# GEOTECHNICAL INVESTIGATION REPORT

**for**

**Kenworth Truck Sales**

**St. George, Utah**

Submitted to:

NBW Architects
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Landmark Project No. 17523

November 1, 2017

LANDMARK TESTING & ENGINEERING

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## ST. GEORGE, UTAH

## 1.0 INTRODUCTION

This report presents the results of Landmark Testing & Engineering's geotechnical investigation for Kenworth Truck Sales building, associated parking, and potential mass grading of 27 acres at the northeast corner of the Southern Parkway roadway and I-15 in St. George, Utah. Figure 1 is a Vicinity Map showing the location of the project relative to surrounding features. Figure 2 is a Site Map showing the approximate locations of the investigatory test pits completed for this investigation.

This investigation was completed to assist in developing opinions and recommendations concerning site earthwork and grading, foundation design, and pavement.

## 2.0 PROPOSED CONSTRUCTION

The project is located on 27 acres of land located between I-15 and Astragalus Drive. Previously a truck stop was constructed in the center portion of the site. The truck stop and the associated parking and road are in significant disrepair. We understand that a Kenworth Truck sales facility with associated parking, access roads, and drainage basins will be constructed proximate to the location of the previous construction.

Significant cuts and fills are anticipated for the site. A cut on the order of 20 feet is anticipated for the hill in the southwest portion of the site. Fills on the order of 20 feet are anticipated in the southwestern and northern portions of the site. Cuts and fills at the proposed building location are anticipated to be less than 3 to 4 feet. Parking is expected to accommodate both light traffic and heavy truck traffic.

## 3.0 SITE SETTING

### 3.1 SURFACE CONDITIONS

The site is located between I-15 and Astragalus Drive in St. George as shown on Figures 1 and 2. There is moderate to abundant vegetation consisting of grass, tumble weeds, bushes and cacti. There is a hill in the southeastern portion of the site. The southwestern portion of the site slopes down to the west. The western portion of the site slopes up to the north to the middle portion of the site where the proposed building is to be located. To the north of the building pad the land slopes down approximately 20 feet into a wash. There

is a hill to the north of the wash approximately the same elevation as the building pad portion of the site. To the north of the hill the site slopes down approximately 17 to 20 feet to the northwest.

## 3.2 SEISMICITY AND FAULTING

Seismicity at the site was determined using the United States Geological Survey, Earthquake Hazards Program website. The following values are presented to assist with seismic design:

- Latitude= 37.0316, Longitude= -113.6007
- Site Class = C - "Very Stiff Soil and Soft Rock", based on ASCE 7 (Table 20.3.1) as referenced in 2012 IBC 1613.3.2
-

| Period (sec) | Sa (g) | Site Class |
|---|---|---|
| 0.2 | 0.499 $S_S$ | B |
| 1.0 | 0.154 $S_1$ | B |
| 0.2 | 0.399 $SD_S$ | C |
| 1.0 | 0.169 $SD_1$ | C |

(2010 ASCE-7, USGS, U.S. Seismic Design Maps Calculator, Version 3.1.0)

The projected trace of the Washington fault is located approximately 6.7 miles east of the project. Higgins and Willis (1995) indicate that the Washington fault displaces late Quaternary sediments and is considered active. The projected trace of the Hurricane fault is located approximately 16 miles east of the project. The latest movement of the Hurricane fault is considered Holocene, which classifies the fault as active. Strong ground motion associated with movement along the Washington, Hurricane, or other faults associated with the Intermountain Seismic Belt is possible, however, the potential for surface fault rupture is considered low.

Groundwater was not encountered in any test pit and the underlying soil is medium dense to dense. The liquefaction potential is considered very low.

## 3.3 SUBSURFACE CONDITIONS

A total of twelve (12) test pits were excavated to determine subsurface conditions at the site. Test pit logs are presented on Figures 3 through 14. A key to the descriptions on the logs is presented on Figure 15. Soil encountered in the test pits in the building pad portion of the site (test pits TP-1 through TP-4) consists of silty sand with gravel and cobbles in the upper 3 to 4.5 feet. Brown sandy silt with gravel was encountered

underlying the sand. The soil graded very difficult to excavate and test pits were terminated at 3.5 to 8 feet. A layer of green sand with gypsum approximately 1 foot thick was encountered in test pit TP-3. The layer sloped down to the north at approximately 40 degrees. Reddish brown sandy silt with clay and gypsum was encountered at 4 feet underlying the green sand in test pit TP-3. Test pit TP-4 was located in the existing parking lot and the mini excavator used to excavate the test pits could not penetrate and remove the asphalt. The asphalt was observed to be at least 1 foot thick.

Test pits TP-5, TP-6, TP-9, and TP-10 were excavated in the parking lot area. Test pits TP-5 and TP-6 were located in the southern portion of the parking lot area and soils consisted of loose to medium dense silty sand. Minor gravel was encountered in test pit TP-5 at 5 feet. Test pits TP-5 and TP-6 were terminated at 6.5 and 4 feet, respectively, due to practical refusal. Test pits TP-9 and TP-10 consisted of silty sand with gravel in the upper 1.5 to 2 feet. The sand graded very gravelly with up to 30 to 40% gravel and up to 10% cobbles. The test pits were terminated at 3 and 3.5 feet when the soil became very difficult to excavate.

Test pits TP- 7, TP-8, TP-11, and TP-12 were completed in the parcels to the north and south of the building pad area. Test pits TP-7 and TP-8 were completed to the south and soils consisted of medium dense to dense silty sand. The sand graded with gravel and cobbles in test pit TP-9 at 3 feet. The test pits were terminated at 2 and 4.5 feet.

Test pits TP-11 and TP-12 were completed on the hill to the north of the building pad area. Silty sand with gravel was encountered in the test pits in the upper 3.5 to 4.5 feet. At 4.5 feet in test pit TP-12 the soil graded to brownish green sandy gypsum. Underlying the gypsum in test pit TP-12 was reddish brown sandy silt with gypsum and minor clay. The silt was very dense. Test pits TP-11 and TP-12 were terminated at 5.5 and 7 feet where the soil became difficult to excavate.

## 4.0 LABORATORY TESTING

Laboratory tests included mechanical gradation analyses and Atterberg limits tests to aid in soil classification, two Proctors to aid in construction management, a CBR to aid in asphalt design, a soluble sulfates test to aid in concrete design, and two swell/consolidation tests. Laboratory results are shown on test pit logs on Figures 3 through 14 and on the laboratory summary on Table 1 on Figure 16.

The results of the Proctors show that the maximum dry density of the near surface soils in test pit TP-5 was 127.4 pcf with an optimum moisture content of 8.8%. The maximum dry density of the near surface soil in test pit TP-5 was 136.0 pcf with an optimum moisture content of 5.9%.

