Hydraulic Analysis of U.S. Highway 75 Crossing of the Fall River at Neodesha, Southeast Kansas

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

Multiply	By	To obtain
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
inch (in.)	25.4	millimeter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

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

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ABSTRACT

A hydraulic analysis of the Fall River in the vicinity of the existing U.S. Highway 75 crossing at Neodesha, southeast Kansas, was conducted using a combination of step-backwater (WSPRO) and culvert (CAP) analysis programs. Hydraulic data for these programs were determined from onsite inspections and surveys, and from previously conducted Flood Insurance Studies (FIS). Discharge values with their appropriate recurrence intervals also were obtained from the previous FIS.

The computation of water-surface elevations using step-backwater and culvert analyses indicate that free flow occurs through all drainage structures for all discharges equal to or less than those having a 100-year recurrence interval (40,000 cubic feet per second) and the water-surface elevations are lower than the lowest point on the roadway. The total capacity of the three drainage-structure openings is sufficient at the 500-year recurrence-interval discharge (55,000 cubic feet per second) to prevent flow over the roadway. Flow over the roadway begins when total discharge exceeds about 58,000 cubic feet per second.

INTRODUCTION

Background

The Kansas Department of Transportation (KDOT) is proposing the realignment of a 1-mi section of U.S. Highway 75 where it crosses the Fall River and its associated flood plain west of the city of Neodesha, southeast Kansas (fig. 1). The construction project proposed by KDOT will include realignment of the existing U.S. Highway 75 roadway, including new road grade and replacement or modification of existing drainage structures. The western terminus of the proposed highway section will join the planned realignment of the existing roadway and new construction of State Highway K–96 approximately 1 mi west of Neodesha (fig. 1).

The current (1996) primary drainage structure is a 120-ft concrete, rainbow-arch bridge that spans the main channel of the Fall River (fig. 2*A*). The roadway embankment continues to the west and southwest crossing the flood plain of the Fall River, which is about 1 mi wide. Flow-relief drainage structures under the roadway consist of a 322-ft concrete bridge 1/2 mi west of the main-channel bridge (fig. 2*B*) and an 11-barrel, concrete box culvert 1/8 mi farther west (fig. 2*C*). A hydraulic analysis of flow conditions for the existing bridge and roadway structures associated with the U.S. Highway 75 crossing of the Fall River at Neodesha is needed to compare flow conditions for several design options for the proposed Fall River crossing.

The U.S. Geological Survey (USGS) performed an investigation, in cooperation with KDOT, to provide an objective analysis of the existing flow conditions and water-surface profiles for increasingly large flow discharges for the Fall River near the U.S. Highway 75 crossing at Neodesha. Results of the investigation will add valuable knowledge as to how different types of drainage structures affect the flow characteristics of streams.

