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**GEOTECHNICAL STUDY  
TRAPPERS RIDGE PHASE 8 SUBDIVISION AT WOLF CREEK  
SOUTH OF INTERSECTION OF  
ELKVIEW DRIVE AND ELKHORN DRIVE  
EDEN, UTAH**

**Project No. 167002**  
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## 1.0 EXECUTIVE SUMMARY

This report presents the results of our geotechnical study for the Trappers Ridge Phase 8 Subdivision located in Eden, Utah. We understand the proposed project, as currently planned, will consist of constructing an eighteen (18) lot residential subdivision with a clubhouse and pool on the approximate 7 acre property with two to three story structures founded on spread footings with the possibility of daylight basements. Asphalt paved residential streets will also be constructed.

Our field exploration included the excavation of five (5) test pits to depths of about 11 to 12 feet below the existing ground surface. Groundwater was not encountered during our initial field investigation except for in Test Pit 2 (TP-2). The groundwater encountered in TP-2 may be a perched water table at a depth of approximately 8 feet below ground surface due to its proximity to a nearby creek that runs along the northeast side of the subject property. The subsurface soils encountered generally consisted of topsoil, overlying layers of native Lean Clay with sand (CL), Sandy Lean Clay with gravel (CL), Lean Clay (CL), Lean Clay with sand and gravel (CL), Clayey Sand (SC) with occasional cobbles and boulders, and Clayey Gravel with sand (GC). Topsoil, boulders and any fill material encountered should be removed beneath the entire building footprints, exterior flatwork, and pavement areas.

Based on the results of our field exploration, laboratory testing, and engineering analyses, it is our opinion that the subject site is suitable for the proposed development, provided the recommendations presented herein are followed and implemented during design and construction. Conventional strip and spread footings may be used to support the structures, with foundations placed entirely on uniform, undisturbed, non-moisture sensitive native soils or entirely on a minimum of 18 inches of properly placed, compacted, and tested structural fill extending to undisturbed native soils.

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 observe 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 south of intersection of Elkview Drive and Elkhorn Drive at Wolf Creek in Eden, Utah. The general location of the site is shown on Figure No. 1, *Vicinity Map*, at the end of this report.

The purposes of this study were to

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

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

## 3.0 PROPOSED CONSTRUCTION

We understand that the proposed project consists of constructing an eighteen (18) lot residential subdivision with a clubhouse and a pool. We anticipate that the future homes will be conventionally framed and be two to three stories in height. The homes will likely be founded on spread footings with the possibility of daylight basements. We have based our recommendations in this report on the assumption that foundation loads for the proposed structures will not exceed 3,000 pounds per linear foot for bearing walls, 15,000 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 residences,
- Exterior concrete flatwork will be placed in the form of curb, gutter, driveways, and sidewalks, and
- Asphalt paved residential streets will be constructed.

#### 4.0 GENERAL SITE DESCRIPTION

At the time of our subsurface investigation, the subject property was vacant, covered with snow and was vegetated with weeds, grasses, and a few trees and boulders. The ground surface had an average of approximately 20% slope across the site with a gentle slope towards south in most of the site, and a steeper slope at the northeastern edge. A creek ran near the south edge and outside of the property. The property was bounded on all directions with residential lots, some of which currently containing an existing residences.

#### 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 January 27, 2016 by excavating five (5) exploratory test pits to depths of about 11 to 12 feet below the existing ground surface using a track-mounted excavator. The approximate locations of the test pits are shown on Figure No. 2, *Aerial Photograph Showing Location of Test Pits*. The conceptual layout was provided by Watts Enterprises. Graphical representations and detailed descriptions of the soils encountered are shown on Figure Nos. 3 through 7, *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. 8, *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 Ogden, Utah laboratory where they will be retained for 30 days following the date of this report and then discarded, unless a written request for additional holding time is received prior to the 30 day limit.

## 6.0 LABORATORY TESTING

Representative soil samples collected during our field exploration were tested in the laboratory to assess pertinent engineering properties and to aid in refining field classifications, if needed. Tests performed included natural moisture content, liquid and plastic limits determinations, dry density, mechanical (partial) gradation analyses, 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 and on Figure Nos. 9 and 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)	
TP-1	6	24	---	39	14	1	51	48	SC
TP-2	6	37	90	41	16	0	9	91	CL
TP-3	8	17	114	43	17	28	33	39	SC
TP-4	2	22	---	37	15	27	24	49	GC
TP-5	10	18	---	---	---	8	63	29	SC

As part of the consolidation test procedure, water was added to the samples to assess moisture sensitivity when the samples were loaded to an equivalent pressure of approximately 1,000 psf. The consolidation test indicated the native soils have a slight to moderate potential for compressibility and a negligible potential for compressibility (collapse) 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 up to 12 inches in depth at the test pit locations. Below the topsoil we encountered layers of native Lean Clay with sand (CL), Sandy Lean Clay with gravel (CL), Lean Clay (CL), Lean Clay

with sand and gravel (CL), Clayey Sand (SC) with occasional cobbles and boulders, and Clayey Gravel with sand (GC) extending to the maximum depths explored of about 11 to 12 feet below the existing ground surface. Based on our experience and observations during field exploration, the clay soils appeared to be soft to stiff, and clayey sand and gravel soils appeared to be medium dense to dense in consistency.

