Gallatin County Road and Bridge

Final Geotechnical Engineering Report

Bozeman, Montana

Prepared for:
Gallatin County
205 West Baxter Lane
Bozeman, MT 59718

Prepared by:
Pioneer Technical Services, Inc.
106 Pronghorn Trail, Suite A
Bozeman, Montana 59718

December 2023

Gallatin County Road and Bridge Shop

Final Geotechnical Engineering Report

Bozeman, Montana

Prepared for:
Gallatin County
205 West Baxter Lane
Bozeman, MT 59718

Prepared by:
Pioneer Technical Services, Inc.
106 Pronghorn Trail, Suite A
Bozeman, Montana 59718

December 2023

Contents

Figures

Tables

Appendices

Revision No.	Author	Version	Description	Date
Rev 0	Travis Sammons	Draft	Internal Draft	
Rev 1	Jeffrey Riedel	Final	Issued to Client	12/8/23

1 INTRODUCTION

This report describes the results of geotechnical engineering services completed for the proposed Gallatin County Yards Shop Project located in Gallatin County, Montana. The project involves constructing a steel framed county shop building. The project location is shown on Figure 1. The purpose of the investigation was to provide information and geotechnical recommendations for:

- Subsurface soil conditions.
- Groundwater conditions.
- Earthwork.
- Shallow foundation design parameters.
- Lateral earth pressure.
- Moisture protection and surface drainage.
- Seismic conditions.

1.1 Geotechnical Investigation

On October 18, 2023, Pioneer Technical Services, Inc. (Pioneer) excavated three test pits (TP-01 through TP-03) within the estimated building footprint. The current test pit locations were selected to provide general coverage across the building's approximated foundation elements. Gallatin County performed the test pit excavations using a John Deere 210G excavator. Pioneer logged the test pit lithology and collected bulk samples for laboratory testing. Test pit locations are shown on Figure 1.

Soil samples were field classified in general accordance with American Society for Testing and Materials (ASTM) D2488 (Standard Practice for Description and Identification of Soils [Visual – Manual Procedure]). Appendix A contains test pit logs that list detailed soil descriptions for each of the test pits and Appendix B contains photographs of the investigation. The stratification lines shown on the test pit logs represent the approximate boundary between soil types as observed within the test pits. The actual *in-situ* transition is variable because of the nature and depositional characteristics of natural soil. Interpolation of subsurface conditions beyond the location of the test pits may be unreliable as soil conditions can change rapidly in both lateral and vertical directions.

2 SUBSURFACE CONDITIONS

2.1 Site Geology

The project site area is geologically mapped as older Alluvial Braid Plains deposits and is generally described as well-rounded, well-sorted bouldery gravel with clasts up to boulder size, and sand, silt and clay (S.M. Vuke, 2003).

2.2 Soil Investigation Results

Soil samples were analyzed at Pioneer's material testing laboratory in Bozeman, Montana. A summary of the investigation and laboratory testing is below:

1. The upper 0 to 0.33 feet of material was ¾-inch minus road mix gravel. Material is imported fill.
2. In test pits TP-01 and TP-02, the road mix was underlaid by 2.5 to 3.0 feet of compacted Pit Run fill material consisting of gravel with silt (GP-GM) and silty gravel with sand (GM), with a maximum diameter of 4 inches.
3. In test pit TP-03, the road mix was underlaid by 1.75 feet of silty gravel with sand (GM) underlaid by 1 foot of lean clay.
4. Underlying the non-native fill material native alluvial gravels were encountered to total depth in all test pits. The alluvial gravel (GP and GW) deposit was observed to have maximum particle sizes reaching 12 inches in diameter.
5. According to local groundwater well logs, available from the Montana Bureau of Mines and Geology Ground Water Information Center (GWIC) website (http://mbmggwic.mtech.edu/), alluvial gravel thickness across the site is about 25 feet. Beneath the gravel is a sand layer, followed by additional interbedded alluvium to a depth of at least 43 feet.

2.2.1 Index Properties

Since the materials were generally classified as course alluvial gravel, index testing was not necessary and no tests were performed on the samples collected.

2.2.2 Shrink/Swell Characteristics

Based on field observations and visual classifications, the volume change potential of the native alluvial gravel and compacted subgrade soils can be considered 'low'. If during excavation, clays, such as those noted in TP-03, are observed at elevations beneath the proposed bearing elements, these materials should be evaluated by the geotechnical engineer prior to construction.

2.2.3 Chemical Properties

The laboratory chemical tests included corrosivity testing (soluble sulfate and pH) on selected samples. Alpine Analytical (Helena, Montana) completed this testing Table 1 lists the test results. Following the table are sections describing corrosivity criteria. Appendix C includes the laboratory data sheets.

Table 1. Corrosivity Testing

Location	Depth (feet)	pH (s.u.)	Soluble Sulfate (%)
TP-2	6-7	8.1	.0017

s.u.: standard unit. cm: centimeter. ohm/cm: ohm/centimeter.

2.2.3.1 Corrosivity Testing Criteria

The team used testing criteria from the American Concrete Institute (ACI; ACI 201.2R-08) (ACI, 2008) to evaluate the soil test results. The ACI criteria for concrete attack, based on soluble sulfate (SO_4) content, are as follows:

Under 0.10% SO_4	Class 0 Exposure – no special requirements for sulfate resistance.
0.10% to 0.20% SO_4	Class 1 Exposure – 0.50 water/cement ratio (w/c), Type II cement.
0.20% to 2.0% SO_4	Class 2 Exposure – 0.45 w/c, Type V cement.
Over 2.0% SO_4	Class 3 Exposure – 0.40 w/c, Type V cement + pozzolan or slag.

2.2.3.2 Corrosivity Testing Results

In the soil sample from Test Pit 2, the soluble sulfates measured from the sample was less than 0.1%, which is a Class 0 Exposure for concrete attack indicating no special requirements.

2.3 Static Groundwater Conditions

No groundwater was encountered in any of the test pits during the investigation. Groundwater well log 91294 which is near the site, available on the GWIC website (http://mbmggwic.mtech.edu/), was also reviewed. At the time of construction, October 1971, the water level was observed 12 feet below ground. This well reading is quite old and therefore may not be a very accurate representation of the site groundwater levels. However, it does show that groundwater is likely in the near surface.

