GEOTECHNICAL ENGINEERING STUDY
MARY RUTH PLACE
306 GALENA STREET
FRISCO, COLORADO 80443

PROJECT NUMBER 16-1068
AUGUST 13, 2017

PREPARED FOR

TOWN OF FRISCO
MS. JOYCE ALLGAIER
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Matthew A. Best, P.E. 8/14/17
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EXECUTIVE SUMMARY

Best Engineering Solutions and Technologies, LLC (BEST) completed a geotechnical engineering study for the Mary Ruth Place project, located at 306 Galena Street in Frisco, Colorado. Design parameters and a discussion of geotechnical engineering considerations related to construction of the proposed residences are included in this report. A summary of the findings include:

1. Subsurface explorations encountered natural, medium dense, silty to clayey, gravels and sands with cobbles and boulders to the depths explored. Man-placed fill was encountered in the southeast corner of the property. Groundwater was not encountered during excavation of the test pits. Fluctuations of the groundwater may occur seasonally or with precipitation events.

2. Based on the subsurface conditions encountered in the test pits and the nature of the proposed construction, we recommend the proposed structures be founded with spread footings bearing on native granular soils or properly compacted structural fill. Spread footings bearing as recommended should be designed for an allowable bearing pressure of 3,000 pounds per square foot (psf).

3. Undisturbed natural granular soils are suitable for support of concrete slab construction, provided any existing fills encountered in slab areas are removed and replaced with structural fill.

4. A representative of our office should observe the construction operations discussed in this report.

5. Keep any exposed soils from excessive drying or wetting during the construction process.

6. More detailed recommendations are made throughout this report. These must be reviewed to assure proper consideration in the design.

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PURPOSE AND SCOPE OF WORK

This report presents the results of a geotechnical engineering study for the Mary Ruth Place Project, located in Frisco, Colorado. The project site is shown on Figure 1. The study was conducted for the purpose of foundation design and support of slabs-on-grade recommendations.

A field exploration study consisting of exploratory test pits was conducted to collect information on the subsurface conditions. Samples of the subsoils collected during the field exploration were tested in the laboratory to determine their classification and engineering characteristics. The results of the field exploration and laboratory testing were analyzed to develop recommendations for foundation types, depths, and allowable pressures for the proposed building foundations.

This report has been prepared to summarize the data obtained during this 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 of the proposed structures are included in this report.

PROPOSED CONSTRUCTION

We understand that the proposed construction will consist of three new residential buildings consisting of a two to three-story structures. Building “D” will have attached garages. Conventional steel and wood frame construction, with column loads expected to be moderate and typical of this type of structure, will be used above grade with cast-in-place concrete foundations below grade. Ground floors will be slab-on-ground. Site development is expected to include sidewalk and landscaped areas.

If the loadings, locations, or grading plans for the structures change significantly from those described above, we should be notified to re-evaluate the recommendations contained in this report.

SITE CONDITIONS

At the time of our field exploration, the property consisted of an existing residence and landscaped yard. The site is bounded to the north by Galena Street, an alley to the south, to west and east by residential properties. The lot slopes slightly toward the northwest and is at an approximate elevation of 9,070 feet MSL.

FIELD EXPLORATION

Two exploratory test pits were excavated on July 19, 2017, approximately at the locations shown on Figure 1 to evaluate the subsurface conditions. The test pits were excavated with a mini-excavator and were logged by a representative of BEST. Samples of the soils were taken with disturbed sampling methods and the depth of the test pits and samples are shown on the Test Pit Log, Figure 3 with Legend and Notes, Figure 4.

SUBSURFACE CONDITIONS

Natural medium dense, silty to clayey, gravels and sands with occasional cobbles and boulders were encountered in the test pits, extending to the depths explored. No free water was encountered in the test pits at the time of excavation. The soils encountered were slightly moist to moist. Groundwater was not encountered at the time of excavation, however, fluctuations in the groundwater levels may occur seasonally or with precipitation events.

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Bulk samples taken from the exploratory test pits were obtained for laboratory testing. The results of the tests performed on the samples obtained from the test pits are shown on Figures 2 to 4. Laboratory testing included index property tests, such as moisture content, (ASTM D 2216), and gradation analysis (ASTM C 136 & C 117).

FOUNDATION BEARING CONDITIONS

The natural soils are suitable to support lightly to moderately loaded slab-on-grade construction. Considering the subsurface conditions encountered in the borings and the nature of the proposed construction, we recommend the proposed structures and slabs-on-grade be placed on the natural granular soils or properly compacted granular structural fill extending to undisturbed natural granular soils.

