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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

FLOODFLOW CHARACTERISTICS RELATED TO CHANNEL GEOMETRY IN OHIO

by Earl E. Webber and John W. Roberts

U.S. GEOLOGICAL SURVEY

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E R R A T A

Page iv - Tables; the title for table 3 should read "Hydrologic data for boundary ungaged sites."

Page 14 - Under Limitation and Reliability of Estimating Equations, first paragraph, fourth line; change "... ranging from 0.12 mi and 7,422 mi" to "... ranging from 0.12 mi^2 to 7,422 mi^2."

Page 20 - Equation 7; the exponent of (A) was blurred in printing. It should read 0.802.

Page 21 - Definition of E, second line; change to read, "... National Geodetic Vertical Datum of 1929, and was computed ..."

Definition of E, seventh line; change to read, "The characteristic used in this regression analysis was average basin elevation index in 1,000's of feet."

* *

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CONVERSION FACTORS

Factors for converting inch-pound units to International System of metric units (SI)

To convert from	To	Multiply by
inch (in)	millimeter (mm)	25.4
foot (ft)	meter (m)	0.3048
mile (mi)	kilometer (km)	1.609
$foot^3$ per second (ft^3/s)	$meter^3$ per second (m^3/s)	0.02832
$mile^2$ (mi^2)	$kilometer^2$ (km^2)	2.590

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ABSTRACT

Techniques for estimating magnitude and frequency of flood-peak discharges, based on channel geometry parameters, are presented as a method for evaluating Ohio floods in geographic areas deficient in flow data. One hundred and sixty gaging stations were selected on streams with alluvial channels unaltered by man. Exposed bedrock is absent from the channels in the vicinity of the surveyed cross sections. Peak stream discharges at the selected sites were related to channel geometry parameters. Active channel width is the only statistically significant parameter. Channel geometry parameters which were tested and found to be statistically insignificant are active channel average depth, bankfull width, and bankfull average depth. The average standard errors of estimate for the resulting statewide equations, with recurrence intervals of 2, 5, 10, 25, 50, and 100 years, range from 42 to 55 percent.

INTRODUCTION

Flood magnitude and frequency data for streams are utilized in the design of dams, bridges, culverts and other structures. Flood data are also needed for flood insurance studies, regulatory activities, land zoning and design of canals and floodways.

This report, initiated in April, 1979, was funded as a cooperative study by the Ohio Department of Transportation, the U.S. Department of Transportation, Federal Highway Administration and the U.S. Geological Survey.

Four previous reports on Ohio flood frequency, by Cross (1946), Cross and Webber (1959), Cross and Mayo (1969), and Webber and Bartlett (1977), were the result of cooperative investigations with the Ohio Department of Natural Resources, Division of Water; Ohio Department of Transportation; U.S. Department of Transportation, Federal Highway Administration; and the U.S. Geological Survey. These reports provided flood frequency information at existing gaged sites and techniques for estimating floods at ungaged sites.

Purpose and Scope

The purpose of this report is to present a peak-discharge estimating technique that will evaluate the location of the present Ohio flood boundaries developed in the Ohio Department of Natural Resources, Division of Water Bulletin 45 (Webber and Bartlett, 1977). This estimating technique is independent of traditional basin characteristics and geographic area boundaries. The flood boundaries of most interest are those in geographic areas deficient of flow data. Peak stream discharges were related to channel geometry parameters by multiple regression analyses for 160 gaging stations in Ohio. The results of the analyses, power-function equations, may be used to estimate the magnitudes and frequencies of floods in ungaged drainage basins. These equations were not developed to replace the recommended procedure presented in Webber and Bartlett (1977).

Previous Work

Previous studies relating streamflows to channel geometry have been made for states mostly west of the Mississippi River by Emmett (1975), Hedman (1970), Osterkamp (1977), and others. Previous flood-frequency studies in Ohio have related peak discharges to basin characteristics such as drainage area, main channel slope and average annual precipitation. This study is the first in Ohio to relate peak discharges to channel geometry.

Acknowledgments

Many individuals and agencies have cooperated over the years to obtain hydrologic data and support the stream gaging program in Ohio. The major support of this program has been given by the Ohio Department of Natural Resources, Ohio Department of Transportation, and the U.S. Army Corps of Engineers.

Waite R. Osterkamp, U.S. Geological Survey, Reston, Virginia gave the authors the necessary channel geometry field training to successfully complete the collection of field measurements.

DESCRIPTION OF THE STUDY AREA

The study area is the entire state of Ohio, totaling 41,249 mi^2, with 29,474 mi^2 draining southward to the Ohio River and 11,775 mi^2 draining northward to Lake Erie. Ohio is divided diagonally, from southwest to northeast by the line of glaciation which is the predominate topographic feature of the state. The northwest part is a flat, multi-glaciated lake-bed region; the southwest, central and northeast parts are rolling, glacial-till plains, with terminal moraines; and the southeast part is hilly and unglaciated. Land elevations range from a low of 450 feet in Hamilton County to 1,550 feet at the highest point in Logan County.

The climate is humid continental, with warm to hot summers and fairly cold winters. Annual precipitation, which ranges from 32 to 44 inches, is distributed rather uniformly throughout the year. Records indicate that floods may occur anytime during the year. Streams having large drainage areas are more susceptible to flooding from January through April and streams having small drainage areas are more susceptible from May through August (Cross and Webber, 1959, p. 24).

WATERSHED SELECTION AND DATA ANALYSIS

Gaging Station Selection

Gaging stations used in this study were selected from 250 stream gaging stations in Ohio where hydrologic information has been collected. A total of 170 stations were selected that met the following criteria:

(1) At least 10 years of annual peak discharge record on unregulated streams.

(2) Alluvial active channel and bankfull cross sections apparently unaltered by man. Exposed bedrock absent from the stream channel in the vicinity of the gage.

Mathematical equations that relate peak discharges to basin parameters were developed in the Ohio Department of Natural Resources, Division of Water Bulletin 45 (Webber and Bartlett, 1977) through multiple regression analyses of data from many gaging stations. To minimize the standard errors of estimate the state was divided into five geographic areas and a set of equations were developed for each area (fig. 1).

The 170 selected stations are uniformly distributed over the state. Drainage areas range from 0.12 to 7,422 mi^2. One hundred and twenty nine are continuous-record stations and 41 are crest-stage gages, with an average length of record of 29 years. The stations are plotted on fig. 1 and pertinent hydrologic data are presented in table 1.

Flood-Frequency Curves

Flood-frequency curves relate flood-peak discharges to exceedance probabilities or recurrence intervals. Flood-frequency curves for the 170 gaging stations were defined using guidelines recommended by the U.S. Water Resources Council (1977). These guidelines describe the procedures for fitting a log-Pearson type III distribution to the observed annual flood data. Details of the above analyses and the resulting peak discharges for Ohio streams are published by Webber and Bartlett (1977). Peak discharges for recurrence intervals of 2, 5, 10, 25, 50, and 100 years for each station in this report are presented in table 1.

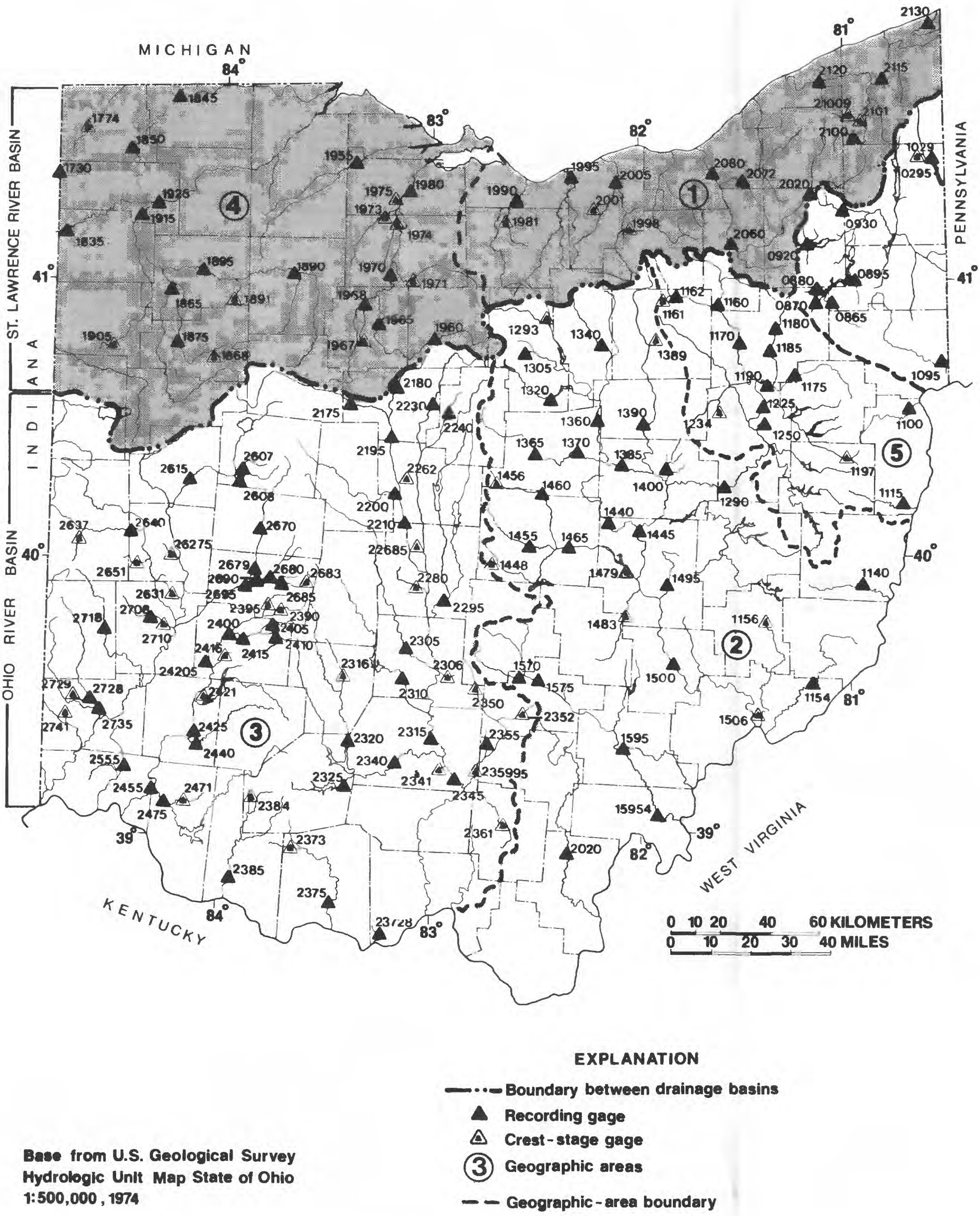


Figure 1.--Location of gaging stations used in this report and geographic areas in Ohio.

