# Geotechnical Recommendations Report for MSU Parking Area Reconstruction – Stadium and Museum of the Rockies Montana State University, Bozeman, MT

FEBRUARY 14, 2024
ISSUED FOR REVIEW
FILE: 117-001068-2400

**PRESENTED TO**

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# ACRONYMS & ABBREVIATIONS

| Acronyms/Abbreviations | Definition |
|---|---|
| AASHTO | American Association of State Highway and Transportation Officials |
| ASTM | American Society for Testing and Materials |
| bgs | below the ground surface |
| CAC | crushed aggregate course |
| CBR | California Bearing Ratio |
| CTB | cement treated base |
| HMA | Hot-Mix-Asphalt |
| MOR | Museum of the Rockies |
| MSU | Montana State University |
| pcf | pounds per cubic foot |
| pci | pounds per cubic inch |
| psi | pounds per square inch |
| SPT | Standard Penetration Test |

# 1.0 INTRODUCTION

Tetra Tech has been retained by Montana State University (MSU) Facilities to perform subsurface explorations and provide geotechnical foundation recommendations for the reconstruction and expansion of the MSU Bobcat Stadium and Museum of the Rockies (MOR) parking areas. The purpose of the project is to replace existing paved areas,  and to improve and expand existing gravel surfaced parking areas around the MSU Stadium.

This report covers the geotechnical exploration and design efforts for the Stadium Lot and MOR Lots within the MSU campus.

# 2.0 SITE DESCRIPTION AND PROJECT UNDERSTANDING

The project site is located within the MSU Campus in the areas directly surrounding the MSU Bobcat Stadium. Currently the area is mostly comprised of gravel parking areas with paved drive lanes surrounding the stadium. In some areas primarily along the south side the parking areas are expected to be expanded into existing undisturbed grass fields with minor landscaping. We understand the proposed project is expected to consist of removing or reclaiming the existing paved drive lanes, regrading the parking areas to improve drainage, and placing an asphalt surface throughout as well as constructing a concrete pavement apron in select areas near the stadium. The approximate limits of the paving areas are shown in Figure 1 and the locations of the exploratory borings are shown in Figure 2.

# 3.0 FIELD EXPLORATION

Tetra Tech performed a geotechnical subsurface exploration within the Stadium and Museum of the Rockies proposed parking areas on December 13th and 14th, 2023, which consisted of advancing 14 boreholes and three infiltration testing boreholes throughout the project area. The borings were advanced up to 6.5 feet below the ground surface (bgs). On February 1st, Tetra Tech performed a second geotechnical exploration at the site, which included advancing three infiltration test boreholes to deeper depths near the locations of the infiltration tests performed in December. The three additional infiltration test boreholes were advanced to 15 feet bgs and terminated within underlying alluvial gravel subsoils. Prior to both phases of the subsurface exploration, we marked exploratory locations and Montana One Call (811DIG) was contacted to request the location and clearance of public underground utilities before performing drilling. MSU facilities personnel visited the site to identify any conflicts with public utilities.

O'Keefe Drilling from Butte, Montana was subcontracted to advance the exploratory borings for both field exploration phases. Borings were advanced using a truck-mounted Mobile B60X drill rig equipped with 8-inch outside diameter, continuous flight, hollow stem augers and 12-inch, continuous flight, hollow stem augers for the infiltration tests. As the boring progressed, Tetra Tech's onsite field engineer provided technical oversight, which consisted of observing drilling operations, visually classifying soil samples collected, bagging select soil samples for laboratory testing, developing field borehole logs, and installing infiltration testing standpipes.

Samples of the subsurface materials were collected by advancing 2-inch outside diameter split-spoon samplers into the subsurface strata using a 140-pound hammer falling 30 inches onto the drill rods. The number of blows required to advance the sampler each of three successive 6-inch increments was recorded and the total number of blows required to advance the sampler the second and third 6-inch increments is the penetration resistance (N value), as described by ASTM International (ASTM) Method D1586. Penetration resistance values generally indicate the relative density or consistency of the subsurface soils. Bulk samples of disturbed materials were collected from auger cuttings for moisture density testing.

Boring logs were prepared noting the borehole location and elevation, equipment and drill methods used, subsurface profile and descriptions per ASTM D2487, and groundwater conditions (not encountered). Depths at which the samples were obtained along with the penetration resistance values are shown on the logs of exploratory borings, presented in Appendix A. Boring locations were collected at the time of the field exploration using a handheld GPS system and elevations were inferred from the plan documents provided by DJ&A.

## 3.1 Infiltration Testing

During the December geotechnical exploration, Tetra Tech installed three 4-inch solid PVC pipes (INF23-01A, 02A, 03A) through hollow stem augers to depths of approximately 5 feet bgs and terminated in clay soils. The infiltration testing of the clay soils indicated little to no infiltration throughout the three hours of testing and the tests were abandoned.

On February 1st, we returned to the site and advanced three exploratory borings near the locations of INF23-01A, 02A, and 03A to perform an infiltration testing on the underlying native gravels. Native gravel soils were encountered in the three borings between 9 and 12 feet bgs in each of the borings and the approximate depths are presented in Figures A-2, A-4, and A-6 in Appendix A. We installed two 4-inch solid PVC pipes through hollow stem augers to the underlying native gravels in INF24-02B and 24-03B. No infiltration testing was performed on INF24-01B, as design plans had changed, per discussions with DJ&A, and the area south of MOR was no longer expected to be developed during this project. Following installation of the PVC, the auger was removed from the borehole and the remaining borehole was backfilled with auger cuttings. Infiltration testing was subsequently performed through the open-end of the pipe. For the infiltration tests, an approximate 4-foot head of water was used at the beginning of each trial and the time for the water column to drop 24 inches was measured. The infiltration rates displayed in Table 3.1 below are the average of the last four measured rates not varying by more than 10 percent.

**Table 3.1: Infiltration Test Results**

| Test Location | Soil Type (USCS) | Depth (Below Existing Ground) | Infiltration Rate (in/hr.) |
|---|---|---|---|
| INF24-02B | GP-GM | 14 ft | 68.5 |
| INF24-03B | GP-GM | 12.5 ft | 94.5 |

# 4.0 LABORATORY TESTING

Samples obtained during the field exploration were taken to Tetra Tech's laboratory, where they were observed and visually classified in accordance with ASTM Method D2488, which is based on the Unified Soil Classification System. Representative samples were selected for testing to determine the physical properties of the soils in general accordance with ASTM or other approved procedures. The following list describes laboratory testing completed, and their purpose:

| **Tests Conducted:** | **To Determine:** |
|---|---|
| Natural Moisture Content | Moisture content representative of field conditions at the time samples were taken. |
| Grain-size Distribution | Size and distribution of soil particles (i.e., clay, silt, sand, and gravel). |
| Atterberg Limits | The effect of varying water content on the consistency of fine-grained soils. |
| Moisture-Density Relationship | The optimum moisture content for compacting soil and the maximum dry unit weight (density) for a given compactive effort. |
| California Bearing Ratio (CBR) | The capacity of a subgrade or subbase to support a pavement section designed to carry a specific traffic load. |

Field and laboratory test results are summarized in presented on Figures B-1 through B-14 in Appendix B. This data, along with the field information, were used to prepare the logs of exploratory borings in Appendix A.

# 5.0 SUBSURFACE CONDITIONS

The following section presents subsurface soil conditions encountered during our geotechnical exploration. Subsurface soils were classified in accordance with the ASTM Soil Classification System and soil classifications are included on the logs and laboratory data presented in Appendix A and B for each soil sample tested.

A characterization of the subsurface profile includes grouping soils having similar physical and engineering properties into several distinct layers. The soils encountered within the exploratory borings are discussed in detail below, beginning at the ground surface. The boring logs in Appendix A should be referenced for complete descriptions of the soil types and their estimated depths.

## 5.1 Asphalt

In general, the site consisted of paved drive lanes accessing the mostly gravel lots throughout the Stadium area. Borings within the existing asphalt areas encountered between three and six inches of asphalt surfacing with the majority being about four inches thick. Visual observations of the asphalt indicated the majority of the drive areas were in fair to good condition within minimal cracking and no signs of rutting.

## 5.2 Base Course

Poorly graded gravel surfacing was encountered throughout developed areas of the site and was used a surfacing layer in parking areas and a base course below paved travel lanes. The granular base course ranged in thickness from 3 to 32-inches and was generally 10 to 12-inches thick throughout the majority of the site. A bulk sample of the base course was tested from a depth of 0.5 to 1.5 feet from Boring 23-09. Results of the testing indicate the base course classified as a poorly graded gravel with silt and sand (GP-GM) and contained approximately 12 percent fines; results of the testing are shown in Figure B-4.

## 5.3 Topsoil

Surficial topsoil was encountered in undeveloped areas around the Stadium Lots and at the proposed MOR lot. The topsoil was generally dark brown to black in color and ranged in thickness from 2 to 24 inches thick.

## 5.4 Clay

The layer immediately beneath the granular base course in the Stadium borings consisted of natural clay soil that extended to about 11 to 12 feet bgs in the two infiltration borings performed within the north end of the Stadium lot. SPT blow counts within the native clay ranged from 2 to 11 blows per foot indicating a soft to stiff relative consistency.

Four bulk samples of the native clay were tested from samples collected at each of the proposed lots. Results of the testing indicated the clay classified as a sandy lean clay (CL) to lean clay with sand (CL). Liquid limits ranged from 42 to 25 percent and plastic limits ranged from 24 to 19 percent. Results of the testing are shown in Figures B-3, B-5, B-6, and B-8. Moisture density tests from bulk samples collected indicate the clays have a theoretical maximum dry density ranging from of 112 to 119 pounds per cubic foot with optimum moisture contents between 10 and 15 percent. Moisture density test results are shown in Figures B-9 through B-11. Bulk clay samples were tested under the California Bearing Ratio procedure to estimate the soils resilient modulus for traffic loading. The results of the CBR testing indicates the native clay soils have a CBR value between 3 and 11.

## 5.5 Native Gravel

Underlying the clay soils, we encountered native alluvial gravels that extended past the depth of exploration in INF24-02B and INF24-03B (Figures A-4 and A-6). A 2.5 foot thick gravel seam was encountered at 9 feet bgs in INF24-01B. Native gravels were generally coarse subrounded to rounded alluvial gravels. SPT blow counts within the gravel soils were generally over 50 blows per foot indicating a very dense relative consistency.

# 6.0 PAVEMENT SECTION DESIGN AND CONSTRUCTION

A pavement section is a layered system designed to distribute concentrated traffic loads to the subgrade. Performance of the pavement structure is directly related to the physical properties of the subgrade soils and the traffic loadings. A uniformly compacted subgrade free of excess moisture is vital for good pavement performance. The following sections discuss the existing subgrade soils, estimated daily traffic loading, flexible and rigid pavement design parameters, pavement alternatives, and associated costs.

## 6.1 Anticipated Traffic

Traffic within the Stadium and MOR Lots is expected to be moderate, consisting of primarily passenger cars, pickup trucks, garbage trucks, snowplows, and occasional semi-trucks and fire trucks. Tetra Tech estimated a maximum of 3 ESAL's per day over the next 20 years for flexible pavements and 30 years for rigid pavements.

## 6.2 Existing Subgrade Soils

Pavement design procedures are based on strength properties of the subgrade and pavement materials, along with the design traffic conditions. For pavement thickness design, subgrade soils are represented by means of a California Bearing Ratio (CBR) value for subgrade soils. The existing subgrade consisted of clay soils that are considered poor subgrade materials based on the AASHTO Soil Classification Chart. A representative CBR value of 3 which corresponds to a conservative soil resilient modulus of 3,000 pounds per square inch (psi) was used in the pavement analyses for the native clay subsoils.

Overlying the clay subgrade, we encountered gravel surfacing either as the wear coarse or underlying an asphalt surfacing layer. The gravel layer ranged in thickness from 3 to 30 inches in depth and averaged approximately 10-inches thick throughout most of the test areas. The boring logs should be referenced to evaluate approximate depths.

## 6.3 Pavement Materials

To best distribute traffic loadings a flexible pavement is generally constructed with a Hot-Mix-Asphalt (HMA) or a Portland Concrete Cement (PCC) surface, overlying a base course material, overlying a subbase course (if necessary), overlying subgrade soils. In accordance with the AASHTO 1993 flexible pavement design methodology, the HMA, base, and subbase materials are given a structural coefficient based on material strength and drainage characteristics. The following list presents pavement section layers and the associated structural layer coefficients used in our analyses and are based on our past project experience and published data.

- Hot-Mix Asphalt (HMA): asphaltic surfacing pavement and wear coarse – structural coefficient of 0.41
- Crushed Aggregate Course (CAC): common road base gravel mix – structural coefficient of 0.14
- Treated Base: for this project we assumed a water-based product, Base One, would be mixed with the existing base course to improve strength properties and decrease moisture penetration – structural coefficient of 0.20 used based on published data for roadway sections stabilized with Base One.
- Subbase – existing in place gravel surfacing – structural coefficient of 0.10

For the analysis and design of the rigid pavement sections we assumed the PCC pavement section would be constructed with 4,000 psi concrete or greater and estimated the clay subgrade and 10 inches of existing base would have an effective modulus of subgrade reaction of approximately 140 pounds per cubic inch (pci).

## 6.4 Site Grading

We evaluated the preliminary site grading plans provided by DJ&A on January 31$^{st}$, 2024 and shown in Figure 3 and 4. The following section presents an overview of the preliminary grading plans for various areas of the Stadium Lot.

### 6.4.1 Lot 20 – West of Stadium

Preliminary grading plans shown on Figure 3 indicate the majority of the lot will require excavation of the existing base and native clay soils to lower the final grade between 4 and 12 inches. Minor fill areas are expected to be required in areas along the south perimeter of the lot and near the north stadium entrance.

### 6.4.2 Lot 25 – East of Stadium

Preliminary grading plans shown on Figure 4 indicate areas north of the east stadium entrance will require excavation of the existing base and native clay soils to lower the final grade up to 13 inches. Areas to the south of the east entrance and along the south entrance to the stadium are expected to require up to 12 inches of fill to promote adequate drainage. Minor fill areas (up to 4 inches) are also expected to be required along the northeast perimeter of the stadium.

### 6.4.3 Grading Recommendations

Our pavement recommendations presented below were evaluated to limit the amount of import and export material by reusing the existing gravel base withing the parking area and balancing with the preliminary grading plans provided by DJ&A. Since the majority of Lot 20 and northern portions of lot 25 are expected to require significant cuts that will remove most if not all of the existing gravel base course. The base course thickness measured in the areas explored varied from 3 inches to over 12 inches. In an effort to reuse the existing base course, we recommend, 1) in the areas where asphalt exists, reclaim the existing asphalt and base in place to a depth of 8 inches, and 2) stockpiling the reclaimed asphalt/base mix and the existing gravel base onsite, for reuse as a subbase. Following stockpiling the entire site can be graded as necessary. This process will provide the most constructable design solution and provide a uniform section throughout the site, rather than cutting in some areas and raising grade at various locations throughout the site. The pavement recommendations in Section 6.5 present our pavement design recommendations based the stockpiling assumption.

### 6.4.4 Grading Drainage Considerations

Depending on the season and precipitation patterns, based on the information obtained at the time of drilling, the natural moisture content in the excavated material may be higher or lower than the optimum moisture content. Moisture- conditioning will be required to adjust the natural moisture content of the soils to within 2 percent of optimum moisture to achieve proper compaction. Unless the soils are processed to adjust the moisture content, it will be difficult to achieve compaction when placed as fill.

In addition, depending on the time of construction, natural moisture conditions and precipitation will influence the mobility of construction equipment. The use of low ground pressure, track-mounted excavation equipment should be anticipated by the contractor since tracks will exert lower ground pressures than pneumatic tires. In fine-grained subgrade soils such as these, pneumatic-tired equipment may rut the subgrade and reduce its shear strength. Construction mats may also be an acceptable alternative to provide a stable working platform for construction equipment and high traffic areas during wetter periods.

Site grading plans must include drainage features to rapidly drain surface run-off away from the site. All grades must provide effective drainage away from the pavement areas during and after construction in accordance with applicable Codes.

Careful attention should be given to weather conditions during preparation of the subgrade to prevent excess moisture from collecting on or penetrating and possibly saturating the subgrade before and after compaction. The subgrade should be temporarily sloped to provide drainage into a low area of the excavation and excess water should be pumped from the excavation into a nearby drainage sump. In the event that areas of subgrade become excessively saturated, the wet area should be excavated, replaced with moisture conditioned soil, and compacted. Such collection and discharge must be in compliance with the Contractor's site-specific storm water pollution prevention plan (SWPPP) and State water discharge permits.

## 6.5 Pavement Recommendations

Based on the anticipated traffic loading, subgrade soils, and preliminary grading plans we recommend reconstructing Lots 20 and 25 within the MSU Stadium Complex by:

- Where asphalt is present, reclaim the existing asphalt and base layers in place with a reclaiming machine, then stockpiling the reclaimed asphalt/base and existing gravel base onsite for reuse as subbase. The reclaimed material can be utilized as a subbase the same as the existing base layer and does not need to be stockpiled separately,
- Re-grade the natural clay subgrade to the desired elevation. Provided the existing clay is properly moisture-conditioned, it can be reused as fill where necessary,
- Proof roll the graded and compacted subgrade with a fully-loaded dump truck to identify soft areas, and replace soft or pumping soils with a high-strength geotextile fabric (Mirafi-380i or equivalent) and a minimum of two feet of pit run gravel fill,
- Place a woven geotextile separation fabric over the remainder of the subgrade that did not require subexcavation (Mirafi-180N or equivalent),
- Construct one of the two recommended pavement section Alternatives discussed in Table 6.1 below.

**Table 6.1: Reconstructed Pavement Section Alternatives**

| Design Section | Alternative 1 – New Base | | Alternative 2 – Base One Treated Base | |
|---|---|---|---|---|
| | Flexible | Rigid | Flexible | Rigid |
| **Layer 1** | 3-inches HMA | 5-inches PCC | 3-inch HMA | 5-inches PCC |
| **Layer 2** | 4-inches CAC | 4-inches CAC | 6-inches *Base One* Stabilized reused base | 6-inches *Base One* Stabilized reused base |
| **Layer 3** | 8-inches Reused Base | 6-inches Reused Base | 3-inches Reused Base | 2-inches Reused Base to serve as a buffer over the geotextile |
| **Separation Fabric** | Mirafi 180N or equivalent | | Mirafi 180N or equivalent | |
| **Assumed Subgrade Type** | Lean Clay | | Lean Clay | |

The above pavement design assumes the majority, or all of the required subbase material quantities will be available from onsite stockpiles of reclaimed gravel base. If additional, subbase materials are required for the final gradation, pit run gravel may be used as additional fill and is available from local sources.

### 6.5.1 Alternative Cost Benefits

The Alternative 2 pavement section provides several cost benefits over Alternative 1, including:

1. a reduced amount of subexcavation into the clay layer will be required based on a 9-inch gravel section for the flexible Alternative 2 in lieu of a 12 inch section for Flexible Alternative 1,
2. no new gravel will need to be imported for either flexible or rigid pavement section of Alternative 2,
3. the stabilized base will provide a much more rigid base layer to bridge over the native clay subgrade and support the asphalt and concrete sections than the crushed granular base layer.

The additional cost Items required for Alternative 2 are the cost to reclaim the existing asphalt in place, the cost of a reclamation machine to inject the base stabilizer, and the cost of the Base One product. The cost differences will need to be evaluated by the design team.

#### 6.5.1.1 Alternative 2 Preliminary Cost Estimate

For Alternative 2, the base stabilizer utilized for the analyses is Base One, a proprietary water-based stabilization agent designed to be used with gravel base layers.

Following is an estimated cost of the Base One product provided by the supplier, based on approximate area of asphalt and concrete provided by DJ&A. The depth of stabilization for this estimate is assumed to be 6 inches for both asphalt and concrete sections per our design.

Asphalt:
Heavy duty Pavement Areas: approximately 112,756 sq ft = 12,530 sq yds of treatment = 380 gallons BASE ONE
Light duty Pavement Areas: approximately 367,366 sq ft = 40,820 sq yds of treatment = 1225 gallons BASE ONE

Total Gallons of BASE ONE product: 1605 gallons x $27.25/gallon = **$43,627** including shipping to Bozeman.

David West is the contact for Base One:

***David West***
**Vice President**
**Team Laboratories – Base One**
**"*Innovative Solutions*"**
**800-721-9537 - Cell**
**800-522-8326 - Office**

Tetra Tech has provided a Base One construction specification in Appendix D for use with the plan and construction documents. Preliminary cost estimates to inject and stabilize six inches of reused base would be on the order of $1.25 per square yard (plus approximately $7k to $10k mobilization) and does not include grading and compaction, this is based on a preliminary quote from Allstate Pavement Recycling and Stabilization out of North Dakota. Additional approved reclamation contractors and contact information are provided in Appendix D.

## 6.6 Design and Construction Criteria

Design and construction criteria presented below should be observed for the pavement section and construction details should be considered when preparing project documents.

4. All existing asphalt driving areas and parking areas should be removed or reclaimed the full depth and stockpiled onsite for re-use as subbase. The reclaimed asphalt/base material can be reused as the subbase or stabilized base layer material provided it is mixed within the stockpile so that the asphalt does not make up more than 50 percent of the product.

