REVISED UTILITY GEOTECHNICAL EVALUATION REPORT

Proposed Storm Water Improvements
Shelby, Montana
Project 14-3255G

Submitted by

SK GEOTECHNICAL

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Prepared for

KLJ
2969 Airport Road
Helena, Montana 59601

October 13, 2014

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October 13, 2014

Project 14-3255G

Mr. Jason Crawford, PE
KLJ
2969 Airport Road
Helena, Montana 59601
Via email: jason.crawford@kljeng.com

Dear Mr. Crawford:

Re: Revised Utility Geotechnical Evaluation, Proposed Storm Water Improvements, Shelby, Montana

We have completed the utility geotechnical evaluation for the above-referenced project authorized on August 15, 2014. The purpose of the evaluation was to assist KLJ in evaluating subsurface soil and groundwater conditions along the proposed storm drain lines and proposed jack and bore drilling, and in preparing plans and specifications for construction of the proposed project. The evaluation was completed in general accordance with our proposal to KLJ dated July 9, 2014.

Summary of Results

Ten soil borings were completed for the proposed project. The soil borings were spread out throughout the extent of the storm drain line. The general soil profile encountered by the borings was 3 to 9 inches of asphalt pavement over clayey gravel base to depths of approximately 2 to 4 feet and then transitioning into lean clay and lean to fat clay alluvium down to the boring termination depths. Boring ST-5 encountered shale bedrock at a depth of 17 feet. Groundwater was encountered in eight of the ten borings at depths ranging from about 6 to 13 feet.

Summary of Analysis and Recommendations

The borings indicate the clays generally become softer and wetter with depth, and below depths of about 5 to 6 feet, the clays are primarily very soft to rather soft. It is our opinion these clays will not provide a suitable platform for direct support of the storm drain and bedding, and 12 inches of foundation material beneath bedding is recommended for the majority of the project. Where high groundwater is a concern, we recommend the foundation material be wrapped in a high survivability non-woven subsurface drainage geotextile.

Based on the borings, dewatering will be required throughout most of the project prior to and during pipe installation. The method of dewatering will need to be determined by the contractor based on their past experience, available equipment, and qualifications. We wish to emphasize that dewatering the clay soils will be very difficult and time consuming, and requires specialized equipment and experience. Vacuum extraction systems have been found to be the best systems for these types of clay soils, and dewatering should be started several weeks prior to excavating.

We wish to also point out the groundwater observations indicated on the attached boring logs were made during drilling. Piezometers to permit long-term measurements were not installed. Several days or weeks may be necessary for groundwater to stabilize in these types of clay soils, but we have attempted to evaluate anticipated groundwater conditions during construction. Groundwater levels can also fluctuate, especially due to variations in rainfall, snow melt, and other man-made or natural water sources. When considering these fluctuations and the difficulties associated with dewatering, we recommend providing a project contingency in case the clays are more difficult to dewater than expected or groundwater levels are higher.

General

Please refer to the attached report for more detailed results of our fieldwork, engineering analyses and recommendations. In particular, it contains more detailed recommendations related to well-graded materials for bedding and foundation material and compaction.

Thank you for using SK Geotechnical Corporation. If you have any questions regarding this report, or require our services during the construction phase of this project, please call Eric Niebler or Greg Staffileno at (406) 652-3930.

Sincerely,

Kim Raynor for

Eric L. Niebler, EI
Engineer Intern

Gregory T. Staffileno, PE
Principal, Geotechnical Engineer

Attachment:
Utility Geotechnical Evaluation Report

Table of Contents

Description **Page**

A. Introduction

A.1. Project

The City of Shelby is planning to construct a storm drain system within the city of Shelby, Montana. KLJ is the civil engineering firm assisting in the design of the project. The general extent of the project is shown on the attached Boring Location Sketch.

A.2. Purpose of this Evaluation

The purpose of the utility geotechnical evaluation was to assist KLJ in evaluating subsurface soil and groundwater conditions along the proposed storm drain alignment and in preparing plans and specifications for the proposed project.

A.3. Scope

We submitted a proposal to perform the utility geotechnical evaluation on July 9, 2014. The work was authorized by Work Order No. 9 of our Master Agreement dated March 26, 2012.

Our scope of services was limited to:

- Obtaining a MDT Encroachment Permit for Boring ST-1 located in MT 67 and Boring ST-7 in US 2.

- Coordinating the locating of underground utilities near the boring locations.

- Conducting 10 penetration test borings along the storm drain alignments.

- Returning the samples to our laboratory for visual classification and logging by a geotechnical engineer.

- Conducting laboratory tests, including moisture content, Atterberg limits (plasticity), gradation, and corrosion.

- Analyzing the results and formulating recommendations for earthwork and construction recommendations.

- Submitting a geotechnical evaluation report containing logs of the borings, our analysis of the field and laboratory tests, and recommendations for earthwork, compaction, and reuse of on-site soils.

A.4. Documents Provided

KLJ provided us with a Preliminary Vicinity Map presenting the locations of the proposed storm drain alignments.

A.5. Locations and Elevations

Boring locations were selected by our personnel with some assistance from KLJ and are shown on the Boring Location Sketch in the Appendix. Some of the borings had to be moved due to conflicts with overhead or underground utilities. The distance moved is indicated on the attached Log of Boring sheets. Borehole locations were staked in the field by KLJ. Ground surface elevations at the borings were also provided by KLJ.

B. Results

B.1. Logs

Log of Boring sheets indicating the depth and identification of the various soil strata, the penetration resistances, laboratory test data, and water level information are attached. It should be noted the depths shown as boundaries between the strata are only approximate. The actual changes may be transitions and the depths of the changes vary between borings.

Geologic origins presented for each stratum on the Log of Boring sheets are based on the soil types, blows per foot, and available common knowledge of the depositional history of the site. Because of the complex glacial and post-glacial depositional environments, geologic origins are frequently difficult to ascertain. A detailed evaluation of the geologic history of the site was not performed.

B.2. Site Conditions

The storm drains will primarily be installed in the streets and highways in Shelby, Montana. Surface elevations at the borings ranged from a high of 3412.5 at Boring ST-10 to a low of 3273.4 at Boring ST-4, resulting in a change in elevation of about 139 feet.

B.3. Pavement and Soils

The general soil profile encountered by the borings was existing pavement underlain by poor quality gravel base over alluvial clays. Borings ST-6 and ST-10 were not performed on roads and encountered topsoil. Shale bedrock was encountered at 17 feet in Boring ST-7. These strata are described in more detail below.

B.3.a. Existing Pavement. Borings ST-1 through ST-5 and ST-7 through ST-9 were performed in paved streets or highways, and therefore encountered 3 to 9 inches of asphalt pavement surfacing. The average thickness of asphalt pavement was about 6 1/2 inches. Poor quality clayey gravel base course was encountered beneath the pavement to depths ranging from 2 to 4 feet in Borings ST-1, ST-5, ST-6, ST-7, ST-8, and ST-9. In Borings ST-2, ST-3, and ST-4, the asphalt pavement (6 to 6 1/2 inches thick) appeared to be placed directly on the alluvial clays (referred to as full-depth asphalt), or the base course was too thin to measure.

Penetration resistances in the clayey gravel base course ranged from 7 to 30 blows per foot (BPF). These values indicated the clayey gravel fill was loose to medium dense.

B.3.b. Topsoil and Existing Fill. Boring ST-6 was performed off the pavement in a small park area along US 2 and encountered 3 inches of topsoil underlain by existing fill consisting of clayey sand to 1 1/2 feet over poorly graded gravel with sand to 4 feet. The sand and gravel fill had penetration resistances of 8 and 9 BPF, indicating it was loose. Boring ST-10 was performed along the south side of Shelby and encountered 8 inches of topsoil underlain by alluvial clays.

B.3.c. Alluvial Clays. Beneath the topsoil, pavement, and base course, the borings primarily encountered alluvial clay deposits consisting of sandy lean clay, lean clay, silty clay, and lean to fat clay to the borings' termination depths ranging from 10 to 15 feet. Penetration resistances in the clays generally decreased with depth as groundwater was approached and the clays became saturated/waterbearing. Penetration resistances generally ranged from 8 to 1 BPF, but in some layers was weight-of-hammer (WH). These values indicate the alluvial clays were medium to very soft, but primarily rather soft to very soft.

B.3.d. Alluvial Sands and Gravels. Layers of alluvial sands and gravels were encountered in two borings. In Boring ST-1, clayey sand was encountered from 6 1/2 to 9 feet over silty gravel with sand to 11 feet. Penetration resistances were only 4 and 7 BPF, indicating they were loose to very loose most likely due to being waterbearing. Boring ST-10 encountered silty sand alluvium beneath topsoil to a depth of 2 feet. The penetration resistance was 12 BPF, indicating it was medium dense.

B.3.e. Shale Bedrock. Boring ST-5 was drilled deeper and encountered shale bedrock at a depth of 17 feet beneath lean to fat clay alluvium. The shale extended to a depth of about 20 feet, where auger refusal occurred. Penetration resistances of 50 blows for 3 inches of penetration occurred in the shale, indicating it was moderately hard hardness by bedrock standards.

B.4. Groundwater Observations

Groundwater was encountered in eight of the soil borings. A summary of the groundwater depths and elevations encountered while drilling is presented in Table 1 below.