## **7.2 Groundwater Conditions**

Groundwater was encountered at depth of approximately 8 feet below ground surface at TP-2, the nearest test pit to the creek located near the site, during our field investigation. Note that groundwater levels will fluctuate in response to the season, precipitation, snow melt, irrigation, and other on and off-site influences. Quantifying these fluctuations would require long term monitoring, which is beyond the scope of this study. The contractor should be prepared to dewater excavations as needed.

## **8.0 SITE GRADING**

### **8.1 General Site Grading**

All surface vegetation and unsuitable soils (such as topsoil, organic soils, soils with pinholes, 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 up to about 12 inches below the existing ground surface. All topsoil encountered (including soil with roots larger than about ¼ inch in diameter), any soil with pinholes, and fill material encountered should be completely removed, even if found to extend deeper than 2 feet, along with any other unsuitable soils that may be encountered. If the topsoil is left below the floor slabs and pavement sections, an increased in maintenance costs over time should be anticipated.

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



### 8.2 Temporary Excavations

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

### 8.3 Fill Material Composition

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

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

**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.

<sup>1</sup> OSHA Health And Safety Standards, Final Rule, CFR 29, part 1926.

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

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

**Table 3: Free-Draining Fill Recommendations**

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

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

#### **8.4 Fill Placement and Compaction**

Fill should be placed on level, horizontal surfaces. Where fill will be placed on 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  $\pm 2$  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**

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

During grading the soil in any obvious soft spots should be removed and replaced with granular material. If rutting or pumping occurs traffic should be stopped in the area of concern. The soil in rutted areas should be removed and replaced with granular material.

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

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

## 9.0 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<sub>1</sub>. The site is located at approximately 41.323 degrees north latitude and -111.813 degrees west longitude from the approximate center of the site. The IRC site value for this property is 0.74g. The design spectral response acceleration parameters are given below.

**Table 4: Design Acceleration for Short Period**

$S_s$	$F_a$	Site Value ( $S_{DS}$ )
1.01 g	1.10	$2/3 S_s F_a$
		0.74 g

$S_s$  = Mapped spectral acceleration for short periods

$F_a$  = Site coefficient from Table 1613.5.3(1)

$S_{DS} = \frac{2}{3} S_{MS} = \frac{2}{3} (F_a S_s) = 5\%$  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<sup>2</sup>, faults may traverse through or immediately adjacent to the site.

## 9.3 Liquefaction Potential

According to current liquefaction maps<sup>1</sup> for Weber County, liquefaction potential at the site has not determined. 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 soil, 4) earthquake strength (magnitude) and duration, and 5) overburden pressures. In addition, the soils must be near saturation 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 stiff clays and loose silty sands. The soils encountered at this project do not appear liquefiable, but the liquefaction susceptibility of underlying soils (deeper than our explorations) is not known and would require deeper explorations to quantify.

## 9.4 Geologic Setting

The subject lot is located on the lower slopes of the northeast sloping foothills of the Ogden Valley located on the east flank of Wasatch Mountain Range in North-Central Utah. These

<sup>1</sup> Utah Geological Survey, Liquefaction-Potential Map For A Part Of Weber County, Utah, Public Information Series 28, August 1994.

foothills start from the southwestern margin of the Ogden Valley, a northwest to southeast trending valley located between the Wasatch Mountains to the west and the southern end of the Bear River Range to the east. The Ogden Valley is part of the Wasatch Hinterlands Section of the Middle Rocky Mountain Physiographic Province. Stokes describes the Wasatch Hinterlands as a belt of mixed, moderately rugged topography located on the east side of the Wasatch Range that has varied topography, with hilly areas dominating valley areas. The Ogden Valley is currently occupied by Pineview Reservoir, a manmade lake formed by damming the Ogden River and several of its tributaries, as well as the towns of Huntsville, Eden, and Liberty.

Structurally the Ogden Valley is a down-faulted block bound on the northeast by the northwest to southeast oriented Northeastern Margin Fault and on the southwest by the northwest to southeast oriented Southwestern Margin Fault, as described by Hecker. The northwest to southeast oriented North Fork Fault also runs below the central portion of the Ogden Valley. None of these faults are mapped by Hecker to be active (showing evidence of movement during Holocene (past 10,000 years) time).

The Ogden Valley was prehistorically occupied by an arm of Lake Bonneville, a Pleistocene age, fresh water lake that covered most of northwestern Utah and parts of northeastern Nevada. Sediment deposited by the lake are still present within portions of the valley and at places within the foothills surrounding the valley below the elevation of the high stand of the lake which was between approximately 5,170 and 5,200 feet above sea level. The Great Salt Lake of northwestern Utah is a remnant of ancient Lake Bonneville.

