Modified Level II Streambed-Scour Analysis for Structure I-74-70-4437 Crossing Eagle Creek in Marion County, Indiana

By BRET A. ROBINSON, DAVID C. VOELKER, and ROBERT L. MILLER

Prepared in cooperation with the
INDIANA DEPARTMENT OF TRANSPORTATION

U.S. GEOLOGICAL SURVEY
Open-File Report 97-308

Indianapolis, Indiana
1997

U.S. DEPARTMENT OF THE INTERIOR
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Tables

CONVERSION FACTORS AND ABBREVIATIONS

Multiply	By	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
square foot (ft^2)	929.0	square centimeter
feet per second (ft/s)	0.3048	meters per second
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

ABBREVIATIONS used in this report:

D_{50}	median diameter of bed material
Q100	100-year discharge
FEMA	Federal Emergency Management Agency
HEC	Hydraulic Engineering Circular
IDNR	Indiana Department of Natural Resources
INDOT	Indiana Department of Transportation
USGS	United States Geological Survey
WSPRO	Water Surface PROfile model

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By Bret A. Robinson, David C. Voelker, *and* Robert L. Miller

ABSTRACT

Level II scour evaluations follow a process in which hydrologic, hydraulic, and sediment-transport data are evaluated to calculate the depth of scour that may result when a given discharge is routed through a bridge opening. The results of the modified Level II analysis for structure I-74-70-4437 on Interstate 74 crossing Eagle Creek in Marion County, Indiana, are presented. The site is near the town of Clermont in the northwestern part of Marion County. Scour depths were computed with the Water Surface PROfile model, version V050196, which incorporates the scour-calculation procedures outlined in Hydraulic Engineering Circular No. 18. Total scour depths at the piers were approximately 16.0 feet for the modeled discharge of 22,700 cubic feet per second and approximately 31.7 feet for the modeled discharge of 31,600 cubic feet per second.

INTRODUCTION

The U.S. Geological Survey (USGS), in cooperation with the Indiana Department of Transportation (INDOT), is conducting Level II scour analyses at a number of bridges throughout Indiana. This report describes the methods applied and the modeling results for bridge I-74-70-4437.

Background and Scope

Level I scour assessment is a process where a large number of bridges are studied as a group. Assessments usually are made by evaluating a combination of geomorphic, hydrologic, and bridge-characteristic data. The results help investigators determine which bridges appear to be most likely to experience streambed-scour problems and which bridges appear to be relatively immune to problems brought on by streambed scour (for example, bridges built on bedrock).

When applied correctly, Level I scour assessments provide an investigator with information to identify those bridges that appear to be relatively safe and those bridges that fall into higher risk categories.

Level II scour evaluations describe the process for an investigator to apply a model to a bridge site and calculate the potential depth of scour that may result from a given flood event. Level II analyses involve the application of basic hydrologic, hydraulic, and sediment-transport engineering concepts and may include an evaluation of flood history, channel hydraulic conditions (for example, water-surface profile analysis), and basic sediment-transport analyses such as scour calculations (Lagasse and others, 1995).

The methods and model outlined in Hydraulic Engineering Circular (HEC) No. 18 (Richardson and Davis, 1995) formulate the basis for Level II scour evaluations. Methods used in this study for Level II scour evaluations are a modification of the HEC-18 standards. These modifications were made to comply with the methodology requested by INDOT (Merril Dougherty, Indiana Department of Transportation, oral commun., 1996). Descriptions of the specific modifications are given in the "Evaluation Methods" section of this report.

This report presents the methods followed for modeling, special considerations for this study site, and the input for and the output from the Water Surface PROfile (WSPRO) model.

Site Description

The study site is located near the town of Clermont in the northwestern part of Marion County. This site is immediately downstream from the Eagle Creek Reservoir Dam. The drainage area for the site is approximately 168 mi^2 (estimated using Hoggatt, 1975, and USGS 7.5-minute topographic data). The predominant land uses in the basin are suburban and agricultural; in the immediate vicinity of the bridge, the land is predominantly grassy with forest nearby.

Within the immediate vicinity of the bridge, Eagle Creek has a channel-bed slope of approximately 0.0012 ft/ft. The channel-bed material is cobbley sandy silt-clay, and the channel banks consist of gravelly sandy silt/clay. At the time of the Level I site visit on June 26, 1995, the banks were observed to have 0 to 50 percent woody vegetative cover; the field report noted that the banks were experiencing some fluvial erosion.

The Interstate 74 crossing of Eagle Creek is a 252-ft-long, multi-lane bridge consisting of five spans supported by concrete and steel piers and sloping earthen spill-through abutments. Additional details describing conditions at the site are included in the Level I data base (Hopkins and Robinson, unpub. data, 1997). Photographs of the site, taken at the time of the Level I site visit, are archived at the USGS office in Indianapolis.

EVALUATION METHODS

The methods described in this section apply to a number of bridge sites in Indiana being evaluated for scour and outline the procedures requested by INDOT for these modified Level II scour analyses. The principal modification requested by INDOT was that the input data to the model come from or be estimated from existing data sources; no additional field data were collected. Actual methods used in the scour evaluation at this particular bridge site use the most applicable method possible, given the data available.