FOUNDATION DESIGN RECOMMENDATIONS

Based on the subsoil conditions encountered in the exploratory pits and the nature of the proposed construction, we recommend that the structures be founded with spread footings bearing on native granular soils or on properly compacted structural fill. The design and construction criteria presented below should be observed for a spread footing foundation system.

1. Footings placed on the native granular soils or on properly compacted structural fill should be designed for an allowable soil bearing pressure of 3,000 pounds per square foot (psf). Based on experience it is expected that settlement of the footings, designed and constructed as discussed in this section, would be approximately 1-inch or less. Differential settlements are estimated to be approximately ½ to ¾ of the total settlement. Most of this settlement will occur during the construction phase.

2. Spread footings placed on granular soils should have a minimum footing width of 18 inches for continuous footings and 24 inches for isolated pads.

3. Exterior footings and footings beneath unheated areas should be provided with adequate soil cover above their bearing elevation for frost protection. Placement of foundations at least 40 inches below exterior grade is required by the Town of Frisco and Summit County. Concrete should not be placed on frost, frozen soils, snow, or ice.

4. Continuous foundation walls should be reinforced top and bottom to span local anomalies by assuming an unsupported length of at least 10 feet.

5. The lateral resistance of a spread footing placed on undisturbed natural soils or properly compacted granular structural fill material will be a combination of the sliding resistance of the footing on the foundation materials and passive earth pressure against the side of the footing. Based on the soil characteristics, the resistance to sliding at the bottoms of the footings can be calculated based on a coefficient of friction of 0.60. Passive pressure against the sides of the footings can be calculated using an equivalent fluid unit weight of 350 pounds per cubic foot (pcf). The at-rest lateral pressures on the walls can be calculated using and equivalent fluid density of 60 psf per foot of depth. The active lateral earth pressures should use and equivalent fluid density of about 40 psf per foot of depth. These lateral resistance values are working values.

6. All loose or soft soils and man-placed fill should be removed and the footing bearing level placed on native granular soils or properly compacted structural fill. The disturbed surface of the native granular soils should be compacted prior to concrete placement. The exploratory pits from soil testing were not compacted when backfilled and should be properly compacted as part of the foundation preparation. If

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water seepage is encountered, the footing areas should be dewatered before concrete placement and BEST should be notified for further evaluation.

7. Structural fill used for support of the structures may consist of the onsite native soils and should be properly placed and compacted to reduce the risk of settlement and distress. Structural fills should be placed in uniform lifts not to exceed 10 inches thick and compacted to at least 98% of the standard Proctor (ASTM D 698) maximum dry density and within 3 percentage points of the optimum moisture content. Fill should extend laterally beyond the edges of the footings at a distance at least equal to the depth of the fill below the footing subgrade. Prior to the fill placement, any loose subgrade soils should be compacted. Any wet and soft subgrade soils should be removed prior to fill placement. Foundations placed on structural fill should be designed for an allowable soil bearing pressure of 3,000 psf.

8. Structural fill placed against the sides of the footings and beneath floor slabs to resist lateral loads should consist of onsite or imported granular material placed and compacted to at least 95% of the standard Proctor (ASTM D 698) maximum dry density within 3 percentage points of the optimum moisture content. Backfill in pavement and walkway areas should also be compacted to at least 95% of the standard within 3 percentage points Proctor (ASTM D 698) maximum dry density within 3 percentage points of the optimum moisture content. Care should be taken when compacting around the foundation walls and underground structures to avoid damage to the structure. Hand compaction procedures may be used to prevent excessive lateral pressures from exceeding the design values. Some settlement of foundation wall backfill should be expected, even if the material is placed correctly, and could result in distress to structures constructed on the backfill.

9. Structural fill placed for backfill may consist of the onsite granular soils. The structural fill should be free of snow and ice, vegetation, topsoil, organics, trash, construction debris, oversized rocks greater than 8 inches in diameter, and other deleterious material.

10. Onsite granular soils for backfilling foundation walls and retaining structures can be utilized for landscaped areas. It should be placed in uniform lifts and compacted to at least 90% of the standard Proctor (ASTM D 698) maximum dry density within 3 percentage points of the optimum moisture content.

