HYDROLOGY AND HYDRAULICS

WOLF CREEK BASIN

MONTGOMERY COUNTY, OHIO

TABLE OF CONTENTS

TABLE OF CONTENTS
LIST OF TABLES

LIST OF PLATES

HYDROLOGY AND HYDRAULICS

I. GENERAL:

The Wolf Creek basin lies entirely within Montgomery County, Ohio which is located in the southwestern portion of the State of Ohio, within the Great Miami River basin. The Great Miami flows generally in a north to south direction and flows into the Ohio River at mile 470.2, just west of Cincinnati, Ohio. The study area includes all of Wolf Creek above stream mile 5.14, which is upstream of the City of Dayton. The Wolf Creek at Dayton USGS gage is located at stream mile 1.86 at which point the drainage area is 68.7 square miles. Wolf Creek at its mouth has a drainage area of approximately 72.3 square miles.

The Wolf Creek drainage basin above the Dayton gage was being modeled using the hydrologic computer program HEC-HMS, while Wolf Creek was being modeled using HEC-RAS from stream mile 5.14 to stream mile 19.73. The two main tributaries to Wolf Creek were also being modeled using HEC-RAS, they are Dry Run from the mouth to stream mile 3.0 and North Branch Wolf Creek from the mouth to stream mile 8.18. Plate 1 is a vicinity map for the study area and Plate 2 is a Wolf Creek drainage basin map. Table 1 shows drainage areas at representative locations within the Wolf Creek basin.

TABLE 1
DRAINAGE AREAS FOR STREAMS
IN THE WOLF CREEK BASIN
ABOVE DAYTON, OHIO

STREAM	DRAINAGE AREA
Wolf Creek @ Dayton, Ohio Gage	68.7 square miles
Wolf Creek Downstream of Dry Run	55.77 square miles
Dry Run @ Mouth	8.25 square miles
Wolf Creek Upstream of Dry Run	47.52 square miles
Wolf Creek Downstream of North Branch Wolf Creek	46.58 square miles
North Branch Wolf Creek @ Mouth	23.71 square miles
North Branch Wolf Creek Downstream of Razor Run	11.3 square miles
Razor Run	5.09 square mile
North Branch Wolf Creek Upstream of Razor Run	6.21 square miles
Wolf Creek Upstream of North Branch Wolf Creek	22.87 square miles
Wolf Creek @ Trotwood, Ohio Gage	
Wolf Creek Downstream of Popular Run	19.58 square miles
Popular Run	3.21 square miles
Wolf Creek Upstream of Popular Run	16.37 square miles

CLIMATE II:

Montgomery County is located in Southwestern Ohio, and has a temperate climate with relatively cold winters and hot, humid summers. The mean annual temperature for the area is about 54 degrees F, with extremes ranging from 30 degrees below zero to 108 degrees F above zero. Average monthly temperatures range from 77 degrees F in July to 28 degrees F in January. Average monthly temperatures, shown in Table 2, are based on 30 years of record at the Dayton, Ohio National Weather Service (NWS) gage. All seasons are marked by weather changes resulting from passing weather fronts and associated centers of high and low pressure.

TABLE 2
MEAN MONTHLY TEMPERATURE (ºF)
FOR THE DAYTON, OHIO AREA

Dayton, Ohio	
Month	**Temperature**
January	27.9
February	31.8
March	41.5
April	52.5
May	63.6
June	72.9
July	77.0
August	75.0
September	67.9
October	55.6
November	44.2
December	33.1

Average Annual - 53.6

III. PRECIPITATION

Precipitation in the Wolf Creek basin is fairly well distributed throughout the year. The average annual precipitation is approximately 39.4 inches, with the monthly averages ranging from about 2.4 inches in February to 4.4 inches in April. Table 3 gives the average monthly rainfall for Dayton, Ohio, which is located on the eastern boundary of the basin.

TABLE 3
MEAN MONTHLY PRECIPITATION (INCHES)
FOR THE DAYTON, OHIO AREA

Cynthiana, Kentucky	
Month	Precipitation (Inches)
January	**2.65**
February	**2.37**
March	**3.08**
April	**4.04**
May	**4.38**
June	**4.17**
July	**3.93**
August	**3.28**
September	**2.61**
October	**2.69**
November	**3.27**
December	**2.94**

Average Annual – 39.41”

IV. HISTORIC STORMS AND FLOODS

On January 20th and 21st, 1959 a large storm event occurred over much of southwestern Ohio, including the Wolf Creek Basin. This event produced 4.81 inches of rainfall that resulted in record flooding along Wolf Creek and its tributaries. On May 27th and 28th, 2004 another storm event occurred producing 4.5 inches of rainfall, resulting in near record flooding along Wolf Creek and its tributaries. Much of the flooding associated with the May 2004 event was centered around Trotwood, Ohio. However, the Wolf Creek at Trotwood USGS gage was no longer in operation, and therefore, flows were not available for comparison of the peak flows within the study area. Wolf Creek at Dayton USGS gage was the only gage that was operating during both events, and based on that gage the 1959 event had a discharge that was approximately 3,000 cfs greater than the 2004 event, and produced a water surface elevation approximately 1.8 feet higher. Many of the local residents indicated that the May 2004 event was worse than the January 1959 event, but there is no data to support that position. Although the rainfall may have been more intense over the upper portions of the Wolf Creek Basin, producing higher flows and flood elevations at Trotwood that were not reflected at the Dayton gage.