To determine drainage area, either published values found in Hoggatt (1975) or 7.5-minute topographic maps with Hoggatt's original drainage-area delineations were used. Where there are no published data, drainage-area segments measured from the maps produced by Hoggatt were either subtracted from downstream sites or added to upstream sites published by Hoggatt (1975).

In Indiana, flood discharges are coordinated by agreement among State and Federal agencies. At sites where flood discharges officially are coordinated among State and Federal agencies in Indiana, the coordinated 100-year discharge (Q100) was modeled. INDOT also provided an additional flood discharge for these coordinated sites in excess of the Q100 to be modeled.

If a flood discharge was not coordinated, the USGS examined Federal Emergency Management Agency (FEMA) studies for Q100 determinations. Where FEMA studies did not produce a Q100, the USGS contacted IDNR for an estimated Q100 in the vicinity of the site being studied. If IDNR did not have a Q100, data from nearby USGS streamflow-gaging stations were analyzed with nearby and similar drainage basins that have been coordinated. At sites having no coordinated discharge data, the two discharges used in the model were 1) the approximated Q100 and 2) a discharge equal to 1.7 times the approximated Q100.

Most of the cross-section and bridge-opening geometry data were taken from the bridge plans (Indiana State Highway Commission, 1958) provided by INDOT. Bridge plans are presumed to be representative of current conditions at the site. To determine the cross-section geometry, a line was drawn on the bridge plans parallel to the bridge stationing and approximately one bridge width from the bridge. For sites where the bridge plans did not extend far enough laterally for collection of all cross-section data required for WSPRO model analysis, additional data were collected from 7.5-minute topographic maps.

The roadway and embankment profile was taken from the bridge and highway plans for those sites where roadway overtopping was expected. The INDOT bridge plans and 7.5-minute topographic maps were used as a guide, based on the water-surface elevations calculated by the WSPRO model, to determine if roadway overtopping might occur.

Roughness values (n-values) for the main channel were estimated by viewing photographs archived from the Level I scour assessments. The n-values for the overbanks were assigned on the basis of the surface-cover data summarized in the Level I data base (Hopkins and Robinson, unpub. data, 1997). From those data, the following roughness values were assigned to the surface-cover categories: urban—0.050, suburban—0.035, row crop—0.045, pasture—0.035, brush—0.120, forest—0.100, and wetland (any area covered by standing water)—0.100. The n-values for the overbanks were adjusted if the Level I photographs provided sufficient detail to warrant an adjustment.

WSPRO version V050196 was used to model flow through the study site. Starting water-surface elevation was obtained with a slope-conveyance computation. The channel-bed slope in the immediate vicinity of the bridge was estimated from the 7.5-minute topographic map and was used as the slope of the energy grade line for this computation.

WSPRO version V050196 includes a field that allows the input of up to four scour-adjustment factors (K1 to K4). For this modeling, the default value for K4 (bed armoring) was chosen. For scour-adjustment factors K1 and K2 (pier-nose shape and angle of attack, respectively), input values were determined by evaluating the data archived in the Level I data base (Hopkins and Robinson, unpub. data, 1997). For the K3 factor (bed forms), a value of 1.1 was applied in all cases.

In some cases, piers set on the overbanks are constructed with footings that are higher in elevation than pier footings in the main channel. In these situations, if the channel position changes, the piers that were initially constructed on the overbank may become part of the main channel. Therefore, to evaluate total potential scour, the model results obtained for contraction scour and deepest local scour in the main channel were added and applied to all piers in the bridge opening. This methodology allowed for an evaluation of potential undermining of pier supports in the event that future channel movement placed overbank piers in the main channel.

Where bridge pairs have a continuous abutment or fill between the bridges that does not allow expansion of flow, the bridge pair was modeled as one bridge. Sites with discontinuous abutments, allowing expansion between the bridges, were modeled as two separate bridges. In those cases, a valley cross section was measured between the bridges and used as the approach section for the downstream bridge and as the exit section for the upstream bridge.

At sites with no embankment to function as a weir or at sites where the tailwater drowns out the embankment, a composite bridge and road section was used to compute flow. Those sites were computed with friction-loss equations rather than with a bridge routine.

Total scour is taken as the sum of local scour plus contraction scour. If the model predicted negative contraction scour (aggradation), the contraction-scour value was assumed to be zero in determining the total scour depth (table 1). This assumption was made so that a negative contraction scour would not mask the potentially detrimental effects of local scour at a pier. No abutment scour evaluations were made in this study.

Table 1. Cumulative scour depths for the modeled discharges at structure I-74-70-4437 crossing Eagle Creek in Marion County, Indiana

[--, no value]

Pier number[1]	Stationing from bridge plans[2]	Initial bed-elevation at pier (feet)	Main-channel contraction scour depth (feet)	Local scour depth (feet)	Worst-case total-scour depth[3] (feet)	Bottom elevation of pier (feet)	Worst-case bed elevation after scour[4] (feet)
Modeled discharge[5] is 22,700 cubic feet per second							
1	749+06	753	9.0	7.0	16.0	737.4	724.5
2	749+67	741	9.0	7.0	16.0	734.4	724.5
3	750+39	741	9.0	7.0	16.0	734.4	724.5
4	751+00	753	9.0	7.0	16.0	737.4	724.5
Modeled discharge is 31,600 cubic feet per second							
1	749+06	753	23.9	7.8	31.7	737.4	708.8
2	749+67	741	23.9	7.8	31.7	734.4	708.8
3	750+39	741	23.9	7.8	31.7	734.4	708.8
4	751+00	753	23.9	7.8	31.7	737.7	708.8

[1]Pier numbers were assigned from left to right as shown on the bridge plans.

