Huddleston-Berry
Engineering & Testing, LLC

# GEOLOGIC HAZARDS AND GEOTECHNICAL INVESTIGATION FIRE STATION #3 GRAND JUNCTION, COLORADO PROJECT#00208-0112

**CITY OF GRAND JUNCTION**
**333 WEST AVENUE, BLDG C**
**GRAND JUNCTION, COLORADO  81501**

**MARCH 26, 2020**

**Huddleston-Berry Engineering and Testing, LLC**
**2789 Riverside Parkway**
**Grand Junction, Colorado 81501**

# SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

As part of the development process, a geotechnical investigation was conducted for the proposed new Fire Station #3 in Grand Junction, Colorado. The project location is shown on Figure 1 – Site Location Map. The purpose of the investigation was to evaluate the subsurface conditions at the site with respect to foundation design, pavement design, and earthwork for the proposed construction. This summary has been prepared to include the information required by civil engineers, structural engineers, and contractors involved in the project.

**<u>Subsurface Conditions (p. 2)</u>**

The subsurface investigation consisted of five geotechnical borings. The locations of the borings are shown on Figure 2 – Site Plan. The borings generally encountered very soft to medium stiff clay soils to depths of between 37 and 39 feet. The clay soils were underlain by dense gravel and cobble soils to the bottoms of the borings. Groundwater was encountered at depths of between 6.0 and 15.5 feet at the time of the investigation. The native clay soils were indicated to be slightly to moderately plastic and slightly expansive.

**<u>Summary of Foundation Recommendations</u>**

- *Foundation Type* – Driven Piles or Helical Piles. (p. 3)

*Driven Piles*

- *Pile Type* - Minimum 10¾ inch diameter pipe piles (p. 4)
- *Anticipated Length* – 40 to 49 feet possible. (p. 4)
- *Axial Capacity* – 50 tons for 10¾ inch pipe piles without pile load testing. (p. 4)

*Helical Piles*

- *Anticipated Length* – 40 to 54 feet possible. (p. 5)
- *Axial Capacity* – Dependent upon pile load testing; however, 30 to 40 tons anticipated. (p. 5)

*General*

- *Seismic Design* – Site Class E (p. 5)
- *Lateral Earth Pressure* – 55 pcf active for controlled fill. 75 pcf at-rest. (p. 7)

**<u>Summary of Pavement Recommendations (p. 8)</u>**

**Automobile Parking Areas**
EDLA = 5, Structural Number = 2.75

| ALTERNATIVE | PAVEMENT SECTION (Inches) | | | | |
|---|---|---|---|---|---|
| | Hot-Mix Asphalt Pavement | CDOT Class 6 Base Course | CDOT Class 3 Subbase Course | Concrete Pavement | TOTAL |
| Full Depth HMA | 7.0 | | | | 7.0 |
| A | 3.0 | 10.0 | | | 13.0 |
| B | 4.0 | 7.0 | | | 11.0 |
| C | 3.0 | 6.0 | 6.0 | | 15.0 |
| Rigid Pavement | | 6.0 | | 6.0 | 12.0 |

**Truck Traffic Areas**

EDLA = 30, Structural Number = 3.70

| ALTERNATIVE | PAVEMENT SECTION (Inches) | | | | |
|---|---|---|---|---|---|
| | Hot-Mix Asphalt Pavement | CDOT Class 6 Base Course | CDOT Class 3 Subbase Course | Concrete Pavement | TOTAL |
| Full Depth HMA | 9.0 | | | | 9.0 |
| A | 3.0 | 17.0 | | | 20.0 |
| B | 4.0 | 14.0 | | | 18.0 |
| C | 3.0 | 6.0 | 16.0 | | 25.0 |
| Rigid Pavement | | 6.0 | | 8.0 | 14.0 |

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### APPENDICES

# 1.0 INTRODUCTION

As part of continued infrastructure improvements, the City of Grand Junction proposes to construct a new Fire Station. As part of the design development process, Huddleston-Berry Engineering and Testing, LLC (HBET) was retained by the City of Grand Junction to conduct a geotechnical investigation for the project.

## 1.1 Scope

As discussed above, a geotechnical investigation was conducted for the proposed new Fire Station #3 in Grand Junction, Colorado. The scope of the investigation included the following components:

- Conducting a subsurface investigation to evaluate the subsurface conditions at the site.
- Collecting soil samples and conducting laboratory testing to determine the engineering properties of the soils at the site.
- Providing recommendations for foundation type and subgrade preparation.
- Providing recommendations for bearing capacity.
- Providing recommendations for lateral earth pressure.
- Providing recommendations for drainage, grading, and general earthwork.
- Providing recommendations for pavement section alternatives.

The investigation and report were prepared by a Colorado registered professional engineer in accordance with generally accepted engineering practices. This report has been prepared for the exclusive use of the City of Grand Junction.

## 1.2 Site Location and Description

The site is located at 582 25½ Road in Grand Junction, Colorado. The project location is shown on Figure 1 – Site Location Map.

At the time of the investigation, the northern portion of the site was occupied by the existing Fire Station #3. The southern portion of the site was a paved parking lot. The site was fairly flat and vegetation was limited to grasses, trees, and bushes in landscaped areas. The site was bordered to the north by Pomona Elementary School, to the south and east by sports fields, and to the west by 25½ Road.

## 1.3 Proposed Construction

The proposed construction is anticipated to include a new fire station. The structure is anticipated to be grouted masonry construction.

# 2.0 GEOLOGIC SETTING

## 2.1 Soils

Soils data was obtained from the USDA Natural Resource Conservation Service Web Soil Survey. The data indicates that the soils at the site consist of Sagers silty clay loam, 0 to 2 percent slopes. Soil survey data is included in Appendix A.

Structure construction in the Sagers soils is described as being somewhat limited due to shrink-swell. Pavement construction in the site soils is indicated to be very limited due to frost action, low strength, and/or shrink-swell. Excavation in the site soils is described as being somewhat limited due to dust and/or unstable excavation walls. The site soils are indicated to have a moderate potential for frost action, moderate risk of corrosion of steel, and moderate risk of corrosion of concrete

## 2.2 Geology

According to the *Geologic Map of the Grand Junction Quadrangle, Mesa County, Colorado* (2002), the site is underlain by undivided alluvium and colluvium.

## 2.3 Groundwater

Groundwater was encountered in the subsurface at depths of between 6.0 and 15.5 feet below the existing ground surface at the time of the investigation.

# 3.0 SUBSURFACE INVESTIGATION

The subsurface investigation consisted of five geotechnical borings drilled on February 21st, 2020. The locations of the borings are shown on Figure 2 – Site Plan. Typed boring logs are included in Appendix B. Samples of the subsurface soils were collected using Standard Penetration Testing (SPT) and bulk sampling methods at the depths shown on the logs.

As indicated on the logs, the subsurface conditions at the site were fairly consistent. The borings generally encountered 3 to 4-inches of asphalt pavement above granular base course to depths of between 1 and 2 feet. The base course was underlain by brown, moist to wet, very soft to medium stiff silty clay with sand to lean clay soils to depths of between 37 and 39 feet. The clay soils were underlain by brown, wet, dense to very dense sandy gravel and cobble soils. As discussed previously, groundwater was encountered in the subsurface at depths of between 6.0 and 15.5 feet at the time of the investigation.

# 4.0 LABORATORY TESTING

Selected soil samples collected from the borings were tested in the Huddleston-Berry Engineering and Testing LLC geotechnical laboratory for natural moisture content, gradation, Atterberg limits, California Bearing Ratio (CBR), and optimum moisture/maximum dry density (Proctor). The laboratory testing results are included in Appendix C.

The laboratory testing results indicate that the native clay soils are slightly to moderately plastic. In addition, the CBR results suggest that the native clay soils are slightly expansive with up to 1.0% expansion measured in the laboratory.

# 5.0 CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Structure Foundations

As discussed previously, very soft clay soils were encountered in the shallow subsurface. Unfortunately, these soils will provide limited structural support. As a result, HBET recommends that the structure be supported by deep foundations bearing on the dense gravel and cobble soils. Specifically, the recommended foundation alternatives include driven piles and helical piles. The alternatives are discussed in the following sections.

<u>Driven Piles</u>

It is anticipated that most of the axial pile capacity will be developed in end bearing in the dense gravel and cobble soils. Therefore, concrete filled pipe piles are recommended.

Based upon the anticipated working loads and pile driving conditions, pipe piles should be a minimum of 10¾ inch diameter. The piles should penetrate the soft clay soils and bear into the dense gravel and cobble soils. The actual penetration of individual piles will be dependent upon driving conditions and size of pile used; however, it is anticipated that the piles will reach refusal within 3 to 10 feet of the top of the gravel and cobble layer. As indicated in the boring logs, the gravel and cobble soils were encountered at depths of between 37 and 39 feet. Therefore, pile lengths of up to approximately 49 feet may be possible (measured from existing grade).