A consolidation test performed on a sample of silty sand from test pit TP-3 at 4 feet collapsed 3.7% when wetted under a load of 1,000 psf. A remolded sample of sandy silt with clay from test pit TP-3 at 6.5 feet swelled 0.8% when compacted to 106.2 pcf at a moisture content of 8.4% under a 60 psf load. The data curves are shown on Figures 17 and 18.

Low density silty soil with abundant gypsum or gypsum honeycombing will have a high collapse potential and should be excavated and properly compacted when encountered.

## 5.0 SITE GRADING AND EARTHWORK

Initial site grading should consist of removal of all the vegetation, old structures, and existing asphalt and concrete. Asphalt in excess of 12 inches thick was encountered in test pit TP-4 which could not be excavated with a mini-excavator. The soil in the upper 6 inches to 1 foot has abundant roots and it will likely not be feasible to remove roots from the soil in order to use it as structural fill. However, on-site soils are suitable for use as fill provided they are free of roots and other deleterious materials.

Based on the cut/fill sheets provided for the anticipated project grading, cuts and fills from 3 to 4 feet in depth may occur in the anticipated building and parking area. Following removal of deleterious material and any unsuitable soils associated with removals of existing elements, fill may be placed directly on existing soils where the upper 8-inches have been scarified, moisture conditioned and compacted to 90% of the maximum dry density as determined by ASTM D-1557. Where cuts are required we recommend that the upper 8-inches of suitable soils be scarified, moisture conditioned to within 2% of the optimum moisture content, and compacted to a minimum of 95% of the maximum dry density as determined by ASTM D-1557. Any large cobbles encountered in the upper 1.5 feet be removed from the site. Low density silty soil with abundant gypsum or gypsum honeycombing, if encountered during excavation or scarification, will have a high collapse potential and should be excavated and properly compacted.

In areas where previous construction has not occurred loose soils were encountered in the upper 1.5 feet of the test pits. Underlying soils were generally medium dense to dense. For fill areas which will comprise the southwest quarter and northern portions of the parcel, following grubbing of vegetation, we recommend that the upper 12-inches be scarified, moisture conditioned to within 2% of the optimum moisture content and compacted to a minimum of 90% of the maximum dry density as determined by ASTM D-1557. Fill may then be placed over compacted subgrade. Large cobbles (6-inches in dimension or greater) can cause areas of poor compaction in the fill and should either be broken up or removed from the site. Occasional cobbles from 6 to 12 inches in dimension may be incorporated in the bottom of deep fills. However, these should be covered by at least 5 feet of 3-inch minus material. Cobbles should be incorporated in a soil matrix such that"nests" of cobbles are not created. Volume loss on the order of 15 percent is anticipated for properly compacted on-site soils.

Deep fills from 7 to 16 feet will be required in depressions and ravines throughout the parcel. The fill in these areas should be placed in horizontal lifts with benches in the sides of the ravines to key the fill into adjacent slopes.

Cut portions of the site will be located near the center, north of the building area, east and southeast corner. Cuts ranging up to 20 feet will be required on hills at the site. Although competent bedrock was not encountered, dense soils were noted in all of the test pits. We anticipate that the hills can to be cut with standard excavating equipment, including track hoes and dozers. A ripper may be required to break up the siltstone/mudstone that may be encountered at depth.

Gypsum interbeds were noted and gypsum was also noted within silty soils. Despite the medium dense to dense condition of the on-site soils, collapse due to gypsum dissolution is possible. We recommend that, where possible, soil with abundant gypsum be blended with sandy and gravelly soils. Any honeycombed soils should be broken up and adequately blended and moisture conditioned.

## 5.1 FILL PLACEMENT AND COMPACTION

All fill to be placed should be considered structural fill. We anticipate that the majority of site soils can be used as structural fill. Any soils with excessive gypsum should be thoroughly mixed with suitable on-site soils prior to compaction. Any imported fill should be granular, well-graded, and meet the gradation requirements below. All soils used as structural fill should meet the compaction requirements.

| GRADATION | PERCENT PASSING |
|---|---|
| 6- inch | 100 |
| 3-inch | 80-100 |
| No. 200 sieve | 5-30 |
| | |
| Liquid Limit | 30 or less |
| Plasticity Index | 10 or less |
| Maximum lift thickness | 8-inch (loose) |
| Minimum compaction | 95% ASTM D-1557 |
| Compacted Moisture Content | within 2% of optimum |

Material not meeting the above requirements may be suitable for use as structural fill at the discretion of the geotechnical engineer. Samples of structural fill should be submitted for testing prior to transporting to the site. All structural fill should be evenly spread on a horizontal plane in eight-inch loose lifts.

## 6.0 FOUNDATION AND CONSTRUCTION CONSIDERATIONS

The majority of the site where the building will be situated has been disturbed. Following removal of existing structures, concrete, asphalt, and unsuitable material, the building may be established on properly compacted on-site soils or on imported structural fill. Low density silty soil with abundant gypsum or gypsum honeycombing, if encountered during excavation or scarification, will have a high collapse potential and should be excavated and properly compacted.

Structural loads have not been provided, however, maximum wall loads are anticipated to be on the order of 3-4 kips per lineal foot and maximum isolated column loads ranging from 50-75 kips. To adequately support anticipated loads we recommend that foundations be supported as indicated in the following table.

| Foundation Type | Depth of Compacted Structural Fill Underlying Foundation |
|---|---|
| Continuous wall and columns up to 75 kips | 24-inches |
| Interior slab | 18-inches |

Columns in excess of 75 kips should be evaluated on a case-by-case basis.

We recommend that the entire building footprint and extending 5 feet beyond the building footprint be overexcavated as indicated above.

## 6.1 FOUNDATION DESIGN

The proposed structure may be supported on conventional spread or continuous footings established on suitable structural fill as shown above. Foundation excavations should be visually observed and tested by qualified personnel prior to placement of reinforcing steel or concrete. Additional foundation recommendations are subsequently presented.

| DESCRIPTION | VALUE |
|---|---|
| Foundation Type | Continuous or spread footings on structural fill |
| Bearing Material | Structural fill |
| Allowable Bearing Capacity | 2000 psf for footings 1.5 feet wide or greater |
| Minimum embedment depth below finished grade | 12-inches (for frost and confinement) |

| DESCRIPTION | VALUE |
|---|---|
| Minimum footing width | 12 inches (continuous) for single-story, 18-inches for two stories, 24-inches (isolated spread) |
| Total estimated settlement | 1-inch |
| Total differential settlement | less than 3/4 inch |

The allowable bearing capacity is based upon dead load plus long term live load. A one-third increase in allowable bearing capacity may be used for short duration loads, such as wind or seismic loads.

