FLOOD DISCHARGES AND HYDRAULICS NEAR THE MOUTHS OF WOLF CREEK, CRAIG BRANCH, MANNS CREEK, DUNLOUP CREEK, AND MILL CREEK IN THE NEW RIVER GORGE NATIONAL RIVER, WEST VIRGINIA

By Jeffrey B. Wiley

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

Multiply	By	To obtain
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi ²)	2.590	square kilometer
cubic foot per second (ft ³ /s)	0.02832	cubic meter per second

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

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ABSTRACT

The U.S. Geological Survey, in cooperation with the National Park Service, studied the frequency and magnitude of flooding near the mouths of five tributaries to the New River in the New River Gorge National River. The 100-year peak discharge at each tributary was estimated from regional frequency equations. The 100-year peak discharge at Wolf Creek, Craig Branch, Manns Creek, Dunloup Creek, and Mill Creek was 3,400 ft³/s (cubic feet per second), 640 ft³/s, 8,200 ft³/s, 7,100 ft³/s, and 4,900 ft³/s, respectively.

Flood elevations for each tributary were estimated by application of a steady-state, one-dimensional flow model. Manning's roughness coefficients for the stream channels ranged from 0.040 to 0.100. Bridges that would be unable to contain the 100-year flood within the bridge opening include: the State Highway 82 bridge on Wolf Creek, the second Fayette County Highway 25 bridge upstream from the confluence with New River on Dunloup Creek, and an abandoned log bridge on Mill Creek.

INTRODUCTION

The New River flows northward from its headwaters in North Carolina, through western Virginia, and into south-central West Virginia, where it joins the Gauley River to form the Kanawha River (fig. 1). The New River Gorge National River was established by Public Law 95-625 on November 10, 1978, and falls within the jurisdiction of the U.S. Department of the Interior, National Park Service (NPS). The NPS is responsible for (1) conserving the natural, scenic, and historical objects, and (2) preserving a 53-mi segment of the lower New River in West Virginia (approximately from Hinton to Fayette) as a free-flowing stream for the enjoyment and benefit of present and future generations. The main attraction of the National River is a combination of scenic wilderness, fishing, and excellent white-water rafting. The recreational quality depends, in part, on regulated flow releases from Bluestone Dam and on the unregulated flow from the Greenbrier River.

The U.S. Geological Survey (USGS), in cooperation with the NPS, studied the frequency and magnitude of flooding for selected tributary streams to the New River Gorge National River. This information will be used by the NPS to develop park facilities. Knowledge of flood levels can be used to prevent unexpected repair and maintenance costs caused by flooding. Some facilities can be located near the tributaries with expectation of frequent flooding, but other facilities might need to be located outside of flood-hazard areas or where flooding is less frequent.

Purpose and Scope

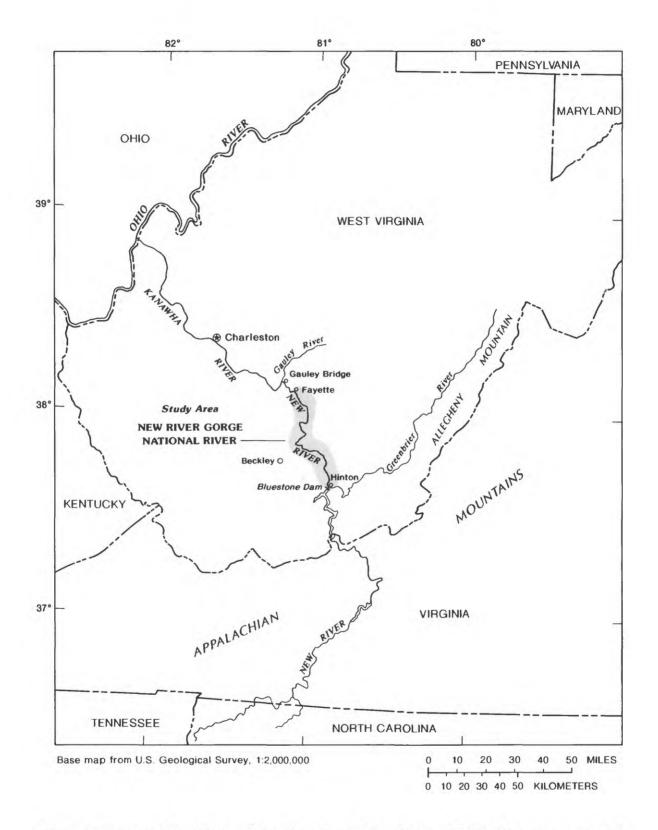
The purpose of this report is to provide estimates of the frequency and magnitude of flooding for selected reaches of five tributary streams to the New River Gorge National River. Flood discharges and elevations are presented for the 2-, 25-, and 100-year recurrence intervals. All study reaches are within the boundaries of the New River Gorge National River, and flood discharges and elevations are applicable only to the tributary streams (backwater effects from the New River are identified when applicable).

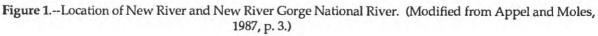
Description of Study Reaches

Five tributary reaches were selected for this study: Wolf Creek at South Fayette, Craig Branch at Kaymoor, Manns Creek at Sewell, Dunloup Creek near Thurmond, and Mill Creek near Quinnimont (fig. 2). In this report, names of river rapids follow those presented by Wiley and Appel (1989) and drainage areas of tributaries are from Mathes and others (1982).

Wolf Creek flows into the New River upstream from Fayette Station Rapid on the left bank at South Fayette (fig. 3). The drainage area of Wolf Creek is 17.4 mi². The streambed slope averages 0.03 ft/ft for the first 600 ft of the study reach, and then increases to 0.07 ft/ft for the remainder of the study reach. From the New River, the tributary follows State Highway 82 for 1,000 ft, where the highway turns northwestward and ascends the gorge, and the tributary continues southward. The study reach begins at the confluence with the New River and ends 50 ft upstream from where Highway 82 turns northwestward. Three bridges are located in the study reach--a private bridge located near the tributary mouth, the Chesapeake and Ohio Railroad bridge located along the intersection between the floor and wall of the gorge, and the Highway 82 bridge located 1,000 ft upstream from the mouth. A chiseled square on top of the downstream-left abutment of the private bridge is 874.1 ft above sea level. A chiseled square on the top-center of the downstream handrail of the Highway 82 bridge is 913.1 ft above sea level.