[2]Stationing is the center line of the pier as determined from the bridge plans. Stationing from bridge plan, 749+06, represents a point 74,906 feet from an arbitrary starting location referenced on the bridge plans.

[3]Worst-case total-scour depths are generated by summing the calculated contraction-scour depth with the worst case of local scour.

[4]Worst-case bed elevation is computed by subtracting the worst-case total-scour depth from the lowest initial bed elevation in the bridge opening (740.5 feet).

[5]Coordinated discharge.

SPECIAL CONSIDERATIONS

Model runs indicate the water-surface elevation at the bridge is lower than the low-steel elevation for the modeled discharges. Therefore, there should be no pressure flow through the bridge opening for the discharges modeled. This site has been modeled without consideration for how Eagle Creek Reservoir affects the hydraulics or streambed-scour conditions.

RESULTS

Scour depths were computed with a version of WSPRO (Larry Arneson, Federal Highway Administration, written commun., 1996) modified from Shearman (1990). This version of WSPRO includes scour calculations in the model output. Scour depths were calculated assuming an infinite depth of material that could erode and a homogeneous particle-size distribution. The results of the scour analysis are presented in table 1; a complete input file and output results are presented in the appendix.

REFERENCES

Hoggatt, R.E., 1975, Drainage areas of Indiana streams: U.S. Geological Survey, Water Resources Division, 231 p.

Indiana State Highway Commission, 1958, Bridge plans Interstate Route 74: Bridge File I-74-70-4437.

Lagasse, P.F.; Schall, J.D.; Johnson, F.; Richardson, E.V.; and Chang, F., 1995, Stream stability at highway structures (2d ed.): Federal Highway Administration, Hydraulic Engineering Circular No. 20, Publication FHWA-IP-90-014, 144 p.

Richardson, E.V., and Davis, S.R., 1995, Evaluating scour at bridges (3d ed.): Federal Highway Administration, Hydraulic Engineering Circular No. 18, Publication FHWA-IP-90-017, 204 p.

Shearman, J.O., 1990, User's manual for WSPRO, a computer model for water-surface profile computations: Federal Highway Administration Publication FHWA-IP-89-027, 177 p.

APPENDIX

WSPRO INPUT FILE

```
T1        I-74 Over Eagle Creek                I74-70-4437
T2        County: Marion                       Quad: Clermont 110D
T3        11-14-96                             Bret A. Robinson
SI        0
Q         22700 31600
SK        .0012 .0012
XS   EXIT 0
GR        73337 790  73402 765  73773 760  74146 755  74882 751  74936 745
GR        74976 741.5  75027 740.5  75075 741.5  75082 743  75101 745
GR        75117 750  76050 760  76174 790
N         .100 .034 .100
SA        74800 75150
XS   FULLV 250
GR        73337 790  73402 765  73773 760  74146 755  74882 751  74936 745
GR        74976 741.5  75027 740.5  75075 741.5  75082 743  75101 745
GR        75117 750  76050 760  76174 790
N         .100 .034 .100
SA        74800 75150
BR   BRDGE 250 764.7 0
GR       74876 0764.7  74876 0764.4  74882 0764.3  74917 0749.1  74942 0746.6
GR       74956 0741.6  75005 0740.5  75056 0741.5  75069 0746.6  75092 0749.0
GR        75130 0764.3  75135 0764.3  75135 0764.8  74876 0764.7
N         .034
PD        742 4 1
PD        753 4 2
PD        753 8 3
CD        3 125 2 764.2
DC 0 BRDGE 74906 75105 74890 75110 * 8
*         LPierEdge RPierEdge PierWdth * * K1 K2 K3(1.1)
DP        74876 75135 2 * * 1 1 1.1
DP        74876 75135 2 * * 1 1 1.1
DP        74876 75135 2 * * 1 1 1.1
DP        74876 75135 2 * * 1 1 1.1
XS   APPR 625
GR        72665 780  72848 775  73720 760  74332 755  74882 751  74936 745
GR        74976 741.5  75027 740.5  75075 741.5  75082 743  75091 745
GR        75117 750  75720 755  76105 760  76233 780
N         .034
EX
ER
```

