McNett Flats Subdivision

Major Subdivision Application

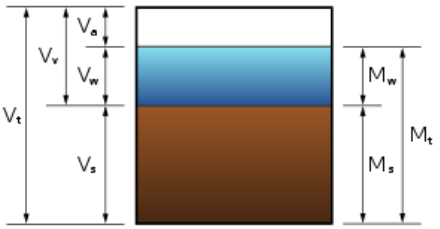
Section 10: Geotechnical Report

Revision	*Date*
1st Element Review Copy	August 25, 2020
1st Sufficiency Review Copy	September 1, 2020
Governing Body Review	December 4, 2020

405 Third Street NW, Suite 206
Great Falls, MT 59404
(406) 761-1955

WOITH ENGINEERING, INC.
ENGINEERS & SURVEYORS

3860 O'Leary Street, Suite A
Missoula, MT 59808
(406) 203-0869



Lorenzen Soil Mechanics, Inc.

George Elmer Drive Extension

Geotechnical Engineering Report

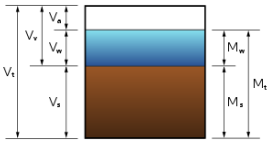
Missoula, Montana

Prepared for:
Tollefson Construction
5075 Expressway
Missoula, MT 59808
&
Woith Engineering
3860 O'Leary Street
Suite A
Missoula, MT 59808

Prepared by:
Lorenzen Soil Mechanics, Inc.
2720 Palmer Drive, Unit C
Missoula, Montana 59808

May 4, 2020

Table of Contents



1 INTRODUCTION

Through Tollefson Construction, Woith Engineering requested Lorenzen Soil Mechanics, Inc. (LSM) to complete a geotechnical/materials investigation for the proposed George Elmer Drive Extension west of Missoula. The streets will service proposed apartment complexes. Lorenzen Soil Mechanics, Inc. (LSM) has completed a geotechnical evaluation for the proposed streets that will serve the development.

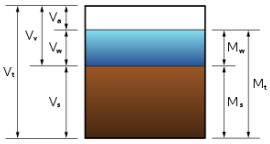
The primary purpose of the evaluation was to assess the street and underground utility subgrade materials, the estimated infiltration rates in the upper soil profile and at depth, and to provide typical sections for the proposed streets. LSM has also provided general recommendations for the apartment complex building foundations based on the soils encountered during the street subsurface investigation. The soils may differ at each of the apartment structure locations and the general recommendations provided may not be applicable. LSM will be available to assess the apartment structures' foundation subgrade soils to verify the general recommendations or modify if necessary.

2 SITE EVALUATION

The proposed George Elmer Drive extension will carry traffic further north and serve apartment complexes. An east-west street will bisect the George Elmer Drive extension and Old Ranch Road, a north-south street that parallels George Elmer Drive to the east. This site is currently undeveloped and is used for agricultural purposes such as pasture grazing and haying. The site is gently undulating. An irrigation canal flows near the site's eastern boundary during the irrigation season. The property to the west is also proposed for residential apartment complex construction.

Geologically, this area is mapped on the Missoula West 30' x 60' Quadrangle Geologic Map (MBMG Open File Report 373) as Quaternary period Alluvium of Alluvial Terrace Deposits (Qat). These deposits are characterized as well-rounded cobbles, gravel, and sand in deposits with flat topped surfaces that are 10 to 30 feet above the present flood plain. Three nearby water wells located southwest of the site and data-based at the Montana Bureau of Mines and Geology, indicate a groundwater table depth ranging from 27 to 50 feet. One of the well-logs includes a lithology of 10 feet of clay overlying gravel, cobbles, and sand with a few varying layers of clay that extended to 112 feet in depth. This was the deepest of the three wells. No bedrock was noted.

LSM conducted a subsurface investigation on February 25th, 2020. A Case 580M Turbo backhoe, owned and operated by the Owner's representative, was used to dig a total of six test pits (TP) to depths up to 11.5 feet at locations representing the proposed street alignments. A 1-inch diameter slotted PVC pipe was inserted in each of the test pits to serve as a piezometer. Figure 2 depicts the test pit locations. Horizontal coordinates were obtained using a Garmin eTrex Vista® HCx GPS unit. The test pit elevations were obtained from Woith Engineering.



In general, silty sand and sandy silt overlie high quality sand and gravel aggregates. The underlying aggregates will allow for rapid stormwater infiltration collected in dry well sumps that extend into the gravel layer. The finer-grained soils overlying the gravels are considered problematic for the construction of roadways but can be addressed with separation/stabilization geotextile and a subbase layer as part of the typical section.

The groundwater table was not encountered in any of the test pits during the test pitting operation. Piezometers were installed in each of the test pits and were last read on May 4th. Each of the piezometers have remained dry. Soil moisture conditions in the test pits ranged from damp to dry.

Logs of the test pits and the testing results are provided in Appendix A. Photographs of the test pitting operations and soil samples are included in Appendix B.

3 RECOMMENDATIONS

3.1 Subgrade Soils

The subgrade soils directly beneath the topsoil for the street alignments tend to be layers of sandy silt (A-4) or silty sand (A-4) and are thicker than 2 feet. An exception was TP-06 where poorly graded sand with silt and gravel (A-1-a) was encountered at a depth of 1.6 feet. The Missoula County Public Works Department classifies A-1-a soils as a 'good' subgrade and A-4 soils as an 'average' subgrade. LSM cautions that an A-4 soil subgrade is susceptible to frost heave during the winter months and frost boils during the thawing periods.

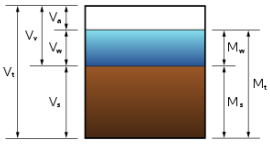
3.2 Street Typical Sections

The upper 2 feet of the existing soil profile can be expected to have a California Bearing Ratio (CBR) between 10 and 19, trending toward 10. Depending on the street grading plans, if there is to be a general fill across the site, LSM recommends keeping the existing vegetation in place and overlying the ground surface with a woven geotextile meeting or exceeding the engineering properties of Contech C-200 or Propex 200ST. The purpose of leaving the vegetative mat in place is that its root mass acts as a low grade stabilization geotextile.

For the top 2 feet of silty subgrades, LSM recommends a street typical section of:

Asphalt Concrete:	3 inches Plant Mix.
Crushed Granular Base:	4 inches Crushed 1.5-inch minus.
Crushed Subbase:	12 inches Crushed 3-inch minus.
Woven Geotextile:	Contech C-200, Propex 200ST, or equal.

For fill sections, LSM recommends preparing the subgrade and constructing the typical section aggregates by:



1. Proof rolling the roadway alignment's footprint by using a fully loaded water truck or similarly loaded vehicle. If ruts in excess of 1 inch are made during the proof rolling process, level the affected area with 3-inch minus subbase material.
2. Providing a woven geotextile meeting or exceeding the engineering properties of Contech C-200 or Propex 200ST and placing it over the roadway footprint.
3. Providing a crushed 3-inch minus subbase course meeting the gradation presented in Table 1. Recycled asphalt and/or concrete are acceptable, provided they meet the gradation bands in Table 1.

Table 1: 3" Minus Crushed Subbase Course

Sieve Size	Percent Passing
3"	90 -100
2 1/2"	85 - 95
1 1/2"	75 - 95
3/4"	65 - 85
No. 4	25 - 60
No. 200	3 - 10

4. Placing the crushed 3-inch minus subbase course in 8-inch (maximum) loose lift thicknesses and compacting each lift to a standard relative compaction (ASTM D698) of at least 95 percent and within 2 percent of its optimum moisture content.
5. Providing a crushed 1 1/2-inch minus base course meeting the gradation presented in Table 2. Recycled asphalt and/or concrete are acceptable, provided they meet the gradation bands in Table 2.

Table 2: 1 1/2" Minus Crushed Base Course

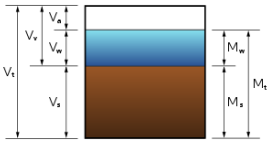
Sieve Size	**Percent Passing**
1 1/2"	100
3/4"	90 - 100
3/8"	70 - 90
No. 4	40 - 70
No. 10	25 - 55
No. 200	2 - 8

6. Placing the crushed 1 1/2-inch minus base course and compacting it to a standard relative compaction of at least 95 percent and within 2 percent of its optimum moisture content.

LSM suggests using a vibratory pad roller compactor having an operating weight of at least 25,000 pounds and a centrifugal force of at least 45,000 pounds to compact the subgrade and the aggregate courses.

For cut sections, LSM recommends preparing the subgrade and constructing the typical section aggregates by:

1. Excavating to the subgrade elevation within the cut section and wetting the surface to, or up to 2 percent over, its optimum moisture content.



2. Compacting the wetted subgrade to a standard relative compaction (ASTM D698) of at least 95 percent.
3. Placing a layer of woven geotextile meeting the engineering characteristics of Contech C-200 or Propex 200ST across the compacted subgrade.
4. Providing a crushed 3-inch minus base course meeting the gradation presented in Table 1. Recycled asphalt and/or concrete are acceptable, provided they meet the gradation bands in Table 1.
5. Placing the crushed 3-inch minus subbase course in 8-inch (maximum) loose lift thicknesses and compacting each lift to a standard relative compaction of at least 95 percent and within 2 percent of its optimum moisture content.
6. Providing a crushed 1 1/2-inch minus base course meeting the gradation presented in Table 2. Recycled asphalt and/or concrete are acceptable, provided they meet the gradation bands in Table 2.
7. Placing the crushed 1 1/2-inch minus base course and compacting it to a standard relative compaction of at least 95 percent and within 2 percent of its optimum moisture content.

LSM suggests using a vibratory pad roller compactor having an operating weight of at least 25,000 pounds and a centrifugal force of at least 45,000 pounds to compact the subgrade and the aggregate courses.

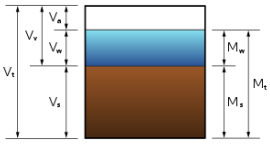
Plant Mix Surfacing

For the asphalt concrete, LSM recommends using either PG 58-28 or PG 64-22 for the binder and the plant mix surfacing aggregate meeting the Montana Public Work's gradation presented in Table 3. The gradation bands represent the job mix target limits, which determine the suitability of aggregate. Provide the final job mix target gradation within the specified bands and uniformly graded from coarse to fine, not to vary from the low limit on one sieve to the high limit on the adjacent sieve, or vice-versa. For example, using the 3/8" and No. 4 sieves, a gradation of 73 percent and 48 percent passing their respective sieves is acceptable, 73 percent and 62 percent passing their respective sieves is not.

Table 3: Plant Mix Surfacing Gradation

Sieve Size	% Passing Job Mix Target Bands	Job Mix Tolerances
3/4"	100	-
1/2"	83 - 93	+/- 7
3/8"	73 - 97	+/- 7
No. 4	47 - 63	+/- 6
No. 10	32 - 43	+/- 6
No. 40	15 - 25	+/- 5
No. 200	5 - 7	+/- 2

The job mix formula establishes target values. During mix production, the gradations are to fall within the job mix limits presented in Table 3, i.e. if a QA job mix target of 6 has been selected for the No. 200 sieve and since the tolerance is +/-2, the job mix gradation for production would be 4 - 8.



Compact the asphalt concrete plant mix surfacing in one lift to an average relative compaction (ASTM D2041) of at least 93 percent, and no individual sample being less than 92 percent.

3.3 Street Subsurface Drainage

Based on the subsurface investigation, dry well sumps extending to the poorly and well-graded gravel with sand (GP, GW) and the silty gravel with sand (GM) layers will provide an avenue for surface drainage. The groundwater table is below the 11.5-foot depth in the test pits. Based on the three area well logs, the groundwater table can be expected to be below 20 feet.

LSM recommends the design infiltration rates at sumps placed within the poorly and well-graded granular soils be taken as 10 inches per hour. This value is based on applying a safety factor of 2.0 to the City of Helena's Engineering Standards' infiltration rates which have been in place since at least 2006 and are included in their latest 2019 Standards. The infiltration values are based on the soil's textural classification and are presented in Table 4.

Table 4: Infiltration Rates Based on USDA Textural Classification[1]

Soil Texture Class (U.S.D.A.)	Infiltration Rates (inches/hour)
Coarse Sand, Cobbles	20.0
Medium Sand	8.0
Fine Sand, Loamy Sand	2.4
Sandy Loam	1.0
Loam	0.5

[1.] City of Helena Engineering Standards, 2019 – Table 4-7

The USDA textural classifications for six hydrometer samples were primarily sandy loam but included loam and silty loam. For these loam soils, LSM recommends the design infiltration rates be taken as 0.25 inches per hour for the soils in the upper 5 feet of the soil profile.

3.4 Compaction Testing Frequency

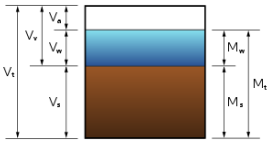
LSM suggests a testing frequency presented in Table 5 for subgrade and backfill compaction and for fresh concrete for the curbing.

Table 5: Testing Frequency

Compaction Testing	
Street Subgrade and Aggregates	1 Test per 5,000 Square Feet per Lift
Concrete Testing	
Curb/Sidewalk Concrete	1 Test per 50 Cubic Yards per Day

3.5 Apartment Complex Foundations

Based on the soils encountered during the street test pitting operations, LSM is making general recommendations for the residential foundations, foundation walls, and slabs-on-grade. If fine-grained soils are encountered that differ from what LSM encountered during the street



excavations, contact LSM to evaluate the subgrade soils and to provide additional design recommendations.