Table 1.--Hydrologic data for 170 selected Ohio streams

Station number	Station name	Geo-graphic area	Drain-age area A (mi^2)	Type of gage[2]	Length of record (years)	Active channel width WAC (ft)	Peak discharge in $feet^3$/second					
							2-year	5-year	10-year	25-year	50-year	100-year
			OHIO RIVER BASIN									
03086500	Mahoning River at Alliance[1]	1	89.2	R	34	45	2,430	3,890	4,980	6,450	7,620	8,840
03087000	Beech Creek near Bolton	1	17.4	R	11	16	1,070	1,580	1,930	2,370	2,700	3,030
03088000	Deer Creek at Limaville	1	31.9	R	15	32	1,060	1,400	1,620	1,880	2,070	2,250
03089500	Mill Creek near Berlin Center	1	19.1	R-C	34	28	966	1,350	1,600	1,920	2,150	2,380
03092090	West Branch Mahoning River near Ravenna	1	21.8	R	10	24	862	1,300	1,600	1,980	2,270	2,560
03093000	Eagle Creek at Phalanx Station	1	97.6	R	46	37	2,420	3,480	4,170	5,010	5,620	6,220
03102900	Clear Creek at Dilworth	1	1.13	C	29	5.0	64	126	181	266	342	429
03102950	Pymatuning Creek at Kinsman	1	96.7	R	10	27	1,280	1,590	1,770	1,990	2,140	2,280
03109500	Little Beaver Creek near East Liverpool	1	496	R	60	126	9,710	14,500	17,900	22,400	26,000	29,600
03110000	Yellow Creek near Hammondsville	5	147	R	35	62	3,340	4,910	6,020	7,480	8,610	9,770
03111500	Short Creek near Dillonvale	5	123	R	34	43	2,850	4,260	5,260	6,570	7,590	8,640
03114000	Captina Creek at Armstrongs Mills	2	134	R	26	85	6,200	9,170	11,300	14,100	16,400	18,700
03115400	Little Muskingum River at Bloomfield	2	210	R	17	68	7,270	9,990	11,700	13,700	15,100	16,400
03115600	Barnes Run near Summerfield	2	3.46	C	29	9.0	557	1,120	1,620	2,390	3,080	3,880
03116000	Tuscarawas River at Clinton	5	174	R	49	43	1,280	1,790	2,110	2,490	2,760	3,020
03116100	Little Chippewa Creek near Smithville	5	16.4	C	26	16	746	1,170	1,480	1,880	2,200	2,530
03116200	Chippewa Creek at Easton	5	146	R	17	60	1,510	2,340	3,090	4,330	5,490	6,910
03117000	Tuscarawas River at Massillon	5	526	R	37	98	3,910	5,230	6,080	7,140	7,910	8,670
03117500	Sandy Creek at Waynesburg	5	253	R	37	75	3,450	5,090	6,290	7,940	9,260	10,700
03118000	Middle Branch Nimishillen Creek at Canton	5	43.1	R	34	32	690	1,040	1,280	1,600	1,840	2,090
03118500	Nimishillen Creek at North Industry[1]	5	175	R	54	58	2,960	4,290	5,210	6,410	7,320	8,260
03119000	Sandy Creek at Sandyville	5	481	R	24	82	7,080	10,500	12,900	15,900	18,100	20,400
03119700	Conotton Creek at Jewett	5	14.3	C	29	16	461	726	920	1,180	1,390	1,610
03122500	Tuscarawas River below Dover Dam near Dover	5	1,405	R	15	277	15,100	21,800	25,700	30,100	32,900	35,500
03123400	Dundee Creek at Dundee	5	0.71	C	10	4.8	94	177	244	341	423	511
03125000	Home Creek near New Philadelphia	5	1.64	R	39	5.5	114	205	275	373	452	536
03129000	Tuscarawas River at Newcomerstown	2	2,443	R-C	17	242	21,200	31,200	38,700	49,100	57,700	66,900
03129014	White Eyes Creek tributary near Coshocton (ARS station 196)	2	0.473	R	34	2.8	110	260	403	637	851	1,100
03129016	White Eyes Creek tributary near Coshocton (ARS station 183)	2	0.116	R	25	2.0	28	74	120	199	275	367
03129300	Whetstone Creek tributary near Olivesburg	2	0.240	C	26	2.5	44	75	99	132	158	187
03130500	Touby Run at Mansfield	2	5.44	R	29	15	411	626	771	955	1,090	1,230
03132000	Clear Fork at Butler	2	136	R	30	54	3,200	4,820	6,030	7,710	9,070	10,500
03134000	Jerome Fork near Jeromeville	2	120	C	30	33	2,510	3,980	5,220	7,170	8,930	11,000
03136000	Mohican River at Greer	2	948	R	17	182	10,700	15,800	19,200	23,600	26,900	30,200
03136500	Kokosing River at Mount Vernon	2	202	R	23	78	4,330	7,110	9,480	13,200	16,500	20,300

See footnotes at end of table.

Table 1.--Hydrologic data for 170 selected Ohio streams.--Continued

Station number	Station name	Geo-graphic area	Drain-age area A (mi^2)	Type of gage[2]	Length of record (years)	Active channel width WAC (ft)	Peak discharge in $feet^3$/second					
							2-year	5-year	10-year	25-year	50-year	100-year
03137000	Kokosing River at Millwood	2	455	R	54	102	9,630	16,200	21,500	29,600	36,600	44,500
03138500	Walhonding River below Mohawk Dam near Nellie	2	1,505	R	17	261	19,600	29,200	35,500	43,400	49,200	54,900
03138900	Jennings Ditch tributary near Wooster	2	0.900	C	11	4.0	58	153	278	561	919	1,470
03139000	Killbuck Creek at Killbuck	2	462	R-C	45	95	3,420	6,340	9,630	16,200	23,700	34,300
03139940	Little Mill Creek near Coshocton (ARS station 92)	2	1.44	R	35	4.3	155	306	433	622	782	959
03139960	Little Mill Creek near Coshocton (ARS station 94)	2	2.38	R	35	5.5	293	615	892	1,310	1,670	2,070
03139990	Little Mill Creek near Coshocton (ARS station 97)	2	7.16	R	36	11	715	1,500	2,190	3,220	4,120	5,120
03140000	Mill Creek near Coshocton[1]	2	27.2	R	39	25	1,460	2,800	3,910	5,600	7,040	8,650
03144000	Wakatomika Creek near Frazeysburg	2	140	R	39	68	3,980	6,790	8,900	11,800	14,100	16,500
03144500	Muskingum River at Dresden	2	5,993	R	17	407	46,000	69,200	86,100	109,000	128,000	147,000
03144800	Etna Creek at Etna	2	1.10	C	10	2.5	93	160	211	280	334	392
03145500	Raccoon Creek at Granville	2	82.7	C	10	48	4,170	6,790	8,690	11,200	13,200	15,200
03145600	Otter Fork near Centerburg	2	3.17	C	29	4.0	129	212	273	353	416	480
03146000	North Fork Licking River at Utica	2	116	R-C	15	68	4,600	6,610	7,930	9,570	10,800	12,000
03146500	Licking River near Newark	2	537	R	36	169	11,500	18,400	23,400	30,100	35,300	40,700
03147900	Timber Run near Zanesville	2	10.1	R-C	29	18	770	1,280	1,650	2,160	2,560	2,980
03148300	Moxahala Creek at Roseville	2	80.6	C	13	65	2,430	3,660	4,510	5,630	6,480	7,350
03149500	Salt Creek near Chandlersville	2	75.7	R	13	35	3,330	4,180	4,710	5,340	5,780	6,210
03150000	Muskingum River at McConnelsville	2	7,422	R	16	495	55,900	86,300	108,000	137,000	159,000	183,000
03150600	Tupper Creek at DeVola	2	0.99	C	10	4.5	155	216	258	312	352	394
03157000	Clear Creek near Rockbridge	2	89.0	R	36	55	2,630	4,220	5,670	8,070	10,400	13,200
03157500	Hocking River at Enterprise	2	459	R	45	91	6,980	11,900	15,700	21,200	25,800	30,900
03159500	Hocking River at Athens[1]	2	943	R	61	131	12,600	19,000	24,000	31,200	37,300	44,000
03159540	Shade River near Chester	2	156	R	10	58	4,400	5,810	6,720	7,860	8,710	9,550
03202000	Raccoon Creek at Adamsville	2	585	R	58	91	6,350	9,410	11,600	14,700	17,100	19,600
03217500	Scioto River at LaRue	3	255	R	24	78	5,300	8,050	9,820	12,000	13,500	15,000
03218000	Little Scioto River above Marion	3	72.4	R	37	37	1,140	1,770	2,250	2,900	3,430	3,990
03219500	Scioto River near Prospect	3	567	R	62	134	6,060	8,450	9,900	11,600	12,800	13,900
03220000	Mill Creek near Bellepoint	3	178	R-C	33	82	4,420	6,550	8,060	10,100	11,600	13,200
03221000	Scioto River below O'Shaughnessy Dam near Dublin	3	980	R	52	187	12,600	20,000	25,600	33,600	40,100	47,200
03223000	Olentangy River at Claridon	3	157	R	29	77	3,060	4,480	5,520	6,940	8,080	9,280
03224000	Shaw Creek at Shawtown	3	25.4	R	10	25	817	1,130	1,360	1,660	1,890	2,130
03226200	Delaware Run near Delaware	3	5.84	C	29	9.0	333	555	714	923	1,080	1,250
03226850	Linworth Run near Linworth	3	0.40	C	10	4.5	81	184	277	421	546	687
03228000	Scioto Big Run at Briggsdale	3	11.0	R-C	29	18.5	1,240	1,830	2,220	2,720	3,090	3,460
03229500	Big Walnut Creek at Rees	3	544	R	32	123	11,900	17,500	21,400	26,300	30,000	33,700
03230500	Big Darby Creek at Darbyville	3	534	R	53	128	8,640	14,000	18,100	23,700	28,300	23,100
03230600	Hominy Creek at Circleville	3	5.66	C	29	14	653	1,600	1,390	1,870	2,290	2,760
03230800	Deer Creek at Mt. Sterling	3	228	R	13	85	5,550	8,560	10,600	13,300	15,300	17,300
03231000	Deer Creek at Williamsport	3	333	R-C	36	95	8,940	16,400	22,300	30,800	37,900	45,500

