1998

Regional Soil Survey

Conference

Field Trip Guide

Lake of the Ozarks Area

June 17, 1998

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Randy Miles

Field Trip Destination and Objectives

The destination is the Lake of the Ozarks area, approximately 90 miles south of Columbia.

Our objectives are to introduce you to the cherty soils of the Ozarks and to demonstrate some of the problems with waste management as high density urbanization impacts portions of the landscape.

The field trip will have a morning component, hosted by Dr. Randy Miles, University of Missouri and Duane Viele, Missouri Department of Natural Resources. Randy and Duane will demonstrate the impacts of urbanization around the Lake of the Ozarks.

The afternoon component will be hosted by Dr. David Hammer, University of Missouri and Jody Maulder, Missouri Department of Natural Resources. Jody is the naturalist for the Ha-Ha Tonka State Park.

The approximate route of the trip is indicated in figure 1.

Each bus will have local soil scientists who will describe the terrain and soils through which we pass on the way to "The Lake."

County	Narrators
Boone	Richard Tummons Greg Caldwel
Cole	Keith Davis Greg Caldwel
Miller/Camden	Duane Viele Dave Wolf

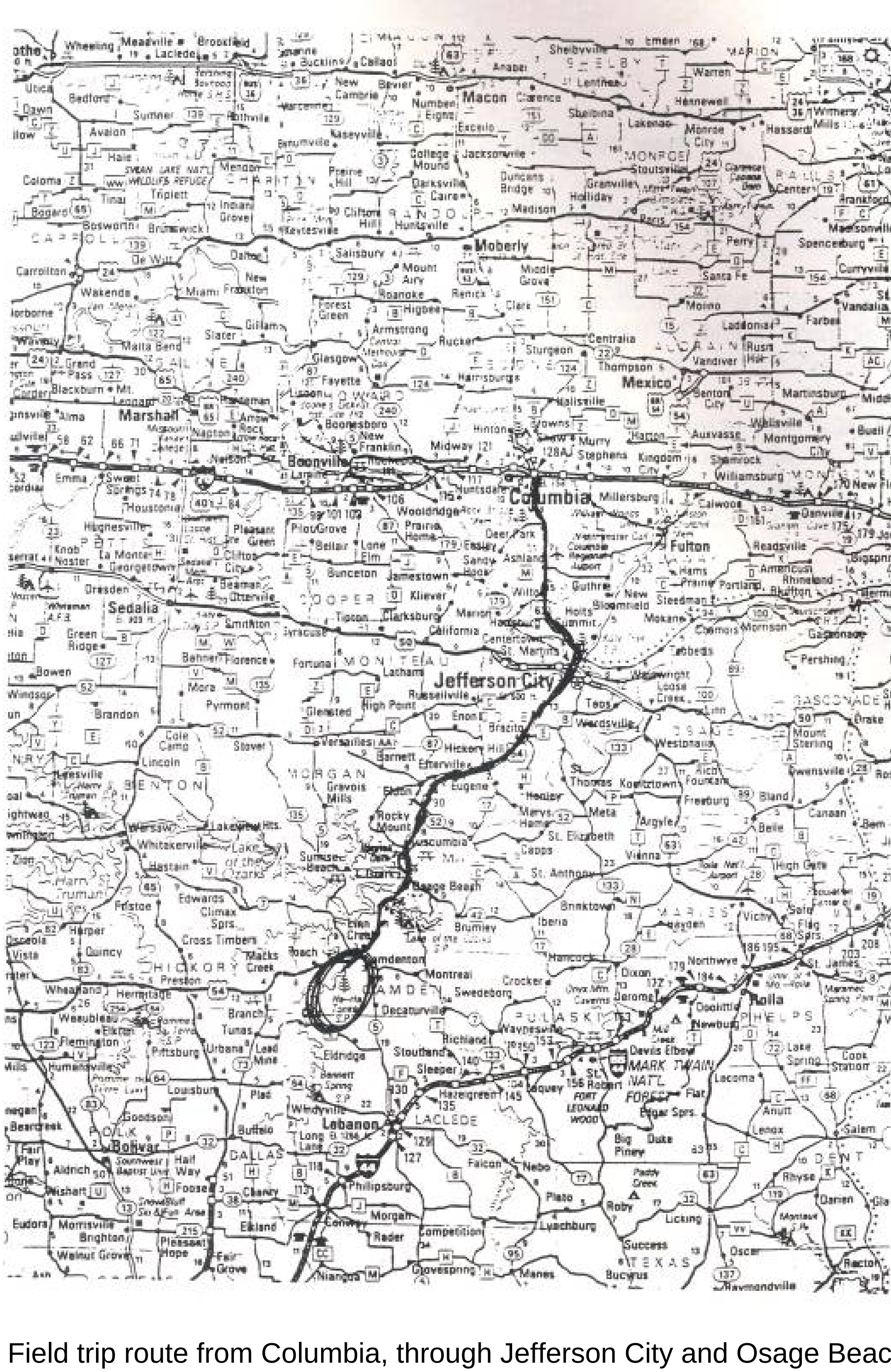


Figure 1. Field trip route from Columbia, through Jefferson City and Osage Beach to Ha-Ha Tonka State Park.

As we drive from Columbia to the Lake of the Ozarks, we will pass first through the deeper loess deposits close to the Missouri River. One of the most productive soils in this area is the Menfro. It is easily erodible and is on steep slopes and narrow interfluve summits. The Scrivner Christmas tree/blueberry farm, at which we feasted Monday, is on the Menfro soil. A description of the Menfro type location and a representative data sheet are enclosed.

The Missouri River roughly marks the terminous of the Kansas glaciation, the last ice sheet known to have entered Missouri. As we move south from Jefferson City, we enter a landscape in which the geologic strata are lower Ordovician.

South of Jefferson City, Highway 54 generally follows the break between forested Ozark soils on the east and the northern Salem Plateau, commonly prairie vegetation and Mollisols were to the west on terrain of more gentle relief than the more dissected, forested Ozark terrain. See figure 2 for an estimate of the distribution of pre-settlement Missouri vegetation.

Figure 2. Native vegetation of pre-settlement Missouri.

Figure 3 is a general parent material map. General terrain and climate distributiions are in figures 4A and 4B.

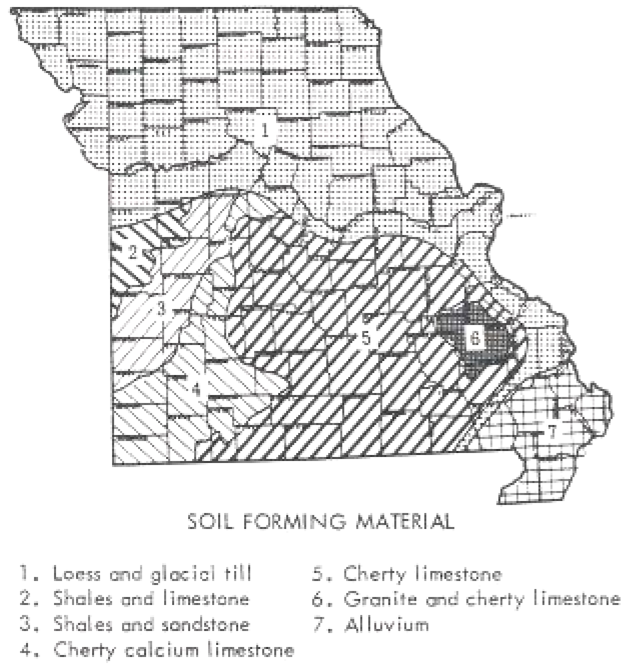


Figure 3. General parent material distribution in Missouri.

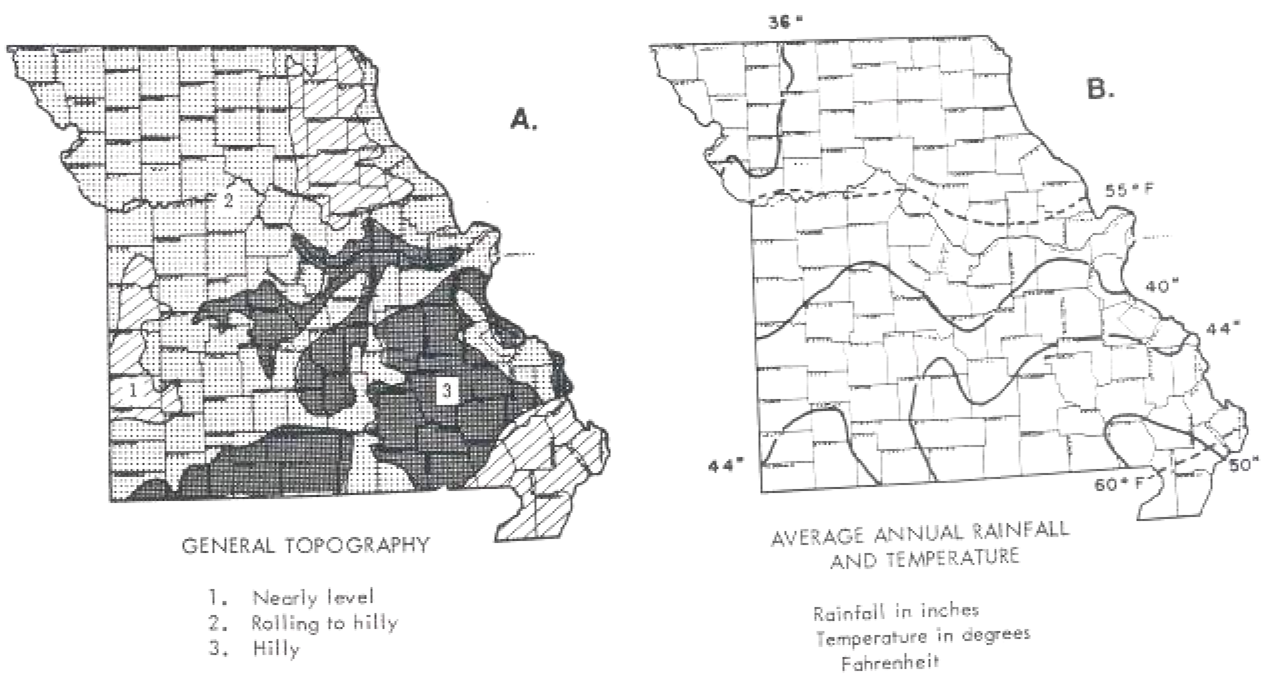


Figure 4. General terrain and climate distributions in Missouri.

Common prairie soils in the area included Eldon and Seymour. Craig, Goss, and Winfield were among the common forest soils. Winfield is similar to Menfro, except that it is in thinner loess deposits. Type locations and laboratory data are included in the field guide for these soils. Block diagrams of commonly associated soils also are included. The forest-prairie ecotone was not stable during the Pleistocene, and many of the soils of these area have features indicative of both forest and prairie historic vegetation. Figures 5 and 6 show common soil associations of the area, and table further illustrates important soil/parent material relationships.

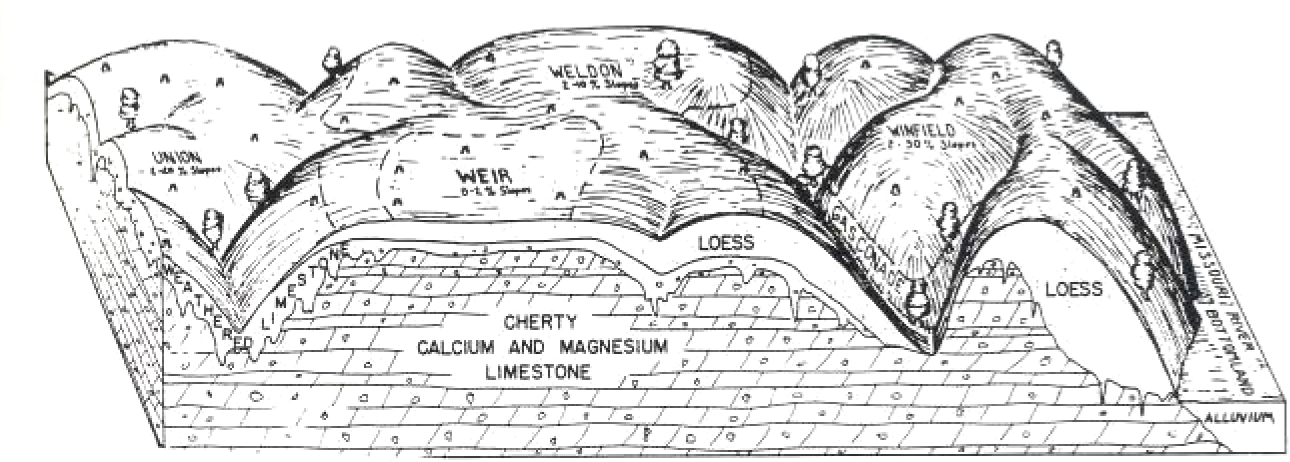


Figure 5. Winfield-Weldon soil landscape in northern Moniteau County, Missouri.

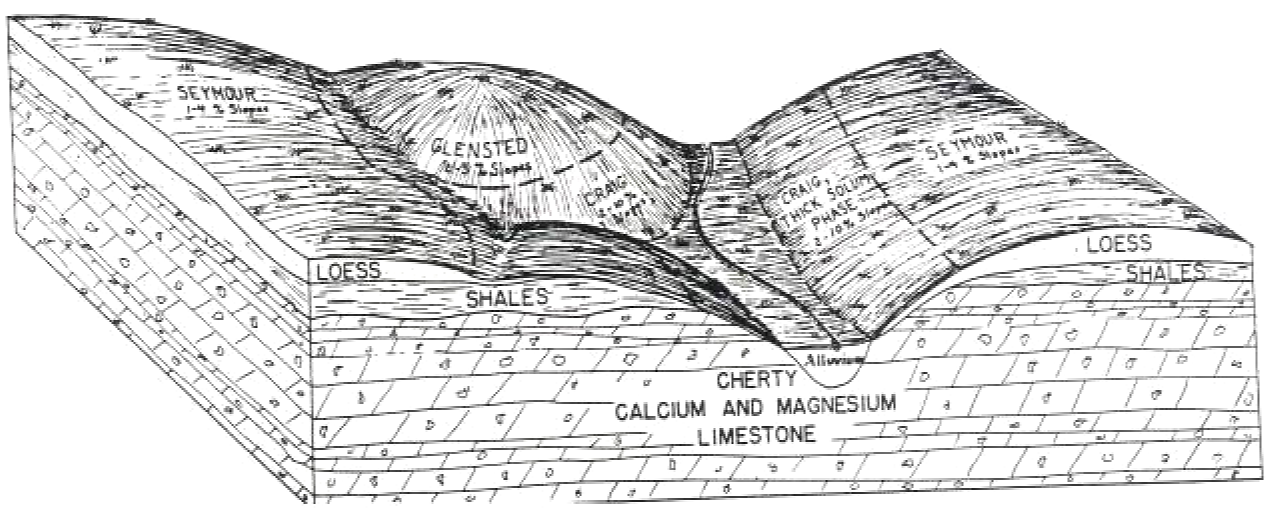
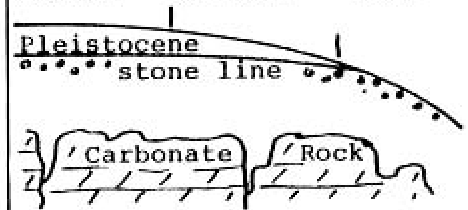
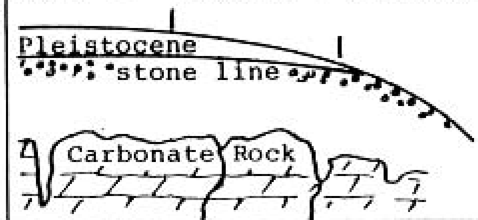


Figure 6. Seymour, Glensted, Craig soil association inMoneteau County, Missouri.

LAND SURFACE POSITION*	STRATIGRAPHY OF MATERIALS	VEGETATIVE COVERS	SOIL NAMES AND RELATION TO POSITION OR MATERIALS	
Upland Divides; Gently Sloping; Springfield and Salem Plateaus	Pleistocene sediments mainly loess; over a cherty stone line (paleo-A of limestone-derived soil); over red cherty clay (paleo-B of limestone-derived soil); over carbonate rock	Prairie or Prairie-Forest Transition	Gerald - Creldon - Keeno 	
		Oak-Hickory Forest	Bado - Lebanon - Wilderness 	
Valley Slopes	Cherty A horizons over red clayey B horizons over carbonate rock at variable depths	Oak-Hickory Forest		Depth to Carbonate Rock
			Clarksville	>200 cm
			Goss	150-200 cm
			Bardley	50-100 cm
		Prairie	Gasconade	<50 cm

* Valley floors constitute a third land surface position for which soils are not summarized. Stream terraces and floodplains are included.

Table 1. Soil-vegetation-parent material relationships on the Salem Plateau.

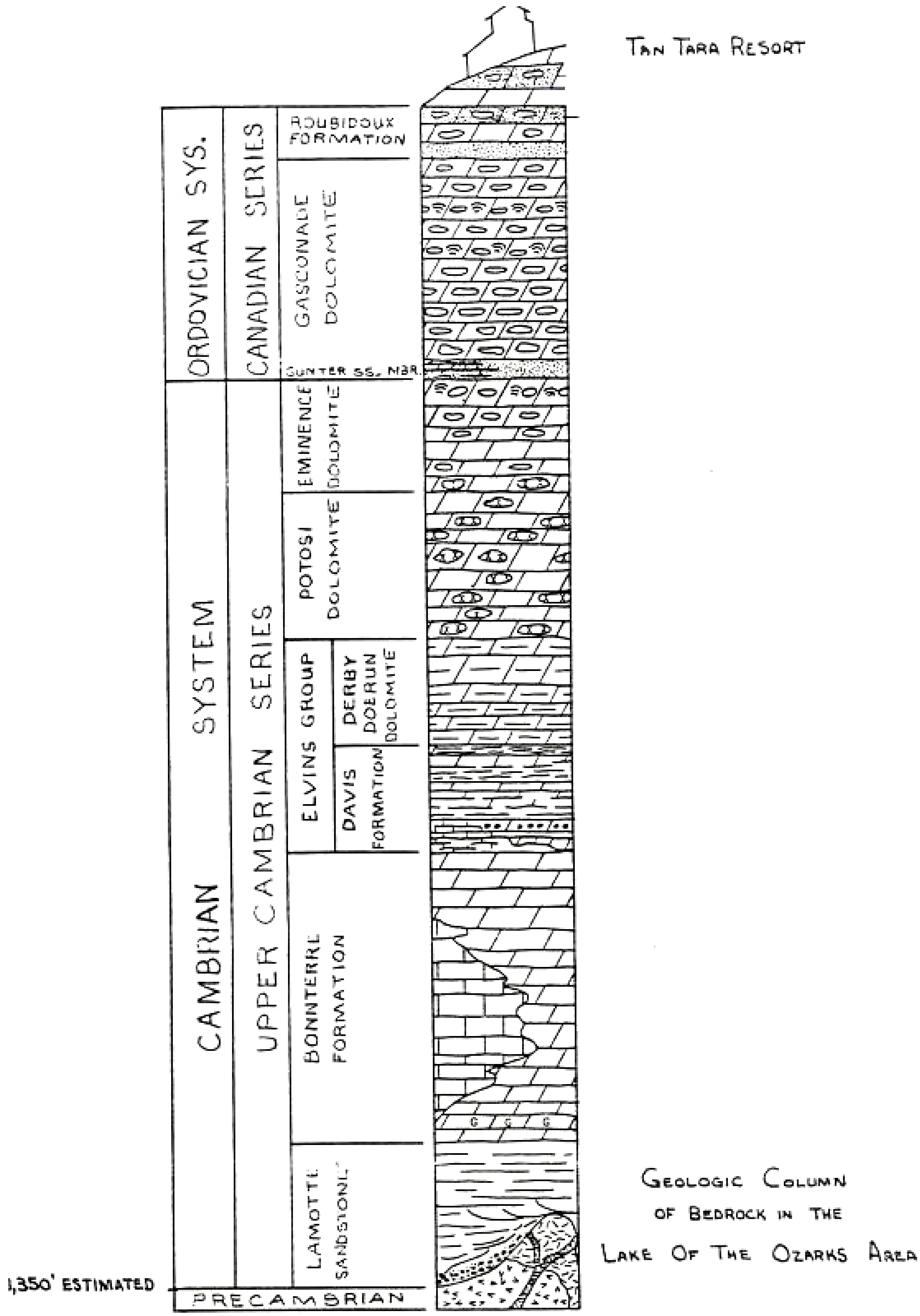


Figure 7. General stratigraphic column for the Lake of the Ozarks area.

The rest of your field trip package contains a handout prepared by Dr. Randy Miles for the wastewater disposal portion of the field trip.

Following these materials are excerpts from the Camden County, Missouri soil survey. The introduction explains the general conditions in Camden County. Field sheets for the portion of Ha-Ha Tonka State Park at which we will see four soil pits are included.

Type location descriptions and representative laboratory data are included for the commonly mapped upland soils in the area. Laboratory data for the four open pits at Ha-Ha Tonka also are included.

Ha-Ha Tonka State Park information is reproduced with permission from the Missouri Department of Natural Resources. These materials include a topographic map of the area, trail guides and maps, and a general description and history of the park.

Finally, the field guide includes a detailed set of schematics for soil development in a local sinkhole. The latter illustrates the amount of material movement and complexity of the local soil-landscape relationships. The sinkhole material is from David Rath's 1975 M.S. thesis, directed by Professor Emeritus C.L. Scrivner.

LOCATION MENFRO MO
Established Series Rev. RWF--KDV 10/88
MENFRO SERIES
The Menfro series consists of deep, well drained, moderately permeable soils formed in thick loess deposits on ridgetops, hills, and bluffs in the uplands adjacent to the Missouri and Mississippi Rivers and their major tributaries. Slopes range from 2 to 60 percent. Mean annual temperature is 56 degrees F, and mean annual precipitation is 36 inches.
TAXONOMIC CLASS: Fine-silty, mixed, mesic Typic Hapludalfs
TYPICAL PEDON: Menfro silt loam - pasture. (Colors are for moist soil unless otherwise stated.)
Ap--0 to 6 inches; dark brown (10YR 3/3) silt loam; dark brown (10YR 4/3) rubbed; pale brown (10YR 6/3) dry; moderate very fine granular structure; very friable; many fine roots; neutral; abrupt smooth boundary. (6 to 9 inches thick)
E--6 to 12 inches; brown (10YR 4/3) silt loam; weak thin platy structure parting to weak very fine subangular blocky; friable; common fine roots; medium acid; clear smooth boundary. (0 to 8 inches thick)
BE-- 12 to 15 inches; dark yellowish brown (10YR 4/4) silt loam; weak fine subangular blocky structure; friable common fine roots; medium acid, clear smooth boundary. (0 to 8 inches thick)
Btl--15 to 30 inches; brown (7.5YR 4/4) silty clay loam; moderate fine and medium subangular blocky structure; firm; few fine roots; many faint dark brown clay films on faces of peds; slightly acid, clear smooth boundary.
Bt2--30 to 40 inches; dark brown (7.5YR 4/4) silty clay loam; strong medium angular blocky structure; firm, few fine roots; many distinct dark brown clay films on faces of peds; common fine pores and old root channels with clay linings; slightly acid; gradual smooth boundary.
Bt3--40 to 68 inches; dark yellowish brown (10YR 4/4) silty clay loam; weak fine subangular blocky structure; friable; few faint clay films on faces of peds and vertical surfaces; slightly acid; diffuse wavy boundary. (Combined thickness of the Bt horizon is 24 to 75 inches.)
C--68 to 86 inches thick; brown (10YR 4/3) silt loam; few fine faint brown (10YR 5/3) mottles; massive; friable; slightly acid.
TYPE LOCATION: Boone County, Missouri. About 40 feet west of center of Rocheport Road, 450 feet south of the south end of Rocheport overpass over Interstate 70; about 132 feet east and 1,320 feet north of the southwest comer of sec. 8, T. 48 N., R. 14 W.
RANGE IN CHARACTERISTICS: The solum typically is 50 to 70 inches thick but ranges from 30 to 100 inches in thickness.
The A horizon has hue of 10YR, value of 2 to 4, and chroma of 2 or 3. and is about 1 to 4 inches thick. The Ap horizon has hue of 10YR, value of 3 or 4, and chroma of 2 or 3, with value of 4 or more rubbed and 5.5 or more dry. The E horizon has hue of 10YR, value of 4 or 5, and chroma of 3 or 4. The A horizon is strongly acid through neutral, depending on local liming practices.
The BE horizon, where present, has hue of 10YR or 7.5YR, value of 4, and chroma of 3 or 4. It is silt loam or silty clay loam.
The Bt horizon has hue of 10YR of 7.5YR, value of 4, and chroma of 3 or 4. The upper 20 inches of the argillic horizon averages between 27 and 35 percent clay, and the horizon with the highest clay maximum ranges from 30 to 38 percent. The BE and Bt horizon ranges from strongly acid to neutral.
The C horizon has hue of 10YR or 7.5YR, value of 4 or 5, and chroma of 3 or 4. It is silt loam or silty clay loam. It is medium acid to neutral in the upper part and ranges to mildly alkaline in the lower part of some pedons.
COMPETING SERIES: These are Alford, Baraboo, Bertrand, Birkbeck, Cadiz, Camden, Dodge, Dubuque, Elco, Eleroy, Fayette, Flagg, Hackers, Inton, Iona, Jackson, Knowles, La Farge, Lomira, Marseilles, Martinsburg, Mayville, Mentor, Middletown, Minnith,

Palsgrove, Rozetta, Rush, Russell, Sandview, Seaton, St. Charles, Sylvan, Uniontown, Weingarten, Westmore, Winfield, and Zurich soils in the same family. The Alford soils tend to have a lower average percent of base saturation at 50 inches below the top of the argillic horizon, a slightly lower clay maximum and average percent of clay in the argillic horizon. Baraboo, Dubuque, Knowles, La Farge, and Marseilles soils have a lithic or paralithic contact at depth of 20 to 40 inches. Bertrand, Hackers, and Jackson soils are formed in alluvium and have strata immediately below the argillic horizon containing more than 15 percent fine sand and coarser. Jackson soils also have mottles with chroma of 2 or less in the lower parts of the sola. Birkbeck, Cadiz, Camden, Dodge, Elco, Flagg, Lomira, Mayville, Mentor, Rush, Russell, St. Charles, and Zurich soils have lower parts of the sola formed in glacial materials containing more than 15 percent fine sand or coarser, with or without pebbles and other rock fragments. Eleroy, Grayford, Palsgrove, and Westmore soils have lithic or paralithic contacts at depths of from 40 inches to about 8 feet and the lower parts of sola or C horizons are either formed in glacial till, residuum, or both. Fayette and Inton soils typically have yellower hue and are typically more acid in the most acid horizons and soil temperature cooler than 54 degrees F. Iona, Rozetta, and Winfield soils have mottles with chroma of 2 or less in the lower part of their sola. Middletown and Minnith soils have more than 15 percent fine sand or coarser in the lower sola and C horizons. Sandview soils have more clay in the lower part of the argillic horizon. Sylvan and Uniontown soils have thinner sola. In addition, Sylvan soils have free carbonates within 40 inches. Martinsburg soils have a thicker E horizon, and the horizon having the maximum clay content is deeper in the profile. Seaton soils have argillic horizons averaging less than 27 percent clay. Weingarten soils have cherty residuum at depths of 40 to 60 inches.

GEOGRAPHIC SETTING: Menfro soils are on ridgetops, hills, and bluffs in the uplands adjacent to the Missouri and Mississippi Rivers and their major tributaries. Slope gradients range from 2 to 6 percent. Menfro soils formed in loess deposits ranging from 6 to 20 feet or more thick. The mean annual temperature ranges from 54 to 59 degrees F, and mean annual precipitation ranges from 32 to 42 inches. GEOGRAPHICALLY ASSOCIATED SOILS: These are the Winfield soils. Winfield soils are moderately well drained and commonly on lower slopes.

DRAINAGE AND PERMEABILITY: Well drained. Runoff is medium to very rapid. Permeability is moderate.

USE AND VEGETATION: Natural vegetation was deciduous hardwoods. The cleared areas are cropped to soybeans, small grain, com, hay, and pasture. Most of the steeper areas are in timber.

DISTRIBUT10N AND EXTENT: Central and eastern Missouri along the Missouri and Mississippi Rivers. The series is of large extent.

SERIES ESTABLISHED: Illinois, (III-2 Edwardsville project), 1939.

REMARKS: Base saturation at 1.25m below the top of the argillic horizon ranges from 60 to 87 percent and averages about 72 percent. The clay mineralogy is mixed but dominated by montmorillonite (est. 60-75 percent) with lesser amounts of illite. Diagnostic horizons and features recognized in this series are: ochric epipedon - the zone from the surface of the soil to a depth of 15 inches (Ap, E, and BE horizons); argillic horizon - the zone from approximately 15 inches to 68 inches (Bt1, Bt2, and Bt3 horizons); udic moisture regime.

National Cooperative Soil Survey U.S.A.

Menfro Map Unit 60008 05-19-98

Fine-silty, mixed, superactive, mesic Typic Hapludalf

M9201931 MISSOURI SOIL CHARACTERIZATION LABORATORY

BOONE COUNTY

SAMPLE #	DEPTH cm	DEPTH in	HORIZON	TOTAL CLAY < .002	TOTAL SILT .002 -.05	TOTAL SAND .05 -2	SILT FINE .002 -.02	SILT COARSE .02 -.05	SAND VF .05 -.10	SAND F .10 -.25	SAND M .25 -.50	SAND C .5 -1	SAND VC 1 -2	SAND >VF .10 -2	TEXT CLASS
				% of <2mm											
M920193101	0-8	0-3	A	16.3	73.7	10.0	28.0	45.7	8.8	0.8	0.1	0.1	0.1	1.2	SIL
M920193102	8-15	3-6	E	14.7	75.8	9.5	28.5	47.3	8.5	0.8	0.0	0.1	0.1	1.0	SIL
M920193103	15-28	6-11	BE	15.0	74.4	10.5	28.4	46.0	9.0	1.0	0.2	0.2	0.1	1.5	SIL
M920193104	28-43	11-17	Bt1	24.0	64.2	11.8	25.0	39.2	7.8	3.5	0.2	0.2	0.1	4.0	SIL
M920193105	43-61	17-24	Bt2	28.8	62.3	9.0	23.6	38.6	7.8	0.7	0.2	0.2	0.1	1.2	SICL
M920193106	61-84	24-33	Bt3	30.0	60.8	9.1	22.3	38.6	8.1	0.7	0.1	0.1	0.0	1.0	SICL
M920193107	84-102	33-40	Bt4	27.3	61.9	10.8	21.3	40.6	9.6	0.9	0.2	0.1	0.0	1.2	SICL
M920193108	102-130	40-51	Bt5	25.4	62.7	11.9	21.9	40.9	10.7	0.9	0.2	0.1	0.0	1.2	SIL
M920193109	130-157	51-62	Bt6	24.7	62.7	12.6	21.3	41.4	11.6	0.9	0.1	0.0	0.0	1.0	SIL
M920193110	157-203	62-80	Bt7	22.7	70.3	7.1	27.5	42.8	6.4	0.6	0.1	0.0	0.0	0.7	SIL

SAMPLE #	NH4OAc EXTRACTABLE BASES Ca	Mg	Na	K	SUM BASES	ACID-ITY	EXTR Al	CEC SUM CATS	CEC NH4 OAc	CEC BASES +AL	Al SAT	BASE SAT SUM	BASE SAT NH4 OAc	ORG C	pH CaCl2 .01M	pH H2O
	meq/100 g										%					
M920193101	13.0	3.3	TR	.5	16.8	6.4	0.0	23.2	19.8	16.8	0	72	85	2.9	5.8	6.2
M920193102	4.1	1.9	TR	.2	6.2	9.3	.9	15.5	12.9	7.1	13	40	48	1.2	4.6	5.1
M920193103	5.5	2.3	TR	.2	8.0	4.8	.1	12.8	10.6	8.1	1	63	75	0.6	4.9	5.6
M920193104	8.7	4.1	.1	.4	13.3	6.2	.1	19.5	15.6	13.4	1	68	85	0.4	5.1	5.6
M920193105	8.5	5.7	.1	.4	14.7	7.3	.2	22.0	18.7	14.9	1	67	79	0.3	5.0	5.5
M920193106	5.5	4.5	.1	.4	10.5	12.8	4.9	23.3	19.3	15.4	32	45	54	0.2	4.1	4.8
M920193107	4.1	4.1	.1	.3	8.6	13.0	5.8	21.6	17.5	14.4	40	40	49	0.2	4.0	4.7
M920193108	4.4	4.5	.2	.3	9.3	12.4	4.5	21.8	17.7	13.9	32	43	53	0.1	3.9	4.6
M920193109	7.6	7.9	.4	.2	16.1	6.9	.5	23.0	19.1	16.6	3	70	84	0.1	4.6	5.1
M920193110	8.8	8.1	.5	.1	17.6	6.1	.6	23.7	19.4	18.2	3	74	91	0.1	5.1	5.2

LOCATION SEYMOUR IA+MO WI

Established Series Rev. JDH-RID-DBO 5/88

SEYMOUR SERIES

The Seymour series consists of deep, somewhat poorly drained, very slowly permeable soils formed in loess on uplands and high stream benches. Slopes range from 2 to 9 percent. Mean annual temperature is about 51 degrees F, and mean annual precipitation is about 33 inches.

