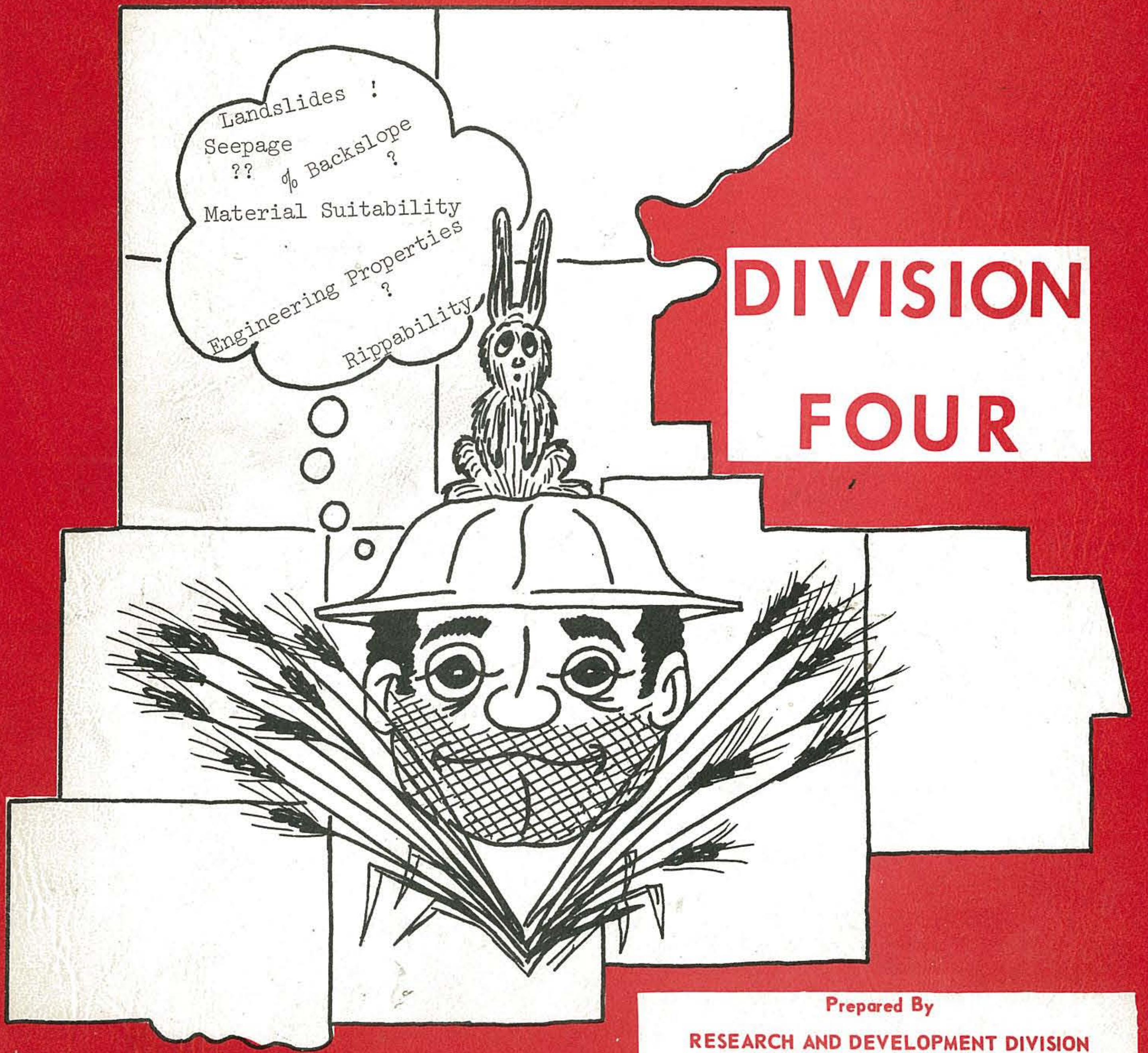
ENGINEERING CLASSIFICATION of GEOLOGIC MATERIALS



DIVISION FOUR

Prepared By

RESEARCH AND DEVELOPMENT DIVISION

OKLAHOMA HIGHWAY DEPARTMENT

In Cooperation with the

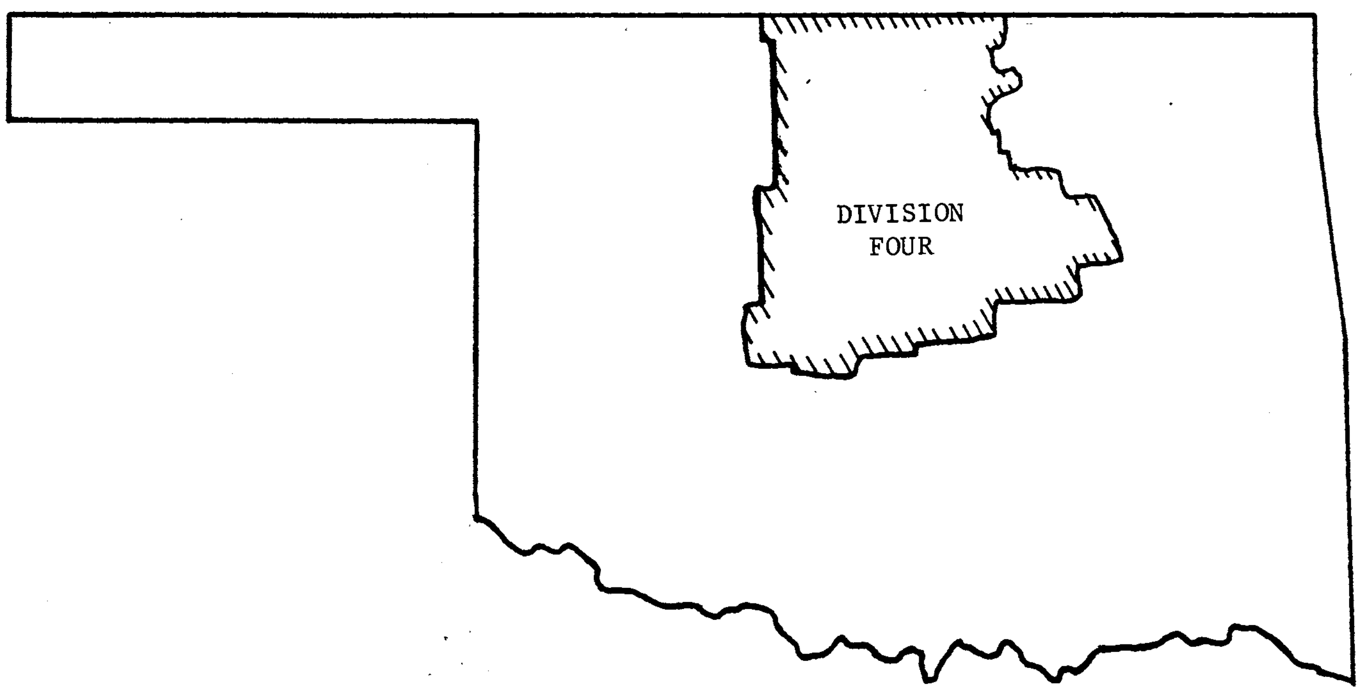
U.S. BUREAU OF PUBLIC ROADS

1967

ENGINEERING CLASSIFICATION OF GEOLOGICAL MATERIALS

AND

(RELATED SOILS)



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IN COOPERATION WITH THE U.S. BUREAU OF PUBLIC ROADS

Oklahoma Research Project 61-01-1

PREPARED BY

RESEARCH AND DEVELOPMENT DIVISION

OKLAHOMA HIGHWAY DEPARTMENT

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ACKNOWLEDGEMENTS

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The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Bureau of Public Roads.

FOREWORD

Geology is the science of the earth and is an organized collection of knowledge about the earth on which we live. The various rock and shale stratum that we see at the surface of the earth are all part of this organized body of knowledge. These exposures of rocks have been named and classified according to age by geologists. While these classifications serve many useful purposes, they are not particularly adaptable to the specific needs of those involved in highway design, engineering, and development. This publication is an attempt, therefore, to provide a classification system specifically designed and devoted to the needs of highway department personnel and individuals associated with the highway industry. It contains the engineering geologic classifications developed by the Research and Development Division of the Oklahoma Highway Department, in cooperation with the Bureau of Public Roads.

More detailed geologic information of specific areas may be obtained from publications listed in the bibliography.

PURPOSE AND SCOPE

The purpose of this publication is to provide a document which will serve as a comprehensive reference for Highway Department personnel concerned with engineering classifications of geologic materials found in the State of Oklahoma. The classification system described herein will assist personnel in the development of plans, designs, engineering, construction, and maintenance of our highways.

It is intended that this classification instrument be presented in such a manner that personnel with little or no understanding of geology may determine and identify the geologic materials in their respective area and operations. To simplify the classification procedure, geologic materials have been grouped into "geologic units", rather than being handled in the more sophisticated classification of ages, formations, and members. Each unit represents a specific area or locale within a county and identifies and describes the various geologic materials found therein together with the engineering characteristics encountered. Illustrations of certain geologic features (such as landslides, seepage, backslope instability, and terrace deposits) identified with each "geologic unit" are also provided. The different types and series of soils associated with geologic materials are described and illustrated together with the soil engineering characteristics.

The data presented herein represents an initial effort to provide a geologic and related soil classification reference for highway engineering. There is room for improvement and subsequent publications will include suggestions and relative field experiences. For instance, it is obvious that the boundaries of a "geologic unit" do not necessarily divide the engineering requirements. One geologic unit may need further division to best describe the engineering aspects while several geologic units within a county may be essentially the same from an engineering standpoint. It is hoped that those using this classification system will find essential information for immediate utilization and that they will record their experience associated with the various geologic units for future publication.

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GENERAL GEOLOGIC INFORMATION

AND

PROCEDURES

GENERAL GEOLOGIC INFORMATION

The information in Chapter One is intended to familiarize one with the general concepts of geology and its application to engineering. It is vital that this chapter be fully understood before proceeding to use the information contained in the rest of the publication.

For this publication, geologic materials are defined as masses and layers of rock, shale, and certain deposits of gravel, sands, silts, clays, and/or mixtures of these. Most of the geologic materials that occur at the surface are mantled with soil from a few inches thick up to as much as seven feet thick.

The geologic materials occur as two major types: (1) consolidated and (2) unconsolidated.

Consolidated Geologic Materials

Consolidated geologic materials are the various types of rocks such as limestone, sandstone, shale, chert, novaculite, gypsum, conglomerate, granite, etc. There may be soft sandstones and shales that are not in the true sense rocks, but they are classified here as such because they occur as a geologic bed or lens.

A geologic bed is one certain type of geologic material (rock) divided from other geologic materials, above and below, by a well-defined divisional plane called a bedding plane. See figure 1, page 4.

A geologic lens is one certain type of geologic material (rock), which can be easily divided from surrounding materials, but it does not have a flat-like bedding plane. It generally occurs as a body of material, which is thick in the approximate center and thins toward the edges. See figure 1, page 4.

Geologic Mass--Some rocks, such as granite, occur as rock masses. See figure 1, page 4.

Unconsolidated Geologic Materials

Unconsolidated geologic materials are the materials that have been deposited by streams, wind, and gravity. The individual grains are very loosely bound together.

Terrace deposits are deposits consisting of sand, silt, clay, gravel, or mixtures of these. These materials were deposited by streams or wind and may be found adjacent to most streams. Figure 2, page 6, shows some types of Terrace deposits.

Alluvium is the materials that have been, and are presently being, deposited by streams. Alluvium consists of sand, silt, clay, gravel, or mixtures of these. See figure 2, page 6.

Wind deposits are sand dunes, etc.

Colluvium is deposits of material occurring on slopes that have moved down, due to gravity. The deposit may consist of mixtures of sand, silt, clay, and gravel, to boulders. See figure 3, page 7.

Now that it is understood which portion of the earth materials are studied by geology and what these materials are, it can be seen how they are classified and grouped.

Classification

As a beginning toward an engineering classification of geologic materials, the present geologic classification and mapping are used with some slight changes. For the purposes of this publication, the geologic unit consists of one or more geologic materials. The outcrop (refer to figure 1, page 4) of this unit is outlined geographically on a map. In other words, it is one or more geologic materials that can be called a single unit, and this single unit is somewhat different from other units. The geologic units generally are named after some town, person, or location; for example, the McAlester Unit was named after the town of McAlester.

The outcrop portion of these geologic units of consolidated and unconsolidated types of material are shown on county geologic unit maps. Here again, it should be made clear that since the geologic units are divided according to a geologic classification, it is not intended that these units are divided completely according to what may be necessary to highway engineering. From available information at this time, it is obvious that in many cases certain engineering conditions are listed within the information of each geologic unit.

It is possible to determine the type of geologic material that is completely covered by soil by using the following criteria:

Soil Series--Certain soil series occur over certain geologic materials. Examples: Lucien occurs over sandstone; Kirkland occurs over shale. The chart on page 92 shows the relationship of the known soil series to geologic materials by counties. For identification of soil series, refer to page 90

Vegetation--Certain types of vegetation occur on certain types of geologic materials. Oak trees grow well on sandstone. Generally, the change from sandstone to shale is evidenced by a change in vegetation from trees to grass. Persimmon sprouts and trees grow well on limestones and some shales. Generally, prairie-land areas occur over shales and some limestones. Plum thickets are generally associated with sand dunes and terrace deposits.

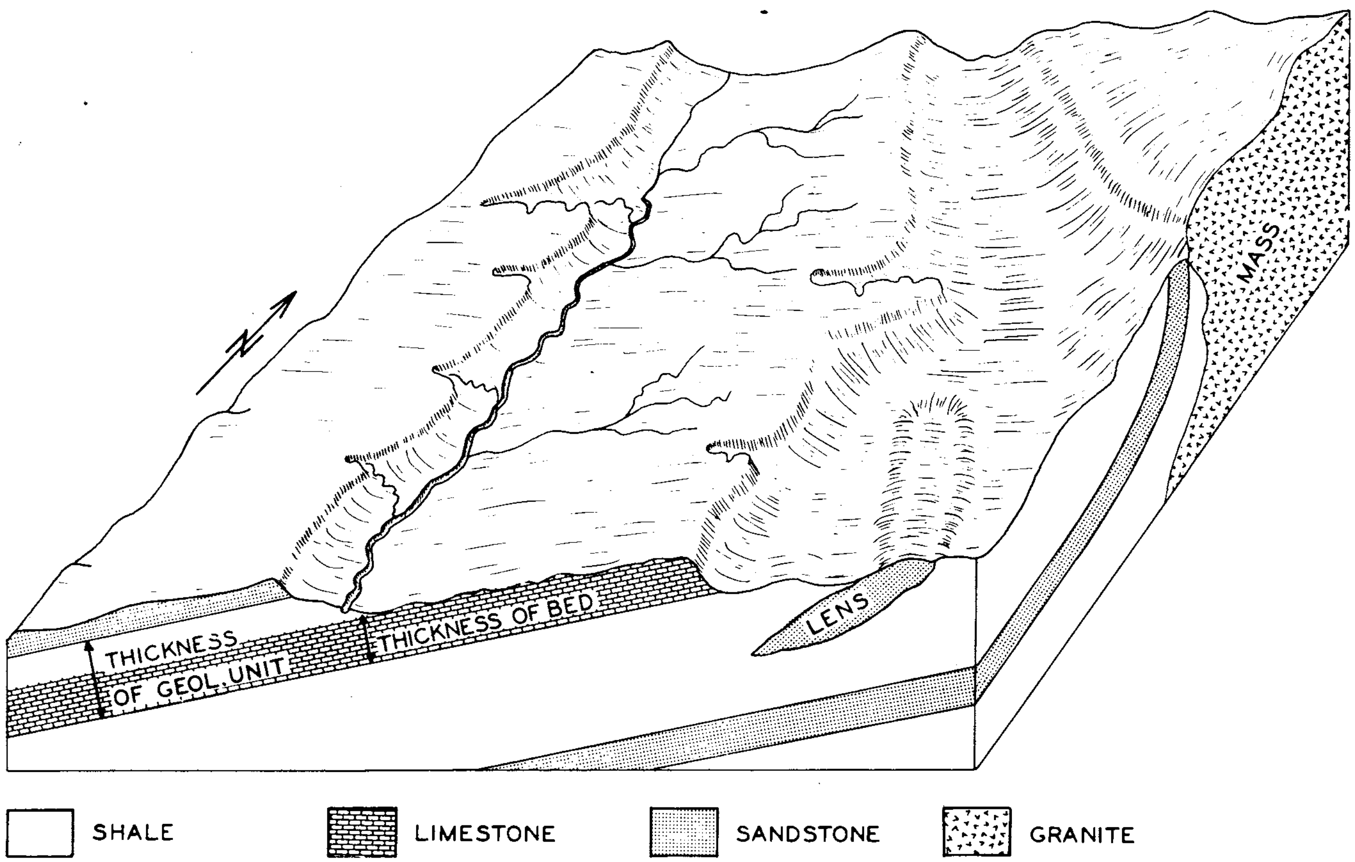


Figure 1

Explanation for figure 1 on page 5.

Explanation for figure 1:

Outcrop--These are the areas shown on the surface portion of the block diagram. The term outcrop, for the purpose of this report, is defined as the coming out at the surface of the earth of any consolidated geologic material. It is the portion of a geologic unit, bed, lens, or mass of rock that is exposed at the surface which may or may not be covered with soil and/or a thin cover of unconsolidated geologic materials.

Thickness--This is the measured distance taken at a right angle to the surface of the bedding plane.

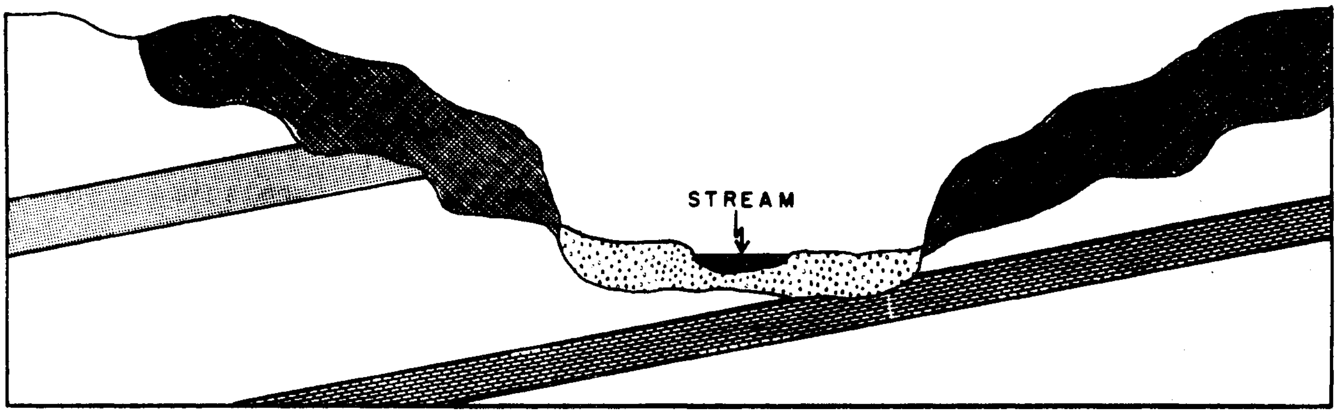
Dip of the Beds--Dip is defined as the angle at which a bed is inclined from the horizontal. The beds in this diagram are dipping west at approximately 5 degrees, or 460 feet per mile, or a 9 percent slope. A bed that outcrops here at a surface elevation of 1000 feet would be approximately 460 feet below the surface one mile west, providing the surface elevation is 1000 feet.

Geologic Lens--This is a certain type of consolidated geologic material which can be easily divided from surrounding materials, but does not have a flat-like bedding plane. It generally occurs as a body of material which is thick in the approximate center and thins toward the edges.

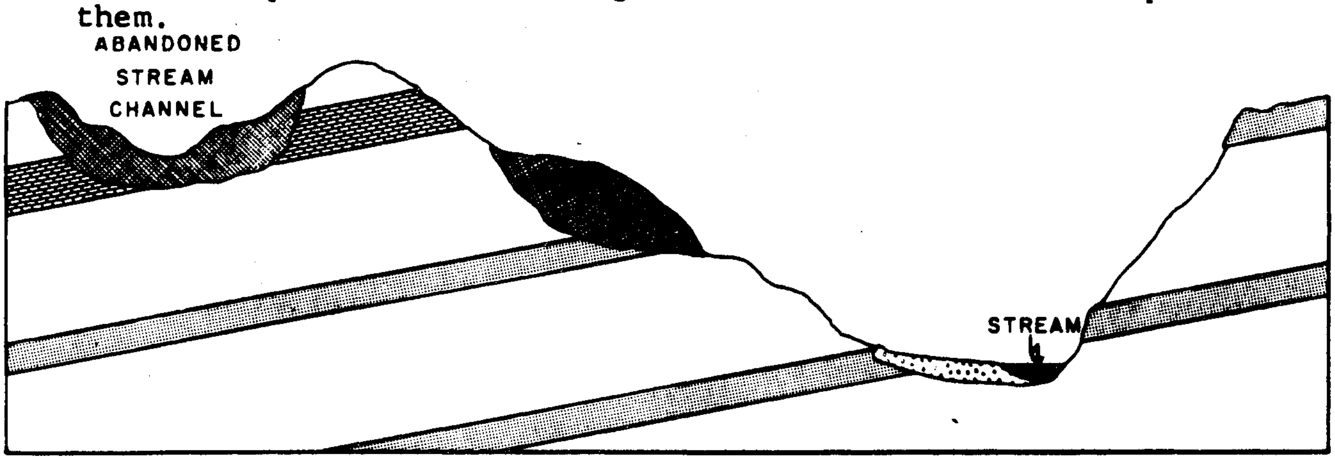
Geologic Mass--Granite and a few other rocks silimar to granite occur as masses and may be found in most any shape. This type of rock does not have a flat-like bedding plane.

The outcrop of geologic materials is generally completely overlaid by soil. Also, the unconsolidated geologic materials (wherever they occur) are laying upon outcrops of the consolidated materials, as shown in figure 3.

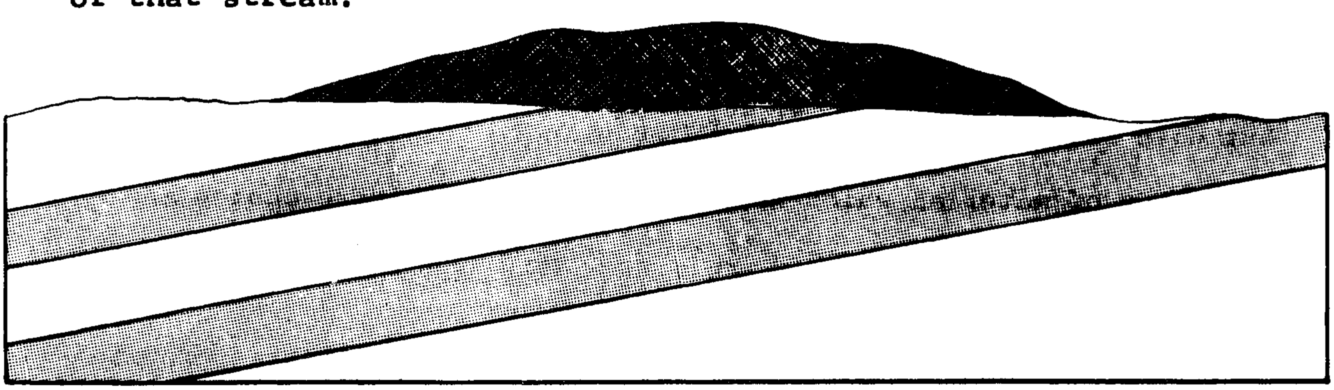
CROSS SECTIONS SHOWING TERRACE DEPOSITS



Terrace deposits that are adjacent to the stream that deposited them.



Terrace deposits that are some distance from the stream that deposited them, but generally can be recognized as being a deposit of that stream.



An upland terrace deposit that was deposited by a stream that is not presently in the same area.

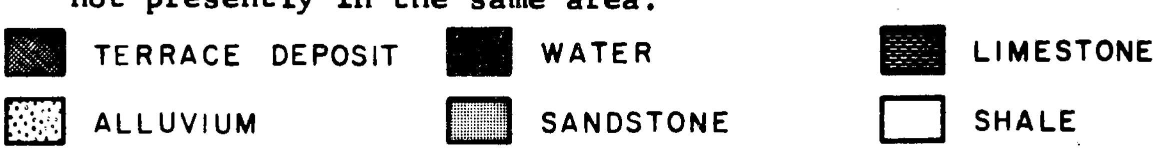


Figure 2

If most outcrops are covered, the question arises, "How does one know a particular geologic unit outcrop is present where it is shown?" The following block diagram shows a few conditions that expose the geologic materials along their outcrops.

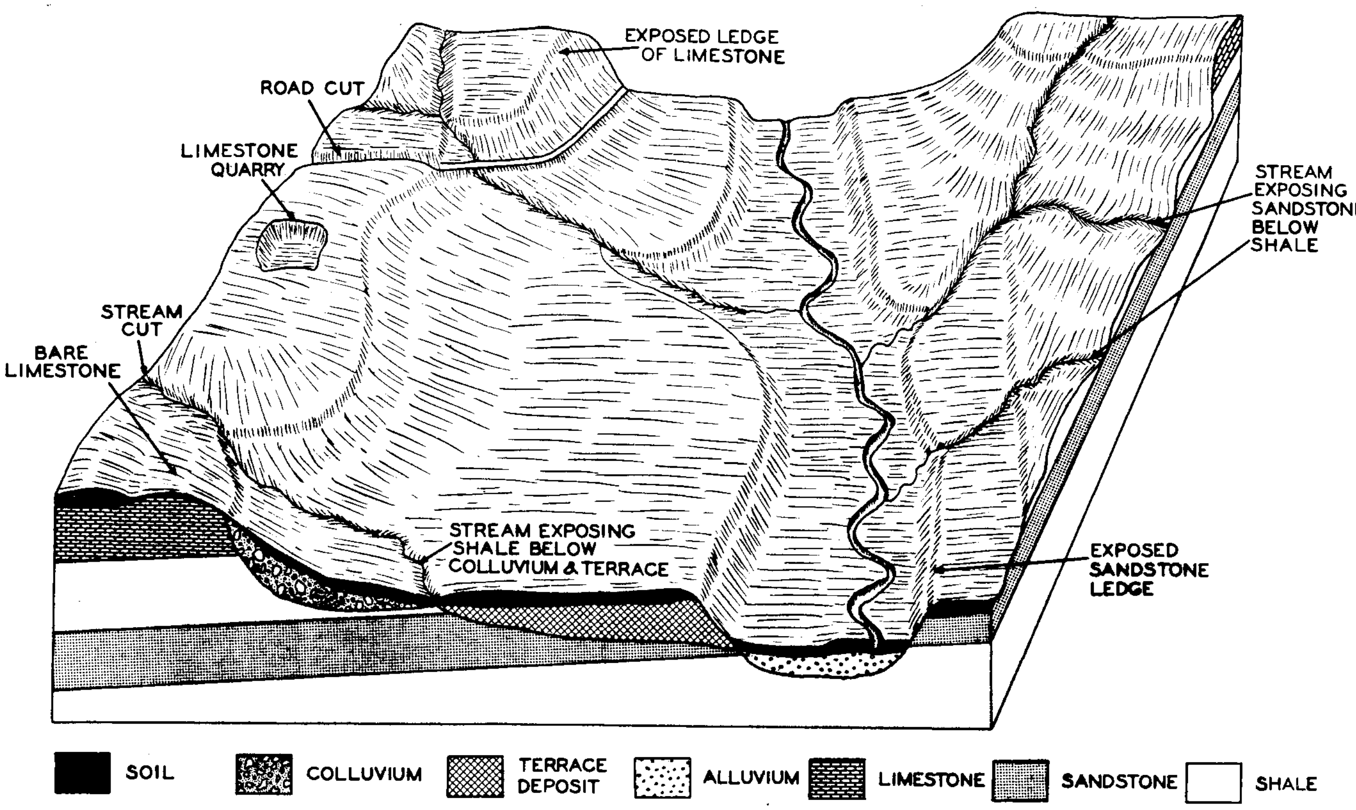


Figure 3

This block diagram shows the following:

1. Areas where erosion has removed the soil and exposed the geologic materials.
    a. Sheet erosion over sloping flat areas.
    b. Gullies and streams cutting through the soil into the geologic materials.
2. Areas with little or no soil development.
3. Rock ledges outcropping on hillsides.
4. Man-made cuts, quarries, pits, etc.

METHOD FOR DETERMINING ENGINEERING CHARACTERISTICS OF GEOLOGIC MATERIALS

Characteristics Determined from Field Observations and Construction

Certain qualities, such as: hardness, texture, and position of geologic materials can be directly correlated with highway engineering. Research Scientists have made field studies on the qualities of geologic materials, compiled information from highway department records, noted construction practices, and obtained information from other reliable sources. From these sources of information, estimates of material suitability, seepage characteristics, rippability, landslide characteristics, and backslope instability were made on geologic materials. This information is listed on charts in Chapter II, beginning on page 51.

Some information could not be obtained during the period of investigation by the Research Division due to the lack of sufficient precipitation to cause seepage, no construction, limited time, and/or lack of sufficient evidence.

One main purpose of this publication is to aid persons in identifying geologic materials and determining their qualities that affect highway engineering, so they can collect and correlate their own experiences with the geologic information.

Landslides

A landslide is a downward and outward movement of materials consisting of rock, soil, man-made fills, or combinations of these materials.

Known landslides are listed according to the geologic unit it occurs within, and reference to the type of landslide is made.

Figures 4, 5, 6, and 7, pages 9, 10, and 11, show some types of conditions involving landslides. It is intended that these illustrations will aid personnel in recognizing landslides and to recognize situations that may cause landslides.

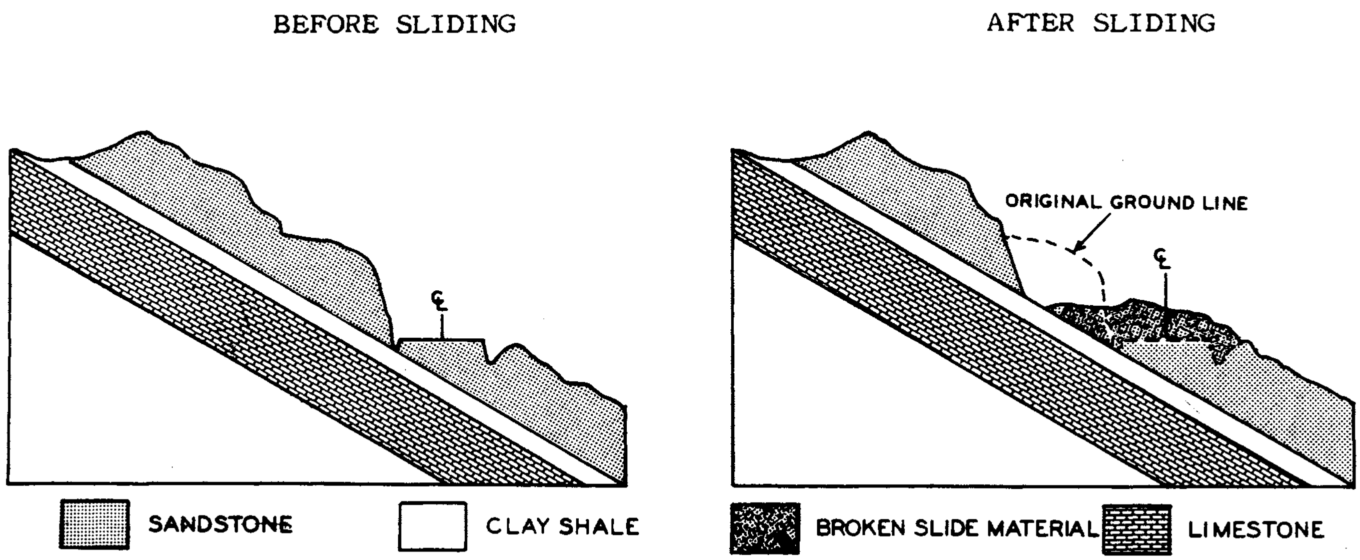


Figure 4

Figure 4 shows a condition where bedded rock dipping toward the roadway slipped, after the road cut removed support. In this condition, sandstone was laying on shale or clay. The moisture percolated through the sandstone and collected at the contact, allowing slippage after the support was removed. Generally, most any type of bedded material will slip if the dip is steep, support is lost, and if it is underlaid by a material that becomes slick when moisture is present. Each individual condition generally is different and requires a study of the factors involved.

Figure 5, page 10, illustrates the most common type of landslide in Oklahoma. The deposit of colluvium is generally an unconsolidated mass of

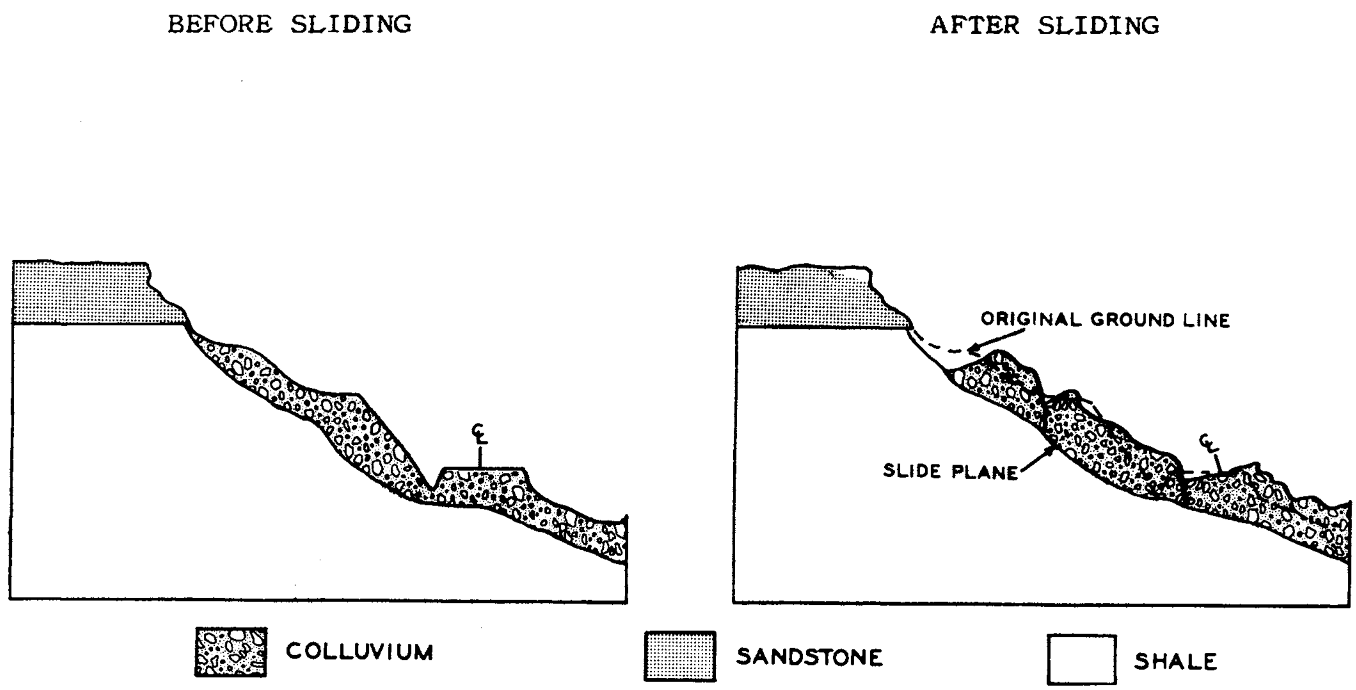


Figure 5

sand, silt, clay, and gravel to boulders. When this mass of material lays upon shale, if enough moisture collects at the contact between the materials, slippage may occur; also, loss of lateral support at some point along the slope allows slippage. Generally, both of these factors are involved. Loss of lateral support was caused by the road cut and when the material moved down upon the roadway, this additional weight moved the road.

Figure 6, page 11, shows a condition where a stream has eroded the toe of a slope of colluvium and created a landslide, which eventually migrated uphill involving the roadway.

Figure 7, page 11, shows where a road cut has caused the material to slide, and the sliding has migrated uphill involving personal property.

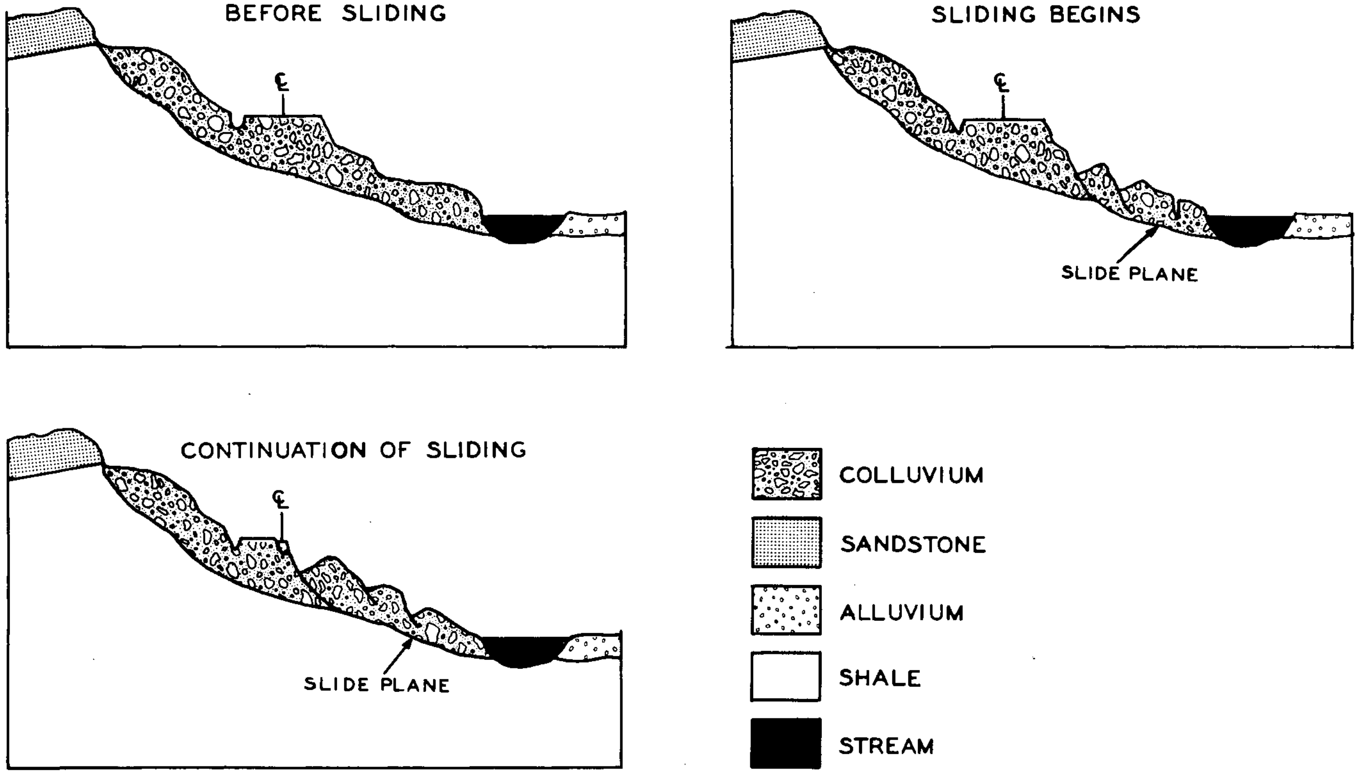


Figure 6

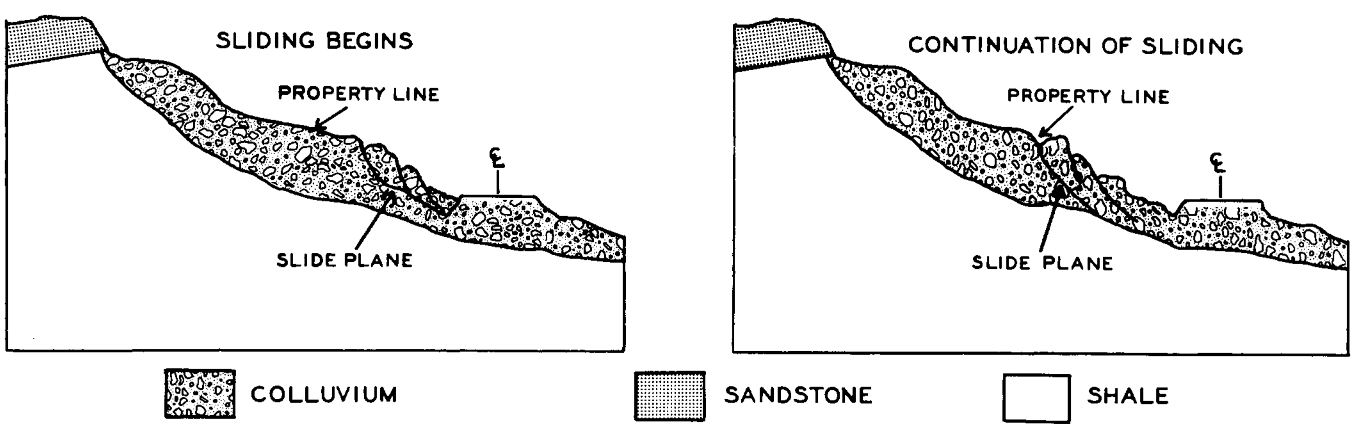


Figure 7

CROSS SECTIONS OF SEEPAGE CONDITIONS

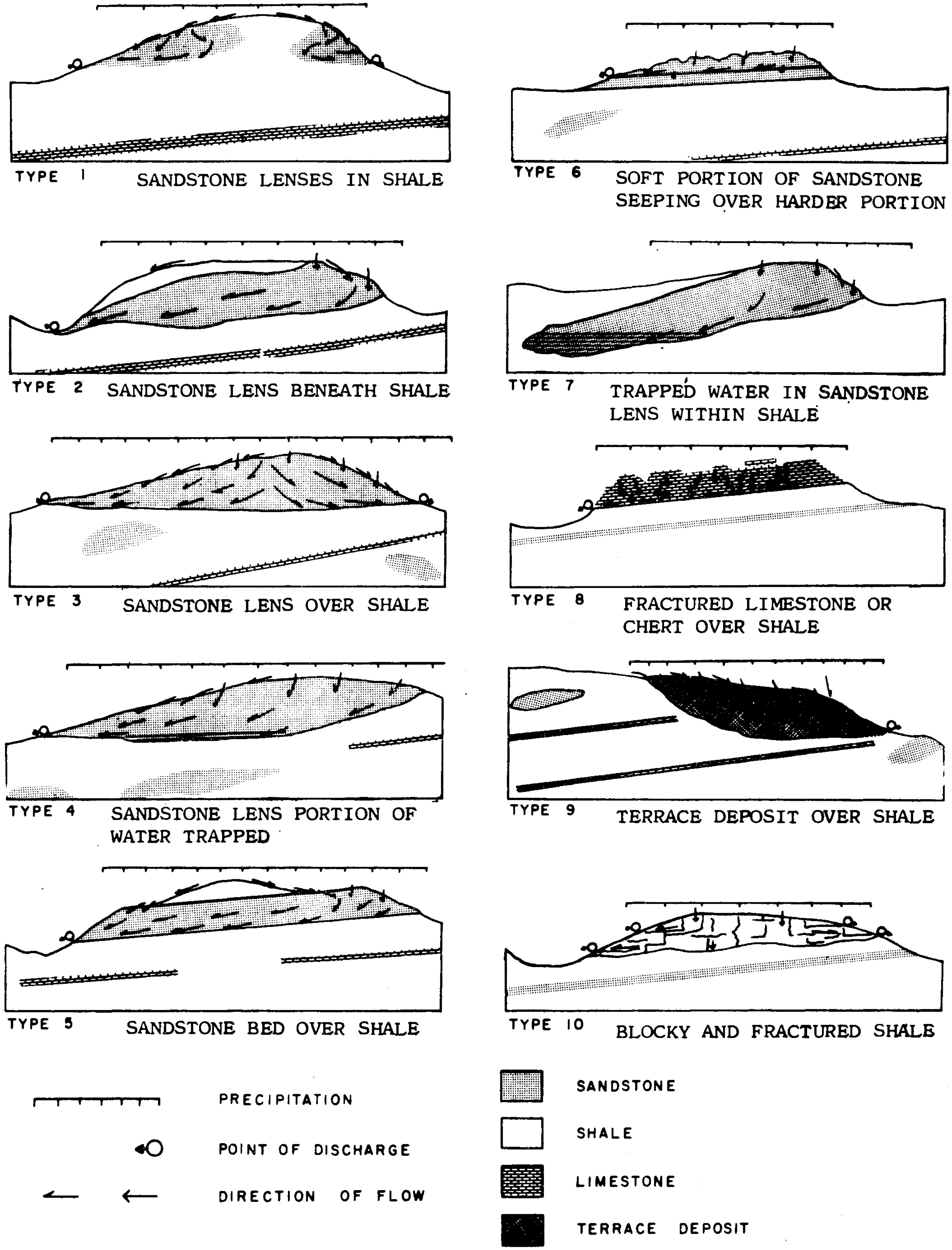


Figure 8

Characteristics of Shales Determined From Laboratory Testing

The shales from Division Four were laboratory tested for sieve analysis (percent passing the numbers 10, 40, 60, and 200), plasticity index, liquid limit, volumetric change, field moisture equivalent, shrinkage limit, pH, and shrinkage ratio.

From these test results, the estimated Suitability for Subgrade, Oklahoma Subgrade Index Number, AASHO Classification with Group Index Number, Potential Vertical Rise, Percent of Asphalt for Stabilization, and Percent Cement for Stabilization were determined by use of charts. See charts 1 through 7, pages 13 through 19. Engineering characteristic charts for these shales begin on page 57, Chapter II.

STATE OF OKLAHOMA

DEPARTMENT OF HIGHWAYS

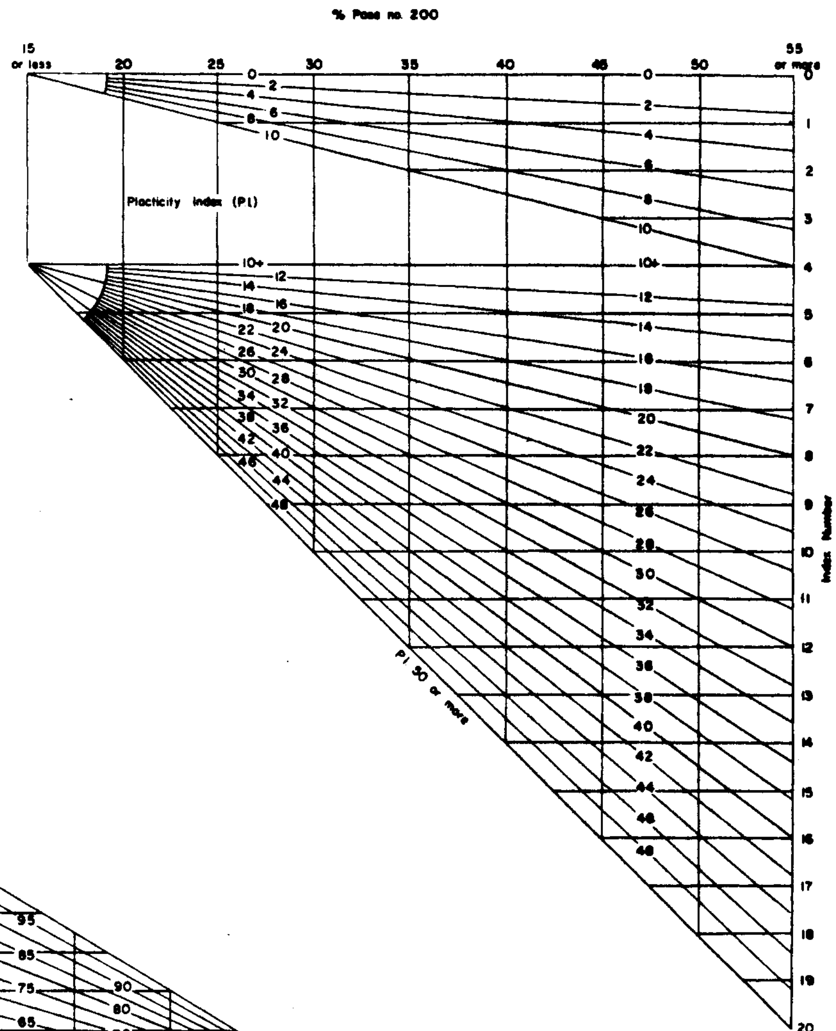
RESEARCH AND DEVELOPMENT DIVISION

ESTIMATED SUITABILITY OF MATERIALS

SUBGRADE	GOOD	FAIR	POOR
OSI	6 or less	7-16	17 or more

Chart 1

OKLAHOMA SUBGRADE INDEX NUMBERS CHART



To Use This Chart

1. Determine the percent of the soil passing the number 200 sieve and the L.L. and P.I. of the soil.
2. On the L.L. chart, find the % pass no. 200 along the bottom of the chart and move vertically up to the L.L. (sloping) line.
3. From the intersection of these lines, move horizontally to the left to determine index number.
4. Follow a similar procedure (reading down and right) and determine the index number from the P.I. chart.
5. The sum of the index numbers determined in steps 3 & 4 is the Oklahoma Subgrade Index number (O.S.I.).

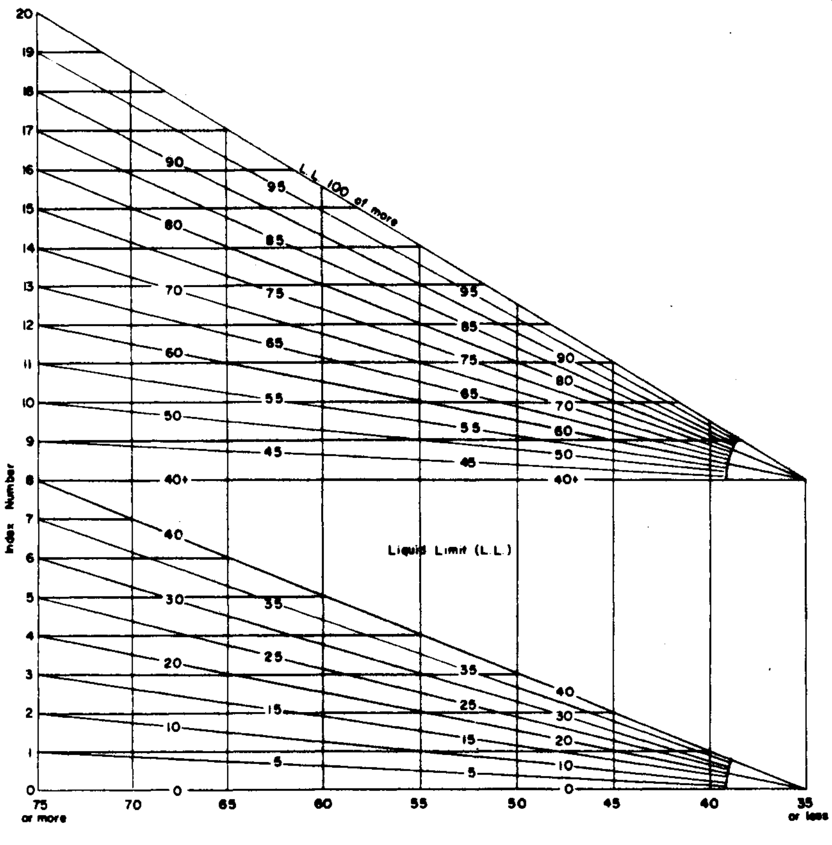


Chart 2

CLASSIFICATION OF SOILS AND SOIL-AGGREGATE MIXTURES. (WITH SUGGESTED SUBGROUPS)[1]

General Classification	GRANULAR MATERIALS (35% or less passing No. 200)							SILT-CLAY MATERIALS (More than 35% 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: Percent passing: No. 10 No. 40 No. 200	50 Max. 30 Max. 15 Max.	— 50 Max. 25 Max.	— 51 Min. 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 Plasticity Index	— 6 Max.		— NP	40 Max. 10 Max.	41 Min. 10 Max.	40 Max. 11 Min.	41 Min. 11 Min.	40 Max. 10 Max.	41 Min 10 Max	40 Max. 11 Min.	41 Min. 11 Min.[2]
Group Index	0		0	0		4 Max.		8 Max.	12 Max	16 Max.	20 Max.
Usual Types of Significant Constituent Materials	Stone Fragments Sand and Gravel		Fine Sand	Silty or clayey Gravel and Sand				Silty Soils		Clayey Soils	
General Rating as Subgrade	Excellent to Good					Fair to Poor					

1 Reproduced from AASHO Designation: M 145-49, Highway Materials, Part I, 7th Edition, AASHO, 1955

2 Plasticity Index of A-7-5 subgroup is equal to or less than LL minus 30. Plasticity Index of A-7-6 subgroup is greater than LL minus 30.

NOTE: If a description of the classification groups is desired, reference is made to footnote No. 1 above.

Chart 3

AASHO DETERMINATION OF GROUP INDEX

To use this chart:

1. Determine the per cent of the soil passing the No. 200 sieve and the L.L. and P.I. of the soil.
2. L.L. Chart: Read % passing 200 along bottom of chart and move vertically up to sloping line of L.L.
3. From intersection of the vertical and L.L. lines move left horizontally and read index number.
4. Follow a similar procedure reading down and to the right and determine the index number from the P.I. chart.
5. The sum of the index numbers determined in steps 3 & 4 is the (AASHO Group Index Number).

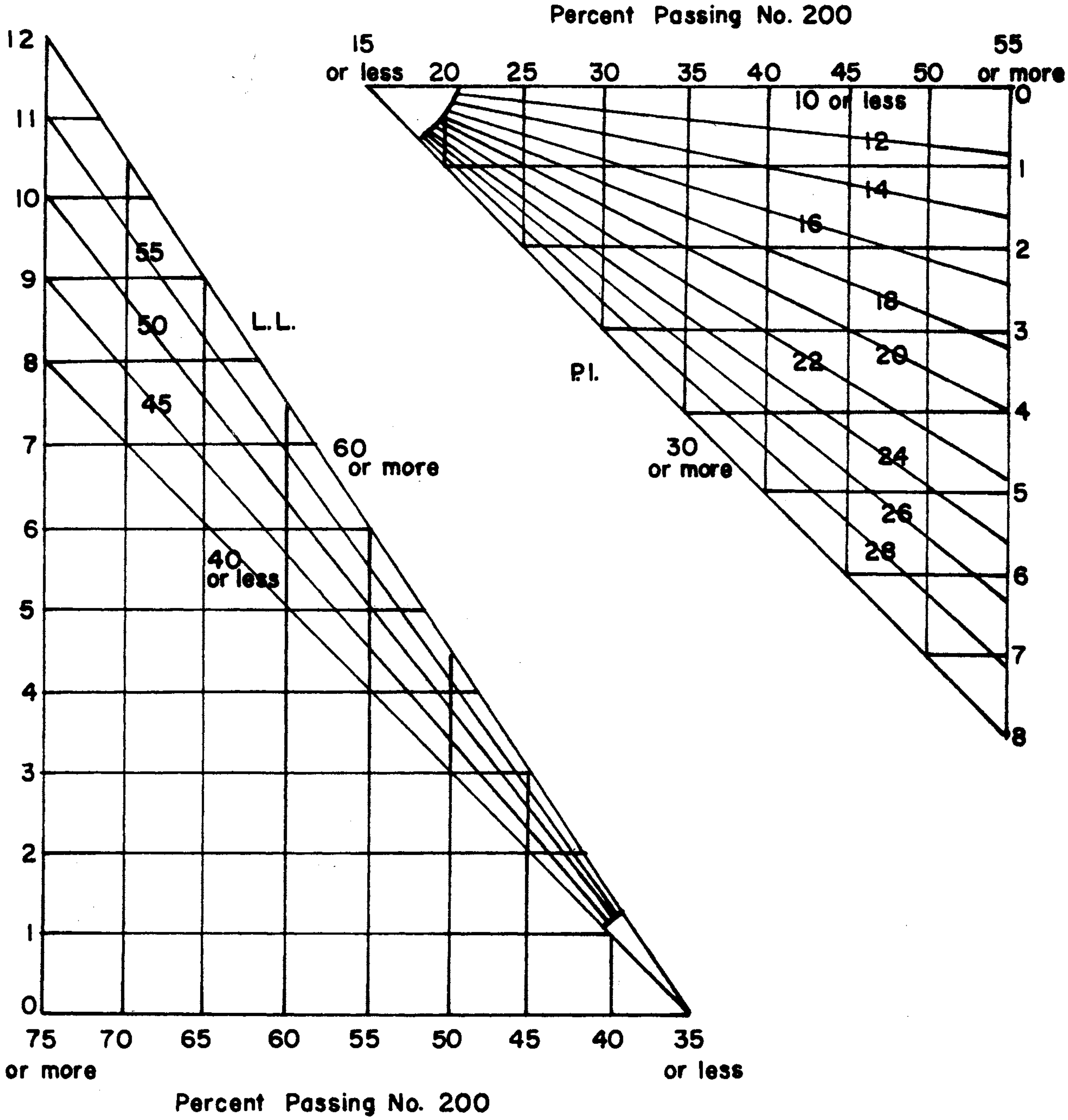
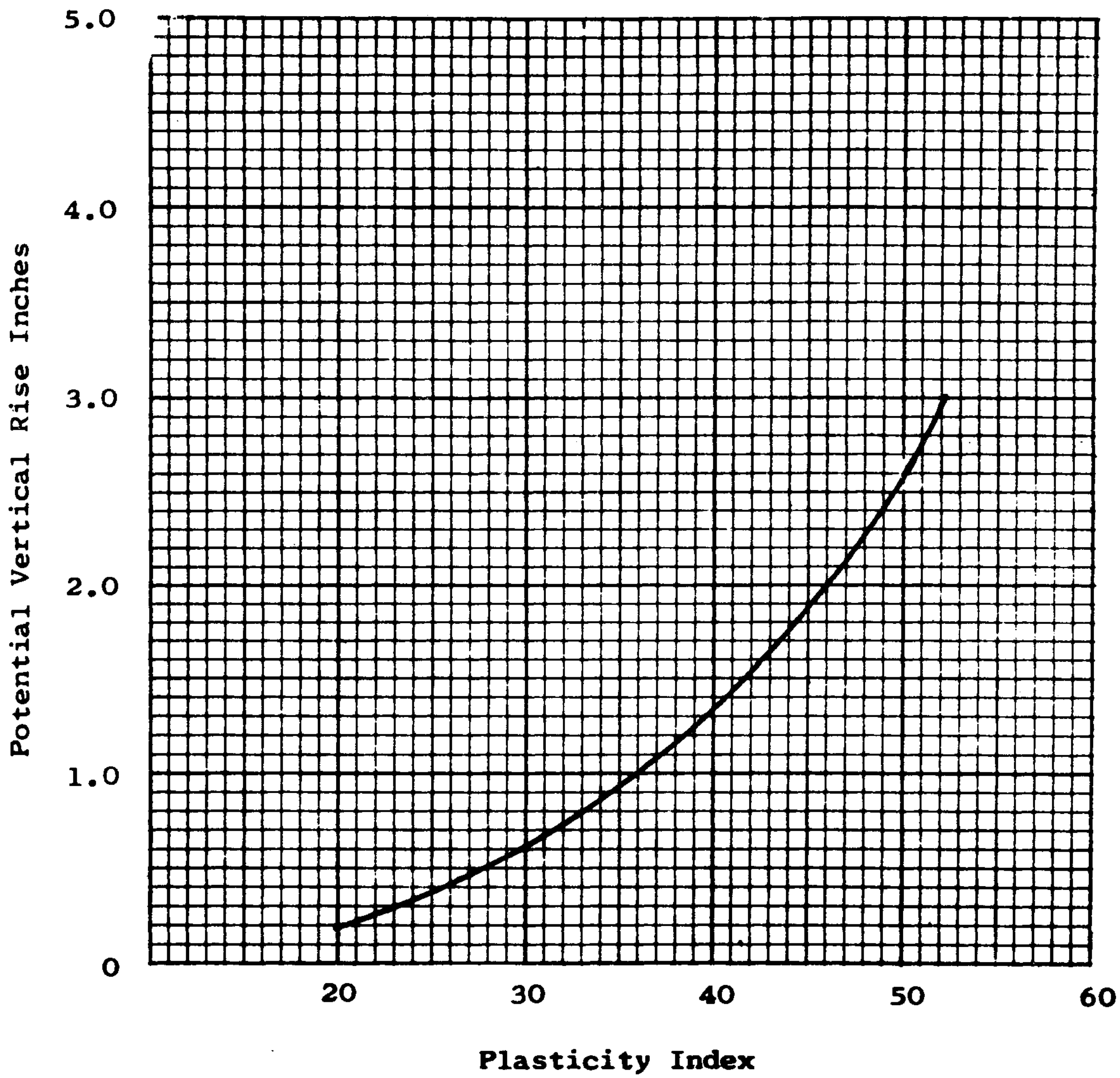


Chart 4

Potential Vertical Rise of Dry Material In A 3 Foot Layer Under One Psi Load

Calculated From Soil Swell Pressure Slide Rule. Developed by Chester McDowell



Taken From Graph

P. I.	Inches P. V. R.
19	.15
20	.20
21	.21
22	.24
23	.28
24	.32
25	.36
26	.39
27	.42
28	.49
29	.52
30	.58
31	.63
32	.70
33	.76
34	.83
35	.90
36	.99
37	1.06
38	1.14
39	1.21
40	1.30
41	1.42
42	1.55
43	1.68
44	1.78
45	1.90
46	2.00
47	2.15
48	2.29
49	2.43
50	2.60

Chart 5

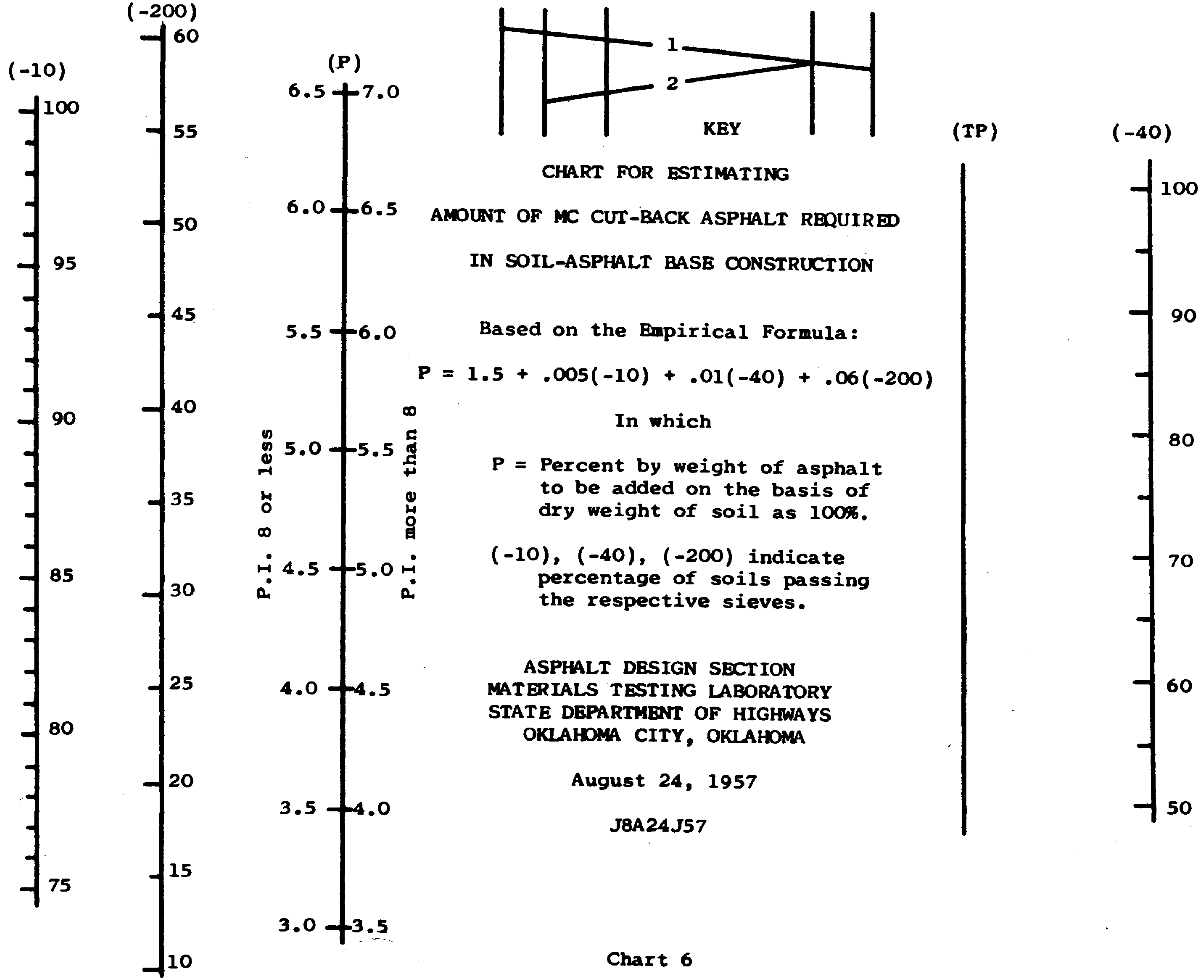


CHART FOR ESTIMATING

AMOUNT OF MC CUT-BACK ASPHALT REQUIRED

IN SOIL-ASPHALT BASE CONSTRUCTION

Based on the Empirical Formula:

$$P = 1.5 + .005(-10) + .01(-40) + .06(-200)$$

In which

P = Percent by weight of asphalt to be added on the basis of dry weight of soil as 100%.

(-10), (-40), (-200) indicate percentage of soils passing the respective sieves.

ASPHALT DESIGN SECTION
MATERIALS TESTING LABORATORY
STATE DEPARTMENT OF HIGHWAYS
OKLAHOMA CITY, OKLAHOMA

August 24, 1957

J8A24J57

Chart 6

ESTIMATED CEMENT REQUIREMENTS

FOR OKLAHOMA SOILS

AASHO	Per Cent Pass 200 Sieve							
Class	0	5	10	15	20	25	30	35
A-1-a	7	7	6	-	-	-	-	-
A-1-b	9	8	8	8	7	7	-	-
A-2-4	9	9	8	8	7	7	8	9
A-2-5	9	9	8	8	8	8	8	9
A-2-6	10	10	9	8	8	8	9	9
A-2-7	11	11	10	9	9	9	10	10

SHALES

A-1, A-2, A-3 --Add 2% cement

A-4, A-5, A-6, A-7 --Add 1% cement

	Texture				
	c	Mc	M	MF	F
A-3	8	9	10	11	12

	Group Index						
	0-2	3-5	6-8	9-11	12-14	15-17	18-20
A-4	9	10	11	-	-	-	-
A-5	9	10	11	11	12	-	-
A-6	10	11	12	12	13	14	-
A-7-5	11	11	12	13	13	14	16
A-7-6	11	12	13	14	14	15	17

Chart 7

TABLE OF TERMS, GEOLOGICAL*

AASHO Classification--A performance value determined by using the percent of soil material passing certain specific sieve sizes, liquid limit, and plasticity index in an emperical mathematical formula. Indicates the suitability of the soils as construction materials. See page 15.

Alluvium--Recent deposits of sands, silts, clays, gravels, or mixtures of these. These deposits are present along stream beds and floodplains.

Bed--A single layer of geologic material that is divided from its neighbors above and below by a more or less well-defined divisional plane. This plane is called a bedding plane.

C--Clay, See Texture. The fine mineral soil grains, less than 0.002 mm in diameter. (Engineers define as less than 0.005 mm in diameter).

Calcareous--Containing calcium carbonate (limy).

Chert--This is consolidated rock, generally very hard and brittle, and occurs in beds distributed with limestones. The grain size is extremely small and requires a microscope to see them. It is a cryptocrystalline variety of silica. It will not fizz when dilute hydrochloric acid is applied.

CL--Clay Loam, See Texture.

Clay Gall--A small, generally somewhat flattened pellet or ball of hard or nearly hard clay. Usually found in sandstones or conglomerates.

Colluvium--These are unconsolidated deposits of material occurring on slopes or at the foot of excarpments that have been deposited by gravity. The deposit may consist of mixtures of sand, silt, clay, and gravel to boulders.

Conglomerate--Rock that is composed of gravel size materials that are cemented together by finer sized materials. Generally in beds or lenses.

*For soils terms see page 268.

Cuesta--A broad flat lying area terminated on one side by a steep scarp.

Dip Slope--A slope of the land surface which conforms approximately to the dip of the underlying rocks.

Dolomite--A consolidated type of geologic material; generally the color may be white, cream, or pink. This rock generally occurs in beds and is very similar to limestone. Its composition is Ca Mg $(CO_3)2$. Dolomite will fizz when diluted hydrochloric acid is applied to powdered dolomite.

Escarpment (Scarp)--An extended line of cliffs, bluffs, or a definite break in a slope due to a rock ledge. An abrupt change in elevation of land form usually produced by erosion, etc.

Fault--A large crack or fracture occurring in the geologic units, where rocks on one side have moved in relation to rocks situated on the other side. Movements can be in a vertical or horizontal direction.

Field Moisture Equivalent--The minimum moisture content, expressed as a percent of oven dry soil, at which a smooth surface of soil will absorb no more water in 30 seconds.

Granite--A consolidated geologic material that occurs as a mass. It will not occur as a bed or lens. It will not fizz when dilute hydrochloric acid is applied.

Gypsum--A consolidated type of geologic material generally occurring in beds. Gypsum occurs as a pure mineral (Ca SO_4 $2H_2O$), which may be alabaster, selenite, or satin spar. Rock gypsum is the impure form of these minerals. Gypsum will not fizz when dilute hydrochloric acid is applied.

Interbedded--Two or more types of geologic materials occurring in alternating beds. The types of material are in approximately equal proportions for a designated unit; such as, alternating limestones, sandstones, and shales.

L--Loam, See Texture.

Limestone--A consolidated type of geologic material; generally the color is gray to dark gray. In certain areas it may occur as brown or reddish-brown. Its composition is Ca CO_3 (Calcium Carbonate), and it will fizz when diluted hydrochloric acid is applied. This rock is mainly composed of crystals.

Limy--A term that indicates that a geologic material contains a certain amount of lime (calcium carbonate), but is predominantly another type of material; such as, limy sandstone which is predominantly sandstone.

Liquid Limit--The moisture content, expressed as a percent of oven dry soil, at which a soil passes from a plastic to a liquid state.

LS--Loamy Sand, See Texture.

Mappable Unit--Group of beds or a single bed that can be easily outlined on aerial photographs or by ground survey. This unit may be drawn on a map to show its geographic location.

Massive--This term applies to geologic beds that are greater than 3 feet thick and consist of only one type of rock. Example: A 10-foot or more thick bed of sandstone (with no other type of geologic material within it) would be massive.

Novaculite--A very dense, even-textured, light-colored, very fine-grained rock, similar to chert.

O.S.I.--Oklahoma Subgrade Index; a modification of the AASHO group index number; a relative support value determined by using the percent of soil material passing the No. 200 sieve, liquid limit, and plasticity index in an emperical mathematical formula. An index number used to determine base thickness requirements for roadways. See page 14.

Outlier--Portions of any geologic unit which lie detached, or out from the main body, separated by erosion from the main unit to which they belong.

Plasticity Index--The numerical difference between liquid limit and plastic limit (LL-PL).

Plastic Limit--The moisture content, expressed as a percent of oven dry soil, at which a soil changes from a semisolid to a plastic state.

Potential Vertical Rise--A measure of vertical expansion of plastic material (soil) under one pound per square inch pressure in a three-foot layer of material, due to moisture increase.

Rippability--Susceptibility of a rock to be broken by a ripping device as pulled by a Caterpillar D9 or its equivalent.

Sand--Small rock or mineral fragments having diameters ranging from 0.05 to 2.0 mm, Also see Texture.

Sandstone--A consolidated type of geologic material that occurs as beds or lenses. Sandstone consists of sand grains cemented together forming stone. The various common cementing agents may be calcite, silica, or iron oxide. The color may be shades of red, brown, gray, and maybe green.

Sandy--Indicates a portion being sandy, with the geologic material being predominantly some other type. Example: Sandy limestone contains sand grains, but is predominantly limestone.

Seepage--Act of seeping; a local spot where water slowly percolates from porous geologic material, such as a sandstone.

SC--Sandy Clay, See Texture.

SCL--Sandy Clay Loam, See Texture.

Shale--A consolidated type of geologic material which occurs in beds and lenses. Shale generally consists of clay minerals with portions of sands and silts. The color ranges from white to black; but gray, green, red, and black are very common. When weathered at the surface, shales lose their bedded structure and may become loosely compacted clays. Shales are characterized by being plastic when wet (due to the plasticity of clay minerals).

Shaly--Indicates that a portion is shale within a geologic material that is predominantly some other type. Example: Shaly sandstone.

Shrinkage Limit--The moisture content, expressed as a percent of oven dry soil, at which a wet soil stops shrinking.

Shrinkage Ratio--The volume change, expressed as a percent of the volume of the fried soil pat, divided by the moisture loss above the shrinkage limit, expressed as a percentage of the weight of the dried soil pat.

SI--Silt, See Texture. Small mineral soil grains having diameters ranging from 0.002 mm to 0.05 mm (Engineers use the limits of 0.005 mm to 0.05 mm).

SIC--Silty Clay, See Texture.

SICL--Silty Clay Loam, See Texture.

SIL--Silt Loam, See Texture.

Sieve Analysis--Percent by weight of materials (soil) passing through the sieve openings; sieve numbers represent the number of openings per linear inch.

Siliceous--Rock containing an abundance of silica ($Si\ O_2$). Example: Cherty or hard sandstones and shales cemented by silica.

Silt--Small mineral soil grains having diameters ranging from 0.002 mm to 0.05 mm. (Engineers usually use the limits of 0.005 to 0.05 mm)

Silty--Indicates that a portion is silt within a geologic material that is predominantly some other type. Example: Silty shale.

SL--Sandy Loam, See Texture.

Texture--

C--Clay. Soil material that contains 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

CL--Clay Loam. Soil material that contains 27 to 40 percent clay and 20 to 45 percent sand.

L--Loam. Soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand.

LS--Loamy Sand. Soil material that contains at the upper limit 85 to 90 percent sand, and the percentage of silt plus 1½ times the percentage of clay is not less than 15; at the lower limit it contains not less than 70 to 85 percent sand, and the percentage of silt plus twice the percentage of clay does not exceed 30.

S--Sand. Soil material that contains 85 percent or more of sand; percentage of silt plus 1½ times the percentage of clay shall not exceed 15. (Includes coarse sand, sand, fine sand, and very fine sand.)

SC--Sandy Clay. Soil material that contains 35 percent or more clay and 45 percent or more sand.

SCL--Sand Clay Loam. Soil material that contains 20 to 35 percent clay, less than 28 percent silt, and 45 percent or more sand.

SL-Sandy Loam. Soil material that contains either 20 percent clay or less, and the percentage of silt plus twice the percentage of clay exceeds 30 to 52 percent or more sand; or less than 7 percent clay, less than 50 percent silt, and between 43 and 50 percent sand. (This includes fine sandy loam and very fine sandy loam.)

SI--Silt. Soil material that contains 80 percent or more silt and less than 12 percent clay.

SIC--Silty Clay. Soil material that contains 40 percent or more clay and 40 percent or more silt.

SICL--Silty Clay Loam. Soil material that contains 27 to 40 percent clay and less than 20 percent sand.

SIL--Silt Loam. Soil material that contains 50 percent or more silt and 12 to 27 percent clay (or) 50 to 80 percent silt and less than 12 percent clay.

Thick-Bedded--Beds or layers of rock that range from 1 foot to 3 feet in thickness and consist of only one kind of rock.

Thin-bedded--Beds or layers of rock that range from 1 inch to 1 foot in thickness and consist of only one kind or rock.

Volume Change--The change in volume for a given moisture content (expressed as a percentage of the dry volume) of the soil mass when the moisture content is reduced from the stipulated percentage to the shrinkage limit.

C H A P T E R III

GEOLOGIC UNITS

IN

DIVISION FOUR

GENERAL GEOLOGY OF DIVISION FOUR

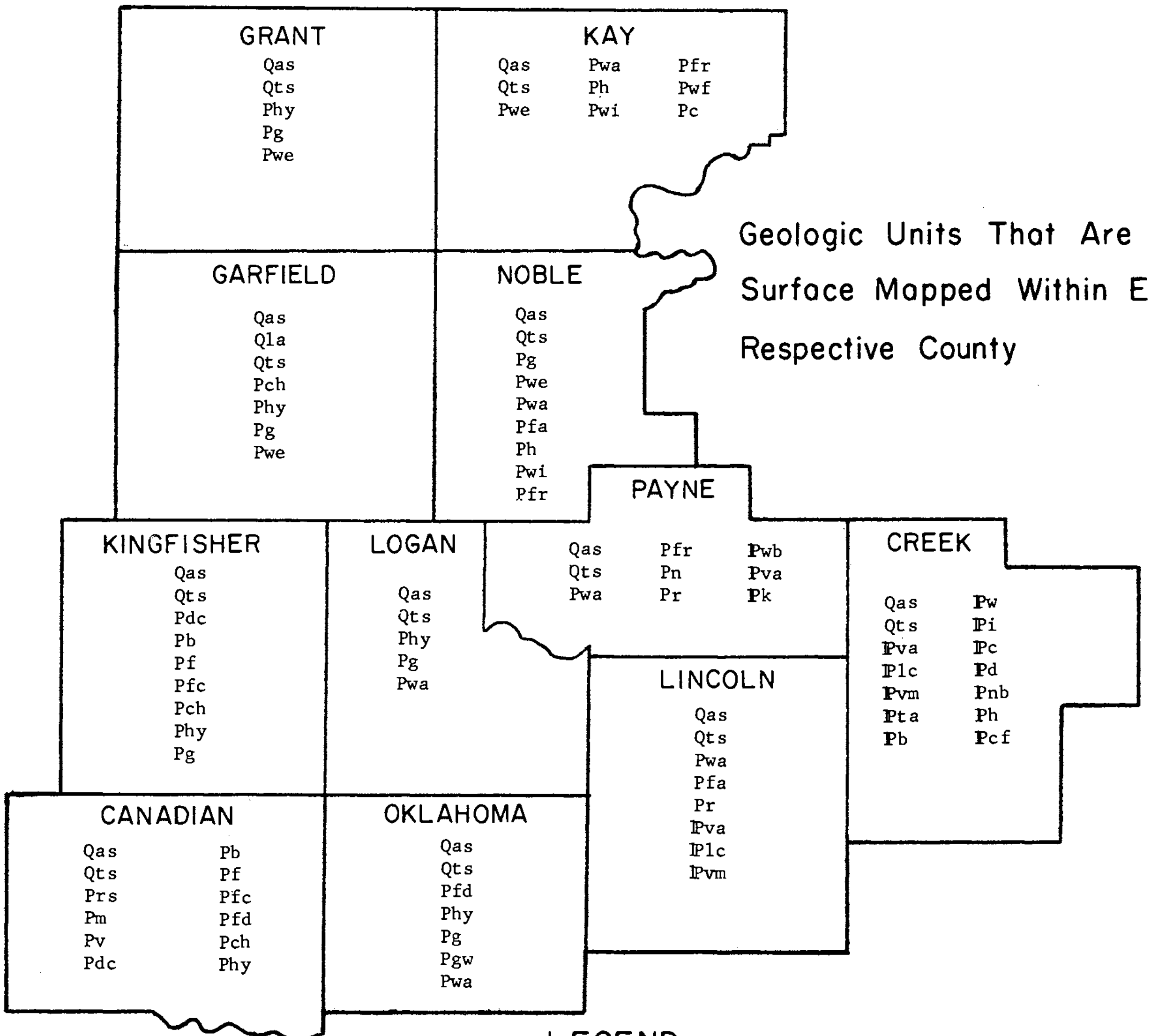
Division Four lies on the gently westward-dipping geologic units of the Prairie Plains Homocline. The homocline is a large broad structural feature involving the nearly flat lying geologic beds of the mid-continent region just to the west of the Ozark Dome of northern Arkansas and southern Missouri. The westward dip is generally about 100 feet per mile. The outcrops of the units usually trend north-south.

