Soils, Crop Production, and Geology in the Fort Cobb Reservoir Watershed, Southwestern Oklahoma

Chapter 3 of

Assessment of Conservation Practices in the Fort Cobb Reservoir Watershed, Southwestern Oklahoma

Compiled by the U.S. Geological Survey and the Agricultural Research Service

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U.S. Department of the Interior
U.S. Geological Survey

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By Patrick J. Starks, John A. Daniel, Daniel N. Moriasi, and Jean L. Steiner

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Conversion Factors

SI to Inch/Pound

Multiply	By	To obtain
	Area	
meter (m)	3.281	foot (ft)
square kilometer (km^2)	247.1	acre
square kilometer (km^2)	0.3861	square mile (mi^2)
	Volume	
liters per minute	0.264	gallons per minute
	Flow Rate	
meter per kilometer (m/km)	5.27983	foot per mile (ft/mi)
millimeter per hour	0.03937	inches per hour

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Soils, Crop Production, and Geology in the Fort Cobb Reservoir Watershed, Southwestern Oklahoma

By Patrick J. Starks,[1] John A. Daniel,[1] and Daniel N. Moriasi,[1] and Jean L. Steiner[1]

Abstract

The purpose of this chapter is to provide an overview of the soils, crop production, and geology in the Fort Cobb Reservoir watershed. Cropland predominates (43 percent) in the watershed with about 33 percent of the land area used as grazing land for cattle. Seven soil mapping units are in the Fort Cobb Reservoir watershed, three of which cover about 70 percent of the watershed. Generally, sandy-textured soils are in the central and eastern parts of the watershed and about 20 percent of the watershed is overlain by highly erosive soils. The erosive soils have the highest sand fractions (87 percent) of all the soil series in the watershed and have the highest saturated hydraulic conductivity values. Structurally, the watershed lies in the axis of the Anadarko Basin and dips in a southwestern direction at a rate of 3.8 to 7.6 meters per kilometer (20 to 40 feet per mile) with the synclinal axis extending northwestward across the Pond Creek Basin; thus, the bedrock becomes progressively younger to the west. The Rush Springs Sandstone is a major aquifer in central Oklahoma (4,765 square kilometers or 1,840 square miles in size) and underlies much of the Fort Cobb Reservoir watershed.

Introduction

The purpose of this chapter is to provide an overview of the soils, crop production, and geology in the Fort Cobb Reservoir watershed. Properties of soils and underlying geology affect the rate of movement of water to aquifers and subsequent rates of water discharge to streams and lakes. Whereas the movement of water is affected by topography, and properties of soil and underlying materials, the quality of water reaching surface water and groundwater may be affected both by natural and anthropogenic activities, including agriculture.

Soils

The Natural Resources Conservation Service State Soil Geographic Database (STATSGO) (U.S. Department of Agriculture, 1994) is commonly used in applications for watershed-scale modeling. Numbered soil mapping units are unique to STATSGO and do not appear in county-level soil survey books. Only the top layer of each soil is described in this report. Information on the several STATSGO soil layers and associated texture classes in the Fort Cobb Reservoir watershed are listed in tables 1 and 2. Saturated hydraulic conductivity (ks) is a measure of the "ease" by which water flows through porous materials, and is affected primarily by the texture and bulk density of those materials. Soil texture is determined by the relative proportions of sand, silt, and clay fractions, whereas bulk density is a quantitative measure of soil compaction. Saturated hydraulic conductivity affects the rate of movement of water through the vadose zone to the underlying saturated zone. References to ks values, such as very high, high, and moderate, are based on classes of ks as found in Soil Survey Division Staff (1993).

Seven STATSGO soil mapping units are in the Fort Cobb Reservoir watershed, three of which (OK107, OK063, and OK142) cover about 70 percent of the watershed (fig.1, table 1). Two soil mapping units, OK109 in the northern part of the watershed and OK124 downstream from the dam of Fort Cobb Reservoir, together cover less than 2.5 percent of the

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Table 1. Natural Resources Conservation Service STATSGO soil mapping unit identification numbers and percent of the Fort Cobb Reservoir watershed and associated subwatersheds covered by each unit.

	Percent map unit			
		Subwatershed		
STATSGO map unit	Fort Cobb Reservoir watershed	Cobb Creek[1]	Lake Creek	Willow Creek
OK107	28.2	1.7	64.9	61.5
OK063	21.6	46.2	0	0
OK142	19.8	9.0	15.6	38.5
OK110	13.3	28.7	0	0
OK088	13.0	12.0	13.9	0
OK109	2.0	2.4	5.6	0
OK124	0.2	0	0	0

[1]Cobb Creek includes the Filemile Creek subwatershed (fig.1).

watershed (table 1). Generally, sandy-textured soils are in the central and eastern parts of the watershed (fig.1, table 2). Silty-textured soils may be found as inclusions in these sandy soil mapping units (table 2), but also are found as single mapping units in the western, northwestern, and northern parts of the watershed (OK063, OK109; fig.1).