Craig Branch flows into the New River upstream from Upper Kaymoor Rapid on the left bank at Kaymoor (fig. 4). The drainage area of Craig Branch is 1.7 mi². The streambed slope is 0.2 ft/ft and approximates the slope of the lower part of the southern gorge wall. From the New River, the tributary flows through a 16-ft-high arched culvert for 83 ft under the Chesapeake and Ohio Railroad and then up the southern wall of the gorge. One abandoned railroad





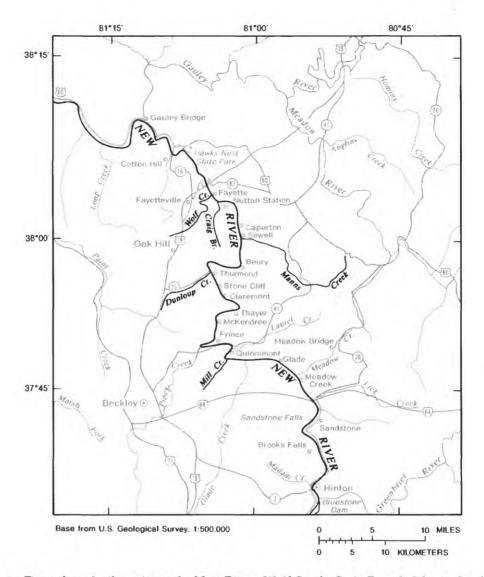


Figure 2.--Five selected tributaries to the New River--Wolf Creek, Craig Branch, Manns Creek, Dunloup Creek, and Mill Creek.

grade and one retired railroad bridge are approximately 350 ft and 500 ft, respectively, upstream from the confluence with the New River along the gorge wall. The study reach begins at the confluence with the New River and ends approximately 150 ft upstream from the retired railroad bridge. A chiseled triangle on top of the upstream-left headwall of the culvert under the Chesapeake and Ohio Railroad is 923.1 ft above sea level.

Manns Creek flows into the New River upstream from Pinball (Indigestion) Rapid on the right bank at Sewell (fig. 5). The drainage area of Manns Creek is 58.6 mi² The streambed slope averages 0.014 ft/ft for the first 900 ft and increases to 0.40 ft/ft for the last 400 ft. From the beginning of the study reach at New River, the tributary extends eastward 400 ft until reaching a Chesapeake and Ohio Railroad bridge, and continues eastward an additional 900 ft to the end of the study reach. A Coast and Geodetic Survey disk designated "Y-192" on top of the downstream-right headwall of the Chesapeake and Ohio Railroad bridge is 1,009.3 ft above sea level.

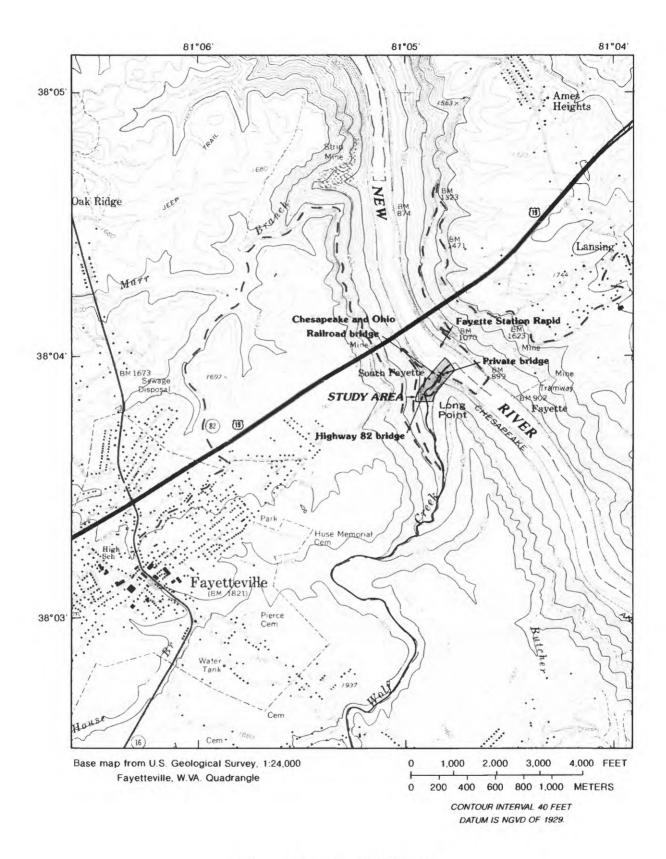


Figure 3.--Location of Wolf Creek

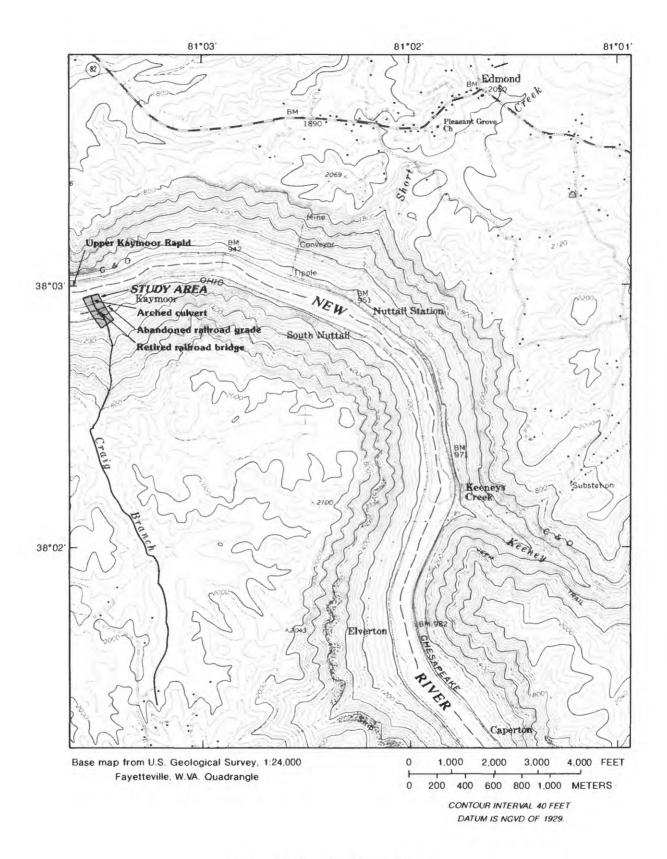


Figure 4.--Location of Craig Branch.