The refusal criterion for driven piles is dependent upon the type and size of the hammer. However, the refusal criteria should be established as the number of blows required for the last few inches of penetration. For a hammer delivering 20,000 foot-pounds of energy to a 10¾ inch pipe pile, we would expect refusal to be at approximately 5 to 8 blows per inch. However, the contractor should coordinate with HBET to develop specific pile refusal criteria for the specific hammer. Due to the nature of the gravel and cobble soils, to reduce the possibility of excessive tip deflection and tip damage, pile tip reinforcement is recommended.

For 10¾-inch diameter, concrete filled pipe piles driven to refusal, HBET recommends an allowable geotechnical capacity of 50 tons. In general, a minimum 3/8-inch wall thickness is recommended. However, ¼-inch wall thickness may be utilized provided the structural engineer and/or contractor can verify that the driving stresses will not damage the thinner walled piles. The lateral capacity of the piles should consider the low lateral support provided by the soft clay soils.

To eliminate reductions in capacity from group effects, the minimum center-to-center spacing of piles should be 3 pile diameters. Group effects should be considered for piles grouped less than 3 diameters apart.

In general, for steel pipe piles driven to refusal, HBET anticipates total settlement will be 1.0-inch or less.

Helical Piles

Helical piles consist of circular or square steel shafts with load carrying helices attached to them. Some of these types of piers are proprietary. Helical piles typically provide slightly less bearing capacity than driven piles; however, helical piles can be easily battered to accommodate lateral loads. In general, the precise type, size, and quantity of piles should be established by the contractor in conjunction with the structural engineer. However, HBET provides the following design comments.

In general, helical piles should be designed to penetrate the soft clay soils and bear into the dense gravel and cobble soils. It is anticipated that the helical piles will reach refusal within 3 to 15 feet of the top of the gravel and cobble soils. Therefore, pile lengths of up to approximately 54 feet may be possible (measured from existing grade). To eliminate reductions in capacity from group effects, the piles should be spaced a distance equal to three times the diameter of the largest helix.

Based upon our experience with other projects utilizing helical piles, allowable axial capacities of between approximately 30 and 40 tons are anticipated for piles with a minimum shaft diameter of 4-inches. However, higher capacities are possible depending on the specific pile type/size proposed. The actual allowable capacity should be determined based upon the results of pile load testing conducted on the project site prior to final design. Where necessary, piles battered up to 15° should be utilized to carry lateral loads.

In general, for properly installed helical piles, HBET anticipates that total settlements will be 1.0-inch or less. However, this should be verified during pile load testing. A reduction in capacity may be necessary where pile load tests indicate excessive deflection.

## 5.2 Seismic Design Criteria

As discussed above, the subsurface profile at the site generally consists of soft clay soils above dense gravel and cobble soils. In general, based upon the presence of soft clay soils, the site classifies as Site Class E.

### 5.3 Lateral Resistance for Seismic and Wind Loads

As discussed above, the native clay soils are soft through most of the profile and are anticipated to provide limited lateral capacity for deep foundations. Based upon the results of the subsurface investigation, the following soil parameters are recommended for use in lateral pile capacity analyses:

| Depth from Grade (in). | 0 to 72 | 72+ |
|---|---|---|
| Soil Type | Soft Clay | Soft Clay |
| Density (pci) | 0.0637 | 0.0318 |
| Cohesion (psi) | 3 | 3 |
| Friction Angle ($\phi$) | 0 | 0 |
| $\varepsilon_{50}$ (in/in) | 0.02 | 0.02 |
| K (pci) | 200 | 200 |
| Modulus – $K_h$ (tcf) | 15 | 15 |

In addition to lateral resistance of the piles, lateral resistance can be developed from sliding friction between the floor slab and the ground. In general, for the native soils, a sliding friction angle of 18° is recommended. This corresponds to a friction factor of 0.32.

### 5.4 Non-Structural Floor Slabs and Exterior Flatwork

As discussed previously, moisture sensitive soils were encountered at the site. In general, the only way to eliminate the risk of differential movement of the floor slab would be to support the floor slab on the deep foundations. However, this may be cost prohibitive. Where a conventional floor slab is used, to reduce the potential for excessive differential movement, it is recommended that the floor slab be constructed above a minimum of 24-inches of structural fill. It is also recommended that exterior slabs-on-grade be constructed above a minimum of 12-inches of structural fill.

As discussed previously, the native clay soils were indicated to be slightly expansive when compacted and introduced to excess moisture. However, the magnitude of swell measured in the laboratory was fairly low. Therefore, with careful moisture control and proper compaction, the native soils are generally suitable for re-use as structural fill. Imported structural fill should consist of a granular, non-free draining, non-expansive material approved by HBET.

Prior to placement of structural fill, it is recommended that the bottoms of the excavations be scarified to a depth of 6 to 8-inches, moisture conditioned, and compacted to a minimum of 95% of the standard Proctor maximum dry density within ±2% of the optimum moisture content as determined in accordance with ASTM D698. However, as discussed previously, shallow groundwater and associated soft soils were present at the site. Therefore, geotextile and/or geogrid reinforcement and up to 30-inches of additional granular fill may be required to stabilize the subgrade. HBET can provide specific recommendations for subgrade stabilization based upon the actual subgrade conditions encountered during construction.

Structural fill should be moisture conditioned, placed in maximum 8-inch loose lifts, and compacted to a minimum of 95% of the standard Proctor maximum dry density for fine grained soils and modified Proctor maximum dry density for coarse grained soils, within ± 2% of the optimum moisture content as determined in accordance with ASTM D698 and D1557, respectively.

For the slab pads prepared as recommended with structural fill consisting of the native soils or imported granular materials, a maximum allowable bearing capacity of 1,000 psf may be used, where necessary. In addition, a modulus of subgrade reaction of 150 pci may be used for structural fill consisting of the native soils. A modulus of 200 pci may be used for approved imported structural fill materials.

Due to the presence of shallow groundwater, a vapor retarder is recommended below floor slabs where moisture sensitive floor coverings are utilized.

## 5.5 Corrosion of Concrete and Steel

The Soil Survey data indicate that the native soils have a moderate degree of potential sulfate attack on concrete. In addition, water soluble sulfates can vary widely in Western Colorado. Therefore, at a minimum, Type I-II sulfate resistant cement is recommended for construction at this site.

The Soil Survey data also indicates that the native soils are moderately corrosive to uncoated steel. In addition, shallow groundwater was encountered at the site and fluctuations in groundwater levels will increase the risk of corrosion. As a result, HBET recommends that the foundation elements consider corrosion in their design either through galvanization or accounting for section loss.

## 5.6 Lateral Earth Pressures

Stemwalls, below grade walls, and/or retaining walls should be designed to resist lateral earth pressures. For backfill consisting of the native soils or suitable imported materials, we recommend that the walls be designed for an active equivalent fluid unit weight of 55 pcf in areas where no surcharge loads are present. An at-rest equivalent fluid unit weight of 75 pcf is recommended for basement or other braced walls. Lateral earth pressures should be increased as necessary to reflect any surcharge loading behind the walls.

In general, HBET recommends that passive pressure be ignored for retaining walls. However, if passive pressure is used, a passive equivalent fluid unit weight of 350 pcf is appropriate for the native soils.

## 5.7 Site Grading and Drainage

The success of the foundations, pavements, floor slabs, and exterior flatwork is dependent upon proper drainage. Therefore, grading at the site should be designed to carry precipitation and runoff away from the structure. It is recommended that the finished ground surface drop at least six inches within the first ten feet away from the structure. However, where impermeable surfaces (i.e. sidewalks, pavements, etc.) are adjacent to the structure, the grade can be reduced to 2.5-inches (ADA grade) within the first ten feet away from the structure.

Downspouts should empty beyond the backfill zone. It is recommended that landscaping within five feet of the structure include primarily desert plants with low water requirements. In addition, it is recommended that automatic irrigation within ten feet of foundations be minimized.

## 5.8 Excavations

Excavations in the native soils at the site may stand for short periods of time but should not be considered to be stable. Trenching and excavations should be sloped back, shored, or shielded for worker protection in accordance with applicable OSHA standards. The existing fill generally classify as Type C soil with regard to OSHA's *Construction Standards for Excavations*. For Type C soils, the maximum allowable slope in temporary cuts is 1.5H:1V.

## 5.9 Pavements

The design California Bearing Ratio (CBR) of the native soils was determined in the laboratory to be less than 2.0. Therefore, the minimum recommended Resilient Modulus of 3,000 psi was used for the pavement section design.

