Hydrology and Sedimentation of Corey Creek and Elk Run Basins, North-Central Pennsylvania

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1532-E

Prepared in cooperation with the Pennsylvania Department of Agriculture, State Soil and Water Conservation Commission

Hydrology and Sedimentation of Corey Creek and Elk Run Basins, North-Central Pennsylvania

By LLOYD A. REED

HYDROLOGIC EFFECTS OF LAND USE

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1532-E

Prepared in cooperation with the Pennsylvania Department of Agriculture, State Soil and Water Conservation Commission

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1971

UNITED STATES DEPARTMENT OF THE INTERIOR

FRED J. RUSSELL, *Acting Secretary*

GEOLOGICAL SURVEY

William T. Pecora, *Director*

Library of Congress catalog-card No. 71-609786

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price 25 cents (paper cover)

CONTENTS

ILLUSTRATIONS

TABLES

HYDROLOGIC EFFECTS OF LAND USE

HYDROLOGY AND SEDIMENTATION OF COREY CREEK AND ELK RUN BASINS, NORTH-CENTRAL PENNSYLVANIA

By Lloyd A. Reed

ABSTRACT

Analysis of data collected from two small agricultural basins in north-central Pennsylvania during the period May 1954 to September 1967 indicates that conservation measures reduced the quantity of suspended sediment leaving the Corey Creek basin as a result of frequent storms during the growing season. Extensive soil conservation treatments were applied in the 12.2-square-mile Corey Creek basin, but only minor treatments were applied in the adjacent 10.2-square-mile Elk Run basin. These treatments included the construction of ponds and diversion terraces and altering land use by such measures as establishing permanent hay land and changing marginal pasture land to wood lands. Elk Run basin, which is topographically and hydrologically similar to the Corey Creek basin, was used as an external control to assist in detecting and evaluating the hydrologic changes in Corey Creek.

Trend analyses of data from both basins indicate a 47-percent decrease in sediment discharge from Corey Creek during the frequent storms that occur in the May to October growing season. Six percent of the sediment discharged from Corey Creek during the period of this investigation (1954–67) was discharged during these frequent growing-season storms. The remaining 94 percent of the sediment was discharged during the November to April dormant season and during two major events during the growing season, one October 1955 and one May 1961. No decrease in sediment discharge was observed for these events or for this period.

The adjacent basin of similar size, topography, and hydrologic characteristics, Elk Run, was not scheduled for extensive conservation treatment; it was selected as a control for this study because of the assumption that any changes in precipitation and runoff patterns would affect both basins in a similar manner. Rainfall, runoff, sediment, and stream-channel data are used in this report to estimate the probable hydrologic behavior of the Corey Creek basin provided the intensive conservation program had not been undertaken.

INTRODUCTION

The purpose of this report is to determine and evaluate the effects that soil conservation practices had on sediment yield, water quality, floods, and low flow for the 12.2-square-mile Corey Creek basin in northcentral Pennsylvania. Documented information regarding the effects of conservation practices is vital to the efficient planning of conservation programs. Elk Run basin, which has an area of 10.2 square miles and is contiguous to the Corey Creek basin, was used as a control area.

In November 1953 the Corey Creek basin was selected by the U.S. Soil Conservation Service for extensive conservation treatment under the Federal Watershed Protection Law (P.L. 566) Pilot Watershed program. The conservation plan provided for the collection and evaluation of hydrologic data by the U.S. Geological Survey during and after conservation treatment. During the period 1954–60, extensive conservation treatments were applied to the Corey Creek basin. These treatments included the planting of trees and the construction of diversion terraces and farm ponds.

The investigation was conducted by the U.S. Geological Survey in cooperation with the Pennsylvania Department of Agriculture, State Soil and Water Conservation Commission, Charles F. Hess, Executive Secretary.

PREVIOUS STUDIES

The Tioga County Soil Conservation District watershed work plan (1954) outlined conservation problems encountered, the remedial practices to be installed, and the financial arrangements for the project. Culbertson (1957), using data collected during the first year and a half of the study, presented a preliminary evaluation of the two basins.

Jones and Unger (1962) reported on the techniques developed for analysis of the data and a brief history of the project. Jones, using data collected through the 1960 water year, presented a progress report in 1964 and a water-supply paper on the two basins in 1966 that covered the period 1954–60.

This report presents an expansion of the data and interpretations as presented by Jones (1966), in order to include the period of October 1960 to September 1967. It defines the relationships between precipitation, streamflow, and sediment yield; analyzes these variables for any changes with time; and describes the relationship between land use and sediment discharge.

INSTRUMENTATION AND DATA COLLECTION

Continuous records of streamflow and records of suspended-sediment discharge were obtained at the outfall of each study area. In addition, sediment data and records of water discharge were collected at several upstream locations in each watershed on a storm basis in order to determine whether any parts of the basins were contributing larger proportions of sediment than other parts. Data on the chemical quality of streamflow were obtained from periodic water samples taken at the outfall of each basin.

Several aggradation-degradation sites were established in each basin. At these sites, the cross sections of the streams were surveyed periodically to determine the rate and magnitude of scour or fill with respect to time and flood flows.

Five rain gages were installed in each basin to ensure accuracy and continuity of record during periods when one or more gages were inoperative. One recording rain gage was centrally located in each basin to determine intensity as well as quantity of precipitation. Figure 1 shows the rain-gage locations as well as other instrument sites and data-collection points.

The conservation practices applied and farming procedures followed were determined yearly for each farm in the Corey Creek and Elk Run basins. This information was collected largely from field tours and interviews with the residents of the basins. Additional information was collected from the county tax offices, Soil Conservation District offices, and Agricultural Stabilization Conservation Committee offices and from studies of aerial photographs of the basins.

DESCRIPTION OF THE BASINS

Corey Creek and Elk Run occupy adjacent basins in north-central Pennsylvania (fig. 1). Corey Creek flows approximately 5.8 miles from its source on Armenia Mountain to the gaging station and 4.2 additional miles to its confluence with the Tioga River. The drainage area above the gage is 12.2 square miles.

Elk Run flows 6.3 miles from its source on Armenia Mountain to the gaging station and an additional 4 miles to its confluence with Mill Creek, a tributary of Tioga River. The drainage area above the gage is 10.2 square miles.

PHYSIOGRAPHY AND TOPOGRAPHY

Elevations in both basins range from 1,300 feet above mean sea level at the gaging stations to about 2,400 feet at the divide. The topography is rolling to steep; the valley floors are flat to gently sloping. The Corey Creek basin has a lower mean elevation and somewhat flatter slopes as indicated by the following table:

	Mean elevation above sea level (feet)	Mean basin slope (percent)	Portion of basin in slopes equal to or greater than 10 percent (percent)
Corey Creek	1,750	15	60
Elk Run	1,800	17	68

Both basins lie within the folded part of the Appalachian Plateau province, a greatly dissected high plain. The two dominant structural features are the Wellsboro anticline and Pine Creek syncline, which trend northeast-southwest and plunge northeastward. Corey Creek and Elk Run begin southeast of the axis of the Wellsboro

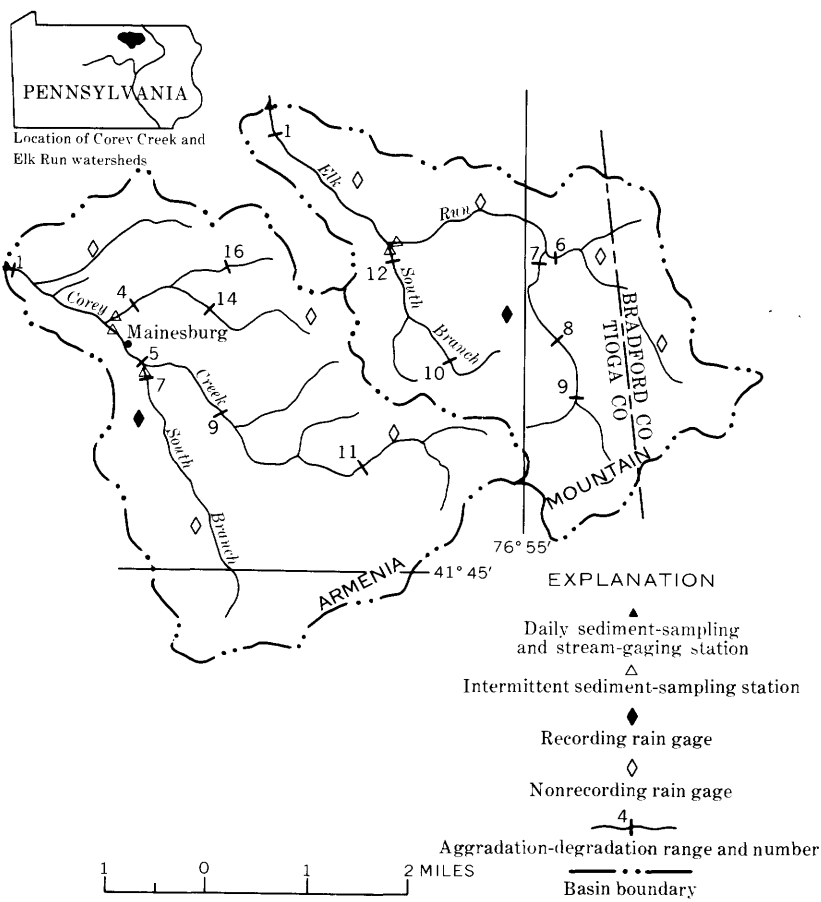

FIGURE 1.—Location of instruments and data-collection points.

anticline and flow across the northwest limb toward the axis of the Pine Creek syncline, which underlies the hills to the northwest. Corey Creek and Elk Run exhibit a modified dendritic drainage pattern.

