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THE INFLUENCES OF LAND USES AND STREAM MODIFICATIONS ON WATER QUALITY IN THE STREAMS OF THE COURT CREEK WATERSHED

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CONTENTS

Report summary 1

Introduction 6
    Report plan 7
    Acknowledgments 7

Description of the watershed 9
    Soil associations 14

Land uses 17

Watershed climate and streamflows 32
    Climate 32
        Precipitation 33
    Streamflows 41
        Rating curves 44
        Flow duration curves 44

Stream sampling 59

Stream chemical concentrations 61
    Base streamflows 65
    Snowmelt streamflows 70
    Rainfall streamflows 74

Stream yields 77
    Middle Creek 84
    North Creek 90
    Sugar Creek 97
    Court Creek 105

Discussion 118

Watershed management plan 126
    Slowing the rate of runoff from steep valley bluffs 129
    Slowing the rate of surface runoff in the floodplain 130
    Watershed restoration programs and agencies 143
        Local programs 143
        State programs 150
        Federal programs 153

References 161

Figures

Figure 1. The watershed of Court Creek.. 11

Figure 2. Landform slopes in the Court Creek watershed 15

Figure 3. Distribution of six soil associations in the Court Creek watershed.. 16

Figure 4. Suitability of land in the Court Creek watershed for grain and forage 18

Figure 5. Land uses in the Court Creek watershed 21

Figure 6. Subwatersheds in each of the four stream basins in the Court Creek watershed 23

Figure 7. Locations of raingages in the Court Creek watershed 34

Figure 8. Areas of influence for raingages in the Court Creek watershed 35

Figure 9. Daily average depth (amount) of precipitation in the Court Creek watershed (December 1980 - April 1983) 36

Figure 10. Locations of streamflow gaging stations in the Court Creek watershed 42

Figure 11. Types of streamflow gaging devices used in the Court Creek watershed 43

Figure 12. Flow duration curves for Court Creek at C2, based on continuous stage recorder records 46

Figure 13. Flow duration curves for Court Creek at C2, based on instantaneous flows and adjusted flows 47

Figure 14 Flow duration curves for Sugar Creek at S5 48

Figure 15. Flow duration curves for Sugar Creek at S3 49

Figure 16. Hydrographs of monitored flow gages during the December 25, 1982, storm 53

Figure 17. Hydrographs of monitored flow gages during the April 1, 1983, storm 54

Figure 18. Hydrographs of monitored flow gages during the December 2, 1982, storm 55

Figure 19. Hydrographs of monitored Sugar Creek flow gages during the April 1, 1983, storm.................................... 56

Figure 20. Locations of stream sampling stations in the Court Creek watershed 60

Figure 21. Streamflow, sediment, and nutrient stream discharges for the M3 and M1 stream sampling stations during the April 1, 1983, storm 88

Figure 22. Areas, land uses, and topography of subwatersheds in the Middle Creek basin 91

Figure 23. Correlation between streamflow, sediment, and nutrient stream discharge at the N1 sampling station during the December 25, 1982, storm 96

Figure 24. Areas, land uses, and topography of subwatersheds in the North Creek basin 98

Figure 25. Areas, land uses, and topography of subwatersheds in the Sugar Creek basin 99

Figure 26. Correlation between streamflow, sediment, and nutrient stream discharges at the S2 sampling station during the April 1, 1983, storm 103

Figure 27. Areas, land uses, and topography of subwatersheds in the Court Creek basin 106

Figure 28. 1940 and 1979 aerial photograph of the C2 subwatershed with former stream channels and bank erosion sites marked..111

Figure 29. Locations of two major bank erosion sites on Court Creek between stations C3 and C4 112

Figure 30. Locations of two major bank erosion sites on Court Creek between C4 and C6 121

Figure 31. Channel modifications along North Creek between stations N1 and N2 122

Figure 32. Channel modifications along North Creek between stations N2 and N3 123

Figure 33. Channel modifications along North Creek between stations N3 and N4 124

Figure 34. Runoff from steep valley bluffs causes high-velocity floods in floodplain subwatersheds . . . 127

Figure 35. Floodwaters flow across floodplain row crops to reenter Court Creek 127

Figure 36. Stable stream channel with dense growth of woody riparian vegetation 132

Figure 37. Large trees block stream channel in Court Creek 135

Figure 38. Trea retarder placement on eroding stream bank 136
Figure 39. Jettied willow pole bank protection 137
Figure 40. Construction of Kellner jacks 138
Figure 41. Placement of Kellner jacks on eroding banks 139
Figure 42. Placement of riprap for bank toe protection 141

Tables

Table 1. Watershed areas of streams in the Court Creek watershed 12

Table 2. Population of the Court Creek watershed 12

Table 3. Ten land use classifications and their abbreviations 20

Table 4. Number of acres of each land use in basins above stream sampling stations, 1979 24

Table S. Percentage of each type of land use in the basins above stream sampling stations, 1979 25

Table 6. Number of acres of each land use in the subwatersheds between stream sampling stations, 1979 ... 27

Table 7. Percentage of each type of land use in the subwatersheds between stream sampling stations, 1979 28

Table 8. Percent of subwatershed area in floodplain and with slight, moderate, and severe slopes 29

Table 9. Number of all cattle marketed in townships in the Court Creek watershed 31

Table 10. Number of hogs and pigs marketed in townships in the Court Creek watershed 31

Table 11. Frequency of daily rainfall classes at Galesburg, Illinois 38

Table 12. Daily average watershed storm precipitation, antecedent moisture conditions and daily mean watershed discharge (streamflow) at the C2 flow gaging station 39

Table 13. The 5-day cumulative rainfall amount determining the class of antecedent moisture conditions during dormant and growing seasons 40

Table 14. Curve numbers (CN) for hydrologic soil-cover complexes in the Court Creek watershed during AMC II 40

Table 15. Weighted curve numbers of Court Creek subwatersheds and basins during AMC II soil moisture conditions 41

Table 16. Adjusted mean daily flows for stations in the Court Creek watershed 50

Table 17 The amounts of rainfall, surfacewater runoff, and resulting curve numbers for the Middle Creek Basin during the April 1, 1983 storm 58

Table 18. Chemical analyses performed on stream samples........ 62

Table 19. Dependence of total metal concentrations in stream samples on suspended sediment concentrations 63

Table 20. Comparison of the total metal concentrations of S5 and C12 stream sampling stations with the Spoon River and Big Creek total metal concentrations 64

Table 21. Chemical concentrations at the C2 sampling station during normal streamflows 66

Table 22. Average stream station parameters during base flow conditions 67

Table 23. A comparison of land use effects on stream water quality during base streamflows 69

Table 24. Stream parameter values during snowmelt runoff 71

Table 25. A comparison of land use effects on stream water quality during snowmeltrunoff 73

Table 26. Geometric means of stream parameters during runoff from rain events 76

Table 27. Increases in the geometric means of suspended sediment concentrations in the floodplain stream sampling stations of Court Creek 76

Table 28. Squares of correlation coefficients of the regression between the log of sediment concentration and the logs of total phosphate concentration and total ammonia concentration 78

Table 29. A comparison of land use effects on stream quality during rainfall events 78

Table 30 Squares of the correlation coefficents of regression analysis between the log of streamflow discharge and the log of the specified stream discharge 80

Table 31. Estimated annual stream yields of stream chemicals for the entire watershed at stream station C2 81

Table 32 A comparison of land use effects on the estimated annual stream yields 83

Table 33. A comparison of the estimated annual stream yields of the individual watersheds of Court Creek and its three tributaries....... 85

Table 34. Basin and subwatershed stream yields for Middle Creek.. 87

Table 35. Basin and subwatershed stream yields for Middle Creek during the April 1, 1983, storm 89

Table 36. Basin stream yields for North Creek 93

Table 37. Subwatershed stream yields for North Creek 94

Table 38. Stream basin yields for No. Creek during storm events 95

Table 39. Basin stream yields for Sugar Creek 100

Table 40. Subwatershed stream yields for Sugar Creek 101

Table 41. Basin stream yields for Sugar Creek during the April 1, 1983, storm 104

Table 42. Stream yields for Sugar Creek during individual storm events 104

Table 43. Basin stream yields for Court Creek 107

Table 44. Contribution of Court Creek floodplain subwatersheds to the stream yields of the entire watershed 108

Table 45. Annual sediment yields of the stream basins and subwatersheds of Court Creek 109

Table 46. Some characteristics of major bank erosion sites on Court Creek, and scope of data collection 113

Table 47. Particle size, nitrogen content, and phosphorus content of soils at some major bank erosion sites 113

Table 48. Amount of sediment and nutrient storm yields eroded from seven bank erosion sites 115

Table 49. Stream station C2 cross section samples 117

Table 50. 1981 Indian Creek daily sediment yields 117

Table 51. Stream length reductions between 1940 and 1979 120

Table 52. Recommended vegetative stream bank cover 134

Table 53. RC&D cost-sharing schedule 147

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REPORT SUMMARY

This brief summary will explain a detailed report and also explain why such detail is important. Erosion and sediment control programs have been based upon control of erosion by alteration of cultivation practices in row crop fields. The details of this report will illustrate the importance of all agricultural lands (including pastures) in the outpouring of sediment and nutrients, which are degrading lakes and streams throughout the Illinois River basin. Streams in western and central Illinois have been found to carry more sediment than streams from northern, eastern, and southern Illinois. Most of these streams are tributary to the Illinois River, the major river basin within Illinois. The Illinois River flows so slowly that much of the sediment delivered from the tributaries is deposited within the floodplain of the Illinois River, especially its backwater lakes. Sediment is destroying the game fishing, commercial fishing, and waterfowl hunting in what was the greatest hunting and fishing river in Illinois.

The Court Creek watershed lies in the center of this region, which the Soil Conservation Service calls the "critical sediment producing area" of the upper Mississippi River basin. At 62,000 acres (almost 100 square miles), this watershed is the largest studied in Illinois for the effects of land use on water quality. Court Creek has three large tributaries (Middle Creek, North Creek, and Sugar Creek), whose watersheds are large enough to contain permanent fish populations. The Illinois Department of Conservation found large numbers of smallmouth bass (up to 2.7 lbs) in upstream segments of Court Creek; however, the downstream segments contained only small panfish and minnows. This downstream fish population is similar to most fishery populations in Illinois streams. Details of this watershed study will explain the loss of water quality and stream fisheries in the Illinois River basin.

The single most important factor controlling the extent of erosion and offsite damages is the speed of floodwaters (rate of surface water runoff). The amount of eroded soil and the distance traveled by eroded soil are entirely dependent upon the speed of runoff. If waters are slowed, erosion is lessened and sediment is deposited. When the speed of floodwaters is increased, eroded soils are transported farther.

The speed of floodwaters is dependent upon the slope of the land and the intensity of the rainfall. While man has little influence upon rainfall intensity, he has significantly altered lands and streams along areas with steep slopes. The vast majority of Illinois is privately owned agricultural lands. Agricultural land uses include row crops, pastures, and woodlands. While the effects of residential housing and strip mining are determined in the report, only agricultural land management practices had severe impacts on stream quality. While many recent agricultural practices slow both erosion and surface water runoff, some practices have increased runoff and erosion from the watershed, especially those areas with steep slopes. This summary will follow the general outline of the report and begin by tracing the formation of watershed topography and soils.

Illinois is largely a relatively flat prairie. However, approximately 12,000 years ago, the melting Wisconsinan Age glacier eroded very large stream and river valleys through central and western Illinois. The stream valleys are much wider than present day streams could have eroded. The adjacent valley bluffs are also much steeper - the land may drop 120 feet in a mile of travel. The upland prairie developed under grass cover into the highly fertile black soils, which are now intensively cultivated. Stream valley bluffs developed under forest cover into less fertile light-colored timber soils. The steeply sloping bluffs have largely served as wooded pastures or have been cleared of timber and are open pastures. In Knox County, the timbered stream valleys have served as sediment traps during floods, so that a highly fertile alluvial soil developed. Streams meandered across the floodplains following timbered stream banks.

At the present time, the larger downstream valleys are in row crops while the narrow upstream valleys are pastures. The amount of sediment and nutrients eroded from the upland prairies and stream valleys during flood events was determined during a time period with a large number of intense rainstorms. From 1981 to the spring of 1983, the amounts of rain falling on the watershed were measured by a network of 13 raingages. Concurrently streamflows were measured through the same time period by a network of nine flow gages. The combinations of raingages and stream flow gages allowed the determination of the relative contributions of upland prairies and stream valleys to flood events. The high contribution of the steep bluffs to peak streamflows was best illustrated by the Middle Creek watershed. The 4000 acres of upland prairie contributed only a peak flow of 78 cfs (cubic feet per second of stream water) while the addition of 2000 acres of stream valley bluffs increased the peak flow to 320 cfs. Both areas received similar amounts of rain approximately 2.2 inches of rain in 9 hours. Therefore the steep valley bluffs (mainly in pasture and wooded pasture) have much greater rates of surface water runoff. Such runoff creates high velocity streamflows during flood events.

Stream and water quality can be measured by the concentrations of chemicals in the water and also by the total amounts of chemicals transported during the year or during individual flood events. The concentrations of sediment and chemicals were determined at 16 stream stations throughout the watershed. In terms of chemical concentrations, water quality of all streams was excellent during normal streamflows (over 80 percent of the time). Water quality during rainstorms decreased because the concentrations of sediment, ammonia, and phosphorus increased greatly. No toxic levels of chemicals were recorded during rainstorms because chemicals were attached to soil particles and not readily available to aquatic life. However, during streamflows from snowmelt, sediment concentrations were much lower, while concentrations of dissolved ammonia and phosphorus were high. The high concentrations of ammonia and phosphorus caused algal blooms to occur in a 500-acre watershed lake, even under ice cover. In stream valleys, concentrations of dissolved ammonia during snowmelt runoff were near acutely toxic levels. Possible sources of ammonia and phosphorus are wastes of confined animal (swine) feedlots along the valley bluffs. Fish kills have been recorded in Court Creek streams during summer spills of animal wastes.

The total amounts of sediment and chemicals transported by a stream can be calculated for the year or for a flood event. The amount of sediment (weight) is the product of the streamflow (volume of water) and the sediment concentration (weight of sediment per volume of water). The amount of sediment or chemical eroded from the watershed is called the stream yield. Stream yields were determined for all 16 subwatersheds in the four stream basins of the Court Creek watershed. In all stream basins, the smaller subwatersheds of the downstream valleys contributed most of the sediment and nutrients. While upland prairie subwatersheds had stream sediment yields of 1.5 tons per acre, subwatersheds in stream valleys had stream yields of 30 to 50 tons per acre. Stream valleys were characterized as pastures and animal feedlots on steep bluffs and row crops on the stream floodplains.

As typified in the Middle Creek basin, stream sediment yields are more closely correlated with runoff rates from subwatersheds than with the extent of row crop acreage within subwatersheds. When more than 75 percent of the peak streamflow of Middle Creek resulted from runoff in the lower 2000 acres of the stream valley, over 70 percent of the sediment and nutrients were also eroded from the lower 2000 acres. The lower 2000 acres is 60 percent pasture and wooded pasture along the steep slopes. Row crops occur along the larger floodplain of the downstream valley. Large bank erosion sites were found in channelized stream segments adjacent to row crop fields. The upper 4000 acres of prairie was over 75 percent row crop; however, only 30 percent' of the sediment was eroded from this acreage.

Large bank erosion sites occurred more frequently along channelized stream segments adjacent to row crop fields in the larger stream valleys of North Creek, Sugar Creek, and Court Creek. Aerial photography between 1940 and 1979 reveals that stream channelizations caused stream length reductions up to 25 percent in stream valley subwatersheds. On North Creek, the subwatershed with the greatest stream length reduction had the largest sediment stream yield -- 45 tons per acre.

Stream bank erosion was measured along seven floodplain row crop fields after individual flood events. The amount of bank soil from only seven fields equaled 5 to 10 percent of the sediment eroded from the entire 62,000 acres during each flood. Aerial photographs between 1940 and 1979 reveal bank erosion of an entire row crop field in 40 years. For 40 years, an average of 2000 tons of soil per year entered Court Creek from this field alone. Landowners in the floodplain receive more damage from high-velocity streamflows than from the submergence of row crops by floodwaters.

Both land management practices along the steep bluffs and stream length reductions in the floodplains have increased the rate of surface water runoff (floodwater speed) and erosion. In essence, effective watershed management must slow the rate of runoff. The only practical method would involve vegetative land management with minimum structural expenses. Such management strategies must be directed not only at row crop areas, but also at the pastures along the steep areas of the watershed where high-velocity runoff occurs. Pasture management, conversion to forests, and construction of brush dams along steep bluffs are poss iblepractices.

The stability of wooded stream banks was observed both in the field and in aerial photographs. The occurrence of woody vegetation on the high-flow stream channel increases flow resistance and decreases velocity by increasing flood duration. If the water storage capacity of the large stream valleys can be utilized to slow floodwaters, then downstream damages from high-velocity floodwaters can be reduced. The wooded stream border tends to deflect high-velocity flow into the stream channel. As a portion of the floodwater is slowed by vegetation, a natural levee is formed along the bank from deposited sand and sediment.

The Soil Conservation Service in the western states of Arizona and California has combined the restoration of wooded stream borders with limited construction expenditures to control floodplain damages and stream bank erosion. The development of low-cost stream maintenance programs should begin in Illinois. Only with stream maintenance will the promotion of woody vegetation along stream banks be effective.

To begin an effective program, watershed landowners have formed a watershed organization to speak with local county, state, and federal agencies. With an active leadership, such a watershed organization is much more likely to receive technical and fiscal assistance from state and federal agencies. This report details local, state, and federal programs to assist watershed landowners. In the Court Creek watershed, the concern of only a few persistent Knox County citizens led to the funding of watershed study in 1980.

With the results from three years of study, the Court Creek Watershed Steering Committee and the Knox County Soil and Water Conservation District have begun a long-term watershed restoration program with assistance from the Illinois Department of Energy and Natural Resources, the Illinois Department of Conservation, the Illinois Department of Agriculture, the Soil Conservation Service (SCS), and the Agricultural Stabilization and Conservation Service (ASCS). As of 1985, watershed funding of conservation practices included an Agriculture Conservation Program CACP) Special Project from the ASCS, the Build Illinois Program of the Illinois Department of Agriculture, and the Watershed Initiative Program from the Illinois Department of Conservation.

INTRODUCTION

Since the passage of the Clean Water Act by Congress in 1972, several efforts have been made on a national level to assess trends in water quality conditions. Prominent among these efforts is the National Stream Quality Accounting Network (NASQAN) maintained by the U.S. Geological Survey (USGS). Generally, USGS analyses for the period 1970-1980 show that water quality has remained stable for most water bodies. This conclusion is supported by other studies performed jointly by the U.S. Environmental Protection Agency (USEPA) and the U.S. Fish and Wildlife Service. On the other hand, significant improvements in water quality for certain water bodies such as Lake Erie are reported by states and regional offices of EPA (USEPA, 1983). Nevertheless NASOAN trend analyses reveal that water quality conditions are not stable or improved but are worsening for certain constituents. Among these constituents are nitrogen, phosphorus, suspended solids, and turbidity. These constituents originate primarily from nonpoint sources (NPS) rather than point sources (USEPA, 1984). There seems to be agreement among fishery biologists that NPS are more often the cause for the degradation of fishery waters than are point sources (Judy et at., 1984).

The major activities related to NPS are agriculture, mining, urban development, silviculture, and construction. Among these major activities, agricultural land uses, including those for tillage practices and animal waste management, are considered the most important source of NPS constituents (Judy et al.,1984) and they are probably the most elusive to manage.

The constituents of concern that are likely to be introduced into surface waters from agricultural practices are nutrients (nitrogen and phosphorus), suspended solids, and toxic substances (pesticides). Common to all NPS, these constituents are mobilized primarily during runoff events. Thus NPS "pollutants" are carried over and through the ground by rainfall and snowmelt. This report addresses the issue of water quality changes in surface water during runoff caused by rainfall and/or snowmelt, across a watershed that is primarily agricultural.

The Court Creek watershed, located in the geographical center of Knox County, Illinois, is the study site. The principal objective of the study is to identify those sectors in the watershed which significantly influence the water quality of surface waters during runoff events. Once critical sectors of NPS are identified, watershed restoration technology must be applied or developed to reduce the NPS inflow into Court Creek streams and impoundments. The concluding sections of this report will detail techniques and governmenta agencies likely to be useful in reducing identified NPS sources.

An earlier report entitled <u>An Inventory of Court Creek Watershed Characteristics That May Relate to Water Quality in the</u>

Watershed (Roseboom et al., 1983) would be useful to readers of this report. Although some basic information and data regarding the watershed are repeated here, nevertheless pertinent data related to climate, landforms, soil types, stream slopes, and point sources of pollution are fully documented in the earlier report and therefore are not treated fully in this report.

Report Plan

This report correlates the water quality data gathered from 1980 to 1983 with the watershed topography, land use, and fishery data detailed in the earlier report (Roseboom et al., I983). The major sections of the report deal with the following topics:

1) Description of the Watershed
2) Land Uses
3) Watershed Climate and Streamflows
4) Strearn Sampling
5) Stream Chemical Concentrations
   a. Base Streamflows
   b. Snowmelt Streamflows
   c. Rainfall Streamflows
6) Strearn Yields
   a. Middle Creek
   b. North Creek
   c. Sugar Creek
   d. Court Creek
7) Discussion
8) Watershed Management Plan

Acknowledgments

This report was prepared under the general administration of Stanley A. Changnon, Jr., Chief of the Illinois State Water Survey, a division of the Illinois Department of Energy and Natural Resources (ENR). The Research and Planning Section of ENR provided financial and administrative support through the offices of David Jones and Walt Zyznieuski. The following individuals also were extremely helpful and important to the success of the Court Creek Study.

Jane Johnson, President of the Spoon River Watershed Tributary Project, labored diligently to bring about a study of land management on the Spoon River and its tributaries. It was through her interest that the project was conceived and mainly through her untiring efforts that the project was funded.

Kenneth Russell, fishery biologist of the Illinois Department of Conservation, performed and evaluated a. fish survey of Court Creek. His 18-year residence in . the Court Creek watershed and his occupational experience throughout the state have made his contribution particularly va??able. Daniel Sallee, Robert Williamson, and Larry Smith performed fish sampling and identification under adverse conditions.

Norman Emmerick, an upland game biologist of the Illinois Department of Conservation, evaluated the hunting and fur-bearing animal populations of the Court Creek watershed.

Robert Johnson of the United States Geological Survey determined the topography of the Court Creek watershed during 1978, so that the watersheds of Court Creek and its tributaries could be accurately measured. The Centerville (Missouri) office was particularly helpful in obtaining advance copies of the topographic maps.

Several individuals of the Agricultural Stabilization and Conservation Service (ASCS) have aided the study. Melvin Neuman, director of the Knox County ASCS office, has been especially helpful in providing direction on obtaining ASCS aerial photographs and their evaluations, as well as in offering meeting room facilities in his office. Mary McDonald of the Las Vegas Aerial Photography Field Office was especially helpful in obtaining early aerial photographs of the Court Creek watershed.

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Illinois State Water Survey personnel who aided the project represented a broad spectrum of environmental sciences. Douglas Jones of the Climate Information Unit developed a network of 13 raingages in the watershed. He and Keith Hendrie established a soil moisture installation in the watershed. Ming T. Lee of the Surface Water Section was extremely helpful in planning the experimental design for the analysis of land management and stormwater runoff data. Also, Michael Terstriep and David Kisser designed a program of stream bank erosion monitoring and bank monuments.

Water quality chemists David Hullinger, Dana Shackleford , Brent Gregory, and James Shields constantly received and analyzed samples at unscheduled dates during occurrences of heavy rainfall. Donald Schnepper and one of the authors of this report, Lyle G. Brooks, undertook the measurement of streamflow velocities at different stream stage heights. Thomas Butts, Richard Twait, Thomas Hill, and John Erickson walked the entire length of Court Creek and North Creek to examine stream bank erosion sites. In addition, Thomas Butts performed a meticulous determination of stream bed length and rate of fall from the USGS topographic maps.

Jim Williams performed a detailed ground truth survey of the 1979 land management data, especially feedlot confinements. Phil Wang and Jud Williams prepared extensive summary tables of computer-compiled data and re-entered data into the Cyber computer system. Robert Sinclair, Carl Lonnquist, Marvin Clevenger, and Ilean Trover established computer programs to evaluate land management data, enumerate raingage records, and establish rainfall and streamflow correlations.

John Erickson, Jim Williams, Jud Williams, and Richard Twait were especially cooperative during stream sampling, as storm-caused flows often occurred after normal work hours or on the weekend. John Erickson, as a resident of Galesburg, maintained raingages, monitored rainfall and streamflows, and summoned the water sampling personnel as conditions warranted.

Linda Johnson typed the original manuscript and the camera copy, and Gail Taylor edited the final report. John W. Brother, Jr., Linda Riggin, William Motherway, Jr., and Vicki Stewart expended great effort in producing the large number of maps and figures required for this type of project. The presentations of ASCS aerial photographs within this report have been especially valuable.

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Most importantly, all the landowners of the Court Creek watershed were vital to the study's success as they related personal information about their land and streams, gave permission to sample stream bank and field soils, and extended help and hospitality to Water Survey personnel throughout our three years of effort.

DESCRIPTION OF THE WATERSHED

As mentioned previously, the Court Creek watershed is located in Knox County. The 97-square-mile (251-sq-km) watershed lies almost entirely within the four townships of Sparta, Copley, Knox, and Persifer (see figure 1). Court Creek flows eastward from Qalesburg for 14.5 miles (23.3 km) along the southern boundary of the watershed. It enters the Spoon River near Oahinda, Illinois. Three main tributaries (Middle Creek, North Creek, and Sugar Creek) flow south from the northern portion of the watershed. Middle Creek is about 10 miles (16.0 km) long, North Creek is about 12 miles (19.1 km) long, and Sugar Creek is about 10 miles (16.0 km) long. The drainage area and the percent of watershed each stream represents is given in table 1.

With the exception of Rice Lake, a man-made impoundment located near the origin of Court Creek, all watershed impoundments are located in the Sugar Creek watershed. The largest is Spoon Valley Lake, which is 4 miles long (6.4 km) with a surface area of 512 acres (2.1 sq km). Its normal water surface elevation is 652 ft (199 meters) above mean sea level. Construction of Spoon Valley Lake was completed in 1971 as a portion of the Oak Run housing development. The other Sugar Creek impoundments result from strip mining activities in Copley Township. Strip mine impoundments are smaller and do not have controlled releases. Recreation areas in the watershed support camping, hiking, fishing, sightseeing, picnicking, and boating. There are numerous sportsmen's clubs in the mine spoils area where impounded waters provide fisheries.

As shown in figure I, there are four incorporated communities in the watershed: East Galesburg, Wataga, the northern portion of Knoxville, and the southeast portion of Galesburg (not shown). Two unincorporated communities, Appleton and Dahinda, lie along Court Creek. In 1971, construction of the Oak Run housing development was begun in Persifer Township south of the major area of strip mining. About 2,133 acres (8.6 sq km) of land were developed. By 1981 over 120 permanent dwellings existed at the Oak Run development, with about 60 summer homes. The rural and incorporated urban population within the entire watershed has not been static nor has growth been phenomenal. Included in table 2 are the recorded populations for the rural and urban areas.

The Court Creek watershed was selected for study not because of recorded occurrences of water quality problems but rather because of the diversity of land use within the watershed and the assured cooperation of its residents and the governmental personnel of Knox County. However, the Surface Water Section of the Illinois State Water Survey has found western Illinois streams to have the largest instream sediment yields -- twice the sediment yields of streams in the remainder of the state (Bonini et al., 1983). The Soil Conservation Service has identified 33 counties in western and central Illinois as constituting one-third of the critical sediment-producing area in the upper Mississippi River basin (Crews, 1983). The Court Creek watershed is located in the center of this critical sediment-producing area of western Illinois. This area includes the basin of the Illinois

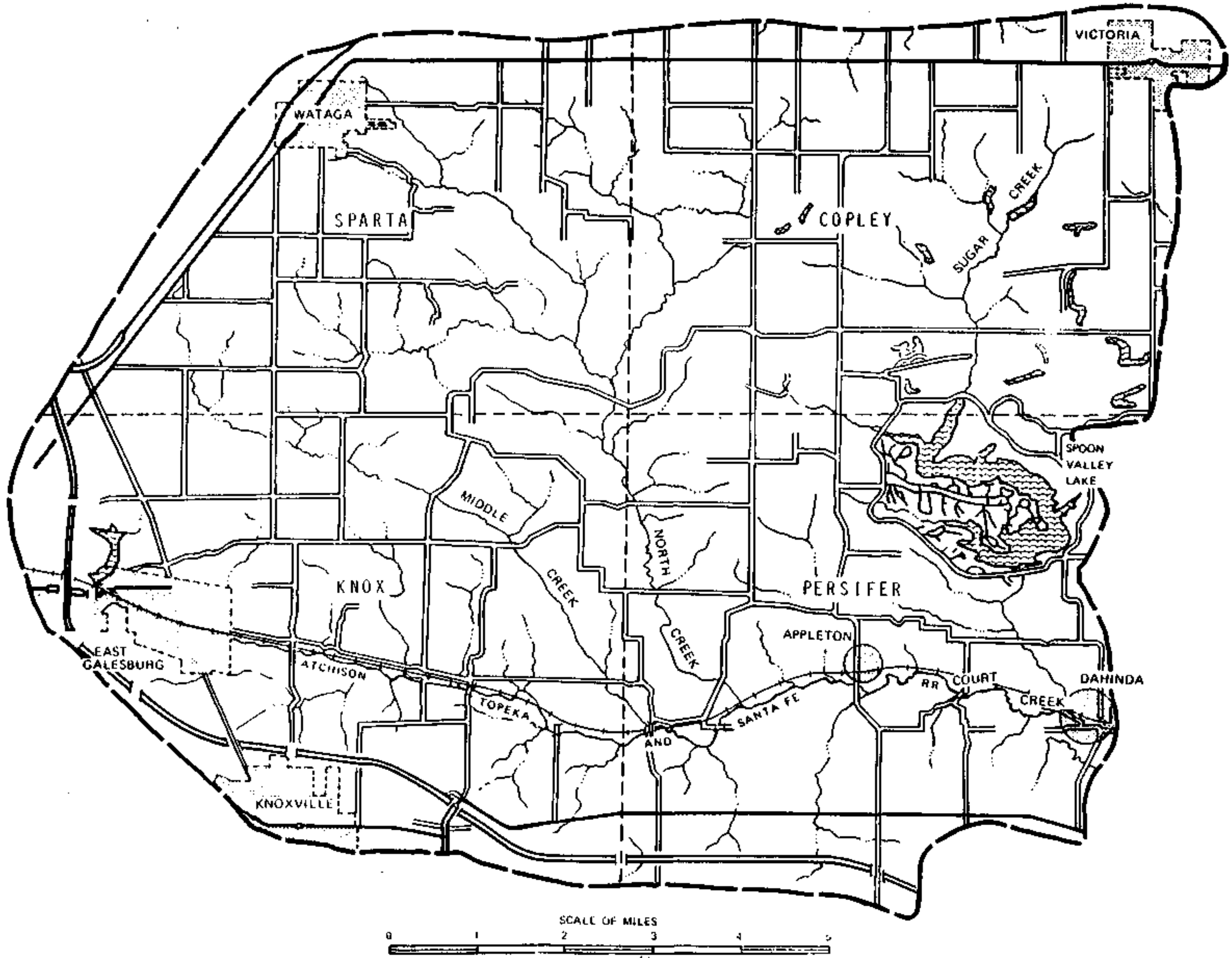


Figure 1. The watershed of Court. Creek

Table 1. Watershed Areas of Streams in the Court Creek Watershed

	Middle Creek	North Creek	Sugar Creek	Court Creek*	Total
Square km	27.2	75.9	59.1	88.8	251.0
Square miles	10.5	29.3	22.8	34.4	97.5
Acres	6,720	18,720	14,560	22,080	62,080
% of watershed	10.8	30.2	23.5	35.5	100.0

* Excluding tributary watersheds

Table 2. Population of the Court Creek watershed

Townships	1940	1950	1960	1970	1980
Sparta	575	528	472	477	445
Copley	538	415	351	327	298
Knox	675	566	733	1046	1582
Persifer	716	724	654	600	822
Urban					
East Galesburg	605	651	660	706	928
Wataga	540	550	570	570	996
Knoxville*	747	736	853	977	1143
Galesburg**	5776	6288	7448	7260	7060

* Estimate based on 33% of total population
** Estimate based on 20% of total population

River, which has been most severely degraded by sedimentation in its backwater lakes.

The basic landform and soils of the Court Creek watershed resulted from glacial ice, flowing water from melting glaciers and later flood events, and windblown deposits of silt. In recent times strip mining, stream channel modifications, and erosion have extensively altered small portions of the watershed. The majority of soil parent material is the result of glaciers and glacio-fluvial deposits during the Wisconsinan and Illinoian glacial periods.

The soil parent material, glacial till, was deposited directly by glaciers with a minimum of water action, so that small pebbles have distinct edges and corners. The glacial till also consists of particles of different sizes, which were mixed together when deposited during the lllinoian stage. In some areas a soil developed in the upper part of the lllinoian glacial till during the time between the lllinoian and Wisconsinan glaciers Cthe Sangamonian Stage). These Sangamonian soils are called paleosol or "old soil." The Atlas and Assumption soil series are a composite of glacial till and paleosol.

Glacial outwash was deposited by flowing water from melting glaciers. Outwash deposits consist of layers of similar-sized particles, such as loamy sand, sandy loam, and loam. As water velocity decreased, large heavy particles were deposited first, and then progressively smaller particles were deposited. Camden and Dickinson soil series are examples of such deposition.

Fine soil particles were also deposited along the Mississippi River waterway by the melting Wisconsinan glacier. After initial deposition some of the fine silt alluvium (loess) was carried by the prevailing wind across western and central Illinois. Loess consists of a very uniform, calcareous material. This windblown silt formed the flat prairie, which is the dominant landscape and principal site of row crop agriculture in western Illinois. In the Court Creek watershed, the lllinoian till is covered by 7 to 16 feet of loess. The majority of upland prairie soils were formed in this manner.

Both loess deposition and the underlying glacial till were eroded by the melting Wisconsinan glacier to form the large glacial-alluvial stream valleys common to the Galesburg Plain of western and central Illinois. Torrential glacial runoff created the steep valley bluffs (exposing the paleosols) and wide stream valleys (where the sandy deposition occurred). In the Court Creek watershed, the highest point occurs in the prairie southwest of Wataga at 840 ft (256 meters) above mean sea level (msl). The watershed drops 260 ft (79 meters) to 580 ft (177 meters) msl near the mouth of Court Creek at Dahinda. The close association of these steep valley bluffs with the relatively wide floodplains is clearly demonstrated on the map of watershed slopes (figure 2). Both the floodplains and the steep valley bluffs extend almost to the watershed boundary.

Floodplain valleys have served as sediment traps during geologically recent flood events (Fehrenbacher et al., 1977). These relatively new floodplain soils are described as alluvium, a waterborne deposition. Huntsville, Lawson, and Sawmill soil series represent these alluvium soils. These floodplain soils generally have a silty texture, which reflects the loess nature of their source.

Native vegetation has greatly affected these parent soil materials. The Tama, Ipava, and Sable soil series of the upland prairie were formed under the tall prairie grasses. These grasses had many fine fibrous roots, which added large amounts of organic matter near the soil surface. Such soils have thick, black or dark brown surface layers and are located on the broad upland divides between streams. Soils located on the steep valley bluffs and the narrow upland divides between stream tributaries were formed under deciduous hardwood forests. Organic contributions of timber soils were from leaf litter as the tree root systems were less fibrous near the surface. This resulted in a thinner, lighter colored surface and subsurface layer. Floodplains contained a mixture of trees and prairie grasses. Trees generally formed woody green belts along the stream borders. However, when an adequate water supply existed, trees did form hardwood bottomland forests. The floodplain soils are much darker because of organic matter deposited during flood events. The upland prairie and the glacial-alluvial floodplain are considered prime farmland.

Soil Associations

The Soil Conservation Service (SCS), as a part of the Knox County Soil Survey, has determined the extent of six major soil associations in the Court Creek watershed (figure 3). The number designation and principal soils of each association are as follows:

Soil Association number	Principal soils
1	Ipava-Sable
2	Ipava-Tama-Assumption
3	Rozetta-Elco-Keomah
4	Hickory-Elco-Marseilles
5	Lawson-Huntsville-Downs
6	Lensburg-Rapatee

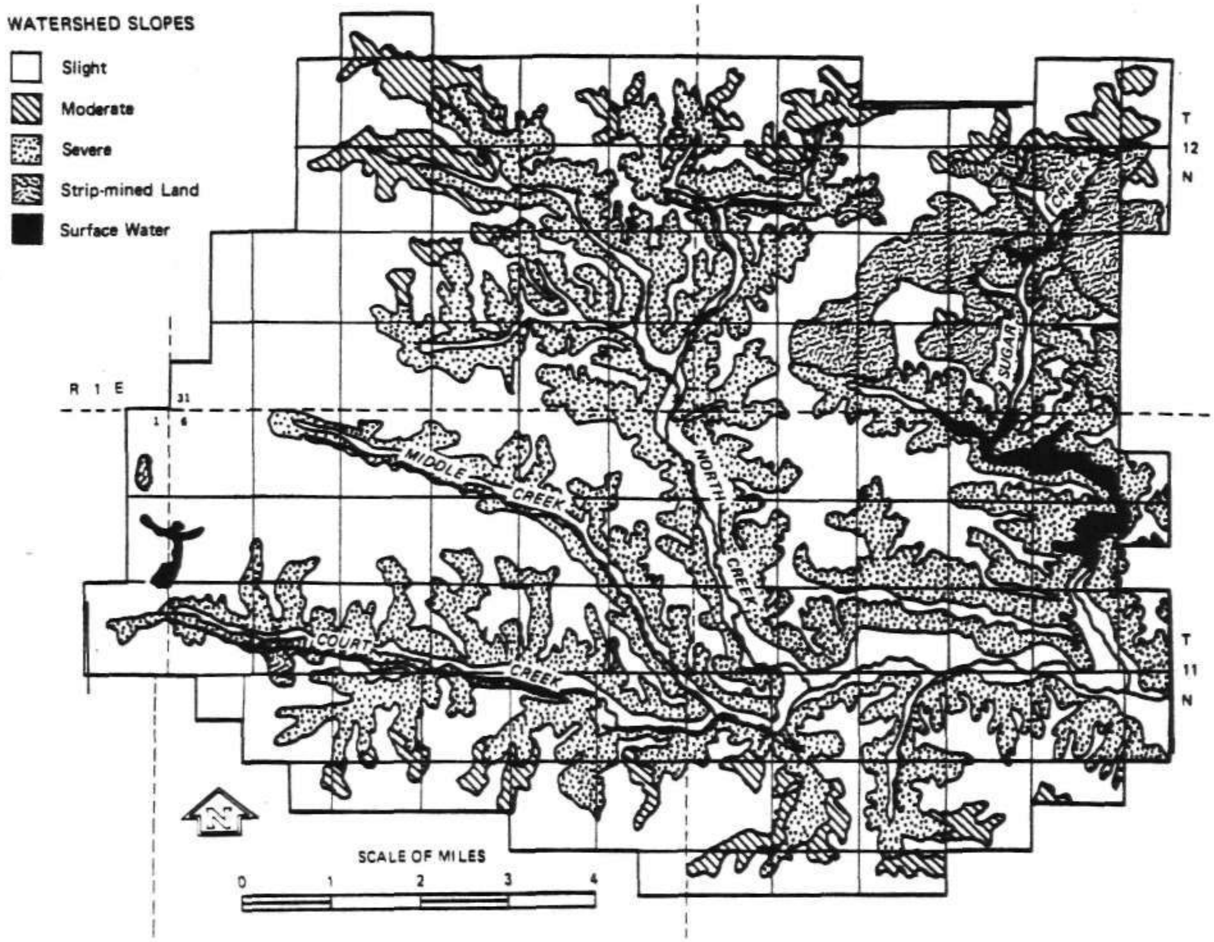


Figure 2. Landform slopes in the Court Creek watershed

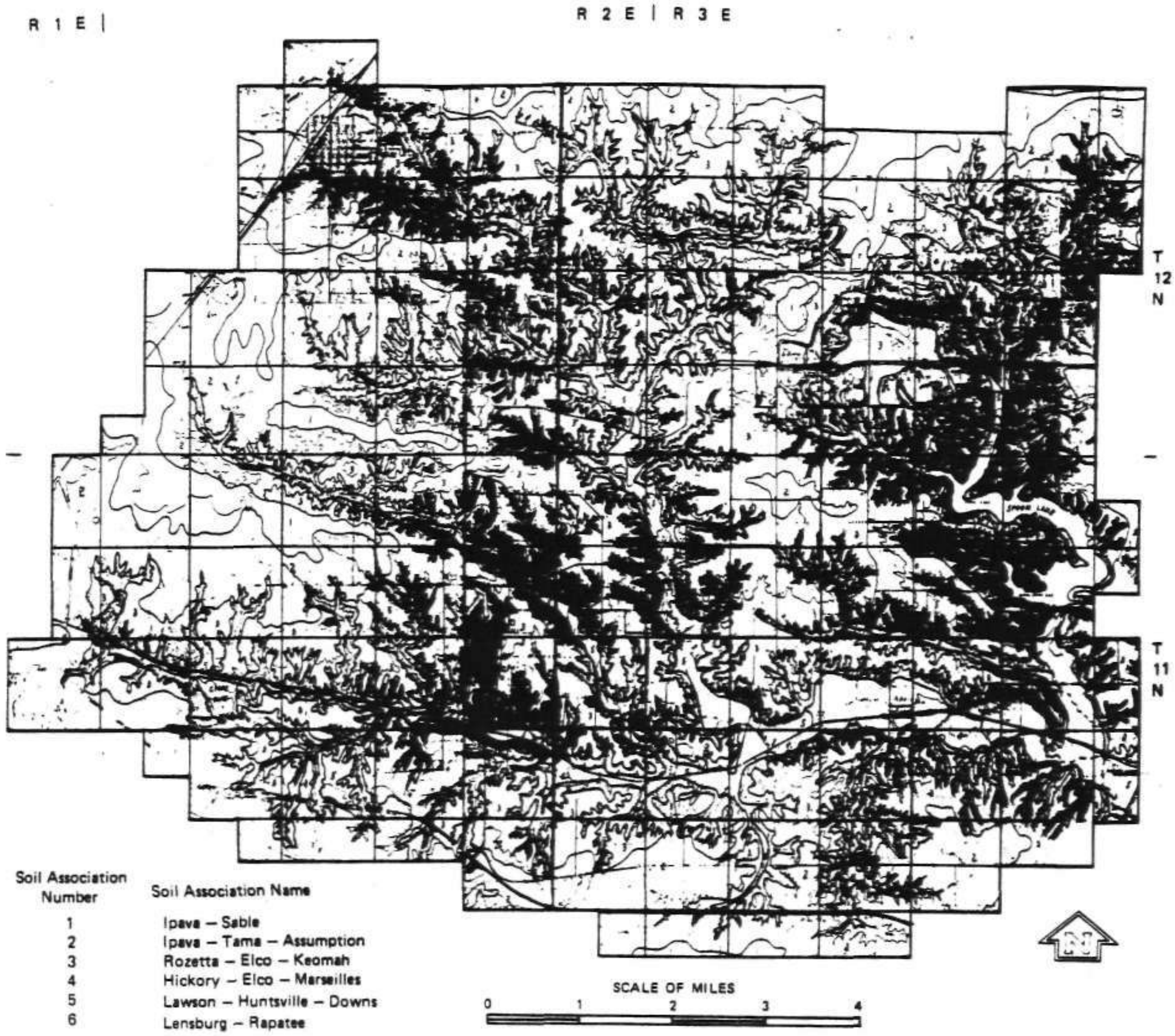


Figure 3. Distribution of six soil associations in the Court Creek watershed

Soil Associations 1, 2, and 3 generally support row crops, while hay and pasture are secondary uses. Soil Associations 1 and 2 are generally flat (slopes <6 percent) in the upland prairie landform, while Soil Association 3 occurs in the less flat divides between stream valleys.