The surface rocks of Division Four are sedimentary and consist of sandstone, shale, limestone, gypsum, and dolomite. The shales in the eastern portion are mostly gray and dark in nature. West of the Neva subunit of the Wellington-Admire unit, the shales are mostly red and maroon interbedded with soft sandstones and are commonly referred to as the "redbeds".

The topography of Division Four is expressed by a series of parallel east-facing ridges or cuestas which trend essentially north-south. The cuestas are capped by resistant sandstones or limestones and are separated by broad valleys which are underlain by less resistant sandstones and limestones and non-resistant shales. Locally, this "ridge and valley" pattern is somewhat modified by local changes in the regional dip of the beds induced by faulting or warping.

In Division Four, areas of oak vegetation generally denote sandstones while limestones and shales promote the growth of native grasses. Large areas formerly in native grasses are now cultivated.

DIVISION FOUR



Geologic Units That Are Surface Mapped Within Each Respective County

LEGEND

GEOLOGIC UNIT	SYMBOL	GEOLOGIC UNIT	SYMBOL
Alluvium	Qas	Fort Riley Subunit	Pfr
Lacustrine Deposits	Qla	Wreford Subunit	Pwf
Terrace	Qts	Cottonwood Subunit	Pc
Rush Springs	Prs	Neva	Pn
Marlow Unit	Pm	Red Eagle	Pr
Verden Subunit	Pv	Vanoss-Ada	ℙva
Dog Creek Unit	Pdc	Brownville Subunit	ℙwb
Blaine	Pb	Wakarusa Subunit	ℙk
Flowerpot Unit	Pf	Lecompton	ℙlc
Chickasha Subunit	Pfc	Vamoosa	ℙvm
Duncan Subunit	Pfd	Tallant	ℙta
Cedar Hills Unit	Pch	Barnsdall	ℙb
Hennessey	Phy	Wann	ℙw
Garber	Pg	Iola	ℙi
Garber-Wellington	Pgw	Chanute	ℙc
Wellington	Pwe	Dewey	ℙd
Wellington-Admire	Pwa	Nellie Bly	ℙnb
Winfield	Pwi	Hogshooter	ℙh
Herington Subunit	Ph	Coffeyville	ℙcf

DESCRIPTIONS OF CONSOLIDATED GEOLOGIC MATERIALS

BARNSDALL UNIT (IPb)

The Barnsdall unit consists of fine to medium grained, generally thin bedded, moderately soft to moderately hard sandstone and reddish brown, silty, platy to blocky shale. The unit is dominantly sandstone in southern Creek County with only about 60 feet of shale in the upper portion. Northward, the shales intergrade and interfinger with the sandstones. In northern Creek County, the sandstones and shales are of nearly equal proportions.

The total thickness of the unit is irregular. It is 140 feet thick in T18N, 200 feet in T17N, and 100 feet in T14N of Creek County.

The topography is rolling to rugged. Sandstones generally cap ridges and support blackjack and scrub oak trees. Shales generally underlie valleys. In southern Creek County, erosion and abundant sandstones have left the area hilly.

BLAINE UNIT (Pb)

This unit consists of dominantly platy to blocky, locally jointed, brick-red to purple shale with some interbedded gypsum and dolomite beds.

The base of the Blaine is marked by a 3 foot white-gray gypsum bed in Kingfisher and extreme northwestern Canadian County, but southward the gypsum bed loses its identity and is replaced by a shale similar to the underlying Flowerpot unit.

The upper limit of the Blaine unit is a dolomite bed about 1 foot thick which is referred to as the Altona dolomite. In southern Canadian County, the Altona dolomite is the only recognizable portion of the unit but the shale underlying the Altona dolomite is mapped as the Blaine unit. The Blaine unit is not mapped south of Canadian County but is included in the Chickasha subunit of the Flowerpot unit.

The total thickness of the Blaine unit varies from 75 to 100 feet.

The unit outcrops in Canadian County and the southwestern corner of Kingfisher County of Division Four.

The Blaine unit generally has rolling topography with the basal and upper portions being easily recognizable throughout much of the outcrop area. The gypsum bed at the base of the Blaine unit and some gypsum beds of the upper Flowerpot Unit are usually covered by mesquite trees and desert type vegetation. The interval between gypsum beds usually underlies a valley with the basal gypsum bed capping buttes and hills locally. The Altona dolomite bed at the top of the Blaine unit is a prominent ridge maker north of the North Canadian River and overlooks the mesquite covered valley. Southward, the ridge becomes less pronounced to non-existent.

BROWNVILLE SUBUNIT (Pwb)

The subunit consists of red and gray mottled, finely crystalline, massive to thin-bedded limestone. Its importance is generally as a "marker bed".

The total thickness of the subunit is less than two feet and generally averages one foot.

The subunit outcrops in Payne County of Division Four and extends into northern Lincoln County where it thins and loses its identity. It is not mapped in northern Lincoln County, but the subunit may be found at the upper boundary of the Vanoss-Ada Unit.

Topographically, the unit is generally found on slopes of slight scarps capped by the overlying sandstones of the Wellington-Admire unit.

CEDAR HILLS UNIT (Pch)

This unit consists of predominantly reddish-brown silty, blocky shale and some massive, orange, silty sandstone and siltstone beds. A massive, orange, fine-grained sandstone about three feet thick, which weathers to a dark red and forms vertical cliffs along creeks, marks the base of the unit. The top of the unit is a greenish-gray siltstone bed about sixteen inches thick which serves as a good marker bed.

The unit has a maximum thickness of an estimated 190 to 200 feet in Kingfisher County. It thins northward to about 180 feet in western Garfield County. Southward, across Canadian County, it thins tremendously to just a few feet near Bethany where it loses its identity beneath the thick terrace deposits of the North Canadian River.

The unit outcrops in Canadian, Garfield, and Kingfisher Counties of Division Four.

Topographically, the unit forms gently rolling hills. The base of the unit generally forms a gently rolling hill with a fair amount of relief which overlooks the underlying Hennessey unit. The slightly more rugged topography of the unit helps distinguish it from the underlying Hennessey and overlying Flowerpot units which are typically more flat lying.

CHANUTE UNIT (IPc)

The Chanute unit consists predominantly of shale with a sandstone situated at the base of the unit. Minor amounts of sandstone occur in the shale above the lowermost sandstone. The sandstone at the base is 10 to 20 feet thick, medium to fine-grained, massive to thin-bedded, moderately soft, and gray in color; it weathers brown. The shale is from 30 to 100 feet thick, silty, and dark gray; it weathers yellow.

The Chanute unit outcrops in Creek County of Division Four. It has a total thickness of 80 feet in T14N, thickens to 110 feet in T16N, and thins to about 45 feet at the north county line.

Topographically, the basal sandstone generally caps prominent ridges, and the upper shale portion underlies the more gently sloping valleys.

CHICKASHA SUBUNIT (Pfc)

This subunit is composed of a random mixture of shales, siltstones, sandstones, clay gall and siltstone conglomerates. Rocks of identical rock character are repeated at many different levels within the subunit. Cross-bedding is typical of the subunit and generally differentiates it from the inter-fingering shales of the overlying Flowerpot unit.

The subunit thins consistently northward from about 330 feet in southern Canadian County, to 200 feet at Okarche, to 115 feet in western Kingfisher County, where it loses its identity in Blaine County of Division Five.

The subunit outcrops in Canadian and Kingfisher Counties of Division Four. Detailed geology of Kingfisher County is unavailable, and its approximate outcrop pattern is estimated in the county by using topographic features.

The subunit generally forms rolling to gently rolling topography being either grass covered or cultivated throughout its outcrop area.

COFFEYVILLE UNIT (IPcf)

The Coffeyville unit consists mostly of shale but contains some lenticular sandstones and some sandy shale. The shales are generally dark and weather yellow to reddish-brown. The sandstones are tan, moderately soft to moderately hard, and have soft beds interbedded with harder beds. A 20 to 100 foot thick sandstone zone occurs near the middle of the unit.

The total thickness of the unit is irregular and varies from 375 to 500 feet along its outcrop in Creek County of Division Four.

The sandstones cap high escarpments; therefore, the Coffeyville falsely appears to be mostly sandstone. The shale, which actually composes most of the unit, outcrops on the steep sideslopes of the rugged hills and escarpments.

COTTONWOOD SUBUNIT (IPc)

The Cottonwood subunit consists dominantly of light tan to gray, irregularly bedded, impure limestone. The top bed is noticeably pitted.

The thickness of the subunit is irregular but generally thins southward from seven feet to 4.5 feet along its outcrop in eastern Kay County of Division Four.

Topographically, the Cottonwood subunit forms a low bench overlooking the Beaver Creek floodplain of eastern Kay County.

The Cottonwood subunit is included in the Wellington-Admire Unit.

DEWEY UNIT (IPd)

The Dewey unit consists of a basal sandstone 5 to 20 feet thick and an overlying shale which is 5 to 30 feet thick. The sandstone is buff to brown, moderately hard when calcareous (limy) and generally massive bedded. The shale is platy, gray, and generally weathers olive to a drab yellow.

The total thickness of the unit varies from 20 to 50 feet along its outcrop in Creek County of Division Four.

Topographically, the basal limy sandstones generally cap a pronounced scarp, but locally the scarp is capped by the overlying Chanute unit.

DOG CREEK UNIT (Pdc)

This unit is predominantly orange to dark red, blocky shale with some thin beds of dolomite, siltstone, and gypsum. A gypsum bed, with a maximum thickness of three feet, is present near the base of the unit north of the Canadian River in Canadian County.

The unit is estimated to be about 200 feet thick. Its boundaries extend from a 1 foot thick dolomite marker bed (the Altonia dolomite) at the top of the Blaine unit to a basal gypsiferous sandstone of the overlying Marlow unit.

The Dog Creek unit outcrops in Canadian County and the southwestern corner of Kingfisher County of Division Four.

Topographically, the unit is nearly flat to gently rolling and is covered extensively by alluvium and terrace deposits (much of which is not mapped) of both the North Canadian and Canadian Rivers. It is usually under cultivation with native grass cover locally.

DUNCAN SUBUNIT (Pfd)

This subunit consists of sandstone, siltstone, mudstone, (hardened, massive, clay) and shale. The subunit has a massive sandstone at both the top and bottom with a shale interval between. The lower sandstone is orange, fine-grained, cross-bedded, and about sixteen feet thick in southern Canadian County. The interval above the lower sandstone consists of red blocky shales along with some mudstones. The upper sandstone is pink-orange, soft to moderately hard, fine-grained, and contains a few clay galls and a small amount of cross-bedding. It is about twenty feet thick in Canadian County.

The total thickness of the subunit is about 100 feet at the southern boundary of Canadian County. Northward, the subunit thins to about 70 feet at Yukon and about 50 feet at the Kingfisher County line. The sandstones also thin northward, become less pronounced, and less identifiable.

The subunit outcrops in Canadian and Oklahoma Counties of Division Four. It extends into Kingfisher County where it pinches out. Detailed geology of Kingfisher County is unavailable; therefore, its thin outcrop is not mapped but is included in the Flowerpot unit.

Topographically, the sandstones of the subunit generally cap scarps and rolling hills which have a fair amount of relief. The scarps become less pronounced northward. The sandstones commonly support the growth of cedar trees (Juniper) and various other trees (mostly Oak) which contrasts with the nearly treeless Chickasha subunit. The shale interval generally forms the slope beneath the upper sandstone and is covered with grass and a few trees.

FALLIS SUBUNIT (Pfa)

The Fallis subunit consists of a "zone" of sandstones and shales. The lower most sandstone's outcrop is geologically mapped in Division Four south of the Salt Fork of the Arkansas River.

The sandstones are generally orange to red, fine-grained, massive, moderately soft, and vary in thicknesses from about 5 feet to a maximum of 40 feet. The shales are mostly red and platy to blocky.

The sandstones are thick and prominent in Lincoln County of Division Four. Northward, in Noble County, the shale intervals are thicker and the sandstone beds have generally thinned to less than ten feet thick.

The total thickness of the Fallis subunit varies from 290 to 320 feet in the Division.

The subunit outcrops in Lincoln, Logan, Payne, and Noble Counties of Division Four.

Topographically, the sandstones form prominent scarps and tree covered hills in southern Division Four. Northward, the scarps and hills become less pronounced and grass covered.

The Fallis subunit occurs within the Wellington (Pwe) and Wellington-Admire (Pwa) unit.

FLOWERPOT UNIT (Pf)

This unit consists dominantly of brick-red, blocky, regular-bedded, silty shale, containing some thin interbedded soft red sandstones. The upper portion contains some thin beds of gypsum.

The Flowerpot unit has two mappable subunits, the Chickasha and Duncan, which are described separately in this publication. The shales of the Flowerpot unit interfinger with the two subunits. South of the North Canadian River in Canadian County, the Flowerpot unit is represented by the two subunits.

The total thickness of the unit varies from about 425 to 470 feet with a general thinning to the northwest.

The Flowerpot unit outcrops in a broad 10 to 18 mile wide pattern across central Canadian County and southwestern Kingfisher County in Division Four.

Topographically, the unit varies from nearly level topography to a "badlands topography" consisting of many deeply eroded gullies.

FORT RILEY SUBUNIT (Pfr)

This subunit consists of massive, light to dark tan, fossiliferous limestone. The upper massive bed has a rough weathered surface. Cylindrical pits similar to those in the Wreford subunit give the exposed face a honey combed appearance.

In Kay County, the total thickness of the Fort Riley subunit is about 20 feet. The subunit is underlain by nine feet of massive, somewhat silty, cherty, dull yellow limestone including thin zones of light tan to light gray shale.

This lower shaly zone is not included in the relatively pure 20 foot thick upper limestone. Southward, the subunit thins across Osage County. It is about three feet thick in Noble County and one foot thick in Payne County north of the Cimarron River. Southward, the subunit loses its identity and is not mapped.

The Fort Riley subunit outcrops in Kay, Noble, and Payne Counties of Division Four.

Topographically, the subunit forms prominent scarps in the northern part of Division Four, but as the subunit thins southward, the scarps become less pronounced and gradually disappear.

The Fort Riley subunit occurs within the Wellington-Admire Unit.

GARBER UNIT (Pg)

This unit consists of a series of red clay shales, red sandy shales, and red massive commonly cross-bedded lenticular sandstones. The sandstones are more prominent in the southern portion of Division Four. Northward, the sandstones thin and shales become more dominant.

The total thickness of the unit is about 400 feet in Oklahoma County, it thickens to about 600 feet in Garfield County and continues to thicken northward to the state line.

The Garber unit outcrops in a 12 to 24 mile band across Grant, Garfield, Kingfisher, Logan, Noble, and Oklahoma Counties of Division Four.

Topographically, the unit is only slightly more rolling in northern Division Four than the overlying Hennessey unit and underlying Wellington unit. In southern Division Four, the increase in sandstone results in a rolling to gently rolling topography with the hills generally capped by sandstones and covered by thick growths of blackjack oak, and post oak trees.

GARBER-WELLINGTON-ADMIRE UNITS (Pg) (Pwe) (Pgw) (Pwa)

The Garber-Wellington-Admire Units consist of a series of alternating sandstones and shales which may be subdivided into individual units locally; but due to the similarity of material commonly known as the "redbeds", the boundaries are indistinguishable and two or more units are generally mapped together.

GARBER-WELLINGTON UNIT (Pgw)

The upper 400 feet of the Garber-Wellington unit consists dominantly of red, massive, soft, lenticular, commonly cross-bedded, sandstone with minor amounts of red clay shale and red sandy shales. The lower 700 feet consists of red to maroon fissile to blocky shale containing some pinkish buff, massive to thin-bedded, fine-grained, lensing sandstones.

The total thickness of the Garber-Wellington unit is about 1100 feet, of which the upper 700 feet outcrops in Division Four. The unit outcrops in southeastern Oklahoma County, south of the North Canadian River.

Topographically, the sandstones generally cap ridges and support black-jack oak and post oak trees. The soft sandstones are easily eroded and locally winds have reworked the surface to form vegetated dunes. Shales generally underlie the valleys and more gently rolling hills.

The Garber-Wellington-Admire units (Pg) (Pgw) (Pwe) (Pwa) consist of a series of alternating sandstones and shales which may be subdivided into individual units locally; but due to the similarity of materials which are commonly known as the "red beds", the boundaries are indistinguishable and two or more units are usually mapped together.

HENNESSEY UNIT (Phy)

This unit consists of red platy to blocky clay shales and mudstone. The mudstones are hard and appear blocky. The red clay shales of the Hennessey unit is characterized by numerous bands or streaks of white or light green color ranging from a few inches to four feet in thickness.

The total thickness of the unit is about 400 feet.

The Hennessey unit outcrops in a 5 to 15 mile north-south band across Grant, Garfield, Kingfisher, Logan, Canadian, and Oklahoma Counties in Division Four. Topographically, the unit is nearly level to gently rolling and is generally grass covered or cultivated.

HERINGTON SUBUNIT (Ph)

The Herington subunit consists dominantly of buff to gray, fossiliferous, limestone. The lower three to four foot thick bed is massive and more resistant to weathering. This lower bed is overlain by soft, flaggy to massive, silty limestone beds containing nodular concretions of white chert and is interbedded with thin shale stringers. The upper portions of the subunit becomes dolomitic southward.

The total thickness is a maximum of twenty feet in northern Kay County. Southward, the subunit thins to less than three feet in section 2, T22N, R2E, of Noble County and continues to thin to where it loses its identity in the southern part of the same township.

The Herington subunit outcrops in Kay and Noble Counties of Division Four.

Topographically, the lower more resistant bed of the Herington subunit generally forms a ledge or scarp which is less pronounced than the underlying Winfield subunit whose outcrop it often parallels. The top beds of the Herington subunit erode back to create and undulating slope. East of the main Herington outcrop, resistant outliers of lower Herington stand as buttes high above the surrounding country.

The Herington subunit is included in the Wellington-Admire Unit.

HOGSHOOTER UNIT (IPh)

This unit consists of limestone grading to sandy limestone and limy sandstone.

Along its outcrop in Creek County of Division Four, the unit changes from a sandy gray limestone in the north part to a brownish limy sandstone in the south part.

The total Hogshooter unit ranges in thickness from about 15 feet in northern Creek County to less than 5 feet throughout the rest of the county.

Topographically, the Hogshooter unit is generally found on the slopes of scarps capped by sandstones of the overlying Nellie Bly unit.

IOLA UNIT (IPi)

This unit consists of buff sandy limestone, brown calcareous sandstone, and gray shale.

The maximum thickness of the unit is about 50 feet in northern Creek County. Southward, the unit pinches out in T14N near the Deep Fork River.

The unit outcrops only in Creek County of Division Four.

Topographically, the unit forms the slope of a scarp capped by the overlying Wann unit. The upper sandstones of the unit are nearly indistinguishable from the sandstones of the basal Wann unit. The scarp is often capped by the Iola sandstones where the Wann sandstones have been removed by erosion.

LECOMPTON UNIT (Plc)

This unit consists of gray thin-bedded to massive limestone at the base and gray fissile to platy shale in the upper portion.

The total thickness of the unit is about 30 feet. The limestone attains a maximum thickness of about 12 feet in T18N, R7E, of Creek County, where it is quarried. Southward the limestone splits into two beds, both of which have a maximum thickness of two feet. These two limestone beds are separated by 4 to 6 feet of gray shale.

The Lecompton unit outcrops in western Creek County and eastern Lincoln County of Division Four.

Topographically, the unit is generally present along the escarpments capped by the base of the Vanoss-Ada unit, but locally may cap prominent scarps.

MARLOW UNIT (Pm)

This unit consists dominantly of orange-red to brick-red, fine-grained, even-bedded, soft to moderately soft sandstone with minor amounts of siltstone, gypsum, and dolomite. The sandstones are composed predominantly of poorly sorted, subangular to rounded grains of quartz cemented with calcite (limy material) and hematite (iron mineral). Some of the more resistant zones are gypsiferous. A channel sandstone within the Marlow unit is designated the Verden subunit and is discussed separately in this publication.

Two beds of light gray to black dolomite serve as marker beds for the top of the Marlow unit and are referred to as the Relay Creek dolomites. The dolomite beds are separated by 6 to 16 feet of sandstone and silty-clay materials. The beds vary in thickness from 0.1 to 1.5 feet.

The total thickness of the Marlow unit is 100 to 130 feet in Division Four. It outcrops only in southwestern Canadian County.

The topography of the unit is gently rolling to rolling with the basal portion of the unit generally capping prominent rounded ridges overlooking the underlying Dog Creek unit. The unit generally produces orange-red soils which are cultivated or grass covered.

NELLIE BLY UNIT (Pnb)

This unit consists mostly of sandstones and silty shales. The basal portion of the unit is dominantly sandstone although the extreme lowermost 50 feet is generally shale. The upper portion of the unit is dominantly shale. The sandstones are generally tan to brown, thin-bedded to massive, irregular in thickness, and moderately soft but contain a few moderately hard massive beds.

The unit is irregular in thickness along its outcrop in Creek County of Division Four. It is 220 feet thick in the north part of T18N, thickens southward to 425 feet in the south part of T17N, and then thins to 385 feet in T14N.

The topography is best described as rolling, with tree-covered hills and pronounced scarps capped by massive sandstones. The valleys are generally underlain by shale and easily erodible soft sandstones.

NEVA SUBUNIT (Pn)

The Neva subunit consists of one bed of fossiliferous, vertically jointed, sandy limestone and serves as a "marker bed" in the Wellington-Admire Unit.

The thickness of the subunit thins from 1.2 feet in northern Payne County to less than two inches in T17N, R4E, Payne County, where it loses its identity.

Topographically, the subunit has no prominent features and exposures are rare. Exposures are generally found along ravines and eroded hillsides.

RED EAGLE SUBUNIT (Pr)

The lithology of the Red Eagle subunit varies along its outcrop in Division Four. In Payne County, north of the Cimmarron River, the subunit consists of blue to dark gray, thin-bedded to massive, hard limestone with some gray shale seams. Southward, the subunit becomes pink to brick-red, sandy, and dolomitic.

The total thickness of the subunit decreases from a maximum of eight feet in northeastern Payne County to about two feet in southern Lincoln County.

Topographically, the Red Eagle subunit is a prominent scarp former along most of its outcrop.

The Red Eagle subunit is included within the Wellington-Admire unit.

RUSH SPRINGS UNIT (Prs)

This unit consists of a friable reddish-brown, cross-bedded to regular bedded, soft, massive sandstone. These sandstones weather rapidly, producing a thick sandy soil that is easily blown about by the wind and in some localities is piled into sand dunes. It is quite similar in rock character to the Marlow unit but is generally coarser grained, and the soils associated with the unit appear to be more red in color and more erodible. The sand grains are subrounded to subangular and fine to very fine sand size.

The total thickness of the unit is about 300 feet but only the lower 200 to 250 feet is present in Division Four.

The outcrop of the Rush Springs unit occurs only in southwestern Canadian County of Division Four and generally southwest of the Canadian River with only erosional outliers present north of the river.

The topography of the unit is variable; it changes from a gently rolling landscape to deep canyons within short distances.

The basal portion generally forms pronounced hills or bluffs overlooking the Marlow unit and numerous springs occur near the contact between the units. The Rush Springs unit is generally grass covered but supports numerous cedar trees in the more rugged landscapes.

TALLANT UNIT (IPta)

This unit consists dominantly of maroon and red platy shale in the upper portion and fine- to medium-grained massive reddish brown sandstone in the lower 10 to 30 feet of the unit.

The unit is irregular in thickness. It is 75 to 100 feet thick in northern Creek County and 35 to 85 feet in the south where the upper shale section is thinner.

The Tallant unit outcrops in a narrow north-south band across central Creek County of Division Four. The unit generally forms valleys, but the basal sandstones often cap ridges.

VAMOOSA UNIT (IPvm)

This unit consists of resistant and nonresistant sandstones and silty shales. The sandstones are thin-bedded to massive, medium to fine-grained, (includes a few conglomerates), generally reddish and brown in color, and somewhat lenticular. They are coarsest and most evident in the south part of Creek County, where several of the resistant sandstones coalesce. Most shales are dark red, but some are lavender; all are silty to sandy.

The unit ranges from about 400 feet in the north part of Creek County to about 300 feet in the south part, but thins to about 220 feet locally.

The Vamoosa unit outcrops only in Creek County in Division Four. The outcrop landscape can be described as rolling, with sandstones generally capping ridges and scarps, and shales underlying valleys. The sandstone ridges support a dense growth of post oak and blackjack oak trees.

VANOSS-ADA UNIT (IPva)

This unit consists dominantly of shale with a lesser amount of limestone and sandstone. Two limestones are described separately in this chapter as subunits, the Brownville and Wakarusa. These subunits are good "marker beds". The shales are dominantly gray below the Wakarusa subunit but are red to gray above the subunit.

The limestones not described as subunits are light gray, buff to light red, and are generally thin-bedded, less than two feet thick. In section 12, T18N, R5E, and section 10, T18N, R6E, Payne County, the limestones thicken locally to about eight feet. The limestones generally thin southward.

The sandstones range from yellow to red, moderately soft to moderately hard, thin-bedded to massive, and range from thin lenses to massive beds up to 20 feet thick. The sandstones generally thicken southward.

The Vanoss-Ada unit ranges from 400 to 500 feet thick in Division Four.

The unit outcrops in a north-south 10 mile wide band across western Creek, and eastern Payne, and Lincoln Counties of Division Four.

Topographically, the unit is rolling. Limestones and sandstones generally cap hills with shales underlying the valleys.

VERDEN SUBUNIT (Pv)

This subunit consists of a dolomitic, pinkish-brown, moderately hard, cross-bedded, lenticular sandstone which was deposited in an ancient stream channel. The sandstone grains range in size from medium-grained to fine-grained and are well cemented with dolomite.

The Verden subunit occurs about 85 to 105 feet above the base of the Marlow unit and attains a maximum thickness of 10 feet.

The subunit is an elongate formation with its outcrop pattern being winding and narrow. It extends southward from southwestern Canadian County, Division Four, to some 70 miles into Caddo, Grady, and Stephens Counties of Division Seven. In Canadian County only erosional outliers occur.

Topographically, the subunit weathers into a series of pronounced tree covered ridges and buttes, marking plainly the course of the ancient channel.

The Verden subunit is included in the Marlow unit.

WAKARUSA SUBUNIT (IPk)

This subunit consists of dense, gray, thin-bedded to massive limestone with a minor amount of gray shale.

The thickness of the unit ranges from 6 to 8 feet with the limestone occupying some 5 to 6 feet of this thickness. The subunit thins southward across Lincoln County.

The Wakarusa subunit outcrops in Payne County and northern Lincoln Counties of Division Four. The unit loses its identity southward in Lincoln County. It is not mapped in Lincoln County primarily due to a lack of adequate map information.

Topographically, the subunit generally forms a prominent east-facing escarpment.

The Wakarusa subunit is included in the Vanoss-Ada unit.

WANN UNIT (IPw)

The Wann unit consists of buff to orange, soft, massive sandstone and red platy shale.

The maximum total thickness of the unit is 180 feet in T18N, Creek County; southward, the unit thins to where it pinches out or loses its identity in T15N, R9E, Creek County.

The unit outcrops in Creek County of Division Four.

The topography of the unit is best described as rolling, with ridges generally capped by sandstone and valleys underlain by shale. The basal Wann caps a prominent scarp across much of Creek County.

WELLINGTON-ADMIRE UNIT (Pwa)

This unit consists of shale, sandstone, limestone, and siltstone. Most of the unit is shale, which for the most part is reddish colored and clayey to silty in texture. Many of the limestones and one sandstone zone are good geologic markers and are described separately as subunits. These subunits are called the Fallis, Herington, Winfield, Fort Riley, Wreford, Cottonwood, Neva, and Red Eagle.

Between the subunits, the material is predominately shale, which contains lenses and beds of sandstone, limestone, and a few thin siltstones. The limestones are most prominent in the northern portion of Division Four. Southward, most of the limestones thin and pinch out. Sandstones are most prominent in the southern portion of Division Four and thin northward. The shale section is the thickest in the middle portion of the division due to the southward thinning of the limestones and northward thinning of the sandstones.

The total thickness of the Wellington-Admire is extremely hard to ascertain because of correlation difficulties with the vast amount of "redbeds". The unit is several hundred feet thick and has a north-south outcrop pattern 20 to 30 miles wide.

The Wellington-Admire unit outcrops in Kay, Noble, Logan, Payne, Lincoln, and Oklahoma Counties of Division Four. In central Noble County and northward to the Kansas state line, the formation lying above the Herington subunit is mapped as the Wellington unit.

The limestones and sandstones cap prominent scarps and hills with long gentle dip slopes. The shales generally underlie the valleys and slopes of the escarpments in both the southern and northern portions of Division Four. In the central part, the shales form gently rolling hills.

WELLINGTON-ADMIRE-GARBER UNITS (Pwe) (Pwa) (Pg) (Pgw)

The Wellington-Admire-Garber Units consist of a series of alternating sandstones and shales which may be subdivided into individual units locally, but due to the similarity of material commonly known as the "redbeds" the boundaries are often indistinguishable and two or more units are often mapped together.

WELLINGTON UNIT (Pwe)

This unit consists dominantly of red, maroon, and gray blocky shales with minor amounts of sandstone, gypsum, and limestone. The gray shales located in Kay County change southward to maroon and red colors. The amount of sandstone also increases southward. The total thickness of the unit ranges from 400 to 800 feet.

The unit outcrops from the state line southward through Kay, Grant, Garfield, and the north half of Noble County. In Central Noble County, the underlying Herington subunit pinches out and the Wellington unit becomes indistinguishable from the underlying strata. The Wellington unit is mapped southward from Noble County as the Wellington-Admire Unit.

Topographically, the unit varies from nearly level to slightly rolling in the northern portion and becomes slightly more rolling southward as the more prominent sandstones cap ridges and hills.

WINFIELD SUBUNIT (Pwi)

The Winfield subunit consists dominantly of massive limestone generally occurring in two beds that are buff on freshly broken surfaces and weather dirty gray to light brown on exposed surfaces.

The total thickness of the subunit varies from 8 to 11 feet.

In Division Four, the Winfield subunit outcrops only in eastern Kay County north of the junction of Highways 77, 60, and 11 in the southeast corner of Section 34, T26N, R2E, where it has become mostly shale. South of that point, no outcrop can be located.

Topographically, the subunit is a prominent scarp former.

The Winfield subunit is included in the Wellington-Admire unit.

WREFORD SUBUNIT (Pwf)

The Wreford subunit consists of light tan to gray, sandy, massive limestone containing light tan chert nodules and interbedded thin gray shales. Vertical pits on the weathered surface create a honey-combed appearance on the exposed side of the limestones.

The total thickness of the subunit varies along its outcrop, but it generally thins southward. In Kay County the subunit is 20 feet thick in section 6, T27N, R5E, 12 feet thick in sec 3, T26N, R4E, and then continues to thin southward across Osage County to Noble County, where it is about 3 feet thick in sec. 13, T24N, R3E.

The subunit outcrops in Kay and Noble Counties of Division Four, but it is not mapped in Noble County because of poor exposures and lack of prominence.

Topographically, the subunit generally caps a prominent grass covered scarp.

The Wreford subunit is included in the Wellington-Admire unit.

DESCRIPTIONS OF UNCONSOLIDATED GEOLOGIC MATERIALS

ALLUVIUM (Qas)

These are deposits of sand, silt, clay, gravel, and/or combinations of materials. Alluvium is found along the flood plains (bottom land) of streams and is normally present at places along all streams. The geologic unit maps outline many deposits, but all of these deposits are not shown. Refer to figure 2, page 6.

TERRACE DEPOSITS (Qts)

These materials consist of sand, silt, clay, gravel, and/or mixtures of these. Terrace materials occur adjacent to or near streams at higher elevations than the flood plain (bottom land). Refer to figure 2, page 6. Like alluvium, these deposits are not all shown on the geologic unit maps.

The engineering properties of the unconsolidated materials are normally the same as the "C" horizon of the overlying soil. Refer to Chapter III, Soils. Most Terrace deposits will have seepage where the underlying geologic material is less pervious.

LACUSTRINE DEPOSITS (Qla)

These are materials deposited in a lake environment; usually fairly uniform in texture but variable in chemical composition. These materials are mostly silt size particles in Division IV.

ENGINEERING CHARACTERISTICS OF GEOLOGIC UNITS
DETERMINED BY
FIELD OBSERVATION AND CONSTRUCTION EXPERIENCE

COUNTY	APPROXIMATE THICKNESS	APPARENT MATERIAL SUITABILITY	APPARENT SEEPAGE	APPARENT RIPPABILITY	LANDSLIDES OR BACKSLOPE FAILURES
		BARNSDALL UNIT (IPb)			
Creek	100-200 feet	Sandstone may be good subbase, etc.	None noted	Appears rippable	Backslope failure noted on shale slopes steeper than 2:1
		BLAINE UNIT (Pb)			
Canadian	75-100 feet	Gypsum is possible subgrade modifier	None noted	Appears rippable	None noted
Kingfisher	25-100 feet	"	"	"	"
		BROWNVILLE SUBUNIT (IPwb)			
Payne	1-2 feet	None	None noted	Appears rippable	None noted
		CEDAR HILLS UNIT (Pch)			
Canadian	20-190 feet	None	Some seepage from sandstone over shale	Appears rippable	None noted
Garfield	180 feet	Sandstones may be suitable for subbase locally	None noted	"	"
Kinfgisher	190-200 feet	None noted	"	"	

COUNTY	APPROXIMATE THICKNESS	APPARENT MATERIAL SUITABILITY	APPARENT SEEPAGE	APPARENT RIPPABILITY	LANDSLIDES OR BACKSLOPE FAILURES
			CHANUTE UNIT (IPc)		
Creek	45-110 feet	Sandstone suitable for subbase locally	None noted, Sandstones may seep in wet seasons	Appears rippable	None noted
			CHICKASHA SUBUNIT (Pfc)		
Canadian	200-300 feet	None	None noted	Appears rippable	None noted
Kingfisher	100-200 feet	"	"	"	"
			COFFEYVILLE UNIT (IPcf)		
Creek	375-500 feet	Sandstone suitable for subgase, etc. locally	Some seepage from sandstone overlying shale	Generally rippable, sandstone near base appears non-rippable	None noted
			COTTONWOOD SUBUNIT (Pc)		
Kay	4.5-7 feet	None	None noted	Appears rippable to marginal	None noted
			DEWEY UNIT (IPd)		
Creek	20-50 feet	Limy sandstones suitable for rip-rap locally.	None noted	Marginal	None noted
			DOG CREEK UNIT (IPdc)		
Canadian	200 feet	None	None noted	Appears rippable	None noted
Kingfisher	lower 30$\pm$ feet	"	"	"	"

COUNTY	APPROXIMATE THICKNESS	APPARENT MATERIAL SUITABILITY	APPARENT SEEPAGE	APPARENT RIPPABILITY	LANDSLIDES OR BACKSLOPE FAILURES
		DUNCAN SUBUNIT (Pd)			
Canadian	50-100 feet	None	None noted	Appears rippable	None noted
Kingfisher	0-50 feet	"	"	"	"
		FALLIS SUBUNIT (Pfa)			
Lincoln	290-320 feet	Sandstones locally suitable for subbase	Numerous seeps noted	Appears rippable	None noted
Logan	300± feet	Sandstones locally suitable for subbase; some locally suitable for rip rap.	"	"	"
Noble	310 feet	"	"	"	"
Payne	300± feet	"	"	"	"
		FLOWERPOT UNIT (Pf)			
Canadian	425-470 feet	None	None noted	Appears rippable	None noted
Kingfisher	425-470 feet	"	"	"	"
		FORT RILEY SUBUNIT (Pfr)			
Kay	20± feet	Limestones locally suitable for base admix, rip-rap, etc.	Some seeps from limestone	Generally appears non-rippable	None noted
Noble	3± feet	None	None noted	Appears rippable	"
Payne	1± feet	"	"	"	"

COUNTY	APPROXIMATE THICKNESS	APPARENT MATERIAL SUITABILITY	APPARENT SEEPAGE	APPARENT RIPPABILITY	LANDSLIDES OR BACKSLOPE FAILURES
			GARBER UNIT (Pg)		
Garfield	600± feet	Sandstones locally suitable for subbase, rip-rap, etc.	Some seeps from sandstones over shales.	Generally rippable; a few sandstones appear marginal	None noted
Grant	600 + feet	None	None noted	Appears rippable	"
Kingfisher	Upper 100± feet	"	"	"	"
Logan	400 - 500 feet	Sandstones locally suitable for subbase, etc.	Seeps from sandstones over shales	"	"
Noble	Lower 300± feet	None	None noted	Generally rippable; a few conglomerates appear marginal.	"
Oklahoma	400± feet	"	"		"
			GARBER-WELLINGTON UNIT (Pgw)		
Oklahoma	Upper 700± feet	Sandstones locally suitable for subbase, etc.	Numerous seeps from sandstones over shales	Appears rippable	None noted
			HENNESSEY UNIT (Ph)		
Canadian	Upper 200 feet	None	Noted some thin-bedded sandstones seeping	Appears rippable	None noted
Garfield	400± feet	"	None noted	"	"
Grant	400± feet	"	"	"	"

COUNTY	APPROXIMATE THICKNESS	APPARENT MATERIAL SUITABILITY	APPARENT SEEPAGE	APPARENT RIPPABILITY	LANDSLIDES OR BACKSLOPE FAILURES
			HENNESSEY UNIT (Ph) - Continued		
Kingfisher	400± feet	None	None noted	Appears rippable	None noted
Logan	lower 200 feet	"	Some seeps in thin sandstone lenses	"	"
Oklahoma	400±	"	Some seepage in sandy shale	"	"
			HERINGTON SUBUNIT (Ph)		
Kay	15-20 feet	Possible concrete aggregate, etc.	Some seeps noted	Appears non-rippable	None noted
Noble	0-3 feet	None	None noted	Appears rippable	"
			HOGSHOOTER UNIT (IPh)		
Creek	1-15 feet	Limestone suitable for base admix & rip-rap locally	Seepage from fractured limestone	Appears non-rippable in north half of county, rippable in south half	None noted
			IOLA UNIT (IPi)		
Creek	0-50 feet	Sandstone locally suitable for subbase, etc.	None noted	Appears rippable	None noted

COUNTY	APPROXIMATE THICKNESS	APPARENT MATERIAL SUITABILITY	APPARENT SEEPAGE	APPARENT RIPPABILITY	LANDSLIDES OR BACKSLOPE FAILURES
		LECOMPTON UNIT (IPlc)			
Creek	30± feet	Suitable for concrete aggregate, etc. locally	Some seepage from limestone	Appears non-rippable	None noted
Lincoln	30± feet	Suitable for rip-rap locally	None noted	Appears marginal	"
		MARLOW UNIT (Pm)			
Canadian	100-130 feet	Sandstones locally suitable for subbase, etc.	None noted	Appears rippable	None noted
		NELLIE BLY UNIT (IP nb)			
Creek	220-425 feet	Sandstones locally suitable for subbase, etc.	Seeps from sandstones over shales	Appears rippable	None noted
		NEVA SUBUNIT (Pn)			
Payne	0-1.2 feet	None	None noted	Appears rippable	None noted

COUNTY	APPROXIMATE THICKNESS	APPARENT MATERIAL SUITABILITY	APPARENT SEEPAGE	APPARENT RIPPABILITY	LANDSLIDES OR BACKSLOPE FAILURES
		RED EAGLE SUBUNIT (Pr)			
Lincoln	2 - 6 feet	Limestone locally suitable for rip-rap, etc.	Seeps from limestones	Appears non-rippable in north portion; marginal in south portion	None noted
Payne	6 - 8 feet	Limestones locally suitable for concrete aggregate, etc.	"	Appears non-rippable	"
		RUSH SPRINGS UNIT (Prs)			
Canadian	200-250 feet	Sandstone appears suitable for subbase, etc.	Numerous seeps at base of unit	Appears rippable	Sandy soils & soft sandstone are highly erosive
		TALLANT UNIT (IPta)			
Creek	35-100 feet	Locally, sandstones at base appear suitable for subbase, etc.	Numerous seeps from sandstone overlying shale near base of unit	Appears rippable	None noted
		VAMOOSA UNIT (IPvm)			
Creek	300-400 feet	Sandstones locally suitable for subbase, etc.	Numerous seeps from sandstones over shales.	Appears rippable; some massive sandstones may require shooting for handling purposes	Slumps on 2 to 1 noted

COUNTY	APPROXIMATE THICKNESS	APPARENT MATERIAL SUITABILITY	APPARENT SEEPAGE	APPARENT RIPPABILITY	LANDSLIDES OR BACKSLOPE FAILURES
		VANOSS-ADA UNIT (Pva)			
Creek	Lower 100± feet	None	None noted	Appears rippable	None noted
Lincoln	400-500 feet	Sandstones locally suitable for subbase, etc.	"	"	"
Payne	400-500 feet	"	"	"	"
		VERDEN SUBUNIT (Pv)			
Canadian	0-10 feet	None	None noted	Appears marginal	None noted
		WAKARUSA SUBUNIT (Pk)			
Payne	6 - 8 feet	Limestone locally suitable for concrete aggregates, etc.	None noted	Appears non-rippable	None noted
Creek	0 - 180 feet	Sandstones locally suitable for subbase, etc.	Some seeps from sandstones over shales	Appears rippable; a few massive sandstones appear marginal	None noted
		WELLINGTON UNIT (Pwe)			
Garfield	Upper 100± feet	None	None noted	Appears rippable	None noted
Grant	Upper 100± feet	"	"	"	"
Kay	600 - 800 feet	"	"	"	"

COUNTY	APPROXIMATE THICKNESS	APPARENT MATERIAL SUITABILITY	APPARENT SEEPAGE	APPARENT RIPPABILITY	LANDSLIDES OR BACKSLOPE FAILURES
		WELLINGTON UNIT (Pwe) Cont.			
Kay	Upper 800± feet	Limestone locally suitable for concrete aggregate, etc.	Numerous seeps from limestones	Generally rippable; a few limestones appear non-rippable	None noted
Lincoln	Lower 1400± feet	Sandstones locally suitable for subbase, etc.	Numerous seeps from sandstones over shales	Appears rippable	Slumps on 2 to 1 noted.
Logan	Upper 600± feet	Sandstones locally suitable for subbase; conglomerates locally suitable for rip-rap, etc.	"	Generally rippable; a few conglomerates appear marginal	None noted
Noble	Upper 1000± feet	"	"	"	"
Oklahoma	Upper 1000± feet	Sandstones locally suitable for subbase, etc.	"	Appears rippable	"
Payne	Lower 1400± feet	"	"	"	"
		WINFIELD SUBUNIT (Pwi)			
Kay	8 - 11 feet	None	None noted	Appears rippable	None noted
		WREFORD SUBUNIT (Pwf)			
Kay	15 - 20 feet	Limestones locally suitable for rip-rap, etc.	None noted	Appears non-rippable	None noted

Highway Engineering Characteristics of Geologic Units

Geologic Unit Name & County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A.)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
BARNSDALL																							
CREEK	16	A-7-6(12)	100	99	98	95					42	18	34	15	1.90	36	-		NO	15		X	
BLAINE																							
CANADIAN	10	A-4(8)	100	100	97	73					32	10	28	14	1.87	25	-	7.6	NO	12		X	
KINGFISHER	10	A-4(8)	100	99	99	94					36	8	34	15	1.85	35	-	7.5	NO	12		X	
CEDAR HILLS																							
CANADIAN	0	A-4(3)	100	87	69	51					NP	NP	-	-	-	-	-	7.9	5.9	11	X		
GARFIELD	11	A-6(8)	100	100	99	99					33	11	28	15	1.86	24	-	7.8	NO	13		X	
KINGFISHER	9	A-4(8)	100	99	96	85					28	9	23	14	1.88	18	-	7.7	NO	12		X	
CHANUTE																							
CREEK	15	A-7-6(11)	100	100	99	94					42	17	38	12	1.97	52	-	6.4	NO	15		X	
CHICKASHA																							
CANADIAN	15	A-7-6(11)	100	99	97	93					41	17	32	13	1.93	37	-	7.7	NO	15		X	
COFFEYVILLE																							
CREEK	17	A-7-6(13)	100	100	99	98					47	20	42	10	2.01	65	.20		NO	15			X

Highway Engineering Characteristics of Geologic Units

Geologic Unit Name & County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A.)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
DEWEY																							
CREEK	13	A-6(10)	100	98	95	89					37	14	33	14	1.92	37	-	8.3	NO	13		X	
DOG CREEK																							
CANADIAN	10	A-4(8)	100	100	99	96					34	9	-	-	-	-	-	7.7	NO	12		X	
CANADIAN	13	A-6(10)	100	99	99	97					36	14	30	13	1.94	33	-		NO	13		X	
KINGFISHER	16	A-7-6(12)	100	99	99	94					45	18	39	14	1.89	47	-	7.7	NO	15			X
DUNCAN																							
CANADIAN	8	A-4(8)	100	100	99	91					25	7	-	-	-	-	-		NO	12		X	
CANADIAN	7	A-4(8)	100	100	99	96					26	5	-	-	-	-	-	5.7	NO	12		X	
FLOWERPOT																							
CANADIAN	10	A-4(8)	100	100	99	91					34	8	-	-	-	-	-	7.6	NO	12		X	
KINGFISHER	10	A-4(8)	100	99	98	95					28	10	22	12	1.98	20	-	8.1	NO	12		X	
OKLAHOMA	11	A-6(8)	100	98	97	87					31	11	28	13	1.91	29	-		NO	13		X	
GARBER																							
GARFIELD	11	A-6(9)	100	98	98	96					31	12	26	14	1.90	24	-	7.9	NO	13		X	
GRANT	1	A-2-4(0)	100	89	68	30					33	7	-	-	-	-	-	6.5	4.6	80	X		
KINGFISHER	8	A-4(8)	100	98	95	90					26	6	-	-	-	-	-	8.0	NO	12		X	

Highway Engineering Characteristics of Geologic Units

Geologic Unit Name & County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A.)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
GARBER																							
LOGAN	10	A-6(9)	100	99	99	88					28	12	24	12	1.95	23	-	7.3	NO	13		X	
NOBLE	8	A-4(8)	100	99	99	90					24	7	-	-	-	-	-	7.1	NO	12		X	
OKLAHOMA	20	A-7-6(16)	100	98	97	92					52	25	45	11	2.02	69	.36		NO	16			X
HENNESSEY																							
CANADIAN	0	A-4(8)	100	96	90	79					NP	NP	-	-	-	-	-	7.9	NO	12	X		
GARFIELD	11	A-6(9)	100	100	100	99					32	12	28	13	1.88	27	-	7.8	NO	13		X	
GARFIELD	2	A-4(1)	100	92	65	40					36	6	-	-	-	-	-	7.7	5.3	80	X		
GRANT	11	A-6(8)	100	100	100	99					32	11	26	17	1.82	17	-	6.7	NO	13		X	
GRANT	11	A-6(8)	100	99	97	92					32	11	28	15	1.87	25	-	7.4	NO	13		X	
KINGFISHER	8	A-4(8)	100	100	98	87					29	6	-	-	-	-	-	8.1	NO	12		X	
LOGAN	11	A-6(9)	100	100	100	96					31	12	26	14	1.94	24	-	8.0	NO	13		X	
OKLAHOMA	7	A-4(3)	100	95	79	52					37	10	35	16	1.85	34	-		6.5	11		X	
IOLA																							
CREEK	16	A-7-6(12)	100	100	100	98					43	18	35	12	1.93	44	-		NO	15		X	
LECOMPTON																							
LINCOLN	16	A-7-6(12)	100	99	99	98					43	19	36	13	1.88	43	.15		NO	15			X

Highway Engineering Characteristics of Geologic Units

Geologic Unit Name & County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A.)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
LECOMPTON																							
CREEK	18	A-7-6(14)	100	100	99	99					47	22	39	15	1.86	44	.24	8.0	NO	16			X
NELLIE BLY																							
CREEK	13	A-6(10)	100	100	99	97					37	14	34	14	1.89	37	-	7.5	NO	13		X	
TALLANT																							
CREEK	15	A-6(11)	100	97	95	90					39	17	36	14	1.96	43	-	8.6	NO	13		X	
VAMOOSA																							
CREEK	17	A-7-6(13)	100	100	99	97					45	19	40	16	1.83	44	.15		NO	15			X
LINCOLN	16	A-7-6(12)	100	98	97	91					44	19	38	11	1.97	53	.15		NO	15			X
VANOSS																							
CREEK	14	A-6(11)	100	100	99	95					37	17	30	14	1.92	31	-		NO	13		X	
VANOSS-ADA																							
CREEK	4	A-2-6(0)									37	17	30	14	1.92	31	-		NO	12	X		
LINCOLN	11	A-6(9)	100	100	100	91					31	13	25	13	1.92	24	-		NO	13		X	
PAYNE	13	A-6(10)	100	83	80	72					38	16	33	12	1.91	40	-	8.0	NO	13		X	

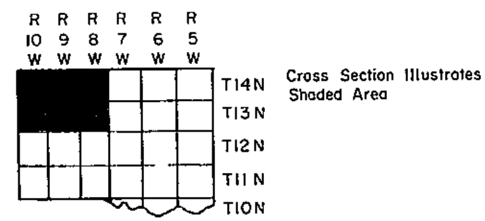
Highway Engineering Characteristics of Geologic Units

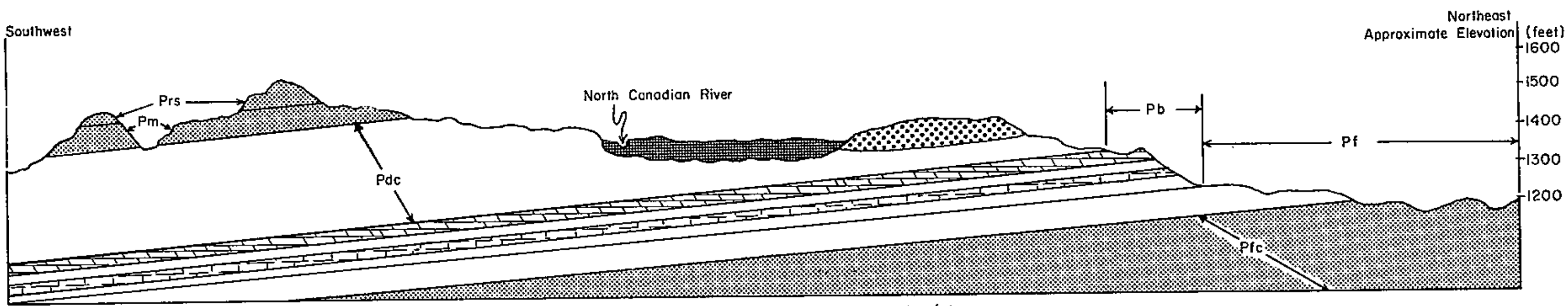
Geologic Unit Name & County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A.)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
WANN																							
CREEK	15	A-7-6(11)	100	99	98	93					42	16	38	11	1.94	52	-	7.9	NO	15		X	
WELLINGTON																							
GRANT	6	A-6(2)	100	97	89	43					39	12	36	16	1.83	36	-	6.7	6.0	12		X	
KAY	17	A-7-5(13)	100	98	97	91					49	18	42	15	1.87	51	-		NO	14			X
KAY	16	A-7-6(12)	100	98	97	91					42	18	34	14	1.87	38	-	7.8	NO	15		X	
KAY	16	A-7-5(12)	100	100	98	82					47	17	42	16	1.81	47	-	7.8	NO	14			X
LINCOLN	10	A-6(8)	100	99	99	95					29	11	26	13	1.91	25	-		NO	13		X	
LINCOLN	17	A-7-6(13)	100	100	99	97					45	21	41	10	2.04	62	.21		NO	15			X
LOGAN	14	A-7-6(9)	100	98	91	70					41	14	37	12	1.96	50	-		NO	15		X	
NOBLE	11	A-6(9)	100	100	100	97					29	12	28	10	2.02	37	-	7.8	NO	13		X	
NOBLE	9	A-4(8)	100	98	97	84					26	10	24	11	1.99	26	-	7.7	NO	12		X	
NOBLE	13	A-6(10)	100	100	99	97					34	15	30	9	2.06	43	-	7.7	NO	13		X	
OKLAHOMA	9	A-4(8)	100	99	97	90					27	10	23	13	1.94	20	-	5.9	NO	12		X	
OKLAHOMA	17	A-7-6(13)	100	97	96	85					41	21	34	7	2.15	58	.21	8.3	NO	15			X
PAYNE	18	A-7-6(14)	100	99	99	97					48	22	41	11	2.02	62	.24		NO	16			X
PAYNE	15	A-7-6(11)	100	100	99	97					42	16	36	13	1.97	46	-	8.0	NO	15		X	
PAYNE	16	A-7-6(12)	100	100	99	98					45	18	40	13	1.89	51	-	8.0	NO	15			X

IDEALIZED CROSS SECTION

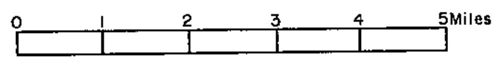
CANADIAN COUNTY

NO. 1



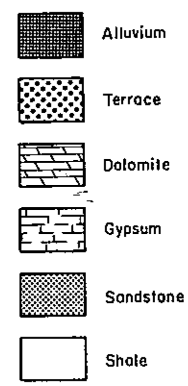


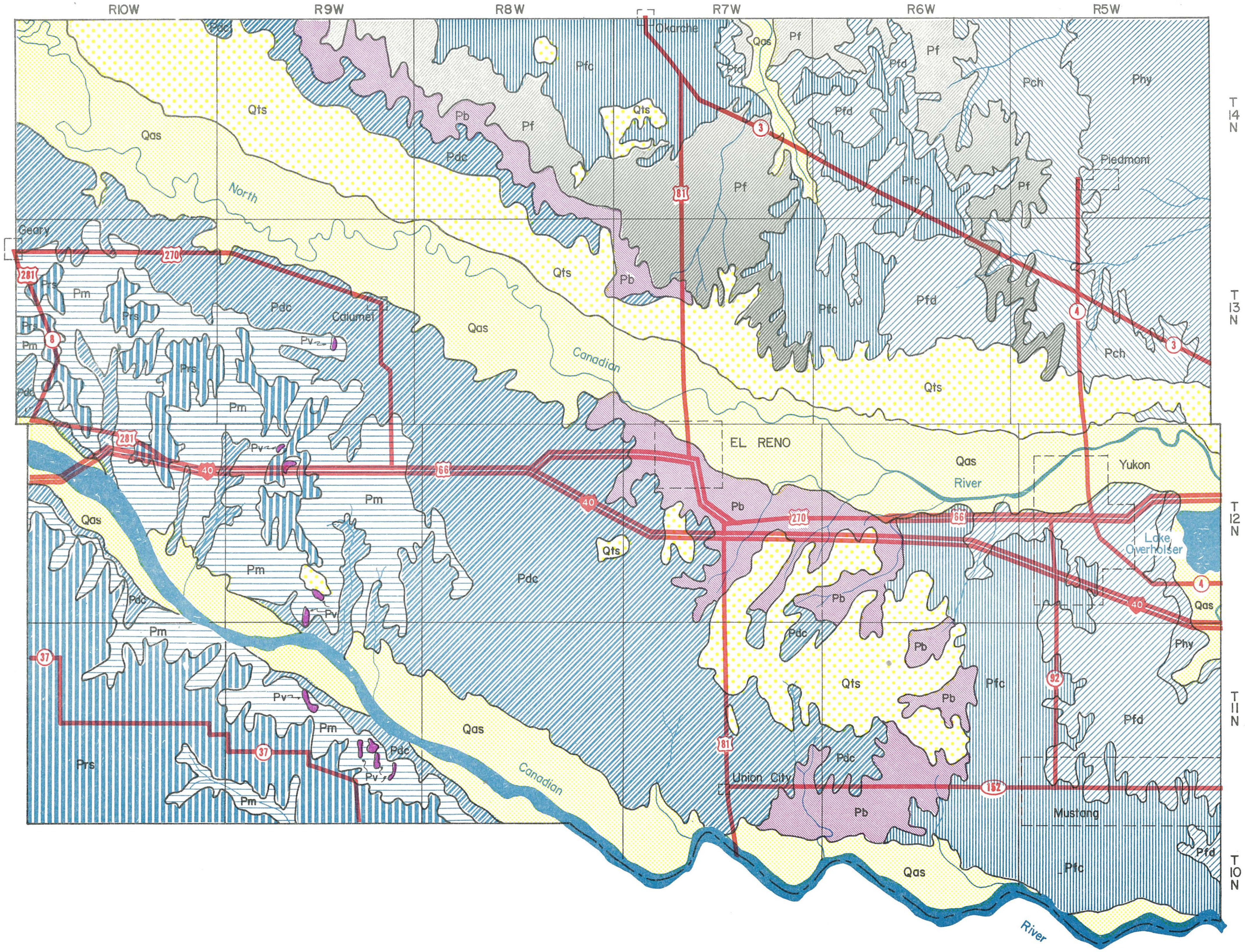
Beds generally dip southwestward 15 to 25 feet/mile



Approximate Scale

GEOLOGIC UNIT	SYMBOL
Rush Springs	Prs
Marlow	Pm
Dog Creek	Pdc
Blaine	Pb
Flowerpot	Pf
Chickasha Subunit	Pfc





GEOLOGIC UNITS OF CANADIAN COUNTY

Prepared by the Oklahoma Department of Highways

Information taken from:

"Geologic Map of NW Canadian County" by Raymond H. Stevenson, MS Thesis, 1958

"Geologic Map of NE Canadian County" by Cecil C. Gillum, MS Thesis, 1958

"Geologic Map of SW Canadian County" by Don E. Trapnell, MS Thesis, 1961

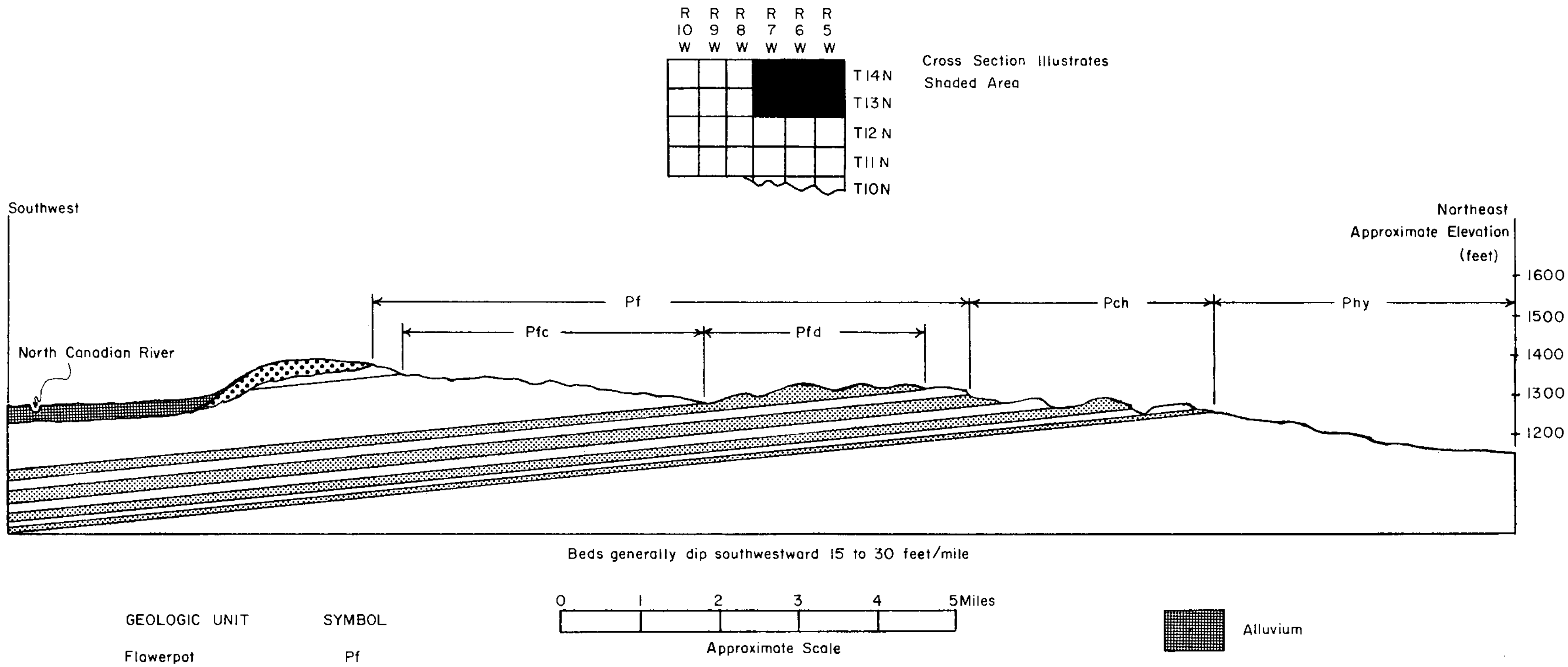
"Geologic Map of SE Canadian County" by Bobby D. Armstrong, MS Thesis, 1958

SCALE

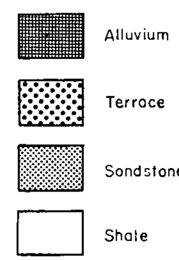
0 1 2 3 4 5 10 miles

- Qas — Alluvium
- Qts — Terrace Deposits
- Prs — Rush Springs Unit
- Pm — Marlow Unit
  - Pv — Verden Subunit
- Pdc — Dog Creek Unit
- Pb — Blaine Unit
- Pf — Flowerpot Unit
  - Pfc — Chickasha Subunit
  - Pfd — Duncan Subunit
- Pch — Cedar Hills Unit
- Phy — Hennessey Unit

IDEALIZED CROSS SECTION
CANADIAN COUNTY
NO. 2



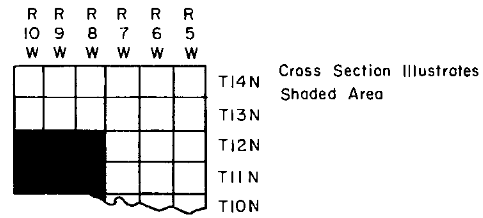
GEOLOGIC UNIT	SYMBOL
Flowerpot	Pf
Chickasha Subunit	Pfc
Duncan Subunit	Pfd
Cedar Hills	Pch
Hennessey	Phy

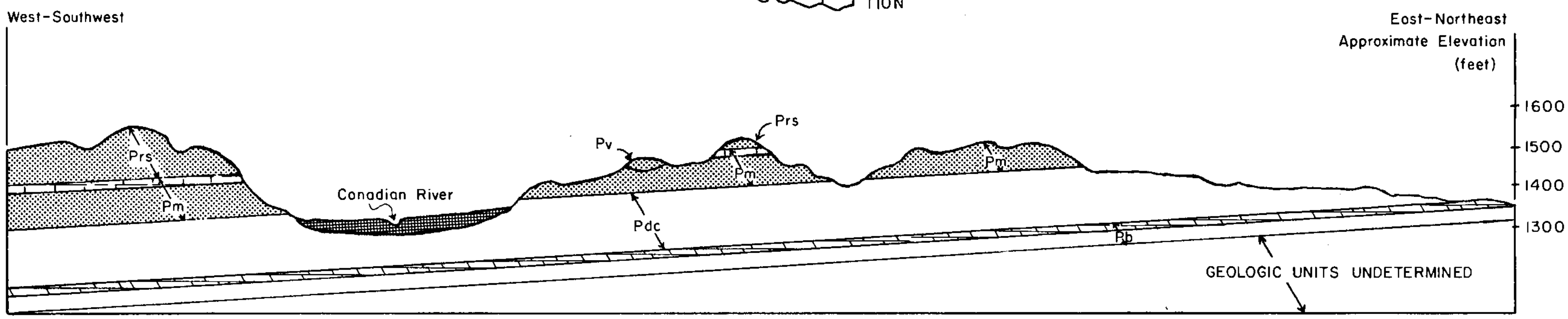


IDEALIZED CROSS SECTION

CANADIAN COUNTY

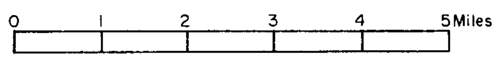
NO. 3



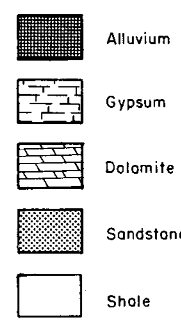


Beds generally dip southwestward 15 to 22 feet/mile

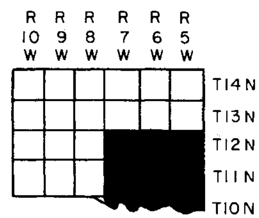
GEOLOGIC UNIT	SYMBOL
Rush Springs	Prs
Marlow	Pm
Verden Subunit	Pv
Dog Creek	Pdc
Blaine	Pb

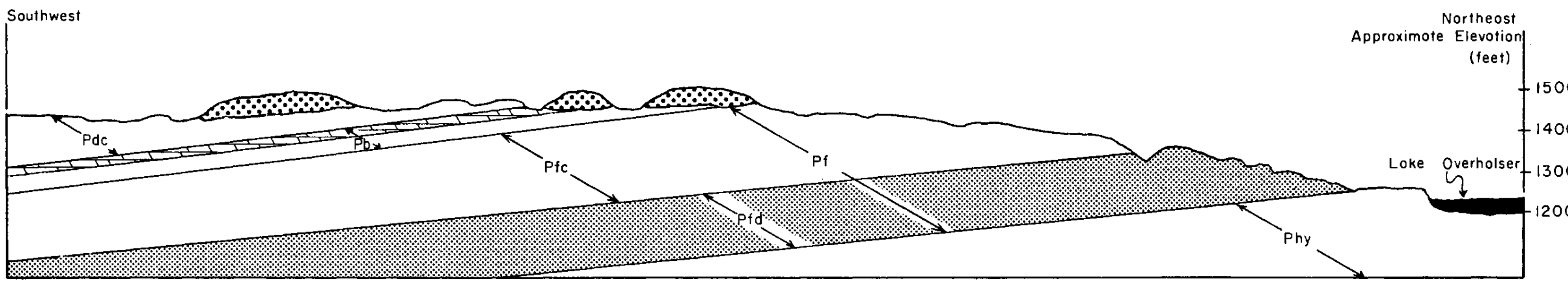


Approximate Scale

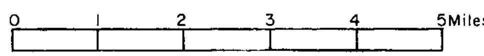


IDEALIZED CROSS SECTION
CANADIAN COUNTY
NO. 4



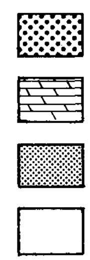


Beds generally dip southwestward 15 to 25 feet/mile



Approximate Scale

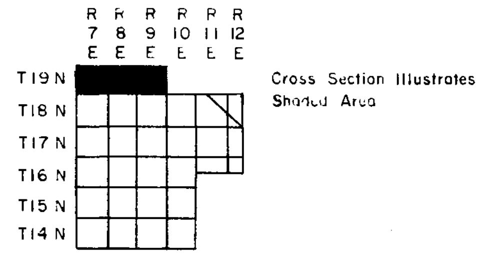
GEOLOGIC UNIT	SYMBOL
Dog Creek	Pdc
Blaine	Pb
Flowerpot	Pf
Chickasha Subunit	Pfc
Duncan Subunit	Pfd
Hennessey	Phy

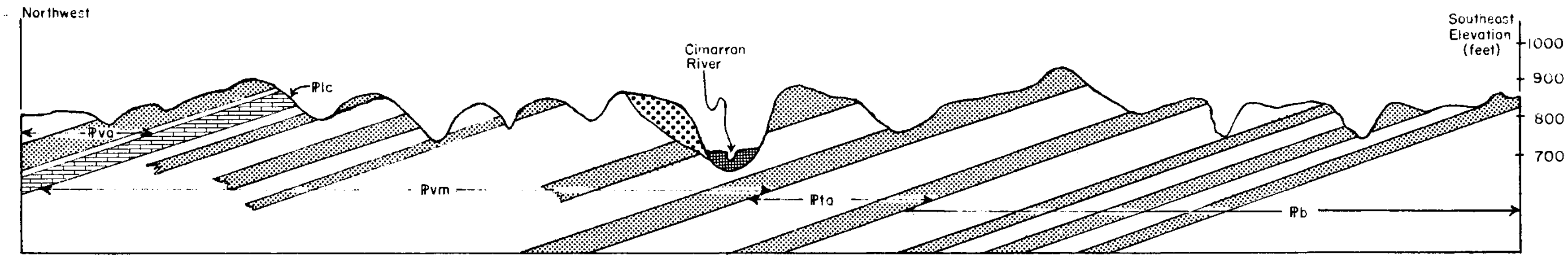


IDEALIZED CROSS SECTION

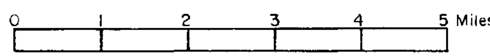
CREEK COUNTY

NO. 1



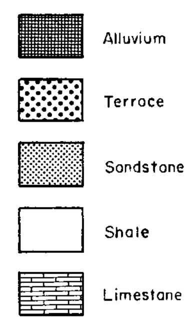


Beds generally dip westward 30 to 100 feet/mile; modified locally by folds and faults.



Approximate Scale

GEOLOGIC UNIT	SYMBOL
Vanoss–Ada	IPva
Lecompton	IPlc
Vamoosa	IPvm
Tallant	IPta
Barnsdall	IPb

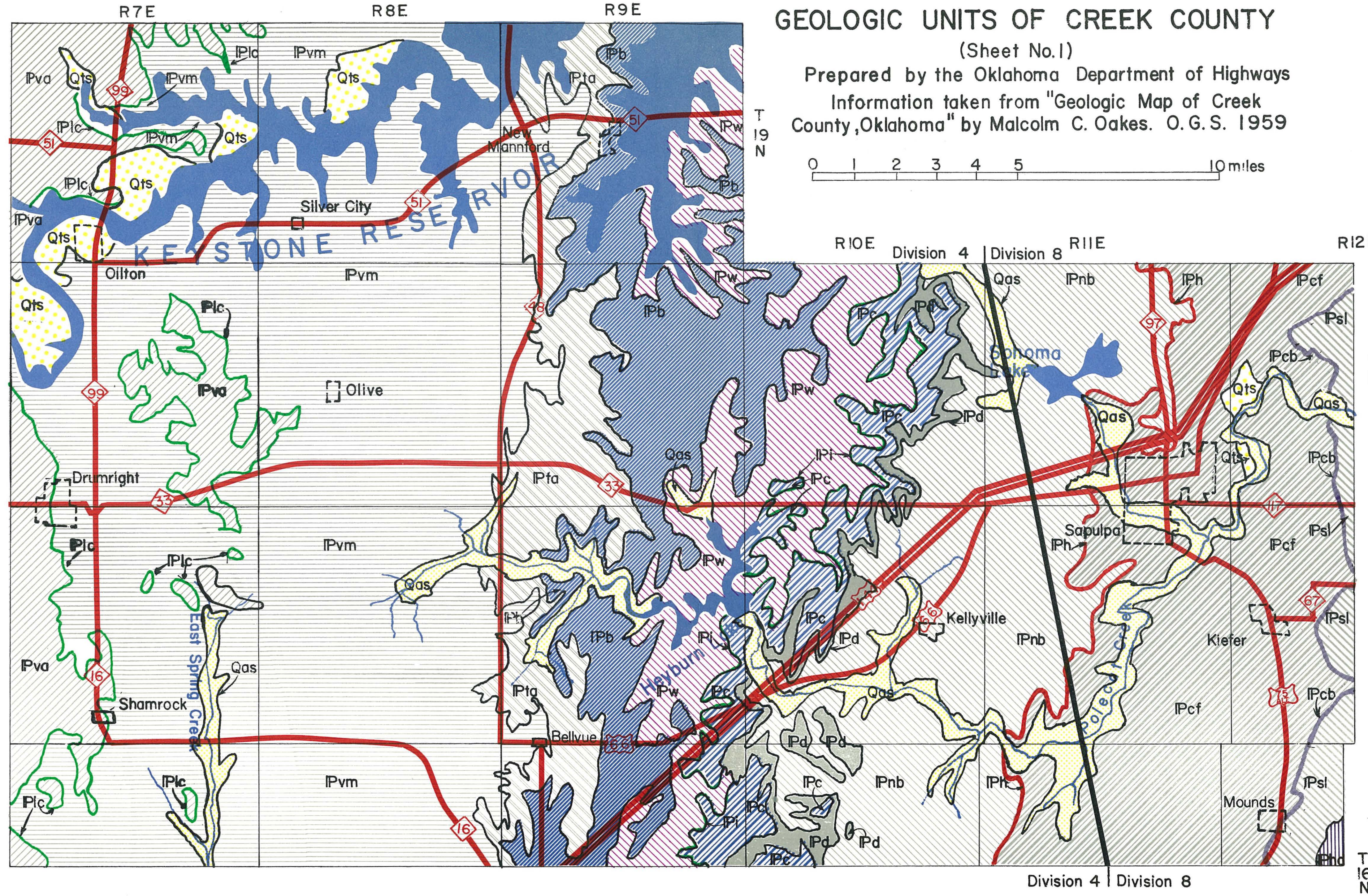


GEOLOGIC UNITS OF CREEK COUNTY

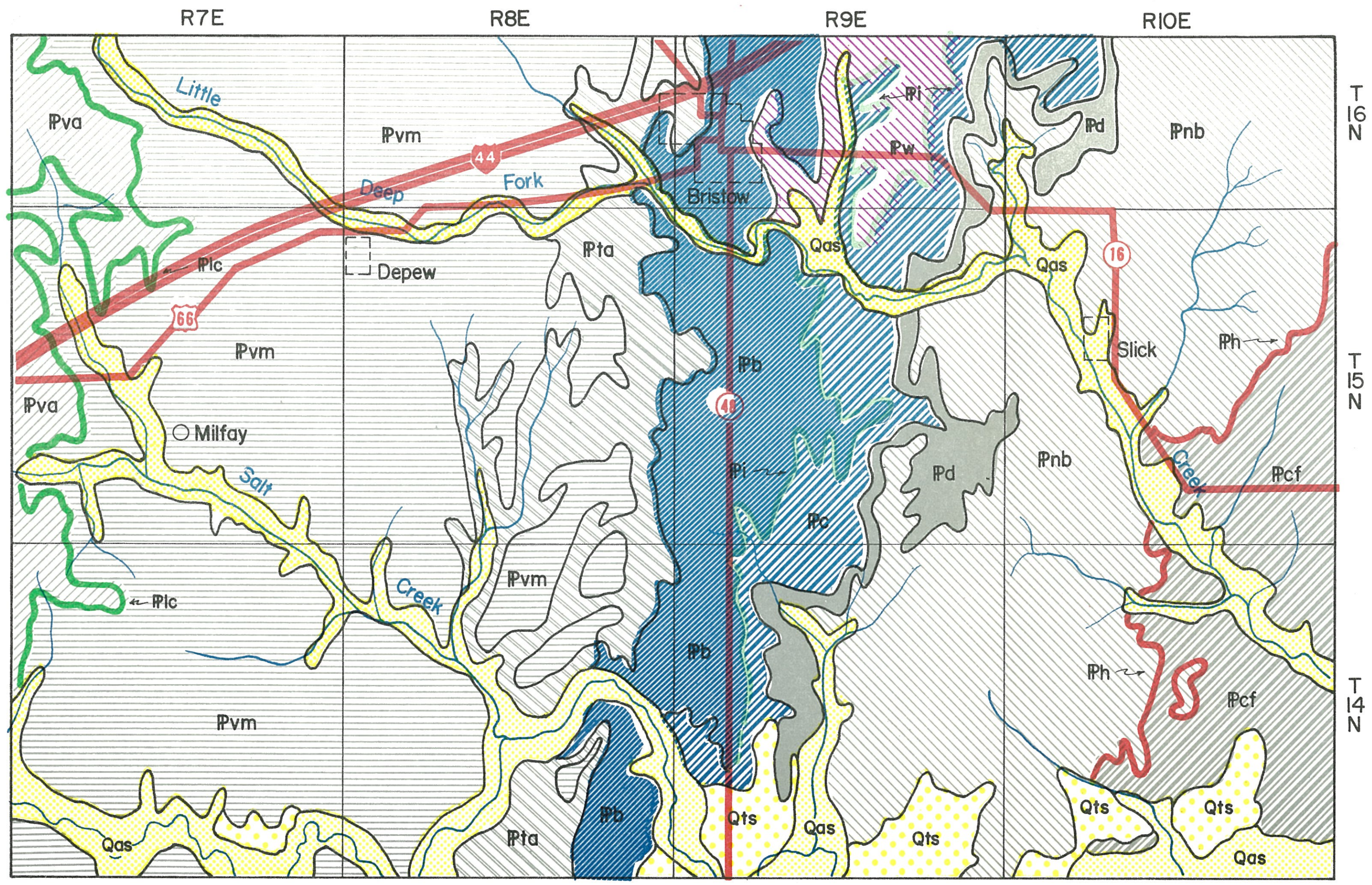
(Sheet No.1)

Prepared by the Oklahoma Department of Highways

Information taken from "Geologic Map of Creek County, Oklahoma" by Malcolm C. Oakes. O.G.S. 1959



- Qas — Alluvium
- Qts — Terrace Deposits
- IPva — Vanoss – Ada Unit
- IPlc — Lecompton Unit
- IPvm — Vamoosa Unit
- IPta — Tallant Unit
- IPb — Barnsdall Unit
- IPw — Wann Unit
- IPi — Iola Unit
- IPc — Chanute Unit
- IPd — Dewey Unit
- IPnb — Nellie Bly Unit
- IPh — Hogshooter Unit
- IPcf — Coffeyville Unit
- IPcb — Checkerboard Unit
- IPsl — Seminole Unit
- IPhd — Holdenville Unit
- U Up / D Down — Fault



GEOLOGIC UNITS OF CREEK COUNTY

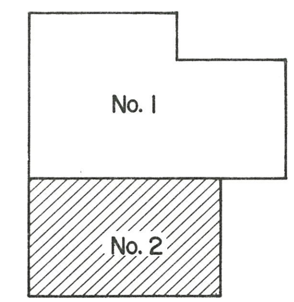
(Sheet No. 2)

Prepared by the Oklahoma Department of Highways

Information taken from:
"Geologic Map of Creek County, Oklahoma"
by Malcolm C. Oakes O.G.S. 1959

SCALE

0 1 2 3 4 5 10 miles

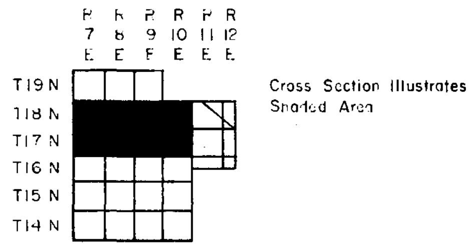


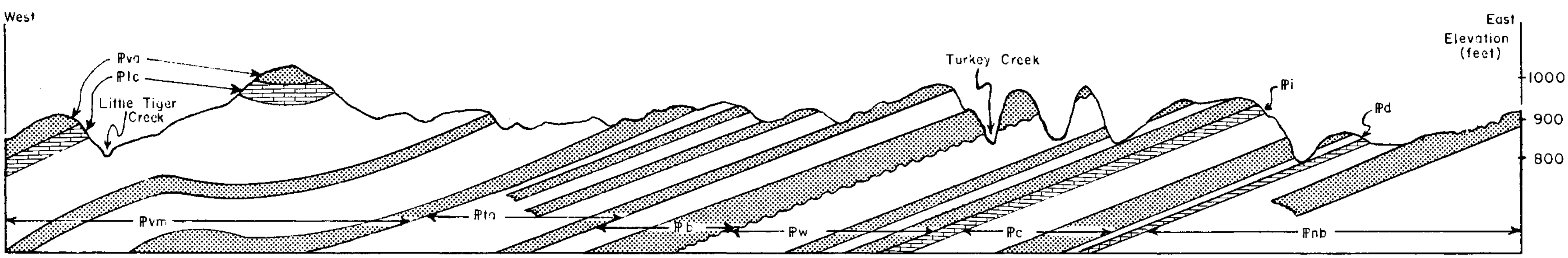
Qas	Alluvium
Qts	Terrace Deposits
Pva	Vanoss-Ada Unit
Plc	Lecompton Unit
Pvm	Vamoosa Unit
Pta	Tallant Unit
Pb	Barnsdall Unit
Pw	Wann Unit
Pi	Iola Unit
Pc	Chanute Unit
Pd	Dewey Unit
Pnb	Nellie Bly Unit
Ph	Hogshooter Unit
Pcf	Coffeyville Unit

IDEALIZED CROSS SECTION

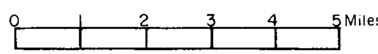
CREEK COUNTY

NO. 2



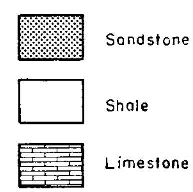


Beds generally dip westward 60 feet/mile, but are affected by folding locally.