Table 1. Summary of Groundwater Level Measurements

Boring	Surface Elevation	Groundwater		Waterbearing Stratum
		Depth (feet)*	Corresponding Elevation*	
ST-1	3296.0	9	3287	Clayey Sand/Silty Gravel
ST-2	3287.3	11	3276½	Lean Clay
ST-3	3278.0	13½	3264½	Silty Clay
ST-4	3273.4	8	3265½	Lean to Fat Clay
ST-5	3299.7	13½**	3286**	Lean to Fat Clay
ST-6	3278.0	6	3272	Lean Clay
ST-7	3286.5	10	3276½	Lean to Fat Clay
ST-8	3292.7	8½	3284	Sandy Lean Clay
ST-9	3341.7	Not Encountered		
ST-10	3412.5	Not Encountered		
*Rounded to the nearest ½ foot.				
**Possible waterbearing soils observed at 7 feet, elevation 3292½.				

As can be seen above, groundwater was encountered in eight of the 10 borings at depths ranging from 6 to 13 1/2 feet. Dewatering will therefore be required to install the storm drain which is discussed in more detail later in this report.

We wish to point out that the groundwater depths and elevations indicated in Table 1 were taken while drilling and may not represent stable groundwater levels. Several days or weeks are required for groundwater to stabilize in these types of soils. It would be necessary to install piezometers in the borings to permit groundwater measurements over time.

B.5. Laboratory Tests

The results of the laboratory tests are presented on the Log of Boring sheets in the Appendix to this report. The results are also discussed in more detail below.

B.5.a. Classification Tests. Classification tests consisting of percent-passing-a-200-sieve and Atterberg limits were performed on the penetration test samples obtained from various borings at various depths. Table 2 below provides a summary of the classification tests.

Table 2. Summary of Laboratory Tests

Boring	Depth (feet)	Atterberg Limits			P_{200} (%)	ASTM Symbol
		LL	PL	PI		
ST-3	2 to 6	38	15	23	57.1	CL
ST-6	9 to 10½	36	18	18	74.2	CL
ST-8	2 to 6	34	17	17	40.3	CL

B.5.b. Proctor Tests. Standard Proctor tests were performed on the same bulk samples of the subgrade from Borings ST-3 and ST-8. The maximum dry densities were 110.0 and 121.5 pounds per cubic foot (pcf), and the optimum moisture contents were 15.0 and 12.2 percent for ST-3 and ST-8, respectively.

B.5.c. Corrosion Tests. Corrosion tests were performed on soil samples obtained from various borings and depths. The corrosion tests were performed in accordance with the Montana Department of Transportation (MDT) "Soil Corrosion Test" procedures. The corrosion tests consisted of pH, marble pH, conductivity, and sulfate content. Samples for sulfate tests were submitted to Energy Laboratories in Billings, Montana. The results of the corrosion tests and analysis from the borings are shown in Table 3 below.

Table 3. Summary of Corrosion Tests

Boring	Depth (feet)	Resistivity (ohm/cm)	Conductivity (mmhos/cm)	pH	Marble pH	Sulfate (%)	Corrosivity to		
							CSP	Aluminum or Type 2 Steel	Concrete
ST-3	6½ to 8	360	2.778	6.54	6.52	1.03	Yes	Yes	Yes
ST-6	9 to 10½	540	1.852	6.59	6.61	1.41	Yes	Yes	Yes
ST-8	6½ to 8	420	2.381	6.41	6.41	1.13	Yes	Yes	Yes

As shown in Table 3 above, all of the samples tested were found to be corrosive to corrugated steel pipe (CSP), aluminum or Type 2 steel, and Portland cement concrete. According to The American Concrete Institute (ACI), sulfates ranging from 0.20 to 2.0 percent represent severe sulfate exposure and Type V cement should be used.

C. Analyses and Recommendations

C.1. Proposed Construction

New storm water drains will be installed over numerous city blocks throughout Shelby, Montana. The storm drains will range in size from 15 to 54 inches and could consist of RCP, PVC, and/or HDPE as determined by the contractor. The pipes will generally be buried about 4 to 8 feet below existing grades. The exception is a portion in an alley between 1st Street South and Main Street where it will be about 15 feet deep.

We were also recently informed that commercial buildings with basements located along this alley have seepage problems. We were asked to provide opinions related to installing an interceptor trench as part of the storm drain work in the area.

It is also our understanding that Montana Department of Transportation (MDT) Standard Specifications will be used instead of Montana Public Works Standard Specifications (MPWSS). We have included Detail 603-18 with this report containing their approach for pipe bedding and foundation material. Modifications to this detail based on our recommendations are addressed later in this report.

C.2. Discussion

Based on the planned storm drain alignments and depths, we anticipate subsurface soils will primarily consist of lean to fat clay, sandy lean clay, and lean clay. In general, the soils encountered by the borings performed along the majority of the proposed storm drains will not be suitable for direct pipe support and foundation material is recommended. High groundwater was also encountered in many areas requiring dewatering prior to and during installation. In high groundwater areas, we recommend wrapping the foundation material in non-woven geotextile fabric. However, in the area of Borings ST-9 and ST-10, the subsurface soils were found to be rather stiff to stiff. Groundwater was not encountered so the use of foundation material will not be required. Near the railroad tracks situated on the east side of the town, directional drilling will likely be used to cross beneath the railroad and interstate. It is our understanding jack and bore is the preferred trenchless installation method. For the railroad crossing, the jack and bore will need to meet BNSF requirements.

C.3. Trench Subgrade

The anticipated trench subgrade conditions at proposed invert elevations are summarized on the boring logs and Table 4 below. As shown in the table, it is anticipated the trench subgrade along the majority of the storm drain alignment will encounter rather soft to very soft, wet lean clay and lean to fat clays. It is our opinion these soft, wet clay subgrades will not provide a suitable platform for the pipe, and foundation material will be required. The alignment within the vicinity of Borings ST-4, ST-5, and ST-6, and perhaps Borings ST-1 and ST-8, will encounter groundwater. In addition to dewatering prior to and during pipe installation, the foundation material should be wrapped in high survivability non-woven geotextile fabric. The length of trench foundation material requiring fabric will need to be determined in the field, but appears to be at least 50 to 60 percent of the total alignment.

Table 4. Summary of Trench Subgrade Conditions at 6- to 8-foot Depths

Boring	Estimated Invert Depth, feet*	Anticipated Soil Conditions	Groundwater Anticipated	Type 2 Bedding Required	Recommended Type 2 Bedding Thickness (inches)
ST-1	5½	Soft lean clay	Maybe	Yes	12 with fabric
ST-2	6	Rather soft to soft lean clay	No	Yes	12
ST-3	7½	Rather soft sandy lean clay	No	Yes	12
ST-4	6	Wet, loose clayey sand over very soft lean to fat clay	Yes	Yes	12 with fabric
ST-5	14½	Rather soft lean to fat clay	Yes	Yes	12 with fabric
ST-6	6	Very soft lean clay	Yes	Yes	12 with fabric
ST-7	4	Medium lean to fat clay	No	No	N/A
ST-8	4	Rather soft sandy lean clay	Maybe	Yes	12 with fabric
ST-9	5½	Medium lean to fat clay	No	No	N/A
ST-10	7½	Stiff sandy lean clay	No	No	N/A
*Rounded to the nearest ½ foot.					

C.4. Open Excavations

Continual trenching will be used throughout the project. For open-cut trenching, it is our opinion the majority of the soils encountered by the borings can be excavated with a backhoe or excavator. The borings indicate the native undisturbed alluvial deposits encountered in the sidewalls of the trench excavations will primarily be 3 to 9 inches of existing pavement over gravel base to depths ranging from 2 to 4 feet underlain by alluvial clays becoming softer with depth. All earthwork and trenching must be conducted in accordance with Department of Labor Occupational Safety and Health Administration (OSHA) guidelines. The existing pavement and gravel base should be considered Type C soils. Native clays to a depth of 5 feet can be considered Type B soils. Clays below 5 feet should be considered Type C soils because they are softer and wetter.

C.5. Materials

C.5.a. Bedding Materials. It is our opinion MDT requirements for bedding material are too lenient and too coarse. When considering the relatively high groundwater table throughout the project, it is our opinion open graded bedding, such as washed rock, must not be used. This material has a high risk of "piping of fines" into the open spaces between the aggregates, resulting in excessive trench and/or roadway settlement. We therefore recommend well graded materials be used as bedding. Bedding should be 1 1/2-inch minus to 3/4-inch minus well-graded aggregates. Our recommendations for bedding material are summarized in Table 5 below.

Table 5. Gradation Requirements for Crushed Base Course Bedding Material

Sieve Size	Percent Passing		
	1 1/2" Minus	1" Minus	3/4" Minus
1 1/2"	100		
1"	---	100	
3/4"	---	---	100
1/2"	70 – 90	75 – 95	---
No. 4	50 – 80	60 – 80	70 – 90
No. 10	---	50 – 70	50 – 70
No. 40	20 – 40	20 – 40	25 – 45
No. 200	2 – 10	2 – 10	2 – 10

Aggregates should meet properties outlined in MDT's standard specifications.

C.5.b. Foundation Material. Similar to bedding material, it is our opinion MDT's requirements for foundation material are too lenient for a storm drain project of this size. Similar to the bedding, we recommend the foundation material also be well graded and meet the requirements indicated in Table 6 below.

Table 6. Gradation Requirements for Foundation Material

Sieve Size	% Passing
3"	100
1"	70 – 90
No. 4	40 – 70
No. 40	20 – 40
No. 200	2 – 10

Aggregates should meet properties outlined in MDT's standard specifications.