See footnotes at end of table.

Table 1.--Hydrologic data for 170 selected Ohio streams.--Continued

Station number	Station name	Geographic area	Drainage area A (mi^2)	Type of gage[2]	Length of record (years)	Active channel width WAC (ft)	Peak discharge in $feet^3$/second 2-year	5-year	10-year	25-year	50-year	100-year
03231500	Scioto River at Chillicothe	3	3,849	R	59	302	41,500	67,000	85,500	110,000	130,000	150,000
03231600	East Fork Paint Creek near Sedalia	3	3.82	C	29	7.5	182	319	419	555	660	767
03232000	Paint Creek near Greenfield	3	249	R-C	44	73	5,180	9,140	12,200	16,400	19,800	23,500
03232500	Rocky Fork near Barretts Mills	3	140	R	12	86	6,430	9,370	11,300	13,800	15,600	17,500
03234000	Paint Creek near Bourneville	3	807	R	49	128	20,300	31,700	40,100	51,500	60,500	69,900
03234100	Indian Creek at Massieville	3	9.60	C	29	30	1,390	2,430	3,240	4,370	5,290	6,280
03234500	Scioto River at Higby[1]	3	5,131	R	45	410	48,900	79,100	102,000	133,000	158,000	184,000
03235000	Salt Creek at Tarlton[1]	3	11.5	R-C	29	22	1,010	1,650	2,140	2,820	3,370	3,960
03235200	Little Blackjack Branch near South Bloomingville	3	0.89	C	10	6.0	123	357	615	1,090	1,560	2,150
03235500	Tar Hollow Creek at Tar Hollow State Park	3	1.35	R	29	9.0	129	238	327	456	563	681
03235995	Salt Creek above dam site near Londonderry	3	268	C	13	92	12,400	19,800	25,700	34,000	41,000	48,600
03236100	South Branch Little Salt Creek at Jackson	3	3.76	C	29	11.5	633	888	1,060	1,260	1,410	1,560
03237280	Upper Twin Creek at McGaw	3	12.2	R	13	39	939	1,790	2,470	3,410	4,170	4,980
03237300	West Branch Turkey Run near Winchester	3	0.89	C	20	4.0	219	381	503	671	805	946
03237500	Ohio Brush Creek near West Union	3	387	R	44	139	21,800	31,800	38,700	47,500	54,100	60,800
03238400	Harwood Creek near Fayetteville	3	0.88	C	10	3,0	132	230	304	407	488	573
03238500	Whiteoak Creek near Georgetown	3	222	R	48	90	9,920	13,700	16,200	19,300	21,600	23,800
03239000	Little Miami River near Selma	3	48.9	R-C	23	35	1,490	3,130	4,520	6,570	8,290	10,200
03239500	North Fork Little Miami River near Pitchin	3	28.9	R-C	23	23	437	940	1,370	2,010	2,550	3,150
03240000	Little Miami River near Oldtown	3	129	R	23	65	2,830	5,490	7,610	10,600	13,000	15,600
03240500	North Fork Massies Creek at Cedarville	3	28.9	R	14	20.5	737	1,520	2,170	3,120	3,920	4,780
03241000	South Fork Massies Creek near Cedarville	3	17.1	R	14	15.5	762	1,400	1,880	2,550	3,090	3,640
03241500	Massies Creek at Wilberforce	3	63.2	R	23	37	1,570	3,160	4,440	6,290	7,810	9,420
03241600	Shawnee Creek at Xenia	3	4.21	C	28	10	413	705	906	1,160	1,340	1,520
03242050	Little Miami River near Spring Valley	3	366	R	33	99	7,780	13,500	17,700	23,200	27,500	31,800
03242100	Wayne Creek at Waynesville	3	1.01	C	10	11	305	524	683	896	1,060	1,230
03242500	Little Miami River near Fort Ancient	3	677	R	17	145	18,400	29,100	36,700	46,600	54,200	61,900
03244000	Todd Fork near Roachester	3	219	R	22	83	10,800	16,200	19,800	24,300	27,600	30,900
03245500	Little Miami River at Milford	3	1,203	R	52	220	31,100	44,500	53,400	64,600	73,000	81,400
03247100	Patterson Run near Owensville	3	3.34	R-C	29	20.5	575	749	853	974	1,060	1,140
03247500	East Fork Little Miami River at Perintown	3	476	R	54	129	20,200	27,800	32,500	38,200	42,200	46,100
03255500	Mill Creek at Reading	3	73.0	R	37	59	3,300	4,270	4,840	5,500	5,960	6,410
03260700	Bokengehalas Creek near DeGraff	3	36.3	R	18	19	782	1,140	1,360	1,630	1,830	2,010
03260800	Stony Creek near DeGraff	3	59.1	R	18	31	1,060	1,760	2,250	2,870	3,340	3,810
03261500	Great Miami River at Sidney	3	541	R	63	95	6,920	11,200	14,400	19,100	23,000	27,300
03262750	Millers Ditch near Tipp City	3	0.81	C	10	4.2	95	153	194	245	283	322
03263100	Poplar Creek near Vandalia	3	3.11	R-C	29	14	407	709	926	1,210	1,430	1,650
03263700	Bridge Creek near Greenville	3	4.83	C	29	8.2	322	597	801	1,070	1,280	1,490
03264000	Greenville Creek near Bradford	3	193	R	45	60	3,220	5,200	6,710	8,820	10,500	12,400
03265100	Hog Run tributary at Laura	3	0.460	R-C	26	2.2	37	62	80	103	120	137

See footnotes at end of table.

Table 1.--Hydrologic data for 170 selected Ohio streams.--Continued

Station number	Station name	Geographic area	Drainage area A (mi^2)	Type of gage[2]	Length of record (years)	Active channel width WAC (ft)	Peak discharge in $feet^3$/second					
							2-year	5-year	10-year	25-year	50-year	100-year
03267000	Mad River near Urbana	3	162	R	42	51	2,540	4,150	5,260	6,690	7,750	8,810
03267900	Mad River, St. Paris Pike, near Eagle City	3	310	R	10	81	5,310	7,350	8,770	10,600	12,100	13,600
03268000	Buck Creek at New Moorefield	3	67.3	R	17	46	1,740	2,290	2,740	3,410	4,000	4,670
03268300	Beaver Creek at Brighton	3	3.33	C	17	8.5	273	502	677	917	1,110	1,310
03268500	Beaver Creek near Springfield	3	39.2	R-C	20	29	2,030	2,920	3,490	4,190	4,690	5,170
03269000	Buck Creek at Springfield	3	139	R-C	56	63	3,230	5,460	7,130	9,420	11,300	13,200
03269500	Mad River near Springfield	3	490	R	65	106	7,720	12,600	16,400	21,700	26,200	31,000
03270800	Wolf Creek at Trotwood	3	22.7	R	14	29	1,540	2,480	3,120	3,930	4,530	5,130
03271000	Wolf Creek at Dayton	3	69.5	R-C	12	40	4,020	7,050	9,260	12,200	14,500	16,800
03271800	Twin Creek near Ingomar	3	197	R	14	84	8,210	12,000	14,700	18,500	21,600	24,800
03272800	Sevenmile Creek at Collinsville	3	120	R	16	87	6,630	10,100	12,400	15,300	17,400	19,400
03272900	Collins Creek at Collinsville	3	0.94	C	10	5.0	206	442	640	930	1,170	1,430
03273500	Fourmile Creek near Hamilton	3	311	R	23	150	14,600	21,400	25,500	30,100	33,100	35,900
03274100	Blake Run near Reily[1]	3	0.29	R-C	33	3.0	64	117	156	209	250	292
		ST. LAWRENCE RIVER BASIN										
04177400	Eagle Creek tributary near Montpelier	4	1.84	C	26	4.5	67	118	155	202	238	274
04178000	St. Joseph River near Newville, Indiana	4	160	R	29	103	3,900	5,600	6,660	7,910	8,790	9,620
04183500	Maumee River at Antwerp	4	2,128	R	64	230	14,300	18,600	20,700	22,700	23,900	24,800
04184500	Bean Creek at Powers	4	206	R	35	48	1,990	2,980	3,600	4,330	4,850	5,350
04185000	Tiffin River at Stryker	4	410	R	44	100	3,230	4,830	5,820	6,970	7,750	8,490
04186500	Auglaize River near Fort Jennings	4	332	R	50	88	4,920	7,030	8,300	9,780	10,800	11,700
04186800	King Run near Harrod	4	0.53	C	10	4.0	82	125	154	189	214	239
04187500	Ottawa River at Allentown	4	160	R	46	58	3,040	4,350	5,160	6,120	6,800	7,440
04189000	Blanchard River near Findlay	4	346	R	49	71	5,220	8,000	9,710	11,700	13,100	14,300
04189100	Tiderishi Creek near Jenera	4	4.65	C	29	6.5	195	304	376	465	528	589
04189500	Blanchard River at Glandorf	4	644	C	13	112	8,140	11,400	13,500	16,100	18,000	19,800
04190500	Roller Creek at Ohio City	4	5.14	R-C	29	5.0	204	286	337	399	444	486
04191500	Auglaize River near Defiance	4	2,318	R	61	360	25,100	36,500	43,500	51,700	57,400	62,700
04192500	Maumee River near Defiance	4	5,545	R	49	490	43,500	60,500	69,800	79,900	86,200	91,800
04195500	Portage River at Woodville	4	428	R	44	83	6,170	8,510	9,920	11,500	12,700	13,700
04196000	Sandusky River near Bucyrus	4	88.8	R	36	50	2,530	3,760	4,640	5,820	6,750	7,710
04196500	Sandusky River near Upper Sandusky	4	298	R	53	99	4,700	6,670	7,900	9,380	10,400	11,400
04196700	St. James Run near Upper Sandusky	4	5.29	C	29	7.0	198	320	403	506	582	656
04196800	Tymochtee Creek at Crawford	4	229	R-C	15	61	3,600	5,080	5,990	7,080	7,850	8,580
04197000	Sandusky River near Mexico[1]	4	774	R	53	125	8,490	12,000	14,200	16,900	18,700	20,600
04197100	Honey Creek at Melmore	4	149	R-C	15	43	2,540	3,320	3,790	4,320	4,690	5,030