Zones of perched and/or trapped groundwater may also occur at times in interbedded alluvial soils. The location and amount of perched water depends on several factors, including hydrological conditions, type of site development, adjacent land use, irrigation, fluctuation in water features, and seasonal weather conditions.

3 ANALYSIS AND RECOMMENDATIONS

3.1 Geotechnical Considerations

The Gallatin County Yards Shop project involves constructing a steel framed county shop building. The site appears suitable for the proposed construction based on geotechnical conditions encountered in the test pits—provided that the findings and recommendations presented herein are incorporated into the project design and construction.

Based on the exploration results and Pioneer's analysis, the proposed structures can be placed on a mat slab or spread footings founded directly on properly prepared subgrade soil and structural fill. The test pit results showed the subsurface materials consist of coarse alluvial gravels with varying amounts of silt and sand fractions. Although limited, fine-grained materials such as silt (ML) or clays (CL) were observed in TP-03, these types of materials may be interbedded with the alluvial gravels in areas between the test pits at depths which may influence the foundations. If clay or silts are encountered during foundation excavations, the geotechnical engineer should be notified to confirm or modify the recommendations presented in this report.

3.2 Site Grading and Earthwork

This section lists recommendations for site preparation, excavation, subgrade preparation, and placement of engineered fill on the project. The section also outlines the recommendations for design and construction of earth-supported elements including foundations and slabs.

3.2.1 Site Preparation

Prior to placing any fill, all vegetation, topsoil, pavements, concrete, possible fill materials, and any otherwise unsuitable materials should be removed from the construction areas. Exposed surfaces should be free of mounds and depressions, which could prevent uniform compaction. Stripped materials consisting of vegetation and organic materials should be removed from the site or used to revegetate landscaped areas or exposed slopes after grading operations are complete.

3.2.2 Excavations

During construction, the sides of the excavations will contain loose material; consequently, the areas should be monitored by workers and loose material should be removed. All excavations should be conducted to Occupational Safety and Health Administration (OSHA) approved slopes.

Excavation activities for any purpose should not remove lateral support from any footing or foundation without first underpinning or protecting the footing or foundation against settlement or lateral translation.

Over-excavation areas and utility trenches should be laid back to safe slopes or properly shored. Excavations and shoring operations should be conducted in accordance with the most recent versions of the OSHA Construction Standards for Excavations, Part 1926, Subpart P and Montana Public Works Standard Specifications (MPWSS). Safety of construction personnel is the responsibility of the contractor. Excavations for utilities should be shored if the proper slope cannot be maintained.

The depth and thickness of the individual layers of materials may be different from what was observed in the borehole. This variability may alter the necessary depth of the excavation at different locations of the proposed footprint. If fine-grained materials (clays or silts) are observed beneath structural elements, the geotechnical engineer should be notified and will determine if the recommendations presented in this report still apply.

3.2.3 Subgrade Preparation

At a minimum, all excavations for footings or slab must be over excavated vertically 1 foot below the bottom of the footing, then backfilled with compacted structural fill. For fills required beneath the footing or slab, the excavation should extend beyond the edge of the footing a distance equal to the depth of the fill placed below the footing. The bearing surfaces of all native soil must be compacted with heavy vibratory equipment before placing the structural fill.

The surface of the excavation should be monitored to detect pockets of soft or loose soil. The bottom of the excavation should be probed to verify all deleterious materials or loose soils have been removed. Where possible, proof-rolling should be performed to aid in locating loose or soft areas. Unstable soil (pumping) should be removed or moisture conditioned and compacted in place prior to placing fill. When loose or disturbed native soil depth is greater than 1 foot, it may be necessary to remove and stockpile the upper loose soils to achieve compaction of all loose or disturbed soils within a foundation excavation.

Subgrade in all areas to receive fill should be compacted to the specified maximum dry unit weight, as obtained by ASTM Test Method D-698 (Standard Proctor). Excavation surfaces to receive compaction should be moisture conditioned and will be kept free of standing water at all times. Excavation surfaces to receive compaction will not be frozen or allowed to freeze following compaction. Frozen soils are identified by the observation of frost, frozen water, or a measured particle temperature less than or equal to 32 degrees Fahrenheit.

Provide the opportunity for the geotechnical engineer to perform a foundation inspection prior to forming foundations. Engineer will direct over-excavation if unsuitable soil (clay), debris, or yielding soil is observed.

3.2.4 Fill Materials and Placement

All fill materials should be inorganic soil free of vegetation, debris, and fragments larger than 6 inches in size. Structural backfill beneath the foundation and slab in any area requiring fill should consist of 6-inch minus, well-graded gravel with less than 6% by weight passing the #200 sieve (Unified Soil Classification System classification GW). If compacted, the fill material will provide a strong, free draining, and non-frost susceptible foundation that will not settle over time. Pea gravel and other similar non-cementitious, poorly graded materials should not be used as fill or backfill without the prior approval of the geotechnical engineer.

Sort and stockpile-excavated soils for re-use. Clean, well-graded granular soils may be stockpiled for re-use as structural fill if they satisfy the structural fill recommendations above. If imported structural fill is necessary, this material should satisfy the gradation shown in Table 2.

Table 2: Structural Fill
MPWSS 1.5-inch Minus Base Course

Sieve Size	Percent Passing
1.5-inch	100
No. 4	25 - 60
No. 200	0 - 8

Clean granular soils may also be stockpiled for use as general fill if they satisfy gradation requirements listed in Table 3.

Table 3: General Fill

Sieve Size	Percent Passing
4-inch	100
1.5-inch	50 - 100
No. 10	20 - 70
No. 200	40 max.

Stripped materials consisting of vegetation and organic materials should be removed from the site or used to revegetate landscaped areas or exposed slopes after grading operations are complete.

Moisture condition subgrade soil, general fill and structural fill to plus or minus 2% of optimum moisture content. Structural fill should be placed on native soil that has been compacted as specified previously in Section 3.2.3. All fill should be compacted to the maximum dry unit weight, as obtained by ASTM Test Method D-698 (Standard Proctor), shown in Table 4 below.

Table 4. Compaction Specifications

Location	Percent Maximum Standard Proctor Density (%)
Beneath Structural Elements	98%
Beneath Slab-On-Grade	95%
Foundation Wall Backfill	95%
Exterior Concrete Flatwork	95%

Fill materials should not be placed, spread, or compacted while the ground is frozen or during unfavorable weather conditions. The excavation must be always kept free of standing water. If water is allowed to pond in excavations, all soil impacted by the standing water should be removed, moisture conditioned, and replaced to the specification listed in Table 4.