C.5.c. Geotextile Fabric. As indicated by MDT Drawing 603-18, where high groundwater is anticipated, the foundation material should be completely wrapped in geotextile fabric. MDT calls for "stabilization geotextile," which is not appropriate for the high groundwater conditions encountered on the site. We recommend using "subsurface drainage geotextile" as specified in accordance with Table 716-4. For the predominant clays throughout the area, we recommend using a Class C non-woven geotextile for the project. We further recommend it be high survivability.

Based on our review of manufacturer products, it appears Propex 801, Mirafi 180N, Contech C-80NW, or equivalent can be used as high survivability non-woven subsurface drainage geotextile fabric for the project.

C.6. Trench Backfill Above Bedding

C.6.a. Trench Settlement. Trench settlement of utility excavations is a common problem and is often difficult to avoid. Even well compacted backfill will settle, in our opinion, and we anticipate normal trench settlement will be approximately 1 percent of the total trench depth. If the backfill is poorly compacted, excessively thick lifts are placed, or surface water infiltrates into the trench, settlement of several inches or more can occur.

C.6.b. Backfill and Compaction. It is our opinion the on-site excavated soils can be reused as backfill above the bedding along the sewer mains. We anticipate the majority of these soils will be moist to wet clays. In trenches where soils are excavated above the groundwater levels, we anticipate the on-site soils will be moist to wet, and at or slightly above optimum moisture content. We anticipate they can be placed and compacted. For trenches where pipes are installed below groundwater and dewatering is necessary, soils excavated within 2 feet of groundwater and deeper are wet, and above the clay's optimum moisture content. It will be necessary to spread these soils out and allow them to dry in order to achieve a moisture content near optimum, which can be time consuming and weather dependent. Consideration can also be given to replacing these soils with similar (clay) imported materials.

In order to minimize trench settlement, it is important that trench backfill be properly placed and compacted throughout the entire storm drain alignment. Qualified personnel should inspect the backfilling processes to confirm the backfill is being properly placed and compacted at the proper moisture content. We recommend trench backfill be placed at a moisture content 1 percent below to 3 percent above optimum moisture content. The trench backfill should be placed in maximum loose lift thicknesses ranging from 6 to 8 inches, depending on the compaction equipment being used, and compacted to a minimum of 98 percent of its maximum dry density determined in accordance with ASTM D 698 (standard Proctor).

C.7. Trench Plugs

To minimize the potential groundwater mitigation along the bedding and foundation material which could cause excessive settlement of trench backfill, we recommend low permeability trench plugs be installed in accordance with MPWSS Section 02222. We recommend trench plugs be placed 10 feet away from buildings (coming in and going out) and at about 1/4-mile intervals along the storm drain lines. Actual locations of trench plugs should be determined by the design engineer.

C.8. Dewatering

As previously indicated, dewatering will be required prior to and during installation of the storm drain in the vicinity of Borings ST-4, ST-5, and ST-6, and most likely Borings ST-1 and ST-8. We obtained groundwater measurements while drilling, but in these types of clay soils, several days or weeks may be necessary for groundwater to stabilize. Also, groundwater levels can fluctuate depending on the time of year as well as rainfall, snow melt, irrigation, and other manmade or natural sources of water.

The method of dewatering will need to be determined by the contractor based on their experience and available equipment. We wish to point out that dewatering clay soils can be extremely difficult, time consuming, and require specialized equipment and experience. Vacuum extraction systems have been found to be the best systems for these types of clays, and dewatering is necessary several weeks prior to excavating. Conventional sump/pump systems set 2 to 3 feet below the trench bottom typically do not work in these types of clays, i.e., they do not lower groundwater in a large enough area.

When considering the variability to the depth and extent of groundwater in Shelby, as well as the complex system needed to lower the groundwater table, we recommend providing a contingency in the budget for dewatering. Higher groundwater covering a larger area could be encountered during construction, resulting in significant costs to the contractor. If possible, construction should be scheduled when groundwater levels are anticipated to be at their lowest. Consideration should also be given to performing a hydrogeologic evaluation of the area to provide better groundwater depths and elevations as well as soil hydraulic conductivities and groundwater pumping volumes.

C.9. Trenchless Pipe Installation

The storm water drain pipe will be installed beneath the BNSF railroad tracks on the eastern side of the town. Jack and bore method will be used to install the storm drain at this location. Near the BNSF railroad tracks, lean clay with sand is anticipated at the jack and bore location. Groundwater was encountered to a depth of 6 feet and significant dewatering, as described above, should be anticipated.

Representative Log of Boring sheets near the crossing locations are attached to this report and should be reviewed by the contractor to evaluate the equipment necessary to extend the casing and storm drain pipe beneath the roadways and rail tracks. The jack and bore drilling should be conducted in accordance with BNSF and other regulatory authority requirements.

C.10. Preliminary Recommendations Related to Interceptor Trench

It is our understanding the commercial buildings with basements in the vicinity of Boring ST-5 have seepage problems due to high groundwater. We were asked to provide some opinions related to installing an interceptor trench in the alley as part of the storm drain construction. The same trench will also have a sanitary sewer at 6 to 7 feet.

Having not seen the buildings, our recommendations should be considered preliminary and more detailed geotechnical observations including additional soil borings are recommended. From a preliminary standpoint, Boring ST-5 encountered alluvial clays to a depth of 17 feet, where moderately hard shale bedrock was encountered to a depth of about 20 feet. Groundwater was measured at a depth of 15 1/2 feet while drilling, although possible waterbearing soils were observed at 7 feet, based on the moisture content results.

It is our preliminary opinion an interceptor trench can be considered. The interceptor trench should be as shallow as possible, but intercept groundwater flowing toward the buildings. We estimate a depth of 15 to 16 feet. The interceptor trench should consist of non-woven geotextile fabric inside the entire trench wrapping open-graded drainage aggregate. Drainage aggregate is specified in Table 701-21 of MDT standard specifications. The drainage aggregate should extend from the shale bedrock up to a depth of about 6 feet below the surface. A relatively large diameter high strength perforated pipe is installed in the bottom of the trench and routed to a sump and pump system for, or drained by gravity, for discharge. Groundwater intercepted by the trench seeps through the fabric into the drainage aggregates then collected by the perforated pipe. The fabric provides separation between the clay sidewalls and the drainage aggregate to prevent piping of fines.

At this time, we cannot provide recommendations related to the size of perforated pipe or pump needed to dewater the area. Hydrogeologic evaluation most likely including pumping tests would be necessary to further evaluate sizes. Also, installing piezometers in and around the area to measure groundwater levels should be considered. Lowering the groundwater throughout the area also increases the risk of subsidence causing commercial buildings to settle excessively. Additional geotechnical work is therefore recommended.

Any time drainage aggregate is used as backfill, settlement is a concern. In this case, assuming the interceptor trench is extended to about 15 to 16 feet, then drainage aggregate will be used from about 6 to 16 feet as trench backfill. Even though most contractors believe drainage aggregate is self-compacting, we recommend the drainage aggregate be compacted during placement. Because it cannot be tested, we recommend a performance method of four compaction passes over each 12-inch maximum lift. Compaction should be with a vibratory hoepack attached to the bucket of the excavator. Even so, this material will consolidate over time, and we recommend assuming 1 to 2 inches of total settlement. The sanitary sewer pipe will be set at a depth of about 6 to 7 feet in the same trench, and we recommend it be designed to tolerate this amount of movement.

C.11. Concrete

As the corrosion tests indicated, high sulfate content exists with the alluvial clays, and Type V cement is recommended for RCP pipes, if used.

D. Construction

D.1. Excavation

Excavation was previously addressed in Section C.4 of this report. All earthwork and excavations should be performed in accordance with OSHA guidelines and the OSHA classification of the soils was addressed. Trenching can likely be accomplished with a backhoe or excavator, although excavation of the shale bedrock encountered below a depth of 17 feet in Boring ST-5 will be very difficult.

D.2. Dewatering

Dewatering is a major concern for the project due to the relatively high groundwater encountered by the borings. Dewatering was addressed in Section C.6 of this report. When considering specialized contractors with proven experience are needed to install dewatering systems in these types of clay soils to lower groundwater, consideration should be given to asking for qualifications from bidding contractors with examples of successfully completed projects. We would like to reiterate that a contingency in the project budget should be provided for dewatering prior to and during storm drain installation and construction. Hydrogeologic evaluation for the proposed interceptor trench as well as the entire project should also be considered.

D.3. Observations

We recommend excavations of the trenches be observed. These observations should be performed by a geotechnical engineer or an engineering assistant working under the direction of a geotechnical engineer. The purpose of these observations is to evaluate if the trench subgrade and sidewall soils are similar to those encountered in the borings.

D.4. Moisture Conditioning

As previously indicated, site soils that will be excavated and reused as trench backfill are likely moist to a depth of about 4 to 5 feet, then become wet and saturated. We anticipate the top 4 to 5 feet of the excavated materials can likely be reused as trench backfill. Below 4 to 5 feet, the on-site soils will be wet, and well above the soils' optimum moisture contents. We anticipate it will be necessary to spread these soils out and allow them to dry in order to achieve a moisture content near or slightly above optimum. This can be a time-consuming process requiring disks and plows, and is also weather dependent.