TAXONOMIC CLASS: Fine, montmorillonitic, mesic Aquic Argiudolls

TYPICAL PEDON: Seymour silt loam with a convex, north-facing slope of 2 percent - cultivated. (Colors are for moist soil unless otherwise stated.)

Ap--0 to 7 inches; very dark gray (10YR 3/1) silt loam (23 percent clay), gray (10YR 5/1) dry; very weak thick platy structure parting to weak fine subangular blocky and fine granular-, friable; many fine roots; very few very fine dark brown (10YR 3/3) soft (oxides) accumulations; slightly acid; abrupt smooth boundary.

A1 --7 to 11 inches; very dark gray (10YR 3/1) and some very dark grayish brown (10YR 3/2) silt loam (25 percent clay), gray (10YR 5/1) dry; weak very fine subangular blocky and weak fine granular structure; friable; many fine roots; few krotovinas; common very fine dark brown (10YR 3/3) and black (10YR 2/1) concretions (oxides); medium acid, clear smooth boundary.

A2--11 to 15 inches; very dark gray (10YR 3/ 1) and 20 percent very dark grayish brown (10YR 3/2) silty clay loam (28 percent clay), grayish brown (10YR 5/2) dry; moderate very fine subangular blocky structure; friable; many fine roots; few worm casts or mixing of dark grayish brown (10YR 4/2); few krotovinas; few thin silt coats on peds; few very fine soft dark brown (10YR 3/3) and black (10YR 2/1) accumulations (oxides); medium acid; clear smooth boundary. (Combined thickness of the A horizons is 10 to 18 inches.)

BA--15 to 19 inches; dark grayish brown (2.5Y 4/2) silty clay loam (35 percent clay), light brownish gray (10YR 6/2) dry; few fine faint olive brown (2.5Y 5/4) mottles; moderate very fine subangular blocky structure; firm; common fine roots; fine dark brown (10YR 3/3) and black (10YR 2/1) accumulations (oxides); medium acid; clear smooth boundary. (0 to 6 inches thick)

Bt1--19 to 23 inches; dark grayish brown (10YR 4/2) silty clay (47 percent clay); faces of peds dark gray (10YR 4/1); common fine faint dark yellowish brown (10YR 4/4) mottles on faces and many fine distinct yellowish brown (10YR 5/4) mottles in interiors of peds; strong very fine subangular blocky structure; very firm; few fine roots; few faint clay films; krotovina filled with very dark gray (10YR 3/1) silty clay loam; common very fine soft dark brown (10YR 3/3) and black (10YR 2/1) accumulations (oxides); medium acid; clear smooth boundary.

Bt2--23 to 28 inches; dark grayish brown (10YR 4/2) silty clay (51 percent clay); few fine faint brown (10YR 4/3) mottles on faces of peds; many fine distinct yellowish brown (10YR 5/4-5/6) mottles in interiors of peds; strong very fine angular and subangular blocky structure; very firm; few fine roots; some large oblique pressure faces; few distinct very dark gray (10YR 3/1) clay films; few fine tubular pores; common fine black (10YR 2/1) concretions (oxides); slightly acid; clear smooth boundary.

Bt3--28 to 36 inches; dark gray (10YR 4/1), dark grayish brown (10YR 4/2), and grayish brown (2.5Y 5/2) silty clay (46 percent clay); faces of peds are dark gray (10YR 4/1); common fine distinct yellowish brown (10YR 5/4) mottles; weak medium prismatic structure parting to moderate fine and medium subangular blocky; firm; some oblique pressure faces; few faint clay films; very few silt coats; slightly acid; clear irregular boundary.

Bt4--36 to 54 inches; olive gray (5Y 5/2) and some dark gray (25Y 4/1) silty clay loam (38 percent clay); common medium and fine prominent yellowish brown (10YR 5/6) mottles; moderate medium prismatic structure parting to moderate medium subangular blocky; firm; some oblique pressure faces; very thin discontinuous clay films on prism faces and in a few pores; common fine black (10YR 2/1) concretions (oxides); a few 1/2 inch diameter clay balls in lower part; neutral; gradual smooth boundary. (Combined thickness of the Bt horizons is 16 to 40 inches.)

BC--54 to 64 inches; olive gray (5Y 5/2) and some dark gray (2.5Y 4/1) silty clay loam (32 percent clay); few fine distinct yellowish brown (10YR 5/6) and strong brown (7.5YR 5/6) mottles; very weak coarse prismatic structure parting to very weak coarse angular blocky; friable; few dark gray (10YR 4/1) clay coats in pores; common 1/2 inch clay balls; neutral.

TYPE LOCATION: Wayne County, Iowa; about 2 miles south of Promise City; 342 feet west and 497 feet south of the center, sec. 3, T. 68 N., R. 20 W.

RANGE IN CHARACTERISTICS: Thickness of the solum commonly is 60 inches or more, and usually the loess lacks carbonates throughout. On uplands, these soils are underlain by paleosols at depths of 4 to 8 feet. On benches, the Seymour soils are underlain below 4 feet by alluvium of early Wisconsin or pre-Wisconsin Age. Content of fine sand and coarser is less than 3 percent. The A or Ap horizon typically is very dark gray (10YR 3/1), but the color ranges from black (10YR 2/1) to very dark gray grayish brown (10YR 3/2). It is silt loam or silty clay loam. Clay content of the A horizon increases as gradient increases on convex slopes. On the less sloping parts of the landscape where these soils intergrade to Edina soils, they have in the A2 horizon thin discontinuous grainy coats, which are not discernible when the soil is moist.

The matrix of the upper part of the Bt horizon is 10YR or 2.5Y in hue with value of 4 or 5 and chroma of 2. The Bt horizon has a subhorizon with a clay content of 50 to 55 percent. Depth to clay maximum decreases as gradient increases on convex slopes. Clay films are common on both horizontal and vertical faces of peds in the Bt horizon. The matrix of the lower part of the Bt horizon has hue of 10YR to 5Y, value of 4 to 6, and chroma of 1 or 2. The BC horizon and the C horizon, where present, have hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 2. The upper part of the C horizon commonly is silty clay loam.

COMPETING SERIES: These are the Adair, Arispe, Chase, Flanagan, Greenton, Grundy, Herrick, Ipava, Lagonda, Lamoni, Macksburg, Mahaska, Malvern, Martin, Mayberry, Pawnee, Rutland, Shorewood, and Wymore series in the same family and the Clarinda, Edina, Kilwinning, and Kniffin series. Adair and Lamoni soils contain more sand and pebbles, and Adair soils have redder hues. Arispe, Flanagan, Grundy, Herrick, Ipava, Macksburg, and Mahaska soils are lower in clay in the finest part of the B horizon. Chase soils have thicker mollic epipedons. Greenton soils have higher chroma colors in the argillic horizon and more clay in the 2BC and 2C horizons. Lagonda, Mayberry, and Pawnee soils have more sand in the solum. Malvern soils have redder hue in much of the solum. Martin soils formed in residuum of clayey shale and have a mollic epipedon 24 to 36 inches thick. Rutland soils have 2B and 2C horizons of lacustrine sediments or glacial till that are clay or silty clay textures. Shorewood soils have a thinner solum. Wymore soils have a thinner solum, are less acid, and have a drier climate. Clarinda soils have lower chroma and fewer mottles in the upper part of the B horizon and contain more sand. Edina soils have an albic horizon, an abrupt change in texture from the A to the B horizon, and dark coatings with chroma. of 1 in the upper part of the B horizon. Kilwinning soils lack a mollic epipedon. Kniffin soils lack a mollic epipedon and have an E horizon.

GEOGRAPHIC SETTING: Most of the Seymour soils are on convex ridgetops and on side slopes surrounding the nearly level stable upland divides in the loess-covered Kansan and Nebraskan till plains. Some are on benches and are underlain at depths greater than 4 feet by alluvium of Wisconsin or pre-Wisconsin Age. Slope gradients range from 2 to 9 percent. Seymour soils formed in loess containing less than 5 percent sand. Mean annual temperature ranges from about 50 to 58 degrees F, and mean annual precipitation ranges from about 32 to 38 inches.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the competing Adair, Clarinda, Edina, Kniffin, and Lagonda series and the Rathbun series. The Seymour soils are in a drainage sequence with the Edina soils. Seymour soils are on the gently sloping to moderately sloping convex interfluves that slope away from Edina soils on stable flats. In uplands, Seymour soils are upslope and generally at slightly higher elevations than Adair, Clarinda, and Lagonda soils which are on steeper, more strongly dissected topography. Seymour, Kniffm, and Rathbun soils are a biosequence of which the Seymour soils are the prairie member, the Kniffin soils the transitional member, and the Rathbun soils the forested member. These soils are on similar landscape positions.

DRAINAGE AND PERMEABILITY: Somewhat poorly drained. Runoff is medium. Permeability is very slow.

USE AND VEGETATION: Corn, oats, and hay and pasture are the major uses. Native vegetation was tall prairie grasses.

DISTRIBUTION AND EXTENT: Southern Iowa and northern Missouri. The series is extensive, and individual areas are large in size.

SERIES ESTABLISHED: Wayne County, Iowa, 1942.
REMARKS: Diagnostic horizons and features recognized in this pedon are: mollic epipedon - the zone from the surface of the soil to a depth of 15 inches (Ap, A1, and A2 horizons); argillic horizon - the zone from a depth of 15 to 54 inches (Btl, Bt2, Bt3, and Bt4 horizon).

National Cooperative Soil Survey U.S.A.

Seymour Taxadjunct   Map Unit 3482   5-6-98

Fine, montmorillonitic, mesic Vertic Epiaqualf

M8819706   MISSOURI SOIL CHARACTERIZATION LABORATORY

SCHUYLER COUNTY

SAMPLE #	DEPTH cm	DEPTH In	HORIZON	TOTAL CLAY <.002	TOTAL SILT .002-.05	TOTAL SAND .05-2	SILT FINE .002-.02	SILT COARSE .02-.05	SAND VF .05-.10	SAND F .10-.25	SAND M .25-.50	SAND C .5-1	SAND VC 1-2	>VF .10-2	TEXT CLASS
				% of <2mm											
M881970801	0-20	0-8	Ap	24.2	70.3	5.6	44.7	25.5	1.0	0.9	1.3	2.1	0.3	4.6	SIL
M881970802	20-36	8-14	Bt1	31.5	63.3	5.2	43.8	19.5	0.7	0.7	0.8	2.0	0.9	4.5	SICL
M881970803	36-48	14-19	Bt2	52.4	46.1	1.5	28.3	17.8	0.4	0.[illegible]	0.2	0.4	0.[illegible]	1.1	SIC
M881970804	48-74	19-29	Bt3	46.7	48.6	2.7	34.4	14.2	0.8	0.8	0.4	0.6	0.1	1.9	SIC
M881970805	74-102	29-40	Bt4	37.3	61.3	1.4	41.0	20.3	0.5	0.3	0.2	0.3	0.1	0.9	SICL
M881970806	102-132	40-52	Bt5	32.7	65.1	2.2	41.8	23.3	0.8	0.7	0.3	0.4	0.0	1.4	SICL
M881970807	132-152	52-60	C	31.3	66.5	0.4	50.2	16.3	0.3	0.1	0.0	0.0	0.0	0.1	SICL

SAMPLE #	NH4OAc EXTRACTABLE BASES Ca	Mg	Na	K	SUM BASES	ACIDITY	EXTR Al	CEC SUM CATS	CEC NH4 OAc	CEC BASES +AL	AL SAT	BASE SAT SUM	BASE SAT NH4 OAc	ORG C	pH CaCl2 .01M	pH H2O
	meq/100 g										%					
M881970801	18.4	2.0	.1	.6	21.1	4.3	0.0	25.4	21.2	21.1	0	83	100	1.4	6.6	7.2
M881970802	15.0	3.7	.2	.4	19.3	7.7	.1	27.0	22.6	19.4	1	71	85	0.7	5.6	5.9
M881970803	19.3	6.8	.7	.6	29.4	14.2	2.0	43.6	37.4	31.4	6	67	79	0.9	4.7	4.9
M881970804	19.2	9.3	1.2	.8	30.5	12.0	.9	42.5	35.7	31.4	3	72	85	0.7	4.9	5.2
M881970805	16.1	8.1	1.5	.5	26.2	6.0	.1	32.2	27.0	26.3	0	81	9[illegible]	0.3	5.4	5.[illegible]
M881970806	15.6	7.6	1.6	.5	25.3	5.2	.1	30.5	25.5	25.4	0	83	99	0.3	5.9	6.7
M881970807	13.7	6.6	1.4	.6	22.3	3.6	0.0	25.9	22.6	22.3	0	86	99	0.2	6.0	6.7

LOCAT10N WINFIELD MO

Established Series Rev. RWF-ICIDV 10/88

WINFIELD SERIES

The Winfield series consists of deep, moderately well drained, moderately permeable soils formed in loess which ranges from 5 to 10 feet thick. These soils are on ridgetops and sideslopes of ridges and hills. Slopes range from 2 to 35 percent. Mean annual temperature is 55 degrees F, and mean annual precipitation is 36 inches.

TAXONOMIC CLASS: Fine-silty, mixed, mesic Typic Hapludalfs

TYPICAL PEDON: Winfield silt loam - on an 8 percent northwest facing slope in pasture. (Colors are for moist soil unless otherwise noted.)

Ap--0 to 6 inches; brown (10YR 4/3) silt loam; pale brown (10YR 6/3) dry; moderate fine granular structure; friable; common fine roots; few dark brown (10YR 3/3) stains; neutral; clear smooth boundary. (5 to 10 inches thick)

E--6 to 10 inches; brown (10YR 4/3) silt loam; weak medium subangular blocky structure; friable; common fine roots; slightly acid; clear smooth boundary. (0 to 6 inches thick)

BE--10 to 14 inches; dark yellowish brown (10YR 4/4) silt loam; moderate medium subangular blocky structure; friable; slightly sticky; many fine roots; slightly acid; clear smooth boundary. (0 to 6 inches thick)

Bt1--14 to 22 inches; yellowish brown (10YR 5/4) silty clay loam; moderate fine subangular blocky structure; firm; common fine roots; many faint brown clay films on faces of peds; strongly acid; gradual smooth boundary.

Bt2--22 to 30 inches; yellowish brown (10YR 5/6) silty clay loam; strong medium subangular blocky structure; firm, few fine roots; common fine very dark brown concretions (Fe and Mn oxides); many faint brown clay films on faces of peds; some peds coated with gray silt; very strongly acid; gradual smooth boundary.

Bt3--30 to 43 inches; mottled light brownish gray (10YR 6/2), dark brown (7.5YR 4/4) and yellowish brown (10YR 5/6) silty clay loam; moderate medium prismatic structure parting to weak medium subangular blocky; firm; few fine roots; many very dark brown concretions (Fe and Mn oxides - 1 to 4 mm diameter); many faint clay films on faces of peds; very thick light brownish gray clay coatings on flows on some vertical prism faces; very strongly acid; gradual smooth boundary. (Combined thickness of the Bt horizon is 12 to 28 inches.)

Btg--43 to 54 inches; gray (10YR 6/1) silty clay loam; many fine distinct dark yellowish brown (10YR 4/4) mottles; moderate medium prismatic structure parting to weak medium subangular blocky; firm; few fine roots; many soft very dark brown accumulations (Fe and Mn oxides); many distinct clay films on vertical faces prisms; few faint clay films on other faces of peds; very strongly acid; diffuse wavy boundary. (8 to 15 inches thick)

Cg--54 to 72 inches; gray (10YR 6/1) silt loam; many fine distinct dark brown (7.5YR 4/4) mottles; massive; friable; few fine roots; common soft very dark brown accumulations (Fe and Mn oxides); medium acid.

TYPE LOCATION: Boone County, Missouri, 990 feet east and 330 feet south of the northwest comer of sec. 33, T. 48 N., R. 13 W.

RANGE IN CHARACTERISTICS: Solum thickness typically is 46 to 60 inches and ranges from 36 to about 77 inches.

The Ap horizon is dark brown (10YR 4/3) or dark grayish brown (10YR 4/2). Uncultivated pedons have an A horizon with hue of 10YR, value of 3 or 4, and chroma of 2 or 3, 1 to 4 inches thick. The surface horizons have dry value of 6 or 7. The E horizon has hue of 10YR, value of 4, 5, or 6, and chroma, of 2 to 4. Texture is usually silt loam but may be silty clay loam in eroded areas. Where limed, the A horizon ranges from medium acid to neutral and unlimed pedons are commonly very strongly acid or strongly acid.

The BE horizon has hue of 10YR or 7.5YR, value of 4 or 5 and chroma of 3 or 4. It is silt loam or silty clay loam. The upper part of the Bt horizon has hue of 10YR or 7.5YR, value of 4 or 5 and chroma of 3 to 6. The lower part of the Bt horizon and Btg horizon is mottled with value of 4 to 6, and chroma of 1 to 6. The upper 20 inches of the argillic horizon averages between 30 and 35 percent clay. Reaction ranges from very strongly acid to medium acid. Some pedons have a BC horizon that is silty clay loam or silt loam. The Cg horizon, when present, has hue of 10YR or 2.5Y, value of 4,

5, or 6, and chroma of 1 to 4. Mottles of higher chroma are common or many, fine or medium and distinct or prominent. The Cg horizon is strongly acid to neutral. COMPETING SERIES: These are the Alford, Baraboo, Bertrand, Birkbeck, Blackhammer, Cadiz, Camden, Dodge, Dubuque, Elco, Eleroy, Fayette, Flagg, Hackers, Inton, Iona, Jackson, Knowles, La Farge, Lomira, Marseilles, Martinsburg, Mayville, Menfro, Mentor, Middletown, Minnith, Palsgrove, Rozetta, Rush, Russell, Sandview, Seaton, St. Charles, Sylvan, Uniontown, Weingarten, Westmore, and Zurich soils in the same family. Alford, Bertrand, Menfro, and Seaton soils are better drained and lack mottles with chroma of 2 or less in the lower parts of the sola. Baraboo, Dubuque, Knowles, La Farge, and Marseilles soil have lithic or paralithic contacts at depths of from 20 to 40 inches. Birkbeck, Cadiz, Camden, Dodge, Elco, Flagg, Lomira, Rush, Russell, St. Charles, and Zurich soils have the lower parts of their sola formed in glacial materials with more than 15 percent fine sand or coarser and variable amounts of pebbles. Eleroy, Grayford, Palsgrove, and Westmore soils have lithic or paralithic contacts at depths of from 40 inches to about 8 feet and the lower parts of the sola or C horizons are either formed in glacial till, residuum, or both. Fayette soils have grayer A horizons, lack mottles with chroma of 2 or less above depths of 36 inches and lack the dominant gray matrix colors in the lower part of the sola and C horizon. Hackers and Jackson soils formed in alluvium and have strata immediately below the argillic horizon that contain more than 15 percent fine sand or coarser. Inton soils have hue of 2.5Y or 5Y in the Bt horizon. Iona and Rozetta soils typically have less acid sola and C horizons that range through neutral, or have free carbonates within depths of 5 or 6 feet. Martinsburg soils have a thicker E horizon and are deeper to the maximum clay. Minnith and Mayville soils have 2B horizons with more than 15 percent sand. Mentor soils typically have stratification. Middletown soils lack mottles with chroma of 2 or less in the lower part of the argillic horizon and the lower part of the solum and C horizons formed in loamy sand or sand. Sandview soils have more clay in the lower part of the argillic horizon. Sylvan and Uniontown soils have thinner, less acid sola and lack mottles with chroma of 2 or less, in the lower parts of the sola and have free carbonates within depths of 40 inches. Weingarten soils have cherty residuum at depths of 40 to 60 inches. GEOGRAPHIC SETTING: Winfield soils are on ridgetops and sideslopes of ridges and on stream terraces. Slope gradients are dominately 2 to 20 percent with an extreme range up to 35 percent. They formed in loess which ranges from 5 to 10 feet thick. Mean annual temperature ranges from 51 to 57 degrees F, and mean annual precipitation ranges from 32 to 42 inches.
GEOGRAPHICALLY ASSOCIATED SOILS: These are the competing Menfro soils and the Union, Weller, and Marion soils. The Winfield series is the moderately well drained soil in a drainage sequence with the well drained Menfro soils and commonly are on lower slopes. Union, Marian, and Weller soils contain more clay in the series control section and occur upslope from the Winfield soils.
DRAINAGE AND PERMEABILITY: Moderately well drained. Runoff is medium to very rapid. Permeability is moderate.
USE AND VEGETATION: Most areas are cleared and cropped to soybeans, small grains, corn, hay, and pasture. Remaining areas are in hardwood forest. Native vegetation is deciduous hardwoods (oak and hickory).
DISTRIBUTION AND EXTENT: Central and eastern Missouri bordering the river hills of the Missouri and Mississippi Rivers. The series is of large extent.
SERIES ESTABLISHED: St. Charles County, Missouri, 1947.
REMARKS: The clay mineralogy is mixed but is estimated to be dominated by montmorillonite with lesser amounts of illite. Diagnostic horizons and features recognized in this series are: ochric epipedon - the zone from the surface of the soil to a depth of 14 inches (Ap, E, and BE horizons); argillic horizon - the zone from approximately 14 inches to 54 inches (Btl, Bt2, Bt3, and Btg horizons); udic moisture regime.

National Cooperative Soil Survey U.S.A.

Winfield Map Unit 60032 05-19-98

Fine-silty, mixed, superactive, mesic Oxyaquic Hapludalf

M9201948 MISSOURI SOIL CHARACTERIZATION LABORATORY

BOONE COUNTY

SAMPLE #	DEPTH cm	DEPTH in	HORIZON	-----TOTAL------ CLAY < .002	SILT .002 -.05	SAND .05 -2	---SILT---- FINE .002 -.02	COARSE .02 -.05	------------SAND----------- VF .05 -.10	F .10 -.25	M .25 -.50	C .5 -1	VC 1 -2	>VF .10 -2	TEXT CLASS
				----------------------	---------------------% of <2mm	-------------------------									
M920194801	0-5	0-2	A	12.3	78.3	9.4	34.7	43.6	5.4	1.8	0.7	0.9	0.6	4.0	SIL
M920194802	5-13	2-5	A2	17.0	78.4	4.6	33.5	44.9	3.4	0.4	0.2	0.4	0.1	1.2	SIL
M920194803	13-28	5-11	BE	16.5	78.5	5.0	34.9	43.6	3.7	0.5	0.3	0.4	0.1	1.3	SIL
M920194804	28-48	11-19	Bt1	26.5	69.8	3.7	32.4	37.4	2.5	0.5	0.3	0.4	0.1	1.2	SIL
M920194805	48-66	19-26	Bt2	21.5	73.5	5.0	31.2	42.3	3.7	0.6	0.3	0.4	0.1	1.3	SIL
M920194806	66-89	26-35	Bt3	30.2	65.7	4.2	27.3	38.4	2.9	0.5	0.3	0.4	0.0	1.3	SICL
M920194807	89-122	35-48	Bt4	28.7	66.0	5.3	27.3	38.7	4.2	0.6	0.2	0.3	0.0	1.1	SICL
M920194808	122-152	48-60	Bt5	33.1	54.3	12.6	16.8	37.4	11.2	0.9	0.2	0.3	0.0	1.4	SICL

SAMPLE #	NH4OAc EXTRACTABLE BASES Ca	Mg	Na	K	SUM BASES	ACID-ITY	EXTR Al	------CEC------ SUM CATS	NH4 OAc	BASES +AL	Al SAT	BASE SAT SUM	NH4 OAc	ORG C	---pH---- CaCl2 .01M	H2O
	---------------------------					----meq/100 g	------------------				---------%---------					
M920194801	26.5	4.3	0.0	1.0	31.8	4.8	.1	36.6	31.5	31.9	0	87	100	5.0	6.6	7.0
M920194802	14.9	2.3	0.0	.7	17.9	5.9	0.0	23.8	21.4	17.9	0	75	84	3.0	6.3	6.7
M920194803	7.7	2.3	0.0	.4	10.4	3.9	0.0	14.3	12.6	10.4	0	73	83	0.5	6.0	6.6
M920194804	10.0	4.2	0.0	.5	14.7	5.4	0.0	20.1	18.2	14.7	0	73	81	0.3	5.7	6.2
M920194805	8.0	3.9	0.0	.4	12.3	5.5	.1	17.8	15.3	12.4	1	69	80	0.3	5.4	6.0
M920194806	10.4	6.3	TR	.4	17.1	7.5	.6	24.6	22.9	17.7	3	70	75	0.2	5.0	5.4
M920194807	10.2	6.3	.1	.4	17.0	7.6	1.1	24.6	22.6	18.1	6	69	75	0.2	4.7	5.1
M920194808	11.2	6.7	.3	.3	18.5	4.0	.2	22.5	21.1	18.7	1	82	88	0.1	5.1	5.5

LOCATION GOSS MO+IA IL
Established Series Rev. FCW-KDV 1/90
GOSS SERIES
The Goss series consists of very deep, well drained, moderately permeable soils formed in residuum from cherty limestone or cherty dolomite and some interbedded shale. These soils are on uplands and have slopes of 2 to 70 percent. Mean annual temperature is 53 degrees F, and mean annual precipitation is 39 inches.
TAXONOMIC CLASS: Clayey-skeletal, mixed, mesic Typic Paleudalfs
TYPICAL PEDON: Goss gravelly silt loam - on a 25 percent slope in forest. (Colors are for moist soil unless otherwise stated.)
A--0 to 6 inches; dark grayish brown (10YR 4/2) gravelly silt loam, light brownish gray (10YR 6/2) dry; moderate fine granular structure; very friable; many roots; 15 percent chert gravel; medium acid; abrupt smooth boundary. (2 to 8 inches thick)
E--6 to 19 inches; brown (10YR 5/3) extremely gravelly silt loam; weak fine granular structure; very friable; many roots; 65 percent chert gravel; medium acid, gradual smooth boundary. (0 to 17 inches thick)
Btl -- 19 to 28 inches; reddish brown (5YR 4/4) and red (2.5YR 4/6) extremely gravelly silty clay; moderate fine subangular blocky structure; firm; few roots; few faint clay films on faces of peds; 65 percent chert gravel; medium acid; clear smooth boundary.
Bt2--28 to 43 inches; red (2.5YR 4/6) gravelly silty clay; many medium prominent brown (10YR 5/3) mottles; moderate fine angular and subangular blocky structure; very firm; few roots; few faint clay films on faces of peds; 30 percent chert gravel; strongly acid; clear smooth boundary.
Bt3--43 to 54 inches; red (2.5YR 4/6) gravelly silty clay; few medium prominent grayish brown (10YR 5/2) mottles; moderate fine subangular blocky structure; very firm; few faint clay films on faces of peds; 30 percent chert gravel; strongly acid; clear smooth boundary.
Bt4--54 to 63 inches; yellowish brown (10YR 5/6) very gravelly silty clay; common medium prominent red (2.5YR 5/6) mottles; weak fine subangular blocky structure; very firm, few faint clay films on faces of peds; 45 percent gravel of chert and limestone fragments; dark stains on faces of peds; medium acid; clear smooth boundary. (Combined thickness of the Bt horizons is 50 inches to several feet).
2C--63 to 69 inches; light gray (10YR 7/1) clay; many medium prominent brownish yellow (10YR 6/6) mottles; massive; very firm, neutral.
TYPE LOCATION: Monroe County, Missouri; about 6 miles east of Paris; 2,550 feet south of the northwest corner of sec. 15, T. 54 N., R. 9 W.
RANGE IN CHARACTERISTICS: The A horizon has hue of 10YR or 7.5YR, value of 2 to 4, 5 or 6 dry and chroma of 2 to 4. It is silt loam, loam, or the ^gravelly, very gravelly, cobbly or very cobbly analogues. Reaction is very strongly acid to slightly acid. Some pedons have a stony surface. The E horizon has hue of 10YR or 7.5YR, value of 4 to 6 and chroma of 3 or 4. It is silt loam, loam, or the gravelly to extremely gravelly or the cobbly to extremely cobbly analogues of silt loam. Reaction is very strongly acid to slightly acid. Some pedons have a BE horizon. The Bt horizon is dominated by hue of 10R to 7.5YR, value of 4 to 6, but can range to 3 in the lower part, chroma of 4 to 8 and is mottled. It is gravelly to extremely gravelly or cobbly to extremely cobbly analogues of silty clay loam, silty clay or clay. Reaction is very strongly acid to medium acid. The C horizon is variable in color and texture. Reaction is very strongly acid to neutral. ^
COMPETING SERIES: There are no other series in the family. Other similar series include the Clarksville, Doniphan, Noark and Poynor soils. Clarksville soils are loamy-skeletal. Doniphan soils are clayey. Poynor soils do not have the high percent of coarse fragments in the lower part of the argillic horizon. Noark soils have lower base saturation at the critical depth.
GEOGRAPHIC SETTING: Goss soils are on uplands and formed in residuum from cherty limestone or cherty dolomite and some interbedded shale. Slopes range from 2 to 70 percent. The mean annual temperature ranges from 47 to 57 degrees F, and mean annual precipitation ranges from 32 to 44 inches.
GEOGRAPHICALLY ASSOCIATED SOILS: These are the Gasconade, Gatewood, Peridge and Wilderness soils in the southern part of the series extent and Keswick and Lindley soils in the northern part. Gasconade soils are shallow, Gatewood soils are moderately deep and these soils are in similar positions where depth to rock is less. Peridge soils are fine-silty and commonly are higher on the landscape. Wilderness soils have a fragipan and are higher on the landscape.

Keswick and Lindley soils do not have the chert fragments having formed in till and are higher on the landscape.
DRAINAGE AND PERMEABILITY: Well drained. Runoff is rapid. Permeability is moderate.
USE AND VEGETATION: Areas are used for woodland and past. Native vegetation is upland hardwoods.
DISTRIBUTION AND EXTENT: Missouri, Iowa, and Illinois. The series is of large extent.
SERIES ESTABLISHED: Monroe County, Missouri, 1973.
REMARKS: Diagnostic horizons and features recognized in the series are: ochric epipedon - the zone from the surface of the soil to a depth of 19 inches (A and E horions); argillic horizon - the zone from approximately 19 inches to 63 inches (Btl, Bt2, Bt3 and Bt4 horizons); udic soil moisture regime.

National Cooperative Soil Survey U.S.A.

