1983

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Douglas Malo

TB 66
NOVEMBER 1983

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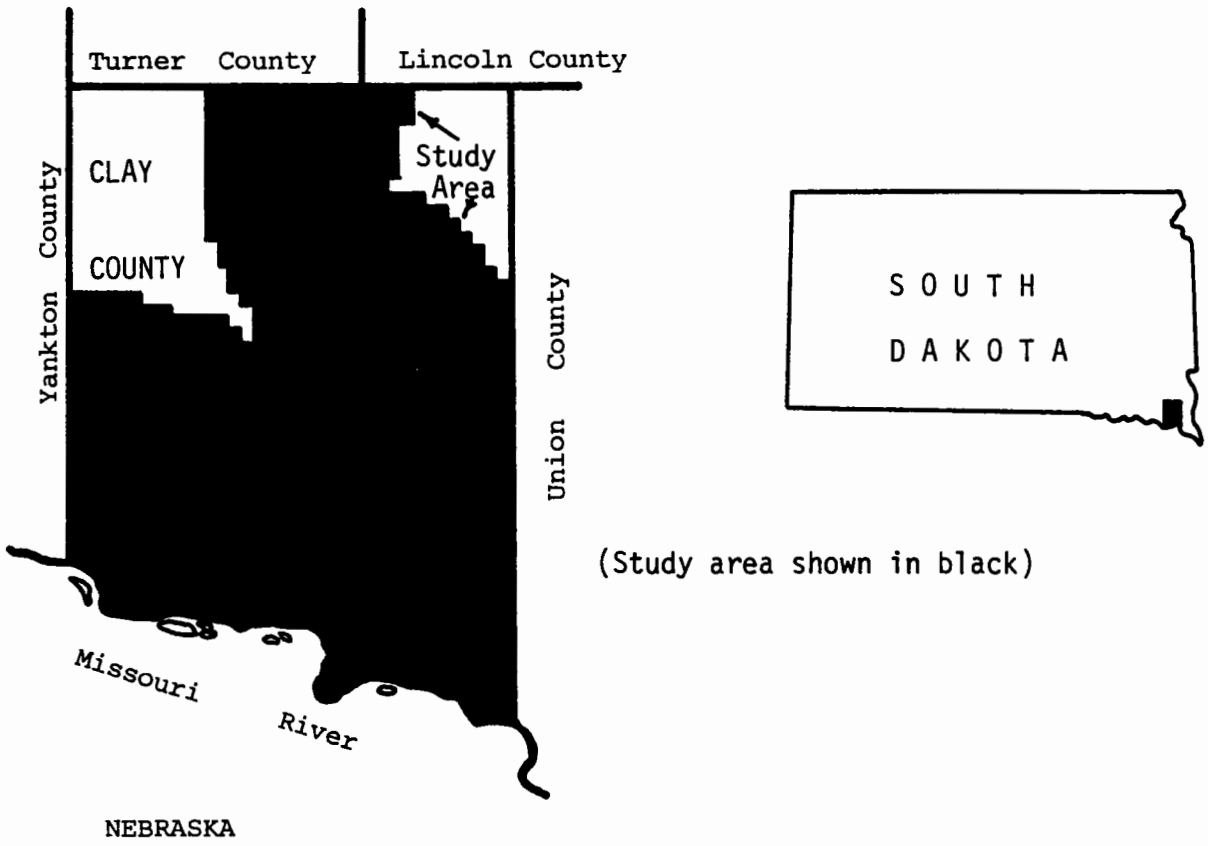

(Study area shown in black)

AGRICULTURAL EXPERIMENT STATION
PLANT SCIENCE DEPARTMENT
SOUTH DAKOTA STATE UNIVERSITY
BROOKINGS

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Acknowledgement

The author wishes to thank Bonnie Hartman and Lori Hofland for their assistance in preparing the soil map sheets and typing the manuscript.

Published in accordance with an Act passed in 1881 by the 14th Legislative Assembly, Dakota Territory, establishing the Dakota Agriculture College and with the Act of re-organization passed in 1887 by the 17th Legislative Assembly, which established the Agricultural Experiment Station at South Dakota State University.

Soil Limitations for Septic Tank Absorption Fields in Selected Areas of Clay County, South Dakota[1]

by

Douglas D. Malo[2]

INTRODUCTION

The aquifers of the Missouri and Vermillion Rivers in Clay County, South Dakota are important sources of water for municipal and agricultural use. Nonincorporated residential developments in rural areas in southeastern South Dakota have increased over the last fifteen years. With this growth the chance for septic system contamination of underlying shallow aquifers and septic system problems has greatly increased. The proper use of soils overlying and draining into the aquifers is critical in maintaining water quality. As a result of this concern for potential pollution hazards and septic system failures, a study was initiated to identify soil limitations for septic tank absorption fields.

The objectives were to:

1) prepare and develop soil limitation ratings for septic tank absorption fields in Clay County soils,
2) transfer the boundaries of the study area and aquifer to a county map (see figure 1), and
3) prepare and develop soil septic tank limitation maps for areas overlying and within one-half mile of designated aquifer areas. This represents an area of approximately 150 square miles along the Missouri Aquifer and 170 square miles along the Vermillion Aquifer or a total of 320 square miles (80 percent) of Clay County.

The bulletin is meant to point out potential problem areas and not provide very detailed site information. It is designed to serve as a guide for county and state officials as they plan the development of the county.

STUDY LIMITATIONS

The maps and data contained in this document are for planning purposes and are not meant to replace "on-site" investigation for residential or other types of urban development. Because of the limitations of the data available the maps in this publication are only useful down to a size of about eight to ten acres.

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[1] Contribution from the Plant Science Department and the Agricultural Experiment Station, South Dakota State University, Brookings, 57007. Project H-151. Funded in part by a grant from East Dakota Conservancy Sub-District and the Interagency Water Quality Management Council.

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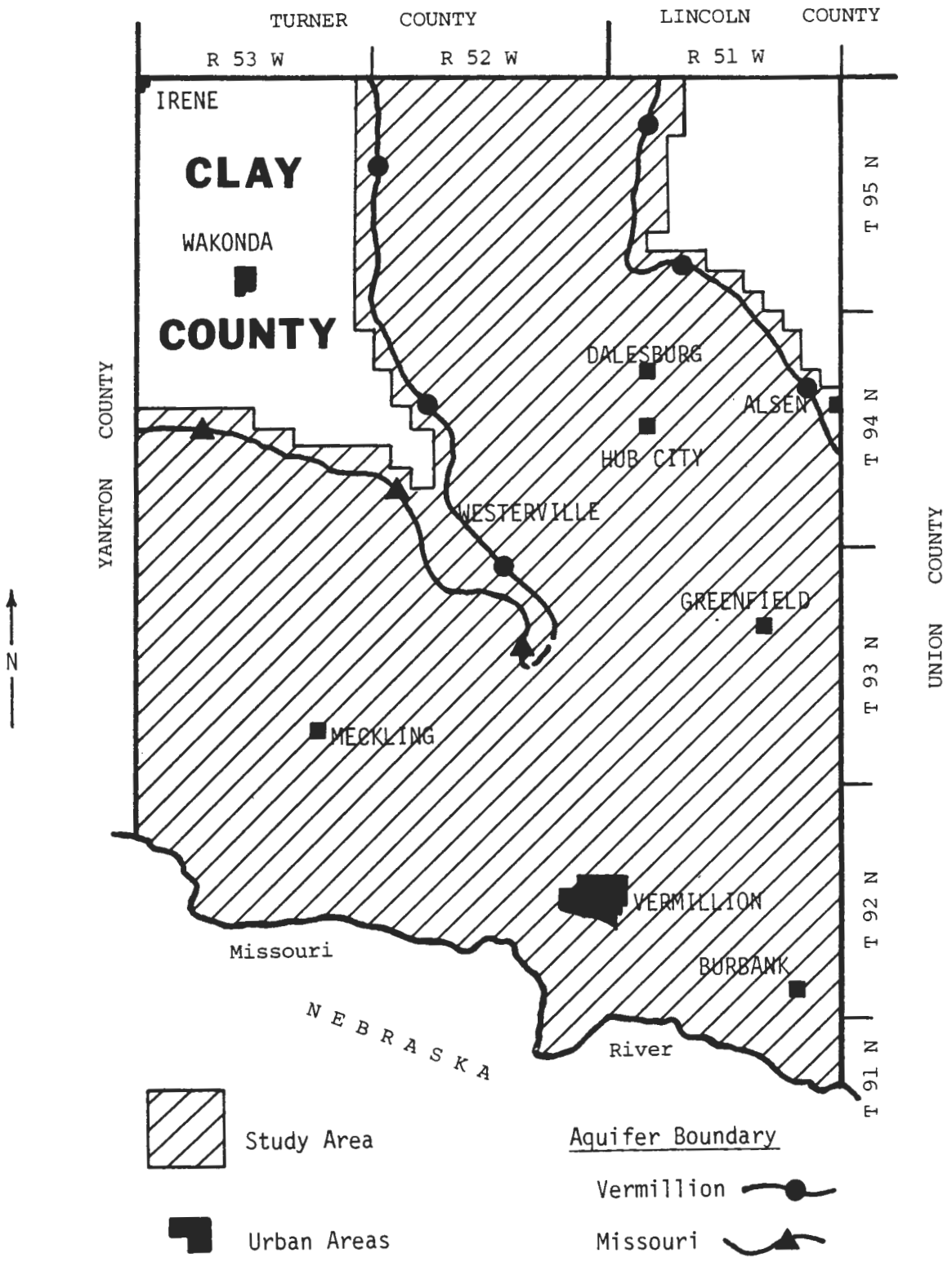


Figure 1. Location of aquifers and study area in Clay County. Map scale = 1:253,440.

SEPTIC TANK ABSORPTION FIELDS

Septic tank absorption fields have subsurface tile lines which distribute sewage effluent from septic tank systems into the soil. The tile line is assumed to be at a depth of 24 to 36 inches. The soil material between 24 inches and 72 inches was evaluated. The soil characteristics and topographic (site) features which affect the absorption of effluent, affect system construction, and may affect public health and water quality were considered (USDA-SCS, 1979; Elliott and Stevenson, 1977; USDHEW, 1967).

Soil properties which affect effluent absorption and system construction include permeability, depth to seasonal high water table, depth to bedrock, susceptibility to flooding or ponding, and stoniness. Excessive slopes (>15%) can cause lateral seepage and surfacing of sewage effluent downslope. Steep slopes (>15%) cause soil erosion and soil slippage which can cause problems for septic systems. If loose sand or gravel occurs at a depth less than 48 inches below the distribution line contamination of shallow ground water supplies may occur. In these situations the soil does not adequately filter the sewage effluent.