About 62 percent of the Willow Creek subwatershed is overlain by mapping unit OK107. This mapping unit contains five soil series (table 2), which are classified as fine sandy loams. Although the sand fraction is 66 percent and the clay fraction is 14 percent of each of these five soil series, saturated hydraulic conductivity ranges from a moderately high value of 26 millimeters per hour (mm/hr) to a high value 73 mm/hr, depending on soil series. The OK142 mapping unit covers about 39 percent of the subwatershed (table 1). The texture of this mapping unit ranges from loamy fine sand to fine sandy loam. The Dougherty and Eufaula soil series account for 53 percent of the OK142 mapping unit, and are considered some of the most erosive soils in the watershed (M. Ramming, Oklahoma Conservation Commission, oral commun., 2006). The Dougherty and Eufaula soils have high sand fractions (87 percent), and very high (350 mm/hr) and high (180 mm/hr) ks, respectively. The Konawa series accounts for 10 percent of the OK142 mapping unit and has the highest ks value (450 mm/hr). The Noble series makes up 17 percent of the OK142 mapping unit, whereas the Darnell is 8 percent and the Pond Creek and Cyril soil series each account for 6 percent of the mapping unit. These four soil series have smaller sand fractions (about 66 percent for each) relative to the Dougherty and Eufaula soils, and ks values range from 26 to 58 mm/hr.

About 80 percent of the Lake Creek subwatershed is covered by fine sandy loam (OK107) and loamy fine sand (OK142) soils (fig.1 and table 1). Silt-textured soils (OK088 and OK109) cover about 20 percent of the subwatershed in the northern and northwestern parts (fig. 1 and table 1). Seven soil series are included in mapping unit OK088 (about 14 percent of the watershed, table 1), of which the Grant and Pond Creek series account for most of the mapping unit (82 percent, table 2). The Grant series is a loam-textured soil containing 37 percent sand and 21 percent clay, and has moderately high ks of 12 mm/hr. The Pond Creek series has a larger silt fraction (68 percent; silt fraction is equal to 100 percent minus clay plus sand percent) and a smaller sand fraction (11 percent), and smaller ks (0.8 mm/hr) than the Grant series. The Pond Creek and Minco series are characterized by large silt fractions and moderately low ks and account for the largest part of mapping unit OK109 (81 percent) (table 2).

Silt-textured soils overlay about 46 percent (fig. 1, mapping unit OK063) of the Cobb Creek subwatershed (which, for the purposes of this chapter, includes the Filemile Creek subwatershed), the largest of the three subwatersheds in the Fort Cobb Reservoir watershed. Mapping unit OK063 contains five soil series (table 2), each having small sand and large silt fractions (table 2) and moderately low ks (table 2). Mapping unit OK110 covers about 29 percent of the Cobb Creek subwatershed (fig. 1)—a mapping unit that contains mostly fine sandy loam soils (Pond Creek, Shellabarger, and Hardeman soil series; table 2). The Pond Creek soil series makes up 41 percent of the mapping unit and has moderately low ks value. The Shellabarger soil series makes up 28 percent of the mapping unit and has high ks value (table 2). Small percentages of silt loam and loam soils (Quinlan and Port) in the OK110 mapping unit, have ks values ranging from 1.6 mm/hr to 17 mm/hr. The southeast part of Cobb Creek subwatershed is overlain by mapping unit OK142.

Analysis of the distribution of soils in the watershed indicated that water and any potential associated contaminants (such as agrichemicals and septic system effluent) will move faster through the sandy soils of the Willow Creek and Lake Creek subwatersheds than through the silt soils farther west in the Cobb Creek subwatershed. About 20 percent of the Fort Cobb Reservoir watershed is overlain by mapping unit OK142 that contains highly erosive soils of the Dougherty, Eufaula, and Konawa series. Theses soils have the highest sand fractions (87 percent) of all the soil series in the watershed and have the highest ks observed in the STATSGO database for this watershed.

Table 2. Natural Resources Conservation Service STATSGO soil mapping unit identification number, soil series in each mapping unit and relative areal contributions to the mapping unit given as a percent, number of soil layers in each series, total thickness of the soil, depth to the upper soil layer, U.S. Department of Agriculture soil texture name, bulk density, saturated hydraulic conductivity (ks), and proportions of organic carbon, clay, and sand for each soil series.