11. All foundation and retaining structures should be designed for appropriate hydrostatic and surcharge pressures, such as adjacent footings, traffic, construction materials, and equipment. The buildup of water behind a wall or an upward sloping backfill surface will increase the lateral pressure imposed on a foundation wall or retaining structure. An underdrain system should be provided to prevent hydrostatic pressure buildup behind the walls. The lateral resistance values identified in Number 4 assume drained conditions behind the walls and a horizontal backfill surface. Refer to the Underdrain System Section for further information.

12. A BEST representative should observe all footing excavations prior to concrete placement to evaluate bearing conditions.

FLOOR SLABS

The natural onsite granular soils are suitable to support lightly to moderately loaded slab-on-grade construction. To reduce the effects of differential movement, floor slabs should be separated from all bearing walls and columns with expansion joints, which allow unrestrained vertical movement. Floor slab control joints should be used to reduce damage due to shrinkage cracking. Joint spacing is dependent on slab thickness, concrete

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aggregate size, and slump, and should be consistent with recognized guidelines such as those of the Portland Cement Association (PCA) and American Concrete Institute (ACI). The joint spacing and slab reinforcement should be established by the designer based on experience and the intended slab use. A minimum 4-inch thick layer of free-draining gravel should be placed beneath basement level slabs to facilitate drainage. This material should consist of minus 1.5-inch aggregate with at least 90% retained on the No. 4 sieve and less than 1% passing the No. 200 sieve.

Existing man-placed fill was encountered in the test pit in the southeast corner of the property. Prior to slab placement, the fill subgrade should be proof-rolled with a heavily loaded rubber-tired vehicle. Soft or loose areas identified during the proof-roll should be densified or reworked to provide a stable surface for placement and compaction of new fill.

Fill placed beneath floor slabs should consist of a nonexpansive, predominantly granular material consisting of onsite natural soils or soils similar to the onsite soils. The existing granular fill materials encountered in the borings and pits may be suitable for reuse as underslab fill, provided the existing fill materials do not include deleterious substances or concentrations of debris. The geotechnical engineer should evaluate the suitability of fill materials prior to placement.

SURFACE DRAINAGE

Proper surface drainage is very important for acceptable performance of the slab-on-grade during construction and after the construction has been completed. The following recommendations should be used as guidelines and changes should be made only after consultation with the geotechnical engineer.

1. Excessive wetting or drying of the excavation and underslab areas should be avoided during construction.

2. The ground surface surrounding the exterior of the building should be sloped to drain away from the foundation in all directions. We recommend a minimum slope of 12 inches in the first 10 feet in unpaved areas and a minimum slope of 3 inches in the first 10 feet in paved areas. Free-draining wall backfill should be capped with approximately 2 feet of the onsite finer graded soils to facilitate surface drainage. Site drainage beyond the 10-foot zone should be designed to promote runoff and reduce infiltration. These slopes may be changed as required for handicap access points in accordance with the Americans with Disabilities Act.

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

DESIGN AND CONSTRUCTION SUPPORT SERVICES

Please consider retaining BEST to provide the following services:

1. Review of the project plans and specifications for conformance with the recommendations provided in this report.

2. Observation and testing to document that the intent of this report and that the requirements of the plans and specifications are being followed during construction.

3. Identification of possible variations in subsurface conditions from those encountered in this study, so that recommendations can be re-evaluated, if needed.

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BEST is also available to assist the design team in preparing specifications for the geotechnical aspects of the project and performing additional studies if necessary to accommodate possible changes in the proposed construction.

LIMITATIONS

This study has been conducted in accordance with generally accepted geotechnical engineering practices in this area for exclusive use by the client for design purposes. We make no warranty either express or implied. The conclusions and recommendations submitted in this report are based upon data obtained from the exploratory test pits at the locations indicated on Fig. 1, and the proposed construction. This report may not reflect subsurface variations that occur between the explorations. The nature and extent of variations across the site may not become evident until site grading and excavations are performed. If fill, soil, rock or water conditions appear to be different from those described herein, Best Engineering Solutions and Technologies, LLC (BEST) should be advised at once so that a re-evaluation of the recommendations presented in this report can be made. BEST is not responsible for liability associated with interpretation of subsurface data by others.

The scope of services for this project does not include any environmental assessment of the site or identification of contaminated or hazardous materials or conditions. In addition, this study does not include determination of the presence, prevention, or possibility of mold or other biological contaminants developing in the future. If the owner is concerned about the potential for such contamination, other studies should be undertaken.