RATING SOIL USE FOR SEPTIC TANK ABSORPTION FIELDS

Soils are rated based on the presence of the most restrictive features for septic systems. Thus, a soil rated severe gives only the soil property that caused the soil to be rated severe. This soil may have other restrictive features for septic tank absorption fields. Soils are rated under natural conditions. No unusual modification of soil materials or site characteristics was considered.

Soil limitations are indicated by the ratings slight, moderate and severe. Slight means that soil properties are favorable and the limitations are minor or easily corrected. No major problems in system performance or maintenance are expected.

Moderate means some soil and/or topographic properties are unfavorable but can be modified or corrected with special design, planning, or maintenance. Artificial drainage, flood control, and extension of absorption tile lines are examples of modifications used to remedy soils with moderate limitations. During at least part of each year the use of these soils for septic systems is less favorable than for soils with slight limitations.

Severe means soil properties are unfavorable for use and are difficult and expensive to correct. These limitations require major soil reclamation, special field design, or intensive maintenance. In some instances the soil can be improved by reducing or removing the soil property limiting its use. Usually this practice is very difficult and costly.

Many soils with moderate or severe limitations for septic systems can be modified to achieve satisfactory performance (Beatty and Bouma, 1973; Bouma, 1974). It is important to remember that in rating soils for nonfarm use, engineers can modify soil properties, site features, or can adjust system designs and management to compensate for most limitations. The key question, however, is cost. Such considerations were not considered in this publication. Soils were considered in their natural, unaltered state.

CRITERIA USED

The criteria used in this study to rank soils based on limitations for septic tank absorption fields are presented in Table 1.

In 1967, the USDHEW developed percolation test criteria which some regulatory agencies use to evaluate soil suitability for septic tank absorption fields. The percolation test criteria differ from the permeability criteria developed by the USDA (Table 1). Percolation tests are performed during the season when the water table is the highest and the soil has its minimum absorptive capacity. The USDHEW indicates that soils having percolation rates (1) faster than 45 minutes per inch (2.54 cm) have slight limitations, (2) between 45 and 60 minutes per inch have moderate limitations and (3) slower than 60 minutes per inch have severe percolation limitations (USDHEW, 1967).

CATEGORIES DEVELOPED

Based on the soil limitation criteria listed in Table 1 categories of soil limitations for septic tank absorption fields were developed and are summarized in Table 2.

Category 1. These are soils which have slight limitations for septic systems. These soils have little or no potential to contaminate the aquifers and they do not require any special septic system design or maintenance plan. All soil properties and site characteritics are favorable for septic system use.

Category 1A. Soil mapping units which have both slight and moderate limitations for septic systems present in the same mapping unit. Both degrees of limitations are so mixed that it is not possible to separate them in the scale of mapping used. Generally the most common types of moderate limitations found in Category 1A in the study area were "percs slowly" and "slope". Soils rated 1A require on-site inspection to locate soils in the mapping unit with slight limitations. Treatments such as control of runoff and erosion, extended absorption fields, or modified system design are needed on soils with moderate limitations.

Category 2. Soil mapping units in this category have moderate limitations for septic systems. In the study area these limitations were "percs slowly, slope, or rare flooding and ponding". The exact limitation should be determined by on-site inspection and reading the soil mapping unit description in the detailed soil survey of the county. Soils rated 2 require site and/or soil treatments to reduce flooding or ponding hazard, extended absorption fields, control of runoff to reduce erosion, or modified system design and maintenance.

Category 2A. Soil mapping units which have both slight and severe limitations for septic systems present in the same mapping unit. Both degrees of limitations are so mixed that it is not possible to separate them in the scale of mapping used. The exact severe limitation should be determined by on-site inspection and reading the soil mapping unit description in the detailed soil survey of the county. Because of the wide range of severe limitations no modifications or reclamation practices are listed here. See discussion of severe limitations in Categories 4 thru 7 for the type of severe limitation found during the on-site inspection.

Table 1. Soil Limitations Criteria for Septic Tank Absorption Fields*

Property	Degree of Limitation			Limitation
	Slight	Moderate	Severe	
Flooding or Ponding	None	Rare	Common, Frequent, Occasional	Floods or Ponds
Depth to Bedrock	>72in. (>183cm)	40-72in. (102-183cm)	<40in. (<102cm)	Depth to Bedrock
Depth to High Water Table	>72in. (>183cm)	48-72in. (122-183cm)	0-48in. (0-122cm)	Wetness
Permeability in 24-72in. (61-183cm) depth	2.0-6.0in/hr (5-15cm/hr)	0.6-2.0in/hr (1.5-5cm/hr)	<0.6in/hr (<1.5cm/hr)	Percs slowly
Filtering 24-72in. (61-183cm) depth	- - - -	- - - -	>6.0in/hr (>15cm/hr)	Poor filter
Slope (avg for mapping unit) in pct.	0-8	8-15	15	Slope
Soil Fraction >3in. (>8cm) in dia. Weight pct to a depth of 40in. (102cm)	<25	25-50	>50	Large stones

* Modified from USDA-SCS, 1979. Application of Soil Survey Information, Table 403.1a.

Table 2. Categories of Soil Limitations for Septic Tank Absorption Fields

Mapping Unit Limitation Code	Degree of Limitation	Limitation(s)
1	Slight	- - -
1A	Slight and Moderate*	Any moderate limitation
2	Moderate	Any moderate limitation
2A**	Slight and Severe*	Any severe limitation
3**	Moderate and Severe*	Any combination of moderate and severe limitations
4**	Severe	Wetness, flooding, or ponding plus other problems including poor filter, percs slowly, and depth to rock
5**	Severe	Poor filter
5A**	Severe	Depth to rock
6**	Severe	Slope and slope plus percs slowly
7**	Severe	Percs slowly
8**	Severe	Combination of two or more different severe limitations

*Both degrees of limitations occur in soil mapping unit.

**On-site inspection and further detailed planning is needed before final approval can be given on soils in these categories for septic tank absorption field use.

Category 3. The soil mapping units in this category have both moderate and severe limitations for septic systems. Both degrees of limitation are so mixed that it is not possible to separate them at the scale of mapping used. The exact limitations present at a specific site must be determined by on-site inspection. Reclamation and modification practices depend on the degree of limitation and type of limitation found at the site.

Category 4. Soil mapping units in this category have a severe wetness problem due to a high water table or flood and pond frequently. In addition, many of the soils in this category have other limitations including, "depth to rock, poor filter, and percs slowly". Some of these soils can be improved by artificial drainage and protection from flooding or ponding. The other non-water related limitations will be discussed later.

Category 5. Category 5 soil mapping units have a severe limitation because they are poor filters and thus can allow contamination of water supplies. These are soils with sand and gravel within 4 feet of the absorption line. Some of these soils can be improved by mounding to increase the depth of soil material overlying the loose sands and gravels.

Category 5A. The soils in Category 5A have a severe limitation for septic systems because of the shallow depth to bedrock. Some of these soils can be improved by mounding soil material to the needed depth and placing the tile absorption lines in the mounds.

Category 6. The soils in Category 6 have severe slope limitations for septic systems. Problems with lateral seepage, erosion, soil slippage and surfacing of sewage effluent are common. In addition, some soils in this category also have very slow permeability. The installation of specialized septic systems and intensive management can improve some soil ratings for septic systems.

Category 7. The soil mapping units in category 7 all have severe limitations as a result of very slow permeability due to high clay contents and low pore space as a result of structural patterns. Some of these soils can be improved by mounding with more permeable material or by modification of the septic system such as lengthening the absorption lines.

Category 8. The soils in this category have many different severe limitations in each mapping unit. On-site inspection is needed to determine which severe limitation is most limiting and whether soil reclamation or site modification is feasible.

RANKING OF SOILS

Using the categories developed and defined in the previous section and listed in Table 2, the soils of Clay County were categorized according to their limitations for septic tank absorption field use (see Table 3). Detailed soils information was obtained from the soil survey of the area (Buntley, Bourne, and Westin, 1953) and from detailed soil series information sheets (USDA-National Cooperative Soil Survey, one sheet per soil series).

Table 3. Categorization of Soils for Septic Tank Absorption Fields in Clay County.

Soil Map Symbol	Description and Name	Limitation Category Code
10	Barnes loam, nearly level, 0-3% slopes	7
11	Barnes loam, undulating, 3-8% slopes	7
12	Barnes loam, eroded, undulating, 3-8% slopes	7
13	Barnes loam, rolling, 8-13% slopes	7
14	Barnes loam, eroded, rolling, 8-13% slopes	7
15	Buse loam, steep, 13-40% slopes	6
16	Buse loam, eroded, steep, 13-40% slopes	8
17	Parnell silty clay loam-Hamerly loam, nearly level, 0-3% slopes	4
18	Parnell silty clay loam, level, 0-1% slopes	4
20	Moody silt loam,, undulating, 3-8% slopes	2
21	Trent silty clay loam, nearly level, 0-3% slopes	3
22	Alsen silty clay loam, level, 0-1% slopes	4
23	Trent silty clay loam-Moody silt loam, nearly level 0-3% slopes	3
24	Trent-Alsen silty clay loams, nearly level, 0-3% slopes	4
25	Wakonda-Trent silty clay loams, nearly level, 0-3% slopes	4
30	Kranzburg silty clay loam-Barnes loam, undulating 3-8% slopes	7
31	Kranzburg silty clay-loam-Barnes loam, eroded, undulating, 3-8% slopes	7
32	Trent silty clay loam-Barnes loam nearly level, 0-3% slopes	7
40	Maddock fine sandy loam and loamy fine sand, nearly level, 0-3% slopes	5
41	Maddock fine sandy loam and loamy fine sand, undulating, 3-8% slopes	5
50	Fordville loam, nearly level, 0-3% slopes	5
51	Fordville loam, gently sloping, 3-8% slopes	5
52	Fordville loam, coarse sand substratum, nearly level, 0-3% slopes	4
53	Flandreau silt loam, terrace phase, nearly level, 0-3% slopes	3
60	Alcester-Judson silt loams, nearly level, 0-3% slopes	3
61	Alcester-Judson silt loams, gently sloping, 3-8% slopes	3
62	Alcester-Judson silt loams, eroded, sloping, 8-13% slopes	2
63	Alcester-Lamoure silt loams, nearly level, 0-3% slopes	4
64	McPaul silt loam, nearly level, 0-3% slopes	4