Association 4 is a soil found on the steep to very steep, moderately well and well-drained slopes of the stream valley bluffs. Slopes range from 15 to 60 percent and are generally short and smooth. It is composed of glacial till, loess, paleosols, and shale. This association primarily supports woodlands, although more gradual slopes are used for pasture.

Soil Association 5, Lawson-Huntsville-Downs, consists of nearly level bottomlands and gently sloping terraces. Slopes range from 0 to 6 percent. These soils are formed in alluvium and in loess. They are well suited as primary row crop areas and secondary pasture. There is an abundance of open-land wildlife and also some wetland game in limited areas. The extension of Soil Associations 4 and 5 from the mouth of Court Creek to the outermost watershed boundaries of even Middle Creek should be noted.

Figure 4 indicates the suitability of land sections in the Court Creek watershed for grain and forage, principally on the basis of soil type and slope. Areas termed "good" represent Soil Associations 1, 2, and 5. Areas indicated as "fair" represent Soil Association 3. Those areas termed "poor" are in Soil Association 4 (Griffin, 1977).

Court Creek watershed maps of soil associations and suitability for grain and forage are similar to the topographic map of watershed slopes because of the overwhelming influence of glaciers on the watershed landform. However since 1930, a new parent soil has been created by strip mining activities for Pennsylvanian No. 6 coal in the upper Sugar Creek watershed. The resultant mine spoils consist of a heterogeneous mixture of glacial till, loess, and Pennsylvanian age shale and sandstone. This strip-mined land is Soil Association 6, the Lensburg-Rapatee soils, shown in figure 3. Slopes range up to 70 percent in high parallel ridges and swales. The soils are well drained and there are numerous small lakes. The land uses are either pasture or idle with some scrub timber.

LAND USES

Is the water quality of streams in the Court Creek watershed governed by land use in the watershed? Deriving an answer to this question is one of the principal objectives of this study. To properly assess what relationship, if any, exists required an inventory of land use in the watershed. Also pertinent to the

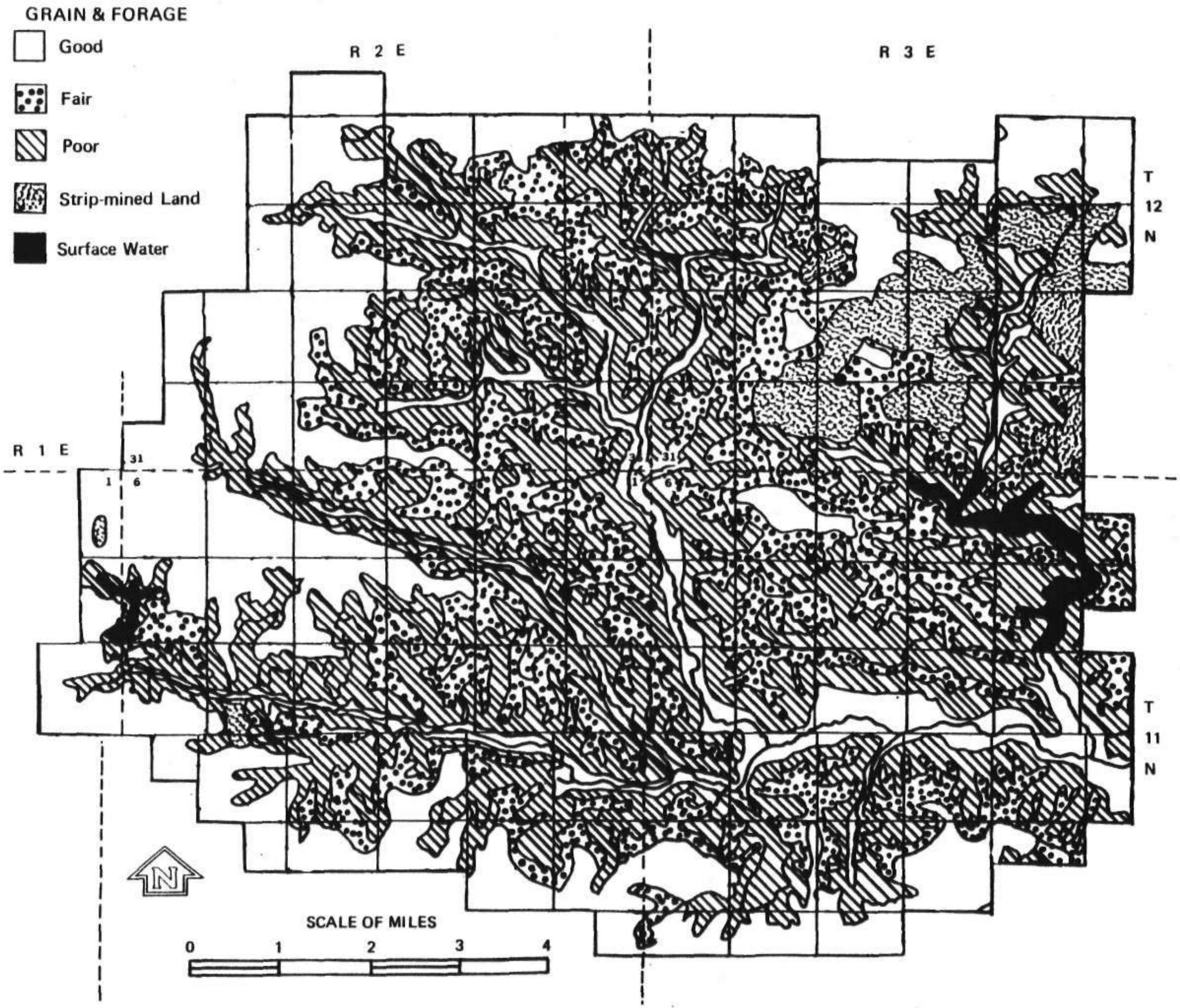


Figure 4. Suitability of land in the Court Creek watershed for grain and forage

assessment is a sense of historical perspective regarding the use of land in past years as well as during the present. With a broader data base the likelihood of accurate predictions for the future is enhanced.

Agriculture has been and continues to be the stable economic force in the watershed. In addition to row crops, livestock management is a significant activity. In 1938 strip mine operations for coal recovery commenced. Operations terminated in 1969. by which time about 3,300 acres (9.3 sq km) had been mined. Most of the strip mining activities were located in Copley Township.

Ten land use classifications Cone of which has two sub-classes) were established for the Court Creek watershed, as shown in table 3. Reliance was placed on the examination of aerial photographs CI" = 660') to define the distribution of the land use classifications in the watershed. Aerial photos for the years 1940, 1950, 1963, 1969, and 1979 were obtained from the depository of the Agricultural Stabilization and Conservation Service CASCS) in Las Vegas, Nevada. Contractual arrangements were made with an aerial data system analyst to examine the photographs and designate land uses for each quarter section CI35 to 160 acres) of land in the watershed. This required land use designations for 388 quarter sections for each of the five separate aerial photograph sets taken over the 40-year period Detailed analyses of the 1940 to 1969 aerial photographs are presented in the earlier report by Roseboom et al (1983).

The land use data for each quarter section in the watershed for a 40-year period, including legal descriptions and watershed locations, were sorted and stored in the Cyber computer system at the University of Illinois. These data were used to prepare the land use map of the watershed depicted in figure 5. A cursory examination of figure 5 shows that most of the land use in the watershed is agriculturally oriented, with row crops and pasture predominating Row crop acreage within the watershed has remained relatively stable. The number of farms, however, has declined. During the past 21 years, there has been an overall decrease of about 46 percent in the number of farms.

As part of the water quality assessment of the streams in the watershed, 16 water sampling stations were established. A more detailed discussion of their use will be presented later in this report. To examine what relationships, if any, exist between land uses and the water quality of surface waters, reliance was placed on land use data from 1979 ASCS aerial photographs compiled for each subwatershed above the 16 stream sampling stations. Land uses in each quarter section were allocated to a subwatershed on the basis of the 1979 USGS topographic maps of the watershed. A subwatershed is defined as that watershed area between stream sampling stations. If runoff from a quarter section entered the stream between stream sampling stations, its land use areas were allocated to the subwatershed of the lower stream station.

Table 3. Ten Land Use Classifications and Their Abbreviations

1.	Row crops	RC
2.	Wooded pasture	WPAS
3.	Pasture	PAS
4.	Woods	WDS
5.	Water	WTR
6.	Confined animal feedlots	CFL
7.	Urban	URB
8.	Non-productive land (farmhouses, sheds)	NP
9.	Active mineral land	AM
10.	Inactive mineral land	IM
	(a) Recreation	IMR
	(b) Pasture	IMP

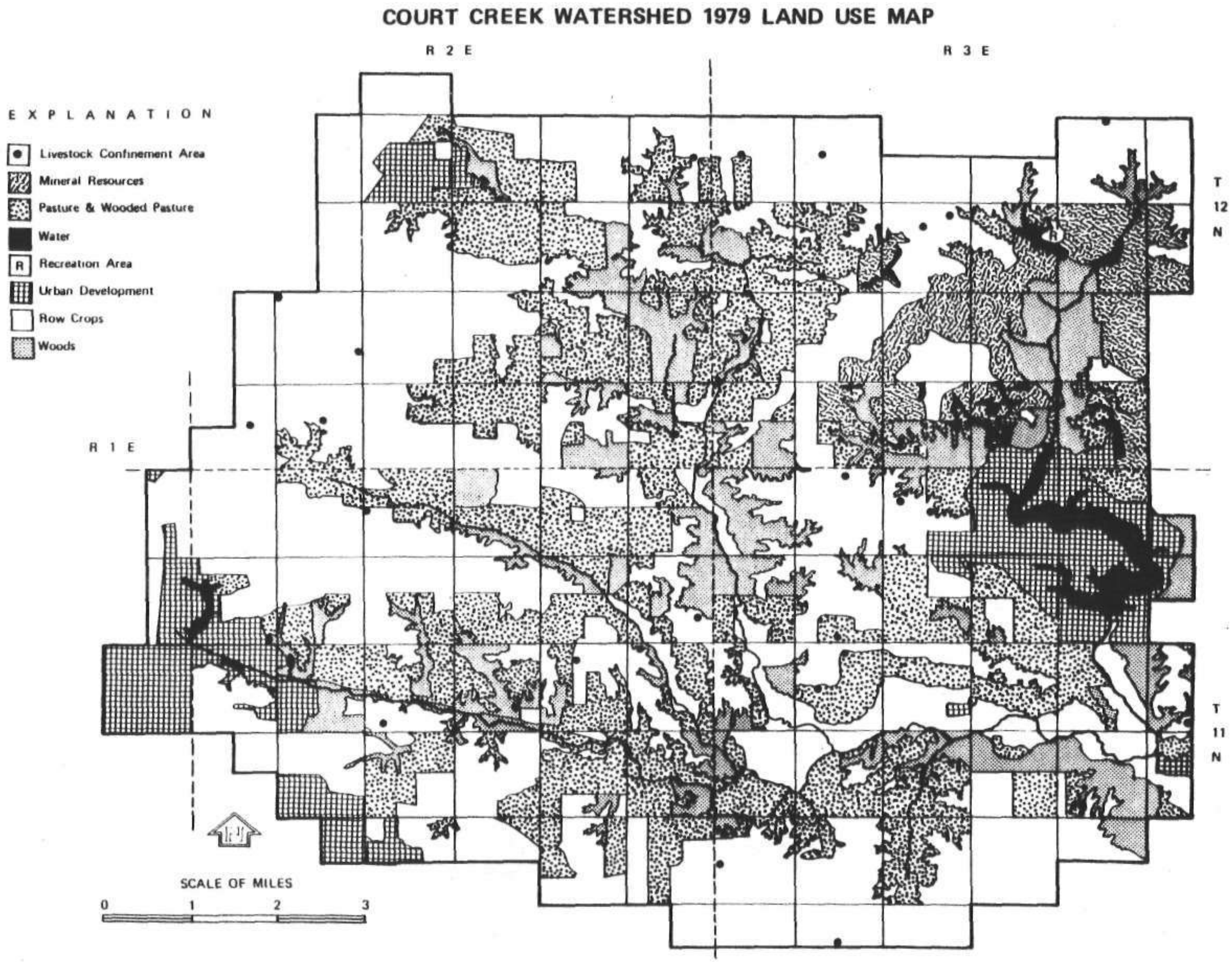


Figure 5. Land uses in the Court Creek watershed

Figure 6 shows in a simplified fashion the portion of the total watershed providing drainage to the 16 sampling stations. Those stations with the prefix "C" are located on Court Creek proper, while those with the prefixes "M," "N," and "S" are located on Middle, North, and Sugar Creeks, respectively. The designation CO signifies the confluence of Court Creek with the Spoon River rather than a sampling site, and the designation MO represents the confluence of Middle and Court Creeks. It is important to realize that although a station such as N4 has a single discrete boundary depicted in figure 6, the drainage basin named N3 is the N4 drainage basin plus the N3 subwatershed. The N3 subwatershed is the difference in watershed area between the N4 drainage basin and the N3 drainage basin. The N3 subwatershed is shown between the dotted subwatershed boundaries in figure 6. Similarly, for example, all "M" drainage basins plus all upstream "C" drainage basins are tributary to station C7. However the C7 subwatershed area is only that watershed area downstream of the MO and C10 drainage basins to the C7 sampling station. It is important to realize that a subwatershed is the watershed area between stream sampling stations, while a drainage basin is the sum of all upstream subwatersheds.

Table 4 shows the land uses and their respective areas in the drainage basins above each sampling station, based on 1979 land use data. A review of table 4 shows either the increasing acreage of a specific land use classification with downstream movement, or else the stability of a specific land use. This occurs as the acres of each land use in successive subwatersheds are added to downstream stream basins. For example, row crop acreage increases from 2115 to 4627 in the Sugar Creek stream basins between sampling station S5 and S1.

Table 5 has been prepared from the information contained in table 4. In table 5 the land use classifications for each drainage basin upstream from the sampling stations are presented as a percentage of the area of the drainage basin. Here the increasing or decreasing importance of a specific land use classification as influenced by downstream movement is shown. Although the acreage of row crops in Sugar Creek stream basins increases from downstream basins, the percentage of row crops in the stream basins drops from 42 percent to 31 percent. For North Creek, however, the contribution of the downstream drainage basins remains fairly constant with downstream movement (N4 to Nl) in terms of a percentage of the land use for each classification.

For the Middle Creek basins, there is also considerable variation for the row crop category from M3 to Ml. Row crop usage makes up about 72 percent of the land area in the M3 basin but only about 61 percent in the M1 basin. It is important to note thai the Ml subwatershed (that watershed area between the M3 and Ml stream sampling stations) is only 40 percent row crop. The

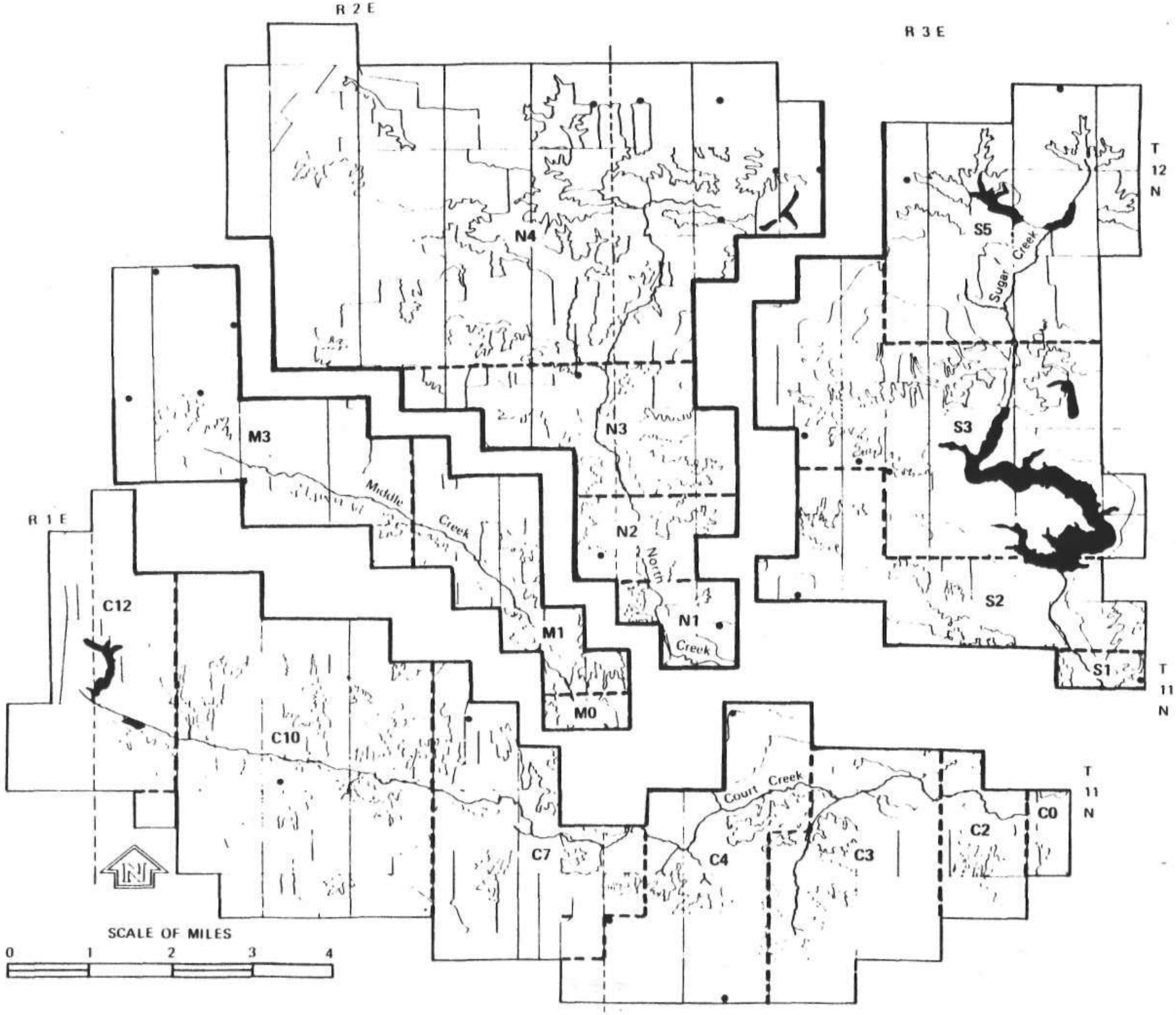


Figure 6. Subwatersheds in each of the four stream basins in the Court Creek watershed

Tabla 4. Number of Acres of Each Land Use in the Basins above Stream Sampling Stations, 1979

	RC	WPAS	PAS	WDS	WTR	CFL	URB	NP	AM	IMR	IMP	TOTAL
Sugar Creek												
S5	2115	246	30	312	82	11	0	55	0	21	2098	4960
S3	3380	1040	240	568	654	17	2078	149	0	21	3238	11360
S2	4488	1901	572	954	709	27	2136	192	0	21	3247	14240
S1	4627	1909	572	1121	709	32	2140	195	0	21	3247	14560
North Creek												
N4	7588	2951	761	1774	41	21	408	332	0	0	197	14080
N3	8756	3325	1008	2638	42	24	408	395	0	0	197	16800
N2	9234	3491	1063	3011	43	43	408	418	0	0	197	17920
N1	9678	3600	1148	3164	43	58	408	423	0	0	197	18720
Middle Creek												
M3	3093	493	385	255	0	4	0	70	0	0	0	4320
Ml	3927	1317	515	480	2	35	0	113	0	0	0	6400
CON	4023	1393	564	571	2	35	0	121	0	0	0	6720
Court Creek												
C12	1358	264	102	0	64	9	1299	103	0	0	0	3200
C10	5011	1706	656	474	151	43	1603	349	0	0	84	10080
C7	11161	4083	1754	1258	172	117	1605	461	0	0	84	20960
C4	23159	8203	3010	4670	210	147	2041	1188	0	0	300	42880
C3	25095	8446	3479	5143	210	147	2047	1276	0	0	300	46080
C2	30194	10388	4107	6732	926	185	4200	1439	0	21	3582	61760
CON	30369	10388	4110	6768	926	185	4284	1446	0	21	3582	62080

Note: Planimetered from 1979 aerial photographs. RC=row crops; WPAS=wooded pasture; PAS=pasture; WDS=woods; WTR=water; CFL=confined animal feedlots; URB=urban (residential); NP=non-productive (farm-houses, sheds); AM= active mining; IMR = inactive mining recreational; IMP= inactive mining pasture; CON= confluence

Table 5. Percentage of Each Type of Land Use in the Basins above Stream Sampling Stations, 1979

	RC	WPAS	PAS	WDS	WTR	CFL	URB	NP	AM	IMR	IMP	TOTAL (acres)
Sugar Creek												
S5	42.6	5.0	0.6	6.3	1.7	2.2	0.0	1.1	0.0	0.4	42.3	4960
S3	29.8	9.2	2.0	5.0	5.8	0.2	18.3	1.3	0.0	0.2	28.5	11360
S2	31.5	13.3	4.0	6.7	5.0	0.2	15.0	1.4	0.0	0.2	22.8	14240
S1	31.8	13.1	3.9	7.7	4 9	0.2	14.7	1.3	0.0	0.1	22.3	14560
North Creek												
N4	53 9	21 0	5.4	12.6	0.3	0.1	2.9	2.4	0.0	0.0	1.4	14082
N3	52.1	19.8	6.0	15.7	0.3	0.1	2.5	2.4	0.0	0.0	1.2	16800
N2	51.5	19.5	5.9	16.8	0.2	0.2	2.3	2.3	0.0	0.0	1.1	17920
N1	51.7	19.2	6.1	16.9	0.2	0.2	2.2	2.3	0.0	0.0	1.1	18720
MiddleCreek												
M3	71.6	11.4	8.9	5.9	0.0	0.0	0.0	1.6	0.0	0.0	0.0	4320
M1	61.4	20.6	8.0	7.5	0.0	0.5	0.0	1.8	0.0	0.0	0.0	6400
CON	59.9	20.7	8.4	8.5	0.0	0.5	0.0	1.8	0.0	0.0	0.0	6720
Court Creek												
C12	42.4	8.3	3.2	0.0	2.0	0.3	40.6	3.2	0.0	0.0	0.0	3200
C10	49.7	16.9	6.5	4.7	1.5	0.4	15.9	3.5	0.0	0.0	0.8	10080
C7	53.3	19.5	8.4	6.0	0.8	0.4	7.9	3.3	0.0	0.0	0.4	20960
C4	54.0	19.1	7.0	10.9	0.5	0.4	4.8	2.8	0.0	0.0	0.7	42880
C3	54.5	18.3	7.6	11.2	0.5	0.3	4.4	2.7	0.0	0.0	0.6	46080
C2	48.9	16.8	6.7	10.9	1.5	0.3	6.8	2.3	0.0	0.0	5.8	61760

Note: Determined from 1979 aerial photographs. RC=row crops; WPAS-wooded pasture; PAS=pasture; WDS=woods; WTR=water; CFL=confined animal feedlots; URB=urban (residential); NP=non-productiwe (farm houses, sheds); AM= active mining; IMR= inactive mining recreational; IMP- inactive mining pasture; C0N= confluence acres and percentages of subwatershed area for each land use in each subwatershed are given in tables 6 and 7. Row crop acreage in the M1 subwatershed is limited by the extent of the steep slopes, which constitute 58 percent of the M1 subwatershed. Land uses on the steep slopes are limited to pasture, wooded pasture, and woods. Row crop acreage in the M1 subwatershed is limited to the floodplain (Soil Association 5) and the narrow divides between tributary valleys (Soil Association 3). The M3 subwatershed represents the prairie landscape (Soil Associations 1 and 2), which is very flat (0 to 6 percent slope). Over 70 percent of the M3 subwatershed has slight slopes and therefore is largely in row crop acreage.

For each subwatershed, the percentages of subwatershed in floodplain, with slight slopes (< 6 percent), with moderate slopes (6 to 15 percent), and with severe slopes (15 to 60 percent) are given in table 8. The areas of slight slopes are almost always in row crops and include the floodplain soils. Subwatershed differences in percent of area with severe slopes will not only affect row crop land use but will also affect the rate of stormwater runoff. While areas of severe slopes are present in the prairie subwatersheds, as above the M3 and C12 stream sampling stations, severe slopes in the prairie subwatersheds are less extensive and are near 15 percent inclines. About 50 percent of the area in downstream floodplain subwatersheds, such as M1 and N2 subwatersheds, has severe slopes. Slopes along the downstream floodplain bluffs have inclines up to 60 percent.

The Sugar Creek S5 subwatershed has the greatest amount of strip-mined pastures in the watershed. Strip-mined pastures have slopes up to 70 percent with many rock outcroppings, so that farm machinery can not traverse the rugged terrain. These strip-mined pastures lie between the prairie row crops on the northern watershed borders and the wooded stream corridor of Sugar Creek (figure 5). The S3 sampling station is the spillway of the 512-acre Spoon Valley Lake. Spoon Valley Lake receives runoff from residential areas along the lakeshore, runoff from agricultural lands on the western portion of its S3 subwatershed, strip-mine runoff from its northern subwatershed area, and S5 strip-mine runoff. A sewage treatment plant collects wastes from residential homes along the lake. The outlet of the treatment plant is just downstream of the S3 sampling station. The S2 and S1 subwatersheds are heavily row crop and pasture. As with the M1 and N2 subwatersheds, much of the S2 and S1 row crops occur on the floodplain of Soil Association 5. As with the downstream floodplain subwatersheds on North Creek and Middle Creek, 50 percent of the S1 and S2 subwatersheds has severe slopes of approximately 60 percent.

The C12 subwatershed of Court Creek represents the subwatershed with the greatest urban (residential) land use. Like the M3 and S5 subwatersheds, the C12 subwatershed is located in the upland prairie landscape at the headwaters of a stream.

Table 6. Number of Acres of Each Land Use in the Subwatersheds between Stream Sampling Stations, 1979

	RC	WPAS	PAS	WOS	WTR	CFL	URB	NP	AM	IMR	IMP	TOTAL
Sugar Creek												
S5	2115	246	30	312	82	11	0	55	0	21	2098	4960
S3	1265	794	194	256	572	6	2078	94	0	0	1140	6400
S2	1108	861	348	386	55	10	58	43	0	0	9	2880
S1	139	8	0	167	0	5	4	3	0	0	0	320
North Creek												
N4	7588	2951	761	1774	41	21	408	332	0	0	197	14080
N3	1168	374	247	864	1	3	0	63	0	0	0	2720
N2	478	166	55	373	0	19	0	23	0	0	0	1120
N1	444	109	85	153	0	15	0	5	0	0	0	800
MiddleCreek												
M3	3093	493	385	255	0	4	0	70	0	0	0	4320
M1	834	824	130	225	2	31	0	43	0	0	0	2080
CON	96	76	49	91	0	0	0	8	0	0	0	320
Court Creek												
C12	1358	264	102	0	64	9	1299	103	0	0	0	3200
C10	3653	1442	554	474	87	34	304	246	0	0	84	6880
C7	2127	984	534	213	19	39	0	0	0	0	0	3360
C4	2320	520	108	248	0	0	30	304	0	0	0	3200
C3	1936	243	469	473	0	0	0	88	0	0	0	3200
C2	472	33	56	468	7	6	19	16	0	0	0	1120
CON	175	0	3	36	0	0	84	7	0	0	0	320

Note: Planimetered from 1979 aerial photographs. RC=row crops; WPAS=wooded pasture; PAS=pasture; WDS=woods; WTR=water; CFL=confined animal feedlots; URB=urban (residential); NP=non-productive (farm-houses, sheds); AM= active mining; IMR= inactive mining recreational; IMP= inactive mining pasture; CON= confluence

Table 7. Percentage of Each Type of Land Use in the Subwatersheds between Stream Sampling Stations, 1979

	RC	PAS	WPAS	WDS	WTR	CFL	URB	NP	AM	IMR	IMP	TOTA
Sugar CreeK												
S5	42.6	0.6	5.0	6.3	1.7	2.2	0.0	1.1	0.0	0.4	42.3	496
S3	19.8	3.0	12.4	4.0	8.9	0.1	32.5	1.5	0.0	0.0	17.8	640
S2	38.5	12.1	29.9	12.1	1.9	0.3	2.0	1.5	0.0	0.0	0.3	288
S1	43.4	0.0	2.5	52.1	0.0	1.5	1.3	0.9	0.0	0.0	0.0	80
North Creek												
N4	53.9	5.4	21.0	12.6	0.3	0.1	2.9	2.4	0.0	0.0	1.4	1408
N3	42.9	9.1	13.8	31.8	0.0	0.1	0.0	2.3	0.0	0.0	0.0	272
N2	42.8	4.9	14.8	33.3	0.0	1.7	0.0	2.1	0.0	0.0	0.0	112
N1	55.5	10.6	13.6	19.1	0.0	1.9	0.0	0.6	0.0	0.0	0.0	80
Middle Creek												
M3	71.6	8.9	11.4	5.9	0.0	0.0	0.0	1.6	0.0	0.0	0.0	432
M1	40.1	6.3	39.6	10.8	0.0	1.5	0.0	2.1	0.0	0.0	0.0	208
CON	30.0	15.3	23.8	28.4	0.0	0.0	0.0	2.5	0.0	0.0	0.0	32
Court Creek												
C12	42.4	3.2	8.3	0.0	2.0	0.3	40.6	3.2	0.0	0.0	0.0	320
C10	53.1	8.1	21.0	6.9	1.3	0.5	4.4	3.6	0.0	0.0	1.2	688
C7	63.3	15.9	29.3	6.3	0.6	1.2	0.0	0.0	0.0	0.0	0.0	336
C4	72.5	3.4	16.3	7.8	0.0	0.0	0.9	9.5	0.0	0.0	0.0	320
C3	60.5	14.7	7.6	14.8	0.0	0.0	0.0	7.4	0.0	0.0	0.0	320
C2	42.1	5.0	2.9	41.8	0.0	0.0	1.7	1.4	0.0	0.0	0.0	112

Note: Determined from 1979 aerial photographs. RC=row crops; WPAS=wooded pastures PAS=pasture; WDS=woods; WTR=water; CFL=confined animal feedlots; URB=urban (residential); NP=non-productive (farm houses, sheds); AM= active mining; IMR= inactive mining recreational; IMP: inactive mining pasture; CON= confluence

Table 8. Percent of Subwatershed Area In Floodplain and with Slight, Moderate, and Severe Slopes

Subwatershed	Floodplain area	Slight slope	Moderate slope	Severe slope
N4SUB	6	53	12	35
N3SUB	10	48		52
N2SUB	16	50		50
N1SUB	31	54		46
M3SUB	5	75		25
M1SUB	25	42		58
S2SUB	5	48		50
S1SUB	50	50		50
C12SUB	1	86		10
C10SUB	10	67	4	28
C7SUB	8	58	5	37
C4SUB	13	58	12	30
C3SUB	16	58	8	34
C2SUB	20	60	3	37

Note: Areas of slight slopes include floodplains as well as upland prairie. Slight slopes =< 6 degrees; moderate slopes = 6-15 degrees; severe slopes = 15-60 degrees.(Griffin et al., 1977)

Although 40 percent of the C12 subwatershed is in row crops, most row crops are upstream of the Rice Lake dam, which acts as an efficient trap for sediment and attached nutrients. The C10 subwatershed is principally agricultural with row crop as the dominant land use. Both the C12 and C1O subwatersheds have a higher percentage of land mass than the downstream subwatersheds of C7, C4, C3, and C2. The percentage of subwatershed in floodplain increases for the downstream subwatersheds on Court Creek, as well as for its tributaries. However the percentage of subwatershed in steep slopes is not as large for the Court Creek subwatersheds as for its tributaries.

The subwatersheds of C12, S5, and M3 best represent the respective land uses of residential housing, strip mining, and agriculture, particularly row crop agriculture. All three subwatersheds are similar in size -- from 3,200 to 5,000 acres. All three are located at the headwaters of streams in what was originally upland prairie. Water quality differences caused by land use only will be illustrated by the water quality at the respective stream sampling stations.

In addition to the examination of aerial photographs coupled with field reconnaissance, a search for available records regarding livestock management and row crop production was performed. The most useful sources were publications issued by the Illinois Department of Agriculture based on the assessor's annual farm census as part of the Illinois Cooperative Reporting Service. Although the records were not of long duration and were sometimes fragmentary, they served a useful purpose. The changing patterns of land use, particularly those changes related to pasture, most likely have had some influence on livestock production in the watershed. The number of cattle marketed in the townships during the period 1961 to 1977 is shown in table 9. Table 10 shows the number of hogs and pigs marketed during the period 1970 to 1977.

Although there have been fluctuations in the number of cattle marketed during the period of record, no trend is suggested in table 9. The average annual number marketed during the 17-year period is about 6,500. On the other hand there was a substantial increase in the number of hogs and pigs marketed during the 8 years of record, as shown in table 10. The total number increased from about 37,000 in I970 to a peak of about 61,000 in 1976. Most of the increase occurred in Copley Township where about 11,500 were marketed in 1970 compared to about 21,500 in 1977, and in Sparta Township, where similar increases from about 6,300 to 10,700 occurred. Production in Knox and Persifer Townships was relatively stable. Most of the hog and pig production, though not all, employs confined feedlots. Some cattle are also maintained in similar facilities.

The locations of confined animal feedlots in the Court Creek watershed, shown in figure 5, were determined from aerial photographs and confirmed by watershed ground inspection. While

Table 9. Number of All Cattle Marketed in Townships in the Court Creek Watershed

Year	Copley	Knox	Persifer	Sparta	Total
1977	1467	961	2031	2050	6509
1976	1405	1199	1970	2509	7083
1975	1397	981	2945	2234	7557
1974	1127	1097	1961	1782	5967
1973	1179	1008	2216	1601	6004
1972	1593	914	2124	1397	6028
1971	1576	833	2106	1125	5640
1970	1857	848	2366	1806	6874
1969	1890	1041	2482	2131	7544
1968	2103	899	1628	1654	6284
1967	1777	1457	1403	1585	6222
1966	1784	1414	1757	1972	6927
1965	1845	1298	1811	1944	6898
1964	1830	1137	1524	1632	6123
1963	1556	1396	524	1877	5353
1962	1356	908	921	2336	5521
1961	1829	1991	1647	2203	7670
Max	2103	1991	2945	2509	7670
Min	1127	833	524	1125	5353
Avg	1622	1140	1848	1873	6483

From: Illinois Agricultural Statistics: Assessor's Annual Farm Census (1962-1978), Illinois Cooperative Reporting Service.

Table 10. Number of All Hogs and Pigs Marketed in Townships in the Court Creek Watershed

Year	Copley	Knox	Persifer	Sparta	Total
1977	21,565	7610	15,516	10,741	55,432
1976	21,387	7705	14,324	17,308	60,724
1975	16,321	7331	12,782	14,732	51,161
1974	14,527	7070	13,145	13,896	48,638
1973	13,980	6302	14,963	13,779	49,044
1972	14,788	6828	13,381	11,098	46,095
1971	15,485	6424	9,055	7,262	38,226
1970	11,471	6400*	13,125	6.349	37,345*

* Estimated

From: Illinois Agricultural Statistics: Assessor's Annual Farm Census (1962-1978), Illinois Cooperative Reporting Service.

many feedlots are located on the watershed perimeter as in the M3 subwatershed, feedlot operations are located near the steep bluffs in the lower subwatersheds of Middle Creek, North Creek, and Sugar Creek. Animal wastes from confined animal feedlots are routinely applied to both row crop fields and pastures. The substantial number of hogs and pigs confined in the watershed (50,000 to 60,000) provides the potential for the introduction of animal waste to surface waters.

What is not shown in the land use tables or land use figures is the likely impact of hydrologic modifications that have been imposed on the various drainage basins by strip-mine operations, stream channelization, and the impoundment of water. These alterations are a major consideration in developing relationships between land use and water quality. Their implications will be discussed later.

The basins of Middle and North Creek are basically agriculturally-oriented without significant influences from mining, urbanization, or water impoundment. The Sugar Creek basin and the C12 subwatershed are influenced by those activities. The lower segments of Court Creek are a composite of all land uses, but agricultural land uses are dominant in its watershed.

WATERSHED CLIMATE AND STREAMFLOWS

Climate

The Court Creek watershed is located entirely in Knox County, which has a continental climate typical of northern Illinois. The annual range of temperatures often varies from 20 degrees below zero (Fahrenheit) in the winter to 100 degrees or higher in the summer. Low pressure areas or storm centers with associated weather fronts bring frequent short-period changes in temperature, humidity, cloudiness, and wind direction.

January is normally the coldest month of the year, with December and February averaging 5 degrees warmer than January. Eighty-five percent of days between December and March are likely to have minimum temperatures below freezing, with an average of eleven days of below zero temperatures From the first of December to the last of February, daily mean temperatures average freezing or below. Light snows are frequent, but on the average there are only 8 to 10 snowfalls of 1 inch or more. The annual snowfall averages about 25 inches, but more than 20 inches have fallen in a single month. During the three winters of the 1980-1983 sampling period, total winter precipitation ranged from 1.3 to 2.5 inches. When expressed as inches of snowfall, this winter precipitation ranges from 13 to 25 inches of snowfall.

Precipitation

Raingages were established at 13 sites in the watershed (figure 7). Each raingage was a Belfort weighing-bucket type with a chart drive for strip charts. Daily precipitation records for each raingage include start times, stop times, duration of each rainfall within the 24-hour period, and the amount of rainfall for each event in a 24-hour period. Hourly precipitation amounts were also recorded for all large storm events. Data bases of daily and hourly raingage measurements are stored on the University of Illinois Cyber computer system.

That portion of watershed area represented by each raingage is called the area of influence of the respective raingage. The area of influence for each gage (figure 8) was determined by the Thiessen method (U.S. Department of Agriculture, 1979). Each quarter section in the raingage area of influence was assigned the daily or hourly rainfall amount as determined by the gage within the area of influence. When a subwatershed contained quarter sections from the areas of influence of two or more raingages, the amount of rainfall of each gage was weighted by the proportion of subwatershed (relative number of quarter sections) which were in each raingage's area of influence. The subwatershed rainfall amount is the sum of "weighted" rainfall amounts. This procedure is fully explained in the publication on Court Creek watershed characteristics (Roseboom et al., 1983).

Rainfall for the entire watershed was determined in a similar manner. Mean daily rainfall amounts (depths of rainfall) for the entire watershed are found in figure 9. Hourly rainfall amounts for all individual subwatersheds were determined for high intensity rain events over the two years of record. This data base has also been placed in the Cyber computer system in Champaign. Intensive stream sampling was carried out during the last three high intensity storms on December 2, 1982; December 25, 1982; and April 1, 1983.

An examination of the Galesburg daily precipitation records from 1960 to 1980 revealed that approximately 45 days per year had rainfall events greater than 0.25 inches. Nearly 60 percent of the precipitation occurs during the crop growing season between mid-April and mid-September. Yearly precipitation averages 35 inches and only one year of record had less than 27 inches. Yearly Court Creek watershed rainfall amounts for 1981 and 1982 were 33.08 and 44.58 inches of rainfall, respectively. In the 20-year period of record for Galesburg, Illinois, only four years had yearly rainfall amounts greater than 44 inches of rain. The largest yearly amount of rainfall was 50.54 inches in 1973. Unless watershed soils were extremely wet, at least 1 inch of rainfall was required before high flow events occurred in Court Creek.