GEOLOGY

Both streams rise in the Catskill Formation of Late Devonian and Early Mississippian age and flow across the Chemung Formation of Late Devonian age. The Catskill is composed of greenish-gray sandy shales, fine-grained greenish-gray sandstones, and some fresh-water red shales. The underlying Chemung consists of similar rocks, but locally may contain thin layers of impure limestone.

The basins have been subjected to continental glaciation at least three times. Evidence of the Wisconsin Glaciation can be found in deposits mantling the consolidated rock and in glacial outwash deposits formed in the flooded streams during times of glacial melting and retreat (Lohman, 1939). This fill largely consists of fragments of sandstone or conglomerate in the gravel size range (2–256 mm).

SOILS

Jones (1966) presented a thorough description of the soils in both basins. More than 90 percent of the soils in each basin may be classified as channery silt loam; two-thirds of these soils are well drained. The extensively cultivated bottom lands are composed of silt loams as much as 1 foot thick. Although the bottom lands produce the best crop yields, they are the areas most susceptible to frost damage. The soils of the Corey Creek and Elk Run basins are similar in type, distribution, and abundance. In general, much of the cropland is on well-drained soil, whereas the more poorly drained soil is used for pasture and grassland.

CLIMATE

At the U.S. Weather Bureau station in Wellsboro, Pa., 17 miles west of the study area, the mean annual temperature is 47°F (8°C). The minimum monthly mean is for January and is 25°F (–3°C). The maximum monthly mean is for July and is 71°F (22°C). Temperatures as low as –10°F (–23°C) and as high as 92°F (33°C) occur in this region. The average frost-free season is 121 days, and extends from May 16 to September 14. Average annual precipitation is 34.75 inches. The maximum monthly averages of 4 inches occur in July and August, and the minimum averages of less than 1.75 inches per month occur in January and February.

AGRICULTURE

The area discussed in this report is a part of a specialized dairy-farming area that includes most of New York State and the northern tier counties of Pennsylvania. The cropland is used primarily for growing feed for the dairy cattle. A typical operator in the region with a 160-acre farm may grow 10–15 acres of corn; 8–10 acres of small grain, mostly oats; and as much as 80 acres of hay. In addition, he may use 20 acres as permanent pasture, and pasture the hay land after harvesting the first cutting of hay.

The crop rotation followed by most farmers in the area is corn, oats, and 4–6 years of hay or pasture; however, in some fields corn may be grown 2 or more years consecutively. Other fields may be in continuous hay or pasture for extended periods. Most of the corn is cut for silage, and many farms have more than one silo. The corn and oats crops get the bulk of the commercial fertilizer. The corn acreage receives the bulk of the available barnyard manure; applications are as great as 8–12 tons per acre.

CONSERVATION PRACTICES

Extensive conservation measures were adopted by the farmers of the Corey Creek basin in conjunction with its designation as Pennsylvania Pilot Watershed Project under the Federal Watershed Protection Law (P.L. 566). The conservation practice adopted most extensively was the construction of diversion terraces to help control gully erosion in fields and to intercept and drain excess surface and subsurface water. During the period of this study, 163,820 feet of diversion terraces were constructed in the Corey Creek basin. Most of the terraces were built during the first 4 years of the program. In addition to the diversion-terrace construction, farm ponds having a total storage of 23.7 acre-feet were constructed, 2,050 feet of stream channel was altered and improved, 349 acres of farmland were drained, and 473 acres of less productive land were planted in trees.

Although Elk Run basin was not designated as part of the conservation area, a few innovative farmers in the basin and surrounding areas were quick to adopt some of the conservation measures being installed by their neighbors in the Corey Creek basin. Table 1 lists the application of conservation techniques on a yearly basis in both Corey Creek and Elk Run basins.

LAND-USE AND FARMING PRACTICES

The major change in farming practices that has taken place in the Corey Creek basin since 1954 has been the increased application of commercial fertilizer. The yearly application has increased from

TABLE 1.—*Conservation measures applied to the Corey Creek and Elk Run basins, 1954–67*

Year	Corey Creek basin: Diversion terrace length (feet)	Corey Creek basin: Impoundments: Capacity (acre-feet)	Corey Creek basin: Impoundments: Drainage area (acres)	Corey Creek basin: Stream channel alteration (feet)	Corey Creek basin: Tree planting (acres)	Elk Run basin: Diversion terrace length (feet)	Elk Run basin: Impoundments: Capacity (acre-feet)	Elk Run basin: Impoundments: Drainage area (acres)	Elk Run basin: Stream channel alteration (feet)	Elk Run basin: Tree planting (acres)
1954	52,605	1.5	30	----	1	----	----	----	----	----
1955	19,020	12.7	222	----	7	1,000	----	----	----	----
1956	19,985	2.7	5	1,300	13	----	----	----	----	----
1957	38,275	1.6	1	----	42	3,835	4.0	18	----	----
1958	16,785	2.7	91	----	238	725	----	----	----	----
1959	6,320	----	----	----	148	5,045	----	----	----	----
1960	7,010	----	----	----	3	8,854	----	----	----	41
1961	----	2.5	15	----	15	----	----	----	900	----
1962	----	----	----	----	----	2,970	----	----	----	----
1963	----	----	----	----	6	----	----	----	----	----
1964	----	----	----	----	----	----	----	----	----	----
1965	3,820	----	----	350	----	----	----	----	----	----
1966	----	----	----	400	----	----	----	----	250	----
1967	----	----	----	----	----	----	----	----	----	----

32 tons in 1954 to 96 tons in 1967. The greatest land-use change has been the planting of 473 acres of trees on the steeper, less productive lands as part of the conservation project. The planted trees and volunteer trees on abandoned farmland have increased the forested land in the Corey Creek basin from 2,340 to 2,940 acres. Table 2 compares the land-use and farming practices in Corey Creek and Elk Run at the beginning of the study with the land-use and farming practices at the conclusion of the study in 1967. The grassland category includes hay, pasture, and idle grassland.

TABLE 2.—*Land-use and farming practices in Corey Creek and Elk Run basins, 1954–67*

[Measurements in acres unless otherwise indicated]

Land use (acres)	Corey Creek 1954	Corey Creek 1967	Elk Run 1954	Elk Run 1967
Grassland	4,635	4,050	3,820	3,724
Woodland	2,340	2,940	2,073	2,150
Cultivated land	490	470	410	425
Farmstead	175	175	135	135
Urban land	100	103	26	28
Roads	70	72	64	66
Commercial fertilizer tons	32	96	26	84
Lime	390	400	340	370

HYDROLOGY

PRECIPITATION AND RUNOFF

Average annual precipitation and runoff for the two watersheds for the study period were as follows:

	Average annual precipitation (inches)	Average annual runoff (inches)
Corey Creek	34.30	12.8
Elk Run	35.36	13.8

Considerable variation existed in the participation-runoff relations for the basins from month to month and from storm to storm, owing to the number of factors that have an influencing effect. Figure 2 shows the average monthly variation in rainfall and runoff from 1954 to 1967. Before any runoff can occur, the precipitation must be adequate to satisfy the demands of the basin. Maximum basin demands for moisture occurred during the average 4-month period from June to September, as indicated by the low June to September discharges in figure 2.