5. Once the native clay subgrade is exposed, the lots should be graded and sloped to the appropriate design elevations. In currently undeveloped areas, the existing subgrade should be subexcavated to the appropriate grade. The clay subgrade can be used as fill provided it is properly moisture-conditioned and compacted to 95 percent of the maximum dry density and compacted in a maximum 8-inch lifts.

6. After grading, the clay subgrade should be proof-rolled with a fully loaded 10 cubic yard dump truck to identify soft of pumping areas. All soft areas should be sub-excavated and replaced with a Mirafi 380i high strength geotextile and a minimum of two foot of pit run gravel fill, and compacted per Item 5. We recommend Tetra Tech observe the proof rolling operations to make the determination of areas that need to be sub excavated.

7. Imported granular fill and reclaimed base course/asphalt material should meet the following gradation for use within the pavement section.

**Table 6.3: Engineered Gravel Fill Gradation**

| Sieve of Screen Size (US No.) | Percent Passing |
|---|---|
| **6-Inch** | 100 |
| **3-Inch** | 90 – 100 |
| **No. 4** | 25 – 50 |
| **No. 200** | 0 – 12 |

8. The base course and subbase material should be prepared by moisture-conditioning to within 2 percent of optimum moisture content and compacting to 95 percent of the dry density as determined by ASTM D698. The testing firm should consider the asphalt millings in the reclaimed layer when evaluating the percent compaction. Once the layer is reclaimed, the testing firm should immediately obtain a sample to determine the maximum dry density and optimum moisture content.

# 7.0 CONTINUING SERVICES

Two additional elements of geotechnical engineering service are important to the successful completion of this project.

1. **Consultation with Tetra Tech during the design phase.** This is essential to ensure that the intent of our recommendations is incorporated in design decisions related to the project and that changes in the design concept consider geotechnical aspects.

2. **Observation and monitoring during construction.** Tetra Tech should be retained to observe the earthwork phases of the project, including the site grading and excavations, to determine that the subsurface conditions are compatible with those described in our analysis. In addition, if environmental contaminants or other concerns are discovered in the subsurface, our personnel are available for consultation.

# 8.0 LIMITATIONS

This study has been conducted in accordance with generally accepted geotechnical engineering practices in the region where the work was conducted. The conclusions and recommendations submitted in this report are based upon project information provided to Tetra Tech, data obtained from the exploratory borings drilled at the locations indicated. The nature and extent of subsurface variations across the site may not become evident until construction.

Tetra Tech should be on site during construction, to verify that actual subsurface conditions are consistent with those described herein.

This report has been prepared exclusively for our client. This report and the data included herein shall not be used by any third party without the express written consent of both the client and Tetra Tech. Tetra Tech is not responsible for technical interpretations by others. As the project evolves, Tetra Tech should provide continued consultation and field services during construction to review and monitor the implementation of the recommendations and verify that the recommendations have been appropriately interpreted. Significant design changes may require additional analysis or modifications of the recommendations presented herein. Tetra Tech recommends on-site observation of excavations and foundation bearing strata and testing of fill by a representative of the geotechnical engineer.

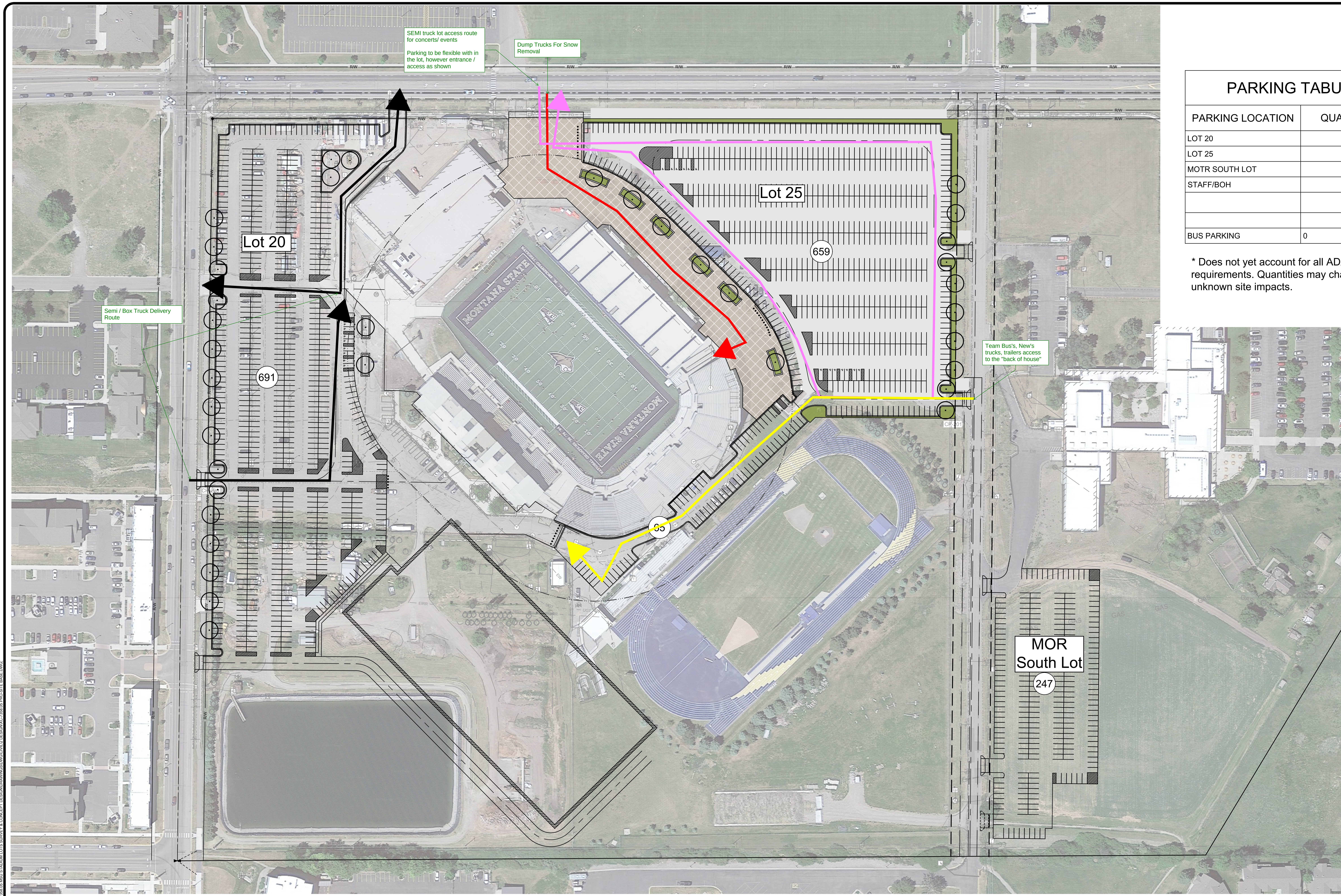
# REFERENCES

Montana Department of Transportation (2018). MDT Pavement Design Manual. November 2018.

Montana Department of Transportation (2008). MDT Geotechnical Design Manual. July 2008.

Federal Highway Administration, (2014), "Standard Specifications for the Construction of Roads and Bridges on Federal Highway Projects" FP-14, U.S. Department of Transportation, Federal Lands Highways, U.S. Govt. Print.

Chamberlain, E. J. (1981). Frost Susceptibility of Soil: Review of Index Tests. Cold Regions Research and Engineering Laboratory, (81–2).




## PARKING TABULATION

| PARKING LOCATION | QUANTITY | |
|---|---|---|
| LOT 20 | 691 | |
| LOT 25 | 659 | |
| MOTR SOUTH LOT | 247 | |
| STAFF/BOH | 65 | |
| | 1662* | TOTAL |
| | | |
| BUS PARKING | 0 | |

* Does not yet account for all ADA parking stall requirements. Quantities may change due to yet unknown site impacts.

12/21/23 10:53 RACHEL.BAKKER F:\7358.05 MSU STADIUM LOTS SURVEY & CONCEPT DESIGN\DRAWINGS\DWG\CIVIL\2 DESIGN\C 7358.05 PRO-SITE BASE.DWG

| REVISION | DATE | DESCRIPTION |
|---|---|---|
| - | - | - |
| - | - | - |
| | | |
| | | |
| | | |

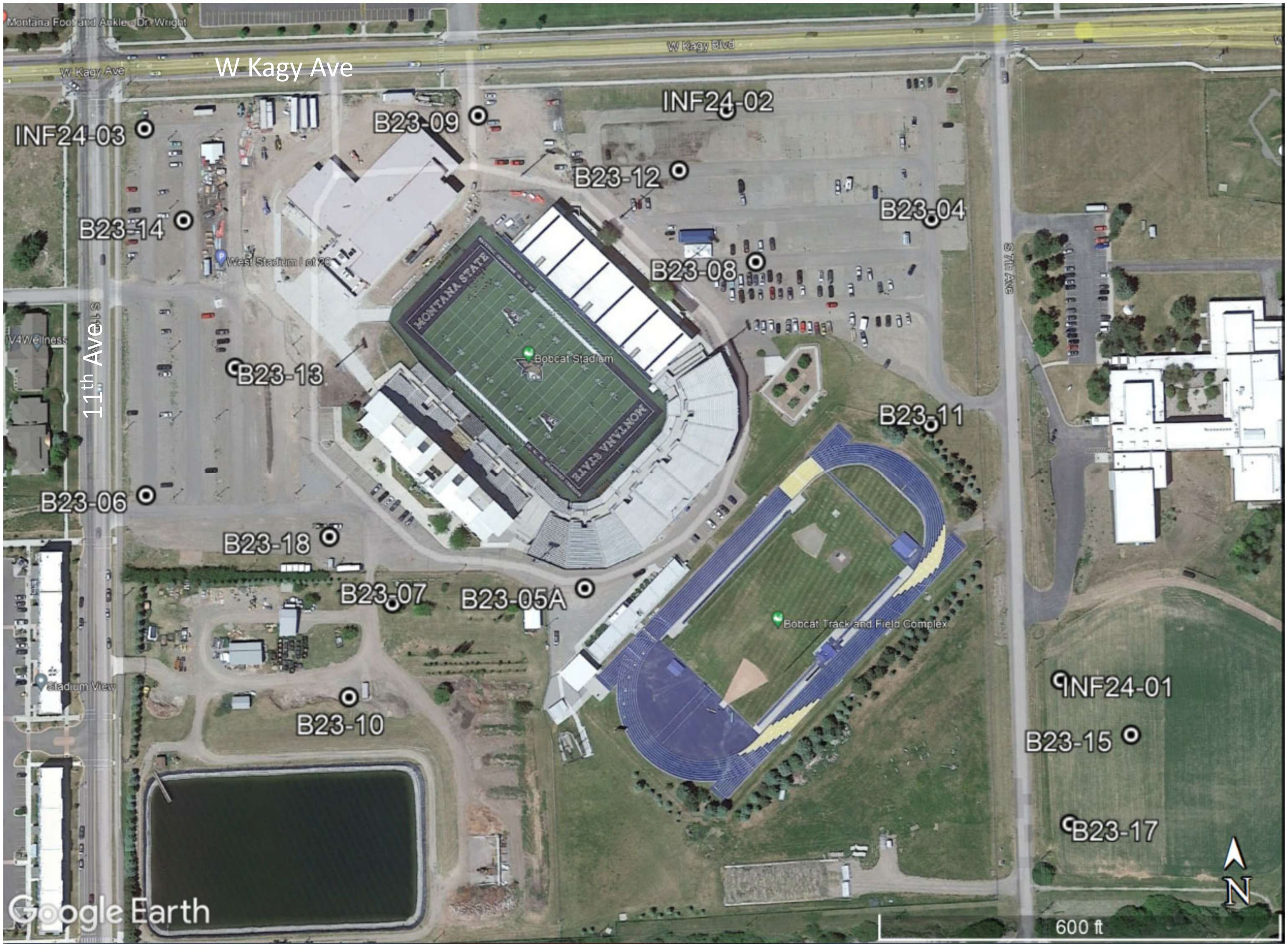
DESIGNER - PROJ. NO. -
DRAWN - DATE -
CHECKED - SURVEYED DJ&A, P.C.

DJ&A
ENGINEERS
PLANNERS
SURVEYORS

MONTANA STATE UNIVERSITY
STADIUM PARKING LOT DESIGN

CONCEPT 9
UPDATED LOT 20
**FIGURE: 1**

SHEET 1 OF 1

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Project No.: 117-001068-24002

**MSU Parking Area Reconstruction**
**Stadium and Museum of the Rockies Lots**
Montana State University, Bozeman, MT
Geotechnical Recommendations Report
**SITE MAP with BORING LOCATIONS**

Date: February 2024

Drawn By: Treven Hembree

Figure Number:
2



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**MSU Parking Area Reconstruction**
**Stadium and Museum of the Rockies Lots**
Montana State University, Bozeman, MT
Geotechnical Recommendations Report
**Preliminary Grading Plans – Lot 20**

Project No.: 117-001068-24002

Date: February 2024

Drawn By: Treven Hembree

Figure Number:
3


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Project No.: 117-001068-24002

Date: February 2024

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**MSU Parking Area Reconstruction**
**Stadium and Museum of the Rockies Lots**
Montana State University, Bozeman, MT
Geotechnical Recommendations Report
**Preliminary Grading Plans – Lot 25**

Figure Number:
4

# APPENDIX A

## LOGS OF EXPLORATORY BORINGS

TETRA TECH

# Tetra Tech Boring Log Descriptive Terminology
# Key to Soil Symbols and Terms

## SOIL CLASSIFICATION CHART

| MAJOR DIVISIONS | | | SYMBOLS: GRAPH | SYMBOLS: LETTER | TYPICAL DESCRIPTIONS |
|---|---|---|---|---|---|
| COARSE GRAINED SOILS<br>MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE | GRAVEL AND GRAVELLY SOILS<br>MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE | CLEAN GRAVELS (LITTLE OR NO FINES) | | GW | Well-graded gravels, gravel sand mixtures, little or no fines. |
| | | | | GP | Poorly graded gravels, gravel-sand mixtures, little or no fines. |
| | | GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES) | | GM | Silty gravels, gravel-sand-silt mixtures. |
| | | | | GC | Clayey gravels, gravel-sand-clay mixtures. |
| | SAND AND SANDY SOILS<br>MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE | CLEAN SANDS (LITTLE OR NO FINES) | | SW | Well-graded sands, gravelly sands, little or no fines. |
| | | | | SP | Poorly graded sands, gravelly sands, little or no fines. |
| | | SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES) | | SM | Silty sands, sand-silt mixtures. |
| | | | | SC | Clayey sands, sand-clay mixures. |
| FINE GRAINED SOILS<br>MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE | SILTS AND CLAYS | LIQUID LIMIT LESS THAN 50 | | ML | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity. |
| | | | | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. |
| | | | | OL | Organic silts and organic silty clays of low plasticity. |
| | SILTS AND CLAYS | LIQUID LIMIT GREATER THAN 50 | | MH | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. |
| | | | | CH | Inorganic clays of high plasticity, fat clays. |
| | | | | OH | Organic clays of medium to high plasticity, organic silts. |
| HIGHLY ORGANIC SOILS | | | | PT | Peat and other highly organic soils. |

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

### Order of Descriptors

- Group Name
- Consistency or Relative Density
- Moisture Condition
- Color
- Particle size descriptor(s) (coarse grained soils only)
- Angularity of coarse grained soils
- Other relevant notes

### Criteria For Descriptors

***Consistency of Fine Grained Soils***

| Consistency | N-Value (uncorrected) |
|---|---|
| Very Soft | < 2 |
| Soft | 2 - 4 |
| Medium Stiff | 5 - 8 |
| Stiff | 9 - 15 |
| Very Stiff | 16 - 30 |
| Hard | > 30 |

***Apparent Density of Coarse Grained Soils***

| Relative Density | N-Value (uncorrected) |
|---|---|
| Very Loose | < 4 |
| Loose | 4 - 10 |
| Medium Dense | 11 - 30 |
| Dense | 31 - 50 |
| Very Dense | > 50 |

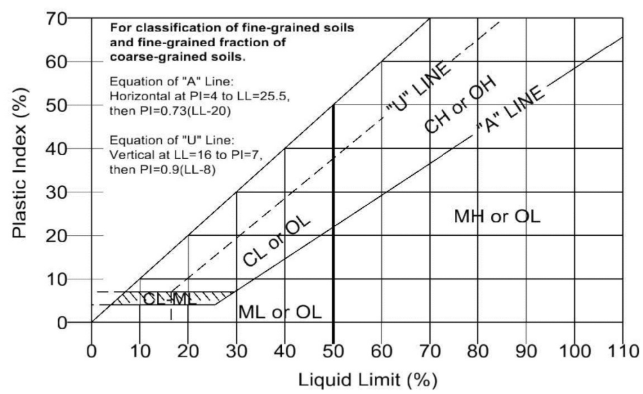
***Moisture Condition***

| | |
|---|---|
| Dry | -Absence of moisture, dusty, dry to the touch. |
| Moist | -Damp, but no visible water. |
| Wet | -Visible free water. |

***Definition of Particle Size Ranges***

| Soil Component | Size Range |
|---|---|
| Boulder | > 12 in (300 mm) |
| Cobble | 3 in (75 mm) - 12 in (300 mm) |
| Gravel | No. 4 Sieve (4.75 mm) to 3 in (75 mm) |
| Sand | No. 200 (0.075 mm) to No. 4 Sieves (4.75 mm) |
| Silt | < No. 200 Sieve (0.075 mm)* |
| Clay | < No. 200 Sieve (0.075 mm)* |

*Atterberg limits and chart below to differentiate between silt and clay.




### Notes

***See Soil Boring Information Special Provision.***

SPT (Standard Penetration Test-ASTM D1586): The number of blows of a 140 lb (63.6 kg) hammer falling 2.5 ft (750 mm) used to drive a 2 in (50 mm) O.D. Split Spoon sampler for a total of 1.5 ft (0.45 m) of penetration.

Written as follows:
first 0.5 ft (0.15 m) - second 0.5 ft (0.15 m) - third 0.5 ft (0.15 m) (ex: 1-3-9)

Note: if the number of blows exceeds 50 before 0.5 ft (0.15 m) of penetration is achieved, the actual penetration rounded to the nearest 0.1 ft (0.03 m) follows the number of blows in parentheses (ex: 12-24-50 (0.09 m), 34-50 (0.4 ft), or 100 (0.3 ft)).WR denotes a zero blow count with the weight of the rods only.
WH denotes a zero blow count with the weight of the rods plus the weight of the hammer.

MC=Moisture Content, LL=Liquid limit, PL=Plastic Limit
-200%=percent soil passing 200 sieve, DD=Dry Density

***Angularity of Coarse-Grained Particles***

| | |
|---|---|
| Angular | -Particles have sharp edges and relative plane sides with unpolished surfaces. |
| Subangular | -Particles are similar to angular description, but have rounded edges. |
| Subrounded | -Particles have nearly plane sides, but have no edges. |
| Rounded | -Particles have smoothly curved sides and well-rounded corners and edges. |

**Soil Classifications are Based on the Unified Soil Classification System, ASTM D2487 and D2488. Also included are the AASHTO group classifications (M145). Descriptions are based on visual observation, except where they have been modified to reflect results of laboratory tests as deemed appropriate.**

Example soil description: Sandy FAT CLAY (CH), soft, wet, brown. (A-7)

TETRA TECH

# Tetra Tech Boring Log Descriptive Terminology
# Key to Rock Symbols and Terms

| Rock Type | Symbol | Rock Type | Symbol | Rock Type | Symbol |
|---|---|---|---|---|---|
| Argillite | | Dolomite | | Quartzite | |
| Basalt | | Gneiss | | Rhyolite | |
| Bedrock (other) | | Granitic | | Sandstone | |
| Breccia | | Limestone | | Schist | |
| Claystone | | Siltstone | | Shale | |
| | | Conglomerate | | | |

Order of Descriptors

- Rock Type
- Color
- Grain size (if applicable)
- Stratification/Foliation (as applicable)
- Field Hardness
- Other relevant notes

Criteria For Descriptors

*Grain Size*

| Description | Characteristic |
|---|---|
| Coarse Grained | -Individual grains can be easily distinguished by eye |
| Fine Grained | -Individual grains can be distinguished with difficulty |

*Stratum Thickness*

| | |
|---|---|
| Thickly Bedded | 3-10 ft (1-3 m) |
| Medium Bedded | 1-3 ft (300 mm - 1 m) |
| Thinly Bedded | 2-12 in (50-300 mm) |
| Very Thinly Bedded | < 2 in (50 mm) |

*Rock Field Hardness*

| | |
|---|---|
| Very Soft | -Can be carved with knife. Can be excavated readily with point of rock hammer. Can be scratched readily by fingernail. |
| Soft | -Can be grooved or gouged readily by knife or point of rock hammer. Can be excavated in fragments from chips to several inches in size by moderate blows of the point of a rock hammer. |
| Medium | -Can be grooved or gouged 0.05 in (2 mm) deep by firm pressure of knife or rock hammer point. Can be excavated in small chips to pieces about 1 in (25 mm) maximum size by hard blows of the point of a rock hammer. |
| Moderately hard | -Can be scratched with knife or pick. Gouges or grooves to 0.25 in (6 mm) can be excavated by hard blow of rock hammer. Hand specimen can be detached by moderate blows. |
| Hard | -Can be scratched with knife or pick only with difficulty. Hard hammer blows required to detach hand specimen. |
| Very Hard | -Cannot be scratched with knife or sharp rock hammer point. Breaking of hand specimens requires several hard blows of a rock hammer. |

Notes:

UCS = Unconfined Compressive Strength obtained from laboratory testing at the given depth.

