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GEOTECHNICAL STUDY
THE CREEK AT ~~LOVERS CREEK SUBDIVISION~~ LOVERS LANE
APPROXIMATELY 13270 SOUTH LOVERS LANE
RIVERTON, UTAH

Project No. 131713

December 4, 2013

Prepared For:

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1.0 EXECUTIVE SUMMARY

This report presents the results of our geotechnical study for Lovers Creek Subdivision in Riverton, Utah. We understand the proposed subdivision as currently planned; will consist of an approximate 4-acre development for single family residences.

Our field exploration included the excavation a total of four (4) test pits to depths of 7½ to 12 feet below the existing ground surface. Groundwater was encountered at depths of approximately 4 to 9½ feet below the existing ground surface. The subsurface soils encountered generally consisted of topsoil followed by layers of medium stiff to soft clay and loose sand. The topsoil should be removed beneath the entire building footprint, beneath exterior flatwork, and pavement areas. The native clay soils have a slight potential for collapse or expansion and slight potential for compressibility under increased moisture contents and anticipated load conditions. The sand soils between depths starting at 5 to 9½ feet have a potential for liquefaction during a moderate to large earthquake event.

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, after the provided the recommendations presented herein are followed and implemented during design and construction. Conventional strip and spread footings may be used to support the structure, with foundations placed entirely on firm native clay soils or entirely on a minimum of 24 inches of properly placed and compacted structural fill or clean gravel. The lowest floor slabs should be limited to one foot below existing ground surface, unless a test pit is excavated before footings are formed to determine ground water levels.

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 13270 South Lovers Lane in Riverton, 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, and concrete floor slabs.

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 subdividing and constructing a residential subdivision. We anticipate that the future homes will be conventionally framed and one to two stories in height, with the possibility of basements. The homes will likely be founded on spread footings with the lowest floor grade at one foot below the existing ground surface. 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 bearing walls, 20,000 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 buildings,
- Exterior concrete flatwork will be placed in the form of curb, gutter, sidewalks, and driveways.

4.0 GENERAL SITE DESCRIPTION

At the time of our subsurface exploration the site was an undeveloped lot vegetated with grasses, weeds, bushes, and trees. A stream runs through the southeast portion of the property, the ground surface on this portion slopes toward the stream at between 10 to 40 percent grades. The northwest portion of this property slopes to the southeast at between 5 and 40 percent grades. Thus, we anticipate up to 3 feet of cut and fill may be required for site grading. The lot was bounded on the north and south by undeveloped land and on the east and west by developed residential lots.

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 October 25, 2013 by excavating four (4) exploratory test pits to depths of about 7½ to 12 feet below the existing ground surface using a track-mounted mini-excavator. The approximate locations of the test pits are shown on Figure No. 2, *Aerial Photograph Showing Location of Test Pits.* Graphical representations and detailed descriptions of the soils encountered are shown on Figure Nos. 3 through 6, *Test Pit 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. 7, *Legend.*

Disturbed bag samples and relatively undisturbed block samples were collected at various depths in each test pit. 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, dry density tests, liquid and plastic limits determinations, full and mechanical (partial) gradation analyses, moisture density relationship tests, California Bearing Ratio tests, and one-dimensional consolidation tests. The table below summarizes the laboratory test results, which are also included on the attached *Test Pit Logs* at the respective sample depths, on Figure Nos. 8 and 9, *Consolidation-Swell Test*, and *Grain Size Distribution*, on Figure No. 10.

Table 1: Laboratory Test Results

Test Pit 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	9	33	88	43	23	0	3	97	CL
TP-2	1½	5	-	-	-	2	44	54	CL
TP-3	6	23	96	27	9	0	8	92	CL
TP-4	6	25	-	—	NP*	0	64	36	SM

* 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. The consolidation test for Test Pit 1 (TP-1) at 9 feet indicated the clay soils have a slight potential for compressibility and a slight potential for expansion (heave) under increased moisture contents and anticipated load conditions. The consolidation test for Test Pit 3 (TP-3) at 6 feet indicated the clay soils have a slight potential for compressibility and a slight potential for collapse (settlement) under increased moisture contents and anticipated load conditions.

7.0 SUBSURFACE CONDITIONS

7.1 Soil Types

On the surface of the site, we encountered topsoil which is estimated to extend about 12 to 18 inches in depth at the test pit locations. Below the topsoil we encountered layers of Clayey Sand (SC), Silty Sand (SM), Lean Clay (CL), Lean Clay with sand (CL), and Sandy Lean Clay (CL) extending about 7½ to 12 feet below the existing ground surface. Based on our experience and observations during field exploration, the clay soils were visually estimated to range from medium stiff to very soft in consistency and the sand soils were visually estimated to have a relative density varying from loose to medium dense.

7.2 Groundwater Conditions

Groundwater was encountered during our field exploration at depths of approximately 4 to 9½ 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 foundations, floor slabs, and exterior concrete flatwork. We encountered topsoil on the surface of the site which we estimated to extend about 12 to 18 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. Over-excavations below footings and slabs may be needed, as discussed in Section 10.0.

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 there is more than 25 feet of relief from either north to south side to the creek, we anticipate that approximately 3 feet of fill may be placed in some areas of the site during grading. 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 native soils are not 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, 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:

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

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

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 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.

