Applied Geotechnical Engineering Consultants, Inc.

GEOTECHNICAL INVESTIGATION

PROPOSED RESIDENCES
LOTS 30, 35 AND 36

WEST RIDGE SUBDIVISION, PHASE II

APPROXIMATELY 2575 LARKSPUR DRIVE

PARK CITY, UTAH

PREPARED FOR:

PATTERSON CONSTRUCTION
12757 WEST ARIZONA, PLACE
LAKEWOOD, COLORADO 80228

ATTENTION: BRIAN PATTERSON

PROJECT NO. 1071528 MARCH 21, 2008

TABLE OF CONTENTS

EXECUTIVE SUMMARY

1. The subsurface materials encountered at the site generally consist of approximately 1 to 1½ feet of topsoil overlying bedrock. Practical trackhoe refusal was met in the bedrock in Test Pits TP-2 and TP-3 at 10 and 7½ feet, respectively. The bedrock extends to the maximum depth investigated, approximately 15 feet.

2. No free water was encountered in the test pits at the time of excavation to the maximum depth investigated, approximately 15 feet.

3. The proposed residences may be supported on spread footings bearing on the undisturbed bedrock or on compacted structural fill extending down to the bedrock. Footings may be designed using a net allowable bearing pressure of 3,500 pounds per square foot. Where the foundation excavation for a house would result in foundations supported partially on bedrock and partially on soil, the footings for that house should be supported entirely on the bedrock or on at least 2 feet of structural fill.

4. Subsurface drains should be considered for the development. Recommendations for subsurface drains are included in the report.

5. We anticipate that excavation of the bedrock may be conducted with heavy-duty excavation equipment. Jackhammering or light blasting may be needed for excavation in bedrock, especially in confined excavations such as utility trenches. Care should be taken not to disturb the proposed foundation bearing material during bedrock removal.

6. Geotechnical information related to foundations, subgrade preparation, pavement design and materials is included in the report.

SCOPE

This report presents the results of a geotechnical investigation for the proposed residences to be constructed on Lots 30, 35 and 36 in the West Ridge Subdivision, Phase II located at approximately 2575 Larkspur Drive in Park City, Utah. The report presents the subsurface conditions encountered, laboratory test results and recommendations for foundations. The study was conducted in general accordance with our proposal dated November 27, 2007.

Field exploration was conducted to obtain information on the subsurface conditions. Samples obtained from the field investigation were tested in the laboratory to determine physical and engineering characteristics of the on-site soil. Information obtained from the field and laboratory was used to define conditions at the site for our engineering analysis and to develop recommendations for the proposed foundations.

This report has been prepared to summarize the data obtained during the study and to present our conclusions and recommendations based on the proposed construction and the subsurface conditions encountered. Design parameters and a discussion of geotechnical engineering considerations related to construction are included in the report.

SITE CONDITIONS

The site consists of two residential lots located north and one lot located south of Larkspur Drive, a two-lane asphalt paved road in fair condition. There were no structures on these lots at the time of our site visit.

The ground surface on these lots slope down to the south at slopes ranging between approximately 1¾ and 4 horizontal to 1 vertical.

Vegetation throughout the site generally consists of weeds, grass and small trees.

The lots north of Larkspur Drive are bordered on the east and west by wood-framed houses in good condition. There is undeveloped land north of these lots. The lot south of Larkspur Drive is bordered on the east, south and west by wood-framed houses in good condition. There are vacant lots located between some of these surrounding houses.

FIELD STUDY

The field study was conducted on February 12, 2008. Five test pits were excavated at the approximate locations indicated on Figure 1. The test pits were excavated using a track-mounted excavator. The test pits were logged and soil samples obtained by a field representative from AGEC. Logs of the subsurface conditions encountered in the test pits with legend and notes are graphically shown on Figure 2.

The test pits were backfilled without significant compaction. The backfill in the test pits should be properly compacted where it will support proposed buildings, slabs and pavement.

SUBSURFACE CONDITIONS

The subsurface materials encountered at the site generally consist of approximately 1 to 1 ½ feet of topsoil overlying bedrock. Practical trackhoe refusal was met in the bedrock in Test Pits TP-2 and TP-3 at 10 and 7½ feet, respectively. The bedrock extends to the maximum depth investigated, approximately 15 feet

A description of the various materials encountered in the test pits follows:

> <u>Topsoil</u> - The topsoil consists of lean clay with small to moderate amounts of sand and gravel. It is slightly moist to moist, brown and contains roots and organics.
>
> <u>Bedrock</u> - The bedrock consists of tuffaceous claystone and sandstone. It is mapped as the Keetley Volcanics (Bromfield and Crittenden, 1971). The bedrock is medium hard to hard, moist to very moist, brown and moderately to highly weathered.