## 7.0 FLOOR SLABS

We recommend that interior floor slabs for the building be established on at least 18 inches of structurally placed soils. A minimum four-inch thick layer of free-draining gravel (containing less than 5% fine grained material passing the #200 sieve) or 6-inches of type II road base should be placed immediately below the floor slabs to help distribute floor loads, break the rise of capillary water, and aid in the concrete curing process. The gravel should be adequately consolidated and placed directly below the floor slab and may count as part of the 18 inches of structural fill.

Concrete slabs should be designed using rebar reinforcement and frequent crack control joints to help control normal shrinkage and stress cracking. Concrete placement and curing should meet ACI[1] requirements including following hot or cold weather placement recommendations, when appropriate. If a moisture-sensitive floor covering will be installed, we recommend that a vapor barrier be installed beneath the concrete slab. The moisture sensitivity of floor finishes, anticipated project conditions, and the potential effects of slab curling and cracking should be considered in determining if the barrier should be placed directly beneath the slab or beneath the free-draining gravel (see ACI 302.IR-96 for more information regarding vapor barrier location). If the vapor barrier is installed directly beneath the slab, measures should be taken to minimize excessive slab curl such as reduced joint spacing and use of a low shrinkage (low water-cement ratio) mix.

1 American Concrete Institute

## 8.0 LATERAL EARTH PRESSURES

Lateral loads imposed on footings may be resisted by the development of passive earth pressures against the sides of footings and friction between the base of the footing and the supporting soils. Lateral earth pressure values are presented in the following table.

| Case Evaluated | Soil Type | Value |
|---|---|---|
| Active | Suitable structural fill | 42 psf/ft |
| | | 58 psf/ft (with seismic) |
| At-Rest | Suitable structural fill | 63 psf/ft |
| Passive | Suitable structural fill | 375 psf/ft |
| | | 330 psf/ft (with seismic) |
| Coefficient of friction | Suitable structural fill | 0.32 |

The lateral earth pressures presented do not include any safety factors. The pressures also assume horizontal backfill behind the walls and the walls are in a drained condition with no build-up of hydrostatic pressure behind the wall. The additional effects of sloping backfill, surcharge, structural loads and groundwater conditions should be included in calculating lateral earth pressures. Backfill should be placed in accordance with the requirements of structural fill except that backfill in landscape and areas that will not be subject to structural loadings may be reduced to 90% of the maximum dry density as determined by ASTM D-1557.

## 9.0 CUT AND FILL SLOPES

Maximum cuts and fills are expected to be on the order of 16 to 20 feet. It is recommended that unrestrained, permanent cut or fill slopes be maintained at a slope of 1 vertical to 2 horizontal (1V:2H) or flatter. Cuts in competent siltstone/mudstone, if encountered, may be maintained at a slope of 1 vertical to 1.5 horizontal (1V:1.5H). Grading of both cut and fill slopes should be such that surface water is directed away from the slopes and not concentrated on slopes or in unprotected channels. Construction procedures should ensure adequate compaction of slope faces. All excavations should conform to OSHA standards.

## 10.0 PAVEMENTS

For the automobile parking a traffic index of 5.5, similar to heavy residential, was used for pavement design. For the access road and apron/approach areas a traffic index of 7.0 (20 loaded three-axle trucks per day) was used and both heavy duty asphalt and concrete pavement parameters are provided.

The following parameters were considered:

- Pavement Design Life - 20 years
- Subgrade CBR Value - 5 (measured)
- Structural Layer Coefficients - Asphalt = 0.44
  - Type II = 0.14

Based on design parameters 3.0 inches of asphaltic concrete over 6 inches of Type II base would be adequate for automobile parking areas. For access road and apron/approach areas for heavy vehicles we recommend a pavement section of 3.5 inches of asphaltic concrete over 10 inches of Type II base.

At a minimum the upper 12-inches of existing subgrade should be scarified, moisture conditioned to within 2% of the optimum moisture content, and compacted to a minimum of 90% of the maximum dry density as determined by ASTM D 1557. The compacted subgrade should extend at least two feet beyond the pavement limits. Trafficking upon and compaction of silty subgrade soils will be extremely difficult during periods of wet weather when the subgrade becomes wet.

Base course material should be compacted to a minimum of 95% of maximum dry density (ASTM D 1557). Asphaltic concrete should be compacted to at least 96 percent of the laboratory Marshal mix design density (ASTM D 6926 and D 2726). Asphaltic concrete and base should be tested prior to site delivery and during placement for conformance with project specifications.

Concrete Pavement

For heavy truck traffic areas such as loading docks and apron/approach areas a rigid pavement option may be preferred. Procedures outlined in the Portland Cement Association's guide "Thickness Design for Concrete Highway and Street Pavements" were utilized for concrete pavement design.

The following design parameters were used:

(1) Average daily truck traffic = 20 (Axle -load category 2)

(2) Subgrade-subbase support = medium (based on site soils)

(3) Concrete modulus of rupture = 650 psi

Based on input parameters, we recommend a minimum of 6.5 inches of concrete and 4 inches of base over a properly prepared subgrade.

As a rough guide, the joint spacing in feet for plain concrete pavement should not generally exceed twice the slab thickness in inches. Thus, for a 6.5 inch thick slab, joint spacing would be on the order of 13 feet. Also, as a general guideline, the ratio of slab width to length should not exceed 1.25.

Joint depth should be 1/4 of the slab thickness and continuous across the slab. If sawn joints are used, the joints should be sawn as soon as possible following concrete set.

## 11.0 MOISTURE CONTROL

Laboratory tests indicate that gypsiferous subgrade soils have a low to moderate collapse potential when allowed to become wet. Wetting of silty soils may cause some degree of volume change within the soil and should also be prevented both during and after construction. The following moisture control measures are recommended:

(1) The ground surface should be graded to drain surface water away from the building in all directions. A minimum grade of 5% (IBC 1803.3) in the first 10 feet is recommended except in ramp areas subject to ADA restrictions. Impervious surfaces such as concrete walkways or asphalt pavement adjacent to the structure are effective in reducing the potential for water

migration beneath foundations and slabs and should be considered in design. Impervious surfaces such as asphalt or concrete within 10 feet of the building foundation should be sloped a minimum of 2% away from the building.

(2) Roof runoff should be collected and discharged well outside of the backfill limits. Alternatively, roof runoff may discharge on impervious surfaces sloped away from the foundation. Water should not be allowed to pond on the site or adjacent to footings or structurally placed fill.

(3) Xeriscape (landscaping that eliminates the need for supplemental irrigation of plants) is recommended within 10 feet of the building foundation.

(4) Inadequate compaction of foundation backfill and utility trench backfill provides a conduit for water migration. All utility trenches within the building footprint and extending 5 feet beyond the footprint should be backfilled with structural fill similar to that approved for the foundations. Backfill adjacent to structures should be compacted to at least 90 percent of the maximum dry density as determined by ASTM D-1557 and the minimum slope requirements should be followed. Backfill beneath structures and pavements should be compacted to at least 95% of the maximum dry density.

