GEOTECHNICAL REPORT

KETCHUM PUBLIC SCHOOLS
ELEMENTARY SCHOOL ADDITION & RENOVATION

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GEOTECHNICAL SERVICES

SUBSURFACE EXPLORATION

Ketchum Elementary School Renovation
404 N Boston Ave
Ketchum, Oklahoma

PROJECT NO. 2030-0549

STANDARD TESTING AND ENGINEERING COMPANY
Since 1951

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October 22, 2020

Ketchum Public Schools
404 N. Boston
Ketchum, OK 74349

Attn: Mrs. Dayna Boynton, AIA
Vice President

Re: Subsurface Exploration
Ketchum Elementary School Renovation
404 N Boston Ave
Ketchum, Oklahoma

Dear Mrs. Boynton:

Standard Testing & Engineering, LLC (Standard Testing) is pleased to present the report covering the subsurface exploration for the subject project. This study was authorized by receipt of the signed "Agreement of Services" contract, dated September 9th, 2020.

Standard Testing conducted a geotechnical investigation at the site of the Ketchum Elementary School Renovation project in Ketchum, Oklahoma. This report contains the detailed results of the geotechnical investigation, including foundation recommendations, pavement recommendations, and construction considerations.

The subsurface soils consist of approximately 11 to 12 feet of fat clay with various amounts of sand overlying limestone rock which exhibit high plasticity characteristics. The estimated potential vertical rise of the soil is 2.6 inches.

Foundation recommendations include: (1) Shallow Footings or (2) Drilled Pier Foundation.

We trust that the results and recommendations contained herein will permit adequate economical design and construction of the proposed structure. Unless you specify otherwise, we will keep samples obtained from these borings in our Oklahoma City laboratory for the next thirty (30) days.

We appreciate the opportunity to assist on this project. Please call on us if we can be of further service.

Respectfully submitted,
STANDARD TESTING & ENGINEERING, LLC

Antonio Franco, E.I.
Staff Geotechnical Engineer

Roy Khalife, P.E.
Geotechnical Engineer

Project No. 2030-0549
Account No. 0230BOY20

STANDARD TESTING AND ENGINEERING COMPANY

GEOTECHNICAL SERVICES

SUBSURFACE EXPLORATION

Ketchum Elementary School Renovation
404 N Boston Ave
Ketchum, Oklahoma

PROJECT NO. 2030-0549

PREPARED FOR

Boynton Williams & Associates
2651 East 21st Street, Suite 510
Tulsa, OK 74114

PREPARED BY

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I certify my e-signature for the study entitled "Subsurface Exploration."
Dated 10/22/2020

October 22, 2020

STANDARD TESTING AND ENGINEERING COMPANY GEOTECHNICAL SERVICES

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Section 1

INTRODUCTION

1.1 Authorization

This report presents the results of a subsurface exploration performed by Standard Testing & Engineering, LLC (Standard Testing) in accordance with the proposal (P-20144) prepared for Mrs. Dayna Boynton, dated July 10th, 2020, and identified as Standard Testing project number 2030-0549. This geotechnical study was authorized by receipt of the signed "Agreement of Services" contract, dated September 9th, 2020.

1.2 Purpose and Scope

A geotechnical investigation was performed for the purpose of (1) determining the subsurface conditions, (2) evaluating the bearing capacity and plasticity characteristics of the soils, and (3) making recommendations concerning the earthwork, pavement, and foundation systems for the facility.

Two (2) exploratory borings (building borings B-1 and B-2) were drilled to depths ranging from 12 to 13 feet. The depths were terminated earlier due to the auger refusal. The boring depths and types of testing were performed according to the scope of work proposed by Standard Testing and accepted by Mrs. Boynton. Narrative descriptions of our findings and recommendations are contained in the body of this report. A site and boring location plan, the boring logs, the soil profile, and a summary sheet of laboratory test results are included in the Appendices of this report.

1.3 Project Location and Description

It is understood that the Ketchum Elementary School Renovation is proposed to be additions at the existing Ketchum Elementary School on 404 N Boston Ave in Ketchum, Oklahoma. Maximum column loads for the proposed facility are unknown while we are preparing this geotechnical report.

If the project is not as described or has changed, Standard Testing must be notified in order to reevaluate the recommendations for the project.

Section 2

FIELD EXPLORATION

2.1 Drilling Information

The field exploration work was performed between the 24th and 25th of September, 2020. Conditions at the site were investigated with two (2) borings at the locations indicated on the site and boring location plan, included in Appendix "A." The boring surface elevations were measured with respect to a Temporary Bench Mark (TBM) established at the F.F. of the existing building. The Temporary Bench Mark (TBM) location is also shown in the site and boring location plan in Appendix “A.” Boring surface elevations, rounded to the nearest foot, are reported on the individual boring logs, included in Appendix “A.”

The benchmark has an assigned relative elevation of 100 feet. Boring depths were 12 to 13 feet within the facility’s footprint. Borings were terminated due to auger refusal. For accurate sampling, cuttings were observed continuously during drilling with specific samples being taken at distinct lithologic changes. The equipment used, field tests performed, and soil samples taken are discussed below.

2.2 Equipment Used

Two (2) borings were drilled with a truck-mounted CME-55 rotary drilling unit equipped with 3.25" I.D. X 7.25" O.D. hollow stem augers (HSA). Standard penetration tests (SPT) used a 1.375" ID split spoon sampler driven by an automatic hammer utilizing a 140 lb. weight falling 30 inches.

2.3 Testing and Sampling Performed

Standard penetration tests were performed in order to estimate the shear strengths of the soils in their natural state. The test was conducted as specified by ASTM D1586, "Penetration Test and Split-Barrel Sampling of Soils." The in-situ bearing strength is related to the N-value from this test. "N" is the number of blows required to drive a split-spoon sampler twelve inches, after a 6-inch seating, into undisturbed soil. The soil samples recovered in the split-spoon barrel were removed from the sample tool in the field, visually classified, and labeled according to boring number and depth. Results of the standard penetration tests are denoted at their respective depths on the boring logs.

Depths of individual split spoon (standard penetration tests) and grab samples are indicated on the boring logs included in Appendix "B." All samples were labeled and sealed in water tight, protective containers and returned to the laboratory for further evaluation and testing.

2.4 Subsurface Conditions

The soils encountered consist of fat clay with various amounts of sand overlying limestone rock. The cohesive soils were found to be very soft to stiff in consistency. Rock material (i.e., defined by standard penetration test refusal) was encountered in the indicated borings at the relative elevation shown in the following table:

Table 1: Relative Elevation of Rock Material

Boring No.	Surface Elevation (feet)	Rock Depth (feet)	Rock Elevation (feet)	Rock Material
B-1	99.0	11.0	88.0	Limestone
B-2	99.0	12.0	87.0	Limestone

2.5 Groundwater

During drilling and at completion of drilling operations, groundwater was encountered in the indicated boring at a depth shown in the elevation of groundwater table. Presence of water should be anticipated in any excavation. Water travelling through soil (subsurface water) is often unpredictable and may be present at shallow depths. Due to the seasonal changes in groundwater and the unpredictable nature of groundwater paths, groundwater levels will fluctuate. Therefore, it is necessary during construction to be observant for groundwater seepage in excavations in order to assess the situation and make necessary changes. We cannot assume responsibility for difficulties experienced during construction or for future operational problems due to elevation or volume of water encountered.

Boring No.	Surface Elevation (feet)	Water Depth (feet)	Water Elevation (feet)
B-2	99.0	5.5	93.5

Section 3
LABORATORY TESTING

Laboratory testing was performed in order to determine the plasticity characteristics of the subsurface materials as well as confirm the soil classifications.

3.1 Tests Performed

- Moisture content tests were performed on split spoon and bag samples, in accordance with ASTM D2216, to determine the in-situ moisture conditions.

- Density tests were performed on intact split spoon samples in accordance with ASTM D7263 Method A.

- Atterberg limits tests were performed on split spoon and bag samples to determine the plasticity characteristics and swell potential of the soil. The tests were performed in accordance with ASTM D4318.

- Sieve analyses were performed on split spoon and bag samples, in accordance with ASTM D2487, for aid in soil classification. These soils were classified according to the Unified Soil Classification System (USCS) and the American Association of State Highway and Transportation Officials (AASHTO) soil classification system.

3.2 Laboratory Summary

General descriptions of the encountered soils together with visual and laboratory classifications and numerical values of the test results are on the boring logs and soil profile included in Appendix "B." A "Summary of Test Results" is included in Appendix "D."

Section 4

ENGINEERING EVALUATION AND RECOMMENDATIONS

4.1 Soil Conditions

A geotechnical concern at this site is the presence of expansive soils. The soils encountered in this investigation consist of fat clay with various amounts of sand overlying limestone rock. The cohesive soils were found to be very soft to stiff in consistency. These near surface soils exhibit high plasticity characteristics. Rock material (i.e., defined by standard penetration test refusal) was encountered in the borings. The plasticity characteristics of the soils encountered indicate that these soils are active for consideration of soil expansion on foundation design. The plasticity index (PI) of a soil indicates a soil's potential to shrink or swell with changes in its moisture content. The near-surface soils at this site generally display high plasticity characteristics and were found in a very moist condition. Atterberg limits test results indicate that on-site plastic soils have PI's up to 38. These soils should be considered active and should be expected to undergo significant volume change upon moisture variation.

These soils are expected to undergo expansion upon moisture increase and, conversely, contraction upon moisture decrease. Oklahoma is well known for its heaving clays and the foundation problems associated with soil expansion and uplift pressures. These soil characteristics accompanied with the seasonal variability in soil moisture content caused by the regional climatic conditions often result in foundation and structural damage. Accordingly, the swelling characteristic of the soil is a primary concern and the Potential Vertical Rise (PVR) becomes an important factor in the foundation design of the proposed facility.

The maximum PVR value computed for this site is 2.6 inches. The procedure used to predict the PVR was developed by Standard Testing based on AASHTO test method T258 and modified to incorporate our experience with actual Oklahoma soils. The displacement associated with the PVR is a relatively long-term effect, associated with significant moisture changes in the soil, and applies to free surface conditions. A maximum PVR of 0.75 inch or less is generally considered tolerable for most structures. These soils should be removed from underneath the slabs and replaced with inert fill as specified in the Earthwork Recommendations Section of this report.

4.2 Seismic Site Class

Based on the results of our investigation, this site is classified as Seismic Site Class C. This recommendation is based on the criteria given in Table 20.3-1 of the ASCE/SEI 7-10, 2015, entitled "Site Class Definitions." According to ASCE/SEI 7-10, section 20.1, if the subsurface data is not known for the full 100-ft depth, then engineering judgement may be used to classify the site. Based on the shallow depth of rock at the site, and the assumption that rock continues in the subsurface past 100 feet in depth, the Seismic Site Class is assumed C. If any boring should indicate that rock material is not present beneath the depth, then Seismic Site Class D should be used.

4.3 Earthwork Recommendations

Building Pad Construction

A critical geotechnical consideration at this site is the swelling soils. If slab-on-grade construction is to be used for the building floor at this site, construction of an inert fill building pad is advisable. The amount of ground surface movement that can be tolerated by the structure should be evaluated by the designer (a value of 0.75 inch or less may be used for most structures) and the corresponding amount of removal and replacement or over ground fill should be performed as indicated in the following options:

Option 1: Cut and Fill

- Remove the required amount of existing soil (see following table) and replace that soil with inert fill, meeting all requirements given herein,

Table 2: Cut and Fill Building Pad Requirements

Depth of Removal and Replacement Soil (feet)*	Estimated Potential Vertical Rise (PVR) (inches)
0	2.6
5	1.0
6	0.7
7	0.5

***Below existing site grade**

or

Option 2: Fill Only

- Place the required amount or more of inert fill (see following table), meeting all requirements given herein, over the native soils.

Table 3: Over Ground Inert Fill Building Pad Requirements

Depth of Over Ground Inert Fill Building Pad (feet)**	Estimated Potential Vertical Rise (PVR) (inches)
0	2.6
5	1.0

6	0.7
7	0.5

****Above existing site grade**

Only low plasticity on-site soils or imported inert fill should be used for fill under structure. Inert fill should meet the following requirements:

Inert Fill Requirements

Amount finer than 2-inch sieve	100%
Amount finer than No. 200 Sieve	12% minimum and, if PI ≤ 7, 60% maximum
Liquid Limit	35 maximum
Plasticity Index (PI)	5 to 15

Subgrade Preparation

The existing subgrade should be:

- Stripped of topsoil, vegetation, pavement, fills and any other deleterious materials,
- Over-excavated to the required depth to reduce PVR to a level appropriate for the structural system to be used referring to the cut and fill building pad requirements and overground inert fill building pad requirements tables and extended to at least five (5) feet beyond building footprint,
- Proofrolled, including removing and replacing any soft material which exhibits permanent subgrade deformation exceeding 0.5 inch when traversed by a loaded truck with a rear axle load of approximately 16,000 lbs./axle, and
- Tested for moisture and density and, if deficient, scarified to a depth of 8 inches, moisture conditioned and compacted to 95 percent or more of standard Proctor maximum dry density (ASTM D698).

Removal of soft subgrade should not exceed a 3-foot depth below final top of subgrade elevation, nor extend below the static groundwater elevation. If such a depth is reached without encountering stable subgrade conditions, 12 inches of ODOT Type A aggregate base should be placed in the bottom of the over-excavated area and suitable fill material placed and compacted to bring the subgrade to design elevation.

Compaction Requirements

All fill in the structural areas should be:

- Compacted to at least 95 percent of standard Proctor maximum dry density (ASTM D698) at a moisture content within -2% to +2% of the optimum.

- Compacted to at least 95 percent of modified Proctor maximum dry density (ASTM D1557) at a moisture content near optimum for ODOT Type A aggregate base.
- Placed in lifts not to exceed eight (8) inches in compacted thickness.
- Tested for field density for each lift of fill at frequencies of every 1,500 sq. ft. in areas under structure and 2,500 sq. ft. in areas under pavement. For utility trenches, test field density at frequencies of 100 linear foot of trench and at frequencies of 50 linear foot of any utility underneath pavement or other structure.

Moisture should be maintained up until the placement of concrete in structural areas to prevent shrinkage (and subsequent post-construction swell) of the soil.

Drainage

The ground immediately adjacent to the foundation shall be sloped away from the building at a slope of not less than six (6) inches vertical fall in the first ten (10) feet measured perpendicular to the face of each wall. Trees and large bushes for landscaping should not be permitted within this 10-foot zone adjacent to the building. General site slopes, drainage swales, or storm drains shall be constructed to provide 1.0 percent slope, or more, along drainage paths which serve to discharge storm water from the site. If surface soil should be left exposed (e.g., flower beds) near the structure foundation, then it is suggested that efforts be taken to maintain such areas at a constant moisture in order to avoid swell/shrinkage of the soil that will affect the foundation system. If a non-expansive (inert fill) building pad is constructed such that it extends below the adjacent higher plasticity soils, the bottom of such excavation shall be cut at a slope of not less than 1.0 percent to provide a subsurface sump. Drainage shall be provided from this sump in the base of the non-expansive building pad by an underdrain with a slope of at least 1.0 percent discharging either to daylight or to a permanent, automated sump pump system. The underdrain at the sump shall extend below the excavation and shall consist of a perforated nonmetallic underdrain conduit (ODOT 726.02(b)6), 4.0 inches diameter or larger, wrapped in drainage geotextile (ODOT 712.03) and surrounded by at least 6 inches of coarse cover aggregate (ODOT 703.04) on all sides.

The underdrain system mentioned in the above paragraph can be waived if a clay cap is placed surrounding the building footprint and all utility line trenches sealed with a clay plug at the building perimeter.

Clay cap should be:

- Over-excavated at least one foot deep below final grade and be extended horizontally to at least five (5) feet beyond edge of the exterior wall;

- Placed with geofabric over the excavated subgrade soils;
- Backfilled with compacted CLAYS of PIs greater than twenty-five (25); and
- Sloped away from the building at a slope of not less than six (6) inches vertical fall in the first ten (10) feet.

On-site CLAYS with PIs greater than twenty-five may be used for the clay cap.

4.4 Foundation Recommendations

Considering the soils encountered and based on the test results of this exploration, the following foundation design parameters are recommended for the indicated foundation systems:

Footing Foundation System

Shallow foundations (e.g. spot or continuous cast-in-place concrete footings) may be used to support the new structures at this site. Footings must be placed a minimum of 2.0 feet below finished grade to provide adequate protection from frost action. Footings may be used with allowable net bearing capacity of 2,000 psf on compacted inert fills or 3,000 psf on 2 feet of properly compacted ODOT Type A aggregate base as described in the Earthwork Recommendations Section of this report. Footings should have a width of at least 16 inches.

Continuous footings and spot footings are expected to undergo no more than 1.0-inch settlement when designed for the recommended bearing pressure.

If this addition is to tie into an existing structure which is supported on shallow footings, we recommend that the proposed addition also be supported with shallow footings. Care should be exercised during the construction of foundations adjacent to the existing building to avoid negatively influencing the existing structure. It is recommended that, where possible, excavations below existing footings not extend below an imaginary plane extending out and down from the outside edge of the existing footings at a slope approximately 2H: 1V. Even with these criteria, excavations that extend below the level of existing foundations should be backfilled the same day they are excavated. Where this is impractical, shoring or underpinning of existing foundation may be required.

Some overlap in stress distribution from new and existing footings may occur, which may cause minor movement of the existing footings and supported structures. Maintaining a clear distance at least equal to the width of the new column spread footings between the edges of new and existing footings could significantly reduce the risk. If connections between the new and existing structures are required, such connections should be designed to allow for the anticipated differential movement.

Subgrade Improvement within Footing Area

Due to the presence of soft subgrade soils with low bearing capacities, encountered in boring B-2 E, near the shallow footing elevation, we recommend all footings to be verified as follows:

- Bearing Capacity should be verified by performing a Dynamic Cone Penetrometer (DCP) or Static Cone Penetrometer (SCP) test at the bottom of the footings where soft soils are encountered
- If the above methods show the loose subgrade soils within the new footing area does not meet the specified bearing capacity, the soft subgrade soils should be over-excavated a minimum depth of 2 foot below bottom of new shallow footings;
- The exposed excavated soils should be compacted by using Jumping Jack or equivalent equipment,
- Either ODOT Type A aggregate base or inert fills or on-site low PI soils (PI between 5 and 15) should then be placed over up to the bottom of new footings.

Moisture should be maintained up prior to pouring concrete.

Pier Foundation System

Structures may be designed to be supported by drilled cast-in-place concrete piers founded 3.0 feet or more below the depths indicated in the "Relative Elevation of Rock Material" table provided in Section 2.4 of this report. Using this type of foundation, each column is supported on a single drilled pier and the building walls are placed on grade beams supported by a series of piers. Loads applied to the piers are transmitted to the rock partially through skin friction along the sides of the pier and partially through end bearing pressure.

All drilled piers should:

- Extend at least 3.0 feet or at least one (1) pier diameter, whichever is deeper, beyond the elevation indicated in the "Elevation of Rock Material" table provided in Section 2.4 of this report,
- Have an aspect ratio (length/diameter) between three (3) and thirty (30),
- Have a spacing between individual piers of three diameters or more (clear spacing),
- Be adequately reinforced with the reinforcement extending into the grade beams and/or pier caps, and
- Have a diameter of at least 18 inches.

Piers may be proportioned using an allowable net end bearing capacity of 20,000 psf and an allowable skin friction capacity of 1,260 psf for that portion of the pier in direct contact with the Limestone. The allowable net bearing capacity and allowable skin friction capacity both include a factor of safety of 3.0. Uplift of the piers can be resisted by using the same skin friction values plus for the pier weight (i.e. 150 pcf x Pier Area x length of Pier). Maximum service load vertical displacement of piers designed in this manner is expected to be on the order of 0.4% of the pier base diameter.

