Special Report

SKUNK RIVER BASIN
Iowa

DRAINAGE REPORT

Prepared by
SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

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SKUNK RIVER BASIN STUDY

Iowa

SPECIAL REPORT

DRAINAGE

UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Conservation Service

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PREFACE

This report was prepared by the Soil Conservation Service (SCS) of the U. S. Department of Agriculture (USDA) at the request of the sponsors of the Skunk River Basin Study. Material herein is based on a study of the potential for increasing the productivity of cropland through improving subsurface drainage. At the present time all the evaluated land is intensively cropped, primarily for the production of corn and soybeans.

The Basin study was conducted under authority of Section 6 of Public Law 83-566, as amended. The law authorizes the Secretary of Agriculture, in cooperation with other federal, state, and local agencies, to make investigations and surveys of the watersheds of rivers and other streams as a basis for the development of coordinated programs.

Sponsors of the Skunk River Basin Study are:

- Skunk River Water Resource District
- Iowa Department of Agriculture and Land Stewardship
  - Division of Soil Conservation
- Iowa Department of Natural Resources
  - Environmental Protection Division
  - Fish and Wildlife Division
  - Forests and Forestry Division
  - Energy and Geological Resources Division
    - Geological Survey Bureau

Other special reports in this series prepared during the Skunk River Basin Study are:

- Water Impoundment Opportunities (full report)
- Water Impoundment Opportunities, Summary Edition
- Watershed Inventory (flood damage reduction feasibility)
- Forest Forage
- Erosion
- Wetlands
- German Creek Watershed Preauthorization Planning Report
- An Overview of Groundwater Quality
- Pesticide Use by Tillage System

INTRODUCTION

This report was prepared to present information regarding the problems of wet cropland soils in five counties of the north part of the Skunk River Basin (Figure 1). Specifically, legally organized drainage districts with tile outlets were inventoried to determine installed capacity. Required capacity to meet current criteria was calculated and compared with existing capacity. An improvement project to bring clearly inadequate drainage up to standard was quantified and an economic analysis prepared.

Agricultural drainage is the orderly collection and disposal of excess water from agricultural land by means of open surface drains or closed subsurface drains. In humid areas the primary purpose of agricultural drainage is to remove excess water from the soil so that plant roots have adequate aeration for optimum crop production.

Wet soils and wetlands are not the same. Wet soils have a high water table that interferes with the growth of agricultural crops. The soils may be covered with water during variable seasonal periods. Wet soils are found in both uplands and in overflow bottomlands. In uplands, basins or flats may be filled with water following heavy rain or melting snow. Most of the wet soils used for cropland in north central Iowa are in land capability classes IIw and IIIw.

To be classed as wetlands, characteristics in addition to the above must be present. Wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes (water loving plants); (2) the substrate is predominantly undrained hydric (wet to the extent of anaerobic conditions) soil; and/or (3) the substrate is nonsoil saturated with water at some time during the growing season. Refer to descriptions of wetland types (Appendix E).

About 233 million acres of nonfederal agricultural land nationwide are wet soils. Insufficient data are available on how much of this land is adequately drained. Wet soils, which make up 25 percent of all cropland (105 million acres), are usually very productive. On the average, they are more fertile and contain more organic matter than soils that are not so wet. The hazard of erosion is less serious, and less energy is needed to produce crops.

Drainage of agricultural land in north central Iowa began soon after 1900. In 1904, a drainage convention was held at Iowa State College to discuss the overall problem of drainage and to enlist support for a drainage law. As a result of this convention, a drainage bill was written and passed by the legislature in 1906.

This drainage law was the basis for establishment of hundreds of legal drainage districts throughout Iowa. Many of the open channel outlets and tile mains in north central Iowa were designed and constructed between 1906 and 1925. The capacities of many of these 60- to 80-year old systems are inadequate for today's agriculture due to deterioration, inadequate design capacity, faulty construction, or lack of an adequate outlet. Along with lack of owner/operator factual knowledge, there are legal, institutional, and funding problems associated with improving drainage systems.

If land is intensively farmed, further improvement of drainage will generally have little impact on existing wildlife species. Improved drainage could hasten the adoption of conservation tillage systems which would also improve wildlife winter habitat due to less fall tillage and increased amounts of residue left on the surface.

Drainage is considered important to the installation of conservation measures because it makes possible broader use of practices such as conservation tillage that reduce water and wind erosion. Research has proven farm drainage to be a valuable cropland enhancement practice making possible a farm management program that will increase economic returns as well as conserve and improve soils. Adequate drainage facilitates more efficient use of water, use of reduced tillage methods, more efficient fertilizer use, reduced miring of equipment, and reduced fuel consumption.

Farm drainage does not affect ground water supplies, change the pattern of rain and snowfall, and does not cause excessive floods or droughts (Manson, 1951). Drainage of existing cropland does not cause irreversible or irretrievable commitment of resources or an adverse effect on quality of the environment.

Drainage increases the number of days available for plant growth and field operations. This permits more flexible land use and improved soil management practices. Most of the reduced tillage methods widely recognized to control both wind and water erosion are more successful with well-drained soils.

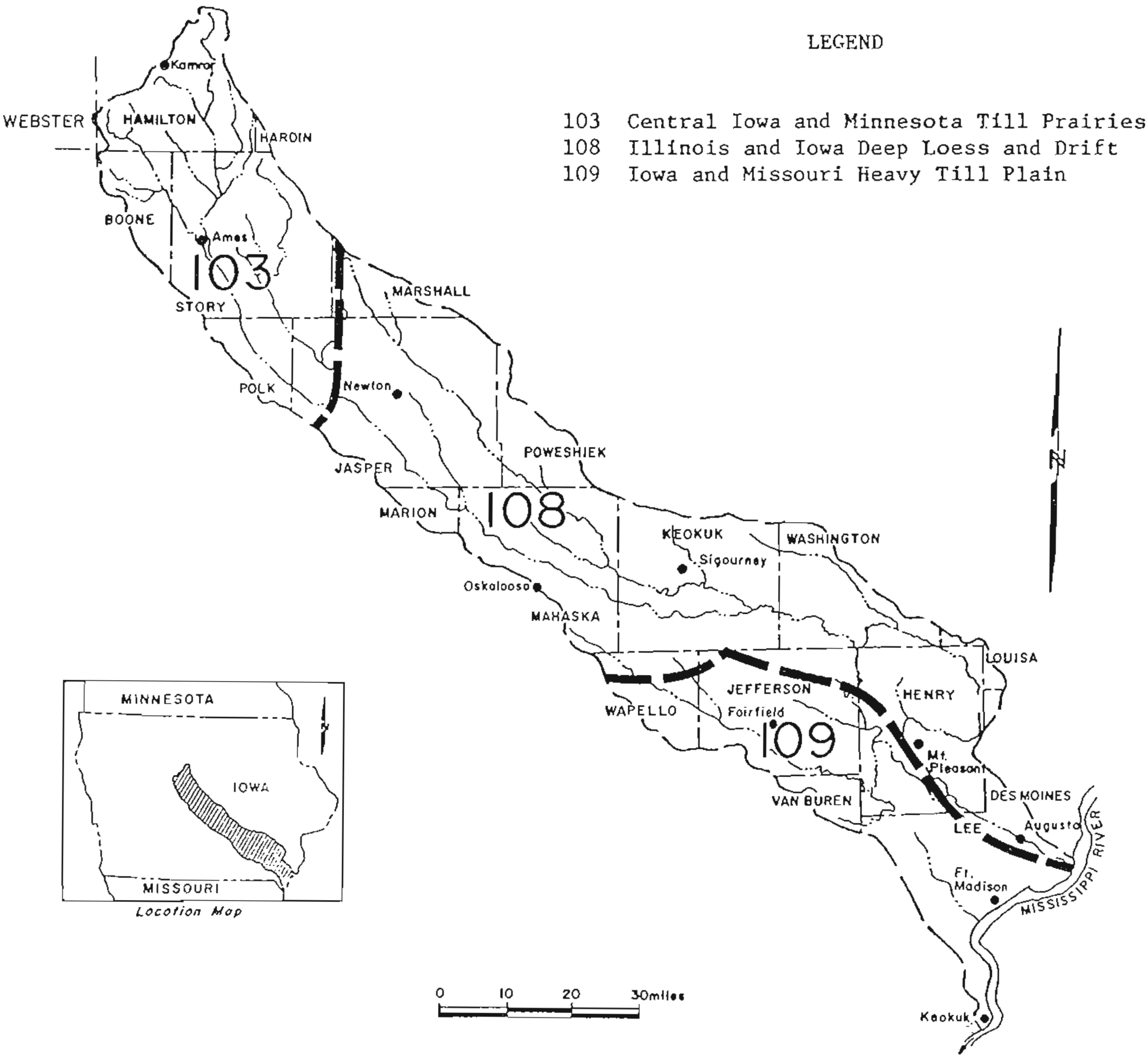
A longer growing season, with an increased number of field operation days, will also provide for more timely application and may reduce the amount of fertilizer needed. Studies show higher nitrogen losses with fall and early spring applications resulting in a greater pollution of runoff water. Applications made in late May or in June are utilized more rapidly by crops reducing leaching losses prior to plant usage and consequently lessening total fertilizer requirements.

Improved drainage also helps to conserve energy. Easier tillage and fewer repetitive operations reduce fuel needs. More timely planting and harvesting also reduce fuel needs for crop drying. The 1980 RCA (Resources Conservation Act) APPRAISAL PART II, notes that 73 trillion BTUs nationwide could be conserved annually through improvement of drainage on 105 million acres of wet soils now being utilized as cropland. Scaling this back to the Skunk River Basin the total savings in fuel could be about 160,000 gallons annually.

Figure 2. Floating dredge excavating a drainage ditch in 1904.

Figure 3

LAND RESOURCE AREAS
SKUNK RIVER BASIN
IOWA



STUDY PROCEDURES

Parts of eight Skunk River Basin counties lie within Land Resource Area (LRA) 103, Central Iowa and Minnesota Till Prairies, and have drainage problems associated with the glaciated topography of north central Iowa (Figure 3). Within that general boundary the study area is all the land in legal drainage districts in Boone, Hamilton, Hardin, Polk, and Story Counties. There are 278 legal drainage districts in these five counties from which tile outlet inventory data were taken from county courthouse records. Total drainage area of the districts makes up approximately one-third of the area. The extent of legal drainage districts is shown in Table 1.

Table 1
STUDY AREA BY COUNTY
Skunk River Basin

County	Area within LRA 103	Study Area (Area in Drainage Districts)
	- - - - - - - - - acres	- - - - - - - - -
Boone	76,642	39,117
Hamilton 1/	194,976	88,416
Hardin	7,098	1,890
Polk	68,134	2,693
Story	321,267	93,231
TOTAL	668,117	225,347

Information about the existing subsurface drains was available for all of the districts in Boone, Hardin, Polk, and Story Counties. In Hamilton County, only about 37 percent of the districts have recorded information stating the gradients of subsurface drains. Gradient is a necessary parameter for calculating drain capacity. Therefore, the data collected for the 37 percent were expanded by area to the rest of the Hamilton County drainage districts in the Skunk Basin part of LRA 103.

1/ Includes a small area of Webster County outletting through a drainage district in Hamilton County.

Table 2
TILE DRAINAGE DISTRICT STATUS
Skunk River Basin

Tile 1/ Capacity Status	County					
	Boone	Hamilton	Hardin	Polk	Story	Total
			Inadequate Status			
Very Low						
Districts (no.)	-	-	-	1	6	7
Area (ac)	-	-	-	1,549	8,749	10,298
Low						
Districts (no.)	7	5	1		20	33
Area (ac)	7,414	12,370	1,890		26,613	48,287
Medium						
Districts (no.)	6	14	-		17	37
Area (ac)	4,086	8,292	-		14,335	26,713
Subtotal for Inadequate Status						
Districts (no.)	13	19	1	1	43	77
Area (ac)	11,500	20,662	1,890	1,549	49,697	85,298
				Percent of total		37.9
			Adequate Status			
High						
Districts (no.)	6	30	-	-	14	50
Area (ac)	3,214	21,711	-	-	17,300	42,225
Very High						
Districts (no.)	30	83	-	1	37	151
Area (ac)	24,403	46,043	-	1,144	26,234	97,824
Subtotal for Adequate Status						
Districts (no.)	36	113	-	1	51	201
Area (ac)	27,617	67,754	-	1,144	43,534	140,049
				Percent of total		62.1
Total						
Districts (no.)	49	132	1	2	94	278
Area (ac)	39,117	88,416	1,890	2,693	93,231	225,347

1/ Tile Capacity Status:
Very Low = Less than 30 percent of required capacity
Low = 30-60 percent of required capacity
Med = 60-80 percent of required capacity
High = 80-100 percent of required capacity
Very High = More than 100 percent of required capacity

Complete tabulation of the inventory data stratified by county and outlet adequacy are shown in Appendix H.

Drainage districts were placed in two broad categories and five specific classifications based upon the installed tile main capacity compared with required capacity (Table 2):

Adequate Status

Very High - Capacity exceeds specifications (Appendix F)

High - Capacity equals 80-100 percent of specifications

Inadequate Status

Medium - Capacity equals 60-80 percent of specifications

Low - Capacity equals 30-60 percent of specifications

Very Low - Capacity less than 30 percent of specifications

Systems in the "adequate" group would likely provide satisfactory drainage to the extent that increasing capacity would be uneconomical. Systems in the "inadequate" group totaling 85,298 acres have such deficient drainage capacity that improving capacity would be economically beneficial.

Information from other recent related studies was useful in pursuing these drainage studies in the LRA 103 part of the Skunk River Basin. Yield data and the percent of Poorly Drained (PD) and Very Poorly Drained (VPD) soils were taken from the Des Moines River Basin Study reports, 1983. Land use was taken from the Upper Skunk River Basin report prepared for the Corps of Engineers by SCS in 1985.

Soils were grouped according to natural properties relating to excessive wetness. "Well Drained" and "Somewhat Poorly Drained" soils, that infiltrate water through the surface and percolate it downward fairly efficiently, are generally not subject to wetness problems resulting in significant economic loss. Thus, the 42,339 acres in the above category are not part of the problem area (Table 3). Soils with slow rates of infiltration and percolation, or high water tables, require improved drainage facilities to remove excess water in a timely manner. Soils with the most severely impaired natural drainage are classified

"Poorly Drained" and "Very Poorly Drained." Economic evaluation was confined to these two groups of soils totaling 42,959 acres with wetness problems clearly evident unless drainage measures have been installed (Table 3). Examples of the problem soils are:

Poorly Drained 1/	Very Poorly Drained 2/
Webster	Blue Earth
Canisteo	Okoboji
Harps	Knoke

Table 3
NATURAL SOIL WETNESS CHARACTERISTICS
Skunk River Basin

Natural Characteristic	Study Area (acres)	Portion (percent)	Economic Potential For Drainage Improvement
Well Drained	23,938	28.1	
Somewhat Poorly Drained	18,401	21.6	
Subtotal	42,339	49.7	Weak
Poorly Drained	39,372	46.1	
Very Poorly Drained	3,587	4.2	
Subtotal	42,959	50.3	Strong
Total	85,298	100.0	

1/ Poorly Drained - By nature water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most Iowa field crops generally cannot be grown profitably unless the soil is artifically drained. The soil is not continuously saturated in layers directly below plow depth. Poor natural drainage results from a high water table and/or a slowly pervious layer within the profile.