D.5. Testing

We recommend compaction tests be taken during construction on the trench backfill, base course, and asphalt pavement. For trench backfill, we recommend compaction tests be taken at 2-foot intervals during the backfilling, and every 100 to 150 linear feet of trench. This will most likely require full-time compaction testing during backfilling. We also recommend qualified technicians perform the work having the necessary experience to recognize appropriate Proctors, contractor approaches to compaction, and calibrated nuclear density gauges. MDT will likely have special testing requirements during construction within the highways. During paving, we recommend the asphalt pavement be tested for quality, compaction, thickness, asphalt cement content, and air voids. SuperPave requirements could be necessary in the Montana highways. For the residential streets, we recommend also testing for the Marshall properties.

D.6. Cold Weather Construction

If site grading and construction is anticipated during cold weather, we recommend good winter construction practices be observed. All snow and ice should be removed from cut and fill areas prior to additional grading. No fill should be placed on soils that have frozen or contain frozen material. No frozen soils should be used as fill.

E. Procedures

E.1. Drilling and Sampling

The penetration test borings were performed on August 26 and 27, 2014, with our CME 75 HT, truck mounted drilling rig. Sampling for the borings was conducted in accordance with ASTM D 1586, "Penetration Test and Split-Barrel Sampling of Soils." Using this method, we advanced the borehole with hollow-stem auger to the desired test depth. Then a 140-pound hammer falling 30 inches drove a standard, 2-inch OD, split-barrel sampler a total penetration of 1 1/2 feet below the tip of the hollow-stem auger. The blows for the last foot of penetration were recorded and are an index of soil strength characteristics.

E.2. Soil Classification

The drill crew chief visually and manually classified the soils encountered in the borings in accordance with ASTM D 2488, "Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)." A summary of the ASTM classification system is attached. All samples were then returned to our laboratory for review of the field classifications by a geotechnical engineer. Representative samples will remain in our office for a period of 60 days to be available for your examination.

E.3. Groundwater Observations

About ten minutes after taking the final sample in the bottom of a boring, the driller probed through the hollow-stem auger to check for the presence of groundwater. Immediately after withdrawal of the auger, the driller again probed the depth to water or cave-in. The boring was then backfilled.

F. General Recommendations

F.1. Basis of Recommendations

The analyses and recommendations submitted in this report are based upon the data obtained from the soil borings performed at the locations indicated on the attached sketch. Often, variations occur between these borings, the nature and extent of which do not become evident until additional exploration or construction is conducted. A reevaluation of the recommendations in this report should be made after performing on-site observations during construction to note the characteristics of any variations. The variations may result in additional foundation costs, and it is suggested a contingency be provided for this purpose.

It is recommended we be retained to perform the observation and testing program for the site preparation phase of this project. This will allow correlation of the soil conditions encountered during construction to the soil borings, and will provide continuity of professional responsibility.

F.2. Review of Design

This report is based on the design of the proposed utilities as related to us for preparation of this report. It is recommended we be retained to review the geotechnical aspects of the designs and specifications. With the review, we will evaluate whether any changes in design have affected the validity of the recommendations, and whether our recommendations have been correctly interpreted and implemented in the design and specifications.

F.3. Groundwater Fluctuations

We made water level observations in the borings at the times and under the conditions stated on the boring logs. These data were interpreted in the text of this report. The period of observation was relatively short, and fluctuation in the groundwater level may occur due to rainfall, flooding, irrigation, spring thaw, drainage, and other seasonal and annual factors not evident at the time the observations were made. Design drawings and specifications and construction planning should recognize the possibility of fluctuations.

F.4. Use of Report

This report is for the exclusive use of the City of Shelby and KLJ to use to design the proposed utilities and prepare construction documents. In the absence of our written approval, we make no representation and assume no responsibility to other parties regarding this report. The data, analyses, and recommendations may not be appropriate for other structures or purposes. We recommend parties contemplating other structures or purposes contact us.

F.5. Level of Care

Services performed by SK Geotechnical Corporation personnel for this project have been conducted with that level of care and skill ordinarily exercised by members of the profession currently practicing in this area under similar budget and time restraints. No warranty, expressed or implied, is made.

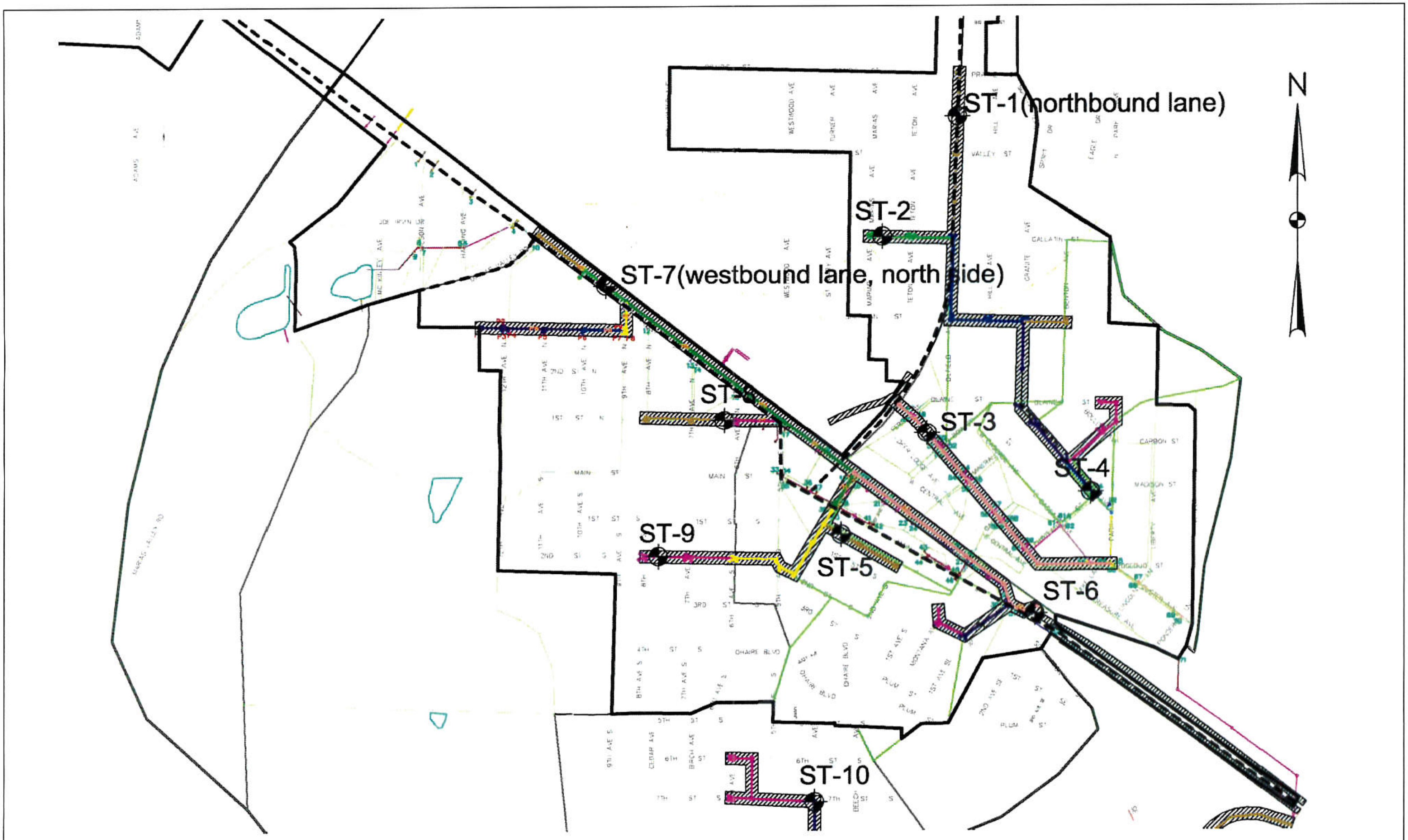
Professional Certification

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

MONTANA
GREGORY T.
STAFFILENO
No. 10798 P.E.
REGISTERED PROFESSIONAL ENGINEER

Gregory T. Staffileno, PE
Principal Geotechnical Engineer
License Number 10798PE
October 13, 2014

Appendix



SK GEOTECHNICAL	**BORING LOCATION SKETCH** Stormwater Improvements Shelby, Montana	Drawn by: E. Niebler	Date 10/2/14	
		Project: 14-3255G		
		Scale: None		FIGURE
		Sheet 1 of 1		

Descriptive Terminology

Standard D 2487
Classification of Soils for Engineering Purposes (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 [C]	$C_U \geq 4$ and $1 \leq C_C \leq 3$ [E]	GW	Well graded gravel [F]
			$C_U < 4$ and/or $1 > C_C > 3$ [E]	GP	Poorly graded gravel [F]
		Gravels with Fines More than 12% fines [C]	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 [D]	$C_U \geq 6$ and $1 \leq C_C \leq 3$ [E]	SW	Well graded sand [I]
			$C_U < 6$ and/or $1 > C_C > 3$ [E]	SP	Poorly graded sand [I]
		Sands with Fines More than 12% fines [D]	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 [J]	CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K, L, M]
		Organic	$\frac{\text{Liquid limit – oven dried}}{\text{Liquid limit – not dried}} < 0.75$	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	$\frac{\text{Liquid limit – oven dried}}{\text{Liquid limit – not dried}} < 0.75$	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" (75 mm) sieve.
B If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" 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-SC well-graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay
E $C_U = D_{60} / D_{10}$
$C_C = (D_{30})^2 / (D_{10} \times D_{60})$
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 hatched 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.