During the dormant season, basin demands for moisture were at a minimum, and large quantities of precipitation were stored as snow which did not contribute to stream discharge until the temperature moderated. The winter snows and early spring rains were responsible for the high surface-water discharges that occurred in

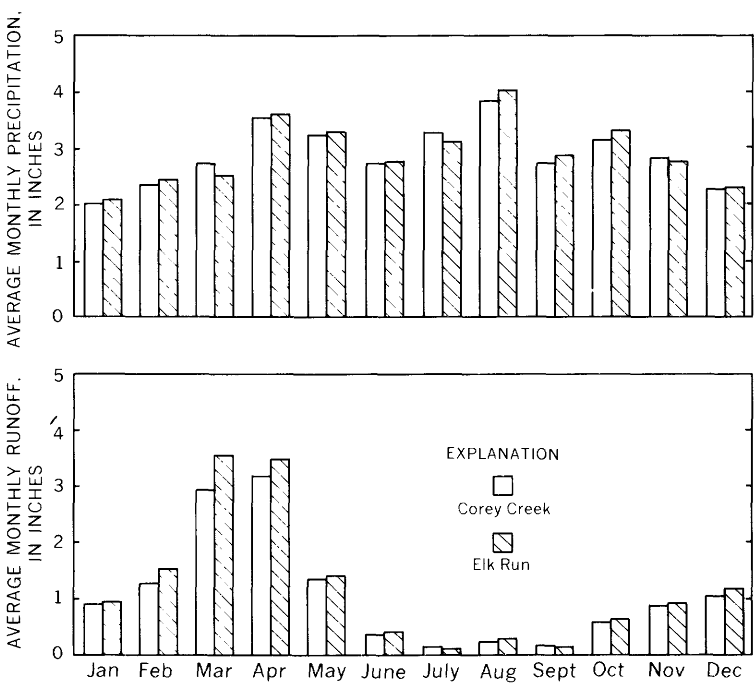

FIGURE 2.—Average monthly precipitation and runoff for the period October 1954 to September 1967.

late winter and early spring. Sixty-five percent of the precipitation that occurred on the Corey Creek basin during the November to April period was discharged as streamflow, whereas 73 percent of the precipitation in the Elk Run basin was discharged as streamflow.

During the growing season (May to October), basin demands for moisture were at a maximum. About 20 percent of the precipitation that occurred over the Corey Creek and Elk Run basins during the growing season was discharged as streamflow.

During the period October 1961 to September 1967, both basins were affected by the drought that occurred in the Northeast United States. Figure 3 indicates the severity of the drought on the Corey Creek and Elk Run watersheds. There was a 27-percent decrease in the average yearly rainfall during the drought years of 1961–67, compared with the 1955–60 period.

The drought affected the water discharge from both basins in a similar manner over the entire range of flows. Figure 4 shows the shift in the flow-duration curves by comparing the October 1954 to September 1960 period with the drought-affected October 1960 to September 1967 period. This curve indicates that low flows occurred more frequently in Elk Run than in Corey Creek. This characteristic may be the result of the steeper slopes in Elk Run basin, or it may indicate that Elk Run basin has a smaller groundwater storage capacity than Corey Creek basin. Figure 5 is a bar graph that shows the number of days when the flow in Corey Creek

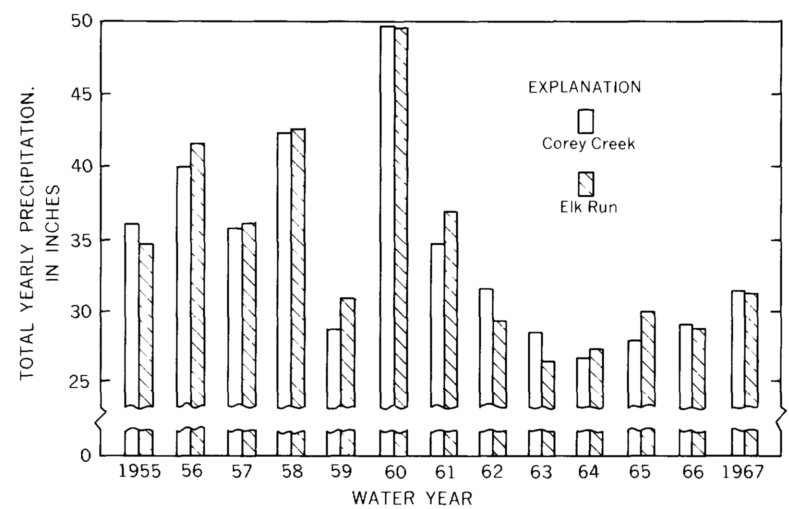

FIGURE 3.—Total yearly precipitation by water years, October 1954 to September 1967.

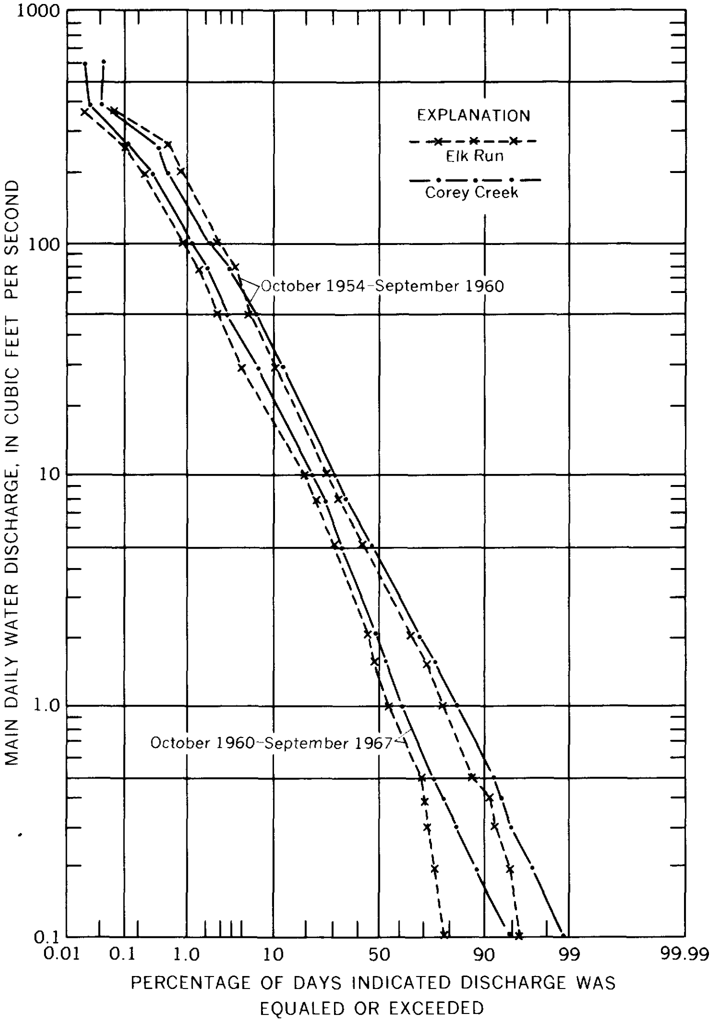

FIGURE 4.—Duration curves of mean daily water discharge, Corey Creek and Elk Run near Mainesburg, Pa., October 1954 to September 1967.

and Elk Run was less than 0.05 cfs (cubic foot per second). The effect of the drought is readily apparent.

The double-mass curve technique was used to test for any relative change in the precipitation and runoff rate in the two basins. Figure 6 shows the double-mass relation of precipitation, and figure 7 shows the double-mass relation of runoff for the two basins. These figures indicate that there has been no change in the relative

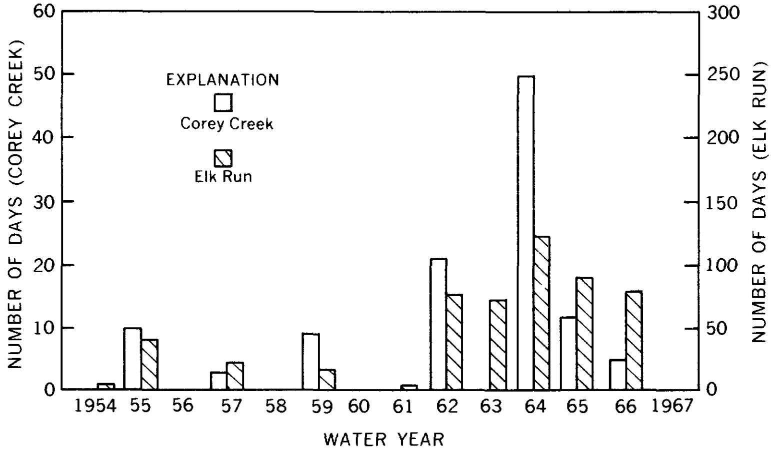

FIGURE 5.—Number of days mean daily flow was less than 0.05 cubic foot per second, Corey Creek and Elk Run near Mainesburg, Pa., October 1954 to September 1967.