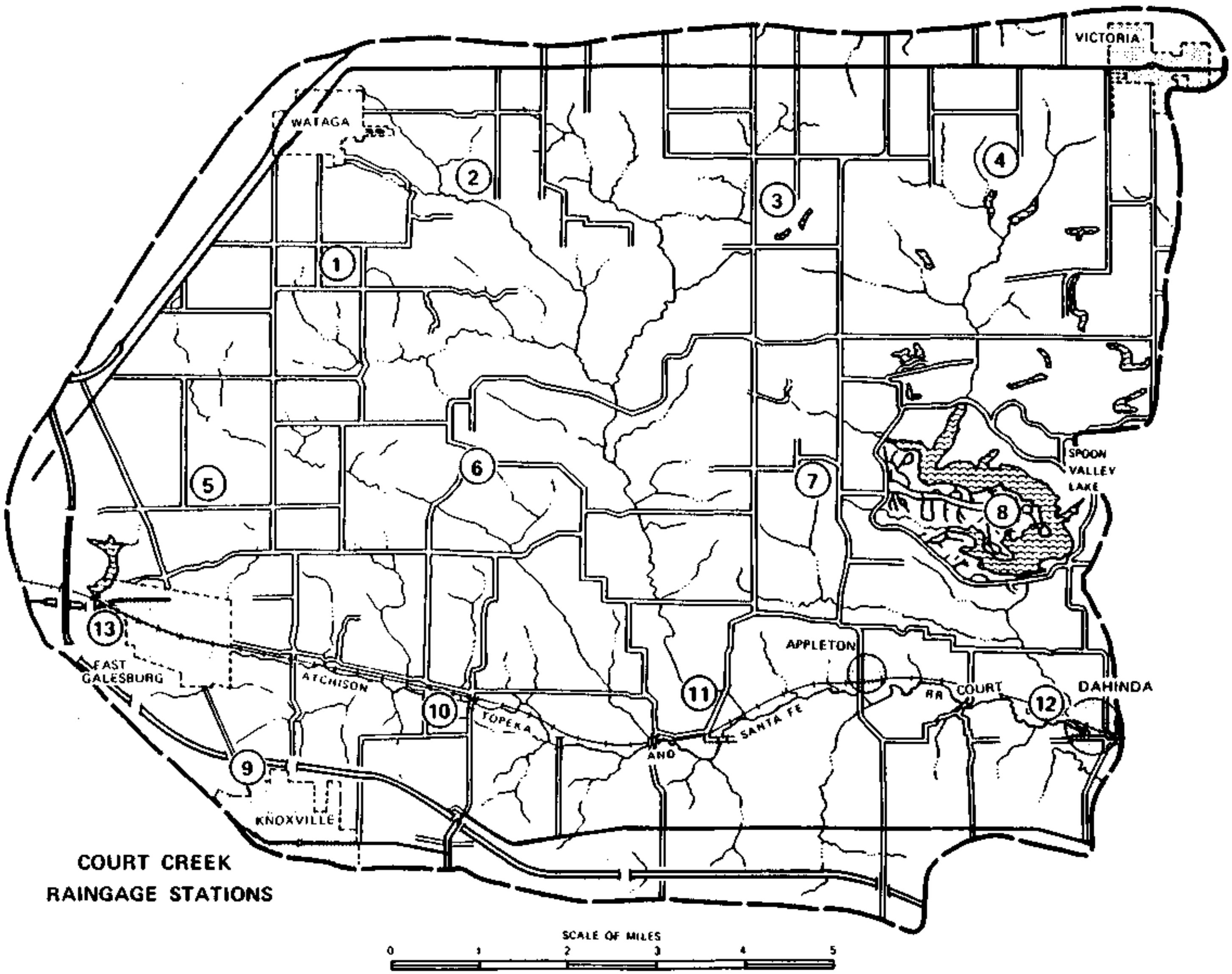


Figure 7. Locations of vaingages in the Court Creek watershed

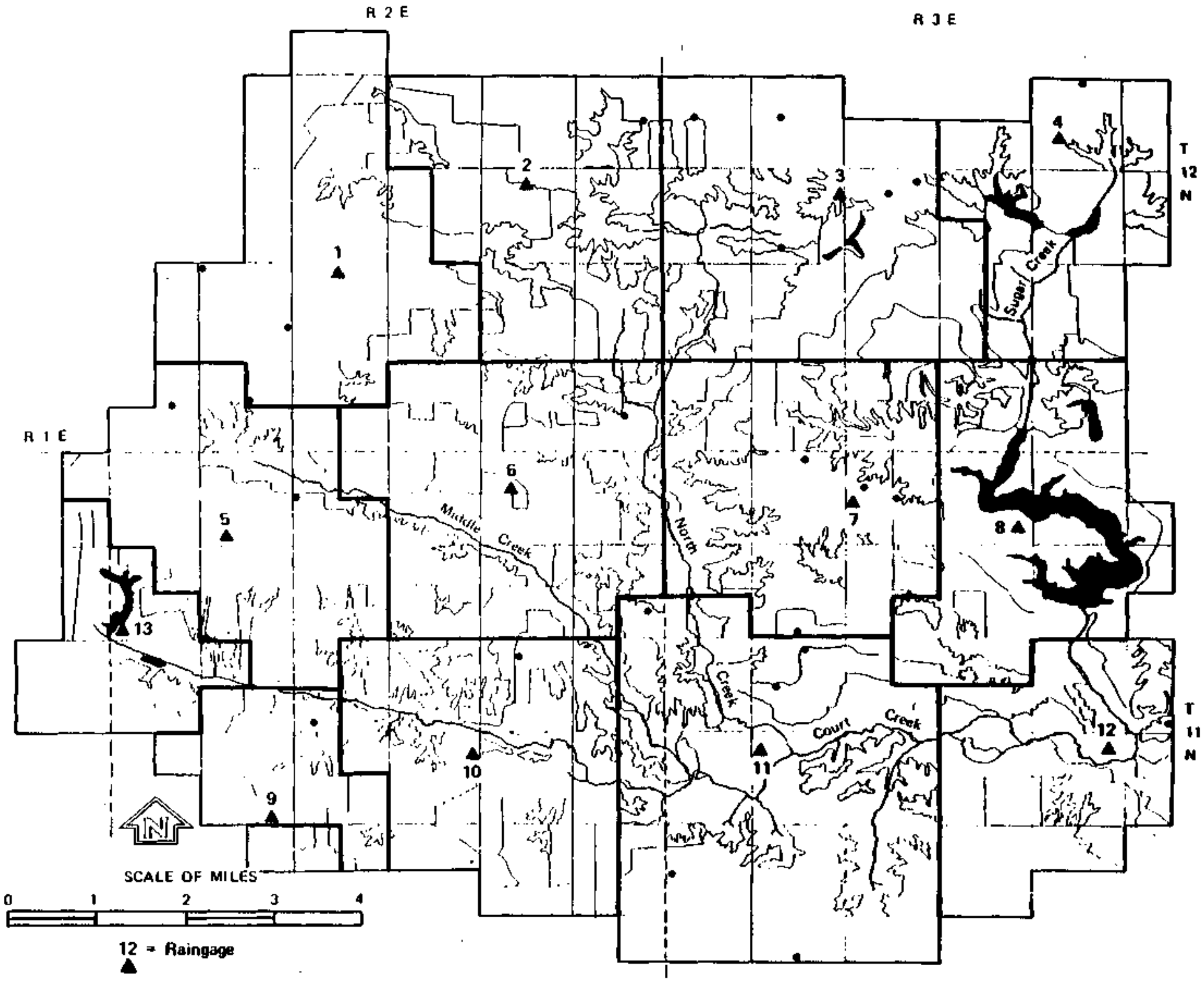


Figure 8. Areas of influence for raingagea in the Court Creek watershed

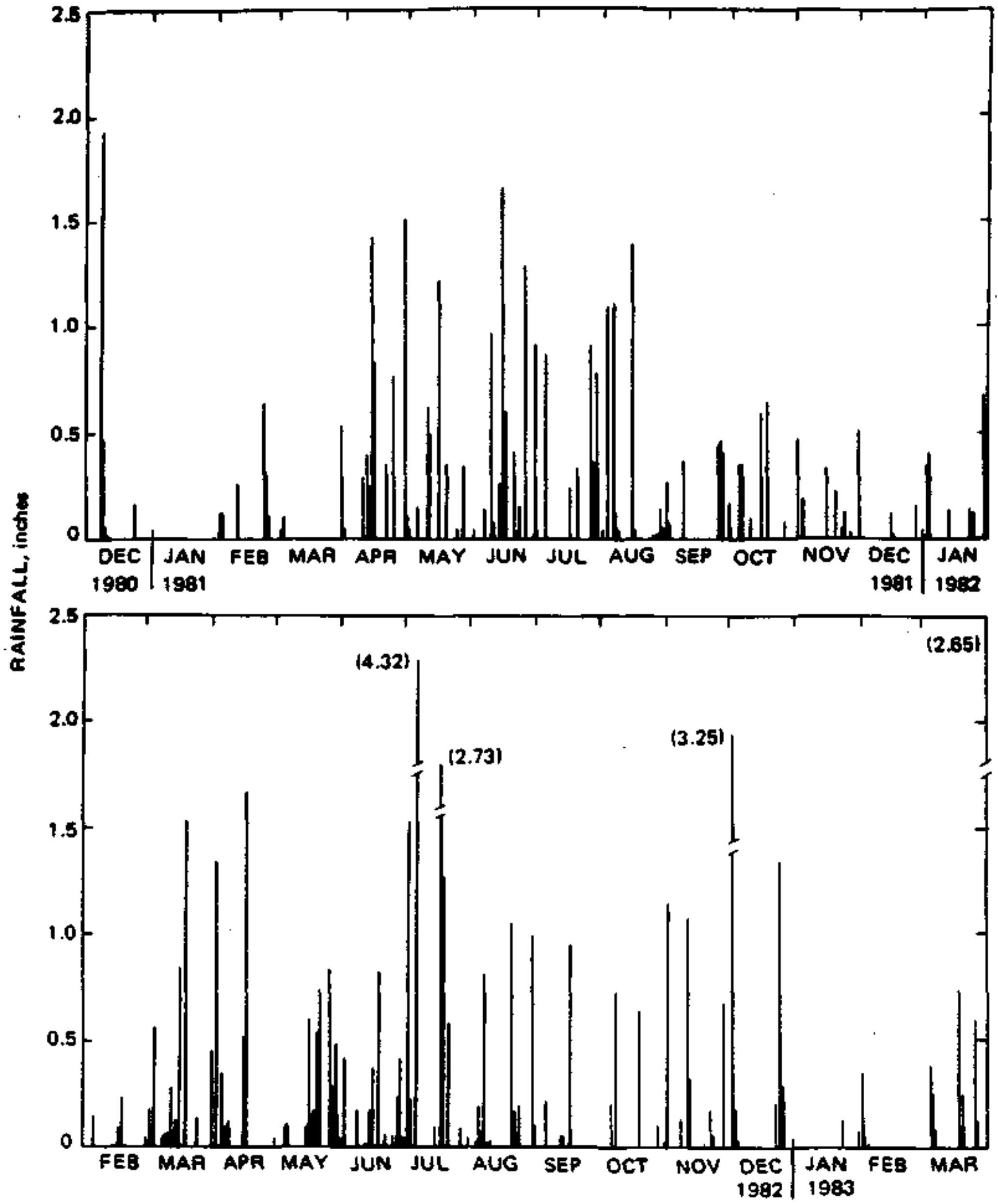


Figure 9. Daily average depth (amount) of precipitation in the Court Creek watershed (December 1980 – April 1983)

The frequency of Galesburg rainfalls greater than I inch is shown in table 11. In 1982, the watershed not only had more than the average number of intense rainfalls, but also had three very large storm systems, when daily rainfall amounts for the entire watershed ranged from 2.7 to 4.3 inches. The maximum daily Galesburg rainfall (from a single raingage) was 4.90 inches in 1961. On July 7, 1982, a daily rainfall of 6.57 inches was recorded by a raingage in the N4 subwatershed. Thus the stream sampling period from 1981 to 1982 had above average rainfall by any criteria.

Rainfall records are useful not only in comparing rainfall during the stream sampling period to long-term records of the watershed, but also as a means of estimating the amount of overland flow entering streams. When combined with the results of the I98I Knox County Soil Survey and the land use maps, rainfall amounts can be used to estimate the amount of runoff from each quarter section in the watershed. The magnitude of storm runoff volume from a given storm rainfall is greatly affected by soil characteristics, vegetation (land use), and antecedent soil moisture condition. The antecedent soil moisture condition at the beginning of a storm is dependent upon the rainfall sequence prior to the storm -- the antecedent moisture conditions (AMC). In table 12, which lists Court Creek rainfall events, the AMC of the entire watershed has been calculated for 5-, 10-, and 15-day periods of total rainfall. The Soil Conservation Service defines three classes of AMC based on the cumulative 5-day total rainfall for the growing season and dormant season (table 13). The dormant season in Illinois is that time period without active plant growth and also without frozen ground or snow cover. In Illinois the growing season extends from early May to late October.

The estimate of storm runoff from a watershed is also decided by the soils and vegetative cover (land use), which is termed a soil-cover complex. The runoff curve number (CN), assigned to each soil-cover complex, is indicative of the runoff potential. When the amount of rainfall prior to a storm increases and causes the AMC to increase from I to III, the CN also increases as defined in table 10.1 of the National Engineering Handbook (Soil Conservation Service, 1972). The higher the CN, the greater the runoff potential.

The CN, assigned to each quarter section in the Court Creek watershed under AMC II conditions, was based on the major land use and soil type of that quarter section as determined from table 14. The position of hydrologic soil groups (B,C, and D) in the watershed was determined by use of the 1981 Knox County soil map and the Illinois Engineering Field Manual Notice - 27 (Soil Conservation Service, 1982). The major land use of each of the 388 quarter sections (figure 5) was determined from the 1979 aerial photographs. The data base, which describes the land use, hydrologic soil group, and curve number assigned to each quarter

Table 11. Frequency of Daily Rainfall Classes at Galesburg, Illinois

Year	Daily rainfall class 1"-2"	Daily rainfall class 2"-3"	Daily rainfall class 3"-4"	Daily rainfall class 4"-5"
1960	6	1		
1961	6	3		1 (4.90)
1962	5			
1963	8			
1964	5			
1965	10	2	1 C3.26)	
1966	4	1		
1967	4	1	1 (3.05)	
1968	6		1(3.15)	
1969	11	1	1(3.74)	1(4.11)
1970	14	1		
1971	5			
1972	4	1		
1973	14	1		
1974	4	2		
1975	6	3		
1976	11	1		
1977	9	2	1(3.10)	
1978	5			
1979	8			
1980	4	3	2 (3.40, 3.06)	
20-year total	149	23	7	2
Avg. occurrence	7.5	1.2	0.4	0.1
1981	9	0	0	0
1982	10	2*	I (3.25)	1 (4.25)

*Includes 4/1/83 storm

Table 12. Daily Average Watershed Storm Precipitation, Antecedent Moisture Conditions and Daily Mean Watershed Discharge (Streamflow) at the C2 Flow Gaging Station

Storm dates	Daily average watershed precipitation (inches)	5-day AMC (inches)	10-day AMC (inches)	15-day AMC (inches)	Daily mean watershed streamflow (cfs)
4/12/81	1.68	0.71	0.71	0.71	822
4/13/81	0.83	2.39	2.39	2.95	1450
4/28/81	1.52	0.00	1.14	1.97	772
5/14/81	1.23	1.13	1.30	1.33	695
6/ 9/81	1.06	0.15	0.15	0.50	162
6/13/81	1.67	1.33	1.48	1.48	884
6/16/81	0.61	1.94	3.15	3.15	304
6/24/81	1.30	0.62	1.23	3.17	808
6/29/81	0.93	1.32	1.94	2.55	208
7/ 4/81	0.88	0.93	2.25	2.87	205
7/25/81	0.94	0.00	0.59	0.65	174
7/28/81	0.80	1.63	1.97	2.22	277
8/ 2/81	1.11	0.80	2.43	2.77	296
8/ 5/81	1.12	1.11	2.60	3.54	850
3/19/82	1.54	0.98	1.40	1.45	***
3/30/82	0.45	0.00	0.14	2.53	196
4/ 2/82	1.35	0.45	0.59	2.13	626
4/15/82	0.52	0.00	0.59	1.94	220
4/16/82	1.67	0.52	0.76	2.46	1370
5/20/82	0.55	1.03	1.03	1.24	120
5/21/82	0.74	1.48	1.58	1.69	889
5/26/82	0.84	0.74	2.22	2.32	391
5/30/82	0.16	1.62	2.36	3.84	148
6/ 2/82	0.42	0.65	1.78	3.24	141
6/15/82	0.38	0.20	0.37	0.95	63
6/18/82	0.83	0.56	0.75	0.75	111
7/ 2/82	1.54	0.66	0.71	1.60	231
7/ 6/82	4.32	1.76	2.42	2.53	3000
7/18/82	2.73	0.10	0.10	4.64	1490
7/19/82	1.32	2.83	2.83	7.15	1100
8/20/82	1.06	0.00	0.03	1.13	127
8/30/82	1.00	0.00	1.43	1.43	128
11/ 1 /82	1.16	0.14	0.14	0.79	187
12/ 2/82	3.25	0.68	0.92	0.94	1505
12/25/82	1.36	0.22	0.22	0.22	800
4/ 1/83	2.64	0.75	1.00	1.84	2010

*** Recorder malfunction

Table 13. The 5-Day Cumulative Rainfall Amount Determining the Class of Antecedent Moisture Conditions during Dormant and Growing Seasons

AMC class	5-day total antecedent rainfall (inches)	
	Dormant season	Growing season
I	< 0.5	< 1.4
II	0.5-1.1	1.4-2.1
III	> 1.1	> 2.1

Table 14. Curve Numbers (CN) for Hydrologic Soil-Cover Complexes in the Court Creek Watershed during AMC II

Land use	Row crops	Pasture	Woods	Urban 0.16-acre lots	Residential 1-acre lots	Strip mine >75% vegetated	Water
Hydrologic condition	Good	Fair	Fair	Good	Good		
Hydrologic soil group							
B	78	69	60	85	68	61	100
C	85	79	73	90	79	74	100
D	89	84	79	92	84	80	100

Table 15. Weighted Curve Numbers of Court Creek Subwatersheds and Basins during AMC II Soil Moisture Conditions

	C2	C3	C4	C7	C1O	C12	Ml	M3	N1	N2	N3	N4	S1	S2	S3	S5
Subwatersheds	76	76	77	75	73	79	72	77	82	73	74	76	85	75	78	76
Upstream basin	76	75	75	75	75	79	76	77	75	75	75	76	76	76	77	76

section, has been placed in the University of Illinois Cyber computer system. The precise measurement of soil-cover groups, such as planimeterings of soil areas, is seldom necessary for hydrologic purposes (Soil Conservation Service, 1972). Grid computations are satisfactory in determining the areal coverage of soil-cover complexes.

The "weighted" curve numbers of individual subwatersheds and also stream basins (which include all upstream subwatersheds) are found in table 15. The CN for the entire watershed basin at C2 is 76 under AMC II conditions. Singh (1982) determined similar curve numbers (72 to 78) for the basins of nearby streams in western and central Illinois. If the Court Creek watershed curve number is 76 under AMC II conditions, then the watershed CNs for AMC I and AMC III are 58 and 89, respectively. Therefore if one inch of rain falls uniformly across the watershed during one day, no runoff should occur under AMC I conditions and only 0.038 inches of runoff should occur under AMC II conditions. Only under AMC III conditions will significant runoff (0.285 inches) occur.

For the 61,760-acre stream basin above the C2 station, mean daily discharges of 99 cfs and 740 cfs are estimated for AMC II and AMC III conditions, respectively. A review of table 12 indicates that such estimates are slightly lower than observed mean daily discharges at C2 during rain events under various AMC conditions. Storm events with approximately I inch of average watershed precipitation occurred on June 9, 1981; June 29, 1981; and July 19, 1982; which represent AMC I, AMC II, and AMC III conditions, respectively. Observed storm flows for those dates are higher than expected for AMC I, AMC II, and AMC III conditions. The comparisons of actual subwatershed streamflows and subwatershed curve numbers will be examined more closely later.

Streamflows

Nine locations for streamflow gaging were established. Their locations and designations are shown in figure 10. Three types of gaging devices were used: continuous recorders, staff gages, and wire-weight gages (see figure 11). Their distribution was as follows (CR = continuous recorder; S = staff gage, W-W = wire-weight gage):

C2 (S and CR)	M3 (S)	N1 (S)	S5 (S)
CIO (S)	Ml (W-W)		S3 (S and CR)
CI2 (S)			S2 (W-W)

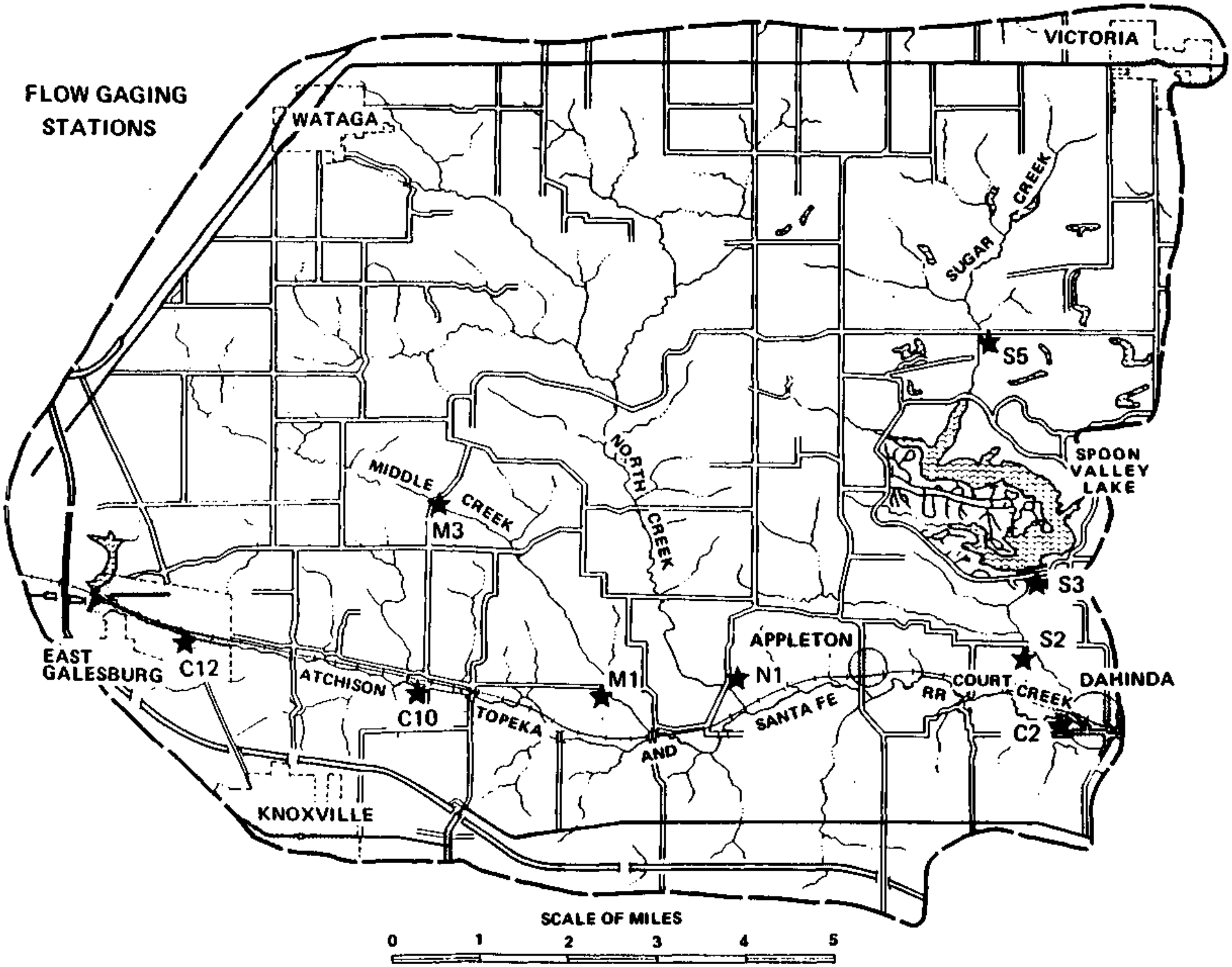
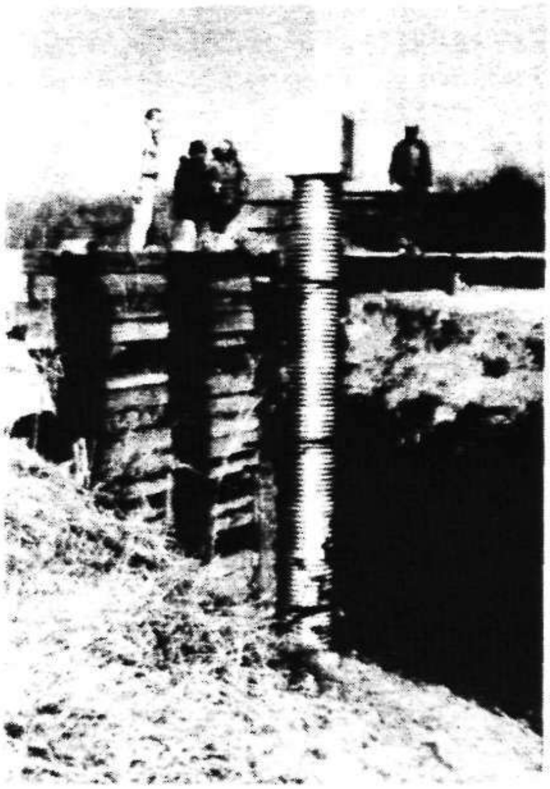
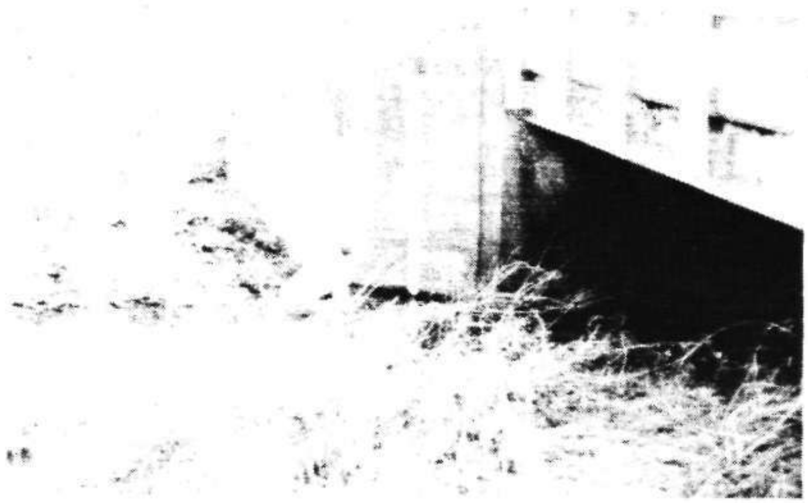


Figure 10. Locations of streamflow gaging stations in the Court Creek watershed



a. Continuous recorder

b. Wire-weight gage



a. Staff gage

. *Figure 11. Types of streamflow gaging devices used in the Court Creek watershed*

Initially a staff gage was used at station S3. It was later supplemented by a continuous recorder located at the dam site on Spoon Valley Lake. The continuous recorders consisted of weight-driven Stevens Model A-35B recorders actuated by 12-inch floats housed in 24-inch corrugated tubes. The staff and wire-weight gages were observed at least weekly, but more frequently during significant precipitation events.

Rating Curves

Rating curves for each streamgage location were developed. The development of rating curves required instantaneous flow measurements in conjunction with observed stage readings. Flow measurements were performed in accordance with U.S. Geological Survey procedures (Rantz, 1982). These procedures require, in addition to adequate stream velocity measurements, rather precise stream cross section information. Stage-flow relationships were developed at each stream gaging station by instream discharge measurements and corresponding stages. From these relationships rating curves were developed for each gaging station. On the basis of the rating curves in conjunction with periodic stage observations, instantaneous streamflows at each station were estimated. At those stream sampling stations where flow gaging stations were not established, streamflows were estimated on the basis of relative drainage areas.

Streamflow data from both the continuous stage recorder at C2 and those flow gages requiring observers were used to determine the watershed streamflow regime during individual storms and for the two-year sampling period. The frequency of high and low streamflow events is demonstrated by flow duration curves developed from the recorded streamflows.

Flow Duration Curves

According to Searcy CI959), the flow duration curve is a cumulative frequency curve that shows the percent of time specified discharges were equaled or exceeded during a given period. The longer the period of record, the more confidence there is in predicting the distribution of future flows. A common weakness of flow duration curves in most watershed studies is the limitation of flow data to the relatively short time period of each study. Flow duration curves developed for each stream sampling station on the Court Creek watershed share in that weakness.

As noted previously, a continuous stage recorder was established on Court Creek near its confluence with Spoon River, i.e., station C2. Mean daily flows were recorded at this station for 464 days. In addition, about MO instantaneous flow measurements (based on stage-flow relationships) were observed at weekly intervals or during stream sampling events at C2 and the other eight flow gaging stations. Flow duration curves were drawn from the instantaneous streamflow measurements for all nine flow gaging stations. An equation was derived for the relationship between flow duration curves developed from instantaneous flow and continuous flow measurements at flow gaging station C2. On the assumption that the flows at other streamflow gaging stations would respond with the same frequency of occurrence as those at C2, flow duration curves from instantaneous flow measurements at the other stations were adjusted by use of the C2 equation. This was accomplished in the following manner.

The flows at station C2 for each type of measurement (continuous and instantaneous record) were ranked separately in order of decreasing magnitude. The probability distribution of each data set was determined by the following equation:

percent probability = 100 Cranking number) / number of measurements

Plots are shown in figures 12 and 13 for the continuous flow and instantaneous flow measurements, respectively. For 27 probability duration points, ranging from 2 percent to 98 percent for each series of measurements, the relationship between each data set was determined by linear regression techniques. That relationship between the data sets can be expressed by the following equation:

log continuous flow = -0.086 + 0.862 (log instantaneous flow)

The equation has a correlation coefficient of 0.992 and a standard error of estimate of 0.084. This relationship was used to develop an adjusted flow duration curve, as shown in figure 13, for station C2. All flow duration curves developed from instantaneous streamflows were adjusted in a similar fashion. Flow duration curves were plotted on logarithmic-probability paper. The probability scale expands both the low flow and high flow ends of the flow duration curve, so that normally distributed data are plotted as a straight line. As the logarithms of discharge are more normally distributed than discharge itself, logarithmic-probability paper tends to straighten out the flow duration curve. In the case of flow gaging stations S5 and S3 (figures 14 and 15), upstream strip-mine impoundments and Spoon Valley Lake attenuate mid-range flows so that a sharp bend occurs in the flow duration curves.

The adjusted median daily flows for all Court Creek stations are listed in table 16. It should be noted that the M3 flow gaging station was established in 1982 after analysis of ASCS aerial photographs determined the high percentage of row crop acreage in the M3 subwatershed. The large number of intense rainfall events in 1982 (see table 11) will have likely increased the median daily flow value for M3 in comparison with the other stations.

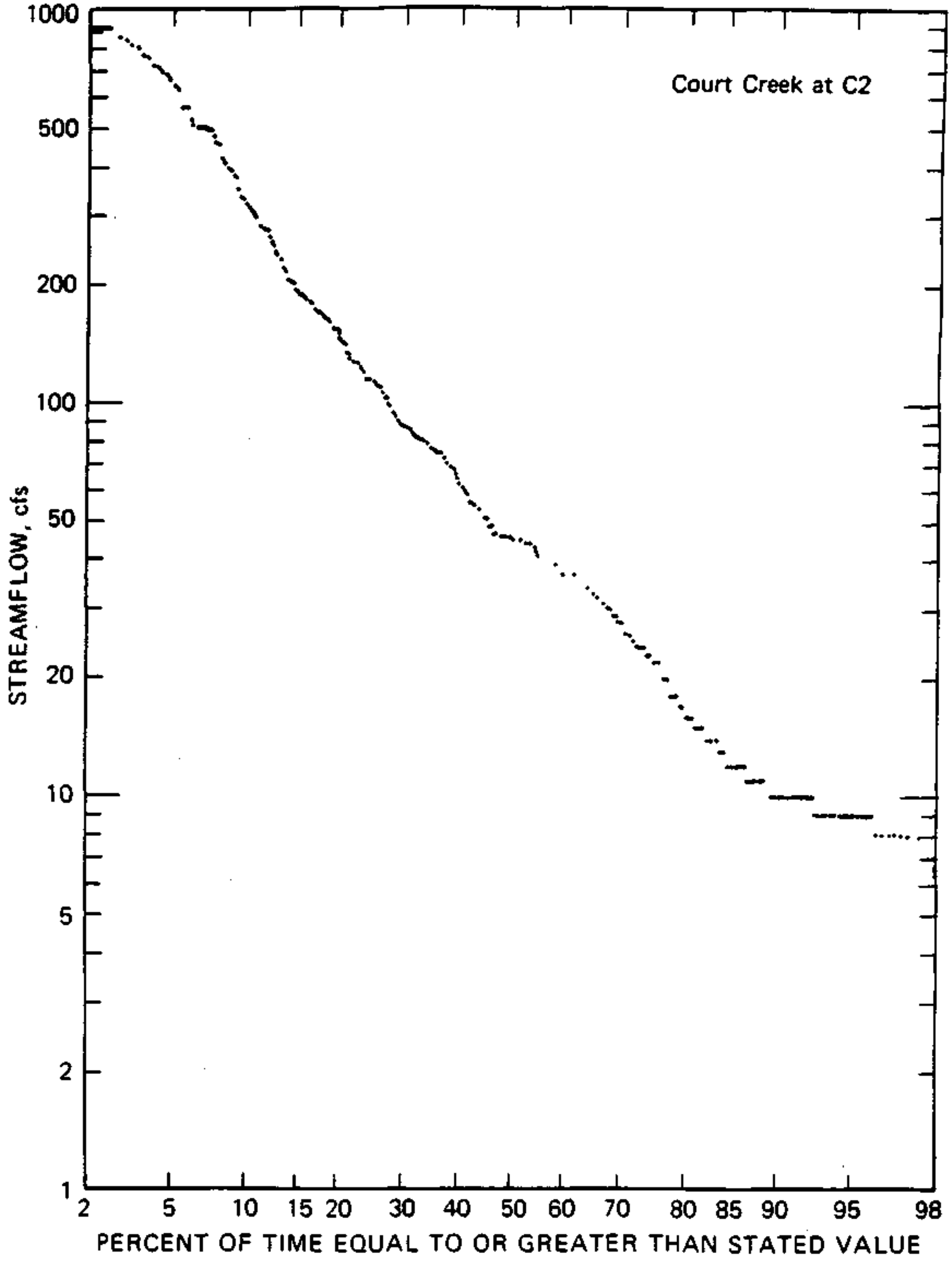


Figure 12. Flow duration curves for Court Creek at C2, based on continuous stage recorder records

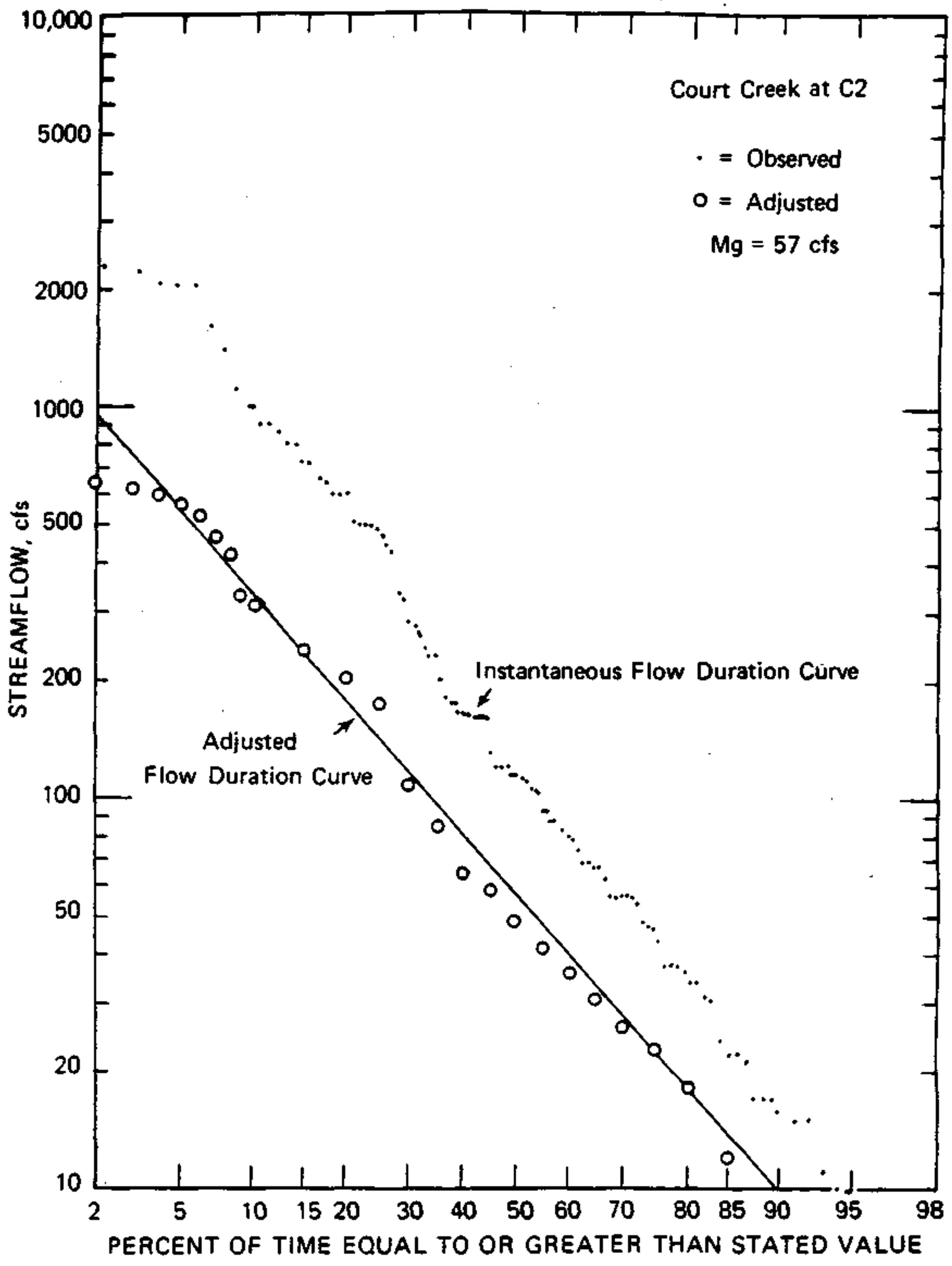


Figure 13. Flow duration curves for Court Creek at C2, based on instantaneous flows and adjusted flows

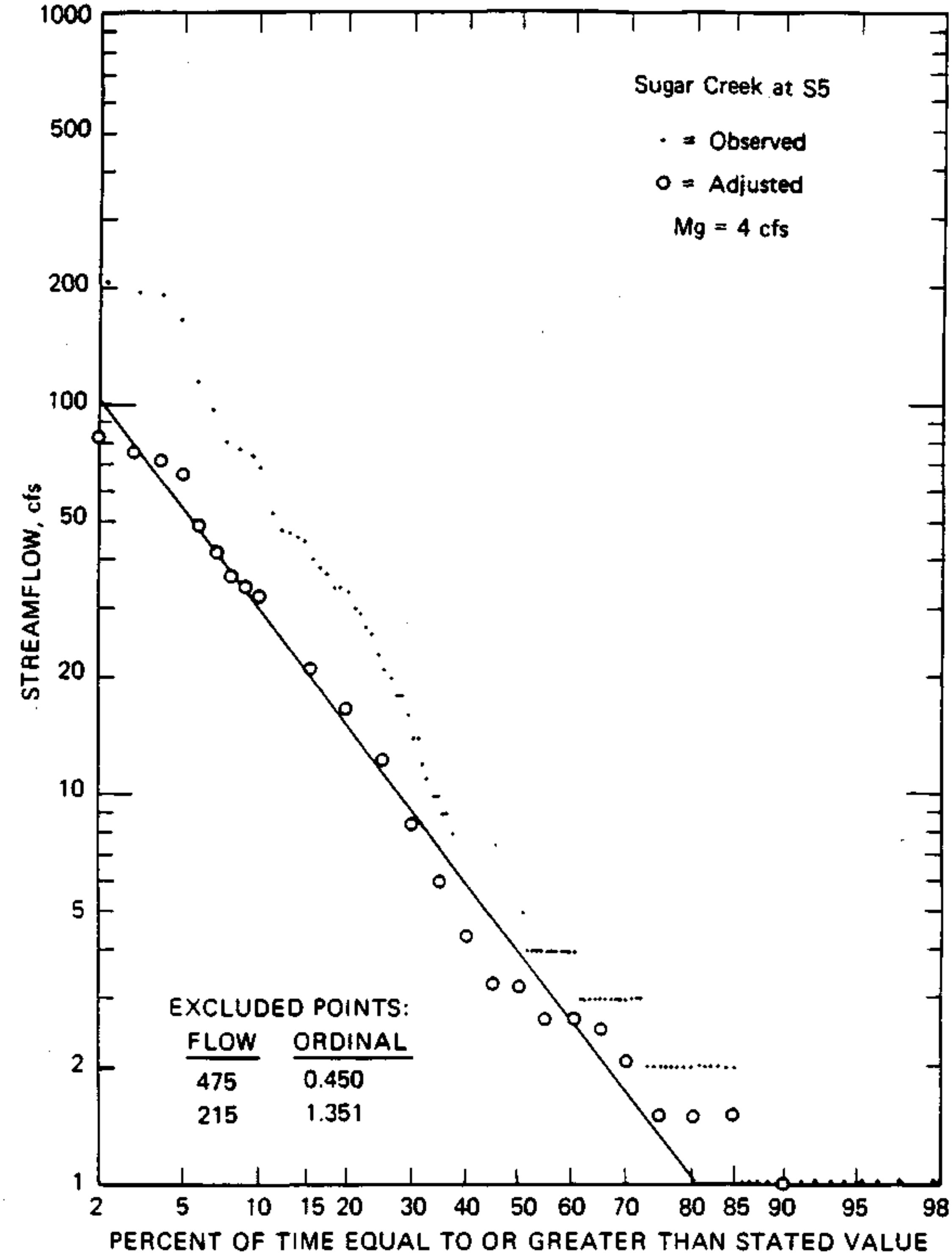


Figure 14. Flow duration curves for Sugar Creek at S5

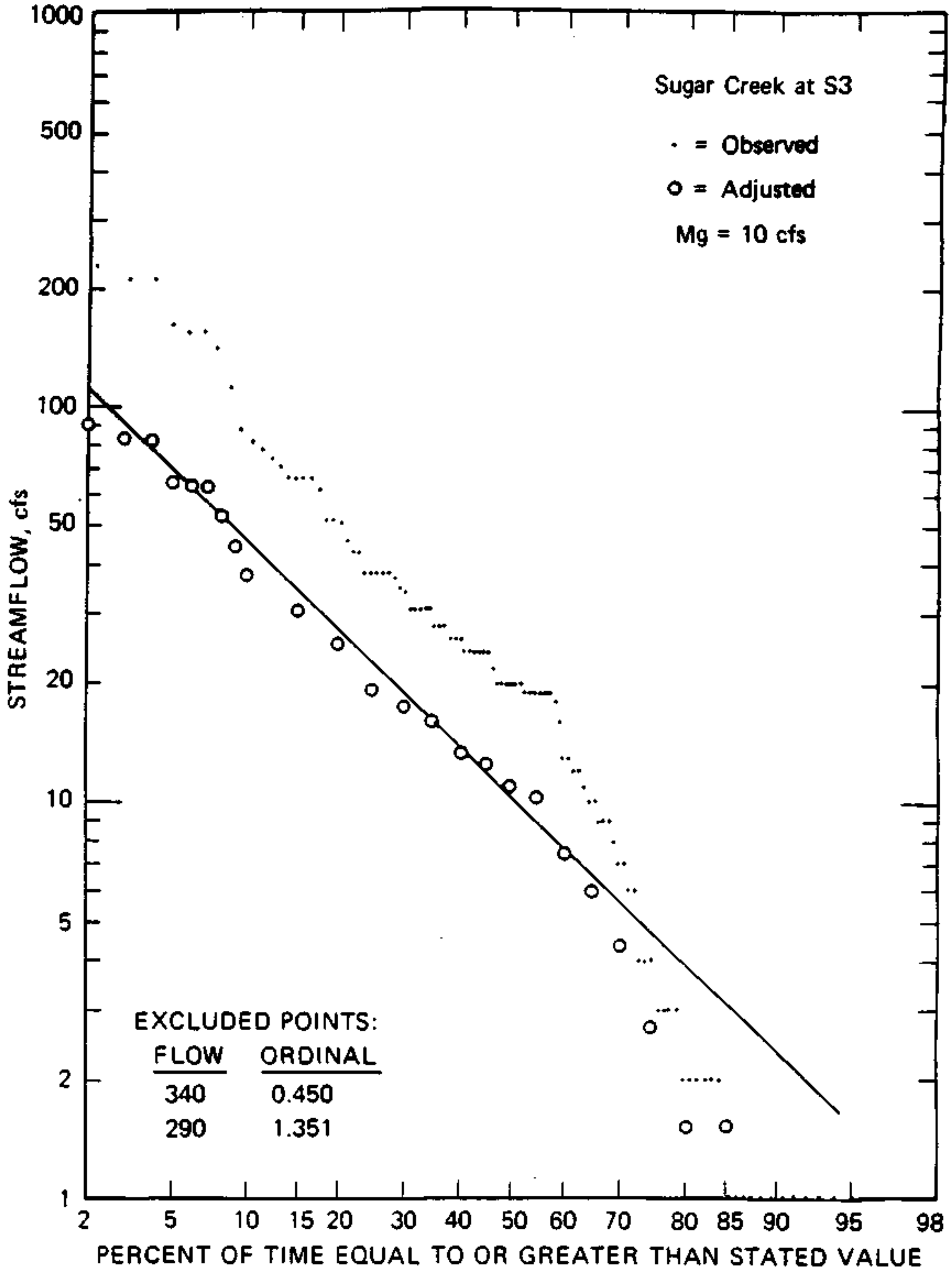


Figure 15. Flow duration curves for Sugar Creek at S3

Table 16. Adjusted Median Daily Flows for Stations in the Court Creek Watershed

Station	Median daily flows (cfs)	Drainage areas Csq mi)	Flows per square mile (cfs/sq mi)
M3	4.0	6.8	0.59
Ml	5.5	10.0	0.55
N1	20.0	29.3	0.68
S5	4.0	7.8	0.51
S3	10.0	17.8	0.56
S2	12.5	22.3	0.56
C12	4.0	5.0	0.80
C10	9.2	15.8	0.59
C4	40.0	67.0	0.59
C3	44.0	72.0	0.61
C2	57.0	97.0	0.59

Streamflow data for the Court Creek watershed, based upon observations during the course of this study, were limited from an historical perspective. This limitation restricts the desirable capability of predicting the frequency of flow occurrences as well as the frequency of occurrence for certain water quality features in the streams of the watershed. In order to overcome this constraint, reliance was placed on the historical flow records of Indian Creek. The Indian Creek watershed is located about 20 miles northeast of the Court Creek watershed. The U.S. Geological Survey has maintained a continuous flow recording device on the stream, in the vicinity of Wyoming, Illinois, since I960. The watershed is located in the same physiographic division of the state (Galesburg Plain) as the Court Creek watershed. Its drainage area is about 163 sq km (63 sq mi) compared to the Court Creek watershed area of 251 sq km (97 sq mi). From the available 22 years of streamflow records at Indian Creek an effort was made to adjust the flow duration curve developed from the continuous stage recorder at the C2 sampling station to the long-term flow record at Indian Creek.

If streamflow records are to be compared to each other, the records must represent (or be adjusted to) concurrent time periods. In this manner the difference between each stream's records will be due to differences in drainage basin characteristics. Mean daily flows were available on both Court Creek at C2 and the USGS Indian Creek flow gaging station for 382 days during the study. The relationship between the two drainage basins was determined by the index-station method of the USGS (Searcy, 1959).

By the index-station method, a relationship is established between two flow gaging stations on the basis of the short-term period of concurrent record by plotting the discharges (flows) for given flow duration points at one station against the corresponding discharges at the other station. The graph and equation of that plotting are assumed to represent the relationship between the flow gaging stations over a long time period. If the assumption is true, the flow available 50 percent of the time at the long-term flow gaging station can be used in the equation of the short-term plot in order to obtain the adjusted (to the long term) flow available 50 percent of the time at the flow gaging station with only a short-term record. Adjusted flows can be determined for other flow duration points in the same manner. Linear regression of the 382 flow duration points, derived from the respective flow duration curves of Court and Indian Creeks, established the following equation:

$$\log(\text{C2 flow}) = -0.21010 + 1.25625 \times \log(\text{Indian Creek flow})$$

R = 0.98706 STD. ERR. OF ESTIMATE = 0.09281

The long-term median daily discharge (flow available 50 percent of the time) from the 22 years of record at Indian Creek is 19.7 cfs. Therefore the adjusted long-term flow duration curve at C2 has a median daily discharge value of 26 cfs. The median daily flow at C2 during the study period was 46 cfs from the continuous recorder flow data and 57 cfs from the adjusted instantaneous flow data.

