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GEOTECHNICAL STUDY
ALPINE SCHOOL DISTRICT
LEHI ANNEXATION
APPROXIMATELY 7730 NORTH 8730 WEST
LEHI, UTAH

1100 West School

Project No. 130230

February 25, 2013

Prepared For:

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1.0 EXECUTIVE SUMMARY

This report presents the results of our geotechnical study for the Alpine School District Lehi Annexation located at approximately 7730 North 8730 West in Lehi, Utah. We understand the proposed building, as currently planned, will consist of a one story structure, including an asphalt parking lot and drive areas.

For the field exploration, we drilled a total of 3 test holes to depths of 18 to 46.5 feet below the existing ground surface. Groundwater was encountered at depths of approximately 4 to 5 feet below the existing ground surface. The subsurface soils encountered generally consisted of topsoil overlying alternating layers of very soft to medium stiff clays and loose to medium dense sands. The topsoil should be removed beneath the entire building footprint and beneath exterior flatwork and pavement areas. These native clay soils have a negligible to slight potential for collapse under increased moisture and load conditions. The sand layers between depths of 14 to 18 feet in TH-1 have a moderate potential for liquefaction during a moderate to large earthquake event; should this layer liquefy, we estimate that 2 to 2¼ inches of liquefaction-induced settlement could occur.

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, provided the recommendations presented herein are followed and implemented during design and construction. Foundations at this site may be constructed on deep foundations, mat footings, or multiple span beam with suspended reinforce concrete slab. The potential for implementing structural solutions should be discussed with a competent structural engineer.

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 regarding any changes made during design and/or construction of the project from those discussed above in Section 3.0 relieves Earthtec from any liability arising from changed conditions at the site. We also strongly recommend that Earthtec observe the building excavations to verify the adequacy of our recommendations presented herein, and that Earthtec perform materials testing and special inspections for this project to provide consistency during construction.

2.0 INTRODUCTION

This report presents the results of our geotechnical study for the Alpine School District Lehi Annexation to be located at approximately 7730 North 8730 West, Lehi, Utah. The general location of the site is shown on Figure 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, miscellaneous concrete flatwork, and asphalt paved parking areas and drive lanes.

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 structure will be a one story building constructed of CMU block and concrete with associated parking areas and drive lanes. We anticipate that the finished floor elevation will be within four and one-half feet of the existing site grades. We have based our recommendations in this report on the assumption that foundation loads for the proposed structures will not exceed 4,000 pounds per linear foot for live and dead loads for bearing walls, no column loads, and 40 pounds per square foot live loads for floor slabs. If structural loads will be greater our office should be notified so that we may review our recommendations and, if necessary, make modifications.

In addition to the construction described above, we anticipate that

- Utilities will be installed to service the proposed buildings,
- Exterior concrete flatwork will be placed in the form of curb, gutter, and sidewalks,
- And asphalt paved parking areas and drive lanes will be constructed.

4.0 GENERAL SITE DESCRIPTION

The subject property was located at approximately 7730 North 8730 West in Lehi, Utah. At the time of our subsurface exploration, the site was an undeveloped parcel. The subject property was being used for agricultural purposes and was vegetated with crops. The ground surface appeared to be relatively flat, thus we anticipate less than 3 1/2 feet of cut and fill may be required for site grading. The lot was bounded on the north, south and west by undeveloped agricultural land and on the east by a church building and associated parking areas.

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 February 5, 2013 by drilling 3 exploratory test holes to depths of about 18 to 46½ feet below the existing ground surface using an all-terrain hydraulic drill rig. The approximate locations of the test holes are shown on Figure 2, *Site Plan and Location of Test* Holes. Graphical representations and detailed descriptions of the soils encountered are shown on Figures 3 through 5, *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 6, *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. Disturbed samples were collected with a 1⅜ inch inside diameter split spoon sampler. The split spoon sampler was 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 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.

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 Orem, 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, liquid and plastic limits determinations, full gradation analyses, and one-dimensional consolidation tests. The following table summarizes the laboratory test results, which are also included on the attached test hole logs at the respective sample depths, on Figure 7, *Grain Size Distribution,* and on Figures 8 through 10, *Consolidation-Swell Test.*

Table 1: Laboratory Test Results

Test 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)	
TH-1	7½	34	83	31	9	---	---	---	CL
TH-1	10	32	---	---	---	0	16	84	CL
TH-2	5	34	82	39	19	---	---	---	CL
TH-2	45	38	---	---	---	0	5	95	ML
TH-3	15	15	110	25	3	---	---	---	ML
TH-3	20	26	---	---	---	0	48	52	ML

* NP = Non-Plastic

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. This part of the consolidation test indicated a negligible to slight potential (less than 1 percent) for collapse (settlement) under increased moisture and anticipated load conditions. Our testing also indicated the native clays are moderately to highly compressible under increased moisture contents and higher load conditions.

7.0 SUBSURFACE CONDITIONS

7.1 Soil Types

On the surface of the site, we encountered topsoil which we estimated to extend about 12 inches in depth at the test hole locations. Below the topsoil we encountered layers of clayey sand, lean clay with sand, silt, and poorly graded sand extending about 18 to 46½ feet below the existing ground surface. Based on the blow counts obtained during field exploration, the clay/silt soils ranged from soft to stiff in consistency and the sand soils had a relative density varying from loose to medium dense. Consolidation test results indicate the clay and silt soils are moderately highly compressible and have negligible to slight potential for moisture induced settlement (collapse).

7.2 Groundwater Conditions

Groundwater was encountered during our field exploration at depths of approximately 4 to 5 feet below the existing ground surface. Note that groundwater levels will fluctuate in response to the season, precipitation and 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 foundation, floor slab, exterior concrete flatwork, and pavement areas. We encountered topsoil on the surface of the site which we estimated to extend about 12 inches below the existing ground surface. The topsoil (including soil with roots larger than about ¼ inch in diameter) should be completely removed, even if found to extend deeper, 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. Because the site is relatively flat, we anticipate that less than 3 1/2 feet of grading fill will be placed. If more than 3 1/2 feet of grading fill will be placed above the existing surface (to raise site grades), Earthtec should be notified so that we may assess potential settlement and make additional recommendations if needed. 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 native soils do not appear to be suitable for use as structural fill. Excavated soils, including clays, 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, pavement, etc. We recommend that a professional engineer or geologist verify that the structural fill to be used on this project meets our requirements, given below. We recommend that structural fill consist of imported sandy/gravelly soils meeting the following requirements:

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 recommendation for

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

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 clayey/silty 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.

