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SURFACE MINING AND THE FLOOD OF APRIL 1977

—WILLIE R. CURTIS
Research Hydrologist
Northeastern Forest Experiment Station
Berea, Ky.

Abstract.—Data from experimental sites in Breathitt County, Kentucky, and Raleigh County, West Virginia, showed that during a major rainstorm on 4 April 1977 streamflow from surface-mined watersheds peaked lower than that from adjacent or nearby unmined watersheds.

On 4 April 1977 a major storm struck southern Appalachia. Reports were that it caused the worst flooding since 1957, or since 1939, or perhaps the worst in history.

Many possible causes of the flooding have been discussed. Among these are forest fires, logging, agriculture, road building, construction on flood plains, and surface mining. But there are few quantitative data to support these conjectures.

One of the first attempts in the U.S. to evaluate the hydrologic impact of surface mining was at Beaver Creek in southeastern Kentucky. Flow from the mined watershed was more variable than that from the unmined control watershed, and also tended toward higher storm flows and lower base flows (Collier et al. 1970).

Strip-mined watersheds in Indiana showed an increase in base flow, apparently due to increased storage capacity. Agnew and Corbett (1973) reported that during the unusually dry summer of 1964, a number of streams draining strip-mined land were flowing while streams draining adjacent unmined areas of similar or larger size were dry.

Although some studies have been made, the effects of surface mining on the hydrograph of discharge remain largely unmeasured. In 1967 the USDA Forest Service's Northeastern Forest Experiment Station began a study of the effects of surface mining on the water resources of small Appalachian watersheds. Three unmined forested watersheds in Bear Branch, Breathitt County, Ky., were selected and instrumented for collection of streamflow and water quality data. Miller Branch and Mullins Fork are adjacent basins; Jenny Fork is about a mile away. Jenny Fork is unmined; Miller Branch and Mullins Fork have been surface mined. Two more watersheds, Dillon and Stover B, in Raleigh County, W. Va., some 120 miles from the Kentucky site, were selected and instrumented in 1969.

Sedimentation basins were built in Miller Branch and Mullins Fork in November of 1969, shortly after mining began. Their original storage capacities were 15.9 and 15.4 acre feet, respectively. In October of 1976, the remaining storage capacity was about 6.5 acre feet for Miller and 3.5 acre feet for Mullins; sediment from the mining operations occupied the rest.

Descriptive data on the watersheds studied are:

Watershed	*Area (acres)*	*Area disturbed by mining*	*Percent of area disturbed*	*Dates of mining*	
				Began	*Ended*
Jenny	287	0	0	—	—
Miller	190	105	55	Aug. '68	Dec. '71
Mullins	327	151	46	Aug. '69	Oct. '72
Dillon	164	0	0	—	—
Stover B	446	250	56	Sept. '72	June '73

A complete detailed analysis of streamflow in relation to surface mining is underway and will be reported; some results of the study have already been reported (Curtis 1971, 1972, 1973, and 1974). But there presently is considerable interest in the flooding that took place during early April 1977, and it seems appropriate to share now some of the knowledge we gained during that period. Of course, the information from three watersheds in Kentucky and two in West Virginia does not necessarily apply to all watersheds in Appalachia, but it does provide some food for thought.

This case history covers a 9-day period beginning on 1 April 1977. There was no precipitation on 1 April. At the Kentucky site rain began at 1930 on 2 April and ended about 2245 after 0.72 inch of water had fallen. At about 2045 on 3 April it started raining again, and continued with periodic high intensities for about 26 hours, ending just before midnight on 4 April. The total precipitation was 3.70 inches (Fig. 1). At the West Virginia site rain began at 2110 on 2 April and ended about 2345 with 0.31 inch. Rain started again at 2145 on 3 April and by midnight on 4 April, 3.85 inches had fallen on the watersheds. Additional small amounts fell on 5 and 6 April (Fig. 2).

Data collected at other nearby gaging sites suggest that all the watersheds in each group received the same amount of rain; and the rain at the Kentucky site was almost the same as that at the West Virginia site (Fig. 1 and 2).

Figure 1 shows the precipitation on the Kentucky watersheds and the flow from them. At Jenny Fork (the unmined watershed), the 0.72 inch of rain on 2 April had little direct influence on streamflow; most of this water apparently went to recharge a moisture deficit in the soil. By the time the next rain started late on the 3rd, water was already stored in the soil; streamflow responded very quickly to rainfall. Note that during the two periods when rainfall intensity declined, streamflow decreased rather sharply. The peak flow came very near the end of the storm. The plot also shows a fairly rapid depletion rate on 5 April.

