

A wide-angle photograph of a river flowing under a concrete bridge. The sky is bright blue with scattered white clouds. The riverbanks are sandy and lined with green trees. The bridge has several support pillars and a few vehicles are visible on top. The overall scene is bright and clear.

**PEDOLOGICAL &
GEOLOGICAL**
soil survey

I-35 & SH 74 Interchange

J/P 32802(04) - McClain County

Prepared For: EST, Inc.

Prepared By: Arrowhead Engineering Company

November 30, 2023

AEC Proj. No.: 1875



Arrowhead Engineering Company

5171 84th Ave. SE

Noble, OK 73068

405.310.8467

www.arrowheadengineering.us

November 30, 2023

Matias M. Mendez Larrain, PhD, PE
Geotechnical and Pavement Engineer
EST, Inc.
615 N. Hudson, Ste. 300
Oklahoma City, OK 73102

**RE: Pedological & Geological Soil Survey
I35 & SH 74 Interchange
J/P 32802(04)
McClain County, OK
AEC Project No.: 1875**

Dear Mr. Mendez:

Arrowhead Engineering Co, LLC (AEC) has completed the Pedological & Geological Soil Survey for the above referenced project.

Mr. Mendez, if you have any questions about the information herein, feel free to contact me anytime at (405) 310-8467.

Sincerely,

Arrowhead Engineering Co, LLC

CA 5959, Exp 6/30/24

A handwritten signature in black ink that reads "Corby W. Key".

Corby W. Key, P.E.
Principal Engineer



- o I34 & SH 74 Interchange
- o J/P 32802(04)
- o McClain County, Oklahoma
- o AEC Project No.: 1875
- o November 30, 2023

TABLE OF CONTENTS

1.0 Introduction.....	1
1.1 Project Authorization	1
1.2 Proposed Construction	1
2.0 Site Condition	2
2.1 Site Description.....	2
2.2 Soil Series Station Extents	4
2.3 Subsurface Conditions	4
2.4 Field Investigation	4
2.5 Soil Series Profiles.....	6
2.5 Soil Taxonomy	7
2.5 Geologic Statement	8
3.0 Laboratory Testing.....	10
3.1 Laboratory Procedures	10
4.0 Shrinkage and Swell Factors.....	10
4.1 Estimation of Shrinkage and Swell Factors.....	10
5.0 Construction Considerations.....	11
5.1 Soil Parameter Considerations and Compacted Fill Requirements.....	11
5.2 Grading Assessment	11
5.2.1 Site and Terrain Analysis	11
5.2.2 Potential Grading Issues	12
5.2.3 Assessment Summary.....	13
5.3 Other Factors	14
5.4 Cut Sections Considerations	15
5.5 Groundwater Observations	16
6.0 Recommendations.....	17
7.0 General Comments	18

- **I34 & SH 74 Interchange**
- **J/P 32802(04)**
- **McClain County, Oklahoma**
- **AEC Project No.: 1875**
- **November 30, 2023**

TABLES

Table 1 – Soil Series Station Extents

Table 2 – Soil Series General Comments

Table 3 – Soil Series Taxonomic Class and Comments

Table 4 – Soil Taxonomy

Table 5 – Shrinkage/Swell Factors for Earthwork Excavation

Table 6 – Characteristics and Ratings Regarding the Suitability for Roadway Fill

Table 7 – Recommended M_R for Pavement Design

APPENDICES

Appendix A—Project Plan Set

Appendix B—Web Soil Survey (Soil Survey Map, Local Roads & Streets, Excavations, OSD)

Appendix C—Soil Series Profiles – Block Diagrams

Appendix D—Soil Description

Appendix E—Soil Taxonomy

Appendix F—Pedological Soil Logs

Appendix G—Standard Proctor Results

Appendix H—Resilient Modulus Test Data

- I34 & SH 74 Interchange
- J/P 32802(04)
- McClain County, Oklahoma
- AEC Project No.: 1875
- November 30, 2023

Pedological & Geological Soil Survey
I35 & SH 74 Interchange
McClain County, Oklahoma
Job Piece No.: 32802(04)

1.0 Introduction

1.1 Project Authorization

The service provided in this report was authorized by EST, Inc. The scope of service for the pedological and geological soil survey included performing resilient modulus testing, standard proctors, soil classification, pH, and soil resistivity testing, soil taxonomy, soil descriptions, geologic statement, problem soils, analysis and recommendations.

The purpose of this study was to explore the subsurface conditions at the site with regards to project earthwork and pavement subgrade construction. The scope does not include any environmental assessment for the presence or absence of wetlands or hazardous or toxic materials in the soil, surface water, groundwater, or air on or below or around the site.

1.2 Proposed Construction

The project consists of constructing a new I-35 interchange with ramps connecting to SH 74 in the Purcell City limits in McClain County. The project construction consists of the following two Parts: a.) I-35 widen, grade, and ramp connections to SH 74 and b.) widening and reconstruction of SH 74. The reference point for both construction parts is the centerline intersection of I-35 and SH74.

The total roadway length of project State Job No. 32802(04) for Part a.) is 6,454.58 feet (1.222) miles, and the total length for Part b.) is 5,467.43 feet (1.035 miles). The Bridge length was 440 feet (0.083 feet) for Part a.), and the Bridge length for Part b.) was 48.08 feet (0.008 miles).

The preliminary design plans were prepared by EST, Inc. at 615 N. Hudson, Ste 300, Oklahoma City, OK 73102. Cross-sections were included in Plan Set in Appendix A.

- I34 & SH 74 Interchange
- J/P 32802(04)
- McClain County, Oklahoma
- AEC Project No.: 1875
- November 30, 2023

2.0 Site Condition

2.1 Site Description

Part a.) of the project extent will involve flattening of the I-35 side slopes and cut grading for Ramps A, B, C, and D. Part b.) of the project extent will involve the widening and grading of SH 74 and connections with local streets and roads. The general location of the project extents is shown in Figure 1.

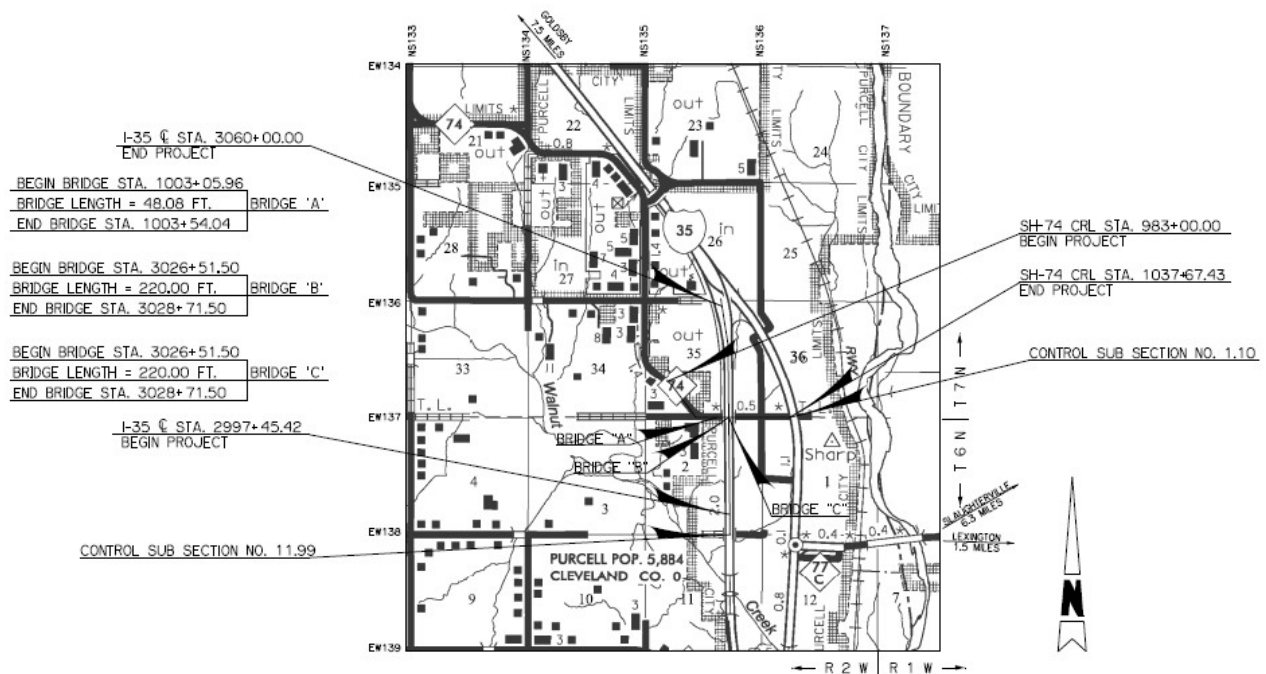


Figure 1. General location of State Job No. 32802(04) near I35 & SH 74 in McClain County.

Utility line locations are shown on the plan and profile sheets in the Plan Set, and they are identified by company name on plan sheet R001. Additional utilities should be anticipated within the I-35 right of way and all along the CRL of SH 74 within the project extents. The surrounding land use along the existing alignment of I-35 and SH 74 is predominantly pastureland and residential property, see Figure 2.

- I34 & SH 74 Interchange
- J/P 32802(04)
- McClain County, Oklahoma
- AEC Project No.: 1875
- November 30, 2023

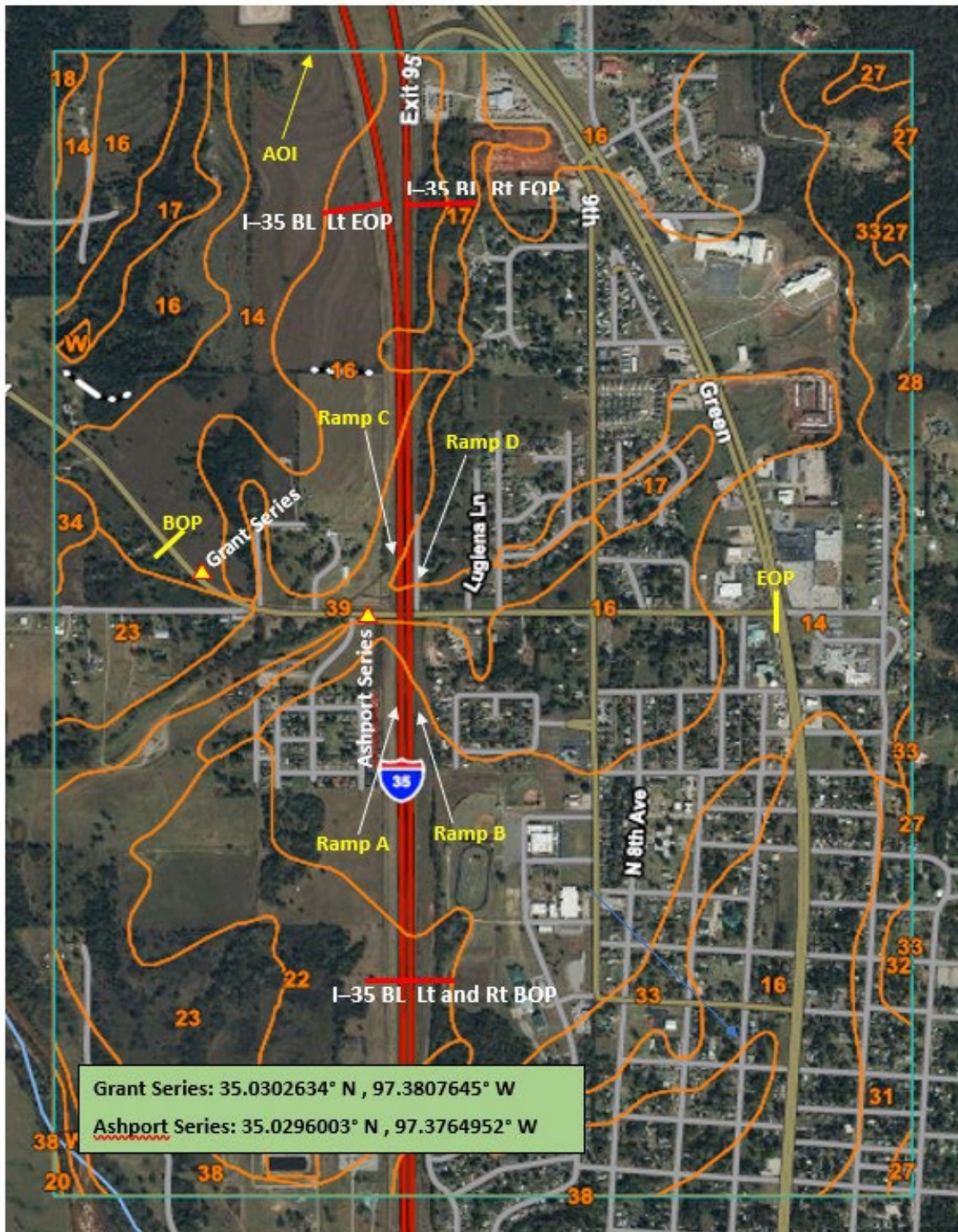


Figure 2. Enlarged soil map indicating the BOP, EOP, AOP, sampling locations for the Grant and Ashport soil series for State Job No. 32802(4) in Purcell, Oklahoma.

- I34 & SH 74 Interchange
- J/P 32802(04)
- McClain County, Oklahoma
- AEC Project No.: 1875
- November 30, 2023

2.2 Soil Series Station Extents

An estimate of the soil series station extents along the project extent was based on using the Web Soil Survey 3.4.0, Soil Map on page 1, see Appendix B. The Soil Map on page 1 was converted to a 1:20,000 map scale and enlarged. The distances for stationing were then scaled in feet referenced from the intersection of the I-35 centerline of survey and SH 74 CRL shown on an enlarged Soil Map from the Web Soil Survey 3.4.0 from Section 2.4 below and from local landmarks in the plan set. The soil series station extents for the project widening and reconstruction are presented in Table 1.

The soil series sampling locations were along the SH 74 CRL extent of the project. The locations of the Grant and Ashport soil series were measured with GPS coordinates for each soil series sampling location using a Bad Elf Flex, Model BE-GPS-5500 receiver. The locations and GPS coordinates of the soil series sampled are shown in the Pedological logs and in Figure 2.

2.3 Subsurface Conditions

The subsurface conditions throughout the I-35 and SH 74 project alignment extents listed in Section 2.2 consist of soils developed from the following:

- Soils formed in material weathered predominantly from siltstone or silty shale
- Soils formed in loamy alluvium
- Soils formed in calcareous loamy alluvium
- Soils formed in sandy and loamy alluvium
- Soils formed in loamy alluvial sediments

The specifics and details of the origin of the soil series, underlying geology, geological age, and landform associated with these soil series within the project extent are presented in Table 2. The project location is in the Central Red Bed Plains geomorphic province. The geomorphic province consists of thin Permian geologic aged red shales and sandstones that form gently rolling hills and broad, flat plains.

2.4 Field Investigation

The field operations and soil sampling were performed on the following date: October 21, 2023.

- **I34 & SH 74 Interchange**
- **J/P 32802(04)**
- **McClain County, Oklahoma**
- **AEC Project No.: 1875**
- **November 30, 2023**

The USDA Natural Resources Conservation Service (NRCS) Web Soil Survey 3.4.0 indicates that there are five – soil series that are within the project extents. The soil series that cross the I–35 BL and SH 74 CRL of the project extent are the (Grant, Ashport, Port, Konawa, and Pulaski – in taxonomic order). These five soil series map units are listed in chronological order of occurrence beginning from the BOP and extending northward and eastward respectively throughout the I–35 and SH 74 project extents to the EOP, see Table 1. The Grant and Konawa soil series occur in singularly mapped soil series units within the project extent, see the Web Soil Survey 3.4.0 in Appendix B and Table 1. The Grant soil series also occurs both singular and complex soil map units. The (Ashport, Port, and Pulaski) occur only in soil series complex map units. A soil series complex means that two or more dissimilar soil series occur in a regular repeating pattern but that these soil series cannot be mapped separately on the soil map on page 1 of Soil Map, see the Web Soil Survey 3.4.0 in Appendix B. Refer to Table 1 for the chronological listed soil complex map units.

The scope of work for the State Job No. 32802(04) project extent called for sampling the the Grant and Ashport soil series soil series. The results from the Web Soil Survey 3.4.0 reported in Appendix B includes the following:

- Soil Survey Map
- Local Roads and Streets and Shallow Excavation extended soil data
- The NRCS Official Soil Description (OSD) of the (Grant, Ashport, Port, Konawa, and Pulaski) soil series

From this point forward in the report, the soil series are listed in taxonomic order as above. The NRCS Field Book for Describing and Sampling Soils, Version 3.0 and the NRCS OSD were used to model the (Grant, Ashport, Port, Konawa, and Pulaski) soil series profile depths and descriptions in the sampling process, see Appendix B. The sampling method along the Interchange I–35 and SH74 project was as follows:

- The Grant was sampled from back slope sampling
- The Ashport soil series was sampled with a 4 $\frac{7}{8}$ -inch mud hand auger

The sampling locations are shown in the pedological logs in Appendix F and in Figure 2 which presents the following data:

- Project BOP and EOP locations
- Sampled locations for the Grant and Ashport soil series
- Soil series mapped units within the area of interest (AOI)

The station and offset distances for the soil series sampled were referenced from the SH 74 CRL, see recorded data in the Arrowhead Engineering Co., LLC pedological logs, in Appendix F.

- I34 & SH 74 Interchange
- J/P 32802(04)
- McClain County, Oklahoma
- AEC Project No.: 1875
- November 30, 2023

2.5 Soil Series Profiles

The NRCS has coupled the Soil Survey Geographic Database (SSURGO) with the Web Soil Survey 3.4.0 within the Google Earth program. The SSURGO database contains information about a soil series as collected by the National Cooperative Soil Survey over the course of time, that may not be included within the Web Soil Survey 3.4.0. The Google Earth NRCS SSURGO allows for the presentation of block diagrams listing all the soil series that have been historically found in Google Earth by tapping on a soil series map unit. The block diagrams record the soil horizon depths in centimeters which are then reported in inches, see Appendix C. The soil map in Google Earth, the NRCS SSURGO is the same as in the Web Soil Survey 3.4.0 Soil Map on page 1, see Appendix B.

The block diagrams from the NRCS SSURGO in Google Earth are inclusive and show the latest updated NRCS OSD soil profile data and percentage of each soil series within a map unit, see the block diagrams in Appendix C. There are ten soil series inclusions (Nash, Pond Creek, Teller, Norge, Renfrow, Lucien, Dougherty, Stephenville, Yahola, and Tribbey) according to the Google Earth NRCS SSURGO soil map other than what is listed in the Web Soil Survey 3.4.0. These soil series inclusions are found in the following soil map units recorded in Table 1:

- Grant silt loam, 3 to 5 percent slopes, eroded (14): Inclusions – (Nash and Pond Creek) soil series
- Grant silt loam, 5 to 8 percent slopes, eroded (16): Inclusions – (Teller, Pond Creek, and Nash) soil series
- Grant–Port, frequently flooded, complex, 0 to 12 percent slopes (17): Inclusions – Norge, Renfrow, Nash, and Lucien) soil series
- Konawa loamy fine sand, 0 to 3 percent slopes (22) and Konawa loamy fine sand, 3 to 8 percent slopes (23) – Dougherty and Stephenville soil series
- Ashport, Port and Pulaski soils, 0 to 1 percent slopes, frequently flooded (39): Inclusion – Yahola and Tribbey soil series

The ten additional soil series inclusions (Nash, Pond Creek, Teller, Norge, Renfrow, Lucien, Dougherty, Stephenville, Yahola, and Tribbey) may range in occurrence within the respective soil map units from 3 to 7 percent in occurrence.

- **I34 & SH 74 Interchange**
- **J/P 32802(04)**
- **McClain County, Oklahoma**
- **AEC Project No.: 1875**
- **November 30, 2023**

2.5 Soil Taxonomy

The soil taxonomic class for all soil series in taxonomic order is (Grant, Ashport, Port, Konawa, and Pulaski) is presented in Table 3. A further taxonomic description for all these soil series is given in Table 4, and their diagnostic horizons and features are presented in the Soil Description in Appendix D. A Soil Taxonomy statement for the (Grant, Ashport, Port, Konawa, and Pulaski) soil series is presented in Appendix E.

Based the Taxonomic Class in Table 3, the NRCS OSD in Appendix B, Soil Description in Appendix D, and the Soil Taxonomy in Appendix E; the key features for all ten–mapped soil series within the project extents are as follows:

- The Grant and Ashport soil series have a mollic epipedon in the upper horizons
- The Konawa and Pulaski soil series have friable soil particle structure (FSPS)
- The Grant and Konawa soil series have an argillic horizon
- The Grant soil series has a paralithic contact and underlying material
- The Ashport and Pulaski soil series have an udic–ustic SMR
- The Ashport, Port, and Pulaski soils are subject to occasional to frequent flooding for very brief to brief periods

The argillic horizons in the Grant and Konawa soil series are not an impediment regarding construction, but the calcium and/or magnesium carbonate contained within the soil horizons provides a filler and a source of lime for the long–term reaction with calcium–based soil stabilizers.

- I34 & SH 74 Interchange
- J/P 32802(04)
- McClain County, Oklahoma
- AEC Project No.: 1875
- November 30, 2023

2.5 Geologic Statement

According to the Oklahoma Geologic Survey, the latest geologic description and map for the project site location is found in Oklahoma Geologic Quadrangle OGQ–100 Geologic Map of the Oklahoma City South 30X60–Minute Quadrangle by Thomas M. Stanley, 2021. The underlying geology is mapped as the Hennessey Formation. See the following very detailed geologic description and excerpt of the OGQ–100 Geologic Map presented in Figure 3.

HENNESSEY FORMATION (Permian, Leonardian) – Mostly a silty claystone or clay shale depending on whether bedding is laminated ($\leq 1\text{cm}$ [0.394 in] (thick: clay shale), or thin ($>1\text{cm}$ [0.394 in] thick: claystone), with local intervals of fine- to very fine-grained sandstone and coarse siltstone. The Purcell Sandstone is the only mappable bed that can be traced with any certainty in the area. Overall, the thickness of the Hennessey Formation varies between approximately 492 feet in the south part of the map to about 1312 feet in the northern part. Claystone's and clay shales are silty to rarely sandy, non-calcareous, typically unstratified to fissile laminated; unstratified claystone's commonly have small-scale slickensides and shrinkage cracks that are evidence of paleosol development. Color a moderate reddish brown to light brown, locally banded with yellowish gray and light greenish gray shale beds. Iron-reduction spots and bands are commonly found in more indurated clay shale lithologies, less so in claystone's; color of spots light greenish gray to pale green, while size of spots usually less than 5 millimeters (0.0394 inches) diameter. Interbedded siltstones moderately indurated to indurated, sandy, and non-calcareous; usually occur as thin laminated intervals of no more than 1 meter (3.281 ft) thick, or as thin partings separating predominantly shale intervals from sandstones. Sandstones are friable, silty to argillaceous, non-calcareous, usually found in thin, lenticular intervals of no more than a meter in thickness; locally contain low angle, tabular cross-bedding with associated ripple marks along bedding surfaces, rarely find trough cross-bedding except in the thickest intervals; the thin, lenticular geometry exhibiting little basal scouring of most sandstone intervals suggests that sand was deposited within shallow tidal channels, probably as a late depositional plug; trace fossils and shale rip-up clasts present but very rare; color same as shale intervals. Sandstone and siltstone intervals are more common in middle third of formation; base of formation mapped at the stratigraphically highest occurring fine-grained, trough-cross bedded sandstone of the Garber Formation. The Purcell Sandstone Member (Phyp): consists of a distinct tan to light brown colored, fine-grained, trough-cross-bedded sandstones with minor interbeds of siltstone and shale. Thickness varies from 0-20 meters (0 – 65.662 feet). Various investigators (see Bingham and Moore, 1975; Carr and Bergman, 1976; Bingham and Bergman, 1980; Morton, 1980) have attempted to elevate the Hennessey Formation to Group status, while breaking out several different “mappable” formations extending from the Kansas-Oklahoma border, southward. It is the current opinion that these “formations” should only be considered as members having very limited, and local, stratigraphic significance. The term “Hennessey Group” should be abandoned, while the interval that traditionally encompasses lithostratigraphic units falling between the Garber and Duncan Formations, north of the Wichita Mountain uplift, should be considered the Hennessey Formation.

- I34 & SH 74 Interchange
- J/P 32802(04)
- McClain County, Oklahoma
- AEC Project No.: 1875
- November 30, 2023



Figure 3. A segment of the geologic map from OGQ-100 Oklahoma City South indicating the Hennessey Formation (Phy) and the Purcell Sandstone Member (Phyp).

- I34 & SH 74 Interchange
- J/P 32802(04)
- McClain County, Oklahoma
- AEC Project No.: 1875
- November 30, 2023

3.0 Laboratory Testing

3.1 Laboratory Procedures

The Grant and Ashport soil series samples obtained during the field exploration were transferred to the Arrowhead Engineering Co., LLC. Norman office for pickup for the laboratory processing and testing. The laboratory tests performed on the soil series samples agreed and applicable AASHTO and ASTM test procedures. The laboratory testing schedule completed by the Arrowhead Engineering Co., Inc. included the following tests: a.) determination of the natural moisture content (AASHTO T 265), b.) Atterburg limits (AASHTO T 89 and T 90), c.) grain size distribution (AASHTO T 88), d.) pH (AASHTO T 200), e.) resistivity (ASTM G57), f.) laboratory moisture-density relations of soils (AASHTO T 99), and g.) the resilient modulus (M_R) (AASHTO T 307). The above test results for these soil series are presented in the Arrowhead Engineering Co., LLC. formatted pedological logs and accompanying test data sheets, see Appendix F.

4.0 Shrinkage and Swell Factors

4.1 Estimation of Shrinkage and Swell Factors

Shrinkage and swell factors for earthwork excavation were estimated from the laboratory Moisture–Density Relations of Soils, Method A (AASHTO T–99) for the Composite samples as follows:

- Composite B horizon sample test results for the Grant and Ashport soil series.

The method used for estimating the shrinkage and swell factors for earthwork excavation is based on an ODOT in–place density chart dated January 14, 1999, see Table 5.

- I34 & SH 74 Interchange
- J/P 32802(04)
- McClain County, Oklahoma
- AEC Project No.: 1875
- November 30, 2023

5.0 Construction Considerations

5.1 Soil Parameter Considerations and Compacted Fill Requirements

The soil parameters for the (Grant, Ashport, Port, Konawa, and Pulaski) soil series that affect compacted fill construction and the long-term performance in a compacted fill are discussed below. The NRCS drainage and permeability classes are listed in Table 6, and they are based on the frequency and duration of wet periods under conditions like those in which the soil developed (in situ condition). The drainage class refers to the natural prevailing wetness conditions of the soil series. The drainage and permeability characteristics of these soil series when placed in a compacted fill are anticipated to have approximately the same properties as in the in-situ condition. The characteristics and ratings are taken from the following: NRCS OSD, Soil Taxonomy, and the Web Soil Survey 3.4.0 Local Roads and Streets extended soil data; see Appendix B. A summary of these characteristics and ratings is presented in Table 6, and they are discussed in the following Section 5.2 Grading Assessment.

5.2 Grading Assessment

5.2.1 Site and Terrain Analysis

Regarding the suitability of the soil series for roadway fill material; the plasticity and textural classifications for the Composite B horizon samples as tested by (see, formatted pedological logs in Appendix F) are reported as follows:

- The Grant soil series Composite B sample is a Sandy Silt, (ML)
- The Ashport soil series Composite B sample is Sandy Lean Clay (CL)

From a terrain analysis standpoint, the origin of the Grant soil series based on a geologic class of development is a residual soil. The (Ashport, Port, Konawa, and Pulaski) soil series based on a geologic class of development are alluvial soils. The topography on site as read by eye was predominately in the range of 1 to 8 percent slope. Refer further to the range of development characteristics indicated in Table 2.

The Grant and Ashport soil series profiles as sampled closely matched the NRCS OSD soil series profile depths and descriptions.

- I34 & SH 74 Interchange
- J/P 32802(04)
- McClain County, Oklahoma
- AEC Project No.: 1875
- November 30, 2023

Grading problems are not anticipated in the excavation, handling, and compaction of these unconsolidated residual and alluvial soil series within the project station extents listed in Section 2.2. Construction grading is not expected to encounter some sequences of silty claystone or clay shale in the Hennessey geology. Within the project extents, the construction grading is anticipated to be predominantly shallow embankment fill grading of variable depths. The maximum height of embankment fill is approximately as follows: I-35 BL Lt 20 feet, I-35 BL Rt 15 feet, Ramp A 16 Feet, Ramp B 16 Feet, Ramp C 22 Feet, and Ramp D 12 Feet.

Regarding the block diagrams in Appendix C, there are potentially a further ten soil series inclusions (Nash, Pond Creek, Teller, Norge, Renfrow, Lucien, Dougherty, Stephenville, Yahola, and Tribbey) within the project station extents as indicated in Section 2.5. These soil series have a predominantly low percentage of occurrence ranging from 3 to 7 percent. The Renfrow soil series is known for being expansive clay soils.

5.2.2 Potential Grading Issues

The potential issues for the (Grant, Ashport, Port, Konawa, and Pulaski) soil series in the construction grading as to their performance as compacted fill are presented in the following discussion and summarized in Table 6 along with listed pertinent notes and definitions related to the ratings.

NRCS OSD and Soil Taxonomy

From the NRCS OSD and Soil Taxonomy, the (Grant, Ashport, Port, Konawa, and Pulaski) soil series have the following diagnostic horizons and features that may influence construction grading from Section 2.6:

- The (Grant, Ashport, and Port) soil series have a mollic epipedon in the upper horizons
- The Konawa and Pulaski soil series have friable soil particle structure (FSPS)
- The Grant and Konawa soil series have an argillic horizon
- The Grant soil series has a paralithic contact and underlying material
- The Ashport and Pulaski soil series have an udic–ustic SMR.
- The Ashport, Port, and Pulaski soils are subject to occasional to frequent flooding for very brief to brief periods.

From Table 6, the drainage characteristics and the permeability rates show some variations; however, all soil series when placed in a well compacted fill–section condition are anticipated to be relatively impervious. The drainage

- I34 & SH 74 Interchange
- J/P 32802(04)
- McClain County, Oklahoma
- AEC Project No.: 1875
- November 30, 2023

characteristics and the permeability rates for compacted fill soil materials are anticipated and expected to be comparable to the in situ soil series characteristics and ratings presented in Table 6.

Web Soil Survey 3.4.0

From the Web Soil Survey 3.4.0 Local Roads and Streets extended soil data, the (Grant, Ashport, Port, Konawa, and Pulaski) soil series address the following key issues:

- Shrink–swell
- Low strength
- Flooding

Specific notes from the Web Soil Survey 3.4.0 regarding the rating terminology and definitions are listed for the above soil series in Table 6. Ratings that were less than (0.10) in the Web Soil Survey 3.4.0 Shallow Excavations extended soil data are shown for completeness in the report but are considered negligible from a practical standpoint.

5.2.3 Assessment Summary

In summary, there appears to be no significant geo–hazards regarding the grading and use of the (Grant, Ashport, Port, Konawa, and Pulaski) soil series soil materials in compacted fill construction or in the long–term performance of compacted fill embankment sections constructed from borrow sources in these soil series that cannot be addressed. The Grant and Konawa are found singularly in soil map units; and the (Ashport, Port, and Pulaski) soil series only occur in complex soil map units, see Table 1. A soil series complex means that two or more dissimilar soil series occur in a regular repeating pattern but that these soil series cannot be mapped separately on the Soil Map on page 1 of the Web Soil Survey 3.4.0

Based on summary of the diagnostic horizons and features in the Soil Description in Appendix D, Soil Taxonomy in Appendix E, and the ratings listed in Table 6; the following characteristics of the (Grant, Ashport, Port, Konawa, and Pulaski) that should be considered in the construction grading are as follows:

1. The (Grant, Ashport, Port, Konawa, and Pulaski) soil series have a potential of low strength. The low strength for these soil series is attributable to a mollic epipedon (ME) and/or friable soil to a particle structure (FSPS) in the upper horizons; see horizon description and depths in Table 4 and in the OSD in Appendix B. The low strength can be addressed by the following:

- **I34 & SH 74 Interchange**
 - **J/P 32802(04)**
 - **McClain County, Oklahoma**
 - **AEC Project No.: 1875**
 - **November 30, 2023**
- a. Undercutting these horizon depths at a borrow source in these soil series station extents and reserving these soil materials for use as topsoil, see Tables 1 and 4.
 - b. Undercutting these horizon depths at station extents of the soil series that are left in–place prior to fill material placement, see OSD in Appendix B and Table 4.
 - c. Avoid placement of soil material from the above listed soil series that have a mollic epipedon and/or friable soil particle structure in the top two feet of the finished subgrade elevation.
2. The Grant soil series has a paralithic contact and underlying paralithic soil material. The paralithic contact refers to material is partially weathered bedrock or weakly consolidated bedrock so hard and consolidated that retains the fabric of the consolidated rock. When moist the paralithic material can be excavated with hand tools.
 3. The Ashport and Pulaski soil series have udic–ustic SMR. The udic–ustic SMR which implies that there is a potential for wetness and/or a perched water table that are both transient and occur in longer time periods that could impact construction grading.
 4. 4. The (Ashport, Port, and Pulaski) soil series are subject to occasional to frequent flooding for very brief to brief time periods that may impact construction grading.

5.3 Other Factors

The (Grant, Ashport, Port, Konawa, and Pulaski) soil series identified along this project extent are not known to have soil dispersive characteristics. However, all these soil series are still subject to erosion, and inappropriate construction grading practices may result in unnecessary erosion. Many of these soil series have sandy soil textures.

All soil series are in Area I of the Oklahoma Corrosion Stress Map (ODOT) indicating little or no stress with regard for potential steel pipe corrosion, see Appendix G. However, the resistivity values reported in the Arrowhead Engineering Co., LLC pedological logs and accompanying test data sheets in Appendix F for the (soil series shows a range of resistivity from 2,390 to 5,320 Ω –cm. The resistivity values in the soil series horizons indicate the following ratings with regard metal drainage pipe corrosion from Appendix G are as follows:

- Grant soil series – slight to moderate corrosion potential
- Ashport soil series – moderate corrosion potential

The soluble sulfate tests were not tested on the Grant and Ashport soil series samples. The soil stabilization and/or modification of the soil series is not anticipated to be a significant issue with the use of calcium based chemical soil stabilizers.

Based on the cross–section sheets in the Plan Set in Appendix A and a site inspection, there would appear that a limited amount of borrow that will need to be identified from an imported borrow source for the embankment fill material. It is assumed further that all incidental cut grading of the existing grade regarding the Standard ODOT typical roadway ditch section and utility relocation grading will be processed and reused on site for embankment fill. Finally, the Not Limited rating for Konawa soil series means that there are no restrictions regarding grading construction.

- I34 & SH 74 Interchange
- J/P 32802(04)
- McClain County, Oklahoma
- AEC Project No.: 1875
- November 30, 2023

As noted in the Geologic Statement in Section 2.7, the Purcell Sandstone Member (Phyp): consists of a distinct tan to light brown colored, fine-grained, trough-cross-bedded sandstones with minor interbeds of siltstone and shale. The Purcell Sandstone Member may be significant in the cut grading because it occurs along both extents of I-35 and SH 74. The Purcell Sandstone Member (Phyp) may be water bearing and occur sporadically within the Hennessey Formation.

As noted in the Geologic Statement in Section 2.7, the Purcell Sandstone Member (Phyp): consists of a distinct tan to light brown colored, fine-grained, trough-cross-bedded sandstones with minor interbeds of siltstone and shale. The Purcell Sandstone Member may be significant in the cut grading because it occurs along both extents of I-35 and SH 74. The Purcell Sandstone Member (Phyp) may be water bearing and occur sporadically within the Hennessey Formation.

5.4 Cut Sections Considerations

Based on a review of the Plan and Profile sheets in Appendix A, the cut-section grading along I-35 and SH 74 project station extents is anticipated involve the following classes of grading:

- Standard ODOT typical ditch section grading.
- Back slope cut grading
- Ramp Cut Grading
- Utility excavation

The depth of cut grading is variable, and maximum depth of cut grading is approximately 18 feet. The (Grant, Ashport, Port, Konawa, and Pulaski) soil series profiles are judged to be rippable. The underlying sequences of silty claystone or clay shale from the Hennessey Unit are anticipated to be encountered in the cut grading, and they are from experience are rippable.

From the Web Soil Survey 3.4.0 Shallow Excavation extended soil data in Appendix B, the (Grant, Ashport, Konawa, and Pulaski) soil series address the following key issues:

- Dusty
- Unstable excavation walls
- Flooding

- I34 & SH 74 Interchange
- J/P 32802(04)
- McClain County, Oklahoma
- AEC Project No.: 1875
- November 30, 2023

Specific notes regarding the rating terminology and definitions are listed for the above soil series in Table 6. Ratings that were less than (0.10) in the Web Soil Survey 3.4.0 Shallow Excavations extended soil data are shown for completeness in the report but are considered negligible from a practical standpoint.

5.5 Groundwater Observations

During the field investigation of the Grant and Ashport soil series, no ground water was encountered at the time of sampling. However, the Ashport soil series had a wet bottom at the end of sampling. Regarding soil moisture regimes (SMR), these soil series are aligned in the following SMR class:

- The Ashport and Pulaski soil series have an udic–ustic SMR.