Goss gravelly silt loam   Map Unit 40F   5-21-96

Clayey-skeletal, mixed, mesic Typic Paleudalf

M8905366   MISSOURI SOIL CHARACTERIZATION LABORATORY

COOPER COUNTY

SAMPLE #	DEPTH cm	DEPTH in	HORIZON	TOTAL CLAY < .002	TOTAL SILT .002 -.05	TOTAL SAND .05 -2	SILT FINE .002 -.02	SILT COARSE .02 -.05	SAND VF .05 -.10	SAND F .10 -.25	SAND M .25 -.50	SAND C .5 -1	SAND VC 1 -2	SAND >VF .10 -2	TEXT CLASS
				% of <2mm											
M890536601	0-10	0-4	A	11.3	82.1	6.6	45.1	37.1	3.2	1.3	0.7	1.1	0.3	3.4	SI
M890536602	10-36	4-14	E1	7.1	85.9	7.0	46.5	39.5	3.4	1.6	0.7	0.9	0.3	3.6	SI
M890536603	36-53	14-21	E2	12.8	75.9	11.2	38.7	37.2	4.2	2.3	1.3	1.9	1.5	7.0	SIL
M890536604	53-74	21-29	BE	23.2	60.2	16.6	28.1	32.1	8.8	4.5	1.3	1.3	0.7	7.8	SIL
M890536605	74-112	29-44	2Bt1	52.5	36.9	10.7	17.9	19.0	4.5	2.6	1.0	1.4	1.2	6.2	C
M890536606	112-152	44-60	2Bt2	52.1	39.7	8.2	21.6	18.1	3.7	2.2	0.8	0.9	0.6	4.5	C

SAMPLE #	NH4OAc EXTRACTABLE BASES Ca	Mg	Na	K	SUM BASES	ACIDITY	EXTR Al	CEC SUM CATS	CEC NH4 OAc	CEC BASES +AL	Al SAT	BASE SAT SUM	BASE SAT NH4 OAc	ORG C	pH CaCl2 .01M	pH H2O
	meq/100 g										%					
M890536601	3.7	1.1	0.0	.3	5.1	8.6	.4	13.7	11.3	5.5	7	37	45	2.1	4.6	5.1
M890536602	.5	.4	0.0	.1	1.0	6.1	2.0	7.1	5.6	3.0	67	14	18	0.6	4.0	4.6
M890536603	.9	.4	TR	.2	1.5	5.9	1.9	7.4	6.3	3.4	56	20	24	0.3	4.1	4.8
M890536604	3.3	1.9	TR	.2	5.4	7.9	3.4	13.3	11.9	8.8	39	41	45	0.2	4.3	5.0
M890536605	8.1	3.8	.1	.4	12.4	16.9	9.3	29.3	25.9	21.8	43	42	48	0.3	4.3	4.8
M890536606	11.6	4.1	.3	.4	16.4	11.4	3.3	27.8	25.3	19.7	17	59	65	0.2	4.5	4.8

LOCATION ELDON MO+AR
Established Series Rev. BEH-KDV 1/90
ELDON SERIES
The Eldon series consists of very deep, well drained, moderately permeable soils formed in residuum from cherty limestone bedrock interbedded with shale and sandstone on uplands . Slopes range from 2 to 25 percent. Mean annual temperature is 56 degrees F, and mean annual precipitation is 41 inches.
TAXONOMIC CLASS: Clayey-skeletal, mixed, mesic Mollic Paleudalfs
TYPICAL PEDON: Eldon gravelly silt loam - on a 6 percent convex southwest-facing slope in broom sedge and lespedeza. (Colors are for moist soil unless otherwise stated.)
Ap--0 to 10 inches; dark brown (7.5YR 3/2) gravelly silt loam, brown (7.5YR 5/2) dry; moderate fine granular structure; very friable; common fine roots; few worm channels and casts; 15 percent chert gravel and 5 percent chert cobbles; medium acid; clear smooth boundary. (6 to 10 inches thick)
Bt1--10 to 19 inches; reddish brown (5YR 4/4) very gravelly silty clay loam; moderate very fine subangular blocky structure; friable; few fine roots; few worm channels and casts; few faint clay films on faces of peds; 55 percent chert gravel and 5 percent chert cobbles; few fine black concretions (oxides); very strongly acid; clear smooth boundary.
Bt2--19 to 24 inches; reddish brown (2.5YR 4/4) extremely gravelly silty clay loam; moderate fine and very fine subangular blocky structure; firm-, few fine roots; few faint clay films on faces of peds; 60 percent chert gravel and 10 percent chert cobbles; few fine black concretions (oxides); very strongly acid; clear smooth boundary.
Bt3--24 to 31 inches; dark red (2.5YR 3/6) very gravelly silty clay; few medium faint dusky red (10R 3/4) mottles; strong fine angular blocky structure; firm; few fine roots; few faint clay films on faces of peds; 55 percent chert gravel and 5 percent chert cobbles; few fine black concretions (oxides); very strongly acid; gradual wavy boundary. (Combined thickness of the Bt horizons is 12 to 36 inches.)
2Bt4--31 to 72 inches; dusky red (10R 3/4) clay; moderate medium subangular blocky structure; very firm; many distinct clay films on faces of peds; 10 percent fine chert gravel; few fine black concretions (oxides); very strongly acid.
TYPE LOCATION: Greene County, Missouri; near the edge of the city of Republic; about 1,930 feet north and 290 feet east of the southwest comer, sec. 16, T. 28 N., R. 23 W.
RANGE IN CHARACTERISTICS: Reaction of the A horizon and Bt horizon range from very strongly acid to medium acid, except where limed, and the 2Bt horizon ranges from very strongly acid to mildly alkaline. The Ap horizon has hue of 10YR or 7.5YR, value of 2 or 3, and chroma of 2 or 3. It is silt loam or loam or their gravelly analogues. The BA horizon, when present, has hue of 10YR to 5YR, value of 3 to 5, and chroma of 3 to 6 and commonly is gravelly or very gravelly analogues of silty clay loam, loam, or silt loam. The upper part of the Bt horizon has hue of 10YR to 2.5YR. ^The lower part commonly is 7.5YR to 10R, but may be 10YR. Value is 3 or 4, and chroma is 3 to 8. It is the gravelly to extremely gravelly or cobbly to extremely cobbly analogues of silty clay loam, silty clay, or clay^. The upper 20 inches of the argillic horizon averages between 35 and 60 percent clay and 35 percent or more chert fragments. The 2Bt horizon has color similar to the Bt horizon. It commonly is clay or gravelly clay, but silty clay or silty clay loam and their gravelly analogues are within the range.
COMPETING SERIES: There are no other series in the family. Competing series in other families are the Craig, Eldorado, Keeno and Olpe soils. Craig and Eldorado soils are thermic. In addition, Eldorado soils are loarny-skeletal. Keeno soils have fragipans. Olpe soils are thermic and have base saturation greater than 50 percent throughout the argillic horizon.
GEOGRAPHIC SETTING: Eldon soils commonly are on gentle slopes and low mounds on ridges in upland areas of the western border Ozarks region. Slopes typically are 2 to 9 percent, but range to as much as 25 percent. These soils formed in residuum from limestone bedrock interbedded with shale and sandstone bedrock. Mean annual temperature ranges from 54 to 59 degrees F, and mean annual precipitation ranges from 36 to 46 inches.
GEOGRAPFUCALLY ASSOCIATED SOILS: These are the Keeno and the Creldon and Gerald series. Keeno soils are on lower side slopes. The Creldon and Gerald soils have fragipans and are on broad ridgetops.

DRAINAGE AND PERMEABILITY: Well drained. Runoff is medium. Permeability is moderate.
USE AND VEGETATION: Used mainly for pasture and small grain or hay. Native vegetation is tall prairie grasses and scattered hardwoods.
DISTRIBUTION AND EXTENT: Southwestern Missouri and northwestern Arkansas. The series is moderately extensive.
SERIES ESTABLISHED: Miller County, Missouri, 1912.
REMARKS: Diagnostic horizons and features recognized in this series are: ochric epipedon - the zone from the surface of the soil to a depth of 10 inches (borderline mollic epipedon - mollic subgroup, Ap horizon); argillic horizon - the zone from approximately 10 to 72 inches or more (Bt1, Bt2, Bt3, and Bt4 horizons).

National Cooperative Soil Survey U.S.A.

Eldon Map Unit -- 8-1-97

Very-fine, mixed, mesic Aquic Paleudalf

M9713101 MISSOURI SOIL CHARACTERIZATION LABORATORY

MILLER COUNTY

SAMPLE #	DEPTH cm	DEPTH in	HORIZON	TOTAL CLAY < .002	TOTAL SILT .002 -.05	TOTAL SAND .05 -2	SILT FINE .002 -.02	SILT COARSE .02 -.05	SAND VF .05 -.10	SAND F .10 -.25	SAND M .25 -.50	SAND C .5 -1	SAND VC 1 -2	SAND >VF .10 -2	TEXT CLASS
				% of < 2mm											
M971310101	0-20	0-8	Ap	22.0	58.4	19.5	28.6	29.8	2.2	6.3	4.2	2.7	4.1	17.3	SIL
M971310102	20-38	8-15	A1	24.2	51.3	24.5	25.2	26.1	1.9	5.7	3.0	2.8	11.1	22.5	SIL
M971310103	38-56	15-22	E	23.9	51.2	24.9	26.9	24.3	3.1	3.7	2.1	3.5	13.4	22.8	SIL
M971310104	56-89	22-35	2Bt1	75.3	16.9	7.8	7.9	9.0	0.7	0.8	0.4	1.2	4.6	7.0	C
M971310105	89-114	35-45	2Bt2	76.5	16.9	6.6	7.6	9.3	0.9	1.4	0.8	1.0	2.5	5.7	C
M971310106	114-119	45-47	3Bt3	59.5	19.1	21.4	10.5	8.5	2.1	10.3	5.6	1.9	1.5	19.4	C
M971310107	145-203	57-80	C	59.7	30.7	9.6	23.2	7.5	1.7	2.8	1.6	1.7	1.8	7.9	C

SAMPLE #	NH4OAc EXTRACTABLE BASES Ca	Mg	Na	K	SUM BASES	ACIDITY	EXTR Al	CEC SUM CATS	CEC NH4 OAc	CEC BASES +Al	Al SAT	BASE SAT SUM	BASE SAT NH4 OAc	ORG C	pH CaCl2 .01M	pH H2O
	meq/100 g										%					
M971310101	10.4	4.4	TR	.1	14.9	7.4	0.0	22.3	17.9	14.9	0	67	83	2.1	5.8	6.3
M971310102	8.0	3.5	.1	.1	11.7	8.5	0.0	20.2	14.5	11.7	0	58	81	1.5	5.6	6.2
M971310103	3.6	2.0	.1	TR	5.7	5.4	.3	11.1	8.1	6.0	5	51	70	0.4	5.0	5.7
M971310104	11.5	9.1	.3	.3	21.2	13.5	3.1	34.7	30.6	24.3	13	61	69	0.4	4.9	5.3
M971310105	16.8	14.4	.3	.3	31.8	6.3	0.0	38.1	34.8	31.8	0	83	91	0.1	6.1	6.4
M971310106	17.0	13.2	.4	.4	31.0	4.6	0.0	--	31.0	--	--	--	100	0.1	6.4	6.7
M971310107	11.4	9.2	.2	.3	21.1	2.8	0.0	23.9	22.8	21.1	0	88	93	TR	6.5	6.9

SAMPLE #	ROUNDED-SUBROUNDED GRAVEL .08-3.0"	ROUNDED-SUBROUNDED COBBLES 3.0-10"	ROUNDED-SUBROUNDED STONES 10-24"	FLAT CHANNERS .08-6.0"	FLAT FLAGSTONES 6.0-15"	FLAT STONES 15-24"
M971310101						
M971310102						
M971310103						
M971310104						
M971310105						
M971310106						
M971310107						

LOCATION CRAIG OK+MO

Established Series Rev. ECN 6/74

CRAIG SERIES

The Craig series is a member of the clayey-skeletal, mixed, thermic family of Mollic RL Paleudalfs. These soils have very dark brown and very dark grayish brown silt loam A horizons, dark grayish brown silt loam A2 horizons, brown silt loam B 1 horizons, dark yellowish brown and yellowish red very cherty clay loam B2t horizons and B3 horizons.

TAXONOMIC CLASS: Clayey-skeletal, mixed, thermic Mollic Paleudalfs

TYPICAL PEDON: Craig silt loam - rangeland. (Colors are for moist soil unless otherwise stated.)

A11--0-7 inches, very dark brown (10YR 2/2) silt loam, dark gray (10YR 4/1) dry; moderate medium and fine granular structure; hard, friable; many fine roots; common fine pores; medium acid; gradual smooth boundary. (6 to 12 inches thick)

A12 -- 7-12 inches, very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak fine granular structure; hard, friable; common fine roots and pores; few medium fragments of chert; strongly acid; gradual smooth boundary. (0 to 10 inches thick)

A2 -- 12-16 inches, dark grayish brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) dry; weak medium granular structure; hard, friable; common fine roots and pores; few medium fragments of chert; strongly acid; gradual wavy boundary. (3 to 5 inches thick)

B1 -- 16-21 inches, brown (10YR 5/3) silt loam, pale brown (10YR 6/3) dry; weak medium subangular blocky structure; hard, friable; few fine roots and pores; 10 percent medium fragments of chert; common 2 to 8 mm dark concretions; strongly acid; gradual wavy boundary. (3 to 12 inches thick)

B21t -- 21-25 inches, dark yellowish brown (10YR 4/4) very cherty clay loam; yellowish brown (10YR 5/4) dry; moderate very fine blocky structure; hard, fxiable; few fine roots and pores; 60 to 70 percent by volume of chert fragments from 2 mm to 100 mm in diameter, thin patchy clay films on faces of peds and chert fragments; common 2 to 5 mm dark concretions; strongly acid; gradual wavy boundary. (4 to 16 inches thick)

B22t -- 25-42 inches, yellowish red (5YR 5/6) very cherty clay loam; common fine, medium, and coarse reddish and brownish mottles on the chert fragments; weak very fine blocky structure; hard, friable; few fine roots and pores; 75 to 85 percent by volume chert fragments from 2 mm to 100 mm; thin patchy clay films on faces of peds, on chert fragments, and in pores; strongly acid; gradual wavy boundary. (10 to 30 inches thick)

B3 -- 42-60 inches, yellowish red (5YR 5/6) very cherty clay loam; common reddish and brownish mottles; structure is obscured by the chert; hard, friable; fractured chert ranges from 2 mm to 100 mm in diameter and occupies about 85 percent of the volume; strongly acid.

TYPE LOCATION: Craig County, Oklahoma; about 5 miles southeast of Vinita; about 3150 feet south and 50 feet east of the northwest comer of sec. 12, T. 24 N., R. 20 E.

RANGE IN CHARACTERISTICS: Solum thickness ranges from 60 to more than 80 inches. The depth to horizons containing more than 35 percent chert by volume ranges from 15 to 30 inches. The soil ranges from medium acid through very strongly acid throughout. The Al horizon is black (10YR 2/1), very dark brown (10YR 2/2), very dark gray (10YR 3/1), very dark grayish brown (10YR 3/2), or dark brown (10YR 3/3). It is loam, silt loam, cherty loam, or cherty silt loam. Coarse fragments more than 3 inches diameter range from 0 to 5 percent of the volume and coarse fragments less than 3 inches diameter range from 0 to 35 percent of the volume. The A2 horizon is dark gray (10YR 4/1), dark grayish brown (10YR 4/2), brown (10YR 4/3, 5/3), gray (10YR 511), or grayish brown (10YR 5/2). Texture and coarse fragments are similar to those in the A1 horizon. The B I horizon is very dark grayish brown (10YR 3/2), dark brown (10YR 3/3; 7.5YR 3/2), dark yellowish brown (10YR 3/4,4/4), dark grayish brown (10YR 4/2), brown (10YR 4/3, 5/3; 7.5YR 4/2, 4/4, 5/2, 5/4), grayish brown (10YR 5/2), or yellowish brown (10YR 5/4). It is loam, silt loam, clay loam, silty clay loam, cherty loam, cherty silt loam, cherty clay loam, or cherty silty clay loam. Coarse fragments more than 3 inches diameter range from 0 to 5 percent of the volume and coarse fragments less than 3 inches diameter make up 1 to 50 percent of the volume.

The B2t horizon is brown (10YR 4/3, 5/3; 7.5YR 4/4, 5/4), dark yellowish brown (10YR 4/4), yellowish brown (10YR 5/4, 5/6), strong brown (7.5YR 5/6), reddish brown (5YR 4/3, 4/4, 5/3, 5/4), or yellowish red (5YR 4/6, 5/6). The lower B2t horizon also includes yellowish brown (10YR 5/8), pale brown (10YR 6/3); light yellowish brown (10YR 6/4), brownish yellow (10YR 6/6, 6/8), strong brown (7.5YR 5/8), light brown (7.5YR 6/4), reddish yellow (7.5YR 6/6, 6/8), or yellowish red (5YR 4/8, 5/8). The B2t horizon is cherty silty clay loam, cherty clay, cherty silty clay, very cherty silty clay loam, very cherty clay loam, very cherty clay, or very cherty silty clay. The upper 20 inches clay percentage ranges from 35 to 45. Coarse fragments more than 3 inches diameter range from 5 to 10 percent of the volume and coarse fragments less than 3 inches diameter range from 35 to 90 percent of the volume.

The B3 horizon is strong brown (7.5YR 5/6, 5/8), reddish yellow (7.5YR 6/6, 6/8; 5YR 6/6, 6/8), yellowish red (5YR 4/6, 4/8, 5/6, 5/8), red (2.5YR 4/6, 4/8, 5/6, 5/8), or light red (2.5YR 6/6, 6/8). It is very cherty clay loam or very cherty clay. Coarse fragments more than 3 inches diameter range from 5 to 10 percent of the volume and coarse fragments less than 3 inches diameter range from 65 to 90 percent of the volume. An R layer of cherty limestone occurs at depths ranging from 5 feet to 30 feet below the surface.

COMPETING SERIES: These are the Boxville, Braxton, Eldon, Eldorado, and Riverton series. Boxville and Braxton soils have clayey control sections. Eldon soils have messic temperatures. Eldorado and Riverton soils have loamy-skeletal control sections.

GEOGRAPHIC SETTING: The Graig soils are on uplands. Slope gradients r from 0 to 5 percent, mainly less than 3 percent. The Craig soils are formed in residuum weathered from cherty limestones. The average annual precipitation ranges from about 37 to 47 inches, the annual Thornthwaite P-E indices from 64 to about 80, and the average annual air temperature ranges from 57 degrees to about 62 degrees F.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the competing Eldorado series, and the Bates, Dennis, and Parsons series. Bates, Dennis, and Parsons soils contain little or no chert.

DRAINAGE AND PERMEABILITY: Well drained; medium runoff-, moderately slow permeability.

USE AND VEGETATION: Some areas cultivated to small grains and sorghums. Some areas are in native range of tall prairie grasses or in improved pasture. The native vegetation is tall grass prairie.

DISTRIBUTION AND EXTENT: Northeastern Oklahoma and possibly in southwestern Missouri, northwestern Arkansas, and southeastern Kansas. The series is minor in extent.

SERIES ESTABLISHED: Craig County, Oklahoma; 1931.

REMARKS: The Craig soils were formerly classified in the Brunizem great soil group.

U.S.A.

On-Site Wastewater Systems in the Lake of the Ozarks Area

On-site wastewater systems (OSWS) serve approximately 30% of the population of Missouri. The Missouri Department of Health has estimated that before the new statewide on-site wastewater law (January 1996) up to 70% of the OSWS systems fail within three years of installation. Because of the lack of a municipal system infrastructure and a larger than normal percentage of the homes being second or vacation homes, more than 50% of homes around the Lake of the Ozarks are served by OSWS.

Soils of the Lake of the Ozarks are not well suited for effective OSWS. A wide array of soil properties limit the efficiency of residential wastewater systems. Some of these soil limitations are: steepness of slope, shallowness to a restrictive horizon (bedrock or fragipan) encouraging the lateral movement of water and effluent within the hillslope, fractured bedrock, relatively shallow impermeable horizons, and large amounts of coarse fragments. Small lots (sometimes as little as 60 ft. x 60 ft.) on the waterfront limit the amount of suitable area for an absorption area. The natural vegetation and soil properties have been drastically changed during the building and development phase such that the natural hydrological properties are damaged beyond restoration for effective OSWS management. Additionally, the recreational attractiveness of the lake area induces seasonal fluxes up to 1.25 million people on weekends such as Memorial Day, July 4th, and Labor Day thus an overloading of existing systems.

On-Site Wastewater Systems Components

An OSWS must perform two tasks to be effective (Sievers and Miles, 1995).

1. Provide adequate treatment of effluent for protection of public health and the environment.
2. Successfully disperse large volumes of water on a continuous basis.

The second task can be challenging because Missouri law requires that effluents from OSWS must remain on the owner's properties. For this reason, the use of water-conserving practices and equipment in the home is encouraged. The preferred on-site disposal option by builders has been the soil absorption trench because of its minimum attention (out of site out of mind). This type of system utilizing better pre-treatment of effluent (aerobic units, sand filters, etc.) before dispersal into the soil and with shallow, dosed dispersal systems has been more effective than the traditional septic tank/gravity system.

Treatment Unit.

Septic tanks (Figure 1) have been the most commonly used treatment component in a traditional OSWS. The tank has four basic functions - 1) separate solids from the liquid, 2) an aerobic digestion of a portion of the organic materials, 3) store solids (sludge), and 4) trap grease. A septic tank gives only partial treatment of organic materials thus may have relatively large total suspended soils (TSS), biological oxidation demand (BOD), ammonium levels, and little significant lowering of bacterial numbers.

Aerator treatment units rely on aerobic treatment of organic materials to chemically simpler inorganic compounds. Oxygen is supplied to the wastewater by diffusing air into the tank or agitating the liquid with a mechanical mixer (Figure 2). Properly operating units produce an effluent with lesser concentrations of TSS and BOD along with fewer offensive odors. The effluent contains larger concentrations of nitrate (instead of ammonium) and phosphate. Removal of indicator bacteria is highly variable. Effluent from aerators must still be dispersed in the soil (aerator effluent is not acceptable for human consumption no matter what the salesman state).

Sand filters are beds of medium to coarse sands (24 to 36 inches deep) (Figure 3)) and underlaid with gravel containing underdrains. Usually primary effluent from a septic tank is applied intermittently to the surface of the sand. Wastewater purification occurs as it percolates through the sand. A variety of treatment processes occur in sand filters but they are not necessarily well understood. Bacterial attached to the sand surfaces are the primary agents. The degree of wastewater treatment in a sand filter depends on initial wastewater strength and environmental conditions (especially air and temperature) in the sand filter. Generally, the sand filter produces a high polished effluent with small BOD and TSS with elevated nitrate and phosphate levels.

In Missouri we are emphasizing greater pre-treatment (polishing) of effluent before dispersal in the soil as this is the component which one can better control.

Soil Dispersal and Absorption.

Subsoil dispersal and absorption are commonly used as the final treatment component for onsite sewage systems. To operate as efficiently as possible the fundamental principle for wastewater dispersal is uniform distribution over the total absorption field. The placement of an excessive hydraulic load on any single point in the system can lead to inadequate treatment and surfacing of wastewater in the absorption field.

Wastewater distribution to a soil-absorption system can be accomplished by three methods: gravity, dosing, and pressure.

Most OSWS absorption systems use gravity distribution. Common gravity distribution methods include the traditional gravel trench system (Figure 4), modified shallows trenches and sand-line trenches (Figure 5). All of these trench systems rely on a coarse material (gravel or sand) to assist in dispersal and/or "holding capacity" during high use periods. Sand line trenches are used primarily in skeletal soils to assist with more even effluent distribution and some effluent treatment. Major limitations of gravity distribution systems are that areas downslope from the home and primary a treatment unit are the only potential absorption areas. It is also difficult to get a uniform distribution in all absorption trenches, especially when the trenches are of different lengths (Sievers and Miles, 1995). Additionally, the placement of coarse materials (especially gravels) give rise to compaction (called gravel masking).

Dosing is a technique which allows the release of effluent on an intermittent basis. This distribution method allows for a known amount of effluent to enter the soil absorption field such that flooding (anaerobic conditions) is averted thus giving wet and resting cycles for more efficient biological activity and treatment.

Dosing may be achieved by siphoning or pressure (pumps). Siphons are relatively simple and do not require an outside energy source. They are, however, restricted to sites where gravity flow can be used.

Pressurized dosing is becoming a more prominent form of distribution in the Ozarks especially in shallow placed absorption systems. The advantages of the shallow-placed pressured dosed systems are:

1. Placement of effluent in a more suitable portion of the soil profile.
2. Greater potential to utilize evapotranspiration.
3. The ability to utilize a large portion of the land area by pumping upslope.

The last reason listed is a major reason why shallow-placed, pressure-dosed systems are becoming a widely utilized system at the Lake of the Ozarks, especially with lake front building sites.

Two major types of shallow-placed pressure dosed systems have gained popularity in use over the past 2 years. They are the low pressure pipe (LPP) system and drip emitter technology. Distribution in an LPP system is accomplished under a small pressure head (5 feet of pressure maximum) in a small pipe with holes (Figures 6 and 7) which produces a uniform distribution over the entire absorption field. Dosing helps maintain aerobic soil conditions and improves treatment of the wastewater. Shallow placement in trenches increases the vertical distance between effluent placement and a restrictive horizon (fragipan, bedrock) and generally allows placement in a more permeable soil material.

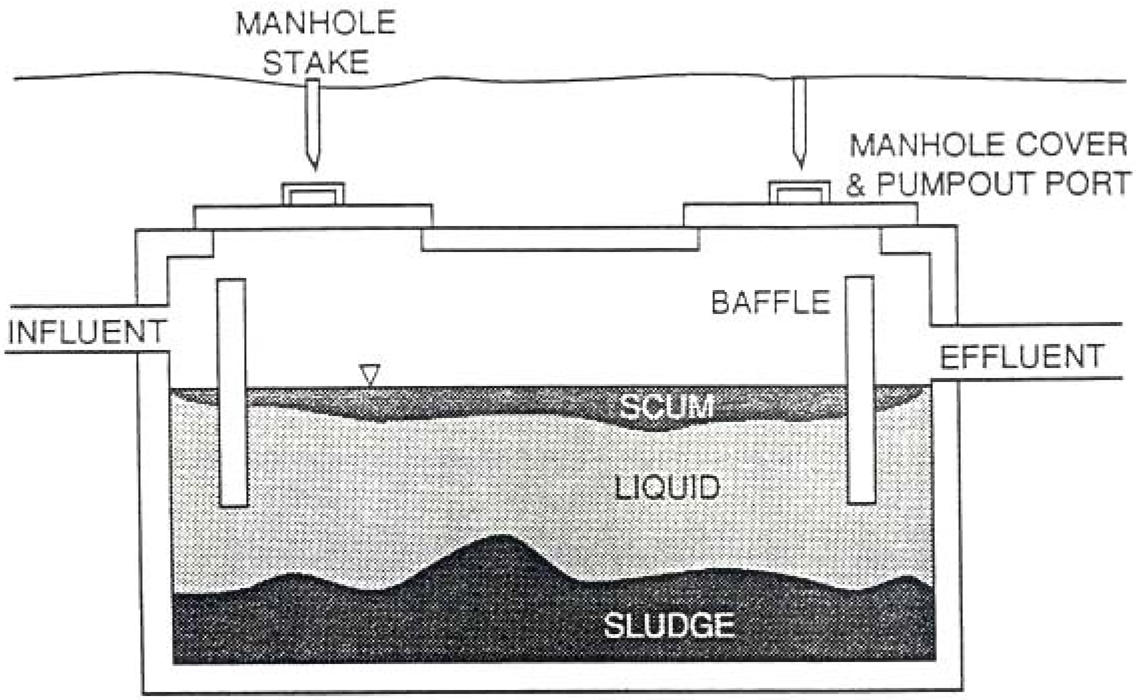
Examples of pump chambers and siphoning systems are delineated in figures 8 and 9.

Drip emitter absorption fields operate on the same principle as an LPP system. The two basic differences are: 1) a drip emitter line is knifed or "plowed" into the soil (much like a telephone line through a mole plow) and 2) highly treated effluent with respect to BOD and TSS solids is needed to not clog the drip emitters.

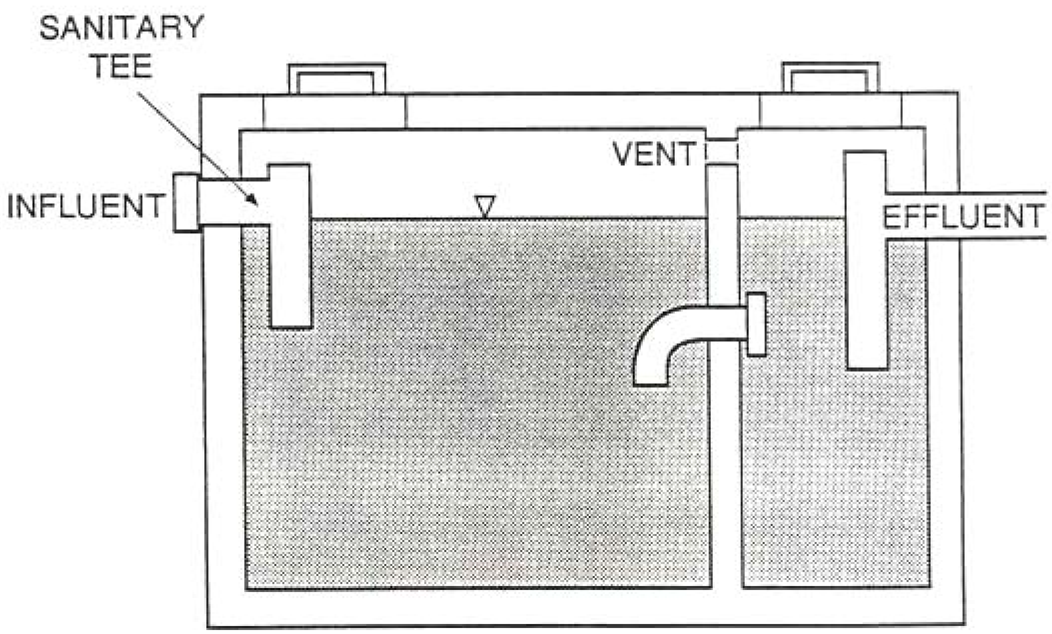
A common drip line (usually polyethylene tubing laterals) is injected (6 to 10 inches deep) in parallel with lines within the absorption field (Figure 10). Within each line, emitters as part of the tubing, disperses a constant flow of effluent when up to a specified pressure so to produce a uniform effluent distribution over the entire field. When the pump stops a vacuum breaker trips to allow drainage back to the pump tank so to minimize freezing.

References:

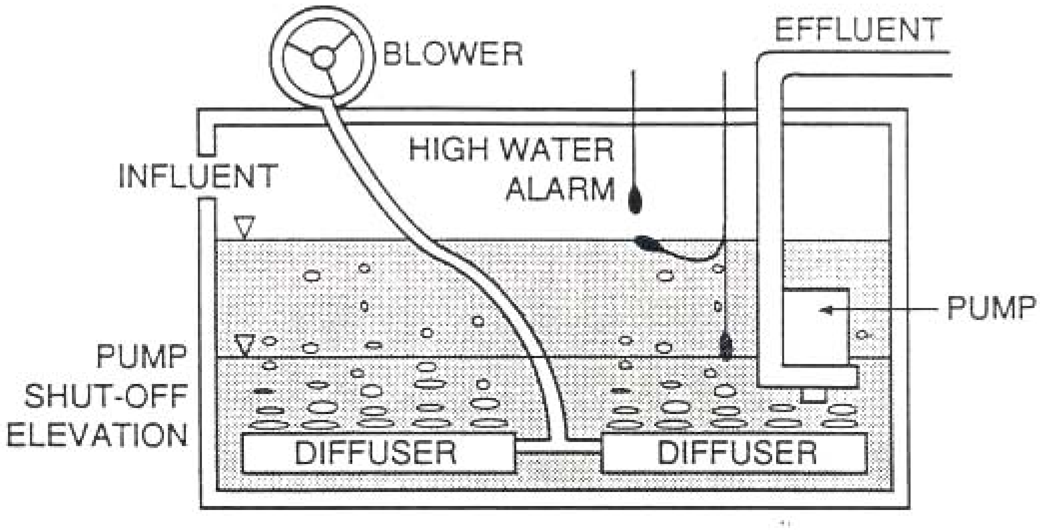
1. Miller, E.R., D.D. Jones, and J.E. Yahner. 1987. Construction guidelines for convention septic systems. Extension Bulletin ID-170, Purdue University Cooperative Extension Service, Purdue University, Lafayette, IN. 6pp.
2. Sievers, D.M. and R. J. Miles. 1995. Design and Construction of On-Site Systems. College of Agriculture, Food and Natural Resources, Agriculture Experiment Station, Special Report 477, 124pp.


