [ksf]	890	1200	1200	35815
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8

Property	Caliche Hard 2	Ogallala 1	Ogallala 2	Ogallala 3
Color				
Unit Weight [kips/ft^3]	0.12	0.12	0.13	0.13
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Enabled
Es [ksf]	55232	80233	53870	123857
Esur [ksf]	55232	80233	53870	123857
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8

Property	Dockum Claystone/ Siltsone	Claystone and Siltstone	Dockum Clay/ Claystone 1	Dockum Silty/ Sands
Color				
Unit Weight [kips/ft^3]	0.13	0.13	0.13	0.13
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Enabled
Es [ksf]	84172	120769	120769	120769
Esur [ksf]	84172	120769	120769	120769
Undrained Su A [kips/ ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8

Property	Dockum Clay/Claystone 2	Dockum Clay/Claystone 3
Color		
Unit Weight [kips/ft^3]	0.13	0.13
K0	1	1
Immediate Settlement	Enabled	Enabled
Es [ksf]	120769	154394
Esur [ksf]	120769	154394
Undrained Su A [kips/ft2]	0	0
Undrained Su S	0.2	0.2
Undrained Su m	0.8	0.8

Query Points

Point #	Query Point Name	(X,Y) Location	Number of Divisions
1	Cask Point 1	11.5, 11.5	Auto: 101
2	Cask Point 2	11.5, 27.5	Auto: 101
3	Cask Point 3	11.5, 43.5	Auto: 101
4	Cask Point 4	11.5, 59.5	Auto: 101
5	Cask Point 5	11.5, 75.5	Auto: 101
6	Cask Point 6	11.5, 91.5	Auto: 101
7	Cask Point 7	11.5, 107.5	Auto: 101
8	Cask Point 8	11.5, 123.5	Auto: 101
9	Cask Point 9	27.5, 11.5	Auto: 101
10	Cask Point 10	27.5, 27.5	Auto: 101
11	Cask Point 11	27.5, 43.5	Auto: 101
12	Cask Point 12	27.5, 59.5	Auto: 101
13	Cask Point 13	27.5, 75.5	Auto: 101
14	Cask Point 14	27.5, 91.5	Auto: 101
15	Cask Point 15	27.5, 107.5	Auto: 101
16	Cask Point 16	27.5, 123.5	Auto: 101
17	Cask Point 17	43.5, 11.5	Auto: 101
18	Cask Point 18	43.5, 27.5	Auto: 101
19	Cask Point 19	43.5, 43.5	Auto: 101
20	Cask Point 20	43.5, 59.5	Auto: 101
21	Cask Point 21	43.5, 75.5	Auto: 101
22	Cask Point 22	43.5, 91.5	Auto: 101
23	Cask Point 23	43.5, 107.5	Auto: 101
24	Cask Point 24	43.5, 123.5	Auto: 101
25	Footing Bottom Left	0, 0	Auto: 101
26	Footing Bottom Right	55, 0	Auto: 101
27	Footing Top Left	0, 135	Auto: 101
28	Footing Top Right	55, 135	Auto: 101
29	Footing Center	27.5, 67.5	Auto: 101
30	Query Point 30	11.973, 99.283	Auto: 101
31	Query Point 31	30, 132.5	Auto: 101
32	Query Point 32	2.5, 67.5	Auto: 101
33	Query Point 33	34.543, 35.669	Auto: 101
34	Query Point 34	27.5, 2.5	Auto: 101

Field Point Grid

Number of points	1672
Expansion Factor	1

Grid Coordinates

X [ft]	Y [ft]
122.5	202.5
122.5	-67.5
-67.5	-67.5
-67.5	202.5

Settle3

Software Validation and Verification

DAN BROWN AND ASSOCIATES

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TECHNICAL MEMORANDUM

Software Verification: Settle3 v5.001
CISF Site
Andrews, TX
DBA Project No. 19-017

To:	Derek Kilday, P.E./GEOServices
From:	Timothy C. Siegel, P.E, G.E., D.GE Tayler J. Day, P.E.
Date:	17 February 2020

1. Introduction

Dan Brown and Associates, P.C. (DBA) was contracted to perform settlement analyses for the subject project. As part of our scope, DBA was to perform and provide verification of the efficacy of the Settle3 v5.001 software used for the analyses. This TM explains the basis of the verification and DBA's conclusion that the software is valid and appropriate for the provided analyses.

2. Selection of Software

DBA routinely performs settlement analyses as a function of our role as industry leaders in foundation and ground improvement design. It is our experience that Settle3 software by Rocscience (currently version 5.001) is an effective tool that uses sound geotechnical and mechanics principles to produce settlement results that can be interpreted by technical and non-technical personnel. Additionally, Settle3 v5.001 (and other Rocscience geotechnical softwares) are routinely used in standard geotechnical engineering practice.

3. Critical Characteristics of Software

Settle3 v5.001 calculates settlement by interpreting the way applied stress is distributed with depth in a soil column using the Westergaard solution. The resulting stress distribution and the user input soil parameters are used to calculate strain/displacement.

The analyses required for the CISF site in Andrews, TX are ultimately concerned with the settlement of a single footing and a group of footings which requires calculations that effectively satisfy the following critical characteristics:

- Calculate stress with depth below the corner of a single rectangular loaded area
- Calculates vertical stress beneath a point within a rectangularly loaded area using the principle of superposition of stresses

- Considers multiple bearing pressure areas and calculates the vertical stress beneath a point outside of a rectangularly loaded area (i.e. between footings) using the principle of superposition.