LSM suggests full basements can take advantage of the underlying well- and poorly graded gravels. Footing over-excavations to the gravels are recommended for crawl spaces. The concrete footings can be seated on the native gravels or on a 2-foot thickness of imported structural fill meeting the subbase gradation presented in Table 1. Interior footings can be placed directly below the slabs-on-grade but are also to be supported on structural fill. Compact the footing subgrades to a standard relative compaction of at least 98 percent and at a moisture content within 2 percent of the subgrade's optimum moisture content.

Provided the foundation subgrades have been prepared and compacted as noted, an allowable soil bearing pressure up to 4,000 pounds per square foot (psf) is recommended for the foundation subgrades on the native poorly and well-graded gravel and sand soils and 3,500 on the imported structural fill.

LSM believes the gravel subgrade at depth is porous and will adequately pass infiltrated surface water that arrives at the foundation elevation. Based on the presence of the gravel soils at the foundation depth, LSM does not believe perimeter foundation drains are necessary.

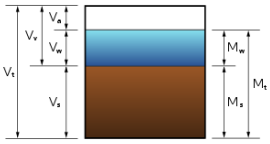
3.6 Foundation Walls

LSM recommends foundation walls associated with the exterior footings be cast-in-place reinforced concrete, water proofed if being used for living spaces, and to include water stops at the foundation wall/footing keyway.

The sandy silt and granular soils can be re-used as backfill against the foundation walls provided the cobbles are at least 1 foot away from the walls. Compacting these materials as backfill will offer an internal angle of friction (ϕ) of 32°, and a moist unit weight (γ_m) of at least 110 pcf. For the on-site soils being used as backfill, LSM recommends using an at-rest equivalent fluid unit weight (γ_f) of 51.7 pounds per cubic foot (pcf) for foundation wall design where the tops of the walls are not allowed to rotate. LSM recommends using an active equivalent fluid unit weight (γ_f) of 33.8 pounds per cubic foot (pcf) for retaining wall design where the tops of the walls are allowed to rotate. With a level backfill, the following equations can be used to obtain a resultant lateral force (pounds per lineal foot) acting at the lower one-third of the wall heights (H in feet):

Active Pressure, P_a:	$16.9 \times H^2$
Passive Pressure, P_p:	$179.0 \times H^2$
At-rest Pressure, P_0:	$25.9 \times H^2$
Seismic Pressure, P_E:	$8.8 \times H^2$
Seismic Active Pressure, $P_{(E+a)}$:	$25.7 \times H^2$

LSM recommends walls associated with the foundation footings or columns be cast-in-place reinforced concrete. Rigid insulation such as Styrofoam Brand SM is suggested for use along the exterior sides of the perimeter walls. In addition to providing insulation benefits, the rigid



insulation board will offer some cushion and protection to the wall waterproofing during the backfilling operations.

3.7 Apartment Complex Slabs-on-Grade

For basement slabs, the underlying granular soils will make an excellent bearing pad for slabs-on-grade. LSM recommends preparing the basement slab-on-grade subgrades by:

1. Excavating to the subgrade elevation and leveling.
2. Compacting the slab subgrade to a relative compaction of at least 95 percent using a vibratory roller compactor having an operating weight of at least 15,000 pounds and a centrifugal force of at least 30,000 pounds.
3. Placing up to a 3-inch thick leveling course of 3/4-inch sandy gravel across the slab-on-grade subgrade. The material presented in Table 2 can be used as the leveling course.

For the slabs placed on the properly compacted and prepared slab subgrades, a modulus of subgrade reaction, k, of 300 pounds per square inch per inch of deflection (pci) can be used for the slab thickness designs. Use a coefficient of friction, μ, of 0.50 for sliding resistance design.

For crawl spaces, on the silty soils that may have a slab-on-grade, LSM recommends including a 9-inch thick gravel layer meeting the gradation in Table 2 and a 3-inch thick leveling course of 3/4-inch sandy gravel beneath the slab. LSM suggests the placement of the aggregates even if there is no slab in the crawl spaces.

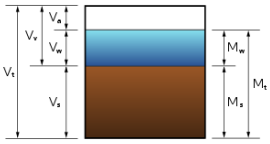
Varying amounts of curling within the slabs are likely to occur due to differences in the moisture content or to temperature variations between the top and the bottom of the slab. To help mitigate potential slab curling, LSM recommends the following options:

1. Putting a chloride-free retardant additive into the fresh concrete mix;
2. Maintaining a minimum of 1.5 inches clearance on all rebar; and,
3. Placing a 15-mil thick polyolefin vapor barrier across the prepared subgrade surface prior to placing the fresh concrete. In addition to being a vapor barrier, the Stego® vapor barrier has a radon diffusion coefficient of 8.8×10^{-12} square meters per second.

The purpose of the retardant in the first option is to slow the set at the surface of the slab. No chlorides are allowed in any of the admixtures for the slabs-on-grade. The concrete at the slab surface will generally harden quicker than the concrete at the bottom of the slab. This is particularly true of concrete placed during hot weather conditions. The use of a retardant can also reduce cold joints, allow smaller crews to finish flat work, and permit later joint sawing.

LSM recommends including isolation and control (contraction) joints within the slab-on-grade. Joint geometries should include:

1. Placing isolation joints at all interior column locations.
2. Spacing saw-cut or forming control joints from 24 to 36 times the thickness of the slab in each direction and extending the control joints to one-quarter the thickness of the slab.



3. Terminating reinforcing bars within 2 inches of both sides of control joints to limit the transfer of shrinkage and contraction restraints.
4. If sawing, cut the joints with a conventional saw within 4 to 12 hours after the concrete is finished, or with a dry-cut early entry saw within 1 to 4 hours after the concrete is finished. If fiber reinforcing is used, increase the saw cut to one-third the thickness of the slab.

If added correctly, fiber reinforcement can limit the growth of shrinkage cracking. LSM yields to the structural engineer for the joint designs.

3.8 Underground Utilities

For utility trench excavations, the trench materials are expected to meet OSHA's requirements for a Type C soil. The steepest unsupported slope within a Type C soil trench is 1.5H:1V.

Use bedding soils that are minus 3/4-inch granular materials and are non-corrosive. A non-corrosive soil has a resistivity value greater than 3,000 ohm-centimeters. LSM recommends extending the bedding soil from the bottom of the utility trench to 6 inches above the top of the utility conduits. The native materials can be re-used as trench backfill over the bedding.

Soil compaction in utility trenches deeper than 5 feet should be performed using a remote trench compactor and observed by an inspector. When the backfill has been brought back to within 5 feet of the surface, perform compaction testing. Compact the trench soils to a standard relative compaction of at least 95 percent.

3.9 Groundwater Table and Surface Water

The groundwater table was not encountered during the test pitting operations which extended to only 11.5 feet at their deepest depths. Piezometers were inserted in each of the test pits and as of their last reading on May 4, 2020, the groundwater table is below the bottom of the piezometers.

The moisture conditions of the test pit soils were generally regarded as 'damp' or 'dry'. Berm all open excavations to prevent surface water from entering. For stormwater design, LSM recommends using design infiltration rates of 10 inches per hour through the clean granular soils and 0.25 inches per hour through the silty soils.

3.10 Seismic Considerations

The Missoula area is within the Northern Intermountain Seismic Belt seismotectonic province. The ASCE/SEI 7-16 Hazards Report was used to develop the spectral response values for a seismic site class 'C', "Very Dense Soils and Soft Rock". LSM recommends the maximum credible spectral response accelerations at short 0.2-second periods, S_{MS}, and at 1-second periods, S_{M1}, to determine the seismic design base shear. A risk category of II was used. The spectral response acceleration parameters are presented in Table 6.

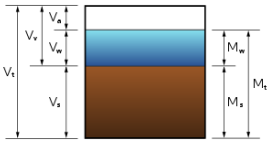


Table 6: Seismic Coefficients

IBC 2012/2015, Earthquake Loads	
Site Class Definition	C
Mapped Spectral Response Acceleration Parameter, S_S for 0.2 second	0.425g
Mapped Spectral Response Acceleration Parameter, S_1 for 1.0 second	0.143g
Adjusted Maximum Considered Earthquake Spectral Response Acceleration Parameter, S_{MS}	0.553g
Adjusted Maximum Considered Earthquake Spectral Response Acceleration Parameter, S_{M1}	0.214g
Design Spectral Response Acceleration Parameter, S_{DS}	0.369g
Design Spectral Response Acceleration Parameter, S_{D1}	0.143g

The seismic backfill pressures against the buried portion of the foundation walls can be determined by adding a seismic event component, P_E, based on Seed and Whitman (1970) to the coefficient of active pressure P_a. The P_E was calculated to be 8.8 x H^2, making the active pressure against the wall during an earthquake equal to 25.7x H^2 and was presented in Section 3.2. A factor of safety of 1.1 can be used for earthquake design lateral earth pressures and the allowable bearing capacity can be increased by one-third for seismic design.

Due to the expected distance to the groundwater table being in excess of 20 feet and the coarse nature of the granular soils encountered in the test pits, liquefaction during a seismic event is not considered a concern at this site during a significant seismic event of a moment magnitude greater than 6.0.

3.11 Shrink/Swell Characteristics

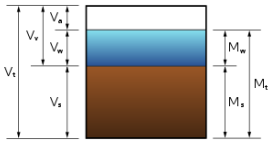
The volume change potential of the on-site granular soils encountered during the street test pitting is expected to be low. The presence of the silty subgrades at the upper portion of the soil profile will present issues regarding frost heaving during the colder winter months and frost boils during the thaw periods beneath sidewalks and patios. For this purpose LSM recommends including at least 9 inches of a base course meeting the gradation in Table 2 beneath exterior flatwork.

The building designs should include eaves and roof gutters with downspouts that will carry roof runoff water at least 10 feet horizontally away from the buildings. Provide positive drainage around the entire building on a 2 percent grade extending at least 15 feet horizontally away from the building.

4 BASIS OF RECOMMENDATIONS

The analyses and recommendations submitted in this report are based upon the subsurface investigation. Often, variations occur within the subgrade, the nature and extent of which do not become evident until additional exploration or construction is conducted.

This report is for the exclusive use of Tollefson Construction, Woith Engineering, and their design team. In the absence of LSM's written approval, LSM makes no representation and assumes no responsibility to other parties regarding this report. The data, analyses, and recommendations may not be appropriate for other structures or purposes. Again, general



recommendations made for the residential sites were based on the soils encountered during the street test pitting operations. If the structure foundation soils differ, contact LSM for additional foundation recommendation guidance. Parties contemplating structures or purposes other than what this report was written are directed to contact LSM.

Professional Certification

I hereby certify that this report was prepared by me and that I am a duly Licensed Professional Engineer under the laws of the State of Montana.

Todd Lorenzen, P.E.
Geotechnical Engineer

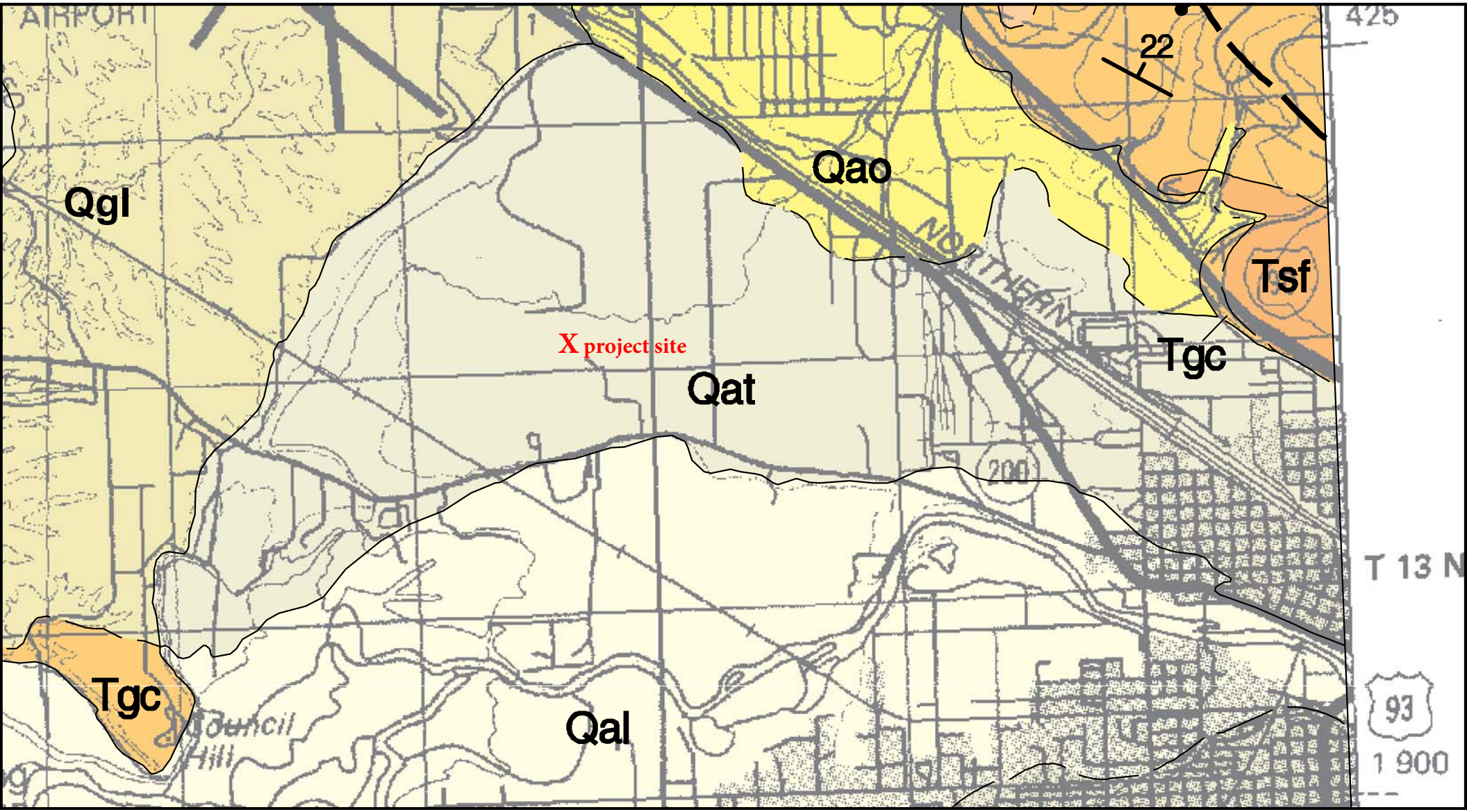
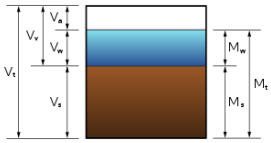