Fill materials should be at the proper moisture content prior to compaction and should contain no frozen soil. When site grading is interrupted by heavy precipitation, filling operations should not resume until a geotechnical engineer approves the moisture and density conditions of the previously placed fill.

3.3 Shallow Foundation

Site soils are suitable to support the proposed structures on mat slab or spread footing shallow foundations provided the native soils are properly compacted in accordance with the recommendations presented herein.

All surfaces to receive fill, mat slab, or spread footing should be excavated flat before placement of any structural fill, and the structural fill should be placed in horizontal layers and compacted in accordance with recommendations for structural fill. Placing the foundations partially on fill and partially on cut is not recommended. This can lead to differential settlement and cause long-term cracking of the foundations.

For an unheated structure, a minimum of 5 feet of fill should be placed over the bottom of the footing. For a heated structure, a minimum of 4 feet of fill should be placed over the bottom of the footing. These depths can be reduced if rigid polystyrene is placed beneath and around the exterior of the foundation to limit frost penetration. Reducing the depth of frost penetration should be evaluated on a case-by-case basis according to American Society of Civil Engineers (ASCE) Design and Construction of Frost-Protected Shallow Foundations guidelines (ASCE, 2001).

Net allowable bearing capacities of 3,000 pounds per square foot (psf) can be accepted for structural fills if the soil beneath the footings are compacted as described previously. This allowable bearing capacity is based on limiting potential long-term settlement. Failure to compact native soils that underlie foundations could result in excessive foundation settlement. A documented testing program should be conducted to verify that compaction requirements were achieved. The net allowable soil pressure includes dead load plus maximum live load. These recommendations assume a minimum depth of burial of the footing of 4 feet and that a maximum total settlement of 1 inch can be tolerated.

Provided the compaction operations are properly conducted and the relative compaction specified in Table 4 is met, the slabs can be designed using a modulus of subgrade reaction, k, of 350 pounds per square inch per inch of deflection (pci).

3.4 Lateral Loads

Lateral loads may be resisted by friction between the footing base and supporting soil and lateral bearing pressure against the side of the footings. To calculate the resistance to sliding, a value of 0.36 should be used as the ultimate coefficient of friction between the footing and the underlying structural fill. For design purposes, earth pressures are listed on a per-foot basis. Compacting site material as backfill will offer an internal angle of friction (ϕ) of at least 32°, and a moist unit weight (γ_m) of at least 135 pounds per cubic foot. For soil pressures in psf against the slab with a level backfill, the following equations can be used:

Active Pressure: $21 \times H^2$
Passive Pressure: $220 \times H^2$
At-rest Pressure: $32 \times H^2$

Where H = height of retaining wall or slab height in feet.

The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on walls.

3.5 Moisture Protection and Surface Drainage

It is important to prevent infiltration of the surface waters to the soil beneath the foundations. Therefore, precautions should be taken during and after construction to provide positive drainage and surface water control near the new foundations.

The recommended slope for landscape areas and areas adjacent to the foundations should be a minimum of 3%. A cap consisting of 12 inches of clayey soils will assist in preventing infiltration of these waters near the foundation perimeter. Positive surface drainage will provide the greatest insurance against infiltration of surface waters. Infiltration of large quantities of water could lead to soil movement due to settlement or piping of foundation soil if foundations are not properly prepared.

All utility trenches within the pad and extending 5 feet beyond the structural footings should be backfilled with structural fill compacted to a relative compaction of 95% of the maximum dry unit weight as obtained by ASTM Test Method D-698 (Standard Proctor).

Surface water drainage should not be concentrated in a gully that will affect property below the development area. The site investigation did not evaluate surface drainage.

3.6 Slab-On-Grade

For a slab-on-grade floor system for the new dining hall, Pioneer recommends the following:

1. Over-excavate a minimum of 6 inches beneath the slab.
2. Inspect the bottom of the excavation. Any soft zones, debris, or areas of yielding should be over-excavated to native sand and gravel deposits.
3. Moisture condition subgrade soil to plus or minus 2% of optimum moisture content and compact the excavation surface to a standard relative compaction (ASTM D698) of at least 95%.
4. Place Structural Fill meeting the gradation specifications listed in Table 2 to slab elevation. Place in 8-inch (maximum) loose lifts and compact each lift to a standard relative compaction of at least 95%.

5. From a geotechnical perspective, a vapor barrier is not required. Vapor barriers are used to prevent moisture and gas vapors (typically radon) from migrating through the floor slab. Some floor coverings are moisture-sensitive and are intended for use with vapor barriers. The project architect should determine the need for a vapor barrier based on the floor coverings and moisture and gas vapor control requirements. If a vapor barrier is to be installed, Pioneer recommends placing a 15-mil polyolefin vapor barrier. The vapor barrier should be installed over the base course prior to pouring the concrete slab if the slab is being placed without a watertight roofing system in place. The vapor barrier can be installed under the base course if the slab is being placed with a watertight roofing system in place.

For structural design of the concrete slab, Pioneer recommends using a subgrade modulus of 300 pci.

3.7 Exterior Concrete Flatwork

For exterior concrete flatwork, Pioneer recommends the following:

1. Over-excavate a minimum of 6-inches below the bottom of any concrete flatwork.
2. Inspect the bottom of the excavation. Any soft zones, debris, or areas of yielding should be over-excavated to native sand and gravel deposits.
3. Moisture condition subgrade soil to plus or minus 2% of optimum moisture content and compact the excavation surface to a standard relative compaction (ASTM D698) of at least 95%.
4. Place base course meeting the gradation requirements listed in Table 2 (Structural Fill). Place in 8-inch (maximum) loose lifts and compact each lift to a standard relative compaction of at least 95% prior to forming for the concrete flatwork.
5. Exterior slabs for pedestrian use should be at least 4 inches in thickness. Exterior slabs for light duty vehicle use should be at least 6 inches in thickness. Please consult Pioneer for specific rigid pavement recommendations if warranted. Exterior concrete flatwork recommendations provided herein are not intended for heavy duty vehicle use or high traffic volumes.
6. To help control shrinkage cracking, concrete slabs should be reinforced with wire mesh reinforcement (6x6 W2.9xW2.9 welded wire fabric). Provide wire supports and spacers to support all reinforcement in proper locations and tie adequately at intersections to hold wire firmly in position while concrete is placed. Wire supports and spacers that rest on exposed surfaces should be hot dipped galvanized or plastic coated. Center the welded wire reinforcement in the slab.
7. Space construction and control joints a maximum of 8 feet on-center. All saw-cut joints will be ‘soft cut’ sawn as soon as allowed by the saw manufacturer’s recommendations. After the slab finishing has been completed, construct joints within 4 hours in hot weather and within 12 hours in cold weather after slab finish is completed.