If groundwater is encountered during pier excavation and cannot be dewatered, concrete may be placed by tremie-pipe method so as to assure no contamination of the fresh concrete by groundwater or drilling fluids. A sufficient head of plastic concrete should be maintained within the casing at all times during its extraction in order to overcome the hydrostatic groundwater pressure outside the casing.

4.5 Concrete Slabs

Concrete slabs-on-grade for floors should be constructed as follows:

- The subgrade, inert fill, and/or soil building pad should be prepared as described in the Earthwork Recommendations section of this report.
- Four (4) inches or more of granular base, meeting the following requirements, should be placed over the subgrade:
  - passing the 1.5 inches sieve……………………………………………………100 %
  - passing the #200 sieve………………………………………………..15 % or less
  - plasticity index…………………………………………………………………6 or less
- At the time of concrete placement, the granular base should be moist, but free of any standing water.
- The concrete slab should be placed a minimum of four (4) inches thick in lightly loaded areas and up to six (6) inches thick in heavily loaded areas and should not be tied into the footings, stemwalls, or structural frame. If it is necessary to tie the concrete slab into the foundation walls, exterior walls, and/or pitwalls, the slab should be jointed no more than 10 to 15 feet from the point of the restraint (ACI 360R-10, Section 14.7). Other control joints should be provided, each way, at a spacing of 24 to 36 times the slab thickness but no more than 18 feet. Refer to ACI 360R-10, Section 6.1.3 and Figure 6.6 for additional guidance on joint spacing.

If floor coverings susceptible to moisture damage by moist floor conditions (capillary moisture) are to be used, a vapor retarder consisting of one or more polyethylene or polypropylene fabric reinforcement layers with one or more bonded polyethylene film layers, at least 10 mils in total thickness, should be placed below the slab. The vapor retarder should be lapped 6 inches and taped at joints and fitted around all service openings. Section 5.2.3.2 of ACI 302.1R-15 provides the most current industry recommendations for use and placement of vapor retarders. Figure 5.2.3.2, in ACI 302.1R-15, provides guidance for determining whether to place the vapor retarder above or below the "granular material" below the slab.

Concrete slabs can be designed using a modulus of subgrade reaction, k_s, of 140 pci for compacted inert fill described in the Earthwork Recommendations Section of this report.

Elevated Floor Slabs

Floor slabs may be constructed so as to be elevated at least four (4) inches from the natural ground surface to avoid contact with the swelling soils or non-engineered fills. This may best be accomplished by casting the concrete over cardboard carton forms or “void” boxes. Such floor slabs must be designed to span between supporting structural elements without the aid of soil support. If floor slabs are designed and constructed to be elevated in this manner and the foundation elements are designed to counteract the soil swelling pressures, then the inert fill subgrade provisions in the Earthwork Recommendations Section of this report may be waived. We recommend that the elevated floor slab be structurally connected to the foundation elements and grade beams.

4.6 Grade Beams

Grade beams, supported by shallow footings or pier foundation systems, may be constructed so as to be elevated at least four (4) inches from the ground to avoid contact with the swelling soils. This may be best accomplished by casting the concrete over cardboard carton forms or “void” boxes.

4.7 Pavement Recommendations

Subgrade Preparation

Prior to the placement of fill or preparation of pavement subbase:

- The natural subgrade should be stripped of all topsoil, vegetation, pavement, fills and any other deleterious materials.
- The parking and drive areas should then be graded and shaped to facilitate drainage, with a minimum slope of 1/8 inch per foot.
- Next, the subgrade should be proofrolled, including removing and replacing any soft material which exhibits permanent subgrade deformation exceeding 0.5 inch when traversed by a loaded truck with a rear axle load of approximately 16,000 lbs./axle. Removal of soft subgrade should not exceed a 3-foot depth below final top of subgrade

elevation, nor extend below the static groundwater elevation. If such a depth is reached without encountering stable subgrade conditions, 12 inches of ODOT Type A aggregate base should be placed in the bottom of the overexcavated area and suitable fill material placed and compacted to bring the subgrade to design elevation.

- Once the subgrade has been satisfactorily proofrolled, the surface layer of the subgrade shall be scarified to a depth of 6 inches.

Pavement Sections

We estimate the CBR value of the near surface soils as 2.0 based on the borings. This would correspond to a modulus of subgrade reaction, k_s, of 50 pci, and a resilient modulus, M_r, of 2,000 psi.

Pavement sections were evaluated based on the AASHTO 1993 guidelines with the following assumptions. If traffic loads are greater than used in the analysis, Standard Testing must be notified in order to reevaluate the recommendations. No borings were completed within the pavement area. The prepared subgrade soils should be tested by *Standard Testing* to verify the assumptions and pavement section recommendations.

- Design Period = 20 years
- Reliability Level = 85% (flexible and rigid)
- Initial Serviceability Index = 4.5 (flexible and rigid)
- Terminal Serviceability Index = 2.0 (flexible and rigid)
- Combined Standard Error (S_0) = 0.5 (flexible) and 0.4 (rigid)
- Light duty (car parking) total design ESALs (W_{18}) = 99,000 (flexible) and 150,000 (rigid)
- Heavy duty (truck parking) total design ESALs (W_{18}) = 348,000 (flexible) and 500,000 (rigid)

We recommend that the following pavement sections be used:

Table 4: Pavement Sections

Pavement Type	Light Duty (inches)	Heavy Duty (inches)
Flexible Pavement		
Surface Course (S4)	2.0	1.5
Intermediate Course (S3)	-	2.5
Base Course (S3)	4.0	3.0
Aggregate Base (ODOT Type A)	8.0	8.0
Rigid Pavement		
Portland Cement Concrete	6.0	7.0
Aggregate Base (ODOT Type A)	8.0	8.0

All access lanes subject to delivery trucks, fuel truck, refuse pickup trucks, or fire trucks should consist of 7.0 inches of Portland cement concrete over 6.0 inches of aggregate base.

If stabilized soil subgrade is desired in lieu of aggregate base for flexible pavements, a mix design may need to be completed and additional recommendations shall be made during construction.

Figure 1: Graphic Representation of Recommended Pavement Sections

Materials and Construction

All materials and construction for base should be in accordance with the Oklahoma Department of Transportation (ODOT), "2009 Standard Specifications for Highway Construction," and the latest Special Provisions adopted by ODOT to supplement the Standard Specifications. ODOT Type "A" aggregate base should be compacted to not less than 95 percent modified Proctor maximum dry density (ASTM D1557). Compacted subgrade should be compacted to not less than 95% of the standard Proctor maximum dry density (ASTM D698) within -2 to +2 percentage points of the corresponding optimum moisture content. Compacted subgrade should extend the full width of the pavement section (i.e., including curb and gutter).

Concrete for paving should have a modulus of rupture, M_r, of at least 550 psi (compressive strength of approximately 3,500 psi or more), should be air entrained with 4 to 7 percent air, should have a cementitious materials content of at least 564 pcy, and should have a maximum water to cementitious materials ratio of 0.45. The concrete mix design submittal should adequately address the criteria of ACI 301, section 4, including documentation of strength test results. Control joints should be saw cut at least one-eighth (0.125) inch wide and one-quarter of pavement thickness deep as soon as possible after concrete reaches final set (i.e., approximately 8 to12 hours after placing the concrete), cleaned by high pressure air jet, and sealed with a suitable pavement joint sealing material to prevent intrusion of surface water into the pavement base. Control joints should be spaced as indicated in the following table:

Table 5: Recommended Transverse Joint Spacings

Concrete Thickness (inches)	Maximum Joint Spacing (feet)
6.0	15.0
7.0	15.0

4.8 Lateral Earth Pressure Parameters

Lateral earth pressure can be assumed to increase linearly with depth and may be represented as an equivalent fluid column equal to the effective unit weight of the soil times the appropriate coefficient of lateral earth pressure times the thickness of overlying soil at the depth in question. For consideration of lateral earth pressure, the effective unit weight of the soil is the weighted average, down to the depth in question, of the moist unit weight of the soil above the groundwater and the submerged unit weight of the soil below the groundwater. The following estimated parameters may be used for determining approximate lateral earth pressures for the retaining walls at this site:

Native Soils - Cohesion

γ =	120 pcf	moist unit weight
ϕ =	12°	angle of internal friction
c =	1,500 psf	apparent cohesion
k_a =	0.66	coefficient of active lateral pressure
k_p =	1.52	coefficient of passive lateral pressure
k_0 =	0.79	coefficient lateral earth pressure at rest

Inert Fill

γ =	110 pcf	moist unit weight
ϕ =	25°	angle of internal friction
c =	500 psf	apparent cohesion
k_a =	0.41	coefficient of active lateral pressure
k_p =	2.46	coefficient of passive lateral pressure
k_0 =	0.58	coefficient of lateral earth pressure at rest

The parameters for inert fill should be used only if the inert fill meets all requirements given in the Earthwork Recommendations Section of this report, testing has confirmed that the inert fill has an angle of internal friction of 25° or more, the slope of the native soil from the toe of the earth-retaining structure is no steeper than 1:1, and only inert fill is used in the backfill between the earth-retaining structure and the native soil slope. If these criteria are not met, then the appropriate parameters for the native soil should be used.

Note: P_{water} (Hydrostatic Pressure; psf) = 62.4 (pcf) x h (ft); h=depth below water level

Ultimate resistance to lateral sliding at the bottoms of footings may be calculated based on a coefficient of friction of 0.35. Sliding resistance may also include ultimate passive pressure against the front of the footings which can be calculated using an equivalent fluid unit weight of 270 pcf. The designer may use the passive pressure in this zone only if there is a certainty of no loss of toe soil. If necessary, additional sliding stability may be derived from the use of a key embedded into soil beneath the base and utilizing 270 pcf equivalent fluid unit weight for passive lateral earth pressure. A factor of safety of at least 1.5 should be used with stability calculations involving lateral earth pressures. The safety factor should be computed as the sum of resisting forces or moments divided by the sum of driving forces or moments.

4.9 Excavation Requirements (OSHA Requirements)

Excavations adjacent to structures or public ways or to which personnel will enter which are more than 5 feet deep must be either be supported (e.g., shoring or trench box) or laid back to a stable slope. If excavations less than 5 feet in depth appear to be unstable, they must also be shored or sloped sufficiently to protect the employees working within them. The recommended slopes provided herein are based on the Occupational Safety and Health Administration (OSHA) requirements and are intended for construction operations. Permanent slopes should not be constructed utilizing the slope angles described herein.

Trees, boulders, and other surface encumbrances, located so as to create a hazard to employees involved in excavation work or in the vicinity thereof at any time during operations, shall be removed or made safe before the excavation begins. Existing underground utility lines shall also be protected during excavation. The excavation slopes specified herein have been determined to hold back the earth banks and not more than 2 feet of stockpiled soil within a distance of 5 feet from the edge of the excavation. Any excavated soil at the edge of the excavation must be stockpiled at a slope of 1.5 or more horizontal to 1.0 vertical. Additionally, no equipment should be allowed within 5 feet of the trench edge.

Someone capable of identifying existing and predictable hazards and who has the authorization to take prompt corrective measures (i.e., a "competent person") must inspect the excavations daily for any condition which may adversely affect the reliability and safety of the excavation. The excavations must also be inspected after each rainstorm or when any change in condition occurs that can increase the possibility of a cave-in or slide. If evidence of possible cave-ins or slides is apparent, all work in the excavation shall cease until the necessary precautions for sloping or bracing have been taken to safeguard the employees and the excavation. Any loose soil shall be scaled from the slope and removed from the excavation to protect workers against falling soil.

An adequate means of egress must be provided within 25 feet of lateral travel to any worker in all trench excavations 4 feet or more in depth. The means of egress may be a ladder or a ramp of stable soil having a slope which can be quickly traversed by personnel exiting the excavation under emergency conditions.

During excavation, the material encountered must be evaluated with respect to the soils encountered during the subsurface investigation as described on the boring logs. If material with different properties (e.g., fill soil, loose sand, etc.) is encountered, the recommendations given in this report may not be adequate to assure safe excavations.

Unless otherwise indicated all sloping requirements are given as a ratio of horizontal distance to vertical distance (i.e., H:V). OSHA soil classifications for the various soil and groundwater conditions encountered in the borings are indicated in the OSHA Soil Classification table:

Table 6: OSHA Soil Classification

Boring No.	Depth Range (feet)	Soil Description	OSHA Soil Type
All Borings	Surface to Groundwater	Clayey Soils	Type C

Sloping requirements for excavation up to 20 feet in depth for the soils encountered are tabulated as follows:

Table 7: Maximum Allowable Slopes

OSHA Soil Type	Maximum Allowable Slopes (H:V)* for Excavations Less Than 20 Feet Deep**
A	¾:1 (53°)
B	1:1 (45°)
C	1.5:1 (34°)

* Numbers shown in parentheses next to maximum allowable lopes are angles expressed in degrees from horizontal. Angles are given to the nearest degree.

** **Sloping or benching for excavations greater than 20 feet deep shall be designed by a registered professional engineer using the conditions unique to the specific excavation.**

OSHA requires that all excavation slopes for any soil type overlying an exposed Type C soil follow Type C recommendations and for all Type A soils overlying an exposed Type B soil to follow Type B recommendations. All soils which are submerged are to be considered Type C.

All water should be continuously removed from the excavations to prevent softening and weakening of the excavation face. All excavations should be protected from rain and groundwater by surface diversion ditches or dikes and appropriate de-watering systems. Water shall be continuously removed to keep the water level below excavation depth. The groundwater levels shown on the boring logs represent its location on the day indicated. Groundwater levels will fluctuate with the seasons and may be encountered during construction at a level other than that shown on the boring logs. Workers should be prohibited from working in excavations where water has accumulated or is accumulating.

Section 5

BASIS FOR RECOMMENDATIONS

5.1 General Comments

The recommendations and conclusions contained in this report are based on the borings drilled and tests performed. We would point out that there may be variations in material properties over the site and would caution that there may be unknown conditions in existence which differ seriously from those encountered by the test borings. Such conditions, if indeed they exist at all, cannot be, and have not been, accounted for in this report. Therefore, the descriptions, recommendations, and conclusions contained herein should be considered as generalized, applying only to the immediate vicinity of the borings.

5.2 Limitations

Since this report is being prepared in advance of much of the detailed design, the finalized soil and structure parameters (i.e., floor elevation, structural system and loading, vertical movement tolerance, etc.) may differ from the ones considered during the preparation of this report. If such a design variance is substantial, Standard Testing would request the opportunity to review the plans and specifications of the proposed facility for applicability to the soil conditions in this report, and assurance of consistency with its intent.

It is recommended that Standard Testing be retained for testing and observation during earthwork and foundation construction phases, to help determine that the design requirements are fulfilled. It is also recommended that Standard Testing's pier inspector be present during the pier drilling operations to verify the hardness of the support soil stratum and the proper depth of embedment.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical practice.

APPENDIX A

Vicinity Map
Site and Boring Location Plan

Vicinity Map

Project Name:	Ketchum Public Schools: Elementary School
Project Location:	Ketchum, Oklahoma
Project No.:	2030-0549

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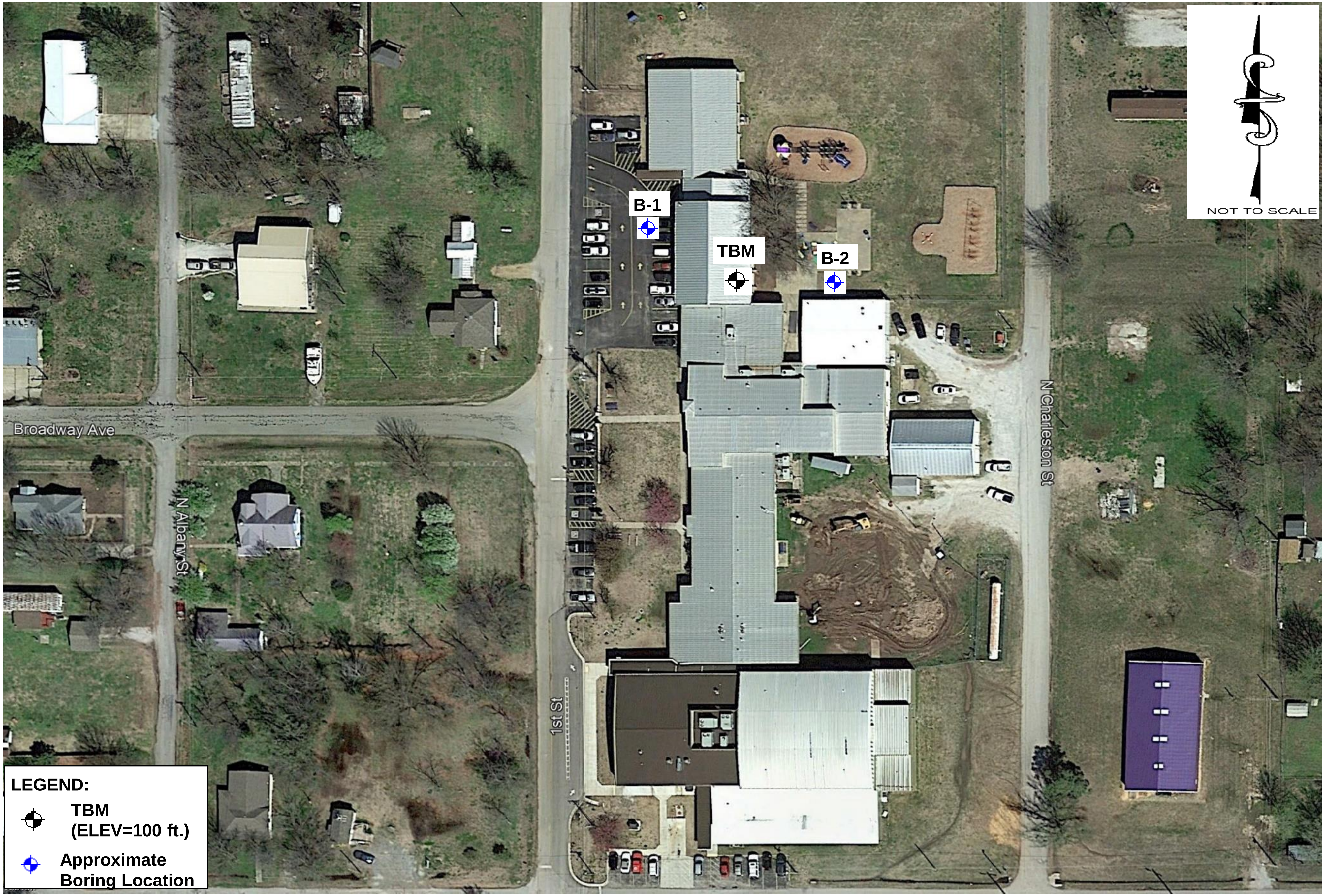

Site and Boring Location Plan

Project Name: Ketchum Elementary School
Project Location: Ketchum, Oklahoma
Project No.: 2030-0549

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APPENDIX B

Boring Logs

Soil Profile

Definition of Descriptive Terms

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BORING LOG B-1 E

PROJECT NAME:	Ketchum Public Schools
PROJECT NUMBER:	2030-0549
PROJECT LOCATION:	Ketchum, OK
CLIENT:	Ketchum Public Schools

SAMPLER SYMBOLS: Grab, ST, RC, SS, TC, HA

DEPTH (FT)	ELEVATION (FT)	USCS	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	BLOW COUNTS (N)	POCKET PENTROMETER (tsf)	RECOVERY % / RQD	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	UCS (psf)	-#200 SIEVE (%)	ATTERBERG LIMITS LL-PL-PI
0			3" ASPHALT PAVEMENT										
		CH	Bk. Brn. FAT CLAY w/ SAND V. Moist, High Plasticity, Firm	Grab	A				22.2				
				SS	B	2-2-3 (5)			23.5			77.8	52-18-34
5	95			ST	C				8.6				
			Gray Brn. Stiff	SS	D	3-4-6 (10)			21.9	102			
10	90			Grab	E				10.5				
				SS	F	20-23-50/5.00"			13.2				
			(ROCK) Tan Brn. LIMESTONE Soft to Hard Rock										
15	85		Bottom of borehole at 13.00 feet Auger Refusal										
20	80												
25	75												
30	70												

WATER LEVELS			ELEVATIONS / LOCATIONS	DRIILLING			
WD		-	GROUND ELEVATION: 99	DRILL START:	9/24/2020	LOGGER:	B.H.
AD		-	TBM: F.F. of the Existing Building	DRILLED END:	9/24/2020	DRILLER:	B.H.
24 Hrs		-	GPS: 36.5277, -95.023541	DRILL RIG:	CME 55	HOLE SIZE:	7.25"
> 24 Hrs		-	STA: OFFSET:	DRILL METHOD:	H.S.A.		