The udic–ustic SMR implies wetness for short time periods as well as for long–term perched water tables in one or more sub–horizons for some periods in normal years. The OSD reports no perched water table depths in a normal year. The (Ashport, Port, and Pulaski) soil series are subject to flooding as reported in the OSD for a normal year as follows:

- Ashport soil series – occasional to frequent flooding for very brief to brief periods during March to August
- Port soil series – occasional to frequent flooding for very brief periods during March to October
- Pulaski soil series – occasional to frequent flooding for very brief periods during March to October

A normal year is defined as a year in which the mean annual precipitation is within plus or minus one standard deviation of the long–term (30 or more years) mean annual precipitation, and monthly precipitation is within plus or minus one standard deviation of the mean monthly precipitation for 8 or more months during the year.

- I34 & SH 74 Interchange
- J/P 32802(04)
- McClain County, Oklahoma
- AEC Project No.: 1875
- November 30, 2023

6.0 Recommendations

The recommendations are collective, based on the findings of the field and laboratory investigation and study at this site. Recommendations for State Job No. 32802(04) for the I-35 and SH 74 interchange project extents are as follows:

1. The recommended horizons that need to be reserved for use as topsoil for the (Grant, Ashport, Port, Konawa, and Pulaski) soil series are tabularized in Table 4.
2. The recommended resilient modulus (M_R) is based on a deviator stress of 6 psi for the Grant and Ashport soil series Composite B horizon samples: The recommended resilient modulus for samples compacted at optimum moisture content at (OMC) and at OMC plus 2% moisture conditions for pavement design is presented in Table 7.
3. Based on the resistivity values recorded in the test data sheet for (Grant, Ashport, Port, Konawa, and Pulaski) soil series, metal drainage pipe may be considered due to variability in the resistivity values with slight to moderate corrosion potential in the horizons for the tested soil series, see resistivity values reported in Appendix F and in Section 5.3. Find enclosed in Appendix G the appropriate abrasion and corrosion rating table and data.
4. The recommended minimum embankment–section slope and cut section slope design is a 3:1 slope ratio.
5. All grading is recommended to be compacted at a compaction moisture content between optimum moisture content and two percent wet of optimum moisture content as specified by plan note.
6. Regarding the soil stabilization of the finished grade excavated from soil material from the (Grant, Ashport, Port, Konawa, and Pulaski) soil series station extents in Table 1; Class C Flyash chemical soil stabilizers are recommended if available. If a limited amount of material from an imported borrow source is to be used in the construction grading of the top two feet of the finished subgrade, a complete soil stabilization mix design should be performed during construction of the finished subgrade in accordance with ODOT OHD L-50, Soil Stabilization Mix Design Procedure to determine the appropriate type and the optimum percentage of chemical soil stabilizer to be used in the top two feet of the finished subgrade.
7. Apply the appropriate mulches and native Bermuda grass to further control all erosion of the grading according to subsections 230, 231, 232, 233, and 234 in the 2019 ODOT Standard Specifications for Highway Construction.
8. A minimum of 12 inches of an ODOT approved topsoil is recommended to be placed on all Standard ODOT typical ditch section slopes, cut section slopes, and for all embankment slopes throughout the project extent.

- **I34 & SH 74 Interchange**
- **J/P 32802(04)**
- **McClain County, Oklahoma**
- **AEC Project No.: 1875**
- **November 30, 2023**

7.0 General Comments

The exploration and analysis of the subsurface conditions reported herein are considered to be in sufficient detail and scope to form reasonable basis for the design of the pavement and grading sections. The recommendations submitted are based on the available soil information, laboratory testing results, local experience with soils and their taxonomy. If deviations from the noted subsurface conditions are encountered during construction, they should be brought to the attention of Arrowhead Engineering Co., LLC. We can not be held responsible for the mis-interpretation or implementation of this report by others. Arrowhead Engineering Co., LLC should be retained to perform services sufficient to determine compliance with its recommendations. If Arrowhead Engineering Co., LLC is not retained in this capacity, it will not accept any responsibility. The geotechnical engineer warrants that the findings, recommendations, specifications, or professional advice contained herein have been made in accordance with the professional engineering practice of geotechnical engineering. No other warranties are implied or expressed. After the design plans and specifications are complete, it is recommended that the geotechnical engineer be provided the opportunity to review the final design plans and specifications so that the report recommendations have been properly interpreted and implemented. This report has been prepared for the exclusive use of EST, Inc. and/or ODOT for application to the proposed roadway improvements for the project Interchange I-35 and SH 74 in McClain County, Oklahoma.

- I34 & SH 74 Interchange
- J/P 32802(04)
- McClain County, Oklahoma
- AEC Project No.: 1875
- November 30, 2023

Tables

Table 1 – Soil Series Station Extents

Table 2 – Soil Series General Comments

Table 3 – Soil Series Taxonomic Class and Comments

Table 4 – Soil Taxonomy

Table 5 – Shrinkage/Swell Factors for Earthwork Excavation

Table 6 – Characteristics and Ratings Regarding the Suitability for Roadway Fill

Table 7 – Recommended M_R for Pavement Design

Table 1. Soil series station extents¹.

Soil series	Symbol	Station	Station
I-35 Ramp A			
Grant silt loam, 3 to 5 percent slopes	14	3013+00 (BOP)	3025+71
Grant silt loam, 5 to 8 percent slopes, eroded	16	3025+71	3027+06
Ashport, Port, and Pluski soils, 0 to 1 percent slopes, frequently flooded	39	3027+06	3027+70.53 (EOP)
I-35 Ramp B			
Grant silt loam, 3 to 5 percent slopes	14	3009+00 (BOP)	3022+02
Grant silt loam, 5 to 8 percent slopes, eroded	16	3022+02	3027+28
Ashport, Port, and Pluski soils, 0 to 1 percent slopes, frequently flooded	39	3027+28	3027+48.41 (EOP)
I-35 Ramp C			
Ashport, Port, and Pluski soils, 0 to 1 percent slopes, frequently flooded	39	3027+54.40 (BOP)	3040+10
Grant silt loam, 5 to 8 percent slopes, eroded	16	3040+10	3047+00 (EOP)
I-35 Ramp D			
Ashport, Port, and Pluski soils, 0 to 1 percent slopes, frequently flooded	39	3027+68.53 (BOP)	3028+16
Grant silt loam, 3 to 5 percent slopes	14	3028+16	3033+04
Ashport, Port, and Pluski soils, 0 to 1 percent slopes, frequently flooded	39	3033+04	3042+00 (EOP)
I-35 BL Lt			
Konawa loamy fine sand, 0 to 3 percent slopes	22	2997+45.42 (BOP)	3001+17
Grant silt loam, 3 to 5 percent slopes	14	3001+17	3023+87
Grant silt loam, 5 to 8 percent slopes, eroded	16	3023+87	3026+68
I-35 Bridge Lt		3026+20	3028+20
Ashport, Port, and Pluski soils, 0 to 1 percent slopes, frequently flooded	39	3028+20	3030+11
Grant silt loam, 3 to 5 percent slopes	14	3030+11	3032+44
Ashport, Port, and Pluski soils, 0 to 1 percent slopes, frequently flooded	39	3032+44	3042+67

Table 1. Soil series station extents.

Soil series	Symbol	Station	Station
Grant silt loam, 5 to 8 percent slopes, eroded	16	3042+67	3047+21
Grant-Port, frequently flooded, complex, 0 to 12 percent slopes	17	3047+21	3050+70
Grant silt loam, 5 to 8 percent slopes, eroded	16	3050+70	3060+00 (EOP)
I-35 BL Rt			
Konawa loamy fine sand, 0 to 3 percent slopes	22	2997+45.42 (BOP	3000++66
Grant silt loam, 3 to 5 percent slopes	14	3000++66	3022+06
Grant silt loam, 5 to 8 percent slopes, eroded	16	3022+06	3026+20
I-35 Bridge Rt		3026+20	3028+20
Ashport, Port, and Pluski soils, 0 to 1 percent slopes, frequently flooded	39	3028+20	3030+95
Grant silt loam, 3 to 5 percent slopes	14	3030+95	3044+60
Ashport, Port, and Pluski soils, 0 to 1 percent slopes, frequently flooded	39	3044+60	3054+07
Grant silt loam, 5 to 8 percent slopes, eroded	16	3054+07	3055+93
Grant-Port, frequently flooded, complex, 0 to 12 percent slopes	17	3055+93	3058+30
Grant silt loam, 5 to 8 percent slopes, eroded	16	3058+30	3059+69.40 (BOP)
SH 74			
Grant silt loam, 3 to 5 percent slopes	14	983+00 (BOP)	992+64
Konawa loamy fine sand, 3 to 8 percent slopes	23	992+64	994+50
Ashport, Port, and Pluski soils, 0 to 1 percent slopes, frequently flooded	39	994+50	1003+02
Bridge A		1003+02	1003+50
Ashport, Port, and Pluski soils, 0 to 1 percent slopes, frequently flooded	39	1003+50	1013+52
Grant silt loam, 5 to 8 percent slopes, eroded	16	1013+52	1029+89
Grant silt loam, 3 to 5 percent slopes	14	1029+89	1037+67.40 (EOP)

Note 1: Reference for stationing was the intersection of the I-35 centerline of survey and SH 74 CRL.

Table 2. General comments on the soil series investigated¹.

Soil Series	Symbol	Geology	Slope, Percent ²
Grant	14, 16	Soils formed in material weathered predominately siltstone or silty shale of Permian geologic age. Landform is on nearly level to moderately steep treads ³ and risers ⁴ of paleoterraces ⁵ in the Central Rolling Red plains (MLRA 80A) ⁶ . The Grant soil series based on origin of development a residual soil	0 to 20
Ashport	39	Soils formed in loamy alluvium of Holocene geologic age. Landform is on flood plains along small streams in the Central Rolling Red plains (MLRA 80A). The Ashport soil series based on origin of development an alluvial soil.	0 to 3
Port	39	Soils formed in calcareous loamy alluvium of Recent geologic age. Landform is on nearly level to very gently sloping narrow flood plains. The Port soil series based on origin of development an alluvial soil.	0 to 3
Konawa	22/23	Soils formed in sandy and loamy alluvium of Pleistocene geologic age. Landform is on nearly level to moderately steep treads and risers of low stream terraces in the Central Rolling Red plains (MLRA 80A). The Konawa soil series based on origin of development an alluvial soil	0 to 20
Pulaski	39	Soils formed in loamy alluvial sediments of Holocene geologic age. Landform is on nearly level to gently sloping flood plains along small tributaries in the Central Rolling Red plains (MLRA 80A). The Pulaski soil series based on origin of development an alluvial soil.	0 to 3

- Notes:
1. General reference: USDA Soil Survey Manual, United States Department of Agriculture Handbook No 18, Issued March 2017.
 2. Slopes as recorded from the OSD data.
 3. A tread is a flat to gently sloping, topmost, laterally extensive slope of terraces, floodplains, or other stepped landforms.
 4. A riser is a vertical or steep side slope of terraces, flood–plain steps, or other stepped landforms.
 5. A paleoterrace is an erosional remnant of a terrace that retains the surface form and alluvial deposits of its origin but emplaced by, and commonly does not grade to, a present–day stream or drainage network.
 6. MLRA – Major land resource area.

Table 3. Soil series taxonomic class.

Soil Series	Symbol	Taxonomic Class
Grant	14, 16	Fine-silty, mixed, superactive ¹ , thermic Udic Argiustolls
Ashport	39	Fine-silty, mixed, superactive, thermic Fluventic Haplustolls
Port	39	Fine-silty, mixed, superactive, thermic Cumulic Haplustolls
Konawa	22/23	Fine-loamy, mixed, active ² , thermic Ultic Haplustalfs
Pulaski	39	Coarse-loamy, mixed, superactive, nonacid, thermic Udic Ustifluvents

Notes:

1. Superactive refers to a cation exchange activity class of the < 2mm fraction material in the particle control section where the CEC/% clay is 0.60 or more.
2. Active refers to a cation exchange activity class of the < 2mm fraction material in the control section where the CEC/% clay is equal to the range of 0.40 to 0.60.

Table 4. Soil taxonomy.

Soil Series	Symbol	Order	Suborder	Great Group	Subgroup Modifier	Particle Size	Mineralogy	Soil Temperature	Top soil ² (ME/FSPS), Inches
Grant	14, 16	Mollisols	Ustolls	Argiustolls	Udic	Fine-silty	Mixed	Thermic	ME- 17: Ap, A, BA
Ashport	39	"	"	Haplustolls	Fluventic	"	"	"	ME- 16: Ap, A
Port	39	"	"	"	Cumulic	"	"	"	ME- 27: Ap, A
Konawa	22/23	Alfisols	Ustalfs	Haplustalfs	Ultic	"	"	"	FSPS- 17: Ap, E
Pulaski	39	Entisols	Fluvents	Ustifluvents	Udic	Coarse-loamy	"	"	FSPS- 7: Ap

Notes: 1. Reference is the Keys to Soil Taxonomy, 12th Edition, 2014.

2. Topsoil: (ME/FSPS) refers to the following: a.) Mollic epipedon soil horizon(s) (ME), b.) Friable soil particle structure (FSPS),

Table 5. Shrinkage/swell factors for earthwork excavation.

Soil Series	Horizon	Depth, Inches	Soil Classification (USCS) ⁴	Compacted Density, Pcf (δ_d)	OMC ⁵ , %	ODOT In-Place Chart Density, Pcf (δ_w)	Shrinkage/Swell Factor ¹	% Shrinkage/Swell ^{2,3}
Grant	Composite B	13-48	ML	116.3	12.9	115.0	1.0847	8.47 (Shrinkage)
Ashport	Composite B	16-80	ML	112.7	13.7	115.0	1.0585	5.85 (Shrinkage)

Notes:

1. Shrinkage/Swell Factor = $0.95 \delta_d (1 + OMC) / \delta_{w\ skrin}$
2. Shrinkage/Swell Factor = Swell < 1.0, Shrinkage > 1.0
3. % Shrinkage / Swell = [1.0000 +/- Factor]100
4. For a dual soil classification, use average value of each soil classification
5. OMC – optimum moisture content in percent

Table 6. Characteristics and ratings regarding the suitability for roadway fill or shallow excavation.

Soil Series	Symbol	OSD		Web Soil Survey 3.4.0 – Suitability for Roadway Fill (Local Roads and Streets) / Shallow Excavations
		Drainage	Permeability / in/hr	
Grant	14, 16	Well drained ¹	Moderate – 0.6 to less than 2.0	Somewhat limited: Low strength ² (0.92), Shrink–swell ³ (0.09) / Somewhat limited: Dusty⁴ (0.33), Unstable excavation walls⁵ (0.01)
Ashport	39	Well drained	Moderate – 0.6 to less than 2.0	Very limited: Flooding ⁶ (1.00), Low strength (0.35), Shrink–swell (0.25) / Somewhat limited: Flooding (0.80), Dusty (0.35), Unstable excavation walls (0.01)
Port	39	Well drained	Moderate – 0.6 to less than 2.0	Very limited: Flooding (1.00), Low strength (0.57) / Somewhat limited: Flooding (0.80), Dusty (0.21), Unstable excavation walls (0.01)
Konawa	22/23	Well drained	Moderate – 0.6 to less than 2.0	Not limited / Somewhat limited: Unstable excavation walls (0.01)
Pulaski	39	Well drained	Moderately rapid – 2.0 to less than 6.0	Very limited: Flooding (1.00) / Somewhat limited: Flooding (0.80), Dusty (0.02), Unstable excavation walls (0.01)

Notes:

1. Well drained means water is removed from the soil readily but not rapidly.
2. Low strength implies subgrade instability when exposed to moisture during construction or subgrade instability due to increasing moisture with time below a paved surface, under an embankment, or other structure.
3. Shrink–swell potential refers to the shrinking of the soil when dry due to drought or localized drying; and the swelling when becoming wet due to accumulated moisture intake over time or from extreme continued rainfall periods.
4. Low strength implies subgrade instability when exposed to moisture during construction or subgrade instability due to increasing moisture with time below a paved surface, under an embankment, or other structure.
5. Unstable excavation walls indicate potential instability and slope wall stability in cut section extents.
6. Dusty is a general term in soil interpretation to describe a soil particle–size group of soil materials which readily become airborne. In most cases it is fine silts and clays that become airborne.

Table 7. Recommended M_R for pavement design.

Soil Series	Horizon	Equation Input ¹	M_R^2 at 6 psi	M_R
Grant	Composite B Horizon – OMC	$K1 = 4,601, K2 = 0.37950$ $K5 = 0.37950$	$M_R = 4,601(6)^{-0.10475} (2)^{0.37950}$	4,961
Grant	Composite B Horizon – OMC +2 %	$K1 = 1,721, K2 = 0.28473$ $K5 = 0.02078$	$M_R = 1,721(6)^{0.28473} (2)^{0.02078}$	2,908
Ashport	Composite B Horizon – OMC	$K1 = 5,604, K2 = -0.13158$ $K5 = 0.32566$	$M_R = 5,604(6)^{-0.13158} (2)^{0.32566}$	5,548
Ashport	Composite B Horizon – OMC +2 %	$K1 = 4,426, K2 = -0.12535$ $K5 = 0.41655$	$M_R = 4,426(6)^{-0.12535} (2)^{0.41655}$	4,719

1. $K1, K2, K5; M_R$ computed on the last five sequences of the confining pressure and maximum axial stress.
2. $M_R = K1 (S_c)^{K2} (S_3)^{K5}$ where $S_3 = 2$ psi and $S_c = 6$ was used in the model equation.

- **I34 & SH 74 Interchange**
- **J/P 32802(04)**
- **McClain County, Oklahoma**
- **AEC Project No.: 1875**
- **November 30, 2023**

Appendix A

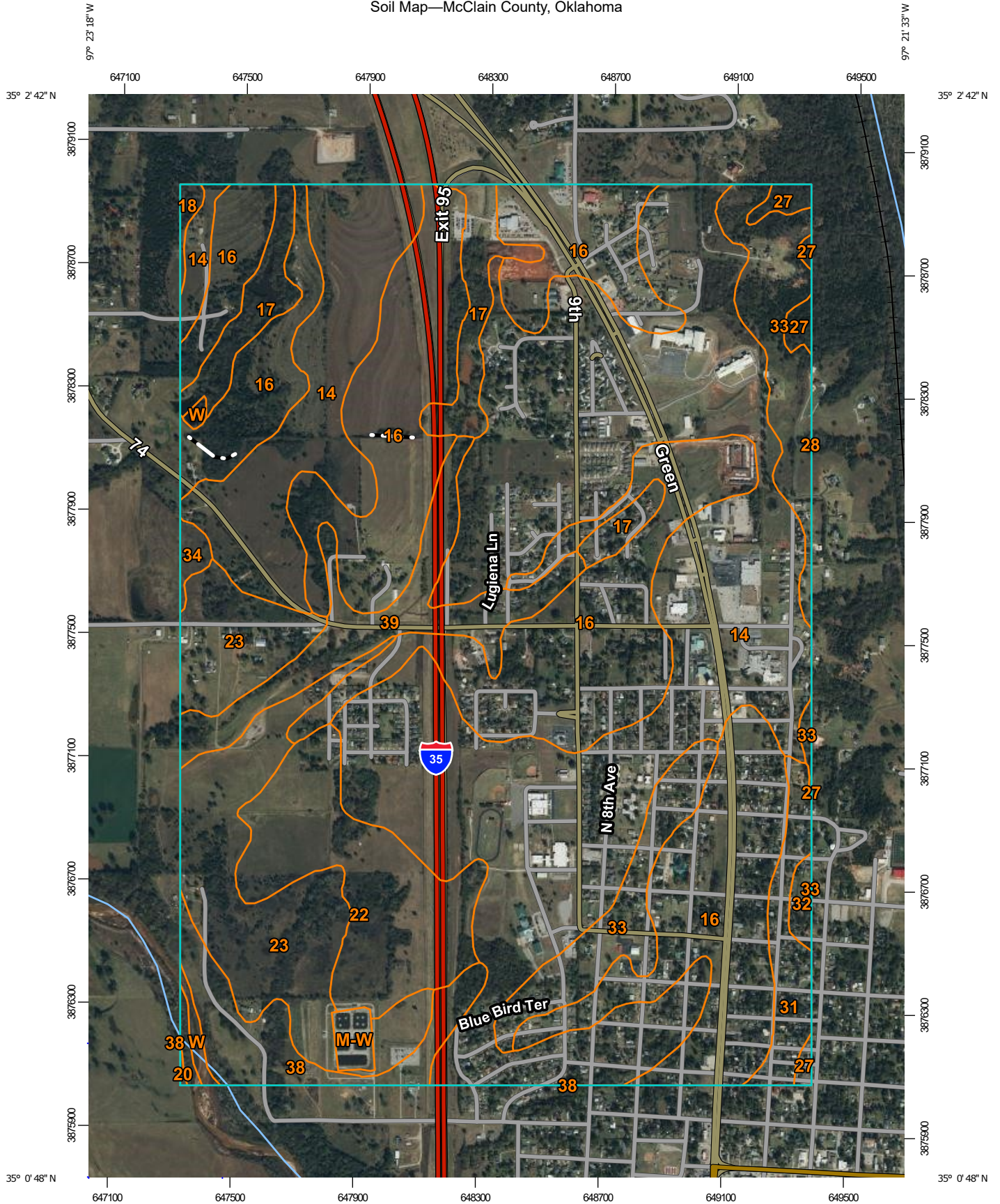
Project Plan Set

- **I34 & SH 74 Interchange**
- **J/P 32802(04)**
- **McClain County, Oklahoma**
- **AEC Project No.: 1875**
- **November 30, 2023**

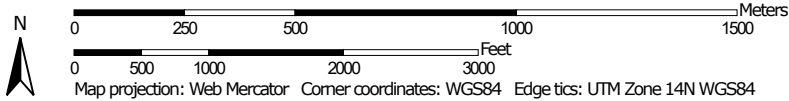
Appendix B

Web Soil Survey

Soil Map—McClain County, Oklahoma



Map Scale: 1:17,100 if printed on A portrait (8.5" x 11") sheet.



Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84




Natural Resources Conservation Service

Web Soil Survey National Cooperative Soil Survey


11/9/2023 Page 1 of 3


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.

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: McClain County, Oklahoma

Survey Area Data: Version 20, Sep 7, 2023

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

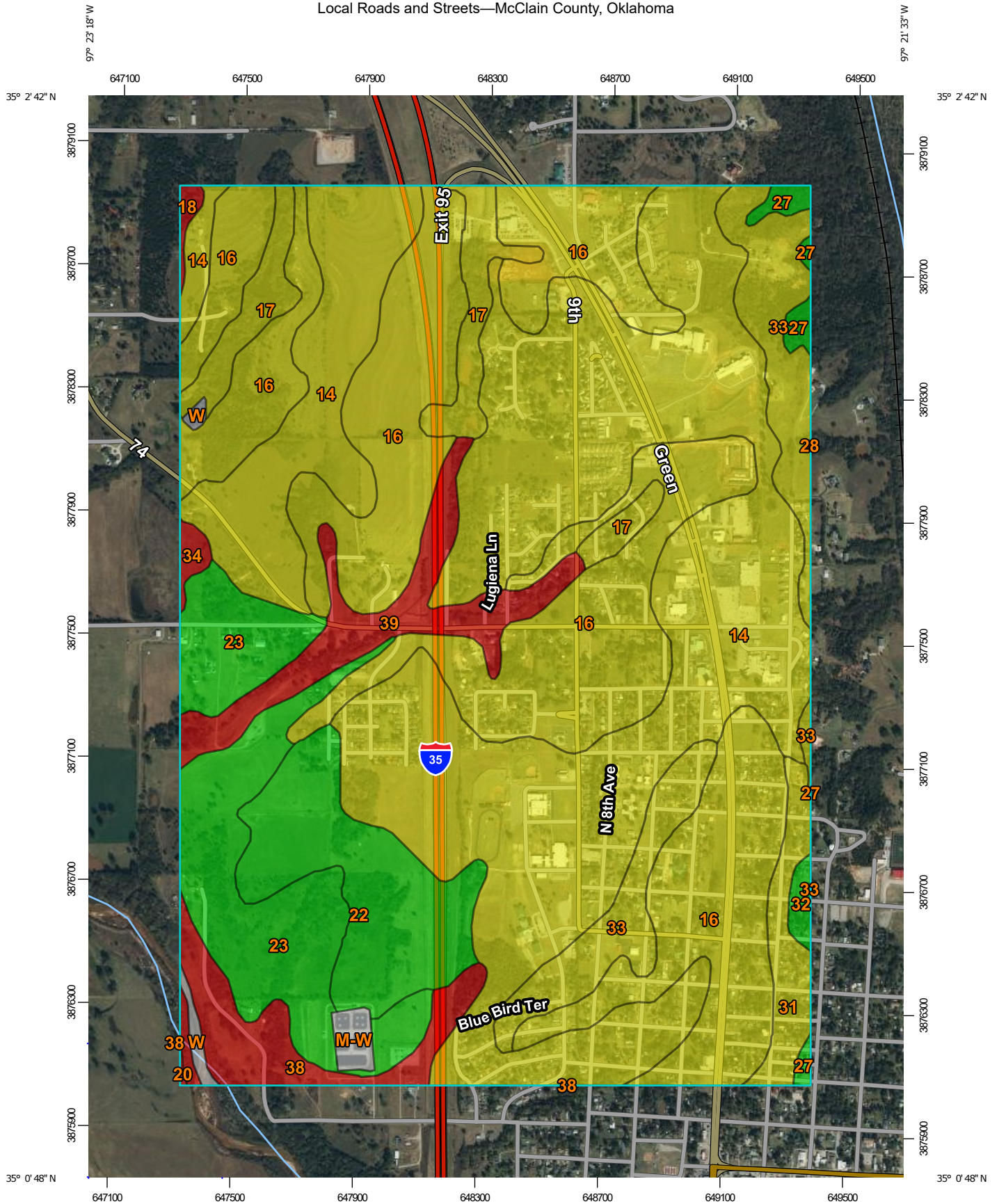
Date(s) aerial images were photographed: Oct 14, 2020—Nov 2, 2020

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.

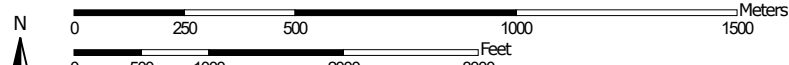
Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
14	Grant silt loam, 3 to 5 percent slopes, eroded	569.6	38.2%
16	Grant silt loam, 5 to 8 percent slopes, eroded	420.5	28.2%
17	Grant-Port, frequently flooded, complex, 0 to 12 percent slopes	49.9	3.3%
18	Gullied land-Grant complex, 3 to 8 percent slopes	2.8	0.2%
20	Keokuk silt loam, 0 to 1 percent slopes, occasionally flooded	0.4	0.0%
22	Konawa loamy fine sand, 0 to 3 percent slopes	86.3	5.8%
23	Konawa loamy fine sand, 3 to 8 percent slopes	128.6	8.6%
27	Minco very fine sandy loam, 5 to 8 percent slopes	9.2	0.6%
28	Minco very fine sandy loam, 8 to 30 percent slopes	0.1	0.0%
31	Minco silt loam, 3 to 5 percent slopes	25.3	1.7%
32	Nash-Lucien complex, 3 to 5 percent slopes	4.4	0.3%
33	Nash-Lucien complex, 5 to 12 percent slopes	83.9	5.6%
34	Pits	4.1	0.3%
38	Pulaski fine sandy loam, 0 to 1 percent slopes, occasionally flooded	41.9	2.8%
39	Ashport, Port and Pulaski soils, 0 to 1 percent slopes, frequently flooded	55.4	3.7%
M-W	Miscellaneous water	6.0	0.4%
W	Water	4.3	0.3%
Totals for Area of Interest		1,492.7	100.0%

Local Roads and Streets—McClain County, Oklahoma



Map Scale: 1:17,100 if printed on A portrait (8.5" x 11") sheet.




Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84




MAP LEGEND

Area of Interest (AOI)





 Area of Interest (AOI)

Background





 Aerial Photography

Soils





Soil Rating Polygons

-  Very limited
-  Somewhat limited
-  Not limited
-  Not rated or not available


Soil Rating Lines

-  Very limited
-  Somewhat limited
-  Not limited
-  Not rated or not available






Soil Rating Points

-  Very limited
-  Somewhat limited
-  Not limited
-  Not rated or not available

Water Features

 Streams and Canals

Transportation

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

MAP INFORMATION

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

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: McClain County, Oklahoma
 Survey Area Data: Version 20, Sep 7, 2023

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

Date(s) aerial images were photographed: Oct 14, 2020—Nov 2, 2020

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.

Soil Description

The soil series identified along the proposed interchange of I-35 and SH 74 the order of occurrence beginning from the BOP are presented in Table 1. Regarding the pedological and geological soil survey, five soil series were identified in the project extents are from three soil orders and three suborders; see Table 4 and the Soil Taxonomic Statement in Appendix E. For the (Port, Konawa, and Plaski) soil series that were not sampled, the official soil description (OSD) depths were used in the following soil descriptions.

The **Grant** soil series diagnostic horizons and features include a mollic epipedon, an argillic horizon, and a paralithic contact. The mollic epipedon refers to a dark colored, organic rich surface horizon that is susceptible to subgrade instability when exposed to moisture during construction or increasing moisture with time and series includes the (Ap, A, and Bt1) horizons from the ground surface to a depth of approximately 28 inches. The argillic horizon develops through a process of illuviation where successive horizons with depth develop with increasing clay content at least 1.2 times more clay content as occurring in an overlying horizon and is represented by the lower-case symbol 't' in the sub horizon identification includes the Bt horizons from approximately 14 to 28 inches from the ground surface. A paralithic contact refers to the boundary between soil and an underlying material that is so hard and consolidated that digging with hand tools is impractical. The paralithic contact was not observed at the sampling location.

The **Ashport** soil series diagnostic horizons and features include a mollic epipedon, cambic horizon, and a udic-ustic soil moisture regime. The mollic epipedon as described above in the Grant soil series includes the Ap, and A horizons from the ground surface to an approximate depth of 16 inches. The cambic horizon refers to a subsoil horizon of very fine sand, loamy very fine sand, or finer texture that is 15 cm (5.91 inches) or thicker with some weak indication of alteration in color from the pedogenic processes and includes the Bw horizon from 16 to 35 inches. The udic-ustic soil moisture regime is described above in the Zaneis soil series. The Ashport soil series is subject to occasional flooding for brief periods during March to August. The udic-ustic soil moisture regime means that in most years, this soil series is not dry in any part of the moisture control section (depth to which plant roots penetrate) for as long as 90 cumulative days and at the same time the moisture control section is moist in some part for more than one-half of the days when the soil temperature is 5° C (41°F) at 50 cm (19.69in).

The **Konawa** soil series diagnostic horizons and features include an ochric epipedon, and an argillic horizon. The ochric epipedon is a surface horizon with color values more than 5 dry or 3 moist, contains less than 0.6 percent organic carbon, or is hard to very hard and massive when dry and includes the Ap and E horizons from the ground surface to an approximate depth of 17 inches. The argillic horizon as described above for the Grant soil series includes the Bt horizon from approximately 17 to 53 inches below the ground surface.

The **Port** soil series diagnostic horizons and features include a mollic epipedon and cambic horizon. The mollic epipedon as described above for the Grant soil series includes the Ap and A horizons from the ground surface to an approximate depth of 27 inches. The cambic horizon as described above for the Ashport series includes the Bk horizon from an approximate depth of 27 to 42 inches below the ground surface.

The **Pulaski** soil series diagnostic horizons and features include an ochric epipedon, irregular carbon content with depth, and udic–ustic soil moisture regime. The ochric epipedon is a surface horizon with color values more than 5 dry or 3 moist, contains less than 0.6 percent organic carbon, or is hard to very hard and massive when dry and includes the Ap and A horizon from the ground surface to an approximate depth of 19 inches. The irregular carbon content with depth is due to alluvial soil stratification. The udic–ustic soil moisture regime is described above for the Ashport soil series.

Local Roads and Streets

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI	
14	Grant silt loam, 3 to 5 percent slopes, eroded	Somewhat limited	Grant (90%)	Low strength (0.92)	569.6	38.2%	
				Shrink-swell (0.09)			
16	Grant silt loam, 5 to 8 percent slopes, eroded	Somewhat limited	Grant, eroded (85%)	Low strength (0.67)	420.5	28.2%	
				Shrink-swell (0.01)			
17	Grant-Port, frequently flooded, complex, 0 to 12 percent slopes	Somewhat limited	Grant (50%)	Low strength (0.82)	49.9	3.3%	
				Shrink-swell (0.07)			
18	Gullied land-Grant complex, 3 to 8 percent slopes	Very limited	Gullied land (45%)	Low strength (1.00)	2.8	0.2%	
			Renfrow, severely eroded (10%)	Low strength (1.00)			
20	Keokuk silt loam, 0 to 1 percent slopes, occasionally flooded	Very limited	Keokuk, occasionally flooded (85%)	Flooding (1.00)	0.4	0.0%	
				Ashport, occasionally flooded (5%)			Flooding (1.00)
							Shrink-swell (0.50)
			Port, occasionally flooded (5%)	Low strength (0.44)			
				Flooding (1.00)			
				Shrink-swell (0.25)			
			Pulaski, occasionally flooded (5%)	Low strength (0.20)			
22	Konawa loamy fine sand, 0 to 3 percent slopes	Not limited	Konawa (90%)		86.3	5.8%	
23	Konawa loamy fine sand, 3 to 8 percent slopes	Not limited	Konawa (90%)		128.6	8.6%	

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
27	Minco very fine sandy loam, 5 to 8 percent slopes	Not limited	Minco (85%)		9.2	0.6%
			Teller (10%)			
28	Minco very fine sandy loam, 8 to 30 percent slopes	Very limited	Minco (85%)	Slope (1.00)	0.1	0.0%
31	Minco silt loam, 3 to 5 percent slopes	Somewhat limited	Minco (90%)	Low strength (0.04)	25.3	1.7%
32	Nash-Lucien complex, 3 to 5 percent slopes	Not limited	Nash (50%)		4.4	0.3%
33	Nash-Lucien complex, 5 to 12 percent slopes	Somewhat limited	Nash (45%)	Slope (0.16)	83.9	5.6%
			Lucien (35%)	Depth to soft bedrock (1.00)		
				Slope (0.16)		
Grant (10%)	Low strength (0.22)					
34	Pits	Very limited	Pits (100%)	Low strength (1.00)	4.1	0.3%
38	Pulaski fine sandy loam, 0 to 1 percent slopes, occasionally flooded	Very limited	Pulaski, occasionally flooded (85%)	Flooding (1.00)	41.9	2.8%
39	Ashport, Port and Pulaski soils, 0 to 1 percent slopes, frequently flooded	Very limited	Ashport, frequently flooded (40%)	Flooding (1.00)	55.4	3.7%
				Low strength (0.35)		
				Shrink-swell (0.25)		
			Port, frequently flooded (35%)	Flooding (1.00)		
				Low strength (0.57)		
			Pulaski, frequently flooded (15%)	Flooding (1.00)		
M-W	Miscellaneous water	Not rated	Water (100%)		6.0	0.4%
W	Water	Not rated	Water (100%)		4.3	0.3%
Totals for Area of Interest					1,492.7	100.0%

Rating	Acres in AOI	Percent of AOI
Somewhat limited	1,149.2	77.0%

Rating	Acres in AOI	Percent of AOI
Not limited	228.6	15.3%
Very limited	104.6	7.0%
Null or Not Rated	10.3	0.7%
Totals for Area of Interest	1,492.7	100.0%

Description

ENG - Engineering

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.