Where needed, we recommend that free draining granular material (clean sand and/or gravel) meet the following requirements:

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 material, or using a well graded, clean filtering material approved by the geotechnical engineer.

8.4 Fill Placement and Compaction

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 a moisture content within ±2 percent of the optimum moisture content, as determined by ASTM D-1557, will facilitate compaction. Typically, the further the moisture content is 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 and silt 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 and/or partial loads, by working in dry times of the year, or by providing a working surface for equipment. However, because of the relatively shallow depth of groundwater, it is likely that rutting and pumping may not be avoidable.

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. The more angular and coarse the material, the thinner the lift that will be required. 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 Tensar TX-5 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. 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 SEISMIC CONSIDERATIONS

9.1 Seismic Design

The State of Utah has adopted the 2009 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. 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." The soils encountered at the site were consistent with the soft soil profile (average N value less than 15 blows per foot) defined by the IBC for Site Class E. Considering our experience in the vicinity of the site and based on the results of our field exploration, we recommend using Site Class E.

The site is located at approximately 40.370 degrees latitude and -111.871 degrees longitude. Using Site Class E, the design spectral response acceleration parameters are given below in Table 5.

Table 4: Design Accelerations

S_S	F_a	S_{MS}	S_{DS}
1.098 g	0.9	0.988 g	0.659 g
S_1	F_v	S_{M1}	S_{D1}
0.458 g	2.4	1.098 g	0.732 g

S_S = Mapped spectral acceleration for short periods
S_1 = Mapped spectral acceleration for 1-second period
$S_{DS} = ⅔S_{MS} = ⅔ (F_a \cdot S_s)$ = 5% damped design spectral response acceleration for short periods
$S_{D1} = ⅔S_{MS} = ⅔ (F_V \cdot S_1)$ = 5% damped design spectral response acceleration for 1-second period

9.2 Faulting

Based upon published geologic maps[2], 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 part of a group of faults beneath Utah Lake located about 1½ miles south of the site.

9.3 Liquefaction Potential

According to current liquefaction maps for Utah County[3], the site is located within an area designated as high in liquefaction potential. Liquefaction can occur when saturated subsurface soils below groundwater lose their intergranular strength due to an increase in soil pore water pressures during a dynamic event such as an earthquake. As part of this study, the

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

potential for liquefaction to occur in the soils we encountered was assessed using Youd *et al*[4] and Boulanger & Idriss[5]. Potential liquefaction-induced movements were evaluated using Tokimatsu & Seed[6] and Youd, Hansen & Bartlett[7].

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 primarily of silts and clays with minor sand beds. Loose to medium dense sands were observed in test hole TH-1 between depths of approximately 14 and 18 feet below the existing ground surface. Our analysis indicates that approximately 2 to 2¼ inches of liquefaction-induced settlement could occur in the area during a moderate to large earthquake event.

10.0 FOUNDATIONS

10.1 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.

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[4] 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.

[5] 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.

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

[7] 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.

Low blow counts (as low as zero blow counts per foot) were observed during field exploration. Low blow counts indicate the presence of soft to very soft soils. To address the issue of soft to very soils within the upper 3 to 25 feet of the soil profile, foundations and slabs should be constructed using one of several alternatives, as follows:

- Continuous and spread footings supported by deep foundations. See Section 10.2, *Continuous and Spread Footing Supported by Deep Foundations.*
- Mat foundation. See Section 10.3, *Mat Foundation.*
- Multiple Span Beam with Suspended Reinforced Concrete Slab. See Section 10.4, *Multiple Span Beam with Suspended Reinforced Concrete Slab.*

In order to reduce settlements after construction of the structure is completed, we recommend that a minimum of one-half inch of settlement occur before the construction of the slabs, footings, and deep foundations and after the placement of the fill. Monitoring of the settlement should begin during the placement of the fill.

Small lightly loaded CMU-framed out-buildings may be supported by conventional spread footings supported on a minimum of 2.5 feet of properly placed and compacted engineered fill.

10.2 Continuous and Spread Footings Supported by Deep Foundations

The recommendations presented below should be considered for lightly to moderately loaded spread footing support (for structures that can tolerate settlement) in design and construction of this facility:

1. Support all interior and exterior footings with a deep foundation such as micro-piles.
2. Properly place and compacted a minimum of two (2) feet of structural fill under all interior slab-on-grade floors as per Section 8.4, *Fill Placement and Compaction.*

3. Footings should be uniformly loaded.

4. Exterior footings should be placed below frost depth which is determined by local building codes. Generally 30 inches of cover is adequate in this area. Interior footings, not subject to frost, should extend at least 18 inches below the lowest adjacent grade.

5. Foundations on continuous footings should be well reinforced both top and bottom. We suggest a minimum amount of steel equivalent to that required for a simply supported span of 12 feet or the distance between the deep foundation supports, whichever is greater.

10.3 Mat Foundation

A mat foundation can be an economical method to mitigate excessive settlement and carry heavy loads. A mat foundation is a relatively thick and heavily reinforced concrete pad on which the structure is founded. Mat foundations at this site should be placed on a minimum of 3 1/2 feet of properly placed and compacted structural fill. The structural fill should extend a minimum of 5 feet beyond the foundation/slab limits. Mat foundations should be designed by the structural engineer to resist a minimum of 2 inches of differential movement. A subgrade modulus of 150 psi/inch may be used for design purposes. A bearing capacity of 1500 psf can be used for mat foundations.