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BORING LOG B-2 E

PROJECT NAME:	Ketchum Public Schools
PROJECT NUMBER:	2030-0549
PROJECT LOCATION:	Ketchum, OK
CLIENT:	Ketchum Public Schools

SAMPLER SYMBOLS: Grab, ST, RC, SS, TC, HA

DEPTH (FT)	ELEVATION (FT)	GRAPHIC LOG	USCS	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	BLOW COUNTS (N)	POCKET PENTROMETER (tsf)	RECOVERY % / RQD	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	UCS (psf)	-#200 SIEVE (%)	ATTERBERG LIMITS LL-PL-PI
0				(Short Grass)										
			CH	Dk. Brn. FAT CLAY Soft	Grab	A				21.0				
					SS	B	2-2-2 (4)			24.1	90			
	95				ST	C				23.1				
5				Brn. V. Moist, High Plasticity, Stiff	SS	D	2-4-6 (10)			21.1	104		93.2	55-17-38
	90				Grab	E				18.8				
10				Tan Brn. V . Soft	SS	F	1-1-1 (2)			25.1				
				(ROCK) Tan Brn. LIMESTONE Hard Rock		G	50/1.00"			20.4				
				Bottom of borehole at 12.08 feet Auger Refusal										
	85													
15														
	80													
20														
	75													
25														
	70													
30														

WATER LEVELS

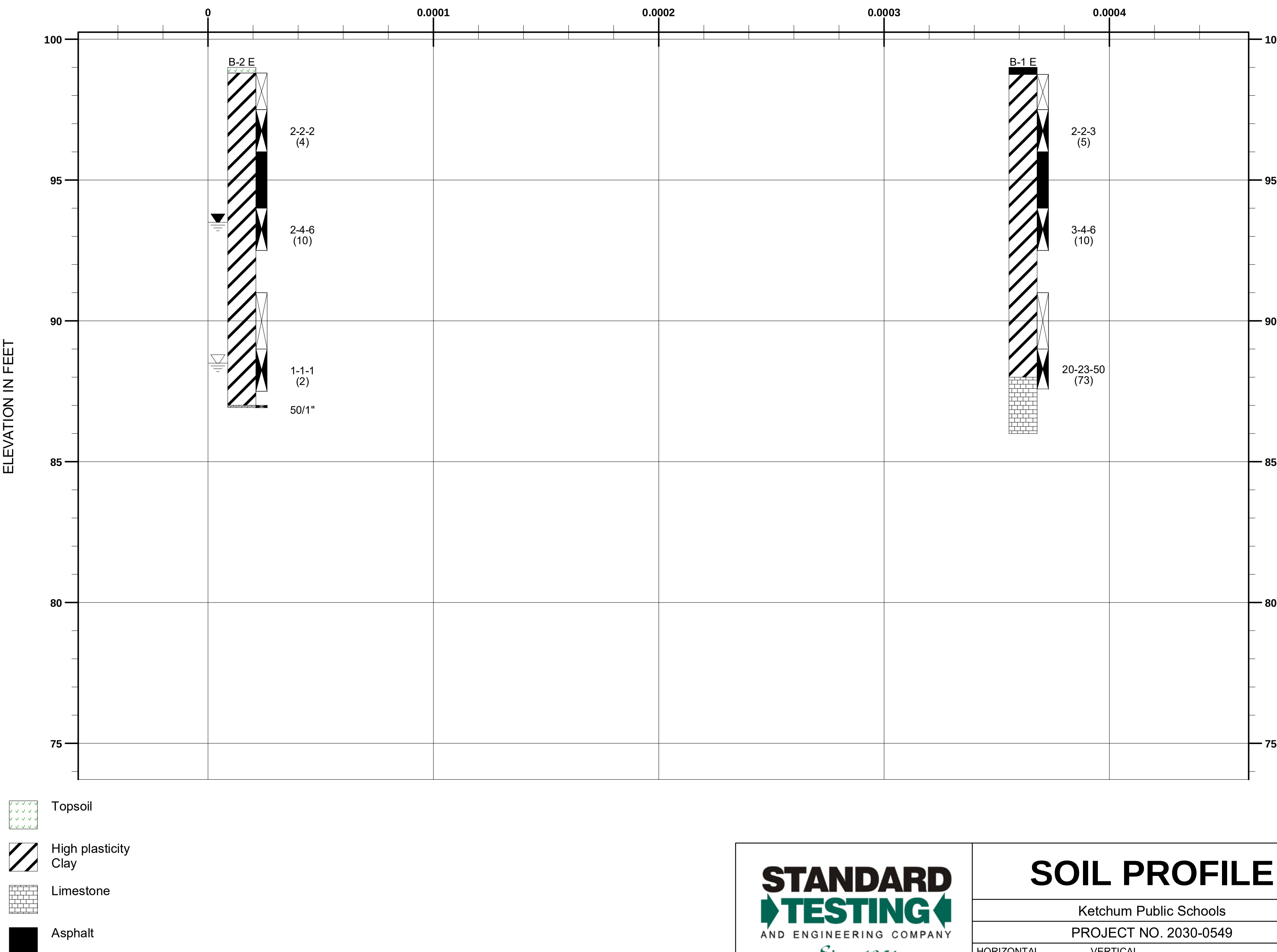
WD	▽	10.5
AD	▼	5.5
24 Hrs	▽	-
> 24 Hrs	▽	-

ELEVATIONS / LOCATIONS

GROUND ELEVATION:	99
TBM:	F.F. of the Existing Building
GPS:	36.527582, -95.023215
STA:	OFFSET:

DRIILLING

DRILL START:	9/25/2020	LOGGER:	B.H.
DRILLED END:	9/25/2020	DRILLER:	B.H.
DRILL RIG:	CME 55	HOLE SIZE:	7.25"
DRILL METHOD:	H.S.A.		



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SOIL PROFILE

Ketchum Public Schools

PROJECT NO. 2030-0549

HORIZONTAL SCALE: 1"=(proportional)

VERTICAL SCALE: 1"=5'

DEFINITION OF DESCRIPTIVE TERMS

Consistency of Cohesive Soils (at moisture content near plastic limit):
- Very Soft - Easily penetrated 4" to 6" by fist; tall core will sag under its own weight.
- Soft - Easily molded by fingers.
- Firm - Can be penetrated 2" to 3" by thumb with moderate effort, imprinted with fingers.
- Stiff - Readily indented by thumb but penetrated only with great effort.
- Very Stiff - Readily indented by thumbnail, imprinted very slightly with pressure from fingers.
- Hard - Indented with difficulty by thumbnail, cannot be imprinted with fingers.

Density of Cohesionless Soils:
- Very Loose - less than 4 SPT "N" value corrected for overburden.
- Loose - 5 to 10 SPT "N" value corrected for overburden.
- Medium Dense - 11 to 30 SPT "N" value corrected for overburden.
- Dense - 31 to 50 SPT "N" value corrected for overburden.
- Very Dense - 51 to 50/6" SPT "N" value corrected for overburden.
- Hard - less than 6" penetration in 50 SPT "N" blows corrected for overburden (cemented).

Hardness of Rock:
- Very Soft - can be scratched readily by fingernail
- Soft - can be grooved readily by knife or pick
- Medium - can be grooved 0.05" deep by firm pressure of knife
- Moderately Hard - can be scratched by knife
- Hard - can be scratched by knife or pick only with difficulty
- Very Hard - cannot be scratched by knife or sharp pick

Other Terms Descriptive of Consistency:
- Brittle - Ruptures with little deformation
- Friable - Crumbles or pulverizes easily.
- Elastic - Returns to original length after small deformation.
- Spongy - Is very porous, loose and elastic.
- Sticky - Adheres or sticks to tools or hands.

In-Situ Moisture Descriptions:
- Dry - powdery
- Slightly Moist - water not readily absorbed by paper
- Moist - water readily absorbed by paper
- Very Moist - water condenses on sample tray
- Wet - water drips from sample

Degree of Plasticity When Moist to Very Moist:
- Nonplastic - cannot be rolled into a ball
- Trace of Plasticity - can be rolled into a ball but not into a 1/8" thread
- Low Plasticity - barely holds its shape when rolled into a 1/8" thread
- Fairly Low Plasticity - 1/8" thread quickly ruptures when bent
- Medium Plasticity - 1/8" thread withstands considerable deformation without rupture.
- Fairly High Plasticity - difficult to rupture a 1/8" thread by bending.
- High Plasticity - can be kneaded without rupture; greasy texture.

Abbreviations:

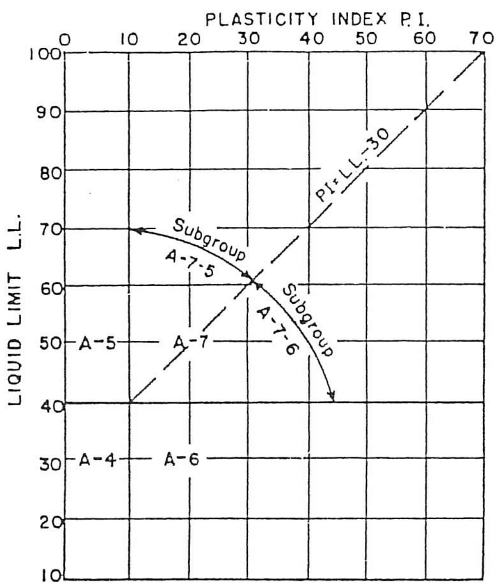
V. - Very	Dk. - Dark	Blk. - Black
Tr. - Trace	Lt. - Light	Brn. - Brown
Fl. - Fairly	Med. - Medium	
Sl. - Slightly		

APPENDIX C

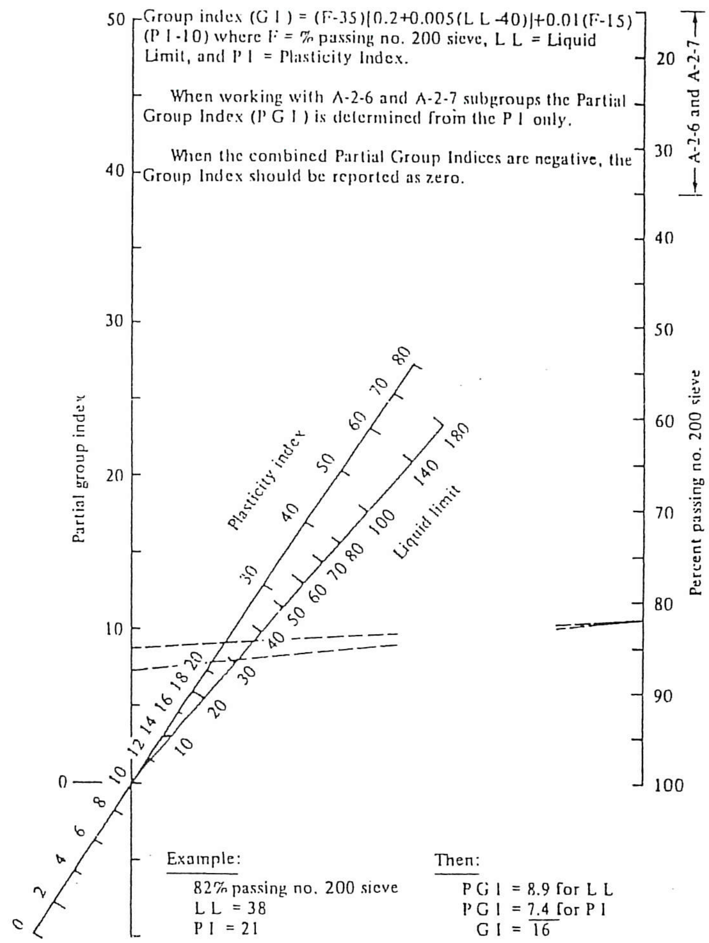
AASHTO Soil Classification System
Unified Soil Classification System

Soil Classification System — American Association of State Highway and Transportation Officials

The tables and charts given below are from AASHTO Designation: M 145-83, The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes. More detailed information as to the background and application of the system may be obtained from the report.



Liquid-limit and plasticity-index ranges for the A-4, A-5, A-6 and A-7 subgrade groups.



Group index chart

Classification of Soils and Soil-Aggregate Mixtures (with Suggested Subgroups)

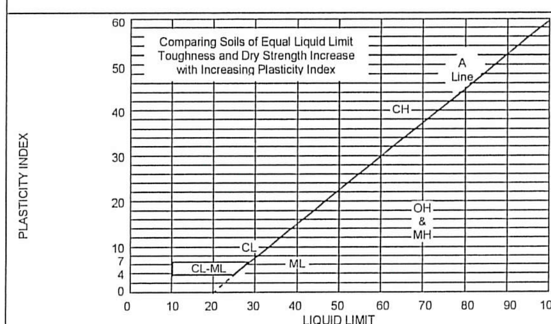
General classification	Granular materials (35 per cent or less passing No. 200)							Silt-clay materials (More than 35 per cent passing No. 200)			
Group classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5; A-7-6
Sieve analysis: Per cent passing:											
No. 10	50 max.	—	—	—	—	—	—	—	—	—	—
No. 40	30 max.	50 max.	51 min.	—	—	—	—	—	—	—	—
No. 200	15 max.	25 max.	10 max.	35 max.	35 max.	35 max.	35 max.	36 min.	36 min.	36 min.	36 min.
Characteristics of fraction passing No. 40:											
Liquid limit	—		—	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.
Plasticity index	6 max.		NP	10 max.	10 max.	11 min.	11 min.	10 max.	10 max.	11 min.	11 min.*
Usual types of significant constituent materials	Stone fragments, gravel and sand		Fine sand	Silty or clayey gravel and sand				Silty soils		Clayey soils	
General rating as subgrade	Excellent to good							Fair to poor			

*P.I. of A-7-5 subgroup is equal to or less than L.L. minus 30. P.I. of A-7-6 subgroup is greater than L.L. minus 30

UNIFIED SOIL CLASSIFICATION
(Including Identification and Description)

Major Divisions (1)	Major Divisions (2)		Group Symbols (3)	Typical Names (4)	Field Identification Procedures (Excluding particles larger than 3 inches and basing fractions on estimated weights) (5)	Information Required for Describing Soils (6)	Laboratory Classification Criteria (7)	
Coarse-grained Soils: More than half of material is <u>larger</u> than No. 200 sieve size. (The No. 200 sieve size is about the smallest particle visible to the naked eye.)	Gravels: More than half of coarse fraction is larger than No. 4 sieve size. (For visual classification, the ¼-in size may be used as equivalent to the No. 4 sieve size)	Clean Gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics	Use grain-size curve in identifying the fractions as given under field identification. Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse-grained soils are classified as follows: Less than 5%: GW, GP, SW, SP; More than 12%: GM, GC SM, SC; 5% to 12%: <u>Borderline</u> cases require use of dual symbols	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.			Not meeting all gradation requirements for GW
		Gravels with Fines (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures.	Nonplastic fines or fines with low plasticity (for identification procedures see ML below).	Give typical name; indicate approximate percentages of sand and gravel, maximum size, angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbol in parentheses.		Atterberg limits below "A" line or PI less than 4. Above "A" Line with PI between 4 and 7 are <u>borderline</u> cases requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures.	Plastic fines (for identification procedures see CL below).			Atterberg limits above "A" line or PI greater than 7. Above "A" Line with PI between 4 and 7 are <u>borderline</u> cases requiring use of dual symbols
	Sands: More than half of coarse fraction is smaller than No. 4 sieve size.	Clean Sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines.	Wide range in grain size and substantial amounts of all intermediate particle sizes.			$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			SP	Poorly-graded sands, gravelly sands, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.	Example: <u>Silty sand</u>, gravelly; about 20% hard, angular gravel particles ½-in. maximum size; rounded and subangular sand grains coarse to fine; about 15% nonplastic fines with low dry strength; well compacted and moist in place; alluvial sand; (SM).		Not meeting all gradation requirements for SW
		Sands with Fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures.	Nonplastic fines or fines with low plasticity (for identification procedures see ML below).			Atterberg limits below "A" line or PI less than 4. Limits plotting in hatched zone with PI between 4 and 7 are <u>borderline</u> cases requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures.	Plastic fines (for identification procedures see CL below).			Atterberg limits above "A" line or PI greater than 7. Limits plotting in hatched zone with PI between 4 and 7 are <u>borderline</u> cases requiring use of dual symbols

Major Divisions (1)	Major Divisions (2)	Group Symbols	Typical Names	Dry Strength (Crushing characteristics)	Dilatancy (Reaction to shaking)	Toughness (Consistency near PL)	Information Required for Describing Soils
				Identification Procedures On Fractions Smaller than No. 40 Sieve Sizes			
Fine-grained Soils: More than half of material is <u>smaller</u> than No. 200 sieve size.	Silts and Clays: Liquid limit less than 50	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.	None to slight	Quick to slow	None	Give typical name, indicate degree and character of plasticity, amount and maximum size of coarse grains, color in wet condition, odor if any, local or geologic name, and other pertinent descriptive information; and symbol in parentheses.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	Medium to high	None to very slow	Medium	
		OL	Organic silts and organic silty clays of low plasticity.	Slight to medium	Slow	Slight	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remolded states, moisture and drainage conditions.
	Silts and Clays: Liquid limit greater than 50	MH	Inorganic silts, micoceous or diotomoceous fine sandy or silty soils, elastic silts.	Slight to medium	Slow to none	Slight to Medium	
		CH	Inorganic clays of high plasticity, fat clays.	High to very high	None	High	Example: <u>Clayey silt</u>, brown, slightly plastic, small percentage of fine sand, numerous vertical root holes, firm and dry in place, loess, (ML).
		OH	Organic clays of medium to high plasticity, organic silts.	Medium to high	None to very slow	Slight to medium	
Highly Organic Soils		PI	Peat and other high organic soils.	Readily identified by color, odor, spongy feel and frequently by fibrous texture.			



PLASTICITY CHART
For laboratory classification of fine-grained soils

(1) <u>Boundary Classifications</u>: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, well-graded gravel-sand mixture with clay binder. (2) All sieve sizes on this chart are U.S. Standard

FIELD IDENTIFICATION PROCEDURES FOR FINE-GRAINED SOILS OR FRACTIONS

These procedures are to be performed on the minus No. 40 sieve size particles, approximately 1/64 in. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

Dilatancy (Reaction to shaking)

After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky. Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat, which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and glass disappear from the surface, the pat stiffens, and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.

Very fine clean sands give the quickest and most distinct reactions whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour show a moderately quick reaction.

Dry Strength (Crushing Characteristics)

After removing particles larger than No. 40 sieve size, mold a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun, or air drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty, whereas a typical silt has the smooth feel of flour.

Toughness (Consistency near plastic limit)

After removing particles larger than the No. 40 sieve size, a specimen of soil about one-half inch cube in size is molded to the consistency of putty. If too dry, water must be added and if sticky, specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eighth inch in diameter. The thread is then folded and rerolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses it's plasticity, and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be lumped together and slight kneading action continued until lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.