***See Soil Boring Information Special Provision.***

# Miscellaneous Soil/Rock Symbols and Terms

- Concrete
- Asphalt
- Water
- Boulders and Cobbles
- Coal
- Fill
- Millings
- Topsoil

**Explanation of Text Fields in Boring Logs:**

Material Description: Lithologic Description of soil or rock encountered.

Remarks: Comments on drilling, including method, bit type, and problems encountered.

Unless stated on logs as being surveyed by district survey, all locations are considered approximate.

**General Notes**

- Descriptions on these boring logs apply only at the specific boring, and at the time the time the borings were made. These logs are not warranted to be representative of subsurface conditions at other locations or times.
- Water level observations apply only at the specific boring, and at the time the borings were made. Due to the variability of groundwater measurements given the type of drilling used, and the stratification of the soil in the boring, these logs are not warranted to be representative of groundwater conditions at other locations or times.
- Other terms may be used as descriptors, as defined by the profession.

**-Soil and Rock descriptions are based on visual observation, except where they have been modified to reflect results of laboratory tests as deemed appropriate.**

Operation Types:
- Auger
- Casing Advancer
- Core Barrel
- Drive Casing

Sample Types:
- Split Spoon
- Shelby
- Bulk Sample
- Grab Sample
- Cone Penetrometer
- Vane Shear
- Special Samplers
- Testpit

*Example Rock Log*

*SANDSTONE, gray, fine grained, thickly bedded, hard field hardness.*

TETRA TECH

# CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

ASTM Designation: D 2487 – 83

*(Based on Unified Soil Classification System)*

| MAJOR DIVISIONS | | | | GROUP SYMBOL | GROUP NAME |
|---|---|---|---|---|---|
| Coarse-Grained Soils More than 50% retained on No. 200 sieve | Gravels More than 50% coarse fraction retained on No. 4 sieve | Clean Gravels Less than 5% fines | $Cu \geq 4$ and $1 \leq Cc \leq 3$[E] | GW | Well graded gravel [F] |
| | | | $Cu < 4$ and/or $1 > Cc > 3$[E] | GP | Poorly graded gravel [F] |
| | | Gravels with Fines More than 12% fines | Fines classify as ML or MH | GM | Silty gravel [F G H] |
| | | | Fines classify as CL or CH | GC | Clayey gravel [F G H] |
| | Sands 50% or more of coarse faction passes No. 4 sieve | Clean Sands Less than 5% fines | $Cu \geq 6$ and $1 \leq Cc \leq 3$[E] | SW | Well-graded sand [I] |
| | | | $Cu < 6$ and/or $1 > Cc > 3$[E] | SP | Poorly graded sand [I] |
| | | Sands with Fines More than 12% fines | Fines classify as ML or MH | SM | Silty Sand [G H I] |
| | | | Fines classify as CL or CH | SC | Clayey sand [G H I] |
| Fine-Grained Soils 50% or more passes the No. 200 sieve | Silts and Clays Liquid limit less than 50 | Inorganic | PI > 7 and plots on or above "A" line | CL | Lean clay [K L M] |
| | | | PI < 4 or plots below "A" line | ML | Silt [K L M] |
| | | Organic | $\frac{\text{Liquid limit – oven dried}}{\text{Liquid limit – not dried}} < 0.75$ | OL | Organic clay [K L M N]<br>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 O]<br>Organic silt [K L M O] |
| Highly organic soils | Primarily organic matter, dark in color, and organic odor | | | PT | Peat |

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

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

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

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

[E] $Cu = D_{60}/D_{10}$ $Cc=(D_{30})^2 / (D_{10} \times D_{90})$

[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.
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 solid contains ≥ 30% plus No. 200, predominantly sand, add "sandy" to group name.

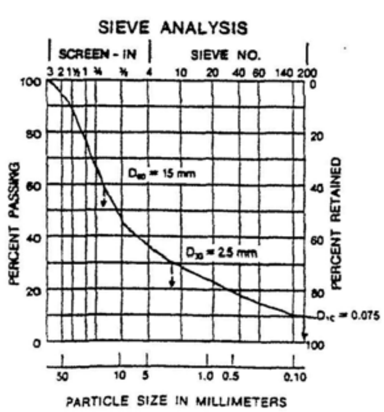
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

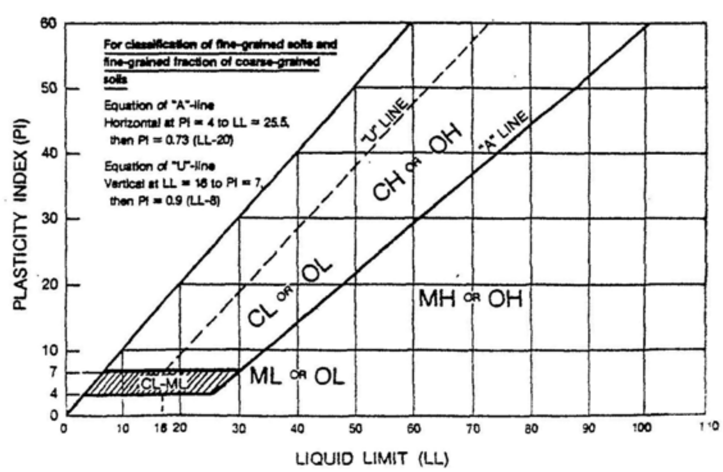
[N] PI ≥ 4 and plots on or above "A" line.

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

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

[Q] PI plots below "A: line.




$C_u = \frac{D_{50}}{D_{1e}} = \frac{15}{0.075} = 200$ $C_c = \frac{(D_{30})2}{D_{12} \times 10_{36}} + \frac{(2.5)-}{0.075 \times 15} = 5.6$

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Figure No. A-1

# LOG OF BORING

**Boring INF23-01A**

TETRA TECH



| | | | |
|---|---|---|---|
| **Project:** MSU Parking Area Reconstruction - Stadium and MoR Lots | **Rig:** Mobile B60HD<br>**Hammer:** Auto | **Boring Location Coordinates** N: 45.65766 E: -111.046484 | |
| **Project Number:** 117-001068-24002 | **Boring Diameter:** 8" | **System:** Decimal Degrees<br>**Datum:** WGS84 | **Top of Boring Elevation:** 4944.0 ft |
| **Date Started:** 12/13/23 **Date Finished:** 12/13/23 | **Drilling Fluid:** None | **Abandonment Method:** Backfilled with Cuttings | |
| **Driller:** O'Keefe<br>**Logger:** K Farber | **Location:** Refer to Site Map. | | |

| Depth (ft) / Elev. (ft) | Operation | Sample Type | Recovery (%) | RQD (%) | Blow Count | Lithology | Material Description | Depth (ft) / Elev. (ft) | MC (%) | LL | PL | -200 (%) | DD | Remarks and Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 / 4943.0 | | | 50 | | 4 - 3 - 4 | | Lean CLAY (CL), medium stiff to soft, moist, dark brown, low plasticity. | | | | | | | |
| 2 / 4942.0 | | | | | | | | | | | | | | |
| 3 / 4941.0 | | | 100 | | 2 - 2 - 2 | | | | | | | | | |
| 4 / 4940.0 | | | | | | | | | | | | | | |
| 5 / 4939.0 | | | | | | | | | | | | | | |
| 6 / 4938.0 | | | 100 | | 0 - 1 - 1 | | | 6.5 / 4937.5 | | | | | | |

Boring Depth: 6.5 ft, *Elevation: 4937.5 ft*

| *Water Level Observations* | During Drilling: Not Encountered | Remarks: |
|---|---|---|
| After Drilling: Not Recorded | After Drilling: Not Recorded | |

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Figure No. A-2

# LOG OF BORING

**Boring INF24-01B**

TETRA TECH



| | | | |
|---|---|---|---|
| **Project:** MSU Parking Area Reconstruction - Stadium and MoR Lots | **Rig:** Mobile B60HD<br>**Hammer:** Auto | **Boring Location Coordinates** N: 45.65766 E: -111.046484 | |
| **Project Number:** 117-001068-24002 | **Boring Diameter:** 8" | **System:** Decimal Degrees<br>**Datum:** WGS84 | **Top of Boring Elevation:** 4944.0 ft |
| **Date Started:** 2/1/24 **Date Finished:** 2/1/24 | **Drilling Fluid:** None | **Abandonment Method:** Backfilled with Cuttings | |
| **Driller:** O'Keefe<br>**Logger:** T Hembree | **Location:** Five feet south of INF23-01A. | | |

| Depth (ft) / *Elev. (ft)* | Operation | Sample Type | Recovery (%) | RQD (%) | Blow Count | Lithology | Material Description | Depth (ft) / *Elev. (ft)* | MC (%) | LL | PL | -200 (%) | DD | Remarks and Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | TOPSOIL, Lean CLAY with sand (CL), moist, dark brown, fine grained. | | | | | | | |
| 2 / *4942.0* | | | | | | | Lean CLAY with sand (CL), medium stiff, moist, brown, fine grained, low plasticity. | 2.0 / *4942.0* | | | | | | |
| 4 / *4940.0* | | | 60 | | 2 - 3 - 3 | | | | | | | | | |
| 6 / *4938.0* | | | | | | | | | | | | | | |
| 8 / *4936.0* | | | | | | | | | | | | | | |
| 10 / *4934.0* | | | 80 | | 27 - 37 - 40 | | Poorly-Graded GRAVEL with silt and sand (GP-GM), very dense, moist, gray to brown, medium to coarse grained, subrounded. | 9.0 / *4935.0* | | | | | | |
| 12 / *4932.0* | | | 60 | | 2 - 3 - 3 | | Lean CLAY with sand (CL), medium stiff, moist, tan, low plasticity. | 11.5 / *4932.5* | | | | | | No infiltration test casing installed per discussion with client. |
| | | | | | | | | 13.0 / *4931.0* | | | | | | |

Boring Depth: 13.0 ft, *Elevation: 4931.0 ft*

| *Water Level Observations* | | Remarks: |
|---|---|---|
| | During Drilling: Not Encountered | |
| After Drilling: Not Recorded | After Drilling: Not Recorded | |

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Figure No. A-3

# LOG OF BORING

**Boring INF23-02A**

TETRA TECH



| | | | |
|---|---|---|---|
| **Project:** MSU Parking Area Reconstruction - Stadium and MoR Lots | **Rig:** Mobile B60HD<br>**Hammer:** Auto | **Boring Location Coordinates** N: 45.658949 E: -111.047263 | |
| **Project Number:** 117-001068-24002 | **Boring Diameter:** 8" | **System:** Decimal Degrees<br>**Datum:** WGS84 | **Top of Boring Elevation:** 4943.0 ft |
| **Date Started:** 12/13/23 **Date Finished:** 12/13/23 | **Drilling Fluid:** None | **Abandonment Method:** Backfilled with Cuttings | |
| **Driller:** O'Keefe<br>**Logger:** K Farber | **Location:** Refer to Site Map. | | |

| Depth (ft) / Elev. (ft) | Operation | Sample Type | Recovery (%) | RQD (%) | Blow Count | Lithology | Material Description | Depth (ft) / Elev. (ft) | MC (%) | LL | PL | -200 (%) | DD | Remarks and Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 67 | | 3 - 1 - 1 | | TOPSOIL, Sandy Lean CLAY (CL), soft, moist, dark brown. | | | | | | | |
| 1 / 4942.0 | | | | | | | Lean CLAY with sand (CL), medium stiff, moist, light brown, low plasticity. | 1.0 / 4942.0 | | | | | | |
| 2 / 4941.0 | | | | | | | | | | | | | | |
| 3 / 4940.0 | | | 67 | | 1 - 3 - 4 | | | | | | | | | |
| 4 / 4939.0 | | | | | | | | | | | | | | |
| 5 / 4938.0 | | | | | | | | | 23 | 39 | 24 | 84 | | |
| 6 / 4937.0 | | | 67 | | 10 - 3 - 4 | | | | | | | | | |
| | | | | | | | Boring Depth: 6.5 ft, *Elevation: 4936.5 ft* | 6.5 / 4936.5 | | | | | | |

| *Water Level Observations* | | Remarks: |
|---|---|---|
| After Drilling: Not Recorded | During Drilling: Not Encountered<br>After Drilling: Not Recorded | |

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Figure No. A-4

# LOG OF BORING

**Boring INF24-02B**

TETRA TECH



| | | | |
|---|---|---|---|
| **Project:** MSU Parking Area Reconstruction - Stadium and MoR Lots | **Rig:** Mobile B60HD<br>**Hammer:** Auto | **Boring Location Coordinates** N: 45.658949 E: -111.047263 | |
| **Project Number:** 117-001068-24002 | **Boring Diameter:** 8" | **System:** Decimal Degrees<br>**Datum:** WGS84 | **Top of Boring Elevation:** 4943.0 ft |
| **Date Started:** 2/1/24 — **Date Finished:** 2/1/24 | **Drilling Fluid:** None | **Abandonment Method:** Backfilled with Cuttings | |
| **Driller:** O'Keefe<br>**Logger:** T Hembree | **Location:** Ten feet north of INF23-02A. | | |

| Depth (ft) / *Elev. (ft)* | Operation | Sample Type | Recovery (%) | RQD (%) | Blow Count | Lithology | Material Description | Depth (ft) / *Elev. (ft)* | MC (%) | LL | PL | -200 (%) | DD | Remarks and Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 – 2 | | | | | | | TOPSOIL, Lean CLAY (CL), moist, dark brown. | | | | | | | |
| 2 / *4941.0* | | | | | | | Lean CLAY with sand (CL), stiff to medium stiff, moist, tan to brown, low plasticity. | 2.0 / *4941.0* | | | | | | |
| 4 / *4939.0* | | | | | | | | | | | | | | |
| 6 / *4937.0* | | | 60 | | 2 - 4 - 5 | | | | | | | | | |
| 8 / *4935.0* | | | | | | | | | | | | | | |
| 10 / *4933.0* | | | 50 | | 3 - 3 - 4 | | | | | | | | | |
| 12 / *4931.0* | | | | | | | Poorly-Graded GRAVEL with silt and sand (GP-GM), moist, gray to brown, medium to coarse grained, subrounded to rounded. | 12.0 / *4931.0* | | | | | | |
| 14 / *4929.0* | | | | | | | | 15.0 / *4928.0* | | | | | | Infiltration test casing installed to 14.1 feet below the ground surface. Infiltration test performed on 2/1/2024. Average test infiltration rate was 68.5 in/hr. |

Boring Depth: 15.0 ft, *Elevation: 4928.0 ft*

| *Water Level Observations* | | |
|---|---|---|
| After Drilling: Not Recorded | During Drilling: Not Encountered<br>After Drilling: Not Recorded | Remarks: |

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**Fax:**

Figure No. A-5

# LOG OF BORING

**Boring INF23-03A**

TETRA TECH



| | | | |
|---|---|---|---|
| **Project:** MSU Parking Area Reconstruction - Stadium and MoR Lots | **Rig:** Mobile B60HD<br>**Hammer:** Auto | **Boring Location Coordinates** N: 45.658949 E: -111.047263 | |
| **Project Number:** 117-001068-24002 | **Boring Diameter:** 8" | **System:** Decimal Degrees<br>**Datum:** WGS84 | **Top of Boring Elevation:** 4942.0 ft |
| **Date Started:** 12/13/23 — **Date Finished:** 12/13/23 | **Drilling Fluid:** None | **Abandonment Method:** Backfilled with Cuttings | |
| **Driller:** O'Keefe<br>**Logger:** K Farber | **Location:** Refer to Site Map. | | |

| Depth (ft) / Elev. (ft) | Recovery (%) | RQD (%) | Blow Count | Material Description | Depth (ft) / Elev. (ft) | MC (%) | LL | PL | -200 (%) | DD | Remarks and Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 – 1 / 4942.0 – 4941.0 | 67 | | 28 - 7 - 6 | BASE COURSE, Poorly-Graded SAND with silt and gravel (SP-SM), medium dense, moist, dark brown, fine to medium grained. | 1.0 / 4941.0 | | | | | | |
| 2 / 4940.0 | | | | Lean CLAY with sand (CL), soft to medium stiff, moist to moist, light brown. | | | 31 | 16 | 56 | 117 | CBR= 5 |
| 3 / 4939.0 | 67 | | 1 - 2 - 2 | | | | | | | | |
| 5 / 4937.0 | | | | | | 22 | | | | | |
| 6 / 4936.0 | 100 | | 2 - 3 - 4 | | 6.5 / 4935.5 | | | | | | |

Boring Depth: 6.5 ft, *Elevation: 4935.5 ft*

| *Water Level Observations* | | |
|---|---|---|
| **After Drilling:** Not Recorded | **During Drilling:** Not Encountered<br>**After Drilling:** Not Recorded | Remarks: |

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Figure No. A-6

# LOG OF BORING

## Boring INF24-03B

TETRA TECH



| | | | |
|---|---|---|---|
| **Project:** MSU Parking Area Reconstruction - Stadium and MoR Lots | **Rig:** Mobile B60HD<br>**Hammer:** Auto | **Boring Location Coordinates** N: 45.658949 E: -111.047263 | |
| **Project Number:** 117-001068-24002 | **Boring Diameter:** 8" | **System:** Decimal Degrees<br>**Datum:** WGS84 | **Top of Boring Elevation:** 4942.0 ft |
| **Date Started:** 2/1/24 / **Date Finished:** 2/1/24 | **Drilling Fluid:** None | **Abandonment Method:** Backfilled with Cuttings | |
| **Driller:** O'Keefe<br>**Logger:** T Hembree | **Location:** Fifteen feet west of INF23-03A. | | |

| Depth (ft) / Elev. (ft) | Operation | Sample Type | Recovery (%) | RQD (%) | Blow Count | Lithology | Material Description | Depth (ft) / Elev. (ft) | MC (%) | LL | PL | -200 (%) | DD | Remarks and Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0–11 (2 / 4940.0, 4 / 4938.0, 6 / 4936.0, 8 / 4934.0, 10 / 4932.0) | | | | | | | Lean CLAY with sand (CL), medium stiff to stiff, moist, tan, low plasticity. | | | | | | | |
| ~4–5.5 | | | 50 | | 3 - 3 - 3 | | | | | | | | | |
| ~9–10.5 | | | 80 | | 2 - 5 - 8 | | | | | | | | | |
| 11–15.5 (12 / 4930.0, 14 / 4928.0) | | | | | | | Poorly-Graded GRAVEL with silt and sand (GP-GM), very dense, moist, gray to brown, medium to coarse grained. | 11.0 / 4931.0 | | | | | | Infiltration test casing installed to 12.4 feet below the ground surface. Infiltration test performed on 2/1/2024. Average test infiltration rate was 94.5 in/hr. |
| ~14–15.5 | | | 50 | | 45 - 50/0.3ft | | | | | | | | | |
| | | | | | | | Boring Depth: 15.5 ft, *Elevation: 4926.5 ft* | 15.5 / 4926.5 | | | | | | |

| *Water Level Observations* | | |
|---|---|---|
| After Drilling: Not Recorded | During Drilling: Not Encountered<br>After Drilling: Not Recorded | Remarks: |

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Figure No. A-7

# LOG OF BORING

**Boring B23-04**

TETRA TECH



| | | | |
|---|---|---|---|
| **Project:** MSU Parking Area Reconstruction - Stadium and MoR Lots | **Rig:** Mobile B60HD<br>**Hammer:** Auto | **Boring Location Coordinates** N: 45.659565 E: -111.047154 | |
| **Project Number:** 117-001068-24002 | **Boring Diameter:** 8" | **System:** Decimal Degrees<br>**Datum:** WGS84 | **Top of Boring Elevation:** 4945.0 ft |
| **Date Started:** 12/14/23 — **Date Finished:** 12/14/23 | **Drilling Fluid:** None | **Abandonment Method:** Backfilled with Cuttings | |
| **Driller:** O'Keefe<br>**Logger:** MF Pearson | **Location:** Refer to Site Map. | | |

| Depth (ft) / Elev. (ft) | Operation | Sample Type | Recovery (%) | RQD (%) | Blow Count | Lithology | Material Description | Depth (ft) / Elev. (ft) | MC (%) | LL | PL | -200 (%) | DD | Remarks and Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Asphalt, black, 4" thick. | 0.3 / 4944.7 | | | | | | |
| 1 / 4944.0 | | | 90 | | 29 - 12 - 4 | | BASE COURSE, Silty GRAVEL with sand (GM), medium dense, moist, gray, coarse grained. | 1.2 / 4943.8 | 3 | | | | | |
| 2 / 4943.0 | | | | | | | Lean CLAY with sand (CL), medium stiff, moist, brown, low plasticity. | | | | | | | |
| | | | | | | | | | | 34 | 18 | 73 | 112 | CBR= 11 |
| 3 / 4942.0 | | | 80 | | 3 - 2 - 3 | | | | | | | | | |
| 4 / 4941.0 | | | | | | | | | 24 | | | | | |
| 5 / 4940.0 | | | 80 | | 3 - 2 - 3 | | | 5.5 / 4939.5 | | | | | | |