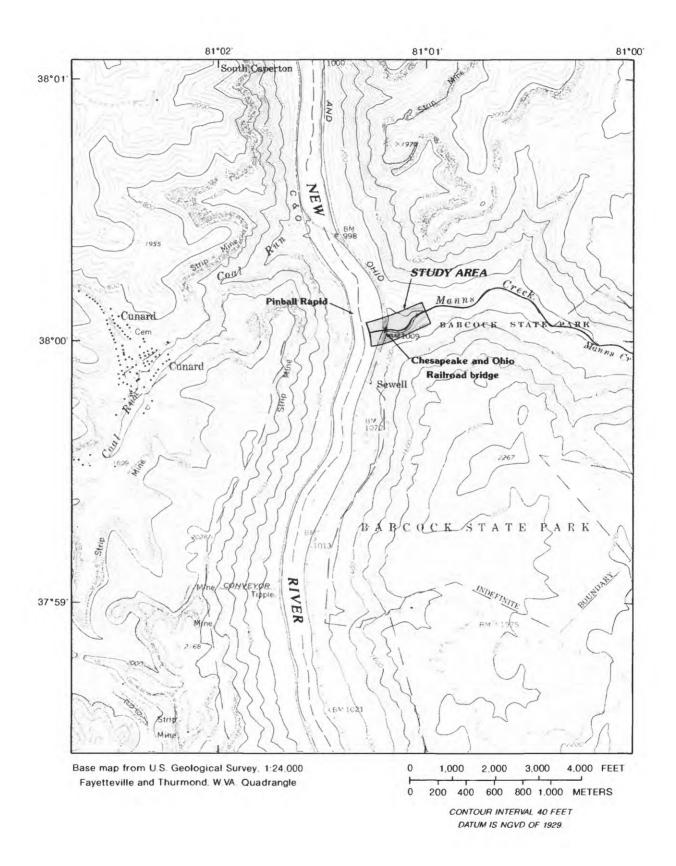


Figure 5.--Location of Manns Creek.

Dunloup Creek flows into the New River upstream from Thurmond Shoals and the Chesapeake and Ohio Railroad bridge (across the New River) on the left bank at Thurmond (fig. 6). The drainage area of Dunloup Creek is 48.5 mi². The streambed slope averages 0.001 ft/ft for the first 500 ft, and then increases to 0.03 ft/ft to the end of the study reach. From the New River, the tributary follows Fayette County Highway 25 southward. Two Highway 25 bridges cross the tributary at 500 ft and 700 ft, repectively, upstream from the confluence with New River. The study reach begins at the confluence with the New River and ends 1,950 ft upstream (approximately 300 ft downstream from a railroad bridge across Dunloup Creek). A chiseled square on the upstream-left abutment of the first Highway 25 bridge upstream from the confluence with New River is 1.062.1 ft above sea level. A chiseled square on the upstream-left handrail of the second Highway 25 bridge upstream from the confluence with New River is 1,058.7 ft above sea level.

Mill Creek flows into the New River near Quinnimont on the left bank (fig. 7). The study area is limited to an abandoned log bridge approximately 800 ft upstream from the tributary mouth. The streambed slope in the area of the abandoned bridge is 0.01 ft/ft, and the drainage area of Mill Creek is 29.1 mi². A chiseled square on top of a large rock outcrop at the edge of the valley wall on the right bank, approximately 30 ft upstream from the abandoned bridge, is 100.0 ft above an arbitrary datum.

FLOOD DISCHARGES

Peak discharges for the 2-, 25-, and 100-year recurrence intervals were estimated with regionalized equations developed by Runner (1980). These equations are functions with one dependent variable (drainage area). Discharges were calculated for each study reach at the tributary's confluence with the New River. Discharges for the five study reaches are presented in table 1.

	Drainage area,		ge for indicated recurrence inte n cubic feet per second	
Location	in square miles	2 years	25 years	100 years
Wolf Creek	17.4	900	2,400	3,400
Craig Branch	1.7	130	420	640
Manns Creek	58.6	2,500	5,900	8,200
Dunloup Creek	48.5	2,100	5,100	7,100
Mill Creek	29.1	1,400	3,500	4,900

Table 1.--Summary of peak discharges

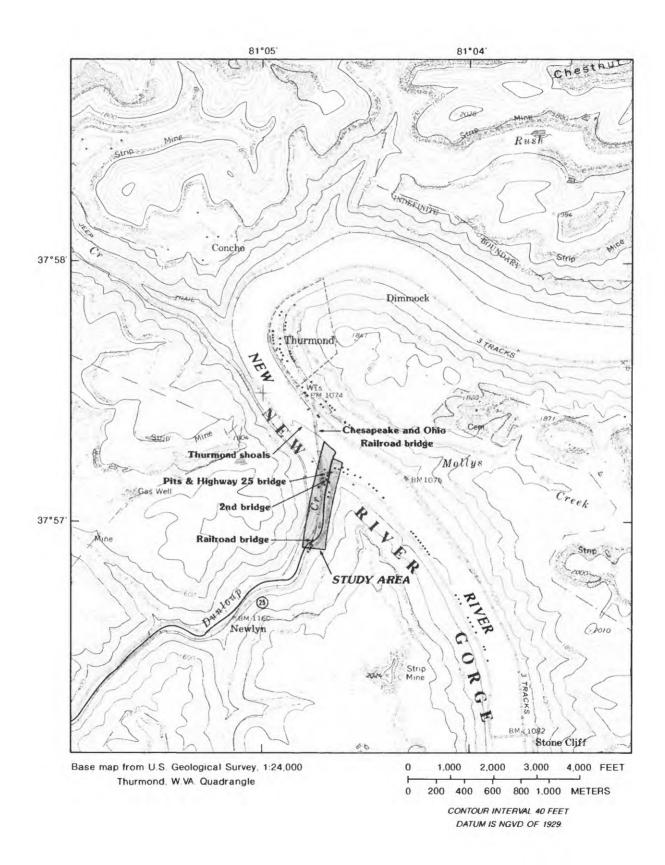


Figure 6.--Location of Dunloup Creek.

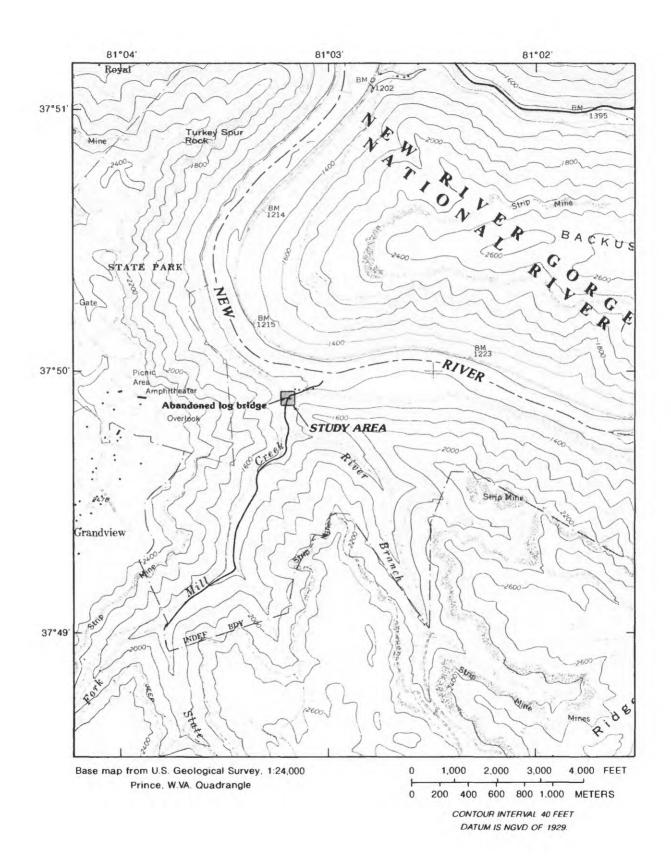


Figure 7.--Location of Mill Creek.