MANHOLE
STAKE
MANHOLE COVER
& PUMPOUT PORT
BAFFLE
INFLUENT
EFFLUENT
SCUM
LIQUID
SLUDGE

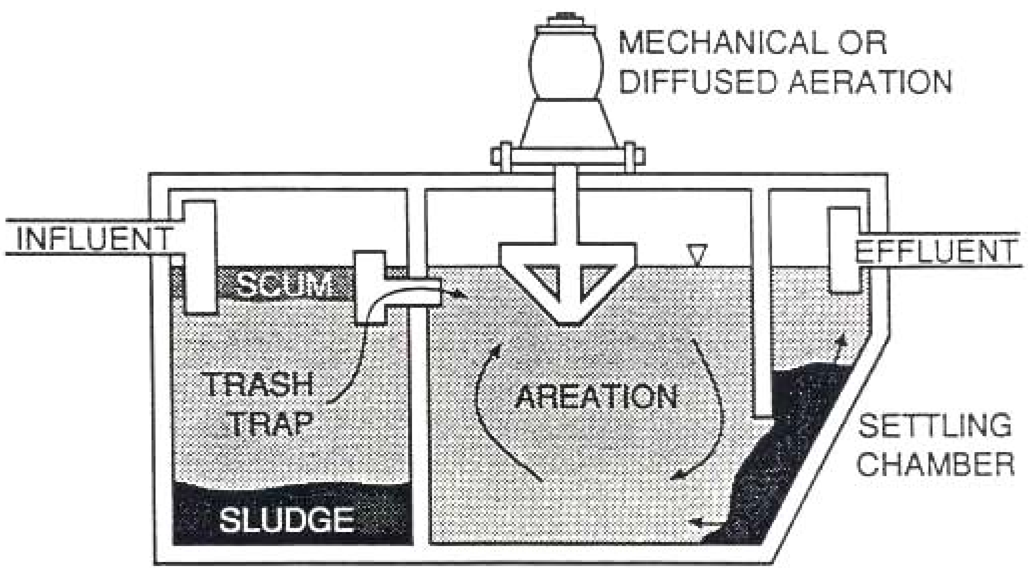
(a)


SANITARY
TEE
VENT
INFLUENT
EFFLUENT

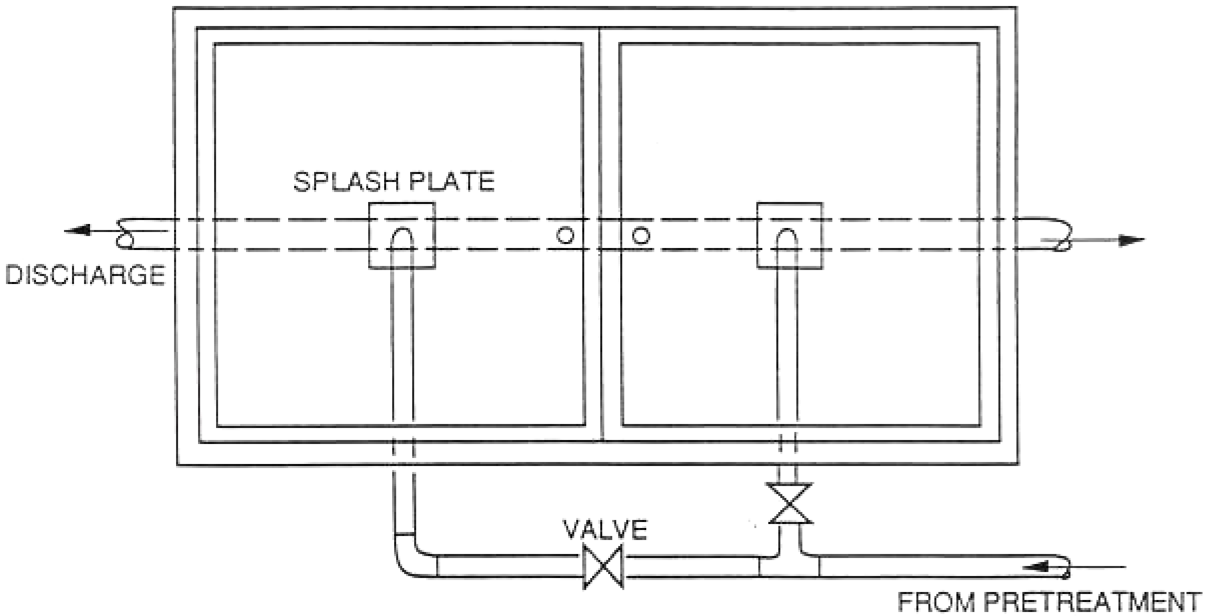
(b)

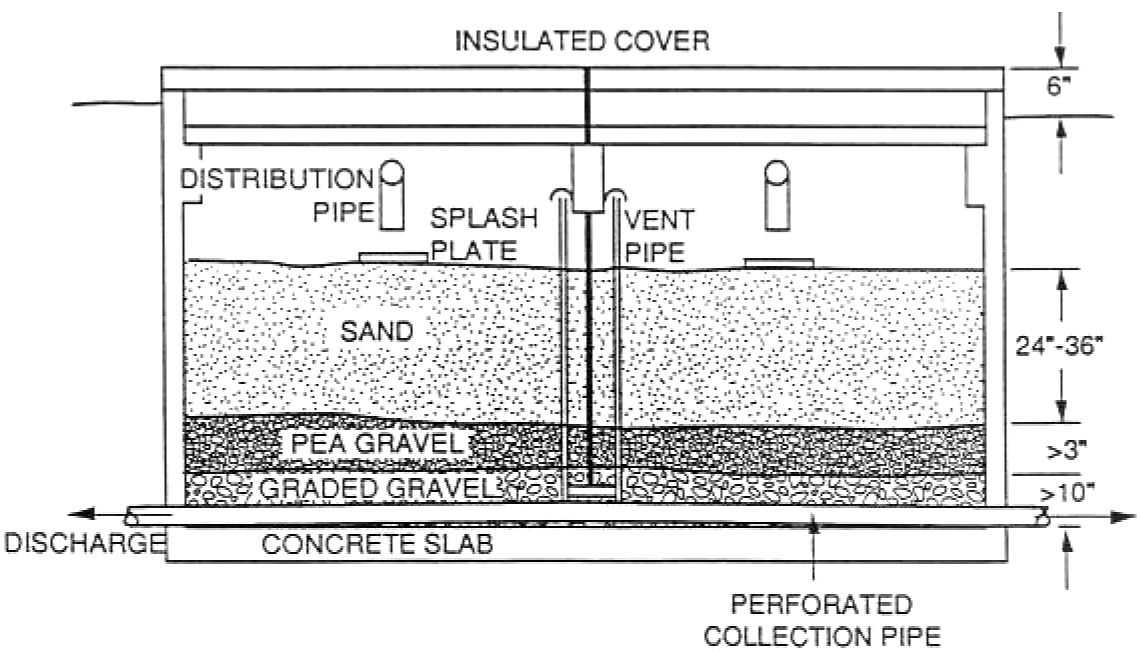

BLOWER
EFFLUENT
HIGH WATER
ALARM
INFLUENT
PUMP
PUMP
SHUT-OFF
ELEVATION
DIFFUSER
DIFFUSER

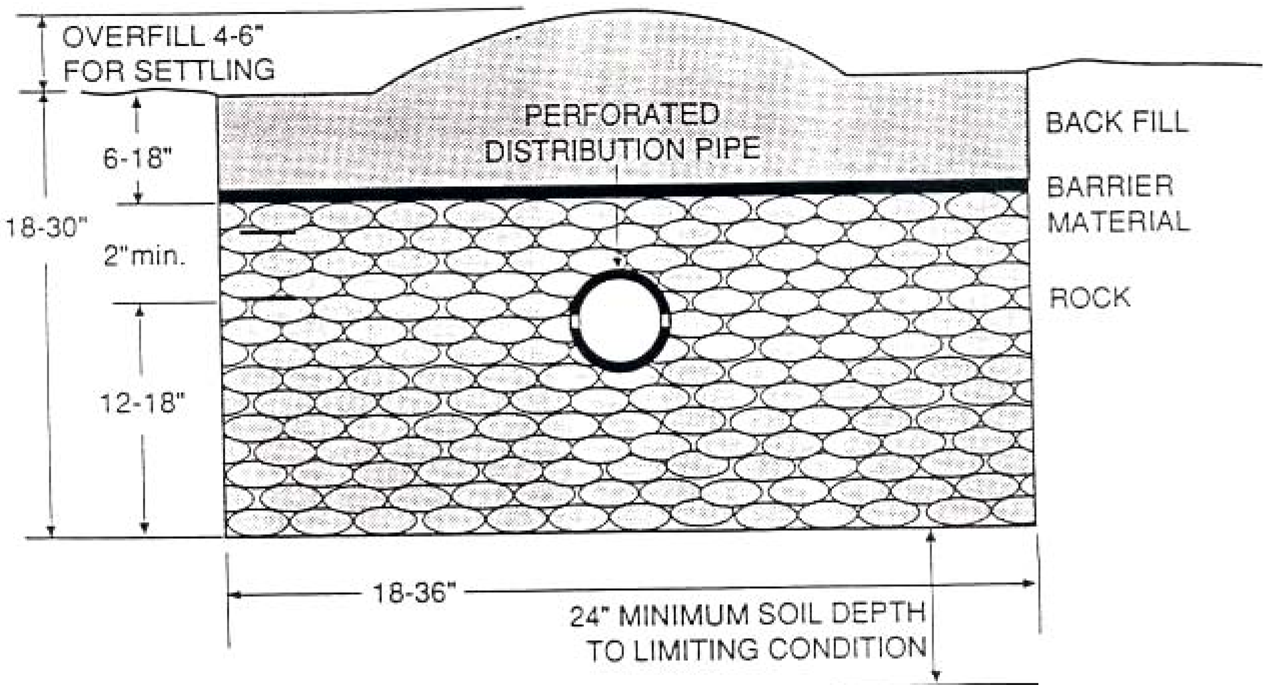
(a)

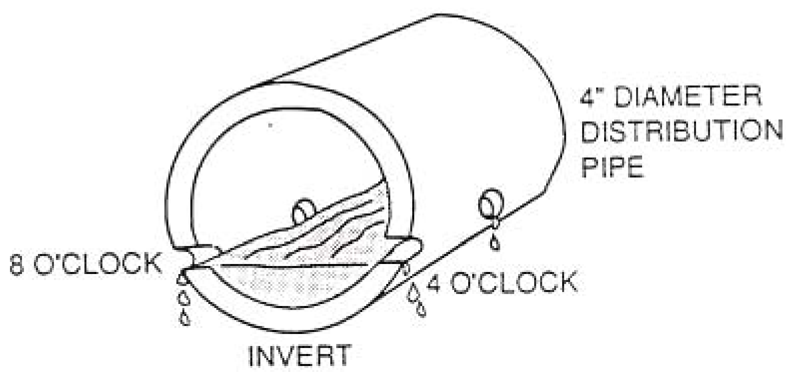

MECHANICAL OR
DIFFUSED AERATION
INFLUENT
SCUM
EFFLUENT
TRASH
TRAP
AREATION
SETTLING
CHAMBER
SLUDGE

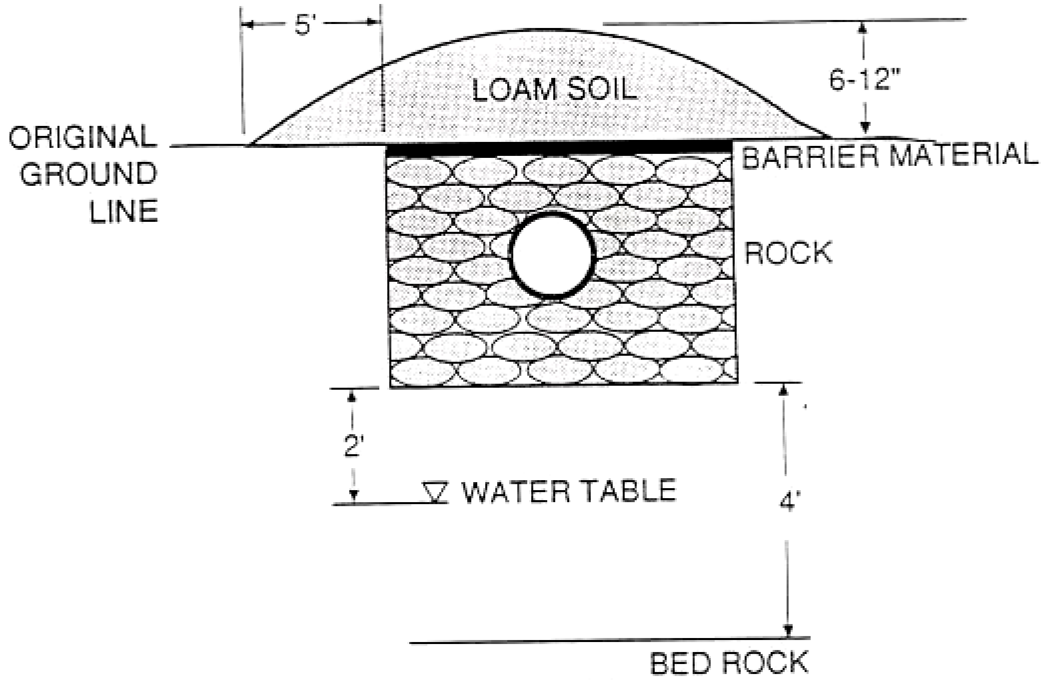
(b)


SPLASH PLATE
DISCHARGE
VALVE
FROM PRETREATMENT

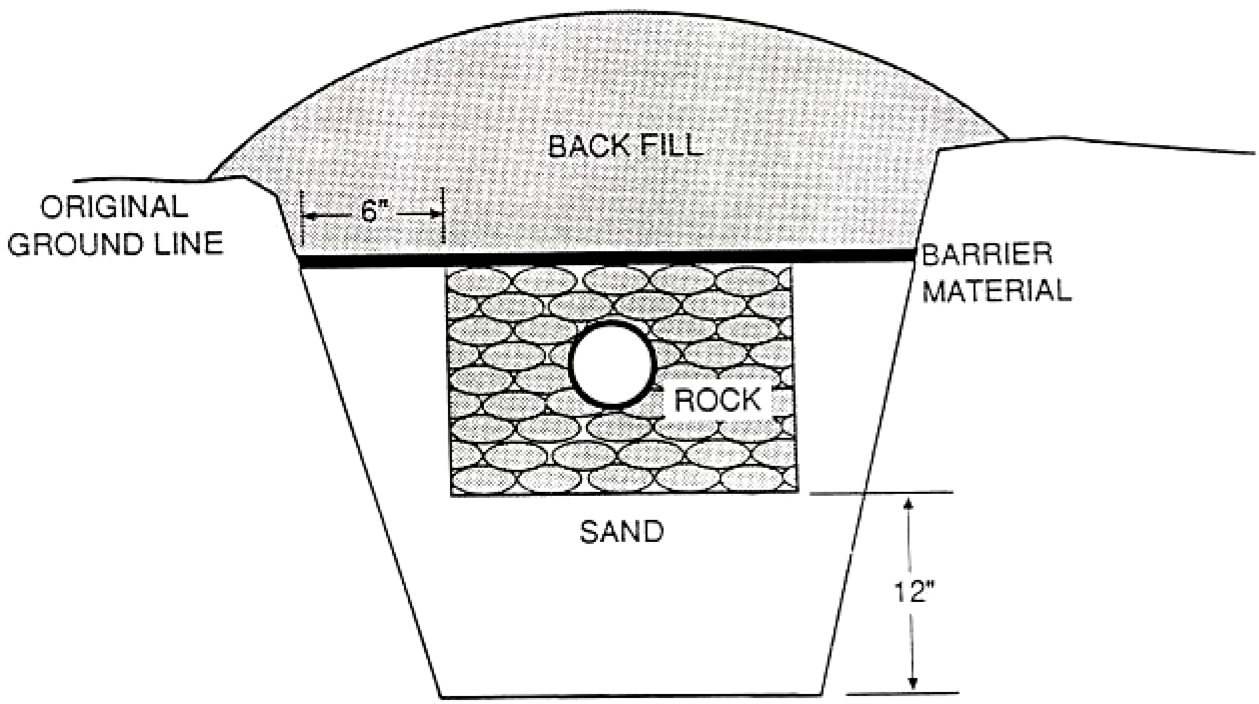

INSULATED COVER
6"
DISTRIBUTION
PIPE
SPLASH
PLATE
VENT
PIPE
SAND
24"-36"
PEA GRAVEL
>3"
GRADED GRAVEL
>10"
DISCHARGE
CONCRETE SLAB
PERFORATED
COLLECTION PIPE


OVERFILL 4-6"
FOR SETTLING
6-18"
18-30"
2"min.
12-18"
PERFORATED
DISTRIBUTION PIPE
BACK FILL
BARRIER
MATERIAL
ROCK
18-36"
24" MINIMUM SOIL DEPTH
TO LIMITING CONDITION

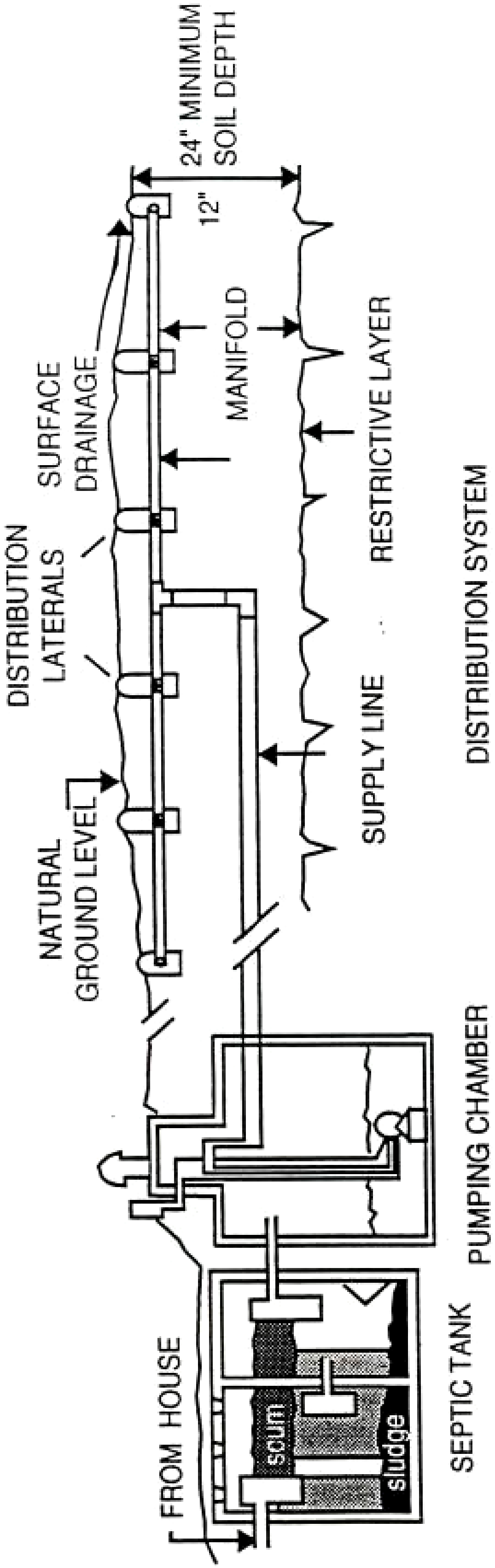

4" DIAMETER
DISTRIBUTION
PIPE
8 O'CLOCK
4 O'CLOCK
INVERT

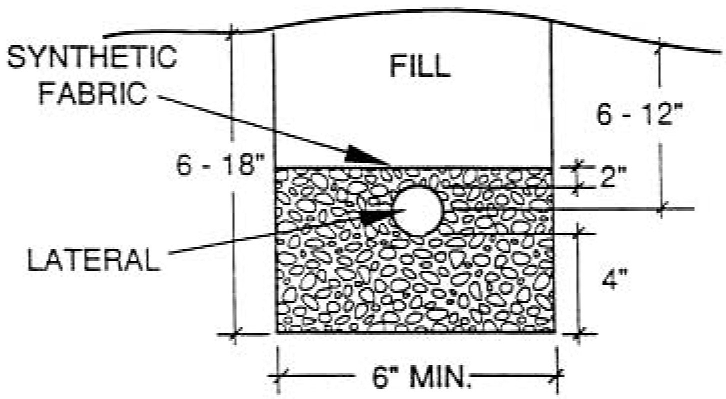

5'
6-12"
LOAM SOIL
ORIGINAL
GROUND
LINE
BARRIER MATERIAL
ROCK
2'
WATER TABLE
4'
BED ROCK

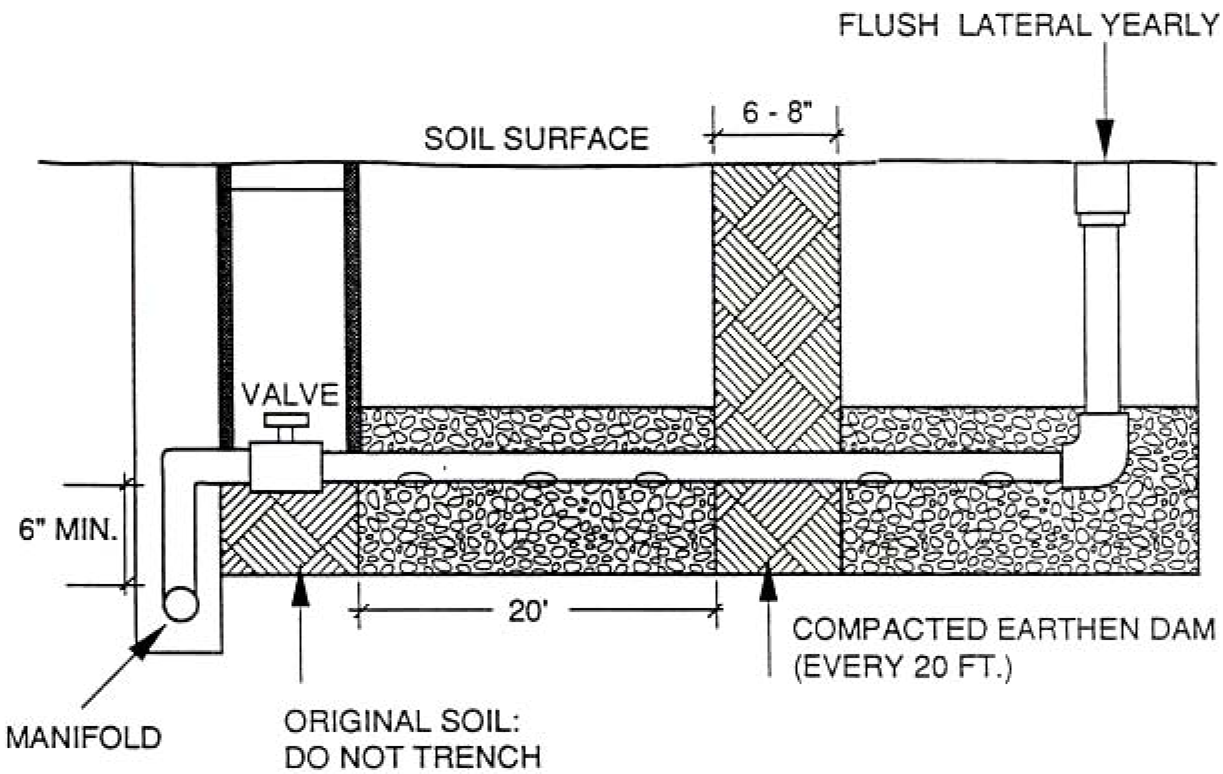
(a)

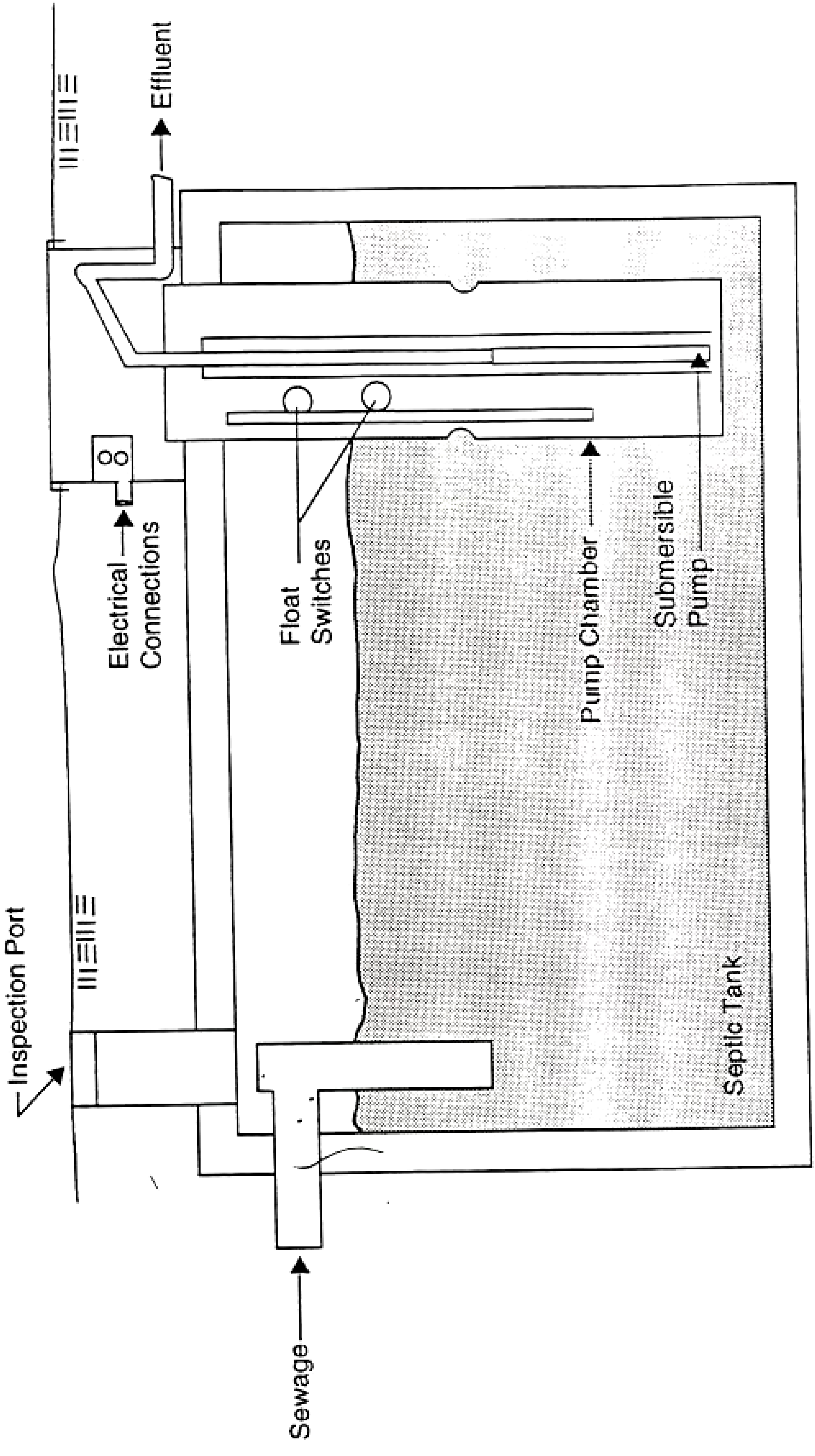

BACK FILL
ORIGINAL
GROUND LINE
6"
BARRIER
MATERIAL
ROCK
SAND
12"

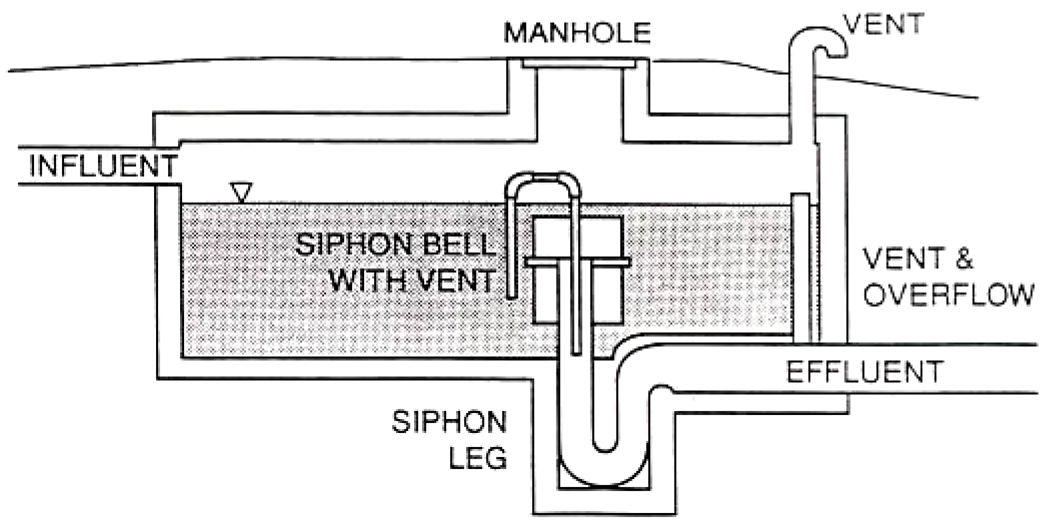
(b)


FROM HOUSE
SEPTIC TANK
scum
sludge
PUMPING CHAMBER
NATURAL GROUND LEVEL
SUPPLY LINE
DISTRIBUTION LATERALS
DISTRIBUTION SYSTEM
SURFACE DRAINAGE
RESTRICTIVE LAYER
MANIFOLD
12"
24" MINIMUM SOIL DEPTH

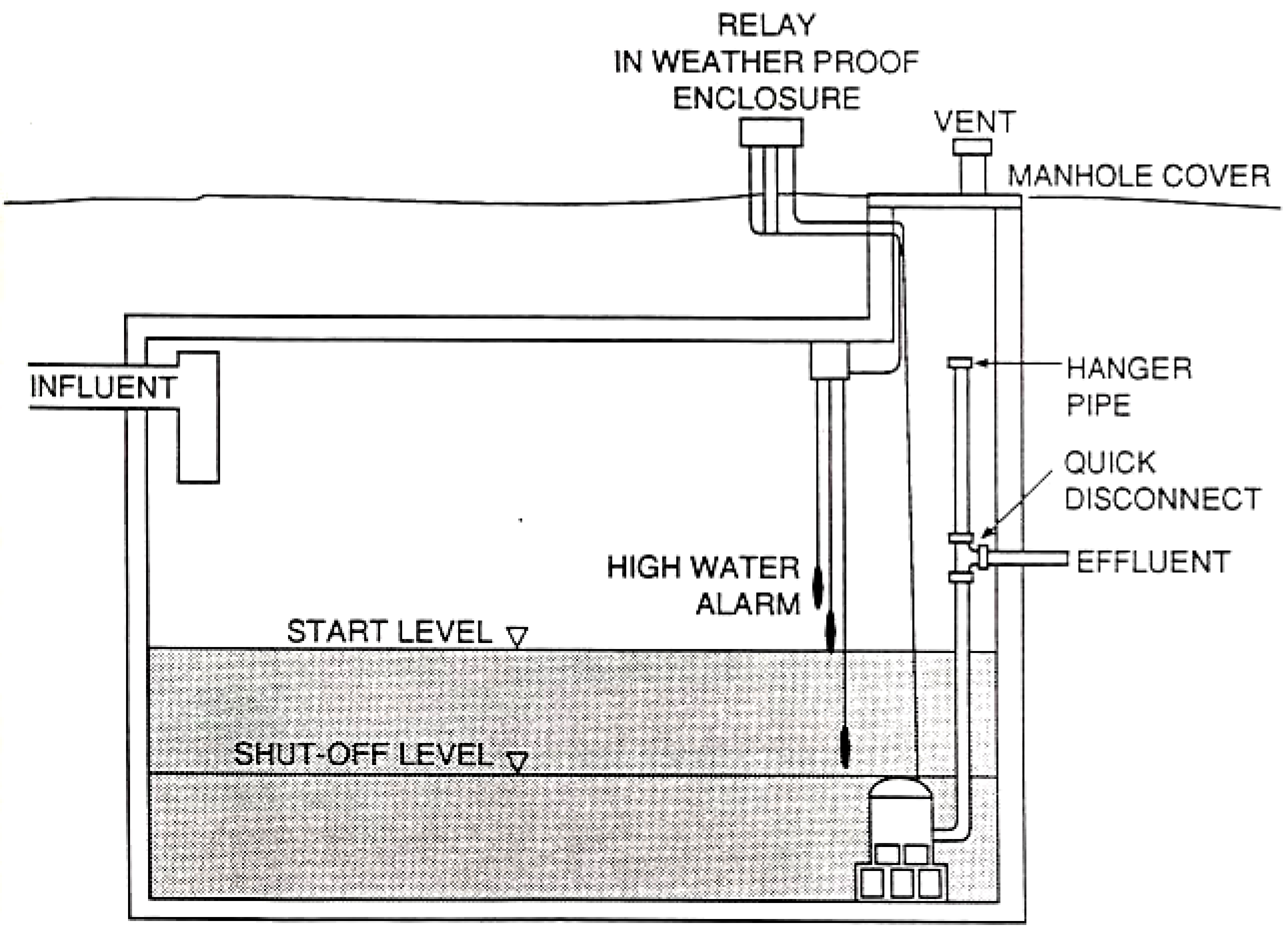

SYNTHETIC
FABRIC
FILL
6 - 12"
6 - 18"
2"
LATERAL
4"
6" MIN.