8. Install expansion joints between slabs no more than 40 feet apart, at the sidewalk/driveway and sidewalk/doorway entry interfaces. At each of these locations, provide expansion joints with a minimum 0.75-inch width. Fill all expansion joints with a field-molded sealant.

3.8 Seismic Considerations

The project is within the area of western Montana, located in the Intermountain region of the U.S., which is characterized by a number of late-Quaternary Basin and Range normal faults and historic seismicity. The two largest historical events in the region are the 1959 Hebgen Lake earthquake with moment magnitude (**M)** 7.3 and the 1925 Clarkson earthquake with **M** 6.6, whose fault source remains unknown (Wong et al., 2005). The Gallatin Valley is bounded by four Quaternary-aged faults. Clockwise and starting in the north, the Central Park Fault (9 miles to the north), Bridger Fault (9 miles to the east, Gallatin Range Fault (10 miles to the south southeast) and the Elk Creek fault (11 miles to the south southwest).

The Central Park fault strikes N77°E from Buffalo Jump State Park to Spring Hill, 18.6 miles. No information is available on the rates of activity of this fault and associated scarps are not known. Estimated slip rates are believed to be less than 0.2 millimeters per year (mm/yr).

The Bridger fault strikes N9°W along the west side of the Bridger Range for 30 miles. No information is available on the rates of activity of this fault and associated scarps are not known. Estimated slip rates are believed to be less than 0.2 mm/yr.

The Gallatin fault strikes N63°E along the northern edge of the Gallatin Range for just over 16 miles. No information is available on the rates of activity of this fault and associated scarps are not known. Estimated slip rates are believed to be less than 0.2 mm/yr.

The Elk Creek fault strikes N62°W along the northern edge of the Spanish Breaks for nearly 17.5 miles. No information is available on the rates of activity of this fault and associated scarps are not known. Estimated slip rates are believed to be less than 0.2 mm/yr.

The team completed a screening level liquefaction assessment. As a definition, liquefaction is regarded as a loss of shearing resistance or the development of excessive strains because of transient or repeated disturbance of saturated cohesionless soils. Three conditions must be in place for liquefaction to occur: 1) a liquefaction susceptible soil; 2) saturated soil; and 3) a seismic event.

Static groundwater was not observed within the test pits. Therefore, condition 2 is not met within the upper 10 to 12 feet, and liquefaction of the site soil is unlikely. Furthermore, coarse alluvial gravels are rarely, if ever, susceptible to liquefaction.

Based on the types of soils and their engineering properties per the 2012 International Building Code, the site is assigned as **Site Class C** for *Very Dense Soil to Soft Rock*. The seismic coefficients were estimated using the 2012 International Building Code, which uses the 2008 U.S. Geological Survey (USGS) hazard data (USGS, 2018). These parameters are for a Risk

Category I/II/III and are a function of the site's seismicity and soil (Table 5). The seismic coefficients data sheet is included in Appendix D.

Table 5: Seismic Coefficients

International Building Code 2012, Earthquake Loads	
Site Class Definition	C
Mapped Spectral Response Acceleration Parameter, S_S for 0.2 second	0.72g
Mapped Spectral Response Acceleration Parameter, S_1 for 1.0 second	0.20g
Adjusted Maximum Considered Earthquake Spectral Response Acceleration Parameter, S_{MS}	0.78g
Adjusted Maximum Considered Earthquake Spectral Response Acceleration Parameter, S_{M1}	0.28g
Design Spectral Response Acceleration Parameter, S_{DS}	0.52g
Design Spectral Response Acceleration Parameter, S_{D1}	0.19g

g: acceleration of gravity 32.2 feet/second^2.

3.9 Underground Utilities and Trench Stability

Utility trenches should be laid back to safe slopes or properly shored. Excavations and shoring operations should be conducted in accordance with the most recent versions of the OSHA Construction Standards for Excavations, Part 1926, Subpart P and MPWSS. Safety of construction personnel is the responsibility of the contractor. Excavations for utilities should be shored if the proper slope cannot be maintained.

Use Type I bedding soils beneath and up to 6 inches above the top of the pipe. Type I bedding soils are 0.75-inch minus granular soils having a soluble sulfate content less than 0.1% and a resistivity greater than 3,000 ohm-centimeters. On-site soil can be used as trench backfill above the bedding soil. Take care when processing on-site soil such that cobbles are not placed next to utilities. Place the trench soil in 8-inch (maximum) loose lifts and compact to a standard relative compaction (ASTM D698) of at least 95%.

3.10 Shrink/Swell Characteristics

The volume change potential of the native sand and gravel is considered low based on the granular composition of the soil. Regardless, Pioneer recommends the following be incorporated into the design:

1. Roof runoff water is to be collected in a gutter/downspout system and routed away from the foundations.
2. Grades (minimum 3%) should be designed and constructed to promote positive drainage away from the building perimeter.
3. Avoid placing plantings and irrigation systems immediately adjacent to the building.

4 EARTHWORK TESTING

Pioneer recommends that a qualified inspector perform compaction testing for subgrade, general fill, structural fill, and base course. Table 6 lists the suggested minimum compaction testing frequency.

Table 6: Compaction Testing Frequency

Location	Frequency
Beneath Strip Footings	1 test per 25 linear feet of footing per lift
Beneath Column Footings	1 test per footing per lift
Beneath Slab-On-Grade	1 test per 400 square feet per lift
Foundation Wall Backfill	1 test per 50 linear feet per lift
Beneath Exterior Concrete Flatwork	1 test per 1,000 square feet per lift or 1 test per 300 lineal feet per lift

Table 7 summarizes the material compaction specifications presented in other sections of this report. Compaction testing should be performed on subgrade, general fill, structural fill, and base course. Frozen soil, ice particles, and soil with organics, debris, or deleterious materials are not suitable for use as fill. Appropriate winter construction techniques must be used, as warranted, to protect subgrade, fill, and cast concrete from frost. Fill or cast concrete must not be placed on top of frozen soil. Maximum loose lift thickness is 8 inches.

