Appendix 1. Details of Hydrologic and Hydraulic Analyses

Background

The U.S. Geological Survey (USGS) and the Ohio Emergency Management Agency (Ohio EMA) cooperated on the development of flood profiles for selected recurrence intervals in several areas for which flood profiles would be needed to assist in a cost-benefit analysis for mitigation assistance. The flood profiles selected for this analysis were the 10-, 50-, 100-, and 500-year-recurrence-interval flood profiles. For this disaster declaration (FEMA–1580–DR), 10 communities required the selected flood profiles: Pleasant City, Derwent, Kimbolton, Quaker City, Birmingham, Ava, Coal Ridge, South Olive, East Union, and McConnelsville. If a detailed Flood Insurance Study (FIS) with the required profiles existed, they were used for the cost-benefit analysis. If no detailed FIS was available, the USGS determined the selected profiles needed. The existing FIS information is listed in table 1–1.

Table 1–1. Summary of existing FIS(s) for selected streams in disaster area FEMA–1580–DR.
[Approximate level of study is area designated by 1 percent annual chance of flood with estimated hydrologic analysis, Detailed level of study is an area designated by a 1 percent annual chance of flood with base flood elevations derived from an approved hydrologic analysis]

Stream name	FIS date	Study name	Community number	Level of study
Village of Pleasant City, Guernsey County				
Wills Creek and Buffalo Creek	2-17-89	Guernsey County, Ohio and Incorporated Areas	390203	Approximate
Village of Derwent, Guernsey County				
Wills Creek	2-17-89	Guernsey County, Ohio and Incorporated Areas	390198	Approximate
Village of Kimbolton, Guernsey County				
Wills Creek	2-17-89	Guernsey County, Ohio and Incorporated Areas	390201	Approximate
Village of Quaker City, Guernsey County				
Leatherwood Creek	2-17-89	Guernsey County, Ohio and Incorporated Areas	390853	Detailed
Village of Birmingham, Guernsey County				
Clear Fork	2-17-89	Guernsey County, Ohio and Incorporated Areas	390198	Approximate
Village of Ava, Noble County				
West Fork Duck Creek	1-1-88	Noble County, Ohio Unincorporated Areas	390428	Approximate
Village of Coal Ridge, Noble County				
West Fork Duck Creek	1-1-88	Noble County, Ohio Unincorporated Areas	390428	Approximate
Village of South Olive, Noble County				
West Fork Duck Creek	1-1-88	Noble County, Ohio Unincorporated Areas	390428	Approximate
Village of East Union, Noble County				
East Fork Duck Creek	1-1-88	Noble County, Ohio Unincorporated Areas	390428	Approximate
City of McConnelsville, Morgan County				
Muskingum River	12-16-04	City of McConnelsville, Morgan County	390422	Detailed
Muskingum River	12-16-04	Village of Malta, Ohio, Morgan County	390421	Detailed

Scope of Work of Study Effort

The scope of this study is to augment previous FIS in the selected areas to provide the 10-, 50-, 100-, and 500-year flood profiles. This study consisted of ten reaches in ten communities. The stream names, reaches studied, and specific comments about each effort follow. Maps of the study areas are shown in the following figures.

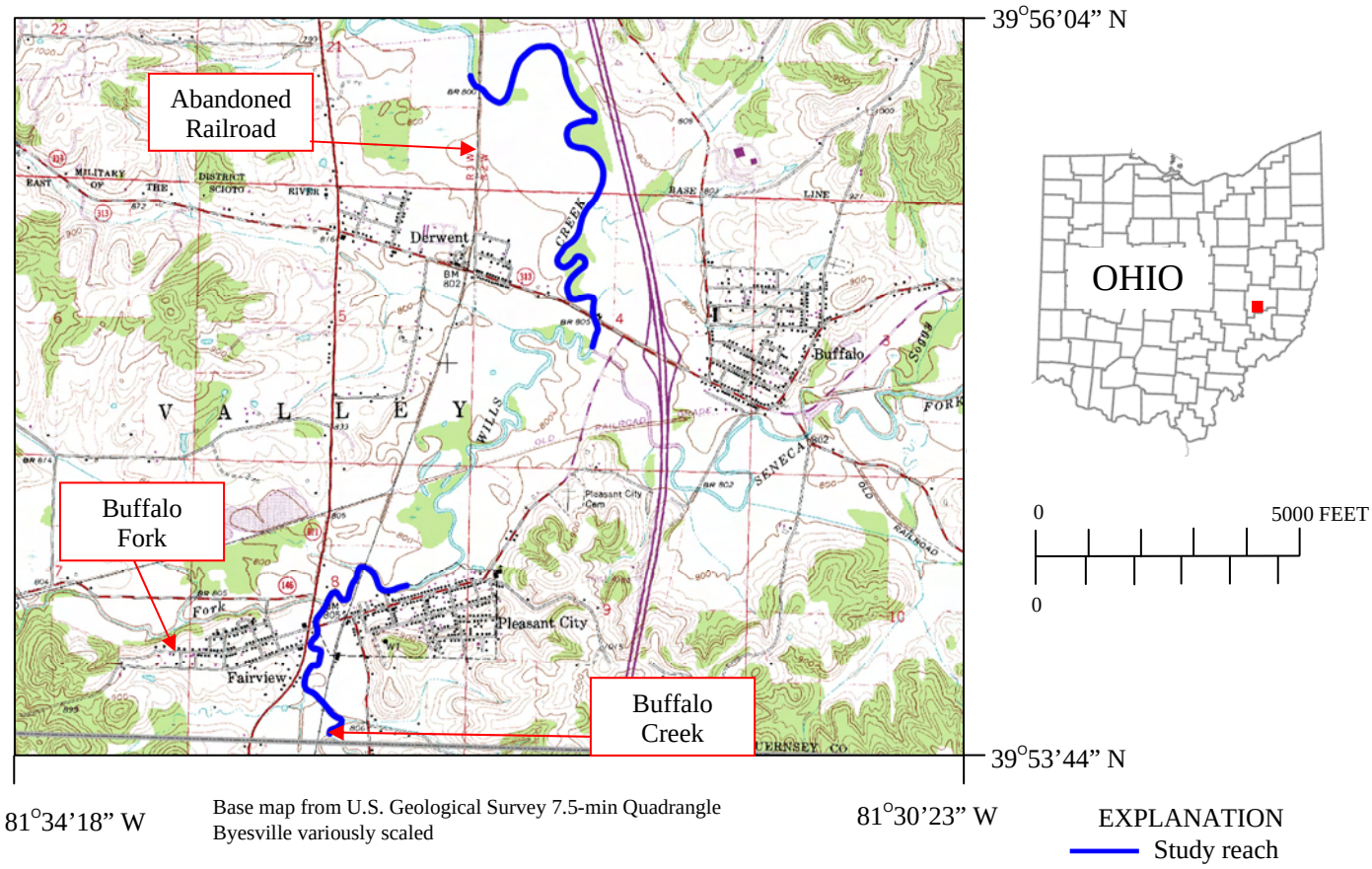
Note: The ten stream reaches studied have been assigned an alphabetical designation (A – Wills Creek and Buffalo Creek, B – Leatherwood Creek, C – Clear Fork, D – West Fork Duck Creek, E – East Fork Duck Creek, and F - Muskingum River) that will be reflected throughout the organization of this appendix. All exhibits pertaining to a particular stream will be labeled using an alphanumeric scheme (for example, A-1, A-2; B-1, B-2, etc.)

1–A. Wills Creek and Buffalo Creek near the Villages of Pleasant City, Derwent, and Kimbolton

Three reaches were studied and are presented in downstream order. The most upstream reach is Buffalo Creek and Wills Creek near the Village of Pleasant City (fig. 1–A1). Buffalo Creek and Buffalo Fork merge to form Wills Creek on the west side of the Village of Pleasant City near the southern Guernsey County line. The downstream limit of this reach is approximately 2,412 ft downstream from the confluence of Buffalo Fork and Buffalo Creek. The upstream limit is Buffalo Creek approximately 3,141 ft above its mouth. The total length of streams modeled is about 5,553 ft.

The middle reach is Wills Creek near the Village of Derwent (fig. 1–A1). The downstream limit of this reach is just downstream from the first abandoned railroad bridge downstream and north of the City of Derwent. The upstream limit is 135 ft upstream from State Route 313. This stream reach is approximately 1.85 mi long.

The third reach is Wills Creek near the Village of Kimbolton (fig. 1–A2). The downstream limit of this reach is approximately 500 ft below the Main Street Bridge on the north side of the Village of Kimbolton. The upstream limit is State Route 541. This stream reach is approximately 0.9 mi long.



Base map from U.S. Geological Survey 7.5-min Quadrangle Byesville variously scaled

Figure 1–A1. Location of the Wills Creek study reaches for the Villages of Pleasant City and Derwent, Ohio.

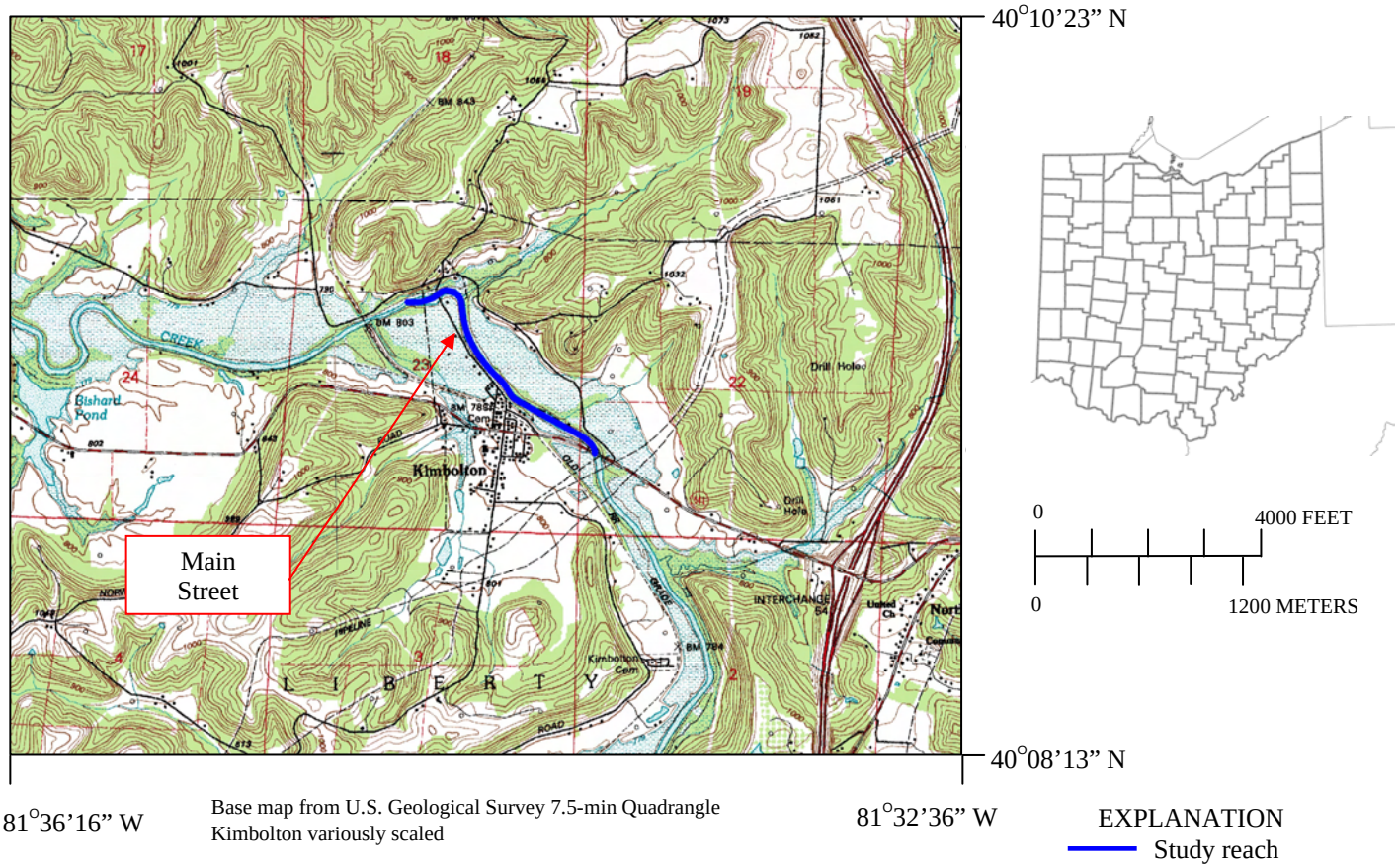
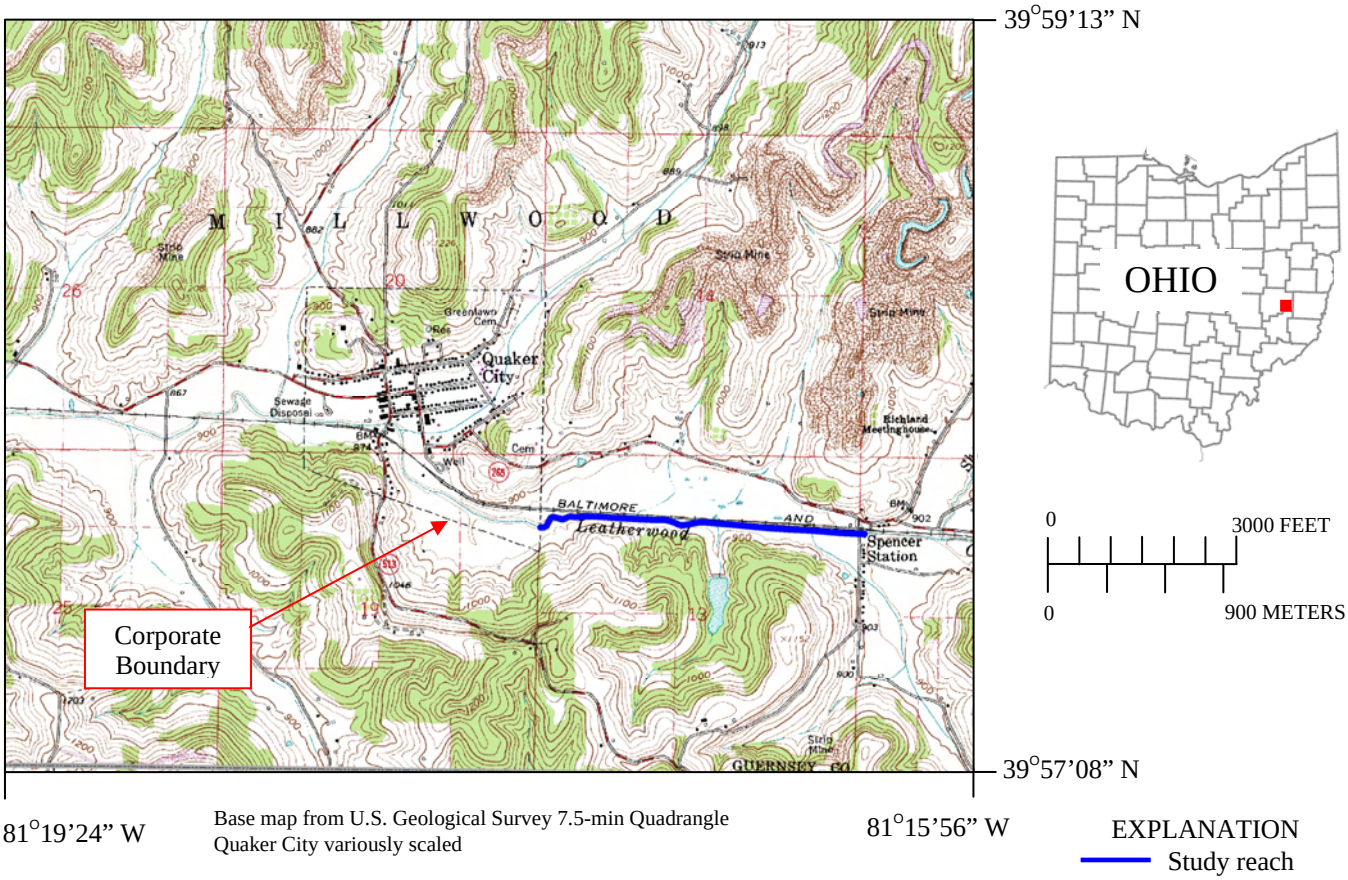


Figure 1–A2. Location of the Wills Creek study reach for the Village of Kimbolton, Ohio.

1–B. Leatherwood Creek near the Village of Quaker City

Leatherwood Creek generally flows west in the southern part of Guernsey County. The downstream limit of the reach studied is the approximately 145 ft east of the eastern corporate boundary of the Village of Quaker City (fig.1–B1). This location is approximately the same as the uppermost cross section from the Leatherwood Creek model in the 1989 FIS. The upstream limit is approximately 35 ft upstream from Eldon Road. This stream reach is approximately 1.0 mi long.



Base map from U.S. Geological Survey 7.5-min Quadrangle Quaker City variously scaled

Figure 1–B1. Location of the Leatherwood Creek study reach for the Village of Quaker City, Ohio.

1–C. Clear Fork near the Village of Birmingham

Clear Fork flows generally southwest in the northeastern part of Guernsey County (fig. 1–C1). The downstream limit of the reach studied is Birmingham Road. The upstream limit is 250 ft downstream from Sligo Road. This stream reach is approximately 0.5 mi long.

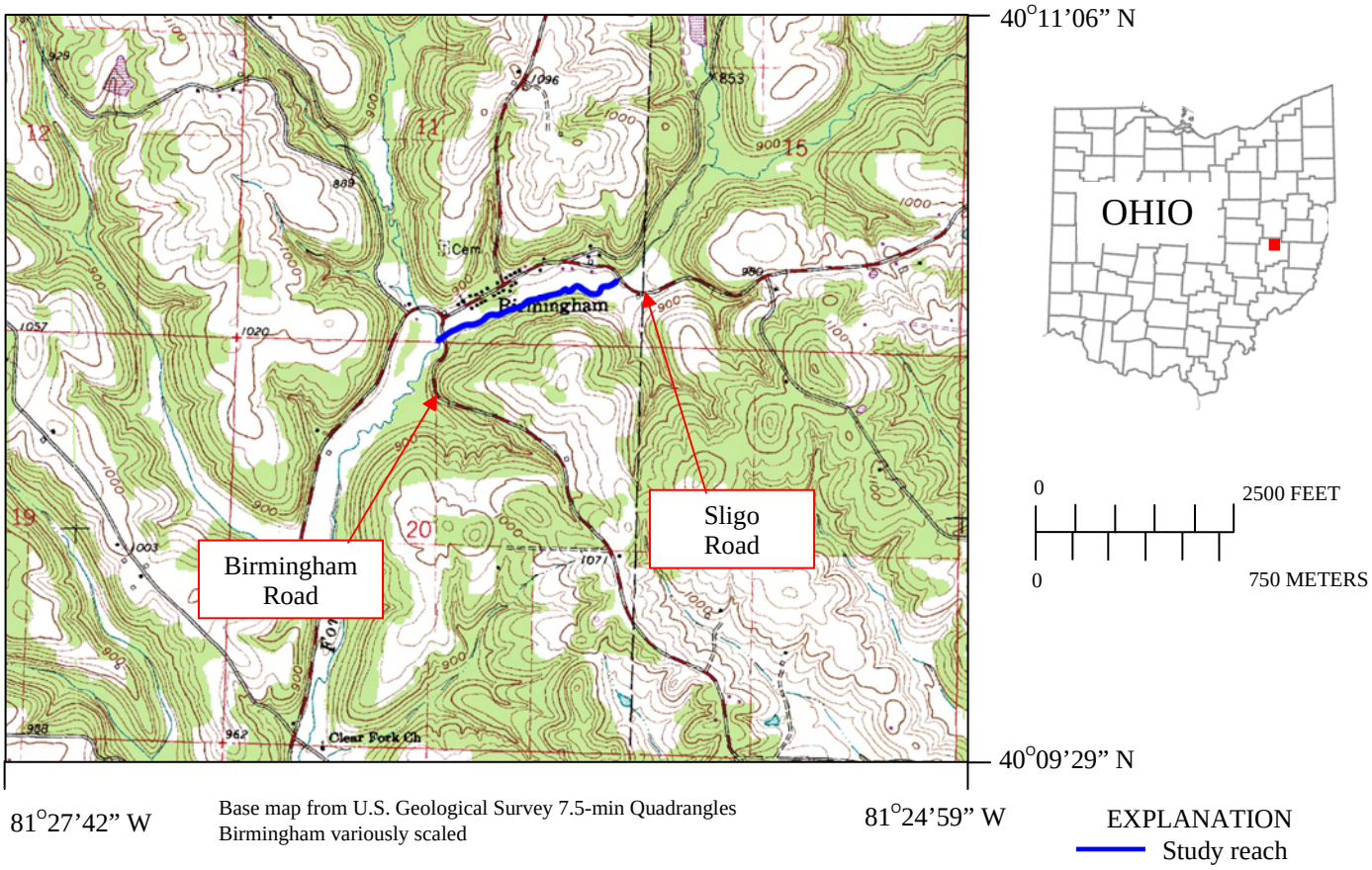


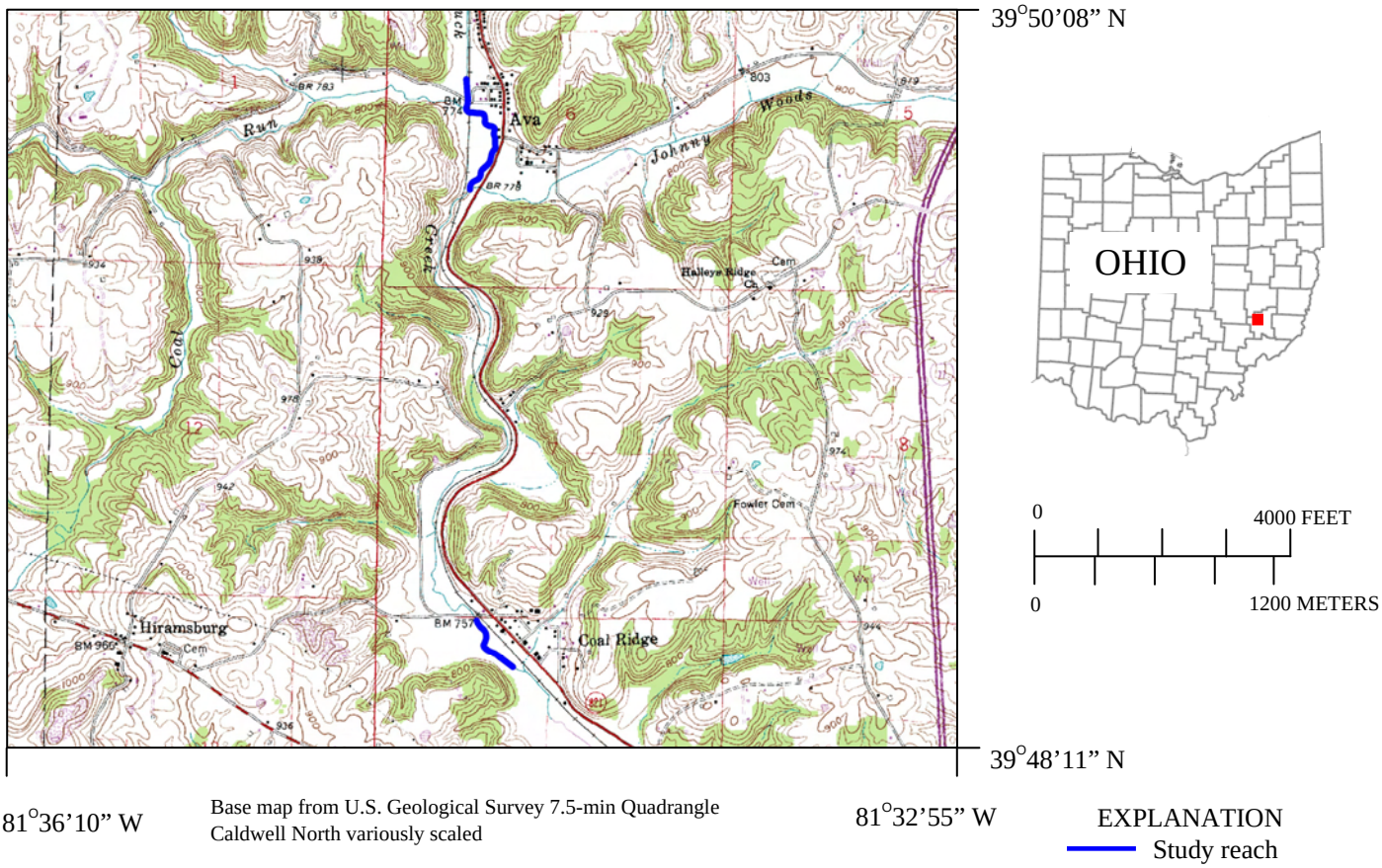
Figure 1–C1. Location of the Clear Fork study reach for the Village of Birmingham, Ohio.

1–D. West Fork Duck Creek near the Villages of Ava, Coal Ridge, and South Olive

Three reaches were studied and are presented in downstream order. The most upstream reach of West Fork Duck Creek is near the Village of Ava, Ohio (fig. 1–D1). The downstream limit of this reach is approximately 1,900 ft downstream from Rayner Road (within the Village of Ava) and just below the confluence of Johnny Woods River. The upstream limit is approximately 650 ft upstream from Rayner Road. This stream reach is approximately 0.5 mile long.