4. Verification Procedure and Acceptance

DBA established the attached calculations to verify the critical characteristics identified in the previous section using hand calculations based on the methods used by Settle3 v5.001. The acceptance criteria established by DBA for each critical characteristic stress calculation was an error of 1% or less to account for any differences in rounding of trigonometric function results.

The hand calculations utilize a closed form solution of the Westergaard Stress Computation Formula found in Taylor (1948)[1]. The final result of the evaluation of the critical characteristics are summarized in Table 1.

Critical Characteristic	Method of Comparison	Acceptable Error Criteria	Measured Error
Vertical stress beneath corner of rectangularly loaded area	Slide3 v5.001 software vs Hand Calculation (attached)	+/- 1%	0%
Vertical stress beneath a point within rectangularly loaded area	Slide3 v5.001 software vs Hand Calculation (attached)	+/- 1%	0%
Vertical stress beneath a between multiple rectangular areas	Slide3 v5.001 software vs Hand Calculation (attached)	+/- 1%	0%

5. Concluding Remarks

Calculations were performed to verify the efficacy of Settle3 v5.001 for the types of analyses required for the CISF storage pads in Andrews, TX. DBA concludes the software is appropriate and accurate for use on the subject project. Please contact the following if you would like to discuss this document or this project.

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[1] Taylor, D.W. (1948). *Fundamentals of Soil Mechanics.* John Wiley, New York. Pg 259.

Attachments

Settle3 v5.001 Verification Analysis

Settle3 by Rocscience Stress Calculation Verification

This calculation set is for the verification of the Westergaard stress computation method in Settle3 Version 5.001 by Rocscience. The Westergaard stress computation method is a common stress computation method for layered strata. The raw form of the Westergaard stress computation method is developed to calculate the vertical stress beneath a point load. This raw form of Westergaard's stress computation method is analytically integrated to calculate the vertical stress beneath the corner of a rectangularly loaded area, and using the principle of superposition, the vertical stress beneath any point within or beyond the loaded area can be calculated. So, the critical characterisitcs to be checked are as follows: 1) Settle3 correctly calculates the vertical stress beneath the corner of a rectangularly loaded area, 2) Settle3 correctly calculates the vertical stress beneath a point within a rectangularly loaded area using the principle of superposition, and 3) Settle3 correctly considers multiple bearing pressures and calculates the vertical stress beneath a point outside of a rectangularly loaded area using the principle of superposition.

Westergaard Stress Computation Formula:

$$\sigma_{z\_Q} := \left(\frac{Q}{z^2}\right)\cdot\frac{\left(\frac{1}{2\pi}\right)\cdot\sqrt{\frac{1-2\cdot\upsilon}{2-2\upsilon}}}{\left[\left(\frac{1-2\upsilon}{2-2\upsilon}\right)+\left(\frac{r}{z}\right)^2\right]^{\frac{3}{2}}}$$

Where:

σ_z = Vertical Stress

Q = Point Load

z = Depth

υ = Poisson's Ratio

r = Horizontal Distance from Point Load

The Westergaard Stress Computation Formula shown above is listed for a point load, however, it is more common to calculate stress for a bearing pressure. The vertical stress beneath the corner of a given rectangular bearing pressure or footing can be obtained by integrating the above equation and the resulting equation is shown below.

Westergaard Stress Computation Formula:

$$\sigma_z := \left(\frac{q}{2\cdot\pi}\right)\cdot \operatorname{acot}\left[\sqrt{\left(\frac{1-2\nu}{2-2\upsilon}\right)\cdot\left(\frac{1}{m^2}+\frac{1}{n^2}\right)+\left(\frac{1-2\cdot\nu}{2-2\cdot\nu}\right)^2\cdot\left(\frac{1}{m^2\cdot n^2}\right)}\right]$$

Where:

σ_z = Vertical Stress

q = Bearing Pressure

υ = Poisson's Ratio

m = L/z

n = W/z

z = Depth

L = Length of Footing or Bearing Pressure Considered

W = Width of Footing or Bearing Pressure Considered

Source: Taylor, D. W. (1948). *Fundamentals of Soil Mechanics*. (pg. 259). John Wiley. New York.

The above equation is formulated to calculate the vertical stress beneath the corner of a rectangular bearing pressure or footing. So to calculate the stress at the center of a rectangular bearing pressure or footing, the rectangular area can be segmented into four equal areas and using the principle of superposition, the stress can be calculated at the center. The following two pages show calculations for stress beneath the corner and the center of a square footing.