10.4 Multiple Span Beam with Suspended Reinforced Concrete Slab

Support the building on a Multiple Span Beam with Suspended Reinforced Concrete Slab utilizing grade beams. Install a deep foundation such as micro-piles, or driven piles extending below the soft soils to support all grade beams. The structural fill should extend a minimum of 5 feet beyond the foundation/slab limits. Multiple span beam with a reinforced concrete slab foundation should be designed by the structural engineer to resist a minimum of 2 inches of differential movement.

10.5 Micro-Pile Design

A micro-pile is a small diameter, bored pile with steel tube reinforcement. The micro-pile is generally continuously grouted during installation. These perform a similar function as helical piers but they have thicker shafts and grout column to reduce buckling risk. A test micro-pile should be installed and tested prior to design of the structure. Micro-piles installed during load testing should be loaded to a minimum of twice the proposed design load of the structure. We anticipate that ultimate vertical loads of 60 kips can be achieved with micro-piles installed into the bedrock or overlying weathered bedrock. Micro-piles are a specialized system and we recommend they be designed by an engineer experienced with this type of system.

The following design and construction precautions should be observed during pile installation:

1. The pile driving contractor should submit to the engineer for review, the plans for pile driving and the piling combination so that an evaluation can be made in advance of the pile installation.

2. The spacing between piles should be at least 3 pile diameters from center to center. If closer spacing is required, further analysis would be necessary to determine allowable loads considering pile group effects.

3. Allowable pile end bearing pressure and lateral bearing pressure may be increased by 1/3 for short term transient loading such as that from wind or seismic conditions as per Section 1806.1 of the 2009 International Building Code where used with the alternative basic load combinations.

4. Observation of the pile driving by an experienced engineer familiar with pile installation should be provided to verify that the design and construction recommendations were understood and fully implemented. Continuous driving logs should be kept on each pile. The piles should be visually checked for buckling, crimping and alignment prior to concrete placement.

5. At least one pile should be load tested to verify stratum support as per ASTM D1143 or ASTM D4925. At least one element shall be load tested in each area of uniform subsoil conditions.

10.6 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 and a half inches and differential settlements will be one-half of the total settlement over a 25-foot length of continuous foundation, for non-earthquake conditions. Additional settlement could occur during an earthquake due to ground shaking, if more than 3 1/2 feet of grading fill is placed above the existing ground surface, and/or if foundation soils are allowed to become wetted.

10.7 Lateral Load Resistance

Resistance to lateral loads (including those due to wind or seismic loads) on foundations may be achieved by frictional resistance between the foundation elements and the underlying soils, and by passive earth resistance of the backfill soils placed against the sides of the foundation elements. For foundation elements on native soils we recommend using a passive static pressure coefficient of 3.25 and a soil unit weight of 135 pcf (equivalent fluid weight of 439 pcf). The friction acting along the base of the foundations may be determined by using a coefficient of friction of 0.35 for foundation elements on structural fill materials. These values are ultimate; therefore, an appropriate factor of safety should be applied when using these values in lateral resistance calculations. Piles will provide lateral support due to the stiffness of the pilings.

11.0 FLOOR SLABS AND FLATWORK

Due to shallow groundwater encountered at the site, basement floor slab depths should be limited to 2 feet below existing site grades. This is intended to provide a minimum of 2 feet of separation between the observed groundwater condition and the bottom of the floor slab.

Exterior flatwork may be supported on a minimum of 6 inches of properly placed and compacted structural fill after appropriate removals and grading as outlined in Section 8.1 are completed. We recommend placing a minimum 4 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 flatwork, we recommend placing a minimum 6 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 50 pounds per cubic inch. 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.

12.0 DRAINAGE

12.1 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 6 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 2 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.

12.2 Subsurface Drainage

Groundwater or indicators of past groundwater levels were encountered/observed at depths of 4 to 5 feet below the existing ground surface. Due to the presence of shallow groundwater throughout property, basements may be difficult to construct. The depth of basements will depend greatly on site grading and drainage. Based on current site conditions, basements may be constructed no deeper than 2 feet below existing site grades. Basement depths can be increased if a land drain system is constructed for the site. The depth of the land drain will then control the allowable depth of the basements. Additionally, we recommend that if a basement is constructed, then a perimeter foundation drain be utilized for the structure. The information below should be used during the design and installation of the perimeter foundation drain:

- 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 (i.e. placing at least 10 inches of free-draining fill beneath footings).

- 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.

13.0 PAVEMENT RECOMMENDATIONS

We understand that asphalt paved parking and driveways areas will be constructed as part of the project. The native soils encountered beneath the topsoil during our field exploration were predominantly composed of clay. We estimate that a California Bearing Ratio (CBR) value of 3 is appropriate for these soils. The flexible pavement section may be reduced if a geosynthetic material is used.

We anticipate the traffic volume will be about 600 vehicles a day or less for the asphalt paved driveways and loading/unloading areas. We anticipate the traffic volume will be about 300 vehicles a day or less for the parking lot, consisting of mostly cars and pickup trucks, with a daily delivery truck and a daily garbage truck. Based on these traffic parameters, the estimated CBR given above, and the procedures and typical design inputs outlined in the UDOT Pavement Design Manual (1998), we recommend the minimum asphalt pavement section presented in the table below.

Table 5: Pavement Section Recommendations

(For drive areas and loading/unloading areas)

Asphalt Thickness (in)	Compacted Roadbase Thickness (in)	Compacted Subbase Thickness (in)
5.5	6	14*
5.5	10	10*

* Stabilization may be required

Table 6: Pavement Section Recommendations

(For general parking areas)

Asphalt Thickness (in)	Compacted Roadbase Thickness (in)	Compacted Subbase Thickness (in)
3	6	18*
3	10	16*

* Stabilization may be required

If the pavement will be required to support construction traffic, more than an occasional semi-tractor or fire truck, or more traffic than listed above, our office should be notified so that we can re-evaluate the pavement section recommendations. The following also apply:

- The subgrade should be prepared by proof rolling to a firm, non-yielding surface, with any identified soft areas stabilized as discussed above in Section 8.5.
- Site grading fills below the pavements should meet structural fill composition and placement recommendations per Sections 8.3 and 8.4 herein.
- Asphaltic concrete, aggregate base and sub-base material composition should meet local, APWA or UDOT requirements.
- Aggregate base and sub-base is compacted to local, APWA, or UDOT requirements, or to at least 95 percent of maximum dry density (ASTM D 1557).
- Asphaltic concrete is compacted to local or UDOT requirements, or to at least 96 percent of the laboratory Marshall density (ASTM D 6927).