2/ Very Poorly Drained - In nature these soils' wetness problem characteristics exceed 1/ above by having free water at or on the surface during most of the growing season. Very Poorly Drained soils are commonly level, or depressed, and are frequently ponded.

This analysis is based upon the premise that the status of tile drainage improvement and crop distribution are present in the same proportion for Poorly Drained and Very Poorly Drained soils as is true for the study area.

Crop yield data were developed during the Iowa State University-Soil Conservation Service cooperative drainage study for LRA 103 completed in 1983 (Appendix A). Yield data for corn and soybeans were compiled for PD and VPD soils depending upon tile drainage status (Table 4). These scenarios show very significant yield depression for "Low" and "Very Low" drainage status conditions.

Table 4
AVERAGE YEILD BY DRAINAGE STATUS 1/
Skunk River Basin

Crop and Natural Soil Wetness Characteristic	Tile Drainage District Status			
	High	Medium	Low	Very Low
	--- bushels per acre ---			
Corn				
Poorly Drained	128	124	89	69
Very Poorly Drained	126	116	61	21
Soybeans				
Poorly Drained	46	45	32	24
Very Poorly Drained	45	40	24	8

1/ Source: Drainage Report, Des Moines River Basin Study, 1983.

Related to the total study area, land use is 90 percent corn and soybeans, divided to corn 51.3 percent and to soybeans 38.7 percent. The remaining 10 percent includes minor acreages of small grain and hay and miscellaneous use such as roads and farmsteads. Economic analyses for evaluating drainage improvement were confined to corn and soybeans (Appendix J).

PROBLEMS AND CONCERNS

Sponsors noted inadequate drainage of cropland as one of the major land and water resource problems of the Skunk River Basin. Inadequate drainage systems result in partial or total crop losses. Some of the associated problems of poor drainage of wet soils are as follows:

1. Reduced farm income because of lower crop yields
2. Reduced quality of products
3. Increased seed and machine costs from replanting
4. Increased energy requirements
5. Increased machinery maintenance
6. Decreased efficiency of farm operations
7. Higher utility and road costs

Wet cropland soils reduce the depth of effective root zone resulting in less nutrient availability to plants. Shallower rooting may cause plant stability problems and greater susceptibility to drought damage. Wet soils, when frozen, cause greater heaving damage to tap roots of perennial plants. Specific heat of wet soils is higher, thus requiring more energy to increase soil temperature. Consequently, wetter soils warm more slowly during the critical early planting period. Thus, length of growing season is reduced when soils are wet. Because wet soils interfere with tillage, retard plant development, and delay harvests, crop yields are reduced, costs increased, and crop quality is lowered.

In this Basin excess water in the soil profile comes from high water tables, precipitation, snowmelt, underground seepage, and floodwater from channels. Agricultural drainage is divided into two broad classes, surface and subsurface. Many systems in the Skunk River Basin serve the dual purpose of surface and subsurface drainage. In LRA 103 it is very difficult to separate drainage and floodwater removal due to the pothole topography and the use of tile to remove surface water runoff. In general, however, drainage channels and subsurface drains are not designed to completely handle peak flow from major storm events. Floodwater damage within an improved drainage project area will continue with such events but to a reduced extent. Improved drainage systems are not expected to appreciably alter downstream flooding (Appendix D).

Many of the open channel outlets and subsurface tile mains in the area were designed and constructed between 1906 and 1925 and some are inadequate for today's agriculture. While competent engineers were usually involved in the design of most of these 60- to 80-year old systems, former criteria required less capacity than is recognized as needed today (Appendix F). Present criteria requires two to four times the capacity of some older systems. Also, for various reasons some of these old systems were actually constructed with less capacity than the engineer's design.

Original capacity of many of these old systems has been reduced through deposition of sediment, physical damage by animals, tree roots, unbalanced loading of lateral tile, subsidence of muck soils, faulty construction, breakage, and lack of a free outlet. While some subsurface drainage is now being installed, the rate is little more than that being lost to deterioration.

Institutional and financial problems retard the installation of needed improvements. The topography of the area results in a need for rather complex drainage systems and many of the present landowners apparently fail to comprehend the needs of their systems. They also may be accepting poor drainage as a fact of life and are not fully recognizing the potential improved drainage benefits which are available.

Inventory data show the status of tile drainage capacity to equal or exceed required capacity on 43 percent of the area. This drainage area meeting current specifications for capacity is higher than expected and more than for the Des Moines River Basin nearby. Lands drained with systems equal to, or exceeding, required capacity were categorized in a "Very High" status. Nineteen percent of the land is drained at rates between 80 percent and 100 percent of requirements and has been labeled as "High" status. The remaining 38 percent, termed "inadequate," needs positive action to raise the drainage level up to standard capacity.

Tile districts in the "inadequate" status number 77 and cover 85,298 acres (Table 2). Some of the soils in these districts are naturally Well Drained and some are Somewhat Poorly Drained (Table 3). On those lands wet soils problems are generally minor and they are not included in the problem area. The problem area includes only naturally Poorly Drained and Very Poorly Drained soils. Soils with these characteristics total 42,959 acres, about 50.3 percent of the study area. To remedy this need for improved drainage 86 miles of supplemental tile relief mains are needed.

In addition to inadequate tile main discharge capacity other problems in many drainage systems include open channels with too shallow depths for gravity outlets from tile mains, and less frequently, inadequate flow capacity. There is a need for 27 miles of open channel reconstruction.

Where tile mains of large diameter (36 inches or more) are broken down and/or otherwise faulty, replacement of these mains with new open channels may be desirable. These situations cause an estimated needed for 16 miles of new open channel.

To assure fully adequate drainage some fields require additional lateral tile due to lack of tile at present, too shallow tile, physical breakdowns, or faulty design. Estimated lateral tile needs sum to 320 miles on about 7,300 acres.

Figure 4. Inadequately drained cropland in LRA 103.

Economic loss due to inadequate drainage in the inventoried area was estimated assuming virtually no gain in meeting drainage improvement needs in the foreseeable future. Crop losses from inadequate drainage causing reduced yields average $2,733,000 annually on 42,959 acres. Additional losses from other causes, such as items two through seven listed at the beginning of this chapter, were not monetarily evaluated.

Table 5
IMPAIRED DRAINAGE LOSS SUMMARY
Skunk River Basin

	Corn	Soybeans	Other 1/	Total
Area (acres)	22,038	16,625	4,296	42,959
Production Loss (1,000 bushels)	712	191	-	-
Annual Crop Loss 2/ (1,000 dollars)	1,779	954	-	2,733

1/ Economic loss not evaluated.
2/ Computations shown in Appendix J.

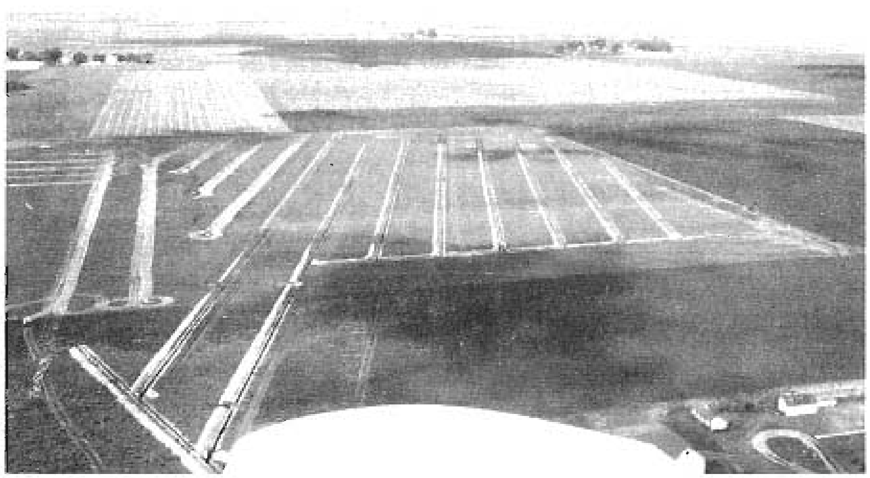


Figure 5. Aerial view of lateral tile system in LRA 103.

RECOMMENDATIONS

A plan to install the drainage improvement needed is outlined in Table 6. Construction is recommended to improve functioning of drainage districts throughout the LRA 103 area in the Skunk River Basin in Boone, Hamilton, Hardin, Polk, and Story Counties. Drainage improvement would be accelerated from the current rate of essentially no net gain to that necessary to complete the plan in 20 years.

The mix of plan elements in Table 6 reflects needs to install or improve open drainage channels, increase tile main capacity by adding relief lines, and constructing or reconstructing field lateral tile lines.

Tile relief mains are recommended for installation in a parallel position near existing tile mains which have inadequate capacity. Sizing of relief mains should be done to bring total capacity up to 100 percent of required capacity. About 500 acres are served per mile of tile main. A small amount of new open channel is needed to replace old, severely deteriorated tile mains. This is a more economic alternative than a total replacement of the tile main would be in certain instances, especially where required tile size is very large. Depending upon land rights cost, excavation costs, tile costs, and landowner preference the size division between tile and open ditch is approximately at 36-inch tile diameter. Open ditches need to be reconstructed where maintenance has been neglected such that capacity and/or depth are inadequate. To fully gain the benefits of improved outlets some lateral tile needs to be added to field systems on about 15 percent of the problem area. To a limited extent owners also need to improve the timely removal of surface water by construction of shallow field drains. Such drains are normally designed so that planted crops occupy the ditch area.

Technical assistance by the Soil Conservation Service would be limited to interpreting soils data and providing engineering criteria for design and construction. Design criteria for drainage is available in the SCS Technical Guide and the Iowa Drainage Guide. The SCS would assist in identifying wetlands. See SCS wetlands policy and note on 1985 Food Security Act (Appendix E). Design plans and construction inspection would be provided by others.

Table 6
DRAINAGE IMPROVEMENT
Skunk River Basin

Plan Element	Unit	Total Amount	Average Annual Amount
Tile Relief Main	miles	86	4.3
New Open Channel	miles	16	0.8
Reconstruct Open Channel	miles	27	1.3
Lateral Tile	miles	320	16.0

The improvement of crop production efficiency on wet soils may reduce the necessity and pressure to farm some highly erodible soils.

Tile main and open channel construction could be carried out through legal drainage district organizations. Private owners would be responsible for installing lateral system tile in fields.

Figure 6. Ponding indicates need for open inlets or surface drains.

CONCLUSIONS

Wet cropland soils problems on 225,347 acres were studied in five counties of the Skunk River Basin. Tile outlet legal drainage districts were inventoried. The outlet capacities were computed and compared with current requirements. A large part of these districts have "adequate" capacity. Other districts are well below current standards and for these districts an improvement program was developed. Economic analyses indicate the improvements to drainage would yield benefits equal to about twice the costs.

Tile outlets with capacities equal to 80 percent, or more, of required capacity were classed as "adequate". In the "inadequate" category 85,298 acres lie in districts with less than 80 percent of required capacity. Naturally Poorly Drained and Very Poorly Drained soils make up slightly over 50 percent of the area and are the soils most needing, and most responsive to, drainage improvements. These 42,959 acres represent the area for which an improvement project was planned. This area is used for 38,663 acres of corn and soybeans for which increased yields from drainage improvements result in substantial financial benefits.

Improving drainage would increase average corn production 712,000 bushels and average soybean production 191,000 bushels annually. Estimated monetary value of the increased production using 1986 normalized prices of $2.50 for corn and $5.00 for soybeans would be $2,733,000. Several additional benefits would accrue but were not evaluated with dollar amounts. Some of those benefits include increased quality of crops, savings in energy, and more efficient labor utilization.

In addition to improving capacity of existing tile outlets other work is required to improve or construct open channels and to add and replace lateral field tile. Drainage practices needed are listed in the "Recommendations" chapter and carry an installation cost of $15,557,000. Amortized for 50 years at 8-5/8 percent interest plus $1.06 per acre average annual maintenance expense yields annual costs of $1,409,000 or an average of $32.80 per acre per year. Benefits average $63.62 per acre annually resulting in a benefit:cost ratio of 1.94 to 1.00.

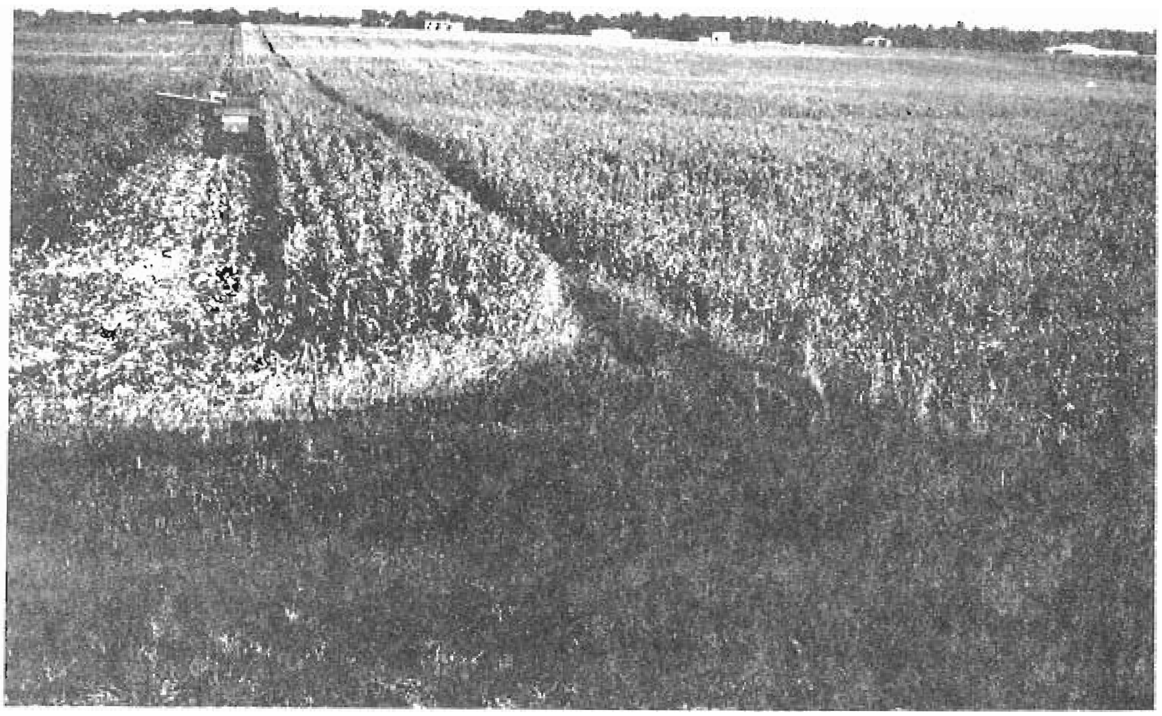


Figure 7. Uniform stands of high yielding crops follow improved drainage.