In conjunction with the rainfall data, streamflow data allowed the determination of which watershed features and land uses contribute the highest rates of stormwater runoff. The North Creek watershed (18,720 acres) is equal to 30 percent of the total Court Creek watershed area. Only about 50 percent of the watershed is in row crop because the remaining 50 percent of the watershed has slopes greater than 15 percent. The steep watershed slopes cause a very rapid increase in North Creek flows as evidenced by the hydrograph of N1 on December 25, 1982 (figure 16). On this 18,760-acre watershed, streamflow at the N1 flow gaging station peaked within 2 hours of a brief intense rainstorm at midnight. The rapid rise and fall of North Creek high velocity streamflows was also illustrated during a major rain event of long duration on April 1, 1983 (figure 17). At flow gaging station N1, peak storm flow subsided within 7 hours after a rainstorm which lasted 20 hours.

This rapid rise in surface water runoff from the steep valley bluffs is also demonstrated by the rapid increase in streamflows at S2 during the December 25 storm (figure 16). Because the level of Spoon Valley Lake had been drawn down 7 feet during the fall of 1982, streamflows at S2 resulted almost entirely from stormwater runoff of the floodplain subwatershed above S2. Less than 100 cfs of flow was released over the dam at S3 during the December 25 storm. Fifty percent of the S2 subwatershed has slopes greater than 15 percent. This watershed topography created a very quick high velocity peak flow at S2 after the brief high intensity rainfall at midnight. On December 2, 1982, a rainstorm of long duration (figure 18) caused sustained high velocity flow at S2, even though Spoon Valley Lake was drawn down at the S3 dam site. Again the high-velocity storm flow decreased rapidly after cessation of the rainfall. It should be noted that Sugar Creek between S3 and S2 has no woody riparian vegetation, while the downstream segment, between S1 and S2, has a narrow but dense band of woody vegetation along most of the stream bank. The correlation between streamflow and stream stage height at S2 was very difficult to determine during high streamflows, because of the tendency of the overhanging tree branches to restrict flow to the center of the stream channel.

The effect of the dam at S3 is also illustrated by the hydrographs of the S3 and S2 flow gaging stations during the April 1, 1983, storm (figure 19). Flow from the S3 station increased much more slowly than streamflows at S2. However, the S3 hydrograph continues to climb after the cessation of rainfall, so that streamflow at S2 is almost entirely from the S3 and S5 subwatersheds after 20 hours. Therefore runoff from the S2

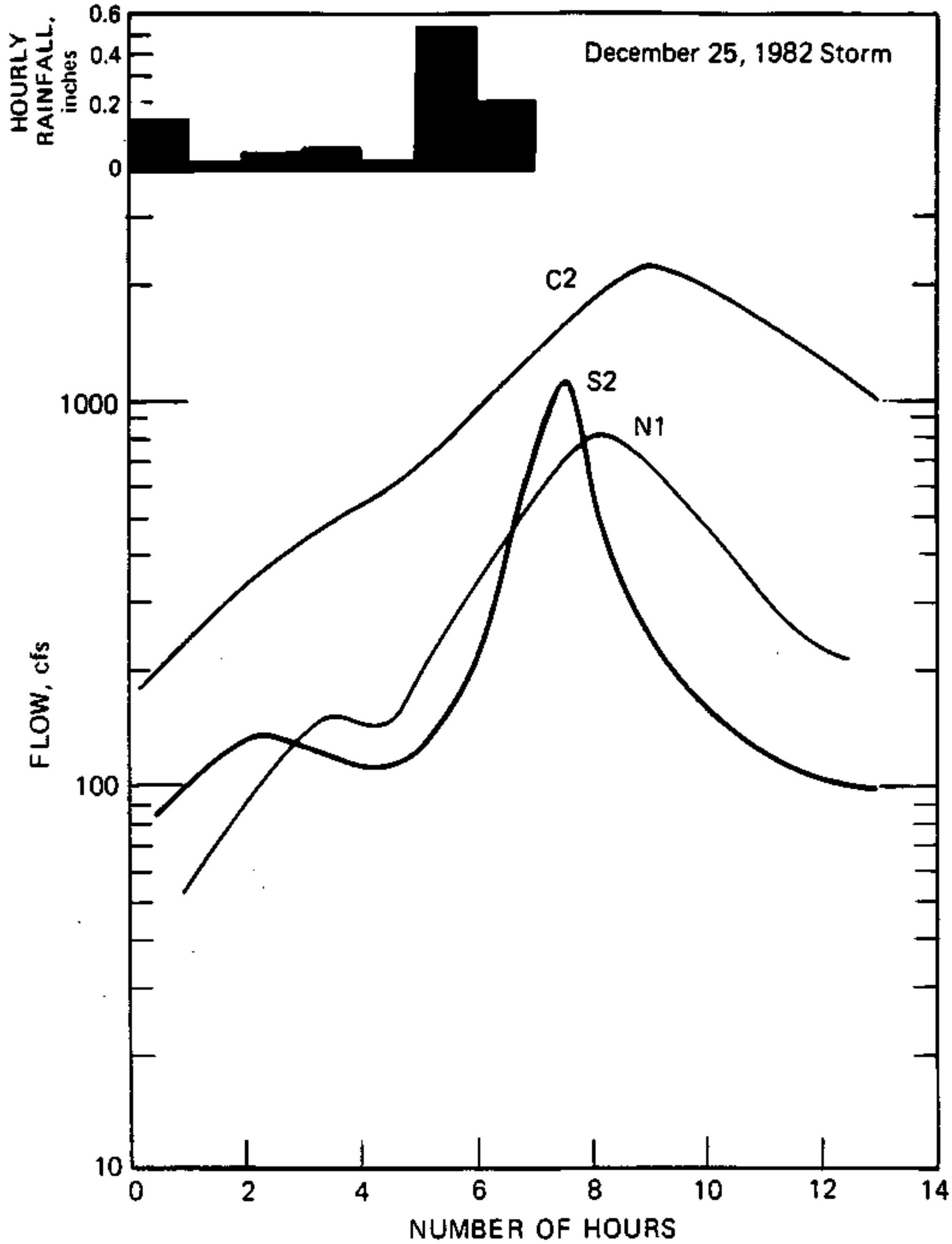


Figure 16. Hydrographs of monitored flow gages during the December 25, 1982, storm

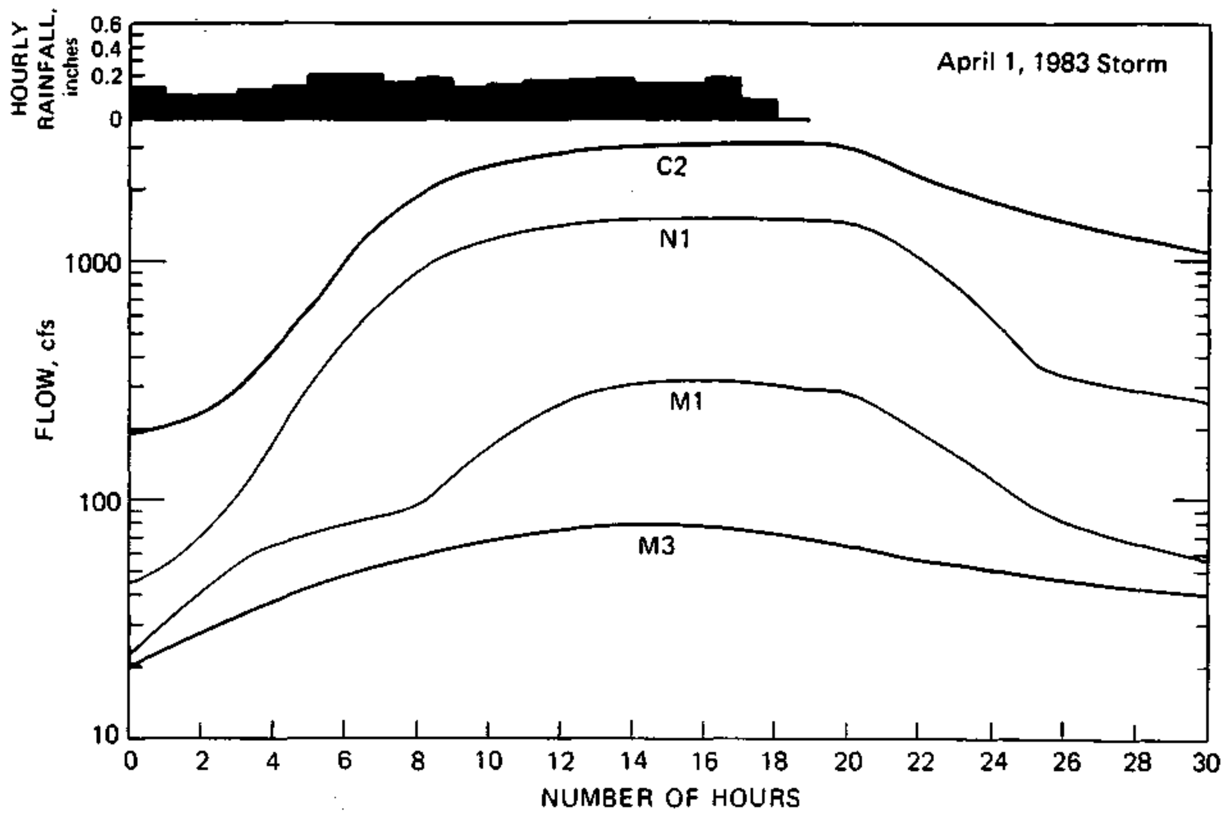


Figure 17. Hydrogvaphs of monitored flow gages during the April 1, 1983, storm

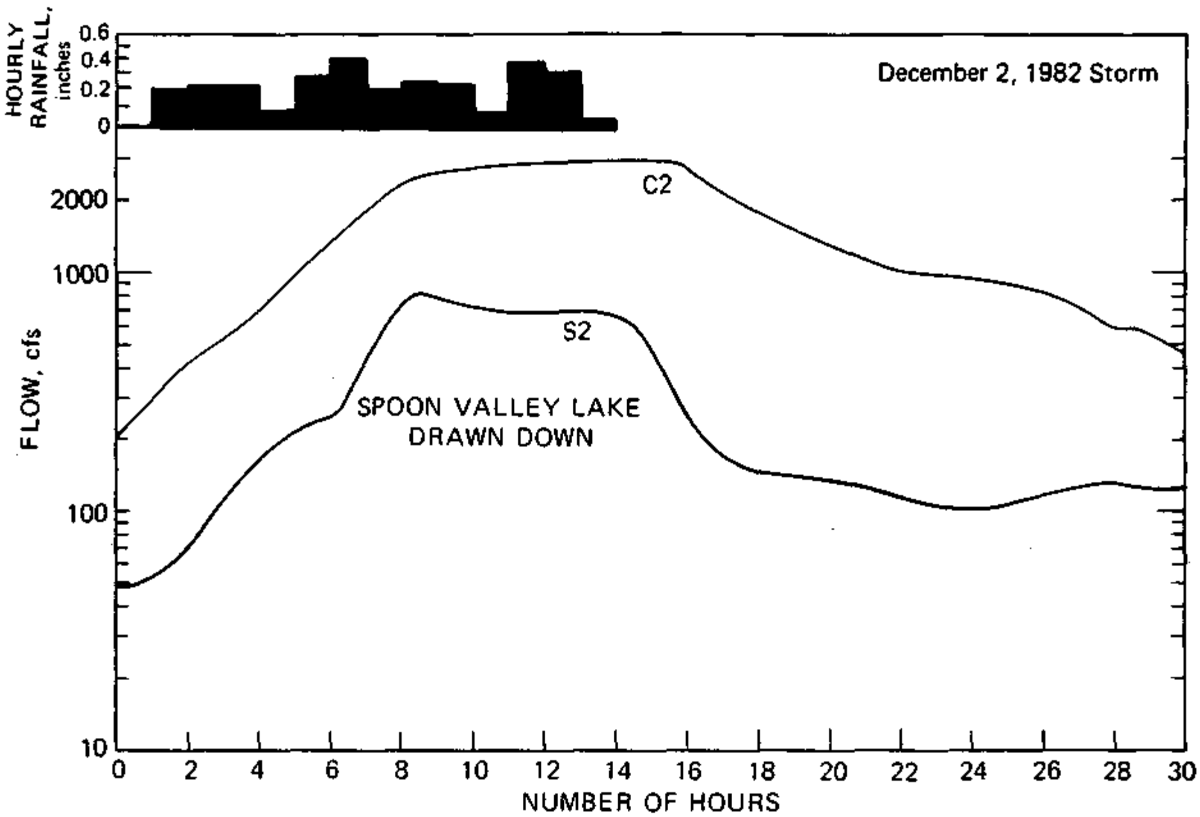


Figure 18. Hydrographs of monitored flow gages during the December 2, 1982, storm

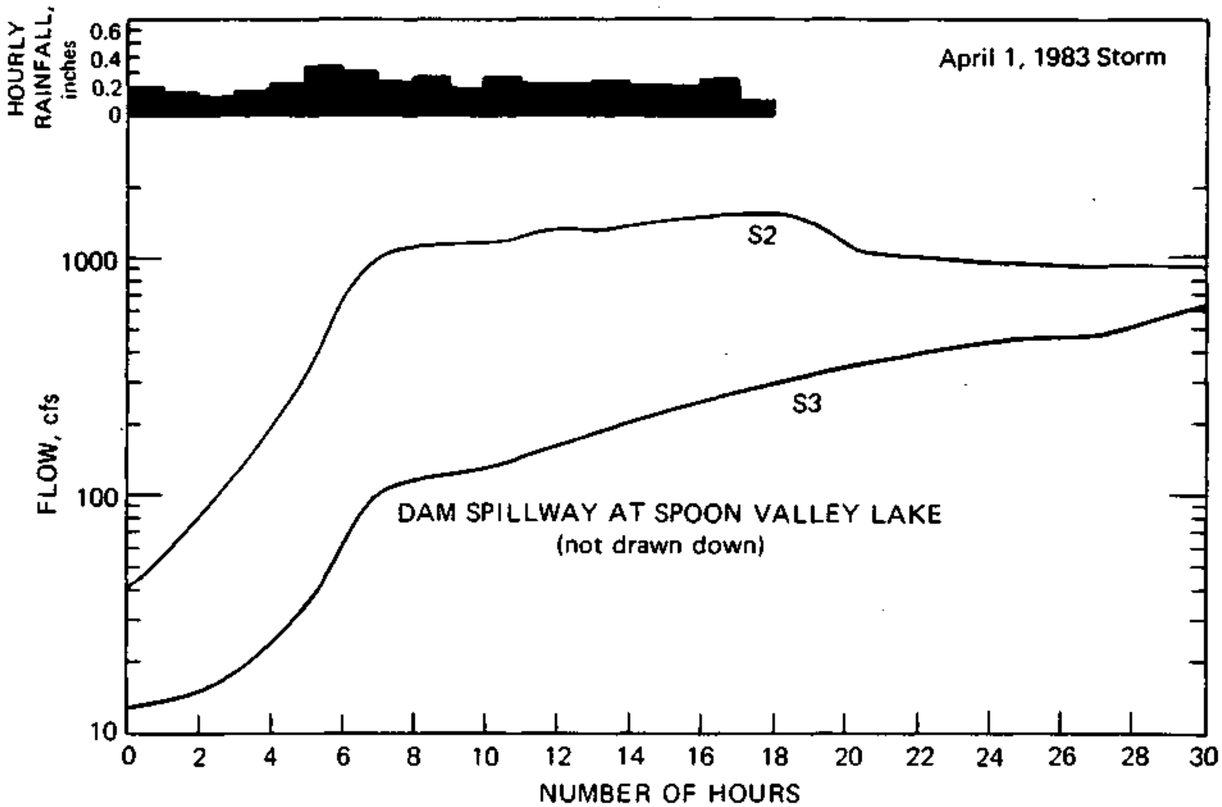


Figure 19. Hydro graphs of monitored Sugar Creek flow gages during the April I, 1983, storm

subwatershed decreased rapidly after cessation of rainfall. It should be noted that rainfall in the S5 subwatershed was 3.72 inches, while the watershed average was 2.65 inches. The effect of the S3 dam is also seen by the slow rate of fall of the C2 hydrograph on April 1, 1983 (figure 17), when compared with the rapid rate of fall of the C2 hydrograph during an even larger storm on December 2, 1982 (figure 18).

The clearest demonstration of the difference in the rates of stormwater runoff from upland prairie subwatersheds and floodplain subwatersheds occurred in the Middle Creek stream basin on April 1, 1983. Flow gaging stations below the M1 and M3 subwatersheds allow an evaluation of the effects of topography on surface water runoff. During the storm of April 1, 1983, the peak flow at M3 was only 78 cfs but the peak flow at M1 was 320 cfs (see figure 17). The M1 subwatershed (2080 acres) is only half the area of the M3 subwatershed (4320 acres). Therefore streamflow velocity increased 300 percent from the surface runoff of the lower one-third of the watershed. Fifty-eight percent of the M1 subwatershed has steep slopes, which speeds the rate of surface water runoff and precludes the development of row crop land uses. Pastures and wooded pastures occupy that 58 percent of the M1 subwatershed with steep slopes. Measurements of streamflow and the amount of rainfall during the April 1 storm allowed the calculation of curve numbers (CN) for the M3 subwatershed, the M1 subwatershed, and the M1 stream basin as a whole (see table 17). The determination of CN from only soil type and land use without consideration of slope gives high values for the M1 subwatershed (77 versus 73), but low values for the Ml subwatershed (72 versus 89). The stream basin upstream of Ml also generated higher curve numbers from actual storm runoff CN calculations (76 versus 80). Slope of subwatersheds must be considered when evaluating the amount and rate of runoff in large watershed studies.

The floodplain (an area of slight slope) is 20 percent of the M1 subwatershed but is only 5 percent of the M3 subwatershed. Since the vast majority of the floodplain land use is row crops, floodplain row crop fields lie below areas in which surface water runoff has reached high velocity. Approximately half of M1 subwatershed row crop acreage (400 of 834 acres) lies in the floodplain. The remaining row crop acreage in the M1 subwatershed lies on the flat divide between stream valleys. By comparison all 3,093 row crop acres of the M3 subwatershed lie in the relatively flat upland prairie.

Table 17. The Amounts of Rainfall, Surface Water Runoff, and Resulting Curve Numbers for the Middle Creek Basin during the April 1, 1983, Storm

Watershed	Area (acres)	Average rainfall (inches)	Amount of rainfall (acre-ft)	Amount of runoff (acre-ft)	Runoff (inches)	Curve number
M3 subwatershed	4320	2.16	778	192	0.53	73.4
Ml subwatershed	2080	2.47	428	281	1.62	89.3
Ml basin	6400	2.26	1205	473	0.87	79.6

STREAM SAMPLING

The selection and location of stream sampling sites on the watershed was an evolutionary process. Coupled with the desire to locate stream sampling sites with streamflow gaging stations was the need to establish them downstream of isolated identifiable land uses such as urban (residential housing), mining, impounded waters, and agricultural practices. With these thoughts in mind nine primary stream sampling locations were initially selected. After several sampling events, an additional seven supplemental stream sampling sites were established. The locations and number designations of the 16 stations are shown in figure 20. The category of each station is as follows:

Primarv	supplemental
C12	C7
C10	C4
C2	C3
Nl	N4
M3	N3
M1	N2
S5	S1
S3	
S2	

The principal differences in the two types of sampling stations relate to whether or not the streamflows at the stations were gaged and the types of analyses performed on the water samples that were collected. All nine primary stations were located at streamflow gaging sites, and generally complete analyses were performed on all water samples collected at these stations. Analyses for the water samples collected at the seven supplemental sites were generally limited to determinations for concentrationsofsuspendedsolids.

The relationships of the 16 sampling stations to their upstream drainage areas have been identified previously (see table 7 and figure 6). These relationships, in combination with estimated runoff and land use for each upstream drainage area, will be used to evaluate water quality characteristics observed at the stream sampling stations.

All water samples were collected with a 22-pound DH-59 sampler equipped with a glass pint container. The sampler was either hand-held or suspended by cable from a crane-mounted winch on bridges. In either case depth integrated samples were collected by lowering the sampler at a uniform rate to the bottom of the stream, instantly reversing it upon contact with the bottom, and raising it to the surface again at a uniform rate. In this manner samples were collected at appropriate intervals

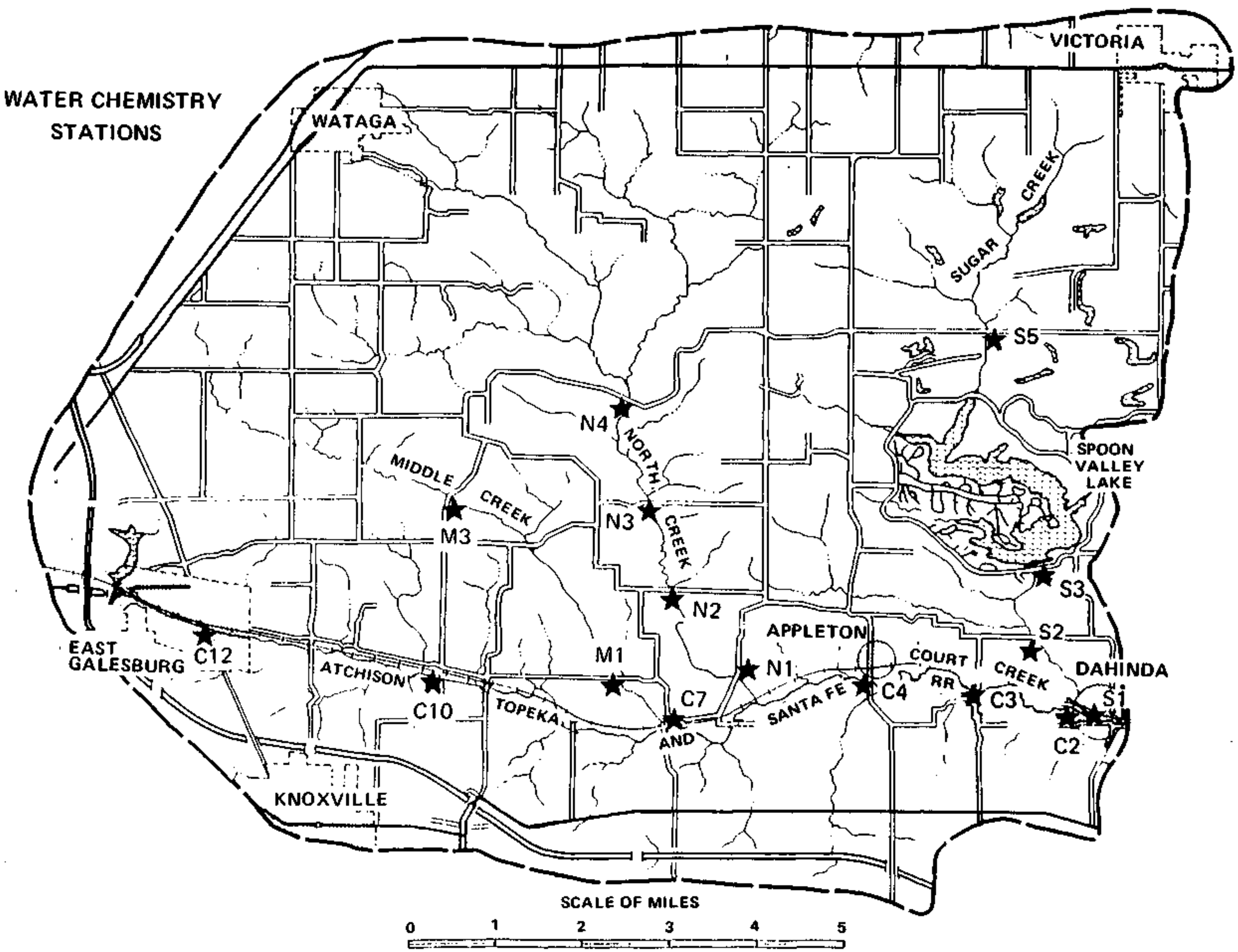


Figure 20. Locations of stream sampling stations in the Court Creek watershed

across the width of the stream until a 2-liter composited sample was obtained. After samples were collected they were transported to laboratory facilities and immediately stored in refrigeration units.

Certain determinations were performed in the field. These included measurements for temperature and dissolved oxygen concentrations. For these a Yellow Springs Model 57 DO meter was usually used. Calibration of the dissolved oxygen probe was accomplished by using the modified Winkler Method for dissolved oxygen determinations. In some cases the Winkler method was used alone for dissolved oxygen determinations.

STREAM CHEMICAL CONCENTRATIONS

As indicated earlier, the types of analyses performed at each sampling station were contingent on whether or not it was a primary or supplemental station. The types of analyses performed on-streamwater samples and the methods of analysis are shown in table 18. As indicated in the table, some determinations were made for the dissolved as well as the total concentration of a constituent. This was the case for ammonia, phosphorus, and the heavy metals lead, copper, zinc, and iron.

Samples from only two stations were routinely examined for heavy metals. One station, S5, is representative of a drainage area dominated by a formerly active strip mining activity. The other station, C12, is representive of urban or residential runoff. At both stream stations, total iron and total copper occasionally exceeded the standards set by the Illinois Pollution Control Board. In all cases the high concentrations of total copper and iron were associated with high levels of suspended sediment during high streamflows. As illustrated in table 19, the concentrations of heavy metals in agricultural streams such as those at M1 and N1 were even higher than in the residential stream at C12 or the stream from the strip-mined subwatershed at S5.

In his analysis of periodic IEPA stream samples from the Galesburg plain, Flemal (1980) found a similar association of high total iron and copper values with high sediment concentrations and high stream discharges. Both copper and iron sources are the result of natural geochemical processes. Values of total iron and copper for streams in the Spoon River basin are similar to those found at S5 and C12 (see table 20). Violations of Illinois state general use standards for total metals resulted largely from large inputs of sediment from all land uses including agricultural.

The collection of stream water samples was generally predicated on the occurrence of a major runoff event. This procedure is essential if relationships between land use and

Table 18. Chemical Analyses Performed on Stream Samples

Temperature (field)	Primary	Thermister
Dissolved oxygen Cfield)	Primary	Oxygen meter
pH	Primary	Glass electrode
Alkalinity	Primary	Potentiometric method
Turbidity	Primary	Nephelometric method
Suspended solids	Primary and supplemental	Gooch filtration
Nitrates	Primary	Chromtrophic method
Sulfates	Primary	Tubidimetric method
Chlorides	Primary	Argentometric method
Ammonia*	Primary	Buchi distillation, Indophenol colorimetric
Phosphorus*	Primary	Ascorbic acid
Lead*	S5 and C12	Atomic absorption
Copper*	S5 and C12	Atomic absorption
Zinc*	S5 and C12	Atomic absorption
Iron*	S5and C12	Atomic absorption

* Total and dissolved forms

Note: Primary stations are C12, C10. C2, N1, M3, Ml, S5, S3, and S5.
Supplemental stations are C7, C4. C3, N4, M3, N2, and S1.

Table 19. Dependence of Total Metal Concentrations in Stream Samples on Suspended Sediment Concentrations *

Sample station	Suspended sediment	Total iron	Total copper	Total lead	Total zinc
C12 Residential	320	2.7	0.02	<0.06	0.04
S5 Strip mining	488	4.4	0.02	<0.06	0.03
M1 Agriculture	616	21.5	0.05	<0.06	0.09
N1 Agriculture	860	24.7	0.05	<0.06	0.09
C2 Entire watershed	1320	33.2	0.04	<0.06	0.11

* All concentrations are in mg/l

Table 20. Comparison of the Total Metal Concentrations of S5 and C12 Stream Sampling Stations with the Spoon River and Big Creek Total Metal Concentrations *

Sample station	Total iron		Total copper		Total lead		Total zinc	
	Geomet. mean	Max.	Geomet. mean	Max.	Geomet. mean	Max.	Geomet. mean	Max.
S5 Strip mining	9.0	34.0	0.26	0.08	0.04	0.14	0.07	0.12
C12 Residential	4.9	36.0	0.31	0.08	0.04	0.19	0.06	0.13
Big Creek Strip mining	1.33	4.3	0.03	0.21	0.06	0.42	0.17	0.50
Spoon River	4.81	50.0	0.04	0.45	0.07	0.42	0.04	0.42
IWPCB general use regulations		1.0		0.02		0.10		1.00

* All concentrations are in mg/l

water quality are to be detected. By definition, a major runoff event occurred when rainfall equalled or exceeded I inch during a 24-hour period. Some collections were performed during base (normal) streamflow conditions as well as 3nowmelt streamflow conditions for comparative purposes.

Base Streamflows

As demonstrated by the flow duration curve of the C2 continuous recorder station, base (normal) streamflows occurred 85 percent of the time (figure 12). During normal (base) streamflow conditions, the water quality of streams in the Court Creek watershed was excellent. Table 21 illustrates stream water quality at C2 during normal or base streamflows (less than 300 cfs). Dissolved oxygen levels at all stream stations were above 7 mg/l during base streamflows, snowmelt streamflows, and rain-induced streamflows. Stream water pH at all stream stations ranged from 7.40 to 8.75 during all streamflows. Thus Court Creek streams were always within the general water use regulations established by the Illinois Water Pollution Control Board (State of Illinois, 1982) for dissolved oxygen and pH. During base streamflows, all chemical parameters except phosphorus were well within the general use water quality standards established by the Illinois Water Pollution Control Board (State of Illinois, 1982). The phosphorus water quality standard will prove difficult to achieve given the high phosphorus content of the loess soils in Knox County (Fehrenbacher et al., 1977). These periodic samples are very similar to western Illinois stream samples analyzed by the Illinois Environmental Protection Agency since 1974 (Flemal, 1980).

During base streamflows, nutrients were generally low in concentration as evidenced by tables 21 and 22. Base streamflows from December to March have slightly higher ammonia and phosphorus levels than streamflows during months with higher temperatures as reported by Flemal (1980). This decrease in concentration is probably the result of increased bacterial and photosynthetic activity during the warmer months. Nitrate levels varied considerably during base streamflows. At warm water and soil temperatures, bacteria rapidly oxidize ammonia to nitrate and thereby increase nitrate levels. Base flows of 100 to 300 cfs resulted in nitrate levels from 2 to 5 mg/l, similar to nitrate levels during streamflows from rainfall or snowmelt runoff. However, streamflows below 100 cfs resulted in constantly decreasing nitrate levels -- down to 0.08 mg/l -- from the combined effects of reduced stream input and aquatic photosynthesis. Stream stations on Middle Creek (M3 and M1) had the highest nitrate concentrations during base streamflows. High mean nitrate concentrations are common in other streams whose watersheds have a high percentage of row crop agriculture (Omernik et al., 1976).

Table 21. Chemical Concentrations (mg/l) at the C2 Sampling Station during Normal Streamflows

Suspended sediment	Total ammonia	Dis. ammonia	Nitrate	Total phosphate	Diss. phosphate	Alkal.	TOS	Diss. sulfate	Chloride
5	.26	.12	.72	.04	0.01	184	417	49	16
10	.07	.03	.29	.07	0.03	254	440	66	24
96	19	19	2.18	.18	0.08	220	356	62	21
22	0.26	0.14	4.19	0.14		214	400	80	19
32	0.10	0.06	4.82	0.06		232	408	71	22
34	0.11	0.11	4.33	0.08		232	400	68	24
31	0.09	0.05	3.65	0.05	0.02	224	400	71	20
57	0.11	0.07	4.05	0.09	0.05	222	430	70	32
63	0.17	0.08	5.52	0.23	0.05	217	404	62	21
84	0.02	0.02	4.92	0.23	0.03	208	410	203	16
41	0.02	0.01	3.85	0.12	0.01	194	392	204	17
25	0.05	0.04	3.26	0.06	0.01	208	432	82	16
32	0.02	0.01	2.94	0.05	0.01	215	422	84	17
34	0.03	0.03	2.87	0.07	0.01	228	430	86	17
55	0.10	0.09	2.46	0.19	0.08	230	422	88	20
73	0.05	0.05	2.62	0.07	0.02	236	416	81	19
32	0.04	0.04	2.22	0.07	0.02	240	424	82	20
22	0.07	0.06	1.53	0.07	0.03	241	422	82	22
28	0.08	0.07	1.10	0.07	0.03	233	410	84	22
94	0.21	0.15	1.23	0.23	0.07	194	364	72	23
23	0.10	0.09	0.89	0.12	0.06	216	418	86	23
19	0.13	0.13	0.06	0.09	0.03	205	384	75	28
40	0.08	0.04	0.04	0.07	0.01	220	380	82	23
24	0.05	0.05	0.08	0.07	0.01	248	402	85	21
56	0.31	0.29	0.08	0.04	0.00	246	438	82	23
48	0.36	0.36	0.08	0.24	0.01	228	430	100	19
35*	0.09«	0.06*	1.17*	0.09*	0.02*	222*	409*	82*	21*
***	1.5**	1.5**	10.0**	0.05**	0.05**	***	1000**	500**	500**

* Indicates geometric mean
** Indicates Illinois general use water quality standards
*** Indicates no Illinois standards established

Table 22. Average Stream Station Parameters during Base Flow Conditions

	S5	S3	S2	N4	N1	M3	M1	C12	C1O	C2
Flow (cfs)	4	10	14	8	11	4	6	3	7	24
Sediment(mg/l)	39	6	38	36	38	28	19	6	11	37
Total ammonia-N Cmg/I)	0.13	0.10	0.17	0.12	0.21	0.40	0.10	0.25	0.18	0.17
Diss. ammonia-N Cmg/I)	0.08	0.10	0.15	0.08	0.20	0.32	0.06	0.16	0.08	0.11
Kjeldahl-nitrogen Cmg/I)	0.54	0.62	0.60	0.85	0.97	0.76	0.66	0.89	1.23	0.68
Nitratr-N (mg/l)	0.73	0.06	0.07	2.18	1.57	4.18	3.46	1.15	1.21	1.06
Total phosphate-P (mg/l)	0.07	0.02	0.07	0.12	0.11	0.51	0.26	0.09	0.05	0.10
Diss. phosphate-P Cmg/I)	0.03	0.01	0.01	0.09	0.04	0.42	0.20	0.07	0.03	0.04
Alkalinity Cmg/I)	235	148	166		265	290	282	179	192	219
Sulfate Cmg/I)	214	146	115		49	55	44	54	25	59
Chlorides Cmg/I)	11	8	9		21	24	22	48	30	21
T0S Cmg/I)	680	390	413		415	458	444	373	367	404

Water quality data at upstream stations during normal streamflows are demonstrated in table 22. While sulfates were much higher in streamflows from the strip-mined region of Sugar Creek (particularly the S5 subwatershed), sulfates and total dissolved solids did not exceed Illinois standards (State of Illinois, 1982) in any stream sample. Sulfates and total dissolved solids (TOS) concentrations are elevated in stream waters from the strip-mined S5 subwatershed of Sugar Creek when compared to stream waters from agriculture lands at M3 on Middle Creek or residential lands at C12 on Court Creek. TDS or sulfate concentrations are not near toxic limits even at S5 (Reed and Evans, 1981). Flemal (1980) observed sulfate violations in certain strip-mined watersheds, but deleterious effects were limited by the relatively low sulfur content of western Illinois coal and the presence of a limestone overburden with the coal deposits. Alkalinity and pH values were also consistently high in all stream samples including those from strip-mined subwatersheds. Water chemistry values for Sugar Creek are similar to those values described by Toler (1981).

Total dissolved solids concentrations are largely the sum of alkalinity, sulfate, and chloride concentrations in the Court Creek watershed streams. Base streamflows have relatively hard waters as reflected by high TDS and alkalinity values. During periods of low streamflow and high water temperature, alkalinity concentrations decreased to 150 mg/l from aquatic photosynthetic activity. TDS concentrations also decreased with alkalinity concentrations to minimum values of 350 mg/l during base streamflows.

Chloride concentrations in the base streamflows at C12 are also elevated when compared to chloride values at other stream sampling stations. As with sulfate levels at S5, however, chloride levels were not near toxic levels (Reed and Evans, 1981; State of Illinois, 1982). Much of the chloride runoff results from roadways in the residential areas.

The greatest concentrations of strip mining, residential, and row crop land uses were found in the S5, M3, and C12 subwatersheds, respectively. Each subwatershed is less than 5000 acres and was located in the upland prairie' landform. The effects of strip mining, residential, and row crop land uses on baseflow stream quality are depicted in table 23. The water quality values from the agricultural floodplain subwatershed of M1 and the entire watershed at C2 are also shown in table 23.

During base flow conditions the highest concentrations of nutrients occurred in stream waters from the agricultural row crop area of M3. AM nutrients, however, were much reduced in concentration at the M1 stream sampling station by either dilution or biological assimilation in the slowly flowing base streamflows. The comparison of these five stream sampling stations will be continued for snowmelt streamflows, rainfall

Table 23. A Comparison of Land Use Effects on Stream Water Quality during Base Streamflows

Landform:	Prairie	Prairie	Prairie	Floodplain	Watershed
Land use:	Strip mine	Residential	Agriculture	Agriculture	AM
Stream station:	S5	C12	M3	M1	C2
Sediment (mg/l)	39	6	28	19	37
Total ammonia-N (mg/l)	0.13	0.25	0.40	0.10	0.17
Diss. ammonia-N (mg/l)	0.08	0.16	0.32	0.06	0.11
Kjeldanl-nitrogen (mg/l)	0.54	0.89	0.76	0.66	0 68
Nitrate-N (mg/l)	0.73	1.15	4.18	3.46	1.06
Total phosphate-P (mg/l)	0.07	0.09	0.51	0.26	0.10
Oiss. phosphate-P (mg/l)	0.03	0.07	0.42	0.21	0 04
Alkalinity (mg/l)	235	179	290	282	219
Sulfate Cmg/l)	214	5 4	55	44	59
Chlorides (mg/l)	11	48	24	22	21
T.D.S. (mg/l)	680	373	458	**444**	**404**

streamflows, and the annual stream yields of sediments and nutrients. These stream subwatersheds most clearly reflect distinct land use effects.

Snowmelt Streamflows

While base streamflow quality was excellent, streamflow during snowmelt runoff had very high concentrations of dissolved minerals and nutrients. Watershed streams were sampled on February 16, 1982, after two days of warm weather, which substantially increased streamflow but not turbidity (samples ranged from 5 to 30 NTU). On March 11, 1982, streams were again sampled when warm temperatures and a light rain again increased streamflows. The March 11 streamflows were more turbid (samples ranged from 50 to 400 NTU). The chemical constituents of stream waters during snowmelt conditions were radically different from base streamflow conditions or rain-induced streamflow conditions. Chloride at the C12 sampling station increased to the highest observed value (330 mg/l) on Feb. 16, 1982, and to 95 mg/l on March 11, 1982 -- the second highest concentration of chloride observed in the watershed. The observed maximum chloride concentration was well below the 500 mg/l standard set by the Illinois Water Pollution Control Board (State of Illinois, 1982).

However, both ammonia and phosphorus concentrations exceeded the general water quality standards at several stations. Unlike rainfall events, the majority of ammonia and phosphorus in snowmelt runoff was not attached to sediment particles. This is shown in table 24 by the small difference in concentration between dissolved and total concentrations of the nutrients. Dornbush et al. (1974) also found that much of the annual nutrient loss occurred during snowmelt and was in the soluble form. Johnson and Baker (1982) found that snowmelt runoff in Iowa streams carried significant portions of the annual ammonia and phosphorus yield in soluble form -- up to 75 percent. On February 16, 1982, the dissolved phosphate concentration at S3 (the dam at Spoon Valley Lake) exceeded the state phosphorus standard of 0.05 mg/l by a factor of 11. All other stream sampling stations exceeded the 0.05 mg/l standard, even though they are not direct portions of a lake system. Although Spoon Valley Lake remained under ice cover, by March 16 an algal bloom had caused the lake outflow to appear green. Water chemistry at S3 also indicated an algal bloom with lowered alkalinity values and the highest pH (8.75) recorded for any stream station during the study.

Interviews with landowners in the watershed revealed the practice of applying animal wastes to the steep bluff pastures in order to increase the growth of pasture grasses. Such applications are permitted even when the slope is greater than 5 percent if the average yearly soil loss is less than 5 tons per

Table 24. Stream Parameter Values during Snowmelt Runoff

Stream parameter	SS	S3	S2	N4	N1	M3	M1	C12	C10	C2
Flow (cfs)	53	1	9	255	339	117	173	57	154	716
Sediment Cmg/l)	20	12	35	186	60	28	40	42	32	170
Total ammonia-N (mg/l)	0.85	0.76	4.81	3.39	4.58	2.40	3.58	1.30		4.17
Dis. ammonia-N (mg/l)	0.60	0.70	4.64	3.22	4.30	2.12	3.53	1.13	2.47	3.96
Kjeldahl-nitrogen (mg/l)	2.46	1.59	10.53	6.81	7.30	4.84	7.36	2.68	5.67	7.72
Nitrate-N (mg/l)	1.42	0.88	2.12	2.92	2.60	3.32	2.82	2.11		2.62
Total phosphate-P (mg/l)	0.17	0.60	0.80	1.35	1.38	1.41	1.44	0.45		1.19
Ois. phosphate-P (mg/l)	0.12	0.55	0.71	1.05	1.10	1.20	1.32	0.30		0.84
Alkalinity (mg/l)	190	106	136		84	63	73	122		98
Sulfate (mg/l)	185	52	46		28	25	26	44		32
Chlorides (mg/l)	14	15	20		19	14	15	330		52
T.D.S. (mg/l)	510	254	336		238	192	214	790		310
Dis. oxygen (mg/l)		12.5	12.8		13.3		12.0	11.9	13.2	12.7
pH (pH units)	8.2	7.4	7.9		7.9	7.7	7.8	7.8		7.9

year. Pastures even on steep slopes are not likely to have an average yearly soil loss of 5 tons per acre unless the pasture is heavily overgrazed. Illinois regulations do not permit the application of livestock waste to frozen or snow-covered land if the slope is greater than 5 percent. Sharpley et al. (1983) found that ammonia and nitrate concentrations increased from less than 1 mg/l in pasture runoff to 3.6 mg/l and 4.5 mg/l, respectively, when urea was applied to pastures.

The effect of snowmelt runoff from feedlots and pastured bluffs in the floodplain subwatersheds is most clearly demonstrated by the increase in dissolved ammonia concentrations at S2 (4.64 mg/l). Outflow from Spoon Valley Lake at S3 contained only 0.70 mg/l dissolved ammonia, so that the instream ammonia concentrations resulted from snowmelt on the 2880-acre S2 subwatershed. On Court Creek and its three tributaries, stream stations in the floodplain subwatersheds have higher dissolved ammonia and phosphorus concentrations than those stream stations in the upland prairie.

A comparison of the data for the S5, C12, and M3 subwatersheds in table 25 shows the relative contribution of various land uses to the amounts of nutrients entering streams during snowmelt. While the abandoned strip-mine lands in the S5 subwatershed were principally used as pastures for cattle and swine, the concentrations of ammonia and phosphorus were much lower than at M3. Of special interest is the sharp increase in ammonia concentrations at M1 while the nitrate concentration decreases from the level found at M3. Such an occurrence would indicate a dilution of the M3 streamflow by M1 subwatershed runoff, which is low in nitrates and high in dissolved ammonia. The amount of runoff from the M1 subwatershed is not proportional to its relative size, as illustrated in table 17. Pastures in both the M3 and M1 subwatersheds are relatively steep, but the soil surface is smooth and is not a hindrance to the mechanical application of animal wastes. Pastures in the strip-mined section of the S5 subwatershed have very rough surfaces with large rock outcrops, which eliminate the mechanical application of animal wastes to steep strip-mined pastures.