Table 3. Categorization of Soils for Septic Tank Absorption Fields in Clay County (continued)

Soil Map Symbol	Description and Name	Limitation Category Code
100	Onawa silty clay, level, 0-1% slopes	4
101	Onawa clay, level, 0-1% slopes	4
102	Onawa silty clay, very shallow to sand, level, 0-1% slopes	4
103	Luton clay, level, 0-1% slopes	4
104	Luton-Solomon silty clays, level, 0-1% slopes	4
105	Napa complex, level, 0-1% slopes	4
200	Blencoe silty clay loam, level, 0-1% slopes	4
201	Blencoe-Gayville silty clay loams, level, 0-1% slopes	4
202	Blencoe-Lamoure silty clay loams, slightly saline, nearly level, 0-3% slopes	4
203	Lamoure silty clay loam, level, 0-1% slopes	4
300	Volin silt loam, level, 0-1% slopes	3
301	Haynie silt loam, nearly level, 0-3% slopes	3
302	Haynie silt loam, sloping, 8-13% slopes	3
303	Wann-Leshara loams, level, 0-1% slopes	4
400	Sarpy fine sandy loam, nearly level, 0-3% slopes	4
401	Sarpy loamy fine sand, nearly level, 0-3% slopes	4
402	Riverwash	4
	Gravel Pits	8

SOIL LIMITATION MAPS

Soil map sheets from the Clay County Soil Survey (1953) were selected to use as base maps for this study. The soil maps were originally published at a scale of 1:56,320 and were photo copied at the same scale. The East Dakota Conservancy Sub-District provided the aquifer map (from Christensen, 1967) and designated the areas to be evaluated. See the Index to Map Sheets (figure 2) which shows the aquifer boundaries, the study area, map sheet location, and section information. The limitation categories for septic tank absorption fields were coded onto each soil map using the criteria and categories developed in previous sections. The coded soil maps appear as Figures 3 thru 14. Legends for the symbols and limitation categories are listed in Tables 4 and 5.

Figure 2. Index to map sheets for Clay County, SD. Map Scale = 1:212,182

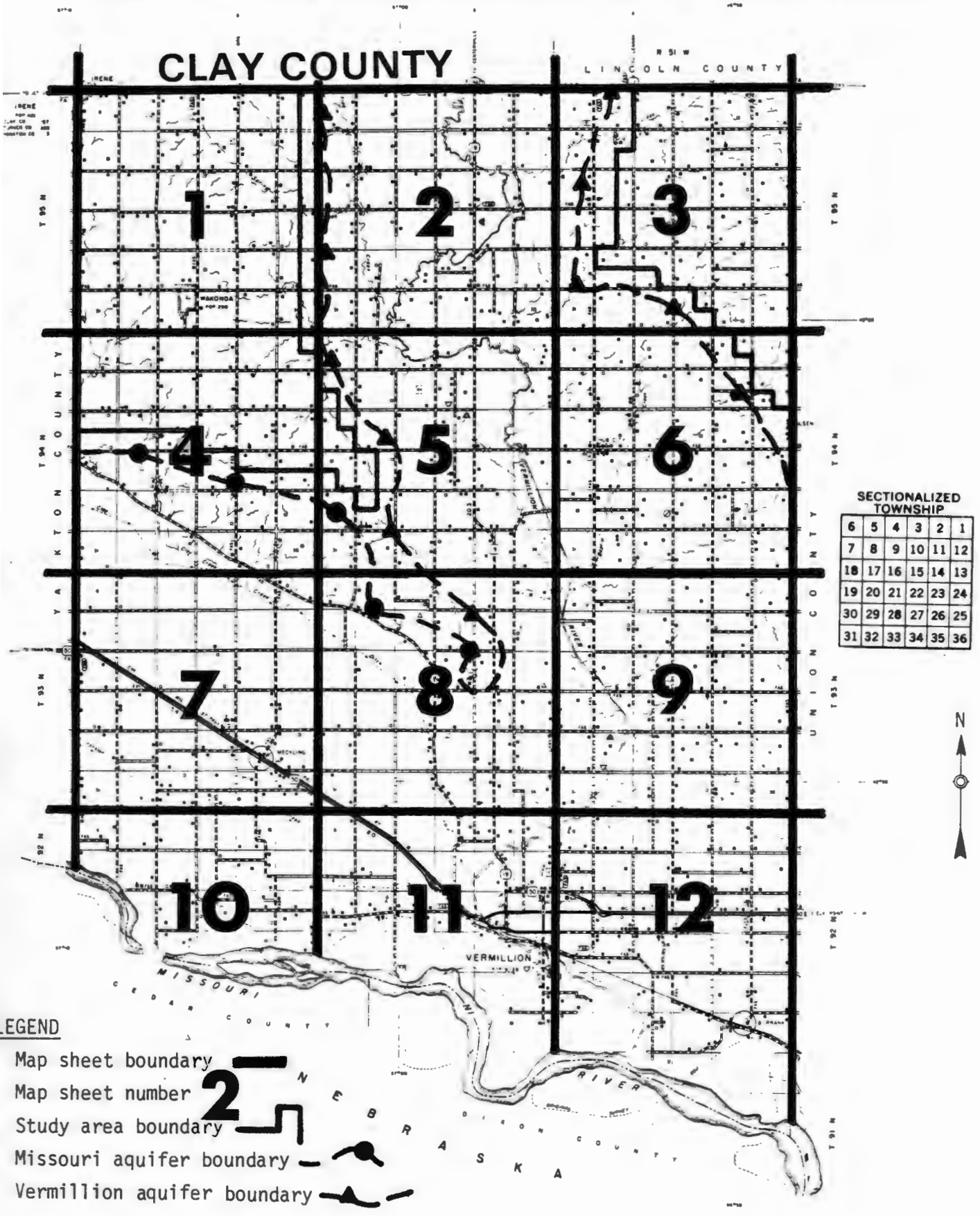
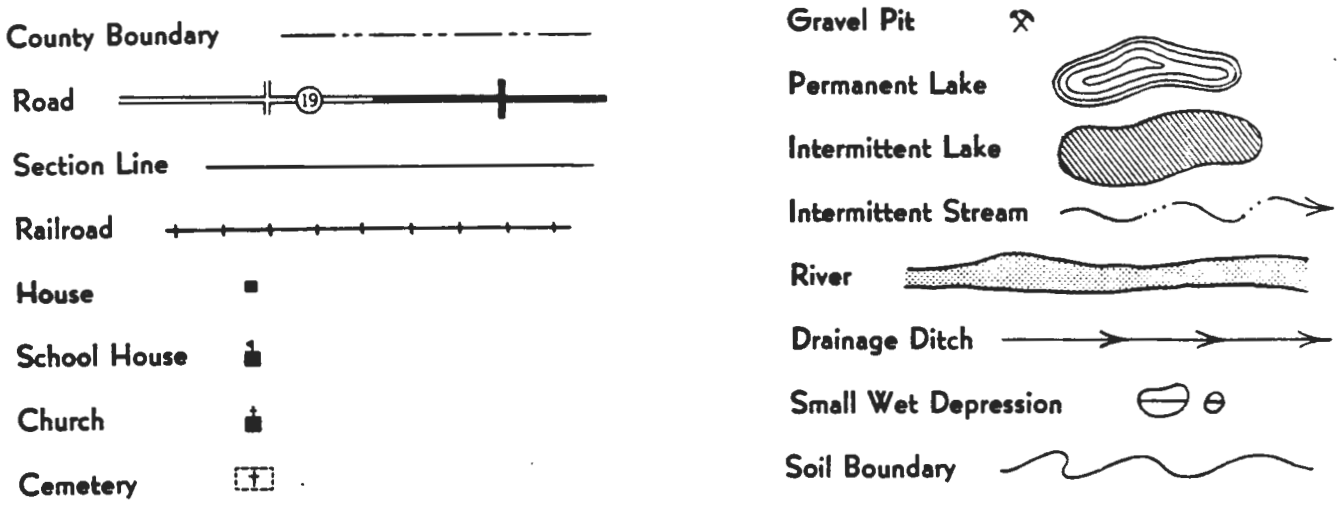


Table 4. Soil Legend for Soil Limitation Maps, Figures 3 thru 14 (Buntley, et al., 1953).

Soil Map Symbol	Description and Name
10	Barnes loam, nearly level, 0-3% slopes
11	Barnes loam, undulating, 3-8% slopes
12	Barnes loam, eroded, undulating, 3-8% slopes
13	Barnes loam, rolling, 8-13% slopes
14	Barnes loam, eroded, rolling, 8-13% slopes
15	Buse loam, steep, 13-40% slopes
16	Buse loam, eroded, steep, 13-40% slopes
17	Parnell silty clay loam-Hamerly loam, nearly level, 0-3% slopes
18	Parnell silty clay loam, level, 0-1% slopes
20	Moody silt loam,, undulating, 3-8% slopes
21	Trent silty clay loam, nearly level, 0-3% slopes
22	Alsen silty clay loam, level, 0-1% slopes
23	Trent silty clay loam-Moody silt loam, nearly level 0-3% slopes
24	Trent-Alsen silty clay loams, nearly level, 0-3% slopes
25	Wakonda-Trent silty clay loams, nearly level, 0-3% slopes
30	Kranzburg silty clay loam-Barnes loam, undulating 3-8% slopes
31	Kranzburg silty clay-loam-Barnes loam, eroded, undulating, 3-8% slopes
32	Trent silty clay loam-Barnes loam nearly level, 0-3% slopes
40	Maddock fine sandy loam and loamy fine sand, nearly level, 0-3% slopes
41	Maddock fine sandy loam and loamy fine sand, undulating, 3-8% slopes
50	Fordville loam, nearly level, 0-3% slopes
51	Fordville loam, gently sloping, 3-8% slopes
52	Fordville loam, coarse sand substratum, nearly level, 0-3% slopes
53	Flandreau silt loam, terrace phase, nearly level, 0-3% slopes
60	Alcester-Judson silt loams, nearly level, 0-3% slopes
61	Alcester-Judson silt loams, gently sloping, 3-8% slopes
62	Alcester-Judson silt loams, eroded, sloping, 8-13% slopes
63	Alcester-Lamoure silt loams, nearly level, 0-3% slopes
64	McPaul silt loam, nearly level, 0-3% slopes
100	Onawa silty clay, level, 0-1% slopes
101	Onawa clay, level, 0-1% slopes
102	Onawa silty clay, very shallow to sand, level, 0-1% slopes
103	Luton clay, level, 0-1% slopes
104	Luton-Solomon silty clays, level, 0-1% slopes
105	Napa complex, level, 0-1% slopes
200	Blencoe silty clay loam, level, 0-1% slopes
201	Blencoe-Gayville silty clay loams, level, 0-1% slopes
202	Blencoe-Lamoure silty clay loams, slightly saline, nearly level, 0-3% slopes
203	Lamoure silty clay loam, level, 0-1% slopes
300	Volin silt loam, level, 0-1% slopes
301	Haynie silt loam, nearly level, 0-3% slopes
302	Haynie silt loam, sloping, 8-13% slopes
303	Wann-Leshara loams, level, 0-1% slopes
400	Sarpy fine sandy loam, nearly level, 0-3% slopes
401	Sarpy loamy fine sand, nearly level, 0-3% slopes
402	Riverwash
	Gravel Pits

Table 5. Conventional and Soil Limitation Symbols Legend for Soil Limitation Maps, Figures 3 thru 14 (modified from Buntley, et al., 1953).