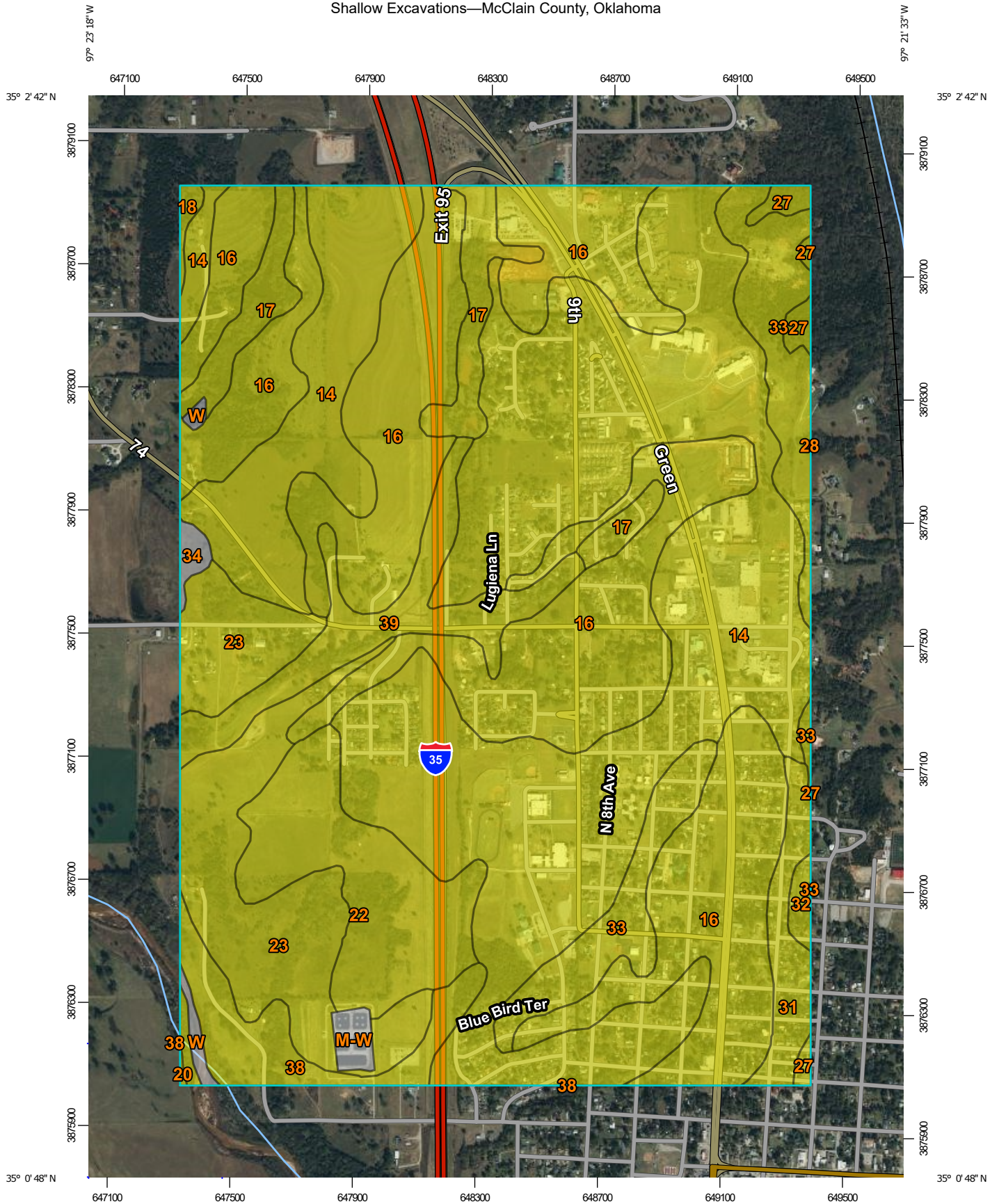
The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the specified use. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance 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 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).

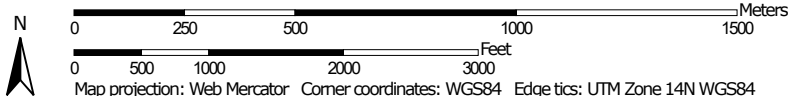
The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Shallow Excavations—McClain County, Oklahoma



Map Scale: 1:17,100 if printed on A portrait (8.5" x 11") sheet.

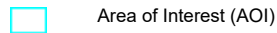


Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84



MAP LEGEND

Area of Interest (AOI)



Area of Interest (AOI)

Background



Aerial Photography

Soils

Soil Rating Polygons



Very limited



Somewhat limited



Not limited



Not rated or not available

Soil Rating Lines



Very limited



Somewhat limited



Not limited



Not rated or not available

Soil Rating Points



Very limited



Somewhat limited



Not limited



Not rated or not available

Water Features



Streams and Canals

Transportation



Rails



Interstate Highways



US Routes



Major Roads



Local Roads

MAP INFORMATION

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

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: McClain County, Oklahoma

Survey Area Data: Version 20, Sep 7, 2023

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

Date(s) aerial images were photographed: Oct 14, 2020—Nov 2, 2020

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.

Shallow Excavations

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
14	Grant silt loam, 3 to 5 percent slopes, eroded	Somewhat limited	Grant (90%)	Dusty (0.33)	569.6	38.2%
				Unstable excavation walls (0.01)		
16	Grant silt loam, 5 to 8 percent slopes, eroded	Somewhat limited	Grant, eroded (85%)	Dusty (0.33)	420.5	28.2%
				Unstable excavation walls (0.01)		
17	Grant-Port, frequently flooded, complex, 0 to 12 percent slopes	Somewhat limited	Grant (50%)	Dusty (0.33)	49.9	3.3%
				Unstable excavation walls (0.01)		
			Port, frequently flooded (30%)	Flooding (0.80)		
				Dusty (0.33)		
Unstable excavation walls (0.01)						
18	Gullied land-Grant complex, 3 to 8 percent slopes	Somewhat limited	Grant, severely eroded (40%)	Dense layer (0.50)	2.8	0.2%
				Dusty (0.33)		
				Unstable excavation walls (0.01)		
			Renfrow, severely eroded (10%)	Unstable excavation walls (0.51)		
				Dusty (0.31)		
				Too clayey (0.13)		
			Nash, severely eroded (5%)	Dense layer (0.50)		
				Depth to soft bedrock (0.46)		
				Dusty (0.18)		
				Unstable excavation walls (0.01)		
20	Keokuk silt loam, 0 to 1 percent slopes, occasionally flooded	Somewhat limited	Keokuk, occasionally flooded (85%)	Flooding (0.60)	0.4	0.0%
				Dusty (0.31)		
				Unstable excavation walls (0.01)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Ashport, occasionally flooded (5%)	Flooding (0.60) Dusty (0.33) Unstable excavation walls (0.01)		
			Port, occasionally flooded (5%)	Flooding (0.60) Dusty (0.33) Unstable excavation walls (0.01)		
			Pulaski, occasionally flooded (5%)	Flooding (0.60) Dusty (0.02) Unstable excavation walls (0.01)		
22	Konawa loamy fine sand, 0 to 3 percent slopes	Somewhat limited	Konawa (90%)	Unstable excavation walls (0.01)	86.3	5.8%
23	Konawa loamy fine sand, 3 to 8 percent slopes	Somewhat limited	Konawa (90%)	Unstable excavation walls (0.01)	128.6	8.6%
27	Minco very fine sandy loam, 5 to 8 percent slopes	Somewhat limited	Minco (85%)	Dusty (0.06) Unstable excavation walls (0.01)	9.2	0.6%
			Teller (10%)	Dusty (0.03) Unstable excavation walls (0.01)		
			Grant (5%)	Dense layer (0.50) Dusty (0.33) Unstable excavation walls (0.01)		
28	Minco very fine sandy loam, 8 to 30 percent slopes	Very limited	Minco (85%)	Slope (1.00) Dusty (0.05) Unstable excavation walls (0.01)	0.1	0.0%
31	Minco silt loam, 3 to 5 percent slopes	Somewhat limited	Minco (90%)	Dusty (0.31) Unstable excavation walls (0.01)	25.3	1.7%

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
32	Nash-Lucien complex, 3 to 5 percent slopes	Somewhat limited	Nash (50%)	Dense layer (0.50)	4.4	0.3%
				Dusty (0.18)		
				Depth to soft bedrock (0.01)		
				Unstable excavation walls (0.01)		
			Grant (10%)	Dense layer (0.50)		
				Dusty (0.33)		
				Unstable excavation walls (0.01)		
			Grainola (5%)	Depth to soft bedrock (0.97)		
				Unstable excavation walls (0.51)		
				Dense layer (0.50)		
				Too clayey (0.28)		
				Dusty (0.27)		
			33	Nash-Lucien complex, 5 to 12 percent slopes		
Depth to soft bedrock (0.29)						
Dusty (0.18)						
Slope (0.16)						
Unstable excavation walls (0.01)						
Grant (10%)	Dense layer (0.50)					
	Dusty (0.33)					
	Unstable excavation walls (0.01)					
Grainola (5%)	Depth to soft bedrock (1.00)					
	Unstable excavation walls (0.51)					
	Dense layer (0.50)					
	Too clayey (0.28)					

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Dusty (0.27)		
34	Pits	Not rated	Pits (100%)		4.1	0.3%
38	Pulaski fine sandy loam, 0 to 1 percent slopes, occasionally flooded	Somewhat limited	Pulaski, occasionally flooded (85%)	Flooding (0.60)	41.9	2.8%
				Dusty (0.02)		
				Unstable excavation walls (0.01)		
39	Ashport, Port and Pulaski soils, 0 to 1 percent slopes, frequently flooded	Somewhat limited	Ashport, frequently flooded (40%)	Flooding (0.80)	55.4	3.7%
				Dusty (0.21)		
				Unstable excavation walls (0.01)		
			Port, frequently flooded (35%)	Flooding (0.80)		
				Dusty (0.21)		
				Unstable excavation walls (0.01)		
			Pulaski, frequently flooded (15%)	Flooding (0.80)		
				Dusty (0.02)		
				Unstable excavation walls (0.01)		
M-W	Miscellaneous water	Not rated	Water (100%)		6.0	0.4%
W	Water	Not rated	Water (100%)		4.3	0.3%
Totals for Area of Interest					1,492.7	100.0%

Rating	Acres in AOI	Percent of AOI
Somewhat limited	1,478.2	99.0%
Very limited	0.1	0.0%
Null or Not Rated	14.4	1.0%
Totals for Area of Interest	1,492.7	100.0%

Description

ENG - Engineering

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.

The ratings 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 the specified use. "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 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).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

LOCATION ASHPORT OK

Established Series
JEH Rev. JGF:GFS:JBB
01/2016

ASHPORT SERIES

The Ashport series consists of very deep, well drained soils that formed in loamy alluvium of Holocene age. These soils are on flood plains along small streams in the Central Rolling Red Prairies (MLRA 80A). Slopes range from 0 to 3 percent. Mean annual precipitation is about 840 mm (33 in), and the mean annual air temperature is about 16 degrees C (61 F).

TAXONOMIC CLASS: Fine-silty, mixed, superactive, thermic Fluventic Haplustolls

TYPICAL PEDON: Ashport silty clay loam, in a cultivated field, at an elevation of 267 m (875 ft). (Colors are for dry soil unless otherwise stated.)

Ap--0 to 13 cm (0 to 5 in); dark reddish gray (5YR 4/2) silty clay loam, dark reddish brown (5YR 3/2) moist; weak fine subangular blocky structure; hard; firm; many fine roots; slightly acid; abrupt smooth boundary. (Thickness of the Ap horizon is 0 to 20 cm [0 to 8 in])

A--13 to 41 cm (5 to 16 in); dark reddish gray (5YR 4/2) silty clay loam, dark reddish brown (5YR 3/2) moist; moderate medium subangular blocky structure; hard, firm; many fine roots; neutral; clear smooth boundary. (Thickness of the A horizon is 0 to 41 cm [0 to 16 in])

Bw--41 to 91 cm (16 to 36 in); reddish brown (5YR 5/4) silty clay loam, reddish brown (5YR 4/4) moist; weak coarse prismatic structure parting to moderate coarse subangular blocky; hard, firm; few fine roots; slightly acid; clear smooth boundary. (Thickness of the Bw horizon is 36 to 137 cm [14 to 54 in])

Ab--91 to 132 cm (36 to 52 in); dark reddish gray (5YR 4/2) loam, dark reddish brown (5YR 3/2) moist; weak coarse prismatic structure parting to weak medium granular; slightly hard, friable; slightly acid; gradual smooth boundary. (Thickness of the Ab horizon is 0 to 51 cm [0 to 20 in])

Bwb1--132 to 168 cm (52 to 66 in); reddish brown (5YR 5/4) loam, reddish brown (5YR 4/4) moist; weak coarse prismatic structure parting to weak medium subangular blocky; slightly hard, friable; slightly acid; gradual smooth boundary. (Combined thickness of the Bwb horizon is 0 to 100 cm [0 to 40 in])

Bwb2--168 to 200 cm (66 to 80 in); yellowish red (5YR 5/6) loam, yellowish red (5YR 4/6) moist; weak coarse prismatic structure parting to weak coarse subangular blocky; slightly hard, friable; neutral.

TYPE LOCATION: Payne County, Oklahoma; about 1/2 mile west of Stillwater, Oklahoma; 2,440 ft east and 920 ft north of the southwest corner of sec. 16, T. 19 N., R. 2 E.

USGS topographic quadrangle: Stillwater South, OK
Latitude: 36 degrees, 7 minutes, 7 seconds N
Longitude: 97 degrees, 5 minutes, 49 seconds W
Datum: NAD 83

Decimal Degrees:

Latitude: 36.1186111
Longitude: -097.0969444

UTM Easting: 671270 m
UTM Northing: 3998781 m
UTM Zone: 14

RANGE IN CHARACTERISTICS:

Depth to bedrock: more than 203 cm (80 in)
Depth to buried horizons: 61 to more than 150 cm (24 to more than 60 in)
Mollic thickness: 31 to 48 cm (12 to 19 in)
Depth to secondary calcium carbonates: 51 to more than 152 cm (20 to more than 60 in)

Particle-size control section (weighted average):
Clay content: 20 to 30 percent
Sand Content: 5 to 20 percent with less than 15 percent fine and coarser sand.

Ap and A horizon:
Hue: 5YR to 10YR
Value: 4 or 5 dry, 2 or 3 moist
Chroma: 2 or 3 dry or moist
Texture: silt loam, loam, clay loam, or silty clay loam
Effervescence: none
Reaction: moderately acid to moderately alkaline

Bw horizon:
Hue: 2.5YR to 7.5YR
Value: 3 to 5 dry, 3 or 4 moist
Chroma: 3 to 6 dry or moist
Texture: silt loam, loam, silty clay loam, or clay loam
Effervescence: Slight in some pedons
Reaction: slightly acid to moderately alkaline

Ab horizon:
Hue: 5YR or 7.5YR
Value: 4 or 5 dry, 2 or 3 moist
Chroma: 2 to 4 dry or moist
Texture: loam or silt loam
Effervescence: Slight in some pedons
Reaction: slightly acid to moderately alkaline

Bwb horizon:
Hue: 2.5YR to 7.5YR
Value: 4 or 5 dry, 3 or 4 moist
Chroma: 3 or 6 dry or moist
Texture: loam or silt loam
Effervescence: Slight in some pedons
Reaction: slightly acid to moderately alkaline

COMPETING SERIES: These are the [Asher](#) , [Goodcreek](#) , and [Lamkin](#) series in the same family. These soils all are calcareous throughout the 10- to 40-inch control section.

GEOGRAPHIC SETTING:

Parent material: loamy alluvium of Holocene age

Landscape: alluvial plain
Landform: flood plains
Slope: 0 to 3 percent
Mean Annual Air Temperature: 13.9 to 17.2 degrees C (57 to 63 degrees F)
Mean Annual Precipitation: 787 to 1041 mm (31 to 41 in)
Frost-Free Period: 181 to 230 days
Elevation: 213 to 475 meters (700 to 1600 ft)
Thorntwaite Annual P-E indices: 44 to 64

GEOGRAPHICALLY ASSOCIATED SOILS: These are the [Dale](#), [Port](#), and [Pulaski](#) series.

[Dale](#) and [Port](#) soils: have a mollic epipedon more than 51 cm (20 in) thick.

[Dale](#) soils: occur slightly higher flood plains that are rarely flooded.

[Port](#) soils: occur on similar landforms, but are usually further from the stream channel.

[Pulaski](#) soils: have a coarse-loamy control section and occur on similar landforms, but are generally nearer to the stream channel.

DRAINAGE AND PERMEABILITY:

Drainage: well drained

Permeability: moderate

Runoff: negligible

Flooding: occasionally or frequently flooded for very brief to brief periods during March to August

USE AND VEGETATION: Used mainly as cropland and hayland. Alfalfa, small grains, and grain sorghum are the most common crops. Some areas are used for improved pasture or livestock grazing. Native vegetation is big bluestem, switchgrass, Indiangrass, and little bluestem with an overstory of pecan, black walnut, bur oak, and eastern cottonwood trees.

DISTRIBUTION AND EXTENT: Central Oklahoma; LRR H, MLRA 80A. The series is extensive.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Temple, Texas

SERIES ESTABLISHED: Payne County, Oklahoma; 1982.

REMARKS:

These soils were formerly included in the Port series in older published reports. Updated as a result of the SDJR initiative (WTS 4/2014).

Diagnostic horizons and features recognized in this pedon are

Mollic epipedon: 0 to 41 cm (0 to 16 in) (Ap and A horizons)

Cambic horizon: 41 to 91 cm (16 to 36 in) (Bw horizon)

Buried soils: 91 to 201 cm (36 to 80 in) (2Ab, 2Bwb1, and 2Bwb2)

Moisture Regime: Udic-Ustic

ADDITIONAL DATA: Oklahoma State University lab data number 76-OK-60-33.

Taxonomic Version: Keys to Soil Taxonomy, Twelfth Edition, 2014

National Cooperative Soil Survey
U.S.A.

LOCATION GRANT

OK+KS

Established Series
Rev. GFS:AMS:JLD
08/2017

GRANT SERIES

The Grant series consist of deep, well drained, moderately permeable soils. They formed in material weathered predominantly from siltstone or silty shale of Permian age. These nearly level to moderately steep soils are on treads and risers of paleoterraces in the Central Rolling Red Prairies (MLRA 80A). Slope ranges from 0 to 20 percent. Mean annual precipitation is 813 mm (32 in) and mean annual air temperature is 16 degrees C (61 degrees F).

TAXONOMIC CLASS: Fine-silty, mixed, superactive, thermic Udic Argiustolls

TYPICAL PEDON: Grant silt loam-cultivated, at an elevation of 397 m (1310 ft). (Colors are for dry soil unless otherwise stated.)

Ap--0 to 18 cm (0 to 7 in); brown (7.5YR 5/2) silt loam, dark brown (7.5YR 3/2) moist; weak fine granular structure; slightly hard, very friable; many fine roots; slightly acid; clear smooth boundary.

A--18 to 30 cm (7 to 12 in); brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) moist; moderate fine granular structure; slightly hard, very friable; many fine roots; slightly acid; gradual smooth boundary. (Combined thickness of the A horizon is 10 to 50 cm [4 to 25 inches])

BA--30 to 41 cm (12 to 16 in); reddish brown (5YR 4/3) silt loam, dark reddish brown (5YR 3/3) moist; moderate medium granular structure; slightly hard, friable; many fine roots; neutral; gradual smooth boundary. (Thickness of the BA horizon is 0 to 33 cm [0 to 13 inches])

Bt--41 to 81 cm (16 to 32 in); reddish brown (5YR 5/4) silty clay loam, reddish brown (5YR 4/4) moist; moderate medium subangular blocky structure; hard, friable; common fine roots; common clay films on faces of peds; neutral; gradual smooth boundary. (Thickness of the Bt horizon is 38 to 76 cm [15 to 30 inches])

BC--81 to 119 cm (32 to 47 in); yellowish red (5YR 5/6) silt loam, yellowish red (5YR 4/6) moist; weak medium subangular blocky structure; hard, friable; few fine roots; slightly alkaline; gradual smooth boundary. (Thickness of the BC horizon is 0 to 76 cm [0 to 30 inches])

C--119 to 150 cm (47 to 59 in); yellowish red (5YR 5/6) silt loam, yellowish red (5YR 4/6) moist; massive; hard, friable; few fine roots; common medium fragments of sandstone; calcareous; strongly effervescent; moderately alkaline; clear smooth boundary. (Thickness of the C horizon is 0 to 76 cm (0 to 30 in))

Cr--150 to 183 cm (59 to 72 in); red (2.5YR 5/6) weakly consolidated siltstone, red (2.5YR 4/6) moist; calcareous in seams; strongly effervescent; moderately alkaline.

TYPE LOCATION: Garfield County, Oklahoma; about 2 miles north and 6 1/2 miles west of Hillsdale, Oklahoma; 500 feet south and 100 feet east of the northwest corner of sec. 6, T. 24 N., R. 8 W.

USGS Topographic Quadrangle: Jet SE, OK
Latitude: 36 degrees, 36 minutes, 31.56 seconds N
Longitude: 98 degrees, 06 minutes, 13.68 seconds W

Decimal Degrees:

Latitude: 36.5921 degrees

Longitude: -98.1038 degrees

Datum: WGS 84

UTM Easting: 580165.2 m

UTM Northing: 4049998 m

UTM Zone: 14N

RANGE IN CHARACTERISTICS:

Depth to paralithic contact: 102 to 152 cm (40 to 60 in) to siltstone or silty shale

Depth to secondary carbonates: 76 to 152 cm (30 to 60 in)

Particle-size control section:

Clay content: 18 to 35 percent

Sand content: 0 to 15 percent

A and Ap horizons:

Hue: 5YR to 10YR

Value: 2 or 3 moist, 4 or 5 dry

Chroma: 2 or 3 moist or dry

Texture: very fine sandy loam, silt loam, or loam

Effervescence: none to slight

Reaction: slightly acid to slightly alkaline

BA horizon:

Hue: 2.5YR to 7.5YR

Value: 2 or 3 moist, 4 or 5 dry

Chroma: 2 to 4 moist or dry

Texture: very fine sandy loam, silt loam, or loam

Effervescence: none to slight

Reaction: slightly acid to slightly alkaline

Bt horizon:

Hue: 2.5YR to 7.5YR

Value: 4 or 5 moist, 5 or 6 dry

Chroma: 2 to 8 moist or dry

Texture: very fine sandy loam, silt loam, loam, silty clay loam, or clay loam

Clay content: 22 to 28 percent, but ranges from 18 to 35 percent

Sand content: less than 15 percent fine sand and coarser sand

Effervescence: slight to strong

Reaction: slightly acid to moderately alkaline

BC horizon:

Hue: 2.5YR or 5YR

Value: 4 to 6 moist, 5 to 7 dry

Chroma: 4 to 8 moist or dry

Texture: silt loam or loam, but includes very fine sandy loam, silty clay loam

Effervescence: none to strong

Reaction: neutral to moderately alkaline

C horizon:

Hue: 2.5YR or 5YR

Value: 4 to 7 moist, 5 to 8 dry

Chroma of 4 to 8 moist or dry

Texture: very fine sandy loam, silt loam, or loam

Fragments: amount-0 to 20 percent by volume; size-5 to 30 mm; kind-sandstone

Effervescence: slight to strong

Reaction: slightly alkaline or moderately alkaline

Cr horizon

Paralithic contact: siltstone or silty shale; the material is dense enough to be root restrictive

Fractures: are greater than 10 cm (4 in) apart

Excavation difficulty: low to moderate

Cementation: slakes in water in less than 15 hours

Other features: calcareous in some pedons

COMPETING SERIES: This is the [Vanoss](#) series in the same family.

[Vanoss](#) soils: solum is more than 152 cm (60 in) to bedrock

GEOGRAPHIC SETTING:

Parent Material: weathered from siltstone or silty shale, some areas are covered with a thin mantle of loess

Landscape: hills

Landform: paleoterraces

Hillslope position: summits and backslopes

Slope: 0 to 20 percent

Mean annual air temperature: 14 to 17 degrees C (57 to 63 degrees F)

Thornthwaite annual P-E indices: 44 to 64

Mean annual precipitation: 660 to 970 mm (26 to 38 in)

Frost-free period: 190 to 220 days

Elevation: 213 to 457 m (700 to 1500 ft)

GEOGRAPHICALLY ASSOCIATED SOILS: These are the [Bethany](#), [Lucien](#)), [Nash](#), [Nashville](#) , [Norge](#) , and [Pond Creek](#) series.

[Bethany](#) soils: have greater than 35 percent clay in the particle-size control section, and are on risers of paleoterraces

[Lucien](#) soils: are 25 to 50 cm (10 to 20 in) to paralithic contact, and on adjacent low hills

[Nash](#) and [Nashville](#) soils: are 50 to 100 cm (20 to 40 in)to bedrock, and occur on adjacent low hills

[Norge](#) and [Pond Creek](#) soils: are more than 203 cm (80 in) to paralithic contact, and are in lower positions

DRAINAGE AND PERMEABILITY:

Drainage: well

Permeability: moderate

Saturated hydraulic conductivity: moderately low

Runoff: negligible on 0 to 1 percent slopes, low on 1 to 5 percent slopes, and medium on 5 to 20 percent slopes

USE AND VEGETATION: Used for cropland. Some areas are in native grassland. Cultivated crops are wheat and other small grains. Native vegetation is tall and mid grasses.

DISTRIBUTION AND EXTENT:

General area: Oklahoma and south-central Kansas

Land Resource Region: H-Central Great Plains Winter Wheat and Range

MLRA 80A-Central Rolling Red Prairies

Extent: large

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Temple, Texas

SERIES ESTABLISHED: Grant County, Oklahoma; 1931.

REMARKS:

Major changes in the OSD were made by Walt Schaefer, as a result of the Soil Data Join Recorrelation Initiative (SDJR) in 06/2013.

Diagnostic horizons and features recognized in this pedon are:
Mollic epipedon: 0 to 41 cm (0 to 16 in) (Ap, A, and BA horizons)
Argillic horizon: 41 to 81 cm (16 to 32 in) (Bt horizon)
Paralithic contact: siltstone at a depth 150 cm (59 in) (Cr horizon)

Edited 08/2017 (JAD-JLD) Changed to tabular format. Updated pedon description, range in characteristics, and other sections.

ADDITIONAL DATA: Soil Survey Investigations Report No. 11, May 1967. Lab Nos. 5480-5487.

TAXONOMIC VERSION: Keys to Soil Taxonomy, Twelfth Edition, 2014

National Cooperative Soil Survey
U.S.A.

LOCATION KONAWA

OK+KS TX

Established Series
Rev CEW:CS:JLD
03/2016

KONAWA SERIES

The Konawa series consists of very deep, well drained soils that formed in sandy and loamy alluvium of Pleistocene age. They are on treads and risers of low stream terraces in the North Cross Timbers (MLRA 84A). Slopes range from 0 to 20 percent. Mean annual precipitation is 914 mm (36 in) and mean annual air temperature is 16 degrees C (61 degrees F).

TAXONOMIC CLASS: Fine-loamy, mixed, active, thermic Ultic Haplustalfs

TYPICAL PEDON: Konawa fine sandy loam in a bermudagrass pasture, at an elevation of 284 m (930 ft). (Colors are for dry soil unless otherwise stated)

Ap--0 to 23 cm (0 to 9 in); brown (7.5YR 5/2) fine sandy loam, dark brown (7.5YR 3/2) moist; weak fine granular structure; slightly hard, very friable; slightly acid; clear smooth boundary. (Thickness of the A horizon is 10 to 25 cm [4 to 10 in])

E--23 to 43 cm (9 to 17 in); light reddish brown (5YR 6/4) fine sandy loam, reddish brown (5YR 4/4) moist; weak fine granular structure; slightly hard, very friable; slightly acid; clear smooth boundary. (Thickness of the E horizon is 0 to 43 cm [0 to 17 in])

Bt--43 to 135 cm (17 to 53 in); red (2.5YR 4/6) sandy clay loam, dark red (2.5YR 3/6) moist; moderate medium subangular blocky structure; very hard, friable; few faint clay films on peds; moderately acid; gradual smooth boundary. (Thickness of the Bt horizon is 25 to 91 cm [10 to 36 in])

BC--135 to 183 (53 to 72 in); red (2.5YR 5/6) fine sandy loam, red (2.5YR 4/6) moist; weak coarse subangular blocky structure; very hard, friable; neutral.

TYPE LOCATION: Payne County, Oklahoma; about 8 miles west and 1 mile south of Perkins; about 2000 ft north and 200 ft west of the southeast corner of sec. 10, T. 17 N., R. 1 E.

USGS Topographic Quadrangle: Coyle, OK
Latitude: 35 degrees, 57 minutes, 42 seconds N
Longitude: 97 degrees, 10 minutes, 35 seconds W

Decimal Degrees:
Latitude: 35.9616667 degrees
Longitude: -097.1763889 degrees
Datum: NAD 83

UTM Easting: 664445 m
UTM Northing: 3981233 m
UTM Zone: 14N

RANGE IN CHARACTERISTICS:

Depth to bedrock: more than 203 cm (80 in)
Thickness of the A and E horizon: less than 51 cm (20 in)

A horizon:

Hue: 5YR to 10YR
Value: 4 to 7 dry, 3 to 5 moist
Chroma: 2 to 6 dry or moist
Texture: fine sand, loamy fine sand, or fine sandy loam
Other features: thickness of the A horizon is less than 25 cm (10 in) where the organic matter is 1 percent or more
Cation exchange capacity (CEC, meq/100 gm): 2 to 12
Reaction: strongly acid to slightly acid, except where limed

E horizon:

Hue: 5YR to 10YR
Value: 5 to 8 dry, 4 to 7 moist
Chroma: 2 to 6 dry or moist
Texture: fine sand, loamy fine sand, or fine sandy loam
Cation exchange capacity (CEC, meq/100 gm): 2 to 10
Reaction: strongly acid to slightly acid, except where limed

Bt horizon:

Hue: 2.5YR to 7.5YR
Value: 4 to 7 dry, 3 to 5 moist
Chroma: 4 to 8 dry or moist
Texture: fine sandy loam or sandy clay loam
Clay content: 18 to 30 percent
Coarse fragments: amount-0 to 5 percent by volume; size-gravel, from 2 mm to 10 mm in diameter; kind- sandstone
Base saturation: ranges 50 to 70 percent
Cation exchange capacity (CEC, meq/100 gm): 16 to 23
Reaction: strongly acid to neutral

BC horizon:

Hue: 2.5YR to 7.5YR
Value: 5 to 7 dry, 4 to 6 moist
Chroma: 4 to 8 dry or moist
Texture: loamy fine sand, fine sandy loam, or sandy clay loam
Coarse fragments: amount-0 to 5 percent by volume; size-gravel from 2 mm to 10 mm in diameter; kind- sandstone
Base saturation: 50 to 70 percent
Cation exchange capacity (CEC, meq/100 gm): 4 to 20
Reaction: strongly acid to neutral

COMPETING SERIES: There are no other series in this family. Similar soils are the [Harrah](#), [Littleaxe](#), [Stephenville](#), and [Weatherford](#) soils.

[Harrah](#) soils: argillic horizon increases clay content by more than 20 percent with depth

[Littleaxe](#), [Stephenville](#), and [Weatherford](#) soils: all have a siliceous mineralogy

[Littleaxe](#) and [Stephenville](#) soils: less than 150 cm (60 in) to paralithic sandstone

GEOGRAPHIC SETTING:

Parent material: loamy and sandy alluvium of Pleistocene age

Landscape: hills

Landform: treads and risers of low stream terraces

Slope: 0 to 20 percent

Soil Moisture Regime: Udic-Ustic

Mean annual precipitation: 787 to 1092 mm (31 to 43 in)

Mean annual air temperature: 15 to 17.2 degrees C (59 to 63 degrees F)

Frost-free period: 181 to 240 days

Elevation: 183 to 534 meters (600 to 1750 ft)

Thornthwaite Annual P-E indices: 48 to 64

GEOGRAPHICALLY ASSOCIATED SOILS: These are the [Bastrop](#), [Dougherty](#), [Eufaula](#), [Stidham](#), and [Teller](#) series.

[Bastrop](#) soils: have thicker argillic horizon that does not decrease in clay content and occur on slightly higher positions

[Dougherty](#) and [Stidham](#) soils: have a loamy particle-size control section and occur on similar to slightly higher positions

[Eufaula](#) soils: have a sandy control section and occur on slightly higher positions adjacent Konawa soils

[Teller](#) soils: have mollic epipedon and occur on similar positions further back from the stream channel

DRAINAGE AND PERMEABILITY:

Drainage: well drained

Permeability: moderate

Saturated hydraulic conductivity: moderately high

Runoff: negligible on 0 to 1 percent slopes, low on 1 to 5 percent slopes, and medium on 5 to 20 percent slopes

USE AND VEGETATION: These soils are mainly cultivated to small grain, sorghum, and peanuts. Some areas are used for tame pasture or range. Native vegetation is mainly post oak, blackjack oak, and hickory with an understory of grasses

DISTRIBUTION AND EXTENT: LRR J; North Cross Timbers (MLRA 84A) of Oklahoma, Kansas, and Texas. The series is extensive.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Temple, Texas

SERIES ESTABLISHED: Pottawatomie County, Oklahoma; 1965

REMARKS:

Konawa soils were formerly included with the Dougherty series. OSD updated extensively as a result of the SDJR Initiative. (JLD 03/2016)

Diagnostic horizons and features recognized for this series:

Ochric horizon: 0 to 43 cm (0 to 17 in) (A and E horizons)

Argillic horizon: 43 to 135 cm (17 to 53 in) (Bt horizon)

ADDITIONAL DATA: Oklahoma State University mineralogy data: 69-OK-60-2, Stillwater, OK; Soil Survey Laboratory, Beltsville, MD mineralogy data: 65-OK-63-51; Oklahoma State University data: 80-OK-49-2-(1-4), 80-OK-49-3-(1-4), 73-OK-57-15-(1-5), 80-OK-49-1-(1-4), 80-OK-49-21-(1-6), and 80-OK-49-20-(1-6), Stillwater, OK

Taxonomic Version: Keys to Soil Taxonomy, Twelfth Edition, 2014

National Cooperative Soil Survey
U.S.A.

LOCATION PORT

OK+KS+TX

Established Series
 Rev.ELG:CRC:GFS
 09/2004

PORT SERIES

The Port series consist of very deep, well drained, moderately permeable flood plain soils that formed in calcareous loamy alluvium of Recent age. These nearly level to very gently sloping soils are on narrow flood plains in the Central Rolling Red Prairies (MLRA-80A) and the Central Rolling Red Prairies (MLRA 78C). Slopes range from 0 to 3 percent. Mean annual precipitation is 32 inches. Mean annual temperature is 63 degrees F.

TAXONOMIC CLASS: Fine-silty, mixed, superactive, thermic Cumulic Haplustolls

TYPICAL PEDON: Port silt loam--cultivated. (Colors are for dry soil unless otherwise stated.)

Ap--0 to 9 inches; reddish brown (5YR 4/3) silt loam, dark reddish brown (5YR 3/3) moist; moderate medium granular structure; soft, very friable; neutral; clear smooth boundary. (0 to 11 inches thick)

A--9 to 27 inches; dark reddish brown (5YR 3/3) silt loam, dark reddish brown (5YR 2/2) moist; moderate coarse granular structure; slightly hard, friable; neutral; gradual smooth boundary. (10 to 30 inches thick)

Bk--27 to 42 inches; reddish brown (5YR 4/4) silty clay loam, dark reddish brown (5YR 3/4) moist; weak fine subangular blocky structure; hard, firm; few thin strata of darker material; common masses and films of calcium carbonate; strongly effervescent; moderately alkaline; diffuse smooth boundary. (0 to 25 inches thick)

C--42 to 72 inches; reddish brown (2.5YR 5/4) silt loam, reddish brown (2.5YR 4/4) moist; massive; hard, firm; few thin strata of dark reddish brown silty clay loam; common masses and films of calcium carbonate; strongly effervescent; moderately alkaline.

TYPE LOCATION: Grady County, Oklahoma; about 7 miles east of Chickasha, Oklahoma; 2,300 feet north and 100 feet east of the southwest corner of sec. 24, T. 7 N., R. 6 W.

RANGE IN CHARACTERISTICS: Depth of secondary calcium carbonates ranges from 20 to 60 inches. Thickness of the mollic epipedon ranges from 20 to 40 inches. The A, Bk/Bw, and C horizons are silt loam, loam, silty clay loam, or clay loam.

The Ap or A horizon has hue of 2.5YR to 10YR, value of 3 to 5, and chroma of 1 to 3. Some pedons are overwashed with fine sandy loam or textures similar to the A horizon, but have hue of 2.5YR to 7.5YR, value of 4 or 5, and chroma of 4. The overwash material is less than 20 inches thick. Reaction of the Ap or A horizon ranges from moderately acid to slightly alkaline.

The Bk or Bw horizon has hue of 2.5YR to 10YR, value of 3 to 6, and chroma of 1 to 6. Reaction ranges from slightly acid to moderately alkaline. Visible calcium carbonate in the form of masses and films ranges from 0 to 5 percent by volume.

The C horizon has hue of 2.5YR to 7.5YR, value of 3 to 6, and chroma of 1 to 6. Thin strata of coarser or fine textures occur in this horizon. Reaction is moderately alkaline and calcareous. Visible calcium carbonate in the form of masses and films ranges from 0 to 5 percent by volume.

Some pedons have buried horizons below 30 inches. These pedons are not diagnostic. Texture, color, and reactions of these horizons are similar to those described throughout the Port profile.

COMPETING SERIES: These are [Bergstrom](#) (TX), [Bigetty](#) (NM), [Clearfork](#)(TX), [Elandco](#) (TX), and [Iraan](#) (TX) series in the same family. Soils in similar families are [Asher](#), [Bippus](#), [Bosque](#), [Dale](#), [Frio](#), [Gageby](#), [Gowen](#), [Kaski](#), [Lamkin](#), [Lawrie](#), [Nipsum](#), [Reinach](#), and [Spur](#) series. Asher, Lamkin, and Spur soils have a mollic epipedon less than 20 inches thick. In addition, Spur soils have a fine-loamy control section. Bergstrom soils are calcareous throughout. Bigetty and Iraan soils are dry for longer periods of time. Bippus, Bosque, Gageby, Gowen, and Kaski soils have a fine-loamy control section. Dale and Reinach soils have a regular decrease in organic matter. In addition, Reinach soils have a coarse-silty control section. Elandco soils have hue of 10YR or 2.5Y throughout. Frio and Nipsum soils have a fine control section. Lawrie soils are slightly higher in the landscape, and do not decrease in clay content by 20 percent of the maximum within 60 inches of the mineral soil surface. Clearfork soils are active CEC activity class.

