133 North 1330 West
Orem, Utah - 84057
Phone (801) 225-5711

3662 West 2100 South
Salt Lake City, Utah - 84120
Phone (801) 808-9310

1596 W. 2650 S. #108
Ogden, Utah - 84401
Phone (801) 399-9516

GEOTECHNICAL STUDY
NORDIC VALLEY CONDOS
APPROXIMATELY 3567 EAST
NORDIC VALLEY DRIVE
EDEN, UTAH

Project No. 145167G

October 29, 2014

Prepared For:

Nordic Valley Ski Resort
Attention: Mr. Greg Jensen
3567 East Nordic Valley
Eden, UT 84310

Prepared By:

EARTHTEC ENGINEERING
Ogden Office

TABLE OF CONTENTS PAGE NO.

TABLE OF CONTENTS (CONTINUED)

1.0 EXECUTIVE SUMMARY

This report presents the results of our geotechnical study for the Nordic Valley Condos project located in Eden, Utah. We understand the proposed building, as currently planned, will consist of a four to five story structure, including underground parking areas and a swimming pool.

For the field exploration, we excavated a total of four (4) test pits and drilled one (1) test hole to depths of about 5½ to 31½ feet below the existing ground surface. Groundwater was encountered at depths of approximately 5½ feet to 14 feet below the existing ground surface during the initial field investigation. The subsurface soils encountered generally consisted of fill material and topsoil overlying layers of Lean Clay with sand (CL), Lean Clay (CL), Poorly Graded Gravel with clay and sand (GP-GC), Sandy Lean Clay (CL), Clayey Sand with gravel (SC), Well Graded Gravel with clay and sand (GW-GC), Clayey Gravel with sand (GC), and Sandstone. All fill material and topsoil should be removed beneath the entire building footprint, exterior flatwork, and pavement areas.

Based on the results of our field exploration, laboratory testing, and engineering analyses, it is our opinion that the subject site is suitable for the proposed development. The recommendations presented herein should be followed and implemented during design and construction. Conventional strip and spread footings may be used to support the structures, with foundations placed entirely on uniform, undisturbed, native gravels or entirely on a minimum of 18 inches of properly placed and compacted structural fill. Foundations should not be constructed on the native clay and clayey sand soils. We anticipate that a minimum of 18 inches of structural fill will be needed based on the varying soils encountered during our field investigation

The global stability of the existing slope at the property was analyzed as part of our study. Our analyses indicate that the proposed slope, meets the required minimum factors of safety. Any modifications to the slope, including the construction of retaining walls, may affect the slope stability and should be properly analyzed, designed, and engineered.

This executive summary provides a general synopsis of our recommendations. Details of our findings, conclusions and recommendations are provided within the body of this report. Failure to consult with Earthtec Engineering (Earthtec) regarding any changes made during design and/or construction of the project from those discussed herein relieves Earthtec from any liability arising from changed conditions at the site. We also strongly recommend that Earthtec observes the building excavations to verify the adequacy of our recommendations presented herein, and that Earthtec performs materials testing and special inspections for this project to provide continuity during construction.

2.0 INTRODUCTION

The project is located at approximately 3567 East Nordic Valley Road within the existing Nordic Valley Ski Resort in Eden, Utah. The general location of the site is shown on Figure No. 1, *Vicinity Map*, at the end of this report.

The purposes of this study were to

- Evaluate the subsurface soil conditions at the site,
- Assess the engineering characteristics of the subsurface soils, and
- Provide geotechnical recommendations for general site grading and the design and construction of foundations, concrete floor slabs, and miscellaneous concrete flatwork.

The scope of work completed for this study included field reconnaissance, subsurface exploration, field and laboratory soil testing, geotechnical engineering analysis, and the preparation of this report.

3.0 PROPOSED CONSTRUCTION

We understand that the proposed project consists of constructing a 50 unit condo building along with underground parking and a swimming pool within the existing Nordic Valley Ski Resort. We anticipate that the building will be conventionally framed and be four to five stories in height. The building will likely be founded on spread footings. We have based our recommendations in this report on the assumption that foundation loads for the proposed structures will not exceed 5,000 pounds per linear foot for bearing walls, 70,000 pounds for column loads, and 100 pounds per square foot for floor slabs. If structural loads will be greater Earthtec should be notified so that we may review our recommendations and make modifications, if necessary.

In addition to the construction described above, we anticipate that

- Utilities will be installed to service the proposed building,
- Exterior concrete flatwork will be placed in the form of driveways, underground parking areas, curb and gutter, and sidewalks, and
- Asphalt paved parking areas will be constructed.

4.0 GENERAL SITE DESCRIPTION

At the time of our subsurface exploration the site was an undeveloped property just south of the existing ski lodge. The site was relatively flat where the majority of the building will be constructed. The property then sloped uphill to the west at approximately 42 to 48 percent grades. The slope was heavily vegetated with grasses. Near the toe of the slope a small creek was observed. The area to the east contained equipment and sheds used for the ski resort. The south end of the property had been previously graded and the material had been placed in the north, east and west portions of the property.

5.0 SUBSURFACE EXPLORATION

5.1 Soil Exploration

Under the direction of a qualified member of our geotechnical staff, subsurface explorations were conducted at the site on June 17, 2014, by excavating four (4) exploratory test pits using a rubber-tire backhoe and mini-trackhoe to depths of about 5½ to 12 feet below the existing ground surface. Equipment refusal was encountered in Test Pit 4 (TP-4) due to small equipment being used and in TP-1 due to encountering a boulder.

Subsurface explorations were conducted at the site on June 18, 2014, by drilling one (1) exploratory test hole using a Mobile B-35 All-Terrain-Vehicle geotechnical drilling rig utilizing 6 inch diameter hollow stem augers to a depth of about 31½ feet below the existing ground surface. The approximate locations of the test pits and test hole are shown on Figure No. 2, *Aerial Photograph Showing Location of Test Hole, Test Pits, and* Slope Cross-Section.

Graphical representations and detailed descriptions of the soils encountered are shown on Figure Nos. 3 through 6, *Test Pit Log,* and on Figure No. 7, *Test Hole Log*, at the end of this report. The stratification lines shown on the logs represent the approximate boundary between soil units; the actual transition may be gradual. Due to potential natural variations inherent in soil deposits, care should be taken in interpolating between and extrapolating beyond exploration points. A key to the symbols and terms on the logs is presented on Figure No. 8, *Legend.*

Samples of the subsurface soils were collected in the test holes at depth intervals of approximately 2½ to 5 feet. Relatively undisturbed samples were collected by pushing thin-walled "Shelby" tubes into undisturbed soils below the augers. Relatively undisturbed samples were also collected with a 1.9 inch inside diameter Modified California sampler. Disturbed samples were collected with a 1⅜ inch inside diameter split spoon sampler. The split spoon and Modified California samplers were driven 18 inches into undisturbed soil with a 140 pound hammer free-falling through a distance of 30 inches. The blows required to drive the sampler through the final 12 inches of penetration is called the "N-value" or "blow count," and is recorded as "blows per foot" on the attached test hole logs at the respective sample depths. The blows for each 6 inch interval (or less) are noted on the logs when more than 50 blows per 6 inches (or less) of sampler driving were achieved. The blow count provides a reasonable indication of the in-place relative density of sandy soils, but provides only a limited indication of the relative stiffness of cohesive (clayey) materials, since the penetration resistance for these soils is a function of the moisture content. In gravelly soils, the blow count may be higher than it otherwise would be, particularly when one or more gravel particles are larger than the sampler diameter.

Disturbed bag and relatively undisturbed block samples were collected at various depths in the test pit locations.

The soil samples collected were classified by visual examination in the field following the guidelines of the Unified Soil Classification System (USCS). The samples were transported to our Ogden, Utah laboratory where they will be retained for 30 days following the date of this report and then discarded, unless a written request for additional holding time is received prior to the 30 day limit.

6.0 LABORATORY TESTING

Representative soil samples collected during our field exploration were tested in the laboratory to assess pertinent engineering properties and to aid in refining field classifications, if needed. Tests performed included natural moisture content, dry density tests, liquid and plastic limits determinations, full and mechanical (partial) gradation analyses, one-dimensional consolidation tests, and a direct shear test. The table below summarizes the laboratory test results, which are also included on the attached Test Pit and Test Hole Logs at the respective sample depths, on Figure Nos. 9 through 10, *Consolidation-Swell Test*, on Figure No. 11, *Direct Shear Test,* and on Figure No. 14, *Grain Size Distribution.*

Table 1: Laboratory Test Results

Test Pit/ Hole No.	Depth (ft.)	Natural Moisture (%)	Natural Dry Density (pcf)	Atterberg Limits		Grain Size Distribution (%)			Soil Type
				Liquid Limit	Plasticity Index	Gravel (+ #4)	Sand	Silt/Clay (- #200)	
TP-1	4½	22	---	35	16	1	18	81	CL
TP-2	5½	7	---	27	10	72	18	10	GP-GC
TP-3	10½	25	96	38	17	11	29	60	CL
TP-4	4	12	111	30	13	18	51	31	SC
TH-1	12½	8	---	22	7	59	30	11	GW-GC
TH-1	25	14	---	25	11	39	32	29	GC
TH-1	27½	25	---	36	19	4	24	72	CL

As part of the consolidation test procedure, water was added to the samples to assess moisture sensitivity when the samples were loaded to an equivalent pressure of approximately 1,000 psf. The consolidation test indicated the clay and clayey sand soils have a slight potential for compressibility and a negligible potential for collapse (settlement) and a slight potential for expansion (heave) under increased moisture contents and anticipated load conditions.

7.0 SUBSURFACE CONDITIONS

7.1 Soil Types

On the surface of the site, we encountered fill material and topsoil which is estimated to extend about 6 inches to 2 feet in depth at the test hole and test pit locations. Below the fill material and topsoil we encountered layers Lean Clay with sand (CL), Poorly Graded Gravel with clay and sand (GP-GC), Sandy Lean Clay (CL), Clayey Sand with gravel (SC), Sandstone, Well Graded Gravel with clay and sand (GW-GC), and Clayey Gravel with sand (GC). Based on the blow counts obtained and observations during field exploration, the clay soils ranged from stiff to very stiff in consistency and the clayey sand and gravel soils had a relative density varying dense to very dense.

It should be considered that small diameter soil borings were used during the course of our subsurface exploration. Fill material composition and contacts are difficult to determine from test hole sampling. Variation in fill depths may occur at the site.

7.2 Groundwater Conditions

Groundwater was encountered at depths of approximately 5½ feet to 14 feet below the existing ground surface during the initial field investigation. In addition, we observed oxidation in the soils, a possible indicator of past water or seepage levels, at a depth of about 2 feet below the existing ground surface in multiple test pit locations. Note that groundwater levels will fluctuate in response to the season, precipitation, snow melt, irrigation, and other on and off-site influences. Quantifying these fluctuations would require long term monitoring, which is beyond the scope of this study. The contractor should be prepared to dewater excavations as needed.