Figure 1: Portion of Missoula West 30'x60' Quadrangle Geologic Map, Open File Report MBMG 373; 1998, Reed S. Lewis

Figure 2: Test Pit Locations



APPENDIX A. LOGS OF TEST PITS AND TESTING INFORMATION

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SS:	Split Spoon - 1-3/8" I.D., 2" O.D., unless otherwise noted	CA:	Casing Advancer
ST:	Thin-Walled Tube - 2" O.D., unless otherwise noted	DA:	Drill Auger
CB:	California Sampler - 2" I.D., 2.5" O.D., unless otherwise noted	HA:	Hand Auger
DB:	Diamond Bit Coring - 4", NX, unless otherwise noted	RB:	Rock Bit
BS:	Bulk Sample or Auger Sample	GS:	Grab Sample

The number of blows required to advance a standard 2-inch O.D. split-spoon sampler (SS) the last 12 inches of the total 18-inch penetration with a 140-pound hammer falling 30 inches is considered the "Standard Penetration" or "N-value". The field blow counts are reported for each 6-inch interval, or portion thereof if greater than 50 blows are required to advance the full 6-inch interval. For over-sized split spoon samplers, non-standard hammers, or non-standard drop heights, the field penetration values are reported on the bore log. The values must be corrected to obtain the N-value.

WL:	Water Level	WS:	While Sampling	NE:	Not Encountered
WCl:	Wet Cave-In	WD:	While Drilling		
DCI:	Dry Cave-In	BCR:	Before Casing Removal		
AB:	After Boring	ACR:	After Casing Removal		

Groundwater table levels indicated on the boring logs are the levels measured in the borings at the times indicated. Groundwater table levels at other times and other locations across the site could vary. In pervious soils, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater table levels may not be possible with only short-term observations.

DESCRIPTIVE SOIL CLASSIFICATION: Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: gravel or sand. Cobbles and boulders are not part of the USCS system but are included, when present, as percentages. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; depending on their plasticity, they are described as clay or silt. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils are defined on the basis of their consistency.

CONSISTENCY OF FINE-GRAINED SOILS

Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-value (SS) Blows/Ft.	Consistency
< 500	0 - 1	Very Soft
500 - 1,000	2 - 4	Soft
1,001 - 2,000	5 - 8	Medium Stiff
2,001 - 4,000	9 - 15	Stiff
4,001 - 8,000	16 - 30	Very Stiff
8,000 +	30 +	Hard

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Standard Penetration or N-value (SS) Blows/Ft.	California Barrel (CB) Blows/Ft.	Relative Density
0 - 4	0 - 6	Very Loose
5 - 10	7 - 18	Loose
11 - 30	19 - 58	Medium Dense
31 - 50	59 - 98	Dense
50 +	99 +	Very Dense

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of Other Constituents	Percent of Dry Weight
Trace	< 15
With	15 - 30
Modifier	> 30

USCS* GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300mm)
Cobbles	12 in. to 3 in. (300mm to 75 mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm)
Silt or Clay	Passing #200 Sieve (0.075mm)

*For AASHTO grain size the #4 sieve is replaced with the #10 sieve

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of Other Constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifiers	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-Plastic	0
Slightly	1 - 5
Low	6 - 10
Medium	11 - 20
Highly	21 - 40
Very Highly	> 40

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification	
				Group Symbol	Group Name [B]
Coarse Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines	$Cu \geq 4$ and $1 \leq Cc \leq 3$	GW	Well-graded Gravel [F]
			$Cu < 4$ and/or $1 > Cc > 3$	GP	Poorly graded gravel [F]
		Gravels with Fines More than 12% fines	Fines classify as ML or MH	GM	Silty Gravel [F,G,H]
			Fines classify as CL or CH	GC	Clayey Gravel [F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines	$Cu \geq 6$ and $1 \leq Cc \leq 3$	SW	Well-graded Sand [I]
			$Cu < 6$ and/or $1 > Cc > 3$	SP	Poorly graded Sand [I]
		Sands with Fines More than 12% fines	Fines classify as ML or MH	SM	Silty Sand [G,H,I]
			Fines classify as CL or CH	SC	Clayey Sand [G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	PI > 7 and plots on or above "A" line	CL	Lean Clay [K,L,M]
			PI < 4 or plots below "A" line	ML	Silt [K,L,M]
		organic	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OL	Organic Clay [K,L,M,N]
					Organic Silt [K,L,M,O]
	Silts and Clays Liquid Limit 50 or more	inorganic	PI plots on or above "A" Line	CH	Fat Clay [K,L,M]
			PI plots below "A" line	MH	Elastic Silt [K,L,M]
		organic	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OH	Organic Clay [K,L,M,P]
					Organic Silt [K,L,M,Q]
Highly organic soils	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve

[B] If field sample contains cobbles and/or boulders, add "with cobbles or boulders, or both" as necessary to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt. GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.

[E] $Cu = D_{60} / D_{10} \quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200, predominantly sand, add "sandy" to group name.

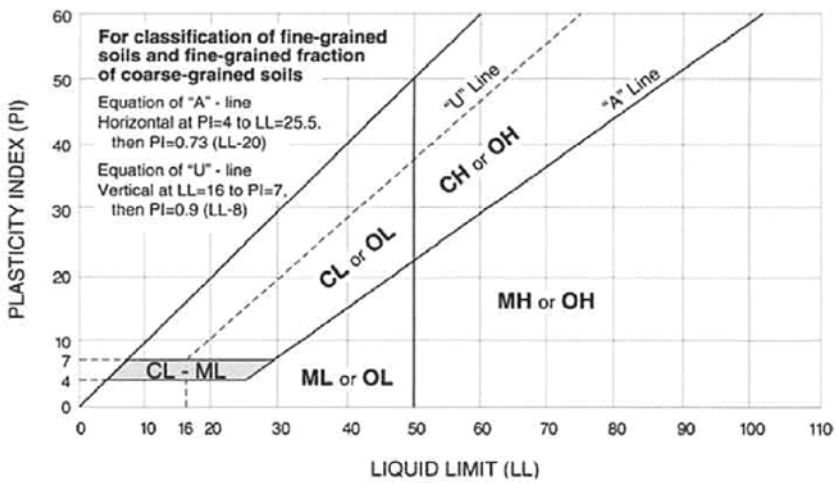
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

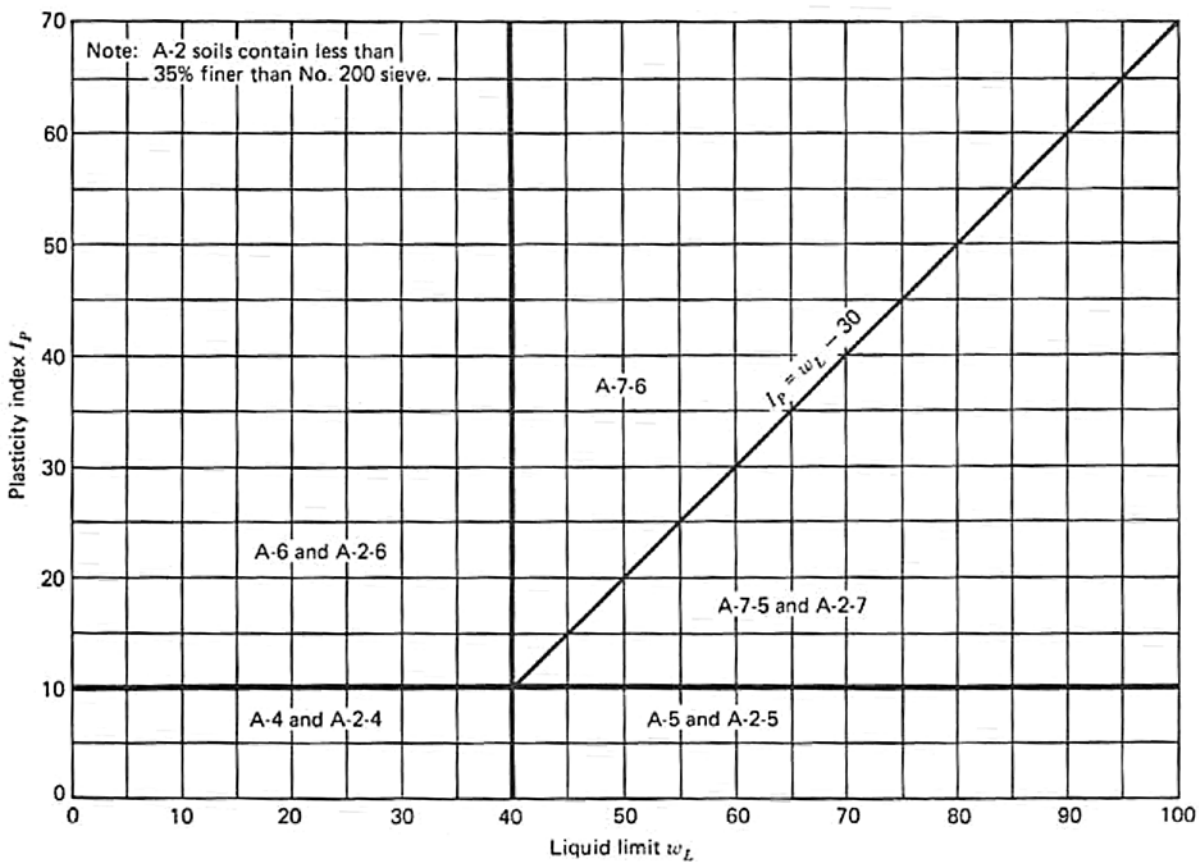
[Q] PI plots below "A" line.



AASHTO SOIL CLASSIFICATION SYSTEM

General classification	**Granular materials** (35 percent or less of total sample passing No. 200)							**Silt-clay material** (More than 35 percent of total sample passing No. 200)			
Group classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7 [1]
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5 A-7-6
Sieve analysis percent passing No. 10 No. 40 No. 200	 50 max 30 max 15 max	 50 max 25 max	 51 max 10 max	 35 max	 35 max	 35 max	 35 max	 36 min	 36 min	 36 min	 36 min
Characteristics of fraction passing No. 40 Liquid limit, w_L Plastic Index, I_P	 6 max	 	 NP	 40 max 10 max	 41 min 10 max	 40 max 11 min	 41 min 11 min	 40 max 10 max	 41 min 10 max	 40 max 11 min	 41 min 11 min
Significant constituent materials	gravel and sand		fine sand	silty and clayey gravel and sand				silty soils		clayey soils	

[1] Plasticity index of A-7-5 subgroup is equal to or less than LL minus 30. Plasticity index of A-7-6 subgroup is greater than LL minus 30.



Lorenzen Soil Mechanics, Inc.
2720 Palmer Street, Unit C
Missoula, MT 59808
Telephone: 406-830-0633

TEST PIT NUMBER TP-01

CLIENT Tollefson Construction
PROJECT NAME George Elmer Drive
PROJECT NUMBER P2020
PROJECT LOCATION Missoula
DATE STARTED 2/25/20 **COMPLETED** 2/25/20
GROUND ELEVATION 3153.7 ft **TEST PIT SIZE** 36 inches
EXCAVATION CONTRACTOR Owner
GROUND WATER LEVELS:
EXCAVATION METHOD CASE 580M Turbo Backhoe
AT TIME OF EXCAVATION --- GW table was not encountered.
LOGGED BY Lorenzen **CHECKED BY** Lorenzen
AT END OF EXCAVATION --- GW table was not encountered.
NOTES N46° 53' 48.6": W114° 04' 14.1"
69 days AFTER EXCAVATION --- GW table was not encountered.

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0.0			ML		(ML) TOPSOIL, Silty Loam with Vegetative Organics; damp; very dark brown (10YR 2/2); no reaction to 10% HCl solution; slightly plastic; low dry strength.
1.0					3152.7
	GB	MC = 16% LL = NP PL = NP Fines = 56%	ML		(ML) Sandy SILT [A-4]; damp to dry; dark yellowish brown (10YR 4/4); no reaction to 10% HCl solution; non-plastic; low dry strength, friable. USDA Soil Texture = LOAM.
2.5					
	GB	MC = 7%			Army Corps of Engineers Cone Penetrometer was pushed 6 inches under a 320 psi loading at 3 feet.
5.0					3148.7
	GB	MC = 11%	ML		(ML) SILT with Sand [A-4]; dry; yellowish brown (10YR 6/4); light yellowish brown; no reaction to 10% HCl solution; slightly plastic; low dry strength. USDA Soil Texture = SILTY LOAM.
	GB	MC = 6% LL = NP PL = NP Fines = 85%			
7.0					3146.7
	GB	MC = 2%	GW-GM		(GW-GM) Well-Graded GRAVEL with Silt and Sand [A-1-a], frequent Cobbles; rounded to subrounded, flat; damp; yellowish brown (10YR 5/4) to dark yellowish brown (10YR 3/6) matrices; no reaction to 10% HCl solution.
7.5					
	GB	LL = NP PL = NP Fines = 6%			
10.0					
	GB	MC = 2%			
	GB	MC = 3%			
11.5					3142.2

Bottom of test pit at 11.5 feet.