(5) Grading should be such that surface water is directed away from the site to an adjacent drainage ditch or retention area. Water should not be allowed to pond on-site. On-site retention should be down gradient of all structures.

It should be emphasized that final grading and landscaping generally occurs after construction of the structure and observation of these features is outside of normal geotechnical inspection and observation. The developer/owner is responsible to ensure that these surface drainage and moisture control recommendations are followed throughout the life of the structure.

## 12.0 SOIL CORROSIVITY

Tests completed on a silty sample from test pit TP-3 at 4.0 feet had a water soluble sulfate percentage of 3.71 percent. As such, site soils would classify as having severe corrosive potential to concrete structures. It is recommended that concrete mixes be designed for severe corrosive potential. This includes 4,500 psi concrete, Type V cement with pozzolan, and a low water to cement ratio. It is recommended that all concrete be designed in accordance with ACI 318, Section 4.3. Buried pipes should be plastic (PVC or HDPE) instead of metal, where possible.

## 13.0 PERCOLATION TEST RESULTS

Two percolation tests were completed to depths of approximately 2 feet in the anticipated drainage basin areas. The percolation test in the north basin area had a stabilized percolation rate of 3.2 minutes per inch. The percolation test in the southwest basin area had a stabilized percolation rate of 3.5 minutes per inch.

## 14.0 FOUNDATION REVIEW AND TESTING

This report has been prepared to assist in project design and construction. Variations from the conditions portrayed in the exploratory investigations may occur which are sometimes sufficient to require modifications to the design. In order to incorporate recommendations provided into actual field conditions and to confirm that the project specifications are implemented, we recommend that observation and testing be performed during construction to monitor over-excavation, grading, and preparation of soils upon which foundations elements or structural loads may be established.

## 15.0 LIMITATIONS

The exploratory data presented in this report were collected to provide geotechnical design recommendations for this project and subsurface site descriptions represent conditions observed at the time and at the locations explored. The investigations may not be indicative of subsurface conditions beyond the investigation location and conditions may change with passage of time. If subsurface conditions are encountered that are significantly different than those reported herein, Landmark should be contacted immediately for the continued applicability of the recommendations. In the event changes to the project are made that differ from those presented in this report, Landmark should be made aware of the changes. Landmark will provide written verification that the recommendations and conclusions remain valid or that modifications are required.

This report has been prepared to assist in project design and construction. We respectfully request the opportunity to review the final design drawings and specifications in order to determine whether the assumptions and recommendations presented herein are applicable to the anticipated designs.

This report is not intended to be used as a bid document. Any information concerning the environmental conditions of the site is beyond the scope of this geotechnical study. This geotechnical report has been prepared to meet the specific needs of our client and may not be appropriate to satisfy the needs of other users.

LANDMARK TESTING & ENGINEERING


Russell Owens, P.E.
Geotechnical Manager

Reviewed by:

Kent Nelson, PE
Project Engineer


| | | |
|---|---|---|
| LANDMARK TESTING & ENGINEERING | VICINITY MAP<br>LANDMARK PROJECT 17523 | FIGURE 1 |


| | | |
|---|---|---|
| LANDMARK TESTING & ENGINEERING | SITE MAP<br>LANDMARK PROJECT 17523 | Figure 2 |

**DATE STARTED** 10/23/17 **COMPLETED** 10/23/17 **EXCAVATION COMPANY** Prime **SURFACE ELEVATION** _____

**EXCAVATION METHOD** CAT305.5E Mini Ex **GROUND WATER LEVELS:**

**LOGGED BY** Kent Nelson **CHECKED BY** Russ Owens **AT TIME OF EXCAVATION** ---

**NOTES** _____ **AT END OF EXCAVATION** ---

| DEPTH (ft) | GRAPHIC LOG | SAMPLE TYPE NUMBER | MATERIAL DESCRIPTION | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | ATTERBERG LIMITS: PLASTICITY INDEX | MECHANICAL GRADATION: GRAVEL (%) | MECHANICAL GRADATION: SAND (%) | MECHANICAL GRADATION: FINES (%) | Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | SILTY SAND (SM), brown, loose, dry | | | | | | | | |
| | | | Grades fine grained with up to 20 - 30% gravel, dense, slightly moist | | | | | | | | |
| 2.5 | | 1 | | | 4.0 | | | 19 | 37 | 44 | |
| | | | SANDY SILT (ML), reddish brown, clayey, gypsiferous, difficult to excavate | | | | | | | | |
| 5.0 | | | | | | | | | | | |

Bottom of test pit at 6.0 feet.

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# TEST PIT NUMBER TP 1



Figure No. 3

**CLIENT** NBW Architects **PROJECT NAME** Kenworth Truck Sales

**PROJECT NUMBER** 17523 **PROJECT LOCATION** St. George, Utah

**DATE STARTED** 10/23/17 **COMPLETED** 10/23/17 **EXCAVATION COMPANY** Prime **SURFACE ELEVATION** _____

**EXCAVATION METHOD** CAT305.5E Mini Ex **GROUND WATER LEVELS:**

**LOGGED BY** Kent Nelson **CHECKED BY** Russ Owens **AT TIME OF EXCAVATION** ---

**NOTES** _____ **AT END OF EXCAVATION** ---

| DEPTH (ft) | GRAPHIC LOG | SAMPLE TYPE NUMBER | MATERIAL DESCRIPTION | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS | | MECHANICAL GRADATION | | | Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | LIQUID LIMIT | PLASTICITY INDEX | GRAVEL (%) | SAND (%) | FINES (%) | |
| 0.0 | | | SILTY SAND (SM), light brown, up to 30 to 40% gravel and 5 to 10% cobbles, very dense | | | | | | | | |
| 2.5 | | 2 | Grades with up to 30% cobbles up to 6 inches, very difficult to excavate | | | | | | | | |

Bottom of test pit at 3.5 feet.