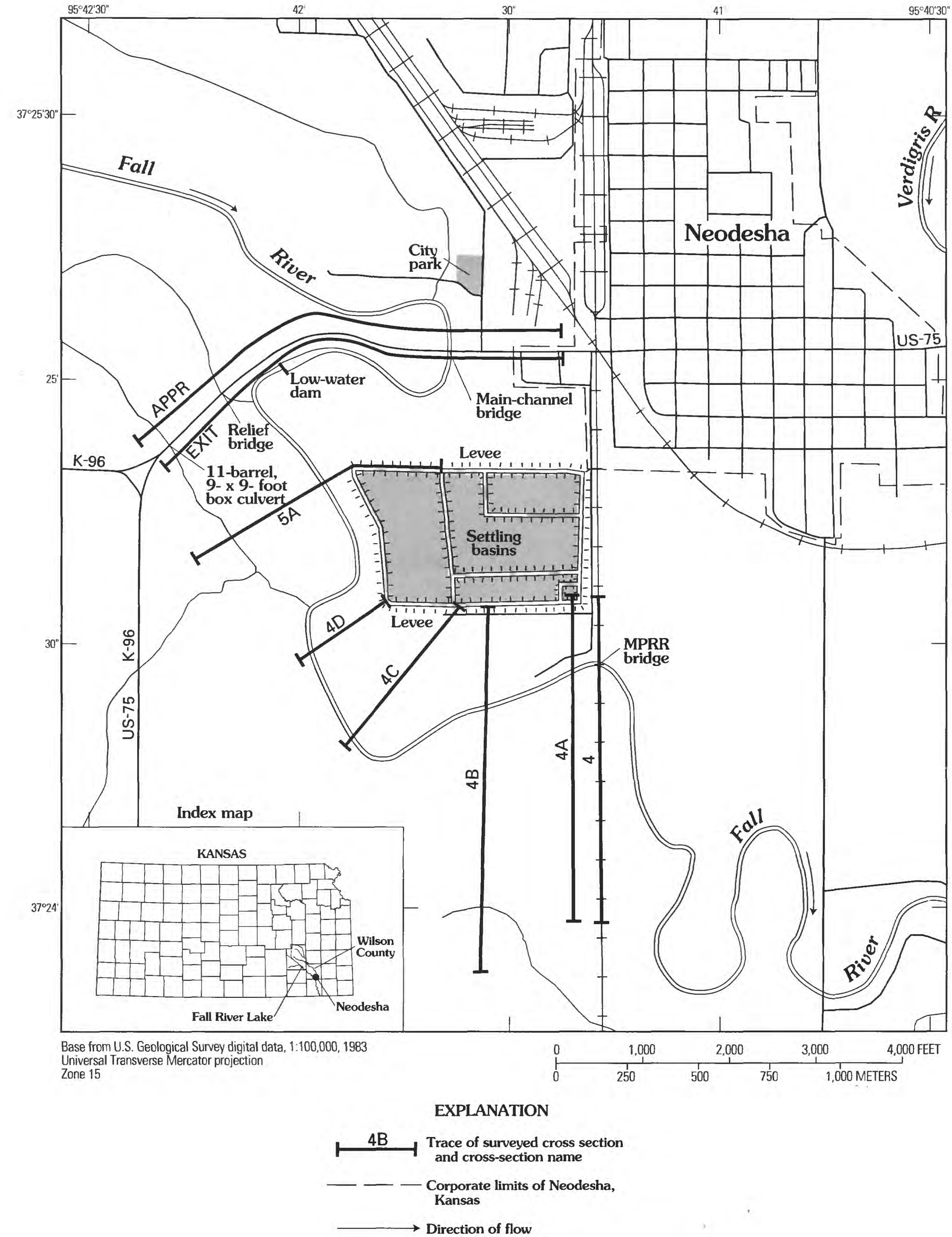

Figure 1. Vicinity of Neodesha, southeast Kansas, and location of surveyed cross sections.

A. Main-channel bridge—120-foot, rainbow-arch bridge spanning main channel of Fall River west of Neodesha (view from upstream).

B. Relief bridge—322-foot concrete bridge with 13 piers approximately 1/2 mile west of main-channel bridge (view from upstream).

C. Concrete box culvert (11-barrel, 9- by 9- foot)—1/8 mile west of relief bridge (view from downstream).

Figure 2. Drainage structures at U.S. Highway 75 crossing of Fall River at Neodesha, Kansas.

Purpose and Scope

This report describes the investigation of hydraulic (flow) conditions downstream and through the existing structures of U.S. Highway 75 and provides water-level computations for an approach (APPR) section approximately 300 ft upstream from the roadway. Flow conditions for the 50-year, 100-year, and 500-year recurrence-interval discharge values are determined as well as the discharge at which flow occurs over the road. This report describes existing hydrologic data, the collection of additional hydrologic data, development of a hydraulic flow model, and use of the model to investigate current (1996) flow conditions.

DESCRIPTION OF SITE

Flood Plain

The flood plain of the Fall River at Neodesha is about 1 mi wide, fairly straight, and oriented in a northwest-to-southeast direction (fig. 1). The main channel meanders considerably across the valley floor. Vegetation in the overflow section of the channel consists of various crops and grasses, with scattered trees along the banks of the river, along ditches, and at the edges of agricultural fields. Levees constructed for settling basins approximately 2/3 mi downstream from the main-channel bridge create a significant constriction to the flood plain. Approximately 5 river mi downstream from the U.S. Highway 75 crossing, the Fall River joins the Verdigris River. The city of Neodesha is located on the slightly higher ground between the two rivers where the land surface has a relief of less than 20 ft (U.S. Department of Housing and Urban Development, 1978). The flood plain extends along the western edge of the city of Neodesha; hence, only small parts of the city are located within the flood plain. However, the city park and several dwellings are located within the flood plain.

Main Channel

The main channel of the Fall River is well defined and incised into the valley floor with streambanks that average about 25 ft high. The flow in the main channel is perennial, averaging about 2 ft in depth. Throughout the study area, the banks of the river are lined with vegetation, primarily sparse brush and trees 8 to 14 in. in diameter. The streambed is primarily clayey silt with occasional rock outcrops that become riffles at low-flow regimes.

The main channel meanders considerably and, in particular, makes two 90-degree bends to the right near the main-channel bridge. One of these bends is located immediately upstream from the main-channel bridge and the other immediately downstream from the structure. The channel parallels the road embankment for about 1/4 mi where a low-water dam maintains a pool of water for the city park. The dam is approximately 8 ft high but becomes submerged at high flows and does not affect water-surface elevations at high river stages.

Existing Alignment and Features of U.S. Highway 75

The section of U.S. Highway 75 that crosses the flood plain of the Fall River is about 1 mi in length. The roadway is 24 ft wide with approximately 8-ft-wide gravel shoulders. The pavement is asphalt. The roadway embankment is on a 4:1 slope and varies from approximately 0 to 10 ft above the flood plain. Elevation of the west end of the roadway embankment increases rapidly after crossing the Fall River flood plain. However, elevations along the east end rise only slightly as U.S. Highway 75 enters the city of Neodesha. The lowest elevation along the U.S. Highway 75 roadway is at the deck of the 11-barrel, 9- by 9-foot box culvert with an elevation of 803.4 ft above sea level. In comparison, the roadway embankment entering Neodesha is at 804.0 ft above sea level.