APPENDIX A

SUMMARY OF COOPERATIVE DRAINAGE STUDY 1/

In recent years the U.S. Soil Conservation Service and Iowa State University cooperated in studying the agronomic, engineering, and economic aspects of drainage in the LRA 103 part of the Des Moines River Basin. The findings and conclusions from that work are applicable in the LRA 103 part of the Skunk River Basin due to the close physical proximity and same soils in both Basins. This appendix includes a brief discussion of the report stemming from that study.

Additional supplies of agricultural commodities may be produced either by planting more acres, by increasing yields, or both. That study emphasized increasing yields by improvement of drainage in the Upper Des Moines River Basin.

During the period 1975-1982 a committee of agronomists, agricultural engineers, and economists at Iowa State University studied the physical, economic, and institutional characteristics of drainage in north central Iowa. The initial study was conducted in Humboldt County. Data from this study were used in formulating and applying procedures for determining optimum levels of corn and soybean production under several price, cost, and levels of drainage scenarios.

Because of these drainage investigations, the committee was requested by the Soil Conservation Service to conduct research for the drainage component of its Des Moines River Basin Study. Consequently, a cooperative agreement was negotiated by Iowa State University and the Soil Conservation Service on May 31, 1979.

The objectives of this cooperative study were to: (1) estimate physical and economic drainage potentials of soils in the Des Moines River Basin, (2) estimate the extent to which this potential is being

1/ Schult, David L. et al, 1981. Present and Potential Agricultural Cropland Drainage Conditions in the Upper Des Moines River Basin. Prepared through a cooperative agreement between Iowa State University and the U.S. Soil Conservation Service.

realized, (3) find out why drainage has been more successful in some drainage districts than in others, and (4) suggest how success in achieving the drainage potential may be realized more fully throughout the Basin.

In conjunction with the Des Moines River Basin Study, parts or all of 10 counties in LRA 103 of north central Iowa were chosen as the study area (Figure A-1).

Survey sampling techniques were used to obtain certain information. Two classes of tile drainage districts were defined for the study. High success districts were defined as those having a drainage coefficient of at least 3/8 inch per day. All other districts were defined as low success districts. For the economic analysis, linear programming was used to: (1) estimate maximum yields of corn and soybeans at different levels of drainage and (2) estimate optimum levels of drainage for production of corn and soybeans associated with varying prices, costs, and discount rates. Models were devised to maximize yields and optimize levels of drainage for both high success and low success districts. The models used were designed to maximize yields and choose among production activities at three different levels of drainage: (1) present, (2) intermediate, and (3) high.

Of the estimated 976,000 acres in the study area, 188,000 acres were naturally well drained soils needing no artificial subsurface drainage. Of the remaining 788,000 acres, 676,000 acres (86 percent) were estimated to be at a high level of field drainage, and 77,000 acres (10 percent) were estimated to be at an intermediate level of field drainage. An estimated 35,000 acres (4 percent) have no tile drainage.

Drainage districts were also classified according to drainage level. Of the 788,000 acres that were potentially drainable, 748,000 acres were estimated to have a low district drainage level, and 40,000 acres were estimated to have an intermediate district drainage level.

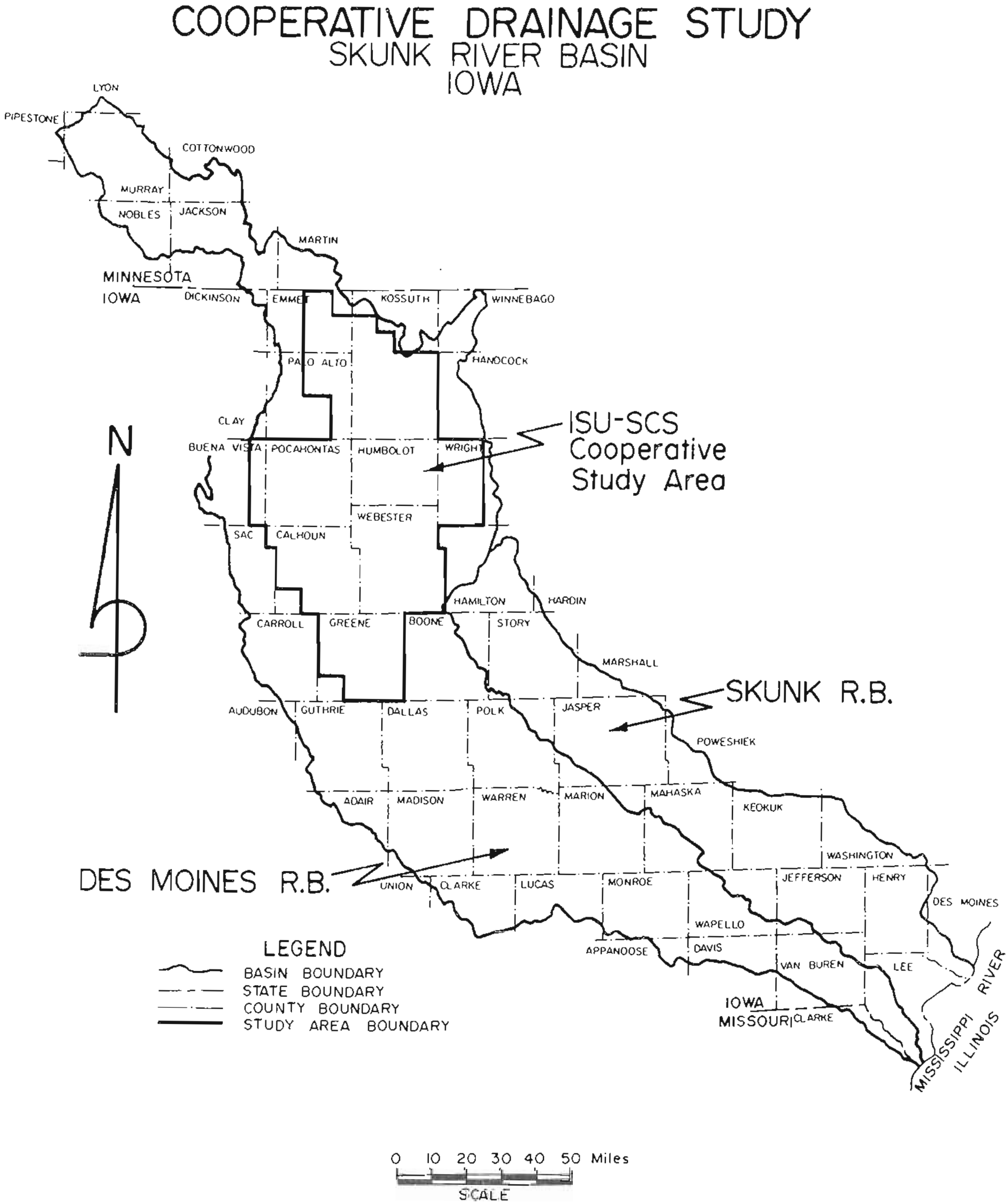
If present yield potentials of corn and soybeans are compared with maximum yields (high drainage situation), only about 68 percent of the maximum yield potential is currently realized. By use of 1980 price-cost relationships, the study analysis demonstrated that 99 percent of the maximum yield potential is obtainable.

The present value of net returns over a 20-year period was estimated using various price, cost, and discount rate combinations. For 1980 prices and costs and a 16 percent discount rate, the present value of expected net returns of drainage for low success districts was $124,738,000 over a 20-year period. For high success districts, the present value of expected net returns of drainage was $4,576,000. Therefore, the present value of the potential net returns of drainage in the study area to be captured over the next 20 years was estimated to be $129,314,000. The average annual net revenues in 1980 dollars over the 20-year period would be $6,466,000. Care must be used in treating these average annual net returns as actual net returns for a given year within the 20-year period. Estimated net returns in a particular year could range from $33,610,000 to - $5,972,000 depending on weather conditions.

Based upon responses of the farm operators in the study sample and the analysis of improved drainage potentials, seven reasons were suggested for failure to achieve production potentials through improved drainage. These reasons are: (1) uncertainties associated with drainage, (2) drainage investment attitudes of farm operators, (3) age of farm operator and drainage investment, (4) farm operator attitudes within low success districts, (5) differences in farmer attitudes between high success and low success districts, (6) farm operator yield expectations, and (7) drainage district operations.

For further details concerning this study refer to Des Moines River Basin Study, Drainage Report, USDA-SCS, 1983.

Figure A-1


COOPERATIVE DRAINAGE STUDY
SKUNK RIVER BASIN
IOWA
LYON
PIPESTONE
COTTONWOOD
MURRAY
NOBLES
JACKSON
MARTIN
MINNESOTA
IOWA
DICKINSON
EMMET
KOSSUTH
WINNEBAGO
PALO ALTO
HANOCOCK
CLAY
ISU-SCS
Cooperative
Study Area
N
BUENA VISTA
POCAHONTAS
HUMBOLOT
WRIGHT
WEBESTER
SAC
CALHOUN
HAMILTON
HARDIN
CARROLL
GREENE
BOONE
STORY
MARSHALL
SKUNK R.B.
AUDUBON
GUTHRIE
DALLAS
POLK
JASPER
POWESHIEK
ADAIR
MADISON
WARREN
MARION
MAHASKA
KEOKUK
WASHINGTON
DES MOINES R.B.
UNION
CLARKE
LUCAS
MONROE
JEFFERSON
HENRY
DES MOINES
WAPELLO
LEGEND
BASIN BOUNDARY
STATE BOUNDARY
COUNTY BOUNDARY
STUDY AREA BOUNDARY
APPANOOSE
DAVIS
VAN BUREN
LEE
IOWA
MISSOURI
CLARKE
MISSISSIPPI RIVER
ILLINOIS
0 10 20 30 40 50 Miles
SCALE

APPENDIX B

GENERAL SOIL INFORMATION

Soils associations of the Skunk River Basin are shown in Figure B-2. The map shows geographic areas where major soil groups occur. These soil groups are called soil associations. A soil association is comprised of soils that are closely associated geographically and occur in a characteristic pattern (Figure B-1).

The group of soils in the Upper Skunk River Basin is dominated by Wisconsin glacial till-derived soils developed under a native vegetation of prairie grasses. Detailed information about the individual soils is available in published soil survey reports or in SCS files. The accompanying General Soil Map (Figure B-2) is not intended for intensive planning and management of a farm or individual field or for selecting exact locations for roads, buildings, or structures. Soils in one association ordinarily differ from soils in another association in one or more of the following characteristics: slope, depth, drainage, and/or other features that affect management. Most drainage improvement needs are located in Soil Association 1. Soil Association number 1 is briefly discussed below:

> Nearly level to moderately sloping (0-9%) prairie-derived soils developed from Wisconsin glacial till on the Cary Lobe. Webster, Okoboji, Canisteo, Clarion, Storden, Nicollet, and Harps are soils found in Soil Association 1.

The soils in this association formed under grass vegetation. Relief varies from short irregular slopes on the higher areas to slight depressions in low areas. Surface drainage is not well-developed and runoff water commonly accumulates in the lowest areas.

Webster soils are Poorly Drained and occur in nearly level areas, and narrow drainageways. They typically occupy lower elevations than the Clarion and Nicollet soils. Tile drainage is needed in most areas of Webster soils.

The Okoboji soils are Very Poorly Drained and commonly occur in depressions. Surface drainage as well as tile drainage is needed on these soils.

The Canisteo soils are Poorly Drained and have a high content of lime. They occupy similar landscape positions as the Webster soils. Tile drainage is also needed in most areas of Canisteo soils.

The Clarion soils are Well Drained and occur predominantly on convex slopes. Erosion control practices are recommended on the more sloping Clarion soils.

The Storden soils are Well Drained and occur on the steeper convex slopes. These soils formed under a native vegetation of grasses. These soils have a high content of lime inherent in their parent materials. These soils erode very easily when used for row crops.

The Nicollet soils are Somewhat Poorly Drained and occur on slightly convex areas between the higher well drained Clarion soils and the lower Poorly Drained Webster or Canisteo soils. Depth to high lime parent materials usually ranges between 2.5 and 4.5 feet in both the Clarion and Nicollet soils. Tile drainage is needed in some areas of Nicollet soils.

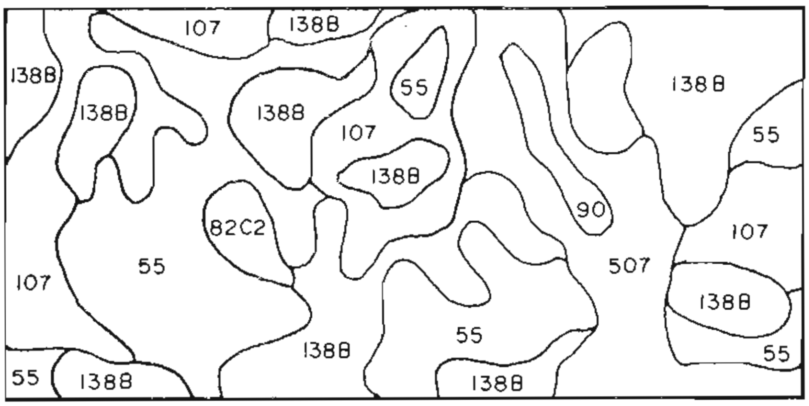
The Harps soils are Poorly Drained and have a very high content of lime. They commonly occur as rings around the Webster and Okoboji soils at slightly higher elevations.

Most of the soils in this association are used for corn and soybeans. Yields of crops are good to excellent in most areas. A management need is to control runoff, wetness, and wind erosion on many of these soils. Conservation tillage, tile, open ditches, terraces, water and sediment control basins, contouring, and grassed waterways should be used where needed.

REPRESENTATIVE SOILS ON AN EXAMPLE FARM IN THE CLARION-NICOLLET-WEBSTER SOIL ASSOCIATION AREA OF NORTH CENTRAL IOWA.