Table 7: Required Relative Compaction

Location	Required Minimum Compaction	Standard
Beneath Foundation Footings	98%	ASTM D698
Beneath Slab-On-Grade	95%	ASTM D698
Foundation Wall Backfill	95%	ASTM D698
Exterior Concrete Flatwork	95%	ASTM D698

Concrete testing frequency should be performed in accordance with project specifications and/or structural engineer requirements.

5 BASIS OF RECOMMENDATIONS

The analyses and recommendations submitted in this report are based on observations made during excavation of the test pits and our general site familiarity. Often, variations occur within the subgrade, the nature and extent of which do not become evident until additional exploration or construction is conducted. Pioneer recommends that during earthmoving operations a qualified geotechnical engineer be present to evaluate the foundation soils to verify their resemblance to those encountered during our site investigation.

5.1 *Review of Design*

This report is based on Pioneer's understanding of the preliminary design locations associated with the proposed foundations. If the locations change, please consult Pioneer to verify that our recommendations still apply.

5.2 *Use of Report*

This report is for the exclusive use of Gallatin County and their design team. In the absence of Pioneer's written approval, Pioneer 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. Pioneer recommends that other parties contemplating other structures or purposes contact us.

CERTIFICATION

Pioneer Technical Services, Inc.

Services performed by Pioneer Technical Services, Inc. personnel for this project have been conducted with the 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 the geotechnical portions of this report were prepared by me and that I am a duly Licensed Professional Engineer under the laws of the State of Montana.

JEFFREY J. RIEDEL
No. 17359 PE

12-8-23

Jeffrey J. Riedel, P.E.
Sr. Geotechnical Engineer

6 REFERENCES

ACI, 2008. ACI 201.2R-08 Guide to Durable Concrete. American Concrete Institute, 2008.

ASCE, 2001. Design and Construction of Frost-Protected Shallow Foundations, SEI/ASCE32-01, American Society of Civil Engineers, Reston, Virginia.

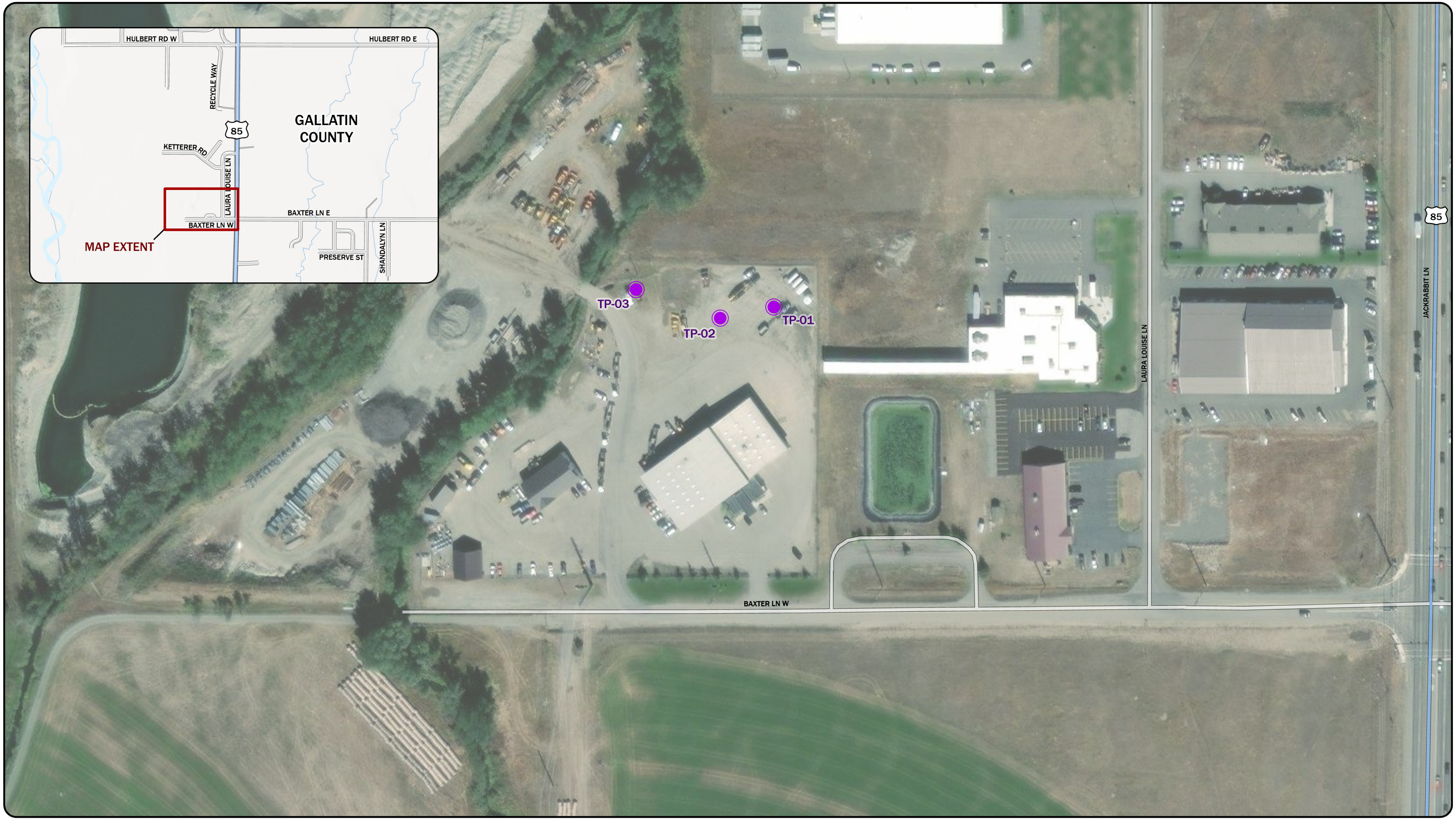
Vuke, S.M., 2003. Geologic Map of Western and Northern Gallatin Valley, Southwestern Montana. Montana Bureau of Mines and Geology Open-File Report 481.

USGS, 2018. U.S. Geological Survey, U.S. Seismic Design Maps. Online Application. Available at https://earthquake.usgs.gov/designmaps/us/application.php. 2020, December 15.