Based upon the subgrade conditions and anticipated traffic loading, pavement section alternatives were developed in accordance with AASHTO design methodologies. The following minimum pavement section alternatives are recommended:

**Automobile Parking Areas**
EDLA = 5, Structural Number = 2.75

| ALTERNATIVE | PAVEMENT SECTION (Inches) | | | | |
|---|---|---|---|---|---|
| | **Hot-Mix Asphalt Pavement** | **CDOT Class 6 Base Course** | **CDOT Class 3 Subbase Course** | **Concrete Pavement** | **TOTAL** |
| Full Depth HMA | 7.0 | | | | 7.0 |
| A | 3.0 | 10.0 | | | 13.0 |
| B | 4.0 | 7.0 | | | 11.0 |
| C | 3.0 | 6.0 | 6.0 | | 15.0 |
| Rigid Pavement | | 6.0 | | 6.0 | 12.0 |

**Truck Traffic Areas**
EDLA = 30, Structural Number = 3.70

| ALTERNATIVE | PAVEMENT SECTION (Inches) | | | | |
|---|---|---|---|---|---|
| | Hot-Mix Asphalt Pavement | CDOT Class 6 Base Course | CDOT Class 3 Subbase Course | Concrete Pavement | TOTAL |
| Full Depth HMA | 9.0 | | | | 9.0 |
| A | 3.0 | 17.0 | | | 20.0 |
| B | 4.0 | 14.0 | | | 18.0 |
| C | 3.0 | 6.0 | 16.0 | | 25.0 |
| Rigid Pavement | | 6.0 | | 8.0 | 14.0 |

Prior to pavement placement, areas to be paved should be stripped of all topsoil and other deleterious materials. It is recommended that the subgrade be scarified to a depth of 12-inches; moisture conditioned, and recompacted to a minimum of 95% of the standard Proctor maximum dry density, within ±2% of optimum moisture content as determined by AASHTO T-99. However, as discussed previously, soft soils were encountered at the site and subgrade stabilization using geotextile and/or geogrid in conjunction with up to 30-inches of granular fill may be required. HBET should be contacted to provide specific recommendations for subgrade stabilization based upon the actual subgrade conditions during construction.

Aggregate base course and subbase course should be placed in maximum 9-inch loose lifts, moisture conditioned, and compacted to a minimum of 95% and 93% of the maximum dry density, respectively, at -2% to +3% of optimum moisture content as determined by AASHTO T-180. In addition to density testing, base course should be proofrolled to verify subgrade stability.

It is recommended that Hot-Mix Asphaltic (HMA) pavement conform to CDOT grading SX or S specifications and consist of an approved 75 gyration Superpave method mix design. HMA pavement should be compacted to between 92% and 96% of the maximum theoretical density. An end point stress of 50 psi should be used. It is recommended that rigid pavements consist of CDOT Class P concrete or alternative approved by the Engineer. Dowels at transverse joints and tie bars at longitudinal joints should be considered to limit the potential for differential movements between panels. In addition, reinforcement of the concrete should be considered to limit cracking.

The long-term performance of the pavements is dependent on positive drainage away from the pavements. Ditches, culverts, and inlet structures in the vicinity of paved areas must be maintained to prevent ponding of water on the pavement.

## 6.0 GENERAL

The recommendations included above are based upon the results of the subsurface investigation and on our local experience. These conclusions and recommendations are valid only for the proposed construction.

As discussed previously, the subsurface conditions at the site were fairly consistent. Although HBET believes that the investigation was sufficient to adequately characterize the range of subsurface conditions at the site, the precise nature and extent of subsurface variability may not become evident until construction. Therefore, it is recommended that a representative of HBET be retained to provide engineering oversight and construction materials testing services during the construction. This is to verify compliance with the recommendations included in this report or permit identification of variations in the subsurface conditions which may require modification of the recommendations.

Huddleston-Berry Engineering and Testing, LLC is pleased to be of service to your project. Please contact us if you have any questions or comments regarding the contents of this report.