Matthew A. Best, P.E.
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MAB/mab

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TABLE 1
SUMMARY OF LABORATORY TEST RESULTS

PROJECT: Mary Ruth Place **PROJECT NO:** 17-1068 **DATE:** August 14, 2017
LOCATION: 306 Galena Street **SOURCE:** Field Borings / Lab Testing

Test Pit No.	Sample No.	Depth in Feet	Sample Type (Note 1)	Nat. Dry Density (PSF)	Natural Moist. (%)	ATTERBERG LIMITS			% Fines	Water Soluble Sulfates (ppm)	Shear Strength (KSF) (Note 2)	Additional Test Results (Note 3)	Soil Description
						LL	PL	PI					
1	1	2-8	BS	-	2.8	-	-	NP	4.7				Silty Sand with Gravel, Brown
2	2	2-8	BS	-	3.1	-	-	NP	6.8				Silty Sand with Gravel, Brown

NOTE 1- Sample Type
BS=Bag Sample
AS=Auger Sample
ST=Shelby Tube
CA=California Sample
RM=Remolded Sample
HD=Hand Drive
AD=Air Dried

NOTE 2-Shear Strength Tests
C1= Unconfined Compression
C2=Miniature Compression
C3=Pocket Penetrometer
C4=Pocket Value

NOTE 3- Additional Test Results
SW=Swell/Consolidation Test
TT=Traxial Test
PT=Proctor
GA=Gradation Analysis
CT=Consolidation Test
RA=Radon Testing (pCi/L)
pH = pH of soil
OR = Organic content of soil

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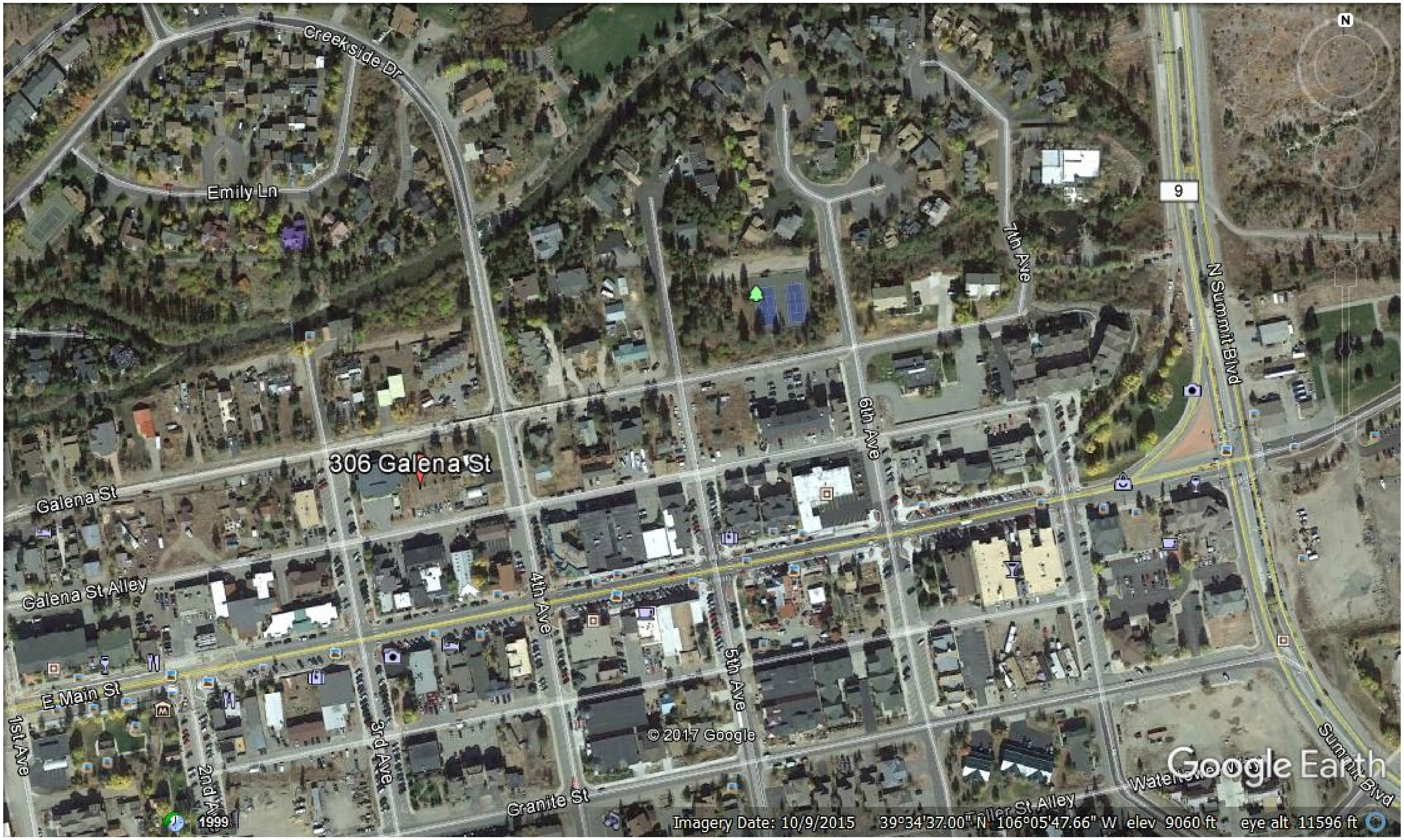
B.E.S.T.