Highly organic clays have a very weak and spongy feel at the plastic limit.

Adopted by Corps of Engineers and Bureau of Reclamation January 1952

APPENDIX D

Summary of Test Results

STANDARD TESTING AND ENGINEERING COMPANY
Since 1951

SUMMARY OF LABORATORY TEST RESULTS

Client: Ketchum Public Schools

Project: Ketchum Public Schools

Date: 10/15/2020

Project No.: 2030-0549

Boring No.	Sample No.	Depth (ft)	Moisture Content (%)	Dry Density (pcf)	Atterberg Limits (% Moisture)			Sieve Analysis (% Passing)					Soil Classification		UCT	
					LL	PL	PI	#4	#10	#40	#100	#200	USCS	AASHTO	Stress (psf)	Strain (%)
B-1 E																
	A	0.3-1.5	22.2													
	B	1.5-3.0	23.5		52	18	34	90	85	81	79	77.8	CH	A-7-6(26)		
	C	3.0-5.0	8.6													
	D	5.0-6.5	21.9	102												
	E	8.0-10.0	10.5													
	F	10.0-11.4	13.2													
B-2 E																
	A	0.2-1.5	21.0													
	B	1.5-3.0	24.1	90												
	C	3.0-5.0	23.1													
	D	5.0-6.5	21.1	104	55	17	38	100	98	97	95	93.2	CH	A-7-6(38)		
	E	8.0-10.0	18.8													
	F	10.0-11.5	25.1													
	G	12.0-12.1	20.4													

United States Department of Agriculture

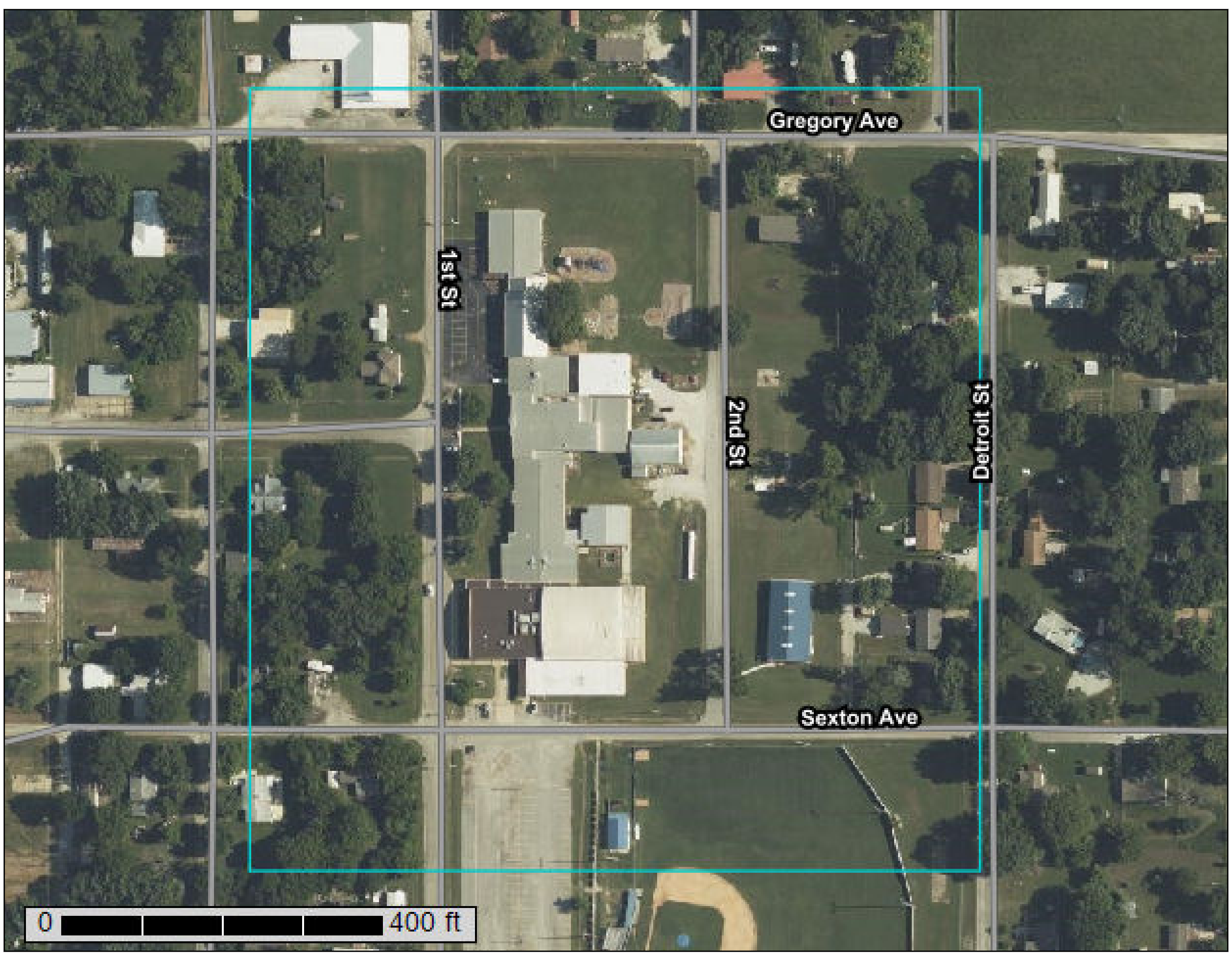
NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Craig County, Oklahoma



October 20, 2020

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

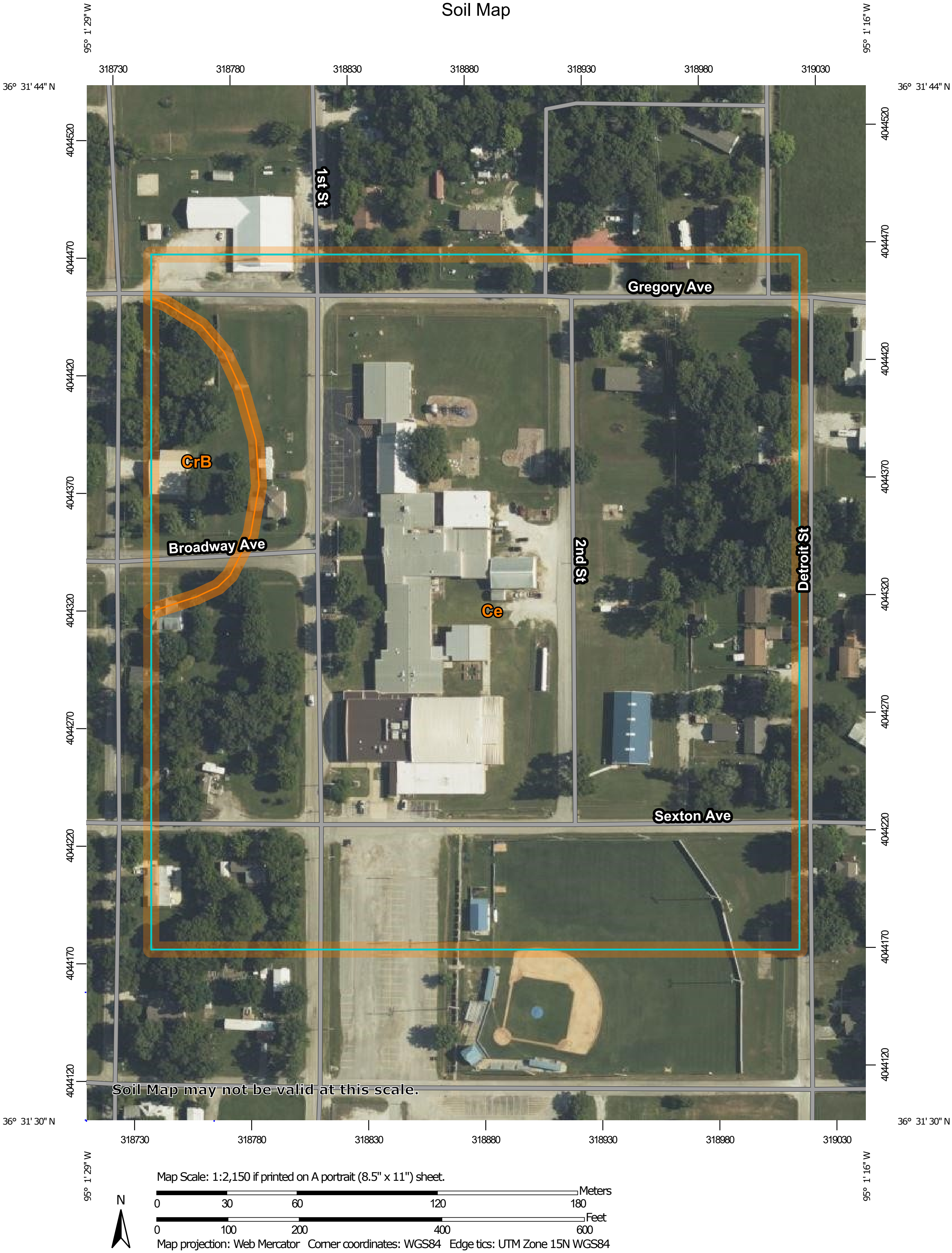
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map



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 1:20,000.

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

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

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

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

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

Soil Survey Area: Craig County, Oklahoma
Survey Area Data: Version 17, May 27, 2020

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

Date(s) aerial images were photographed: Jul 18, 2019—Nov 9, 2019

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
Ce	Cherokee silt loam, 0 to 1 percent slopes	19.1	94.3%
CrB	Craig silt loam, 1 to 3 percent slopes	1.2	5.7%
Totals for Area of Interest		**20.3**	**100.0%**

Map Unit Descriptions

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

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

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

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

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

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

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

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

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

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

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

Craig County, Oklahoma

Ce—Cherokee silt loam, 0 to 1 percent slopes

Map Unit Setting

National map unit symbol: 2tgtj
Elevation: 710 to 1,160 feet
Mean annual precipitation: 43 to 47 inches
Mean annual air temperature: 55 to 61 degrees F
Frost-free period: 183 to 255 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Cherokee and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Cherokee

Setting

Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Loess over ancient clayey alluvium

Typical profile

Ap - 0 to 7 inches: silt loam
A - 7 to 12 inches: silt loam
Eg - 12 to 17 inches: silt loam
Btg1 - 17 to 32 inches: silty clay
2Btg2 - 32 to 52 inches: silty clay loam
2BCg - 52 to 70 inches: silty clay loam

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 8.0
Available water capacity: High (about 10.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2s
Hydrologic Soil Group: D
Ecological site: R112XY102KS - Clayey Upland
Hydric soil rating: No

Minor Components

Dennis

Percent of map unit: 3 percent
Landform: Interfluves
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: R112XY103KS - Loamy Upland
Hydric soil rating: No

Hepler

Percent of map unit: 2 percent
Landform: Flood-plain steps
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R112XY122OK - Wet Terrace
Hydric soil rating: No

Pharoah

Percent of map unit: 2 percent
Landform: Paleoterraces
Landform position (three-dimensional): Tread
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: R112XY102KS - Clayey Upland
Hydric soil rating: No

Craig

Percent of map unit: 2 percent
Landform: Interfluves
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: R112XY104KS - Gravelly Upland
Hydric soil rating: No

Aquolls

Percent of map unit: 1 percent
Landform: Divides
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

CrB—Craig silt loam, 1 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2tgtw
Elevation: 590 to 1,120 feet
Mean annual precipitation: 42 to 47 inches
Mean annual air temperature: 55 to 61 degrees F
Frost-free period: 190 to 220 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Craig and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Craig

Setting

Landform: Interfluves
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Clayey residuum weathered from cherty limestone

Typical profile

A - 0 to 12 inches: silt loam
E - 12 to 16 inches: silt loam
BE - 16 to 21 inches: silt loam
Bt - 21 to 42 inches: very gravelly clay loam
BC - 42 to 70 inches: extremely gravelly clay loam

Properties and qualities

Slope: 1 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water capacity: Low (about 5.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2s
Hydrologic Soil Group: C
Ecological site: R112XY104KS - Gravelly Upland
Hydric soil rating: No

Minor Components

Eldorado

Percent of map unit: 7 percent
Landform: Interfluves
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: R112XY104KS - Gravelly Upland
Hydric soil rating: No

Dennis

Percent of map unit: 4 percent
Landform: Interfluves
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: R112XY103KS - Loamy Upland
Hydric soil rating: No

Parsons

Percent of map unit: 3 percent
Landform: Divides
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: R112XY101KS - Claypan Upland
Hydric soil rating: No

Apperson

Percent of map unit: 1 percent
Landform: Interfluves
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R112XY102KS - Clayey Upland
Hydric soil rating: No

Soil Information for All Uses

Suitabilities and Limitations for Use

The Suitabilities and Limitations for Use section includes various soil interpretations displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each interpretation.

Building Site Development

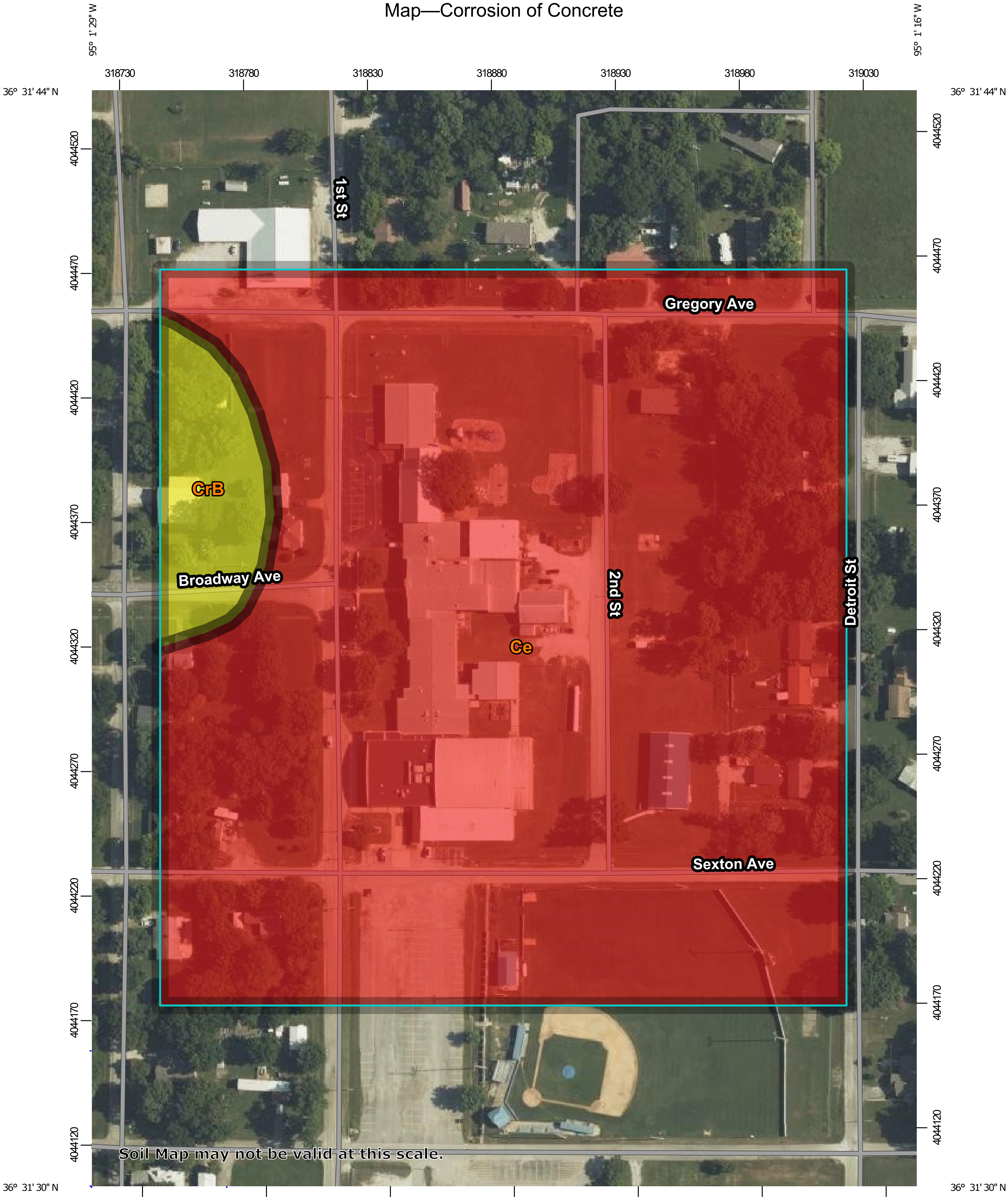
Building site development interpretations are designed to be used as tools for evaluating soil suitability and identifying soil limitations for various construction purposes. As part of the interpretation process, the rating applies to each soil in its described condition and does not consider present land use. Example interpretations can include corrosion of concrete and steel, shallow excavations, dwellings with and without basements, small commercial buildings, local roads and streets, and lawns and landscaping.

Corrosion of Concrete

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

The risk of corrosion is expressed as "low," "moderate," or "high."

Map—Corrosion of Concrete



Map Scale: 1:2,150 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 30, 60, 120, 180

Feet: 0, 100, 200, 400, 600

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 15N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

High

Moderate

Low

Not rated or not available

Soil Rating Lines

High

Moderate

Low

Not rated or not available

Soil Rating Points

High

Moderate

Low

Not rated or not available

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 1:20,000.

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

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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)

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Table—Corrosion of Concrete

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
Ce	Cherokee silt loam, 0 to 1 percent slopes	High	19.1	94.3%
CrB	Craig silt loam, 1 to 3 percent slopes	Moderate	1.2	5.7%
Totals for Area of Interest			**20.3**	**100.0%**

Rating Options—Corrosion of Concrete

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

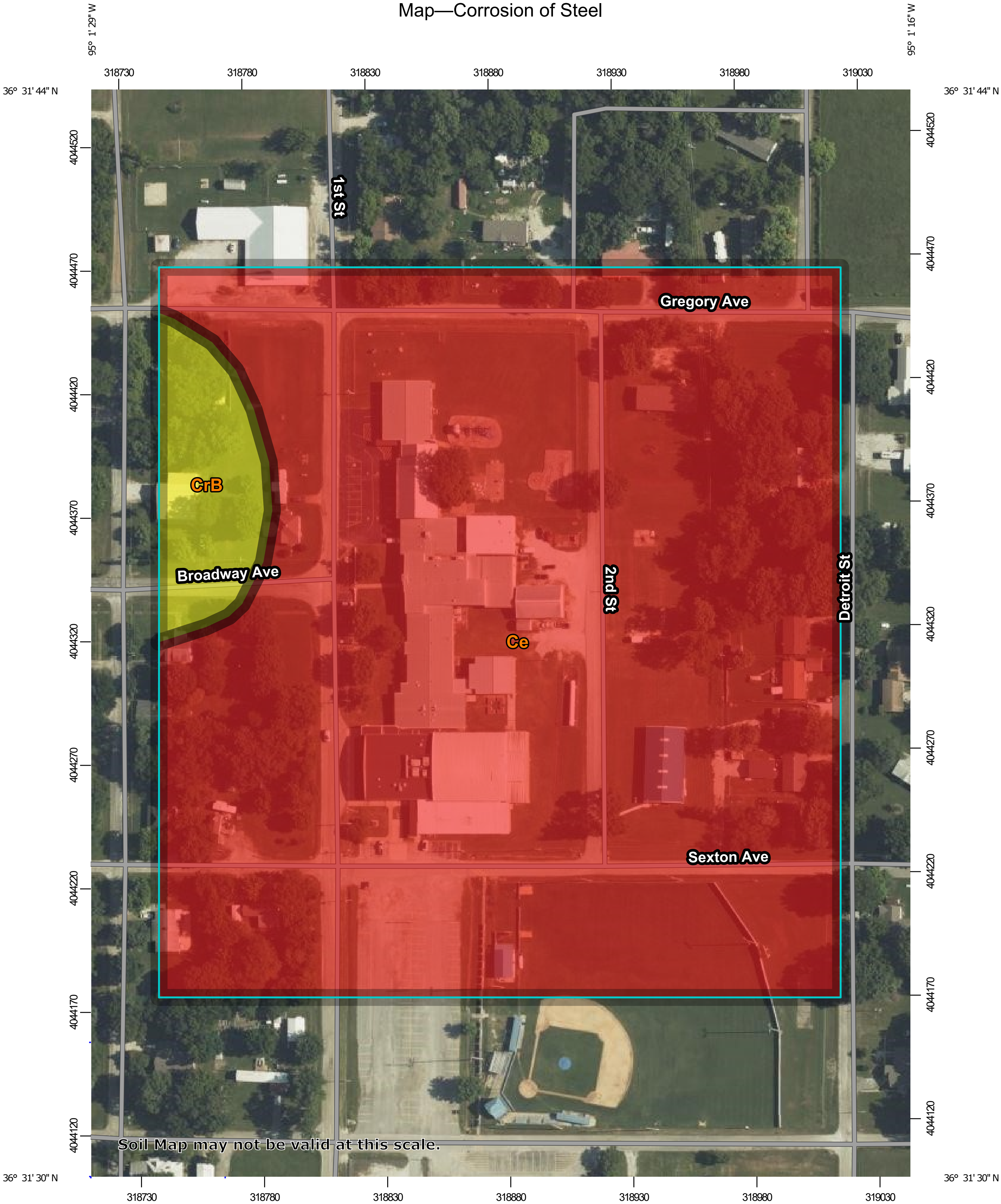
Tie-break Rule: Higher

Corrosion of Steel

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

The risk of corrosion is expressed as "low," "moderate," or "high."