Respectfully Submitted:
**Huddleston-Berry Engineering and Testing, LLC**


Michael A. Berry, P.E.
Vice President of Engineering

# FIGURES

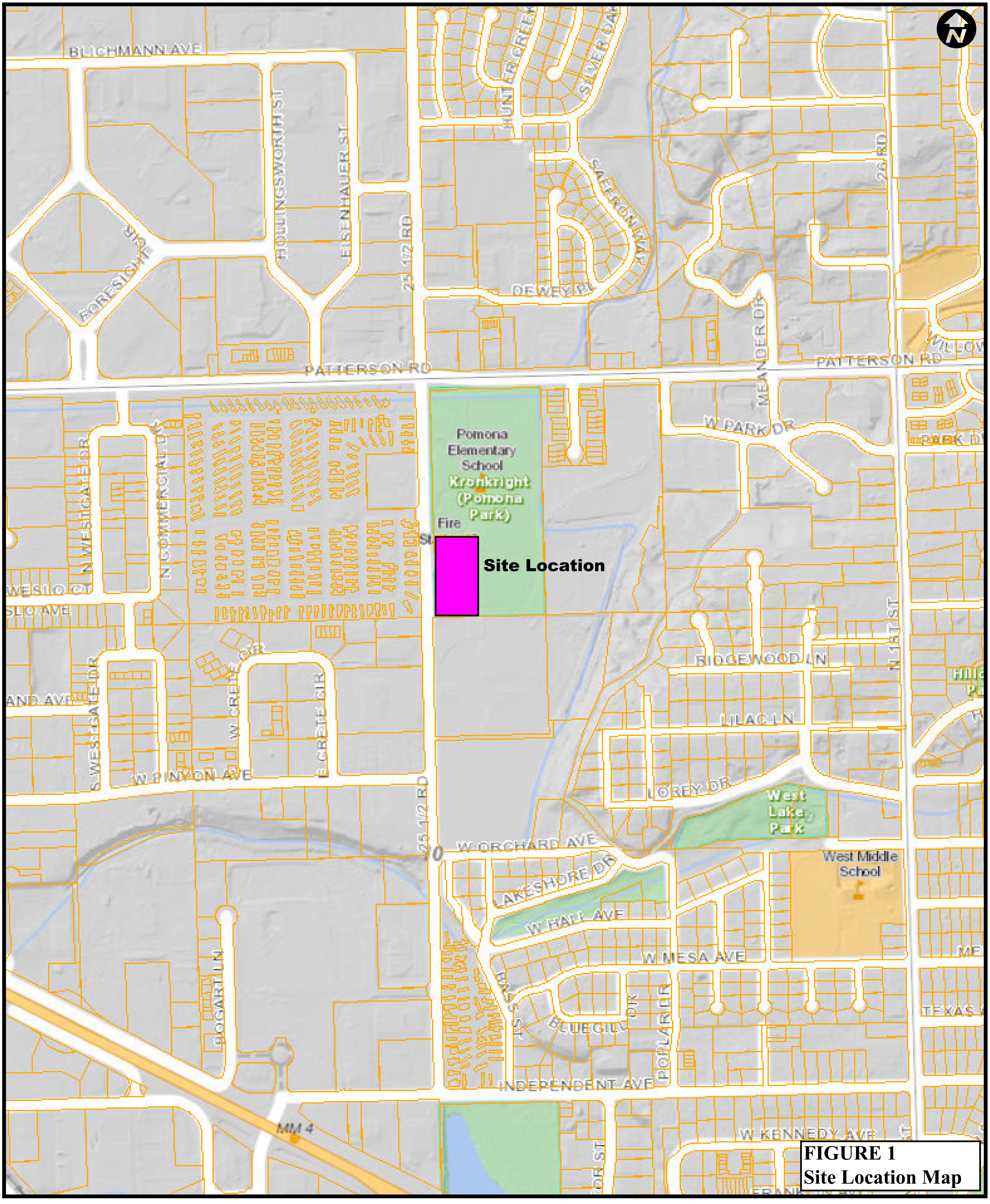



**FIGURE 1**
**Site Location Map**

# Mesa County Map



0 0.05 0.1 0.2 mi

0 0.075 0.15 0.3 km

Print Date: March 26, 2020

Mesa County, Colorado
GIS/IT Department
gis.mesacounty.us

# City of Grand Junction

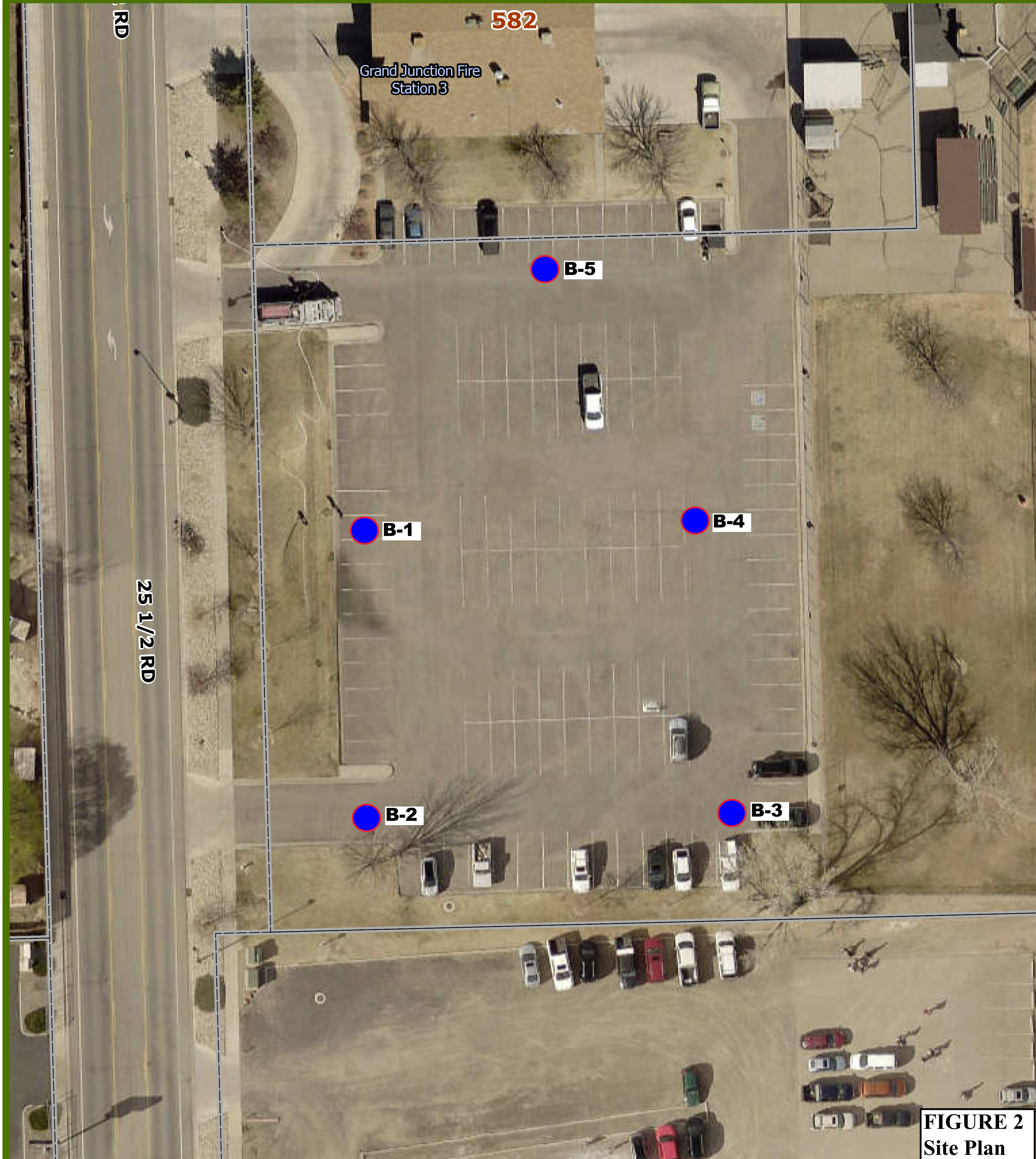



FIGURE 2
Site Plan

N
0 0.01 0.03 mi

Printed: 3/26/2020
1 inch equals 47 feet
Scale: 1:564

CITY OF Grand Junction COLORADO
GEOGRAPHIC INFORMATION SYSTEM

# APPENDIX A
# USDA Soil Survey Data

Soil Map—Mesa County Area, Colorado

## MAP LEGEND

**Area of Interest (AOI)**

- Area of Interest (AOI)

**Soils**

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

**Special Point Features**

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

**Water Features**

- Streams and Canals

**Transportation**

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

**Background**

- Aerial Photography

## MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Mesa County Area, Colorado
Survey Area Data: Version 10, Sep 13, 2019

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Sep 13, 2010—Aug 8, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

# Map Unit Legend

| Map Unit Symbol | Map Unit Name | Acres in AOI | Percent of AOI |
|---|---|---|---|
| Bc | Sagers silty clay loam, 0 to 2 percent slopes | 2.5 | 100.0% |
| **Totals for Area of Interest** | | **2.5** | **100.0%** |

# Map Unit Description

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions in this report, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named, soils that are similar to the named components, and some minor components that differ in use and management from the major soils.

Most of the soils similar to the major components have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Some minor components, however, have properties and behavior characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. All the soils of a series have major horizons that are similar in composition, thickness, and arrangement. Soils of a given series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Additional information about the map units described in this report is available in other soil reports, which give properties of the soils and the limitations, capabilities, and potentials for many uses. Also, the narratives that accompany the soil reports define some of the properties included in the map unit descriptions.

# Report—Map Unit Description

# Mesa County Area, Colorado

## Bc—Sagers silty clay loam, 0 to 2 percent slopes

### Map Unit Setting

*National map unit symbol:* k0bq
*Elevation:* 4,490 to 5,900 feet

*Mean annual precipitation:* 6 to 9 inches
*Mean annual air temperature:* 50 to 55 degrees F
*Frost-free period:* 140 to 180 days
*Farmland classification:* Prime farmland if irrigated

**Map Unit Composition**

*Sagers and similar soils:* 90 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

**Description of Sagers**

**Setting**

*Landform:* Terraces
*Landform position (three-dimensional):* Tread
*Down-slope shape:* Linear, concave
*Across-slope shape:* Linear
*Parent material:* Cretaceous source alluvium derived from sandstone and shale

**Typical profile**

*Ap - 0 to 12 inches:* silty clay loam
*C - 12 to 25 inches:* silty clay loam
*Cy - 25 to 60 inches:* silty clay loam

**Properties and qualities**

*Slope:* 0 to 2 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Runoff class:* Low
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high (0.21 to 0.71 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 15 percent
*Gypsum, maximum in profile:* 5 percent
*Salinity, maximum in profile:* Very slightly saline to moderately saline (2.0 to 8.0 mmhos/cm)
*Available water storage in profile:* High (about 9.7 inches)

**Interpretive groups**

*Land capability classification (irrigated):* 4e
*Land capability classification (nonirrigated):* 7c
*Hydrologic Soil Group:* C
*Ecological site:* Desert Loam (Shadscale) (R034BY106UT)
*Hydric soil rating:* No

## Data Source Information

Soil Survey Area: Mesa County Area, Colorado
Survey Area Data: Version 10, Sep 13, 2019

# Dwellings and Small Commercial Buildings

Soil properties influence the development of building sites, including the selection of the site, the design of the structure, construction, performance after construction, and maintenance. This table shows the degree and kind of soil limitations that affect dwellings and small commercial buildings.

The ratings in the table are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect building site development. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

*Dwellings* are single-family houses of three stories or less. For dwellings without basements, the foundation is assumed to consist of spread footings of reinforced concrete built on undisturbed soil at a depth of 2 feet or at the depth of maximum frost penetration, whichever is deeper. For dwellings with basements, the foundation is assumed to consist of spread footings of reinforced concrete built on undisturbed soil at a depth of about 7 feet. The ratings for dwellings are based on the soil properties that affect the capacity of the soil to support a load without movement and on the properties that affect excavation and construction costs. The properties that affect the load-supporting capacity include depth to a water table, ponding, flooding, subsidence, linear extensibility (shrink-swell potential), and compressibility. Compressibility is inferred from the Unified classification. The properties that affect the ease and amount of excavation include depth to a water table, ponding, flooding, slope, depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, and the amount and size of rock fragments.

*Small commercial buildings* are structures that are less than three stories high and do not have basements. The foundation is assumed to consist of spread footings of reinforced concrete built on undisturbed soil at a depth of 2 feet or at the depth of maximum frost penetration, whichever is deeper. The ratings are based on the soil properties that affect the capacity of the soil to support a load without movement and on the properties that affect excavation and construction costs. The properties that affect the load-supporting capacity include depth to a water table, ponding, flooding, subsidence, linear extensibility (shrink-swell potential), and compressibility (which is inferred from the Unified classification). The properties that affect the ease and amount of excavation include flooding, depth to a water table, ponding, slope, depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, and the amount and size of rock fragments.

Information in this table is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil between the surface and a depth of 5 to 7 feet. Because of the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this table. Local ordinances and regulations should be considered in planning, in site selection, and in design.

## Report—Dwellings and Small Commercial Buildings

[Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the potential limitation. The table shows only the top five limitations for any given soil. The soil may have additional limitations]

| Dwellings and Small Commercial Buildings–Mesa County Area, Colorado | | | | | | | |
|---|---|---|---|---|---|---|---|
| Map symbol and soil name | Pct. of map unit | Dwellings without basements | | Dwellings with basements | | Small commercial buildings | |
| | | Rating class and limiting features | Value | Rating class and limiting features | Value | Rating class and limiting features | Value |
| Bc—Sagers silty clay loam, 0 to 2 percent slopes | | | | | | | |
| Sagers | 90 | Somewhat limited | | Somewhat limited | | Somewhat limited | |
| | | Shrink-swell | 0.03 | Shrink-swell | 0.03 | Shrink-swell | 0.03 |

## Data Source Information

Soil Survey Area: Mesa County Area, Colorado
Survey Area Data: Version 10, Sep 13, 2019

# Roads and Streets, Shallow Excavations, and Lawns and Landscaping

Soil properties influence the development of building sites, including the selection of the site, the design of the structure, construction, performance after construction, and maintenance. This table shows the degree and kind of soil limitations that affect local roads and streets, shallow excavations, and lawns and landscaping.

The ratings in the table are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect building site development. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

*Local roads and streets* have an all-weather surface and carry automobile and light truck traffic all year. They have a subgrade of cut or fill soil material; a base of gravel, crushed rock, or soil material stabilized by lime or cement; and a surface of flexible material (asphalt), rigid material (concrete), or gravel with a binder. The ratings are based on the soil properties that affect the ease of excavation and grading and the traffic-supporting capacity. The properties that affect the ease of excavation and grading are depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, depth to a water table, ponding, flooding, the amount of large stones, and slope. The properties that affect the traffic-supporting capacity are soil strength (as inferred from the AASHTO group index number), subsidence, linear extensibility (shrink-swell potential), the potential for frost action, depth to a water table, and ponding.