8.0 SITE GRADING

8.1 General Site Grading

All surface vegetation and unsuitable soils (such as topsoil, organic soils, undocumented fill, soft, loose, or disturbed native soils, and any other inapt materials) should be removed from below foundations, floor slabs, exterior concrete flatwork, and pavement areas. We encountered fill material and topsoil on the surface of the site which we estimated to extend about 2 feet below the existing ground surface. The fill encountered on the site is considered undocumented (untested). The fill material and topsoil (including soil with roots larger than about ¼ inch in diameter) should be completely removed, even if found to extend deeper than 2 feet, along with any other unsuitable soils that may be encountered. .

Fill placed over large areas, even if only a few feet in depth, can cause consolidation in the underlying native soils resulting in settlement of the fill. If more than 3 feet of grading fill will be placed above the existing surface (to raise site grades), Earthtec should be notified so that we may provide additional recommendations, if required. Such recommendations will likely include placing the fill several weeks (or possibly more) prior to construction to allow settlement to occur.

8.2 Temporary Excavations

Temporary excavations that are less than 4 feet in depth and above groundwater should have side slopes no steeper than ½H:1V (Horizontal:Vertical). Temporary excavations where water is encountered in the upper 4 feet or that extend deeper than 4 feet below site grades should be sloped or braced in accordance with OSHA[1] requirements for Type C soils.

8.3 Fill Material Composition

The existing fill material and native soils are not suitable for use as structural fill. Excavated soils, including fill material and topsoil, may be stockpiled for use as fill in landscape areas.

Structural fill is defined as fill material that will ultimately be subjected to any kind of structural loading, such as those imposed by footings, floor slabs, pavements, etc. We recommend that a professional engineer or geologist verify that the structural fill to be used on this project meets the requirements, stated below. We recommend that structural fill consist of imported sandy/gravelly soils meeting the following requirements in the table below:

---

[1] OSHA Health And Safety Standards, Final Rule, CFR 29, part 1926.

Table 2: Structural Fill Recommendations

Sieve Size/Other	Percent Passing (by weight)
4 inches	100
3/4 inches	70 – 100
No. 4	40 – 80
No. 40	15 – 50
No. 200	0 – 20
Liquid Limit	35 maximum
Plasticity Index	15 maximum

In some situations, particles larger than 4 inches and/or more than 30 percent coarse gravel may be acceptable, but would likely make compaction more difficult and/or significantly reduce the possibility of successful compaction testing. Consequently, more strict quality control measures than normally used may be required, such as using thinner lifts and increased or full time observation of fill placement.

We recommend that utility trenches below any structural load be backfilled using structural fill. Note that most local governments and utility companies require Type A-1-a or A-1-b (AASHTO classification) soils (which overall is stricter than our recommendations for structural fill) be used as backfill above utilities in certain areas. In other areas or situations, utility trenches may be backfilled with the native soil, but the contractor should be aware that native clay, sandy clay, and gravel soils (as observed in the explorations) may be time consuming to compact due to potential difficulties in controlling the moisture content needed to obtain optimum compaction. All backfill soil should have a maximum particle size of 4 inches, a maximum Liquid Limit of 35 and a maximum Plasticity Index of 15.

If required (i.e. fill in submerged areas), we recommend that free draining granular material (clean sand and/or gravel) meet the following requirements in the table below:

Table 3: Free-Draining Fill Recommendations

Sieve Size/Other	Percent Passing (by weight)
3 inches	100
No. 10	0 – 25
No. 40	0 – 15
No. 200	0 – 5
Plasticity Index	Non-plastic

Three inch minus washed rock (sometimes called river rock or drain rock) and pea gravel materials usually meet these requirements and may be used as free draining fill. If free draining fill will be placed adjacent to soil containing a significant amount of sand or silt/clay, precautions should be taken to prevent the migration of fine soil into the free draining fill. Such precautions should include either placing a filter fabric between the free draining fill and the adjacent soil material, or using a well-graded, clean filtering material approved by the geotechnical engineer.

8.4 Fill Placement and Compaction

Fill should be placed on level, horizontal surfaces. Where fill will be placed on existing slopes steeper than 5H:1V, the existing ground should be benched prior to placing fill. We recommend bench heights of 1 to 4 feet, with the lowest bench being a minimum 3 feet below adjacent grade and at least 10 feet wide.

The thickness of each lift should be appropriate for the compaction equipment that is used. We recommend a maximum lift thickness prior to compaction of 4 inches for hand operated equipment, 6 inches for most "trench compactors" and 8 inches for larger rollers, unless it can be demonstrated by in-place density tests that the required compaction can be obtained throughout a thicker lift. The full thickness of each lift of structural fill placed should be compacted to at least the following percentages of the maximum dry density, as determined by ASTM D-1557:

- In landscape and other areas not below structurally loaded areas: 90%
- Less than 5 feet of fill below structurally loaded areas: 95%
- Between 5 and 10 feet of fill below structurally loaded areas: 98%

Generally, placing and compacting fill at moisture contents within ±2 percent of the optimum moisture content, as determined by ASTM D-1557, will facilitate compaction. Typically, the further the moisture content deviates from optimum the more difficult it will be to achieve the required compaction.

Fill should be tested frequently during placement and we recommend early testing to demonstrate that placement and compaction methods are achieving the required compaction. The contractor is responsible to ensure that fill materials and compaction efforts are consistent so that tested areas are representative of the entire fill.

8.5 Stabilization Recommendations

Near surface layers of clay were encountered during our field exploration. These soils may rut and pump during grading and construction. The likelihood of rutting and/or pumping, and the depth of disturbance, is proportional to the moisture content in the soil, the load applied to the ground surface, and the frequency of the load. Consequently, rutting and pumping can be minimized by avoiding concentrated traffic, minimizing the load applied to the ground surface by using lighter equipment, partially loaded equipment, tracked equipment, by working in dry times of the year, and/or by providing a working surface for equipment.

During grading the soil in any obvious soft spots should be removed and replaced with granular material. If rutting or pumping occurs traffic should be stopped in the area of concern. The soil in rutted areas should be removed and replaced with granular material. In areas where pumping occurs the soil should either be allowed to sit until pore pressures dissipate (several hours to several days) and the soil firms up, or be removed and replaced with granular material. Typically, we recommend removal to a minimum depth of 24 inches. For granular material, we recommend using angular well-graded gravel, such as pit run, or crushed rock with a maximum particle size of four inches. We suggest that the initial lift be approximately 12 inches thick and be compacted with a static roller-type compactor. A finer granular material such as sand, gravelly sand, sandy gravel or road base may also be used. Materials which are more angular and coarse may require thinner lifts in order to achieve compaction. We recommend that the fines content (percent passing the No. 200 sieve) be less than 15%, the liquid limit be less than 35, and the plasticity index be less than 15.

Using a geosynthetic fabric, such as Mirafi 600X or equivalent, may also reduce the amount of material required and avoid mixing of the granular material and the subgrade. If a fabric is used, following removal of disturbed soils and water, the fabric should be placed over the bottom and up the sides of the excavation a minimum of 24 inches. The fabric should be placed in accordance with the manufacturer's recommendations, including proper overlaps. The granular material should then be placed over the fabric in compacted lifts. Again, we suggest that the initial lift be approximately 12 inches thick and be compacted with a static roller-type compactor.

9.0 SLOPE STABILITY

We evaluated the overall stability of the proposed slope at the subject property. The properties of the native soils at the site were estimated using laboratory testing on samples recovered during our field investigations and our experience with similar soils. Our direct shear testing on the native Lean Clay with sand (CL) soils encountered during our field investigation indicated the soils have an internal friction angle of about 33 degrees and cohesion of about 270 psf, a saturated unit weight of 130 pcf, and a moist unit weight of 120 pcf for our analyses.

Based on tests performed by the Bureau of Reclamation[2], "clayey gravels, poorly graded graded gravel, gravel-sand-clay" have an internal friction angle greater than 31. Accordingly, we used an internal friction angle of 36 degrees, an apparent cohesion of 100 psf, a saturated unit weight of 135 pcf, and a moist unit weight of 125 pcf for our analyses. The Bureau of Reclamation also states "clayey sands, poorly graded sand-clay mixture" have an internal friction angle of 28 to 34 degrees and a cohesion value of 120 to 360 psf. Accordingly, we used an internal friction angle of 30 degrees, an apparent cohesion of 200 psf, a saturated unit weight of 120 pcf, and a moist unit weight of 115 pcf for our analyses.

For the seismic (pseudostatic) analysis, a peak horizontal ground acceleration of 0.498g for the 2% probability of exceedance in 50 years was obtained for site (grid) locations of 41.308 degrees north latitude and -111.864 degrees west longitude. Typically, one-third to one-half this value is utilized in analysis. Accordingly, a value of 0.166 was used as the pseudostatic coefficient for the stability analysis.

We evaluated the global stability of the proposed site using the computer program XSTABLE. This program uses a limit equilibrium (Bishop's modified) method for calculating factors of safety against sliding on an assumed failure surface and evaluates numerous potential failure surfaces, with the most critical failure surface identified as the one yielding

---

[2] U.S. Bureau of Reclamation, 1987, "Design Standards No. 13, Embankment Dams," Denver, Colorado.

the lowest factor of safety of those evaluated. The configuration analyzed was based on our observations during the field investigation, assumption of the foundation layout, and the elevation plans that were provided to us by Vanzeben Architecture. The configuration of the existing slope was analyzed at Cross-Section A-A'. It starts at the east portion of the property near the Nordic Valley Drive and a slight incline was modeled. The property was then relatively flat for approximately 300 feet to the west. Two foundation steps were placed approximately 10 feet in height. It was then modeled for approximately 120 feet a relatively flat area where the building will be placed. The property then sloped up hill and to the west at approximately 22 percent grade for approximately 70 feet. The property then sloped uphill and to the west at approximately 47 percent grade. A water table was conservatively placed at approximately 5 feet below the ground surface, although groundwater was encountered at approximately 5½ feet below the existing site grades in TP-1 during our field exploration.

To model the load imposed on the slope by the building, a 3,000 psf load was modeled on the slope. Typically, the required minimum factors of safety are 1.5 for static conditions and 1.0 for seismic (pseudostatic) conditions. The results of our analyses indicate that the slope configuration described above meets both these requirements. The slope stability data are attached as Figure Nos. 12 and 13, *Stability Results*. Any modifications to the slope, including the construction of retaining walls, should be properly designed and engineered.

It should be clearly understood that slope movements or even failure can occur if the slope is undermined or the slope soils become saturated. The property owner and the owner's representatives should be made aware of the risks should these or other conditions occur that could saturate or erode/undermine the soils. Surface water should be directed away from the top and bottom of the slope, the slope should be vegetated with drought resistant plants, and sprinklers should not be placed on the face of the slope.