The geology at the location of the subject lot and surrounding area has been mapped by Sorenson and Crittenden 1979<sup>2</sup>. The geology at the location of the subject site (Trappers Ridge & Fairways Subdivisions) as shown on the referenced map is described as boulder, colluvium and slopewash deposits chiefly along eastern margin of Ogden Valley; in part lag from Tertiary units (Map Unit Qcs, Holocene) overlying Holocene age silt deposits (Qs) and older gravel and cobble deposits of the Pleistocene age (Qog) that predates high stands of

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<sup>2</sup> Geologic Map of the Huntsville Quadrangle, Weber and Cash Counties, Utah, by Martin L. Sorensen and Max D. Crittenden, Jr, 1979, USGS GQ-1503.

Lake Bonneville and the Norwood Formation (Map Unit Tn, lower Oligocene and upper Eocene). As shown on Figure No. 1, *Vicinity Map*, the topography of the site and surrounding area generally slopes down to the west-northwest at less than 2 percent grades.

## 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.

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

### 10.2 Strip/Spread Footings

Conventional strip and spread footings may be used to support the structures, with foundations placed entirely on uniform, undisturbed, non-moisture sensitive native soils or entirely on a minimum of 18 inches of properly placed, compacted, and tested structural fill 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 36 inches of structural fill may be designed using a maximum allowable bearing capacity of 2,000 pounds per square foot. The values for vertical foundation pressure can be increased by one-third for wind and seismic conditions per Section 1806.1 when used with the Alternative Basic Load Combinations found in Section 1605.3.2 of the 2012 International Building Code.

- Continuous and spot footings should be uniformly loaded and should have a minimum width of 20 and 30 inches, respectively.
- Exterior footings should be placed below frost depth which is determined by local building codes. In general 30 inches of cover is adequate for most sites; however local code should be verified by the end design professional. Interior footings, not subject to frost (heated structures), should extend at least 18 inches below the lowest adjacent grade.
- Foundation walls and footings should be properly reinforced to resist all vertical and lateral loads and differential settlement.
- The bottom of footing excavations should be compacted with at least 4 passes of an approved non-vibratory roller prior to erection of forms or placement of structural fill to densify soils that may have been loosened during excavation and to identify soft spots. If soft areas are encountered, they should be stabilized as recommended in Section 8.5.
- Footing excavations should be observed by the geotechnical engineer prior to beginning footing construction to evaluate whether suitable bearing soils have been exposed and whether excavation bottoms are free of loose or disturbed soils.
- Due to shallow groundwater encountered at the site at approximately 8 feet below ground surface in TP-2, basement floor slab depths should be limited to 5 feet below existing site grades. This is intended to provide a minimum of 3 feet of separation between the observed groundwater condition and the bottom of the floor slab. However, due to seasonal fluctuation of the water table, floor slab depth should be adjusted according to the highest groundwater elevation found at the site.
- Structural fill used below foundations should extend laterally a minimum of 6 inches for every 12 vertical inches of structural fill placed. For example, if 18 inches of structural fill are required to bring the excavation to footing grade, the structural fill should extend laterally a minimum of 9 inches beyond the edge of the footings on both sides.

### **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, and/or if foundation soils are allowed to become wetted.



#### 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 dependent on the rigidity of the structure and its ability to resist rotation. Most retaining walls that can rotate or move slightly will develop an active lateral earth pressure condition. Structures that are not allowed to rotate or move laterally, such as subgrade basement walls, will develop an at-rest lateral earth pressure condition. Lateral pressures applied to structures may be computed by multiplying the vertical depth of backfill material by the appropriate equivalent fluid density. Any surcharge loads in excess of the soil weight applied to the backfill should be multiplied by the appropriate lateral pressure coefficient and added to the soil pressure. For static conditions the resultant forces is applied at about one-third the wall height (measured from bottom of wall). For seismic conditions, the resultant forces are applied at about two-third times the height of the wall both measured from the bottom of the wall. The lateral pressures presented in the table below are based on drained, horizontally placed native soils (as outlined in this report) as backfill material using a 30° friction angle and a dry unit weight of 120 pcf.

**Table 5: Lateral Earth Pressures (Static and Dynamic)**

Condition	Case	Lateral Pressure Coefficient	Equivalent Fluid Pressure (pcf)
Active	Static	0.33	40
	Seismic	0.46	55
At-Rest	Static	0.50	60
	Seismic	0.69	82
Passive	Static	3.00	360
	Seismic	4.10	491

\*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 clays, 0.45 for native sand and gravel, and 0.55 for structural fill meeting the recommendations presented herein. For allowable stress design, the lateral resistance may be computed using Section 1807 of the 2012 International Building Code and all sections referenced therein. Retaining wall lateral resistance design should further reference Section 1807.2.3 for reference of Safety Factors. Retaining systems are assumed to be founded upon and backfilled with granular structural fill. The values for lateral foundation pressure can be increased by one-third for wind and seismic conditions per Section 1806.1 when used with the Alternative Basic Load Combinations found in Section 1605.3.2 of the 2012 International Building Code.