*Shallow excavations* are trenches or holes dug to a maximum depth of 5 or 6 feet for graves, utility lines, open ditches, or other purposes. The ratings are based on the soil properties that influence the ease of digging and the resistance to sloughing. Depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, the amount of large stones, and dense layers influence the ease of digging, filling, and compacting. Depth to the seasonal high water table, flooding, and ponding may restrict the period when excavations can be made. Slope influences the ease of using machinery. Soil texture, depth to the water table, and linear extensibility (shrink-swell potential) influence the resistance to sloughing.

*Lawns and landscaping* require soils on which turf and ornamental trees and shrubs can be established and maintained. Irrigation is not considered in the ratings. The ratings are based on the soil properties that affect plant growth and trafficability after vegetation is established. The properties that affect plant growth are reaction; depth to a water table; ponding; depth to bedrock or a cemented pan; the available water capacity in the upper 40 inches; the content of salts, sodium, or calcium carbonate; and sulfidic materials. The properties that affect trafficability are flooding, depth to a water table, ponding, slope, stoniness, and the amount of sand, clay, or organic matter in the surface layer.

Information in this table is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil between the surface and a depth of 5 to 7 feet. Because of the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this table. Local ordinances and regulations should be considered in planning, in site selection, and in design.

## Report—Roads and Streets, Shallow Excavations, and Lawns and Landscaping

[Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the potential limitation. The table shows only the top five limitations for any given soil. The soil may have additional limitations]

| Roads and Streets, Shallow Excavations, and Lawns and Landscaping–Mesa County Area, Colorado | | | | | | | |
|---|---|---|---|---|---|---|---|
| Map symbol and soil name | Pct. of map unit | Lawns and landscaping | | Local roads and streets | | Shallow excavations | |
| | | Rating class and limiting features | Value | Rating class and limiting features | Value | Rating class and limiting features | Value |
| Bc—Sagers silty clay loam, 0 to 2 percent slopes | | | | | | | |
| Sagers | 90 | Somewhat limited | | Very limited | | Somewhat limited | |
| | | Dusty | 0.50 | Low strength | 1.00 | Dusty | 0.50 |
| | | | | Frost action | 0.50 | Unstable excavation walls | 0.01 |
| | | | | Shrink-swell | 0.03 | | |

## Data Source Information

Soil Survey Area: Mesa County Area, Colorado
Survey Area Data: Version 10, Sep 13, 2019

# Soil Features

This table gives estimates of various soil features. The estimates are used in land use planning that involves engineering considerations.

A *restrictive layer* is a nearly continuous layer that has one or more physical, chemical, or thermal properties that significantly impede the movement of water and air through the soil or that restrict roots or otherwise provide an unfavorable root environment. Examples are bedrock, cemented layers, dense layers, and frozen layers. The table indicates the hardness and thickness of the restrictive layer, both of which significantly affect the ease of excavation. *Depth to top* is the vertical distance from the soil surface to the upper boundary of the restrictive layer.

*Subsidence* is the settlement of organic soils or of saturated mineral soils of very low density. Subsidence generally results from either desiccation and shrinkage, or oxidation of organic material, or both, following drainage. Subsidence takes place gradually, usually over a period of several years. The table shows the expected initial subsidence, which usually is a result of drainage, and total subsidence, which results from a combination of factors.

*Potential for frost action* is the likelihood of upward or lateral expansion of the soil caused by the formation of segregated ice lenses (frost heave) and the subsequent collapse of the soil and loss of strength on thawing. Frost action occurs when moisture moves into the freezing zone of the soil. Temperature, texture, density, saturated hydraulic conductivity (Ksat), content of organic matter, and depth to the water table are the most important factors considered in evaluating the potential for frost action. It is assumed that the soil is not insulated by vegetation or snow and is not artificially drained. Silty and highly structured, clayey soils that have a high water table in winter are the most susceptible to frost action. Well drained, very gravelly, or very sandy soils are the least susceptible. Frost heave and low soil strength during thawing cause damage to pavements and other rigid structures.

*Risk of corrosion* pertains to potential soil-induced electrochemical or chemical action that corrodes or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors results in a severe hazard of corrosion. The steel or concrete in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than the steel or concrete in installations that are entirely within one kind of soil or within one soil layer.

For uncoated steel, the risk of corrosion, expressed as *low*, *moderate*, or *high*, is based on soil drainage class, total acidity, electrical resistivity near field capacity, and electrical conductivity of the saturation extract.

For concrete, the risk of corrosion also is expressed as *low*, *moderate*, or *high.* It is based on soil texture, acidity, and amount of sulfates in the saturation extract.

# Report—Soil Features

| Soil Features–Mesa County Area, Colorado | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Map symbol and soil name | Restrictive Layer | | | | Subsidence | | Potential for frost action | Risk of corrosion | |
| | Kind | Depth to top | Thickness | Hardness | Initial | Total | | Uncoated steel | Concrete |
| | | *Low-RV-High* | *Range* | | *Low-High* | *Low-High* | | | |
| | | *In* | *In* | | *In* | *In* | | | |
| Bc—Sagers silty clay loam, 0 to 2 percent slopes | | | | | | | | | |
| Sagers | | — | — | | 0 | 0 | Moderate | Moderate | Moderate |

# Data Source Information

Soil Survey Area: Mesa County Area, Colorado
Survey Area Data: Version 10, Sep 13, 2019

# APPENDIX B
## Typed Boring Logs

Huddleston-Berry Engineering & Testing, LLC
2789 Riverside Parkway
Grand Junction, CO 81501
970-255-8005

# BORING NUMBER B-1



**CLIENT** City of Grand Junction
**PROJECT NAME** Fire Station #3
**PROJECT NUMBER** 00208-0112
**PROJECT LOCATION** Grand Junction, CO
**DATE STARTED** 2/21/20 **COMPLETED** 2/21/20
**GROUND ELEVATION** **HOLE SIZE** 4-inches
**DRILLING CONTRACTOR** S. McKracken
**GROUND WATER LEVELS:**
**DRILLING METHOD** Simco 2000 Track Rig
**AT TIME OF DRILLING** 15.5 ft
**LOGGED BY** SD **CHECKED BY** MAB
**AT END OF DRILLING** 15.5 ft
**NOTES**
**AFTER DRILLING** ---

| DEPTH (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN. (tsf) | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | ATTERBERG LIMITS: PLASTIC LIMIT | ATTERBERG LIMITS: PLASTICITY INDEX | FINES CONTENT (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | ASPHALT Pavement | | | | | | | | | | |
| | | Granular BASE COURSE | | | | | | | | | | |
| | | Silty CLAY with Sand (CL-ML) to Lean CLAY (cl), brown, moist to wet, very soft to medium stiff<br>***Lab Classified SS1 | SS 1 | 83 | 3-3-3 (6) | | | 20 | 23 | 18 | 5 | 70 |
| 5 | | | | | | | | | | | | |
| | | | SS 2 | 89 | 1-1-1 (2) | | | | | | | |
| 10 | | | | | | | | | | | | |
| | | | SS 3 | 56 | 1-2-1 (3) | | | | | | | |
| 15 | ▼ | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 35 | | | | | | | | | | | | |
| | | Sandy GRAVEL and COBBLES (gw), brown, wet, dense to very dense | | | | | | | | | | |
| 40 | | | | | | | | | | | | |

Bottom of hole at 40.0 feet.

Huddleston-Berry Engineering & Testing, LLC
2789 Riverside Parkway
Grand Junction, CO 81501
970-255-8005

# BORING NUMBER B-2



**CLIENT** City of Grand Junction
**PROJECT NAME** Fire Station #3
**PROJECT NUMBER** 00208-0112
**PROJECT LOCATION** Grand Junction, CO
**DATE STARTED** 2/21/20 **COMPLETED** 2/21/20
**GROUND ELEVATION** **HOLE SIZE** 4-inches
**DRILLING CONTRACTOR** S. McKracken
**GROUND WATER LEVELS:**
**DRILLING METHOD** Simco 2000 Track Rig
▽ **AT TIME OF DRILLING** 7.0 ft
**LOGGED BY** SD **CHECKED BY** MAB
▼ **AT END OF DRILLING** 7.0 ft
**NOTES**
**AFTER DRILLING** ---

| DEPTH (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN. (tsf) | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | ATTERBERG LIMITS: PLASTIC LIMIT | ATTERBERG LIMITS: PLASTICITY INDEX | FINES CONTENT (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | ASPHALT Pavement | | | | | | | | | | |
| | | Granular BASE COURSE | | | | | | | | | | |
| | | Silty CLAY with Sand (cl-ml) to Lean CLAY (cl), brown, moist to wet, soft to medium stiff | SS 1 | 22 | 5-3-4 (7) | | | | | | | |
| 5 | | | | | | | | | | | | |
| | ▼ | | SS 2 | 100 | 1-1-2 (3) | | | | | | | |
| 10 | | | | | | | | | | | | |
| | | | SS 3 | 100 | 1-2-3 (5) | | | | | | | |
| 15 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 35 | | | | | | | | | | | | |
| | | ***Cone driven from 37' to 41' | SS 4 | 0 | 27-30-32-36 (62) | | | | | | | |
| 40 | | Sandy GRAVEL and COBBLES (gw), brown, wet, dense to very dense | SS 5 | 0 | 46-45-48-50 (93) | | | | | | | |
| | | Bottom of hole at 41.0 feet. | | | | | | | | | | |