FLOOD HYDRAULICS

Flood elevations for the study reaches were determined by use of a steady-state, one-dimensional flow model, Water Surface PROfile (WSPRO) (Shearman, 1990). The WSPRO model is a FORTRAN (FORmula TRANslation) program that computes the water-surface elevation by solving the energy equation between successive cross sections. Input data include crosssection reference distance, cross-section geometry, Manning's roughness coefficient, stream discharge, and starting water-surface elevation. The program offers many options, which include calculating water-surface elevations through bridges and culverts; varying Manning's roughness coefficient with hydraulic depth and subareas of cross sections; specifying flow lengths between cross sections or subareas of cross sections that override reference distances; solving the equation for critical or subcritical flows in the upstream direction or for critical or supercritical flows in the downstream direction; and providing user-defined output tables selected from more than 50 parameters and variables used in the model.

For this study (1) cross-section reference distances were measured with a graduated beaded cable, (2) cross-section geometry data were measured with an engineer's level and leveling rod, (3) Manning's roughness coefficients were estimated by comparing photographs of streams where roughness coefficients were measured (Barnes, 1967) to the study reaches, (4) discharges were estimated using equations as discussed in the "Flood Discharges" section of this report, and (5) starting water-surface elevations were determined by the slope-conveyance method described in the manual for WSPRO users (Shearman, 1990). Flood elevations of the New River (Wiley, 1993) were used to determine backwater effects of the New River on the tributary streams. Convergence testing was not conducted on computed water-surface elevations. Therefore, additional cross sections or different cross sections for the same stream reach may result in computing

different water-surface elevations. Sensitivity testing was not conducted for roughness parameters or boundary conditions.

At Wolf Creek, cross-section reference distances were measured from the confluence with the New River at South Fayette. Manning's roughness coefficients for the stream channel ranged from 0.040 to 0.080. The Chesapeake and Ohio Railroad bridge, which is located just upstream from the private bridge, does not constrict the stream channel, thus the bridge was not treated as a hydraulic structure for model applications. The water-surface elevation corresponding to the 100-year flood approximately equaled the elevation of the substructure of the private bridge, and was greater than the road-approach elevation of the State Highway 82 bridge. Streambed and flood profiles are presented in figure 8, and flood elevations are listed in table 2.

At Craig Branch, cross-section reference distances were measured from the confluence with the New River at Kaymoor. Manning's roughness coefficients for the stream channel ranged from 0.045 to 0.100. The arched culvert under the Chesapeake and Ohio Railroad was not treated as a hydraulic structure because streamflow was not affected by pressures at the entrance or exit; instead, an open-channel analysis with a Manning's roughness coefficient of 0.025 was used. The old railroad grade and retired railroad bridge were not treated as structures, because channel constriction (at the evaluated discharges) was insignificant and because critical streamflows were evaluated at the bridge openings and exit sections. The water-surface elevation corresponding to the 100-year flood was about 4.5 ft greater than the invert elevation at the culvert exit and about 3.5 ft greater than the invert elevation at the culvert entrance. The water-surface elevation corresponding to the 100-year flood also was less than the elevation of the substructure of the retired railroad bridge. Streambed and flood profiles are presented in figure 9. Flood elevations are listed in table 3.

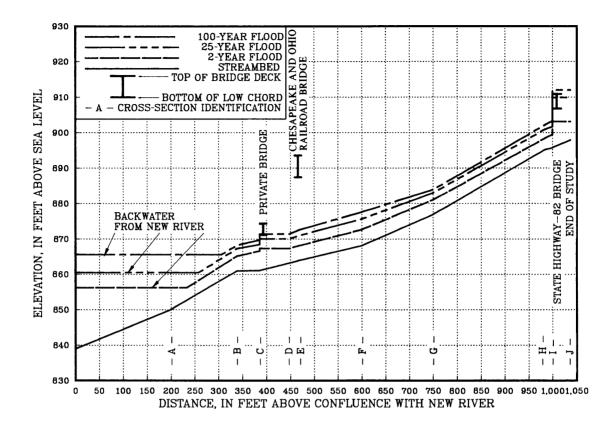


Figure 8.--Streambed and flood profiles for Wolf Creek.

Cross-section	Reference distance,	Flood elevation for indicated recurrence interval, in feet above sea level			
identification	in feet ¹	2 years	25 years	100 years	
Ā	200	² 856.2	² 860.5	² 865.6	
В	338	865.2	867.3	868.3	
С	386	866.7	868.6	869.8	
D	448	867.4	870.1	871.5	
Е	466	868.1	870.9	872.5	
F	600	872.7	875.7	877.6	
G	750	881.1	883.0	884.0	
Н	982	889.3	900.8	902.1	
I	1,000	899.6	901.7	903.4	
J	1,037	903.1	909.9	912.1	

Table 2.--Summary of flood elevations for Wolf Creek

¹ Distance is measured from confluence with the New River.

² Elevation is for backwater from the New River.

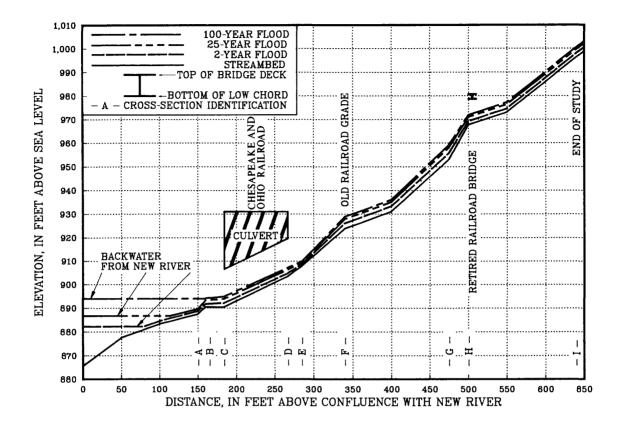


Figure 9.--Streambed and flood profiles for Craig Branch.

Cross-section	Reference distance,	Flood elevation for indicated recurrence interval, in feet above sea level			
identification	in feet ¹	2 years	25 years	100 years	
A	150	888.8	889.7	² 893.9	
В	160	891.8	893.3	894.2	
С	184	892.2	893. 9	895.0	
D	267	904.8	906.4	907.3	
E	285	908.7	909.4	909.9	
F	340	926.1	927.9	928.9	
G	475	955.8	958.1	959.3	
Н	500	969.3	971.0	971.9	
I	650	1,000.6	1,002.2	1,003.1	

Table 3.--Summary of flood elevations for Craig Branch

¹ Distance is measured from confluence with the New River.

² Elevation is for backwater from the New River.