FLUSH LATERAL YEARLY
6 - 8"
SOIL SURFACE
VALVE
6" MIN.
20'
COMPACTED EARTHEN DAM
(EVERY 20 FT.)
MANIFOLD
ORIGINAL SOIL:
DO NOT TRENCH

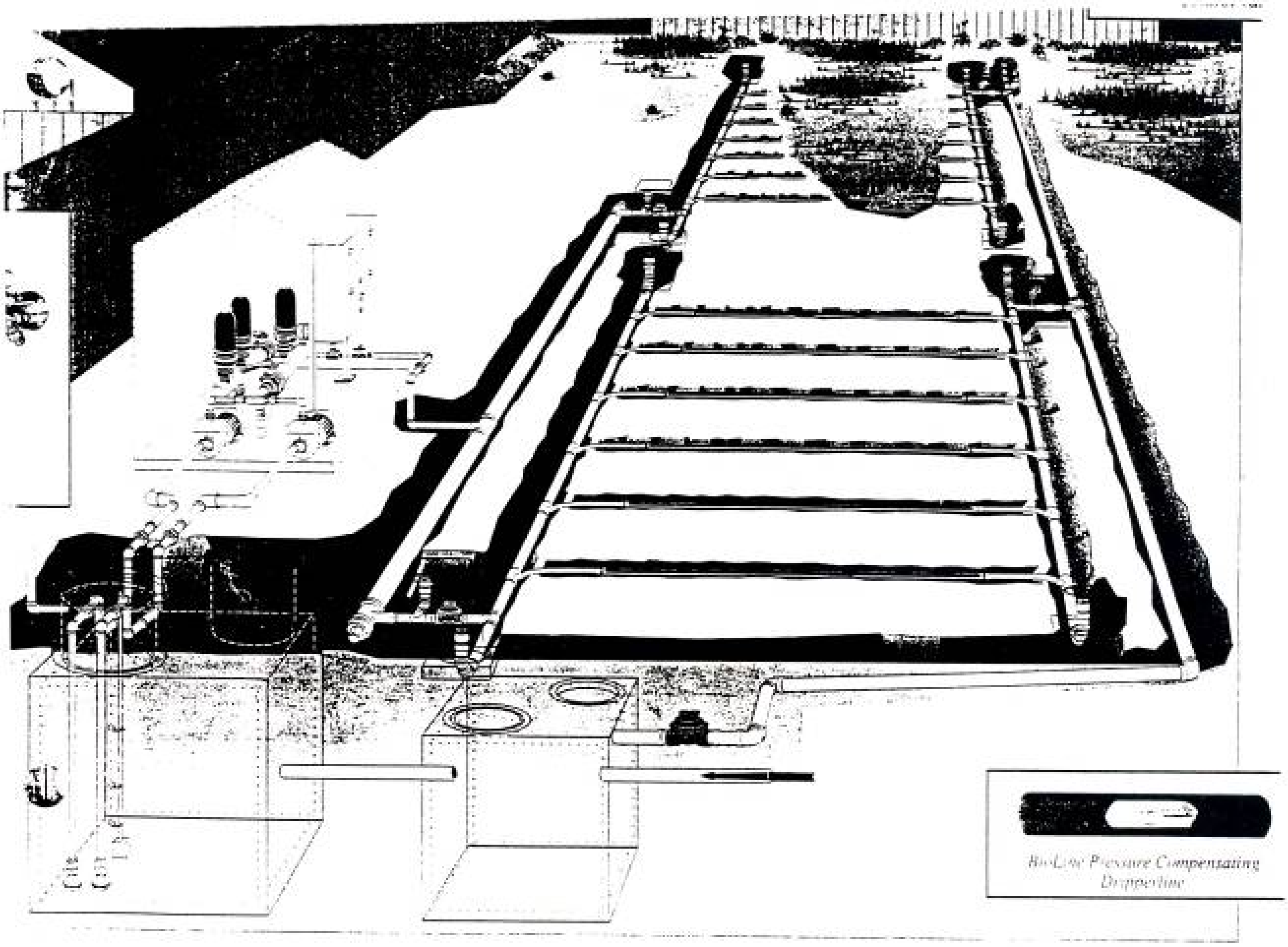

Inspection Port
Effluent
Electrical Connections
Float Switches
Pump Chamber
Submersible Pump
Septic Tank
Sewage


MANHOLE
VENT
INFLUENT
SIPHON BELL
WITH VENT
VENT &
OVERFLOW
EFFLUENT
SIPHON
LEG

(a)


RELAY
IN WEATHER PROOF
ENCLOSURE
VENT
MANHOLE COVER
INFLUENT
HANGER
PIPE
QUICK
DISCONNECT
EFFLUENT
HIGH WATER
ALARM
START LEVEL
SHUT-OFF LEVEL

(b)


Bio-Line Pressure Compensating
Dripperline

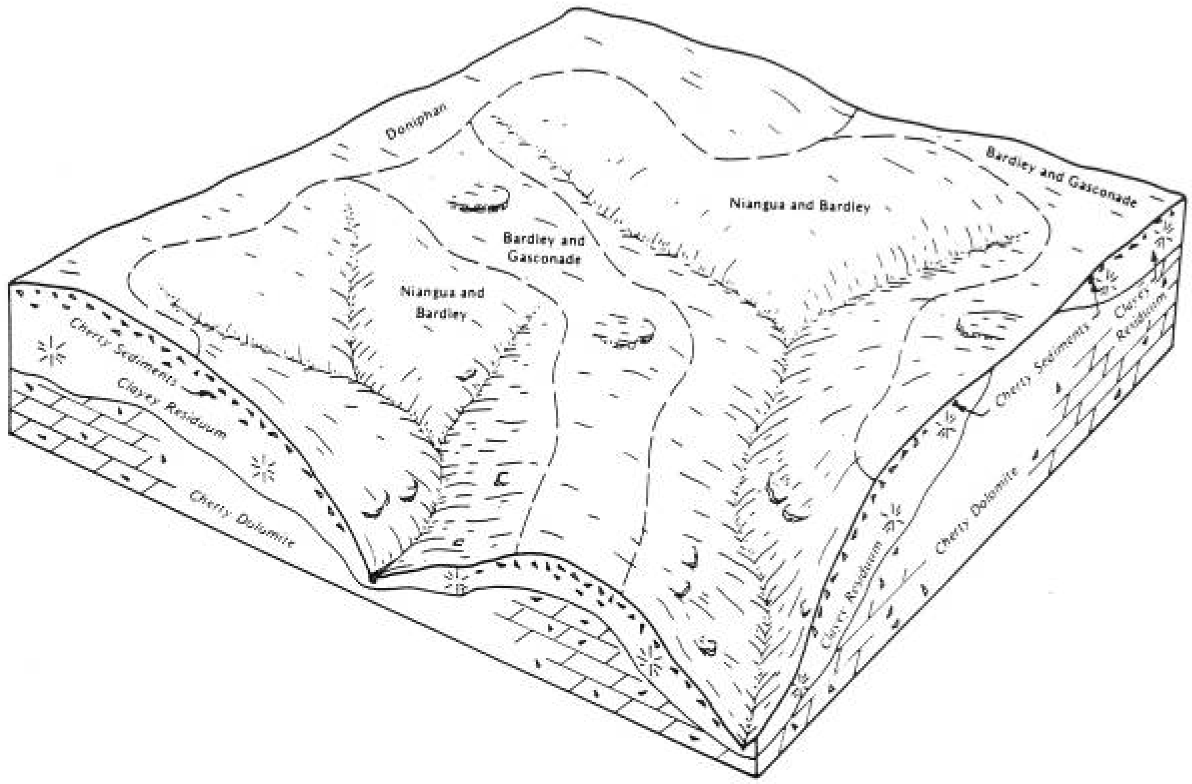


Figure 2.—Typical pattern of soils and parent material in the Niangua-Bardley association.

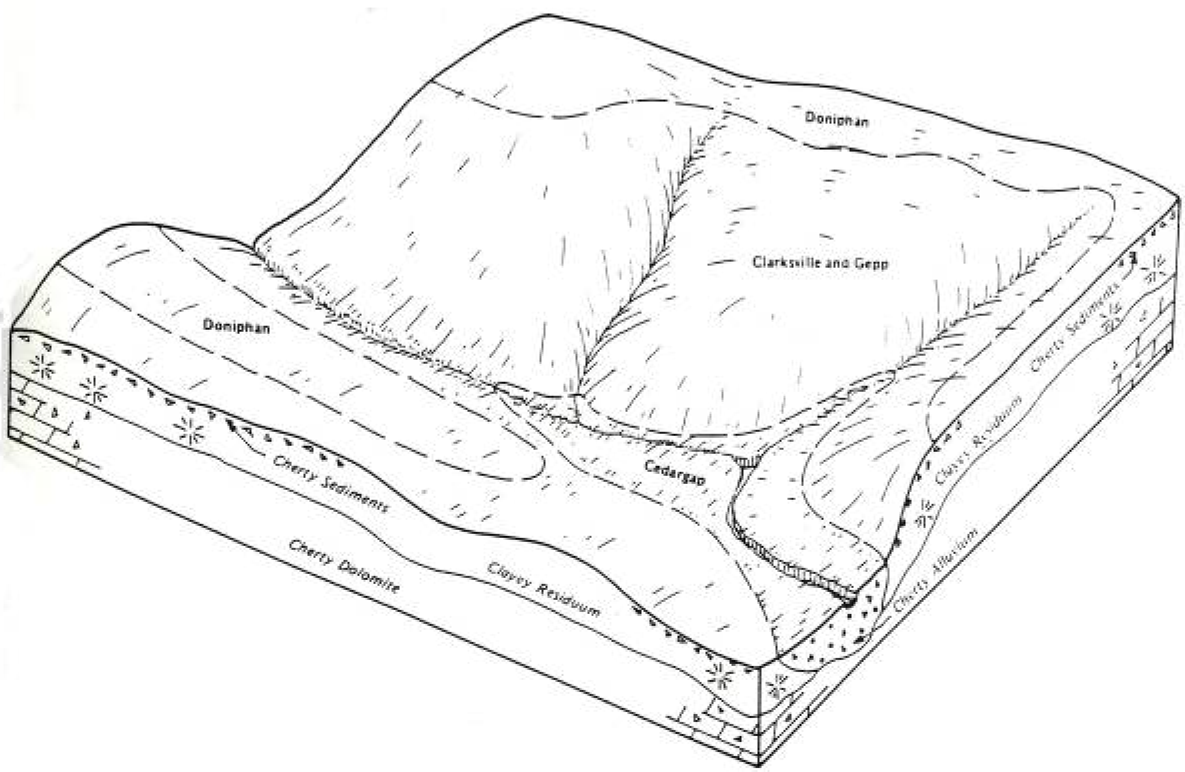


Figure 3.—Typical pattern of soils and parent material in the Clarksville-Doniphan-Gepp association.

GEOMORPHOLOGY OF THE OZARKS

The "Ozarks", as defined by Bretz (1965), includes "the relatively high country that lies south of the Missouri River, east of the Prairie Plains of Kansas and Oklahoma, north of the Arkansas Valley, and west of the Mississippi Valley and Embayment. The province also has an eastward linear extension across the Mississippi River into southern Illinois." Bretz recognizes five subdivisions within his "Ozark Plateaus physiographic province". They are: 1) The Boston Mountains Plateau in northern Arkansas and eastern Oklahoma; 2) the Springfield Plateau of southwestern Missouri and northwestern Arkansas; 3) the Salem Plateau of southcentral Missouri and north-central Arkansas; 4) the St. Francois Mountains, which are surrounded by the Salem Plateau; and 5) the Shawneetown Ridge in southern Illinois. Within the "Ozarks" the three plateau surfaces recognized are separated by escarpments. In addition, within major valleys of the Ozark surface (Salem Plateau) two and possibly three strath terrace levels are observed for certain geographic areas. Alluvial terraces at yet lower elevations are commonly preserved within these same valleys.

The Boston Mountains surface, the highest and southernmost surface, has elevations which range from 1,900 feet to 2,200 feet above sea level. The surface has been eroded across Pennsylvanian sandstones and shales of the Atoka Formation, which dip gently into the Arkansas Valley. The Boston Mountains Escarpments separates the Boston Mountains surface from the Springfield surface.

The Springfield surface to the north stands at elevations of 1,000 to 1,900 feet to 2,200 feet above sea level. Relief is generally less than 100 feet. The surface cuts the "Boone -formation" of Mississippian (Osagean) age, a dense sequence of very cherty limestone.

The Eureaka Springs Escarpment separates the Springfield Plateau from the Salem Plateau on the north and east. The Salem Plateau ranges in elevation from 250 feet on the east to 1,250 feet on the west. Cherty dolomites of Ordovician age are cut by this surface.

Bretz recognizes two additional levels within the Salem Plateau, with the exception of the west-central and southeastern sectors. The Osage strath is the highest in elevation below the Ozark surface (Salem Plateau). In the area of the Niangua River it is inferred to be at 800± feet above sea level. The post-Osage strath of Bretz may or may not be present.

Two major mechanisms for the geomorphic development of the Ozarks have been proposed. Knox (1966) indicates these processes to be peneplaination and pediplaination; however, he includes structural-plains stripping and dynamic equilibrium as possible alternate concepts. Additional field and laboratory investigation needs to be carried out before any of the concepts can be proven or disproven.

Bretz, J. Harlen, 1965, Geomorphic History of the Ozarks of Missouri: Missouri Geological Survey and Water Resources, 2d ser., V. 41, 147 p., 2 pls., 8 figs., 2 tbls., 3 apps.

Knox, Burnal Ray, 1966, Pleistocene and Recent Geology of the Southwest Ozark Plateaus: Unpubl. Ph.D. Diss., U. of Iowa.

Quinn, James H., 1958, Plateau Surfaces of the Ozarks: Proceedings of the Ark. Acad. of Sci., Vol. 11, p. 36-43.

Soil Survey of
Camden County, Missouri

By David W. Wolf, Soil Conservation Service

Fieldwork by David W. Wolf, Soil Conservation Service, and Duane E. Viele, Missouri Department of Natural Resources

United States Department of Agriculture, Soil Conservation Service, in cooperation with the Missouri Agricultural Experiment Station

CAMDEN COUNTY is in the south-central part of Missouri (fig. 1). It has a total area of about 708 square miles, or 453,216 acres, of which about 67 square miles, or 42,944 acres, is water. Camdenton, the county at, is in the south-central part of the county. In 1980, the population of Camden County was 20,017 and the population of Camdenton was 2,303 (6).

Beef cattle, dairy cattle, and hogs are raised in the county. Cool-season grasses and shallow-rooted legumes, such as tall fescue and red clover, are the main forage crops grown for pasture and hay. Only a very small acreage of row crops is grown in the county. Most of the pasture and hayland is in gently sloping and moderately sloping areas in the uplands and in areas of soils on bottom land. The deeply dissected uplands support most of the woodland in the county.

The survey area is dominantly rural, but much of the land is used for nonagricultural purposes. Nearly 60 percent of the farmers in Camden County report their principal occupation as something other than farming (12).

A major portion of the Lake of the Ozarks is in Camden County. The lake is a major tourist attraction and retirement area and contributes significantly to the economy of the county. The area around the Lake of Ozarks has developed rapidly in recent years. This development has contributed to the increased construction of dwellings and new businesses and to the expansion of existing businesses. Soil scientists have identified 21 different kinds of soil in the survey area. The soils range widely in texture, natural drainage, depth to bedrock, and other characteristics. Most soils in the uplands formed in cherty limestone residuum or in a thin mantle of loess and the underlying cherty limestone residuum.

Figure 1. Location of Camden County in Missouri.

General Nature of the County

This section provides general information about Camden County. It describes climate and history and development.

Climate

Table 1 gives data on temperature and precipitation for the survey area as recorded at Camdenton in the period 1951 to 1987. Table 2 shows probable dates of the first freeze in fall and the last freeze in spring. Table 3 provides data on length of the growing season.

In winter, the average temperature is 35 degrees F and the average daily minimum temperature is 24 degrees. The lowest temperature on record, which occurred at Camdenton on December 25, 1983, is -20 degrees. In summer, the average temperature is 77 degrees and the average daily maximum temperature is 89 degrees. The highest recorded temperature, which occurred on July 14, 1954, is 115 degrees.

Growing degree days are shown in table 1. They are equivalent to "heat units." During the month, growing degree days accumulate by the amount that the average temperature each day exceeds a base temperature (50 degrees F). The normal monthly accumulation is used to schedule single or successive plantings of a crop between the last freeze in spring and the first freeze in fall.

The total annual precipitation is 42.32 inches. Of this, 25 inches, or about 59 percent, usually falls in April through September. The growing season for most crops falls within this period. In 2 years out of 10, the rainfall in April through September is less than 20 inches. The heaviest 1-day rainfall during the period of record was 4.67 inches at Camdenton on October 13, 1968. Thunderstorms occur on about 53 days each year.

The average seasonal snowfall is about 19 inches. The greatest snow depth at any one time during the period of record was 16 inches. On the average, 12 days of the year have at least 1 inch of snow on the ground. The number of such days varies greatly from year to year.

The average relative humidity in midafternoon is about 60 percent. Humidity is higher at night, and the average at dawn is about 80 percent. The sun shines 65 percent of the time possible in summer and 50 percent in winter. The prevailing wind is from the south-southwest. Average windspeed is highest, 12 miles per hour, in spring.

Tornadoes and severe thunderstorms occur occasionally, but they are local in extent and of short duration. They may cause damage in scattered areas. The amount of damage varies. Hailstorms sometimes occur in scattered small areas during the warmer part of the year.

History and Development

Osage and Delaware Indians once inhabited the territory now known as Camden County. They built their villages on the terraces along major streams, where they hunted, fished, and raised corn, beans, and pumpkins. In 1827, white settlers began moving into the area after the Indians signed a treaty ceding the land to the U.S. Government (3). For many years after the treaty was signed, the Indians continued to hunt in the area. They camped at various places and hunted deer, bears, turkeys, and raccoons and other small game. They preserved the meat by drying it on scaffolds over fires. After 1846, they no longer returned to the area as a group (3).

Ruben Berry and William Pogue were among the earliest permanent white settlers in the survey area. When they arrived in 1827, they discovered the hull of a keelboat submerged in the Osage River (3). Also, a wooden fur press was found at the mouth of Linn Creek. These artifacts were evidence that French or Spanish explorers, hunters, and trappers had also been in the area. Other settlers later came to the area from Kentucky, Tennessee, and Virginia (8).

Kinderhook County, which is now known as Camden County, was organized in accordance with an act of the Legislature and approved by Governor Thomas Reynolds on January 20, 1841 (3). A site was selected for the county seat on April 12, 1841, in the town of Oregon. The county name was changed to Camden County by an act of the General Assembly of Missouri on February 23, 1843, and the name of the county seat was changed from Oregon to Erie. In 1850, the county seat was moved from Erie to Linn Creek (3). When Linn Creek was inundated by the creation of the Lake of the Ozarks, the county seat was moved to its present location at Camdenton.

Because of the cherty soils, limited transportation facilities, distant markets, and hilly, forested topography, the agricultural enterprises of the area were generally limited to part-time livestock farming. Timber was harvested mostly for railroad ties, fuel, and building material. Other occupations centered around hunting and fishing and the handcrafting of necessities for subsistence. Some row crops were grown in small areas on the stream terraces and flood plains and were used as livestock feed. After World War II, the livestock economy was based on the production of unfinished feeder cattle (5). Higher cattle prices in the 1960's and 1970's made the conversion of timberland to pasture profitable.

Although the area was generally unsuited to agricultural enterprise, many people from Kansas City, St. Louis, and Chicago were attracted to the area's scenic hills and rivers. In order to expand the recreational potential of the area, construction of Bagnell Dam began on August 6, 1929 (4). The Lake of the Ozarks began to fill on February 2, 1931, and the area was opened to the public in May of that year. Camdenton and the new Linn Creek were created for the relocation of families living in the area flooded by the lake. The stock market crash that heralded the Great Depression took place four months after construction of the dam began. While the rest of the country was affected by the Depression, the Bagnell project brought about a growth and expansion in mid-Missouri that continues today. Land development for recreational resorts and associated operations and for businesses and homes continues to be the major economical enterprise of the area.

How This Survey Was Made

This survey was made to provide information about the soils in the survey area. The information includes a description of the soils and their location and a discussion of the suitability, limitations, and management of the soils for specified uses. Soil scientists observed the steepness, length, and shape of slopes; the general pattern of drainage; the kinds of crops and native plants growing on the soils; and the kinds of bedrock. They dug many holes to study the soil profile, which is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

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

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

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

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

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

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

The descriptions, names, and delineations of the soils in this survey do not fully agree with those in the surveys of adjacent counties published at a different date. Differences are the result of additional soil data, variations in the intensity of mapping, and correlation decisions that reflect local conditions.

Map Unit Composition

A map unit delineation on a soil map represents an area dominated by one major kind of soil or an area dominated by two or three kinds of soil. A map unit is identified and named according to the taxonomic classification of the dominant soil or soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural objects. In common with other natural objects, they have a characteristic variability in their properties. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of soils of other taxonomic classes. Consequently, every map unit is made up of the soil or soils for which it is named and some soils that belong to other taxonomic classes. These latter soils are called inclusions or included soils.

Most inclusions have properties and behavioral patterns similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting (similar) inclusions. They may or may not be mentioned in the map unit descriptions. Other inclusions, however, have properties and behavior divergent enough to affect use or require different management. These are contrasting (dissimilar) inclusions. They generally occupy small areas and cannot be shown separately on the soil maps because of the scale used in mapping. The inclusions of contrasting soils are mentioned in the map unit descriptions. A few inclusions may not have been observed and consequently are not mentioned in the descriptions, especially where the soil pattern was so complex that. it was impractical to make enough observations to identify all of the kinds of soil on the landscape.

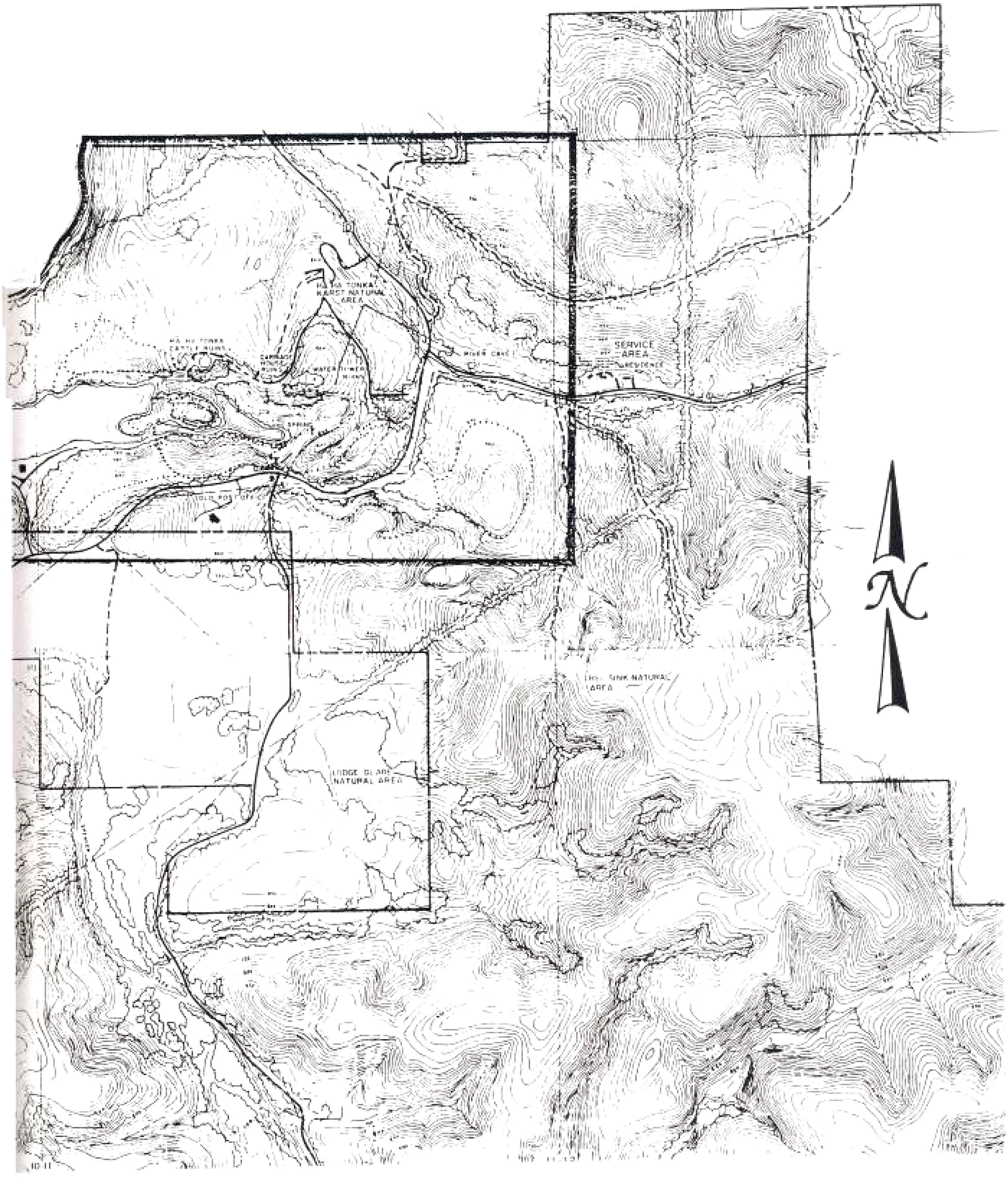
The presence of inclusions in a map unit in no way diminishes the usefulness or accuracy of the soil data. The objective of soil mapping is not to delineate pure taxonomic classes of soils but rather to separate the landscape into segments that have similar use and management requirements. The delineation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

TABLE 19. CLASSIFICATION OF THE SOILS

Soil name	Family or higher taxonomic class

Bardley	Very fine, mixed, mesic TyPic B&Plud&lf
Cedargap	Loamy-skeletal, mixed, mesic Cumulic Hapludolls
Clarksville	Loamy-skeletal, siliceous, mesic Typic Paleudults
Doniphan	Clayey, mixed, mesic Typic Paleudults
Gasconade	Clayey-skelotal, mixed, mesic Lithic Hapludolls
Gatewood	Very fine, mixed, mesic Typic Hapludalf
Gepp	Very fine, mixed, mesic Typic Paleudalf:
Gunlock	Fine, mixed, mesic Typic Hapludalfs
Hartville	Fine, mixed, mesic Aquic Hapludalfs
Huntington	Fine-silty, mixed, mesic Fluventic Hapludolls
Kaintuck	Coarse-loamy, siliceous, nonacid, mesic Typic Udifluvents
Knobby	Loamy-skeletal, mixed, mesic Lithic Hapludolls
Lebanon	Fine, mixed, mesic Typic Fragiudalfs
Moniteau	Fine-silty, mixed, mesic Typic Ochraqualfs
Niangua	Very fine, mixed, mesic Typic Hapludalfs
Nolin	Fine-silty, mixed, mesic Dystric Fluventic Eutrochrepts
Peridge	Fine-silty, mixed, mesic Typic Paleudalfs
Plato	Fine, mixed, mesic Aquic Fragiudalfs
Poynor	Loamy-skeletal over clayey, siliceous, mesic Typic Paleudults
Razort	Fine-loamy, mixed, mesic Mollic Hapludalfs
Viraton	Fine-loamy, siliceous, mesic Typic Fragiudalfs

Ha-Ha Tonka Soil Information



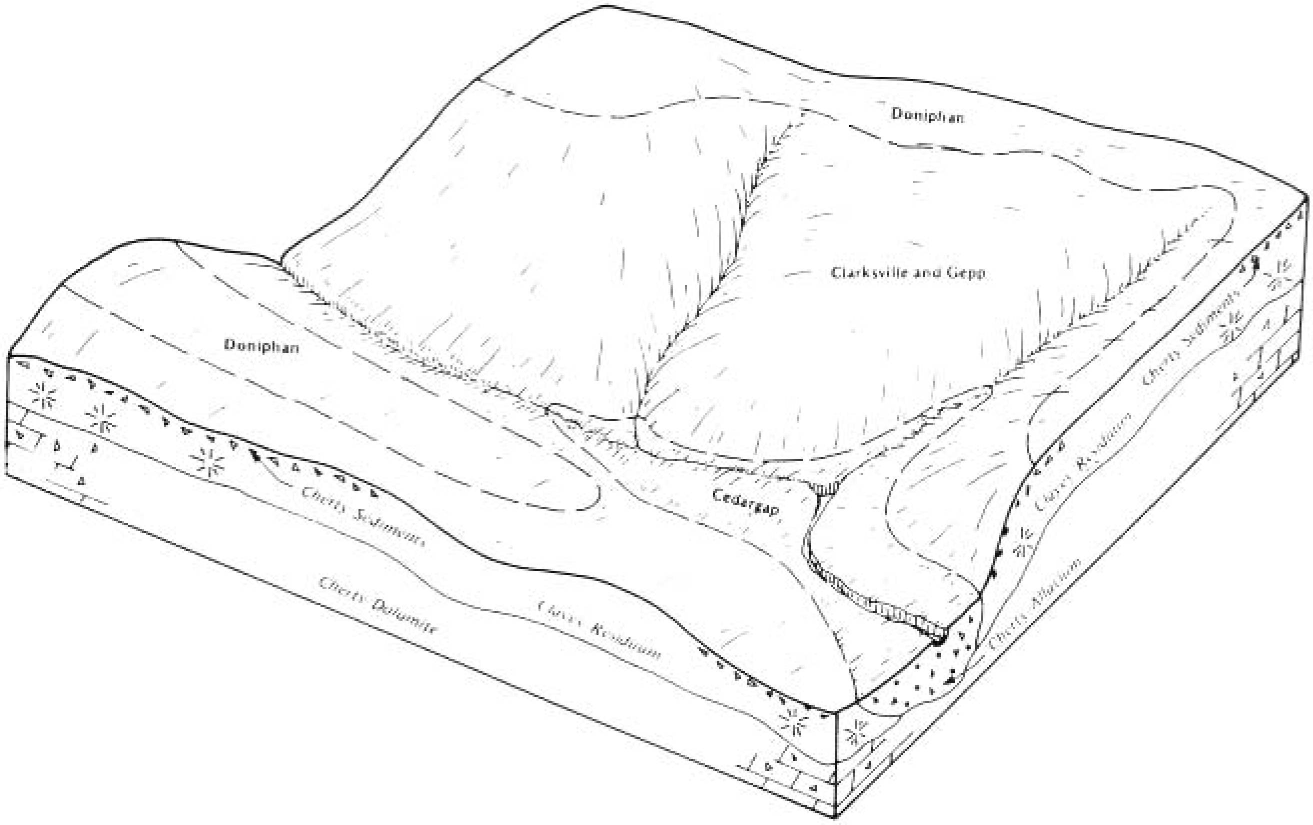


Figure 3.—Typical pattern of soils and parent material in the Clarksville-Doniphan-Gepp association.

SAMPLE #	DEPTH cm	DEPTH in	HORIZON	TOTAL CLAY < .002	TOTAL SILT .002 -.05	TOTAL SAND .05 -2	SILT FINE .002 -.02	SILT COARSE .02 -.05	SAND VF .05 -.10	SAND F .10 -.25	SAND M .25 -.50	SAND C .5 -1	SAND VC 1 -2	SAND >VF .10 -2	TEXT CLASS
				% of < 2mm											
SU 01	0-6	0-2	A	10.4	71.1	18.6	47.0	24.1	1.3	3.3	2.5	3.5	8.0	17.2	SIL
SU 02	6-14	2-6	AB	10.0	70.9	19.1	45.6	25.3	1.3	3.4	2.7	3.4	8.4	17.8	SIL
SU 03	14-26	6-10	Bt1	10.2	68.2	21.6	44.5	23.7	1.2	3.6	2.6	4.1	10.0	20.3	SIL
SU 04	26-35	10-14	Bt2	11.8	48.1	40.0	33.0	15.1	0.9	2.5	2.8	7.2	26.7	39.1	L
SU 05	35-42	14-17	E	16.3	52.7	31.0	37.3	15.4	1.4	5.0	3.8	6.6	14.2	29.6	SIL
SU 06	42-54	17-21	2E/Bt	29.8	56.8	13.4	38.0	18.8	1.7	3.1	1.7	2.0	5.0	11.7	SICL
SU 07	54-68	21-27	2Bt	31.7	52.8	15.5	33.7	19.1	1.9	4.0	2.0	2.4	5.3	13.6	SICL
SU 08	68-87	27-34	2Btg1	64.8	24.6	10.6	15.3	9.3	1.2	4.1	2.3	1.3	1.8	9.4	C
SU 09	87-102	34-40	2Btg2	66.8	17.4	15.8	9.2	8.2	1.9	6.2	4.8	1.7	1.2	13.9	C

SAMPLE #	NH4OAc EXTRACTABLE BASES Ca	Mg	Na	K	SUM BASES	ACID-ITY	EXTR Al	CEC SUM CATS	CEC NH4 OAc	CEC BASES +Al	Al SAT	BASE SAT SUM	BASE SAT NH4 OAc	ORG C	pH CaCl2 .01M	pH H2O
	meq/100 g										%					
SU 01	1.2	.4	0.0	.2	1.8	13.4	3.6	15.2	10.5	5.4	67	12	17	2.3	4.3	4.6
SU 02	.5	.4	0.0	.1	1.0	4.4	2.4	5.4	5.4	3.4	71	19	19	0.5	4.4	5.0
SU 03	.5	.4	0.0	.1	1.0	5.8	2.4	6.8	5.5	3.4	71	15	18	0.5	4.3	4.8
SU 04	0.0	.4	0.0	.1	0.5	5.9	3.1	6.4	5.6	3.6	86	8	9	0.3	4.3	5.0
SU 05	0.0	.8	0.0	.1	0.9	8.2	4.2	9.1	7.3	5.1	82	10	12	0.3	4.2	4.9
SU 06	0.0	1.2	0.0	.1	1.3	14.7	8.5	16.0	13.5	9.8	87	8	10	0.4	4.1	4.9
SU 07	1.7	1.6	0.0	.1	3.4	15.0	8.6	18.4	14.1	12.0	72	18	24	0.4	4.2	4.9
SU 08	.7	2.3	TR	.2	3.2	24.8	15.3	28.0	23.2	18.5	83	11	14	0.4	4.1	4.8
SU 09	1.7	2.8	0.0	.2	4.7	26.4	16.7	31.1	24.6	21.4	78	15	19	0.4	4.0	4.6

Ha Ha Tonka upper bench 1-27-98 MISSOURI SOIL CHARACTERIZATION LABORATORY

SAMPLE #	DEPTH cm	DEPTH in	HORIZON	TOTAL CLAY < .002	TOTAL SILT .002 -.05	TOTAL SAND .05 -2	SILT FINE .002 -.02	SILT COARSE .02 -.05	SAND VF .05 -.10	SAND F .10 -.25	SAND M .25 -.50	SAND C .5 -1	SAND VC 1 -2	SAND >VF .10 -2	TEXT CLASS
				% of < 2mm											
BEU 01	0-7	0-3	A	9.6	69.8	20.6	40.5	29.3	1.5	3.0	2.5	4.4	9.2	19.1	SIL
BEU 02	7-15	3-6	AB	8.7	70.3	21.0	42.4	27.9	1.6	3.3	2.5	4.0	9.7	19.4	SIL
BEU 03	15-30	6-12	Bt	9.3	69.6	21.2	42.3	27.3	1.4	2.9	2.4	3.9	10.6	19.7	SIL
BEU 04	30-42	12-17	2Bt/E	17.7	62.1	20.2	39.1	23.0	1.3	1.9	1.3	3.5	12.0	18.8	SIL
BEU 05	42-64	17-25	2Bt1	21.3	59.4	19.3	35.4	24.0	1.3	2.2	1.5	3.2	11.1	18.0	SIL
BEU 06	64-81	25-32	2Btx2	29.5	58.7	11.9	33.1	25.6	1.4	1.5	0.8	1.5	6.8	10.5	SICL
BEU 07	81-105	32-41	3Btg1	44.6	48.4	7.0	27.4	21.0	1.4	1.5	0.7	1.2	2.2	5.6	SIC
BEU 08	105-124	41-49	3Btg2	68.0	21.5	10.5	10.7	10.8	1.7	2.1	1.1	2.0	3.6	8.8	C
BEU 09	124-152	49-60	3Btg3	67.3	10.8	22.0	5.6	5.2	1.6	5.2	6.8	6.4	1.9	20.4	C
BEU 10	152-180	60-71	4Bt	68.2	9.4	22.3	4.5	4.9	2.0	5.7	7.0	6.4	1.3	20.4	C