Map—Corrosion of Steel



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MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

High

Moderate

Low

Not rated or not available

Soil Rating Lines

High

Moderate

Low

Not rated or not available

Soil Rating Points

High

Moderate

Low

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

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Totals for Area of Interest			**20.3**	**100.0%**

Rating Options—Corrosion of Steel

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Soil Properties and Qualities

The Soil Properties and Qualities section includes various soil properties and qualities displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each property or quality.

Soil Chemical Properties

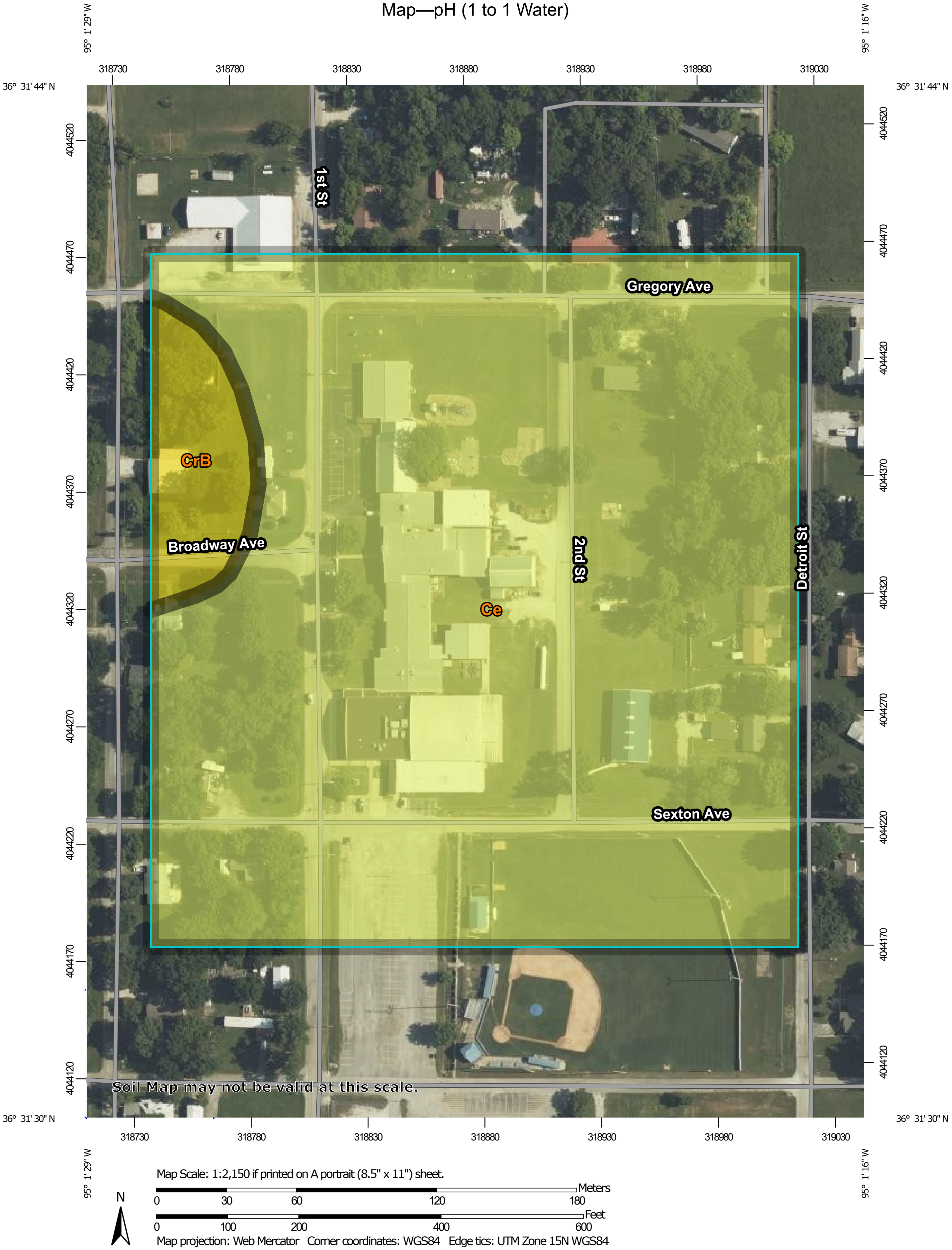
Soil Chemical Properties are measured or inferred from direct observations in the field or laboratory. Examples of soil chemical properties include pH, cation exchange capacity, calcium carbonate, gypsum, and electrical conductivity.

pH (1 to 1 Water)

Soil reaction is a measure of acidity or alkalinity. It is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion. In general, soils that are either highly alkaline or highly acid are likely to be very corrosive to steel. The most common soil laboratory measurement of pH is the 1:1 water method. A crushed soil sample is mixed with an equal amount of water, and a measurement is made of the suspension.

For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

Map—pH (1 to 1 Water)



Map Scale: 1:2,150 if printed on A portrait (8.5" x 11") sheet.

Meters: 0 30 60 120 180

Feet: 0 100 200 400 600

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 15N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- Ultra acid (ph < 3.5)
- Extremely acid (pH 3.5 - 4.4)
- Very strongly acid (pH 4.5 - 5.0)
- Strongly acid (pH 5.1 - 5.5)
- Moderately acid (pH 5.6 - 6.0)
- Slightly acid (pH 6.1 - 6.5)
- Neutral (pH 6.6 - 7.3)
- Slightly alkaline (pH 7.4 - 7.8)
- Moderately alkaline (pH 7.9 - 8.4)
- Strongly alkaline (pH 8.5 - 9.0)
- Very strongly alkaline (pH > 9.0)
- Not rated or not available

Soil Rating Lines

- Ultra acid (ph < 3.5)
- Extremely acid (pH 3.5 - 4.4)
- Very strongly acid (pH 4.5 - 5.0)
- Strongly acid (pH 5.1 - 5.5)
- Moderately acid (pH 5.6 - 6.0)
- Slightly acid (pH 6.1 - 6.5)
- Neutral (pH 6.6 - 7.3)
- Slightly alkaline (pH 7.4 - 7.8)
- Moderately alkaline (pH 7.9 - 8.4)
- Strongly alkaline (pH 8.5 - 9.0)
- Very strongly alkaline (pH > 9.0)
- Not rated or not available

Soil Rating Points

- Ultra acid (ph < 3.5)
- Extremely acid (pH 3.5 - 4.4)
- Very strongly acid (pH 4.5 - 5.0)
- Strongly acid (pH 5.1 - 5.5)
- Moderately acid (pH 5.6 - 6.0)
- Slightly acid (pH 6.1 - 6.5)
- Neutral (pH 6.6 - 7.3)
- Slightly alkaline (pH 7.4 - 7.8)
- Moderately alkaline (pH 7.9 - 8.4)
- Strongly alkaline (pH 8.5 - 9.0)
- Very strongly alkaline (pH > 9.0)
- Not rated or not available

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 1:20,000.

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

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

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

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

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

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

Soil Survey Area: Craig County, Oklahoma
Survey Area Data: Version 17, May 27, 2020

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

Date(s) aerial images were photographed: Jul 18, 2019—Nov 9, 2019

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.

Table—pH (1 to 1 Water)

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
Ce	Cherokee silt loam, 0 to 1 percent slopes	5.7	19.1	94.3%
CrB	Craig silt loam, 1 to 3 percent slopes	5.3	1.2	5.7%
Totals for Area of Interest			**20.3**	**100.0%**

Rating Options—pH (1 to 1 Water)

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Interpret Nulls as Zero: No

Layer Options (Horizon Aggregation Method): Depth Range (Weighted Average)

Top Depth: 0

Bottom Depth: 60

Units of Measure: Centimeters

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GEOTECHNICAL REPORT

KETCHUM PUBLIC SCHOOLS
HIGH SCHOOL ADDITION & RENOVATION

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Issue Date
4 March 2021
Project Number
T19055

SUBSURFACE EXPLORATION

Ketchum New Middle School Addition
236 N Fulton St
Ketchum, Oklahoma

PROJECT NO. 2030-0549

STANDARD TESTING AND ENGINEERING COMPANY
Since 1951

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October 22, 2020

Boynton Williams & Associates
2651 East 21st Street, Suite 510
Tulsa, OK 74114

Attn: Mrs. Dayna Boynton, AIA
Vice President

Re: Subsurface Exploration
Ketchum New Middle School Addition
236 N Fulton St
Ketchum, Oklahoma

Dear Mrs. Boynton:

Standard Testing & Engineering, LLC (Standard Testing) is pleased to present the report covering the subsurface exploration for the subject project. This study was authorized by receipt of the signed "Agreement of Services" contract, dated September 9th, 2020.

Standard Testing conducted a geotechnical investigation at the site of the new Ketchum New Middle School Addition project in Ketchum, Oklahoma. This report contains the detailed results of the geotechnical investigation, including foundation recommendations, pavement recommendations, and construction considerations.

The subsurface soils consist of approximately 9 to 12 feet of clay with various amounts of sand and sand with various amounts of gravel, silt, and clay overlying limestone rock and shale rock which exhibit low to high plasticity characteristics.

Foundation recommendations include: (1) Shallow Footings or (2) Drilled Pier Foundation.

We trust that the results and recommendations contained herein will permit adequate economical design and construction of the proposed structure. Unless you specify otherwise, we will keep samples obtained from these borings in our Oklahoma City laboratory for the next thirty (30) days.

We appreciate the opportunity to assist on this project. Please call on us if we can be of further service.

Respectfully submitted,
STANDARD TESTING & ENGINEERING, LLC

Antonio Franco, E.I.
Staff Geotechnical Engineer

Roy Khalife, P.E.
Geotechnical Engineer

Project No. 2030-0549
Account No. 0230BOY20

GEOTECHNICAL SERVICES

SUBSURFACE EXPLORATION

Ketchum New Middle School Addition
236 N Fulton St
Ketchum, Oklahoma

PROJECT NO. 2030-0549

PREPARED FOR

Boynton Williams & Associates
2651 East 21st Street, Suite 510
Tulsa, OK 74114

PREPARED BY

STANDARD TESTING & ENGINEERING, LLC
3400 N. Lincoln Blvd.
Oklahoma City, OK 73105
Certificate of Authorization No. 7933, Expiration 6/30/2021
(405) 528-0541

Prepared By:

Antonio Franco, E.I.
Staff Geotechnical Engineer

LICENSED PROFESSIONAL ENGINEER
ROY
KHALIFE
23446
OKLAHOMA

Reviewed By:

Roy Khalife, P.E.
Geotechnical Engineer

I certify my e-signature for the study entitled "Subsurface Exploration."

Dated 10/22/2020

October 22, 2020

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Appendix C	AASHTO Soil Classification System Unified Soil Classification System
Appendix D	Summary of Test Results

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Section 1

INTRODUCTION

1.1 Authorization

This report presents the results of a subsurface exploration performed by Standard Testing & Engineering, LLC (Standard Testing) in accordance with the proposal (P-20144) prepared for Mrs. Dayna Boynton, dated July 10th, 2020, and identified as Standard Testing project number 2030-0549. This geotechnical study was authorized by receipt of the signed "Agreement of Services" contract, dated September 9th, 2020.

1.2 Purpose and Scope

A geotechnical investigation was performed for the purpose of (1) determining the subsurface conditions, (2) evaluating the bearing capacity and plasticity characteristics of the soils, and (3) making recommendations concerning the earthwork, pavement recommendations, and foundation systems for the facility.

Five (5) exploratory borings (building borings B-1 through B-5) were drilled to depths ranging from 9 to 20 feet. Borings were terminated earlier than proposed due to auger refusal. The boring depths and types of testing were performed according to the scope of work proposed by Standard Testing and accepted by Mrs. Boynton. Narrative descriptions of our findings and recommendations are contained in the body of this report. A site and boring location plan, the boring logs, the soil profile, and a summary sheet of laboratory test results are included in the Appendices of this report.

1.3 Project Location and Description

It is understood that the Ketchum New Middle School Addition is proposed to be constructed onto Ketchum High School on 236 N Fulton St in Ketchum, Oklahoma. Maximum column loads for the proposed facility are unknown while we are preparing this geotechnical report.

If the project is not as described or has changed, Standard Testing must be notified in order to reevaluate the recommendations for the project.

Section 2

FIELD EXPLORATION

2.1 Drilling Information

The field exploration work was performed on September 24th, 2020. Conditions at the site were investigated with five (5) borings at the locations indicated on the site and boring location plan, included in Appendix "A." The boring surface elevations were measured with respect to a Temporary Bench Mark (TBM) established at the Fire Hydrant. The Temporary Bench Mark (TBM) location is also shown in the site and boring location plan in Appendix “A.” Boring surface elevations, rounded to the nearest foot, are reported on the individual boring logs, included in Appendix “A.”

The benchmark has an assigned relative elevation of 100 feet. Boring depths were 9 to 20 feet within the facility’s footprint. Borings were terminated due to auger refusal. For accurate sampling, cuttings were observed continuously during drilling with specific samples being taken at distinct lithologic changes. The equipment used, field tests performed, and soil samples taken are discussed below.

2.2 Equipment Used

Five (5) borings were drilled with a truck-mounted CME-55 rotary drilling unit equipped with 3.25" I.D. X 7.25" O.D. hollow stem augers (HSA). Standard penetration tests (SPT) used a 1.375" ID split spoon sampler driven by an automatic hammer utilizing a 140 lb. weight falling 30 inches.

2.3 Testing and Sampling Performed

Standard penetration tests were performed in order to estimate the shear strengths of the soils in their natural state. The test was conducted as specified by ASTM D1586, "Penetration Test and Split-Barrel Sampling of Soils." The in-situ bearing strength is related to the N-value from this test. "N" is the number of blows required to drive a split-spoon sampler twelve inches, after a 6-inch seating, into undisturbed soil. The soil samples recovered in the split-spoon barrel were removed from the sample tool in the field, visually classified, and labeled according to boring number and depth. Results of the standard penetration tests are denoted at their respective depths on the boring logs.

Depths of individual split spoon (standard penetration tests) and grab samples are indicated on the boring logs included in Appendix "B." All samples were labeled and sealed in water tight, protective containers and returned to the laboratory for further evaluation and testing.

2.4 Subsurface Conditions

The soils encountered consist of clay with various amounts of sand and sand with various amounts of gravel, silt, and clay overlying limestone rock and shale rock. The cohesive soils were found to be firm to very stiff in consistency and the cohesionless soils were found to have very loose to very dense relative density. Rock materials (i.e., defined by standard penetration test refusal) were encountered in the indicated borings at the relative elevation shown in the following table:

Table 1: Relative Elevation of Rock Material

Boring No.	Surface Elevation (feet)	Rock Depth (feet)	Rock Elevation (feet)	Rock Material
B-1 H	95.0	21.0	74.0	Shale
B-2 H	97.0	10.0	87.0	Limestone
B-3 H	98.0	12.0	86.0	Limestone
B-4 H	106.0	10.5	95.5	Limestone
B-5 H	113.0	9.0	104.0	Limestone

2.5 Groundwater

During drilling and at completion of drilling operations, groundwater was NOT encountered in the borings. Presence of water should be anticipated in any excavation. Water travelling through soil (subsurface water) is often unpredictable and may be present at shallow depths. Due to the seasonal changes in groundwater and the unpredictable nature of groundwater paths, groundwater levels will fluctuate. Therefore, it is necessary during construction to be observant for groundwater seepage in excavations in order to assess the situation and make necessary changes. We cannot assume responsibility for difficulties experienced during construction or for future operational problems due to elevation or volume of water encountered.

Section 3

LABORATORY TESTING

Laboratory testing was performed in order to determine the plasticity characteristics of the subsurface materials as well as confirm the soil classifications.

3.1 Tests Performed

- Moisture content tests were performed on split spoon and bag samples, in accordance with ASTM D2216, to determine the in-situ moisture conditions.

- Density tests were performed on intact split spoon samples in accordance with ASTM D7263 Method A.

- Atterberg limits tests were performed on split spoon and bag samples to determine the plasticity characteristics and swell potential of the soil. The tests were performed in accordance with ASTM D4318.

- Sieve analyses were performed on split spoon and bag samples, in accordance with ASTM D2487, for aid in soil classification. These soils were classified according to the Unified Soil Classification System (USCS) and the American Association of State Highway and Transportation Officials (AASHTO) soil classification system.

3.2 Laboratory Summary

General descriptions of the encountered soils together with visual and laboratory classifications and numerical values of the test results are on the boring logs and soil profile included in Appendix "B." A "Summary of Test Results" is included in Appendix "D."

Section 4

ENGINEERING EVALUATION AND RECOMMENDATIONS

4.1 Soil Conditions

The soils encountered in this investigation consist of clay with various amounts of sand and sand with various amounts of gravel, silt, and clay overlying limestone rock and shale rock. The cohesive soils were found to be firm to very stiff in consistency and the cohesionless soils were found to have very loose to dense relative density. Rock materials (i.e., defined by standard penetration test refusal) were encountered in the borings. The characteristics of the soils encountered indicate that these soils are inactive for consideration of soil expansion on foundation design.

4.2 Seismic Site Class

Based on the results of our investigation, this site is classified as Seismic Site Class C. This recommendation is based on the criteria given in Table 20.3-1 of the ASCE/SEI 7-10, 2015, entitled "Site Class Definitions."

4.3 Earthwork Recommendations

Due to the topography of the site and given that there may be over 10 feet difference in elevation between the north and south sections of the proposed building, grading at this site will be very important. Depending on the grading plan, the amount of cut and fill planned for this building may be significant. <u>Therefore, Standard Testing must be retained to test and approved the material from the cut section before it is used as borrow to ensure that no high plasticity soils are placed under the building slabs and foundations</u>.

<u>Subgrade Preparation</u>

The existing subgrade should be:

- Stripped of topsoil, vegetation, pavement, fills and any other deleterious materials,
- Proofrolled, including removing and replacing any soft material which exhibits permanent subgrade deformation exceeding 0.5 inch when traversed by a loaded truck with a rear axle load of approximately 16,000 lbs./axle, and
- Tested for moisture and density and, if deficient, scarified to a depth of 8 inches, moisture conditioned and compacted to 95 percent or more of standard Proctor maximum dry density (ASTM D698).