Laboratory tests performed on samples of the bedrock indicate that it has natural moisture contents ranging from 19 to 34 percent and natural dry densities ranging from 73 to 89 pounds per cubic foot (pcf).

Results of consolidation tests performed on samples of the bedrock indicate that the bedrock will compress a small to moderate amount with the addition of light to moderate loads. The tests also indicate that the bedrock is slightly expansive when wetted. Results of the consolidation test are presented on Figures 3 through 5.

A summary of the laboratory test results is presented on Table I and included on the logs of the test pits.

SUBSURFACE WATER

No free water was encountered in the test pits at the time of excavation to the maximum depth investigated, approximately 15 feet.

PROPOSED CONSTRUCTION

We understand that a single-family residence will be constructed on each of the three lots. We anticipate that the residences will consist of two to three-story, wood-frame structures with basements. We understand that cuts on the order of 14 feet below existing grade for the proposed basements are planned.

We have assumed maximum column loads of 30 kips and maximum wall loads of 3 kips per lineal foot.

If the proposed construction or building loads are significantly different from what are described above, we should be notified so that we can reevaluate the recommendations given.

RECOMMENDATIONS

Based on the subsurface conditions encountered, laboratory test results and the proposed construction, the following recommendations are given:

A. Site Grading

We anticipate that the final ground surface around the residences will be at the same approximate elevation as the existing ground surface.

1. Slopes

   Temporary, unretained excavation slopes up to 20 feet in height in the bedrock may be constructed at 1 horizontal to 1 vertical or flatter. Flatter slopes in bedrock may be needed depending on orientation of bedding, fractures and other weaknesses in the bedrock.

   Permanent, unretained cut and fill slopes up to 20 feet in height may be constructed at slopes of 2 horizontal to 1 vertical or flatter. Steeper slopes in bedrock may be considered and should be evaluated on an individual basis.

   Good surface drainage should be provided upslope of cut and fill slopes to direct surface runoff away from the face of the slopes. The slopes should be protected from erosion by re-vegetation or other methods.

2. Subgrade Preparation

   Prior to placing grading fill or base course, organic material, unsuitable fill and other deleterious material should be removed from the area of the proposed residences.

3. Excavation

   We anticipate that excavation in the bedrock can be conducted using heavy-duty excavation equipment. Heavy-duty excavation equipment with rippers and possibly some jackhammering or light blasting will be needed for deep excavations into the bedrock. Difficult excavation conditions may be encountered in confined excavations such as utility trenches.

4. Compaction

Compaction of materials placed at the site should equal or exceed the minimum densities as indicated below when compared to the maximum dry density as determined by ASTM D-1557.

Fill To Support	Compaction
Foundations	≥ 95%
Concrete Slabs and Pavement	≥ 90%
Landscaping	≥ 85%
Retaining Wall Backfill	85 - 90%

To facilitate the compaction process, the material should be compacted at a moisture content within 2 percent of the optimum moisture content.

The base course should be compacted to at least 95 percent of the maximum dry density as determined by ASTM D-1557.

Fill and pavement materials placed for the project should be frequently tested for compaction.

5. Materials

Materials placed as fill to support foundations should be nonexpansive granular soil. The bedrock is not recommended for use as structural fill. The bedrock may be considered for use as site grading fill and utility trench backfill if the organics, topsoil and other deleterious materials are removed.

Listed below are materials recommended for imported structural fill.

Fill to Support	Recommendations
Footings	Non-expansive granular soil Passing No. 200 Sieve < 35% Liquid Limit < 30% Maximum size 4 inches
Floor Slab (Upper 4 inches)	Sand and/or Gravel Passing No. 200 Sieve < 5% Maximum size 2 inches
Slab Support	Non-expansive granular soil Passing No. 200 Sieve < 50% Liquid Limit < 30% Maximum size 6 inches

6. <u>Drainage</u>

With the moisture-sensitive bedrock present at the site, it is important that the following drainage precautions be observed during construction and maintained at all times after the residences have been completed.

a. Excessive wetting or drying of bedrock and foundation excavations should be avoided.

b. The ground surface surrounding the exterior of the residences should be sloped away from the structures in all directions maintaining a slope of at least ½ foot of drop for the first 10 feet out from the buildings.

c. The upper 2 feet of foundation wall backfill should be low permeable soil. The backfill, including the low-permeable fill, should be compacted to at least 90 percent of the maximum dry density as determined by ASTM D-1557. Low permeable fill should consist of soil containing at least 30 percent passing the No. 200 sieve.

d. Roof downspouts and drains should discharge well beyond the limits of backfill.

e. Sprinkler lines and sprinkler heads should not be placed within 10 feet of foundation walls.