SAMPLE #	NH4OAc EXTRACTABLE BASES Ca	Mg	Na	K	SUM BASES	ACIDITY	EXTR Al	CEC SUM CATS	CEC NH4 OAc	CEC BASES +Al	Al SAT	BASE SAT SUM	BASE SAT NH4 OAc	ORG C	pH CaCl2 .01M	pH H2O
	meq/100 g										%					
BEU 01	2.2	.8	0.0	.3	3.3	7.9	1.2	11.2	8.2	4.5	27	29	40	1.6	4.7	5.1
BEU 02	1.0	.4	TR	.2	1.6	4.9	1.3	6.5	5.0	2.9	45	25	32	0.6	4.6	5.1
BEU 03	.7	.4	0.0	.1	1.2	4.4	1.9	5.6	4.8	3.1	61	21	25	0.3	4.3	5.0
BEU 04	.5	.8	0.0	.1	1.4	6.9	3.3	8.3	7.2	4.7	70	17	19	0.1	4.3	5.1
BEU 05	.5	1.2	0.0	.1	1.8	7.6	4.0	9.3	8.8	5.8	69	19	20	0.1	4.4	5.2
BEU 06	1.3	1.2	TR	.1	2.6	8.8	3.5	11.5	9.3	6.1	57	23	28	0.1	4.4	5.2
BEU 07	1.2	2.0	TR	.1	3.3	14.0	5.8	17.3	14.1	9.1	64	19	23	0.2	4.2	4.9
BEU 08	2.7	2.8	.1	.1	5.7	20.2	10.2	25.9	21.6	15.9	64	22	26	0.2	4.2	4.7
BEU 09	4.4	3.6	.3	.3	8.6	19.7	11.0	28.3	23.9	19.6	56	30	36	0.2	4.0	4.1
BEU 10	5.4	4.9	.5	.3	11.1	19.0	11.4	30.1	25.9	22.5	51	37	43	0.2	4.0	4.1

SAMPLE #	DEPTH cm	DEPTH in	HORIZON	-----TOTAL------ CLAY < .002	SILT .002 -.05	SAND .05 -2	---SILT---- FINE .002 -.02	COARSE .02 -.05	------------SAND------------ VF .05 -.10	F .10 -.25	M .25 -.50	C .5 -1	VC 1 -2	>VF .10 -2	TEXT CLASS
				---------------------% of < 2mm---------------------------											
BEL 01	0-4	0-2	A	13.8	80.5	5.7	48.4	32.1	0.5	1.0	1.0	1.9	1.4	5.2	SIL
BEL 02	4-11	2-4	E	15.8	79.4	4.8	50.1	29.3	0.4	0.8	0.9	1.7	1.0	4.4	SIL
BEL 03	11-27	4-11	Bt1	29.0	68.3	2.7	46.9	21.4	0.3	0.7	0.6	0.8	0.4	2.5	SICL
BEL 04	27-38	11-15	Bt2	40.4	57.5	2.1	38.6	18.9	0.3	0.5	0.4	0.6	0.3	1.8	SIC
BEL 05	38-49	15-19	Bt3	58.6	39.7	1.7	25.3	14.4	0.2	0.4	0.3	0.4	0.4	1.5	C
BEL 06	49-54	19-21	2Btg1	57.0	40.7	2.3	24.5	16.2	0.3	0.7	0.5	0.6	0.3	2.0	SIC
BEL 07	54-59	21-23	2Btg1	56.8	40.5	2.7	23.9	16.6	0.2	0.7	0.6	0.7	0.5	2.5	SIC
BEL 08	59-64	23-25	2Btg1	54.4	42.1	3.5	26.3	15.8	0.4	1.0	0.8	0.9	0.4	3.1	SIC
BEL 09	64-71	25-28	2Btg2	53.6	43.9	2.6	27.7	16.1	0.2	0.8	0.7	0.6	0.2	2.3	SIC
BEL 10	71-77	28-30	2Btg2	53.8	43.5	2.6	26.7	.16.9	0.3	0.8	0.7	0.6	0.3	2.3	SIC
BEL 11	77-88	30-35	3Btg3	38.4	54.2	7.4	33.9	20.3	0.6	2.1	1.8	1.8	1.1	6.8	SICL
BEL 12	88-104	35-41	3Btx1	22.2	60.0	17.7	37.0	23.0	1.1	3.4	2.8	3.4	7.0	16.6	SIL
BEL 13	104-120	41-47	3Btx2	20.5	59.8	19.7	35.5	24.3	1.2	2.9	2.4	3.4	9.8	18.5	SIL
BEL 14	120+	47+	4	36.2	45.9	17.9	21.0	24.9	1.1	2.4	1.9	2.5	10.0	16.8	SICL
BEL 15	122-135	48-53		60.9	30.9	8.2	13.6	17.3	0.5	0.9	0.5	1.1	5.1	7.7	C
BEL 16	135-142	53-56		74.2	19.2	6.6	8.1	11.0	0.5	0.9	0.5	1.0	3.8	6.1	C
BEL 17	142-157	56-62		76.0	16.9	7.1	6.1	10.8	0.6	1.2	0.8	1.2	3.4	6.6	C
BEL 18	157-168	62-66		73.6	11.7	14.7	5.4	6.4	1.0	4.1	2.4	2.8	4.4	13.7	C
BEL 19	168-183	66-72		70.0	12.2	17.8	5.7	6.5	0.9	4.4	3.3	3.6	5.5	16.9	C
BEL 20	183-193	72-76		79.0	10.0	10.9	4.0	6.0	0.3	2.5	3.7	3.3	1.2	10.6	C

Ha Ha Tonka lower bench 1-27-98

SAMPLE #	NH4OAc EXTRACTABLE BASES Ca	Mg	Na	K	SUM BASES	ACIDITY	EXTR Al	CEC SUM CATS	CEC NH4 OAc	CEC BASES +Al	Al SAT	BASE SAT SUM	BASE SAT NH4 OAc	ORG C	pH CaCl2 .01M	pH H2O
	meq/100 g										%					
BEL 01	3.0	.8	TR	.3	4.1	9.7	1.3	13.8	10.3	5.4	24	30	40	1.5	4.3	4.9
BEL 02	2.2	.8	0.0	.2	3.2	7.5	2.0	10.7	8.8	5.2	38	30	36	0.6	4.2	4.7
BEL 03	1.2	2.0	TR	.3	3.5	14.2	8.3	17.7	15.1	11.9	71	20	23	0.3	4.1	4.7
BEL 04	.9	3.5	.1	.3	4.8	20.5	13.5	25.3	23.4	18.3	74	19	21	0.3	3.9	4.6
BEL 05	1.0	6.8	.1	.4	8.3	31.6	21.7	39.9	36.0	30.0	72	21	23	0.3	3.9	4.1
BEL 06	.7	7.0	.2	.4	8.3	31.9	22.0	40.2	37.1	30.3	73	21	22	0.3	3.8	4.3
BEL 07	.7	7.2	.2	.4	8.5	31.8	21.7	40.3	36.1	30.2	72	21	24	0.2	3.8	4.2
BEL 08	2.0	7.3	.2	.4	9.8	31.2	20.6	41.1	35.9	30.5	68	24	28	0.2	3.9	4.2
BEL 09	1.4	7.0	.2	.4	9.0	29.5	20.2	38.5	35.3	29.2	69	23	25	0.2	3.8	4.2
BEL 10	.9	7.0	.2	.4	8.5	30.8	20.1	39.3	35.2	28.6	70	22	24	0.2	3.8	4.0
BEL 11	.5	5.1	.2	.2	6.0	22.8	16.0	28.8	25.7	22.0	73	21	23	0.2	3.8	4.2
BEL 12	.5	2.8	.1	.1	3.5	14.0	9.3	17.5	15.5	12.9	73	20	23	0.1	4.1	4.6
BEL 13	.5	1.6	.1	.1	2.3	9.3	6.2	11.6	10.7	8.5	73	20	21	0.1	4.1	4.7
BEL 14	3.1	3.5	.3	.1	7.0	10.0	4.5	17.0	14.6	11.5	39	41	48	0.1	4.2	4.7
BEL 15	5.5	5.9	.5	.2	12.1	14.3	6.1	26.4	23.7	18.2	34	46	51	0.1	4.4	4.8
BEL 16	9.2	8.2	.8	.3	18.5	16.5	5.4	35.0	28.1	23.9	23	53	66	0.2	4.3	4.7
BEL 17	9.3	8.6	.9	.3	19.1	15.9	4.2	35.0	28.6	23.3	18	55	67	0.2	4.4	4.8
BEL 18	9.6	8.8	1.3	.3	20.0	12.0	2.0	32.0	26.5	22.0	9	63	75	0.2	4.7	4.9
BEL 19	8.7	7.9	1.5	.3	18.4	9.6	.5	28.0	22.9	18.9	3	66	80	0.1	4.8	5.0
BEL 20	12.5	11.9	2.5	.5	27.4	9.3	.2	36.8	30.6	27.6	1	74	90	0.2	5.1	5.2

SAMPLE #	DEPTH cm	DEPTH in	HORIZON	TOTAL: CLAY < .002	TOTAL: SILT .002 -.05	TOTAL: SAND .05 -2	SILT: FINE .002 -.02	SILT: COARSE .02 -.05	SAND: VF .05 -.10	SAND: F .10 -.25	SAND: M .25 -.50	SAND: C .5 -1	SAND: VC 1 -2	SAND: >VF .10 -2	TEXT CLASS
				% of < 2mm											
BS 01	0-3	0-1	A	9.1	74.6	16.2	46.1	28.5	0.9	2.5	2.1	3.1	7.6	15.3	SIL
BS 02	3-7	1-3	E	9.3	75.5	15.2	48.5	27.0	0.9	2.5	1.9	2.9	6.9	14.3	SIL
BS 03	7-27	3-11	Bt1	9.5	75.4	15.1	48.8	26.6	0.9	2.4	2.1	3.0	6.7	14.2	SIL
BS 04	27-43	11-17	Bt2	11.0	72.6	16.4	46.0	26.6	0.7	2.5	2.0	3.2	8.1	15.8	SIL
BS 05	43-56	17-22	2Btx1	11.7	70.1	18.2	45.5	24.6	0.8	2.1	1.7	2.8	10.9	17.4	SIL
BS 06	56-73	22-29	2Btx2	12.5	78.2	9.3	45.1	33.0	2.1	2.2	0.9	1.3	2.9	7.2	SIL
BS 07	73-90	29-35	3Btx3	22.1	62.5	15.4	33.3	29.2	2.1	3.2	1.7	2.6	5.8	13.3	SIL
BS 08	90-104	35-41	3Bt1	46.6	36.6	16.9	22.9	13.7	2.1	3.2	1.9	3.5	6.2	14.8	C
BS 09	104-117	41-46	3Btg2	47.7	43.8	8.5	29.5	14.3	1.9	2.5	1.2	1.5	1.4	6.6	SIC

SAMPLE #	NH4OAc EXTRACTABLE BASES: Ca	Mg	Na	K	SUM BASES	ACID-ITY	EXTR Al	CEC: SUM CATS	CEC: NH4 OAc	CEC: BASES +Al	Al SAT	BASE SAT: SUM	BASE SAT: NH4 OAc	ORG C	pH: CaCl2 .01M	pH: H2O
	meq/100 g										%					
BS 01	4.9	.4	0.0	.3	5.6	5.8	.1	11.4	9.1	5.7	2	49	62	2.8	5.3	5.7
BS 02	2.2	.4	0.0	.2	2.8	4.9	.7	7.7	5.6	3.5	20	36	50	0.5	4.7	5.3
BS 03	1.5	0.0	0.0	.1	1.6	4.1	1.1	5.7	4.6	2.7	41	28	35	0.4	4.6	5.2
BS 04	2.6	.4	0.0	.2	3.2	2.9	.1	6.1	4.9	3.3	3	52	65	0.3	5.3	5.8
BS 05	2.6	.4	0.0	.2	3.2	2.9	.3	6.1	5.0	3.5	9	52	64	0.2	5.1	5.8
BS 06	.7	.8	0.0	.2	1.7	5.1	2.9	6.8	5.4	4.6	63	25	31	0.1	4.2	4.9
BS 07	.5	.8	TR	.2	1.5	8.5	4.9	10.0	8.6	6.4	77	15	17	0.1	4.3	4.8
BS 08	.7	1.6	TR	.3	2.6	16.4	10.0	19.0	15.3	12.6	79	14	17	0.1	4.2	4.9
BS 09	.5	2.0	TR	.2	2.7	17.3	10.8	20.0	16.0	13.5	80	14	17	0.2	4.0	4.6

Nitrogen and Phosphorus
Ha Ha Tonka

		Total N (%)		Total N (mean)		P
Sample	Horizon	Run 1	Run 2	(%)	g / kg	ppm
SU-1	A	0.150	0.155	0.153	1.53	7.1
SU-2	E	0.100	0.090	0.095	0.95	2.9
SU-3	Bt1	0.091	0.067	0.079	0.79	2.7
SU-4	Bt2	0.109	0.078	0.094	0.94	2.3
SU-5	2Btx1	0.047	0.056	0.052	0.52	1.9
SU-6	2Btx2	0.022	0.026	0.024	0.24	0.2
SU-7	3Btx3	0.041	0.026	0.034	0.34	0.3
SU-8	3Bt	0.047	0.041	0.044	0.44	0.0
SU-9	3Btg	0.061	0.049	0.055	0.55	0.0
BS-1	A	0.131	0.128	0.130	1.30	4.9
BS-2	AB	0.092	0.093	0.093	0.93	2.5
BS-3	Bt1	0.101	0.064	0.083	0.83	2.8
BS-4	Bt2	0.074	0.055	0.065	0.65	3.9
BS-5	E	0.043	0.056	0.050	0.50	1.0
BS-6	2E/Bt	0.084	0.077	0.081	0.81	0.4
BS-7	2Bt	0.069	0.105	0.087	0.87	0.0
BS-8	2Btg1	0.064	0.091	0.078	0.78	0.0
BS-9	2Btg2	0.070	0.076	0.073	0.73	0.0
BEL-1	A	0.149	0.133	0.141	1.41	5.3
BEL-2	E	0.101	0.078	0.090	0.90	1.2
BEL-3	Bt1	0.068	0.079	0.074	0.74	0.0
BEL-4	Bt2	0.073	0.061	0.067	0.67	0.0
BEL-5	Bt3	0.100	0.060	0.080	0.80	0.0
BEL-6	2Btg1 (upper)	0.075	0.077	0.076	0.76	0.0
BEL-7	2Btg1	0.061	0.053	0.057	0.57	0.0
BEL-8	2Btg1 (lower)	0.068	0.085	0.077	0.77	0.0
BEL-9	2Btg2	0.068	0.073	0.071	0.71	0.0
BEL-10	2Btg2 (@70 cm)	0.053	0.084	0.069	0.69	0.0
BEL-11	3Btg3	0.054	0.038	0.046	0.46	0.0
BEL-12	3Btx1	0.044	0.052	0.048	0.48	0.0
BEL-13	3Btx2	0.033	0.065	0.049	0.49	0.0
BEL-14	4 material	0.052	0.048	0.050	0.50	0.0
BEL-15	122-135 cm	0.070	0.042	0.056	0.56	0.0
BEL-16	135-142	0.065	0.036	0.051	0.51	0.0
BEL-17	142-158	0.045	0.056	0.051	0.51	0.0
BEL-18	158-168	0.073	0.044	0.059	0.59	0.0

Nitrogen and Phosphorus
Ha Ha Tonka

		Total N (%)		Total N (mean)		P
Sample	Horizon	Run 1	Run 2	(%)	g / kg	ppm
BEL-19	168-183	0.072	0.017	0.045	0.45	0.0
BEL-20	183-193	0.016	0.032	0.024	0.24	0.0
BEU-1	A	0.135	0.094	0.115	1.15	6.4
BEU-2	AB	0.057	0.055	0.056	0.56	2.9
BEU-3	Bt	0.059	0.076	0.068	0.68	1.9
BEU-4	2Bt/E	0.035	0.020	0.028	0.28	0.5
BEU-5	2Bt1	0.059	0.051	0.055	0.55	0.3
BEU-6	2Bt2 (2Btx)	0.034	0.039	0.037	0.37	0.0
BEU-7	3Btg1	0.056	0.050	0.053	0.53	0.0
BEU-8	3Btg2	0.061	0.033	0.047	0.47	0.0
BEU-9	3Btg3	0.057	0.058	0.058	0.58	0.0
BEU-10	4Bt	0.058	0.055	0.057	0.57	0.0

LOCATION BARDLEY MO
Established Series
Rev. FLG-KDV 9/89
BARDLEY SERIES
The Bardley series consists of moderately deep, well drained, moderately permeable soils that formed in cherty sediments and residuum from dolomite interbedded with some limestone and sandstone. These soils are on upland ridges, side slopes and nose slopes. Slope gradients range from 2 to 100 percent. Mean annual temperature is 56 degrees F, and mean annual precipitation is 42 inches.
TAXONOMIC CLASS: Very-fine, mixed, mesic Typic Hapludalfs
TYPICAL PEDON: Bardley gravelly silt loam - on a 13 percent convex east- facing slope in forest. (Colors are for moist soil unless otherwise stated.)
A--0 to 4 inches; dark grayish brown (10YR 4/2) gravelly silt loam, light brownish gray (10YR 6/2) dry; moderate very fine granular structure; very friable; many coarse roots; many fine continuous vesicular pores; many worm channels and casts; few fine concretions (oxides); about 35 percent chert fragments; slightly acid; abrupt smooth boundary. (2 to 6 inches thick)
E-4 to 8 inches; brown (10YR 5/3) extremely gravelly silt loam; weak very fine granular structure; many medium roots; many fine, continuous vesicular pores; many worm channels and casts; few fine concretions (oxides); 65 percent chert fragments; slightly acid; clear smooth boundary. (0 to 10 inches thick)
2Bt1--8 to 15 inches; yellowish red (5YR 4/6) clay; strong very fine subangular blocky structure; very firm; many medium roots; many fine continuous vesicular pores; few worm channels and casts; few faint reddish brown clay films on faces of peds; common fine concretions (oxides); strongly acid; clear smooth boundary.
2Bt2--15 to 23 inches; yellowish red (5YR 5/6) clay; strong very fine subangular blocky structure; very firm; common medium roots; many fine continuous vesicular pores; few worm channels and casts; many faint yellowish red clay films on faces of peds; common fine concretions (oxides); medium acid; abrupt wavy boundary.
2Bt3--23 to 27 inches; strong brown (7.5YR 5/4) clay; many fine distinct strong brown (7.5YR 4/6) mottles; strong very fine subangular blocky structure; very firm; few fine roots; many fine continuous vesicular pores; few worm channels and casts; many faint yellowish red clay films on faces of peds; common fine concretions (oxides); medium acid. (Combined thickness of the 2Bt horizons is 12 to 24 inches.)
2R--27 inches; hard dolomitic limestone.
TYPE LOCATION: Ripley County, Missouri; 23 10 feet south and 30 feet west of the northeast corner of section 8, T. 22 N., R. 1 W.
RANGE IN CHARACTERISTICS: Depth to the bedrock ranges from 20 to 40 inches. Gravel or flagstone content of the surface ranges from 15 to 70 percent by volume. Some pedons are stony. The A horizon has hue of 10YR or 7.5YR, value of 3 or 4, and chroma of 2 or 3. Some pedons have an Ap horizon with hue of 7.5YR, 5YR, or 10; value of 3 to 5; and chroma of 2 to 6. Where the value is 3.5 or lower, they are less than 6 inches thick. Texture is silt loam or the gravelly, flaggy, very gravelly, or extremely gravelly analogues of sandy loam, loam, silt loam, or silty clay loam. Reaction ranges from very strongly acid to neutral. The E horizon has hue of 10YR or 7.5YR, value of 4 to 6, and chroma of 2 to 4. Texture is silt loam or the gravelly, flaggy, very gravelly, or extremely gravelly analogues of sandy loam, loam, silt loam, or silty clay loam. Reaction ranges from very strongly acid to neutral. The 213t horizon has hue of I OR, 2.5YR, or 5YR; value of 3 to 5; and chroma of 4 to 6. Just above the lithic contact hues of 7.5YR or redder are permitted. The texture is silty clay, clay, gravelly silty clay, or gravelly clay. The upper 20 inches of the argillic horizon averages over 60 percent clay. The upper part of the 2Bt horizon ranges from very strongly acid to medium acid and the lower part of the 2Bt horizon is medium acid or slightly acid. Some pedons have a BC horizon just above the lithic contact that is neutral in reaction. Some pedons have a 2C horizon that has hue of 5YR, 7.5YR, or 10YR; value of 4 to 6; and chroma of 2 to 6. It usually is sand but ranges from sand to clay loam. This horizon is 2 to

4 inches in thickness and rests on the lithic contact. Reaction is slightly acid to moderately alkaline.
COMPETING SERIES: These are the Carbo, Chilhowie, Endcav, Gatewood, Niangua M and Oshkosh series. The Carbo, Chilhowie, and Gatewood soils are yellower than 5YR in the Bt horizon. In addition, Carbo soils are not cherty in any part. The Endcav, Niangua and Oshkosh soils do not have bedrock within a depth of 40 inches of the surface.
GEOGRAPHIC SETTING: The Bardley soils are on upland ridges, side slopes and nose slopes. Slope gradients range from 2 to 100 percent. They formed in cherty sediments and residuum from dolomite interbedded with some limestone and sandstone. The mean annual temperature ranges from 50 to 57 degrees F, and the mean annual precipitation ranges from 37 to 47 inches.
GEOGRAPHICALLY ASSOCIATED SOILS: These are the Clarksville, Crider, Doniphan, Gasconade, and Gatewood soils. Clarksville soils are loamy-skeletal and occur on similar landscapes. Crider soils are fine-silty and occur above the Bardley soils in the landscape. Doniphan soils do not have a lithic contact within a depth of 40 inches of the surface and occur on similar landscapes. Gasconade soils are less than 20 inches to bedrock and usually occur lower in the landscape. Gatewood soils are yellower than 5YR in the 2Bt horizon and occur lower in the landscape.
DRAINAGE AND PERMEABILITY: Well drained. Runoff is medium or rapid. Permeability is moderate.
USE AND VEGETATION: Most of the Bardley soils are forested. Some are used for pasture. Native vegetation is mixed hardwoods.
DISTRIBUTION AND EXTENT: The Ozark region of Missouri. The series is of moderate extent.
SERIES ESTABLISHED: Ripley County, Missouri, 1982.
REMARKS: These soils were first classified as fine, mixed, mesic Typic Hapludalfs but were reclassified based on data available from the University of Missouri and field work in progressive soil surveys. University of Missouri laboratory data lists clay percentages in the 2Bt as 87 and 89 percent. Diagnostic horizons and features recognized in this series are: ochric epipedon - the zone from the surface to a depth of 8 inches (A and E horizons); argillic horizon - the zone from approximately 8 to 27 inches (Btl, W, and Bt3 horizons).

National Cooperative Soil Survey
U.S.A.

Bardley Map Unit 73028 12-24-97

Very-fine, mixed, active, mesic Typic Hapludalf

M9210599 MISSOURI SOIL CHARACTERIZATION LABORATORY

LACLEDE COUNTY

SAMPLE #	DEPTH cm	DEPTH in	HORIZON	-----TOTAL------ CLAY < .002	SILT .002 -.05	SAND .05 -2	---SILT---- FINE .002 -.02	COARSE .02 -.05	------------SAND---------- VF .05 -.10	F .10 -.25	M .25 -.50	C .5 -1	VC 1 -2	>VF .10 -2	TEXT CLASS
				---------------------% of <2mm											
M921059901	0-5	0-2	A	9.6	60.8	29.5	39.4	21.5	2.7	3.9	2.3	5.1	15.5	26.8	SIL
M921059902	5-18	2-7	E	13.8	65.6	20.6	45.0	20.6	2.6	3.4	2.0	3.4	9.2	18.0	SIL
M921059903	18-30	7-12	Bt1	34.5	52.7	12.8	39.4	13.3	1.9	2.4	1.3	2.4	4.8	10.9	SICL
M921059904	30-41	12-16	Bt2	70.4	23.3	6.3	17.7	5.6	1.0	1.5	1.0	1.3	1.4	5.3	C
M921059905	41-61	16-24	Bt3	76.6	17.5	5.9	9.8	7.7	1.7	1.1	0.6	0.8	1.7	4.2	C
M921059906	61-74	24-29	Bt4	56.2	19.9	23.9	14.8	5.0	2.0	3.7	3.1	6.7	8.5	21.9	C

SAMPLE #	NH4OAc EXTRACTABLE BASES Ca	Mg	Na	K	SUM BASES	ACID-ITY	EXTR Al	------CEC------ SUM CATS	NH4 OAc	BASES +AL	Al SAT	BASE SAT SUM	NH4 OAc	ORG C	---pH---- CaCl2 .01M	H2O
	---------------------------meq/100 g										--------%---------					
M921059901	2.9	1.2	0.0	.2	4.3	7.5	.9	11.8	9.2	5.2	17	36	47	2.3	4.5	5.0
M921059902	.5	.8	0.0	.1	1.4	3.8	1.4	5.2	5.0	2.8	50	27	28	0.4	4.3	4.9
M921059903	1.9	2.4	TR	.1	4.4	5.2	1.2	9.6	8.3	5.6	21	46	52	0.2	4.5	5.3
M921059904	8.6	8.7	TR	.3	17.6	10.0	1.1	27.6	23.7	18.7	6	64	74	0.5	4.8	5.4
M921059905	13.5	12.9	.1	.5	27.0	10.9	.7	37.9	33.6	27.7	3	71	80	0.4	5.1	5.5
M921059906	11.8	11.1	TR	.4	23.3	4.1	.1	27.4	24.4	23.4	0	85	95	0.3	6.1	6.4

LOCATION CLARKSVILLE MO+AR IL KS KY OK IN VA
Established Series Rev. FLG-KDV 9/89
CLARKSVILLE SERIES
The Clarksville series consists of deep, somewhat excessively drained soils formed in residuum and locally transported colluvial-alluvial materials from cherty dolomite or cherry limestone on steep side slopes and narrow ridgetops. Permeability is moderate. Slopes range from 1 to 60 percent. Mean annual precipitation is 43 inches, and mean annual temperature is 55 degrees F.
TAXONOMIC CLASS: Loamy-skeletal, siliceous, mesic Typic Paleudults
TYPICAL PEDON: Clarksville very gravelly silt loam--on a west-facing concave slope of 25 percent under mixed hardwoods and pine. (Colors are for moist soil unless otherwise stated.)
0i-- 1 to 0 inches; partly decomposed forest litter from pines and deciduous trees. (1/2 to 2 inches thick)
A--0 to 3 inches; grayish brown (10YR 5/2) very gravelly silt loam, light gray (10YR 712) dry; moderate very fine granular structure; very friable; many fine roots; 50 percent chert fragments; very strongly acid; abrupt smooth boundary. (1 to 4 inches thick)
E--3 to 13 inches; pale brown (10YR 6/3) very gravelly silt loam; weak very fine subangular blocky structure; very friable; common fine roots; 50 percent chert fragments; very strongly acid; clear wavy boundary. (6 to 28 inches thick)
BE--13 to 20 inches; light yellowish brown (10YR 6/4) extremely gravelly silty clay loam; weak very fine subangular blocky structure; friable; common fine roots; 65 percent chert fragments; very strongly acid; clear smooth boundary. (0 to 9 inches thick)
Bt1--20 to 38 inches; strong brown (7.5YR 5/6) extremely gravelly silty clay loam; weak very fine subangular blocky structure; friable; common fine roots; many fine pores and root channels; many faint clay films on faces of peds and in pores and root channels; common fine black concretions (oxides) in lower part; 65 percent chert fragments; very strongly acid; clear smooth boundary.
Bt2--38 to 47 inches; strong brown (7.5YR 5/6) gravelly silty clay loam; weak fine subangular blocky structure; firm; common fine roots; many fine pores and root channels; many faint clay films on faces of peds and in pores and root channels; 30 percent chert fragments; very strongly acid; clear wavy boundary.
Bt3--47 to 63 inches; yellowish red (5YR 5/6) very gravelly silty clay; few fine distinct yellowish brown (10YR 5/6) mottles, strong brown (7.5YR 516) crushed; moderate fine subangular blocky structure; firm; few fine roots; common fine pores and root channels; many faint clay films on faces of peds and in pores and root channels; 50 percent chert fragments; very strongly acid; gradual smooth boundary.
Bt4--63 to 96 inches; yellowish red (5YR 5/6) extremely gravelly silty clay; weak fine subangular blocky structure; firm; few fine roots; many distinct clay films on faces of peds; few fine black coatings (oxides); few small pockets of fight yellowish brown loam; 65 percent chert fragments; very strongly acid; diffuse smooth boundary. (Combined thickness of the Bt horizons is 24 to 88 inches.)
C--96 to 102 inches; strong brown (7.5YR 5/6) extremely gravelly silty clay loam; few small yellowish red pockets; weak medium angular blocky structure; firm; few fine roots; 70 percent chert fragments; very strongly acid.
TYPE LOCATION: Reynolds County, Missouri; in edge of woods, 50 feet northeast of center of Missouri Route 21; 1,400 feet west and 2,800 feet south of the northeast corner, sec. 5, T. 31N., R. 1E. RANGE IN CHARACTERISTICS: Coarse fragments mainly consist of chert, but sandstone and siltstone fragments may be present. The chert fragments range in size from 2 mm to about 4 inches, but some are larger. In some pedons the chert fragments in the solum are partially rounded. Reaction ranges from extremely acid to medium acid in the surface horizon and extremely acid to strongly acid below.
The A horizon has hue of 10YR, value of 2 to 6, and chroma of 1 to 3. The Ap horizon has hue of 10YR, value of 4 to 6, and chroma of 2 to 4. The A horizons are the gravelly to extremely gravelly analogues of silt loam or loam and contain 20 to about 80 percent by volume of chert fragments. Some pedons are cobbly or stony on the surface. The E horizon has hue of 10YR,

value of 4 to 7, and chroma of 2 to 4. Texture is gravelly to extremely gravelly analogues of silt loam or loam and contain 20 to about 80 percent by volume of chert fragments.

The BE and upper part of the Bt horizon has hue of 7.5YR to 2.5YR, value is mostly 5 or 6 but some are 4, and chroma is 4 to 6. These horizons are the gravelly, very gravelly, or extremely gravelly analogues of silty clay loam or silt loam. The fine earth fraction of the upper 20 inches of the argillic horizon contains less than 35 percent clay and less than 20 percent sand. The upper 20 inches of the argillic horizon contains more than 35 percent by volume chert fragments, and individual subhorizons range from 35 to 80 percent. The lower Bt and C horizons are quite variable in color and may be mottled. Hue ranges from 10YR to 2.5YR, value ranges from 4 to 6, except it is as low as 3 when accompanied by redder hues, and chroma ranges from 4 to 6. They are the gravelly, very gravelly, or extremely gravelly analogues of silty clay or clay.

COMPETING SERIES: These are the Bouldin and Coulstone series. Bouldin soils have 20 to 55 percent sand coarser than fine sand in the B horizons, contain sandstone fragments and no chert fragments, and loam, sandy loam, and clay loam textures. Coulstone soils contain more than 20 percent sand in the Bt horizon and a mixture of sandstone fragments with the chert fragments.

GEOGRAPHIC SETTING: Clarksville soils are on steep side slopes and narrow ridgetops. Slope gradients range from 1 to 60 percent. The soils formed in residuum and locally transported colluvial-alluvial materials from cherty dolomite or cherry limestone. The mean annual temperature ranges from 54 to 59 degrees F, and the mean annual precipitation ranges from 40 to 46 inches.

GEOGRAPHICALLY ASSOCIATED SOILS: In addition to the competing Coulstone soils, these are the Captina, Hobson, Lebanon, Nixa, Noark, Poyner, and Wilderness soils. Captina, Hobson, Lebanon, Nixa, and Wilderness soils have fragipans and occur on wide, nearly level to gently sloping ridgetops. Noark soils are clayey-skeletal and Poyner soils are loamy- skeletal over clayey. These soils are on similar landscape positions.

DRAINAGE AND PERMEABILITY: Somewhat excessively drained. Runoff is medium or rapid. Permeability is moderate.

USE AND VEGETATION: Most of the soil is in second growth timber similar to the original forest. Some areas are used for growing pasture or hay, and small areas are cropped to corn, small grains, and sorghum. Native vegetation is forest of black oak, white oak, blackjack oak, post oak, hickory, ash, sugar maple, and dogwood.

DISTRIBUTION AND EXTENT: Ozark region of Missouri, Oklahoma, and Arkansas, and dissected cherty areas in other states of the southeastern United States. The series is of large extent.

SERIES ESTABLISHED: Montgomery County, Tennessee, 1901.

REMARKS: Diagnostic horizons and features recognized in this series are: ochric epipedon - the zone from the surface of the soil to a depth of 20 inches (A, E, and BE horizons); albic horizon - the zone from approximately 3 to 13 inches (E horizon); argillic horizon - the zone from approximately 20 to 96 inches (Bt1, Bt2, Bt3, and Bt4 horizons); udic moisture regime.

National Cooperative Soil Survey
U.S.A.