SITE MAP



N

Not to Scale

Project Number 17-1068 **Figure 1**

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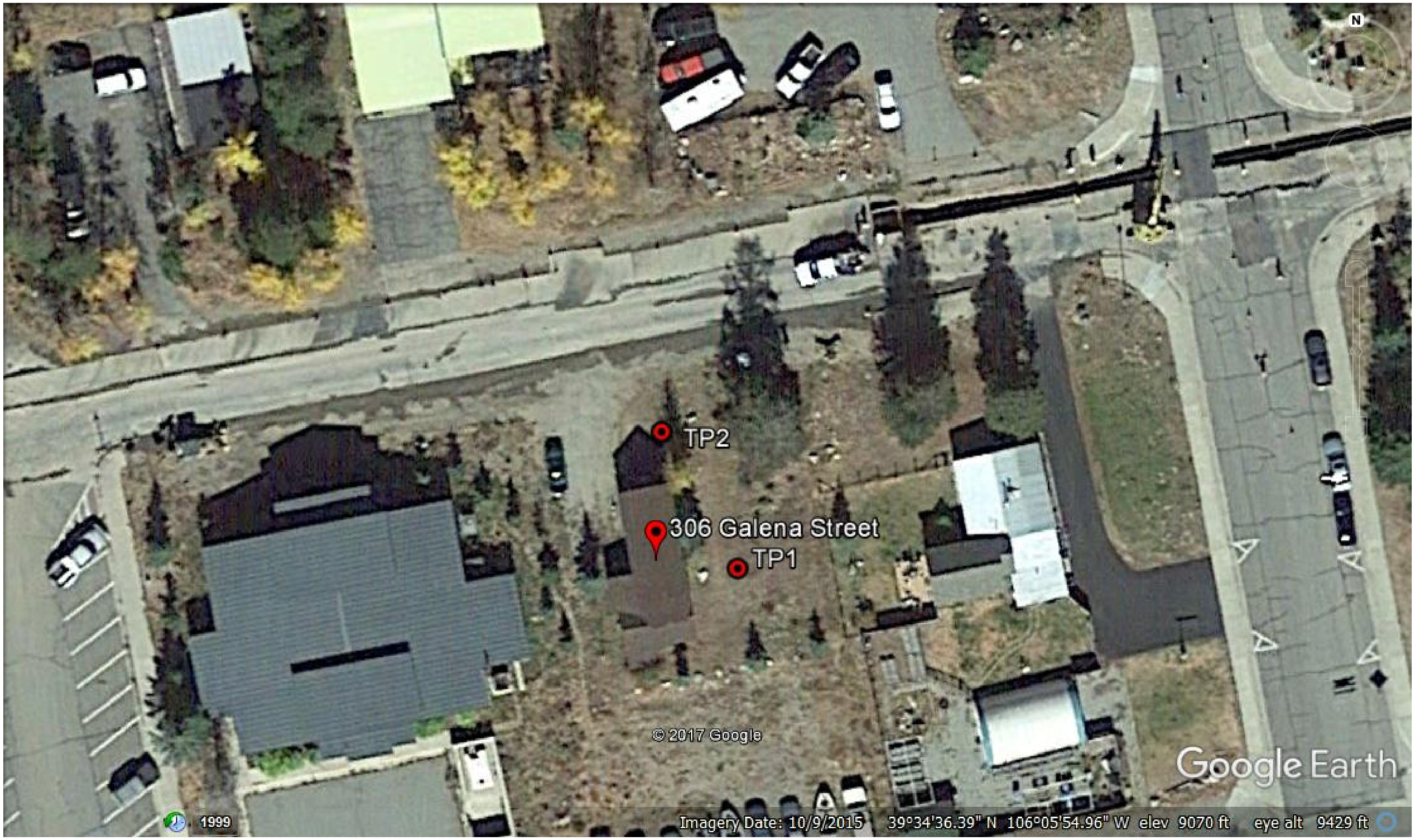
747 Sheridan Boulevard, Unit 2A ▪ Lakewood, Colorado 80214 ▪ Phone: 303.238.1770 ▪ Office@De-Rey.com