If required (i.e. fill in submerged areas or stabilize soft soils), 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. 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. 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 SEISMIC AND GEOLOGIC CONSIDERATIONS

9.1 Seismic Design

The residential structures should be designed in accordance with the International Residential Code (IRC). The IRC designates this area as a seismic design class D_2.

The site is located at approximately 40.509 degrees latitude and -111.924 degrees longitude from the approximate center of the site. The IRC site value for this property is 0.85g. The design spectral response acceleration parameters are given below.

Table 4: Design Acceleration for Short Period

S_S	F_a	Site Value (S_{DS})
▨	▨	2/3 S_S*F_a
1.28g	1.00	0.85g

S_S = Mapped spectral acceleration for short periods
F_a = Site coefficient from Table 1613.5.3(1)
S_{DS} = ⅔S_{MS}= ⅔ (F_a·S_s) = 5% damped design spectral response acceleration for short periods

9.2 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[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 the Wasatch Fault located about 4½ miles east of the site.

9.3 Liquefaction Potential

According to current liquefaction maps[3] for Salt Lake County, the southern half of this site which is adjacent to the stream is located within an area designated as "High" in liquefaction potential, and the northern half of this 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 soil pore water pressures during a dynamic event such as an earthquake. The potential for liquefaction is based on several factors, including 1) the grain size distribution of the soil, 2) the plasticity of the fine fraction of the soil (material passing the No. 200 sieve), 3) relative density of the

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[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 Salt Lake County, Utah, Public Information Series 25, August 1994

soil, 4) earthquake strength (magnitude) and duration, and 5) overburden pressures. In addition, the soils must be saturated for liquefaction to occur.

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 and sands with loose to medium dense sandy soils encountered in the test pits between depths of 5 and 9½ feet below the existing ground surface. The sand soils encountered on this project are assumed to be liquefiable, but to determine liquefaction susceptibility for the site; it would require a deeper exploration to perform the analysis. The liquefaction potential at the site can be mitigated using one of the following alternatives:

- Densify the liquefiable soils by installing aggregate piers on a grid pattern below the building and extending at least 5 feet beyond the perimeter footings.
- Densify the liquefiable soils by installing grouted columns in a grid pattern below the building and extending at least 5 feet beyond the perimeter footings.
- Install earthquake drains, such as Nilex drains, to relieve increases in pore water pressure during a seismic event.
- Connect/tie all footings together using reinforced grade beams and connect reinforced slabs to the footings so that the building will react as a cohesive unit. This may result in some tilting of the building due to differential liquefaction-induced movements. The buildings may also move laterally due to lateral spreading.

9.4 Geologic Setting

The subject property is located in the southern portion of Salt Lake Valley near the western bank of the Jordan River north of Utah Lake. The elevation of the site ranges from approximately 4,430 feet to 4,390 feet above sea level. Salt Lake Valley is a deep, sediment-filled basin that is part of the Basin and Range Physiographic Province. The valley was formed by extensional tectonic processes during the Tertiary and Quaternary geologic time periods. The valley is bordered by the Wasatch Mountain Range on the east and the Oquirrh Mountain Range on the west. Much of northwestern Utah, including Salt Lake Valley, was previously covered by the Pleistocene age Lake Bonneville. The Great Salt Lake, which currently covers much of the northern portion of the valley, is a remnant of this ancient fresh water lake. The surficial geology of much of the eastern margin of the valley has been mapped by *Personius and Scott*, 1992[4]. The surficial geology at the location of the subject site and adjacent properties is mapped as "Stream alluvium 1" (Map Unit al1) dated to be upper Holocene, "Stream alluvium 2" (Map Unit al2) dated to be middle Holocene to uppermost Pleistocene, and "Lacustrine clay and silt, undivided" (Map Unit lbpm) dated to be upper Pleistocene. These deposits are generally described in the referenced mapping as "sand, silt, and minor clay and gravel", "sand, silt, clay, and local gravel", and "clay, silt, and minor fine sand and pebble gravel" Based on our observations of the site and the referenced geologic map, no other geologic hazards appear to pose a significant risk to the property and the proposed development.

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.

10.2 Strip/Spread Footings

We recommend that conventional strip and spread foundations be constructed entirely on firm, undisturbed, uniform clay soils (i.e. completely on clay soils) or entirely on a minimum 24 inches of structural fill or clean gravel extending to undisturbed native soils. For foundation design we recommend the following:

- Footings founded on native soils may be designed using a maximum allowable bearing capacity of 1,500 pounds per square foot. Footings founded on a minimum 24 inches of structural fill or clean gravel may be designed using a maximum allowable bearing capacity of 1,800 pounds per square foot. The values for vertical foundation pressure can be increased by one-third for wind and seismic conditions

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[4] Personius, S.F., and Scott, W.E., 1992, *Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah*; U.S. Geological Survey, Map I-2106, Scale 1: 50,000.

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 and observed by the geotechnical engineer prior to erection of forms or placement of structural fill or clean gravel 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.
- Because of shallow groundwater conditions encountered at the site, we anticipate that 24 inches of structural fill will be required below the proposed structure to provide a firm surface upon which to construct the proposed structure. In lieu of traditional structural fill, clean 1- to 2-inch clean gravel may be used in conjunction with a stabilization fabric, such as Mirafi 600X or equivalent, which should be placed between the native soils and the clean gravel (additional recommendations for placing clean gravel and stabilization fabric are given in Section 8.5 of this report).
- Due to shallow groundwater encountered at the site, lowest floor slab depths should be limited to one foot below existing site grades, or provide a groundwater observation to determine the groundwater at time of construction. This is intended to provide a minimum of 3 feet of separation between the observed groundwater condition and the bottom of the lowest floor slab.
- Structural fill and clean gravel 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.