If reinforcing for stabilization is used, install Tensar TX-5 or equivalent.

Table 7: Reinforced Pavement Section Recommendations

(For drive areas and loading/unloading areas)

Asphalt Thickness (in)	Compacted Roadbase Thickness (in)	Install Tensar TX-5	Compacted Subbase Thickness (in)	Install Tensar TX-5
4	12	Yes	11	No
4	10	Yes	11	Yes

Table 8: Reinforced Pavement Section Recommendations

(For general parking areas)

Asphalt Thickness (in)	Compacted Roadbase Thickness (in)	Install Tensar TX-5	Compacted Subbase Thickness (in)	Install Tensar TX-5
3	8	Yes	12	No
3	7	Yes	11	Yes

As an option, rigid pavement may be used. The existing clayey soils exhibit poor support for rigid pavement. Rigid pavement shall not be established over non-engineered fills. The rigid pavement sections are for non-reinforced Portland cement concrete. The concrete should have a minimum 28-day compressive strength of 4000 psi and contain 5% to 7% entrained air.

The following also apply:

- The subgrade should be prepared by proof rolling to a firm, non-yielding surface, with any identified soft areas stabilized as discussed above in Section 8.5.
- Site grading fills below the pavements should meet structural fill composition and placement recommendations per Sections 8.3 and 8.4 herein.
- Portland cement concrete, aggregate base and sub-base material composition should meet local, APWA or UDOT requirements.
- Aggregate base and sub-base is compacted to local, APWA, or UDOT requirements, or to at least 95 percent of maximum dry density (ASTM D 1557).

Table 9: Rigid Pavement Section Recommendations

Area	Concrete Thickness (in)	Compacted Roadbase Thickness (in)
Driveways	7.5	6
Parking Areas	7	4

14.0 GENERAL CONDITIONS

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, either expressed or implied, is intended in our proposals, contracts or reports.

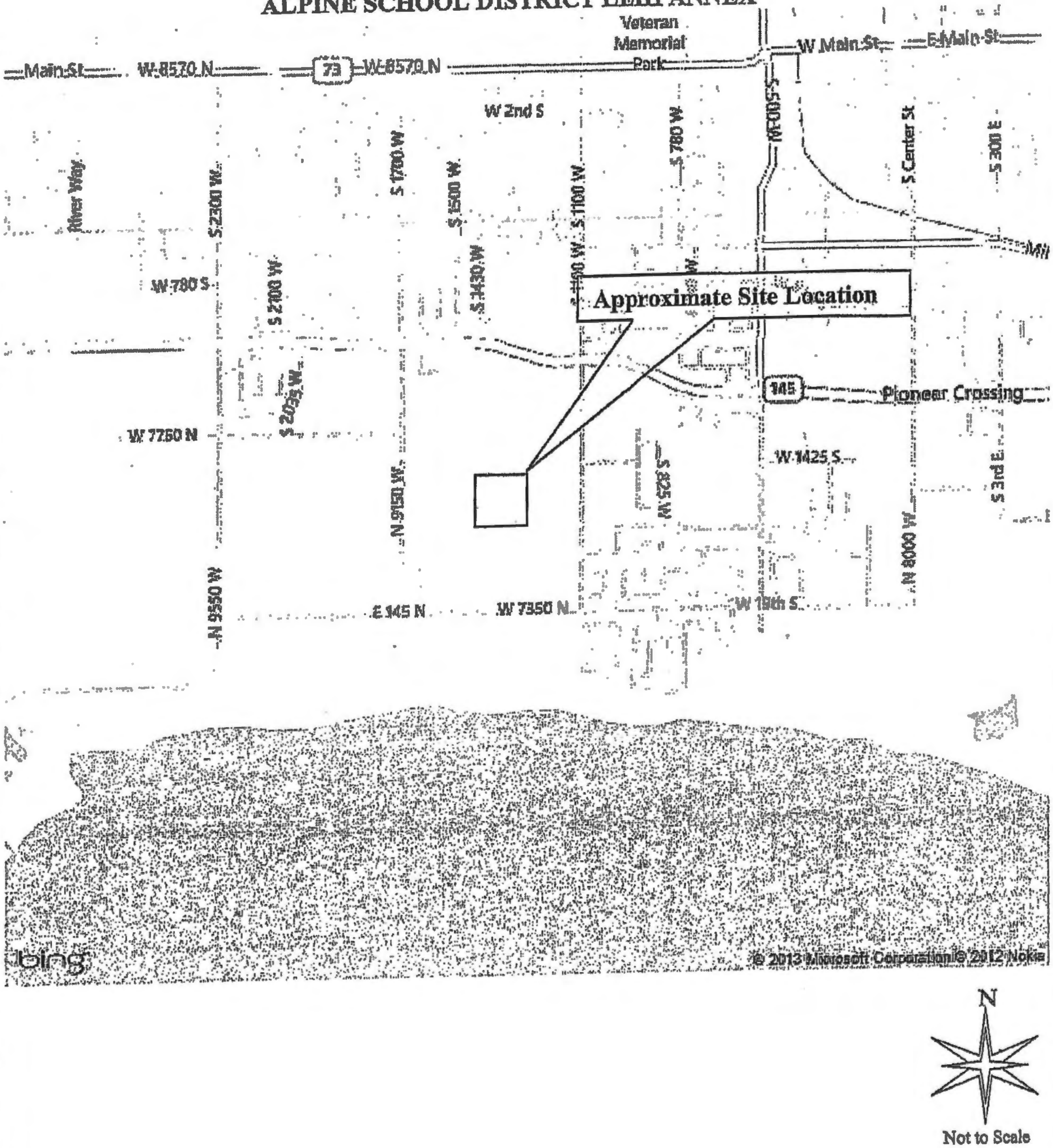
This geotechnical report is based on relatively limited subsurface explorations and laboratory testing. Subsurface conditions may differ in some locations of the site from those described herein, which may require additional analyses and possibly modified recommendations. Thus we strongly recommend consulting with Earthtec Engineering, Inc. regarding any changes made during design and construction of the project from those discussed above in Section 3.0. Failure to consult with Earthtec regarding any such changes relieves Earthtec from any liability arising from changed conditions at the site.