There are three existing drainage structures under the U.S. Highway 75 roadway. The primary drainage structure is a 120-ft rainbow-arch bridge constructed about 1924 (fig. 2*A*). The bridge is located over the main channel at the eastern edge of the flood plain. Low-chord elevation of the main-channel bridge is at 801.6 ft above sea level. There is slight constriction of flow through the bridge opening.

Two relief structures also are located under the roadway as it crosses the flood plain. The largest relief structure is a 13-bay, concrete-pier bridge with a 322-ft opening (fig. 2*B*). It is located about 1/2 mi west of the main-channel bridge. Low chord is at an elevation of

801.2 ft above sea level. The other relief structure is a culvert consisting of eleven 9- by 9-ft concrete boxes (fig. 2*C*), located approximately 1/8 mi west of the 13-bay, concrete-pier bridge. Generally, this culvert conveys local runoff under the roadway but provides relief for overbank flow during high-flow periods. Minimum and maximum elevations of the culvert inlet are 792.2 and 801.2 ft above sea level, respectively.

HYDROLOGY

The Fall River Basin has a drainage area of approximately 880 mi^2. Floodflows have been regulated since 1949 with the completion of Fall River Lake located upstream approximately 50 mi (fig. 1, index map). Fall River Lake controls runoff from 585 mi^2 (or 66 percent of the Fall River Basin at Neodesha). Floodflows are significantly reduced downstream from Fall River Lake and are controlled by the U.S. Army Corps of Engineers, Tulsa Oklahoma District. The nearest streamflow-gaging station to Neodesha on the river is Fall River at Fredonia (USGS station number 07169500), approximately 20 mi upstream. Highest flows at this location since closure of Fall River Lake were 32,800 ft^3/s on October 3, 1986, and 31,000 ft^3/s on April 28, 1994 (Geiger and others, 1987, 1995).

Streamflow discharges used in this study are those that were established in conjunction with Flood Insurance Studies (FIS) conducted by the U.S. Department of Housing and Urban Development, Federal Insurance Administration, for the city of Neodesha (1978) and Wilson County (1989). The program is currently administered by the Federal Emergency Management Agency (FEMA). The 50-year recurrence-interval flood discharge was determined to be 34,000 ft^3/s; the 100-year flood discharge was 40,000 ft^3/s, and the 500-year flood discharge was 55,000 ft^3/s (U.S. Department of Housing and Urban Development, 1978, 1989).

FALL RIVER VALLEY CROSS SECTIONS

Cross-sectional data (cross sections 4, 4A, 4B, and 4C, fig. 1) were available from the previously published FIS studies completed in 1978 and 1989. This information was sufficient to compute a starting elevation for the river reach downstream from the settling basins. However, this information lacked adequate definition of the overflow areas farther upstream; hence, additional data were collected by USGS personnel. These data included two additional channel cross sections (4D and 5A), an exit section (EXIT), a roadway profile, roadway-embankment cross sections, an approach section (APPR), and geometric details of the three drainage structures. Bridge and culvert elevations were either surveyed or taken from original construction plans (on file with Kansas Department of Transportation, Topeka, Kansas). Channel roughness coefficients were estimated from onsite inspection and from photographs of the channel, overflow sections, and drainage structures.

Cross section 4D (fig. 3) was located at the narrowest part of the valley as a result of encroachment of the flood plain by the levee for the settling basins. Cross section 5A (fig. 4) was substantially wider because part of the settling-basin levee had been removed. This cross section also had two small channels that drained the flood plain of the Fall River. The EXIT cross section (fig. 5) was surveyed just downstream from U.S. Highway 75. The roadway profile, openings of the main-channel bridge, relief bridge, and the box culvert, and the approach section (APPR) are shown in figure 6.

HYDRAULIC ANALYSIS

WSPRO Step-Backwater Program

The hydraulic flow model used in this investigation is WSPRO (Water Surface Profile) (Shearman, 1990). The WSPRO model was developed by the U.S. Geological Survey in cooperation with the U.S. Department of Transportation, Federal Highway Administration (FWA). It is a step-backwater-type model that integrates computation routines to define the flow through bridge openings (Matthai, 1967) and flow over the roadway. It uses one-dimensional, gradually varied, steady-state conditions to estimate water elevations in open channels (Davidian, 1984). The model is flexible and can be easily used to investigate different flow discharges as well as various drainage and roadway geometries. However, it is not well adapted for concurrently calculating flow characteristics through culverts.