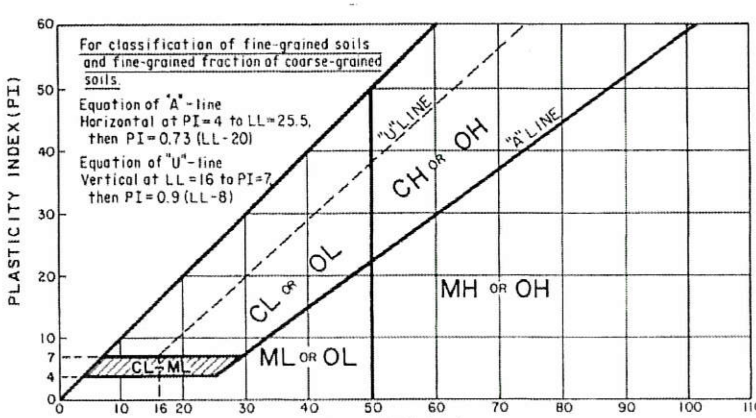


FIG. 4 Plasticity Chart

Laboratory Tests

DD Dry density, pcf
WD Wet density, pcf
LL Liquid limit
PI Plasticity index
qu Unconfined compressive strength, psf
qp Pocket penetrometer strength, tsf
OC Organic content, %
P_{200} % passing 200 sieve
PL Plastic limit
MC Natural moisture content, %

Particle Size Identification

Boulders.................................over 12"
Cobbles.................................3" to 12"
Gravel
coarse.................................3/4" to 3"
fine.................................No. 4 to 3/4"
Sand
coarse.......................No. 4 to No. 10
medium...................No. 10 to No. 40
fine.......................No. 40 to No. 200
Silt.......................No. 200 to .005 mm
Clay ....less than .005 mm

Relative Density of Cohesionless Soils

very loose ....0 to 4 BPF
loose.................................5 to 10 BPF
medium dense.................11 to 30 BPF
dense...............................31 to 50 BPF
very dense........................over 50 BPF

Consistency of Cohesive Soils

very soft..............................0 to 1 BPF
soft.....................................2 to 3 BPF
rather soft............................4 to 5 BPF
medium...............................6 to 8 BPF
rather stiff.........................9 to 12 BPF
stiff.................................13 to 16 BPF
very stiff ....17 to 30 BPF
hard..................................over 30 BPF

Moisture Content (MC) Description

rather dry	MC less than 5%, absence of moisture, dusty
moist	MC below optimum, but no visible water
wet	MC over optimum, visible free water, typically below water table
saturated	Clay soils were MC over optimum

Drilling Notes

Standard penetration test borings were advanced by 3¼" or 4¼" ID hollow-stem augers, unless noted otherwise. Standard penetration test borings are designated by the prefix "ST" (split tube). Hand auger borings were advanced manually with a 2 to 3" diameter auger to the depths indicated. Hand auger borings are indicated by the prefix "HA."

Sampling. All samples were taken with the standard 2" OD split-tube sampler, except where noted. TW indicates thin-walled tube sample. CS indicates California tube sample.

BPF. Numbers indicate blows per foot recorded in standard penetration test, also known as "N" value. The sampler was set 6" into undisturbed soil below the hollow-stem auger. Driving resistances were then counted for second and third 6" increments and added to get BPF. Where they differed significantly, they were separated by backslash (/). In very dense/hard strata, the depth driven in 50 blows is indicated.

WH. WH indicates the sampler penetrated soil under weight of hammer and rods alone; driving not required.

Note. All tests were run in general accordance with applicable ASTM standards.

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LOG OF BORING

PROJECT: 14-3255G
UTILITY GEOTECHNICAL EVALUATION
Proposed Stormwater Improvements
Shelby, Montana

BORING: **ST-1**
LOCATION: See Boring Location Sketch

DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 8/26/14 | SCALE: 1" = 3'

Elev. 3296.0	Depth 0.0	Symbol	Description of Materials	BPF	WL MC	qp*	Remarks
3295.5	0.5		FILL: Asphalt Pavement (6 1/2" thick).				Elevations: Provided by KLJ.
3294.0	2.0		FILL: Clayey Gravel with Sand, fine- to coarse-grained, brown, moist, loose. (Base Course)	7	4.4		
3292.5	3.5	CL	SANDY LEAN CLAY, low to medium plasticity, trace gravels, brown, moist, medium. (Alluvium)	6	4.8		
3289.5	6.5	CL	LEAN CLAY with SAND, medium plasticity, trace gravels, brown, moist to wet, soft. (Alluvium)	2	14.6		Pipe Invert 3290.6 //////////////////
3287.0	9.0	SC	CLAYEY SAND, fine-grained, brown, wet, very loose. (Alluvium)	4	12.1		
					∇		
3285.0	11.0	GM	SILTY GRAVEL with SAND, fine- to coarse-grained, multi-colored, waterbearing, loose. (Alluvium)	7	14.2		An open triangle in the water level (WL) column indicates the depth at which groundwater was first observed while drilling.
3280.5	15.5	CL CH	LEAN to FAT CLAY, medium to high plasticity, brown, waterbearing, soft. (Alluvium)	3 2	20.3 21.5		

END OF BORING

Water down 11.3' with 11.5' of hollow-stem auger in the ground.

Water down 9' with 14' of hollow-stem auger in the ground.

Water not observed to dry cave-in depth of 6.7' immediately after withdrawal of auger.

Boring then backfilled.

Several days may be necessary for groundwater to stabilize in these types of clay soils.

*qp=pocket penetrometer estimate of unconfined compressive strength, tons per square foot.

BORING BPF WL-MC QP* 3255.GPJ LAGNNN06.GDT 10/9/14

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LOG OF BORING

PROJECT: 14-3255G **UTILITY GEOTECHNICAL EVALUATION** Proposed Stormwater Improvements Shelby, Montana	BORING: **ST-2** LOCATION: See Boring Location Sketch

DRILLED BY: C. Larsen	METHOD: 3 1/4" HSA, Automatic	DATE: 8/26/14	SCALE: 1" = 3'

Elev. 3287.3	Depth 0.0	Symbol	Description of Materials	BPF	WL MC	qp	Remarks
3286.8	0.5		FILL: Asphalt Pavement (6 1/2" thick).				Boring moved 2' north.
		CL	LEAN CLAY, medium plasticity, trace salts, dark brown, moist to wet, very soft to medium. (Alluvium)	6	16.5	4+	
				4	20.4	2½	
			-trace gravels	5	15.9	2½	
							Pipe Invert 3281.4
				3	20.6	1½	
				2	19.9		
					▽		
			-some sand seams	WH	23.0		
3271.8	15.5			2	22.0		
			END OF BORING Water not observed with 14' of hollow-stem auger in the ground. Water not observed to dry cave-in depth of 5' immediately after withdrawal of auger. Waterbearing soils observed below 11' while drilling. Boring then backfilled. Several days may be necessary for groundwater to stabilize in these types of clay soils.				

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LOG OF BORING

PROJECT: 14-3255G
UTILITY GEOTECHNICAL EVALUATION
Proposed Stormwater Improvements
Shelby, Montana

BORING: **ST-3**
LOCATION: See Boring Location Sketch

DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 8/27/14 | SCALE: 1" = 3'

Elev. 3278.0	Depth 0.0	Symbol	Description of Materials	BPF	WL MC	qp	Remarks
3277.5	0.5		FILL: Asphalt Pavement (6" thick).				Boring moved 7' north.
		CL	SANDY LEAN CLAY, medium plasticity, trace gravels, dark brown, moist to wet, soft to medium. (Alluvium)	8	17.7		
				4	13.1	2¼	Bulk bag sample 2'-6' LL=38, PL=15, PI=23 P_{200}=57.1%
				3	18.8	2¼	
				5	20.2	2¾	Pipe Invert 3270.4 /////////////////
				8	21.6	1½	
3266.5	11.5	CL ML	SILTY CLAY with SAND, slightly plastic, dark brown, wet to waterbearing, rather soft. (Alluvium)	4	22.7		
					▽		
				5	21.3		
3262.5	15.5		END OF BORING				

Water down 13.7' with 14' of hollow-stem auger in the ground.

Water not observed to dry cave-in depth of 9' immediately after withdrawal of auger.

Boring then backfilled.

Several days may be necessary for groundwater to stabilize in these types of clay soils.

BORING BPF WL-MC QP 3255.GPJ LAGNNN06.GDT 10/9/14

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LOG OF BORING

PROJECT: 14-3255G
UTILITY GEOTECHNICAL EVALUATION
Proposed Stormwater Improvements
Shelby, Montana

BORING: **ST-4**
LOCATION:
See Boring Location Sketch

DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 8/27/14 | SCALE: 1" = 3'

Elev. 3273.4	Depth 0.0	Symbol	Description of Materials	BPF	WL MC	qp	Remarks
3272.9	0.5		FILL: Asphalt Pavement (6 1/2" thick).				
		CL	LEAN CLAY, medium plasticity, some FeOx stains, dark brown, moist, medium to rather stiff. (Alluvium)	9	19.1	3½	
3270.9	2.5			8	6.0	2	
		SC	CLAYEY SAND, fine-grained, brown, moist to wet, very loose. (Alluvium)	3	16.9		
							Pipe Invert 3267.3
3266.4	7.0				18.6		
		CL CH	LEAN to FAT CLAY with SAND, medium to high plasticity, trace salts, dark brown, wet to waterbearing, very soft to soft. (Alluvium)	1	∇	1½	
				3	22.7	1¾	
			-with salts				
				2	23.0		
				5	22.9		
3257.9	15.5		END OF BORING				

Waterbearing soils observed at about 8' while drilling.