[ID, identification; mm, millimeters; g/cm^3, grams per cubic centimeter; mm/hr, millimeters per hour; pct, percent; USDA, U.S. Department of Agriculture; SIL, Silt loam; SICL, silty clay loam; CL, clay loam; L, Loam; WB, weathered bedrock; FSL, fine sandy loam; VFSL, very fine sandy loam; COSL, coarse sandy loam; SIC, silty clay; LFS, loamy fine sand; SCL, sandy clay loam; C, clay; LVFS, loamy very fine sand; FS, fine sand]

STATSGO map unit ID number	Soil series name	Map unit composition (pct)	Number of soil layers	Total thickness of soil (mm)	Upper soil depth (mm)	USDA soil texture name	Bulk density (g/cm^3)	Saturated hydraulic conductivity (mm/hr)	Organic carbon (pct)	Clay (pct)	Sand (pct)
OK063	ST. PAUL	39	6	1,778	305	SIL-SICL-CL-CL-SICL-L	1.42	0.8	1.2	21	11
OK063	CAREY	31	4	2,032	356	SIL-SICL-L-WB	1.45	1.1	1.2	18	14
OK063	WOODWARD	16	3	1,016	254	SIL-SIL-WB	1.45	3.1	0.7	14	14
OK063	QUINLAN	11	3	1,651	203	SIL-L-WB	1.42	5.2	0.4	21	26
OK063	CLAIREMONT	3	2	1,524	203	SIL-SICL	1.50	1.6	0.6	21	11
OK088	GRANT	43	4	1,829	305	L-SICL-L-WB	1.40	12.0	1.2	21	37
OK088	POND CREEK	39	2	1,727	305	SIL-SICL	1.40	0.8	1.2	21	11
OK088	MINCO	4	3	1,829	381	VFSL-SIL-SIL	1.48	65.0	1.2	13	60
OK088	BINGER	6	3	1,016	254	FSL-SCL-WB	1.45	70.0	0.4	14	66
OK088	DILL	2	3	1,016	305	FSL-FSL-WB	1.45	41.0	0.4	13	67
OK088	SHELLABARGER	2	3	1,524	330	FSL-SCL-COSL	1.42	54.0	0.9	12	68
OK088	QUINLAN	4	3	1,651	203	L-L-WB	1.42	17.0	0.4	21	42
OK107	POND CREEK	45	2	1,727	305	FSL-SICL	1.45	41.0	1.2	14	66
OK107	BINGER	34	3	1,016	254	FSL-SCL-WB	1.45	70.0	0.4	14	66
OK107	NOBLE	12	1	1,829	1,829	FSL	1.45	26.0	0.4	14	66
OK107	LUCIEN	6	3	762	102	FSL-L-WB	1.45	73.0	1.2	14	66
OK107	PULASKI	3	3	1,626	178	FSL-L-LFS	1.45	70.0	0.4	14	66
OK109	POND CREEK	63	2	1,727	305	SIL-SICL	1.40	0.8	1.2	21	11
OK109	MINCO	18	3	1,829	381	SIL-SIL-SIL	1.48	3.6	1.2	13	14
OK109	LUCIEN	11	3	762	102	FSL-L-WB	1.45	73.0	1.2	14	66
OK109	TELLER	8	3	1,778	508	FSL-SCL-L	1.45	81.0	1.2	14	66
OK110	POND CREEK[1]	30	2	1,727	305	FSL-SICL	1.45	41.0	1.2	14	66
OK110	SHELLABARGER	28	3	1,524	330	FSL-SCL-COSL	1.42	54.0	0.9	12	68
OK110	HARDEMAN	15	2	1,626	457	FSL-L	1.45	34.0	0.4	14	66
OK110	POND CREEK	11	2	1,727	305	SIL-SICL	1.40	0.8	1.2	21	11
OK110	QUINLAN	9	3	1,651	203	L-L-WB	1.42	17.0	0.4	21	42

Table 2. Natural Resources Conservation Service STATSGO soil mapping unit identification number, soil series in each mapping unit and relative areal contributions to the mapping unit given as a percent, number of soil layers in each series, total thickness of the soil, depth to the upper soil layer, U.S. Department of Agriculture soil texture name, bulk density, saturated hydraulic conductivity (ks), and proportions of organic carbon, clay, and sand for each soil series. —Continued

[ID, identification; mm, millimeters; g/cm³, grams per cubic centimeter; mm/hr, millimeters per hour; pct, percent; USDA, U.S. Department of Agriculture; SIL, Silt loam; SICL, silty clay loam; CL, clay loam; L, Loam; WB, weathered bedrock; FSL, fine sandy loam; VFSL, very fine sandy loam; COSL, coarse sandy loam; SIC, silty clay; LFS, loamy fine sand; SCL, sandy clay loam; C, clay; LVFS, loamy very fine sand; FS, fine sand]