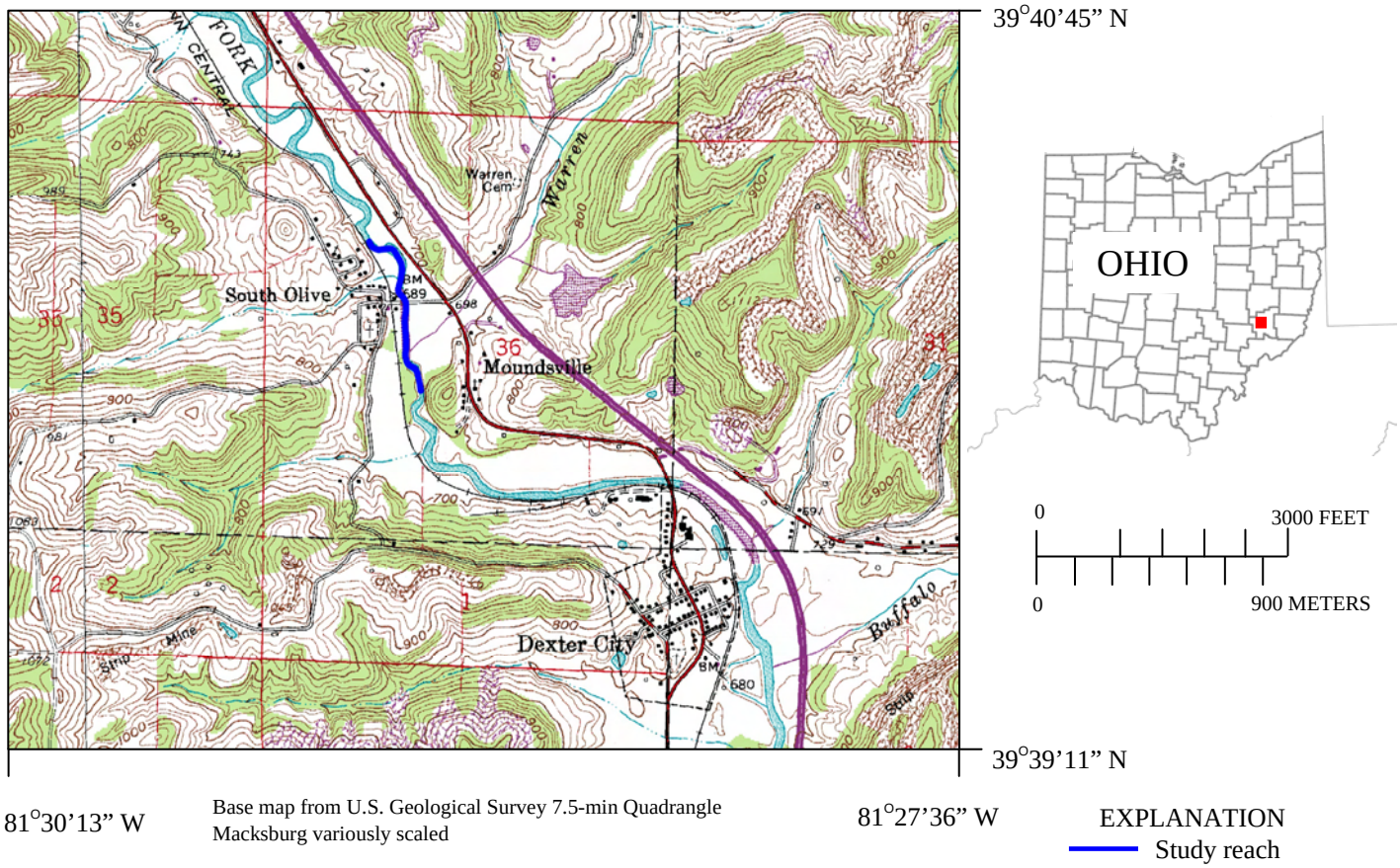
The middle reach of West Fork Duck Creek is near the Village of Coal Ridge, Ohio (fig. 1–D1). The downstream limit of the reach studied is the approximately 1,400 ft downstream from Moore Street within Village of Coal Ridge. The upstream limit is approximately 280 ft downstream of Moore Street. This stream reach is approximately 0.2 mi long.

The third reach is near the Village of South Olive (fig. 1–D2). The downstream limit of the reach studied is the approximately 1,250 ft downstream from Ashton Hill Road, and about 600 ft below the confluence of Warren Run. The upstream limit is approximately 1,000 ft upstream from Ashton Hill Road. This stream reach is approximately 0.4 mi long.



Base map from U.S. Geological Survey 7.5-min Quadrangle Caldwell North variously scaled

Figure 1–D1. Location of the West Fork Duck Creek study reaches for the Villages of Ava and Coal Ridge, Ohio.



Base map from U.S. Geological Survey 7.5-min Quadrangle Macksburg variously scaled

Figure 1–D2. Location of the West Fork Duck Creek study reach for the Village of South Olive, Ohio.

1–E. East Fork Duck Creek near the Village of East Union

East Fork Duck Creek flows generally south through the northern part of Noble County (fig. 1–E1). The downstream limit of the reach studied is approximately 50 ft downstream from State Route 78 and just above the confluence of West Fork Duck Creek. The upstream limit is approximately 1,169 ft upstream of State Route 78. This stream reach is approximately 0.2 mi long.

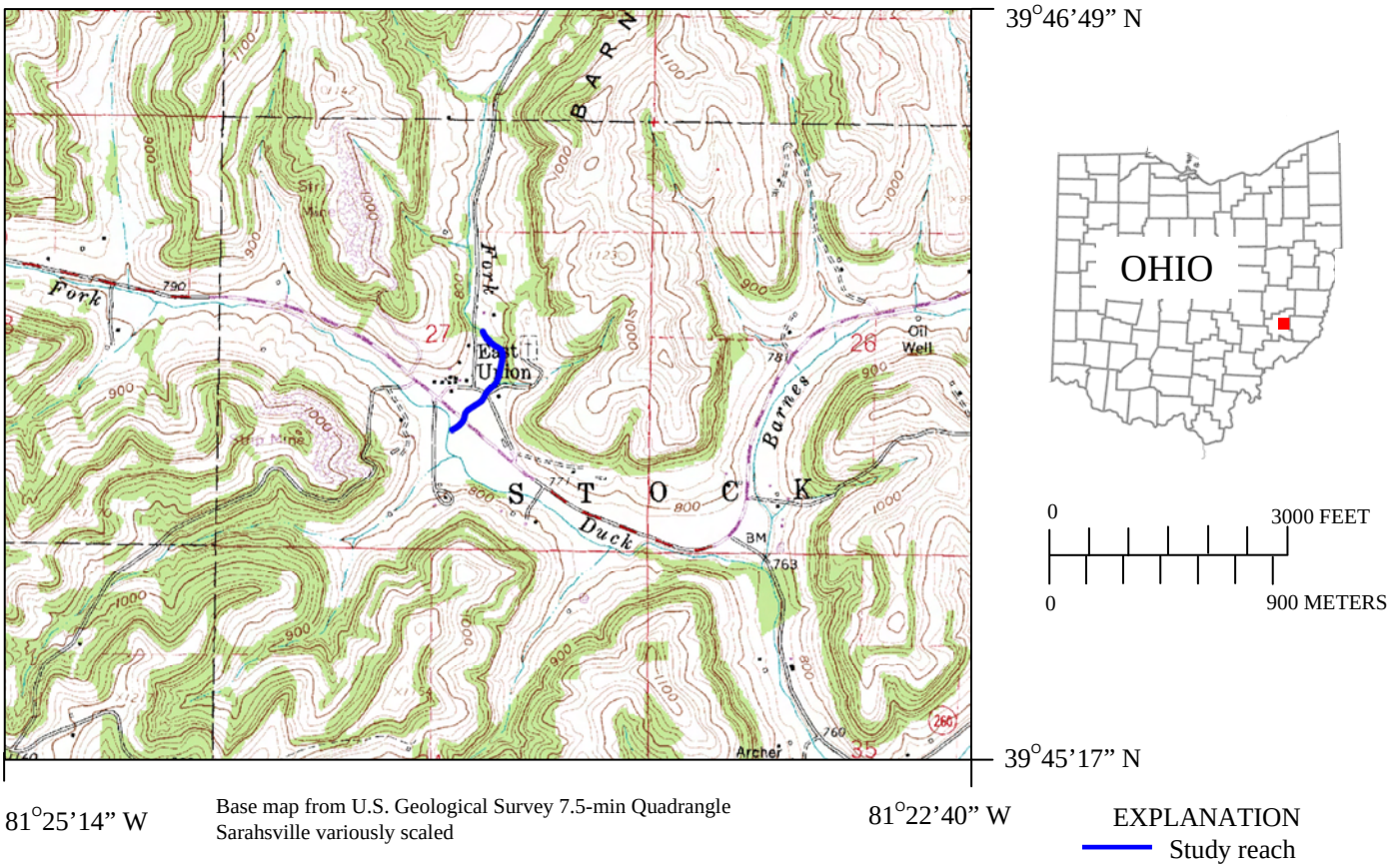
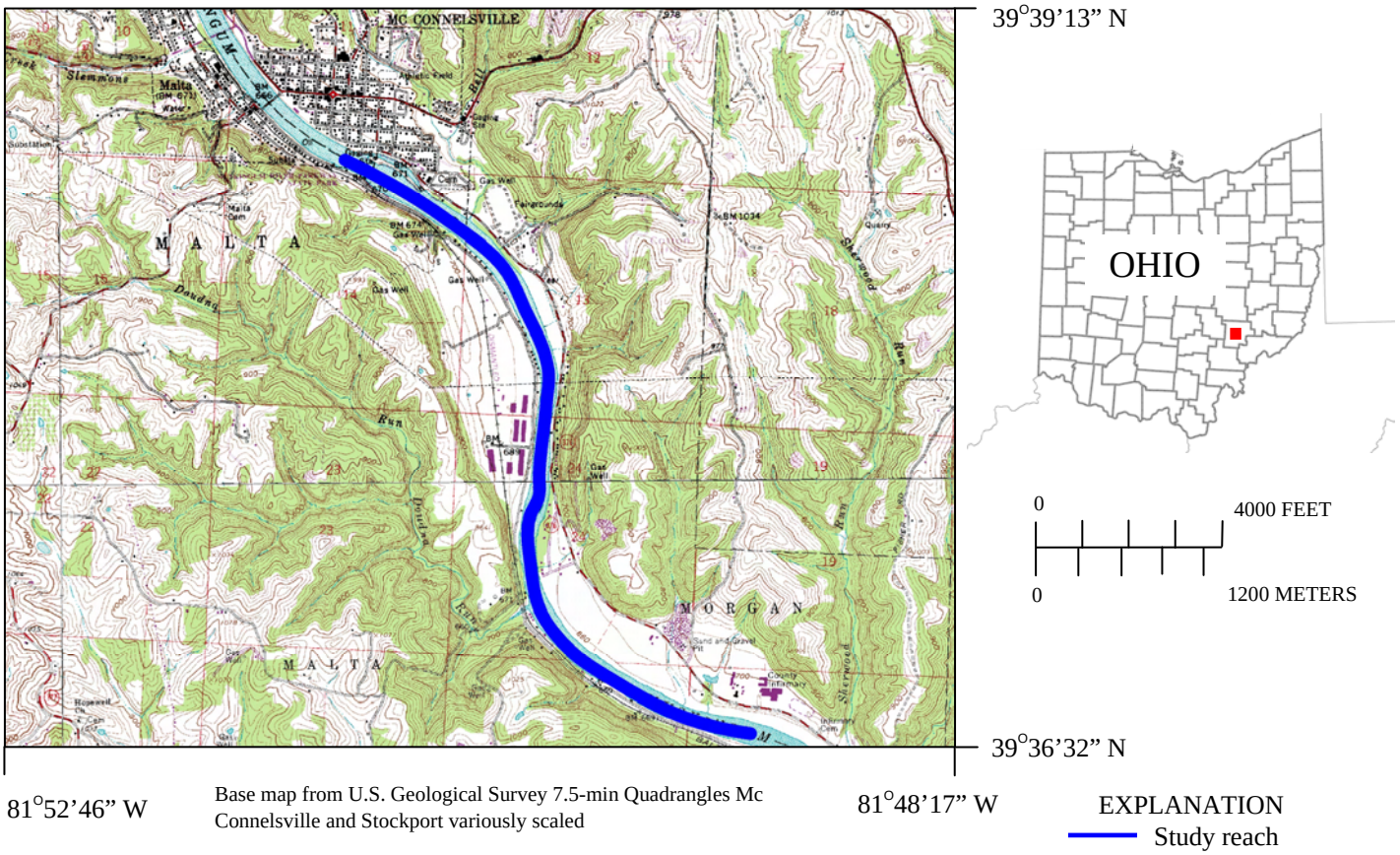


Figure 1–E1. Location of the East Fork Duck Creek study reach for the Village of East Union, Ohio.

1–F. Muskingum River near the City of McConnelsville

The Muskingum River flows generally south in the eastern part of Ohio. The reach studied is a section near the City of McConnelsville (fig. 1–F1). The downstream limit of the reach studied is cross section 44.710 (approximately 4.72 mi below the dam at McConnelsville) from the December 16, 2004, Village of McConnelsville, Morgan County, FIS. The upstream limit is approximately cross section 49.19 (approximately 0.25 mi below the dam at McConnelsville). This stream reach is approximately 4.5 mi long.



Base map from U.S. Geological Survey 7.5-min Quadrangles Mc Connelsville and Stockport variously scaled

Figure 1–F1. Location of the Muskingum River study reach for the City of McConnelsville, Ohio.

Engineering Analyses

Hydrologic Analyses

The USGS conducted an FIS for the Ohio EMA in 10 communities in southeastern Ohio. Selected flood profiles were determined for areas where they were needed to complete a cost-benefit analysis within the communities of Pleasant City, Derwent, Kimbolton, Ava, Coal Ridge, South Olive, East Union, Birmingham, Quaker City, and McConnelsville. Some communities already had detailed estimates and profiles from previous FISs for the 100-year-recurrence-interval flood. Some communities only had approximate estimates of the flood profiles. If existing detailed estimates of the profiles were available, they were used for the cost-benefit analysis. Any missing profiles were computed and added to the existing profiles to ensure an estimate for the 10-, 50-, 100-, and 500-year-recurrence-interval peak flood profiles was available. Discharges, reported in cubic feet per second (ft^3/s), were determined at various locations along each stream for this study. The paragraphs following describe the hydrologic analyses conducted for each stream.

If peak flood estimates were needed for any of the 10-, 50-, 100-, and 500-year peak discharges, they were initially determined using a Web-based program, StreamStats, a method described in Water-Resources Investigations Report 06–5312 (Koltun and others, 2006). Specific revisions to the estimates are discussed individually below. To compute peak-discharge estimates using StreamStats, drainage area in square miles (mi^2), main-channel slope in feet per mile (ft/mi), and percentage of the basin classified as water or wetlands are required. These basin characteristics were determined using a geographic information system (GIS), applying methods described in Koltun and others (2006). The percentage of the basin classified as water or wetlands, for this discussion, is defined as the percentage of the drainage area designated as wetlands or open water in the 1992 National Land Cover dataset (U.S. Geological Survey, 2000) compared to the total drainage area of the basin. The explanatory variables used in the regression equations, as well as the resulting flood-peak discharges, are presented in table 1–2.

1–A. Wills Creek and Buffalo Creek near the Villages of Pleasant City, Derwent, and Kimbolton

Peak flows for the most upstream reach on Wills Creek near the Village of Pleasant City were determined using the method described in Koltun and others (2006). Buffalo Fork (head of Wills Creek) and Buffalo Creek join to form Wills Creek on the west side of the Village of Pleasant City. There is a short study reach on Buffalo Creek just above the confluence of Buffalo Fork and Buffalo Creek. All peak flow estimates are presented in table 1–2.

Peak flows for the reach of Wills Creek near the Village of Derwent are affected by operations of Senecaville Lake. Therefore, direct use of the method described in Koltun and others (2006) is not appropriate. StreamStats does not account for regulated flow. Wills Creek below the confluence with Seneca Fork is regulated due to the presence of Senecaville Lake on Seneca Fork. Flood-frequency estimates for the reach of Wills Creek near the Village of Derwent were computed by (1) computing flood frequency estimates for Wills Creek above Seneca Fork, (2) summing flood-frequency estimates provided by the U.S. Army Corps of Engineers (USACE) for Senecaville Lake, and (3) summing flood-

frequency estimates for the intervening drainage between a point just downstream from Senecaville Lake and the mouth of Seneca Fork. Flood-frequency estimates for the intervening drainage were determined by estimating unregulated peak flows just below Senecaville Lake and at the mouth of Seneca Fork and computing the difference. Other than those provided by the USACE, flood-frequency estimates were determined by StreamStats.

Peak flows for the reach of Wills Creek near the Village of Kimbolton are considered regulated by operations at the Senecaville Reservoir by the USACE and Salt Creek Reservoir by the Ohio Department of Natural Resources (ODNR). Estimates of flow were provided for this reach by the USACE at Cambridge and at Salt Fork Reservoir. Simply combining the flood peak estimates from the two sources (Cambridge and Salt Fork) and not including the intervening drainage area yielded significantly higher flow estimates than estimates from StreamStats. Routing the flood flows through this system of reservoirs is beyond the scope of this project. Therefore, the flood peak estimates from StreamStats were used in this study. The peak flow estimates computed by StreamStats at the Main Street bridge on the north side of the Village of Kimbolton are presented in table 1–2.

The area around the Village of Kimbolton is affected by backwater from the operation of Wills Creek Reservoir approximately 36 mi downstream. It was determined through cooperative agreement with the Ohio EMA to use the StreamStats values of flow for this reach even though they should be slightly higher than the actual flow estimates.

1–B. Leatherwood Creek near the Village of Quaker City

Peak-discharge estimates for the downstream model limit were obtained from a previously published FIS (Guernsey County, Ohio and Incorporated Areas, February, 17, 1989, Quaker City # 390853). The location of interest for which previously estimates were available was Leatherwood Creek upstream from confluence of Smith Creek (drainage area of 21.70 mi^2). The reported values for the 10-, 50-, 100-, and 500-year peak flood discharges at this location were 3,252 ft^3/s, 5,194 ft^3/s, 6,060 ft^3/s, and 7,909 ft^3/s, respectively. Peak flood estimates above an un-named tributary were determined using a drainage area reduction calculation. The results of the hydrologic analyses are listed in table 1–2.

1–C. Clear Fork near the Village of Birmingham

The peak-flow estimates for this reach were developed with StreamStats. The peak flow estimates are listed in table 1–2.

1–D. West Fork Duck Creek near the Villages of Ava, Coal Ridge, and South Olive

The peak-flow estimates for all three reaches were developed with StreamStats. The peak flow estimates are listed in table 1–2.

1–E. East Fork Duck Creek near the Village of East Union

The peak-flow estimates for this reach were developed with StreamStats. The peak flow estimates are listed in table 1–2.

1–F. Muskingum River near the City of McConnelsville

A peak-discharge estimate of 77,700 ft^3/s for the 100-year flood profile was published in the December 16, 2004, Village of McConnelsville, Morgan County FIS. However, after requesting and obtaining a paper copy of the Muskingum River hydraulic model from FEMA archives, it was determined that a peak discharge of 78,800 ft^3/s had been used for the reach to be re-studied in this 2007 effort. No peak discharges were available (FIS or hydraulic model) for the 10-, 50-, or 500-year profiles.

Because the Muskingum River is regulated, the USGS contacted the USACE to obtain estimates for the 10-, 50-, and 500-year peak discharges. The USACE provided peak-discharge estimates at the Malta Lock and Dam of 47,500 ft^3/s, 65,500 ft^3/s, 77,700 ft^3/s, and 115,100 ft^3/s for the 10-, 50-, 100-, and 500-year events, respectively. After discussing the difference between the published 100-year peak-discharge estimate of 77,700 ft^3/s and the modeled 100-year peak-discharge estimate of 78,800 ft^3/s with the USACE, the USACE indicated it would be appropriate to increase all the provided peak-discharge estimates by 1.416 percent to match the previous profile. The provided peak-discharge estimates were increased by 1.416 percent and rounded to the appropriate number of significant figures. The results of the hydrologic analyses are listed in table 1–2.

Table 1–2. Summary of the explanatory-variable values used in the regression equations and the resulting 10-, 50-, 100-, and 500-year flood-peak discharge estimates.

Location description	Drainage area (square miles)	Main-channel slope (feet per mile)	Water or wetlands area (percent)	Peak discharge for indicated recurrence interval (cubic feet per second)			
				10-year	50-year	100-year	500-year
Wills Creek and Buffalo Creek							
Near the Village of Pleasant City							
Buffalo Creek at mouth[1]	50	8.28	0.12	3,930	5,740	6,540	8,410
Below confluence of Buffalo Creek and Buffalo Fork	121	8.15	1.54	6,260	8,880	10,000	12,700
Near the Village of Derwent							
Above Seneca Fork	124	6.39	1.55	6,080	8,560	9,620	12,100
Senecaville Lake outlet[2]	NA			650	800	900	1,210
Seneca Fork below Senecaville Lake	118	6.94	5.48	4,690	6,430	7,170	8,890
Seneca Fork at mouth	150	3.29	4.5	5,100	6,860	7,600	9,330
Below Seneca Fork[3]	NA			7,140	9,790	10,950	13,750
Near the Village of Kimbolton							
At Main Street[4]	666	1.43	2.71	14,900	19,700	21,700	26,400
Leatherwood Creek near the Village of Quaker City							
Above Smith Creek	21.7	NA		3,250	5,190	6,060	7,910
Above unnamed tributary	17.8	NA		2,660	4,250	4,960	6,470
Clear Fork near the Village of Birmingham							
At Birmingham Road	6.9	53.6	0.14	1,210	1,880	2,180	2,880
West Fork Duck Creek							
Near the Village of Ava							
Above Coal Run	4.09	70.6	0.093	881	1,400	1,630	2,180
Above Johnny Woods River	14.6	42.0	0.57	1,920	2,950	3,410	4,490
Below Johnny Woods River	18.4	42.0	0.52	2,310	3,540	4,090	5,390
Near the Village of Coal Ridge							
0.4 mile below Moore Street (County Road 11)	20.9	28.8	0.47	2,390	3,630	4,180	5,460
Near the Village of South Olive							
0.25 mile below Ashton Hill Road	74.7	7.24	1.02	4,450	6,380	7,230	9,130
East Fork Duck Creek near the Village of East Union							
Above West Fork Creek	7.7	41.9	0.1	1,290	2,010	2,330	3,090
Muskingum River near the City of McConnelsville							
At McConnelsville[2]	NA			48,200	66,500	78,800	116,800

[1] Buffalo Creek and Buffalo Fork merge to form Wills Creek on the west side of the Village of Pleasant City.
[2] Discharge estimates provided by the U.S. Army Corps of Engineers, Huntington District.
[3] Values determined by summing the values from above Seneca Fork, Senecaville Lake Outlet, and the difference between Seneca Fork below Senecaville Lake and Seneca Fork at mouth.
[4] Values determined from StreamStats.

HYDRAULIC ANALYSES

HEC-RAS (version 3.1.1), with the HEC-2 conveyance computations option, was used to model flood profiles for all streams analyzed in this study effort. After the initial hydraulic models calculations were completed, warnings presented by the HEC-RAS model were reviewed. The results were assessed for validity, accuracy, and appropriate engineering practices. Some of the areas of concern included (1) critical water-surface calculations, (2) water-surface elevation differences between adjacent cross sections, and (3) correct usage of ineffective flow areas. After the initial areas of concern were addressed, the HEC-RAS models were recalculated. All remaining warnings generated by HEC-RAS were reviewed and judged acceptable for the final models presented in this study. Table 1–3 lists the models used and the model analysis date for each stream submitted in this project.

Table 1–3. Summary of the hydraulic model version and analysis date for each of the studied stream reaches.

Flooding source	Hydraulic model version	Model analysis date
Wills Creek and Buffalo Creek near the Village of Pleasant City	HEC-RAS 3.1.1	12/14/2006
Wills Creek near the Village of Derwent	HEC-RAS 3.1.1	12/8/2006
Wills Creek near the Village of Kimbolton	HEC-RAS 3.1.1	1/17/2007
Leatherwood Creek near the Village of Quaker City	HEC-RAS 3.1.1	11/13/2006
Clear Fork near the Village of Birmingham	HEC-RAS 3.1.1	11/14/2006
West Fork Duck Creek near the Village of Ava	HEC-RAS 3.1.1	5/9/2007
West Fork Duck Creek near the Village of Coal Ridge	HEC-RAS 3.1.1	5/10/2007
West Fork Duck Creek near the Village of South Olive	HEC-RAS 3.1.1	5/4/2007
East Fork Duck Creek near the Village of East Union	HEC-RAS 3.1.1	5/11/2007
Muskingum River near the City of McConnelsville	HEC-RAS 3.1.1	5/22/2007

Special Hydraulic Considerations

Solution Check at Bridges

During high-flow conditions, it is possible for pressure flow to occur at a bridge or culvert. Pressure flow occurs when the water surface on the upstream side of a bridge equals or exceeds the low-chord elevation. The validity of this type of solution was checked at all bridges where the water-surface elevation derived from the energy equation was found to be within 1.0 ft of the low-chord elevation of a bridge.

The standard-step method (energy equation) is applicable to the widest range of hydraulic problems (U.S. Army Corps of Engineers, 2002a). However, if flow conditions are such that the bridge opening may act like a pressurized orifice (flow comes in contact with the low chord), pressure-flow computations are warranted.

Submergence Check at Culverts

During high-flow conditions, it is also possible for road overflow to occur. Road overflow may result in weir flow if; there is sufficient drop in channel/overbank elevation on the downstream side of the structure and the structure is not submerged. Submergence is determined as a function of the ratio of

the downstream flow depth to the upstream energy grade line, as measured from the minimum high chord of the deck (U.S. Army Corps of Engineers, 2002b). The HEC-RAS model uses a default maximum submergence ratio of 0.95 for weir-flow calculations. The HEC-RAS Applications Guide states, “When this ratio is exceeded for a bridge analysis, the program will switch from the weir-flow equation to the energy method to determine the upstream flow depth. For a culvert analysis, this ratio is not used because the program cannot perform a backwater analysis through a culvert flowing full. Therefore, a weir analysis will always be used when overflow occurs.” As a result, when road overflow occurs at a culvert and a weir-flow computation is determined to be invalid, other modeling techniques must be used to account for an energy-based solution. For situations in which road grades do not act like weirs, Shearman and others (1986) recommend abandoning culvert and weir hydraulics in favor of composite sections (the combination of the road and culvert cross-section geometries) to reflect pseudo-open-channel conditions.