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# TEST PIT NUMBER TP 2



Figure No. 4

**CLIENT** NBW Architects **PROJECT NAME** Kenworth Truck Sales

**PROJECT NUMBER** 17523 **PROJECT LOCATION** St. George, Utah

**DATE STARTED** 10/23/17 **COMPLETED** 10/23/17 **EXCAVATION COMPANY** Prime **SURFACE ELEVATION** _____

**EXCAVATION METHOD** CAT305.5E Mini Ex **GROUND WATER LEVELS:**

**LOGGED BY** Kent Nelson **CHECKED BY** Russ Owens **AT TIME OF EXCAVATION** ---

**NOTES** _____ **AT END OF EXCAVATION** ---

| DEPTH (ft) | GRAPHIC LOG | SAMPLE TYPE NUMBER | MATERIAL DESCRIPTION | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | ATTERBERG LIMITS: PLASTICITY INDEX | MECHANICAL GRADATION: GRAVEL (%) | MECHANICAL GRADATION: SAND (%) | MECHANICAL GRADATION: FINES (%) | Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | SILTY SAND WITH GRAVEL AND COBBLES (SM), light brown, up to 30% gravel and 20% cobbles, medium dense to dense, dry | | | | | | | | |
| 2.5 | | | | | | | | | | | |
| | | 1 | SANDY SILT (ML), brown, minor gravel, medium dense, slightly moist | 71.2 | 3.6 | | | | | | Soluble Sulfate = 3.71% 3.7% Collapse @ 1000 psf |
| 5.0 | | | Green sand with gypsum approximately 1 foot thick, very light weight, slopes down to the north approximately 40% | | | | | | | | |
| | | 2 | SILT (ML), reddish brown, gypsiferous, clayey, difficult to excavate, slightly moist | 106.2 | 8.0 | | | 4 | 33 | 63 | 0.8% Swell @ 1000 psf |
| 7.5 | | | | | | | | | | | |

Bottom of test pit at 8.5 feet.

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# TEST PIT NUMBER TP 3



Figure No. 5

**CLIENT** NBW Architects **PROJECT NAME** Kenworth Truck Sales

**PROJECT NUMBER** 17523 **PROJECT LOCATION** St. George, Utah

**DATE STARTED** 10/23/17 **COMPLETED** 10/23/17 **EXCAVATION COMPANY** Prime **SURFACE ELEVATION** _____

**EXCAVATION METHOD** CAT305.5E Mini Ex **GROUND WATER LEVELS:**

**LOGGED BY** Kent Nelson **CHECKED BY** Russ Owens **AT TIME OF EXCAVATION** ---

**NOTES** _____ **AT END OF EXCAVATION** ---

| DEPTH (ft) | GRAPHIC LOG | SAMPLE TYPE NUMBER | MATERIAL DESCRIPTION | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS | | MECHANICAL GRADATION | | | Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | LIQUID LIMIT | PLASTICITY INDEX | GRAVEL (%) | SAND (%) | FINES (%) | |
| 0.0 | | | Minimum of 1 foot of asphalt, could not excavate through entirety of parking lot | | | | | | | | |

Refusal at 1.0 feet.
Bottom of test pit at 1.0 feet.

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# TEST PIT NUMBER TP 4



Figure No. 6

**CLIENT** NBW Architects **PROJECT NAME** Kenworth Truck Sales

**PROJECT NUMBER** 17523 **PROJECT LOCATION** St. George, Utah

**DATE STARTED** 10/23/17 **COMPLETED** 10/23/17 **EXCAVATION COMPANY** Prime **SURFACE ELEVATION** ---

**EXCAVATION METHOD** CAT305.5E Mini Ex **GROUND WATER LEVELS:**

**LOGGED BY** Kent Nelson **CHECKED BY** Russ Owens **AT TIME OF EXCAVATION** ---

**NOTES** **AT END OF EXCAVATION** ---

| DEPTH (ft) | GRAPHIC LOG | SAMPLE TYPE NUMBER | MATERIAL DESCRIPTION | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS | | MECHANICAL GRADATION | | | Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | LIQUID LIMIT | PLASTICITY INDEX | GRAVEL (%) | SAND (%) | FINES (%) | |
| 0.0 | | | SILTY SAND WITH GRAVEL (SM), light brown, loose, dry | | | | | | | | |
| 2.5 | | | Grades loose to medium dense | | | | | | | | CBR = 5 |
| 5.0 | | | Grades with minor gravel | | | | | | | | |

Refusal at 6.5 feet.
Bottom of test pit at 6.5 feet.

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# TEST PIT NUMBER TP 5



Figure No. 7

**CLIENT** NBW Architects **PROJECT NAME** Kenworth Truck Sales

**PROJECT NUMBER** 17523 **PROJECT LOCATION** St. George, Utah

**DATE STARTED** 10/23/17 **COMPLETED** 10/23/17 **EXCAVATION COMPANY** Prime **SURFACE ELEVATION** ---

**EXCAVATION METHOD** CAT305.5E Mini Ex **GROUND WATER LEVELS:**

**LOGGED BY** Kent Nelson **CHECKED BY** Russ Owens **AT TIME OF EXCAVATION** ---

**NOTES** **AT END OF EXCAVATION** ---

| DEPTH (ft) | GRAPHIC LOG | SAMPLE TYPE NUMBER | MATERIAL DESCRIPTION | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS | | MECHANICAL GRADATION | | | Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | LIQUID LIMIT | PLASTICITY INDEX | GRAVEL (%) | SAND (%) | FINES (%) | |
| 0.0 | | | GRAVELLY SILTY SAND (SM), light brown, loose, dry to slightly moist | | | | | | | | |
| 2.5 | | ☒ 1 | | | 3.5 | NP | NP | 16 | 35 | 49 | |

Refusal at 4.0 feet.
Bottom of test pit at 4.0 feet.

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# TEST PIT NUMBER TP 6



Figure No. 8

**CLIENT** NBW Architects **PROJECT NAME** Kenworth Truck Sales

**PROJECT NUMBER** 17523 **PROJECT LOCATION** St. George, Utah

DATE STARTED 10/23/17 COMPLETED 10/23/17 EXCAVATION COMPANY Prime SURFACE ELEVATION

EXCAVATION METHOD CAT305.5E Mini Ex GROUND WATER LEVELS:

LOGGED BY Kent Nelson CHECKED BY Russ Owens AT TIME OF EXCAVATION ---

NOTES AT END OF EXCAVATION ---

| DEPTH (ft) | GRAPHIC LOG | SAMPLE TYPE NUMBER | MATERIAL DESCRIPTION | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | ATTERBERG LIMITS: PLASTICITY INDEX | MECHANICAL GRADATION: GRAVEL (%) | MECHANICAL GRADATION: SAND (%) | MECHANICAL GRADATION: FINES (%) | Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | SILTY SAND WITH GRAVEL (SM), light brown, medium dense, slightly moist | | | | | | | | |
| | | 1 | Grades gravelly, very difficult to excavate | | 4.6 | | | 26 | 37 | 37 | |

Bottom of test pit at 2.0 feet.