GEOGRAPHIC SETTING: Port soils are on nearly level or very gently sloping flood plains in the eastern part of the Central Rolling Red Plains and in the Central Rolling Red Prairies. Slopes range from 0 to 3 percent. The soil formed in calcareous loamy alluvium of Recent age. Mean Annual Precipitation: 26 to 40 inches. Mean Annual Temperature: 57 to 64 degrees F. Thornthwaite Annual P-E indices: 44 to 64. Frost free days range from 185 to 220.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the [Ashport](#), [Brewer](#), [Canadian](#), [Dale](#), [Easpur](#), [Gaddy](#), [Lawrie](#), [McLain](#), [Miller](#), [Pulaski](#), [Reinach](#) and [Yahola](#) series. Ashport and Easpur soils have a mollic epipedon less than 20 inches thick and are on slightly lower flood plains and closer to the stream. Brewer, Canadian, Dale, Lawrie, McLain, and Reinach soils occur on slightly higher flood plains. Brewer and McLain soils have a fine control section and have argillic horizons. Lawrie soils have argillic horizons. Canadian soils have a mollic epipedon less than 20 inches thick and have a coarse-loamy control section. Gaddy soils usually occur on slightly lower flood plains closer to the stream channel, have a sandy control section and lack a mollic epipedon. Miller, Pulaski, and Yahola soils occur on similar areas. Miller soils have a fine control section. Pulaski and Yahola soils have a coarse-loamy control section and lack a mollic epipedon.

DRAINAGE AND PERMEABILITY: Port soils are well drained. Runoff is negligible on 0 to 1 percent slopes and very low on 1 to 3 percent slopes. Permeability is moderate. These soils are occasionally or frequently flooded for very brief periods during March to October.

USE AND VEGETATION: Mainly cultivated to alfalfa, small grains, grain sorghum, and cotton. Some areas are used for tame pasture or rangeland for grazing beef cattle. Native vegetation is tall grasses with an overstory of pecan, black walnut, bur oak, and eastern cottonwood trees.

DISTRIBUTION AND EXTENT: Eastern part of the Central Rolling Red Plains (MLRA-78C) and the Central Rolling Red Prairies (MLRA-80A) of Oklahoma, Kansas, and Texas. The series is extensive.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Temple, Texas

SERIES ESTABLISHED: Jackson County, Oklahoma; 1942.

REMARKS:

Soil Interpretation Record: Series OK0087.

Moisture regime: Udic-Ustic or Typic-Ustic.

Diagnostic horizons and features recognized in this pedon are:

Mollic epipedon - the zone from the surface of the soil to a depth of 27 inches (A horizon and sometimes the Bk/Bw horizon).

Cambic horizon - the zone from 27 inches to depth of 42 inches (Bk/Bw horizon).

ADDITIONAL DATA: Laboratory data from NSSL, Sample S90OK-103-004.

LOCATION PULASKI

OK+AR TX

Established Series

Rev. CEW:CS:CRC:JLD

03/2016

PULASKI SERIES

The Pulaski series consists of very deep, well drained, moderately rapidly permeable flood plain soils that formed in loamy alluvial sediments of Holocene age. These nearly level to very gently sloping flood plain soils are on small tributaries in the Cross Timbers (MLRA-84A). Slope ranges from 0 to 3 percent. Mean annual temperature is 16.1 degrees C (61 degrees F), and mean annual precipitation is 864 mm (34 in).

TAXONOMIC CLASS: Coarse-loamy, mixed, superactive, nonacid, thermic Udic Ustifluvents

TYPICAL PEDON: Pulaski fine sandy loam-cultivated, at an elevation of 260 m (850 ft). (Colors are for dry soils unless otherwise stated.)

Ap--0 to 18 cm (0 to 7 in); reddish brown (5YR 5/4) fine sandy loam, reddish brown (5YR 4/4) moist; weak fine and very fine granular structure; soft, very friable; moderately acid; clear smooth boundary. (Thickness of the Ap horizon is 0 to 30 cm [0 to 12 in])

A--18 to 48 cm (7 to 19 in); reddish brown (5YR 5/4) fine sandy loam, reddish brown (5YR 4/4) moist; weak fine and very fine granular structure; slightly hard, very friable; moderately acid; gradual smooth boundary. (Thickness of the A horizon is 10 to 51 cm [4 to 20 in])

C1--48 to 102 cm (19 to 40 in); yellowish red (5YR 5/6) fine sandy loam, yellowish red (5YR 4/6) moist; massive; slightly hard, very friable; few thin strata of darker colored fine sandy loam in lower part; slightly acid; gradual smooth boundary. (Thickness of the C1 horizon is 41 to 104 cm [16 to 41 in])

C2--102 to 163 cm (40 to 64 in); reddish yellow (5YR 6/6) fine sandy loam, yellowish red (5YR 5/6) moist; massive, slightly hard, very friable; common thin strata of loamy fine sand; slightly acid.

TYPE LOCATION: Lincoln County, Oklahoma; about 6 miles north and 1 mile east of Chandler; 1,135 feet north and 200 feet east of the southwest corner of sec. 2, T. 15 N., R. 4 E.

USGS topographic quadrangle: Kendrick, OK

Latitude: 35 degrees, 48 minutes, 1 seconds N

Longitude: 96 degrees, 51 minutes, 27 seconds W

Datum: NAD 83:

Decimal Degrees

Latitude: 35.80016

Longitude: -96.85757

UTM Easting: 693592.16 m

UTM Northing: 3963901.8 m

UTM Zone: 14N

RANGE IN CHARACTERISTICS:

Buried horizons: in some pedons below a depth of 76 cm (30 in)

Particle-size control section (weighted average):

Effervescence: none

A horizon:

Hue: 2.5YR to 10YR

Value: 5 to 7 dry, 4 to 6 moist

Chroma: 2 to 6 dry or moist

Other features: where the A horizon has moist value and chroma less than 3.5 and is more than 25 cm (10 in) thick, the organic matter content is less than 1 percent

Texture: loamy fine sand, fine sandy loam, or loam; where the texture is loamy fine sand, the thickness is less than 25 cm (10 in)

Reaction: moderately acid to slightly alkaline

C horizon:

Hue: 2.5YR to 7.5YR

Value: 5 to 7 dry, 4 to 6 moist

Chroma: 3 to 8 dry or moist

Texture: fine sandy loam, very fine sandy loam, or loam; some pedons have a texture of loamy fine sand below a depth of 102 cm (40 in)

Other features: strata of coarser or finer materials occur throughout; strata range from 2 to 25 mm thick and from 1 cm to 15 cm apart

Reaction: moderately acid to slightly alkaline to a depth of 102 cm (40 in), and below a depth of 102 cm (40 in) moderately acid to moderately alkaline

COMPETING SERIES: There are no known series in the same family. [Yahola](#) soils are in a similar family.

[Yahola](#) soils: are calcareous throughout

GEOGRAPHIC SETTING:

Parent material: loamy alluvial sediments of Holocene age

Landscape: alluvial plains

Landform: flood plains

Slope: 0 to 3 percent

Mean annual air temperature: 14.4 to 17.2 degrees C (58 to 63 degrees F)

Mean annual precipitation: 762 to 1020 mm (30 to 40 in)

Frost-free period: 200 to 230 days

Elevation: 213 to 396 m (700 to 1300 ft)

Thornthwaite Annual P-E indices: 44 to 64

GEOGRAPHICALLY ASSOCIATED SOILS: These are the [Gaddy](#), [Tribbey](#), [Yahola](#), [Ashport](#), [Cyril](#), [Easpur](#), [Gracemont](#), [Gracemore](#), and [Port](#) series.

[Cyril](#), [Tribbey](#), and [Yahola](#) soils: occur on similar positions; in addition, [Ashport](#), [Easpur](#), and [Port](#) soils: occur on slightly higher positions; in addition Ashport and Port soils have a mollic epipedon and a fine-silty textural control section; Easpur soils have a mollic epipedon and a fine-loamy textural control section

[Cyril](#) soils have a mollic epipedon

[Gaddy](#), [Gracemont](#), and [Gracemore](#) soils: usually occur on flood plains nearer the stream channel of the larger streams; in addition, Gracemont and Gracemore soils have an apparent water table within 51 to 102 cm (20 to 40 in) of the soils surface and are calcareous throughout; and Gracemore soils have a sandy control section.

DRAINAGE AND PERMEABILITY:

Drainage: well drained

Permeability: moderately rapid

Runoff: negligible

Flooding: these soils are occasionally or frequently flooded for very brief periods of time during the months of March to October

USE AND VEGETATION: Mainly cultivated to alfalfa, small grains, grain sorghums, cotton, and tame pasture. Native vegetation is tall and midgrasses with an overstory of pecan, black walnut, American elm, eastern cottonwood, and tamarisk.

DISTRIBUTION AND EXTENT: LRR J; Northern Cross Timbers (MLRA 84A) of Oklahoma, Kansas, and Texas. The series is extensive.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Temple, Texas

SERIES ESTABLISHED: Lonoke County, Arkansas; 1921.

REMARKS:

Soil Interpretation Record No. OK0035

Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon: 0 to 48 cm (0 to 19 in) (Ap, A horizons)

Other features: an irregular decrease in organic carbon

Moisture regime: Udic-Ustic

ADDITIONAL DATA: None

Taxonomic Version: Keys To Soil Taxonomy, Twelfth Edition, 2014

National Cooperative Soil Survey
U.S.A.

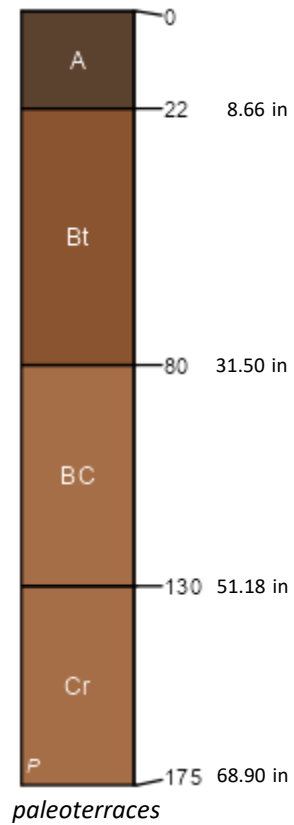
- **I34 & SH 74 Interchange**
- **J/P 32802(04)**
- **McClain County, Oklahoma**
- **AEC Project No.: 1875**
- **November 30, 2023**

Appendix C

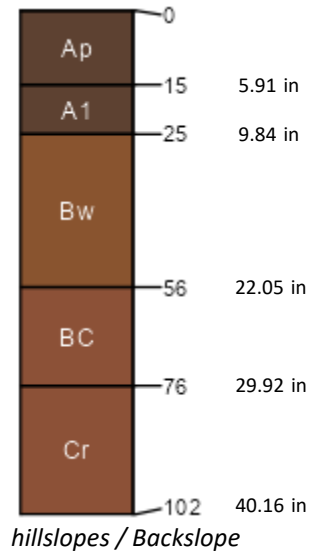
Soil Series Profiles – Block Diagrams

14: Grant silt loam, 3 to 5 percent slopes, eroded (383769)

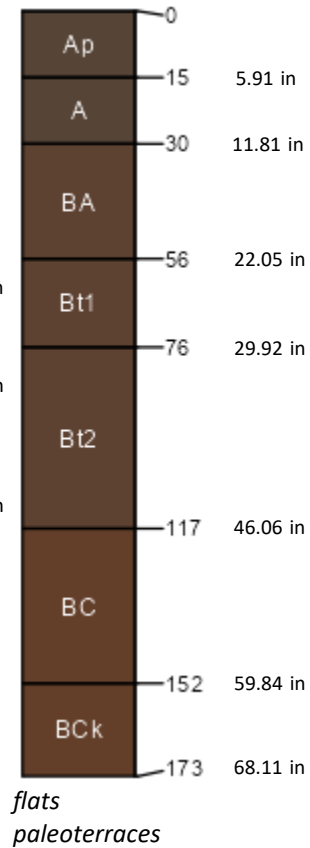
Grant (90%)
Loamy Upland
 Udic Argiustolls
 Well drained
 Hydric: No
 PAWS: 24 cm



Nash (5%)
Loamy Upland
 Udic Haplustolls
 Well drained
 Hydric: No
 PAWS: NA

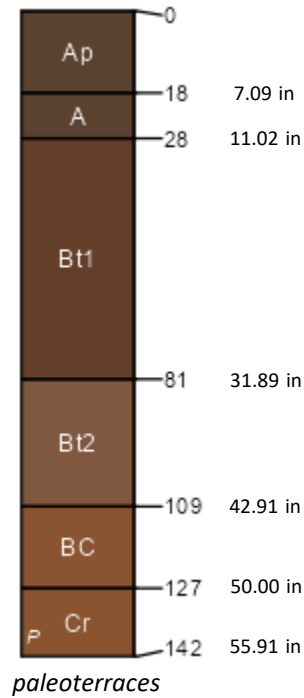


Pond Creek (5%)
Loamy Upland
 Pachic Argiustolls
 Well drained
 Hydric: No
 PAWS: NA

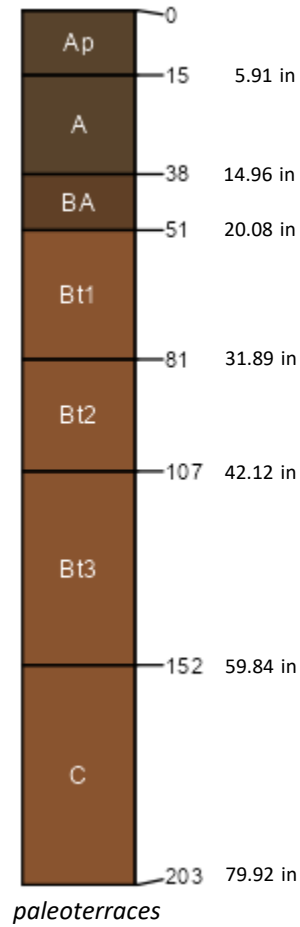


16: Grant silt loam, 5 to 8 percent slopes, eroded (383771)

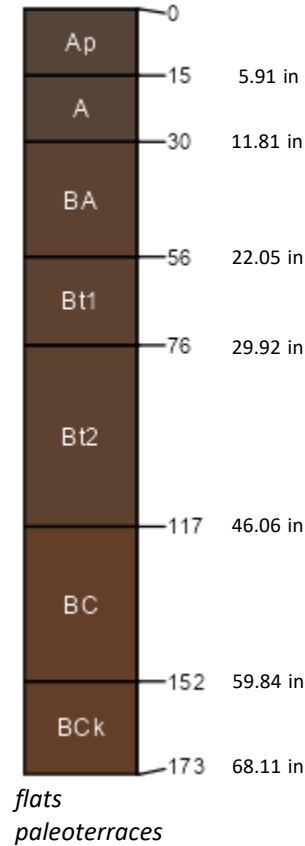
Grant (85%)
Loamy Upland
 Udic Argiustolls
 Well drained
 Hydric: No
 PAWS: 21 cm



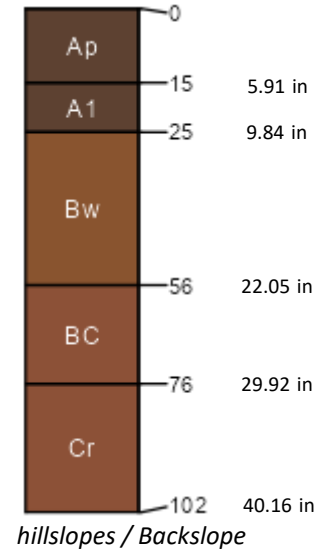
Teller (5%)
Loamy Upland
 Udic Argiustolls
 Well drained
 Hydric: No
 PAWS: NA



Pond Creek (5%)
Loamy Upland
 Pachic Argiustolls
 Well drained
 Hydric: No
 PAWS: NA



Nash (5%)
Loamy Upland
 Udic Haplustolls
 Well drained
 Hydric: No
 PAWS: NA



17: Grant-Port, frequently flooded, complex, 0 to 12 percent slopes (383772)

Grant (50%)

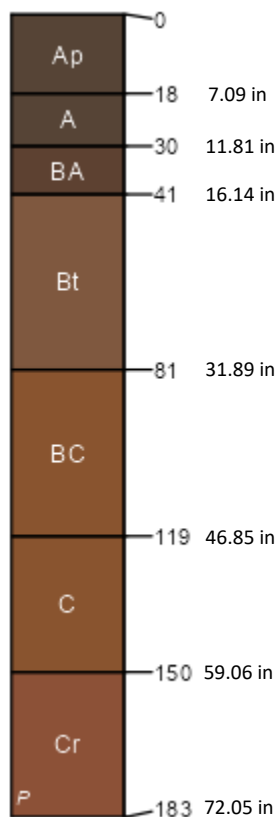
Loamy Upland

Udic Argiustolls

Well drained

Hydric: No

PAWS: 30 cm



paleoterraces

Port (30%)

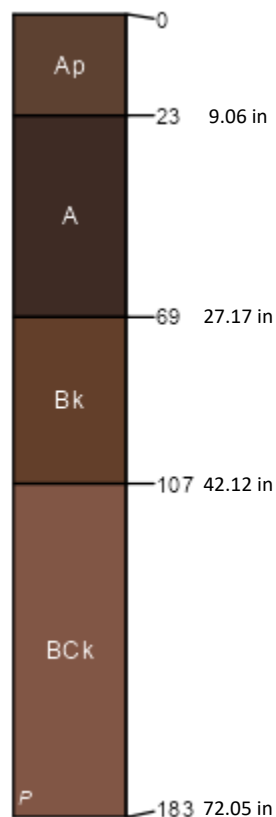
Loamy Bottomland

Cumulic Haplustolls

Well drained

Hydric: No

PAWS: 37 cm



flood plains

Norge (7%)

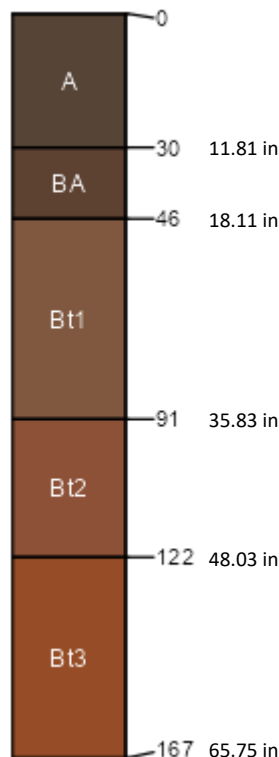
Loamy Upland

Udic Paleustolls

Well drained

Hydric: No

PAWS: NA



paleoterraces

Renfrow (5%)

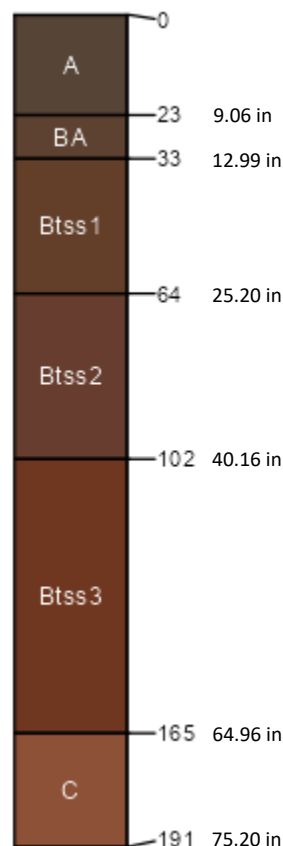
Claypan Upland (North)

Udertic Paleustolls

Well drained

Hydric: No

PAWS: NA



hillslopes / Shoulder

hillslopes / Backslope

Nash (5%)

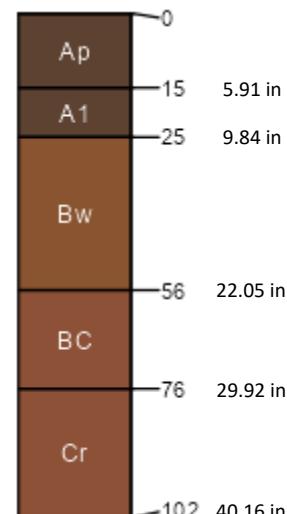
Loamy Upland

Udic Haplustolls

Well drained

Hydric: No

PAWS: NA



hillslopes / Backslope

Lucien (3%)

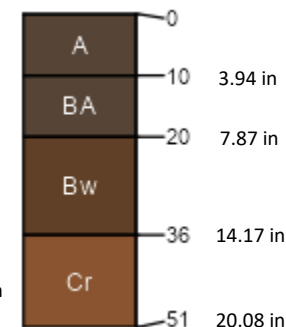
Shallow Upland

Udic Haplustolls

Well drained

Hydric: No

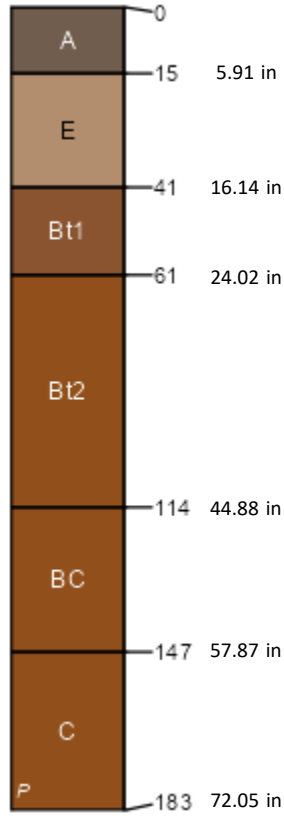
PAWS: NA



hillslopes / Backslope

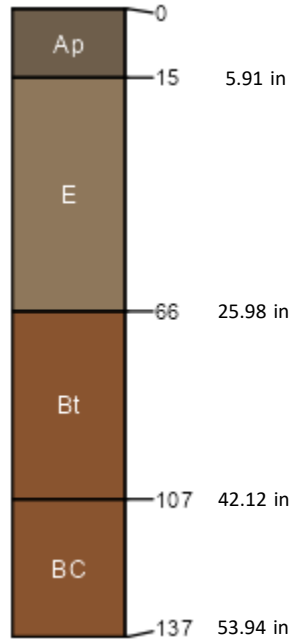
22: Konawa loamy fine sand, 0 to 3 percent slopes (383778)

Konawa (90%)
[Deep Sand Savannah](#)
 Ultic Haplustalfs
 Well drained
 Hydric: No
 PAWS: 25 cm



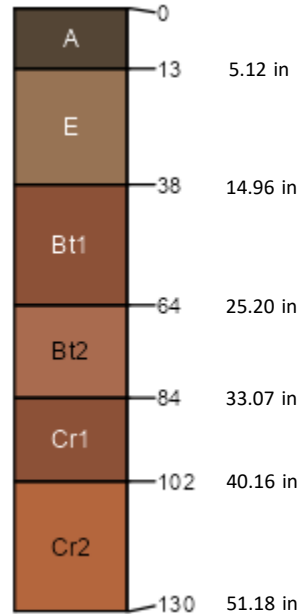
hillslopes / Backslope

Dougherty (7%)
[Deep Sand Savannah](#)
 Arenic Haplustalfs
 Well drained
 Hydric: No
 PAWS: NA



dunes / Backslope

Stephenville (3%)
[Sandy Loam Savannah](#)
 Ultic Haplustalfs
 Well drained
 Hydric: No
 PAWS: NA



hillslopes / Backslope

23: Konawa loamy fine sand, 3 to 8 percent slopes (383779) : Along SH 74 has the same soil profiles as reported for Number 22

39: Ashport, Port and Pulaski soils, 0 to 1 percent slopes, frequently flooded (383796)

Ashport (40%)

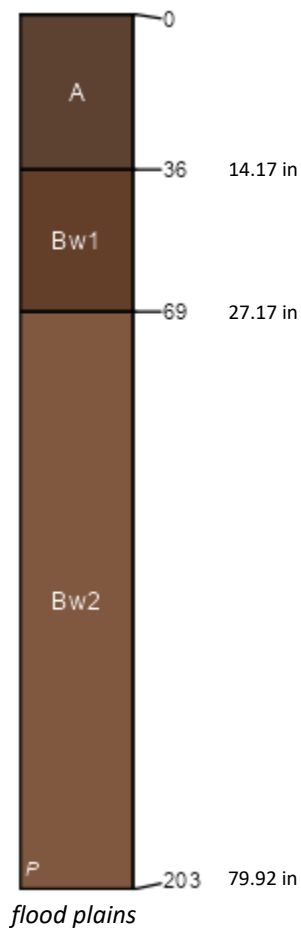
Loamy Bottomland

Fluventic Haplustolls

Well drained

Hydric: No

PAWS: 40 cm



Port (35%)

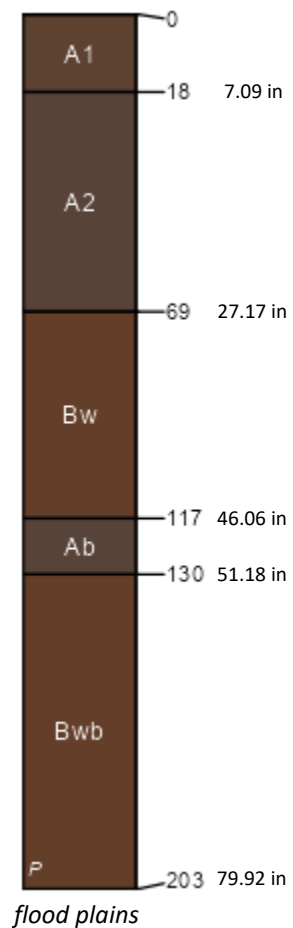
Loamy Bottomland

Cumulic Haplustolls

Well drained

Hydric: No

PAWS: 40 cm



Pulaski (15%)

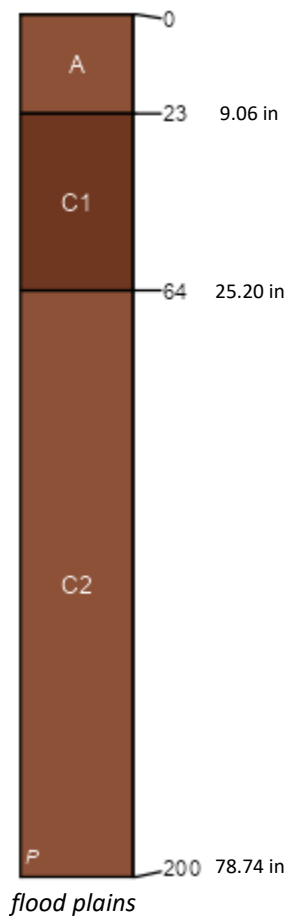
Loamy Bottomland

Udic Ustifluvents

Well drained

Hydric: No

PAWS: 30 cm



Yahola (7%)

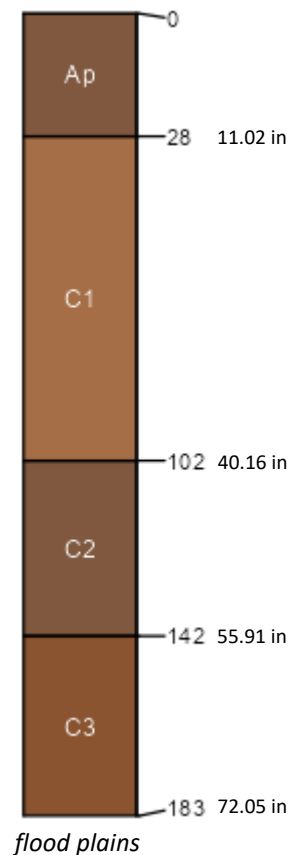
Loamy Bottomland

Udic Ustifluvents

Well drained

Hydric: No

PAWS: NA



Tribbey (3%)

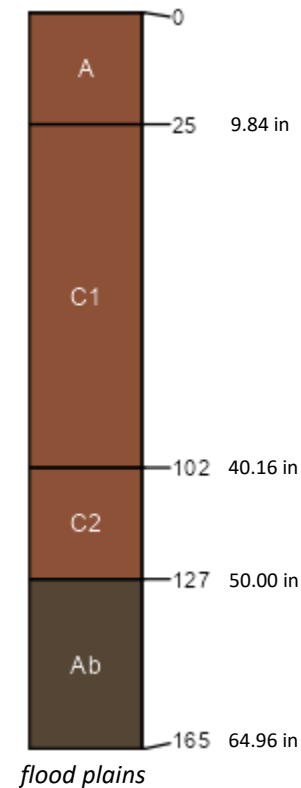
Subirrigated Bottomland

Oxyaquic Udifluvents

Somewhat poorly drained

Hydric: No

PAWS: NA



- **I34 & SH 74 Interchange**
- **J/P 32802(04)**
- **McClain County, Oklahoma**
- **AEC Project No.: 1875**
- **November 30, 2023**

Appendix D

Soil Description

Soil Description

The soil series identified along the proposed interchange of I-35 and SH 74 the order of occurrence beginning from the BOP are presented in Table 1. Regarding the pedological and geological soil survey, five soil series were identified in the project extents are from three soil orders and three suborders; see Table 4 and the Soil Taxonomic Statement in Appendix E. For the (Port, Konawa, and Plaski) soil series that were not sampled, the official soil description (OSD) depths were used in the following soil descriptions.

The **Grant** soil series diagnostic horizons and features include a mollic epipedon, an argillic horizon, and a paralithic contact. The mollic epipedon refers to a dark colored, organic rich surface horizon that is susceptible to subgrade instability when exposed to moisture during construction or increasing moisture with time and series includes the (Ap, A, and Bt1) horizons from the ground surface to a depth of approximately 28 inches. The argillic horizon develops through a process of illuviation where successive horizons with depth develop with increasing clay content at least 1.2 times more clay content as occurring in an overlying horizon and is represented by the lower-case symbol 't' in the sub horizon identification includes the Bt horizons from approximately 14 to 28 inches from the ground surface. A paralithic contact refers to the boundary between soil and an underlying material that is so hard and consolidated that digging with hand tools is impractical. The paralithic contact was not observed at the sampling location.

The **Ashport** soil series diagnostic horizons and features include a mollic epipedon, cambic horizon, and a udic-ustic soil moisture regime. The mollic epipedon as described above in the Grant soil series includes the Ap, and A horizons from the ground surface to an approximate depth of 16 inches. The cambic horizon refers to a subsoil horizon of very fine sand, loamy very fine sand, or finer texture that is 15 cm (5.91 inches) or thicker with some weak indication of alteration in color from the pedogenic processes and includes the Bw horizon from 16 to 35 inches. The udic-ustic soil moisture regime is described above in the Zaneis soil series. The Ashport soil series is subject to occasional flooding for brief periods during March to August. The udic-ustic soil moisture regime means that in most years, this soil series is not dry in any part of the moisture control section (depth to which plant roots penetrate) for as long as 90 cumulative days and at the same time the moisture control section is moist in some part for more than one-half of the days when the soil temperature is 5° C (41°F) at 50 cm (19.69in).

The **Konawa** soil series diagnostic horizons and features include an ochric epipedon, and an argillic horizon. The ochric epipedon is a surface horizon with color values more than 5 dry or 3 moist, contains less than 0.6 percent organic carbon, or is hard to very hard and massive when dry and includes the Ap and E horizons from the ground surface to an approximate depth of 17 inches. The argillic horizon as described above for the Grant soil series includes the Bt horizon from approximately 17 to 53 inches below the ground surface.

The **Port** soil series diagnostic horizons and features include a mollic epipedon and cambic horizon. The mollic epipedon as described above for the Grant soil series includes the Ap and A horizons from the ground surface to an approximate depth of 27 inches. The cambic horizon as described above for the Ashport series includes the Bk horizon from an approximate depth of 27 to 42 inches below the ground surface.

The **Pulaski** soil series diagnostic horizons and features include an ochric epipedon, irregular carbon content with depth, and udic–ustic soil moisture regime. The ochric epipedon is a surface horizon with color values more than 5 dry or 3 moist, contains less than 0.6 percent organic carbon, or is hard to very hard and massive when dry and includes the Ap and A horizon from the ground surface to an approximate depth of 19 inches. The irregular carbon content with depth is due to alluvial soil stratification. The udic–ustic soil moisture regime is described above for the Ashport soil series.

- **I34 & SH 74 Interchange**
- **J/P 32802(04)**
- **McClain County, Oklahoma**
- **AEC Project No.: 1875**
- **November 30, 2023**

Appendix E

Soil Taxonomy

Soil Taxonomy Statement

Grant Series

- Order: Mollisols
Mollisols are formed in a grassland setting and have a mollic epipedon that is a soft, dark, and organic rich surface horizon. The Mollisol also have a thick, illuvial, and argillic 'B' horizon. This horizon is typically very clayey and neutral to moderately alkaline.
- Suborder: Ustolls
Ustolls are the more or less freely drained Mollisols formed in Holocene to mid-Pleistocene geological deposits. Ustolls are found in sub-humid to semi-arid climates and are associated with regions where rainfall is erratic but often occurs in heavy rains. Drought is frequent and may be severe. During drought conditions wind erosion becomes a problem. Ustolls have mollic epipedon and a calcium or lime rich horizon. The mollic epipedon refers to a surface horizon (typically the A and parts of the B horizon) that is soft and has substantial organic matter.
- Great Group: Argiustolls
Argiustolls has an argillic horizon meaning that the B horizon has much more clay content than the A horizon above it. Horizons formed through illuviation.
- Subgroup Udic
Modifier: Udic refers to the udic soil moisture regime which means in normal years that these soils are not dry in any part of the moisture control section (depth of root penetration) for as long as 90 cumulative days.
- Particle Size: Fine-Silty
Fine-Silty refers to a particle size class where the soil has in the fraction less than 75 mm (2.95 in) in diameter, less than 15 percent by weight particles with diameters of 0.1 to 75 mm (0.0039 to 2.95 in) [fine sand or coarser, including rock fragments up to 7.5 cm (2.95 in) in diameter] and in the fine earth fraction 18 to 35 percent by weight clay.
- Mineralogy: Mixed
Mixed refers to a mineralogy class indicating that no one clay mineral type predominates.
- Temperature: Thermic
Thermic refers to a soil temperature classification that ranges from 59 to 72° F. Soil series supports good plant growth.

Ashport Series

- Order:** Mollisols
Mollisols are formed in a grassland setting and have a mollic epipedon that is a soft, dark, and organic rich surface horizon. The Mollisol also have a thick, illuvial, and argillic 'B' horizon. This horizon is typically very clayey and neutral to moderately alkaline.
- Suborder:** Ustolls
Ustolls are the freely drained Mollisols formed in Holocene to mid-Pleistocene geological deposits. Ustolls are found in sub-humid to semi-arid climates and are associated with regions where rainfall is erratic but often occurs in heavy rains. Drought is frequent and may be severe. During drought conditions wind erosion becomes a problem. Ustolls have mollic epipedon and a calcium or lime rich horizon. The mollic epipedon refers to a surface horizon (typically the A and parts of the B horizon) that is soft and has substantial organic matter.
- Great Group:** Haplustolls
Haplustolls are Ustolls that have a cambic horizon which refers to a subsoil horizon of very fine sand, loamy fine sand, or finer texture. Haplustolls have a horizon in which carbonates or soluble salts have accumulated.
- Particle Size:** Fine-Silty
Fine-Silty refers to a particle size class where the soil has in the fraction less than 75 mm (2.95 in) in diameter, less than 15 percent by weight particles with diameters of 0.1 to 75 mm (0.039 to 2.95 in) (fine sand or coarser, including rock fragments up to 7.5 cm in diameter) and in the fine earth fraction 18 to 35 percent by weight clay.
- Mineralogy:** Mixed
Mixed refers to a mineralogy class indicating that no one clay mineral type predominates.
- Temperature:** Thermic
Thermic refers to a soil temperature classification that ranges from 59 to 72° F. Soil series supports good plant growth.

Port Series

- Order:** Mollisols
Mollisols are formed in a grassland setting and have a mollic epipedon that is a soft, dark, and organic rich surface horizon. The Mollisol also

have a thick, illuvial, and argillic 'B' horizon. This horizon is typically very clayey and neutral to moderately alkaline.

Suborder: Ustolls
Ustolls are the freely drained Mollisols formed in Holocene to mid-Pleistocene geological deposits. Ustolls are found in sub-humid to semi-arid climates and are associated with regions where rainfall is erratic but often occurs in heavy rains. Drought is frequent and may be severe. During drought conditions wind erosion becomes a problem. Ustolls have mollic epipedon and a calcium or lime rich horizon. The mollic epipedon refers to a surface horizon (typically the A and parts of the B horizon) that is soft and has substantial organic matter.

Great Group: Haplustolls
Haplustolls are Ustolls that have a cambic horizon which refers to a subsoil horizon of very fine sand, loamy fine sand, or finer texture. Haplustolls have a horizon in which carbonates or soluble salts have accumulated.

Subgroup Cumulic
Modifier: Cumulic is a term that refers to deposition of mineral material on the surface by water (flooding in this case).

Particle Size: Fine-Silty
Fine-Silty refers to a particle size class where the soil has in the fraction less than 75 mm (2.95 in) in diameter, less than 15 percent by weight particles with diameters of 0.1 to 75 mm (0.039 to 2.95 in) [fine sand or coarser, including rock fragments up to 7.5 cm (2.95) in diameter] and in the fine earth fraction 18 to 35 percent by weight clay.

Mineralogy: Mixed
Mixed refers to a mineralogy class indicating that no one clay mineral type predominates.