Water down 9' immediately after withdrawal of auger.

Water not observed to wet cave-in depth of 9.6' immediately after withdrawal of auger.

Boring then backfilled.

Several days may be necessary for groundwater to stabilize in these types of clay soils.

BORING BPF WL-MC QP 3255.GPJ LAGNNN06.GDT 10/9/14

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LOG OF BORING

PROJECT: 14-3255G **UTILITY GEOTECHNICAL EVALUATION** Proposed Stormwater Improvements Shelby, Montana	BORING: **ST-5** LOCATION: See Boring Location Sketch
DRILLED BY: C. Larsen; METHOD: 3 1/4" HSA, Automatic	DATE: 8/27/14; SCALE: 1" = 3'

Elev. 3299.7	Depth 0.0	Symbol	Description of Materials	BPF	WL MC	qp	Remarks
3299.4	0.3		FILL: Asphalt Pavement (3" thick).				Boring moved 16' west and 13' south.
		GC	FILL: Clayey Gravel, fine- to coarse-grained, multi-colored, moist, loose. (Base Course)	7	5.9		
3297.2	2.5	CL CH	LEAN to FAT CLAY with SAND, medium to high plasticity, dark brown, moist to wet, rather soft to rather stiff. (Alluvium)	9	21.0	3	
				5	21.9	2¼	
				9	20.8	½	Possible waterbearing soils at 7'.
				5	22.1	¾	
			-some sand seams				
				5	21.2		
					∇		
				8	24.5		Pipe Invert 3285.0
3282.7	17.0		SHALE BEDROCK, very thinly bedded, dark gray, highly weathered to decomposed, moderately hard hardness.	50-3"	9.9		
3279.9	19.8			50-3"	16.3		

END OF BORING - Auger Refusal
Water down 18' with 17.5' of hollow-stem auger in the ground.
Waterbearing soils observed at 13 1/2' while drilling.
Water down 15.5' immediately after withdrawal of auger.
Water not observed to wet cave-in depth of 15.5' immediately after withdrawal of auger.
Boring then backfilled.

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LOG OF BORING

PROJECT: 14-3255G **UTILITY GEOTECHNICAL EVALUATION** Proposed Stormwater Improvements Shelby, Montana	BORING: **ST-5** **(cont.)** LOCATION: See Boring Location Sketch
DRILLED BY: C. Larsen — METHOD: 3 1/4" HSA, Automatic	DATE: 8/27/14 — SCALE: 1" = 3'

Elev. 3275.7	Depth 24.0	Symbol	Description of Materials	BPF	WL MC	qp	Remarks
			Several days may be necessary for groundwater to stabilize in these types of clay soils.				

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LOG OF BORING

PROJECT: 14-3255G
UTILITY GEOTECHNICAL EVALUATION
Proposed Stormwater Improvements
Shelby, Montana

BORING: **ST-6**
LOCATION: See Boring Location Sketch

DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 8/26/14 | SCALE: 1" = 3'

Elev. 3278.0	Depth 0.0	Symbol	Description of Materials	BPF	WL MC	qp	Remarks
			FILL: 3" topsoil and root zone over Clayey Sand, fine-grained, trace roots, brown, moist, loose.	8	6.5		Boring moved 7' south.
3276.5	1.5		FILL: Poorly Graded Gravel with Sand, fine- to coarse-grained, brown, moist, loose.	9	3.0		
3274.0	4.0	CL	LEAN CLAY with SAND, medium plasticity, trace gravels and salts, brown, wet to waterbearing, very soft to rather soft. (Alluvium)	5	17.5		
					▽		Pipe Invert 3271.9
				2	19.5	¼	
				WH	23.3	< ¼	LL=36, PL=18, PI=18 P_{200}=74.2%
			-some sand seams				
				WH	22.0		
				2	26.0		
				4	21.4	1½	
3257.5	20.5		END OF BORING Water down 6' with 9' of hollow-stem auger in the ground. Water observed at 7' to wet cave-in depth of 7.5' immediately after withdrawal of auger. Boring then backfilled.				Several days may be necessary for groundwater to stabilize in these types of clay soils.

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LOG OF BORING

PROJECT: 14-3255G
UTILITY GEOTECHNICAL EVALUATION
Proposed Stormwater Improvements
Shelby, Montana

BORING: **ST-7**

LOCATION: See Boring Location Sketch

DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 8/26/14 | SCALE: 1" = 3'

Elev. 3286.5	Depth 0.0	Symbol	Description of Materials	BPF	WL MC	qp	Remarks
3286.0	0.5		FILL: Asphalt Pavement (6" thick).				
			FILL: Clayey Gravel with Sand, fine- to coarse-grained, dark brown, moist, medium dense. (Base Course)	30	5.0		
				18	6.5		
3282.5	4.0						Pipe Invert 3282.6
		CL CH	LEAN to FAT CLAY with SAND, medium to high plasticity, dark brown, wet, soft to medium. (Alluvium)	7	21.4	1½	
				6	24.1	1½	
			-some sand seams	3	21.8 ∇	½	
				6	24.4		
				4	24.8	½	
3271.0	15.5		END OF BORING				

Waterbearing soils observed at about 10' while drilling.

Water not observed with 14' of hollow-stem auger in the ground.

Water not observed immediately after withdrawal of auger.

Water not observed to dry cave-in depth of 4 1/2' immediately after withdrawal of auger.

Boring then backfilled.

Several days may be necessary for groundwater to stabilize in these types of clay soils.

BORING BPF WL-MC QP 3255.GPJ LAGNNN06.GDT 10/9/14

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LOG OF BORING

PROJECT: 14-3255G
UTILITY GEOTECHNICAL EVALUATION
Proposed Stormwater Improvements
Shelby, Montana

BORING: **ST-8**

LOCATION:
See Boring Location Sketch

DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 8/27/14 | SCALE: 1" = 3'

Elev. 3292.7	Depth 0.0	Symbol	Description of Materials	BPF	WL MC	qp	Remarks
3291.9	0.8		FILL: Asphalt Pavement (9" thick).				
			FILL: Clayey Gravel with Sand, fine- to coarse-grained, brown, moist, medium dense. (Base Course)	20	7.3		
3289.7	3.0			11	7.1		Bulk bag sample 2'-6' LL=34, PL=17, PI=17 P_{200}=40.3%
		CL	SANDY LEAN CLAY, medium plasticity, dark brown, moist to wet, very soft to rather soft. (Alluvium)				Pipe Invert 3288.7
				4	12.4		
				2	21.5	½	
			-waterbearing below 8 1/2'		∇		
				2	24.7	¾	
			-some sand seams	WH	28.0		
3277.2	15.5			5	22.1		

END OF BORING

Water not observed with 14' of hollow-stem auger in the ground.

Water not observed immediately after withdrawal of auger.

Waterbearing soils observed below 8 1/2' while drilling.

Boring then backfilled.

Several days may be necessary for groundwater to stabilize in these types of clay soils.

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LOG OF BORING

PROJECT: 14-3255G **UTILITY GEOTECHNICAL EVALUATION** Proposed Stormwater Improvements Shelby, Montana	BORING: **ST-9** LOCATION: See Boring Location Sketch

DRILLED BY: C. Larsen	METHOD: 3 1/4" HSA, Automatic	DATE: 8/27/14	SCALE: 1" = 3'

Elev.	Depth	Symbol	Description of Materials	BPF	WL MC	qp	Remarks
3341.7	0.0						
3341.4	0.3		FILL: Asphalt Pavement (3" thick).				
			FILL: Clayey Gravel, fine- to coarse-grained, brown, moist, very loose to loose. (Base Course)	8	7.9		
3339.2	2.5	CL CH	LEAN to FAT CLAY, medium to high plasticity, brown, moist, medium to rather stiff. (Alluvium)	5	10.7	2½	
				6	21.7	2	Pipe Invert 3336.4
			-trace salts, some FeOx staining	11	22.0	2½	
			-some sand seams	9	20.9	2¾	
				10	22.9		
				13	20.5		
3326.2	15.5		END OF BORING				

Water not observed with 14' of hollow-stem auger in the ground.

Water not observed immediately after withdrawal of auger.

Water not observed to dry cave-in depth of 7.7' immediately after withdrawal of auger.

Boring then backfilled.

Several days may be necessary for groundwater to stabilize in these types of clay soils.

BORING BPF WL-MC QP 3255.GPJ LAGNNN06.GDT 10/9/14

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LOG OF BORING

PROJECT: 14-3255G
UTILITY GEOTECHNICAL EVALUATION
Proposed Stormwater Improvements
Shelby, Montana

BORING: **ST-10**
LOCATION: See Boring Location Sketch

DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 8/27/14 | SCALE: 1" = 3'

Elev.	Depth	Symbol	Description of Materials	BPF	WL MC	qp	Remarks
3412.5	0.0						
3411.8	0.7	OL	Topsoil and root zone (8" thick).				
3410.5	2.0	SM	SILTY SAND, fine-grained, with roots, light brown, moist, medium dense. (Alluvium)	12	4.8		
3407.0	5.5	CL ML	SANDY SILTY CLAY, slightly plastic, trace gravels, light brown, moist, very stiff to stiff. (Alluvium)	18	7.3	4+	
				14	5.6	4+	
3402.0	10.5	CL	SANDY LEAN CLAY, low plasticity, trace gravels, brown, moist, stiff to very stiff. (Alluvium)	19	16.0		Pipe Invert 3404.7
				15	18.2	4+	

END OF BORING

Water not observed with 9' of hollow-stem auger in the ground.