	Kinds of soils	Percent of area
138B	Clarion loam, 2 to 5 percent slopes. Includes small areas of 138, Clarion and 62, Storden soils on 5 to 9 percent slopes	30
55	Nicollet loam, 0 to 2 percent slopes	30
107	Webster silty clay loam, 0 to 2 percent slopes	20
507	Canisteo silty clay loam, 0 to 2 percent slopes. Includes small areas of 90, Okoboji silty clay loam, 0 to 1 percent slopes	20

Example: Soil Survey Map - 320 Acres



Relationship of Parent Material, Topography, Vegetation and Soils

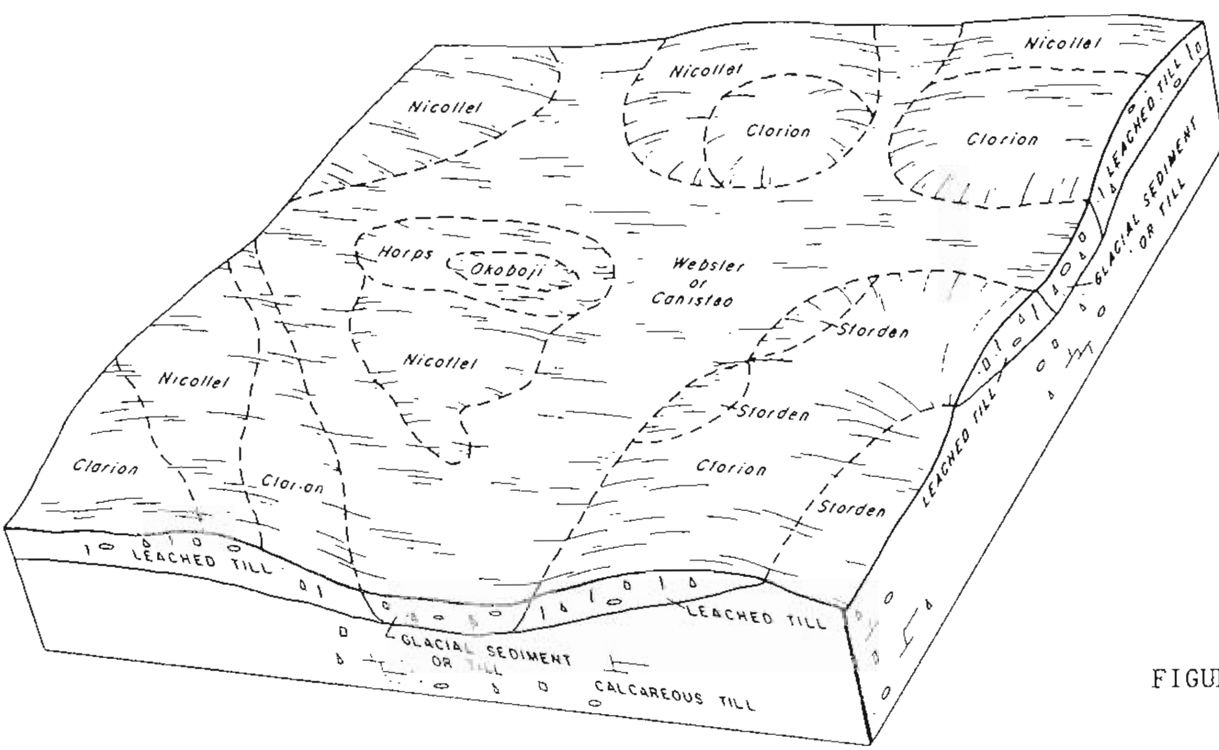
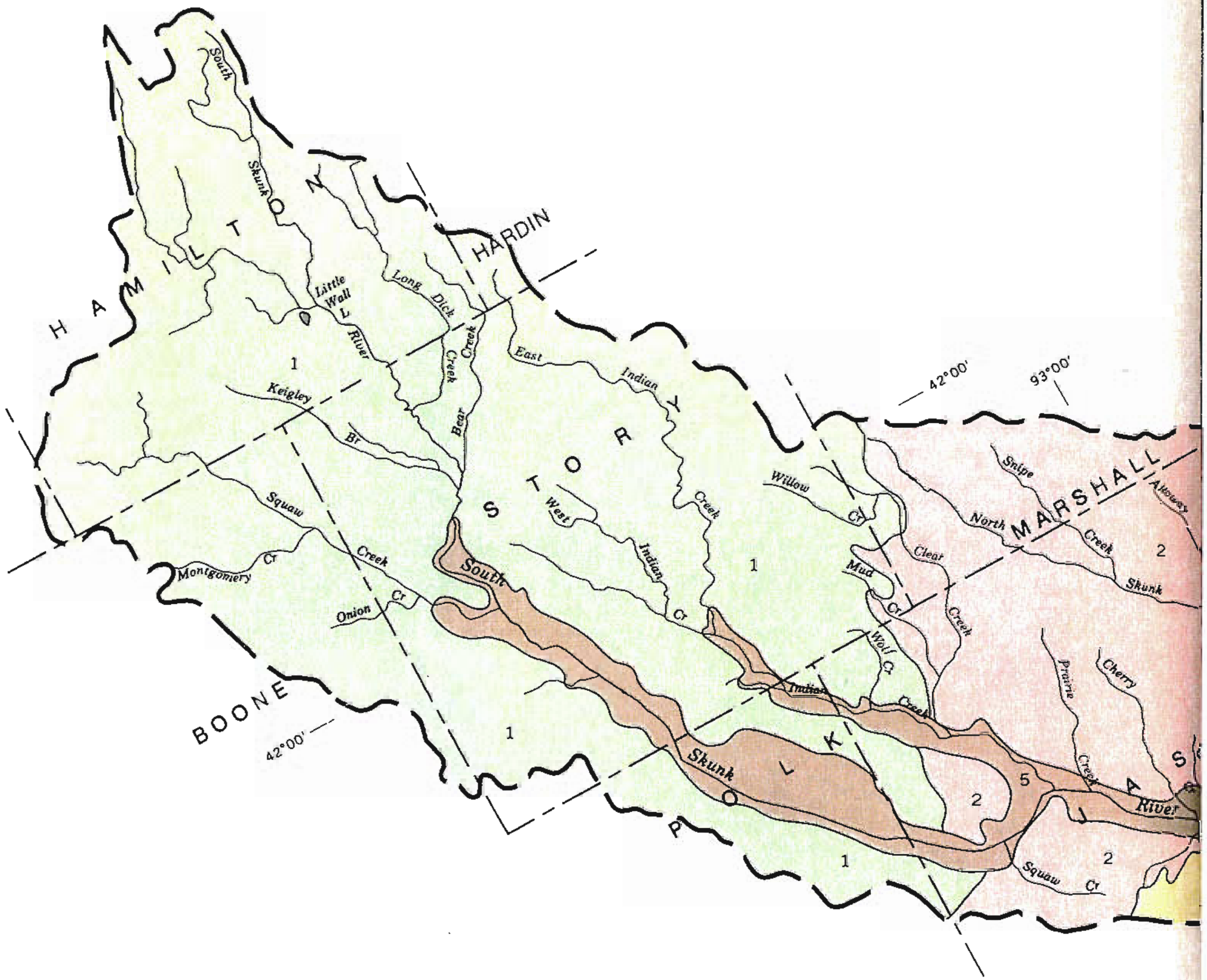


FIGURE B-1

U.S. DEPARTMENT OF AGRICULTURE



LEGEND

- BASIN BOUNDARY
- STATE BOUNDARY
- COUNTY BOUNDARY
- DRAINAGE
- LAKE

SOURCE: U.S.G.S. GEOLOGICAL SURVEY HYDROLOGIC UNIT MAP - 1974 AND COUNTY GENERAL HIGHWAY MAPS, POLYCONIC PROJECTION.

USDA-SCS-NATIONAL CARTOGRAPHIC CENTER, FT. WORTH, TX.-1987

SOIL ASSOCIATIONS

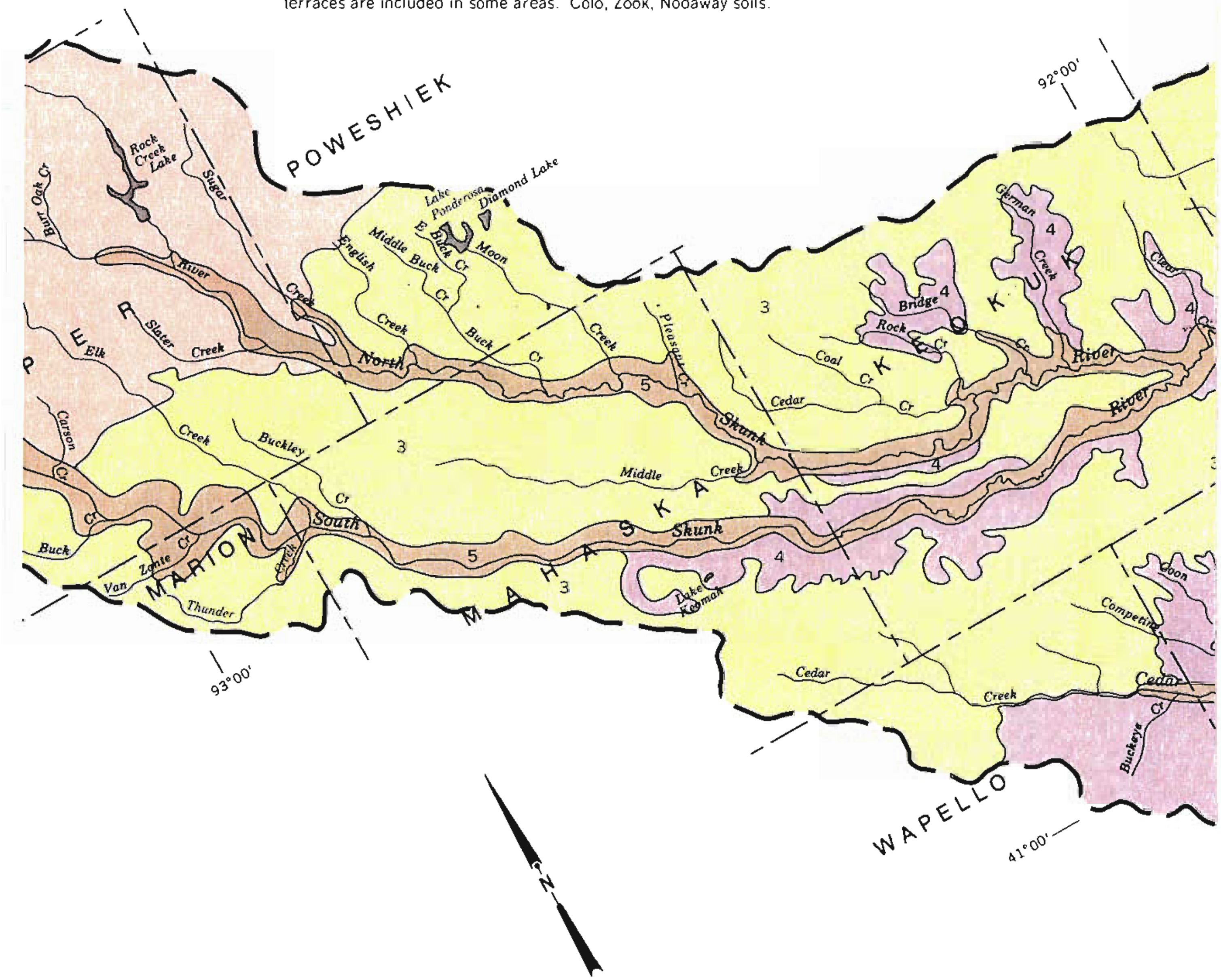
1 Nearly level to moderately sloping (0-9%) prairie-derived soils developed from Wisconsin glacial till on the Cary Lobe. Clarion, Nicollet, Webster, and Canisteo soils, and small areas of Storden, Harps, and Okoboji soils.

2 Nearly level to steep (0-25%) prairie to forest-derived soils developed from loess or from pre-Illinoian glacial till. Tama, Muscatine, and Garwin soils and smaller areas of Shelby, Lindley, Downs, and Fayette soils

3 Nearly level to strongly sloping (0-14%) prairie to forest-derived soils developed from loess, pre-Illinoian paleosols, or pre-Illinoian glacial till. Otley, Mahaska, and Taintor soils, and smaller areas of Ladoga, Clinton, Shelby, and Adair soils.

4 Gently sloping to very steep (2-30%) forest-derived soils developed from loess, pre-Illinoian glacial till or pre-Illinoian paleosols. Clinton, Lindley, and Weller soils, and smaller areas of Pershing and Keswick soils.

5 Nearly level and gently sloping (0-5%) prairie-derived soils developed from alluvium on bottomlands. Soils on stream terraces are included in some areas. Colo, Zook, Nodaway soils.