See footnotes at end of table.

Table 1.--Hydrologic data for 170 selected Ohio streams.--Continued

Station number	Station name	Geo-graphic area	Drain-age area A (mi^2)	Type of gage[2]	Length of record (years)	Active channel width WAC (ft)	Peak discharge in $feet^3$/second					
							2-year	5-year	10-year	25-year	50-year	100-year
04197300	Wolf Creek at Bettsville	4	66.2	C	15	35	1,550	1,970	2,240	2,590	2,860	3,120
04197400	East Branch Wolf Creek at Fort Seneca	4	70.1	C	15	34	1,780	2,220	2,470	2,750	2,930	3,100
04197500	Havens Creek at Havens	4	4.28	R-C	29	7.0	136	206	251	306	346	384
04198000	Sandusky River near Fremont	4	1,251	R	50	240	14,700	19,400	22,100	25,200	27,200	29,000
04198100	Norwalk Creek at Norwalk	1	4.92	C	29	7.5	320	560	742	996	1,200	1,410
04199000	Huron River at Milan	1	371	R	26	110	7,810	11,700	15,100	20,700	26,000	32,400
04199500	Vermilion River at Vermilion	1	262	R	26	107	5,600	9,280	12,700	18,400	24,000	30,900
04199800	Neff Run near Litchfield	1	0.76	C	10	4.0	72	115	144	182	211	240
04200100	Plum Creek at Oberlin	1	4.83	C	29	6.5	286	484	634	842	1,010	1,190
04200500	Black River at Elyria	1	396	R	31	92	6,890	10,400	13,200	17,300	21,000	25,100
04202000	Cuyahoga River at Hiram Rapids	1	151	R	24	69	1,550	2,310	2,810	3,450	3,930	4,410
04206000	Cuyahoga River at Old Portage	1	404	R	52	102	3,000	3,700	4,250	5,100	5,800	6,600
04207200	Tinkers Creek at Bedford	1	83.9	R	13	35	2,520	3,510	4,140	4,900	5,450	5,980
04208000	Cuyahoga River at Independence	1	707	R	47	90	8,250	10,900	12,600	14,700	16,300	18,000
04210000	Phelps Creek near Windsor	1	25.6	R	18	21	1,850	2,700	3,240	3,870	4,320	4,740
04210090	Montville Ditch at Montville	1	0.29	C	10	3.0	23	41	55	75	91	107
04210100	Hoskins Creek at Hartsgrove	1	5.11	C	29	7.0	209	335	425	543	633	726
04211500	Mill Creek near Jefferson	1	82.0	R	33	41	3,370	4,670	5,560	6,730	7,630	8,560
04212000	Grand River near Madison	1	581	R-C	51	88	8,830	11,600	13,300	15,300	16,800	18,200
04213000	Conneaut Creek at Conneaut	1	175	R	40	59	6,010	8,840	10,700	13,100	14,900	16,700

[1] Check station, not used in regression analysis.
[2] Type of gage: R = recording, C = crest-stage.

Channel Geometry Data

Channel geometry field data (fig. 2) obtained in the vicinity of each gaging station were as follows:

WAC = width of active channel in feet.
DAC = average depth of active channel in feet.
WBF = width of bankfull channel in feet.
DBF = average depth of bankfull channel in feet.
BEDSC = percent of silt and clay in stream bed.
BANKSC = percent of silt and clay in stream banks.

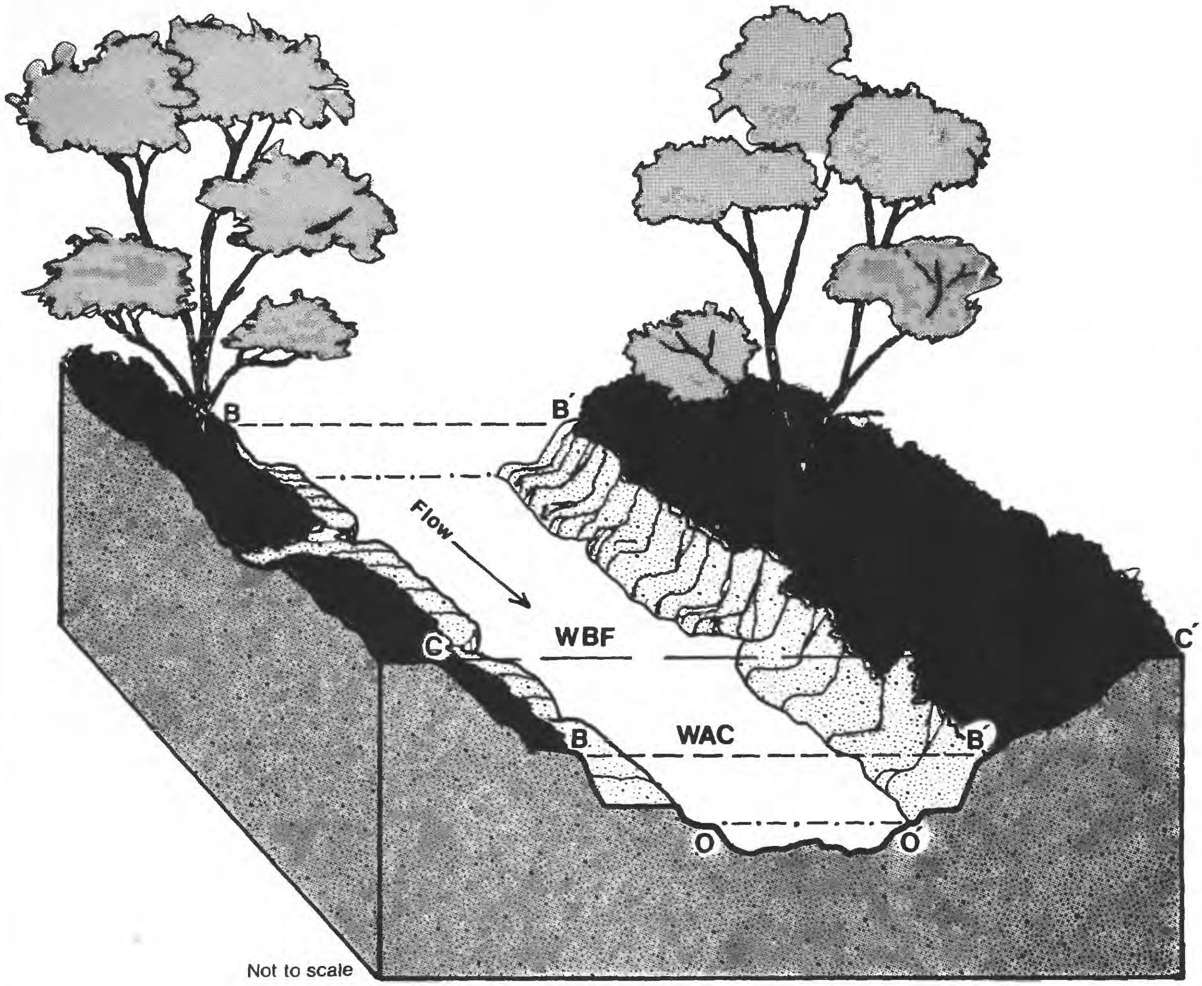
As defined by Osterkamp and Hedman (1977, p. 256), "The active channel is a short-term geomorphic feature subject to change by prevailing discharges. The upper limit is defined by a break in the relatively steep bank slope of the active channel to a more gently sloping surface beyond the channel edge. The break in slope normally coincides with the lower limit of permanent vegetation so that the two features, individually or in combination, define the active channel reference level. The section beneath the reference level is that portion of the stream entrenchment in which the channel is actively, if not totally, sculptured by the normal process of water and sediment discharge."