Tables 4 and 5 contain the maximum discharge, recorded stage, and corresponding peak elevation for each year of record for the USGS Wolf Creek @ Dayton and Wolf Creek at Trotwood.

TABLE 4
ANNUAL PEAK DISCHARGES AND STAGES
WOLF CREEK
@ DAYTON, OHIO

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)	Peak Elevation (ft. above msl)
1959*	Jan. 21, 1959	55.1	12,500[E]	755.1
1987	Nov. 26, 1986	7.98	4,820	747.81
1988	Feb. 2, 1988	6.50	2,680	746.33
1989	May 23, 1989	11.96	8,060	751.79
1990	Jul. 12, 1990	7.68	4,000	747.51
1991	Dec. 30,1990	11.25	7,600	751.08
1992	Apr. 18, 1992	6.11	2,370	745.94
1993	Apr. 25, 1993	6.80	3,110	746.63
1994	Apr. 10,1994	6.50	2,800	746.33
1995	Aug. 9, 1995	9.66	6,050	749.49
1996	Apr. 29,1996	11.10	7,480	750.93
1997	Jun. 1 1997	6.89	3,200	746.72
1998	May 7, 1998	7.90	4,230	747.73
1999	Feb. 28,1999	5.70	1,940	745.53
2000	Apr. 8, 2000	9.30	5,690	749.13
2001	Apr. 11, 2001	7.37	3,680	747.20
2002	Dec. 17, 2001	8.03	4.360	747.86
2003	Mau 10,. 12003	8.37	4,720	748.2
2004	May 28, 2004	13.50	9,420	753.33
2005	Jan 5, 2005	7.86	4,180	747.69
2006	Mar. 12, 2006	8.02	4,350	747.85

*Historical Peak for Discharge and Stage.
Datum of the gage was 700.00 ngvd (pre 1929)
Current Gage Datum is 739.83 ngvd 1929 (1987 and after)
E – Estimated Discharge

TABLE 5
ANNUAL PEAK DISCHARGES AND STAGES
WOLF CREEK
@ TROTWOOD, OHIO

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)	Peak Elevation (ft. above msl)
1959*	Jan. 21, 1959	8.00	3,900[E]	834.28
1963**	Mar. 04, 1963	3.46	614	829.74
1964**	Mar. 04, 1963	6.48	2,440	832.76
1965**	Mar. 04, 1963	3.46	614	829.74
1966	Feb. 10, 1966	3.55	735	829.85
1967	May 7,1967	4.65	1,360	830.93
1968	May 24, 1968	6.47	2,970	832.75
1969	Jun. 24, 1969	4.86	1,590	830.74
1970	Apr. 24,1970	5.70	2,260	831.98
1971	Feb. 22, 1971	3.98	1,040	830.26
1972	Dec. 30,1971	3.53	888	829.81
1973	Jun. 5, 1973	4.82	1,720	831.10
1974	Jun. 22, 1974	5.46	2,220	831.74
1975	Feb. 23, 1975	5.25	2,020	831.53
1976	Jan. 26, 1976	3.73	1,020	830.01
1977	Apr. 2, 1977	5.43	2,190	831.71
1978	Mar. 14,1978	4.82	1,720	831.10
1979	Aug. 19,1979	5.58	2,470	831.86
1980	Jun. 2,1980	4.72	1,750	831.00
1981	Jun. 5, 1981	3.68	1,040	829.96
1982	Jan. 23, 1982	4.27	1,420	830.55
1983	Dec. 27, 1982	4.07	1,290	830.35
1984	Mar. 16,1984	No Data	690[E]	No Data
1985	Jul. 1, 1985	6.19	3,010	832.47
1986	Mar. 13, 1986	5.65	2,520	831.93

*Historical Peak for Discharge and Stage.
Datum of the gage was 826.28 NGVD 1929.
E – Estimated Discharge
** Questionable Data

V. HIGHWATER MARKS

There were no high water marks set for either the January 1959 flood event or the May 2004 flood event.