GENERAL SOIL MAP
SKUNK RIVER BASIN
IOWA

0 10 20 MILES
0 10 20 KM
APPROXIMATE SCALE

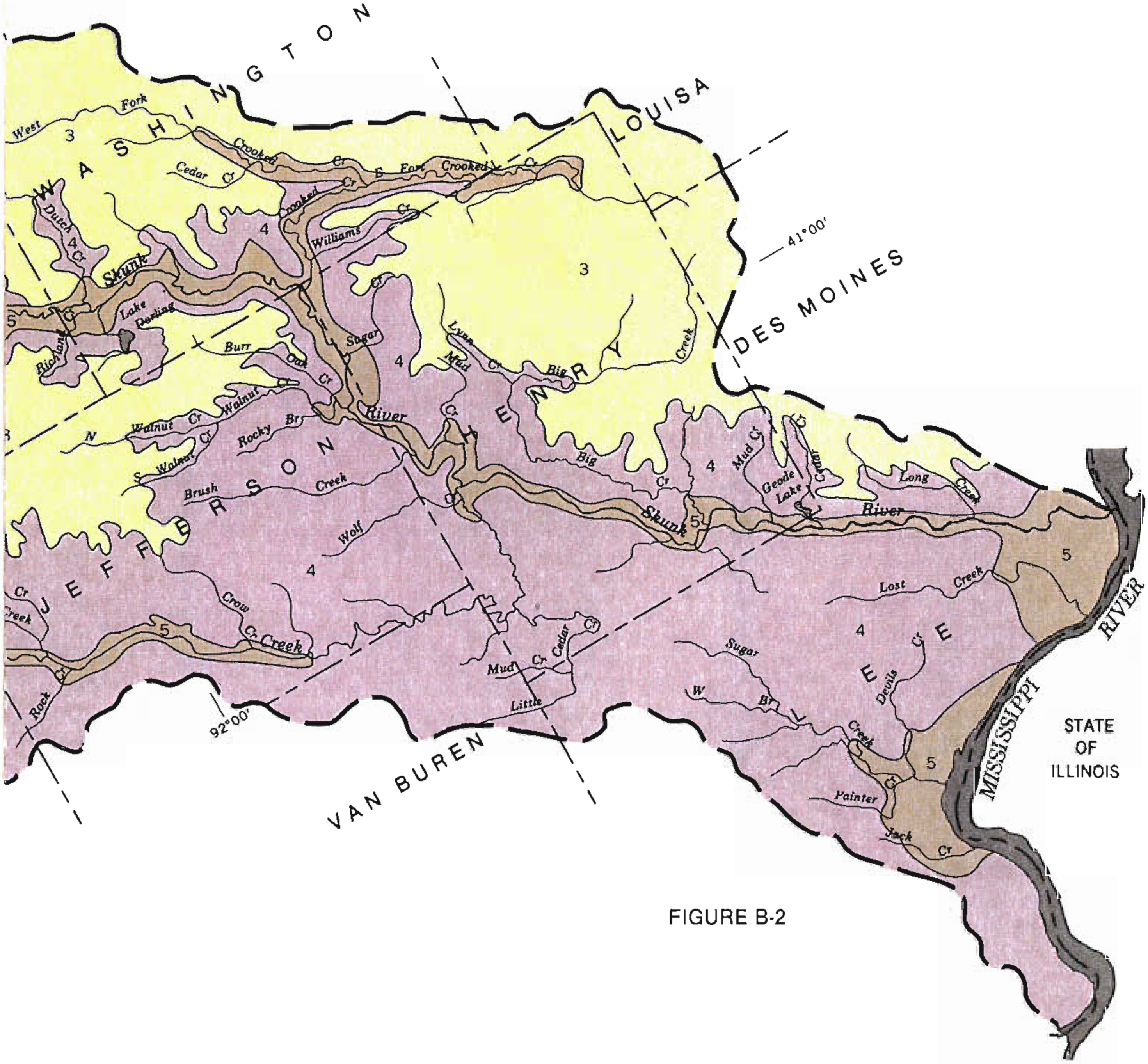


FIGURE B-2

JANUARY 1987 4-R-40039

USD

APPENDIX C

CLIMATIC CHARACTERISTICS WITH RESPECT TO WET CROPLAND SOILS PROBLEMS

The problem of wet cropland soils is due to one or more of the following: excessive rainfall, fine soil texture, high water table, level topography, and depressional locations. A measure of excessive rainfall provides an insight into the climatic effects upon this problem. Streams tend to convey greater rates of flow during times of higher water table and during surface runoff. Hence monthly distribution of streamflow is an indicator of surface and subsurface moisture conditions. Figure C-1 displays the portion of runoff occurring each month for the South Skunk River stream gage near Ames, Iowa. This stream flow record is representative of the monthly flows for streams in the major wet cropland soils area of the Upper Skunk River Basin. It should be observed that the greatest flows are during March, April, May, and June indicating greater soil moisture at that time. Field preparation, planting and crop care are normally carried out during this period. As timely operations are essential and excessively wet soils inhibit plant growth it is imperative for farmers to provide for timely removal of excess water from their fields.

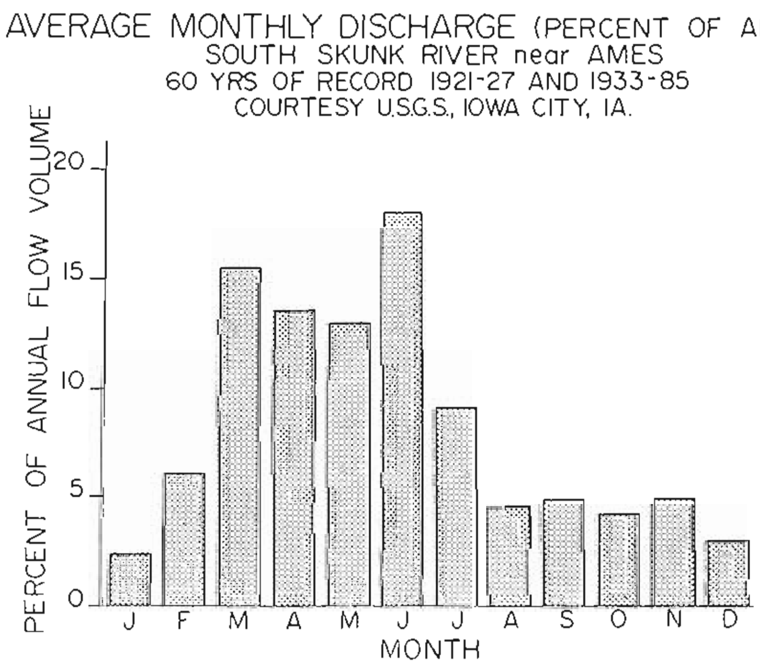


Figure C-1. Monthly Stream Flow

APPENDIX D

IMPACT OF DRAINAGE ON FLOOD DAMAGES

The following statement is the view of the Soil Conservation Service on drainage as given in response to questions from Senator Buckley at hearings held by the Senate Committee on Public Works on July 27, 1971.

Question: What impact occurs on floods, sediment production, and the productivity of the land when a marsh is drained? Please cite the documentation for your conclusion.

Answer: As indicated in our reply to the previous question, we do not plan the drainage of marshes and, therefore, have little information concerning this. In general we would expect the effects of marsh drainage on floods and sediment production to be similar to these effects for other land discussed below. Concerning the effect of drainage on marsh productivity, we would expect the productivity of water-tolerant vegetation to decrease and other vegetation to increase as the water table is lowered, provided the soils are suitable. Other forms of life dependent on such vegetation would be affected similarly.

We do have considerable information about the effects of drainage on wet agricultural land. Our conclusions and their basis are as follows:

1. Drainage does not increase the size of floods, especially in large basins.

2. Sediment production is not a significant problem in drained lands.

3. Agricultural productivity usually increases with drainage, the amount depending on adequacy of drainage, type of soil, overall management, and other factors of production.

4. Drainage is best planned on an overall project basis, where a total system can be well planned and designed, rather than on a piecemeal basis. This is done in watershed projects.

There is evidence that farm drainage has no effect on floods in large drainage basins. In small drainage basins peak discharges may increase or decrease depending on the design of the drainage system, soils, time of year, and distribution and timing of the flood-causing precipitation.

The "sponge theory" is often used to support the idea that drainage causes floods. Some people say that wetlands help prevent floods by absorbing flood waters. Actually the opposite is true. A saturated soil or pothole full of water cannot soak up water any more than an already saturated sponge. However, when wetlands are drained, the soil acts as a sponge in soaking up water and letting it out slowly. Some soils can store six or more inches of water, depending on type and depth of soils.

Mr. Philip W. Manson of the Department of Agricultural Engineering, in his paper "Water and Agricultural Land", Miscellaneous Journal Series Paper No. 947, August 1957, University of Minnesota Agricultural Experiment Station, states that "farm drainage does not affect major floods." He based this on his studies and on:

1. U.S. Geological Survey records on the Mississippi River at St. Paul which show that from 1867 to 1957, there have been 19 years in which floods occurred; twelve in the first half and 7 in the last half of this period. During this time, there has been extensive drainage in this Basin.
2. A paper by Sherman M. Woodward and Floyd B. Nagler "Agriculture Drainage and Flood Runoff", 1929, Paper No. 1709 of the Transactions of the American Society of Civil Engineers. Their study areas included ten million acres in the Des Moines River Basin and two million acres in the Iowa River Basin. The types of drainage in these basins include tile, open ditch, and stream channel straightening. One-third of the total basin areas were drained. In the Des Moines Basin, there was one unit of four million acres which was 67 percent drained. Another unit of two million acres was 100 percent drained. The conclusion of the author included in Mr. Manson's paper: "A critical examination of the records of these two streams shows that there has been no significant change in their behavior which can be attributed to drainage. The total runoff from streams of like precipitation, the maximum rate of discharge, and the rainwater storage conditions within the basin seem to have been unaltered by the extensive drainage operations. It is believed that if any of these factors had been changed to a measurable amount, such fact could easily have been detected by the analysis made in this paper."

Manson goes on to state in his paper, "Each small watershed is a case by itself but normally a well-designed complete drainage system for a small watershed will not increase the peak runoff, although an incomplete or partial system may either slightly increase the peak flow or it may slightly decrease the peak flow. Therefore, it is important to plan drainage systems on a watershed basis and not by piecemeal. The Soil Conservation Service endorses this view. 1/

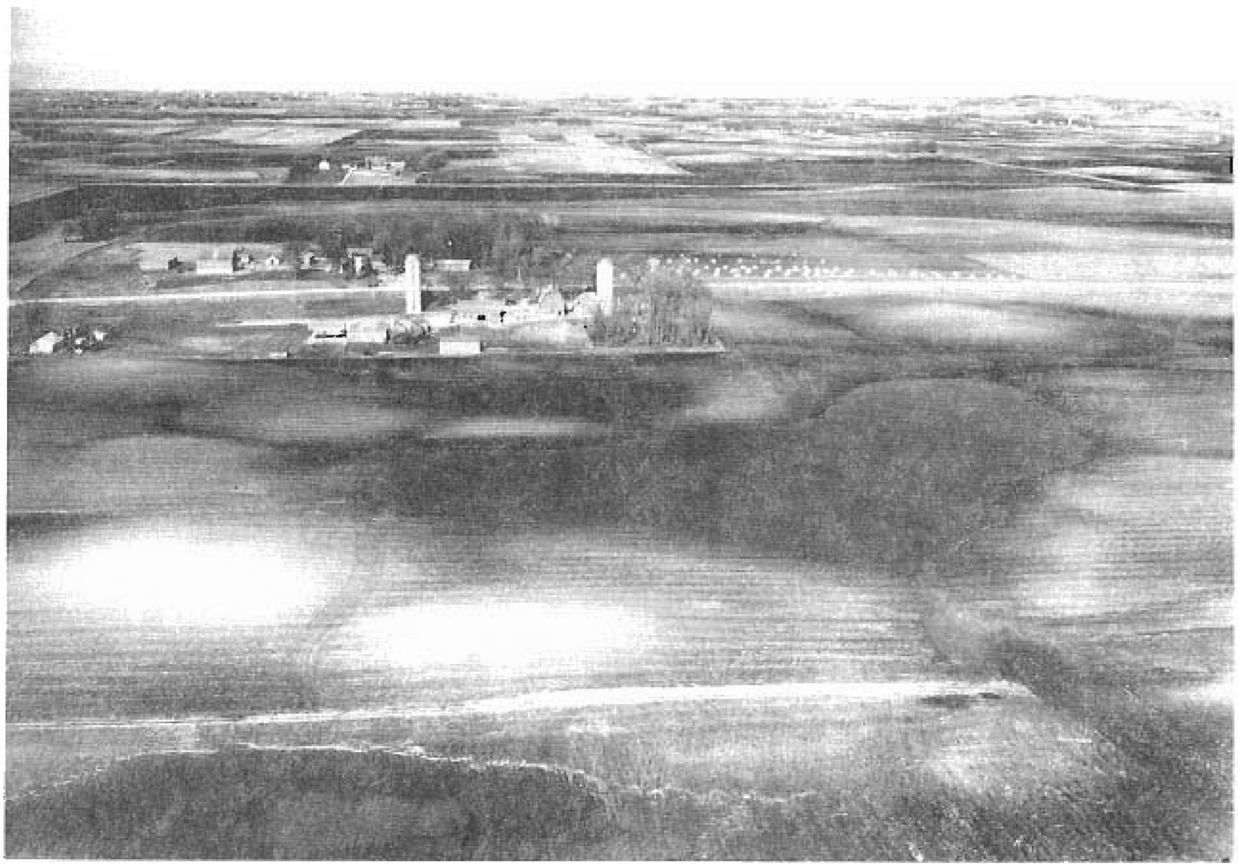


Figure D-1. This farm has a large, inadequately drained ponding area.

1/ Statement made in Advisory WS-5 (January 30, 1973) by William B. Davey, Deputy Administrator for Watersheds.

APPENDIX E

DEFINITIONS OF WETLAND TYPES

"Wetlands of the United States," Circular 39, published by United States Department of the Interior, Fish and Wildlife Service, lists 20 types of wetlands. Types 1 through 5 are found in the Skunk River Basin. A brief description of these is as follows:

Type 1 - Seasonably flooded basins or flats. The soil is covered with water, or is waterlogged, during variable seasonal periods but usually is well drained during much of the growing season. Vegetation varies greatly according to the season and the duration of flooding. It includes bottomland hardwoods as well as some herbaceous growths. Where the water has receded early in the growing season, smartweeds, wild millet, fall panicum, teal lovegrass, redroot flatsedge, and weeds (such as ragweed and cocklebursz) are likely to occur. Shallow basins that are submerged only very temporarily usually develop little or no wetlands vegetation.

Type 2 - Inland fresh meadows. The soil is without standing water during most of the growing season but is waterlogged within at least a few inches of its surface. Vegetation includes grasses, sedges, rushes, and various broad-leaved plants. Wild hay is sometimes cut from such areas. Fresh meadows are used somewhat in the North by nesting waterfowl, but in most of the country their value is mainly as supplemental feeding areas.

Type 3 - Inland shallow fresh marshes. The soil is usually waterlogged during the growing season; often it is covered with as much as six inches or more of water. Vegetation includes grasses, bulrushes, spikerushes, and various other marsh plants such as cattails, arrowheads, pickelweed, and smartweeds. In combination with deep fresh marshes (Type 4) they constitute the principal production areas for waterfowl.

Type 4 - Inland deep fresh marshes. The soil is covered with six inches to three feet or more of water during the growing season. These may border open lakes or fill shallow lake basins. Vegetation includes cattails, reeds, bulrushes, spikerushes, and wildrice. In open areas, pondweeds, naiads, coontail, watermilfoils, waterweeds, duckweeds, waterlilies, or spatterdocks may occur.

Deep fresh marshes constitute the best breeding habitat in the country, and they are also important feeding places.

Type 5 - Inland open fresh water. Shallow ponds and reservoirs are included in this type. Water is usually less than ten feet deep and is fringed by a border of emergent vegetation. Vegetation (mainly at water depths less than six feet) includes pondweeds, naiads, wildcelery, coontail, watermilfoils, waterlilies, and spatterdocks. These areas are used extensively as brood areas when, in midsummer and late summer, the less permanent marshes begin to dry out.

Soil Conservation Service Policy

It is the general policy of the SCS to aid in protecting, maintaining, and managing existing wetlands to assure the continuation of their beneficial effects. Assistance also will be given to restore damaged wetlands that are not irrevocably committed to other uses and to create new wetlands, where appropriate.

The swampbuster provision of the Food Security Act of 1985 is aimed at discouraging the conversion of wetland for agricultural purposes. Farmers who convert wetlands to cropland use may lose eligibility for certain USDA program benefits.