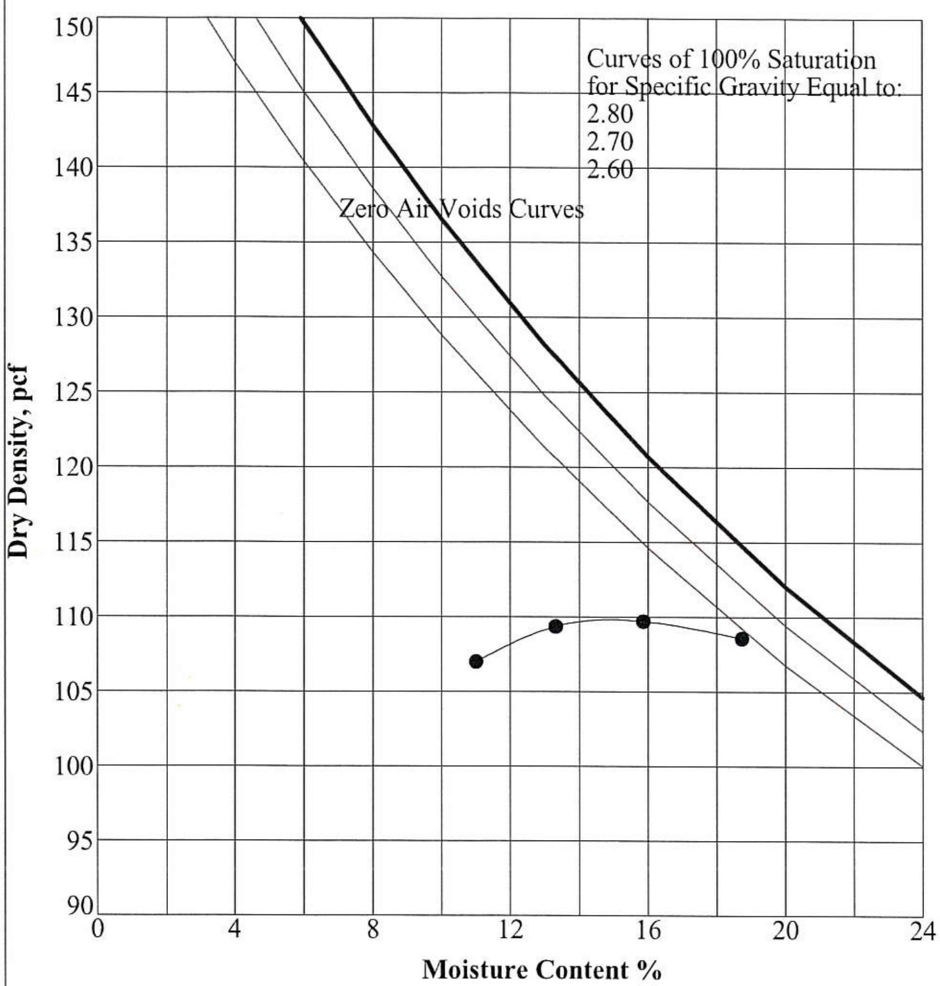
Water not observed immediately after withdrawal of auger.

Water not observed to dry cave-in depth of 5' immediately after withdrawal of auger.

Boring then backfilled.

Several days may be necessary for groundwater to stabilize in these types of clay soils.

BORING BPF WL-MC QP 3255.GPJ LAGNNN06.GDT 10/9/14



ASTM D 698 Method A

Maximum Dry Density, pcf	Optimum Moisture Content %
110.0	**15.0**

Rammer Type: Mechanical
Preparation Method: Moist

Soil Description (Visual-Manual)

SANDY LEAN CLAY, medium plasticity, dark brown, moist to wet.

Sieve Size	% Retained
1 1/2"	0
3/4"	0
3/8"	0
#4	0

Sample No:	1
Lab Sample No:	P-1
Date Sampled:	08/27/2014
Sampled By:	Drill Crew
Date Received:	09/08/2014
Sampled From:	ST-3
Depth:	2' to 6'
Performed by:	RJQ/SKG
Date Performed:	09/15/2014

Comments

Remarks

SK GEOTECHNICAL

2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

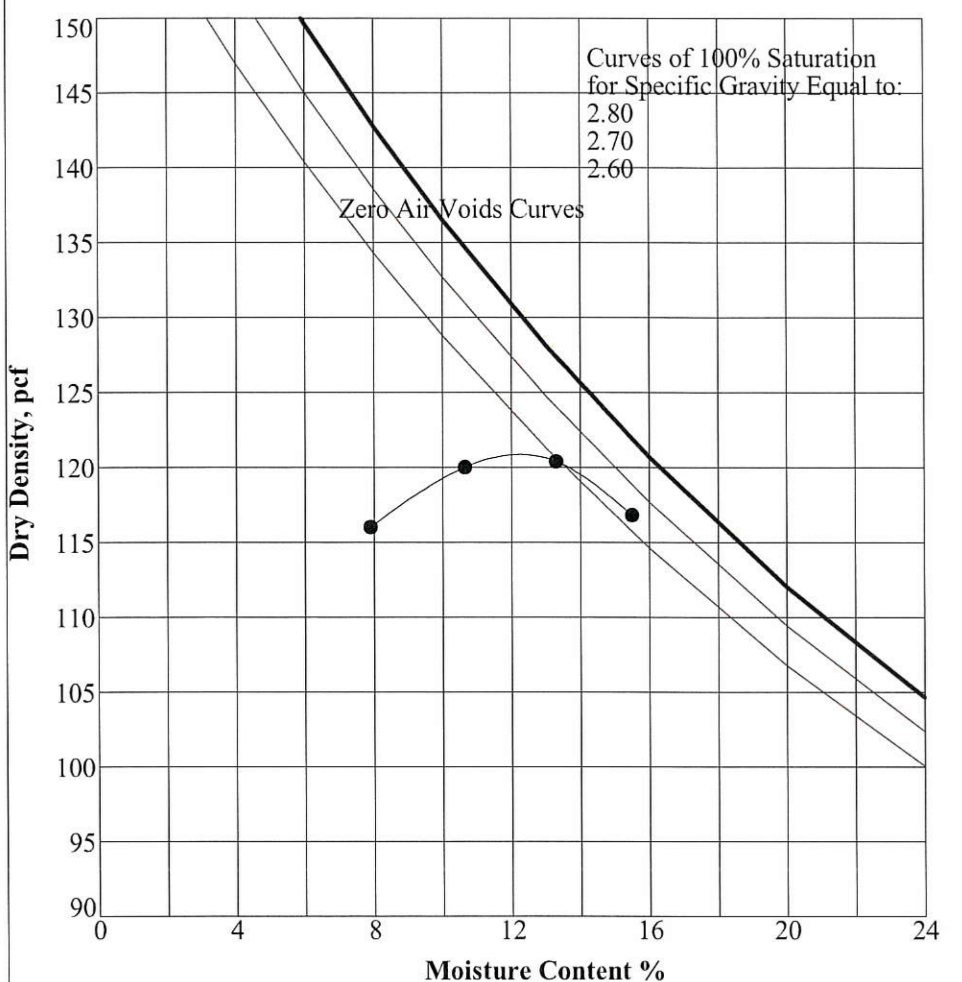
Laboratory Compaction Characteristics of Soil (Proctor)

Project No.: 14-3255G
Proposed Stormwater Improvements
Shelby, Montana

PROCTOR

P-1

10/9/14



ASTM D 698 Method B

Maximum Dry Density, pcf	Optimum Moisture Content %
121.5	**12.2**

Rammer Type: Mechanical
Preparation Method: Moist

Soil Description (Visual-Manual)

SANDY LEAN CLAY, medium plasticity, dark brown, moist to wet.

Sieve Size	% Retained
1 1/2"	0
3/4"	2
3/8"	6
#4	14

Sample No:	2
Lab Sample No:	P-2
Date Sampled:	08/27/2014
Sampled By:	Drill Crew
Date Received:	09/08/2014
Sampled From:	ST-8
Depth:	2' to 6'
Performed by:	RJQ/SKG
Date Performed:	09/15/2014

Comments

Remarks

SK GEOTECHNICAL
2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

Laboratory Compaction Characteristics of Soil (Proctor)

Project No.: 14-3255G
Proposed Stormwater Improvements
Shelby, Montana

PROCTOR

P-2

10/9/14

ANALYTICAL SUMMARY REPORT

December 06, 2016

Aqua Tech Laboratory
PO Box 1205
Lewistown, MT 59457-1205

Work Order: B16111981 Quote ID: B2928

Project Name: MT0000328 Williamson Bldg

Energy Laboratories Inc Billings MT received the following 1 sample for Aqua Tech Laboratory on 11/28/2016 for analysis.

Lab ID	Client Sample ID	Collect Date	Receive Date	Matrix	Test
B16111981-001	C2447, Williamson Building	11/21/16 10:30	11/28/16	Drinking Water	Metals by ICP/ICPMS, Acid Soluble Conductivity Livestock Suitability; Irrigation Classification Sodium Adsorption Ratio

The analyses presented in this report were performed by Energy Laboratories, Inc., 1120 S 27th St., Billings, MT 59101, unless otherwise noted. Any exceptions or problems with the analyses are noted in the Laboratory Analytical Report, the QA/QC Summary Report, or the Case Narrative.

The results as reported relate only to the item(s) submitted for testing.