Huddleston-Berry Engineering & Testing, LLC
2789 Riverside Parkway
Grand Junction, CO 81501
970-255-8005

# BORING NUMBER B-3



**CLIENT** City of Grand Junction
**PROJECT NAME** Fire Station #3
**PROJECT NUMBER** 00208-0112
**PROJECT LOCATION** Grand Junction, CO
**DATE STARTED** 2/21/20 **COMPLETED** 2/21/20
**GROUND ELEVATION** ______ **HOLE SIZE** 4-inches
**DRILLING CONTRACTOR** S. McKracken
**GROUND WATER LEVELS:**
**DRILLING METHOD** Simco 2000 Track Rig
▽ **AT TIME OF DRILLING** 6.0 ft
**LOGGED BY** SD **CHECKED BY** MAB
▼ **AT END OF DRILLING** 6.0 ft
**NOTES** ______
**AFTER DRILLING** ---

| MATERIAL DESCRIPTION | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN. (tsf) | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | ATTERBERG LIMITS: PLASTIC LIMIT | ATTERBERG LIMITS: PLASTICITY INDEX | FINES CONTENT (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| ASPHALT Pavement | | | | | | | | | | |
| Granular BASE COURSE | | | | | | | | | | |
| Silty CLAY with Sand (cl-ml) to Lean CLAY (CL), brown, moist to wet, very soft to medium dense | SS 1 | 22 | 2-1-1 (2) | | | | | | | |
| ▼ | | | | | | | | | | |
| | SS 2 | 0 | 2-1-2 (3) | | | | | | | |
| ***Lab Classified SS3 | SS 3 | 94 | 2-3-3 (6) | | | 23 | 34 | 18 | 16 | 96 |
| ***Cone driven from 36' to 43' | SS 4 | 0 | 24-30-36-35 (66) | | | | | | | |
| Sandy GRAVEL and COBBLES (gw), brown, wet, dense to very dense | SS 5 | 0 | 30-38-44-43 (82) | | | | | | | |
| | SS 6 | 0 | 40-43-44-40 (87) | | | | | | | |
| | SS 7 | 0 | 45-73 | | | | | | | |
| Bottom of hole at 43.0 feet. | | | | | | | | | | |

Huddleston-Berry Engineering & Testing, LLC
2789 Riverside Parkway
Grand Junction, CO 81501
970-255-8005

# BORING NUMBER B-4



**CLIENT** City of Grand Junction

**PROJECT NAME** Fire Station #3

**PROJECT NUMBER** 00208-0112

**PROJECT LOCATION** Grand Junction, CO

**DATE STARTED** 2/21/20 **COMPLETED** 2/21/20

**GROUND ELEVATION** **HOLE SIZE** 4-inches

**DRILLING CONTRACTOR** S. McKracken

**GROUND WATER LEVELS:**

**DRILLING METHOD** Simco 2000 Track Rig

**AT TIME OF DRILLING** 9.0 ft

**LOGGED BY** SD **CHECKED BY** MAB

**AT END OF DRILLING** 9.0 ft

**NOTES**

**AFTER DRILLING** ---

| DEPTH (ft) | MATERIAL DESCRIPTION | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN. (tsf) | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | PLASTIC LIMIT | PLASTICITY INDEX | FINES CONTENT (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | ASPHALT Pavement | | | | | | | | | | |
| | Granular BASE COURSE | | | | | | | | | | |
| | Silty CLAY with Sand (cl-ml) to Lean CLAY (cl), brown, moist to wet, very soft to medium stiff | SS 1 | 0 | 1-2-1 (3) | | | | | | | |
| 5 | | | | | | | | | | | |
| | | SS 2 | 100 | 0-1-1 (2) | | | | | | | |
| 10 | | | | | | | | | | | |
| 15 | | | | | | | | | | | |
| 20 | | | | | | | | | | | |
| 25 | | | | | | | | | | | |
| 30 | | | | | | | | | | | |
| 35 | ***Cone driven from 35' to 44' | SS 3 | 0 | 25-31-34-32 (65) | | | | | | | |
| | | SS 4 | 0 | 32-30-31-31 (61) | | | | | | | |
| 40 | Sandy GRAVEL and COBBLES (gw), brown, wet, dense to very dense | SS 5 | 0 | 36-37-38-37 (75) | | | | | | | |
| | | SS 6 | 0 | 38-40-40-36 (80) | | | | | | | |
| | | SS 7 | 0 | 38-65 | | | | | | | |
| | Bottom of hole at 44.0 feet. | | | | | | | | | | |

Huddleston-Berry Engineering & Testing, LLC
2789 Riverside Parkway
Grand Junction, CO 81501
970-255-8005

# BORING NUMBER B-5



**CLIENT** City of Grand Junction
**PROJECT NAME** Fire Station #3
**PROJECT NUMBER** 00208-0112
**PROJECT LOCATION** Grand Junction, CO
**DATE STARTED** 2/21/20 **COMPLETED** 2/21/20
**GROUND ELEVATION** **HOLE SIZE** 4-inches
**DRILLING CONTRACTOR** S. McKracken
**GROUND WATER LEVELS:**
**DRILLING METHOD** Simco 2000 Track Rig
**AT TIME OF DRILLING** dry
**LOGGED BY** SD **CHECKED BY** MAB
**AT END OF DRILLING** dry
**NOTES**
**AFTER DRILLING** ---

| DEPTH (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN. (tsf) | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | ATTERBERG LIMITS: PLASTIC LIMIT | ATTERBERG LIMITS: PLASTICITY INDEX | FINES CONTENT (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | ASPHALT Pavement | | | | | | | | | | |
| | | Granular BASE COURSE | | | | | | | | | | |
| | | Silty CLAY with Sand (cl-ml) to Lean CLAY (cl), brown, moist, medium stiff | | | | | | | | | | |
| 2.5 | | | | | | | | | | | | |
| 5.0 | | | | | | | | | | | | |
| 7.5 | | | | | | | | | | | | |
| 10.0 | | | | | | | | | | | | |
| | | Bottom of hole at 11.5 feet. | | | | | | | | | | |

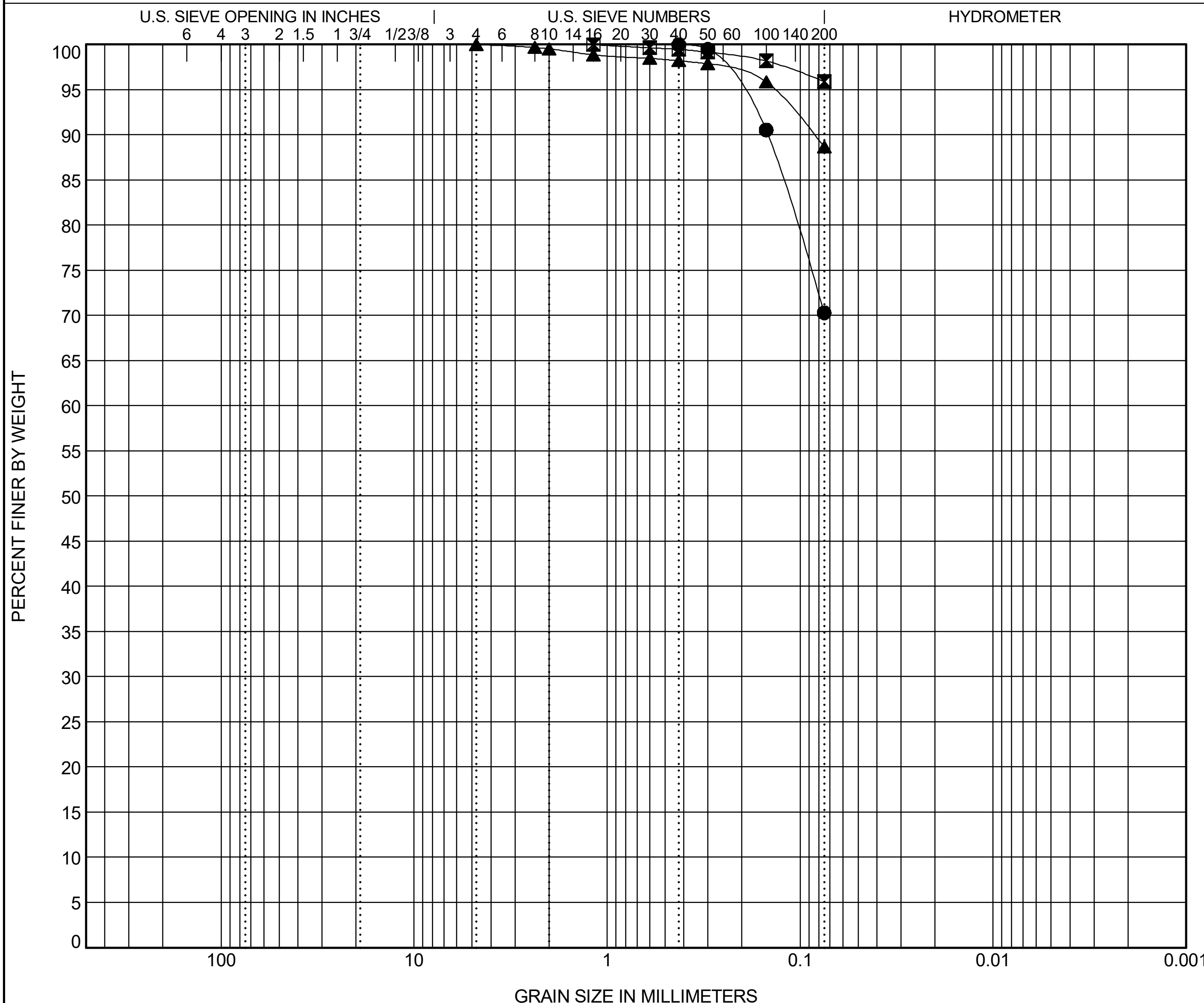
# APPENDIX C
## Laboratory Testing Results