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# TEST PIT NUMBER TP 7



Figure No. 9

CLIENT NBW Architects PROJECT NAME Kenworth Truck Sales

PROJECT NUMBER 17523 PROJECT LOCATION St. George, Utah

**DATE STARTED** 10/23/17 **COMPLETED** 10/23/17 **EXCAVATION COMPANY** Prime **SURFACE ELEVATION** _____

**EXCAVATION METHOD** CAT305.5E Mini Ex **GROUND WATER LEVELS:**

**LOGGED BY** Kent Nelson **CHECKED BY** Russ Owens **AT TIME OF EXCAVATION** ---

**NOTES** _____ **AT END OF EXCAVATION** ---

| DEPTH (ft) | GRAPHIC LOG | SAMPLE TYPE NUMBER | MATERIAL DESCRIPTION | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS | | MECHANICAL GRADATION | | | Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | LIQUID LIMIT | PLASTICITY INDEX | GRAVEL (%) | SAND (%) | FINES (%) | |
| 0.0 | | | SILTY SAND (SM), lightly brown, medium dense, dry to slightly moist | | | | | | | | |
| 2.5 | | | SILTY SAND WITH GRAVEL AND COBBLES (SM), difficult to excavate | | | | | | | | |

Bottom of test pit at 4.5 feet.

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# TEST PIT NUMBER TP 8



Figure No. 10

**CLIENT** NBW Architects **PROJECT NAME** Kenworth Truck Sales

**PROJECT NUMBER** 17523 **PROJECT LOCATION** St. George, Utah

**DATE STARTED** 10/23/17 **COMPLETED** 10/23/17 **EXCAVATION COMPANY** Prime **SURFACE ELEVATION** _____

**EXCAVATION METHOD** CAT305.5E Mini Ex **GROUND WATER LEVELS:**

**LOGGED BY** Kent Nelson **CHECKED BY** Russ Owens **AT TIME OF EXCAVATION** ---

**NOTES** _____ **AT END OF EXCAVATION** ---

| DEPTH (ft) | GRAPHIC LOG | SAMPLE TYPE NUMBER | MATERIAL DESCRIPTION | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS | | MECHANICAL GRADATION | | | Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | LIQUID LIMIT | PLASTICITY INDEX | GRAVEL (%) | SAND (%) | FINES (%) | |
| 0.0 | | | SILTY SAND (SM), light brown, minor gravel, loose, dry | | | | | | | | |
| 2.5 | | | SILTY SAND WITH GRAVEL AND COBBLES (SM), light brown, up to 30 to 40% gravel, up to 10% cobbles, very difficult to excavate | | | | | | | | |

Bottom of test pit at 3.5 feet.

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# TEST PIT NUMBER TP 9



Figure No. 11

**CLIENT** NBW Architects **PROJECT NAME** Kenworth Truck Sales

**PROJECT NUMBER** 17523 **PROJECT LOCATION** St. George, Utah

**DATE STARTED** 10/23/17 **COMPLETED** 10/23/17 **EXCAVATION COMPANY** Prime **SURFACE ELEVATION** _____

**EXCAVATION METHOD** CAT305.5E Mini Ex **GROUND WATER LEVELS:**

**LOGGED BY** Kent Nelson **CHECKED BY** Russ Owens **AT TIME OF EXCAVATION** ---

**NOTES** _____ **AT END OF EXCAVATION** ---

| DEPTH (ft) | GRAPHIC LOG | SAMPLE TYPE NUMBER | MATERIAL DESCRIPTION | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | ATTERBERG LIMITS: PLASTICITY INDEX | MECHANICAL GRADATION: GRAVEL (%) | MECHANICAL GRADATION: SAND (%) | MECHANICAL GRADATION: FINES (%) | Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | 1 | SILTY SAND (SM), light brown, minor gravel, loose, dry | | 1.6 | | | 16 | 39 | 45 | |
| 2.5 | | | SILTY SAND WITH GRAVEL AND COBBLES (SM), light brown, up to 30 to 40% gravel, up to 10% cobbles, very difficult to excavate | | | | | | | | |

Bottom of test pit at 3.0 feet.

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# TEST PIT NUMBER TP 10



Figure No. 12

**CLIENT** NBW Architects **PROJECT NAME** Kenworth Truck Sales

**PROJECT NUMBER** 17523 **PROJECT LOCATION** St. George, Utah

**DATE STARTED** 10/23/17 **COMPLETED** 10/23/17 **EXCAVATION COMPANY** Prime **SURFACE ELEVATION** ---

**EXCAVATION METHOD** CAT305.5E Mini Ex **GROUND WATER LEVELS:**

**LOGGED BY** Kent Nelson **CHECKED BY** Russ Owens **AT TIME OF EXCAVATION** ---

**NOTES** **AT END OF EXCAVATION** ---

| DEPTH (ft) | GRAPHIC LOG | SAMPLE TYPE NUMBER | MATERIAL DESCRIPTION | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | ATTERBERG LIMITS: PLASTICITY INDEX | MECHANICAL GRADATION: GRAVEL (%) | MECHANICAL GRADATION: SAND (%) | MECHANICAL GRADATION: FINES (%) | Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | SILTY SAND WITH GRAVEL (SM), light brown, medium dense, dry to slightly moist | | | | | | | | |
| 2.5 | | 1 | SANDY SILT WITH GRAVEL (ML), light brown, medium dense, dry | | 3.5 | | | 31 | 17 | 52 | |
| 5.0 | | 2 | SANDY SILT (ML), reddish brown, minor clay, gypsiferous, very dense, slightly moist | | 10.8 | NP | NP | 8 | 12 | 80 | |

Bottom of test pit at 5.5 feet.

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# TEST PIT NUMBER TP 11



Figure No. 13

**CLIENT** NBW Architects **PROJECT NAME** Kenworth Truck Sales

**PROJECT NUMBER** 17523 **PROJECT LOCATION** St. George, Utah

**DATE STARTED** 10/23/17 **COMPLETED** 10/23/17 **EXCAVATION COMPANY** Prime **SURFACE ELEVATION** _____

**EXCAVATION METHOD** CAT305.5E Mini Ex **GROUND WATER LEVELS:**

**LOGGED BY** Kent Nelson **CHECKED BY** Russ Owens **AT TIME OF EXCAVATION** ---

**NOTES** _____ **AT END OF EXCAVATION** ---

| DEPTH (ft) | GRAPHIC LOG | SAMPLE TYPE NUMBER | MATERIAL DESCRIPTION | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | ATTERBERG LIMITS: PLASTICITY INDEX | MECHANICAL GRADATION: GRAVEL (%) | MECHANICAL GRADATION: SAND (%) | MECHANICAL GRADATION: FINES (%) | Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | 1 | SILTY SANDY GRAVEL (GM), light brown, up to 20 to 30% gravel and cobbles, medium dense, dry | | 2.3 | | | 56 | 17 | 27 | |
| 2.5 | | | SANDY GYPSUM, brownish green, abundant gypsum, very light weight | | | | | | | | |
| 5.0 | | 2 | | | 11.8 | | | 7 | 26 | 67 | |
| | | | SANDY SILT (ML), reddish brown, minor clay, gypsiferous, very dense, slightly moist | | | | | | | | |

Bottom of test pit at 7.0 feet.