If you have any questions regarding these test results, please call.

Report Approved By: Technical Data Reviewer

Digitally signed by
Jillian B. Miller
Date: 2016.12.06 13:52:11 -07:00

ENERGY LABORATORIES
Trust our People. Trust our Data.
www.energylab.com
Billings, MT 800.735.4489 • Casper, WY 888.235.0515
College Station, TX 888.690.2218 • Gillette, WY 866.686.7175 • Helena, MT 877.472.0711

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Aqua Tech Laboratory
Lab ID: B16111981-001
Client Sample ID: C2447, Williamson Building
Report Date: 12/06/16
PWS #: MT0000328 **Name:** SHELBY CITY OF
Collection Date: 11/21/16 10:30
Facility ID: DS001
Date Received: 11/28/16
SamplingPoint/Location: SP001 / Williamson Building
Matrix: Drinking Water
Project ID: MT0000328 Williamson Bldg
Federal ID#: MT00005
Collector's Name: Rob Habets **Contact Phone #:** 406-538-6988
Compliance Sample: NO **Sample Type:** RT

FRDS Analyses	Result	Units	Qual	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
1064 Conductivity @ 25 C	2940	umhos/cm		5		A2510 B	11/28/16 10:10 / pjw
INORGANICS							
1047 Sodium Adsorption Ratio (SAR)	1.01	unitless		0.01		Calculation	11/30/16 08:12 / jbm
METALS, ACID-SOLUBLE							
1016 Calcium	507	mg/L		1		E200.7	11/29/16 12:16 / jh
1031 Magnesium	133	mg/L		1		E200.7	11/29/16 12:16 / jh
1052 Sodium	99	mg/L	D	2		E200.7	11/29/16 12:16 / jh

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

Sample ID: B16111981-001
Client ID: AQ-TCH-LBRTRY

Irrigation Classification			
Salinity Hazard	**C4**	**Very High Salinity Water:**	not suitable for irrigation under ordinary conditions, but may be used occasionally under very special circumstances. The soils must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching, and very salt-tolerant crops should be selected.
Sodium (Alkali) Hazard	**S1**	**Low-Sodium Water:**	can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium. However, sodium-sensitive crops such as stone-fruit trees and avocados may accumulate injurious concentrations of sodium.

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Aqua Tech Laboratory

Project: MT0000328 Williamson Bldg

Report Date: 12/06/16

Work Order: B16111981

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: A2510 B										Batch: R270937
Lab ID: SC 2nd 1413		Laboratory Control Sample				Run: PHSC _101-B_161128A				11/28/16 08:46
Conductivity @ 25 C		1420	umhos/cm	5.0	101	90	110			
Lab ID: MBLK		Method Blank				Run: PHSC _101-B_161128A				11/28/16 10:07
Conductivity @ 25 C		4	umhos/cm							
Lab ID: B16111981-001ADUP		Sample Duplicate				Run: PHSC _101-B_161128A				11/28/16 10:12
Conductivity @ 25 C		2910	umhos/cm	5.0				1.1	10	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Aqua Tech Laboratory **Report Date:** 12/06/16

Project: MT0000328 Williamson Bldg **Work Order:** B16111981

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E200.7							Analytical Run: ICP203-B_161129A			
Lab ID: ICV	3	Continuing Calibration Verification Standard							11/29/16 11:01	
Calcium		24.3	mg/L	1.0	97	95	105			
Magnesium		24.0	mg/L	1.0	96	95	105			
Sodium		24.1	mg/L	1.0	96	95	105			
Method: E200.7									Batch: R271028	
Lab ID: MB-6500DIS161129A	3	Method Blank				Run: ICP203-B_161129A			11/29/16 11:08	
Calcium		ND	mg/L	0.06						
Magnesium		ND	mg/L	0.002						
Sodium		ND	mg/L	0.04						
Lab ID: LFB-6500DIS161129A	3	Laboratory Fortified Blank				Run: ICP203-B_161129A			11/29/16 11:15	
Calcium		47.4	mg/L	1.0	95	85	115			
Magnesium		48.5	mg/L	1.0	97	85	115			
Sodium		47.7	mg/L	1.0	95	85	115			
Lab ID: B16111981-001BMS2	3	Sample Matrix Spike				Run: ICP203-B_161129A			11/29/16 12:23	
Calcium		735	mg/L	1.0	91	70	130			
Magnesium		374	mg/L	1.0	97	70	130			
Sodium		336	mg/L	1.8	95	70	130			
Lab ID: B16111981-001BMSD	3	Sample Matrix Spike Duplicate				Run: ICP203-B_161129A			11/29/16 12:33	
Calcium		722	mg/L	1.0	86	70	130	1.8	20	
Magnesium		370	mg/L	1.0	95	70	130	1.2	20	
Sodium		333	mg/L	1.8	94	70	130	1.0	20	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

Work Order Receipt Checklist

Aqua Tech Laboratory   B16111981

Login completed by:	Gina McCartney	Date Received:	11/28/2016
Reviewed by:	BL2000\tedwards	Received by:	shc
Reviewed Date:	11/28/2016	Carrier name:	Std US Mail

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐
Custody seals intact on all shipping container(s)/cooler(s)?	Yes ☐	No ☐	Not Present ☑
Custody seals intact on all sample bottles?	Yes ☐	No ☐	Not Present ☑
Chain of custody present?	Yes ☑	No ☐	
Chain of custody signed when relinquished and received?	Yes ☑	No ☐	
Chain of custody agrees with sample labels?	Yes ☑	No ☐	
Samples in proper container/bottle?	Yes ☑	No ☐	
Sample containers intact?	Yes ☑	No ☐	
Sufficient sample volume for indicated test?	Yes ☑	No ☐	
All samples received within holding time? (Exclude analyses that are considered field parameters such as pH, DO, Res Cl, Sulfite, etc.)	Yes ☑	No ☐	
Temp Blank received in all shipping container(s)/cooler(s)?	Yes ☐	No ☑	Not Applicable ☐
Container/Temp Blank temperature:	19.2°C No Ice		
Water - VOA vials have zero headspace?	Yes ☐	No ☐	Not Applicable ☑
Water - pH acceptable upon receipt?	Yes ☑	No ☐	Not Applicable ☐

Standard Reporting Procedures:

Lab measurement of analytes considered field parameters that require analysis within 15 minutes of sampling such as pH, Dissolved Oxygen and Residual Chlorine, are qualified as being analyzed outside of recommended holding time.

Solid/soil samples are reported on a wet weight basis (as received) unless specifically indicated. If moisture corrected, data units are typically noted as –dry. For agricultural and mining soil parameters/characteristics, all samples are dried and ground prior to sample analysis.

Contact and Corrective Action Comments:

Sample for Total Metals was preserved to pH <2 with 2mL of nitric acid per 250mL in the laboratory.

ENERGY LABORATORIES

Chain of Custody and Analytical Request Record

Page 1 of 1

PLEASE PRINT (Provide as much information as possible.)

Company Name: City of Shelby	Project Name, PWS, Permit, Etc. address 00328, Williamson Bldg	Sample Origin State: MT	EPA/State Compliance: Yes ☐ No ☒
Report Mail Address: Aqua Tech Laboratory 505 W. Main Suite 320 ~~P.O. Box 1205~~	Contact Name: Loren Skartved Phone/Fax: 450-4319	Email: loren@3riversnet	Sampler: (Please Print) Rob Habets
Invoice Address: Lewistown, MT 59457 (406) 538-6988	← Invoice Contact & Phone: Julie Sara 434-5222	Purchase Order: —	Quote/Bottle Order: B2928

Special Report/Formats:

☒ DW
☐ POTW/WWTP
☐ State: ______
☐ Other: ______
☐ EDD/EDT (Electronic Data)
Format: ______
☐ LEVEL IV
☐ NELAC

Number of Containers
Sample Type: A W S V B O DW
Air Water Soils/Solids Vegetation Bioassay Other
DW - Drinking Water

ANALYSIS REQUESTED: Irrigation Panel

SEE ATTACHED

Standard Turnaround (TAT)

RUSH

➡ Contact ELI prior to RUSH sample submittal for charges and scheduling – See Instruction Page

Comments:

Shipped by:

Cooler ID(s):

Receipt Temp ______ °C

On Ice: Y N

Custody Seal On Bottle Y N

On Cooler Y N

Intact Y N

Signature Match Y N

	SAMPLE IDENTIFICATION (Name, Location, Interval, etc.)	Collection Date	Collection Time	MATRIX	Irrigation Panel		LABORATORY USE ONLY
1	Site Williamson Building	11-21-16	10:30am	DW	X		B16111198-001
2	C 2447						
3							
4							
5							
6							
7							
8							
9							
10							

Custody Record MUST be Signed					
Relinquished by (print): Rob Habets	Date/Time: 11-21-16 10:30am	Signature: Rob Habets	Received by (print):	Date/Time:	Signature:
Relinquished by (print): Julie Fogle	Date/Time: 11/26/16	Signature: [signature]	Received by (print):	Date/Time:	Signature:
Sample Disposal: Return to Client: ______		Lab Disposal: X	Received by Laboratory: [signature]	Date/Time: 11/28/16 0745	Signature:

In certain circumstances, samples submitted to Energy Laboratories, Inc. may be subcontracted to other certified laboratories in order to complete the analysis requested.
This serves as notice of this possibility. All sub-contract data will be clearly notated on your analytical report.
Visit our web site at www.energylab.com for additional information, downloadable fee schedule, forms, and links.

Private Form