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

#### **11.0 FLOOR SLABS AND FLATWORK**

Due to shallow groundwater encountered at the site, basement floor slab depths should be limited to 5 feet below existing site grades. This is intended to provide a minimum of 3 feet of separation between the observed groundwater condition and the bottom of the floor slab.

Concrete floor slabs and exterior flatwork may be supported on the native soils 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. A 6-mil polyethylene vapor retarder shall be applied over the porous layer with the basement the basement floor constructed over the polyethylene, as per Section R405 of the 2012 International Residential Code. To help control normal shrinkage and stress cracking, we recommend that floor slabs have adequate reinforcement for the anticipated floor loads with the reinforcement continuous through interior floor joints, frequent crack control joints, and non-rigid attachment of the slabs to foundation and bearing walls. Special precautions should be taken during placement and curing of all concrete slabs and flatwork. Excessive slump (high water-cement ratios) of the concrete and/or improper finishing and curing procedures used during hot or cold weather conditions may lead to excessive shrinkage, cracking, spalling, or curling of slabs. We recommend all concrete placement and curing operations be performed in accordance with American Concrete Institute (ACI) codes and practices.

## 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:

- The contractor should take precautions to prevent significant wetting of the soil at the base of the excavation. Such precautions may include: grading to prevent runoff from entering the excavation, excavating during normally dry times of the year, covering the base of the excavation if significant rain or snow is forecast, backfill at the earliest possible date, frame floors and/or the roof at the earliest possible date, other precautions that might become evident during construction.
- Adequate compaction of foundation backfill should be provided i.e. a minimum of 90% of ASTM D-1557. Water consolidation methods should not be used.
- The ground surface should be graded to drain away from the building in all directions. We recommend a minimum fall of 8 inches in the first 10 feet.
- Roof runoff should be collected in rain gutters with down spouts designed to discharge well outside of the backfill limits, or at least 10 feet from foundations, whichever is greater.
- Sprinkler nozzles should be aimed away, and all sprinkler components kept at least 5 feet, from foundation walls. Also, sprinklers should not be placed at the top or on the face of slopes. Sprinkler systems should be designed with proper drainage and well maintained. Over-watering should be avoided.

- Any additional precautions which may become evident during construction.

## 12.2 Subsurface Drainage

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 majority of the soils observed in the explorations consisted of clay soils; therefore foundation drains are required if footings are founded on clay soils. If foundation drains are installed, 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 roads will be constructed as part of the project. The native soils encountered beneath the during our field exploration were predominantly composed of clay, sand, and gravel. We assumed a California Bearing Ratio (CBR) value of 3 for these soils for the pavement design.

We anticipate the traffic volume will be about 200 vehicles a day or less for the road, consisting of mostly cars and pickup trucks, with a daily delivery truck and a weekly garbage truck. Based on these traffic parameters, the measured 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	12*	0
3	6	6*

\* 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.
- Site grading fills below the pavements should meet structural fill composition and placement recommendations described above.
- 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 pits may occur and which may be sufficient to require modifications in the design. If during construction, conditions are different than presented in this report, Earthtec should be advised immediately so that the appropriate modifications can be made.

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

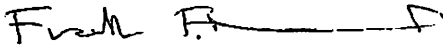
This geotechnical report is based on relatively limited subsurface explorations and laboratory testing. Subsurface conditions may differ in some locations of the site from those described herein, which may require additional analyses and possibly modified recommendations. Thus we strongly recommend consulting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

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

provide observation and testing services during grading, excavation, foundation construction, and other earth-related construction phases of the project.