The width of active channel (WAC) can be measured if the water level is below the upper limit of a defined active channel.

The boundaries that define the bankfull channel are the abrupt breaks in slope, farther up the banks than the active channel boundaries, that coincide with the flood plain.

A channel geometry cross section should be located in a straight reach. Ideally, uniform width should be exhibited throughout the reach for a length of five to seven times the active channel width. Reaches of bedrock control, altered channel, split channel, and apparent channel instability should be avoided as sites for measurement. Photographs of all channel geometry sections were taken; views of six typical sites are shown in fig. 3.

Percent of silt and clay in the streambed and banks was determined by dry sieve sediment analysis. The streambed samples were composite samples taken across the stream channels. The left and right bank samples obtained at each site were composite samples taken up each bank. The percent of silt and clay in the banks represents a composite of the left and right banks.



EXPLANATION

C-C′ = ——— ——— Bankfull reference line

B-B′ = — — — — — Active-channel reference line

O-O′ = ·— ·—·—·— Low-flow water level

WBF = Bankfull width

WAC = Active-channel width

Figure 2.--Block diagram of a typical stream channel.

3-A Tuscarawas River at Newcomerstown

3-B Scioto River at LaRue

3-C Stoney Creek near DeGraff

3-D North Fork Little Miami River near Pitchin

3-E Collins Creek at Collinsville

3-F North Fork Licking River at Utica

Figure 3.--Channel geometry measuring sites at six Ohio streams.

REGIONALIZATION

Needs and Methods

Flood flow information is often desired at sites where stream gaging stations are not located. Flood flows may be estimated at ungaged sites by using regional analysis. One method of regionalization is a multiple regression technique by which mathematical equations that relate peak discharges to channel geometry parameters at gaging stations are developed. Channel geometry parameters for a qualifying ungaged site within the area may then be used in the developed regional equations to compute peak discharges for selected recurrence intervals for the site.

Individual regression equations were developed in this report for peak flows, Q_T, where T represents recurrence intervals of 2, 5, 10, 25, 50, and 100 years. Peak-flow data for natural flows at gaged sites (table 1) were used as the dependent variables. The independent variables were the six channel geometry parameters, previously described, WAC, DAC, WBF, DBF, BEDSC, and BANKSC. The developed flood frequency estimating equations have the general form:

$$Q_T = cX_1^{b_1}, X_2^{b_2}, \ldots X_n^{b_n}$$

where Q_T is the peak discharge with a recurrence interval of T-years,
$X_1, X_2, \ldots X_n$ are channel geometry parameters,
$b_1, b_2, \ldots b_n$ are regression exponents and,
c is the regression constant.

All six of the channel geometry parameters were used initially as independent variables. However, only the width of active channel (WAC) is statistically significant at the 5-percent level. The five other variables were eliminated. Equations for the 2-, 5-, 10-, 25-, 50-, and 100-year floods were developed using flood-peak data at 160 gaging stations (10 stations were reserved for verification analysis) in a statewide analysis, for which the average standard error of estimate ranges from 42 to 55 percent.

The statewide multiple regression residuals (the difference between the observed and computed flood flows at each station) were plotted on a map similar to that used in figure 1. The residuals for the 2-year recurrence interval and the 100-year recurrence interval floods were plotted on separate maps. An analysis of those residuals indicates that the statewide equations are not geographically biased. Since no bias was found and because one of the purposes for developing these equations is to have a technique independent of boundary locations, it was decided to use the statewide multiple regression equations.

Flood-Frequency Estimating Equations

The flood-frequency estimating equations based on the statewide regression analyses are:

Equation	Standard error of estimate, percent: +	Average	-	Equation number
$Q_2 = 16.5\ (WAC)^{1.31}$	51	42	34	1
$Q_5 = 32.1\ (WAC)^{1.25}$	52	43	34	2
$Q_{10} = 45.0\ (WAC)^{1.22}$	55	45	35	3
$Q_{25} = 63.5\ (WAC)^{1.19}$	60	49	37	4
$Q_{50} = 78.9\ (WAC)^{1.18}$	64	52	39	5
$Q_{100} = 95.7\ (WAC)^{1.16}$	69	55	41	6

where Q_2, Q_5, Q_{10}, Q_{25}, Q_{50}, and Q_{100} are the peak discharges, in ft^3/s, corresponding to the 2, 5, 10, 25, 50, and 100-year recurrence interval floods (Q_T), respectively. WAC is the width of active channel in feet. The Q_2 and Q_{100} equations and supporting 160 data points are presented graphically in figures 4 and 5.

Limitation and Reliability of Estimating Equations

The flood-frequency equations presented in this report are limited to unregulated, rural streams in Ohio with alluvial channels unaltered by man. The estimating equations are based on data from watersheds with drainage areas ranging from 0.12 mi and 7,422 mi .

Use of the equations for drainage basins larger or smaller than the above range could result in solutions less reliable than those indicated by the standard errors of estimate.

The average standard error of estimate, which is a measure of the distribution of the observed values around the line of regression, equals the average of the positive and negative departures in percent. Two-thirds of the observations lie between the plus and minus departures. The average standard errors of estimate in this study range from 42 percent for Q_2 to 55 percent for Q_{100}.

The verification of developed equations may also be determined by comparing equation results with observed values at stations which were excluded from the regression analysis. The differences between observed and computed values (residual difference) indicate the reliability of the developed equations. Ten stations, distributed over the state, with lengths of record between 29 and 61 years and drainage areas between 0.29 mi^2 and 5,131 mi^2 were used for

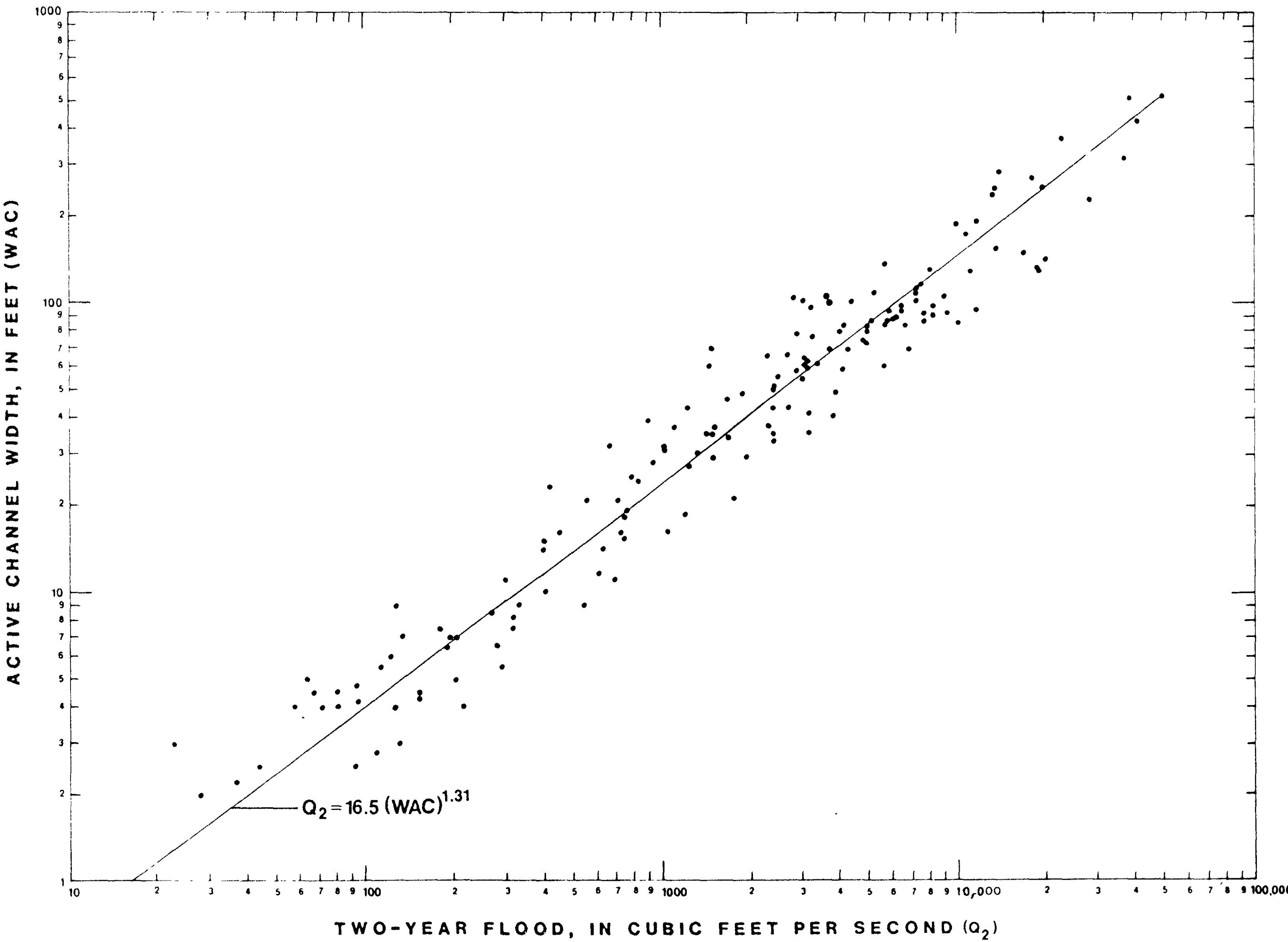


Figure 4.--Relationship between active channel width and two-year flood.