Removal of soft subgrade should not exceed a 3-foot depth below final top of subgrade elevation, nor extend below the static groundwater elevation. If such a depth is reached without encountering stable subgrade conditions, 12 inches of ODOT Type A aggregate base should be placed in the bottom of the over-excavated area and suitable fill material placed and compacted to bring the subgrade to design elevation.

Inert Fill Requirements

Only low plasticity on-site soils or imported inert fill should be used for fill under structure. Inert fill should meet the following requirements:

Amount finer than 2-inch sieve	100%
Amount finer than No. 200 Sieve	12% minimum and, if PI ≤ 7, 60% maximum
Liquid Limit	35 maximum
Plasticity Index (PI)	5 to 15

Compaction Requirements

All fill in the structural areas should be:

- Compacted to at least 95 percent of standard Proctor maximum dry density (ASTM D698) at a moisture content within -2% to +2% of the optimum.
- Compacted to at least 95 percent of modified Proctor maximum dry density (ASTM D1557) at a moisture content near optimum for ODOT Type A aggregate base.
- Placed in lifts not to exceed eight (8) inches in compacted thickness.
- Tested for field density for each lift of fill at frequencies of every 1,500 sq. ft. in areas under structure and 2,500 sq. ft. in areas under pavement. For utility trenches, test field density at frequencies of 100 linear foot of trench and at frequencies of 50 linear foot of any utility underneath pavement or other structure.

Moisture should be maintained up until the placement of concrete in structural areas to prevent shrinkage (and subsequent post-construction swell) of the soil.

Drainage

The ground immediately adjacent to the foundation shall be sloped away from the building at a slope of not less than six (6) inches vertical fall in the first ten (10) feet measured perpendicular to the face of each wall. Trees and large bushes for landscaping should not be permitted within this 10-foot zone adjacent to the building. General site slopes, drainage swales, or storm drains shall be constructed to provide 1.0 percent slope, or more, along drainage paths which serve to discharge storm water from the site. If surface soil should be left exposed (e.g., flower beds) near the structure foundation, then it is suggested that efforts be taken to maintain such areas at a constant moisture in order to avoid swell/shrinkage of the soil that will affect the foundation system.

4.4 Foundation Recommendations

Considering the soils encountered and based on the test results of this exploration, the following foundation design parameters are recommended for the indicated foundation systems:

Footing Foundation System

Shallow foundations (e.g. spot or continuous cast-in-place concrete footings) may be used to support the new structures at this site. Footings must be placed a minimum of 2.0 feet below finished grade to provide adequate protection from frost action. Footings may be used with allowable net bearing capacity of 2,000 psf on native soils, 2,000 psf on compacted inert fill, or 3,000 psf on 2 feet of properly compacted ODOT Type A aggregate base as described in the Earthwork Recommendations Section of this report. Footings should have a width of at least 16 inches.

Continuous footings and spot footings are expected to undergo no more than 1.0-inch settlement when designed for the recommended bearing pressure.

If this addition is to tie into an existing structure which is supported on shallow footings, we recommend that the proposed addition also be supported with shallow footings. Care should be exercised during the construction of foundations adjacent to the existing building to avoid negatively influencing the existing structure. It is recommended that, where possible, excavations below existing footings not extend below an imaginary plane extending out and down from the outside edge of the existing footings at a slope approximately 2H: 1V. Even with these criteria, excavations that extend below the level of existing foundations should be backfilled the same day they are excavated. Where this is impractical, shoring or underpinning of existing foundation may be required.

Some overlap in stress distribution from new and existing footings may occur, which may cause minor movement of the existing footings and supported structures. Maintaining a clear distance at least equal to the width of the new column spread footings between the edges of new and existing footings could significantly reduce the risk. If connections between the new and existing structures are required, such connections should be designed to allow for the anticipated differential movement.

Subgrade Improvement within Footing Area

Due to the presence of loose subgrade soils with low bearing capacities, encountered in boring B-2 H, near the shallow footing elevation, we recommend footings near B-2 H to be verified as follows:

- Bearing Capacity should be verified by performing a Dynamic Cone Penetrometer (DCP) test or Static Cone Penetrometer (SCP) at the bottom of the footings where loose soils are encountered
- If the DCP or SCP shows the loose subgrade soils within the new footing area does not meet the specified bearing capacity, the loose subgrade soils should be over-excavated a minimum depth of 2 foot below bottom of new shallow footings;
- The exposed excavated soils should be compacted by using Jumping Jack or equivalent equipment,
- Either ODOT Type A aggregate base or inert fills or on-site low PI soils (PI between 5 and 15) should then be placed over up to the bottom of new footings.

Moisture should be maintained up prior to pouring concrete.

Pier Foundation System

Structures may be designed to be supported by drilled cast-in-place concrete piers founded 3.0 feet or more below the depths indicated in the "Relative Elevation of Rock Material" table provided in Section 2.4 of this report. Using this type of foundation, each column is supported on a single drilled pier and the building walls are placed on grade beams supported by a series of piers. Loads applied to the piers are transmitted to the rock partially through skin friction along the sides of the pier and partially through end bearing pressure.

All drilled piers should:

- Extend at least 3.0 feet or at least one (1) pier diameter, whichever is deeper, beyond the elevation indicated in the "Elevation of Rock Material" table provided in Section 2.4 of this report,
- Have an aspect ratio (length/diameter) between three (3) and thirty (30),
- Have a spacing between individual piers of three diameters or more (clear spacing),
- Be adequately reinforced with the reinforcement extending into the grade beams and/or pier caps, and
- Have a diameter of at least 18 inches.

Piers may be proportioned using an allowable net end bearing capacity of 15,600 psf and an allowable skin friction capacity of 1,040 psf for that portion of the pier in direct contact with the Limestone/Shale. The allowable net bearing capacity and allowable skin friction capacity both include a factor of safety of 3.0. Uplift of the piers can be resisted by using the same skin friction values plus for the pier weight (i.e. 150 pcf x Pier Area x length of Pier). Maximum service load vertical displacement of piers designed in this manner is expected to be on the order of 0.8% of the pier base diameter.

If groundwater is encountered during pier excavation and cannot be dewatered, concrete may be placed by tremie-pipe method so as to assure no contamination of the fresh concrete by groundwater or drilling fluids. A sufficient head of plastic concrete should be maintained within the casing at all times during its extraction in order to overcome the hydrostatic groundwater pressure outside the casing.

4.5 Pavement Recommendations

Subgrade Preparation

Prior to the placement of fill or preparation of pavement subbase:

- The natural subgrade should be stripped of all topsoil, vegetation, pavement, fills and any other deleterious materials.
- The parking and drive areas should then be graded and shaped to facilitate drainage, with a minimum slope of 1/8 inch per foot.
- Next, the subgrade should be proofrolled, including removing and replacing any soft material which exhibits permanent subgrade deformation exceeding 0.5 inch when traversed by a loaded truck with a rear axle load of approximately 16,000 lbs./axle. Removal of soft subgrade should not exceed a 3-foot depth below final top of subgrade elevation, nor extend below the static groundwater elevation. If such a depth is reached without encountering stable subgrade conditions, 12 inches of ODOT Type A aggregate base should be placed in the bottom of the overexcavated area and suitable fill material placed and compacted to bring the subgrade to design elevation.
- Once the subgrade has been satisfactorily proofrolled, the surface layer of the subgrade shall be scarified to a depth of 6 inches.

Pavement Sections

We estimate the CBR value of the near surface soils as 5.0 based on the borings. This would correspond to a modulus of subgrade reaction, k_s, of 140 pci, and a resilient modulus, M_r, of 5,000 psi.

Pavement sections were evaluated based on the AASHTO 1993 guidelines with the following assumptions. If traffic loads are greater than used in the analysis, Standard Testing must be notified in order to reevaluate the recommendations. No borings were completed within the pavement area. The prepared subgrade soils should be tested by *Standard Testing* to verify the assumptions and pavement section recommendations.

- Design Period = 20 years
- Reliability Level = 85% (flexible and rigid)
- Initial Serviceability Index = 4.5 (flexible and rigid)
- Terminal Serviceability Index = 2.0 (flexible and rigid)
- Combined Standard Error (S_0) = 0.5 (flexible) and 0.4 (rigid)
- Light duty (car parking) total design ESALs (W_{18}) = 99,000 (flexible) and 150,000 (rigid)
- Heavy duty (truck parking) total design ESALs (W_{18}) = 348,000 (flexible) and 500,000 (rigid)

We recommend that the following pavement sections be used:

Table 2: Pavement Sections

Pavement Type	Light Duty (inches)	Heavy Duty (inches)
Flexible Pavement		
Surface Course (S4)	2.0	1.5
Intermediate Course (S3)	-	2.5
Base Course (S3)	3.0	3.0
Aggregate Base (ODOT Type A)	6.0	6.0
Rigid Pavement		
Portland Cement Concrete	5.0	7.0
Aggregate Base (ODOT Type A)	6.0	6.0

All access lanes subject to delivery trucks, fuel truck, refuse pickup trucks, or fire trucks should consist of 7.0 inches of Portland cement concrete over 6.0 inches of aggregate base.

If stabilized soil subgrade is desired in lieu of aggregate base for flexible pavements, a mix design may need to be completed and additional recommendations shall be made during construction.

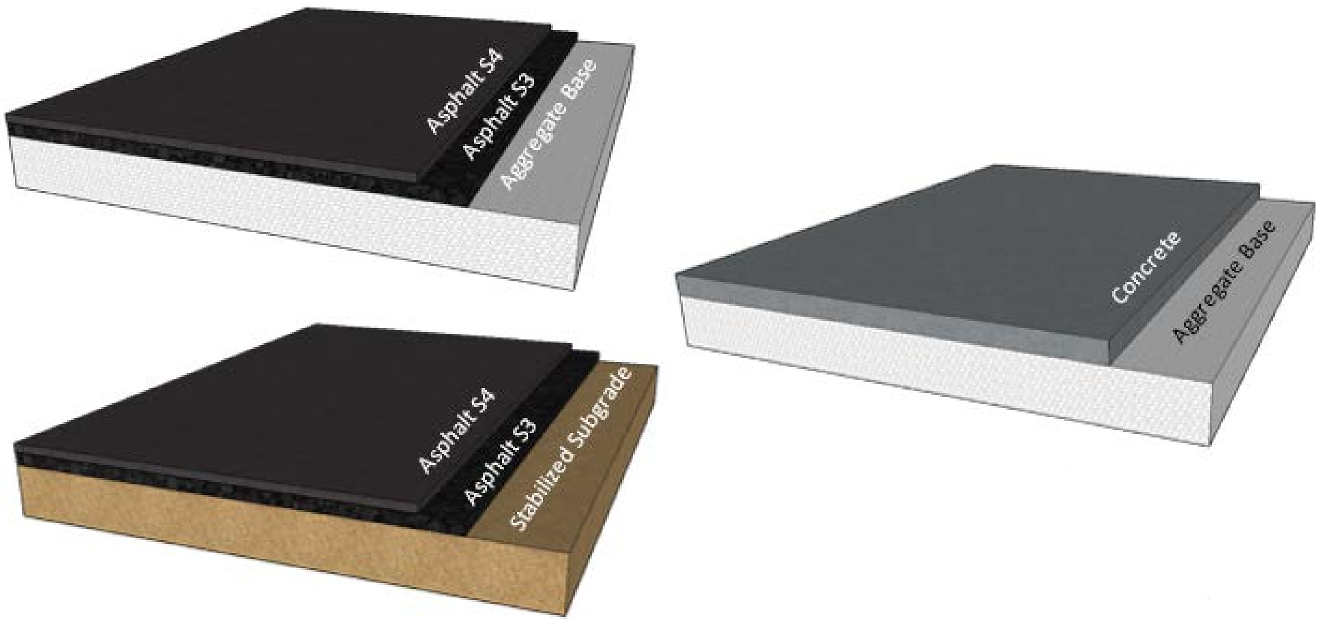

Figure 1: Graphic Representation of Recommended Pavement Sections

Materials and Construction

All materials and construction for base should be in accordance with the Oklahoma Department of Transportation (ODOT), "2009 Standard Specifications for Highway Construction," and the latest Special Provisions adopted by ODOT to supplement the Standard Specifications. ODOT Type "A" aggregate base should be compacted to not less than 95 percent modified Proctor maximum dry density (ASTM D1557). Compacted subgrade should be compacted to not less than 95% of the standard Proctor maximum dry density (ASTM D698) within -2 to +2 percentage points of the corresponding optimum moisture content. Compacted subgrade should extend the full width of the pavement section (i.e., including curb and gutter).

Concrete for paving should have a modulus of rupture, M_r, of at least 550 psi (compressive strength of approximately 3,500 psi or more), should be air entrained with 4 to 7 percent air, should have a cementitious materials content of at least 564 pcy, and should have a maximum water to cementitious materials ratio of 0.45. The concrete mix design submittal should adequately address the criteria of ACI 301, section 4, including documentation of strength test results. Control joints should be saw cut at least one-eighth (0.125) inch wide and one-quarter of pavement thickness deep as soon as possible after concrete reaches final set (i.e., approximately 8 to12 hours after placing the concrete), cleaned by high pressure air jet, and sealed with a suitable pavement joint sealing material to prevent intrusion of surface water into the pavement base. Control joints should be spaced as indicated in the following table:

Table 3: Recommended Transverse Joint Spacings

Concrete Thickness (inches)	Maximum Joint Spacing (feet)
5.0	12.5
7.0	15.0

4.6 Concrete Slabs

Concrete slabs-on-grade for floors should be constructed as follows:

- The subgrade, inert fill, and/or soil building pad should be prepared as described in the Earthwork Recommendations section of this report.
- Four (4) inches or more of granular base, meeting the following requirements, should be placed over the subgrade:

  passing the 1.5 inches sieve……………………………………………….100 %
  passing the #200 sieve………………………………………………..15 % or less
  plasticity index…………………………………………………………….6 or less
- At the time of concrete placement, the granular base should be moist, but free of any standing water.
- The concrete slab should be placed a minimum of four (4) inches thick in lightly loaded areas and up to six (6) inches thick in heavily loaded areas and should not be tied into the footings, stemwalls, or structural frame. If it is necessary to tie the concrete slab into the foundation walls, exterior walls, and/or pitwalls, the slab should be jointed no more than 10 to 15 feet from the point of the restraint (ACI 360R-10, Section 14.7). Other control joints should be provided, each way, at a spacing of 24 to 36 times the slab thickness but no more than 18 feet. Refer to ACI 360R-10, Section 6.1.3 and Figure 6.6 for additional guidance on joint spacing.

If floor coverings susceptible to moisture damage by moist floor conditions (capillary moisture) are to be used, a vapor retarder consisting of one or more polyethylene or polypropylene fabric reinforcement layers with one or more bonded polyethylene film layers, at least 10 mils in total thickness, should be placed below the slab. The vapor retarder should be lapped 6 inches and taped at joints and fitted around all service openings. Section 5.2.3.2 of ACI 302.1R-15 provides the most current industry recommendations for use and placement of vapor retarders. Figure 5.2.3.2, in ACI 302.1R-15, provides guidance for determining whether to place the vapor retarder above or below the "granular material" below the slab.

Concrete slabs can be designed using a modulus of subgrade reaction, k_s, of 140 pci for native soil.

4.7 Lateral Earth Pressure Parameters

Lateral earth pressure can be assumed to increase linearly with depth and may be represented as an equivalent fluid column equal to the effective unit weight of the soil times the appropriate coefficient of lateral earth pressure times the thickness of overlying soil at the depth in question. For consideration of lateral earth pressure, the effective unit weight of the soil is the weighted average, down to the depth in question, of the moist unit weight of the soil above the groundwater and the submerged unit weight of the soil below the groundwater. The following estimated parameters may be used for determining approximate lateral earth pressures for the retaining walls at this site:

Native Soils – Clayey/Sandy Soils

γ =	120 pcf	moist unit weight
ϕ =	20°	angle of internal friction
c =	700 psf	apparent cohesion
k_a =	0.49	coefficient of active lateral pressure
k_p =	2.04	coefficient of passive lateral pressure
k_0 =	0.66	coefficient of lateral earth pressure at rest

Inert Fill

γ =	110 pcf	moist unit weight
ϕ =	25°	angle of internal friction
c =	500 psf	apparent cohesion
k_a =	0.41	coefficient of active lateral pressure
k_p =	2.46	coefficient of passive lateral pressure
k_0 =	0.58	coefficient of lateral earth pressure at rest

The parameters for inert fill should be used only if the inert fill meets all requirements given in the Earthwork Recommendations Section of this report, testing has confirmed that the inert fill has an angle of internal friction of 25° or more, the slope of the native soil from the toe of the earth-retaining structure is no steeper than 1:1, and only inert fill is used in the backfill between the earth-retaining structure and the native soil slope. If these criteria are not met, then the appropriate parameters for the native soil should be used.

Note: P_{water} (Hydrostatic Pressure; psf) = 62.4 (pcf) x h (ft); h=depth below water level

Soil retaining structures (i.e., retaining walls) will be subjected to horizontal loading due to lateral earth pressure. The magnitude of this lateral earth pressure depends on the natural and backfill soils, extent of the original excavation, and wall deflections (i.e., stiffness). The appropriate coefficient of lateral earth pressure will vary, based on these considerations, between the coefficient of active lateral earth pressure and the coefficient of lateral earth pressure at rest. Greater wall deflections result in the development of greater internal shear strength in the retained soil, thereby lowering the lateral pressure on the wall. Granular backfill and clay backfill require horizontal deflections of the top of the wall on the order of 0.2 percent and 2 percent, respectively, of the wall height to mobilize the full internal shear strength of the soil. Thus, at reasonably small wall deflections, a greater portion of the internal strength of granular backfill is mobilized reducing the lateral earth pressure on the wall for this type of material.

Retaining walls which are laterally supported and can be expected to undergo only a slight amount of deflection (i.e., less than 0.1 percent of wall height for granular soils or less than 1.0 percent of wall height for clay soils) should be designed for lateral loadings based on lateral earth pressure computed using the coefficient of lateral pressure at rest.

Retaining structures which can deflect sufficiently to mobilize the full active earth pressure condition should be designed for a smaller active lateral earth pressure computed using the coefficient of active lateral earth pressure. Walls designed for such loading must be detailed and specified such that (1) hydrostatic pressure cannot develop and (2) compaction effort used on backfill is limited to that required to achieve 95 percent of modified Proctor density.

If the slope of the undisturbed soil beyond the backfill behind retaining walls is steeper than the equivalent of a 1:1 slope measured from the base of the wall, then the active earth pressure should be based on the greater of the earth pressure value described above for backfill or the earth pressure computed based on the coefficient of lateral earth pressure at rest for the undisturbed soil.

A continuous back drain system should be installed at the heel of all walls to prevent water pressure build-up behind the walls. It is recommended that a free-draining, cohesionless material such as crushed stone having a gradation corresponding to ASTM C33, size 6, 7, or

67 be used to form a drainage blanket against the backside of the walls. The drainage blanket should have a minimum horizontal thickness of 12 inches and should extend from the bottom of the buried walls to within 18 inches of the finish ground surface. The crushed stone should be separated from soil surfaces by use of a fabric meeting the requirements of AASHTO M288 for a Class 2 subsurface drainage geotextile rated for soils with less than 50 percent passing the 0.075 mm sieve. A minimum 4 inch diameter, slotted or perforated, corrugated polyethylene pipe should be placed in the bottom of the drainage blanket to collect and transport groundwater to an appropriate point for disposal. Manufactured wall drain systems may be considered in lieu of the described gravel drainage blanket. With a drainage system in place, it is recommended that the buried walls be designed to resist lateral pressures equivalent to those produced by a fluid having a unit weight calculated from the parameters at the beginning of this section plus a uniform pressure equal to 40 percent of any anticipated surcharges adjacent to the walls.