Temperature: Thermic
Thermic refers to a soil temperature classification that ranges from 59 to 72° F. Soil series supports good plant growth.

Konawa Series

Order: Alfisols
The central concept of Alfisols is that of soils that have an argillic horizon and a base saturation of 35 percent or greater. Alfisols have redoximorphic features in all horizons. Argillic horizons refer to a B

horizon that has at least 1.2 times as much clay as does an above horizon. Redoximorphic features refer to the alternation between reducing and oxidizing conditions that are responsible for the release of iron and manganese from primary minerals. This redox condition results in mottled soil colors and generally indicates a fluctuating water table.

Suborder: Ustalfs
Ustalfs have an ustic moisture regime which implies that in most years part of the moisture control section (depth of root penetration) is dry for more than 90 cumulative days. Ustalfs have calcium carbonate accumulation throughout the horizon.

Great Group: Haplustafts
Haplustafts that have a sandy or sandy-skeletal particle-size class throughout extending from the mineral soil surface to the top of the argillic horizon depth of 50 cm (19.69 in) or more.

Subgroup
Modifier: Ultic
Ultic means that the soil also fits the central theme of Ustisols.

Particle Size: Fine-loamy
Fine-loamy refers to a particle class where the soil less than 75 mm (2.95 in) diameter has 15 or more by weight particles with diameters of 0.1 to 75 mm (0.00394 to 2.95 in) [fine sand or coarser, including rock fragments up to 7.5 cm in diameter] and 18 to 35 percent by dry weight clay.

Mineralogy: Mixed
Mixed refers to a mineralogy class indicating that no one clay mineral type predominates.

Temperature: Thermic
Thermic refers to a soil temperature classification that ranges from 59° to 72° F. Soil series supports good plant growth.

Pulaski Series

Order: Entisols
The central concept of Entisols is that of soils that have little or no evidence of pedogenic horizon development. Typical of entisols is an ochric epipedon, a surface horizon that is light in color.

Suborder: Fluvents

Fluvents are loamy and clayey (finer in texture than loamy fine sand) alluvial soils with very simple profiles. Irregularity of content of organic matter with depth is diagnostic. Stratification is common in alluvium and soils derived from alluvium.

Great Group: Ustifluvents

Ustifluvents have ustic moisture regimes. In most years, part of the moisture control section of these soils is dry for more than 90 cumulative days but moist in some part more than one-half the days that the soil temperature is above 5 C at 50 cm (19.69 in).

Subgroup Udic

Modifier: Udic refers to the udic soil moisture regime which means in normal years that these soils are not dry in any part of the moisture control section (depth of root penetration) for as long as 90 cumulative days.

Particle Size: Coarse-Loamy

Coarse-Loamy refers to a particle size class where the soil in the fraction less than 75 mm (2.95 in) in diameter has 15 percent or more by weight particles with diameters of 0.1 to 75 mm (0.0039 to 2.95 in) [fine sand or coarser, including rock fragments up to 7.5 cm (2.95 in) in diameter] and in the fine earth fraction, less than 18 percent by weight clay.

Mineralogy: Mixed

Mixed refers to a mineralogy class indicating that no one clay mineral type predominates.

Temperature: Thermic

Thermic refers to a soil temperature classification that ranges from 59 to 72° F. Soil series supports good plant growth.

- **I34 & SH 74 Interchange**
- **J/P 32802(04)**
- **McClain County, Oklahoma**
- **AEC Project No.: 1875**
- **November 30, 2023**

Appendix F

Pedological Soil Logs



ARROWHEAD ENGINEERING CO, LLC
JP 32802(04)

SH-74 & I-35, RAMPS A THRU D
PEDOLOGICAL & GEOLOGICAL SOILS SURVEY

ARROWHEAD ENGINEERING COMPANY

WWW.ARROWHEADENGINEERING.US

PROJECT NO.: J/P 32802(04)	DATE SURVEYED: OCTOBER 21, 2023
LOCATION: SH-74 & I-35 RAMPS A THRU D	CLIENT: EST, INC.
AEC PROJECT NO.: 1875	SURVEYED BY: J. NEVELS, B. DOZIER

COUNTY: MCCLAIN COUNTY, OKLAHOMA

FIELD NO.	AASHTO (GROUP INDEX)	STATION (CRL)	DESCRIPTION	DEPTH (Inches)	NP = NON-PLASTIC		% PASSING						OSI	pH	RESISTIVITY (Ω -cm)	Sulfate (ppm)	SOIL GROUP NAME
					LL	PI	3"	3/4"	#4	#10	#40	#200					
		1006+99.00, 28.00 FT RT	ASHPORT SERIES														
1A	A-4(1)		AP HORIZON	0-6	23	4	100	100	100	100	99	69	6	7.9	3,350		SANDY SILT
1B	A-4(0)		A Horizon	6-16	NP	NP	100	100	99	99	99	69	0	7.6	3,660		SILT WITH SAND
1C	A-4(2)		Bw Horizon	16-35	24	5	100	100	100	100	100	77	7	6.8	2,800		SILTY CLAY WITH SAND
1D	A-4(4)		Ab Horizon	35-52	28	8	100	100	100	100	99	69	8	8.5	2,390		SANDY LEAN CLAY
1E	A-6(6)		Bwb1 Horizon	52-66	29	12	100	100	100	100	100	70	10	7.7	2,560		SANDY LEAN CLAY
1F	A-4(4)		Bwb2 Horizon	66-80	28	10	100	100	100	100	100	66	8	8.0	2,760		SANDY LEAN CLAY
			Geology: Loamy Alluvium	80+													
BS-1A	A-4(0)		Composite B Horizon	16-80	NP	NP	100	100	100	100	99	61	0				SANDY SILT

Note: 1. The Ab horizon was included in the Composite B Horizon sample due to similar texture, plasticity and color. 2. Auger borings were dry at end of sampling; Bwb 1 and Bwb 2 horizons becoming wetter with depth



ARROWHEAD ENGINEERING CO, LLC

JP 32802(04)

SH-74 & I-35, RAMPS A THRU D

PEDOLOGICAL & GEOLOGICAL SOILS SURVEY

ARROWHEAD ENGINEERING COMPANY

WWW.ARROWHEADENGINEERING.US

PROJECT NO.: J/P 32802(04)	DATE SURVEYED: OCTOBER 21, 2023
LOCATION: SH-74 & I-35 RAMPS A THRU D	CLIENT: EST, INC.
AEC PROJECT NO.: 1875	SURVEYED BY: J. NEVELS, B. DOZIER

COUNTY: MCCLAIN COUNTY, OKLAHOMA

FIELD NO.	AASHTO (GROUP INDEX)	STATION (CRL)	DESCRIPTION	DEPTH (Inches)	NP = NON-PLASTIC		% PASSING						OSI	pH	RESISTIVITY (Ω-cm)	Sulfate (ppm)	SOIL GROUP NAME
					LL	PI	3"	3/4"	#4	#10	#40	#200					
		992+48.00, 67.00 FT LT	GRANT SERIES														
2A	A-4(0)		Ap Horizon	0-8	NP	NP	100	100	100	100	100	69	0	5.9	2,980		SANDY SILT
2B	A-4(4)		A Horizon	8-13	28	10	100	100	100	100	100	65	8	6.1	3,370		SANDY LEAN CLAY
2C	A-4(0)		BA Horizon	13-17	NP	NP	100	100	100	100	99	60	0	6.3	4,200		SANDY SILT
2D	A-4(1)		Bt Horizon	17-32	25	5	100	100	100	100	99	61	5	6.3	5,320		SANDY SILTY CLAY
2E	A-4(0)		BC Horizon	32-48	NP	NP	100	100	100	100	99	56	0	6.2	4,690		SANDY SILT
2F	A-4(1)		C Horizon	48-60	26	5	100	100	100	100	99	59	5	7.0	4,220		SANDY SILTY CLAY
2G	A-4(6)		Cr Horizon	60-75	26	6	100	100	100	100	99	60	6	7.2	2,470		SANDY SILTY CLAY
		Geology: Shallow Terrace Underlain by Siltstone or Silty Shale		75+													
BS-2A	A-4(0)		Composite B Horizon	13-48	NP	NP	100	100	100	100	99	67	0				SANDY SILT

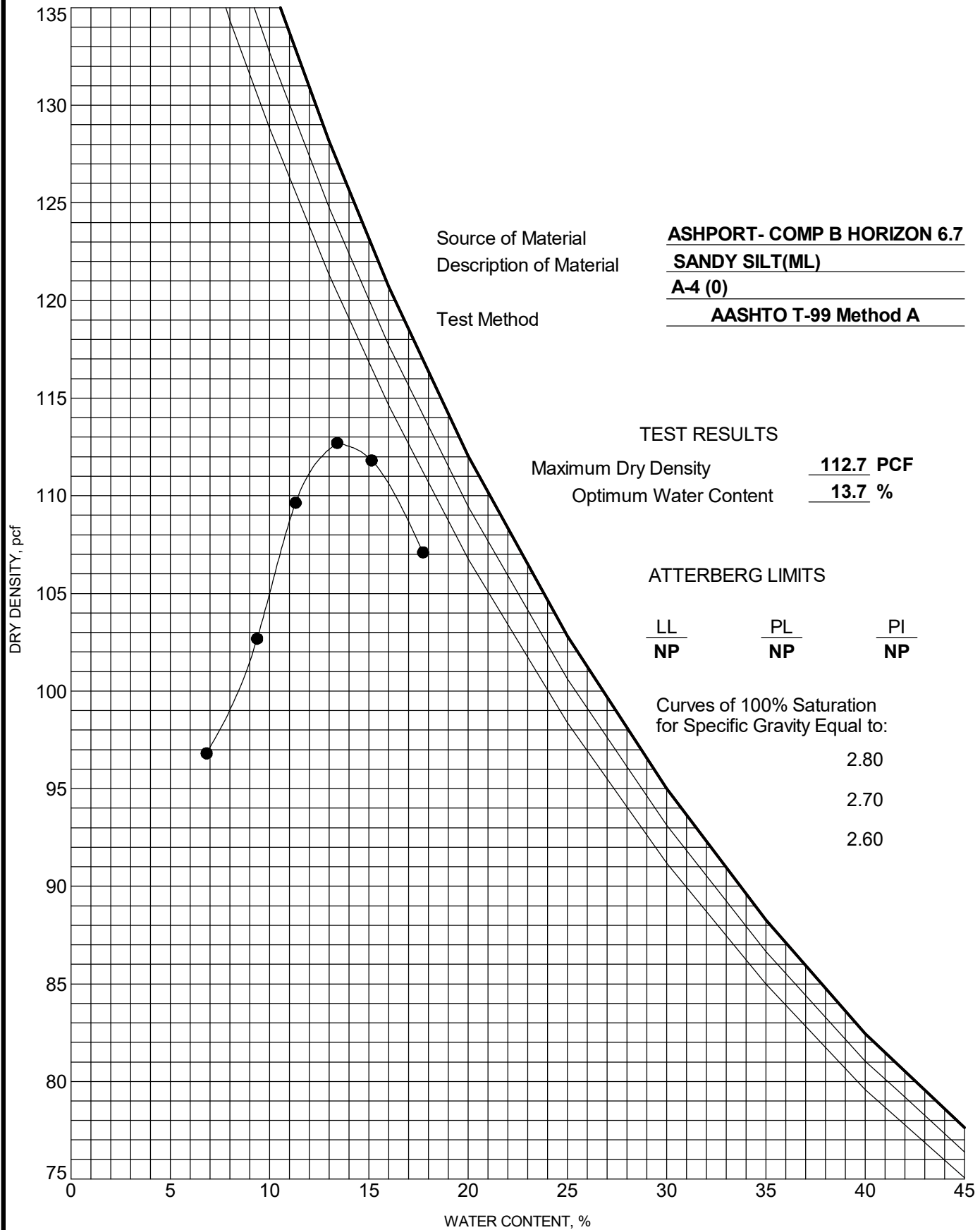
Note: 1. Slope dry at end of sampling.

- **I34 & SH 74 Interchange**
- **J/P 32802(04)**
- **McClain County, Oklahoma**
- **AEC Project No.: 1875**
- **November 30, 2023**

Appendix G

Standard Proctor Results

C:\USERS\CORBY\ONE\DRIVE\DESKTOP\FIGINT\1875.GPJ FIRE



5171 84TH AVE SE
NOBLE, OK 73068
OFFICE (405) 310-8467 FAX (405) 310-8468

Job #: 1875

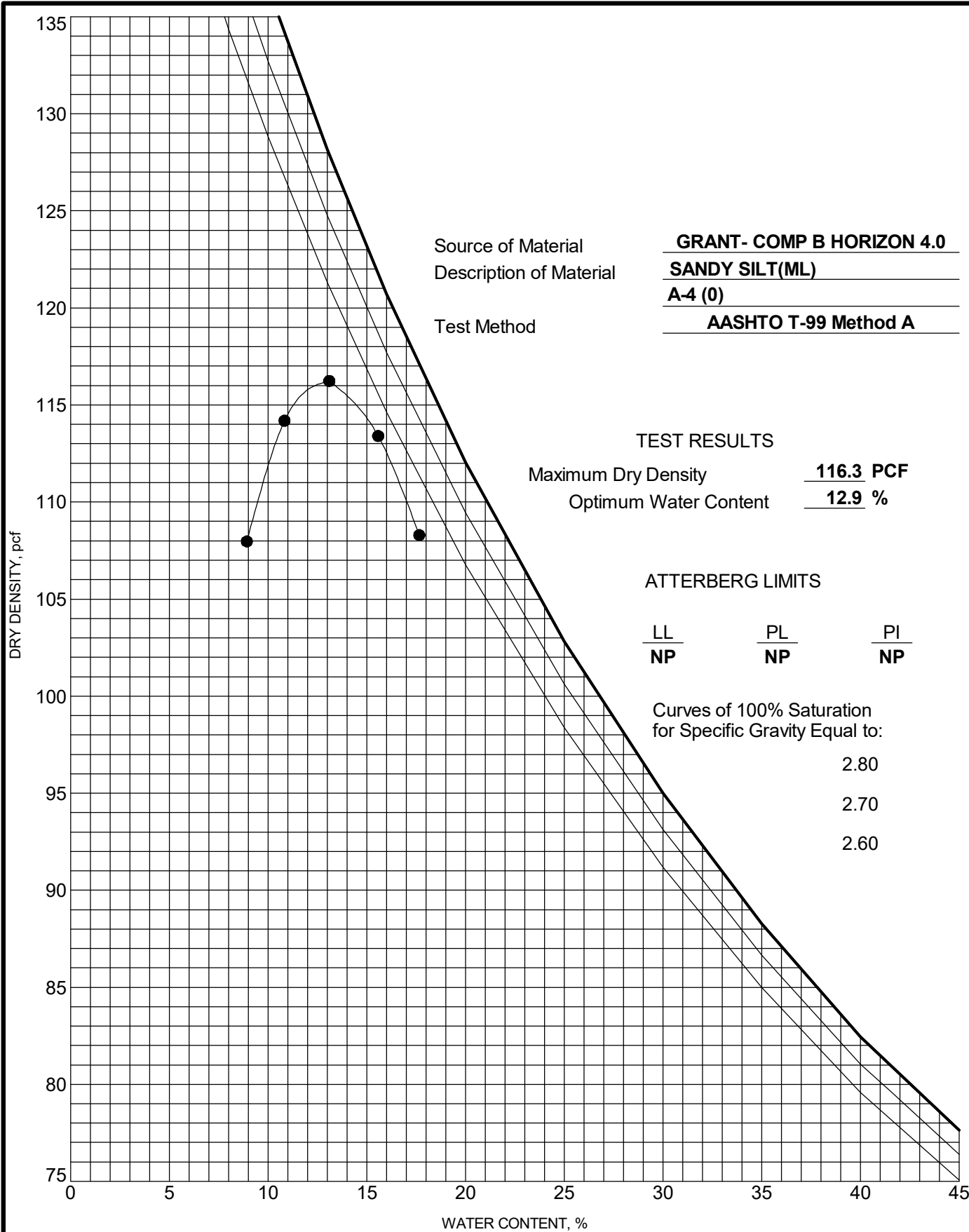
MOISTURE-DENSITY RELATIONSHIP

Customer: EST, INC.

Engineer:

Location:

Project: SH-74 & I-35 RAMPS



C:\USERS\CORBY\ONEDRIVE\DESKTOP\FIGINT\1875.GPJ FIRE



5171 84TH AVE SE
 NOBLE, OK 73068
 OFFICE (405) 310-8467 FAX (405) 310-8468

Job #: 1875

MOISTURE-DENSITY RELATIONSHIP

Customer: EST, INC.

Engineer:

Location:

Project: SH-74 & I-35 RAMPS

- **I34 & SH 74 Interchange**
- **J/P 32802(04)**
- **McClain County, Oklahoma**
- **AEC Project No.: 1875**
- **November 30, 2023**

Appendix H

Resilient Modulus Test Data



AASHTO T 307-99
Resilient Modulus of Subgrade Soils and Untreated Base/Subbase Materials
(RECOMPACTED / THINWALL TUBE SAMPLES)

LABORATORY: Boudreau Engineering, Inc. PROJECT NAME: I35/SH74 Interchange (Ramps A-D)
Norcross, Georgia PROJECT NO.: Arrowhead #1875 [JP:32802(04)]
DATE RECEIVED: 11-02-2023 QUANTITY (REPRESENTED): N.A.
IDENTIFICATION MARKS: Ashport B SOURCE OF MATERIAL: Ashport B at OMC

1.	SAMPLING DATE:	<u>N.R.</u>
2.	SAMPLE NUMBER:	<u>Ashport B</u>
3.	LAYER TYPE (1 - Subgrade, 2 - Base/Subbase)	<u>1</u>
4.	MATERIAL TYPE (Type 1 or Type 2)	<u>2</u>
5.	APPROX. DISTANCE FROM TOP OF SUBGRADE TO SAMPLE, ft (for tube samples)	<u>N/A</u>
6.	TEST INFORMATION	
	PRECONDITIONING - GREATER THAN 5% PERM. STRAIN? (Y = YES OR N = NO)	<u>N</u>
	TESTING - GREATER THAN 5% PERM. STRAIN? (Y = YES OR N = NO)	<u>N</u>
	TESTING - NUMBER OF LOAD SEQUENCES COMPLETED (0 - 15)	<u>15</u>
7.	SPECIMEN INFO.:	
	SPECIMEN DIAM., inch	
	TOP	<u>2.9</u>
	MIDDLE	<u>2.9</u>
	BOTTOM	<u>2.9</u>
	AVERAGE	<u>2.9</u>
	MEMBRANE THICKNESS (1), inch	<u>0.00</u>
	MEMBRANE THICKNESS (2), inch	<u>0.00</u>
	NET DIAM., inch	<u>2.9</u>
	HEIGHT OF SPECIMEN, CAP AND BASE, inch	<u>5.66</u>
	HEIGHT OF CAP AND BASE, inch	<u>0.0</u>
	INITIAL LENGTH, L_o , inch	<u>5.7</u>
	INITIAL AREA, A_o , in ²	<u>6.5</u>
	INITIAL VOLUME $A_o L_o$, in ³	<u>36.9</u>
	INITIAL WEIGHT, lbs (for tube samples)	<u>N/A</u>
8.	SOIL SPECIMEN WEIGHT (for remolded samples):	
	INITIAL WEIGHT OF CONTAINER AND WET SOIL, grams	<u>1179.04</u>
	FINAL WEIGHT OF CONTAINER AND WET SOIL, grams	<u>0.00</u>
	WEIGHT OF WET SOIL USED, grams	<u>1179.04</u>
9.	SOIL PROPERTIES.:	
	For Remolded Samples:	
	IN SITU MOISTURE CONTENT (NUCLEAR), %	<u>N/A</u>
	IN SITU WET DENSITY (NUCLEAR), pcf	<u>N/A</u>
	or	
	OPTIMUM MOISTURE CONTENT, %	<u>13.7</u>
	MAX. DRY DENSITY, pcf	<u>112.7</u>
	For Tube Samples:	
	IN SITU MOISTURE CONTENT, %	<u>N/A</u>
	MOISTURE CONTENT AFTER RESILIENT MODULUS TESTING, %	<u>N/A</u>
	WET DENSITY, pcf	<u>N/A</u>
	DRY DENSITY, pcf	<u>N/A</u>
10.	SPECIMEN PROPERTIES (for remolded samples):	
	COMPACTION MOISTURE CONTENT, %	<u>13.7</u>
	MOISTURE CONTENT AFTER RESILIENT MODULUS TESTING, %	<u>13.5</u>
	COMPACTION DRY DENSITY, γ_d , pcf	<u>107.0</u>
	TARGET DRY DENSITY, $\% \gamma_d$ <u>95</u> TARGET MOISTURE CONTENT, %	<u>13.7</u>
	COMPACTION LEVEL ACHIEVED	<u>95.0%</u>
11.	QUICK SHEAR TEST	
	STRESS - STRAIN PLOT ATTACHED (Y = YES, N = NO)	<u>Y</u>
	TRIAXIAL SHEAR MAXIMUM STRENGTH (MAX. LOAD/X-SECTION AREA), psi	<u>34</u>
	SPECIMEN FAIL DURING TRIAXIAL SHEAR? (Y = YES, N = NO)	<u>Y</u>
12.	TEST DATE	<u>11-06-2023</u>
13.	GENERAL REMARKS:	

TESTED BY RLB DATE 11-06-2023



AASHTO T307-99 REPORT FORM X1.1
Resilient Modulus of Subgrade Soils and Untreated Base/Subbase Materials

1. **PROJECT NO(S):** Arrowhead #1875 [JP:32802(04)]
 2. **PROJECT NAME:** I35/SH74 Interchange (Ramps A-D)
 3. **SOURCE OF MATERIAL:** Ashport B at OMC
 4. **REMOULDING TARGETS:** 95% Maximum Dry Density at 13.7% Moisture Content
 5. **LAYER TYPE (1 - subgrade, 2 - base/subbase)** 1
 6. **MATERIAL TYPE (Type 1 or Type 2)** 2
 7. **TEST DATE** 11-06-2023
 8. **RESILIENT MODULUS TESTING**

LABORATORY: Boudreau Engineering, Inc.
 Norcross, Georgia

COLUMN #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
PARAMETER	Chamber Confining Pressure	Nominal Maximum Axial Stress	Cycle No.	Actual Applied Max. Axial Load	Actual Applied Cyclic Load	Actual Applied Contact Load	Actual Applied Max. Axial Stress	Actual Applied Cyclic Stress	Actual Applied Contact Stress	Actual Applied Contact Stress	Recov. Def. LVDT #1 Reading	Recov. Def. LVDT #2 Reading	Average Recov Def. LVDT 1 and 2	Resilient Strain	Resilient Modulus
DESIGNATION	S ₃	S _{cyclic}	c ₁	P _{max}	P _{cyclic}	P _{contact}	S _{max}	S _{cyclic}	S _{contact}	H ₁	H ₂	H _{avg}	ε _r	M _r	
UNIT	psi	psi	---	lbs	lbs	lbs	psi	psi	psi	in	in	in	in/in	psi	
PRECISION															
SEQUENCE 1	6.0	2.0	96	13.2	11.8	1.4	2.0	1.8	0.2	0.00106	0.00113	0.00109	0.00019	9,386	
			97	13.2	11.8	1.4	2.0	1.8	0.2	0.00106	0.00112	0.00109	0.00019	9,326	
			98	13.2	11.8	1.4	2.0	1.8	0.2	0.00107	0.00113	0.00110	0.00019	9,329	
			99	13.3	11.9	1.4	2.0	1.8	0.2	0.00106	0.00113	0.00109	0.00019	9,452	
			100	13.2	11.8	1.4	2.0	1.8	0.2	0.00106	0.00113	0.00109	0.00019	9,355	
COLUMN AVERAGE				13.2	11.8	1.4	2.0	1.8	0.2	0.00106	0.00113	0.00109	0.00019	9,370	
STANDARD DEV.				0.0	0.1	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	52	

Project Name: I35/SH74 Interchange (Ramps A-D)

Identification Marks: Ashport B

Material Source: Ashport B at OMC

SEQUENCE 2	6.0	4.0	96	25.9	23.5	2.4	4.0	3.6	0.4	0.00225	0.00237	0.00231	0.00041	8,820
			97	26.0	23.5	2.4	4.0	3.6	0.4	0.00224	0.00237	0.00231	0.00041	8,846
			98	25.9	23.5	2.4	4.0	3.6	0.4	0.00224	0.00237	0.00231	0.00041	8,833
			99	25.9	23.5	2.5	4.0	3.6	0.4	0.00224	0.00237	0.00231	0.00041	8,831
			100	25.9	23.5	2.5	4.0	3.6	0.4	0.00225	0.00237	0.00231	0.00041	8,811
COLUMN AVERAGE				25.9	23.5	2.4	4.0	3.6	0.4	0.00224	0.00237	0.00231	0.00041	8,828
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00000	0.00000	0.00000	13
SEQUENCE 3	6.0	6.0	96	38.5	34.7	3.8	5.9	5.3	0.6	0.00361	0.00380	0.00371	0.00065	8,128
			97	38.6	34.8	3.8	5.9	5.3	0.6	0.00362	0.00380	0.00371	0.00066	8,147
			98	38.5	34.8	3.7	5.9	5.3	0.6	0.00362	0.00380	0.00371	0.00066	8,130
			99	38.6	34.8	3.7	5.9	5.3	0.6	0.00361	0.00380	0.00371	0.00066	8,151
			100	38.5	34.7	3.8	5.9	5.3	0.6	0.00361	0.00381	0.00371	0.00066	8,121
COLUMN AVERAGE				38.5	34.8	3.7	5.9	5.3	0.6	0.00361	0.00380	0.00371	0.00066	8,135
STANDARD DEV.				0.1	0.1	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	13
SEQUENCE 4	6.0	8.0	96	51.1	46.1	5.0	7.8	7.1	0.8	0.00509	0.00533	0.00521	0.00092	7,670
			97	51.1	46.0	5.0	7.8	7.1	0.8	0.00509	0.00532	0.00521	0.00092	7,671
			98	51.0	45.9	5.0	7.8	7.0	0.8	0.00509	0.00533	0.00521	0.00092	7,653
			99	51.0	46.0	5.0	7.8	7.1	0.8	0.00509	0.00532	0.00521	0.00092	7,669
			100	51.1	46.1	5.0	7.8	7.1	0.8	0.00509	0.00532	0.00520	0.00092	7,680
COLUMN AVERAGE				51.0	46.0	5.0	7.8	7.1	0.8	0.00509	0.00532	0.00521	0.00092	7,669
STANDARD DEV.				0.1	0.1	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	10
SEQUENCE 5	6.0	10.0	96	63.7	57.4	6.3	9.8	8.8	1.0	0.00652	0.00679	0.00665	0.00118	7,489
			97	63.8	57.5	6.3	9.8	8.8	1.0	0.00652	0.00679	0.00665	0.00118	7,497
			98	63.7	57.4	6.3	9.8	8.8	1.0	0.00652	0.00678	0.00665	0.00118	7,481
			99	63.8	57.6	6.3	9.8	8.8	1.0	0.00652	0.00678	0.00665	0.00118	7,508
			100	63.8	57.5	6.3	9.8	8.8	1.0	0.00652	0.00678	0.00665	0.00118	7,498
COLUMN AVERAGE				63.8	57.5	6.3	9.8	8.8	1.0	0.00652	0.00678	0.00665	0.00118	7,495
STANDARD DEV.				0.1	0.1	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	10

Project Name: I35/SH74 Interchange (Ramps A-D)

Identification Marks: Ashport B

Material Source: Ashport B at OMC

SEQUENCE 6	4.0	2.0	96	13.5	11.7	1.8	2.1	1.8	0.3	0.00123	0.00130	0.00127	0.00022	7,996
			97	13.4	11.6	1.8	2.1	1.8	0.3	0.00123	0.00129	0.00126	0.00022	8,010
			98	13.4	11.6	1.8	2.1	1.8	0.3	0.00123	0.00130	0.00126	0.00022	7,972
			99	13.5	11.7	1.8	2.1	1.8	0.3	0.00122	0.00130	0.00126	0.00022	8,030
			100	13.5	11.7	1.8	2.1	1.8	0.3	0.00122	0.00131	0.00127	0.00022	8,046
COLUMN AVERAGE				13.5	11.7	1.8	2.1	1.8	0.3	0.00123	0.00130	0.00126	0.00022	8,011
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00001	0.00000	0.00000	29
SEQUENCE 7	4.0	4.0	96	25.5	23.0	2.4	3.9	3.5	0.4	0.00266	0.00278	0.00272	0.00048	7,346
			97	25.4	23.0	2.4	3.9	3.5	0.4	0.00266	0.00278	0.00272	0.00048	7,338
			98	25.5	23.1	2.5	3.9	3.5	0.4	0.00266	0.00279	0.00272	0.00048	7,344
			99	25.5	23.0	2.5	3.9	3.5	0.4	0.00266	0.00277	0.00272	0.00048	7,348
			100	25.5	23.1	2.4	3.9	3.5	0.4	0.00266	0.00278	0.00272	0.00048	7,360
COLUMN AVERAGE				25.5	23.0	2.4	3.9	3.5	0.4	0.00266	0.00278	0.00272	0.00048	7,347
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	8
SEQUENCE 8	4.0	6.0	96	38.0	34.3	3.7	5.8	5.3	0.6	0.00418	0.00435	0.00427	0.00075	6,971
			97	38.0	34.3	3.8	5.8	5.3	0.6	0.00418	0.00436	0.00427	0.00075	6,962
			98	37.9	34.2	3.8	5.8	5.2	0.6	0.00418	0.00435	0.00426	0.00075	6,951
			99	37.9	34.1	3.7	5.8	5.2	0.6	0.00418	0.00434	0.00426	0.00075	6,945
			100	37.9	34.2	3.7	5.8	5.2	0.6	0.00418	0.00434	0.00426	0.00075	6,968
COLUMN AVERAGE				37.9	34.2	3.7	5.8	5.2	0.6	0.00418	0.00435	0.00426	0.00075	6,959
STANDARD DEV.				0.1	0.1	0.0	0.0	0.0	0.0	0.00000	0.00001	0.00000	0.00000	11
SEQUENCE 9	4.0	8.0	96	50.5	45.5	5.0	7.7	7.0	0.8	0.00577	0.00598	0.00587	0.00104	6,728
			97	50.6	45.6	5.0	7.8	7.0	0.8	0.00578	0.00599	0.00588	0.00104	6,725
			98	50.7	45.7	5.0	7.8	7.0	0.8	0.00577	0.00598	0.00587	0.00104	6,753
			99	50.6	45.6	5.0	7.8	7.0	0.8	0.00577	0.00598	0.00588	0.00104	6,725
			100	50.7	45.6	5.0	7.8	7.0	0.8	0.00577	0.00598	0.00588	0.00104	6,736
COLUMN AVERAGE				50.6	45.6	5.0	7.8	7.0	0.8	0.00577	0.00598	0.00588	0.00104	6,734
STANDARD DEV.				0.1	0.1	0.0	0.0	0.0	0.0	0.00000	0.00001	0.00000	0.00000	12

Project Name: I35/SH74 Interchange (Ramps A-D)

Identification Marks: Ashport B

Material Source: Ashport B at OMC

SEQUENCE 10	4.0	10.0	96	63.3	57.0	6.3	9.7	8.7	1.0	0.00734	0.00761	0.00748	0.00132	6,614
			97	63.3	57.1	6.3	9.7	8.7	1.0	0.00734	0.00761	0.00748	0.00132	6,623
			98	63.3	57.0	6.3	9.7	8.7	1.0	0.00735	0.00761	0.00748	0.00132	6,614
			99	63.3	57.0	6.3	9.7	8.7	1.0	0.00734	0.00761	0.00748	0.00132	6,612
			100	63.4	57.1	6.3	9.7	8.8	1.0	0.00734	0.00762	0.00748	0.00132	6,623
COLUMN AVERAGE				63.3	57.0	6.3	9.7	8.7	1.0	0.00734	0.00761	0.00748	0.00132	6,617
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	5
SEQUENCE 11	2.0	2.0	96	13.5	11.4	2.1	2.1	1.7	0.3	0.00148	0.00154	0.00151	0.00027	6,562
			97	13.5	11.4	2.2	2.1	1.7	0.3	0.00148	0.00154	0.00151	0.00027	6,557
			98	13.6	11.4	2.2	2.1	1.7	0.3	0.00148	0.00154	0.00151	0.00027	6,564
			99	13.6	11.4	2.2	2.1	1.7	0.3	0.00147	0.00154	0.00151	0.00027	6,562
			100	13.6	11.4	2.2	2.1	1.8	0.3	0.00147	0.00154	0.00151	0.00027	6,598
COLUMN AVERAGE				13.6	11.4	2.2	2.1	1.7	0.3	0.00148	0.00154	0.00151	0.00027	6,569
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	17
SEQUENCE 12	2.0	4.0	96	24.7	22.3	2.4	3.8	3.4	0.4	0.00322	0.00332	0.00327	0.00058	5,923
			97	24.8	22.3	2.5	3.8	3.4	0.4	0.00321	0.00333	0.00327	0.00058	5,930
			98	24.7	22.3	2.5	3.8	3.4	0.4	0.00321	0.00332	0.00326	0.00058	5,920
			99	24.8	22.3	2.5	3.8	3.4	0.4	0.00321	0.00331	0.00326	0.00058	5,932
			100	24.8	22.4	2.4	3.8	3.4	0.4	0.00321	0.00332	0.00326	0.00058	5,950
COLUMN AVERAGE				24.8	22.3	2.4	3.8	3.4	0.4	0.00321	0.00332	0.00326	0.00058	5,931
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	12
SEQUENCE 13	2.0	6.0	96	37.0	33.3	3.7	5.7	5.1	0.6	0.00506	0.00521	0.00514	0.00091	5,629
			97	36.9	33.2	3.7	5.7	5.1	0.6	0.00505	0.00521	0.00513	0.00091	5,616
			98	37.0	33.3	3.7	5.7	5.1	0.6	0.00505	0.00521	0.00513	0.00091	5,627
			99	37.0	33.3	3.7	5.7	5.1	0.6	0.00505	0.00521	0.00513	0.00091	5,624
			100	37.0	33.3	3.7	5.7	5.1	0.6	0.00506	0.00521	0.00513	0.00091	5,630
COLUMN AVERAGE				37.0	33.3	3.7	5.7	5.1	0.6	0.00506	0.00521	0.00513	0.00091	5,625
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	6

Project Name: I35/SH74 Interchange (Ramps A-D)

Identification Marks: Ashport B

Material Source: Ashport B at OMC

SEQUENCE 14	2.0	8.0	96	49.4	44.4	5.0	7.6	6.8	0.8	0.00693	0.00714	0.00704	0.00124	5,472
			97	49.5	44.5	5.0	7.6	6.8	0.8	0.00694	0.00714	0.00704	0.00124	5,482
			98	49.4	44.5	5.0	7.6	6.8	0.8	0.00693	0.00715	0.00704	0.00124	5,477
			99	49.5	44.5	5.0	7.6	6.8	0.8	0.00694	0.00714	0.00704	0.00124	5,481
			100	49.4	44.4	5.0	7.6	6.8	0.8	0.00693	0.00714	0.00704	0.00124	5,476
COLUMN AVERAGE				49.4	44.5	5.0	7.6	6.8	0.8	0.00694	0.00714	0.00704	0.00124	5,478
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	4
SEQUENCE 15	2.0	10.0	96	62.0	55.8	6.2	9.5	8.6	1.0	0.00877	0.00904	0.00890	0.00157	5,440
			97	62.0	55.7	6.3	9.5	8.5	1.0	0.00878	0.00904	0.00891	0.00157	5,430
			98	62.1	55.8	6.2	9.5	8.6	1.0	0.00877	0.00903	0.00890	0.00157	5,439
			99	62.0	55.8	6.2	9.5	8.6	1.0	0.00877	0.00903	0.00890	0.00157	5,438
			100	62.1	55.8	6.3	9.5	8.6	1.0	0.00877	0.00903	0.00890	0.00157	5,438
COLUMN AVERAGE				62.0	55.8	6.2	9.5	8.6	1.0	0.00877	0.00903	0.00890	0.00157	5,437
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	4