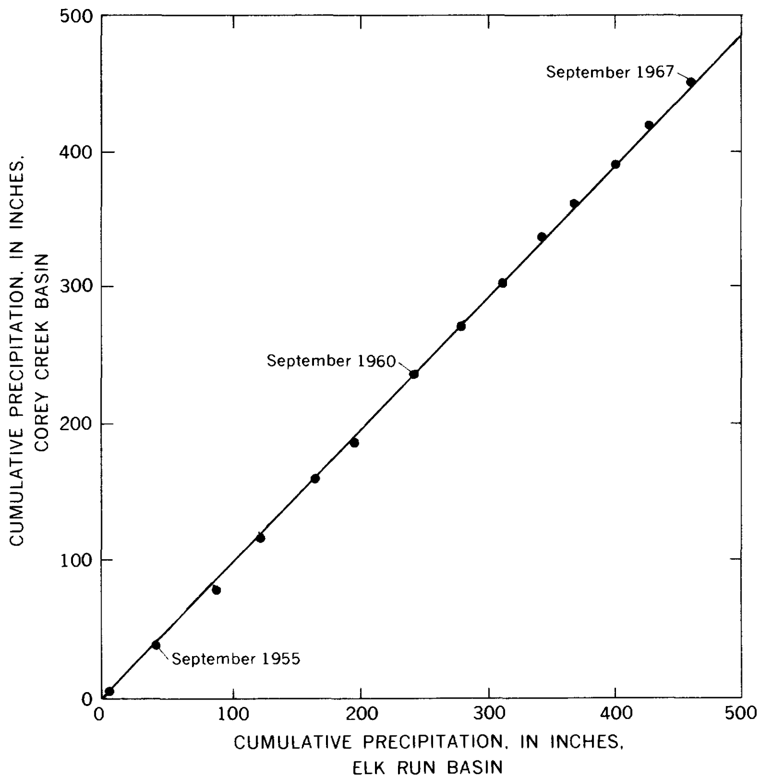

FIGURE 6.—Double-mass relation of precipitation, 1954–67.

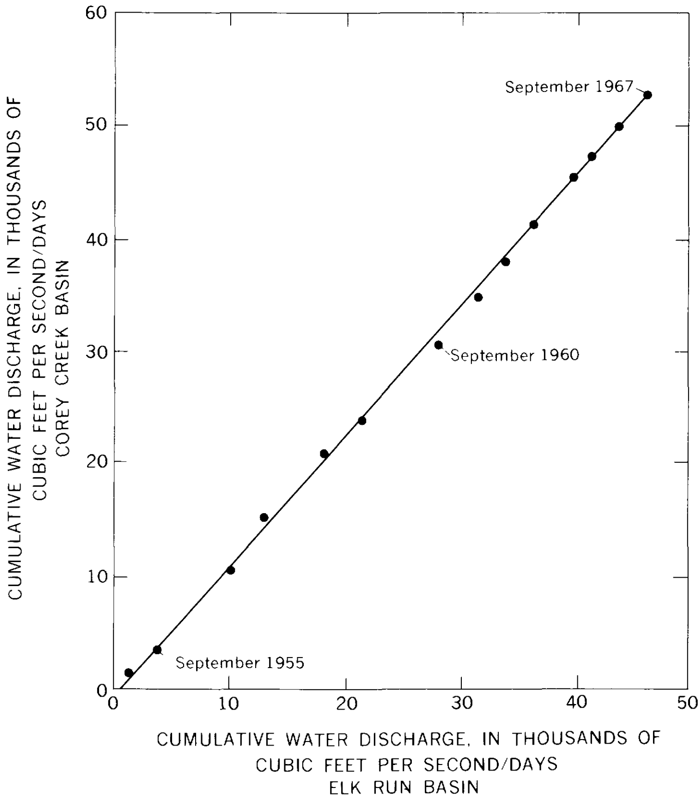

FIGURE 7.—Double-mass relation of runoff, Corey Creek and Elk Run near Mainesburg, Pa., 1954–67.

rates of precipitation and runoff between the two basins during the period of study.

RUNOFF PEAKEDNESS

Runoff peakedness was defined by Jones (1966, p. 12) as the ratio of the peak rate of direct water discharge to the mean direct water discharge for a given storm. High peakedness indicates a high peak flow and rapid runoff from the basin, and the rapid runoff generally results in high suspended-sediment loads. Two methods were used to test for a change in peakedness during the period of study. The first method was to compute a peakedness factor (P) where the factor was computed as

$$P = \frac{Q_p - Q_b}{Q_m - Q_b},$$

in which Q_p is the instantaneous peak water discharge, Q_b is base

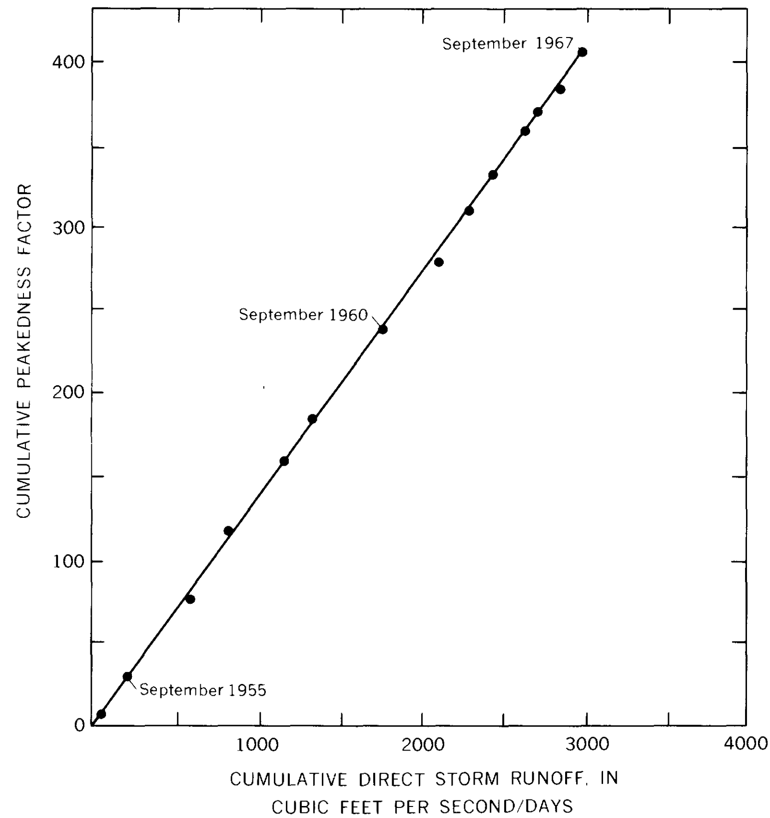

FIGURE 8.—Double-mass relation of storm runoff and peakedness factor, Corey Creek near Mainesburg, Pa., 1954–67.

flow, and Q_m is the time-weighted mean flow for the storm period in cubic feet per second (cfs). Only those storms with greater than one-half inch of rainfall were analyzed. The peakedness factors calculated were accumulated and plotted versus the cumulative direct storm runoff. The resulting double-mass curve is shown in figure 8. The slope of the double-mass curve indicates that no long-term change has occurred. The second method used to analyze for a change in peakedness with time was a double-mass curve (fig. 9) of the accumulated discharge increase ($\Sigma Q_p - Q_b$) at Corey Creek and Elk Run for all storms that resulted in a discharge increase of 10 cfs or more in either basin. From this and the previous analysis, it must be concluded that no change in peakedness has occurred in Corey Creek runoff as a result of watershed treatment.

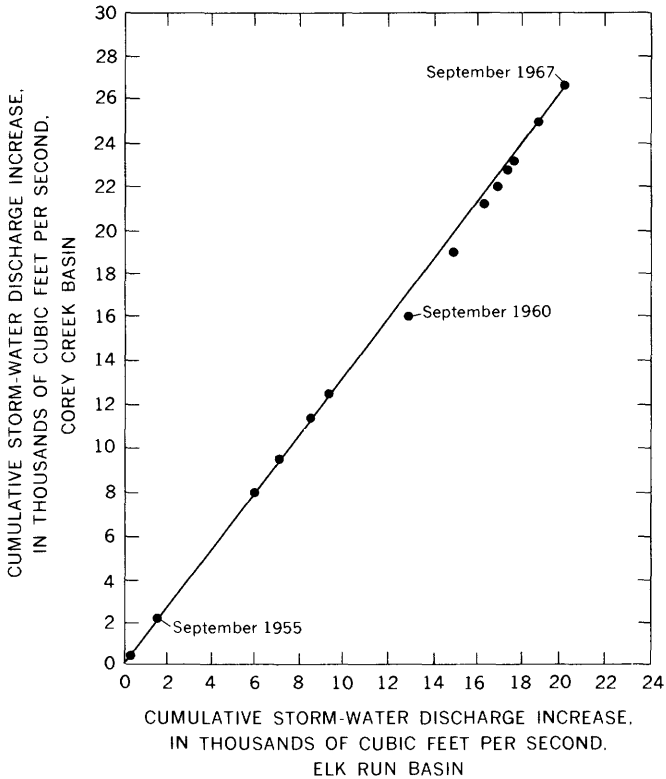

FIGURE 9.—Double-mass relation of storm-water discharge increase ($\Sigma Q_p - Q_b$), Corey Creek and Elk Run near Mainesburg, Pa., 1954–67.