Boring Depth: 5.5 ft, *Elevation: 4939.5 ft*

| *Water Level Observations* | | Remarks: |
|---|---|---|
| After Drilling: Not Recorded | During Drilling: Not Encountered<br>After Drilling: Not Recorded | |

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Figure No. A-8

# LOG OF BORING

**Boring B23-05**

TETRA TECH



| | | | |
|---|---|---|---|
| **Project:** MSU Parking Area Reconstruction - Stadium and MoR Lots | **Rig:** Mobile B60HD **Hammer:** Auto | **Boring Location Coordinates** N: 45.658083 E: -111.049248 | |
| **Project Number:** 117-001068-24002 | **Boring Diameter:** 8" | **System:** Decimal Degrees **Datum:** WGS84 | **Top of Boring Elevation:** 4955.0 ft |
| **Date Started:** 12/14/23 **Date Finished:** 12/14/23 | **Drilling Fluid:** None | **Abandonment Method:** Backfilled with Cuttings | |
| **Driller:** O'Keefe **Logger:** MF Pearson | **Location:** Refer to Site Map. | | |

| Depth (ft) / *Elev. (ft)* | Operation | Sample Type | Recovery (%) | RQD (%) | Blow Count | Lithology | Material Description | Depth (ft) / *Elev. (ft)* | MC (%) | LL | PL | -200 (%) | DD | Remarks and Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 / *4954.0* | | | 70 | | 35 - 32 - 55 | | BASE COURSE, Poorly-Graded GRAVEL with silt and sand (GP-GM), very dense to medium dense, moist, brown, coarse grained. | | | | | | | |
| 2 / *4953.0* | | | | | | | | | | | | | | |
| 3 / *4952.0* | | | 70 | | 12 - 13 - 5 | | Lean CLAY with sand (CL), medium stiff, moist, brown, low plasticity. | 2.7 / *4952.3* | 19 | | | | | |
| 4 / *4951.0* | | | | | | | | | | | | | | |
| 5 / *4950.0* | | | 75 | | 5 - 3 - 3 | | | 5.5 / *4949.5* | | | | | | |

Boring Depth: 5.5 ft, *Elevation: 4949.5 ft*

| *Water Level Observations* | During Drilling: Not Encountered | Remarks: |
|---|---|---|
| After Drilling: Not Recorded | After Drilling: Not Recorded | |

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Figure No. A-9

# LOG OF BORING

## Boring B23-06

TETRA TECH



| | | | |
|---|---|---|---|
| **Project:** MSU Parking Area Reconstruction - Stadium and MoR Lots | **Rig:** Mobile B60HD<br>**Hammer:** Auto | **Boring Location Coordinates** N: 45.658505 E: -111.051806 | |
| **Project Number:** 117-001068-24002 | **Boring Diameter:** 8" | **System:** Decimal Degrees<br>**Datum:** WGS84 | **Top of Boring Elevation:** 4948.0 ft |
| **Date Started:** 12/14/23 — **Date Finished:** 12/14/23 | **Drilling Fluid:** None | **Abandonment Method:** Backfilled with Cuttings | |
| **Driller:** O'Keefe<br>**Logger:** MF Pearson | **Location:** Refer to Site Map. | | |

| Depth (ft) / Elev. (ft) | Operation | Sample Type | Recovery (%) | RQD (%) | Blow Count | Lithology | Material Description | Depth (ft) / Elev. (ft) | MC (%) | LL | PL | -200 (%) | DD | Remarks and Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Asphalt, black, 3" thick. | 0.3 / 4947.7 | | | | | | |
| | | | | | | | BASE COURSE, Poorly-Graded GRAVEL with silt and sand (GP-GM), moist, dark brown, coarse grained. | 0.5 / 4947.5 | | | | | | |
| 1 / 4947.0 | | | 75 | | 12 - 4 - 3 | | Lean CLAY with sand (CL), medium stiff, moist, brown. | | | | | | | |
| 2 / 4946.0 | | | | | | | | | | | | | | |
| | | | | | | | | | 22 | | | | | |
| 3 / 4945.0 | | | 80 | | 3 - 3 - 2 | | | | | | | | | |
| 4 / 4944.0 | | | | | | | | | | | | | | |
| 5 / 4943.0 | | | 80 | | 2 - 3 - 3 | | | | | | | | | |
| | | | | | | | | 5.5 / 4942.5 | | | | | | |

Boring Depth: 5.5 ft, *Elevation: 4942.5 ft*

| *Water Level Observations* | | Remarks: |
|---|---|---|
| After Drilling: Not Recorded | During Drilling: Not Encountered<br>After Drilling: Not Recorded | |

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Figure No. A-10

# LOG OF BORING

## Boring B23-07

TETRA TECH



| | | | |
|---|---|---|---|
| **Project:** MSU Parking Area Reconstruction - Stadium and MoR Lots | | **Rig:** Mobile B60HD<br>**Hammer:** Auto | **Boring Location Coordinates** N: 45.658041 E: -111.05037 |
| **Project Number:** 117-001068-24002 | | **Boring Diameter:** 8" | **System:** Decimal Degrees<br>**Datum:** WGS84<br>**Top of Boring Elevation:** 4955.0 ft |
| **Date Started:** 12/14/23 | **Date Finished:** 12/14/23 | **Drilling Fluid:** None | **Abandonment Method:** Backfilled with Cuttings |
| **Driller:** O'Keefe<br>**Logger:** MF Pearson | | **Location:** Refer to Site Map. | |

| Depth (ft) / Elev. (ft) | Operation | Sample Type | Recovery (%) | RQD (%) | Blow Count | Lithology | Material Description | Depth (ft) / Elev. (ft) | MC (%) | LL | PL | -200 (%) | DD | Remarks and Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | BASE COURSE, Poorly-Graded GRAVEL with silt and sand (GP-GM), moist, brown. | 0.4 / 4954.7 | | | | | | |
| 1 / 4954.0 | | | 70 | | 25 - 6 - 4 | | Lean CLAY with sand (CL), stiff to medium stiff, moist, brown, fine grained, low plasticity. | | | | | | | |
| | | | | | | | | | 19 | 38 | 22 | 84 | | |
| 2 / 4953.0 | | | | | | | | | | | | | | |
| 3 / 4952.0 | | | | | | | | | 23 | | | | | |
| | | | 90 | | 4 - 3 - 3 | | | | | | | | | |
| 4 / 4951.0 | | | | | | | | | | | | | | |
| | | | 80 | | 3 - 3 - 3 | | | | | | | | | |
| 5 / 4950.0 | | | | | | | | 5.5 / 4949.5 | | | | | | |

Boring Depth: 5.5 ft, *Elevation: 4949.5 ft*

| *Water Level Observations* | During Drilling: Not Encountered | Remarks: |
|---|---|---|
| After Drilling: Not Recorded | After Drilling: Not Recorded | |

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Figure No. A-11

# LOG OF BORING

**Boring B23-08**

TETRA TECH



| | | | |
|---|---|---|---|
| **Project:** MSU Parking Area Reconstruction - Stadium and MoR Lots | **Rig:** Mobile B60HD<br>**Hammer:** Auto | **Boring Location Coordinates** N: 45.659405 E: -111.048199 | |
| **Project Number:** 117-001068-24002 | **Boring Diameter:** 8" | **System:** Decimal Degrees<br>**Datum:** WGS84 | **Top of Boring Elevation:** 4946.0 ft |
| **Date Started:** 12/14/23 / **Date Finished:** 12/14/23 | **Drilling Fluid:** None | **Abandonment Method:** Backfilled with Cuttings | |
| **Driller:** O'Keefe<br>**Logger:** MF Pearson | **Location:** Refer to Site Map. | | |

| Depth (ft) / Elev. (ft) | Operation | Sample Type | Recovery (%) | RQD (%) | Blow Count | Lithology | Material Description | Depth (ft) / Elev. (ft) | MC (%) | LL | PL | -200 (%) | DD | Remarks and Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Asphalt, black, 3" thick. | 0.3 / 4945.8 | | | | | | |
| 1 / 4945.0 | | | 70 | | 13 - 5 - 4 | | BASE COURSE, Poorly-Graded GRAVEL with silt and sand (GP-GM), loose, moist, dark brown, medium to coarse grained. | 1.1 / 4944.9 | 7 | | | | | |
| 2 / 4944.0 | | | | | | | SILT (CL), soft, moist, brown, fine grained. | | | | | | | |
| 3 / 4943.0 | | | 80 | | 3 - 2 - 2 | | | | 21 | | | | | |
| 4 / 4942.0 | | | | | | | | | | | | | | |
| 5 / 4941.0 | | | 80 | | 2 - 3 - 4 | | | 5.5 / 4940.5 | | | | | | |

Boring Depth: 5.5 ft, *Elevation: 4940.5 ft*

| *Water Level Observations* | | Remarks: |
|---|---|---|
| | During Drilling: Not Encountered | |
| After Drilling: Not Recorded | After Drilling: Not Recorded | |

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Figure No. A-12

# LOG OF BORING

**Boring B23-09**

TETRA TECH



| | | | |
|---|---|---|---|
| **Project:** MSU Parking Area Reconstruction - Stadium and MoR Lots | **Rig:** Mobile B60HD<br>**Hammer:** Auto | **Boring Location Coordinates** N: 45.660043 E: -111.049818 | |
| **Project Number:** 117-001068-24002 | **Boring Diameter:** 8" | **System:** Decimal Degrees<br>**Datum:** WGS84 | **Top of Boring Elevation:** 4942.0 ft |
| **Date Started:** 12/14/23 | **Date Finished:** 12/14/23 | **Drilling Fluid:** None | **Abandonment Method:** Backfilled with Cuttings |
| **Driller:** O'Keefe<br>**Logger:** MF Pearson | | **Location:** Refer to Site Map. | |

| Depth (ft) / *Elev. (ft)* | Operation | Sample Type | Recovery (%) | RQD (%) | Blow Count | Lithology | Material Description | Depth (ft) / *Elev. (ft)* | MC (%) | LL | PL | -200 (%) | DD | Remarks and Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Asphalt, black, 6" thick. | | | | | | | |
| 1 / *4941.0* | | | 75 | | 16 - 17 - 14 | | BASE COURSE, Poorly-Graded GRAVEL with silt and sand (GP-GM), dense, moist, brown, medium to coarse grained. | 0.5 / *4941.5* | 3 | NV | NP | 12 | | |
| 2 / *4940.0* | | | | | | | Lean CLAY with sand (CL), medium stiff, moist, brown, trace fine gravel. | 2.0 / *4940.0* | 23 | | | | | |
| 3 / *4939.0* | | | 80 | | 2 - 3 - 4 | | | | | | | | | |
| 4 / *4938.0* | | | | | | | | | | | | | | |
| 5 / *4937.0* | | | 80 | | 1 - 2 - 3 | | | 5.5 / *4936.5* | | | | | | |

Boring Depth: 5.5 ft, *Elevation: 4936.5 ft*

| *Water Level Observations* | | |
|---|---|---|
| After Drilling: Not Recorded | During Drilling: Not Encountered<br>After Drilling: Not Recorded | Remarks: |

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Figure No. A-13

# LOG OF BORING

## Boring B23-10

TETRA TECH



| | | | |
|---|---|---|---|
| **Project:** MSU Parking Area Reconstruction - Stadium and MoR Lots | **Rig:** Mobile B60HD<br>**Hammer:** Auto | **Boring Location Coordinates** N: 45.657667 E: -111.05063 | |
| **Project Number:** 117-001068-24002 | **Boring Diameter:** 8" | **System:** Decimal Degrees<br>**Datum:** WGS84 | **Top of Boring Elevation:** 4958.0 ft |
| **Date Started:** 12/14/23 — **Date Finished:** 12/14/23 | **Drilling Fluid:** None | **Abandonment Method:** Backfilled with Cuttings | |
| **Driller:** O'Keefe<br>**Logger:** MF Pearson | **Location:** Refer to Site Map. | | |

| Depth (ft) / *Elev. (ft)* | Operation | Sample Type | Recovery (%) | RQD (%) | Blow Count | Lithology | Material Description | Depth (ft) / *Elev. (ft)* | MC (%) | LL | PL | -200 (%) | DD | Remarks and Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | | 16 - 9 - 10 | | BASE COURSE, Poorly-Graded GRAVEL with silt and sand (GP-GM), medium dense, moist, dark brown, medium to coarse grained. | | | | | | | |
| 1 / *4957.0* | | | | | | | | | 20 | | | | | |
| 2 / *4956.0* | | | 70 | | 9 - 10 - 4 | | | | | | | | | |
| | | | | | | | Sandy Lean CLAY (CL), medium stiff, moist, brown, fine to medium grained, trace wood debris. | 2.5 / *4955.5* | 9 | | | | | |
| 3 / *4955.0* | | | 100 | | 6 - 4 - 3 | | | | | | | | | |
| 4 / *4954.0* | | | | | | | Lean CLAY with sand (CL), moist, brown. | 4.2 / *4953.8* | | | | | | |
| | | | | | | | Boring Depth: 4.5 ft, *Elevation: 4953.5 ft* | 4.5 / *4953.5* | | | | | | |

| *Water Level Observations* | | |
|---|---|---|
| **After Drilling:** Not Recorded | **During Drilling:** Not Encountered<br>**After Drilling:** Not Recorded | Remarks: |

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Figure No. A-14

# LOG OF BORING

**Boring B23-11**

TETRA TECH



| | | | |
|---|---|---|---|
| **Project:** MSU Parking Area Reconstruction - Stadium and MoR Lots | **Rig:** Mobile B60HD **Hammer:** Auto | **Boring Location Coordinates** N: 45.658717 E: -111.047201 | |
| **Project Number:** 117-001068-24002 | **Boring Diameter:** 8" | **System:** Decimal Degrees **Datum:** WGS84 | **Top of Boring Elevation:** 4951.0 ft |
| **Date Started:** 12/14/23 **Date Finished:** 12/14/23 | **Drilling Fluid:** None | **Abandonment Method:** Backfilled with Cuttings | |
| **Driller:** O'Keefe **Logger:** MF Pearson | **Location:** Refer to Site Map. | | |

| Depth (ft) / *Elev. (ft)* | Operation | Sample Type | Recovery (%) | RQD (%) | Blow Count | Lithology | Material Description | Depth (ft) / *Elev. (ft)* | MC (%) | LL | PL | -200 (%) | DD | Remarks and Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | TOPSOIL, Sandy Lean CLAY (CL), moist, brown to black. | 0.3 / *4950.7* | | | | | | |
| 1 / *4950.0* | | | 70 | | 20 - 11 - 4 | | Sandy Lean CLAY (CL), stiff to soft, moist, brown, low plasticity. | | | | | | | |
| | | | | | | | | | 13 | 42 | 23 | 62 | | |
| 2 / *4949.0* | | | 75 | | 4 - 3 - 3 | | | | | | | | | |
| 3 / *4948.0* | | | | | | | | | 24 | | | | | |
| 4 / *4947.0* | | | 75 | | 2 - 2 - 2 | | | | | | | | | |
| 5 / *4946.0* | | | | | | | | 5.0 / *4946.0* | | | | | | |

Boring Depth: 5.0 ft, *Elevation: 4946.0 ft*

| *Water Level Observations* | | Remarks: |
|---|---|---|
| | During Drilling: Not Encountered | |
| After Drilling: Not Recorded | After Drilling: Not Recorded | |

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Figure No. A-15

# LOG OF BORING

## Boring B23-12

TETRA TECH



| | | | |
|---|---|---|---|
| **Project:** MSU Parking Area Reconstruction - Stadium and MoR Lots | **Rig:** Mobile B60HD<br>**Hammer:** Auto | **Boring Location Coordinates** N: 45.659793 E: -111.048637 | |
| **Project Number:** 117-001068-24002 | **Boring Diameter:** 8" | **System:** Decimal Degrees<br>**Datum:** WGS84 | **Top of Boring Elevation:** 4946.0 ft |
| **Date Started:** 12/14/23 · **Date Finished:** 12/14/23 | **Drilling Fluid:** None | **Abandonment Method:** Backfilled with Cuttings | |
| **Driller:** O'Keefe<br>**Logger:** MF Pearson | **Location:** Refer to Site Map. | | |

| Depth (ft) / *Elev. (ft)* | Operation | Sample Type | Recovery (%) | RQD (%) | Blow Count | Lithology | Material Description | Depth (ft) / *Elev. (ft)* | MC (%) | LL | PL | -200 (%) | DD | Remarks and Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Asphalt, black, 4.5" thick. | 0.4 / *4945.6* | | | | | | |
| | | | | | | | BASE COURSE, Poorly-Graded GRAVEL with sand (GP-GM), medium dense, moist, dark brown, medium to coarse grained. | 0.6 / *4945.4* | | | | | | |
| 1 / *4945.0* | | | 70 | | 15 - 8 - 6 | | Lean CLAY with sand (CL), medium stiff, moist, brown. | | | | | | | |
| 2 / *4944.0* | | | | | | | | | | | | | | |
| | | | | | | | | | 18 | 34 | 19 | 84 | | |
| 3 / *4943.0* | | | 75 | | 4 - 3 - 3 | | | | | | | | | |
| 4 / *4942.0* | | | | | | | | | | | | | | |
| 5 / *4941.0* | | | 75 | | 2 - 3 - 3 | | | 5.5 / *4940.5* | | | | | | |

Boring Depth: 5.5 ft, *Elevation: 4940.5 ft*

| *Water Level Observations* | | |
|---|---|---|
| | During Drilling: Not Encountered | Remarks: |
| After Drilling: Not Recorded | After Drilling: Not Recorded | |

TT LOG OF BORING - MDT_REVISED_2009+.GDT - 2/12/24 19:09 - \\TT.LOCAL\GFS\US\VOLUME4\LEGACY\TTS079FS1\DATA\GEOTECH\REPORTS\REPORT 2023\MSU PARKING LOT REPAVING 001068-24001\24002 MSU STADIUM & MOR PAVEMENTS\LAB LOGS\BOR

7100 Commercial Ave.
Billings, MT 59101
Phone: 406-248-9161
Fax:

Figure No. A-16

# LOG OF BORING

**Boring B23-13**

TETRA TECH



| | | | |
|---|---|---|---|
| **Project:** MSU Parking Area Reconstruction - Stadium and MoR Lots | **Rig:** Mobile B60HD<br>**Hammer:** Auto | **Boring Location Coordinates** N: 45.659021 E: -111.051272 | |
| **Project Number:** 117-001068-24002 | **Boring Diameter:** 8" | **System:** Decimal Degrees<br>**Datum:** WGS84 | **Top of Boring Elevation:** 4949.0 ft |
| **Date Started:** 12/14/23 **Date Finished:** 12/14/23 | **Drilling Fluid:** None | **Abandonment Method:** Backfilled with Cuttings | |
| **Driller:** O'Keefe<br>**Logger:** MF Pearson | **Location:** Refer to Site Map. | | |

| Depth (ft) / *Elev. (ft)* | Sample Type | Recovery (%) | RQD (%) | Blow Count | Lithology | Material Description | Depth (ft) / *Elev. (ft)* | MC (%) | LL | PL | -200 (%) | DD | Remarks and Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Asphalt, black, 4" thick. | 0.3 / *4948.7* | | | | | | |
| | | | | | | BASE COURSE, Poorly-Graded GRAVEL with silt and sand (GP-GM), loose, moist, brown, medium to coarse grained. | 1.0 / *4948.0* | | | | | | |
| 1 / *4948.0* | | 70 | | 10 - 3 - 3 | | Lean CLAY with sand (CL), medium stiff, moist, brown, fine grained. | | | | | | | |
| 2 / *4947.0* | | | | | | | | | | | | | |
| | | | | | | | | 21 | | | | | |
| 3 / *4946.0* | | 80 | | 4 - 3 - 2 | | | | | | | | | |
| 4 / *4945.0* | | | | | | | | 25 | | | | | |
| 5 / *4944.0* | | 80 | | 3 - 3 - 3 | | | 5.5 / *4943.5* | | | | | | |

Boring Depth: 5.5 ft, *Elevation: 4943.5 ft*

| *Water Level Observations* | During Drilling: Not Encountered | Remarks: |
|---|---|---|
| After Drilling: Not Recorded | After Drilling: Not Recorded | |

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Fax:

Figure No. A-17

# LOG OF BORING

**Boring B23-14**

TETRA TECH



| | | | |
|---|---|---|---|
| **Project:** MSU Parking Area Reconstruction - Stadium and MoR Lots | **Rig:** Mobile B60HD<br>**Hammer:** Auto | **Boring Location Coordinates** N: 45.659636 E: -111.051569 | |
| **Project Number:** 117-001068-24002 | **Boring Diameter:** 8" | **System:** Decimal Degrees<br>**Datum:** WGS84 | **Top of Boring Elevation:** 4944.0 ft |
| **Date Started:** 12/14/23 / **Date Finished:** 12/14/23 | **Drilling Fluid:** None | **Abandonment Method:** Backfilled with Cuttings | |
| **Driller:** O'Keefe<br>**Logger:** MF Pearson | **Location:** Refer to Site Map. | | |

| Depth (ft) / Elev. (ft) | Operation | Sample Type | Recovery (%) | RQD (%) | Blow Count | Lithology | Material Description | Depth (ft) / Elev. (ft) | MC (%) | LL | PL | -200 (%) | DD | Remarks and Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Asphalt, black, 5" thick. | 0.4 / 4943.6 | | | | | | |
| | | | | | | | BASE COURSE, Silty, Clayey GRAVEL with sand (GP-GM), loose, moist, brown, medium to coarse grained. | 1.0 / 4943.0 | | | | | | |
| 1 / 4943.0 | | | 75 | | 8 - 4 - 3 | | Lean CLAY with sand (CL), medium stiff, moist, brown, low plasticity. | | | | | | | |
| 2 / 4942.0 | | | | | | | | | | | | | | |
| | | | | | | | | | 4 | 25 | 19 | 35 | 119 | CBR= 4 |
| 3 / 4941.0 | | | 80 | | 3 - 2 - 3 | | | | | | | | | |
| 4 / 4940.0 | | | | | | | | | 21 | | | | | |
| 5 / 4939.0 | | | 80 | | 2 - 2 - 3 | | | 5.5 / 4938.5 | | | | | | |