CONVENTIONAL SIGNS



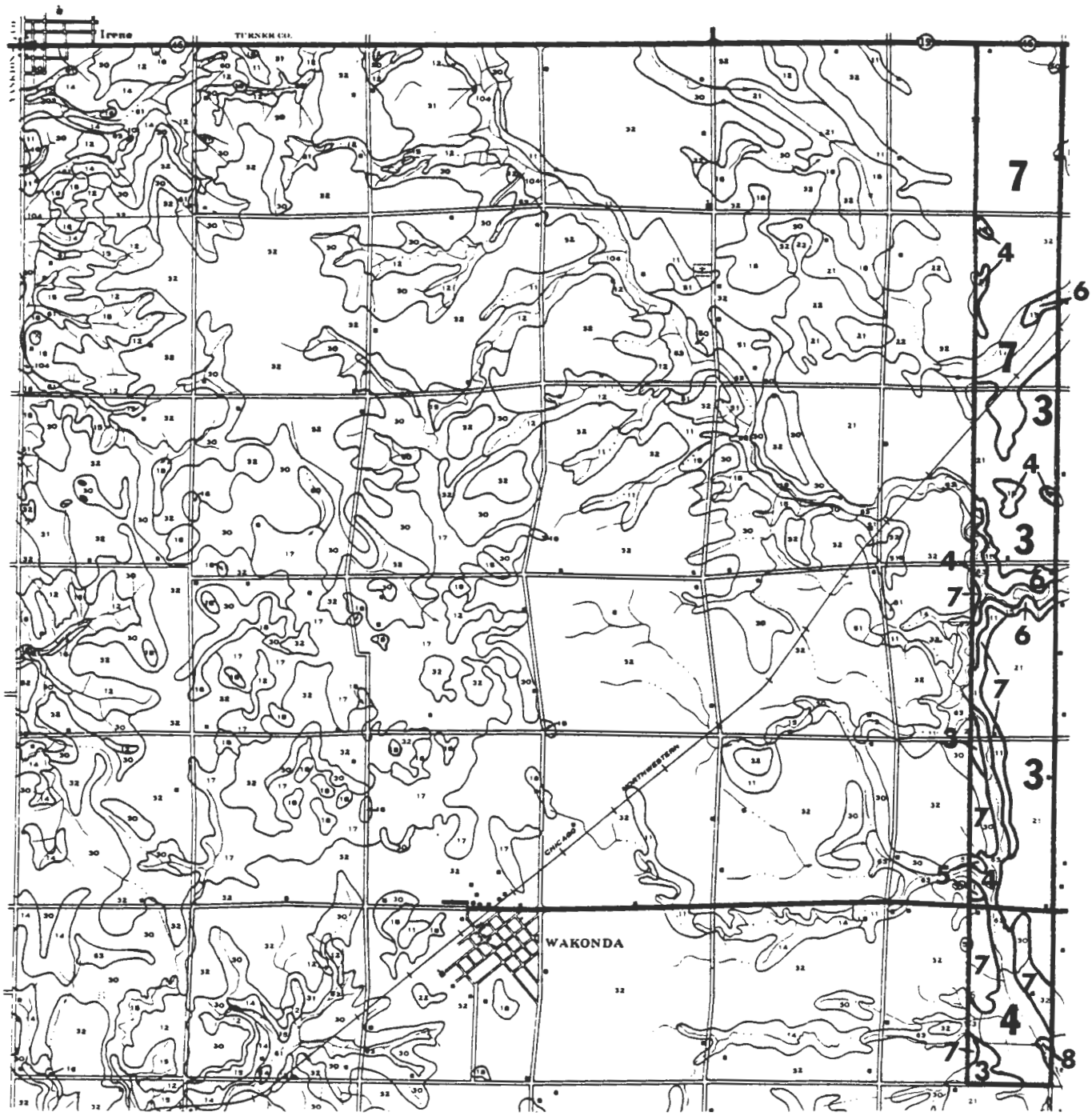
SOIL LIMITATION SYMBOLS

Soil Boundary and Limitation Symbol 

Severity of Limitation	Limitation	Limitation Symbol
Slight		1
Slight and Moderate	Any	1A
Moderate	Any	2
Slight and Severe	Any	2A
Moderate and Severe	Any	3
Severe	Wetness, flooding	4
Severe	Poor filter	5
Severe	Depth to rock	5A
Severe	Slope	6
Severe	Percs slowly	7
Severe	At least 2 different limitations present	8

Figure 3-Soil Limitation Map
Clay County
Soil Survey Map Sheet No. 1
Scale 1:56,320 Page 14
T95N, R53W

R 53 W



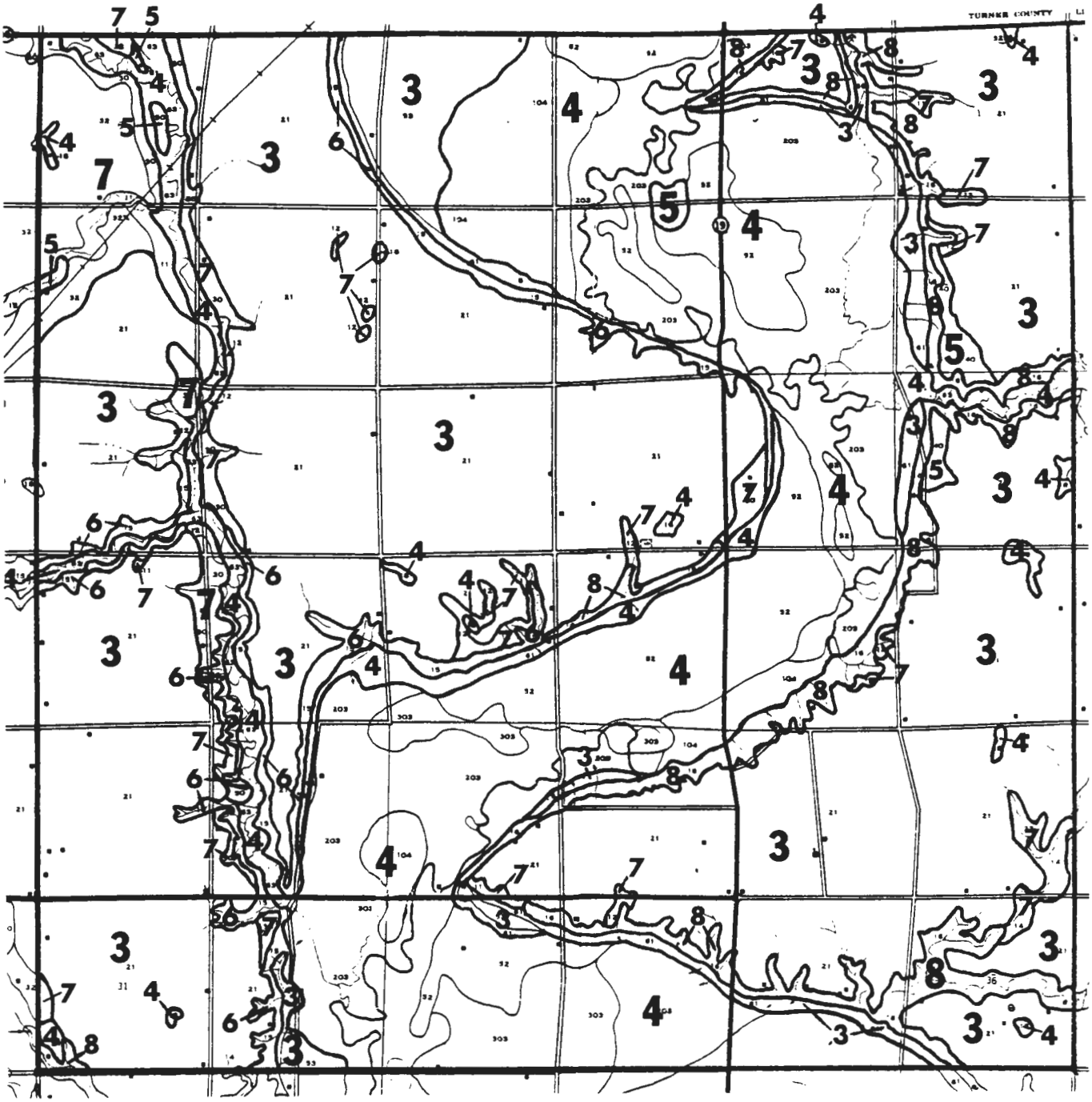
T 95 N

Scale in miles

1 0 1 2

Figure 4-Soil Limitation Map
Clay County
Soil Survey Map Sheet No. 2
Scale 1:56,320 Page 15
T95N, R52W