WSPRO OUTPUT

```
************************  W S P R O  ***************************
        Federal Highway Administration  -  U. S. Geological Survey
              Model for Water-Surface Profile Computations.
          Run Date & Time:  8/ 4/97  1:51 pm     Version V050196
           Input File: 4437.dat       Output File: 4437.LST
    *-------------------------------------------------------------*
T1         I-74 OVER EAGLE CREEK              I74-70-4437
T2         COUNTY: MARION                     QUAD: CLERMONT 110D
T3         11-14-96                           BRET A. ROBINSON
SI         0
Q          22700 31600

 ***   Processing Flow Data; Placing Information into Sequence  1   ***

SK         .0012 .0012

    ************************  W S P R O  ***************************
       Federal Highway Administration  -  U. S. Geological Survey
             Model for Water-Surface Profile Computations.
            Input Units: English  /  Output Units: English
    *-------------------------------------------------------------*
          I-74 OVER EAGLE CREEK              I74-70-4437
       COUNTY: MARION                     QUAD: CLERMONT 110D
         11-14-96                           BRET A. ROBINSON

          *-------------------------------------------------*
          *      Starting To Process Header Record EXIT     *
          *-------------------------------------------------*

XS   EXIT 0
GR         73337 790  73402 765  73773 760  74146 755  74882 751  74936 745
GR         74976 741.5  75027 740.5  75075 741.5  75082 743  75101 745
GR         75117 750  76050 760  76174 790
N          .100 .034 .100
SA         74800 75150

 ***   Completed Reading Data Associated With Header Record EXIT    ***
 ***  Storing X-Section Data In Temporary File As Record Number  1  ***

 ***              Data Summary For Header Record EXIT               ***
 SRD Location:        0.   Cross-Section Skew:    .0   Error Code   0
 Valley Slope:   .00000    Averaging Conveyance By Geometric Mean.
 Energy Loss Coefficients ->   Expansion:   .50   Contraction:   .00

                     X,Y-coordinates (14 pairs)
     X          Y            X          Y            X          Y
----------  ----------   ----------  ----------   ----------  ----------
 73337.000     790.000    73402.000     765.000    73773.000     760.000
 74146.000     755.000    74882.000     751.000    74936.000     745.000
 74976.000     741.500    75027.000     740.500    75075.000     741.500
 75082.000     743.000    75101.000     745.000    75117.000     750.000
 76050.000     760.000    76174.000     790.000
----------  ----------   ----------  ----------   ----------  ----------
```

WSPRO OUTPUT

```
                Minimum and Maximum X,Y-coordinates
  Minimum X-Station:   73337.000  ( associated Y-Elevation:  790.000 )
  Maximum X-Station:   76174.000  ( associated Y-Elevation:  790.000 )
  Minimum Y-Elevation:   740.500  ( associated X-Station:  75027.000 )
  Maximum Y-Elevation:   790.000  ( associated X-Station:  73337.000 )

                    Roughness Data (  3 SubAreas )
                             Roughness   Horizontal
                   SubArea  Coefficient  Breakpoint
                   -------  -----------  ----------
                      1         .100        ---
                                ---       ********
                      2         .034        ---
                                ---       ********
                      3         .100        ---
                   -------  -----------  ----------

          *-------------------------------------------------*
          *      Finished Processing Header Record EXIT     *
          *-------------------------------------------------*

    ************************* W S P R O ***************************
       Federal Highway Administration - U. S. Geological Survey
             Model for Water-Surface Profile Computations.
           Input Units: English  /  Output Units: English
    *-------------------------------------------------------------*
          I-74 OVER EAGLE CREEK              I74-70-4437
       COUNTY: MARION                     QUAD: CLERMONT 110D
         11-14-96                           BRET A. ROBINSON

          *-------------------------------------------------*
          *      Starting To Process Header Record FULLV    *
          *-------------------------------------------------*

XS   FULLV 250
GR        73337 790  73402 765  73773 760  74146 755  74882 751  74936 745
GR        74976 741.5  75027 740.5  75075 741.5  75082 743  75101 745
GR        75117 750  76050 760  76174 790
N         .100 .034 .100
SA        74800 75150

 ***   Completed Reading Data Associated With Header Record FULLV   ***
 ***  Storing X-Section Data In Temporary File As Record Number  2  ***

 ***              Data Summary For Header Record FULLV              ***
 SRD Location:      250.   Cross-Section Skew:    .0   Error Code   0
 Valley Slope:   .00000    Averaging Conveyance By Geometric Mean.
 Energy Loss Coefficients ->   Expansion:   .50   Contraction:   .00

                    X,Y-coordinates (14 pairs)
     X          Y            X          Y            X          Y
----------  ----------   ----------  ----------   ----------  ----------
 73337.000     790.000    73402.000     765.000    73773.000     760.000
 74146.000     755.000    74882.000     751.000    74936.000     745.000
```