Boring Depth: 5.5 ft, *Elevation: 4938.5 ft*

| *Water Level Observations* | During Drilling: Not Encountered | Remarks: |
|---|---|---|
| After Drilling: Not Recorded | After Drilling: Not Recorded | |

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TT LOG OF BORING - MDT_REVISED_2009+.GDT - 2/12/24 19:09 - \\TT.LOCAL\GFS\US\VOLUME4\LEGACY\TTS079FS1\DATA\GEOTECH\REPORTS\REPORT 2023\MSU PARKING LOT REPAVING 001068-24001\24002 MSU STADIUM & MOR PAVEMENTS\LAB LOGS\BOF

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Phone: 406-248-9161
Fax:

Figure No. A-18

# LOG OF BORING

## Boring B23-15

TETRA TECH



| | | | |
|---|---|---|---|
| **Project:** MSU Parking Area Reconstruction - Stadium and MoR Lots | **Rig:** Mobile B60HD<br>**Hammer:** Auto | **Boring Location Coordinates** N: 45.658949 E: -111.047263 | |
| **Project Number:** 117-001068-24002 | **Boring Diameter:** 8" | **System:** Decimal Degrees<br>**Datum:** WGS84 | **Top of Boring Elevation:** 4938.0 ft |
| **Date Started:** 12/13/23 / **Date Finished:** 12/13/23 | **Drilling Fluid:** None | **Abandonment Method:** Backfilled with Cuttings | |
| **Driller:** O'Keefe<br>**Logger:** K Farber | **Location:** Refer to Site Map. | | |

| Depth (ft) / *Elev. (ft)* | Operation | Sample Type | Recovery (%) | RQD (%) | Blow Count | Lithology | Material Description | Depth (ft) / *Elev. (ft)* | MC (%) | LL | PL | -200 (%) | DD | Remarks and Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0–1 | | | 67 | | 4 - 4 - 4 | | TOPSOIL, Sandy Lean CLAY (CL), medium stiff, moist. | | | | | | | |
| 1 / *4937.0* | | | | | | | Lean CLAY with sand (CL), medium stiff to very soft, moist, light brown, low plasticity. | 1.0 / *4937.0* | | | | | | |
| 2 / *4936.0* | | | | | | | | | | | | | | |
| 3 / *4935.0* | | | 67 | | 3 - 4 - 2 | | | | | | | | | |
| 4 / *4934.0* | | | | | | | | | | | | | | |
| 5 / *4933.0* | | | | | | | | | | | | | | |
| 6 / *4932.0* | | | 0 | | 0 - 0 - 1 | | | 6.5 / *4931.5* | | | | | | |

Boring Depth: 6.5 ft, *Elevation: 4931.5 ft*

| *Water Level Observations* | | Remarks: |
|---|---|---|
| After Drilling: Not Recorded | During Drilling: Not Encountered<br>After Drilling: Not Recorded | |

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Figure No. A-19

# LOG OF BORING

**Boring B23-17**

TETRA TECH



| | | | |
|---|---|---|---|
| **Project:** MSU Parking Area Reconstruction - Stadium and MoR Lots | **Rig:** Mobile B60HD<br>**Hammer:** Auto | **Boring Location Coordinates** N: 45.658949 E: -111.047263 | |
| **Project Number:** 117-001068-24002 | **Boring Diameter:** 8" | **System:** Decimal Degrees<br>**Datum:** WGS84 | **Top of Boring Elevation:** 4939.0 ft |
| **Date Started:** 12/13/23 / **Date Finished:** 12/13/23 | **Drilling Fluid:** None | **Abandonment Method:** Backfilled with Cuttings | |
| **Driller:** O'Keefe<br>**Logger:** K Farber | **Location:** Refer to Site Map. | | |

| Depth (ft) / *Elev. (ft)* | Operation | Sample Type | Recovery (%) | RQD (%) | Blow Count | Lithology | Material Description | Depth (ft) / *Elev. (ft)* | MC (%) | LL | PL | -200 (%) | DD | Remarks and Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0–0.8 | | | 53 | | 3 - 2 - 3 | | TOPSOIL, Sandy Lean CLAY (CL), soft, moist, dark brown. | 0.8 / *4938.2* | | | | | | |
| 1 / *4938.0* | | | | | | | Lean CLAY with sand (CL), soft, moist, light brown, low plasticity. | | | | | | | |
| 2 / *4937.0* | | | | | | | | | | | | | | |
| 3 / *4936.0* | | | 67 | | 2 - 2 - 1 | | | | | | | | | |
| 4 / *4935.0* | | | | | | | | | | | | | | |
| 5 / *4934.0* | | | | | | | | | | | | | | |
| 6 / *4933.0* | | | 133 | | 0 - 0 - 4 | | | 6.5 / *4932.5* | | | | | | |

Boring Depth: 6.5 ft, *Elevation: 4932.5 ft*

| *Water Level Observations* | | Remarks: |
|---|---|---|
| After Drilling: Not Recorded | During Drilling: Not Encountered<br>After Drilling: Not Recorded | |

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TT LOG OF BORING - MDT_REVISED_2009+.GDT - 2/12/24 19:09 - \\TT.LOCAL\GFS\US\VOLUME4\LEGACY\TTS079FS1\DATA\GEOTECH\REPORTS\REPORT 2023\MSU PARKING LOT REPAVING 001068-24001\24002 MSU STADIUM & MOR PAVEMENTS\LAB LOGS\BOR

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Phone: 406-248-9161
Fax:

Figure No. A-20

# LOG OF BORING

## Boring B23-18

TETRA TECH



| | | | |
|---|---|---|---|
| **Project:** MSU Parking Area Reconstruction - Stadium and MoR Lots | **Rig:** Mobile B60HD<br>**Hammer:** Auto | **Boring Location Coordinates** N: 45.658318 E: -111.050732 | |
| **Project Number:** 117-001068-24002 | **Boring Diameter:** 8" | **System:** Decimal Degrees<br>**Datum:** WGS84 | **Top of Boring Elevation:** 4953.0 ft |
| **Date Started:** 12/14/23 / **Date Finished:** 12/14/23 | **Drilling Fluid:** None | **Abandonment Method:** Backfilled with Cuttings | |
| **Driller:** O'Keefe<br>**Logger:** MF Pearson | **Location:** Refer to Site Map. | | |

| Depth (ft) / *Elev. (ft)* | Operation | Sample Type | Recovery (%) | RQD (%) | Blow Count | Lithology | Material Description | Depth (ft) / *Elev. (ft)* | MC (%) | LL | PL | -200 (%) | DD | Remarks and Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Asphalt, black. | 0.3 / *4952.7* | | | | | | |
| 1 / *4952.0* | | | 70 | | 20 - 7 - 5 | | BASE COURSE, Poorly-Graded GRAVEL with silt and sand (GP-GM), medium dense, moist, brown to gray, medium to coarse grained. | 1.0 / *4952.0* | | | | | | |
| 2 / *4951.0* | | | | | | | Lean CLAY with sand (CL), medium stiff, moist, brown, low plasticity. | | | | | | | |
| 3 / *4950.0* | | | 80 | | 3 - 3 - 3 | | | | 21 | | | | | |
| 4 / *4949.0* | | | | | | | | | 22 | | | | | |
| 5 / *4948.0* | | | 80 | | 3 - 2 - 3 | | | 5.5 / *4947.5* | | | | | | |

Boring Depth: 5.5 ft, *Elevation: 4947.5 ft*

| *Water Level Observations* | | Remarks: |
|---|---|---|
| After Drilling: Not Recorded | During Drilling: Not Encountered | |
| | After Drilling: Not Recorded | |

# APPENDIX B

## LABORATORY TESTING

TETRA TECH

| | | | |
|---|---|---|---|
| **PROJECT:** | MSU Pavement | **PROJECT NO:** | 117-001068-24002 |
| **LOCATION:** | Stadium & MOR | **WORK ORDER NO:** | |
| **MATERIAL:** | | **LAB NO:** | |
| **SAMPLE SOURCE:** | | **DATE SAMPLED:** | |
| | | **REVIEWED BY:** | |

## MOISTURE CONTENT OF SOIL (ASTM D2216)

| BOREHOLE ID. | DEPTH RANGE | WET WT. (gram) | DRY WT. (gram) | MOISTURE CONTENT |
|---|---|---|---|---|
| B23-02 | 5-6.5 | 494.8 | 401.6 | 23.2% |
| B23-03 | 5-6.5 | 193.5 | 158.7 | 21.9% |
| B23-04 | 0.31-1.8 | 211.3 | 205.4 | 2.9% |
| | 2.5-4 | 127.1 | 127.1 | 0.0% |
| | 4-5.5 | 115.1 | 93.0 | 23.8% |
| B23-05 | 3-4.5 | 145.7 | 122.3 | 19.1% |
| B23-06 | 2.5-4 | 168.4 | 137.8 | 22.2% |
| B23-07 | 1.5-3 | 495.5 | 415.6 | 19.2% |
| | 3-4.5 | 157.4 | 127.7 | 23.3% |
| B23-08 | 0.25-1.75 | 179.0 | 167.0 | 7.2% |
| | 2.5-4 | 108.6 | 89.6 | 21.2% |
| B23-09 | 0.51-1.5 | 269.9 | 262.9 | 2.7% |
| | 2.25-3.75 | 171.0 | 139.6 | 22.5% |
| B23-10 | 1.5-3 | 178.6 | 149.5 | 19.5% |
| | 3-4.2 | 178.3 | 164.0 | 8.7% |
| B23-11 | 1.5-3 | 137.2 | 121.2 | 13.2% |
| | 3-4.5 | 218.7 | 176.0 | 24.3% |
| B23-12 | 2.5-4 | 411.3 | 349.8 | 17.6% |
| B23-13 | 2.5-4 | 119.8 | 99.3 | 20.6% |
| | 4-5.5 | 138.4 | 110.6 | 25.1% |
| B23-14 | 2.5-5.5 | 151.7 | 145.4 | 4.3% |
| | 4-5.5 | 176.2 | 146.0 | 20.7% |
| B23-18 | 2.5-4 | 192.1 | 159.4 | 20.5% |
| | 4-5.5 | 175.2 | 144.0 | 21.7% |
| | | | | |
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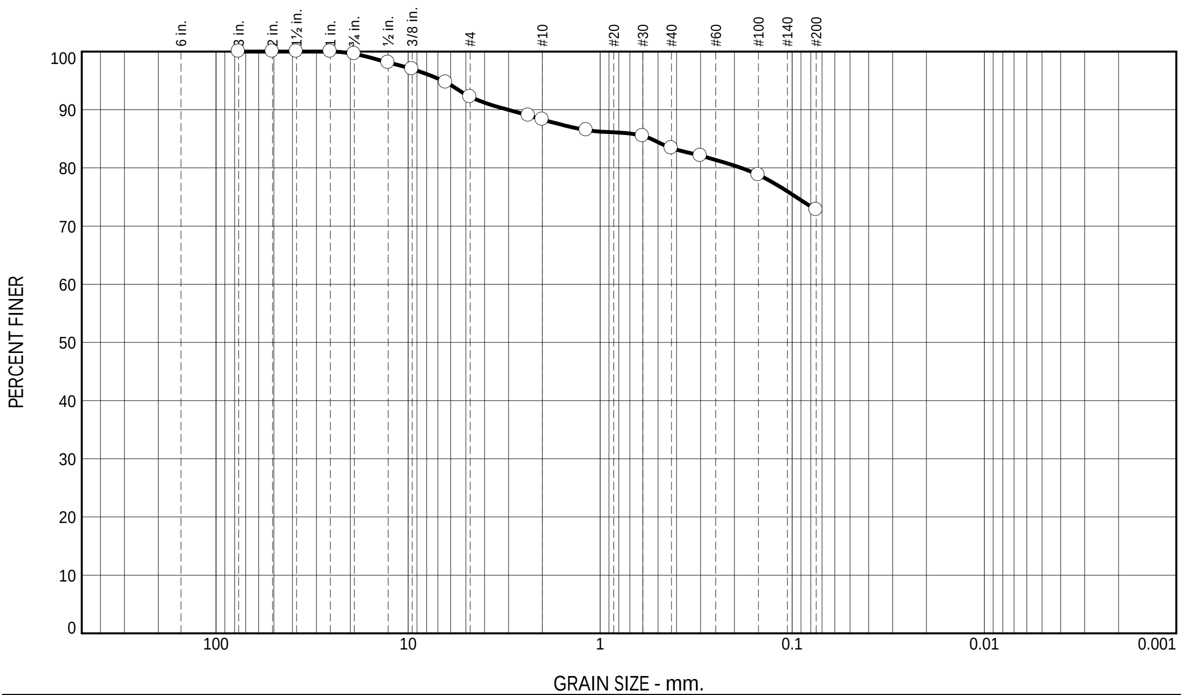
FIGURE: B-1

# Particle Size Distribution Report



| % +3" | % Gravel Coarse | % Gravel Fine | % Sand Coarse | % Sand Medium | % Sand Fine | % Fines Silt | % Fines Clay |
|---|---|---|---|---|---|---|---|
| 0.0 | 0.4 | 7.4 | 3.9 | 4.9 | 10.6 | 72.8 | |

**Test Results (ASTM D422)**

| Sieve Size or Diam. (mm.) | Finer (%) | Spec.* (%) | Out of Spec. (%) |
|---|---|---|---|
| 3 | 100.0 | | |
| 2 | 100.0 | | |
| 1.5 | 100.0 | | |
| 1 | 100.0 | | |
| .75 | 99.6 | | |
| .5 | 98.1 | | |
| .375 | 97.0 | | |
| .25 | 94.7 | | |
| #4 | 92.2 | | |
| #8 | 89.0 | | |
| #10 | 88.3 | | |
| #16 | 86.5 | | |
| #30 | 85.5 | | |
| #40 | 83.4 | | |
| #50 | 82.1 | | |
| #100 | 78.8 | | |
| #200 | 72.8 | | |

* (no specification provided)

Location: B23-04 & B23-08
Depth: 0.31-1.8 ft

**Material Description**

silt with sand

**Atterberg (ASTM D4318)**

PL= NP LL= NP PI= NP

**Coefficients**

$D_{90}$= 3.0226 $D_{85}$= 0.5441
$D_{60}$= $D_{50}$=
$D_{30}$= $D_{15}$=
$D_{10}$=
$C_u$= $C_c$=

**Sieve Test (ASTM D422)**

Test Date: 1/15/24 Technician: TL/LP

Test Notes

**Hydrometer Test**

Test Date: Technician:

Test Notes

**USCS (ASTM D2487)**

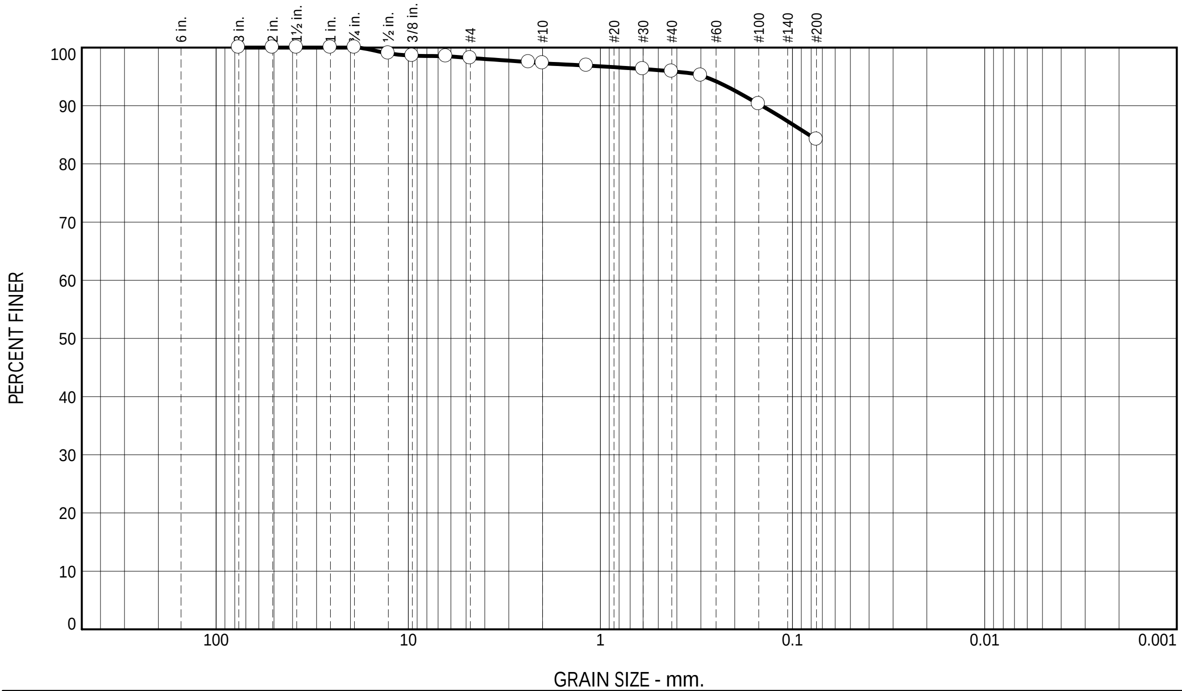
ML

Date Sampled:
Date Received:
Checked By: LP
Title:

Tetra Tech
Missoula, MT

Client:
Project: MSU Pavement - Stadium & MOR
Project No: 117-001068-24002 Figure: **B-2**

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 0.0 | 1.8 | 0.9 | 1.4 | 11.7 | 84.2 | |

Test Results (ASTM D422)

| Sieve Size or Diam. (mm.) | Finer (%) | Spec.* (%) | Out of Spec. (%) |
|---|---|---|---|
| 3 | 100.0 | | |
| 2 | 100.0 | | |
| 1.5 | 100.0 | | |
| 1 | 100.0 | | |
| .75 | 100.0 | | |
| .5 | 99.0 | | |
| .375 | 98.6 | | |
| .25 | 98.5 | | |
| #4 | 98.2 | | |
| #8 | 97.5 | | |
| #10 | 97.3 | | |
| #16 | 96.9 | | |
| #30 | 96.3 | | |
| #40 | 95.9 | | |
| #50 | 95.2 | | |
| #100 | 90.3 | | |
| #200 | 84.2 | | |

· (no specification provided)

**Material Description**

lean clay with sand

**Atterberg (ASTM D4318)**

PL= 22 LL= 38 PI= 16

**Coefficients**

$D_{90}$= 0.1445 $D_{85}$= 0.0821
$D_{60}$= $D_{50}$=
$D_{30}$= $D_{15}$=
$D_{10}$=
$C_u$= $C_c$=

**Sieve Test (ASTM D422)**

Test Date: 1/17/24 Technician: TL/EM

Test Notes

**Hydrometer Test**

Test Date: ____________ Technician: ____________

Test Notes

**USCS (ASTM D2487)**

CL

Date Sampled: ____________
Date Received: ____________
Checked By: LP
Title: ____________

Location: B23-07
Depth: 1.5-3 ft

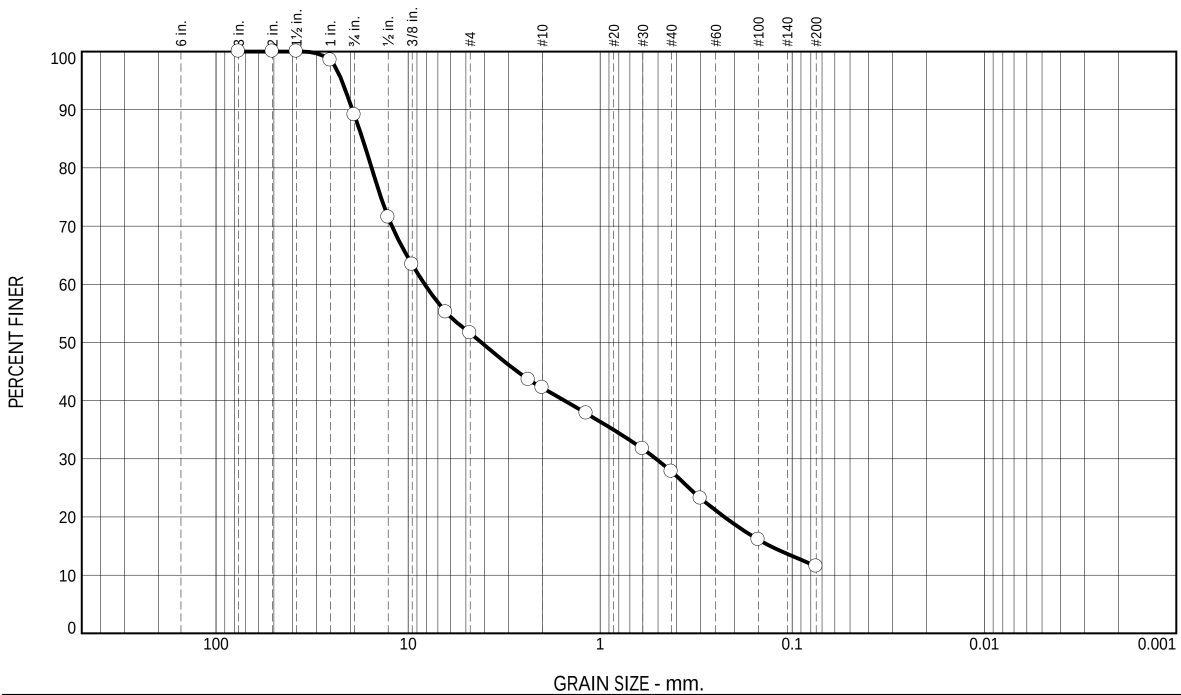
Tetra Tech

Missoula, MT

Client:
Project: MSU Pavement - Stadium & MOR
Project No: 117-001068-24002

Figure: **B-3**

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 10.9 | 37.5 | 9.4 | 14.4 | 16.3 | 11.5 | |