APPENDIX F

CRITERIA FOR TILE DESIGN IN IOWA 1/

Establishing the degree of drainage for tile capacity design is dependent upon (1) the maximum allowable height of the water table, (2) the minimum rate at which the water table must be lowered, or (3) the maximum allowable duration and frequency of ponding. Crop requirements are a consideration in selecting an appropriate degree of drainage.

The drainage coefficient is the rate at which water can be removed and is expressed as the equivalent depth of water covering the surface that can be removed in 24 hours. The table below can be used to determine the minimum recommended drainage coefficient for various conditions.

Table F-1
TILE CAPACITY
Skunk River Basin

Crops and Degree of Surface Drainage	Drainage Coefficient 1/ (in. of water per day)	
	Mineral soil	Organic soil
Field Crops		
Good Surface drainage 2/	3/8 to 1/2	1/2 to 3/4
Blind inlets 3/	1/2 to 3/4	3/4 to 1
Surface inlets 3/	1/2 to 1	1-1/2 to 2
Truck Crops		
Good Surface drainage 2/	1/2 to 3/4	3/4 to 1-1/2
Blind inlets 3/	3/4 to 1	1-1/2 to 2
Surface inlets 3/	1 to 1-1/2	2 to 4

1/ "Iowa Drainage Guide", Special Report 13 (Revised), Iowa State University, Ames, Iowa. March 1987.

2/ Consider only the area that will be tiled or that could be tiled as the drainage area. It is assumed that surface water is removed by field ditches or watercourses. For fields having slopes of less than 0.2 percent, use the higher end of the drainage coefficient range.

3/ Use the entire contributing watershed as the drainage area.

If surface or blind inlets must be used to drain depressional areas where adequate surface drainage does not exist, the drain must have capacity to remove runoff from the entire contributing watershed area. An exception may be made for small depressions if surveys are available and the volume of the depressional area can be determined accurately. In this case, the tile should be able to remove the appropriate drainage coefficient from the land area that needs tile drainage plus the water in the depression within 24 hours. If the drainage area to depressional area ratio is large, it may not be practical to drain the depressional area within 24 hours. The depressional area, perhaps, should become a sacrifice area rather than spend large sums for a tile water removal system that would drain it within 24 hours.

Subsurface drain (tile) criteria for assuring quality design and construction is available in the Technical Guide at all SCS offices. Considerations addressed in this standard are:

Depth, spacing, location	Tube material
Minimum velocity and grade	Bedding
Maximum velocity and grade	Anxiliary structures
Outlets	Placement, inspection
Capacity	Trees
Filters, envelopes	Alignment

Figure F-1. Installing plastic tubing for a subsurface drain.

APPENDIX G

HOW DRAINAGE DISTRICT LINES ARE REPAIRED IN IOWA 1/

This winter's huge snowfalls are causing a variety of problems this spring as the snow melts. In areas of the state where the terrain is basically flat, melting snow could create increasingly larger amounts of standing water in the fields.

Consequently, the condition of drainage lines in rural areas may be a particular concern. This article describes the provision of Iowa law dealing with the repair and improvement of drainage lines within drainage districts.

Iowa law provides that drainage districts be supervised and managed by either the county board of supervisors or a panel of trustees elected by landowners within the district. In either event, the governing body of the district is required to keep the improvement in repair.

It is necessary to differentiate between the "repair" of a drainage district and an "improvement." A repair to a drain involves restoring it to its original condition following injury or decay.

On the other hand, an improvement is defined under Iowa law as a project intended to expand, enlarge, or otherwise increase the capacity of any existing ditch, drain, or other facility above that for which it was designed.

To keep the district in repair, the board or panel of trustees may at any time, order done whatever is necessary to restore the line to its original efficiency. This can be done without notifying landowners within the district.

The order may include removing silt and debris, repairing any damaged structures, removing weeds and other vegetative growth, and basically any other work necessary to restore the line's efficiency.

Before ordering this work done, the board or panel may obtain an engineer's report as to the most feasible means of repair and the

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1/ Prepared by Farm Division-Iowa Attorney General's Office (Reprint from Wallaces Farmer, March 13, 1982) probable cost. The board or panel may order temporary construction or, if it is more economical, order that a new line be constructed which is still considered a repair.

Should the estimated cost of the repair exceed $10,000 or 75% of the original total cost of the district and subsequent improvements, whichever amount is greater, the board or panel of trustees must give notice to landowners within the district and conduct a hearing.

The hearing is conducted to decide whether to perform the repairs and to hear objections, if any, to the proposed repairs. If the repairs are minor or involve the eradication of brush and weeds along open ditches in an amount not exceeding $5000, the board may have the repairs or eradication done by the county's secondary road or weed fund equipment. However, the board may order this work done only where it will result in a savings to the district, and the drainage district must reimburse the county.

The process for constructing an <u>improvement</u> to a drainage line is essentially the same as that for repairs. When the board or panel of trustees determines that an improvement to a drainage line is necessary, it appoints an engineer to conduct a survey and prepare a report showing the estimated costs of the improvements.

If the estimated cost of the improvement does not exceed $500 or 25% of the original cost of the district and subsequent improvements, whichever is the greater amount, the board may order the work done. Again, landowners within the district do not need to be notified. Should the cost of the improvement exceed this amount, the board or panel of trustees must give notice to affected landowners and conduct a hearing.

The cost of repairs or improvements are paid from the funds of the drainage district. Drainage district funds are created through the assessments levied on landowners within the district based on the benefits they receive.

If the district's funds are insufficient to pay the costs, the board of trustees can levy an additional assessment.

In addition to the power to repair and improve drainage lines, the governing body of a drainage district is required to remove from ditches, drains, and laterals of their districts any obstructions interfering with the flow of water. These obstructions include trees, hedges, shrubbery, and their roots.

In removing obstructions, the board or panel of trustees may relay the tile drain in concrete or other adequate protection. Again, the costs of this work are paid from the funds of the district.

Landowners in drainage districts who feel that there are obstructions within drainage lines or that these lines need repair should contact either the board of supervisors or panel of trustees, whichever body manages the district.

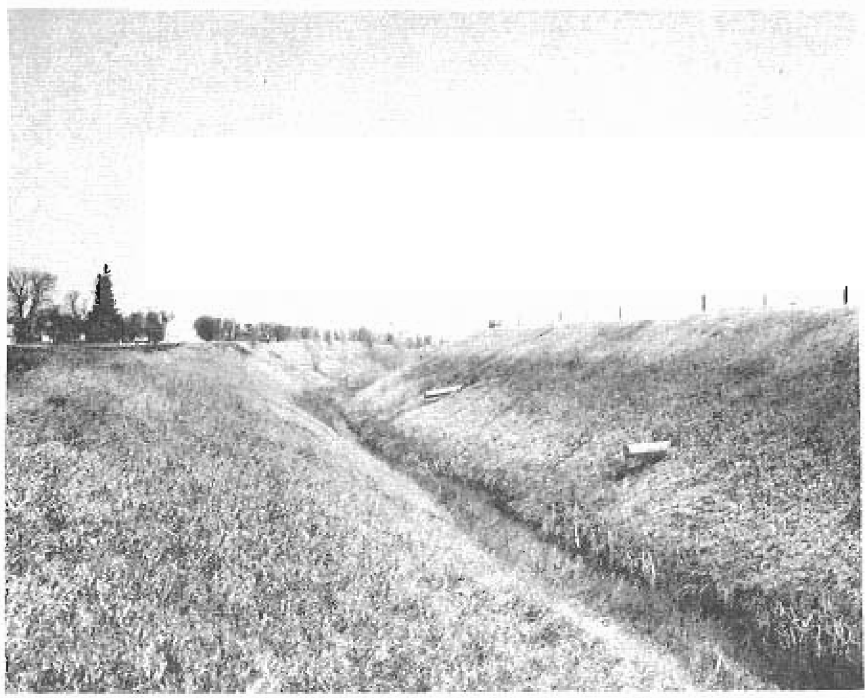


Figure G-1. Example of a well maintained open drainage channel.

APPENDIX H

LEGAL DRAINAGE DISTRICTS INVENTORIES

The District Conservationists (DC) in Boone, Hamilton, Hardin, Polk, and Story Counties each furnished tile outlet legal drainage district data from the official records on file in the respective county courthouses. Data supplied included the state watershed inventory number, drainage district number, drainage area, outlet grade, tile diameter, and date installed. Each DC evaluated the percentage of surface water in each district which outlets through the tile system. In other words this is the portion which is impounded. The survey also included the percentage of each of the major soil types in each district. This reveals the extent of wet soils which by nature need drainage.

From the inventory data, capacity of each system was computed at its outlet in inches per day. The percentage of impounded area and extent of wet soils were analyzed to determine required capacity in inches per day. Where existing capacity is less than 80 percent of required capacity a relief tile main is needed. A higher percentage might have been used as a cut-off point but 80 percent seems consistent with the data and analysis used. Prior to designing improvements, a field study of each system is needed to verify the existing sizes and grades which determine capacity. Also needed is an on-site evaluation of the drainage area to calculate required capacity for good agricultural drainage.

The following data (Tables H-1 and H-2) include legal drainage districts for which information was compiled from plans of record in Boone, Hamilton, Hardin, Polk, and Story Counties.

TABLE H-1
TILE OUTLET CAPACITY SUMMARY
Skunk River Basin

County	Drainage Districts	Area Adequate	Area Inadequate	Total Area
	number	acres	acres	acres
Boone	49	27,617	11,500	39,117
Hamilton	49 (132) 1/	25,069 (67,754)	7,645 (20,662)	32,714 (88,416)
Hardin	1	---	1,890	1,890
Polk	2	1,144	1,549	2,693
Story	94	43,534	49,697	93,231
Total	195 (278)	97,364 (140,049)	72,281 (85,298)	169,645 (225,347)

1/ As explained in an earlier chapter complete information needed to calculate present drainage capacity was available for 37 percent of Hamilton County tile drainage districts. Numerical data for Hamilton County were expanded by dividing by 37 percent. The expanded data are shown in parentheses and represent the best estimate for tile drainage districts in Hamilton County and for the LRA 103 area of the Skunk River Basin.

Figure H-1. A recently installed subsurface drainage outlet.

TABLE H-2
TILE OUTLET CAPACITY
Skunk River Basin

Watershed	Drainage District	Date Installed	Drainage Area	Outlet Grade	Tile Diameter	Outlet Capacity	Present Required Capacity
number	number	year	acre	percent	inch	in/day	in/day
			BOONE COUNTY				
Adequate Outlet							
16	125	----	2,357	0.20	40	0.48	0.45
16	186	1919	1,408	0.44	30	0.54	0.44
16	185	1921	304	0.65	18	0.78	0.42
16	118	1914	824	0.44	24	0.50	0.43
16	195	1921	787	0.36	26	0.60	0.43
16	132	1922	1,199	0.40	30	0.62	0.44
16	92	1911	845	0.84	20	0.42	0.45
16	113	1913	884	0.44	26	0.59	0.45
16	56	1908	621	0.10	24	0.33	0.40
16	166	1914	1,213	0.40	34	0.84	0.43
16	164	1917	285	0.30	18	0.58	0.45
16	134	1916	423	1.60	16	0.67	0.42
16	155	1915	372	0.90	12	0.26	0.30
16	144	1915	759	0.54	24	0.63	0.45
16	211	1928	368	0.55	18	0.60	0.40
16	128	1914	505	0.50	18	0.42	0.38
16	129	1914	226	1.62	12	0.58	0.30
16	160	1917	404	1.28	16	0.61	0.40
16	231	1952	180	1.00	12	0.55	0.42
16	142	1916	304	0.18	14	0.22	0.25
16	230	1954	463	0.66	14	0.27	0.25
16	135	1914	802	0.30	20	0.27	0.30
16	143	1917	1,962	0.36	32	0.43	0.35
16	96	1912	479	0.50	18	0.45	0.30
16	116	1913	805	0.20	26	0.44	0.30
16	50	1911	387	0.24	18	0.38	0.30
16	205	1924	933	0.52	26	0.61	0.25
16	159	1917	1,189	0.48	26	0.46	0.40
16	215	1930	1,298	0.37	28	0.46	0.30
16	169	1918	1,576	0.30	34	0.56	0.30
16	6	----	720	0.32	24	0.50	0.35
16	194	1921	387	0.56	18	0.58	0.40
16	69	1908	189	0.95	12	0.52	0.30
16	131	1915	1,700	0.16	36	0.45	0.40
16	12	1905	270	0.80	12	0.34	0.40
16	69S	1908	189	0.95	12	0.52	0.40
	Subtotal		27,617				

TABLE H-2
TILE OUTLET CAPACITY
Skunk River Basin

Watershed	Drainage District	Date Installed	Drainage Area	Outlet Grade	Tile Diameter	Outlet Capacity	Present Required Capacity
number	number	year	acre	percent	inch	in/day	in/day
			BOONE COUNTY cont.				
Inadequate Outlet							
16	49	1908	513	0.87	14	0.28	0.45
16	52	1908	637	0.50	16	0.24	0.43
16	121	1914	260	0.10	16	0.26	0.40
16	197	1921	105	0.22	10	0.28	0.38
16	109	1911	1,420	0.14	26	0.20	0.30
16	162	1917	1,114	0.74	16	0.17	0.45
16	222	1950	1,465	0.43	18	0.13	0.38
16	25	1941	520	0.34	16	0.25	0.43
16	93	1910	1,032	0.20	20	0.17	0.35
16	117	1913	894	0.25	22	0.28	0.40
16	150	1917	1,233	0.10	26	0.20	0.40
16	93B	1913	894	0.25	22	0.28	0.40
16	2B	1917	1,413	0.10	28	0.20	0.40
	Subtotal		11,500				
	Total Boone County		39,117				