Wong, I., S. Olig, M. Dober, D. Wright, E. Nemser, D. Lageson, W. Silva, M. Stickney, M. Lemieux, and L. Anderson, 2005. Probabilistic Earthquake Hazard Maps for the State of Montana. Prepared for: Montana Department of Natural Resources and Conservation Dam Safety Program, Montana Bureau of Mines and Geology.

Figures

Figure 1. Site Map



LEGEND

● TEST PIT LOCATIONS

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD 1983
UNITS: INT'L FEET
SOURCE: ESRI/PIONEER

0 100 200 400
US Feet

PIONEER
TECHNICAL SERVICES, INC.

GALLATIN COUNTY SHOP
TEST PIT LOCATIONS

DATE: 12/8/2023

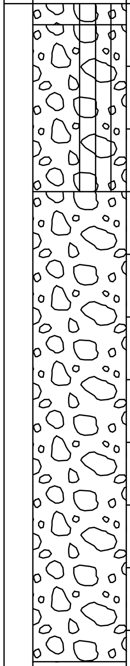
Path: Z:\Shared\Active Projects\GallatinCoShop\GallatinCoShop_Figures\GallatinCoShop_Figures.aprx\Test Pit Locations_GallatinCountyShop

Appendix A
Test Pit Logs

Test Pit No. TP-01

PROJECT NAME: Gallatin County Yards Shop
DATE STARTED / FINISHED: 10/18/23 - 10/18/23
LOGGED BY: N. Griffis
GROUND SURFACE ELEVATION:
TEST PIT LOCATION:
EXCAVATION CO.: Gallatin County
EXCAVATOR TYPE: 210G John Deere Excavation
BUCKET TYPE: NA
WHEELED OR TRACKED:

This log is part of a report prepared by Pioneer Technical, Inc. for this project and should be read with the report. This summary applies only at the location of the boring and at the time of the drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplication of actual conditions encountered.



WELL LOG	GRAPHIC LOG	DEPTH (FT)	SAMPLES DRIVE	SAMPLES UNDISTURBED	SAMPLES BULK	SAMPLE ID	RECOVERY (%)	MATERIAL DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	CORRECTED SPT	DRY DENSITY (pcf)	MOISTURE (%)	REMARKS / TESTING
								Moist, Dark gray, GRAVEL with Silt and Sand, GP-GM, non-plastic, Compacted 3/4-inch minus road mix.						
		1 2						Moist, Very dark grayish brown [10YR 3/2], GRAVEL with Silt and Sand, GP-GM, non-plastic, Compacted Pit Run, gravels rounded to subrounded to 3-inch maximum diameter.						
		3 4 5 6 7						Moist, Dark brown [10YR 3/3], GRAVEL with Sand, GP, non-plastic, gravels and cobbles rounded to subrounded to maximum 12" diameter, calcium carbonate undercoatings observed..						
		8 9 10			☒	G23427								Becoming more difficult to dig with depth
		11 12 13 14 15 16 17 18 19 20 21												Total depth = 10.5'; no free water observed while excavating

PIONEER
TECHNICAL SERVICES, INC.

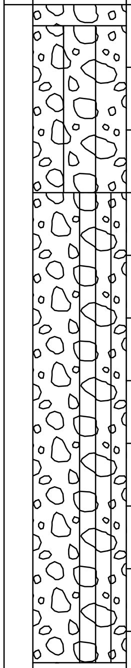
CLIENT: Gallatin County
ADDRESS: 205 West Baxter Lane
Bozeman, Montana
PHONE NUMBER:

Test Pit No. TP-02

PAGE 1 of 1

PROJECT NAME: Gallatin County Yards Shop
DATE STARTED / FINISHED: 10/18/23 - 10/18/23
LOGGED BY: N. Griffis
GROUND SURFACE ELEVATION:
TEST PIT LOCATION:
EXCAVATION CO.: Gallatin County
EXCAVATOR TYPE: 210G John Deere Excavation
BUCKET TYPE: NA
WHEELED OR TRACKED:

This log is part of a report prepared by Pioneer Technical, Inc. for this project and should be read with the report. This summary applies only at the location of the boring and at the time of the drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplication of actual conditions encountered.



WELL LOG	GRAPHIC LOG	DEPTH (FT)	SAMPLES: DRIVE	SAMPLES: UNDISTURBED	SAMPLES: BULK	SAMPLE ID	RECOVERY (%)	MATERIAL DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	CORRECTED SPT	DRY DENSITY (pcf)	MOISTURE (%)	REMARKS / TESTING
								Moist, GRAVEL with Sand, GP, non-plastic, 3/4" Minus Road Mix.						
		1 2						Moist, Brown, SILTY GRAVEL with Sand, GM, non-plastic, Compacted pit run fill; maximum gravel size = 4".						
		3 4 5						Moist, Brown, GRAVEL with Silt and Sand, GP-GM, non-plastic, Rounded to subrounded; maximum cobble size = 12".						
		6 7			☒	G23428								
		8 9 10												
		11 12 13 14 15 16 17 18 19 20 21												Total depth = 10.5'; no free water observed while excavating

PIONEER TECHNICAL SERVICES, INC.

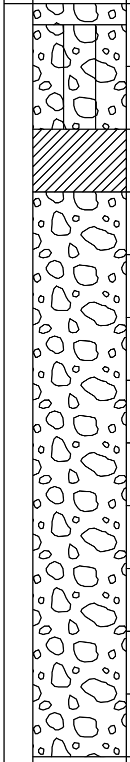
CLIENT: Gallatin County
ADDRESS: 205 West Baxter Lane
Bozeman, Montana
PHONE NUMBER:

Test Pit No. TP-03

PAGE 1 of 1

PROJECT NAME: Gallatin County Yards Shop	
DATE STARTED / FINISHED: 10/18/23 - 10/18/23	EXCAVATION CO.: Gallatin County
LOGGED BY: N. Griffis	EXCAVATOR TYPE: 210G John Deere Excavation
GROUND SURFACE ELEVATION:	BUCKET TYPE: NA
TEST PIT LOCATION:	WHEELED OR TRACKED:

This log is part of a report prepared by Pioneer Technical, Inc. for this project and should be read with the report. This summary applies only at the location of the boring and at the time of the drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplication of actual conditions encountered.