10.3 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 3 feet of grading fill is placed above the existing ground surface.

10.4 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 dependant 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 table below are based on drained, horizontally placed native soils as backfill material using a 28° friction angle and a dry unit weight of 110 pcf.

Table 5: Lateral Earth Pressures (Static and Dynamic)

Condition	Case	Lateral Pressure Coefficient	Equivalent Fluid Pressure (pcf)
Active	Static	0.36	40
	Seismic	0.57	62
At-Rest	Static	0.53	58
	Seismic	0.76	83
Passive	Static	2.77	305
	Seismic	3.26	359

*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 0.30 for native clay, 0.35 for native silty sand, and 0.55 for clean 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. If backfilling with clay or silt, it is required to contact Earthtec prior to construction for further review and recommendations. 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.

11.0 FLOOR SLABS AND FLATWORK

Due to shallow groundwater encountered at the site in areas near the stream, lowest floor slab depths should be limited to one foot below existing site grades. This is intended to provide a minimum of 3 feet of separation between the observed groundwater condition and the lowest of the floor slab. In areas 15 feet above the stream, a test pit should be excavated before footings are formed to determine ground water levels, to provide a minimum of 3 feet of separation between the observed groundwater condition and the lowest floor slab.

Concrete floor slabs may be supported on 12 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 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. 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 was encountered and observed at depths of 4 to 9½ feet below the existing ground surface across the site. Due to the presence of shallow groundwater throughout property, basements for residences 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 one foot below existing site grades. Basement depths can be increased if a land drain system is constructed for the subdivision. The depth of the land drain will then control the allowable depth of the basements.

Additional Section R405.1 of the 2012 International Residential Code states, "Drains shall be provided around all concrete and masonry foundations that retain earth and enclose habitable or usable spaces located below grade." Section R310.2.2 of the 2012 International Residential Code states, "Window wells shall be designed for proper drainage by connecting to the building's foundation drainage system." An exception is allowed when the foundation is installed on well drained ground consisting of Group 1 soils, which include those defined by the Unified Soil Classification System as GW, GP, SW, SP, GM, and SM. The soils observed in the explorations at the depth of foundation consisted primarily of clay (CL) which is not a Group 1 soil. If basements are included on the residences, 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.

- A perforated 4-inch minimum diameter pipe should be installed in all window wells and connected to the foundation drain.

- 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.

13.0 PAVEMENT RECOMMENDATIONS

We understand that asphalt paved residential streets will be constructed as part of the development. The native soils encountered beneath the topsoil during our field exploration were predominantly composed of clay. California Bearing Ratio (CBR) testing performed on a representative sample of these soils indicate a CBR value of 8.1, but to account for some variability in the near-surface soils, we used a design CBR of 6. The topsoil should be removed below the concrete flatwork and pavement areas.

We anticipate the traffic volume will be less than 500 vehicles a day or less for the residential street, consisting of mostly cars and pickup trucks, with a daily delivery truck and a weekly garbage truck. Based on these traffic parameters, the design 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 below.

Table 6: Pavement Section Recommendations

Asphalt Thickness (in)	Compacted Roadbase Thickness (in)	Compacted Subbase Thickness (in)
3	6	8*

* 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).

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 holes 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, 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;
EARTHTEC ENGINEERING