R 52 W



T
95
N

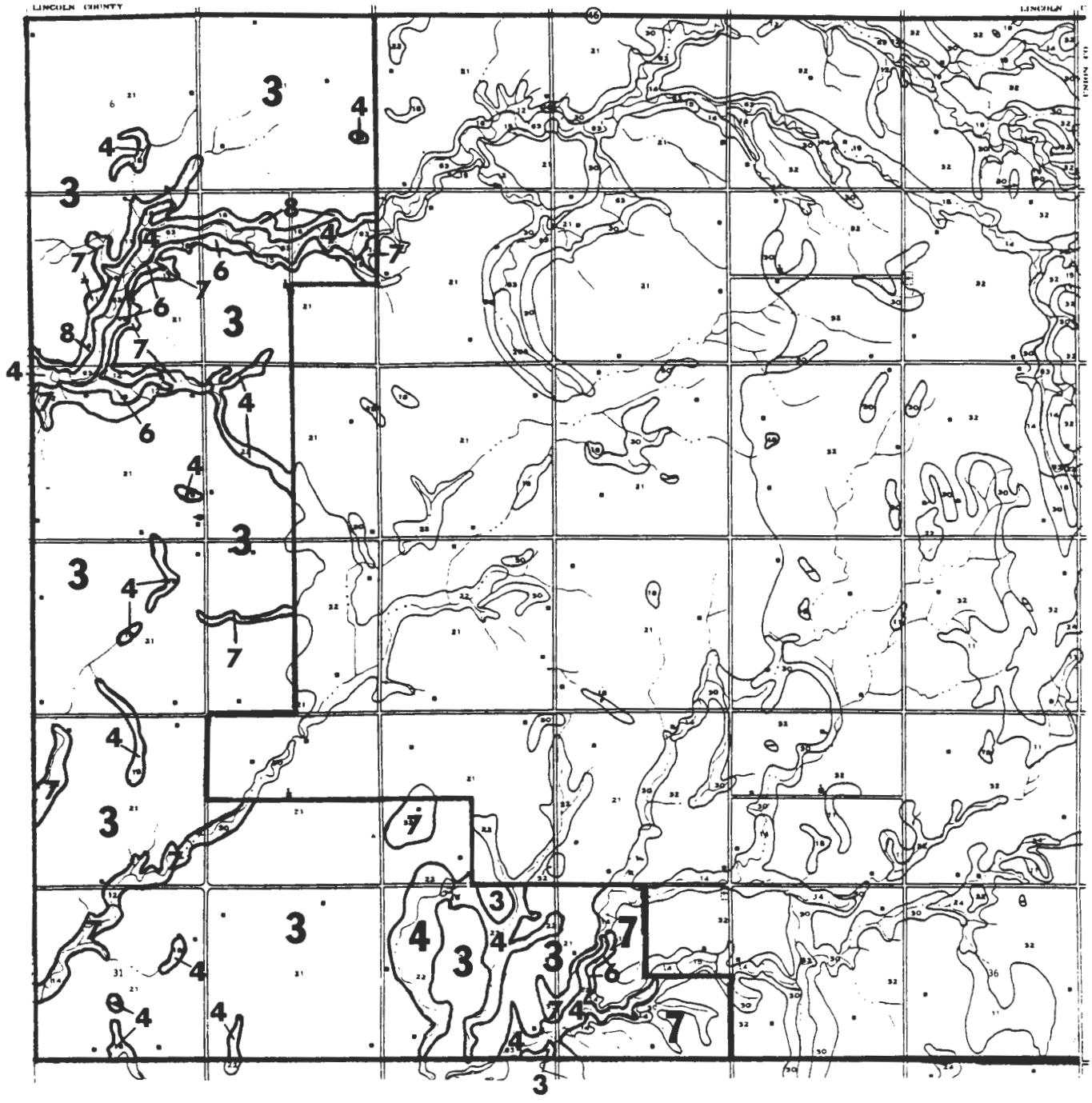
Scale in miles

1 0 1 2

Figure 5-Soil Limitation Map
Clay County
Soil Survey Map Sheet No. 3
Scale 1:56,320 Page 16
T95N, R51W

R 51 W

T
95
N

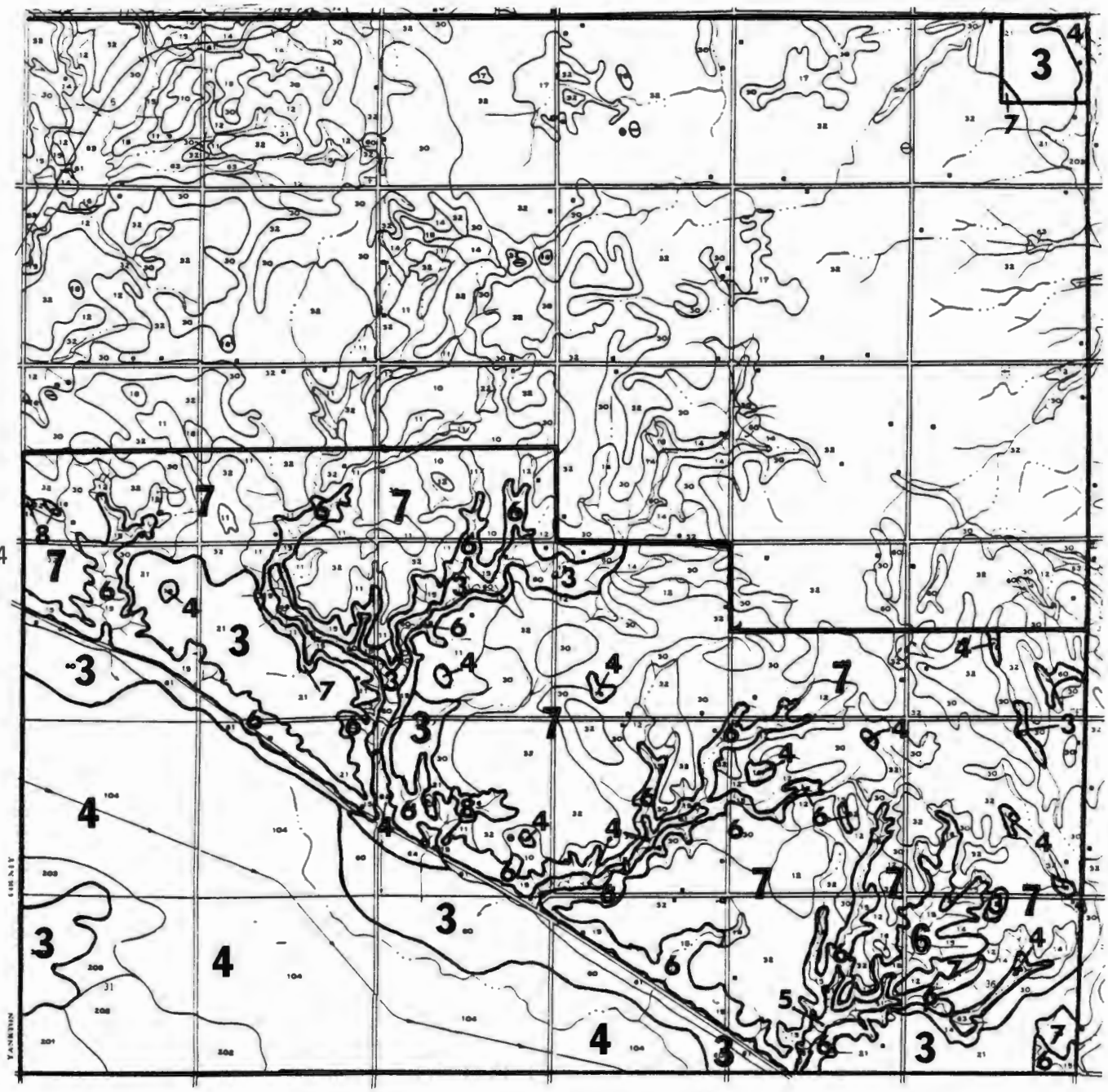


Scale in miles

1 0 1 2

Figure 6-Soil Limitation Map
Clay County
Soil Survey Map Sheet No. 4
Scale 1:56,320 Page 17
T94N, R53W

R 53 W



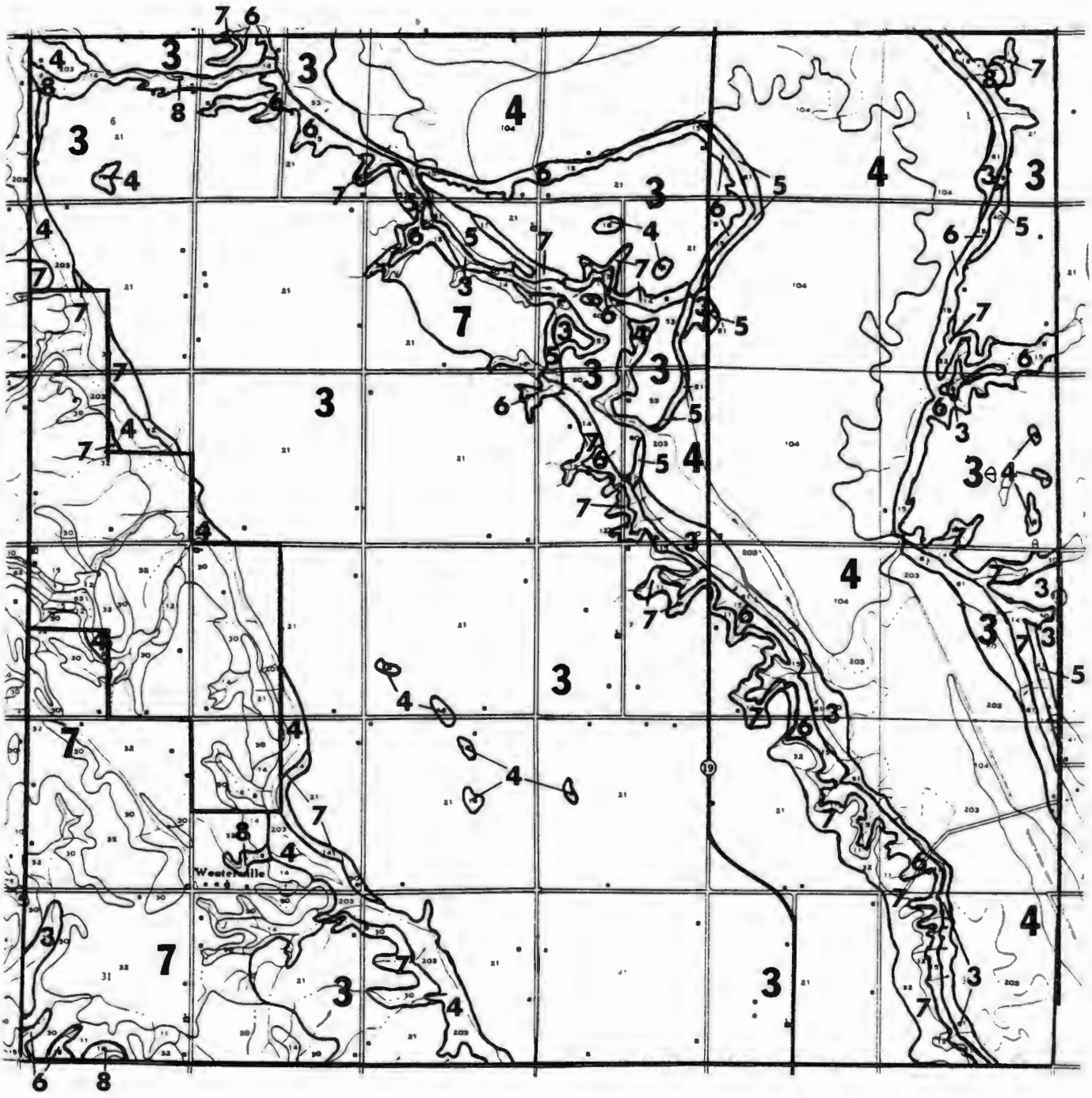
Scale in miles

1 0 1 2

Figure 7-Soil Limitation Map
Clay County
Soil Survey Map Sheet No. 5
Scale 1:56,320 Page 18
T94N, R52W