WELL LOG	GRAPHIC LOG	DEPTH (FT)	SAMPLES DRIVE	SAMPLES UNDISTURBED	SAMPLES BULK	SAMPLE ID	RECOVERY (%)	MATERIAL DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	CORRECTED SPT	DRY DENSITY (pcf)	MOISTURE (%)	REMARKS / TESTING
								Moist, Dark gray, GRAVEL with Sand, GP, non-plastic, Compacted 3/4-inch minus road mix.						
		1			☒	G23429		Moist, Very dark brown [10YR 2/2], SILTY GRAVEL with Sand, GM, non-plastic, Fill, easy digging, gravel round to subround to 4-inch maximum diameter.						
		2			☒	G23430		Moist, Black [10YR 2/1], LEAN CLAY, CL, low plasticity, likely native material.						Easy digging
		3 4 5 6 7 8 9 10 11						Moist, Dark brown [10YR 3/3], GRAVEL with Sand, GP, non-plastic, gravels and cobbles are round to subrounded to a maximum diameter of 12".						
		12 13 14 15 16 17 18 19 20 21												Total depth = 12.0'; no free water observed while excavating

PIONEER TECHNICAL SERVICES, INC.

CLIENT: Gallatin County

ADDRESS: 205 West Baxter Lane
Bozeman, Montana

PHONE NUMBER:

Appendix B
Photographic Log

Photograph 1:	TP-01

Photograph 2:	TP-01

Photograph 3:	TP-02

Photograph 4:	TP-02

Photograph 5:	TP-03

Photograph 6:	TP-03

Appendix C
Laboratory Analytical Data

Alpine Analytical Laboratory

1315 Cherry, Helena, MT 59601
(406)449-6282

Client: Pioneer Technical Services

Date Reported: 07-Nov-23

Sample ID: TP-2 (6'-7')
Project ID: Gallatin County Road & Bridge
Site ID: Gallatin County Shops

Chain of Custody #: 285

Laboratory ID: 05M142
Sample Matrix: Soil

Date / Time Sampled: 18-Oct-23
Date / Time Received: 03-Nov-23 @ 11:00

			Analyzed		Method
Parameter	**Result**	**PQL**	**Date/Time**	**By**	**Reference**
Soluble Sulfate, %	0.0017	0.00005	06-Nov-23 @ 18:44	CE	EPA 300.0
pH, s.u.	8.1	0.01	06-Nov-23 @ 12:15	CE	MT 232-04

Comments:

PQL - Practical Quantitation Limit

References:

Methods for Chemical Analysis of Water and Wastes, US EPA, 600/4-79-020
Method of Sampling and Testing MT232-04, *Soil Corrosion Test* (Montana Method).

Reviewed by: CE

Alpine Analytical Laboratory

1315 Cherry Ave. Helena, MT 59601
(406) 449-6282

Chain of Custody 0285

www.alpineanalytical.com

Invoice to: Pioneer Technical Services Inc.
(Karren Dorvall)
Address 1101 S. Montana St
City Butte State MT Zip 59701
Phone 406-782-55177
e-mail kdorvall@pioneer-technical.com
Send Via: Mail ☐ e-mail ☐ Pick-up ☐
Report: Yes ☐ No ☐

Report To: (If different than invoice) Pioneer technical Services
(Jeff Riedel)
Address 106 Proghorn Trail
City Bozeman State MT Zip 59718
Phone 406-723-1995 ext. 8704
e-mail jriedel@pioneer-technical.com
Send Via: Mail ☐ e-mail ☒ Pick-up ☐
Copy of Invoice: Yes ☐ No ☐

Gallatin County Road and Bridge
Project ID Gallatin County Shops
Site ID Niki Griffis
Sampler (print)
Sampler (signature)

Analysis Requested

Sample Identification	Sample Date	Sample Time	Type Grab	Type Comp	Matrix	Number of Containers	Soil Corrosion (pH & Sulphates)				Comments	Lab use only LAB ID
TP-2 (6'-7')	10-18					1 Bucket	X				Native Gravel	G23428
												SM#2

Relinquished by: Travis Sammons
Date: 10-30-23
Time: 9:54
Received by: Kae
Date: 10/31/23
Time: 11:00

Temperature Received °C / Condition Received
Shipped: FEDEX ☐ UPS ☐ MAIL ☐ HAND DELIVERED ☐ BUS ☐
Remarks:

** An additional cost may be incurred for samples disposed of by *Alpine Analytical Laboratory*.
** An additional weekend cost will be incurred for samples that are read back on a weekend or a Holiday. (ex. Total Coliform, Fecal Coliform, BOD, etc.)

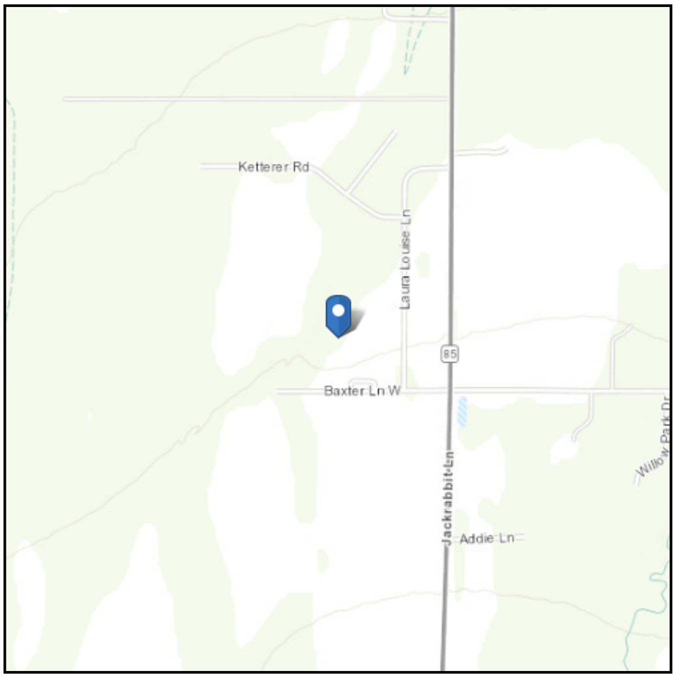
Appendix D
Seismic Data

ASCE 7 Hazards Report

Address:
No Address at This Location

Standard: ASCE/SEI 7-22
Risk Category: III
Soil Class: C - Very Dense Soil and Soft Rock