B. Foundations

1. Bearing Material

With the proposed construction and subsurface conditions encountered, the proposed residences may be supported on spread footings bearing on the undisturbed bedrock or on compacted structural fill. Where foundation excavation for a house would result in foundations supported partially on bedrock and partially on soil, the footings for the house should be extended down to the bedrock or supported on at least 2 feet of structural fill. Structural fill should extend out away from the edge of the footings at least a distance equal to the depth of fill beneath the footings.

Topsoil, organics, debris, unsuitable fill and other deleterious materials should be removed from below proposed foundations.

2. Bearing Pressures

Spread footings may be designed for a net allowable bearing pressure of 3,500 pounds per square foot. Footings should have a width of at least 1 ½ feet and a depth of embedment of at least 10 inches.

3. Temporary Loading Conditions

The allowable bearing pressure may be increased by one-half for temporary loading conditions such as wind or seismic loads.

4. Settlement

Based on the subsurface conditions encountered and the assumed building loads, we estimate that total and differential settlement will be less than 1 and ¾ inch, respectively.

5. Frost Depth

Exterior footings and footings beneath unheated areas should be placed at least 40 inches below grade for frost protection.

6. Foundation Base

The base of footing excavations should be cleared of loose or deleterious material prior to structural fill or concrete placement.

7. Construction Observation

A representative of the geotechnical engineer should observe footing excavations and subgrade areas prior to structural fill or concrete placement.

C. Concrete Slab-on-Grade

1. Slab Support

Concrete slabs may be supported on the undisturbed bedrock or on compacted structural fill extending down to the undisturbed bedrock. Topsoil, organics, debris and other deleterious materials should be removed from below proposed floor slabs.

2. Underslab Sand and/or Gravel

A 4-inch layer of free-draining sand and/or gravel (less than 5 percent passing the No. 200 sieve) should be placed below the floor slab to promote even curing of the concrete.

D. Lateral Earth Pressures

1. Lateral Resistance for Footings

Lateral resistance for spread footings placed on the natural soil or on compacted structural fill is controlled by sliding resistance between the footing and the foundation soils. A friction value of 0.45 may be used in design for ultimate lateral resistance.

2. Subgrade Walls and Retaining Structures

The following equivalent fluid weights are given for design of subgrade walls and retaining structures. The active condition is where the wall moves away from the soil. The passive condition is where the wall moves into the soil and the at-rest condition is where the wall does not move. The values listed below assume a horizontal surface adjacent the top and bottom of the wall.

Soil Type	Active	At-Rest	Passive
Clay & Silt	50 pcf	65 pcf	250 pcf
Sand & Gravel	40 pcf	55 pcf	300 pcf

3. Seismic Conditions

Under seismic conditions, the equivalent fluid weight should be increased by 16 pcf for active and at-rest conditions and decreased by 16 pcf for the passive condition. This assumes a short period spectral response acceleration of 0.68g for a 2 percent probability of exceedance in a 50-year period (IBC, 2006).

4. Safety Factors

The values recommended above assume mobilization of the soil to achieve soil strength. Conventional safety factors used for structural analysis for such items as overturning and sliding resistance should be used in design.

E. Subsurface Drains

Based on our experience in the area and the possibility of perched water conditions, we recommend that houses with floor levels extending below grade should be protected with a perimeter drain. The perimeter drain system should consist of at least the following items:

1. The underdrain system should consist of a perforated pipe installed in a gravel filled trench around the perimeter of the subgrade floor portion of the building.

2. The flow line of the pipe should be placed at least 18 inches below the finished floor level and should slope to a sump or outlet where water can be removed by pumping or by gravity flow.

3. If placing the gravel and drain pipe requires excavation below the bearing level of the footing, the excavation for the drain pipe and gravel should have a slope no steeper than 1 horizontal to 1 vertical so as not to disturb the soil below the footing.

4. A filter fabric should be placed between the natural soil and the drain gravel. This will help reduce the potential for fine-grained material filling in the void spaces of the gravel.

5. The subgrade floor slab should have at least 6 inches of free-draining gravel placed below it and the underslab gravel should connect to the perimeter drain.

6. Consideration should be given to installing cleanouts to allow access into the perimeter drain should cleaning of the pipe be required in the future.