Clarksville Map Unit 73014 12-23-97

Loamy-skeletal, siliceous, mesic Typic Paleudult

M9210571 MISSOURI SOIL CHARACTERIZATION LABORATORY

LACLEDE COUNTY

SAMPLE #	DEPTH cm	DEPTH in	HORIZON	TOTAL CLAY < .002	TOTAL SILT .002 -.05	TOTAL SAND .05 -2	SILT FINE .002 -.02	SILT COARSE .02 -.05	SAND VF .05 -.10	SAND F .10 -.25	SAND M .25 -.50	SAND C .5 -1	SAND VC 1 -2	SAND >VF .10 -2	TEXT CLASS
				% of <2mm											
M921057101	0-13	0-5	A	8.6	69.7	21.7	45.0	24.8	1.4	3.4	3.0	4.5	9.4	20.3	SIL
M921057102	13-43	5-17	E	9.0	70.8	20.3	49.0	21.8	1.2	2.5	2.1	3.4	11.1	19.1	SIL
M921057103	43-71	17-28	Bt1	14.9	73.3	11.8	44.4	28.9	2.2	3.4	1.9	2.0	2.2	9.6	SIL
M921057104	71-99	28-39	Bt2	31.1	56.7	12.2	36.1	20.6	1.5	2.5	1.7	2.8	3.7	10.7	SICL
M921057105	99-152	39-60	Bt3	48.4	39.4	12.2	25.6	13.8	1.4	2.7	1.3	2.4	4.3	10.8	C
M921057106	-----	----	B.S.												

SAMPLE #	NH4OAc EXTRACTABLE BASES Ca	Mg	Na	K	SUM BASES	ACIDITY	EXTR Al	CEC SUM CATS	CEC NH4 OAc	CEC BASES +AL	Al SAT	BASE SAT SUM	BASE SAT NH4 OAc	ORG C	pH CaCl2 .01M	pH H2O
	meq/100 g										%					
M921057101	7.9	.8	0.0	.4	9.1	4.9	0.0	14.0	11.5	9.1	0	65	79	2.6	5.7	6.3
M921057102	3.0	0.0	0.0	.2	3.2	2.2	0.0	5.4	4.9	3.2	0	59	65	0.4	5.5	6.2
M921057103	3.6	.8	TR	.1	4.5	3.5	.4	8.0	6.5	4.9	8	56	69	0.2	4.9	5.7
M921057104	1.0	1.2	TR	.2	2.4	10.1	5.8	12.5	10.5	8.2	71	19	23	TR	3.9	5.0
M921057105	1.4	2.0	TR	.2	3.6	13.3	7.1	16.9	14.0	10.7	66	21	26	0.1	4.0	4.9
M921057106	1.4	2.4	TR	.2	4.0	12.4	6.7	16.4	13.8	10.7	63	24	29	0.1	4.0	4.8

LOCATION DONIPHAN MO+AR
Established Series Rev. LHG-DKP 3/90
DONIPHAN SERIES
The Doniphan series consists of deep, well drained soils formed in cherty sediments and residuum from clayey shales and cherty dolomite or cherty limestone on side slopes and narrow ridgetops. These soils have moderate permeability. Slopes range from 2 to 60 percent. Mean annual temperature is about 56 degrees F, and mean annual precipitation is about 46 inches.
TAXONOMIC CLASS: Clayey, mixed, mesic Typic Paleudults
TYPICAL PEDON: Doniphan very cherty silt loam, on a southwest-facing slope of 6 percent under a mixed hardwood forest. (Colors are for moist soil unless otherwise stated.)
A--0 to 2 inches; dark grayish brown (10YR 4/2) very cherty silt loam, light brownish gray (10YR 6/2) dry; moderate very fine and fine granular structure; very friable; common medium and fine roots; many fine pores; many worm channels and casts; a few fine dark concretions (oxides); 60 percent chert fragments; slightly acid; abrupt smooth boundary. (1 to 6 inches thick)
E--2 to 12 inches; light yellowish brown (10YR 6/4) very cherty silt loam; many fine faint yellowish brown (10YR 5/4) mottles; weak very fine granular structure; very friable; common medium and fine roots; many fine pores; common worm channels and casts; common fine concretions (oxides); 55 percent chert fragments; strongly acid; clear wavy boundary. (2 to 14 inches thick)
B/E--12 to 16 inches; yellowish red (5YR 5/8) cherty silty clay loam (Bt); light yellowish brown (10YR 6/4) silt loam (E) comprises about 10 percent of the mass; moderate fine and very fine subangular blocky structure; friable; common fine roots; many fine pores; common worm channels and casts; few faint red clay films on faces of peds; common fine dark concretions (oxides); 15 percent chert fragments; strongly acid; clear wavy boundary. (0 to 6 inches thick)
2Bt1--16 to 27 inches; red (2.5YR 4/6) clay; few fine prominent light yellowish brown (10YR 6/4) and strong brown (7.5YR 5/6) mottles; strong fine angular blocky structure; firm; common fine roots; few fine pores; few faint red (10YR 4/6) clay films on faces of peds; few worm channels; few fine dark concretions (oxides); few fine chert fragments; very strongly acid; clear wavy boundary. (5 to 20 inches thick)
2Bt2--27 to 41 inches; red (2.5YR 4/6) clay; common fine prominent light yellowish brown (10YR 6/4) and strong brown (7.5YR 5/6) mottles; strong fine angular blocky structure; firm; common fine roots; few fine pores; few faint red clay films on faces of peds; few worm channels; few fine dark concretions (oxides); less than 5 percent chert fragments; very strongly acid; clear wavy boundary. (5 to 20 inches thick)
2Bt3--41 to 55 inches; mottled red (2.5YR 4/6) and brownish yellow (10YR 6/6) clay; common fine prominent strong brown (7.5YR 5/8), few fine distinct light yellowish brown (10YR 6/4) and prominent light gray (10YR 7/2) mottles; moderate fine angular blocky structure; friable; common fine roots; few fine pores; few faint red clay films on faces of peds; few worm channels; few fine dark concretions (oxides); few fine chert fragments; very strongly acid; abrupt wavy boundary. (7 to 20 inches thick)
2Bt4--55 to 77 inches; brownish yellow (10YR 6/6) clay; common coarse distinct red (10YR 4/6) and prominent light gray (N 7/) and few fine distinct light yellowish brown (10YR 6/4) mottles; moderate fine and very fine angular blocky structure; friable; common fine roots; few fine pores; many distinct clay films on faces of peds; few worm channels; few fine dark concretions (oxides); few fine chert fragments; very strongly acid.
TYPE LOCATION: Ripley County, Missouri; about 1 1/2 miles west of the town of Burr; ^1,240^feet south and 1,400 feet east of the northwest corner, sec. 6, T. 21 N., R. 1 E.
RANGE IN CHARACTERISTICS: Content of chert fragments ranges from 25 to 75 percent by volume in the A and E horizons, from 0 to 30 percent by volume in the Bt horizon and upper part of the 2Bt horizon, and from 0 to 80 percent in lower part of the 2Bt horizon. Some pedons have stone size fragments on the surface.
The A horizon has hue of 10YR, value of 2 to 4, and chroma of 1 to 3. The Ap horizon has hue of 10YR, value of 4 to 6, and chroma of 2 or 3. The E horizon has hue of 10YR, value of

4 to 6, and chroma of 3 or 4. They are the cherty or very cherty analogues of silt loam or loam. Reaction is very strongly acid to slightly acid.
The Bt part of the B/E horizon and upper part of the 2Bt horizons have hue of 1OR to 7.5YR, value of 3 to 5, and chroma of 4 to 8. Color of the lower part of the 2Bt horizons are quite variable, and colors are mottled in most pedons. They have hue of ^2.5YR^ to 10YR, value of 3 to 7, and chroma of 4 to 8 except for few or common gray mottles that are neutral or have chroma of 1 or 2. The upper 20 inches of the argillic horizon averages between 48 and 70 percent clay. The 2Bt horizon ranges from strongly acid to extremely acid. The Bt part of the B/E horizon is silty clay loam or cherty silty clay loam. The upper part of the 2Bt horizon is ^Silty clay or clay or their cherty analogues^. The lower part is clay or the cherty to extremely cherty analogues of clay.
COMPETING SERIES: The Macedonia and Frederick series are the only other members of the family. Other closely related soils include those the Baxter, Christiana, Dunmore, Gepp, and Maury series. Macedonia soils have less clay in the upper part of the argillic horizon and commonly less coarse fragments in the upper part of the solum. Frederick soils have less than 25 percent coarse fragments in the upper part of the solum and are typical of the Appalachian region in Virginia. Baxter, Gepp, and Maury soils have higher base saturation levels at the critical depth. Christiana and Dunmore soils have kaolinitic mineralogy and typically have fewer coarse fragments in the upper part of the solum.
GEOGRAPHIC SETTING: Doniphan soils are on side slopes and narrow ridgetops. Slope gradients typically range from 10 to 35 percent, but have an extreme range of 2 to 60 percent. The soils formed in is residuum from clayey shales and cherty dolomite or cherty limestone. Mean annual temperature ranges from 55 to 59 degrees F, and mean annual precipitation ranges from 40 to 50 inches. GEOGRAPHICALLY ASSOCIATED SOILS: These are the competing Macedonia and the Bardley, Coulstone, Clarksville, Gasconade, Gassville, Gatewood, Hobson, Lebanon, Opequon, Poynor, Viraton, and Wilderness soils. Macedonia soils are commonly on higher ridgetops. Bardley and Gatewood soils have lithic contacts within 40 inches of the surface and occur above Doniphan in the landscape. Coulstone and Clarksville soils are loamy-skeletal and occur on steep side slopes and narrow ridgetops. Gasconade and Opequon soils have lithic contacts within 20 inches of the surface and occur on slopes below the Doniphan soils. Poynor soils are loamy-skeletal over clayey and occur on similar slopes as Doniphan. Gassville soils are on adjacent lower side slopes and have solums less than 40 inches thick. Hobson, Lebanon, Viraton, and Widerness soils have fragipans and occur on broad ridgetops.
DRAINAGE AND PERMEABILITY: Well drained. Medium to rapid runoff. Permeability is moderate.
USE AND VEGETATION: The majority of these soils are in second growth timber. Pasture and hay or grain crops are grown on some areas. Native vegetation is deciduous hardwoods.
DISTRIBUTION AND EXTENT: Ozarks region of Missouri and Arkansas. The series is extensive. SERIES ESTABLISHED: Mark Twain National Forest in Carter, Oregon, Ripley, and Shannon Counties, Missouri, 1972.
REMARKS: Diagnostic horizons and features recognized in this series are: ochric epipedon - the zone from the surface of the soil to a depth of 12 inches (A and E horizons); argillic horizon - the zone from approximately 12 to 77 inches or more (B/E, 2Btl, 2Bt2, 2Bt3, and 2Bt3 horizons). Doniphan soils were formerly part of the Baxter series in Missouri.

National Cooperative Soil Survey
U.S.A.

Doniphan Map Unit 43C 9-2-93

Loamy-skeletal over clayey, mixed, mesic Typic Paleudult

M9304301 MISSOURI SOIL CHARACTERIZATION LABORATORY

CHRISTIAN COUNTY

SAMPLE #	DEPTH cm	DEPTH in	HORIZON	TOTAL: CLAY < .002	TOTAL: SILT .002 -.05	TOTAL: SAND .05 -2	SILT: FINE .002 -.02	SILT: COARSE .02 -.05	SAND: VF .05 -.10	SAND: F .10 -.25	SAND: M .25 -.50	SAND: C .5 -1	SAND: VC 1 -2	SAND: >VF .10 -2	TEXT CLASS
				% of < 2mm											
M930430101	0-10	0-4	A	15.5	72.0	12.5	51.8	20.2	1.5	1.5	0.9	2.0	6.6	11.0	SIL
M930430102	10-23	4-9	E	14.4	75.6	10.0	51.5	24.1	1.6	1.5	0.9	1.5	4.4	8.4	SIL
M930430103	23-33	9-13	Bt1	20.5	72.4	7.0	50.7	21.7	1.1	1.1	0.6	1.0	3.3	6.0	SIL
M930430104	33-46	13-18	2Bt2	34.6	60.9	4.5	42.5	18.3	0.8	0.6	0.3	0.7	2.0	3.7	SICL
M930430105	46-81	18-32	2Bt3	70.3	28.7	0.9	14.1	14.7	0.2	0.2	0.1	0.2	0.3	0.7	C
M930430106	81-122	32-48	2Bt4	65.0	30.3	4.6	16.8	13.5	0.9	1.1	0.6	1.0	1.1	3.7	C
M930430107	122-160	48-63	2Bt5	74.1	21.5	4.4	9.3	12.2	0.5	0.8	0.5	1.0	1.6	3.9	C
M930430108	-	-	B.S.												

SAMPLE #	NH4OAc EXTRACTABLE BASES: Ca	Mg	Na	K	SUM BASES	ACIDITY	EXTR Al	CEC: SUM CATS	CEC: NH4 OAc	CEC: BASES +Al	Al SAT	BASE SAT: SUM	BASE SAT: NH4 OAc	ORG C	pH: CaCl2 .01M	pH: H2O
	meq/100 g										%					
M930430101	4.9	.8	0.0	.6	6.3	8.2	.1	14.5	11.5	6.4	2	43	55	2.6	--	4.9
M930430102	2.2	.4	0.0	.3	2.9	5.0	.4	7.9	6.3	3.3	12	37	46	0.8	--	5.1
M930430103	2.1	.4	TR	.3	2.8	5.2	1.3	8.0	6.7	4.1	32	35	42	0.3	--	5.0
M930430104	2.9	.8	TR	.5	4.2	7.1	2.7	11.3	10.0	6.9	39	37	42	0.3	--	4.9
M930430105	7.1	3.1	TR	.6	10.8	12.8	3.7	23.6	18.8	14.5	26	46	57	0.2	--	5.0
M930430106	4.7	2.7	.1	.4	7.9	14.2	6.0	22.1	18.9	13.9	43	36	42	0.2	--	5.0
M930430107	4.4	3.1	TR	.3	7.8	18.1	8.1	25.9	20.8	15.9	51	30	38	0.3	--	5.0
M930430108	4.5	3.1	TR	.3	7.9	19.3	9.0	27.2	23.2	16.9	53	29	34	--	--	4.8

SAMPLE #	ROUNDED-SUBROUNDED: GRAVEL .08-3.0"	ROUNDED-SUBROUNDED: COBBLES 3.0-10"	ROUNDED-SUBROUNDED: STONES 10-24"	FLAT: CHANNERS .08-6.0"	FLAT: FLAGSTONES 6.0-15"	FLAT: STONES 15-24"
M930430101						
M930430102						
M930430103						
M930430104						
M930430105						
M930430106						
M930430107						
M930430108						

LOCATION GASCONADE MO+IA OH
Established Series Rev. JCB-KDV 3/88
GASCONADE SERIES
The Gasconade series consists of somewhat excessively drained, moderately slowly permeable soils formed in thin clayey layers with considerable amount of coarse fragments from residuum of the underlying limestone bedrock. These soils are on steep dissected upland landscapes and generally are isolated glade areas. Slope gradients range from 2 to 50 percent. Mean annual temperature is 55 degrees F, and mean annual precipitation is 40 inches.
TAXONOMIC CLASS: Clayey-skeletal, mixed, mesic Lithic Hapludolls
TYPICAL PEDON: Gasconade flaggy clay loam, very stony - on an 8 percent southwest-facing slope in a hardwood forest. (Colors are for moist soil unless otherwise stated.)
A--0 to 7 inches; very dark brown (10YR 2/2) flaggy clay loam; dark grayish brown (10YR 4/2) dry; moderate fine granular structure; firm; 20 percent by volume limestone fragments 1/2 to 8 inches in diameter and about 3 to 10 percent of the surface is covered with stones; neutral; clear smooth boundary. (4 to 10 inches thick)
Bw--7 to 14 inches; dark brown (7.5YR 3/2) very flaggy clay; moderate medium subangular blocky structure; very firm; 60 percent by volume limestone fragments 2 to 4 inches thick and chert fragments; mildly alkaline; clear irregular boundary. (0 to 15 inches thick)
R-- 14 inches; hard limestone bedrock with weathered cracks and partings containing clayey materials in the upper part.
TYPE LOCATION: Henry County, Missouri; about 7 miles south of Tightwad; about 2,190 feet south and 240 feet east of the northwest corner, sec. 26, T. 40 N., R. 24 W.
RANGE IN CHARACTERISTICS: The thickness of the sola ranges from 4 to 20 inches and commonly is the same as depth to limestone bedrock. The quantity of coarse fragments greater than 3 inches in diameter ranges to as much as 60 percent by volume in any horizon. Approximately 2/3 of the coarse fragments between 2 mm and 76 mm in diameter are larger than 5 mm. Coarse fragments between 2 mm and 76 mm are variable in quantity but commonly average less than 35 percent by volume. The solum ranges from mildly alkaline to slightly acid.
The A horizon has hue of 10YR, value of 2 or 3, and chroma of I to 3. It is the flaggy, very flaggy, cherty or very cherty analogues of silty clay loam, silty clay, or clay loam.
The Bw horizon has hue of 7.5YR to 2.5Y, value of 2 to 4, and chroma of 2 or 4. It dominantly is very flaggy, very channery or very cherty analogues of clay or silty clay, but in some pedons it is the those analogues of clay loam or silty clay loam. Clay content ranges from 35 to 60 percent.
COMPETING SERIES: The Gasconade series is the only member of the family. Other similar series are the Barfield, Edmund, Moko, Sogn, Swink, and Tarrant series. Barfield, Swink, and Tarrant soils are thermic. In addition, Barfield and Tarrant soils are dry for a longer period. Edmund soils have argillic horizons and have fewer coarse fragments in the sola. Moko soils are loamy-skeletal. Sogn soils contain fewer coarse fragment and less clay in the sola.
GEOGRAPHIC SET`TING: These soils are on steep dissected landscapes and generally in isolated glade areas. Slope gradients typically are 20 to 35 percent but range from 2 to 50 percent. Gasconade soils formed in thin clayey layers with considerable amount of coarse fragments from residuum of the underlying limestone bedrock. Depth to bedrock varies greatly within short distance. Mean annual temperature varies from 54 to 59 degrees F, and mean annual precipitation varies from 35 to 45 inches.
GEOGRAPHICALLY ASSOCIATED SOILS: These are the Bardley, Caneyville, Clarksville, Crider, Eldon, Gatewood, Goss, Pembroke, and Peridge soils. All of these soils are deeper to bedrock and commonly are at higher elevations in the landscape.
DRAINAGE AND PERMEABILITY: Somewhat excessively drained. Runoff is rapid. Permeability is moderately slow.

USE AND VEGETATION: Most areas are in native grasses with a sparse population of cedar and low quality oaks.
DISTRIBUTION AND EXTENT: Missouri and Ohio. The series is moderately extensive.
SERIES ESTABLISHED: Crawford County, Missouri, 1905.
REMARKS: Diagnostic horizons and features recognized in this series are: mollic epipedon - the zone from the surface of the soil to a depth of 14 inches (A and Bw horizons) lithic contact - 14 inches.

National Cooperative Soil Survey
U.S.A.

Gasconade Map Unit 73029 11-24-97

Clayey-skeletal, mixed, superactive, mesic Lithic Hapludoll

M9010508 MISSOURI SOIL CHARACTERIZATION LABORATORY

LACLEDE COUNTY

SAMPLE #	DEPTH cm	DEPTH in	HORIZON	TOTAL CLAY < .002	TOTAL SILT .002 -.05	TOTAL SAND .05 -2	SILT FINE .002 -.02	SILT COARSE .02 -.05	SAND VF .05 -.10	SAND F .10 -.25	SAND M .25 -.50	SAND C .5 -1	SAND VC 1 -2	SAND >VF .10 -2	TEXT CLASS
				% of <2mm											
M901050801	0-8	0-3	A	39.6	41.0	19.5	25.1	15.9	1.8	5.0	5.2	5.1	2.4	17.7	SICL
M901050802	8-15	3-6	Bw1	40.9	39.2	20.0	24.6	14.5	1.8	4.3	4.2	5.3	4.4	18.2	C
M901050803	15-30	6-12	Bw2	44.9	32.8	22.3	20.8	12.0	1.7	4.4	4.2	5.9	6.1	20.6	C

SAMPLE #	NH4OAc EXTRACTABLE BASES Ca	Mg	Na	K	SUM BASES	ACID-ITY	EXTR Al	CEC SUM CATS	CEC NH4 OAc	CEC BASES +AL	Al SAT	BASE SAT SUM	BASE SAT NH4 OAc	ORG C	pH CaCl2 .01M	pH H2O
	meq/100 g										%					
M901050801	25.3	13.9	.1	.8	40.1	8.8	--	49.0	40.6	--	--	82	99	6.9	6.2	6.8
M901050802	18.3	11.1	.1	.4	29.9	9.3	--	39.2	32.5	--	--	76	92	3.6	6.0	6.6
M901050803	14.3	10.6	.1	.3	25.3	9.0	--	34.3	28.3	--	--	74	89	2.3	5.8	6.5

LOCATION LEBANON MO
Established Series Rev. CLS-KDV 6/88
LEBANON SERIES
The Lebanon series consists of deep, moderately well drained soils that have fragipans at depths of 18 to 26 inches. They formed in loess and the underlying cherty residuum on uplands. Permeability is moderately slow above the fragipan and very slow in the fragipan. Slopes commonly are 2 to 5 percent, but range to 14 percent. The average annual temperature is 55 degrees F, and mean annual precipitation is 44 inches.
TAXONOMIC CLASS: Fine, mixed, mesic Typic Fragiudalfs
TYPICAL PEDON: Lebanon silt loam - on a convex slope of 4 percent under second growth hardwoods. (Colors are for moist soil unless otherwise stated.)
Ap--0 to 6 inches; brown (10YR 5/3) silt loam, pale brown (10YR 6/3) dry; weak very fine granular structure; very friable; medium acid; abrupt smooth boundary. (4 to 9 inches thick)
BE--6 to 9 inches; strong brown (7.5YR 5/6) silt loam; moderate very fine subangular blocky structure; friable; very strongly acid; abrupt wavy boundary. (0 to 5 inches thick)
Bt1--9 to 12 inches; strong brown (7.5YR 5/6) silty clay loam; moderate very fine subangular blocky structure; firm; few faint dark brown clay films on faces of peds; few fine black concretions (iron and manganese oxides); very strongly acid; clear wavy boundary.
Bt2--12 to 18 inches; brown (7.5YR 4/4) silty clay; moderate fine subangular blocky structure; firm; many faint dark brown clay films on faces of peds; few fine black concretions (iron and manganese oxides); very strongly acid; clear wavy boundary.
Bt3--18 to 23 inches; pale brown (10YR 6/3) silty clay loam; few fine faint yellowish brown (10YR 5/4) and strong brown (7.5YR 5/6) mottles; moderate fine subangular blocky structure; firm; many faint brown clay films on faces of peds; very strongly acid; clear wavy boundary. (Combined thickness of the Bt horizon is 10 to 20 inches.)
2Ex--23 to 30 inches; grayish brown (10YR 5/2) very cherty silt loam; weak medium platy and very fine subangular blocky structure; very firm; brittle; few very fine vesicular pores; 45 percent chert fragments; very strongly acid; gradual wavy boundary. (0 to 9 inches thick)
2Bx--30 to 35 inches; mottled gray (10YR 5/1), yellowish brown (10YR 5/6) and light olive brown (2.5Y 5/4) very cherty silty clay loam; weak thin and medium platy structure; very firm; brittle; few very fine vesicular pores; 35 percent chert fragments; very strongly acid; gradual wavy boundary. (4 to 12 inches thick).
2Bt1--35 to 41 inches; mottled pale brown (10YR 6/3), grayish brown (lOYR 5/2) and yellowish red (5YR 5/6) cherty silty clay; weak fine subangular blocky structure; very firm; 30 percent chert fragments; common faint dark gray clay films on faces of peds and chert fragments; very strongly acid; clear smooth boundary.
2Bt2--41 to 49 inches; yellowish brown (10YR 5/4) clay; many fine prominent dark red (10R 3/6) mottles; strong very fine angular blocky structure; very firm; many prominent dark yellowish brown clay films on faces of peds; few small pockets of very dark gray clay; 5 percent chert fragments; very strongly acid; gradual smooth boundary.
2Bt3--49 to 60 inches; dark red (10R 3/6) clay; common medium prominent yellowish brown (10YR 5/4) and gray (10YR 6/1) mottles; strong fine angular blocky structure; firm; many prominent dusky red clay films on faces of peds; very few pockets of very dark gray clay; 5 percent chert fragments; very strongly acid.
TYPE LOCATION: Phelps County, Missouri; just north and west of Edgar Springs; 1,800 feet north and 1,300 feet east of the southwest corner, sec. 26, T. 35 N., R. 9 W.
RANGE IN CHARACTERISTICS: The depth to the fragipan ranges from 18 to 26 inches. Coarse fragments larger than 3 inches in diameter range from 0 to 5 percent above the fragipan and 0 to 10 percent in and below the fragipan. Coarse fragments less than 3 inches in diameter range from 0 to 20 percent above the fragipan with the highest chert content being just above the fragipan, 5 to 70 percent in the fragipan and 5 to about 60 percent in the clayey residuum below the fragipan. The reaction is medium acid to slightly acid in the surface soil and very strongly acid or strongly acid below.

The Ap horizon has hue of 10YR, value of 4 or 5 and chroma of 3 or 4. Undisturbed areas have A horizons with hue of 10YR, value of 3 or 4 and chroma of 2 or 3 and are commonly 2 to 4 inches thick. Some pedons have E horizons. It commonly is silt loam but includes cherty silt loam.

The BE horizon has hue of 10YR or 7.5YR, value of 4 or 5, and chroma of 4 to 6. It is commonly silt loam or silty clay loam, but may be cherty in some pedons. The Bt horizons have hue of 10YR to 5YR, value of 4 to 6. Chroma is 3 to 6, but may be 2 just above the fragipan. They are silty clay loam or silty clay or their cherty analogues.

The 2Ex and 2Bx horizons have hue of 10YR, value of 4 to 6, and chroma of 2, or are mottled in hues of 7.5YR to 2.5Y, values of 4 to 6 and chroma of 1 to 3. They are silt loam or silty clay loam or their cherty to extremely cherty analogues. The 2Bt horizon has hue of 10YR to 2.5YR, value of 3 to 6, and chroma of 2 to 6. They are silty clay, clay, or their cherty or very cherty analogues.

COMPETING SERIES: The Union series is the only other competing series. Union soils are 26 to 36 inches deep to a fragipan and have less cherty material at depths shallower than 30 inches. GEOGRAPHIC SETTING: The Lebanon soils occupy gently to moderately sloping upland positions with gradients of 2 to 14 percent but gradients commonly are 2 to 6 percent. The regolith consists of approximately 18 to 26 inches of loess underlain by cherty limestone residuum. The contact of the contrasting material is marked by a cherty old erosional surface in which the fragipan has developed. The mean annual temperature ranges from 54 to 57 degrees F, and mean annual precipitation ranges from 42 to 48 inches.

GEOGRAPHICALLY ASSOCIATED SOILS: These include the Captina, Clarksville, Coulstone, Hobson, Needleye, Nixa, and Wilderness soils. The Captina and Needleye soils have less clay above the fragipan and are found on similar landscapes. Clarksville and Coulstone soils have more than 35 percent coarse fragments in the control section, and occur on steeper side slopes. Hobson soils are fine-loamy and are on similar landscapes. Nixa and Wilderness soils have less clay, more than 35 percent coarse fragments in the control section and occur on similar landscapes.

DRAINAGE AND PERMEABILITY: Moderately well drained. Runoff is medium. Permeability is moderately slow above the fragipan and very slow in the fragipan.

USE AND VEGETATION: A large part is cleared and cropped to com and small grains or used for hay and pasture. The remainder is in forest. Native vegetation is hardwood forest. DISTRIBUTION AND EXTENT: The Ozark area of southern Missouri. Lebanon soils are moderately extensive.

SERIES ESTABLISHED: Laclede County, Missouri, 1911.

REMARKS: These soils are close to the Fragiudult boundary but the available information would indicate they are best placed as Fragiudalfs. Diagnostic horizons and features recognized in this series are:

ochric epipedon - the zone from the surface of the soil to a depth of 9 inches (Ap and BE horizons).

argillic horizon - the zone from approximately 9 inches to 23 inches and 35 to 60 inches (BtI, Bt2, and Bt3 horizons and 2Btl, 2Bt2, and 2Bt3 horizons).

fragipan - the zone from approximately 23 to 35 inches (2Ex and 2Bx horizons).

National Cooperative Soil Survey
U.S.A.

Lebanon Map Unit 40B 10-28-96

Fine, mixed, mesic Typic Fragiudalf

M9605506 MISSOURI SOIL CHARACTERIZATION LABORATORY

CRAWFORD COUNTY

SAMPLE #	DEPTH cm	DEPTH in	HORIZON	TOTAL: CLAY < .002	TOTAL: SILT .002 -.05	TOTAL: SAND .05 -2	SILT: FINE .002 -.02	SILT: COARSE .02 -.05	SAND: VF .05 -.10	SAND: F .10 -.25	SAND: M .25 -.50	SAND: C .5 -1	SAND: VC 1 -2	SAND: >VF .10 -2	TEXT CLASS
				% of < 2mm											
M960550601	0-8	0-3	A	15.2	76.8	8.0	51.0	25.8	0.7	1.9	1.9	1.7	1.9	7.3	SIL
M960550602	8-15	3-6	BE	18.4	74.2	7.4	50.6	23.6	0.6	2.0	1.9	1.7	1.1	6.7	SIL
M960550603	15-28	6-11	Bt1	30.1	63.7	6.1	45.1	18.6	0.6	1.5	1.5	1.2	1.4	5.5	SICL
M960550604	28-46	11-18	Bt2	44.1	48.8	7.1	34.1	14.8	0.4	1.4	1.1	1.1	2.9	6.7	SIC
M960550605	46-66	18-26	Bt3	16.7	66.4	16.8	48.0	18.4	1.2	4.3	3.7	2.3	5.3	15.6	SIL
M960550606	66-89	26-35	2Btx4	23.5	63.4	13.1	42.0	21.4	1.5	3.7	2.3	1.7	3.9	11.6	SIL
M960550607	89-124	35-49	3Bt5	75.9	15.6	8.5	7.4	8.2	0.6	1.5	1.4	1.2	3.7	7.9	C
M960550608	124-160	49-63	3Bt6	73.0	12.8	14.3	6.2	6.6	0.9	5.0	5.2	1.7	1.5	13.4	C
M960550609	160-180	63-71	3Bt7	64.6	11.0	24.3	6.0	5.1	1.5	6.4	5.5	4.5	6.5	22.8	C
M960550610	180-203	71-80	3Bt8	26.0	8.5	65.4	5.5	3.1	9.7	25.0	14.4	11.1	5.2	55.7	SCL
M960550611	-	-	B.S.												

SAMPLE #	NH4OAc EXTRACTABLE BASES: Ca	Mg	Na	K	SUM BASES	ACID-ITY	EXTR Al	CEC: SUM CATS	CEC: NH4 OAc	CEC: BASES +Al	Al SAT	BASE SAT: SUM	BASE SAT: NH4 OAc	ORG C	pH: CaCl2 .01M	pH: H2O
	meq/100 g										%					
M960550601	2.8	1.2	TR	.3	4.3	11.6	1.6	15.9	14.4	5.9	27	27	30	3.5	4.2	4.9
M960550602	1.2	.8	TR	.1	2.1	12.4	5.7	14.5	10.9	7.8	73	14	19	0.6	3.9	4.8
M960550603	1.9	2.4	.1	.2	4.6	15.1	9.5	19.7	17.1	14.1	67	23	27	0.6	4.0	4.8
M960550604	2.2	4.9	.2	.2	7.5	22.4	15.2	29.9	24.6	22.7	67	25	30	0.5	3.9	4.7
M960550605	2.2	1.6	.2	.1	4.1	9.5	6.0	13.6	10.6	10.1	59	30	39	0.1	3.9	4.8
M960550606	1.9	2.0	.4	.1	4.4	7.5	4.7	11.9	10.8	9.1	52	37	41	0.1	4.0	4.9
M960550607	9.0	8.2	.8	.2	18.2	16.7	7.6	34.9	29.8	25.8	29	52	61	0.2	4.2	5.0
M960550608	9.2	9.1	1.2	.3	19.8	14.5	5.1	34.3	28.8	24.9	20	58	69	0.3	4.3	5.0
M960550609	8.5	8.0	1.2	.4	18.1	12.2	3.9	30.3	25.4	22.0	18	60	71	0.2	4.4	4.9
M960550610	3.3	2.4	.5	.2	6.4	4.4	1.3	10.8	8.7	7.7	17	59	74	0.1	4.3	5.0
M960550611	10.5	10.4	1.4	.4	22.7	15.4	--	38.1	32.2	--	--	60	70	--	--	--

Ha Ha Tonka State Park

TRAIL AND NATURAL AREA GUIDE

Ha Ha Tonka State Park is comprised of approximately 2,697 acres on the Niangua Arm of the Lake of the Ozarks, five miles southwest of Camdenton. The most significant natural and man made features, however, are concentrated in a 750 acre area adjacent to the lake and its confluence with Ha Ha Tonka Spring. Within this area exists a rich mixture of natural beauty, geologic oddity, romantic history, and abiding mystery unequaled in Missouri. The Missouri Department of Natural Resources purchased the property in December 1978, and Ha Ha Tonka State Park was dedicated and opened to the public on June 10, 1979.

CULTURAL HISTORY

The stark, vertical stone ruins of Ha Ha Tonka castle are nearly all that remain of one man's dream. In the early 1900s, Robert McClure Snyder, a prominent Kansas City businessman, conceived a private retreat, the centerpiece of which would be a magnificent European-style mansion or castle. The mansion was designed with 60 rooms grouped on three floors around a central hall rising three-and-a-half stories upward to a skylight. A stone carriage house, an 80-foot high water tower, and nine greenhouses were built to attend the main house.