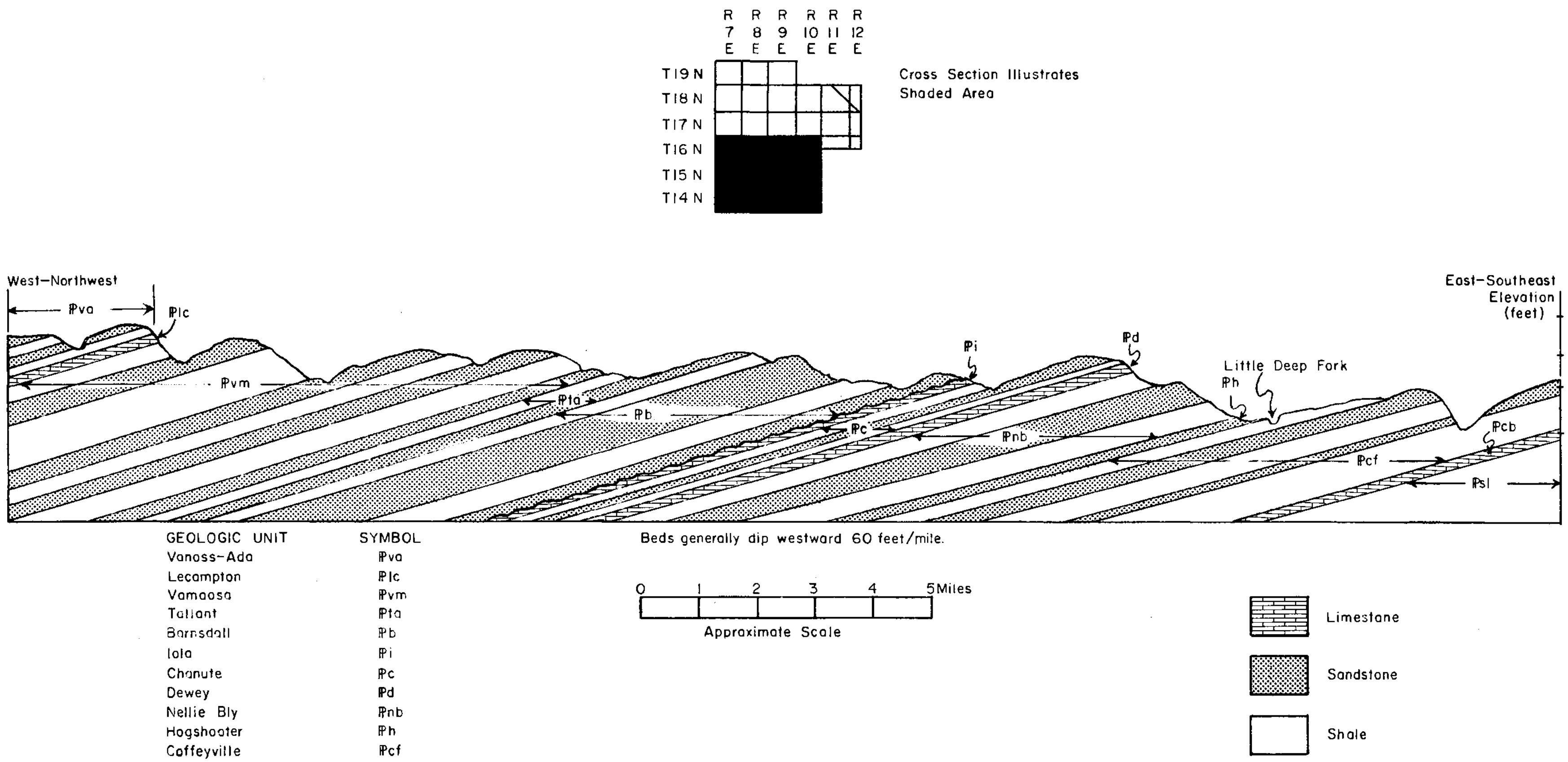


Approximate Scale

GEOLOGIC UNIT	SYMBOL
Vanoss-Ada	Pva
Lecompton	Plc
Vamoosa	Pvm
Tallant	Pta
Barnsdall	Pb
Wann	Pw
Iola	Pi
Chanute	Pc
Dewey	Pd
Nellie Bly	Pnb

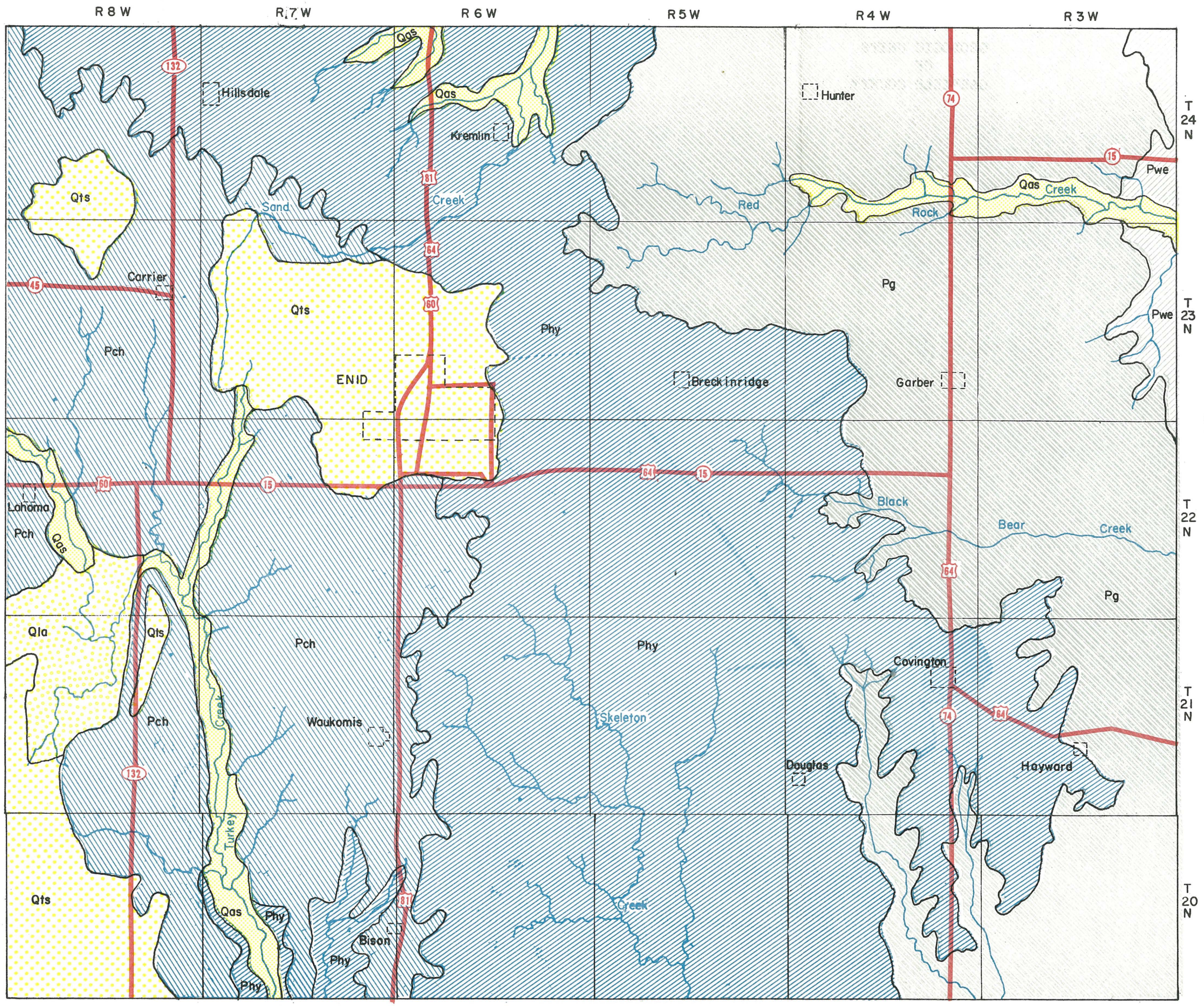


IDEALIZED CROSS SECTION
CREEK COUNTY
NO. 3



Beds generally dip westward 60 feet/mile.

GEOLOGIC UNIT	SYMBOL
Vanoss-Ada	Ꝑva
Lecompton	Ꝑlc
Vamoosa	Ꝑvm
Tallant	Ꝑta
Barnsdall	Ꝑb
Iola	Ꝑi
Chanute	Ꝑc
Dewey	Ꝑd
Nellie Bly	Ꝑnb
Hogshooter	Ꝑh
Coffeyville	Ꝑcf
Checkerboard	Ꝑcb
Seminole	Ꝑsl



GEOLOGIC UNITS of GARFIELD COUNTY

Prepared by the Oklahoma Department of Highways
Information taken from:
"Geologic Map of Oklahoma"
by Hugh D. Miser and others
U.S.G.S. 1954

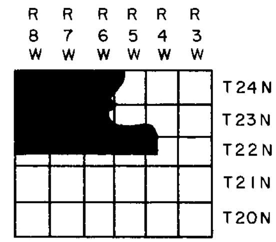
Scale

0 1 2 3 4 5 10 Miles

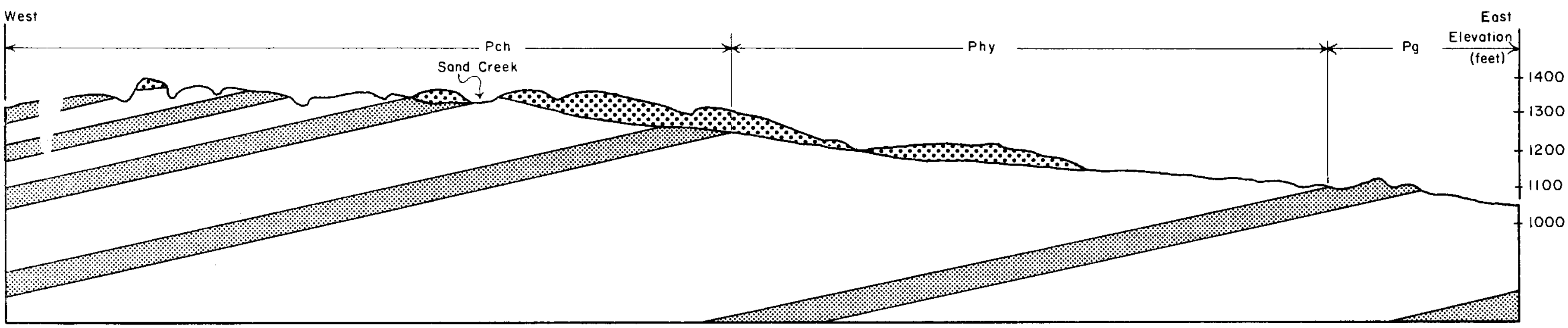
Qas	Alluvium
Qla	Lacustrine and Alluvial deposits in depressions
Qts	Terrace deposits
Pch	Cedar Hills Unit
Phy	Hennessey Unit
Pg	Garber Unit
Pwe	Wellington Unit

IDEALIZED CROSS SECTION

GARFIELD COUNTY
NO. 1

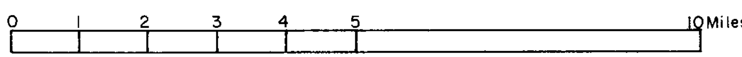


Cross Section Illustrates Shaded Area



Beds generally dip southwestward 20 to 30 feet/ mile.

GEOLOGIC UNIT	SYMBOL
Cedar Hills	Pch
Hennessey	Phy
Garber	Pg



Approximate Scale

Terrace

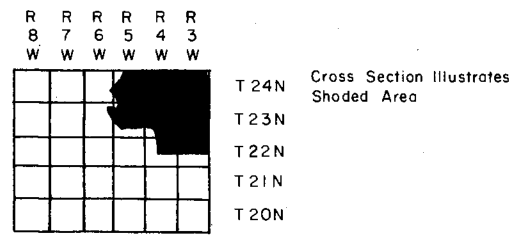
Sandstone

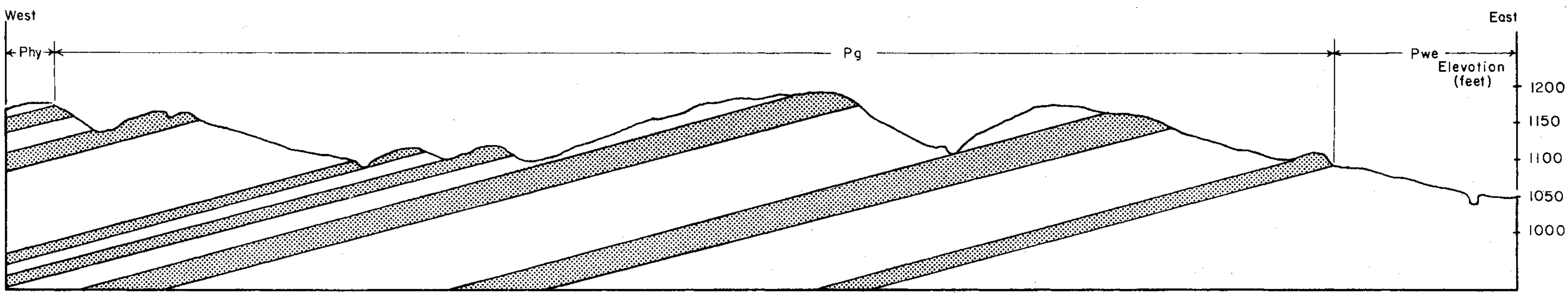
Shale

IDEALIZED CROSS SECTION

GARFIELD COUNTY

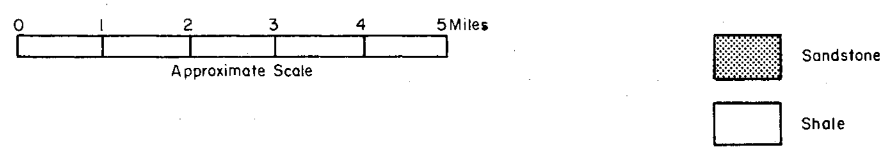
NO. 2





Beds generally dip southwestward 20 to 30 feet/ mile.

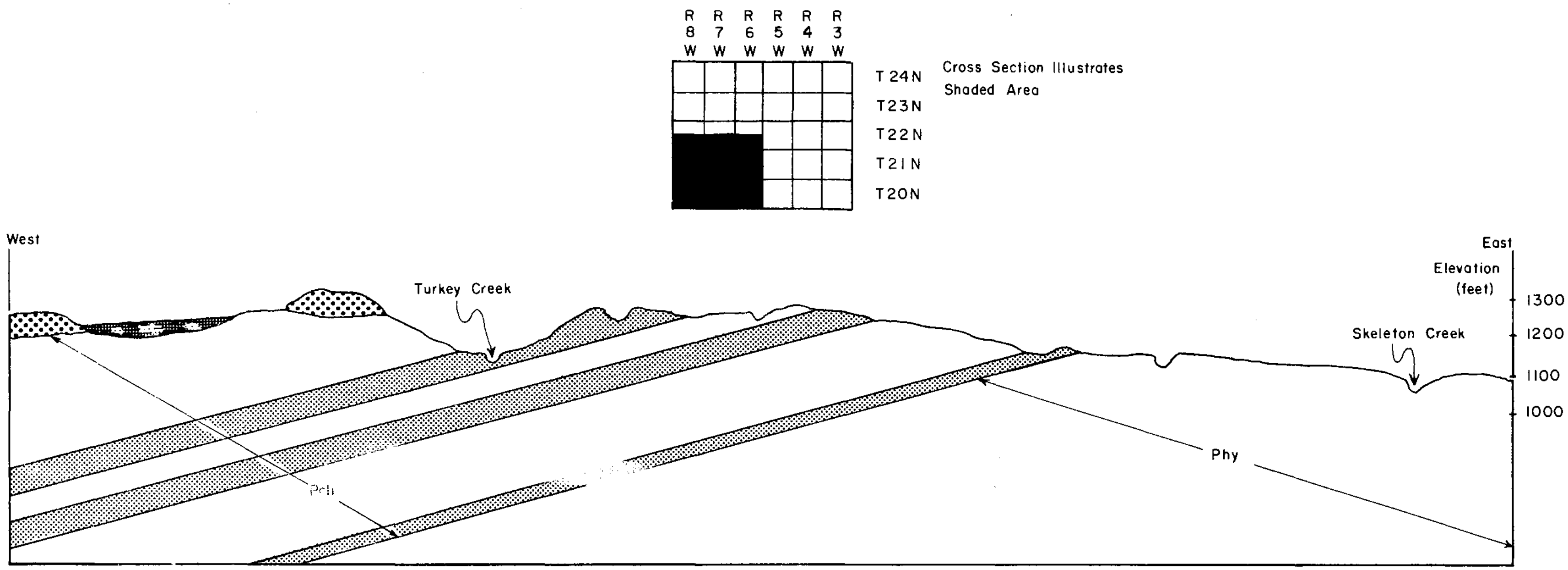
GEOLOGIC UNIT	SYMBOL
Hennessey	Phy
Garber	Pg
Wellington	Pwe



IDEALIZED CROSS SECTION

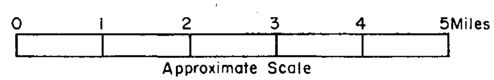
GARFIELD COUNTY

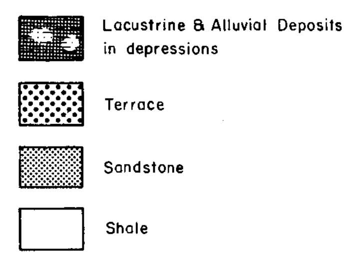
NO. 3



Beds generally dip southwestward 20 to 30 feet/mile.

GEOLOGIC UNIT	SYMBOL
Cedar Hills	Pch
Hennessey	Phy

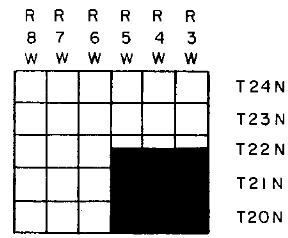




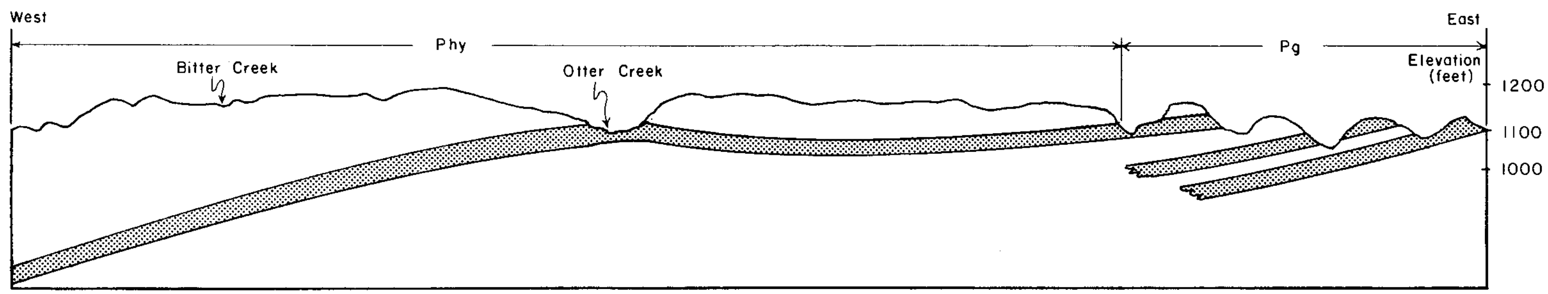
IDEALIZED CROSS SECTION

GARFIELD COUNTY

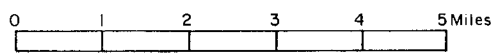
NO. 4



Cross Section Illustrates Shaded Area

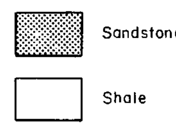


Beds generally dip southwestward 20 to 30 feet/mile.



Approximate Scale

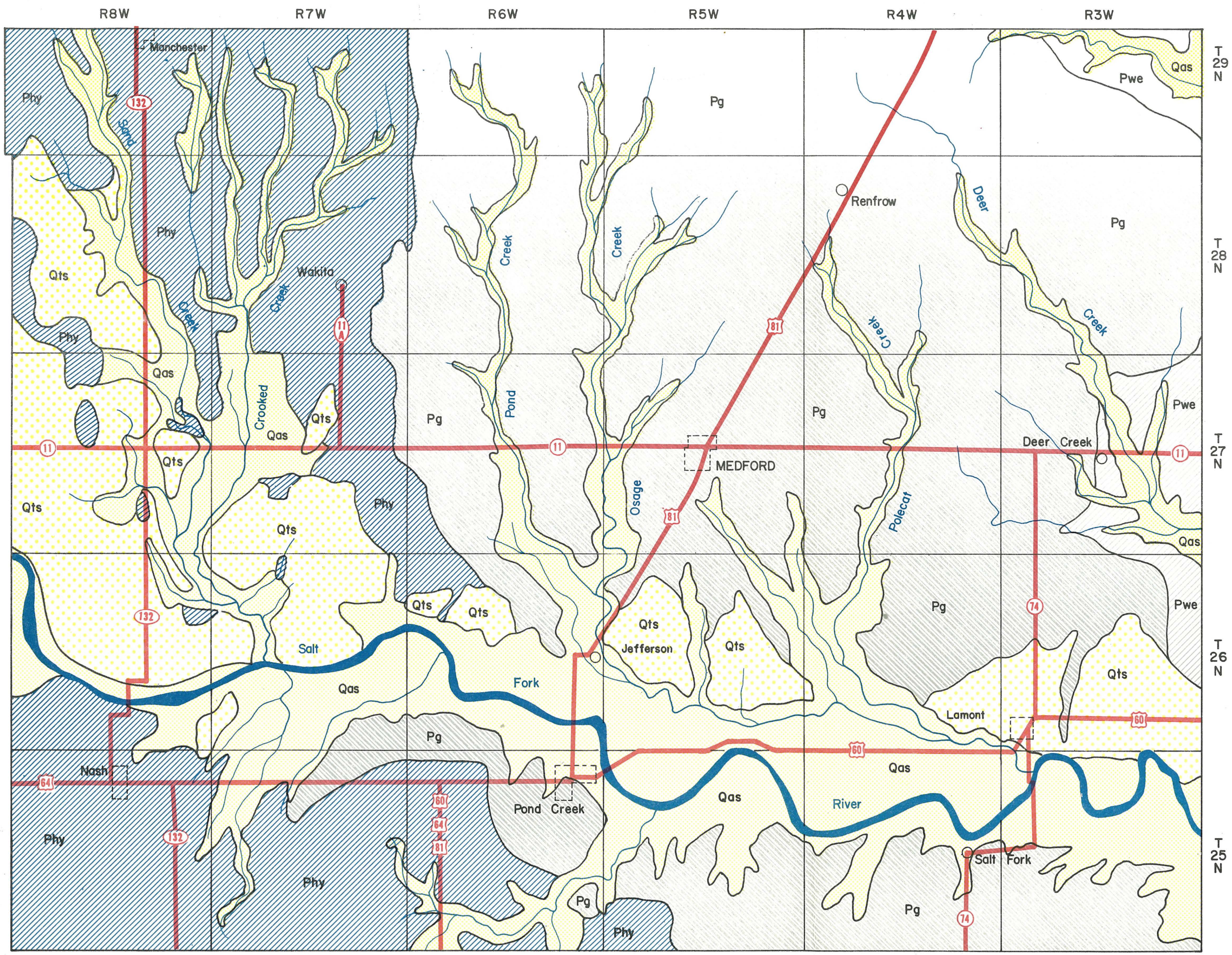
GEOLOGIC UNIT	SYMBOL
Hennessey	Phy
Garber	Pg



GEOLOGIC UNITS OF GRANT COUNTY

Prepared by the Oklahoma Department of Highways

Information taken from: "Geologic Map of Oklahoma" by Hugh D. Miser and others U.S.G.S. 1954



SCALE

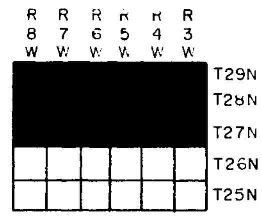
0 1 2 3 4 5 10 miles

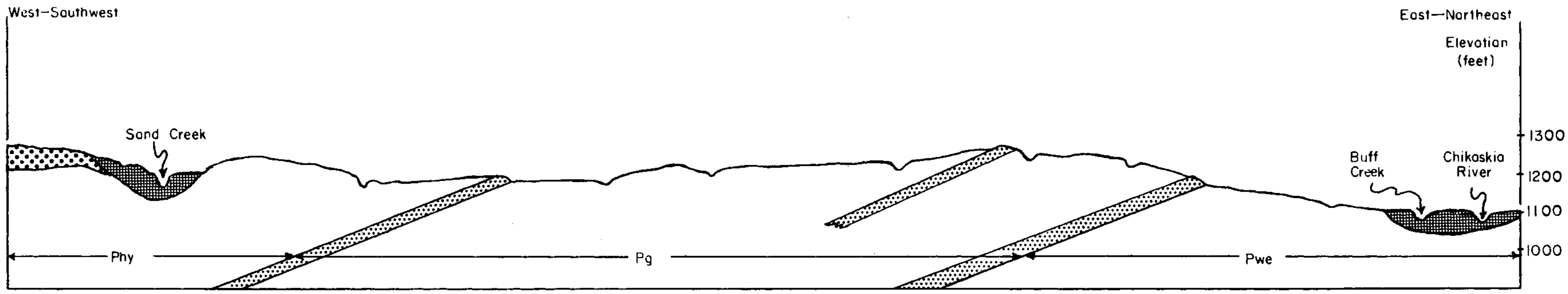
Qas	Alluvium
Qts	Terrace Deposits
Phy	Hennessey Unit
Pg	Garber Unit
Pwe	Wellington Unit

IDEALIZED CROSS SECTION

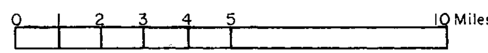
GRANT COUNTY

NO. 1



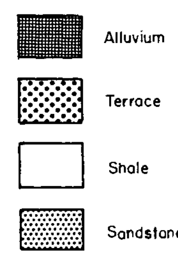


Beds generally dip westward 40 feet / mile



Approximate Scale

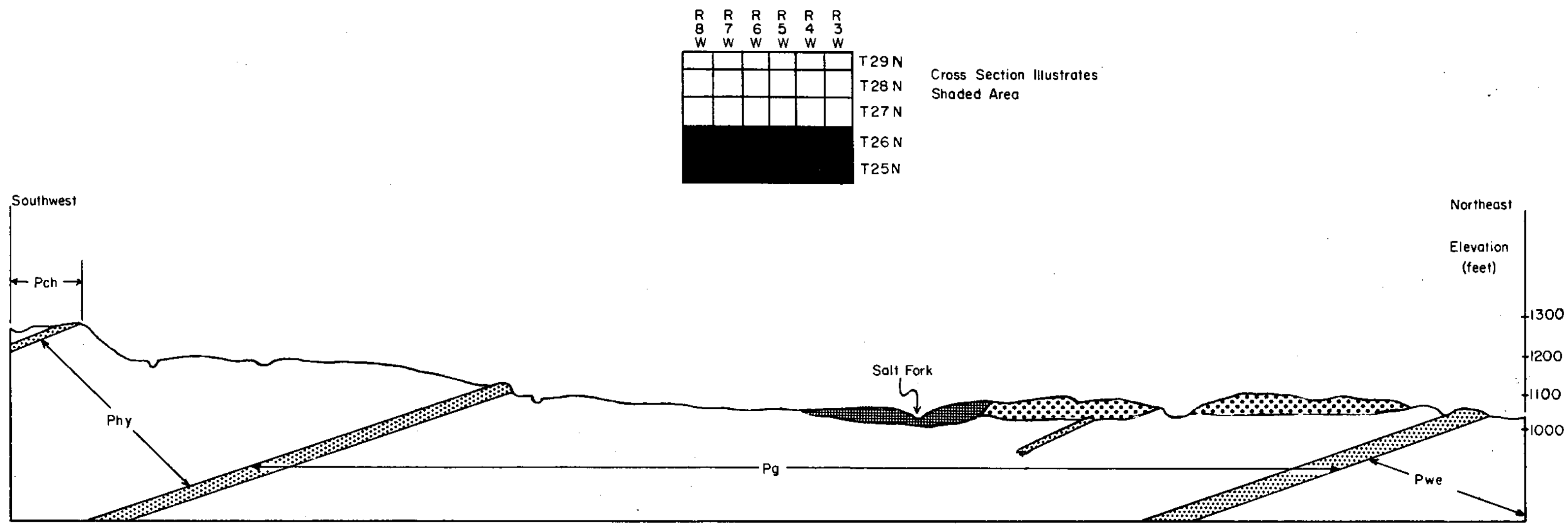
GEOLOGIC UNIT	SYMBOL
Hennessey	Phy
Garber	Pg
Wellington	Pwe



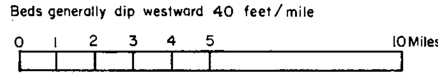
IDEALIZED CROSS SECTION

GRANT COUNTY

NO. 2

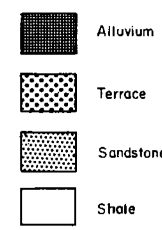


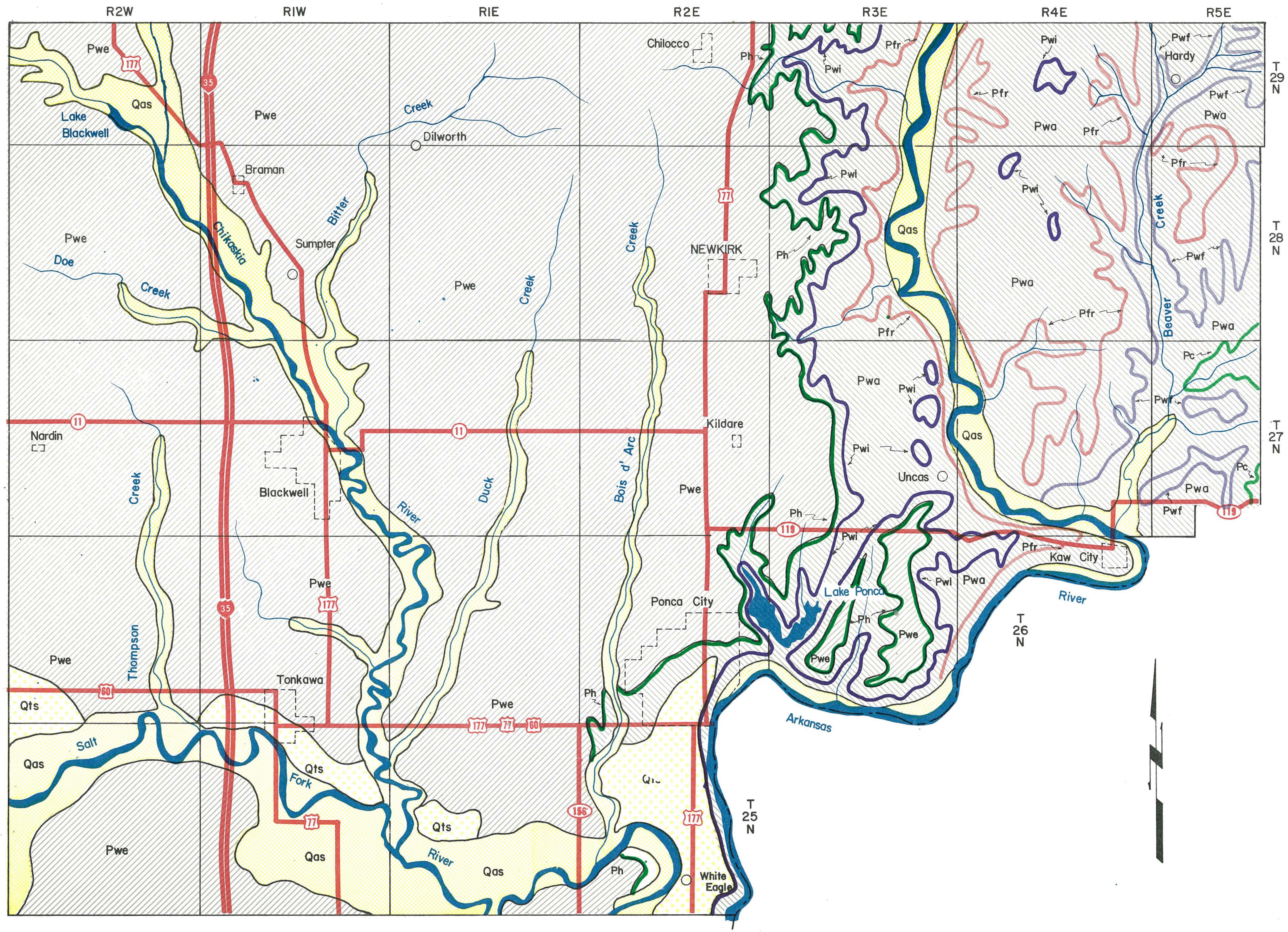
Beds generally dip westward 40 feet / mile



Approximate Scale

GEOLOGIC UNIT	SYMBOL
Cedar Hills	Pch
Hennessey	Phy
Garber	Pg
Wellington	Pwe





GEOLOGIC UNITS OF KAY COUNTY

Prepared by the Oklahoma Department of Highways

Information taken from:
"Geologic Map of Oklahoma" by Hugh D. Miser and others U.S.G.S. 1954

"Geology of Northeastern Kay County" by A. J. Hruby 1955

"Geology of Southeastern Kay County" by C. R. Noll Jr. 1955

SCALE

0 1 2 3 4 5 10 miles

Qas Alluvium

Qts Terrace Deposits

Pwe Wellington Unit

Ph Herington Subunit

Pwa

Pwi Winfield Subunit

Pfr Fort Riley Subunit

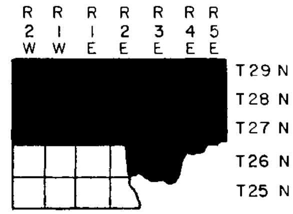
Pwa

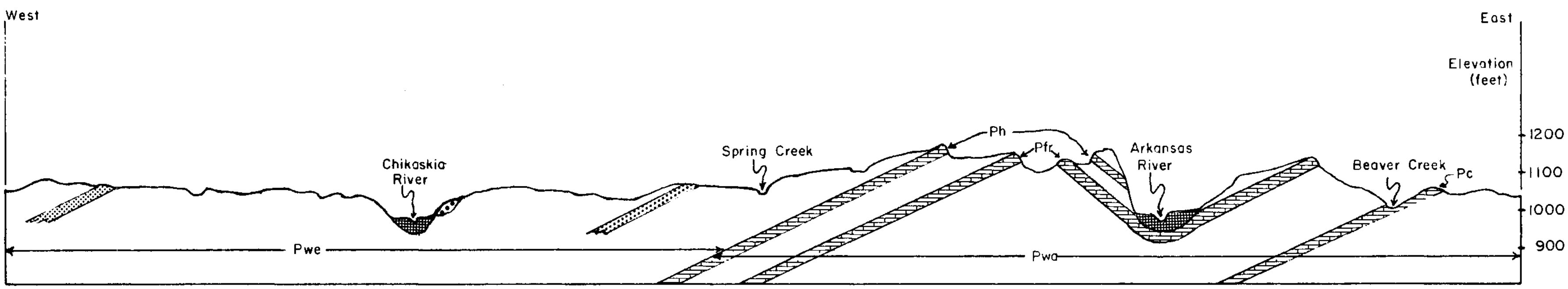
Pwf Wreford Subunit

Pc Cottonwood Subunit

Wellington-Admire Unit

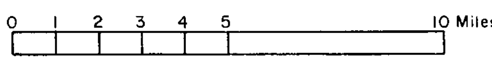
IDEALIZED CROSS SECTION
KAY COUNTY
NO. 1



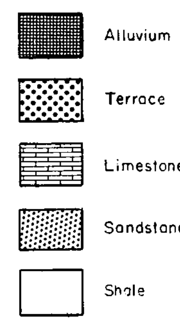


Beds generally dip westward 40 to 50 feet/mile, but are reversed locally by folding

GEOLOGIC UNIT	SYMBOL
Wellington	Pwe
Wellington—Admire	Pwa
Herington Subunit	Ph
Fort Riley Subunit	Pfr
Cottonwood Subunit	Pc



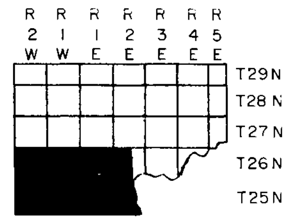
Approximate Scale



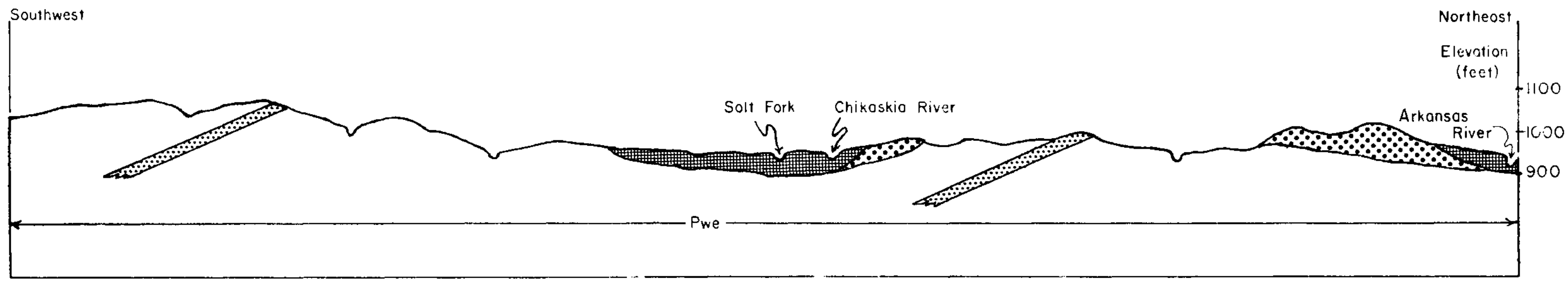
IDEALIZED CROSS SECTION

KAY COUNTY

NO. 2



Cross Section Illustrates Shaded Area

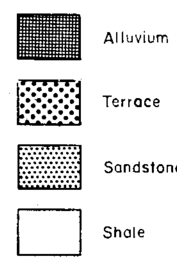


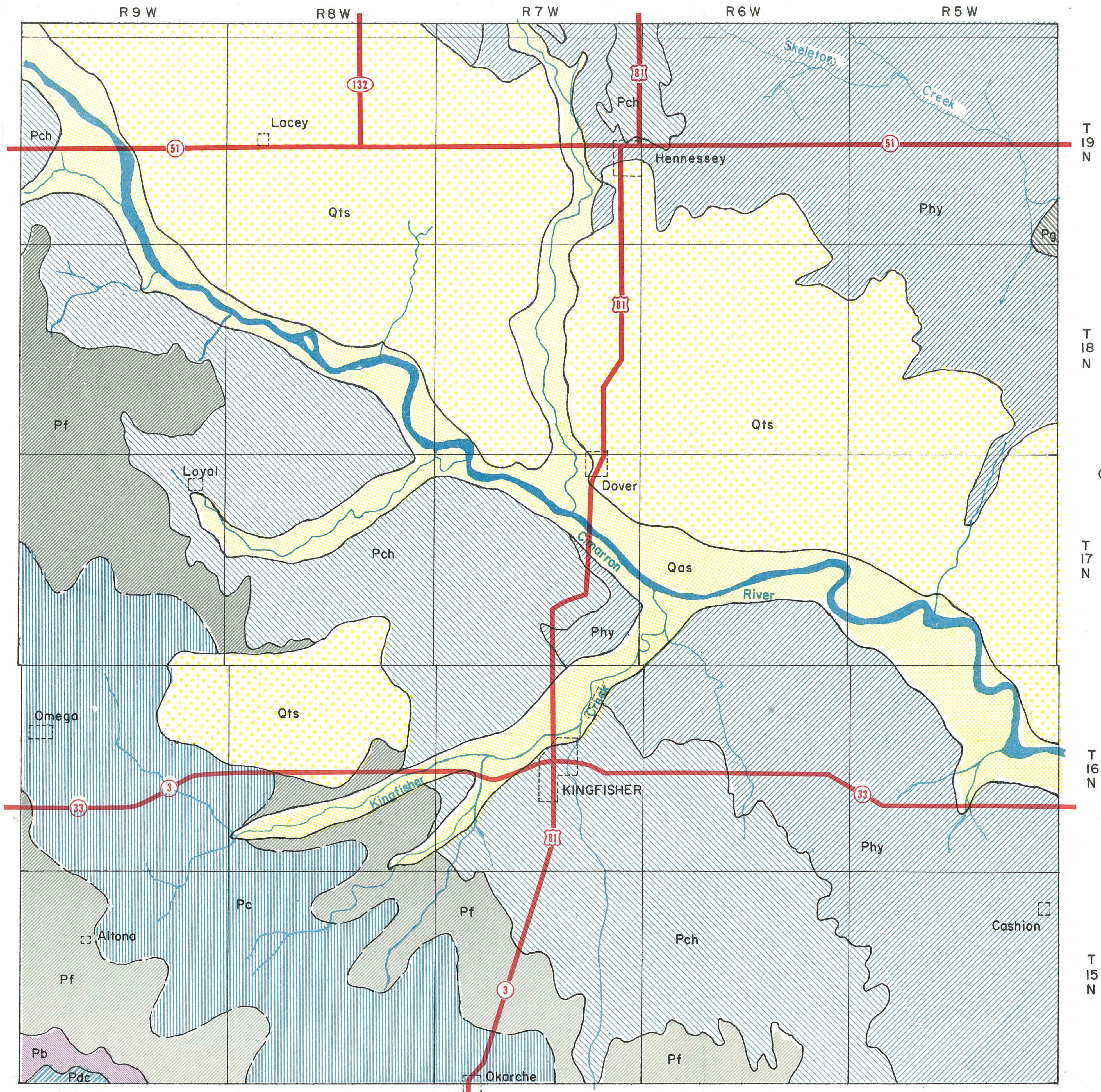
Beds generally dip westward 40 to 50 feet/mile

0 1 2 3 4 5 Miles

Approximate Scale

GEOLOGIC UNIT	SYMBOL
Wellington	Pwe





GEOLOGIC UNITS OF KINGFISHER COUNTY

Prepared by the Oklahoma Department of Highways.

Information taken from the "Geologic Map of Oklahoma" by Hugh D. Miser and others. U.S.G.S. 1954

SCALE

0 1 2 3 4 5 10 Miles

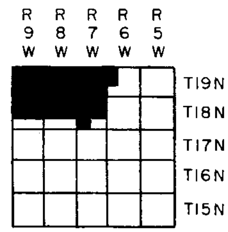
Qas	Alluvium
Qts	Terrace Deposits
Pdc	Dog Creek Unit
Pb	Blaine Unit
Pf	Flowerpot Unit
Pc	Chickasha Subunit (Estimated Outcrop)
Pch	Cedar Hills Unit
Phy	Hennessey Unit
Pg	Garber Unit

N

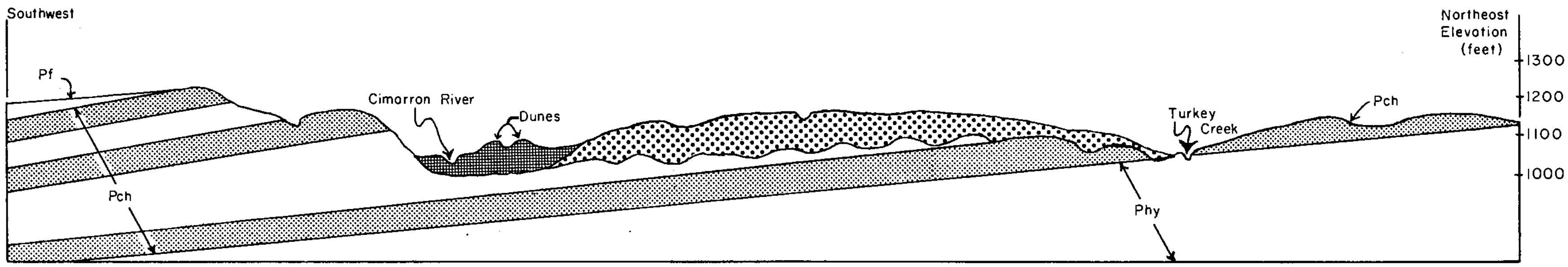
IDEALIZED CROSS SECTION

KINGFISHER COUNTY

NO. 1

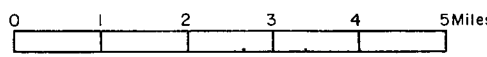


Cross Section Illustrates Shaded Area

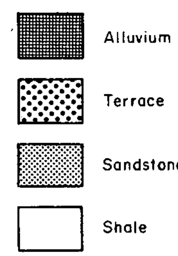


Beds generally dip southwestward 15 to 25 feet/mile

GEOLOGIC UNIT	SYMBOL
Flowerpot	Pf
Cedar Hills	Pch
Hennessey	Phy



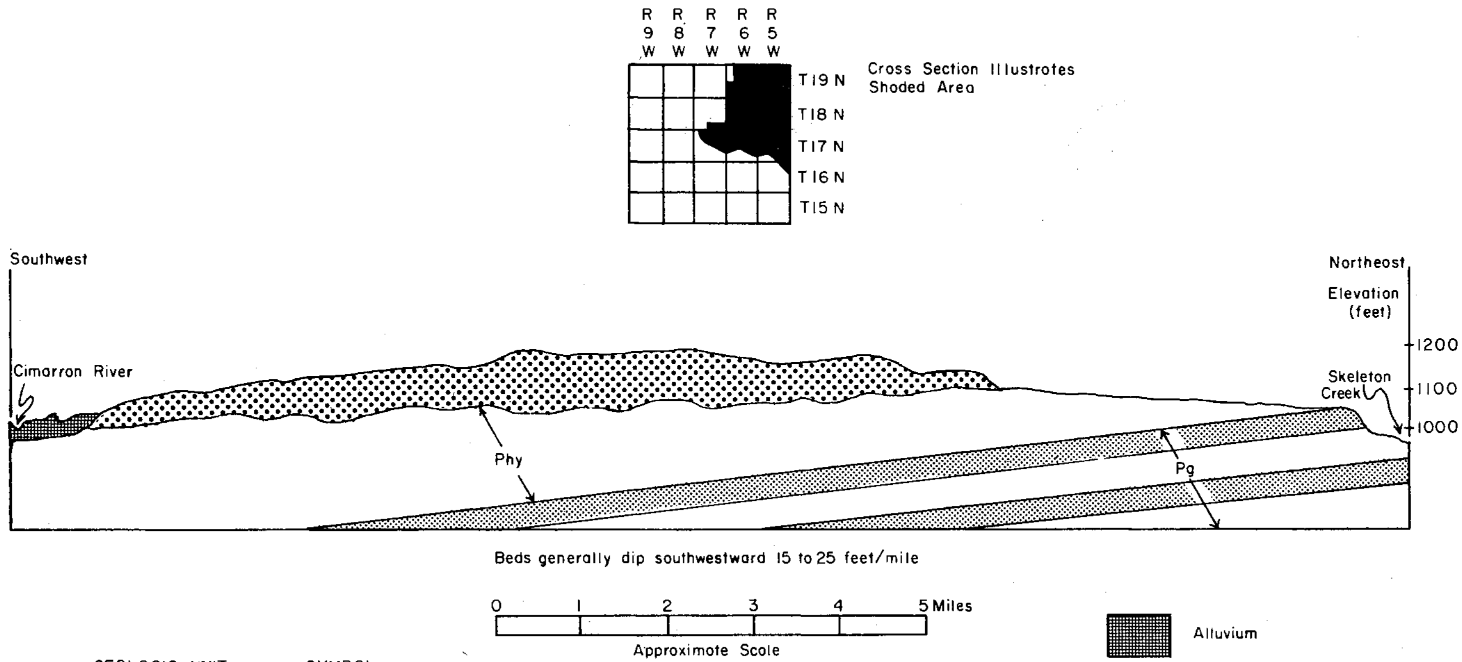
Approximate Scale



IDEALIZED CROSS SECTION

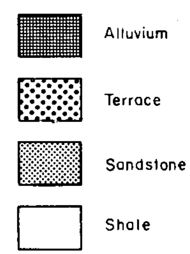
KINGFISHER COUNTY

NO. 2



Beds generally dip southwestward 15 to 25 feet/mile

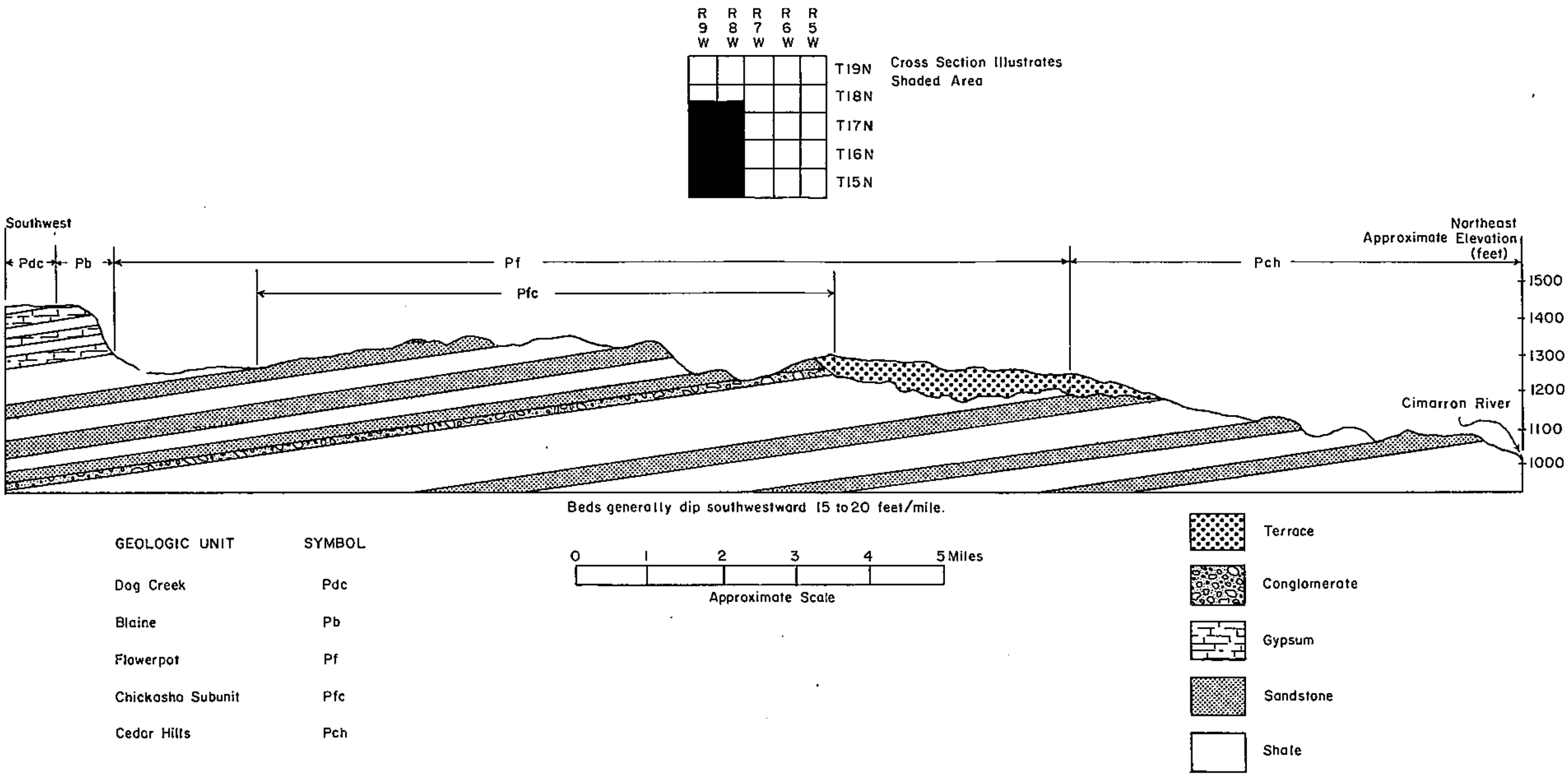
GEOLOGIC UNIT	SYMBOL
Hennessey	Phy
Garber	Pg



IDEALIZED CROSS SECTION

KINGFISHER COUNTY

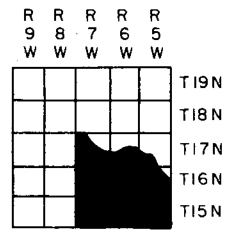
NO. 3



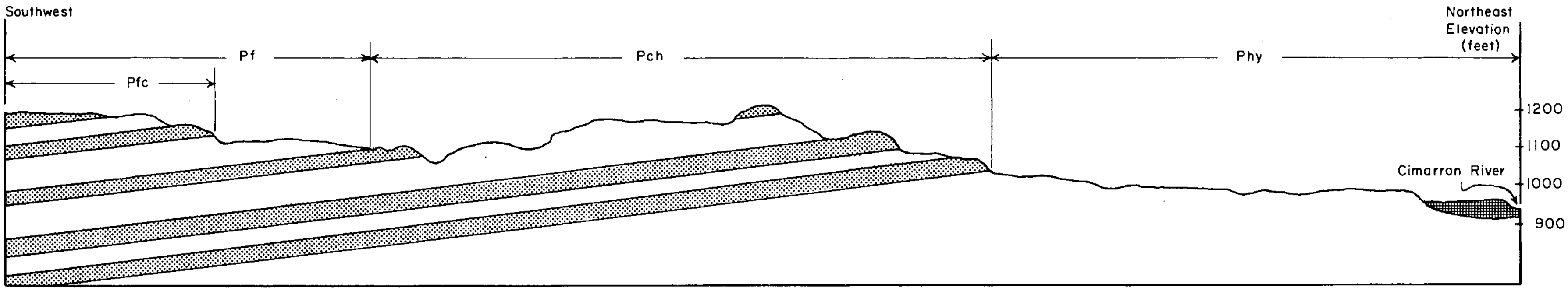
IDEALIZED CROSS SECTION

KINGFISHER COUNTY

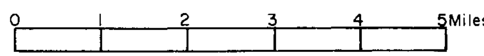
NO. 4



Cross Section Illustrates Shaded Area



Beds generally dip southwestward 15 to 25 feet/mile.



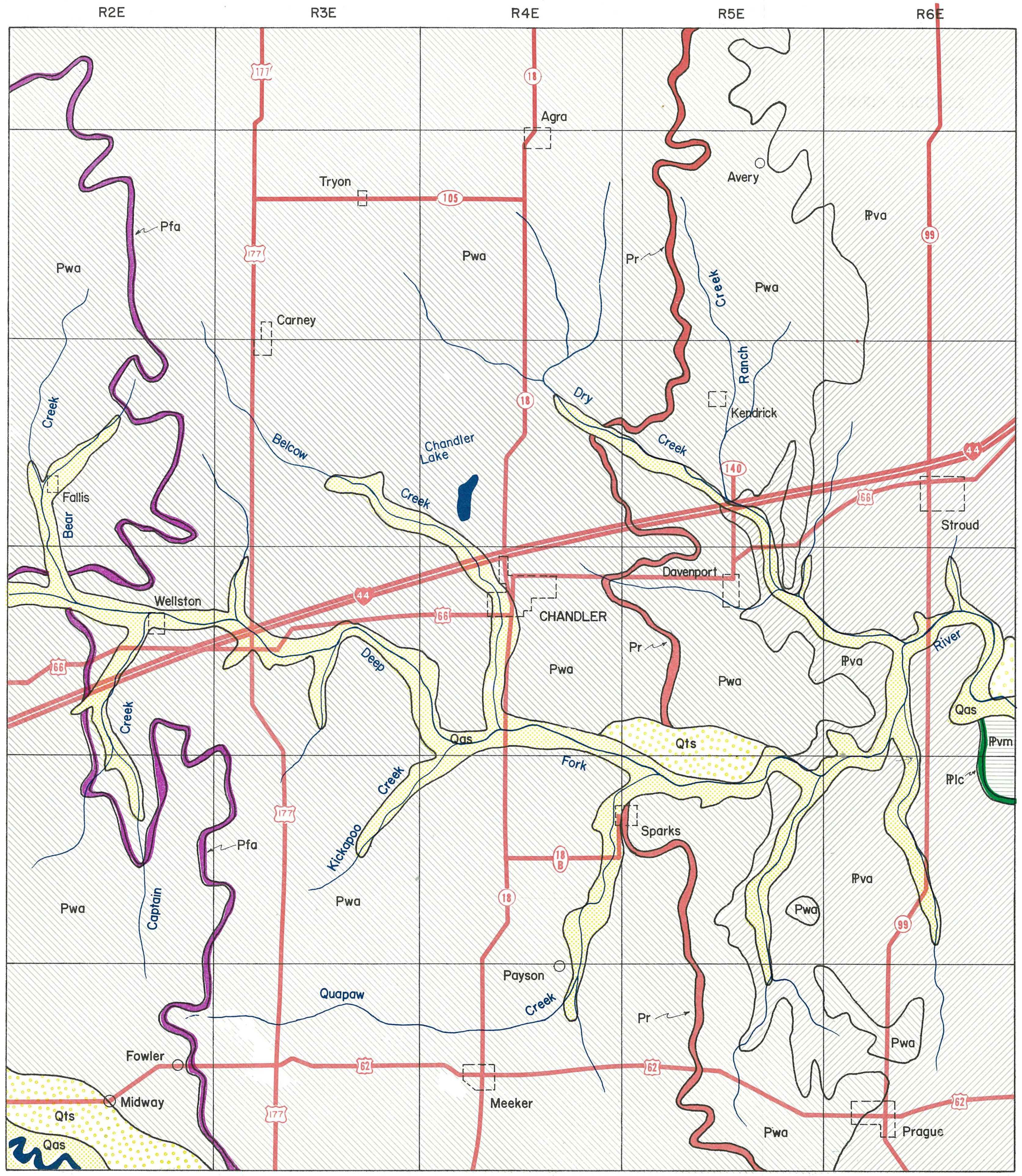
Approximate Scale

GEOLOGIC UNIT	SYMBOL
Flowerpot	Pf
Chickasha Subunit	Pfc
Cedar Hills	Pch
Hennessey	Phy

Alluvium

Sandstone

Shale



GEOLOGIC UNITS OF LINCOLN COUNTY

Prepared by the Oklahoma Department of Highways

Information taken from: "Geologic Map of Oklahoma" by Hugh D. Miser and others U.S.G.S. 1954

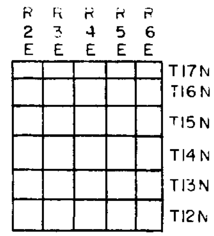
SCALE

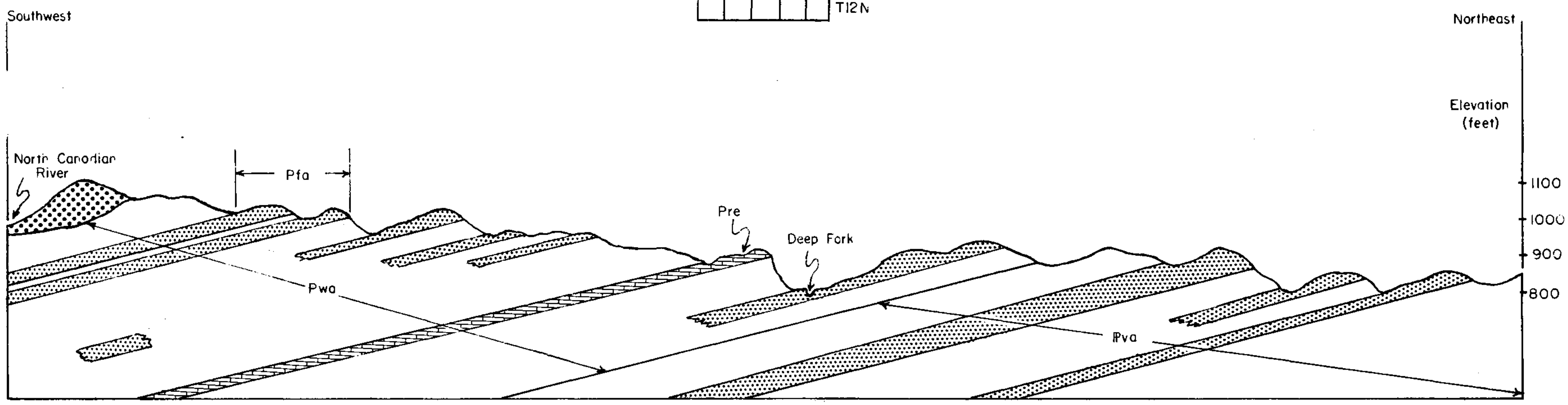
0 1 2 3 4 5 10 miles

Qas	Alluvium	
Qts	Terrace Deposits	
Pfa	Fallis Subunit	Wellington-Admire Unit
Pwa		Wellington-Admire Unit
Pr	Red Eagle Subunit	Wellington-Admire Unit
Pva	Vanoss-Ada Unit	
Plc	Lecompton Unit	
Pvm	Vamoosa Unit	

IDEALIZED CROSS SECTION

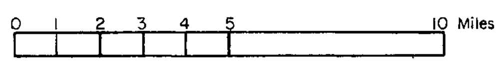
LINCOLN COUNTY



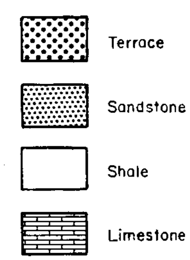


Beds generally dip westward 40 to 50 feet/mile

GEOLOGIC UNIT	SYMBOL
Wellington Admire	Pwa
Fallis Subunit	Pfa
Red Eagle Subunit	Pre
Vanoss-Ada	Pva



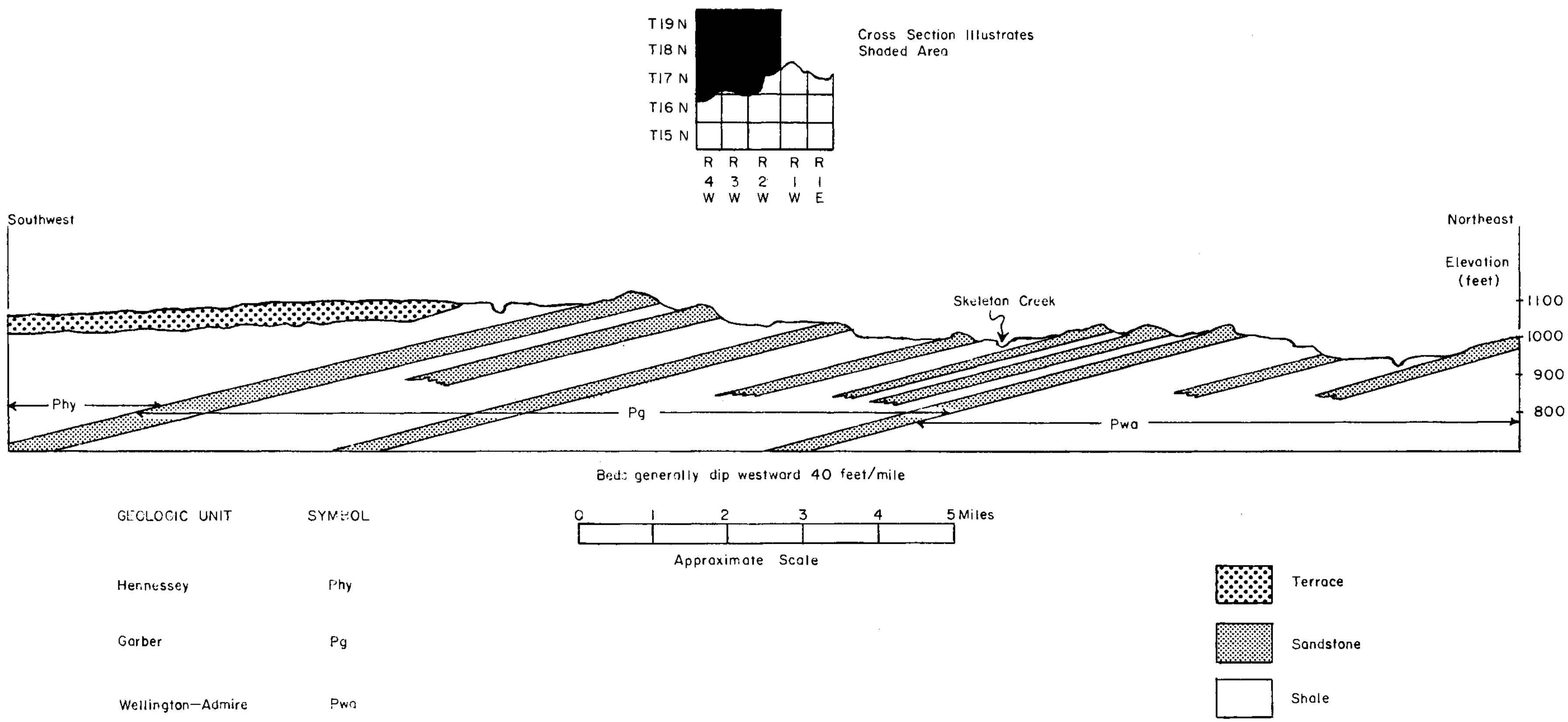
Approximate Scale

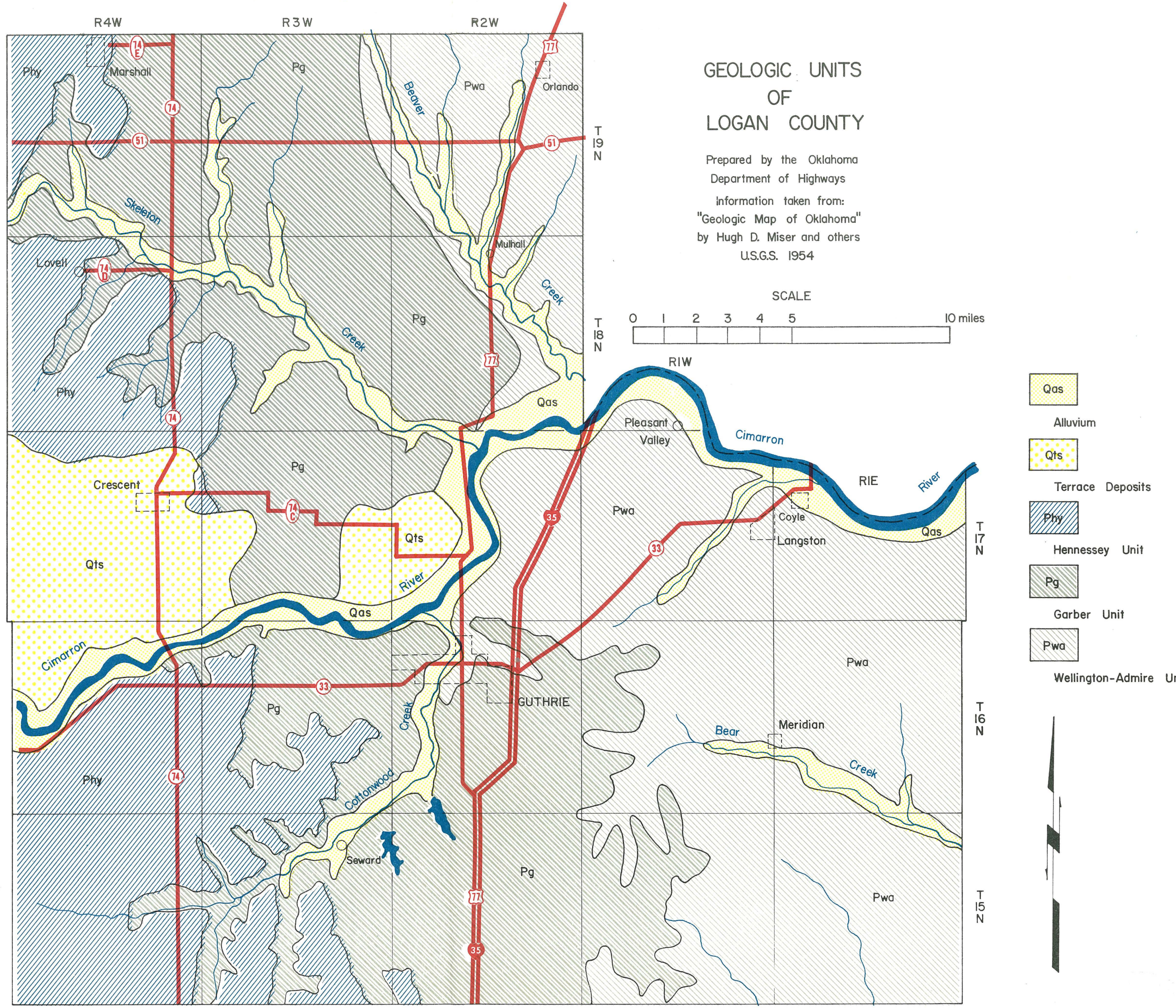


IDEALIZED CROSS SECTION

LOGAN COUNTY

NO. 1

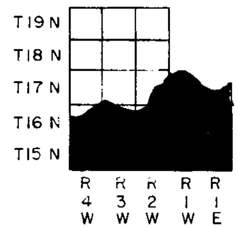



GEOLOGIC UNITS
OF
LOGAN COUNTY
Prepared by the Oklahoma
Department of Highways
Information taken from:
"Geologic Map of Oklahoma"
by Hugh D. Miser and others
U.S.G.S. 1954
SCALE
0 1 2 3 4 5 10 miles
Qas
Alluvium
Qts
Terrace Deposits
Phy
Hennessey Unit
Pg
Garber Unit
Pwa
Wellington-Admire Unit
R4W
R3W
R2W
R1W
R1E
T 19 N
T 18 N
T 17 N
T 16 N
T 15 N
Marshall
Orlando
Mulhall
Lovell
Crescent
Pleasant Valley
Coyle
Langston
GUTHRIE
Meridian
Seward
Skeleton
Creek
Beaver
Cimarron
River
Cottonwood
Bear

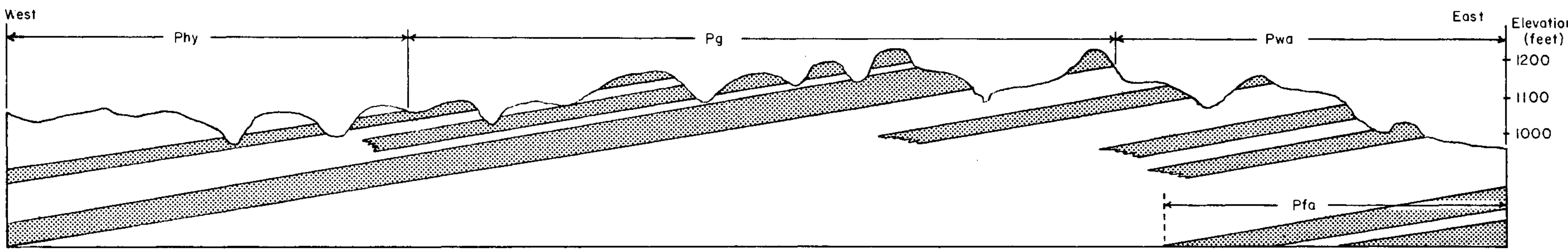
IDEALIZED CROSS SECTION

LOGAN COUNTY

NO. 2



Cross Section Illustrates Shaded Area



Beds generally dip westward 50 feet/mile.