Lorenzen Soil Mechanics, Inc.
2720 Palmer Street, Unit C
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TEST PIT NUMBER TP-02

CLIENT Tollefson Construction
PROJECT NAME George Elmer Drive
PROJECT NUMBER P2020
PROJECT LOCATION Missoula
DATE STARTED 2/25/20 **COMPLETED** 2/25/20
GROUND ELEVATION 3156.4 ft **TEST PIT SIZE** 36 inches
EXCAVATION CONTRACTOR Owner
GROUND WATER LEVELS:
EXCAVATION METHOD CASE 580M Turbo Backhoe
AT TIME OF EXCAVATION --- GW table was not encountered.
LOGGED BY Lorenzen **CHECKED BY** Lorenzen
AT END OF EXCAVATION --- GW table was not encountered.
NOTES N46° 53' 49.1": W114° 04' 06.5
69 days AFTER EXCAVATION --- GW table was not encountered.

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0.0	GB	MC = 15%	ML		(ML) TOPSOIL, Silty Loam with Vegetative Organics; damp; very dark brown (10YR 2/2); no reaction to 10% HCl solution; slightly plastic; low dry strength.	
					1.1	3155.3
	GB	MC = 12%	SM		(SM) Silty SAND [A-4]; damp; brown (10YR 4/3); strong reaction to 10% HCl solution; low dry strength, friable. Fines are slightly to non-plastic.	
2.5	GB	MC = 10%			Army Corps of Engineers Cone Penetrometer was pushed its full 21 inches under a 260 psi loading at 3 feet.	
5.0					5.0	3151.4
	GB	MC = 11%	SM		(SM) Silty SAND [A-4]; damp; dark yellowish brown (10YR 4/6); no reaction to 10% HCl solution; low dry strength, friable. Fines are slightly to non-plastic.	
					7.0	3149.4
	GB	MC = 4%	GW-GM		(GW-GM) Well-Graded GRAVEL with Silt and Sand [A-1-a], frequent Cobbles; rounded to subrounded, flat; damp; yellowish brown (10YR 5/6) to dark yellowish brown (10YR 3/6) matrices; strong to no reaction to 10% HCl solution.	
7.5						
	GB	MC = 5%				
10.0						
	GB	MC = 3%				
					10.5	3145.9

Bottom of test pit at 10.5 feet.

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TEST PIT NUMBER TP-03

CLIENT Tollefson Construction
PROJECT NAME George Elmer Drive
PROJECT NUMBER P2020
PROJECT LOCATION Missoula
DATE STARTED 2/25/20 **COMPLETED** 2/25/20
GROUND ELEVATION 3256.5 ft **TEST PIT SIZE** 36 inches
EXCAVATION CONTRACTOR Owner
GROUND WATER LEVELS:
EXCAVATION METHOD CASE 580M Turbo Backhoe
AT TIME OF EXCAVATION --- GW table was not encountered.
LOGGED BY Lorenzen **CHECKED BY** Lorenzen
AT END OF EXCAVATION --- GW table was not encountered.
NOTES N46° 53' 50.8": W114° 04' 06.8"
69 days AFTER EXCAVATION --- GW table was not encountered.

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0.0			ML		(ML) TOPSOIL, Silty Loam with Vegetative Organics; frozen to 1 foot; very dark brown (10YR 2/2); no reaction to 10% HCl solution; slightly plastic; low dry strength.
1.0					3255.5
	GB	MC = 12% LL = NP PL = NP Fines = 51%	ML		(ML) Sandy SILT [A-4]; damp to dry; dark yellowish brown (10YR 4/4) to yellowish brown (10YR 5/4); strong to weak reaction to 10% HCl solution; non-plastic; low dry strength, friable. USDA Soil Texture = SANDY LOAM.
2.5	GB	MC = 10%			Army Corps of Engineers Cone Penetrometer was pushed 2.5 inches under a 320 psi loading at 3 feet.
4.0					3252.5
5.0	GB	MC = 9%	ML		(ML) Sandy SILT [A-4]; damp to dry; brown (10YR 4/3) to yellowish brown (10YR 5/4); strong to weak reaction to 10% HCl solution; non-plastic; low dry strenth, friable.
7.0					3249.5
7.5	GB	MC = 3%	GP-GM		(GP-GM) Poorly Graded GRAVEL with Silt and Sand [A-1-a], frequent Cobbles; rounded to subrounded, flat; damp; yellowish brown (10YR 5/4) to dark yellowish brown (10YR 4/6) matrices; no reaction to 10% HCl solution. Fines are non-plastic.
10.0	GB	LL = 18 PL = 18 Fines = 10%			
	GB	MC = 3%			
11.0					3245.5

Bottom of test pit at 11.0 feet.

Lorenzen Soil Mechanics, Inc.
2720 Palmer Street, Unit C
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TEST PIT NUMBER TP-04

CLIENT Tollefson Construction
PROJECT NAME George Elmer Drive
PROJECT NUMBER P2020
PROJECT LOCATION Missoula
DATE STARTED 2/25/20 **COMPLETED** 2/25/20
GROUND ELEVATION 3156.9 ft **TEST PIT SIZE** 36 inches
EXCAVATION CONTRACTOR Owner
GROUND WATER LEVELS:
EXCAVATION METHOD CASE 580M Turbo Backhoe
AT TIME OF EXCAVATION --- GW table was not encountered.
LOGGED BY Lorenzen **CHECKED BY** Lorenzen
AT END OF EXCAVATION --- GW table was not encountered.
NOTES N46° 53' 51.4": W114° 03' 59.8"
69 days AFTER EXCAVATION --- GW table was not encountered.

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0.0			ML		(ML) TOPSOIL, Silty Loam with Vegetative Organics; damp; very dark brown (10YR 2/2); no reaction to 10% HCl solution; slightly plastic; low dry strength.	
					1.0	3155.9
	GB	MC = 10% LL = NP PL = NP Fines = 45%	SM		(SM) Silty SAND [A-4]; damp; dark yellowish brown (10YR 4/4); no reaction to 10% HCl solution; non-plastic; low dry strength, friable. USDA Soil Texture = SANDY LOAM.	
					2.0	3154.9
2.5	GB	MC = 4%	SP		(SP) Pooly Graded SAND with Gravel [A-1-a]; damp; dark yellowish brown (10YR 4/4); no reaction to 10% HCl solution. Gravels are fine-grained and rounded to subrounded, flat. Fines are non-plastic.	
	GB	LL = NP PL = NP Fines = 1%			Army Corps of Engineers Cone Penetrometer was pushed 7.25 inches under a 320 psi loading at 2.4 feet.	
					4.0	3152.9
5.0			SP-SM		(SP-SM) Poorly Graded SAND with Silt and Gravel [A-1-a]; damp; dark yellowish brown (10YR 3/6); no reaction to 10% HCl solution. Fines are non-plastic.	
					7.0	3149.9
	GB	MC = 7%	GP-GM		(GP-GM) Poorly Graded GRAVEL with Silt and Sand [A-1-a], frequent Cobbles; rounded to subrounded, flat; damp; dark yellowish brown (10YR 4/6) matrix; no reaction to 10% HCl solution. Fines are non-plastic.	
7.5						
10.0						
	GB	MC = 3%			11.5	3145.4

Bottom of test pit at 11.0 feet.

Lorenzen Soil Mechanics, Inc.
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TEST PIT NUMBER TP-05

CLIENT Tollefson Construction
PROJECT NAME George Elmer Drive
PROJECT NUMBER P2020
PROJECT LOCATION Missoula
DATE STARTED 2/25/20 **COMPLETED** 2/25/20
GROUND ELEVATION 3157.1 ft **TEST PIT SIZE** 36 inches
EXCAVATION CONTRACTOR Owner
GROUND WATER LEVELS:
EXCAVATION METHOD CASE 580M Turbo Backhoe
AT TIME OF EXCAVATION --- GW table was not encountered.
LOGGED BY Lorenzen **CHECKED BY** Lorenzen
AT END OF EXCAVATION --- GW table was not encountered.
NOTES N46° 53' 49.4": W114° 04' 00.0"
69 days AFTER EXCAVATION --- GW table was not encountered.

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0.0	GB	MC = 16% LL = NP PL = NP Fines = 47%	SM		(SM) TOPSOIL, Sandy Loam with Vegetative Organics; damp; very dark grayish brown (10YR 3/2); no reaction to 10% HCl solution; slightly plastic; low dry strength. USDA Soil Texture = SANDY LOAM.
					1.0 3156.1
	GB	MC = 15%			(SM) Silty SAND [A-4]; damp; brown (10YR 4/3) to yellowish brown (10YR 5/8); no reaction to 10% HCl solution; non-plastic; low dry strength, friable. Fines are non-plastic. USDA Soil Texture = SANDY LOAM.
2.5					
	GB	MC = 13% LL = NP PL = NP Fines = 43%			Army Corps of Engineers Cone Penetrometer was pushed its full 21 inches under a 240 psi loading at 3 feet.
			SM		
5.0					
	GB	MC = 13%			
					7.0 3150.1
	GB	MC = 6%			(SP-SM) Poorly Graded SAND with Silt and Gravel [A-1-a]; damp; dark yellowish brown (10YR 4/6); no reaction to 10% HCl solution. Gravels are rounded to subrounded, flat. Fines are non-plastic.
7.5					
			SP-SM		
10.0					
	GB	MC = 3%			
					11.8 3145.4
					Bottom of test pit at 11.8 feet.

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TEST PIT NUMBER TP-06

CLIENT Tollefson Construction
PROJECT NAME George Elmer Drive
PROJECT NUMBER P2020
PROJECT LOCATION Missoula
DATE STARTED 2/25/20 **COMPLETED** 2/25/20
GROUND ELEVATION 3151.6 ft **TEST PIT SIZE** 36 inches
EXCAVATION CONTRACTOR Owner
GROUND WATER LEVELS:
EXCAVATION METHOD CASE 580M Turbo Backhoe
AT TIME OF EXCAVATION --- GW table was not encountered.
LOGGED BY Lorenzen **CHECKED BY** Lorenzen
AT END OF EXCAVATION --- GW table was not encountered.
NOTES N46° 53' 46.6": W114° 04' 06.3"
69 days AFTER EXCAVATION --- GW table was not encountered.

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0.0			SM		(SM) FILL, Sandy Loam with Vegetative Organics; damp; very dark grayish brown (10YR 3/2); no reaction to 10% HCl solution; slightly plastic; low dry strength.	
1.0						3150.6
			SM		(SM) Silty SAND [A-4]; damp; brown (10YR 5/3); no reaction to 10% HCl solution; non-plastic; low dry strength, friable. Fines are non-plastic.	
1.6						3150.0
	GB	MC = 8%	SP-SM		(SP-SM) Poorly Graded SAND with Silt and Gravel [A-1-a]; damp; dark yellowish brown (10YR 4/6); no reaction to 10% HCl solution. Fines are non-plastic. Gravels are rounded to subrounded, flat.	
2.5						
	GB	MC = 3%				
	GB	LL = NP PL = NP Fines = 7%			Army Corps of Engineers Cone Penetrometer was pushed 6 inches under a 320 psi loading at 3 feet.	
5.0						
	GB	MC = 5%				
5.5						3146.1
	GB	MC = 5%	GP-GM		(GP-GM) Poorly Graded GRAVEL with Silt and Sand [A-1-a], frequent Cobbles; rounded to subrounded, flat; damp; dark yellowish brown (10YR 4/4) matrix; no reaction to 10% HCl solution. Fines are non-plastic.	
7.5						
10.0						
	GB	MC = 3%				
11.5						3140.1