Flemal (1980) reports that ammonia is one of the parameters most commonly in violation of IPCB standards in the western Illinois streams of the Galesburg plain. Winter ammonia levels are long lasting because the low water temperatures inhibit the oxidation of ammonia to nitrate by nitrifying bacteria and the assimilation of ammonia by aquatic photosynthesis. Therefore the reduction in ammonia levels as stream waters flow downstream, as noted by Kothandaraman and Evans (1977) and by Flemal (1980), is very much slowed. The sources of ammonia and phosphorus in snowmelt runoff are believed to be animal wastes from confined animal feed lots in the watershed. Khaleel et al. (1980) found that snowmelt runoff from feedlots contains 200 to 300 percent more nutrients than rainfall runoff. The ratio of ammonia to phosphorus (3 to 1) in snowmelt runoff is approximately the same

Table 25. A Comparison of Land Use Effects on Stream Water Quality during Snowmelt Runoff

Land form:	Prairie	Prairie	Prairie	Floodplain	Watershed
Land use:	Strip mine	Residential	Agriculture	Agriculture	All
Stream station:	S5	C12	M3	Ml	C2
Sediment (mg/l)	20	42	28	. 44	170
Total ammonia-N (mg/l)	0.85	1.30	2.40	3.58	4.17
Diss. ammonia-N (mg/l)	0.60	0.62	2.12	3.53	3.96
Kjeldahl-nitrogen (mg/l)	2.46	2.68	4.84	7.36	7.72
Nitrate-N (mg/l)	1.42	2.11	3.32	2.82	2.62
Total phosphate-P (mg/l)	0.17	0.45	1.41	1.44	1.19
Diss. phosphate-P (mg/l)	0.12	0.30	1.20	1.32	0.84
Alkalinity (mg/l)	190	122	63	73	98
Sulfate (mg/l)	185	44	25	26	32
Chlorides (mg/l)	14	330	14	15	52
TDS (mg/l)	510	790	192	214	310

as the ammonia to phosphorus ratio found in the animal wastes from swine and beef cattle (State of Illinois, 1984). There are approximately 55,000 swine and 10,000 cattle in the Court Creek watershed as shown in tables 9 and 10.

During the summers of 1979 and 1980, the Illinois EPA recorded three occurrences of fish kills in Court Creek watershed streams from the misapplication of animal wastes. Stream waters receiving such animal wastes had ammonia values ranging from 51 to 118 mg/l ammonia. At warm summer water temperatures, the rapid oxidation of ammonia by bacteria rapidly removed oxygen from the stream water and resulted in a fish kill. Lowered dissolved oxygen levels are usually limited to a relatively small stream segment. One fish kill occurred at one of the intended North Creek fish survey sites during the Illinois Department of Conservation fish survey of Court Creek streams.

Dissolved ammonia values exceeded Illinois state water quality standards because the levels of un-ionized ammonia were greater than 0.04 mg/l at sampling stations S2, N1, C4, and C2 for the observed pH and water temperature. Reinbold and Pescitelli (1981) found that bluegill, fathead minnows, and rainbow trout were more sensitive to un-ionized ammonia at winter water temperatures than at the higher water temperatures typical of summer. Therefore the prolonged occurrence of high dissolved ammonia concentrations at low water temperatures would be especially significant. Bluegill appeared to be the species most sensitive to the effect of ammonia toxicity at low water temperatures. Bluegill are members of the centrarchid fish family, which includes largemouth and smallmouth bass. Centrarchid fishes compose the majority of game or sport fish in western Illinois streams. Populations of centrarchid fishes, especially smallmouth bass, have steadily decreased in western and northwestern Illinois streams.

Because of the toxicity of un-ionized ammonia at low water temperatures and the evidences of eutrophication in Spoon Valley Lake, the study of snowmelt runoff effects on aquatic resources should be expanded. The concentrations of un-ionized ammonia should be determined throughout the entire snowmelt period of runoff. Toxicity of un-ionized ammonia to sport fish such as smallmouth bass should be determined under winter climate conditions. Watershed analysis of snowmelt runoff should be designed to determine the relative ammonia and phosphorus contributions to watershed streams from animal wastes applied to steep bluff pastures and also from animal feedlots directly.

Rainfall Streamfiows

Stream sampling during the three-year study was determined primarily by rainfall occurrences, particularly rainfall events with greater than 1 inch of precipitation. As shown in the

"Watershed Climate and Streamflows" section, even when watershed soils were "wet," streamflows did not increase significantly until at least 1 inch of precipitation occurred. Streams were sampled during 80 percent of the rain events with more than 1 inch of rainfall. Streams were sampled during all storms with greater than 1.5 inches of precipitation. The geometric mean of each chemical parameter for each primary stream station during rainfall runoff is shown in table 26.

The effects of Spoon Valley Lake on stream water quality are demonstrated by the reduced suspended sediment concentrations at the S3 stream sampling station. The lake effectively slows streamflow and causes the deposition of suspended sediments and nutrients attached to sediment particles. The decreases in Kjeldahl-nitrogen and total phosphate concentrations are also pronounced. The increase of suspended sediment and nutrients at the S2 stream sampling station results from the agricultural runoff from the S2 floodplain subwatershed. During rainfall events, the vast majority of the sediment and nutrients entering Court Creek from the Sugar Creek tributary are contributed from the relatively small 2880-acre subwatershed below Spoon Valley Lake. The effect of surface water runoff from the floodplain watershed is illustrated by the decrease in the concentration of sulfates at S2 during rainfall events. As shown in the streamflow section of this report, runoff from the steep bluffs in the S2 subwatershed is very rapid, while the rate of streamflow increase at the Spoon Valley Dam is more gradual. Since most of the sediment and attached nutrients measured at S2 result from the S2 subwatershed runoff, high concentrations of suspended sediment most often coincide with the incidence of intense rainfall rather than with peak streamflows.

Suspended sediment concentrations have a general tendency to increase when proceeding downstream from the upland prairie subwatersheds into the floodplain subwatersheds even though streamflows are also increasing rapidly. This effect is illustrated in table 26 by the differences in the mean concentrations of suspended sediment, total ammonia, Kjeldahl-nitrogen, and total phosphate between stream stations N4 and N1, stream stations M3 and M1, and stream stations C12 and C2. This tendency is illustrated most clearly by the increase of mean suspended sediment concentrations on Court Creek when proceeding from the C12 to C2 sampling stations Csee table 27). The highest concentrations of suspended sediment are found in the floodplain stream sampling stations at C4, C3, and C2.

flemal (1980) found agriculture, including livestock management, to be the major source of nonpoint pollution in western Illinois streams. During rainfall events in the Court Creek watershed, suspended sediments, total phosphate, total ammonia, and Kjeldahl-nitrogen had the greatest increases in concentrations over their respective chemical levels during base streamflow conditions. The nutrients were largely attached to sediment particles as indicated by the much lower dissolved

Table 26. Geometric Means of Stream Parameters during Runoff from Rain Events

	S5	S3	S2	N4	N1	M3	M1	C12	C10	C2
Flow (cfs)	50	65	97	134	193	32	49	25	74	756
Sediment (mg/l)	244	27	358	1156	1879	904	1380	107	701	2754
Total ammonu-N (mg/l)	0.23	0.23	0.39	0.56	0.70	0.52	0.79	0.22	0.41	0.95
Diss. ammonia-N (mg/l)	0.14	0.16	0.16	0.12	0.13	0.16	0.26	0.12	0.12	0.19
Kjeldahl-nitrogen (mg/l)	1.40	0.70	2.70	4.40	6.40	4.80	6.60	0.97	2.35	8.50
Nitrate-N (mg/l)	1.47	0.18	1.30	2.51	2.24	3.12	2.25	2.70	3.03	2.68
Total phosphate-P (mg/l)	0.33	0.08	1.24	2.12	2.59	2.72	2.82	0.34	1.17	4.40
Diss. phosphate-P (mg/l)	0.04	0.01	0.10	0.12	0.11	0.21	0.17	0.07	0.08	0.10
Alkalinity (mg/l)	139	138	117		113	82	110	146	137	125
Sulfate (mg/l)	179	156	89		28	19	28	55	83	33
Chlorides (mg/l)	7	8	8		5	3	6	25	18	11
TDS (mg/l)	469	419	279		207	160	205	308	301	227
Diss. oxygen (mg/l)	9.30	10.20	9.50		9.00	9.50	9.00	8.90	8.70	8.40
pH (units)	7.90	8.20	7.90		7.74	7.60	7.68	7.86	7.78	7.71

Table 27. Increases in the Geometric Means of Suspended Sediment Concentrations in the Floodplain Stream Sampling Stations of Court Creek

Stream station	C12	C10	C7	C4	C3	C2
Suspended sediment (mg/l)	107	701	1531	2193	2415	2754

ammonia and phosphorus concentrations in stream water samples. Stream samples of suspended sediment, total ammonia, and total phosphate were taken throughout the rise and fall of floodwater during three rainfall events at the end of this study. The amounts of total phosphate and total ammonia were highly correlated with suspended sediment in these high streamflow events (see table 28). Johnson and Baker (1982) found that nutrient losses associated with sediment usually exceed those associated with water. Flemal (1980) found suspended sediment, phosphorus, and ammonia to be the greatest water pollution problems for streams in the Galesburg plain. With the exception of streams heavily impacted by sewage treatment plants, nonpoint pollution was indicated as the primary source of the stream quality violations and was associated with high streamflows.

In table 29, the effects of the three major land uses (strip mining, residential housing, and agriculture) in the upland prairie subwatersheds on water quality at S5, C12, and M3 are compared with the floodplain water quality of M1 and the water quality of the entire watershed at C2. Of the three land uses in the upland prairie subwatersheds, agriculture, principally row crops, causes the greatest increase in the concentration of suspended sediment and particulate nutrients. Nitrate concentrations in the runoff from the M3 subwatershed are also the highest of those at any station. However, suspended sediment, total ammonia, total phosphate, and Kjeldahl-nitrogen concentrations increased greatly at the floodplain stream sampling stations M1 and C2. Strip mining and residential land uses increase the sulfate and chloride levels at S5 and C12, respectively, but these are well below regulated levels.

Major water quality problems resulting from the rainfall runoff of the entire watershed are found at C2. Suspended sediment and nutrients (total ammonia, Kjeldahl-nitrogen, and total phosphate) are the most critical water quality problems, as seen in table 29.

STREAM YIELDS

The amount of any chemical transported by a stream depends upon amount of streamflow (water discharge) and the constituent concentration in the stream water. In the case of sediment, the sediment discharge is the product of the water discharge, the sediment concentration of the stream water, and an appropriate factor. If regression analysis of sediment discharge and stream water discharge demonstrates a high degree of correlation, then flow duration curves can be used to estimate the annual sediment stream yield. The procedure is outlined below for suspended sediment.

Table 28. Squares of Correlation Coefficients of the Regression between the Log of Sediment Concentration and the Logs of Total Phosphate Concentration and Total Ammonia Concentration

Sample station	Total phosphate	Total ammonia
C2	0.97	0.94
C3	0.98	0.96
C4	0.99	0.95
C7	0.82	0.77
M1	0.99	0.96
M3	0.98	0.96
N1	0.99	0.94
N2	0.99	0.94
N3	0.99.	0.96
N4	0.99	0.96
S1	0.94	0.78
S2	0 . 96	0 .80
S3	0.94	0.36

Table 29. A Comparison of Land Use Effects on Stream Quality during Rainfall Events

Landform: / Land use:	Prairie Strip mine	Prairie Residential	Prairie Agriculture	Floodplain Agriculture	Watershed All
Stream station:	S5	C12	M3	Ml	C2
Flo* (cfj)	50	25	32	49	756
Sediment (mg/l)	244	107	904	1380	2754
Total ammonia-N (mg/l)	0.23	0.22	0.52	0.79	0.95
Diss. ammonia-N (mg/l)	0.14	0.12	0.16	0.26	0.19
Kjeldahl-nitrogen (mg/l)	1.40	'1.00	4.80	6.60	8.50
Nitrate Cmg/I)	1.47	2.70	3.12	2.25	2.68
Total phosphate-P (mg/l)	0.33	0.34	2.72	2.82	4.40
Diss. phosphate-P (mg/l)	0.04	0.07	0.21	0.17	0.10
Alkalinity (mg/l)	139	146	82	110	125
Suifaie(mg/l)	179	55	19	28	33
Chlorides (mg/l)	7	25	3	6	11
TDS (mg/l)	469	308	160	205	227

Mean annual suspended sediment loads can be computed from short-term intermittent stream sampling by a method using sediment transport curves and flow duration curves. In developing estimated annual sediment loads, reliance was placed on the techniques described by Miller (1951) and Colby (1956) and demonstrated by Simmons (1976).

Sediment samples were collected at each sampling station over a wide range of streamflows. The concentration of each sample was converted to loads (tons per day) by the relationship:

$$Q_s = 0.0027 \; C \; Q$$

where 0 equals the suspended sediment discharge in tons per day, C equals the concentration of the suspended sediment in mg/l, and 0 equals the instantaneous water discharge in cfs.

Log values of the sediment loadings were regressed with the log values of the corresponding streamflows to develop a mathematical expression that would adequately represent a sediment transport curve. In this manner a corresponding sediment load could be estimated for each condition of streamflow. With the flow duration curves that have been developed and described previously, the percentage of time a stream's flow equaled or exceeded a specified rate was available. Estimated annual stream yields were the sum of the sediment yields derived for each of 26 flow duration points on the flow duration curve of each station. Calculations for mean annual stream yields likely to occur at each station were made in accordance with the procedures described by Simmons (1976).

The same procedure can be followed for other water quality parameters such as nitrate. Kothandaraman and Evans (1979) demonstrated the calculation of estimated annual nitrate yield for streams in the Rend Lake watershed. This procedure allowed the estimate of annual stream yields for suspended sediment, nutrients, and other chemical parameters when stream samples are not taken on a daily basis. The squares of the correlation coefficients of each chemical discharge with stream water discharge at each sampling station are given in table 30. Stations S3 and S2 below the dam on Spoon Valley Lake and stream station M3 on Middle Creek generally had the lowest correlation coefficients. The chemical characteristics of Spoon Valley Lake outflow most often reflect the chemical composition of the large volume of lake water and not the chemical composition of land runoff during the rain event. The M3 stream station has only one year of data since it was included after land use analysis determined the large percentage of row crops in the M3 subwatershed. The calculations of chloride stream yields at the agricultural stream stations N1, M1, and M3 had the lowest correlation coefficients with stream discharge. Stream concentrations of chloride at those stations were extremely low.

The annual stream yields for the entire watershed at the C2 stream sampling station are given in table 31. The stream yield

Table 30. Squares of the Correlation Coefficients
of Regression Analysis between the Log of Streamflow Discharge
and the Log of the Specified Stream Discharge

	55	53	52	N4	N1	M3	H1	C12	C1O	C2
Sediment	0 881	0.606	0.652	0.819	0.778	0.579	0.750	0.797	0.899	0.895
Total ammonia-N	0.887	0.834	0.761	0.908	0.918	0.809	0.836	0.822	0.934	0.869
Diss. ammonia-N	0.786	0.799	0.648	0.649	0.644	0.541	0.618	0.712	0.756	0.705
Kjeldahl-nitrogen	0.862	0.770	0.731	0.869	0.917	0.801	0 853	0.727	0.723	0.844
Nitrate-N	0.818	0.663	0.743	0.905	0.903	0.941	0 830	0.921	0.807	0.899
Total phosphate-P	0.909	0.700	0.782	0.846 .	0.855	0.797	0.839	0.838	0.830	0.867
Diss. phosphate-P	0.865	0.642	0.671	0.877	0.798	0.847	0.856	0.839	0.920	0.848
Alkalinity	0.987	0.984	0.981		0.975	0.839	0.925	0.984	0.963	0.972
Sulfate	0.970	0.978	0.882		0.945	0.863	0.925	0.803	0.466	0.944
Chlorides	0.913	0.984	0.942		0.461	0.017	0.316	0.712	0.909	**0.866**
TD5	**0.986**	**0.991**	**0.956**		**0.976**	**0.869**	**0.929**	**0.961**	**0.953**	**0.981**

Table 31. Estimated Annual Stream Yields of Stream Chemicals for the Entire Watershed at Stream Station C2

	Yield/year	Yield/acre/year
Sediment (tons)	461,620	7.5
Total ammonia-N (lbs)	228,410	3.7
Diss. ammonia-N (lbs)	60,150	1.0
Kjeldahl-nitrogen (lbs)	1,851,460	30.0
Nitrate-N (lbs)	639,390	10.4
Total phosphate-P (lbs)	874,800	14.2
Diss. phosphate-P (lbs)	30,175	0.5
Alkalinity (tons)	19,910	0.3
Sulfate (tons)	5,555	0.1
Chlorides (tons)	2,115	0.0
TDS (tons)	38,400	0.6

of suspended sediment at C2 is very high. This value was derived during a sampling period with a large number of rainfalls greater than 1 inch. Table 11 in the section on rainfall reveals this fact by comparing Galesburg rainfall events during the 1981 and 1982 years with the previous 20 years. When the flow duration curve for C2 is adjusted to the long-term flow record at Indian Creek, the annual stream sediment yield drops to 2.0 tons per acre. This value is similar to stream sediment yields for western Illinois streams as determined by Bonini et al. (1983). Stream yields for the other chemical parameters have similar reductions when streamflow is adjusted to the long-term record.

Stream nutrient yields indicate that large amounts of total ammonia and total phosphate are being carried with the suspended sediment. The affinity of clay particles for dissolved ammonia and phosphorus ions increases the amounts of nutrients attached to sediment particles, especially in the very turbulent flood waters. The estimated annual loadings of nitrate at C2 are similar to the annual nitrate loadings on the Spoon River. (Kothandaraman and Evans, 1977), which ranged from 10.0 to 16.5 pounds per acre. Total phosphate, Kjeldahl-nitrogen, and total ammonia represent significant inputs of nutrients into the stream system.

The relative effects of land use on stream yields are shown in table 32 for the five prairie and floodplain subwatersheds of S5, C12, M3, Ml, and C2. Of the three upland prairie subwatersheds, the agricultural row crop M3 subwatershed had the greatest sediment yield. Brabets (1984) also found that agricultural watersheds transport more sediment than strip-mined watersheds. The strip-mined subwatershed S5 had higher sediment stream yields than the residential C12 subwatershed. However, the residential C12 subwatershed had higher nutrient stream yields in every parameter except Kjeldahl-nitrogen.

Of the three major land uses in the three upland prairie subwatersheds, the row crop and feedlot operations in the M3 subwatershed had by far the greatest water quality impacts on the receiving stream. The M3 stream yields of sediment and total ammonia were at least 70 percent greater than those at either C12 or S5. Stream yields of Kjeldahl-nitrogen at M3 were more than double the annual stream yields at C12 and S5. Nitrate yields at M3 and C12 were similar but were almost 100 percent higher than at S5. Oissolved ammonia stream yields had very little variation between any of the subwatersheds, but dissolved phosphorus stream yield from the M3 subwatershed was at least three times greater than at C12 or S5. None of the dissolved minerals, including sulfate, chloride, and TDS stream yields, present water quality problems even in the subwatersheds with the greatest stream yields. On a per-acre basis, the stream yields for the entire watershed at C2 are similar to the M1 subwatershed yields.

The relative contributions of Court Creek and each of its

Table 32. A Comparison of Land Use Effects on the Estimated Annual Stream Yields *

Landform:	Prairie	Prairie	Prairie	Floodplain	Watershed
Land use:	Strip mine	Residential	Agriculture	Agriculture	All
Stream station:	S5	C12	M3	M1	C2
Sediment Ctons)	1.0	0.7	1.7	9.2	7.5
Total ammonia-N (lbs)	1.4	1.8	2.5	4.6	3.7
Diss. ammonia-N (lbs)	0.9	1.0	1.0	1.1	1.0
Kjeldahl-nitrogen (lbs)	8.2	8.0	18.7	40.8	30 0
Nitrate-N (lbs)	8.0	15.6	14.5	2.3	10.4
Total phosphate-P (lbs)	2.0	2.9	7.4	14.0	14.2
Diss. phosphate-P (lbs)	0.2	0.5	1.5	-0.6	0.6
Alkalinity (tons)	0.4	0.4	0.3	0.2	0.3
Sulfate (tons)	0.5	0.1	0.0	0.0	0.0
Chlorides (tons)	0.0	0.1	0.0	0.0	0.0
TDS (tons)	1.4	0.9	0.6	0.4	0.6

*Calculated on a per-acre basis

tributaries to the annual stream yields for the entire watershed are shown in table 33. The percentage of annual sediment yield from Sugar Creek and Middle Creek is substantially less than from the other streams. The watersheds of Sugar and Middle Creeks represent 33 percent of the watershed area but only 8 percent of the sediment yield. However the individual North Creek and Court Court watersheds contribute substantially more of the annual sediment yield than their relative watershed size would indicate. With the exception of total phosphate yield from North Creek, the pattern of total ammonia, Kjeldahl-nitrogen, and total phosphate stream yields from the four stream basins are similar to the pattern of sediment yields.

The subwatersheds of Court Creek without any tributary contributions account for a much higher percentage of sediment and nutrient (total ammonia, Kjeldahl-nitrogen , and total phosphate) stream yields than their relative percentage of watershed area (36 percent). However, the respective percentages of annual dissolved ammonia (31 percent) and dissolved phosphate C24 percent) are less than the percentage of subwatershed area. Dissolved phosphorus and dissolved ammonia annual yields from the combined tributaries represent more than 60 percent of the stream yields for the entire watershed. It should be noted that most of the confined animal feedlots occur in the tributary subwatersheds.

In the next four sections of the report, the relative contributions of individual subwatersheds to stream yields of sediments and nutrients are examined in detail for the subwatersheds of Middle Creek, North Creek, and Sugar Creek and for the main stem of Court Creek. The estimated annual stream basin yields and stream subwatershed yields are presented in tabular format for each of the four stream watersheds. Stream basin and subwatershed yields of sediment and nutrients for individual rainstorms are compared to the estimated annual stream yields. The impacts of stream channelization and bank erosion on stream sediment and nutrient yields are demonstrated in the discussion of the Court Creek subwatersheds.

Middle Creek

While row crop agriculture had a significant effect on the stream yields at M3, the contribution of the smaller M1 subwatershed was much greater in terms of annual sediment, total ammonia, Kjeldahl-nitrogen, and total phosphate stream yields. As mentioned in the watershed description, a subwatershed area is that watershed area between two stream sampling stations. Those subwatersheds located at the headwaters of streams are identical to stream basins (the M3 basin is also the M3 subwatershed). The Ml subwatershed stream yields are the difference between M1 and M3 stream basin yields. Losses of M3 stream yields by sedimentation in the floodplain soils of the M1 subwatershed were

Table 33. A Comparison of the Estimated Annual Stream Yields of the Individual Watersheds of Court Creek and Its Three Tributaries *

	Sugar Creek at S2	Middle Creek , at Ml	North Creek at N1	Combined Tributary	Court Creek
Watershed (acres):	14240	6400	18720	39360	22400
Watershed (percent):	23.0	10.4	30.3	63.7	36.3
Sediment	2.3	5.7	41.0	49.0	51.0
Total ammonia-N	9.4	9.0	38.0	56.4	43.6
Diss. ammonia-N	17.5	11.6	32.1	60.9	31.1
Kjeldahl-nitrogen	7.6	8.9	34.4	50.9	49.1
Nitrate-N	8.4	10.5	35.1	54.0	46.0
Total phosphate-P	7.0	7.0	26.4	40.4	59.6
Diss. phosphate-P	14.8	16.8	44.6	76.2	23.8

* Calculated as a percentage of the stream yield from the entire 61,760 acre watershed

not determined. Losses could be estimated only when the stream yield at the downstream station (in this case Ml) was less than the stream yield of the upstream station Cin this case M3). No attempt to measure floodplain deposition of sediment and attached particulate nutrients was made in this study. Nutrient scavenging of dissolved ammonia or phosphorus by suspended soil particles could also be estimated only when dissolved nutrient yields at the downstream station were less than the yields at the upstream stream station.

Over 70 percent of the sediment yield measured at the M1 stream station was eroded from the Ml subwatershed (table 34). Nutrient stream yields of total ammonia, total phosphorus, and Kjeldahl-nitrogen from the M1 subwatershed ranged from 47 to 51 percent of the M1 stream basin yields. Since the M1 subwatershed is only 33 percent of the M1 stream basin area, the amounts of eroded soils and nutrients reaching the stream from the M1 subwatershed must represent a high delivery ratio as evidenced by the higher stream yields per acre in the M1 subwatershed.

As shown in table 30, the correlation coefficients of streamflow discharge and stream sediment and nutrient discharge for Middle Creek stations and the lower Sugar Creek stream stations at S3 and S2 were lower than the correlation coefficients at other watershed stream stations. The relative contributions of stream subwatersheds, as determined by the estimated annual stream yields, were compared to the relative subwatershed contributions during individual storm events. Streamflows, sediment yields, and nutrient yields were measured during individual storm or flood events. Streams were sampled during the rise and fall of floodwaters (the rising and falling limb of the hydrograph). Each stream sample represented a time period on the hydrograph. The stream yield for that sampling time period was based upon the streamflow and stream water concentrations of sediment and nutrients when sampled. Sediment and nutrient yields (lbs) per sampling period (minutes) were determined as the product of streamflow (cfs), sample concentration (mg/l), time period (min.) and a factor of 0.003747. The stream yields of sediment and nutrients for individual storms were the sums of the sampling period yields.

Stream water discharge, sediment discharge, and nutrient discharge curves for the M1 and M3 stream stations are shown in figure 21 for the April 1, 1983 storm. As noted previously in the streamflow section, 75 percent of the peak flow discharge resulted from runoff in the M1 subwatershed. Simultaneous increases in sediment and nutrient stream discharges also resulted from runoff in the M1 subwatershed. Storm yields of sediment and nutrients for Middle Creek stream stations are given in table 35. Between 66 and 75 percent of the Middle Creek yields of sediment, total ammonia, and total phosphate were delivered from the M1 subwatershed during the April storm. This compares favorably with the estimated annual sediment yields in table 33. During the April storm, the Middle Creek sediment yield was 8.9

Table 34. Basin and Subwatershed Stream Yields for Middle Creek

	M3 basin	Ml basin	Ml subwatershed
Watershed area (acres)	4320	6400	2080
Percent of watershed	67.5	100	32.5
Sediment (tons)	7133	26386	19233
Percent of yield	27.1	100.0	72.9
Tons per acre	1.7	4.1	9.2
Total ammonia-N (lbs)	10832	20492	9659
Percent of yield	52.9	100.0	47.1
Lbs per acre	2.5	3.2	4.6
Diss. ammonia-N (lbs)	4483	6818	2335
Percent of yield	65.7	100.0	34.2
Lbsperacre	1.0	1.1	1.1
Kjeldahl-nitrogen (lbs)	80623	165437	,84814
Percent of yield	48.7	100.0	51.3
Lbs per acre	18.7	25.8	40.8
Nitrate-N (lbs)	62462	67342	4880
Percent of yield	92.8	100.0	7.2
Lbsperacre	14.5	105	2.3
Total phosphate-P (lbs)	31991	61177	29186
Percent of yield	52.3	100.0	47.7
Lbsperacre	7.4	9.6	14.0
Diss. phosphate-P (lbs)	6307	5054	-1253
Percent of yield	124.8	100.0	-24.8
Lbsperacre	1.5	0.8	-0.6

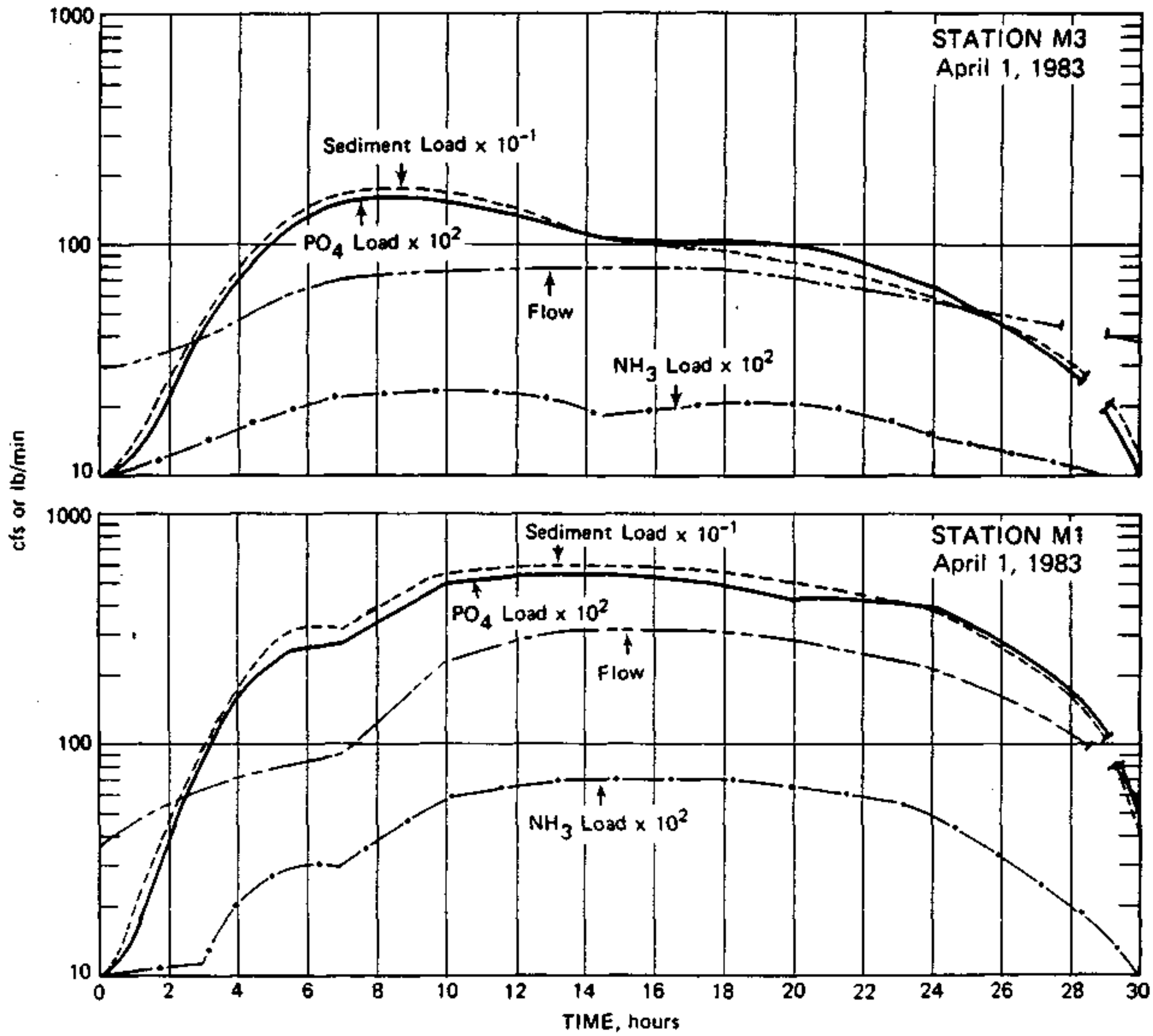


Figure 21. Streamflow, sediment, and nutrient stream discharges for the M3 and Ml stream sampling stations during the April 1, 198Z, storm

Table 35. Basin and Subwatershed Stream Yields for Middle Creek during the April 1, 1983, Storm

	M3 basin	Ml basin	M1 subwatershed
Watershed area (acres)	4320	6400	2080
Percent of watershed	67.5	100	32.5
Sediment (tons)	754	2950	2196
Percent of yield	25.6	100.0	74.4
Total ammonia-N (lbs)	281	826	545
Percent of yield	34.0	100.0	66.0
Total phosphate-P (lbs)	1479	5722	4243
Percent of yield	25.9	100.0	74.1

percent of the 33,293 tons of sediment passing C2 from the entire watershed. The estimated annual sediment yield for Middle Creek was 5.7 percent of the annual sediment yield for the entire watershed at C2 (table 33).

Approximately 75 percent of the M3 subwatershed (which is the M3 basin) has slight slopes with only 25 percent of the subwatershed occurring as steep slopes. Row crops occupy the 3,093 acres of flat land in the 4420-acre M3 subwatershed. Pastures are the primary land use along the steeper stream border in the remainder of the subwatershed (see figure 22). The topography of the 2080-acre M1 subwatershed is 58 percent steep slopes, which speeds the rate of surface water runoff and precludes the development of row crop land uses. Approximately 60 percent of the M1 subwatershed occurs as steep bluff pastures and woods. The floodplain (an area of slight slope) is 25 percent of the M1 subwatershed but only 5 percent of the M3 subwatershed. Since the vast majority of the floodplain land use is row crops, floodplain row crop fields lie below areas in which surface water runoff has reached high velocity. Row crop acreage increases by only 834 acres in the M1 subwatershed as compared to 3093 acres in the M3 subwatershed. Approximately half of the M1 subwatershed row crop acreage lies in the floodplain. This floodplain row crop acreage is located immediately upstream of the M1 sampling station (figure 22). Since 1940 that stream segment length has been reduced from 10,900 feet to 9,800 feet -- about a 10 percent reduction. Stream length reductions increase stream velocity during floods and thereby increase in-channel erosion and the delivery of eroded material to off-site areas.

Only annual stream yields of dissolved ammonia, dissolved phosphate, and nitrate did not increase in the M1 subwatershed (table 34). Over 90 percent of the nitrate stream yield resulted from the M3 subwatershed. Nitrate stream yields are frequently associated with tile drainage from row crop fields (Johnson and Baker, 1982). The loss of dissolved phosphorus would result from the attachment of phosphorus ions to the clay particles in the highly turbid and turbulent flood waters in the M1 subwatershed. Sharpley and Syers (1979) also found phosphorus stream yields to vary between dissolved and particulate forms because of the interaction between dissolved phosphorus and particulate material. Sediment enrichment by the attachment of dissolved ammonia ions to clay soil particles has also been observed. The loss of dissolved phosphorus stream yield from the M3 subwatershed by sediment enrichment would account for only 2 percent of the 47 percent total phosphate stream yield from the M1 subwatershed. While confined feedlots are located only in the M3 subwatershed, animal wastes from these operations are applied to row crops and pastures in both subwatersheds.

<u>North Creek</u>

Annual stream yields of sediment and nutrients for North Creek stream basins and subwatersheds were derived in the same

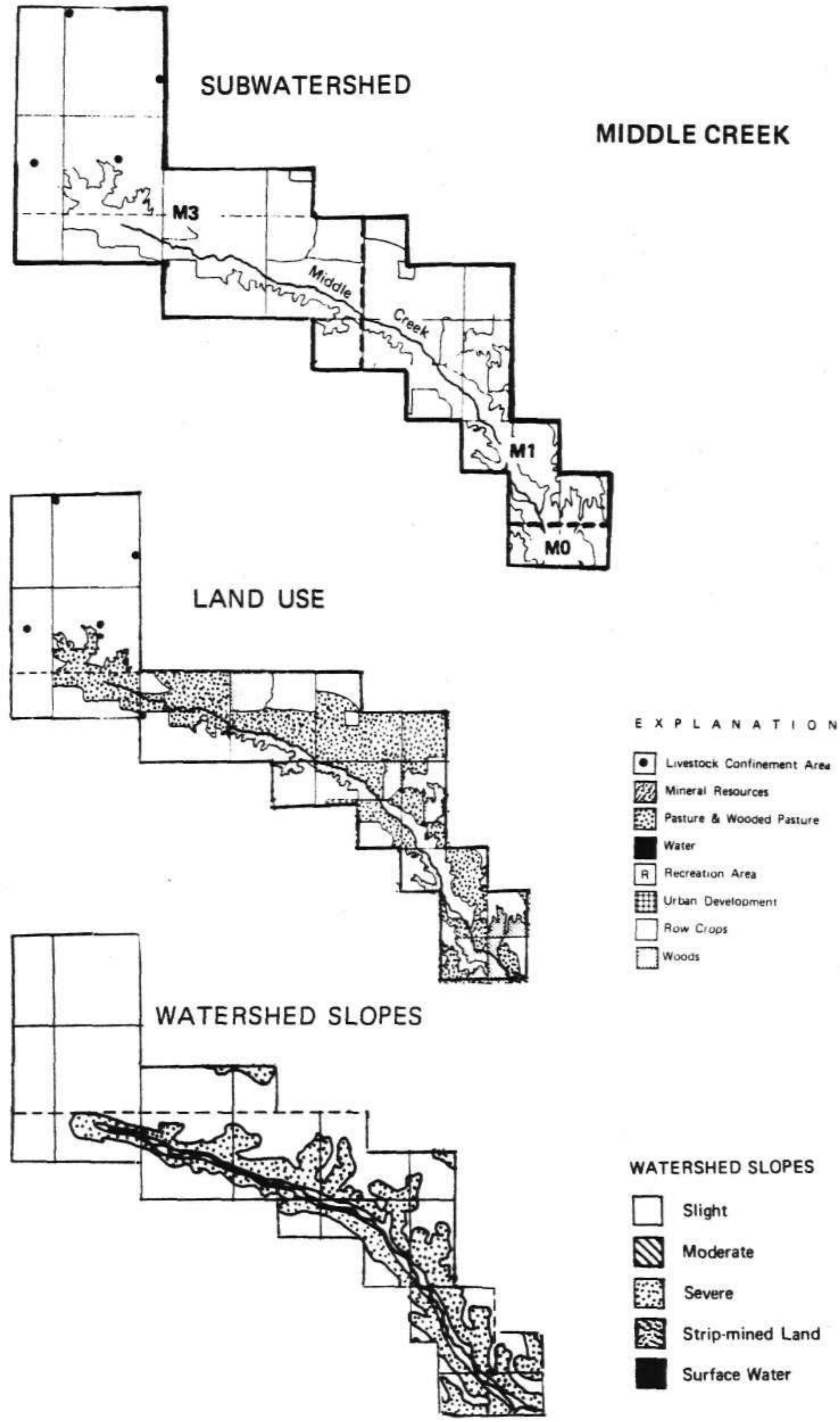


Figure 22. Areas, land uses, and topography of subwatersheds in the Middle Creek basin

manner that Middle Creek annual stream yields were. The annual yields are given in table 36 for North Creek basins and in table 37 for North Creek subwatersheds. As in Middle Creek, the downstream floodplain subwatersheds (N1, N2, and N3) contributed a much greater proportion of sediment and nutrients delivered to the stream than their relative land area would indicate. Approximately 68 percent of the North Creek sediment yield came from the three floodplain subwatersheds representing 25 percent of the North Creek watershed. From 38 to 45 percent of the total ammonia, Kjeldahl-nitrogen, and total phosphate stream yields were delivered from the three floodplain subwatersheds. The N2 subwatershed had the largest rate of sediment, Kjeldahl-nitrogen, and total phosphate delivered to the stream, while the N1 subwatershed had the largest instream yield of total ammonia. Sedimentation in the floodplain of the N1 subwatershed is indicated by the relatively low sediment yield on a tons-per-acre basis. Kjeldahl-nitrogen and total phosphate stream yields have net losses between stream stations N1 and N2. Both total phosphate and Kjeldahl-nitrogen are predominantly transported on orwithinsediment particles.

As with Middle Creek, stream yields of sediment, total ammonia, and total phosphate were determined during individual storms. Table 38 gives the stream basin yields for North Creek sampling stations during an overbank flood event on April 1, 1983 and an in-bank high flow event on December 25, 1982. Sediment yields for the floodplain subwatersheds between N1 and N4 ranged from 47 to 57 percent of the North Creek stream yields. During the overbank flood on April 1, approximately 5 percent more sediment passed N2 than N1. Total ammonia and total phosphate stream yields were also reduced at N1. The correlation between stream flow, sediment yields, and nutrient yields on North Creek is illustrated by the hydrograph of N1 during the December 25th storm (figure 23). North Creek sediment yields were 24.5 percent and 63.5 percent of the 13,206 and 33,293 tons of sediment passing from the entire watershed during the December 25 and April 1 storms. The estimated annual sediment yield for North Creek was 41.0 percent of the annual yield for the entire watershed (table 33).

As with Middle Creek, over 90 percent of the annual stream nitrate yield resulted from the upstream subwatershed of N4 (table 37). Row crops represent 50 percent of the land use in the N4 subwatershed. About 80 percent of the dissolved phosphorus came from the upland N4 subwatershed. However, dissolved ammonia stream yields were less than the value commensurable with the area of the N4 subwatershed. One difference between the floodplain subwatersheds on Middle Creek and North Creek is the presence of confined feedlot operations on North Creek floodplain bluffs. Runoff from these operations and animal wastes applied on the steep bluff pastures would increase the relative ammonia contribution of floodplain subwatersheds. Concentrations of

Table 36. Basin Stream Yields for North Creek

Stream basin	N4	N3	N2	N1
Watershed area (acres)	14080	16800	17920	18720
Percent of watershed	75.2	89.7	95.7	100.0
Sediment (tons)	61072	118144	170221	188914
Percent of yield	32.3	62.5	90.1	100.0
Tons per acre	4.3	7.0	9.5	10.1
Total ammonla-N (lbs)	51659	58684	69269	86791
Percent of yield	59.5	67.6	79.8	100.0
Lbs per acre	3.7	3.5	3.9	4.6
Diss. ammonia-N (lbs)	13261	**	**	19324
Percent of yield	68.6	**	**	100.0
Lbsperacre	0.9	**	**	1.0
Kjeldahl-nitrogen Clbs)	347741	516442	656140	636677
Percent of yield	54.6	81.1	.103.0	100.0
Lbs per acre	24.7	30.7	36.6	34.0
Nitrate-N (lbs)	208885	**	**	224386
Percent of yield	93.1	**	**	100.0
Lbsperacre	14.8	**	**	12.0
Total phosphate-P (lbs)	146094	189932	246038	230974
Percent of yield	63.3	82.2	106.0	100.0
Lbsperacre	10.4	11.3	13.7	12.3
Diss. phosphate-P (lbs)	10754	**	**	13446
Percent of yield	80.0	**	**	100.0
Lbsperacre	0.8	**	**	0.7

Table 37. Subwatershed Stream Yields for North Creek

Stream subwatershed	N4	N3	N2	N1
Watershed area (acres)	14080	2720	1120	800
Percent of watershed	75.2	14.5	6.0	4.3
Sediment (tons)	61072	57071	52077	18694
Percent of yield	32.3	30.2	27.6	9.9
Tons per acre	4.3	21.0	46.5	23.4
Total ammonia-N (lbs)	51659	7024	10586	17521
Percent of yield	59.5	8.1	12.2	20.2
Lbs per acre	3.7	2.6	9.5	21.9
Diss. ammonia-N (lbs)	13261	**	**	6063
Percent of yield	68.6	**	**	31.4
Lbs per acre	0.9	**	**	1.3
Kjeldahl-nitrogen (lbs)	347741	168700	139698	-19462
Percent of yield	54.6	26.5	21.2	-3.1
Lbs per acre	24.7	62.0	124.7	-17.4
Nitrate-N (lbs)	208885	**	**	15501
Percent of yield	93.1	**	**	6.9
Lbs per acre	14.8	**	**	3.3
Total phosphate-P (lbs)	146094	43838	56106	-15064
Percent of yield	63.3	19 0	24.3	-6.5
Lbs per acre	10 4	16.1	50.1	-18.8
Diss, phosphate-P (lbs)	10754	**	**	2692
Percent of yield	80.0	**	**	20.0
Lbs per acre	0.8	**	**	0.6

Table 38. Stream Basin Yields for North Creek during Storm Events

Stream subwatershed	N4	N3	N2	N1
Watershed area (acres)	14080	16800	17920	18720
Percent of watershed	75	90	96	100
April 1, 1983				
Sediment (tons)	11326	16781	22330	21222
Percent of yield	53	79	105	100
Total ammonia-N (lbs)	2993	5004	6585	4066
Percent of yield	74	123	162	100
Total phosphate-P (lbs)	19468	27117	34319	33403
Percent of yield	58	81	103	100
December 25, 1982				
Sediment (tons)	1750	3341	3153	4084
Percent of yield	43	82	77	100
Total ammonia-N (lbs)	570	670	876	864
Percent of yield	66	75	101	100
Total phosphate-P (lbs)	4486	7065	7145	8680
Percent of yield	52	82	88	100

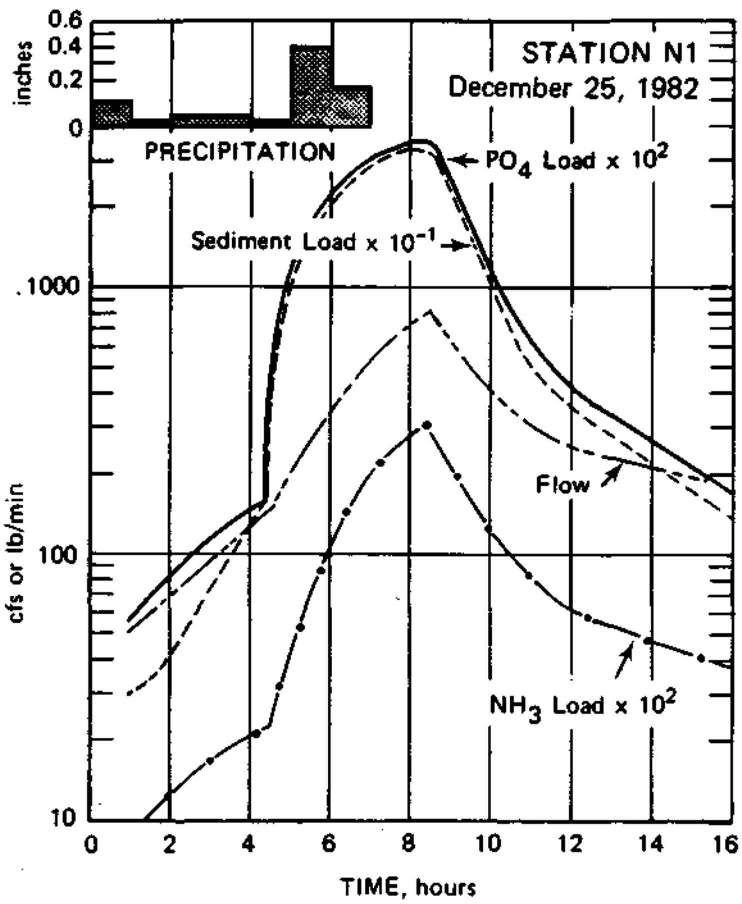


Figure 23. Correlation between streamflow, sediment, and nutrient stream discharge at the N1 sampling station during the December 25, 1982, storm

dissolved and total ammonia in snowmelt runoff were higher at N1 than at N4 (table 24).