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

Respectfully;  
**EARTHTEC ENGINEERING**



Frank F. Namdar, P.G., E.I.T.  
Geotechnical Engineer



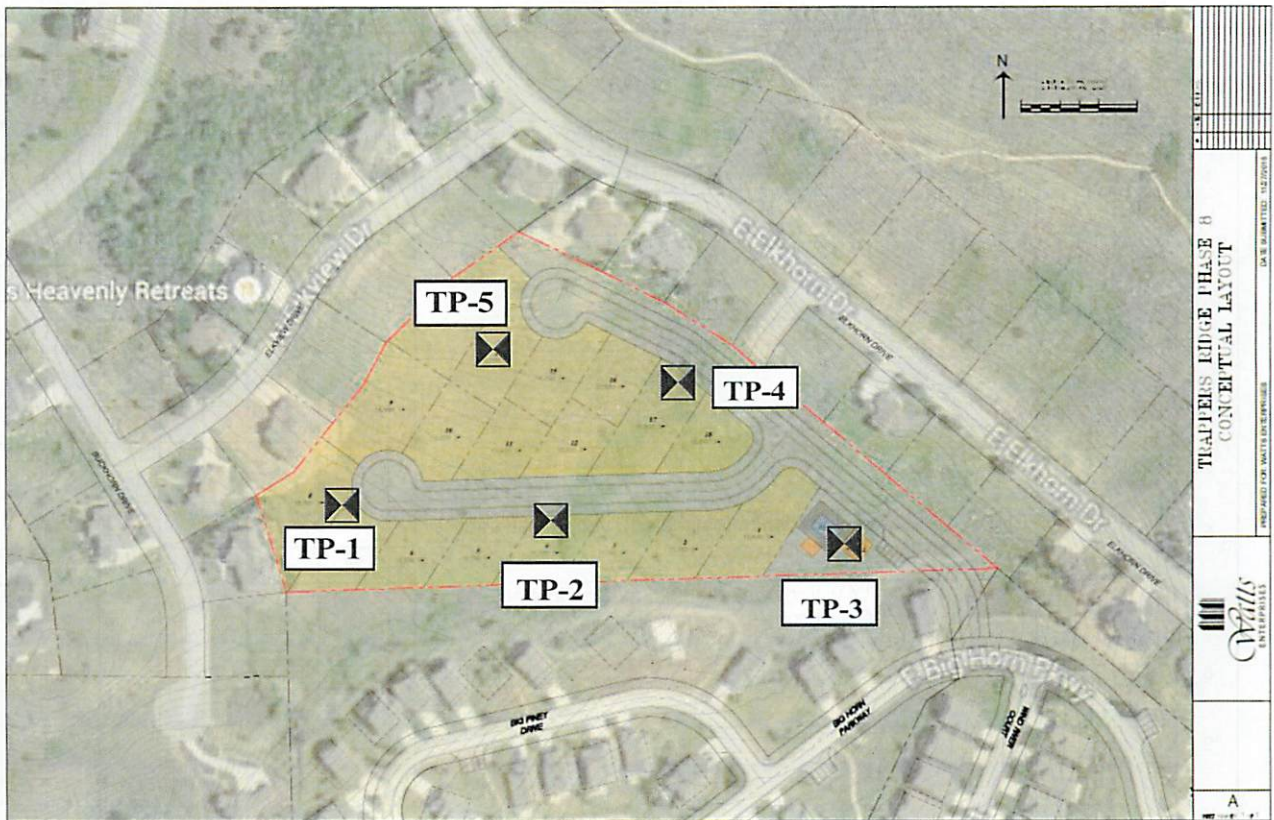
Timothy A. Mitchell, P.E.  
Geotechnical Engineer





# AERIAL PHOTOGRAPH SHOWING LOCATION OF TEST PITS

TRAPPERS RIDGE PHASE 8 SUBDIVISION AT WOLF CREEK  
SOUTH OF INTERSECTION OF ELKVIEW AND ELKHORN DRIVE  
EDEN, UTAH



Approximate Location of Test Pits



Approximate Boundary

(Aerial photograph provided by Watts Enterprises)



Not to Scale

PROJECT NO.: 167002



FIGURE NO.: 2

# TEST PIT LOG

## NO.: TP-1

**PROJECT:** Trappers Ridge Phase 8 Subdivision  
**CLIENT:** Watts Enterprises  
**LOCATION:** See Figure 2  
**OPERATOR:** C.E. Butters Construction  
**EQUIPMENT:** Rubber-tire Backhoe  
**DEPTH TO WATER; INITIAL  $\nabla$  :**

**PROJECT NO.:** 167002  
**DATE:** 01/27/16  
**ELEVATION:** Not Determined  
**LOGGED BY:** F. Namdar

**AT COMPLETION  $\nabla$  :**

Depth (Ft.)	Graphic Log	USCS	Description	Samples	TEST RESULTS									
					Water Cont. (%)	Dry Dens. (pcf)	LL	PI	Gravel (%)	Sand (%)	Fines (%)	Other Tests		
0			TOPSOIL, clay, very moist, dark brown, organic rich											
1	[Hatched Pattern]	CL	Sandy Lean CLAY, medium stiff (estimated), very moist, red, occasional cobbles											
2														
3														
4														
5														
6		SC	Clayey SAND, medium dense (estimated), very moist, light brown, occasional cobble											
7		CL	Sandy Lean CLAY with gravel, medium stiff (estimated), very moist, red, occasional cobbles, more cobbles from 10 feet down											
8														
9														
10														
11														
12			MAXIMUM DEPTH EXPLORED APPROXIMATELY 12 FEET											
13														
14														
15														

**Notes:** No groundwater encountered.

**Tests Key**

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

**PROJECT NO.:** 167002



**FIGURE NO.:** 3

LOG OF TESTPIT 167002.GPJ EARTHTEC.GDT 2/28/16

# TEST PIT LOG

## NO.: TP-2

**PROJECT:** Trappers Ridge Phase 8 Subdivision  
**CLIENT:** Watts Enterprises  
**LOCATION:** See Figure 2  
**OPERATOR:** C.E. Butters Construction  
**EQUIPMENT:** Rubber-tire Backhoe  
**DEPTH TO WATER; INITIAL  $\nabla$  :** 8 ft.