TESTED BY RLB

DATE 11-06-2023



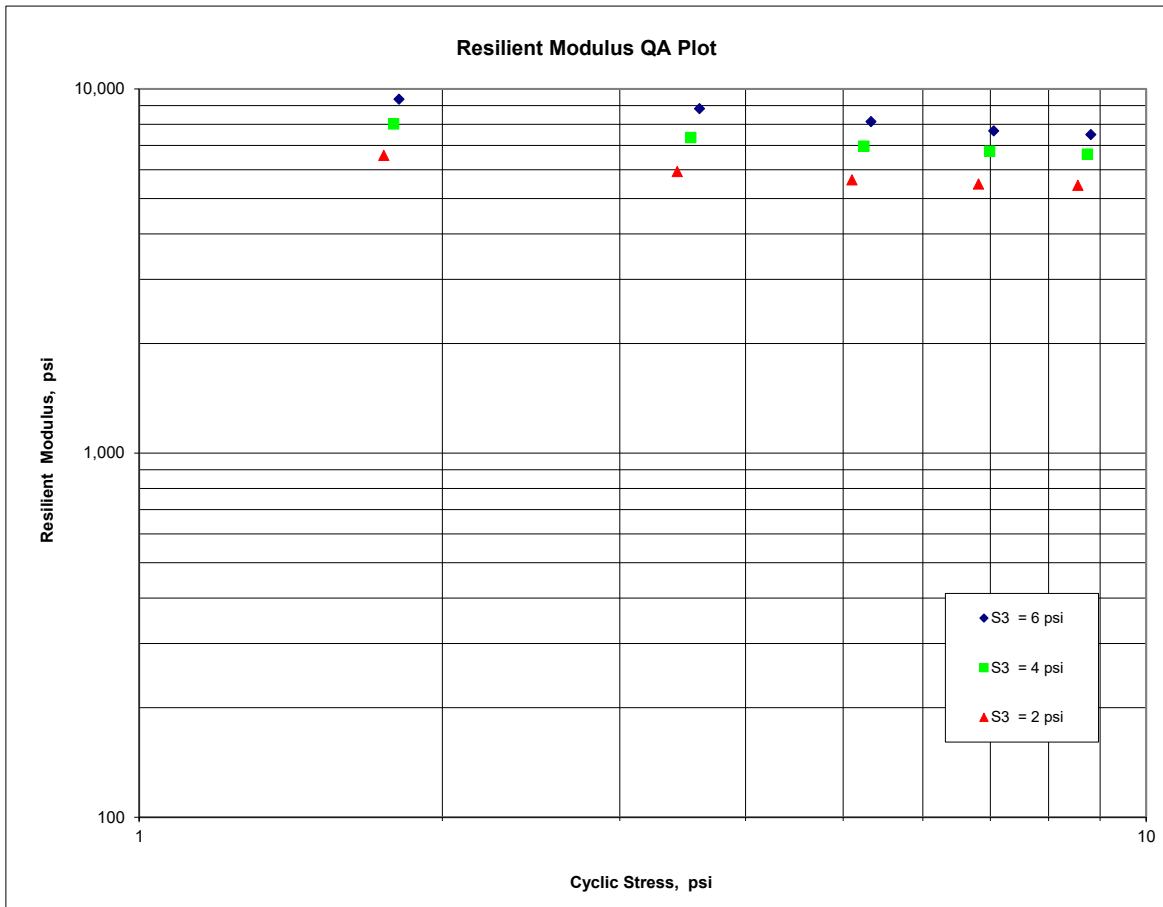
AASHTO T307-99

FIGURE 1 - Logarithmic Plot of Resilient Modulus (M_R) vs Cyclic Stress (S_C)

1. PROJECT NO(S):	Arrowhead #1875 [JP:32802(04)]
2. PROJECT NAME:	I35/SH74 Interchange (Ramps A-D)
3. SOURCE OF MATERIAL:	Ashport B at OMC
4. REMOLDING TARGETS:	95% Maximum Dry Density at 13.7% Moisture Content
5. LAYER TYPE (1 - subgrade, 2 - base/subbase)	1
6. MATERIAL TYPE (Type 1 or Type 2)	2
7. TEST DATE	11-06-2023

$$M_R = K_1 (S_C)^{K_2} (S_3)^{K_5}$$

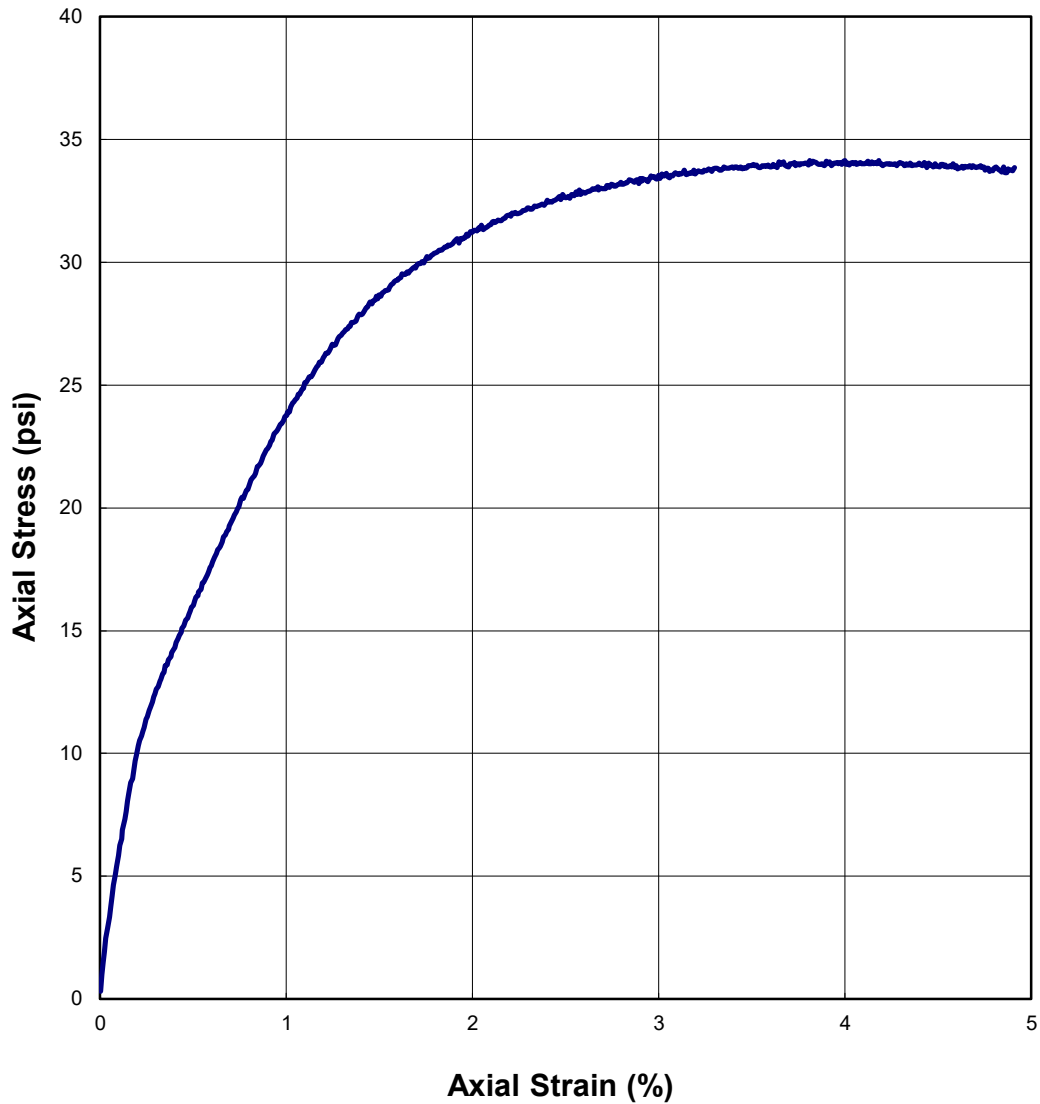
K1 =	5,604
K2 =	-0.13158
K5 =	0.32566
R ² =	0.99



AASHTO T307-99

FIGURE 2 - Quick Shear Stress vs Strain

1. PROJECT NO(S):	<u>Arrowhead #1875 [JP:32802(04)]</u>
2. PROJECT NAME:	<u>I35/SH74 Interchange (Ramps A-D)</u>
3. SOURCE OF MATERIAL:	<u>Ashport B at OMC</u>
4. REMOLDING TARGETS:	<u>95% Maximum Dry Density at 13.7% Moisture Content</u>
5. LAYER TYPE (1 - subgrade, 2 - base/subbase)	<u>1</u>
6. MATERIAL TYPE (Type 1 or Type 2)	<u>2</u>
7. TEST DATE	<u>11-06-2023</u>



AASHTO T307-99 SUMMARY SHEET
Resilient Modulus of Subgrade Soils and Untreated Base/Subbase Materials

PROJECT NO(S): Arrowhead #1875 [JP:32802(04)]
PROJECT NAME: I35/SH74 Interchange (Ramps A-D)
COUNTY/STATE NAME: McClain/Oklahoma
SOURCE OF MATERIAL: Ashport B at OMC
REMOLDING TARGETS: 95% Maximum Dry Density at 13.7% Moisture Content
MATERIAL TYPE (Type 1 or Type 2) 2
TEST DATE 11-06-2023

CLIENT: ODOT
OPTIMUM MOISTURE CONTENT, %: 13.7
MAXIMUM DRY DENSITY, pcf: 112.7
95% MDD, pcf: 107.1

NET DIAMETER, in: 2.9
INITIAL SPECIMEN HEIGHT, in: 5.7
WET WEIGHT, g: 1179.0
COMPACTION WATER CONTENT, %: 13.7
COMPACTION DRY DENSITY, pcf: 107.0
MOISTURE CONTENT AFTER Mr TEST, %: 13.5

PRECONDITIONING-PERMANENT STRAIN>5% N
TESTING-PERMANENT STRAIN>5% N
NUMBER OF LOAD SEQUENCES COMPLETED 15
QUICK SHEAR TEST Y

COLUMN #	1	2	4	5	6	7	8	9	10	11	12	13	14	15
PARAMETER	Chamber Confining Pressure	Nominal Maximum Axial Stress	Actual Applied Max. Axial Load	Actual Applied Cyclic Load	Actual Applied Contact Load	Actual Applied Max. Axial Stress	Actual Applied Cyclic Stress	Actual Applied Contact Stress	Recov. Def. LVDT #1 Reading	Recov. Def. LVDT #2 Reading	Average Recov Def. LVDT 1 and 2	Resilient Strain	Actual Resilient Modulus	Predicted Resilient Modulus*
DESIGNATION	σ_3	σ_{cyclic}	P_{max}	P_{cyclic}	$P_{contact}$	σ_{max}	σ_{cyclic}	$\sigma_{contact}$	H_1	H_2	H_{avg}	ϵ_r	M_r	M_r
UNIT	psi	psi	lbs	lbs	lbs	psi	psi	psi	in	in	in	in/in	psi	psi
PRECISION														
SEQUENCE 1	6.0	2.0	13.2	11.8	1.4	2.0	1.8	0.2	0.00106	0.00113	0.00109	0.00019	9,370	9,169
SEQUENCE 2	6.0	4.0	25.9	23.5	2.4	4.0	3.6	0.4	0.00224	0.00237	0.00231	0.00041	8,828	8,369
SEQUENCE 3	6.0	6.0	38.5	34.8	3.7	5.9	5.3	0.6	0.00361	0.00380	0.00371	0.00066	8,135	7,935
SEQUENCE 4	6.0	8.0	51.0	46.0	5.0	7.8	7.1	0.8	0.00509	0.00532	0.00521	0.00092	7,669	7,640
SEQUENCE 5	6.0	10.0	63.8	57.5	6.3	9.8	8.8	1.0	0.00652	0.00678	0.00665	0.00118	7,495	7,419
SEQUENCE 6	4.0	2.0	13.5	11.7	1.8	2.1	1.8	0.3	0.00123	0.00130	0.00126	0.00022	8,011	8,034
SEQUENCE 7	4.0	4.0	25.5	23.0	2.4	3.9	3.5	0.4	0.00266	0.00278	0.00272	0.00048	7,347	7,334
SEQUENCE 8	4.0	6.0	37.9	34.2	3.7	5.8	5.2	0.6	0.00418	0.00435	0.00426	0.00075	6,959	6,953
SEQUENCE 9	4.0	8.0	50.6	45.6	5.0	7.8	7.0	0.8	0.00577	0.00598	0.00588	0.00104	6,734	6,695
SEQUENCE 10	4.0	10.0	63.3	57.0	6.3	9.7	8.7	1.0	0.00734	0.00761	0.00748	0.00132	6,617	6,501
SEQUENCE 11	2.0	2.0	13.6	11.4	2.2	2.1	1.7	0.3	0.00148	0.00154	0.00151	0.00027	6,569	6,411
SEQUENCE 12	2.0	4.0	24.8	22.3	2.4	3.8	3.4	0.4	0.00321	0.00332	0.00326	0.00058	5,931	5,852
SEQUENCE 13	2.0	6.0	37.0	33.3	3.7	5.7	5.1	0.6	0.00506	0.00521	0.00513	0.00091	5,625	5,548
SEQUENCE 14	2.0	8.0	49.4	44.5	5.0	7.6	6.8	0.8	0.00694	0.00714	0.00704	0.00124	5,478	5,342
SEQUENCE 15	2.0	10.0	62.0	55.8	6.2	9.5	8.6	1.0	0.00877	0.00903	0.00890	0.00157	5,437	5,187

*Predicted Mr values determined using the equation shown on Figure 1 sheet.

TESTED BY RLB DATE 11-06-2023

LABORATORY: Boudreau Engineering, Inc.
Lawrenceville, Georgia



AASHTO T 307-99
Resilient Modulus of Subgrade Soils and Untreated Base/Subbase Materials
(RECOMPACTED / THINWALL TUBE SAMPLES)

LABORATORY: Boudreau Engineering, Inc. PROJECT NAME: I35/SH74 Interchange (Ramps A-D)
Norcross, Georgia PROJECT NO.: Arrowhead #1875 [JP:32802(04)]
DATE RECEIVED: 11-02-2023 QUANTITY (REPRESENTED): N.A.
IDENTIFICATION MARKS: Ashport B SOURCE OF MATERIAL: Ashport B at 2% above OMC

1.	SAMPLING DATE:	<u>N.R.</u>
2.	SAMPLE NUMBER:	<u>Ashport B</u>
3.	LAYER TYPE (1 - Subgrade, 2 - Base/Subbase)	<u>1</u>
4.	MATERIAL TYPE (Type 1 or Type 2)	<u>2</u>
5.	APPROX. DISTANCE FROM TOP OF SUBGRADE TO SAMPLE, ft (for tube samples)	<u>N/A</u>
6.	TEST INFORMATION	
	PRECONDITIONING - GREATER THAN 5% PERM. STRAIN? (Y = YES OR N = NO)	<u>N</u>
	TESTING - GREATER THAN 5% PERM. STRAIN? (Y = YES OR N = NO)	<u>N</u>
	TESTING - NUMBER OF LOAD SEQUENCES COMPLETED (0 - 15)	<u>15</u>
7.	SPECIMEN INFO.:	
	SPECIMEN DIAM., inch	
	TOP	<u>2.9</u>
	MIDDLE	<u>2.9</u>
	BOTTOM	<u>2.9</u>
	AVERAGE	<u>2.9</u>
	MEMBRANE THICKNESS (1), inch	<u>0.00</u>
	MEMBRANE THICKNESS (2), inch	<u>0.00</u>
	NET DIAM., inch	<u>2.9</u>
	HEIGHT OF SPECIMEN, CAP AND BASE, inch	<u>5.67</u>
	HEIGHT OF CAP AND BASE, inch	<u>0.0</u>
	INITIAL LENGTH, L_o , inch	<u>5.7</u>
	INITIAL AREA, A_o , in ²	<u>6.5</u>
	INITIAL VOLUME $A_o L_o$, in ³	<u>36.9</u>
	INITIAL WEIGHT, lbs (for tube samples)	<u>N/A</u>
8.	SOIL SPECIMEN WEIGHT (for remolded samples):	
	INITIAL WEIGHT OF CONTAINER AND WET SOIL, grams	<u>1198.10</u>
	FINAL WEIGHT OF CONTAINER AND WET SOIL, grams	<u>0.00</u>
	WEIGHT OF WET SOIL USED, grams	<u>1198.10</u>
9.	SOIL PROPERTIES.:	
	For Remolded Samples:	
	IN SITU MOISTURE CONTENT (NUCLEAR), %	<u>N/A</u>
	IN SITU WET DENSITY (NUCLEAR), pcf	<u>N/A</u>
	or	
	OPTIMUM MOISTURE CONTENT, %	<u>13.7</u>
	MAX. DRY DENSITY, pcf	<u>112.7</u>
	For Tube Samples:	
	IN SITU MOISTURE CONTENT, %	<u>N/A</u>
	MOISTURE CONTENT AFTER RESILIENT MODULUS TESTING, %	<u>N/A</u>
	WET DENSITY, pcf	<u>N/A</u>
	DRY DENSITY, pcf	<u>N/A</u>
10.	SPECIMEN PROPERTIES (for remolded samples):	
	COMPACTION MOISTURE CONTENT, %	<u>15.7</u>
	MOISTURE CONTENT AFTER RESILIENT MODULUS TESTING, %	<u>15.6</u>
	COMPACTION DRY DENSITY, γ_d , pcf	<u>107.0</u>
	TARGET DRY DENSITY, $\% \gamma_d$ <u>95</u> TARGET MOISTURE CONTENT, %	<u>15.7</u>
	COMPACTION LEVEL ACHIEVED	<u>95.0%</u>
11.	QUICK SHEAR TEST	
	STRESS - STRAIN PLOT ATTACHED (Y = YES, N = NO)	<u>Y</u>
	TRIAXIAL SHEAR MAXIMUM STRENGTH (MAX. LOAD/X-SECTION AREA), psi	<u>27</u>
	SPECIMEN FAIL DURING TRIAXIAL SHEAR? (Y = YES, N = NO)	<u>N</u>
12.	TEST DATE	<u>11-06-2023</u>
13.	GENERAL REMARKS:	

TESTED BY RLB DATE 11-06-2023



AASHTO T307-99 REPORT FORM X1.1
Resilient Modulus of Subgrade Soils and Untreated Base/Subbase Materials

1. **PROJECT NO(S):** Arrowhead #1875 [JP:32802(04)]
 2. **PROJECT NAME:** I35/SH74 Interchange (Ramps A-D)
 3. **SOURCE OF MATERIAL:** Ashport B at 2% above OMC
 4. **REMOULDING TARGETS:** 95% Maximum Dry Density at 15.7% Moisture Content
 5. **LAYER TYPE (1 - subgrade, 2 - base/subbase)** 1
 6. **MATERIAL TYPE (Type 1 or Type 2)** 2
 7. **TEST DATE** 11-06-2023
 8. **RESILIENT MODULUS TESTING**

LABORATORY: Boudreau Engineering, Inc.
Norcross, Georgia

COLUMN #	1	2	3	4	5	6	7	8	9	10	11	12	13	14
PARAMETER	Chamber Confining Pressure	Nominal Maximum Axial Stress	Cycle No.	Actual Applied Max. Axial Load	Actual Applied Cyclic Load	Actual Applied Contact Load	Actual Applied Max. Axial Stress	Actual Applied Cyclic Stress	Actual Applied Contact Stress	Recov. Def. LVDT #1 Reading	Recov. Def. LVDT #2 Reading	Average Recov Def. LVDT 1 and 2	Resilient Strain	Resilient Modulus
DESIGNATION	S ₃	S _{cyclic}	c ₁	P _{max}	P _{cyclic}	P _{contact}	S _{max}	S _{cyclic}	S _{contact}	H ₁	H ₂	H _{avg}	ε _r	M _r
UNIT	psi	psi	---	lbs	lbs	lbs	psi	psi	psi	in	in	in	in/in	psi
PRECISION														
SEQUENCE 1	6.0	2.0	96	13.0	11.6	1.4	2.0	1.8	0.2	0.00114	0.00115	0.00115	0.00020	8,773
			97	12.9	11.6	1.4	2.0	1.8	0.2	0.00114	0.00116	0.00115	0.00020	8,764
			98	12.9	11.5	1.4	2.0	1.8	0.2	0.00115	0.00115	0.00115	0.00020	8,700
			99	13.0	11.6	1.4	2.0	1.8	0.2	0.00115	0.00115	0.00115	0.00020	8,758
			100	12.9	11.5	1.4	2.0	1.8	0.2	0.00115	0.00115	0.00115	0.00020	8,735
COLUMN AVERAGE				12.9	11.6	1.4	2.0	1.8	0.2	0.00115	0.00115	0.00115	0.00020	8,746
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	29

Project Name: I35/SH74 Interchange (Ramps A-D)

Identification Marks: Ashport B

Material Source: Ashport B at 2% above OMC

SEQUENCE 2	6.0	4.0	96	25.4	22.9	2.4	3.9	3.5	0.4	0.00243	0.00242	0.00243	0.00043	8,226
			97	25.4	23.0	2.4	3.9	3.5	0.4	0.00242	0.00242	0.00242	0.00043	8,272
			98	25.4	23.0	2.4	3.9	3.5	0.4	0.00243	0.00242	0.00242	0.00043	8,263
			99	25.4	23.0	2.4	3.9	3.5	0.4	0.00243	0.00242	0.00242	0.00043	8,262
			100	25.4	22.9	2.4	3.9	3.5	0.4	0.00242	0.00242	0.00242	0.00043	8,251
COLUMN AVERAGE				25.4	23.0	2.4	3.9	3.5	0.4	0.00243	0.00242	0.00242	0.00043	8,255
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	18
SEQUENCE 3	6.0	6.0	96	37.5	33.8	3.7	5.8	5.2	0.6	0.00388	0.00386	0.00387	0.00068	7,611
			97	37.5	33.7	3.7	5.8	5.2	0.6	0.00387	0.00386	0.00387	0.00068	7,602
			98	37.4	33.7	3.7	5.8	5.2	0.6	0.00388	0.00386	0.00387	0.00068	7,583
			99	37.5	33.7	3.7	5.8	5.2	0.6	0.00387	0.00386	0.00387	0.00068	7,601
			100	37.5	33.8	3.7	5.8	5.2	0.6	0.00387	0.00386	0.00387	0.00068	7,610
COLUMN AVERAGE				37.5	33.8	3.7	5.8	5.2	0.6	0.00387	0.00386	0.00387	0.00068	7,601
STANDARD DEV.				0.0	0.1	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	11
SEQUENCE 4	6.0	8.0	96	49.7	44.7	5.0	7.6	6.9	0.8	0.00540	0.00540	0.00540	0.00095	7,211
			97	49.7	44.8	5.0	7.6	6.9	0.8	0.00541	0.00539	0.00540	0.00095	7,222
			98	49.7	44.8	5.0	7.6	6.9	0.8	0.00541	0.00539	0.00540	0.00095	7,219
			99	49.7	44.7	4.9	7.6	6.9	0.8	0.00541	0.00539	0.00540	0.00095	7,219
			100	49.7	44.7	5.0	7.6	6.9	0.8	0.00541	0.00539	0.00540	0.00095	7,217
COLUMN AVERAGE				49.7	44.7	5.0	7.6	6.9	0.8	0.00541	0.00539	0.00540	0.00095	7,218
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	4
SEQUENCE 5	6.0	10.0	96	62.2	56.0	6.2	9.6	8.6	0.9	0.00687	0.00684	0.00685	0.00121	7,124
			97	62.2	56.0	6.2	9.6	8.6	1.0	0.00688	0.00683	0.00685	0.00121	7,112
			98	62.2	56.0	6.2	9.6	8.6	1.0	0.00687	0.00684	0.00685	0.00121	7,118
			99	62.2	56.0	6.2	9.6	8.6	1.0	0.00687	0.00683	0.00685	0.00121	7,126
			100	62.2	56.0	6.2	9.6	8.6	1.0	0.00687	0.00682	0.00685	0.00121	7,125
COLUMN AVERAGE				62.2	56.0	6.2	9.6	8.6	1.0	0.00687	0.00683	0.00685	0.00121	7,121
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00001	0.00000	0.00000	6

Project Name: I35/SH74 Interchange (Ramps A-D)

Identification Marks: Ashport B

Material Source: Ashport B at 2% above OMC

SEQUENCE 6	4.0	2.0	96	13.0	11.2	1.8	2.0	1.7	0.3	0.00134	0.00134	0.00134	0.00024	7,289
			97	13.0	11.2	1.8	2.0	1.7	0.3	0.00134	0.00133	0.00133	0.00024	7,333
			98	13.0	11.2	1.8	2.0	1.7	0.3	0.00134	0.00134	0.00134	0.00024	7,317
			99	13.0	11.3	1.8	2.0	1.7	0.3	0.00134	0.00133	0.00134	0.00024	7,348
			100	13.1	11.3	1.8	2.0	1.7	0.3	0.00134	0.00133	0.00133	0.00024	7,383
COLUMN AVERAGE				13.0	11.3	1.8	2.0	1.7	0.3	0.00134	0.00134	0.00134	0.00024	7,334
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	35
SEQUENCE 7	4.0	4.0	96	24.5	22.1	2.4	3.8	3.4	0.4	0.00290	0.00288	0.00289	0.00051	6,672
			97	24.5	22.1	2.4	3.8	3.4	0.4	0.00290	0.00289	0.00289	0.00051	6,657
			98	24.6	22.1	2.4	3.8	3.4	0.4	0.00291	0.00288	0.00290	0.00051	6,660
			99	24.6	22.1	2.4	3.8	3.4	0.4	0.00290	0.00288	0.00289	0.00051	6,659
			100	24.5	22.1	2.4	3.8	3.4	0.4	0.00290	0.00288	0.00289	0.00051	6,671
COLUMN AVERAGE				24.5	22.1	2.4	3.8	3.4	0.4	0.00290	0.00288	0.00289	0.00051	6,664
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	7
SEQUENCE 8	4.0	6.0	96	36.4	32.8	3.6	5.6	5.0	0.6	0.00454	0.00452	0.00453	0.00080	6,302
			97	36.5	32.8	3.7	5.6	5.0	0.6	0.00454	0.00452	0.00453	0.00080	6,302
			98	36.5	32.8	3.7	5.6	5.0	0.6	0.00454	0.00452	0.00453	0.00080	6,307
			99	36.5	32.8	3.7	5.6	5.0	0.6	0.00455	0.00452	0.00453	0.00080	6,311
			100	36.5	32.8	3.6	5.6	5.0	0.6	0.00453	0.00452	0.00453	0.00080	6,321
COLUMN AVERAGE				36.5	32.8	3.7	5.6	5.0	0.6	0.00454	0.00452	0.00453	0.00080	6,309
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	8
SEQUENCE 9	4.0	8.0	96	48.7	43.9	4.9	7.5	6.7	0.7	0.00623	0.00620	0.00622	0.00110	6,147
			97	48.8	43.9	4.9	7.5	6.7	0.8	0.00624	0.00621	0.00622	0.00110	6,140
			98	48.8	43.9	4.9	7.5	6.7	0.8	0.00624	0.00620	0.00622	0.00110	6,148
			99	48.8	43.9	4.9	7.5	6.7	0.8	0.00624	0.00621	0.00622	0.00110	6,141
			100	48.7	43.8	4.9	7.5	6.7	0.8	0.00624	0.00620	0.00622	0.00110	6,136
COLUMN AVERAGE				48.8	43.9	4.9	7.5	6.7	0.8	0.00624	0.00620	0.00622	0.00110	6,142
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	5

Project Name: I35/SH74 Interchange (Ramps A-D)

Identification Marks: Ashport B

Material Source: Ashport B at 2% above OMC

SEQUENCE 10	4.0	10.0	96	61.2	55.1	6.1	9.4	8.5	0.9	0.00790	0.00787	0.00789	0.00139	6,081
			97	61.3	55.2	6.1	9.4	8.5	0.9	0.00791	0.00787	0.00789	0.00139	6,088
			98	61.3	55.2	6.1	9.4	8.5	0.9	0.00790	0.00787	0.00788	0.00139	6,097
			99	61.2	55.1	6.1	9.4	8.5	0.9	0.00791	0.00786	0.00789	0.00139	6,086
			100	61.3	55.2	6.1	9.4	8.5	0.9	0.00792	0.00786	0.00789	0.00139	6,088
COLUMN AVERAGE				61.3	55.1	6.1	9.4	8.5	0.9	0.00791	0.00787	0.00789	0.00139	6,088
STANDARD DEV.				0.0	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00000	0.00000	6
SEQUENCE 11	2.0	2.0	96	12.9	10.7	2.1	2.0	1.6	0.3	0.00167	0.00165	0.00166	0.00029	5,620
			97	12.9	10.8	2.1	2.0	1.7	0.3	0.00166	0.00165	0.00166	0.00029	5,679
			98	12.8	10.7	2.1	2.0	1.6	0.3	0.00167	0.00165	0.00166	0.00029	5,628
			99	12.9	10.7	2.1	2.0	1.6	0.3	0.00167	0.00165	0.00166	0.00029	5,623
			100	12.9	10.8	2.1	2.0	1.7	0.3	0.00167	0.00166	0.00166	0.00029	5,646
COLUMN AVERAGE				12.9	10.7	2.1	2.0	1.7	0.3	0.00167	0.00165	0.00166	0.00029	5,639
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	25
SEQUENCE 12	2.0	4.0	96	23.0	20.7	2.4	3.5	3.2	0.4	0.00361	0.00359	0.00360	0.00064	4,995
			97	23.1	20.6	2.4	3.5	3.2	0.4	0.00361	0.00359	0.00360	0.00064	4,994
			98	23.1	20.7	2.4	3.6	3.2	0.4	0.00362	0.00359	0.00360	0.00064	5,012
			99	23.1	20.7	2.4	3.5	3.2	0.4	0.00361	0.00358	0.00360	0.00064	5,001
			100	23.1	20.7	2.4	3.6	3.2	0.4	0.00362	0.00359	0.00360	0.00064	4,996
COLUMN AVERAGE				23.1	20.7	2.4	3.5	3.2	0.4	0.00362	0.00359	0.00360	0.00064	5,000
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	7
SEQUENCE 13	2.0	6.0	96	34.6	31.0	3.6	5.3	4.8	0.6	0.00569	0.00565	0.00567	0.00100	4,752
			97	34.5	30.9	3.6	5.3	4.8	0.6	0.00569	0.00565	0.00567	0.00100	4,746
			98	34.6	30.9	3.6	5.3	4.8	0.6	0.00570	0.00565	0.00567	0.00100	4,747
			99	34.6	30.9	3.7	5.3	4.8	0.6	0.00569	0.00566	0.00568	0.00100	4,747
			100	34.6	31.0	3.6	5.3	4.8	0.6	0.00570	0.00565	0.00567	0.00100	4,753
COLUMN AVERAGE				34.6	30.9	3.6	5.3	4.8	0.6	0.00569	0.00565	0.00567	0.00100	4,749
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	3

Project Name: I35/SH74 Interchange (Ramps A-D)

Identification Marks: Ashport B

Material Source: Ashport B at 2% above OMC

SEQUENCE 14	2.0	8.0	96	46.6	41.7	4.8	7.2	6.4	0.7	0.00778	0.00773	0.00776	0.00137	4,686
			97	46.7	41.8	4.8	7.2	6.4	0.7	0.00778	0.00773	0.00775	0.00137	4,699
			98	46.6	41.8	4.9	7.2	6.4	0.7	0.00778	0.00773	0.00776	0.00137	4,693
			99	46.7	41.9	4.9	7.2	6.4	0.7	0.00779	0.00772	0.00775	0.00137	4,704
			100	46.7	41.8	4.9	7.2	6.4	0.7	0.00779	0.00772	0.00776	0.00137	4,696
COLUMN AVERAGE				46.7	41.8	4.8	7.2	6.4	0.7	0.00779	0.00773	0.00776	0.00137	4,696
STANDARD DEV.				0.1	0.1	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	7
SEQUENCE 15	2.0	10.0	96	59.0	52.9	6.1	9.1	8.1	0.9	0.00975	0.00969	0.00972	0.00172	4,739
			97	58.9	52.8	6.1	9.1	8.1	0.9	0.00977	0.00968	0.00972	0.00172	4,729
			98	58.8	52.8	6.1	9.0	8.1	0.9	0.00977	0.00969	0.00973	0.00172	4,725
			99	58.8	52.8	6.1	9.0	8.1	0.9	0.00976	0.00968	0.00972	0.00172	4,727
			100	58.9	52.8	6.1	9.1	8.1	0.9	0.00977	0.00969	0.00973	0.00172	4,729
COLUMN AVERAGE				58.9	52.8	6.1	9.1	8.1	0.9	0.00977	0.00968	0.00973	0.00172	4,730
STANDARD DEV.				0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00000	0.00000	0.00000	6

TESTED BY RLB

DATE 11-06-2023



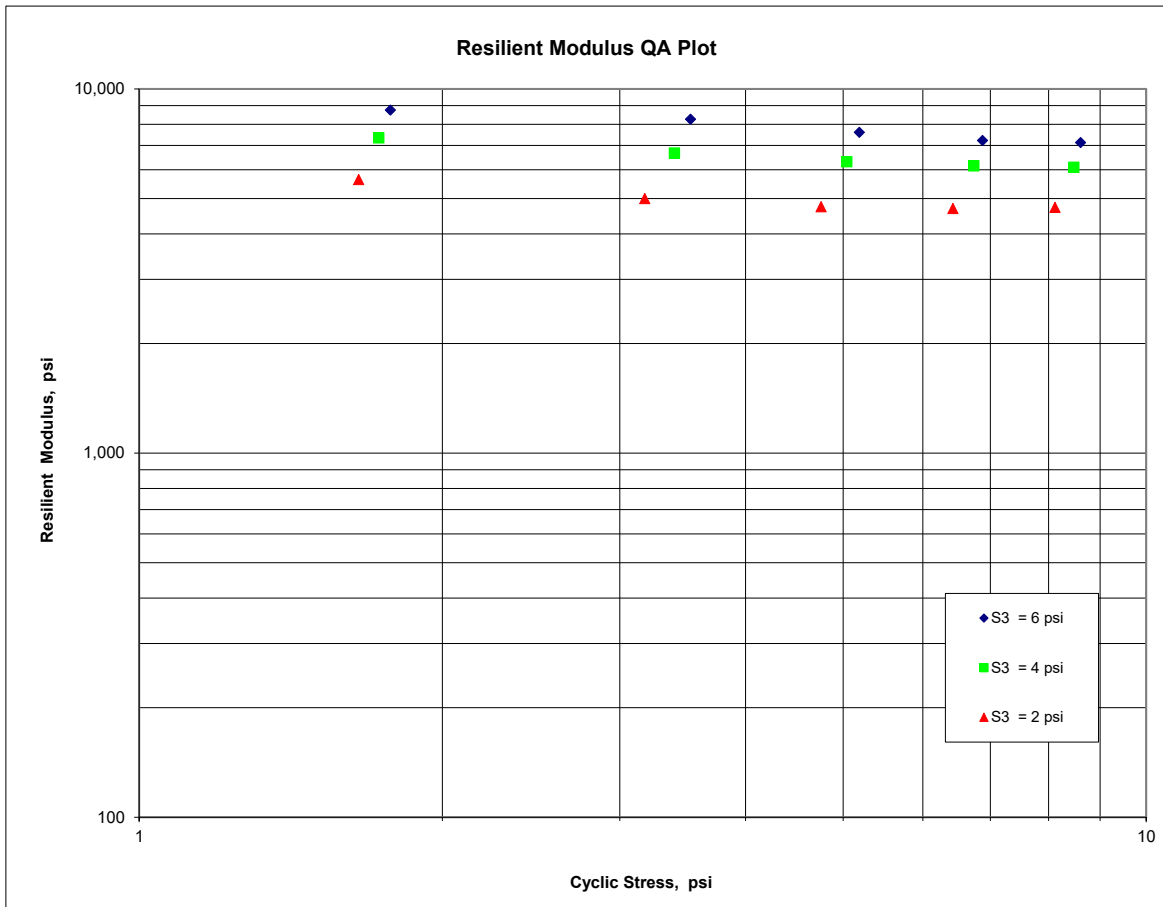
AASHTO T307-99

FIGURE 1 - Logarithmic Plot of Resilient Modulus (M_R) vs Cyclic Stress (S_C)