STATSGO map unit ID number	Soil series name	Map unit composition (pct)	Number of soil layers	Total thickness of soil (mm)	Upper soil depth (mm)	USDA soil texture name	Bulk density (g/cm³)	Saturated hydraulic conductivity (mm/hr)	Organic carbon (pct)	Clay (pct)	Sand (pct)
OK110	DILL	4	3	1,016	305	FSL-FSL-WB	1.45	41.0	0.4	13	67
OK110	PORT	3	2	1,829	686	SIL-SICL	1.42	1.6	1.2	19	12
OK124	YAHOLA	26	3	1,829	279	FSL-FSL-LFS	1.45	70.0	0.4	14	66
OK124	DALE	19	2	1,524	533	SIL-SICL	1.40	1.8	1.2	21	11
OK124	REINACH	12	2	2,032	762	SIL-SIL	1.42	2.3	1.2	15	14
OK124	MCLAIN	10	3	1,524	356	SICL-SIC-SICL	1.45	5.0	1.2	31	20
OK124	KEOKUK	6	3	1,651	305	SIL-SIL-SIL	1.42	3.3	1.2	14	14
OK124	LELA	6	2	2,210	330	C-SIC	1.35	0.7	1.2	50	22
OK124	PORT	6	2	1,829	686	SIL-SICL	1.42	1.6	1.2	19	12
OK124	GRACEMONT	5	3	1,626	356	FSL-L-L	1.45	70.0	0.4	14	66
OK124	WATONGA	4	2	1,829	559	C-SIC	1.35	0.6	1.2	50	22
OK124	ASHER	3	3	1,651	254	SICL-SICL-LVFS	1.45	1.6	1.2	34	7
OK124	AMBER	1	3	1,829	305	VFSL-SIL-SIL	1.42	48.0	0.3	14	60
OK124	GADDY	1	2	1,524	203	LFS-FS	1.42	150.0	0.2	10	84
OK124	GARVIN	1	2	1,880	813	SIC-SIC	1.35	0.2	1.2	50	5
OK142	DOUGHERTY	30	4	1,778	660	LFS-SCL-FSL-LFS	1.42	350.0	0.4	6	87
OK142	EUFAULA	23	2	2,032	1016	LFS-LFS	1.42	180.0	0.4	6	87
OK142	NOBLE	17	1	1,829	1829	FSL	1.45	26.0	0.4	14	66
OK142	KONAWA	10	4	1,829	229	LFS-LFS-SCL-FSL	1.42	450.0	0.4	6	87
OK142	DARNELL	8	3	762	127	FSL-L-WB	1.48	58.0	0.4	15	65
OK142	POND CREEK	6	2	1,727	305	FSL-SICL	1.45	41.0	1.2	14	66
OK142	CYRIL	6	2	1,524	305	FSL-L	1.45	41.0	1.2	14	66

[1]Soil series with the same name within a mapping unit represent different phases of that series. A soil phase represents differences in slope, variations in clay, sand, and silt fractions, variations in stoniness, etc.