Calculation of the Vertical Stress Beneath the Corner of a Square Footing:

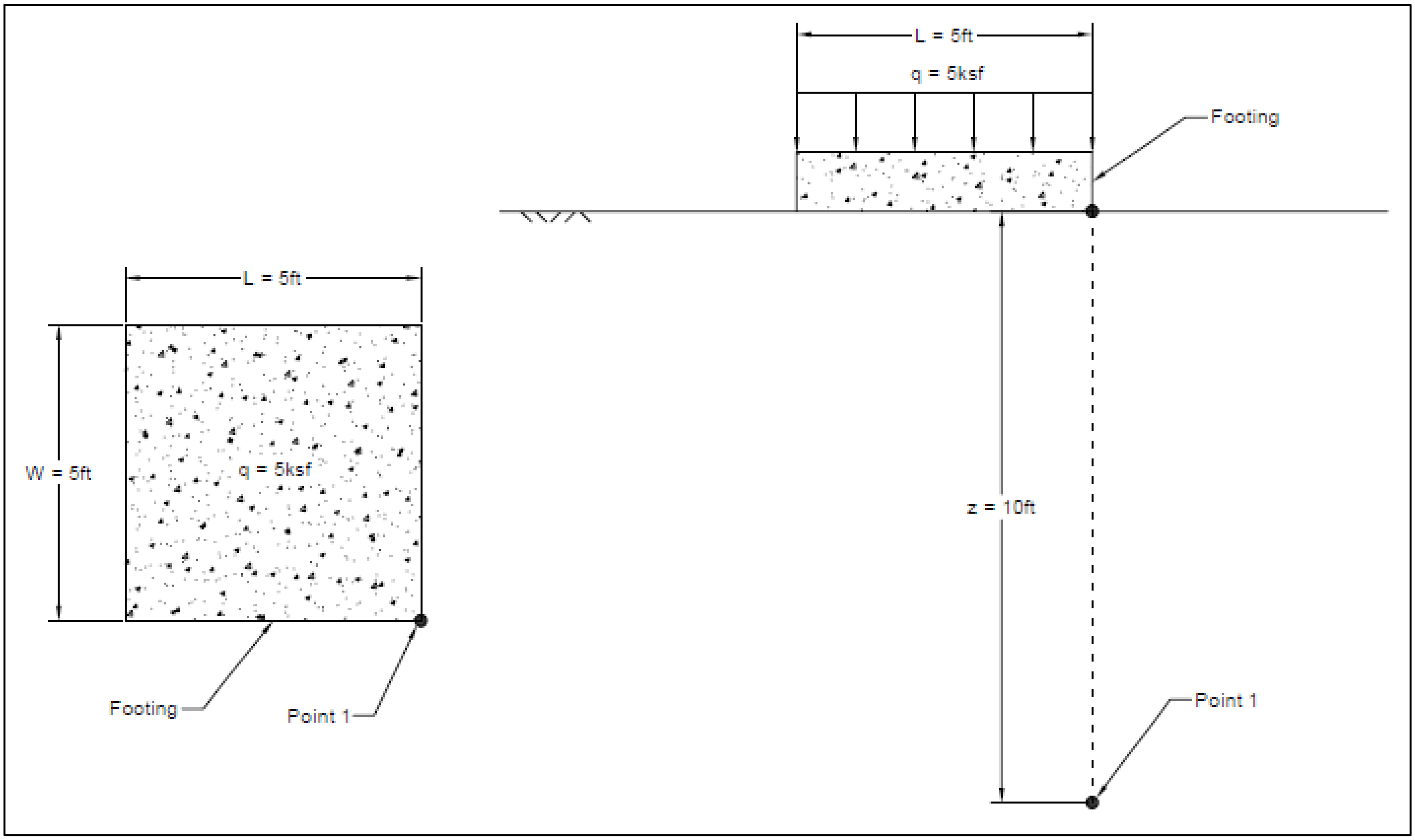

Figure 1 - Stress Beneath Corner of Square Footing Diagram (Left - Plan View, Right - Cross Section)

Footing Length: $L_1 := 5\text{ft}$

Footing Width: $W_1 := 5\text{ft}$

Bearing Pressure: $q_1 := 5\text{ksf}$

Poisson's Ratio: $\upsilon := 0.33$

Depth of Interest: $z_1 := 10\text{ft}$

Length-to-Depth Ratio: $m_1 := \frac{L_1}{z_1} = 0.5$

Width-to-Depth Ratio: $n_1 := \frac{W_1}{z_1} = 0.5$

$$\sigma_{z1} := \left(\frac{q_1}{2\cdot\pi}\right)\cdot \text{acot}\left[\sqrt{\left(\frac{1-2\cdot\upsilon}{2-2\upsilon}\right)\cdot\left(\frac{1}{m_1^{\,2}}+\frac{1}{n_1^{\,2}}\right)+\left(\frac{1-2\cdot\upsilon}{2-2\cdot\upsilon}\right)^2\cdot\left(\frac{1}{m_1^{\,2}\cdot n_1^{\,2}}\right)}\right] = 413\cdot\text{psf}$$

DAN BROWN AND ASSOCIATES

Project WCS Storage Facility
Project No. 19-017
Sheet 3 of 9
Date 01 / 14 / 2020
Engineer WPS
Checked by TJD

Calculation of the Vertical Stress Beneath the Center of a Square Footing:

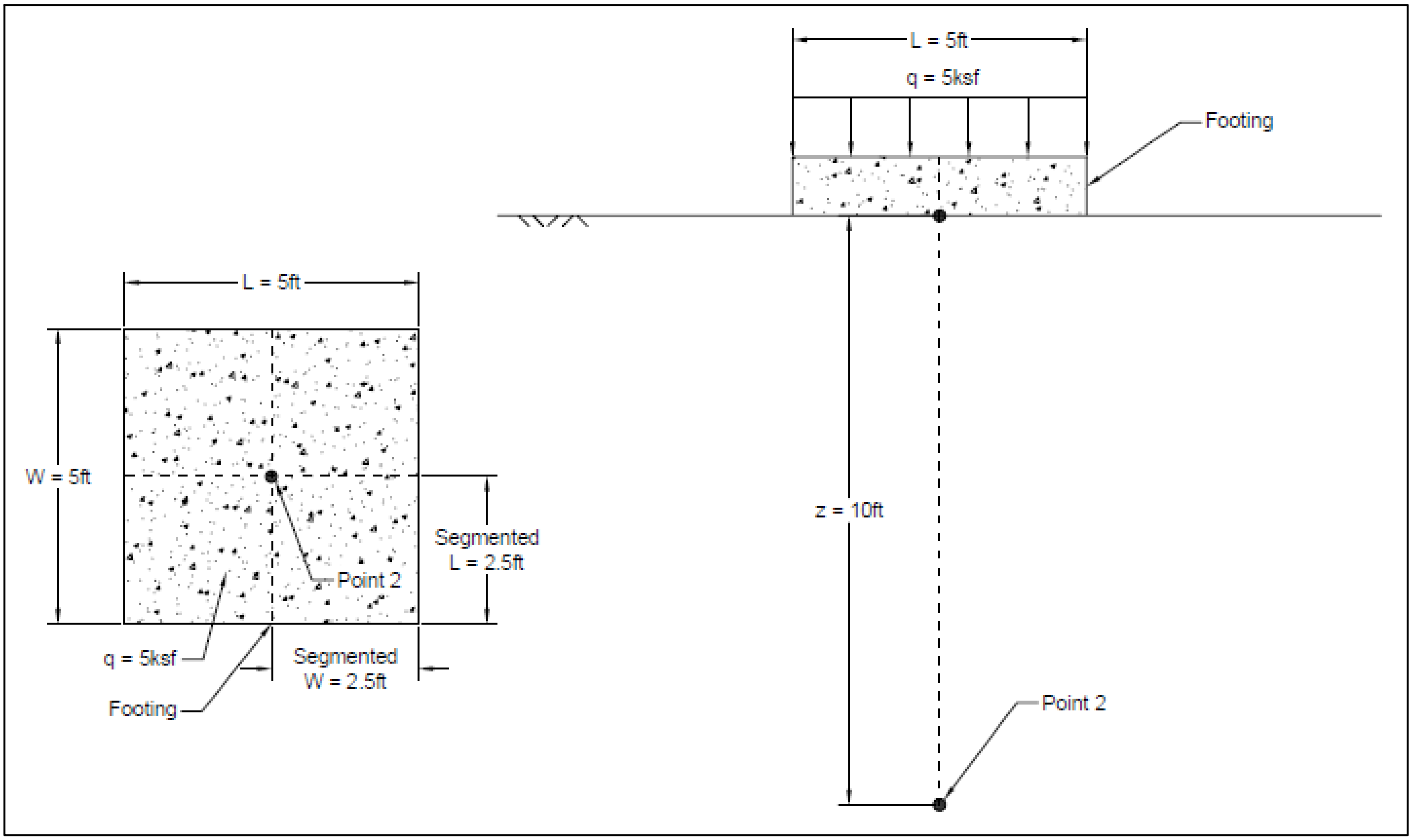

Figure 2 - Stress Beneath Center of Square Footing Diagram (Left - Plan View, Right - Cross Section)

Segmented Footing Length: $L_2 := 2.5\text{ft}$

Segmented Footing Width: $W_2 := 2.5\text{ft}$

Bearing Pressure: $q_2 := 5\text{ksf}$

Poisson's Ratio: $\upsilon := 0.33$

Depth of Interest: $z_2 := 10\text{ft}$

Length-to-Depth Ratio: $m_2 := \frac{L_2}{z_2} = 0.25$

Width-to-Depth Ratio: $n_2 := \frac{W_2}{z_2} = 0.25$

$$\sigma_{z2} := 4\left(\frac{q_2}{2\cdot\pi}\right)\cdot \text{acot}\left[\sqrt{\left(\frac{1-2\cdot\upsilon}{2-2\upsilon}\right)\cdot\left(\frac{1}{m_2^{\,2}}+\frac{1}{n_2^{\,2}}\right)+\left(\frac{1-2\cdot\upsilon}{2-2\cdot\upsilon}\right)^2\cdot\left(\frac{1}{m_2^{\,2}\cdot n_2^{\,2}}\right)}\right] = 633\cdot\text{psf}$$

Note: Using the principle of superposition, the equation for the stress beneath the corner of a rectangularly loaded area is multiplied by 4 in this case account for all 4, 2.5ft x 2.5ft loaded areas.

Calculation of the Vertical Stress Beneath a Point Between Two Rectangular Footings:

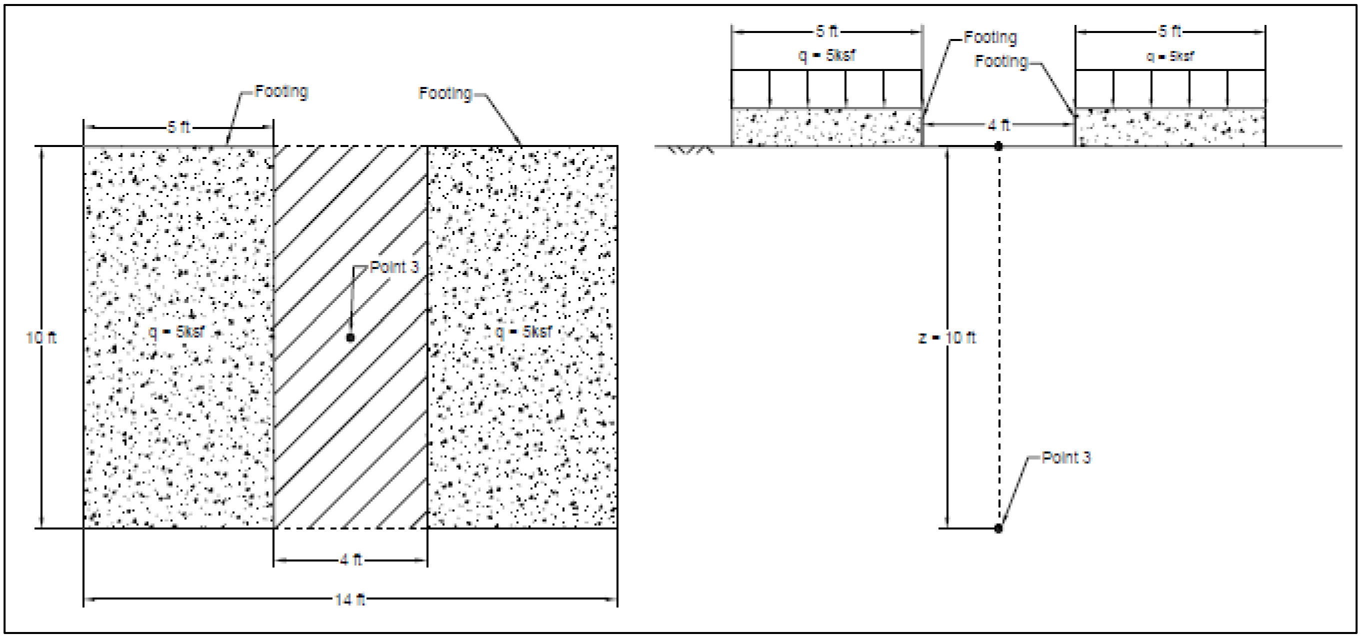

Figure 3 - Vertical Stress Beneath a Point Between Two Rectangular Footings Diagram
(Left - Plan View, Right - Cross Section)

In this case, the principle of superposition is used to add the stress from 4 rectangles with a common point at Point 3 and then subtract out the stress from the areas that are not loaded. See Figure 4 and commentary below for details.

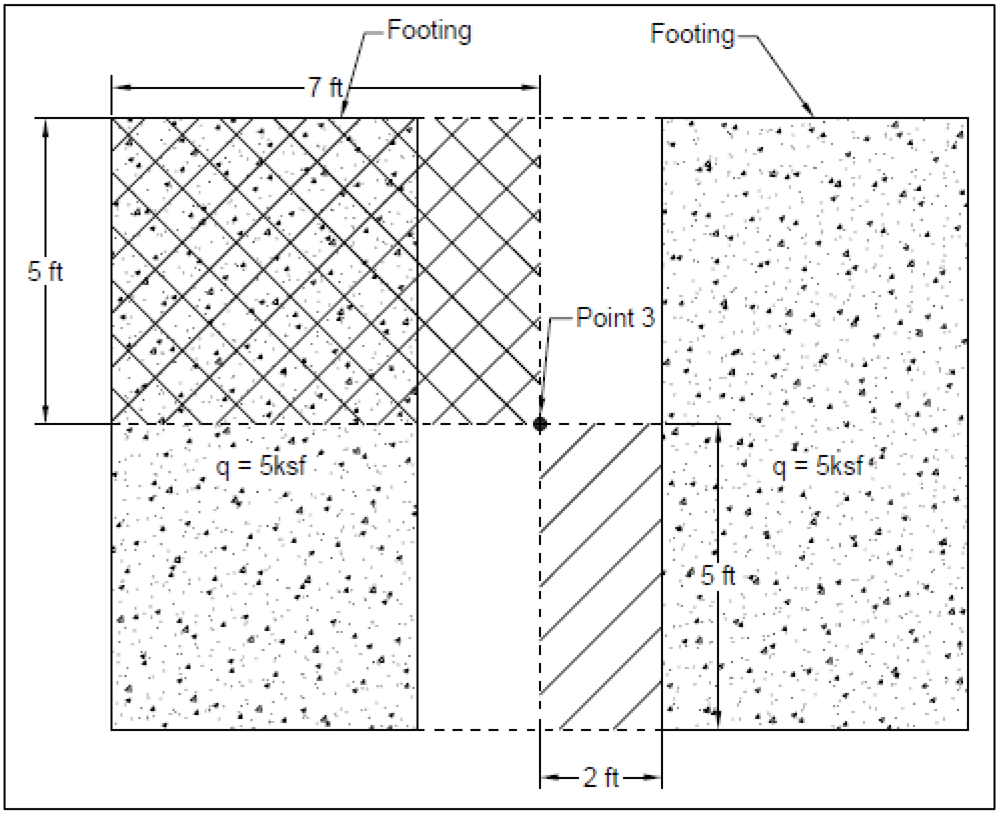

Figure 4 - Vertical Stress Beneath a Point Between Two Rectangular Footings Diagram. The Stress Computation Areas are Hatched and Cross-Hatched (Plan View)

To calculate the stress beneath Point 3, consider the entire cross-hatched area is loaded with a bearing pressure of 5ksf - just like the footings. Four times the vertical stress resulting from Westergaard's equation for the cross-hatched area will be equal to the vertical stress if the whole area, even the area between the two footings, is loaded with a bearing pressure of 5ksf. But the whole area is not loaded; the area between the footings has no load. So using the principle of superposition and Westergaard's equation for the vertical stress beneath the corner of a rectangularly loaded area, four times the vertical stress from the hatched area is subtracted from four times the vertical stress from the cross-hatched area to get the stress at Point 3. Calculations are shown below.