TEST PIT LOCATIONS



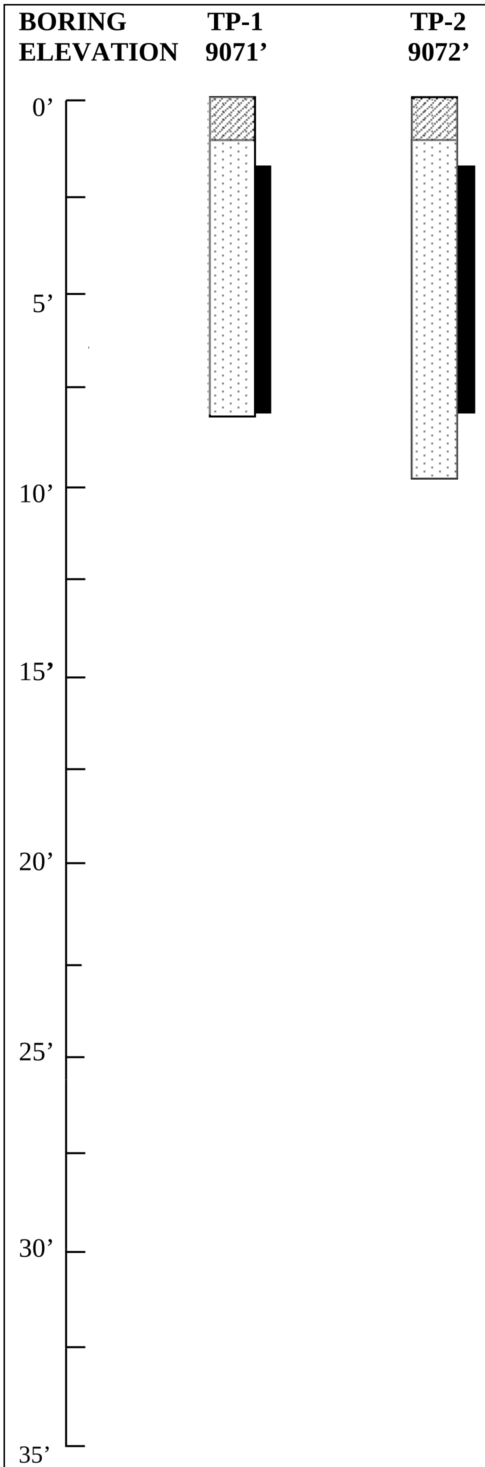
N

Not to Scale

LEGEND:

TP-1 – Indicates location of exploratory test pit

Project Number 17-1068 **Figure 2**



BORING LOGS

B.E.S.T.

Soil and Foundation Investigation
Mary Ruth Place
Frisco, Colorado

DRAWN BY: KRB **CHECKED BY:** MB **DATE:** August 14, 2017	**SCALE:** Vertical: 1”= 5’ Horizontal:
PROJECT NO: 17-1068	**FIGURE:** 3

Sandy Clay, light to dark brown, stiff to very stiff, moist, (CL)

Silty Sand with gravel, light brown, dense to very dense, moist (SC)

Water level, time after excavation.