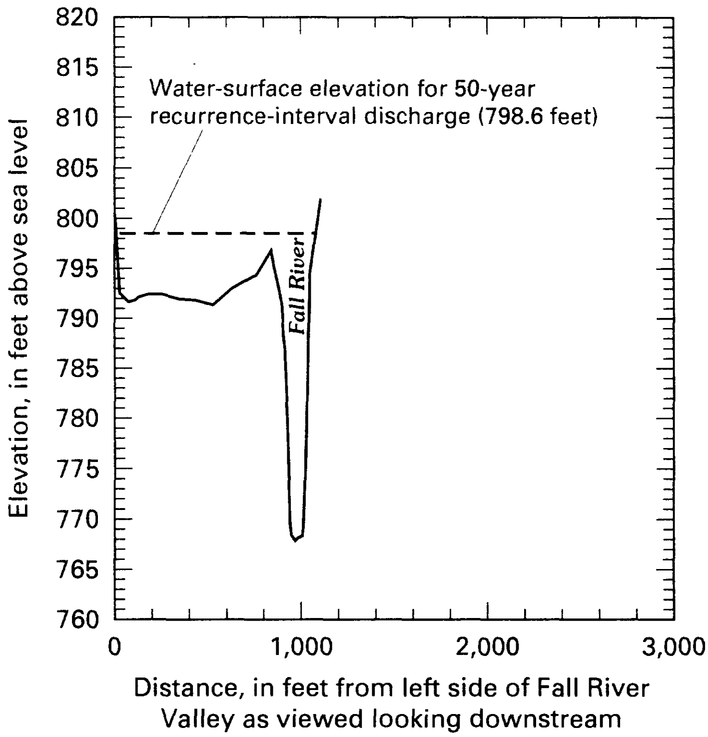

Figure 3. Cross section 4D across the Fall River near Neodesha, Kansas, with water-surface elevation for 50-year recurrence-interval discharge. Trace of cross section shown in figure 1.

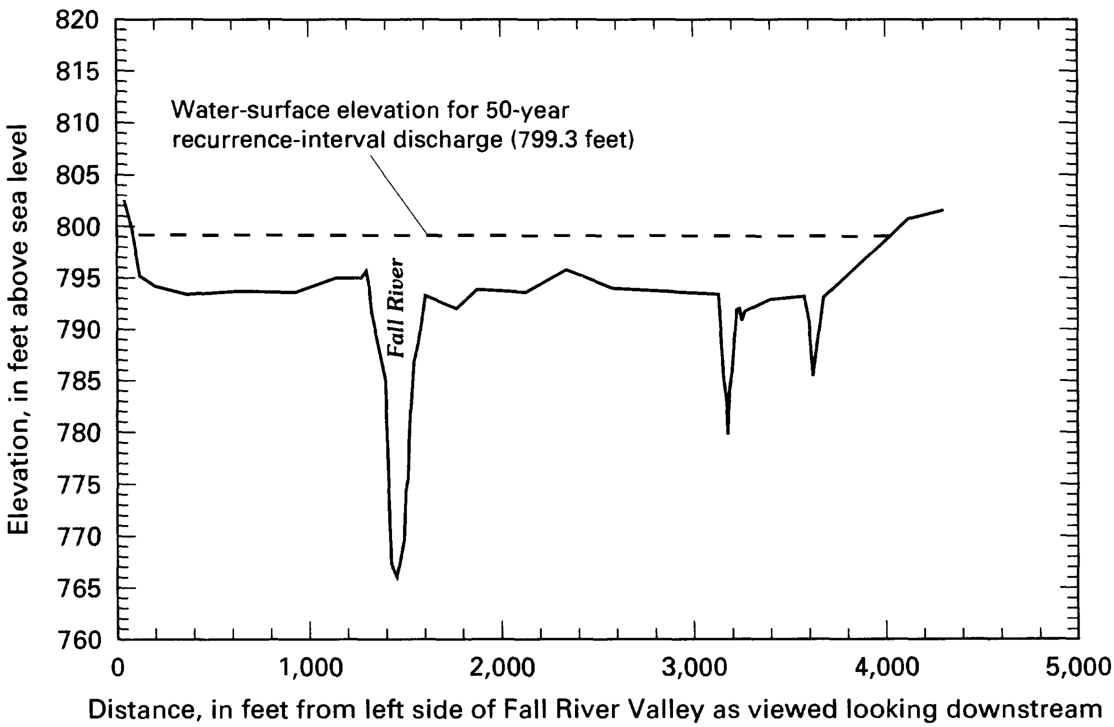

Figure 4. Cross section 5A across the Fall River near Neodesha, Kansas, with water-surface elevation for 50-year recurrence-interval discharge. Trace of cross section shown in figure 1.