North Creek subwatersheds do not clearly define the limits between the upland prairie land uses and the floodplain land uses. The watershed is fan-shaped (figure 24) and the uppermost stream sampling station still has over 75 percent of the watershed above it. In addition, the watershed is extremely rugged as indicated by the steep topography of all subwatersheds. Therefore, rates of surface water runoff should be more uniform between North Creek subwatersheds than between the M1 and M3 subwatersheds on Middle Creek. However, the floodplain between N4 and N1 is very broad and has substantial row crop acreage. There is a tendency to alter stream channels in order to maximize row crop field size and to divert eroding floodwaters from floodplain row crop fields. The N2 subwatershed with the greatest annual sediment yield also had a 25 percent reduction in stream length between 1940 and 1979. The correlation between floodplain channelization and instream sediment yield will be examined more closely in a later section.

Sugar Creek

The Sugar Creek watershed has been greatly affected by all three major land uses -- strip mining, residential land development, and agriculture (figure 25). Annual stream yields of sediment and nutrients for Sugar Creek stream basins and subwatersheds were derived in the same manner that Middle Creek annual stream yields were (tables 39 and 40). The effects of strip mining land use on the S5 subwatershed have been discussed previously. Much of the stream yields from land use in the S5 and S3 subwatersheds are stored in the "sink" created by the formation of Spoon Valley Lake. The effectiveness of this "sink" is shown by the net loss of annual sediment and nutrient stream yields from the S5 subwatershed at stream station S3, Even nitrates and dissolved phosphate stream yields have net losses. Losses by sedimentation and biological metabolism within the lake system would account for such net losses.

No measurement of the amount of soil eroded or sediment deposited from the S3 subwatershed is possible from stream yields. As discussed in, the Middle Creek section, only net losses from sedimentation, not total losses from sedimentation, can be determined by the difference between upstream and downstream stream yields. Although major sources of erosion were found in the S3 subwatershed, stream sampling did not determine the magnitude of the eroded material. The lack of sedimentation measurements within Spoon Valley Lake and in the floodplain valleys of Court Creek and its tributaries is a major deficiency of this study. It should be added that the lack of sedimentation measurements between sources of eroded material and stream sampling stations is a major shortcoming in many land use studies

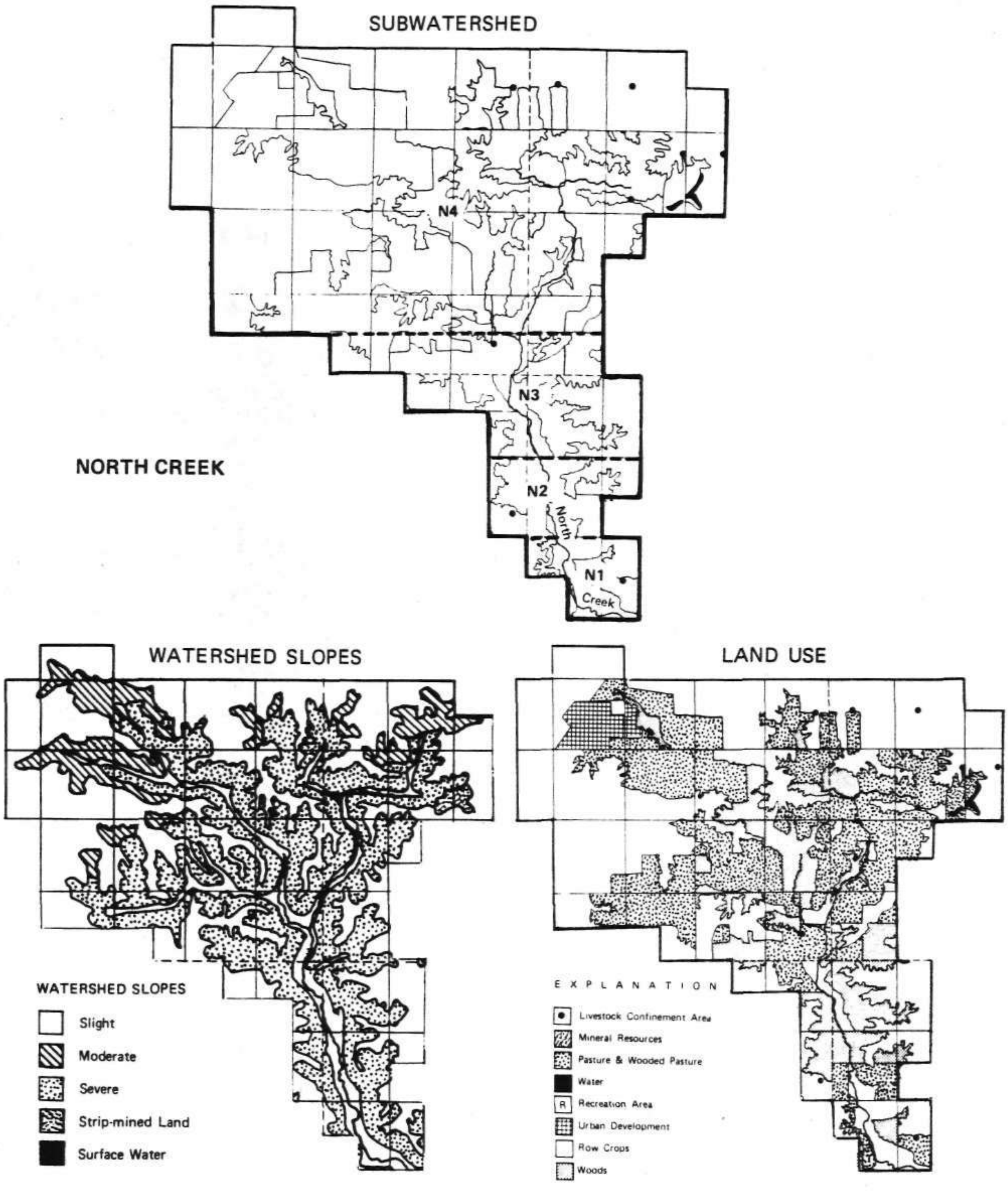


Figure 24. Areas, land uses, and topography of subwatersheds in the North Creek basin

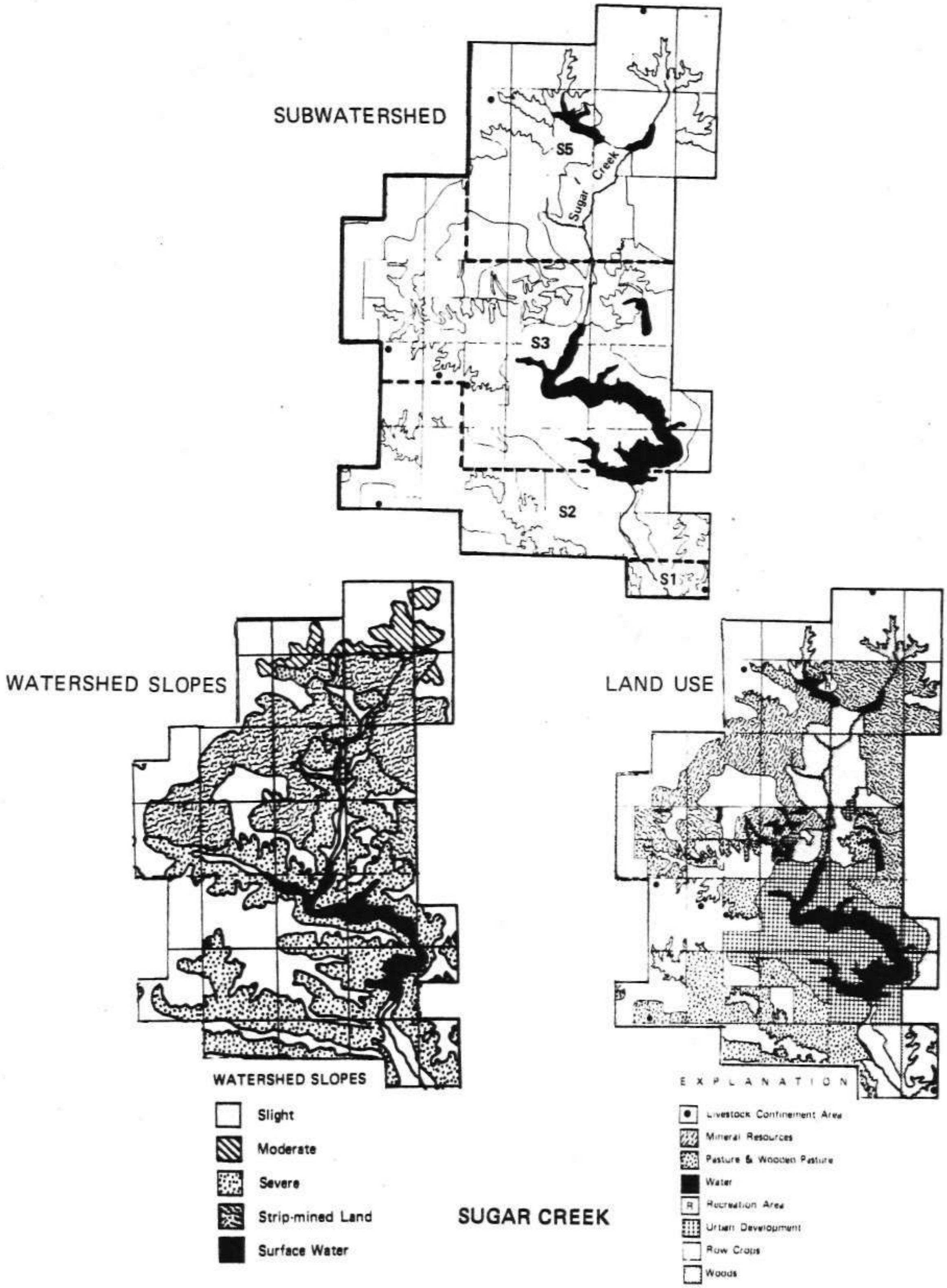


Figure 25. Areas, land uses, and topography of subwatersheds in the Sugar Creek basin

Table 39. Basin Stream Yields for Sugar Creek

Stream basin	S5	S3	S2	S1
Watershed area (acres)	4960	11360	14240	14560
Percent of watershed	34.1	78.0	97.8	100.0
Sediment (tons)	5078	457	10533	11024
Percent of yield	46.1	4.1	95.5	100.0
Tons per acre	1.0	0.0	0.7	0.8
Total ammonia-N (lbs)	7018	7981	21386	**
Percent of yield	32.8	37.3	100.0	**
Lbs per acre	1.4	0.7	1.5	**
Diss. ammonia-N (lbs)	4282	5688	10510	**
Percent of yield	40.7	54.1	100.0	**
Lbs per acre	0.9	0.5	0.7	**
Kjeldahl-nitrogen (lbs)	40634	24767	140101	**
Percent of yield	29.0	17.7	100.0	**
Lbs per acre	8.2	2.2	9.8	**
Nitrate-N (lbs)	39927	6391	53751	**
Percent of yield	74.3	11.9	100.0	**
Lbs per acre	8.0	0.6	3.8	**
Total phosphate-P (lbs)	9934	2766	61569	**
Percent of yield	16.1	4.5	100.0	**
Lbs per acre	2.0	0.2	4.3	**
Diss. phosphate-P (lbs)	1219	585	4466	**
Percent of yield	27.3	13.1	100.0	**
Lbsperacre	0.2	0.1	0.3	**

Table 40. Subwatershed Stream Yields for Sugar Creek

Stream subwatershed	S5	S3	S2	S1
Subwatershed area (acres)	4960	6400	2880	320
Percent of watershed	34.1	44.0	19.8	2.2
Sediment (tons)	5078	-4621	10066	491
Percent of yield	46.1	4.1	91.3	4.5
Tons per acre	1.0	-0.7	3.5	1.6
Total ammonia-N (lbs)	7018	963	13405	**
Percent of yield	32.8	4.5	62.7	**
Lbs per acre	1.4	0.2	4.7	**
Diss. ammonia-N (lbs)	4282	1406	4822	**
Percent of yield	40.7	13.4	45.9	**
Lbs per acre	0.9	0.2	1.7	**
Kjeldahl-nitrogen (lbs)	40634	-15857	115334	**
Percent of yield	29.0	17.7	82.3	**
Lbs per acre	8.2	-2.7	40.0	**
Nitrate-N (lbs)	39927	-33536	47360	**
Percent of yield	74.3	11.9	88.1	**
Lbs per acre	8.0	-5.2	16.4	**
Total phosphate-P (lbs)	9934	-7168	58830	**
Percent of yield	16.1	4.5	86.9	**
Lbs per acre	2.0	-1.1	20.4	**
Diss. phosphate-P (lbs)	1219	-634	3881	**
Percent of yield	27.3	13.1	86.9	**
Lbs per acre	0.2	-0.1	1.3	**

also. The most common technique is the calculation of an overall sediment delivery ratio based upon the calculated amount of eroded soil and the amount of sediment measured in the stream. As illustrated by the stream yield determinations on North Creek and Sugar Creek, placement of the stream sampling stations can alter the value of the sediment and nutrient delivery ratios because of losses within the floodplain or within lakes.

Between 80 and 90 percent of the stream sediment and nutrient yields for Sugar Creek are contributed from the S2 subwatershed (table 40). Only total ammonia yield (62.7 percent) and dissolved ammonia yield (45 percent) from the S2 subwatershed were less than 80 percent. The effect of the Spoon Valley Lake dam on flow duration curves at the S3 and S2 stream stations has been reported earlier. The correlations between stream water discharge and other stream parameter discharges at the S2 stream station are affected by the inflows of high concentrations of sediment . and nutrients from the S2 subwatershed and low concentrations of sediment and nutrients from the lake at S3. Estimates of annual yields were expected to be less accurate since the correlation coefficients of streamflow discharges with other stream parameter discharges at S2 and S3 were generally found to be lower (table 30). Variations in the stream sediment and nutrient discharges with stream water discharge are shown in figure 26 for the April 1 storm. Since the runoff from the S2 subwatershed is very rapid (as shown in the streamflow section), the rising limb of the hydrograph will carry most of the sediment and nutrient yield unless the rainstorm continues over an extended period.

Stream yields of sediment, total ammonia, and total phosphate during individual high streamflow events also illustrated the effectiveness of Spoon Valley Lake in limiting inflows of sediment and nutrients from upstream subwatersheds (table 41). During the April 1 storm, only 1.7 percent of the entire Sugar Creek sediment yield came from the subwatersheds upstream of S3. Over 98 percent of the sediment yield came from the S2 subwatershed, even though streamflow from S3 contributed most of the peak flow at S2. During the storms of December 2 and 25, Spoon Valley Lake was drawn down 6 feet, so that flow was limited to less than 100 cfs through a small gate valve in the dam spillway. The hydrographs of S2 in the streamflow section (figures 16, 18, and 19) illustrate the difference in peak flows between the December storms and the April storm.

The estimated annual sediment stream yields for Sugar Creek represent only 2.3 percent of the entire watershed's sediment yield at C2, as shown in table 33. The estimated annual yield method is low for S2 stream yields because the stream sampling program attempted to sample all stations at their peak flows. Peak flows from the S2 stream station result from the outflow of Spoon Valley Lake during most storms. Peak flows from S2 have highly variable sediment and nutrient discharges when compared with streamflow discharge (figure 26). On the basis of stream

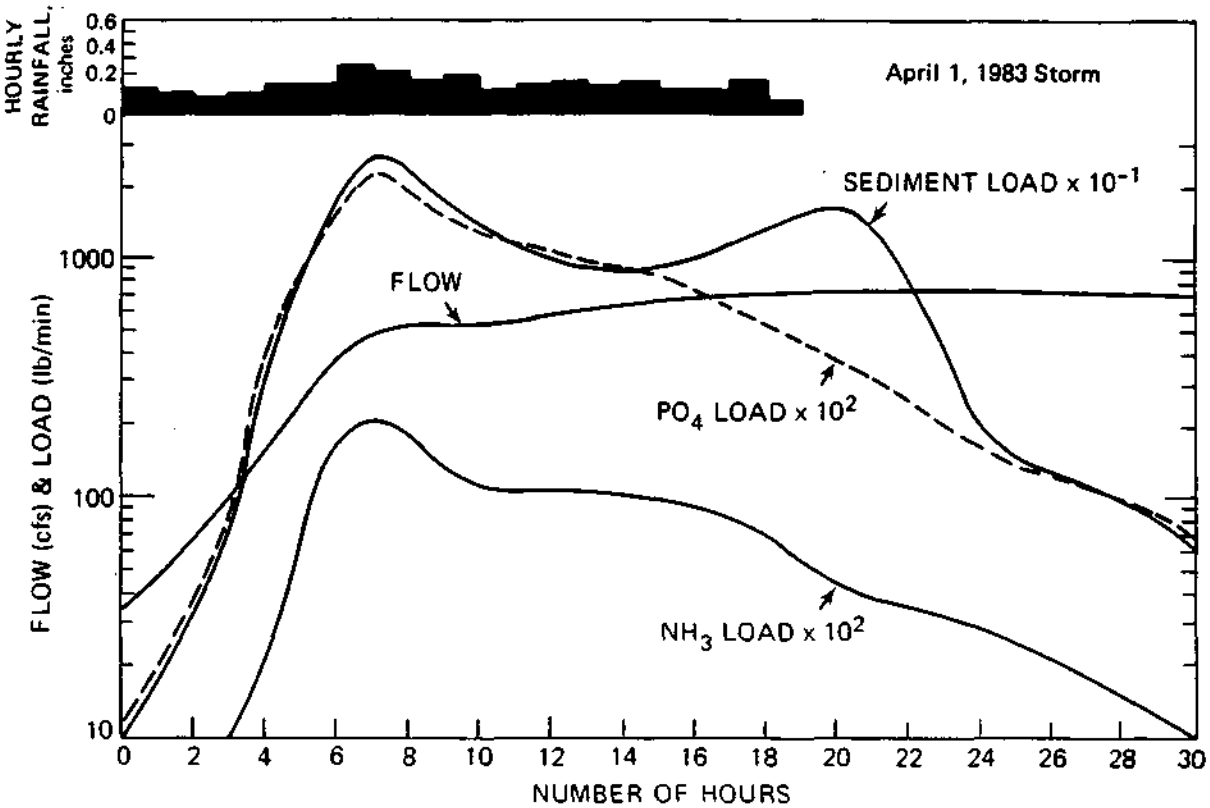


Figure 26. Correlation between streamflow, sediment, and nutrient stream discharges at the S2 sampling station during the April 1, 1983, storm

Table 41. Basin Stream Yields for Sugar Creek during the April 1, 1983, Storm

Stream basin	S3	S2	S1
Watershed area (acres)	11360	14240	14560
Percent of watershed	78.0	97.8	100.0
Sediment (tons)	134	8021	8023
Percent of yield	1.7	99.9	100.0
Total ammonia-N (lbs)	248	1237	1593
Percent of yield	15.6	77.7	100.0
Total phosphate-P (lbs)	506	12247	11963
Percent of yield	4.2	102	100.0

Table 42. Stream Yields for Sugar Creek during Individual Storm Events

	December 2, 1982	December 25, 1982	April 1, 1983
Sediment (tons)	2241	3115	8023
Percent of C2 storm yield	16.7	23.6	24.1
Total ammonia-N (lbs)	1149	901	1593
Percent of C2 storm yield	25.1	25.6	18.8
Total phosphate-P (lbs)	14710	7355	11963
Percent of C2 storm yield	38.9	25.1	22.4

yields determined from individual storm events, the S2 subwatershed contributed up to 24 percent of the sediment yield for the entire watershed at C2 (table 42). The S2 subwatershed is only 2,880 acres and represents only 4.7 percent of the entire water shed.

As in the North Creek basin, there are confined feedlot operations located on or near the steep bluffs in the downstream floodplain subwatersheds. The Illinois Department of Conservation reported a fish kill from feedlot runoff in the S2 subwatershed during the summer of 1982. Feedlots and application of animal wastes to steep bluff pastures would account for the high stream yields of ammonia from the S2 subwatershed. The maximum concentration of dissolved ammonia was found in the snowmelt runoff from the S2 subwatershed.

Court Creek

Subwatersheds on the main stem of Court Creek are shown in figure 27. Stream basin yields (table 43) included not only all upstream Court Creek subwatersheds but also Middle Creek, North Creek, and Sugar Creek. The contribution of the floodplain subwatersheds (C2 through C7 in table 44) was determined by subtracting the stream basin yields at C1O, at M1 on Middle Creek, at N1 on North Creek, and at S2 on Sugar Creek from the stream basin yields for the entire watershed at C2. Floodplain subwatersheds contributed 40 percent of the sediment yield even though they are only 20 percent of the watershed area. Over 35 percent of the total phosphorus yield and total Kjeldahl-nitrogen yield came from the C2 through C7 subwatersheds. Additional sediment sampling at stations C3, C4, and C7 allowed the estimate of annual sediment yield from individual Court Creek subwatersheds (table 45). Court Creek subwatersheds -- C12, C10, and C7 -- show sediment yield increasing downstream as indicated by yield increases of 0.7, 6.9, and 15.8 tons per acre of subwatershed, respectively.

There is a substantial floodplain deposition of sediment in the C4 subwatershed as indicated by a net loss of 24,200 tons of sediment at C4 (table 45). North Creek enters the C4 subwatershed just above the raised county road and bridge near Appleton, Illinois. Overbank floodwaters from North Creek and Court Creek pool behind the raised roadway. The surface of floodplain row crop fields in the C4 subwatershed west of the Appleton blacktop is visibly higher than that of row crop fields east of the highway in the C3 subwatershed. Landowners of floodplain row crop fields have had to replace fences because the sediment deposition reduced fence height by 3 feet.

The C3 and C2 subwatersheds show even larger sediment yields than the C7 subwatershed when measured on a tons-per-acre basis. Aerial photographs of the C2 and C3 subwatersheds reveal major

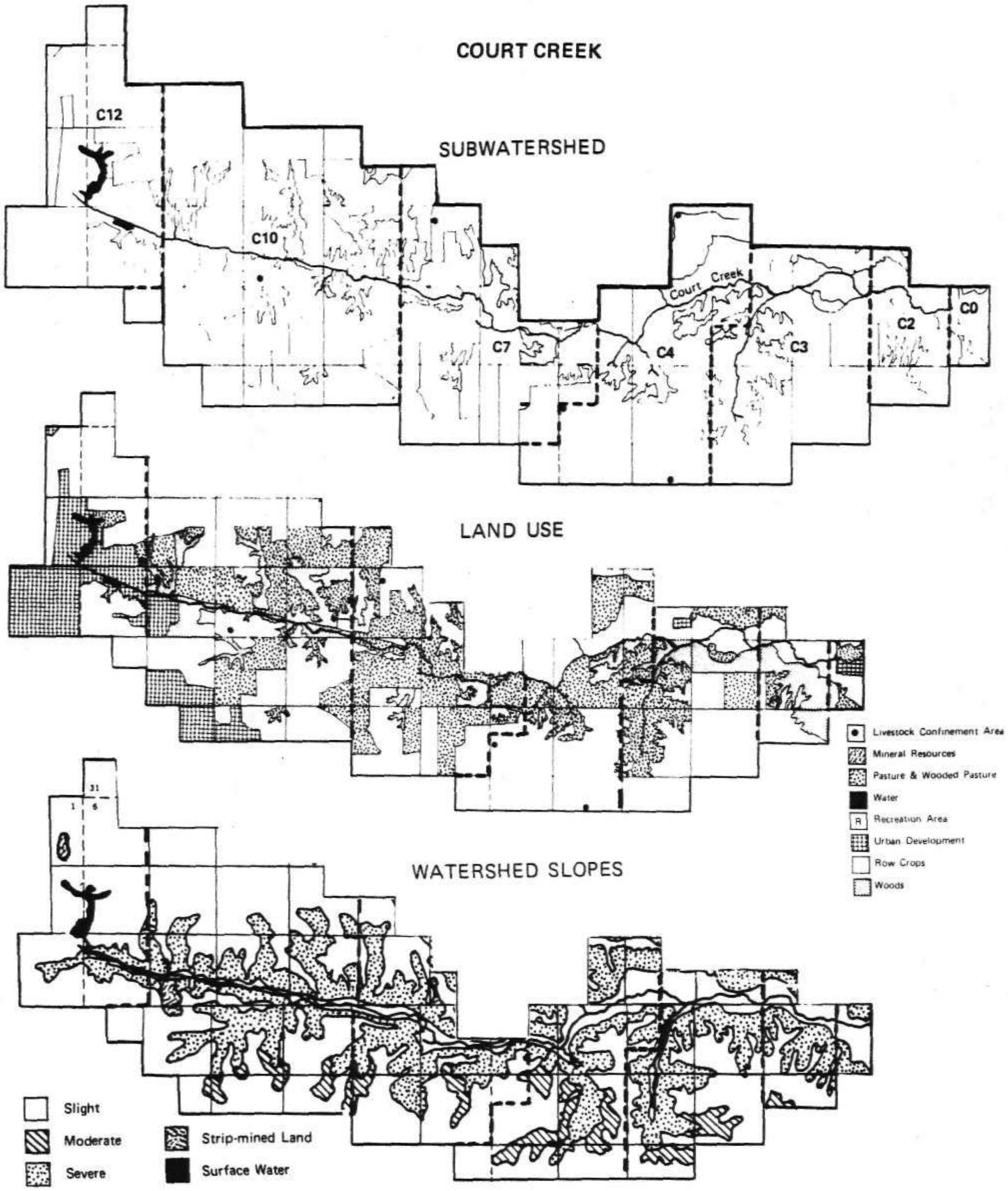


Figure 27. Areas, land uses, and topography of subwatersheds in the Court Creek basin

Table 43. Basin Stream Yields for Court Creek

Stream basin	C12	C10	C2
Watershed area (acres)	3200	1008	61760
Percent of watershed	5.2	16.3	100.0
Sediment (tons)	2317	50150	461621
Percent of yield	0.5	10.9	100.0
Tons per acre	0.7	5.0	7.5
Total ammonia-N (lbs)	5870	38807	228412
Percent of yield	2.6	16.9	100.0
Lbsperacre	1.8	3.8	3.7
Diss. ammonia-N (lbs)	3293	943	60149
Percent of yield	5.5	15.7	100.0
Lbsperacre	1.0	0.9	1.0
Kjeldahl-nitrogen (lbs)	25588	20907	1851457
Percent of yield	1.4	11.3	100.0
Lbsperacre	8.0	20.7	30.0
Nitrate-N (lbs)	49875	1299	639392
Percent of yield	7.8	20.3	100.0
Lbs per acre	15.6	12.9	10.4
Total phosphate-P CIbs)	9293	215246	874807
Percent of yield	1.1	24.6	100.0
Lbsperacre	2.9	21.4	14.2
Diss. phosphate-P (lbs)	1515	3451	30175
Percent of yield	5.0	11.4	100.0
Lbs per acre	0.5	0.3	0.5

Table 44. Contribution of Court Creek Floodplain Subwatersheds to the Annual Stream Yields of the Entire Watershed

Stream basin	C2	C2-C7 floodplain	C10	N1	M1	S2
Watershed area (ac res)	61760	12320	10080	18720	6400	14240
Percent of watershed	100.0	19.9	16.3	30.3	10.4	23.1
Sediment Ctons)	461621	185638	50150	188914	26386	10533
Percent of yield	100.0	40.2	10.9	41.0	5.7	2.3
Tons per acre	7.5	15.1	5.0	10.1	4.1	0.7
Total ammonia-N (lbs)	228412	60936	38807	86791	20492	21386
Percent of yield	100.0	26.7	16.9	38.0	9.0	9.4
Lbs per acre	3.7	4.9	3.8	4.6	3.2	1.5
Diss. ammonia-N Clbs)	60149	14060	9437	19324	6818	10510
Percent of yield	100.0	23.4	15.7	32.1	11.3	17.5
Lbs per acre	1.0	1.1	0.9	1.0	1.1	0.7
Kjeldahl-nitrogen (lbs)	1851457	700163	209079	636677	165437	140101
Percent of yield	100.0	37.8	11.3	34.4	8.9	7.6
Lbs'per acre	30.0	5.7	20.7	34.0	25.8	9.8
Nitrate-N (lbs)	639392	144004	129909	244386	67342	53751
Percent of yield	100.0	22.5	20.3	38.2	10.5	8.4
Lbs per acre	10.4	11.7	12.9	12.0	10.5	3.8
Total phosphate-P (lbs)	874807	305814	215246	230974	61177	61596
Percent of yield	100.0	35.0	24.6	26.4	7.0	7.0
Lbs per acre	14.2	24.8	21.4	12.3	9.6	4.3
Diss phosphate-P (lbs)	30175	3756	3451	13446	5054	4466
Percent of yield	100.0	12.4	114	44.6	16.7	14.8
Lbs per acre	0.5	0.3	0.3	0.7	0.8	0.3

Table 45. Annual Sediment Yields of the Stream Basins and Subwatersheds of Court Creek

Stream Station	Stream basin area (acres)	Sediment yield (tons)	Subwatershed area (acres)	Subwatershed yield (tons)	Yield per subwatershed area (tons/acre)
C12	3200	2317	3200	2317	0.7
C10	10080	50150	6880	47833	6.9
C7	20960	142084	4160	65548	15.8
C4	42880	306785	2880	-24214	-8.4
C3	46080	392685	3200	85900	26.8
C2	61760	461621	1120	58403	52.1

stream alterations since 1940 (figures 28 and 29). The broken white lines indicate former stream channels, which have been converted to row crop fields during channelization efforts since 1940. Even prior to 1940, channelization was a common practice as evidenced in the 1940 aerial photograph, where a former stream channel of Sugar Creek can be seen west of the channelized stream. By 1979 there is no visible evidence of this channel in the row crop field. Stream surveys of Court Creek revealed major bank erosion sites in channelized stream segments. Seven bank erosion sites in the C2 and C3 subwatersheds (marked by Roman numerals in figures 28 and 29) were monitored in 1982. Physical and chemical characteristics of soils at major bank erosion sites along Court Creek are given in tables 46 and 47. In the eroding banks, Soil Conservation Service (SCS) personnel identified a sandy overburden of recent origin, a well-developed soil layer developed over thousands of years, and a sandy glacial outwash dating from the glacial ages. During collection of soils from the erosion sites, SCS soil scientist Bruce Houghtby made the following observations:

> At all locations a recent overwash was present. This layer varied from 8 to 36 inches in depth and was either sandy or loamy in general texture. The next layer was a developed soil in most cases. It was usually a silt loam or silty clay loam in texture and ranged from 24 to 72 inches thick. A third layer was usually observed. It was usually sandy but ranged from sand to silt loam in texture. This layer was observed at a depth of 48 to 84 inches below the surface. These soils were observed in the streambank cuts, which varied from 6 to 10 feet in vertical height.
>
> The top layer must be recent overwash. When I looked at the soil away from the bank (30+ feet), this sandy layer was not evident and the silty material was on the surface. This is an example of a natural levee forming close to the stream, where floods are more frequent and material is deposited at a faster rate. This top layer was also stratified with thin individual layers and showed no signs of development.
>
> The middle layer was a well developed soil. It had moderate structure and, therefore, must be thousands of years old in order to be this well developed. The layer usually had a silt loam texture.
>
> The bottom layer, when present, was stratified sandy material. But the individual strata were sand, sandy loam, loam, clay loam, and silt loam in texture. This layer must be very, very old since it is below a developed layer. This layer is possibly Wisconsinan in age. Even though the Court Creek watershed was never

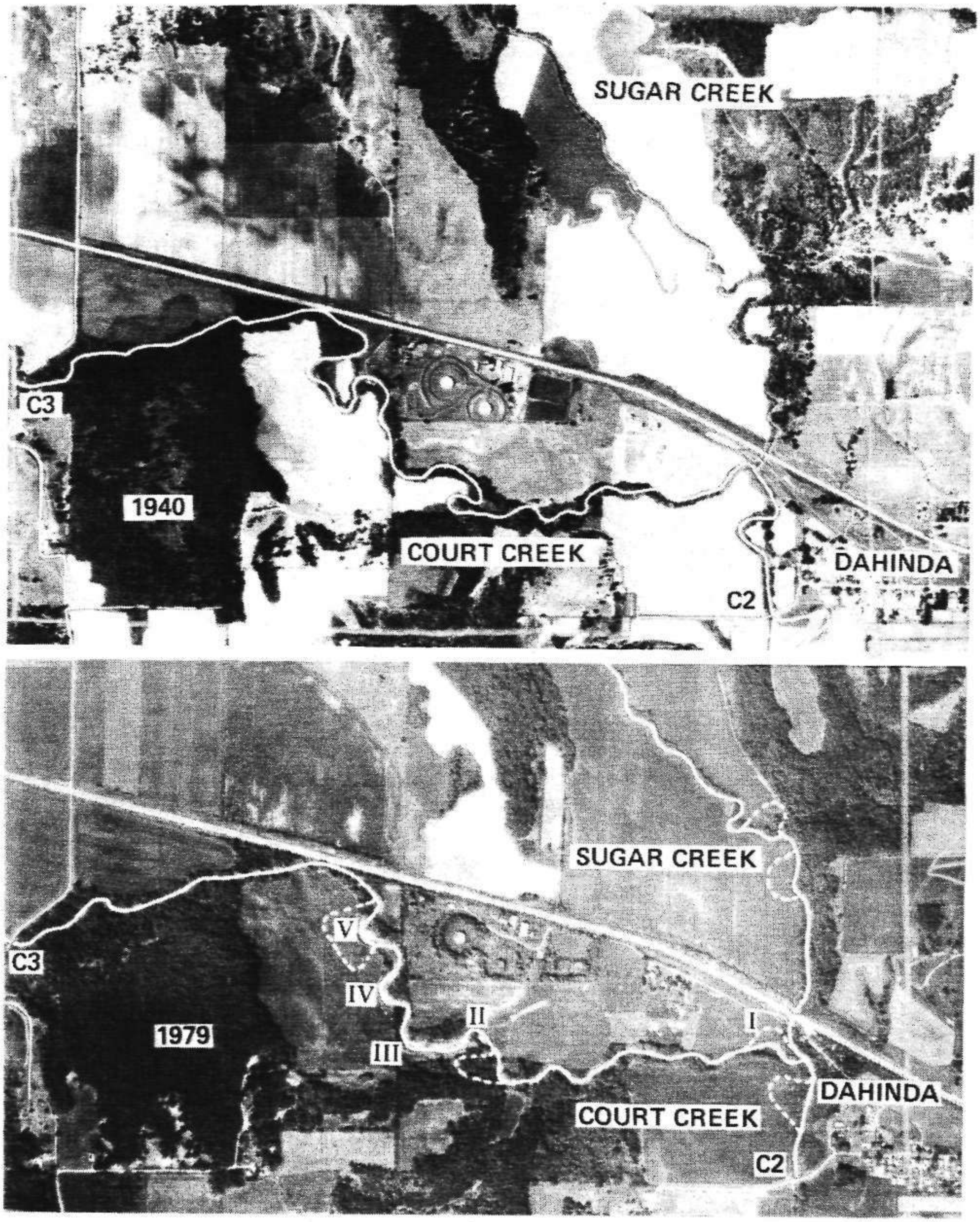


Figure 28. 1940 and 1979 aerial photographs of the C2 subwatershed with former stream channels and bank erosion sites marked (Dashed line represents the channel of the stream in 1940 that has subsequently been modified)

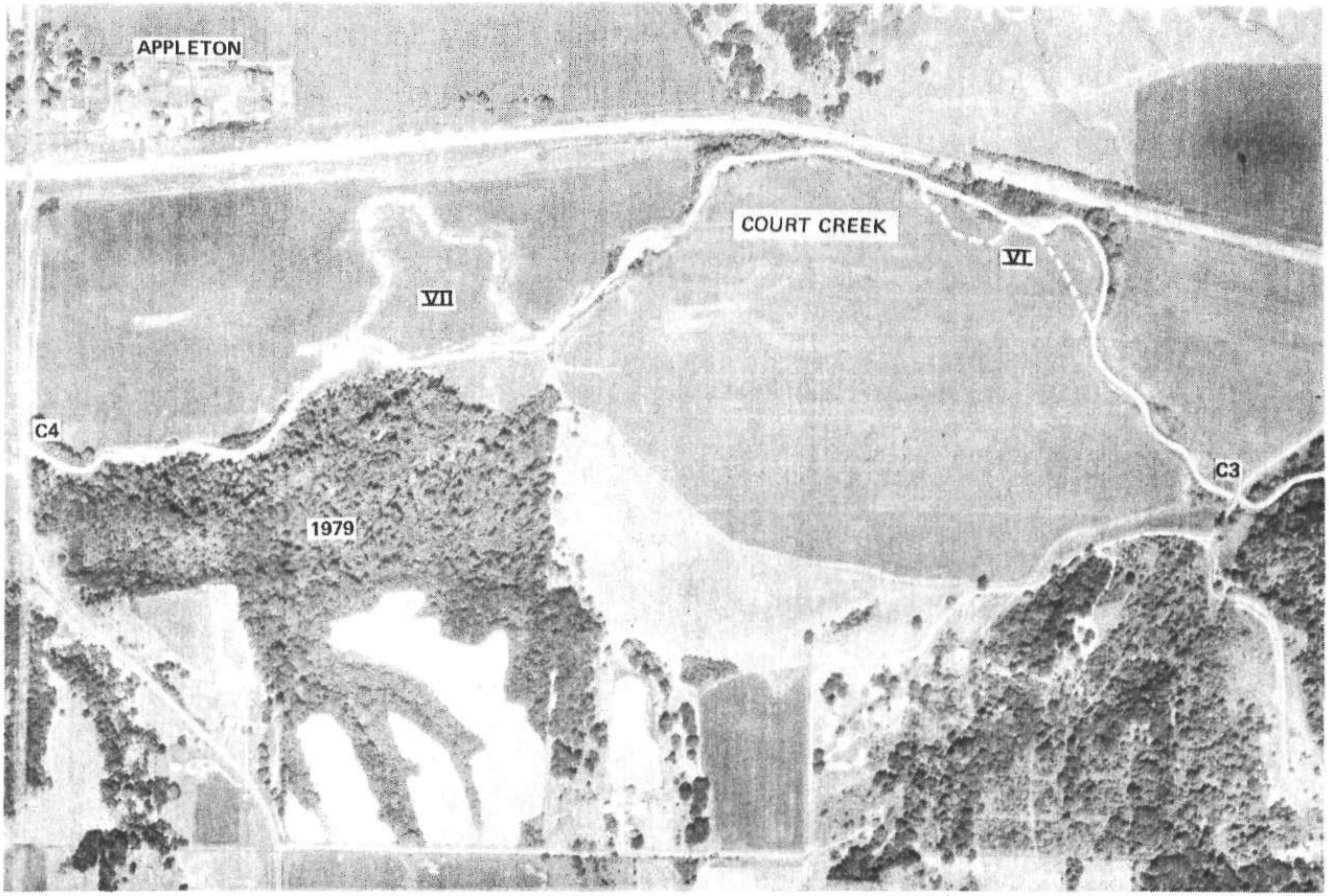


Figure 29. Locations of two major bank erosion sites on Court Creek between stations CZ and C4 (Dashed line represents the channel of the stream in 1940 that has subsequently been modified)

Table 46. Some Characteristics of Major Bank Erosion Sites on Court Creek, and Scope of Data Collection

Site	Soil series	Depth and Type of Material			Monuments
I	Huntswille (77A)	0-36" sandy overwash	36"-96" stratified loamy, sandy	*****	yes
II	Dickinson (87B)	0-36" sandy overwash	36"-96" stratified loamy, sandy		yes
III	Hun t sv	ille	(77A)		yes
IV	Huntsville (77A)	0-12" sandy overwash	12"-60" silty	60"-96" sandy	yes
V	Huntsville C77A)	0-36" sandy overwash	36"-84" silty	84"-96" sandy	yes
VI	Orion (415)	0-24" loamy overwash	24"-96" silty		yes
VII	Huntsville (77A)	0-8" loamy overwash	8"-72" silty	72"-96" loamy	yes
VIM	Huntsville (77A)	0-24" sandy overwash	24"-48" silty	48"-96" stratified sandy, silty	no
IX.	Huntsville (77A)	0-24" sandy overwash	24"-60" silty	60"-96" loamy	no

Table 47. Particle Size, Nitrogen Content, and Phosphorus Content of Soils at Some Major Bank Erosion Sites

[Site	Sand (percent)	Silt (percent)	Clay (percent)	Total ammo nia-N (ppm)	Total phosphate-P (ppm)	Kjeldahl-nitrogen (ppm)
II	21.5	58.8	19.7	74	1980	766
V	38.6	42.4	19.0	54	---	585
VI	31.6.	52.0	16.6	--	---	---
VII	32.9	49.0	18.1	51	3420	608
VI I I	41 .8	43.3	14.9	70	---	732
IX	48.3	37.3	14.4	63	---	795

> covered by the Wisconsinan glacier, the nearby Spoon River must have carried melt waters from the Wisconsinan glacier and could have deposited this material along the Court Creek floodplain.
>
> The soils at these sites would not be typical of the soil series in which they are included. Because of their close proximity to Court Creek, each soil had a varying amount of overwash on the surface and therefore [they] are not typical of the named soil series.

A 48-inch steel pin was driven into each bank layer following the method described by J.M. Hooke (1979) in his paper <u>An Analysis of the Processes of River Bank Erosion</u>. Six-foot wooden stakes were driven vertically into the stream bed and bank to mark each pin position. The location of each set of three pins was marked by a wooden stake placed 15 feet from the edge of the bank. Bank erosion measurements were made with a steel surveyor's tape after each storm. The weight of the eroded bank was the product of the length of the section, the height of the bank, the depth of erosion into the bank, and a unit weight of 90 lbs/cubic foot. SCS personnel from the Knox County soil survey supplied this unit weight during the Inspection of the eroding banks.

In addition, the seven sites were monumented and cross sections were established by transit and stadia. Cross-sectional areas of each bank erosion site were surveyed in May and October of 1982. At bank erosion site V, five cross sections were surveyed, so that the volume displacement of the eroding outside bank as well as the complete stream bed could be calculated. The number of tons of bank soil eroded at site V, as calculated by both the bank pin method of Hooke and by transit and stadia, is as foilows:

Hooke bank pins; outside bank only -- 1166

Transit-stadia; outside bank only -- 1398

Transit-stadia; entire stream bed -- 1787

In July 1982, floodwaters eroded more than 1150 tons of soil from bank erosion site V during one storm. The July storms also caused an extensive uprooting of very large trees, which hung up on sand bars and diverted much of the streamflow into stream banks and across row crop fields. In an attempt to assess the contribution of eroding stream banks to the sediment budget of large streams, the amounts of bank erosion from the seven monumented bank sites were measured during the next three storms. The total amount of bank soil eroded from all seven sites during the three storms is shown in column 4 of table 48.