Test Results (ASTM D422)

| Sieve Size or Diam. (mm.) | Finer (%) | Spec.* (%) | Out of Spec. (%) |
|---|---|---|---|
| 3 | 100.0 | | |
| 2 | 100.0 | | |
| 1.5 | 100.0 | | |
| 1 | 98.5 | | |
| .75 | 89.1 | | |
| .5 | 71.5 | | |
| .375 | 63.4 | | |
| .25 | 55.2 | | |
| #4 | 51.6 | | |
| #8 | 43.6 | | |
| #10 | 42.2 | | |
| #16 | 37.8 | | |
| #30 | 31.7 | | |
| #40 | 27.8 | | |
| #50 | 23.2 | | |
| #100 | 16.1 | | |
| #200 | 11.5 | | |

· (no specification provided)

**Material Description**

poorly graded gravel with silt and sand

**Atterberg (ASTM D4318)**

PL= NP LL= NP PI= NP

**Coefficients**

$D_{90}$= 19.4969 $D_{85}$= 17.2672

$D_{60}$= 8.2007 $D_{50}$= 4.1563

$D_{30}$= 0.5122 $D_{15}$= 0.1302

$D_{10}$=

$C_u$= $C_c$=

**Sieve Test (ASTM D422)**

Test Date: 1/25/24 Technician: TL/LP

Test Notes

**Hydrometer Test**

Test Date: ______ Technician: ______

Test Notes

**USCS (ASTM D2487)**

GP-GM

Date Sampled: ______

Date Received: ______

Checked By: LP

Title: ______

Location: B23-09
Depth: 0.51-1.5 ft

Tetra Tech

Missoula, MT

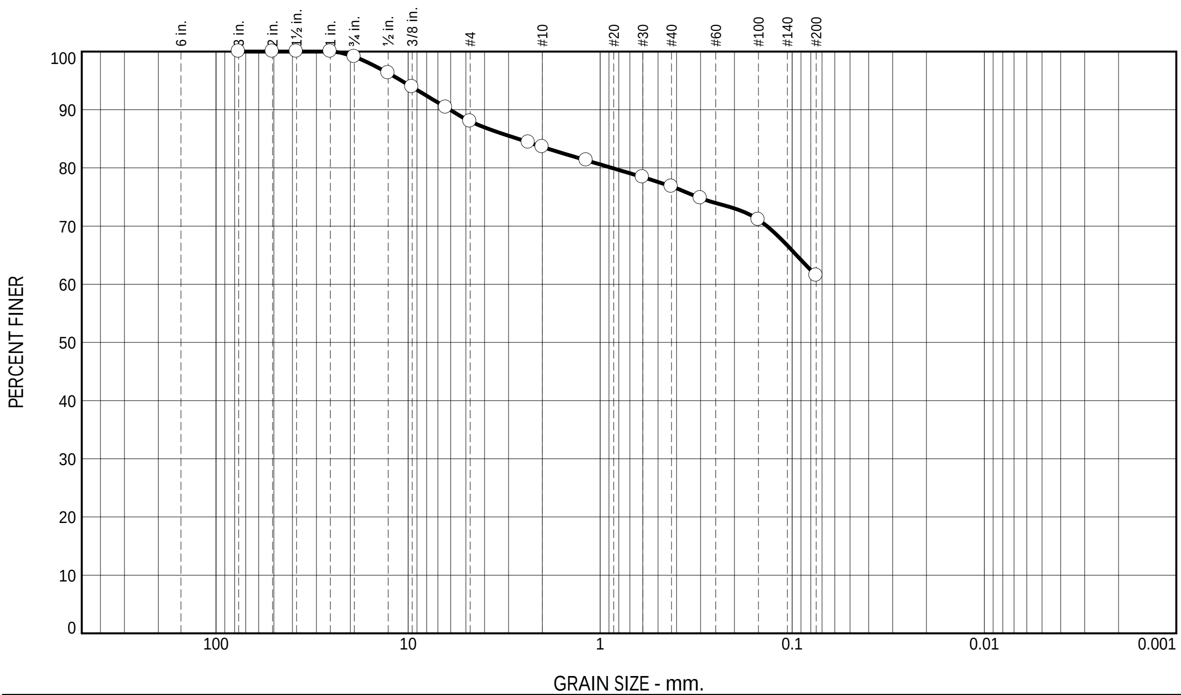
Client:

Project: MSU Pavement - Stadium & MOR

Project No: 117-001068-24002

Figure: **B-4**

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 0.9 | 11.1 | 4.4 | 6.8 | 15.3 | 61.5 | |

| Test Results (ASTM D422) | | | |
|---|---|---|---|
| Sieve Size or Diam. (mm.) | Finer (%) | Spec.* (%) | Out of Spec. (%) |
| 3 | 100.0 | | |
| 2 | 100.0 | | |
| 1.5 | 100.0 | | |
| 1 | 100.0 | | |
| .75 | 99.1 | | |
| .5 | 96.3 | | |
| .375 | 93.9 | | |
| .25 | 90.4 | | |
| #4 | 88.0 | | |
| #8 | 84.4 | | |
| #10 | 83.6 | | |
| #16 | 81.3 | | |
| #30 | 78.4 | | |
| #40 | 76.8 | | |
| #50 | 74.8 | | |
| #100 | 71.1 | | |
| #200 | 61.5 | | |

* (no specification provided)

**Material Description**

sandy lean clay

**Atterberg (ASTM D4318)**

PL= 23 LL= 42 PI= 19

**Coefficients**

$D_{90}$= 6.0616 $D_{85}$= 2.6734

$D_{60}$= $D_{50}$=

$D_{30}$= $D_{15}$=

$D_{10}$=

$C_u$= $C_c$=

**Sieve Test (ASTM D422)**

Test Date: 1/18/24 Technician: TL/LP

Test Notes

**Hydrometer Test**

Test Date: _____ Technician: _____

Test Notes

**USCS (ASTM D2487)**

CL

Date Sampled:

Date Received:

Checked By: LP

Title:

Location: B23-11
Depth: 1-2 ft

Tetra Tech

Missoula, MT

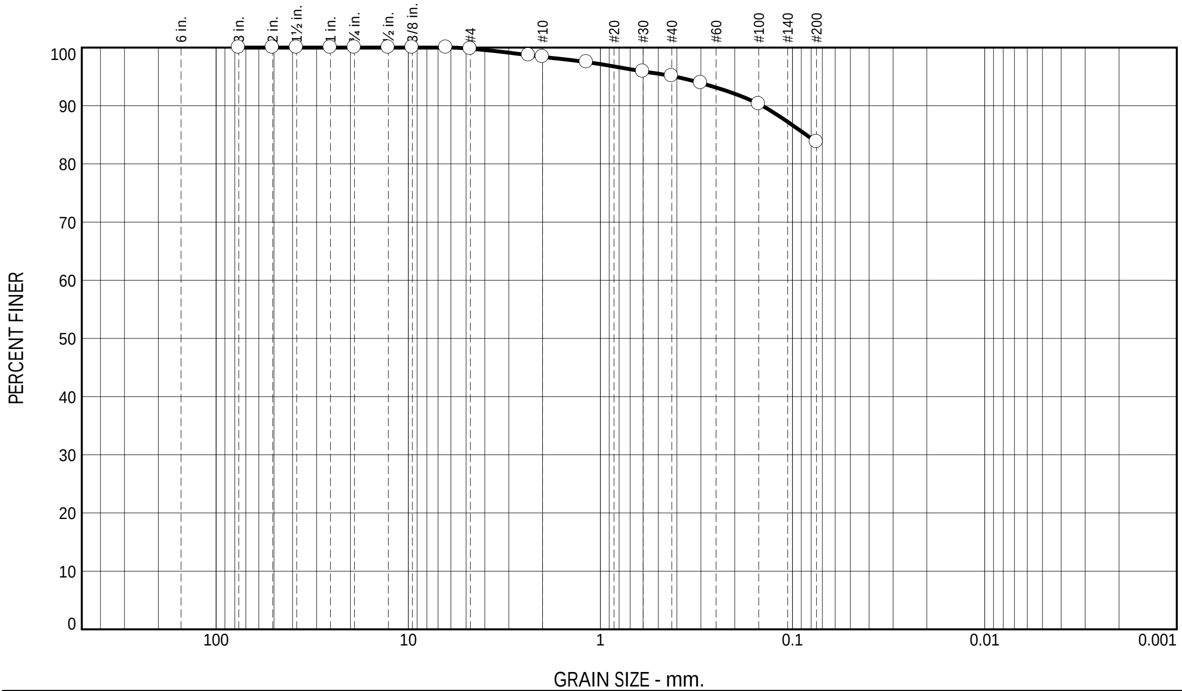
Client:

Project: MSU Pavement - Stadium & MOR

Project No: 117-001068-24002

Figure: **B-5**

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 0.0 | 0.2 | 1.4 | 3.3 | 11.3 | 83.8 | |

**Test Results (ASTM D422)**

| Sieve Size or Diam. (mm.) | Finer (%) | Spec.* (%) | Out of Spec. (%) |
|---|---|---|---|
| 3 | 100.0 | | |
| 2 | 100.0 | | |
| 1.5 | 100.0 | | |
| 1 | 100.0 | | |
| .75 | 100.0 | | |
| .5 | 100.0 | | |
| .375 | 100.0 | | |
| .25 | 100.0 | | |
| #4 | 99.8 | | |
| #8 | 98.7 | | |
| #10 | 98.4 | | |
| #16 | 97.5 | | |
| #30 | 95.9 | | |
| #40 | 95.1 | | |
| #50 | 93.9 | | |
| #100 | 90.3 | | |
| #200 | 83.8 | | |

· (no specification provided)

**Material Description**

lean clay with sand

**Atterberg (ASTM D4318)**

PL= 19 LL= 34 PI= 15

**Coefficients**

$D_{90}$= 0.1441 $D_{85}$= 0.0849
$D_{60}$= $D_{50}$=
$D_{30}$= $D_{15}$=
$D_{10}$=
$C_u$= $C_c$=

**Sieve Test (ASTM D422)**

Test Date: 1/17/24 Technician: TL/EM

Test Notes

**Hydrometer Test**

Test Date: ______ Technician: ______

Test Notes

**USCS (ASTM D2487)**

CL

Date Sampled: ______
Date Received: ______
Checked By: LP
Title: ______

Location: B23-12
Depth: 2.5-4 ft

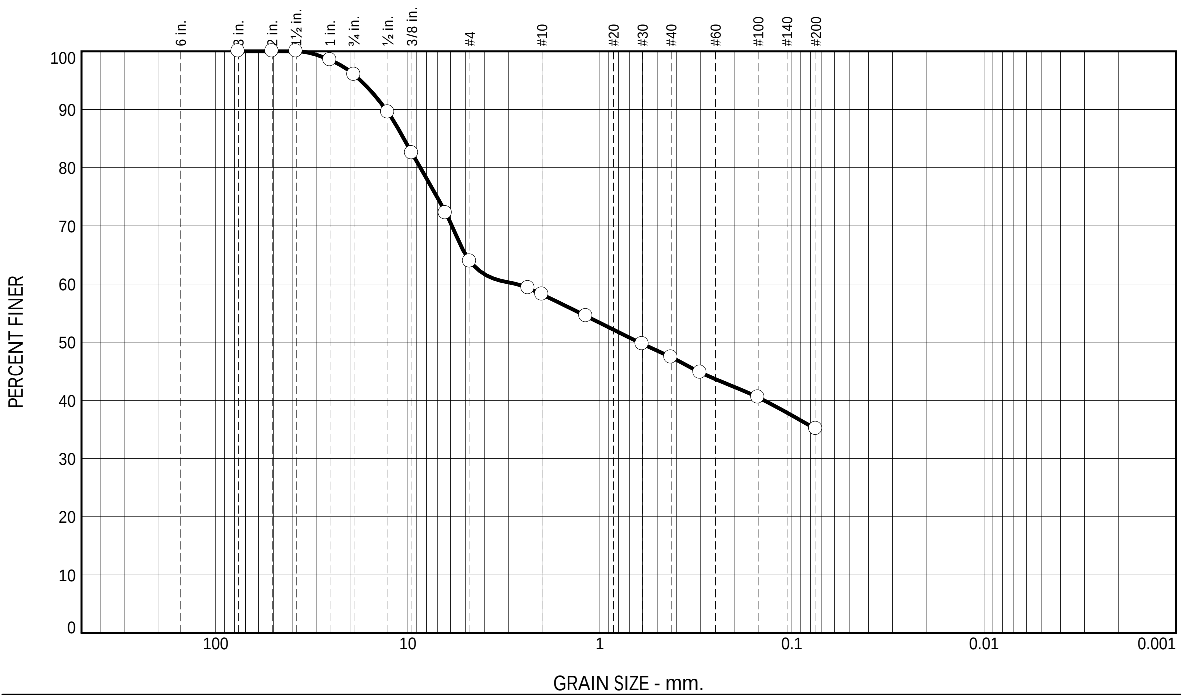
Tetra Tech

Missoula, MT

Client:
Project: MSU Pavement - Stadium & MOR
Project No: 117-001068-24002

Figure: **B-6**

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 4.0 | 32.1 | 5.7 | 10.8 | 12.3 | 35.1 | |

| Test Results (ASTM D422) | | | |
|---|---|---|---|
| Sieve Size or Diam. (mm.) | Finer (%) | Spec.* (%) | Out of Spec. (%) |
| 3 | 100.0 | | |
| 2 | 100.0 | | |
| 1.5 | 100.0 | | |
| 1 | 98.5 | | |
| .75 | 96.0 | | |
| .5 | 89.5 | | |
| .375 | 82.5 | | |
| .25 | 72.2 | | |
| #4 | 63.9 | | |
| #8 | 59.3 | | |
| #10 | 58.2 | | |
| #16 | 54.5 | | |
| #30 | 49.7 | | |
| #40 | 47.4 | | |
| #50 | 44.8 | | |
| #100 | 40.5 | | |
| #200 | 35.1 | | |

· (no specification provided)

**Material Description**

silty clayey gravel with sand

**Atterberg (ASTM D4318)**

PL= 19 LL= 25 PI= 6

**Coefficients**

$D_{90}$= 13.0232 $D_{85}$= 10.5062

$D_{60}$= 2.7326 $D_{50}$= 0.6266

$D_{30}$= $D_{15}$=

$D_{10}$=

$C_u$= $C_c$=

**Sieve Test (ASTM D422)**

Test Date: 1/19/24 Technician: DH/LP

Test Notes

**Hydrometer Test**

Test Date: ______ Technician: ______

Test Notes

**USCS (ASTM D2487)**

GC-GM

Date Sampled: ______

Date Received: ______

Checked By: LP

Title: ______

Location: B23-14
Depth: 2.5-5.5 ft

Tetra Tech

Missoula, MT

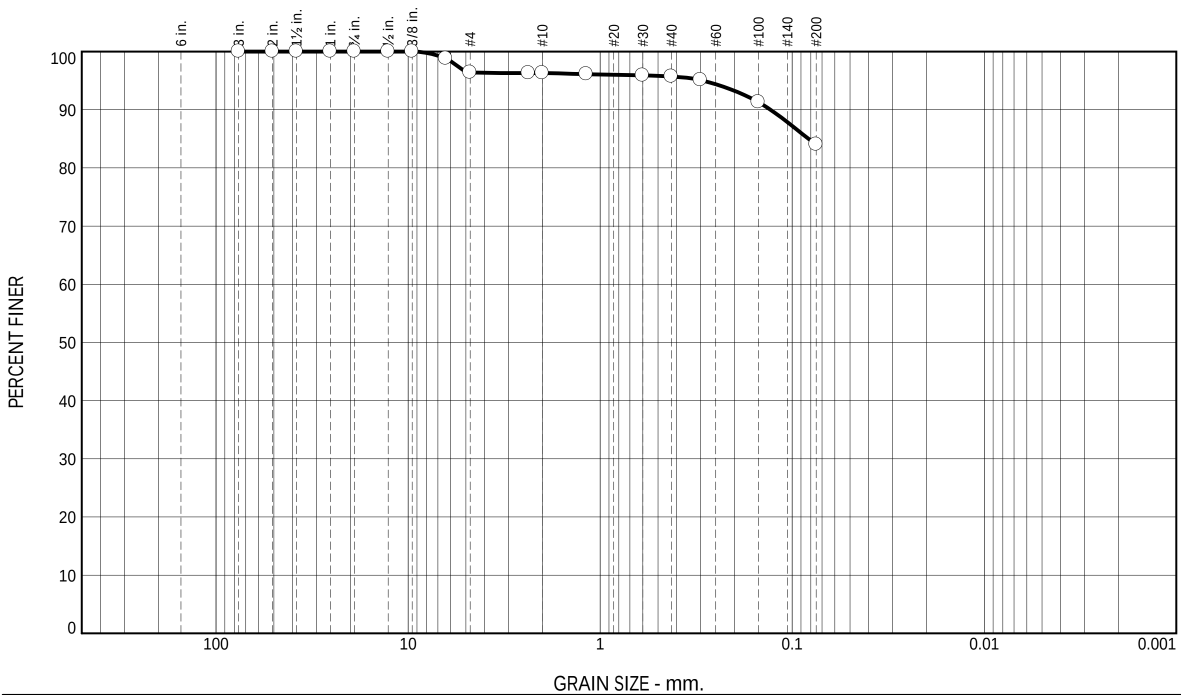
Client:

Project: MSU Pavement - Stadium & MOR

Project No: 117-001068-24002

Figure: **B-7**

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 0.0 | 3.6 | 0.1 | 0.6 | 11.7 | 84.0 | |

Test Results (ASTM D422)

| Sieve Size or Diam. (mm.) | Finer (%) | Spec.* (%) | Out of Spec. (%) |
|---|---|---|---|
| 3 | 100.0 | | |
| 2 | 100.0 | | |
| 1.5 | 100.0 | | |
| 1 | 100.0 | | |
| .75 | 100.0 | | |
| .5 | 100.0 | | |
| .375 | 100.0 | | |
| .25 | 98.8 | | |
| #4 | 96.4 | | |
| #8 | 96.3 | | |
| #10 | 96.3 | | |
| #16 | 96.1 | | |
| #30 | 95.9 | | |
| #40 | 95.7 | | |
| #50 | 95.1 | | |
| #100 | 91.3 | | |
| #200 | 84.0 | | |

· (no specification provided)

**Material Description**

lean clay with sand

**Sieve Test (ASTM D422)**

Test Date: 1/22/24 Technician: TL

Test Notes

**Hydrometer Test**

Test Date: ______ Technician: ______

Test Notes

**Atterberg (ASTM D4318)**

PL= 24 LL= 39 PI= 15

**Coefficients**

$D_{90}$= 0.1297 $D_{85}$= 0.0823

$D_{60}$= $D_{50}$=

$D_{30}$= $D_{15}$=

$D_{10}$=

$C_u$= $C_c$=

**USCS (ASTM D2487)**

CL

Date Sampled: ______

Date Received: ______

Checked By: LP

Title: ______

Location: INF23-02
Depth: 5-6.5 ft

Tetra Tech

Missoula, MT

Client:

Project: MSU Pavement - Stadium & MOR

Project No: 117-001068-24002

Figure: **B-8**

# COMPACTION TEST REPORT

Project No.: 117-001068-24002 Date:
Project: MSU Pavement - Stadium & MOR
Client:
Location: B23-04
Depth: 2-5 ft
Remarks:

MATERIAL DESCRIPTION

Description: lean clay with sand

Classifications - USCS: CL AASHTO:
Nat. Moist. = Sp.G. =
Liquid Limit = 34 Plasticity Index = 16
%<No.10 = %<No.40 =
%<No.60 = %<No.200 = 72.8 %

| ROCK CORRECTED TEST RESULTS | UNCORRECTED |
|---|---|
| Maximum dry density = 111.9 pcf | 109.0 pcf |
| Optimum moisture = 14.2 % | 15.4 % |