TABLE H-2
TILE OUTLET CAPACITY
Skunk River Basin

Watershed	Drainage District	Date Installed	Drainage Area	Outlet Grade	Tile Diameter	Outlet Capacity	Present Required Capacity
number	number	year	acre	percent	inch	in/day	in/day
			HAMILTON COUNTY				
Adequate Outlet							
16	56	----	485	0.40	24	0.80	0.40
16	91	----	618	0.58	24	0.77	0.40
16	115	----	1,482	0.10	36	0.40	0.40
16	169	----	356	0.07	26	0.60	0.40
16	211	----	55	0.20	8	0.28	0.25
16	214	----	304	0.22	24	0.98	0.40
16	229	----	1,971	0.25	36	0.48	0.30
16	240	----	576	0.50	18	0.37	0.35
16	252	----	246	0.10	20	0.50	0.40
16	260	----	1,256	0.40	24	0.32	0.35
16	278	----	265	0.22	16	0.38	0.35
16	292	----	889	0.45	26	0.60	0.45
17	219	----	86	0.14	12	0.44	0.45
17	248	1921	680	0.22	28	0.60	0.50
18	256	1923	2,248	0.08	39	0.30	0.28
18	259	----	51	0.20	10	0.60	0.45
18	277	----	237	0.15	16	0.36	0.40
19	46	----	199	0.50	14	0.54	0.40
19	216	----	1,875	0.20	32	0.33	0.35
20	224	----	88	1.40	12	1.30	0.40
21	14	1906	1,458	0.12	32	0.33	0.35
21	17	1906	193	0.20	12	0.23	0.26
21	21	1906	194	0.35	12	0.31	0.30
21	38	1908	131	0.10	12	0.25	0.30
21	52	----	181	0.25	14	0.42	0.38
21	63	----	876	0.18	24	0.31	0.33
21	123	1924	1,198	0.15	34	0.52	0.38
21	180	1915	234	0.60	15	0.61	0.25
21	209	----	165	0.10	15	0.36	0.38
21	227	----	212	1.00	18	1.40	0.30
21	228	----	163	0.90	18	1.75	0.28
21	234	----	332	0.10	22	0.49	0.35
21	247	1920	366	0.08	22	0.39	0.40
21	267	----	133	0.30	16	0.90	0.50
22	298	----	30	0.40	10	1.30	0.50
22	136	1912	1,642	0.10	32	0.26	0.25
22	193	1916	1,420	0.12	30	0.29	0.30

TABLE H-2
TILE OUTLET CAPACITY
Skunk River Basin

Watershed	Drainage District	Date Installed	Drainage Area	Outlet Grade	Tile Diameter	Outlet Capacity	Present Required Capacity
number	number	year	acre	percent	inch	in/day	in/day
			HAMILTON COUNTY cont.				
Adequate Outlet cont.							
22	230	1919	696	0.10	26	0.35	0.35
22	243	1920	440	0.10	26	0.55	0.35
22	287	1952	515	0.36	20	0.46	0.45
22	288	1951	350	0.18	22	0.62	0.28
22	238	----	173	0.14	24	1.30	0.50
	Subtotal		25,069				
Inadequate Outlet							
17	42	----	540	0.60	16	0.32	0.50
18	40	----	525	0.30	18	0.32	0.42
18	163	1955	3,927	0.11	36	0.16	0.40
19	102	----	333	0.10	18	0.29	0.40
21	19	1906	459	0.20	18	0.30	0.38
22	48	----	650	0.09	22	0.23	0.50
22	212	1917	1,211	0.20	22	0.29	0.45
	Subtotal		7,645				
	Total Hamilton County		32,714				

TABLE H-2
TILE OUTLET CAPACITY
Skunk River Basin

Watershed	Drainage District	Date Installed	Drainage Area	Outlet Grade	Tile Diameter	Outlet Capacity	Present Required Capacity
number	number	year	acre	percent	inch	in/day	in/day
			HARDIN COUNTY				
Inadequate Outlet							
11	34	1912	1,890	0.19	24	0.15	0.35
	Subtotal		1,890				
	Total Hardin County		1,890				
			POLK COUNTY				
Adequate Outlet							
13	4	1920	1,144	0.42	24	0.35	0.25
	Subtotal		1,144				
Inadequate Outlet							
8	12	1919	1,549	0.05	24	0.09	0.38
	Subtotal		1,549				
	Total Polk County		2,693				

TABLE H-2
TILE OUTLET CAPACITY
Skunk River Basin

Watershed	Drainage District	Date Installed	Drainage Area	Outlet Grade	Tile Diameter	Outlet Capacity	Present Required Capacity
number	number	year	acre	percent	inch	in/day	in/day
			STORY COUNTY				
Adequate Outlet							
09	51	1912	1,090	0.20	24	0.26	0.32
09	56	1913	772	0.40	26	0.65	0.41
09	72	1915	909	0.14	26	0.31	0.30
09	100	1921	1,641	0.30	32	0.39	0.30
09	104	1922	1,200	0.30	28	0.44	0.45
10	77	1916	2,138	0.20	36	0.40	0.30
11	9	1905	1,650	0.40	30	0.45	0.40
11	19	1909	1,000	0.20	30	0.52	0.45
11	34	1910	1,167	0.45	24	0.36	0.38
11	36	1981	2,571	0.28	42	0.60	0.45
11	48	1912	275	1.00	12	0.37	0.28
11	60	1913	1,355	0.20	26	0.26	0.28
11	69	1916	3,246	0.12	45	0.37	0.45
11	71	1915	740	0.24	26	0.52	0.35
11	75	1916	2,160	0.20	36	0.39	0.33
11	76	1916	1,650	0.24	30	0.35	0.40
11	85	1918	236	0.34	14	0.38	0.35
11	88	1919	561	2.00	14	0.39	0.45
11	89	1919	415	0.08	26	0.53	0.33
11	92	1919	285	1.60	14	0.68	0.40
11	94	1919	118	3.00	8	0.48	0.30
11	97	1920	355	0.20	18	0.38	0.25
11	107	1921	781	0.60	20	0.40	0.40
11	113	1924	231	0.84	14	0.62	0.30
12	66	1915	970	0.10	28	0.30	0.34
13	BS3	----	500	0.10	24	0.40	0.40
13	BS3	----	600	0.10	30	0.60	0.45
13	BS3	----	200	0.15	18	0.58	0.45
13	16	1908	100	0.30	15	1.00	0.20
13	38	1910	100	0.25	10	0.31	0.22
13	39	1910	241	0.10	18	0.40	0.48
13	59	1913	625	0.28	20	0.34	0.30
13	87	1916	401	0.50	16	0.39	0.46
13	111	1922	77	2.40	10	0.85	0.35
13	N2	1924	355	0.24	18	0.42	0.28
13	101	1920	126	1.84	8	0.38	0.40
13	115	1944	551	0.50	20	0.52	0.45

TABLE H-2
TILE OUTLET CAPACITY
Skunk River Basin

Watershed	Drainage District	Date Installed	Drainage Area	Outlet Grade	Tile Diameter	Outlet Capacity	Present Required Capacity
number	number	year	acre	percent	inch	in/day	in/day
			STORY COUNTY cont.				
Adequate Outlet cont.							
14	28	1909	421	0.80	16	0.47	0.43
16	6	1914	842	0.30	20	0.26	0.30
16	8	1915	1,962	0.36	32	0.43	0.43
16	37	1910	520	0.25	20	0.38	0.36
16	63	1914	112	0.46	14	0.93	0.43
16	67	1915	424	0.64	15	0.34	0.43
16	70	1915	4,027	0.27	42	0.37	0.43
16	95	1922	1,229	0.50	28	0.56	0.45
17	53	1913	475	0.45	18	0.43	0.40
17	102	1920	83	0.16	12	0.50	0.27
17	106	1921	629	0.50	20	0.45	0.45
18	80	1916	450	0.20	20	0.40	0.30
19	50	----	150	0.10	14	0.32	0.30
20	HS 3&4	1921	818	0.22	28	0.55	0.43
	Subtotal		43,534				
Inadequate Outlet							
9	43	1911	625	0.15	20	0.25	0.38
11	10	1906	2,023	0.45	24	0.21	0.48
11	17	1922	3,100	0.10	32	0.14	0.48
11	20	1909	2,115	0.27	22	0.12	0.45
11	20	1909	1,164	0.30	20	0.19	0.45
11	21	1909	391	0.20	18	0.34	0.50
11	25	1909	952	0.25	20	0.21	0.42
11	26	1950	96	0.10	12	0.35	0.45
11	32	1911	3,840	0.20	36	0.22	0.43
11	35	1910	481	0.10	18	0.20	0.50
11	45	1911	1,247	0.10	28	0.23	0.43
11	49	----	2,505	0.15	33	0.20	0.48
11	52	1912	1,130	0.45	20	0.24	0.45
11	54	1913	1,500	0.10	28	0.20	0.28
11	57	1913	750	0.10	20	0.17	0.25
11	62	1913	1,747	0.10	26	0.14	0.48
11	68	1914	1,967	0.30	28	0.27	0.45

TABLE H-2
TILE OUTLET CAPACITY
Skunk River Basin

Watershed number		Drainage District number	Date Installed year	Drainage Area acre	Outlet Grade percent	Tile Diameter inch	Outlet Capacity in/day	Present Required Capacity in/day
				STORY COUNTY cont.				
Inadequate Outlet cont.								
11		78	1916	550	0.10	24	0.37	0.48
11		81	1916	2,656	0.10	39	0.28	0.40
11		83	1917	558	0.12	20	0.25	0.48
11		84	1917	525	0.10	22	0.31	0.50
13		15	1909	376	0.80	12	0.25	0.38
13		24	1909	460	0.59	12	0.17	0.33
13		30	1910	182	0.10	10	0.11	0.40
13		40	1910	276	0.60	12	0.28	0.42
13		55	1913	202	0.70	10	0.26	0.42
14		BS 1	1917	900	0.37	18	0.21	0.43
14		BS 10	1923	1,966	0.10	36	0.30	0.48
14		93	1919	307	0.08	14	0.14	0.48
14		109	1921	323	0.24	14	0.23	0.48
16		215	1930	1,298	0.10	14	0.04	0.43
16		230	1954	463	0.66	14	0.27	0.40
17		HS 3	1914	2,200	0.16	34	0.29	0.50
17		29	1909	1,064	0.16	22	0.20	0.43
17		44	1912	1,043	0.15	22	0.19	0.40
17		73	1915	850	0.10	22	0.19	0.48
18		1	1910	2,500	0.20	30	0.21	0.45
18		BS 5	1911	1,432	0.14	26	0.21	0.48
18		105	1921	100	0.10	12	0.31	0.48
19		27	1910	1,000	0.20	22	0.23	0.40
19	two	46	1912	941	0.10	24	0.21	0.48
19	mains	46	1912	392	0.08	20	0.29	0.48
20		HS 2	1912	1,500	0.10	30	0.24	0.40
		Subtotal		49,697				
		Total Story County		93,231 acres				

APPENDIX I

SUMMARY OF INPUT TO REEVALUATION STUDY

During 1985 the Soil Conservation Service participated with the U.S. Army Corps of Engineers (COE) to investigate aspects of the Upper Skunk River Basin pertaining to reservoirs under study. The SCS engaged in this work with the COE due to availability of relevant data, required expertise, and a particular interest in the area due to its location within the Skunk River Basin Study.

The Upper Skunk River Basin is located in Story, Boone, Webster, and Hamilton Counties, Iowa (Figure I-1). Ames, located near the south boundary, is the major city within this area. This study area includes 556 square miles (about 355,800 acres) draining to the Story County highway just downstream from the junction of Squaw Creek with the South Skunk River near the south boundary of Ames, Iowa. There are two principal stream systems, Squaw Creek and South Skunk River. At its junction with South Skunk River the Squaw Creek drainage area is 227 square miles or about 145,300 acres. The drainage area of South Skunk River at its intersection with Squaw Creek is 329 square miles or about 210,500 acres.

The Upper Skunk River Basin is totally within LRA 103 and is basically a youthful till plain formed by the Wisconsin glaciation. Numerous closed depressions in this area are evidence of its geologic youth. Topography in this area is characterized by nearly level to gently undulating slopes. A high percentage of the area is prime farmland. The nearly level to gently sloping soils are dark colored and productive. Vertical relief between bottomlands and uplands is small. Peak flows developed in the downstream area are quite low compared to more steep, deeply incised topographies. Because of the youthful topography, with less incised valleys and the nearly level topography, available storage for flood retardation within the valleys is generally quite small.

Mutually agreed-to studies were:

1. Determine feasibility of watershed protection (land treatment) projects.
2. Provide a general assessment of structural project potential.

3. Evaluate effects of increased amounts of soil conservation land treatment practices upon:
   - Soil erosion by water
   - Sediment yields to four potential reservoirs
   - Flood peaks
   - Aquifer recharge
4. Inventory potential impoundment sites with less than five square miles drainage area.
5. Address the effects of reservoir pools upon drainage.

Item 5 relates to this special report. Effects of reservoir levels upon tile drainage were analyzed at four reservoir sites: SR-1, SR-4, SC-1, and SC-6 (Figure I-1).

Lands in the Basin above Ames need subsurface drainage for efficient crop production because they either have a slowly permeable soil profile, have high groundwater tables, impound surface water in depressions, or they have nearly flat surface gradients. Gravity outlets for drains in these lands require a sharp change in surface profile such as occurs at a stream channel or escarpment. If a tile outlet is inundated by a reservoir, all of the wet soils drained by the tile system are adversely affected. In most cases it is impossible to reconstruct a free outlet above the pool elevation. Therefore, all the lands which drain into the system have no suitable outlet.