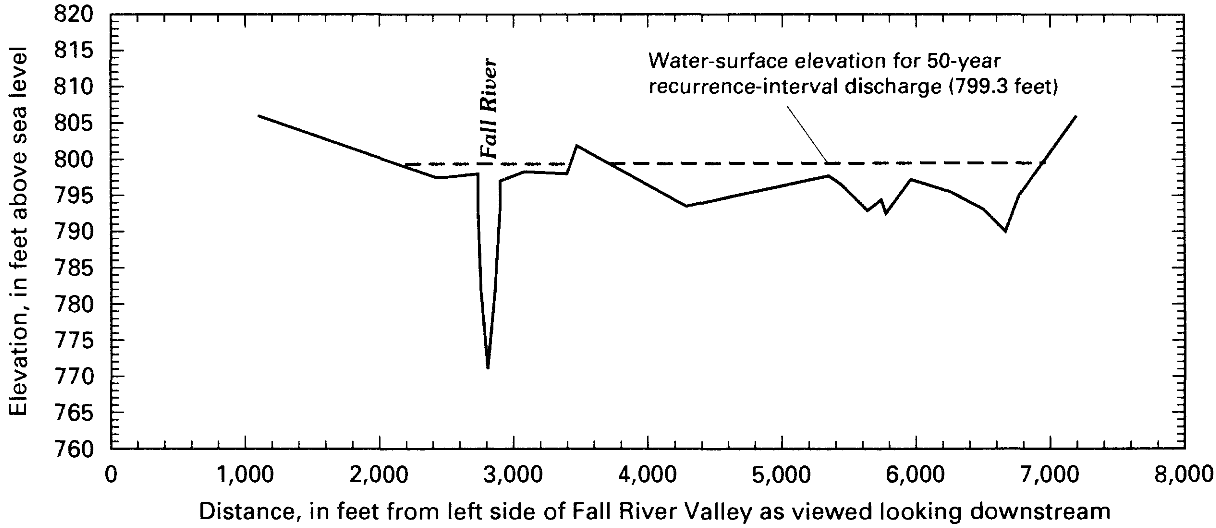

Figure 5. Cross section EXIT across the Fall River near Neodesha, Kansas, with water-surface elevation for 50-year recurrence-interval discharge. Trace of cross section shown in figure 1.

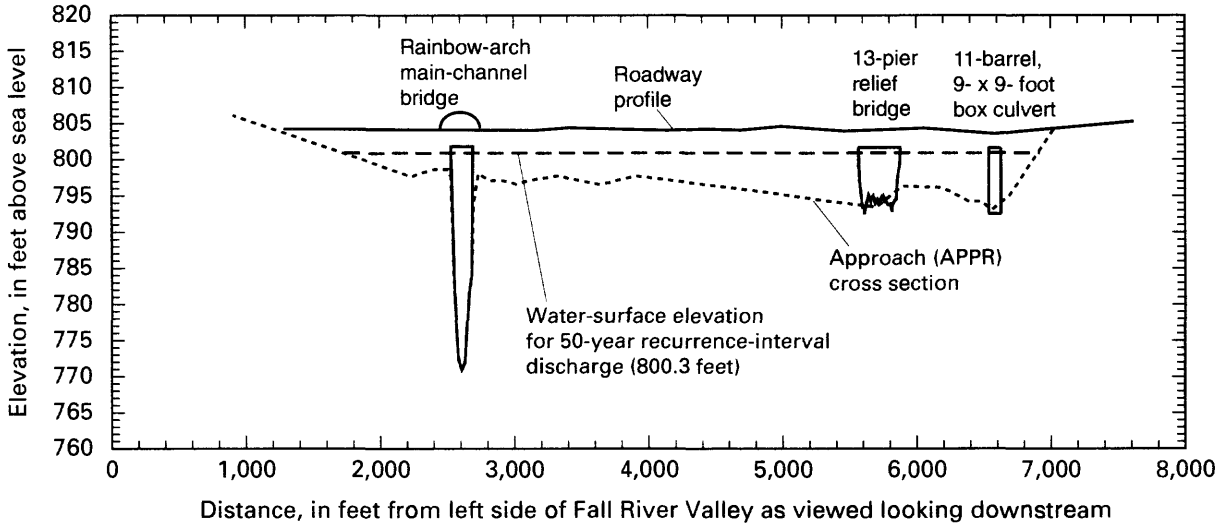

Figure 6. Cross section APPR and roadway profile across the Fall River near Neodesha, Kansas, and flow-structure openings with water-surface elevation for 50-year recurrence-interval discharge. Trace of cross section shown in figure 1.

Culvert Analysis Program

The culvert analysis program (CAP) (Fulford, 1995) was used to determine the flow characteristics through the culvert flow-relief structure. This program is based on the information presented in Bodhaine (1968). CAP uses input files that have formats compatible with those used by the WSPRO program (see "Appendix"); it computes water profiles at culverts under various flow conditions.

Water-Surface Profiles

Starting water-surface elevations at cross section 4D for each flow discharge were determined by an iterative process of computing a normal depth of flow using WSPRO and cross sections 4A, 4B, 4C, and 4D. Profiles for each discharge were continued upstream using the appropriate starting water-surface elevation for each discharge.

At average discharge (approximately 500 ft^3/s), the flow of the Fall River is entirely contained within the banks of the main channel. Bank overflow begins when flow in the main channel exceeds about 13,000 ft^3/s. As the overbank flow increases, an ever-increasing proportion of the total discharge flows through the relief structures. The proportion of the total discharge flowing through each drainage structure was determined by balancing the energy gradient upstream from each structure. The discharge was varied until the same energy-gradient value was obtained in the approach (APPR) section that was partitioned for each drainage structure. Discharges for each drainage structure for the selected total-discharge values used in this analysis are listed in table 1.