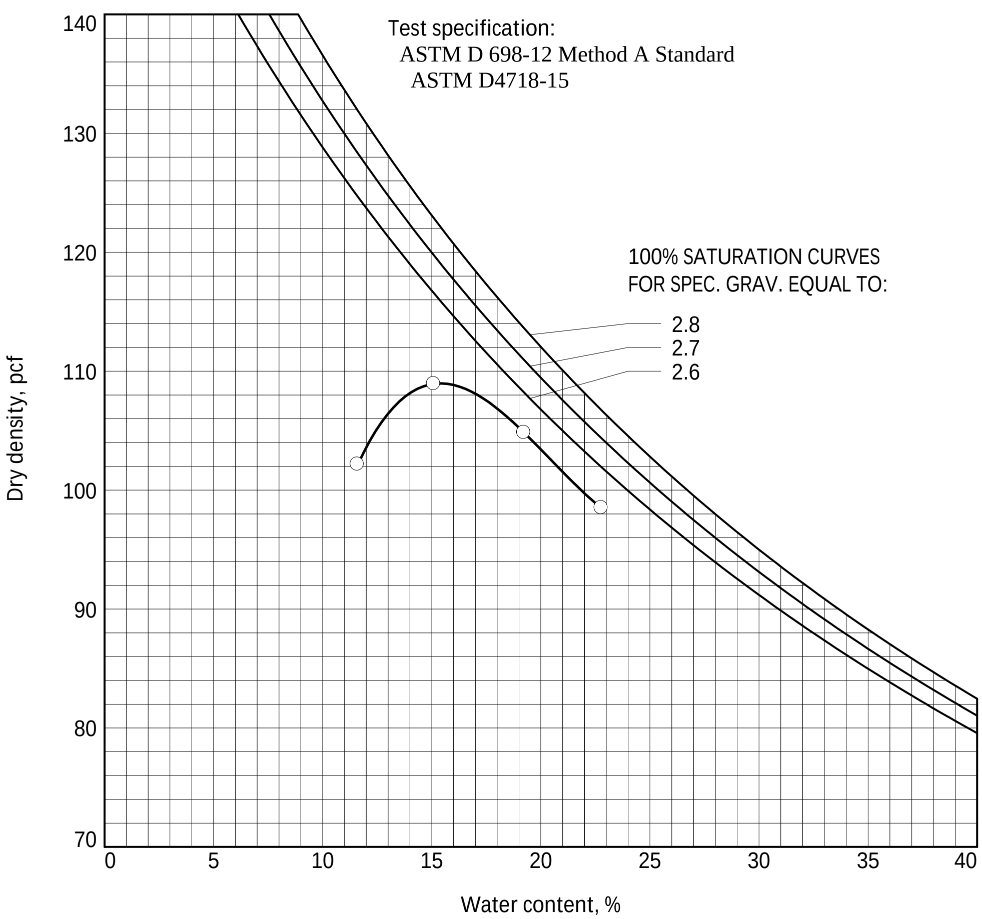



Figure: **B-9**

Tetra Tech

Tested By: AB Checked By: LP

# COMPACTION TEST REPORT

Project No.: 117-001068-24002 Date:

Project: MSU Pavement - Stadium & MOR

Client:

Location: B23-14

Depth: 2.5-5.5 ft

Remarks:

MATERIAL DESCRIPTION

Description: silty clayey gravel with sand

| | | | |
|---|---|---|---|
| Classifications - | USCS: GC-GM | AASHTO: A-2-4(0) | |
| Nat. Moist. = | | Sp.G. = | |
| Liquid Limit = | 25 | Plasticity Index = | 6 |
| %<No.10 = | 58.2 % | %<No.40 = | 47.4 % |
| %<No.60 = | 43.6 % | %<No.200 = | 35.1 % |

| ROCK CORRECTED TEST RESULTS |
|---|
| Maximum dry density = 118.7 pcf |
| Optimum moisture = 10.7 % |

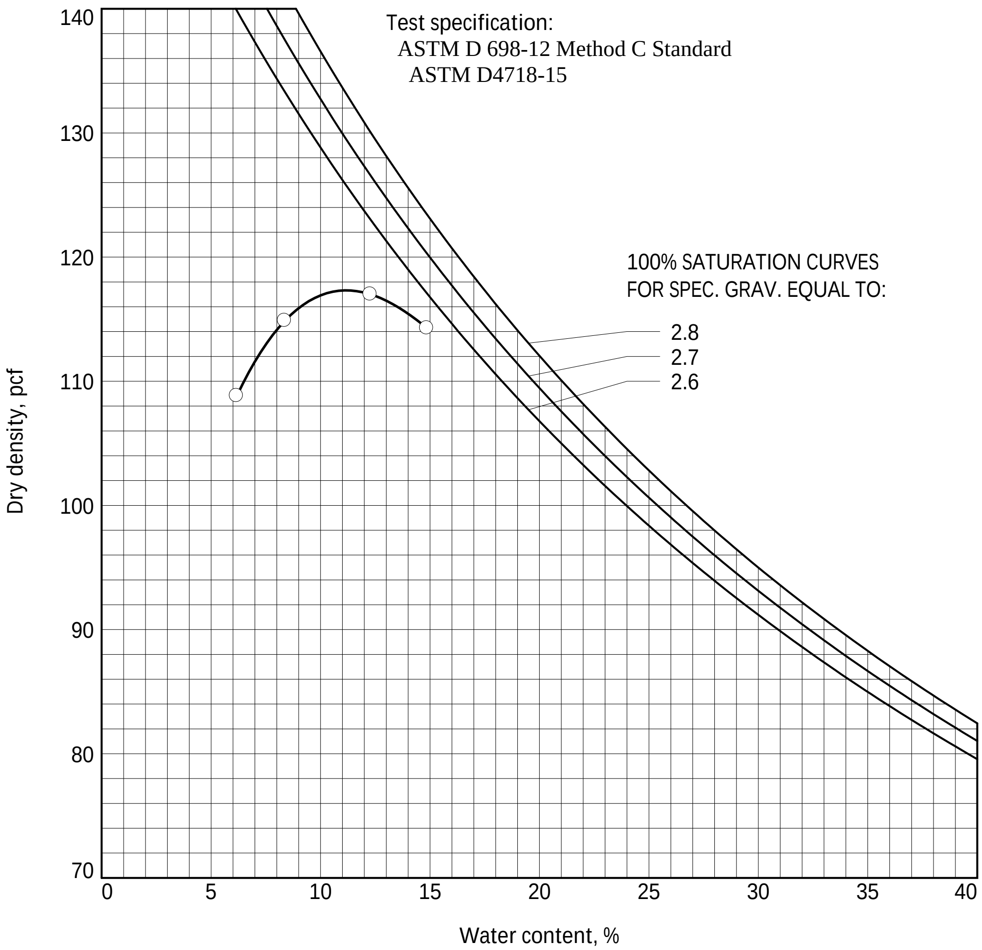



Figure: **B-10**

# COMPACTION TEST REPORT

Project No.: 117-001068-24002 Date:

Project: MSU Pavement - Stadium & MOR

Client:

Location: INF23-03

Depth: 2-4 ft

Remarks:

MATERIAL DESCRIPTION

Description: sandy lean clay with gravel

Classifications - USCS: CL AASHTO:

Nat. Moist. = Sp.G. =

Liquid Limit = 31 Plasticity Index = 15

%<No.10 = %<No.40 =

%<No.60 = %<No.200 = 56.2 %

| ROCK CORRECTED TEST RESULTS | UNCORRECTED |
|---|---|
| Maximum dry density = 117.2 pcf | 109.6 pcf |
| Optimum moisture = 12.1 % | 15.0 % |

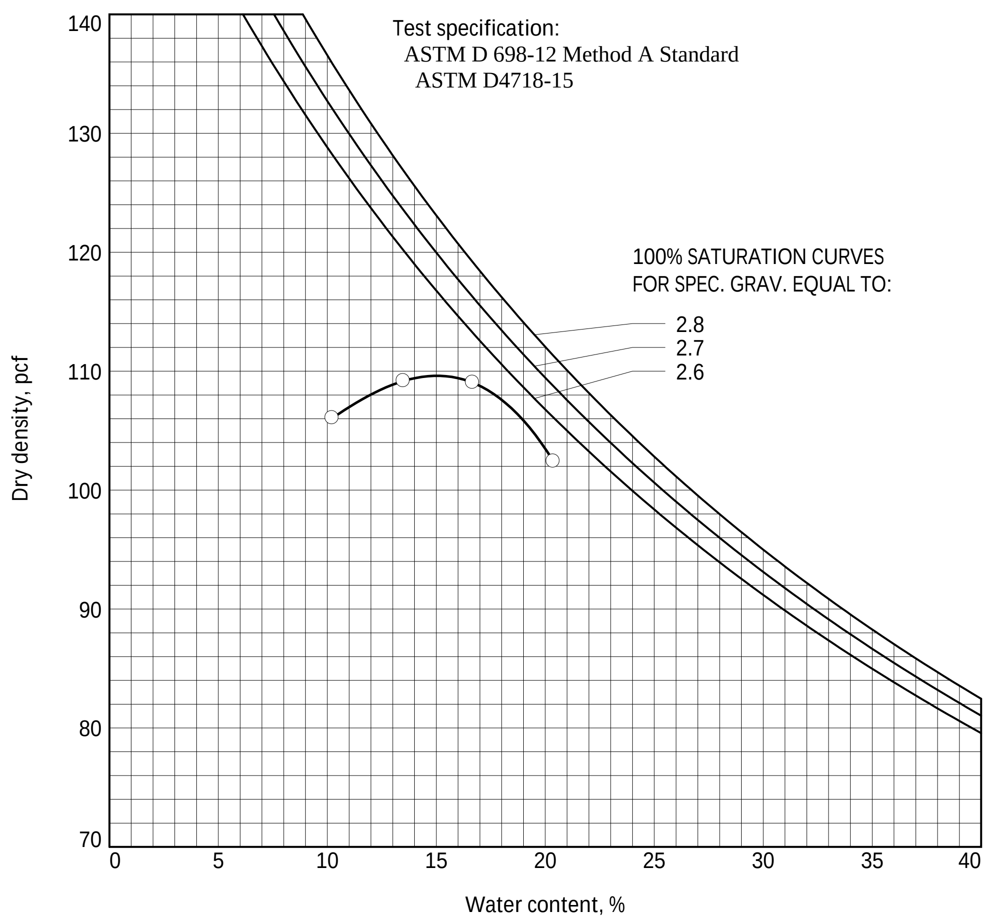



Figure: **B-11**

Tetra Tech

Tested By: TL Checked By: LP

**TETRA TECH**

| | | | |
|---|---|---|---|
| **PROJECT:** | MSU Pavement | **PROJECT NO:** | 117-001068-24002 |
| **LOCATION:** | Stadium & MOR | **WORK ORDER NO:** | |
| **BORING:** | B23-04 | **LAB NO:** | |
| **DEPTH:** | 2 - 5 feet | **DATE SAMPLED:** | |
| **REVIEWED BY:** | | | |

**CBR(CALIFORNIA BEARING RATIO) OF LABORATORY-COMPACTED SOILS(ASTM D1883)**

COMPACTION(%) 99.1

PERCENT SWELL 0.55%

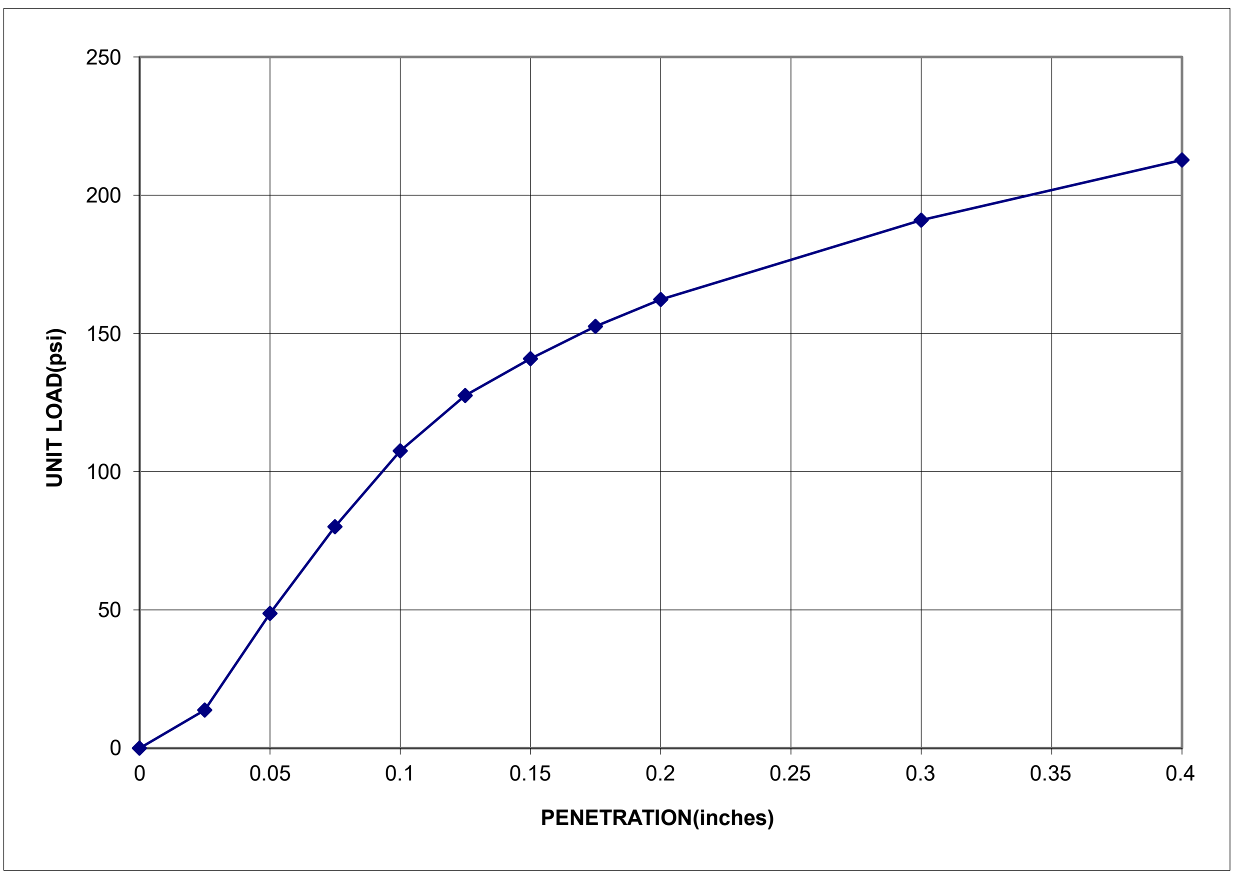
| PENETRATION | CORRECTED C B R |
|---|---|
| 0.100 | 11 |
| 0.200 | 11 |

| | BEFORE SOAK | AFTER SOAK |
|---|---|---|
| DRY DENSITY | 110.9 lbs./cu.ft | 109.0 lbs./cu.ft |
| PERCENT MOISTURE | 13.5 % | 19.4 % |

ASTM D698

| | |
|---|---|
| DRY DENSITY(pcf) | 111.9 |
| MOISTURE(%) | 14.2 |

SURCHARGE WEIGHT 10 lbs.




CBR 11

**FIGURE B-12**

| | | | |
|---|---|---|---|
| **PROJECT:** | MSU Pavement | **PROJECT NO:** | 117-001068-24002 |
| **LOCATION:** | Stadium & MOR | **WORK ORDER NO:** | |
| **BORING:** | B23-14 | **LAB NO:** | |
| **DEPTH:** | 2.5 - 5.5 feet | **DATE SAMPLED:** | |
| **REVIEWED BY:** | | | |

**CBR(CALIFORNIA BEARING RATIO) OF LABORATORY-COMPACTED SOILS(ASTM D1883)**

COMPACTION(%) 94.8

PERCENT SWELL 2.44%

| PENETRATION | CORRECTED C B R |
|---|---|
| 0.100 | 3 |
| 0.200 | 4 |

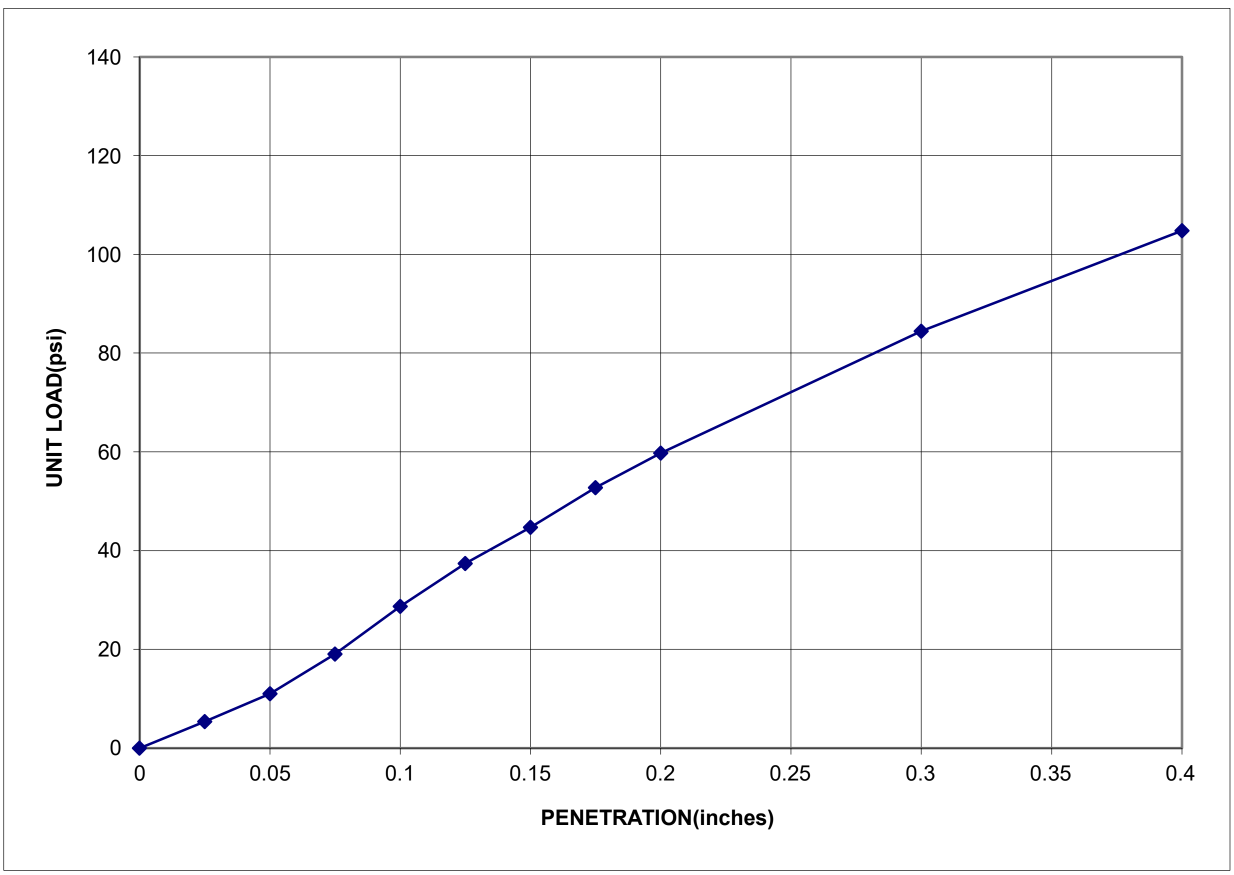
| | BEFORE SOAK | AFTER SOAK |
|---|---|---|
| DRY DENSITY | 112.5 lbs./cu.ft | 109.8 lbs./cu.ft |
| PERCENT MOISTURE | 7.3 % | 20.7 % |

ASTM D698

DRY DENSITY(pcf) 118.7

MOISTURE(%) 10.7

SURCHARGE WEIGHT 10 lbs.