Surveys Conducted by the USGS

The USGS conducted both Global Positioning System (GPS) and conventional surveys for this study. The GPS surveys were conducted to establish a control network at pertinent locations along each of the streams studied. Conventional surveys were conducted to obtain stream and hydraulic-structure geometry. Third-order accuracy (horizontal and vertical) was maintained for all conventional survey data collected (Federal Geodetic Control Committee, 1984).

Unless otherwise noted, the horizontal datum for the survey is the North American Datum of 1983 (NAD83), Ohio State Plane (Ohio North or Ohio South) coordinates. The vertical datum for the survey is the North American Vertical Datum of 1988 (NAVD 88).

GPS surveys were conducted by the USGS using both Real-Time Kinematic (RTK) and static surveying techniques. Control for the USGS survey was established using a majority of National Geodetic Survey (NGS) monuments with known horizontal and/or vertical coordinates. A comparison of the published coordinates and surveyed coordinates is shown in each section for each stream. The bench marks used for each area network are listed in each section.

1–A. Wills Creek and Buffalo Creek Near the Villages of Pleasant City, Derwent, and Kimbolton

Work Conducted by the USGS

Cross sections surveyed in the field and synthetic cross sections derived from a digital 20-foot contour map developed from the USGS 1:24,000-scale topographic quadrangle maps Byesville and Kimbolton were used to establish the 10-, 50-, 100-, and 500-year flood profiles by use of HEC-RAS.

Scope of Work

The downstream limit of the Wills Creek reach studied near the Village of Pleasant City is approximately 2,412 ft downstream from the confluence of Buffalo Fork and Buffalo Creek. The upstream limit is Buffalo Creek approximately 3,141 ft above its mouth. The total length of streams modeled is about 5,553 ft. The downstream limit of the Wills Creek reach studied near the Village of Derwent is just downstream from the first railroad bridge downstream and north of the Village of Derwent. The upstream limit is 135 ft upstream of State Route 313. This stream reach is approximately 1.85 mi long. The downstream limit of the reach studied near the Village of Kimbolton is approximately 500 ft below the Main Street bridge on the north side of the Village of Kimbolton. The upstream limit is State Route 541. This stream reach is approximately 0.9 mi long.

Hydraulic Baseline

Stationing used for the hydraulic baseline for the stream reach near the Village of Pleasant City is referenced to feet above the downstream limit (approximately 2,412 ft downstream from the confluence of Buffalo Fork and Buffalo Creek). Stationing used for the hydraulic baseline for the stream reach near the Village of Derwent is referenced to a point 340 ft downstream from the Conrail railroad bridge. Stationing used for the hydraulic baseline for the stream reach near the Village of Kimbolton is referenced to 483 ft below Main Street on the north side of the Village of Kimbolton.

Cross-Section and Contracted-Opening-Geometry Data Surveyed in the Field

The USGS surveyed 31 cross sections, including 16 open-channel sections and 4 hydraulic structures. All surveys were referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29) and the North American Datum of 1983 (NAD 83).

Synthetic Cross-Sectional-Geometry Data

A total of 54 synthetic or partially synthetic cross sections at desired locations along the stream reach were generated from a Triangulated Irregular Network (TIN) developed from the USGS 7.5-minute quadrangle maps Byesville and Kimbolton. In-channel data for the synthetic cross sections were estimated by interpolation from cross-sectional data surveyed in the field.

Starting Water-Surface Elevation

The starting water-surface elevation at the initial section for each profile for the reach near the Village of Pleasant City was obtained by means of a slope-conveyance calculation. A slope of 0.00061 ft/ft was calculated from the river stations and minimum channel elevations for the cross sections at station 4,852 and station 1,382. These cross sections were obtained from field surveys and were assumed to provide a representative slope for the channel. Based on the calculated slope, starting water-surface elevations of 800.62, 801.48, 801.81, and 802.59 ft were determined at the initial section for the 10-, 50-, 100-, and 500-year profiles, respectively. The starting water-surface elevation at the initial section for each profile for the reach near the Village of Derwent was obtained by means of a slope-conveyance calculation. A slope of 0.00008 ft/ft was calculated from the river stations and minimum channel elevations at stations 263 and 9,704. Based on the calculated slope, starting water-surface elevations of 802.47, 802.92, 803.19, and 803.79 ft were determined at the initial section for the 10-, 50-, 100-, and 500-year profiles. The starting water-surface elevation at the initial section for each profile for the reach near the Village of Kimbolton was obtained by the slope-conveyance calculation. A slope of 0.00011223 ft/ft was calculated by dividing the contour interval (20 ft) by the distance between the contours (33.7 mi) on a historical USGS 15-minute topographic map Newcomerstown, 1912. No contours crossed the stream on current 7.5-minute topographic maps because of backwater caused by the Wills Creek Lake Dam. The historical maps were used to determine the slope of the channel before the construction of Wills Creek Reservoir.

Manning's Roughness Coefficients

Manning's roughness coefficients (*n*) for the main channel and overbank areas were determined from field observation by experienced personnel. Estimates of Manning's roughness coefficients were determined to be from 0.035 to 0.090 for the main channel and from 0.050 to 0.090 for the overbank areas.

Flow Lengths

Main-channel and overbank flow lengths were computed with HEC-GeoRAS. Flow paths are drawn in the GIS by the user for both the main channel and overbanks. HEC-GeoRAS computes all flow lengths on the basis of the flow paths drawn.

Hydraulic-Structure Solution Reviews

For this study, all hydraulic-structure computations were reviewed for the appropriate modeling solutions (see “Special Hydraulic Considerations” section of “Hydraulic Analyses”). Initial reviews focused on the type of solution computed at each structure (based on energy equation or on pressure and/or weir-flow equations). Table 1–A1 lists the river station, a location description, the type of structure, the presence of road overflow, and the solution type of all structures affecting the 10-, 50-, 100-, and 500-year flood profiles for Wills Creek.

Buffalo Creek and Wills Creek were modeled as one stream. Peak flows on the Wills Creek part of the model reflect the combined flows from Buffalo Creek and Buffalo Fork. Cross section 2,412 is at the confluence of Buffalo Creek and Buffalo Fork, which form Wills Creek. Above cross section 2,412, the peak flows reflect only drainage from Buffalo Creek.

Table 1–A1. Summary of hydraulic-structure solutions for the 10-, 50-, 100-, and 500-year profiles of Wills Creek near the Villages of Pleasant City, Derwent, and Kimbolton.

River station (feet)	Location description	Structure type	Recurrence interval (years)	Presence of road overflow	Solution type
Wills Creek near the Village of Pleasant City					
2,897	Main Street	Bridge	10	Y	Pressure
2,897	Main Street	Bridge	50	Y	Pressure
2,897	Main Street	Bridge	100	Y	Pressure
2,897	Main Street	Bridge	500	Y	Pressure
Wills Creek near the Village of Derwent					
362	Conrail	Bridge	10	N	Energy
362	Conrail	Bridge	50	Y	Energy
362	Conrail	Bridge	100	Y	Energy
362	Conrail	Bridge	500	Y	Energy
9,843	State Route 313	Bridge	10	Y	Energy
9,843	State Route 313	Bridge	50	Y	Energy
9,843	State Route 313	Bridge	100	Y	Energy
9,843	State Route 313	Bridge	500	Y	Energy
Wills Creek near the Village of Kimbolton					
483	Main Street	Bridge	10	Y	Energy
483	Main Street	Bridge	50	Y	Energy
483	Main Street	Bridge	100	Y	Energy
483	Main Street	Bridge	500	Y	Energy

Backwater Elevation

The two study reaches at the Villages of Pleasant City and Derwent are not affected by backwater. Wills Creek near the Village of Kimbolton could be affected by backwater from the operations of Wills Creek Dam 36 mi downstream. If water flows over the emergency spillway at the Wills Creek Dam, parts of the Village of Kimbolton will be submerged. The emergency spillway elevation is 779 ft. A stage-frequency calculation was determined on the basis of daily lake levels provided by the USACE. Data from 1952 to 2006 were used as well as three pool-elevation estimates for three major events prior to and during construction of the Wills Creek Dam. The events were in January 1913, August 1935, and March 1937. The backwater elevations for the 10-, 50-, 100-, and 500-year stage are 774.10, 782.70, 785.90, and 792.60 ft respectively.

Base-Mapping Information

The base maps used for these study reaches were digitized from copies of the USGS Byesville and Kimbolton topographic quadrangle maps.

Surveys Conducted by the USGS

A GPS survey was conducted by the USGS using Real-Time Kinematic (RTK) techniques and static surveying techniques. Control for the USGS survey was established by use of three NGS control monuments with known elevation and one USGS monument with known elevation and location. A comparison of the published elevations and surveyed elevations is given in table 1–A2. The bench mark descriptions also are included below.

Table 1–A2. Comparison of published coordinates to USGS-surveyed coordinates and bench marks used in the study of Wills Creek near the Villages of Pleasant City, Derwent, and Kimbolton.
[All data shown in feet, NAD 83 and NGVD 29; shaded boxes indicate control points; NA, not available]

Reference mark number	Bench mark name	Published easting	Published northing	Published elevation	Surveyed easting	Surveyed northing	Surveyed elevation	Delta easting	Delta northing	Delta elevation
National Geodetic Survey (NGS) monuments										
1	MURPHY	2259141.652	686997.363	1210.717[a]	2259141.652	686997.363	1210.717	0.00	0.00	0.00
2	G 186	NA	NA	783.981	NA[b]	NA[b]	783.951	NA	NA	0.03
3	N 186	NA	NA	788.791	2227604.842	785933.028	788.791	NA	NA	0.00
U.S. Geological Survey (USGS) monument										
4	ODOT 809.576	2223919.077[3]	713989.657[c]	809.576	2223919.007	713989.578	809.567	0.070	0.090	0.009

[a] Elevation published in NAVD 88 and converted to NGVD 29 with Corpscon Version 6.0.1 (U.S. Army Corps of Engineers, 2008).
[b] Northing and easting were not surveyed; elevation only.
[c] Bench mark reset by Ohio Department of Transportation.

Bench Mark Descriptions

RM1

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1       NATIONAL GEODETIC SURVEY,   RETRIEVAL DATE = JULY 27, 2006
 JX2102 ***********************************************************************
 JX2102  DESIGNATION -  MURPHY
 JX2102  PID        -  JX2102
 JX2102  STATE/COUNTY-  OH/NOBLE
 JX2102  USGS QUAD   -  SENECAVILLE (1994)
 JX2102
 JX2102                     *CURRENT SURVEY CONTROL
 JX2102  ______________________________________________________________________
 JX2102* NAD 83(1995)-  39 52 53.83834(N)    081 27 51.60250(W)    ADJUSTED
 JX2102* NAVD 88     -      368.85   (+/-2CM)    1210.1    (FEET)  VERTCON
 JX2102  ______________________________________________________________________
 JX2102  LAPLACE CORR-          0.67  (SECONDS)                  DEFLEC99
 JX2102  GEOID HEIGHT-        -33.98  (METERS)                   GEOID03
 JX2102
 JX2102  HORZ ORDER  -  FIRST
 JX2102  VERT ORDER  -  THIRD ? (SEE BELOW)
 JX2102
 JX2102.THE HORIZONTAL COORDINATES WERE ESTABLISHED BY CLASSICAL GEODETIC METHODS
 JX2102.AND ADJUSTED BY THE NATIONAL GEODETIC SURVEY IN APRIL 1998.
 JX2102
 JX2102.THE NAVD 88 HEIGHT WAS COMPUTED BY APPLYING THE VERTCON SHIFT VALUE TO
 JX2102.THE NGVD 29 HEIGHT (DISPLAYED UNDER SUPERSEDED SURVEY CONTROL.)
 JX2102.THE VERTICAL ORDER PERTAINS TO THE NGVD 29 SUPERSEDED VALUE.
 JX2102
 JX2102.THE LAPLACE CORRECTION WAS COMPUTED FROM DEFLEC99 DERIVED DEFLECTIONS.
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JX2102
JX2102.THE GEOID HEIGHT WAS DETERMINED BY GEOID03.
JX2102
JX2102;                 NORTH        EAST    UNITS SCALE FACTOR CONVERG.
JX2102;SPC OH S    -   209,397.215   688,587.753   MT  0.99997351   +0 39 25.7
JX2102;UTM  17     - 4,414,721.687   460,296.150   MT  0.99961941   -0 17 51.9
JX2102
JX2102!           -  ELEV FACTOR  X  SCALE FACTOR =   COMBINED FACTOR
JX2102!SPC OH S    -   0.99994747  X   0.99997351  =   0.99992098
JX2102!UTM  17     -   0.99994747  X   0.99961941  =   0.99956690
JX2102
JX2102:             PRIMARY AZIMUTH MARK                  GRID AZ
JX2102:SPC OH S    -  MURPHY AZ MK                          139 05 46.9
JX2102:UTM  17     -  MURPHY AZ MK                          140 03 04.5
JX2102
JX2102|-------------------------------------------------------------------|
JX2102| PID    REFERENCE OBJECT                  DISTANCE     GEOD. AZ  |
JX2102|                                                      DDDMMSS .S |
JX2102| CD1991 MURPHY AZ MK                                    1394512.6 |
JX2102| CD1992 MURPHY RM 1                      46.692 METERS 23449     |
JX2102| CD1993 MURPHY RM 2                      22.890 METERS 33201     |
JX2102|-------------------------------------------------------------------|
JX2102
JX2102                      SUPERSEDED SURVEY CONTROL
JX2102
JX2102  NAD 83(1986)-  39 52 53.84636(N)    081 27 51.61049(W) AD(      ) 1
JX2102  NAD 27     -  39 52 53.58500(N)    081 27 52.17500(W) AD(      ) 1
JX2102  NGVD 29 (07/19/86)  369.04   (M)        1210.8    (F) LEVELING    3
JX2102
JX2102.SUPERSEDED VALUES ARE NOT RECOMMENDED FOR SURVEY CONTROL.
JX2102.NGS NO LONGER ADJUSTS PROJECTS TO THE NAD 27 OR NGVD 29 DATUMS.
JX2102.SEE FILE DSDATA.TXT TO DETERMINE HOW THE SUPERSEDED DATA WERE DERIVED.
JX2102
JX2102_U.S. NATIONAL GRID SPATIAL ADDRESS: 17SME6029614722(NAD 83)
JX2102_MARKER: DS = TRIANGULATION STATION DISK
JX2102_SETTING: 0 = UNSPECIFIED SETTING
JX2102
JX2102  HISTORY    - DATE    CONDITION       REPORT BY
JX2102  HISTORY    - 1944    MONUMENTED      CGS
JX2102  HISTORY    - 1958    GOOD            CGS
JX2102  HISTORY    - 1962    GOOD            LOCENG
JX2102
JX2102                      STATION DESCRIPTION
JX2102
JX2102'DESCRIBED BY COAST AND GEODETIC SURVEY 1944 (FN)
JX2102'STATION IS LOCATED
JX2102'ABOUT 5 MILES (AIR
JX2102'LINE) DUE N OF THE VILLAGE OF SARAHSVILLE.  THE
JX2102'MARK IS SITUATED ON THE HIGHEST POINT
JX2102'OF A BARE HILL, IN A PASTURE
JX2102'FIELD, AND ON LAND OWNED BY S.S. MURPHY WHO LIVES N OF
JX2102'THE
JX2102'STATION.  IT IS 14 FEET E OF A SMALL OIL STORAGE TANK.  THE DISK
JX2102'IS STAMPED MURPHY
JX2102'1944.
JX2102'
JX2102'SURFACE, UNDERGROUND, REFERENCE, AND AZIMUTH MARKS ARE BRONZE
JX2102'DISKS SET IN
JX2102'CONCRETE.
JX2102'
JX2102'REFERENCE MARK 1 IS 153.19 FEET SW OF THE STATION AND 1 FOOT
JX2102'E OF A N-S
JX2102'FENCELINE.  IT IS STAMPED MURPHY NO 1 1944.
JX2102'
JX2102'REFERENCE MARK 2 IS 75.10 FEET NW OF THE STATION.  IT IS
JX2102'STAMPED MURPHY NO
JX2102'2 1944.
JX2102'
JX2102'AZIMUTH MARK IS 30 FEET E OF THE APPROXIMATE CENTER LINE OF
JX2102'GRAVELED ROAD, 4
JX2102'FEET N OF A WOODEN WITNESS POST, AND 1 FOOT W
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JX2102'OF THE E RIGHT-OF-WAY FENCELINE.
JX2102'IT IS STAMPED MURPHY 1944.
JX2102'
JX2102'TO REACH THE STATION FROM THE JUNCTION OF STATE HIGHWAYS 146
JX2102'AND 285 IN THE N
JX2102'EDGE OF THE VILLAGE OF SARSHSVILLE, GO N ON
JX2102'HIGHWAY 285 FOR 5.4 MILES TO THE
JX2102'AZIMUTH MARK ON THE RIGHT.  CONTINUE
JX2102'AHEAD FOR 0.6 MILE TO A RED PAINTED BOARD GATE ON
JX2102'THE LEFT.
JX2102'TURN LEFT AND GO 0.1 MILE TO THE TOP OF THE HILL AND STATION.
JX2102'
JX2102'HEIGHT OF LIGHT ABOVE STATION MARK - 30 METERS.
JX2102
JX2102                      STATION RECOVERY (1958)
JX2102
JX2102'RECOVERY NOTE BY COAST AND GEODETIC SURVEY 1958 (HBW)
JX2102'THE STATION, AZIMUTH MARK AND REFERENCE MARK NO. 1 WERE RECOVERED IN
JX2102'GOOD CONDITION.
JX2102'REFERENCE MARK NO. 2 WAS NOT SEARCHED FOR.
JX2102'
JX2102'THE STATION AND AZIMUTH MARK ARE NOT INTER-VISIBLE FROM POINTS FIVE
JX2102'FEET ABOVE EACH DISK DURING
JX2102'THE SUMMER MONTHS DUE TO GROWTH OF BRUSH AND TREES.
JX2102'
JX2102'A LIGHT PLACED TEN FEET ABOVE STATION ROBBINS IS VISIBLE THE YEAR
JX2102'AROUND FROM A POINT
JX2102'FIVE FEET ABOVE STATION MURPHY.
JX2102
JX2102                      STATION RECOVERY (1962)
JX2102
JX2102'RECOVERY NOTE BY LOCAL ENGINEER (INDIVIDUAL OR FIRM) 1962 (JEG)
JX2102'ALL MARKS FOUND IN GOOD CONDITION.
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RM2

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1       NATIONAL GEODETIC SURVEY,   RETRIEVAL DATE = JULY 11, 2006
KY1527 ***********************************************************************
KY1527  DESIGNATION -  G 186
KY1527  PID        -  KY1527
KY1527  STATE/COUNTY-  OH/GUERNSEY
KY1527  USGS QUAD   -  KIMBOLTON (1994)
KY1527
KY1527                    *CURRENT SURVEY CONTROL
KY1527  ______________________________________________________________________
KY1527* NAD 83(1986)-  40 08 32.    (N)   081 33 41.    (W)    SCALED
KY1527* NAVD 88    -      238.743  (METERS)    783.28   (FEET)  ADJUSTED
KY1527  ______________________________________________________________________
KY1527  GEOID HEIGHT-        -33.72  (METERS)                  GEOID03
KY1527  DYNAMIC HT  -        238.615 (METERS)    782.86  (FEET)  COMP
KY1527  MODELED GRAV-    980,084.0   (MGAL)                    NAVD 88
KY1527
KY1527  VERT ORDER  -  FIRST    CLASS II
KY1527
KY1527.THE HORIZONTAL COORDINATES WERE SCALED FROM A TOPOGRAPHIC MAP AND HAVE
KY1527.AN ESTIMATED ACCURACY OF +/- 6 SECONDS.
KY1527
KY1527.THE ORTHOMETRIC HEIGHT WAS DETERMINED BY DIFFERENTIAL LEVELING
KY1527.AND ADJUSTED BY THE NATIONAL GEODETIC SURVEY IN JUNE 1991.
KY1527
KY1527.THE GEOID HEIGHT WAS DETERMINED BY GEOID03.
KY1527
KY1527.THE DYNAMIC HEIGHT IS COMPUTED BY DIVIDING THE NAVD 88
KY1527.GEOPOTENTIAL NUMBER BY THE NORMAL GRAVITY VALUE COMPUTED ON THE
KY1527.GEODETIC REFERENCE SYSTEM OF 1980 (GRS 80) ELLIPSOID AT 45
KY1527.DEGREES LATITUDE (G = 980.6199 GALS.).
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KY1527
KY1527.THE MODELED GRAVITY WAS INTERPOLATED FROM OBSERVED GRAVITY VALUES.
KY1527;                 NORTH        EAST    UNITS  ESTIMATED ACCURACY
KY1527;SPC OH S     -   238,240.     679,990.     MT  (+/- 180 METERS SCALED)
KY1527
KY1527                      SUPERSEDED SURVEY CONTROL
KY1527
KY1527  NGVD 29 (??/??/92)  238.958  (M)        783.98   (F) ADJ UNCH    1 2
KY1527
KY1527.SUPERSEDED VALUES ARE NOT RECOMMENDED FOR SURVEY CONTROL.
KY1527.NGS NO LONGER ADJUSTS PROJECTS TO THE NAD 27 OR NGVD 29 DATUMS.
KY1527.SEE FILE DSDATA.TXT TO DETERMINE HOW THE SUPERSEDED DATA WERE DERIVED.
KY1527
KY1527_U.S. NATIONAL GRID SPATIAL ADDRESS: 17TME521436(NAD 83)
KY1527_MARKER: DB = BENCH MARK DISK
KY1527_SETTING: 7 = SET IN TOP OF CONCRETE MONUMENT
KY1527_SP_SET: SET IN TOP OF CONCRETE MONUMENT
KY1527_STAMPING: G 186 1954
KY1527_STABILITY: C = MAY HOLD, BUT OF TYPE COMMONLY SUBJECT TO
KY1527+STABILITY: SURFACE MOTION
KY1527
KY1527  HISTORY    - DATE    CONDITION       REPORT BY
KY1527  HISTORY    - 1954    MONUMENTED      CGS
KY1527
KY1527                      STATION DESCRIPTION
KY1527'DESCRIBED BY COAST AND GEODETIC SURVEY 1954
KY1527'10 MI N FROM CAMBRIDGE.
KY1527'10.05 MILES NORTH ALONG THE PENNSYLVANIA RAILROAD FROM THE
KY1527'BALTIMORE AND OHIO RAILROAD STATION AT CAMBRIDGE, ABOUT 10.9
KY1527'MILES SOUTH OF THE STATION AT NEWCOMERSTOWN, TUSCARAWAS COUNTY,
KY1527'ABOUT 1.05 MILES SOUTHEAST OF THE MAIN NORTH-SOUTH STREET CROSSING
KY1527'AT KIMBOLTON, 21 1/2 FEET WEST OF WEST RAIL, 429 FEET SOUTH
KY1527'AND ACROSS TRACK FROM MILE POST 68, 223 FEET NORTH OF THE NORTHEAST
KY1527'CORNER OF A PROMINENT VERY WELL KEPT CEMETERY, 9 FEET SOUTH
KY1527'OF CENTER OF A GATE IN FENCE, 26 FEET WEST-SOUTHWEST OF CENTER
KY1527'OF A DIM FARM ROAD CROSSING, 1 FOOT EAST OF A FENCE LINE, 2 FEET
KY1527'NORTH OF A WHITE WOODEN WITNESS POST, ABOUT 2 1/2 FEET BELOW
KY1527'LEVEL OF TRACK AND SET IN THE TOP OF A CONCRETE POST PROJECTING
KY1527'INCHES
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RM3