GEOLOGIC UNIT	SYMBOL
Hennessey	Phy
Garber	Pg
Wellington–Admire	Pwa
Fallis Subunit	Pfa

0 1 2 3 4 5 Miles

Approximate Scale

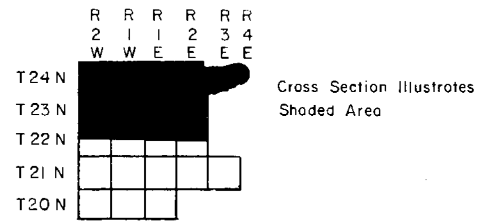
Sandstone

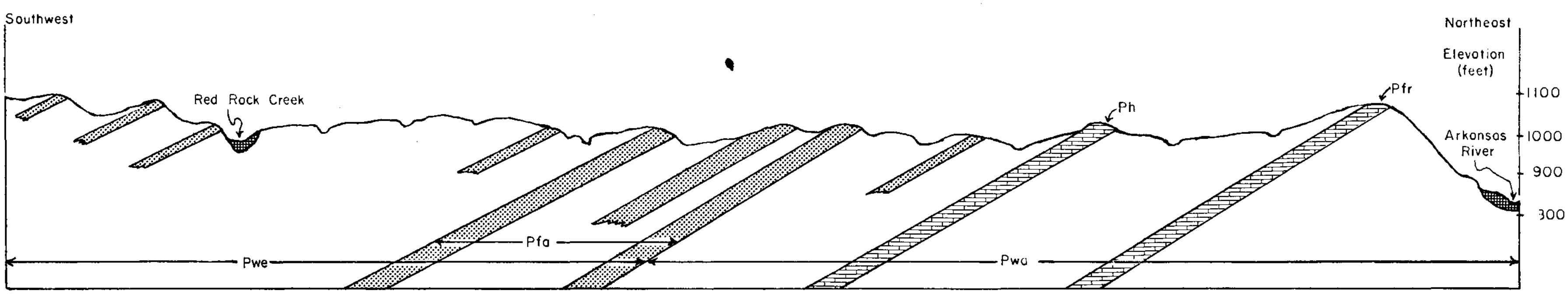
Shale

IDEALIZED CROSS SECTION

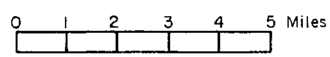
NOBLE COUNTY

NO. 1



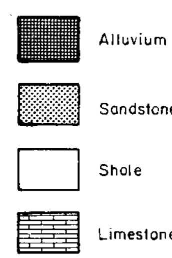


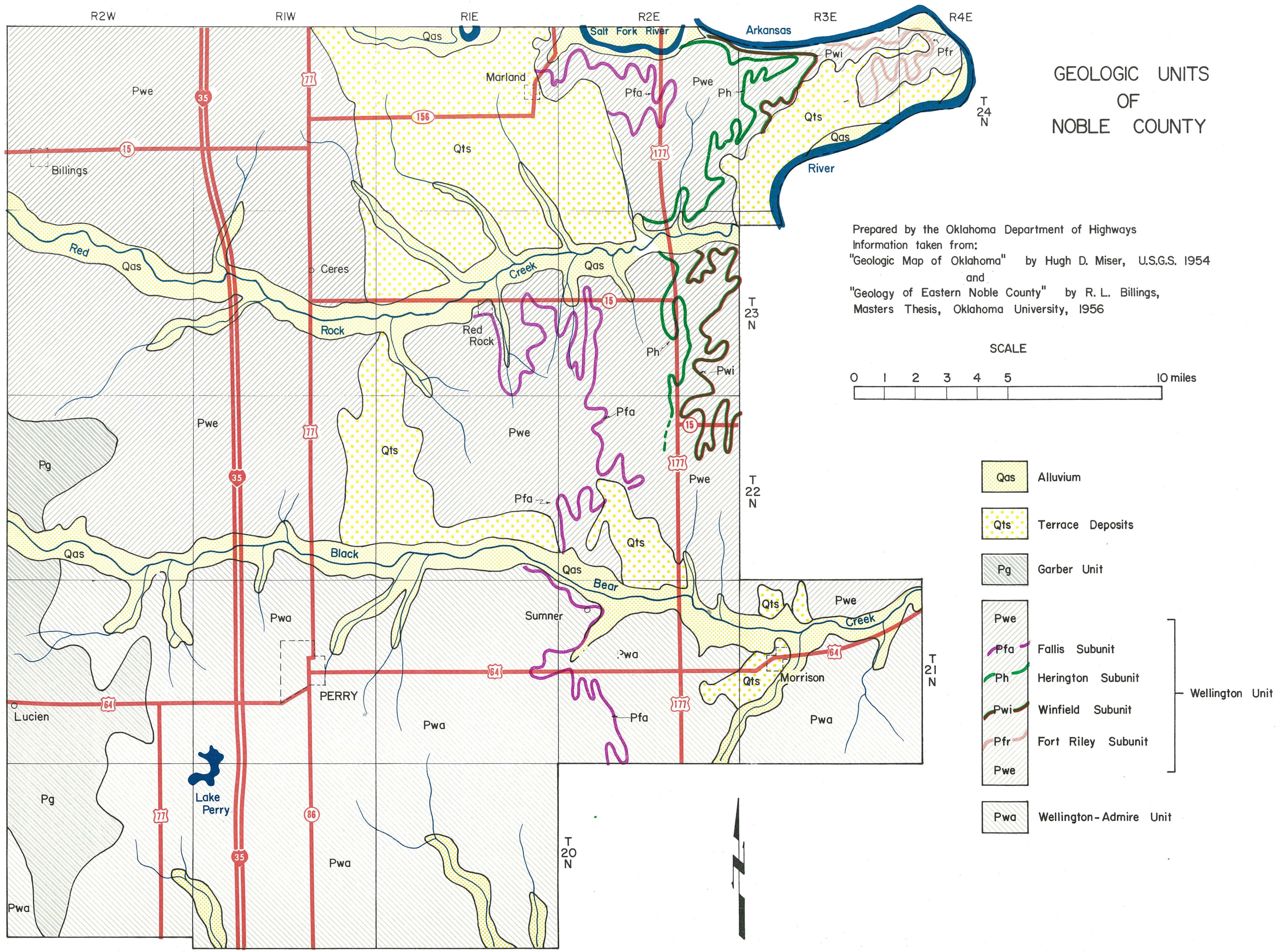
Beds generally dip westward 40 to 50 feet / mile



Approximate Scale

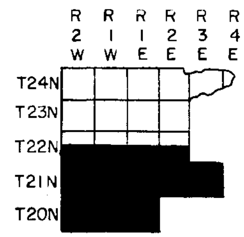
GEOLOGIC UNIT	SYMBOL
Wellington	Pwe
Fallis Subunit	Pfa
Wellington–Admire	Pwa
Herington Subunit	Ph
Fort Riley Subunit	Pfr



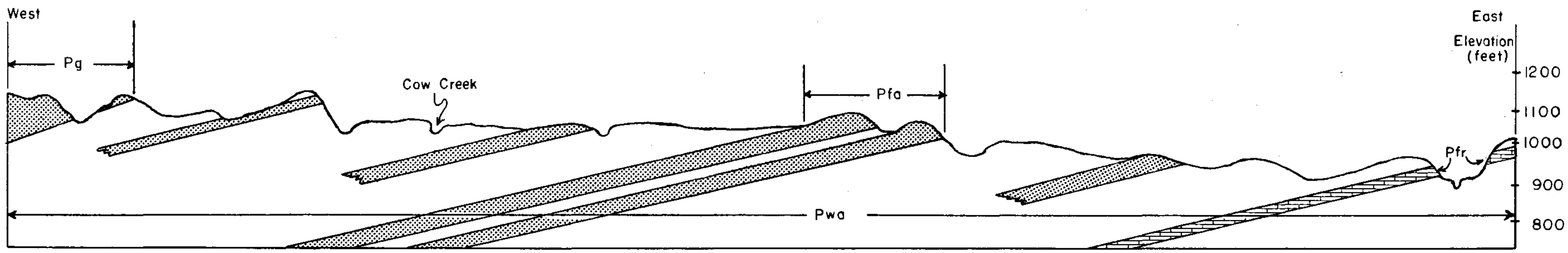

GEOLOGIC UNITS OF NOBLE COUNTY
Prepared by the Oklahoma Department of Highways
Information taken from:
"Geologic Map of Oklahoma" by Hugh D. Miser, U.S.G.S. 1954
and
"Geology of Eastern Noble County" by R. L. Billings, Masters Thesis, Oklahoma University, 1956
SCALE
0 1 2 3 4 5 10 miles
Qas Alluvium
Qts Terrace Deposits
Pg Garber Unit
Pwe
Pfa Fallis Subunit
Ph Herington Subunit
Pwi Winfield Subunit
Pfr Fort Riley Subunit
Pwe
Wellington Unit
Pwa Wellington-Admire Unit
R2W
RIW
RIE
R2E
R3E
R4E
T 24 N
T 23 N
T 22 N
T 21 N
T 20 N
Salt Fork River
Arkansas River
Red Rock Creek
Black Bear Creek
Marland
Billings
Ceres
Red Rock
Sumner
PERRY
Morrison
Lucien
Lake Perry

IDEALIZED CROSS SECTION

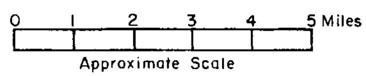
NOBLE COUNTY
NO. 2



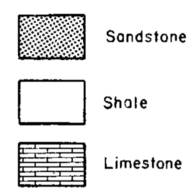
Cross Section Illustrates Shaded Area



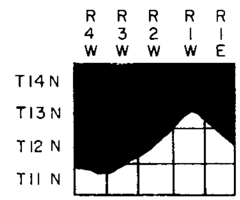
Beds generally dip westward 40 to 50 feet/mile.



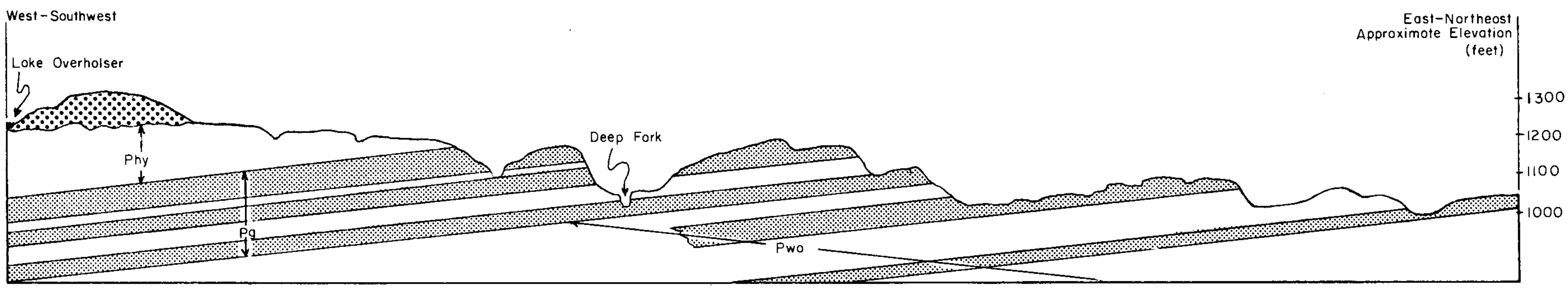
GEOLOGIC UNIT	SYMBOL
Garber	Pg
Wellington—Admire	Pwa
Fallis Subunit	Pfa
Fort Riley Subunit	Pfr



IDEALIZED CROSS SECTION
OKLAHOMA COUNTY
NO. 1

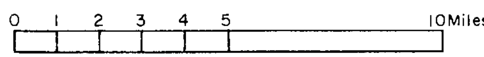


Cross Section Illustrates Shaded Area

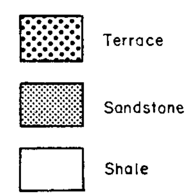


Beds generally dip westward 40 feet/mile

GEOLOGIC UNIT	SYMBOL
Hennessey	Phy
Garber	Pg
Wellington—Admire	Pwa

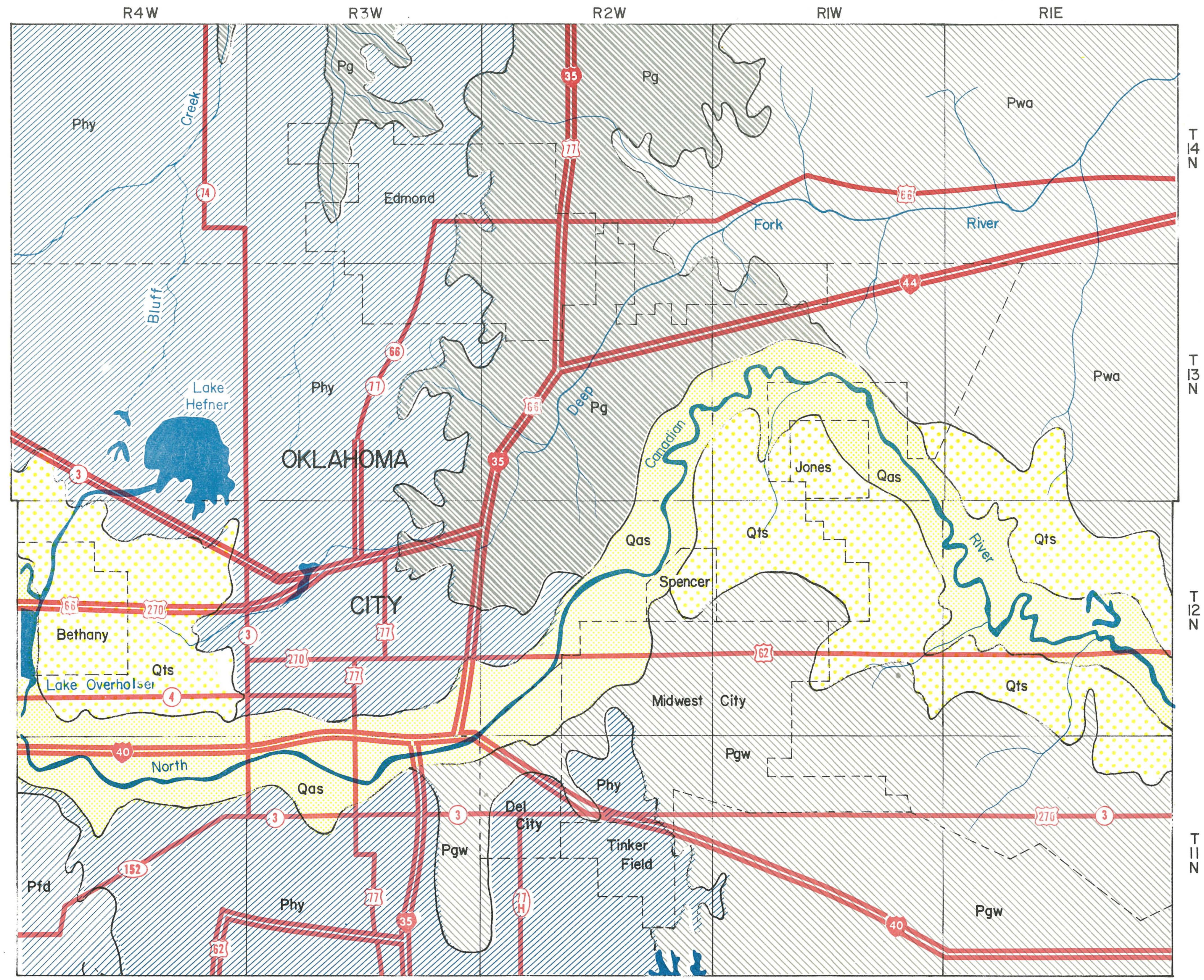


Approximate Scale



GEOLOGIC UNITS OF OKLAHOMA COUNTY

Prepared by the Oklahoma Department of Highways
Information taken from:
"Geologic Map of Oklahoma"
by Hugh D. Miser and others
U.S.G.S. 1954



SCALE

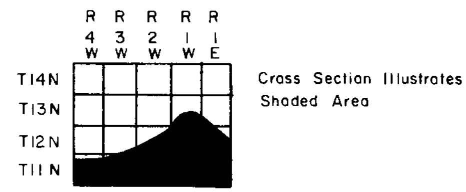
0 1 2 3 4 5 10 miles

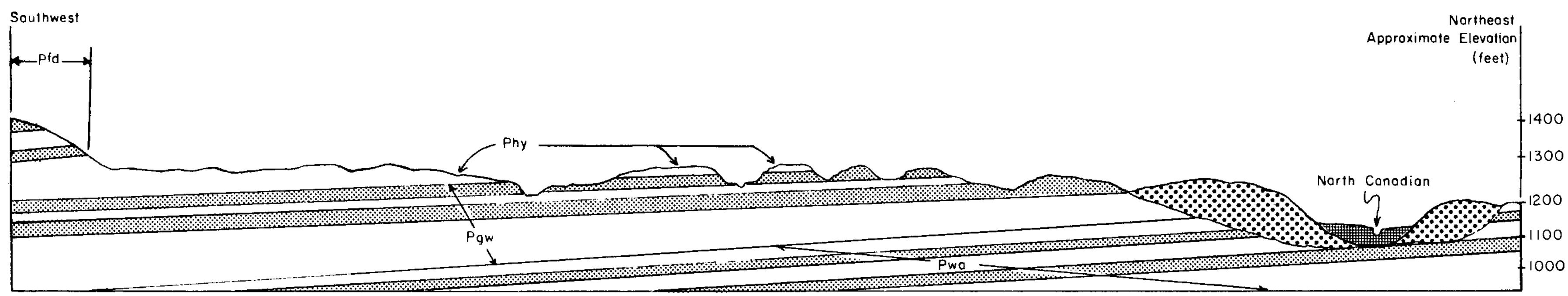
Qas	Alluvium
Qts	Terrace Deposits
Pfd	Flowerpot Unit Duncan Subunit
Phy	Hennessey Unit
Pg	Garber Unit
Pgw	Garber-Wellington Unit
Pwa	Wellington-Admire Unit

IDEALIZED CROSS SECTION

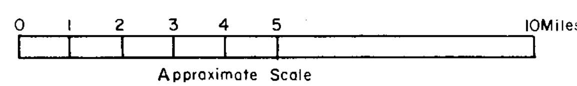
OKLAHOMA COUNTY

NO. 2

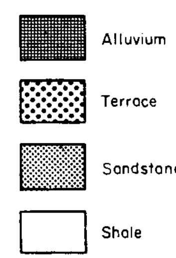




Beds generally dip westward 40 feet/mile



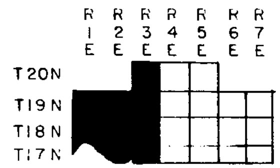
GEOLOGIC UNIT	SYMBOL
Duncan Subunit	Pfd
Hennessey	Phy
Garber-Wellington	Pgw
Wellington-Admire	Pwa

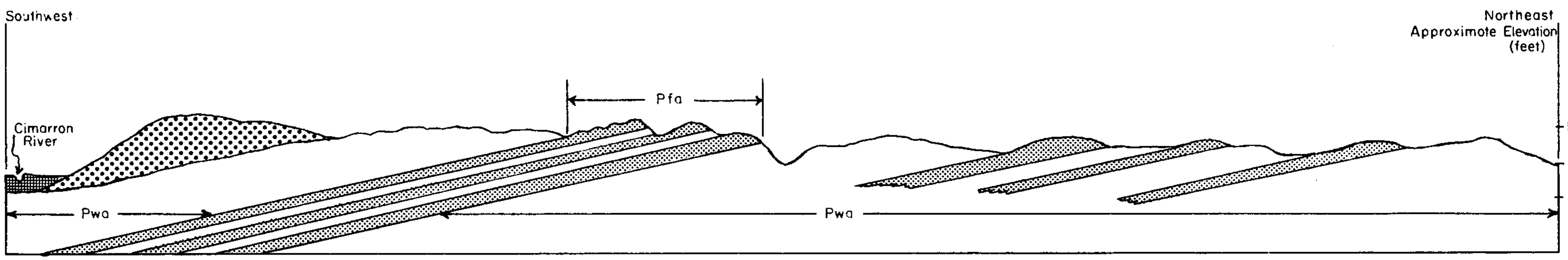


IDEALIZED CROSS SECTION

PAYNE COUNTY

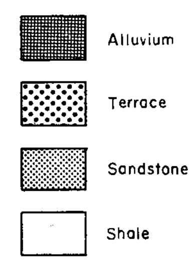
NO. 1

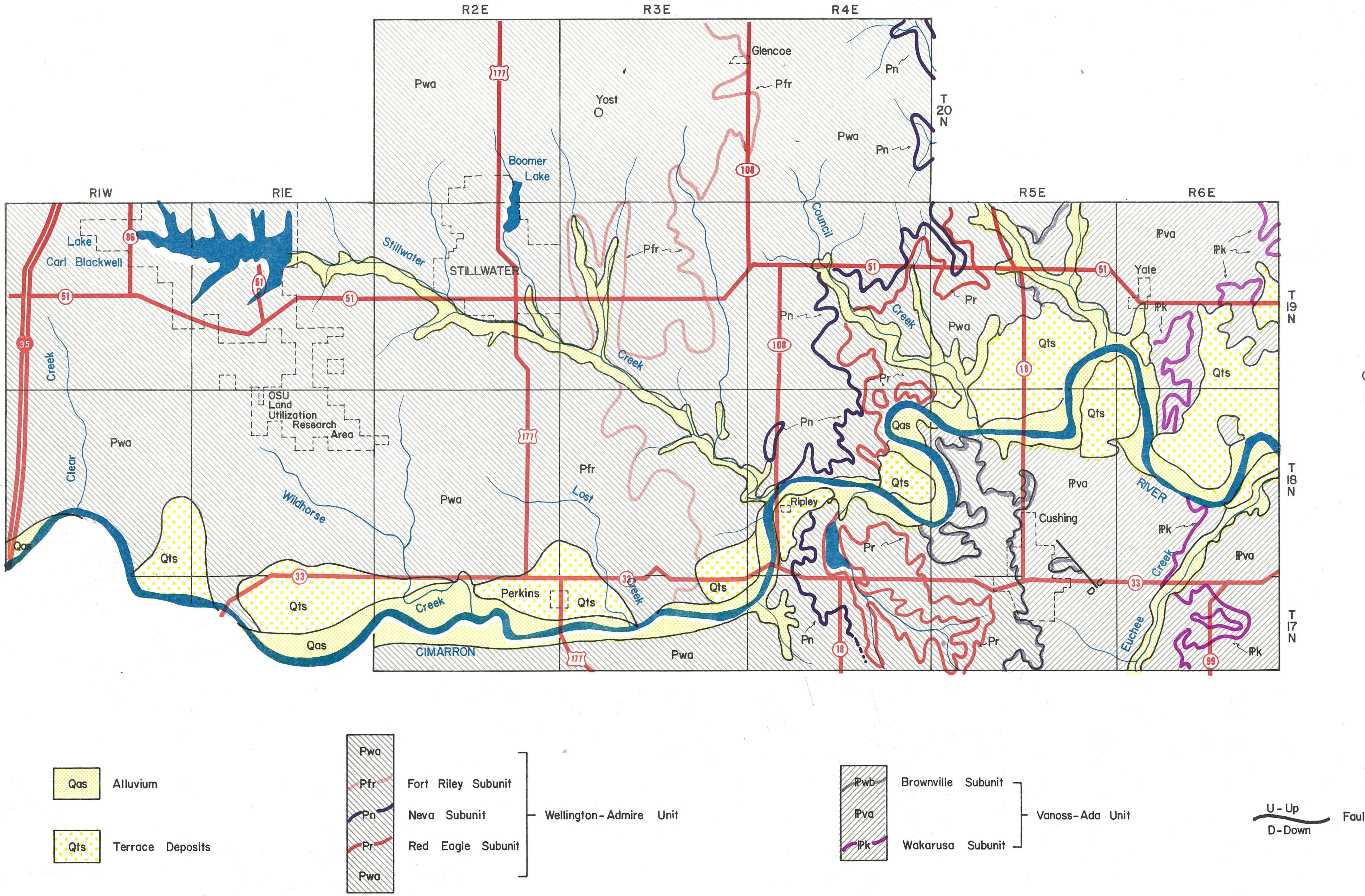




Beds generally dip westward 50 to 100 feet/mile

GEOLOGIC UNIT	SYMBOL
Wellington—Admire	Pwa
Fallis Subunit	Pfa





GEOLOGIC UNITS OF PAYNE COUNTY

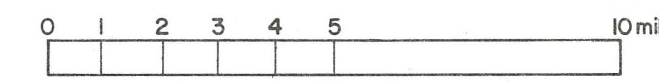
Prepared by the Oklahoma Department of Highways

Information taken from:
"Geologic Map of Oklahoma" by Hugh D. Miser and others U.S.G.S. 1954

"Geology of Southeastern Payne County" by Eugene Nakayama 1953

"Geology of Northeastern Payne County" by A. F. Fenoglio 1957

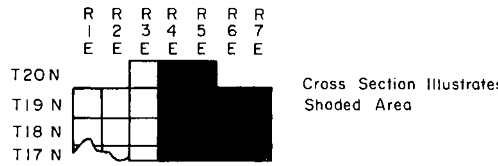
SCALE

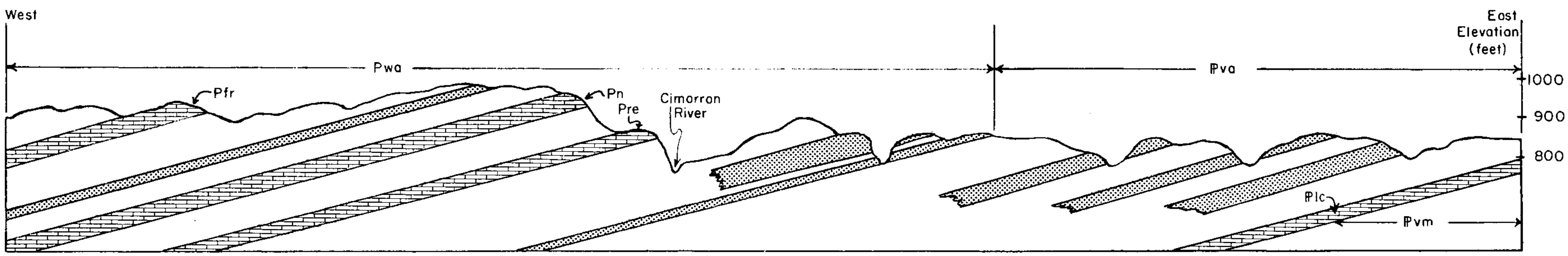


IDEALIZED CROSS SECTION

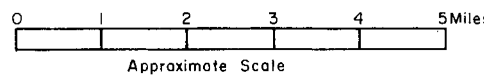
PAYNE COUNTY

NO. 2

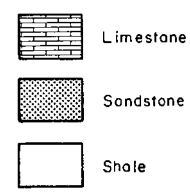




Beds generally dip westward 50 to 100 feet/mile



GEOLOGIC UNIT	SYMBOL
Wellington–Admire	Pwa
Fort Riley Subunit	Pfr
Nevo Subunit	Pn
Red Eagle Subunit	Pre
Vanoss–Ada	Pva
Lecompton	Plc
Vamoosa	Pvm



C H A P T E R I I I

SOILS

GENERAL SOILS INFORMATION

Soil is defined as a natural occurring body of unindurated earth materials consisting of sand, silt, clay, gravel, or mixtures of these. Soil is the product of the action of climate and living organisms upon the geologic materials as conditioned by local relief and time.

The Soil Conservation Service of the Department of Agriculture maps and classifies soil. The "soil series" is the basic unit used for mapping, and it may be defined as a group of soils formed on similar parent material (geologic material) and having, except for the "A" horizon, similar internal characteristics. Important internal characteristics are thickness, structure, color, and texture.

A soil horizon may be defined as a layer of soil approximately parallel to the soil surface. The "A" horizon is commonly called top soil and is the layer from the surface down to a designated depth. Below the "A" horizon is the layer called the subsoil or "B" horizon, and below the "B" horizon is the "C" horizon. At some depth, solid rock or shale will be present, and this is called the "D" or "R" layer. This sequence of soil horizons is called the soil profile. See figure 9 page 91.

Some soils do not have a "B" horizon. The "B" horizon is absent because sufficient time has not passed to allow this horizon to form. These soils may be designated as having an "A" - "C" profile or an "A", "AC", "C" profile.

Soil series are named from a location, usually a town, near where the soil was first identified and mapped; for example, Muskogee series was named from the town of Muskogee. Soil is discussed at greater length in the "Soils Manual", 1961, and "Highway Soils Technology", 1963, prepared by the Research and Development Division, Oklahoma Highway Department.

SOIL PROFILE

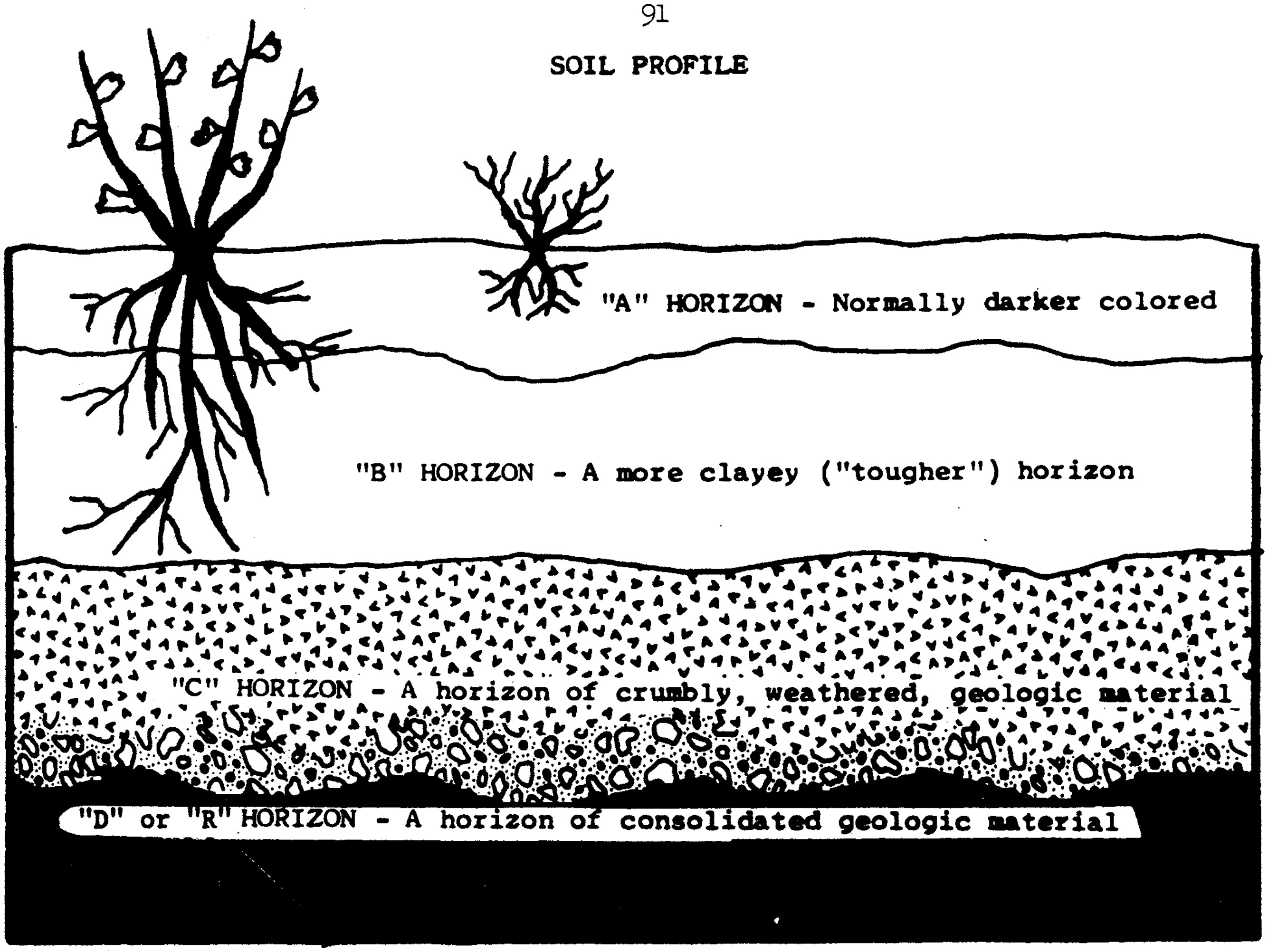


Figure 9

Beginning on page 94 are cross sections illustrating the topographic position, association, and geologic material on which the soil series occur.

Beginning on page 101, the descriptions of the soil series are listed in alphabetical order by name.

Beginning on page 222 are the charts listing the engineering characteristics of the soil series. These characteristics were determined by laboratory testing, and the methods of determination are the same as used for shales. Refer to Chapter I, page 13.

DIVISION

GRANT

ALLUVIUM
Brazos
Drummond
Lincoln
Miller
Port
Reinach
Yahola

SANDSTONE
Quinlan

SHALE
Bethany
Drummond
Grant
Kingfisher
Kirkland
Nash
Renfrow
Tabler
Vernon

TERRACE
Bethany
Carwile
Minco
Norge
Pond Creek
Pratt
Shellabarger
Tivoli
Vanoss

GARFIELD

ALLUVIUM
Drummond
Miller
Port
Yahola

SHALE
Bethany
Drummond
Grant
Kingfisher
Kirkland
Nash
Renfrow
Vernon
Zaneis

SANDSTONE
Lucien
Zaneis

TERRACE
Bethany
Carmen
Carwile
Meno
Norge
Ost
PondCreek
Pratt
Reinach
Shellabarger
Tabler

KINGFISHER

ALLUVIUM
Drummond
Lincoln
Port
Tivoli
Yahola

SHALE
Bethany
Drummond
Kingfisher
Kirkland
Renfrow
Vernon

TERRACE
Bethany
Carwile
Dougherty
Eufaula
Norge
Pond Creek
Pratt
Shellabarger
Tabler

SANDSTONE
Lucien

LOGAN

TERRACE
Bethany
Derby
Dougherty
Minco
Norge
Reinach
Teller
Vanoss

SANDSTONE
Chickasha
Darnell
Lucien
Stephenville
Zaneis

ALLUVIUM
Noble
Port
Pulaski
Yahola

SHALE
Bethany
Kirkland
Renfrow
Vernon
Zaneis

CANADIAN

TERRACE
Albion
Bethany
Canadian
Cobb
Dale
Konawa
Leshara
McLain
Minco
Norge
Reinach
Shellabarger
Vanoss

SHALE
Bethany
Grant
Kirkland
Renfrow
Vernon

SANDSTONE
Cobb
Darnell
Lucien
Quinlan

ALLUVIUM
Brewer
Lela
Lincoln
Port
Pulaski
Tivoli
Yahola

OKLAHOMA

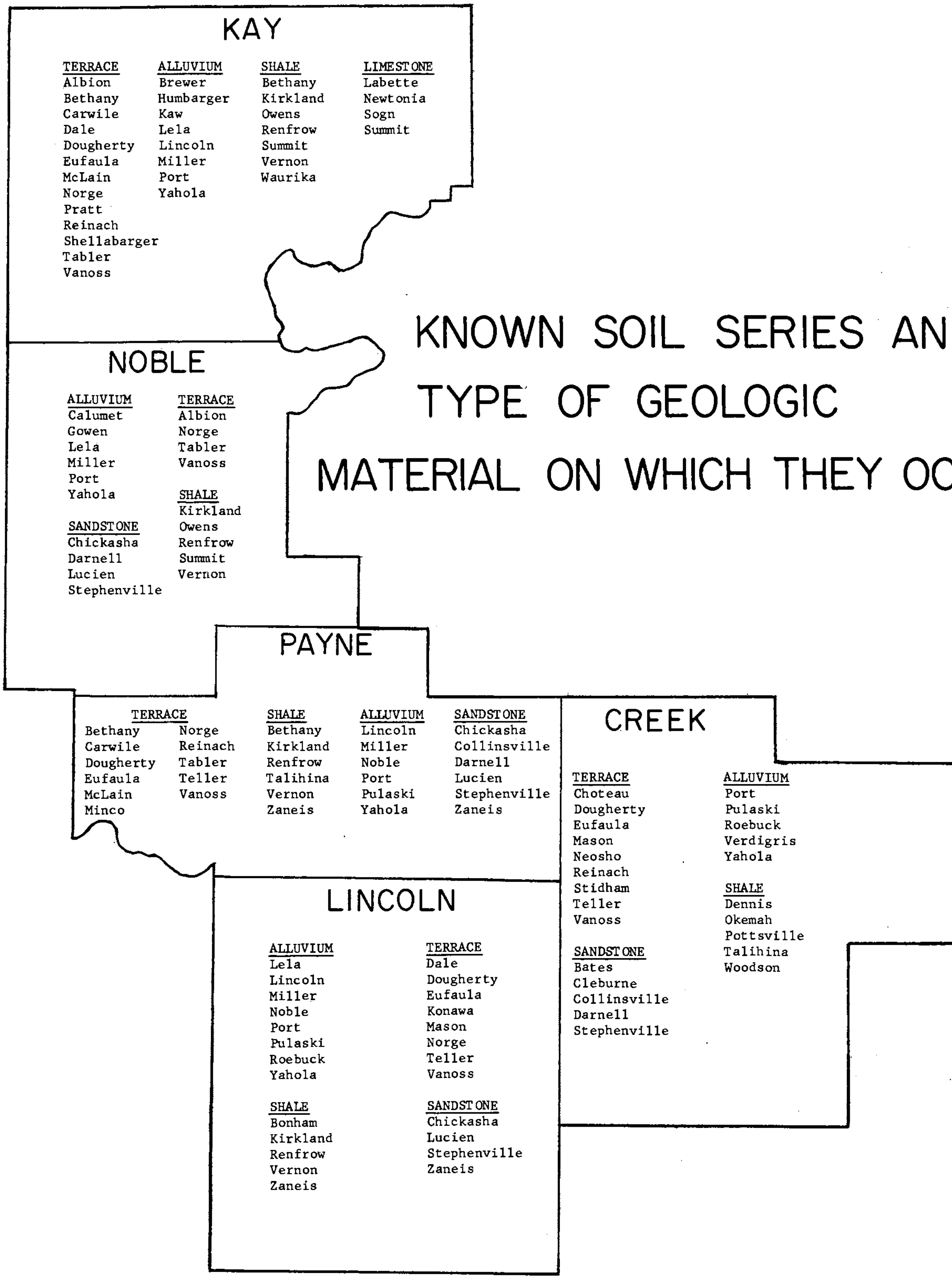
ALLUVIUM
Lincoln
Lela
Miller
Noble
Port
Pulaski

SHALE
Bethany
Grant
Kirkland
Renfrow
Vernon
Zaneis

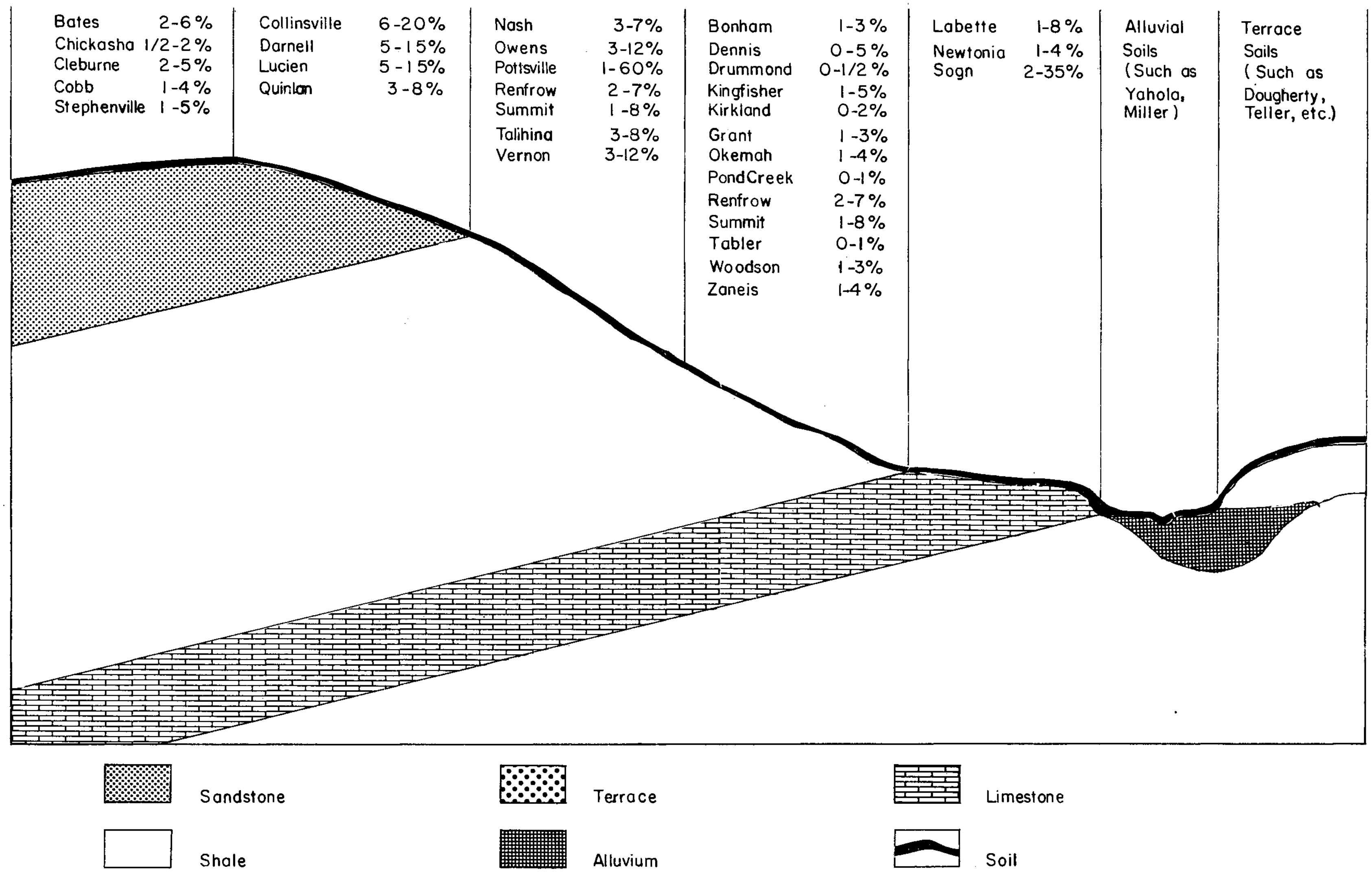
SANDSTONE
Chickasha
Darnell
Lucien
Stephenville
Zaneis

TERRACE
Bethany
Canadian
Dale
Dougherty
Konawa
Norge
Teller
Vanoss

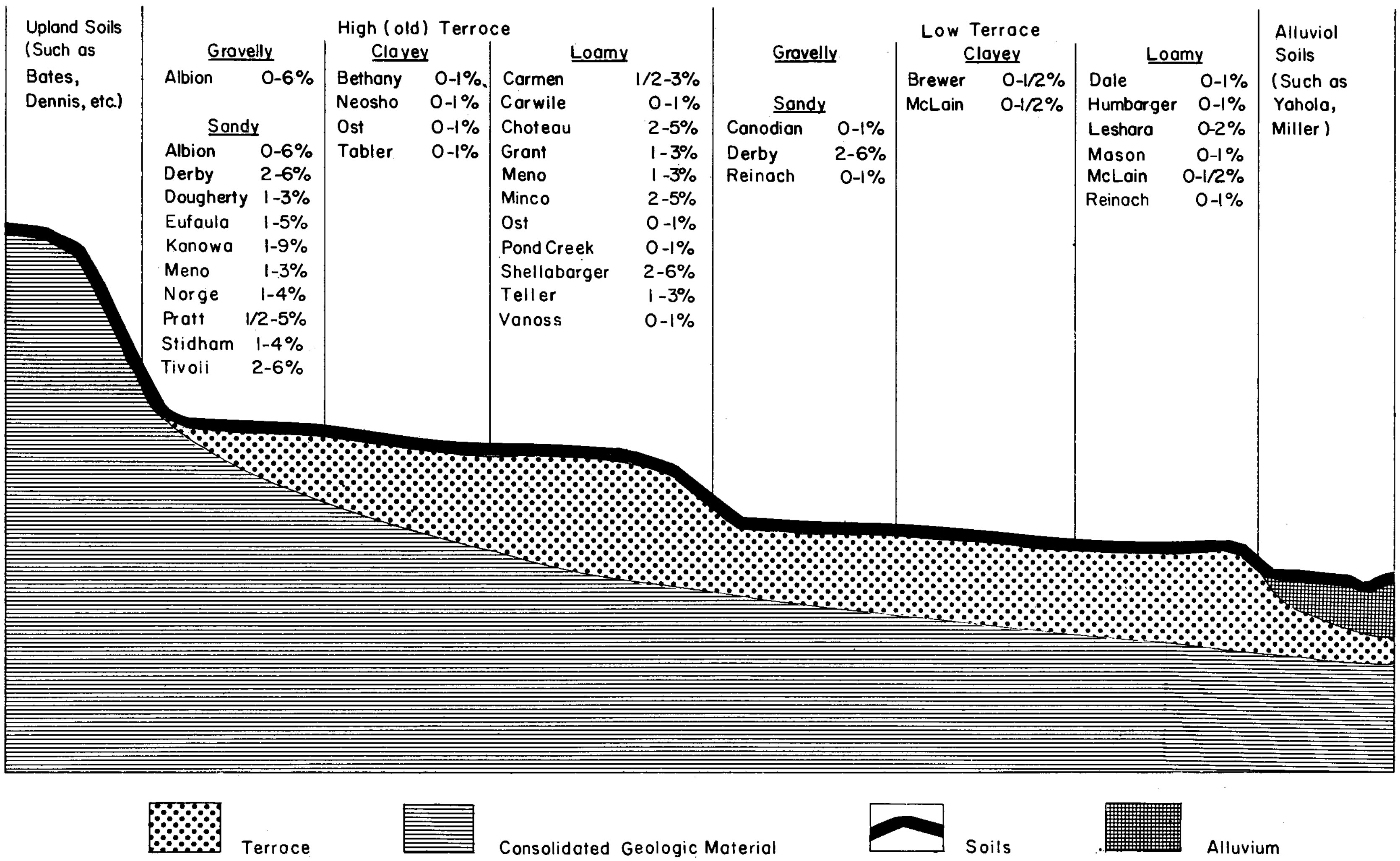
KNOWN SOIL SERIES AND TYPE OF GEOLOGIC MATERIAL ON WHICH THEY OCCUR



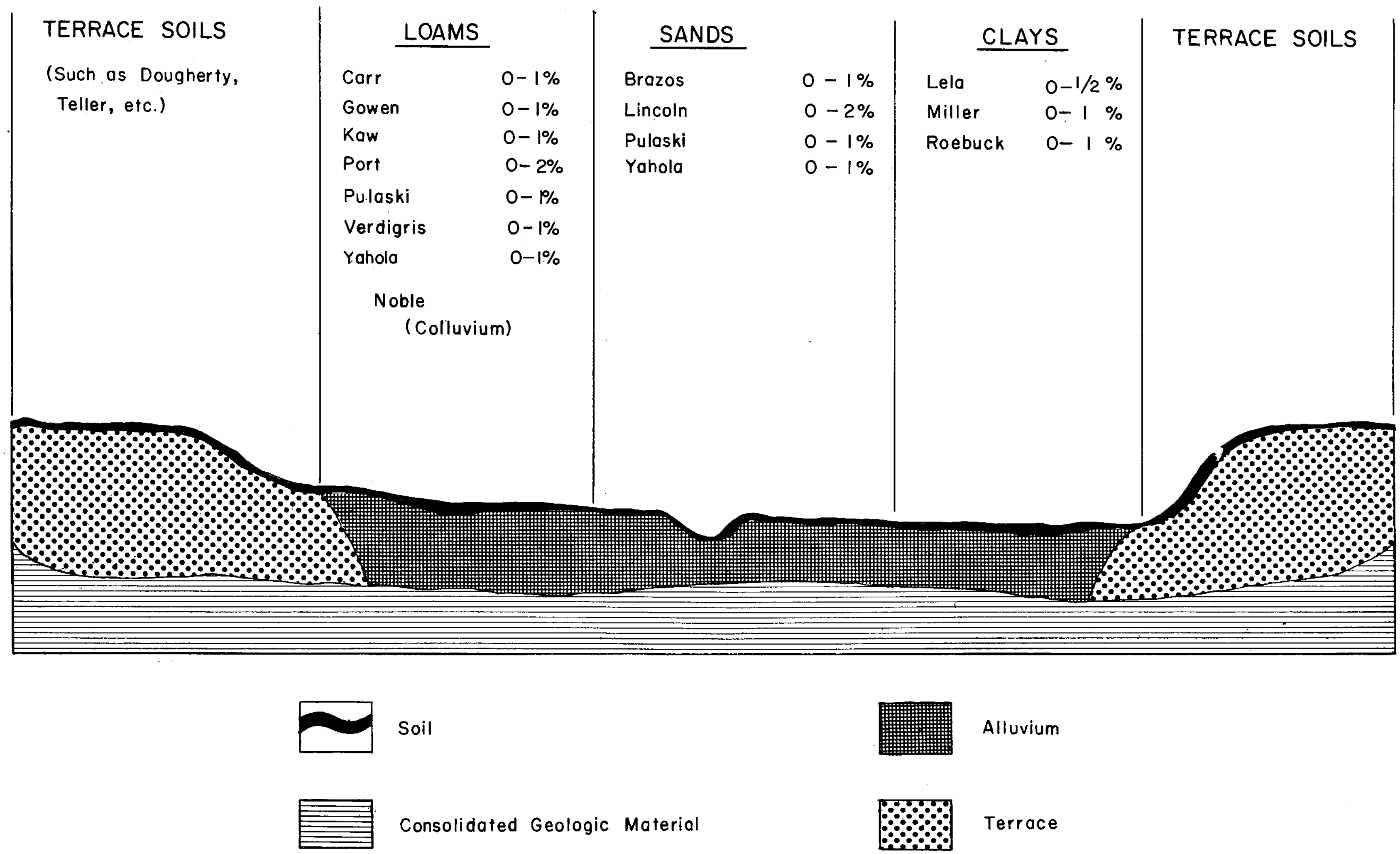
Soils-Geology-Slope (%) Relationships of Upland Soils in Division 4



Soils-Geology-Slope (%) Relationships
of
Terrace Soils
in
Division 4



Soils-Geology-Slope(%) Relationships
of
Alluvial Soils
in
Division 4



SOILS SERIES DESCRIPTIONS

The known soil series of Division Four are described on the following pages in alphabetical order. The soil series descriptions are written and published by the National Cooperative Soil Survey and U. S. Department of Agriculture. The information is written in such a manner to be used by persons familiar with soils; so for this publication, it is thought a detailed explanation is necessary.

An example description is listed below. The introductory paragraph lists the soil series broad classification name, vegetation, parent material (geologic material), the principal associated soil series, and some differences in soil series that are similar. The color code numbers are taken from the "Munsell Soil Color Charts", 1954 Edition, Munsell Color Company, Inc., Baltimore 2, Maryland, U. S. A.

EXAMPLE DESCRIPTION

Established Series

DENNIS SERIES

The Dennis series comprises deep well-drained prairie soils developed principally from noncalcareous silty or sandy Pennsylvanian "shales" within the grasslands (known as the Cherokee Prairies) in eastern Kansas, eastern Oklahoma, and western Missouri. They are deeply developed soils of about clay loam texture, which are very low in weatherable minerals and have montmorillonite dominant in the clay faction. The sola are generally 3½ to 6 feet deep and characterized by (1) gradational changes between all horizons, (2) relatively thick B_1 or AB horizons, and (3) yellowish B_2 horizons of relatively compact, blocky medium clay loam to light clay mottled with reddish-brown spots and lying (in uneroded areas) more than 16 inches below the surface. As the parent materials become more sandy, the Dennis series grades into Bates soils, which has a less clayey friable B horizon generally underlain by sandstone within 4 feet or less. With increased clay content and an abrupt A-B horizon boundary, the Dennis soils give way to the Parsons series, even though the B_2 horizon may be less yellowish and more clayey than in the latter soils. Dennis soils are more acid and slightly less dark and clayey than the Okemah series. The A horizon is less thick than in Choteau soils and lacks the light colored lower part, or A_2, characteristic of that series. The associated Lithosols are Talihina soils (on shale) and Collinsville soils (on sandstone).

Soil Profile: **Dennis silt loam--virgin**

Surface

Down

Dry color, Number is color code

A_1 0-15" **Dark grayish-brown (10YR 4/2) silt loam becoming heavy silt loam at 10 inches, very dark brown (10YR 2. 5/2) when moist; moderate medium granular structure; friable;**
Mainly used for agriculture, insignificant to highways
pH 5.5; gradual boundary.
Number system indicating acidity and alkalinity, 7 is neutral, below 7 is acid, above 7 is alkaline

B_1 15-20" **Brown (10YR 5/3) coarse clay loam, dark brown (10YR 4/3) when moist; strong coarse granular or fine subangular blocky structure; firm; pH 5.5; gradual boundary.**
Gradual change into the underlying horizon

B_2 20-40" **Yellowish-brown (10YR 5/4) fine clay loam, dark yellowish-brown (10YR 4/4) when moist; much mottled with reddish-**
Flecks or spots of different color
brown; strong medium irregular blocky structure becoming coarser and more cuboidal with depth; the peds coated with
Natural soil aggregate, insignificant to highways
Thin coating of clay on the peds
distinct continuous clay skins; very firm; some iron concretions present; pH 5.5 above, becoming 6.0 below;
Small pellets of iron oxide resembling buck
gradual boundary. *Shot, Normally hard and dark colored*

The letter designation is not always included - but is sometimes inferred.

Down

B_3 40-60" Coarsely mottled yellowish-brown, strong brown, and very pale brown fine clay loam or coarse clay; moderate coarse blocky structure; very firm; pH 6.0 to 6.5; diffuse boundary.
Difficult to locate

C 60-70"+ Coarsely mottled or banded yellowish-brown and pale brown compact fine clay loam showing obscure bedding planes that become more distinct with depth; noncalcareous; this
Refers to all geologic units with a (P) symbol
represents slightly altered Pennsylvania "shale". The beds are nonfissile and discolored by weathering to depths
Not splitting into thin layers
of more than 15 feet.

R *At some depth firm shale would be present. If the geologic material is sandstone, chert, etc. it would also be called the "R" horizon*

Range in Characteristics: Texture of A horizon ranges from silt loam to loam; of the B_2 horizon from medium clay loam to fine clay or silty clay. In uneroded areas, thickness of the A horizon ranges between about 10 and 16 inches; depth to the B_2 horizon is between about 16 and 24 inches. Thickness of the B_1 horizon ranges between 2 and 12 inches. Texture of the B_2 horizon ranges from medium clay loam to fine clay or silty clay; the color varies much in details of mottling and becomes 7.5YR hue in local places. Occasional thin layers of sandstone occur in substrata; thin lenses of limestone occur in some exceptional localities. Eroded phases are common on the stronger slopes. Except where specified moist, the colors refer to dry soil.

Topography: Undulating to rolling erosional upland. Slopes of about 1/2 to 10%, mostly 1 to 5%. Surfaces mostly convex.

Drainage and Permeability: Medium to rapid from the surface; slow or very slow internally. The ground water table remains well below the solum. Well drained.

Vegetation: Tall-grass prairie.

Use: Mostly as cropland. Principal crops are small grains, corn, alfalfa, some cotton in the southernmost areas. Moderately to highly productive where uneroded and well managed.

Distribution: Very extensive in the shale prairies of eastern Oklahoma, eastern Kansas, Western Missouri, and some in Arkansas.

Type Location: Wagoner County, Oklahoma; 3½ miles NW of Wagoner; 600 feet east and 250 feet north of southwest corner of Section 29, T18N, R18E.

Series Established: Verdi-Grand SCD, Wagoner County, Oklahoma, 1941. The series name is from a village in Labette County, Kansas.

Remarks: Relatively complete analyses are available from three relatively typical profiles (53-OK-59-37, 53-OK-73-20, and 53-OK-73-23) from Pawnee and Wagoner Counties, Oklahoma.

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USA

Rev. EHT

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ALBION SERIES

The Albion series comprises Reddish-Prairie soils having Bt horizons of light sandy clay loam or heavy sandy loam and developed from moderately sandy alluvium under grass vegetation. The solum is truncated below by very sandy or gravelly and sandy sediments, which may be "Plains outwash." Commonly associated soils are the Shellabarger, Farnum, Pratt, and Naron series. Shellabarger soils have less sandy B horizons of clay loam or heavy sandy clay loam texture. Farnum soils are less sandy and higher in clay in the solum. Pratt soils have less well expressed B horizons that are light sandy loam in texture and thus lower in clay. The Naron soils are less red, being of 10YR hue, and have appreciably thicker solums and B2 horizons as well as less coarse textured C horizons. The Albion series occurs in a sub-humid region, has fairly wide distribution, and is fairly extensive.

Soil Profile: Albion sandy loam

A1 0-12" Dark brown (7.5YR 4/2) sandy loam, dark brown (7.5YR 3/2) moist; weak fine granular structure; slightly hard, very friable; few fine gravel; medium acid; gradual boundary. 8 to 16 inches thick.

B2t 12-30" Brown (7.5YR 4/4) light sandy clay loam; dark brown (7.5YR 3/4) moist; weak coarse subangular blocky and weak coarse prismatic structure; hard, friable; slightly acid; gradual boundary. 10 to 25 inches thick.

IIC 30-40" Light brown (7.5YR 6/3) coarse sand without fines; brown (7.5YR 5/3) moist; loose; porous; noncalcareous and about neutral.

Range in Characteristics: The principal type is sandy loam. The A horizon ranges in dry color from dark brown through brown and dark grayish brown. The B horizon ranges in color from brown through reddish brown dry and from dark brown through strong brown moist. The texture range is heavy sandy loam to sandy clay loam, inclusive, with about 15 to 25 percent clay. Depth to loose sand or to sand and gravel ranges from about 20 to 40 inches. Colors given are for dry conditions unless otherwise stated.

Topography: Level or moderately sloping, convex or plane surfaces in undulating or gently rolling upland. The surface gradient is very largely between 0 and 6 percent but ranges up to about 12 percent on inextensive short slopes.

Drainage and Permeability: Well drained with little surface runoff, permeable subsoil, rapidly permeable porous substrate, and ground water table remaining more than 20 feet below the surface.

Vegetation: Originally prairie dominated by little bluestem but including big bluestem and other grasses.

Use: Mostly in cultivation and devoted to winter wheat and sorghums.
Distribution: South-central Kansas, southwestern Oklahoma, and southcentral Nebraska. Total extent is of the order of one-fourth million acres.

Type Location: Reno County, Kansas; 200 ft. east and 150 ft. south of the north quarter-corner of Sec. 20, T25S, R8W. (About 3 mis. SW of Arlington).

Series Established: Reno County, Kansas, 1911. (Name probably is from the village in Harper County, Kansas.)

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BATES SERIES

The Bates series includes dark-colored friable Prairie soils of the transition zone between the Prairie and Reddish-Prairie soils zones, developed principally in thinbedded sandstones with interbedded sandy and silty shales constituting a minor proportion of the formation. These soils differ primarily from those of the Dennis series in having somewhat coarser-textured subsoils and parent materials. Although in most instances the Bates soils are somewhat shallower to bedrock, they are differentiated from the Dennis soils primarily on the differences in the character of the subsoil. The associated Collinsville soils are Lithosols of the same catena. Fitzhugh soils are similar except that they have redder subsoils and are considered to be Reddish Prairie soils. Chickasha soils are similar except that they are developed on sandy materials of the Red Beds. The principal types now recognized are very fine sandy loam, loam, and fine sandy loam.

			Range in thickness
1. Soil Profile (Bates loam):			
1. A_1	0-10"	Dark-brown (dry) to very dark brown (moist) 1/ friable loam; crumb structure; medium to slightly acid.	8-12"
2. B_1	10-22"	Pale-brown to light yellowish-brown loam or sandy clay loam with mottles of strong brown and yellowish gray; medium to slightly acid.	10-15"
3. B_2	22-30"	Light brownish-gray friable sandy clay loam or light clay loam mottled with light yellowish brown, noncalcareous.	6-30"
4. C_1	30" +	Interbedded yellowish-brown and yellowish-gray rotten sandstone and somewhat sandy shale with occasional thin strata of silt-stone; noncalcareous.	

II. Range in Characteristics: Chiefly minor variations of depth, color and texture; normal depth to layer 4 is 20 to 40 inches; in shallow phases all horizons are thinned, depth of solum is less than 20 inches, and horizon 3 is absent locally.

III. Topography: Undulating to slightly rolling uplands. Gradients commonly range from 2 to 6 percent.

IV. Drainage: Surface runoff is medium to high; permeability, moderate.

V. Vegetation: Prairie grasses, mainly big and little bluestems.

VI. Use: Mostly for growing corn, wheat, and other small grains, sorghums, and cotton. A small proportion of the soils is in native pasture.

VII. Distributed: Western Missouri and eastern Oklahoma and Kansas. Small areas have been mapped in southwestern Wisconsin.
Type location: Labette County, Kansas
Series established: Bates County, Missouri, 1908.

BETHANY SERIES

The Bethany series comprises Reddish Prairie soils of central Oklahoma and other similar grasslands that are closely related to Kirkland and Calumet but differ in having granular permeable A and upper B horizons more than 14 inches deep over dense very slowly permeable clay. They are developed in smooth well-drained areas of upland or high terrace and have substrata of calcareous or alkaline usually reddish clays, silts, or shales. Minco, Vanoss, Norge, and other series developed in aeolian or alluvial mantles are common associates.

Soil Profile: Bethany silt loam

A1	0-14"	Dark grayish brown (10YR 4/2; 2½/2, moist) silt loam; moderate to strong medium granular; not crusty; friable; slightly acid; grades to next horizon. 10 to 18 inches thick.
B_1	14-18"	Brown (10YR 4/3; 3/2½, moist) silty clay loam; strong coarse granular; no gray film evident, firm; slightly acid to neutral; grades to horizon below. 4 to 8 inches thick.
B_2	18-30"	Brown (10YR 5/3; 3/2, moist) clay; very firm and compact; weakly blocky, the exteriors of the blocks being slightly varnished; extremely hard when dry; neutral to mildly alkaline; grades to horizon below. 10 to 15 inches thick.
B_3	30-54"	Brown (10YR 5/4; 4/3, moist) clay; very firm and compact; noncalcareous but contains a few (2%) small semi-indurated concretions of $CaCO_3$; alkaline. 15 to 30 inches thick.
C_1	54-70"	Red (3YR 5/6) clay mottled with 20% of light brownish gray (10YR or 2.5Y 6/2); slightly less compact than 30-54" layer; grades to horizon below. 10 to 20 inches thick.
C	70-90"	Red (2.5YR 5/6; 4/6, moist) silty clay loam; firm to friable; distinctly less compact than 30-54" layer; noncalcareous; pH 8.5; contains a few ferro-manganese concretions -- no conclusive evidence whether this is alluvium, loess, or residium.

Range in Characteristics: The A horizon ranges from dark grayish brown to brown and from slightly acid to neutral; depth to compact very slowly permeable clay ranges from 14 to 30 inches but generally is less than 20.

Topography: Nearly level uplandor high terrace; gradients dominantly less than 1 percent.

Drainage: Slow from the surface and internally; favorable for alfalfa and other field crops.

Vegetation: Prairie grasses, mainly bluestems.

Use: Almost entirely in cultivation and devoted mainly to wheat, cotton, corn, sorghums, and alfalfa; fertile and productive.

Distribution: Reddish Prairie soil zone; central Oklahoma.
Type location: Oklahoma County, Oklahoma (½ mile north of Wheatland)
Series established: Cleveland County, Oklahoma, 1947.

Remarks: Prior to establishment of the Bethany series these soils were classified as Kirkland or Calumet. Colors are described with provisional Soil Survey Color names (1947) and unless otherwise stated refer to dry soil.

EHT-HO 2/8/47

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ARA - U. S. Department of Agriculture

BONHAM SERIES

The Bonham series includes well drained dark granular Reddish Prairie soils developed on slightly calcareous clays and sandy clays in the warm humid region. The series is associated with the Crockett and Wilson series but differs from them in having granular more friable upper subsoils.

Soil Profile: Bonham clay loam

0-8" Dark grayish brown (10YR 3/2) clay loam. (10YR 2/2 moist); medium granular structure, friable; slightly acid. 6 to 10 inches thick.

8-20" Brown (10YR 5/2) clay or silty clay, brown (10YR 3/3) moist; slightly mottled with reddish and grayish brown; strong medium-granular; friable; medium to strongly acid; grades into layer below. 10 to 14 inches thick.

20-40" Mottled reddish brown and yellowish brown clay; medium blocky structure, very firm; stiff; strongly acid. 15 to 25 inches thick.

40-70" Pale brown mottled with reddish brown clay, strongly acid above, grading to neutral below; contains small black concretions. 25 to 50 inches thick.

70" + Parent material of pale yellow calcareous clay.

Range in Characteristics: Soil types thus far encountered are clay loam and silt loam. Basic color of horizon 2 ranges from brown to reddish brown. In some small areas near timbered lands there is more sandy material in some of the layers and an encroachment of trees. Colors refer to dry soil, unless otherwise stated.

Topography: Nearly level to gently rolling erosional upland; gradients of 1 to 3 percent are strongly dominant but slope phases occur.

Drainage: Surface drainage is slow, but water does not stand; internal drainage is moderate to slow.

Vegetation: Prairie grasses - largely coarse bunch grasses.

Use: Largely in cultivation, and quite productive. Cotton, corn, sorghums, and oats are the principal crops; alfalfa thrives.

Distribution: Prairies of northeastern Texas and possibly small prairies of timberlands farther east.

Type Location: Fannin County, Texas, 1938.

Series Established: Fannin County, Texas, 1938.

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Established Series

BRAZOS SERIES

The Brazos series is of youthful Alluvial soils weakly developed in stratified, somewhat reddish calcareous alluvium of such streams as the Brazos, Red, and Canadian Rivers of Texas and Oklahoma. These soils occur mainly in the zone of Reddish Prairie soils on low youthful terraces or high rarely-flooded bottoms of streams that drain grasslands underlain by red beds. They are closely related to Reinach soils but have more sandy loose subsoils. The surface soil is more darkened and more thoroughly leached of free carbonates than in the Lincoln and Yahola series.

Soil Profile: Brazos silt loam

A_1 0-15" Brown (7.5YR 4/3; 3/3, moist) silt loam; very friable; moderate medium granular; neutral. 12 to 25 inches thick.

C 15-50"+ Light reddish-brown (5YR 6/4; 5/4, moist) calcareous, loose loamy fine sand stratified with thin seams of silt and clay.

Range in Characteristics: Color of surface soil ranges from brown to reddish-brown (hues 5YR and 7.5YR; values 4 and 5; chromas 2 to 4) being least dark in the sandiest types; reaction of surface soil ranges from calcareous to neutral; texture of subsoil ranges from sand to loam, very fine sand.

Topography: Level and nearly level areas, mostly of convex surface, on low terraces and high bottoms, mostly along major streams.

Drainage: Slow from the surface; rapid internally; inundated rarely or at intervals averaging more than 10 years.

Vegetation: Flood-plain forest generally with considerable ground cover of coarse grasses.

Use: Largely cropland or former cropland now retired to pasture; droughty and only moderately productive owing to the very sandy subsoil of low waterholding capacity; cropland on the more sandy types is susceptible to soil blowing.

Distribution: Low terraces and high bottoms along the Red, Brazos, Canadian, and like streams in Texas and Oklahoma; mainly in the zone of Reddish Prairie Soils; relatively inextensive.

Type Location: McLennan County, Texas, in Brazos bottoms 7 miles north of Waco.

Series Established: McLennan County, Texas, 1947.

Remarks: Prior to 1947, these soils were included in the Reinach series. The series name is taken from the Brazos River. Colors are described with Provisional Soil Survey Color names (1947) and unless stated otherwise, refer to dry soil.

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National Cooperative Soil Survey
USA

Established Series

BREWER SERIES

The Brewer series consists of slowly-drained, weakly-illuviated Prairie soils (Brunizems) developed in reddish, calcareous, moderately clayey sediments under tall grass vegetation and temperate, moist-subhumid, continental climate. The series occurs on undissected alluvial terraces, recent to Late Pleistocene in age, along streams that drain subhumid plains on Red Beds. The profile is comparatively youthful for the regional environment--darker, more granular, and less illuviated than prevails on nearby smooth but freely drained erosional upland. The Brewer series differs from Irving soils in having darker and less grayish (lower value, higher chroma) A and B horizons, more granular and less crusty A horizon, less textural contrast and much more gradational change between the A and B horizons, less compact or blocky B horizon, and generally more reddish substrata. The solum is darker; is darkened to greater depth; and has a slightly coarser, less blocky, and less compact B_2 horizon than the Bethany series, which occurs on older surfaces. The profile is more clayey, is less deeply leached of bases, and has more evident horizonation than the Lonoke series, which occurs under higher rainfall. Brewer soils have more of a textural profile, are darker in the A_1 horizon, are darkened to greater depths, and are deeper to calcareous material and to reddish colors than McLain soils. Commonly found in immediate association with Brewer soils are the Vanoss, Teller, Reinach, and Port series. The Brewer series is of moderate extent and agricultural importance.

Soil Profile: Brewer clay loam

A_1 0-12" Very dark grayish-brown (10YR 3/2) silty clay loam, very dark brown (10YR 2/2) when moist; moderate to strong medium granular structure; friable; medium acid; (pH 6.0); gradual boundary.

B_{21} 12-30" Very dark grayish-brown (10YR 3/2) heavy silty clay loam, very dark brown (10YR 2/2) when moist; strong subangular blocky structure, fine in the upper part gradually coarsening to medium size in the lower half; firm; peds have lustrous exteriors and probable thin, continuous, clay films; probably slowly permeable; pores and open rootlet channels are moderately numerous; slightly acid in upper part becoming neutral at about 24 inches; gradual boundary.

B_{22} 30-50" Dark brown (7.5YR 4/2) heavy silty clay loam, very dark grayish brown (10YR 3/2) when moist; moderate coarse subangular blocky structure; probably thin clay films; firm; moderately alkaline; (pH about 8); gradual boundary.

B_3 50-80" Reddish-brown (5YR 4/3) heavy silty clay loam; dark reddish brown (5YR 3/3) when moist; weak coarse subangular blocky structure; firm; moderately alkaline; (pH about 8); gradual boundary.

C 80-90"+ Reddish-brown (5YR 4/4) heavy silty clay loam, dark reddish brown (5YR 3/4) when moist; firm; contains fine concretions of $CaCO_3$ but the fine earth is mostly noncalcareous.

Range in Characteristics: Texture of the A horizon is mostly silty clay loam but in many places it is clay loam, in some others, it is silt loam or loam, and probably in a few places, it is sandy loam. The plow layer of cultivated areas is generally weakly granular and dark grayish-brown. The A_1 horizon below tillage has color values of 2.5 to 4, when moist, chromas of 1.5 to 2.5 and hues of 7.5YR to 10YR. Texture of the B_2 horizon ranges from heavy clay loam to silty clay (from about 33 to 45% clay). Depth to material redder than 7.5YR hue ranges between 30 and 75 inches; to color less dark than a value of 5 or moist value of 3.5, between about 24 and 70 inches; to the uppermost lime concretions, between about 24 and 100 inches. Locally, mostly in slightly depressional sites, some mottling with grayer and browner shades occurs below 2 feet.

Topography: Nearly level low terraces and high flood plains. Surfaces plane to weakly concave. Surface gradient rarely more than 1/2%.

Drainage and Permeability: Slow from the surface and internally but generally adequate without artificial drainage for excellent yields of such crops as corn and alfalfa. The ground water table is generally within 20 feet. It rises to near the surface during occasional cool wet seasons or during the immediately following floods. Most areas lie above overflow from adjoining streams; some, however, are inundated as frequently as once per 5 years.

Vegetation: Tall grass prairie, probably dominantly of big bluestem, switch grass, and Indian grass with subordinate little bluestem and also with some slough grass in the more depressional areas.

Use: Very largely in cultivation, mainly to corn, alfalfa, small grains and (in the more southern areas) cotton. Of high natural fertility, very productive, and highly valued for cropland.

Distribution: South-central Kansas to east-central Texas along the Arkansas, Cimarron, Canadian, Washita, Red, and Brazos Rivers and various tributaries. Mainly in parts of eastern Oklahoma having annual precipitation of between 35 and 42 inches. The total extent is several hundred thousand acres.

Type Location: Pawnee County, Oklahoma; 200 feet east and 900 feet north of the SW corner of Section 29, T22N, R5E (1/2 mile north of Pawnee on east side of Oklahoma Highway 18 in northern margin of the valley floor along Black Bear Creek).

Series Established: Muskogee County, Oklahoma, 1913.

Remarks: As used in published soil survey based on work done prior to 1941, the Brewer series included a number of soils outside of the present range. These are chiefly the Lela, Lonoke, Irving, and McLain series. Virtually none of the Brewer clay of published surveys is included in the series as now defined. Excepting that shown as Kay clay, most of the soils classed as Kay series in published soil surveys would now be classed as Brewer soils.

The available analyses on Brewer soils include (1) mechanical analyses, pH and organic carbon in profile 51-OK-59-13, Brewer clay loam from Pawnee County, Oklahoma, and (2) like analyses on Kay and Brewer soils reported in the published soil surveys of Noble, Okfuskee, and Grant Counties, Oklahoma.

CANADIAN SERIES

The Canadian series comprises youthful brown or dark-brown soils having very friable subsoils in which the clay content is less than about 25%. These soils occur in the Reddish Chestnut and the western or drier part of the Reddish Prairie soil zones on low terraces along such streams as the Canadian River that flow through the Sandy Tertiary deposits of southern Kansas, western Oklahoma, and northwestern Texas. The Canadian soils are less reddish than the Reinach soils, have more sandy subsoils than the Tipton soils, and include little or no admixture of sediments form red beds.

I. Soil Profile (Canadian very fine sandy loam): — Range in thickness

				Range in thickness
1.	A	0-15"	Brown (10YR 4/2.5; 3/2.5 moist) sandy loam; weakly granular and crushed material is less (about 1 value) dark than uncrushed; very friable; slightly alkaline but noncalcareous.	10-18"
2.	C_1	15-25"	Pale-brown (10YR 6/3; 5/4, moist) very fine sandy loam; structureless but freely permeable; very friable; generally calcareous and never acid.	0-20"
3.	C_2	25"+	Pale-yellow or very pale brown loamy fine sand stratified with more silty and sandy layers.	

II. Range in Characteristics: Very fine sandy loam, silt loam, and loam are the principal types but small areas of nearly every other texture occur; color of surface soil ranges from grayish brown (10YR 5/2) to dark brown (10YR 3/3), the heavier types being the darkest; reaction of all layers ranges from neutral to strongly alkaline.

III. Topography: Nearly level, low stream terraces; gradient of surface is generally 1% or less.

IV. Drainage: Mostly internal, which is free to rapid; depth to water table ranges from 5 to 30 feet.

V. Vegetation: Coarse bunch grasses, mainly little and big bluestem and Indian grass.

VI. Use: Almost entirely in cultivation and devoted to general farm crops, mainly cotton, corn, sorghums, wheat, oats, and alfalfa; fertile and moderately to highly productive.

VII. Distribution: Central and western Oklahoma, northwestern Texas, and southwestern Kansas; moderately extensive.

Type location: Canadian County, Oklahoma.

Series established; Roger Mills County, Oklahoma, 1914.

VIII. Remarks: Color terms used are Provisional Soil Survey color names based on Munsell Color Charts and refer to dry soil.

CARMEN SERIES

The Carmen series compresses well-drained brown calcareous Intrazonal soils occurring within the eastern part of the Reddish Chestnut soils zone in the Osage Plains of western Oklahoma. The parent material is strongly calcareous old alluvium, Pleistocene or late Tertiary in age, in which calcareous carbonage appears to have been precipitated from ground water prior to development of the present soil. Carmen soils are much like Mansker but occur in more eastern somewhat more humid areas, are slightly browner and slightly deeper, and generally contains a few hard concretion of $CaCO_3$ in all horizons. The principal associated series are Pratt and Carwile.

Soil Profile: (Carmen loam)

A	0-10"	Brown (7.5YR 4/2; 3/3, moist) loam; moderate medium granular; friable; contains a few hard concretions of $CaCO_3$; calcareous. 5 to 12 inches thick.
B	10-20"	Brown (7.5YR 5/4; 4/4, moist) clay loam; strong medium granular; friable; contains a few hard concretions of $CaCO_3$; slightly less dark (light brown, 7.5YR 6/4) in the lower half; strongly calcareous. 12 to 20 inches thick.
C_c	20-40"	Light reddish brown (7.5YR 6/4; 5/6, moist) clay loam containing some 20% of soft concretions of $CaCO_3$; very strongly calcareous. 12 to 50 inches thick.
C	40-60"	Similar to horizon 3 except for fewer concretions of $CaCO_3$.

Range in Characteristics: Loam, fine sandy loam, and clay loam are the principal or only types; surface soil ranges from brown to grayish-brown (hues 7.5YR to 10YR) in color and locally is noncalcareous; texture of horizons 2 and 4 ranges from loam to clay loam; content of $CaCO_3$ in horizon 3 ranges from about 10 to 50%; most areas are underlain by red beds within 10 or 20 feet of the surface and where these are shallow, horizons 3 and 4 are distinctly reddish.

Topography: Nearly level to gently undulating erosional upland with gradients generally between 1/2 and 3 percent.

Drainage: Free from the surface and also internally except where inhibited by a shallow water table in a few local areas where the soils merge with those of the Carwile series.

Vegetation: Tall grasses, mainly bluestems.

Use: Largely cultivated and devoted mainly to wheat and lesser acreages of sorghums; moderately productive.

Distribution: Western Oklahoma in eastern edge of the Reddish Chestnut soil zone.

Remarks: Color terms used are provisional Soil Survey color names (1946) and refer to dry soil.

Type location: Alfalfa County, Oklahoma, 2 miles SE of Carmen.

Series established: Alfalfa County, Oklahoma, 1933.

Established Series
Rev. JMA
6-10-65

CARR SERIES

The Carr series is a member of a coarse-loamy, mixed, calcareous, mesic family of Typic Udifluvents. They have light colored calcareous A horizons; they are somewhat stratified between 10 and 40 inches but the average texture is fine sandy loam.

Typifying Pedon: Carr fine sandy loam - cultivated
(Colors are for dry soil unless otherwise noted).

A_1 0-12" Light brownish-gray (10YR 6/2) fine sandy loam, dark grayish-brown (10YR 4/2) moist; weak medium granular structure; soft, very friable; calcareous; clear boundary. (3 to 18 inches thick.)

AC 12-50" Light brownish-gray (10YR 6/3) fine sandy loam, thinly stratified with more sandy and more clayey layers; grayish-brown (10YR 5/2) moist; weakly granular structure in upper part and structureless, massive below; soft, very friable; calcareous; clear boundary. (20 to 48 inches thick.)

C 50-60"+ Light gray (10YR 7/2) fine sand, permeable (10YR 6/3) moist; structureless, single grain; loose calcareous.

Type Location: Republic County, Kansas; 2060 feet east and 215 feet south of the northwest corner of section 20, T. 3 S., R. 4W., 1 mile south and 0.6 miles west of Scandia.

Range in Characteristics: Depth to free carbonates is less than 10 inches. Fine sandy loam is the dominant surface soil texture; more sandy, silty or clayey textures are less common. Color of the A1 horizon ranges from grayish-brown to pale brown; values are 4.5 to 6.5 when dry and 3 to 5 when moist, chromas are 1 to 3, and hue centers on 10YR. The upper part of the A1 horizon in some pedons has color values darker than 5.5 dry and 3.5 moist. Texture of the 10- to 40- inch control section ranges from sandy loam to light loam containing more than 15 percent of fine and coarser grades of sand and less than 15 percent clay. Thin strata of somewhat more sandy or silty material are throughout the control section in many pedons. In some pedons faint mottles are below 20 inches and distinct mottles below 30 inches.

Competing Series and their Differentiae: The Las Animas and Wann series have similar texture but they have distinct mottlings at depths of less than 24 inches and are classed in an aquic subgroup. The Cass series in a coarse-loamy family and one Eudora series in a coarse-silty family have dark colored upper horizons that qualify as mollic epipedons, and in addition they are free of carbonates in the upper part. The Humbarger series is finer in texture and has darker colored surface horizons. The Sarpy series has coarser textures in the 10- to 40-inch control section than the Carr series. The Bayard series resembles the Carr series but it has a mollic epipedon and is formed in local alluvium on fans. The Glenburg series of semiarid areas is usually dry and is classified in a subgroup and family of Ustifluvents.

Setting: The Carr soiles are formed on nearly level flood plains of through flowing streams in the Central Great Plains. The parent alluvium is light colored, calcareous, and moderately sandy, and is derived mainly from sedimentary rocks. The climate is subhumid. Mean annual precipitation is 20 to 35 inches, and about 70 percent falls during the growing season. The mean annual air temperature at the type location is about 54°F.