A summary of adverse effects of inundated tile outlets is as follows:

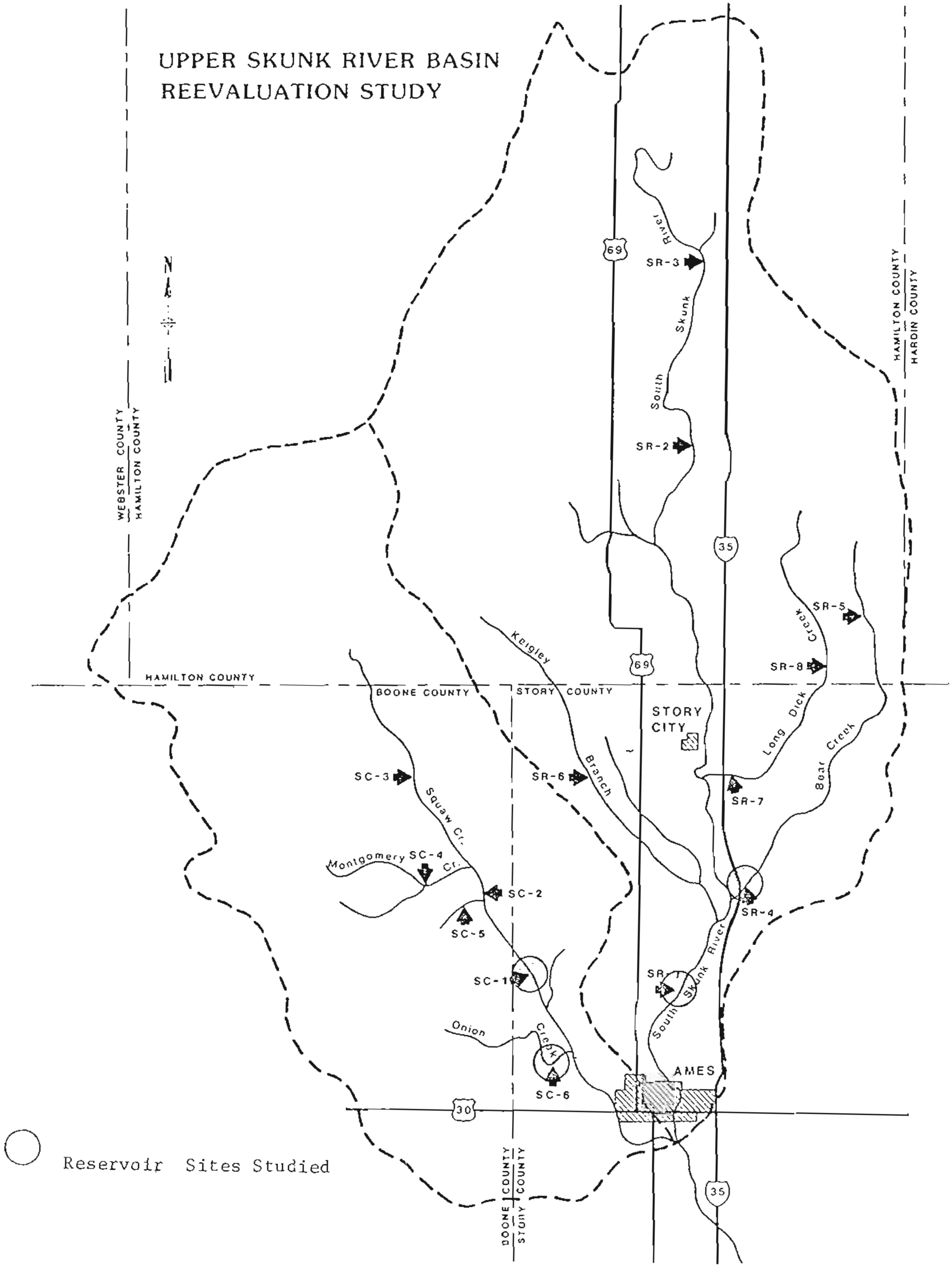
1. Increased maintenance costs caused by sedimentation at outlets.
2. Blocked, or partially blocked, outlets reduce the drainage coefficient causing soils to drain more slowly.
3. Reduced opportunity to use conservation tillage systems since better drainage is needed.
4. Reduced length of planting and harvesting time periods.
5. Reduced farmability of field units which have affected wet soils.
6. Blocked outlets prevent landowners from improving drainage on their land forcing a change to less intensive uses.

Based upon the study for the Des Moines River Basin in 1981 by Iowa State University and SCS in 10 north central Iowa counties, most of the older tile systems have much less than recommended capacity. Any infringement upon these marginal systems will have greater adverse effects than on fully adequate systems. Possible alternatives include pump outlets or open ditches if grade is available.

For the COE study SCS drew potential damage area boundaries on 7-1/2 minute USGS quadrangle maps. These boundaries are the centerlines of the proposed dams and the full pool (100-year pool) contour. All legal drainage district (D.D.) outlets, both open ditch and tile, and all known private outlets of 10-inch diameter or larger within the contour boundaries were located and shown planimetrically. From the plotted locations it was possible to closely estimate the tile outlet elevations which are shown in tabular data (Tables I-1, I-2, I-3, and I-4).

Data presented in the following tables for the four proposed reservoirs, SR-1, SR-4, SC-1, and SC-6 show impacted area at various pool elevations. Impacted areas include lands dependent upon currently installed drainage improvements. Starting with the conservation pool elevations supplied by the COE, areas affected are listed by five-foot increments in elevation up to the 100-year frequency or full flood pool elevation. The notation "loses 1 ft. outfall" indicates that the estimated tile outlet elevation and the indicated pool elevation are approximately equal. If such is the case then the outlet will not have one foot of outfall as recommended by the Iowa Drainage Guide (Appendix F) for protection from sediment and ice.

Figure I-1



UPPER SKUNK RIVER BASIN
REEVALUATION STUDY
N
WEBSTER COUNTY
HAMILTON COUNTY
HAMILTON COUNTY
HARDIN COUNTY
HAMILTON COUNTY
BOONE COUNTY
STORY COUNTY
BOONE COUNTY
STORY COUNTY
69
35
30
South Skunk River
Keigley Branch
Long Dick Creek
Bear Creek
Squaw Cr.
Montgomery Cr.
Onion Creek
STORY CITY
AMES
SR-1
SR-2
SR-3
SR-4
SR-5
SR-6
SR-7
SR-8
SC-1
SC-2
SC-3
SC-4
SC-5
SC-6
Reservoir Sites Studied

Table I-1

DRAINAGE OUTLETS AFFECTED BY SKUNK R. DAM, SR-1

DRAINAGE DISTRICT INVENTORY

COUNTY: Story BY: DSG DATE: 9/23/85 SHEET 1 OF 4

Sec. Twp. Range	D.D. No.	D.A. Ac.	Outlet Grade %	Tile Diam. In.	Channel Length Mi.	Date Installed Yr.	Outlet Elev.	Area Impacted, Ac.							
								940 Pool	945 Pool	950 Pool	955 Pool	960 Pool	965 Pool	970 Pool	975 Pool
25-85-24	1	6,010	0.20	30	4.8	1910	968	0	0	0	0	0	0	Floods Open Ditch	Floods Open Ditch
30-85-23	44	1,043	0.15	22	–	1912	960	0	0	0	0	Loses 1' Outfall	750	750	750
6-85-23	102	83	0.16	12	–	1920	970	0	0	0	0	0	0	Loses 1' Outfall	45
12-85-24	106	629	0.50	20	–	1921	960	0	0	0	0	Loses 1' Outfall	330	330	330
5-84-23	P 1	360	0.45	14	–	1966	960	0	0	0	0	Loses 1' Outfall	245	245	245
25-85-24	P 2	90	0.20	10	–	1962	960	0	0	0	0	Loses 1' Outfall	15	15	15
25-85-24	P 3	90	0.40	12	–	1974	968	0	0	0	0	0	0	35	35
6-85-23	P 4	125	0.15	14	–		970	0	0	0	0	0	0	Loses 1' Outfall	75
19-85-23	P 5	80	0.10	10	–		972	0	0	0	0	0	0	0	65
36-85-24	P 8	100	0.20	14	–	1975	950	0	0	Loses 1' Outfall	35	35	35	35	35
31-85-23	P 9	100	0.20	14	–		940	Loses 1' Outfall	55	55	55	55	55	55	55
31-85-23	P 10	300	0.15	14	–		935	180	180	180	180	180	180	180	180
Total	–	9010	–	–	–	–	–	180	235	235	270	270	1,610	1,645	1,830

Table I-2

DRAINAGE OUTLETS AFFECTED BY BEAR CREEK DAM, SR-4

DRAINAGE DISTRICT INVENTORY

COUNTY: Story BY: DSG DATE: 9-24-85 SHEET 2 OF 4

Sec. / Twp. / Range	D.D. No.	D.A. Ac.	Outlet Grade %	Tile Diam. In.	Channel Length Mi.	Date Installed Yr.	Outlet Elev.	Area Impacted, Ac.				
								940 Pool	950 Pool	960 Pool	970 Pool	975 Pool
33-85-23	P6	440	0.10	12	—		987	0	0	0	0	0
28-85-23	P7	90	0.20	10	—		992	0	0	0	0	0

No tile outlets of 10" diameter or larger were found within the proposed pool. The above two listed outlets are approximately 12 ft. and 17 ft. above proposed pool and will probably not be affected.

Table I-3

DRAINAGE OUTLETS AFFECTED BY SQUAW CREEK DAM, SC-1

DRAINAGE DISTRICT INVENTORY

COUNTY: Story/Boone BY: DSG DATE: 9/23/85 SHEET 3 OF 4

Sec Twp Range	D.D. No.	D.A. Ac.	Outlet Grade %	Tile Diam. In.	Channel Length Mi.	Date Installed Yr.	Outlet Elev.	Area Impacted, Ac				
								930 Pool	935 Pool	940 Pool	945 Pool	950 Pool
7-84-24	8	1,962	0.36	32	—	1915	923	1,080	1,080	1,080	1,080	1,080
7-84-24	67	424	0.64	15	—	1915	925	320	320	320	320	320
7-84-24	95	1,229	0.50	28	—	1922	919	860	860	860	860	860
26-85-25	230	463	0.66	14	—	1954	957	Not affected. Ditch has 1% gr. below tile outlet				
35-85-25	P17	160	0.50	12	—	1968	950	0	0	0	0	Loses 1' outfall
1-84-25	P19	92	0.20	10	—	—	955	Not affected. Ditch has 1% gr. below tile outlet				
Total	—	4,330	—	—	—	—	—	2,260	2,260	2,260	2,260	2,260

Table I-4

DRAINAGE OUTLETS AFFECTED BY ONION CREEK DAM, SC-6

DRAINAGE DISTRICT INVENTORY

COUNTY: Story BY: DSG DATE: 9-24-85 SHEET 4 OF 4

Sec. Twp. Range	D.D. No.	D.A. Ac.	Outlet Grade %	Tile Diam. In.	Channel Length Mi.	Date Installed Yr.	Outlet Elev.	Area Impacted, Ac. 930 Pool	935 Pool	940 Pool	945 Pool	950 Pool
32-84-24	63	112	0.46	14	–	1914	965	0	0	0	0	0
31-84-24	P13	50	0.30	10	–	1963	985	0	0	0	0	0
31-84-24	P14	60	0.60	10	–	1965	938	0	0	35	35	35
30-84-24	P15	547	1.19	18	–	1970	963	0	0	0	0	0
Total	–	60	–	–	–	–	–	0	0	35	35	35

Only one significant tile outlet was found within the proposed pool.
Approximately 35 acres of wet soils would be affected.

APPENDIX J

CROP LOSS COMPUTATIONS

Computation of impaired drainage financial loss is shown for corn and soybeans (Tables J-2 and J-3). For each crop, there are six scenarios to account for natural soil wetness and tile capacity status. Multiplying factors used to find the acreage for each scenario are summarized below (Table J-1) and then shown in the location where used in the computations (Tables J-2 and J-3). These factors apply to the total study area, 225,347 acres.

Table J-1
FACTORS FOR WETNESS AND STATUS SCENARIOS
Skunk River Basin

Crop	Natural Soil Wetness	Tile Capacity Status
Corn (.513)	Very Poorly Drained (.042)	Very Low (.046)
Soybeans (.387)	Poorly Drained (.461)	Low (.214)
		Medium (.119)

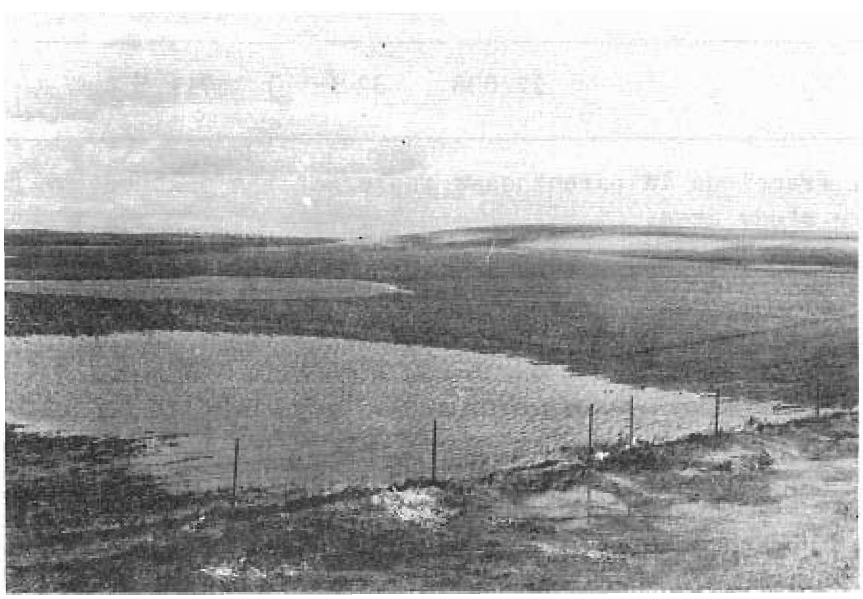


Figure J-1. Managing wet soils includes drainage improvement.

Table J-2
AVERAGE ANNUAL IMPAIRED DRAINAGE LOSS FOR CORN (.513) 1/
Skunk River Basin

Natural Soil 5/ Wetness Characteristic	Tile 4/ Capacity Status	Area (ac)	Yield 3/ Reduction (bu/ac)	Production Loss (bu)	Loss 2/ of Income (dollars)
V. Poorly Drained (.042)	Very Low (.046)	223	105	23,451	58,628
	Low (.214)	1,039	65	67,538	168,844
	Medium (.119)	578	10	5,778	14,445
	Subtotal	1,840	53 (ave)	96,767	241,917
Poorly Drained (.461)	Very Low (.046)	2,451	59	144,637	361,593
	Low (.214)	11,405	39	444,783	1,111,958
	Medium (.119)	6,342	4	25,367	63,419
	Subtotal	20,198	30 (ave)	614,787	1,536,970
TOTAL		22,038	32 (ave)	711,554	1,778,887

1/ The decimal fractions in parentheses represent the part of the total 225,347 acre study area.

2/ Price of corn used was $2.50/bushel, the 1986 normalized price.

3/ Yield reduction from ISU-SCS cooperative study, 1981.

4/ Status from Skunk River Basin inventory in five LRA 103 counties.

5/ From soils data developed for Des Moines River Basin Study.

Table J-3
AVERAGE ANNUAL IMPAIRED DRAINAGE LOSS FOR SOYBEANS (.387) 1/
Skunk River Basin

Natural Soil 5/ Wetness Characteristic	Tile 4/ Capacity Status	Area (ac)	Yield 3/ Reduction (bu/ac)	Production Loss (bu)	Loss 2/ of Income (dollars)
V. Poorly Drained (.042)	Very Low (.046)	168	37	6,234	31,170
	Low (.214)	784	21	16,461	82,303
	Medium (.119)	436	5	2,179	10,897
	Subtotal	1,388	18 (ave)	24,874	124,370
Poorly Drained (.461)	Very Low (.046)	1,849	22	40,686	203,430
	Low (.214)	8,604	14	120,450	602,248
	Medium (.119)	4,784	1	4,784	23,921
	Subtotal	15,237	11 (ave)	165,920	829,599
TOTAL		16,625	11 (ave)	190,794	953,969

1/ The decimal fractions in parentheses represent the part of the total 225,347 acre study area.

2/ Price of soybeans used was $5.00/bushel, the 1986 normalized price.

3/ Yield reduction from ISU-SCS cooperative study, 1981.

4/ Status from Skunk River Basin inventory in five LRA 103 counties.

5/ From soils data developed for Des Moines River Basin Study.

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