Huddleston-Berry Engineering & Testing, LLC
2789 Riverside Parkway
Grand Junction, CO 81501
970-255-8005

# GRAIN SIZE DISTRIBUTION

**CLIENT** City of Grand Junction **PROJECT NAME** Fire Station #3

**PROJECT NUMBER** 00208-0112 **PROJECT LOCATION** Grand Junction, CO




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

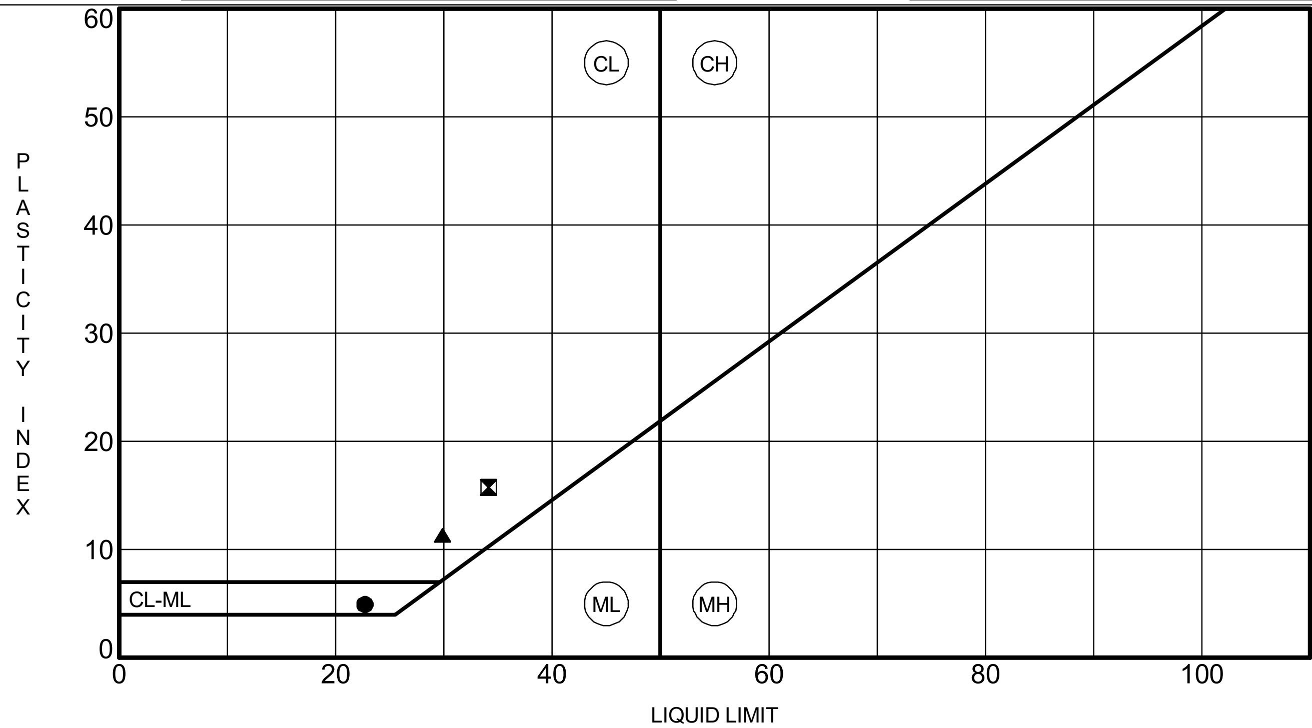
| | Specimen Identification | | Classification | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | B-1, SS1 | 2/20 | SILTY CLAY with SAND(CL-ML) | 23 | 18 | 5 | | |
| ⊠ | B-3, SS3 | 2/20 | LEAN CLAY(CL) | 34 | 18 | 16 | | |
| ▲ | Composite | 2/20 | LEAN CLAY(CL) | 30 | 19 | 11 | | |
| | | | | | | | | |
| | | | | | | | | |

| | Specimen Identification | | D100 | D60 | D30 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | B-1, SS1 | 2/20 | 0.425 | | | | 0.0 | 29.7 | 70.3 | |
| ⊠ | B-3, SS3 | 2/20 | 1.18 | | | | 0.0 | 4.1 | 95.9 | |
| ▲ | Composite | 2/20 | 4.75 | | | | 0.0 | 11.4 | 88.6 | |
| | | | | | | | | | | |
| | | | | | | | | | | |

Huddleston-Berry Engineering & Testing, LLC
2789 Riverside Parkway
Grand Junction, CO 81501
970-255-8005

# ATTERBERG LIMITS' RESULTS

**CLIENT** City of Grand Junction
**PROJECT NAME** Fire Station #3
**PROJECT NUMBER** 00208-0112
**PROJECT LOCATION** Grand Junction, CO




| | Specimen Identification | | LL | PL | PI | #200 | Classification |
|---|---|---|---|---|---|---|---|
| ● | **B-1, SS1** | **2/21/2020** | **23** | **18** | **5** | **70** | **SILTY CLAY with SAND(CL-ML)** |
| ⊠ | **B-3, SS3** | **2/21/2020** | **34** | **18** | **16** | **96** | **LEAN CLAY(CL)** |
| ▲ | **Composite** | **2/21/2020** | **30** | **19** | **11** | **89** | **LEAN CLAY(CL)** |

Huddleston-Berry Engineering & Testing, LLC
2789 Riverside Parkway
Grand Junction, CO 81501
970-255-8005