F. Seismicity, Faulting and Liquefaction

1. Seismicity

Listed below is a summary of the site parameters for the 2006 International Building Code.

a.	Site Class	C
b.	Short Period Spectral Response Acceleration, S_S	0.68g
c.	One Second Period Spectral Response Acceleration, S_1	0.25g

2. Faulting

There are no mapped active faults extending through the site. The closest mapped active fault to the site is the Wasatch Fault located approximately 16 miles to the west (Black and others, 2003).

3. Liquefaction

The site is located in area mapped as having a "very low" liquefaction potential (Anderson and others, 1989). Based on the subsurface conditions encountered at the site and our understanding of the geology of the area, liquefaction is not a hazard at the site.

G. Water Soluble Sulfates

One sample of the natural soil was tested in the laboratory for water soluble sulfate content. Test results indicate there is less than 0.1 percent water soluble sulfate in the sample tested. Based on the results of the test and published literature, the natural soil possesses negligible sulfate attack potential on concrete. No special cement type is required for concrete placed in contact with the natural soil. Other conditions may dictate the type of cement to be used in concrete for the project.

LIMITATIONS

This report has been prepared in accordance with generally accepted soil and foundation engineering practices in the area for the use of the client for design purposes. The conclusions and recommendations included within the report are based on the information obtained from the test pits excavated at the approximate locations indicated on Figure 1 and the data obtained from laboratory testing. Variations in the subsurface conditions may not become evident until additional exploration or excavation is conducted. If the subsurface conditions or groundwater level is found to be significantly different from what is described above, we should be notified to reevaluate our recommendations.

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

W. Mark Phillips, P.E.

Reviewed by Douglas R. Hawkes, P.E., P.G.