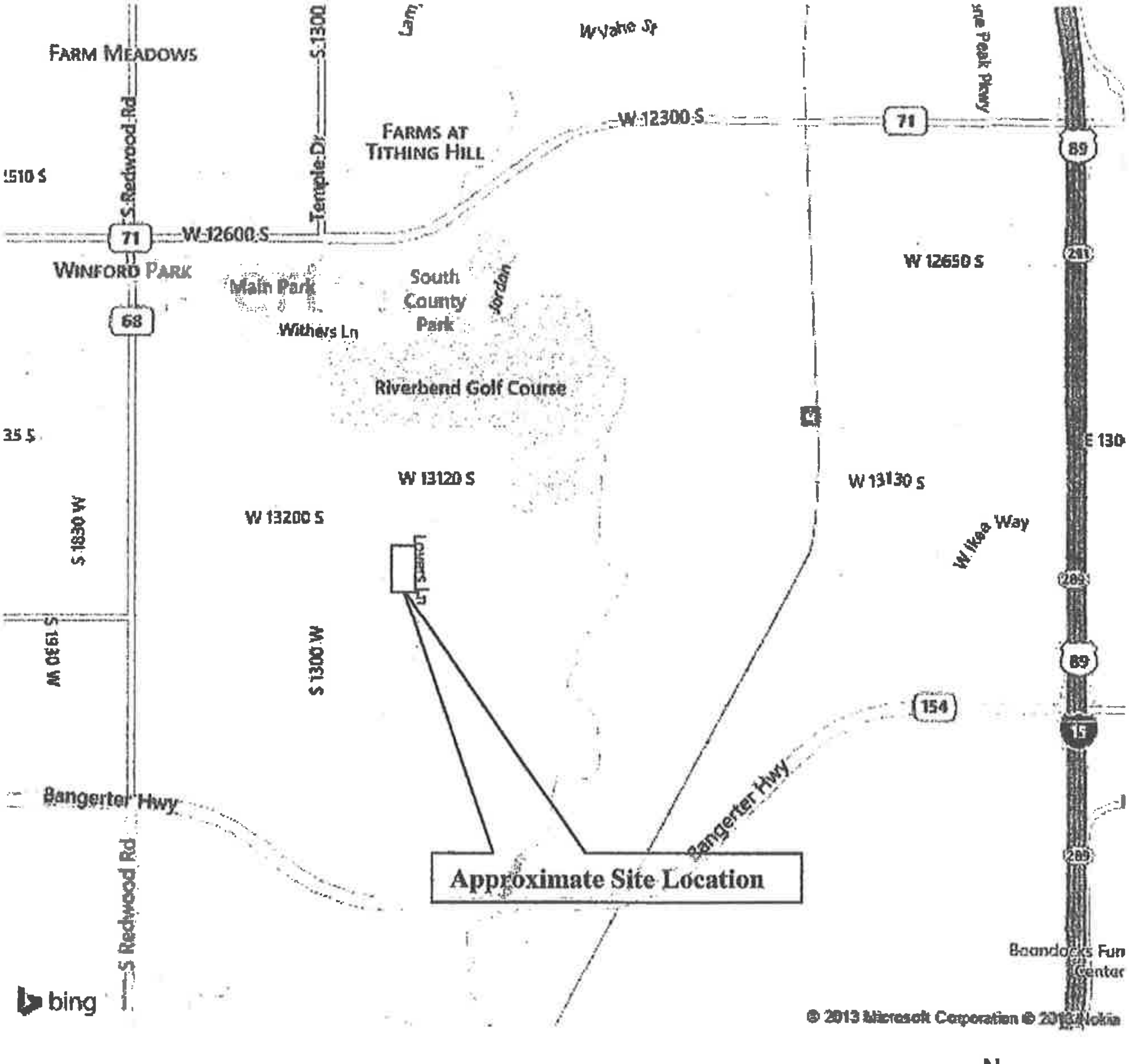
Caleb R. Allred, E.I.T.
Staff Engineer

No. 5367049-2202
TIMOTHY ALLAN MITCHELL
12/4/13

Timothy A. Mitchell, P.E.
Geotechnical Engineer

VICINITY MAP

LOVERS CREEK SUBDIVISION
APPROXIMATELY 13270 SOUTH LOVERS LANE
RIVERTON, UTAH



Not to Scale

*Base map from www.bingmaps.com

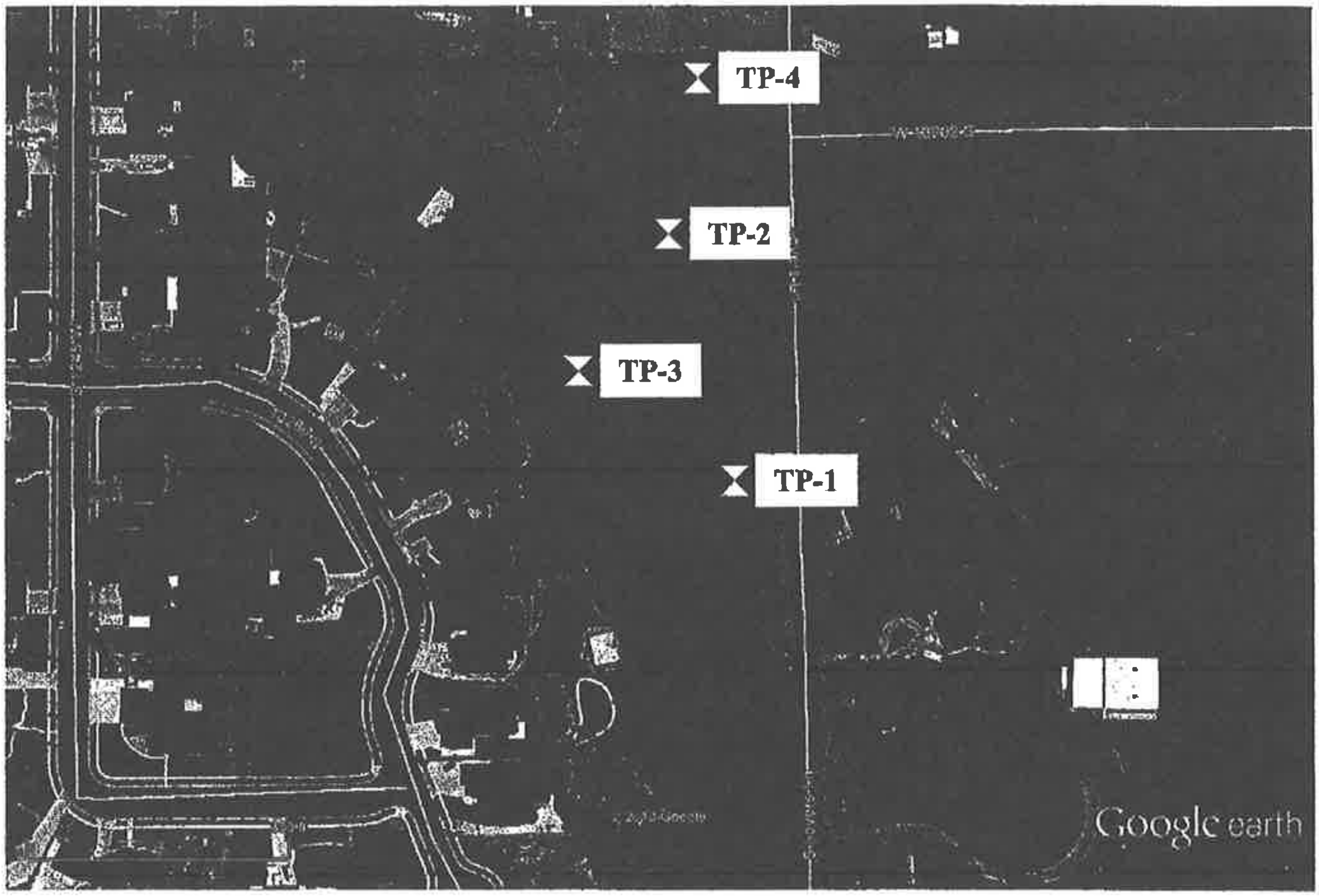
PROJECT NO.: 131713

Earthtec Engineering

FIGURE NO.: 1

AERIAL PHOTOGRAPH SHOWING LOCATION OF TEST PITS

LOVERS CREEK SUBDIVISION
APPROXIMATELY 13270 SOUTH LOVERS LANE
RIVERTON, UTAH



☒ **Approximate Test Pit Location**

N

Not to Scale

*Base aerial photo from www.earth.google.com

PROJECT NO.: 131713	Earthtec Engineering	**FIGURE NO.:** 2

TEST PIT LOG

No.: TP-1

PROJECT: Lover Creek Subdivision
CLIENT: Lighten Investment
LOCATION: See Figure 2.
OPERATOR: JSI
EQUIPMENT: Mini Trackhoe
DEPTH TO WATER; INITIAL ▽: 9½ feet

Project No.: 131713
Date: 10/25/2013
Elevation: Not taken
Logged By: M. Larsen
AT COMPLETION ▼: 9½ feet

Depth (ft.)	Graphic Log	USCS	Description	Samples	TEST RESULTS								
					Water Cont. (%)	Dry Dens. (pcf)	LL	PI	Gravel (%)	Sand (%)	Fines (%)	Pocket Penet. (tsf)	Other Tests
1			TOPSOIL, Silty Clay with organics, slight moist, gray-light brown.										
2		SC	Clayey SAND, medium dense (estimated), moist, gray-light brown.										
3				☒									
4		CL	Lean CLAY, medium stiff to soft (estimated), moist to wet, gray-light brown to gray, interbedded sand layers.										
5													
				■									
6													
7													
8													
9													
			▼	■	33	88	43	23	0	3	97		C
10													
11													
12													
13			Maximum depth explored of approximately 12 feet.										

Notes: Groundwater encountered during field investigation at approximately 9½ feet.

Test Keys
CBR = California Bearing Ratio
C = Consolidation
P = Percolation

PROJECT NO.: 131713

Earthtec Engineering

FIGURE NO.: 3

TEST PIT LOG

No.: TP-2

PROJECT:	Lover Creek Subdivision	**Project No.:**	131713
CLIENT:	Lighten Investment	**Date:**	10/25/2013