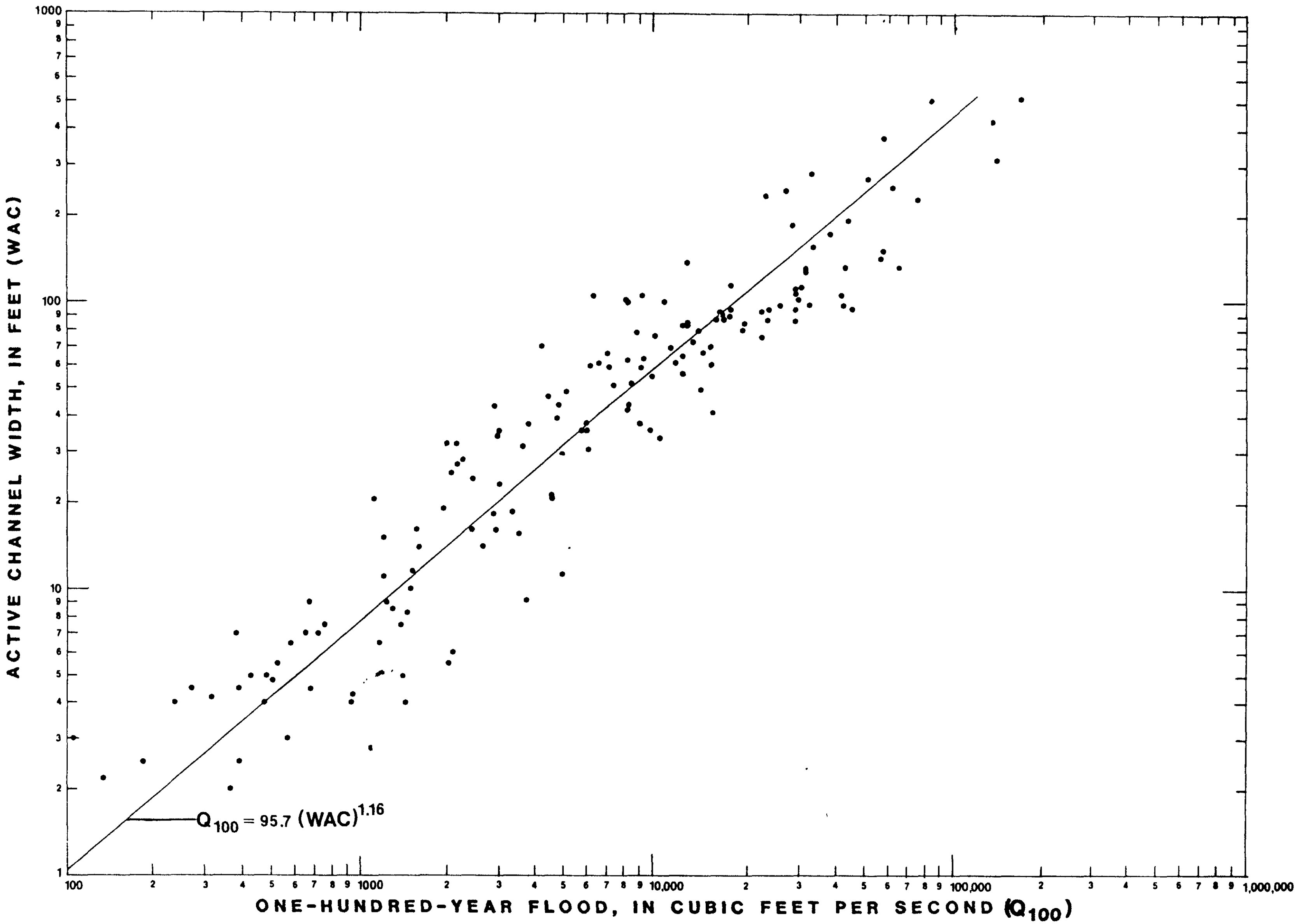


Figure 5.--Relationship between active channel width and one-hundred-year flood.

verification analysis. There were 60 verification values (10 stations with 6 floods each) with maximum and minimum residual differences of 54 percent and 0 percent, respectively. The average residual difference is 21 percent which compares favorably with the average standard error of estimate which ranges from 42 to 55 percent for the six flood-frequency estimating equations. The verification results, presented in table 2, indicate that no bias exists with regard to drainage area size.

An additional verification of developed equations was obtained by arbitrarily dividing the total 170-station sample into two 85-station groups and comparing these developed regression equations with the equations based on the total sample. No significant differences were found.

APPLICATION OF REGIONAL EQUATIONS

Illustrative Examples

Techniques used to estimate peak flood magnitudes and frequencies are illustrated by the following two examples:

Example 1. Estimate the 50-year flood at a site having a natural channel and a rural drainage area of 6.19 mi^2 on Lisbon Creek at Lisbon, Columbiana County, Ohio.

(a) The measured active channel width (WAC) of Lisbon Creek at Lisbon was 12 feet.

(b) Equation 5 may be directly applied to estimate the 50-year flood as follows:

$$\begin{aligned} Q_{50} &= 78.9 \ (WAC)^{1.18} \\ &= 78.9 \ (12)^{1.18} \\ &= 1{,}480 \text{ ft}^3/\text{s}. \end{aligned}$$

(c) The equation developed for geographic area 1, presented by Webber and Bartlett (1977), estimates the 50-year flood as follows:

$$\begin{aligned} Q_{50} &= 166(A)^{0.752}(Sl)^{0.222}(St)^{-0.411} \\ &= 166(6.19)^{0.752}(55.6)^{0.222}(4)^{-0.411} \\ &= 902 \text{ ft}^3/\text{s}. \end{aligned}$$

Table 2.--Regression equations verification data

Station number	Stream	Length of record (years)	Drainage area (mi2)	Floods in feet3/second																	
				2-year			5-year			10-year			25-year			50-year			100-year		
				Observed[1]	Computed[2]	Difference, in percent	Observed[1]	Computed[2]	Difference, in percent	Observed	Computed[2]	Difference, in percent	Observed[1]	Computed[2]	Difference, in percent	Observed[1]	Computed[2]	Difference, in percent	Observed[1]	Computed[2]	Difference, in percent
03086500	Mahoning River	34	89.2	2,430	2,420	0	3,890	3,740	-4	4,980	4,680	-6	6,450	5,890	-9	7,620	7,040	-8	8,840	7,920	-10
03109500	Little Beaver Creek	60	496	9,710	9,310	-4	14,500	13,600	-6	17,900	16,400	-8	22,400	20,100	-10	26,000	23,700	-9	29,600	26,100	-12
03118500	Nimishillen Creek	54	175	2,960	3,370	+14	4,290	5,140	+20	5,210	6,380	+22	6,410	7,970	+24	7,320	9,500	+30	8,260	10,600	+28
03140000	Mill Creek	39	27.2	1,460	1,120	-23	2,800	1,790	-36	3,910	2,280	-42	5,600	2,930	-48	7,040	3,520	-50	8,650	4,000	-54
03159500	Hocking River	61	943	12,600	9,800	-22	19,000	14,200	-25	24,000	17,200	-28	31,200	21,000	-33	37,300	24,900	-33	44,000	27,300	-38
03234500	Scioto River	45	5,131	48,900	43,700	-11	29,100	59,200	-25	102,000	69,300	-32	133,000	81,700	-39	158,000	95,500	-40	184,000	103,000	-44
03235000	Salt Creek	29	11.5	1,010	946	-6	1,650	1,530	-7	2,140	1,950	-9	2,820	2,510	-11	3,370	3,030	-10	3,960	3,450	-13
03274100	Blake Run	33	0.29	64	70	+9	117	127	+9	156	172	+10	209	235	+12	250	288	+15	292	342	+17
04186500	Auglaize River	50	332	4,920	5,820	+18	7,030	8,650	+23	8,300	10,600	+28	9,780	13,100	+34	10,800	15,500	+44	11,700	17,200	+47
04197000	Sandusky River	53	774	8,490	9,210	+8	12,000	13,400	+12	14,200	16,300	+15	16,900	19,900	+18	18,700	23,500	+26	20,600	25,900	+26
	Average	46	--			12			17			20			24			26			29
	Maximum	61	5,131			23			36			42			48			50			54
	Minimum	29	0.29			0			4			6			9			8			10

Total number of verification points = 60
Average percent difference of all 60 points = 21 percent
Maximum percent difference of all 60 points = 54 percent
Minimum percent difference of all 60 points = 0 percent

[1] From Log Pearson Type III flood frequency analysis of station data.
[2] From Statewide regression equations developed in this report.

where: Q_{50} = discharge in ft^3/s for a 50-year recurrence interval,

A = drainage area in mi^2, as determined from U.S. Geological Survey 7.5 minute series topographic quadrangle maps and tabulated in Ohio Department of Natural Resources, Ohio Water Plan Inventory Report 12a (Cross, 1967),

Sl = main-channel slope in ft/mi and was computed as the difference between elevations, respectively, at 10 and 85 percent of the channel distance from the site to the basin divide, divided by the channel distance between the two points as determined from U.S. Geological Survey topographic maps,

St = surface-storage index in percent, is the percentage of total drainage area occupied by lakes, ponds, and swamps, as determined from U.S. Geological Survey topographic maps. The characteristic used in regression was surface storage index plus 1.0 percent.

Lisbon Creek at Lisbon is the site of a crest-stage gage with 29 years of record. The 50-year flood as determined by log-Pearson type III flood frequency analysis of station data is 1,230 ft^3/s.

Example 2. Estimate the 100-year flood on the unregulated Licking River at Toboso, Licking County, Ohio (drainage area = 672 mi^2).

(a) The active channel width (WAC) of the Licking River at Toboso was 186 feet.

(b) Equation 6 may be directly applied to estimate the 100-year flood at Toboso as follows:

$$Q_{100} = 95.7\ (WAC)^{1.16}$$
$$= 95.7\ (186)^{1.16}$$
$$= 41{,}100\ ft^3/s$$

(c) The equation developed for geographic area 2, presented by Webber and Bartlett (1977), estimates the 100-year flood as follows:

$$Q_{100} = 52.6(A)^{0.857}(Sl)^{0.619}$$
$$= 52.6(672)^{0.857}(8.2)^{0.619}$$
$$= 51{,}200 \text{ ft}^3/\text{s}.$$

Licking River at Toboso is the site of a discontinued stream gaging station with 45 years of record. The 100-year flood as determined by log-Pearson type III flood frequency analysis of station data is 46,600 ft³/s.