At Manns Creek, the cross-section reference distances were measured from the confluence with the New River at Sewell. Manning's roughness coefficients for the stream channel ranged from 0.040 to 0.065. The 2- and 25-year flood elevations computed downstream from the Chesapeake and Ohio Railroad bridge were less than the flood elevations of the New River. The 100-year flood elevations of the New River were greater than the flood elevations of Manns Creek for approximately 400 ft upstream from the Chesapeake and Ohio Railroad bridge. The water-surface elevation corresponding to the 100-year flood was less than the elevation of the top of the arched bridge openings on the Chesapeake and Ohio Railroad bridge. Streambed and flood profiles are presented in figure 10. Flood elevations are listed in table 4.

At Dunloup Creek, the cross-section reference distances were measured from the confluence with the New River near Thurmond. Man-ning's roughness coefficients for the stream channel ranged from 0.040 to 0.050. Two bridges over Highway 25 cross the tributary at 500 ft and 700 ft, respectively, upstream from the confluence with the New River. The watersurface elevation corresponding to the 100-year flood was less than the elevation of the substructure of the Fayette County Highway 25 bridge nearest to the New River, and was greater than the road-approach elevation of the second Highway 25 bridge. Flood elevations computed for Dunloup Creek downstream from the Highway 25 bridge nearest to the New River were less than the flood elevations of the New River. Streambed and flood profiles are presented in figure 11. Flood elevations are listed in table 5.

At Mill Creek near Quinnimont, the crosssection reference distances were measured 24 ft downstream from the abandoned log bridge. Manning's roughness coefficients for the stream channel ranged from 0.045 to 0.050. The watersurface elevation corresponding to the 2-year flood approximately equaled the elevation of the lower edge of the bridge substructure, but was less than the elevation at the top of the channel banks. The 25-year and 100-year floods resulted in water flowing across the road and approaching the bridge from the right bank; however water did not flow across the bridge deck. Backwater from the New River did not affect elevations of flood profiles. Streambed and flood profiles are presented in figure 12. Flood elevations are listed in table 6.

SUMMARY

The U.S. Geological Survey, in cooperation with the National Park Service, studied the frequency and magnitude of flooding near the mouths of five tributaries to the New River in the New River Gorge National River--Wolf Creek at South Fayette, Craig Branch at Kaymoor, Manns Creek at Sewell, Dunloup Creek near Thurmond, and Mill Creek near Quinnimont. The National River was established and jurisdiction was given to the NPS by Public Law 95-625 on November 10, 1978.

Peak discharges for the 2-, 25-, and 100-year recurrence intervals were estimated with regionalized equations developed by Runner (1980). The 100-year peak discharges at Wolf Creek, Craig Branch, Manns Creek, Dunloup Creek, and Mill Creek were $3,400 \text{ ft}^3/\text{s}, 640 \text{ ft}^3/\text{s}, 8,200 \text{ ft}^3/\text{s}, 7,100 \text{ ft}^3/\text{s}, and 4,900 \text{ ft}^3/\text{s}, respectively}. Manning's roughness coefficients for the stream channels ranged from 0.040 to 0.100.$

A steady-state, one-dimensional flow model (WSPRO) was used to determine flood elevations. Streambed and flood profiles were prepared from model output. Three bridges in the study reaches would be unable to contain the 100-year flood within the bridge opening--State Highway 82 bridge on Wolf Creek, the second Fayette County Highway 25 bridge upstream from the confluence with New River on Dunloup Creek, and an abandoned log bridge on Mill Creek.

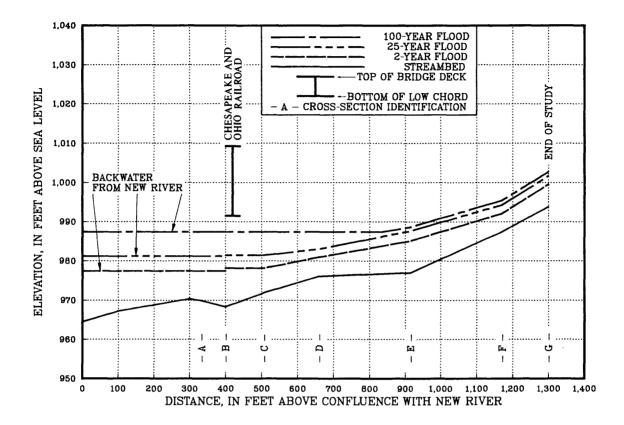


Figure 10.--Streambed and flood profiles for Manns Creek.

Cross-section	Reference distance,		tion for indicated re eet above sea level	ecurrence interv
identification	in feet ¹	2 years	25 years	100 years
Α	333	² 977.4	² 981.2	² 987.4
В	400	² 977.4	² 981.2	² 987.4
С	507	978.2	981.5	² 987.4
D	660	981.0	983.0	² 987.4
Е	915	985.1	987.7	988.7
F	1,170	992.1	994.3	995.5
G	1,300	999.6	1,001.7	1,002.8

Table 4.--Summary of flood elevations for Manns Creek

¹ Distance is measured from confluence with the New River.

² Elevation is for backwater from the New River.

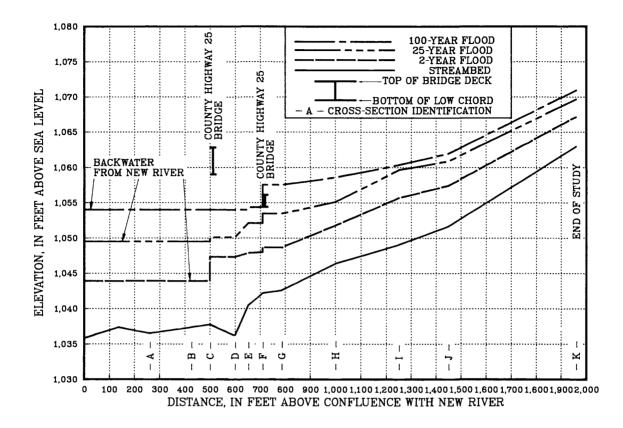


Figure 11.--Streambed and flood profiles for Dunloup Creek.

Cross-section	Reference distance,	Flood elevation for indicated recurrence interval, in feet above sea level			
identification	in feet ¹	2 years	25 years	100 years	
A	260	² 1,043.9	² 1,049.5	² 1,054.0	
В	425	² 1,043.9	² 1,049.5	² 1,054.0	
С	500	1,044.2	² 1,049.5	² 1,054.0	
D	599	1,047.4	1,050.1	² 1,054.0	
Ε	652	1,047.9	1,052.1	1,054.4	
F	710	1,048.0	1,052.1	1,054.4	
G	786	1,048.7	1,053.5	1,057.6	
Н	1,000	1,051.8	1,055.1	1,058.6	
Ι	1,250	1,055.7	1,059.6	1,060.4	
J	1,450	1,057.4	1,060.9	1,062.0	
K	1,960	1,067.2	1,069.7	1,070.9	

Table 5.--Summary of flood elevations for Dunloup Creek

¹ Distance is measured from confluence with the New River.