VI. HYDROLOGIC MODEL

A detailed hydrologic model was developed for the Wolf Creek basin above the USGS Wolf Creek at Dayton gage for existing conditions using the HEC-HMS “Hydrologic Modeling System” computer program. The basin was divided into 78 sub-basins. Of these sub-basins 29 were in the North Branch Wolf Creek basin, and 13 were in the Dry Run basin. Included in the model are the drainage areas, times of concentration, lag times when appropriate, channel routing parameters (Muskingum-Cunge), and the SCS curve numbers for each sub-basin needed to compute the SCS dimensionless unit hydrograph. The SCS curve numbers were used to calculate the initial losses. These curve numbers were adjusted within an acceptable range, and to the extent necessary to calibrate the hydrologic model. The time of concentration was calculated for each sub-basin using the length of sheet flow, length of shallow concentrated flow and the length of channel flow. With the timing of the hydrographs being the major factor in calculating stream flows, the analysis is sensitive to changes in the times of concentrations for the sub-basins and would also be sensitive to changes in the channel routing parameters used in the Muskingum-Cunge method. Therefore great care was taken in determining the time of concentration for a sub-basin. Results of the analysis were not sensitive to minor changes in the SCS curve numbers and constant loss rates. Plate 3 is a map of the sub-divided basin.

The hydrologic model was calibrated by reproduction of the frequency flows at the two USGS gage locations along Wolf Creek. Flood frequency analysis methodologies were used to determine the frequency discharges based upon the 33 years of annual peak flows at the Wolf Creek at Dayton gage and 24 years of record at the Wolf Creek at Trotwood gage. The computer program HEC-FFA (Flood Frequency Analysis) was used to compute the frequency flows at the gage sites based upon the annual peak flows for the period of record. Frequency flows from the hydrologic model (HEC-HMS), were based upon frequency rainfall obtained from NOAA (National Oceanic and Atmospheric Administration) Atlas 14. Verification of the calibrated hydrologic model was attained through close comparison of the May 2004 flood event. The resulting comparison between the discharge-frequency curve from the FFA program and the HEC-HMS computer model is shown on Plate 4 and Plate 5, with the values tabulated in Table 6 and Table 7. The maximum variation between the FFA and the HEC-HMS program occurred for the most frequent event (100%) at the Trotwood gage, and had a difference of approximately 45%. This difference could be attributed to the years of record being used, the fact that the records are not continuous and the development having a more significant influence on the high frequency events. For the less frequent events used in this study, the differences were less than 10 percent.

TABLE 6
COMPARISON OF FFA FLOWS WITH THE HEC-HMS FLOWS AT DAYTON, OHIO

Flood Frequency	FFA Program Cubic Feet Per Second	HEC-HMS Program Cubic Feet Per Second
100%	1690	2283
50%	4490	3655
20%	6790	5780
10%	8550	7615
4%	10500	10350
2%	13300	12656
1%	15700	15094
0.2%	22700	21120

TABLE 7
COMPARISON OF FFA FLOWS WITH THE HEC-HMS FLOWS AT TROTWOOD, OHIO

Flood Frequency	FFA Program Cubic Feet Per Second	HEC-HMS Program Cubic Feet Per Second
100%	455	828
50%	1530	1,392
20%	2420	2,290
10%	3090	3,074
4%	3820	4,218
2%	4890	5,173
1%	5800	6,186
0.2%	8420	8,710

VII. WATER SURFACE PROFILES

Water surface elevations for all frequency floods were computed through the use of the HEC-RAS computer program, “River Analysis System”. The mapping provided by the local sponsor was utilized to generate channel cross-sections using GEO-RAS. These cross-sections were exported to an HEC-RAS file. Actual channel cross-sections were taken at bridges and the bridge or culvert opening defined so that it could be accurately modeled. The channel cross-sections were used to insure that the cross-sections generated from GEORAS model accurately defined the channel. In many places the mapping did not accurately define the channel bottom and the cross-sections had to be modified to represent what the surveyed cross-section showed. The roughness coefficients, “Manning’s “n-values”, were based on field inspections. Since there were no high water marks, there was no way to adjust “n-values” to accurately pattern the actual conditions. However, the “n-values are based on the professional judgment of two Senior Hydraulic Engineers with more than 50 years of combined experience. Plate 6 through Plate 6D shows the existing profiles for the 100%, 50%, 20%, 10%, 4%, 2%, 1% and 0.2% chance frequency events on Wolf Creek. Plate 7 through Plate 7C shows the existing profiles for North Branch Wolf Creek and Plate 8 shows the existing profiles for Dry Run.

VIII. FLOODPLAIN MAPPING

The final step in this study was to delineate the floodplain associated with the 1% and 0.2% chance frequency flood events on the mapping. This was accomplished by exporting the results from the HEC-RAS model back into GEO-RAS. The floodplain was plotted on the mapping and then checked to insure an accurate representation. The program being utilized does not have the ability to accurately depict all that is happening in the system and the individual checking the floodplain has to evaluate where the water could actually flow. Plate 9 through Plate 9H shows the floodplain for the 1% chance frequency flood event, while Plate 10 through Plate 10H shows the floodplain for the 0.2% chance frequency flood event for Wolf Creek. The floodplain extent for the 1% and 0.2% chance frequency flood events for North Branch Wolf Creek is shown on Plate 11 through Plate 11D and Plate 12 to 12D, respectively. The Dry Run floodplain is shown on Plate 13 for the 1% chance frequency event and Plate 14 for the 0.2% for the chance frequency event.