LOCATION:	See Figure 2.	**Elevation:**	Not taken
OPERATOR:	JSI	**Logged By:**	M. Larsen
EQUIPMENT:	Mini Trackhoe		
DEPTH TO WATER; INITIAL ▽:	4 feet	**AT COMPLETION ▼:**	4 feet

Depth (ft.)	Graphic Log	USCS	Description	Samples	Water Cont. (%)	Dry Dens. (pcf)	LL	PI	Gravel (%)	Sand (%)	Fines (%)	Pocket Penet. (tsf)	Other Tests
					TEST RESULTS								
1	▩		TOPSOIL, Sandy Clay, organics, moist, brown.										
2	▨		Sandy Lean CLAY, soft to very soft (estimated), moist to wet, gray-brown.	☒	5				2	44	54		CBR
3	▨												
4	▨	▼		☒									
5	▨	CL											
6	▨												
7	▨			☒									
8			Maximum depth explored at approximately 7½ feet, due to sides of pit caving in.										
9													
10													
11													
12													
13													

Notes: Groundwater encountered during field investigation at approximately 4 feet.

Test Keys
CBR = California Bearing Ratio
C = Consolidation
P = Percolation

PROJECT NO.: 131713

Earthtec Engineering

FIGURE NO.: 4

TEST PIT LOG

No.: TP-3

PROJECT: Lover Creek Subdivision
CLIENT: Lighten Investment
LOCATION: See Figure 2.
OPERATOR: JSI
EQUIPMENT: Mini Trackhoe
DEPTH TO WATER; INITIAL ∇: 8½ feet

Project No.: 131713
Date: 10/25/2013
Elevation: Not taken
Logged By: M. Larsen
AT COMPLETION ▼: 8½ feet

Depth (ft.)	Graphic Log	USCS	Description	Samples	TEST RESULTS								
					Water Cont. (%)	Dry Dens. (pcf)	LL	PI	Gravel (%)	Sand (%)	Fines (%)	Pocket Penet. (tsf)	Other Tests
1			TOPSOIL, Sandy Lean Clay, organics, moist, brown.										
2			Clayey SAND, loose (estimated), moist, gray to light brown.										
3		SC											
4			Lean CLAY, medium stiff to soft (estimated), moist to wet, gray to gray-brown.	■									
5													
6													
7		CL		☒	23	96	27	9	0	8	92		C
8													
9		▼											
10			Silty SAND, medium dense to loose (estimated), wet, light brown.	☒									
11													
12			Maximum depth explored approximately 11½ feet.										
13													

Notes: Groundwater encountered during field investigation at approximately 8½ feet.