The water-surface profiles for the various total discharges modeled for the Fall River are shown in figure 7. For the 50-year recurrence-interval discharge (34,000 ft^3/s), all drainage-structure openings have sufficient conveyance to prevent the water surface from reaching the lowest chord elevation of any of the relief structures. Backwater from the highway embankment is indicated to be approximately 0.7 ft. At the 100-year recurrence-interval discharge (40,000 ft^3/s), the backwater is approximately 1.7 ft, but the roadway minimum elevation is 1.6 ft higher. First, the culvert inlet becomes submerged at an elevation of 801.2 ft above sea level and conveyance decreases. As the total discharge increases, the upstream water-surface elevation increases until all structures have their openings completely filled by the discharge of 60,000 ft^3/s, and the highway backwater becomes approximately 2.3 ft. At the 500-year recurrence-interval discharge (55,000 ft^3/s), the water-surface elevation is within 0.3 ft of the minimum roadway elevation. At approximately 58,000 ft^3/s, flow over the road commences. Total discharge of 60,000 ft^3/s results in flow of approximately 200 ft^3/s over the roadway at a maximum depth of 0.6 ft.

SUMMARY

The Kansas Department of Transportation has proposed realignment of U.S. Highway 75 where it crosses the Fall River and its associated flood plain west of the city of Neodesha, southeast Kansas. A hydraulic analysis of the existing main-channel bridge and overflow relief structures under the highway west of the main channel was made to determine the existing water-surface profiles for various stream discharges. For a 50-year recurrence-interval discharge of 34,000 ft^3/s, the analysis showed that the U.S. Highway 75 crossing

Table 1. Distribution of total discharge, in cubic feet per second, among three drainage structures at U.S. Highway 75 crossing of the Fall River and water-surface elevations, in feet above sea level, at the APPR cross section upstream from the crossing

Drainage structure	Discharge, in cubic feet per second	Water-surface elevation, in feet	Discharge, in cubic feet per second	Water-surface elevation, in feet	Discharge, in cubic feet per second	Water-surface elevation, in feet	Discharge, in cubic feet per second	Water-surface elevation, in feet	Discharge, in cubic feet per second	Water-surface elevation, in feet
Main-channel bridge	22,500	800.4	24,550	801.9	30,200	802.5	33,000	803.1	34,750	804.1
Relief bridge	6,000	800.4	8,800	801.9	11,400	802.5	12,900	803.1	14,875	804.1
Culvert	5,500	800.4	6,650	801.9	8,400	802.5	9,100	803.1	10,375	804.1
Total discharge	**[1]34,000**		**[2]40,000**		**50,000**		**[3]55,000**		**60,000**	

[1]Discharge equal to that having a 50-year recurrence interval.
[2]Discharge equal to that having a 100-year recurrence interval.
[3]Discharge equal to that having a 500-year recurrence interval.

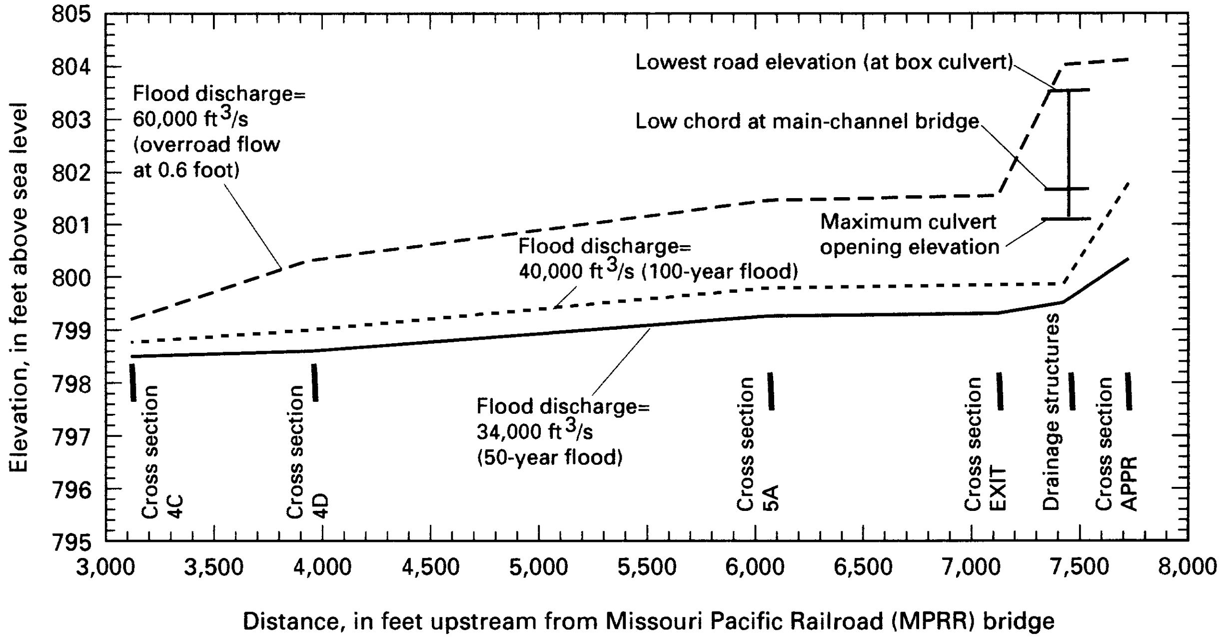

Figure 7. Water-surface profiles, in feet above sea level, for the Fall River at Neodesha, Kansas, for various flood discharges, in cubic feet per second (ft^3/s). Location of cross sections shown in figure 1.

causes a 0.7-ft increase in the water-surface elevation. At the 100-year recurrence-interval discharge of 40,000 ft^3/s, the increase is 1.7 ft, but the water surface upstream is at an elevation of 801.8 ft above sea level, which is 1.6 ft below the minimum road elevation. At the 500-year recurrence-interval discharge of 55,000 ft^3/s, the water surface is 0.3 ft below the roadway. Flow over the road begins when total discharge exceeds about 58,000 ft^3/s, and at 60,000 ft^3/s, approximately 200 ft^3/s, of water flows over the road.