1. PROJECT NO(S):	Arrowhead #1875 [JP:32802(04)]
2. PROJECT NAME:	I35/SH74 Interchange (Ramps A-D)
3. SOURCE OF MATERIAL:	Ashport B at 2% above OMC
4. REMOLDING TARGETS:	95% Maximum Dry Density at 15.7% Moisture Content
5. LAYER TYPE (1 - subgrade, 2 - base/subbase)	1
6. MATERIAL TYPE (Type 1 or Type 2)	2
7. TEST DATE	11-06-2023

$$M_R = K1 (S_C)^{K2} (S_3)^{K5}$$

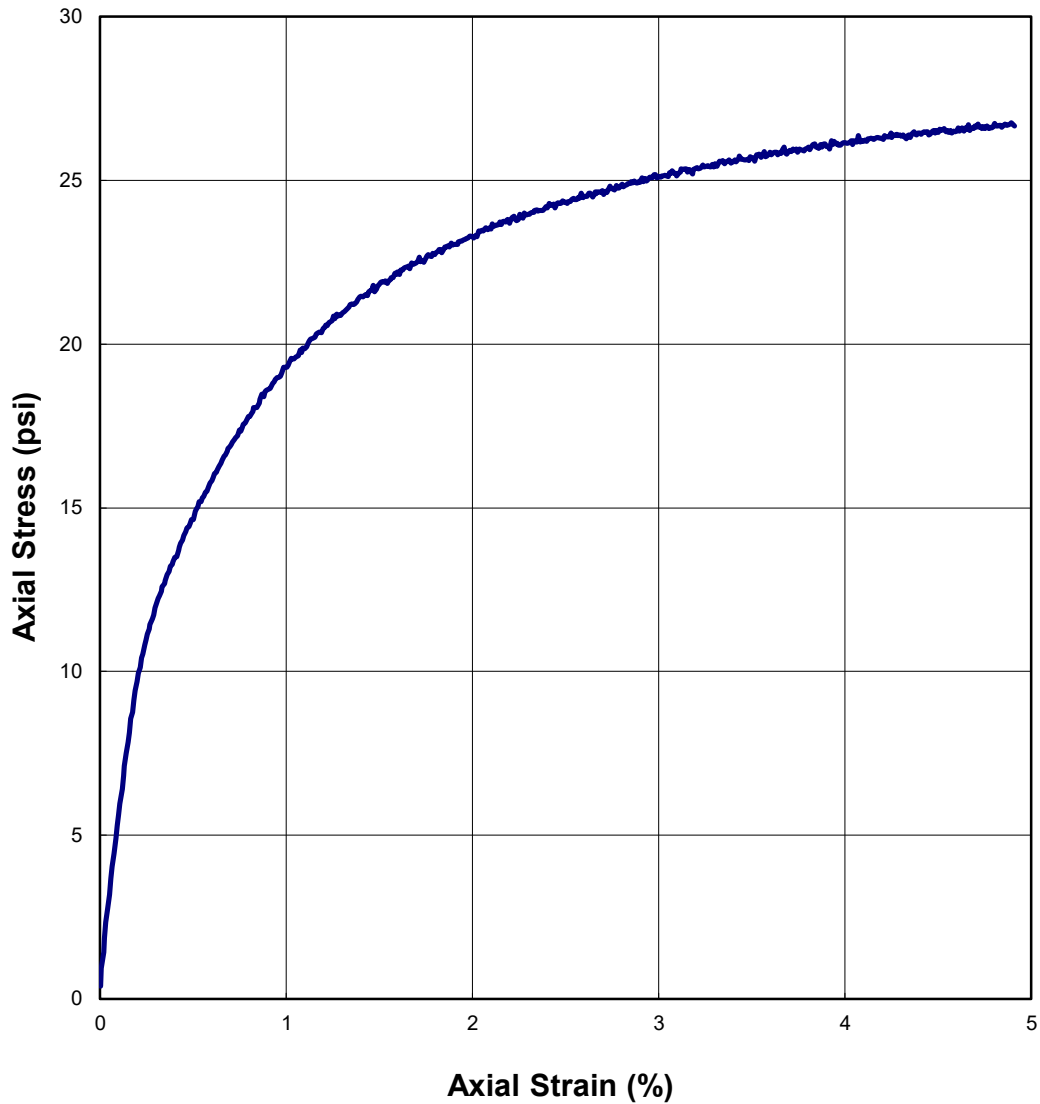
K1 =	4,426
K2 =	-0.12535
K5 =	0.41655
R ² =	0.99



AASHTO T307-99

FIGURE 2 - Quick Shear Stress vs Strain

1. PROJECT NO(S):	Arrowhead #1875 [JP:32802(04)]
2. PROJECT NAME:	I35/SH74 Interchange (Ramps A-D)
3. SOURCE OF MATERIAL:	Ashport B at 2% above OMC
4. REMOLDING TARGETS:	95% Maximum Dry Density at 15.7% Moisture Content
5. LAYER TYPE (1 - subgrade, 2 - base/subbase)	1
6. MATERIAL TYPE (Type 1 or Type 2)	2
7. TEST DATE	11-06-2023



AASHTO T307-99 SUMMARY SHEET
Resilient Modulus of Subgrade Soils and Untreated Base/Subbase Materials

PROJECT NO(S): Arrowhead #1875 [JP:32802(04)]
PROJECT NAME: I35/SH74 Interchange (Ramps A-D)
COUNTY/STATE NAME: McClain/Oklahoma
SOURCE OF MATERIAL: Ashport B at 2% above OMC
REMOLDING TARGETS: 95% Maximum Dry Density at 15.7% Moisture Content
MATERIAL TYPE (Type 1 or Type 2) 2
TEST DATE 11-06-2023

CLIENT: ODOT
OPTIMUM MOISTURE CONTENT, %: 13.7
MAXIMUM DRY DENSITY, pcf: 112.7
95% MDD, pcf: 107.1

NET DIAMETER, in: 2.9
INITIAL SPECIMEN HEIGHT, in: 5.7
WET WEIGHT, g: 1198.1
COMPACTION WATER CONTENT, %: 15.7
COMPACTION DRY DENSITY, pcf: 107.0
MOISTURE CONTENT AFTER Mr TEST, %: 15.6

PRECONDITIONING-PERMANENT STRAIN>5% N
TESTING-PERMANENT STRAIN>5% N
NUMBER OF LOAD SEQUENCES COMPLETED 15
QUICK SHEAR TEST Y

COLUMN #	1	2	4	5	6	7	8	9	10	11	12	13	14	15
PARAMETER	Chamber Confining Pressure	Nominal Maximum Axial Stress	Actual Applied Max. Axial Load	Actual Applied Cyclic Load	Actual Applied Contact Load	Actual Applied Max. Axial Stress	Actual Applied Cyclic Stress	Actual Applied Contact Stress	Recov. Def. LVDT #1 Reading	Recov. Def. LVDT #2 Reading	Average Recov Def. LVDT 1 and 2	Resilient Strain	Actual Resilient Modulus	Predicted Resilient Modulus*
DESIGNATION	σ_3	σ_{cyclic}	P_{max}	P_{cyclic}	$P_{contact}$	σ_{max}	σ_{cyclic}	$\sigma_{contact}$	H_1	H_2	H_{avg}	ϵ_r	M_r	M_r
UNIT	psi	psi	lbs	lbs	lbs	psi	psi	psi	in	in	in	in/in	psi	psi
PRECISION														
SEQUENCE 1	6.0	2.0	12.9	11.6	1.4	2.0	1.8	0.2	0.00115	0.00115	0.00115	0.00020	8,746	8,560
SEQUENCE 2	6.0	4.0	25.4	23.0	2.4	3.9	3.5	0.4	0.00243	0.00242	0.00242	0.00043	8,255	7,847
SEQUENCE 3	6.0	6.0	37.5	33.8	3.7	5.8	5.2	0.6	0.00387	0.00386	0.00387	0.00068	7,601	7,458
SEQUENCE 4	6.0	8.0	49.7	44.7	5.0	7.6	6.9	0.8	0.00541	0.00539	0.00540	0.00095	7,218	7,194
SEQUENCE 5	6.0	10.0	62.2	56.0	6.2	9.6	8.6	1.0	0.00687	0.00683	0.00685	0.00121	7,121	6,996
SEQUENCE 6	4.0	2.0	13.0	11.3	1.8	2.0	1.7	0.3	0.00134	0.00134	0.00134	0.00024	7,334	7,229
SEQUENCE 7	4.0	4.0	24.5	22.1	2.4	3.8	3.4	0.4	0.00290	0.00288	0.00289	0.00051	6,664	6,628
SEQUENCE 8	4.0	6.0	36.5	32.8	3.7	5.6	5.0	0.6	0.00454	0.00452	0.00453	0.00080	6,309	6,299
SEQUENCE 9	4.0	8.0	48.8	43.9	4.9	7.5	6.7	0.8	0.00624	0.00620	0.00622	0.00110	6,142	6,076
SEQUENCE 10	4.0	10.0	61.3	55.1	6.1	9.4	8.5	0.9	0.00791	0.00787	0.00789	0.00139	6,088	5,909
SEQUENCE 11	2.0	2.0	12.9	10.7	2.1	2.0	1.7	0.3	0.00167	0.00165	0.00166	0.00029	5,639	5,416
SEQUENCE 12	2.0	4.0	23.1	20.7	2.4	3.5	3.2	0.4	0.00362	0.00359	0.00360	0.00064	5,000	4,966
SEQUENCE 13	2.0	6.0	34.6	30.9	3.6	5.3	4.8	0.6	0.00569	0.00565	0.00567	0.00100	4,749	4,720
SEQUENCE 14	2.0	8.0	46.7	41.8	4.8	7.2	6.4	0.7	0.00779	0.00773	0.00776	0.00137	4,696	4,552
SEQUENCE 15	2.0	10.0	58.9	52.8	6.1	9.1	8.1	0.9	0.00977	0.00968	0.00973	0.00172	4,730	4,427

*Predicted Mr values determined using the equation shown on Figure 1 sheet.

TESTED BY RLB DATE 11-06-2023

LABORATORY: Boudreau Engineering, Inc.
Lawrenceville, Georgia



AASHTO T 307-99
Resilient Modulus of Subgrade Soils and Untreated Base/Subbase Materials
(RECOMPACTED / THINWALL TUBE SAMPLES)

LABORATORY: Boudreau Engineering, Inc. PROJECT NAME: I35/SH74 Interchange (Ramps A-D)
Norcross, Georgia PROJECT NO.: Arrowhead #1875 [JP:32802(04)]
DATE RECEIVED: 11-02-2023 QUANTITY (REPRESENTED): N.A.
IDENTIFICATION MARKS: Grant B SOURCE OF MATERIAL: Grant B at OMC

1.	SAMPLING DATE:	<u>N.R.</u>
2.	SAMPLE NUMBER:	<u>Grant B</u>
3.	LAYER TYPE (1 - Subgrade, 2 - Base/Subbase)	<u>1</u>
4.	MATERIAL TYPE (Type 1 or Type 2)	<u>2</u>
5.	APPROX. DISTANCE FROM TOP OF SUBGRADE TO SAMPLE, ft (for tube samples)	<u>N/A</u>
6.	TEST INFORMATION	
	PRECONDITIONING - GREATER THAN 5% PERM. STRAIN? (Y = YES OR N = NO)	<u>N</u>
	TESTING - GREATER THAN 5% PERM. STRAIN? (Y = YES OR N = NO)	<u>N</u>
	TESTING - NUMBER OF LOAD SEQUENCES COMPLETED (0 - 15)	<u>15</u>
7.	SPECIMEN INFO.:	
	SPECIMEN DIAM., inch	
	TOP	<u>2.9</u>
	MIDDLE	<u>2.9</u>
	BOTTOM	<u>2.9</u>
	AVERAGE	<u>2.9</u>
	MEMBRANE THICKNESS (1), inch	<u>0.00</u>
	MEMBRANE THICKNESS (2), inch	<u>0.00</u>
	NET DIAM., inch	<u>2.9</u>
	HEIGHT OF SPECIMEN, CAP AND BASE, inch	<u>5.65</u>
	HEIGHT OF CAP AND BASE, inch	<u>0.0</u>
	INITIAL LENGTH, L_o , inch	<u>5.7</u>
	INITIAL AREA, A_o , in ²	<u>6.5</u>
	INITIAL VOLUME $A_o L_o$, in ³	<u>36.8</u>
	INITIAL WEIGHT, lbs (for tube samples)	<u>N/A</u>
8.	SOIL SPECIMEN WEIGHT (for remolded samples):	
	INITIAL WEIGHT OF CONTAINER AND WET SOIL, grams	<u>1235.40</u>
	FINAL WEIGHT OF CONTAINER AND WET SOIL, grams	<u>0.00</u>
	WEIGHT OF WET SOIL USED, grams	<u>1235.40</u>
9.	SOIL PROPERTIES.:	
	For Remolded Samples:	
	IN SITU MOISTURE CONTENT (NUCLEAR), %	<u>N/A</u>
	IN SITU WET DENSITY (NUCLEAR), pcf	<u>N/A</u>
	or	
	OPTIMUM MOISTURE CONTENT, %	<u>15.7</u>
	MAX. DRY DENSITY, pcf	<u>116.3</u>
	For Tube Samples:	
	IN SITU MOISTURE CONTENT, %	<u>N/A</u>
	MOISTURE CONTENT AFTER RESILIENT MODULUS TESTING, %	<u>N/A</u>
	WET DENSITY, pcf	<u>N/A</u>
	DRY DENSITY, pcf	<u>N/A</u>
10.	SPECIMEN PROPERTIES (for remolded samples):	
	COMPACTION MOISTURE CONTENT, %	<u>15.7</u>
	MOISTURE CONTENT AFTER RESILIENT MODULUS TESTING, %	<u>15.6</u>
	COMPACTION DRY DENSITY, γ_d , pcf	<u>110.6</u>
	TARGET DRY DENSITY, $\% \gamma_d$ <u>95</u> TARGET MOISTURE CONTENT, %	<u>15.7</u>
	COMPACTION LEVEL ACHIEVED	<u>95.1%</u>
11.	QUICK SHEAR TEST	
	STRESS - STRAIN PLOT ATTACHED (Y = YES, N = NO)	<u>Y</u>
	TRIAXIAL SHEAR MAXIMUM STRENGTH (MAX. LOAD/X-SECTION AREA), psi	<u>26</u>
	SPECIMEN FAIL DURING TRIAXIAL SHEAR? (Y = YES, N = NO)	<u>N</u>
12.	TEST DATE	<u>11-06-2023</u>
13.	GENERAL REMARKS:	

TESTED BY RLB DATE 11-06-2023



AASHTO T307-99 REPORT FORM X1.1
Resilient Modulus of Subgrade Soils and Untreated Base/Subbase Materials

1. **PROJECT NO(S):** Arrowhead #1875 [JP:32802(04)]
 2. **PROJECT NAME:** I35/SH74 Interchange (Ramps A-D)
 3. **SOURCE OF MATERIAL:** Grant B at OMC
 4. **REMOULDING TARGETS:** 95% Maximum Dry Density at 15.7% Moisture Content
 5. **LAYER TYPE (1 - subgrade, 2 - base/subbase)** 1
 6. **MATERIAL TYPE (Type 1 or Type 2)** 2
 7. **TEST DATE** 11-06-2023
 8. **RESILIENT MODULUS TESTING**

LABORATORY: Boudreau Engineering, Inc.
 Norcross, Georgia

COLUMN #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
PARAMETER	Chamber Confining Pressure	Nominal Maximum Axial Stress	Cycle No.	Actual Applied Max. Axial Load	Actual Applied Cyclic Load	Actual Applied Contact Load	Actual Applied Max. Axial Stress	Actual Applied Cyclic Stress	Actual Applied Contact Stress	Actual Applied Contact Stress	Recov. Def. LVDT #1 Reading	Recov. Def. LVDT #2 Reading	Average Recov Def. LVDT 1 and 2	Resilient Strain	Resilient Modulus
DESIGNATION	S ₃	S _{cyclic}	c ₁	P _{max}	P _{cyclic}	P _{contact}	S _{max}	S _{cyclic}	S _{contact}	H ₁	H ₂	H _{avg}	ε _r	M _r	
UNIT	psi	psi	---	lbs	lbs	lbs	psi	psi	psi	in	in	in	in/in	psi	
PRECISION															
SEQUENCE 1	6.0	2.0	96	13.0	11.6	1.4	2.0	1.8	0.2	0.00116	0.00117	0.00116	0.00021	8,671	
			97	13.0	11.7	1.4	2.0	1.8	0.2	0.00115	0.00117	0.00116	0.00021	8,726	
			98	13.0	11.7	1.4	2.0	1.8	0.2	0.00115	0.00117	0.00116	0.00021	8,723	
			99	13.1	11.7	1.4	2.0	1.8	0.2	0.00115	0.00117	0.00116	0.00021	8,734	
			100	13.0	11.6	1.4	2.0	1.8	0.2	0.00116	0.00117	0.00116	0.00021	8,690	
COLUMN AVERAGE				13.0	11.6	1.4	2.0	1.8	0.2	0.00115	0.00117	0.00116	0.00021	8,709	
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	27	

Project Name: I35/SH74 Interchange (Ramps A-D)

Identification Marks: Grant B

Material Source: Grant B at OMC

SEQUENCE 2	6.0	4.0	96	25.5	23.1	2.4	3.9	3.5	0.4	0.00241	0.00243	0.00242	0.00043	8,280
			97	25.5	23.1	2.4	3.9	3.5	0.4	0.00241	0.00244	0.00242	0.00043	8,276
			98	25.5	23.0	2.4	3.9	3.5	0.4	0.00241	0.00243	0.00242	0.00043	8,264
			99	25.5	23.1	2.4	3.9	3.5	0.4	0.00241	0.00243	0.00242	0.00043	8,286
			100	25.5	23.1	2.5	3.9	3.5	0.4	0.00241	0.00243	0.00242	0.00043	8,272
COLUMN AVERAGE				25.5	23.1	2.4	3.9	3.5	0.4	0.00241	0.00243	0.00242	0.00043	8,276
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	8
SEQUENCE 3	6.0	6.0	96	37.6	33.9	3.7	5.8	5.2	0.6	0.00386	0.00389	0.00387	0.00069	7,602
			97	37.6	33.9	3.7	5.8	5.2	0.6	0.00386	0.00389	0.00387	0.00069	7,605
			98	37.6	33.9	3.7	5.8	5.2	0.6	0.00386	0.00389	0.00387	0.00069	7,588
			99	37.6	33.9	3.7	5.8	5.2	0.6	0.00386	0.00388	0.00387	0.00069	7,596
			100	37.7	34.0	3.7	5.8	5.2	0.6	0.00385	0.00389	0.00387	0.00068	7,631
COLUMN AVERAGE				37.6	33.9	3.7	5.8	5.2	0.6	0.00386	0.00389	0.00387	0.00069	7,604
STANDARD DEV.				0.0	0.1	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	16
SEQUENCE 4	6.0	8.0	96	50.0	45.0	5.0	7.7	6.9	0.8	0.00535	0.00540	0.00538	0.00095	7,266
			97	50.0	45.0	5.0	7.7	6.9	0.8	0.00535	0.00540	0.00538	0.00095	7,271
			98	50.1	45.1	5.0	7.7	6.9	0.8	0.00534	0.00540	0.00537	0.00095	7,291
			99	50.0	45.0	5.0	7.7	6.9	0.8	0.00535	0.00539	0.00537	0.00095	7,282
			100	50.0	45.0	5.0	7.7	6.9	0.8	0.00534	0.00539	0.00537	0.00095	7,282
COLUMN AVERAGE				50.0	45.0	5.0	7.7	6.9	0.8	0.00535	0.00540	0.00537	0.00095	7,278
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00000	0.00000	10
SEQUENCE 5	6.0	10.0	96	62.8	56.5	6.2	9.6	8.7	1.0	0.00675	0.00681	0.00678	0.00120	7,240
			97	62.8	56.5	6.2	9.6	8.7	1.0	0.00676	0.00681	0.00678	0.00120	7,238
			98	62.8	56.6	6.2	9.6	8.7	1.0	0.00674	0.00680	0.00677	0.00120	7,251
			99	62.7	56.5	6.3	9.6	8.7	1.0	0.00674	0.00680	0.00677	0.00120	7,243
			100	62.7	56.5	6.2	9.6	8.7	1.0	0.00674	0.00681	0.00677	0.00120	7,241
COLUMN AVERAGE				62.8	56.5	6.2	9.6	8.7	1.0	0.00675	0.00680	0.00677	0.00120	7,243
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00000	0.00000	0.00000	5

Project Name: I35/SH74 Interchange (Ramps A-D)

Identification Marks: Grant B

Material Source: Grant B at OMC

SEQUENCE 6	4.0	2.0	96	13.1	11.3	1.8	2.0	1.7	0.3	0.00135	0.00137	0.00136	0.00024	7,234
			97	13.2	11.4	1.8	2.0	1.8	0.3	0.00135	0.00137	0.00136	0.00024	7,296
			98	13.1	11.3	1.8	2.0	1.7	0.3	0.00134	0.00136	0.00135	0.00024	7,267
			99	13.2	11.4	1.8	2.0	1.8	0.3	0.00134	0.00137	0.00136	0.00024	7,307
			100	13.1	11.4	1.8	2.0	1.7	0.3	0.00135	0.00136	0.00136	0.00024	7,278
COLUMN AVERAGE				13.1	11.4	1.8	2.0	1.7	0.3	0.00135	0.00137	0.00136	0.00024	7,276
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	29
SEQUENCE 7	4.0	4.0	96	24.8	22.4	2.4	3.8	3.4	0.4	0.00288	0.00290	0.00289	0.00051	6,716
			97	24.7	22.2	2.4	3.8	3.4	0.4	0.00288	0.00290	0.00289	0.00051	6,681
			98	24.7	22.3	2.4	3.8	3.4	0.4	0.00288	0.00290	0.00289	0.00051	6,694
			99	24.7	22.3	2.5	3.8	3.4	0.4	0.00287	0.00290	0.00288	0.00051	6,705
			100	24.7	22.3	2.4	3.8	3.4	0.4	0.00288	0.00290	0.00289	0.00051	6,710
COLUMN AVERAGE				24.7	22.3	2.4	3.8	3.4	0.4	0.00288	0.00290	0.00289	0.00051	6,701
STANDARD DEV.				0.0	0.1	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	14
SEQUENCE 8	4.0	6.0	96	36.9	33.2	3.7	5.7	5.1	0.6	0.00448	0.00450	0.00449	0.00080	6,409
			97	36.9	33.2	3.7	5.7	5.1	0.6	0.00448	0.00451	0.00449	0.00079	6,416
			98	36.9	33.2	3.7	5.7	5.1	0.6	0.00447	0.00450	0.00449	0.00079	6,422
			99	36.9	33.2	3.7	5.7	5.1	0.6	0.00448	0.00450	0.00449	0.00079	6,425
			100	36.9	33.2	3.7	5.7	5.1	0.6	0.00447	0.00450	0.00449	0.00079	6,425
COLUMN AVERAGE				36.9	33.2	3.7	5.7	5.1	0.6	0.00448	0.00450	0.00449	0.00079	6,419
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00000	0.00000	0.00000	7
SEQUENCE 9	4.0	8.0	96	49.4	44.5	4.9	7.6	6.8	0.8	0.00610	0.00614	0.00612	0.00108	6,309
			97	49.4	44.5	4.9	7.6	6.8	0.8	0.00611	0.00615	0.00613	0.00108	6,300
			98	49.4	44.5	4.9	7.6	6.8	0.8	0.00611	0.00614	0.00612	0.00108	6,306
			99	49.4	44.4	5.0	7.6	6.8	0.8	0.00611	0.00613	0.00612	0.00108	6,294
			100	49.4	44.4	4.9	7.6	6.8	0.8	0.00611	0.00613	0.00612	0.00108	6,304
COLUMN AVERAGE				49.4	44.5	4.9	7.6	6.8	0.8	0.00611	0.00614	0.00612	0.00108	6,303
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	6

Project Name: I35/SH74 Interchange (Ramps A-D)

Identification Marks: Grant B

Material Source: Grant B at OMC

SEQUENCE 10	4.0	10.0	96	62.0	55.8	6.2	9.5	8.6	1.0	0.00771	0.00777	0.00774	0.00137	6,251
			97	62.1	55.9	6.2	9.5	8.6	1.0	0.00772	0.00777	0.00775	0.00137	6,261
			98	62.0	55.8	6.2	9.5	8.6	0.9	0.00771	0.00777	0.00774	0.00137	6,259
			99	62.0	55.8	6.2	9.5	8.6	1.0	0.00771	0.00777	0.00774	0.00137	6,256
			100	61.9	55.7	6.2	9.5	8.6	1.0	0.00771	0.00777	0.00774	0.00137	6,248
COLUMN AVERAGE				62.0	55.8	6.2	9.5	8.6	1.0	0.00771	0.00777	0.00774	0.00137	6,255
STANDARD DEV.				0.0	0.1	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	5
SEQUENCE 11	2.0	2.0	96	13.1	11.0	2.1	2.0	1.7	0.3	0.00163	0.00165	0.00164	0.00029	5,790
			97	13.1	10.9	2.1	2.0	1.7	0.3	0.00164	0.00165	0.00165	0.00029	5,747
			98	13.0	10.9	2.2	2.0	1.7	0.3	0.00164	0.00166	0.00165	0.00029	5,734
			99	13.0	10.9	2.1	2.0	1.7	0.3	0.00164	0.00165	0.00164	0.00029	5,743
			100	13.1	10.9	2.2	2.0	1.7	0.3	0.00163	0.00165	0.00164	0.00029	5,780
COLUMN AVERAGE				13.0	10.9	2.1	2.0	1.7	0.3	0.00164	0.00165	0.00164	0.00029	5,759
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	24
SEQUENCE 12	2.0	4.0	96	23.5	21.1	2.4	3.6	3.2	0.4	0.00354	0.00356	0.00355	0.00063	5,154
			97	23.4	21.0	2.4	3.6	3.2	0.4	0.00355	0.00355	0.00355	0.00063	5,132
			98	23.4	21.0	2.4	3.6	3.2	0.4	0.00354	0.00355	0.00355	0.00063	5,146
			99	23.5	21.0	2.4	3.6	3.2	0.4	0.00354	0.00355	0.00354	0.00063	5,153
			100	23.4	21.0	2.4	3.6	3.2	0.4	0.00353	0.00355	0.00354	0.00063	5,160
COLUMN AVERAGE				23.5	21.0	2.4	3.6	3.2	0.4	0.00354	0.00355	0.00355	0.00063	5,149
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00000	0.00000	0.00000	11
SEQUENCE 13	2.0	6.0	96	35.3	31.6	3.7	5.4	4.9	0.6	0.00553	0.00555	0.00554	0.00098	4,959
			97	35.3	31.6	3.7	5.4	4.9	0.6	0.00553	0.00555	0.00554	0.00098	4,954
			98	35.3	31.7	3.6	5.4	4.9	0.6	0.00553	0.00555	0.00554	0.00098	4,963
			99	35.2	31.6	3.7	5.4	4.8	0.6	0.00553	0.00555	0.00554	0.00098	4,948
			100	35.2	31.6	3.7	5.4	4.8	0.6	0.00553	0.00556	0.00554	0.00098	4,943
COLUMN AVERAGE				35.3	31.6	3.7	5.4	4.9	0.6	0.00553	0.00555	0.00554	0.00098	4,953
STANDARD DEV.				0.0	0.1	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	8

Project Name: I35/SH74 Interchange (Ramps A-D)

Identification Marks: Grant B

Material Source: Grant B at OMC

SEQUENCE 14	2.0	8.0	96	47.8	42.9	4.9	7.3	6.6	0.8	0.00747	0.00752	0.00749	0.00133	4,965
			97	47.8	42.9	4.9	7.3	6.6	0.8	0.00747	0.00752	0.00750	0.00133	4,963
			98	47.8	42.9	4.9	7.3	6.6	0.7	0.00747	0.00752	0.00750	0.00133	4,968
			99	47.8	43.0	4.9	7.3	6.6	0.7	0.00747	0.00752	0.00749	0.00133	4,976
			100	47.8	42.9	4.9	7.3	6.6	0.8	0.00747	0.00752	0.00749	0.00133	4,969
COLUMN AVERAGE				47.8	42.9	4.9	7.3	6.6	0.7	0.00747	0.00752	0.00750	0.00133	4,968
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	5
SEQUENCE 15	2.0	10.0	96	60.1	54.0	6.1	9.2	8.3	0.9	0.00931	0.00936	0.00934	0.00165	5,017
			97	60.1	53.9	6.2	9.2	8.3	0.9	0.00931	0.00935	0.00933	0.00165	5,017
			98	60.1	54.0	6.2	9.2	8.3	0.9	0.00931	0.00935	0.00933	0.00165	5,022
			99	60.1	53.9	6.1	9.2	8.3	0.9	0.00931	0.00936	0.00933	0.00165	5,016
			100	60.1	54.0	6.2	9.2	8.3	0.9	0.00931	0.00935	0.00933	0.00165	5,022
COLUMN AVERAGE				60.1	54.0	6.2	9.2	8.3	0.9	0.00931	0.00935	0.00933	0.00165	5,019
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00001	0.00000	0.00000	3

TESTED BY RLB

DATE 11-06-2023

Boudreau Engineering, Inc.

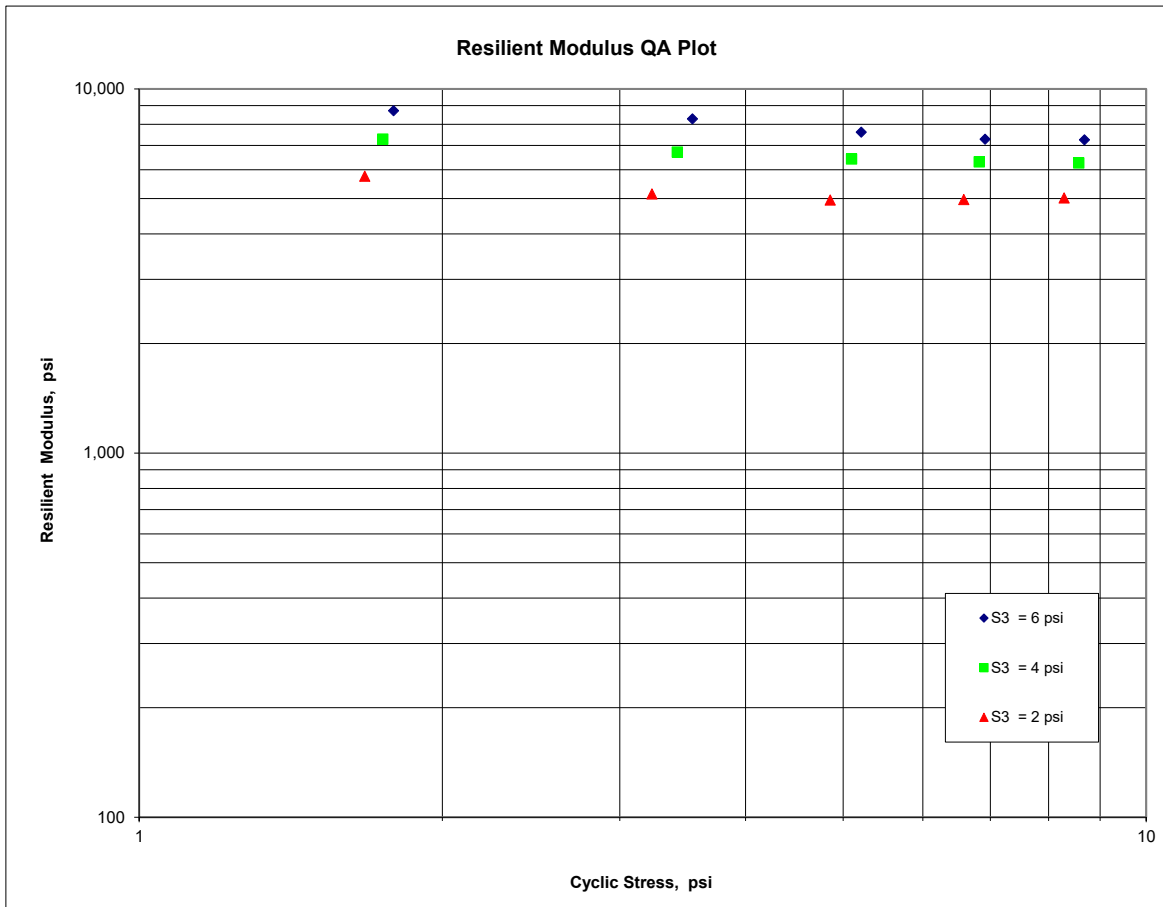
AASHTO T307-99

FIGURE 1 - Logarithmic Plot of Resilient Modulus (M_R) vs Cyclic Stress (S_C)

1. PROJECT NO(S):	Arrowhead #1875 [JP:32802(04)]
2. PROJECT NAME:	I35/SH74 Interchange (Ramps A-D)
3. SOURCE OF MATERIAL:	Grant B at OMC
4. REMOLDING TARGETS:	95% Maximum Dry Density at 15.7% Moisture Content
5. LAYER TYPE (1 - subgrade, 2 - base/subbase)	1
6. MATERIAL TYPE (Type 1 or Type 2)	2
7. TEST DATE	11-06-2023

$$M_R = K1 (S_C)^{K2} (S_3)^{K5}$$

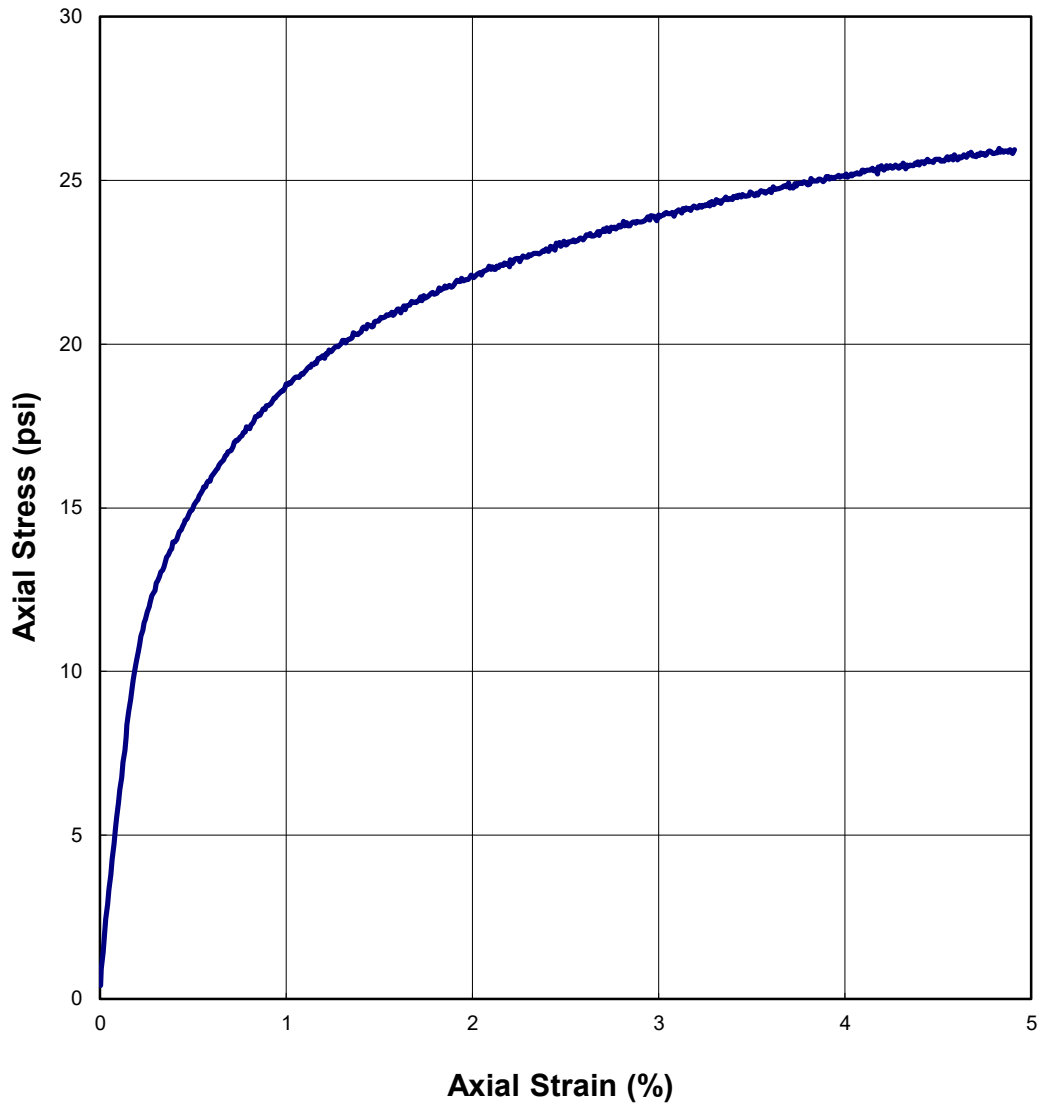
K1 =	4,601
K2 =	-0.10476
K5 =	0.37950
R ² =	0.99



AASHTO T307-99

FIGURE 2 - Quick Shear Stress vs Strain

1. PROJECT NO(S):	<u>Arrowhead #1875 [JP:32802(04)]</u>
2. PROJECT NAME:	<u>I35/SH74 Interchange (Ramps A-D)</u>
3. SOURCE OF MATERIAL:	<u>Grant B at OMC</u>
4. REMOLDING TARGETS:	<u>95% Maximum Dry Density at 15.7% Moisture Content</u>
5. LAYER TYPE (1 - subgrade, 2 - base/subbase)	<u>1</u>
6. MATERIAL TYPE (Type 1 or Type 2)	<u>2</u>
7. TEST DATE	<u>11-06-2023</u>



AASHTO T307-99 SUMMARY SHEET
Resilient Modulus of Subgrade Soils and Untreated Base/Subbase Materials

PROJECT NO(S): Arrowhead #1875 [JP:32802(04)]
PROJECT NAME: I35/SH74 Interchange (Ramps A-D)
COUNTY/STATE NAME: McClain/Oklahoma
SOURCE OF MATERIAL: Grant B at OMC
REMOLDING TARGETS: 95% Maximum Dry Density at 15.7% Moisture Content
MATERIAL TYPE (Type 1 or Type 2) 2
TEST DATE 11-06-2023

CLIENT: ODOT
OPTIMUM MOISTURE CONTENT, %: 15.7
MAXIMUM DRY DENSITY, pcf: 116.3
95% MDD, pcf: 110.5

NET DIAMETER, in: 2.9
INITIAL SPECIMEN HEIGHT, in: 5.7
WET WEIGHT, g: 1235.4
COMPACTION WATER CONTENT, %: 15.7
COMPACTION DRY DENSITY, pcf: 110.6
MOISTURE CONTENT AFTER Mr TEST, %: 15.6

PRECONDITIONING-PERMANENT STRAIN>5% N
TESTING-PERMANENT STRAIN>5% N
NUMBER OF LOAD SEQUENCES COMPLETED 15
QUICK SHEAR TEST Y

COLUMN #	1	2	4	5	6	7	8	9	10	11	12	13	14	15
PARAMETER	Chamber Confining Pressure	Nominal Maximum Axial Stress	Actual Applied Max. Axial Load	Actual Applied Cyclic Load	Actual Applied Contact Load	Actual Applied Max. Axial Stress	Actual Applied Cyclic Stress	Actual Applied Contact Stress	Recov. Def. LVDT #1 Reading	Recov. Def. LVDT #2 Reading	Average Recov Def. LVDT 1 and 2	Resilient Strain	Actual Resilient Modulus	Predicted Resilient Modulus*
DESIGNATION	σ_3	σ_{cyclic}	P_{max}	P_{cyclic}	$P_{contact}$	σ_{max}	σ_{cyclic}	$\sigma_{contact}$	H_1	H_2	H_{avg}	ϵ_r	M_r	M_r
UNIT	psi	psi	lbs	lbs	lbs	psi	psi	psi	in	in	in	in/in	psi	psi
PRECISION														
SEQUENCE 1	6.0	2.0	13.0	11.6	1.4	2.0	1.8	0.2	0.00115	0.00117	0.00116	0.00021	8,709	8,445
SEQUENCE 2	6.0	4.0	25.5	23.1	2.4	3.9	3.5	0.4	0.00241	0.00243	0.00242	0.00043	8,276	7,854
SEQUENCE 3	6.0	6.0	37.6	33.9	3.7	5.8	5.2	0.6	0.00386	0.00389	0.00387	0.00069	7,604	7,527
SEQUENCE 4	6.0	8.0	50.0	45.0	5.0	7.7	6.9	0.8	0.00535	0.00540	0.00537	0.00095	7,278	7,303
SEQUENCE 5	6.0	10.0	62.8	56.5	6.2	9.6	8.7	1.0	0.00675	0.00680	0.00677	0.00120	7,243	7,135
SEQUENCE 6	4.0	2.0	13.1	11.4	1.8	2.0	1.7	0.3	0.00135	0.00137	0.00136	0.00024	7,276	7,241
SEQUENCE 7	4.0	4.0	24.7	22.3	2.4	3.8	3.4	0.4	0.00288	0.00290	0.00289	0.00051	6,701	6,733
SEQUENCE 8	4.0	6.0	36.9	33.2	3.7	5.7	5.1	0.6	0.00448	0.00450	0.00449	0.00079	6,419	6,453
SEQUENCE 9	4.0	8.0	49.4	44.5	4.9	7.6	6.8	0.8	0.00611	0.00614	0.00612	0.00108	6,303	6,262
SEQUENCE 10	4.0	10.0	62.0	55.8	6.2	9.5	8.6	1.0	0.00771	0.00777	0.00774	0.00137	6,255	6,117
SEQUENCE 11	2.0	2.0	13.0	10.9	2.1	2.0	1.7	0.3	0.00164	0.00165	0.00164	0.00029	5,759	5,566
SEQUENCE 12	2.0	4.0	23.5	21.0	2.4	3.6	3.2	0.4	0.00354	0.00355	0.00355	0.00063	5,149	5,176
SEQUENCE 13	2.0	6.0	35.3	31.6	3.7	5.4	4.9	0.6	0.00553	0.00555	0.00554	0.00098	4,953	4,961
SEQUENCE 14	2.0	8.0	47.8	42.9	4.9	7.3	6.6	0.7	0.00747	0.00752	0.00750	0.00133	4,968	4,814
SEQUENCE 15	2.0	10.0	60.1	54.0	6.2	9.2	8.3	0.9	0.00931	0.00935	0.00933	0.00165	5,019	4,702

*Predicted Mr values determined using the equation shown on Figure 1 sheet.