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1       NATIONAL GEODETIC SURVEY,   RETRIEVAL DATE = JULY 11, 2006
KY1528 ***********************************************************************
KY1528  DESIGNATION -  N 186
KY1528  PID        -  KY1528
KY1528  STATE/COUNTY-  OH/GUERNSEY
KY1528  USGS QUAD   -  KIMBOLTON (1994)
KY1528
KY1528                    *CURRENT SURVEY CONTROL
KY1528  ______________________________________________________________________
KY1528* NAD 83(1986)-  40 09 15.    (N)    081 34 24.    (W)    SCALED
KY1528* NAVD 88    -      240.210  (METERS)    788.09   (FEET)  ADJUSTED
KY1528  ______________________________________________________________________
KY1528  GEOID HEIGHT-        -33.70  (METERS)                 GEOID03
KY1528  DYNAMIC HT  -        240.082 (METERS)    787.67  (FEET)  COMP
KY1528  MODELED GRAV-    980,084.0   (MGAL)                   NAVD 88
KY1528
KY1528  VERT ORDER  -  FIRST    CLASS II
KY1528
KY1528.THE HORIZONTAL COORDINATES WERE SCALED FROM A TOPOGRAPHIC MAP AND HAVE
KY1528.AN ESTIMATED ACCURACY OF +/- 6 SECONDS.
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KY1528
KY1528.THE ORTHOMETRIC HEIGHT WAS DETERMINED BY DIFFERENTIAL LEVELING
KY1528.AND ADJUSTED BY THE NATIONAL GEODETIC SURVEY IN JUNE 1991.
KY1528
KY1528.THE GEOID HEIGHT WAS DETERMINED BY GEOID03.
KY1528
KY1528.THE DYNAMIC HEIGHT IS COMPUTED BY DIVIDING THE NAVD 88
KY1528.GEOPOTENTIAL NUMBER BY THE NORMAL GRAVITY VALUE COMPUTED ON THE
KY1528.GEODETIC REFERENCE SYSTEM OF 1980 (GRS 80) ELLIPSOID AT 45
KY1528.DEGREES LATITUDE (G = 980.6199 GALS.).
KY1528
KY1528.THE MODELED GRAVITY WAS INTERPOLATED FROM OBSERVED GRAVITY VALUES.
KY1528
KY1528;                 NORTH        EAST    UNITS  ESTIMATED ACCURACY
KY1528;SPC OH S     -   239,560.     678,950.     MT  (+/- 180 METERS SCALED)
KY1528
KY1528                      SUPERSEDED SURVEY CONTROL
KY1528
KY1528  NGVD 29 (??/??/92)  240.424  (M)        788.79   (F) ADJ UNCH    1 2
KY1528
KY1528.SUPERSEDED VALUES ARE NOT RECOMMENDED FOR SURVEY CONTROL.
KY1528.NGS NO LONGER ADJUSTS PROJECTS TO THE NAD 27 OR NGVD 29 DATUMS.
KY1528.SEE FILE DSDATA.TXT TO DETERMINE HOW THE SUPERSEDED DATA WERE DERIVED.
KY1528
KY1528_U.S. NATIONAL GRID SPATIAL ADDRESS: 17TME511450(NAD 83)
KY1528_MARKER: DB = BENCH MARK DISK
KY1528_SETTING: 7 = SET IN TOP OF CONCRETE MONUMENT
KY1528_SP_SET: SET IN TOP OF CONCRETE MONUMENT
KY1528_STAMPING: N 186 1954
KY1528_STABILITY: C = MAY HOLD, BUT OF TYPE COMMONLY SUBJECT TO
KY1528+STABILITY: SURFACE MOTION
KY1528
KY1528  HISTORY     - DATE     CONDITION       REPORT BY
KY1528  HISTORY     - 1954     MONUMENTED      CGS
KY1528
KY1528                      STATION DESCRIPTION
KY1528
KY1528'DESCRIBED BY COAST AND GEODETIC SURVEY 1954
KY1528'9.8 MI S FROM NEWCOMERSTOWN.
KY1528'9.8 MILES SOUTH ALONG THE PENNSYLVANIA RAILROAD FROM THE STATION
KY1528'AT NEWCOMERSTOWN, AT KIMBOLTON, ABOUT 0.2 MILE NORTHWEST OF
KY1528'CROSSING OF STATE HIGHWAY 271, AT THE MAIN NORTH-SOUTH STREET
KY1528'CROSSING, 31 FEET SOUTH OF SOUTH RAIL OF MAIN TRACK, 240 FEET
KY1528'WEST OF CENTER OF CROSSING OF MAIN NORTH-SOUTH STREET, 196 FEET
KY1528'SOUTHEAST AND ACROSS TRACKS FROM MILE POST 69, 30 FEET
KY1528'NORTH-NORTHWEST OF NORTHEAST CORNER OF TILE FOUNDATION OF PORCH
KY1528'OF A WHITE FRAME HOUSE, 29 FEET SOUTHWEST OF A SWITCH STAND FOR
KY1528'A SIDING TO THE WEST, 5 1/2 FEET NORTHEAST OF A TELEPHONE POLE,
KY1528'17 FEET WEST-SOUTHWEST OF SOUTHWEST CORNER OF GRILL COVERED
KY1528'CATCH BASIN, 2 FEET NORTHEAST OF A WHITE WOODEN WITNESS POST,
KY1528'ABOUT 1 FOOT BELOW LEVEL OF TRACK AND SET IN THE TOP OF A
KY1528'CONCRETE POST PROJECTING 3 INCHES.
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RM4

ODOT 809.576
Claysville, 0.8 mi E. of, along State Highway 313, thence 4.2 mi NE. along State Highway 660; in sec. 18, T. 1 N., R. 3 W.; 215 ft SW. of, and level with centerline of junction of Highway 660 and Jackson Township Road 44; 11 ft S. of, and 3 ft higher than centerline of hwy.; in parapet at SW. end of concrete culvert; standard tablet stamped "142 WSM 1959 812"

NOTE: The structure and bench mark was replaced by ODOT. The new bench mark is stamped "ODOT 809.576"

Northing (SPOHS, NAD 83) = 2223919.077 ft	Elevation (NGVD 29) = 809.576 ft
Easting (SPOHS, NAD 83) = 713989.657 ft	Elevation (NAVD 88) = 808.897 ft

Flood Profiles

The flood profiles for Wills Creek and Buffalo Creek near the Village of Pleasant City for the 10-, 50-, 100-, and 500-year-recurrence-interval floods are presented in figure 1–A3. The flood profiles for Wills Creek near the Villages of Derwent and Kimbolton for the 10-, 50-, 100-, and 500-year-recurrence-interval floods are presented in figures 1–A4 and 1–A5, respectively. The locations of the cross sections for Wills Creek and Buffalo Creek near the Villages of Pleasant City, Derwent, and Kimbolton are presented in figures 1–A6, 1–A7, and 1–A8, respectively.

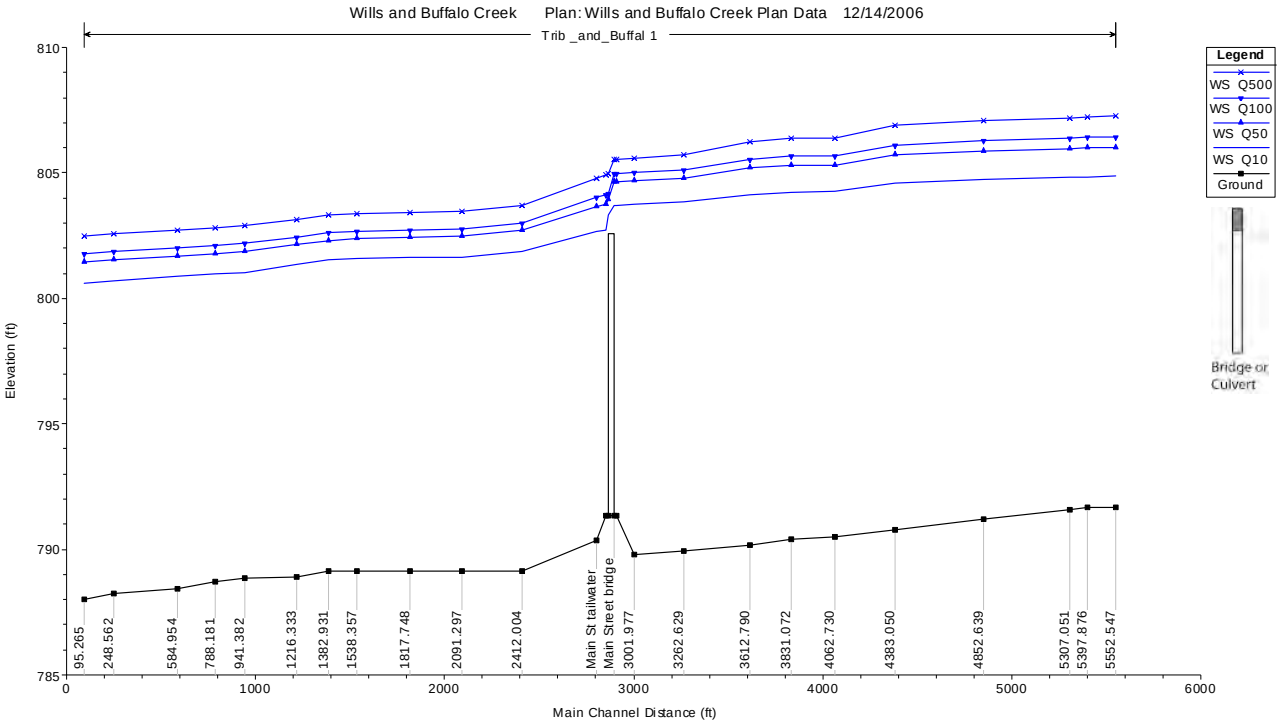

Figure 1–A3. Flood profiles for Wills Creek and Buffalo Creek near the Village of Pleasant City for the 10-, 50-, 100-, and 500-year-recurrence-interval floods.

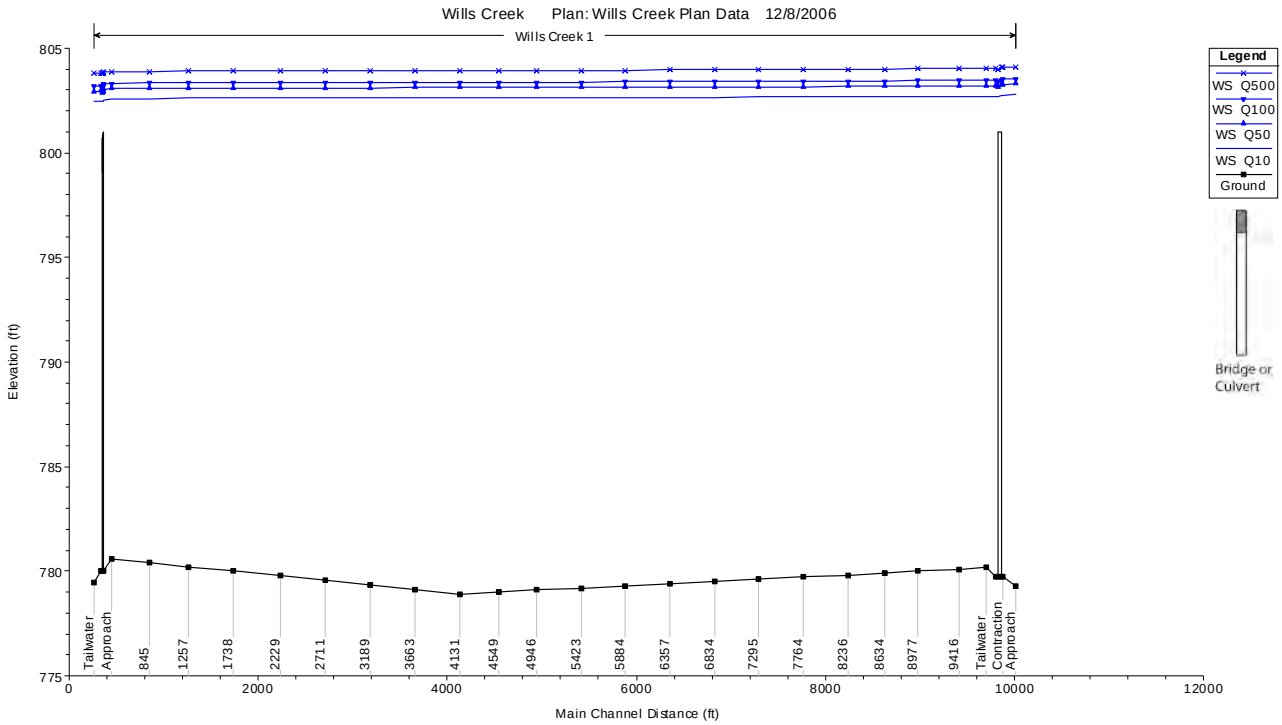

Figure 1–A4. Flood profiles for Wills Creek near the Village of Derwent for the 10-, 50-, 100-, and 500-year-recurrence-interval floods.

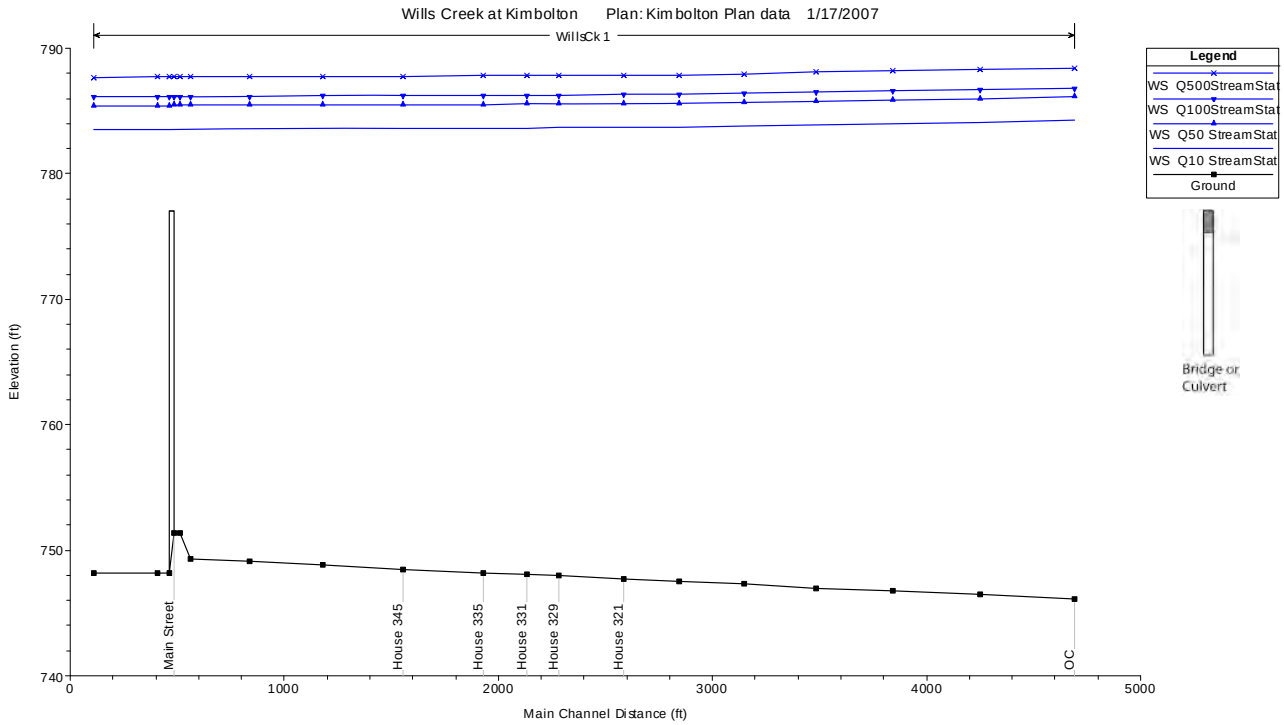

Figure 1–A5. Flood profiles for Wills Creek near the Village of Kimbolton for the 10-, 50-, 100-, and 500-year-recurrence-interval floods.

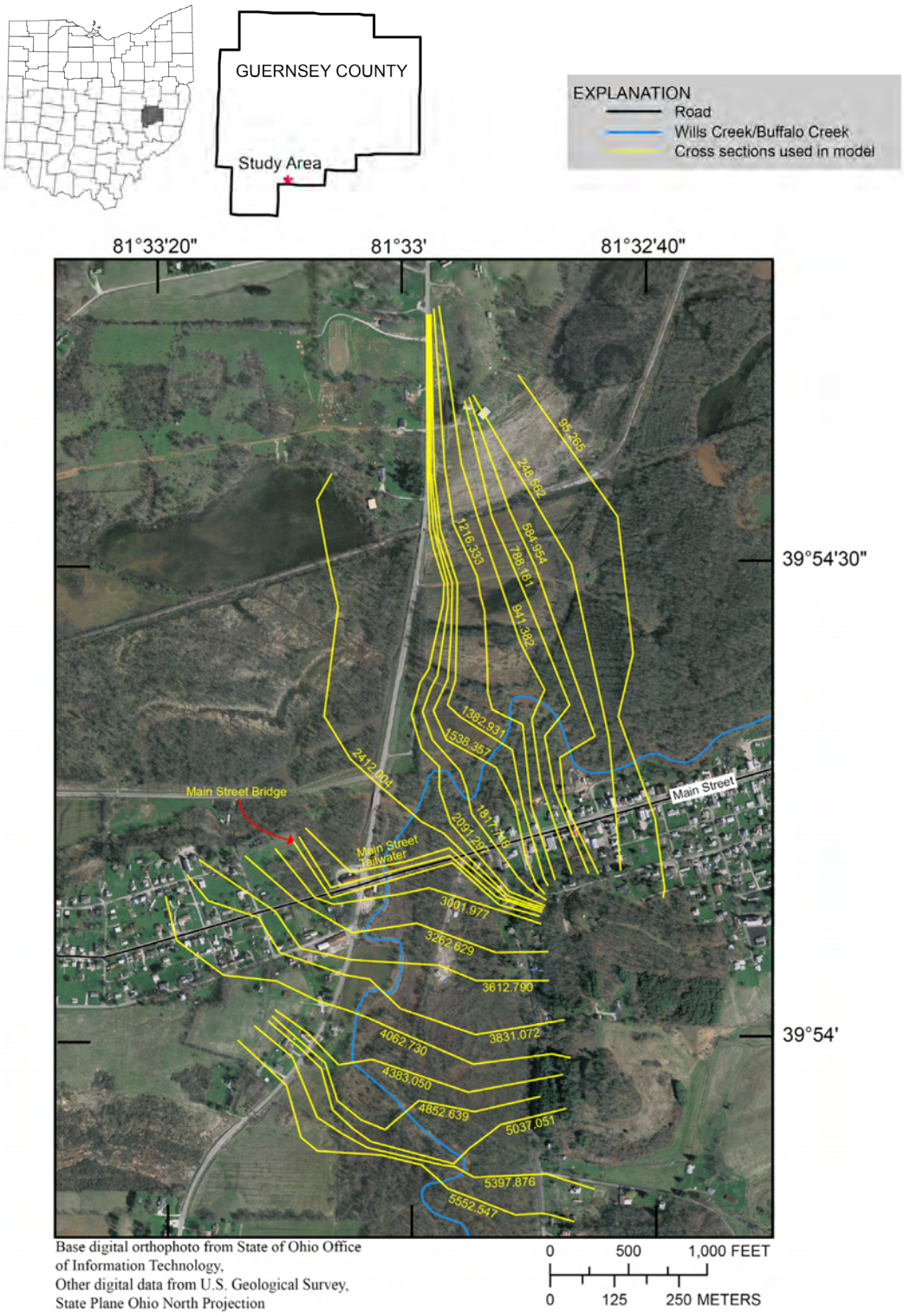

Figure 1–A6. Cross-section locations for flood profiles on Buffalo and Wills Creek near the Village of Pleasant City, Ohio.

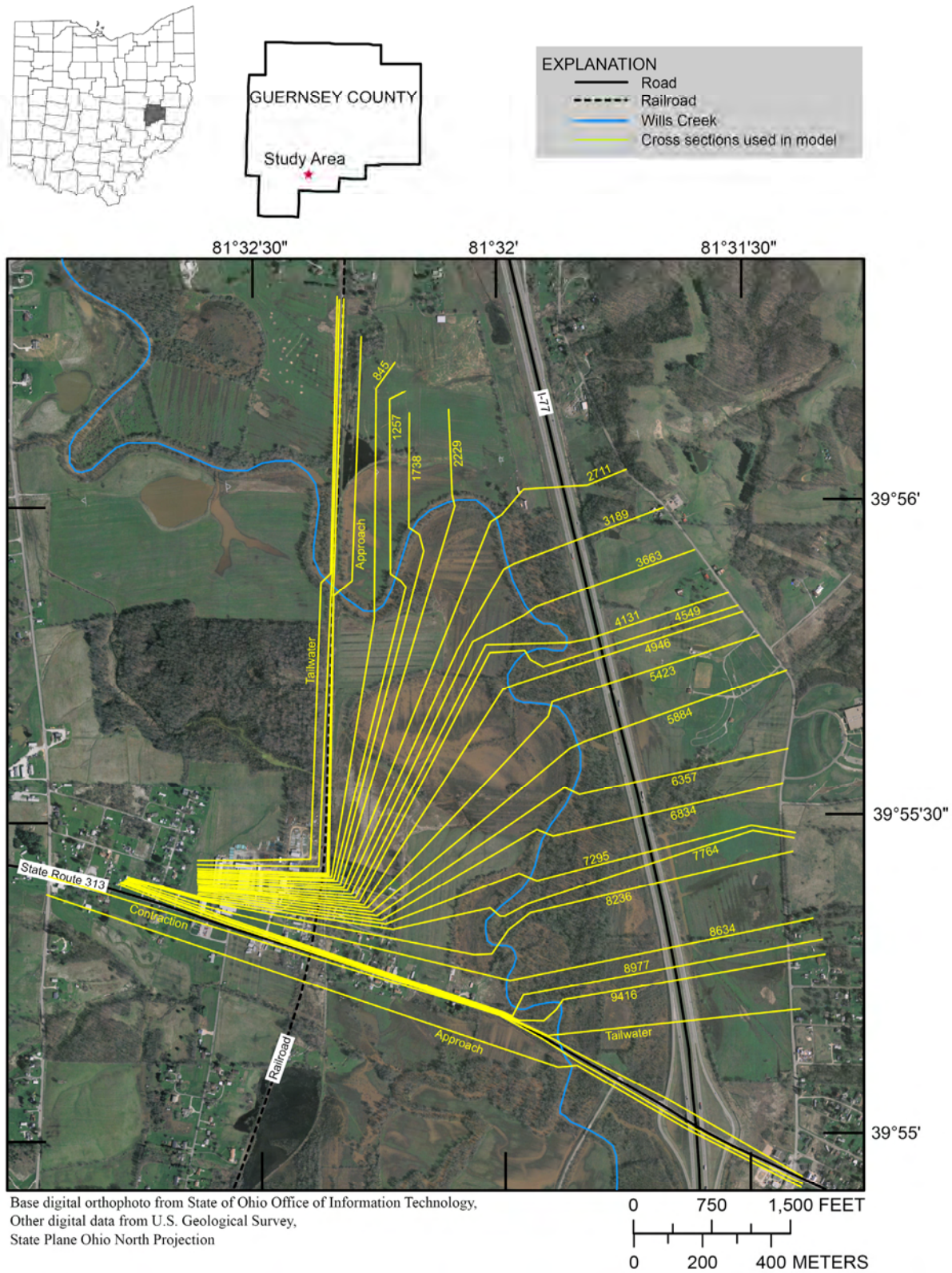

Figure 1–A7. Cross-section locations for flood profiles on Wills Creek near the Village of Derwent, Ohio.

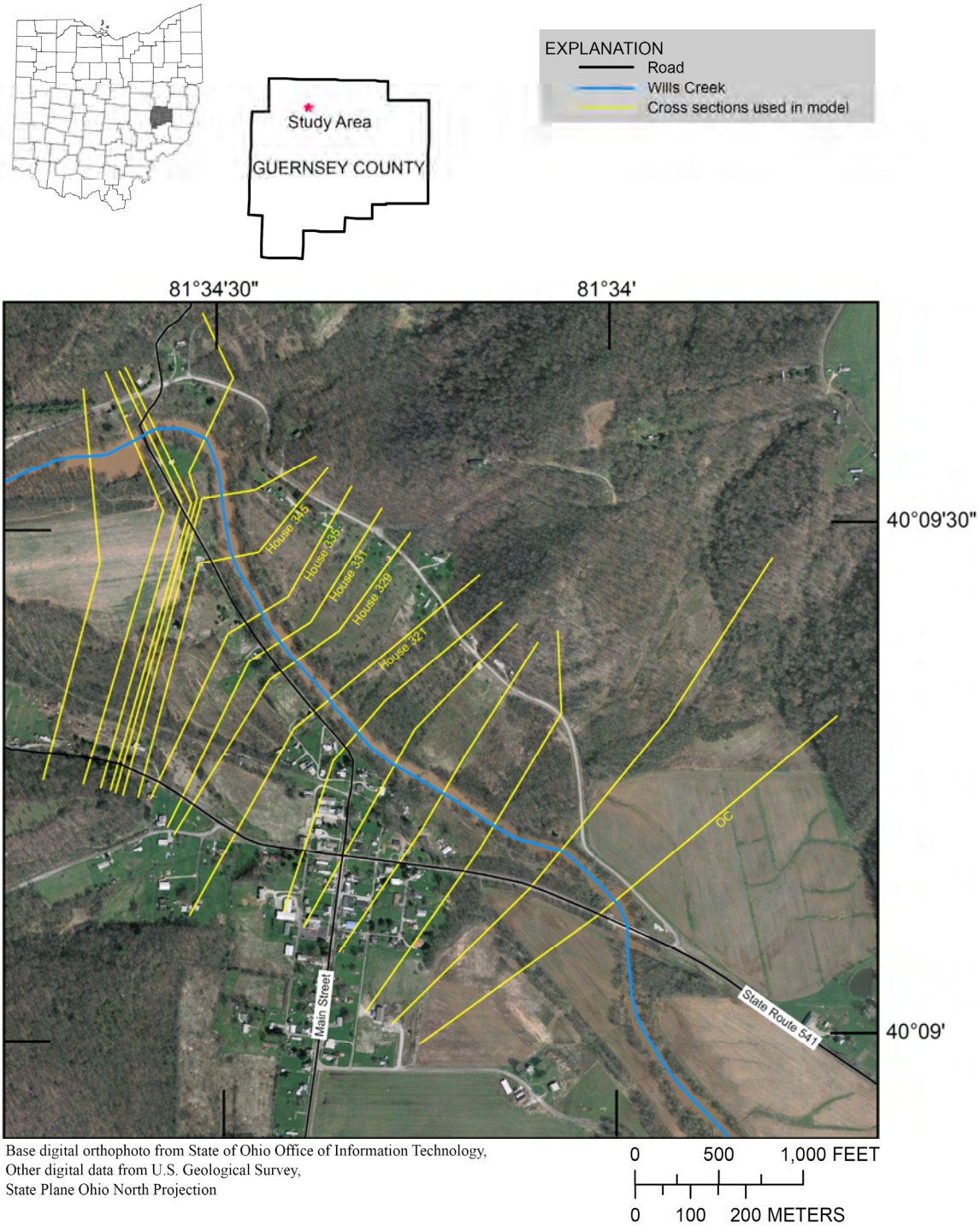

Figure 1–A8. Cross-section locations for flood profiles on Wills Creek near the Village of Kimbolton, Ohio.

1–B. Leatherwood Creek Near the Village of Quaker City

Work Conducted by the USGS

Cross sections surveyed in the field and synthetic cross sections derived from a digital 20-ft contour map developed from the USGS 1:24,000-scale topographic quadrangle map Quaker City were used to establish the 10-, 50-, 100-, and 500-year flood profiles by use of HEC-RAS.

Scope of Work

The downstream limit of the reach studied is the approximately 145 ft east of the eastern corporate boundary of the Village of Quaker City. This location is approximately the same as the uppermost cross section from the Leatherwood Creek model in the 1989 FIS. The upstream limit is approximately 35 ft upstream from Eldon Road. This stream reach is approximately 1.0 mi long.

Hydraulic Baseline

Stationing used for the hydraulic baseline for this stream was referenced to miles above the mouth in the previous 1989 FIS. The stationing was converted to feet above the mouth for this study.