Principal Associated Soils: The Humbarger and Sarpy soils are on flood plains adjacent to Carr soils. Cass and Eudora soils are on adjoining slightly higher levels; Wann and Leshara soils are on the wetter parts of the flood plains.

Drainage and Permeability: Well drained to moderately well drained. Runoff is slow and internal drainage is medium to rapid. These soils are flooded occasionally. The water table remains below 6 feet except for short periods during and after periods of high stream flow.

Use and Vegetation: Mostly in cultivation. Native vegetation was tall prairie grasses except for trees bordering the stream channels.

Distribution and Extent: Kansas, Nebraska, and possibly other states of the central Great Plains. The series is of small extent, but locally it is important to agriculture.

Series Established: Washington County, Nebraska, 1961.

Remarks: This series was formerly classed in the Alluvial great soil group.

National Cooperative Soil Survey
USA

Established Series

Draft - Subject to
Review and Approval

CARWILE SERIES

The Carwile series compreses moderately dark Planosols with subsoils of mottled compact sandy clay developed in small depressions. They occur in association with sandy Reddish Chestnut and Reddish Prairie soils of such series as Pratt and Polo, mainly in western and central Oklahoma. The parent materials consist of Aeolian and alluvial sands and sandy clays ranging in age from late Tertiary to early Recent.

I. Soil Profile: (Carwile find sandy loam)

1. A 0-7" Dark grayish-brown fine sandy loam; weakly granular; friable; noncalcareous. 5 to 12 inches thick.

2. B_1 8-13" Dark grayish-brown sandy clay loam slightly mottled with brown; weakly blocky; firm when moist, very hard when dry. 1 to 10 inches thick.

3. B_2 15-24" Mottled gray or grayish-brown and yellowish-brown sandy clay; weak coarse blocky; very firm and slowly permeable; neutral to alkaline. 8 to 20 inches thick.

4. B_c 24-40" Mottled gray and yellowish-brown sandy clay; firm to very firm; calcareous and contains concretions of $CaCO_3$. 5 to 20 inches thick.

5. C 40"+ Yellowish friable sandy earths containing less clay than horizons 3 and 4, usually calcareous.

II. Range in Characteristics: Types range from loamy fine sand to clay loam; shades and degree of mottling in the B horizons vary widely, layer 2 being unmottled in places; all layers are noncalcareous in some of the more sandy areas; color of topsoil ranges from dark grayish brown to grayish brown and brown; saline phases occur.

III. Topography: Level or depressed areas in upland that is generally wind modified.

IV. Drainage: Water collects; slow to very slow internally; the water table is generally within 10 feet and rises to near or at the surface in rainy seasons; the areas generally can be farmed without artificial drainage but planting is greatly delayed and yields are lowered.

V. Vegetation: Prairie grasses.

VI. Utilization: Cropland and native pasture; small grains and sorghums are the principal crops.

VII. Distribution: Western and central Oklahoma; possibly also in Kansas.

VIII. Remarks: Colors are described with approximate Provisional Soil Survey color names and refer to dry soil.

Type location: Alfalfa County, Oklahoma; SE¼, Sec. 11, T24N, R12W.

Series established: Alfalfa County, Oklahoma, 1933.

CHICKASHA SERIES

The Chickasha series comprises well-drained Reddish Prairie Soils with brown or yellowish-brown friable subsoils developed on silty or sandy red beds. The catenal associates are Grant, which is of normal soils with reddish subsoils; Nash, which is of somewhat youthful medium-depth soils; and Quinlan, which is of Lithosols. Chickasha is of the same family as Bates, Choctaw, and Vanoss.

I. Soil Profile (Chickasha fine sandy loam):

				Range in Thickness
1.	A	0-10"	Dark grayish-brown (10YR 3/2) fine sandy loam; weakly granular; friable; slightly acid.	7-12"
2.	B_1	10-15"	Dark grayish-brown (10YR 3/2) sandy clay loam; moderately granular; friable; slightly acid.	5-10"
3.	B_2	16-24"	Brown (10YR 4/3) sandy clay loam; friable; slightly acid.	5-15"
4.	B_3	24-45"	Yellowish-brown (10YR 5/4) sandy clay loam coarsely mottled with yellowish-red; friable; slightly acid.	15-30"
5.	C	45" +	Reddish-brown sandy clay loam comprising partly weathered sandy red beds. This grades into weakly consolidated red sandy shale or pack-sand of neutral to weakly calcareous reaction at depths ranging 4 and 7 feet	

II. Range in Characteristics: Types range from fine sandy loam to silt loam; color of A horizon ranges from dark grayish brown to brown, and of horizon 3, from brown to dark yellowish brown; balck ferro-magnesian concretions are common below 24 inches.

III. Topography: Smooth erosional upland; gradients of 0 to 4%, dominantly ½ to 2.

IV. Drainage: Moderate to slow from the surface; free internally; very favorable for crops.

V. Vegetations: Prairie grasses, principally little bluestem; some marginal areas have scattered post oak.

VI. Use: Very largely in cultivation and devoted mainly to cotton, corn, sorghums, and small grains; productive.

VII. Distribution: Western part of the Reddish Prairie soil zone; mainly in central Oklahoma; extensive

Type location: Grady County, Oklahoma; SE¼, Sec. 17, T. 6N., R. 7W.

Series established: Grady County, Oklahoma (Little Washita Project), 1939.

Chickasha Series p. 2

VIII. Remarks: The series name is from Chickasha, Oklahoma

Colors are described with provisional Soil Survey color names (1946) and refer to dry soil.

EGF:MB
4-5-39
Rev. EHT
9-7-46

Division of Soil Survey
Bureau of Plant Industry, Soils,
and Agricultural Engineering
Agricultural Research Administration
U. S. Department of Agriculture

Established Series

CHOTEAU SERIES

The Choteau series comprises very acid and much weathered Prairie soils developed in old loess or loamy alluvium on well-drained uplands in or near northeastern Oklahoma. It is characterized by a thick A horizon that is light colored in its lower part and very gradationally underlain, at depths varying between about 15 and 35 inches, by a yellowish and much mottled though relatively permeable B horizon of moderately firm clay loam somewhat similar to that of the Dennis soils. The principal associate, developed in similar sediments, is the Taloka series which is a Planosol with a thick A horizon and a B horizon of claypan character similar to that of Parsons series. As the sediments become more sandy, the Choteau soils grade to the Dougherty and Stidham series which are Red-Yellow Podzolic soils with thin A_1 horizons. As the humidity increases, the Taloka series seemingly grades to the Muskogee soils, a Red-Yellow Podzolic soil, with a thin A_1 horizon. Mainly because of their A_2 horizon are the Choteau soils, unlike the Peck soils. The Taloka soils are more weathered and acid than the Vanoss, Teller, or Norge soils. The pale and thick A_2 horizon distinguishes the Choteau solum from those of the Dennis and Bates series.

Soil Profile: Choteau loam--virgin

A_1	0-15"	Grayish-brown (10YR 5/2.5) loam, dark brown (10YR 3/3) when moist; high in very fine sand and coarse silt; weak medium granular structure; very friable; medium acid in the upper part grading to very strongly acid below 7 inches; gradual boundary.
A_2	15-22"	Pale brown (10YR 6.5/2.5) loam, brown (10YR 5/3) when moist; faintly mottled with browner spots; almost structureless; very friable; permeated by a network of small root channels; pH about 5.0; gradual boundary.
AB	22-28"	Light yellowish-brown (10YR 6/4) heavy loam, yellowish-brown (10YR 5/4) when moist; many strong brown to reddish mottles and veins that are more ferruginous than the matrix; weak subangular blocky structure; friable, hard; pH about 5.5; diffuse boundary.
B_2	28-50"	Brownish-yellow (10YR 6/6) clay loam, yellowish-brown (10YR 5/6) when moist; many strong brown and pale yellow mottles; nearly structureless; clay skins discontinuous; (they line the pores, abundant small root channels, and random crevices, but do not outline distinct peds); firm; pH about 6.0 becoming 6.5 toward the base; diffuse boundary.
B_3	50-70"	Mottled or reticulately veined pale yellow, reddish yellow and strong brown clay loam; nearly structureless; firm; pH about 7.0; hardly distinguishable from the B_2 but has more variegated and somewhat coarser color pattern and few pores and crevices lined with clay skins; diffuse boundary.
C	70-100"	Dominantly reddish-yellow to brownish-yellow clay loam, reticulately veined with light gray or pale yellow; noncalcareous; pH 7.0 to 7.5.

Range in Characteristics: In texture, the A_1 horizon ranges from loam to silt loam and heavy fine sandy loam; in color, from grayish-brown to dark grayish-brown; and in thickness, between about 7 and 20 inches, thinning as the areas become more sandy or eroded. Color of the A_2 horizon ranges from pale brown to very pale brown and light brownish-gray. Thickness of the light-colored horizons (combined A_2 and AB horizons) ranges between about 3 and 30 inches. Texture of the B_2 horizon ranges from clay loam to silty clay loam or heavy sandy clay loam. The crushed color of the B_2 horizon is generally brownish-yellow but ranges to yellow in gradations toward the Muskogee soils and to strong brown in gradations toward Peck series; its mottling varies widely in detail but is generally pronounced, often includes yellowish-red spots, and never includes gray colors of chroma less than 1. Structure of the B horizons varies from massive to moderate medium subangular blocky. Ferruginous veins and concretions range from slight to very abundant and pronounced. Eroded phases are common on slopes of more than about 4 percent. Solonetzic transitions occur on slopes of more than about 4 percent. Solonetzic transitions occur surrounding slick spots that are occasionally intermingled on sloping areas. Except where specified moist, the colors given are for dry soil.

Topography: Undulating to rolling erosional upland--mostly high, obscure dissected alluvial terraces or plains. Surfaces generally convex. Gradients mostly between 2 and 5 percent but ranging from about 1 to 8 percent.

Drainage and Permeability: Well drained. Moderately slow to rapid from the surface; moderate or moderately slow internally. The ground water table remains below 10 feet.

Vegetation: Primarily tall grass (mostly little bluestem). Either treeless prairie or tall-grass savannah with scattered overstory of post oak and other hardwoods. In some areas not cultivated, woody vegetation has thickened since settlement and now forms a scrub forest.

Use: Mostly in cultivation to general field crops.

Distribution: Primarily in eastern Oklahoma along the Arkansas and Canadian Rivers in localities where the annual precipitation is between 37 and 45 inches. Probably some in extreme southeastern Kansas. Total extent probably is between 50,000 and 250,000 acres.

Type Location: Wagoner County, Oklahoma; 500 feet west and 1300 feet north of the southeast corner of Section 32, T17N, R18E.

Series Established: Wagoner County, Oklahoma, (Verid-Grad SCD), 1941. The series name is from a village in Mayes County, Oklahoma.

Remarks: This series as hereby revised excludes the inextensive soils having the solum of the Dennis series (without A_2 or unusually thick A horizon) developed on terraces. In many areas along the Arkansas River, the reaction profile and presence of clay skins lining pores in the A_2 evidence thickening of the A horizon by loess deposition subsequent to formation of the B horizon. Data from mechanical analyses and determination of pH and exchangeable cations are available for 2 profiles (53-OK-73-21 and -23) of Choteau loam.

EHT: 3-30-57

Established Series

CLEBURNE SERIES

Soils of the Cleburne series are upland zonal soils of the Red and Yellow Podzolic region. They have developed on residual material from acid sandstone. Cleburne soils are associated with soils of the Linker, Hanceville, Hector, and Muskingum series. Hector and Muskingum soils differ from Cleburne in being shallow lithosols. Linker and Hanceville soils have reddish-brown or red subsoils. Subsoil of the Cleburne series is pale brown to yellowish-brown. Cleburne soils are moderately extensive and are important agricultural soils.

Soil Profile: Cleburne fine sandy loam

A_2	0-6"	Brown (10YR 5/3), weak medium granular, medium acid, fine sandy loam. 6 to 12 inches thick.
A_3	6-12"	Yellowish-brown (10YR 5/8), moderate medium blocky, strongly acid, fine sandy loam. 3 to 6 inches thick.
B_3	12-30"	Yellowish-red (7.5YR 5/8), moderate medium blocky, strongly acid sandy clay loam. 15 to 30 inches thick.
C	40-50"	Gray, brown, and yellow mottled; medium large blocky; strongly acid; sandy loam up to 20 inches thick.
D		Sandstone.

Range in Characteristics: Surface soil varies from medium to strongly acid in reaction; very fine sandy loam to gravelly sandy loam and loamy sand in texture; brown to pale brown in color. Subsoil reaction ranges from medium to strongly acid in reaction; may have sandy clay layers from thin interbedded shales; color ranges from yellowish-brown to pale brown. A_3 horizon may be absent. In woodland, there is a surface layer of partially decomposed leaf litter and the upper 2 to 4 inches of topsoil will be dark from the content of organic matter.

Topography: Slopes range from gently undulating to rolling (1 to 10 percent). Usual gradient 2 to 5 percent.

Drainage: Surface drainage moderate to rapid; internal drainage moderate to rapid.

Vegetation: Pine, post oak, hickory, red oak, white oak, grape muscadine, huckleberry, and blackjack oak.

Use: Cotton, corn, orchards, truck crops, annual legumes, small grains, sericea lespedeza, pasture, and woodland.

Distribution: North and west Arkansas, eastern Oklahoma, southern Missouri, east Tennessee, north Alabama.
Type Location: Pope County, Arkansas.
Series Established: Arkansas, SCD8, Pope County, Arkansas, 1930.

Revised
ML
4-30-47

Division of Soil Survey
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COBB SERIES

The Cobb series comprises moderately deep Reddish Chestnut soils that have B horizons of clay accumulation of reddish sandy clay loam or sandy loam texture underlain by parent sandstone at depths of less than 4 feet. Developed mainly from acid or neutral reddish, medium grained sandstones, such as those of Permian age, the Cobb series has distinct or moderate textural horizonation. It has a more clayey subsoil and a lower content of very fine sand and silt than the Dill series developed from somewhat finer grained sandstone. It has a thinner solum and is formed in a shallower regolith than the closely related Miles series. It has a more sandy B horizon than do the Carey, Grant, and Zaneis series and also a less acid B horizon than the Zaneis series. The A horizon is darker, more loamy, less strongly eluviated, and less acid than in the Stephenville series and is without a light-colored lower part. The areas of occurrence have a sub-humid climate with annual precipitation between 20 and 28 inches and a Thornthwaite PE index between 30 and 50. The Cobb series is of moderate distribution and extent (around 50,000 acres) and of moderate agricultural importance.

Soil Profile: Cobb fine sandy loam

A1	0-8"	Reddish brown (5YR 4/3) fine sandy loam; dark reddish brown (5YR 3/3) moist; very weak granular structure; hard; very friable; slightly acid; gradual smooth boundary. 6 to 12 inches thick,
B2t	8-29"	Reddish brown (5YR 4/4) light sandy clay loam becoming slightly less dark but reddish brown (5YR 5/4) below 20 inches; dark reddish brown (5YR 3/4) moist; compound structure of weak coarse prismatic breaking to weak fine subangular blocky; very hard; friable; slightly acid to 20 inches, becoming neutral below; abrupt irregular boundary. 10 to 30 inches thick.
R	29-60"+	Weakly cemented noncalcareous reddish sandstone.

Range in Characteristics: The A horizon is mostly fine sandy loam but may be loamy fine sand in winnowed plow layers. Neglecting overburden and much winnowed plow layers, the dry color of the A horizon ranges from dark brown through brown and reddish brown with dry value of 3.5 through 5, moist value of 2.5 through 3.5 and dry and moist chromas of 2 through 3.5 in 7.5YR or 5YR hue. The B horizon may be heavy fine sandy loam or sandy clay loam with clay content of about 17 to 28 percent. Its dry color ranges from reddish brown to yellowish red and red with value of 3.5 through 5.5 and chroma of 4 through 6 in 5YR or 2.5YR hue. Reaction of the A and B horizons ranges from slightly acid to neutural, inclusive. Depth to sandstone ranges between about 20 and 48 inches. Coatings of segregated $CaCO_3$ coat crevices and partings in the bedrock in some areas.

Topography: Nearly level to undulating erosional upland. Surfaces convex to plane; surface gradients of 1/2 to 8 percent, mostly between 1 and 4 percent.

Drainage and Permeability: Well drained with slow to rapid runoff, moderately permeable subsoil and substrata, and no shallow water table.

Vegetation: Originally mid-grass prairie.

Distribution: Western Texas and southwestern Oklahoma. Mainly on the outcrop of the San Angelo formation in texas; mainly on the Rush Springs formation in Oklahoma.

Type Location: Foard County, Texas; 0.20 miles west and 0.30 miles north of the intersection of a county road with US Highway 70, 1.5 miles west of the court house in Crowell.

Series Established: Washita County, Oklahoma, 1935. (Name is from Cobb Creek in eastern part of county).

Rev. EHT: 1-2-63 National Cooperative Soil Survey

Reproduced by Materials Research Branch, March, 1963

Established Series

COLLINSVILLE SERIES

The Collinsville series comprises acid dark colored loamy lithosols which are very shallow over acid sandstones. Characteristically, the soils have evident A_1 horizons of fair thickness grading into stony C horizons or D horizons. Closely related soils are the Darnell and Talihina series and less closely related soils are the Bates, Dennis, Hector, and Ramsey series. Darnell soils have lighter colored and thinner A_1 horizons, having been formed under forest. Talihina soils are finer textured, being derived from shale. Bates and Dennis soils have distinct B horizons of clay accumulation and are much deeper to bedrock. Hector soils are distinctly redder in color whereas Ramsey soils are deeper and have B horizons which are faint or evident in terms of color, structure, or consistence. Collinsville soils are of moderate extent and distribution and of limited importance to agriculture.

Soils Profile: Collinsville stony fine sandy loam

A_1	0-7"	Dark grayish-brown (10YR 4/2) stony fine sandy loam, very dark grayish-brown (10YR 3/2) moist; moderate medium granular structure; slightly hard, very friable; medium acid; gradual irregular boundary. 2 to 10 inches thick.
C	7-9"	Mixture of yellowish-brown sandstone fragments and fine earth in 60:40 proportions; fine earth is brown (10YR 5/3) fine sandy loam, brown (10YR 4/3) moist; porous massive; slightly hard, very friable; medium acid; abrupt irregular boundary. 0 to 6 inches thick.
D_r	9"+	Partially weathered and somewhat fractured yellowish brown sandstone.

Range in Characteristics: Stony fine sandy loam and stony loam are most common with some bodies free of stones on the surface. Color of the A horizon ranges in value from 3 through 5 when dry, 2 through 3.5 when moist, and in chroma mostly near 2, but ranges to 3 in 10YR and 7.5YR hues. Reaction of the A horizon ranges from slightly through strongly acid. Color of the underlying sandstone may be in any of 5YR through 10YR hues with values of 4 through 6 when dry, values of 3 through 5 when moist, and chromas of 4 through 8. Color of the transitional layer between the two is intermediate between those of the A_1 and D_r horizons. Depth to partly weathered and fractured sandstone ranges from 4 to 15 inches. Unless specified moist, colors given are for dry conditions.

Topography: Rolling to hilly erosional upland. Convex surfaces of gradient mostly between 2 and 15 percent but ranging up to 35 percent.

Drainage and Permeability: Well drained with medium to rapid runoff, rapid permeability, and deep water table.

Vegetation: Prairie; mainly little bluestem.

Use: Chiefly as native range for grazing.

Distribution: Eastern Oklahoma, southeastern Kansas, and possibly northwestern Arkansas.

Type Location: Rogers County, Oklahoma; about 2 miles north and 1 1/2 miles east of Inola, Oklahoma; 125 feet east and 45 feet south of the north quarter corner of Section 27, T20N, R17E.

Series Established: Tulsa County, Oklahoma, 1935.

Rev. HTO
5-29-62
Re-mimeo. 9-62

National Cooperative Soil Survey
USA

Established Series

DALE SERIES

The Dale series comprises fertile well-drained dark youthful soils occurring in the Reddish Prairie and adjoining soil zones, mainly in east-central Oklahoma, on low terraces above overflow along the Canadian River and similar streams. The series is developed in nonreddish alkaline alluvium that is relatively high in content of plant nutrients and mostly about clay loam in texture. Dale soils are closely related to McLain but less reddish; they are darker than Canadian and Arkansas soils, and have less heavy subsoils than Brewer and Kay.

Soil Profile:		Dale silty clay loam	Range in Thickness
A_1	0-20"	Dark grayish-brown (10YR 3/2; 2/2, moist) silty clay loam; strong medium granular; friable; permeable; about neutral.	15-25"
A_3	20-30"	Brown (10YR 5/3; 4/4, moist) silty clay loam; strong medium granular; friable; neutral to alkaline.	5-25"
C	30"+	Yellowish-brown somewhat stratified alluvium averaging about clay loam in texture; becomes distinctly sandy at depths ranging from 3 to 6 feet; neutral to calcareous.	

Range in Characteristics: Color of surface soil ranges from dark grayish-brown to dark brown and grayish-brown (hues yellower than 7.5YR; values 2.5 to 4.5; chromas 1.5 to 3); horizons 1 and 2 may contain thin layers of clay or sand; decidedly sandy substrata are confined mainly to areas along through-flowing rivers, which are most extensive, and uncommon in areas on small streams; films or concretions of segregated $CaCO_3$ occur in the lower subsoil of some areas.

Topography: Level or nearly level areas on low undissected stream terraces; surfaces plane or weakly convex.

Drainage: Slow from the surface; free internally; most areas lie above the highest floods on record but some are very rarely inundated.

Vegetation: Dense hardwood forest in the more eastern areas; deciduous trees and grasses in the more western.

Use: Almost entirely in cultivation and devoted mainly to alfalfa, corn, cotton, and small grains; fertile and highly productive.

Distribution: Oklahoma and southern Kansas on low terraces mainly along the Canadian and Arkansas Rivers.

Remarks: The series name is from a village in northwestern Pottawatomie County, Oklahoma.

Type Location: Okfuskee County, Oklahoma (1/10 mile north of south quarter corner Section 32, T11N, R9E).

Series Established: Okfuskee County, Oklahoma, 1940.

Colors are described with provisional Soil Survey color names (1946) and unless stated otherwise refer to dry soil.

EGF
9-27-40
Rev. EGF 2-11-42
Rev. EHT 2-18-47

Division of Soil Survey
Bureau of Plant Industry, Soils,
and Agricultural Engineering
Agricultural Research Administration
U. S. Department of Agriculture

Established Series

DARNELL SERIES

The Darnell series comprises forested Lithosols developed on noncalcareous mostly reddish sandstones in the broad transition between the zones of Red and Yellow Podzolic and Reddish Prairie Soils. The zonal soils developed on similar materials under forest are Stephenville and Windthorst. The Darnell series is closely related to Hector, but occurs under lower rainfall and is slightly darker, less acid, and less strongly leached. The grassland analogue of Darnell is Lucien.

Soil Profile:		Darnell fine sandy loam	Range in Thickness
A_1	0-5"	Grayish-brown fine sandy loam; very weakly granular; very friable; slightly acid; grades to horizon below.	3-7"
A_2	5-12"	Light-brown light fine sandy loam structureless; very friable moist; nearly loose when dry; contains fragments of sandstone in its lower part.	6-15"
C		Yellowish-red noncalcareous sandstone.	

Range in Characteristics: Color of the surface soil ranges from grayish-brown to brown and of the A_2 from light brown to reddish-yellow or pale brown; locally there is a thin B horizon 2 to 5 inches thick of reddish-brown light loam; sandstone outcrops are common; depth to sandstone bedrock ranges from 6 to 20 inches within a distance of a few feet.

Topography: Erosional upland with gradients ranging up to about 15%.

Drainage: Rapid from the surface and internally.

Vegetation: Scrub forest of blackjack and post oak.

Use: Mainly as woodland pasture of low carrying capacity and affording forage of indifferent nutritive quality.

Distribution: Cross timbers of central Oklahoma and Texas.

Type Location: Payne County, Oklahoma.

Series Established: Payne County, Stillwater Creek Project, Oklahoma, 1937.

Remarks: Colors are approximate provisional Soil Survey colors and refer to dry soil.

EGF-MB
4-13-37
Rev. HO-EHT
1-7-47

Division of Soil Survey
Bureau of Plant Industry, Soils, and Agricultural Engineering
Agricultural Research Administration
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DENNIS SERIES

The Dennis series comprises deep well-drained Prairie soils developed principally from noncalcareous silty or sandy Pennsylvanian "shales" within the grasslands, known as the Cherokee Prairies, in eastern Kansas, eastern Oklahoma and western Missouri. They are deeply developed soils formed in sediments of about clay loam texture, which are very low in weatherable minerals and have montmorillonite dominant in the clay faction. The sola are generally 3 1/2 to 6 feet deep and characterized by (1) gradational changes between all horizons, (2) relatively thick B_1 or AB horizons, and (3) yellowish B_2 horizons of relatively compact, blocky medium clay loam to light clay mottled with reddish-brown spots and lying (in uneroded areas) more than 16 inches below the surface. As the parent materials become more sandy, the Dennis series grades into Bates soils, which has a less clayey friable B horizon generally underlain by sandstone within 4 feet or less. With increased clay content and an abrupt A-B horizon boundary, the Dennis soils give way to the Parsons series, even though the B_2 horizon may be less yellowish and more clayey than in the latter soils. Dennis soils are more acid and slightly less dark and clayey than the Okemah series. The A horizon is less thick than in Choteau soils and lacks the light colored lower part, or A_2, characteristic of that series. The associated Lithosols are Talihina soils (on shale) and Collinsville soils (on sandstone).

Soil Profile: Dennis silt loam--virgin

A_1	0-15"	Dark grayish-brown (10YR 4/2) silt loam becoming heavy silt loam at 10 inches, very dark brown (10YR 2.5/2) when moist; moderate medium granular structure; friable; pH 5.5; gradual boundary.
B_1	15-20"	Brown (10YR 5/3) coarse clay loam, dark brown (10YR 4/3) when moist; strong coarse granular or fine subangular blocky structure; firm; pH 5.5; gradual boundary.
B_2	20-40"	Yellowish-brown (10YR 5/4) fine clay loam, dark yellowish brown (10YR 4/4) when moist; much mottled with reddish brown; strong medium irregular blocky structure becoming coarser and more cuboidal with depth; the peds coated with distinct continuous clay skins; very firm; some iron concretions present; pH 5.5 above, becoming 6.0 below; gradual boundary.
B_3	40-60"	Coarsely mottled yellowish-brown, strong brown, and very pale brown fine clay loam or coarse clay; moderate coarse blocky structure; very firm; pH 6.0 to 6.5; diffuse boundary.
C	60-80"	Coarsely mottled or banded yellowish-brown and pale brown compact fine clay loam showing obscure bedding planes that become more distinct with depth; noncalcareous; this represents slightly altered Pennsylvanian "shale". The beds are nonfissile and discolored by weathering to depths of more than 15 feet.

Range in Characteristics: Texture of A horizon ranges from silt loam to loam; of the B_2 horizon from medium clay loam to fine clay or silty clay. In uneroded areas, thickness of the A horizon ranges between about 10 and 16 inches; depth to the B_2 horizon is between about 16 and 24 inches. Thickness of the B_1 horizon ranges between 2 and 12 inches. Texture of the B_2 horizon ranges from medium clay loam to fine clay or silty clay; the color varies much in details of mottling and becomes 7.5YR hue in local places. Occasional thin layers of sandstone occur in substrata; thin lenses of limestone occur in some exceptional localities. Eroded phases are common on the stronger slopes. Except where specified moist, the colors refer to dry soil.

Topography: Undulating to rolling erosional upland. Slopes of about 1/2 to 10%, mostly 1 to 5%. Surfaces mostly convex.

Drainage and Permeability: Medium to rapid from the surface; slow or very slow internally. The ground water table remains well below the solum. Well drained.

Vegetation: Tall-grass prairie.

Use: Mostly as cropland. Principal crops are small grains, corn, alfalfa, some cotton in the southernmost areas. Moderately to high productive where uneroded and well managed.

Distribution: Very extensive in the shale prairies of eastern Oklahoma, eastern Kansas and western Missouri; some in Arkansas.

Type Location: Wagoner County, Oklahoma; 3 1/2 miles NW of Wagoner; 600 feet east and 250 feet north of southwest corner of Section 29, T18N, R18E.

Series Established: Verdi-Grand SCD, Wagoner County, Oklahoma, 1941.

The series name is from a village in Labette County, Kansas.

Remarks: Relatively complete analyses are available from three relatively typical profiles (53-OK-59-37; 53-OK-73-20, and 53-OK-73-23) from Pawnee and Wagoner Counties, Oklahoma.

Rev. EHT
4-23-57
Mimeo. 1957

National Cooperative Soil Survey
USA

DERBY SERIES

The Derby series includes sandy soils of the Reddish Prairie soils zone developed largely from old unconsolidated water-laid sandy deposits which have been more of less shifted and reworked by wind. These soils have little profile development. They are the Reddish Prairie soils-zone correlatives of the Tivoli soils which occur in the Reddish Chestnut and Reddish-Brown soils zones. They differ from Valentine soils chiefly in having a noticeably reddish tinge in the solum.

1. Soil Profile: (Derby loamy fine sand)

			Range in thickness
1.	0-8"	Brown (7.5YR 4/3)/ noncalcareous loose, slightly acid loamy fine sand.	4 to 10 in.
2.	8-60"	Light-brown (7.5YR 6/4) incoherent or only slightly coherent, slightly acid, loamy fine sand. The color generally becomes slightly lighter below three feet.	Several feet thick.

II. Range in Characteristics: In some places, the reddish tinge is less pronounced and layer 2 is light yellowish brown or pale yellow.

III. Topography: Nearly level to undulating; hummocky or dune-like in places.

IV. Drainage: External drainage is good, but stream channels are poorly established as these soils rapidly absorb the rain. Internal drainage is good to excessive.

V. Vegetation: Coarse grasses and shrubs, also some scattered oak trees in places. Big bluestem is the dominant grass.

IV. Use: Chiefly for growing cotton, corn, sorghums, and sorge. Some truck crops are produces. The excessively sandy types are used mainly for pasture.

VII. Distribution: Central and central-western Oklahoma and southern Kansas.

VIII. Remarks: As originally mapped, the Derby series also included silt loam soils, with clayey but friable subsoils, developed from deeply leached loess. These soils are now called Geary series.

Type location: Grant County, Oklahoma

Series established: Wichita Area, Kansas, 1902

1/ Provisional Soil Survey color names based on Munsell color charts.

Established Series

DOUGHERTY SERIES

The Dougherty series consists of Red-Yellow Podzolic soils of high base status with a B horizon of red to yellowish-red friable sandy clay loam. Dougherty soils are developed under subhumid climate and scrub-oak forest from old (mostly Plio-Pleistocene), slightly acid to weakly alkaline, moderately sandy alluvium of streams such as the Red and Canadian Rivers, which drain subhumid areas underlain in part by red beds. The Dougherty series differs from Teller soils in being more acid and leached, and in having a distinct light colored A_2 horizon. It is very closely related to the Milam series, recognized along streams south of the Red River. It differs from soils such as the Ruston, Orangeburg, Chattahoochee, and Cahaba series, which occur under more humid environment, in being less acid and of higher base status in the B and the upper C horizons. The Dougherty series is the counterpart of the Stephenville series developed in unconsolidated terrestrial sediments. This series is of moderate extent and agricultural importance.

Soil Profile: Dougherty fine sandy loam--forested

A_1 0-5" Grayish-brown (10YR 5/2) light fine sandy loam, dark grayish-brown (10YR 4/2) when moist; very weak granular structure; very friable; slightly acid; gradual boundary. 3 to 12 inches thick.

A_2 5-14" Light brown (7.5YR 6/4) light fine sandy loam, brown (7.5YR 5/4) when moist; very weak granular structure to massive; very friable; slightly acid; gradual boundary. 7 to 12 inches thick.

B_2 14-38" Red (2.5YR 5/6) sandy clay loam, red (2.5YR 4/6) when moist; hard, friable; medium acid; diffuse boundary. 20 to 30 inches thick.

B_3 38-60" Reddish-yellow (5YR 6/8) sandy clay loam, yellowish-red (5YR 5/8) when moist; massive; friable; slightly acid. 15 to 30 inches thick.

C 60-80"+ Reddish-yellow (5YR 6/6) sandy alluvium, yellowish-red (5YR 5/6) when dry; thick strata of loamy fine sand to fine sandy loam interrupted by occasional more clayey strata; slightly acid to weakly alkaline.

Range in Characteristics: Fine sandy loam, very fine sandy loam, and loamy fine sand are the principal types. In cultivated areas, the A_p horizon is pale brown. In the loamy fine sand type, the depth to B horizon of sandy clay loam is 15 to 30 inches. The color of the B horizon ranges from red to yellowish-red and strong brown (hues of 2.5YR to 7.5YR); its texture, from sandy clay loam to heavy fine sandy loam (about 15 to 30% clay). Acidity of the A horizons ranges from slight to medium; of the B, from medium to strong. Locally, a few waterworn pebbles, generally quartzite or chert, occur throughout the solum. In many areas, the material below 3 or 5 feet is layered or mottled with light yellow. Eroded phases are common. Colors are for dry soil, except as otherwise indicated.

Topography: Undulating to nearly level upland comprising dissected old alluvial plains lying 30 to 200 feet above the present flood plains. Surfaces mostly convex with gradients between 1 and about 15% but mostly less than 3%.

Drainage and Permeability: Good. Medium to rapid from the surface; medium internally.

Vegetation: Mainly post oak, blackjack oak, hickory and elm, which form an open-canopied forest with considerable ground cover of little bluestem and other grasses.

Use: A half or more of the total area has at some time been cleared and cropped. Much former cropland has been abandoned. The principal cultivated crops are cotton, corn, sorghums, peanuts, vegetables, fruits, and improved pasture. Fertility is low, but physical characteristics are very favorable and responsiveness to management is very high. The environment is drier than favorable for forestry.

Distribution: Mainly in central and southern Oklahoma west of the 42-inch rainfall line on old terraces along the Red, Canadian, and Washita Rivers. Lesser areas occur in Texas along the Red River; a few small areas occur in eastern Kansas.

Type Location: Murray County, Oklahoma; middle of Section 18, T1N, R2E.

Series Established: Murray County, Oklahoma, 1935.

Remarks: So far as is now known, there is no appreciable difference between the Dougherty series and the previously established Milam series from Texas; however, the parent material of Dougherty contains a somewhat higher proportion of sediments from red beds. The parent alluvium, known as the Gertie formation, is generally classed as early Pleistocene.

Rev. EHT-HO
4-23-59

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USA

Established Series

DRUMMOND SERIES

The Drummond series comprises Solonetz soils developed from loamy earths of various colors and geological origin, but generally is stratified old alluvium. They have columnar B horizons of clay loam to light clay and have a fluctuating high water table. The very hard and compact B horizon and more widely fluctuating water table distinguishes them from such series as the Ovina, Elsmere, and Sweetwater soils. The Drummond series is of limited extent and agricultural importance.

Soil Profile: Drummond loam

A_1	0-7"	Grayish-brown (10YR 5/2) loam; very dark grayish-brown (10YR 3/2) moist; generally has a vesicular crust up to 1/2 inch thick grading below to porous massive; friable; hard noncalcareous; wavy boundary.
B_2	7-16"	Brown (7.5YR 4/2) clay loam; dark brown (7.5YR 3/2) moist; weak columnar structure, column faces being coated with dark brown shiny films; very firm and very compact; very hard; noncalcareous; few fine concretions of $CaCO_3$; clear boundary.
B_3	16-22"	Reddish-brown (5YR 4/4) clay loam weakly mottled with various shades of brown; dark reddish-brown (5YR 3/4) moist; massive; firm; very hard; calcareous; few fine concretions of $CaCO_3$; gradual boundary.
C	22-50"+	Reddish-brown (5YR 5/4) fine sandy loam; reddish-brown (5YR 4/4) moist; stratified with more sandy and clayey layers; massive; friable; hard; calcareous.

Range in Characteristics: The A horizon ranges in thickness from 3 to 15 inches. Its color ranges around hue 10YR with dry values of 3 to 6, moist values of 2 to 4, and chromas of 2 to 3, dry or moist. The B horizon ranges in texture from clay loam to light clay. Its structure is weak to moderate columnar, but it may be nearly massive when moist. The range of its matrix color comprises departures from the modal colors up to one color chip interval. The substrata are of varied colors and generally stratified with sandy loam to clay. White crystals (probably gypsum) are common below about 15 inches. When dry, a weakly expressed A_2 horizon up to about 4 inches thick can be recognized in undisturbed areas.

Topography: Mostly nearly level valley floors not subject to flooding. Minor areas are moderately sloping. Local irregularity of the surface comprising microrelief of 3 to 8 inches is common.

Drainage and Permeability: Generally very slow from the surface and very slow internally. Poorly to somewhat poorly (imperfectly) drained. The ground water table fluctuates between about 2 and 10 feet below the surface.

Vegetation: Originally such grasses as switchgrass, salt grass, and alkali sacaton. In areas long heavily grazed salt grass has become dominant.

Use: Mostly for production of native grass. Small areas within fields, largely of other soils, are in cultivation.

Distribution: Subhumid areas in Oklahoma, Kansas, and Texas.

Type Location: Garfield County, Oklahoma; three miles northwest of Drummond, Oklahoma; 185 feet south and 35 feet east of the northwest corner of Section 8, T21N, R8W.

Series Established: Garfield County, Oklahoma, 1935.

Rev. HTO-EHT:
7-31-61

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USA

Established Series

EUFAULA SERIES

The Eufaula series includes light-colored acid deep loose sands of the western or drier part of the zone of Red and Yellow Podzolic Soils. The series differs from Stidham and Nimrod in having no distinctly loamy subsoil, or heavier layer, to a depth of more than 3 feet. The series is related to Derby, but is developed under forest instead of grass and is lighter-colored.

Soil Profile: Eufaula fine sand		Range in Thickness
0-3"	Pale brown (10YR 6/3; 5/3, moist) fine sand; loose; slightly acid.	2-5"
3-30"	Very pale brown (10YR 8/3; 7/4, moist) fine sand; loose; medium to slightly acid.	10-30"
30-50"+	Fine sand or loamy fine sand slightly yellower (10YR 8/4; 7/4, moist) and more acid than layer 2.	

Range in Characteristics: Color of soil below the thin darkened surface layer ranges from very pale brown to pale yellow; fine sand and loamy fine sand are the principal types; most typically, loose very sandy material continues to a depth of 6 feet and more but below 3 feet some areas have a thin illuviated B horizon of strongly acid friable sandy clay loam or sandy loam, generally brownish-yellow splotched with yellowish-red and about one foot thick grading below into more sandy material.

Topography: Upland, mostly nearly level; very little on slopes of more than 5%.

Drainage: Rapid; mostly internal.

Vegetation: Deciduous scrub forest of post oak, blackjack, and some hickory.

Use: Mainly relatively unproductive pastured woodland or abandoned fields; where cultivated, the principal crops are peanuts, fruits, cotton, and corn; of low inherent fertility and susceptible to soil blowing and loss of nutrients by leaching.

Distribution: Eastern Oklahoma and Texas.

Type Location: McIntosh County, Oklahoma, Section 18, T10N, R17E.

Series Established: McIntosh County, Oklahoma, 1943.

Remarks: The soils to date correlated in this series are on high old terraces of the Canadian, Red, Brazos, and like rivers that drain the southern Great Plains. The parent materials probably were alkaline when deposited but are leached and acid to depths of more than 8 feet.
Colors are described with provisional Soil Survey color names (1946) and unless stated otherwise refer to dry soil.

WCT:EHT:EGF
6-16-44
Revised: 2-22-47
EHT

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Approved by Principal Soil Correlator
South Region TSC: 6/14/66

Established Series
Rev. WRE; GSM 6/6/66

GOWEN SERIES

The Gowen series is a member of a fine loamy, mixed, thermic family of Cumulic Hapludolls. These soils have a dark noncalcareous A horizon about 30 inches thick over a dark, stratified, loamy C horizon.

Typifying Pedon: Gowen Clay loam - pasture
(Colors refer to dry soil unless specified as moist.)

A11 0-15" Dark grayish-brown (10YR 4/2) clay loam, very dark grayish-brown (10YR 3/2) moist; moderate medim granular structure; hard, firm, sticky; contains common number of fine and medium pores; plentiful roots; neutral; clear smooth boundary. 10 to 30 inches thick.

A12 15-30" Brown (10YR 5/3) light clay loam, dark brown (10YR 3/3) moist; weak subangular blocky structure; hard, firm, sticky; contains common number of fine and medium pores and worm-casts; plentiful roots; clear smooth boundary. 0 to 25 inches thick.

C 30-60" + Dark grayish-brown (10YR 4/2) clay loam, very dark grayish-brown (10YR 3/2) moist; structureless; very hard, firm; common number of roots; contains thin strata of pale brown fine sandy loam, and lenses and thin strata of grayish-brown clay in the lower part; few very dark brown stains, apparently remnants of leaves; neutral.

Type Location: Erath County, Texas. Approximately 21 miles northwest of Stephenville; in pasture 100 feet east of road, which point is 0.2 mile south and 1.6 miles east via county road from the intersection with Texas Highway 108, this intersection being 21 miles northwest from the Erath County Courthouse in Stephenville.

Range in Characteristics: Thickness of darkened surface horizons with developed structure, at least 0.58 percent organic carbon, and moist color values of less than 3.5 ranges from 24 to about 40 inches. Dry color of the A horizon ranges from dark gray to brown, in hues of 10YR and 7.5YR; any chromas of 2 or less are not due to wetness; structure ranges from moderate to weak granular and subangular blocky. The soil is usually moist and is not dry in any part of the 10- to 40-inch control section for as long as 90 cumulative days during most years. Dry color of the C horizon ranges from dark gray to brownish-yellow in hues of 10YR and 7.5YR, and contains no mottles with chromas of 2 or less that are due to wetness. The average clay content of the 10- to 40-inch control section ranges from 18 to 35 percent clay with more than 15 percent coarser than very fine sand. The reaction of the control section varies from neutral to moderately alkaline. The soil contains from the surface downward to a depth of 40 inches less than 40 percent of any one weatherable mineral.

Competing Series and Their Differentiae: These include the Asa soils of the same subgroup. Other competitors include the Bosque, Kosse, Bunyan, Kaufman, and Frio soils. Asa soils have 10- to 40-inch control sections with less than

15 percent coarser than very fine sand. Bosque soils are calcareous throughout. Kosse soils lack an epipedon as thick as 24 inches with moist color values less than 3.5 and 0.58 percent or more of organic carbon; in addition, Kosse soils have mottles with chromas of 2 or less that are due to wetness. Bunyan soils have no epipedon with developed structure and lack moist color values of 3.5 or less, and have evident bedding planes throughout. Frio and Kaufman soils have more than 35 percent clay in the 10- to 40-inch control section.

Setting: These soils occur in the nearly level flood plains of streams that carry loamy sediments dominantly from noncalcareous soils. Flooding occurs at intervals ranging from 1 or more times per year to once about every 5 years. Mean annual air temperatures are 64° to 70° F., with 20 to 45 inches of average annual rainfall, and Thornthwaite annual P-E indices of 44 to 70.

Principal Associated Soils: The principal associated soils are the competing Bunyan, Bosque, Kosse, and Kaufman series, and to a lesser extent, the Frio series.

Drainage and Permeability: Well drained. Permeability is moderate. Surface runoff is slow to medium.

Use and Vegetation: Most areas are being farmed to peanuts, sorghums and pecan orchards. Areas that flood frequently are used mainly for bermudagrass pastures and pecan orchards. Native areas are in hardwood forest, including hackberry, elm, and pecan trees.

Distribution and Extent: This soil occurs mainly in the mixed post oak and prairie areas of central Texas, and in adjoining areas of Oklahoma. Moderate extent.

Series Established: Stephens County, Oklahoma.

Remarks: This series was classified in the Alluvial Great Soil Group in the 1938-49 Classification System.

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GRANT SERIES

The Grant series is of deep, moderately dark, granular, neutral soils with reddish-brown friable subsoils developed in parent material of reddish, calcareous, friable, silty or loamu earths rich in phosphorous and potash. These soils occupy gently sloping upland within the transition between the zones of Reddish Prairie and Reddish Chestnut Soils in or near parts of northern Oklahoma, underlain by silty and sandy red beds of the Enid (Permian) formation. The principal catenal associates are Pond Creek, which occupies level areas and is darker to greater depth, and Nash, which is redder, calcareous at shallow depth, and generally more sloping. The Grant series is browner and less red and generally somewhat more silty than Dill, which is developed in sandy red beds farther south in Oklahoma. It has more friable less clayey subsoils than Norge and Zaneis and is of higher natural fertility and less acid. The Reddish Chestnut analogue of Grant is Carey.

				Range in Thickness
I. Soil Profile (Grant silt loam):				
1.	A_1	0-10"	Brown (7.5YR 4/3; 3/3, moist) silt loam; very friable; moderate, medium granular; grades indistinctly to horizon 2; about neutral.	8-12"
2.	A_3	10-20"	Brown (7.5YR 4/3; 3/3, moist) heavy silt loam or light silty clay loam; strong medium granular; friable; grades to horizon 3; neutral.	8-12"
3.	B_2	20-30"	Reddish brown (5YR 4.5/3; 4/4, moist) light silty clay loam; friable; almost massive but porous and permeable; neutral.	8-12"
4.	B_3	30-48"	Yellowish red (5YR 5/6; 4/6, moist) light silty clay loam; friable; neutral to mildly alkaline but noncalcareous.	12-40"
5.	C	48-72"+	Yellowish red very friable calcareous silt loam or light silty clay loam; contains a few tilms or concretions of segregated lime carbonate.	

II. Range in Characteristics: Types range from very fine sandy loam to silt loam; horizons 3 and 4 range from loam and silt loam to silty clay loam and generally are from one-half to one textural grade heavier than the surface soil; depth to reddish-brown material ranges from 12 to 24 inches, and to calcareous, from 3 to 6 feet; generally the substrata is unconsolidated and free of grit to a depth of more than 6 feet but red beds of Permian age or old alluvium containing a few waterworn pebbles may occur at any depth below 3 feet; darkened or heavier layers representing horizons of buried soils occur below 3 feet in some areas.

III. Topography: Very gently to moderately sloping erosional upland; surfaces convex to plane; gradients mostly from 1 to 4%.

IV. Drainage: Free from the surface and internally.

V. Vegetation: Originally of tall prairie grasses.

VI. Use: Practically all in cultivation, very largely to winter wheat; very fertile, productive, and highly valued.

VII. Distribution: Northwest-central Oklahoma and south-central Kansas; extensive within these localities and occupies broad areas extending over several square miles.

Type location: Grant County, Oklahoma; SE quarter section 4, T 25N, R. 6W.

Series established: Grant County, Oklahoma, 1931.

VIII. Remarks: These are submature soils with weak textural profiles developed for the most part in deposits younger than middle Pleistocene. They are generally classed as Reddish Prairie Soils but are less acid than typical of that group; they lack the distinct carbonate zone characteristic of Reddish Chestnut Soils. In undisturbed areas, the content of organic matter generally is between 2.5 and 4.0% in the upper 6 inches, and about 1.5% in the second foot. The content of readily available phosphorous is about the same in all layers, generally exceeds 50 parts per million ranging up to as much as 300, and tends to decrease to the east. Most areas are developed in what is now believed to be a late Pleistocene mantle of loess that originated largely in silty red beds of the Permian, similar to those that underlie the soils at depths ranging from 3 to 30 feet; the range of the series, however, includes soils developed either in loess or residuum or alluvium.

Colors are described with Provisional Soil Survey Color Names (1947) and unless stated otherwise refer to dry soil.

EGF-MB
2-9-40
Rev. EHT
9-8-47

Division of Soil Survey
Bureau of Plant Industry, Soils,
and Agricultural Engineering
Agricultural Research Administration
U. S. Department of Agriculture

HUMBARGER SERIES

The Humbarger soils are moderately dark, well drained, calcareous chernozemic Alluvial soils that have subsoils of silty clay loam to heavy loam. They occur in flood plains of central Kansas and similar areas elsewhere within the region of Chernozem soils, in the western part of the Prairie soil zone, and perhaps in part of the Chestnut soil zone. They have developed under a tall grass vegetation in subhumid to semiarid climates from alluvium washed from soils underlain by unconsolidated nonreddish sediments high in weatherable minerals. Humbarger soils differ from the Detroit, Muir, and Dale series in having a less dark and distinct A_1 and in being calcareous to the surface and more stratified. They occur in floodplains where sedimentation is active. The Humbarger series lacks the shallow water table and subsoil mottling characteristic of Sears soils. Other series morphologically similar to Humbarger soils but in alluvium from other sources include Frio, Catalpa, and Norwood soils. The New Cambria series, having a fine textured subsoil, is the counterpart of the Humbarger series.

Soil Profile: Humbarger clay loam

A_1	0-18"	Grayish brown (10YR 4.5/2) clay loam, very dark grayish brown (10YR 3/2) when moist; moderate medium granular structure; many worm casts, open channels and pores; moderately calcareous; gradual boundary.
AC	18-30"	Grayish brown (10YR 5/2) clay loam, dark or very dark grayish brown (10YR 3.5/2) when moist; weak subangular blocky structure; weakly stratified with slightly less clayey layers; a few obscure bedding planes are detectable; calcareous but no segregation of carbonates; gradual boundary.
C	30-60"+	Light brownish gray (10YR 6/2) clay loam, dark grayish brown (10YR 4/2) when moist; weakly layered with strata containing differing amounts of clay.

Range in Characteristics: The clay loam type is dominant; there is much of the silt loam type; any texture of surface soil may occur. Thicknesses of the A_1 and AC range between two-thirds and one-and-one half of those in the profile given above. Color of the A_1 ranges from grayish brown to dark grayish brown and encompasses values of 4/ to 5.5/ (moist values of 3/ to 4/), and chromas of /1.5 to /2+ in hues between 7.5YR and 2.5Y. Texture of the subsoil ranges between heavy silty clay loam and heavy loam. Some stratification with slightly more clayey or sandy layers is usual in all horizons.

Topography: Generally nearly level flood plain. May occur on recent alluvial fans and aprons, though no such areas have been reported to date.

Drainage and Permeability: Good to moderately good; slow from the surface; slow to medium internally. The water table remains below 6 feet except for short periods during and immediately following floods. Subject to occasional flooding; generally at intervals of 1 to 5 years.

Vegetation: Tall prairie grass with occasional trees along the stream channels.

Use: Almost wholly in cultivation. Highly productive and adapted to a wide variety of crops.

Distribution: Kansas and probably other states of the Central Great Plains. Mainly in the Chernozem and western most part of the Prairie soil zones but may occur in the Chestnut soil zone. Extensive in the valley of the Kansas River and its tributaries.

Type Location: Saline County, Kansas; in floodplain of Smoky Hill River 0.4 mile west of the SE corner of Sec. 30, T 14S, R 2W.

Series Established: Saline County, Kansas, 1952. The name is from a rural school in that county.

National Cooperative Soil Survey
USA

Rev. EHT
8-22-57

Established Series

KAW SERIES

The Kaw series comprises very dark, loamy, neutral or medium acid, moderately well drained, chernozemic Alluvial soils developed in generally grayish-brown silty alluvium from shale and limestone prairies. The A_1 horizon is darker and thicker than in the Verdigris, Mason, and Gowen series formed in similar alluvium. The subsoil is less clayey, more permeable, or both, and the natural drainage is more rapid than in the Osage soils. Horizonation is faint, less than in the Mason and Muir series, with very gradual and minor decrease in darkness with depth below 18 inches. The Hobbs, Kennebec, and Colo series, developed largely from loess in more northern localities, are closely related soils believed to be higher in weatherable minerals. The Kennebec series is like the Kaw series in color and drainage. Hobbs soils, which occur in less humid climates, have less dark and slightly browner A horizons, whereas Colo soils are more poorly drained and have less brownish subsoils. The localities of occurrence of the Kaw series have annual precipitation of 32 or 45 inches, mean annual temperature of 55 to 65°F., and Thornthwaite P/E index of 80. Though only of moderate extent, the Kaw soils are highly productive and important to agriculture.

Soil Profile: Kaw silty clay loam

A_1 0-24" Very dark gray (10YR 3/1) light silty clay loam; black (10YR 2/1 moist); moderate medium granular structure in the upper part becomes coarser with depth; firm (approaching friable); slightly acid; diffuse boundary. 18 to 30 inches thick.

AC 24-36" Light silty clay loam of color intermediate between those of the A_1 and C horizons; moderate medium subangular blocky structure; firm; slightly acid; diffuse boundary. 8 to 20 inches thick.

C 36-60"+ Dark grayish-brown (10YR 4/2) light silty clay loam with few faint fine mottles of strong brown; very dark grayish-brown (10YR 3/2) moist; weak subangular blocky structure; firm; slightly acid.

Range in Characteristics: Texture of the subsoil ranges from light silty clay loam through heavy silt loam and medium clay loam, the range in clay content being about 25 to 35 percent. Color of the A_1 horizon centers around very dark gray and very dark grayish-brown when dry, with ranges of 2.5/ to 3.5/ in dry value, 1.5/ to 2.5/ in moist value, /1 to /2 in chroma, and 7.5YR to 2.5Y in hue. Reaction of the A_1 and AC horizons ranges from slightly acid through neutral and medium acid; the C horizon is generally of like reaction. In areas gradational to somewhat poorly drained soils, the substrata below 30 inches become appreciably mottled with browner and grayer shades; some brownish but no gray nor light gray mottling may occur within 20-inch depth. Colors are for dry soil unless specified as moist.

Topography: Nearly level flood plains.

Drainage and Permeability: Moderately well drained with slow surface drainage, slow to moderate permeability of subsoil and substrata, groundwater table generally below 6 feet, and occasional to rare inundation by flood waters.

Vegetation: Originally mostly tall-grass prairie with scattered deciduous trees along the watercourses.

Use: Very largely in cultivation and devoted to general field crops, mainly corn, winter wheat, and alfalfa.

Distribution: Northeastern Oklahoma and eastern Kansas in flood plains of shale and limestone prairies south of the Kansas River.

Type Location: Ottawa County, Oklahoma; 600 feet south of the NE corner of Section 28, T28N, R23E.

Series Established: Ottawa County, Oklahoma, 1962. The name is from Kaw City, Oklahoma.

Remarks: In early surveys, the Kaw soils were included in the Osage series, which has since been restricted to soils having clayey, very slowly permeable subsoils.

EHT-HTO
12-13-62

National Cooperative Soil Survey
USA

Established Series
Rev. HTO
9-4-64

KINGFISHER SERIES

The Kingfisher series is a member of the fine silty, mixed, thermic family of Typic Argiustolls. These soils have reddish-brown slightly acid silt loam A horizons, reddish-brown neutral silty clay loam B2t horizons and C horizons of compact red beds.

Typifying Pedon: Kingfisher silt loam - cultivated
(Colors are for dry soil unless otherwise noted.)

A1 0-14" Reddish-brown (5YR 4/3) silt loam, dark reddish-brown (5YR 3/3) moist; upper 6 inches mixed by cultivation; moderate medium granular structure; friable, slightly hard; many roots; many pores; slightly acid; gradual boundary. 8 to 16 inches thick.

B1 14-21" Reddish-brown (5YR 4/3) light silty clay loam, dark reddish-brown (5YR 3/4) moist; moderate coarse granular structure; friable, hard; neutral; gradual boundary. 4 to 10 inches thick.

B21t 21-32" Reddish-brown (5YR 4/4) silty clay loam, dark reddish-brown (5YR 3/4) moist; moderate medium subangular blocky structure; firm, hard; common fine roots in and through peds; distinct continuous clay films; mildly alkaline; gradual boundary. 6 to 16 inches thick.

B22t 32-38" Reddish-brown (2.5YR 4/4) silty clay loam, dark reddish-brown (2.5YR 3/4) moist; moderate medium subangular blocky structure; firm, hard; few pores; distinct continuous clay films; moderately alkaline; gradual boundary. 2 to 10 inches thick.

C 38-46" Red (2.5YR 5/8), (2.5YR 4/8) moist partially weathered silty red beds; weakly calcareous.

Type Location: Kingfisher County, Oklahoma; 1800 feet west of the northeast corner of Section 16, T15N, R7W.

Range in Characteristics: Thickness of the solum ranges from 30 to 60 inches. The A horizon ranges from reddish-brown to brown in color. The B2 horizon ranges from reddish-brown to yellowish-red. It has silty clay loam texture and contains 30 to 40 percent clay in the finest part. The C horizon is commonly calcareous; in some places, it is noncalcareous but alkaline.

Competing Series and their Differentiae: These are in the Bethany, Grant, Norge, Pond Creek, Renfrow, and Zaneis series. The Grant series has less clayey B2t horizons. The Norge and Pond Creek series are formed in unconsolidated sediments and lack the compact red beds in the C horizons. The Zaneis soils contain less silt throughout, and they are more acid in reaction especially in the lower B and C horizons. The Renfrow and Bethany series have more clayey B2t horizons and the Bethany series is not reddish in color.

Page 2--Kingfisher Series

Setting: The Kingfisher soils are on gently sloping to rolling uplands. The slopes are mostly convex and gradients are dominantly between 1 and 5 percent. On the steeper slopes, Kingfisher soils are generally in complexes with the Quinlan or Lucien series. The underlying more or less compacted but unlithified Permian silts and clays are mainly of the Cedar Hills and Flowerpot formations.

Principal Associated Soils: These are in the Bethany, Grant, Lucien, Norge, and Pond Creek series. Kingfisher soils are commonly in a complex with slickspots.

Drainage and Permeability: Well drained. Permeability is moderately slow.

Use and Vegetation: Except for the most sloping areas, almost entirely under cultivation; used principally for growing winter wheat. Original vegetation was tall-grass prairie.

Distribution and Extent: North central Oklahoma and probably in south central Kansas. The series is of moderate extent.

Series Established: Kingfisher County, Oklahoma, 1960.

Remarks: The Kingfisher series was formerly classified in the Reddish Prairie great soil group.

National Cooperative Soil Survey
USA

Established Series

KIRKLAND SERIES

The Kirkland series comprises slightly acid, moderately to highly fertile Reddisth Prairie soils characterized by A horizons less than 14 inches thick, abrupt to clear boundaries between the A and B horizons, and brownish claypans not overlain by a distinct "gray layer". It is developed in alkaline, mostly reddish clays and shales, commonly of the Permian. The catenal associates are Vernon, Renfrow, and Tabler. It is the more humid equivalent of Foard, a Reddish Chestnut series that differs from Kirkland in being neutral and having a more marked and somewhat shallower carbonate horizon. Other related series are Bethany, which has a thicker A horizon and pronounced A_3 and B_1 horizons; and Calumet, the alluvial terrace equivalent of Kirkland.

Soil Profile: Kirkland silt loam

A_1 0-11" Dark brown (7.5YR 4/2; 3/2, moist) silt loam; friable; moderate medium granular; slightly acid; rests on or grades shortly to horizon beneath. 8 to 14 inches thick.

B_2 11-26" Dark brown (7.5YR 4/2; 3/2, moist) clay; blocky; very compact; slightly acid to neutral; grades indistinctly to horizon beneath. 12 to 20 inches thick.

B_3(?) 26-38" Brown (7.5YR 4.5/3; 3/3, moist) clay; massive to weak blocky; noncalcareous grades to horizon beneath. 8 to 18 inches thick.

C_{ca} 38-70" Reddish-brown clay; massive; compact; alkaline and contains a few scattered $CaCO_3$ concretions that increase with depth; soil mass noncalcareous in upper part, usually calcareous in lower. 25 to 50 inches thick.

C 70-100"+ Red or reddish-brown weakly consolidated shale; alkaline; usually weakly calcareous.

Range in Characteristics: Silt loam is the principal type, but much clay loam and some sandy loams occur in the southern half of the geographic range. The A horizon ranges from brown to dark grayish-brown (hues 7.5YR to 10YR) in color, medium acid to almost neutral in reaction, weak to moderate in degree of granulation. This horizon averages thicker and more granular in the northern areas than in the southern, and in the clay loam type, ranges from 5 to 9 inches thick. Some areas have a 1- to 2-inch transition between the A and B horizons of brown granular clay loam with or without inconspicuous grayish coatings. In many areas, no reddish coloration is reached within 4 feet and a few have nonreddish substrata.

Topography: Nearly level to very gently undulating erosional upland with gradients mostly less than 2 percent.

Drainage: Slow to moderate from the surface; very slow internally, but adequate for common field crops.

Vegetation: Tall prairie grasses, which have been largely replaced by short grasses in pastured areas.

Use: Largely in cultivation to oats, wheat, cotton, and sorghums; moderately productive.

Distribution: Reddish Prairie of north-central Texas, central Oklahoma, and southern Kansas.

Type Location: Logan County, Oklahoma; 900 feet north of south quarter corner Section 36, T16N, R4W.

Series Established: Reconnaissance Soil Survey of the Panhandle Region of Texas, 1910, for soils in the vicinity of Kirkland, Texas, that are now classed as Foard and Hollister. The series was restricted to the Reddish Prairie zone about 1919.

Remarks: Unless otherwise stated, colors refer to dry soil. Many of the areas from central Oklahoma northward, especially those with relatively thick A horizons, probably are affected by a very thin mantle of loess. The distinction of Calumet from Kirkland often is impossible with high accuracy, and the basis of that distinction is under review.

WTC:FAH:MB
4-30-40
Rev. HO:EHT
5-24-46
Rev. EHT:HO
1-16-52

Division of Soil Survey - BPISAE
ARA - U. S. Department of Agriculture

Established Series
HTO-LBJ
5-15-65

KONAWA SERIES

The Konawa series is in the fine loamy, mixed, thermic family of Udultic Haplustalfs. These soils have light colored sandy A horizons that are less than 20 inches thick over reddish moderately fine textured B2t horizons that grade to less acid, reddish, and sandy C horizons.

Typifying Pdeon: Konawa loamy fine sand
(Colors for dry conditions unless otherwise noted).

Ap	0-6"	Grayish-brown (10YR 5/2) loamy fine sand, dark grayish-brown (10YR 4/2) moist; weak fine granular structure; soft, very friable; slightly acid (pH 6.5); clear smooth boundary. 3 to 8 inches thick.
A2	6-14"	Very pale brown (10YR 7/3) loamy fine sand, brown (10YR 5/3) moist; massive; soft, very friable; medium acid (pH 6.0); clear smooth boundary. 4 to 17 inches thick.
B2t	14-38"	Yellowish-red (5YR 5/6) sandy clay loam, yellowish-red (5YR 4/6) moist; moderate coarse prismatic structure breaking to weak medium subangular blocky structure; very hard, friable; clay films on ped faces and bridging sand grains; medium acid (pH 5.8); diffuse smooth boundary. 15 to 35 inches thick.
B3	38-54"	Yellowish-red (5YR 5/6) fine sandy loam, yellowish-red (5YR 4/6) moist; weak coarse prismatic structure; hard, friable; medium acid (pH 6.0); diffuse smooth boundary. 10 to 30 inches thick.
C	54-70"+	Yellowish-red (5YR 5/7) loamy fine sand, yellowish-red (5YR 4/8) moist; massive; slightly hard, friable; medium acid (pH 6.0).

Type Location: Pottawatomie County, Oklahoma; 700 feet south and 100 feet west of the northeast corner of Section 36, T6N, R4E.

Range in Characteristics: The A horizon ranges in thickness from 7 to 20 inches. The color of the upper A horizon ranges from pale brown to dark grayish-brown and brown in hues of 10YR and 7.5YR; of the A2 from very pale brown to light yellowish-brown and light brown in hues of 10YR and 7.5YR. The texture of the A ranges from loamy fine sand to fine sandy loam. The B2t horizon ranges in color from red to reddish-brown, yellowish-red, and reddish-yellow in hues of 2.5YR to 7.5YR; in reaction from medium to strongly acid; and in clay content from about 18 to 35 percent. The texture of the C horizon ranges from loamy fine sand to light sandy clay loam. The C horizon is less acid than the B2 horizon and reaches neutrality at about 10 feet.

Competing Series and Their Differentiae: These include the Stidham, Dougherty, Stephenville, Windthorst, and Travis series. The Stidham series has less reddish B horizons and thicker A horizons (20 to 40 inches). The Dougherty series has A horizons ranging in thickness from 20 to 40 inches. The Stephenville series has sandstone at depths less than 48 inches. The Windthorst and Travis series have fine textured B2t horizons.

Setting: The Konawa soils occur on nearly level to sloping uplands and are formed in medium acid to neutral sandy to loamy sediments. The slopes are dominantly between 1 and 9 percent. The climate is subhumid to moist subhumid (east of PE 44 isobar). At the type location, the average annual precipitation is about 35 inches and the mean annual temperature about 61°F.

Principal Associated Soils: These include the Stephenville, Stidham, Eufaula, and Dougherty series. The Eufaula soils have A horizons that are more than 40 inches thick.

Drainage and Permeability: Well drained. Moderate permeability.

Use and Vegetation: Areas having slopes of less than 5 percent are largely in cultivation; sorghums, small grains, and peanuts are the main crops. Native vegetation is mainly post oak, blackjack, hickory, and elm with ground cover of little bluestem and other grasses.

Distribution and Extent: Central and eastern Oklahoma and Texas; possibly in southeastern Kansas, western Arkansas, and western Louisiana. This series is likely of large extent.

Series Established: Pottawatomie County, Oklahoma, 1965.

Remarks: This series consists of soils formerly classified in the Dougherty series but their sandy surface layers are too thin to fit the requirements of an arenic subgroup. These kinds of soils were formerly classified in the Red-Yellow Podzolic great soil group.

National Cooperative Soil Survey
USA

LABETTE SERIES

The Labette soils are well-drained Reddish Prairie Soils developed in residuum from limestone or interbedded limestone and calcareous shale. They occur mainly in the Cherokee Prairies of southwestern Kansas, northeastern Oklahoma, and southeastern Missouri -- within the transition from the Reddish Prairie to the Prairie soil zones. This series differs from Newtonia in having darker, less reddish A horizons. The Labette soils are browner than Summit soils, have less yellowish and somewhat less clayey subsoils, and generally are developed in parent limestone less interbedded with shale or clay. They are more granular, have less clayey subsoils, and contain more organic matter than Crawford and Denton soils, which are developed under warmer climate, mainly on Cretaceous limestones.

I. Soil Profile (Labette silt loam):

				Range in thickness
1.	A_1	0-10"	Dark-brown (7.5YR 3/2; 2/2, moist) silt loam; strong medium granular; grades to horizon 2; slightly to medium acid.	8-14"
2.	B_1	10-20"	Dark-brown (7.5YR 3.5/2; 2.5/2, moist) silty clay loam; strong medium granular structure; friable; grades to horizon 3; slightly to medium acid.	6-15"
3.	B_2	20-28"	Reddish-brown (5YR 4/4) silty clay slightly variegated with grayer and redder shades of brown; strong medium to coarse granular structure; firm; grades to horizon 4; neutral to medium acid.	
4.	B_3	28-48"	Reddish-brown (2.5YR 4.5/5; 4/6, moist) silty clay splotched with strong brown; firm; about neutral.	
5.	D	48" +	Partly weathered limestone.	

II. Range in Characteristics: Depth to limestone varies from 2 to about 5 feet. Horizons 3 and 4 range from reddish brown to yellowish red or strong brown, and commonly contain black films and concretions that probably are oxides of manganese and iron.

III. Topography: Undulating or gently rolling uplands.

IV. Drainage: External, moderate to rapid; internal, moderate.

V. Vegetation: Prairie grasses, with bluestem dominant.

VI. Use: The greater part of these soils is cultivated and used for growing corn, wheat, oats, sorghums, flax, and legumes.

VII. Distribution: Cherokee Prairies of northeastern Oklahoma, east-central and southeastern Kansas, and southwestern Missouri; extensive.

Type location: Allen County, Kansas; 2 miles west of Moran at SW corner sec. 27, T. 24 S., R. 20E.

Series established: Labette County, Kansas, 1926.

Established Series

LELA SERIES

The Lela series comprises imperfectly drained Grumusols developed from reddish calcareous clayey alluvium in moist-subhumid to warm-temperate grasslands (Reddish Prairie zone and transitions to Prairie and Reddish Chestnut zones) of Oklahoma, Kansas, and Texas. The series is characterized by (1) very dark color to depths of 18 or 50 inches, (2) clay texture throughout (excepting overburden of more recent sediments), (3) medium-high content of organic matter--of the order of 3% to 5% in the surface soil and decreasing slowly with depth, (4) noncalcareous and commonly about neutral in the surface soil, becoming alkaline with depth, (5) moderately granular structure and extremely sticky and plastic consistence of surface soil, which crumbles naturally on drying, (6) relatively high contents of available phosphorus, potash, and weatherable minerals, and (7) substrata of reddish calcareous clay. The parent material is old alluvium from subhumid grasslands in the Southern Great Plains underlain by Permian red beds. The Lela series occurs on younger surfaces, has somewhat cooler environment, and is higher in organic matter than the Burleson and Lake Charles soils. It has a more clayey subsoil and is more intensely darkened to greater depth than McLain series. It differs from the Brewer soils in having no genetic B horizon. The solum is less acid than in Page soil; the environment is cooler, the organic matter higher, and the frequency of flooding generally less than in Pledger soils.

Soil Profile: Lela clay

A_{11}	0-1"	Very dark gray (7.5YR 3/1) clay, very dark brown (7.5YR 2/2) when moist; strong fine granular structure when dry (the granules are discrete); extremely plastic, very firm, very hard; about neutral. 1/2 to 2 inches thick in virgin areas.
A_{12}	1-45"	Very dark gray (7.5YR 3/1) clay, very dark brown (7.5YR 2/2) when moist; compound moderate medium granular and weak irregular blocky structure, the granules gradually coarsening and becoming less distinct with depth; very firm, extremely plastic; very slowly permeable when wet; about neutral; noncalcareous; gradual boundary.
AC	45-75"	Dark reddish-brown (5YR 3/2) clay, dark reddish-brown (5YR 3/3) when moist; weak medium blocky or prismatic structure; extremely plastic, very firm; mildly alkaline; soil mass noncalcareous but a few concretions of $CaCO_3$ present; gradual boundary.
C	75-90"+	Reddish-brown (5YR 4/3) clay, dark reddish-brown (5YR 3/4) when moist; moderately alkaline (pH8); noncalcareous or mildly calcareous; scattered concretions of $CaCO_3$ present. This is old alluvium.

Range in Characteristics: Color of the A_1 horizon ranges from very dark gray to dark brown (hues of 7.5YR to 10YR; values of 2.5/ to 4/; chromas of /1 to /2). The A_1 horizon may be slightly mottled with brown or reddish-brown below 15 inches. Silted phases with more recent overwash of various textures and colors are common. Colors are for dry soil unless otherwise indicated.

Topography: Level lowlands bordering or within flood plains; gradients of 0 to 1/2%; surfaces plane or broadly concave.

Drainage and Permeability: Somewhat poorly to moderately well drained. Internal drainage is very slow or none. During cool wet seasons, the soil is saturated. Most areas receive runoff from adjoining higher areas; some are occasionally flooded from nearby streams. During dry summers, the soil dries to or below the wilting coefficient to depths of several feet; the deep substrata probably never becomes dry.

Vegetation: Tall grass with or without scattered trees.

Use: Mostly cultivated to corn, wheat, oats, cotton, and some alfalfa. Yields are mostly medium to high; natural fertility is very high. Drainage has been improved in most areas by construction of roadside borrow ditches and other shallow open drains.

Distribution: Widely scattered bodies ranging up to a thousand or more acres in size, mainly in northern and northeastern Oklahoma. The total extent probably is between 10 and 50 thousand acres.

Series Established: Pawnee County, Oklahoma, 1954. The name is taken from a village in this county.

Type Location: Noble County, Oklahoma, the west quarter corner of Section 6, T24N, R1E.

Remarks: These soils have heretofore been classed as clay types of the Kay and Brewer series.

Rev. EHT:HMG
10-6-54
Mimeo 1957

National Cooperative Soil Survey
USA

This series established in final correlation of Clay County, South Dakota, April 1, 1953.

Tentative; Not Correlated

LESHARA SERIES

The Leshara series includes imperfectly drained azonal Alluvial or Alluvial-Humic Gley soils intergrades with weak zonal characteristics of Prairie and Chernozem soils. These soils occupy low terraces or high bottoms along major streams in the western part of the Prairie soils zone and eastern part of the Chernozem soils zone. Their parent materials are silty or only slightly sandy alluvium 24 to 36 inches thick over stratified alluvium consisting of loamy fine and very fine sands, very fine sandy loam, loam and silt loam. Occasional strata of coarser and finer texture may be present. At an additional depth of one foot or more their substrata consists of loamy fine sand, loose incoherent sands, sand-fine gravel mixture or old buried dark soils which rest on a coarse substratum at a depth of 5 to 7 feet. Leshara soils differ from Wann soils chiefly in having thicker coherent sola over the coarse substrata and in their better drainage due to the slightly higher position they occupy in the alluvial plain. They differ from Yutan* soils, in the same general area, in being a little more poorly drained (average less depth to watertable) and in containing appreciable free lime carbonate from or near the surface downward.

				Range in Thickness
I.	Soil Profile:		Leshara silt loam	
1.	A_p	0-6"	Dark gray (10YR 4/1, dry) to black (10YR 2/1, moist) friable, soft granular or crumb silt loam; neutral.	6-8"
2.	A_{11}	6-11"	Dark gray (10YR 4/1, dry) to very dark brown (10YR 2/2, moist) friable, granular or crumb silt loam; neutral to alkaline.	4-8"
3.	A_{12}	11-15"	Gray (10YR 5/1, dry) to dark gray (10YR 3/1, moist) friable, granular silt loam; alkaline, with a few calcareous spots.	4-8"
4.	C	15-28"	Light gray (10YR 6/1, dry) to dark gray (10YR 4/1, moist) friable, ill defined weak blocky-granular silt loam containing thin lenses of very fine sandy loam in the lower part; strongly calcareous including fine, white spots and streaks of free lime carbonate, more abundant in the lower part.	8-16"
5.	D_1	28-44"	Light gray (10YR 7/2, dry) to light brownish-gray (10YR 6/2, moist) very friable, somewhat loose, stratified fine and very fine sands, loamy very fine sand and thin lenses of loam or silt loam; slightly calcareous in upper part, alkaline but no free lime carbonate in lower part.	
6.	D_{2g}	44-50"	Gray (10YR 5/1, dry) to dark gray (10YR 4/1, moist) massive silty clay loam or silty clay; plastic wet; hard, dry; contains darker-and	0-10"

*New series proposed in Saunders County, Nebraska

		lighter-colored, thin sedimentary lenses; calcareous, including some white lime streaks and possibly other salts in the lower part.	0-10"
7.	A_{1bg} 50-60"	Very dark gray (10YR 3/1, dry) to black (10YR 2/2, moist) silty clay loam; moderately friable, moist; moderately hard, dry; calcareous. This is a somewhat gleyed A_1 of a buried soil.	0-12"

II. Range in Characteristics: Aside from their relatively thick dark A_1 horizons and coherent, medium textured upper subsoil horizons, these soils lack uniformity. The arrangement, thickness, color and texture of the alluvial strata in their lower subsoils and substrata are quite variable. But the composite texture of these strata is in the moderately coarse range and they are predominantly light colored. Dark or very dark strata comprising A_1 horizons of buried soils, however, may be present at any depth below one or two feet. In places the buried dark layers are continuous with the present A_1 horizons and form a two-story A_1 as much as 24 inches thick. Associated noncalcareous soils may comprise minor mapping inclusions in Leshara soils.

III. Topography: Nearly level and gently undulating low terraces or high bottoms.

IV. Drainage: External drainage slow to moderate; internal drainage moderate to the watertable which fluctuates between depths of about three feet and five feet depending on seasonal precipitation. The soils are seldom if ever flooded. Some faint, fine mottlings and weak gleyzation are visible in the deeper strata, particularly in the finer textured strata. The capillary fringe from the watertable is within reach of the roots of most crops even in the driest years.

V. Vegetation: Mainly tall-grass association.

VI. Use: Chiefly for growing corn which is rotated in some years with small grains and sweet clover.

VII. Distribution: Eastern Nebraska and possibly in adjacent parts of adjoining states.

VIII. Remarks: These soils formerly were included with the Wann series which previously had been taken out of the Cess series to include the dark, variably but somewhat poorly drained calcareous Alluvial soils. The Wann series is now restricted to soils with similar dark surface layers but with coarse textured subsoils and substrata and a watertable that fluctuates between depths of about two feet and five feet.

Type Location: Saunders County, Nebraska

Series Proposed: Saunders County Soil Survey, 1952.

Soil Survey
Soil Conservation Service
U. S. Department of Agriculture

BHW
1-9-53

Established Series

LINCOLN SERIES

The Lincoln series comprises pale-brown to light yellowish-brown and brown calcareous Alluvial Soils, mainly of the Reddish Chestnut and Reddish Prairie soil zones that have very sandy subsoils. These soils are subject to recurrent flooding and deposition of fresh material and consist of little altered sandy alluvium, generally from the extensive Tertiary deposits of western Oklahoma, Kansas, and Texas. The Lincoln soils have sandier subsoils and somewhat less dark surface soils than the Sweetwater soils, less reddish than the Yahola, more alkaline than the Coleta and Pulaski, and without the subsoil mottling characteristic of the Las Animas soil.

Soil Profile: Lincoln loamy fine sand		Range in Thickness
0-15"	Pale brown (10YR 6/3; 5/3, moist) loamy fine sand; single grain to very weakly granular; nearly loose; calcareous.	10-20"
15-50"+	Light yellowish-brown (10YR 6/4; 5/4, moist) loamy fine sand; calcareous; commonly stratified with sand below 30 inches.	

Range in Characteristics: Types ranging from fine sand to fine sandy loam are dominant but minor areas of clay loam and clay (which have grayish-brown surface soils) occur; surface soil ranges from pale brown to light yellowish-brown, pale yellow, and light brownish-gray; subsoil is loamy fine sand or coarser below 15 inches; a few areas contain thin seams of fine gravel; saline phases occur.

Topography: Level to undulating flood plains.

Drainage: Slow from the surface; very rapid internally; the ground water table commonly lies at a depth ranging between 4 and 20 feet.

Vegetation: Tall grasses (mainly bluestems, Indian, and dropseeds); alkali sacaton and salt grass occur on saline phases; a few cottonwood trees are commonly present.