Test Keys
CBR = California Bearing Ratio
C = Consolidation
P = Percolation

PROJECT NO.: 131713

Earthtec Engineering

FIGURE NO.: 5

TEST PIT LOG

No.: TP-4

PROJECT: Lover Creek Subdivision
CLIENT: Lighten Investment
LOCATION: See Figure 2.
OPERATOR: JSI
EQUIPMENT: Mini Trackhoe
DEPTH TO WATER; INITIAL ▽: 4 feet

Project No.: 131713
Date: 10/25/2013
Elevation: Not taken
Logged By: M. Larsen
AT COMPLETION ▼: 4 feet

					TEST RESULTS								
Depth (ft.)	Graphic Log	USCS	Description	Samples	Water Cont. (%)	Dry Dens. (pcf)	LL	PI	Gravel (%)	Sand (%)	Fines (%)	Pocket Penet. (tsf)	Other Tests
1	▒		TOPSOIL, Silty Sand, roots throughout, slightly moist, light brown.										
2	▨		Lean CLAY with sand, medium stiff to very soft (estimated), moist to wet, gray-brown.										
3	▨	CL		■									
4	▨	▼											
5	▨			☒									
6	░		Silty SAND, loose (estimated), wet, light brown.										
7	░	SM		☒	25		-	NP	0	64	36		
8	░												
9			Maximum depth explored approximately 8 feet, due to sides of pit caving in.										
10													
11													
12													
13													

Notes: Groundwater encountered during field investigation at approximately 4 feet.

Test Keys
CBR = California Bearing Ratio
C = Consolidation
P = Percolation

PROJECT NO.: 131713

Earthtec Engineering

FIGURE NO.: 6

LEGEND

PROJECT: Lover Creek Subdivision
CLIENT: Lighten Investment

Date: 10/25/2013
Logged By: M. Larsen

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR SOIL DIVISIONS			USCS SYMBOL		TYPICAL SOIL DESCRIPTIONS
COARSE GRAINED SOILS (More than 50% retained 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 Silt or Clay, May Contain Gravel and/or Sand
HIGHLY ORGANIC SOILS			▨	PT	Peat, Primarily Organic Matter

SAMPLER DESCRIPTIONS

◩ SPLIT SPOON SAMPLE (1 3/8 inch inside daimeter)

⧗ MODIFIED CALIFORNIA SAMPLE (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 field exploration

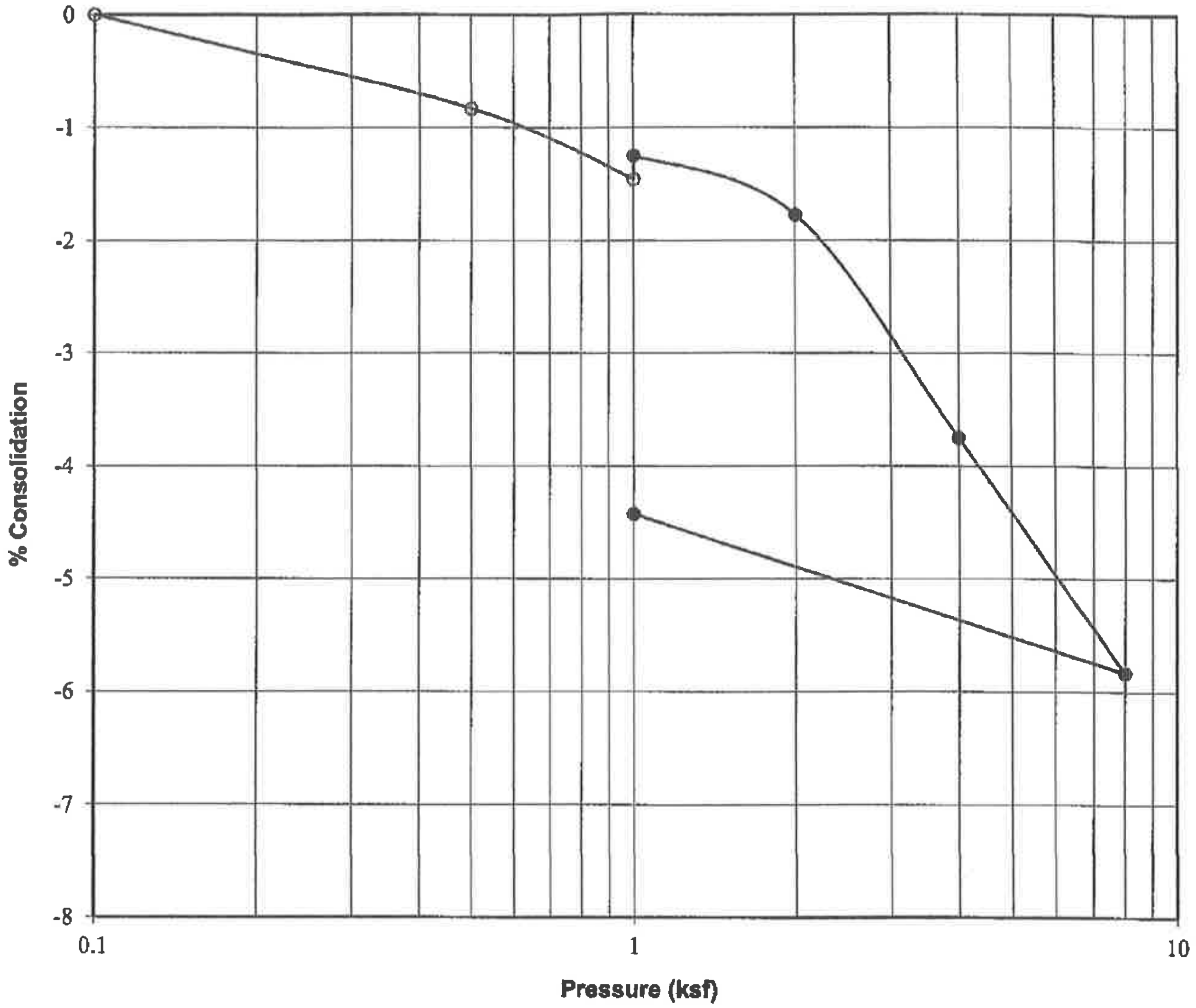
NOTES:
1. The logs are subject to the limitations, conclusions, and recommendations in this report.
2. results of test conducted on samles recovered are reported on the logs and any applicable graphs.
3. Strata lines on the logs represent approximate boundaries only. Actual transition may be gradual.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