Below the streamflow data from Jenny Fork are plotted those from Mullins Fork. Keep in mind that Mullins Fork contains about 150 acres of land disturbed by surface mining; Jenny Fork is completely forested. The two lower curves show the similarity of flow from the two mined watersheds.

Figure 2 shows the streamflow response of the unmined and mined watersheds in West Virginia. The precipitation pattern is nearly the same as that for the Kentucky area. Note that the mined watershed peaked about 16 percent lower than the unmined watershed.

Runoff from Jenny Fork peaked at a rate of 160 cubic feet per second per square mile ($ft^3/s/mi^2$) while Mullins peaked at 93 and Miller at 64. Unmined Dillon peaked at 109 and Stover B at 91. Table 1 summarizes the flow in both mean daily cubic feet per second per square mile and area inches per day for each of the 9 days. An area inch is the volume of water that would cover the entire drainage area to a depth of 1 inch. By comparing area inches for Jenny with those of Mullins or Miller Branch we see that Jenny yielded nearly twice as much flow as Mullins and more than twice as much as Miller on 4 April; furthermore both Miller and Mullins yielded more water than Jenny for each of the next 5 days. In the West Virginia watersheds, unmined Dillon yielded about 18 percent more water on 4 April than Stover B. It is interesting that the West Virginia stream had more discharge on the 5th than on the 4th, just the opposite of the Kentucky streams. This is probably because the general eastward movement of the storm system caused the West Virginia streams to rise and peak later than the Kentucky streams.

According to our calculations, Jenny Fork yielded 4.03 area inches of water while Miller yielded 2.73 and Mullins 2.88 during the first 9

Figure 1.—Precipitation and streamflow from watersheds in Kentucky. Jenny Fork is unmined; Mullins and Miller have been mined.

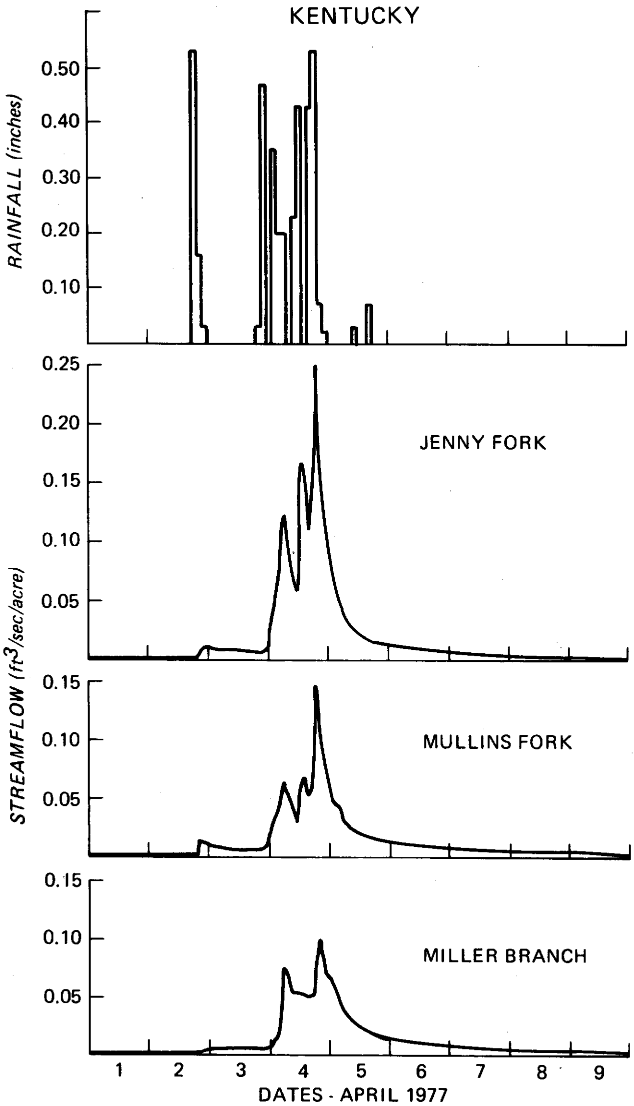
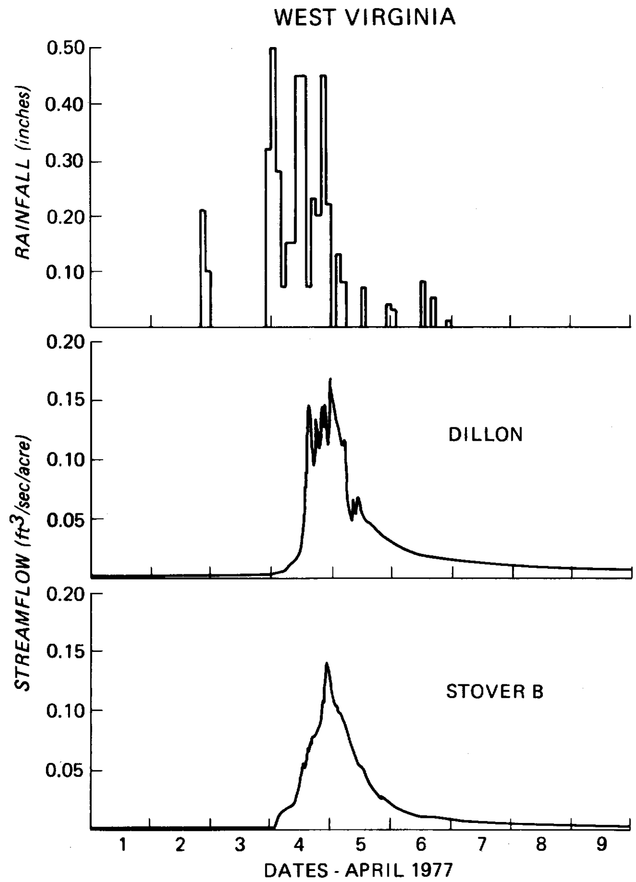