R 52 W

T
94
N

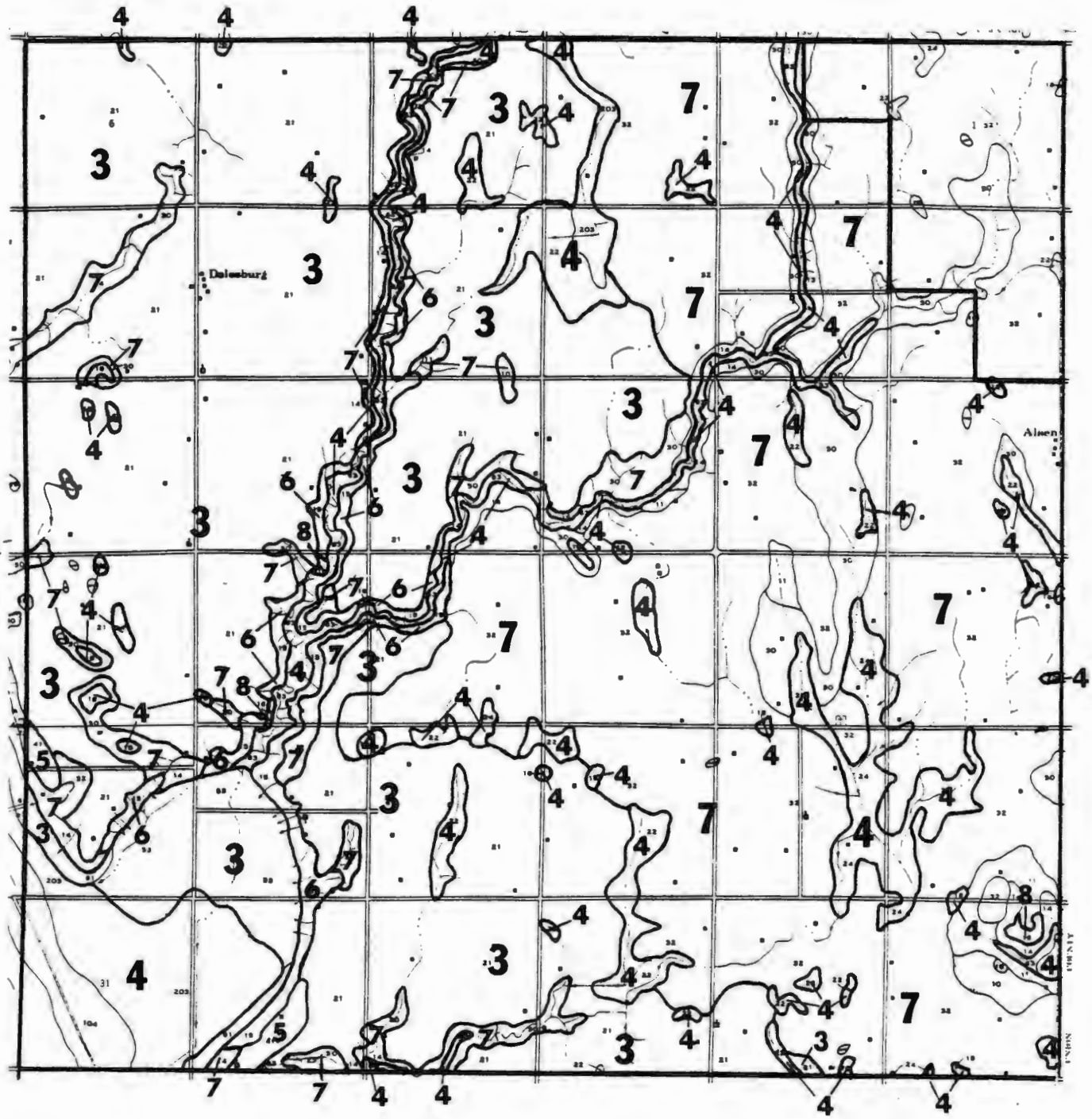


Scale in miles

1 0 1 2

Figure 8-Soil Limitation Map
Clay County
Soil Survey Map Sheet No. 6
Scale 1:56, 320 Page 19
T94N, R51W

R 51 W



Scale in miles

1 0 1 2

Figure 9-Soil Limitation Map
Clay County
Soil Survey Map Sheet No. 7
Scale 1:56,320 Page 20
T93N, R53W

R 53 W

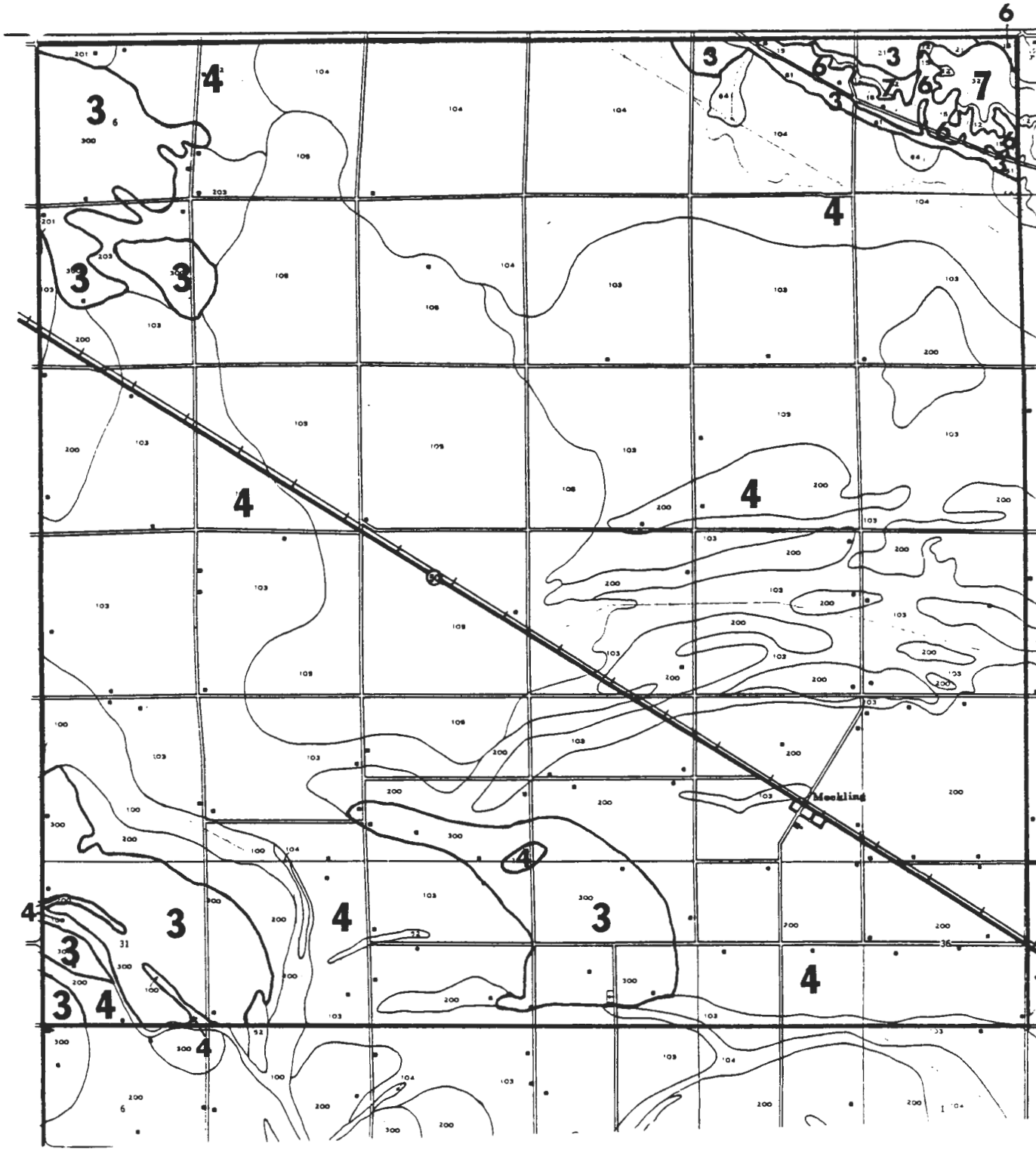
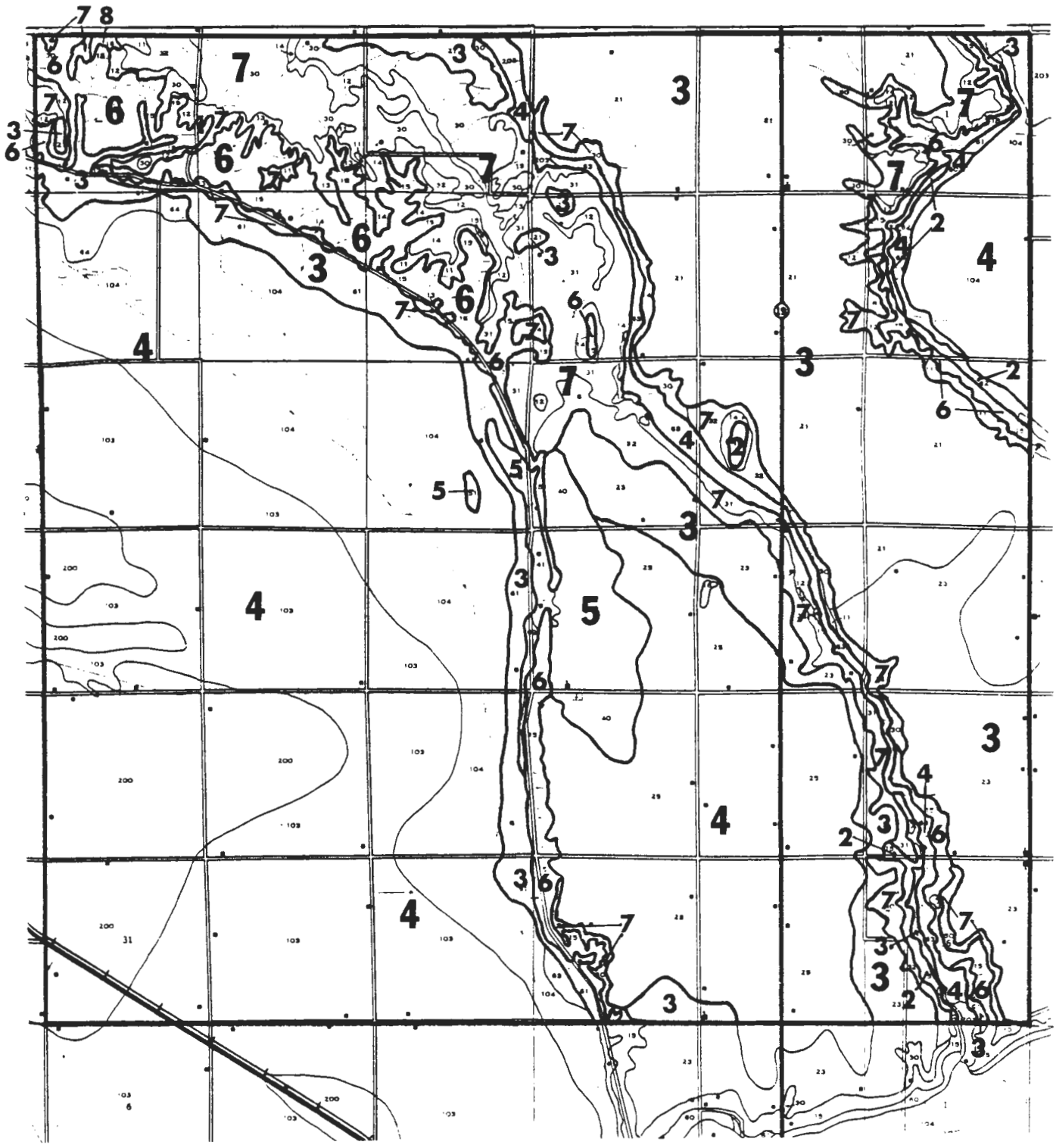