**PROJECT NO.:** 167002  
**DATE:** 01/27/16  
**ELEVATION:** Not Determined  
**LOGGED BY:** F. Namdar  
**AT COMPLETION  $\nabla$  :**

Depth (Fl.)	Graphic Log	USCS	Description	Samples	TEST RESULTS								
					Water Cont. (%)	Dry Dens. (pcf)	LL	PI	Gravel (%)	Sand (%)	Fines (%)	Other Tests	
0			TOPSOIL, clay, very moist, dark brown, organic rich										
1			Lean CLAY, soft to medium stiff (estimated), very moist, dark brown to gray										
2													
3													
4													
5													
6													
7		CL											
8		$\nabla$											
9													
10													
11													
12													
13			MAXIMUM DEPTH EXPLORED APPROXIMATELY 12 FEET										
14													
15													

**Notes:** Groundwater encountered at 8 feet below the ground surface.

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

**PROJECT NO.:** 167002



**FIGURE NO.:** 4

LOG OF TESTPIT 167002.GPJ EARTHTEC.GDT 3/1/16

# TEST PIT LOG

## NO.: TP-3

**PROJECT:** Trappers Ridge Phase 8 Subdivision  
**CLIENT:** Watts Enterprises  
**LOCATION:** See Figure 2  
**OPERATOR:** C.E. Butters Construction  
**EQUIPMENT:** Rubber-tire Backhoe  
**DEPTH TO WATER; INITIAL  $\nabla$  :**

**PROJECT NO.:** 167002  
**DATE:** 01/27/16  
**ELEVATION:** Not Determined  
**LOGGED BY:** F. Namdar  
**AT COMPLETION  $\nabla$  :**

Depth (Ft)	Graphic Log	USCS	Description	Samples	TEST RESULTS								
					Water Cont. (%)	Dry Dens. (pcf)	LL	PI	Gravel (%)	Sand (%)	Fines (%)	Other Tests	
0			TOPSOIL, clay, very moist, dark brown, organic rich										
1			Lean CLAY with sand and gravel, medium stiff to stiff (estimated), very moist, brown										
2		CL		X									
3													
4					X								
5													
6			Clayey SAND with gravel and cobbles, medium dense to dense (estimated), moist, brown to gray										
7		SC		X									
8													
9					X	17	114	43	17	28	33	39	C
10				X									
11													
12			MAXIMUM DEPTH EXPLORED APPROXIMATELY 12 FEET										
13													
14													
15													

**Notes:** No groundwater encountered.

**Tests Key**

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

**PROJECT NO.:** 167002



**FIGURE NO.:** 5

LOG OF TESTPIT: 167002.GPJ EARTHTEC.GDT 3/8/16

# TEST PIT LOG

## NO.: TP-4

**PROJECT:** Trappers Ridge Phase 8 Subdivision  
**CLIENT:** Watts Enterprises  
**LOCATION:** See Figure 2  
**OPERATOR:** C.E. Butters Construction  
**EQUIPMENT:** Rubber-tire Backhoe  
**DEPTH TO WATER; INITIAL ∇ :**

**PROJECT NO.:** 167002  
**DATE:** 01/27/16  
**ELEVATION:** Not Determined  
**LOGGED BY:** F. Namdar  
**AT COMPLETION ∇ :**

Depth (Ft.)	Graphic Log	USCS	Description	Samples	TEST RESULTS									
					Water Cont. (%)	Dry Dens. (pcf)	LL	PI	Gravel (%)	Sand (%)	Fines (%)	Other Tests		
0			TOPSOIL, clay, very moist, dark brown, organic rich											
1			Clayey GRAVEL with sand and gravel, loose to dense (estimated), very moist, brown, occasional cobbles											
2		GC		X	22		37	15	27	24	49			
3														
4					X									
5														
6					X									
7														
8					X									
9														
10					X									
11														
12			MAXIMUM DEPTH EXPLORED APPROXIMATELY 12 FEET											
13														
14														
15														

**Notes:** No groundwater encountered.

**Tests Key**

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

**PROJECT NO.:** 167002



**FIGURE NO.:** 6

LOG OF TESTPIT 167002.GPJ EARTHTEC.GDT 3/8/16

# TEST PIT LOG

## NO.: TP-5

**PROJECT:** Trappers Ridge Phase 8 Subdivision  
**CLIENT:** Watts Enterprises  
**LOCATION:** See Figure 2  
**OPERATOR:** C.E. Butters Construction  
**EQUIPMENT:** Rubber-tire Backhoe  
**DEPTH TO WATER; INITIAL  $\nabla$  :**

**PROJECT NO.:** 167002  
**DATE:** 01/27/16  
**ELEVATION:** Not Determined  
**LOGGED BY:** F. Namdar

**AT COMPLETION  $\nabla$  :**

Depth (Ft.)	Graphic Log	USCS	Description	Samples	TEST RESULTS								
					Water Cont. (%)	Dry Dens. (pcf)	LL	PI	Gravel (%)	Sand (%)	Fines (%)	Other Tests	
0			TOPSOIL, clay, very moist, dark brown, organic rich										
1			Lean CLAY with sand and gravel, medium stiff to stiff (estimated), very moist, brown, occasional cobbles										
2													
3													
4													
5		CL											
6													
7													
8													
9													
10		SC		Clayey SAND with occasional cobble and boulder, medium dense (estimated) moist, brown									
11					18			8	63	29			
12			MAXIMUM DEPTH EXPLORED APPROXIMATELY 11 FEET										
13													
14													
15													