Disturbed sample collected

Undisturbed sample collected

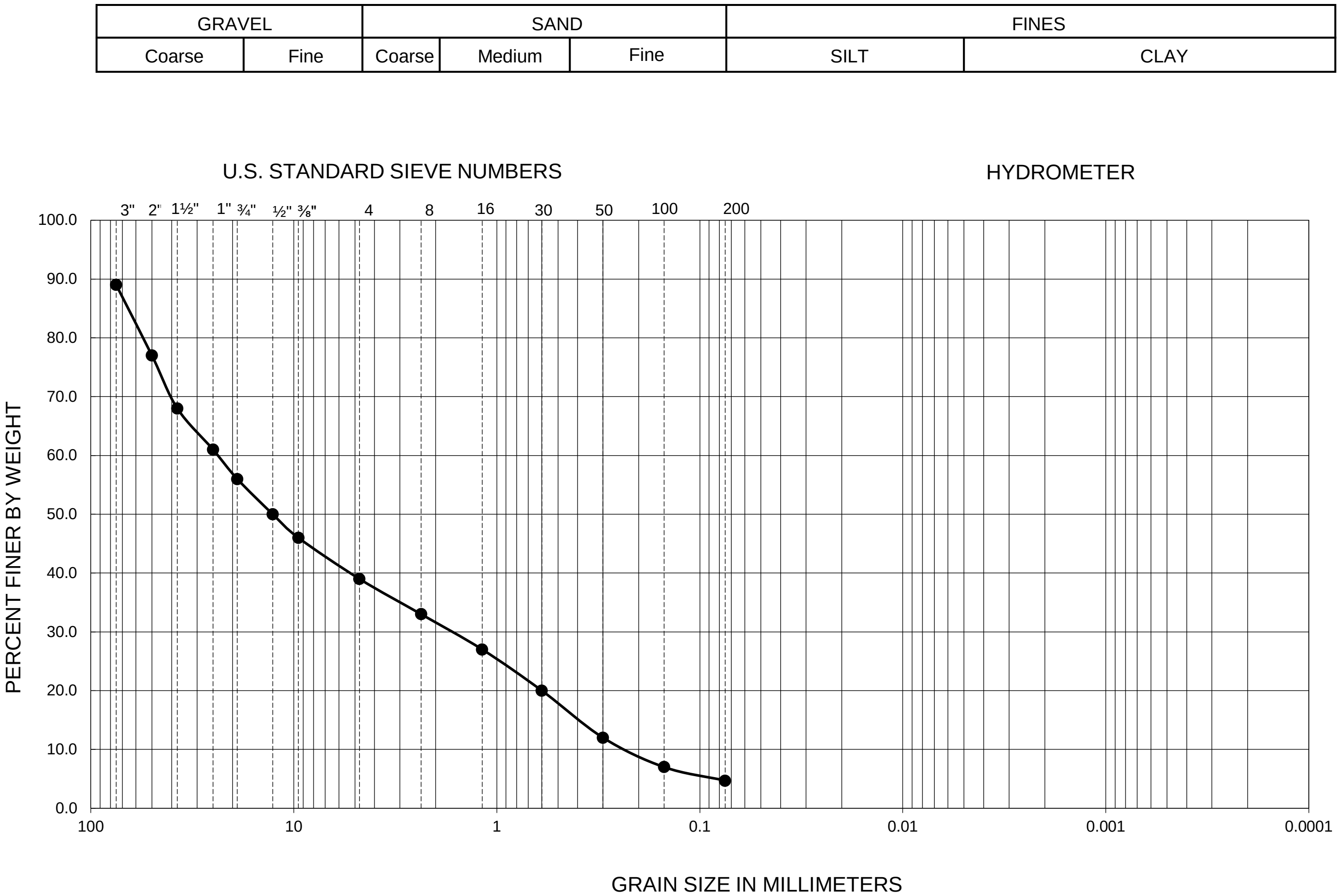
42/12" Blow counts; it took about forty two (42) blows to drive the sample 12 inches (ASTM D-1586)

((13)) Depth of Caving Soils

NOTES:

1. The samples were collected on July 19, 2017 with a mini-excavator.
2. The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
3. The boring logs show subsurface conditions at the dates and locations indicated, and it is not warranted that they are representative of subsurface conditions at other locations or times.

LEGEND & NOTES	B.E.S.T.	
Soil and Foundation Investigation Mary Ruth Place Frisco, Colorado	**DRAWN BY:** KRB **CHECKED BY:** MB **DATE:** August 14, 2017	**SCALE:** Vertical: Horizontal: NA
	PROJECT NO: 17-1068	**FIGURE:** 4