For consistency, we strongly recommend that Earthtec 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).

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.

VICINITY MAP

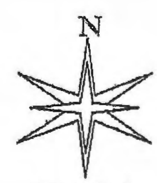
ALPINE SCHOOL DISTRICT LEHI ANNEX



PROJECT NO.: 130230	Earthtec Engineering Inc.	FIGURE NO.: 1

SITE PLAN & LOCATION OF TEST HOLES
ALPINE SCHOOL DISTRICT LEHI ANNEXATION

Approximate Test Hole Location



Not to Scale

PROJECT NO.: 130230		**FIGURE NO.:** 2

TEST HOLE LOG

NO.: TH-1

PROJECT: Alpine School District Lehi Annexation
CLIENT: Alpine School District
LOCATION: See Figure 2
OPERATOR: Great Basin Drilling
EQUIPMENT: ATV Drill Rig
DEPTH TO WATER; INITIAL ▽: 5 ft.

PROJECT NO.: 130230
DATE: 02/05/13
ELEVATION:
LOGGED BY: Sterling Howell
AT COMPLETION ▼:

Depth (Ft.)	Graphic Log	USCS	Description	Samples	Blows per foot	Water Cont. (%)	Dry Dens. (pcf)	LL	PI	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0			Topsoil										
		SC-SM	Silty to Clayey SAND (SC-SM), soft, moist to very moist, brown.										
3		CL	Lean CLAY (CL) with sand, soft, moist to wet, brown to dark brown.		3								
6					1								
						34	83	31	22				
9					2	32				0	16	84	
12													
15		SP	Poorly Graded SAND (SP) with some gravel, wet, medium dense, gray to tan.										
					7								
18			Bottom of test hole at approximately 18 feet.										
21													
24													
27													

Notes:

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

PROJECT NO.: 130230

Earthtec Engineering Inc.

FIGURE NO.: 3

LOG OF TESTHOLE TEST HOLE LOGS.GPJ EARTHTEC.GDT 2/18/13

TEST HOLE LOG

NO.: TH-2

PROJECT: Alpine School District Lehi Annexation
CLIENT: Alpine School District
LOCATION: See Figure 2
OPERATOR: Great Basin Drilling
EQUIPMENT: ATV Drill Rig
DEPTH TO WATER; INITIAL ∇: 4.5 ft.

PROJECT NO.: 130230
DATE: 02/05/13
ELEVATION:
LOGGED BY: Sterling Howell
AT COMPLETION ▼:

Depth (Ft.)	Graphic Log	USCS	Description	Samples	Blows per foot	Water Cont. (%)	Dry Dens. (pcf)	LL	PI	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0			Topsoil										
		CL	Lean CLAY (CL) with sand, moist to wet, soft, brown.										
3					2								
6						34	82	39	19				
9					0								
					0								
12													
15													
18													
21					8								
24													
		CL	Lean CLAY (CL), wet, medium stiff to stiff, gray to gray/blue.		17								
27													

TEST RESULTS

Notes:

Tests Key

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

PROJECT NO.: 130230

Earthtec Engineering Inc.

FIGURE NO.: 4a

TEST HOLE LOG

NO.: TH-2

PROJECT: Alpine School District Lehi Annexation
CLIENT: Alpine School District
LOCATION: See Figure 2
OPERATOR: Great Basin Drilling
EQUIPMENT: ATV Drill Rig
DEPTH TO WATER; INITIAL ∇ : 4.5 ft.

PROJECT NO.: 130230
DATE: 02/05/13
ELEVATION:
LOGGED BY: Sterling Howell
AT COMPLETION ▼ :

Depth (Ft.)	Graphic Log	USCS	Description	Samples	Blows per foot	Water Cont. (%)	Dry Dens. (pcf)	LL	PI	Gravel (%)	Sand (%)	Fines (%)	Other Tests
27		CL	Lean CLAY (CL), wet, medium stiff to stiff, gray to gray/blue.										
30					22								
33													
36					14								
39													
42					20								
		ML	SILT (ML), stiff, wet, gray to gray/blue.										
45					10	38				0	5	95	
			Bottom of test hole at approximately 46.5 feet.										
48													
51													
54													

Notes:

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

PROJECT NO.: 130230

Earthtec Engineering Inc.

FIGURE NO.: 4b

TEST HOLE LOG

NO.: TH-3

PROJECT: Alpine School District Lehi Annexation
CLIENT: Alpine School District
LOCATION: See Figure 2
OPERATOR: Great Basin Drilling
EQUIPMENT: ATV Drill Rig
DEPTH TO WATER; INITIAL ∇: 4 ft.