WSPRO OUTPUT

```
   74976.000     741.500    75027.000     740.500    75075.000     741.500
   75082.000     743.000    75101.000     745.000    75117.000     750.000
   76050.000     760.000    76174.000     790.000
  ----------   ----------   ----------  ----------   ----------  ----------

                  Minimum and Maximum X,Y-coordinates
    Minimum X-Station:   73337.000  ( associated Y-Elevation:  790.000 )
    Maximum X-Station:   76174.000  ( associated Y-Elevation:  790.000 )
    Minimum Y-Elevation:   740.500  ( associated X-Station:  75027.000 )
    Maximum Y-Elevation:   790.000  ( associated X-Station:  73337.000 )

                     Roughness Data (  3 SubAreas )
                             Roughness   Horizontal
                   SubArea  Coefficient  Breakpoint
                   -------  -----------  ----------
                      1         .100        ---
                                ---        ********
                      2         .034        ---
                                ---        ********
                      3         .100        ---
                   -------  -----------  ----------

          *-----------------------------------------------------*
          *      Finished Processing Header Record FULLV        *
          *-----------------------------------------------------*

     ************************  W S P R O  ****************************
        Federal Highway Administration  -  U. S. Geological Survey
              Model for Water-Surface Profile Computations.
             Input Units: English  /  Output Units: English
     *-------------------------------------------------------------*
           I-74 OVER EAGLE CREEK              I74-70-4437
        COUNTY: MARION                     QUAD: CLERMONT 110D
          11-14-96                           BRET A. ROBINSON

          *-----------------------------------------------------*
          *      Starting To Process Header Record BRDGE        *
          *-----------------------------------------------------*

   BR   BRDGE 250 764.7 0
   GR        74876 0764.7  74876 0764.4  74882 0764.3  74917 0749.1  74942
0746.6
   GR        74956 0741.6  75005 0740.5  75056 0741.5  75069 0746.6  75092
0749.0
   GR        75130 0764.3  75135 0764.3  75135 0764.8  74876 0764.7
   N         .034
   PD        742 4 1
   PD        753 4 2
   PD        753 8 3
   CD        3 125 2 764.2

    ***   Completed Reading Data Associated With Header Record BRDGE   ***
 +++072 NOTICE:  X-coordinate # 2 increased to eliminate vertical segment.
 +++072 NOTICE:  X-coordinate #13 increased to eliminate vertical segment.
```

WSPRO OUTPUT

```
***   Storing Bridge Data In Temporary File As Record Number  3     ***

***                Data Summary For Bridge Record BRDGE                ***
SRD Location:      250.   Cross-Section Skew:     .0   Error Code    0
Valley Slope:  *******    Averaging Conveyance By Geometric Mean.
Energy Loss Coefficients ->   Expansion:   .50   Contraction:    .00
```

X,Y-coordinates (14 pairs)

X	Y	X	Y	X	Y
74876.000	764.700	74876.100	764.400	74882.000	764.300
74917.000	749.100	74942.000	746.600	74956.000	741.600
75005.000	740.500	75056.000	741.500	75069.000	746.600
75092.000	749.000	75130.000	764.300	75135.000	764.300
75135.100	764.800	74876.000	764.700		

Minimum and Maximum X,Y-coordinates

```
 Minimum X-Station:   74876.000  ( associated Y-Elevation:  764.700 )
 Maximum X-Station:   75135.100  ( associated Y-Elevation:  764.800 )
 Minimum Y-Elevation:   740.500  ( associated X-Station:  75005.000 )
 Maximum Y-Elevation:   764.800  ( associated X-Station:  75135.100 )
```

Roughness Data (1 SubAreas)

SubArea	Roughness Coefficient	Horizontal Breakpoint
1	.034	---

Discharge coefficient parameters

BRType	BRWdth	EMBSS	EMBElv	UserCD
3	125.000	2.00	764.200	**********

Pressure flow elevations

AVBCEL	PFElev
*********	764.700

Abutment Parameters

ABSLPL	ABSLPR	XTOELT	YTOELT	XTOERT	YTOERT
*******	*******	*********	*********	*********	*********

Pier/Pile Data (3 Group(s))

Code Indicates Bridge Uses Piers

Group	Elevation	Gross Width	Number
1	742.000	4.000	1
2	753.000	4.000	2
3	753.000	8.000	3

```
*------------------------------------------------*
*      Finished Processing Header Record BRDGE   *
```

WSPRO OUTPUT

```
        *-------------------------------------------------*

   ************************  W S P R O  ***************************
      Federal Highway Administration  -  U. S. Geological Survey
            Model for Water-Surface Profile Computations.
           Input Units: English  /  Output Units: English
   *-------------------------------------------------------------*
          I-74 OVER EAGLE CREEK              I74-70-4437
       COUNTY: MARION                     QUAD: CLERMONT 110D
         11-14-96                           BRET A. ROBINSON
DC 0 BRDGE 74906 75105 74890 75110 * 8
DP         74876 75135 2 * * 1 1 1.1
DP         74876 75135 2 * * 1 1 1.1
DP         74876 75135 2 * * 1 1 1.1
DP         74876 75135 2 * * 1 1 1.1

         *-------------------------------------------------*
         *      Starting To Process Header Record APPR     *
         *-------------------------------------------------*

XS   APPR 625
GR         72665 780  72848 775  73720 760  74332 755  74882 751  74936 745
GR         74976 741.5  75027 740.5  75075 741.5  75082 743  75091 745
GR         75117 750  75720 755  76105 760  76233 780
N          .034

 ***   Completed Reading Data Associated With Header Record APPR     ***
 ***  Storing X-Section Data In Temporary File As Record Number  4   ***

 ***              Data Summary For Header Record APPR                 ***
 SRD Location:      625.   Cross-Section Skew:    .0   Error Code    0
 Valley Slope:   .00000    Averaging Conveyance By Geometric Mean.
 Energy Loss Coefficients ->   Expansion:   .50   Contraction:   .00

                    X,Y-coordinates (15 pairs)
    X          Y             X          Y             X          Y
----------  ----------   ----------  ----------   ----------  ----------
 72665.000     780.000    72848.000     775.000    73720.000     760.000
 74332.000     755.000    74882.000     751.000    74936.000     745.000
 74976.000     741.500    75027.000     740.500    75075.000     741.500
 75082.000     743.000    75091.000     745.000    75117.000     750.000
 75720.000     755.000    76105.000     760.000    76233.000     780.000
----------  ----------   ----------  ----------   ----------  ----------

                Minimum and Maximum X,Y-coordinates
  Minimum X-Station:   72665.000  ( associated Y-Elevation:  780.000 )
  Maximum X-Station:   76233.000  ( associated Y-Elevation:  780.000 )
  Minimum Y-Elevation:   740.500  ( associated X-Station:  75027.000 )
  Maximum Y-Elevation:   780.000  ( associated X-Station:  72665.000 )

                    Roughness Data (  1 SubAreas )
                           Roughness   Horizontal
                  SubArea  Coefficient  Breakpoint
                  -------  -----------  ----------
```