WMP/hl

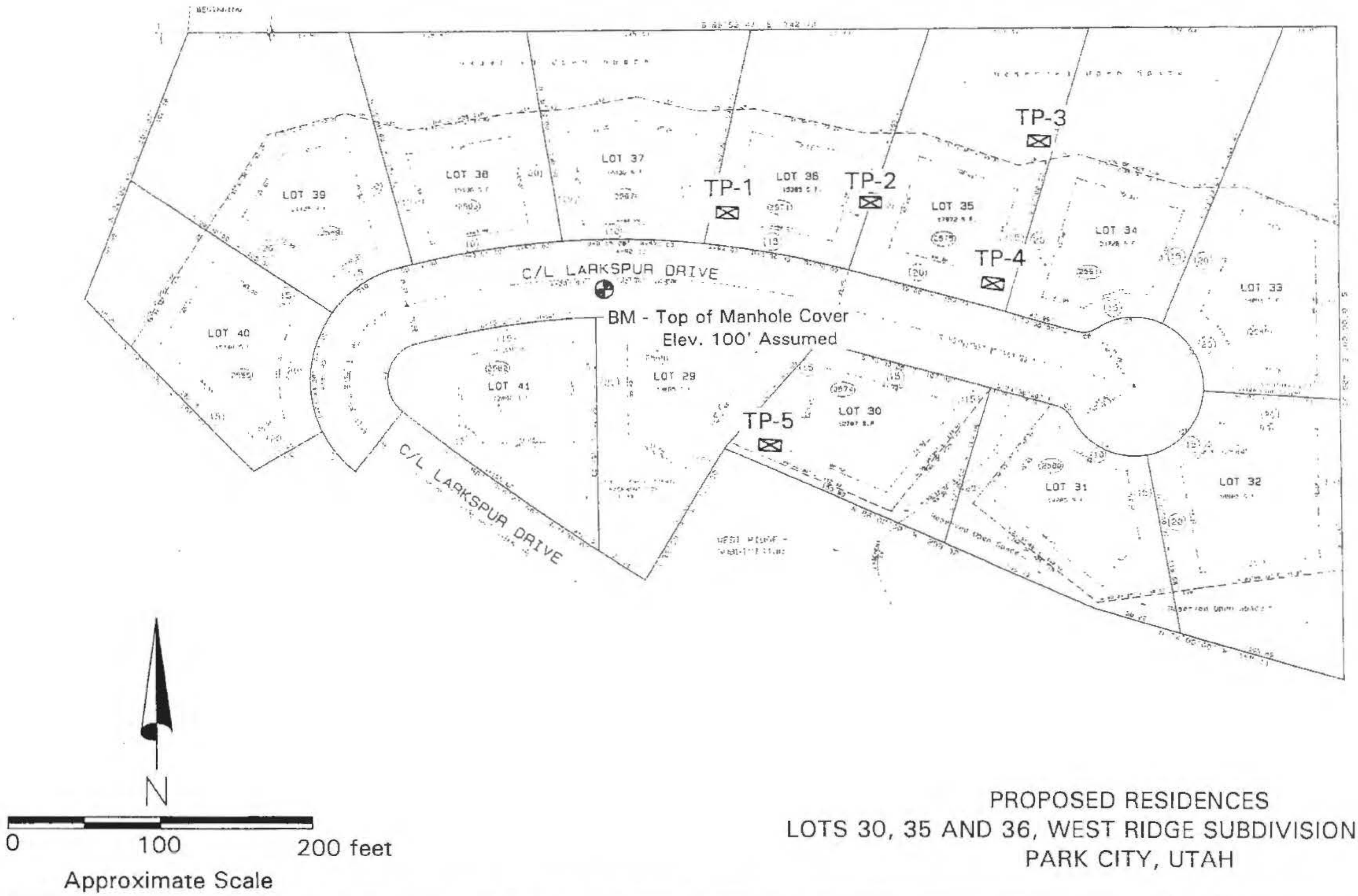
REFERENCES CITED

Anderson, L., Keaton, J. and Rice, J., 1989; Liquefaction Potential, Central Utah, Plate 1 (Park City-Heber), US Geological Survey, Contract No. 14-08-0001-G1384.

Black, B.D., Hecker, S., Hylland, M.D., Christenson, G.E., and McDonald, G.N., 2003; Quaternary fault and fold database and map of Utah; Utah Geological Survey Map 193DM.

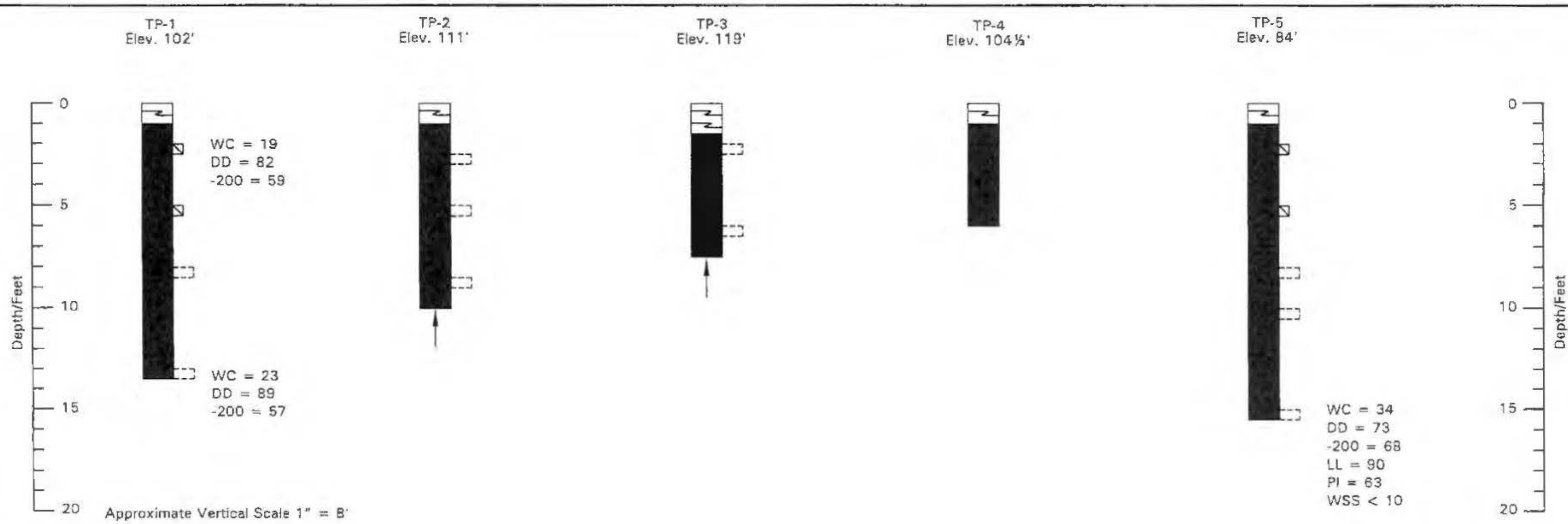
Bromfield, C.S. and Crittenden, M.D. Jr. 1971; Geologic map of the Park City east quadrangle, Summit and Wasatch Counties, Utah; US Geological Survey Map GQ-852.

International Building Code, 2006; International Code Council, Inc., Falls Church, Virginia.



PROPOSED RESIDENCES
LOTS 30, 35 AND 36, WEST RIDGE SUBDIVISION, PHASE II
PARK CITY, UTAH

1071528	AGEC	Locations of Test Pits	Figure 1



LEGEND:

Topsoil; lean clay with small to moderate amounts of sand and gravel, slightly moist to moist, roots, brown.