SEDIMENTATION AND EROSION

Suspended-sediment discharge was measured during this study to determine whether agricultural conservation practices applied to reduce erosion actually resulted in a reduction in the suspended-sediment discharge. The average annual suspended-sediment yield from Corey Creek and Elk Run basins for the period of study (13 years) was 126 and 137 tons per square mile per year, respectively (table 3). The dormant-season (November to April) sediment discharge averaged 96 and 110 tons per square mile per year for Corey Creek and Elk Run basins, respectively. The remaining sediment was discharged during the May to October growing season, and averaged 30 and 27 tons per square mile per year for the Corey Creek and Elk Run basins.

TABLE 3.—*Suspended-sediment discharge, Corey Creek and Elk Run near Mainesburg, Pa., May 1954 to September 1967*

Basin	Suspended sediment discharge							
	Total		Dormant Season			Growing Season		
	Tons	Tons per square mile per year	Tons	Tons per square mile per season	Percent of total	Tons	Tons per square mile per season	Percent of total
Corey Creek	20,450	126	15,500	96	76	4,950	30	24
Elk Run	18,280	137	14,700	110	80	3,580	27	20

TRENDS IN SEDIMENT DISCHARGE

The collection of data was initiated shortly after the start of construction of the conservation measures. The suspended-sediment discharge from the Corey Creek and Elk Run basins was analyzed to determine the sediment-discharge relation between the two basins. The data were analyzed by two methods. In the first method, the periods that yielded abnormally high sediment discharges were eliminated. In the second method, all data were analyzed.

Data for October 1955, April 1957, and May 1961 were excluded in the first method of analysis because the sediment discharged at one or both stations was abnormally high and amounted to a significant percentage of the total (table 4). Figure 10 shows the double-mass relation of sediment based on the 13.5 years of data collection for the growing season, excluding data for October 1955 and May 1961, and for the dormant season, excluding data for April 1957.

The slope of the growing-season curve increased from 0.83 for the May 1954 to May 1955 period to 2.90 for the June 1955 to May 1958 period. After May 1958 the slope decreased to 0.44 and remained at that value for the rest of the study. Therefore, the rate

TABLE 4.—*Suspended-sediment discharge, Corey Creek and Elk Run near Mainesburg, Pa., May 1954 to September 1967*

[Data for October 1955, April 1957, and May 1961 excluded]

Basin	Suspended sediment discharge									
	Dormant Season					Growing Season				
	Total sediment discharge	Excluded data April 1957		Net sediment discharge		Total sediment discharge	Excluded data October 1955 and May 1961		Net sediment discharge	
	Tons	Tons	Percent of seasonal total	Tons	Tons per square mile per year	Tons	Tons	Percent of seasonal total	Tons	Tons per square mile per year
Corey Creek	15,500	2,125	14	13,375	84	4,950	3,725	75	1,225	7
Elk Run	14,700	1,050	7	13,650	103	3,580	1,725	48	1,855	13

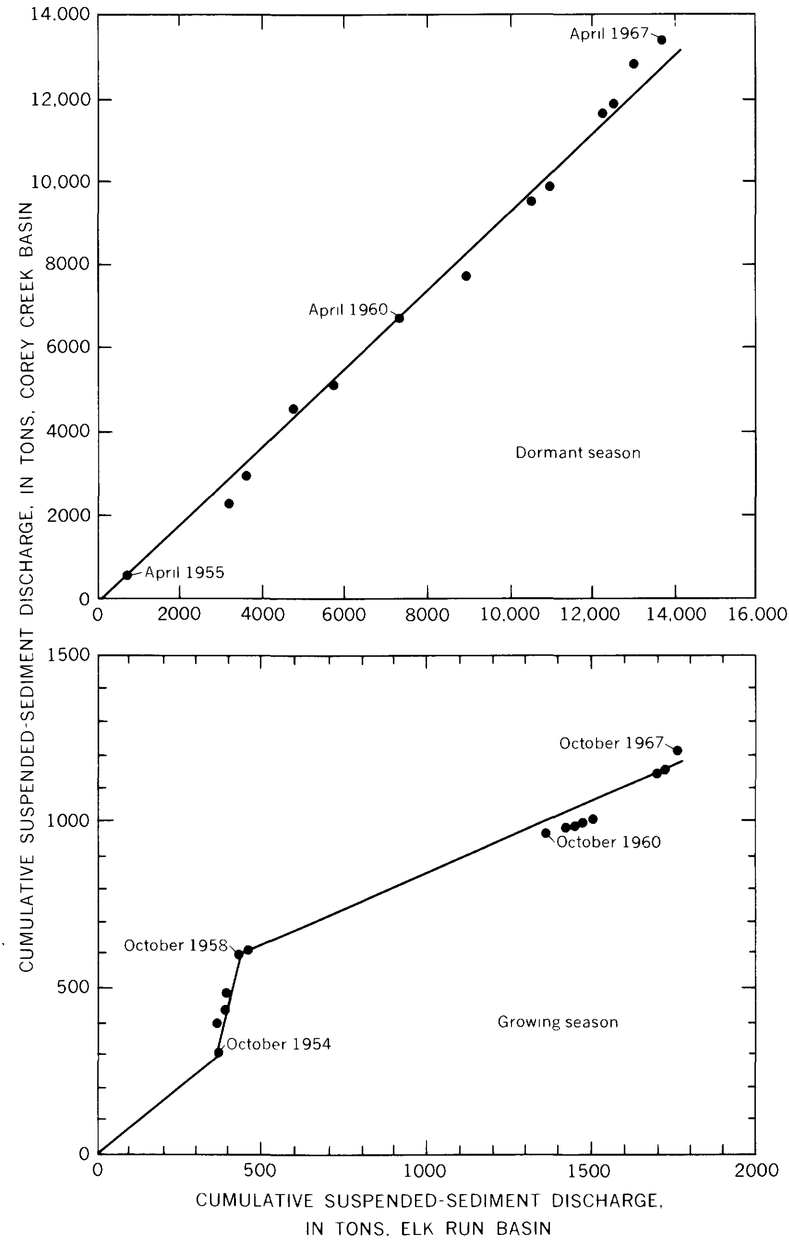

FIGURE 10.—Double-mass relations of monthly sediment discharge for dormant and growing seasons, Corey Creek and Elk Run near Mainesburg, Pa., May 1954 to October 1967. Data for October 1955, April 1957, and May 1961 are excluded.

of suspended-sediment discharge observed during the growing seasons between May 1958 and October 1967 represents a 47-percent

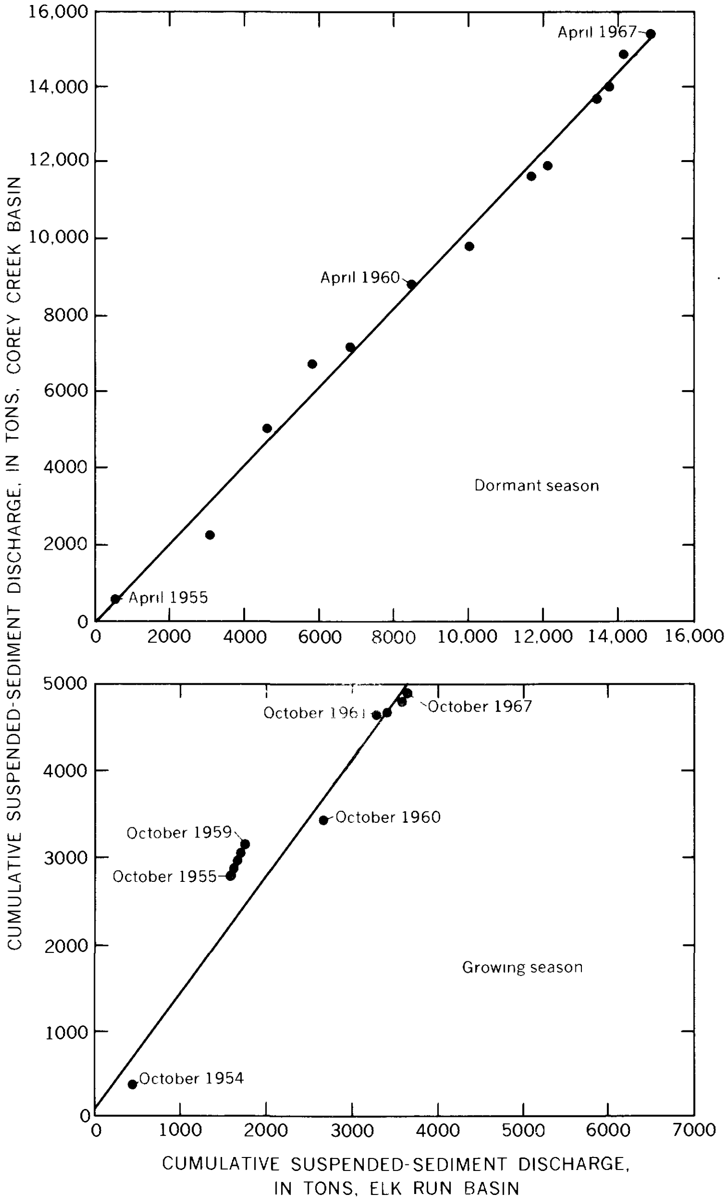

FIGURE 11.—Double-mass relations of monthly sediment discharge for dormant and growing seasons, Corey Creek and Elk Run near Mainesburg, Pa., May 1954 to October 1967.

decrease from the initial growing-season rate observed during the period May 1954 to May 1955.