WSPRO OUTPUT

```
                    1         .034        ---
                -------  -----------  ----------

Bridge datum projection(s):  XREFLT  XREFRT  FDSTLT  FDSTRT
                            ******* ******* ******* *******

          *---------------------------------------------------*
          *      Finished Processing Header Record APPR       *
          *---------------------------------------------------*

    ************************* W S P R O ****************************
       Federal Highway Administration  -  U. S. Geological Survey
             Model for Water-Surface Profile Computations.
            Input Units: English  /  Output Units: English
    *-------------------------------------------------------------*
          I-74 OVER EAGLE CREEK              I74-70-4437
       COUNTY: MARION                     QUAD: CLERMONT 110D
         11-14-96                          BRET A. ROBINSON
  EX

          *===================================================*
          *     Summary of Boundary Condition Information     *
          *===================================================*

          Reach       Water Surface   Friction
     #   Discharge      Elevation      Slope          Flow Regime
    --   ---------    -------------   --------   --------------------
     1    22700.00       ********        .0012        Sub-Critical
     2    31600.00       ********        .0012        Sub-Critical
    --   ---------    -------------   --------   --------------------

          *===================================================*
          *        Beginning  2 Profile Calculation(s)        *
          *===================================================*


    ************************* W S P R O ****************************
       Federal Highway Administration  -  U. S. Geological Survey
             Model for Water-Surface Profile Computations.
            Input Units: English  /  Output Units: English
    *-------------------------------------------------------------*
          I-74 OVER EAGLE CREEK              I74-70-4437
       COUNTY: MARION                     QUAD: CLERMONT 110D
         11-14-96                          BRET A. ROBINSON

                      WSEL     VHD       Q          AREA       SRDL       LEW
                      EGEL      HF       V            K        FLEN       REW
                      CRWS      HO      FR #         SF        ALPHA      ERR
                    --------- ------ ---------- ---------- --------- ---------
 Section: EXIT       755.125   .612  22700.000   5471.388 ********* 74136.680
 Header Type: XS     755.737 ******      4.149  654930.10 ********* 75595.160
 SRD:       .000     750.541 ******       .571     ******     2.286    ******

 Section: FULLV      755.475   .542  22700.000   5992.653   250.000 74110.550
```

WSPRO OUTPUT

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Header Type: FV    756.017   .278      3.788  708470.10   250.000 75627.840
SRD:    250.000    750.541   .000       .524       .0011     2.429      .003

       <<< The Preceding Data Reflect The "Unconstricted" Profile >>>

Section: APPR      756.190   .163  22700.000   7017.645   375.000 74186.340
Header Type: AS    756.353   .336      3.235  812811.60   375.000 75811.630
SRD:    625.000    751.706   .000       .274       .0009     1.000      .000

       <<< The Preceding Data Reflect The "Unconstricted" Profile >>>

        <<< The Following Data Reflect The "Constricted" Profile >>>
          <<< Beginning Bridge/Culvert Hydraulic Computations >>>


                    WSEL     VHD       Q          AREA       SRDL       LEW
                    EGEL      HF       V           K         FLEN       REW
                    CRWS      HO      FR #         SF        ALPHA      ERR
                  --------- ------ ---------- ---------- --------- ---------
Section: BRDGE     754.747  2.520  22700.000   2070.282   250.000 74904.000
Header Type: BR    757.266   .481     10.965  420485.50   250.000 75106.270
SRD:    250.000    751.682 1.046       .701     ******     1.348     -.006

Specific Bridge Information   C      P/A    PFELEV    BLEN      XLAB      XRAB
Bridge Type 3   Flow Type 1 ------ ----- -------- -------- -------- --------
Pier/Pile Code  0             .8615  .028  764.700 ******** ******** ********
--------------------------- ------ ----- -------- -------- -------- --------