Table 48. Amount of Sediment and Nutrient Storm Yields Eroded from Seven Bank Erosion Sites *

Type of yield	Storm date	Storm yield	Amount eroded from seven bank sites	Percent yield from eroded banks
Sediment	12/ 2/82	13387	1391	10.4
(tons)	12/24/82	13206	639	4.8
	4/ 1/83	33293	2551	7.7
T. ammonia	12/2/82	4569	166.9	3.7
(lbs.)	12/24/82	3524	76.7	2.2
	4/ 1/83	8470	306.1	3.6
T. phosphorus	12/ 2/82	37858	7511	19.8
(lbs.)	12/24/82	29311	3451	11.8
	4/ 1/83	53381	13775	25.8

* Calculated on a bank soil unit weight of 90 lbs/cu ft with an average soil content of 60 ppm ammonia-N and 2700 ppm of phosphate-P

Chemical analysis of bank soils for total ammonia and total phosphorus permitted the determination of the amounts of ammonia and phosphorus entering the stream with the bank soil Ccolumn 4, table 48). The soil samples were composites of individual soil probe samples taken on the vertical from the top of the eroding bank by SCS personnel. Approximately 10 grams of bank soil were placed in a liter of deionized water, so that the sample sediment concentrations would resemble the sediment concentrations at C2 during storm events. Chemical analyses of bank soils in solution were then performed in the same manner as for stream water samples during storm events. By chemically analyzing soils and floodwaters with the same method, the nutrient contribution of the eroded soils to the stream yield could be accurately determined.

The amounts of suspended sediment, total ammonia, and total phosphorus leaving the entire 61,760-acre watershed were determined by sampling segments of the rising and falling limbs of the hydrograph at the C2 sampling bridge. All stream samples were taken with a USGS depth-integrating DH-59 sampler from the middle of the bridge. For purposes of comparison, the chemical concentrations of the mid-bridge sample (D) and the chemical concentrations of samples taken at six other marked intervals across the bridge are given in table 49. From 8 to 20 samples were taken from the middle of sampling bridges during each storm event. The time periods which samples represent were determined by the rate in the rise or fall of floodwaters. When the rate of rise or fall was rapid, samples were taken as quickly as possible. Individual stream samples represented longer time periods for the April 1 storm when Middle Creek and North Creek were also sampled.

Sediment and nutrient yields (lbs) per sampling period (min) were determined as the product of streamflow (cfs), sample concentration (mg/l), time period (min) and a factor of 0.003747. The storm yields were the sum of the sampling period yields. Storm yields are given in table 48. Court Creek storm sediment yields are similar to those calculated by the U.S. Geological Survey during 1981 for Indian Creek (table 50), a 68-square-mile watershed located 20 miles from Court Creek (U.S. Geological Survey, 1982).

Bank erosion from just seven bank erosion sites represents a significant proportion of the sediment, phosphorus, and ammonia leaving the entire watershed at C2. These seven bank erosion sites represent 0.8 percent of the stream length for Court Creek and its three tributaries. Numerous unnamed tributaries in the floodplain subwatersheds, visible on the topographic maps in figure 6, also have severe bank erosion sites as they descend down the steep valley bluffs onto floodplain fields. Given the extent of bank instability found during stream surveys of Court Creek and its three tributaries, these seven sites are not estimated to contribute more than 10 percent of the total bank erosion occurring during major storms.

Table 49. Stream Station C2 Cross Section Samples, December 2, 1982

Analysis (mg/l)	A	B	C	D	E	F	G
Sediment	6620	7230	6970	6780	7050	6860	6650
T. phosphorus	7.78	8.73	9.14	8.58	9.32	8.84	8.77
T. ammonia	0.80	0.82	0.86	0.77	0.94	0.78	0.88

Table 50. 1981 Indian Creek Daily Sediment Yields

Date	Peak flow (cfs)	Sediment yield (tons)
April 14	1600	31,100
June 13	1280	12,800
June 24	1150	18,300
August 8	1650	10,800
August 15	2200	24,900

Since eroded bank soil from only seven sites represents 5 to 10 percent of the sediment yield in a 61,760-acre watershed, bank erosion would reasonably represent at least 50 percent of the sediment yield from the entire watershed. However, the high percentage of eroded bank soil introduced into the stream does not indicate that bank erosion is the only source of sediment in the watershed, only that the process of sedimentation is occurring as the streams overflow their banks onto the floodplain. Decreases in annual sediment yield in the larger floodplain subwatersheds were indications of the sedimentation process. Observations of sand deposits on stream border regions and silt in floodplain row crop fields were always made after overbank streamflows, just as deposits of silt were visible in roadside ditches along row crop fields in the upland plain.

As a result of chemical analyses of the eroding stream bank soils, the contribution of bank erosion to the total ammonia and total phosphorus stream yields could be determined. This contribution is illustrated in table 48. If the seven monitored bank erosion sites represent 10 percent of the bank erosion in the watershed, bank erosion will contribute 20 to 35 percent of the total ammonia yield. The storm yield of total phosphorus from only seven bank erosion sites was at least 12 percent of the total phosphate yield at C2. The estimated annual sediment and total phosphate stream yields from the Court Creek floodplain subwatersheds (table 44) also indicated a large contribution of sediment and total phosphate from these subwatersheds.

DISCUSSION

The four stream basins in the Court Creek watershed were divided into 16 subwatersheds, which represent the transition between the upland prairie landforms and alluvial floodplain landforms of Fehrenbacher et al. (1977) . The highest rates of surface water runoff resulted from the steep valley bluffs associated with the floodplain subwatersheds. During two years (1981 and 1982) with an above average number of high intensity rain events, the amounts of sediment and nutrients entering watershed streams during high streamflow events were measured. In each stream basin of the Court Creek watershed, runoff from floodplain subwatersheds was found to deliver major amounts of sediment, total phosphate, total ammonia, and Kjeldahl-nitrogen to the stream.

High velocity streamflows were found to erode stream banks into floodplain row crop fields and to deliver major amounts of sediment and nutrients to Court Creek. These bank erosion sites were found on channelized stream segments without riparian vegetation. Overbank streamflows would flow along former stream channels in row crop fields. Where streamflows were rapid, erosion on the stream bank and into the floodplain fields was severe. Where floodwaters would slow, sedimentation would occur.

The extent of channel modification in the floodplain subwatersheds is detailed in table 51 and in aerial photographs (figures 28 through 33). The conventional and generally accepted assumption is that artificial straightening, which increases the channel slope of a stream, causes an increase in the velocity of the water (Keller, 1976). The faster water then facilitates erosion of the stream bed and banks, increasing the sediment concentration until a new balance is established between the load imposed (sediment concentration) and work done to erode, transport, and deposit sediment.

Stream equilibrium conditions of natural channels have developed in response to water discharge regimes that are a function of the characteristic precipitation regime of the watershed, watershed vegetation, and other factors influencing the proportion of precipitation that runs off and enters the stream. Drainage modifications and changes in land use lead to altered discharge regimes and sediment loads, and consequently to changes in channel characteristics. In other words, the stream is changed from a system of long-term equilibrium to one of short-term instability. Channelization adds to the instability by further manipulating hydraulic variables so that whatever stability the system possessed is destroyed.

Landowners have modified streams to improve drainage of the land surface and to reduce bank erosion and other bank instabilities stimulated by the modification of the land surface with the advent of agriculture and urban development. Many landowners believe stream meanders are the cause of bank erosion and "straightened" streams will not erode. However, the increased velocity of surface runoff causes even greater erosion, particularly when stream banks are not stabilized. Karr and Schlosser (1981) state that these channelization activities create more instabilities in the aquatic environment which result in:

1) Rapid runoff, causing drastic fluctuations in the water levels of streams. These include floods during heavy rains and nearly stagnant conditions during dry periods. These conditions were observed on Court Creek. The primary complaint of floodplain row crop landowners is about flood damages caused by high velocity runoff moving across row crop fields, not about submergence of crops.

2) Loss of large volumes of nutrients and sediment from terrestrial ecosystems to aquatic ecosystems. These conditions were observed on Court Creek.

3) Increased fluctuations in stream temperature.

Table 51. Stream Length Reductions between 1940 and 1979

Stream segment	Stream length (ft) 1940	1979	Percent stream length change
C2 to C3	10,925	9,225	-16%
C3 to C4	8,650	7,725	-1 1%
C4 to North Creek	10,250	8,125	-21%
N1 to N2	8,775	8,375	-5%
N2 to N3	8,625	6.475	-25%
N3 to N4	8,890	7,675	-14%
M1 to M3	17,250	16,000	-7%
M3 to M5	12, 800	1 1 ,900	-7%

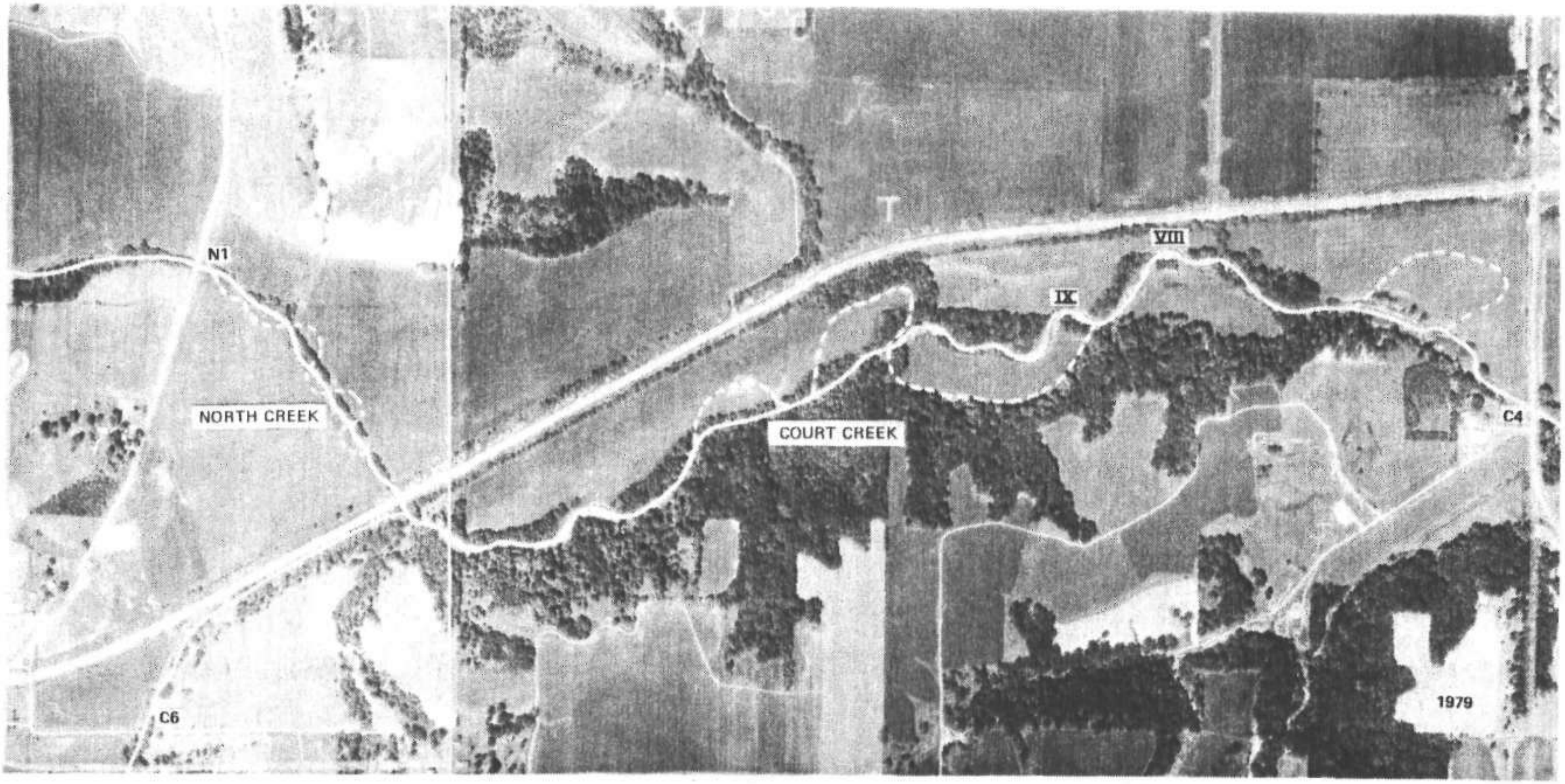


Figure 30. *Locations of two major bank erosion sites on Court Creek between stations C4 and C6 (Dashed line represents the channel of the stream in 1940 that has subsequently been modified)*

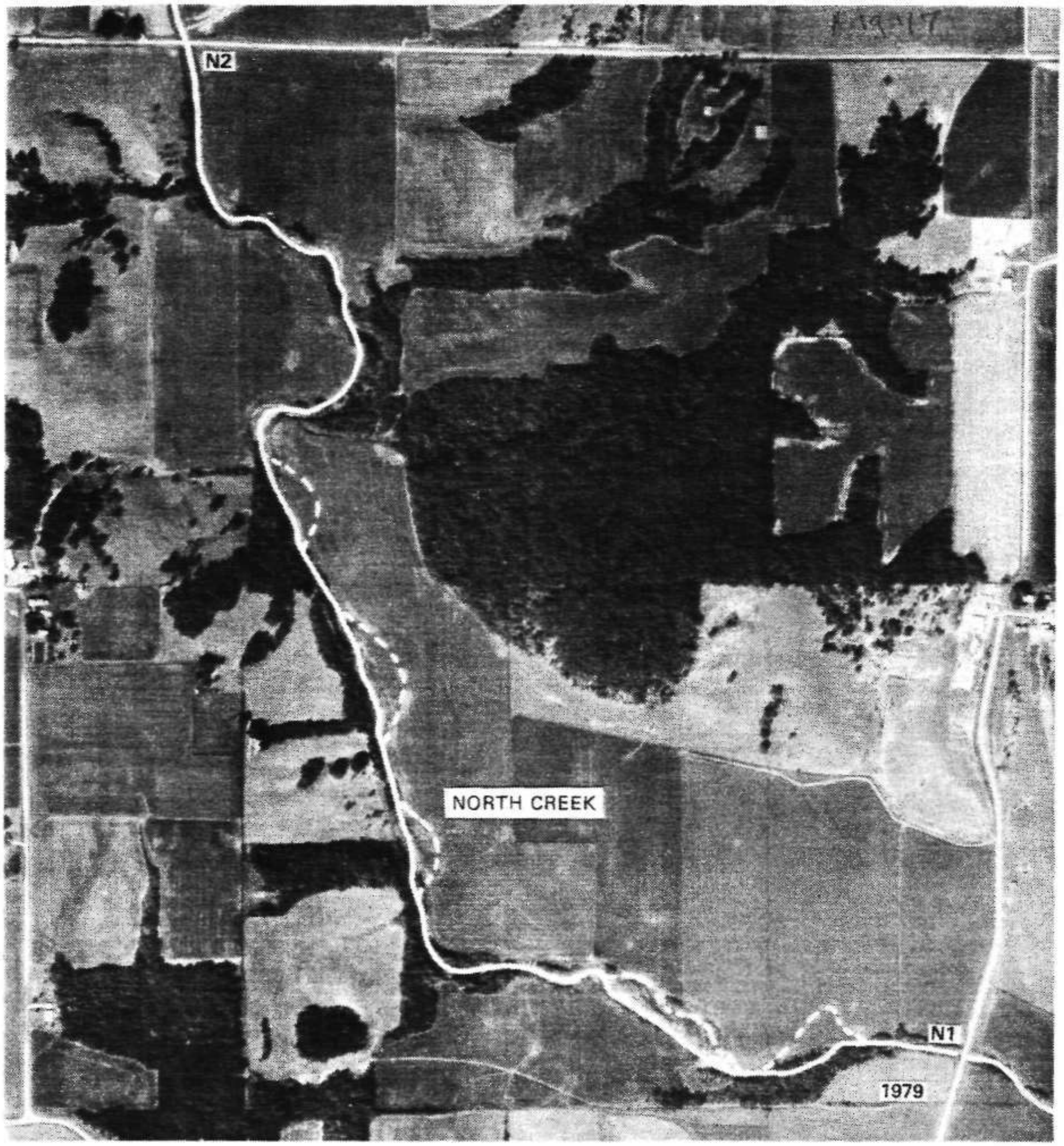


Figure 31. Channel modifications along North Creek between stations N1 and N2 (Dashed line represents the channel of the stream in 1940 that has subsequently been modified)

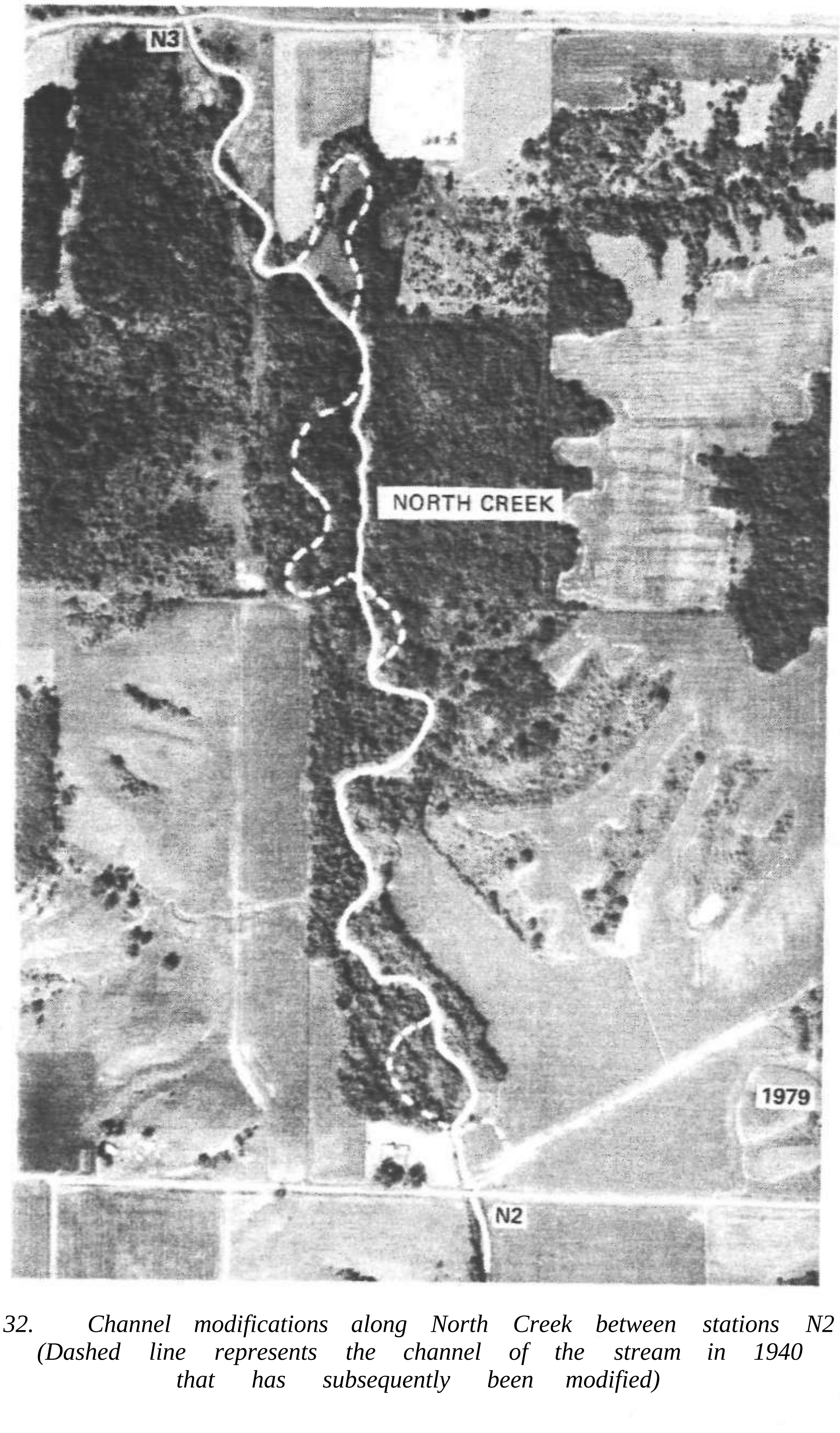


Figure 32. Channel modifications along North Creek between stations N2 and N3 (Dashed line represents the channel of the stream in 1940 that has subsequently been modified)

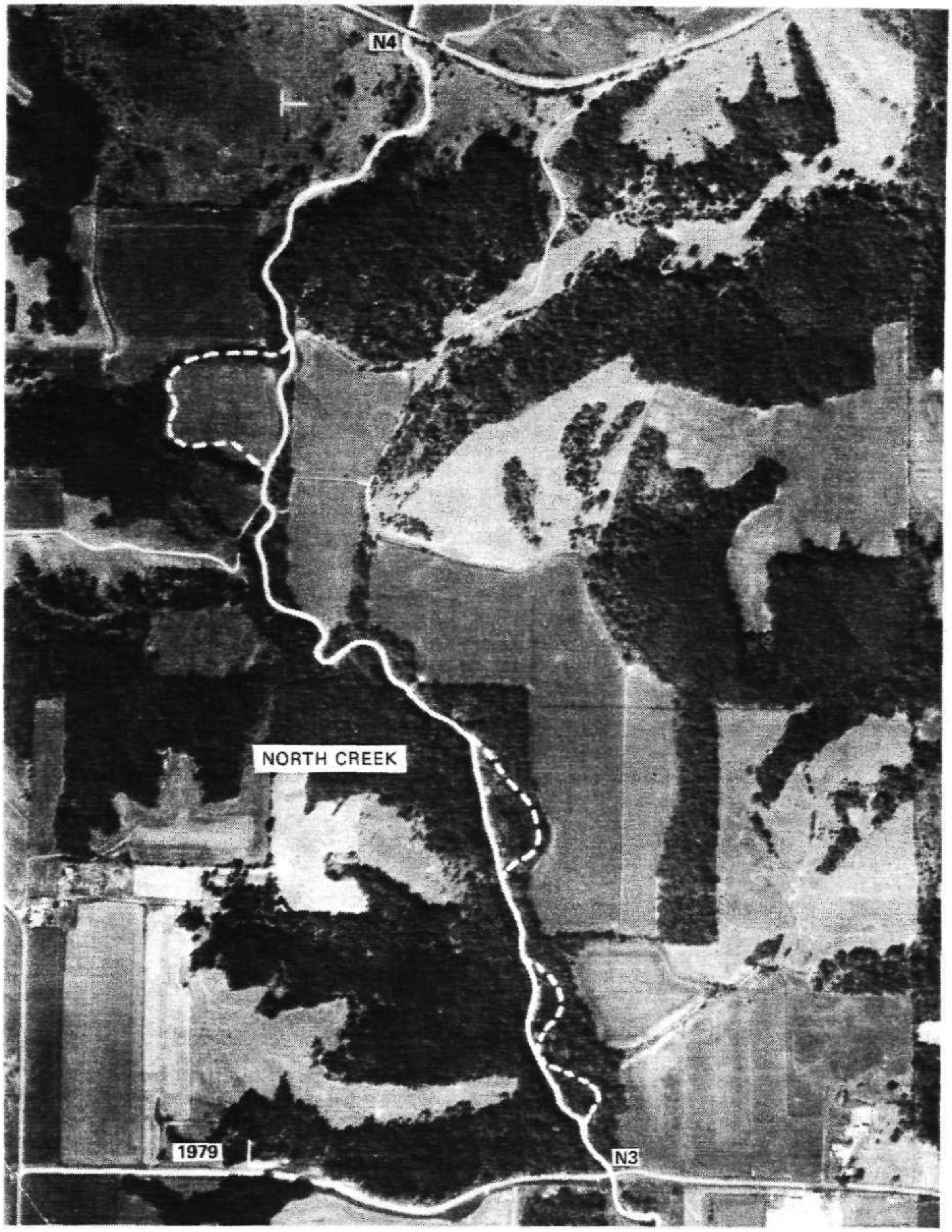


Figure 33. Channel modifications along North Creek between stations N3 and N4 (Dashed line represents the channel of the stream in 1940 that has subsequently been modified)

4) Increased stream bank erosion as the stream attempts to re-establish its equilibrium by forming pools, riffles, and meanders. These conditions were observed in Court Creek.

5) Decreased diversity and stability in the biotic component of the aquatic ecosystem due to the less stable environment. These conditions were observed in Court Creek by the Illinois Department of Conservation during the fish survey of Court Creek streams (Roseboom et al., 1983). Because deposition of fine sands covered instream fish habitat and decreased normal stream water depths, the lower sections of Court Creek contained few small gamefish when upstream sections contained smallmouth bass up to 2.7 lbs. Eroding bank soils contained a substantial amount of fine sand (table 47), especially in the lowest strata of sand and gravel.

In Illinois and other midwestern states, the extent and severity of the impact of bank erosion on water quality has only recently been discerned. Evans and Schnepper (1977) estimated that over 40 percent of the sediment in Spoon River in western Illinois resulted from bank erosion Leedy (1979) estimated that over 50 percent of the annual sediment yield of Illinois streams resulted from stream bed erosion. Using stream cross-sectional data, Lee et al. (1982) estimated that 50 percent of the sediment yield from the Blue Creek watershed in western Illinois came from the eroding stream bed. Through the use of an approved SCS field survey technique, Davenport (1983) estimated that only a small percentage of the sediment yield from the Blue Creek watershed resulted from bank erosion. Vagt (1982) estimated that 50 percent of the annual sediment yield in northern Illinois streams resulted from bank erosion. Hamlett et al. (1982) estimated that stream channel contributions of sediment to an lowa stream represent between 25 and 50 percent of stream sediment yield. Sharpley and Syers (1979) found that stream bank erosion and resuspension of stream sediment contributed the major portion of annual sediment and phosphate stream yields.

Wilkin and Hebel (1982) estimated that only a small fraction of soil eroded from upland row crop fields actually reached an Illinois stream. The vast majority of instream sediment resulted from floodplain and valley bluff erosion. Only one very broad row-cropped floodplain with pooled floodwaters had evidence of sediment deposition (similar to the C4 subwatershed). However, forested floodplain areas had very strong evidence of deposition. The forested floodplain had sedimentation rates of 10 to 20 tons per acre per year. Unfortunately most floodplain areas were row-cropped with no forested areas positioned to decrease sediment levels in runoff. The active floodplain row crop areas had estimated erosion rates of 15 to 60 tons per acre per year.

WATERSHED MANAGEMENT PLAN

Stream quality in the Court Creek watershed is determined for the most part by high-velocity surface water runoff from the steep bluffs eroding into prime farmland on floodplain soils Cfigure 34). Such high-velocity flows erode the stream channel into floodplain fields and scour field surfaces during overbank flows (figure 35). In addition nutrients and sediment from the steep bluffs are transported in the runoff. Repeated small-scale stream channelizations throughout the floodplain subwatersheds represent the efforts of farmers to divert floodwaters from eroding floodplain row crop fields. The combined effect of many small-scale channelization efforts is the unstable stream system now present in the floodplain. Unstable stream beds have been eroding through row crop fields because of the even higher rate of flow (energy) created by shortening the stream length. This is evident from a comparison of 1940 and 1979 aerial photographs (figure 28). The 1940 stream channel meander at bank erosion site V was removed during the 1940's to form a relatively straight channel from bank erosion site V to bank erosion site III. By 1979 three bank erosion sites (III, IV, and V) had been cut into row crop fields as the stream bed began to assume a meandering form. Note the increase of row crop field size resulting from the removal of the 1940 stream meander. Also note the loss of a similar sized row crop field at bank erosion site III between 1940 and 1979. Since 1940, bank erosion site III has contributed an average of 2000 tons of row crop soil annually.

In 1982, over 1,150 tons of prime row crop soil entered the stream from bank erosion site V during one storm. Since 30,000 to 40,000 tons of soil will pass from the entire 61,760-acre watershed during a large rainstorm (table 48), these bank sites are major contributors of sediment during periods of flooding. In this stream segment, both downstream fields and the fields along the straightened stream segment are eroding rapidly. This effect is important because channelization is regarded by many landowners and agencies as a major method of preventing bank erosion into floodplain row crop fields. Effects of stream channelization on stream and floodplain erosion have been summarized by Keller (1976) and also Apmann and Otis (1965). Leedy (1979) and Vagt (1982) have described increased stream channel erosion of Illinois streams resulting from increased rates of watershed drainage from agricultural land development.

In Knox County, the floodplains of streams no longer serve only as the sedimentation basins described by Fehrenbacher et al. (1977); instead, the floodplains have become primary sources of stream sediment. Wilkin and Hebel (1982) and Jackson and Wilkin (1980) have identified the active floodplain as the principal source of instream sediment and nutrients. Fehrenbacher et al. state that the floodplains were forested bottomland during the thousands of years of alluvial soil development from sedimentation. Wilkin and Hebel found

Figure 34. Runoff from steep valley bluffs causes high-velocity floods in floodplain subwatersheds

Figure 35. Floodwaters flow across floodplain row crops to reenter Court Creek

sedimentation occurring in forested floodplains and forested stream border bluffs. These conclusions led to development of a possible non-structural approach to reduce floodplain erosion by reducing the rate of runoff in Court Creek floodplains.

Sediment and nutrients are significant water pollutants only when the velocity of runoff waters can transport them to stream or lake locations in sufficient quantities to damage water quality and aquatic inhabitants by their presence. Erosion, sedimentation, and eutrophicat ion are natural processes when that delivery rate is slow. Of special significance then is the rapid rate of bank erosion into floodplain soils, which had developed from the process of sedimentation over thousands of years.

The Court Creek watershed management program is a water management program which proposes to slow high-velocity surface runoff across the land surface and in waterways on (1) the steep valley bluffs and (2) the flat floodplains. Rapid surface runoff from row crop, pasture, and woodland on the steep valley bluffs combines to create flood damages to prime farmland and stream resources in the floodplain. Consequently, effective watershed management programs combine the efforts of local, state, and federal agencies mandated to protect agricultural lands, reduce flood damages, regulate stream modifications, and enhance aquatic and riparian resources. The development of multipurpose techniques, which (1) reduce the rate of surface water runoff, (2) reduce on-site and off-site erosion damages in floodplain subwatersheds, and (3) increase wildlife habitat along the borders of the intensely cultivated upland prairies and floodplains, are the first steps in developing a non-point solution to non-point pollution.

The Illinois State Water Plan (Illinois State Water Plan Task Force, 1984) has determined that erosion and sediment control, flood damage mitigation, and aquatic and riparian habitat are critical water resource issues to Illinois residents. Lead Illinois agencies for each critical issue are the Illinois Department of Agriculture Cerosion and sediment control), the Illinois Department of Transportation - Division of Water Resources (flood damage mitigation), and Illinois Department of Conservation (aquatic and riparian habitat). The State Water Plan describes the unquantified link between soil erosion and water quality as a difficulty in assessing the improvement of water quality by erosion control methodology. The Court Creek study was designed to quantify the links between water quality and soil erosion in watersheds with high-velocity runoff in floodplain streams. Such watersheds are common in the Illinois River basin.

In the Illinois State Water Plan (Illinois State Water Plan Task Force, 1984), the Division of Water Resources states that flood damage mitigation requires a vigorous program of structural and non-structural measures at all levels of government. In order to be economically feasible for local landowners and government agencies, efforts to reduce the rate of surface runoff in the Court Creek watershed will require non-structural land treatment with limited structural expenditures.

Slowing the Rate of Runoff from Steep Valley Bluffs

Runoff from pasturelands in the steeply sloping valley bluffs could be slowed by converting pastures to woodlands, which would have high economic value. Even contour plantings of dense herbaceous vegetation Cas hill prairie grasses) around the base of slopes (figure 34) would slow surface runoff. Through a 1985 ACP Special Project, agricultural agencies offer landowners cost sharing for practices to convert row crops and pastures to permanent vegetative cover and also to plant trees. (Descriptions of ACP Special Projects and other financial aid programs available through county offices of state and federal agencies are included later in this report.) Other ACP land practices such as no-till corn planting and terraces are effective measures for those row crop areas along the valley bluffs.

An SCS program," Plant Materials for Conservation," provides shrubs and trees for field testing at demonstration sites. Large-scale production is conducted by cooperating commercial producers in conjunction with Soil Conservation Districts, State Agricultural Experiment Stations, and other agencies. Over 150 varieties of grasses, legumes, shrubs, and trees are readily available for conservation purposes such as stream bank protection, surface-mined land reclamation, wildlife food and cover, and beautification. State and federal agencies and cooperators in conservation districts are eligible for plant field testing.

The Department of Conservation also has a program of providing tree planting stock at low cost for the promotion of forestry programs. In Illinois, this program makes seedlings available at reasonable price (cost or below) for use on the almost 2,000,000 acres of idle, open, submarginal state and private lands needing revegetation to produce forest products, wildlife habitat, and land stabilization, thereby enhancing watershed and environmental values. Order blanks are available from local offices of the Department of Conservation or the SCS.

The Illinois Department of Conservation promotes a Wildlife Habitat Development Program, which provides technical assistance to promote the development and improvement of wildlife habitats. The program focuses on individual private farms and is coordinated with the Illinois Department of Agriculture soil conservation and watershed development programs. Any soil and water conservation district is eligible.

Rains (1977) has described the effectiveness of low-cost brush dams to slow gully runoff, increase sedimentation, and create favorable tree planting sites. In the highly erosive loess soils in the Yazoo River watershed, brush dam construction costs ranged from $45 to S135 per acre. Tree seedlings planted behind brush dams grew 27 percent more than seedlings planted in the surrounding landscape. The higher initial cost of preparing a brush dam is often offset by savings on replanting. Over 800,000 dams were constructed.

The construction of small low-cost water impoundments and shallow water areas for wildlife in gullies draining the steep borderlands would not require prime farmland in the floodplain. These impoundments would also slow the rate of runoff and create wetland game habitat. Dense vegetative growth (especially woody vegetation) should be encouraged above and below the impoundments so that resistance to high velocity flows continues even after the impoundments fill with sediment. Such practices are available for the Court Creek watershed through the 1985 ACP Special Project.

The effectiveness of non-structural and limited-scale structural techniques on surface runoff from steep valley bluffs should be determined on small-scale pilot project areas such as the M1 subwatershed or the S2 subwatershed. These subwatersheds contribute a disproportionate amount of streamflow and instream constituent yields to Middle Creek and Sugar Creek. Both subwatersheds have excellent locations for streamflow gaging stations upstream and downstream. Both subwatersheds define the floodplain land use effects on stream quality and both have limited areas so that pilot studies are practical. The effectiveness of limited structural and non-structural practices should be determined by landowners and specialists from the areas of agriculture, hydrology, water quality, and aquatic resources.

Slowing the Rate of Surface Runoff in the Floodplain

A survey of floodplain landowners found that more damage complaints resulted from high-velocity floodwater through row crop fields than from submergence of crops. Even on floodplain row crops downstream of stream station C2, landowners sustained more damage from high-velocity Court Creek floodwaters than from submergence by the backwaters of the Spoon River. Hydrographs of intense rainstorms (figures 16 - 19) revealed the rapid rise and fall of floodwaters at stream gaging stations. Stream channelization increases the flood peak height and velocity. Levees or very large impoundments are often proposed to reduce the damages resulting from these high velocity floods when the cost-benefit ratio is favorable. Levees are placed on stream borders to keep floodwaters within the stream channel and away from floodplain fields. Floodwater-control impoundments slowly release floodwaters so that streamflow velocity is reduced. Upstrearn floodplain lands serve as a temporary reservoir. In the

Court Creek watershed and many other watersheds, the cost-benefit ratio of such large constructions is not favorable CHartman, 1984).

A dense strip of woody vegetation is proposed along the stream corridors to direct high-velocity waters to the center of the stream channel and away from stream banks and row crop fields. While floodwaters will enter the row crop fields, the velocity of the overbank stream currents would be reduced. Sand deposition would occur within the riparian vegetation and not in row crop fields. The increase of woody vegetation along the high-flow stream channel will increase resistance to high-velocity flows and slow the rate of runoff in floodplain streams. However, the middle of the stream channel will still receive high-velocity streamflows, which limit sedimentation in the channel. Removal of obstructions and potential obstructions to streamflow is necessary so that drainage of floodplain row crop fields is not hindered.

The stability of stream segments, even channelized stream segments, that have a woody perimeter is illustrated in figure 28. Between the rapidly eroding bank site V and sampling station C3, the straightened stream channel maintained its morphology from 1940 to 1979. That stream segment is characterized by a well developed border of woody vegetation on both stream banks (figure 36). There are fewer bank erosion sites and the sites are smaller than in upstream or downstream stream reaches without woody riparian vegetation. High velocity streamflows are channeled away from the stream banks into the center of the stream bed. These dense continuous stands of trees (not isolated groups of trees) reduce the velocity of overbank streamflows entering the adjacent row crop fields. Large sand bars are deposited among the trees, unlike the depositions of sand occurring in upstream and downstream row crop fields. Any stream management program should include the establishment of a protective green border along high velocity segments of the stream if only because it is the most economical form of bank protection to apply and maintain. Isolated trees increase the erosion of bank soils during high-velocity floods. Stands of trees are required along the stream bank.

Reductions in the rate of runoff will lengthen the time of flooding in the floodplain fields while reducing the velocity of overbank streamflows. If prolonging the submergence of upstream floodplain fields from 12 hours to 24 hours is acceptable to local landowners, promoting woody vegetation will slow strearn flows along the entire stream length and cause floodwaters to stand in the very broad floodplain valley. Row crop landowners in the floodplain below stream station C2 undergo longer periods of field submergence routinely. The pooled floodwaters, upstream of the raised Appleton blacktop roadway, increased sedimentation in the C4 subwatershed. However, row crop lands in the C4 subwatershed floodplain benefited from the fine sediment deposited by the pooled floodwaters according to the landowner of thosefields.

Figure 36. Stable stream channel with dense growth of woody riparian vegetation

In the Illinois State Water Plan (Illinois State Water Plan Task Force, 1984), the Illinois Department of Conservation states that the losses of riparian habitat are a major cause in the aquatic resource degradation of Illinois streams. Techniques of stream restoration or renovation have been applied successfully in other states (Nunnally, 1978; Keller, 1976) in place of channelization. These methods promote runoff within the stream channel while retaining much of the woody vegetation and stream meanders. Drainage is enhanced by removal of trees, which are or soon will be large obstructions to floodwaters in the main stream channel.

Maintenance also includes the removal of large trees on the stream bank, when such trees will be eroded into the stream channel. Such trees can be placed as retarders along the eroding stream bank to divert streamflow into the center of the stream bed. The conversion of a potential flow obstruction into a low-cost tree retarder is an old soil conservation technique (Lester, 1946), which has received added emphasis as a Palmiter river restoration technique (Willeke and Baldwin, 1982). The removal of eroding trees from the bank and from the stream channel should follow guidelines established by the Illinois Department of Conservation (IDOC, 1982) and the American Fisheries Society (1983). Stream maintenance programs should also remove such trees and plant trees recommended by the Illinois Department of Conservation and the Soil Conservation Service. Table 52 gives a list of recommended trees and shrubs. Snagging operations should follow the recommendations of the Illinois Department of Conservation (1982) and should involve only the use of chain saws where possible.

In the Court Creek watershed, major bank erosion sites and complete blockages of streamflow resulted when large trees were uprooted and fell into the stream. Even streamflows resulting from a 3-inch rainstorm did not dislodge these trees (figure 37). Such occurrences are the major reason that floodplain landowners do not teadily accept "green belts" of trees along streams. Only with an annual stream maintenance program will stream borders of woody vegetation be accepted by landowners.