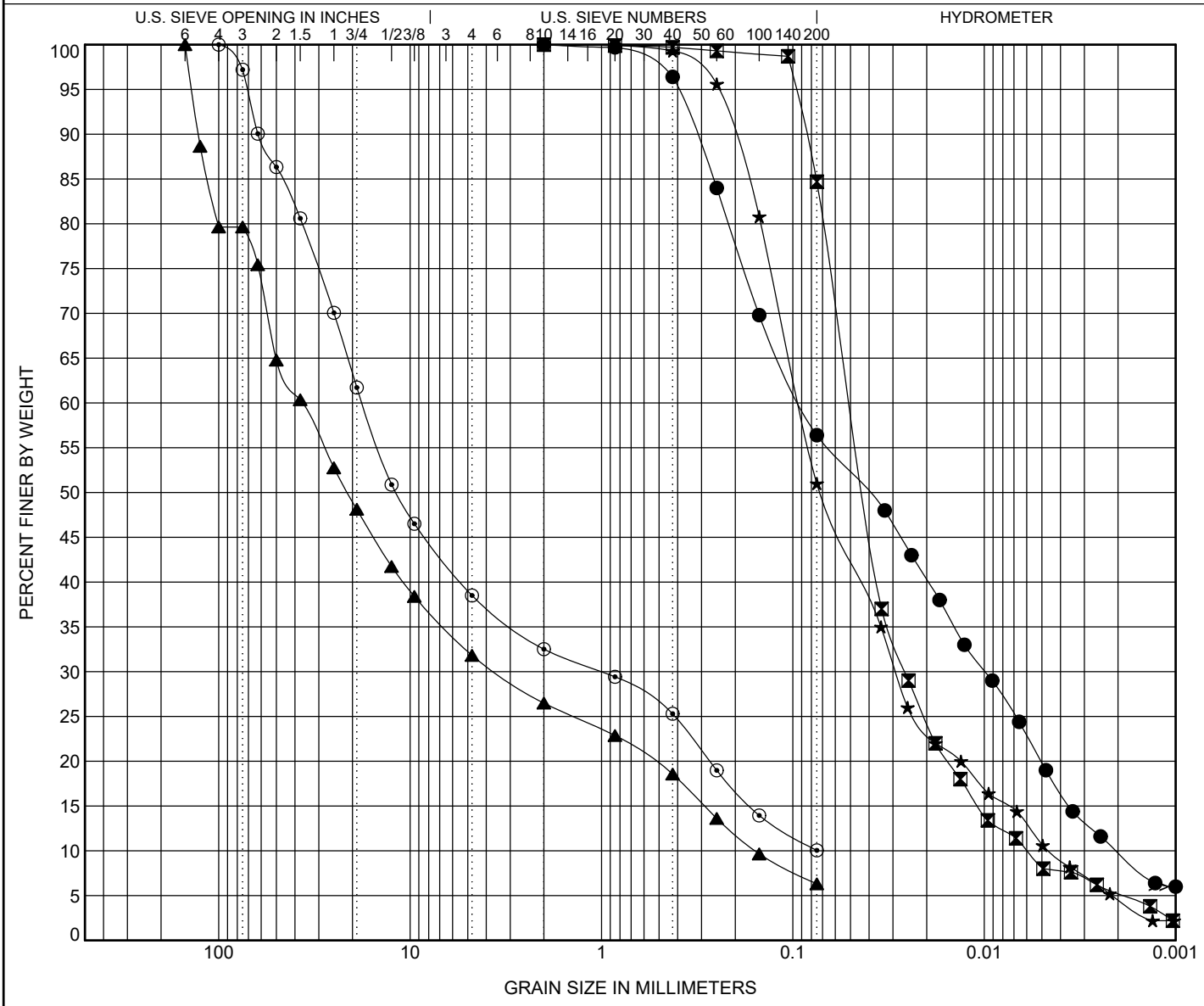
Bottom of test pit at 11.5 feet.

GRAIN SIZE DISTRIBUTION

Lorenzen Soil Mechanics, Inc.
2720 Palmer Street, Unit C
Missoula, MT 59808
Telephone: 406-830-0633

CLIENT Tollefson Construction **PROJECT NAME** George Elmer Drive

PROJECT NUMBER P2020 **PROJECT LOCATION** Missoula



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BOREHOLE	DEPTH	Classification	LL	PL	PI	Cc	Cu
●	TP-01	1.0	SANDY SILT(ML)	NP	NP	NP	0.54	44.80
⊠	TP-01	6.0	SILT with SAND(ML)	NP	NP	NP	2.24	8.39
▲	TP-01	8.0	WELL-GRADED GRAVEL with SILT and SAND(GW-GM)	NP	NP	NP	2.17	234.51
★	TP-03	1.5	SANDY SILT(ML)	NP	NP	NP	1.99	20.25
⊙	TP-03	9.0	POORLY GRADED GRAVEL with SILT and SAND(GP-GM)	18	18	NP	0.75	239.21

	BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	TP-01	1.0	2	0.09	0.01	0.002	0.0	43.6	36.6	19.8
⊠	TP-01	6.0	2	0.05	0.026	0.006	0.0	15.3	76.5	8.2
▲	TP-01	8.0	150	36.794	3.536	0.157	47.8	25.5	6.3	
★	TP-03	1.5	2	0.092	0.029	0.005	0.0	49.0	40.3	10.7
⊙	TP-03	9.0	100	17.779	0.996		58.7	28.5	10.1	

GRAIN SIZE DISTRIBUTION

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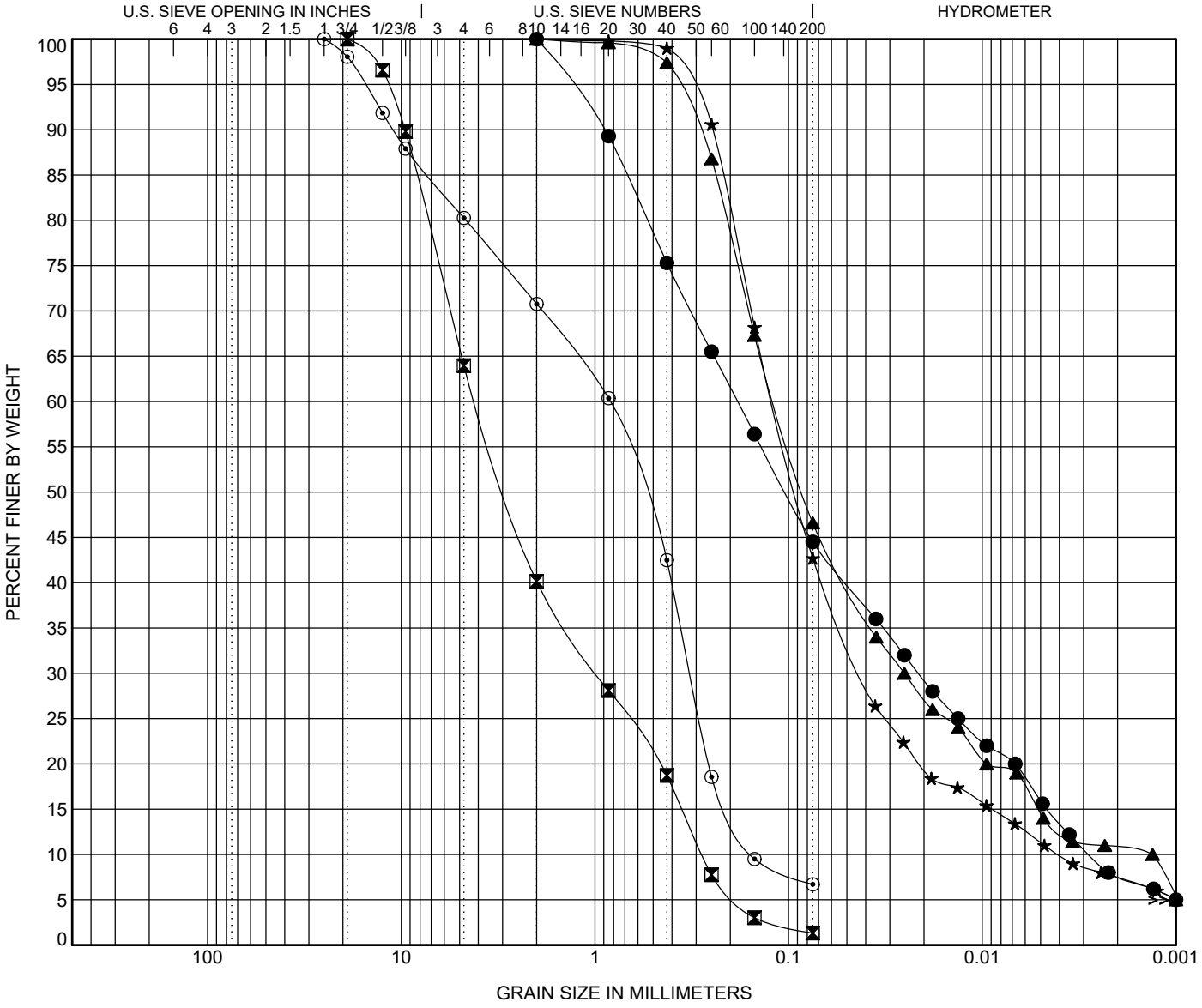
Telephone: 406-830-0633

CLIENT Tollefson Construction **PROJECT NAME** George Elmer Drive

PROJECT NUMBER P2020 **PROJECT LOCATION** Missoula



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BOREHOLE	DEPTH	Classification	LL	PL	PI	Cc	Cu
●	TP-04	1.0	SILTY SAND(SM)	NP	NP	NP	0.89	65.98
⊠	TP-04	2.5	POORLY GRADED SAND with GRAVEL(SP)	NP	NP	NP	0.83	14.77
▲	TP-05	0.5	SILTY SAND(SM)	NP	NP	NP	4.11	89.06
★	TP-05	3.0	SILTY SAND(SM)	NP	NP	NP	3.66	29.77
⊙	TP-06	3.5	POORLY GRADED SAND with SILT and GRAVEL(SP-SM)	NP	NP	NP	0.80	5.43

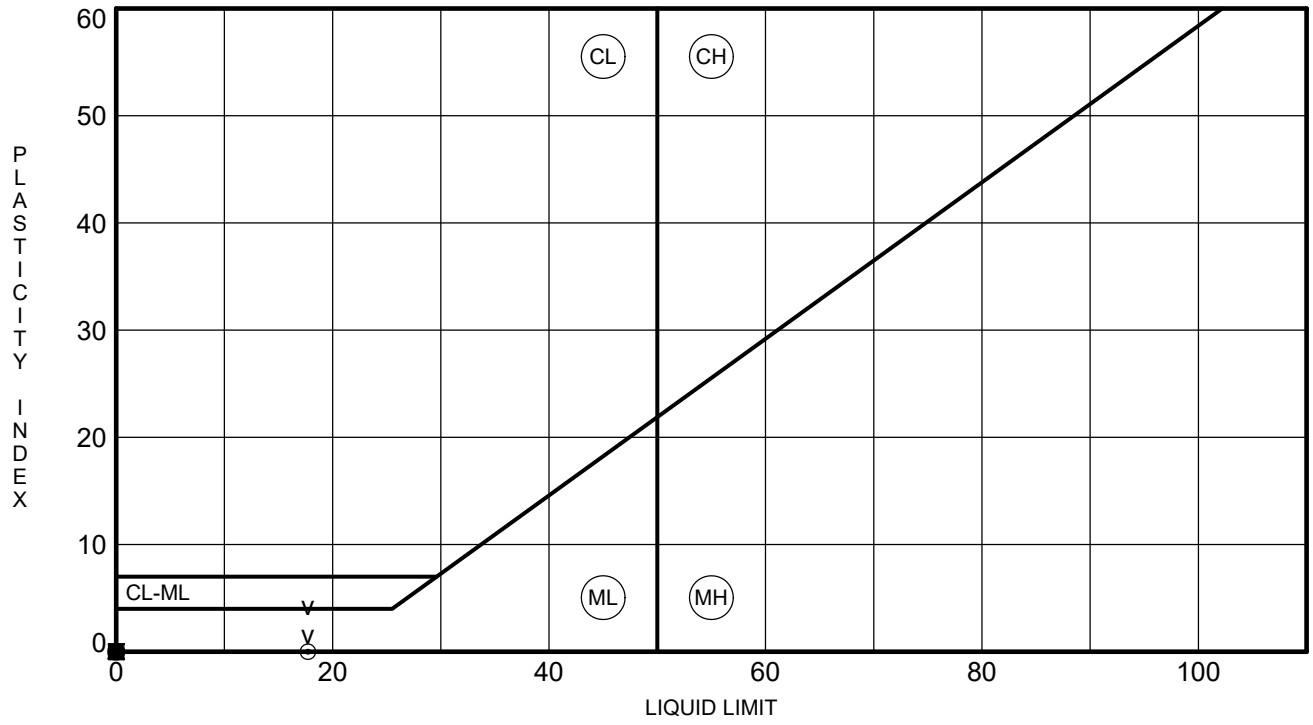
	BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	TP-04	1.0	2	0.184	0.021	0.003	0.0	55.5	28.6	15.9
⊠	TP-04	2.5	19	4.114	0.973	0.279	36.0	62.6	1.3	
▲	TP-05	0.5	2	0.117	0.025	0.001	0.0	53.4	32.1	14.5
★	TP-05	3.0	2	0.12	0.042	0.004	0.0	57.3	31.4	11.3
⊙	TP-06	3.5	25	0.838	0.322	0.154	19.7	73.6	6.7	

ATTERBERG LIMITS' RESULTS

Lorenzen Soil Mechanics, Inc.
2720 Palmer Street, Unit C
Missoula, MT 59808
Telephone: 406-830-0633

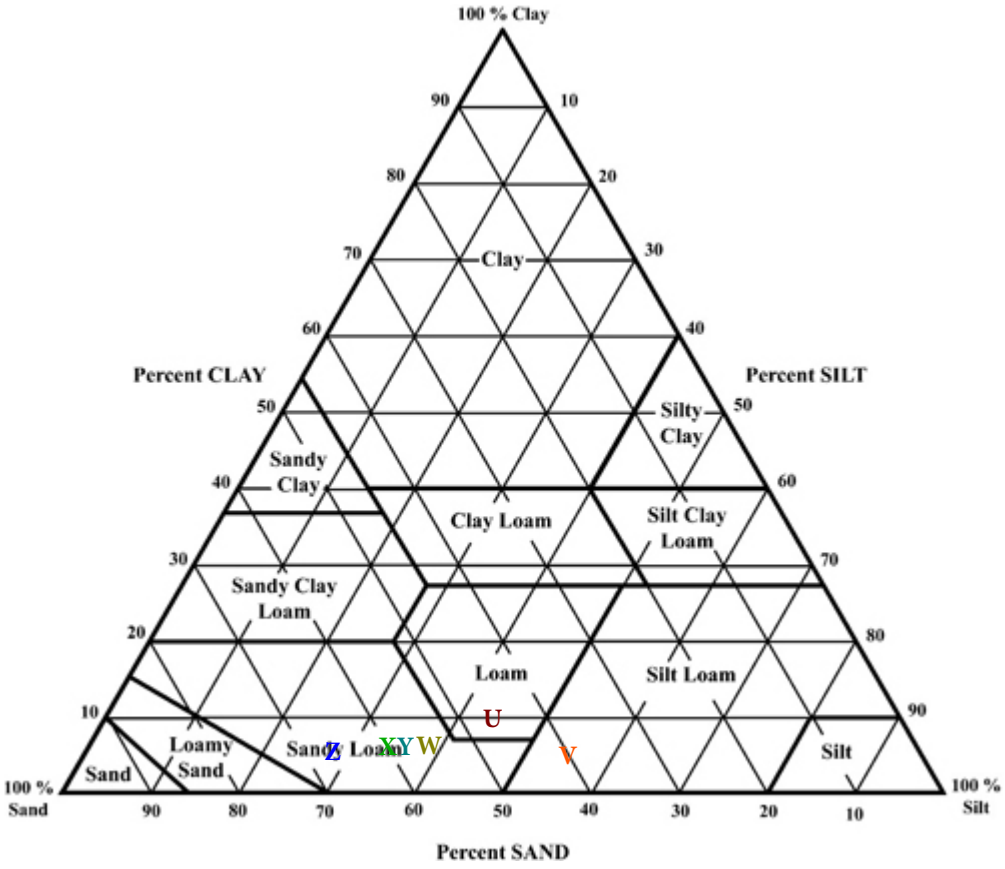
CLIENT Tollefson Construction **PROJECT NAME** George Elmer Drive