PROJECT NO.: 131713

Earthtec Engineering

FIGURE NO.: 7

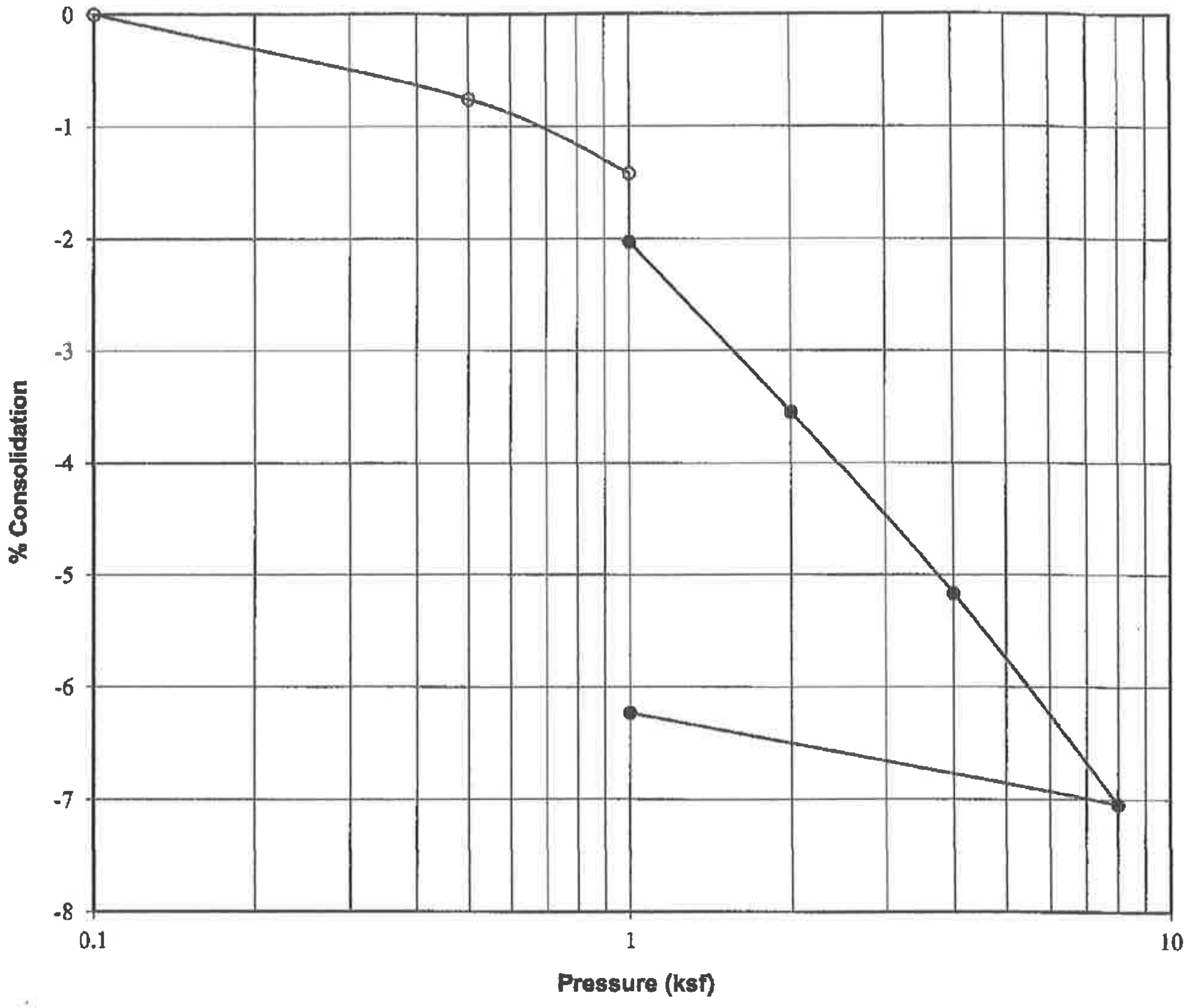
CONSOLIDATION - SWELL TEST



Project:	Lovers Creek Sub.
Location:	TP-1
Sample Depth, ft:	9
Description:	Block
Soil Type:	Lean CLAY (CL)
Natural Moisture, %:	33
Dry Density, pcf:	88
Liquid Limit:	43
Plasticity Index:	23
Water Added at:	1 ksf
Percent Swell:	0.2