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# TEST PIT NUMBER TP 12



Figure No. 14

**CLIENT** NBW Architects **PROJECT NAME** Kenworth Truck Sales

**PROJECT NUMBER** 17523 **PROJECT LOCATION** St. George, Utah

## UNIFIED SOIL CLASSIFICATION SYSTEM

| MAJOR DIVISIONS | | SYMBOL | TYPICAL NAMES |
|---|---|---|---|
| COARSE-GRAINED SOILS (More than 1/2 of soil > No.200 sieve size) | **GRAVELS** (More than 1/2 of coarse fraction > No. 4 sieve size) | GW | Well graded gravels or gravel-sand mixtures little or no fines |
| | | GP | Poorly graded gravels or gravel-sand mixtures, little or no fines |
| | | GM | Silty gravels, gravel-sand-silt mixtures |
| | | GC | Clayey gravels, gravel-sand-clay mixtures |
| | **SANDS** (More than 1/2 of coarse fraction < No. 4 sieve size) | SW | Well graded sands or gravelly sands, little or no fines |
| | | SP | Poorly graded sands or gravelly sands, little or no fines |
| | | SM | Silty sands, sand-silt mixtures |
| | | SC | Clayey sands, sand-clay mixtures |
| FINE-GRAINED SOILS (More than 1/2 of soil < No.200 sieve size) | **SILTS & CLAYS** Liquid Limit <50 | ML | Inorganic silts and very fine sands, rock flour, silty fine sands or clayey silts with slight plasticity |
| | | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandys clays, silty clays, lean clays |
| | | OL | Organic silts and organic silty clays of low plasticity |
| | **SILTS & CLAYS** Liquid Limit >50 | MH | Inorganic silts, micaceous or diatomaceous fine sand or silty soils, elastic silts |
| | | CH | Inorganic clays of high plasticity, fat clays |
| | | OH | Organic clays of medium to high plasticity, organic silty clays, organic silts |
| **HIGHLY ORGANIC SOILS** | | PT | Peat and other highly organic soils |

| GRAIN SIZE CHART | | |
|---|---|---|
| CLASSIFICATION | RANGE OF GRAIN SIZE | |
| | U.S. Standard Sieve Size | Grain Size in Millimeters |
| **BOULDERS** | Above 12" | Above 305 |
| **COBBLES** | 12" to 3" | 305 to 76.2 |
| **GRAVEL** | 3" to No.4 | 76.2 to 4.76 |
| Coarse | 3" to ¾" | 76.2 to 19.1 |
| Fine | ¾" to No.4 | 19.1 to 4.76 |
| **SAND** | No.4 to No.200 | 4.76 to 0.074 |
| Coarse | No.4 to No.10 | 4.76 to 2.00 |
| Medium | No.10 to No.40 | 2.00 to 0.420 |
| Fine | No.40 to No.200 | 0.420 to 0.074 |
| **SILT & CLAY** | Below No.200 | Below 0.074 |

| Hardness of Rock | |
|---|---|
| Descriptive Term | Characteristics |
| Moderately Hard | Can be scratched with a knife with light to moderate pressure; breaks with moderate hammer blow. |
| Hard | Can be scratched with a knife with difficulty; can be broken with heavy hammer blow. |
| Very Hard | Cannot be scratched with a knife; can only be broken with repeated heavy hammer blows. |

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**SOIL CLASSIFICATION**

FIGURE 15

**TABLE 1**
**LABORATORY TEST SUMMARY**

Project: Kenworth Truck Sales Project No. 17523
Client: NBW Architects

| TEST PIT No. | DEPTH BELOW GROUND SURFACE (ft.) | MOISTURE CONTENT (%) | IN-PLACE DRY DENSITY (PCF) | COLLAPSE at 1,000 PSF, % | ATTERBERG LIMITS | | MECHANICAL GRADATION | | | USCS GROUP SYMBOL |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | LIQUID LIMIT (%) | PLASTICITY INDEX (%) | GRAVEL (%) | SAND (%) | SILT & CLAY (%) | |
| TP-1 | 3.0 | 4.0 | | | | | 19 | 37 | 44 | SM |
| | | | | | | | | | | |
| TP-2 | 0-3 | Maximum Dry Density = 127.4 pcf, Optimum Moisture Content = 8.8% | | | | | | | | SM |
| | | | | | | | | | | |
| TP-3 | 4.0 | 3.6 | 71.2 | 3.7 | | | Sulfate = 3.71% | | | ML |
| | 6.5 | 18.0 | 106.2 | 0.8% swell | | | 4 | 33 | 63 | ML-CL |
| TP-5 | 0-3 | Maximum Dry Density = 136.0 pcf, Optimum Moisture Content = 5.9%, CBR=5 | | | | | | | | |
| | | | | | | | | | | |
| TP-6 | 3.5 | 3.5 | | | NP | NP | 16 | 35 | 49 | |
| | | | | | | | | | | |
| TP-7 | 1.5 | 4.6 | | | | | 26 | 37 | 37 | SM |
| | | | | | | | | | | |
| TP-10 | 0.5 | 1.6 | | | | | 16 | 39 | 45 | SM |
| | | | | | | | | | | |
| TP-11 | 3.0 | 3.5 | | | | | 31 | 17 | 52 | ML |
| | 5.0 | 10.8 | | | NP | NP | 8 | 12 | 80 | ML |
| | | | | | | | | | | |
| TP-12 | 1.0 | 2.3 | | | | | 56 | 17 | 27 | GM |
| | 5.5 | 11.8 | | | | | 7 | 26 | 67 | ML |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