If stands of trees are to be established on the severely eroding stream banks, then bank stabilization structures (at least temporary ones) will have to be constructed. Most bank erosion areas can be stabilized with tree plantings and with additional temporary structures such as tree retarders, willow jetties, and Kellner jacks (figures 38 - 41). These temporary structures slow the velocity of stream waters and allow sediment deposition near the bank. Such structures are described in technical publications by the Illinois Department of Conservation (1982), the Soil Conservation Service (Kautz, 1979), the U.S. Army Corps of Engineers (1980) and the U.S. Fish and Wildlife Service (Schnick et al., 1982). As a secondary phase, willow

Table 52. Recommended Vegetative Stream Bank Cover

Common name	Scientific name	Plant description	Habitat description
Willow*	Salix species	Thicket-forming deciduous plants	Wet soils
Alder	Alnus rugosa Alnus serrulata	Fast growing, nitrogen-fixing large shrubs	Poorly drained soils
Chokeberry	Aronia arbutifolia Aronia melanocarpa	Shrubs with white flowers, wildlife food value	Moist or wet soils
Holly	Ilex decidua Ilex verticil lata	Large dioecious shrub	Wet, acid soils
Buttonbush	Cephalanthus occidentalis	Fast-growing shrub	Swamp soils
Flowering dogwood	Cornus florida	Small, wildlife food value	Shade tolerant
Hornbeam	Carpinus carolihiana	Adaptable understory tree	Tolerant of wet and shady sites
Red maple Silver maple	Acer rubum Acer saccharinum	Fast growing	Water tolerant
Pin oak Red oak	Quercus palustris Quercus boreal i 3	Fast growing	Water tolerant

* The Soil Conservation Service (1978) has recommended a willow (Salix purpurea) for bank stabilization of large streams

Figure 37. Large trees block stream channel in Court Creek

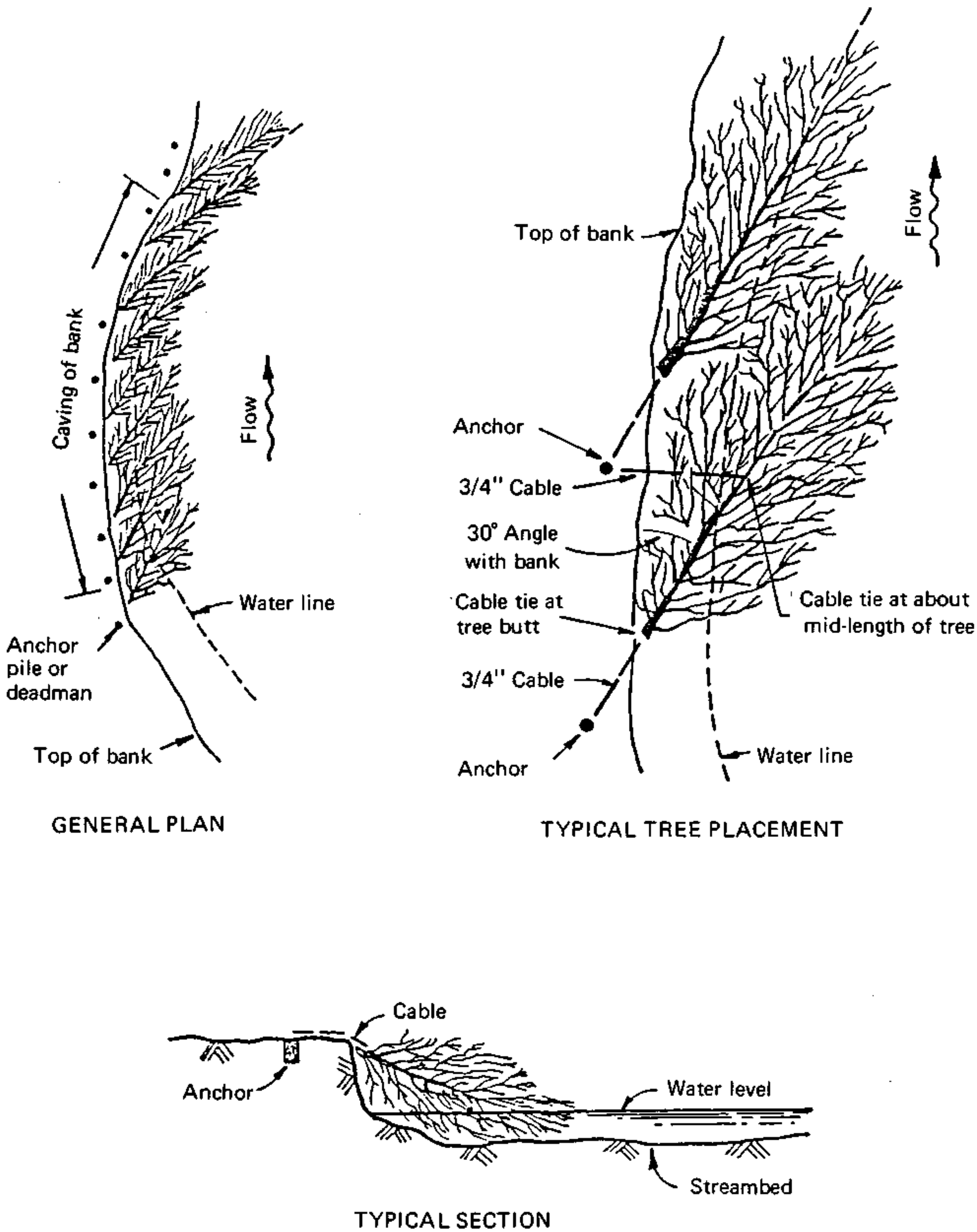


Figure 38. Tree retarder placement on eroding stream bank

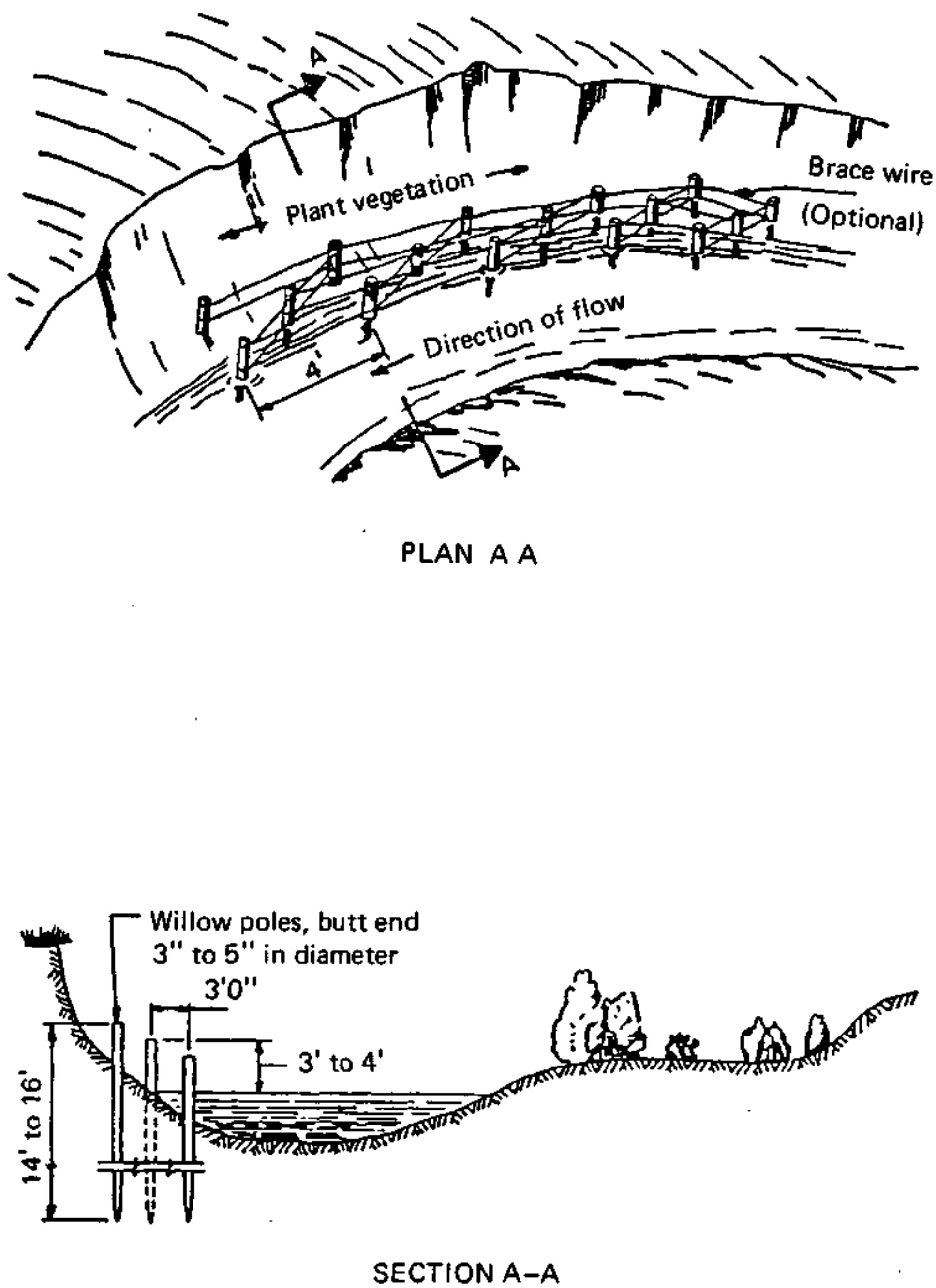
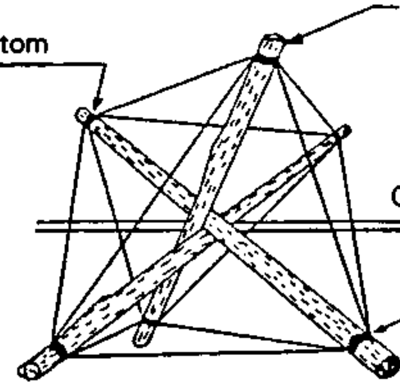
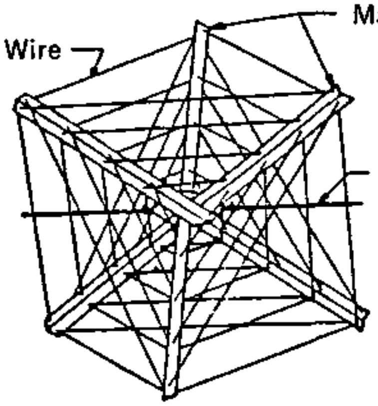


Figure 39. Jettied willow pole bank protection



LOG JACK



METAL KELLNER JACK

Figure 40. Construction of Kellner jacks

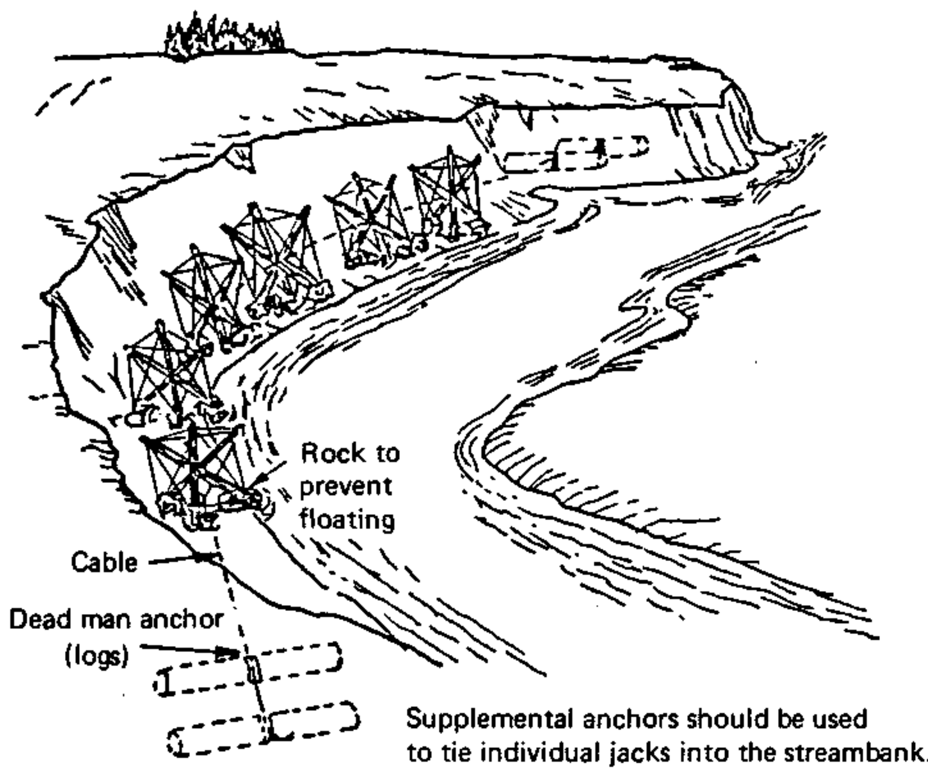


Figure 41. Placement of Kellner jacks on eroding banks

plantings should be made in the deposited sediment. The temporary structures protect tree plantings until the vegetation is established. Larger trees should be planted higher on the bank, so that willows will die out after the green belt is established. This process will lessen the chances of willows reducing stream channels by growth during drought periods.

These floodplain restoration techniques have low material costs but are labor intensive. The Palmiter river restoration technique (Willeke and Baldwin, 1982) is one type of low-cost stream maintenance. Landowners can meet a major portion of the cost of these bank stabilization costs with their own labor and machinery. Such low-cost methods are very important to the long-term maintenance of high quality streams by the local landowner.

A preliminary survey of the Court Creek watershed by George Palmiter (Willeke and Baldwin, 1982; Willeke and Baldwin, 1984) found severe bank erosion sites where the Palmiter river restoration techniques are not likely to work. The application of Kellner jacks or riprap should be attempted at such sites when desired by the landowner. Severe bank erosion sites must be protected from undercutting by floodwaters. This is especially true at bank erosion sites similar to V, VI, and VII since the earth-filled portions of former stream meanders are highly susceptible to bank erosion. Erosion of the stream channel into the former meander allows additional erosion to occur in the relatively stable bank soils immediately downstream. The stable downstream bank protrudes into the newly eroded stream channel and becomes very susceptible to further erosion. The Soil Conservation Service offices in California and Arizona have developed methods to limit construction expenditures at severe sites by incorporating tree cuttings (Soil Conservation Service, 1983). Some tree species such as willow and cottonwood are able to regrow from cut sections of branches. Large-diameter tree cuttings of willow and cottonwood species are placed into the ground-water table of the stream bank. Such deep placement requires long cutting lengths (6 to 10 ft). Formations of these cuttings serve as jetties or jacks along eroding stream banks and levees (York, 1985).

The addition of riprap may be essential to protect the unstable earth of the former stream meanders. Schultze and Wilcox C1985) have described California Soil Conservation Service practices of bank stabilization in conjunction with willow plantings. These permanent modifications are suggested only for degraded areas of Court Creek streams, where severe bank erosion and reduced fish habitat have been defined. Since the point bar directs the flow of water into the former stream meander, riprap should extend from the base of the eroding bank into the stream channel (figure 42). The stream channel should pass through the extended point bar along the edge of the riprap. This will reduce the broad sand point bar of major bank erosion sites. Deposition of sediment should be promoted on the outside bank and

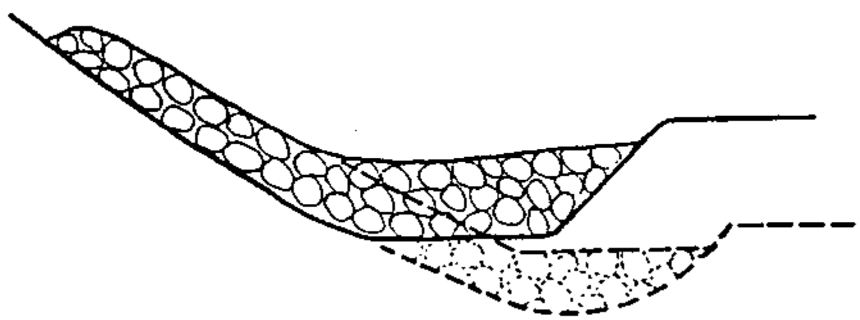


Figure 42. Placement of riprap for bank toe protection

restricted on the inside curve of the bank erosion sites. The present wide cross-sectional area and heavy inflow of bank soils promote the deposition of sand on the point bar. Since restricting the lateral cutting of stream banks often initiates the downcutting of stream bed materials, end sills should also be applied across the stream bottom to prevent downcutting from extending up the stream channel. These structures should be used in combination with vegetative stabilization of the upper banks. Stream bed modifications are recommended only for those sites which are already degraded and can not be treated by less expensive methods.

Initial floodplain projects to stabilize stream banks and to slow the rate of overbank streamflows should be pilot studies in small subwatersheds. The subwatersheds should include S2 or Ml where the rates of bluff runoff are to be reduced. In addition the floodplain stream restoration techniques should be tested in subwatersheds with high-velocity streamflows CC2, C3, or N2) in order to determine site-selection criteria. These subwatersheds can be monitored for streamflow, water quality and fishery responses to the land and stream management techniques in the floodplain and adjacent stream valley bluffs. Stream lengths within the subwatersheds are short enough for pilot demonstrations of restoration techniques. Once successful methods are found, the most cost-effective stream restoration techniques *can* be applied on a larger scale to the entire watershed.

In the state of Illinois, any streamside construction plans may be reviewed by the U.S. Army Corps of Engineers, the Illinois Environmental Protection Agency, or the Illinois Department of Transportation - Division of Water Resources. Depending upon the nature and extent of the project, authorization may be required by one or more of the above agencies. In addition to these three regulatory agencies, the Illinois Department of Conservation, the U.S. Fish and Wildlife Service, and the State Historic Preservation Officer may also be asked to review any permit to insure that all aspects of natural and cultural resources are considered. All stream activities - channelization or bank stabilization structures - in the Court Creek watershed should be reviewed by these agencies. Watershed management plans will have a better chance of success if the expertise of the respective agencies is followed.

In 1968, the Corps of Engineers expanded the list of factors, besides navigation, to be considered in permit applications. These factors were fish and wildlife, conservation, pollution, aesthetics, ecology, and the general public interest. The Federal Water Pollution Control Act Amendments of 1972 Cthe Clean Water Act) established a permit program for discharges of dredged and fill materiai into streams. Section 404 of the Clean Water Act defines fill material as replacement of an aquatic area by dry land or changing of the bottom elevation of a water body. The streams affected by the expansion of Section 404.include rivers and streams that are used, were used, or might be used in interstate commerce. The tributaries and adjacent marshlands of such navigational streams are also regulated, as are any intrastate waters whose pollution might affect interstate commerce.

Section 404 permits must be reviewed by the Illinois Environmental Protection Agency (IEPA) for dredge and fill activities that may result in a discharge into navigable water. No permit may be issued by a federal agency until certification has been obtained from the IEPA.

The Division of Water Resources (IDOT-DWR) regulates waterway activities to protect the public interests from various adverse effects including potential flood damages, obstructions to navigation, improper encroachments, and unnecessary damages to the natural conditions of Illinois water. The authority to regulate is the Illinois Revised Statutes, Chapter 19, Sections 52-78: "An Act in relation to the regulation of the rivers, lakes, and streams of the State of Illinois." Permits are required for construction or filling activities in, or within the floodway of, any strearn with a drainage area of 1 square mile or more in urban areas and 10 square miles or more in rural areas.

Both the U.S. Fish and Wildlife Service and the Illinois Department of Conservation review permit applications submitted to the U.S. Army Corps of Engineers. Section 320.4(c) of the Federal Clean Water Act specifies that the Corps "will consult with the Regional Director, U.S. Fish and Wildlife Service, ... and the head of the agency responsible for fish and wildlife in the state in which the work is to be performed [the Illinois Department of Conservation] with a view to the conservation of wildlife resources by prevention of their direct or indirect loss and damage due to the activity proposed in a permit application." The basis of this consultation is contained in the Fish and Wildlife Coordination Act (16 USC 661---666c). The IDOT-DWR also has asked the Department of Conservation to review water-related construction projects.

Watershed Restoration Programs and Agencies

Local Programs

The Knox County Soil and Water Conservation District is one of 98 locally organized and operated units of government that promote the protection, maintenance, improvement, and wise use of soil and water. The district has the following powers:

1) Conduct surveys, investigations, and research on erosion, floodwater, and sediment damage, including control and preventive measures.

2) Carry out preventive and control measures in the district with the consent of the landowners.

3) Cooperate or enter into agreements to furnish financial or other aid to any agency, owner, or occupier of lands within the district in carrying on erosion control and flood prevention.

4) Make available to land users the use of agricultural or engineering materials and equipment for erosion control purposes.

5) Sponsor and manage any soil and water conservation project within district boundaries.

6) Develop and adopt a soil erosion and sediment control program and standards which are technically feasible, economically reasonable, and consistent with the state program and guidelines developed by the Illinois Department of Agriculture.

Soil and Water Conservation Districts require landowners to be cooperators in the district before assistance is given. This includes the completion of an application form with the landowner's name, address, number of acres, and description of the land's location. The district can get loan assistance from the Farmer's Home Administration (FmHA) for watershed protection and flood prevention.

Loan funds may be used to help local sponsors provide the local share of the cost of watershed improvement for flood prevention, irrigation, drainage, water quality management, sedimentation control, fish and wildlife development, public water-based recreation, and water storage and related costs. The total amount of watershed loans outstanding in any one watershed cannot exceed $10,000,000. A time limitation is not specified for the use of FmHA loan funds. Funds will be awarded when all FmHA requirements are met, and the project can be completed on a timely basis. Funds may be advanced on an as-needed basis by FmHA. The range of loans runs from $4,000 to $5,450,000 with an average of $363,000.

To be eligible for a watershed loan, an applicant must: I) be a sponsoring local organization, such as a municipal corporation, soil and water conservation district, or other organization not operated for profit in the approved watershed project; and 2) have authority under state law to obtain, give security for, and raise revenues to repay the loan and to operate and maintain the facilities to be financed with the loan. Assistance is authorized for eligible applicants in approved watershed areas. The applicant must have evidence of legal capacity, economic feasibility, and financial responsibility relative to the activity for which assistance is requested.

Applications are subject to state and areawide clearinghouses' review pursuant to procedures in Part I, Attachment A, of OMB Circular No. A-95 (revised). The standard application forms as furnished by the federal agency and required by OMB Circular No. A-102 must be used for this program. An environmental impact assessment is required for this program. Pre-application Form AD-621 is filed at county or district FmHA offices from which assistance is sought. After the pre-application has been reviewed by the District Director, it is forwarded to the FmHA state Director for review and processing instructions. Following review by the state Director, the applicant is notified about eligibility, availability of funds, and if an application should be filed. Upon favorable approval of a complete application package, funds are made available to the District FmHA Director for delivery. Notification of the awards must be made to the designated state Central Information Reception Agency in accordance with Treasury Circular 1082.

There are no deadline dates for this program. Approval or disapproval should be known within 30 to 60 days. If an application is rejected, the reasons for rejection are fully stated. The applicant may request a review of the decision from the next higher management level of FmHA.

<u>Resource Conservation and Development (RC&D) Councils</u> were formed as a result of the Food and Agricultural Act of 1962, Public Law 87-703. Knox County is in the Prairie Hills RC&D group. The following are among the many RC&D functions:

1) Develop land and water resources for agricultural, municipal, or industrial use.

2) Carry out such measures as critical area management, flood prevention, soil and water management for agriculture related pollution control, and public water-based fish, wildlife, and recreation development.

3) Reduce pollution of air, water, and soil.

4) Speed up conservation work on individual farms, other private lands, and public land.

5) Make needed adjustments in land use by converting poorly suited cropland to more beneficial uses, such as pasture, woodland, wildlife, and recreational land.

RC&D is a locally initiated, sponsored, and directed program usually covering several counties which have similar problems and opportunities in regard to their natural resources. An RC&D council is made up of representatives from the various sponsors in the RC&D area. In Illinois, councils generally include members from local soil and water conservation districts and county planning boards or commissions. The exact makeup of the councils, as it relates to the sponsoring units of government, may vary among RC&D areas.

An RC&D measure is a proposed activity which is adopted by an RC&D council as a method for accomplishing its goals and objectives. By adopting the proposal, the council makes a commitment to help move the measure forward to completion by assuming either an active supporting or leadership role in working with sponsors of the proposed measure.

Measures which can receive financial assistance through the RC&D program of the Soil Conservation Service (table 53) include critical area treatment, flood prevention, farm irrigation, land drainage, soil and water management for agriculture related pollutant control, public water-based fish and wildlife and recreation development, water quality management, and accelerated services for solving conservation problems.

Associated measures are those carried out with resources from sources other than RC&D. These may include accelerated forestry assistance, funding rural water supply or solid waste disposal systems, holding workshops and seminars, developing new markets for local products, enticing industry into the area to use important resources, developing non-water based recreational areas, etc.

A proposal for an RC&D measure may be submitted to the council by individuals, agency representatives, special interest groups, organizations, or council members themselves.

Following are key steps in the planning process for RC&D measures. Not all steps will apply to all measures, and in some cases additional steps may be needed.

1) Present proposed measure to the RC&D council.

2) Establish the feasibility of the proposal.

3) Adopt the proposal. Evaluate priorities -- enter into short-term plan (consult with SCS representatives).

4) Prepare preliminary investigation report and initial environmental assessment.

5) Deliver preliminary report to sponsors.

6) Complete A-95 Review Procedures.

7) Make formai request to SCS state conservationist for planning and installation assistance.

8) Schedule work with sponsors to prepare the plan.

Table 53. RC&D Cost-Sharing Schedule

Purpose	Technical service maximum (percent)	Financial assistance
1 Critical area treatment	100	Not to exceed the level of going programs
2. Flood prevention	100	Up to 100 percent of construction cost
3. Farm irrigation	100	Up to 50 percent of construction costs
4. Land drainage	100	Up to 50 percent of construction costs
5. Soil and water management for agriculture-related pollutant control	100	Not to exceed the level of going programs
6. Public water-based fish & wildlife and recreation development		
a. Structures	100	Up to 50 percent of construction costs
b. Landrights	consultive	Up to 50 percent of landrights costs
c. Basic facilities	50	Up to 50 percent of costs
7. Water quality management	100	Up to 50 percent of costs
8. Accelerated services	100	100 percent of construction costs

9) Complete the environmental evaluation. Make notification of intent to prepare or not to prepare an environmental impact appraisal or environmental impact statement.

10) Resolve any environmental issues.

11) Review proposed plan.

12) Return plan to sponsor for review and signature. Acquire state conservationist's signature.

13) Prepare land rights map. Obtain land rights.

14) Enter plan implementation phase in council's short-term plan.

15) Apply for funding.

16) Submit final design.

17) Sign project and operation and maintenance agreements.

18) Obtain bids.

19) Construct or carry out measure.

20) Operate and maintain completed measure.

The Resource Conservation and Development (RC&D) Program provides project grants, advisory services, and counseling to assist local people in initiating and carrying out a long-range program of resource conservation and development. The program attempts to create a dynamic rural community with a satisfactory level of income and pleasing environment and to create a favorable investment climate attractive to private capital.

Knox County is a member of the Prairie Hills RC&D area, which is eligible for RC&D loans. These 'loans provide assistance to local sponsoring agencies in RC&D areas where acceleration of programs of resource conservation, development, and utilization will increase economic opportunities for local people. This assistance is in the form of guaranteed/insured loans.

Loan funds may be used for: 1) rural community public outdoor-oriented water-based recreational facilities; 2) soil and water development, conservation, control and use facilities; 3) shift-in-land-use facilities; 4) community water storage facilities; and 5) special purpose equipment to carry out the above purposes. The project must be located in an authorized RC&D area. A loan for a single RC&D measure cannot exceed $500,000.

A time limitation is not specified for use of FmHA loan funds. Funds will be awarded when FmHA requirements are met, and the project can be completed on a timely basis. Funds may be advanced on an as-needed basis by FmHA.

Public agencies and local non-profit corporations in authorized Resource Conservation and Development (RC&D) areas (see "Resource Conservation and Development Councils") may be eligible for loan assistance provided they: 1) are a sponsor of the RC&D measure for which the loan is requested and which is included in the RC&D project plan; 2) have authority to borrow funds, to repay the loan, to pledge security for the loan, and to operate the facilities or services provided; and 3) are financially sound and so organized and managed that they will be able to provide efficient service. Assistance is authorized for eligible applicants in approved RC&D areas.

The applicant must show evidence of legal capacity, financial responsibility, and economic feasibility relative to the activity for which assistance is requested.

In Illinois there are four RC&D areas:

Shawnee -- Alexander, Edwards, Franklin, Gallatin, Hamilton, Hardin, Jackson, Jefferson, Johnson, Massac, Perry, Pope, Pulaski, Saline, Union, Wabash, Wayne, White, and Williamson Counties.

Two Rivers -- Adams, Brown, Pike, Schuyler, and Calhoun Counties.

Blackhawk Hills -- Carroll, JoDaviess, Stephenson, Ogle, Lee, and Whiteside Counties.

Prairie Hills -- Fulton, Hancock, Henderson, Knox, McDonough, and Warren Counties.

Applications are subject to state and areawide clearinghouses' review pursuant to procedures in Part I, Attachment A of OMB Circular No. A-95 (revised). The standard application forms as furnished by the federal agency and required by OMB Circular No. A-102 must be used for this program. An informal pre-application conference is recommended. An environmental impact assessment is required for this program.

Pre-application Form AD-621 is filed at the county or district FmHA office from which assistance may be obtained. After the pre-application is reviewed by the District Director, it is forwarded to the FmHA state Director for review and processing instructions. Following review by the state Director the applicant is notified about eligibility, availability of funds, and if an application should be filed. Upon favorable review and approval of a complete application package, funds are made available to the District FmHA Director for delivery. Notification of the awards must be made to the designated state Central Information Reception Agency in accordance with Treasury Circular 1082.

There are no deadlines. Approval or disapproval should be known within 30 to 90 days. If an application is rejected, the reasons for rejection are fully stated. The applicant may request a review of the decision from the next higher management level of FmHA.

State Programs

The Division of Natural Resources of the Illinois Deoartment of Agriculture was formed to encourage and facilitate soil erosion and water pollution control practices and natural resource management. The division provides assistance to the directors of Soil and Water Conservation Districts. State funds are available to eligible districts for salaries, educational and promotional materials, and operation costs. Division staff have specific responsibilities and expertise in the following areas: farmland protection, water resources, land reclamation, sediment and erosion control, soil surveys, district operations, and promotional-educational materials. The majority of assistance is directed towards local Soil and Water Conservation Districts. Knox County is located in Region 3 of the division. The regional office is located at 1020 E. Jackson St., Macomb, IL 6I455.

The Illinois Conservation Rights Law was passed by the Illinois Legislature in September 1977. McHenry County in northern Illinois has been one of the first counties to meet state requirements. The following is a description of the law as followed in McHenry County:

> The land owner must donate conservation rights of land parcel to a state or county agency. The owner or heir may still sell or transfer ownership but the land must remain in its natural state. The public does not have right of access.
>
> Tax benefits are twofold. The local county tax assessor will appraise the property at its present value and at its value when returned to the wild state. This provides an immediate IRS tax deduction as a loss and a long-term tax advantage from the lower property tax assessment.

The McHenry County Conservation District guided the establishment of such areas. Ken Fiske, a bank farm manager and director of the district, sent the following legal interpretation of the law (Fiske, 1983, personal communication):

> The General Assembly enacted two significant pieces of legislation of particular significance to

conservationists within the state. The first of these related to "conservation rights" in real estate. Public Act 80-584 defines "conservation rights" as encompassing three broad classifications of real property: parcels having a particular architectural, historical and/or cultural significance; parcels having a natural significance as a result of scenic conditions or suitability as habitats for fish, plants or wildlife; and parcels uniquely suited as archaeological sites. The creation or reservation of a conservation right may require, prohibit, condition, limit or control any one of the property rights elaborated in the Act. By way of example, the right of access to the property and the right to construct or improve the property could be effectively limited by the provisions of the Act.

Perhaps most importantly, the Act provides that the conservation rights created or reserved pursuant to it will not be unenforceable on account of lack of privity of contract or lack of benefit to particular land or because the right involved has been assigned or is assignable. In other words, third parties not originally involved in either the creation or reservation of the conservation right, will have standing to enforce conservation rights under the Act. The Act specifically provides that conservation rights may be released by the holder of such rights to the holder of the fee interest in the land. In addition, the holder of such rights may transfer or assign the conservation rights, but only to an agency of the state, a unit of local government or a not-for-profit corporation or trust.

The Act seems to contemplate that only agencies of the state, units of local government and not-for-profit corporations and trusts will hold conservation rights. That is, the ownership and assignment of conservation rights by private parties, other than not-for-profit corporations or trusts, does not seem to have been contemplated by the framers of this provision; it is important to note, however, that this possibility is not expressly prohibited.

Section 2 of the Act states specifically that "any owner" of real estate may convey a conservation right to an agency of the state, unit of local government or not-for-profit corporation or trust. Such a conveyance, however, is not effective until such time as it is accepted by the grantee. Such acceptance may be conditioned upon certain 'requirements satisfactory to the grantee being fulfilled by the grantor. The Act notes, as a possible requirement, the payment of funds by the grantor to underwrite the management of the conservation rights granted.

Section 3 of the Act defines "owner" to include not only the owner of the fee simple title to the property but also the owner of any other interest including, without limitation, a contract purchaser, lessee and life tenant. Section 4 provides that the conservation rights created pursuant to the Act may be enforced through an action seeking injunctive relief, specific performance or damages in the county where the rights are being exercised. The agencies of the state, unit of local government and not-for-profit corporation or trust holding the conservation rights are, of course, specifically allowed to enforce any rights held by them pursuant to the Act. In addition, and most importantly, the owner of any real estate abutting or within five hundred (500) feet of the property which is the subject of the conservation right may also seek the permitted remedies. If the owner of the property subject to a conservation right willfully violates the terms of the conservation right, a court may in its discretion hold said party liable for punitive damages in an amount equal to the value of the real estate property subject thereto.

Section 5 requires instruments creating conservation rights to be duly recorded in the county where the land is situated so as to effect title in the same manner as any other conveyance of real estate interest. Of course, it is necessary that such instruments contain a legal description of the land which is to be subject to the conservation rights being reserved or created. Section 5 also contains a directive to the recorder of deeds registrar of titles that a copy of any such instrument be mailed to the Illinois Department of Conservation. This proviso is important and should be stressed when delivering an instrument creating a conservation right for recording or registration.

In summary, the crucial tenets of Public Act 80-584 may be summarized as follows:

(1) Enforceability - Conservation rights are now enforceable by the holder of such rights provided said holder is an agency of the state, unit of local government or not-for-profit corporation or trust or the owner of real property abutting or within five hundred (500) feet of the property subject to the conservation rights, irregardless of whether there is privity of contract between the parties or benefit to particular land or the rights reserved or created are assigned or assignable;

(2) Punitive Damages - The owner of real estate encumbered with conservation rights who willfully violates the terms of such rights may be liable for punitive damages in an amount equal to the value of the real estate subject to said conservation rights; and

(3) Reservation/Creation of Conservation Rights - Conservation rights are reserved or created in common with other rights in real property by instrument executed and recorded in the county in which the property is situated. Public Act 80-584 contains the additional requirement that a copy of the document creating or reserving the conservation rights be mailed to the Illinois Department of Conservation. Presumably, failure to comply with this requirement would not affect the validity or enforceability of the conservation rights.

Federal Programs

The Soil Conservation Service (SCS) and Agricultural Stabilization and Conservation Service (ASCS) of the U.S. Department of Agriculture (USDA) coordinate with state and local agencies on programs to conserve soil and water in watersheds. The SCS was established in the USDA by Congress in 1935 to conserve and develop our soil and water resources (Public Law 46, 74th Congress, 1935). Specifically SCS helps formulate watershed protection and flood prevention projects, as well as river basin investigations, with other agencies (Flood Control Act, Public Law 534, 78th Congress, 1944; Public Law 566, 83rd Congress, 1954). SCS also helps local sponsors develop and carry out multi-county resource conservation and development projects (Food and Agriculture Act, Public Law 703, 87th Congress, 1962).

The Agricultural Conservation Program (ACP) was established by the ASCS to:

1) Control erosion and sedimentation.

2) Encourage voluntary compliance with federal and state requirements to solve point and non-point source pollution.

3) Achieve priorities in the National Environmental Protection Act.

4) Improve water quality.

The conservation practices are to be used on agricultural land and must be performed satisfactorily and in accordance with applicable specifications. The wildlife conservation practices must also conserve soil and water. Program participants are responsible for the upkeep and maintenance of practices installed with cost-share assistance. The cost-share assistance does not apply if the primary purpose is to bring new land into production.

The ACP is national in scope and is available for participation by all farmers and ranchers who, through consultation with others in the conservation and environmental field, establish the need for cost-share assistance in solving resource conservation and agricultural pollution problems.

The program emphasizes enduring soil, water, and forestry management and pollution control measures of long-term benefit to the public. Annual, short-term contracting arrangements are available.

Cost-sharing is available under annual agreements or long-term agreements (LT's). Requests for long-term agreements can be accepted for complete farms for a period of three to ten years, or for a portion of a farm for a period of three to five years (mini-LTA's).

The federal government may share up to 75 percent of the cost to install practices under annual agreements (or at a higher rate if authorized by the Secretary of Agriculture). Under long-term agreements, cost-sharing may range between 50 to 75 percent. The federal share of the cost depends on the public benefits resulting from the conservation or pollution abatement practices. Before any long-term agreement can be approved, producers must indicate a readiness to carry out practices as scheduled over the next three to five years.

Producers must agree to maintain practices for a specified number of years. Producers who fail to maintain practices for the specified life spans are required to refund all or part of the federal funds provided for installation of the practice.

Among practices eligible for cost-sharing assistance under ACP are establishment or improvement of permanent vegetative cover, or of contour strip-cropping, or terrace systems; development of springs, seeps, and wells; installation of pipelines, storage facilities, and other measures intended to provide erosion control on range or pastureland; installation of water impoundment reservoirs for erosion control, conservation, and environmental and wildlife enhancement; planting of trees and shrubs and improvement of timber stands for protection against wind and water erosion and protection of trees for timber production; and development or rehabilitation of shallow water areas to support food, habitat and cover for wildlife.

Payment rates range up to 75 percent of out-of-pocket cost. The remainder is paid by the landowner monetarily or through the contribution of labor and/or materials. Recipients are subject to an audit by the Office of Inspector General, USDA.

Any person who as owner, landlord, tenant, or share-cropper on a farm or ranch, including associated groups, bears a part of the cost of an approved conservation practice is eligible to apply for cost-share assistance.

Eligible persons make application on Form ACP-245 for cost-sharing at any time during the year, at the ASCS county office for the county in which the land is located. The ASCS county committee must approve applications in whole or in part within the county allocation of federal funds for that purpose. Application for payment must be filed with the ASCS county committee by an announced date. Participants may appeal any determination to the ASCS county committee which acted on Application Form ACP-245. If the person is not satisfied with the county committee determination, he/she may appeal to the state ASCS committee or Deputy Administrator, ASCS.

To participate, the farmer files his request with the ASCS county committee Cat the ASCS county office) for ACP cost-sharing. An ACP practice must be approved before the practice is started.

The county committee will notify the applicant by letter that the request for cost-sharing has been approved subject to a determination by the Soil Conservation Service CSCS), in the case of certain practices, that the practice is feasible. For LTA's a conservation plan must be developed by a representative of SCS and approved by the Soil and Water Conservation District before final approval by the county ASCS committee can be obtained.

After the practice is completed, the farmer certifies to the county office that all installation specifications, technical standards, and any state or local applicable regulations have been met. The farmer pays the total cost of establishing the approved practices and is then reimbursed for the government's share of the cost.

Each year the county ASCS committee decides which ACP practices to fund within the county, and the cost-share rate of each practice to be funded, under state and federal guidelines. Local ASCS offices should be contacted for specific information.

<u>The Watershed Protection and Flood Prevent ion Program (PL-S66: Small Watershed Program)</u> was developed to provide technical and financial assistance in planning and carrying out works of improvement to protect, develop, and utilize the land and water resources in small watersheds. The four levels of jurisdictions required for PL566 approval in a given calendar year are:

1) Watershed landowners ask the District Board of SCS for assistance.

a) Two representatives of landowners should attend board meetings with a petition signed by all landowners.

2) If the District Board agrees to assist with a PL566 project, the Board fills out an application and sends it to the Land Use Council Chairman by February 15.

3) The Land Use Council reviews applications and ranks them in priority order (flood prevention has a high priority). This report must be received by the state Watershed Priority Committee by April 1.

4) By May of each year, the state Watershed Priority Committee will make their recommendations to the Division of Natural Resources, Department of Agriculture.

Assistance is provided in planning, designing, and installing watershed works of improvement; in sharing costs of flood prevention, irrigation, drainage, sedimentation control, and public water-based recreation, and fish and wildlife measures; and in extending long-term credit to help local interests with their share of the costs. The watershed area must not exceed 250,000 acres. Capacity of a single structure is limited to 25,000 acre-feet of total capacity and 12,500 acre-feet of floodwater detention capacity.

The technical and financial assistance, by which program funds provide certain prescribed services and costs and a percentage of other costs on the basis of a contract, varies according to purpose of the works of improvement. For example, for construction costs under the Act, program funds may pay 100 percent for flood prevention; up to 50 percent of agricultural water management, public recreation, and fish and wildlife measures; and none of the costs for certain other non-agr icultural water management purposes. All of the applicants installation costs are eligible for program loans. Reimbursable advances are available for preservation of sites and future municipal water supplies.

Assistance continues until all works of improvement are installed or their installation is terminated by mutual agreement. Federal assistance for planning is provided as it becomes available, and leads to preparation of a watershed work plan which outlines the works of improvement, the general time schedule, and other arrangements for their installation.

Any state agency, county or groups of counties, municipality, town or township, soil and water conservation district, flood prevention or flood control district, or any other non-profit agency with authority under state law to carry out, maintain and operate watershed works of improvement may apply for assistance.

Applications must designate the proposed project area, be properly signed and attested to by all applicants, and set forth the need for the proposed project. Costs will be determined in accordance with OMB Circular No. A-87 for state and local governments.

Potential applicants must notify state planning and developments clearinghouses that they intend to apply for assistance. Up to 60 days is allowed for review. Applications are subject to state and areawide clearinghouses' review pursuant to procedures in Part I, Attachment A, of OMB Circular No. A-95 (revised). The standard application forms as furnished by the federal agency and required by OMB Circular No. A-102 must be used for this program. Environmental impact statements are required for all Public Law 83-566 projects and Public Law 78-534 subwatershed projects approved for operations after January 1, 1970, which on the basis of environmental assessment are determined to be federal actions significantly affecting the environment.

Application forms and information are available in all SCS offices and from designated state agencies. Details of the procedure are available from the state and field offices of the Soil Conservation Service. Receipt of the application will be acknowledged as soon as it is determined to be valid.

Criteria for selecting proposals are:

1) The watershed must meet the requirement of the law.

2) The governor or his representative must recommend the watershed for planning assistance.

3) It should be evident that problems can be solved by project action under authority of Public Law 83-566.

4) The local sponsors should have authority under state statutes to carry out their responsibility for installation and operation and maintenance of project measures.

5) The local sponsors should indicate willingness to carry out a watershed project.

6) The project should have good prospects for a favorable benefit-cost ratio.

7) No critical environmental issues should be raised.

8) There should be available capabilities and resources for developing a watershed plan.

Note: This assistance is available to farmers only when a watershed project is under way. If farmers feel that soil erosion and water pollution are occurring in a watershed, any of the groups eligible for this assistance should be contacted. Landowner interest may help get a watershed project started.

The Rural Clean Water Program (RCWP) is also an ASCS attempt to develop and test methods for improving water quality by assisting agricultural landowners in reducing agricultural nonpoint source water pollutants. Clean water practices are those which reduce the amount of pollutants at the sources, improve water quality, reduce costs to cities for water purification, prevent fish loss, enhance the environment,and provide new and improved recreation areas for water based sports. Not eligible are practices aimed primarily at bringing new land into production, increasing production on existing land, or controling floods, or practices which do not have a significant impact on the quality of the receiving waters.

The RCWP provides financial and technical assistance to landowners and operators in approved project areas. The assistance is provided through long-term contracts of three to ten years for installation of Best Management Practices to solve critical water quality problems resulting from agricultural non-point source pollution. Contracts may be modified where there is a change in status of the participant, the land under agreement, or the farming operation. The project area must reflect the water quality priority concerns developed through the established water quality management process. Participation is voluntary.

Financial assistance is in the form of cost-sharing. Payment may range from 30 to 75 percent of the cost of the Best Management Practice. Total maximum payment to a producer is limited to $50,000 during the project's life span. There is no annual limitation.

Best Management Practices can be recommended by or to the county ASCS committee and developed at the local level. They need approval by the state ASCS committee and the Secretary of Agriculture with the concurrence of the Environmental Protection Agency (EPA). Eligible practices may involve design and engineering work or better conservation management of agricultural land.

ASCS cooperates with the Soil Conservation Service, conservation districts, the Cooperative Extension Service, and state soil and water conservation and water quality agencies in support of approved RCWP projects. Coordinating committees at the national, state and local levels assist in project administration and development.

Requests for RCWP assistance are filed with the ASCS county committee. A water quality plan is prepared by the Soil Conservation Service and approved by the Soil and Water Conservation District. The RCWP contract is entered into by the county ASCS county committee and the landowner or operator of a farm which significantly contributes to the water quality problem.

Representative RCWP project areas will be selected for comprehensive monitoring, evaluation, and analysis to determine the improvement of water quality and make projections on a nationwide basis. This is a joint USDA/EPA responsibility and includes cost effectiveness of practices and the impact of the program on water quality.

RCWP is applicable only to privately-owned agricultural lands in project areas. Any landowner or operator in an approved project area whose land or activity contributes to the area's water quality problems and who has an approved water quality plan may enter into an RCWP contract. An individual partnership, corporation (except corporations whose stock is publicly traded), Indian tribe, irrigation district, or other entity is eligible. Federal, state, or local governments, or subdivisions thereof, . except irrigation districts, are not eligible.

The project areas must be identified and approved for RCWP funding.

Eligible persons make application on Form RCWP-1 for cost-sharing at any time during the year, at the ASCS county office for the county in which the land is located.

The ASCS county committee approves applications within the county allocation of federal funds for that purpose.

Applications must be filed with the ASCS county committee by an announced date. The local ASCS office can provide information on application dates.

Approval/disapproval should be known after 30 to 180 days.

The criteria for selecting the projects include 1) severity of water quality problems and determination of pollutant sources; 2) demonstration of public benefits that would result from treatment of the problems; 3) determination of the project areas; 4) treatment and BMP's needed; 5) costs of the project including technical assistance estimates; 6) suitability of the project for testing programs, policies and procedures for non-point source pollution control; 7) monitoring and evaluation potential; and 8) estimated participation, local commitment, and inter-agency cooperation.

Note: An approved project must be under way for individual farmers to receive assistance through this program.

<u>The federal Internal Revenue Service (URS)</u> also offers tax advantages for certain conservation practices. Deductible expenditures are those made with regard to land that is being used or has been used by a farmer or his tenant for farming,

either at the time of the expenditures or before such expenditures are made. They include (but are not limited to):

1) The treatment or movement of earth, such as leveling, conditioning, grading, terracing, contour furrowing, or restoration of pollution-control facility.

2) The construction, control, and protection of diversion channels, drainage ditches, irrigation ditches, earthen dams, water courses, outlets, and ponds.

3) Eradication of brush.

4) The planting of windbreaks.

Expenditures for depreciable soil and water conservation assets may not be deducted. The landowner must capitalize his expenditures for structures or facilities of a nature that are subject to allowance for depreciation, such as water wells Cpipe or tile) or for wooden, masonry, metal, or concrete dams. The landowner must recover his capital investment through annual allowances for depreciation.

In any tax year, the total deduction of expenditures of a capital nature for soil and water conservation is limited to 25 percent of his gross income from farming during the year. The landowner may carry over any unused deductions to succeeding years, if his deductible soil and water conservation expenditures in any year are more than 25 percent of his gross income from farming for that year.

Ordinary and necessary expenses for maintaining completed soil and water conservation structures, such as the annual removal of sediment from a drainage ditch, are farm business expenses that are deductible without regard to the 25 percent limitation.

Note: For additional information, publications and forms can be picked up from the IRS Forms Distribution Center or the IRS can be reached at the telephone number listed in the telephone book under United States Government, Internal Revenue Service.

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