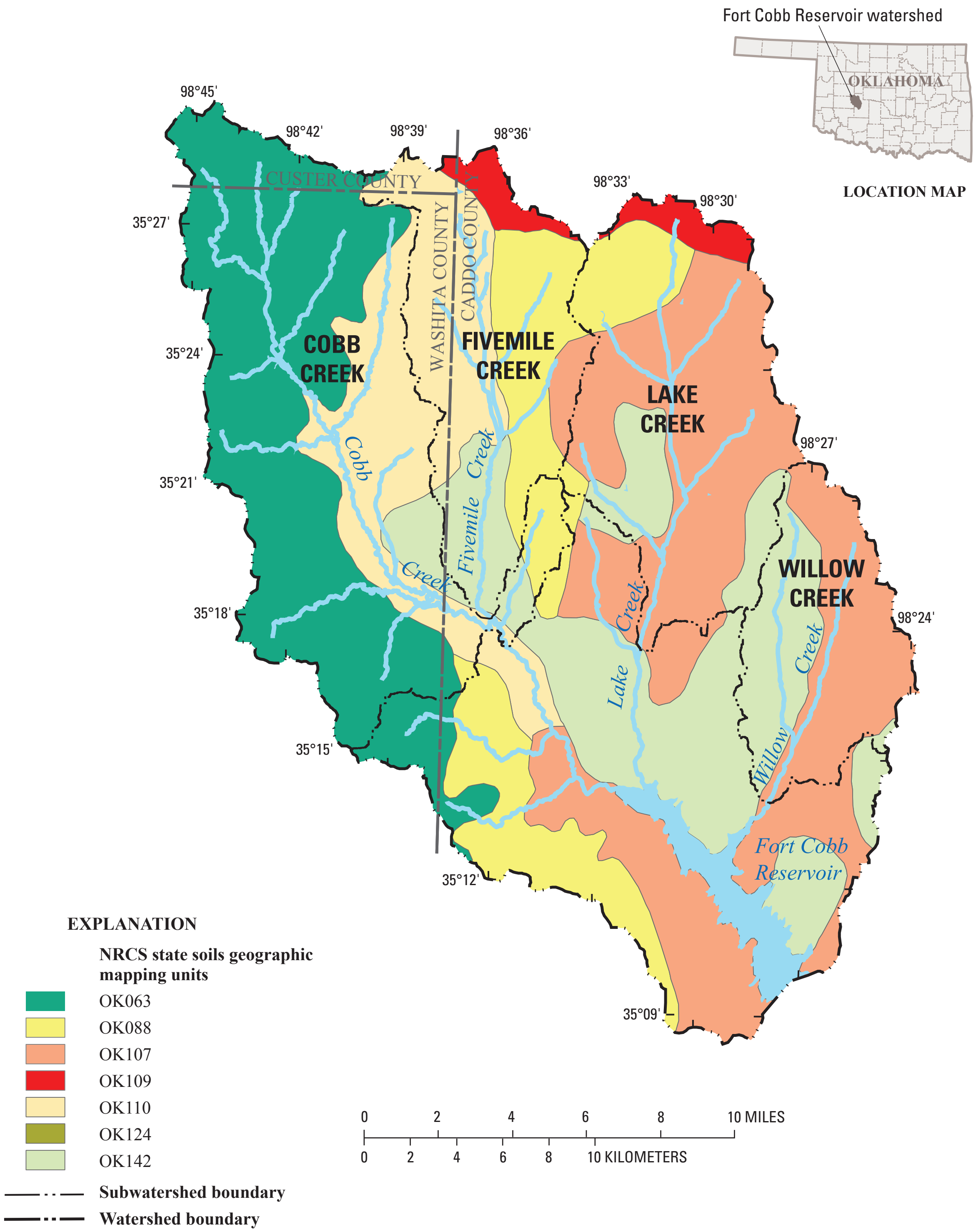

Figure 1. Natural Resources Conservation Service STATSGO (State Soils Geographic) mapping units in the Fort Cobb Reservoir watershed, southwestern Oklahoma. (Data source: Natural Resources Conservation Service, 2008.)

Crop Production

From figure 1 it is observed that only a minor portion of Custer County falls within the boundary of the Fort Cobb watershed. Thus, crop production is only discussed with reference to Caddo and Washita Counties in this section.

Crops grown in Caddo and Washita Counties, since 1950, include wheat and small grains (barley, oats, and rye), sorghum, and cotton (fig. 2). In the 1940s and 1950s about 54 percent or 178,816 hectares (ha) of Caddo County was in crop production. By 2007 the amount of land devoted to crop production decreased to 40 percent or 133,162 ha (National Agricultural Statistics Services, 1940-2007). In the 1950s in Washita County, about 75 percent of the land area or 196,587 ha was devoted to crop production. The amount of land used for crop production has steadily declined since the 1950s, and by 2007 about 54 percent or 140,530 ha of land area was used for crop production.

The introduction of irrigation in the 1960s increased the production of peanuts, wheat, and other irrigated crops. According to the agricultural statistics for Washita County, irrigation has never exceeded 2 percent of the cropland area. In 2007, only about 2,955 ha of cropland were irrigated in the county. According to Steiner and others (2008), 3,500 ha of Caddo County were irrigated in 1958. Since that time, the amount of land irrigated in Caddo County increased to 19,691 ha in 1992, but declined to 13,421 ha in 2007. Field reconnaissance of the watershed revealed that a few of the older solid-set or side-roll irrigation systems are still used in the watershed, but that most irrigation systems have been upgraded to center-pivot systems.

In 2002, programs promoting cattle production and the concurrent decrease in peanut prices encouraged several landowners to convert land used for growing peanuts to pasture land or other crops (Phil Perryman, Natural Resource Conservation Service, Caddo County, oral commun., 2008). The 2005 land use study discussed in Chapter 5 indicated that about 52 percent of land in the Fort Cobb Reservoir watershed was used for crops in 2005—winter wheat and small grains (43 percent), pasture/grass (34 percent), peanuts and cotton (9 percent), forest (5 percent), and other summer crops (4 percent). The rest of the watershed area is roads and urban development (5 percent), and water (less than 2 percent).

Several conservation practices have been implemented in the Fort Cobb Reservoir watershed in recent years including adoption of no-tillage management, conversion of cropland to grassland, installation of fencing to exclude cattle from streams, various structural practices, and water management practices (Monty Ramming, Oklahoma Conservation Commission, oral commun., 2007). The Oklahoma Conservation Commission has focused on increasing no-tillage in the watershed. Conversion to reduced tillage and more intense crop rotations have increased in the watershed in recent years, partially driven by increasing fuel costs. From 1992 to 2004, conventional tillage in the watershed decreased from about 71 to 44 percent (fig. 3).