TESTED BY RLB DATE 11-06-2023

LABORATORY: Boudreau Engineering, Inc.
Lawrenceville, Georgia



AASHTO T 307-99
Resilient Modulus of Subgrade Soils and Untreated Base/Subbase Materials
(RECOMPACTED / THINWALL TUBE SAMPLES)

LABORATORY: Boudreau Engineering, Inc. PROJECT NAME: I35/SH74 Interchange (Ramps A-D)
Norcross, Georgia PROJECT NO.: Arrowhead #1875 [JP:32802(04)]
DATE RECEIVED: 11-02-2023 QUANTITY (REPRESENTED): N.A.
IDENTIFICATION MARKS: Grant B SOURCE OF MATERIAL: Grant B at 2% above OMC

1.	SAMPLING DATE:	<u>N.R.</u>
2.	SAMPLE NUMBER:	<u>Grant B</u>
3.	LAYER TYPE (1 - Subgrade, 2 - Base/Subbase)	<u>1</u>
4.	MATERIAL TYPE (Type 1 or Type 2)	<u>2</u>
5.	APPROX. DISTANCE FROM TOP OF SUBGRADE TO SAMPLE, ft (for tube samples)	<u>N/A</u>
6.	TEST INFORMATION	
	PRECONDITIONING - GREATER THAN 5% PERM. STRAIN? (Y = YES OR N = NO)	<u>N</u>
	TESTING - GREATER THAN 5% PERM. STRAIN? (Y = YES OR N = NO)	<u>N</u>
	TESTING - NUMBER OF LOAD SEQUENCES COMPLETED (0 - 15)	<u>15</u>
7.	SPECIMEN INFO.:	
	SPECIMEN DIAM., inch	
	TOP	<u>2.9</u>
	MIDDLE	<u>2.9</u>
	BOTTOM	<u>2.9</u>
	AVERAGE	<u>2.9</u>
	MEMBRANE THICKNESS (1), inch	<u>0.01</u>
	MEMBRANE THICKNESS (2), inch	<u>0.01</u>
	NET DIAM., inch	<u>2.9</u>
	HEIGHT OF SPECIMEN, CAP AND BASE, inch	<u>5.71</u>
	HEIGHT OF CAP AND BASE, inch	<u>0.0</u>
	INITIAL LENGTH, L_o , inch	<u>5.7</u>
	INITIAL AREA, A_o , in ²	<u>6.5</u>
	INITIAL VOLUME $A_o L_o$, in ³	<u>37.2</u>
	INITIAL WEIGHT, lbs (for tube samples)	<u>N/A</u>
8.	SOIL SPECIMEN WEIGHT (for remolded samples):	
	INITIAL WEIGHT OF CONTAINER AND WET SOIL, grams	<u>1266.10</u>
	FINAL WEIGHT OF CONTAINER AND WET SOIL, grams	<u>0.00</u>
	WEIGHT OF WET SOIL USED, grams	<u>1266.10</u>
9.	SOIL PROPERTIES.:	
	For Remolded Samples:	
	IN SITU MOISTURE CONTENT (NUCLEAR), %	<u>N/A</u>
	IN SITU WET DENSITY (NUCLEAR), pcf	<u>N/A</u>
	or	
	OPTIMUM MOISTURE CONTENT, %	<u>15.7</u>
	MAX. DRY DENSITY, pcf	<u>116.3</u>
	For Tube Samples:	
	IN SITU MOISTURE CONTENT, %	<u>N/A</u>
	MOISTURE CONTENT AFTER RESILIENT MODULUS TESTING, %	<u>N/A</u>
	WET DENSITY, pcf	<u>N/A</u>
	DRY DENSITY, pcf	<u>N/A</u>
10.	SPECIMEN PROPERTIES (for remolded samples):	
	COMPACTION MOISTURE CONTENT, %	<u>17.7</u>
	MOISTURE CONTENT AFTER RESILIENT MODULUS TESTING, %	<u>17.4</u>
	COMPACTION DRY DENSITY, γ_d , pcf	<u>110.1</u>
	TARGET DRY DENSITY, $\% \gamma_d$ <u>95</u> TARGET MOISTURE CONTENT, %	<u>17.7</u>
	COMPACTION LEVEL ACHIEVED	<u>94.7%</u>
11.	QUICK SHEAR TEST	
	STRESS - STRAIN PLOT ATTACHED (Y = YES, N = NO)	<u>Y</u>
	TRIAXIAL SHEAR MAXIMUM STRENGTH (MAX. LOAD/X-SECTION AREA), psi	<u>19</u>
	SPECIMEN FAIL DURING TRIAXIAL SHEAR? (Y = YES, N = NO)	<u>N</u>
12.	TEST DATE	<u>11-06-2023</u>
13.	GENERAL REMARKS:	

TESTED BY RLB DATE 11-06-2023



AASHTO T307-99 REPORT FORM X1.1
Resilient Modulus of Subgrade Soils and Untreated Base/Subbase Materials

1. **PROJECT NO(S):** Arrowhead #1875 [JP:32802(04)]
 2. **PROJECT NAME:** I35/SH74 Interchange (Ramps A-D)
 3. **SOURCE OF MATERIAL:** Grant B at 2% above OMC
 4. **REMOULDING TARGETS:** 95% Maximum Dry Density at 17.7% Moisture Content
 5. **LAYER TYPE (1 - subgrade, 2 - base/subbase)** 1
 6. **MATERIAL TYPE (Type 1 or Type 2)** 2
 7. **TEST DATE** 11-06-2023
 8. **RESILIENT MODULUS TESTING**

LABORATORY: Boudreau Engineering, Inc.
Norcross, Georgia

COLUMN #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
PARAMETER	Chamber Confining Pressure	Nominal Maximum Axial Stress	Cycle No.	Actual Applied Max. Axial Load	Actual Applied Cyclic Load	Actual Applied Contact Load	Actual Applied Max. Axial Stress	Actual Applied Cyclic Stress	Actual Applied Contact Stress	Actual Applied Contact Stress	Recov. Def. LVDT #1 Reading	Recov. Def. LVDT #2 Reading	Average Recov Def. LVDT 1 and 2	Resilient Strain	Resilient Modulus
DESIGNATION	S ₃	S _{cyclic}	c ₁	P _{max}	P _{cyclic}	P _{contact}	S _{max}	S _{cyclic}	S _{contact}	H ₁	H ₂	H _{avg}	ε _r	M _r	
UNIT	psi	psi	---	lbs	lbs	lbs	psi	psi	psi	in	in	in	in/in	psi	
PRECISION															
SEQUENCE 1	6.0	2.0	96	10.7	9.4	1.3	1.6	1.4	0.2	0.00421	0.00425	0.00423	0.00074	1,942	
			97	10.7	9.4	1.3	1.6	1.4	0.2	0.00421	0.00424	0.00422	0.00074	1,952	
			98	10.6	9.3	1.3	1.6	1.4	0.2	0.00421	0.00424	0.00423	0.00074	1,932	
			99	10.7	9.4	1.3	1.6	1.4	0.2	0.00421	0.00425	0.00423	0.00074	1,946	
			100	10.7	9.4	1.3	1.6	1.4	0.2	0.00421	0.00424	0.00422	0.00074	1,948	
COLUMN AVERAGE				10.7	9.4	1.3	1.6	1.4	0.2	0.00421	0.00424	0.00423	0.00074	1,944	
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	7	

Project Name: I35/SH74 Interchange (Ramps A-D)

Identification Marks: Grant B

Material Source: Grant B at 2% above OMC

SEQUENCE 2	6.0	4.0	96	22.7	20.5	2.2	3.5	3.1	0.3	0.00677	0.00677	0.00677	0.00119	2,655
			97	22.6	20.4	2.1	3.5	3.1	0.3	0.00677	0.00677	0.00677	0.00119	2,645
			98	22.7	20.5	2.2	3.5	3.1	0.3	0.00677	0.00676	0.00677	0.00118	2,651
			99	22.7	20.5	2.2	3.5	3.1	0.3	0.00678	0.00676	0.00677	0.00118	2,656
			100	22.6	20.5	2.2	3.5	3.1	0.3	0.00677	0.00676	0.00677	0.00118	2,653
COLUMN AVERAGE				22.6	20.5	2.2	3.5	3.1	0.3	0.00677	0.00676	0.00677	0.00118	2,652
STANDARD DEV.				0.1	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	5
SEQUENCE 3	6.0	6.0	96	33.6	30.3	3.3	5.2	4.7	0.5	0.01056	0.01045	0.01051	0.00184	2,531
			97	33.9	30.6	3.3	5.2	4.7	0.5	0.01056	0.01045	0.01050	0.00184	2,552
			98	33.8	30.5	3.3	5.2	4.7	0.5	0.01056	0.01045	0.01050	0.00184	2,548
			99	33.8	30.5	3.3	5.2	4.7	0.5	0.01056	0.01045	0.01050	0.00184	2,549
			100	33.7	30.4	3.3	5.2	4.7	0.5	0.01055	0.01044	0.01049	0.00184	2,541
COLUMN AVERAGE				33.8	30.5	3.3	5.2	4.7	0.5	0.01056	0.01045	0.01050	0.00184	2,544
STANDARD DEV.				0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	9
SEQUENCE 4	6.0	8.0	96	46.7	42.2	4.5	7.2	6.5	0.7	0.01285	0.01271	0.01278	0.00224	2,895
			97	46.8	42.2	4.5	7.2	6.5	0.7	0.01284	0.01269	0.01277	0.00224	2,901
			98	46.9	42.4	4.5	7.2	6.5	0.7	0.01283	0.01268	0.01275	0.00223	2,914
			99	46.9	42.5	4.5	7.2	6.5	0.7	0.01282	0.01267	0.01275	0.00223	2,922
			100	46.7	42.2	4.5	7.2	6.5	0.7	0.01281	0.01266	0.01273	0.00223	2,908
COLUMN AVERAGE				46.8	42.3	4.5	7.2	6.5	0.7	0.01283	0.01268	0.01276	0.00223	2,908
STANDARD DEV.				0.1	0.1	0.0	0.0	0.0	0.0	0.00002	0.00002	0.00002	0.00000	11
SEQUENCE 5	6.0	10.0	96	60.6	54.8	5.8	9.3	8.4	0.9	0.01422	0.01397	0.01410	0.00247	3,411
			97	60.8	55.0	5.8	9.3	8.4	0.9	0.01422	0.01394	0.01408	0.00247	3,424
			98	60.7	54.9	5.8	9.3	8.4	0.9	0.01420	0.01393	0.01407	0.00246	3,423
			99	60.8	55.0	5.8	9.3	8.4	0.9	0.01418	0.01391	0.01404	0.00246	3,434
			100	60.6	54.9	5.7	9.3	8.4	0.9	0.01416	0.01390	0.01403	0.00246	3,429
COLUMN AVERAGE				60.7	54.9	5.8	9.3	8.4	0.9	0.01420	0.01393	0.01406	0.00246	3,424
STANDARD DEV.				0.1	0.1	0.0	0.0	0.0	0.0	0.00003	0.00003	0.00003	0.00000	8

Project Name: I35/SH74 Interchange (Ramps A-D)

Identification Marks: Grant B

Material Source: Grant B at 2% above OMC

SEQUENCE 6	4.0	2.0	96	10.9	9.2	1.7	1.7	1.4	0.3	0.00402	0.00397	0.00400	0.00070	2,011
			97	10.9	9.2	1.7	1.7	1.4	0.3	0.00402	0.00397	0.00399	0.00070	2,023
			98	10.9	9.2	1.7	1.7	1.4	0.3	0.00402	0.00397	0.00399	0.00070	2,017
			99	10.9	9.1	1.7	1.7	1.4	0.3	0.00401	0.00397	0.00399	0.00070	2,007
			100	10.9	9.3	1.7	1.7	1.4	0.3	0.00401	0.00397	0.00399	0.00070	2,035
COLUMN AVERAGE				10.9	9.2	1.7	1.7	1.4	0.3	0.00402	0.00397	0.00399	0.00070	2,019
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	11
SEQUENCE 7	4.0	4.0	96	21.6	19.4	2.2	3.3	3.0	0.3	0.00750	0.00738	0.00744	0.00130	2,288
			97	21.7	19.5	2.2	3.3	3.0	0.3	0.00750	0.00738	0.00744	0.00130	2,299
			98	21.7	19.5	2.2	3.3	3.0	0.3	0.00749	0.00737	0.00743	0.00130	2,298
			99	21.6	19.4	2.2	3.3	3.0	0.3	0.00750	0.00738	0.00744	0.00130	2,288
			100	21.5	19.4	2.2	3.3	3.0	0.3	0.00749	0.00738	0.00744	0.00130	2,283
COLUMN AVERAGE				21.6	19.4	2.2	3.3	3.0	0.3	0.00750	0.00738	0.00744	0.00130	2,291
STANDARD DEV.				0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	7
SEQUENCE 8	4.0	6.0	96	34.9	31.7	3.2	5.4	4.9	0.5	0.01042	0.01023	0.01033	0.00181	2,688
			97	35.0	31.8	3.2	5.4	4.9	0.5	0.01042	0.01022	0.01032	0.00181	2,697
			98	34.8	31.6	3.2	5.3	4.9	0.5	0.01042	0.01022	0.01032	0.00181	2,686
			99	35.1	31.8	3.2	5.4	4.9	0.5	0.01041	0.01021	0.01031	0.00181	2,706
			100	34.9	31.7	3.2	5.4	4.9	0.5	0.01041	0.01021	0.01031	0.00180	2,695
COLUMN AVERAGE				34.9	31.7	3.2	5.4	4.9	0.5	0.01042	0.01022	0.01032	0.00181	2,694
STANDARD DEV.				0.1	0.1	0.0	0.0	0.0	0.0	0.00000	0.00001	0.00001	0.00000	8
SEQUENCE 9	4.0	8.0	96	48.9	44.4	4.5	7.5	6.8	0.7	0.01238	0.01211	0.01225	0.00214	3,180
			97	48.8	44.3	4.5	7.5	6.8	0.7	0.01238	0.01212	0.01225	0.00214	3,171
			98	49.0	44.6	4.4	7.5	6.8	0.7	0.01237	0.01211	0.01224	0.00214	3,192
			99	48.7	44.3	4.5	7.5	6.8	0.7	0.01237	0.01210	0.01223	0.00214	3,173
			100	48.8	44.4	4.4	7.5	6.8	0.7	0.01236	0.01210	0.01223	0.00214	3,182
COLUMN AVERAGE				48.8	44.4	4.4	7.5	6.8	0.7	0.01237	0.01211	0.01224	0.00214	3,180
STANDARD DEV.				0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	8

Project Name: I35/SH74 Interchange (Ramps A-D)

Identification Marks: Grant B

Material Source: Grant B at 2% above OMC

SEQUENCE 10	4.0	10.0	96	61.6	55.8	5.7	9.5	8.6	0.9	0.01416	0.01386	0.01401	0.00245	3,495
			97	61.5	55.8	5.7	9.4	8.6	0.9	0.01415	0.01387	0.01401	0.00245	3,492
			98	61.5	55.8	5.7	9.4	8.6	0.9	0.01413	0.01386	0.01400	0.00245	3,493
			99	61.7	56.0	5.7	9.5	8.6	0.9	0.01413	0.01385	0.01399	0.00245	3,509
			100	61.6	55.9	5.7	9.5	8.6	0.9	0.01412	0.01384	0.01398	0.00245	3,508
COLUMN AVERAGE				61.6	55.9	5.7	9.5	8.6	0.9	0.01414	0.01386	0.01400	0.00245	3,500
STANDARD DEV.				0.1	0.1	0.0	0.0	0.0	0.0	0.00002	0.00001	0.00001	0.00000	8
SEQUENCE 11	2.0	2.0	96	11.4	9.3	2.1	1.7	1.4	0.3	0.00376	0.00372	0.00374	0.00066	2,176
			97	11.3	9.3	2.1	1.7	1.4	0.3	0.00376	0.00372	0.00374	0.00065	2,171
			98	11.3	9.2	2.1	1.7	1.4	0.3	0.00376	0.00372	0.00374	0.00065	2,168
			99	11.4	9.3	2.1	1.7	1.4	0.3	0.00375	0.00372	0.00373	0.00065	2,172
			100	11.3	9.2	2.1	1.7	1.4	0.3	0.00376	0.00372	0.00374	0.00065	2,155
COLUMN AVERAGE				11.3	9.2	2.1	1.7	1.4	0.3	0.00376	0.00372	0.00374	0.00065	2,169
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	8
SEQUENCE 12	2.0	4.0	96	21.2	19.1	2.1	3.3	2.9	0.3	0.00805	0.00796	0.00800	0.00140	2,090
			97	21.3	19.1	2.1	3.3	2.9	0.3	0.00806	0.00795	0.00801	0.00140	2,095
			98	21.2	19.0	2.2	3.3	2.9	0.3	0.00805	0.00796	0.00800	0.00140	2,086
			99	21.2	19.1	2.1	3.3	2.9	0.3	0.00806	0.00796	0.00801	0.00140	2,090
			100	21.2	19.1	2.1	3.3	2.9	0.3	0.00805	0.00796	0.00800	0.00140	2,090
COLUMN AVERAGE				21.2	19.1	2.1	3.3	2.9	0.3	0.00805	0.00796	0.00800	0.00140	2,090
STANDARD DEV.				0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00000	0.00000	0.00000	3
SEQUENCE 13	2.0	6.0	96	34.7	31.5	3.2	5.3	4.8	0.5	0.01104	0.01088	0.01096	0.00192	2,522
			97	34.7	31.5	3.2	5.3	4.8	0.5	0.01105	0.01088	0.01096	0.00192	2,517
			98	34.9	31.7	3.2	5.3	4.9	0.5	0.01104	0.01087	0.01096	0.00192	2,534
			99	34.8	31.6	3.2	5.3	4.9	0.5	0.01104	0.01087	0.01096	0.00192	2,531
			100	35.0	31.8	3.2	5.4	4.9	0.5	0.01104	0.01087	0.01095	0.00192	2,549
COLUMN AVERAGE				34.8	31.6	3.2	5.3	4.9	0.5	0.01104	0.01087	0.01096	0.00192	2,531
STANDARD DEV.				0.1	0.1	0.0	0.0	0.0	0.0	0.00000	0.00001	0.00000	0.00000	12

Project Name: I35/SH74 Interchange (Ramps A-D)

Identification Marks: Grant B

Material Source: Grant B at 2% above OMC

SEQUENCE 14	2.0	8.0	96	48.9	44.5	4.5	7.5	6.8	0.7	0.01296	0.01271	0.01284	0.00225	3,039
			97	48.8	44.4	4.4	7.5	6.8	0.7	0.01295	0.01270	0.01283	0.00225	3,035
			98	48.8	44.4	4.4	7.5	6.8	0.7	0.01295	0.01270	0.01283	0.00225	3,036
			99	48.9	44.4	4.4	7.5	6.8	0.7	0.01294	0.01270	0.01282	0.00224	3,040
			100	49.0	44.6	4.4	7.5	6.9	0.7	0.01294	0.01270	0.01282	0.00224	3,053
COLUMN AVERAGE				48.9	44.5	4.4	7.5	6.8	0.7	0.01295	0.01270	0.01283	0.00225	3,041
STANDARD DEV.				0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00000	0.00001	0.00000	7
SEQUENCE 15	2.0	10.0	96	61.6	55.9	5.7	9.5	8.6	0.9	0.01457	0.01426	0.01441	0.00252	3,401
			97	61.6	55.9	5.7	9.5	8.6	0.9	0.01457	0.01424	0.01441	0.00252	3,405
			98	61.9	56.2	5.7	9.5	8.6	0.9	0.01455	0.01424	0.01440	0.00252	3,423
			99	61.7	56.0	5.7	9.5	8.6	0.9	0.01455	0.01423	0.01439	0.00252	3,415
			100	61.8	56.1	5.7	9.5	8.6	0.9	0.01453	0.01422	0.01438	0.00252	3,424
COLUMN AVERAGE				61.7	56.0	5.7	9.5	8.6	0.9	0.01456	0.01424	0.01440	0.00252	3,414
STANDARD DEV.				0.1	0.1	0.0	0.0	0.0	0.0	0.00002	0.00001	0.00001	0.00000	10

TESTED BY

RLB

DATE

11-06-2023

Boudreau Engineering, Inc.

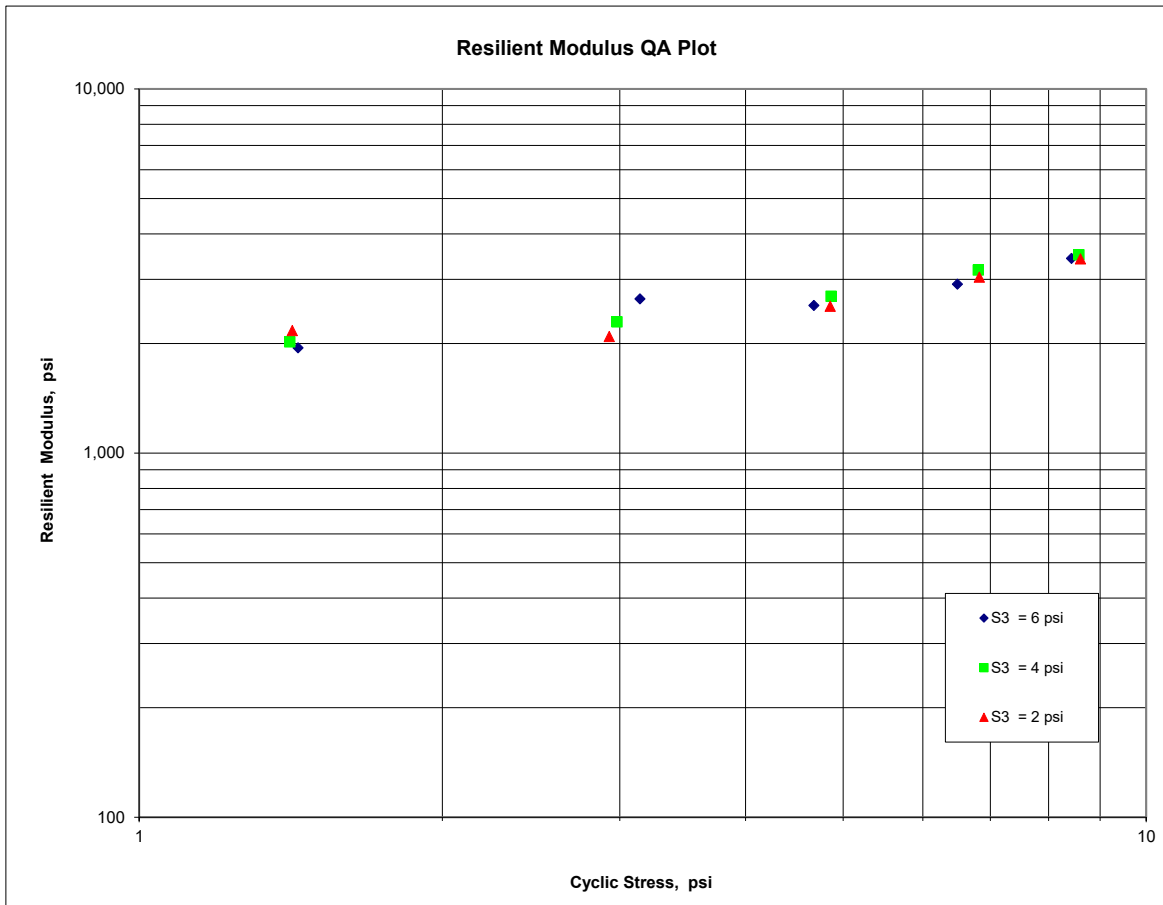
AASHTO T307-99

FIGURE 1 - Logarithmic Plot of Resilient Modulus (M_R) vs Cyclic Stress (S_C)

1. PROJECT NO(S):	Arrowhead #1875 [JP:32802(04)]
2. PROJECT NAME:	I35/SH74 Interchange (Ramps A-D)
3. SOURCE OF MATERIAL:	Grant B at 2% above OMC
4. REMOLDING TARGETS:	95% Maximum Dry Density at 17.7% Moisture Content
5. LAYER TYPE (1 - subgrade, 2 - base/subbase)	1
6. MATERIAL TYPE (Type 1 or Type 2)	2
7. TEST DATE	11-06-2023

$$M_R = K_1 (S_C)^{K_2} (S_3)^{K_5}$$

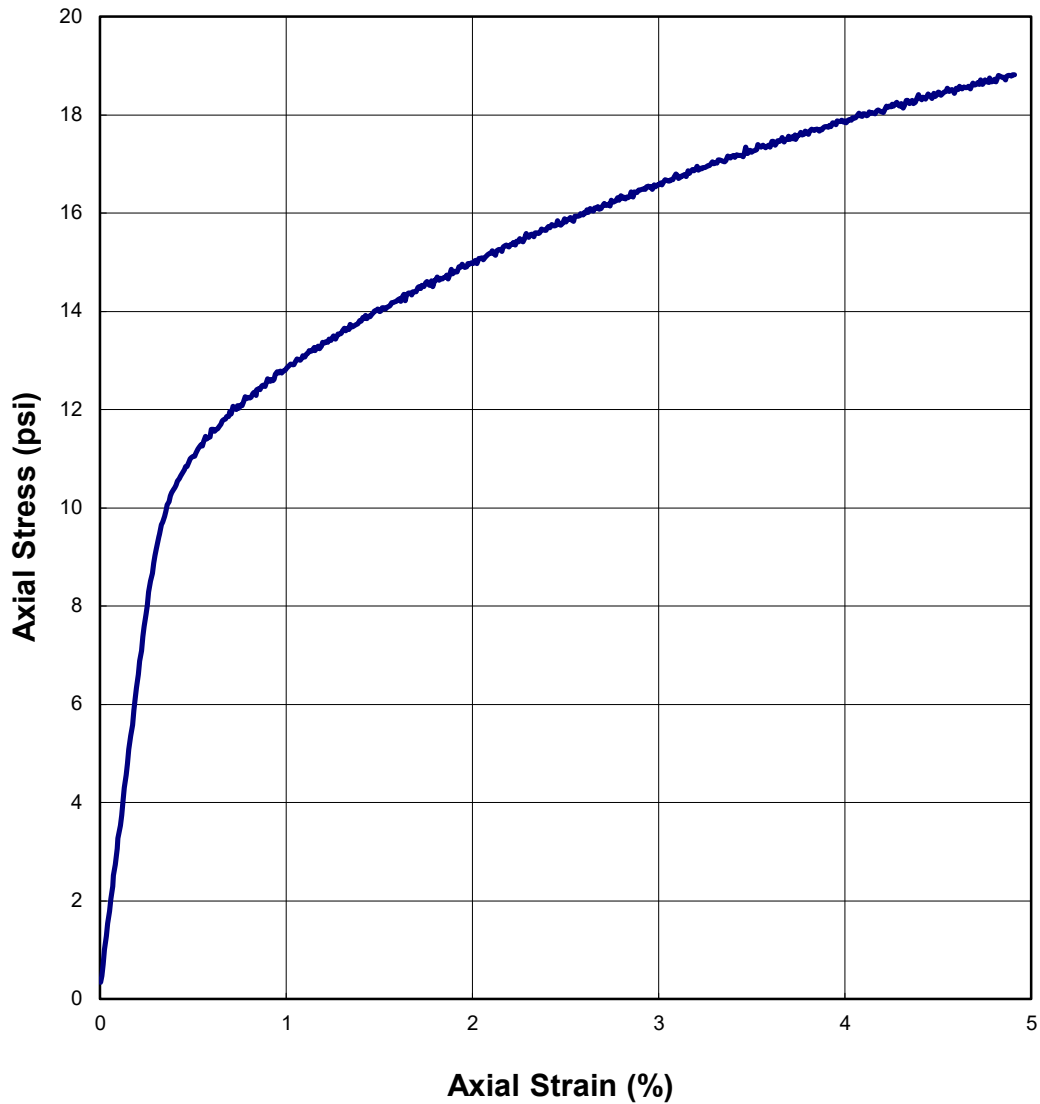
K1 =	1,721
K2 =	0.28473
K5 =	0.02078
R ² =	0.88



AASHTO T307-99

FIGURE 2 - Quick Shear Stress vs Strain

1. PROJECT NO(S):	Arrowhead #1875 [JP:32802(04)]
2. PROJECT NAME:	I35/SH74 Interchange (Ramps A-D)
3. SOURCE OF MATERIAL:	Grant B at 2% above OMC
4. REMOLDING TARGETS:	95% Maximum Dry Density at 17.7% Moisture Content
5. LAYER TYPE (1 - subgrade, 2 - base/subbase)	<u>1</u>
6. MATERIAL TYPE (Type 1 or Type 2)	<u>2</u>
7. TEST DATE	<u>11-06-2023</u>



AASHTO T307-99 SUMMARY SHEET
Resilient Modulus of Subgrade Soils and Untreated Base/Subbase Materials

PROJECT NO(S): Arrowhead #1875 [JP:32802(04)]
PROJECT NAME: I35/SH74 Interchange (Ramps A-D)
COUNTY/STATE NAME: McClain/Oklahoma
SOURCE OF MATERIAL: Grant B at 2% above OMC
REMOLDING TARGETS: 95% Maximum Dry Density at 17.7% Moisture Content
MATERIAL TYPE (Type 1 or Type 2) 2
TEST DATE 11-06-2023

CLIENT: ODOT
OPTIMUM MOISTURE CONTENT, %: 15.7
MAXIMUM DRY DENSITY, pcf: 116.3
95% MDD, pcf: 110.5

NET DIAMETER, in: 2.9
INITIAL SPECIMEN HEIGHT, in: 5.7
WET WEIGHT, g: 1266.1
COMPACTION WATER CONTENT, %: 17.7
COMPACTION DRY DENSITY, pcf: 110.1
MOISTURE CONTENT AFTER Mr TEST, %: 17.4

PRECONDITIONING-PERMANENT STRAIN>5% N
TESTING-PERMANENT STRAIN>5% N
NUMBER OF LOAD SEQUENCES COMPLETED 15
QUICK SHEAR TEST Y

COLUMN #	1	2	4	5	6	7	8	9	10	11	12	13	14	15
PARAMETER	Chamber Confining Pressure	Nominal Maximum Axial Stress	Actual Applied Max. Axial Load	Actual Applied Cyclic Load	Actual Applied Contact Load	Actual Applied Max. Axial Stress	Actual Applied Cyclic Stress	Actual Applied Contact Stress	Recov. Def. LVDT #1 Reading	Recov. Def. LVDT #2 Reading	Average Recov Def. LVDT 1 and 2	Resilient Strain	Actual Resilient Modulus	Predicted Resilient Modulus*
DESIGNATION	σ_3	σ_{cyclic}	P_{max}	P_{cyclic}	$P_{contact}$	σ_{max}	σ_{cyclic}	$\sigma_{contact}$	H_1	H_2	H_{avg}	ϵ_r	M_r	M_r
UNIT	psi	psi	lbs	lbs	lbs	psi	psi	psi	in	in	in	in/in	psi	psi
PRECISION														
SEQUENCE 1	6.0	2.0	10.7	9.4	1.3	1.6	1.4	0.2	0.00421	0.00424	0.00423	0.00074	1,944	2,175
SEQUENCE 2	6.0	4.0	22.6	20.5	2.2	3.5	3.1	0.3	0.00677	0.00676	0.00677	0.00118	2,652	2,650
SEQUENCE 3	6.0	6.0	33.8	30.5	3.3	5.2	4.7	0.5	0.01056	0.01045	0.01050	0.00184	2,544	2,974
SEQUENCE 4	6.0	8.0	46.8	42.3	4.5	7.2	6.5	0.7	0.01283	0.01268	0.01276	0.00223	2,908	3,228
SEQUENCE 5	6.0	10.0	60.7	54.9	5.8	9.3	8.4	0.9	0.01420	0.01393	0.01406	0.00246	3,424	3,440
SEQUENCE 6	4.0	2.0	10.9	9.2	1.7	1.7	1.4	0.3	0.00402	0.00397	0.00399	0.00070	2,019	2,157
SEQUENCE 7	4.0	4.0	21.6	19.4	2.2	3.3	3.0	0.3	0.00750	0.00738	0.00744	0.00130	2,291	2,628
SEQUENCE 8	4.0	6.0	34.9	31.7	3.2	5.4	4.9	0.5	0.01042	0.01022	0.01032	0.00181	2,694	2,949
SEQUENCE 9	4.0	8.0	48.8	44.4	4.4	7.5	6.8	0.7	0.01237	0.01211	0.01224	0.00214	3,180	3,201
SEQUENCE 10	4.0	10.0	61.6	55.9	5.7	9.5	8.6	0.9	0.01414	0.01386	0.01400	0.00245	3,500	3,411
SEQUENCE 11	2.0	2.0	11.3	9.2	2.1	1.7	1.4	0.3	0.00376	0.00372	0.00374	0.00065	2,169	2,126
SEQUENCE 12	2.0	4.0	21.2	19.1	2.1	3.3	2.9	0.3	0.00805	0.00796	0.00800	0.00140	2,090	2,590
SEQUENCE 13	2.0	6.0	34.8	31.6	3.2	5.3	4.9	0.5	0.01104	0.01087	0.01096	0.00192	2,531	2,907
SEQUENCE 14	2.0	8.0	48.9	44.5	4.4	7.5	6.8	0.7	0.01295	0.01270	0.01283	0.00225	3,041	3,155
SEQUENCE 15	2.0	10.0	61.7	56.0	5.7	9.5	8.6	0.9	0.01456	0.01424	0.01440	0.00252	3,414	3,362

*Predicted Mr values determined using the equation shown on Figure 1 sheet.

TESTED BY RLB DATE 11-06-2023

LABORATORY: Boudreau Engineering, Inc.
Lawrenceville, Georgia