PROJECT NO.: 130230
DATE: 02/05/13
ELEVATION:
LOGGED BY: Sterling Howell
AT COMPLETION ▼:

Depth (Ft.)	Graphic Log	USCS	Description	Samples	Blows per foot	Water Cont. (%)	Dry Dens. (pcf)	LL	PI	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0			Topsoil										
		CL	Lean CLAY (CL) with sand and trace gravel, soft to medium stiff, brown to gray.										
3					2								
6					0								
9													
					3								
12													
		ML	Silt (ML), moist, stiff, gray to gray/blue.										
15						15	110	25	3				
18													
21					8	26				0	48	52	
			Bottom of test pit at approximately 18 feet.										
24													
27													

Notes:

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

LEGEND

PROJECT: Alpine School District Lehi Annexation **DATE:**
CLIENT: Alpine School District **LOGGED BY:**

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			PT	Peat, Primarily Organic Matter

SAMPLER DESCRIPTIONS

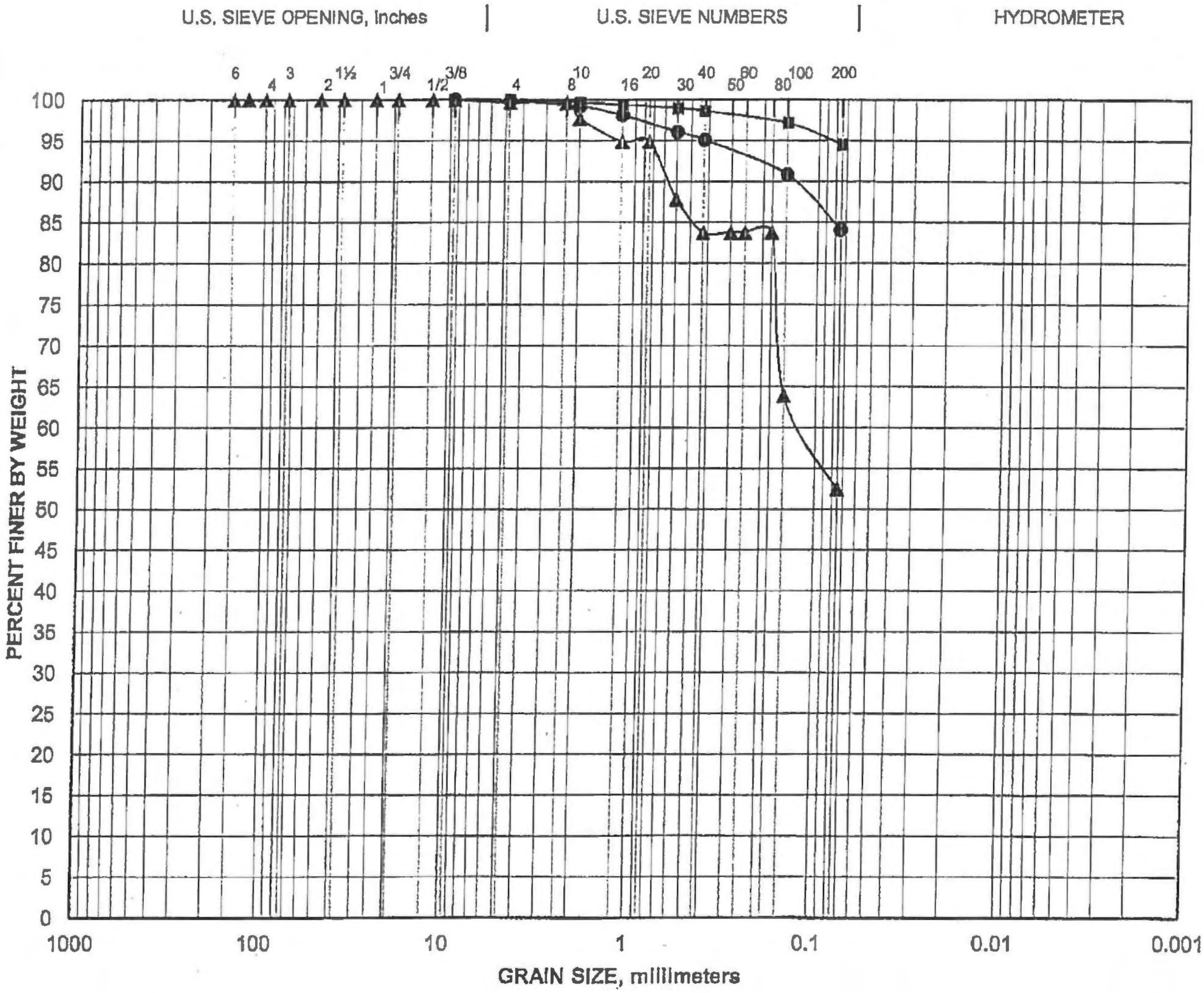
- SPLIT SPOON SAMPLER (1 3/8 inch inside diameter)
- MODIFIED CALIFORNIA SAMPLER (2 inch outside diameter)
- SHELBY TUBE (3 inch outside diameter)
- BLOCK SAMPLE
- BAG/BULK SAMPLE

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.