10.0 SEISMIC AND GEOLOGIC CONSIDERATIONS

10.1 Seismic Design

The State of Utah has adopted the 2012 International Building Code (IBC) for seismic design and the structure should be designed in accordance with Chapter 16 of the IBC. The

Site Class definitions in the IBC are based upon the soil properties in the upper 100 feet of the soil profile, according to Chapter 20 in ASCE 7. These properties are determined from sampler blow counts, undrained shear strength values, and/or shear velocity measurements. The code states, "When the soil properties are not known in sufficient detail to determine the site class, Site Class D shall be used unless the building official or geotechnical data determines that Site Class E or F soil is likely to be present at the site." Considering our experience in the vicinity of the site and based on the results of our field exploration, we recommend using Site Class D.

The site is located at approximately 41.308 degrees north latitude and -111.864 degrees west longitude. Using Site Class D, the design spectral response acceleration parameters are given below.

Table 4: Design Accelerations

S_S	F_a	S_{MS}	S_{DS}
1.030 g	1.088	1.121 g	0.747 g
S_1	**F_v**	**S_{M1}**	**S_{D1}**
0.361 g	1.678	0.606 g	0.404 g

S_S = Mapped spectral acceleration for short periods
S_1 = Mapped spectral acceleration for 1-second period
$S_{DS} = \frac{2}{3}S_{MS} = \frac{2}{3}(F_a \cdot S_s)$ = 5% damped design spectral response acceleration for short periods
$S_{D1} = \frac{2}{3}S_{MS} = \frac{2}{3}(F_v \cdot S_1)$ = 5% damped design spectral response acceleration for 1-second period

10.2 Faulting

The subject property is located within the Intermountain Seismic Belt where the potential for active faulting and related earthquakes is present. Based upon published geologic maps[3], no active faults traverse through or immediately adjacent to the site and the site is not located within local fault study zones. The nearest mapped fault trace is the Ogden Valley Southwestern Marginal Fault located about 0.3 miles west of the site.

10.3 Liquefaction Potential

According to current liquefaction maps[4] for Weber County, the site is located within an area designated as "Very Low" in liquefaction potential. Liquefaction can occur when saturated subsurface soils below groundwater lose their inter-granular strength due to an increase in

---

[3] U.S. Geological Survey, Quaternary Fault and Fold Database of the United States, November 3, 2010
[4] Utah Geological Survey, Liquefaction-Potential Map For A Part Of Davis County, Utah, Public Information Series 28, August 1994

soil pore water pressures during a dynamic event such as an earthquake. As part of this study, the potential for liquefaction to occur in the soils we encountered was assessed using Youd *et al*[5] and Boulanger & Idriss[6]. Potential liquefaction-induced movements were evaluated using Tokimatsu & Seed[7] and Youd, Hansen & Bartlett[8].

Loose, saturated sands are most susceptible to liquefaction, but some loose, saturated gravels and relatively sensitive silt to low-plasticity silty clay soils can also liquefy during a seismic event. Subsurface soils were composed of clay with dense to very dense gravels. The soils encountered at this project do not appear liquefiable.

10.4 Geologic Setting

The surficial geology at the location of the subject site has been mapped as "Alluvial Fan Deposits" dated Holocene by Martin L. Sorensen and Max D. Crittenden, Jr. (1979)[9]. These deposits are labeled as Unit Qlf on the referenced map. As shown on Figure No. 1, *Vicinity Map*, the topography of the site and surrounding area generally slopes upward to the west.

11.0 FOUNDATIONS

11.1 General

The foundation recommendations presented in this report are based on the soil conditions encountered during our field exploration, the results of laboratory testing of samples of the native soils, the site grading recommendations presented in this report, and the foundation loading conditions presented in Section 3.0, *Proposed Construction*, of this report. If loading conditions and assumptions related to foundations are significantly different, Earthtec should be notified so that we can re-evaluate our design parameters and estimates (higher loads may cause more settlement), and to provide additional recommendations if necessary.

---

[5] Youd, T.L. (Chair), Idriss, I.M. (Co-Chair), and 20 other authors, 2001, Liquefaction Resistance Of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, October 2001, p. 817-833.

[6] Boulanger, R.W. and Idriss, I.M., 2006, Liquefaction Susceptibility Criteria for Silts and Clays, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, November 2006, p. 1413-1426.

[7] Tokimatsu, K. and Seed, H.B., 1987, Evaluation of Settlements in Sands due to Earthquake Shaking, Journal of Geotechnical Engineering, ASCE, p. 861-878.

[8] Youd, T.L., Hansen, C.M. and Bartlett, S.F., 2002, Revised Multilinear Regression Equations for Prediction of Lateral Spread Displacement, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, December 2002, p. 1007-1017.

[9] Geologic Map of the Huntsville Quadrangle, Weber and Cache Counties, Utah.

Conventional strip and spread footings may be used to support the proposed structures after appropriate removals as outlined in Section 8.1. Foundations should not be installed on topsoil, undocumented fill, debris, combination soils, organic soils, frozen soil, or in ponded water. If foundation soils become disturbed during construction they should be removed or recompacted.

11.2 Strip/Spread Footings

We recommend that conventional strip and spread foundations be constructed entirely on native granular soil (Well Graded Gravel with clay and sand and Poorly Graded Gravel with clay and sand) or entirely on structural fill extending to undisturbed native soils. Foundations should not be constructed on the native clay or clayey sand soils. For foundation design we recommend the following:

- Footings founded on the native gravels may be designed using a maximum allowable bearing capacity of 2,000 pounds per square foot. Footings founded on a minimum of 18 inches of structural fill may be designed using a maximum allowable bearing capacity of 2,500 pounds per square foot. The values for vertical foundation pressure can be increased by one-third for wind and seismic conditions per Section 1806.1 when used with the Alternative Basic Load Combinations found in Section 1605.3.2 of the 2012 International Building Code.

- Continuous and spot footings should be uniformly loaded and should have a minimum width of 20 and 30 inches, respectively.

- Exterior footings should be placed below frost depth which is determined by local building codes. In general 30 inches of cover is adequate for most sites; however local code should be verified by the end design professional. Interior footings, not subject to frost (heated structures), should extend at least 18 inches below the lowest adjacent grade.

- Foundation walls and footings should be properly reinforced to resist all vertical and lateral loads and differential settlement.

- The bottom of footing excavations should be compacted with at least 4 passes of an approved non-vibratory roller prior to erection of forms or placement of structural fill to densify soils that may have been loosened during excavation and to identify soft spots. If soft areas are encountered, they should be stabilized as recommended in Section 8.5.

- Footing excavations should be observed by the geotechnical engineer prior to beginning footing construction to evaluate whether suitable bearing soils have been exposed and whether excavation bottoms are free of loose or disturbed soils.

- Due to the varying soils and to reduce differential settlement, we anticipate that structural fill will be needed on all exterior and interior footings.

- Due to the possibility of shallow groundwater conditions encountered at the site, clean 1- to 2-inch clean gravel may be used in conjunction with a filter fabric, such as Mirafi 140N or equivalent, which should be placed between the native soils and the clean gravel (additional recommendations for placing clean gravel and stabilization and filter fabric are given in Section 8.3 and 8.5 of this report).

- Structural fill used below foundations should extend laterally a minimum of 6 inches for every 12 vertical inches of structural fill placed. For example, if 18 inches of structural fill are required to bring the excavation to footing grade, the structural fill should extend laterally a minimum of 9 inches beyond the edge of the footings on both sides.

11.3 Estimated Settlements

If the proposed foundations are properly designed and constructed using the parameters provided above, we estimate that total settlements should not exceed one inch and differential settlements should be one-half of the total settlement over a 25-foot length of continuous foundation, for non-earthquake conditions. Additional settlement could occur during a seismic event due to ground shaking, if more than 2 feet of grading fill is placed above the existing ground surface.

11.4 Lateral Earth Pressures

Below grade walls act as soil retaining structures and should be designed to resist pressures induced by the backfill soils. The lateral pressures imposed on a retaining structure are dependent on the rigidity of the structure and its ability to resist rotation. Most retaining walls that can rotate or move slightly will develop an active lateral earth pressure condition. Structures that are not allowed to rotate or move laterally, such as subgrade basement walls, will develop an at-rest lateral earth pressure condition. Lateral pressures applied to structures may be computed by multiplying the vertical depth of backfill material by the appropriate equivalent fluid density. Any surcharge loads in excess of the soil weight applied to the backfill should be multiplied by the appropriate lateral pressure coefficient and added to the soil pressure. For static conditions the resultant forces is applied at about one-third the wall height (measured from bottom of wall). For seismic conditions, the resultant forces are applied at about two-third times the height of the wall both measured from the bottom of the wall. The lateral pressures presented in the table below are based on drained, horizontally placed native soils as backfill material using a 28° friction angle and a dry unit weight of 120 pcf.

Table 5: Lateral Earth Pressures (Static and Dynamic)

Condition	Case	Lateral Pressure Coefficient	Equivalent Fluid Pressure (pcf)
Active	Static	0.36	43
	Seismic	0.54	65
At-Rest	Static	0.53	64
	Seismic	0.74	88
Passive	Static	2.77	332
	Seismic	3.36	403

*Seismic values combine the static and dynamic values

These pressure values do not include any surcharge, and are based on a relatively level ground surface at the top of the wall and drained conditions behind the wall. It is important that water is not allowed to build up (hydrostatic pressures) behind retaining structures. Retaining walls should incorporate drainage behind the walls as appropriate, and surface water should be directed away from the top and bottom of the walls.

Lateral loads are typically resisted by friction between the underlying soil and footing bottoms. Resistance to sliding may incorporate the friction acting along the base of foundations, which may be computed using a coefficient of friction of soils against concrete of 0.55 for native gravels and structural fill meeting the recommendations presented herein. For allowable stress design, the lateral resistance may be computed using Section 1807 of the 2012 International Building Code and all sections referenced therein. Retaining wall lateral resistance design should further reference Section 1807.2.3 for reference of Safety Factors. Retaining systems are assumed to be founded upon and backfilled with granular structural fill. The values for lateral foundation pressure can be increased by one-third for wind and seismic conditions per Section 1806.1 when used with the Alternative Basic Load Combinations found in Section 1605.3.2 of the 2012 International Building Code.

The pressure and coefficient values presented above are ultimate; therefore an appropriate factor of safety may need to be applied to these values for design purposes. The appropriate factor of safety will depend on the design condition and should be determined by the project structural engineer.

12.0 FLOOR SLABS AND FLATWORK

Concrete floor slabs and exterior flatwork may be supported on native soils after appropriate removals and grading as outlined in Section 8.1 are completed. We recommend placing a minimum 6 inches of free-draining fill material (see Section 8.3) beneath floor slabs to facilitate construction, act as a capillary break, and aid in distributing floor loads. For exterior flatwork, we recommend placing a minimum 4 inches of roadbase material. Prior to placing the free-draining fill or roadbase materials, the native subgrade should be proof-rolled to identify soft spots, which should be stabilized as discussed above in Section 8.5.