Use: The sands and loamy sands are of low fertility, susceptible to soil blowing, and mainly in native pasture or meadow; the less inextensive heavier types are somewhat more fertile but droughty.

Distribution: Western parts of Oklahoma, Texas, and Kansas, mainly in flood plains of streams that rise in or west of the High Plains; moderately extensive.
Type Location: Woodward County, Oklahoma.
Series Established: Russel County (Russel Area), Kansas, 1903.
Remarks: In the past, some soils with loamy subsoils of good moisture holding capacity that would now be classed as Arkansas have been included in the Lincoln series. Color names used are provisional Soil Survey color names (1946) and refer to dry soil.

Rev. JT
6-5-46
Rev. EHT
10-4-46

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Established Series

LUCIEN SERIES

The Lucien series comprises reddish noncalcareous Lithosols of the Reddish Prairie soil zone, formed under grass in residuum from red noncalcareous soft fine-grained sandstones and sandy shales, mainly in the prairies of central Oklahoma. They are shallower and lower in phosphorus than Nash, and more sandy and friable than Vernon, the associated generally calcareous Lithosol developed in clayey materials. Lucien soils are closely related to Darnell, a forested Lithosol, but slightly darker and commonly somewhat redder.

Soil Profile:		Lucien very fine sandy loam	Range in Thickness
A_1	0-10"	Reddish-brown (2.5YR 4/3; 3/3, moist) very fine sandy loam; moderate medium granular; very friable; slightly acid; grades to horizon below.	5-14"
A_3	10-15"	Reddish-brown (2.5YR 4/4; 3/4, moist) very fine sandy loam; compound coarse prismatic and medium granular; very friable; medium acid; grades through a thin transition to material below.	0-12"
C	18-30"+	Reddish-brown (2.5YR 4/4) noncalcareous soft fine-grained sandstone often interbedded with red clay; noncalcareous; commonly neutral.	

Range in Characteristics: Very fine sandy loam is the principal type; color of the surface soil ranges from dark reddish-brown to reddish-brown, and the reaction, from neutral to medium acid; the A_3 horizon is very thin or lacking where the soils are less than about 10 inches deep; thickness of the solum is variable within short distances, and ranges from as little as 2 inches in the stony types to about 20 inches in the nonstony types.

Topography: Gently to strongly sloping erosional upland.

Drainage: Surface runoff is moderate to rapid; internal drainage is moderate; very susceptible to erosion if not carefully managed.

Vegetation: Mainly bluestem and grama grasses, which forms a moderate to thick cover.

Use: Three-fourths or more is in native pasture or meadow. The small acreages in cultivation are devoted mainly to wheat, oats, cotton, and sorghums, and are of low productivity; generally unsuited for cultivation; the native vegetation generally is relatively low in phosphorus.

Distribution: Mainly in the eastern part of the Reddish Prairie soil zone of Oklahoma; moderately extensive.

Type Location: Noble County, Oklahoma; SE quarter Section 12, T21N, R1E.

Series Established: Noble County, Oklahoma, 3-10-47.

Remarks: Prior to establishment of the Lucien series, these soils were generally classed as sandy types of Vernon. Colors are described with approximate provisional Soil Survey color names (1947) and refer to dry soil.

EGF
9-23-43
Rev. HO:EHT
3-3-48

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Established Series

McLAIN SERIES

The McLain series comprises youthful Reddish Prairie Soils developed on reddish calcareous alluvium that originated mainly in warm-temperate prairies and subhumid plains underlain by red beds. The series occurs on low terraces above overflow and has a distinct color profile and free carbonates removed to a depth of several feet, but lacks a distinct textural profile. The principal catenal associate is Brewer, which is more slowly drained and less brown and has grayer heavier subsoils. McLain soils are darker and occur above overflow and under more humid climate than the Port soils; the carbonates are leached to a greater depth than in the Asa soils; and the several horizons are browner or redder than in the Kay soils, which are on alluvium having a smaller proportion of sediments from red beds.

Soil Profile: McLain silty clay loam		Range in Thickness
0-10"	Dark-brown (7.5YR 3.5/2; 2.5/2, moist) clay loam; granular; friable; about neutral; grades to horizon below.	6-15"
10-30"	Reddish-brown (5YR 4/3; 3/3, moist) heavy silty clay loam; granular; friable; hard when dry; neutral to alkaline but noncalcareous.	15-25"
30-50"	Reddish-brown (5YR 5/4; 4/4, moist) heavy silty clay loam; massive; slowly permeable; firm; weakly alkaline but noncalcareous.	15-25"
48-60"+	Yellowish-red (5YR 5/5; 4/6, moist) calcareous friable silty clay loam.	

Range in Characteristics: Types range from very fine sandy loam to silty clay but silt loam and silty clay loam are predominant; surface soil ranges from dark brown to brown and dark reddish-brown and from slightly acid to mildly alkaline; texture of subsoil as a whole ranges from clay loam to silty clay but the strata of clay are not uncommon; dark layers comprising buried soils occur at erratic depths in many areas.

Topography: Level low stream terraces lying 5 to 20 feet above present flood plains.

Drainage: Slow from the surface; moderate internally; very favorable for crops.

Vegetation: Originally forested with oak, elm, pecan, hackberry, and ash.

Use: Practically all in cultivation and devoted mainly to corn, cotton, alfalfa, small grain, sorghums, and broomcorn; very fertile and highly productive.

Distribution: Mainly in central and southern Oklahoma on terraces of the Washita, Canadian, and Red Rivers.

Type Location: Murray County, Oklahoma; SW 1/4 Section 30, T1N, R3E.

Series Established: Muskogee County, Oklahoma, 1913.

Remarks: As originally described in the Soil Survey of Muskogee County, Oklahoma, the McLain series comprised reddish soils with dark brown to black subsoils, which evidently represented a two-story soil consisting of reddish more recent sediments over a buried dark soil. This accidental soil condition, however, is very inextensive and in 1937 the series concept was modified to include the soils as now defined.

Colors are described with provisional Soil Survey color names (1946) and unless stated otherwise refer to dry soil.

Rev. EGT:WTC
5-23-38
Rev. EHT:HO
9-5-46

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Established Series

MASON SERIES

The Mason series comprises dark, moderately well-drained, friable, noncalcareous soils developed on silty and clayey alluvium on low terraces, mainly in the Reddish Prairie soil zone. Mason lies somewhat higher than the associated Verdigris, which it resembles, but is above overflow and has a somewhat more developed texture and structure profile. Other related series are Dale, which has browner, lighter-textured, more friable subsoils; Kaw, which lacks the mottled substratum, occurs under drier climate, and is no more than slightly acid; and Neodesha, which is grayer and has strongly mottled subsoils.

Soil Profile: Mason silt loam

A_1	0-14"	Dark grayish-brown (10YR 4/2, 3/2 moist) silt loam; strong medium granular; very friable; medium acid. 10 to 18 inches thick.
B_2	14-26"	Dark grayish-brown (10YR 4/2, 3/2 moist) silty clay loam; strongly medium granular; friable; permeable; slightly acid. 10 to 24 inches thick.
B_3	26-40"	Grayish-brown (10YR 4/2.5) silty clay loam mottled with 10 to 20% of brown (7.5YR 4/4) and some yellowish and reddish-brown; massive to weakly blocky; permeable; firm to friable; slightly acid. 10 to 16 inches thick.
C	40-60"+	Mottled grayish-brown and yellowish-brown (10YR 5/2 and 5/5) silty clay loam; firm; moderately permeable; slightly acid to neutral.

Range in Characteristics: Silt loams and clay loams are the principal types; color of the surface soil ranges from grayish-brown to very dark grayish-brown, the lighter textures being the less dark; reaction ranges from medium to slightly acid; horizon 2 ranges from loam to silty clay loam, from grayish-brown to dark brown (hues of 10YR to 6.5YR), and from slightly acid to neutral; depth to the mottled horizon 3 ranges from about 20 to 44 inches; substrata below about 50 inches ranges from silty clay to weakly stratified silty and clayey alluvium, medium acid to weakly alkaline in reaction.

Topography: Nearly level low terraces lying 5 to 15 feet above normal overflow.

Drainage: Moderately slow from the surface and internally but very favorable for all common field crops, including alfalfa.

Natural Vegetation: Deciduous forest mainly of elm, oak, hackberry, and pecan.

Use: Largely cultivated and used for growing corn, cotton, oats, sorghums, and some alfalfa and lespedeza; fertile and highly productive.

Distribution: Reddish Prairie soil zone, mainly in eastern Oklahoma.
Type Location: Okfuskee County, Oklahoma, SE corner Section 20, T11N, R10E.
Series Established: Okfuskee County, Oklahoma, 1940.

Rev. 5-3-48 HO:EHT
Mimeo June 1956

Soil Survey
Soil Conservation Service
U. S. Department of Agriculture

MENO SERIES

The Meno Series comprises Brunizems having mottled Bt horizons of sandy clay loam or sandy loam and developed from moderately sandy, weakly stratified deposits of wind-modified old alluvium. The principal associated soils are the Shellabarger, Naron and Carwile series. Another related soil is the Altus series. Shellabarger and Naron soils lack mottling in their B horizons. The Carwile soils have more clay in the Bt horizon, whereas the Altus series has a darker A horizon, is neutral, and is free of mottling above depths of 35 inches. The Meno series occurs in regions with mean annual precipitation of 22 to 32 inches and mean annual temperatures of 54 to 60°F. Total extent of the series is of the order of 150,000 acres.

Soil Profile: Meno loamy fine sand

A11 0-10" Brown (10YR 5/3) loamy fine sand; dark brown (10YR 3/3) moist; very weak medium granular structure; soft dry; very friable moist; medium acid; gradual boundary. 6 to 14 inches thick.

A12 10-24" Brown (7.5YR 5/3) loamy fine sand; brown (7.5YR 4/3) moist; very weak medium granular structure; soft dry; very friable moist; slightly acid; gradual boundary. 10 to 18 inches thick.

B21t 24-34" Brown (7.5YR 5/4) light sandy clay loam; brown (7.5YR 4/4) moist; few faint mottles of strong brown and grayish brown; weak medium subangular blocky structure; hard dry; friable moist; slightly acid; gradual boundary. 7 to 14 inches thick.

B22t 34-44" Mottled brown (7.5YR 5/4), strong brown (7.5YR 5/6), and gray (10YR 6/1) sandy clay loam; weak medium subangular blocky structure; hard dry; friable moist; slightly acid; diffuse boundary. 6 to 14 inches thick.

C 44-60"+ Mottled strong brown (7.5YR 5/6) and grayish brown (10YR 5/2) fine sandy loam; massive; slightly acid.

Range in Characteristics: Loamy fine sand is the only type recognized so far but fine sandy loam may occur. The color of the A horizon has an inclusive range of 4 to 5.5 in dry value, 2.5 to 4 in moist value, and chroma of 2 to 4 in 10YR and 7.5YR hues. Color of the B2t horizon may be brown or yellowish brown with mottles of one or more of gray, yellowish brown, strong brown, and reddish brown. Texture of the B2t horizon may be sandy clay loam or heavy fine sandy loam with clay content of about 17-30 percent. Depth to mottling from the soil surface ranges from 20 to 35 inches. Underlying materials may be stratified, with textures of individual beds ranging from loamy sand to clay loam, inclusive. Reaction of the A and B horizons may be medium or slightly acid and of the substrata medium acid through neutral. Colors given are for dry conditions unless otherwise specified.

Topography: Gently undulating to nearly level uplands.

Drainage and Permeability: Moderately well drained. Runoff is slow. Permeability is moderate.

Vegetation: Originally tall grass prairie dominated by sand bluestem, big bluestem, little bluestem, switchgrass, and Indiangrass. Few scattered scrub oak in places.

Use: Mostly farmed to small grains and sorghums. Good yields are obtained under good management.

Distribution: Parts of north-central Oklahoma and south-central Kansas.

Type Location: Major County, Oklahoma; 670 feet north and 350 feet east of the south quarter corner of Sec 24 T.20N R.9W.

Series Proposed: Major County, Oklahoma, 1963. (Name is from small town in the county, (pronounced Mé no.)

HTO-JMA-FPA
11-15-63

National Cooperative Soil Survey
USA

Established Series

MILLER SERIES

The Miller series consists of reddish calcareous Alluvial soils with clay subsoils. They occur mainly within the Reddish Prairie and Red-Yellow Podzolic regions and are concentrated in the floodplains of rivers that drain areas in Texas and Oklahoma underlain by red beds. The associated poorly drained soil having a somewhat mottled subsoil is the Roebuck series. Other commonly associated soils are the Yahola series with sandy subsoil and the Norwood series with silty or loamy subsoil. Miller soils resemble the Treadway series in color, texture and reaction but are of more weathered alluvium. They are higher in organic matter, have more developed structure, are more porous and permeable and are higher in fertility than soils of the Treadway series which is of relatively unaltered alluvium from raw outcrops of red beds.

Soil Profile: Miller clay

A_1	0-15"	Reddish-brown (5YR 4/3) clay; dark reddish-brown (5YR 3/3) moist; moderate to strong fine blocky and granular structure; crumbly and friable when moist; very sticky and plastic when wet; on drying, the soil naturally separates to a mass of fine extremely hard aggregates; calcareous; gradual wavy boundary.
AC	15-40"	Reddish-brown (5YR 4/4) clay; dark reddish-brown (5YR 3/4) moist; moderate fine blocky structure; firm; very sticky and plastic when wet; few fine pores; strongly calcareous; gradual smooth boundary.
C	40-80"+	Red (2.5YR 4/6) clay; dark red (2.5YR 3/6) moist; massive; very firm and very plastic; apparently very slowly permeable; calcareous.

Range in Characteristics: Clay is the dominant type but there is also a large total area of other types including fine sandy loam, silt loam and clay loam. Color of the surface soil ranges from weak red to brown, the finer textures are the darkest. All horizons are dominantly calcareous, although in some areas they are noncalcareous but are alkaline. Locally, some stratification with fine sandy loam or clay loam occurs in the C horizon.

Topography: Nearly level flood plains; weak gilgai microrelief in most undisturbed areas.

Drainage and Permeability: Very slow from the surface and internally but usually adequate for field crops except in local weakly depressed areas that need surface drainage for best yields. Deep cracks form when the soil is extremely dry and aid in internal drainage and water penetration. Rarely to frequently flooded.

Vegetation: Forested with elm, ash, hackberry, oak, pecan, and other hardwoods in the humid region; mainly mesquite, elm, and buffalo grass in subhumid areas.

Use: Largely cultivated except in some narrow frequently flooded areas; cotton, corn, grain sorghums, sorgo, alfalfa, and oats are the principal crops. High yields are obtained except during extremely wet or extremely dry years.

Distribution: Texas, Oklahoma, Arkansas, and Louisiana. Very extensive in flood plains of the Brazos, Red, and Colorado Rivers.

Type Location: Three miles east of Allenfarm, Brazos County, Texas.

Series Established: Miller County, Arkansas, 1903.

Rev. HO-EHT
5-15-57
Mimeo. 1957

National Cooperative Soil Survey
USA

Established Series

MINCO SERIES

The Minco series comprises brown noncalcareous youthful soils of the Reddish Prairie soil zone. It is developed to alkaline to weakly calcareous recent aeolian silts and very fine sands that mantle narrow belts along the Canadian, Arkansas, Red, and similar rivers that rise in subhumid and semiarid regions and have broad sand-choked channels. The Minco series is of more youthful soils than the associated Vanoss and Norge series, has less clayey subsoils, and lacks a texture profile. It is more loamy than Derby and constitutes the approximate pedalferic equivalent of Enterprise, which occurs under subhumid climate and is generally somewhat redder and more alkaline.

Soil Profile:	Minco silt loam	Range in Thickness
0-14"	Brown (7.5YR 4/2; 3/2, moist) silt loam moderate medium granular; very friable; slightly acid; grades into horizon below.	10-18"
14-30"	Brown (7.5YR 4/5; 3/5, moist) silt loam; weakly granular; very friable; about neutral; grades into horizon below.	15-30"
30-50"	Reddish-brown (5YR 4/5; 3/5, moist) silt loam; structureless; friable and permeable; neutral to alkaline in upper part; alkaline in lower part.	15-30"
50-90"+	Reddish-brown (5YR 4/5) friable silt loam; alkaline to weakly calcareous.	

Range in Characteristics: Silt loam and very fine sandy loam are the principal or only types; horizon 1 ranges from brown to dark brown in color, and from slightly acid to neutral in reaction; horizon 2 ranges from very fine sandy loam to silt loam in texture from brown to light reddish-brown in color, and from about neutral to weakly alkaline in reaction; where the mantle in which these soils are developed thins, substrata of any character may occur below 3 feet.

Topography: Nearly level to strongly sloping mantled upland or terrace; gradients dominantly 2 to 5 percent.

Drainage: Moderate to rapid from the surface; rapid internally.

Vegetation: Grasses, mainly bluestems and gramas; a few trees occur in some areas.

Use: Very largely in cultivation except for areas of more than 8% gradient; the cropland is devoted largely to corn, cotton, alfalfa, and sorghums; moderately to highly productive.

Distribution: Mainly in central Oklahoma and Texas bordering rivers that drain subhumid plains partly underlain by red beds; and very largely confined to areas within 5 miles of the river channels; mainly along the Canadian, Arkansas, Washita, and to a lesser extent, the Red Rivers; moderately extensive; occupies most of the area within its belts of occurrence, which are more extensive along the northern (leeward to the prevaling wind direction) than along the southern sides of the river valleys.

Type Location: Grady County, Oklahoma.

Series Established: Grady County, Oklahoma. (Washita Watershed.)

Remarks: Colors are described with provisional Soil Survey color names (1947) and unless otherwise stated, refer to dry soil.

EGF
5-8-40
Rev. HO:EHT
2-28-48

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NASH SERIES

The Nash series includes medium-depth Reddish Prairie Soils developed on neutral or calcareous red very fine sandy and silty shales, mainly of the Permian. These soils are intermediate in character between the Grant and Lucien or Quinlan. They are less acid than the Zaneis soils and their subsoils are less clayey and more friable than those of the Renfrow. The similar series of the Reddish Chestnut soils zone is Woodward.

I. Soil Profile (Nash very fine sandy loam):

			Range in thickness
1.	0-6"	Reddish-brown (5YR 4/4; dark reddish-brown 5YR 4/3, moist) very fine sandy loam; moderately granular; very friable; hard when dry; neutral.	4-8"
2.	6-14"	Yellowish-red (5YR 4/6; 5YR 3/6, moist) very fine sandy loam; moderately granular; very friable; hard; neutral or slightly alkaline; grades into horizon below.	4-10"
3.	14-26"	Yellowish-red (5YR 5/8; 5YR 4/8, moist) very fine sandy loam; massive; porous; very friable; neutral to alkaline.	8-12"
4.	26-36"+	Yellowish-red (5YR 5/8) neutral or calcareous partially weathered sandy shale containing a few grayish streaks or strata.	

II. Range in Characteristics: Silt loam and very fine sandy loam are the principal or only types; color of the surface soil ranges from dark reddish brown to brown; horizon 3 is a light clay loam or loam in places; thickness of solum ranges from 20 to 36 inches.

III. Topography: Gently rolling upland with gradients up to about 12 percent, dominantly 3 to 7.

IV. Drainage: Free from the surface and internally; erodes very rapidly where unprotected.

V. Vegetation: Principally bluestem, side-oats grama, blue grama, and buffalo grasses; which form a thick cover.

VI. Use: Probably about one-half of this soil is now cultivated; wheat, sorghums, and sudan grass are the principal crops. The other half is largely native prairie pasture. Moderately productive when first placed in cultivation, but deteriorates rapidly under poor management. Virgin pastures have a high carrying capacity.

VII. Distribution: Oklahoma and Kansas.
Type location: Garfield County, Oklahoma.
Series established: Garfield County, Oklahoma, 1935.

VIII. Remarks: Color terms are Provisional Soil Survey color names, based on Munsell Color Charts and unless stated otherwise refer to dry soil.

EGF-WTC-FAH-NB 5-8-42
Rev. AES:HO 5-3-46

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NEOSHO SERIES

The Neosho soils are Planosols developed on terraces, chiefly in the Prairie soils zone, from sediments brought down from weathered shales and limestone. These soils have light-colored surface soils, a nearly white subsurface layer and an underlying compact, almost impervious clay. They are the terrace analogs of the Cherokee soils, and in places resemble the Parsons soils. They are associated with both of these soils but occupy terrace positions.

I. Soil Profile (Neosho silt loam):

	Horizon	Depth	Description	Range in Thickness
1.	A_1	0-6"	Very pale brown (10YR 7/2 dry) to brown (10YR 4/2 moist) faintly phylliform silt loam; medium to strongly acid.	4-8"
2.	A_2	6-14"	White (10YR 9/2 dry) to pale-brown (10YR 6/2 moist) massive to phylliform silt loam; strongly acid.	4-10"
3.	B_2-1	14-18"	Claypan horizon of grayish-brown (10YR 5/1 dry) to brown (10YR 4/2 moist) massive or prismatic clay, having yellowish-red (5 YR 4/6 moist) and yellowish-brown (10YR 4/6 moist) mottles; medium acid.	3-6"
4.	B_{2-2}	18-26"	Grayish-brown (10YR 5/1 dry* to very dark brown (10YR 2/2 moist) massive clay, slightly lighter colored and more mottled than horizon 3.	6-12"
5.	B_{2-3}	26-34"	Pale-brown (10YR 6/2 dry) to dark-brown (10YR 1/2 moist) massive clay, mottled as in 4; slightly acid.	8-16"
6.	C_1	34-42"	Very pale brown (10YR 7/3 dry) to pale-brown or yellowish-brown (10YR 6/3 or 5/4 moist) silty clay. This horizon is more highly mottled than horizons 4 and 5. Slightly acid to neutral.	6-10"
7.	C_2	42-60"	Lighter-colored, slightly lighter textured material than above. Stratified silt, fine sand, clay and occasional seams of gravel in deeper layers.	1 to many feet

II. Range in Characteristics: Variations are mainly in the thickness, percent and color of mottlings, and density of the claypan.

III. Topography: Nearly level.

IV. Drainage: External, slow to ponded; Internal, very slow.

V. Vegetation: Tall grasses.

VI. Use: A part of these soils is used for the production of native hay, wheat, other small grains, and to a less extent corn, grain sorghum, and flax are grown on the cultivated land.

VII. Distribution: Southeastern Kansas and adjacent parts of adjoining states.

Type Location: Cherokee County, Kansas.

Series established: Allen County, Kansas, 1904.

1/ Provisional Soil Survey color names, based on Munsell Color Charts.

TDR:FAH:MB
4/4/40
Rev. FAH:EBE:WHM
7-2-40
Rev. FAH
4/30-41
Rev. WIW:JT
5/23-46

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Established Series

NEWTONIA SERIES

The Newtonia series includes Reddish Prairie soils developed in clayey materials weathered from limestone and cherty limestone, intercallated with reddish shales. They are redder than the Labette soils and differ from Crawford soils in having granular less clayey subsoils.

Soil Profile:		Newtonia silt loam	Range in Thickness
A_1-1	0-5"	Reddish-brown (5YR 5/4 dry or moist) weakly granular, friable silt loam; slightly to medium acid.	5-8"
A_1-2	5-9"	Reddish-yellow (5YR 6/6 dry) to dark reddish-brown (5YR 3/3 moist) friable granular silt loam or light silty clay loam; slightly acid.	3-8"
B_1	9-18"	Reddish-brown (5YR 4/4 dry) to dark reddish-brown (5YR 3/4 moist) friable granular silty clay loam; slightly acid.	6-10"
B_2	18-36"	Red (2.5YR 5/6 dry to 2.5YR 3/6 moist) granular silty clay loam, containing a few fragments of limestone or chert below a depth of about two feet, slightly acid.	12-24"
	36"+	Intercallated limestone or cherty limestone and shales.	

Range in Characteristics: The depth of bedrock may vary somewhat more than indicated in the profile description. Bedrock may lie as deep as 8 feet below the surface and locally may be somewhat less than 20 inches and may be limestone, cherty limestone, or limestone intercallated with marl, clay, or shales, In the latter case, shallow phases are recognized. In many places, the uppermost 2 horizons have been eroded away.

Topography: Undulating and gently rolling uplands.

Drainage: External, moderate to rapid; internal, moderate to rapid. These soils have a tendency to be droughty, especially the shallower members.

Vegetation: Dominantly tall prairie grasses; some broadleafed timber in places.

Use: For producing corn, small grains, clover, cotton, and apples.

Distribution: Western Missouri and eastern parts of Kansas and Oklahoma, and northwestern Arkansas.

Type Location: Lawrence County, Missouri.

Series Established: Lawrence County, Missouri, 1923.

Remarks: Newtonia soils occur in the warmer parts of the Prairie soils, as well as in the Reddish Prairie soils zone.

1/ Provisional Soil Survey color names, based on Munsell color charts.

FAH:MB
3-18-40
Rev. FAH
4-30-41
Rev. WIW:JT
5-30-46
Rev. WIW:JT
6-29-46

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NOBLE SERIES

The Noble series is of well-drained Alluvial soils characterized by (1) reddish colors, free permeability, and moderately coarse to medium textures throughout the profiles, (2) a distinct A_1 horizon, (3) no developed texture profile or B horizon, (4) parent material of reddish noncalcareous moderately coarse to medium textured local alluvium from such soils are Darnell, Lucien and Zaneis and comparatively low in phosphorus, (5) position on footslopes, and (6) warm-temperate semihumid environment (Reddish Chestnut soils zone). Noble is similar in profile features to Reinach, from which it differs in topography and in having noncalcareous low-phosphorus parent material. It differs from Pulaski in having a more strongly developed A_1 horizon.

Soil Profile: Noble fine sandy loam

A_1	0-7"	Reddish-brown (5YR 5/3; 3/3, moist) fine sandy loam; moderate medium granular; very friable; freely permeable; neutral to slightly acid; grades indistinctly to horizon beneath. 6 to 12 inches thick.
AC	7-15"	Reddish-brown (2.5YR 5/4; 4/4, moist) fine sandy loam; very friable; freely permeable; weak medium granular to porous-massive; slightly acid to neutral; grades indistinctly to material beneath. 6 to 12 inches thick.
C	15-50"+	Red (10YR 5/6; 3/6, moist) fine sandy loam; porous-massive; very friable; slightly acid. This parent material is local alluvium from adjoining slopes of Darnell and Stephenville soil.

Range in Characteristics: The texture of both the surface soil and deeper layers is principally fine sandy loam but ranges to light loam and coarse silt loam. The range of dry color of surface soils is about hues of 2.5YR to 6.5YR, values of 4 to 5.5, chromas of 2.5 to 4. In cultivated areas the surface soil is little darker than the substrata. Overwash, eroded and gullied phases are prevalent. Intergrades to alluvial-fan phases of Teller are common.

Topography: Footslopes with gradients mostly 2 to 6 percent.

Drainage: Good. Rapid to moderate from the surface and internally. The areas lie above overflow from the nearby streams.

Vegetation: Mostly originally forested with post oak and blackjack. Some areas were tall-grass prairie.

Use: Areas of size sufficient for fields, either alone or in combination with adjoining areas of other arable soils, are largely in cultivation and devoted mainly to cotton, corn, alfalfa, and small grains. The soils is dought resistant and very responsive to management but of only moderate natural fertility. It is susceptible to gullying because of the combination of footslope position and friable substrata. Many areas formerly cropped are gullied and retired from cultivation.

Distribution: Numerous small areas, rarely more than 300 feet wide, on footslopes in the prairies and Cross Timbers of central Oklahoma mainly within the outcrop of the Garber and Stillwater sandstones of the Permian. Relatively inextensive.

Remarks: The series name is from a village in Cleveland County, Oklahoma, where the series was first proposed. Except where otherwise specified, colors refer to dry soil.

Type location: Logan County, Oklahoma- 1/4 mile south of NE corner section 25, T17N, R1E.

Series established: Logan County, Oklahoma (survey of Lake Guthrie Watershed), 1938.

EDF-MB 4-15-39
EHT Rev. 5-2-48
EHT Rev. 8-18-52

Division of Survey - BPISAE
ARA - U.S. Department of Agriculture

Established Series

NORGE SERIES

The Norge series comprises freely drained Reddish Prairie Soils developed in calcareous or alkaline old alluvium in central Oklahoma and Texas. The catenal associates on calcareous alluvium are Lewisville, Payne, and Irving. The reddish subsoils of Norge contain more clay and are less friable than those of the Polo, Teller, Bastrop, and Vanoss series. The surface soil is darker than in the Travis Dougherty, and Milam soils which are associated Red Podzolic Soils.

Soil Profile:		Norge fine sandy loam	Range in Thickness
A	0-12"	Reddish-brown (5YR 4/4; 3/4, moist) fine sandy loam; weakly granular; friable; about neutral; grades to horizon below.	8-14"
B_2	12-38"	Red (2.5YR 4/6; 3.5/6, moist) sandy clay; massive to very weakly blocky; firm, very hard when dry; medium acid; grades to horizon below.	20-30"
C_1	38-60"	Yellowish-red (5YR 5/8; same color, moist) sandy clay; massive; porous; friable; very hard when dry; about neutral.	15-30"
C	60-100"+	Reddish-yellow (5YR 6/8); friable sandy earths of more or less stratified sandy clay and sandy loam; weakly calcareous with a few small concretions of $CaCO_3$.	

Range in Characteristics: Types range from fine sandy loam to clay loam; color of the surface soil ranges from brown to reddish-brown, and of horizon 2, from yellowish-red to red encompassing values of 4 to 5, hues of 2.5YR to 7.5YR, and chromas of 6 to 8; reaction of horizon 1 ranges from medium to slightly acid, and of horizon 3, from slightly acid to weakly alkaline; a few waterworn pebbles of quartz or quartzite usually occur in all horizons.

Topography: Nearly level to gently sloping erosional upland comprising remnants of old alluvial plains on stream divides; surfaces convex with gradients of 1 to 7%, dominantly 1 to 4.

Drainage: Moderate to rapid from the surface; moderate internally.

Vegetation: Originally mainly coarse grasses, mainly little bluestem. The less sloping areas are largely farmed to cotton, corn, sorghums, oats, peanuts, and sudan grass; some used for vegetable crops and fruits; of only moderate fertility but very responsive to management; very susceptible to erosion under usual cultural practices.

Distribution: Reddish Prairie sections of Oklahoma and Texas; dissected remnants of high stream terraces or alluvial plains; inextensive.

Type Location: McLennan County, Texas; 2 miles south of Waco on U. S. Highway 81, one mile south of highway circle.

Series Established: Grady County, (Washita Watershed Survey) Oklahoma, 1942.

Page 2--Norge Series

Remarks: The series name is from a village in Grady County, Oklahoma.

Colors are described with provisional Soil Survey color names (1946) and unless stated otherwise refer to dry soil.

EGF
5-8-40
Rev. WTC
2-27-41
Rev. HO:EHT
8-22-46

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Established Series

OKEMAH SERIES

The Okemah series includes moderately well-drained, slightly acid soils that have dark, grayish, granular, silty A and B_1 horizons more than 16 inches thick over mottled olive-yellow and gray very compact clay. These soils are developed over olive and gray, mildly alkaline to slightly calcareous, weakly consolidated shales and clays, generally of the Pennsylvanian, in the more humid, eastern part of the zone of Reddish Prairie soils. The more closely related series include Dennis and Bonham, which are browner and have less compact,more silty lower subsoils; Parsons, Cherokee, Taloka, and LeFlore, which have less dark more acid A horizons resting abruptly on clay pans; Woodson, which has dark-gray subsoils and somewhat thinner and more clayey A horizons; and Bethany, which is neutral at shallower depth and has browner unmottled subsoils and reddish substrata. Areas adjoining bodies of Okemah soils generally are of the Woodson, Parsons, or Talihina series.

Soil Profile: Okemah silt loam

A_1	0-14"	Dark-gray (10YR 4/1; 2/2 moist) silt loam with weak to moderate granular structure. Friable; hard when dry. Slightly acid. 10-18" thick.
A_3	14-18"	Dark grayish-brown (10YR 4/2; 3/2 moist) silt loam slightly mottled with brown (10YR 5/3) which comprises no more than 3 to 5% of the mass; the aggregates have thin gray coatings (10YR 5/1); color of the soil crushed is grayish-brown (10YR 5/2) strong medium granular structure. Friable; hard when dry. Grades to horizon below. Slightly acid. 3-10" thick.
B_1	18-22"	Dark grayish-brown (10YR 4/2; 3/2 moist) silty clay loam mottled with light yellowish-brown (2.5YR 6/4) and strong brown (7.5YR 5/6); the mottles comprise about 10% of the mass. Compound medium subangular blocky and medium granular structure. Crumbly and friable when moist; moderately sticky and plastic wet. Grades to horizon below. Slightly acid to neutral. 3-7" thick.
B_2	22-38"	Mottled olive-yellow (2.5Y 6/6; 5/6 moist) and light gray (2.5Y 7/2; 5/2 moist) clay with weak blocky structure. Very compact; extremely hard when dry; very sticky and stiff when wet. Very slowly permeable. Grades to horizon below. Noncalcareous; mildly alkaline. 14-24" thick.
B_{22} or B_3	38-52"	Mottled light gray (2.5Y 7/2; 6/2 moist), olive-yellow (2.5Y 6/8; 7/6 moist), and brownish-yellow (10YR 6/5; 5/6 moist) clay. Massive, very compact and very slowly permeable. Grades to horizon below. Noncalcareous; mildly alkaline. 10-20" thick.
C	52-90"+	Mottled light gray (5Y 7/1; 6/2 moist) and brownish-yellow (10YR 6/8; 5/6 moist) clay. Massive; compact. A few small fragments of soft partly weathered sandstone are interbedded in the lower part. Medium alkaline but not calcareous. A few to numerous small iron oxide concretions are present in horizons 4 to 6.

Page 2--Okemah Series

Range in Characteristics: Silt loam is the strongly dominant type; color or horizon 1 ranges from very dark gray (10YR 3/1) in virgin areas to gray (10YR 5/1) in the plowed layer where cultivated; horizon 2 ranges from very dark grayish-brown (10YR 3/2) to grayish-brown (10YR 5/2) with or without slight mottling of brown; the gray coating of aggregates ranges from indistinct to pronounced. Horizon 3 ranges from clay loam to silty clay with mottling ranging from 5 to 15% of the mass. Horizons 4 and 5 range from mottled olive-yellow and light gray with or without brownish-yellow mottling to light olive gray with faint to strong mottling of olive-yellow and brownish-yellow. Small concretions of $CaCO_3$ occur erratically in horizons 5 and 6; thin seams or laminae of calcareous light gray clay of soft sandstone occur in the lower subsoil and substratum. The upper surface of the heavy compact subsoil, horizon 4, is wavy or undulating in places and its depth below the surface ranges from 16 to 30 inches within a distance of 12 to 15 feet.

Topography: Nearly level to gently sloping erosional upland; surfaces weakly convex to plane; gradients range from 1 to 4% but are dominantly 1 to 3.

Drainage: Slow to moderate from the surface; very slow internally. Adequate for all crops commonly grown including alfalfa. Temporary perched water table occurs immediately above horizon 4 during extremely wet periods.

Vegetation: Thick cover of tall grasses, mainly bluestems.

Use: Mainly cultivated; principal crops are corn, cotton, and small grains; moderately fertile and productive; small areas are native prairie meadows.

Distribution: Northeastern Oklahoma and probably southeastern Kansas in the northern part of the Reddish Prairie soil zone.

Remarks: Unless stated otherwise, color descriptions refer to dry soil.

Type Location: Okfuskee County, Oklahoma, NE NW NE Section 31, T11N, R10E, 3 miles southeast of Okemah.

Series Established: Okfuskee County, Oklahoma, June 1, 1948.

HO:JT:EHT
7-8-49

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Agricultural Research Administration
U. S. Department of Agriculture

Draft: Subject to
Review and Approval
(HTO:10-3-63)

Tentative Series

OST SERIES

The Ost series comprises Chernozems with brownish moderately clayey Bt horizons and having substrata containing some 30 to 80 percent of whitish masses of impure $CaCO_3$. These parent sediments are calcified, highly calcareous, old alluvium (plains sediments) and of texture ranging from loam to light clay. The Ost soils have distinct textural horizonation and are noncalcareous in the A and upper B horizons; the associated Clark soils lack textural horizonation and are calcareous within 12 inches of the surface. The Bethany and Tabler soils are without the conspicuous whitish masses of $CaCO_3$ and are noncalcareous to greater depths than the Ost soils.

Soil Profile: Ost clay loam (Unless specified as moist, colors are dry.)

A1 0-10" Dark grayish brown (10YR 4/2) clay loam; very dark brown (10YR 2/2) when moist; strong very fine granular structure; friable; neutral; gradual lower boundary. 6 to 14 inches thick.

B2t 10-26" Dark brown (7.5YR 4/3) heavy clay loam; 7.5YR 3/3 when moist; strong grading to moderate fine subangular blocky structure with continuous clay films; very hard; firm; neutral above 18 inches, calcareous with some 5% of whitish masses of impure $CaCO_3$ below 18 inches; gradual lower boundary. 10 to 30 inches thick.

B3ca 26-36" Subequal proportions of brown (7.5YR 5/3) heavy clay loam and whitish masses of impure $CaCO_3$; the fine earth has moderate fine subangular blocky structure with patchy clay films; very hard; firm; diffuse lower boundary. 5 to 15 inches thick.

Cca 36-60"+ Light brown (7.5YR 6/3) clay loam with some 30 percent of whitish masses of impure $CaCO_3$.

Range in Characteristics: Clay loam and loam are the principal types. The dry color of the A horizon ranges from very dark gray to grayish brown (dry values of 3/ to 5/, moist values 2/ to 3.5/, and chromas of 1/ to /25 in hues 7.5YR to 10YR) The texture of the B2t horizon ranges from clay loam or silty clay loam to light clay (about 30 to 45% of clay); its dry color ranges from dark brown to brown and yellowish brown (dry values 3/ to 5.5/, moist values 2.5/ to 4/, and chromas of /2 to /4 in hues 7.5YR to 10YR), the dry color of the substrata ranges from light brown to pale brown and light reddish brown. Depth to calcareous soil mass ranges from 12 to 26 inches.

Topography: Nearly level, mostly plane to weakly concave surfaces in gently rolling erosional upland. The surface gradient is mostly less than 1% but ranges up to 3%.

Drainage and Permeability: Well drained with slowly permeable subsoil and substrata and ground water remaining more than 20 feet below the surface.

Vegetation: Originally mid-grass prairie probably dominated by little bluestem.

Page 2--Ost Series

Use: Mostly in cultivation, with winter wheat the principal crop.

Distribution: Parts of south-central Kansas and north-central Oklahoma having mean annual precipitation of 24 to 30 inches and mean annual temperature of 56 to 60° F. The total extent is of the order of 100,000 acres.

Series Proposed: Reno County, Kansas, May, 1960. The series name is from a former post office in that county.

Series Recommended for Establishment: Reno County, Kansas, 1963.

Type Location: Reno County, Kansas. 298 feet west and 197 feet south of the north quarter-corner of Sec. 6-T25S-R5W (about 7 miles south of Hutchinson).

HTO:10-3-63

National Cooperative Soil Survey
USA

Remarks: In the 7th Approximation Ost in Typic Argiustoll (5.630) mixed mineralogy, centering in clayey but including some fine loamy and some fine silty.

OWENS SERIES

The Owens series includes grayish-brown shallow calcareous soils developed from yellow and gray weakly calcareous shales under grass in the Reddish Chestnut soil zone. They are associated with Abilene soils which are more granular, of deeper development less calcareous, and less sloping and Vernon soils, which are developed on red beds.

I. Soil Profile: (Owens clay) — Range in Thickness

1. 0 to 8 inches: Grayish-brown (olive, moist) clay; moderate medium granular; crumbly and friable; very sticky and plastic; calcareous; grades into horizon below. — 5 to 14 in.

2. 8 to 24 inches: Yellowish-brown or olive clay; massive; very slowly permeable; very firm; very sticky and stiff; calcareous; contains small secretions of $CaCO_3$. — 10 to 24 in.

3. 24 inches, plus: Olive-yellow calcareous shaly clay which passes below into olive yellow and gray shale.

II. Range in Characteristics: Only the clay type has been recongized to date; color of the surface soil ranges from grayish brown to olive gray; in places the shale substrata contains thin layers of limestone.

III. Topography: Gentle to strong slopes of 2 to about 8 percent.

IV. Drainage: Rapid from the surface; very slow internally.

V. Vegetation: Short grasses, mainly buffalo, early mesquite, and grama, loto bush, prickly pear, tasajillo and agarite are abundant and a few small mesquite trees occur.

VI. Use: Mainly for pasture; carrying capacity is only moderate; small areas are farmed to general crops; low yeilds are obtained..

VII. Distribution: Rolling Plains of western Texas and southwestern Oklahoma in the reddish Chestnut zone; mainly on shales of the Pennsylvania; moderate extensive.

VIII. Remarks: Colors are approximate Provisional Soil Survey color names and refer to dry soil unless stated otherwise.

Type Location: Brown County, Texas, near Owens.

Series established: Brown County, Texas, 1938.

10-31-40
NTC
Revised: 6-4-46
EO:EHT

POND CREEK SERIES

The Pond Creek series comprises dark-brown well-drained very fertile grassland soils with dark-brown strongly granular permeable subsoils immaturely developed in reddish calcareous loess-like earths rich in phosphorus. The series occurs on broad well-drained flats in central north Oklahoma and adjacent parts of Kansas, within the coolest and driest part of the Reddish Chestnut soil zone and transitions to the Prairie, Chernosem, and Reddish Chestnut zones. Except for reaction, which is neutral, it has the characteristics of Prairie Soils. It is the darkest member, the least rapidly but well-drained member, of a partial catena comprising the Pond Creek, Grant, and Nash series. Pond Creek is very similar to St. Paul, its Reddish Chestnut analogue, but is noncalcareous to slightly greater depth and occurs under slightly more humid and somewhat cooler climate.

I. Soil Profile: (Pond Creek silt loam)

				Range in Thickness
1.	A_1	0-15"	Dark-brown (7.5YR 4/2; 2.5/2, moist) silt loam; strong medium granular; friable; grades to horizon beneath; about neutral.	9-20"
2.	B_2	15-22"	Dark-brown (7.5YR 4/2; 4/3, when crushed; 3/3, moist) silty clay loam; strong medium granular; friable; permeable; grades to horizon beneath; about neutral.	5-10"
3.	B_3	22-36"	Brown (7.5YR 4.5/3 4/3, moist) silty clay loam; weak medium blocky; friable; grades to horizon beneath; about neutral.	10-20"
4.	C_1	36-60"	Light-brown or light reddish brown silty clay loam; friable; mildly alkaline but noncalcareous.	20-40"
5.	C2	60-70"+	Light-brown to yellowish-red calcareous silty clay loam free of sand or grit detectable by field methods; commonly contains concretions of $CaCO_3$ below depths of 6 or 10 feet; probably is loess.	

II. Range in Characteristics: The silt loam probably is the only type; color of surface soil ranges from dark brown to very dark grayish brown; reaction of surface soil ranges from slightly acid to mildly alkaline; depth to calcareous material ranges between about 4 and 6 feet; in typical areas comprising transitions toward Tabler or Bethany layers of heavy, sometimes dark-colored, clay occur below 2 feet and probably represent buried soils covered with a thin mantle or loess; red soft silty shades (red beds) underlie most areas at depths more than 10 feet; some areas have substrata of old alluvium; the parent material may be any reddish calcareous silty earth rich in phosphorus and of appropriate mineralogical composition irrespective of whether it accumulated as loess, alluvium, or residuum from red beds.

III. Topography: Nearly level upland flats, some of which appear to be alluvial plains mantled with loess.

IV. Drainage: Slow from the surface, moderate internally; well drained for field crops.

V. Vegetation: Tall prairie grasses, mainly Andropogons.

VI. Use: Almost entirely in cultivation, very largely to winter wheat but some alfalfa, oats, corn, and sorghums are grown; very fertile and highly productive; the areas of this soil are prosperous agricultural communities and comprise choice cropland.

VII. Distribution: Prairies of west-central Oklahoma, north of the Cimmarron River, and northward into Kansas; in areas having annual precipitation of from about 27 to 33 inches and mean annual temperatures of less than about 60°F. Most areas are large, very uniform, to the east of and no more than 15 miles distant from sandy belts of Pratt and Tivoli soils that parallel the courses of the Cimmarron and other similar rivers with sandchoked channels.

VIII. Remarks: Formerly, these soils were interpreted as developed in residuum from silty red beds of the Permian.

The series name is from a town in southern Grant County, Oklahoma.

Type location: Alfalfa County, Oklahoma, 2 miles north of Carmen.

Series established: Grant County, Oklahoma.

EGF:MB
2-29-40
Revised: 5-5-48
EHT

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Established Series

PORT SERIES

The Port series comprises brown to dark reddish-brown noncalcareous Alluvial Soils with alkaline to calcareous subsoils ranging in texture from clay loams to silty clay. It occurs in flood plains, which are rarely to occasionally inundated, within the zones of Reddish Prairie and Reddish Chestnut Soils. The parent materials are of reddish calcareous silty alluvium from subhumid plains underlain in part by red beds and usually mostly from such soils as Tillman, Vernon, and Renfrow. Port soils have a weak color and reaction profile but no developed textural profile. The Reinach soils have more silty or sandy subsoils and are slightly less dark than Port. The Tipton soils, though somewhat youthful, are older than Port, lie above overflow, and have less reddish subsoils and have an evident, though weak textural profile. The Port series is closely related to Gowen but more reddish. It differs from Spur in having noncalcareous surface soil. Port soils are mostly developed in less alkaline materials than the Asa soils and generally are slightly more reddish.

Soil Profile:	Port silty clay loam	Range in Thickness
0-14"	Brown (7.5YR 4/3; 3/4, moist) silty clay loam; moderate medium granular; friable grades into horizon below; mildly alkaline but noncalcareous.	10-18"
14-30"	Brown (7.5YR 5/3; 4/3, moist) clay loam; moderate granular; friable and permeable; grades into horizon below; mildly alkaline.	12-30"
30-40"	Reddish-brown (5YR 5/4; 4/4, moist) clay loam, same structure and consistence as horizon 2; calcareous.	8-15"
40-60"	Similar to horizon 3 but strongly calcareous and having threads of segregated $CaCO_3$.	

Range in Characteristics: Clay loams and silt loams are the principal types but minor areas of very fine sandy loam and probably other types occur; surface soil ranges from dark brown to dark reddish-brown (hues of 7.5YR to 5YR) and is locally calcareous in recently inundated areas; horizons 2 and 3 range in color from brown or reddish-brown to yellowish-red and in texture from clay loams to silty clay; darkened horizons of buried soils at depths of 3 to 5 feet below surface are not uncommon.

Topography: Flood plains of streams having entrenched channels.

Drainage: Slow from the surface; moderate internally; rarely to occasionally inundated and then for relatively short periods; adequately drained for all crops, including alfalfa.

Vegetation: Originally deciduous forest; now mostly cleared and cultivated.

Use: Nearly all in cultivation and used mainly for cotton, alfalfa, corn, small grains, and sorghums; inherently very fertile, responsive to management, and highly productive.

Distribution: Central and western Oklahoma, Texas, and southern Kansas, in flood plains of streams that drain grasslands underlain by red beds; moderately extensive and economically important.

Type Location: Logan County, Oklahoma.

Series Established: Jackson County, Oklahoma, October, 1942.

Remarks: The series name is from a village in Washita County, Oklahoma. Prior to recognition of the Port series, these soils were generally classed as Portland. Colors are described with provisional Soil Survey colors and unless stated otherwise, refer to dry soil.

EGF
1-26-43
Rev. HO:EHT
3-5-48

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Established Series

POTTSVILLE SERIES

The Pottsville series include Lithosols of the Red and Yellow Podzolic region. These soils consist of material derived from acid thin-bedded shales and sandstones, and are associated with Enders, Conway, and Montevallo soils. The Enders and Conway series are both zonal soils developed from shale and have a much higher degree of horizon differentiation than that of the Pottsville soils. The Pottsville soils are derived from interbedded sandstones and shales, whereas the Montevallo soils are derived from thick beds of shales. Pottsville soils cover a large area but are low in value to agriculture.

Soil Profile:		Pottsville gravelly fine sandy loam	Range in Thickness
A_{00}, A_0	1-0"	Partially decomposed leaf litter.	
A_1	0-4"	Brown (10YR 5/3)1/) loose gravelly fine sandy loam.	
A_2	4-14"	Yellowish-brown (10YR 5/4) friable gravelly sandy loam, strongly acid.	4-16"
C	14"+	Partially weathered shale or sandstone, gradually grading into unweathered shale or sandstone.	

Range in Characteristics: The texture of the A_1 horizon ranges from stony sandy loam to silty clay loam with stone and sand particles inherited from former overlying sandstone strata. A faint B horizon may be present in some profiles, and where it does occur it ranges in texture from sandy clay loam to silty clay and in color from yellowish-brown to reddish-brown. The B horizon, where it does occur, is very thin. The C horizon is seldom thick, with total depth to bedrock commonly ranging from 8 to 20 inches. Reaction of the soil is from medium to strongly acid.

Topography: Undulating to steep (1 to 60 percent). Common gradient 10 percent.

Drainage: Surface drainage rapid to excessive. Internal drainage slow.

Vegetation: Blackjack oak, pine, hickory, post oak, prickly pear, cedar, huckleberry, hawthorne.

Use: Mainly in pasture and woodland; occasional areas are used for small grain, annual legumes, and cotton.

Distribution: Northern and western Arkansas, eastern Oklahoma, southern Missouri, eastern Tennessee, and northern Alabama.

Type Location: Pope County, Arkansas, near town of Pottsville.

Series Established: Pope County, Arkansas, 1938.

1/ Provisional soil color names by the 1946 Committee; color of soil moist unless otherwise stated.

Rev. ML-ILM
7-18-47

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PRATT SERIES

The Pratt series is of moderately-dark sandy grassland soils of about neutral reaction and having somewhat coherent subsoils that contain little or no more clay than the surface horizons. The parent materials are terrestrial, usually aeolian, somewhat arkosic sands that mantle broad areas along through-flowing rivers in the plains of western Kansas and Oklahoma. The series has many of the characteristics of Reddish Chestnut Soils but has little or no horizon of carbonate accumulation and no or only a very weak textural profile. It occurs associated with Reddish Chestnut, Reddish Prairie, Chestnut, and Chernozem Soils. Pratt soils seem to be relatively young soils developed in comparatively recent aeolian deposits. They are darker and less sandy than Tivoli and Derby, Which have loose incoherent very sandy subsoils. The Pratt series is darker and less reddish than Springer and Enterprise. It has sandier subsoils than Amarillo, Dalhart, Norge, and Vanoss, and is of coarser, less silty materials than Minco. The imperfectly drained associate of Pratt having mottled clayey subsoils is Carwile.

Soil Profile:		(Pratt fine sandy loam)	Range in Thickness
A_1	0-10"	Brown (7.5YR 4/2; 3/2, moist) fine sandy loam weak granular; very friable; slightly acid to neutral.	8-12"
B_2	10-25"	Brown (7.5YR 4.5/3; 4/3, moist) fine sandy loam containing slightly more clay than horizon 1; weak granular; friable; slightly sticky; slightly acid to neutral.	12-18"
B_3	25-40"	Brown (7.5YR 5/4; 4/4, moist) fine sandy loam slightly less dark than horizon 2; friable; neutral to mildly alkaline.	10-20"
C	40-60"+	Light-brown calcareous fine sandy loam becoming more sandy with depth.	

Range in Characteristics: The types range from fine sandy loam to loamy sands. Color of surface soil ranges from dark grayish brown to brown (hues 7.5YR to 10YR, values 3.5 to 4.5; chromas 2 to 3); the B horizons range from coherent loamy sands (mostly in loamy sand types) to sticky sandy loams or loam (mostly in sandy loam types). Color of the B_2 horizon ranges from brown to grayish brown or light brown; the B_3, from brown to light brown, light yellowish brown, or strong brown. Reaction of substrata below 5 feet ranges from calcareous to neutral (the latter prevailing in the more sandy types and the more humid portions of the series' range); their texture ranges from loamy sands to loam, sometimes with layers of fine gravel; their color varies from pale brown to strong brown and reddish yellow.

Topography: Undulating upland plains often of broad subdued dune configuration; gradients from about ½ to 5 percent.

Drainage: Free from the surface and internally.

Vegetation: Tall grasses, mainly Andropogons.

Use: Largely in cultivation, mainly to winter wheat and sorghums; moderately fertile, drought resistant and productive but susceptible to soil blowing.

Distribution: Plains of north-central and northwestern Oklahoma and southern Kansas; in the Reddish Chestnut, Reddish Prairie, Chestnut, and Chernozem soils zones; extensive.

Type Location: Woods County, Oklahoma; NW 1/4 of section 23, T. 23N., R. 13W.

Series established: Reconnoissance Soil Survey of Western Kansas, 1910.

Approved by Principal Soil Correlator
South Region TSC; 3/2/66

Established Series
Rev. JDN-GEW; 2/66

PULASKI SERIES

The Pulaski series is a member of a coarse loamy, siliceous, nonacid, thermic family of Entisols. Pulaski soils have brownish, moderately coarse textured A horizons and brownish to reddish, moderately coarse textured C horizons that have bedding planes.

Typifying Pedon: Pulaski fine sandy loam - cultivated (Colors are for dry conditions unless otherwise stated.)

Ap	0-7"	Reddish-brown (5YR 5/4) fine sandy loam; reddish-brown (5YR 4/4) moist; weak fine and very fine granular structure; very friable; soft; medium acid; clear smooth boundary. 6 to 10 inches thick.
A12	7-19"	Reddish-brown (5YR 5/4) fine sandy loam; reddish-brown (5YR 4/4) moist; weak fine and very fine granular structure; very friable; slightly hard; medium acid; gradual boundary. 4 to 20 inches thick.
C1	19-44"	Yellowish-red (5YR 5/6) fine sandy loam; yellowish-red (5YR 4/6) moist; structureless; very friable; slightly hard; thin strata of darker fine sandy loam in the lower part; slightly acid; gradual boundary. 16 to 36 inches thick.
C2	44-64"+	Reddish-yellow (5YR 6/6) fine sandy loam; yellowish-red (5YR 5/6) moist; structureless; very friable; slightly hard; contains thin strata of loamy fine sand; slightly acid.

Type Location: Lincoln County, Oklahoma. Six miles north and one mile east of Chandler. One-fourth mile north, 200 feet east, and 185 feet south of the southwest corner of Section 2, T15N, R4E.

Range in Characteristics: These soils are usually moist in some part of the upper 60 inches of the soil but are dry in some part for 90 to 135 days (cumulative) in most years. The average texture of the 10 to 40 inch control section is less than 18 percent clay, has more than 15 percent material coarser than very fine sand, and is finer than loamy fine sand. Textures average fine sandy loam but range to light loams. These soils have bedding planes within 50 inches of the surface and eratic particle size distribution with depth. The thickness of the A horizons range from 6 to 24 inches. The color ranges in value from 4 to 7 when dry and 3 to 5 when moist; in chromas of 3 to 6 in hues of 2.5YR to 10YR. When the color value is less than 5.5 when dry and 3.5 when moist, in chromas of 4 or less, and more than 10 inches thick, the organic matter content is less than 1 percent. The texture of the A horizon ranges from loamy fine sand to light loam but is mainly fine sandy loam. The reaction of the A horizon is medium acid to neutral. The color of the C horizons ranges from 5 to 7 in value when dry and 4 to 6 when moist, in chromas of 4 to 8, in hues 2.5YR to 10YR. Bedding planes are evident and darker and lighter colored strata of loamy sand to clay loam are present. Textures finer or coarser than those given for the average of the control section may occur at depths greater than 40 inches from the surface. The reaction is medium acid to neutral above 40 inches but may become alkaline at greater depths.

Competing Series and their Differentiae: These include Yahola, Port, Reinach, Canadian, Cleora, Ochlockonee, Noble, and Zavala. The Yahola soils are calcareous in all parts of the fine earth fraction between 10 and 20 inches. The Cleora, Port, Reinach, and Canadian soils have A1 horizons more than 10 inches thick that have dry color values less than 5.5 and moist color values less than 3.5, in chromas of 4 or less, and organic matter contents higher than 1 percent. The Port soils also have more than 18 percent clay, and the Reinach soils have less than 15 percent material coarser than very fine sand. The Cleora and Ochlockonee soils are dry in some part for less than 90 days (cumulative) in most years. The Ochlockonee soils are strongly acid. The Noble soils are similar in texture, reaction, and color, but have distinct A1 horizons and cambic horizons. The have no bedding planes within 50 inches and occur on footslopes. The Zavala soils are dry for more than 135 days (cumulative) in most years.

Setting: Pulaski soils occur on nearly level to gently sloping floodplains along small creeks and usually near the channel on larger creeks and rivers. Slopes are mainly less than 1 percent but range up to 5 percent. They are of slightly altered, moderately coarse textured sediments from soils under scrub oak vegetation (cross timbers). The Thornthwaite annual PE index is from about 33 to 64. The mean annual air temperature is from 57 to about 70 degrees.

Principal Associated Soils: These include Stephenville, Windthorst, Darnell, and Dougherty soils, as well as the competing Noble, Yahola, Port, and Reinach soils. The Darnell soils occur on uplands and are less than 20 inches thick over sandstone. The Stephenville, Windthorst, and Doutherty soils have argillic horizons.

Drainage and Permeability: Well drained. Moderately rapid permeability. Slow runoff.

Use and Vegetation: The native vegetation is bottomland hardwoods. Mostly cleared and used for cultivated crops and tame pastures.

Distribution and Extent: In the cross-timbers of Oklahoma and Texas and minor amounts in south central Kansas. The series is extensive.

Series Established: Lonoke County, Arkansas, 1921.

Remarks: The subgroup Udic Ustifluvents has been proposed for soils having characteristics of this series. The soils were formerly classified in the Alluvial Great Soil Group.

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QUINLAN SERIES

The Quinlan series comprises Lithosols developed from calcareous very weakly consolidated sandy or silty red beds, mainly of the Permian, in the warm-temperate subhumid grasslands of western Oklahoma and adjacent areas. It occurs mainly in the Reddish Chestnut soils zone in catenal association with Woodward, Carey, and St. Paul but to a lesser extent also in the western part of the Reddish Prairie soils zone in association with Grant and Nash. Quinlan soils are shallower than Woodward and Nash, have less clayey subsoils than Vernon and Weymouth, and differ from Lucien in being of Alkaline reaction and generally high in phosphorous.

I. Soil Profile (Quinlan very fine sandy loam): — Range in Thickness

				Range in Thickness
1.	A	0-15"	Reddish-brown (5YR 5/4) very fine sandy loam; weakly granular; very friable, calcareous; grades to underlying parent material.	10-20"
2.	C	15" +	Red calcareous very weakly consolidated fine-grained sandstone or packsand.	

II. Range in Characteristics: Color of soil ranges from reddish brown to light reddish brown or light red and commonly is slightly redder below 10 inches than above.

III. Topography: Erosional upland; mostly convex surfaces with gradients of 3 to 8% but ranging up to about 15.

IV. Drainage: Rapid from the surface and internally.

V. Vegetation: Grasses, mainly little bluestem and gramas.

VI. Use: Largely in native pasture which is of rather low carrying capacity but affords forage of excellent quality.

VII. Distribution: Western Oklahoma and Texas east of the High Plains; moderately extensive.

Type location: Woodward County, Oklahoma, near Quinlan.

Series established: Woodward County, Oklahoma, 1932.

VIII. Remarks: In the survey of Woodward County, where the series originated, the areas mapped as Quinlan include both shallow soils to which the series is now restricted and medium depth soils, for which the Woodward series has since been established.

Colors are approximate provisional Soil Survey color names and refer to dry soil.

EGF-MB
12-14-39
Rev. EHT
1-3-47

Division of Soil Survey
Bureau of Plant Industry, Soils,
and Agricultural Engineering
Agricultural Research Administration
U. S. Department of Agriculture

Established Series

REINACH SERIES

The Reinach series consists of somewhat reddish youthful soils with silty or only moderately sandy subsoils developed in calcareous reddish alluvium in the zones of Reddish Prairie and Reddish Chestnut soils. The soils occur on low terraces of streams that originate in and carry sediments mainly from subhumid plains that are largely underlain by Red Beds. The series is closely related to the Yahola series of the present flood plains but lies a few feet higher, above ordinary overflow, and has a slightly darkened generally noncalcareous surface layer. It differs from the Canadian, Dale, and Asa series mainly in being more reddish, has less sandy subsoils than Brazos, and has less dark surface soils and less clayey subsoils and free drainage than McLain and Kay.

Soil Profile: Reinach very fine sandy loam		Range in Thickness
0-18"	Reddish-brown (7.5YR 5/6; 4/6, moist) silt loam; moderate medium granular; very friable; slightly alkaline but noncalcareous; grades into horizon below.	12-20"
18-60"+	Yellowish-red (5YR 5/6; 4/6, moist) silt loam; weakly granular; very friable; calcareous.	0-20"

Range in Characteristics: Sandy loams and silt loams are predominant but other types occupy small areas; color of the surface soil ranges from brown (7.5YR 5/3) to dark reddish-brown (5YR 3/3) and of substrata from yellowish-red to reddish-brown or light brown; reaction of horizons 1 and 2 ranges from neutral to calcareous.

Topography: Nearly level low stream terraces lying a few feet above present flood plains.

Drainage: Moderate to rapid from the surface and internally; some low terraces are inundated once in 10 to 25 years.

Vegetation: Prairie grasses with scattered mesquite and elm trees in more western parts; forested with elm, hackberry, oaks, and hickory in the humid region.

Use: Largely cultivated and used for growing corn, alfalfa, small grains, cotton, and sorghums, generally with high yields.

Distribution: Oklahoma and central and northern Texas in valleys of streams, such as the Red, Canadian, and Brazos Rivers, that drain western plains partly underlain by Red Beds.

Type Location: Muskogee County, Oklahoma.

Series Established: Muskogee County, Oklahoma, 1913.

Remarks: Color terms are provisional Soil Survey color names based on Munsell Color Charts and refer to dry soil.

EGF:FAH:MB
4-22-40
Revised: HO:EHT
4-7-46
Revised: EHT
6-16-47

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Established Series

RENFROW SERIES

The Renfrow series includes normal Reddish Prairie soils developed from weakly calcareous clayey Red Beds. The principal associated series are Kirkland and Tabler, which are Planosols; Vernon, a Lithosol; and Nash, which is developed on less clayey Red Beds and has a more friable subsoil.

Soil Profile:	Renfrow silt loam	Range in Thickness
0-6"	Reddish-brown; (5YR 5/4; dark reddish-brown 5YR 3/4, moist) silt loam; weak medium granular; friable; neutral to slightly acid; grades into horizon below.	5-8"
6-10"	Reddish-brown (5YR 5/4; dark reddish-brown 5YR 3/3, moist) silty clay loam; weakly prismatic; friable; hard when dry; neutral; passes abruptly into horizon below.	3-7"
10-26"	Reddish-brown (2.5YR 5/4; 4/4, moist) clay; weak medium blocky; firm to very firm; very hard when dry; slightly alkaline; grades into horizon below.	12-20"
26-38"	Red (2.5YR 5/6; 4/6, moist) clay massive, slowly permeable; firm to very firm; very hard when dry; slightly alkaline to calcareous.	8-15"
38-50"+	Red (2.5YR 5/6) slightly calcareous clay grades into slightly calcareous red shale at depths of 3 to 5 feet.	

Range in Characteristics: Clay loams and silt loams are the principal types but small areas of clay and fine sandy loam occur; color of the surface and subsurface layers ranges from brown to dark reddish-brown; horizon 3 and 4 are calcareous where the substratum is strongly calcareous; locally the clay type is calcareous throughout.

Topography: Undulating erosional upland with gradients of about 2 to 7 percent, dominantly 2 to 4.

Drainage: Moderate to rapid from the surface; very slow internally.

Vegetation: Originally of tall prairie grasses, dominantly bluestems (*Andropogon* spp.) grama and buffalo grasses are predominant in pastures.

Use: Largely cultivated; wheat is the principal crop, but sorghums, oats, and Sudan grass are grown; moderately productive.

Distribution: Reddish Prairie sections of southern Kansas, Oklahoma, and central-northern Texas; very extensive.

Remarks: Color terms are Provisional Soil Survey color names based on Munsell Color Charts and unless stated otherwise, refer to dry soil.

Type Location: Garfield County, Oklahoma.

Series Established: Grant County, Oklahoma, 1931.

Rev. HO:EHT
6-7-46

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ROEBUCK SERIES

The Roebuck series comprises poorly-drained, reddish-brown, calcareous Alluvial Soils with mottled clay subsoils. It is largely confined to sloughs, or abandoned stream channels, within the Reddish Prairie and western or drier part of the Redland Yellow Podzolic soil zones. These soils consist of only slightly modified alluvium of rivers that drain prairie and subhumid grasslands in central and western Oklahoma, Texas, and Kansas, that are underlain by red beds. The principal associated series are Miller, which is better drained and has red unmottled subsoils, and Yahola and Norwood, which have friable permeable subsoils. Roebuck soils are more youthful than Portland, have calcareous less darkened surface soils, and for the most part occur in areas of lower rainfall.

Soil Profile: Roebuck clay

0-10"	Reddish-brown (5YR 4/3; 3/4, moist) clay; strong medium granular; crumbly and friable; calcareous, 6 to 15 inches thick.
10-26"	Reddish-brown (5YR 5/4; 4/4, moist) clay faintly mottled with other shades of brown; massive; slowly permeable; very sticky and very plastic when wet; weakly stratified with layers of dark material in the lower part; calcareous. 10 to 20 inches thick.
26-45"+	Reddish-brown calcareous clay stratified with grayish-brown clay loam.

Range in Characteristics: The clay is the principal type; color of the surface soil ranges from brown to reddish brown (hues of 7.5YR to 2.5YR); layer 2 is reddish-brown clay mottled with grayish brown and brown or weakly stratified reddish-brown clay and grayish-brown clay loam and silt loam over reddish-brown calcareous clay; there are minor areas of Roebuck developed in alkaline but noncalcareous alluvium and in these the soil material is noncalcareous.

Topography: Depressed areas and partly filled abandoned channels in flood plains.

Drainage: Very slow from the surface and internally; inadequate for crop production; during wet seasons water stands on the surface for many weeks.

Vegetation: Forested with elm, hackberry, oak, willow, ash, and cottonwood.

Use: Largely in forest but some areas cleared and drained and used for producting corn, cotton, sorghums; naturally unsuited for cropland but highly productive if drained and protected from overflow.

Distribution: Depressed small areas in flood plains of such rivers as the Brazos, Red, and Canadian Rivers that carry sediments from the western plains; not extensive.

Type Location: Choctaw County, Oklahoma.

Series Established: Choctaw County, Oklahoma, 1940.

VIII. Remarks: In earlier surveys these soils were included in the Portland and Miller series.

Color terms are approximate provisional Soil Survey colors and refer to dry soil.

Type location: Choctaw County, Oklahoma.

Series established: Choctaw County, Oklahoma, 1940.

EGF
2-29-40
Revised: 3-12-48
HO:EHT

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SHELLABARGER SERIES

The Shellabarger series includes well-drained, moderately fine-textured, moderately developed Prairie soils ("Brunizems") forming in loamy eolian deposits in the tension zone between Prairie soils and Chernozems in Kansas and possibly adjoining states. These soils occur mostly as small patches on undulating and rolling hills bordering terraces of the major river valleys. They have dark colored, friable, granular, loamy A horizons; brown, prismatic, friable, clay loam or sandy clay loam B horizons; and friable, massive, non-calcareous sandy loam substrata. Geographic associates of the Shellabarger soils are members of the Geary, Smolan and Niles series. Shellabarger soils closely resemble the Geary soils in most profile features but differ in having significant quantities of sand in nearly all horizons, particularly in the B and C horizons. Smolan and Niles soils are unlike the Shellabarger series in both profile features and parent material. Shellabrager soil profiles resemble those of the proposed Corbin series but have grayer (less brown) A horizons and coarser-textured substrata. Furthermore, Corbin soils are developing in what appears to be alluvial or residual rather than eolian deposits.

Soil Profile: Shellabarger loam

A_1	0-12"	Dark-gray to very dark-gray (10YR 4/1 dry; 3/1 moist) loam; soft, friable; weak very fine granular structure; neutral; clear lower boundary; 7 to 14 inches thick.
A_3	12-18"	Dark-gray to very dark-gray (10YR 4/1.5 dry; 3/1.5 moist) loam; soft, friable; weak fine granular loam; mildly alkaline; clear lower boundary; 4 to 9 inches thick.
B_1	18-24"	Dark-brown (7.5YR 4/2 dry; 3/2 moist) loam; soft, friable; weak medium and coarse prismatic structure that breaks to weak fine and very fine subangular blocks; slightly acid; gradual boundary; 4 to 8 inches thick.
B_2	24-34"	Inconspicuously mottled brown and dark-brown (7.5YR 5/4 and 4/2 dry) to dark-brown (7.5YR 4/3 and 3/2 moist) sandy clay loam; slightly hard; friable; weak medium and coarse prismatic structure that breaks to irregular clods and finally to moderate very fine subangular blocks; slightly acid; gradual boundary; 6 to 12 inches thick.
C_1	38-48"	Brown to dark-brown (7.5YR 5/4 dry; 4/3 moist) heavy sandy loam; soft, friable; massive; slightly acid; gradual boundary; 10 to 15 inches thick.
C_2	48-60"	Reddish-yellow to dark-brown (7.5YR 6/5 dry; 4/4 moist) sandy loam; friable; massive; slightly acid; few to many feet thick.

Range in Characteristics: The color of B and C horizons varies slightly, but is generally of hue 7.5YR. Loam, fine sandy loam and silt loam types have been recognized. Level, undulating, rolling, eroded and severely eroded phases have been mapped.

Topography: Undulating to rolling upland. Dominant slope gradients are 2 to 6 percent.

Drainage: Well drained. Runoff is medium to rapid; permeability, moderate.

Vegetation: Moderate cover of tall and short grasses, the former predominating. Principal species are blue grama, bluestems, creep lovegrass and dropseed grasses.

Use: Most areas of this soil are devoted to pasture, but some with favorable topography are used for wheat, corn and grain sorghums.

Distribution: Mainly in eastern Kansas, but possibly in adjoining states.

Type Location: 1/3 mile S, 1/5 mile W of NE corner, Sec. 10, T13S, R1W, Saline County, Kansas.

Series Established: Saline County, Kansas, 1952. The name is taken from Shellabarger Mills in Saline County, Kansas.

WMJ:AJC 4-10-54
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(reproduced by the Oklahoma Highway Department, Research Section).

Established Series

SOGN SERIES

The Sogn series comprises the dark colored, calcareous to neutral loamy Lithosols very shallow over limestone within the prairies of the central United States north of the Arbuckle uplift in southern Oklahoma. Outcrops of limestone are common in bodies of Sogn soils. The series is darker and more humid than Penrose and Laporte series (light colored semiarid Lithosols); slightly darker and higher in organic matter than Tarrant series (a more southern, warmer climate counterpart of Sogn series, difficulty distinguishable on profile); less clayey and shallower to limestone than Snead series (clayey regosolic Brunizems developed in humid prairie-forest transition over shale with subordinate interbedded limestone). The comparable series for regosolic Chernozems over highly calcareous friable marine marl or "shale" is Kipson. From Nebraska southward the deeper soils associated with Sogn series are mostly of the Labette, Summit, Newtonia, Florence, Dennis, Irwin, Okemah, and Tully series; to the north the Dodgeville and Ruckton series are the common associates. All of these associated deeper series have distinct B horizons, except the Rockton soils, formed in a shallow mantle of glacial drift over residuum from limestone.

Soil Profile: Sogn rocky clay loam--virgin

A_1 0-7" Very dark grayish-brown (10YR 3/2) clay loam, very dark brown (10YR 2/2) moist; strong medium and fine granular structure; friable; calcareous; abrupt irregular boundary. 2 to 15 inches thick.

D_r 7-60" Somewhat weathered, level-bedded earthy limestone having clayey partings and interrupted by vertical weathering joints, which average about a foot apart. Extensions of the dark colored A horizon fill crevices in the bedrock to about 15 inches but comprise less than 5 percent of the volume. A few grass roots penetrate crevices to depths below 6 feet.

Range in Characteristics: The dry color of the A horizon ranges from nearly black to grayish-brown (dry values of 2.5/ to 5/; moist values of 1.5/ to 3.5/; chromas mostly about /2 but locally approaching /1.) Its texture ranges from loam and silt loam to heavy clay loam or silty clay loam with or without limestone fragments. Its reaction ranges from strongly calcareous to noncalcareous but about neutral. The bedrock ranges from earthy or chalky marine limestone generally interbedded with calcareous "clay" or "shale" to dense massive limestone. The change from A horizon to bedrock ranges from gradual and smooth (mostly where the bedrock is more earthy or least consolidated) to quite abrupt and very irregular (mostly on the denser, more resistant limestones). Thickness of the A horizon may range from 2 to 15 inches in an area with a radius of 10 feet.

Topography: Undulating to hilly erosional upland. Mostly convex surfaces of 2 to 15 percent gradient but ranging up to more than 35%. On the stronger slopes, Sogn soils are generally concentrated toward the crests, the lower halves of the slopes being mostly of deep soils in colluvium or marine "clays" that underlie the limestone.

Drainage and Permeability: Moderate to rapid from the surface; rapid internally. Well drained in the sense of no ground-water table ever within the soil. Moisture-storage capacity is limited by the small volume of soil per unit area. Root distribution and the survival of native vegetation through protracted drouths indicate considerable storage of available moisture in the bedrock.

Vegetation: Originally mostly treeless prairie with little bluestem and side-oats grama as the two dominant grasses. Considerable overstory of sumac, buck brush, or other deciduous woody shrubs in many areas, especially those on strong slopes or underlain by dense limestone. Savannah of scattered deciduous trees surmounting tall grass in most areas within generally forested localities. Some in the most humid localities originally supported an open-canopied, somewhat dwarfed, deciduous forest.

Use: Mostly native range or unimproved pasture. These soils are not tillable with ordinary implements and are generally classed as nonarable.

Distribution: Northeastern Oklahoma to southwestern Wisconsin. Extensive in Kansas and Oklahoma, where the total area is of the order of 1,000,000 acres. Scattered, mostly small areas in Wisconsin, Minnesota, Missouri, Illinois, and eastern Nebraska.

Series Established: Goodhue County, Minnesota, 1913. (Series name is from a hamlet in that county.)

Type Location: Geary County, Kansas; 75 feet east of the northwest corner Section 15, T12S, R7E.

Rev. EHT-AHP-JKA
2-23-60

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Approved by Principal Soil Correlator
South Region TSC: 6/2/66

Established Series
Rev. NTO-DGB-JDN: 5/2/66

STEPHENVILLE SERIES

The Stephenville series is a member of a fine loamy, mixed, thermic family of Udultic Haplustalfs. Typically, these soils have brown, moderately coarse textured upper A horizons and light brown, moderately coarse textured lower A horizons with reddish, moderately fine textured B2t horizons. Slightly acid reddish sandstone occurs at about 34 inches.

Typifying Pedon: Stephenville fine sandy loam - rangeland
(Colors for dry conditions unless otherwise noted.)

A1 0-4" Brown (7.5YR 5/2) fine sandy loam; dark brown (7.5YR 4/2) when moist; weak fine granular structure; slightly hard; very friable; medium acid; gradual smooth boundary. 3 to 7 inches thick.

A2 4-12" Light brown (7.5YR 6/3) fine sandy loam; brown (7.5YR 5/3) when moist; massive; soft; very friable; medium acid; clear smooth boundary. 3 to 13 inches thick.

B21t 12-22" Yellowish-red (5YR 5/6) sandy clay loam; yellowish-red (5YR 4/6) when moist; weak medium subangular blocky structure; very hard; friable; clay films on ped faces and bridging sand grains; medium acid; diffuse smooth boundary. 4 to 18 inches thick.

B22t 22-34" Red (2.5YR 5/6) light sandy clay loam; red (2.5YR 4/6) when moist; weak coarse subangular blocky structure; very hard; friable; clay films bridging the sand grains; medium acid; abrupt irregular boundary. 4 to 18 inches thick.

R 34-40"+ Light red (2.5YR 6/6) slightly acid sandstone.

Type Location: Oklahoma County, Oklahoma. 2400 feet west and 400 feet north of the southeast corner of Section 25, T11N, R1E. About 7 miles south of Harrah.

Range in Characteristics: These soils are usually moist in some part of the upper 60 inches of the soil but are dry in some part for 90 to 135 days (cumulative) in most years. The reaction of all horizons range from slightly acid to strongly acid. Thickness of the A horizons range from 6 to 20 inches. The color of the A1 horizon ranges in hues 7.5YR and 10YR with dry values of 4 to 6; moist values 3 to 5; and chromas of 2 and 3. They have an A1 horizon having a moist color value not so dark as 3.5 or not containing more than 1.2 percent organic matter in the upper 4 inches. The texture of the A1 horizon is mainly fine sandy loam but loamy fine sands occur. The color of the A2 horizon ranges in hues 5YR to 10YR with dry values of 5 to 7; moist values 4 to 6; and chromas of 2 to 4. The texture of the A2 horizon is mainly fine sandy loam but loamy fine sands occur. The color of the B2t horizons range in hues 2.5YR to 7.5YR with dry values of 4 to 6; moist values 3 to 5; chromas of 4 to 8. The texture of the B2t horizons range from sandy clay loam to heavy fine sandy loam with clay content of 18 to 35 percent. The depth to sandstone ranges from 20 to 48 inches. The sandstone is hard to extremely hard when dry and on wetting it may be extremely resistant to pressure or range to weakly resistant to pressure.

Competing Series and their Differentiae: These include the Konawa, Linker, Cobb, and Windthorst soils. The Konawa soils are thicker than 48 inches. The Linker soils are typically strongly acid. They have a base saturation of less than 35 percent in some part of the argillic horizon. The Cobb soils have Al horizons more than 6 inches thick that have dry color values less than 5.5 and moist color values less than 3.5. The Windthorst soils have more than 35 percent clay in the upper 20 inches of the argillic horizon.