Bedrock; tuffaceous claystone and sandstone, moderately to highly weathered, medium hard to hard, moist to very moist, brown.

Indicates relatively undisturbed hand drive sample taken.

Indicates disturbed sample taken.

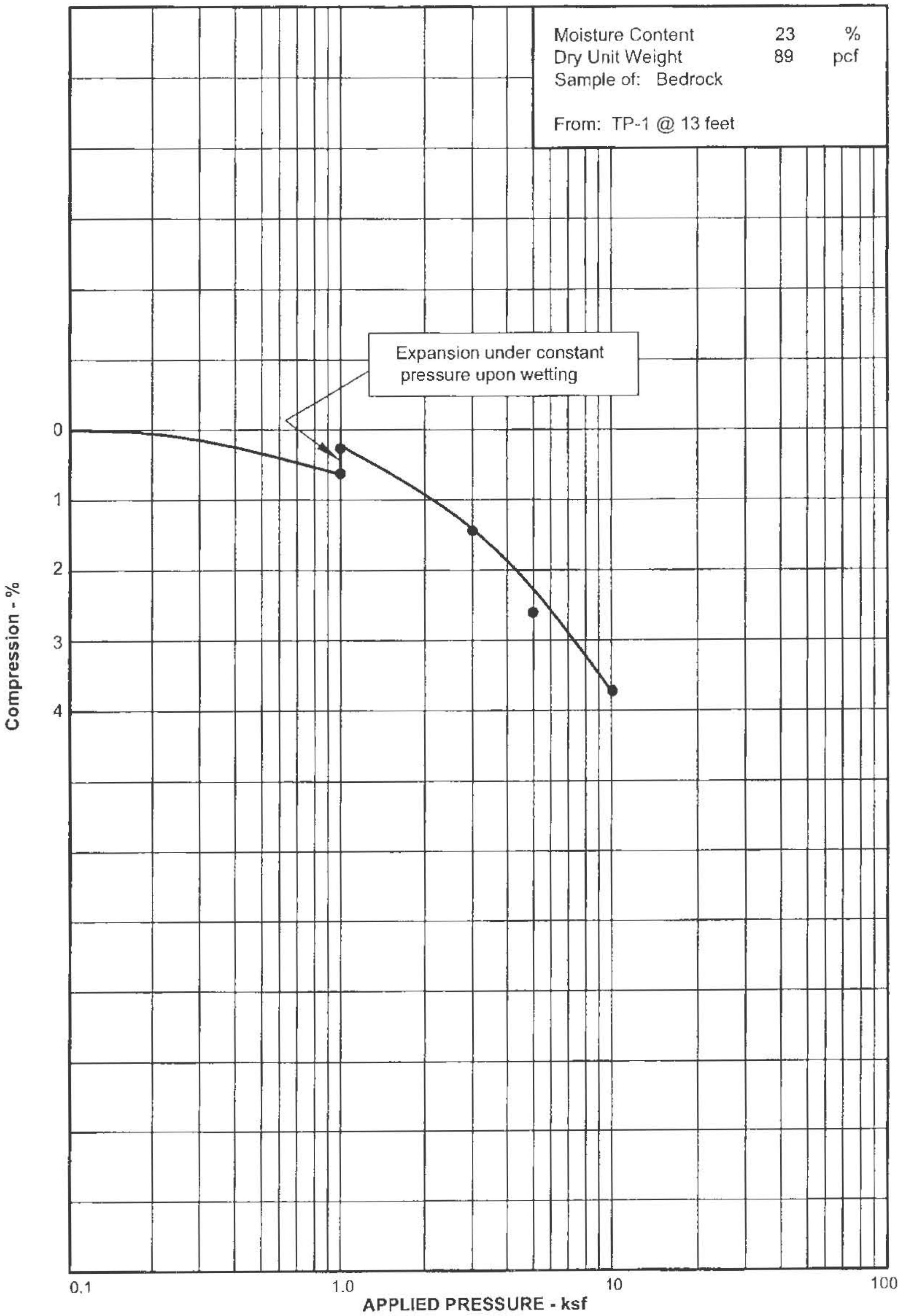
Indicates practical excavation refusal.

NOTES:

1. Test pits were excavated on February 12, 2008, with a rubber-tired backhoe.
2. Locations of test pits were measured approximately by pacing from features shown on the site plan provided.
3. Elevations of test pits were measured by hand level and refer to the bench mark shown on Figure 1.
4. The test pit locations and elevations should be considered accurate only to the degree implied by the method used.
5. The lines between the materials shown on the test pit logs represent the approximate boundaries between material types and the transitions may be gradual.
6. No free water was encountered in the test pits at the time of excavation.
7. WC = Water Content (%);
   DD = Dry Density (pcf);
   -200 = Percent Passing No. 200 Sieve;
   LL = Liquid Limit (%);
   PI = Plasticity Index (%);
   WSS = Water Soluble Sulfates (ppm).