For slab design, we recommend using a modulus of subgrade reaction of 110 pounds per cubic inch. The thickness of slabs supported directly on the ground shall not be less than 3½ inches. A 6-mil polyethylene vapor retarder with joints lapped not less than 6 inches shall be placed between the ground surface and the concrete, as per Section 1907 of the 2012 International Building Code. To help control normal shrinkage and stress cracking, we recommend that floor slabs have adequate reinforcement for the anticipated floor loads with the reinforcement continuous through interior floor joints, frequent crack control joints, and non-rigid attachment of the slabs to foundation and bearing walls. Special precautions should be taken during placement and curing of all concrete slabs and flatwork. Excessive slump (high water-cement ratios) of the concrete and/or improper finishing and curing procedures used during hot or cold weather conditions may lead to excessive shrinkage, cracking, spalling, or curling of slabs. We recommend all concrete placement and curing operations be performed in accordance with American Concrete Institute (ACI) codes and practices.

13.0 DRAINAGE

13.1 Surface Drainage

As part of good construction practice, precautions should be taken during and after construction to reduce the potential for water to collect near foundation walls. Accordingly, we recommend the following:

- Adequate compaction of foundation backfill should be provided i.e. a minimum of 90% of ASTM D-1557. Water consolidation methods should not be used.

- The ground surface should be graded to drain away from the building in all directions. We recommend a minimum fall of 8 inches in the first 10 feet.
- Roof runoff should be collected in rain gutters with downspouts designed to discharge well outside of the backfill limits, or at least 10 feet from foundations, whichever is greater.
- Sprinklers should be aimed away, and all sprinkler components (valves, lines, sprinkler heads) should be placed at least 5 feet from foundation walls. Sprinkler systems should be well maintained, checked for leaks frequently, and repaired promptly. Overwatering at any time should be avoided.
- Any additional precautions which may become evident during construction.

13.2 Subsurface Drainage

Due to the presence of shallow groundwater and constructing an underground parking structure, we recommend placing a foundation drain system. The recommendations presented below should be followed during design and construction of the foundation drains:

- A perforated 4-inch minimum diameter pipe should be enveloped in at least 12 inches of free-draining gravel and placed adjacent to the perimeter footings. The perforations should be oriented such that they are not located on the bottom side of the pipe, as much as possible. The free-draining gravel should consist of primarily ¾- to 2-inch size gravel having less than 5 percent passing the No. 4 sieve, and should be wrapped with a separation fabric such as Mirafi 140N or equivalent.
- The highest point of the perforated pipe bottom should be equal to the bottom elevation of the footings. The pipe should be uniformly graded to drain to an appropriate outlet (storm drain, land drain, other gravity outlet, etc.) or to one or more sumps where water can be removed by pumping.
- To facilitate drainage beneath basement floor slabs we recommend that the minimum thickness of free-draining fill beneath the slabs be increased to at least 10 inches (approximately equal to the bottom of footing elevations). A separation fabric such as Mirafi 140N or equivalent should be placed beneath the free-draining gravel. Connections should be made to allow any water beneath the slabs to reach the perimeter foundation drain.
- The drain system should be periodically inspected and clean-outs should be installed for the foundation drain to allow occasional cleaning/purging, as needed. Proper drain operation depends on proper construction and maintenance.

14.0 GENERAL CONDITIONS

The exploratory data presented in this report was collected to provide geotechnical design recommendations for this project. The explorations may not be indicative of subsurface conditions outside the study area or between points explored and thus have a limited value in depicting subsurface conditions for contractor bidding. Variations from the conditions portrayed in the test pits and test hole may occur and which may be sufficient to require modifications in the design. If during construction, conditions are different than presented in this report, Earthtec should be advised immediately so that the appropriate modifications can be made.

The findings and recommendations presented in this geotechnical report were prepared in accordance with generally accepted geotechnical engineering principles and practice in this area of Utah at this time. No warranty or representation is intended in our proposals, contracts, letters, or reports.

This geotechnical report is based on relatively limited subsurface explorations and laboratory testing. Subsurface conditions may differ in some locations of the site from those described herein, which may require additional analyses and possibly modified recommendations. Thus we strongly recommend consulting with Earthtec regarding any changes made during design and construction of the project from those discussed herein. Failure to consult with Earthtec regarding any such changes relieves Earthtec from any liability arising from changed conditions at the site.

To maintain continuity, Earthtec should also perform materials testing and special inspections for this project. The recommendations presented herein are based on the assumption that an adequate program of tests and observations will be followed during construction to verify compliance with our recommendations. We also assume that we will review the project plans and specifications to verify that our conclusions and recommendations are incorporated and remain appropriate (based on the actual design). Earthtec should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Earthtec also should be retained to provide observation and testing services during grading, excavation, foundation construction, and other earth-related construction phases of the project.

We appreciate the opportunity of providing our services on this project. If we can answer questions or be of further service, please contact Earthtec at your convenience.

Respectfully Submitted,
EARTHTEC ENGINEERING

Shawn A. Stuart

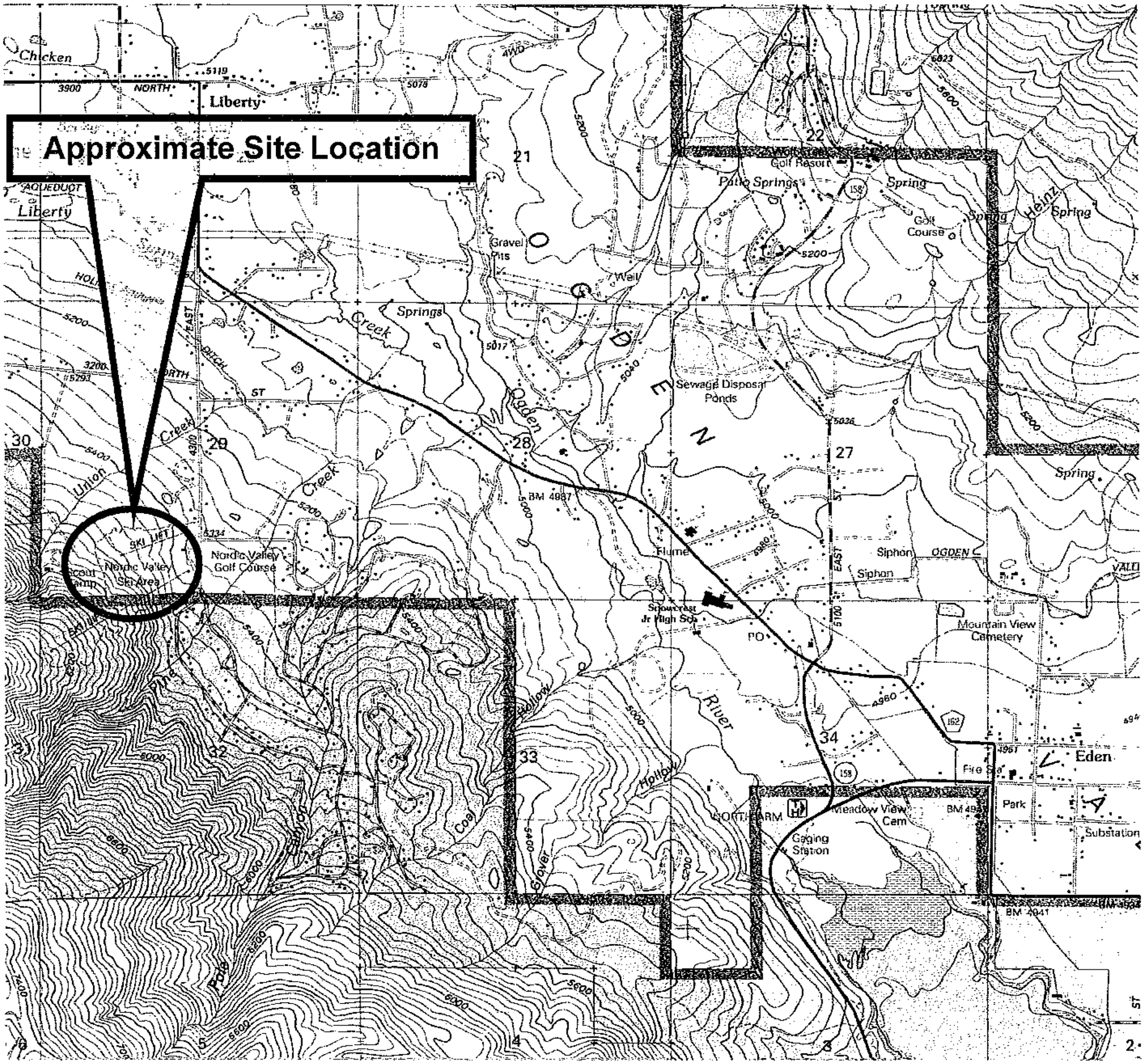
Shawn A. Stuart, E.I.T.
Staff Geotechnical Engineer

No. 5567049-2202
TIMOTHY ALLAN MITCHELL
10/29/14

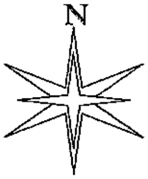
Timothy A. Mitchell, P.E.
Geotechnical Engineer

VICINITY MAP

NORDIC VALLEY CONDOS
APPROXIMATELY 3567 EAST NORDIC VALLEY ROAD
EDEN, UTAH



(cida.usgs.gov)