CBR 4

**FIGURE B-13**

**TETRA TECH**

| | | | |
|---|---|---|---|
| **PROJECT:** | MSU Pavement | **PROJECT NO:** | 117-001068-24002 |
| **LOCATION:** | Stadium & MOR | **WORK ORDER NO:** | |
| **BORING:** | INF23-03 | **LAB NO:** | |
| **DEPTH:** | 2 - 4 feet | **DATE SAMPLED:** | |
| **REVIEWED BY:** | | | |

**CBR(CALIFORNIA BEARING RATIO) OF LABORATORY-COMPACTED SOILS(ASTM D1883)**

COMPACTION(%) 93.6

PERCENT SWELL 1.79%

| PENETRATION | CORRECTED C B R |
|---|---|
| 0.100 | 5 |
| 0.200 | 5 |

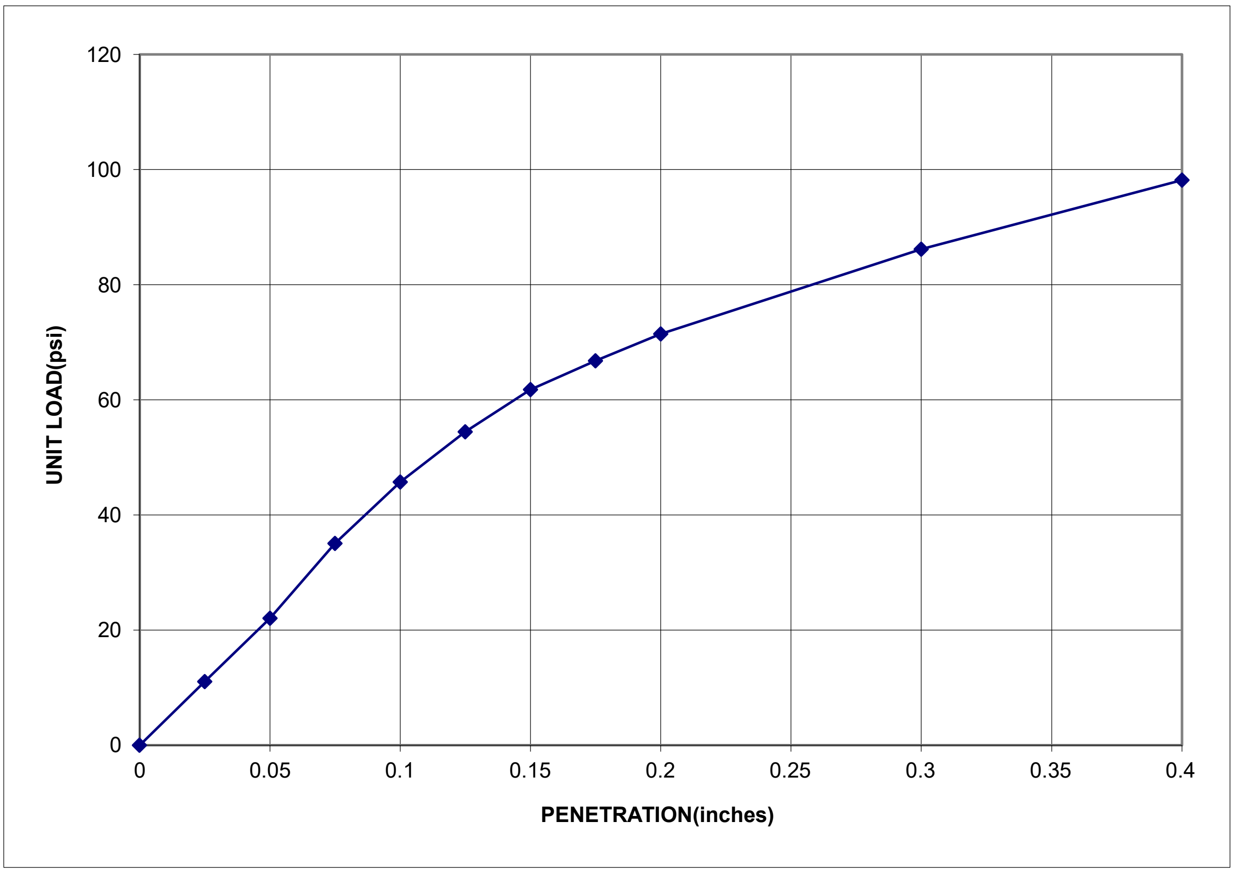
| | BEFORE SOAK | AFTER SOAK |
|---|---|---|
| DRY DENSITY | 109.7 lbs./cu.ft | 107.4 lbs./cu.ft |
| PERCENT MOISTURE | 11.3 % | 20.4 % |

ASTM D698

DRY DENSITY(pcf) 117.2

MOISTURE(%) 12.1

SURCHARGE WEIGHT 10 lbs.




CBR 5

**FIGURE B-14**

# APPENDIX C

## PAVEMENT SECTION ANALYSIS

## Figure C-1

| | | | |
|---|---|---|---|
| Project Number | 117-001068-24002 | | |
| Route | MSU Stadium &MOR Parking Areas | | |
| Name | MSU Stadium &MOR Parking Areas | | |
| Date of Run | 2/13/2024 | Des. Eng. | Tetra Tech |

| | PMS Raise Grade | | Maintain Grade - Treated Base | |
|---|---|---|---|---|
| **Typical Section** | **1 - Average Existing Base** | **1 - Average Existing Base** | **2 - Parking** | **2 - Heavy Traffic** |
| **Traffic** | **c Mirafi 180N or equivalent** | | | |
| Daily ESAL<br>Yearly ESAL | See Traffic Calcs | See Traffic Calcs | See Traffic Calcs | See Traffic Calcs |
| 20 Year ESAL | 22000 | 22000 | 22000 | 22000 |
| | | | | |
| ***Demand*** | | | | |
| *Note* | | | | |
| *Note* | | | | |
| *Reliability* | 85 | 85 | 85 | 85 |
| *So* | 0.45 | 0.45 | 0.45 | 0.45 |
| *DeltaPSI* | 1.7 | 1.7 | 1.7 | 1.7 |
| *Mr* | 3000 | 3000 | 3000 | 3000 |
| **SNDES** | **2.52** | **2.52** | **2.52** | **2.52** |
| *W18* | *22000* | *22000* | *22000* | *22000* |
| *Zr* | *-1.037* | *-1.037* | *-1.037* | *-1.037* |
| *ESAL* | *3* | *3* | *3* | *3* |
| *Life* | *20.0* | *20.0* | *20.0* | *20.0* |
| | | | | |
| **Capacity** | PMS Raise Grade | | Maintain Grade - Treated Base | |
| a1 | 0.41 | 0.41 | 0.41 | 0.41 |
| D1 (in) | **3** | **4** | **3** | **3** |
| SN1 | 1.2 | 1.6 | 1.2 | 1.2 |
| a2 | 0.14 | 0.14 | 0.2 | 0.2 |
| m2 | 1 | 1 | 1 | 1 |
| D2 (in) | 4 | 2 | 6 | 6 |
| SN2 | 0.6 | 0.3 | 1.2 | 1.2 |
| a3 | 0.1 | 0.1 | 0.1 | 0.09 |
| m3 | 1 | 1 | 1 | 1 |
| D3 (in) | 8 | 8 | 2 | 4 |
| SN3 | 0.8 | 0.8 | 0.2 | 0.4 |
| **Sntot = SN1+SN2+SN3+SN4** | **2.59** | **2.72** | **2.63** | **2.79** |
| Traffic Chk W18=20 Yr ESAL | OK | OK | OK | OK |
| SN Check | OK | OK | OK | OK |
| Design Check | **DESIGN OK** | **DESIGN OK** | **DESIGN OK** | **DESIGN OK** |
| | | | | |
| Layer 1 (ft) | 0.25 | 0.33 | 0.25 | 0.25 |
| Layer 2 (ft) | 0.33 | 0.17 | 0.50 | 0.50 |
| Layer 3 (ft) | 0.67 | 0.67 | 0.17 | 0.33 |
| Layer 4 (ft) | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 1.25 | 1.17 | 0.92 | 1.08 |
| | | | | |
| Layer 1 (mm) | 76 | 102 | 76 | 76 |
| Layer 2 (mm) | 102 | 51 | 152 | 152 |
| Layer 3 (mm) | 203 | 203 | 51 | 102 |
| Layer 4 (mm) | 0 | 0 | 0 | 0 |
| Total | 381 | 356 | 279 | 330 |

# APPENDIX D

## CEMENT TREATED BASE SPECIAL PROVISION

## XXX. BITUMINOUS RECLAMATION

### A. Description

Furnish all labor, equipment and materials to reclaim the existing base course in accordance with these specifications and to the lines, grades and details shown in the plans or as established by the Project Manager.

### B. Materials

1. Base One®, a liquid-based aggregate stabilization product that is diluted and applied with water, manufactured by Team Labs, 28650 State Highway 34, Detroit Lakes, MN 56501. Contact: David West, Team Labs, 1-800-721-9537

### C. EQUIPMENT

1. The Road Reclaimer – The Contractor shall furnish a self-propelled machine designed to mix and inject Base One into the base layer. It shall be capable of uniformly blending the material to the depths shown in the Plans or as directed by the Engineer. This machine shall have automatic depth and cross-slope controls and maintain a constant cutting depth. The automatic depth controls shall maintain the cutting depth to within plus or minus ¼ inch of the depth shown on the Plans. The Road Reclaimer shall be fitted with equipment capable of adequately mixing the reclaimed material while injecting the Base One®/water mixture as detailed in the Mixing/Injecting portion of this specification. The equipment shall provide a positive means for accurately controlling the rate of flow and total delivery of the Base One®/water mixture in relation to the speed of the reclaiming machine and quantity of material being blended. The injection system shall accurately and uniformly add the specified percent of water to the binder. The equipment shall be fitted with a sampling nozzle to provide field samples of the Base One®/water mixture.

2. Mixing/Injecting- All reclaimed materials and aggregates shall be mixed properly to provide a homogenous material prior to injecting the Base One®/water mixture. Where there is existing asphalt in place, the Reclaiming Machine shall produce a material that has 100 percent of the particles smaller than the 2-inch size. This asphalt reclamation process should take place prior to stockpiling the remaining base course layer. The Reclaiming Machine shall be capable of injecting the Base One®/water mixture and automatically metering it with a variation of not more than plus or minus 0.2 percent by weight of the Base One®. The unit shall be equipped with facilities so that the Contractor can verify and calibrate these items by a method acceptable to the Engineer.

3. Water Additive Systems- The Reclaimer shall be equipped with a system capable of adding Base One®/water mixture for material compaction, from bulk tankers, directly into the mixing chamber.

4. Controls for Liquid Additive Systems- All pumps shall be separately controlled by the automatic system in the operator’s cabin. During automatic operation, the system will allow liquids to be added only when the machine is in motion.

The pumps shall have a separate hydraulic drive systems.

The control system shall be capable of fully automated operation, as well as manual operation, when injecting the liquids to be add/mixed. All functions shall be controlled from the operation's station including automatic nozzle cleaning, partial spray bar use, and on-the-fly changes to the quantities of the materials being added. Non-contact flow meters shall be employed to measure liquid volumes and the control systems shall be proportional to the machines advance speed and shall be capable of maintaining accurate mixing regardless of changes in the machines working speed.

There shall be a system allowing the operator to verify that the nozzles on the spray bars are open and working from the operator's cabin.

There shall be provided a gallon per minute gauge to indicate instantaneous flow.

## D. Construction

A. Contractor Qualifications:

1. The bidder shall carefully examine the site of the proposed work and become thoroughly familiar with the existing site conditions, the application requirements of the Base One® product, and the conditions of the contract. A geotechnical report for the project was prepared by Tetra Tech, Inc., dated February 14, 2024. The report gives a general overview of the subsurface conditions that may be encountered at the project site, not information on specific locations or variations in the subsurface stratigraphy. To better define subsurface conditions along the proposed alignment, potential bidders are encouraged to perform additional site visits or investigations, at no additional cost to the owner.

2. The Contractor performing the work described in this Specification shall have a minimum of 5 years of experience performing highway/roadway/parking area reclamation work with a minimum of three projects in the last 3 years. The contractor shall assign a supervisor with a minimum of 5 years of experience on highway/roadway/parking area reclamation projects. The contractor may not use consultants or manufacturers representatives in order to meet the requirements of this section. Reclamation operators and on-site personnel shall have a minimum of three years of experience on highway/roadway reclamation projects.

## E. Reclamation:

1. All vegetation and topsoil that is adjacent to the surface (mainline or shoulder) that is to be reclaimed shall be removed prior to the start of reclamation, as directed by the Engineer.

2. The road reclaimer shall be a self-propelled machine capable of effectively mixing the in- place base material to a depth of 6 inches in one pass. All

areas containing existing asphalt surfacing should be reclaimed to a depth of 1 foot and thoroughly mixed prior to stockpiling with the existing base material.

3. The machine shall have either an upward or downward rotational cutting hand and controls to maintain a constant cutting depth so as to produce a uniformly blended reclaimed mixture.

4. The stockpiled and relaid base and asphalt/base mixed material shall be placed in a 6-inch compacted lift, graded, then mixed with Base One to the width and depth shown on the plans.

5. During the reclamation operation the Contractor shall physically dig down, approximately every 1,000 feet (each pass), to check the blending depth and visually verify the base material has been mix and blended with Base One without contamination from the clay subgrade. Additional depth verifications will be performed by the owner representative at intervals determined by the engineer.

6. The Contractor shall take care to avoid disturbing or damaging any existing drainage or utility structures on the Project. The Contractor shall repair damage to any structure resulting from the reclamation operation at no expense to the Owner.

**7.** The reclaimer shall have the capacity to uniformly inject the Base One®/water mixture through the reclamation machine into the reclaimed layer, whether on the $1^{st}$ reclamation pass or on a subsequent pass. **Spraying the product onto the surface or on windrows is not allowed.**

8. Base-One® product shall be injected at a rate of 0.0075 gallons per square yard per inch of reclamation depth, or, given the specified reclamation depth of 6 inches, the application rate will be 0.045 gallons per square yard of reclaimed area. The Base One® product should be diluted with water to bring the reclaimed material to the required moisture content for compaction. Methods for application of the Base One®/water mixture are covered in the Equipment portion of this provision.

9. An owner's representative should perform moisture tests at intervals specified by the Engineer to determine the moisture content of the reclaimed material. The results of the moisture tests should be used in conjunction with moisture/density values, determined using ASTM D698, to determine the application rate of the Base One®/ water mixture and subsequently the ratio of Base One® to water.

10. The contractor shall initially utilize a sheetsfoot vibratory roller that is self propelled and has a minimum weight of 25,000 pounds. The contractor shall additionally utilize either a vibratory steel drum roller capable of producing 250 lbs/in of drum width or a pneumatic tired roller (self propelled or towed) having a compacting width of 5 feet or more and sufficient mass to provide 100-250 lbs./in of rolling width.

11. The contractor shall compact the reclaimed layer to a minimum of 95 percent of ASTM D698. During the reclamation and compaction process, the contractor shall provide sufficient water so the reclaimed mixture will be at +/-

2 percent of the optimum moisture content per ASTM D698. If a nuclear density gauge is used to determine the in-situ density and moisture content, care should be taken to correct for the asphalt content of the reclaimed material. All reclaimed material shall be blended, spread, watered, compacted, and shaped, by the end of the workday.

12. Following reclamation and prior to paving, the contractor shall maintain the reclaimed surface so it is free of ruts, washboards, and potholes. This may require application of water and using a scarifying blade on a road grader. Reclaimed material with a “wash board” surface condition shall be scarified to a depth below that lowest surface of the wash boarded area and recompacted immediately prior to paving. This work shall be performed at no additional cost to the Owner. Any costs associated with maintaining this surface is incidental to Bituminous Reclamation.

13. The contractor shall allow the Base One®-treated surface to cure for a **minimum of 10 calendar days** prior to paving. Traffic will be allowed to travel on the surface upon completion of compaction. Should the Base One®-treated surface be exposed to significant rainfall (more than 4 hours of continuous rainfall per day) during the recommended 10 day cure period, the reclaimed material should be allowed a minimum of one additional ‘dry’ day (no rainfall) to cure for each day where rain fell for more than 4 hours.

14. Prior to paving, water shall be applied **when directed by the engineer** for dust control.

## F. Method of Measurement

1. Bituminous Reclamation will be measured and paid for on the basis of square yards reclaimed, graded and compacted. Payment will be by the square yard at the unit price shown on the Proposal for contract work.

## G. Basis of Payment

1. Payment for Bituminous Reclamation at the Contract bid price will be compensation in full for all labor, equipment, and material costs required to perform the reclamation as specified, including the costs of traffic control, pulverizing, blending, spreading, watering, compacting, and shaping of the reclaimed bituminous pavement and aggregate material. Costs associated with the blading, shaping, and compacting of the reclaimed material to meet the required profile and cross-section is included in the Bituminous Reclamation bid price

2. No direct compensation will be made for water used in conjunction with the operations associated with pulverizing, blending, placing, compacting, shaping, and maintaining the reclaim material finished surface.

3. Payment is full compensation for all labor, tools, equipment, materials, and other incidentals necessary to complete the work in accordance with the specifications and as directed by the Engineer.

## H. Currently Approved Contractors

1. Allstates Pavement Recycling and Stabilization
    i. Contact: Andy Dauk (612) 465-9848, adauk@aprsgroup.net
2. Midstate Reclamation
    i. Aaron Mather (612) 916-3035
3. Base One
    i. David West (800) 721-9537

# APPENDIX E

## IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL ENGINEERING REPORT

# IMPORTANT INFORMATION
## ABOUT YOUR
# GEOTECHNICAL ENGINEERING REPORT

More construction problems are caused by site subsurface conditions than any other factor. As troublesome as subsurface problems can be, their frequency and extent have been lessened considerably in recent years, due in large measure to programs and publications of ASFE/The Association of Engineering Firms Practicing in the Geosciences.

The following suggestions and observations are offered to help you reduce the Geotechnical-related delays, cost-overruns and other costly headaches that can occur during a construction project.

## A GEOTECHNICAL ENGINEERING REPORT IS BASED ON A UNIQUE SET OF PROJECT-SPECIFIC FACTORS

A Geotechnical engineering report is based on a subsurface exploration plan designed to incorporate a unique set of project-specific factors. These typically include: the general nature of the structure involved, its size and configuration; the location of the structure on the site and its orientation; physical concomitants such as access roads, parking lots, and underground utilities, and the level of additional risk which the client assumed by virtue of limitations imposed upon the exploratory program. To help avoid costly problems, consult the geotechnical engineer to determine how any factors which change subsequent to the date of the report may affect its recommendations.

Unless your consulting Geotechnical engineer indicates otherwise, *your Geotechnical engineer report should not be used:*

- When the nature of the proposed structure is changed, for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one;
- when the size or configuration of the proposed structure is altered;
- when the location or orientation of the proposed structure is modified:
- when there is a change of ownership, or
- for application to an adjacent site.

*Geotechnical engineers cannot accept responsibility for problems which may develop if they are not consulted after factors considered in their reports' development have changed.*

## MOST GEOTECHNICAL "FINDINGS" ARE PROFESSIONAL ESTIMATES

Site exploration identifies actual subsurface conditions only at those points where samples are taken, when they are taken. Data derived through sampling and subsequent laboratory testing are extrapolated by Geotechnical engineers who then render an opinion about overall subsurface conditions, their likely reaction to proposed conditions, their likely reaction to proposed construction activity, and appropriate foundation design. Even under optimal circumstances actual conditions may differ from those inferred to exist, because no Geotechnical engineer, no matter how qualified, and not subsurface exploration program, no matter how comprehensive, can reveal what is hidden by earth, rock and time. The actual interface between materials may be fare more gradual or abrupt than a report indicates. Actual conditions in areas not sampled may differ from predictions. *Nothing can be done to prevent the unanticipated, but steps can be taken to help minimize their impact.* For this reason, *most experienced owners retain their Geotechnical consultants through the construction stage*, to identify variances, conduct additional tests which may be needed, and to recommend solutions to problems encountered on site.

## SUBSURFACE CONDITIONS CAN CHANGE

Subsurface conditions may be modified by constantly-changing natural forces. Because a Geotechnical engineering report is based on conditions which existed at the time of subsurface exploration, *construction decisions should not be based on a Geotechnical engineering report whose adequacy may have been affected by time.* Speak with the Geotechnical consultant to learn if additional tests are advisable before construction starts.

Construction operations at or adjacent to the site and natural events such as flood, earthquakes or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical report. The geotechnical engineer should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

## GEOTECHNICAL SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND PERSONS

Geotechnical engineers' reports are prepared to meet the specific needs of specific individuals. A report prepared for a consulting civil engineer may not be adequate for a construction contractor, or even some other consulting civil engineer. Unless indicated otherwise, this report was prepared expressly for the client involved and expressly for purposes indicated by the client. Use by any other persons for any purpose, or by the client for a different purpose, may result in problems. *No individual other than the client should apply this report for its intended purpose without first conferring with the* *geotechnical engineer. No person should apply this report for any purpose other than that originally contemplated without first conferring with the geotechnical engineer.*

## A GEOTECHNICAL ENGINEERING REPORT IS SUBJECT TO MISINTERPRETATION

Costly problems can occur when other design professionals develop their plants based on misinterpretations of a geotechnical engineering report. To help avoid these problems, the geotechnical engineer should be retained to work with other appropriate design professionals to explain relevant geotechnical findings and to review the adequacy of their plans and specifications relative to geotechnical issues.

## BORING LOGS SHOULD NOT BE SEPARATED FROM THE ENGINEERING REPORT

Final boring logs are developed by geotechnical engineers based upon their interpretation of field logs (assembled by site personnel) and laboratory evalution of field samples. Only final boring logs customarily are included in geotechnical engineering reports. *These logs should not under any circumstances be redrawn* for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process. Although photographic reproduction eliminates this problem, it does nothing to minimize the possibility of contractors misinterpreting the logs during bid preparation. When this occurs, delays, disputes and unanticipated costs are the all-too-frequent result.

To minimize the likelihood of boring log misinterpretation, *give contractors ready access to the complete geotechnical engineering report* prepared or authorized for their use. Those who do not provide such access may proceed under the *mistaken* impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes which aggravate them to disproportionate scale.

## READ RESPONSIBILITY CLAUSES CLOSELY

Because geotechnical engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against geotechnical consultants. To help prevent this problem, geotechnical engineers have developed model clauses for use in written transmittals. These are *not* exculpatory clauses designed to foist geotechnical engineers' liabilities onto someone else. Rather, they are definitive clauses which identify where geotechnical engineers' responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your geotechnical engineering report, and you are encouraged to read them closely. your geotechnical engineer will be pleased to give full and frank answers to your questions.

## OTHER STEPS YOU CAN TAKE TO REDUCE RISK

Your consulting geotechnical engineer will be pleased to discuss other techniques which can be employed to mitigate risk. In addition, ASFE as developed a variety of materials which may be beneficial. Contact ASFE for a complimentary copy of its publications directory.

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