GRAIN SIZE DISTRIBUTION



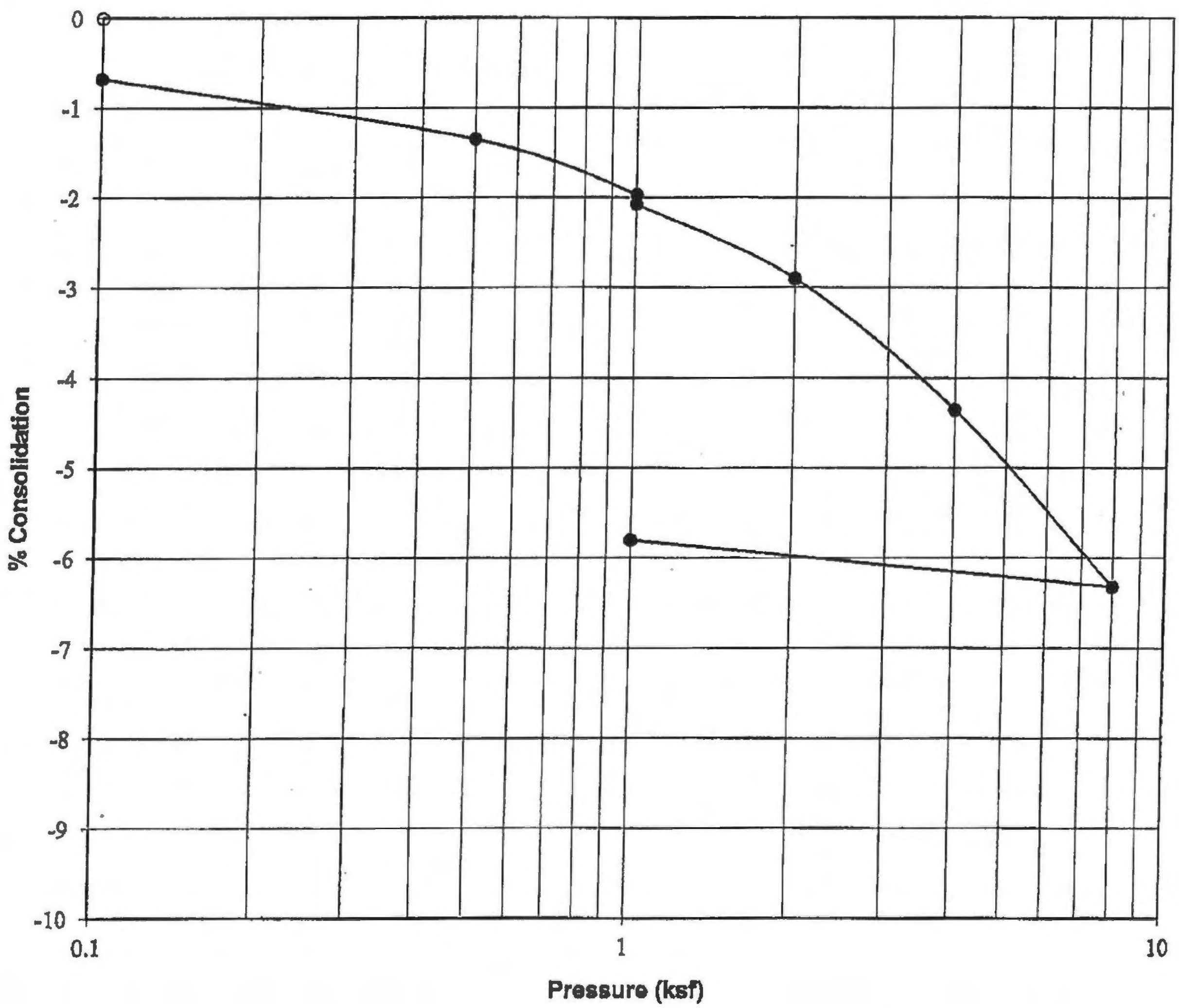
COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
●	TH-1 @ 11 ft.	Lean CLAY with sand (CL)	32					
■	TH-2 @ 45 ft.	SILT (ML)	38					
▲	TH-3@20'	Sandy SILT (ML)	26					
◆								
X								

	Specimen Identification	D100	D85	D60	D30	D15	D10	%Gravel	%Sand	%Silt	%Clay
●	TH-1 @ 11 ft.	9.50	0.035					0	16	84	
■	TH-2 @ 45 ft.	9.50						0	5	95	
▲	TH-3@20'	150	0.472	0.145				0	48	52	
◆											
X											

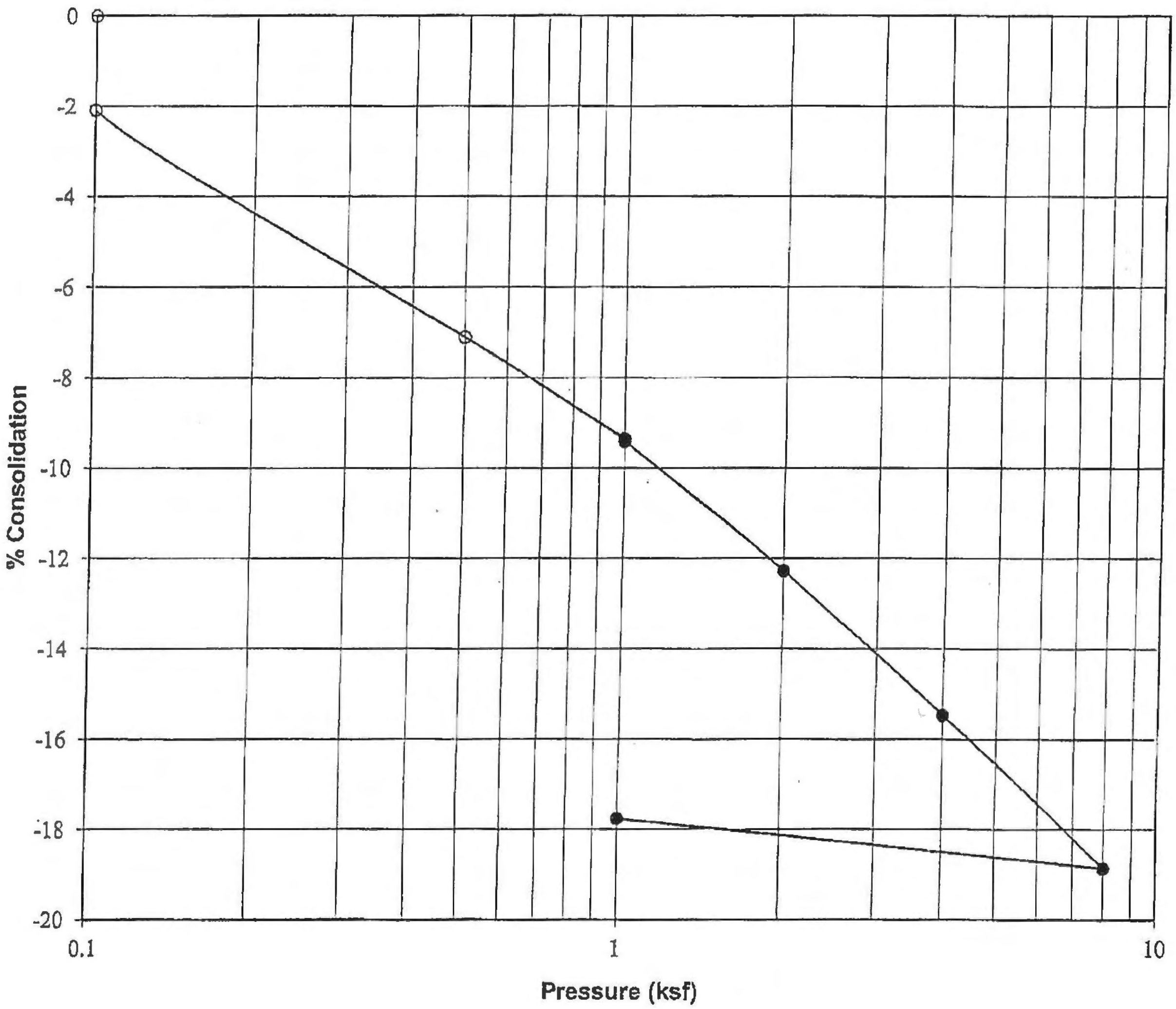
PROJECT NO.: 130230	Earthtec Engineering Inc.	FIGURE NO.: 7