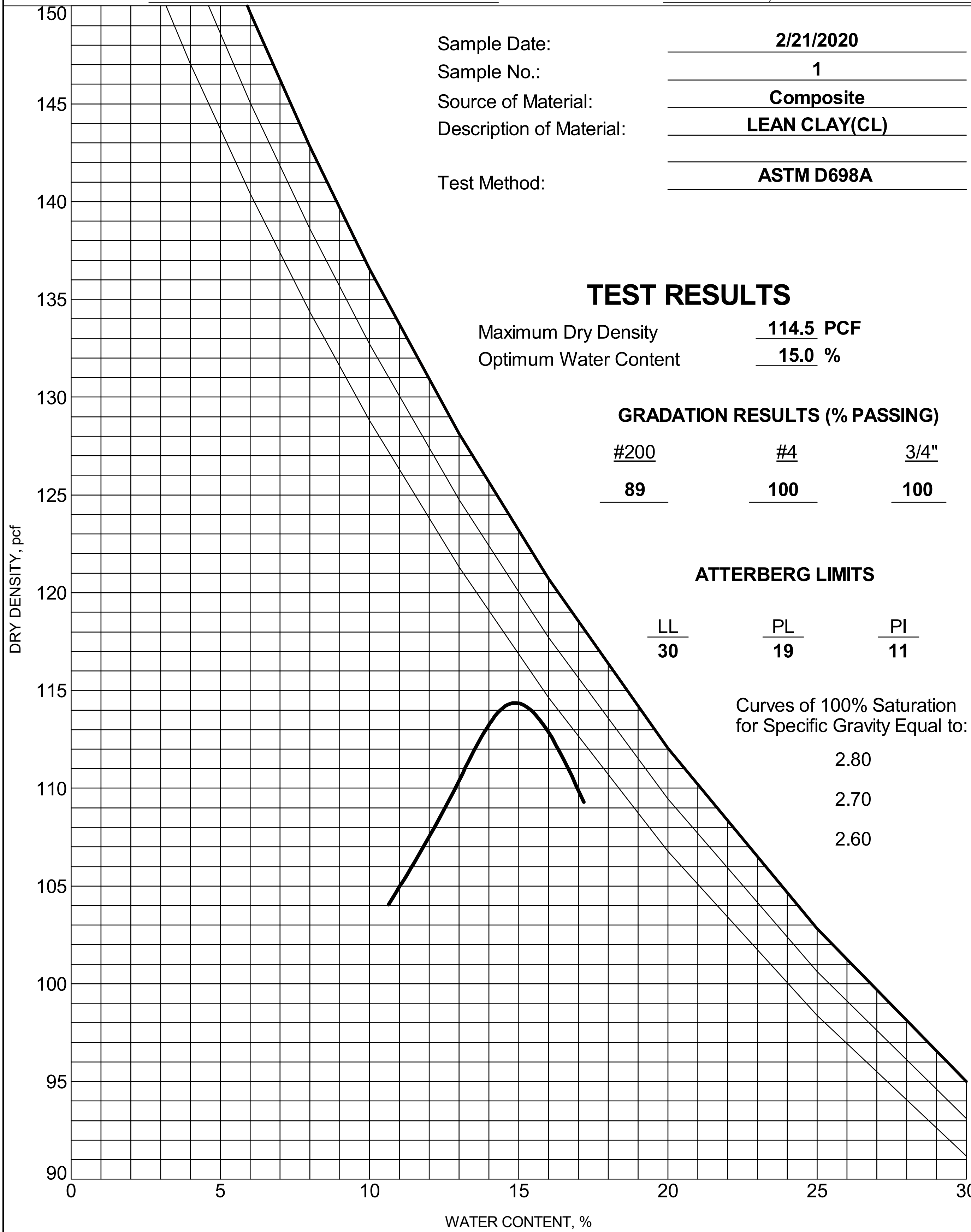
# MOISTURE-DENSITY RELATIONSHIP

**CLIENT** City of Grand Junction

**PROJECT NAME** Fire Station #3

**PROJECT NUMBER** 00208-0112

**PROJECT LOCATION** Grand Junction, CO




| | |
|---|---|
| Sample Date: | **2/21/2020** |
| Sample No.: | **1** |
| Source of Material: | **Composite** |
| Description of Material: | **LEAN CLAY(CL)** |
| | |
| Test Method: | **ASTM D698A** |

## TEST RESULTS

Maximum Dry Density **114.5 PCF**

Optimum Water Content **15.0 %**

### GRADATION RESULTS (% PASSING)

| #200 | #4 | 3/4" |
|---|---|---|
| **89** | **100** | **100** |

### ATTERBERG LIMITS

| LL | PL | PI |
|---|---|---|
| **30** | **19** | **11** |

COMPACTION 00208-0112 FIRE STATION 3.GPJ GINT US LAB.GDT 3/26/20

Huddleston-Berry
Engineering & Testing, LLC

# CALIFORNIA BEARING RATIO
## ASTM D1883

| | | | | | |
|---|---|---|---|---|---|
| **Project No.:** | 00208-0112 | **Authorized By:** | Client | **Date:** | 02/21/20 |
| **Project Name:** | Fire Station #3 | **Sampled By:** | SD | **Date:** | 02/21/20 |
| **Client Name:** | City of Grand Junction | **Submitted By:** | SD | **Date:** | 02/21/20 |
| **Sample Number:** | 20-0140 **Location:** Composite | **Reviewed By:** | MAB | **Date:** | 03/25/20 |

**Compaction Methoc** ASTM D698, Method A

**Maximum Dry Density (pcf):** 114.5

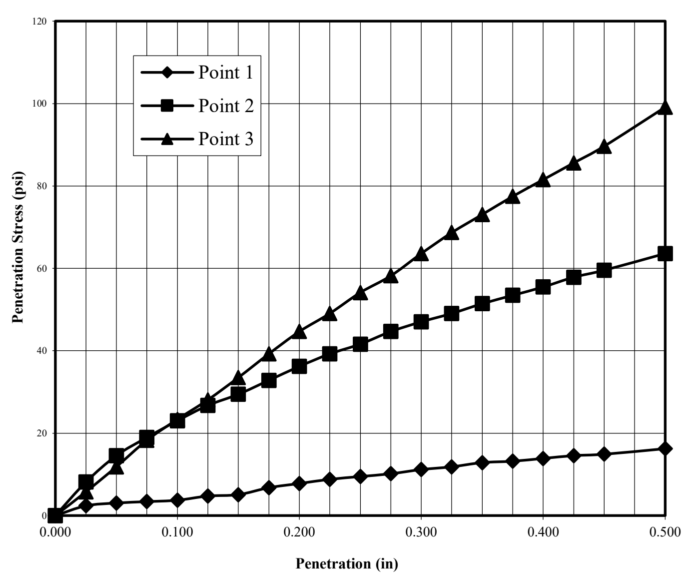
**Opt. Moisture Content (%):** 15.0

**Sample Condition:** Soaked

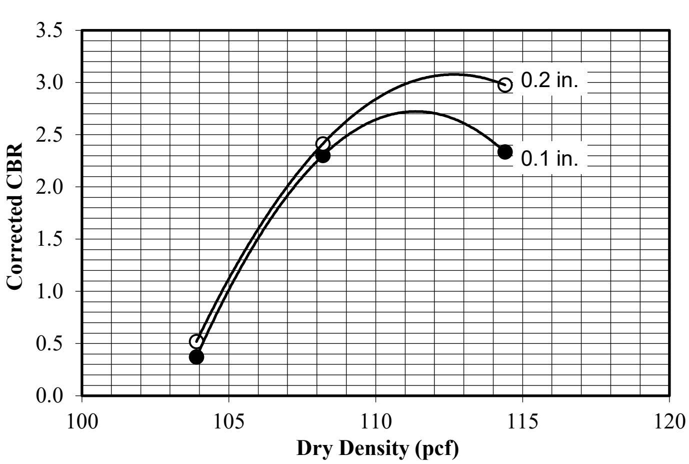
**Remarks:**

| Sample Data | | Point 1 | Point 2 | Point 3 |
|---|---|---|---|---|
| Blows per Compacted Lift: | | 15 | 25 | 56 |
| Surcharge Weight (lbs): | | 10.0 | 10.0 | 10.0 |
| Dry Density Before Soak (pcf): | | 103.9 | 108.2 | 114.4 |
| Dry Density After Soak (pcf): | | 103.0 | 107.1 | 113.5 |
| Moisture Content (%) | Bottom Pre-Test | 14.5 | 14.6 | 13.9 |
| | Top Pre-Test | 14.6 | 14.6 | 14.3 |
| | Top 1" After Test | 20.5 | 20.0 | 18.3 |
| | Average After Soak: | 25.0 | 19.2 | 17.6 |
| Percent Swell After Soak: | | 0.9 | 1.0 | 0.8 |

**Load Pentration Curve(s)**




**Dry Density vs CBR**




| Penetration Data | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Point 1 | | | Point 2 | | | Point 3 | | |
| Dist. (in) | Load (lbs) | Stress (psi) | Dist. (in) | Load (lbs) | Stress (psi) | Dist. (in) | Load (lbs) | Stress (psi) |
| 0.000 | 0 | 0 | 0.000 | 0 | 0 | 0.000 | 0 | 0 |
| 0.025 | 7 | 2 | 0.025 | 24 | 8 | 0.025 | 17 | 6 |
| 0.050 | 9 | 3 | 0.050 | 43 | 15 | 0.050 | 35 | 12 |
| 0.075 | 10 | 3 | 0.075 | 56 | 19 | 0.075 | 54 | 18 |
| 0.100 | 11 | 4 | 0.100 | 68 | 23 | 0.100 | 69 | 23 |
| 0.125 | 14 | 5 | 0.125 | 79 | 27 | 0.125 | 83 | 28 |
| 0.150 | 15 | 5 | 0.150 | 87 | 29 | 0.150 | 99 | 33 |
| 0.175 | 20 | 7 | 0.175 | 97 | 33 | 0.175 | 116 | 39 |
| 0.200 | 23 | 8 | 0.200 | 107 | 36 | 0.200 | 132 | 45 |
| 0.225 | 26 | 9 | 0.225 | 116 | 39 | 0.225 | 145 | 49 |
| 0.250 | 28 | 9 | 0.250 | 123 | 42 | 0.250 | 160 | 54 |
| 0.275 | 30 | 10 | 0.275 | 132 | 45 | 0.275 | 172 | 58 |
| 0.300 | 33 | 11 | 0.300 | 139 | 47 | 0.300 | 188 | 64 |
| 0.325 | 35 | 12 | 0.325 | 145 | 49 | 0.325 | 203 | 69 |
| 0.350 | 38 | 13 | 0.350 | 152 | 51 | 0.350 | 216 | 73 |
| 0.375 | 39 | 13 | 0.375 | 158 | 53 | 0.375 | 229 | 77 |
| 0.400 | 41 | 14 | 0.400 | 164 | 55 | 0.400 | 241 | 82 |
| 0.425 | 43 | 15 | 0.425 | 171 | 58 | 0.425 | 253 | 86 |
| 0.450 | 44 | 15 | 0.450 | 176 | 60 | 0.450 | 265 | 90 |
| 0.500 | 48 | 16 | 0.500 | 188 | 64 | 0.500 | 293 | 99 |

| Corrected CBR @ 0.1" | | |
|---|---|---|
| 0.4 | 2.3 | 2.3 |
| **Corrected CBR @ 0.2"** | | |
| 0.5 | 2.4 | 3.0 |

| Penetration Distance Correction (in) | | |
|---|---|---|
| 0.000 | 0.000 | 0.000 |

**Figure:** ____