Ultimate resistance to lateral sliding at the bottoms of footings may be calculated based on a coefficient of friction of 0.35. Sliding resistance may also include ultimate passive pressure against the front of the footings which can be calculated using an equivalent fluid unit weight of 270 pcf. The designer may use the passive pressure in this zone only if there is a certainty of no loss of toe soil. If necessary, additional sliding stability may be derived from the use of a key embedded into soil beneath the base and utilizing 270 pcf equivalent fluid unit weight for passive lateral earth pressure. A factor of safety of at least 1.5 should be used with stability calculations involving lateral earth pressures. The safety factor should be computed as the sum of resisting forces or moments divided by the sum of driving forces or moments.

4.8 Excavation Requirements (OSHA Requirements)

Excavations adjacent to structures or public ways or to which personnel will enter which are more than 5 feet deep must be either be supported (e.g., shoring or trench box) or laid back to a stable slope. If excavations less than 5 feet in depth appear to be unstable, they must also be shored or sloped sufficiently to protect the employees working within them. The recommended slopes provided herein are based on the Occupational Safety and Health Administration (OSHA) requirements and are intended for construction operations. Permanent slopes should not be constructed utilizing the slope angles described herein.

Trees, boulders, and other surface encumbrances, located so as to create a hazard to employees involved in excavation work or in the vicinity thereof at any time during operations, shall be removed or made safe before the excavation begins. Existing underground utility lines shall also be protected during excavation. The excavation slopes specified herein have been determined to hold back the earth banks and not more than 2 feet of stockpiled soil within a distance of 5 feet from the edge of the excavation. Any excavated soil at the edge of the excavation must be stockpiled at a slope of 1.5 or more horizontal to 1.0 vertical. Additionally, no equipment should be allowed within 5 feet of the trench edge.

Someone capable of identifying existing and predictable hazards and who has the authorization to take prompt corrective measures (i.e., a "competent person") must inspect the excavations daily for any condition which may adversely affect the reliability and safety of the excavation. The excavations must also be inspected after each rainstorm or when any change in condition occurs that can increase the possibility of a cave-in or slide. If evidence of possible cave-ins or slides is apparent, all work in the excavation shall cease until the necessary precautions for sloping or bracing have been taken to safeguard the employees and the excavation. Any loose soil shall be scaled from the slope and removed from the excavation to protect workers against falling soil.

An adequate means of egress must be provided within 25 feet of lateral travel to any worker in all trench excavations 4 feet or more in depth. The means of egress may be a ladder or a ramp of stable soil having a slope which can be quickly traversed by personnel exiting the excavation under emergency conditions.

During excavation, the material encountered must be evaluated with respect to the soils encountered during the subsurface investigation as described on the boring logs. If material with different properties (e.g., fill soil, loose sand, etc.) is encountered, the recommendations given in this report may not be adequate to assure safe excavations.

Unless otherwise indicated all sloping requirements are given as a ratio of horizontal distance to vertical distance (i.e., H:V). OSHA soil classifications for the various soil and groundwater conditions encountered in the borings are indicated in the OSHA Soil Classification table:

Table 4: OSHA Soil Classification

Boring No.	Depth Range (feet)	Soil Description	OSHA Soil Type
All Borings	Surface to Groundwater	Clayey Soils	Type C

Sloping requirements for excavation up to 20 feet in depth for the soils encountered are tabulated as follows:

Table 5: Maximum Allowable Slopes

OSHA Soil Type	Maximum Allowable Slopes (H:V)* for Excavations Less Than 20 Feet Deep**
A	¾:1 (53°)
B	1:1 (45°)
C	1.5:1 (34°)

* Numbers shown in parentheses next to maximum allowable lopes are angles expressed in degrees from horizontal. Angles are given to the nearest degree.

** **Sloping or benching for excavations greater than 20 feet deep shall be designed by a registered professional engineer using the conditions unique to the specific excavation.**

OSHA requires that all excavation slopes for any soil type overlying an exposed Type C soil follow Type C recommendations and for all Type A soils overlying an exposed Type B soil to follow Type B recommendations. All soils which are submerged are to be considered Type C.

All water should be continuously removed from the excavations to prevent softening and weakening of the excavation face. All excavations should be protected from rain and groundwater by surface diversion ditches or dikes and appropriate de-watering systems. Water shall be continuously removed to keep the water level below excavation depth. The groundwater levels shown on the boring logs represent its location on the day indicated. Groundwater levels will fluctuate with the seasons and may be encountered during construction at a level other than that shown on the boring logs. Workers should be prohibited from working in excavations where water has accumulated or is accumulating.

4.9 Construction Procedures and Considerations

If ground water is encountered during excavation of the footings and trenches, water should be removed from the excavation area and Standard Testing should be contacted to verify to inspection the bearing soils and verify the recommended bearing capacity before the construction of the foundations is resumed.

Unless otherwise indicated all sloping requirements are given in horizontal: vertical. The OSHA Soil Classification for the soil and groundwater conditions encountered in the borings is a type C.

We recommend a slope no steeper than 1.5:1 for the subsurface conditions encountered. Sloping or benching for excavations greater than 20 feet deep shall be explicitly designed by a registered professional engineer.

The soils encountered are susceptible to rapid erosion from rainfall. Excavation slopes should be protected from erosion by some type of impermeable covering, such as plastic sheeting.

If space limitations prevent a 1.5:1 excavation side slope, use of shoring or sheet piles will be necessary.

Section 5

BASIS FOR RECOMMENDATIONS

5.1 General Comments

The recommendations and conclusions contained in this report are based on the borings drilled and tests performed. We would point out that there may be variations in material properties over the site and would caution that there may be unknown conditions in existence which differ seriously from those encountered by the test borings. Such conditions, if indeed they exist at all, cannot be, and have not been, accounted for in this report. Therefore, the descriptions, recommendations, and conclusions contained herein should be considered as generalized, applying only to the immediate vicinity of the borings.

5.2 Limitations

Since this report is being prepared in advance of much of the detailed design, the finalized soil and structure parameters (i.e., floor elevation, structural system and loading, vertical movement tolerance, etc.) may differ from the ones considered during the preparation of this report. If such a design variance is substantial, Standard Testing would request the opportunity to review the plans and specifications of the proposed facility for applicability to the soil conditions in this report, and assurance of consistency with its intent.

It is recommended that Standard Testing be retained for testing and observation during earthwork and foundation construction phases, to help determine that the design requirements are fulfilled. It is also recommended that Standard Testing's pier inspector be present during the pier drilling operations to verify the hardness of the support soil stratum and the proper depth of embedment.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical practice.

APPENDIX A

Vicinity Map
Site and Boring Location Plan

Vicinity Map

Project Name: Ketchum Middle School Addition
Project Location: Ketchum, Oklahoma
Project No.: 2030-0549

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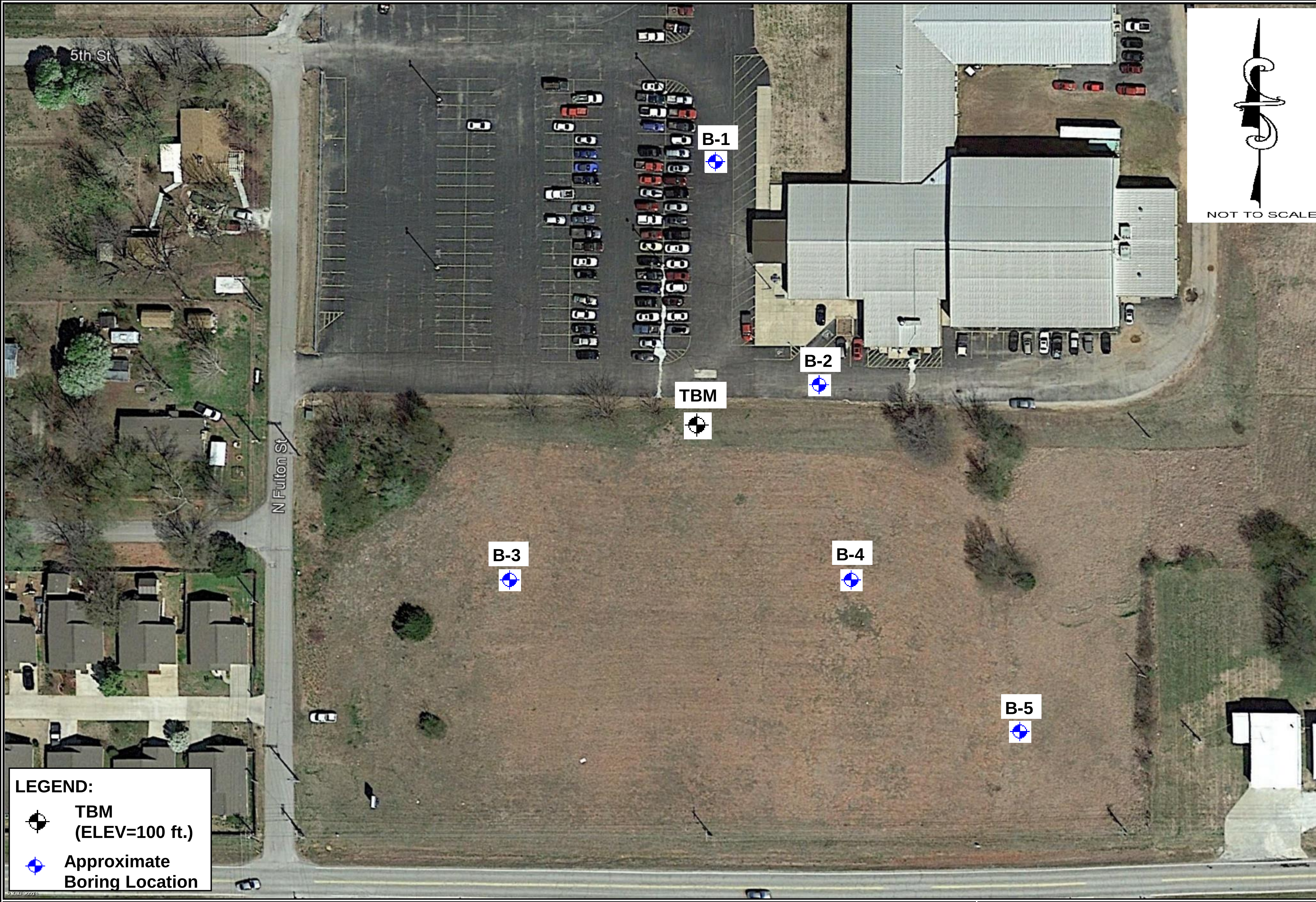

Site and Boring Location Plan

Project Name: Ketchum Middle School Addition
Project Location: Ketchum, Oklahoma
Project No.: 2030-0549

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APPENDIX B

Boring Logs
Soil Profile
Key to Symbols
Definition of Descriptive Terms

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BORING LOG B-1 H
(1 of 1)

PROJECT NAME:	Ketchum Public Schools
PROJECT NUMBER:	2030-0549
PROJECT LOCATION:	Ketchum, OK
CLIENT:	Ketchum Public Schools

SAMPLER SYMBOLS: Grab, ST, RC, SS, TC, HA

DEPTH (FT)	ELEVATION (FT)	USCS	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	BLOW COUNTS (N)	POCKET PENETROMETER (tsf)	RECOVERY % / RQD	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	UCS (psf)	-#200 SIEVE (%)	ATTERBERG LIMITS LL-PL-PI
0	95		3" ASPHALT PAVEMENT										
		SC	Reddish Brn. CLAYEY SAND w/ GRAVEL Moist, Moderate Plasticity, Med. Dense	Grab	A				14.7				
				SS	B	4-6-13 (19)		78	19.0			39.8	35-19-16
5	90			Grab	C				19.9				
				SS	D	4-4-4 (8)			20.1	108			
			Reddish Brn. CLAY Firm										
10	85			Grab	E				21.5				
			Reddish Brn. VERY WEATHERED SHALE V. Stiff	SS	F	10-14-17 (31)			13.3				
15	80			SS	G	10-8-13 (21)			25.9				
20	75			SS	H	2-2-50/3.00"			18.2				
			(ROCK) Reddish Brn. SHALE Med. Hard Rock										
			Bottom of borehole at 21.25 feet Auger Refusal										
25	70												
30	65												

WATER LEVELS

WD		-
AD		-
24 Hrs		-
> 24 Hrs		-

ELEVATIONS / LOCATIONS

GROUND ELEVATION: 95
TBM: Fire Hydrant
GPS: 36.526018, -95.018287
STA: OFFSET:

DRIILLING

DRILL START:	9/24/2020	LOGGER:	B.H.
DRILLED END:	9/24/2020	DRILLER:	B.H.
DRILL RIG:	CME 55	HOLE SIZE:	7.25"
DRILL METHOD:	H.S.A.		

BORING LOG B-2 H

STANDARD TESTING AND ENGINEERING COMPANY
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PROJECT NAME:	Ketchum Public Schools
PROJECT NUMBER:	2030-0549
PROJECT LOCATION:	Ketchum, OK
CLIENT:	Ketchum Public Schools

SAMPLER SYMBOLS: Grab, ST, RC, SS, TC, HA

DEPTH (FT)	ELEVATION (FT)	GRAPHIC LOG	USCS	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	BLOW COUNTS (N)	POCKET PENETROMETER (tsf)	RECOVERY % / RQD	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	UCS (psf)	-#200 SIEVE (%)	ATTERBERG LIMITS LL-PL-PI
0				ASPHALT										
	95		SC	Reddish Brn. CLAYEY SAND w/ GRAVEL Med. Dense Moist, High Plasticity	Grab	A				24.2				
					SS	B	10-11-8 (19)			21.0				
5					Grab	C				19.3			39.0	48-18-30
				Loose	SS	D	2-5-3 (8)			20.2				
	90				Grab	E				21.2				
10				(ROCK) Tan Brn. LIMESTONE Hard Rock		F	50/1.00"							
	85			Bottom of borehole at 10.08 feet Auger Refusal										
15	80													
20	75													
25	70													
30														

WATER LEVELS		ELEVATIONS / LOCATIONS	DRIILLING			
WD	-	GROUND ELEVATION: 97	DRILL START:	9/24/2020	LOGGER:	B.H.
AD	-	TBM: Fire Hydrant	DRILLED END:	9/24/2020	DRILLER:	B.H.
24 Hrs	-	GPS: 36.525566, -95.018051	DRILL RIG:	CME 55	HOLE SIZE:	7.25"
> 24 Hrs	-	STA: OFFSET:	DRILL METHOD:	H.S.A.		

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BORING LOG B-3 H

PROJECT NAME:	Ketchum Public Schools
PROJECT NUMBER:	2030-0549
PROJECT LOCATION:	Ketchum, OK
CLIENT:	Ketchum Public Schools

SAMPLER SYMBOLS: Grab, ST, RC, SS, TC, HA

DEPTH (FT)	ELEVATION (FT)	USCS	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	BLOW COUNTS (N)	POCKET PENTROMETER (tsf)	RECOVERY % / RQD	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	UCS (psf)	-#200 SIEVE (%)	ATTERBERG LIMITS LL-PL-PI
0			(Short Grass)										
		SC	Brn. CLAYEY SAND w/ GRAVEL	Grab	A				21.3				
	95		Reddish Brn. V. Stiff	SS	B	31-35-13 (48)		61	23.2				
5				Grab	C				25.3				
			V. Moist, Moderate to High Plasticity	SS	D	11-13-10 (23)			28.1			48.9	50-22-28
	90			Grab	E				23.1				
10			V. Loose	SS	F	2-2-2 (4)			9.8				
	85		(ROCK) Brn. LIMESTONE Hard Rock		G	50/0.50"							
			Bottom of borehole at 12.04 feet Auger Refusal										

Depth scale: 0, 5, 10, 15, 20, 25, 30; Elevation scale: 95, 90, 85, 80, 75, 70

WATER LEVELS

WD		-
AD		-
24 Hrs		-
> 24 Hrs		-

ELEVATIONS / LOCATIONS

GROUND ELEVATION:	98
TBM:	Fire Hydrant
GPS:	36.525146, -95.018782
STA:	OFFSET:

DRIILLING

DRILL START:	9/24/2020	LOGGER:	B.H.
DRILLED END:	9/24/2020	DRILLER:	B.H.
DRILL RIG:	CME 55	HOLE SIZE:	7.25"
DRILL METHOD:	H.S.A.		

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BORING LOG B-4 H

PROJECT NAME: Ketchum Public Schools
PROJECT NUMBER: 2030-0549
PROJECT LOCATION: Ketchum, OK
CLIENT: Ketchum Public Schools

SAMPLER SYMBOLS: Grab, ST, RC, SS, TC, HA

DEPTH (FT)	ELEVATION (FT)	USCS	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	BLOW COUNTS (N)	POCKET PENTROMETER (tsf)	RECOVERY % / RQD	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	UCS (psf)	-#200 SIEVE (%)	ATTERBERG LIMITS LL-PL-PI
0	106		(Short Grass)										
	105	SM	Dk. Reddish Brn. SILTY SAND V. Moist, Low Plasticity, Med. Dense	Grab	A				12.0				
				SS	B	9-11-10 (21)		78	20.5			47.4	34-25-9
				Grab	C				28.6				
5	100			SS	D	23-18-12 (30)		100	21.2	92			
				Grab	E				24.9				
10				SS	F	12-50/3.00"		67	19.7				
	95		(ROCK) Brn. LIMESTONE Med. Hard Rock										
			Bottom of borehole at 10.75 feet Auger Refusal										
15	90												
20	85												
25	80												
30	75												

WATER LEVELS		ELEVATIONS / LOCATIONS	DRIILLING			
WD	-	GROUND ELEVATION: 106	DRILL START:	9/24/2020	LOGGER:	B.H.
AD	-	TBM: Fire Hydrant	DRILLED END:	9/24/2020	DRILLER:	B.H.
24 Hrs	-	GPS: 36.525164, -95.017983	DRILL RIG:	CME 55	HOLE SIZE:	7.25"
> 24 Hrs	-	STA: OFFSET:	DRILL METHOD:	H.S.A.		