Figure 10-Soil Limitation Map
Clay County
Soil Survey Map Sheet No. 8
Scale 1:56,320 Page 21
T93N, R52W

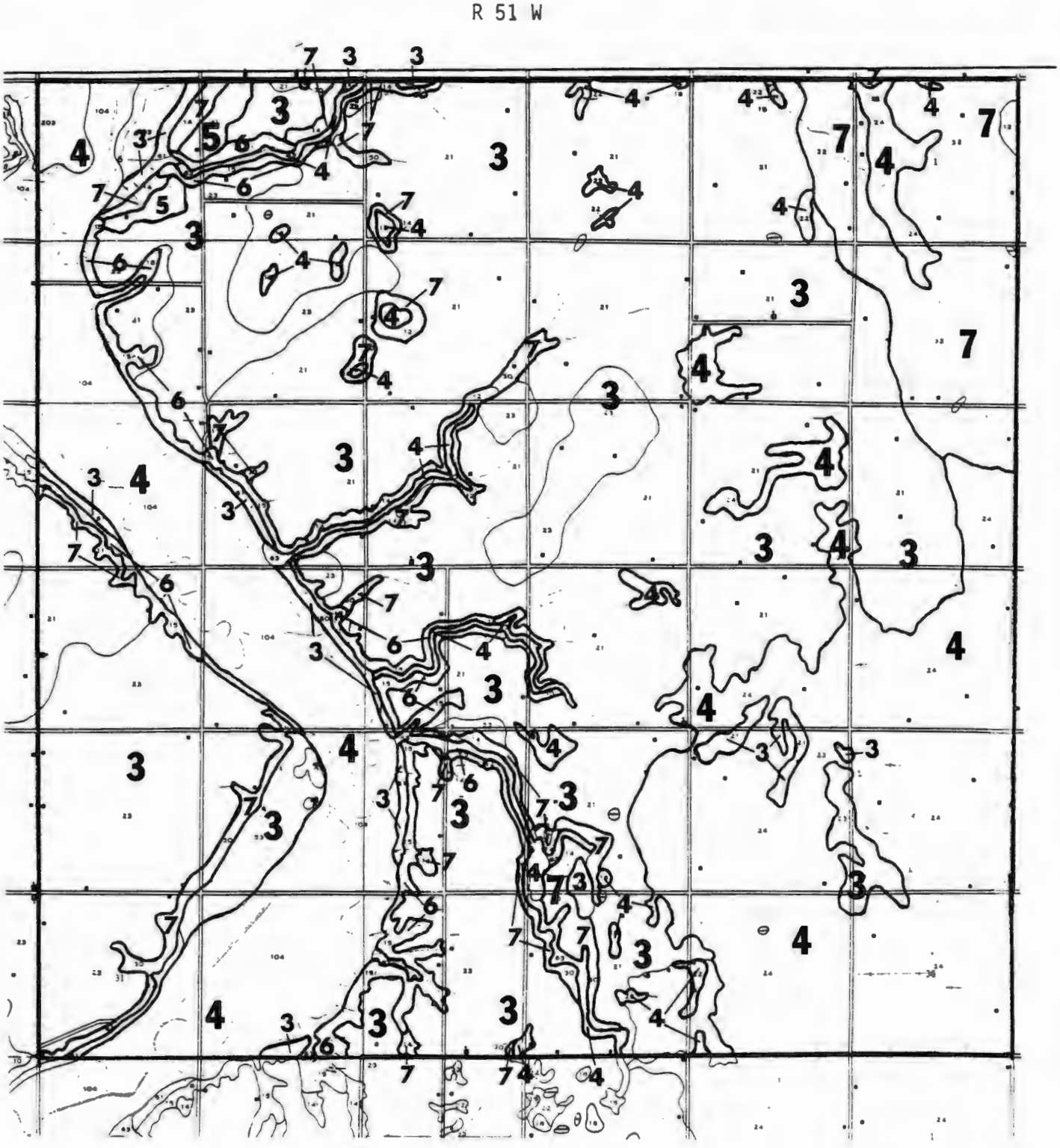
R 52 W

T
93
N



Scale in miles

Figure 11-Soil Limitation Map
Clay County
Soil Survey Map Sheet No. 9
Scale 1:56,320 Page 22
T93N, R51W



Scale in miles

1 0 1 2

Figure 12-Soil Limitation Map
Clay County
Soil Survey Map Sheet No. 10
Scale 1:56,320 Page 23
T92N, R53W

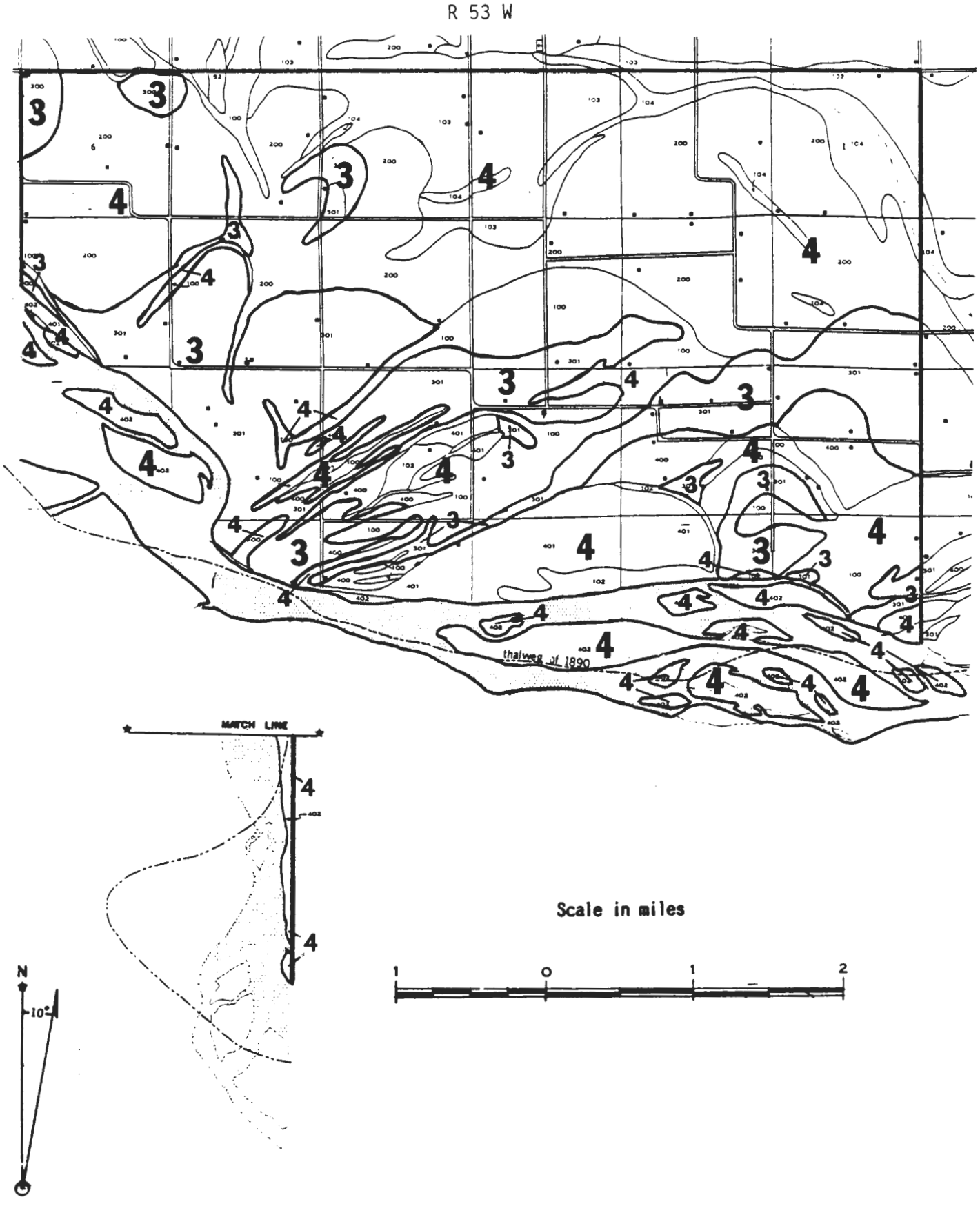


Figure 13-Soil Limitation Map
Clay County
Soil Survey Map Sheet No. 11
Scale 1:56,320 Page 24
T92N, T91N, R52W