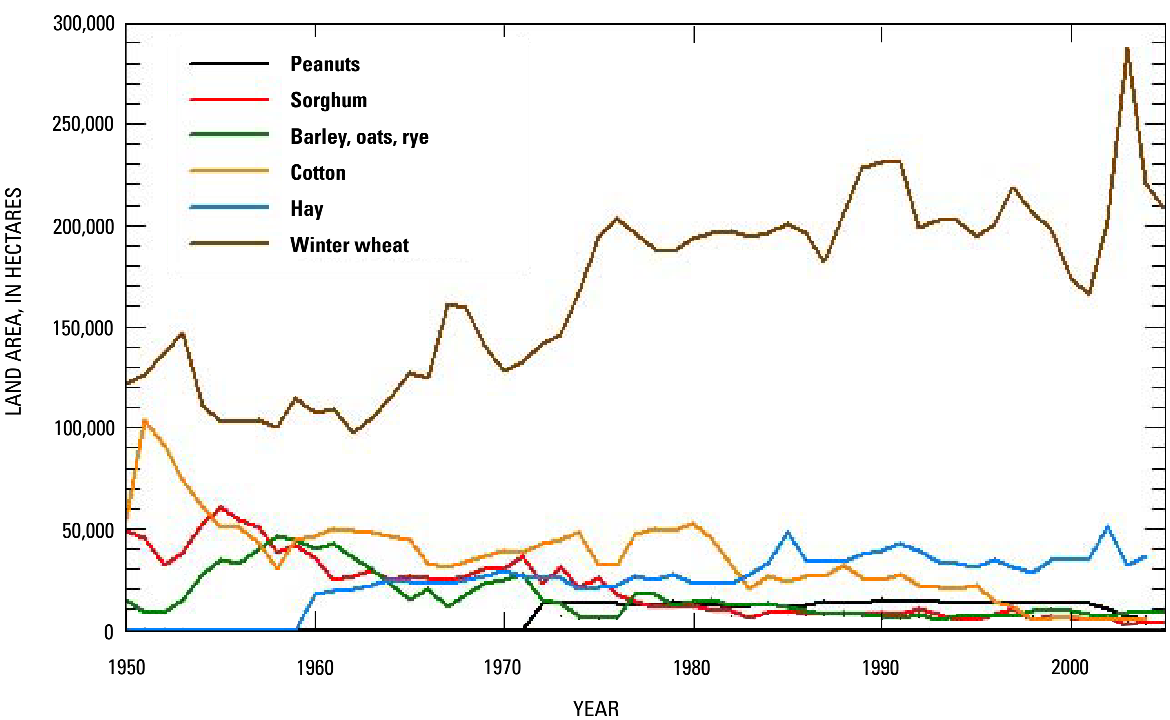

Figure 2. Area of land planted with selected crops in Caddo and Washita Counties, Oklahoma, since 1950. (Data source: National Agricultural Statistics Service annual agricultural statistics. Figure prepared by C. Godsey, Oklahoma State University, Stillwater, Oklahoma.)