FIGURE 16

## LANDMARK TESTING AND ENGINEERING

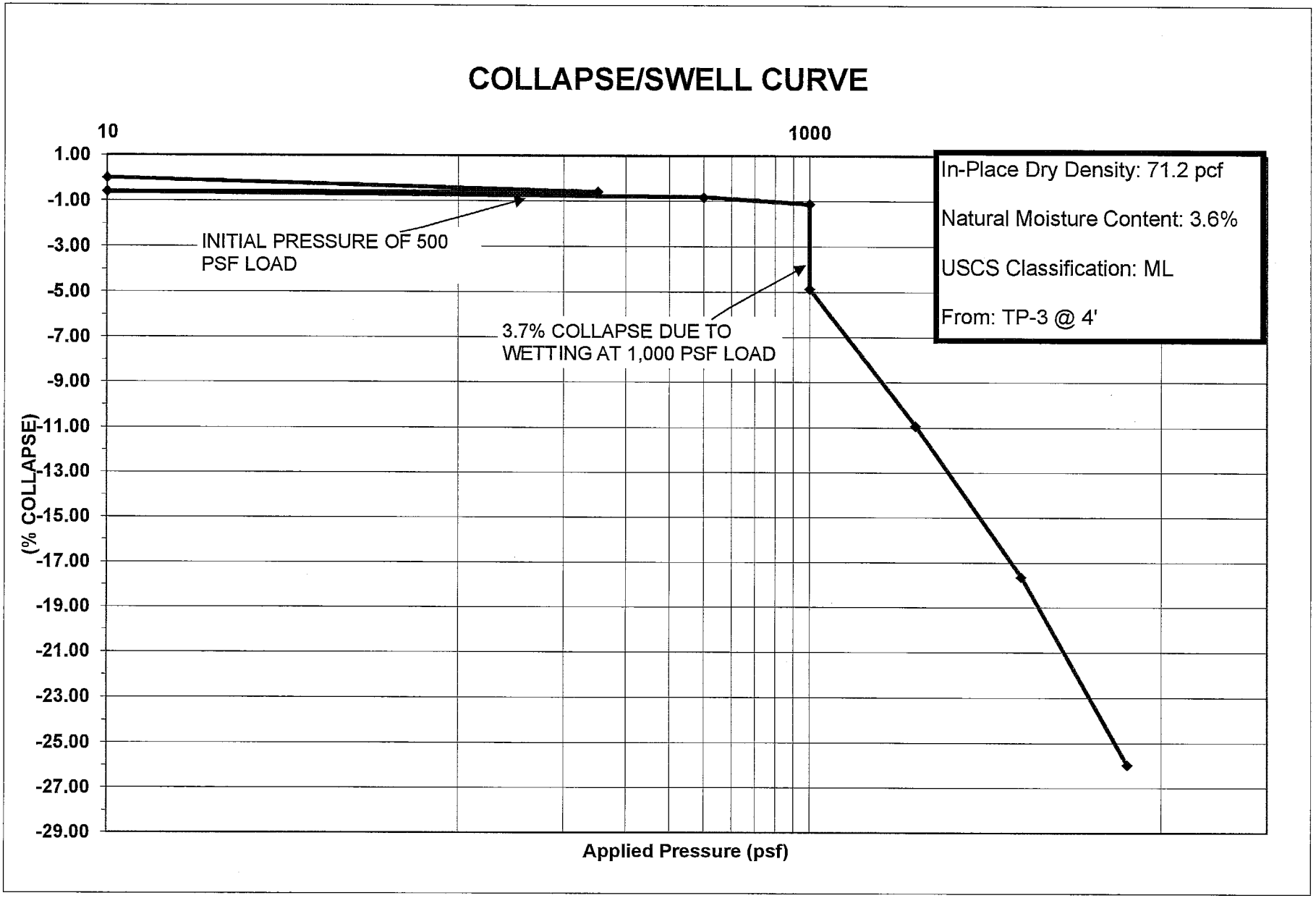


FIGURE 17

## LANDMARK TESTING AND ENGINEERING

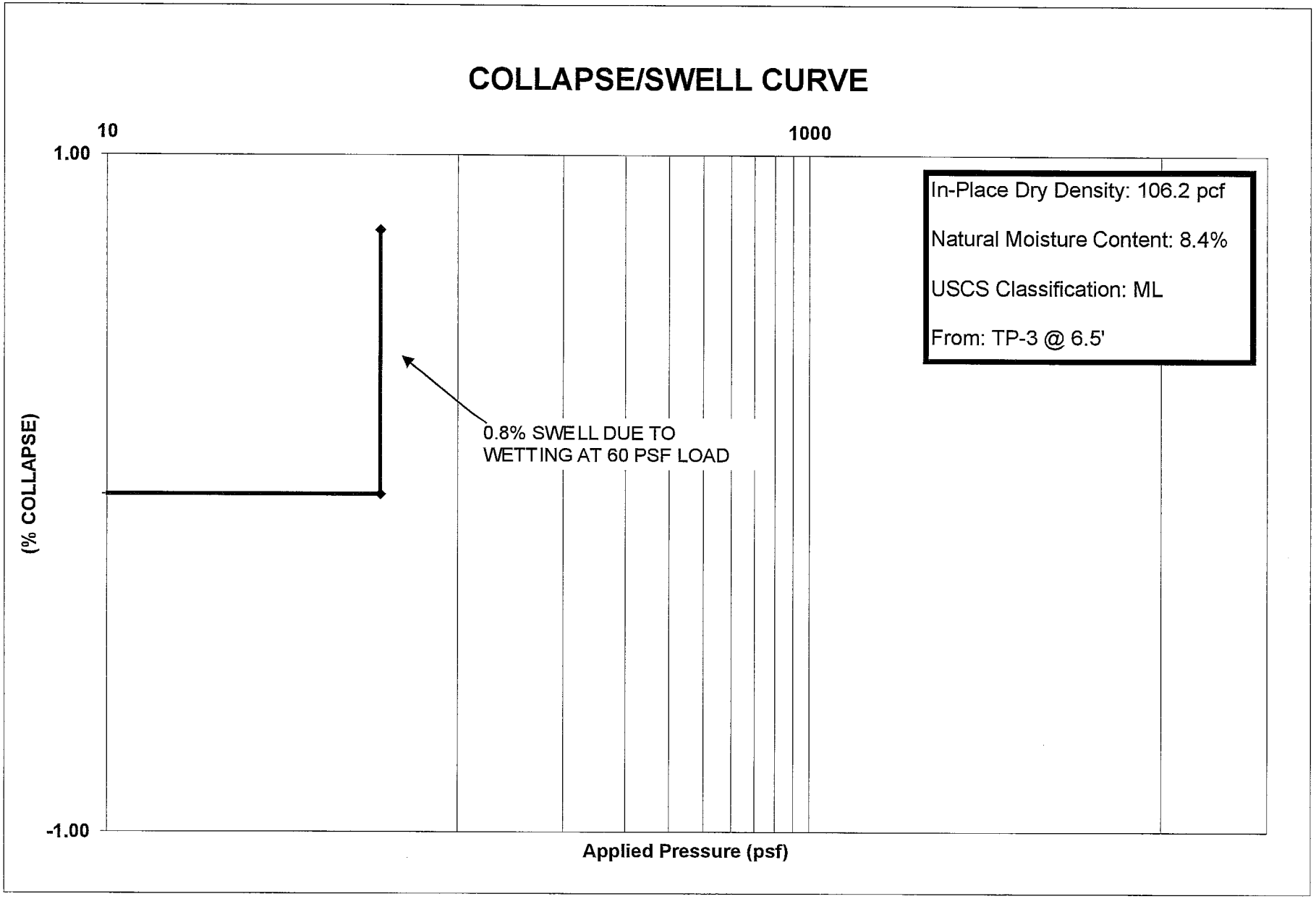


FIGURE 18