R 52 W

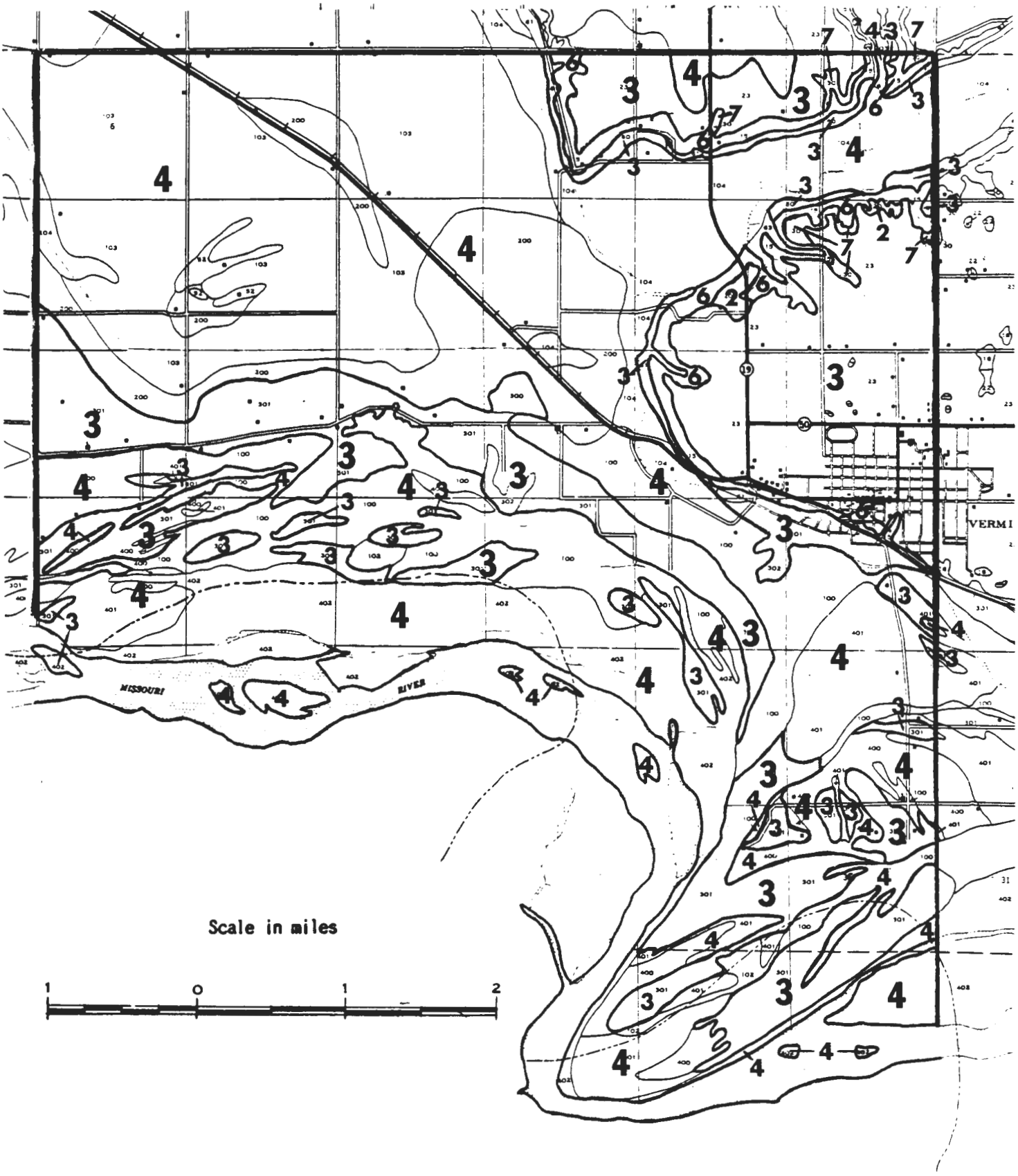
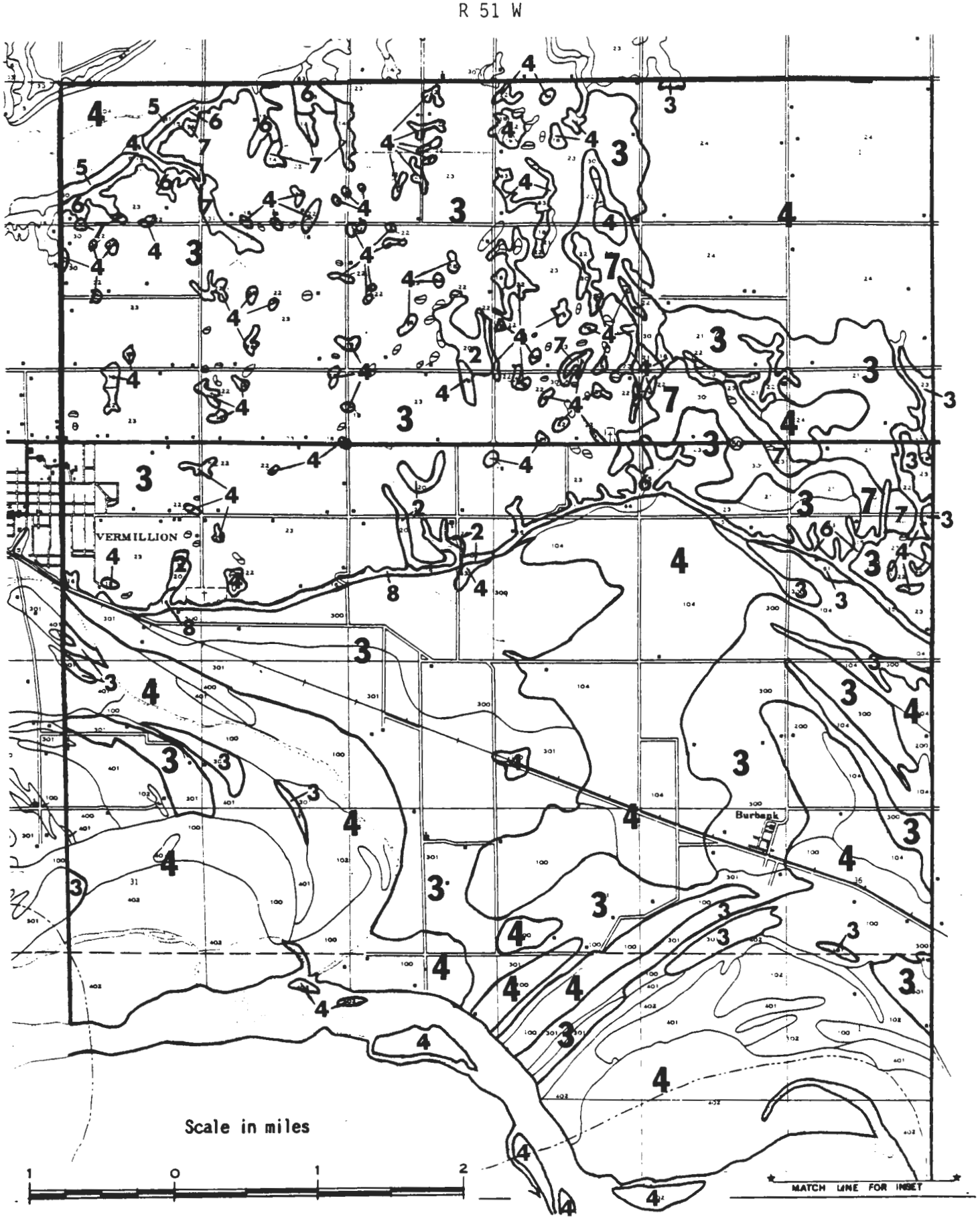


Figure 14-Soil Limitation Map
Clay County
Soil Survey Map Sheet No. 12
Scale 1:56,320 Page 25
T92N, T91N, R51W



REFERENCES

Beatty, M.T. and Bouma, J. 1973. Application of Soil Surveys to Selection of Sites for On-site Disposal of Liquid Household Wastes. Geoderma, 10:113-122.

Bouma, J. 1974. New Concepts in Soil Survey Interpretations for On-site Disposal of Septic Tank Effluent. SSSAP Vol. 38, No. 6:941-950.

Buntley, G.J., W.C. Bourne, F.C. Westin. 1953. Soils of Clay County South Dakota. Bulletin 430. Agronomy Dept. South Dak. Agric. Exp. Sta. South Dak. St. College , Brookings.

Christensen, C.M. 1967. Plate Number 4. Map showing thickness of major buried outwash sediments in Clay County, South Dakota. In Geology and Hydrology of Clay County, South Dakota. Part 1, Geology Bulletin 19. South Dakota State Geological Survey. Univ. South Dakota, Vermillion.

Elliott, L.F. and F.J. Stevenson, ed. 1977. Soils for Management of Organic Wastes and Waste Waters. American Society of Agronomy. Madison, WI. 53711.

USDA-National Cooperative Soil Survey. 1983a. Haynie Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1983b. Lakeport Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1982a. Davison Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1982b. Ethan Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1982c. Wakonda Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1981a. Albaton Series. Form SCS-SOIls-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1981b. Alcester Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1981c. Bonilla Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1981d. Dempster Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1981e. Luton Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1981f. Onawa Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1981g. Sarpy Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1980a. Arlo Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1980b. Blencoe Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1980c. Chancellor Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1980d. Dimo Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1980e. Graceville Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1980f. McPaul Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1980g. Salmo Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1980h. Trent Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1979a. Baltic Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1979b. Betts Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washigton, DC. 20201.

_____. 1979c. Blendon Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1979d. Clamo Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1979e. Clarno Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1979f. Crossplain Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1979g. Davis Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1979h. Delmont Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1979i. Egan Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1979j. Enet Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1979k. Gayville Series. SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1979l. Henkin Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1979m. Huntimer Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1979n. James Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1979o. Lamo Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1979p. Moody Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1979q. Napa Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1979r. Roxbury Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1979s. Talmo Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1979t. Tetonka Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1979u. Wentworth Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1979v. Worthing Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1978. Chaska Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1976a. Flandreau Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1976b. Judson Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1976c. Leshara Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1974. Wann Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

_____. 1968. Solomon Series. Form SCS-SOILS-5 Soil Interpretation Record. USDA-SCS. Washington, DC. 20201.

USDA-SCS. 1983. National Soils Handbook. Part 600. Application of Soil Survey Information. USDA-SCS, Washington, DC. 20402. p. 603-59 to 603-61.

USDHEW-Public Health Service. 1967. Manual of Septic Tank Practice. PHS Publication No. 526. US Government Printing Office, Washington, DC. 20201.