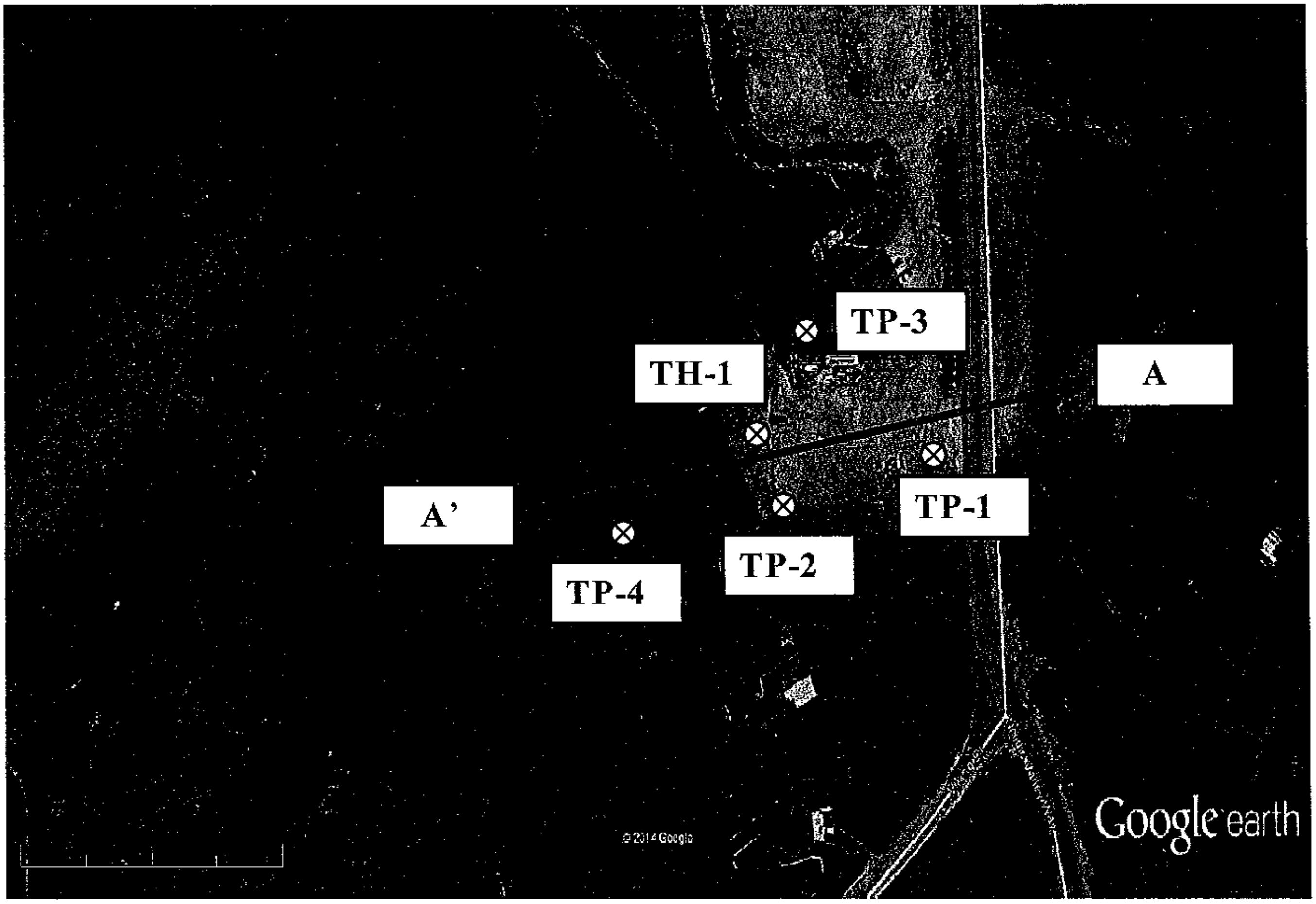


Not to Scale

PROJECT NO.: 145167G	Earthtec Engineering	**FIGURE NO.:** 1

AERIAL PHOTOGRAPH SHOWING LOCATION OF TEST PITS, TEST HOLE, AND SLOPE CROSS-SECTION

NORDIC VALLEY CONDOS
APPROXIMATELY 3567 EAST NORDIC VALLEY ROAD
EDEN, UTAH



⊗ **Approximate Location of Test Pits and Test Hole**

\ **Approximate Slope Cross-Section Analyzed**

(Aerial photograph provided by Google Earth)

N

Not to Scale

PROJECT NO.: 145167G	Earthtec Engineering	**FIGURE NO.:** 2

TEST PIT LOG
NO.: TP-1

PROJECT: Nordic Valley Condos
CLIENT: Nordic Valley Ski Resort
LOCATION: See Figure 2
OPERATOR: Client
EQUIPMENT: Rubber-tire Backhoe
DEPTH TO WATER; INITIAL ∇ : 5.5 ft.

PROJECT NO.: 145167G
DATE: 06/17/14
ELEVATION: Not Measured
LOGGED BY: S. Stuart
AT COMPLETION ▼ :

					TEST RESULTS							
Depth (Ft.)	Graphic Log	USCS	Description	Samples	Water Cont. (%)	Dry Dens. (pcf)	LL	PI	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0	▩		FILL, consisting of sand and gravel, moist, brown									
1	▒		TOPSOIL, clay, minor sand and gravel, moist, black, organic rich									
2	▨		Lean CLAY with sand, stiff (estimated), moist, gray to light brown, moderate iron oxide staining below 2½ feet, some cobbles up to 6 inches in diameter									
3												
4												
5		CL	∇	■	22		35	16	1	18	81	
6												
7												
8	▨		Poorly Graded GRAVEL with clay and sand, very dense (estimated), moist, light brown, moderate cobbles up to 8 inches in diameter									
9				☒								
10		GP-GC										
11			MAXIMUM DEPTH EXPLORED APPROXIMATELY 11½ FEET									
12												
13												
14												

Notes: Groundwater encountered at approximately 5½ feet below adjacent ground surface during initial site investigation. Equipment refusal at 11 feet below adjacent ground surface.

Tests Key
CBR = California Bearing Ratio
C = Consolidation
R = Resistivity
DS = Direct Shear
SS = Soluble Sulfates
UC = Unconfined Compressive Strength

LOG OF TESTPIT 145167G-PIT.GPJ EARTHTEC.GDT 10/10/14

PROJECT NO.: 145167G

Earthtec Engineering

FIGURE NO.: 3

TEST PIT LOG
NO.: TP-2

PROJECT: Nordic Valley Condos
CLIENT: Nordic Valley Ski Resort
LOCATION: See Figure 2
OPERATOR: Client
EQUIPMENT: Rubber-tire Backhoe
DEPTH TO WATER; INITIAL ∇ : 9 ft.

PROJECT NO.: 145167G
DATE: 06/17/14
ELEVATION: Not Measured
LOGGED BY: S. Stuart
AT COMPLETION ▼ :

Depth (Ft.) 0	Graphic Log	USCS	Description	Samples	TEST RESULTS Water Cont. (%)	Dry Dens. (pcf)	LL	PI	Gravel (%)	Sand (%)	Fines (%)	Other Tests
			TOPSOIL, clay, moist, black, organic rich									
1			Poorly Graded GRAVEL with clay and sand, dense to very dense (estimated), dry to very moist, brown to light brown, moderate cobbles up to 8 inches in diameter, minor pinhole texture to 4 feet									
2												
3												
4				☒								
			moderate iron oxide staining below 4 feet, some sandstone particles up to 6 inches in diameter									
5												
6				☒	7		27	10	72	18	10	
		GP-GC										
7												
8												
9		∇										
10												
11												
12			MAXIMUM DEPTH EXPLORED APPROXIMATELY 12 FEET									
13												
14												

Notes: Groundwater encountered at approximately 9 feet below adjacent ground surface during initial site investigation.

Tests Key
CBR = California Bearing Ratio
C = Consolidation
R = Resistivity
DS = Direct Shear
SS = Soluble Sulfates
UC = Unconfined Compressive Strength

PROJECT NO.: 145167G

Earthtec Engineering

FIGURE NO.: 4

TEST PIT LOG

NO.: TP-3

PROJECT: Nordic Valley Condos
CLIENT: Nordic Valley Ski Resort
LOCATION: See Figure 2
OPERATOR: Client
EQUIPMENT: Rubber-tire Backhoe
DEPTH TO WATER; INITIAL ∇ **:** 8 ft.

PROJECT NO.: 145167G
DATE: 06/17/14
ELEVATION: Not Measured
LOGGED BY: S. Stuart
AT COMPLETION ▼ **:**

Depth (Ft.) 0	Graphic Log	USCS	Description	Samples	Water Cont. (%)	Dry Dens. (pcf)	LL	PI	Gravel (%)	Sand (%)	Fines (%)	Other Tests
1 2			TOPSOIL, clay, slightly moist to dry, dark brown, organic rich									
3 4		CL	Lean Clay with sand, stiff (estimated), moist, light brown, moderate to heavy iron oxide staining, minor thin root material	■								
5 6 7 8 9		GP-GC	Poorly Graded GRAVEL with clay and sand, dense to very dense, very moist, light brown, cobbles up to 6 inches in diameter ∇	☒								
10 11		CL	Sandy Lean CLAY, stiff (estimated), moist, light brown	■	25	96	38	17	11	29	60	C
12 13 14			MAXIMUM DEPTH EXPLORED APPROXIMATELY 11 FEET									

Notes: Groundwater encountered at approximately 8 feet below adjacent ground surface during initial site investigation.

Tests Key
CBR = California Bearing Ratio
C = Consolidation
R = Resistivity
DS = Direct Shear
SS = Soluble Sulfates
UC = Unconfined Compressive Strength

PROJECT NO.: 145167G

Earthtec Engineering

FIGURE NO.: 5

TEST PIT LOG
NO.: TP-4

PROJECT: Nordic Valley Condos
CLIENT: Nordic Valley Ski Resort
LOCATION: See Figure 2
OPERATOR: Client
EQUIPMENT: Rubber-tire Backhoe
DEPTH TO WATER; INITIAL ▽ **:**

PROJECT NO.: 145167G
DATE: 06/17/14
ELEVATION: Not Measured
LOGGED BY: S. Stuart
AT COMPLETION ▼ **:**

Depth (Ft.)	Graphic Log	USCS	Description	Samples	TEST RESULTS							
					Water Cont. (%)	Dry Dens. (pcf)	LL	PI	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0			TOPSOIL, clayey sand, dry to slightly moist, brown, organic rich									
1 2 3 4		SC	Clayey SAND with gravel, dense (estimated), slightly moist, light brown, moderate thin root material	▮	12	111	30	13	18	51	31	C
5		SANDSTONE	SANDSTONE, moderately hard (estimated), dry, light brown	☒								
6 7 8 9 10 11 12 13 14			MAXIMUM DEPTH EXPLORED APPROXIMATELY 5½ FEET									

Notes: No groundwater encountered. Equipment refusal at 5½ feet below adjacent ground surface.

Tests Key
CBR = California Bearing Ratio
C = Consolidation
R = Resistivity
DS = Direct Shear
SS = Soluble Sulfates
UC = Unconfined Compressive Strength

PROJECT NO.: 145167G

Earthtec Engineering

FIGURE NO.: 6

TEST HOLE LOG

NO.: TH-1

PROJECT: Nordic Valley Condo
CLIENT: Nordic Valley Ski Resort
LOCATION: See Figure 2
OPERATOR: Great Basin Drilling, Inc.
EQUIPMENT: Mobile B-35
DEPTH TO WATER; INITIAL ∇ : 14 ft.

PROJECT NO.: 145167G
DATE: 06/18/14
ELEVATION: Not Measured
LOGGED BY: S. Stuart
AT COMPLETION ▼ :

Depth (Ft.) 0	Graphic Log	USCS	Description	Samples	TEST RESULTS Blows per foot	Water Cont. (%)	Dry Dens. (pcf)	LL	PI	Gravel (%)	Sand (%)	Fines (%)	Pocket Penet. (psf)	Other Tests
	▩		FILL, consisting of clay with gravel, very moist to moist, brown											
	▨	CL	Lean CLAY, very stiff, slightly moist, light brown, moderate iron oxide staining											
3	▨			◣	19									
	▨			◣	76									
6	▦	GW-GC	Well Graded GRAVEL with clay and sand, dense to very dense, slightly moist to very moist, light brown											
9	▦													
	▦			⧗	51									
12	▦													
	▦			⧗	76	8		22	7	59	30	11		
	▦		∇											
15	▦													
	▦			⧗	60									

Notes: Groundwater encountered at approximately 14 feet below existing site grades during initial site investigation.