                    WSEL     VHD       Q          AREA       SRDL       LEW
                    EGEL      HF       V           K         FLEN       REW
                    CRWS      HO      FR #         SF        ALPHA      ERR
                  --------- ------ ---------- ---------- --------- ---------
Section: APPR      757.887   .079  22700.000  10063.630   250.000 73978.590
Header Type: AS    757.966   .280      2.256 1306773.00   288.677 75942.330
SRD:    625.000    751.706   .424       .176       .0009     1.000      .017

          Approach Section APPR  Flow Contraction Information
           M( G )   M( K )     KQ       XLKQ     XRKQ     OTEL
          -------- -------- --------- -------- -------- --------
              .873     .401  778737.9 ******** ******** 757.887
          -------- -------- --------- -------- -------- --------

             <<< End of Bridge Hydraulics Computations >>>


   ************************* W S P R O *****************************
      Federal Highway Administration - U. S. Geological Survey
            Model for Water-Surface Profile Computations.
            Input Units: English  /  Output Units: English
   *-------------------------------------------------------------*
          I-74 OVER EAGLE CREEK              I74-70-4437
       COUNTY: MARION                    QUAD: CLERMONT 110D
         11-14-96                          BRET A. ROBINSON
```

WSPRO OUTPUT

	WSEL EGEL CRWS	VHD HF HO	Q V FR #	AREA K SF	SRDL FLEN ALPHA	LEW REW ERR
Section: EXIT	756.672	.707	31600.000	7928.978	*********	74021.260
Header Type: XS	757.379	******	3.985	911933.80	*********	75739.520
SRD: .000	752.672	******	.553	******	2.863	******
Section: FULLV	757.019	.634	31600.000	8535.311	250.000	73995.370
Header Type: FV	757.653	.280	3.702	976961.60	250.000	75771.890
SRD: 250.000	752.672	.000	.514	.0011	2.974	-.006

<<< The Preceding Data Reflect The "Unconstricted" Profile >>>

Section: APPR	757.794	.159	31600.000	9881.290	375.000	73990.010
Header Type: AS	757.953	.300	3.198	1275617.00	375.000	75935.140
SRD: 625.000	753.062	.000	.250	.0008	1.000	.000

<<< The Preceding Data Reflect The "Unconstricted" Profile >>>

<<< The Following Data Reflect The "Constricted" Profile >>>
<<< Beginning Bridge/Culvert Hydraulic Computations >>>

	WSEL EGEL CRWS	VHD HF HO	Q V FR #	AREA K SF	SRDL FLEN ALPHA	LEW REW ERR
Section: BRDGE	755.917	4.531	31600.000	2310.182	250.000	74901.300
Header Type: BR	760.448	.569	13.679	495141.40	250.000	75109.180
SRD: 250.000	753.683	2.498	.903	******	1.557	-.002

Specific Bridge Information	C	P/A	PFELEV	BLEN	XLAB	XRAB
Bridge Type 3 Flow Type 1						
Pier/Pile Code 0	.8014	.029	764.700	********	********	********

	WSEL EGEL CRWS	VHD HF HO	Q V FR #	AREA K SF	SRDL FLEN ALPHA	LEW REW ERR
Section: APPR	761.183	.051	31600.000	17522.970	250.000	73651.250
Header Type: AS	761.233	.221	1.803	2833095.00	300.595	76112.570
SRD: 625.000	753.062	.566	.119	.0008	1.000	.008

Approach Section APPR Flow Contraction Information

M(G)	M(K)	KQ	XLKQ	XRKQ	OTEL
.890	.609	1105968.0	********	********	761.183

<<< End of Bridge Hydraulics Computations >>>

WSPRO OUTPUT

```
************************* W S P R O ***************************
   Federal Highway Administration - U. S. Geological Survey
         Model for Water-Surface Profile Computations.
         Input Units: English / Output Units: English
*-------------------------------------------------------------*
      I-74 OVER EAGLE CREEK              I74-70-4437
   COUNTY: MARION                     QUAD: CLERMONT 110D
     11-14-96                          BRET A. ROBINSON

***  Live-Bed Contraction Scour Calculations for Header Record BRDGE  ***

                  Constants and Input Variables

            *-----------------------------------------------*
             Bed Material Transport Mode Factor (k1):    .64
             Total Pier Width Value             (Pw): 8.000
            *-----------------------------------------------*

    Scour      -- Flow --          -- Width --        --- X-Limits ---
 #  Depth  Contract Approach  Contract Approach  Side   Contract Approach
--  ------ --------- --------- -------- --------  ------ -------- --------
 1  9.049 22700.000 14254.170  191.000  220.000  Left:  ******** ********
    ..... Approach Channel Depth:   14.442 .....  Right: ******** ********
 2 23.909 31600.000 12891.660  191.000  220.000  Left:  ******** ********
    ..... Approach Channel Depth:   17.737 .....  Right: ******** ********
--  ------ --------- --------- -------- --------  ------ -------- --------

************************* W S P R O ***************************
   Federal Highway Administration - U. S. Geological Survey
         Model for Water-Surface Profile Computations.
         Input Units: English / Output Units: English
*-------------------------------------------------------------*
      I-74 OVER EAGLE CREEK              I74-70-4437
   COUNTY: MARION                     QUAD: CLERMONT 110D
     11-14-96                          BRET A. ROBINSON