The decrease in sediment discharge during the growing season from Corey Creek relative to Elk Run, as shown by this analysis, was 47 percent, but October 1955 and May 1961 are excluded from the analysis. However, only 6 percent of the total sediment was discharged during this period. The temporary increase prior to 1958 probably was caused by the intensive construction activity. The double-mass relation for the dormant season, excluding data for April 1957, does not show any decrease in sediment discharge for the period.

In the second method, inclusion of the October 1955 and May 1961 data in the analysis of growing-season sediment discharge resulted in a change in the double-mass sediment discharge relation between the two basins. These two months produced 75 percent of the total sediment discharged by Corey Creek during the 14 growing seasons of data collection. Most of this sediment was discharged by two storm runoff events, one that occurred October 14, 1955, and the other on May 9, 1961.

Figure 11 shows the double-mass relation of sediment discharge for the growing and dormant seasons with all data included. Neither the growing season nor the dormant season double-mass curve shows a significant decreasing trend in sediment discharge.)

SIZE DISTRIBUTION OF SUSPENDED SEDIMENT

(Size distribution of the suspended sediments was determined during the study because a change in the size distribution would indicate any change in the type of soil being eroded. Figure 12 shows the distribution of sand, silt, and clay in suspended-sediment samples collected from the streams in each of the basins. More than three-fourths of these samples correspond to the silt-loam soil class that is the predominant textural class in the basins.

TABLE 5.—*Seasonal variation of the size distribution of suspended sediment in Corey Creek and Elk Run basins, 1955–67*

Season	Number of analyses	Mean flow (cfs)	Concentration mean (mg/l)	Percent suspended sediment in size class		
				Sand	Silt	Clay
Corey Creek near Mainesburg, Pa.						
Dormant	16	275	770	16.7	58.9	24.4
Growing	7	300	290	8.0	59.6	32.4
Elk Run near Mainesburg, Pa.						
Dormant	20	364	628	23.4	56.4	20.2
Growing	5	353	1,360	17.2	59.6	23.2

Table 5 shows the seasonal variation in the size distribution of suspended sediments in Corey Creek and Elk Run. This table also indicates a reduction in sediment concentration in Corey Creek compared with Elk Run for the frequently recurring storms in the growing season. The reduction in sediment concentration corresponded with the reduction in sediment discharge from Corey Creek basin by the frequently recurring storms in the growing season. The relatively heavier sand fractions found in the dormant-season sediments indicated that the sediment was derived from a sandy source area located close to streamflow capable of transporting the sand. One such area could have been gullies and small stream channels that partly fill with material annually from the action of frequently recurring summer storms and from bank caving in the winter and early spring.

The lower sand and higher clay content found in samples collected during the growing season indicates that the sand fraction either was not eroded or was dropped from suspension before

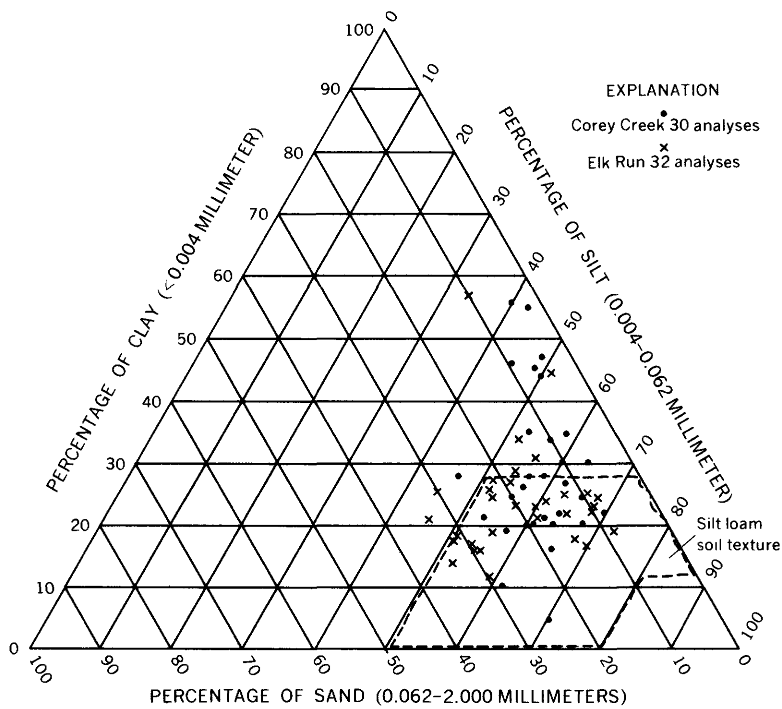

FIGURE 12.— Trilinear diagram showing percentages of sand, silt, and clay in suspended-sediment samples, Corey Creek and Elk Run near Mainesburg, Pa., 1955–67.

reaching streamflow capable of sustaining the larger particles in suspension.

STREAM-CHANNEL CHANGES

Data collected at the aggradation-degradation sites in Corey Creek showed a net fill at six sites and a net scour at two sites. The changes at the aggradation-degradation sites in Elk Run were more evenly distributed; four sites showed a net fill and three showed a net scour. Most changes that occurred in both basins were the result of cutting or filling of the streambanks and the bordering flood plain. The mean elevation of the streambeds remained generally unchanged.

Table 6 gives the sites that were resurveyed regularly during the study and shows the net change and average annual change as either scour or fill. The locations of the aggradation-degradation sites are shown in figure 1.

TABLE 6.—*Changes in cross-sectional area of aggradation-degradation sites, Corey Creek and Elk Run, 1954–67*

Site	Scour (square feet)		Fill (square feet)	
	Net change	Average annual change	Net change	Average annual change
Corey Creek				
1	6.26	0.48	--------	--------
4	--------	--------	8.03	0.62
5	--------	--------	3.24	.25
7	--------	--------	33.99	2.61
9	--------	--------	9.03	.70
11	--------	--------	59.31	4.56
14	9.99	.77	--------	--------
16	--------	--------	.32	.02
Elk Run				
1	--------	--------	0.35	0.03
6	--------	--------	13.82	1.06
7	15.08	1.16	--------	--------
8	--------	--------	3.78	.29
9	3.95	.30	--------	--------
10	5.52	.42	--------	--------
12	--------	--------	.81	.06

Figure 13 shows several representative aggradation-degradation site cross sections from both basins. The cross sections shown are based on the surveys made November 17, 1954, and June 22, 1967, and are intended to show where scour and fill occurred within the cross sections. Most of the change in the cross-sectional areas occurred during high flows. This is apparent particularly on ranges 7 and 11 in Corey Creek, where a large section of the flood plain filled during overbank flows. The low velocity of the streamflow