Figure 2.—Precipitation and streamflow from watershed in West Virginia. Dillon is unmined; Stover has been mined.



days of April. This means that more than 1 inch of rain went into retention storage in the two mined watersheds while very little went into storage in the unmined watershed.

Remembering that the data presented here are for only one storm on only two unmined and three mined watersheds, can we discern any implications? The soils in the unmined watersheds are relatively thin, generally from 1 to 3 feet thick. This means that water retention in these soils is about 3 to 10 inches. If this storage is filled, any water added will be available for streamflow. On the other hand, surface mining creates vast quantities of broken-up rock which provide storage space for large quantities of water. This could account for the reduced peak flows and the reduced volume of flow as well as the higher depletion flow rates on the mined watersheds.

Unfilled sediment basins can reduce local peak flows and prolong discharge for a few hours by regulating release from relatively small headwater drainages such as those in this study. However, measurements made along the high water mark in the Kentucky watersheds on 26 April showed that neither of the basins had been filled to capacity during the study period. In fact at maximum storage the basin in Miller Branch held only 38,800 cubic feet—less than

Table 1.—*Summary of stream discharges for the period 1 April to 9 April 1977*

Date in April 1977	Unmined watersheds				Mined watersheds					
	Jenny Fork		Dillon		Miller Branch		Mullins Fork		Stover B	
	Mean daily ft³/s/mi²	Mean area inches per day	Mean daily ft³/s/mi²	Mean area inches per day	Mean daily ft³/s/mi²	Mean area inches per day	Mean daily ft³/s/mi²	Mean area inches per day	Mean daily ft³/s/mi²	Mean area inches per day
1	0.577	0.022	1.093	0.041	0.891	0.033	0.884	0.033	0.603	0.022
2	1.392	.052	1.312	.049	1.160	.043	2.091	.078	.582	.021
3	4.176	.155	1.313	.049	3.116	.116	3.578	.133	.672	.025
4	70.060	2.606	40.508	1.506	33.808	1.257	38.488	1.432	33.016	1.228
5	19.481	.725	42.449	1.579	19.230	.715	16.047	.597	38.393	1.429
6	5.475	.204	12.422	.462	5.961	.222	5.768	.214	8.550	.318
7	3.356	.125	7.260	.270	4.059	.151	4.169	.155	4.250	.158
8	2.309	.086	5.512	.205	2.897	.108	3.424	.127	3.028	.113
9	1.646	.061	4.224	.157	2.206	.082	3.083	.115	2.386	.089
Totals		4.036		4.318		2.727		2.884		3.403

one acre foot. The Mullins Fork basin held less than 3,000 cubic feet during maximum storage. These volumes are so small relative to the total storm discharges that they could not have had any significant influence on either peak flow rates or total streamflow. This tends to support our theory that retention and detention storage is in or on the mine spoil.

The same pattern of streamflow response on surface-mined watersheds was documented for a major storm on 4 April 1977 in areas more than 120 miles apart. The magnitude of the response was less pronounced at the West Virginia site where a smaller percentage of the watershed had been disturbed by mining.

Data on the effects of surface mining on our water resource are badly needed by resource managers. These preliminary results suggest that conventional wisdom about disturbed land may not be a good guide to hydrologic effects.

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