In 1906, only one year after the start of construction, Snyder was killed in an automobile accident near his Kansas City home. The interior of the castle remained unfinished until his son had it completed in 1922 and occupied the upper two floors. In 1942, sparks from a fireplace kindled a tragic fire that gutted the castle and carriage house. Fires set by vandals destroyed the water tower in 1976.

NATURAL HISTORY

Ha Ha Tonka State Park is perhaps most noted for its complex of geologic features and formations. Geologically, Ha Ha Tonka is a classic example of "karst" topography, a landscape that is characterized by sinks, caves, underground streams, large springs, and natural bridges. Examples of all of these can be seen within a very small area of the park. Karst topography is the result of water percolating through porous underlying dolomite bedrock and causing it to dissolve. The weathering action of the water on the rock after many years forms the various karst features.

In the United States, Missouri is widely recognized for the karst landscape that occurs in the southern part of the state. This karst is best represented in more than 4,000 caves that are known in the state. Eight caves have been recorded so far in Ha Ha Tonka State Park. The caves, in addition to the wide variety of other karst features, make this state park one of Missouri's most outstanding karst areas and one of the nation's most important geologic sites.

In a broader sense, Ha Ha Tonka State Park is part of the Osage River Hills region of the Ozarks, a transition area between the prairie landscape farther west and the rugged forested hills farther east. Early records point out that this part of the country was very open. The original forests, where they occurred, were very poor because of thin and rocky soils. Within the sparse forest were native grasses and a mixture of prairie plants. Today we call this landscape type "savanna" and in presettlement times it was found throughout what is today Ha Ha Tonka State Park. Examples of the savanna landscape can be seen from several of the trails. A few well protected hillsides that receive greater amounts of moisture contain fairly rich forests of northern red oak, shagbark hickory, and basswood, while on very dry south-facing hillsides and along woodland hilltops, there are open groves of blackjack oak, post oak, and black oak. Trail users will find not only a diverse assemblage of natural geologic wonders, but also a wide array of forest, savanna, and glade communities.

THE TRAILS

The trails at Ha Ha Tonka provide access to most of the main features of the park. They have been designed to minimize destruction of the surrounding vegetation and prevent soil erosion. Please stay on the trails and DO NOT TAKE SHORTCUTS.

Due to the location of the trails, the high concentration of people and the steep topography in the park, it is critical to the safety of others that NO ROCKS be thrown or kicked from the trails, bluffs, or overlooks.

In addition to the trails described below, there are other well defined paths in the park providing access to the water tower, the carriage house, and Ha Ha Tonka castle. The trail leading from the parking area to the castle is accessible to the disabled and contains a developed overlook from which most of the natural and cultural features of Ha Ha Tonka State Park can be seen. Part of Spring Trail and Dell Rim Trail are also accessible to the disabled.

DELL RIM TRAIL - 1/2 MILE (One Way)

Dell Rim Trail does not provide a loop hike. It is a boardwalk trail that begins at the castle parking area and proceeds around the rim of Whispering Dell Sinkhole. This trail provides access to the water tower and excellent views of the surrounding countryside. The first half of this trail is an easy hike; the second half, which descends by a series of steps to an overlook in the saddle between Whispering Dell and the spring, is quite strenuous and should be hiked only by persons in good physical condition. Remember you must return by the same route. That portion of the trail from the parking lot to the first overlook is accessible to the disabled. The trail is identified by red direction arrows.

CASTLE BLUFF TRAIL - 1/2 MILE (One Way)

Castle Bluff Trail is a one-way trail that begins on the west side of the castle and procedes to the lake. Visitors arriving by boat may use the trail to access the castle. The trail leads to the greenhouse ruins and one of the old quarries from which stone for the castle was obtained. It is marked with brown arrows.

COLOSSEUM TRAIL - 1/2 MILE

This trail originates at the natural bridge parking area. Descending to the valley floor, the trail passes beneath the natural bridge, makes its way along the hillside, climbs to the rim above the spring and Whispering Dell, and then returns to its starting point by crossing over the natural bridge. The trail, marked with yellow arrows in a clockwise direction, provides a hike of moderate difficulty.

BOULDER RIDGE TRAIL - 1 MILE

Boulder Ridge Trail is a moderately difficult loop trail that traverses the small ridge to the west of the spring area picnic shelter. Large lichen-covered rocks scattered along the ridge create an inviting environment for hikers. The trailhead is located approximately 300 feet beyond the junction of the spring road and Highway D. The trail is signed in a clockwise direction.

QUARRY TRAIL - 1-1/2 MILES

Quarry Trail is a short loop trail that begins near the northwest corner of the castle and exits at the carriage house. The trail passes through beautiful glade that allows open views of the lake and through one of the old quarries that was a source of stone for structures located in the park. The trail is marked with green arrows in a clockwise direction and provides an easy hike. By using the white connector trail, a shorter hike of one mile is possible.

SPRING TRAIL - 1-1/2 MILES

Spring Trail is a loop trail that can be entered from the spring parking area or from the parking area along Highway D just beyond the old post office. The lower section of Spring Trail, located between the parking area and Ha Ha Tonka Spring, is easily traveled, while the upper section is more strenuous. Approximately three-quarters of the lower portion of the trail is paved and accessible to the disabled. An overlook at the end of the disabled-accessible portion is an excellent resting spot that provides good views of the spring branch. A boardwalk proceeds from this point to the spring. Blue arrows identify the main route, which is signed in a clockwise direction. A white connector trail provides easy access between the upper and lower levels of the trail.

ISLAND TRAIL - 3/4 MILE

This trail loops around the entire island and provides excellent views of Balanced Rock and the collapsed cavern system with its 250-foot rock walls. The trail begins at the mill race and proceeds in a counter-clockwise direction around the island. Island Trail has both moderate and difficult sections. Green arrows identify the main loop and white arrows identify a connector trail that allows a shorter hike of about half the distance.

DEVIL'S KITCHEN TRAIL - 1 MILE

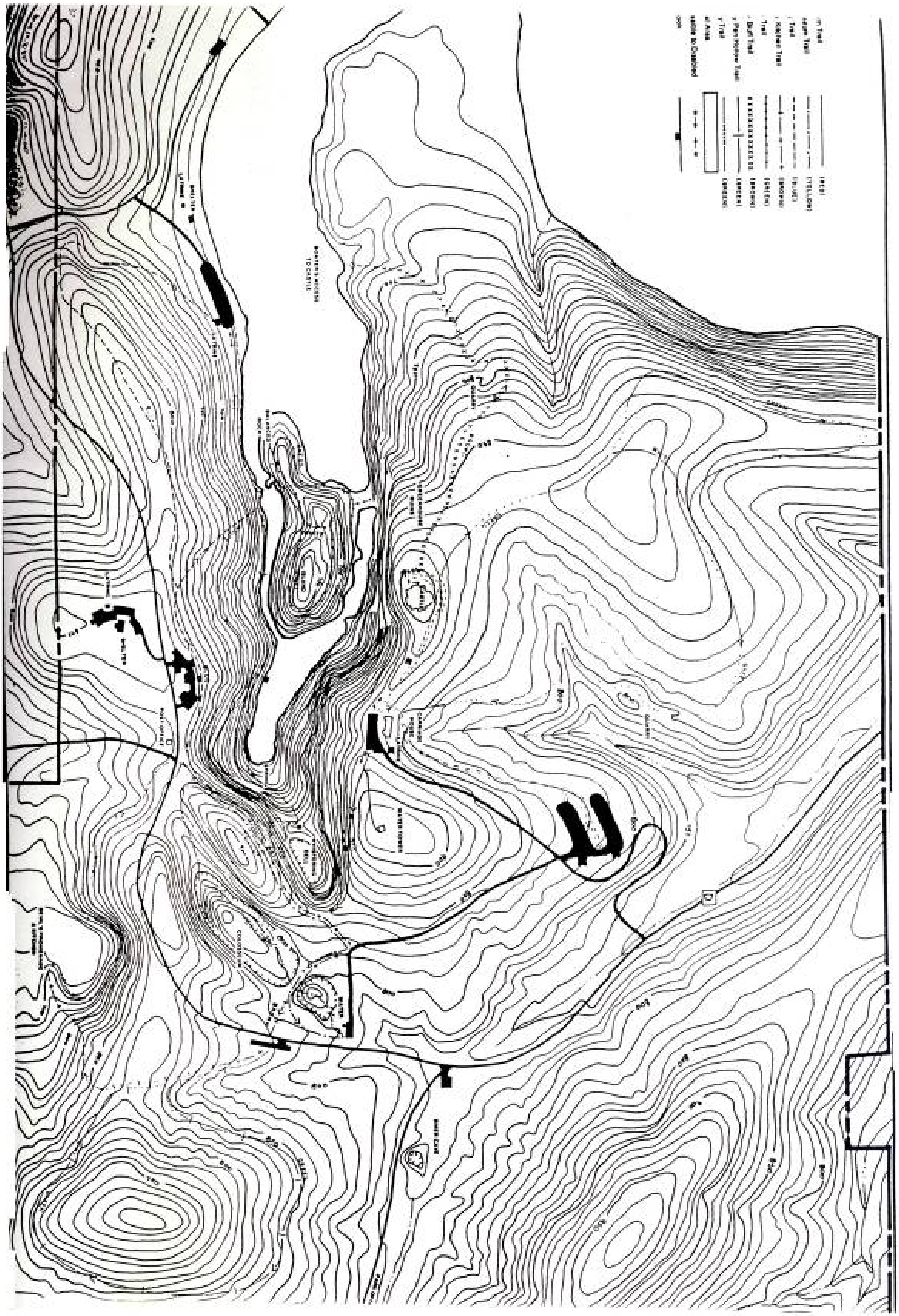
Devil's Kitchen Trail begins from the parking area located east of Highway D just beyond the park entrance road. Hikers can visit woodland, glade, and unique geologic features known as Devil's Kitchen and Devil's Promenade along this trail. Devil's Kitchen Trail can provide a more remote and private hike than other trails in the park. Hiking on this trail is moderately difficult. The trail is marked with brown arrows in a clockwise direction.

TURKEY PEN HOLLOW TRAIL — 3/4 MILE

Turkey Pen Hollow Trail shares the route of Devil's Kitchen Trail for approximately 400 feet before separating and turning to the left. It is a loop trail that traverses a portion of the park that is being maintained as savanna. The trail is named after a hollow located at the southern end of the savanna management area. A self-guiding booklet that interprets the savanna is available at the trailhead. It is an easy hike that offers surprisingly good views of the water tower. Green arrows identify the trail, which is signed in a clockwise direction.

If you have any questions concerning the trails or natural area at Ha Ha Tonka State Park, please contact the park superintendent at Route 1, Box 658, Camdenton, MO 65020, or call (314)346-2986.

For information on the more than 300 miles of trail and 30 natural areas in other state parks, contact the Missouri Department of Natural Resources, P.O. Box 176, Jefferson City, MO 65102, or call toll-free 1-800-334-6946.



THE NATURAL AREA PROGRAM

Missouri has been blessed with an unusual diversity of native plants, animals, and scenic areas. The state has some of the largest springs in North America and the greatest number of caves of any state. There are tallgrass prairies, deep rich forests, barren glades, and numerous crystal clear streams. All these make for an unusually varied, beautiful, and interesting natural history that has shaped Missouri's cultural history as well.

As you tour Missouri's state parks, you will learn about our state's natural and cultural heritage. To ensure that special recognition and protection is afforded to some of the significant natural elements, certain areas have been designated as Missouri Natural Areas. Natural areas are managed and protected for their scientific, educational, and historical values. They are formally recognized as the least disturbed and highest quality biological and geological sites across the state.

Missouri Natural Areas are specially signed and you are invited to explore them as you tour Missouri's state park system.

HA HA TONKA KARST NATURAL AREA

The 70 acre Ha Ha Tonka Karst Natural Area recognizes the most significant karst terrain in the park. Found here are an ancient collapsed cavern, a major deep circulating spring, two large sinkholes, a natural bridge, and six caves.

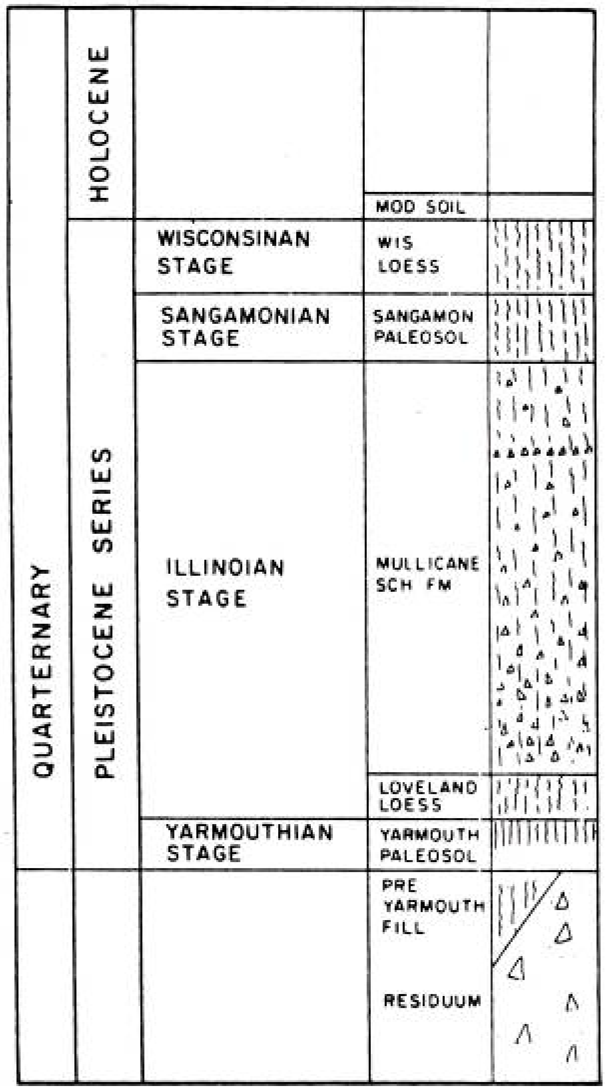
The central feature is the Ha Ha Tonka canyon or gorge, which is one of the most spectacular chasms in the state. This chasm is the result of the collapse of an ancient cave system. This collapse created the island that now divides the spring branch and exposed the 250 foot bluffs that line one side of the chasm.

At the upper end of the canyon is Ha Ha Tonka Spring, the 12th largest in the state, with an average daily flow of 48 million gallons of water. This spring is the successor to the earlier and much larger underground water system that formed the now collapsed cave system.

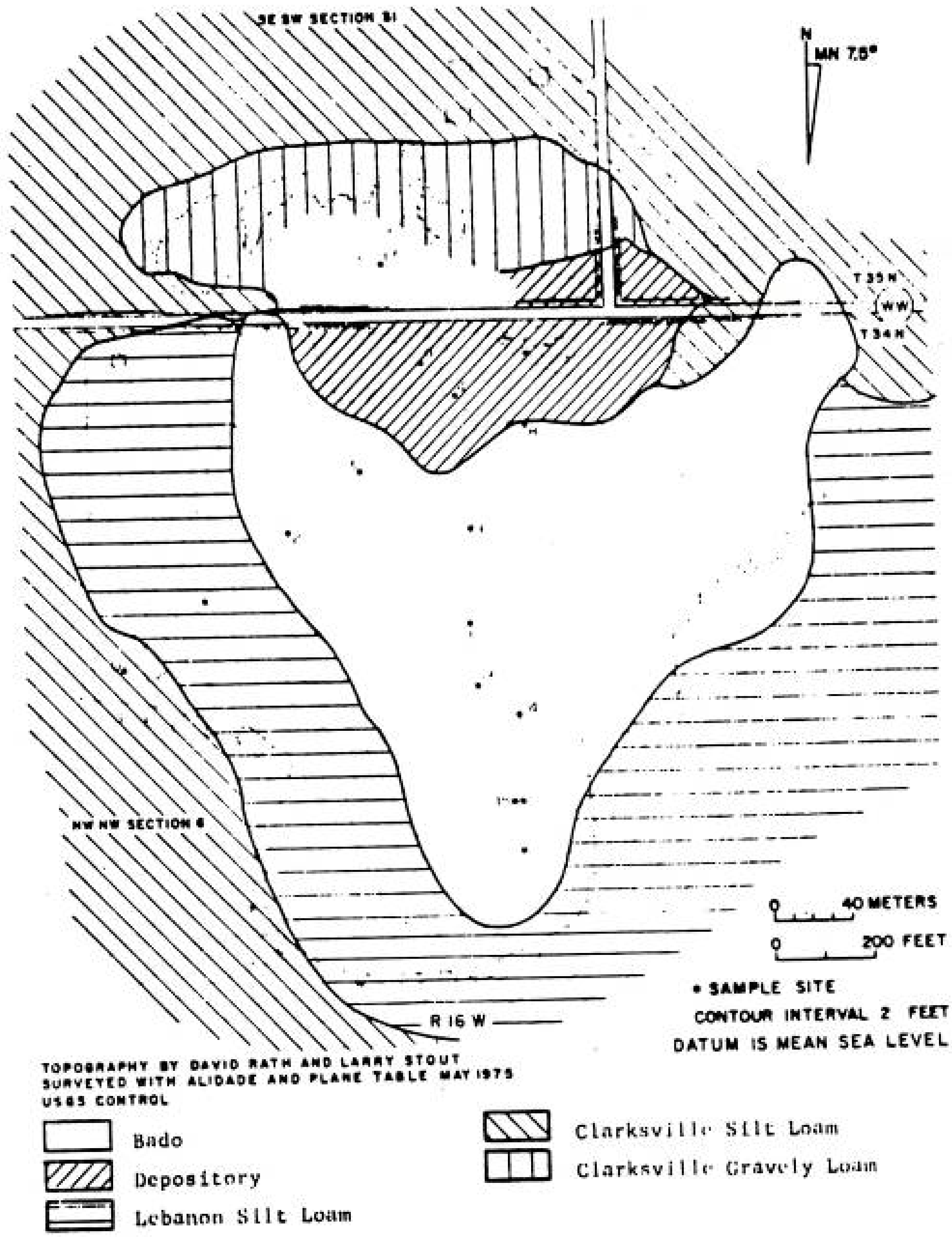
Just east of the spring there are two major sinkholes known as Whispering Dell and the Colosseum. Whispering Dell houses two small caves, while the Colosseum boasts an impressive natural bridge that is approximately 70 feet wide, 50 feet high, and spans almost 50 feet. The natural bridge is a remnant of the original cave roof.

Another significant feature of the natural area, although separated by the main park road, is River Cave, the largest cavern in the park. Waters entering River Cave Sinkhole reach an underground recharge area for the spring, only one half mile away. River Cave also serves as a nursery site for gray bats. To protect the bat colony, the cave is closed to visitation from April 1 to Oct. 30. At other times of the year, park visitors may enter the cave with an approved caving permit, which may be obtained at the park office.

Excerpts from "A Study of Middle to Late Quaternary Sediments in a Karst Trap" by David Rath (M.S. Thesis)



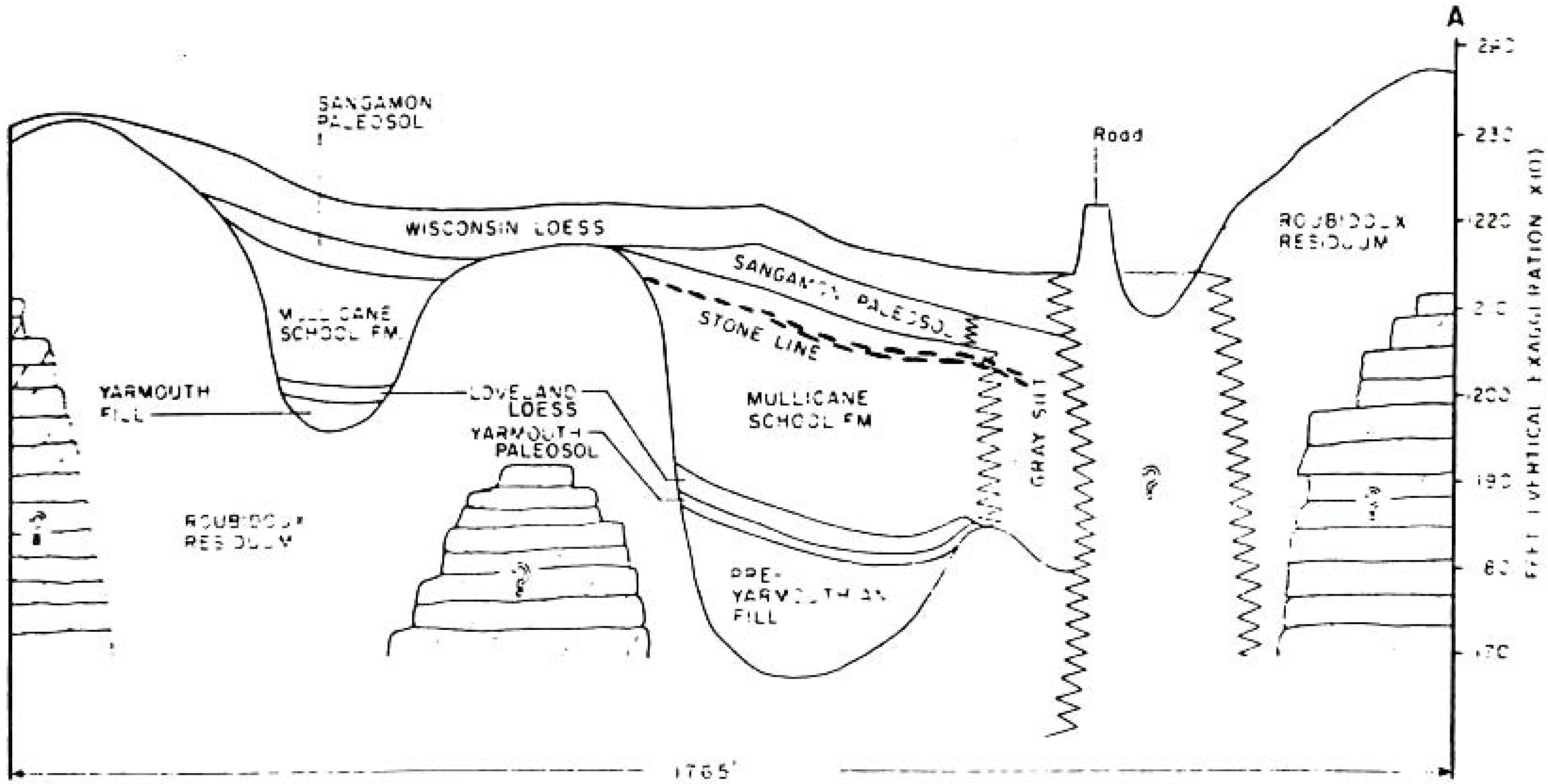
Stratigraphic column for the Lemery-Guion Sink



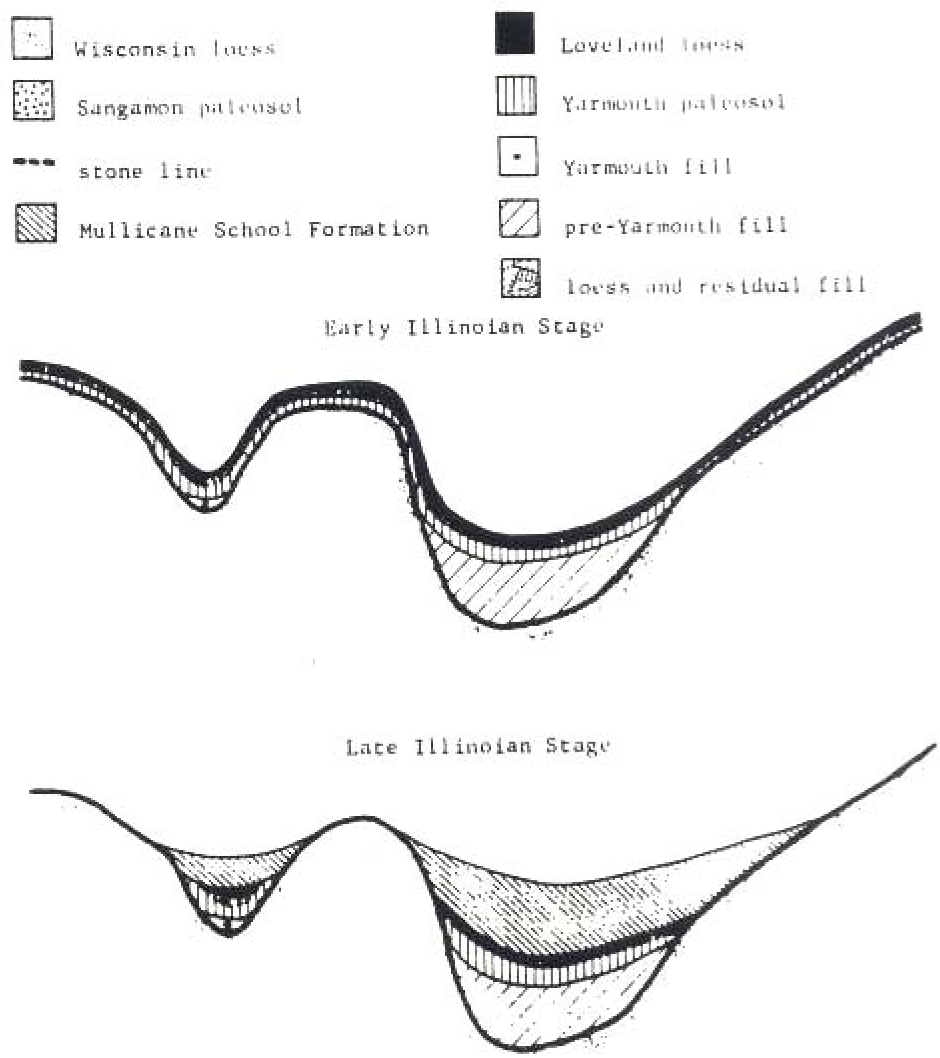
Soils map of the closed system

Figure 27

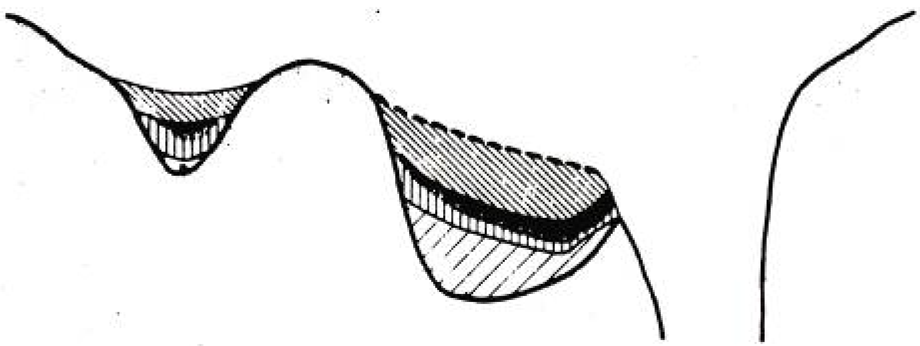
Cross section of the closed system along A-A'



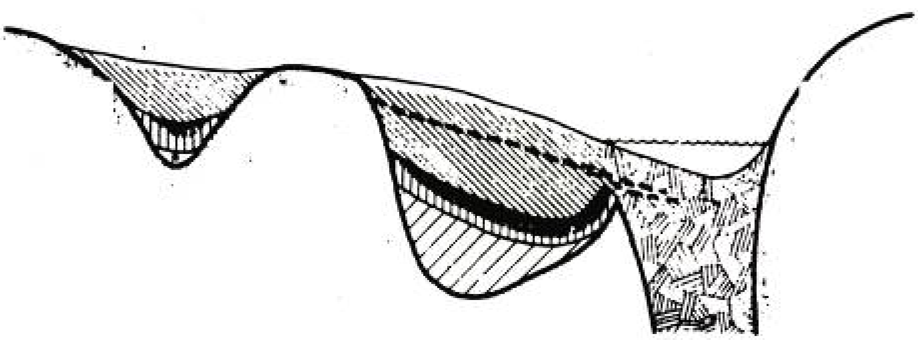
Generalized depositional history of the karst trap



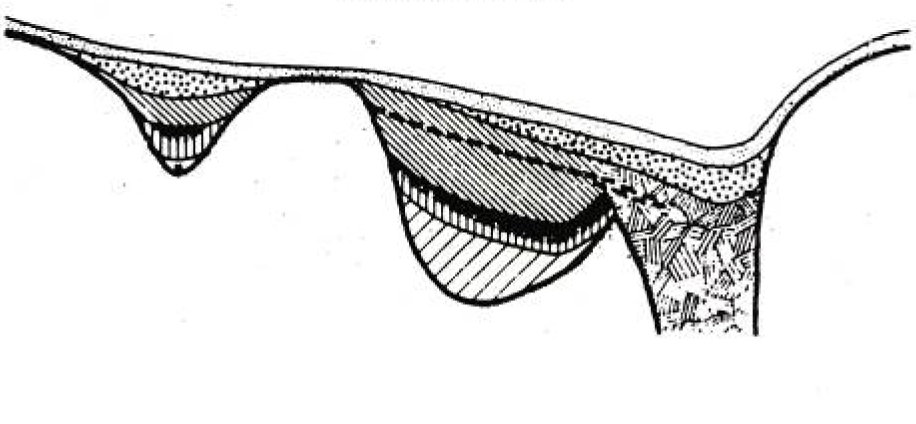
Late Illinoian Stage



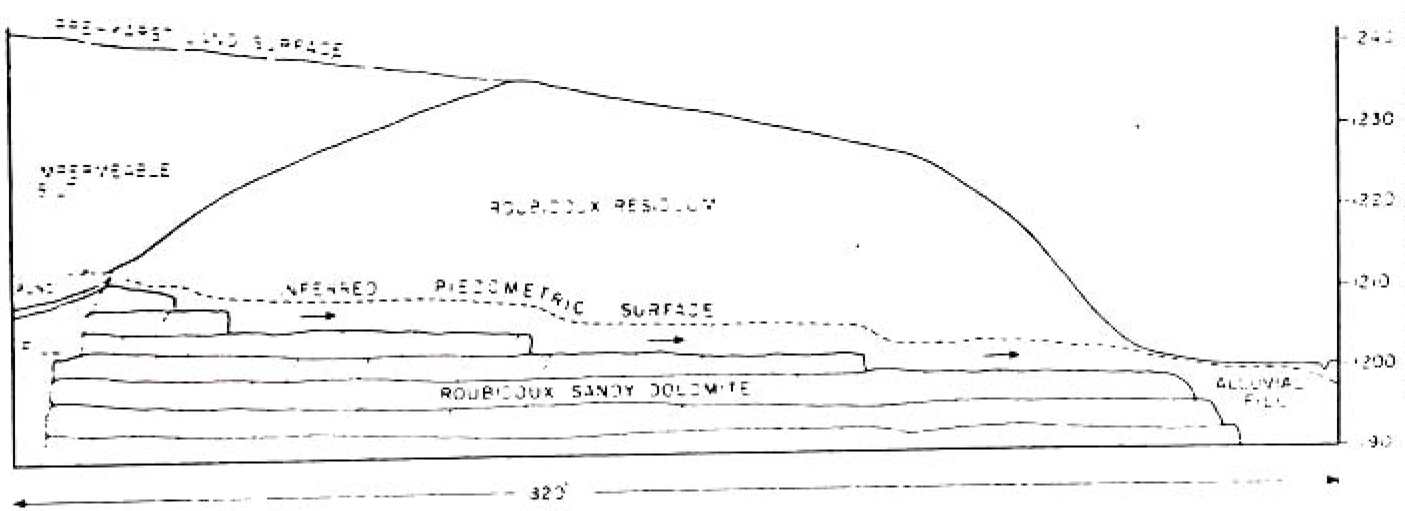
Sangamonian Stage



Wisconsinan Stage



Generalized cross section of north rim
The pre-karst land surface was inferred from the local topography



V. CONCLUSIONS

A. General

The coalescence of sinks as a result of upland karst development has provided large gentle depressions through erosion , deposition , and subsequent slope reduction. These karst traps have protected the enclosed sediments from the normal upland erosion and removal which has taken place in much of the Ozarks. In this closed system the record of middle to late Quaternary events on the Lebanon uplands which have long since been eroded away are preserved. The closed system studied in this thesis is believed to be pre-Yarmouthian in age. Not much can be said about how much older than Yarmouthian this system may be. Possibly there are such closed systems which are much older than Yarmouthian, and there is a possibility that sediments prior to the Yarmouthian Stage might be found. Many depressions are also known to be younger.

B. Recommendations for Further Research

Many such closed depressions as studied here exist on the Ozark uplands, such as in the Vichy, Salem, and West Plains areas. Closed depressions from other parts of the Ozark uplands should be investigated to see if any correlation exists between them and tile system studied herein. Many of those closed systems, as was found in the Lebanon area, have been breached and become part of the present drainage system. However, in the flatter upland areas, modern drainage has probably affected only. the very upper portions of the system near the surface. These systems probably contain as much information, if not more, than the systems studied here. Correlations and differences between systems on tile Salem and Springfield Plateaus may also prove interesting.

Because of time constraints, geochemical analysis was of Iimited value for the purpose of this study. However, geochemical studies of surficial materials in Missouri (Boerngen, Van Trump, and Ebens,1975) promise to provide a useful tool for studying; and correlating; karst deposits.