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APPENDIX—WSPRO AND CAP DATA FILES

WSPRO

```
T1          FALL RIVER AT NEODESHA, KANSAS - U.S. Highway 75 BRIDGE SITE
T2          Water-surface computation from cross-section 4D to EXIT cross section
T3                                    FALL RIVER
J3            5 23 7 11 14 4 6 3
Q            34000.0  40000.0  50000.0  60000.0
WS            798.60   799.00   799.69   800.32
*             new section
XS       4D   3945.0       *      0.3      0.1
GR               0.0 802.0   22.0 796.6   33.0 792.5   79.0 791.6  116.0 791.8
GR             133.0 792.1  186.0 792.4  255.0 792.4  349.0 791.9  431.0 791.8
GR             527.0 791.3  629.0 793.0  741.0 794.2  759.0 794.3  839.0 796.8
GR             853.0 795.2  869.0 793.8  880.0 792.8  894.0 791.3  903.0 788.2
GR             911.0 786.8  924.0 779.5  938.0 769.3  944.0 768.2  964.0 767.6
GR             979.0 767.9 1002.0 768.1 1008.0 769.1 1016.0 773.0 1026.0 779.4
GR            1043.0 794.5 1100.0 802.0
N              0.035           0.045           0.040
SA                     853.0           894.0
*
*             new section
XS       5A   6060.0       *      0.3      0.1
GR               0.0 802.8   37.0 800.2   80.0 795.4  161.0 794.4  324.0 793.6
GR             588.0 793.9  892.0 793.8 1106.0 795.2 1238.0 795.2 1265.0 795.9
GR            1279.0 794.4 1290.0 791.9 1362.0 785.3 1374.0 778.4 1391.0 767.4
GR            1422.0 766.1 1459.0 769.7 1472.0 775.0 1480.0 775.6 1487.0 779.8
GR            1495.0 782.5 1512.0 787.0 1536.0 788.9 1572.0 793.5 1736.0 792.2
GR            1844.0 794.1 2097.0 793.8 2311.0 796.0 2553.0 794.2 2904.0 793.6
GR            2929.0 785.3 2944.0 783.1 2951.0 779.9 2959.0 784.3 2974.0 786.2
GR            2998.0 792.1 3013.0 792.2 3024.0 791.0 3040.0 791.9 3172.0 793.1
GR            3452.0 793.4 3476.0 791.0 3496.0 785.6 3552.0 793.3 3900.0 801.0
GR            4150.0 803.0
N              0.040   0.035  0.045   0.035  0.040   0.035   0.045   0.045
SA                 1265.0   1572.0  2311  3804   3940    4276    4352
*
XS    DNSTM 7116.0       *      0.3      0.1  0.0015
GR          900.0   806.0  2225.0  797.5  2300.0  797.5  2540.0  798.0
GR         2540.0   793.0  2560.0  782.0  2610.0  771.0  2665.0  782.0
GR         2705.0   793.5  2705.0  797.0  2885.0  798.3  3202.0  798.0
GR         3275.0   801.9  4090.0  793.5  5150.0  797.7  5245.0  796.5
GR         5440.0   792.9  5545.0  794.4  5580.0  792.5  5765.0  797.2
GR         6060.0   795.5  6305.0  793.1  6470.0  790.0  6570.0  795.0
GR         7000.0   806.0
N           0.055       0.035        0.055        0.040       0.035    0.035
SA                2540         2705         3275         5150       5765
*
EX
ER
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```
T1        FALL RIVER AT NEODESHA, KANSAS - U.S. HWY 75 BRIDGE SITE
T2        Water-surface computation from EXIT cross section through embankment
T3                         FALL RIVER - Main-channel bridge
J3         5 23 7 11 14 4 6 3
*            34k     40k     50k     60k
Q           22400   25625   30200   33974
WS         799.37  799.82  800.82  801.65
XS    DNSTM 7116.0      *      0.3     0.1  0.0015
GR          900.0  806.0  2225.0  797.5  2300.0  797.5  2540.0  798.0
GR         2540.0  793.0  2560.0  782.0  2610.0  771.0  2665.0  782.0
GR         2705.0  793.5  2705.0  797.0  2885.0  798.3  3202.0  798.0
GR         3275.0  801.9  3275.0  806.0
N           0.055       0.035        0.055
SA               2540         2705
Q             22380
*
XS    FULLV 7416.0      *      0.3     0.1
*
BR    MCHBR   7416.0  801.6     0.0
GR            2520.0  801.6   2520.0  797.5   2545.0  782.0   2575.0  772.5
GR            2600.0  771.0   2625.0  772.0   2655.0  781.5   2675.0  784.0
GR            2685.0  801.6   2520.0  801.6
N              0.045           0.040
SA                  2655.0
CD              2  32.0  2.5  801.6
*                BL            165 2520 2685