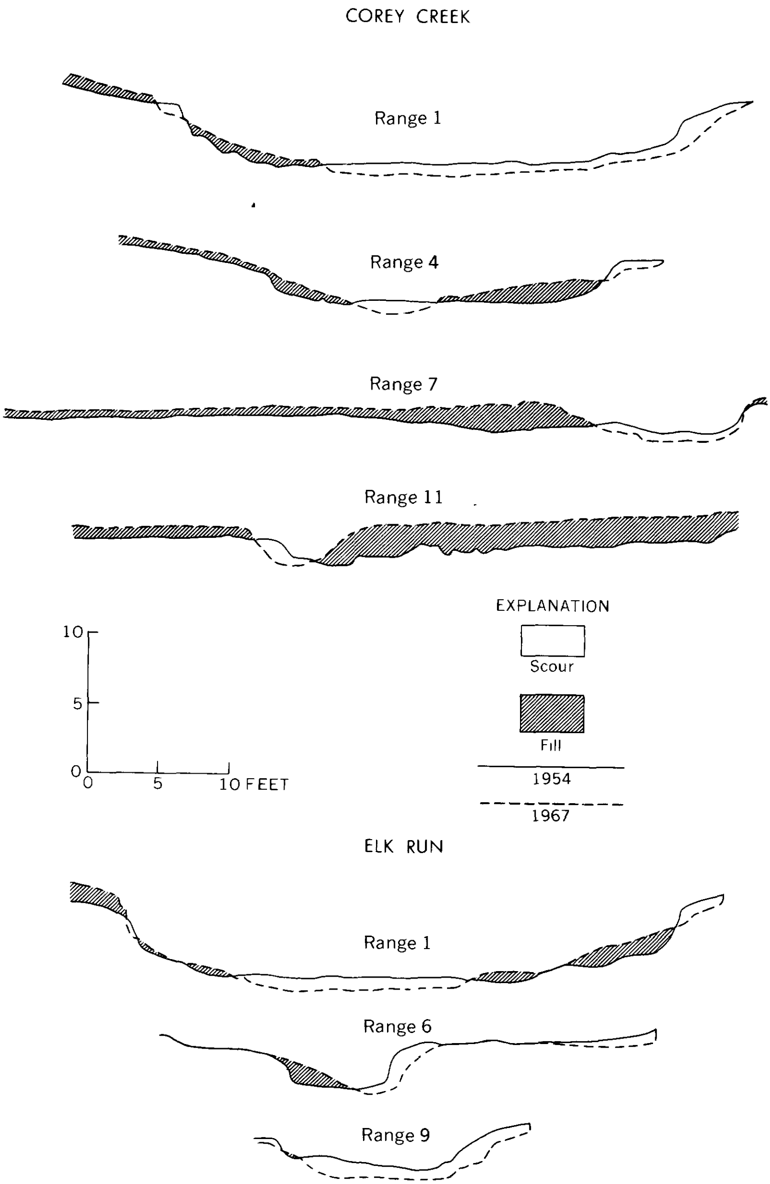

FIGURE 13.—Changes in stream cross sections at selected ranges, 1954–67.

over the flood plains resulted in large sediment deposition in these areas.

Most of the changes at the aggradation-degradation sites in both basins occurred on October 14, 1955, when a slow-moving frontal

TABLE 7.—*Chemical analyses of water, Corey Creek and Elk Run near Mainesburg, Pa., 1956–67*

[In milligrams per liter, except as indicated]

Date of collection	Instantaneous discharge (cfs)	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color
Corey Creek																			
6- 2-56	2.9	-----	2.6	0.02	18	3.2	5.5		69	17	2.0	0.1	0.2	93	58	9	141	7.7	4
12-10-56	15	-----	4.6	.01	15	2.3	2.0	1.7	38	18	2.7	.1	1.6	78	47	16	113	7.8	3
10- 8-58	1.5	16	1.1	.03	26	3.9	4.3	1.9	80	19	3.9	.1	.4	110	81	16	172	7.5	5
4- 2-59	95	4	4.1	.02	10	2.4	2.0	1.9	22	15	3.6	.3	5.2	80	35	17	90	6.5	7
8- 8-59	.2	-----	5.6	.02	30	4.3	6.2	2.5	107	13	4.8	.0	.6	126	93	5	205	7.4	5
4-11-60	15	9	4.9	.02	11	3.3	2.5	1.3	28	17	2.6	.1	1.8	76	41	18	92	7.3	5
6-24-60	474	-----	3.9	.03	8.6	1.8	2.0	2.4	22	9.6	1.8	.1	3.4	59	29	11	71	7.1	22
7-14-60	11	17	10	.01	21	3.6	4.0	3.0	61	15	7.3	.1	1.1	114	68	18	155	7.1	7
6- 5-61	3.2	26	1.1	.02	16	3.0	3.4	2.0	53	14	2.4	.2	.4	77	53	9	126	7.2	4
10-12-61	.7	20	1.6	.02	24	5.6	5.4	2.2	90	14	5.2	.1	.2	105	83	9	176	8.2	3
8-15-62	.3	28	3.2	.00	29	3.8	4.8	1.0	97	16	6.4	.1	.4	118	88	9	204	7.9	3
10-10-62	1.3	17	4.1	.00	26	4.1	4.8	2.5	74	24	6.8	.0	.9	117	82	22	201	7.8	2
5-13-63	7.0	16	3.8	.00	13	1.9	3.0	.5	36	13	3.8	.0	1.1	67	41	11	102	6.9	3
7-16-63	.3	25	2.5	.01	26	3.6	5.6	2.6	86	15	9.0	.1	1.1	115	80	10	190	7.0	10
10-25-63	.3	10	1.6	.00	31	5.1	6.4	1.1	111	15	8.3	.0	.4	124	99	8	230	7.3	3
1-23-64	49	1	4.3	.00	15	2.2	3.6	.7	31	19	6.1	.1	2.4	78	47	21	123	7.1	4
6- 8-64	3.6	22	3.5	.00	23	3.6	6.0	2.2	66	18	12.0	.2	1.2	120	73	19	179	6.9	4
3-23-65	3.2	1	1.7	.00	18	4.4	5.5	1.0	44	27	8.2	.1	2.0	91	63	27	158	7.2	4
6- 2-65	284	16	4.1	.01	14	2.4	3.3	2.6	25	20	5.1	.1	4.8	87	44	25	117	6.9	37
10-19-65	.8	14	1.1	.01	25	3.6	6.0	1.7	76	19	7.5	.1	.6	110	77	15	185	7.3	3
7-26-66	.05	27	3.2	.00	28	5.4	6.2	2.1	93	17	11.0	.1	.4	131	92	16	207	7.4	10
9-29-66	.4	13	1.8	.00	26	4.2	5.8	1.9	84	18	8.3	.0	.4	113	83	14	194	7.6	2
1-18-67	3.0	0	4.7	.01	25	3.5	5.0	1.6	58	28	9.5	.1	2.0	112	77	29	188	6.9	2
5-26-67	6.0	12	2.7	.00	16	2.0	2.8	1.1	34	19	4.8	.0	.5	85	48	20	113	6.6	2

Elk Run

6- 2-56	1.4	-----	1.8	0.02	16	2.5	6.7		55	16	1.5	0.1	0.8	88	50	5	126	7.1	5
12-10-56	14	-----	5.5	.02	14	1.8	1.8	1.2	34	16	2.5	.0	1.0	58	42	14	100	7.6	3
10- 8-58	.8	16	6.4	.03	24	3.2	4.6	2.5	78	15	4.6	.1	.5	107	73	9	169	7.3	3
8- 8-59	.1	20	3.1	.02	27	3.4	6.2	2.4	96	12	5.8	.0	.1	139	82	3	189	7.4	5
3-29-60	191	-----	6.9	.01	8.2	1.6	1.5	1.9	16	12	1.9	.2	6.8	57	27	14	71	6.6	12
4-11-60	22	9	4.1	.00	9.8	2.8	2.5	1.3	24	18	2.8	.1	1.8	69	36	17	86	6.8	3
7-12-60	.9	27	6.6	.00	19	2.7	4.0	2.2	61	13	3.4	.1	.7	97	59	9	134	7.3	3
6-15-61	2.9	26	.9	.01	15	7.3	3.4	2.0	49	13	2.1	.1	.2	70	47	7	113	7.6	6
10-12-61	.7	21	1.1	.02	21	3.6	4.3	3.0	56	12	4.6	.1	.2	85	68	5	154	8.7	3
10-10-62	2.0	17	.3	.01	22	3.2	4.2	1.4	61	22	5.4	.1	.4	116	68	18	174	7.5	10
3-18-63	35	3	3.9	.03	9.6	1.7	2.1	2.0	20	13	4.6	.0	2.8	64	31	15	94	6.8	7
5-14-63	4.9	13	3.0	.00	12	1.5	3.0	.5	34	13	2.4	.0	.7	59	36	8	90	7.3	5
10-25-63	.1	13	2.2	.00	26	3.9	5.2	1.4	85	15	7.4	.2	.6	103	81	12	192	6.9	3
1-23-64	19	1	4.3	.03	14	2.2	3.0	1.0	26	18	8.6	.1	2.9	79	44	23	123	6.7	5
2- 7-65	420	4	2.2	.06	6	1.2	3.5	6.5	7	11	7.0	.1	11.0	59	20	15	83	6.5	30
3-23-65	4.2	1	2.5	.00	16	3.4	5.5	1.0	32	23	11.0	.1	1.5	85	54	28	148	7.0	3
5- 2-65	66	13	4.4	.00	14	2.4	3.4	1.2	20	23	6.5	.2	3.5	85	45	29	118	6.8	20
5-27-65	12	20	4.9	.06	19	2.7	4.3	2.2	44	20	7.5	.3	3.1	101	58	23	147	7.1	25
6- 2-65	287	16	4.0	.04	14	1.9	3.1	2.2	24	20	4.5	.2	6.4	91	44	24	118	6.5	42
6-10-65	14	21	4.1	.00	16	1.5	2.9	1.7	36	17	4.9	.1	1.3	77	66	17	114	6.6	10
10-19-65	.75	16	1.9	.01	23	3.4	5.5	2.3	70	17	6.5	.1	.5	101	72	14	173	7.4	3
3- 5-66	338	5	5.5	.00	10	1.6	2.8	2.4	16	17	4.6	.0	5.7	73	32	18	90	6.6	8
5-17-66	11.4	16	4.0	.05	13	1.8	3.2	1.3	29	18	4.6	.0	.5	73	40	16	106	6.9	5
9-29-66	.1	12	2.2	.00	28	3.5	6.0	1.5	70	23	12.0	.2	.4	100	85	27	154	6.6	2
1-18-67	2.9	0	2.7	.00	21	2.8	4.5	1.6	45	25	8.0	.1	1.4	93	64	27	154	6.6	2
5-26-67	5.8	12	3.3	.00	15	2.1	2.7	1.8	32	19	5.6	.2	.4	71	46	20	111	6.5	10