Latitude: 45.701417
Longitude: -111.18937
Elevation: 4635.864966851611 ft (NAVD 88)



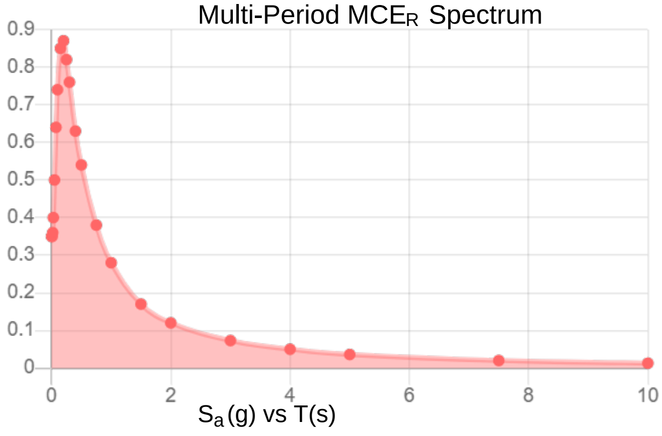
Seismic

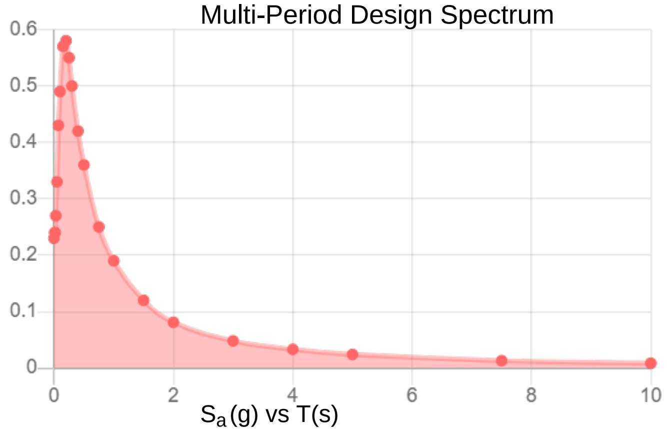
Site Soil Class: C - Very Dense Soil and Soft Rock

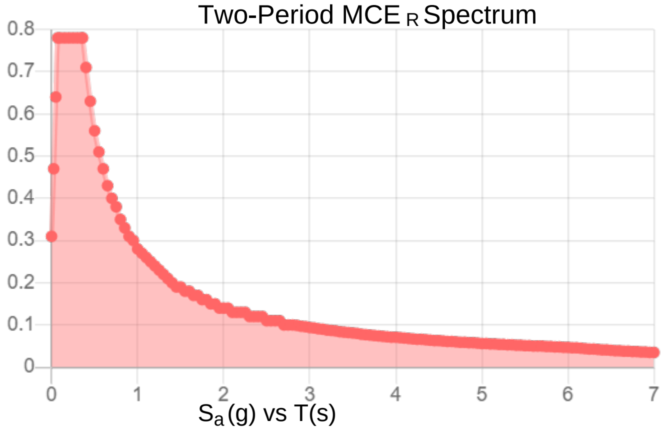
Results:

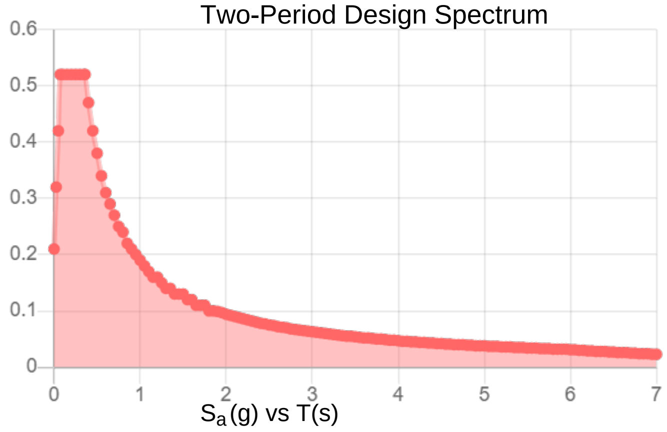
PGA_M :	0.33	T_L :	6
S_{MS} :	0.78	S_S :	0.72
S_{M1} :	0.28	S_1 :	0.2
S_{DS} :	0.52	V_{S30} :	530
S_{D1} :	0.19		

Seismic Design Category: D


Multi-Period MCE_R Spectrum


Multi-Period Design Spectrum


Two-Period MCE_R Spectrum


Two-Period Design Spectrum

MCE_R Vertical Response Spectrum

Vertical ground motion data has not yet been made available by USGS.

Design Vertical Response Spectrum

Vertical ground motion data has not yet been made available by USGS.

Data Accessed: **Thu Dec 07 2023**

Date Source:

USGS Seismic Design Maps based on ASCE/SEI 7-22 and ASCE/SEI 7-22 Table 1.5-2. Additional data for site-specific ground motion procedures in accordance with ASCE/SEI 7-22 Ch. 21 are available from USGS.

The ASCE 7 Hazard Tool is provided for your convenience, for informational purposes only, and is provided “as is” and without warranties of any kind. The location data included herein has been obtained from information developed, produced, and maintained by third party providers; or has been extrapolated from maps incorporated in the ASCE 7 standard. While ASCE has made every effort to use data obtained from reliable sources or methodologies, ASCE does not make any representations or warranties as to the accuracy, completeness, reliability, currency, or quality of any data provided herein. Any third-party links provided by this Tool should not be construed as an endorsement, affiliation, relationship, or sponsorship of such third-party content by or from ASCE.

ASCE does not intend, nor should anyone interpret, the results provided by this Tool to replace the sound judgment of a competent professional, having knowledge and experience in the appropriate field(s) of practice, nor to substitute for the standard of care required of such professionals in interpreting and applying the contents of this Tool or the ASCE 7 standard.

In using this Tool, you expressly assume all risks associated with your use. Under no circumstances shall ASCE or its officers, directors, employees, members, affiliates, or agents be liable to you or any other person for any direct, indirect, special, incidental, or consequential damages arising from or related to your use of, or reliance on, the Tool or any information obtained therein. To the fullest extent permitted by law, you agree to release and hold harmless ASCE from any and all liability of any nature arising out of or resulting from any use of data provided by the ASCE 7 Hazard Tool.