PROJECT NUMBER P2020 **PROJECT LOCATION** Missoula



	BOREHOLE	DEPTH	LL	PL	PI	Fines	Classification
●	**TP-01**	**1.0**	**NP**	**NP**	**NP**	**56**	**SANDY SILT(ML)**
⊠	**TP-01**	**6.0**	**NP**	**NP**	**NP**	**85**	**SILT with SAND(ML)**
▲	**TP-01**	**8.0**	**NP**	**NP**	**NP**	**6**	**WELL-GRADED GRAVEL with SILT and SAND(GW-GM)**
★	**TP-03**	**1.5**	**NP**	**NP**	**NP**	**51**	**SANDY SILT(ML)**
⊙	**TP-03**	**9.0**	**18**	**18**	**NP**	**10**	**POORLY GRADED GRAVEL with SILT and SAND(GP-GM)**
✿	**TP-04**	**1.0**	**NP**	**NP**	**NP**	**45**	**SILTY SAND(SM)**
○	**TP-04**	**2.5**	**NP**	**NP**	**NP**	**1**	**POORLY GRADED SAND with GRAVEL(SP)**
△	**TP-05**	**0.5**	**NP**	**NP**	**NP**	**47**	**SILTY SAND(SM)**
⊗	**TP-05**	**3.0**	**NP**	**NP**	**NP**	**43**	**SILTY SAND(SM)**
⊕	**TP-06**	**3.5**	**NP**	**NP**	**NP**	**7**	**POORLY GRADED SAND with SILT and GRAVEL(SP-SM)**

George Elmer Drive Extension



U = TP-01 @ 1 foot

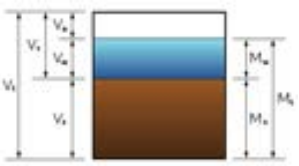
V = TP-01 @ 6 feet

W= TP-03 @ 1.5 feet

X = TP-04 @ 2.5 feet

Y = TP-05 @ 0.5 feet

Z = TP-05 @ 3 feet



Lorenzen Soil Mechanics, Inc.

U.S.D.A. Textural Classification

MONTANA WELL LOG REPORT

This well log reports the activities of a licensed Montana well driller, serves as the official record of work done within the borehole and casing, and describes the amount of water encountered. This report is compiled electronically from the contents of the Ground Water Information Center (GWIC) database for this site. Acquiring water rights is the well owner's responsibility and is NOT accomplished by the filing of this report.

Other Options

Return to menu
Plot this site in State Library Digital Atlas
Plot this site in Google Maps
View scanned well log (2/20/2009 10:38:21 AM)

Site Name: FLYNN G. ELMER
GWIC Id: 69564

Section 1: Well Owner(s)
1) FLYNN, ELMER (MAIL)
RT 2
MISSOULA MT N/A [01/01/1865]

Section 2: Location

Township	Range	Section	Quarter Sections
13N	20W	12	SW¼ SE¼

County
MISSOULA

Geocode

Latitude	Longitude	Geomethod	Datum
46.894227	-114.068752	TRS-SEC	NAD83

Ground Surface Altitude	Ground Surface Method	Datum Date
3223		

Addition **Block** **Lot**

Section 3: Proposed Use of Water
DOMESTIC (1)
STOCKWATER (2)

Section 4: Type of Work
Drilling Method:
Status: NEW WELL

Section 5: Well Completion Date
Date well completed: Sunday, January 1, 1865

Section 6: Well Construction Details
There are no borehole dimensions assigned to this well.
There are no casing strings assigned to this well.
There are no completion records assigned to this well.
Annular Space (Seal/Grout/Packer)

There are no annular space records assigned to this well.

Section 7: Well Test Data

Total Depth:
Static Water Level: 50
Water Temperature:

Unknown Test Method *

Yield 40 gpm.
Pumping water level _ feet.
Time of recovery _ hours.
Recovery water level _ feet.

* *During the well test the discharge rate shall be as uniform as possible. This rate may or may not be the sustainable yield of the well. Sustainable yield does not include the reservoir of the well casing.*

Section 8: Remarks
`

Section 9: Well Log
Geologic Source
110ALVM - ALLUVIUM (QUATERNARY)
Lithology Data

There are no lithologic details assigned to this well.

Driller Certification
All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.

Name:
Company:
License No: -
Date Completed: 1/1/1865

MONTANA WELL LOG REPORT

This well log reports the activities of a licensed Montana well driller, serves as the official record of work done within the borehole and casing, and describes the amount of water encountered. This report is compiled electronically from the contents of the Ground Water Information Center (GWIC) database for this site. Acquiring water rights is the well owner's responsibility and is NOT accomplished by the filing of this report.

Other Options

Return to menu
Plot this site in State Library Digital Atlas
Plot this site in Google Maps

Site Name: FLYNN RANCH
GWIC Id: 706414

Section 1: Well Owner(s)

Section 2: Location

Township	Range	Section	Quarter Sections
13N	20W	12	SW¼ SE¼

County / **Geocode**
MISSOULA

Latitude	Longitude	Geomethod	Datum
46.8944	-114.0669	MAP	NAD27

Ground Surface Altitude **Ground Surface Method** **Datum** **Date**

Addition **Block** **Lot**

Section 3: Proposed Use of Water
DOMESTIC (1)

Section 4: Type of Work
Drilling Method: CABLE
Status: NEW WELL

Section 5: Well Completion Date
Date well completed: Saturday, January 1, 1944

Section 6: Well Construction Details
There are no borehole dimensions assigned to this well.

Casing

From	To	Diameter	Wall Thickness	Pressure Rating	Joint	Type
0	58	6				

There are no completion records assigned to this well.

Annular Space (Seal/Grout/Packer)

There are no annular space records assigned to this well.

Section 7: Well Test Data

Total Depth: 58
Static Water Level: 30
Water Temperature:

Unknown Test Method *

Yield 30 gpm.
Pumping water level 33 feet.
Time of recovery _ hours.
Recovery water level _ feet.

** During the well test the discharge rate shall be as uniform as possible. This rate may or may not be the sustainable yield of the well. Sustainable yield does not include the reservoir of the well casing.*

Section 8: Remarks

Section 9: Well Log

Geologic Source
111ALVM - ALLUVIUM (HOLOCENE)
Lithology Data

There are no lithologic details assigned to this well.

Driller Certification

All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.

Name:
Company:
License No: -
Date Completed: 1/1/1944

MONTANA WELL LOG REPORT

This well log reports the activities of a licensed Montana well driller, serves as the official record of work done within the borehole and casing, and describes the amount of water encountered. This report is compiled electronically from the contents of the Ground Water Information Center (GWIC) database for this site. Acquiring water rights is the well owner's responsibility and is NOT accomplished by the filing of this report.

Other Options

Return to menu
Plot this site in State Library Digital Atlas
Plot this site in Google Maps
View scanned well log (6/6/2013 1:44:30 PM)

Site Name: FLYNN RANCH HOMEOWNERS ASSOCIATION
GWIC Id: 267856

Section 1: Well Owner(s)

1) FLYNN RANCH HOMEOWNERS ASSOCIATION (MAIL)
BOX 2060
SUN VALLEY ID 83353 [05/22/2012]

Section 2: Location

Township	Range	Section	Quarter Sections
13N	20W	12	SW¼ SE¼

County: MISSOULA
Geocode:

Latitude	Longitude	Geomethod	Datum
46.8942273879	-114.0687518065	TRS-SEC	NAD83

Ground Surface Altitude: **Ground Surface Method**: **Datum**: **Date**:

Addition: **Block**: **Lot**:

Section 3: Proposed Use of Water

DOMESTIC (1)

Section 4: Type of Work

Drilling Method: ROTARY
Status: NEW WELL

Section 5: Well Completion Date

Date well completed: Tuesday, May 22, 2012

Section 6: Well Construction Details

Borehole dimensions

From	To	Diameter
0	112	6

Casing

From	To	Diameter	Wall Thickness	Pressure Rating	Joint	Type
-2	112	6	0.25		WELDED	STEEL

Completion (Perf/Screen)

From	To	Diameter	# of Openings	Size of Openings	Description
87	97	6	10	3/16X1	HOLTE PERFORATOR SLOTS

Annular Space (Seal/Grout/Packer)

From	To	Description	Cont. Fed?
0	0	BENTONITE	Y

Section 7: Well Test Data

Total Depth: 112
Static Water Level: 27
Water Temperature:

Air Test *

40 gpm with drill stem set at 105 feet for 2 hours.
Time of recovery 0.08 hours.
Recovery water level 27 feet.
Pumping water level _ feet.

** During the well test the discharge rate shall be as uniform as possible. This rate may or may not be the sustainable yield of the well. Sustainable yield does not include the reservoir of the well casing.*

Section 8: Remarks

Section 9: Well Log

Geologic Source
Unassigned

From	To	Description
0	10	TAN CLAY
10	31	GRAVEL, COBBLES AND SAND
31	65	CLAY, SAND LAYERS, GRAVEL AND WATER
65	87	GRAVEL, COBBLES, SAND AND WATER
87	97	GRAVEL, COBBLES, TAN CLAY AND WATER
97	110	SAND, CEMENTED GRAVEL AND WATER
110	112	TAN CLAY

Driller Certification

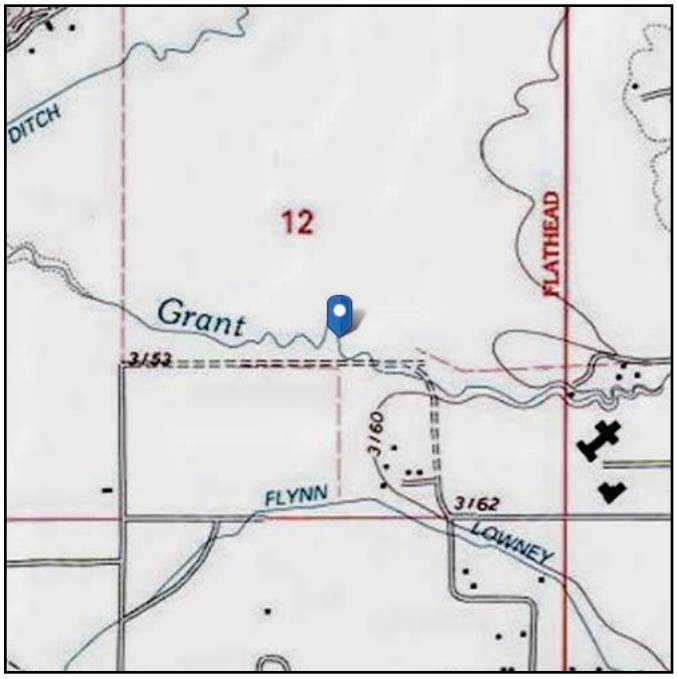
All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.