Vertical Stress at Point 3: Cross-Hatched Area

Segmented Footing Length: $L_{3a} := 7\text{ft}$

Segmented Footing Width: $W_{3a} := 5\text{ft}$

Bearing Pressure: $q_3 := 5\text{ksf}$

Poisson's Ratio: $\upsilon := 0.33$

Depth of Interest: $z_3 := 10\text{ft}$

Length-to-Depth Ratio: $m_{3a} := \frac{L_{3a}}{z_3} = 0.7$

Width-to-Depth Ratio: $n_{3a} := \frac{W_{3a}}{z_3} = 0.5$

$$\sigma_{z3a} := 4\left(\frac{q_3}{2\cdot\pi}\right)\cdot\text{acot}\left[\sqrt{\left(\frac{1-2\cdot\upsilon}{2-2\upsilon}\right)\cdot\left(\frac{1}{m_{3a}^2}+\frac{1}{n_{3a}^2}\right)+\left(\frac{1-2\cdot\upsilon}{2-2\cdot\upsilon}\right)^2\cdot\left(\frac{1}{m_{3a}^2\cdot n_{3a}^2}\right)}\right] = 1938\cdot\text{psf}$$

Vertical Stress at Point 3: Hatched Area

Segmented Footing Length: $L_{3b} := 2ft$

Segmented Footing Width: $W_{3b} := 5ft$

Bearing Pressure: $q_3 := 5ksf$

Poisson's Ratio: $\upsilon := 0.33$

Depth of Interest: $z_3 := 10ft$

Length-to-Depth Ratio: $m_{3b} := \frac{L_{3b}}{z_3} = 0.2$

Width-to-Depth Ratio: $n_{3b} := \frac{W_{3b}}{z_3} = 0.5$

$$\sigma_{z3b} := 4\left(\frac{q_3}{2\cdot\pi}\right)\cdot \text{acot}\left[\sqrt{\left(\frac{1-2\cdot\upsilon}{2-2\upsilon}\right)\cdot\left(\frac{1}{m_{3b}^{\ 2}}+\frac{1}{n_{3b}^{\ 2}}\right)+\left(\frac{1-2\cdot\upsilon}{2-2\cdot\upsilon}\right)^2\cdot\left(\frac{1}{m_{3b}^{\ 2}\cdot n_{3b}^{\ 2}}\right)}\right] = 837\cdot psf$$

Vertical Stress at Point 3 - Subtract Hatched Area Vertical Stress from Cross-Hatched Area Vertical Stress:

Vertical Stress at Point 3: $\sigma_{z3} := \sigma_{z3a} - \sigma_{z3b} = 1100\cdot psf$

Plots of Vertical Stress vs Depth Comparing Hand Calculations to Settle3 Output:

The above calculations using Westergaard's equation for the vertical stress beneath the corner of a 5ft x 5ft footing, the center of a 5ft x 5ft footing, and a point between two 10ft x 5ft footings, where all footings are loaded with a 5ksf bearing pressure, were carried out in Microsoft Excel from 0 to 100ft depth. This data is plotted in Figures 5, 6, and 7 and compared with the output from the same problems modelled in *Settle3 Version 5.001 by Rocscience*. As shown in Figures 5, 6, and 7, the results from the hand calculations and Settle3 are identical, thus, the critical characteristics of Settle3 are confirmed.