Setting: The Stephenville soils occur on nearly level to gently rolling erosional uplands and are developed on neutral to slightly acid sandstone. The slopes are dominantly of gradients between 1 to 5 percent but range to about 10 percent. The climate is subhumid to moist subhumid. At the type location, the average annual precipitation is about 33 inches and the mean annual temperature about 61° F. The Thornthwaite P-E index in the area of occurrence is from 44 to 64 and the mean annual air temperature from 57° F. to about 70° F.

Principal Associated Soils: These include the Konawa, Darnell, Windthorst, and Dougherty series. The Darnell soils are less than 20 inches thick over sandstone. The Dougherty soils have combined A horizons, more than 20 inches thick, of loamy fine sand or coarser and are thicker than 48 inches.

Drainage and Permeability: Well drained. Moderate permeability. Runoff is slow to medium.

Use and Vegetation: Areas on slopes of less than 5 percent are largely in cultivation with sorghums, small grains and peanuts as the main crops. The native vegetation is mainly postoak, blackjack, hickory, and elm with considerable understory of little bluestem, Indiangrass, and other grasses.

Distribution and Extent: Central and eastern Oklahoma, north central Texas, and southeastern Kansas. This series is of large extent.

Series Established: Erath County, Texas, about 1921.

Remarks: The Stephenville was formerly classified in the Red and Yellow Podzolic Great Soil Group.

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USA

STIDHAM SERIES

The Stidham series includes well-drained Yellow Podzolic Soils with friable subsoils developed on neutral to alkaline sandy alluvium of rivers that drain subhumid plains. The series closely resembles Bowie, from which it differs principally in that the parent material is old alluvium from grasslands, nonacid in reaction, and usually somewhat reddish owing to admixture of sediments from red beds. The Stidham series differs from Dougherty, with which it is catenally associated in having a yellow upper subsoil and a coarsely mottled or splotched yellow and red lower subsoil.

Soil Profile: Stidham fine sandy loam

A_1	0-3"	Pale brown (10YR 6/3; 5/3, moist) light fine sandy loam; weakly granular; very friable; slightly acid; grades to horizon below. 2 to 5 inches thick
A_2	3-14"	Very pale brown (10YR 7/4; 6/5, moist) light fine sandy loam; massive; porous; friable; slightly acid; grades to horizon below. 10 to 15 inches thick
B_{21}	14-20"	Yellow (10YR 7/6; yellowish-brown 10YR 5/6, moist) sandy clay loam; weakly blocky porous; friable; hard when dry; strongly acid; grades to horizon below. 4 to 12 inches thick
B_{22}	20-36"	Yellow sandy clay coarsely mottled or splotched with yellowish red; friable; blocky, the exteriors of the blocks being yellow or yellowish brown; strongly acid; grades indistinctly to horizon below. 15 to 30 inches thick
C_1	36-45"+	Similar but slightly more sandy (a heavy sandy clay loam) and only slightly acid, becoming alkaline below 4 feet, and weakly calcareous below 10 or 15 feet.

Range in Characteristics: Fine sandy loam and loamy fine sand are the principal types, the loamy fine sand having a thicker A horizon, usually more than 15 inches deep over layer 3; in cultivated areas the A_1 is light brownish gray to plow depth; reaction of the A horizon ranges from acid to neutral; the subsoil ranges from brownish yellow to yellowish brown and from sandy clay loam to light sandy clay; some reddish brown splotches may occur in the lower subsoil or substratum; in many areas the substratum below about 4 feet is mottled light gray and yellow fine sandy loam or loam.

Topography: Undulating to nearly level old stream terraces lying 40 to 80 feet above the present flood plains; the modal gradient is from about 1 to 4 percent.

Drainage: Moderate to rapid from the surface; moderate internally.

Vegetation: Originally mainly post oak, blackjack, red oak, and hickory with some coarse grasses.

Use: Largely cleared and used for growing corn, cotton, sorghums, and peanuts; fertility is low but soil is very responsive to management.

Distribution: Southern and eastern Oklahoma and adjoining States; on old high dissected terraces along such streams as the Red and Arkansas Rivers, which drain subhumid and semiarid grasslands partly underlain by red beds.

Remarks: The deep sands formerly included in the Stidham series as sand types are now classed as Eufaula.

Colors are described with provisional Soil Survey Color Names (1947) and unless stated otherwise refer to dry soil.

Type location: Pontotoc County, Oklahoma.

Series Established: McIntosh County, Oklahoma, 1935.

WTC:MB 3-18-39
Rev. HO:EHT 3-5-48
Mimeo. Sept. 1960

National Cooperative Soil Survey
USA

Established Series

SUMMIT SERIES

The Summit series includes very dark granular soils developed from limestone residuum and soft calcareous shales in the Prairie and Reddish Prairie soils zones. These soils may be considered to be Rendzinas. They differ from those of the Labette series in having darker surface layers and heavier subsoils which are very dark grayish-brown or almost black in the upper part, whereas the corresponding part of the Labette soils is reddish-brown. They differ from Woodson soils in having deeper and more granular surface soils and no claypan.

Soil Profile: Summit silty clay		Range in Thickness
0-2"	Very dark olive-gray 1/ (5.0Y 3/1 dry) to black (5.0Y 2/1 moist) silty clay of fine crumb structure; slightly acid to neutral.	2-3"
2-10"	Very dark olive-gray (5.0Y 3/1 dry) to black (5.0Y 2/1 moist) granular silty clay, slightly acid.	8-12"
10-16"	Dark grayish-brown (2.5Y 3/2 dry) to a dark brown (10YR 3/2 moist), coarse granular cloddy silty clay; a few rust-brown pellets in places; slightly acid to neutral.	6-8"
16-22"	Dark grayish-brown (2.5Y 3/2 dry) to dark brown (10YR 3/2 moist) silty clay or clay with a blocky structure; neutral or slightly alkaline.	4-8"
22-40"	Olive-gray (5.0Y 5/2 dry) to dark grayish-brown (2.5Y 4/2 moist) massive or blocky clay which rests on disintegrated limestone or calcareous shale.	8-20"

Range in Characteristics: Thickness of the dark surface layer and depth to bedrock are variable. A few lime carbonate nodules may occur below 30 inches.

Topography: Undulating or rolling uplands. Some of these soils occupy colluvial slopes.

Drainage: Surface runoff, medium to high; permeability, moderate to slow.

Vegetation: Prairie grasses, with bluestems dominate.

Use: These soils are very productive and are used for growing all important crops common to the region of their occurrences. Some areas remain in native pastures.
Distribution: Eastern Oklahoma, southeastern Kansas, and southwestern Missouri.
Type Location: Tulsa County, Oklahoma.
Series Established: Bates County, Missouri, 1908.
1/ Provisional soil color names proposed by the 1946 committee; color of soil dry unless otherwise stated. Symbols express Munsell notations.

EGF:MB
2-8-40
Rev. FAH:EBE:WHM
7-3-40
Rev. WIW
6-25-46

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TABLER SERIES

The Tabler series comprises very slowly drained soils with dark, grayish claypans. It is developed from somewhat calcareous clays or other finer textured earths in the zone of Reddish Prairie Soils. The parent material may be alluvial or eolian mantle, or residuum from red beds or other shales, but is confined to clays, clastics which form much clay upon weathering, that are comparatively rich in phosphorus and other elements needed by plants. Tabler soils are grayer and have darker subsoils than Kirkland and Renfrow, which occupy less level areas. Associated Lithosols on red beds are of the Vernon series. The Tabler series is rather closely related to the Wilson and Woodson series but is developed in somewhat different parent material. In addition, Tabler occurs under cooler or drier climate than the Wilson, and is restricted to areas west and north of the Grand Prairie of Texas.

Soil Profile: Tabler silt loam

A_1 0-10" Dark-gray (10YR 4/1; 3/1, moist) silt loam; moderate medium granular; friable; medium acid; grades indistinctly to horizon beneath. 6 to 12 inches thick.

A_2 10-12" Similar to horizon 1 except that aggregates are faintly coated with indistinct films of gray or light gray; passes shortly to horizon beneath. 0 to 4 inches thick.

B_2 12-30" Very dark gray (10YR 3/1; 2/1, moist) heavy clay; weak coarse blocky; very firm and compact; extremely hard when dry; very slowly permeable when moist; aggregates are varnished or coated with shiny films; grades indistinctly to horizon beneath; medium acid above becoming neutral below. 15 to 25 inches thick

B_3 30-50" Dark-gray (10YR 4/1.5; 3/2, moist) heavy clay; nearly massive; very compact; slightly mottled with brown and yellowish brown; fine earth is noncalcareous but horizon contains scattered hard concretions of $CaCO_3$, which have pitted or "solution" surfaces; mildly alkaline. 12 to 20 inches thick.

C_1 50-70" Brown (7.5YR 4/2) noncalcareous or weakly calcareous clay slightly mottled or streaked with grayish and reddish brown; contains a few very dark brown ferruginous concretions and films; grades indistinctly to layer beneath; alkaline. 15 to 25 inches thick.

C_2 Substrata of various characters, alternatively (a) yellowish-red or other colored, slightly calcareous, more or less clayey alluvium; (b) silty earths that may be loess or altered loess, (c) partly weathered clayey red beds or other colored shale or clay.

Range in Characteristics: Types range from fine sandy loam to clay loam; color of surface soil ranges from gray to dark gray and dark grayish brown, the clay loam type being the darkest; color of B_2 horizon ranges from dark gray to dark grayish brown and black; mottling in horizon 4 includes grays, yellowish browns, and reddish browns. A close relative with less dark, lighter gray surface soil and a more extreme A_2, which probably deserves recognition as a separate series, occupies concave more poorly drained surfaces but to date has been included in the areas mapped as Tabler.

Topography: Level upland or high terrace; plane surfaces.

Drainage: Very slow from the surface and internally; adequate for crop production and generally for good yields.

Vegetation: Prairie grasses; a few scattered trees occur in some marginal areas.

Use: Largely in cultivation and devoted mainly to wheat, oats, and sorghums; yields of small grains are high; a few areas are native meadow.

Distribution: Extensive in central Oklahoma; inextensive in central and northcentral Texas.

Type Location: Grant County, Oklahoma; large area extending east from Renfrow to Noble County line.

Series Established: Grady County (Little Washita Project), Oklahoma, 1939.

Remarks: Prior to 1939 the Tabler soils were included in the Oswego series. The series name is from a village in Grady County, Oklahoma.

Colors are described with approximate provisional Soil Survey color names and refer to dry soil.

Rev. EHT: 3-6-48
Mimeo. -1957

National Cooperative Soil Survey
USA

Established Series

TALIHINA SERIES

The Talihina series comprises olive-gray noncalcareous Lithosols on noncalcareous olive and gray shales in the eastern part of the Reddish Prairie soils zone. The principal associated series are Eram, a medium-depth soil developed on like material; Hanceville, a shallow stony soil with reddish subsoil over sandstone; and Hector, a grayish-brown Lithosol over sandstone.

Soil Profile: Talihina clay loam

A 0-10" Olive-gray (5Y 4/2; 3/3, moist) clay loam or silty clay loam; weakly granular; crumbly and friable when moist; moderately sticky and plastic when wet; contains a few to numerous small fragments of shale and siltstone; the surface 3 to 4 inches is slightly darker than the lower part neutral to slightly acid. 5 to 15 inches thick.

C 10"+ Olive (5Y 5/4; 4/5, moist) slightly weathered shale with laminea of brown or light gray clay or silty shale; alkaline to neutral but weakly calcareous at variable depths.

Range in Characteristics: The types range from loams to clays, and some are stony; color of the surface soil ranges from dark grayish-brown to olive-gray or olive; content of shale and siltstone fragments ranges from about 5 to 25 percent of the soil mass; shale outcrops and some sandstone fragments on the surface are common in the more sloping areas.

Topography: Gently to strongly erosional upland with gradients dominantly of 3 to 8 percent.

Drainage: Moderate to rapid from the surface; very slow or lacking internally.

Vegetation: Mainly coarse prairie grasses but some areas have a scattered to moderately thick cover of elm, blackjack, haw, persimmon, and hickory trees.

Use: Native pasture of relatively low carrying capacity and grazed mainly by cattle and some sheep; the pasturage is of relatively low nutritive quality unless fertilizers are used.

Distribution: Prairies underlain by shale and sandstone in eastern and northeastern Oklahoma and adjoining parts of Kansas, Missouri, and Arkansas; moderately extensive.

Type Location: LeFlore County, Oklahoma; NW 1/4 Section 22, T8N, R25E.

Series Established: LeFlore County, Oklahoma, 1931.

EGF
2-19-38
Rev. HO:EHT
5-6-48

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Established Series

TELLER SERIES

The Teller series comprises somewhat youthful brownish neutral to slightly acid soils with friable reddish subsoils developed on stream terraces in southeastern Oklahoma and adjoining areas from calcareous, loamy or silty, reddish alluvium or eolian earths that originated largely in subhumid plains and prairies underlain by red beds. The associated older soils of the uplands are largely Red and Yellow Podzolic soils, but some of the more western areas are in the Reddish Prairie soil zone. The principal series associated with Teller on stream terraces are Vanoss, Lonoke, Brewer, Bressie, Dougherty, and Stidham. Teller differs from Dougherty in having browner, less acid, generally somewhat more loamy A horizons with no light colored A_2 and represents a less advanced stage of development.

Soil Profile:		Teller very fine sandy loam	Range in Thickness
A	0-10"	Brown (7.5YR 4/2; 3/2, moist) very fine sandy loam; very friable; weakly granular; grades to B horizon through a 2- to 4-inch transition; neutral.	8-16"
B_2	10-35"	Reddish-brown (5YR 5/4; 4/6, moist) clay loam; moderately granular; friable; permeable; neutral to slightly acid.	8-24"
C_1	35-75"	Yellowish-red (5YR 5/6; 5/8, moist) clay loam; friable; neutral to mildly alkaline but noncalcareous.	25-100"
C	75"+	Reddish-yellow (5YR 6/6) calcareous clay loam.	

Range in Characteristics: Types range from silt loam to fine sandy loam; most typically, no horizon is more than slightly acid but in the easternmost areas the B horizon becomes moderately acid in places; B horizon ranges from reddish-brown to yellowish-red (hues of 5YR to 7.5YR) and from heavy loam to light silty clay; depth to calcareous material ranges from 4 to 10 feet.

Topography: Stream terraces, mostly on surfaces with less than 3% grade but sloping phases occur on escarpments; surfaces plane to convex.

Drainage: Free from the surface and internally.

Vegetation: Deciduous forest, mainly of post oak, blackjack, red oak, pecan, and hickory.

Use: Excepting the sloping phases on escarpments, practically all is in cultivation, mainly to cotton, corn, and some alfalfa; moderately fertile and very responsive to management.

Distribution: Terraces along the Red and Canadian Rivers and their tributaries in eastern Oklahoma, Louisiana, Arkansas, and northeastern Texas, moderately extensive.

Type Location: Johnston County, Oklahoma.

Page 2--Teller Series

Series Established: Johnston County (Tishomingo Area), Oklahoma, 1906.

Remarks: Color names used are provisional Soil Survey color names (1946) and refer to dry soil.

EGF:WTC
5-24-38
Rev. EHT
1-14-47

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TIVOLI SERIES

The Tivoli series comprises light-colored loose sands with no textural profile that occur within the Reddish Chestnut and Reddish Brown soil zones. The parent materials are aeolian sands, largely Quaternary, and the only evident soil development consists of slight accumulation of organic matter and darkening of the upper few inches. Tivoli soils differ from the Valentine soils, which occur under cooler climate, in being browner, or less grayish. They differ from Derby soils in being neutral or alkaline in reaction and occur under drier environment. The subsoils of the Tivoli soils are more sandy than those of the Pratt and Enterprise soils.

			Range in thickness
I. Soil Profile (Tivoli fine sand):			
1.	A 0-8"	Pale-brown (10YR 6/3; 5/4, moist) fine sand; single grained; loose; neutral to weakly alkaline.	4-10"
2.	C 8-60"+	Yellow (10YR 7/6) fine sand; loose; neutral to weakly alkaline.	

II. Range in Characteristics: Color of surface soil ranges from pale brown to light yellowish brown or light brown, and of subsoil, from yellow to very pale brown to pink and yellowish red (hues of 5YR to 10YR).

III. Topography: Undulating to rolling; stabilized dunes are common; mostly upland.

IV. Drainage: These loose sands absorb the limited precipitation as it falls; internal drainage is very rapid.

V. Vegetation: Tall grasses--cheifly bluestems, Indian grass, and sand dropseed--and low shrubs of sand sage and shin oak.

VI. Use: Native range grazed mainly to beef cattle; carrying capacity is low but higher than that of more loamy soils during droughts; very susceptible to soil blowing.

VII. Distribution: Reddish Chestnut and Reddish Brown soil zones of the Southern Great Plains; very extensive.

Type location: Major County, Oklahoma; near Tivoli School in SW¼, Sec. 25, T. 20N., R. 15W.

Series established: Major County, Oklahoma, 1936.

VIII. Remarks: Prior to establishment of the Tivoli series in 1936, these loose sands were included in Enterprise, Derby, Amarillo, and various other series.

Color terms used are provisional Soil Survey color names (1946) and refer to dry soil.

WTC-EGF-MB
3-30-39
Rev. EHT-HO
9-2-46

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Established Series

VANOSS SERIES

The Vanoss series comprises deep, well-drained, somewhat youthful Reddish Prairie soils developed in friable, alkaline, usually reddish, eolian or alluvial silty or loamy Pleistocene or Recent, sediments that are relatively high in weatherable minerals. The Vanoss series is less reddish than Teller and Norge, and has more friable permeable subsoils containing less clay than those of Bethany, Taloka, and Calumet and heavier subsoils than the often associated youthful Minco soils. Newkirk is a close relative of Vanoss, which is slightly more acid in reaction, has a layer of heavy clay between depths of about 3 and 7 feet, and comprises older or more weathered soils of somewhat lower inherent fertility. Vanoss differs from Lonoke in having less reddish lower subsoils and occurrence under somewhat drier climate in areas situated well above overflow.

Soil Profile:		Vanoss silt loam	Range in Thickness
A_1	0-15"	Grayish-brown (10YR 4/2; 3/2, moist) silt loam, moderate to strong medium granular; friable; grades into horizon 2; about neutral.	10-20"
B_2	15-30"	Brown (7.5YR 5/3; 4/3; moist) silty clay loam; strong coarse granular; friable; about neutral.	10-20"
B_3	30-45"	Brown (10YR 5/3; 4/3, moist) silty clay loam faintly mottled with about 5% of reddish yellow; friable to firm; contains a few black ferromagnesian (?) concretions; alkaline.	10-20"
C_1	45-70"	Light yellowish-brown (10YR 6/4) silty clay loam; friable to firm; alkaline; contains a few black ferromagnesian concretions.	18-30"
C	70"+	Yellowish-red (5YR 5/6) sandy clay; alkaline.	

Range in Characteristics: Types range from silt loam to fine sandy loam; color of surface soil ranges from brown to grayish-brown and dark grayish-brown, and reaction, from slightly acid to mildly alkaline; subsoil ranges from brown to yellowish-brown (hues of 7.5YR to 10YR) in color and from silty clay loam to sandy clay loam in texture; the substrata are calcareous in some areas but noncalcareous though alkaline in others and range from red unstratified silts in some areas of undulating upland to stratified, somewhat sandy, often yellowish alluvial sediments in areas on low terraces.

Topography: Nearly level areas in mantled erosional upland or on alluvial terraces lying above overflow; surfaces plane to weakly convex.

Drainage: Slow from the surface; free internally; very favorable for crops.

Vegetation: Tall grasses in most areas; some areas on low terraces are forested.

Use: Practically all in cultivation to cotton, alfalfa, corn, sorghums, and small grains; inherently fertile, very responsive to management, and highly productive.

Distribution: Central Oklahoma and Texas adjacent to the Brazos, Red, and Canadian and other rivers that drain subhumid plains partly underlain by Red Beds; mostly in high areas, some erosional upland and other old stream terraces, that appear to be mantled with loess; some areas occur on stream terraces only a few feet above overflow; moderately extensive.

Type Location: Cleveland County, Oklahoma; 5 miles west of Moore at SE corner Section 14, T10N, R4W.

Series Established: Pontotoc County, Oklahoma, 1936.

Remarks: The series name is from a village in Pontotoc County, Oklahoma. The soils indicated as Vanoss in the area where the series originated are slowly drained acid soils with compact subsoils and are now classed as other series.

Colors are described with provisional Soil Survey color names (1946) and unless stated otherwise, refer to dry soil.

WTC:MB
4/12/39
Rev. EHT:HO
9/3/46
Rev. EHT
1/6/47

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U. S. Department of Agriculture

Established Series

VERDIGRIS SERIES

The Verdigris series consists of relatively well-drained, acid, loamy chernozemic Alluvial soils in flood plains of streams that drain the shale and sandstone prairies. The subsoil ranges from silt loam to clay loam. The Verdigris soils are less rapidly drained, less sandy, and slightly less brown than the Cleora soils, less dark and better drained than the Osage soils, and darker, less mottled and better drained than the Lightning soils. The Mason series is the more developed counterpart of the Verdigris series. It is found on rarely inundated low terraces and has a more distinct A_1 horizon with an obvious decrease of darkening at about 20 inches..

Soil Profile: Verdigris silt loam

A_1 0-15" Dark grayish-brown (10YR 4/2) silt loam, very dark grayish-brown (10YR 3/2) when moist; weak medium granular structure; friable; medium acid; gradual boundary.

AC 15-30" Grayish-brown (10YR 5/2) silt loam, dark grayish-brown (10YR 3.5/2) when moist; porous massive or very weak subangular blocky structure; friable; contains erratic layers of light clay loam that represents slightly more clayey strata; worm casts and root channels numerous; medium acid; gradual boundary.

C 30-70"+ Pale brown (10YR 6/2.5) silt loam; brown (10YR 4/3) when moist; stratified with clay loam; friable; relatively porous and permeable; medium acid.

Range in Characteristics: The texture of subsoil ranges from silt loam to clay loam or silty clay loam with the percentage of clay usually between 20 and 35. Color of A horizon ranges around dark grayish-brown (hue mostly 10YR; dry values of 3.5 to 3.0 to 5.5, moist values of 2.5 to 3.5; chroma 1.5 to 2.5) being darkest in the clay loam type. The less well-drained areas somewhat gradational to the Osage or Lightning soils the subsoil and substrata become slightly mottled with browner and grayer shades. Thickness of the A_1 and AC range between about two-thirds and one-and-one-half of those in the representative profile. Except where specified moist, the colors refer to dry soil.

Topography: Nearly level flood plain.

Drainage and Permeability: Good or moderately good. Surface runoff slow; internal drainage, medium or moderately rapid. The water table generally lies below 10 feet. Soils are occasionally to frequently flooded.

Vegetation: Deciduous lowland forest consisting of oaks, elm, ash, and pecan. There is a considerable understory of grass in westernmost areas.

Use: Mostly cropland devoted primarily to corn, alfalfa, and small grains. The more frequently flooded areas are mostly pastured woodland.

Distribution: Extensive in eastern Kansas and Oklahoma; considerable in southwestern Missouri; and some in Arkansas. This is the dominant soil series in flood plains of streams that drain the Cherokee Prairies. Its total area is of the order of a half-million acres. Occurs under mean annual precipitation of 35 to 45 inches. The divide between the Marias des Cynges and the Kaw or Missouri Rivers forms a convenient geographic boundary between the Verdigris soils and such related series as Kennebec and Hobbs, which are in alluvium mainly from loess or till. To the south, the Ouachita-Arbuckle uplift separates the area of occurrence from that of Gowen series.

Series Established: Montgomery County, Kansas, 1913. The series name is from the Verdigris River.

Type Location: Labette County, Kansas.

Rev. EHT
7-31-57

National Cooperative Soil Survey
USA

Established Series

VERNON SERIES

The Vernon series comprises reddish, calcareous, clayey Lithosols shallow over reddish, calcareous, compact, impervious marine clays, which are generally of Permian, Triassic, or Pennsylvanian age. It occurs in semiarid to subhumid grasslands. The Vernon profile is more clayey, less granular, less permeable, and generally lower in $CaCO_3$ than that of Weymouth soils, the horizon of $CaCO_3$ accumulation is weaker. Depth to impervious substrata of raw clay is less than in the Stanford series. The Vernon profile is more clayey than those of Quinlan and Lucien soils, redder than that of Owens soils, and less compact or more pervious in the upper part than that of Treadway soils. Commonly associated zonal soils are the Tillman, Hollister, Foard, Renfrow, and Zaneis series. Although extensive, the Vernon series has limited importance to agriculture.

Soil Profile: Vernon clay

A_1 0-8" Reddish-brown (2.5YR 4/4) clay; dark reddish-brown (2.5YR 3/4) moist; moderate medium blocky structure when dry, massive when wet; very hard; very firm; calcareous with few fine $CaCO_3$ concretions; moderately alkaline; diffuse lower boundary. 6 to 10 inches thick.

AC 8-16" Red (2.5YR 4/6) clay; dark red (2.5YR 3/6) moist; weak medium blocky structure approaching massive; very hard; very firm; calcareous with few fine nodules of $CaCO_3$; moderately alkaline; diffuse lower boundary. 0 to 15 inches thick.

D_r 16-60"+ Red (2.5YR 3/6) compact, calcareous, massive clay of bulk density more than 1.8; few thin seams and roundish pockets of gray (N 5/0) clay; essentially unaltered clayey "red beds".

Range in Characteristics: The texture range is clay and clay loam in the surface soil and clay and heavy clay loam in the subsoil and substrata. The color of the A horizon ranges from reddish-brown to brown and red with dry value of 4 or 5, moist value of 3 or 4 and chroma of 2 through 5 in 2.5YR through 7.5YR hues. Color of the subsoil and substrata range from red to strong brown (hue of 7.5YR through 7.5R with hue of 10R or redder being rare). In the more humid areas some of the Vernon soil is noncalcareous but mildly alkaline in the surface layer. Depth to the weakly consolidated bedrock of very compact marine clay ranges from 6 to 25 inches. Locally, the underlying rock is indurated red claystone. Colors are for dry conditions unless specified otherwise.

Topography: Undulating to rolling erosional upland; slopes are mostly 3 to 12 percent but range between about 1 and 15 percent.

Drainage and Permeability: Well drained with rapid runoff. The subsoil is slowly to very slowly permeable; the substrata are nearly impervious.

Vegetation: Generally short grass with buffalo, blue grama, hairy grama; and tobosa the more prevalent species. Scattered dwarfed mesquite shrubs are common in the southern areas. Some little bluestem and sideoats grama occur in the more humid localities.

Use: Mainly as native range. A few areas on slopes of less than 3 percent are cultivated and used for small grains or grain sorghums.

Distribution: Northwestern Texas, western and central Oklahoma, southern Kansas and eastern New Mexico.

Type Location: Wilbarger County, Texas; about 2.5 miles NNW of Vernon (from downtown Vernon, go northwesterly on US Hwy. 287 0.4 miles beyond bridge across the Pease River; thence northeast 0.40 miles on Farm Road 925; thence 0.25 mile south).

Series Established: Wilbarger County (Vernon Area), Texas, 1902.

Rev. RED-HO-EHT
7-18-62

National Cooperative Soil Survey
USA

Established Series

WOODSON SERIES

The Woodson series comprises planosolic Brunizems developed over olive to gray alkaline and usually mildly calcareous shale or clay. The A horizon is darker than in the Parsons, Taloka, and Cherokee series and is without an evident, lighter colored A2 horizon; the upper B2 horizon is darker, less mottled and generally somewhat less acid than in those series. The clear boundary between the A and B horizons (with less than a 2-inch transition) together with less brownish color of the B2 horizon distinguish the Woodson from the closely related Okemah series. The Woodson series closely resembles the Wilson series of more southern localities having higher temperatures but has a somewhat more granular A horizon containing about twice as much organic matter. The Woodson series is of moderate extent and agricultural importance.

Soil Profile: Woodson silt loam

A1	0-9"	Dark gray (10YR 4/1) heavy silt loam; very dark gray (10YR 3/1) moist; moderate medium granular structure; hard, friable; medium acid; clear boundary. 7 to 14 inches thick.
B21	9-24"	Dark gray (10YR 4/1) silty clay; very dark gray (10YR 3/1) moist; weak fine blocky structure; extremely hard; very firm; compact with few visible pores or voids; shiny surfaces on peds, few fine black concretions; slightly acid; diffuse boundary. 10 to 20 inches thick.
B22	24-33"	Gray (10YR 5/1) silty clay with few fine distinct mottles of olive brown; very dark gray (10YR 3/1) moist; weak fine blocky structure, extremely hard; very firm; shiny surfaces on peds; common fine black concretions; about neutral; diffuse boundary. 7 to 14 inches.
B3	33-44"	Gray (2.5Y 6/1) silty clay with common distinct mottles of olive yellow; dark gray (2.5Y 4/1) moist; massive; extremely hard; very firm; common fine black concretions; few $CaCO_3$ concretions; few nests of gypsum; mildly alkaline; diffuse boundary. 8 to 20 inches thick.
C	44-60"+	Gray (2.5Y 6/1) silty clay with many distinct mottles of brownish-yellow; gray (2.5Y 5/1) moist; massive; extremely hard; very firm; common fine black concretions and coarse $CaCO_3$ concretions; mildly alkaline.

Range in Characteristics: Silt loam is the more extensive type but considerable areas of silty clay loam also occur. The color of the A and upper B horizon ranges from dry values of 3 through 5, moist values of 2 through 3, and chromas of 0.5 through 1.5 in hues of 10YR to 2.5Y inclusive. The color of the lower B horizon ranges from dry values of 4 through 6, moist values of 3 through 4, and chromas of 0.5 through 1.5 in hues of 10YR to 5Y, inclusive. The color of the C horizon is mottled gray and brown or yellowish-brown. The upper B horizon may be faintly mottled. The lower B horizon is distinctly mottled. The lower part of the A horizon may have gray or light gray ped coatings. Colors are for dry conditions unless specified moist.

Topography: Level to very gently sloping upland or alluvial terrace. The surface gradient ranges from 0 to 3 percent, but is mostly less than 1 percent.

Drainage and Permeability: Moderately well to somewhat poorly (imperfectly) drained. Runoff is slow. Permeability is very slow.

Vegetation: Originally tall-grass prairie.

Use: Mostly cultivated with small grains as the principal crops; some native meadow and pasture.

Distribution: Eastern Kansas, eastern Oklahoma north of Arbuckle uplift, and southwestern Missouri.

Type Location: Allen County, Kansas; 1500 feet west and 100 feet north of the SE corner of Section 26, T24S, R20E; 1/2 mile north of Moran.

Series Established: Neosho County, Kansas, 1930. (Name is from Woodson County).

Rev. HTO
9-1-62

National Cooperative Soil Survey
USA

Approved by Principal Soil Correlator
South Region TSC: 7/5/66

Established Series
Rev. JDN-HLM: 6/28/66

YAHOLA SERIES

The Yahola series is a member of a coarse-loamy, mixed, calcareous, thermic, family of Typic Ustifluvents. Yahola soils have moderately coarse textured A horizons and reddish to brownish, moderately coarse textured subsurface horizons that lack soil structure.

Typifying Pedon: Yahola fine sandy loam - cultivated
(Colors refer to dry soil unless otherwise noted.)

A1 0-11" Reddish brown (5YR 5/4) find sandy loam; reddish brown (5YR 4/4) moist; weak fine granular structure; soft; very friable; the upper 6 inches is a plowed horizon and does not differ noticeably from the lower part of the horizon; calcareous; gradual smooth boundary. 4 to 20 inches thick.

C1 11-40 Reddish yellow (5YR 6/6 fine sandy loam; yellowish red (5YR 5/6) moist; massive; slightly hard; very friable; thin strata of loamy fine sand and silt loam in the lower part; calcareous; gradual boundary. 10 to 30 inches thick.

C2 40-56" Reddish brown (5YR 6/4) light loam; reddish brown (5YR 4/4) moist; weak fine granular structure; slightly hard; friable; calcareous; gradual boundary. 0 to 30 inches thick.

C3 56-72" Yellowish red (5YR 5/6) fine sandy loam with thin strata of loamy fine sand to clay loam; yellowish red (5YR 4/6) moist; massive; slightly hard; very friable; calcareous.

Type Location: Jefferson County, Oklahoma; approximately 4 miles west and 8½ miles south of Waurika. About 2000 feet north and 200 feet east of the southwest corner of Section 18-T6S-R8W.

Range in Characteristics: These soils are usually moist but are dry in some part of the upper 40 inches for more than 90 days (cumulative) in most years. These soils are calcareous in all parts of the fine earth fraction between 10 and 20 inches and are generally calcareous to the surface. These soils have bedding planes within 50 inches of the surface and have erratic particle size and organic matter distribution with depth. The color of the surface horizon ranges in value from 4 to 7 when dry and 3 to 5 when moist in chromas of 2 to 6 in hues of 2.5YR to 10YR. When the color value is less than 5.5 when dry and 3.5 when moist in chromas of 4 or less and the horizon is more than 10 inches thick, the organic matter content is less than 1 percent. The texture of the surfact horizon is mainly fine sandy loam but loamy fine sands to loams are common and lesser amounts of finer textures occur. The color value of the 10 to 40 inch control section ranges from 5 to 7 when dry and 4 to 6 when moist in chromas of 3 to 8 in hues of 2.5YR to 10YR. Darker colored, buried horizons may or may not be present. The texture of the 10 to 40 inch control section ranges from about 5 to less than 18 percent clay, has more than 15 percent material coarser than very fine sand and is finer than loamy fine sand. Texture classes average mainly fine sandy loams but light loams, very fine sandy loams or loamy very fine sands occur. This section is typically stratified with coarser or finer soil material. The C horizons are structureless. Textures averaging coarser, or less commonly finer, than those given for the control section may occur below 40 inches.

Competing Series and Their Differentiae: These include Canadian, Cleora, Colorado, Guadalupe, Pulaski, Reinach, and Zavala soils. The Canadian, Cleora and Reinach soils have A1 horizons more than 10 inches thick that have dry color values less than 5.5 and moist color values less than 3.5, in chromas of 4 or less and have organic matter contents higher than 1 percent. The Colorado soils have more than 18 percent clay in the 10 to 40 inch section. The Pulaski soils are neutral to medium acid in the 10 to 40 inch section. The Zavala soils are noncalcareous and have average annual soil temperatures greater than 71.6^{o} F. The Guadalupe soils are characterized by subsurface colors that are yellower than 7.5YR hues.

Setting: These soils occur on nearly level floodplains along creeks and rivers. They are of slightly altered, moderately coarse textured, calcareous sediments. The Thornthwaite annual P-E index is from about 33 to 64. The mean annual air temperature is from about 57 to 70^{o}F. Most areas not protected by dams or levees flood about once in 1 to 15 years.

Principal Associated Soils: These include Brazos, Crevasse, Lincoln, Port, and Miller as well as the competing Reinach and Canadian soils. The Brazos, Crevasse, and Lincoln soils have textures of loamy fine sand or coarser in the 10 to 40 inch section, the Port soils have control sections with more than 18 percent clay in the 10 to 40 inch section, and the Miller soils have fine textures in the 10 to 40 inch section.

Drainage and Permeability: Well drained. Moderately rapid permeability. Slow runoff.

Use and Vegetation: Dominantly used for cultivated crops of alfalfa, cotton, small grains, and sorghums. The native vegetation is bottomland hardwoods with cottonwood predominant in the western part of the range and elm, pecan, and cottonwood in the eastern part.

Distribution and Extent: Along streams in central Oklahoma and Texas and in South Central Kansas. The series is extensive.

Series Established: Muskogee County, Oklahoma, 1913.

Remarks: The Yahola soils were formerly classified in the Alluvial Great Soil Group.

National Cooperative Soil Survey
USA

Established Series

ZANEIS SERIES

The Zaneis series comprises Reddish Prairie soils with subsoils of red or reddish-brown granular clay or silty clay developed over noncalcareous or weakly calcareous red beds. The subsoils are less compact and more permeable than those of Renfrow soils but heavier than those of Grant. Associated Lithosols are the Vernon soils; associated Planosols are the Kirkland and Tabler soils. The Reddish Chestnut correlative of Zaneis is *Girard.

Soil Profile:		Zaneis loam	Range in Thickness
A	0-6"	Brown (dark-brown, moist) loam; moderately granular; friable; slightly acid.	4-10"
B_1	6-12"	Reddish-brown clay loam; moderate to strong granular; friable; slightly acid to neutral.	4-10"
B_2	12-42"	Red light clay or silty clay; moderate granular; friable; neutral to mildly alkaline but noncalcareous.	20-35"
C	42"+	Red shaly silty clay or interbedded shale and fine-grained sandstone; weakly calcareous to neutral.	

Range in Characteristics: Loam, silt loam, and very fine sandy loam are the principal types; color of surface soil ranges from brown to reddish-brown; colors of B horizons range from reddish-brown to red; texture of layer 3 ranges from heavy clay loam to light clay; ferruginous concretions or films often occur in lower part of layer 3; where the substrata is calcareous, a few $CaCO_3$ concretions occur in the lower part of horizon 3.

Topography: Gently rolling erosional upland; convex surfaces with gradients of 1 to about 6%, mostly 1 to 4.

Drainage: Free from the surface; moderate internally.

Vegetation: Tall grasses, mainly little bluestem.

Use: Largely in cultivation and devoted mainly to small grains, cotton, corn, and sorghums; moderately productive.

Distribution: Reddish Prairies of central Oklahoma; minor areas possibly in north central Texas; relatively inextensive.

Type Location: Carter County, Oklahoma; 200 yards south of NE corner Section 33, T4S, R3W.

Series Established: Carter County, Oklahoma, 1932.

Page 2--Zaneis Series

Remarks: As originally established, the Zaneis series included both soils with granular friable subsoils, to which it is now restricted, and others with firm subsoils of heavy clay, which are Renfrow.

Colors are described with approximate provisional Soil Survey color names and refer to dry soil.

* Provisional Series

EGF
2-21-38
Rev. EGF
5-8-42
Rev. EHT-HO
9-4-46

Division of Soil Survey
Bureau of Plant Industry, Soils, and Agricultural Engineering
Agricultural Research Administration
U. S. Department of Agriculture

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
ALBION																							
CANADIAN																							
A	5	A-4(5)	100	91	87	59					25	5	-	-	-	-	-	6.5	6.4	10	X		
B	6	A-4(5)	100	87	83	58					28	7	-	-	-	-	-	6.2	6.3	10		X	
C	4	A-4(3)	89	82	76	52					25	6	-	-	-	-	-	7.4	5.8	10	X		
KAY																							
A	3	A-4(3)	100	94	80	51					20	4	-	-	-	-	-	5.4	6.0	10	X		
B	7	A-6(4)	100	93	79	55					30	11	27	14	1.89	26	-	6.2	6.7	11		X	
C	0	A-2-4(0)	100	99	86	21					NP	NP	-	-	-	-	-	7.0	4.2	7	X		
NOBLE																							
A	0	A-2-4(0)	100	43	39	34					20	2	-	-	-	-	-	5.4	4.4	8	X		
B	1	A-2-4(0)	73	31	29	25					25	8	-	-	-	-	-	6.9	3.6	7	X		
C	4	A-2-6(0)	68	21	19	16					28	11	25	13	1.89	23	-	6.5	3.5	8	X		
GATES																							
CREEK																							
A	0	A-2-4(0)	100	99	98	34					NP	NP	-	-	-	-	-	6.2	5.0	8	X		
B	6	A-4(5)	100	99	98	59					26	7	-	-	-	-	-	5.4	NO	10	X		
C	5	A-4(3)	100	99	99	51					28	7	-	-	-	-	-	5.5	6.0	10	X		
BETHANY																							
CANADIAN																							
A	9	A-4(8)	100	100	99	92					31	8	-	-	-	-	-	6.6	NO	11		X	
B	17	A-7-6(13)	100	97	96	89					44	21	37	10	1.97	52	.21	6.3	NO	14			X
C	17	A-7-6(13)	100	97	97	91					43	22	35	10	1.99	50	.24	7.8	NO	14			X

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	Q.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
BETHANY																							
GARFIELD																							
A	7	A-4(8)	100	100	99	96					25	4	-	-	-	-	-	6.1	NO	11		X	
B	18	A-7-6(14)	100	98	97	95					46	21	40	10	1.98	60	.21	6.6	NO	14			X
C	15	A-6(11)	100	95	93	88					40	17	34	11	1.95	44	-	7.5	NO	12		X	
GRANT																							
A	6	A-4(8)	100	99	99	97					23	4	-	-	-	-	-	6.3	NO	11		X	
B	16	A-7-6(12)	100	98	93	85					42	20	36	10	1.96	52	.20	6.8	NO	14			X
C	14	A-6(11)	100	99	99	98					36	17	31	10	1.97	42	-	7.3	NO	12		X	
KAY																							
A	10	A-4(8)	100	99	98	94					32	8	-	-	-	-	-	5.3	NO	11		X	
B	18	A-7-6(14)	100	99	98	96					46	21	41	12	1.95	57	.21	6.5	NO	14			X
C	15	A-7-6(11)	100	98	97	97					41	17	36	12	1.92	45	-	7.7	NO	14		X	
KINGFISHER																							
A	12	A-6(9)	100	100	98	91	20	65	15	SIL	36	12	-	21	1.67	12	-		NO	12	X		
B	18	A-7-6(14)	100	100	98	92	15	48	37	SICL	47	22	-	14	1.91	53	.24		NO	14			X
C	16	A-6(12)	100	99	97	84	37	34	29	CL	40	19	-	14	1.89	40	-		NO	13	X		
LOGAN																							
A	5	A-4(7)	100	98	94	72					20	3	-	-	-	-	-	6.0	NO	11	X		
B	15	A-7-6(11)	100	99	96	83					41	18	35	12	1.92	44	-	5.8	NO	14		X	
C	11	A-6(9)	100	99	95	75					30	12	26	15	1.81	19	-	6.5	NO	12		X	
OKLAHOMA																							
A	6	A-4(8)	100	100	100	94	20	64	26	SIL	27	5	-	20	1.72	7	-		NO	11	X		
B	20	A-7-6(16)	100	100	100	97	10	52	38	SICL	49	24	-	10	2.00	72	.32		NO	15			X

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
BETHANY																							
PAYNE																							
A	6	A-4(7)	100	98	89	71					22	4	-	-	-	-	-	7.0	NO	11	X		
B	15	A-6(11)	100	99	89	74					38	18	34	10	2.01	48	-	6.3	NO	12		X	
C	9	A-6(6)	100	99	84	61					30	12	28	12	1.93	31	-	7.0	NO	12		X	
BONHAM																							
LINCOLN																							
A	0	A-4(4)	100	99	98	57					NP	NP	-	-	-	-	-	5.6	6.4	10	X		
B	13	A-6(10)	100	100	99	92					36	15	30	13	1.88	33	-	5.7	NO	12		X	
C	11	A-6(7)	100	100	99	62					36	15	30	13	1.86	31	-	5.9	NO	12		X	
BRAZOS																							
GRANT																							
A	0	A-4(5)	100	99	92	61					NP	NP	-	-	-	-	-	6.0	NO	11	X		
C	0	A-4(1)	100	99	88	39					NP	NP	-	-	-	-	-	7.7	5.3	9	X		
BREWER																							
CANADIAN																							
A	12	A-6(9)	100	100	99	90					36	12	32	14	1.84	34	-	8.0	NO	12		X	
B	18	A-7-6(14)	100	100	100	95					47	22	38	11	1.94	52	.24	7.8	NO	15			X
C	24	A-7-6(20)	100	100	99	97					60	31	47	9	2.03	77	.63	7.6	NO	17			X
KAY																							
A	11	A-6(9)	100	100	99	97	8	64	28	SICL	33	12	-	15	1.82	26	-		NO	12	X		
B	19	A-7-6(11)	100	100	100	96	12	44	44	SIC	49	24	-	10	2.02	55	.32		NO	14			X
C	21	A-7-6(17)	100	100	100	98	14	46	40	SIC	50	27	-	12	1.91	50	.42		NO	15			X

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
CALUMET																							
NOBLE																							
A	12	A-6(9)	100	100	99	96					34	13	30	13	1.84	32	-	5.8	NO	12		X	
C	17	A-7-6(13)	100	99	98	94					44	20	42	9	2.02	67	.20	7.3	NO	14			X
CANADIAN																							
CANADIAN																							
A	0	A-2-4(0)	100	99	93	23					NP	NP	-	-	-	-	-	6.3	4.3	7	X		
C	0	A-2-4(0)	100	100	92	11					NP	NP	-	-	-	-	-	7.1	3.6	8	X		
OKLAHOMA																							
A	6	A-4(7)	100	99	99	68					26	5	-	-	-	-	-	5.9	NO	11		X	
C	0	A-4(7)	100	100	100	72					NP	NP	-	-	-	-	-	7.8	NO	11	X		
CARMEN																							
GARFIELD																							
A	7	A-4(8)	100	97	92	73					26	6	-	-	-	-	-	7.7	NO	11		X	
B	9	A-4(8)	100	97	95	78					29	9	-	-	-	-	-	7.7	NO	11		X	
C	9	A-4(7)	92	91	87	72					27	10	25	13	1.88	22	-	7.6	NO	11		X	
CARR																							
KAY																							
A	0	A-4(0)	100	91	69	37					NP	NP	-	-	-	-	-	7.6	5.1	9	X		
AC	0	A-2-4(0)	100	90	64	17					NP	NP	-	-	-	-	-	7.5	3.9	8	X		
C	5	A-4(5)	100	100	98	60					22	5	-	-	-	-	-	8.0	NO	10	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization % Asphalt	Stabilization % Cement	Subgrade Good	Subgrade Fair	Subgrade Poor
CARWILE																							
GARFIELD																							
A	0	A-4(5)	100	99	90	59	62	30	8	SL	NP	NP	-	-	-	-	-		6.5	10	X		
B	19	A-7-6(14)	100	99	95	85	23	38	39	CL	47	24	-	10	2.03	61	.32		NO	14			X
GRANT																							
A	9	A-4(8)	100	95	88	76					31	7	-	-	-	-	-	5.1	NO	11		X	
B	9	A-6(7)	100	86	76	64					31	12	28	12	1.89	30	-	6.4	NO	12		X	
C	8	A-4(8)	100	99	99	95					27	6	-	-	-	-	-	7.4	NO	11		X	
KAY																							
A	0	A-2-4(0)	100	88	54	35					NP	NP	-	-	-	-	-	5.1	4.9	9	X		
B	19	A-7-6(15)	100	95	88	79					47	24	35	9	2.03	52	.32	7.7	NO	15			X
C	20	A-7-6(16)	100	97	92	89					50	26	42	8	2.08	70	.39	8.0	NO	15			X
KINGFISHER																							
A	0	A-2-4(0)	100	93	65	28					NP	NP	-	-	-	-	-	6.2	4.6	7	X		
B	8	A-6(6)	100	95	87	60					29	12	25	13	1.87	23	-	7.4	NO	12		X	
C	3	A-4(3)	100	96	81	48					23	5	-	-	-	-	-	7.4	5.8	10	X		
PAYNE																							
A	3	A-4(3)	100	97	83	50					21	4	-	-	-	-	-	6.3	5.9	10	X		
B	8	A-6(4)	100	94	75	46					34	16	30	12	1.91	35	-	6.0	6.2	11		X	
C	1	A-2-4(0)	100	92	66	27					20	6	-	-	-	-	-	6.4	4.5	7	X		
CHICKASHA																							
LINCOLN																							
A	3	A-4(2)	100	99	96	45	61	23	16	SL	27	6	-	18	1.80	19	-		5.5	9	X		
B	9	A-6(5)	100	99	97	49	56	14	30	SCL	36	15	-	14	1.88	32	-		6.5	11	X		
C	6	A-6(2)	100	98	95	41	62	9	29	SCL	32	12	-	16	1.84	22	-		6.0	10	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
CHICKASHA																							
LOGAN																							
A	0	A-4(4)	100	99	98	57					NP	NP	-	-	-	-	-	5.9	6.4	10	X		
B	9	A-6(6)	100	100	99	63					31	12	28	14	1.86	27	-	5.7	NO	12		X	
C	11	A-6(9)	100	100	99	68					33	15	27	12	1.92	28	-	6.2	NO	12		X	
NOBLE																							
A	0	A-4(4)	100	99	88	55					NP	NP	-	-	-	-	-	6.6	6.2	10	X		
B	8	A-6(5)	100	99	86	60					31	11	29		2.00	59	-	6.7	NO	12		X	
C	9	A-4(8)	100	100	99	81					27	9	-	-	-	-	-	7.5	NO	11		X	
OKLAHOMA																							
A	0	A-2-4(0)	100	99	94	30					NP	NP	-	-	-	-	-	5.7	4.7	8	X		
B	0	A-4(2)	100	100	81	43					NP	NP	-	-	-	-	-	5.4	5.5	9	X		
C	2	A-4(1)	100	100	81	38					27	8	-	-	-	-	-	7.1	5.2	9	X		
PAYNE																							
A	4	A-4(3)	100	99	99	50					26	6	-	-	-	-	-	6.0	5.9	10	X		
B	6	A-4(4)	100	100	100	54					28	9	-	-	-	-	-	6.8	6.7	10		X	
C	11	A-6(8)	100	100	100	64					35	16	26	14	1.86	22	-	7.6	NO	12		X	
CHOTEAU																							
CREEK																							
A	0	A-4(6)	100	99	97	65					NP	NP	-	-	-	-	-	6.7	NO	11	X		
B	16	A-7-6(12)	100	100	98	83					41	20	37	11	1.94	51	.20	6.2	NO	14			X
C	15	A-6(12)	100	100	98	78					37	19	30	11	1.97	38	.15	7.1	NO	13		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
CLEBURNE																							
CREEK																							
A	0	A-4(1)	100	96	80	41					NP	NP	-	-	-	-	-	6.0	5.4	9	X		
B	7	A-6(4)	100	96	84	52					29	11	31	12	1.95	37	-	6.5	6.5	11		X	
C	6	A-4(3)	100	97	84	52					30	10	-	-	-	-	-	6.6	6.5	10		X	
COBB																							
CANADIAN																							
A	0	A-2-4(0)	100	100	100	28					NP	NP	-	-	-	-	-	7.4	4.6	7	X		
B	5	A-4(4)	100	100	99	54					26	6	-	-	-	-	-	7.1	6.2	10	X		
C	0	A-4(1)	100	100	100	40					NP	NP	-	-	-	-	-	7.6	5.4	9	X		
COLLINSVILLE																							
CREEK																							
A	0	A-2-4(0)	100	95	78	32					NP	NP	-	-	-	-	-	6.3	4.8	8	X		
PAYNE																							
A	0	A-2-4(0)	100	100	96	32					NP	NP	-	-	-	-	-	5.8	4.9	8	X		
C	0	A-2-4(0)	100	100	99	30					NP	NP	-	-	-	-	-	5.6	4.8	8	X		
DALE																							
CANADIAN																							
A	14	A-6(11)	100	100	100	88					38	17	-	-	-	-	-	6.3	NO	12		X	
C	14	A-6(10)	100	100	99	90					36	16	-	-	-	-	-	7.6	NO	12		X	
KAY																							
A	14	A-6(10)	100	100	99	94					40	14	34	16	1.78	32	-	5.9	NO	12		X	
AC	13	A-6(10)	100	99	99	91					37	14	33	15	1.83	33	-	6.0	NO	12		X	
C	12	A-6(9)	100	100	99	92					34	13	30	15	1.83	28	-	6.1	NO	12		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
DALE																							
LINCOLN																							
A	8	A-4(8)	100	100	100	95					28	6	-	-	-	-	-	6.2	NO	11		X	
C	17	A-7-6(13)	100	100	100	99					46	20	37	13	1.84	43	.20	7.2	NO	14			X
OKLAHOMA																							
A	16	A-7-6(12)	100	98	97	89					45	18	40	13	1.89	52	-	5.9	NO	14			X
C	10	A-4(8)	100	100	99	86					32	9	-	-	-	-	-	6.0	NO	11		X	
DARNELL																							
CANADIAN																							
A	0	A-2-4(0)	100	100	98	35					NP	NP	-	-	-	-	-	6.0	5.1	9	X		
C	0	A-2-4(0)	100	100	99	28					NP	NP	-	-	-	-	-	6.0	4.6	7	X		
CREEK																							
A	0	A-2-4(0)	100	100	96	25					NP	NP	-	-	-	-	-	6.1	4.5	7	X		
LOGAN																							
A	0	A-2-4(0)	100	100	99	20					NP	NP	-	-	-	-	-	6.1	4.2	7	X		
NOBLE																							
A	0	A-4(4)	100	99	98	54					NP	NP	-	-	-	-	-	5.7	6.2	10	X		
C	0	A-4(4)	100	100	100	57					NP	NP	-	-	-	-	-	5.3	6.4	10	X		
OKLAHOMA																							
A	0	A-4(0)	100	99	95	36					NP	NP	-	-	-	-	-	5.7	5.1	9	X		
PAYNE																							
A	5	A-4(6)	100	100	99	66					24	3	-	-	-	-	-	5.9	NO	11	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
DENNIS																							
CREEK																							
A	9	A-4(8)	100	99	97	88					31	6	-	-	-	-	-	5.9	NO	11		X	
B	16	A-7-6(12)	100	99	98	84					43	18	37	11	1.93	50	-	6.2	NO	14		X	
C	10	A-6(7)	100	99	97	60					33	15	27	10	2.00	34	-	6.7	NO	12		X	
DERBY																							
LOGAN																							
A	0	A-4(4)	100	98	90	57					NP	NP	-	-	-	-	-	6.6	6.4	10	X		
C	0	A-2-4(0)	100	94	82	34					NP	NP	-	-	-	-	-	8.0	4.9	8	X		
DOUGHERTY																							
CREEK																							
A	0	A-4(2)	100	99	90	43					NP	NP	-	-	-	-	-	6.4	5.5	9	X		
B	3	A-4(2)	100	99	91	45					21	5	-	-	-	-	-	5.9	5.6	9	X		
C	4	A-4(2)	100	99	91	47					25	8	-	-	-	-	-	5.1	5.8	10	X		
KAY																							
A	0	A-2-4(0)	100	79	49	29					NP	NP	-	-	-	-	-	6.6	4.5	7	X		
B	1	A-2-4(0)	100	76	43	26					26	8	-	-	-	-	-	5.2	4.3	7	X		
C	0	A-2-4(0)	100	80	35	11					NP	NP	-	-	-	-	-	6.4	3.4	8	X		
KINGFISHER																							
A	0	A-2-3(0)	100	98	80	19	90	7	3	S	NP	NP	-	-	-	-	-		4.0	7	X		
B	4	A-2-4(0)	100	96	78	27	65	8	27	SCL	27	9	-	18	1.84	27	-		5.0	7	X		
C	0	A-3(0)	100	99	83	9	92	5	3	S	NP	NP	-	-	-	-	-		3.5	8	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
DOUGHERTY																							
LINCOLN																							
A	0	A-2-4(0)	100	99	91	11					NP	NP	-	-	-	-	-	7.0	3.6	8	X		
B	2	A-4(1)	100	100	93	41					23	5	-	-	-	-	-	5.5	5.4	9	X		
C	0	A-2-4(0)	100	100	91	14					NP	NP	-	-	-	-	-	5.8	3.8	8	X		
LOGAN																							
A	0	A-2-4(0)	100	99	85	15					NP	NP	-	-	-	-	-	6.4	3.8	8	X		
B	1	A-4(0)	100	99	86	36					21	6	-	-	-	-	-	4.9	5.1	9	X		
C	1	A-2-4(0)	100	99	83	33					18	3	-	-	-	-	-	5.4	4.9	8	X		
OKLAHOMA																							
A	0	A-2-3(0)	100	98	82	22	87	9	4	S	NP	NP	-	-	-	-	-		4.5	7	X		
B	5	A-4(2)	100	99	87	44	67	9	24	SCL	29	10	-	16	1.85	20	-		6.0	9	X		
PAYNE																							
A	0	A-2-3(0)	100	98	74	19	91	7	2	S	NP	NP	-	-	-	-	-		4.0	7	X		
B	5	A-2-6(1)	100	99	88	34	69	4	27	SCL	33	15	-	17	1.76	26	-		5.5	10	X		
C	0	A-2-3(0)	100	99	72	13	90	3	7	S	NP	NP	-	-	-	-	-		4.0	8	X		
DRUMMOND																							
GARFIELD																							
A	10	A-4(8)	100	98	98	94					32	9	-	-	-	-	-	8.5	NO	11		X	
B	9	A-4(8)	100	99	99	95					29	7	-	-	-	-	-	8.7	NO	11		X	
C	7	A-4(8)	100	98	98	92					26	5	-	-	-	-	-	5.2	NO	11		X	
GRANT																							
A	2	A-4(2)	100	92	74	44					17	3	-	-	-	-	-	8.0	5.5	9	X		
B	3	A-4(3)	100	94	78	48					23	6	-	-	-	-	-	7.8	5.8	10	X		
C	11	A-6(8)	100	95	81	57					34	18	25	14	1.86	21	-	8.0	6.8	12		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
DRUMMOND																							
KINGFISHER																							
A	19	A-7-6(15)	100	99	95	85					45	24	36	10	2.02	53	.32	7.3	NO	15			X
B	16	A-7-6(12)	100	100	94	82					42	20	35	10	2.03	52	.20	7.6	NO	14			X
EUFAULA																							
CREEK																							
A	0	A-2-4(0)	100	100	90	12					NP	NP	-	-	-	-	-	5.6	3.7	8	X		
C	0	A-2-4(0)	100	100	93	17					NP	NP	-	-	-	-	-	7.5	4.0	8	X		
KAY																							
A	0	A-2-4(0)	100	84	46	26					NP	NP	-	-	-	-	-	6.9	4.4	7	X		
C	0	A-2-4(0)	100	78	37	17					NP	NP	-	-	-	-	-	6.0	3.8	8	X		
KINGFISHER																							
A	0	A-2-4(0)	100	96	76	20					NP	NP	-	-	-	-	-	6.5	4.1	7	X		
B	0	A-3(0)	100	94	72	7					NP	NP	-	-	-	-	-	6.9	3.3	12	X		
C	0	A-3(0)	100	58	52	8					NP	NP	-	-	-	-	-	6.8	3.0	8	X		
LINCOLN																							
A	0	A-2-4(0)	100	100	97	17					NP	NP	-	-	-	-	-	5.9	4.0	8	X		
C	0	A-3(0)	100	100	97	7					NP	NP	-	-	-	-	-	6.4	3.4	12	X		
PAYNE																							
A	0	A-3(0)	100	98	77	10					NP	NP	-	-	-	-	-	6.8	3.5	12	X		
C	0	A-3(0)	100	95	61	7					NP	NP	-	-	-	-	-	6.9	3.3	12	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
GOWEN																							
NOBLE																							
A	9	A-4(8)	100	99	99	94					31	8	-	-	-	-	-	6.9	NO	11		X	
C	9	A-4(8)	100	100	100	97					29	7	-	-	-	-	-	6.3	NO	11		X	
GRANT																							
CANADIAN																							
A	6	A-4(8)	100	100	99	77					23	4	-	-	-	-	-	5.8	NO	11		X	
B	8	A-4(6)	100	100	99	63					31	9	-	-	-	-	-	6.4	NO	11		X	
C	8	A-4(6)	100	100	100	65					31	8	-	-	-	-	-	5.9	NO	11		X	
GARFIELD																							
A	8	A-4(8)	100	100	100	97	12	74	14	SIL	30	4	-	24	1.60	8	-		NO	11	X		
B	11	A-6(8)	100	100	100	99	7	68	25	SIL	33	11	-	19	1.75	22	-		NO	12	X		
C	12	A-6(9)	100	100	100	99	9	66	25	SIL	34	12	-	17	1.78	27	-		NO	12	X		
GRANT																							
A	6	A-4(8)	100	100	100	97					23	4	-	-	-	-	-	6.5	NO	11		X	
B	7	A-4(8)	100	100	100	98					26	5	-	-	-	-	-	6.2	NO	11		X	
C	9	A-4(8)	100	100	100	98					29	9	25	16	1.77	15	-	7.6	NO	11		X	
OKLAHOMA																							
A	0	A-4(6)	100	100	99	63					NP	NP	-	-	-	-	-	6.4	NO	11	X		
B	9	A-4(7)	100	100	99	72					31	9	-	-	-	-	-	6.1	NO	11		X	
C	6	A-4(5)	100	100	99	61					27	5	-	-	-	-	-	7.6	NO	11	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
HUMBARGER																							
KAY																							
A	5	A-4(4)	100	97	93	57					24	6	-	-	-	-	-	7.5	6.3	10	X		
AC	1	A-4(1)	100	92	82	42					18	3	-	-	-	-	-	7.6	5.4	9	X		
C	12	A-6(9)	100	99	95	86					34	13	31	13	1.89	34	-	7.5	NO	12		X	
KAW																							
KAY																							
A	13	A-6(9)	100	100	99	96					37	13	32	16	1.77	28	-	5.9	NO	12		X	
AC	15	A-7-6(11)	100	99	98	93					42	17	38	14	1.84	43	-	6.0	NO	14		X	
C	16	A-7-6(12)	100	100	98	97					42	19	35	12	1.93	45	.15	6.3	NO	14		X	
KINGFISHER																							
CANADIAN																							
A	5	A-4(7)	100	100	100	70					20	4	-	-	-	-	-	4.9	NO	11	X		
B	19	A-7-6(15)	100	99	99	86					45	25	-	-	-	-	.36	6.2	NO	15			X
C	0	A-4(3)	100	100	100	49					NP	NP	-	-	-	-	-	6.7	5.9	10	X		
GARFIELD																							
A	6	A-4(8)	100	100	99	94					23	3	-	-	-	-	-	5.8	NO	11	X		
B	16	A-7-6(12)	100	99	99	96					42	18	36	11	1.95	48	-	7.3	NO	14		X	
C	13	A-6(10)	100	99	97	93					36	15	30	10	2.01	39	-	7.7	NO	12		X	
GRANT																							
A	6	A-4(8)	100	99	98	95					22	3	-	-	-	-	-	4.7	NO	11	X		
B	11	A-6(9)	100	97	95	87					32	12	30	12	1.89	34	-	6.6	NO	12		X	
C	6	A-4(8)	100	99	97	90					23	4	-	-	-	-	-	6.8	NO	11		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
KINGFISHER																							
KINGFISHER																							
A	7	A-4(8)	100	100	100	82	51	34	15	L	26	6	-	20	1.72	7	-				X		
B	16	A-6(12)	100	100	100	91	31	30	29	CL	38	20	-	17	1.81	27	.20				X		
C	9	A-4(8)	100	100	100	87	50	33	17	L	27	9	-	17	1.77	15	-				X		
KINGFISHER SLICKSP																							
KINGFISHER																							
A	5	A-4(7)	100	100	100	72					23	2	-	-	-	-	-	8.5	NO	11	X		
B	10	A-6(8)	100	99	98	97					30	11	27	11	1.99	31	-	8.2	NO	12		X	
C	11	A-6(9)	100	98	98	96					31	12	26	12	1.99	29	-	8.2	NO	12		X	
KIRKLAND																							
CANADIAN																							
A	6	A-4(8)	100	99	99	98					24	4	35	15	1.86	37	-	7.0	NO	11		X	
B	16	A-7-6(12)	100	99	99	92					43	19	35	10	1.98	50	.15	8.0	NO	14			X
C	17	A-7-6(13)	100	98	98	94					43	22	34	9	2.01	50	.24	8.1	NO	14			X
GARFIELD																							
A	7	A-4(8)	100	99	99	98					27	5	-	-	-	-	-	5.8	NO	11		X	
B	17	A-7-6(13)	100	100	99	98					45	19	40	11	1.98	58	.15	7.2	NO	14			X
C	14	A-6(10)	100	100	99	97					40	16	35	14	1.87	39	-	7.7	NO	12		X	
GRANT																							
A	6	A-4(8)	100	100	99	98					24	3	-	-	-	-	-	5.7	NO	11	X		
B	16	A-7-6(12)	100	100	99	98					42	18	36	10	1.96	51	-	6.9	NO	14		X	
C	12	A-6(9)	100	99	98	96					33	13	29	12	1.90	32	-	7.3	NO	12		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization % Asphalt	Stabilization % Cement	Subgrade Good	Subgrade Fair	Subgrade Poor
KIRKLAND																							
KAY																							
A	11	A-4(8)	100	100	99	98	13	61	26	SIL	34	10	-	17	1.77	28	-			11	X		
B	22	A-7-6(18)	100	100	100	98	8	49	43	SIC	56	27	-	11	2.00	76	.42			17			X
C	24	A-7-6(19)	99	98	98	97	10	48	42	SIC	57	32	-	11	2.01	69	.70			17			X
KINGFISHER																							
A	7	A-4(8)	100	100	99	96					25	4	-	-	-	-	-	6.0	NO	11		X	
B	17	A-7-6(13)	100	100	99	97					46	20	41	10	2.02	63	.20	7.4	NO	14			X
C	18	A-7-6(14)	100	99	98	95					47	22	44	10	2.01	68	.24	7.2	NO	15			X
LINCOLN																							
A	9	A-4(8)	100	99	98	92					31	8	-	-	-	-	-	6.3	NO	11		X	
B	19	A-7-6(15)	100	99	98	94					46	24	33	11	1.94	42	.32	7.4	NO	15			X
C	15	A-6(11)	100	100	98	95					38	18	30	12	1.98	36	-	7.1	NO	13		X	
LOGAN																							
A	9	A-4(8)	100	99	99	96					28	9	-	-	-	-	-	5.9	NO	11		X	
B	17	A-7-6(13)	100	100	99	97					45	21	39	10	1.99	58	.21	6.9	NO	14			X
C	19	A-7-6(15)	100	99	98	96					47	23	39	11	1.97	55	.28	7.8	NO	15			X
NOBLE																							
A	7	A-4(8)	100	99	97	82					25	4	-	-	-	-	-	6.6	NO	11		X	
B	23	A-7-6(18)	100	98	96	85					52	31	36	9	1.99	54	.63	6.9	NO	17			X
C	14	A-6(11)	100	100	99	89					37	17	31	11	1.96	39	-	7.8	NO	12		X	
OKLAHOMA																							
A	7	A-4(8)	100	99	99	95					27	5	-	-	-	-	-	5.8	NO	11		X	
B	17	A-7-6(13)	100	99	99	98					45	20	4	29	2.03	70	.20	7.2	NO	14			X
C	14	A-6(10)	100	99	99	95					40	16	35	13	1.87	41	-	7.7	NO	12		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
KIRKLAND																							
PAYNE																							
A	9	A-4(8)	100	100	98	81	34	46	20	L	29	9	-	17	1.78	28	-		NO	11	X		
B	21	A-7-6(17)	100	100	100	88	19	39	42	C	51	26	-	10	2.02	44	.39		NO	15			X
KONAWA																							
CANADIAN																							
A	0	A-2-4(0)	100	98	86	24					NP	NP	-	-	-	-	-	5.7	4.4	7	X		
B	4	A-2-6(0)	100	97	81	19					23	11	-	-	-	-	-	4.7	4.6	8	X		
C	0	A-2-4(0)	100	97	84	19					NP	NP	-	-	-	-	-	5.1	4.1	8	X		
LINCOLN																							
A	0	A-2-4(0)	100	100	97	32					NP	NP	-	-	-	-	-	5.4	4.9	8	X		
B	7	A-6(4)	100	100	96	49					28	12	23	12	1.88	20	-	5.2	6.4	11		X	
C	0	A-2-4(0)	100	100	94	29					NP	NP	-	-	-	-	-	5.6	4.7	7	X		
OKLAHOMA																							
A	0	A-2-4(0)	100	90	64	30					NP	NP	-	-	-	-	-	6.4	4.7	8	X		
B	2	A-4(1)	100	84	59	38					22	6	-	-	-	-	-	6.3	5.1	9	X		
C	0	A-2-4(0)	100	79	42	16					NP	NP	-	-	-	-	-	6.0	3.7	8	X		
LABETTE																							
KAY																							
A	15	A-7-5(11)	100	99	98	92					49	13	44	16	1.76	50	-	6.0	NO	13		X	
B	21	A-7-5(17)	100	98	97	94					55	25	48	10	2.00	76	.36	6.5	NO	14			X
C	19	A-7-6(15)	100	96	95	93					50	23	45	10	2.02	70	.28	6.5	NO	15			X

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
LELA																							
CANADIAN																							
A	23	A-7-5(19)	100	97	91	78					63	27	54	11	1.88	82	.42	6.8	NO	16			X
C	35	A-7-6(20)	100	99	99	87					77	52	-	-	-	-	-	8.2	NO	17			X
KAY																							
A	17	A-7-6(13)	100	95	94	92					48	19	44	11	1.91	63	.15	6.5	NO	14			X
AC	16	A-7-6(12)	100	99	98	95					44	19	38	11	1.94	52	.15	7.5	NO	14			X
C	18	A-7-6(14)	100	92	89	87					45	22	35	11	1.99	48	.24	7.8	NO	14			X
LINCOLN																							
A	19	A-7-6(15)	100	100	100	99					51	23	42	11	1.89	59	.28	7.0	NO	15			X
C	28	A-7-5(20)	100	100	99	98					71	34	59	9	2.01	100	.83	7.6	NO	16			X
NOBLE																							
A	20	A-7-6(16)	100	99	99	96					53	24	46	10	1.98	72	.32	6.8	NO	15			X
AC	19	A-7-6(15)	100	100	99	98					50	23	49	9	2.02	81	.28	7.0	NO	15			X
C	17	A-7-6(13)	100	98	98	96					44	20	40	8	2.06	66	.20	7.4	NO	14			X
OKLAHOMA																							
A	22	A-7-5(17)	100	100	100	98	7	48	45	SIC	57	25	-	11	1.96	87	.36		NO	15			X
C	39	A-7-5(20)	100	100	100	100	7	25	68	C	92	51	-	9	2.02	29	2.70			16			X
LESHARA																							
CANADIAN																							
A	6	A-4(6)	100	99	95	64					25	6	-	-	-	-	-	8.7	NO	11		X	
AC	0	A-4(3)	100	98	92	49					NP	NP	-	-	-	-	-	8.5	5.9	10	X		
C	0	A-2-4(0)	100	99	94	19					NP	NP	-	-	-	-	-	6.0	4.1	8	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
LINCOLN																							
CANADIAN																							
A	7	A-4(8)	100	100	98	92					27	5	-	-	-	-	-	7.3	NO	11		X	
C	0	A-3(0)	100	99	76	9					NP	NP	-	-	-	-	-	8.5	3.5	12	X		
GRANT																							
A	0	A-4(4)	100	97	90	55					NP	NP	-	-	-	-	-	6.3	6.2	10	X		
C	0	A-2-4(0)	100	93	80	31					NP	NP	-	-	-	-	-	7.2	4.7	8	X		
KAY																							
A	0	A-2-4(0)	100	94	62	11					NP	NP	-	-	-	-	-	7.3	3.6	8	X		
C	0	A-3(0)	100	95	58	3					NP	NP	-	-	-	-	-	6.8	3.1	12	X		
KINGFISHER																							
A	0	A-3(0)	100	75	37	4					NP	NP	-	-	-	-	-	8.8	NO	10	X		
C	0	A-2-4(0)	100	94	72	20					NP	NP	-	-	-	-	-	7.9	4.1	7	X		
LINCOLN																							
A	0	A-2-4(0)	100	94	73	16					NP	NP	-	-	-	-	-	7.4	3.9	8	X		
C	0	A-3(0)	100	92	51	10					NP	NP	-	-	-	-	-	8.1	3.5	12	X		
OKLAHOMA																							
A	0	A-4(0)	100	100	92	36					NP	NP	-	-	-	-	-	7.8	5.1	9	X		
C	0	A-2-4(0)	100	100	94	16					NP	NP	-	-	-	-	-	7.7	3.9	8	X		
PAYNE																							
A	0	A-3(0)	100	99	79	9					NP	NP	-	-	-	-	-	7.5	3.5	12	X		
C	0	A-2-4(0)	100	100	76	13					NP	NP	-	-	-	-	-	8.8	3.7	8	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
LUCIEN																							
CANADIAN																							
A	7	A-4(7)	100	100	99	70					26	5	-	-	-	-	-	7.1	NO	11		X	
C	6	A-4(4)	100	100	100	55					28	7	-	-	-	-	-	6.8	6.3	10	X		
GARFIELD																							
A	4	A-4(6)	100	100	100	63	63	27	10	SL	23	1	-	20	1.65	8	-		NO	11	X		
C	0	A-4(4)	100	100	100	45	78	12	10	SL	NP	NP	-	-	-	-	-		5.5	10	X		
KINGFISHER																							
A	8	A-4(8)	100	98	96	86					28	5	-	-	-	-	-	7.5	NO	11		X	
C	8	A-4(8)	100	99	94	84					28	7	-	-	-	-	-	7.7	NO	11		X	
LINCOLN																							
A	2	A-4(2)	100	99	97	47					19	4	-	-	-	-	-	6.4	5.8	10	X		
AC	6	A-4(5)	100	99	97	58					25	8	-	-	-	-	-	5.7	6.4	10		X	
C	6	A-4(4)	100	100	99	53					31	8	-	-	-	-	-	5.5	6.1	10	X		
LOGAN																							
A	0	A-4(3)	100	100	98	48					NP	NP	-	-	-	-	-	6.6	5.8	10	X		
C	4	A-4(4)	100	96	94	53					25	5	-	-	-	-	-	8.1	6.1	10	X		
NOBLE																							
A	5	A-4(6)	100	100	99	67					21	3	-	-	-	-	-	5.5	NO	11	X		
C	5	A-4(4)	100	97	93	55					27	6	-	-	-	-	-	6.6	6.2	10	X		
OKLAHOMA																							
A	0	A-2-4(0)	100	99	96	33					NP	NP	-	-	-	-	-	7.1	4.9	8	X		
C	0	A-2-4(0)	100	100	97	22					NP	NP	-	-	-	-	-	6.9	4.3	7	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
LUCIEN																							
PAYNE																							
A	2	A-4(4)	100	95	99	51	52	34	14	SL	25	5	-	17	1.78	8	-		6.0	10	X		
AC	6	A-4(6)	100	100	99	64	53	33	14	SL	26	6	-	17	1.76	7	-		NO	11	X		
C	1	A-4(1)	100	99	99	41	69	19	12	SL	22	2	-	17	1.78	11	-		5.5	9	X		
MASON																							
CREEK																							
A	9	A-4(8)	100	100	99	93					29	8	-	-	-	-	-	5.9	NO	11		X	
B	19	A-7-6(15)	100	100	100	96					47	23	37	11	1.93	51	.28	5.1	NO	15			X
C	16	A-7-6(12)	100	99	98	87					42	20	36	10	1.97	51	.20	6.3	NO	14			X
LINCOLN																							
A	7	A-4(8)	100	100	99	76					25	6	-	-	-	-	-	5.5	NO	11		X	
B	8	A-4(6)	100	100	98	67					29	8	-	-	-	-	-	5.8	NO	11		X	
C	9	A-4(7)	100	100	99	69					27	10	22	13	1.88	17	-	6.7	NO	11		X	
MCLAIN																							
CANADIAN																							
A	14	A-6(10)	100	100	99	95					40	16	35	14	1.82	39	-	6.3	NO	12		X	
B	14	A-6(11)	100	100	100	98					36	17	31	10	1.98	41	-	7.1	NO	12		X	
C	15	A-6(11)	100	100	100	100					39	18	34	14	1.86	37	-	7.6	NO	13		X	
KAY																							
A	9	A-4(8)	100	100	100	96					29	7	-	-	-	-	-	6.0	NO	11		X	
B	15	A-7-6(11)	100	100	100	96					41	16	33	14	1.84	34	-	6.5	NO	14		X	
C	8	A-4(8)	100	100	100	98					28	5	-	-	-	-	-	7.1	NO	11		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
MCLAIN																							
PAYNE																							
A	9	A-4(8)	100	99	97	85					30	8	-	-	-	-	-	7.5	NO	11		X	
B	14	A-6(10)	100	100	100	94					40	14	-	-	-	-	-	7.1	NO	12		X	
C	10	A-4(8)	100	99	99	95					30	10	27	15	1.79	21	-	7.9	NO	11		X	
MENO																							
GARFIELD																							
A	0	A-2-4(0)	100	96	74	13					NP	NP	-	-	-	-	-	6.2	3.7	8	X		
B	1	A-2-4(0)	100	97	80	33					22	3	-	-	-	-	-	5.9	4.9	8	X		
C	0	A-2-4(0)	100	97	80	30					22	3	-	-	-	-	-	5.8	4.7	8	X		
MILLER																							
GARFIELD																							
A	17	A-7-6(13)	100	100	100	99	4	55	41	SIC	44	19	-	12	1.95	52	.15			14			X
AC	30	A-7-6(20)	100	99	99	98	5	44	51	SIC	69	41	-	9	2.03	77	1.42			17			X
C	27	A-7-5(20)	100	100	100	99	6	38	56	C	65	35	-	11	2.10	78	.90			17			X
GRANT																							
A	9	A-4(8)	100	100	99	98					28	8	25	15	1.80	18	-	6.9	NO	11		X	
AC	14	A-6(10)	100	99	99	97					36	16	29	10	1.97	37	-	7.4	NO	12		X	
C	14	A-6(11)	100	99	98	97					34	17	27	10	1.99	33	-	7.0	NO	12		X	
KAY																							
A	14	A-6(10)	100	99	97	89					38	15	32	11	1.97	42	-	7.1	NO	12		X	
AC	10	A-4(8)	100	100	99	97					30	10	27	16	1.79	20	-	7.9	NO	11		X	
C	2	A-4(3)	100	96	88	50					19	3	-	-	-	-	-	8.0	5.9	10	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
MILLER																							
LINCOLN																							
A	19	A-7-5(15)	100	99	99	97					52	22	44	9	1.99	69	.24	7.2	NO	14			X
C	19	A-7-6(15)	100	100	99	98					49	24	40	9	2.04	64	.32	8.0	NO	15			X
NOBLE																							
A	12	A-6(9)	100	99	99	96					35	13	34	10	1.97	47	-	6.9	NO	12		X	
C	13	A-5(9)	100	97	96	94					47	9	38	8	2.09	62	-	8.0	NO	11		X	
OKLAHOMA																							
A	20	A-7-6(16)	100	99	98	96					52	24	44	10	2.04	69	.32	7.4	NO	15			X
C	21	A-7-6(17)	100	99	98	96					54	25	45	11	1.99	67	.36	7.7	NO	15			X
PAYNE																							
A	11	A-6(9)	100	100	99	93					33	12	29	13	1.85	29	-	7.4	NO	12		X	
AC	16	A-7-6(12)	100	100	100	96					44	19	38	10	2.00	56	.15	7.2	NO	14			X
C	15	A-6(11)	100	100	100	96					38	18	30	9	2.06	43	-	7.8	NO	13		X	
MINCO																							
CANADIAN																							
A	8	A-4(8)	100	100	99	83					28	6	-	-	-	-	-	6.3	NO	11		X	
B	7	A-4(8)	100	100	100	80					27	5	-	-	-	-	-	6.2	NO	11		X	
C	8	A-4(8)	100	100	100	78					26	7	-	-	-	-	-	6.2	NO	11		X	
GRANT																							
A	0	A-4(8)	100	100	99	94					NP	NP	-	-	-	-	-	5.2	NO	11	X		
B	7	A-4(8)	100	100	99	96					25	5	-	-	-	-	-	6.3	NO	11		X	
C	10	A-4(8)	100	99	99	95					32	8	27	14	1.84	23	-	6.6	NO	11		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
MINCO																							
LOGAN																							
A	0	A-4(2)	100	96	73	47					NP	NP	-	-	-	-	-	6.9	5.7	10	X		
B	5	A-4(4)	100	100	86	56					26	5	-	-	-	-	-	6.7	6.3	10	X		
C	0	A-2-4(0)	100	94	59	15					NP	NP	-	-	-	-	-	7.0	3.8	8	X		
PAYNE																							
A	0	A-4(4)	100	99	89	57	67	25	8	SL	NP	NP	-	-	-	-	-		6.5	10	X		
C	7	A-4(8)	100	99	94	81	53	32	15	SL	24	6	-	17	1.75	20	-		NO	11	X		
NASH																							
GARFIELD																							
A	1	A-4(1)	100	92	70	41					18	2	-	-	-	-	-	6.9	5.3	9	X		
B	10	A-4(8)	100	97	89	76					29	10	-	-	-	-	-	7.0	NO	11		X	
C	5	A-4(7)	100	98	87	71					22	3	-	-	-	-	-	7.5	NO	11	X		
GRANT																							
A	5	A-4(7)	100	88	78	70					20	4	-	-	-	-	-	5.0	NO	11	X		
B	9	A-6(7)	100	86	77	68					28	11	25	13	1.88	22	-	6.5	NO	12		X	
C	8	A-4(6)	100	85	78	67					28	9	-	-	-	-	-	7.5	NO	11		X	
OKLAHOMA																							
A	0	A-2-4(0)	100	100	98	34					NP	NP	-	-	-	-	-	7.5	5.0	8	X		
B	11	A-6(9)	100	100	98	77					30	13	-	-	-	-	-	7.8	NO	12		X	
C	7	A-4(7)	100	98	97	72					26	5	-	-	-	-	-	8.1	NO	11		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
NEOSHO																							
CREEK																							
A	5	A-4(7)	100	99	97	69					20	3	-	-	-	-	-	7.2	NO	11	X		
B	12	A-6(10)	100	100	96	74					32	15	26	13	1.89	25	-	6.6	NO	12		X	
C	9	A-6(8)	100	100	96	71					28	11	25	12	1.88	24	-	6.8	NO	12		X	
NEWTONIA																							
KAY																							
A	8	A-4(8)	100	100	99	95					28	6	-	-	-	-	-	5.7	NO	11		X	
B	16	A-7-6(12)	100	100	99	96					42	19	36	12	1.89	45	.15	7.1	NO	14		X	
C	17	A-7-6(13)	100	99	99	97					44	20	38	13	1.90	47	.20	7.8	NO	14			X
NOBLE																							
CANADIAN																							
A	0	A-4(3)	100	100	100	49					NP	NP	-	-	-	-	-	6.7	5.9	10	X		
B	0	A-4(2)	100	100	99	46					NP	NP	-	-	-	-	-	5.9	5.7	10	X		
C	0	A-2-4(0)	100	100	99	32					NP	NP	-	-	-	-	-	7.2	4.9	8	X		
LINCOLN																							
A	0	A-4(1)	100	99	97	42					NP	NP	-	-	-	-	-	6.6	5.5	9	X		
C	2	A-4(2)	100	100	96	44					19	4	-	-	-	-	-	6.2	5.6	9	X		
LOGAN																							
A	0	A-4(3)	100	99	99	51					NP	NP	-	-	-	-	-	6.6	6.0	10	X		
C	2	A-4(1)	100	100	100	39					19	5	-	-	-	-	-	6.1	5.3	9	X		
OKLAHOMA																							
A	0	A-2-4(0)	100	100	98	17					NP	NP	-	-	-	-	-	6.4	4.0	8	X		
C	0	A-2-4(0)	100	100	98	18					NP	NP	-	-	-	-	-	6.5	4.0	8	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
NOBLE																							
PAYNE																							
A	4	A-4(4)	100	100	99	57					23	3	-	-	-	-	-	6.6	6.4	10			
AC	7	A-4(6)	100	100	100	63					27	7	-	-	-	-	-	5.9	NO	11		X	
C	7	A-4(6)	100	100	98	63					27	7	-	-	-	-	-	5.9	NO	11		X	
NORGE																							
CANADIAN																							
A	8	A-4(8)	100	99	98	91					29	6	-	-	-	-	-	6.0	NO	11		X	
B	15	A-6(11)	100	99	99	93					39	17	37	16	1.77	37	-	6.7	NO	12		X	
C	14	A-6(11)	100	98	97	87					36	17	31	12	1.91	37	-	[illegible].0	NO	12		X	
GARFIELD																							
A	7	A-4(8)	100	94	89	83					26	5	-	-	-	-	-	5.4	NO	11		X	
B	14	A-6(10)	100	94	90	81					39	15	35	12	1.92	43	-	5.9	NO	12		X	
C	8	A-6(5)	100	80	68	55					32	13	27	13	1.91	28	-	[illegible].5	6.6	12		X	
GRANT																							
A	6	A-4(8)	100	95	90	84					23	4	-	-	-	-	-	5.0	NO	11		X	
B	14	A-6(10)	100	95	92	87					40	16	37	12	1.91	48	-	5.6	NO	12		X	
C	11	A-6(9)	100	86	78	73					32	13	28	14	1.84	27	-	6.7	NO	12		X	
KAY																							
A	8	A-4(8)	100	93	88	82					28	5	-	-	-	-	-	5.0	NO	11		X	
B	16	A-7-6(12)	100	94	91	83					44	18	39	12	1.93	52	-	6.0	NO	14		X	
C	16	A-7-6(6)	100	64	51	44					48	23	38	11	1.98	54	.28	6.6	5.7	13			X
KINGFISHER																							
A	2	A-4(3)	100	96	78	51	73	20	7	SL	19	2	-	15	1.81	5	-		6.0	10	X		
B	9	A-6(7)	100	97	84	61	55	22	23	SCL	33	15	-	14	1.83	28	-		NO	12	X		