CONSOLIDATION - SWELL TEST



Project:	Alpine School Lehi Annex
Location:	TH-1
Sample Depth:	7½
Description:	Lean CLAY, moist to wet, brown to dark brown
Soil Type:	(CL-ML)
Natural Moisture, %:	34
Dry Density, pcf:	83
Liquid Limit:	22
Plasticity Index:	9
Water Added at:	0.1 ksf
Percent Collapse:	0.7

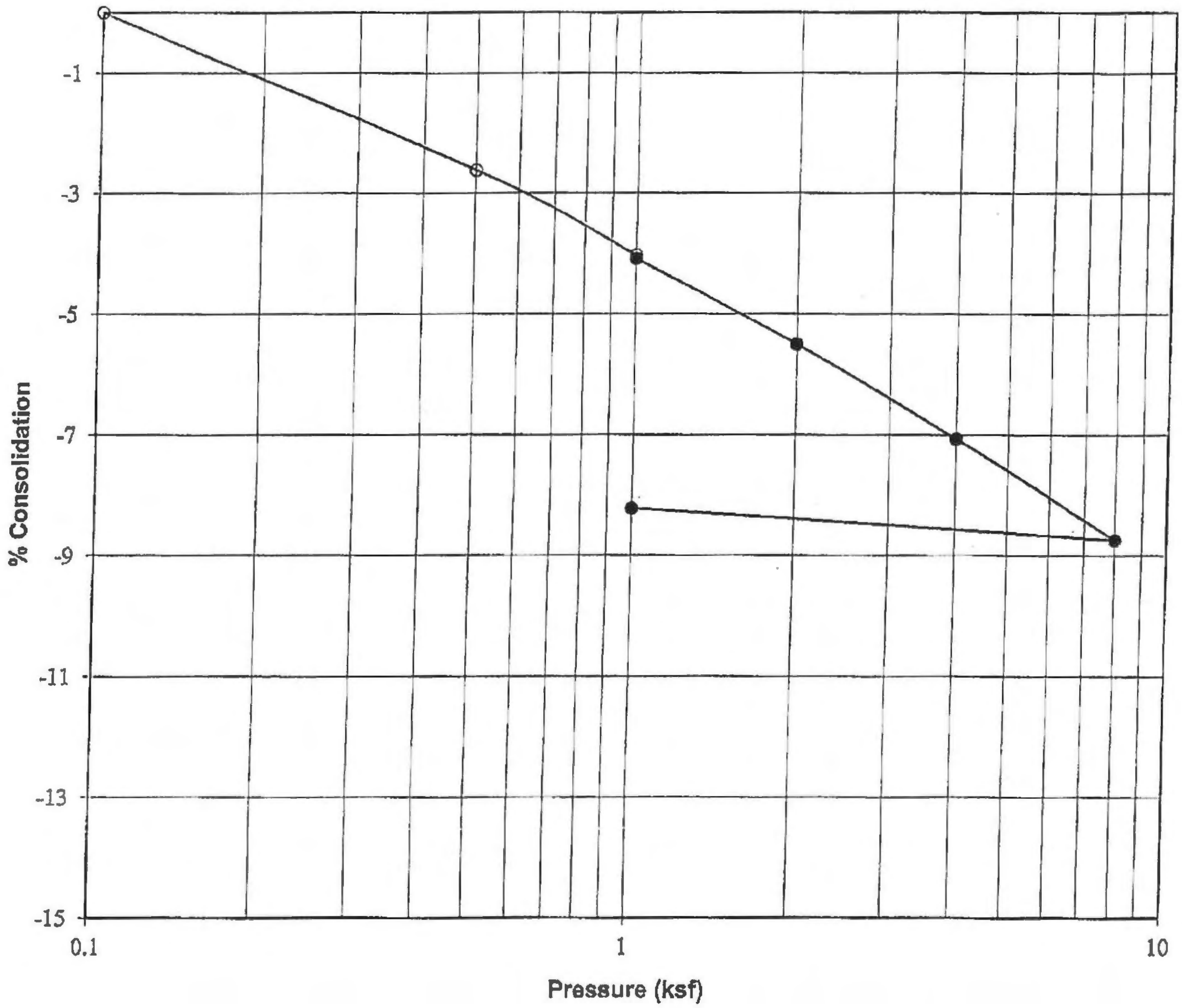
CONSOLIDATION - SWELL TEST



Project:	Alpine School Lehi Annex
Location:	TH-2
Sample Depth:	5
Description:	Lean CLAY with sand, moist to wet, soft, brown
Soil Type:	(CL)
Natural Moisture, %:	33
Dry Density, pcf:	82
Liquid Limit:	39
Plasticity Index:	19
Water Added at:	1 ksf
Percent Collapse:	0.1

PROJECT NO.: 130230	Earthtec Engineering Inc.	FIGURE NO.: 9

CONSOLIDATION - SWELL TEST



Project:	Alpine School Lehi Annex
Location:	TH-3
Sample Depth:	15
Description:	Sandy SILT, gray, moist, stiff
Soil Type:	(ML)
Natural Moisture, %:	15
Dry Density, pcf:	110
Liquid Limit:	25
Plasticity Index:	3
Water Added at:	1 ksf
Percent Collapse:	0.1