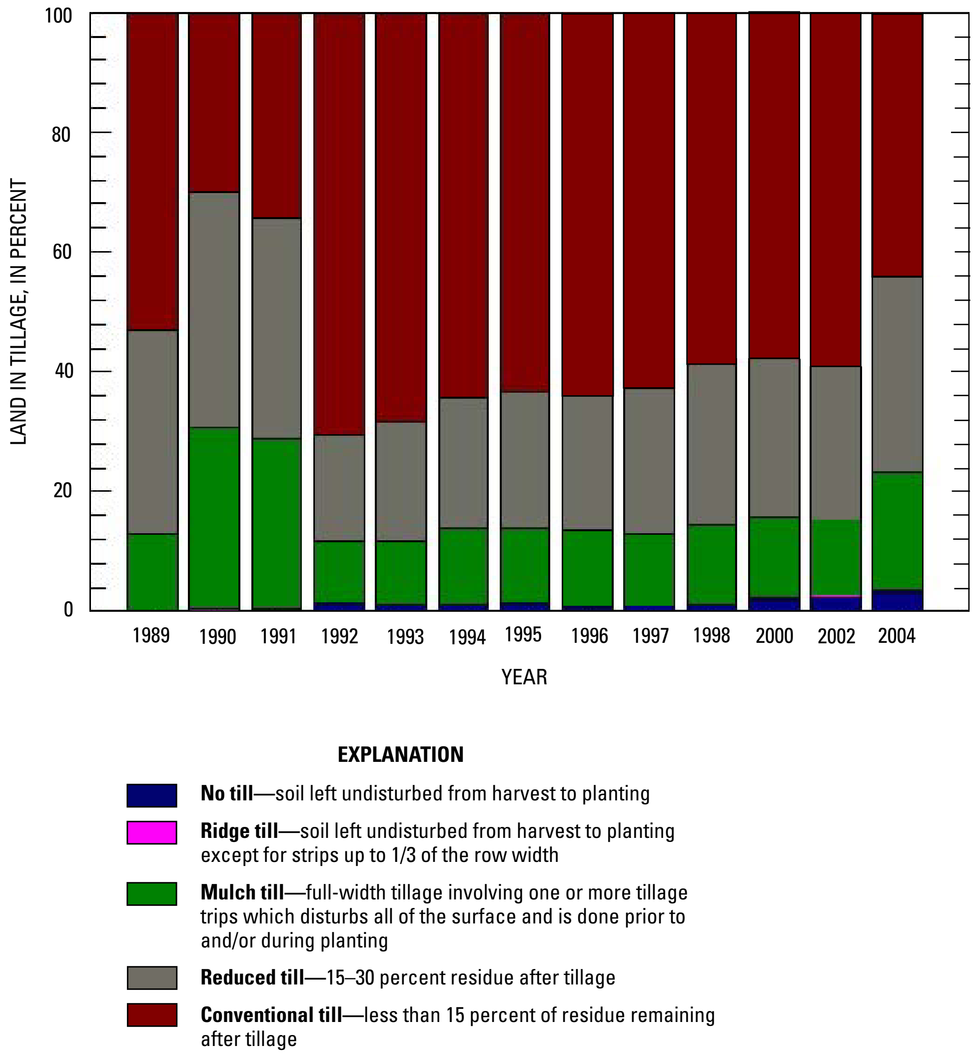

Figure 3. Percent of land in given tillage practices in Caddo and Washita Counties, Oklahoma. (Data source: Conservation Technology Information Center, 2006. Figure prepared by C. Godsey, Oklahoma State University, Stillwater, Oklahoma.)

Geology

The Fort Cobb Reservoir watershed has geologic outcrops of consolidated rocks and unconsolidated material. Unconsolidated material includes alluvial and terrace deposits from fluvial systems. All exposed consolidated rock units are classified as Permian System and often referred to as "redbeds" because of the prevalent reddish color. The red color of the bedrock comes from iron oxide minerals deposited during sedimentation processes. These sedimentary rock units formed as deposits in a shallow, restricted ocean basin that covered the areas that would eventually become far western Oklahoma and the Texas Panhandle (Johnson, 1989). Structurally, the watershed lies in the axis of the Anadarko Basin and dips in a southwestern direction at a rate of 3.8 to 7.6 meters per kilometer (20 to 40 feet per mile) with the synclinal axis extending northwestward across the Pond Creek Basin (Davis, 1950). Therefore, bedrock in the Upper Washita River watershed becomes progressively younger to the west.

The Rush Springs Sandstone is the primary rock unit in the Fort Cobb Reservoir watershed (fig. 4). The Rush Springs Sandstone is a major aquifer in central Oklahoma, covering