1071528	AGEC	Logs, Legend and Notes of Test Pits	Figure 2

Applied Geotechnical Engineering Consultants, Inc.

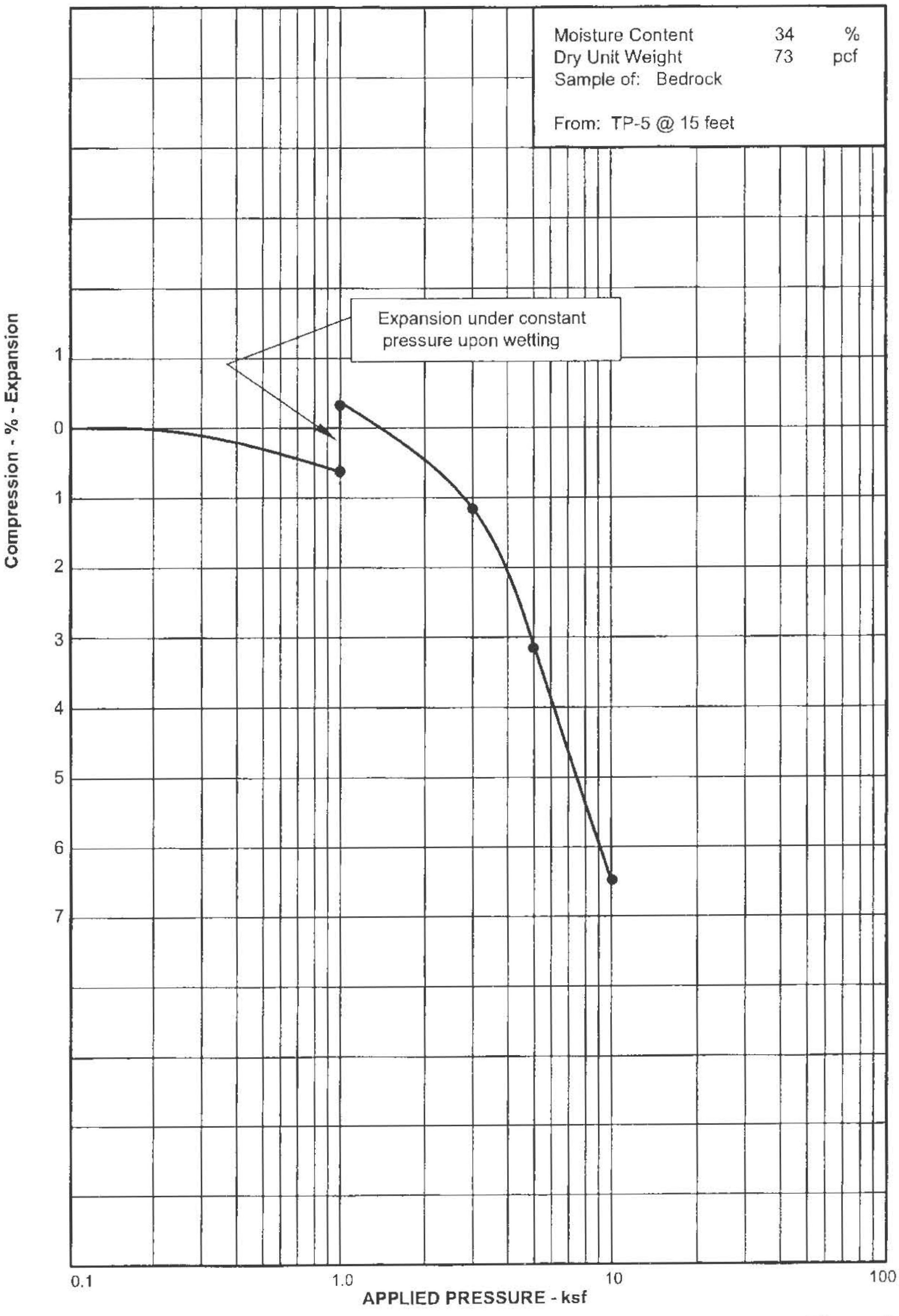


Project No. 1071528

CONSOLIDATION TEST RESULTS

Figure 3

Applied Geotechnical Engineering Consultants, Inc.