² Elevation is for backwater from the New River.

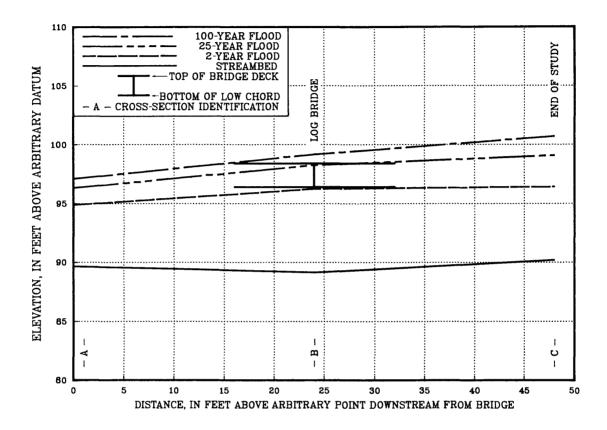


Figure 12.--Streambed and flood profiles for Mill Creek.

Cross-section	Reference distance,		tion for indicated in feet above arbit	
identification	in feet ¹	2 years	25 years	100 years
A	0	94.9	96.3	97.1
В	24	96.3	9 8.3	99.2
С	48	96.4	99.1	100.7

¹ Distance is measured 24 ft downstream from abandoned log bridge.

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- Wiley, J.B., 1993, Flood characterisitics for the New River in the New River Gorge National River, West Virginia: U.S. Geological Survey Open-File Report 93-77, 100 p.

APPENDIXES

APPENDIX A--Cross-section geometry data for Wolf Creek

	DATA SU	MMARY F	OR SECTIO	N "A " X-Y C	CORDINATE	E PAIRS:	
х	Y	Х	Y	х	Y	х	Y
-94.0	855.44	-82.0	853.73	-74.0	851.09	-67.0	850.27
-56.0	850.16	-42.0	851.09	-31.0	855.95	0.0	859.41
15.0	861.64						
	DATA SU	MMARY F	OR SECTIO	N "B " X-Y C	OORDINATE	E PAIRS:	
х	Y	Х	Y	х	Y	х	Y
-104.0	874.38	<i>-</i> 95.0	874.84	-84.0	863.03	-76.0	861.03
-72.0	862.23	-66.0	863.03	-64.0	864.23	-60.0	864.23
-60.0	863.03	-53.0	863.07	-43.0	862.91	-40.0	865.44
-26.0	866.42	- 7.0	873.14	41.0	874.55	43.0	878.28
	DATA SU	MMARY F	OR SECTIO	N " C " X-Y C	COORDINATI	E PAIRS:	
х	Y	х	Y	х	Y	х	Y
2.0	871.20	2.1	866.92	8.0	866.38	12.0	863.46
20.0	861.16	25.0	862.96	30.0	863.16	41.0	863.46
48.0	865.51	50.0	871.19	2.0	871.20		
	DATA SU	MMARY F	OR SECTIO	N "Ɗ" X-Y C	OORDINATE	E PAIRS:	
х	Y	х	Y	х	Y	Х	Y
-8.0	875.00	0.0	864.00	8.0	863.00	22.0	863.50
33.0	866.00	38.0	873.50	60.0	874.00	65.0	879.00
	DATA SU	MMARY F	OR SECTIO	N "E" X-Y C	OORDINATE	PAIRS:	
Х	Y	Х	Y	х	Y	Х	Y
0.0	879.00	0.0	863.90	3.0	866.90	6.0	863.90
8.0	864.40	14.0	864.30	19.0	864.60	25.0	865.70
29.0	866.35	29.0	873.65	52.0	873.77	52.0	879.14
	DATA SU	MMARY F	OR SECTIO	N "F " X-Y C	OORDINATE	PAIRS:	
х	Y	х	Y	х	Y	Х	Y
-80.0	883.30	-76.0	876.05	-75.0	870.72	-66.0	871.05
-61.0	870.22	-54.0	868.22	-44.0	870.36	-34.0	870.54
-25.0	871.15	-17.0	878.00	0.0	878.10	9.0	877.55
15.0	883.30		· · ·				· · ·

APPENDIX A--Cross-section geometry data for Wolf Creek--Continued

х	Y	Х	Y	Х	Y	х	Y
-132.0	894.17	-122.0	888.58	-115.0	886.15	-83.0	881.27
-83.0	876.95	-60.0	881.34	-59.0	879.30	-48.0	877.70
-39.0	881.02	-33.0	882.14	-31.0	878.75	-25.0	878.29
-16.0	888.77	0.0	888.67	6.0	888.67	12.0	894.17
	DATA SU	MMARY F	OR SECTIO	N " H " X-Y C	OORDINATE	E PAIRS:	
Х	Y	Х	Y	Х	Y	Х	Y
-48.0	916.31	-42.0	913.32	0.0	910.70	12.0	910.64
14.0	896.56	24.0	896.75	30.0	895.15	38.0	895.15
52.0	895.55	54.0	901.49	62.0	899.86	68.0	916.31
						DAIDC	
	DATAS	JMMAKY I	OK SECTIC	N "I" X-Y C	OORDINATE	PAIKS:	
х	Y	Х	Y	Х	Y	Х	Y
25.0	906.47	20.0	895.83	32.0	895.88	38.0	896.29
44.0	896.54	44.0	907.06	25.0	906.47		
	DATA SU	JMMARY I	OR SECTIC	DN "J" X-Y C	OORDINATE	PAIRS:	
х	Y	х	Y	х	Y	х	Y
-13.0	916.31	-13.0	913.26	20.0	911.22	38.0	897.96
50.0	898.36	52.0	902.16	60.0	904.16	72.0	906.42
90.0	912.84	92.0	916.31	20.0	201.10	, 2.0	, IL
20.0	>12.04	72.0	- 10.01				

DATA SUMMARY FOR SECTION "G" X-Y COORDINATE PAIRS:

DATA SUMMARY FOR SECTION "A" X-Y COORDINATE PAIRS: Х Υ Х Υ Х Υ Х Υ -16.0 897.15 -6.0 891.15 0.0 887.71 7.0 887.52 17.0 887.71 26.0 889.14 38.0 888.24 43.0 897.15 DATA SUMMARY FOR SECTION "B" X-Y COORDINATE PAIRS: Х Υ Х Y Х Υ Х Y 0.0 898.00 0.0 890.50 16.0 890.50 16.0 898.00 DATA SUMMARY FOR SECTION "C" X-Y COORDINATE PAIRS: Х Y Y Y Х Х Х Y 0.0 898.00 0.0 890.47 16.0 890.47 898.00 16.0 DATA SUMMARY FOR SECTION "D" X-Y COORDINATE PAIRS: Х Y Х Y Х Y Х Y 0.0 0.0 911.58 903.58 16.0 903.58 16.0 911.58 DATA SUMMARY FOR SECTION "E" X-Y COORDINATE PAIRS: Y Х Υ Х Υ Х Х Υ -30.0 925.17 -16.0 907.96 32.0 908.32 929.09 44.0 DATA SUMMARY FOR SECTION "F" X-Y COORDINATE PAIRS: Х Υ Х Υ Υ Х Х Υ -8.0 937.31 0.0 934.63 0.0 923.91 924.02 5.0 935.05 932.72 13.0 926.29 15.0 19.0 935.05 19.0 39.0 938.90 DATA SUMMARY FOR SECTION "G" X-Y COORDINATE PAIRS: Х Υ Х Υ Х Υ Х Υ -7.0 961.27 0.0 953.17 4.0 953.17 7.0 956.54 964.86 11.0 960.38 20.0 DATA SUMMARY FOR SECTION "H" X-Y COORDINATE PAIRS: Х Υ Х Υ Х Υ Х Υ -14.0 981.68 0.0 980.98 0.0 967.88 13.0 967.75 13.0 969.78 970.41 980.38 980.38 16.0 16.0 36.0 DATA SUMMARY FOR SECTION "I" X-Y COORDINATE PAIRS:

APPENDIX B--Cross-section geometry data for Craig Branch

х	Y	Х	Y	Х	Y	Х	Y	
0.0	1,009.37	17.0	1,002.75	21.0	999.34	34.0	998.96	
37.0	1,005.34	56.0	1,004.58	61.0	1,001.80	63.0	1,004.44	
71.0	1,007.23	75.0	1,009.37					

APPENDIX C--*Cross-section geometry data for Manns Creek*

	DATA SU	MMARY F	OR SECTIO	N " A " X-Y C	OORDINATI	E PAIRS:	
х	Y	х	Y	х	Y	х	Y
-10.0	993.03	10.0	979.51	30.0	977.85	50.0	975.24
60.0	971.41	70.0	969.93	85.0	971.37	107.0	970.73
128.0	987.63	200.0	987.13	215.0	993.03		
	DATA SU	MMARY F	OR SECTIO	N "B " X-Y C	OORDINATI	E PAIRS:	
63.0	985.04	63.0	968.32	92.0	970.07	97.0	973.51
101.0	972.09	118.0	974.61	130.0	975.17	130.0	985.02
129.0	990.20	128.0	992.27	127.0	995.06	122.0	998.47
115.5	999.51	109.0	998.47	104.0	995.06	103.0	992.27
102.0	990.20	101.0	985.02	92.0	985.02	91.0	990.20
90.0	992. 27	89.0	995.06	84.0	998.47	77.5	999.51
71.0	998.47	66.0	995.06	65.0	992.27	64.0	990.20
63.0	985.04						
	DATA SU	MMARY F	OR SECTIO	N " C " X-Y C	OORDINATI	E PAIRS:	
10.0	994.35	20.0	989.35	28.0	987.30	44.0	977.03
58.0	973.02	60.0	972.01	70.0	973.17	85.0	973.06
100.0	975.34	107.0	975.34	107.0	971.97	120.0	972.97
133.0	978.15	143.0	987.71	168.0	997.71		
	DATA SU	MMARY F	OR SECTIO	N "Ɗ" X-Y C	COORDINATI	E PAIRS:	
-20.0	996.87	-10.0	986.87	0.0	984.39	14.0	983.61
28.0	980.75	40.0	976.42	50.0	976.65	68.0	977.03
75.0	976.10	86.0	977.01	95.0	979.88	105.0	980.48
117.0	980.77	125.0	979.69	130.0	980.77	140.0	986.20
155.0	996.20						
	DATA SU	MMARY F	OR SECTIO	N "E" X-Y C	OORDINATE	E PAIRS:	
х	Y	х	Y	х	Y	х	Y
-18.0	994.94	-10.0	987.93	0.0	984.25	8.0	980.60
14.0	979.00	20.0	978.90	24.0	977.00	34.0	978.80
40.0	978.80	52.0	980.60	56.0	982.23	67.0	989.14
90.0	991.71	105.0	990.09	114.0	984.44	120.0	984.07
125.0	983.76	132.0	984.28	140.0	984.74	152.0	987.59
160.0	985.73	170.0	984.34	180.0	985.97	184.0	990.61
195.0	1,000.97						
	·						

APPENDIX C--Cross-section geometry data for Manns Creek--Continued

Х	Y	Х	Y	Х	Y	Х	Y
-20.0	1,002.18	-15.0	999.15	-10.0	993.18	0.0	991.20
10.0	991.45	16.0	989.09	26.0	989.00	32.0	987.70
38.0	987.50	45.0	989.37	55.0	989.81	65.0	988.76
70.0	987.69	85.0	989.22	90.0	991.89	105.0	995.40
113.0	996.20	116.0	999.15	133.0	1,004.20		
	DATA SU	MMARY	OR SECTIO		COORDINATI	PATRS	
	Diffi		OROLEHOI			I AIKJ.	
х	Y	X	Y	X	Y	χ	Y
X -20.0							Y 999.67
	Y	х	Y	x	Y	Х	-
-20.0	Y 1,009.81	X -15.0	Y 1007.19	X 0.0	Y 1,000.81	X 10.0	999.67
-20.0 22.0	Y 1,009.81 998.24	X -15.0 30.0	Y 1007.19 997.20	X 0.0 35.0	Y 1000.81 995.92	X 10.0 40.0	999.67 994.50
-20.0 22.0 50.0	Y 1,009.81 998.24 993.90	X -15.0 30.0 55.0	Y 1007.19 997.20 995.30	X 0.0 35.0 62.0	Y 1,000.81 995.92 993.90	X 10.0 40.0 69.0	999.67 994.50 995.92
-20.0 22.0 50.0 75.0	Y 1,009.81 998.24 993.90 998.06	X -15.0 30.0 55.0 100.0	Y 1007.19 997.20 995.30 998.06	X 0.0 35.0 62.0 115.0	Y 1000.81 995.92 993.90 1,000.21	X 10.0 40.0 69.0	999.67 994.50 995.92

DATA SUMMARY FOR SECTION "F" X-Y COORDINATE PAIRS:

APPENDIX D--*Cross-section geometry data for Dunloup Creek*

	DATA SU	MMARY	FOR SECTIO	N "A " X-Y (COORDINATI	E PAIRS:	
х	Y	х	Y	х	Y	х	Y
-132.0	1,055.00	-131.0	1,049.21	-78.0	1,044.53	0.0	1,045.10
34.0	1,049.21	36.0	1,038.53	46.0	1,036.50	54.0	1,036.90
64.0	1,037.40	74.0	1,037.50	84.0	1,038.53	92.0	1,042.95
100.0	1,048.38	105.0	1,055.00				-
	DATA SU	MMARY	FOR SECTIO	N " B " X-Y (COORDINATE	E PAIRS:	
х	Y	х	Y	х	Y	х	Y
-88.0	1,062.12	-79.0	1,060.27	0.0	1,057.97	20.0	1,056.80
37.0	1,046.72	56.0	1,045.75	63.0	1,041.97	75.0	1,039.33
93.0	1,037.40	103.0	1,037.60	113.0	1,039.39	137.0	1,059.40
143.0	1,063.40	156.0	1,064.40				
	DATA SU	MMARY	FOR SECTIO	N " C " X-Y (COORDINATI	E PAIRS:	
Х	Y	х	Y	Х	Y	х	Y
49.0	1,058.71	49.0	1,051.51	59.0	1,050.22	62.0	1,041.52
84.0	1,040.58	96.0	1,039.20	108.0	1,037.80	110.0	1,045.50
115.0	1,044.89	117.0	1,057.77	124.0	1,059.37	49.0	1,058.71
	DATA SU	MMARY	FOR SECTION	N "D" X-Y (COORDINATI	E PAIRS:	
Х	Y	Х	Y	Х	Y	х	Y
-81.0	1,059.35	-25.0	1056.67	0.0	1,055.67	30.0	1,054.59
52.0	1,052.51	67.0	1048.45	79.0	1,041.94	86.0	1,041.27
96.0	1,039.77	101.0	1039.27	110.0	1,036.00	112.0	1,061.87
	DATA SU	IMMARY	FOR SECTIO	N "E" X-Y (COORDINATE	E PAIRS:	
х	Y	Х	Y	х	Y	х	Y
-25.0	1,057.07	0.0	1,056.76	30.0	1,055.99	82.0	1,053.42
95.0	1,049.16	106.0	1,042.26	115.0	1,040.96	130.0	1,041.36
135.0	1,040.46	143.0	1,042.26	151.0	1,046.38	173.0	1,047.82
173.0	1,061.29						
	DATA SU	MMARY	FOR SECTIO	N "F" X-Y (COORDINATE	PAIRS:	
x	Y	x	Y	x	Y	х	Y
102.0	1,042.68	110.0	1,042.75	120.0	1,042.20	130.0	1,042.26
142.0	1,042.00		1,042.75	120.0	1,042.20	160.0	1,042.20

~	1	~	1	~	1	~	1	
102.0	1,042.68	110.0	1,042.75	120.0	1,042.20	130.0	1,042.26	
143.0	1,043.93	155.0	1,043.97	160.0	1,045.57	160.0	1,045.73	
150.0	1,051.45	140.0	1,053.77	130.0	1,054.39	120.0	1,053.19	
110.0	1,050.32	102.0	1,045.01	102.0	1,042.68			

APPENDIX D--*Cross-section geometry data for Dunloup Creek*--Continued

DATA SUMMARY FOR SECTION "G" X-Y COORDINATE PAIRS:

DATA SUMMARY FOR SECTION "G" X-Y COORDINATE PAIRS:								
х	Y	Х	Y	х	Y	х	Y	
33.0	1,060.21	33.0	1,054.86	65.0	1,053.30	92.0	1,052.66	
100.0	1,049.06	108.0	1,044.21	115.0	1,042.81	120.0	1,042.61	
140.0	1,042.71	150.0	1,044.21	157.0	1,044.86	170.0	1,047.59	
178.0	1,051.97	190.0	1,053.13	220.0	1,054.36	255.0	1,055.70	
257.0	1,060.21	170.0	1,000.10	220.0	1,004.00	200.0	1,000.70	
207.0	1,000.21							
	DATA SU	MMARYI	FOR SECTIC	N "H" X-Y (COORDINATI	E PAIRS:		
X	Y	X	Y	X	Y	X	Y	
-82.0	1,062.22	-79.0	1,048.40	-78.0	1,046.40	-65.0	1,046.60	
-44.0	1,048.39	-41.0	1,048.76	-24.0	1,055.91	0.0	1,057.02	
58.0	1,057.68	135.0	1,057.39	147.0	1,062.22			
	DATA SU	JMMARY	FOR SECTIO	ON "I" X-Y C	COORDINATE	PAIRS:		
х	Y	х	Y	х	Y	х	Y	
-70.0	1,062.34	-67.0	1,051.67	-65.0	1,050.67	-57.0	1,049.07	
-50.0	1,049.07	-40.0	1,049.87	-30.0	1,049.97	-21.0	1,050.67	
-10.0	1,057.39	0.0	1,057.24	37.0	1,058.10	42.0	1,062.34	
	·				•			
	DATA SL	MMARY	FOR SECTIO	ON "I" X-Y C	OORDINATE	PAIRS:		
N				•			N/	
X	Y	X	Y	X	Y	X	Υ	
-134.0	1,078.63	-124.0	1,058.63	-102.0	1,057.78	-90.0	1,054.47	
-82.0	1,051.67	-76.0	1,052.47	-61.0	1,052.99	-50.0	1,054.47	
-28.0	1,056.45	-15.0	1,065.79	0.0	1,067.47	30.0	1,068.44	
34.0	1,072.67							
	DATA SU	MMARY I	FOR SECTIC	N "K" X-Y C	COORDINATI	E PAIRS:		
Х	Y	Х	Y	Х	Y	Х	Y	
-122.0	1,076.91	-106.0	1,072.88	-92.0	1,069.57	-82.0	1,068.52	
-67.0	1,065.41	-49.0	1,064.46	-34.0	1,063.46	-26.0	1,062.96	
-5.0	1,063.37	-5.0	1,064.46	0.0	1,072.00	26.0	1,072.31	
32.0	1,077.20		•		-			
	-							

APPENDIX E--*Cross-section geometry data for Mill Creek*

DATA SUMMARY FOR SECTION "A" X-Y COORDINATE PAIRS:									
х	Y	Х	Y	х	Y	Х	Y		
-30.0	103.07	0.0	100.68	27.0	99.96	34.0	93.95		
38.0	90.13	46.0	89.63	54.0	90.27	56.0	92.74		
75.0	94.58	100.0	91.93	110.0	93.19	122.0	93.73		
149.0	94.79	155.0	103.35						
	DATA SU	MMARY F	OR SECTIO	N " B " X-Y C	OORDINATE	PAIRS:			
х	Y	Х	Y	х	Y	Х	Y		
38.0	96.50	38.0	90.97	40.0	90.49	46.0	89.12		
54.0	90.10	54.0	96.20	38.0	96.50				
	DATA SU	MMARY F	OR SECTIO	N " C " X-Y C	OORDINATE	E PAIRS:			
х	Y	х	Y	х	Y	Х	Y		
-30.0	102.75	4.0	101.24	16.0	97.76	32.0	96.70		
38.0	92.46	44.0	91.16	50.0	90.19	56.0	91.09		
62.0	98.22	70.0	96.23	75.0	98.16	90.0	97.25		
107.0	98.12	120.0	100.69	135.0	101.68	145.0	103.35		