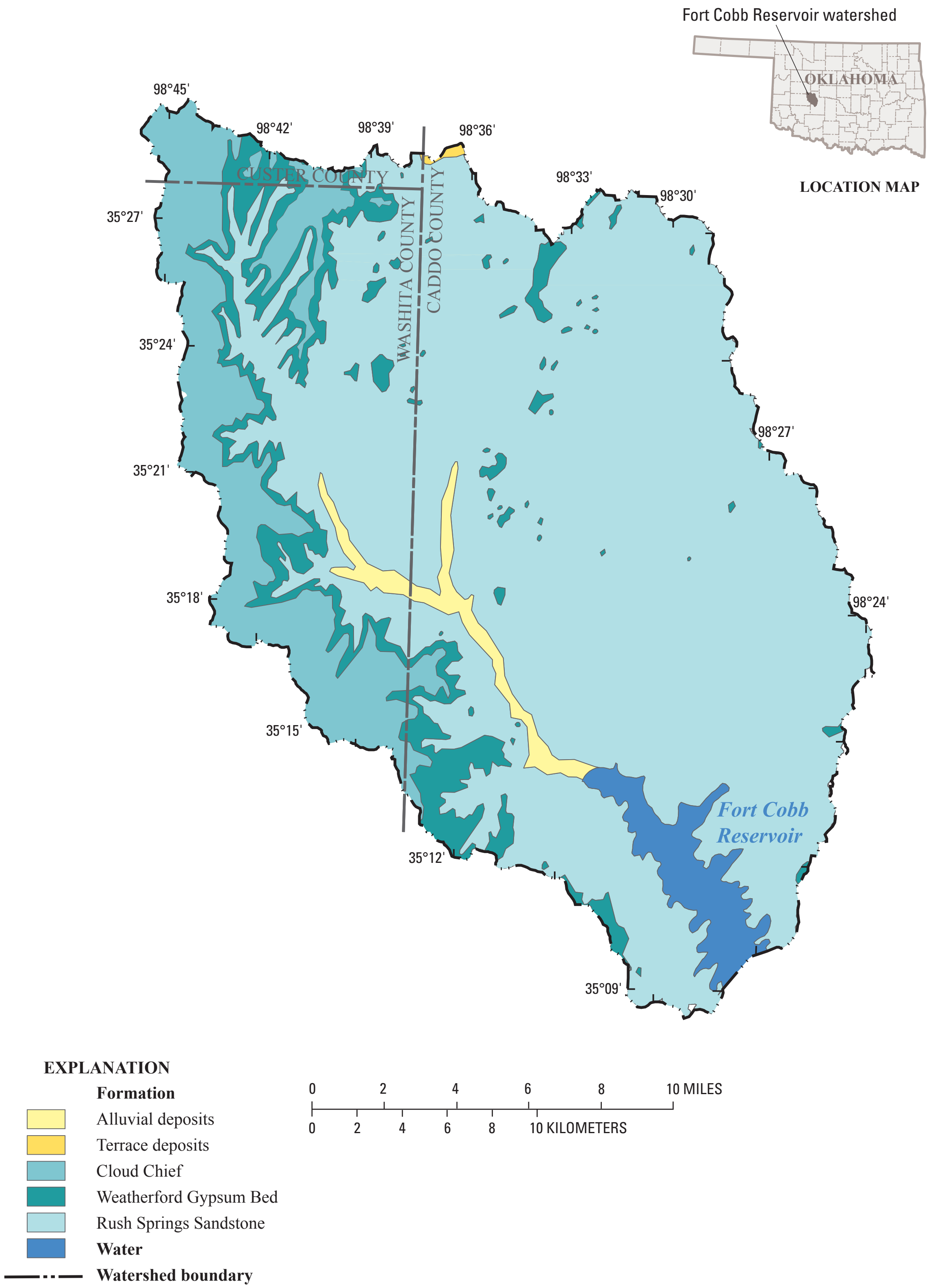

Figure 4. Surficial geology of the Fort Cobb Reservoir watershed, southwestern Oklahoma. (Data source: Cederstrand, 1996.)

an area of 4,765 square kilometers (1,840 square miles). The Rush Springs Sandstone consists of friable reddish-brown, cross-bedded to regular-bedded sandstone (Reeves, 1921) and can reach a thickness of 102 meters (334 feet) (Tanaka and Davis, 1963, p. 21). The thickness, extent, and hydrologic properties of the Rush Springs Sandstone make it a major aquifer and a drinking water source for some municipalities and a source for agricultural irrigation. Porosity of the Rush Springs aquifer averages 32 percent, with a specific yield of 25 percent and permeability of 1,222 liters per day per square meter (30 gallons per day per square foot) (Oklahoma Water Resources Board, 1966).

The Cloud Chief Formation is a minor rock unit in the Fort Cobb Reservoir watershed and forms cap rock on several buttes or hills (Davis, 1955). The Cloud Chief Formation consists of a veneer of impure dolomite, gypsum, gypsiferous sandstone, and shale. The base of the Cloud Chief Formation consists of a layer of gypsum (the Weatherford Gypsum Bed) that unconformably overlies the Rush Springs Sandstone. The water yield of the Cloud Chief Formation is low because of the high clay content (Tanaka and Davis, 1963, p. 24).

Alluvial deposits underlying flood plains and terrace deposits in the watershed are of Quaternary age. Alluvial deposits consist of fine-grained sandy silt and coarse sand and gravel eroded from the Rush Springs Sandstone and can reach a maximum thickness of 9.1 meters (30 feet) (Davis, 1955). Alluvial deposits are water bearing, yielding water in greater abundance and better quality than local bedrock formations (Hart, 1965). Layers in the lower part of the alluvial deposits provide water yields from 94.6 to 1,136 liters per minute (25 to 300 gallons per minute) (Davis, 1955). Terrace deposits are found in the extreme northern edge of the Fort Cobb Reservoir watershed. These deposits consist of coarse gravel that can reach a maximum thickness of 7.6 m (25 ft) (Davis, 1955). The sediments composing the terrace deposits were generated by glacial runoff from the Rocky Mountains (Johnson, 1972). Terrace deposits represent earlier-established flood plains that have been incised as a response to lowering of river base level (Tanaka and Davis, 1963).

Summary

Soils in the Lake and Willow Creek subwatersheds of the Fort Cobb Reservoir watershed are predominantly fine sandy loams with relatively large hydraulic conductivities. In the Cobb Creek subwatershed, however, nearly one-half of the soils are predominantly silty, with lesser hydraulic conductivities.

Agriculture in the Fort Cobb Reservoir watershed is predominantly cropland (43 percent, dominated mostly by winter wheat and other small grains) and pasture for cattle (33 percent). Irrigated crops, such as winter wheat and peanuts, have increased in predominance since the 1960s in the watershed.

Aquifers in the Fort Cobb Reservoir watershed consist mostly of sandy alluvial and terrace deposits of Quaternary age and the Rush Springs aquifer, consisting of red-colored cross-bedded sandstone of Permian age. Alluvial deposits, which generally are no thicker than 30 ft, generally produce the greatest yields and best quality of groundwater in the Fort Cobb Reservoir watershed.

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