GEOGRAPHIC AREAS

Boundary Check Method

Although Ohio is relatively well covered with streamflow stations, a deficiency of flow data in selected geographic areas has caused the boundaries between flood areas, as developed in Ohio Department Natural Resources, Division of Water Bulletin 45 (Webber and Bartlett, 1977), to be poorly defined in some locations. The southern-most section of the boundary between geographic area 2 and area 3 is one such boundary in question (fig. 6). This boundary location as well as the location of other poorly defined flood area boundaries in Ohio may be evaluated by using the regression equations developed in this report. The peak discharge estimating method presented in this report is independent of the basin characteristics method presented by Webber and Bartlett (1977).

Active channel widths were measured at 28 qualified ungaged sites on both sides of the southern-most section of the boundary between area 2 and area 3 (fig. 6). The peak discharges for the 2-year and 100-year floods were calculated for each site by the appropriate equations developed in this report, equations (1) and (6), respectively, (table 3). Also calculated for each ungaged site were the peak discharges for the 2-year and 100-year floods, representative, of area 2 and area 3, obtained from equations derived in Webber and Bartlett (1977).

Geographic area 2 equations:

$$Q_2 = 42.6\ (A)^{0.802}\ (Sl)^{0.225} \qquad (7)$$
$$Q_{100} = 52.6\ (A)^{0.857}\ (Sl)^{0.619} \qquad (8)$$

Geographic area 3 equations:

$$Q_2 = 7.27\ (A)^{0.771}\ (Sl)^{0.244}\ (E)^{-1.54}\ (P)^{0.802} \qquad (9)$$
$$Q_{100} = 34.7\ (A)^{0.729}\ (Sl)^{0.290}\ (E)^{-1.30}\ (P)^{0.718} \qquad (10)$$

where

E = average basin elevation index, in feet, above the National Geodetic Vertical Datum of 1929, was computed by averaging the elevations at the 10 and 85 percent distance points along the channel as determined from U.S. Geological Survey topographic maps. The reliability of this method is discussed by Benson (1964). The characteristics used in this regression analysis was average basin elevation index of 1,000's of feet.

P = average annual precipitation, in inches, determined from an isohyetal map, shown in fig. 7 and published by the Ohio Department of Natural Resources (1961). The characteristic used for regression analysis was average annual precipitation minus 27 (to facilitate computations).

Percentage differences were determined for each ungaged site between peak discharge values calculated from equations (1) and (6) and from those calculated from the geographic area 2 and area 3 equations, Q_{DNR}.

$$\text{percent difference} = \frac{(Q_{DNR}) - (Q_{WAC})}{(Q_{WAC})} \times 100$$

The percent difference values (table 3) indicate that the geographic area 2 equations more nearly represent the flood-flow characteristics of the ungaged sites that were checked. The percent difference values also indicate that the peak discharge is overestimated when the geographic area 3 equation is applied to the ungaged sites in geographic area 3. The actual redefinition of poorly defined geographic area boundaries is beyond the scope of this report.

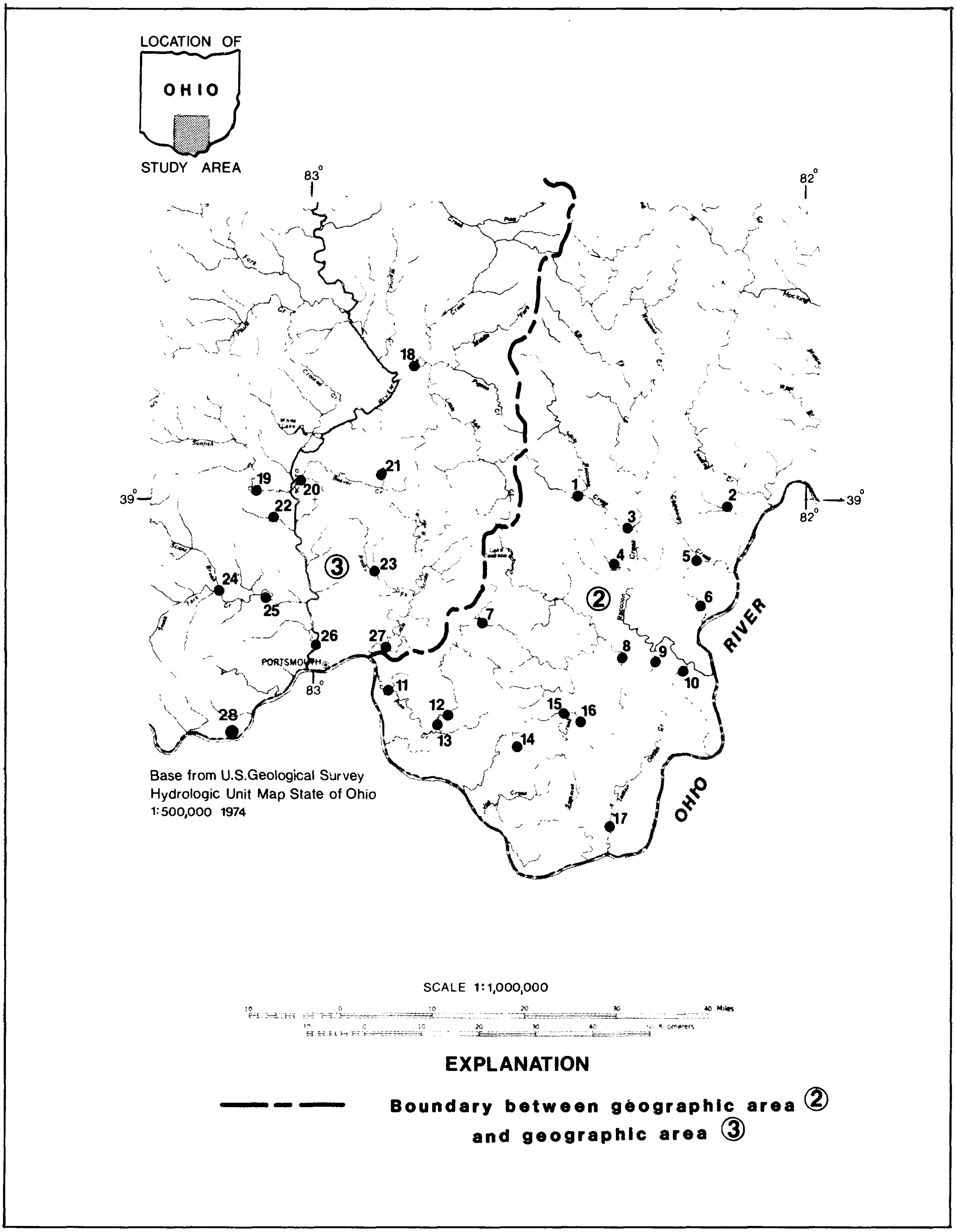
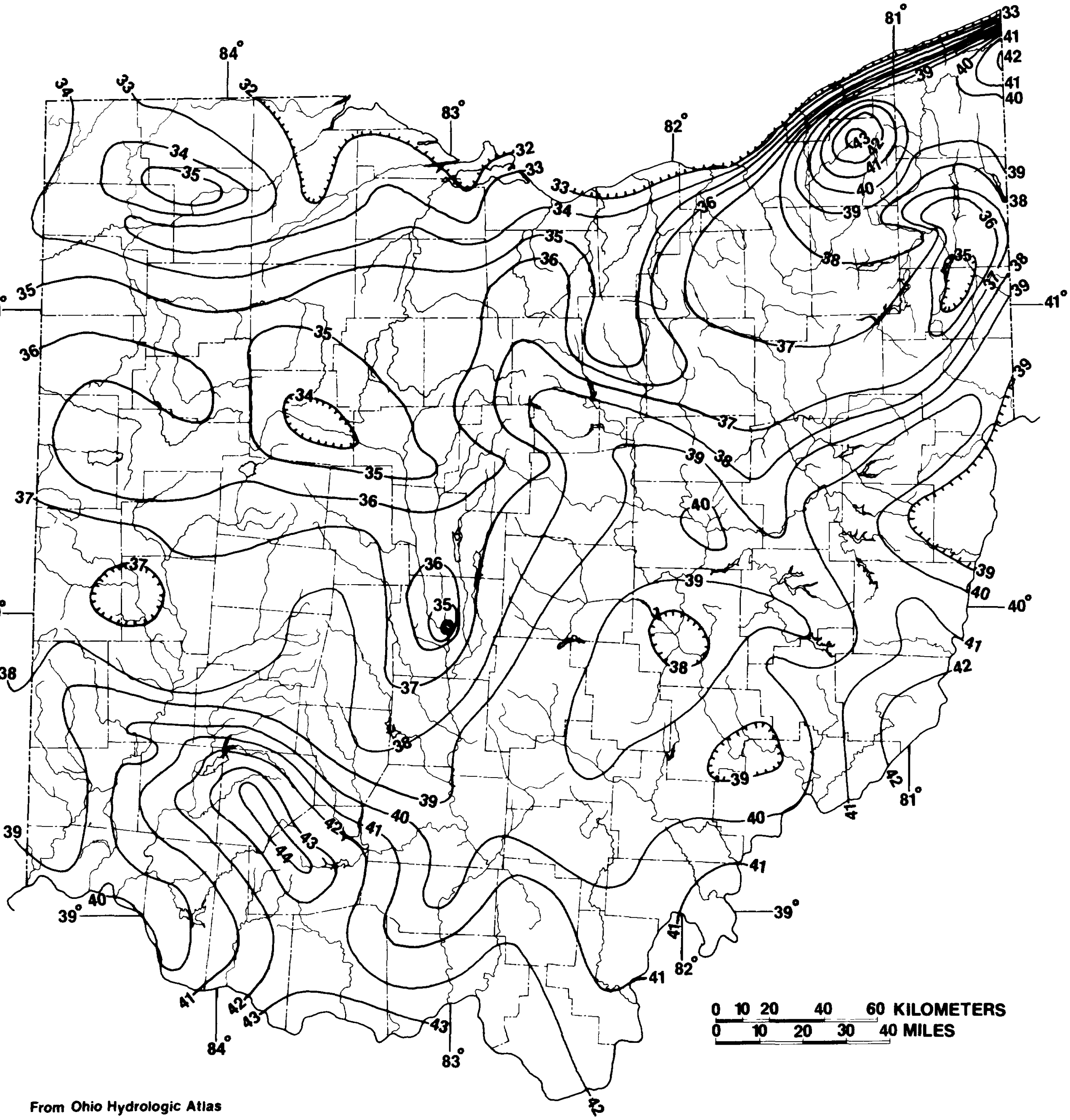


Figure 6.--Flood boundary study area and ungaged sites.