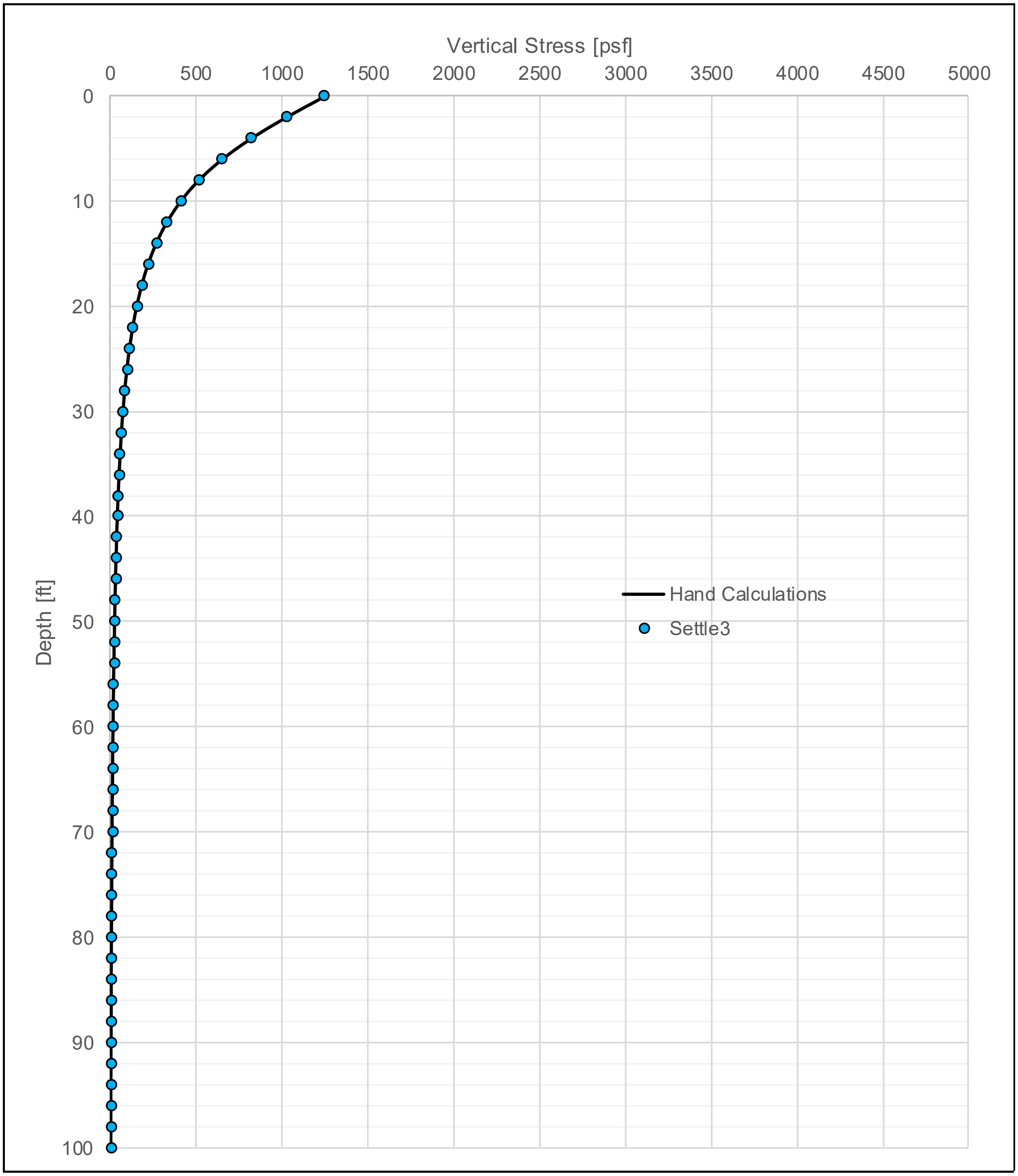

Figure 5 - Vertical Stress Beneath the Corner of a 5ft x 5ft Footing with a Bearing Pressure of 5ksf
Note: The results from hand calculations and Settle3 are compared and shown to be the same