**Notes:** No groundwater encountered.

**Tests Key**

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

**PROJECT NO.:** 167002



**FIGURE NO.:** 7

LOG OF TESTPIT 167002.GPJ EARTHTEC.GDT 3/8/16

# LEGEND

**PROJECT:** Trappers Ridge Phase 8 Subdivision  
**CLIENT:** Watts Enterprises

**DATE:** 01/27/16  
**LOGGED BY:** F. Namdar

## UNIFIED SOIL CLASSIFICATION SYSTEM

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

### SAMPLER DESCRIPTIONS

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

### WATER SYMBOLS

- Water level encountered during field exploration
- Water level encountered at completion of field exploration

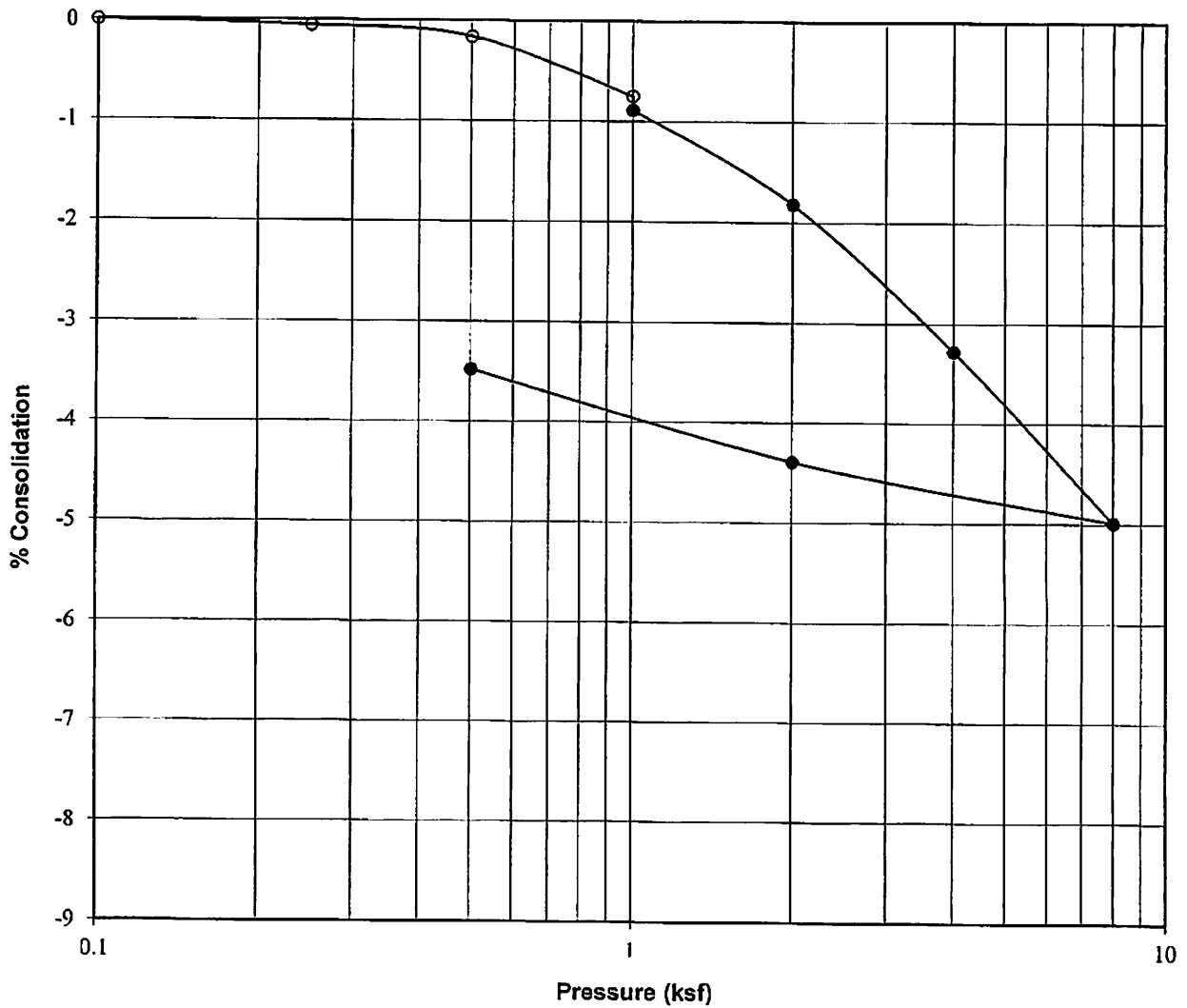
- NOTES:**
1. The logs are subject to the limitations, conclusions, and recommendations in this report.
  2. Results of tests conducted on samples recovered are reported on the logs and any applicable graphs.
  3. Strata lines on the logs represent approximate boundaries only. Actual transitions may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