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Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
NORGE																							
LINCOLN																							
A	9	A-4(8)	100	99	98	92					32	6	-	-	-	-	-	6.1	NO	11		X	
B	15	A-6(11)	100	99	98	78					38	18	31	12	1.91	35	-	5.9	NO	13		X	
C	15	A-6(11)	100	100	99	75					38	18	34	11	1.93	44	-	6.7	NO	13		X	
LOGAN																							
A	0	A-4(6)	100	99	97	67					NP	NP	-	-	-	-	-	5.7	NO	11	X		
B	16	A-7-6(12)	100	99	98	86					43	19	38	12	1.92	50	.15	6.1	NO	14			X
C	15	A-6(11)	100	99	98	86					39	18	34	13	1.88	40	-	6.5	NO	13		X	
NOBLE																							
A	11	A-6(9)	100	99	99	82					33	12	30	14	1.83	30	-	5.6	NO	12		X	
B	17	A-6(13)	100	100	100	81					40	23	-	-	-	-	.28	5.7	NO	13			X
C	14	A-6(12)	100	100	100	79					34	19	-	-	-	-	.15	6.2	NO	13		X	
OKLAHOMA																							
A	7	A-4(8)	100	97	94	82	35	47	28	L	25	5	-	17	1.80	12	-		NO	11	X		
B	16	A-7-6(12)	100	98	97	85	24	45	31	CL	42	20	-	14	1.90	40	.20		NO	14	X		
PAYNE																							
A	11	A-4(8)	100	100	99	82	34	48	18	L	35	9	-	19	1.71	17	-		NO	11	X		
B	16	A-6(11)	100	100	99	82	27	37	36	CL	39	19	-	13	1.90	42	-		NO	12	X		
C	14	A-6(11)	100	100	99	73	40	32	28	CL	36	18	-	14	1.87	36	-		NO	12	X		
NORGE SLICKSPOT																							
KINGFISHER																							
A	0	A-4(0)	100	95	74	36					NP	NP	-	-	-	-	-	9.7	5.1	9	X		
B	3	A-4(4)	100	93	89	53					21	4	-	-	-	-	-	8.2	6.1	10	X		
C	9	A-6(6)	100	92	82	61					29	12	26	12	1.95	28	-	7.8	NO	12		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
OKEMAH																							
CREEK																							
A	12	A-6(8)	100	93	89	78					39	11	32	16	1.78	29	-	5.6	NO	12		X	
B	17	A-7-5(11)	100	84	76	62					54	19	47	15	1.86	59	.15	6.0	NO	13			X
C	22	A-7-5(18)	100	97	95	88					60	25	57	12	1.96	88	.36	7.1	NO	16			X
OST																							
GARFIELD																							
A	8	A-4(8)	100	96	89	75					26	6	-	-	-	-	-	7.7	NO	11		X	
B	9	A-4(8)	100	97	92	81					26	9	-	-	-	-	-	7.7	NO	11		X	
C	13	A-6(10)	100	96	91	79					35	15	30	12	1.92	34	-	7.7	NO	12		X	
OWENS																							
KAY																							
A	19	A-7-5(15)	100	99	97	88					53	22	45	13	1.83	58	.24	7.0	NO	14			X
AC	23	A-7-5(19)	100	95	93	89					60	27	48	12	1.93	70	.42	7.9	NO	16			X
C	20	A-7-6(16)	100	96	95	91					53	24	43	12	1.94	60	.32	7.6	NO	15			X
NOBLE																							
A	14	A-6(10)	100	98	97	84					40	15	35	14	1.83	39	-	7.1	NO	12		X	
B	14	A-6(10)	100	97	97	90					40	16	36	11	1.94	48	-	7.5	NO	12		X	
C	9	A-6(5)	100	99	76	58					36	11	33	14	1.88	35	-	7.7	6.9	11		X	
POND CREEK																							
GARFIELD																							
A	5	A-4(8)	100	100	99	95	15	69	26	SIL	24	3	-	19	1.72	8	-		NO	11	X		
B	18	A-7-6(15)	100	100	98	94	12	49	39	SICL	47	21	-	11	1.99	59	.21		NO	15			X

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
POND CREEK																							
GRANT																							
A	6	A-4(8)	100	100	99	97					24	4	-	-	-	-	-	5.0	NO	11		X	
B	16	A-6(12)	100	100	100	97					40	19	-	-	-	-	.15	5.9	NO	13		X	
C	14	A-6(10)	100	99	99	98					38	16	-	-	-	-	-	7.5	NO	12		X	
KINGFISHER																							
A	7	A-4(8)	100	100	99	87					26	4	-	-	-	-	-	6.1	NO	11		X	
B	15	A-7-6(11)	100	100	99	94					41	18	36	12	1.93	46	-	6.9	NO	14		X	
C	14	A-6(10)	100	100	99	94					38	15	33	13	1.90	38	-	7.5	NO	12		X	
PORT																							
CANADIAN																							
A	9	A-4(8)	84	84	84	79					29	9	-	-	-	-	-	6.7	NO	11		X	
C	8	A-4(8)	100	100	100	92					27	6	-	-	-	-	-	7.7	NO	11		X	
CREEK																							
A	12	A-6(9)	100	99	99	92					34	13	28	13	1.86	28	-	7.1	NO	12		X	
C	12	A-6(10)	100	100	99	85					33	14	29	12	1.94	34	-	7.9	NO	12		X	
GARFIELD																							
A	8	A-4(8)	100	100	99	96					28	7	-	-	-	-	-	6.1	NO	11		X	
B	10	A-4(8)	100	100	100	97					30	9	-	-	-	-	-	7.2	NO	11		X	
C	11	A-6(9)	100	100	100	98					31	12	28	14	1.87	27	-	7.4	NO	12		X	
GRANT																							
A	11	A-6(9)	100	97	95	93					30	12	28	12	1.92	31	-	6.4	NO	12		X	
C	11	A-6(9)	100	100	99	98					29	12	24	13	1.89	20	-	6.9	NO	12		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
PORT																							
KAY																							
A	6	A-4(8)	100	100	99	81					24	3	-	-	-	-	-	5.8	NO	11	X		
AC	7	A-4(8)	100	100	100	81					25	4	-	-	-	-	-	6.0	NO	11		X	
C	9	A-4(8)	100	100	99	89					28	8	-	-	-	-	-	6.9	NO	11		X	
KINGFISHER																							
A	16	A-6(12)	100	100	100	94	19	51	30	SICL	39	19	-	17	1.83	33	.15		NO	13	X		
C	13	A-6(10)	100	100	100	85	39	37	24	L	33	15	-	16	1.84	26	-		NO	12	X		
LINCOLN																							
A	9	A-4(8)	100	98	97	92					27	8	41	10	2.01	61	-	6.9	NO	11		X	
C	13	A-6(10)	100	100	99	95					34	16	30	10	1.99	39	-	7.9	NO	12		X	
LOGAN																							
A	8	A-4(8)	100	100	100	98					28	7	-	-	-	-	-	7.8	NO	11		X	
C	11	A-6(8)	100	100	100	99					32	11	27	16	1.78	20	-	8.0	NO	12		X	
NOBLE																							
A	7	A-4(8)	100	100	99	83					25	5	-	-	-	-	-	5.7	NO	11		X	
C	10	A-6(8)	100	99	98	88					28	11	25	12	1.94	26	-	7.2	NO	12		X	
OKLAHOMA																							
A	11	A-6(8)	100	100	99	96					32	11	-	-	-	-	-	7.3	NO	12		X	
C	11	A-6(9)	100	93	91	87					30	12	46	8	2.12	81	-	7.3	NO	12		X	
PAYNE																							
A	8	A-4(8)	100	100	99	81	38	45	27	L	26	7	-	16	1.77	20	-		NO	11	X		
C	0	A-4(3)	100	100	99	52	63	17	10	SL	NP	NP	-	-	-	-	-		6.0	10	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
POTTSVILLE																							
CREEK																							
A	0	A-4(1)	100	100	99	38					NP	NP	-	-	-	-	-	5.4	5.2	9	X		
C	15	A-7-6(11)	100	100	100	94					41	17	37	16	1.81	38	-	4.6	NO	14		X	
PRATT																							
GARFIELD																							
A	0	A-2-4(0)	100	93	67	15					NP	NP	-	-	-	-	-	6.0	3.8	8	X		
B	0	A-2-4(0)	100	96	76	26					23	4	-	-	-	-	-	5.7	4.5	7	X		
C	0	A-2-4(0)	100	96	76	22					NP	NP	-	-	-	-	-	7.6	4.2	7	X		
GRANT																							
A	0	A-2-4(0)	100	79	46	19					NP	NP	-	-	-	-	-	5.5	3.9	8	X		
B	0	A-2-4(0)	100	83	51	21					NP	NP	-	-	-	-	-	5.7	4.0	7	X		
C	0	A-2-4(0)	100	76	44	16					NP	NP	-	-	-	-	-	7.3	3.7	8	X		
KAY																							
A	0	A-2-3(0)	100	92	58	18	87	7	6	LS	NP	NP	-	-	-	-	-		4.0	7	X		
B	0	A-2-3(0)	100	92	55	16	88	3	9	LS	NP	NP	-	-	-	-	-		4.0	8	X		
KINGFISHER																							
A	0	A-4(1)	100	97	84	42	74	22	4	LS	NP	NP	-	-	-	-	-		5.5	9	X		
B	4	A-6(2)	100	96	81	47	70	17	13	SL	21	3	-	16	1.81	6	-		6.5	9	X		
PULASKI																							
CANADIAN																							
A	0	A-2-4(0)	100	100	100	26					NP	NP	-	-	-	-	-	6.5	4.5	7	X		
C	3	A-4(3)	100	100	100	50					20	4	-	-	-	-	-	7.9	6.0	10	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
PULASKI																							
CREEK																							
A	0	A-4(2)	100	98	80	46					NP	NP	-	-	-	-	-	6.0	5.7	10	X		
C	0	A-2-4(0)	100	99	88	15					NP	NP	-	-	-	-	-	6.7	3.8	8	X		
LINCOLN																							
A	2	A-4(3)	100	100	98	53	66	23	11	SL	20	2	-	17	1.78	4	-		6.0	10	X		
C	0	A-4(1)	100	100	99	41	77	13	10	SL	NP	NP	-	-	-	-	-		5.5	9	X		
LOGAN																							
A	0	A-4(1)	100	100	99	40					NP	NP	-	-	-	-	-	6.2	5.4	9	X		
C	0	A-4(1)	100	100	100	41					NP	NP	-	-	-	-	-	6.8	5.4	9	X		
OKLAHOMA																							
A	4	A-4(4)	100	100	94	55					22	5	-	-	-	-	-	6.5	6.3	10	X		
C	6	A-4(7)	100	99	98	69					20	6	29	11	1.98	37	-	7.6	NO	11	X		
PAYNE																							
A	0	A-4(1)	100	98	86	40					NP	NP	-	-	-	-	-	7.1	5.3	9	X		
C	3	A-4(2)	100	99	93	45					21	5	-	-	-	-	-	6.8	5.6	9	X		
QUINLAN																							
CANADIAN																							
A	8	A-4(8)	100	100	99	76					28	6	-	-	-	-	-	7.4	NO	11		X	
C	0	A-4(8)	100	100	99	93					NP	NP	-	-	-	-	-	7.2	NO	11	X		
GRANT																							
A	8	A-4(8)	100	99	98	94					26	6	-	-	-	-	-	5.1	NO	11		X	
C	7	A-4(8)	100	100	100	98					23	5	-	-	-	-	-	7.0	NO	11		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
REINACH																							
CANADIAN																							
A	6	A-4(7)	100	99	92	70					25	4	-	-	-	-	-	7.6	NO	11	X		
B	9	A-4(8)	100	100	100	94					30	7	-	-	-	-	-	7.7	NO	11		X	
C	0	A-4(3)	100	100	100	50					NP	NP	-	-	-	-	-	7.4	6.0	10	X		
CREEK																							
A	7	A-4(8)	100	100	99	85					26	4	-	-	-	-	-	7.0	NO	11		X	
C	5	A-4(8)	100	100	100	73					23	2	-	-	-	-	-	7.8	NO	11	X		
GARFIELD																							
A	6	A-4(8)	100	100	99	89					24	3	-	-	-	-	-	5.7	NO	11	X		
C	6	A-4(8)	100	100	100	92					24	2	-	-	-	-	-	7.3	NO	11	X		
GRANT																							
A	7	A-4(8)	100	100	99	92					23	5	-	-	-	-	-	6.4	NO	11		X	
C	0	A-4(8)	100	100	100	79					NP	NP	-	-	-	-	-	6.7	NO	11	X		
KAY																							
A	7	A-4(8)	100	100	100	94					26	5	-	-	-	-	-	6.6	NO	11		X	
AC	9	A-4(8)	100	100	100	95					29	7	-	-	-	-	-	6.6	NO	11		X	
C	8	A-4(8)	100	100	100	95					28	7	-	-	-	-	-	7.1	NO	11		X	
LOGAN																							
A	0	A-4(5)	100	98	93	58					NP	NP	-	-	-	-	-	5.5	6.4	10	X		
C	5	A-4(5)	100	99	94	59					23	5	-	-	-	-	-	6.1	NO	10	X		
PAYNE																							
A	5	A-4(5)	100	99	95	61					23	4	-	-	-	-	-	7.5	NO	11	X		
C	0	A-4(8)	100	100	100	80					NP	NP	-	-	-	-	-	8.2	NO	11	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
RENFROW																							
CANADIAN																							
A	7	A-4(8)	100	100	99	97					27	5	-	-	-	-	-	6.6	NO	11		X	
B	17	A-7-6(13)	100	99	99	93					47	19	39	9	2.01	61	.15	7.0	NO	14			X
C	19	A-7-6(15)	100	99	98	95					49	22	42	9	2.07	69	.24	7.8	NO	15			X
GARFIELD																							
A	12	A-6(9)	100	100	99	97					36	13	32	11	1.95	40	-	7.4	NO	12		X	
B	17	A-7-6(13)	100	100	100	98					45	20	37	10	2.03	55	.20	7.3	NO	14			X
C	16	A-7-6(12)	100	99	98	87					43	19	30	15	1.84	27	.15	8.0	NO	14			X
GRANT																							
A	7	A-4(8)	100	99	99	97					25	4	-	-	-	-	-	5.5	NO	11		X	
B	17	A-7-6(13)	100	99	99	95					44	20	38	9	2.01	59	.20	6.1	NO	14			X
C	16	A-7-6(12)	100	98	98	97					41	20	33	10	1.97	46	.20	7.1	NO	14			X
KAY																							
A	12	A-6(8)	100	99	98	91					38	11	-	-	-	-	-	6.1	NO	12		X	
B	19	A-7-6(15)	100	99	99	96					50	22	44	11	1.94	64	.24	6.5	NO	15			X
C	22	A-7-6(18)	100	97	96	93					53	28	40	10	2.02	61	.49	7.4	NO	17			X
KINGFISHER																							
A	9	A-4(8)	100	100	100	99	17	58	25	SIL	29	9	-	17	1.80	17	-		NO	11	X		
B	25	A-7-6(20)	100	100	100	99	10	33	57	C	58	33	-	13	1.99	52	.76		NO	17			X
C	20	A-7-6(15)	100	98	97	94	20	32	48	C	47	26	-	13	1.97	36	.39		NO	15			X
LINCOLN																							
A	7	A-4(6)	100	100	99	67					27	7	-	-	-	-	-	5.4	NO	11		X	
B	18	A-7-6(14)	100	100	99	80					47	21	41	10	1.98	62	.21	7.3	NO	14			X
C	19	A-7-6(15)	100	99	98	82					45	24	34	10	2.04	50	.32	7.8	NO	15			X

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
RENFROW																							
LOGAN																							
A	11	A-4(8)	100	99	98	88					35	10	-	-	-	-	-	6.5	NO	11		X	
B	18	A-7-6(14)	100	99	99	93					46	22	40	9	1.99	61	.24	7.1	NO	14			X
C	13	A-6(10)	100	99	98	85					36	15	31	13	1.88	34	-	6.5	NO	12		X	
NOBLE																							
A	12	A-6(9)	100	99	96	75					38	12	36	15	1.76	38	-	6.8	NO	12		X	
B	20	A-7-5(16)	100	100	99	93					55	23	46	7	2.10	81	.28	7.3	NO	14			X
C	13	A-6(10)	100	99	98	84					35	16	29	9	2.05	41	-	7.7	NO	12		X	
OKLAHOMA																							
A	13	A-6(10)	100	100	100	94	13	57	40	SICL	35	14	-	15	1.89	32	-		NO	12	X		
B	17	A-7-6(12)	100	100	100	97	6	46	48	SIC	45	19	-	10	2.04	65	.15		NO	14			X
PAYNE																							
A	8	A-4(8)	100	99	98	79					28	5	-	-	-	-	-	6.5	NO	11		X	
B	20	A-7-6(16)	100	99	98	85					50	25	41	9	2.03	65	.36	6.7	NO	15			X
C	17	A-7-6(13)	100	98	97	82					42	21	34	11	2.01	47	.21	7.3	NO	14			X
ROEBUCK																							
CREEK																							
A	18	A-7-6(14)	100	99	98	95					49	21	41	13	1.84	51	.21	7.4	NO	15			X
C	23	A-7-5(19)	100	100	99	97					59	28	49	11	1.93	73	.49	7.7	NO	16			X
LINCOLN																							
A	27	A-7-5(20)	100	100	100	100	4	33	63	C	67	33	-	10	2.01	86	.76			16			X
C	24	A-7-6(20)	100	100	100	99	4	40	56	SIC	60	31	-	8	2.10	92	.63			17			X

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
HELLABARGER																							
CANADIAN																							
A	0	A-2-4(0)	100	94	79	33					NP	NP	-	-	-	-	-	6.5	4.9	8	X		
B	1	A-4(0)	100	95	83	36					20	3	-	-	-	-	-	5.8	5.1	9	X		
C	2	A-4(2)	100	97	88	43					22	5	-	-	-	-	-	6.8	5.5	9	X		
GARFIELD																							
A	0	A-4(1)	100	97	80	41					NP	NP	-	-	-	-	-	6.9	5.4	9	X		
B	6	A-4(4)	100	98	87	53					26	9	-	-	-	-	-	6.3	6.6	10	X		
C	5	A-4(4)	100	99	90	53					23	7	-	-	-	-	-	6.2	6.1	10	X		
GRANT																							
A	6	A-4(8)	100	94	88	75					23	3	-	-	-	-	-	6.8	NO	11	X		
B	10	A-6(7)	100	92	82	64					32	14	26	10	1.96	31	-	6.1	NO	12		X	
C	9	A-6(7)	100	94	82	64					27	12	23	12	1.90	21	-	6.2	NO	12		X	
KAY																							
A	8	A-4(7)	100	99	90	71	44	45	11	L	31	6	-	21	1.62	11	-		NO	11	X		
B	8	A-4(6)	100	98	95	64	43	36	21	L	29	10	-	14	1.88	25	-			12	X		
C	1	A-4(0)	100	96	74	39	70	15	15	SL	20	3	-	14	1.86	12	-		5.5	9	X		
KINGFISHER																							
A	1	A-4(0)	100	98	83	37	75	14	11	SL	22	5	-	15	1.84	11	-		5.0	9	X		
B	8	A-6(4)	100	99	88	45	68	11	21	SCL	28	17	-	17	1.82	16	-		6.0	11	X		
C	0	A-2(0)	100	99	93	28	84	6	10	LS	19	1	-	17	1.76	3	-		5.0	8	X		
OGN																							
KAY																							
A	16	A-7-5(12)	100	99	96	90					49	16	46	16	1.74	52	-	6.9	NO	13			X

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
STEPHENVILLE																							
CREEK																							
A	0	A-4(1)	100	99	94	41					NP	NP	-	-	-	-	-	6.9	5.4	9	X		
B	9	A-4(6)	100	100	95	64					34	10	-	-	-	-	-	5.3	NO	11		X	
C	6	A-4(4)	100	100	96	54					27	9	-	-	-	-	-	4.9	6.7	10		X	
LINCOLN																							
A	0	A-2-4(0)	100	100	83	19					NP	NP	-	-	-	-	-	6.6	4.1	8	X		
B	6	A-4(5)	100	99	88	61					24	6	-	-	-	-	-	5.6	NO	11	X		
C	4	A-4(5)	100	100	90	58					21	5	-	-	-	-	-	4.8	6.4	10	X		
LOGAN																							
A	0	A-4(0)	100	99	75	37					NP	NP	-	-	-	-	-	6.0	5.2	9	X		
B	5	A-4(3)	100	100	99	50					29	9	-	-	-	-	-	5.5	6.5	10	X		
C	1	A-2-4(0)	100	100	98	31					20	4	-	-	-	-	-	5.8	4.8	8	X		
NOBLE																							
A	0	A-4(6)	100	99	99	63					NP	NP	-	-	-	-	-	5.8	NO	11	X		
B	8	A-4(7)	100	98	97	71					27	8	-	-	-	-	-	5.1	NO	11		X	
C	7	A-4(7)	100	97	96	70					24	6	-	-	-	-	-	6.4	NO	11		X	
OKLAHOMA																							
A	0	A-2-3(0)	100	100	91	25	86	10	4	LS	NP	NP	-	-	-	-	-		4.5	7	X		
B	5	A-4(2)	100	100	95	46	65	10	25	SCL	27	9	-	17	1.82	16	-		6.0	9	X		
PAYNE																							
A	5	A-4(4)	100	99	68	55					28	5	-	-	-	-	-	6.3	6.2	10	X		
B	13	A-6(10)	100	100	99	80					36	15	32	13	1.88	36	-	5.6	NO	12		X	
C	10	A-6(8)	100	100	100	81					28	11	25	13	1.90	23	-	6.1	NO	12		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
STIDHAM																							
CREEK																							
A	0	A-2-4(0)	100	99	92	23					NP	NP	-	-	-	-	-	6.1	4.3	7	X		
B	1	A-4(0)	100	100	94	36					18	3	-	-	-	-	-	6.2	5.1	9	X		
C	3	A-4(1)	100	100	95	40					24	8	-	-	-	-	-	6.3	5.4	9	X		
SUMMIT																							
KAY																							
A	15	A-7-5(11)	100	98	94	84					47	13	41	16	1.72	42	-	6.0	NO	13		X	
B	18	A-7-5(14)	100	98	98	94					52	20	47	12	1.89	66	.20	5.8	NO	14			X
C	22	A-7-5(18)	100	95	94	90					56	26	48	9	2.00	78	.39	6.6	NO	16			X
NOBLE																							
A	9	A-4(8)	100	99	97	92					33	7	-	-	-	-	-	6.2	NO	11		X	
B	21	A-7-6(17)	100	99	99	96					53	25	42	10	1.96	63	.36	7.1	NO	15			X
C	20	A-7-6(16)	100	98	96	93					50	25	40	9	2.02	62	.36	7.8	NO	15			X
TABLER																							
GARFIELD																							
A	6	A-4(8)	100	99	99	97	12	71	27	SIL	25	3	-	20	1.71	5	-		NO	11	X		
B	22	A-7-6(17)	100	100	99	98	9	44	47	SIC	53	28	-	11	1.98	61	.49		NO	15			X
C	24	A-7-6(17)	100	100	99	97	8	49	43	SIC	56	31	-	10	2.03	68	.63		NO	15			X
GRANT																							
A	7	A-4(8)	100	100	99	97					24	6	-	-	-	-	-	5.5	NO	11		X	
B	15	A-7-6(11)	100	99	99	97					41	18	36	10	1.98	52	-	7.0	NO	14		X	
C	17	A-7-6(13)	100	99	98	97					44	20	36	9	2.04	56	.20	7.6	NO	14			X

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
TABLER																							
KAY																							
A	7	A-4(8)	100	100	99	97	11	68	21	SIL	27	9	-	18	1.74	13	-			11	X		
B	26	A-7-6(20)	100	100	99	98	5	47	48	SIC	63	33	-	9	2.05	81	.76		NO	17			X
C	10	A-7-6(17)	100	99	98	96	11	49	40	SIC	50	25	-	10	2.01	67	.36		NO	15			X
KINGFISHER																							
A	8	A-4(8)	100	98	95	85					27	6	-	-	-	-	-	8.2	NO	11		X	
B	17	A-7-6(13)	100	99	95	92					43	21	38	18	1.71	34	.21	7.3	NO	14			X
C	18	A-7-6(14)	100	98	95	87					44	22	38	9	2.06	60	.24	7.3	NO	14			X
NOBLE																							
A	5	A-4(8)	100	99	98	89					21	3	-	-	-	-	-	4.5	NO	11	X		
B	18	A-7-6(14)	100	99	98	90					46	22	41	10	2.00	62	.24	6.9	NO	14			X
C	12	A-6(9)	100	99	98	78					32	13	28	13	1.88	29	-	7.5	NO	12		X	
PAYNE																							
A	9	A-4(8)	100	98	97	82					31	7	-	-	-	-	-	6.3	NO	11		X	
B	24	A-7-6(19)	100	99	99	95					57	31	46	9	2.01	74	.63	7.5	NO	17			X
C	15	A-6(11)	100	99	93	78					38	18	32	13	1.89	36	-	7.8	NO	13		X	
TABLER SLICKSPOT																							
KINGFISHER																							
A	6	A-4(8)	100	100	97	85					23	3	-	-	-	-	-	6.7	NO	11	X		
B	15	A-6(11)	100	100	97	85					39	18	33	11	1.96	44	-	7.3	NO	13		X	
C	18	A-7-6(14)	100	99	96	87					44	22	37	10	2.02	55	.24	7.5	NO	14			X

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
TALIHINA																							
CREEK																							
A	4	A-4(4)	100	99	90	53					21	5	-	-	-	-	-	7.5	6.1	10	X		
C	11	A-6(8)	100	99	93	70					34	12	29	12	1.92	32	-	7.6	NO	12		X	
PAYNE																							
A	15	A-7-6(11)	100	99	97	78					42	17	37	12	1.86	47	-	7.5	NO	14		X	
C	23	A-7-6(19)	100	98	97	93					56	30	43	6	2.15	79	.58	8.2	NO	17			X
TELLER																							
CREEK																							
A	6	A-4(8)	100	98	95	74					23	5	-	-	-	-	-	6.3	NO	11		X	
B	12	A-6(10)	100	98	96	83					32	14	27	14	1.85	24	-	6.5	NO	12		X	
C	11	A-6(9)	100	98	96	81					31	12	28	15	1.80	24	-	7.6	NO	12		X	
LINCOLN																							
A	0	A-4(3)	100	100	99	51					NP	NP	-	-	-	-	-	6.0	6.0	10	X		
B	11	A-6(9)	100	100	99	75					30	13	36	11	1.97	50	-	6.9	NO	12		X	
C	9	A-6(6)	100	100	100	57					30	13	23	14	1.85	17	-	6.5	6.9	12		X	
LOGAN																							
A	0	A-4(8)	100	100	99	87					NP	NP	-	-	-	-	-	6.0	NO	11	X		
B	14	A-6(10)	100	100	99	92					37	16	32	13	1.88	35	-	6.7	NO	12		X	
C	14	A-6(10)	100	100	100	94					36	16	29	13	1.90	30	-	7.6	NO	12		X	
OKLAHOMA																							
A	0	A-4(1)	100	88	76	42					NP	NP	-	-	-	-	-	6.4	5.4	9	X		
B	6	A-4(5)	100	97	92	59					26	7	-	-	-	-	-	5.9	NO	10	X		
C	4	A-4(3)	100	98	89	50					24	5	-	-	-	-	-	5.6	5.9	10	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
TELLER																							
PAYNE																							
A	0	A-4(2)	100	99	81	45	69	22	9	SL	NP	NP	-	-	-	-	-		5.5	9	X		
B	8	A-6(6)	100	98	88	58	56	21	23	SCL	29	12	-	13	1.88	29	-		7.0	12	X		
C	11	A-6(8)	100	99	95	69	53	26	21	SCL	32	12	-	17	1.76	24	-		NO	12	X		
TIVOLI																							
CANADIAN																							
A	0	A-2-4(0)	100	99	98	23					NP	NP	-	-	-	-	-	7.5	4.3	7	X		
C	0	A-2-4(0)	100	100	98	13					NP	NP	-	-	-	-	-	6.5	3.7	8	X		
GRANT																							
A	0	A-2-4(0)	100	93	62	13					NP	NP	-	-	-	-	-	5.0	3.7	8	X		
C	0	A-2-4(0)	100	87	56	16					NP	NP	-	-	-	-	-	6.7	3.8	8	X		
KINGFISHER																							
A	0	A-3(0)	100	99	86	4					NP	NP	-	-	-	-	-	7.2	3.2	12	X		
C	0	A-3(0)	100	100	86	2					NP	NP	-	-	-	-	-	8.5	3.1	12	X		
VANOSS																							
CANADIAN																							
A	0	A-4(8)	100	100	99	83					NP	NP	-	-	-	-	-	5.4	NO	11	X		
B	11	A-6(8)	100	100	99	88					31	11	28	15	1.79	23	-	6.5	NO	12		X	
C	14	A-6(10)	100	99	98	82					36	16	31	12	1.90	36	-	6.8	NO	12		X	
CREEK																							
A	10	A-4(8)	100	100	99	84					34	9	-	-	-	-	-	5.6	NO	11		X	
B	12	A-6(9)	100	100	99	89					34	13	30	15	1.81	27	-	5.8	NO	12		X	
C	13	A-6(10)	100	100	99	87					35	14	32	14	1.88	34	-	5.9	NO	12		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
VANOSS																							
GRANT																							
A	6	A-4(8)	100	97	94	88					23	3	-	-	-	-	-	5.5	NO	11	X		
B	10	A-4(8)	100	98	95	91					30	9	-	-	-	-	-	6.2	NO	11		X	
C	9	A-6(6)	100	84	70	58					31	13	28	12	1.95	32	-	7.2	6.8	12		X	
KAY																							
A	8	A-4(8)	100	99	100	96	13	66	21	SIL	28	5	-	20	1.74	11	-		NO	11	X		
B	18	A-7-6(14)	100	100	100	99	5	60	35	SICL	48	20	-	15	1.87	55	.20		NO	14			X
C	14	A-7-6(11)	100	99	100	97	9	62	29	SICL	40	16	-	16	1.81	37	-		NO	14	X		
LINCOLN																							
A	7	A-4(8)	100	100	99	76					26	5	-	-	-	-	-	6.8	NO	11		X	
B	12	A-6(9)	100	100	99	83					33	13	30	12	1.91	34	-	7.1	NO	12		X	
C	13	A-6(10)	100	100	100	76					33	15	29	14	1.86	28	-	7.7	NO	12		X	
LOGAN																							
A	7	A-4(8)	100	99	98	78					25	5	-	-	-	-	-	6.3	NO	11		X	
B	15	A-6(11)	100	99	99	92					39	18	34	12	1.90	41	-	6.1	NO	13		X	
C	18	A-7-6(14)	100	99	98	88					45	23	37	12	1.97	50	.28	7.7	NO	15			X
NOBLE																							
A	6	A-4(8)	100	100	99	90					21	4	-	-	-	-	-	4.9	NO	11	X		
B	15	A-6(11)	100	99	99	88					39	17	33	13	1.90	38	-	6.9	NO	12		X	
C	13	A-6(10)	100	100	99	87					35	14	31	12	1.92	37	-	6.2	NO	12		X	
OKLAHOMA																							
A	6	A-4(8)	100	100	99	87	26	60	24	SIL	24	3	-	20	1.70	5	-		NO	11	X		
B	11	A-6(8)	100	100	99	92	24	52	24	SIL	32	11	-	16	1.81	22	-			12	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
VANOSS																							
PAYNE																							
A	4	A-4(6)	100	99	91	65					19	4	-	-	-	-	-	6.4	NO	11	X		
B	10	A-6(7)	100	97	79	65					33	13	29	11	1.96	35	-	5.5	NO	12		X	
C	3	A-4(1)	100	98	81	42					24	7	-	-	-	-	-	6.5	5.5	9	X		
VERDIGRIS																							
CREEK																							
A	11	A-6(8)	100	100	99	91					35	11	34	17	1.72	29	-	5.9	NO	12		X	
C	10	A-4(8)	100	99	98	83					31	10	31	14	1.83	30	-	5.9	NO	11		X	
VERNON																							
CANADIAN																							
A	12	A-6(9)	100	98	92	76					35	12	30	15	1.82	28	-	7.1	NO	12		X	
C	9	A-6(5)	100	88	69	45					39	19	-	-	-	-	.15	8.2	6.0	11		X	
GARFIELD																							
A	9	A-4(8)	100	100	99	97					30	7	-	-	-	-	-	7.3	NO	11		X	
C	13	A-6(10)	100	98	95	89					37	15	33	12	1.96	42	-	7.6	NO	12		X	
GRANT																							
A	12	A-6(10)	100	95	88	80					30	14	-	-	-	-	-	6.9	NO	12		X	
C	12	A-6(10)	100	95	88	77					29	16	-	-	-	-	-	7.8	NO	12		X	
KAY																							
A	11	A-6(8)	100	99	98	88					31	11	28	13	1.87	28	-	6.9	NO	12		X	
C	16	A-7-6(12)	100	99	97	92					42	19	34	11	1.96	46	.15	7.6	NO	14		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
VERNON																							
KINGFISHER																							
A	13	A-6(10)	100	99	98	94	20	50	30	CL	36	15	-	16	1.79	29	-		NO	12	X		
C	10	A-4(8)	100	98	89	73	40	40	20	L	34	10	-	23	1.66	15	-		NO	11	X		
LINCOLN																							
A	5	A-4(4)	100	100	95	54					26	7	-	-	-	-	-	6.9	6.2	10	X		
C	12	A-6(10)	100	99	97	79					34	14	28	11	1.97	34	-	7.9	NO	12		X	
LOGAN																							
A	8	A-4(7)	100	99	98	68					27	8	-	-	-	-	-	6.6	NO	11		X	
C	19	A-7-6(15)	100	99	99	96					45	25	34	9	2.09	53	.36	7.8	NO	15			X
NOBLE																							
A	8	A-4(8)	100	95	93	75					29	6	-	-	-	-	-	7.2	NO	11		X	
C	17	A-7-6(13)	100	98	97	92					41	21	34	8	2.11	56	.21	7.9	NO	14			X
OKLAHOMA																							
A	14	A-7-6(10)	100	100	100	98	11	56	33	SICL	42	15	-	15	1.84	46	-		NO	14	X		
C	22	A-7-5(18)	100	99	99	99	5	39	56	C	57	26	-	8	2.10	79	.39			17			X
PAYNE																							
A	16	A-7-6(12)	100	99	99	93	16	49	35	SICL	41	19	-	11	1.99	49	.15		NO	14	X		
C	25	A-7-5(20)	100	99	99	97	7	34	59	C	62	31	-	18	1.77	54	.63		NO	16			X
WAURIKA																							
KAY																							
A	7	A-4(8)	100	99	98	95	11	71	18	SIL	25	4	-	20	1.74	5	-		NO	11	X		
B	27	A-7-5(20)	100	100	99	98	7	43	50	SIC	66	35	-	8	2.07	86	.90		NO	16			X
C	20	A-7-6(18)	100	99	98	96	9	53	38	SICL	49	26	-	9	2.06	57	.39		NO	17			X

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
WOODSON																							
CREEK																							
A	12	A-6(9)	100	98	96	85					37	12	38	16	1.74	38	-	6.4	NO	12		X	
B	19	A-7-6(15)	100	99	98	91					51	22	48	16	1.93	62	.24	5.8	NO	15			X
C	20	A-7-6(16)	100	98	97	93					51	24	50	9	2.05	84	.32	6.3	NO	15			X
YAHOLA																							
CANADIAN																							
A	5	A-4(6)	100	99	99	66					22	3	-	-	-	-	-	7.9	NO	11	X		
C	0	A-4(3)	100	99	99	51					NP	NP	-	-	-	-	-	8.1	6.0	10	X		
CREEK																							
A	0	A-4(1)	100	100	99	41					NP	NP	-	-	-	-	-	7.5	5.4	9	X		
C	0	A-2-4(0)	100	100	100	34					NP	NP	-	-	-	-	-	7.9	5.0	8	X		
GARFIELD																							
A	0	A-2-4(0)	100	82	48	14					NP	NP	-	-	-	-	-	7.2	3.6	8	X		
C	0	A-3(0)	100	84	64	8					NP	NP	-	-	-	-	-	7.1	3.3	11	X		
GRANT																							
A	8	A-4(8)	100	98	93	82					26	6	-	-	-	-	-	6.5	NO	11		X	
C	0	A-2-4(0)	100	100	67	24					NP	NP	-	-	-	-	-	7.5	4.4	7	X		
KAY																							
A	5	A-4(7)	100	98	93	68					21	3	-	-	-	-	-	7.7	NO	11	X		
AC	0	A-2-4(0)	100	97	85	31					NP	NP	-	-	-	-	-	7.9	4.8	8	X		
C	0	A-4(7)	100	100	98	72					NP	NP	-	-	-	-	-	8.0	NO	11	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
YAHOLA																							
KINGFISHER																							
A	0	A-4(5)	100	99	97	62					NP	NP	-	-	-	-	-	7.2	NO	11	X		
C	0	A-2-4(0)	100	97	85	22					NP	NP	-	-	-	-	-	7.9	4.2	7	X		
LINCOLN																							
A	0	A-4(1)	100	100	98	39					NP	NP	-	-	-	-	-	7.9	5.3	9	X		
C	0	A-2-4(0)	100	100	97	27					NP	NP	-	-	-	-	-	7.7	4.6	7	X		
LOGAN																							
A	0	A-4(8)	100	99	97	77					NP	NP	-	-	-	-	-	8.0	NO	11	X		
C	0	A-3(0)	100	80	35	3					NP	NP	-	-	-	-	-	8.5	NO	10	X		
NOBLE																							
A	9	A-4(8)	100	99	98	89					31	8	-	-	-	-	-	7.0	NO	11		X	
C	8	A-4(8)	100	98	97	87					28	6	-	-	-	-	-	7.8	NO	11		X	
PAYNE																							
A	0	A-4(6)	100	100	99	64	62	30	38	SL	NP	NP	-	-	-	-	-		NO	11	X		
C	0	A-2-3(0)	100	97	67	14	93	5	2	S	NP	NP	-	-	-	-	-		4.0	8	X		
ZANEIS																							
GARFIELD																							
A	5	A-4(7)	100	100	100	70	46	40	14	L	23	2	-	17	1.74	9	-		NO	11	X		
B	15	A-6(10)	100	100	100	79	30	38	32	CL	40	17	-	13	1.91	44	-		NO	12	X		
C	4	A-4(2)	100	100	100	47	63	15	22	SCL	27	8	-	16	1.78	13	-		6.0	9	X		
LINCOLN																							
A	11	A-4(8)	100	100	99	84	29	55	16	SIL	37	8	-	14	1.57	34	-			11	X		
B	12	A-6(9)	100	99	98	87	26	44	30	CL	36	13	-	16	1.75	31	-			12	X		
C	8	A-4(7)	100	98	97	69	45	31	24	L	27	9	-	9	1.87	20	-			11	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
ZANEIS																							
LOGAN																							
A	6	A-4(5)	100	99	98	62					27	7	-	-	-	-	-	5.8	NO	11		X	
B	9	A-6(6)	100	100	99	59					31	12	26	13	1.88	24	-	6.1	NO	12		X	
C	7	A-4(6)	100	99	90	65					25	7	-	-	-	-	-	6.0	NO	11		X	
OKLAHOMA																							
A	4	A-4(4)	100	98	98	54					25	4	-	-	-	-	-	6.3	6.2	10	X		
B	13	A-6(10)	100	99	99	82					36	15	29	14	1.86	28	-	7.6	NO	12		X	
C	7	A-4(5)	100	100	100	58					30	10	26	17	1.75	16	-	5.8	6.9	10		X	
PAYNE																							
A	12	A-6(9)	100	99	98	73	41	39	20	L	36	12	-	17	1.75	34	-		NO	12	X		
B	18	A-7-6(13)	100	100	99	85	27	34	39	CL	46	21	-	12	1.94	61	.21		NO	14			X
C	15	A-6(11)	100	100	99	85	38	34	28	CL	39	19	-	15	1.83	32	.15		NO	12	X		

TABLE OF TERMS, SOILS*

A HORIZON--See HORIZON, SOIL.

AASHO--American Association of State Highway Officials; a performance value determined by using the percent of soil material passing certain specific sieve sizes, liquid limit, and plasticity index in an emperical mathematical formula. Indicates the suitability of the soils as construction materials. See page 15.

ABC SOIL--A soil with a complete profile, including clearly developed A, B, and C horizons.

AC SOIL--A soil having only A and C horizons developed; no clearly developed B horizon.

ACID SOIL--A soil that gives an acid reaction (precisely, below pH 7.0; practically, below pH 6.6).

AEOLIAN--Wind-transported materials, including wind-blown sands, wind-blown silt, and wind-carried volcanic ash. (Eolian).

ALKALI SOIL--A soil in which soldium occupies 15 percent or more of the total exchange capacity (usually indicated by a pH value of 8.5 or higher).

ALLUVIAL SOILS--1. Soils developed from relatively recently deposited materials, transported by flowing water.

2. A Great Soil Group (taxonomic unit) which is comprised of azonal soils developed from transported and recently deposited alluvium characterized by a weak modification (or none) of the original soil-forming processes. "Alluvial" is capitalized when used with this meaning.

ALLUVIUM--Fine material; such as sand, mud, or other sediments deposited on land by streams. Stratification is a common characteristic.

AZONAL--A soil that does not have a strongly developed profile because of extreme youth, strong relief, or unusually stony parent material.

B HORIZON--See HORIZON, SOIL.

BEDROCK--The solid rock underlying soils or other superficial formation.

BLOCKY (OR BLOCK-LIKE) STRUCTURE--See STRUCTURE, SOIL.

BRITTLE--See CONSISTENCE.

BRUNIZEM SOILS--The name used for Prairie Soils by Simonson, et al, (see PRAIRIE SOILS).

C--Clay, See TEXTURE.

C HORIZON--See HORIZON, SOIL.

*For Geological terms see page 20.

CALCAREOUS SOIL--Soil containing sufficient calcium carbonate (often with magnesium carbonate) to effervesce visibly when treated with hydrochloric acid. Soil alkaline in reaction, owing to the presence of free calcium carbonate.

CATENA--A group of soil series within any one soil zone developed from similar parent material, but with contrasting characteristics of the solum due to differences in relief or drainage.

CHERNOZEM SOILS--A zonal group of soils having a deep, dark-colored to nearly-black surface horizon, rich in organic matter, which grades below into lighter-colored soil and finally into a layer of lime accumulation; developed under tall and mixed grasses in a temperate to cool subhumid climate.

CL--Clay Loam, See TEXTURE.

CLAY--See SEPARATE and TEXTURE.

CLAYPAN--A compact soil horizon or layer rich in clay and separated more or less abruptly from the overlying horizon; hard when dry, and plastic or stiff when wet. Probably formed in part by the accumulation of clay from the upper horizons.

COLUMNAR STRUCTURE--See STRUCTURE, SOIL.

COMPACT--See CONSISTENCE.

COMPLEX, SOIL--A soil association composed of such an intimate mixture or areas of soil series, types, or phases that these cannot be indicated separately upon maps of the scale used, so that the association is mapped as a unit.

CONCRETIONS--Hardened local concentrations of certain chemical compounds, such as calcium carbonate and iron and manganese oxides, that form indurated grains or nodules of various sizes, shapes, and colors.

CONCRETIONS, LIME--Usually lime concretions consist of calcium carbonate and other included soil constituents. They vary greatly in size, from very small particles up to two feet in diameter. They take many shapes, with spheres, rough tubular or branched tubular, and rough plates being the common forms.

Iron and Manganese--Often called "shot." These are indurated accumulations of iron and manganese oxides. They are commonly in the form of spherical pellets.

CONSISTENCE, SOIL--The relative mutual attraction of the particles in the whole soil mass or their resistance to separation of deformation (as evidenced in cohesion and plasticity). The terms used in soil descriptions for consistence as given in the Soil Survey Manual follow:

WHEN DRY--

LOOSE--Noncoherent.

SOFT--Soil mass is very weakly coherent and fragile; breaks to powder or individual grains under very slight pressure.

SLIGHTLY HARD--Weakly resistant to pressure; easily broken between thumb and forefinger.

HARD--Moderately resistant to pressure; can be broken in the hands without difficulty, but is barely breakable between thumb and forefinger.

VERY HARD--Very resistant to pressure; can be broken in the hands only with difficulty; not breakable between thumb and forefinger.

EXTREMELY HARD--Extremely resistant to pressure; cannot be broken in the hands.

WHEN MOIST--

LOOSE--Noncoherent.

VERY FRIABLE--Soil material crushes under very gentle pressure, but coheres when pressed together.

FRIABLE--Soil material crushes easily under gentle to moderate pressure between thumb and forefinger, and coheres when pressed together.

FIRM--Soil material crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

VERY FIRM--Soil material crushes under strong pressure; barely crushable between thumb and forefinger.

EXTREMELY FIRM--Soil material crushes only under very strong pressure; cannot be crushed between thumb and forefinger and must be broken apart bit by bit.

COMPACT--A combination of firm consistence and close packing or arrangement of particles.

WHEN WET--Determined when the moisture of the soil material is at or slightly above field capacity.

PLASTICITY--The ability to change shape continuously under the influence of applied stress and to retain the new shape upon removal of the stress. For field determination of plasticity, roll the soil material between thumb and finger and observe whether or not a wire or thin rod of soil can be formed. Express degree of resistance to deformation at a moisture content at or slightly above field capacity as follows:

NONPLASTIC--No wire is formable.

SLIGHTLY PLASTIC--Wire formable, but soil mass easily deformable.

PLASTIC--Wire formable and moderate pressure required for deformation of the soil mass.

VERY PLASTIC--Wire formable and much pressure required for deformation of the soil mass.

CRUMB STRUCTURE--See STRUCTURE, SOIL.

DEGRADATION--Change of a soil type to one more highly leached.

DRAINAGE, SOIL--Refers to the rapidity and extent of the removal of water from the soil, in relation to additions, especially by surface runoff and by flow through the soil.

Permeability--That quality of the soil that enables it to transmit water or air. It is measured in terms of rate of flow through a unit cross section of saturated soil in unit time.

EOLIAN--See AEOLIAN.

FERRUNGINOUS--Iron-bearing; usually refers to material of comparatively high iron oxide content.

FIELD MOISTURE EQUIVALENT--The minimum moisture content, expressed as a percent of oven dry soil, at which a smooth surface of soil will absorb no more water in 30 seconds.

FIRM--See CONSISTENCE WHEN MOIST.

FLOURY--Fine-textured soil consisting predominantly of silt, or silt-size aggregates of clay particles, which is incoherent when dry, smooth, and dust-like.

FLUFFY--See CONSISTENCE.

FRAGIPANS--Compact horizons, rich in silt, sand, or both, and usually low in clay. When dry, the horizon appears to be indurated, but the apparent induration disappears upon moistening. Undisturbed fragipans are nearly impermeable to water.

FRIABLE--See CONSISTENCE WHEN MOIST.

GLEIZATION--A general term for the process of soil formation leading to the development, under the influence of excessive moistening, of a glei (gley) horizon in the lower part of the solum. A soil horizon in which the material ordinarily is bluish-gray or olive-gray, more or less sticky, compact, and often structureless, is called a glei horizon and is developed under the influence of excessive moistening.

GRANULAR STRUCTURE--See STRUCTURE.

GRAY-BROWN PODZOLIC SOILS--A zonal group of soils having a comparatively thin organic covering and organic-mineral layers over a grayish-brown leached layer resting upon a brown, blocky, illuvial B horizon; developed under deciduous forest in a temperate, moist climate.

GREAT SOIL GROUP (SOIL CLASSIFICATION)--A group of soils having common internal soil characteristics; includes one or more families of soils. Among the zonal soils, each great soil group includes the soils having common internal characteristics developed through the influence of environmental forces of broad geographic significance, especially vegetation and climate; among the intrazonal soils, each great soil group includes the soils having common internal characteristics developed through the influence of environmental forces of both broad and local significance; among the azonal soils, each great soil group includes similar soils that are without developed characteristics, owing to the influence of some local condition of parent material or relief. (See AZONAL SOIL, INTRAZONAL SOIL, ZONAL SOIL.)

GRITTY--Containing enough angular particles of sand that they dominate the feel. Usually applied to soils where the actual quantity of sand is small.

HARD--See CONSISTENCE WHEN DRY.

HARDPAN--A hardened or cemented soil horizon. The term should not be applied to hard clay layers that are not cememted. (See CLAYPAN.) The soil may have any texture and is compacted or cemented by iron oxide, organic matter, silica, calcium carbonate, or other substances.

HEAVY--Applied to fine-textured soils in which clay predominates, with a firm to compact consistence, that are heavy to work. A term not used in literature at the present time.

HORIZON, SOIL--A layer of soil approximately parallel to the land surface with characteristics produced by soil-forming processes.

ILLITE (HYDROUS MICA)--One of the three major groups of silicate clay minerals. The crystals are built up of units of three alternating sheets, two silica sheets to one alumina or a 2-to-1 lattice. The units are bonded together by potassium atoms, which exert a stabilizing effect on the crystal lattice. The illites may expand slightly, but rarely enough to be of significance. (See KAOLINITE and MONTMORILLONITE.)

INDURATED--Mass is very strongly cemented; brittle, does not soften under prolonged wetting and is so extremely hard that a sharp blow with a hammer is required to break; hammer generally rings as a result of the blow.

INTRAZONAL--A soil that has well-developed characteristics, but the influence of climate and vegetation is over shadowed by slope and/or parent material.

KAOLINITE--One of the three major groups of silicate clay minerals. The crystals are plate-like and roughly hexagonal in shape. The crystals are built up of flat crystal units, each unit being composed of alternate layers of silica and alumina sheets. There is one alumina sheet for each silica sheet of a 1-to-1 lattice. The kaolinite crystals are the most stable of the layer silicate clay minerals; the bonding between the units is firm, and they offer less surface area than the other clay minerals. The kaolinites exhibit few colloidal properties. (See ILLITE and MONTMORILLONITE.)

L--Loam, See TEXTURE.

LEACHING--Removal of materials in solution.

LIGHT--Applied to soils that are easy to work, usually of medium to coarse texture with low silt and clay content, incoherent single-grained structure. A term not used in literature at the present time.

LIQUID LIMIT--The moisture content, expressed as a percent of oven dry soil, at which a soil passes from a plastic to a liquid state.

LITHOSOLS--Azonal soils having no clearly expressed soil morphology and consisting of a freshly and imperfectly weathered mass of rock fragments; largely confined to steeply sloping land.

LOAM--A soil that has roughly equal percentages of sand and silt and a small amount of clay. (See CLASS, SOIL, TEXTURE.)

LOESS--Soil material consisting primarily of uniform silt that was transported and deposited by wind.

LOOSE--See CONSISTENCE WHEN DRY.

LS--Loamy Sand, See TEXTURE.

MASSIVE STRUCTURE--See STRUCTURE, SOIL.

MATURE SOIL--A soil with well-developed characteristics produced by the natural processes of soil formation, and in equilibrium with its environment.

MEALY--See CONSISTENCE, SOIL.

MELLOW--See CONSISTENCE, SOIL.

MONTMORILLONITE--One of the three major groups of silicate clay minerals. The crystals are built of units of three alternating sheets, two silica sheets to an alumina, magnesium, or iron sheet or a 2-to-1 lattice. The units are bonded together by weak oxygen-to-cation-to-oxygen linkages, which allows the crystal lattice to absorb water on the internal surfaces. This condition gives the montmorillonite high swelling and shrinkage properties. The crystals are much smaller than the crystals of illite and kaolinite. Montmorillonite is noted for its high plasticity and cohesion. (Bentonite is a rock formed from volcanic ash that has been weathered to montmorillonite.)

MOTTLED--Irregularly marked with spots of different colors.

NEUTRAL SOIL--A soil that is not acid or alkaline; practically, one having a pH between 6.6 and 7.3.

NUT STRUCTURE--See STRUCTURE, SOIL.

ORGANIC MATTER--Soil carbonaceous material consisting of the remains of plants and animals and their decomposition products.

O.S.I.--Oklahoma Subgrade Index; a modification of the AASHO group index number; a relative support value determined by using the percent of soil material passing the No. 200 sieve, liquid limit, and plasticity index in an emperical mathematical formula. An index number used to determine base thickness requirements for roadways. See page 14.

PARENT MATERIAL--The relatively unaltered, unconsolidated material beneath the solum (the A and B horizons) from which the soil is formed.

PARENT ROCK--The rock from which the parent material is formed, the "D" or "R" horizon.

PERCOLATION--The process of water filtering through the soil mass.

PERMEABILITY--See DRAINAGE, SOIL.

pH--A notation used to designate the degree of acidity or alkalinity of a system, the common logarithm of the reciprocal of the hydrogen-ion concentration. pH of 7 is neutral, lower values indicate acidity, and higher values indicate alkalinity.

PHASE, SOIL--That part of a soil unit or soil type having minor variations in characteristics used in soil classification from the characteristics normal for the type. Although minor, these variations may be of great practical importance. The variations are chiefly in such external characteristics as relief, stoniness, or accelerated erosion.

PLANOSOL SOILS--An intrazonal group of soils with eluviated surface horizons underlain by B horizons more strongly illuviated, cemented, or compacted than associated normal soils, developed upon nearly flat, upland surface under grass or forest vegetation in a humid or subhumid climate.

PLASTIC--Capable of being molded without rupture.

PLASTICITY INDEX--The numerical difference between liquid limit and plastic limit (LL-PL).

PLASTIC LIMIT--The moisture content, expressed as a percent of oven dry soil, at which a soil changes from a semisolid to a plastic state.

PLATY STRUCTURE--See STRUCTURE, SOIL.

PODZOL SOILS--A zonal group of soils having an organic mat and a very thin organic mineral layer above a gray leached layer, which rests upon an illuvial dark-brown horizon, developed under coniferous, mixed forest, or under heath vegetation in a temperate to cold, moist climate. Iron oxide and alumina, and sometimes organic matter, have been removed from the A and deposited in the B horizon.

PODZOLIZATION--A general term referring to that process (or those processes) by which soils are depleted of bases, become acid, and have developed eluvial A horizons (surface layers of removal) and illuvial B horizons (lower horizons of accumulation). Specifically, the term refers to the process by which a podzol is developed, including the more rapid removal of iron and alumina than of silica from the surface horizons; but it is also used to include similar processes operative in the formation of certain other soils of humid regions.

POROSITY--The degree to which the soil mass is permeated with pores or cavities. It is expressed as the percentage of the whole volume of the soil that is unoccupied by solid particles.

POTENTIAL VERTICAL RISE--A measure of vertical expansion of plastic material (soil) under one-pound-per-square-inch pressure in a three-foot layer of material, due to moisture increase.

PRAIRIE SOILS--The zonal group of soils having a very dark-brown or grayish-brown surface horizon, grading through brown soil to lighter-colored parent material at 2 to 5 feet, developed under tall grasses, in a temperate, relatively humid climate. The term has a restricted meaning in soil science and is not applied to all dark-colored soils of the treeless plains, but only to those in which carbonates have not been concentrated in any part of the profile by the soil-forming processes.

PRISMATIC STRUCTURE--See STRUCTURE, SOIL.

PROFILE, SOIL--A vertical section of the soil through all its horizons and extending into the parent material.

RECENT SOIL--Relatively unweathered or immature soil, without definite horizons. (This term is becoming obsolete.)

REDDISH-BROWN SOILS--A zonal group of soils with a light-brown surface horizon of a slightly reddish cast, which grades into dull reddish-brown or red material heavier than the surface soil, thence into a horizon of whitish or pinkish lime accumulation. Developed under shrub and short-grass vegetation of warm-temperate to tropical regions of semi-arid climate.

REDDISH CHESTNUT SOILS--A zonal group of soils with dark-brown, tinted pinkish, or reddish surface soils up to 2 feet thick over heavier, reddish-brown soil over grayish or pinkish lime accumulation; developed under warm-temperate semi-arid climate and mixed grass vegetation with some shrubs. Approximately equivalent to southern chernozem.

REDDISH PRAIRIE SOILS--A zonal group of soils with dark reddish-brown, slightly to medium acid surface soils grading through somewhat heavier reddish material to the parent material; developed under warm-temperate humid to subhumid climate and tall-grass vegetation.

REGOLITH--All of the unconsolidated material above the bed rock.

REGOSOLS--Azonal soils that consist mainly of soft or unconsolidated mineral materials in which there is no clearly developed soil morphology. They include relatively fresh glacial debris, beach sand, sand dunes, and recent accumulations of volcanic ash.

RENDZINA SOILS--An intrazonal group of soils, usually with brown or black friable surface horizons underlain by light-gray or yellowish calcareous material; developed under grass vegetation or mixed grasses and forest in humid and semi-arid regions from relatively soft calcareous parent material.

RESIDUAL MATERIAL--Soil material formed in place, presumably from the same rock on which it lies.

RIPPABILITY--Susceptibility of a rock to be broken by a ripping device. A rock may be rippable for one type of machine and not for another.

S--Sand. See TEXTURE and SEPARATE.

SALINE SOIL--A soil containing an excess of soluble salts yet which is not excessively alkaline. Saline soils may contain carbonates, sulfates, or chlorides.

SAND--See TEXTURE and SEPARATE.

SC--Sandy Clay. See TEXTURE.

SCL--Sandy Clay Loam. See TEXTURE.

SEEPAGE--Act of seeping; a local spot where water slowly percolates from porous geologic material, such as a sandstone.

SEPARATE, SOIL--A group of mineral particles of a specific size range. A soil sample will always contain more than one separate. (See TEXTURE.)

SAND SEPARATE--Small rock or mineral fragments having diameters ranging from 0.05 to 2.0 mm.

SILT SEPARATE--Small mineral soil grains having diameters ranging from 0.002 to 0.05 mm. (Engineers usually use the limits of 0.005 to 0.05 mm.)

CLAY SEPARATE--The fine mineral soil grains, less than 0.002 mm in diameter. (Engineers usually define as less than 0.005 mm in diameter.)

SERIES, SOIL--A group of soils developed from the same parent material, having similar soil horizons, and having essentially the same characteristics throughout the profile except for the texture of the A, or surface horizon.

SESQUIOXIDE--Fe_2O_3 and/or Al_2O_3.

SHOT--Concretions of iron and manganese oxides in the form of indurated spherical pellets.

SHRINKAGE LIMIT--The moisture content, expressed as a percent of oven dry soil, at which a wet soil stops shrinking.

SHRINKAGE RATIO--The volume change, expressed as a percent of the volume of the dried soil pat, divided by the moisture loss above the shrinkage limit, expressed as a percentage of the weight of the dried soil pat.

SI--Silt. See TEXTURE and SEPARATE.

SIC--Silty Clay. See TEXTURE.

SICL--Silty Clay Loam. See TEXTURE.

SIEROZEM SOILS--A zonal group of soils having a brownish-gray surface horizon that grades through lighter-colored material into a layer of carbonate accumulation and frequently into a hardpan layer, developed under mixed shrub vegetation in a temperate to cool, arid climate.

SIEVE ANALYSIS--Percent by weight of materials (soil) passing through the sieve openings; sieve numbers represent the number of openings per square inch.

SIL--Silt Loam. See TEXTURE.

SILT--See SEPARATE and TEXTURE.

SINGLE-GRAIN STRUCTURE--See STRUCTURE, SOIL.

SL--Sandy Loam. See TEXTURE.

SLOPE, SOIL--Refers to the incline of the surface of the soil area. Slopes may be defined as single or complex. Slope names and the ranges in slope percent as defined in the Soil Survey Manual are as follows:

Slope Range (%)	Slope Name	Slope Type
0-3	Level	Single or complex
1-8	Gently sloping	Single
1-8	Undulating	Complex
5-16	Sloping	Single
5-16	Rolling	Complex
10-30	Moderately steep	Single
10-30	Hilly	Complex
20-65	Steep	Single or complex
45-65	Very steep	Single or complex

SMOOTH SOIL--Used to modify textural term. No abrasive feel.

SOFT--See CONSISTENCE WHEN DRY.

SOLUM--That part of the soil profile, above the parent material, in which the processes of soil formation are taking place. In mature soils, this includes the A and B horizons, and the character of the material may be greatly unlike that of the parent material.

STONE--Rock fragments larger than 10 inches in diameter, if rounded; and longer than 15 inches along the longer axis, if flat.

STRATIFIED--Composed of, or arranged in, layers. The term is applied to geological materials, as stratified alluvium. Those layers in soils that are produced by the soil-forming processes are called horizons, while those inherited from the parent material are called strata.

STRUCTURE, SOIL--The aggregation of soil particles into clusters of particles, which are separated from adjoining aggregates by surfaces of weakness.

BLOCK-LIKE (OR BLOCKY)--The soil aggregates have a blocky shape, irregularly six-faced, and with the three dimensions nearly equal. The size of these aggregates ranges from a fraction of an inch to 3 or 4 inches in thickness. This structure is found in the B horizon of many soils. When the edges of the cubes are sharp and rectangular faces are distinct, the type is identified as blocky or angular blocky. If sub-rounding is apparent, the aggregates are identified as nut-like, nuciform, or subangular blocky.

COLUMNAR--Structure with the vertical axis of aggregates longer than the horizontal and with rounded tops. When the tops are level and clean cut, the structure is identified as prismatic. Found in the B horizon, when present.

CRUMB--Small, soft, porous aggregates irregular in shape and rarely larger than 1/3 inch in size. If the aggregates are relatively nonporous, they are identified as granular. Both types are found in surface soils, especially those high in organic matter.

GRANULAR--See CRUMB.

LAMINATED--Platy structure with the plates or very thin layers lying horizontal or parallel to the surface. See PLATE-LIKE.

MASSIVE--Large uniform masses of cohesive soil, structureless.

NUT OR NUCIFORM--See BLOCK-LIKE.

PLATE-LIKE (PLATY)--Flat aggregates with vertical dimension much less than the horizontal dimensions, found most often in surface horizons, but may be found in the subsoil as it is often inherited from the parent materials.

PRISMATIC--Elongated column structure with level and clean-cut tops. If the tops are rounded, the structure is identified as columnar. Found in the B horizon, when present.

SINGLE-GRAIN--No aggregation of the particles, such as in dune sand.

SUBSOIL--Refers to the B horizon of soils with distinct profiles. In soils with weak profiles, it is the soil below the surface soil. It is a poor term.

SUBSTRATUM--Any layer below the true soil (solum) such as the C horizon, or it may be distinctly different from the parent material of the soil.

SUBSURFACE SOIL--Refers to that part of the A horizon below the surface soil.

SURFACE SOIL--The soil ordinarily disturbed by tillage or its equivalent depth in uncultivated soils, about 5 to 8 inches.

TEXTURE--The relative proportion of the various particle-size groups of individual grains; the coarseness or fineness of the soil.

C--Clay. Soil material that contains 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt. (AASHO - smaller than .005 mm, USDA - smaller than .002 mm)

CL--Clay Loam. Soil material that contains 27 to 40 percent clay and 20 to 45 percent sand.

L--Loam. Soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand.

LS--Loamy Sand. Soil material that contains at the upper limit 85 to 90 percent sand, and the percentage of silt plus $1\frac{1}{2}$ times the percentage of clay is not less than 15; at the lower limit it contains not less than 70 to 85 percent sand, and the percentage of silt plus twice the percentage of clay does not exceed 30.

S--Sand. Soil material that contains 85 percent or more of sand; percentage of silt plus $1\frac{1}{2}$ times the percentage of clay shall not exceed 15. Includes coarse sand, sand, fine sand, and very fine sand. (AASHO - #200 sieve to #10, USDA - #270 sieve to #10.)

SC--Sandy Clay. Soil material that contains 35 percent or more clay and 45 percent or more sand.

SCL--Sandy Clay Loam. Soil material that contains 20 to 35 percent clay, less than 28 percent silt, and 45 percent or more sand.

SL--Sandy Loam. Soil material that contains either 20 percent clay or less, and the percentage of silt plus twice the percentage of clay exceeds 30 to 52 percent or more sand; or less than 7 percent clay, less than 50 percent silt, and between 43 and 50 percent sand. (This includes fine sandy loam and very fine sandy loam.)

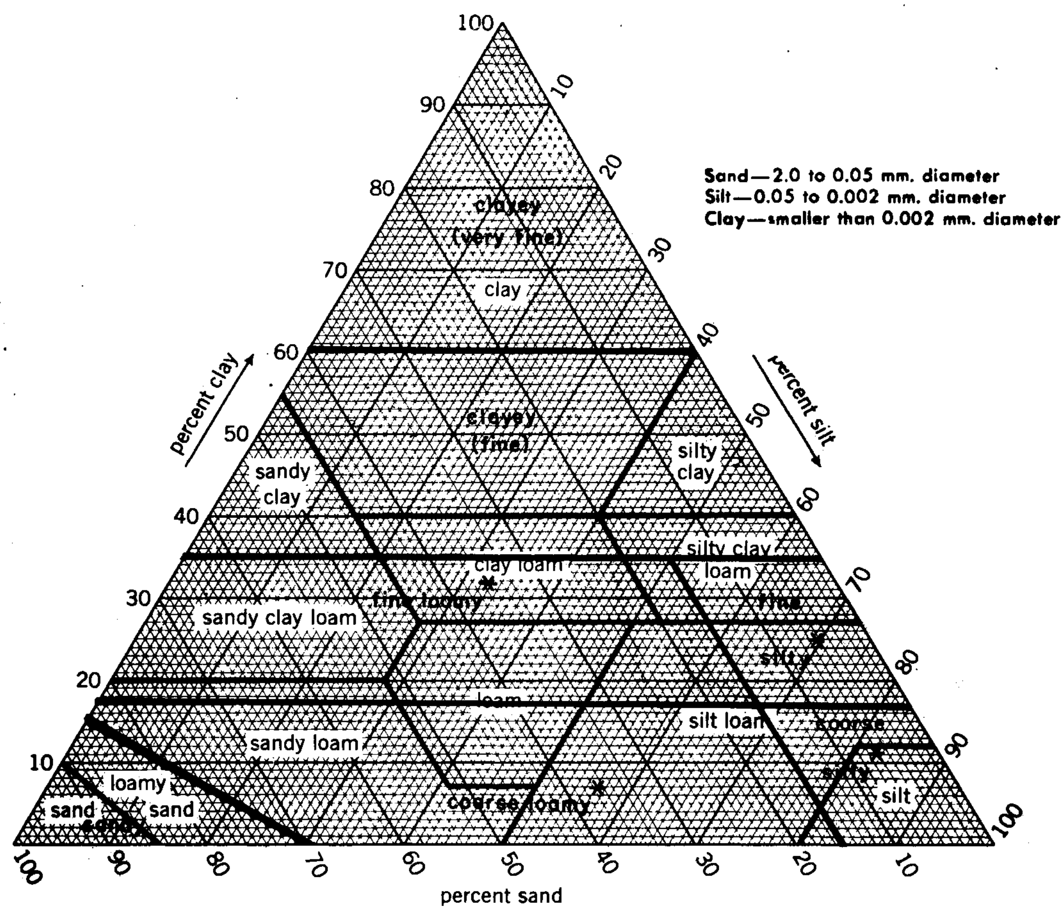
SI--Silt. Soil material that contains 80 percent or more silt and less than 12 percent clay. (AASHO - .005 to #200 sieve, USDA - .002 to #270 sieve.)

SIC--Silty Clay. Soil material that contains 40 percent or more clay and 40 percent or more silt.

SICL--Silty Clay Loam. Soil material that contains 27 to 40 percent clay and less than 20 percent sand.

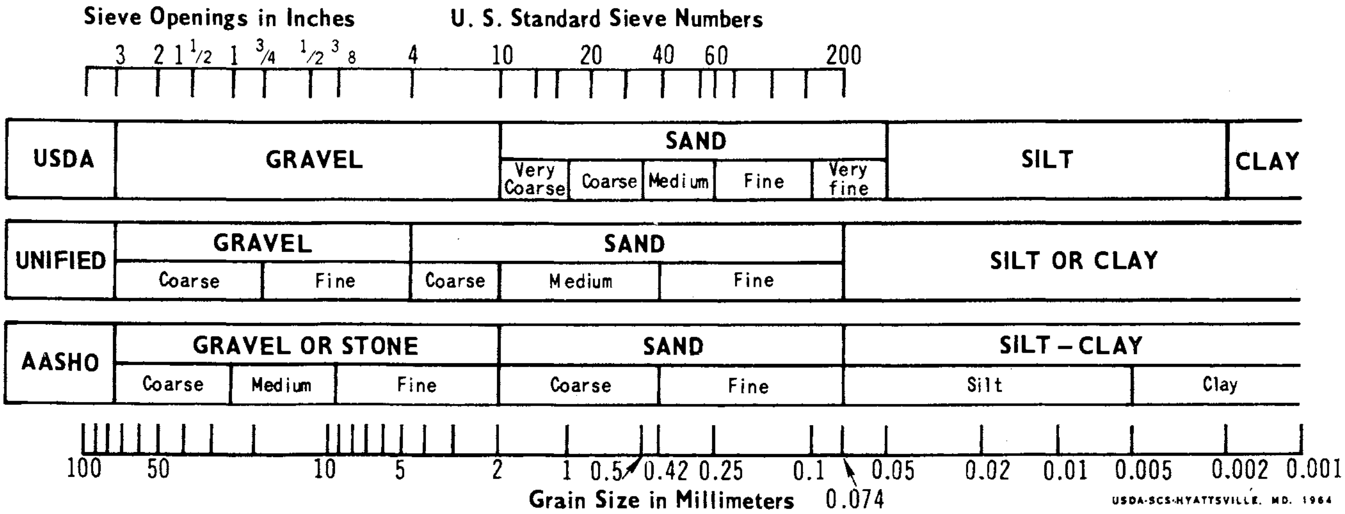
SIL--Silt Loam. Soil material that contains 50 percent or more silt and 12 to 27 percent clay (or) 50 to 80 percent silt and less than 12 percent clay.

GUIDE FOR TEXTURAL CLASSIFICATION IN SOIL FAMILIES



* Very fine sand (0.05 – 0.1) is treated as silt for family groupings coarse fragments are considered the equivalent of coarse sand in the boundary between the silty and loamy classes.

COMPARISON OF PARTICLE SIZE SCALES



TIGHT--A term applied to a horizon or layer that is compact, impervious, tenacious, and usually plastic.

TOPSOIL--A general term used in at least four senses: (1) For the plow layer; (2) for the A_1 horizon, and therefore, exceedingly variable in depth for different soils; (3) for the full A horizon; and (4) for presumed fertile soil, usually of high organic content.

TOUGH--Resistant to rupture. An auger can be readily bored into a layer referred to as tough, but will require much force in shearing loose and pulling out the core of soil.

VOLUME CHANGE--The change in volume for a given moisture content (expressed as a percentage of the dry volume) of the soil mass when the moisture content is reduced from the stipulated percentage to the shrinkage limit.

WEATHERING--The physical and chemical disintegration and decomposition of rocks and minerals by natural processes; such as oxidation, reduction, hydration, solution, carbonation, and freezing and thawing.

YELLOW PODZOLIC SOILS--A zonal group of soils having thin, organic and organic-mineral layers over a grayish-yellow, leached layer resting on a yellow horizon, developed under the coniferous or mixed forest in a warm-temperate moist climate. Equivalent to yellow soils.

ZONAL--Soils that have well-developed soil characteristics that are due mainly to the influence of climate and vegetation.

The descriptions for the table of terms were taken from the "Highway Research Board Special Report 25, Glossary of Pedological (Soils) and Landform Terminology."

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*These texts will aid in a better understanding and application of the information presented in this publication.