Cross-Section and Contracted-Opening-Geometry Data Surveyed in the Field

The USGS surveyed six cross sections, including two open-channel sections and one hydraulic structure. All surveys were referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29) and the North American Datum of 1983 (NAD 83).

Synthetic Cross-Sectional-Geometry Data

A total of 12 synthetic or partially synthetic cross sections at desired locations along the stream reach were generated from a TIN developed from the USGS 7.5-minute quadrangle map Quaker City. In-channel data for the synthetic cross sections were estimated by interpolation from cross-sectional data surveyed in the field.

Starting Water-Surface Elevation

The starting water-surface elevation at the initial section for each profile was obtained from the upper-limit cross section of the 1989 FIS. Starting water-surface elevations of 874.80, 878.40, 879.8, and 882.00 ft were used at the initial section for the 10-, 50-, 100-, and 500-year flood profiles, respectively.

Manning's Roughness Coefficients

Manning's roughness coefficients (*n*) for the main channel and overbank areas were determined from field observation by experienced personnel. Estimates of Manning's roughness coefficients range from 0.040 to 0.046 for the main channel and from 0.036 to 0.058 for the overbank areas.

Flow Lengths

Main-channel and overbank flow lengths were computed with HEC-GeoRAS. Flow paths are drawn in the GIS by the user for both the main channel and overbanks. HEC-GeoRAS computes all flow lengths on the basis of the flow paths drawn.

Hydraulic-Structure Solution Reviews

For this study, all hydraulic-structure computations were reviewed for the appropriate modeling solutions (see “Special Hydraulic Considerations” section of “Hydraulic Analyses”). Initial reviews focused on the type of solution computed at the structure (based on energy equation or on pressure and/or weir-flow equations). Table 1–B1 lists the river station, a location description, the type of structure, the presence of road overflow, and the solution type of all structures affecting the 10-, 50-, 100-, and 500-year flood profiles for Leatherwood Creek.

Table 1–B1. Summary of hydraulic-structure solutions for the 10-, 50-, 100-, and 500-year profiles of Leatherwood Creek near the Village of Quaker City.

River station (feet)	Location description	Structure type	Recurrence interval (years)	Presence of road overflow	Solution type
125,347	Eldon Road	Bridge	10	Y	Energy
125,347	Eldon Road	Bridge	50	Y	Energy
125,347	Eldon Road	Bridge	100	Y	Energy
125,347	Eldon Road	Bridge	500	Y	Energy

Backwater Elevation

Leatherwood Creek should not be subject to backwater.

Base-Mapping Information

The base map used for this study was a digitized copy of the USGS Quaker City topographic quadrangle map.

Surveys Conducted by the USGS

A GPS survey was conducted by the USGS using Real-Time Kinematic (RTK) techniques and static surveying techniques. Control for the USGS survey was established by use of one U.S. Coast and Geodetic Survey (USC&GS) monument with known elevation and one NGS monument with known elevation. A comparison of the published elevations and surveyed elevations is given in table 1–B2. The bench mark descriptions also are included below.

Table 1–B2. Comparison of published coordinates to USGS-surveyed coordinates and bench marks used in the study of Leatherwood Creek near the Village of Quaker City.
[All data shown in feet, NAD 83 and NGVD 29; shaded boxes indicate control ponits; NA, not available]

Reference mark number	Bench mark name	Published easting	Published northing	Published elevation	Surveyed easting	Surveyed northing	Surveyed elevation	Delta easting	Delta northing	Delta elevation
U.S. Coast & Geodetic Survey (USC&GS) monument										
1	63 JEA 1959	NA	NA	902.132	2313491.392	717805.809	902.132	NA	NA	0.000
National Geodetic Survey (NGS) monument										
2	N64 Reset	NA	NA	856.90[a]	NA[b]	NA[b]	856.974	NA	NA	-0.074

[a] Elevation published in NAVD 88 and converted to NGVD 29 with Corpscon Version 6.0.1 (U.S. Army Corps of Engineers, 2008).
[b] Northing and easting were not surveyed; elevation only.

Bench Mark Descriptions

RM1

63 JEA 1959
Quaker City, 1.9 mi. E. of, along State Highway 265; at Spencera Station; in NW. ¼ sec. 7, T. 9 N., R. 7 W.; 250 ft N. of intersection of Highway 265 and County Road 177; 25 ft E. of centerline of county rd.; at concrete walk at dairy barn; in NE. corner of walk; standard tablet stamped “63 JEA 1959 902”

Elevation (NGVD 29) = 902.132 ft

RM2

```
1       NATIONAL GEODETIC SURVEY,   RETRIEVAL DATE = JULY 11, 2006
 KY1437 ***********************************************************************
 KY1437  DESIGNATION -  N 64 RESET
 KY1437  PID        -  KY1437
 KY1437  STATE/COUNTY-  OH/GUERNSEY
 KY1437  USGS QUAD   -  ANTRIM (1994)
 KY1437
 KY1437                    *CURRENT SURVEY CONTROL
 KY1437  ___________________________________________________________________
 KY1437* NAD 83(1986)-  40 02 47.    (N)   081 21 30.    (W)    SCALED
 KY1437* NAVD 88     -      260.96  (+/-2CM)    856.2   (FEET)  VERTCON
 KY1437  ___________________________________________________________________
 KY1437  GEOID HEIGHT-        -33.88  (METERS)                GEOID03
 KY1437
 KY1437  VERT ORDER  -  THIRD (SEE BELOW)
 KY1437
 KY1437.THE HORIZONTAL COORDINATES WERE SCALED FROM A TOPOGRAPHIC MAP AND HAVE
 KY1437.AN ESTIMATED ACCURACY OF +/- 6 SECONDS.
 KY1437
 KY1437.THE NAVD 88 HEIGHT WAS COMPUTED BY APPLYING THE VERTCON SHIFT VALUE TO
 KY1437.THE NGVD 29 HEIGHT (DISPLAYED UNDER SUPERSEDED SURVEY CONTROL.)
 KY1437.THE VERTICAL ORDER PERTAINS TO THE NGVD 29 SUPERSEDED VALUE.
 KY1437
 KY1437.THE GEOID HEIGHT WAS DETERMINED BY GEOID03.
 KY1437
 KY1437;                 NORTH        EAST    UNITS  ESTIMATED ACCURACY
 KY1437;SPC OH S     -   227,800.     697,420.     MT  (+/- 180 METERS SCALED)
 KY1437
 KY1437                      SUPERSEDED SURVEY CONTROL
```

```
KY1437
KY1437  NGVD 29 (10/13/05)  261.17   (M)        856.9    (F) RESET      3
KY1437
KY1437.SUPERSEDED VALUES ARE NOT RECOMMENDED FOR SURVEY CONTROL.
KY1437.NGS NO LONGER ADJUSTS PROJECTS TO THE NAD 27 OR NGVD 29 DATUMS.
KY1437.SEE FILE DSDATA.TXT TO DETERMINE HOW THE SUPERSEDED DATA WERE DERIVED.
KY1437
KY1437_U.S. NATIONAL GRID SPATIAL ADDRESS: 17TME694329(NAD 83)
KY1437_MARKER: DD = SURVEY DISK
KY1437_SETTING: 36 = SET IN A MASSIVE STRUCTURE
KY1437_SP_SET: PIER
KY1437_STAMPING: N 64 RESET 1963
KY1437_MARK LOGO: OHDT
KY1437_STABILITY: B = PROBABLY HOLD POSITION/ELEVATION WELL
KY1437
KY1437  HISTORY    - DATE    CONDITION       REPORT BY
KY1437  HISTORY    - 1963    MONUMENTED      OHDT
KY1437  HISTORY    - 1966    GOOD            CGS
KY1437
KY1437                     STATION DESCRIPTION
KY1437
KY1437'DESCRIBED BY COAST AND GEODETIC SURVEY 1966
KY1437'1.4 MI W FROM MIDDLEBOURNE.
KY1437'ABOUT 1.4 MILES WEST ALONG U.S. HIGHWAY 40 FROM THE METHODIST
KY1437'CHURCH AT MIDDLEBOURNE, NEAR THE MARIANNA VALLEY SCHOOL, SET IN
KY1437'THE WEST FACE OF THE WEST COLUMN OF THE CENTER PIER OF STRUCTURE
KY1437'OVER INTERSTATE HIGHWAY 70, 13 FEET WEST OF THE CENTER LINE OF
KY1437'COUNTY ROAD 301, AT CENTER LINE STATION 289+61 ON INTERSTATE
KY1437'HIGHWAY 70, ABOUT 4 FEET ABOVE THE GROUND.
```

Flood Profiles

The flood profiles for the Leatherwood Creek near the Village of Quaker City for the 10-, 50-, 100-, and 500-year-recurrence-interval floods are presented in figure 1–B2. The locations of the cross sections for Leatherwood Creek near the Village of Quaker City are presented in figure 1–B3.

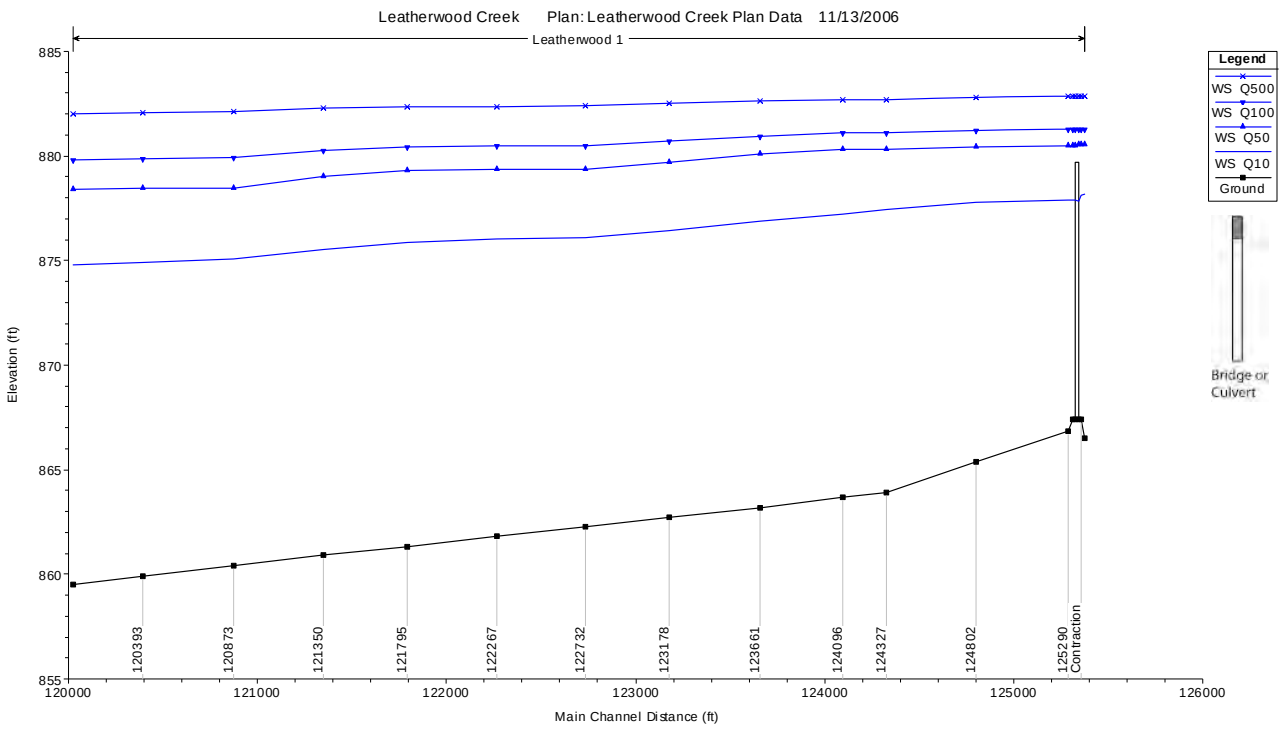

Figure 1–B2. Flood profiles for Leatherwood Creek near the Village of Quaker City for the 10-, 50-, 100-, and 500-year-recurrence-interval floods.

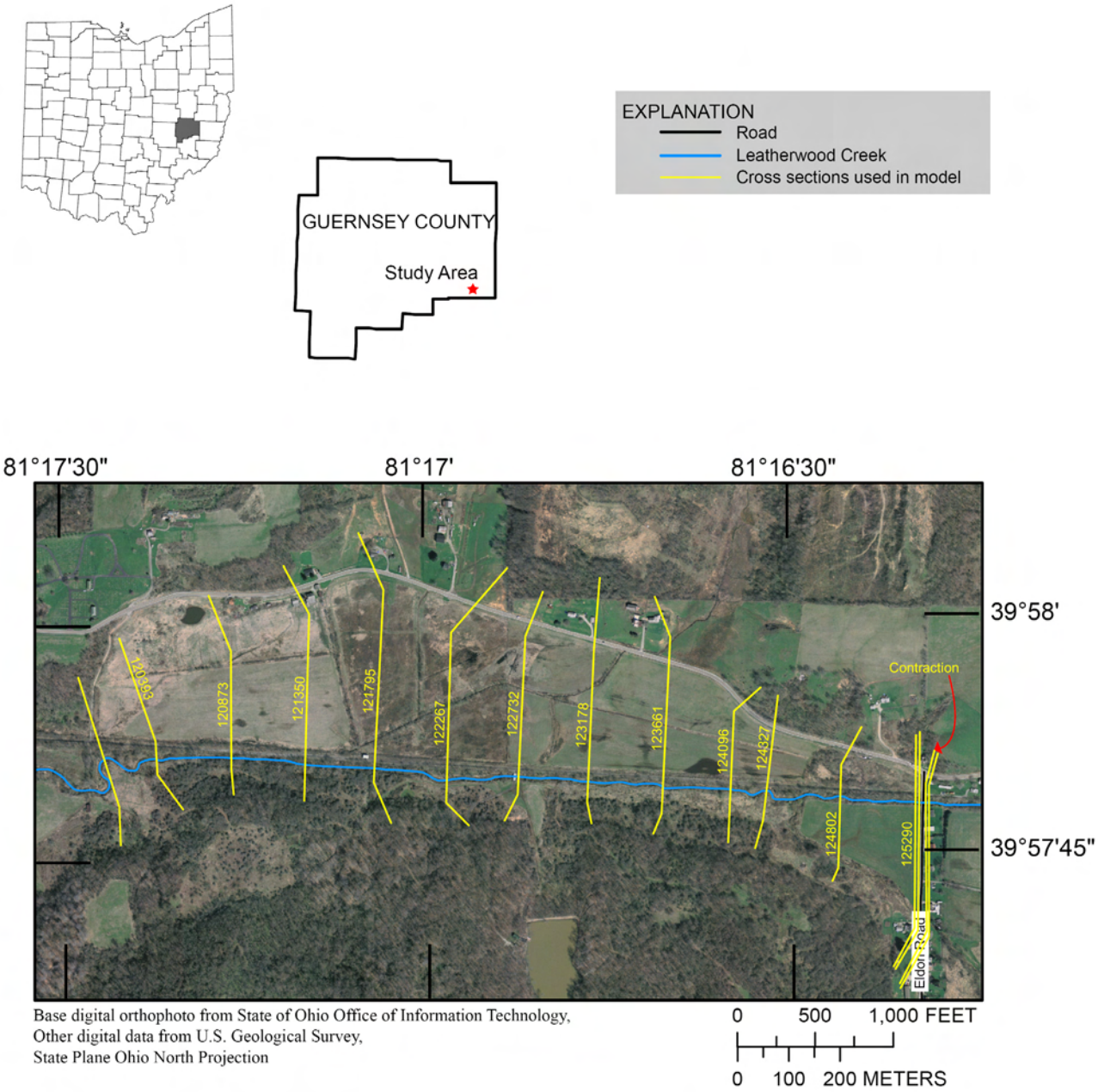

Figure 1–B3. Cross-section locations for flood profiles on Leatherwood Creek near the Village of Quaker City, Ohio.

1–C. Clear Fork Near the Village of Birmingham

Work Conducted by the USGS

Cross sections surveyed in the field and synthetic cross sections derived from a digital 20-ft contour map developed from the USGS 1:24,000-scale topographic quadrangle map Birmingham were used to establish the 10-, 50-, 100-, and 500-year flood profiles by use of HEC-RAS.

Scope of Work

The downstream limit of the reach studied is Birmingham Road. The upstream limit is 250 ft downstream from Sligo Road. This stream reach is approximately 0.5 mi long.

Hydraulic Baseline

Stationing used for the hydraulic baseline for this stream is referenced to feet upstream of Birmingham Road. To convert from the stationing in the 2006 model to feet above Birmingham Road, subtract 207 ft.

Cross-Section and Contracted-Opening-Geometry Data Surveyed in the Field

The USGS surveyed six cross sections, including two open-channel sections and one hydraulic structure. All surveys were referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29) and the North American Datum of 1983 (NAD 83).

Synthetic Cross-Sectional-Geometry Data

A total of 13 synthetic or partially synthetic cross sections at desired locations along the stream reach were generated from a TIN developed from the USGS 7.5-minute quadrangle map Birmingham. In-channel data for the synthetic cross sections were estimated by interpolation from cross-sectional data surveyed in the field.

Starting Water-Surface Elevation

The starting water-surface elevation at the initial section for the profile was obtained by means of a slope conveyance calculation. A slope of 0.0035 ft/ft was calculated from the river stations and minimum channel elevations for cross sections 24 and 912. These cross sections were obtained from field surveys and were assumed to provide a representative slope for the channel. Based on the calculated slope, starting water-surface elevations of 830.02, 830.66, 830.86, and 831.27 ft were determined at the initial section for the 10-, 50-, 100-, and 500-year profiles.

Manning's Roughness Coefficients

Manning's roughness coefficients (*n*) for the main channel and overbank areas were determined from field observation by experienced personnel. Estimates of Manning's roughness coefficients range from 0.040 to 0.046 for the main channel and from 0.040 to 0.064 for the overbank areas.

Flow Lengths

Main-channel and overbank flow lengths were computed with HEC-GeoRAS. Flow paths are drawn in the GIS by the user for both the main channel and overbanks. HEC-GeoRAS computes all flow lengths on the basis of the flow paths drawn.

Hydraulic-Structure Solution Reviews

For this study, all hydraulic-structure computations were reviewed for the appropriate modeling solutions (see “Special Hydraulic Considerations” section of “Hydraulic Analyses”). Initial reviews focused on the type of solution computed at each structure (based on energy equation or on pressure and/or weir-flow equations). Table 1–C1 lists the river station, a location description, the type of structure, the presence of road overflow, and the solution type of all structures affecting the 10-, 50-, 100-, and 500-year flood profiles for the reach.

Table 1–C1. Summary of hydraulic-structure solutions for the 10-, 50-, 100-, and 500-year profiles of Clear Fork near the Village of Birmingham.

River station (feet)	Location description	Structure type	Recurrence interval (years)	Presence of road overflow	Solution type
207	Birmingham Road	Bridge	10	N	Energy
207	Birmingham Road	Bridge	50	N	Energy
207	Birmingham Road	Bridge	100	Y	Pressure
207	Birmingham Road	Bridge	500	Y	Pressure

Backwater Elevation

Clear Fork should not be subject to backwater.

Base-Mapping Information

The base map used for this study was a digitized copy of the USGS Birmingham topographic quadrangle map.

Surveys Conducted by the USGS

A GPS survey was conducted by the USGS using Real-Time Kinematic (RTK) techniques and static surveying techniques. Control for the USGS survey was established by use of two USC&GS monuments with known elevation. A comparison of the published elevations and surveyed elevations is given in table 1–C2. The bench mark descriptions also are included below.

Table 1–C2. Comparison of published coordinates to USGS-surveyed coordinates and bench marks used in the study of Clear Fork near the Village of Birmingham.
[All data shown in feet, NAD 83 and NGVD 29; shaded boxes indicate control ponits; NA, not available]

Reference mark number	Bench mark name	Published easting	Published northing	Published elevation	Surveyed easting	Surveyed northing	Surveyed elevation	Delta easting	Delta northing	Delta elevation
U.S. Coast & Geodetic Survey (USC&GS) monuments										
1	105 JEA 1959	NA	NA	1023.955	NA[a]	NA[a]	1023.878	NA	NA	0.077
2	113 JEA 1959	NA	NA	1135.398	NA[a]	NA[a]	1135.398	NA	NA	0.000

[a] Northing and easting were not surveyed; elevation only.

Bench Mark Descriptions

RM1

105 JEA 1959
Antrim, 2.5 mi NW. of United Presbyterian Church, along County Road 61; in sec. 4, T. 3 N., R. 1 W.; 20 ft N. of rd.; at farm owned by Charles R. Moore; in W. edge of concrete sidewalk to house; standard tablet stamped “105 JEA 1959 1024”

Elevation (NGVD 29) = 1023.955 ft

RM2

113 JEA 1959
Odell, 2.3 mi N. of; at Irish Ridge Church and cemetery; in sec. 13, T. 4 N., R. 2 W.; 430 ft E. of junction of County Road 68 and 92; 120 ft N. of centerline of rd.; in W. face of stone foundation of church; standard tablet stamped “113 JEA 1959 1135”

Elevation (NGVD 29) = 1135.398 ft

Flood Profiles

The flood profiles for the Clear Fork for the 10-, 50-, 100-, and 500-year-recurrence-interval floods are presented in figure 1–C2. The locations of the cross sections for Clear Fork near the Village of Birmingham are presented in figure 1–C3.

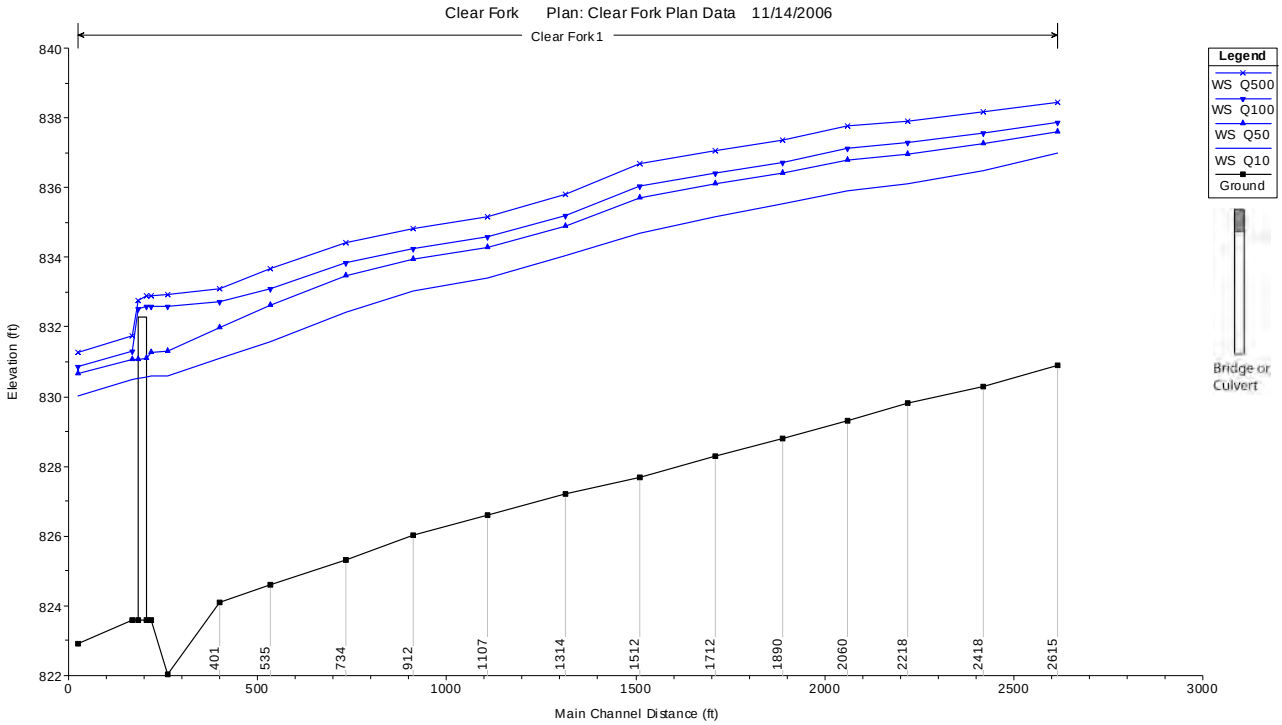

Figure 1–C2. Flood profiles for Clear Fork near the Village of Birmingham for the 10-, 50-, 100-, and 500-year-recurrence-interval floods.