Tests Key
CBR = California Bearing Ratio
C = Consolidation
R = Resistivity
DS = Direct Shear
SS = Soluble Sulfates
UC = Unconfined Compressive Strength

PROJECT NO.: 145167G

Earthtec Engineering

FIGURE NO.: 7a

TEST HOLE LOG

NO.: TH-1

PROJECT: Nordic Valley Condo
CLIENT: Nordic Valley Ski Resort
LOCATION: See Figure 2
OPERATOR: Great Basin Drilling, Inc.
EQUIPMENT: Mobile B-35
DEPTH TO WATER; INITIAL ∇ : 14 ft.

PROJECT NO.: 145167G
DATE: 06/18/14
ELEVATION: Not Measured
LOGGED BY: S. Stuart
AT COMPLETION ▼ :

Depth (Ft.)	Graphic Log	USCS	Description	Samples	TEST RESULTS Blows per foot	Water Cont. (%)	Dry Dens. (pcf)	LL	PI	Gravel (%)	Sand (%)	Fines (%)	Pocket Penet. (psf)	Other Tests
18		SANDSTONE	SANDSTONE, Moderately soft, dry, olive											
					50/1									
21														
24		GC	Clayey GRAVEL with sand, medium dense, moist, olive		32									
						14		25	11	39	32	29		
27		CL	Lean CLAY with sand, very stiff, moist, gray											
						25		36	19	4	24	72		DS
30					16									
33			MAXIMUM DEPTH EXPLORED APPROXIMATELY 31½ FEET											

Notes: Groundwater encountered at approximately 14 feet below existing site grades during initial site investigation.

Tests Key

CBR= California Bearing Ratio
C = Consolidation
R = Resistivity
DS = Direct Shear
SS = Soluble Sulfates
UC = Unconfined Compressive Strength

PROJECT NO.: 145167G

Earthtec Engineering

FIGURE NO.: 7b

LEGEND

PROJECT: Nordic Valley Condos
CLIENT: Nordic Valley Ski Resort
DATE: 06/17/14 - 06/18/14
LOGGED BY: S. Stuart

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR SOIL DIVISIONS			USCS SYMBOL		TYPICAL SOIL DESCRIPTIONS
COARSE GRAINED SOILS (More than 50% retaining on No. 200 Sieve)	GRAVELS (More than 50% of coarse fraction retained on No. 4 Sieve)	CLEAN GRAVELS (Less than 5% fines)	○	GW	Well Graded Gravel, May Contain Sand, Very Little Fines
			○	GP	Poorly Graded Gravel, May Contain Sand, Very Little Fines
		GRAVELS WITH FINES (More than 12% fines)	○	GM	Silty Gravel, May Contain Sand
			▨	GC	Clayey Gravel, May Contain Sand
	SANDS (50% or more of coarse fraction passes No. 4 Sieve)	CLEAN SANDS (Less than 5% fines)	░	SW	Well Graded Sand, May Contain Gravel, Very Little Fines
			░	SP	Poorly Graded Sand, May Contain Gravel, Very Little Fines
		SANDS WITH FINES (More than 12% fines)	▥	SM	Silty Sand, May Contain Gravel
			▨	SC	Clayey Sand, May Contain Gravel
FINE GRAINED SOILS (More than 50% passing No. 200 Sieve)	SILTS AND CLAYS (Liquid Limit less than 50)		▨	CL	Lean Clay, Inorganic, May Contain Gravel and/or Sand
			▥	ML	Silt, Inorganic, May Contain Gravel and/or Sand
			☰	OL	Organic Silt or Clay, May Contain Gravel and/or Sand
	SILTS AND CLAYS (Liquid Limit Greater than 50)		▨	CH	Fat Clay, Inorganic, May Contain Gravel and/or Sand
			▥	MH	Elastic Silt, Inorganic, May Contain Gravel and/or Sand
			≋	OH	Organic Clay or Silt, May Contain Gravel and/or Sand
HIGHLY ORGANIC SOILS			ψ	PT	Peat, Primarily Organic Matter

SAMPLER DESCRIPTIONS

◩	SPLIT SPOON SAMPLER (1 3/8 inch inside diameter)
⧗	MODIFIED CALIFORNIA SAMPLER (2 inch outside diameter)
▥	SHELBY TUBE (3 inch outside diameter)
◨	BLOCK SAMPLE
☒	BAG/BULK SAMPLE

WATER SYMBOLS

▽	Water level encountered during field exploration
▼	Water level encountered at completion of field exploration

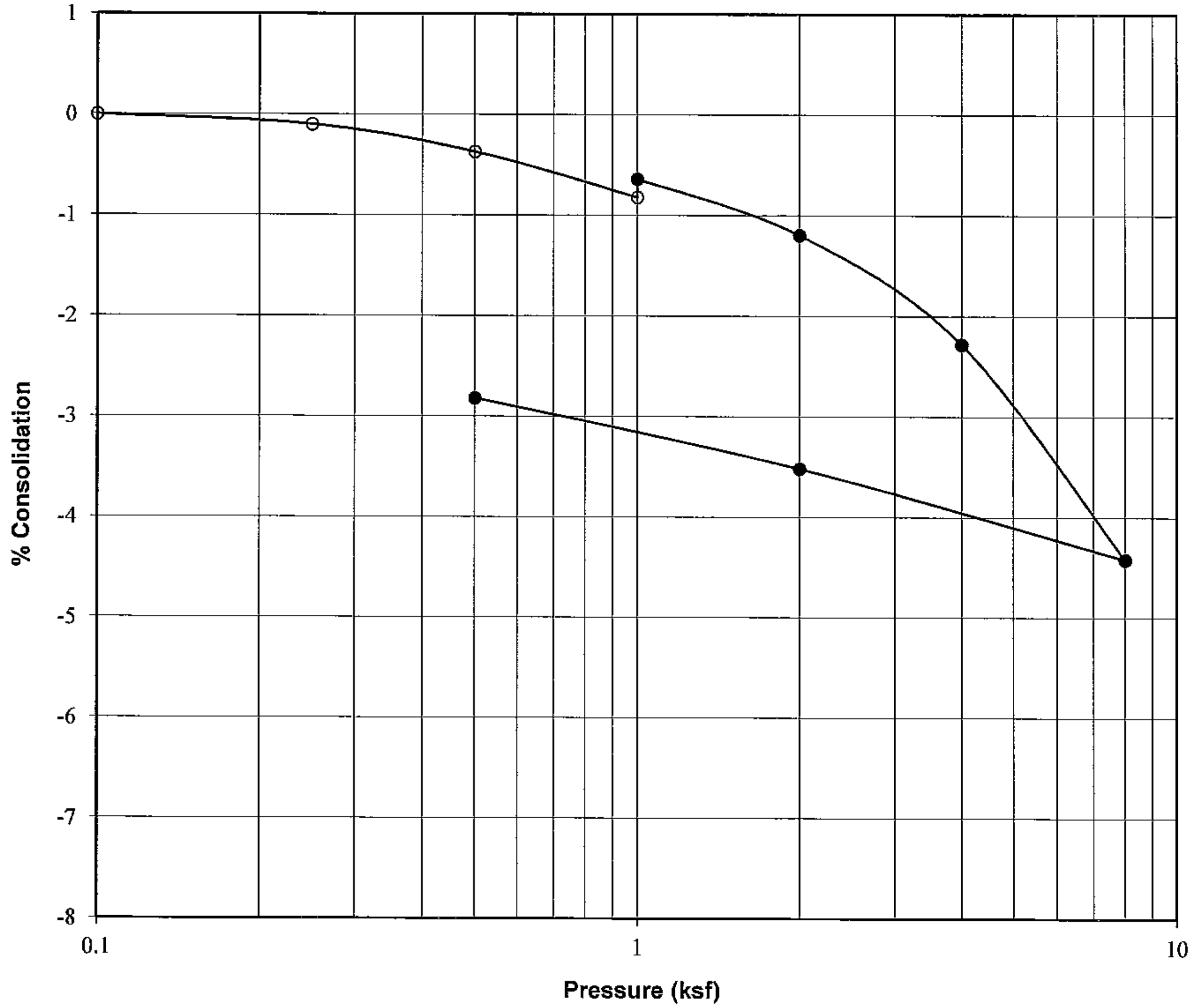
NOTES:
1. The logs are subject to the limitations, conclusions, and recommendations in this report.
2. Results of tests conducted on samples recovered are reported on the logs and any applicable graphs.
3. Strata lines on the logs represent approximate boundaries only. Actual transitions may be gradual.
4. In general, USCS symbols shown on the logs are based on visual methods only: actual designations (based on laboratory tests) may vary.

PROJECT NO.: 145167G

Earthtec Engineering

FIGURE NO.: 8

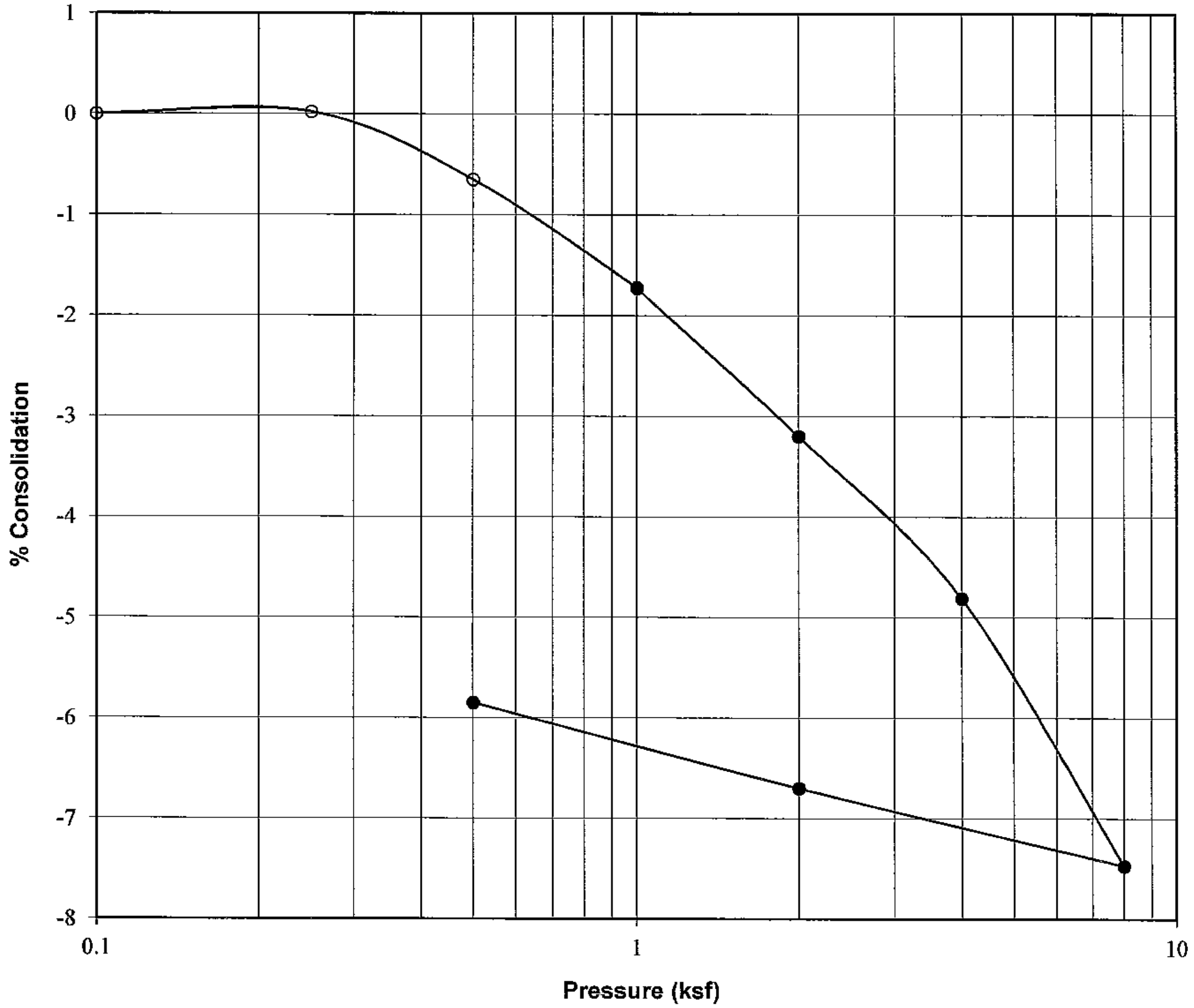
CONSOLIDATION - SWELL TEST



Project:	Nordic Valley Condos
Location:	TP-3
Sample Depth, ft:	10
Description:	Block
Soil Type:	Sandy Lean CLAY (CL)
Natural Moisture, %:	25
Dry Density, pcf:	96
Liquid Limit:	38
Plasticity Index:	17
Water Added at:	1 ksf
Percent Swell:	0.2