PROJECT NO.: 167002



FIGURE NO.: 8

# CONSOLIDATION - SWELL TEST



<b>Project:</b>	Trappers Ridge Phase 8
<b>Location:</b>	TP-2
<b>Sample Depth, ft:</b>	6
<b>Description:</b>	Block
<b>Soil Type:</b>	Lean CLAY (CL)
<b>Natural Moisture, %:</b>	37
<b>Dry Density, pcf:</b>	90
<b>Liquid Limit:</b>	41
<b>Plasticity Index:</b>	16
<b>Water Added at:</b>	1 ksf
<b>Percent Collapse:</b>	0.1

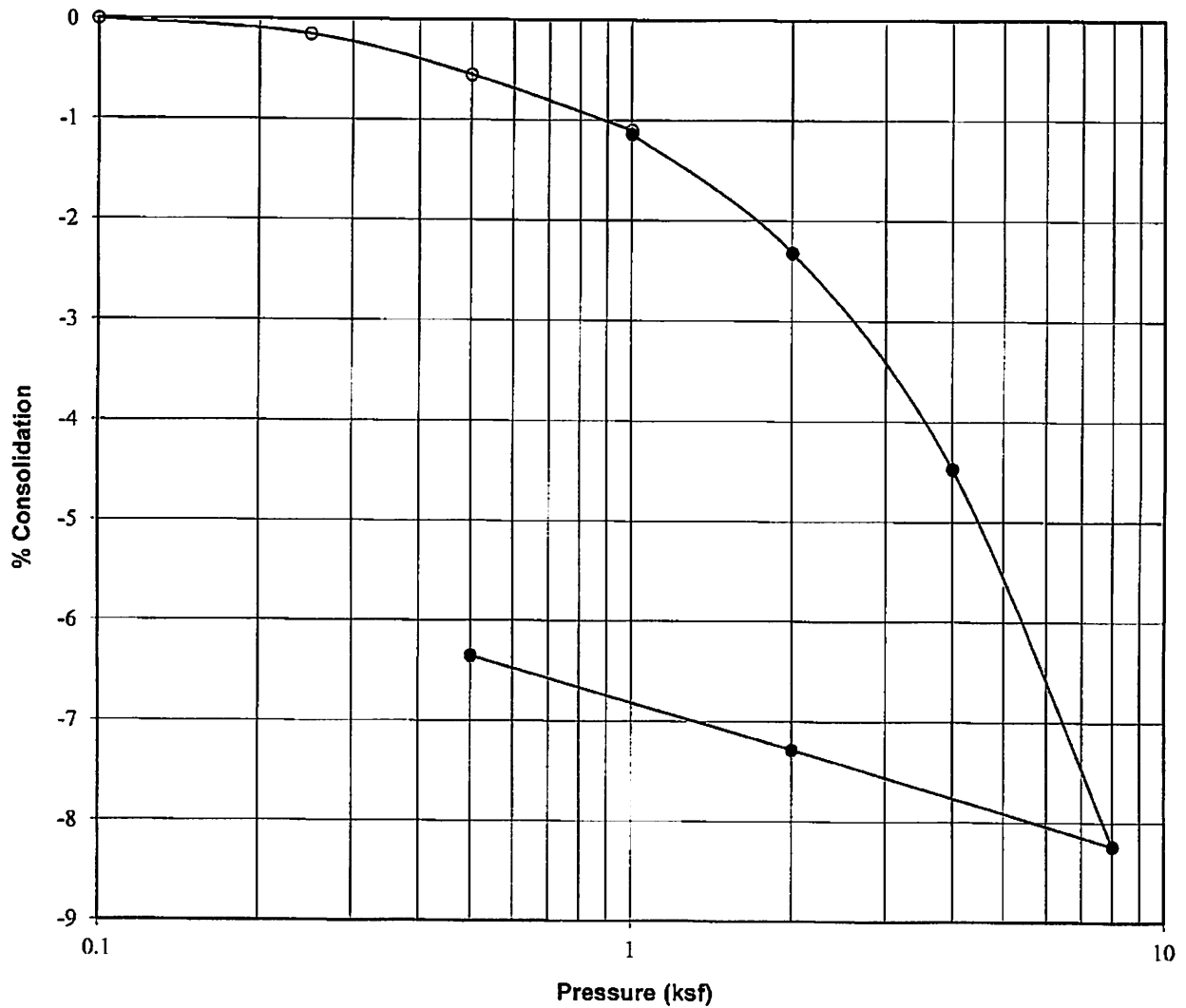
PROJECT NO.: 167002



FIGURE NO.: 9



# CONSOLIDATION - SWELL TEST



<b>Project:</b>	Trappers Ridge Phase 8
<b>Location:</b>	TP-3
<b>Sample Depth, ft:</b>	10
<b>Description:</b>	Block
<b>Soil Type:</b>	Clayey SAND with gravel (SC)
<b>Natural Moisture, %:</b>	17
<b>Dry Density, pcf:</b>	114
<b>Liquid Limit:</b>	43
<b>Plasticity Index:</b>	17
<b>Water Added at:</b>	1 ksf
<b>Percent Collapse:</b>	0.0

PROJECT NO.: 167002



FIGURE NO.: 10