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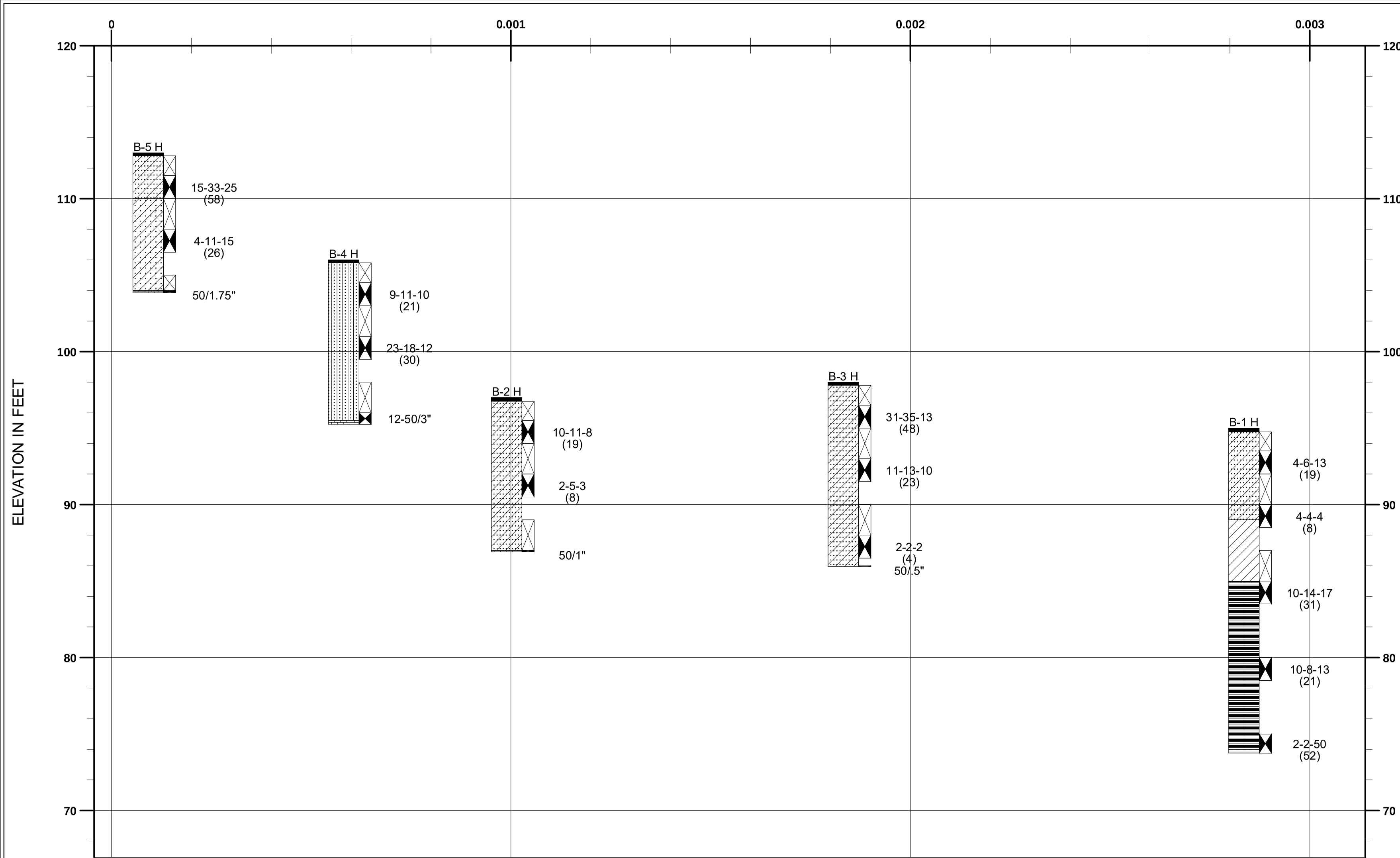
BORING LOG B-5 H

PROJECT NAME:	Ketchum Public Schools
PROJECT NUMBER:	2030-0549
PROJECT LOCATION:	Ketchum, OK
CLIENT:	Ketchum Public Schools

SAMPLER SYMBOLS: Grab, ST, RC, SS, TC, HA

DEPTH (FT)	ELEVATION (FT)	USCS	MATERIAL DESCRIPTION	SAMPLE NUMBER	BLOW COUNTS (N)	POCKET PENETROMETER (tsf)	RECOVERY % / RQD	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	UCS (psf)	-#200 SIEVE (%)	ATTERBERG LIMITS LL-PL-PI
0			(Short Grass)									
			Reddish Brn. CLAYEY SAND w/ GRAVEL V. Dense	A				19.3				
	110			B	15-33-25 (58)		83	14.8				
		CL	Reddish Brn. SANDY LEAN CLAY Sl. Moist, Moderate Plasticity V. Stiff	C				13.2			63.0	44-20-24
5				D	4-11-15 (26)		89	24.7	95			
	105			E				22.3				
			(ROCK) Brn. LIMESTONE Hard Rock	F	50/1.75"			7.5				
10			Bottom of borehole at 9.15 feet Auger Refusal									
	100											
15												
	95											
20												
	90											
25												
	85											
30												

WATER LEVELS		ELEVATIONS / LOCATIONS	DRIILLING			
WD	-	GROUND ELEVATION: 113	DRILL START:	9/24/2020	LOGGER:	B.H.
AD	-	TBM: Fire Hydrant	DRILLED END:	9/24/2020	DRILLER:	B.H.
24 Hrs	-	GPS: 36.524872, -95.01759	DRILL RIG:	CME 55	HOLE SIZE:	7.25"
> 24 Hrs	-	STA: OFFSET:	DRILL METHOD:	H.S.A.		



Asphalt

Clayey sand

Sandy Lean Clay

Limestone

Silty sand

Lean Clay

Weathered Shale

Shale

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SOIL PROFILE

Ketchum Public Schools

PROJECT NO. 2030-0549

HORIZONTAL	VERTICAL
SCALE: 1"=(proportional)	SCALE: 1"=10'

DEFINITION OF DESCRIPTIVE TERMS

Consistency of Cohesive Soils (at moisture content near plastic limit):
- Very Soft - Easily penetrated 4" to 6" by fist; tall core will sag under its own weight.
- Soft - Easily molded by fingers.
- Firm - Can be penetrated 2" to 3" by thumb with moderate effort, imprinted with fingers.
- Stiff - Readily indented by thumb but penetrated only with great effort.
- Very Stiff - Readily indented by thumbnail, imprinted very slightly with pressure from fingers.
- Hard - Indented with difficulty by thumbnail, cannot be imprinted with fingers.

Density of Cohesionless Soils:
- Very Loose - less than 4 SPT "N" value corrected for overburden.
- Loose - 5 to 10 SPT "N" value corrected for overburden.
- Medium Dense - 11 to 30 SPT "N" value corrected for overburden.
- Dense - 31 to 50 SPT "N" value corrected for overburden.
- Very Dense - 51 to 50/6" SPT "N" value corrected for overburden.
- Hard - less than 6" penetration in 50 SPT "N" blows corrected for overburden (cemented).

Hardness of Rock:
- Very Soft - can be scratched readily by fingernail
- Soft - can be grooved readily by knife or pick
- Medium - can be grooved 0.05" deep by firm pressure of knife
- Moderately Hard - can be scratched by knife
- Hard - can be scratched by knife or pick only with difficulty
- Very Hard - cannot be scratched by knife or sharp pick

Other Terms Descriptive of Consistency:
- Brittle - Ruptures with little deformation
- Friable - Crumbles or pulverizes easily.
- Elastic - Returns to original length after small deformation.
- Spongy - Is very porous, loose and elastic.
- Sticky - Adheres or sticks to tools or hands.

In-Situ Moisture Descriptions:
- Dry - powdery
- Slightly Moist - water not readily absorbed by paper
- Moist - water readily absorbed by paper
- Very Moist - water condenses on sample tray
- Wet - water drips from sample

Degree of Plasticity When Moist to Very Moist:
- Nonplastic - cannot be rolled into a ball
- Trace of Plasticity - can be rolled into a ball but not into a 1/8" thread
- Low Plasticity - barely holds its shape when rolled into a 1/8" thread
- Fairly Low Plasticity - 1/8" thread quickly ruptures when bent
- Medium Plasticity - 1/8" thread withstands considerable deformation without rupture.
- Fairly High Plasticity - difficult to rupture a 1/8" thread by bending.
- High Plasticity - can be kneaded without rupture; greasy texture.

Abbreviations:

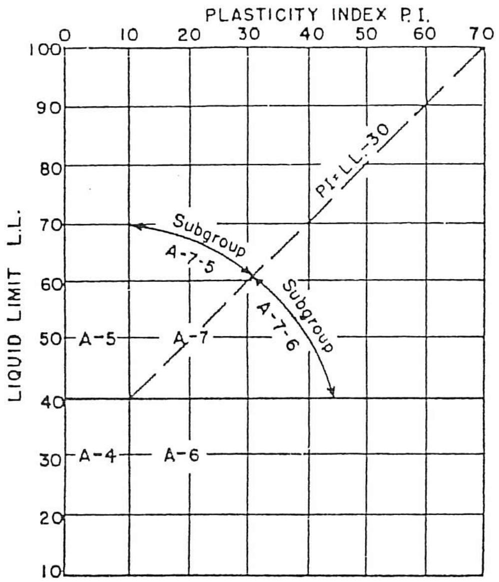
V. - Very	Dk. - Dark	Blk. - Black
Tr. - Trace	Lt. - Light	Brn. - Brown
Fl. - Fairly	Med. - Medium	
Sl. - Slightly		

APPENDIX C

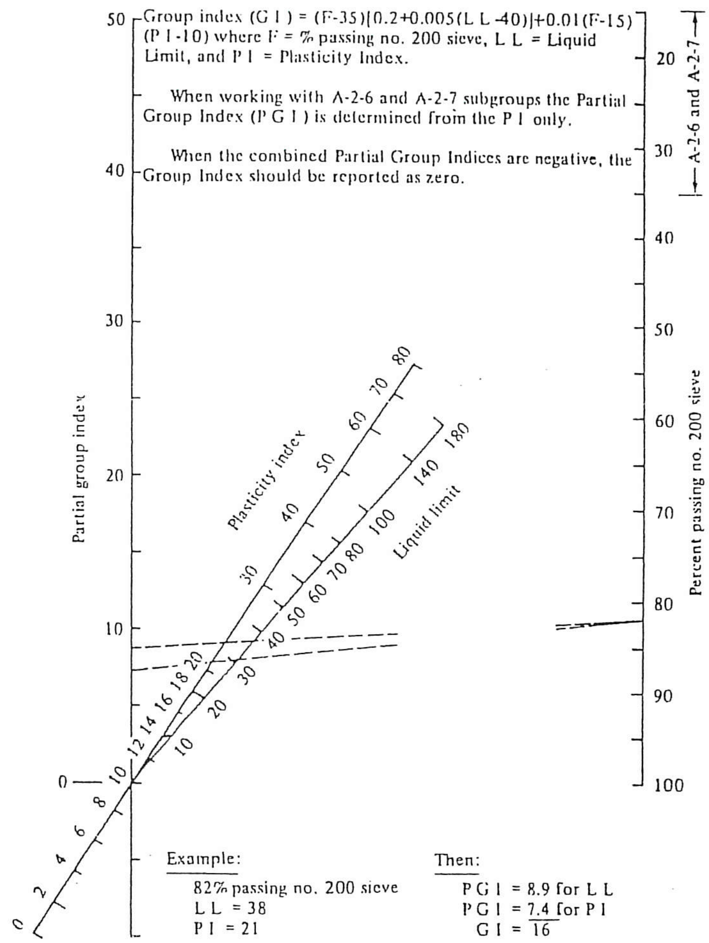
AASHTO Soil Classification System
Unified Soil Classification System

Soil Classification System — American Association of State Highway and Transportation Officials

The tables and charts given below are from AASHTO Designation: M 145-83, The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes. More detailed information as to the background and application of the system may be obtained from the report.



Liquid-limit and plasticity-index ranges for the A-4, A-5, A-6 and A-7 subgrade groups.



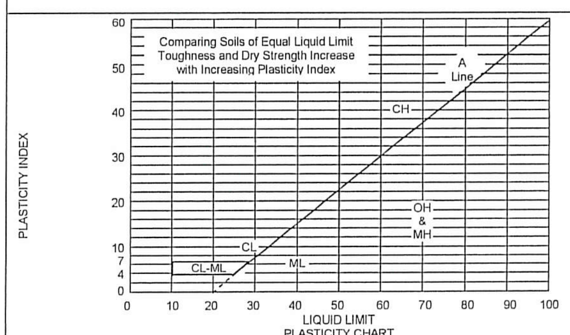
Group index chart

Classification of Soils and Soil-Aggregate Mixtures (with Suggested Subgroups)

General classification	Granular materials (35 per cent or less passing No. 200)							Silt-clay materials (More than 35 per cent passing No. 200)			
Group classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5; A-7-6
Sieve analysis: Per cent passing:											
No. 10	50 max.	—	—	—	—	—	—	—	—	—	—
No. 40	30 max.	50 max.	51 min.	—	—	—	—	—	—	—	—
No. 200	15 max.	25 max.	10 max.	35 max.	35 max.	35 max.	35 max.	36 min.	36 min.	36 min.	36 min.
Characteristics of fraction passing No. 40:											
Liquid limit	—		—	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.
Plasticity index	6 max.		NP	10 max.	10 max.	11 min.	11 min.	10 max.	10 max.	11 min.	11 min.*
Usual types of significant constituent materials	Stone fragments, gravel and sand		Fine sand	Silty or clayey gravel and sand				Silty soils		Clayey soils	
General rating as subgrade	Excellent to good							Fair to poor			

*P.I. of A-7-5 subgroup is equal to or less than L.L. minus 30. P.I. of A-7-6 subgroup is greater than L.L. minus 30

UNIFIED SOIL CLASSIFICATION
(Including Identification and Description)

Major Divisions			Group Symbols	Typical Names	Field Identification Procedures (Excluding particles larger than 3 inches and basing fractions on estimated weights)			Information Required for Describing Soils	Laboratory Classification Criteria
1	2		3	4	5			6	7
Coarse-grained Soils More than half of material is <u>larger</u> than No. 200 sieve size. The No. 200 sieve size is about the smallest particle visible to the naked eye.	Gravels More than half of coarse fraction is larger than No. 4 sieve size. (For visual classification, the ¼-in size may be used as equivalent to the No. 4 sieve size)	Clean Gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.			For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics	Use grain-size curve in identifying the fractions as given under field identification Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse-grained soils are classified as follows: Less than 5% GW, GP, SW, SP More than 12% GM, GC SM, SC 5% to 12% <u>Borderline</u> cases require use of dual symbols $C_u = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.				Not meeting all gradation requirements for GW
		Gravels with Fines (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures.	Nonplastic fines or fines with low plasticity (for identification procedures see ML below).			Give typical name; indicate approximate percentages of sand and gravel, maximum size, angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbol in parentheses.	Atterberg limits below "A" line or PI less than 4 — Above "A" Line with PI between 4 and 7 are <u>borderline</u> cases requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures.	Plastic fines (for identification procedures see CL below).				Atterberg limits above "A" line or PI greater than 7
	Sands More than half of coarse fraction is smaller than No. 4 sieve size.	Clean Sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines.	Wide range in grain size and substantial amounts of all intermediate particle sizes.				$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			SP	Poorly-graded sands, gravelly sands, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.			Example: <u>Silty sand</u>, gravelly; about 20% hard, angular gravel particles ½-in. maximum size; rounded and subangular sand grains coarse to fine; about 15% nonplastic fines with low dry strength; well compacted and moist in place; alluvial sand; (SM).	Not meeting all gradation requirements for SW
		Sands with Fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures.	Nonplastic fines or fines with low plasticity (for identification procedures see ML below).				Atterberg limits below "A" line or PI less than 4 — Limits plotting in hatched zone with PI between 4 and 7 are <u>borderline</u> cases requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures.	Plastic fines (for identification procedures see CL below).				Atterberg limits above "A" line or PI greater than 7
					Identification Procedures On Fractions Smaller than No. 40 Sieve Sizes				
					Dry Strength (Crushing characteristics)	Dilatancy (Reaction to shaking)	Toughness (Consistency near PL)		
Fine-grained Soils More than half of material is <u>smaller</u> than No. 200 sieve size.	Silts and Clays Liquid limit less than 50		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.	None to slight	Quick to slow	None	Give typical name, indicate degree and character of plasticity, amount and maximum size of coarse grains, color in wet condition, odor if any, local or geologic name, and other pertinent descriptive information; and symbol in parentheses.	
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	Medium to high	None to very slow	Medium		
			OL	Organic silts and organic silty clays of low plasticity.	Slight to medium	Slow	Slight		
	Silts and Clays Liquid limit greater than 50		MH	Inorganic silts, micoceous or diotomoceous fine sandy or silty soils, elastic silts.	Slight to medium	Slow to none	Slight to Medium	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remolded states, moisture and drainage conditions.	
			CH	Inorganic clays of high plasticity, fat clays.	High to very high	None	High		
			OH	Organic clays of medium to high plasticity, organic silts.	Medium to high	None to very slow	Slight to medium	Example: <u>Clayey silt</u>, brown, slightly plastic, small percentage of fine sand, numerous vertical root holes, firm and dry in place, loess, (ML).	
Highly Organic Soils			PI	Peat and other high organic soils.	Readily identified by color, odor, spongy feel and frequently by fibrous texture.				PLASTICITY CHART For laboratory classification of fine-grained soils

(1) Boundary Classifications: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, well-graded gravel-sand mixture with clay binder. (2) All sieve sizes on this chart are U.S. Standard

FIELD IDENTIFICATION PROCEDURES FOR FINE-GRAINED SOILS OR FRACTIONS

These procedures are to be performed on the minus No. 40 sieve size particles, approximately 1/64 in. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

Dilatancy (Reaction to shaking)

After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky. Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat, which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and glass disappear from the surface, the pat stiffens, and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.

Very fine clean sands give the quickest and most distinct reactions whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour show a moderately quick reaction.

Dry Strength (Crushing Characteristics)

After removing particles larger than No. 40 sieve size, mold a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun, or air drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty, whereas a typical silt has the smooth feel of flour.

Toughness (Consistency near plastic limit)

After removing particles larger than the No. 40 sieve size, a specimen of soil about one-half inch cube in size is molded to the consistency of putty. If too dry, water must be added and if sticky, specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eighth inch in diameter. The thread is then folded and rerolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses it's plasticity, and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be lumped together and slight kneading action continued until lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.

Highly organic clays have a very weak and spongy feel at the plastic limit.

Adopted by Corps of Engineers and Bureau of Reclamation January 1952

APPENDIX D

Summary of Test Results

STANDARD TESTING AND ENGINEERING COMPANY
Since 1951

SUMMARY OF LABORATORY TEST RESULTS

Client: Ketchum Public Schools

Project: Ketchum Public Schools

Date: 10/15/2020

Project No.: 2030-0549

Boring No.	Sample No.	Depth (ft)	Moisture Content (%)	Dry Density (pcf)	Atterberg Limits (% Moisture)			Sieve Analysis (% Passing)					Soil Classification		UCT	
					LL	PL	PI	#4	#10	#40	#100	#200	USCS	AASHTO	Stress (psf)	Strain (%)
B-1 H																
	A	0.3-1.5	14.7													
	B	1.5-3.0	19.0		35	19	16	81	63	47	42	39.8	SC	A-6(2)		
	C	3.0-5.0	19.9													
	D	5.0-6.5	20.1	108												
	E	8.0-10.0	21.5													
	F	10.0-11.5	13.3													
	G	15.0-16.5	25.9													
	H	20.0-21.3	18.2													
B-2 H																
	A	0.3-1.5	24.2													
	B	1.5-3.0	21.0													
	C	3.0-5.0	19.3		48	18	30	77	60	45	41	39.0	SC	A-7-6(6)		
	D	5.0-6.5	20.2													
	E	8.0-10.0	21.2													
	F	10.0-10.1														
B-3 H																
	A	0.2-1.5	21.3													
	B	1.5-3.0	23.2													
	C	3.0-5.0	25.3													
	D	5.0-6.5	28.1		50	22	28	81	68	55	51	48.9	SC	A-7-6(10)		
	E	8.0-10.0	23.1													
	F	10.0-11.5	9.8													
	G	12.0-12.0														
B-4 H																
	A	0.2-1.5	12.0													
	B	1.5-3.0	20.5		34	25	9	86	72	54	50	47.4	SM	A-4(2)		
	C	3.0-5.0	28.6													
	D	5.0-6.5	21.2	92												
	E	8.0-10.0	24.9													

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Since 1951

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Boring No.	Sample No.	Depth (ft)	Moisture Content (%)	Dry Density (pcf)	Atterberg Limits (% Moisture)			Sieve Analysis (% Passing)					Soil Classification		UCT	
					LL	PL	PI	#4	#10	#40	#100	#200	USCS	AASHTO	Stress (psf)	Strain (%)
	F	10.0-10.8	19.7													
B-5 H																
	A	0.2-1.5	19.3													
	B	1.5-3.0	14.8													
	C	3.0-5.0	13.2		44	20	24	89	79	69	65	63.0	CL	A-7-6(13)		
	D	5.0-6.5	24.7	95												
	E	8.0-9.0	22.3													
	F	9.0-9.1	7.5													