PROJECT NO.: 145167G	Earthtec Engineering	**FIGURE NO.:** 9

CONSOLIDATION - SWELL TEST



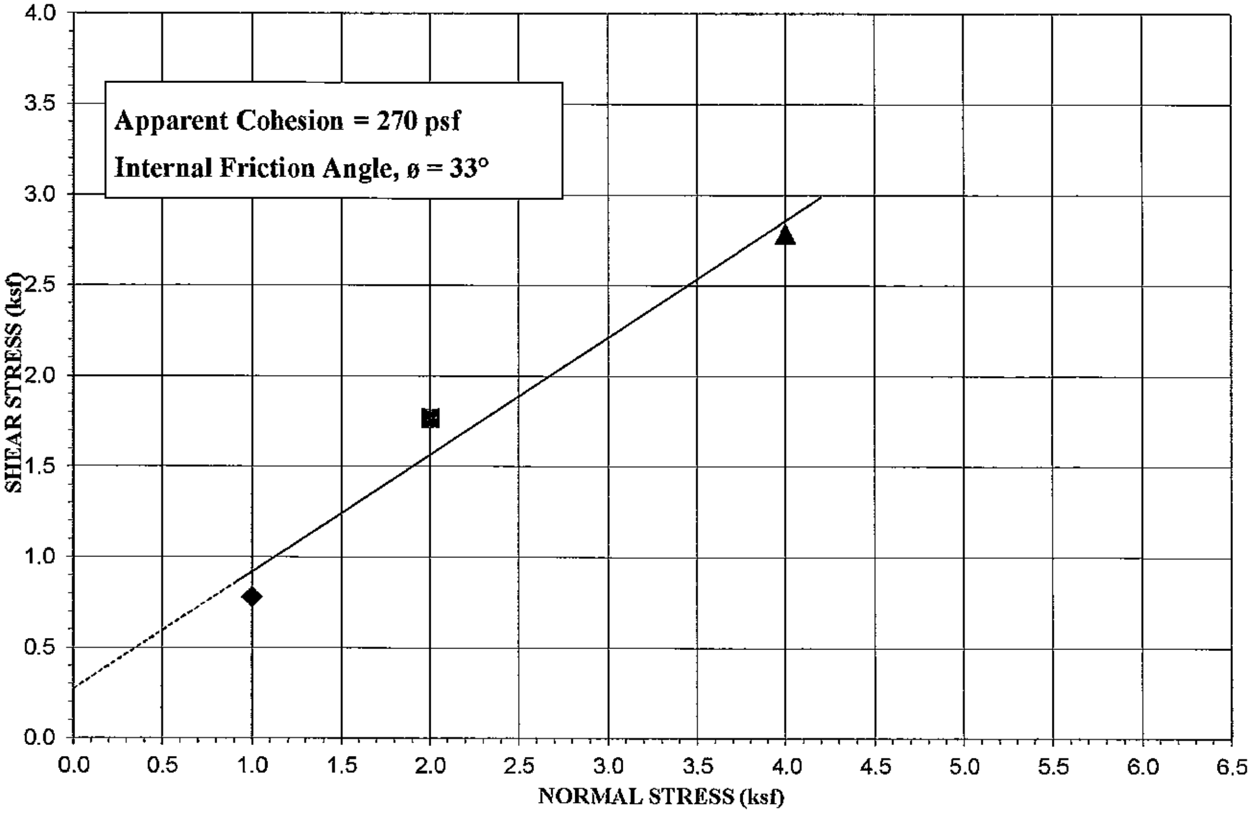
Project:	Nordic Valley Condos
Location:	TP-4
Sample Depth, ft:	4
Description:	Block
Soil Type:	Clayey SAND with gravel (SC)
Natural Moisture, %:	12
Dry Density, pcf:	111
Liquid Limit:	30
Plasticity Index:	13
Water Added at:	1 ksf
Percent Collapse:	0.0

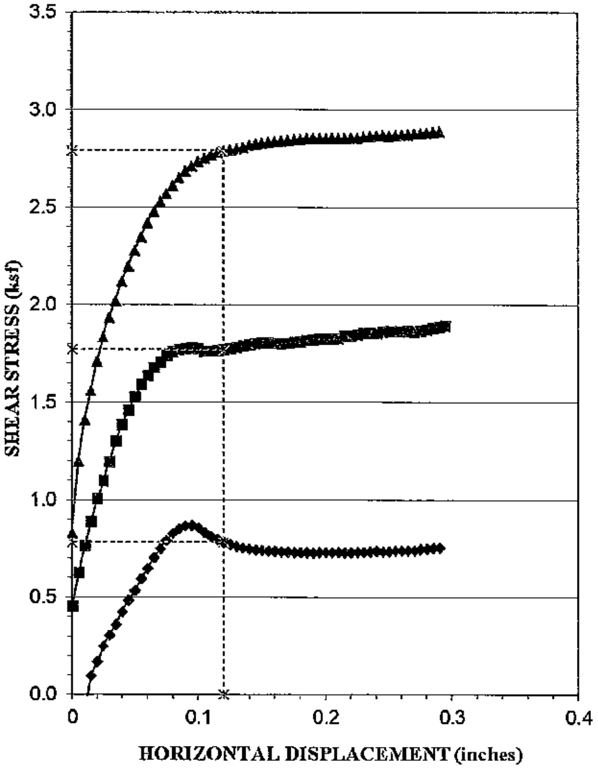
PROJECT NO.: 145167G

Earthtec Engineering

FIGURE NO.: 10

DIRECT SHEAR TEST





Source: TH-1	**Depth:** 27.5 ft		
Type of Test:	Consolidated Drained/Saturated		
Test No. (Symbol)	**1 (◆)**	**2 (■)**	**3 (▲)**
Sample Type	Undisturbed		
Initial Height, in.	1	1	1
Diameter, in.	2.4	2.4	2.4
Dry Density Before, pcf	98.1	101.4	100.0
Dry Density After, pcf	103.3	106.8	105.6
Moisture % Before	25.2	25.2	25.2
Moisture % After	25.0	24.4	22.9
Normal Load, ksf	1.0	2.0	4.0
Shear Stress, ksf	0.78	1.77	2.79
Strain Rate	.00005246 IN/SEC		

Sample Properties	
Cohesion, psf	270
Friction Angle, ϕ	33
Liquid Limit, %	36
Plasticity Index, %	19
Percent Gravel	4
Percent Sand	24
Percent Passing No. 200 sieve	72
Classification	Lean CLAY with sand (CL)

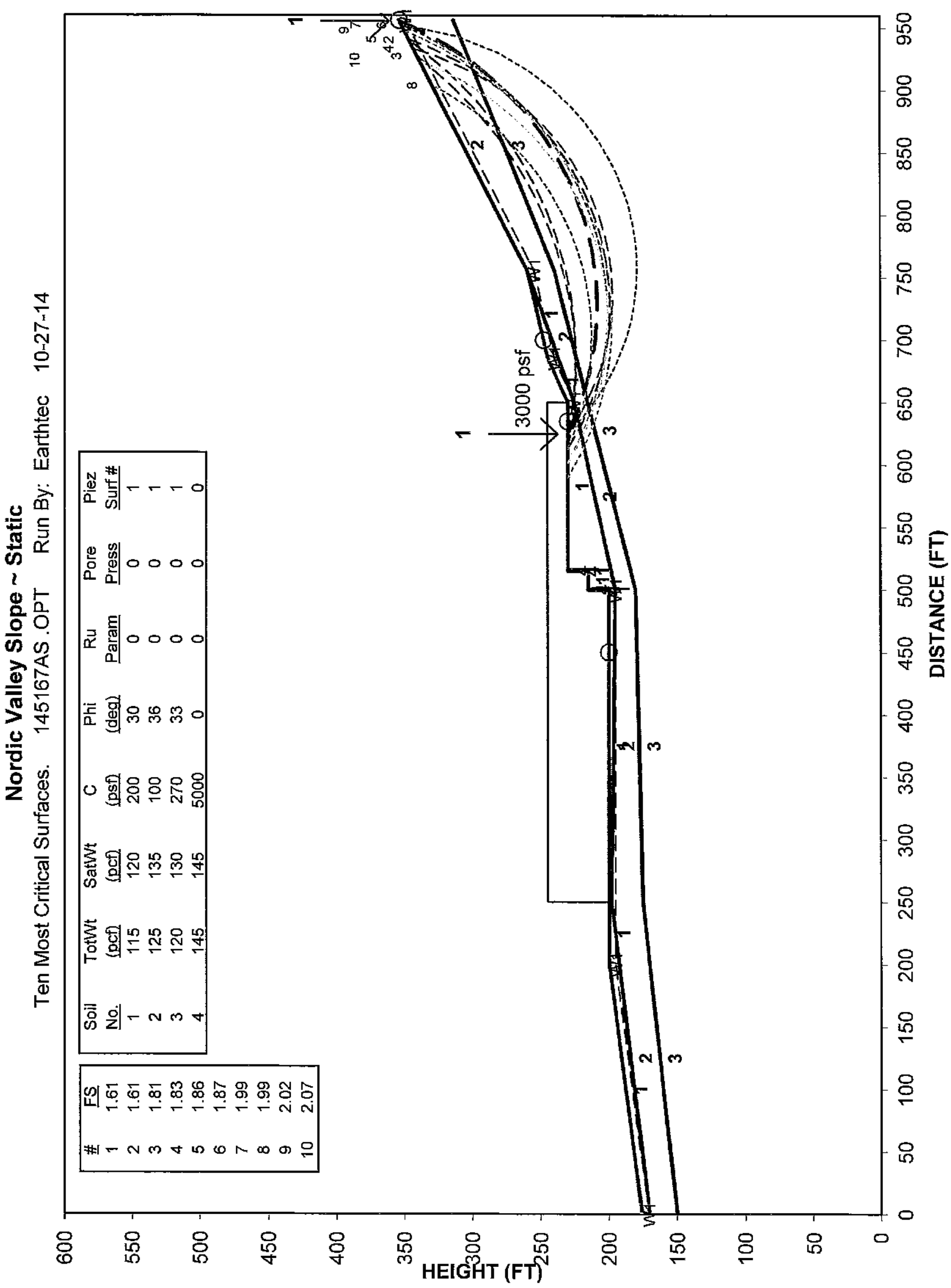
PROJECT: Nordic Valley Condos

PROJECT NO.: 145167G

Earthtec Engineering

FIGURE NO.: 11

STABILITY RESULTS



Nordic Valley Slope ~ Static

Ten Most Critical Surfaces. 145167AS.OPT Run By: Earthtec 10-27-14

#	FS
1	1.61
2	1.61
3	1.81
4	1.83
5	1.86
6	1.87
7	1.99
8	1.99
9	2.02
10	2.07

Soil No.	TotWt (pcf)	SatWt (pcf)	C (psf)	Phi (deg)	Ru Param	Pore Press	Piez Surf #
1	115	120	200	30	0	0	1
2	125	135	100	36	0	0	1
3	120	130	270	33	0	0	1
4	145	145	5000	0	0	0	0