*
XR    RDWY   7416   32  1   0.90 0
GR               0.0   803.96      325.0   803.96      484.0   803.95
GR             515.0   803.95      770.0   804.30     1140.0   804.11
GR            1512.0   803.93     1782.0   804.12     2068.0   803.97
GR            2370.0   804.51     2845.0   803.83     3455.0   804.24
GR            3982.0   803.45     4270.0   803.94     5032.0   805.18
N              0.015
BP           325.0 484 16 16
*
AS    UPSTM 7716.0      *      0.3     0.1
GR          900.0 806.0 2225.0 797.5  2300.0 798.0  2400.0 798.5  2500.0 798.5
GR         2520.0 797.5 2545.0 781.5  2575.0 772.5  2600.0 771.0  2625.0 772.0
GR         2655.0 781.5 2675.0 784.0  2685.0 793.5  2725.0 798.0  2800.0 797.0
GR         2900.0 797.0 3000.0 796.5  3100.0 797.0  3310.0 797.6  3630.0 796.4
GR         3890.0 797.6 3890.0 806.0
N            0.040           0.040           0.040
SA                  2300.0          3000.0
*
EX
ER
```

```
T1        FALL RIVER AT NEODESHA, KANSAS - U.S. HWY 75 BRIDGE SITE
T2        Water-surface computation from EXIT cross section through embankment
T3                     FALL RIVER -  Main relief structure
J3         5 23 7 11 14 4 6 3
*           34k      40k        50k       60k
Q          6100.0   7825.0   11400.0  14554.0
WS         799.37   799.82    800.82   801.65 801.65
XS    DNSTM 7116.0       *      0.3      0.1  0.0015
GR         3275.0  806.0  3275.0  801.9  4090.0  793.5  5150.0  797.7
GR         5245.0  796.5  5440.0  792.9  5545.0  794.4  5580.0  792.5
GR         5765.0  797.2  5765.0  806.0
N           0.040       0.035
SA                5150
*
XS    FULLV 7416.0       *      0.3      0.1
*
BR    LOBBR 7416.0  802.2  0.0
GR            0.0  802.2   0.0  798.4    8.0  796.7  18.0  795.1  30.0  793.3
GR           32.5  793.4  43.0  792.9   46.0  792.1  54.0  792.8  62.0  793.3
GR           65.0  793.7  79.0  794.7   95.0  793.9  97.0  794.1 114.0  794.6
GR          127.0  793.8 130.0  793.6  146.0  794.1 154.0  793.6 162.0  793.8
GR          180.0  794.5 193.0  794.1  195.0  794.4 200.0  794.2 225.0  793.4
GR          228.0  793.4 244.0  793.5  258.0  792.4 260.0  793.3 278.0  794.0
GR          289.0  794.1 292.0  795.5  300.0  797.2 316.0  798.6 322.0  801.2
GR            0.0  802.2
N             0.035
*          pier width
PW 0        793.0,20.3   800.2,20.3 800.2,27.0 801.2,27.0
CD             2  32.0  2.5  801.2  *   *
*               BL             322   5330  5682
*
XR    RDWY   7416   32  1   0.90 0
GR              0.0   803.96      325.0   803.96      484.0   803.95
GR            515.0   803.95      770.0   804.30     1140.0   804.11
GR           1512.0   803.93     1782.0   804.12     2068.0   803.97
GR           2370.0   804.51     2845.0   803.83     3455.0   804.24
GR           3982.0   803.45     4270.0   803.94     5032.0   805.18
N             0.015
BP          325.0 484 16 16
*
AS    UPSTM 7716.0       *      0.3      0.1
GR         3890.0 806.0  3890.0 797.6 4760.0 795.6  5330.0 794.1
GR         5682.0 793.3  5875.0 796.2 5875.2 806
N             0.040
*
EX
ER
```

```
*     Culvert computation - CAP
*     Water-surface computation from EXIT cross section through embankment
ID        FALL R - Culvert 60k tot.
*     SECID  SRD     XCTR    CULENG  DSINV     USINV    NBBL
CV    CULRT 7416.0  5800     50.0   792.00    792.25    11
*
*             ICODE RISE   SPAN
CG              116  108   1188
*            34k     40k      50k       60k
*CQ          5500.0  6550.0  8400.0  10250.0
*CX          799.37  799.82   800.82   801.64801.65
*CN          0.015
*CF          5
*C1
*C3        1.0750  1.0700 30 1
*C5        0.96   0.46,1.5 0.52,2.0 0.56,3.0 0.58,5.0
*     SECID  SRD
XS    APPR  7716.0
GR          3800.0 804.0 3890.0 797.6 4760.0 795.6  5330.0 794.1  5682.0 793.3
GR          5875.0 796.2 6170.0 796.0 6370.0 794.1  6460.0 794.1  6540.0 792.9
GR          6672.0 794.9 7000.0 804.0
N             0.040
*PD         0 22 1.1
```