storm produced more than 5 inches of rain and peak streamflows of 2,150 and 1,220 cfs in Corey Creek and Elk Run, respectively. Since that time the ranges in Corey Creek have shown a slight filling tendency, whereas the ranges in Elk Run have shown a slight tendency to scour; however, the high flow on October 14, 1955, produced larger changes than the combined changes produced by all events since.

SEDIMENT SOURCES

The lack of a trend in sediment discharge during the dormant season can be attributed to a difference in sediment source areas during part of the dormant season. About 40 percent of the dormant-season sediment discharge occurs as a result of snowmelt or a combination of rains and snowmelt. When snowmelt or snowmelt accompanied by rain occurs, the sediment must come from areas where sediment is available and where the runoff is concentrated. This condition occurs most commonly on and along rills, gullies, and channels where the flow concentrates and where vegetal cover is at a minimum. In the growing season these rills, gullies, and channels act as sediment traps, but during the dormant season they act as source areas. Some of the sediment trapped during the prior growing season acts as a source, and additional material is supplied by the frost heaving that moves soil downslope.

Land-use areas other than cropland, such as roads and urban areas, contribute significantly to sediment discharge, especially when the carrying capacity of roadside gullies is greatly exceeded. Resulting erosion of the berm and roadway can leave the roadway impassable.

Analysis of the subbasin sediment yield data (Jones, 1966, p. 35) showed that the lower basin area contributed two times as much sediment per square mile as the upper basin areas. This might be expected, because the urban area of Mainesburg has a high erosion potential, and there is only a relatively small area of the lower basin in woodland.

WATER CHEMISTRY

Chemical analyses of periodic samples of the water in Corey Creek and Elk Run are given in table 7. Information on the chemical elements in the stream gave some indication of the magnitude and rate of chemical weathering and erosion. The list of samples represents all seasonal conditions and the range of discharge from low to high flow.

TABLE 8.—*Comparison of chemical and physical properties of water, Corey Creek and Elk Run near Mainesburg, Pa., 1955–60 and 1961–67*

Interval and change	Average annual discharge (cfs-days)	Mean dissolved solids concentration (mg/l)	Average annual dissolved solids discharge (tons)	Average annual suspended sediment discharge (tons)	Mean chloride ion concentration (mg/l)	Average annual chloride ion discharge (tons)
Corey Creek						
1955–60	4,935	79	1,043	1,990	2.8	38
1961–67	3,279	85	753	1,160	6.0	48
Percent change	–33	+8	–28	–42	+112	+26
Elk Run						
1955–60	4,640	63	794	1,760	2.4	30
1961–67	2,784	79	588	1,040	6.0	45
Percent change	–40	+25	–26	–41	+150	+50

The chemical data in table 7 were analyzed with respect to the four flow-duration curves shown in figure 4. Table 8 shows the results of this analysis and compares the mean concentration and average annual discharge of dissolved solids and chloride ion with the average annual water and sediment discharge. In both basins the mean yearly discharge of water for the period 1961–67 decreased more than 30 percent from the mean yearly discharge of the 1955–60 period. The chloride ion was the only exception to the trend of decreasing discharges during the final 7 years. The concentration of chloride ion increased 3.2 mg/l (milligrams per liter) in Corey Creek and 3.6 mg/l in Elk Run. The increased concentration resulted in an increase of the chloride-ion discharge in both basins. This could be the result of increased application of chloride salts to highways for ice removal.

SUMMARY AND CONCLUSIONS

Data collected during the period 1954–67 have been used in this report to determine the effects that extensive agricultural conservation practices have had on the hydrology of Corey Creek. The method of determination was a comparison of the hydrologic events observed in Corey Creek with the concurrent hydrologic events observed in Elk Run, a stream draining an adjacent basin that did not receive an intense application of conservation practices.

A reduction in the sediment discharged for low-recurrence-interval storms from Corey Creek during the growing season was accomplished by the installation of conservation practices and the general educational program that accompanied these practices. This amounted to a 47-percent reduction in sediment discharge by low-recurrence-interval storms during the May to October growing season, when 6 percent of the sediment was discharged. A reduction in sediment discharge during major events of the growing season and the November to April dormant season, when 94 percent of the sediment was discharged, could not be detected. Indications are that the primary source of dormant-season sediment discharge was from areas other than prime agricultural land.

The discharge of chloride from the basin increased during the period of investigation, even though total water discharge was less than normal, owing to the drought. Generally, the chemical quality of the water from both basins was good even during periods of low flow.

There was no significant change in the peakedness of flow events in Corey Creek or in the occurrence of low flows in Corey Creek as compared with Elk Run during the period of investigation.

SELECTED REFERENCES

Culbertson, J. K., 1957, Progress report of hydrology and sedimentation in Bixler Run, Corey Creek and Elk Run watersheds, Pennsylvania: U.S. Geol. Survey open-file report, 44 p.

Frevert, R. K., Schwab, G. O., Edminster, T. W., Barnes, K. K., 1955, Soil and Water Conservation Engineering: New York, John Wiley & Sons, Inc., 479 p.

Guy, H. P., 1957, The trend of suspended-sediment discharge of the Brandywine Creek at Wilmington, Del., 1947–55: U.S. Geol. Survey open-file report, p. 1b–12b.

Hendrickson, B. H., Burke, R. T. A., Goodman, K. V., and Smith, R. L., 1929, Soil survey of Tioga County, Pennsylvania: U.S. Dept. Agriculture, Bur. Chemistry and Soils, Soil Survey Rept. 30, 47 p.

Jones, B. L., 1964, Sedimentation and land use in Corey Creek and Elk Run basins, Pennsylvania, 1954–60 (a progress report): U.S. Geol. Survey open-file report, 112 p.

——— 1966, Effects of Agricultural conservation practices on the hydrology of Corey Creek basin Pennsylvania, 1954–60: U.S. Geol. Survey Water-Supply Paper 1532–C, 55 p.

Jones, B. L., and Unger, D. G., 1962, Measuring effects of conservation: Soil and Water Conserv. Jour., v. 17, no. 4, p. 172–174.

Linsley, R. K., Kohler, Max A., and Paulhus, L. H., 1949, Applied hydrology: New York, McGraw-Hill Book Co., 689 p.

Lohman, S. W., 1939, Ground water in north-central Pennsylvania: Pennsylvania Topog. and Geol. Survey Bull. W–6, p. 8–15.

Musgrave, G. W., 1947, The quantitative evaluation of factors in water erosion —a first approximation: Soil and Water Conserv. Jour., v. 2, no. 3, p. 133–138.

Schneider, W. J., and Ayer, G. R., 1961 Effect of reforestation on streamflow in central New York: U.S. Geol. Survey Water-Supply Paper 1602, 61 p.

Searcy, J. K., and Hardison, C. H., 1960, Double-mass curves: U.S. Geol. Survey Water-Supply Paper 1541–B, 66 p.

Tioga County Soil Conservation District, 1954, Work plan Corey Creek watershed protection project: Wellsboro, Pa., 43 p.

U.S. Department of Agriculture, 1957, Soils: The Yearbook of Agriculture 1957: Washington, U.S. Govt. Printing Office, 784 p.

Van Doren, C. A., and Bartelli, L. J., 1956, A method of forecasting soil losses: Agr. Eng., v. 37, no. 5, p. 335–341.

☆U.S. GOVERNMENT PRINTING OFFICE: 1971 O—407–620

6958