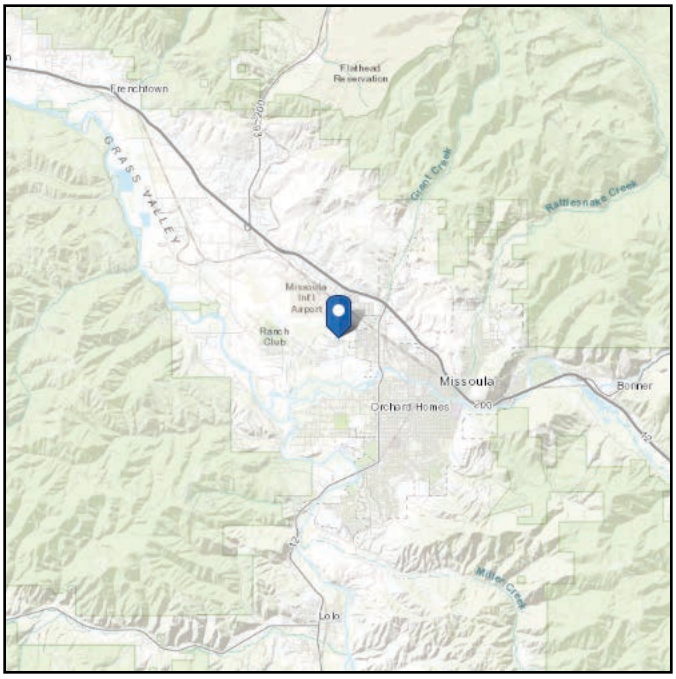
Name: RANDAL KOTECKI
Company: JEROMES DRILLING CO
License No: WWC-600
Date Completed: 5/22/2012

ASCE 7 Hazards Report

Address:
No Address at This Location

Standard:	ASCE/SEI 7-16	**Elevation:**	3158.1 ft (NAVD 88)
Risk Category:	II	**Latitude:**	46.896563
Soil Class:	C - Very Dense Soil and Soft Rock	**Longitude:**	-114.068493





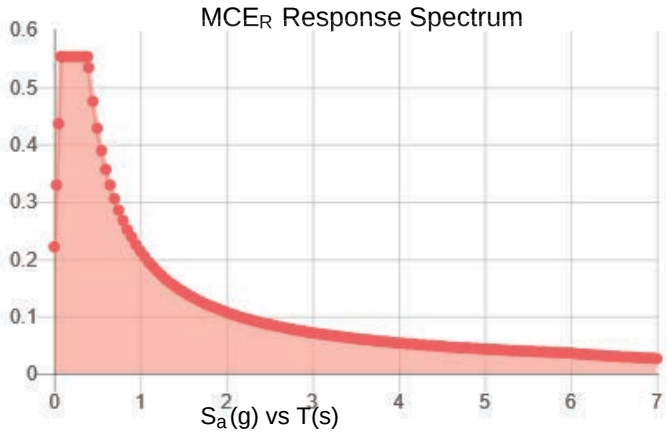
Seismic

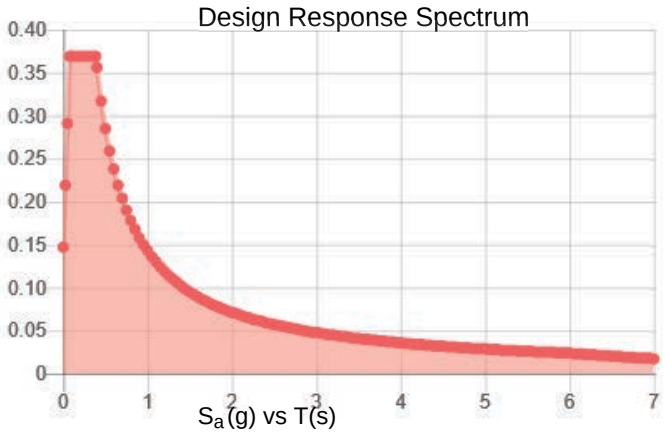
Site Soil Class: C - Very Dense Soil and Soft Rock

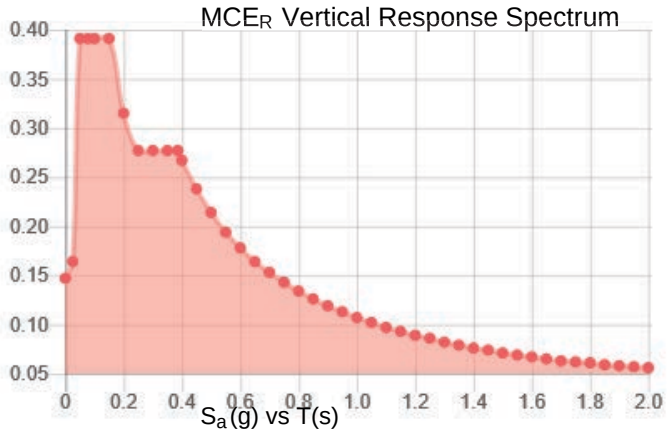
Results:

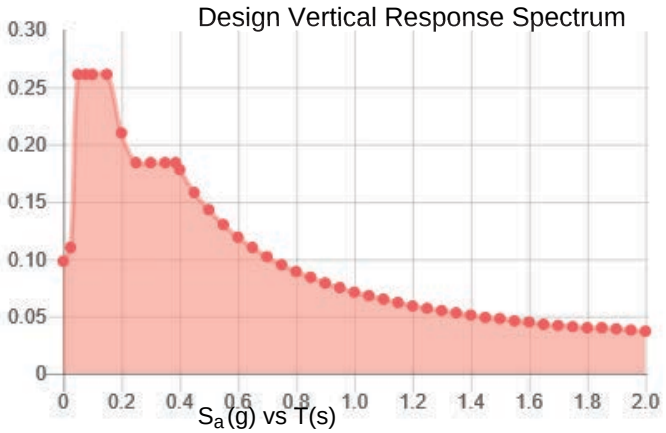
S_S :	0.425	S_{D1} :	0.143
S_1 :	0.143	T_L :	6
F_a :	1.3	PGA :	0.189
F_v :	1.5	PGA_M :	0.229
S_{MS} :	0.553	F_{PGA} :	1.211
S_{M1} :	0.214	I_e :	1
S_{DS} :	0.369	C_v :	0.884

Seismic Design Category C









Data Accessed: Mon May 04 2020

Date Source: USGS Seismic Design Maps based on ASCE/SEI 7-16 and ASCE/SEI 7-16 Table 1.5-2. Additional data for site-specific ground motion procedures in accordance with ASCE/SEI 7-16 Ch. 21 are available from USGS.

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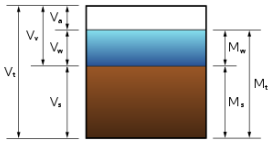


APPENDIX B. PHOTOGRAPHS

Description: TP-01 Location. View is to the south.

Description: TP-01 Jar sample from 1 foot.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-01 Jar sample from 3.5 feet. Army Corps of Engineer Cone Penetrometer was pushed 6 inches under a 320 psi loading.

Description: TP-01 Jar sample from 5 feet.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-01 Jar sample from 7 feet.

Description: TP-01 Jar sample from 10 feet.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

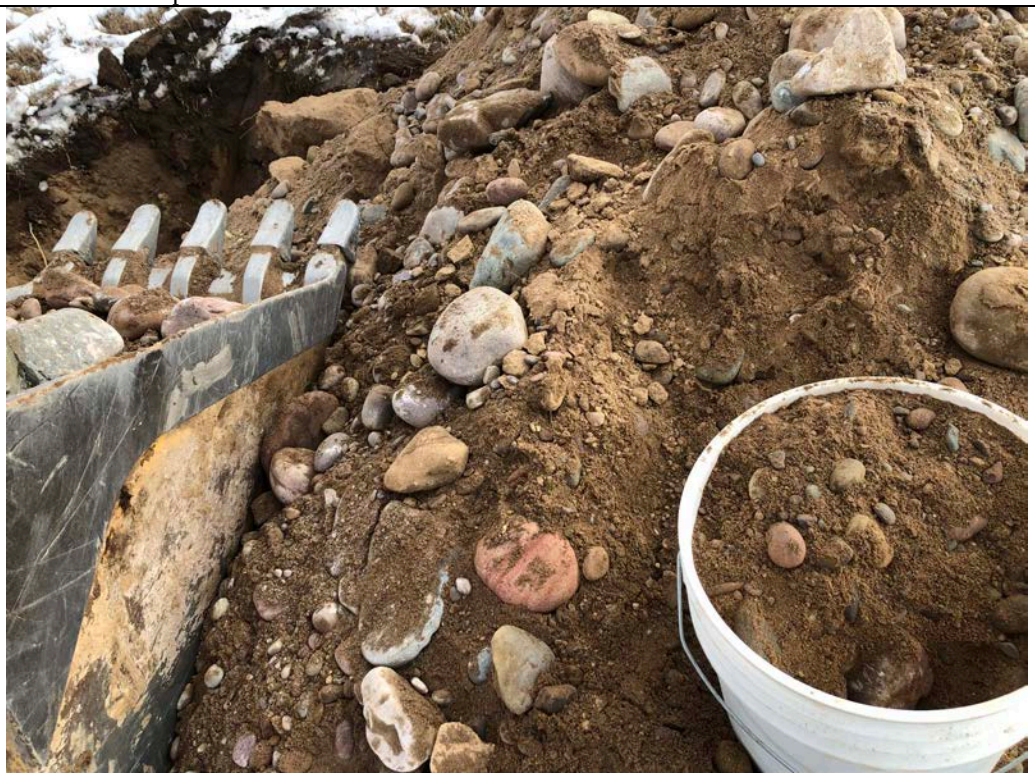
Description: TP-01 Spoils pile from above 11.5 feet.

Description: TP-01 Excavated to 11.5 feet.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-01 Jar sample from 11.5 feet.



Description: TP-01 Bucket sample from 10 to 11.5 feet.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-01 Excavated into gravel and sand with cobbles.

Description: TP-01 Piezometer installation.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-02 Location. View is to the north.

Description: TP-02 Location. View is to the east.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-02 Location. View is to the south toward the present alignment of George Elmer Drive.

Description: TP-02 Jar sample from 0.5 feet.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-02 Jar sample from 1.5 feet.

Description: TP-02 Jar sample from 3 feet. Cone penetrometer was pushed its full 21 inches under a 300 psi loading.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-02 Jar sample from 5 feet.

Description: TP-02 Jar sample from 7 feet.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-02 Jar sample from 9.5 feet.

Description: TP-02 Jar sample from 10.5 feet.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-02 Spoils pile from above 10.5 feet.

Description: TP-02 Excavated to 10.5 feet.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-02 Spoils pile above 10.5 feet.

Description: TP-03 Location. View is to the south. TP-02 location can be seen in the background.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-03 Location. View is to the east.

Description: TP-03 Location. View is to the north.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-03 Jar sample from 1.5 feet.

Description: TP-03 Jar sample from 3 feet. Cone penetrometer was pushed 2.5 inches under a 320 psi loading.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-03 Jar sample from 3 feet – trench wall in fine sand / silt.

Description: TP-03 from 5 feet.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-03 Jar sample from 7.5 feet.

Description: TP-03 Jar sample from 11 feet.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-03 Spoils pile from above 11 feet.

Description: TP-03 Excavated to 11 feet.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-04 Location. View is to the west toward TP-03.

Description: TP-04 Location. View is to the south.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-04 Location. View is to the east.

Description: TP-04 Jar sample from 1 foot. Below the color change interface. Test pit is excavated to 2.4 feet here.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-04 Color change interface of topsoil with sand at 1-foot depth.

Description: TP-04 Jar sample from 2.4 feet. Cone penetrometer was pushed 7.25 inches under a 320 psi loading.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-04 2.4-foot sample depth. Dry fine gravel with sand layer.

Description: TP-04 Jar sample from 7 feet.

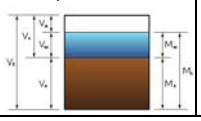
Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-04 Spoils pile from above 11.5 feet.

Description: TP-04 Excavated to 11.5 feet.

Lorenzen Soil Mechanics, Inc.



Project: George Elmer Drive

Description: TP-04 Jar sample from 11.5 feet.

Description: TP-05 Location. View is to the west toward TP-02 and TP-01.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-05 Location. View is to the north

Description: TP-05 Jar sample from 0.5 feet.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-05 Jar sample from 2 feet.

Description: TP-05 Jar sample from 3 feet. Cone penetrometer was pushed its full 21 inches under a 240 psi loading.

Lorenzen Soil Mechanics, Inc.

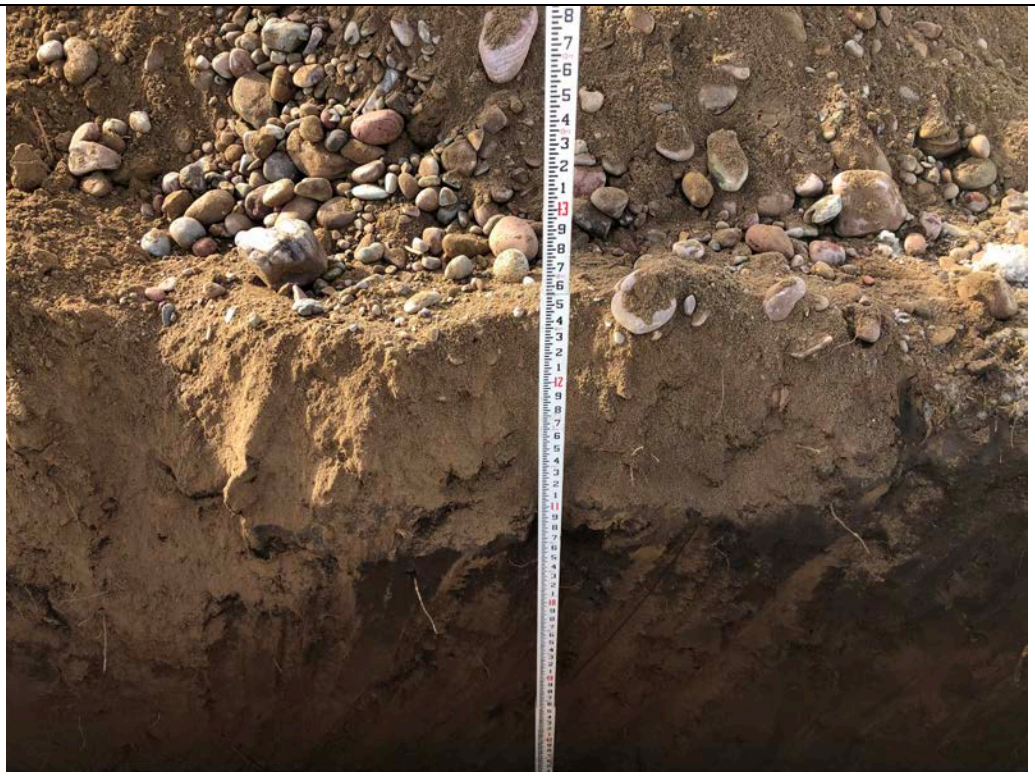
Project: George Elmer Drive

Description: TP-05 Jar sample from 6 feet.