From Ohio Hydrologic Atlas
Report No. 13
Division of Water
Ohio Department of Natural Resources
State of Ohio, 1962

EXPLANATION

—44— Average annual precipitation in inches, 1931–1960

Figure 7.--Average annual precipitation in Ohio, in inches, 1931-1960.

Table 3.--Hydrologic data for boundary ungaged sites in Ohio

Site number (Fig.6)	Stream	Geo-graphic area	Location: latitude longitude	Drain-age area (mi^2)	Main channel slope (ft/mi)	Average basin elevation (ft/1,000)	Average annual precipi-tation (in inches -27 inches)	Active channel width WAC (ft)	Computed Q_2 and Q_{100} equations (1) and (6) (ft^3/s)	Computed Q_2 and Q_{100} geographic area 2 equations (ft^3/s)	Dif-ference, in percent	Computed Q_2 and Q_{100} geographic area 3 equations (ft^3/s)	Dif-ference, in percent
1	Dickason Run	2	39°00'24" 82°28'12"	22.5	12	0.681	14	19	781 2,910	905 3,530	16 21	2,210 7,570	183 160
2	Jessie Creek	2	38°59'16" 82°09'02"	2.69	46	0.686	13.5	8	251 1,070	223 1,310	-11 22	572 2,290	128 114
3	Little Raccoon Creek	2	38°57'11" 82°21'57"	154	3	0.655	13.5	50	2,770 8,950	3,100 7,780	12 -13	7,150 21,100	158 136
4	Little Indian Creek	2	38°53'34" 82°22'58"	10.2	22	0.661	14	19	781 2,910	550 2,610	-30 -10	1,450 5,270	86 81
5	Campaign Creek	2	38°54'18" 82°13'10"	32.2	11	0.635	14	33	1,610 5,530	1,180 4,550	-27 -18	3,170 10,500	97 90
6	Chickamauga Creek	2	38°50'27" 82°13'18"	19.4	19	0.605	14	21	890 3,270	891 4,130	0 26	2,640 9,050	197 177
7	Brady Run	2	38°48'17" 82°39'16"	6.06	32	0.720	15	12.5	451 1,790	394 2,110	-13 18	989 3,780	119 111
8	Sand Fork	2	38°44'54" 82°22'35"	37.1	8	0.687	14	25	1,120 4,000	1,230 4,220	10 6	2,900 9,580	159 140
9	Claylick Run	2	38°44'52" 82°18'14"	4.75	49	0.655	14	13	475 1,880	357 2,220	-25 18	995 3,850	109 105
10	Bullskin Creek	2	38°43'33" 82°15'08"	13.1	28	0.628	14	22	946 3,450	710 3,750	-25 9	2,020 7,250	114 110
11	Pine Creek	2	38°41'51" 82°50'50"	168	3	0.581	15.5	60	3,520 11,100	3,320 8,380	-6 -25	10,300 29,000	193 161
12	Pine Creek	2	38°39'14" 82°44'33"	102	4	0.614	15.5	38	1,940 6,510	2,380 6,530	23 0	6,890 20,400	255 213
13	Little Pine Creek	2	38°37'50" 82°43'54"	29.2	14	0.620	15.5	25	1,120 4,000	1,150 4,860	3 22	3,510 11,600	213 190
14	Paddle Creek	2	38°36'40" 82°35'27"	2.25	47	0.710	15	9.5	315 1,300	194 1,140	-38 -12	517 2,090	64 61

Table 3.--Hydrologic data for boundary ungaged sites in Ohio.--Continued

Site number (Fig.6)	Stream	Geo-graphic area	Location: latitude longitude	Drain-age area (mi^2)	Main channel slope (ft/mi)	Average basin elevation (ft/1,000)	Average annual precipi-tation (in inches -27 inches)	Active channel width WAC (ft)	Computed Q_2 and Q_{100} equations (1) and (6) (ft^3/s)	Computed Q_2 and Q_{100} geographic area 2 equations (ft^3/s)	Dif-ference, in percent	Computed Q_2 and Q_{100} geographic area 3 equations (ft^3/s)	Dif-ference, in percent
15	Aaron Creek	2	38°39'44" 82°29'26"	8.21	26	0.656	15	14	523 2,040	480 2,400	-8 18	1,370 5,010	162 146
16	Long Creek	2	38°39'07" 82°27'57"	14.5	22	0.648	15	25	1,120 4,000	729 3,530	-35 -12	2,080 7,340	86 84
17	Indian Guyan Creek	2	38°28'42" 82°23'53"	67.5	6	0.619	15	40	2,070 6,910	1,870 5,890	-10 -15	5,320 16,400	157 137
18	Middle Fork Salt Creek	3	39°13'00" 82°45'46"	109	7	0.648	13.5	54	3,070 9,780	2,840 9,780	-7 0	6,840 21,200	123 117
19	Sunfish Creek	3	39°00'46" 83°07'14"	136	8	0.628	13	76	4,800 14,500	3,500 12,800	-27 -12	8,540 26,300	78 81
20	Big Beaver Creek	3	39°01'54" 83°01'38"	68.9	6	0.595	13	43	2,280 7,510	1,900 6,000	-17 -20	5,120 15,800	125 110
21	Buck Hollow Creek	3	39°02'21" 82°51'56"	4.59	53	0.740	14	11	382 1,540	353 2,270	-8 47	819 3,280	114 113
22	Camp Creek	3	38°58'26" 83°04'53"	26.7	56	0.770	13.5	32	1,550 5,330	1,470 10,600	-5 99	2,950 11,100	90 108
23	McConnel Creek	3	38°53'16" 82°52'12"	10.1	20	0.678	14.5	17	675 2,560	534 2,440	-21 -5	1,400 5,050	207 97
24	Rocky Fork	3	38°51'03" 83°12'09"	22.8	40	0.760	14.5	33	1,610 5,530	1,200 7,520	-25 36	2,600 9,630	61 74
25	Scioto Brush Creek	3	38°50'28" 83°05'45"	261	6	0.620	14.5	108	7,610 21,900	5,530 18,800	-27 -14	14,600 42,800	92 95
26	Carrol Run	3	38°46'08" 82°59'09"	0.434	277	0.665	15	5	136 619	77 836	-43 35	248 1,150	82 86
27	Wards Run	3	38°46'03" 82°50'34"	7.36	29	0.610	15.5	16	624 2,390	450 2,340	-28 -2	1,490 5,370	139 125
28	McAtee Run	3	38°37'41" 83°09'34"	1.58	184	0.690	16	14	523 2,040	199 1,960	-62 -4	604 2,610	15 28

SUMMARY AND CONCLUSIONS

Magnitude and frequency estimating equations for flood-peak discharge based on channel geometry parameters, are given in this report. They may be used as a method to evaluate present Ohio flood boundaries in geographic areas deficient in flow data. One hundred and sixty gaging stations were selected that have a minimum period of record of 10 years with natural flow and alluvial stream channels unaltered by man. Exposed bedrock is absent from the channels in the vicinity of the surveyed cross sections. The watersheds are well distributed over the state and range in area from 0.12 mi^2 to 7,422 mi^2.

Multiple regression analyses were used to relate T-year peak stream discharges at the selected gaged sites with channel geometry parameters. Active channel width is the only statistically significant parameter. Channel geometry parameters which were tested and found to be statistically insignificant are active channel average depth, bankfull width, and bankfull average depth. The percentage of silt and clay in the streambed and banks also proved to be statistically insignificant. The average standard errors of estimate for the resulting statewide equations, with recurrence intervals of 2, 5, 10, 25, 50, and 100 years, range from 42 to 55 percent.

The southernmost section of boundary between geographic area 2 and area 3, as delineated in Webber and Bartlett (1977), was evaluated. Peak discharge values were determined for 28 ungaged sites, located on both sides of the boundary, by using equations (1) and (6) and geographic area 2 and area 3 equations. These peak discharge values indicate that all of the ungaged sites more nearly represent geographic area 2 flood-flow characteristics. The results also indicate that the peak discharge is overestimated when the geographic area 3 equation is applied to ungaged sites located in geographic area 3. The actual redefinition of poorly defined geographic area boundaries is beyond the scope of this report.

The technique developed in Webber and Bartlett (1977) is the present recommended procedure for estimating flood magnitudes and frequencies. The standard errors of estimate for the geographic area equations (Webber and Bartlett, 1977) are smaller than those of the statewide equations developed in this report.

These statewide equations are advantageous when a flood estimate is needed which is independent of geographic area boundaries and traditional basin characteristics.

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