PROJECT NO.: 145167

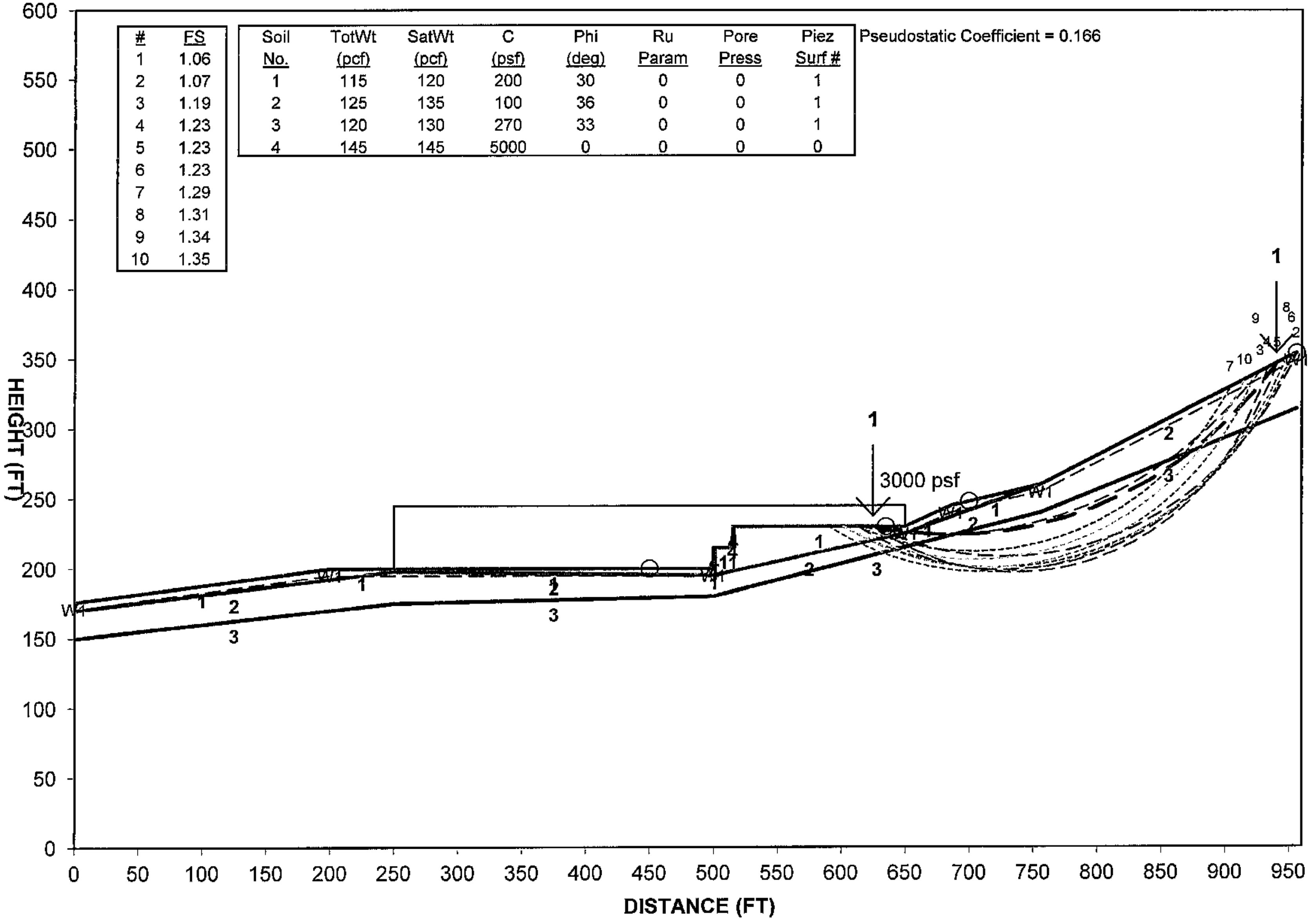
Earthtec Engineering

FIGURE NO.: 12

STABILITY RESULTS

Nordic Valley Slope ~ Seismic

Ten Most Critical Surfaces. 145167AD .OPT Run By: Earthtec 10-27-14



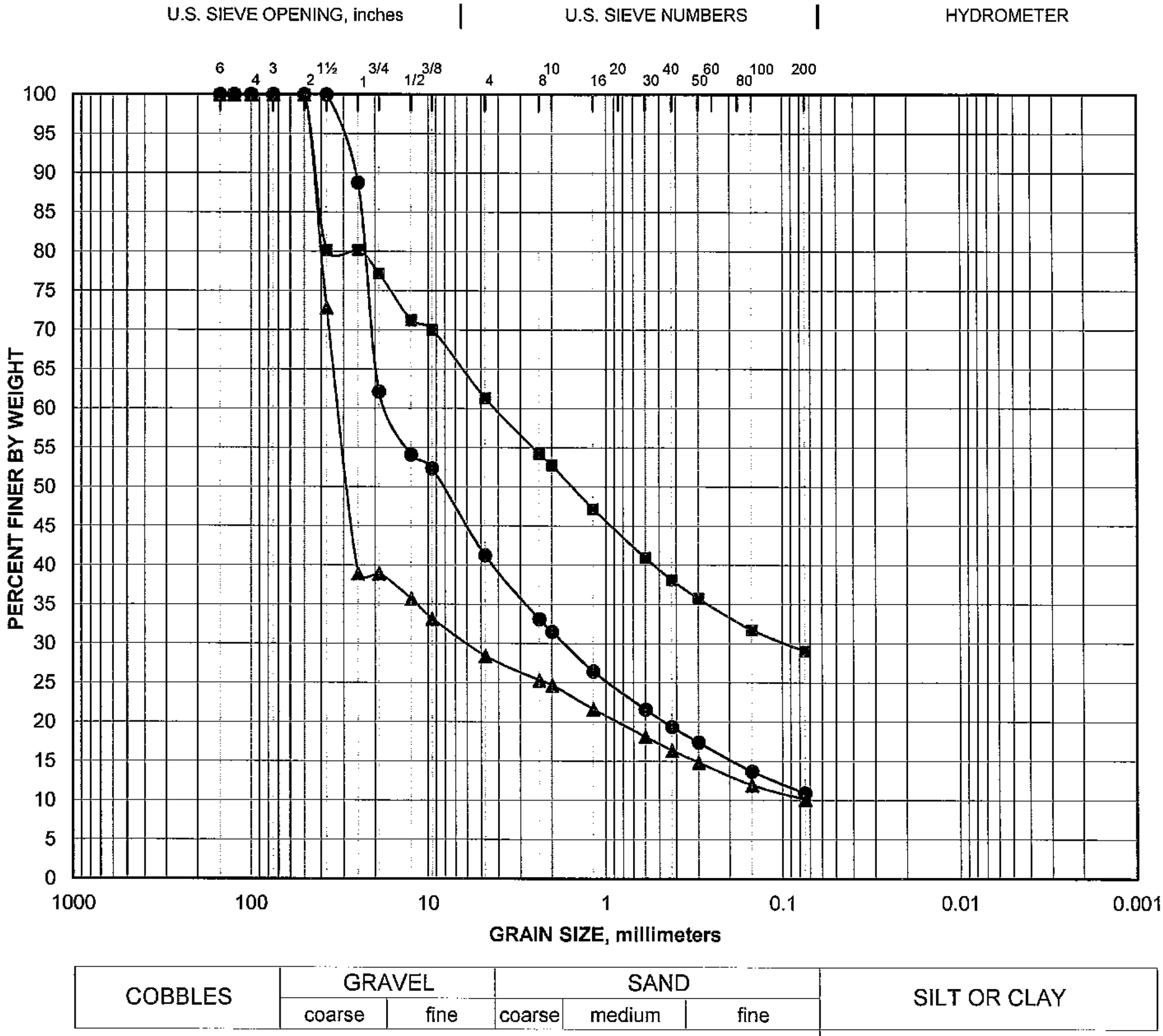
#	FS
1	1.06
2	1.07
3	1.19
4	1.23
5	1.23
6	1.23
7	1.29
8	1.31
9	1.34
10	1.35

Soil No.	TotWt (pcf)	SatWt (pcf)	C (psf)	Phi (deg)	Ru Param	Pore Press	Piez Surf #
1	115	120	200	30	0	0	1
2	125	135	100	36	0	0	1
3	120	130	270	33	0	0	1
4	145	145	5000	0	0	0	0

PROJECT NO.: 145167

FIGURE NO.: 13

GRAIN SIZE DISTRIBUTION



Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
●	TH-1 @ 12½'	Well Graded GRAVEL with clay and sand (GW-GC)	8	22	15	7	2.9	287
■	TH-1 @ 25'	Clayey GRAVEL with sand (GC)	14	25	14	11		
▲	TP-2 @ 5½'	Poorly Graded GRAVEL with clay and sand (GC)	7	27	17	10	15.5	449
◆								
x								

Specimen Identification		D100	D85	D60	D30	D15	D10	%Gravel	%Sand	%Silt	%Clay
●	TH-1 @ 12½'	150	24.1	17.0	1.71	0.191		59	30	11	
■	TH-1 @ 25'	150	40.2	4.18	0.111			39	32	29	
▲	TP-2 @ 5½'	150	42.7	32.2	5.97	0.312		72	18	10	
◆											
x											

PROJECT NO.: 145167G

Earthtec Engineering

FIGURE NO.: 14