Project No. 1071528 **CONSOLIDATION TEST RESULTS** **Figure 4**

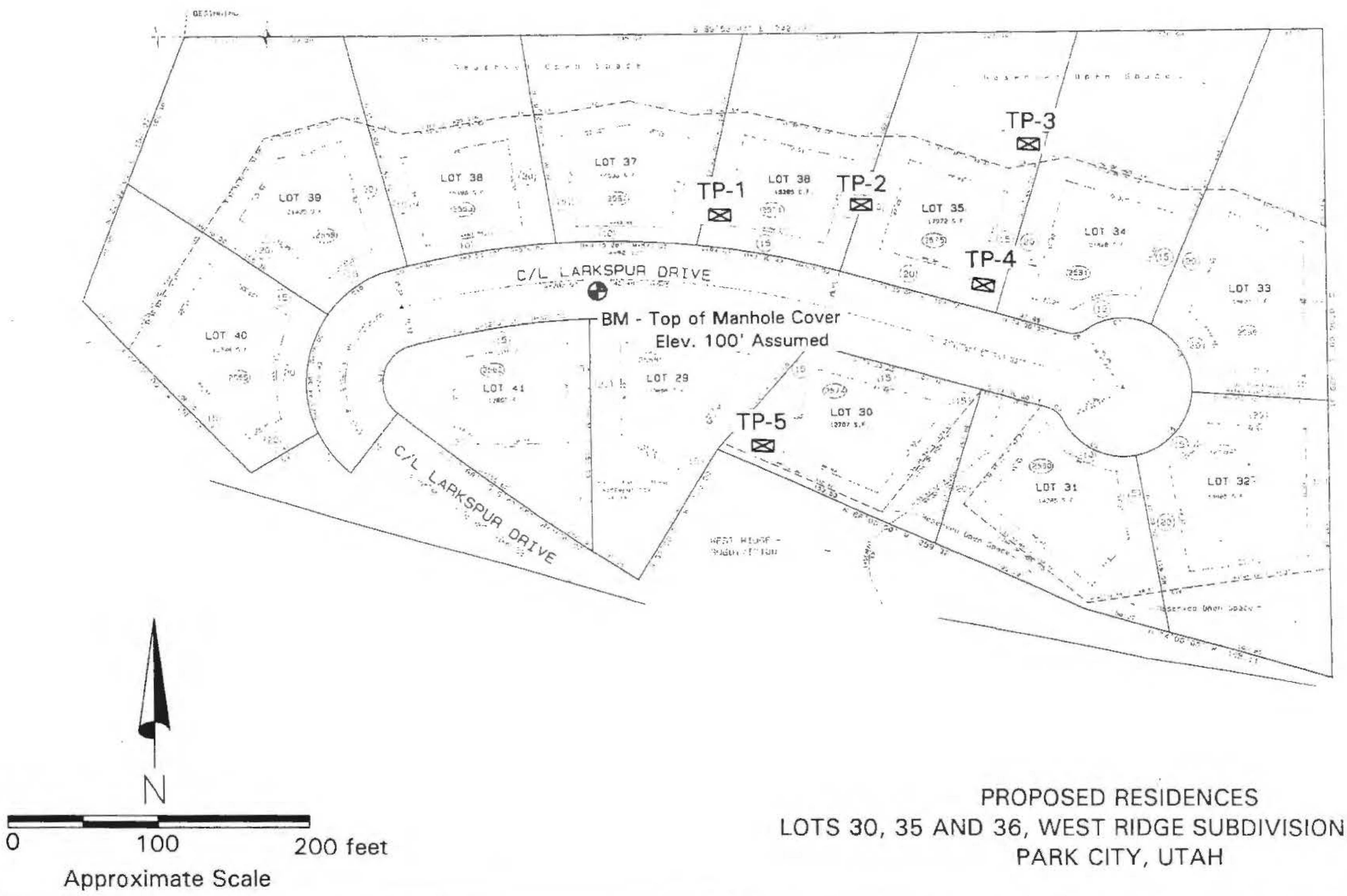
APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NUMBER 1071528

SAMPLE LOCATION		NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (PCF)	GRADATION			ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH (PSF)	WATER SOLUBLE SULFATE (ppm)	SAMPLE CLASSIFICATION
TEST PIT	DEPTH (FEET)			GRAVEL (%)	SAND (%)	SILT/ CLAY (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)			
TP-1	2	19	82			59					Bedrock
	13	23	89			57					Bedrock
TP-5	15	34	73			68	90	63		<10	Bedrock



PROPOSED RESIDENCES
LOTS 30, 35 AND 36, WEST RIDGE SUBDIVISION, PHASE II
PARK CITY, UTAH

1071528	AGEC	Locations of Test Pits	Figure 1