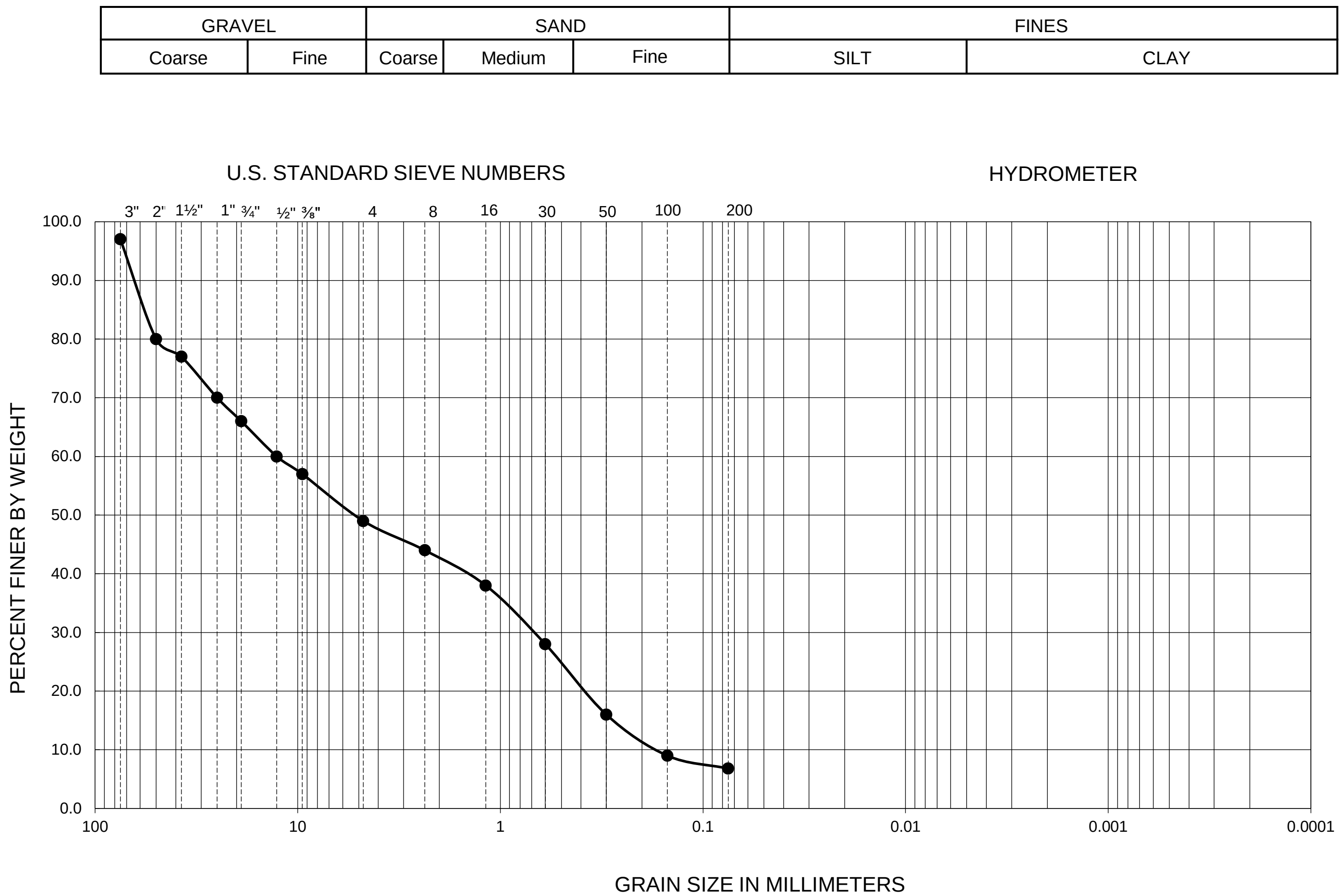


Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	AASHTO
●	TP-1	2-8 Ft	NP	NP	NP	0.24	1.67	24.13	100.5	0.5	4.7	SM

PERFORMED IN GENERAL ACCORDANCE WITH ASTM C 117 AND ASTM C 136

NP - INDICATES NON-PLASTIC

		GRADATION TEST RESULTS	FIGURE
PROJECT NO.	DATE	Mary Ruth Place 306 Galena Street Frisco, Colorado	**Fig. 5a**
17-1068	7/27/17		



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	AASHTO
●	TP-2	2-8 Ft	NP	NP	NP	0.17	0.72	12.70	74.7	0.2	6.8	SM

PERFORMED IN GENERAL ACCORDANCE WITH ASTM C 117 AND ASTM C 136

NP - INDICATES NON-PLASTIC

		GRADATION TEST RESULTS	FIGURE
PROJECT NO.	DATE	Mary Ruth Place 306 Galena Street Frisco, Colorado	**Fig. 5b**
17-1068	7/27/17		