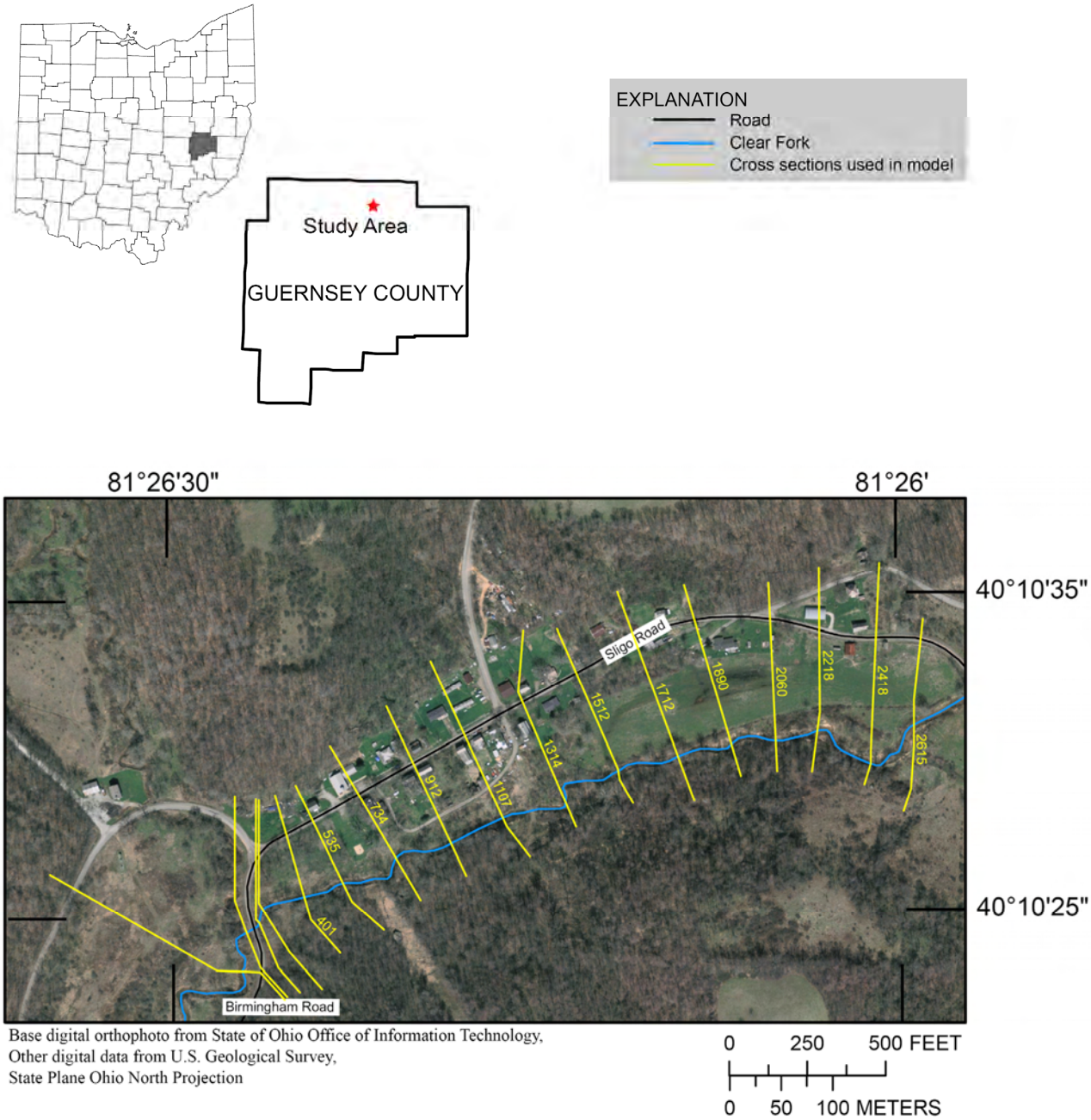

Figure 1–C3. Cross-section locations for flood profiles on Clear Fork near the Village of Birmingham, Ohio.

1–D. West Fork Duck Creek Near the Villages of Ava, Coal Ridge, and South Olive

Work Conducted by the USGS

Cross sections surveyed in the field and synthetic cross sections derived from a digital 20-ft contour map developed from the USGS 1:24,000-scale topographic maps Caldwell North and Macksburg were used to establish the 10-, 50-, 100-, and 500-year flood profiles by use of HEC-RAS.

Scope of Work

The downstream limit of the reach of West Fork Duck Creek near the Village of Ava is the approximately 1,900 ft downstream from Rayner Road (within the Village of Ava) and just below the confluence of Johnny Woods River. The upstream limit is approximately 650 ft upstream of Rayner Road. This stream reach is approximately 0.5 mi long.

The downstream limit of the reach of West Fork Duck Creek near the Village of Coal Ridge is the approximately 1,400 ft downstream from Moore Street within the Village of Coal Ridge. The upstream limit is approximately 280 ft downstream from Moore Street. This stream reach is approximately 0.2 mi long.

The downstream limit of the reach of West Fork Duck Creek near the Village of South Olive is the approximately 1,250 ft downstream from Ashton Hill Road and about 600 ft below the confluence of Warren Run. The upstream limit is approximately 1,000 ft upstream from Ashton Hill Road. This stream reach is approximately 0.4 mi long.

Hydraulic Baseline

Stationing used for the hydraulic baseline for the stream reaches near the Villages of Ava and Coal Ridge are referenced to feet above State Route 340. Stationing used for the hydraulic baseline for stream reach near the Village of South Olive is referenced to feet above Ashton Hill Road. Because some of the cross sections are below Ashton Hill Road, they will show negative stationing.

Cross-Section and Contracted-Opening-Geometry Data Surveyed in the Field

The USGS surveyed 15 cross sections, including 7 open-channel sections and 2 hydraulic structures. All surveys were referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29) and the North American Datum of 1927 (NAD 27).

Synthetic Cross-Sectional-Geometry Data

A total of 16 synthetic or partially synthetic cross sections at desired locations along the stream reach were generated from a TIN developed from the USGS 7.5-minute quadrangle maps Caldwell North and Macksburg. In-channel data for the synthetic cross sections were estimated by interpolation from cross-sectional data surveyed in the field.

Starting Water-Surface Elevation

The starting water-surface elevations for each profile of all three reaches were obtained from slope conveyance. Starting water-surface elevations for the reach near the Village of Ava are 770.94, 772.34, 772.86, and 773.95 ft for the 10-, 50-, 100-, and 500-year flood profiles, respectively.

Starting water-surface elevations for the reach near the Village of Coal Ridge are 755.08, 756.04, 776.40, and 757.13 ft for the 10-, 50-, 100-, and 500-year flood profiles, respectively. The minimum channel elevation was higher downstream than upstream at the surveyed cross sections. The slope of the water-surface elevation on the day of the surveys was used to compute the slope for the slope conveyance.

Because of a negative minimum channel slope for the short reach near the Village of South Olive that was surveyed, an approximate slope of 0.0015 ft/ft (8 ft/mi) was assumed. This value was in line with additional upstream surveys performed along West Fork Duck Creek for other modeling efforts, as well as the stream slope computed by StreamStats. Using the assumed channel slope, starting water-surface elevations of 684.89, 686.06, 686.51, and 687.41 ft were computed at the initial section for the 10-, 50-, 100-, and 500-year flood profiles, respectively.

Manning's Roughness Coefficients

Manning's roughness coefficients (*n*) for the main channel and overbank areas for the reach near the Village of Ava were determined from field observation by experienced personnel. Estimates of Manning's roughness coefficients were set to 0.042 for the main channel and range from 0.05 to 0.054 for the overbank areas.

Manning's roughness coefficients for the main channel and overbank areas for the reach near the Village of Coal Ridge were determined from field observation by experienced personnel. Estimates of Manning's roughness coefficients were set to 0.040 for the main channel and 0.050 for the overbank areas.

Manning's roughness coefficients for the main channel and overbank areas for the reach near the Village of South Olive were determined from field observation by experienced personnel. Estimates of Manning's roughness coefficients range from 0.040 to 0.046 for the main channel and from 0.044 to 0.054 for the overbank areas.

Flow Lengths

Main-channel and overbank flow lengths were computed with HEC-GeoRAS. Flow paths are drawn in the GIS by the user for both the main channel and overbanks. HEC-GeoRAS computes all flow lengths on the basis of the flow paths drawn.

Hydraulic-Structure Solution Reviews

For this study, all hydraulic-structure computations were reviewed for the appropriate modeling solutions (see “Special Hydraulic Considerations” section of “Hydraulic Analyses”). Initial reviews focused on the type of solution computed at each structure (based on energy equation or on pressure and/or weir-flow equations). Table 1–D1 lists the river station, a location description, the type of structure, the presence of road overflow, and the solution type of all structures affecting the 10-, 50-, 100-, and 500-year flood profiles for West Fork Duck Creek. There were no hydraulic structures for the reach of West Fork Duck Creek near the Village of Coal Ridge.

Table 1–D1. Summary of hydraulic-structure solutions for the 10-, 50-, 100-, and 500-year profiles of West Fork Duck Creek near the Villages of Ava and South Olive.

River station (feet)	Location description	Structure type	Recurrence interval (years)	Presence of road overflow	Solution type
West Fork Duck Creek near the Village of Ava					
10	19,189	Rayner Road	Bridge	No	Energy
50	19,189	Rayner Road	Bridge	Yes	Pressure
100	19,189	Rayner Road	Bridge	Yes	Energy
500	19,189	Rayner Road	Bridge	Yes	Energy
West Fork Duck Creek near the Village of South Olive					
10	0	Ashton Hill Road	Bridge	No	Pressure
50	0	Ashton Hill Road	Bridge	Yes	Pressure
100	0	Ashton Hill Road	Bridge	Yes	Pressure
500	0	Ashton Hill Road	Bridge	Yes	Pressure

Backwater Elevation

West Fork Duck Creek should not be subject to backwater.

Base-Mapping Information

The base map used for this study was a digitized copy of the USGS North Caldwell and Macksburg topographic quadrangle maps.

Surveys Conducted by the USGS

A GPS survey was conducted by the USGS using Real-Time Kinematic (RTK) techniques and static surveying techniques. Control for the USGS survey was established by use of one NGS control monument with known elevation and three USC&GS monuments with known elevation. A comparison of the published elevations and surveyed elevations is given in table 1–D2. The bench mark descriptions also are included below.

Table 1–D2. Comparison of published coordinates to USGS-surveyed coordinates and bench marks used in the study of West Fork Duck Creek near the Villages of Ava, Coal Ridge, and South Olive.
[All data shown in feet, NAD 83 and NGVD 29; shaded boxes indicate control points; NA, not available]

Reference mark number	Bench mark name	Published easting	Published northing	Published elevation	Surveyed easting	Surveyed northing	Surveyed elevation	Delta easting	Delta northing	Delta elevation
National Geodetic Survey (NGS) monument										
1	C 65	2228042.846	668535.592	773.84[a]	2228042.846	668535.592	773.84	0.000	0.000	0.000
U.S. Coast & Geodetic Survey (USC&GS) monuments										
2	148 WSM	NA	NA	854.470	2236944.016	668139.978	855.369	NA	NA	-0.899
3	127 JEA	NA	NA	776.216	2261928.507	624560.741	776.216	NA	NA	0.000
4	128 JEA	NA	NA	773.337	2266884.750	620069.244	773.413	NA	NA	-0.076

[a] Elevation published in NAVD 88 and converted to NGVD 29 with Corpscon Version 6.0.1 (U.S. Army Corps of Engineers, 2008).

Bench Mark Descriptions

RM1

```
1       NATIONAL GEODETIC SURVEY,   RETRIEVAL DATE = JULY 27, 2006
 JX1456 ***********************************************************************
 JX1456  DESIGNATION -  C 65
 JX1456  PID        -  JX1456
 JX1456  STATE/COUNTY-  OH/NOBLE
 JX1456  USGS QUAD   -  CALDWELL NORTH (1994)
 JX1456
 JX1456                     *CURRENT SURVEY CONTROL
 JX1456  ______________________________________________________________________
 JX1456* NAD 83(1995)-  39 49 54.72879(N)    081 34 32.93723(W)    ADJUSTED
 JX1456* NAVD 88     -      235.682  (METERS)    773.23   (FEET)  ADJUSTED
 JX1456  ______________________________________________________________________
 JX1456  X          -    718,562.054 (METERS)                  COMP
 JX1456  Y          -  -4,851,920.657 (METERS)                  COMP
 JX1456  Z          -   4,063,796.540 (METERS)                  COMP
 JX1456  LAPLACE CORR-          0.23  (SECONDS)                 DEFLEC99
 JX1456  ELLIP HEIGHT-        201.60  (METERS)         (10/07/05) GPS OBS
 JX1456  GEOID HEIGHT-        -34.02  (METERS)                  GEOID03
 JX1456  DYNAMIC HT  -        235.547 (METERS)    772.79  (FEET)  COMP
 JX1456  MODELED GRAV-    980,050.9   (MGAL)                     NAVD 88
 JX1456
 JX1456  HORZ ORDER  -  FIRST
 JX1456  VERT ORDER  -  SECOND    CLASS 0
 JX1456  ELLP ORDER  -  FOURTH    CLASS I
 JX1456
 JX1456.THE HORIZONTAL COORDINATES WERE ESTABLISHED BY GPS OBSERVATIONS
 JX1456.AND ADJUSTED BY THE NATIONAL GEODETIC SURVEY IN APRIL 1998.
 JX1456
 JX1456.THE ORTHOMETRIC HEIGHT WAS DETERMINED BY DIFFERENTIAL LEVELING
 JX1456.AND ADJUSTED BY THE NATIONAL GEODETIC SURVEY IN JUNE 1991.
 JX1456
 JX1456.THE X, Y, AND Z WERE COMPUTED FROM THE POSITION AND THE ELLIPSOIDAL HT.
 JX1456
 JX1456.THE LAPLACE CORRECTION WAS COMPUTED FROM DEFLEC99 DERIVED DEFLECTIONS.
 JX1456
 JX1456.THE ELLIPSOIDAL HEIGHT WAS DETERMINED BY GPS OBSERVATIONS
 JX1456.AND IS REFERENCED TO NAD 83.
 JX1456
 JX1456.THE GEOID HEIGHT WAS DETERMINED BY GEOID03.
 JX1456
```

```
JX1456.THE DYNAMIC HEIGHT IS COMPUTED BY DIVIDING THE NAVD 88
JX1456.GEOPOTENTIAL NUMBER BY THE NORMAL GRAVITY VALUE COMPUTED ON THE
JX1456.GEODETIC REFERENCE SYSTEM OF 1980 (GRS 80) ELLIPSOID AT 45
JX1456.DEGREES LATITUDE (G = 980.6199 GALS.).
JX1456
JX1456.THE MODELED GRAVITY WAS INTERPOLATED FROM OBSERVED GRAVITY VALUES.
JX1456
JX1456;                 NORTH        EAST     UNITS SCALE FACTOR CONVERG.
JX1456;SPC OH S     -   203,770.056   679,108.818   MT  0.99996635   +0 35 11.1
JX1456;UTM  17      - 4,409,255.198   450,728.042   MT  0.99962989   -0 22 07.8
JX1456
JX1456!            -  ELEV FACTOR  X  SCALE FACTOR =   COMBINED FACTOR
JX1456!SPC OH S     -   0.99996837  X   0.99996635  =   0.99993472
JX1456!UTM  17      -   0.99996837  X   0.99962989  =   0.99959828
JX1456
JX1456                      SUPERSEDED SURVEY CONTROL
JX1456
JX1456  ELLIP H (04/01/98)  201.67   (M)                    GP(      ) 4 1
JX1456  NAD 83(1986)-  39 49 54.73486(N)    081 34 32.94601(W) AD(      ) 1
JX1456  NAVD 88 (05/31/95)  235.68   (M)         773.2    (F) LEVELING    3
JX1456  NGVD 29 (??/??/92)  235.867  (M)         773.84   (F) ADJ UNCH    2 0
JX1456
JX1456.SUPERSEDED VALUES ARE NOT RECOMMENDED FOR SURVEY CONTROL.
JX1456.NGS NO LONGER ADJUSTS PROJECTS TO THE NAD 27 OR NGVD 29 DATUMS.
JX1456.SEE FILE DSDATA.TXT TO DETERMINE HOW THE SUPERSEDED DATA WERE DERIVED.
JX1456
JX1456_U.S. NATIONAL GRID SPATIAL ADDRESS: 17SME5072809255(NAD 83)
JX1456_MARKER: DB = BENCH MARK DISK
JX1456_SETTING: 7 = SET IN TOP OF CONCRETE MONUMENT
JX1456_SP_SET: SET IN TOP OF CONCRETE MONUMENT
JX1456_STAMPING: C 65 1934
JX1456_MARK LOGO: CGS
JX1456_MAGNETIC: N = NO MAGNETIC MATERIAL
JX1456_STABILITY: C = MAY HOLD, BUT OF TYPE COMMONLY SUBJECT TO
JX1456+STABILITY: SURFACE MOTION
JX1456_SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR
JX1456+SATELLITE: SATELLITE OBSERVATIONS - DECEMBER 17, 1992
JX1456
JX1456  HISTORY     - DATE     CONDITION       REPORT BY
JX1456  HISTORY     - 1934     MONUMENTED       CGS
JX1456  HISTORY     - 1942     GOOD            NGS
JX1456  HISTORY     - 19921217 GOOD             OH-119
JX1456
JX1456                      STATION DESCRIPTION
JX1456
JX1456'DESCRIBED BY NATIONAL GEODETIC SURVEY 1942
JX1456'AT AVA.
JX1456'AT AVA, NOBLE COUNTY, ON THE PENNSYLVANIA RAILROAD, 125 YARDS
JX1456'SOUTHWEST OF THE SOUTHWEST CORNER OF A WHITE FRAME CHURCH, 15.5
JX1456'YARDS SOUTHEAST OF THE CROSSING OF A DIRT ROAD, 20.5 FEET EAST
JX1456'OF THE EAST RAIL, 4 FEET WEST OF A POLE, AND ABOUT 6 INCHES
JX1456'LOWER THAN THE TRACK.  A STANDARD DISK, STAMPED C 65 1934 AND
JX1456'SET IN THE TOP OF A CONCRETE POST.
JX1456
JX1456                      STATION RECOVERY (1992)
JX1456
JX1456'RECOVERY NOTE BY MUSKINGUM COUNTY OHIO 1992 (LCC)
JX1456'RECOVERED AS DESCRIBED IN 1986 BY B. L. LAMBERT
```

RM2

148 WSM

Ava, 1.8 mi E. of, along Noble County Road 12; in sec. 5, T. 7 N., R. 9 W.; 65 ft E. of, and 10 ft higher than centerline of junction of Y-rd.; 13 ft N. of rd. NE.; 4 ft above ground; set vertically in rock face; standard tablet stamped “148 WSM 1959 854”

Elevation (NGVD 29) = 854.47 ft

RM3

127 JEA
Ashton, 0.5 mi SE. of; 2.5 mi SW. of Fulda; in sec. 18, T. 6 N., R. 8 W.; 400 ft S. of junction of State Highway 564 and County Road 15; in SW. concrete wingwall of bridge over Middle Fork Duck Creek; standard tablet stamped "127 JEA 1959 RESET 1961"

Elevation (NGVD 29) = 776.216 ft

RM4

128 JEA
Middleburg, 3.7 mi NW. of, along State Highway 564; 1.9 mi SE. of Ashton; in sec. 20, T. 6 N., R. 8 W.; about 175 ft N. of junction of Highway 564 and Township Road 295; 100 ft NE. of centerline of hwy.; 20 ft N. of NE. corner of residence of E.J. Saling; in SE. corner of concrete well base; standard tablet stamped "128 JEA 1959 774"

Elevation (NGVD 29) = 773.337 ft

Flood Profiles

The flood profiles for the reaches of West Fork Duck Creek near the Villages of Ava, Coal Ridge, and South Olive for the 10-, 50-, 100-, and 500-year-recurrence-interval floods are presented in figure 1–D3, 1–D4, and 1–D5, respectively. The locations of the cross sections for West Fork Duck Creek near the Villages of Ava, Coal Ridge, and South Olive are presented in figures 1–D6, 1–D7, and 1–D8, respectively.

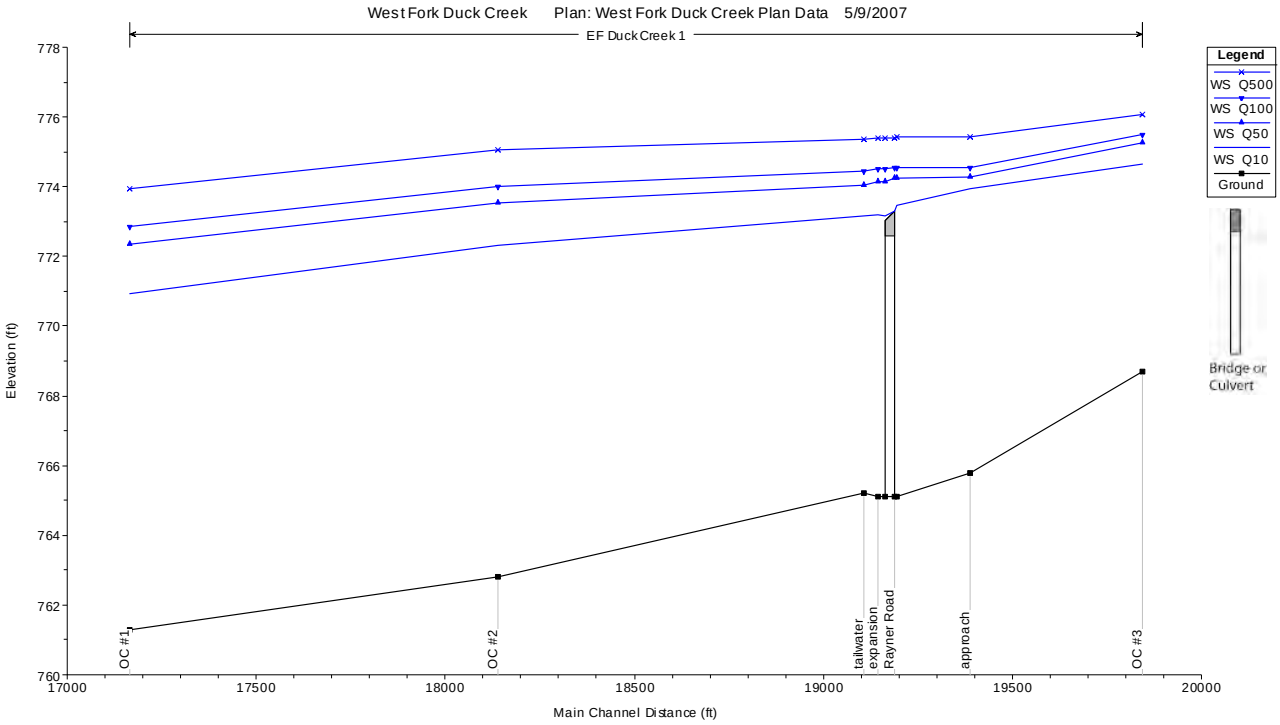

Figure 1–D3. Flood profiles for West Fork Duck Creek near the Village of Ava for the 10-, 50-, 100-, and 500-year-recurrence-interval floods.

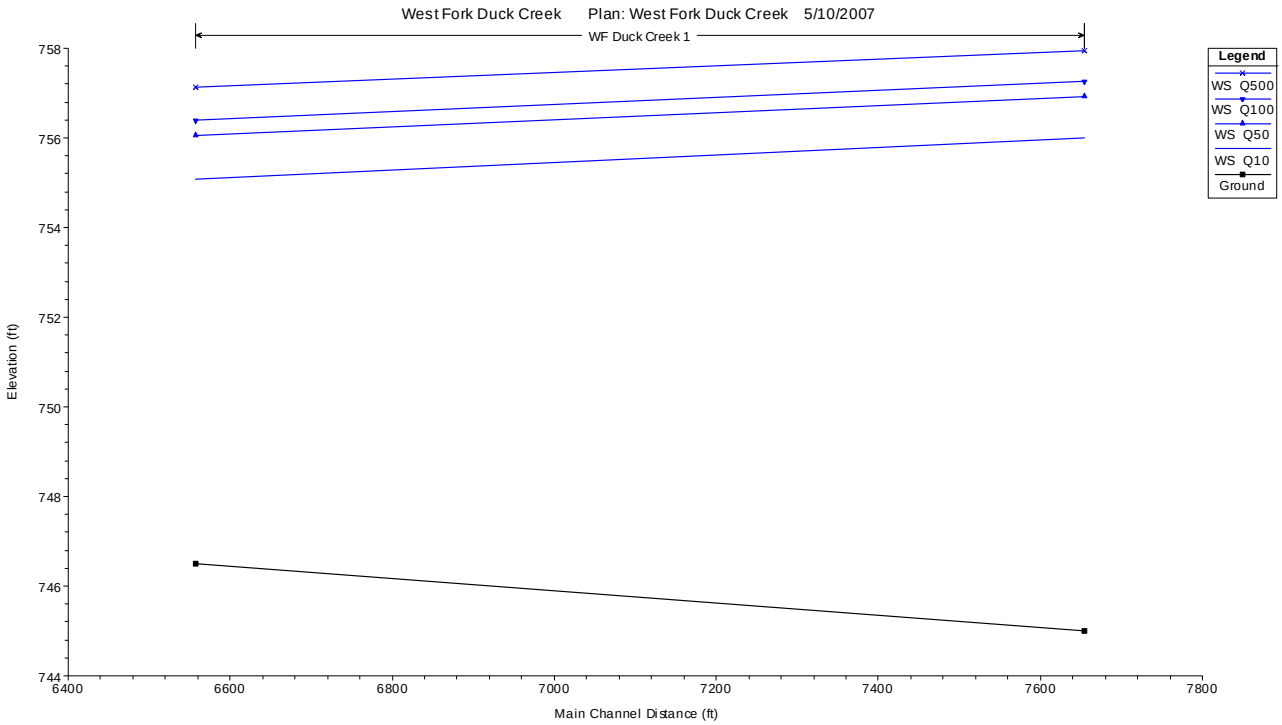

Figure 1–D4. Flood profiles for West Fork Duck Creek near the Village of Coal Ridge for the 10-, 50-, 100-, and 500-year-recurrence-interval floods.