     ***  Pier Scour Calculations for Header Record BRDGE  ***

                  Constants and Input Variables

                        Pier Width:   2.000
            *-----------------------------------------*
              Pier Shape Factor            (K1):  1.00
              Flow Angle of Attack Factor  (K2):  1.00
              Bed Condition Factor         (K3):  1.10
              Bed Material Factor          (K4):  1.00
              Velocity Multiplier          (VM):  1.00
              Depth Multiplier             (YM):  1.00
            *-----------------------------------------*

    Scour    ---- Localized Hydraulic Properties ----     -- X-Stations --
 #  Depth     Flow      WSE    Depth  Velocity Froude #   Left      Right
--  ----- ---------- -------- ------ -------- -------- --------- ---------
 1   7.01  22700.000  755.171 14.671  12.659     .582  74876.000 75135.000
```

WSPRO OUTPUT

2	7.77	31600.000	756.483	15.983	15.672	.691	74876.000	75135.000

```
********************** W S P R O **************************
   Federal Highway Administration - U. S. Geological Survey
         Model for Water-Surface Profile Computations.
        Input Units: English / Output Units: English
*-----------------------------------------------------------*
       I-74 OVER EAGLE CREEK            I74-70-4437
   COUNTY: MARION                   QUAD: CLERMONT 110D
     11-14-96                         BRET A. ROBINSON

    ***  Pier Scour Calculations for Header Record BRDGE  ***

                Constants and Input Variables

                    Pier Width:   2.000
             *----------------------------------------*
               Pier Shape Factor           (K1):   1.00
               Flow Angle of Attack Factor (K2):   1.00
               Bed Condition Factor        (K3):   1.10
               Bed Material Factor         (K4):   1.00
               Velocity Multiplier         (VM):   1.00
               Depth Multiplier            (YM):   1.00
             *----------------------------------------*
```

	Scour	---- Localized Hydraulic Properties ----				-- X-Stations --	
#	Depth	Flow	WSE	Depth	Velocity	Froude #	Left	Right
1	7.01	22700.000	755.171	14.671	12.659	.582	74876.000	75135.000
2	7.77	31600.000	756.483	15.983	15.672	.691	74876.000	75135.000

```
********************** W S P R O **************************
   Federal Highway Administration - U. S. Geological Survey
         Model for Water-Surface Profile Computations.
        Input Units: English / Output Units: English
*-----------------------------------------------------------*
       I-74 OVER EAGLE CREEK            I74-70-4437
   COUNTY: MARION                   QUAD: CLERMONT 110D
     11-14-96                         BRET A. ROBINSON

    ***  Pier Scour Calculations for Header Record BRDGE  ***

                Constants and Input Variables

                    Pier Width:   2.000
             *----------------------------------------*
               Pier Shape Factor           (K1):   1.00
               Flow Angle of Attack Factor (K2):   1.00
               Bed Condition Factor        (K3):   1.10
               Bed Material Factor         (K4):   1.00
```

WSPRO OUTPUT

```
                Velocity Multiplier          (VM):   1.00
                Depth Multiplier             (YM):   1.00
              *-----------------------------------------*

     Scour    ---- Localized Hydraulic Properties ----      -- X-Stations --
 #   Depth     Flow       WSE     Depth  Velocity Froude #   Left       Right
--   ----- ---------- -------- ------ -------- -------- --------- ---------
 1    7.01  22700.000  755.171 14.671  12.659      .582  74876.000 75135.000
 2    7.77  31600.000  756.483 15.983  15.672      .691  74876.000 75135.000
--   ----- ---------- -------- ------ -------- -------- --------- ---------


     ************************* W S P R O ****************************
        Federal Highway Administration  -  U. S. Geological Survey
              Model for Water-Surface Profile Computations.
             Input Units: English  /  Output Units: English
     *-------------------------------------------------------------*
            I-74 OVER EAGLE CREEK              I74-70-4437
        COUNTY: MARION                      QUAD: CLERMONT 110D
          11-14-96                            BRET A. ROBINSON

         ***  Pier Scour Calculations for Header Record BRDGE  ***

                      Constants and Input Variables

                          Pier Width:   2.000
                *-----------------------------------------*
                  Pier Shape Factor            (K1):   1.00
                  Flow Angle of Attack Factor  (K2):   1.00
                  Bed Condition Factor         (K3):   1.10
                  Bed Material Factor          (K4):   1.00
                  Velocity Multiplier          (VM):   1.00
                  Depth Multiplier             (YM):   1.00
                *-----------------------------------------*

     Scour    ---- Localized Hydraulic Properties ----      -- X-Stations --
 #   Depth     Flow       WSE     Depth  Velocity Froude #   Left       Right
--   ----- ---------- -------- ------ -------- -------- --------- ---------
 1    7.01  22700.000  755.171 14.671  12.659      .582  74876.000 75135.000
 2    7.77  31600.000  756.483 15.983  15.672      .691  74876.000 75135.000
--   ----- ---------- -------- ------ -------- -------- --------- ---------

  ER

    ******************  Normal end of WSPRO execution.  *****************
    ***************  Elapsed Time:    0 Minutes  4 Seconds  **************
```