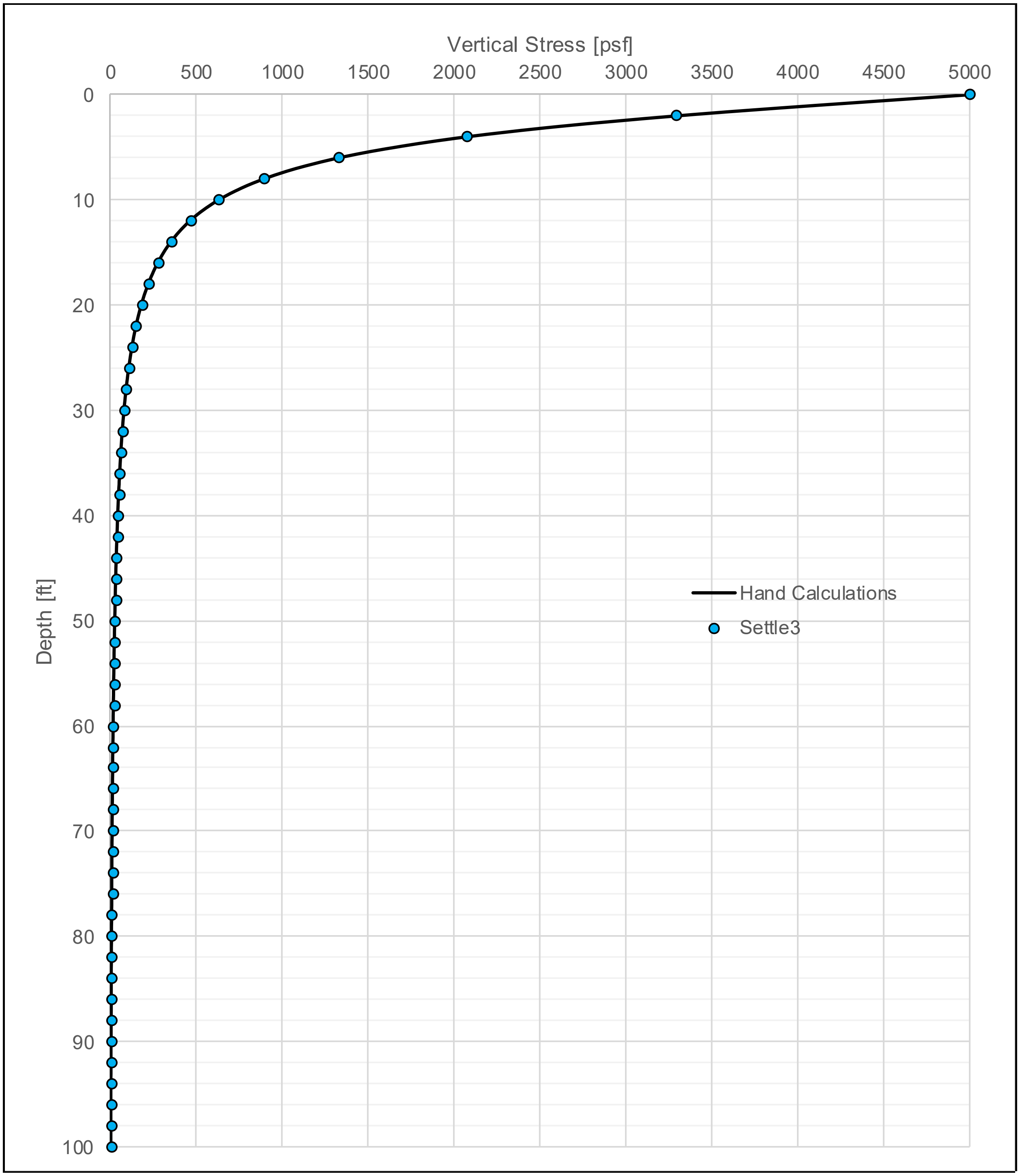

Figure 6 - Vertical Stress Beneath the Center of a 5ft x 5ft Footing with a Bearing Pressure of 5ksf
Note: The results from hand calculations and Settle3 are compared and shown to be the same

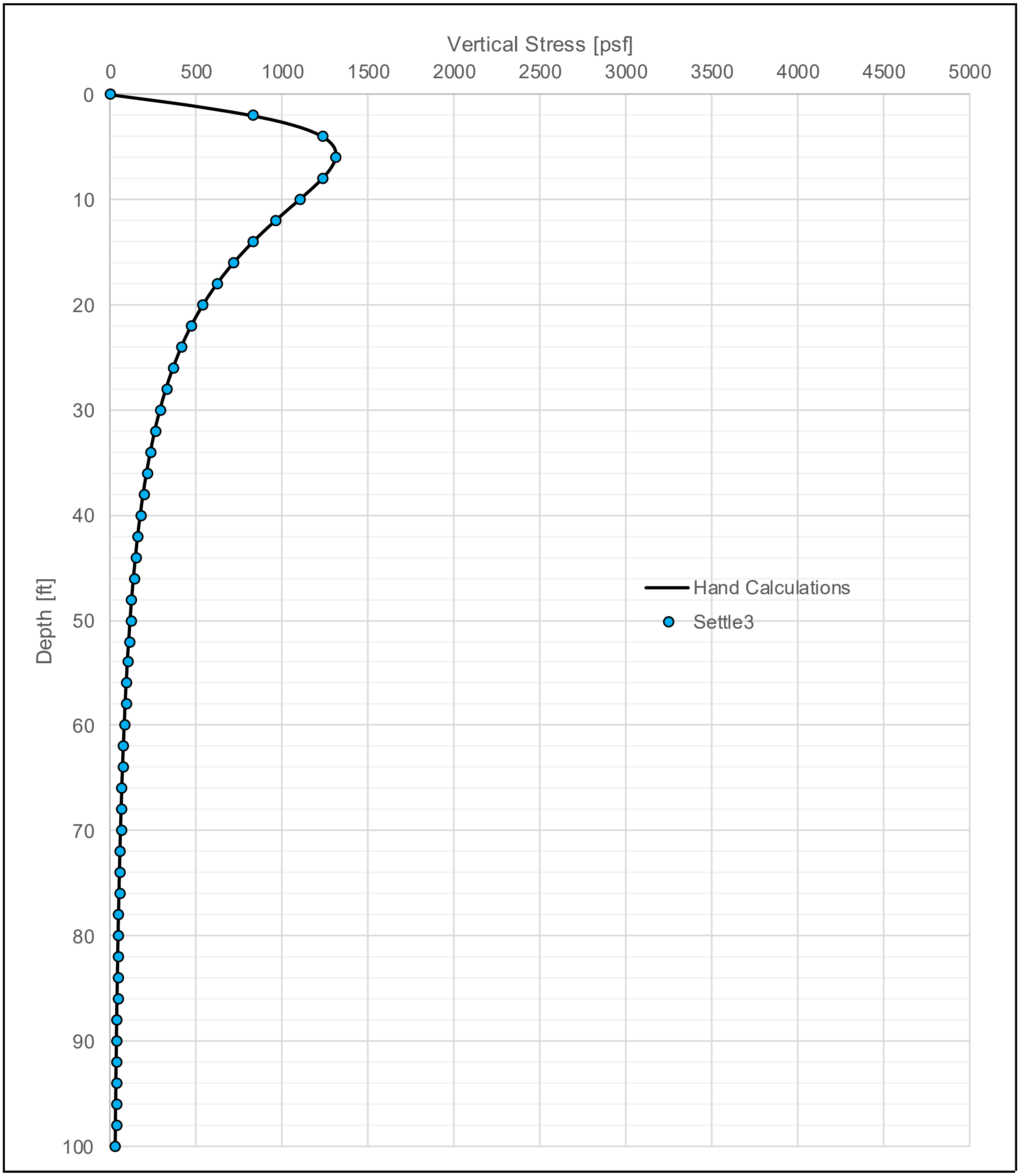

Figure 7 - Vertical Stress Beneath a Point Between Two, 10ft x 5ft Footings with a Bearing Pressure of 5ksf
Note: The results from hand calculations and Settle3 are compared and shown to be the same