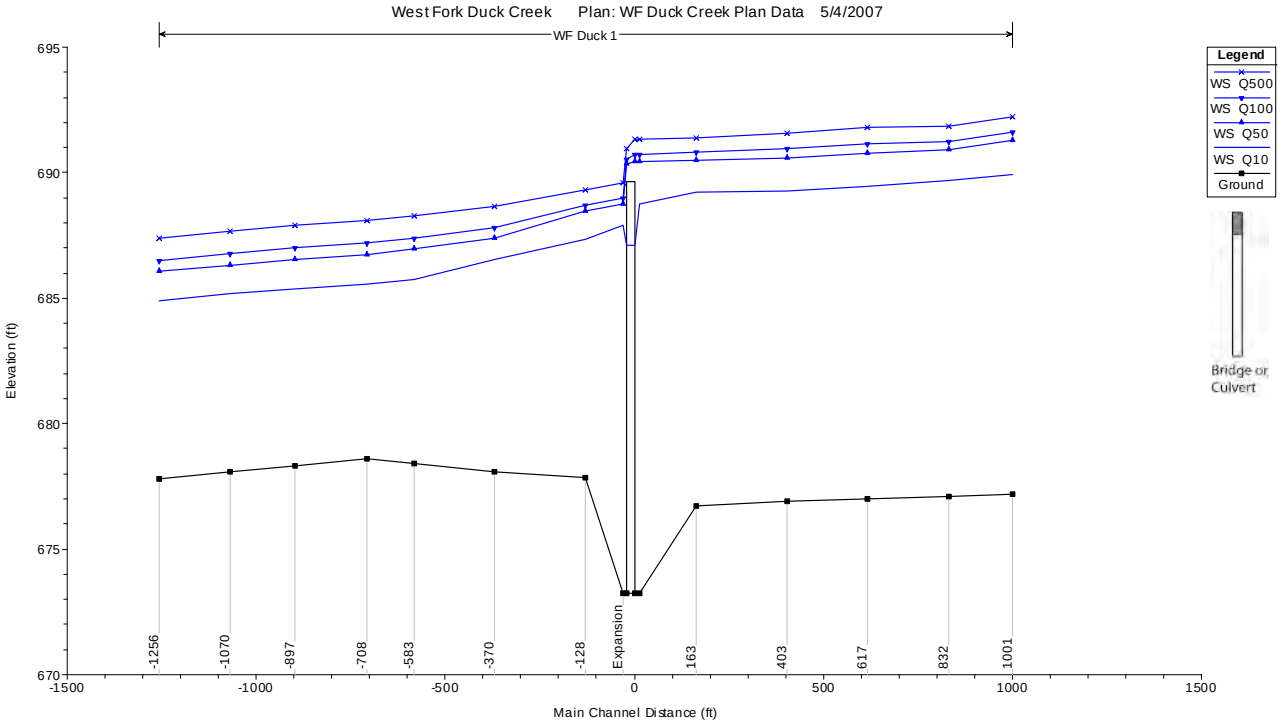

Figure 1–D5. Flood profiles for West Fork Duck Creek near the Village of South Olive for the 10-, 50-, 100-, and 500-year-recurrence-interval floods.

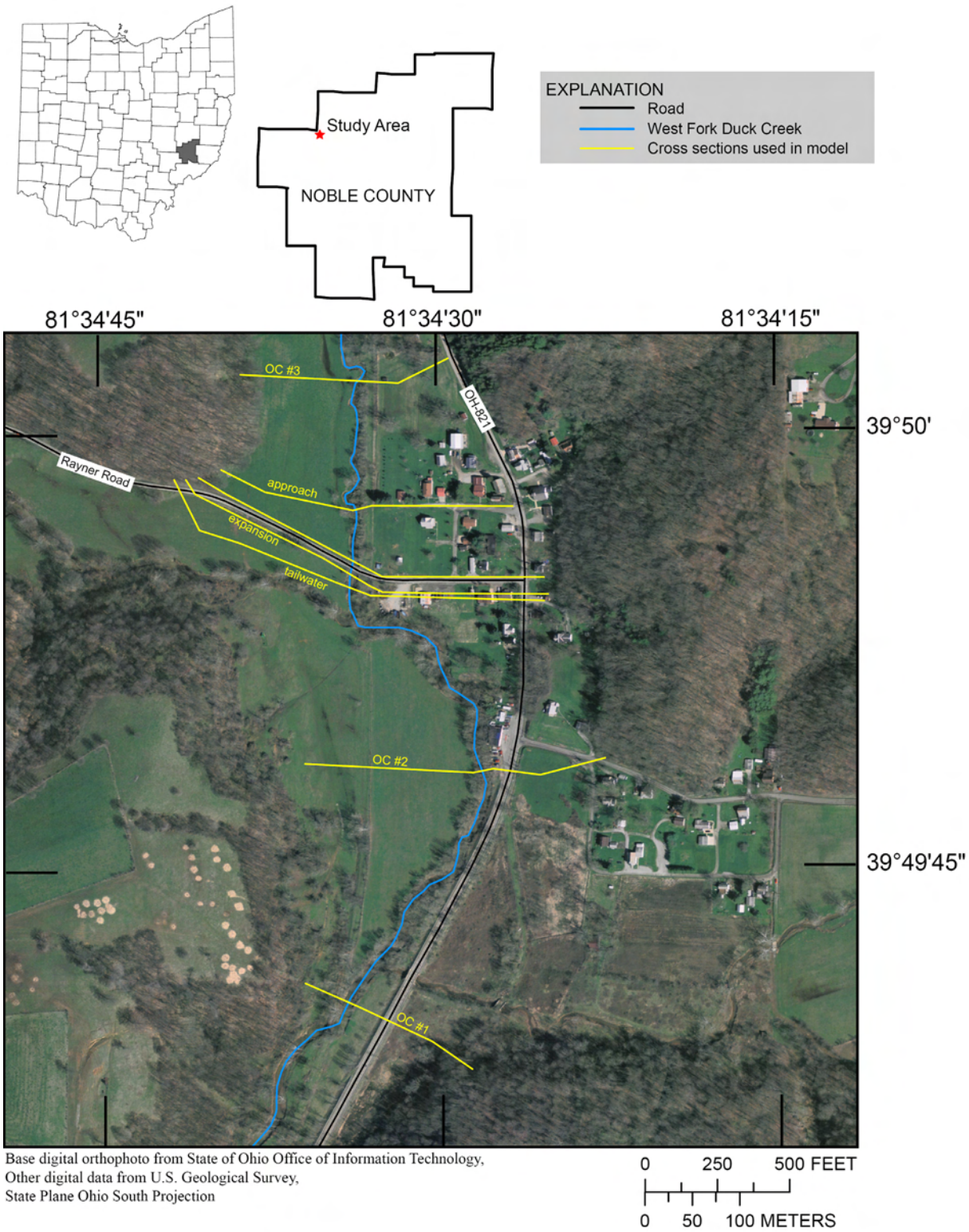

Figure 1–D6. Cross-section locations for flood profiles on West Fork Duck Creek near the Village of Ava, Ohio.

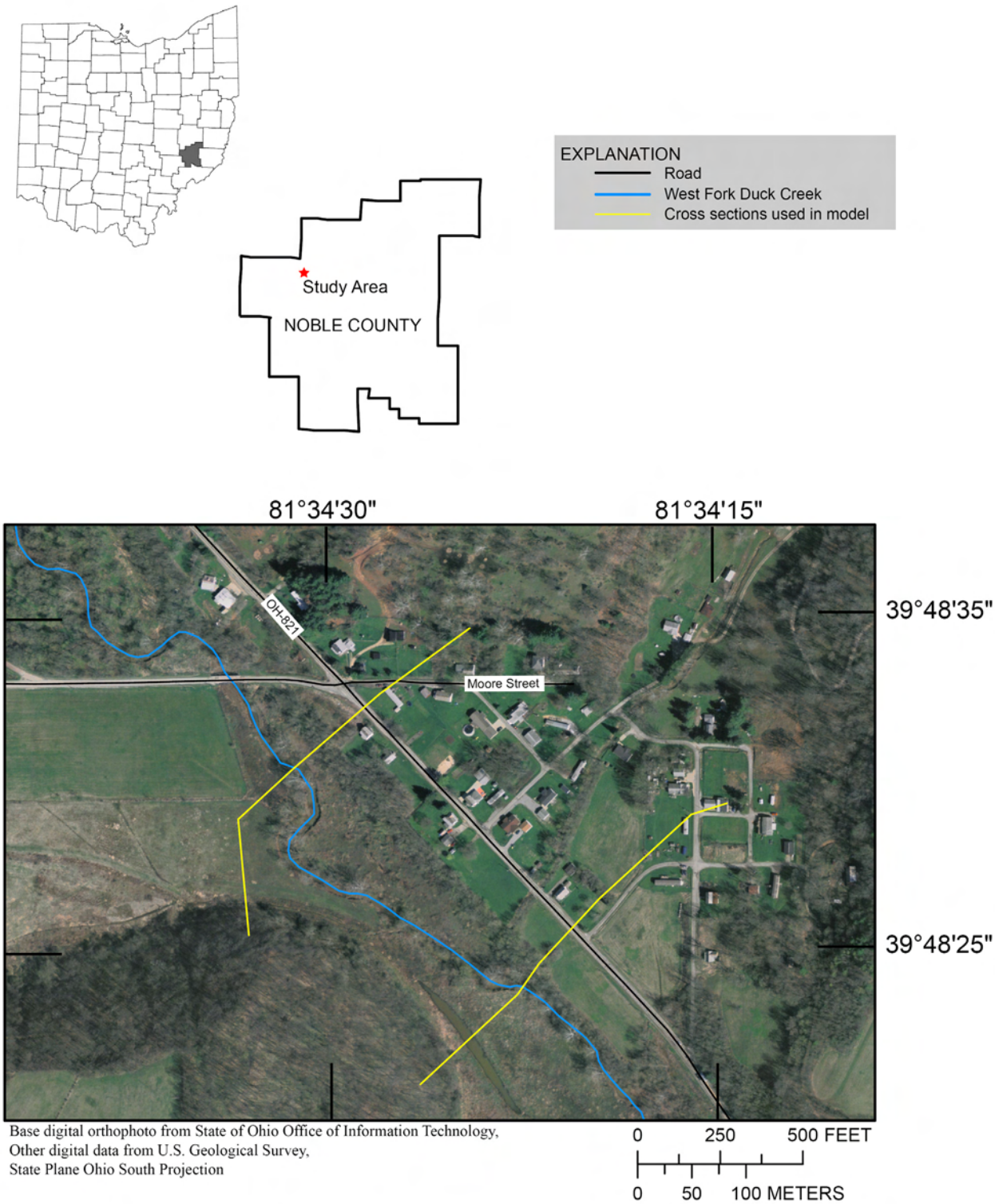

Figure 1–D7. Cross-section locations for flood profiles on West Fork Duck Creek near the Village of Coal Ridge, Ohio.

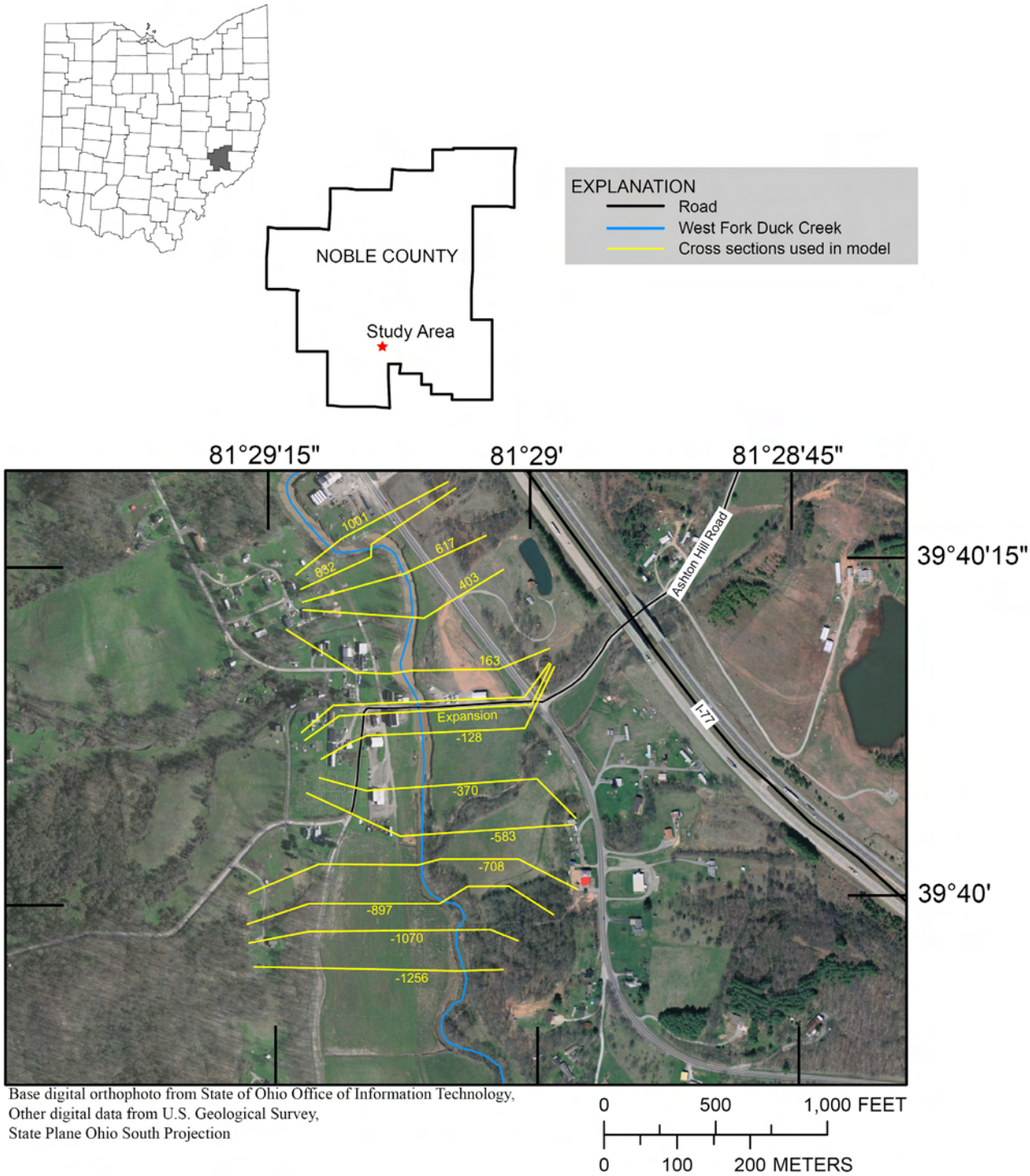

Figure 1–D8. Cross-section locations for flood profiles on West Fork Duck Creek near the Village of South Olive, Ohio.

1–E. East Fork Duck Creek Near the Village of East Union

Work Conducted by the USGS

Cross sections surveyed in the field and synthetic cross sections derived from a digital 20-ft contour map developed from the USGS 1:24,000-scale topographic quadrangle map Sarahsville were used to establish the 10-, 50-, 100-, and 500-year flood profiles by use of HEC-RAS.

Scope of Work

The downstream limit of the reach studied is approximately 50 ft downstream from State Route 78 and just above the confluence of West Fork Duck Creek. The upstream limit is approximately 1,169 ft upstream from State Route 78. This stream reach is approximately 0.2 mi long.

Hydraulic Baseline

Stationing used for the hydraulic baseline for this stream is referenced to feet above the confluence of Barnes Run.

Cross-Section and Contracted-Opening-Geometry Data Surveyed in the Field

The USGS surveyed eight cross sections, including one open-channel section and two hydraulic structures. All surveys were referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29) and the North American Datum of 1983 (NAD 83).

Synthetic Cross-Sectional-Geometry Data

A total of two synthetic or partially synthetic cross sections at desired locations along the stream reach were generated from a TIN developed from the USGS 7.5-minute quadrangle map Sarahsville. In-channel data for the synthetic cross sections were estimated by interpolation from cross-sectional data surveyed in the field.

Starting Water-Surface Elevation

The starting water-surface elevation at the initial section for each profile was obtained from slope conveyance. Starting water-surface elevations of 772.40, 773.07, 773.33, and 773.89 ft were computed at the initial section for the 10-, 50-,100-, and 500-year flood profiles, respectively.

Manning's Roughness Coefficients

Manning's roughness coefficients (*n*) for the main channel and overbank areas were determined from field observation by experienced personnel. For all three models, estimates of Manning's roughness coefficients were 0.042 for the main channel and 0.050 for the overbank areas.

Flow Lengths

Main-channel and overbank flow lengths were computed with HEC-GeoRAS. Flow paths are drawn in the GIS by the user for both the main channel and overbanks. HEC-GeoRAS computes all flow lengths based on the basis of the flow paths drawn.

Hydraulic-Structure Solution Reviews

For this study, all hydraulic-structure computations were reviewed for the appropriate modeling solutions (see “Special Hydraulic Considerations” section of “Hydraulic Analyses”). Initial reviews focused on the type of solution computed at each structure (based on energy equation or on pressure and/or weir-flow equations). In the cases where road overflow occurred at a culvert, a submergence check was made. In the cases where the hydraulic model computed weir flow at a culvert that was determined to be submerged, the culvert was replaced with composite sections. Table 1–E1 lists the river station, a location description, the type of structure, the presence of road overflow, and the solution type of all structures affecting the 10-, 50-, 100-, and 500-year flood profiles for East Fork Duck Creek.

Table 1–E1. Summary of hydraulic-structure solutions for the 10-, 50-, 100-, and 500-year profiles of East Fork Duck Creek near the Village of East Union.

River station (feet)	Location description	Structure type	Recurrence interval (years)	Presence of road overflow	Solution type
4,988	State Route 78	Multiple Opening	10	N	Energy
4,988	State Route 78	Multiple Opening	50	Y	Energy
4,988	State Route 78	Multiple Opening	100	Y	Energy
4,988	State Route 78	Multiple Opening	500	Y	Energy
5,418	East Union Lane	Bridge	10	Y	Pressure
5,418	East Union Lane	Bridge	50	Y	Pressure
5,418	East Union Lane	Bridge	100	Y	Pressure
5,418	East Union Lane	Bridge	500	Y	Energy

Backwater Elevation

East Fork Duck Creek should not be subject to backwater.

Base-Mapping Information

The base map used for this study was a digitized copy of the USGS Sarahsville topographic quadrangle map.

Surveys Conducted by the USGS

A GPS survey was conducted by the USGS using Real-Time Kinematic (RTK) techniques and static surveying techniques. Control for the USGS survey was established by use of two USC&GS control monuments with known elevation. The USGS held one monuments as true (143 JEA) in elevation, as obtained from USC&GS. A comparison of the published elevations and surveyed elevations is give in table 1–E2. The bench mark descriptions also are included below.

Table 1–E2. Comparison of published coordinates to USGS-surveyed coordinates and bench marks used in the study of East Fork Duck Creek near the Village of East Union.
[All data shown in feet, NAD 83 and NGVD 29; shaded boxes indicate control ponits; NA, not available]

Reference mark number	Bench mark name	Published easting	Published northing	Published elevation	Surveyed easting	Surveyed northing	Surveyed elevation	Delta easting	Delta northing	Delta elevation
U.S. Coast & Geodetic Survey (USC&GS) monuments										
1	151 JEA RESET 1992	NA	NA	762.934	2281417.775	643588.036	765.774	NA	NA	-2.48
2	143 JEA	NA	NA	1108.529	2267386.083	638319.895	1108.529	NA	NA	0.000

Bench Mark Descriptions

RM1

151 JEA RESET 1992
Summerfield, 3.8 mi W. of, junction of State Highway 146, along State Highway 78; 2.4 mi N. of Carlisle; 450 ft S. of junction of State Highway 78 and 260; in SE. concrete wingwall of bridge over Barnes Run; standard tablet stamped “151 JEA 1959 763”

Elevation (NGVD 29) = 762.934 ft

RM2

143 JEA
Ashton, 0.4 mi NW. of, thence 2.0 mi NE.; 0.7 mi W. of Archers Ridge Church; in sec. 5, T. 6 N., R. 8 W.; 40 ft W. of, and 1 ft higher than centerline of junction of Y-rd.; in SW. end of V-shaped concrete headwall; standard tablet stamped “143 JEA 1959 1109”

Elevation (NGVD 29) = 1108.529 ft

Flood Profiles

The flood profiles for East Fork Duck Creek near the Village of East Union for the 10-, 50-, 100-, and 500-year-recurrence-interval floods are presented in figure 1–E2. The locations of the cross sections for East Fork Duck Creek near the Village of East Union are presented in figure 1–E3.

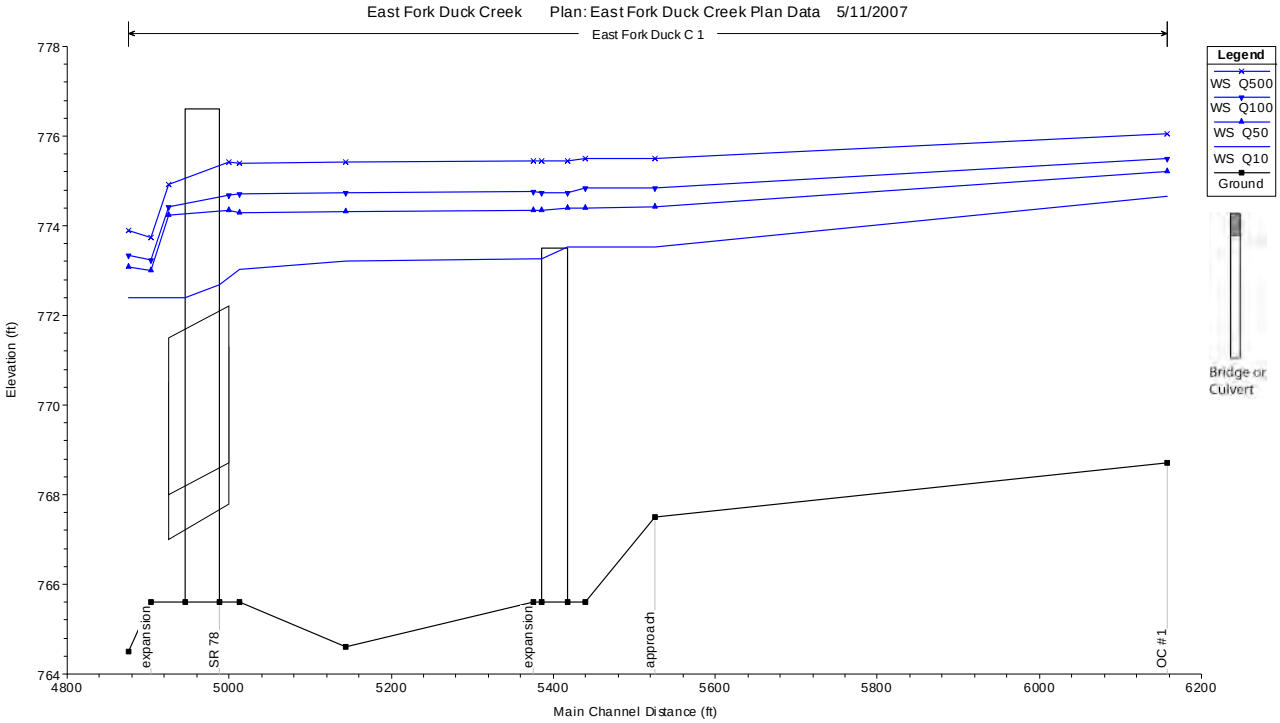

Figure 1–E2. Flood profiles for East Fork Duck Creek near the Village of East Union for the 10-, 50-, 100-, and 500-year-recurrence-interval floods.

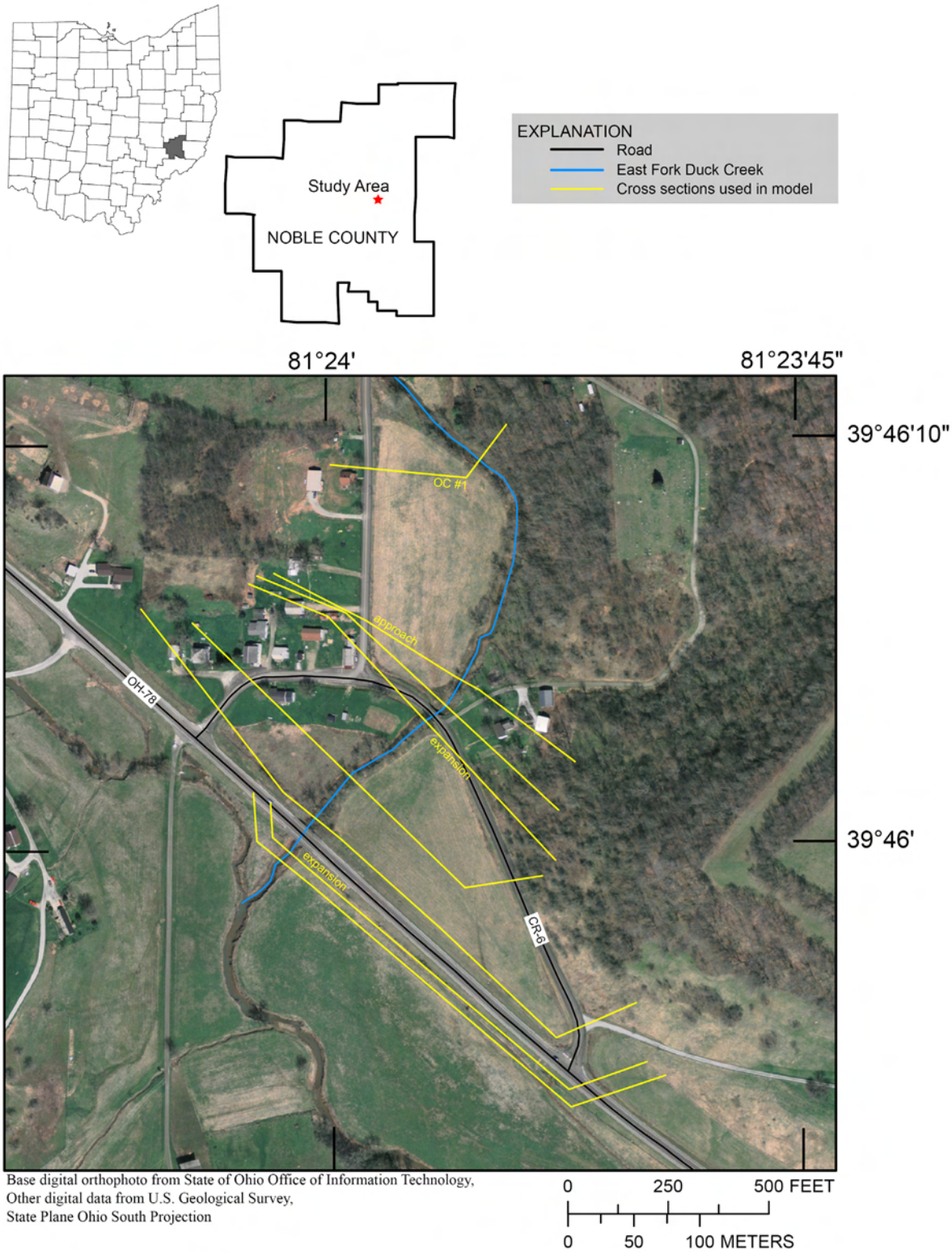

Figure 1–E3. Cross-section locations for flood profiles on East Fork Duck Creek near the Village of East Union, Ohio.