PROJECT NO.: 131713	Earthtec Engineering	**FIGURE NO.:** 8

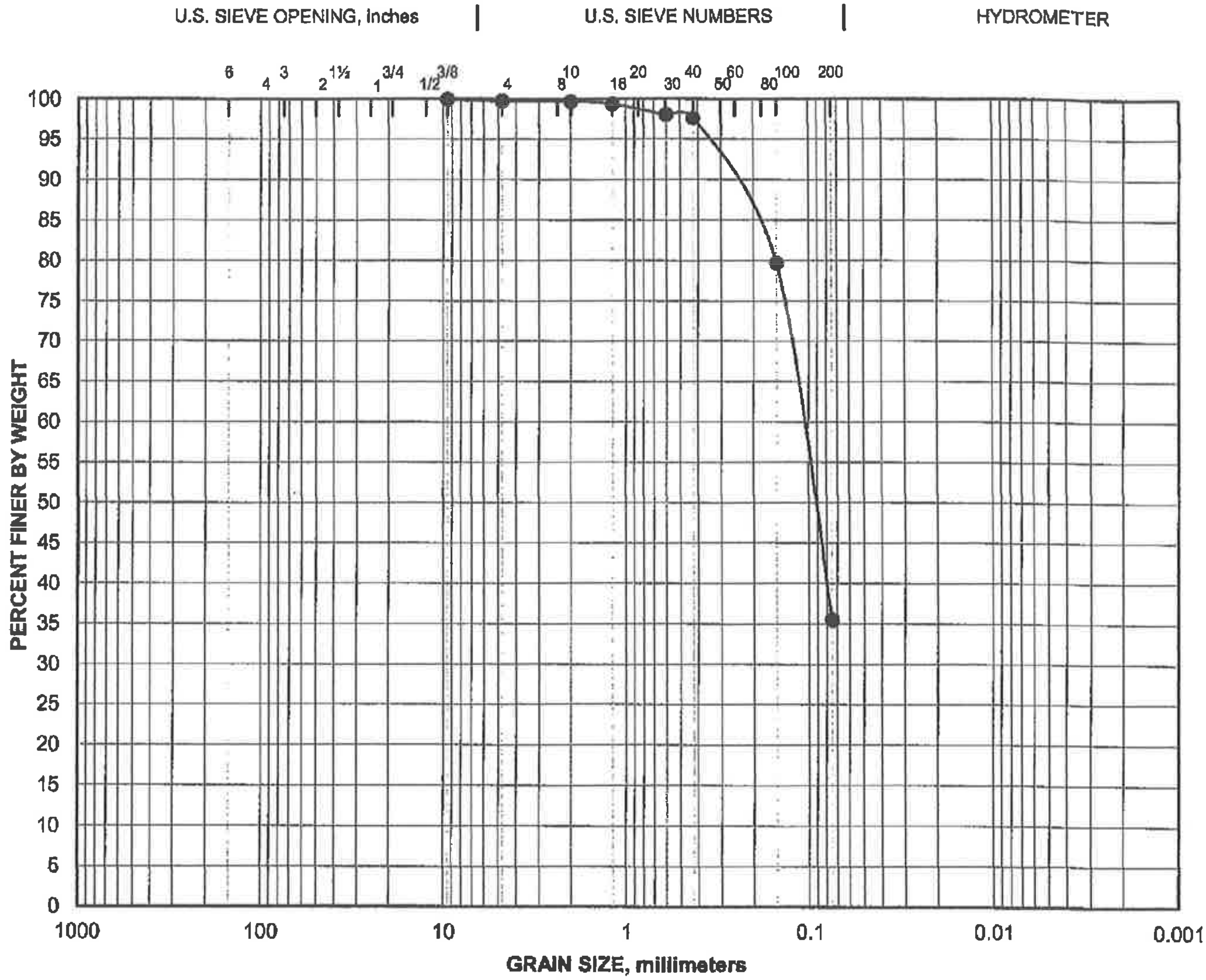
CONSOLIDATION - SWELL TEST



Project:	Lovers Creek Sub.
Location:	TP-3
Sample Depth, ft:	6
Description:	Block
Soil Type:	Lean CLAY (CL)
Natural Moisture, %:	23
Dry Density, pcf:	96
Liquid Limit:	27
Plasticity Index:	9
Water Added at:	1 ksf
Percent Collapse:	0.6

PROJECT NO.: 131713 Earthtec Engineering **FIGURE NO.:** 9

GRAIN SIZE DISTRIBUTION



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
●	**TP-4 @ 6 ft.**	**Silty SAND (SM)**	**25**	**-**	**NP**	**NP**		
■								
▲								
◆								
X								

	Specimen Identification	D100	D85	D60	D30	D15	D10	%Gravel	%Sand	%Silt	%Clay
●	**TP-4 @ 6 ft.**	**9.50**	**0.204**	**0.048**				**0**	**64**	**36**	
■											
▲											
◆											
X											

PROJECT NO.: 131713

Earthtec Engineering

FIGURE NO.: 10