Description: TP-05 Jar sample from 7 feet.

Lorenzen Soil Mechanics, Inc.

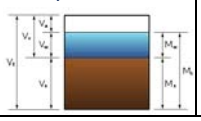
Project: George Elmer Drive



Description: TP-05 Spoils pile from above 11.5 feet.

Description: TP-05 Excavated to 11.5 feet.

Lorenzen Soil Mechanics, Inc.



Project: George Elmer Drive

Description: TP-05 Jar sample from 11.5 feet.

Description: TP-05 Spoils pile from above 11.5 feet.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-06 Location. View is to the south towards the present George Elmer Drive terminus.

Description: TP-06 Location. View is to the west.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-06 Location. View is to the east.

Description: TP-06 Location. View is to the north from the present George Elmer terminus.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-06 Jar sample from 1.5 feet.

Description: TP-06 Jar sample from 3 feet. Cone penetrometer was pushed 6 inches under a 320 psi loading.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-06 Plastic twine string at 1-foot depth.

Description: TP-06 Plastic twine string at 1-foot depth.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-06 Jar sample from 5 feet.

Description: TP-06 Jar sample from 5.5 feet.

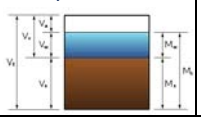
Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-06 Spoils pile from above 11.5 feet.

Description: TP-06 Excavated to 11.5 feet.

Lorenzen Soil Mechanics, Inc.



Project: George Elmer Drive

Description: TP-06 Jar sample from 11.5 feet.

Description: TP-06 Spoils pile from above 11.5 feet. View is to the south.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-01 Moisture content samples prior to being placed into the drying oven.

Description: TP-01 Moisture content samples after being taken out of the drying oven.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-02 Moisture content samples prior to being placed into the drying oven.

Description: TP-02 Moisture content samples after being taken out of the drying oven.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-03 Moisture content samples prior to being placed into the drying oven.

Description: TP-03 Moisture content samples after being taken out of the drying oven.

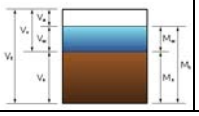
Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-04 Moisture content samples prior to being placed into the drying oven. First jar should be with TP-05 photo.

Description: TP-04 Moisture content samples after being taken out of the drying oven.

Lorenzen Soil Mechanics, Inc.



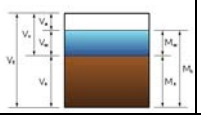
Project: George Elmer Drive

TP-05 Pre-drying photo is missing.

Description:

Description: TP-05 Moisture content samples after being taken out of the drying oven.

Lorenzen Soil Mechanics, Inc.



Project: George Elmer Drive

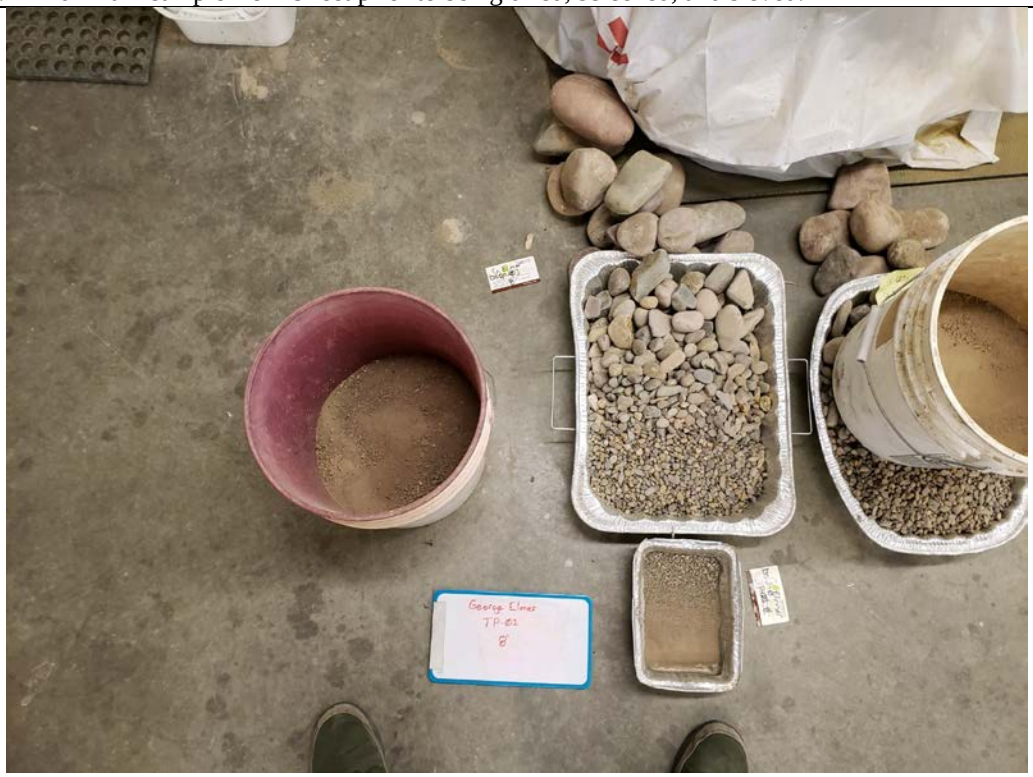
Description: TP-06 Moisture content samples prior to being placed into the drying oven.

Description: TP-06 Moisture content samples after being taken out of the drying oven.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-01 Bulk sample from 8 feet prior to being dried, screened, and sieved.



Description: TP-01 Bulk sample from 8 feet following screening and sieving.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

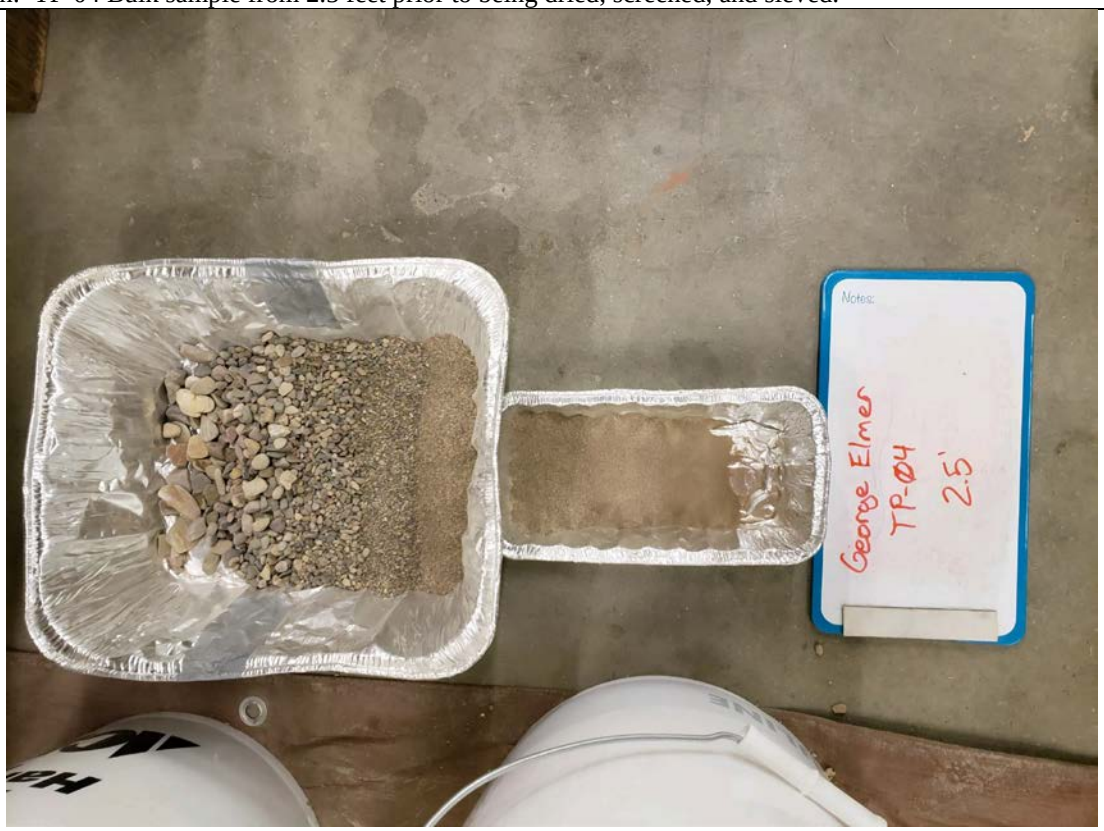
Description: TP-03 Bulk sample from 9 feet prior to being dried, screened, and sieved.

Description: TP-03 Bulk sample from 9 feet following screening and sieving.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive

Description: TP-04 Bulk sample from 2.5 feet prior to being dried, screened, and sieved.



Description: TP-04 Bulk sample from 2.5 feet following screening and sieving.

Lorenzen Soil Mechanics, Inc.

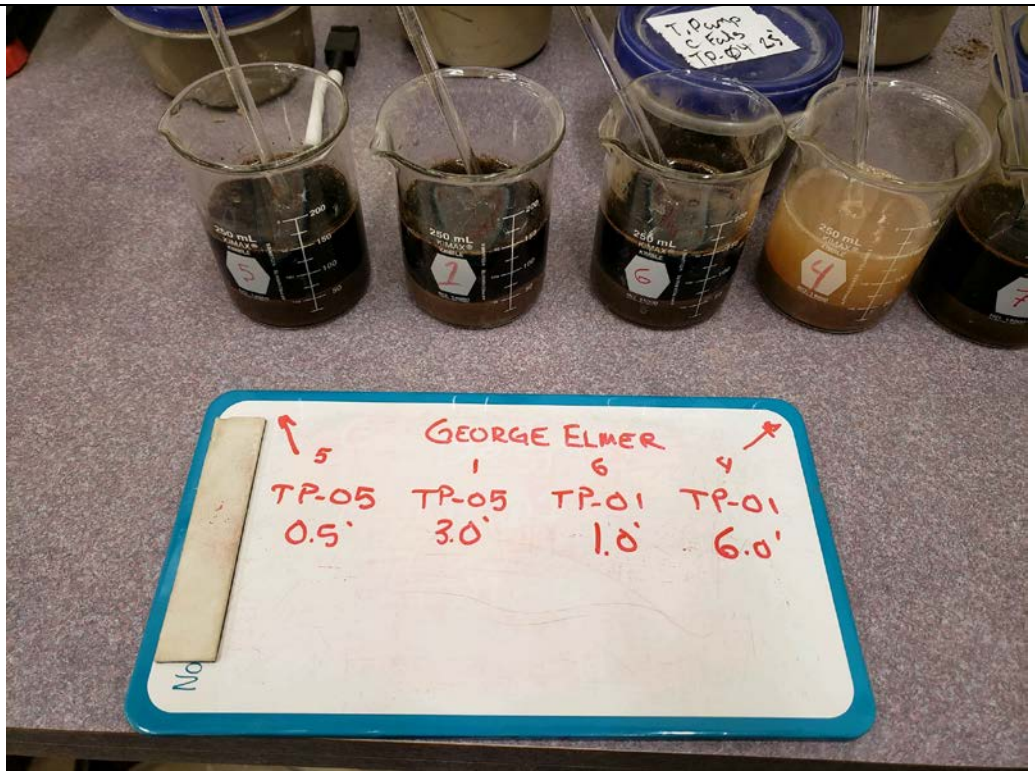
Project: George Elmer Drive

Description: TP-06 Bulk sample from 3.5 feet prior to being dried, screened, and sieved.

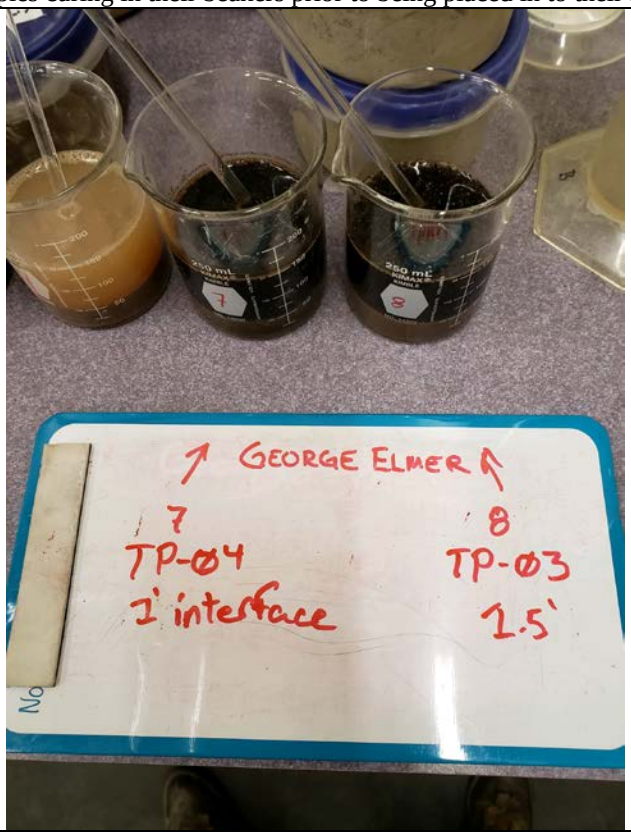
Description: TP-06 Bulk sample from3.5 feet following screening and sieving.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive



Description: Hydrometer samples curing in their beakers prior to being placed in to their sedimentation jars.



Description: Hydrometer samples curing in their beakers prior to being placed in to their sedimentation jars.

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Project: George Elmer Drive

Description: Hydrometer testing being conducted in the sedimentation jars.

Description: Plus 200 sieve material after washing and sieving the initial 50.0 grams used for each hydrometer test.

Lorenzen Soil Mechanics, Inc.

Project: George Elmer Drive