1–F. Muskingum River Near the City of McConnelsville

Work Conducted by the USGS

The USGS requested and obtained paper copies of the hydraulic model and work maps used in the December 16, 2004, Village of McConnelsville, Morgan County, FIS from FEMA archives. Part of the original model (five cross sections) was converted from HEC 2 to HEC-RAS (version 3.1.1) and rerun in an attempt to match the existing 100-year flood profile. With the exception of one cross section located downstream from the 2006 study reach (station 44.710, which differed by 0.01 ft), the 100-year profile was duplicated.

Scope of Work

The downstream limit of the reach studied is cross section 44.710 (approximately 4.72 mi below the dam at McConnelsville). The upstream limit is approximately cross section 49.19 (approximately 0.25 mi below the dam at McConnelsville). This stream reach is approximately 4.5 mi long.

Hydraulic Baseline

Stationing used for the hydraulic baseline for this stream was taken directly from the December 16, 2004, Village of McConnelsville, Morgan County, FIS and is referenced to miles above the mouth.

Starting Water-Surface Elevation

A starting water-surface elevation of 660.10 ft at cross section 44.710 (the initial section) for the 100-year profile was obtained from the archived hydraulic model. Because no other starting water-surface elevation data were available for the 10-, 50-, or 500-year profiles, the USGS started all profiles with the slope-conveyance option. The slope chosen (0.000302 foot per mile) was selected so that the resulting 100-year water-surface profile would match the original profile as closely as possible. As stated earlier, with the exception of one cross section, all 100-year water-surface elevations matched the original model. Using the assumed channel slope, starting water-surface elevations of 652.69, 657.31, 660.09, and 667.02 ft were computed at the initial section for the 10-, 50-, 100-, and 500-year flood profiles, respectively.

Manning's Roughness Coefficients

Manning's roughness coefficients (*n*) for the main channel and overbank areas were taken directly from the archived hydraulic model used in the December 16, 2004, Village of McConnelsville, Morgan County, FIS. The Manning's roughness coefficients were set to 0.037 for the main channel and 0.050 for the overbank areas.

Backwater Elevation

The Muskingum River should not be subject to backwater.

Surveys Conducted by the USGS

A GPS survey was conducted by the USGS using Real-Time Kinematic (RTK) techniques and static surveying techniques. Control for the USGS survey was established by use of three NGS control monuments with known elevation. A comparison of the published elevations and surveyed elevations is given in table 1–F1. The bench mark descriptions also are included below.

Table 1–F1. Comparison of published coordinates to USGS-surveyed coordinates and bench marks used in the study of the Muskingum River near the City of McConnelsville.
[All data shown in feet, NAD 83 and NGVD 29; shaded boxes indicate control ponits; NA, not available]

Reference mark number	Bench mark name	Published easting	Published northing	Published elevation	Surveyed easting	Surveyed northing	Surveyed elevation	Delta easting	Delta northing	Delta elevation
National Geodetic Survey (NGS) monuments										
1	L 246	NA	NA	668.56	2156405.622	588061.492	668.501	NA	NA	0.06
2	P 246	NA	NA	673.73	2152682.861	598340.937	673.730	NA	NA	0.00
3	S 246	NA	NA	669.55	2151425.387	599107.696	669.547	NA	NA	0.00

Bench Mark Descriptions

RM1

```
1       NATIONAL GEODETIC SURVEY,   RETRIEVAL DATE = JULY 27, 2006
 JX1510 ***********************************************************************
 JX1510  DESIGNATION -  L 246
 JX1510  PID        -  JX1510
 JX1510  STATE/COUNTY-  OH/MORGAN
 JX1510  USGS QUAD   -  STOCKPORT (1994)
 JX1510
 JX1510                     *CURRENT SURVEY CONTROL
 JX1510  ______________________________________________________________________
 JX1510* NAD 83(1986)-  39 36 46.     (N)    081 49 58.     (W)    SCALED
 JX1510* NAVD 88     -      203.576  (METERS)    667.90   (FEET)  ADJUSTED
 JX1510  ______________________________________________________________________
 JX1510  GEOID HEIGHT-        -34.12  (METERS)                   GEOID03
 JX1510  DYNAMIC HT  -        203.456 (METERS)    667.51  (FEET)  COMP
 JX1510  MODELED GRAV-    980,030.8   (MGAL)                     NAVD 88
 JX1510
 JX1510  VERT ORDER  -  FIRST    CLASS II
 JX1510
 JX1510.THE HORIZONTAL COORDINATES WERE SCALED FROM A TOPOGRAPHIC MAP AND HAVE
 JX1510.AN ESTIMATED ACCURACY OF +/- 6 SECONDS.
 JX1510
 JX1510.THE ORTHOMETRIC HEIGHT WAS DETERMINED BY DIFFERENTIAL LEVELING
 JX1510.AND ADJUSTED BY THE NATIONAL GEODETIC SURVEY IN JUNE 1991.
 JX1510
 JX1510.THE GEOID HEIGHT WAS DETERMINED BY GEOID03.
 JX1510
 JX1510.THE DYNAMIC HEIGHT IS COMPUTED BY DIVIDING THE NAVD 88
 JX1510.GEOPOTENTIAL NUMBER BY THE NORMAL GRAVITY VALUE COMPUTED ON THE
 JX1510.GEODETIC REFERENCE SYSTEM OF 1980 (GRS 80) ELLIPSOID AT 45
 JX1510.DEGREES LATITUDE (G = 980.6199 GALS.).
 JX1510
 JX1510.THE MODELED GRAVITY WAS INTERPOLATED FROM OBSERVED GRAVITY VALUES.
 JX1510
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```
JX1510;                 North        East    Units  Estimated Accuracy
JX1510;SPC OH S     -   179,250.     657,290.     MT  (+/- 180 meters Scaled)
JX1510
JX1510                      SUPERSEDED SURVEY CONTROL
JX1510
JX1510  NGVD 29 (??/??/92)  203.778  (m)        668.56   (f) ADJ UNCH    1 2
JX1510
JX1510.Superseded values are not recommended for survey control.
JX1510.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
JX1510.See file dsdata.txt to determine how the superseded data were derived.
JX1510
JX1510_U.S. NATIONAL GRID SPATIAL ADDRESS: 17SMD285851(NAD 83)
JX1510_MARKER: DB = BENCH MARK DISK
JX1510_SETTING: 30 = SET IN A LIGHT STRUCTURE
JX1510_SP_SET: CULVERT
JX1510_STAMPING: L 246 1959
JX1510_STABILITY: D = MARK OF QUESTIONABLE OR UNKNOWN STABILITY
JX1510
JX1510  HISTORY     - Date     Condition       Report By
JX1510  HISTORY     - 1959     MONUMENTED       CGS
JX1510  HISTORY     - 1972     GOOD            OHHD
JX1510
JX1510                      STATION DESCRIPTION
JX1510
JX1510'DESCRIBED BY COAST AND GEODETIC SURVEY 1959
JX1510'3.2 MI SE FROM MALTA.
JX1510'ABOUT 3.2 MILES SOUTHEAST ALONG THE BALTIMORE AND OHIO RAILROAD
JX1510'FROM THE STATION AT MALTA, BETWEEN MILEPOLES 27+24 AND 27+25, IN
JX1510'SECTION 25, T-10-N R-12-W, 15 FEET SOUTHWEST OF THE SOUTHWEST
JX1510'RAIL, 87 YARDS NORTHWEST OF MILEPOST 28 (IRON RAIL PROJECTING
JX1510'6 1/2 FEET), 30 YARDS WEST OF A BLACK TOP ROAD CROSSING AND
JX1510'CROSSING SIGN NO. 5266, 12 1/2 FEET NORTHEAST OF THE CENTER LINE
JX1510'OF BLACK TOP ROAD, IN TOP OF THE NORTHWEST END OF THE NORTHEAST
JX1510'HEAD WALL OF A 7-FOOT CONCRETE CULVERT UNDER THE BLACK TOP ROAD,
JX1510'4 FEET WEST OF THE WEST CORNER OF A CATCH BASIN, ABOUT 1 FOOT
JX1510'ABOVE THE LEVEL OF THE TRACK AND ABOUT LEVEL WITH THE ROAD.
JX1510'NOTE-- PLACED WITNESS POST AND SIGN 16 FEET SE OF MON.
JX1510
JX1510                      STATION RECOVERY (1972)
JX1510
JX1510'RECOVERY NOTE BY OHIO HIGHWAY DEPARTMENT (NOW OHDT) 1972
JX1510'RECOVERED IN GOOD CONDITION.
```

RM2

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1       National Geodetic Survey,   Retrieval Date = JULY 27, 2006
 JX1507 ***********************************************************************
 JX1507  DESIGNATION -  P 246
 JX1507  PID        -  JX1507
 JX1507  STATE/COUNTY-  OH/MORGAN
 JX1507  USGS QUAD   -  MC CONNELSVILLE (1994)
 JX1507
 JX1507                     *CURRENT SURVEY CONTROL
 JX1507  ______________________________________________________________________
 JX1507* NAD 83(1986)-  39 38 27.    (N)    081 50 45.    (W)    SCALED
 JX1507* NAVD 88     -      205.149  (meters)    673.06   (feet)  ADJUSTED
 JX1507  ______________________________________________________________________
 JX1507  GEOID HEIGHT-        -34.09  (meters)                   GEOID03
 JX1507  DYNAMIC HT  -        205.029 (meters)    672.67  (feet)  COMP
 JX1507  MODELED GRAV-     980,036.5   (mgal)                     NAVD 88
 JX1507
 JX1507  VERT ORDER  -  FIRST     CLASS II
 JX1507
 JX1507.The horizontal coordinates were scaled from a topographic map and have
 JX1507.an estimated accuracy of +/- 6 seconds.
 JX1507
 JX1507.The orthometric height was determined by differential leveling
 JX1507.and adjusted by the National Geodetic Survey in June 1991.
 JX1507
 JX1507.The geoid height was determined by GEOID03.
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JX1507
JX1507.THE DYNAMIC HEIGHT IS COMPUTED BY DIVIDING THE NAVD 88
JX1507.GEOPOTENTIAL NUMBER BY THE NORMAL GRAVITY VALUE COMPUTED ON THE
JX1507.GEODETIC REFERENCE SYSTEM OF 1980 (GRS 80) ELLIPSOID AT 45
JX1507.DEGREES LATITUDE (G = 980.6199 GALS.).
JX1507
JX1507.THE MODELED GRAVITY WAS INTERPOLATED FROM OBSERVED GRAVITY VALUES.
JX1507
JX1507;                  NORTH        EAST    UNITS  ESTIMATED ACCURACY
JX1507;SPC OH S     -   182,360.     656,150.     MT  (+/- 180 METERS SCALED)
JX1507
JX1507                       SUPERSEDED SURVEY CONTROL
JX1507
JX1507  NGVD 29 (??/??/92)  205.353  (M)         673.73   (F) ADJ UNCH    1 2
JX1507
JX1507.SUPERSEDED VALUES ARE NOT RECOMMENDED FOR SURVEY CONTROL.
JX1507.NGS NO LONGER ADJUSTS PROJECTS TO THE NAD 27 OR NGVD 29 DATUMS.
JX1507.SEE FILE DSDATA.TXT TO DETERMINE HOW THE SUPERSEDED DATA WERE DERIVED.
JX1507
JX1507_U.S. NATIONAL GRID SPATIAL ADDRESS: 17SMD274882(NAD 83)
JX1507_MARKER: DB = BENCH MARK DISK
JX1507_SETTING: 7 = SET IN TOP OF CONCRETE MONUMENT
JX1507_SP_SET: SET IN TOP OF CONCRETE MONUMENT
JX1507_STAMPING: P 246 1959
JX1507_STABILITY: C = MAY HOLD, BUT OF TYPE COMMONLY SUBJECT TO
JX1507+STABILITY: SURFACE MOTION
JX1507
JX1507  HISTORY     - DATE     CONDITION       REPORT BY
JX1507  HISTORY     - 1959     MONUMENTED       CGS
JX1507  HISTORY     - 1972     GOOD            OHHD
JX1507
JX1507                       STATION DESCRIPTION
JX1507
JX1507'DESCRIBED BY COAST AND GEODETIC SURVEY 1959
JX1507'1 MI SE FROM MALTA.
JX1507'ABOUT 1.0 MILE SOUTHEAST ALONG THE BALTIMORE AND OHIO RAILROAD
JX1507'FROM THE STATION AT MALTA, ACROSS THE TRACK FROM A POINT, BETWEEN
JX1507'MILEPOLES 25+19 AND 25+20, IN SECTION 14, T-10-N R-12-W, 28.8
JX1507'FEET SOUTHWEST OF THE SOUTHWEST RAIL, 41 1/2 FEET SOUTH OF THE
JX1507'CENTER OF THE CROSSING OF A GRAVEL ROAD LEADING NORTH-SOUTH,
JX1507'24 1/2 FEET SOUTHEAST OF THE CROSSING SIGN 5264, 15 FEET WEST
JX1507'OF THE CENTER OF THE JUNCTION OF A GRAVEL ROAD LEADING SOUTH AND
JX1507'SOUTHEAST, 2 FEET NORTH OF A STEEL WITNESS POST, ABOUT 1/2 FOOT
JX1507'ABOVE THE LEVEL OF THE TRACK, AND SET IN TOP OF A CONCRETE POST
JX1507'PROJECTING 5 INCHES ABOVE THE GROUND.  NOTE-- REPLACED SIGN.
JX1507
JX1507                       STATION RECOVERY (1972)
JX1507
JX1507'RECOVERY NOTE BY OHIO HIGHWAY DEPARTMENT (NOW OHDT) 1972
JX1507'RECOVERED IN GOOD CONDITION.
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RM3

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1       NATIONAL GEODETIC SURVEY,   RETRIEVAL DATE = JULY 27, 2006
 JX1506 ***********************************************************************
 JX1506  DESIGNATION -  S 246
 JX1506  PID        -  JX1506
 JX1506  STATE/COUNTY-  OH/MORGAN
 JX1506  USGS QUAD   -  MC CONNELSVILLE (1994)
 JX1506
 JX1506                     *CURRENT SURVEY CONTROL
 JX1506  ___________________________________________________________________
 JX1506* NAD 83(1986)-  39 38 36.     (N)    081 51 01.     (W)    SCALED
 JX1506* NAVD 88     -      203.875  (METERS)     668.88   (FEET)  ADJUSTED
 JX1506  ___________________________________________________________________
 JX1506  GEOID HEIGHT-        -34.08  (METERS)                   GEOID03
 JX1506  DYNAMIC HT  -        203.756 (METERS)     668.49  (FEET)  COMP
 JX1506  MODELED GRAV-     980,037.2   (MGAL)                     NAVD 88
 JX1506
 JX1506  VERT ORDER  -  FIRST     CLASS II
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JX1506
JX1506.THE HORIZONTAL COORDINATES WERE SCALED FROM A TOPOGRAPHIC MAP AND HAVE
JX1506.AN ESTIMATED ACCURACY OF +/- 6 SECONDS.
JX1506
JX1506.THE ORTHOMETRIC HEIGHT WAS DETERMINED BY DIFFERENTIAL LEVELING
JX1506.AND ADJUSTED BY THE NATIONAL GEODETIC SURVEY IN JUNE 1991.
JX1506
JX1506.THE GEOID HEIGHT WAS DETERMINED BY GEOID03.
JX1506
JX1506.THE DYNAMIC HEIGHT IS COMPUTED BY DIVIDING THE NAVD 88
JX1506.GEOPOTENTIAL NUMBER BY THE NORMAL GRAVITY VALUE COMPUTED ON THE
JX1506.GEODETIC REFERENCE SYSTEM OF 1980 (GRS 80) ELLIPSOID AT 45
JX1506.DEGREES LATITUDE (G = 980.6199 GALS.).
JX1506
JX1506.THE MODELED GRAVITY WAS INTERPOLATED FROM OBSERVED GRAVITY VALUES.
JX1506
JX1506;                  NORTH        EAST    UNITS  ESTIMATED ACCURACY
JX1506;SPC OH S     -   182,630.     655,770.     MT  (+/- 180 METERS SCALED)
JX1506
JX1506                       SUPERSEDED SURVEY CONTROL
JX1506
JX1506  NGVD 29 (??/??/92)  204.079  (M)         669.55   (F) ADJ UNCH    1 2
JX1506
JX1506.SUPERSEDED VALUES ARE NOT RECOMMENDED FOR SURVEY CONTROL.
JX1506.NGS NO LONGER ADJUSTS PROJECTS TO THE NAD 27 OR NGVD 29 DATUMS.
JX1506.SEE FILE DSDATA.TXT TO DETERMINE HOW THE SUPERSEDED DATA WERE DERIVED.
JX1506
JX1506_U.S. NATIONAL GRID SPATIAL ADDRESS: 17SMD270885(NAD 83)
JX1506_MARKER: DR = REFERENCE MARK DISK
JX1506_SETTING: 36 = SET IN A MASSIVE STRUCTURE
JX1506_SP_SET: ABUTMENT
JX1506_STAMPING: S 246 1959
JX1506_STABILITY: B = PROBABLY HOLD POSITION/ELEVATION WELL
JX1506
JX1506  HISTORY     - DATE     CONDITION       REPORT BY
JX1506  HISTORY     - 1959     MONUMENTED        USGS
JX1506  HISTORY     - 1972     GOOD             OHHD
JX1506
JX1506                       STATION DESCRIPTION
JX1506
JX1506'DESCRIBED BY US GEOLOGICAL SURVEY 1959
JX1506'0.8 MI SE FROM MALTA.
JX1506'ABOUT 0.75 MILE SOUTHEAST ALONG THE BALTIMORE AND OHIO RAILROAD
JX1506'FROM THE STATION AT MALTA, ALONG THE SOUTHWEST BANK OF MUSKINGUM
JX1506'RIVER, BETWEEN MILEPOLES 25+13 AND 25+14, IN SECTION 14, T-10-N
JX1506'R-12-W, AT THE SOUTHWEST END OF REMAINS OF DAM AND LOCK ACROSS
JX1506'RIVER, 136 FEET NORTHEAST OF AND ACROSS A BLACK TOP ROAD FROM THE
JX1506'NORTHEAST RAIL, 75 FEET NORTHEAST OF THE CENTER LINE OF BLACK
JX1506'TOP ROAD, IN TOP OF SOUTHEAST PART OF CONCRETE REMAINS OF
JX1506'ABUTMENT, AND ABOUT 3 FEET ABOVE THE LEVEL OF THE ROAD.  NOTE-- SET
JX1506'POST AND SIGN NEAR BLACKTOP ROAD, 17 FEET SW OF MON.
JX1506
JX1506                       STATION RECOVERY (1972)
JX1506
JX1506'RECOVERY NOTE BY OHIO HIGHWAY DEPARTMENT (NOW OHDT) 1972
JX1506'RECOVERED IN GOOD CONDITION.
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Flood Profiles

The flood profiles for the Muskingum River near the City of McConnelsville for the 10-, 50-, 100-, and 500-year-recurrence-interval floods are presented in figure 1–F2. The locations of the cross sections for Muskingum River near the City of McConnelsville are presented in figure 1–F3.

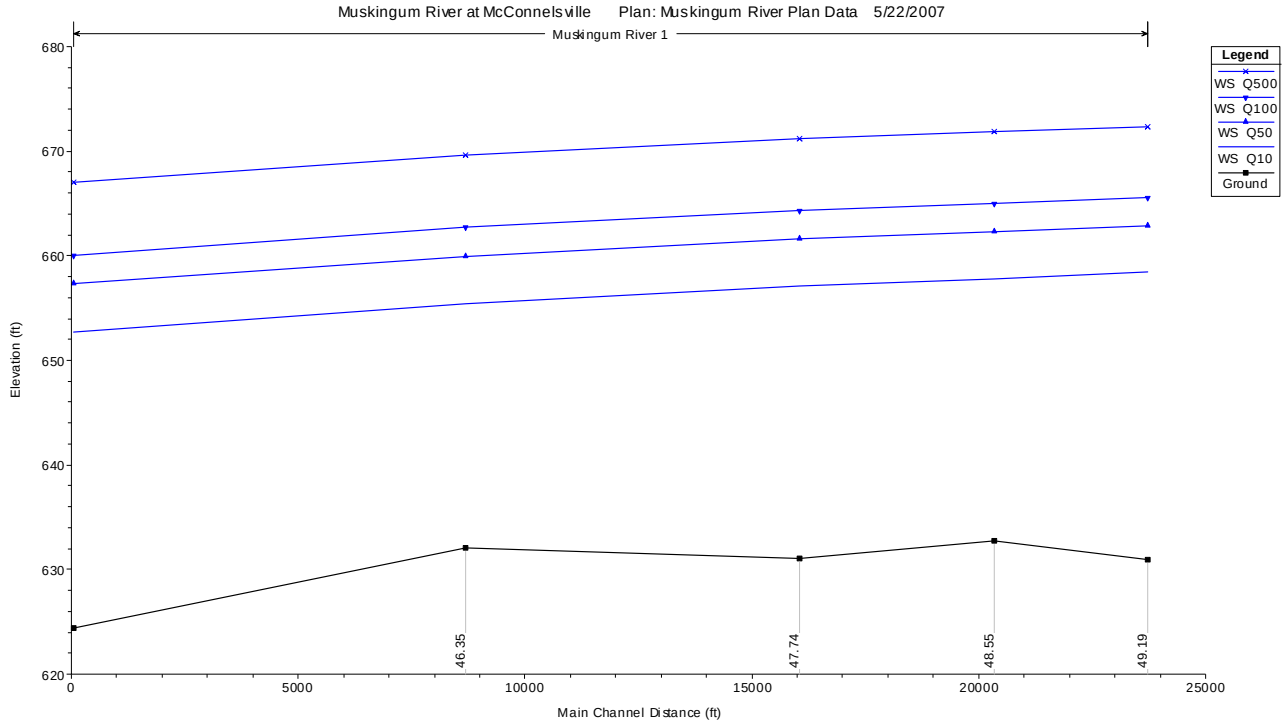

Figure 1–F2. Flood profiles for the Muskingum River near the City of McConnelsville for the 10-, 50-, 100-, and 500-year-recurrence-interval floods.

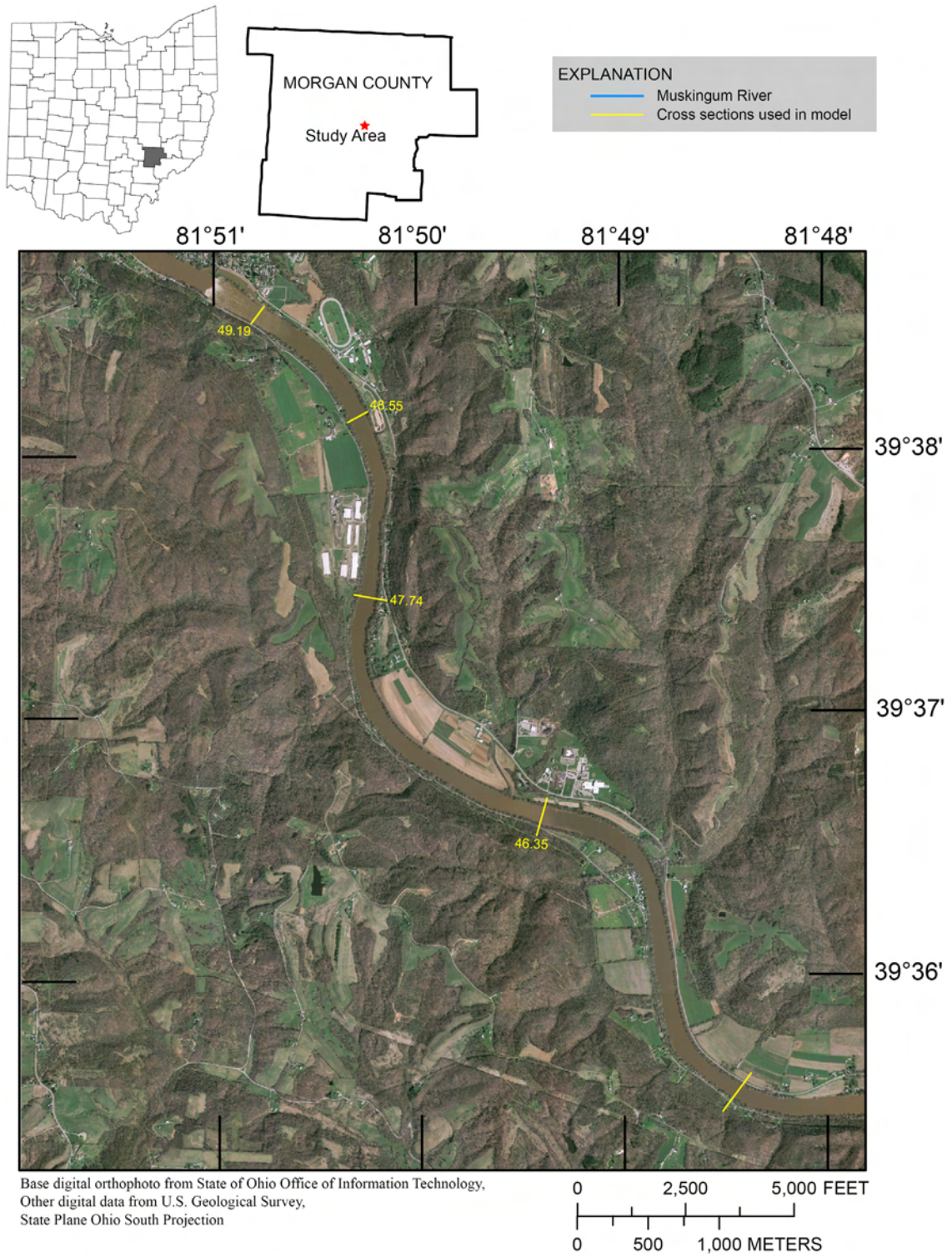

Figure 1–F3. Cross-section locations for flood profiles on Muskingum River near the City of McConnelsville, Ohio.

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